Direct Cycle between Coproduct and Reactant: an Approach to Improve Atom Economy and Applications for the Synthesis and Protection of Primary Amines

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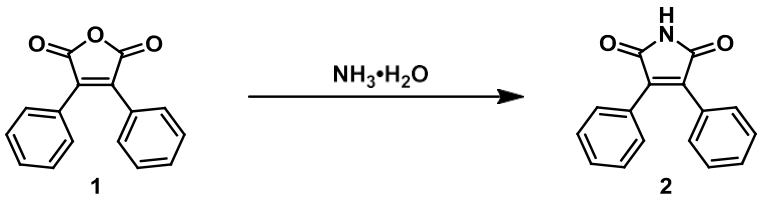
Supplementary Information—Table of Contents

Table S1. Optimization of the synthesis of 3,4-diphenyl maleimide. All of the reactions were carried out in sealed reaction vessels.

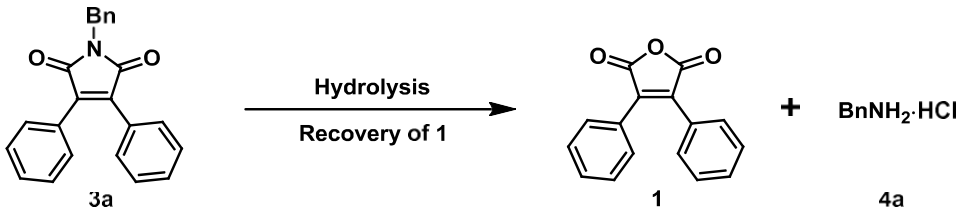


1 2

Entry	NH_3 (eq.)	Heating conditions	Temp (°C)	Time (min)	Yied (%)[a]
1	100	MW	100	20	62
2	100	MW	110	20	82
3	100	MW	120	20	95
4	100	MW	120	10	95
5	100	MW	120	4	98
6	100	MW	120	2	90
7	50	MW	120	4	98
8	10	MW	120	4	98
9	2	MW	120	4	98
10	2	Heating	100	20	34
11	1	MW	120	4	50

[a] Isolated yield

Table S2. The hydrolysis of 3,4-diphenyl N-benzyl maleimide. All of the microwave reactions were carried out in sealed reaction vessels.



Entry	Solvent	Acid or Base (eq.)	Temp (MW, °C)	Time (min)	Yied (%)[a] **4a**	Yied (%)[b] **1**
1	H_2O	HCl (50)	100	30	-	-
2	H_2O+EtOH (1/1)	HCl (50)	100	30	-	-
3	H_2O+Acetone (1/1)	HCl (50)	100	30	-	-
4	H_2O+CH_3CN (1/1)	HCl (50)	100	30	-	-
5	H_2O+dioxane (1/1)	HCl (50)	100	30	-	-
6	H_2O	KOH (10)	100	20	-	-
7	EtOH	KOH (10)	100	20	52	76
8	H_2O+EtOH (1/1)	KOH (10)	100	20	69	92
9	H_2O+EtOH (2/1)	KOH (10)	100	20	86	96
10	H_2O+EtOH (3/1)	KOH (10)	100	20	80	95
11	H_2O+EtOH (2/1)	KOH (6)	100	20	86	95
12	H_2O+EtOH (2/1)	KOH (5)	100	20	84	94
13	H_2O+EtOH (2/1)	KOH (6)	100	8	83	94
14	H_2O+EtOH (2/1)	KOH (6)	105	8	89	98
15	H_2O+EtOH (2/1)	KOH (6)	110	8	90	98
16	H_2O+EtOH (2/1)	KOH (6)	105	6	85	94

[a] For the acid aqueous layer, 50% potassium hydroxide was utilized to adjust the pH to around 10. After extraction and acidification by using dry hydrogen chloride, **4a** was precipitated by filtration.

[b] After hydrolysis under microwave irradiation, standard acidification for recovery of **1** by 18% hydrochloric acid was applied in entries 6-16 and **1** was precipitated from the reaction mixture and recovered by filtration.

Figure S1. Purity of the recovered compound **1**.

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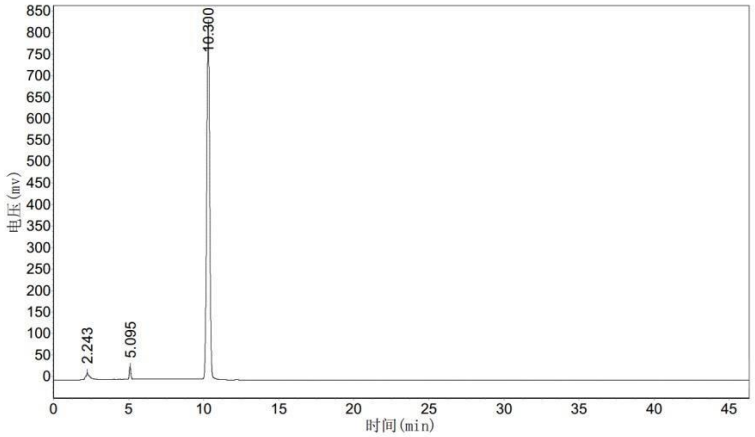

分析结果表

峰号	峰名	保留时间	峰高	峰面积	含量
1		2.243	16168.813	278054.000	2.3423
2		5.095	29089.000	205420.297	1.7305
3		10.300	826478.000	11387310.000	95.9272
总计			871735.813	11870784.297	100.0000

系统评价

峰号	峰名	保留时间	半峰宽	理论塔板数	分离度	拖尾因子	不对称度
1		2.243	0.212	625.066	0.000	1.725	2.063
2		5.095	0.110	11900.918	8.860	1.029	1.049
3		10.300	0.217	12576.477	3.691	0.989	0.950

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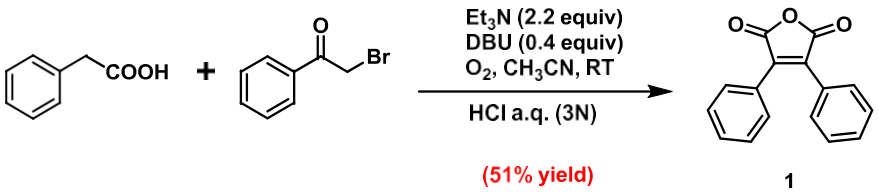
Materials and Methods.

All chemicals and solvents were of American Chemical Society grade or HPLC purity. Sigma-Aldrich (Beijing, China) is the commercial source for the starting materials utilized in the presented synthesis and the reagents were used without purification. Organic solvents were dried by standard methods when necessary. The column chromatography was performed using silica gel (200-300 mesh) from Qingdao Ocean Chemicals (Qingdao, Shandong, China). Ultrasound irradiation were performed on an ultrasonic cleaner (KQ-400KDE, made in Kunshan Ultrasonic Equipment Co., Ltd.) with frequency of 25 kHz and a nominal power of 400 W at 25-30 ^{o}C. The microwave reactions were performed on a discover-sp single mode microwave reactor from CEM Corporation (DISCOVERY-SP W/ACTIVENT, 909155, Matthews, NC, US). Melting points were measured on a hot-stage microscope (X-4, Beijing Taike Ltd.) and are uncorrected. Mass spectra (MS) were obtained in ESI mode on Agilent 1100 LC-MS (Agilent, Palo Alto, CA, USA) or Agilent Technologies 6890 GC and 5975 Series MS in EI mode. High resolution accurate mass determinations (HRMS) for all final target compounds were obtained on a Bruker Micromass Time of Flight mass spectrometer equipped with electrospray ionisation (ESI). ^{1}H and ^{13}C NMR spectra were obtained in D_2O, DMSO-d_6 or $CDCl_3$ on Bruker ARX-400, 400/100 MHz spectrometers (Bruker Bioscience, Billerica, MA, USA) using TMS as internal standard. Signals are designated as follows: s, singlet; d, doublet; dd, doublets of doublets; t, triplet; m, multiplet. Infrared spectra were recorded using KBr plates on a PE Spectrum-100 instrument. ctrometers with TMS as the internal reference (Bruker BioSciences). Purity of the recovered compound **1** was determined by using an Shimadzu HPLC-20AT with UV detector and a DIAMONSIL® C18 column (150 × 4.6 mm, 5 μm), flow rate 1.0 mL/min, UV detection at 254 nm, and injection volume of 20 μL. Mobile elution was conducted with a mixture of solvents A and B [Condition: CH_3CN/H_2O 65/35].

Experimental Procedures

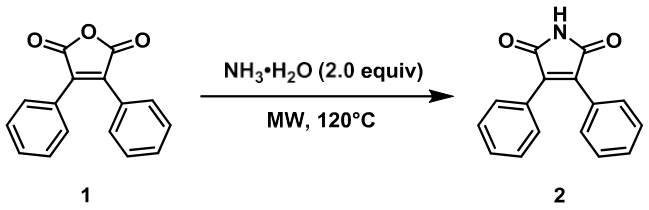
1. Application of 3,4-diphenylmaleic anhydride for synthesis of primary amines

A. Synthesis of 3,4-diphenylfuran-2,5-dione (1)



Et_3N (2.2 mmol, 2.2 equiv) was slowly added with stirring to a solution of phenacyl bromide (199.0 mg, 1.0 mmol, 1.0 equiv) and 2-phenylacetic acid (136.0 mg, 1.0 mmol, 1.0 equiv) in CH_3CN. Stirring was continued for 1 h at RT, DBU (0.4 mmol, 0.4 equiv) was added slowly and dropwise at RT in the presence of atmospheric oxygen. Stirring was continued for 6 h at RT, and the reaction mixture was acidified with 3N HCl. The mixture was diluted with H_2O (20 mL) then extracted with EtOAc (3×20 mL) and the combined organic phases were washed with brine (10 mL), dried over Na_2SO_4 and evaporated under reduced pressure. The residue was purified by flash column chromatography on silica using 50:1 hexanes/EtOAc as eluent, to give 127.5 mg (0.51 mmol) of pure product as a yellow solid (51% yield). mp: 158-160°C. These data are in agreement with that previously reported in the literature.[1]

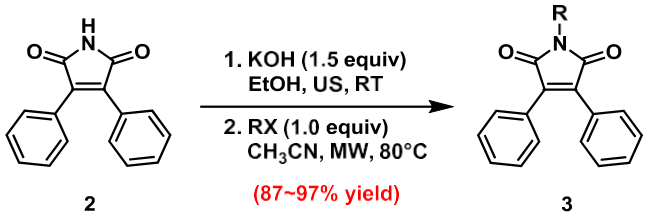
B. Synthesis of 3,4-diphenyl-1*H*-pyrrole-2,5-dione (2)



A mixture of **1** (250.0 mg, 1.0 mmol, 1.0 equiv), ammonia (0.15 mL, 2.0 mmol, 2.0 equiv), and water (5 mL) was added to the sealed reaction vessel of the monomodal CEM Discover® microwave synthesizer. The reaction mixture reacted under microwave irradiation at 50 W power and 120 °C for 4 min. The automatic mode stirred helps in mixing and the uniform heating of the reactants. The reaction vessel was cooled to room temperature. The mixture was diluted with H_2O (10 mL)

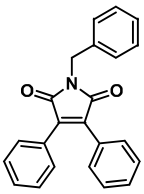
then extracted with EtOAc (3×10 mL) and the combined organic phases were washed with brine (10 mL), dried over Na_2SO_4 and evaporated under reduced pressure to give compound **2** as a light yellow solid. mp: 206-207°C; ^{1}H NMR (400MHz, $CDCl_3$): δ 7.40 (m, 10H). These data are in agreement with that previously reported in the literature.[2]

C. General procedure for the synthesis of 3,4-diphenyl N-benzyl maleimides (3)



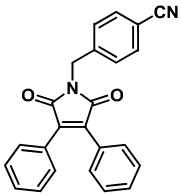
The mixture of **2** (0.4 mmol, 1.0 equiv) and KOH (0.4 mmol, 1.5 equiv) in ethonal (6 mL) was irradiated with ultrasound for 5 min at RT, and evaporated under reduced pressure. The respective alkyl halide RX (0.4 mmol, 1.0 equiv) was directly added into the solution of the residue and acetonitrile (6 mL), and then the reaction mixture was irradiated under microwave at 80 °C for 10 min. After cooling at RT, the mixture was diluted with H_2O (20 mL) then extracted with EtOAc (3×20 mL) and the combined organic phases were washed with brine (20 mL), dried over Na_2SO_4 and evaporated under reduced pressure. The residue was purified by flash column chromatography on silica to give pure product. Note: 1) Spectral data of 3,4-diphenyl N-benzyl maleimides matched those previously reported: **3a**[3], **3n**[3], and **3o**[3], with the exception of **3b~3m**, and **3p**. 2) Isolated yields of **3a-3p**: **3a-3p** were purified through flash column chromatography on silica for the structure characterization. During the synthesis of the final products **4a-4p**, the crude **3a-3p** were used without purification.

1-benzyl-3,4-diphenyl-1*H*-pyrrole-2,5-dione (3a).



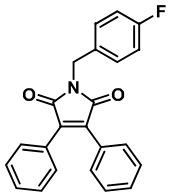
Prepared according to general procedure. Flash column chromatography on silica using 20:1 hexanes/EtOAc as eluent gave pure product as a yellow solid (94% yield). mp: 100-101°C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.46 (m, 6H), 7.33 (m, 9H), 4.80 (s, 2H); HRMS-ESI (m/z): $[M+H]^+$ calcd for $C_{23}H_{18}NO_2$, 340.1338; found 340.1331.

1-(4-cyanobenzyl)-3,4-diphenyl-1*H*-pyrrole-2,5-dione (3b).



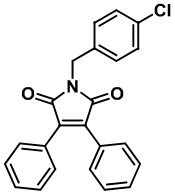
Prepared according to general procedure. Flash column chromatography on silica using 15:1 hexanes/EtOAc as eluent gave pure product as a yellow solid (95% yield). mp: 156-158°C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.64 (d, *J*=8.3 Hz, 2H), 7.55 (d, *J*=8.3 Hz, 2 H), 7.40 (m, 10H), 4.85 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 170.1 (×2), 141.3, 136.2 (×2), 132.4 (×2), 130.0 (×2), 129.7 (×4), 129.2 (×2), 128.5 (×4), 128.2 (×2), 118.4, 111.7, 41.4; HRMS-ESI (m/z): $[M+H]^+$ calcd for $C_{24}H_{17}N_2O_2$, 365.1290; found 365.1281.

1-(4-fluorobenzyl)-3,4-diphenyl-1*H*-pyrrole-2,5-dione (3c).



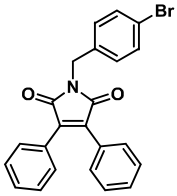
Prepared according to general procedure. Flash column chromatography on silica using 20:1 hexanes/EtOAc as eluent gave pure product as a yellow solid (94% yield). mp: 128-130°C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.39 (m, 12H), 7.01 (t, *J*=8.6, 2H), 4.77 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 170.3 (×2), 161.5-163.1 (×1, *J*=204.3 Hz), 136.1 (×2), 132.1-132.2 (×1, *J*=7.2 Hz), 130.6-130.7 (×2, *J*=6.9 Hz), 129.8 (×2), 129.8 (×4), 128.5 (×4), 128.4 (×2), 115.4-115.5 (×2, *J*=17.8 Hz), 41.2; HRMS-ESI (m/z): $[M+H]^+$ calcd for $C_{23}H_{17}FNO_2$, 358.1243; found 358.1243.

1-(4-chlorobenzyl)-3,4-diphenyl-1H-pyrrole-2,5-dione (3d).



Prepared according to general procedure. Flash column chromatography on silica using 20:1 hexanes/EtOAc as eluent gave pure product as a yellow solid (93% yield). mp: 156°C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.46 (m, 4H), 7.35 (m, 10H), 4.77 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 170.3 (×2), 136.1 (×2), 134.8, 133.7, 130.1 (×2), 129.8 (×4), 128.8 (×2), 128.5 (×4), 128.2 (×2), 128.4 (×2), 41.2; HRMS-ESI (m/z): $[M+H]^+$ calcd for $C_{23}H_{17}ClNO_2$, 374.0948; found 374.0950.

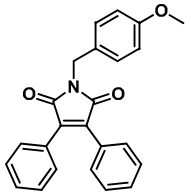
1-(4-bromobenzyl)-3,4-diphenyl-1*H*-pyrrole-2,5-dione (3e).



Prepared according to general procedure. Flash column chromatography on silica using 20:1 hexanes/EtOAc as eluent gave pure product as a yellow solid (97% yield). mp: 157-158°C; ^{1}H NMR

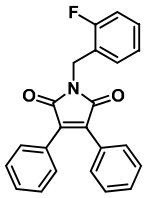
(400 MHz, $CDCl_3$): δ 7.46 (m, 6H), 7.34 (m, 8H), 4.75 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 170.3 (×2), 136.2 (×2), 135.3, 131.8 (×2), 130.6 (×2), 129.9 (×2), 129.8 (×4), 128.5 (×4), 128.4 (×2), 122.0, 41.4; HRMS-ESI (m/z): $[M+H]^+$ calcd for $C_{23}H_{17}BrNO_2$, 418.0443; found 418.0425.

1-(4-methoxybenzyl)-3,4-diphenyl-1*H*-pyrrole-2,5-dione (3f).



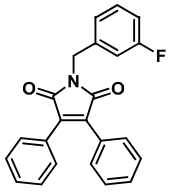
Prepared according to general procedure. Flash column chromatography on silica using 15:1 hexanes/EtOAc as eluent gave pure product as a yellow solid (91% yield). mp: 128-129°C; ^1H NMR (400 MHz, $CDCl_3$): δ 7.40 (m, 12H), 6.86 (d, *J*=8.6, 2H), 4.75 (s, 2H), 3.79 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 170.3 (×2), 136.2 (×2), 134.8, 133.8, 130.3 (×2), 129.9 (×2), 129.8 (×4), 128.8 (×2), 128.5 (×4), 128.4 (×2), 50.8, 41.3; HRMS-ESI (m/z): $[M+H]^+$ calcd for $C_{24}H_{20}NO_3$, 370.1443; found 370.1451.

1-(2-fluorobenzyl)-3,4-diphenyl-1*H*-pyrrole-2,5-dione (3g).



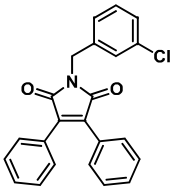
Prepared according to general procedure. Flash column chromatography on silica using 20:1 hexanes/EtOAc as eluent gave pure product as a yellow solid (96% yield). mp: 123-124°C; ^1H NMR (400 MHz, $CDCl_3$): δ 7.39 (m, 12H), 7.08 (m, 2H), 4.90 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 170.2 (×2), 159.8-161.4 (×1, *J*=205.8 Hz), 136.2 (×2), 130.5 (×1, *J*=2.9 Hz), 129.9 (×8), 129.6 (×1, *J*=6.7 Hz), 128.5 (×4), 124.2 (×1, *J*=3.0 Hz), 123.1-123.2 (×1, *J*=12.1 Hz), 115.5-115.6 (×1, *J*=17.8 Hz), 35.6 (×1, *J*=3.6 Hz); HRMS-ESI (m/z): $[M+H]^+$ calcd for $C_{23}H_{17}FNO_2$, 358.1243; found 358.1241.

1-(3-fluorobenzyl)-3,4-diphenyl-1*H*-pyrrole-2,5-dione (3h).



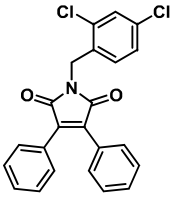
Prepared according to general procedure. Flash column chromatography on silica using 20:1 hexanes/EtOAc as eluent gave pure product as a yellow solid (95% yield). mp: 59-61°C; ^1H NMR (400 MHz, $CDCl_3$): δ 7.47 (m, 4H), 7.33 (m, 7H), 7.22 (d, *J*=7.6 Hz, 1H), 7.16 (m, 1H), 6.98 (m, 1H), 4.79 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 170.3 (×2), 161.9-163.6 (×1, *J*=204.4 Hz), 137.4 (×1, *J*=6.5 Hz), 130.4-130.5 (×1, *J*=6.9 Hz), 130.3 (×4), 130.2 (×4), 129.8 (×2), 128.5 (×2), 123.7 (×2), 123.7 (×1, *J*=2.6 Hz), 115.5-115.6 (×1, *J*=17.6 Hz), 115.1-115.2 (×1, *J*=18.3 Hz), 41.9; HRMS-ESI (m/z): $[M+H]^+$ calcd for $C_{23}H_{17}FNO_2$, 358.1243; found 358.1248.

1-(3-chlorobenzyl)-3,4-diphenyl-1*H*-pyrrole-2,5-dione (3i).



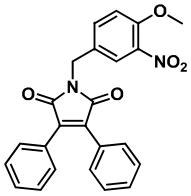
Prepared according to general procedure. Flash column chromatography on silica using 20:1 hexanes/EtOAc as eluent gave pure product as a yellow solid (94% yield). mp: 138-139°C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.38 (m, 14H), 4.77 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 170.3 (×2), 138.2, 136.2 (×2), 134.4, 129.9 (×4), 129.8 (×4), 128.8, 128.5 (×4), 128.4, 128.1, 126.9, 41.9; HRMS-ESI (m/z): $[M+H]^+$ calcd for $C_{23}H_{17}ClNO_2$, 374.0948; found 374.0929.

1-(2,4-dichlorobenzyl)-3,4-diphenyl-1*H*-pyrrole-2,5-dione (3j).



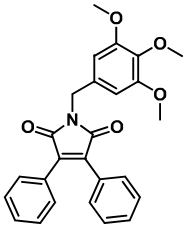
Prepared according to general procedure. Flash column chromatography on silica using 20:1 hexanes/EtOAc as eluent gave pure product as a yellow solid (96% yield). mp: 105-106°C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.50 (m, 4H), 7.42 (d, *J*=2.0 Hz, 1H), 7.36 (m, 6H), 7.31 (d, *J*=8.4 Hz, 1H), 7.22 (q, *J*=2.1 and 8.3 Hz, 1H), 4.92 (s, 2 H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 170.2 (×2), 138.2, 136.2 (×2), 134.4, 129.9 (×4), 129.8 (×4), 128.8, 128.5 (×4), 128.4, 128.1, 126.9, 41.9; HRMS-ESI (m/z): $[M+H]^+$ calcd for $C_{23}H_{16}Cl_2NO_2$, 408.0558; found 408.0574.

1-(4-methoxy-3-nitrobenzyl)-3,4-diphenyl-1*H*-pyrrole-2,5-dione (3k).



Prepared according to general procedure. Flash column chromatography on silica using 10:1 hexanes/EtOAc as eluent gave pure product as a yellow solid (95% yield). mp: 131-132°C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.93 (d, *J*=2.2 Hz, 1H), 7.66 (q, *J*=2.2 and 8.6 Hz, 1H), 7.47 (m, 4H), 7.38 (m, 2H), 7.34 (m, 4H), 7.05 (d, *J*=8.6 Hz, 1H), 4.78 (s, 2H), 3.94 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 170.2 (×2), 152.5, 139.5, 136.2 (×2), 134.7, 129.9 (×2), 129.8 (×4), 128.7, 128.5 (×4), 128.3 (×2), 126.0, 113.7, 56.5, 40.6; HRMS-ESI (m/z): $[M+H]^+$ calcd for $C_{24}H_{19}N_2O_5$, 415.1294; found 415.1312.

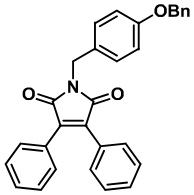
1-(3,4,5-trimethoxybenzyl)-3,4-diphenyl-1*H*-pyrrole-2,5-dione (3l).



Prepared according to general procedure. Flash column chromatography on silica using 15:1 hexanes/EtOAc as eluent gave

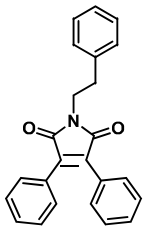
pure product as a yellow solid (87% yield). mp: 125-126°C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.39 (m, 10H), 6.73 (s, 2H), 4.72 (s, 2H), 3.87 (s, 6H), 3.83 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 170.4 (×2), 153.2 (×2), 137.5, 136.2 (×2), 132.0, 129.8 (×2), 129.7 (×4), 128.5 (×6), 106.1 (×2), 60.7, 56.1 (×2), 42.2; HRMS-ESI (m/z): $[M+H]^+$ calcd for $C_{26}H_{24}NO_5$, 430.1654; found 430.1657.

1-(4-benzyloxybenzyl)-3,4-diphenyl-1*H*-pyrrole-2,5-dione (3m).



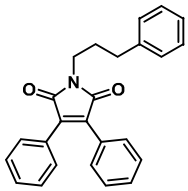
Prepared according to general procedure. Flash column chromatography on silica using 20:1 hexanes/EtOAc as eluent gave pure product as a yellow solid (92% yield). mp: 155-156°C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.38 (m, 17H), 6.93 (d, *J*=8.5 Hz, 2H), 5.04 (m, 2H), 4.74 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 170.4 (×2), 158.4, 136.8, 136.1 (×2), 130.3 (×2), 130.0, 129.8 (×4), 129.7 (×2), 128.9, 128.5 (×4), 128.4 (×4), 127.9, 127.4, 114.8 (×2), 69.9, 41.3; HRMS-ESI (m/z): $[M+H]^+$ calcd for $C_{30}H_{24}NO_3$, 446.1756; found 446.1763.

1-phenethyl-3,4-diphenyl-1*H*-pyrrole-2,5-dione (3n).



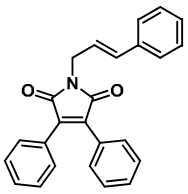
Prepared according to general procedure. Flash column chromatography on silica using 20:1 hexanes/EtOAc as eluent gave pure product as a yellow solid (93% yield). mp: 163-164°C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.37 (m, 14H), 7.34 (t, *J*=7.6 Hz, 2H), 7.23 (m, 1H), 3.00 (t, *J*=7.5 and 8.0 Hz, 2H); HRMS-ESI (m/z): $[M+H]^+$ calcd for $C_{24}H_{20}NO_2$, 354.1494; found 354.1501.

1-(3-phenylpropyl)-3,4-diphenyl-1*H*-pyrrole-2,5-dione (3o).



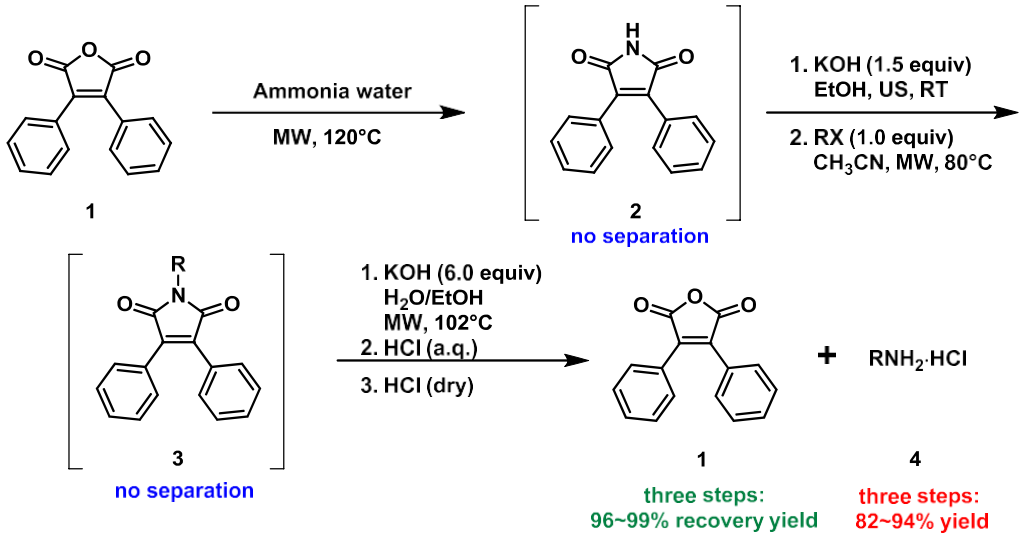
Prepared according to general procedure. Flash column chromatography on silica using 20:1 hexanes/EtOAc as eluent gave pure product as a yellow solid (90% yield). mp: 83-84°C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.37 (m, 11H), 7.19 (m, 4H), 3.98 (t, *J*=7.0 Hz, 2 H), 2.72 (t, *J*=7.5 Hz, 2H), 2.08 (m, *J*=7.3 Hz, 2H); HRMS-ESI (m/z): $[M+H]^+$ calcd for $C_{25}H_{22}NO_2$, 368.1651; found 368.1653.

(*Z*)-1-cinnamyl-3,4-diphenyl-1*H*-pyrrole-2,5-dione (3p).



Prepared according to general procedure. Flash column chromatography on silica using 20:1 hexanes/EtOAc as eluent gave pure product as a yellow solid (94% yield). mp: 165-166°C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.48 (m, 4H), 7.36 (m, 8H), 7.30 (m, 2H), 7.23 (t, *J*=7.3 Hz, 1H), 6.69 (d, *J*=15.9 Hz, 1H), 6.28 (m, 1H), 4.41 (dd, *J*=1.1, 6.6 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 170.5 (×2), 138.0, 136.1 (×2), 129.8 (×6), 128.9 (×2), 128.6 (×2), 128.5 (×7), 126.6 (×2), 39.6; HRMS-ESI (m/z): $[M+H]^+$ calcd for $C_{25}H_{20}NO_2$, 366.1494; found 366.1503.

D. General procedure for the synthesis of primary amine hydrochlorides (4)

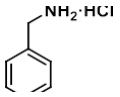


According to the general procedure described in **1C**, **3** was used in the following step without further purification. A mixture of **3** (0.4 mmol, 1.0 equiv), KOH (134.3 mg, 2.4 mmol, 6.0 equiv) and H_2O/ethanol (2/1, 3.0 mL) was irradiated under microwave at 102 °C for 8 min. After the reaction was completed, the reaction mixture was acidified with 18% HCl solution to pH 4. The solid was separated by filtration, washed with 5% HCl solution, and dried to recover **1**. The combined aqueous layer was alkalized with a 50% KOH solution to pH 11, and then extracted with *t*-butyl methyl ether (3×20.0 mL). The combined organic phases were washed with brine (10 mL), dried over Na_2SO_4 and filtered. Dry hydrogen chloride was bubbled into the filtrate and then the precipitate was collected by filtration, washed

with dry *t*-butyl methyl ether, and vacuum dry in low temperature to yield the amino hydrochloride without further purification.

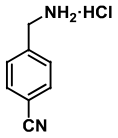
Note: Spectral data of amides matched those previously reported: **4a**[4]**, 4b**[5]**, 4c**-**h**[4], **4i**[6], **4j**[7], **4k**[8], **4l**[9], **4m**[10], **4n**[4], **4o**[11] and **4p**[12].

Phenylmethanamine hydrochloride (4a).



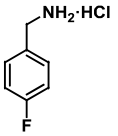
Prepared according to general procedure. White solid (89% yield); ^{1}H NMR (400 MHz, D_2O): δ 7.40 (m, 5H), 4.10 (s, 2H); ^{13}C NMR (100 MHz, D_2O): δ 135.4, 132.0 (×3), 131.6 (×2), 45.9; IR (film): 3441, 3293, 2997, 2891, 1597, 1497, 1216; GC-MS (EI): 107.2 $[M]^+$.

(4-cyanophenyl)methanamine hydrochloride (4b).



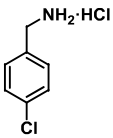
Prepared according to general procedure. White solid (85% yield); ^{1}H NMR (400 MHz, D_2O): δ 7.70 (d, *J*=8.2 Hz, 2H), 7.50 (d, *J*=8.2 Hz, 2H), 4.17 (s, 2H); ^{13}C NMR (100 MHz, D_2O): δ 141.2, 136.0 (×2), 132.2 (×2), 122.0, 114.4, 45.5; IR (film): 3419, 2977, 2885, 2238, 1594, 1510, 1217, 1111; GC-MS (EI): 132.1 $[M]^+$.

(4-fluorophenyl)methanamine hydrochloride (4c).



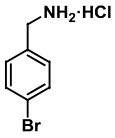
Prepared according to general procedure. White solid (85% yield); ^{1}H NMR (400 MHz, D_2O): δ 7.39 (m, 2H), 7.11 (t, *J*=8.8 Hz, 2H), 4.09 (s, 2H); ^{13}C NMR (100 MHz, D_2O): δ 164.5-167.0 (×1, *J*=243.9 Hz), 133.9-134.0 (×2, *J*=8.8 Hz), 131.4-131.5 (×1, *J*=3.2 Hz), 118.8-119.0 (×2, *J*=21.8 Hz), 45.3; IR (film): 3438, 3006, 2887, 1599, 1517, 1242, 1166; GC-MS (EI): 125.1 $[M]^+$.

(4-chlorophenyl)methanamine hydrochloride (4d).



Prepared according to general procedure. White solid (87% yield); ^{1}H NMR (400 MHz, D_2O): δ 7.35 (m, 4H), 4.08 (s, 2H); ^{13}C NMR (100 MHz, D_2O): δ 137.4, 134.0, 133.3 (×2), 132.0 (×2), 45.3; IR (film): 3218, 3104, 2952, 1596, 1493, 1093; GC-MS (EI): 141.1 $[M]^+$.

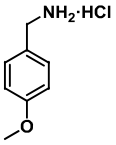
(4-bromophenyl)methanamine hydrochloride (4e).



Prepared according to general procedure. White solid (94% yield); ^{1}H NMR (400 MHz, D_2O): δ 7.53 (m, 2H), 7.26 (d, *J*=8.4 Hz, 2H), 4.05 (s, 2H); ^{13}C

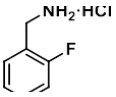
NMR (100 MHz, D_2O): δ 135.0 (×2), 134.5, 133.5 (×2), 125.6, 45.4; IR (film): 3322, 3101, 2953, 2813, 1592, 1489, 1074; GC-MS (EI): 186.0 $[M]^+$.

(4-methoxyphenyl)methanamine hydrochloride (4f).



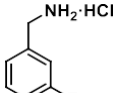
Prepared according to general procedure. White solid (90% yield); ^1H NMR (400 MHz, D_2O): δ 7.32 (d, *J*=8.6 Hz, 2H), 6.94 (d, *J*=8.6 Hz, 2H), 4.03 (s, 2H), 3.73 (s, 3H); ^{13}C NMR (100 MHz, D_2O): δ 162.2, 133.4 (×2), 128.0, 117.4 (×2), 58.3, 45.5; IR (film): 3427, 2945, 2895, 1612, 1518, 1255, 1186; GC-MS (EI): 137.2 $[M]^+$.

(2-fluorophenyl)methanamine hydrochloride (4g).



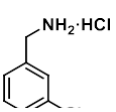
Prepared according to general procedure. White solid (85% yield); ^1H NMR (400 MHz, D_2O): δ 7.42 (m, 2H), 7.19 (m, 2H), 4.19 (s, 2H); ^{13}C NMR (100 MHz, D_2O): δ 162.5-165.0 (×1, *J*=244.6 Hz), 134.5-134.6 (×1, *J*=8.5 Hz), 134.1 (×1, *J*=2.6 Hz), 127.8 (×1, *J*=3.5 Hz), 122.3-122.5 (×1, *J*=15.0 Hz), 118.5-118.7 (×1, *J*=20.8 Hz), 40.0 (×1, *J*=4.2 Hz); IR (film): 3432, 3003, 2859, 1589, 1498, 1235, 1123; GC-MS (EI): 125.1 $[M]^+$.

(3-fluorophenyl)methanamine hydrochloride (4h).



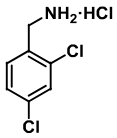
Prepared according to general procedure. White solid (85% yield); ^1H NMR (400 MHz, D_2O): δ 7.39 (q, 1H), 7.19 (d, *J*=7.8 Hz, 1H), 7.14 (d, *J*=9.4 Hz, 1H), 7.10 (m, 1H), 4.12 (s, 2H); ^{13}C NMR (100 MHz, D_2O): δ 164.2-166.7 (×1, *J*=243.0 Hz), 137.6-137.7 (×1, *J*=7.6 Hz), 133.9-134.0 (×1, *J*=8.7 Hz), 127.5-127.6 (×1, J = 2.7 Hz), 118.8-119.0 (×1, J = 20.8 Hz), 118.4-118.6 (×1, *J*=22.3 Hz), 45.4-45.5 (×1, *J*=1.3 Hz); IR (film): 3436, 3005, 1588, 1485, 1261, 1155; GC-MS (EI): 125.1 $[M]^+$.

(3-chlorophenyl)methanamine hydrochloride (4i).



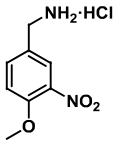
Prepared according to general procedure. White solid (83% yield); ^1H NMR (400 MHz, D_2O): δ 7.40 (s, 1H), 7.37 (d, *J*=1.8 Hz, 1H), 7.34 (d, *J*=7.9 Hz, 1H), 7.29 (m, 1H), 4.09 (s, 2H); ^{13}C NMR (100 MHz, D_2O): δ 137.3, 137.0, 133.5, 132.1, 131.6, 130.0, 45.4; IR (film): 3431, 2996, 2887, 1577, 1461, 1217, 1112; GC-MS (EI): 141.1 $[M]^+$.

(2,4-dichlorophenyl)methanamine hydrochloride (4j).



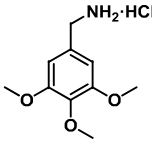
Prepared according to general procedure. White solid (91% yield); ^{1}H NMR (400 MHz, D_2O): δ 7.49 (d, *J*=2.0 Hz, 1H), 7.39 (d, *J*=8.3 Hz, 1H), 7.32 (dd, *J*=2.0, 8.3 Hz, 1H), 4.22 (s, 2H); ^{13}C NMR (100 MHz, D_2O): δ 138.4, 137.5, 135.0, 132.4, 131.8, 130.8, 43.1; IR (film): 3441, 3069, 2972, 1597, 1484, 1132; GC-MS (EI): 176.0 $[M]^+$.

(4-methoxy-3-nitrophenyl)methanamine hydrochloride (4k).



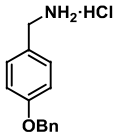
Prepared according to general procedure. White solid (83% yield); ^{1}H NMR (400 MHz, D_2O): δ 7.97 (d, *J*=2.2 Hz, 1H), 7.67 (dd, *J*=2.2 and 8.76 Hz, 1H), 7.25 (d, *J*=8.8 Hz, 1H), 4.12 (s, 2H), 3.88 (s, 3H); ^{13}C NMR (100 MHz, D_2O): δ 156.4, 141.0, 139.3, 129.7, 127.8, 118.0, 59.7, 44.7; IR (film): 3431, 2977, 1630, 1538, 1349, 1267, 1184; GC-MS (EI): 182.1 $[M]^+$.

(3,4,5-trimethoxyphenyl)methanamine hydrochloride (4l).



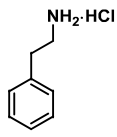
Prepared according to general procedure. White solid (87% yield); ^{1}H NMR (400 MHz, D_2O): δ 6.70 (s, 2H), 4.04 (s, 2H), 3.78 (s, 6H), 3.68 (s, 3H); ^{13}C NMR (100 MHz, D_2O): δ 155.6, 139.9, 132.1, 109.3 (×2), 63.7, 59.0 (×2), 46.1; IR (film): 3427, 2995, 2838, 1592, 1511, 1254, 1126; GC-MS (EI): 197.2 $[M]^+$.

(4-benzyloxyphenyl)methanamine hydrochloride (4m).



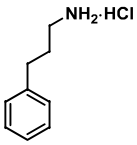
Prepared according to general procedure. White solid (89% yield); ^{1}H NMR (400 MHz, D_2O): δ 7.39 (d, *J*=7.1 Hz, 2H), 7.35 (t, *J*=7.4 Hz, 2H), 7.31 (m, 1H), 7.29 (d, *J*=8.5 Hz, 2H), 6.99 (d, *J*=8.6 Hz, 2H), 5.06 (s, 2H), 4.01 (s, 2H); ^{13}C NMR (100 MHz, D_2O): δ 161.2, 139.3, 133.5 (×2), 131.7 (×2), 131.4, 131.0 (×2), 128.5, 118.6 (×2), 73.2, 45.4; IR (film): 3439, 2946, 2890, 2866, 1612, 1518, 1256, 1186; GC-MS (EI): 213.2 $[M]^+$.

2-phenylethan-1-amine hydrochloride (4n).



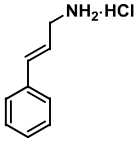
Prepared according to general procedure. White solid (82% yield); ^{1}H NMR (400 MHz, D_2O): δ 7.30 (m, 5H), 3.19 (t, *J*=7.4 Hz, 2H), 2.92 (t, *J*=7.3 Hz, 2H); ^{13}C NMR (100 MHz, D_2O): δ 139.5, 131.9 (×2), 131.7 (×2), 130.2, 43.4, 35.6; IR (film): 3439, 2996, 1604, 1498, 1260, 1144; GC-MS (EI): 121.1 $[M]^+$.

3-phenylpropan-1-amine hydrochloride (4o).



Prepared according to general procedure. White solid (84% yield); ^{1}H NMR (400 MHz, D_2O): δ 7.30 (t, *J*=7.3, 2H), 7.21 (m, 3H), 2.91 (t, *J*=7.8 Hz, 2H), 2.63 (t, *J*=7.8 Hz, 2H), 1.89 (m, 2H); ^{13}C NMR (100 MHz, D_2O): δ 143.7, 131.6 (×2), 131.2 (×2), 129.2, 41.8, 34.6, 31.2; IR (film): 3442, 2975, 1600, 1485, 1236, 1148; GC-MS (EI): 135.1 $[M]^+$.

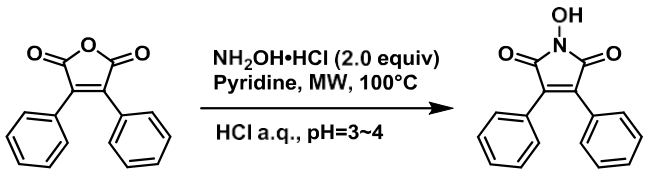
(*Z*)-3-phenylprop-2-en-1-amine hydrochloride (4p).



Prepared according to general procedure. White solid (88% yield); ^{1}H NMR (400 MHz, D_2O): δ 7.42 (d, *J*=7.4 Hz, 2H), 7.33 (t, *J*=7.7 Hz, 2H), 7.28 (t, *J*=7.4 Hz, 1H), 6.71 (d, *J*=15.9 Hz, 1H), 6.22 (m, *J*=15.9 Hz, 1H), 3.67 (d, *J*=6.8 Hz, 2H); ^{13}C NMR (100 MHz, D_2O): δ 138.9, 138.5, 131.8 (×2), 131.6, 129.6 (×2), 123.0, 44.1; IR (film): 3442, 2994, 1594, 1495, 1277, 1150; GC-MS (EI): 133.1 $[M]^+$.

2. Application of 3,4-diphenylmaleic anhydride for synthesis of O-alkylated hydroxylamines

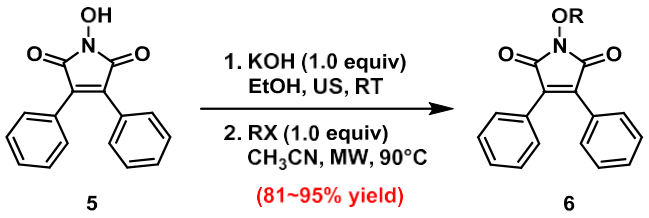
A. Synthesis of 1-hydroxy-3,4-diphenyl-1*H*-pyrrole-2,5-dione (5)



1 **5**

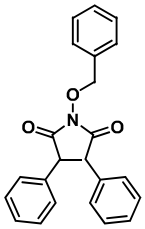
A mixture of **1** (500.0 mg, 2.0 mmol, 1.0 equiv) and hydroxylamine hydrochloride (0.28 g, 4.0 mmol, 2.0 equiv) in pyridine (15.0 mL) was irradiated with microwave (100°C, 50 W) in the presence of a stirrer for 2 min. After cooling at RT, the mixture was acidified with 18% HCl solution to pH 3-4, then extracted with EtOAc (3×20 mL) and the combined organic phases were washed with brine (10 mL), dried over Na_2SO_4 and evaporated under reduced pressure to give compound **5** as a yellow solid. mp: 202-203°C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.02 (s, 1H), 7.46 (m, 4H), 7.37 (m, 6H); MS (ESI): m/z 266.0 $[M+H]^+$, 288.0 $[M+Na]^+$, 553.1 $[2M+Na]^+$. These data are in agreement with that previously reported in the literature.[13]

B. General procedure for the synthesis of 3,4-diphenyl N-benzyl maleimides (6)



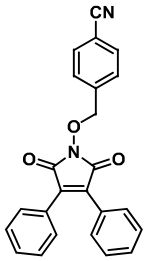
The mixture of **5** (0.4 mmol, 1.0 equiv) and KOH (0.4 mmol, 1.0 equiv) in ethonal (10 mL) was irradiated with ultrasound for 10 min at RT, and evaporated under reduced pressure. The respective alkyl halide RX (0.4 mmol, 1.0 equiv) was directly added into the solution of the residue and acetonitrile (10 mL), and then the reaction mixture was irradiated under microwave at 90°C for 10 min. After cooling at RT, the mixture was diluted with H_2O (20 mL) then extracted with EtOAc (3×20 mL) and the combined organic phases were washed with brine (20 mL), dried over Na_2SO_4 and evaporated under reduced pressure. The residue was purified by flash column chromatography on silica to give pure product. Note: Isolated yields of **6a-6n**: **6a-6p** were purified through flash column chromatography on silica for the structure characterization. During the synthesis of the final products **7a-7n**, the crude **6a-6n** were used without purification.

1-(benzyloxy)-3,4-diphenyl-1*H*-pyrrole-2,5-dione (6a).



Prepared according to general procedure. Flash column chromatography on silica using 20:1 hexanes/EtOAc as eluent gave pure product as a yellow solid (91% yield). mp: 122-124°C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.46 (m, 2H), 7.40 (m, 13H), 5.21 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 166.4 (×2), 134.0, 133.7 (×2), 130.2 (×2), 129.8 (×6), 129.2, 128.6 (×4), 128.5 (×2), 128.0 (×2), 79.8; HRMS-ESI (m/z): $[M+H]^+$ calcd for $C_{23}H_{18}NO_3$, 356.1287; found 356.1282.

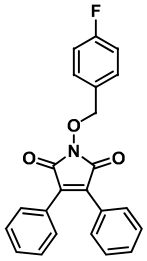
1-(4-cyanobenzyloxy)-3,4-diphenyl-1H-pyrrole-2,5-dione (6b).



Prepared according to general procedure. Flash column chromatography on silica using 15:1 hexanes/EtOAc as eluent gave pure product as a yellow solid (93% yield). mp: 141-142°C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.70 (s, 4H), 7.40 (m, 10H), 5.26 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 166.4 (×2), 139.3, 133.9 (×2), 132.2 (×2), 130.3 (×2),

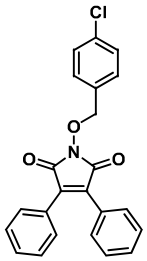
129.7 (×4), 129.6 (×2), 128.6 (×4), 127.7 (×2), 118.4, 112.7, 78.5; HRMS-ESI (m/z): $[M+H]^+$ calcd for $C_{24}H_{17}N_2O_3$, 381.1239; found 381.1245.

1-(4-fluorobenzyloxy)-3,4-diphenyl-1*H*-pyrrole-2,5-dione (6c).



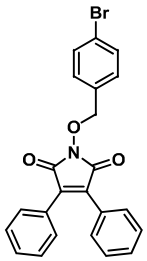
Prepared according to general procedure. Flash column chromatography on silica using 20:1 hexanes/EtOAc as eluent gave pure product as a yellow solid (95% yield). mp: 131-132°C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.54 (m, 2H), 7.37 (m, 10H), 7.08 (m, 2H), 5.17 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 166.4 (×2), 162.5-164.1 (×1, *J*=205.6 Hz), 133.8 (×2), 131.7-134.8 (×2, *J*=7.2 Hz), 130.2 (×2), 129.9 (×1, *J*=2.9 Hz), 129.8 (×4), 128.6 (×4), 128.0 (×2), 115.6-115.5 (×2, *J*=17.8 Hz), 79.0; HRMS-ESI (m/z): $[M+H]^+$ calcd for $C_{23}H_{17}FNO_3$, 374.1192; found 374.1206.

1-(4-chlorobenzyloxy)-3,4-diphenyl-1*H*-pyrrole-2,5-dione (6d).



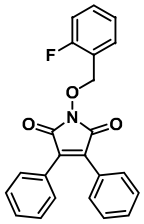
Prepared according to general procedure. Flash column chromatography on silica using 20:1 hexanes/EtOAc as eluent gave pure product as a yellow solid (93% yield). mp: 128°C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.41 (m, 14H), 5.16 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 166.4 (×2), 135.2, 133.8 (×2), 132.5, 131.0 (×2), 130.2 (×2), 129.8 (×4), 128.7 (×2), 128.6 (×4), 127.9 (×2), 78.9; HRMS-ESI (m/z): $[M+H]^+$ calcd for $C_{23}H_{17}ClNO_3$, 390.0897; found 390.0909.

1-(4-bromobenzyloxy)-3,4-diphenyl-1*H*-pyrrole-2,5-dione (6e).



Prepared according to general procedure. Flash column chromatography on silica using 20:1 hexanes/EtOAc as eluent gave pure product as a yellow solid (95% yield). mp: 129-131°C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.38 (m, 12H), 5.53 (d, *J*=8.4 Hz, 2H), 5.16 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 166.5 (×2), 133.8 (×2), 133.1, 131.7 (×2), 131.3 (×2), 130.3 (×2), 129.8 (×4), 128.7 (×4), 127.9 (×2), 123.5, 79.0; HRMS-ESI (m/z): $[M+H]^+$ calcd for $C_{23}H_{17}BrNO_3$, 434.0392; found 434.0406.

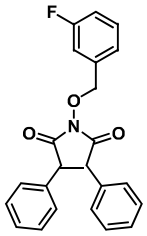
1-(2-fluorobenzyloxy)-3,4-diphenyl-1*H*-pyrrole-2,5-dione (6f).



Prepared according to general procedure. Flash column chromatography on silica using 20:1 hexanes/EtOAc as eluent gave pure product as a yellow solid (92% yield). mp: 105-107°C; ^{1}H NMR (400 MHz, $CDCl_3$):

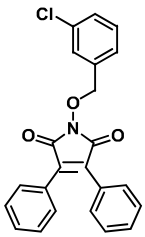
δ 7.61 (t, *J*=7.4 Hz, 1H), 7.44 (m, 4H), 7.36 (m, 7H), 7.19 (t, *J*=7.5 Hz, 1H), 7.11 (t, *J*=9.2 Hz, 1H), 5.30 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 166.3 (×2), 160.8-162.4 (×1, *J*=207.0 Hz), 133.8 (×2), 132.1 (×1, *J*=2.7 Hz), 131.3-131.4 (×1, *J*=6.9 Hz), 130.2 (×2), 129.8 (×4), 128.6 (×4), 128.0 (×2), 124.3 (×1, *J*=3.2 Hz), 121.4-121.5 (×1, *J*=12.5 Hz), 115.5-115.6 (×1, *J*=17.7 Hz), 73.0 (×1, *J*=2.9 Hz); HRMS-ESI (m/z): $[M+H]^+$ calcd for $C_{23}H_{17}FNO_3$, 374.1192; found 374.1204.

1-(3-fluorobenzyloxy)-3,4-diphenyl-1*H*-pyrrole-2,5-dione (6g).



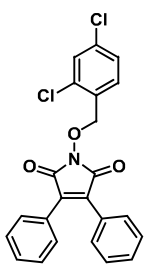
Prepared according to general procedure. Flash column chromatography on silica using 20:1 hexanes/EtOAc as eluent gave pure product as a yellow solid (92% yield). mp: 105-107°C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.38 (m, 13H), 7.07 (m, 1H), 5.19 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 166.4 (×2), 161.8-163.5 (×1, *J*=204.4 Hz), 136.3-136.4 (×1, *J*=5.7 Hz), 133.8 (×2), 130.2 (×2), 130.0-130.1 (×1, *J*=6.7 Hz), 129.7 (×4), 128.6 (×4), 127.9 (×2), 125.0 (×1, *J*=2.6 Hz), 116.2-116.4 (×1, *J*=18.3 Hz), 116.0-116.1 (×1, *J*=17.2 Hz), 78.9; HRMS-ESI (m/z): $[M+H]^+$ calcd for $C_{23}H_{17}FNO_3$, 374.1192; found 374.1205.

1-(3-chlorobenzyloxy)-3,4-diphenyl-1*H*-pyrrole-2,5-dione (6h).



Prepared according to general procedure. Flash column chromatography on silica using 20:1 hexanes/EtOAc as eluent gave pure product as a yellow solid (91% yield). mp: 115-116°C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.55 (s, 1H), 7.39 (m, 13H), 5.18 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 166.4 (×2), 135.9, 134.3, 133.8 (×2), 130.9, 130.2 (×2), 129.8 (×4), 129.5, 129.3, 128.6 (×4), 127.9 (×2), 127.6, 78.9; HRMS-ESI (m/z): $[M+H]^+$ calcd for $C_{23}H_{17}ClNO_3$, 390.0897; found 390.0910.

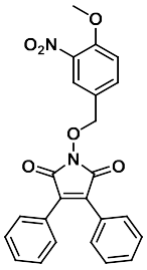
1-(2,4-dichlorobenzyloxy)-3,4-diphenyl-1*H*-pyrrole-2,5-dione (6i).



Prepared according to general procedure. Flash column chromatography on silica using 20:1 hexanes/EtOAc as eluent gave pure product as a yellow solid (93% yield). mp: 108-109°C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.63 (d, *J*=8.2 Hz, 1H), 7.46 (m, 4H), 7.43 (d, *J*=2.1 Hz, 1H), 7.39 (m,

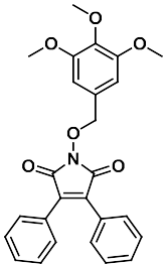
2H), 7.35 (m, 4H), 7.30 (q, *J*=2.0, 8.3 Hz, 1H), 5.32 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 166.3 (×2), 135.6, 135.2, 133.9 (×2), 132.3, 130.9, 130.2 (×2), 129.8 (×4), 129.4, 128.6 (×4), 127.9 (×2), 127.3, 75.7; HRMS-ESI (m/z): $[M+H]^+$ calcd for $C_{23}H_{16}Cl_2NO_3$, 424.0507; found 424.0521.

1-(4-methoxy-3-nitrobenzyloxy)-3,4-diphenyl-1*H*-pyrrole-2,5-dione (6j).



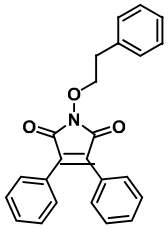
Prepared according to general procedure. Flash column chromatography on silica using 15:1 hexanes/EtOAc as eluent gave pure product as a yellow solid (94% yield). mp: 114-116°C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.00 (d, *J*=2.2 Hz, 1H), 7.81 (q, *J*=2.2 and 8.6 Hz, 1H), 7.45 (m, 4H), 7.39 (m, 2H), 7.34 (m, 4H), 7.13 (d, *J*=8.7 Hz, 1H), 5.17 (s, 2H), 3,97 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 166.4 (×2), 153.4, 139.1, 135.6, 133.9 (×2), 130.2 (×2), 129.7 (×4), 128.6 (×4), 127.8 (×2), 126.8, 126.4, 113.6, 78.0, 56.5; HRMS-ESI (m/z): $[M+H]^+$ calcd for $C_{24}H_{19}N_2O_6$, 431.1243; found 431.1239.

1-(3,4,5-trimethoxybenzyloxy)-3,4-diphenyl-1*H*-pyrrole-2,5-dione (6k).



Prepared according to general procedure. Flash column chromatography on silica using 15:1 hexanes/EtOAc as eluent gave pure product as a yellow solid (86% yield). mp: 155-156°C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.38 (m, 10H), 6.80 (s, 2H), 5.17 (s, 2H), 3.89 (s, 6H), 3.86 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 166.5 (×2), 153.2 (×2), 138.6, 133.8 (×2), 130.2 (×2), 129.8 (×4), 129.5, 128.7 (×4), 128.0 (×2), 106.5 (×2), 79.9, 60.8, 56.2 (×2); HRMS-ESI (m/z): $[M+H]^+$ calcd for $C_{26}H_{24}NO_6$, 446.1604; found 446.1607.

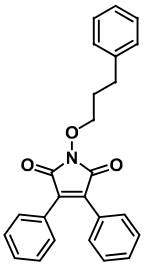
1-phenethoxy-3,4-diphenyl-1*H*-pyrrole-2,5-dione (6l).



Prepared according to general procedure. Flash column chromatography on silica using 20:1 hexanes/EtOAc as eluent gave pure product as a yellow solid (84% yield). mp: 111-112°C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.45 (m, 4H), 7.35 (m, 10H), 7.23 (m, 1H), 4.46 (t, *J*=7.2 Hz, 2H), 3.16 (t, *J*=7.2 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 166.5 (×2), 137.0, 133.8 (×2), 130.2 (×2), 129.8 (×4), 128.8 (×2), 128.6 (×4), 128.5 (×2),

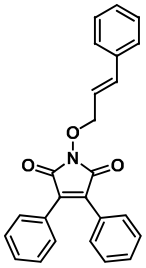
128.0 (×2), 126.6, 78.3, 34.7; HRMS-ESI (m/z): $[M+H]^+$ calcd for $C_{24}H_{20}NO_3$, 370.1443; found 370.1440.

1-(3-phenylpropoxy)-3,4-diphenyl-1*H*-pyrrole-2,5-dione (6m).



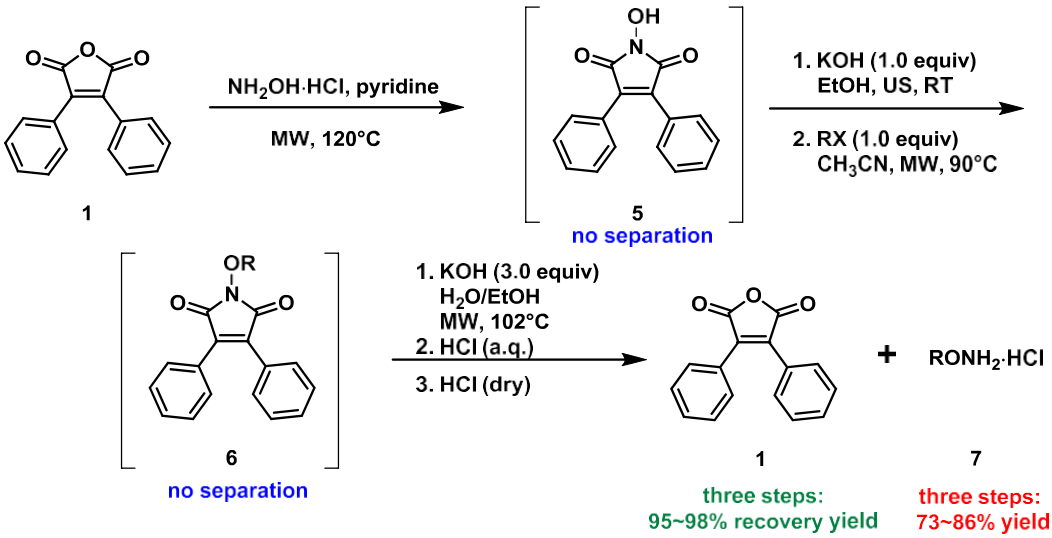
Prepared according to general procedure. Flash column chromatography on silica using 20:1 hexanes/EtOAc as eluent gave pure product as a yellow solid (81% yield). mp: 105-106°C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.46 (m, 4H), 7.34 (m, 10H), 7.20 (m, 1H), 4.22 (t, *J*=6.4 Hz, 2H), 2.88 (t, *J*=7.9 Hz, 2H), 2.11 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 166.6 (×2), 141.2, 133.8 (×2), 130.1 (×2), 129.8 (×4), 128.6 (×6), 128.4 (×2), 128.0 (×2), 126.0, 77.4, 31.7, 30.0; HRMS-ESI (m/z): $[M+H]^+$ calcd for $C_{25}H_{22}NO_3$, 384.1600; found 384.1606.

(*Z*)- 1-(cinnamyloxy)-3,4-diphenyl-1*H*-pyrrole-2,5-dione (6n).



Prepared according to general procedure. Flash column chromatography on silica using 20:1 hexanes/EtOAc as eluent gave pure product as a yellow solid (88% yield). mp: 150-152°C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.41 (m, 6H), 7.38 (m, 2H), 7.33 (m, 6H), 7.27 (m, 1H), 6.72 (d, *J*=15.9 Hz, 1H), 6.48 (m, 1 H), 4.45 (dd, *J*=1.0 and 7.0 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 166.8 (×2), 137.3, 135.8, 133.7 (×2), 130.1 (×2), 129.8 (×4), 128.6 (×6), 128.4, 128.0 (×2), 126.9 (×2), 122.3, 78.5; HRMS-ESI (m/z): $[M+H]^+$ calcd for $C_{25}H_{20}NO_3$, 382.1443; found 382.1451.

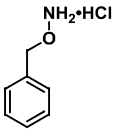
C. General procedure for the synthesis of O-alkylated hydroxylamine hydrochlorides (7)



According to the general procedure described in **2B**, **6** was used in the following step without further purification. A mixture of **6** (0.4 mmol, 1.0 equiv), KOH (67.2 mg, 1.2 mmol, 3.0 equiv) and H_2O/ethanol (2/1, 3.0 mL) was irradiated under microwave at 102 °C for 5 min. After the reaction was completed, the reaction mixture was acidified with 18% HCl solution to pH 4. The solid was separated by filtration, washed with 5% HCl solution, and dried to recover **1**. The combined aqueous layer was alkalized with a 50% KOH solution to pH 11, and then extracted with *t*-butyl methyl ether (3×20.0 mL). The combined organic phases were washed with brine (10 mL), dried over Na_2SO_4 and filtered. Dry hydrogen chloride was bubbled into the filtrate and then the precipitate was collected by filtration, washed with dry *t*-butyl methyl ether, and vacuum dry in low temperature to yield the O-alkylated hydroxylamine hydrochloride without further purification.

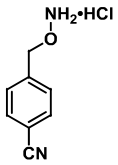
Note: Spectral data of O-alkylated hydroxylamine hydrochlorides matched those previously reported: **7a-i**[14], **7j**[15], **7k**[16], **7l**[17], **7m**[18], and **7n**[18]

O-benzylhydroxylamine hydrochloride (7a)



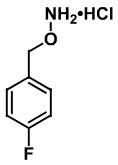
Prepared according to general procedure. White solid (78% yield); ^{1}H NMR (400 MHz, D_2O): δ 7.36 (s, 5H), 4.95 (s, 2H); ^{13}C NMR (100 MHz, D_2O): δ 135.5, 132.9, 132.5 (×2), 132.0 (×2), 80.0; IR (film): 3439, 2946, 2890, 2866, 1612, 1518, 1256, 1186; IR (film): 3432, 2962, 1599, 1510, 1182; GC-MS (EI): 123.1 $[M]^+$.

O-(4-cyanobenzyl)hydroxylamine hydrochloride (7b).



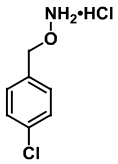
Prepared according to general procedure. White solid (83% yield); ^{1}H NMR (400 MHz, D_2O): δ 7.67 (d, *J*=8.2 Hz, 2H), 7.48 (d, *J*=8.2 Hz, 2H), 5.05 (s, 2H); ^{13}C NMR (100 MHz, D_2O): δ 141.4, 135.9 (×2), 132.4 (×2), 122.2, 114.9, 78.8; IR (film): 3422, 3002, 2243, 1595, 1507, 1284, 1179; GC-MS (EI): m/z 148.1 $[M]^+$.

O-(4-fluorobenzyl)hydroxylamine hydrochloride (7c).



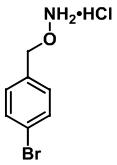
Prepared according to general **p**rocedure. White solid (86% yield); ^{1}H NMR (400 MHz, D_2O): δ 7.34 (m, 2H), 7.08 (t, *J*=8.8 Hz, 2H), 4.94 (s, 2H); ^{13}C NMR (100 MHz, D_2O): δ 165.0-167.5 (×1, *J*=244.3 Hz), 134.6-134.7 (×2, *J*=8.7 Hz), 132.0 (×1, *J*=3.0 Hz), 118.7-118.9 (×2, *J*=21.8 Hz), 79.3; IR (film): 3440, 2964, 1601, 1510, 1247, 1159; GC-MS (EI): m/z 141.1 $[M]^+$.

O-(4-chlorobenzyl)hydroxylamine hydrochloride (7d).



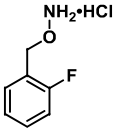
Prepared according to general procedure. White solid (84% yield); ^{1}H NMR (400 MHz, D_2O): δ 7.37 (m, 4H), 4.97 (s, 2H); ^{13}C NMR (100 MHz, D_2O): δ 138.0, 134.6, 133.9 (×2), 132.0 (×2), 79.2; IR (film): 3395, 2957, 2921, 1599, 1493, 1179, 1095; GC-MS (EI): m/z 157.1 $[M]^+$.

O-(4-bromobenzyl)hydroxylamine hydrochloride (7e).



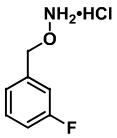
Prepared according to general procedure. White solid (85% yield); ^{1}H NMR (400 MHz, D_2O): δ 7.53 (m, 2H), 7.26 (d, *J*=8.4 Hz, 2H), 4.05 (s, 2H); ^{13}C NMR (100 MHz, D_2O): δ 135.0 (×2), 134.5, 133.5 (×2), 125.6, 45.4; IR (film): 3419, 1593, 1487, 1285, 1180; GC-MS (EI): m/z 201.0 $[M]^+$.

O-(3-fluorobenzyl)hydroxylamine hydrochloride (7f).



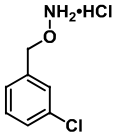
Prepared according to general procedure. White solid (82% yield); ^{1}H NMR (400 MHz, D_2O): δ 7.38 (m, 2H), 7.15 (t, *J*=7.5 Hz, 1H), 7.09 (t, *J*=9.1 Hz, 1H), 5.04 (s, 2H); ^{13}C NMR (100 MHz, D_2O): δ 163.2-165.6 (×1, *J*=246.5 Hz), 135.3-135.4 (× 1, *J*=9.1 Hz), 135.0-135.1 (× 1, *J*=3.2 Hz), 127.7-127.8 (×1, *J*=3.6 Hz), 122.6-122.8 (×1, *J*=14.5 Hz), 118.6-118.8 (×1, *J*=20.8 Hz), 73.9 (×1, *J*=3.3 Hz); IR (film): 3425, 2964, 1590, 1495, 1245, 1138; GC-MS (EI): m/z 141.1 $[M]^+$.

O-(3-fluorobenzyl)hydroxylamine hydrochloride (7g).



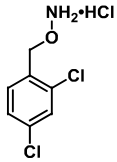
Prepared according to general procedure. White solid (78% yield); ^{1}H NMR (400 MHz, D_2O): δ 7.39 (q, 1H), 7.19 (d, *J*=7.8 Hz, 1H), 7.14 (d, *J*=9.4 Hz, 1H), 7.10 (m, 1H), 4.12 (s, 2H); ^{13}C NMR (100 MHz, D_2O): δ 164.2-166.7 (×1, *J*=243.0 Hz), 137.6-137.7 (×1, *J*=7.6 Hz), 133.9-134.0 (×1, *J*=8.7 Hz), 127.6 (×1, *J*=2.7 Hz), 118.8-119.0 (×1, *J*=20.8 Hz), 118.4-118.6 (×1, *J*=2.3 Hz), 45.4-45. 5 (×1, *J*=1.3 Hz); IR (film): 3431, 2966, 1597, 1488, 1265, 1146; GC-MS (EI): m/z 141.1 $[M]^+$.

O-(3-chlorobenzyl)hydroxylamine hydrochloride (7h).



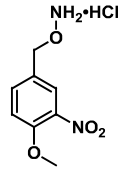
Prepared according to general procedure. White solid (77% yield); ^{1}H NMR (400 MHz, D_2O): δ 7.39 (s, 1H), 7.36 (m, 1H), 7.32 (d, *J*=7.4 Hz, 1H), 7.28 (m, 1H), 4.95 (s, 2H); ^{13}C NMR (100 MHz, D_2O): δ 137.7, 137.0, 133.5, 132.7, 132.1, 130.6, 79.1; IR (film): 3444, 2965, 2891, 1596, 1508, 1213, 1081; GC-MS (EI): m/z 157.1 $[M]^+$.

O-(2,4-dichlorobenzyl)hydroxylamine hydrochloride (7i).



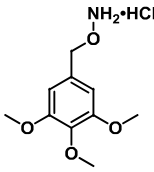
Prepared according to general procedure. White solid (81% yield); ^{1}H NMR (400 MHz, D_2O): δ 7.42 (d, *J*=2.0 Hz, 1H), 7.34 (d, *J*=8.3 Hz, 1H), 7.26 (dd, *J*=2.0, 8.3 Hz, 1H), 5.05 (s, 2H); ^{13}C NMR (100 MHz, D_2O): δ138.9, 138.2, 135.7, 132.5, 132.0, 130.6, 76.5; IR (film): 3390, 2923, 2843, 1594, 1476, 1213, 1105; GC-MS (EI): m/z 191.1 $[M]^+$.

O-(4-methoxy-3-nitrobenzyl)hydroxylamine hydrochloride (7j).



Prepared according to general procedure. White solid (82% yield); ^{1}H NMR (400 MHz, D_2O): δ 7.86 (d, *J*=2.2 Hz, 1H), 7.59 (dd, *J*=2.2 and 8.7 Hz, 1H), 7.14 (d, *J*=8.7 Hz, 1H), 4,93 (s, 2H), 3.81 (s, 3H); ^{13}C NMR (100 MHz, D_2O): δ 156.8, 140.9, 139.7, 130.1, 128.3, 117.8, 78.3, 59.8; IR (film): 3396, 2951, 1626, 1534, 1273, 1157; GC-MS (EI): m/z 198.1 $[M]^+$.

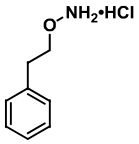
O-(3,4,5-trimethoxybenzyl)hydroxylamine hydrochloride (7k).



Prepared according to general procedure. White solid (77% yield); ^{1}H NMR (400 MHz, D_2O): δ 6.67 (s, 2H), 4.87 (s, 2H), 3.72 (s, 6H), 3.62 (s,

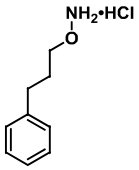
3H); ^{13}C NMR (100 MHz, D_2O): δ 155.6 (×2), 140.5, 132.6, 109.9 (×2), 80.0, 63.9, 59.1 (×2); IR (film): 3407, 3104, 3070, 2943, 2843, 1597, 1507, 1235, 1124; GC-MS (EI): m/z 213.2 $[M]^+$.

O-phenethylhydroxylamine hydrochloride (7l).



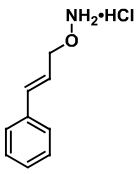
Prepared according to general procedure. White solid (75% yield); ^{1}H NMR (400 MHz, D_2O): δ 7.27 (m, 2H), 7.19 (m, 3H), 4.19 (t, *J*=6.5 Hz, 2H), 2.88 (t, *J*=6.5 Hz, 2H); ^{13}C NMR (100 MHz, D_2O): δ 140.2, 131.8 (×2), 131.7 (×2), 129.8, 78.5, 36.3; IR (film): 3423, 3315, 2920, 2864, 1601, 1496, 1270, 1184; GC-MS (EI): m/z 137.1 $[M]^+$.

O-(3-phenylpropyl)hydroxylamine hydrochloride (7m).



Prepared according to general procedure. White solid (73% yield); ^{1}H NMR (400 MHz, D_2O): δ 7.26 (t, *J*=7.5 Hz, 2H), 7.17 (m, 3H), 3.95 (t, *J*=6.4 Hz, 2H), 2.61 (t, *J*=7.7 Hz, 2H), 1.88 (m, 2H); ^{13}C NMR (100 MHz, D_2O): δ 144.4, 131.6 (×2), 131.5 (×2), 129.2, 77.6, 33.8, 31.6; IR (film): 3427, 3153, 2958, 1600, 1509, 1249, 1191; GC-MS (EI): m/z 151.1 $[M]^+$.

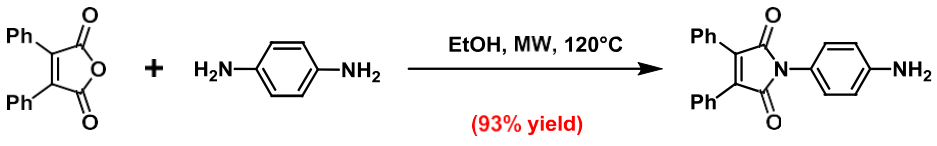
(*Z*)-O-cinnamylhydroxylamine hydrochloride (7n).



Prepared according to general procedure. White solid (82% yield); ^{1}H NMR (400 MHz, D_2O): δ 7.43 (m, 2H), 7.30 (m, 3H), 6.76 (d, *J*=16.0 Hz, 1H), 6.25 (m, 1H), 4.60 (d, *J*=7.0 Hz, 2H); ^{13}C NMR (100 MHz, D_2O): δ 141.2, 138.5, 131.9 (×4), 130.0, 123.5, 78.7; IR (film): 3439, 2963, 1597, 1511, 1282, 1184; GC-MS (EI): m/z 149.1 $[M]^+$.

3. Application of 3,4-diphenylmaleic anhydride for protection of primary amines.

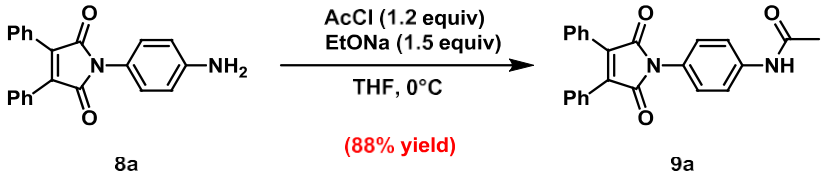
Entry 1.



1 8a

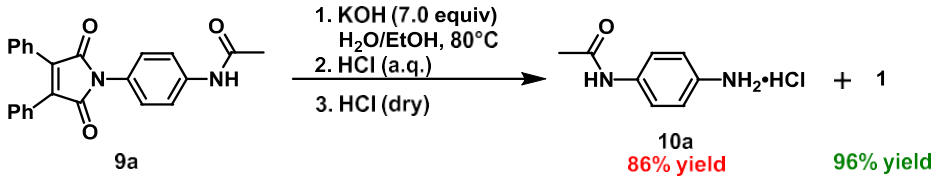
A mixture of **1** (500.0 mg, 2.0 mmol, 1.0 equiv) and benzene-1,4-diamine (216.1 mg, 2.0 mmol, 1.0 equiv) in ethanol (15.0 mL) was irradiated with microwave

(120 °C, 50 W) in the presence of a stirrer for 10 min. After cooling at RT, the reaction mixture was evaporated under reduced pressure. The resulting crude solid material (632.4 mg, 1.86 mmol, 93% yield) was used in the subsequent step without further purification. mp: 215-217°C; ^{1}H NMR (400 MHz, DMSO-*d*$_6$): δ 7.42 (m, 10H), 6.64 (d, *J*=8.6 Hz, 2H), 8.57 (d, *J*=8.6 Hz, 2H), 5.32 (s, 2H); ^{13}C NMR (100 MHz, DMSO-*d*$_6$): δ 170.0 (×2), 148.8, 136.1 (×2), 129.8 (×4), 129.7 (×2), 128.9 (×2), 128.6 (×4), 128.2 (×2), 119.8, 113.7 (×2); HRMS-ESI (m/z): $[M+H]^+$ calcd for $C_{22}H_{17}N_2O_2$, 341.1290; found 341.1295.



8a 9a

To a solution of **8a** (98.6 mg, 0.29 mmol, 1.0 equiv), sodium ethoxide (29.9 mg, 0.44 mmol, 1.5 equiv), and dry THF (6.0 mL), was added dropwise a solution of acetyl chloride (0.02 mL, 0.35 mmol, 1.2 equiv) in dry THF (4.0 mL). The reaction mixture was stirred at 0 °C for 2 h, then extracted with EtOAc (3×20 mL) and the combined organic phases were washed with brine (10 mL), dried over Na_2SO_4 and evaporated under reduced pressure. The residue was purified by flash column chromatography on silica using 3:1:0.02 hexanes/EtOAc/HCOOH as eluent, to give 100.8 mg (0.26 mmol) of pure product as a yellow solid (88% yield). mp: 249-252°C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.63 (d, *J*=8.3 Hz, 2H), 7.52 (dd, *J*=1.5 and 7.9 Hz, 4H), 7.39 (m, 8H), 7.36 (s, 1H), 2.18 (s, 3H); ^{13}C NMR (100 MHz, DMSO-*d*$_6$): δ 169.8 (×2), 168.6, 139.0, 136.3 (×2), 129.8 (×6), 128.8 (×2), 128.6 (×4), 127.5 (×2), 119.3 (×2), 24.1; HRMS-ESI (m/z): $[M+H]^+$ calcd for $C_{24}H_{19}N_2O_3$, 383.1396; found 383.1401.

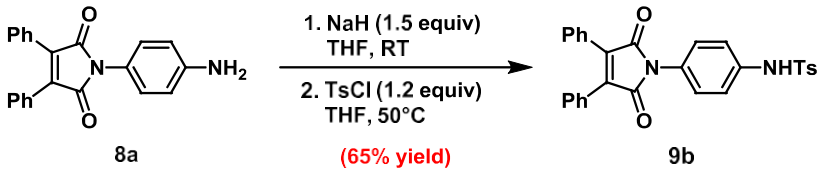


9a 10a 86% yield 96% yield

To a mixture of KOH (307.8 mg, 5.5 mmol, 7.0 equiv) and H_2O/ethanol (2/1, 15 mL) was added **7** (302.0 mg, 0.79 mmol, 1.0 equiv). The resulting mixture was stirred

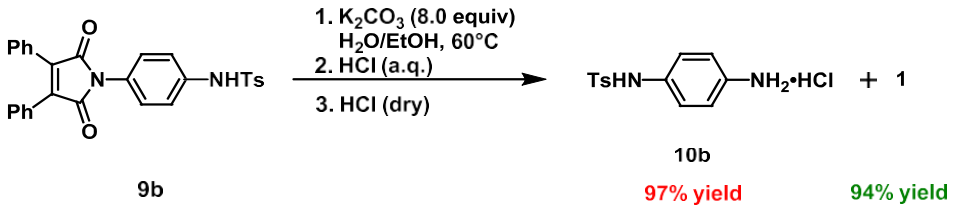
at 80 °C for 2 h, and then was acidified with 18% HCl solution to pH 4. The solid was separated by filtration, washed with 5% HCl solution, and dried to recover **1**. The combined aqueous layer was alkalized with a 50% KOH solution to pH 11, and then extracted with *t*-butyl methyl ether (3×20.0 mL). The combined organic phases were washed with brine (10 mL), dried over Na_2SO_4 and filtered. Dry hydrogen chloride was bubbled into the filtrate and then the precipitate was collected by filtration, washed with dry *t*-butyl methyl ether, and vacuum dry in low temperature to yield a white solid (126.4 mg, 0.68 mmol, 86% yield) without further purification. mp: 112-115°C; ^{1}H NMR (400 MHz, D_2O): δ 7.54 (m, 2H), 7.50 (s, 1H), 7.38 (m, 2H), 2.15 (s, 3H); MS (ESI): m/z 151.2 $[M+H]^+$, 173.1 $[M+Na]^+$, 323.1 $[2M+Na]^+$. These data are in agreement with that previously reported in the literature. [19]

Entry 2.



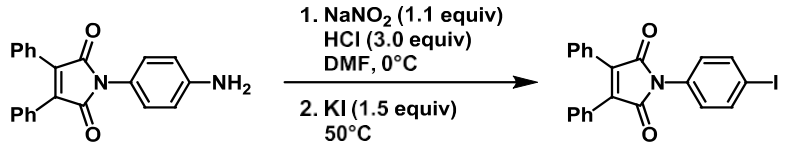
8a 9b

To a mixture of NaH (60% dispersion in mineral oil, 0.44 mmol, 1.5 equiv) in dry THF (10 mL) was added a solution of **8a** (98.6 mg, 0.29 mmol, 1.0 equiv) in dry THF (5 mL) at RT. The reaction mixture was stirred at RT for 0.5 h. To this mixture was added a solution of TsCl (66.5 mg, 0.35 mmol, 1.2 equiv) in dry THF (10 mL) via cannula. The reaction mixture was stirred at 50 °C for 5h and quenched with sat.NH_4Cl (aq., 30 mL). The aqueous phase was extracted with EtOAc, dried over Na_2SO_4, filtered and evaporated under reduced pressure to give crude product, which was purified by flash column chromatography on silica using 8:1 hexanes/EtOAc as eluent, to give 80.9 mg (0.16 mmol) of pure product as a yellow solid (65% yield). mp: 234-237°C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.71 (m, 2H), 7.51 (m, 4H), 7.38 (m, 8H), 7.26 (m, 2H), 7.19 (m, 2H), 3.50 (s, 1H), 2.39 (s, 3H); ^{13}C NMR (100 MHz, DMSO-d_6): δ 169.3 (×2), 143.6, 137.4, 136.7, 136.3 (×2), 129.9 (×2), 128.8 (×6), 128.7 (×2), 128.6 (×4), 127.9 (×2), 127.6, 126.8 (×2), 119.7 (×2), 21.1; HRMS-ESI (m/z): $[M+H]^+$ calcd for $C_{29}H_{23}N_2O_4S$, 495.1379; found 495.1385.

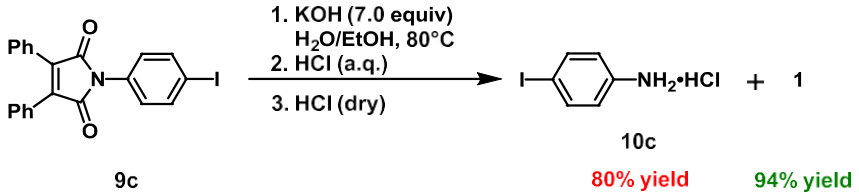


Followed representative procedure for synthesis of **10a** in entry 1. **10b**: mp: 175-178°C; ^{1}H NMR (400 MHz, D_2O): δ 7.65 (d, *J*=8.1 Hz, 2H), 7.34 (d, *J*=8.1 Hz, 2H), 7.30 (d, *J*=8.2 Hz, 2H), 7.22 (d, *J*=8.8 Hz, 2H), 2.35 (s, 3H); ^{13}C NMR (100 MHz, D_2O): δ 145.5, 137.1, 134.0, 129.9 (×2), 127.0 (×3), 124.1 (×2), 123.0 (×2), 20.6; MS (ESI): m/z 263.1 $[M+H]^+$, 285.1 $[M+Na]^+$, 547.1 $[2M+Na]^+$, 261.0 $[M-H]^-$. These data are in agreement with that previously reported in the literature.[20]

Entry 3.

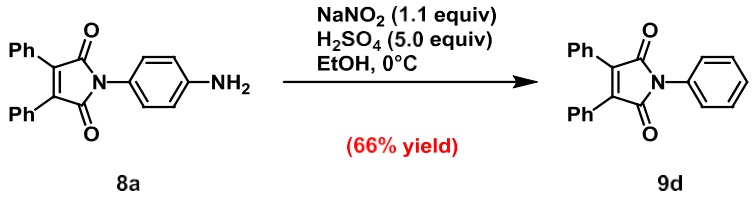


To a solution of **8a** (98.6 mg, 0.29 mmol, 1.0 equiv), concentrated hydrochloric acid (0.03 mL, 0.88 mmol, 3.0 equiv), and dimethyl formamide (5.0 mL), was added dropwise a solution of sodium nitrite (22.1 mg, 0.32 mmol, 1.1 equiv) in water (5.0 mL). The reaction mixture was stirred at 0 °C for 20 min, then added dropwise into a solution of potassium iodide (73.0 mg, 0.44 mmol, 1.5 equiv) in water (5.0 mL). The reaction mixture was stirred at 50 °C for 30 min, then extracted with EtOAc (3×20 mL) and the combined organic phases were washed with saturated solution of sodium thiosulfate (10 mL) and brine (10 mL), dried over Na_2SO_4 and evaporated under reduced pressure. The residue was purified by flash column chromatography on silica using 5:1 hexanes/EtOAc as eluent, to give 113.8 mg (0.25 mmol) of pure product as a yellow solid (87% yield). mp: 149-152°C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.53 (m, 4H), 7.48 (m, 4H), 7.40 (m, 6H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 169.7 (×2), 137.8, 136.2 (×2), 130.0 (×4), 129.9 (×2), 129.7 (×2), 129.1, 128.6 (×4), 128.5 (×2), 126.1 (×2); HRMS-ESI (m/z): $[M+H]^+$ calcd for $C_{22}H_{15}INO_2$, 452.0147; found 452.0155.

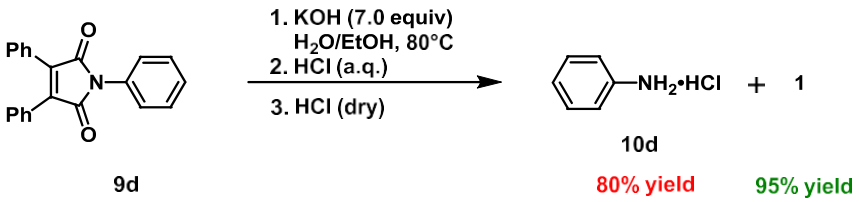


Followed representative procedure for synthesis of **10a** in entry 1. **10c**: mp: 167-169°C; ^{1}H NMR (400 MHz, D_2O): δ 7.87 (d, *J*=9.0 Hz, 2H), 7.15 (d, *J*=9.0 Hz, 2H); ^{13}C NMR (100 MHz, D_2O): δ 139.1 (×2), 131.5, 124.2 (×2), 92.5; MS (ESI): m/z 220.0 $[M+H]^+$. These data are in agreement with that previously reported in the literature.[21]

Entry 4.



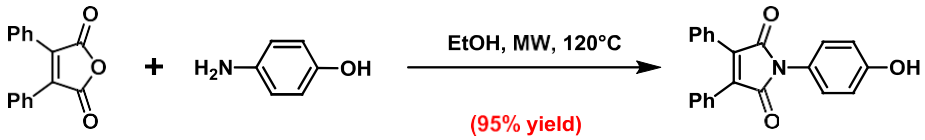
To a solution of **8a** (98.6 mg, 0.29 mmol, 1.0 equiv), concentrated sulfuric acid (860.0 mg, 2.05 mmol, 5.0 equiv), and ethanol (10.0 mL), was added dropwise a solution of sodium nitrite (20.1 mg, 0.32 mmol, 1.1 equiv) in water (5.0 mL). The reaction mixture was stirred at 0 °C for 3 h, then extracted with EtOAc (3×20 mL) and the combined organic phases were washed with brine (10 mL), dried over Na_2SO_4 and evaporated under reduced pressure. The residue was purified by flash column chromatography on silica using 8:1 hexanes/EtOAc as eluent, to give 90.5 mg (0.28 mmol) of pure product as a yellow solid (66% yield). mp: 152-154°C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.53 (m, 5H), 7.47 (m, 3H), 7.39 (m, 7H); HRMS-ESI (m/z): $[M+H]^+$ calcd for $C_{22}H_{16}NO_2$, 326.1181; found 326.1186. These data are in agreement with that previously reported in the literature.[21]



Followed representative procedure for synthesis of **10a** in entry 1. **10d**: mp: 190-192°C; ^{1}H NMR (400 MHz, DMSO-d_6): δ 7.02 (m, 2H), 6.60 (m, 2H), 6.48 (m,

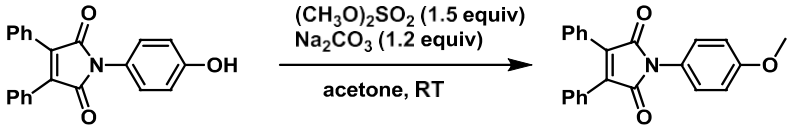
1H), 4.99 (s, 2H); ^{13}C NMR (100 MHz, DMSO-d_6): δ 149.0, 129.3 (×2), 116.2, 114.4 (×2); GC-MS (EI): m/z 93.2 $[M]^+$. These data are in agreement with that previously reported in the literature.[21]

Entry 5.



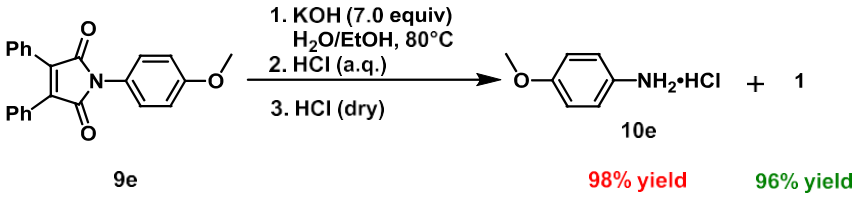
1 8b

Followed representative procedure for synthesis of **8a** in entry 1. **8b**: mp: 225-227°C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.52 (dd, *J*=1.4 and 7.6 Hz, 2H), 7.38 (m, 6H), 7.21 (d, *J*=8.8 Hz, 2H), 6.83 (d, *J*=8.8 Hz, 2H), 5.99 (s, 1H); ^{13}C NMR (100 MHz, DMSO-d_6): δ 169.7 (×2), 157.3, 136.2 (×2), 129.8 (×4), 129.8 (×2), 128.8 (× 2), 128.6 (× 6), 123.0, 115.6 (× 2); HRMS-ESI (m/z): $[M-H]^-$ calcd for $C_{22}H_{14}NO_3$, 340.0974; found 340.0971.



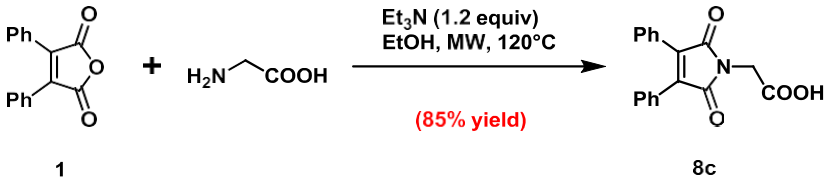
8b 9e

To a solution of **8b** (98.9 mg, 0.29 mmol, 1.0 equiv), sodium carbonate (48.3 mg, 0.35mmol, 1.2 equiv), and acetone (10.0 mL), was added dropwise a solution of dimethyl sulphate (54.8 mg, 0.44 mmol, 1.5 equiv) in acetone (5.0 mL). The reaction mixture was stirred at RT for 3 h, then extracted with EtOAc (3×20 mL) and the combined organic phases were washed with brine (10 mL), dried over Na_2SO_4 and evaporated under reduced pressure. The residue was purified by flash column chromatography on silica using 5:1 hexanes/EtOAc as eluent, to give 77.2 mg (0.22 mmol) of pure product as a yellow solid (75% yield). mp: 191-194°C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.51 (dd, *J*=1.6 and 7.8 Hz, 4H), 7.34 (m, 8H), 6.98 (d, *J*=8.9 Hz, 2H), 3.83 (s, 3H); HRMS-ESI (m/z): $[M+H]^+$ calcd for $C_{22}H_{18}NO_3$, 356.1287; found 356.1291. These data are in agreement with that previously reported in the literature.[20]

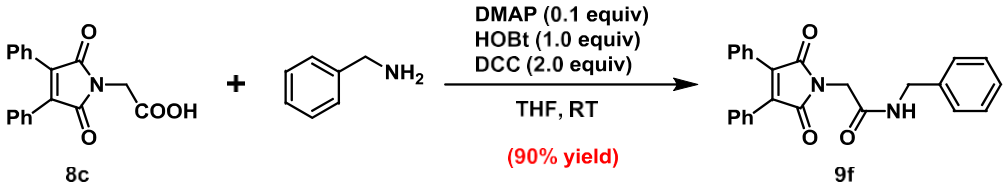


Followed representative procedure for synthesis of **10a** in entry 1. **10e**: mp: 189-190°C; ^{1}H NMR (400 MHz, DMSO-d_6): δ 6.64 (d, J=9.0 Hz, 2H), 6.52 (d, J=9.0 Hz, 2H), 4.58 (s, 2H), 3.61(s, 3H); ^{13}C NMR (100 MHz, DMSO-d_6): δ 151.2, 142.7, 115.5 (×2), 115.0 (×2), 55.7; MS (ESI): m/z 124.1 $[M+H]^{+}$.[22]

Entry 6.

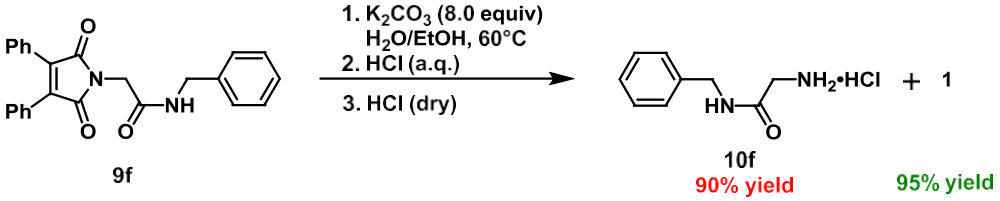


A mixture of **1** (50.0 mg, 0.2 mmol, 1.0 equiv), glycine (15.0 mg, 0.2 mmol, 1.0 equiv) and triethylamine (0.03 mL, 0.24 mmol, 1.2 equiv) in ethanol (15.0 mL) was irradiated with microwave (120 °C, 50 W) in the presence of a stirrer for 10 min. After cooling at RT, the reaction mixture was evaporated under reduced pressure, and then acidified with 18% HCl solution to pH 4. The solid was separated by filtration, washed with 5% HCl solution to give 52.2 mg (0.17 mmol) of pure product as a yellow solid (85% yield). mp: 147-151°C; ^{1}H NMR (400 MHz, DMSO-d_6): δ 7.42 (m, 10H), 4.29 (s, 2H); ^{13}C NMR (100 MHz, DMSO-d_6): δ 169.8 (×2), 169.1, 136.4 (×2), 130.0 (×2), 129.7 (×4), 128.7 (×4), 128.4 (×2), 48.7; HRMS-ESI (m/z): $[M-H]^{-}$ calcd for $C_{18}H_{12}NO_4$, 306.0766; found 306.0763.



To a mixture of **8c** (49.1 mg, 0.16 mmol, 1.0 equiv), DCC (67.0 mg, 0.32 mmol, 2.0 equiv), HOBt (22.0 mg 0.16 mmol, 1.0 equiv), DMAP (2.0 mg, 0.016 mmol, 0.1 equiv) and dry THF (10.0 mL) was added benzylamine (0.018 mL, 0.16 mmol, 1.0 equiv). The resulting mixture was stirred at RT for 2 h, and then diluted with deionized water (20 mL) and transferred to a separatory funnel with EtOAc (50 mL)

and brine (50 mL). The aqueous layer was extracted with EtOAc (3×10 mL), then the organic layers were combined and washed with deionized water (3×15 mL), dried over Na_2SO_4, and evaporated under reduced pressure. The residue was purified by flash column chromatography on silica using 5:1 hexanes/EtOAc as eluent, to give 60.2 mg (0.15 mmol) of pure product as a yellow solid (90% yield). mp: 195-197°C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.48 (m, 4H), 7.36 (m, 8H), 7.29 (m, 2H), 4.48 (d, *J*=5.7 Hz, 2H), 4.34 (s, 2H); HRMS-ESI (m/z): $[M+H]^+$ calcd for $C_{25}H_{21}N_2O_3$, 398.1552; found 398.1556.



Followed representative procedure for synthesis of **10a** in entry 1. **10f**: mp: 156-157°C; ^{1}H NMR (400 MHz, D_2O): δ 7.45 (m, 2H), 7.38 (m, 3H), 4.47 (s, 2H), 3.88 (s, 2H); MS (ESI): m/z 165.2 $[M+H]^+$, 187.1 $[M+Na]^+$. These data are in agreement with that previously reported in the literature.[23]

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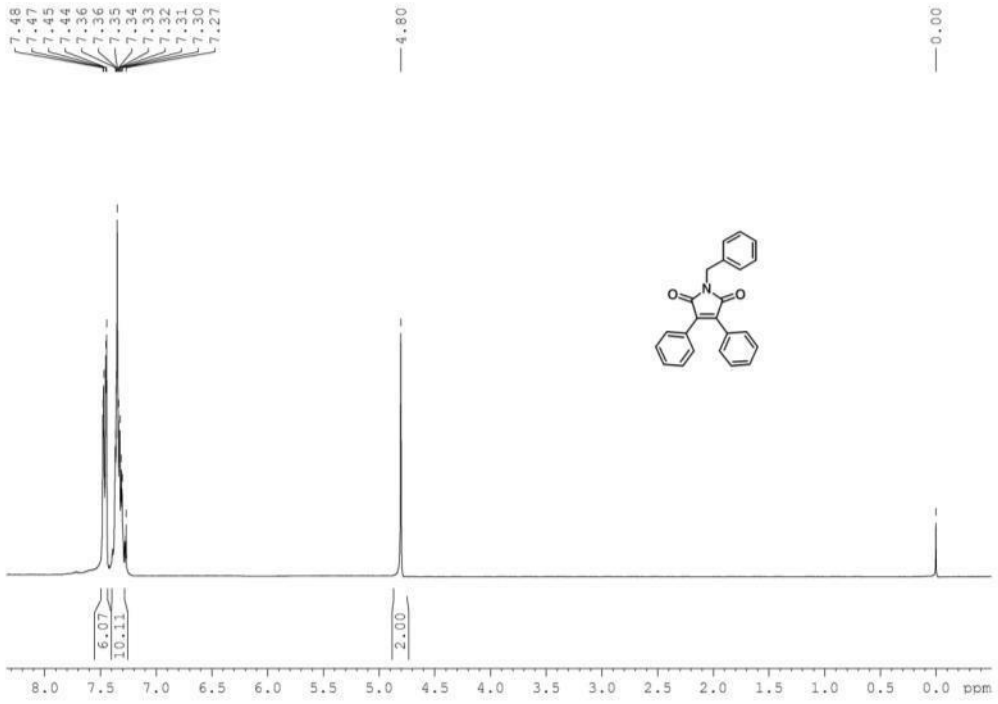
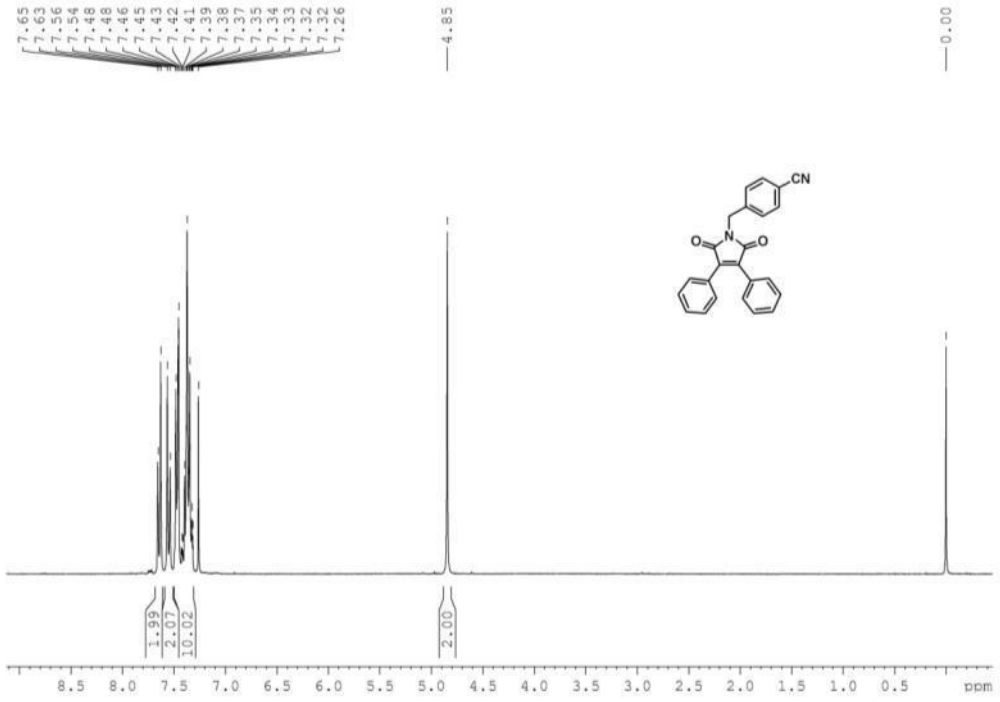
NMR Spectra

1-benzyl-3,4-diphenyl-1*H*-pyrrole-2,5-dione (3a)

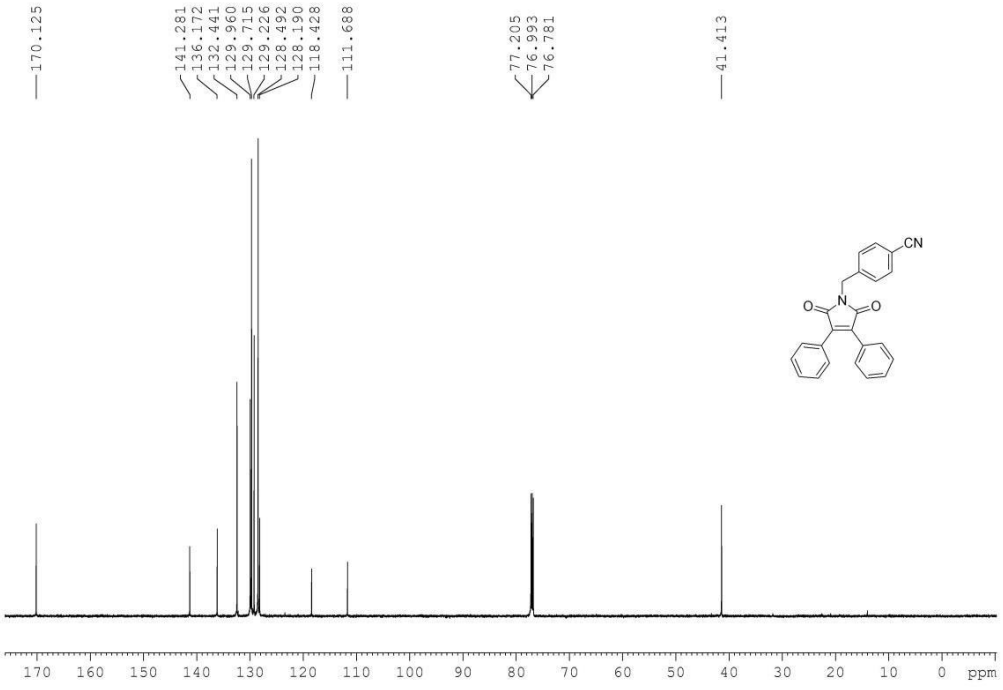


^{1}H NMR ($CDCl_3$, 400 MHz)

1-(4-cyanobenzyl)-3,4-diphenyl-1*H*-pyrrole-2,5-dione (3b)

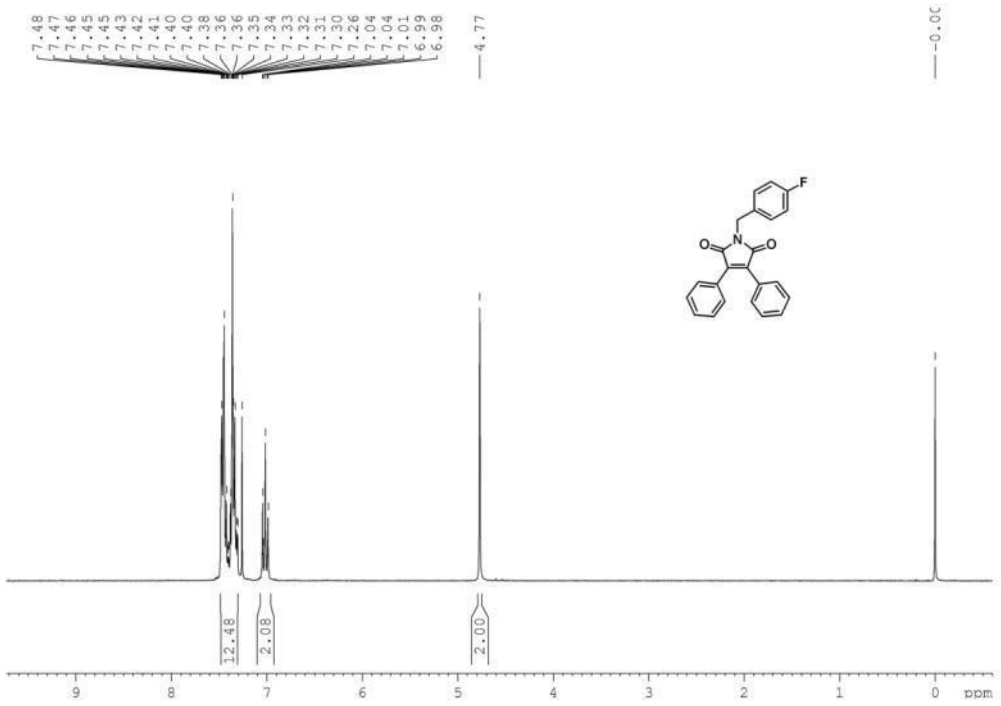


^{1}H NMR ($CDCl_3$, 400 MHz)

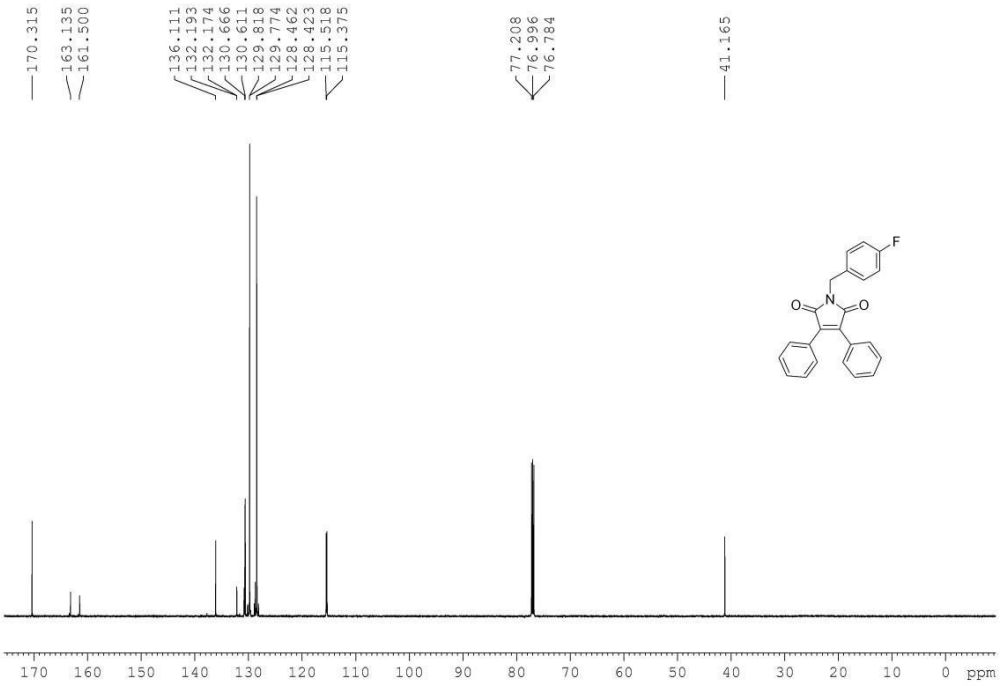


^{13}C NMR ($CDCl_3$, 100 MHz)

1-(4-fluorobenzyl)-3,4-diphenyl-1*H*-pyrrole-2,5-dione (3c)

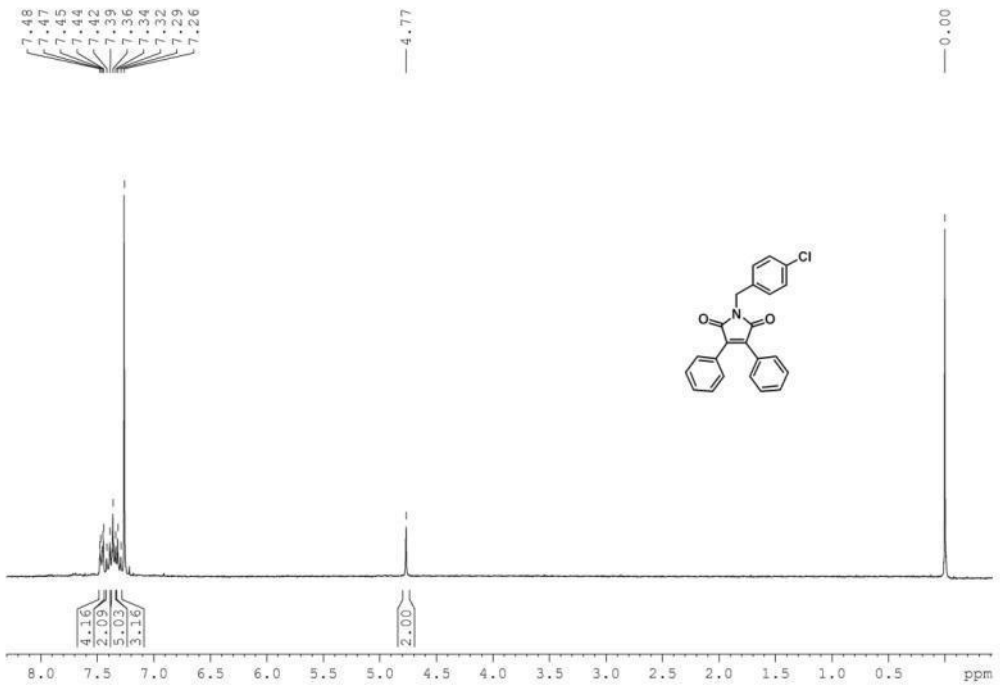


^{1}H NMR ($CDCl_3$, 400 MHz)

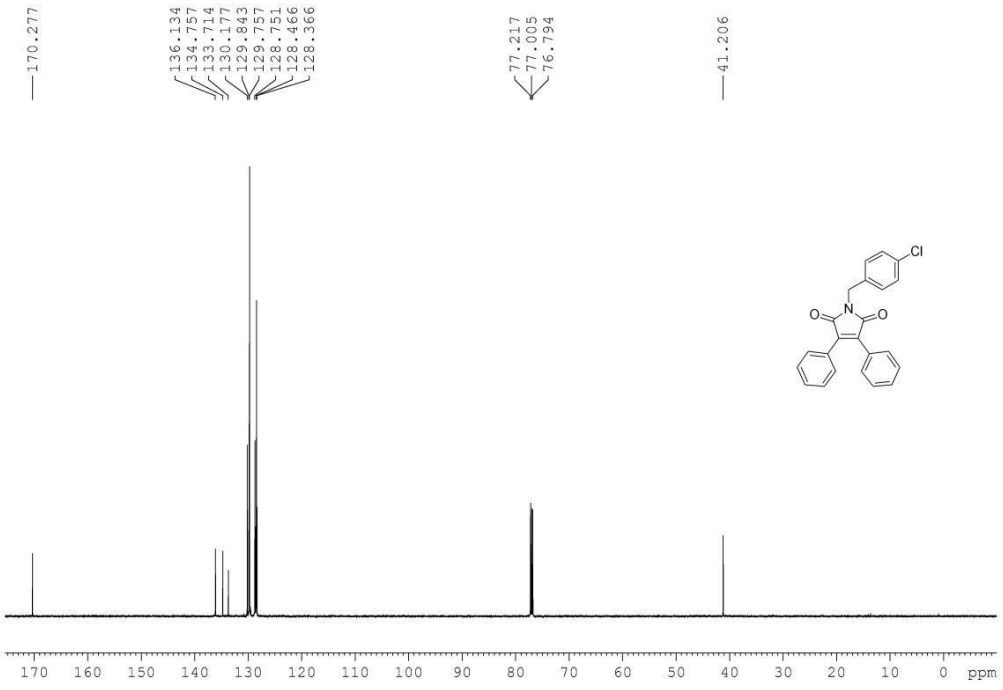


^{13}C NMR ($CDCl_3$, 100 MHz)

1-(4-chlorobenzyl)-3,4-diphenyl-1H-pyrrole-2,5-dione (3d)

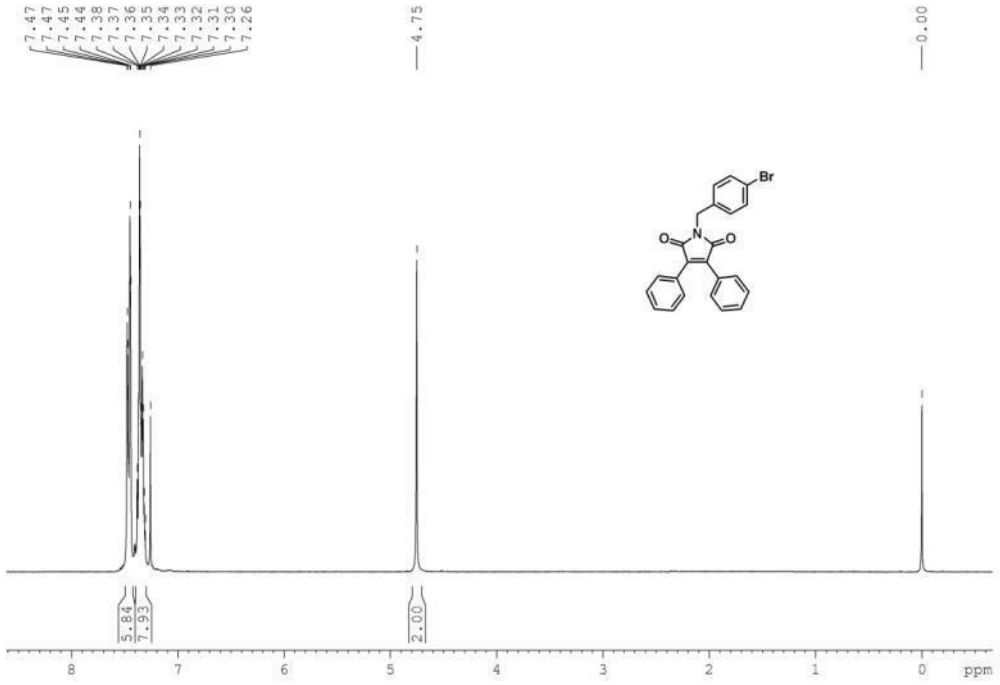


^{1}H NMR ($CDCl_3$, 400 MHz)

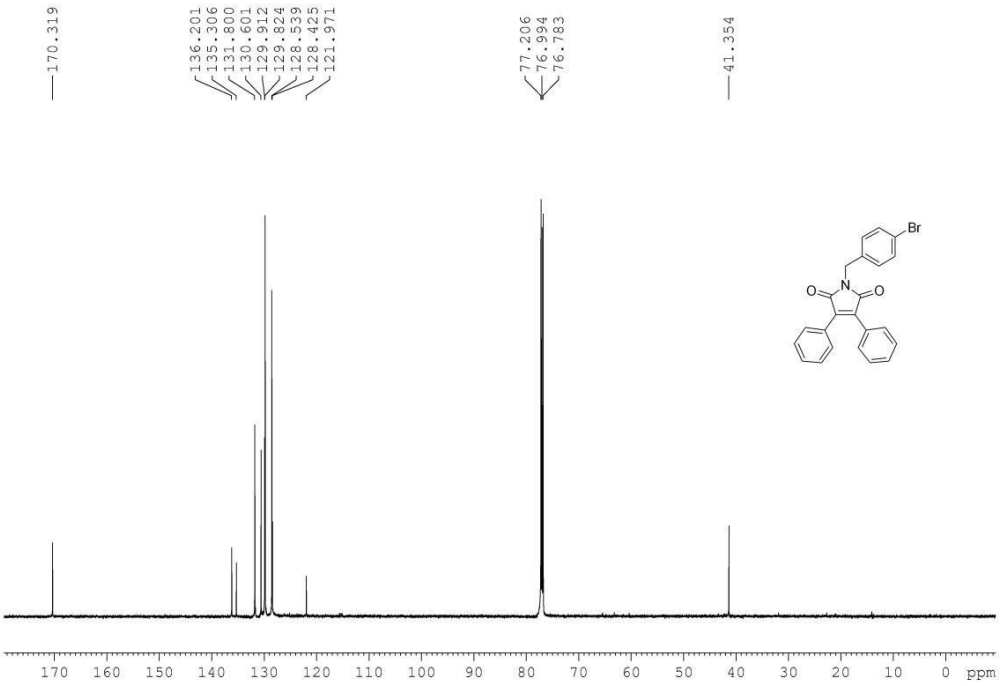


^{13}C NMR ($CDCl_3$, 100 MHz)

1-(4-bromobenzyl)-3,4-diphenyl-1*H*-pyrrole-2,5-dione (3e)

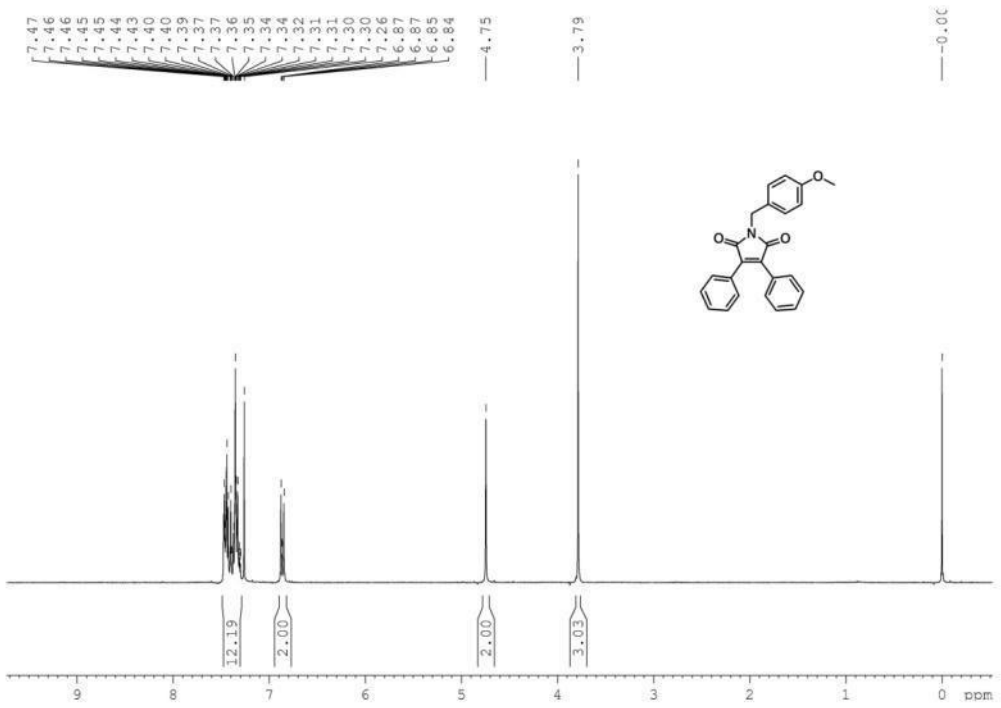


^{1}H NMR ($CDCl_3$, 400 MHz)

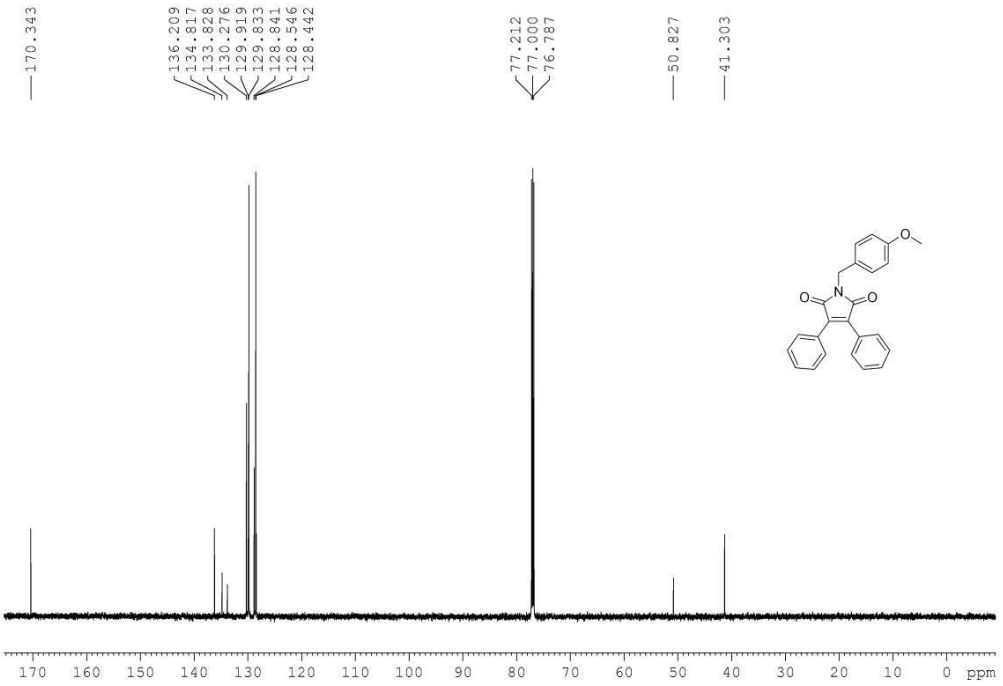


^{13}C NMR ($CDCl_3$, 100 MHz)

1-(4-methoxybenzyl)-3,4-diphenyl-1*H*-pyrrole-2,5-dione (3f)

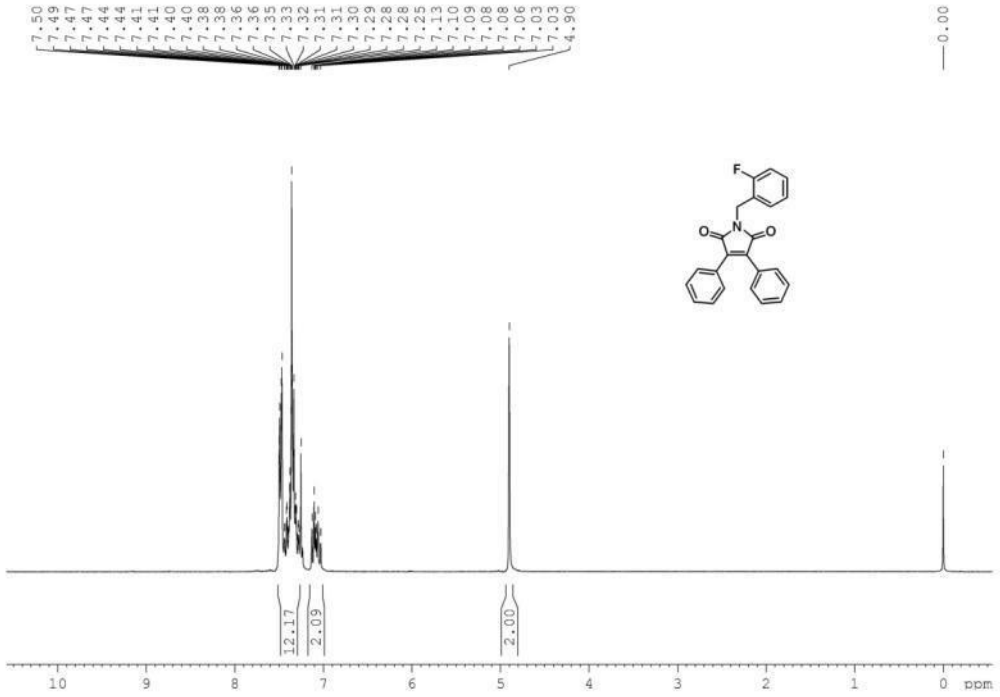


^{1}H NMR ($CDCl_3$, 400 MHz)

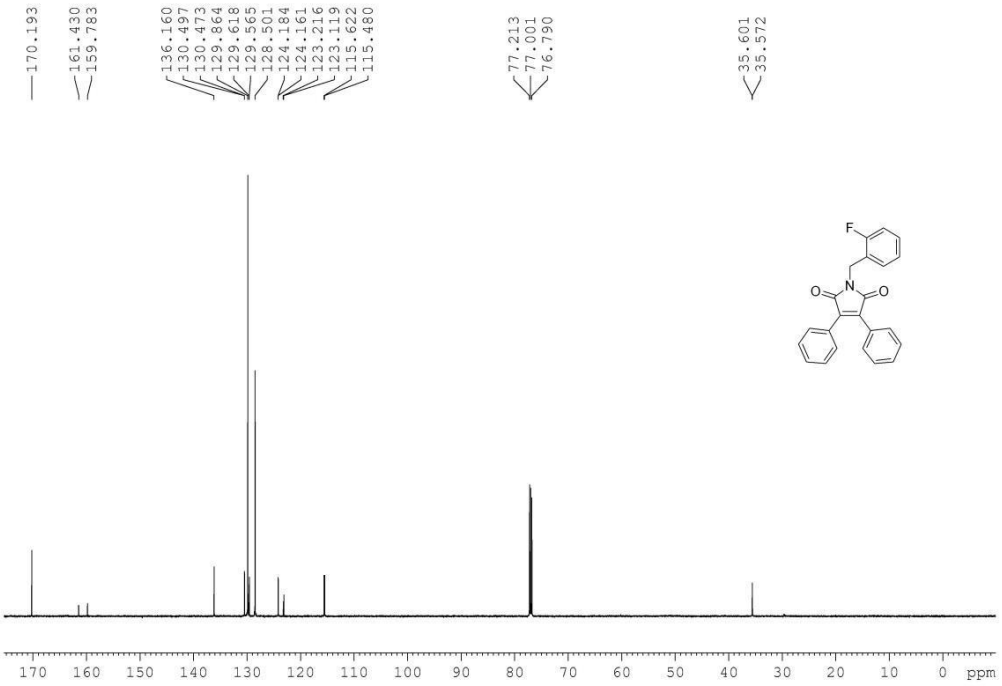


^{13}C NMR ($CDCl_3$, 100 MHz)

1-(2-fluorobenzyl)-3,4-diphenyl-1*H*-pyrrole-2,5-dione (3g)

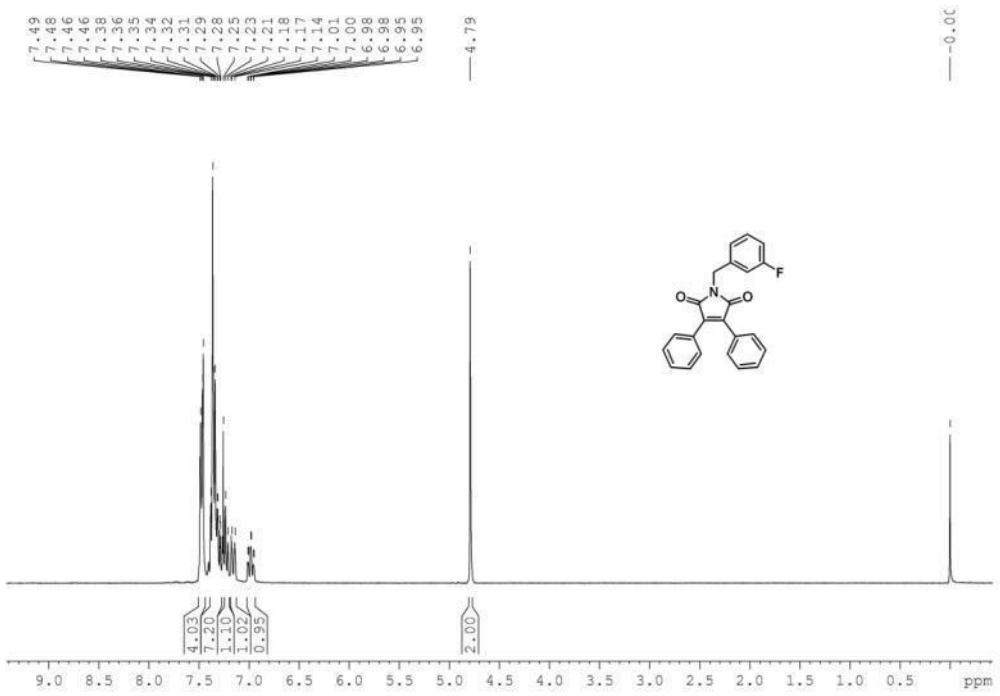


^{1}H NMR ($CDCl_3$, 400 MHz)

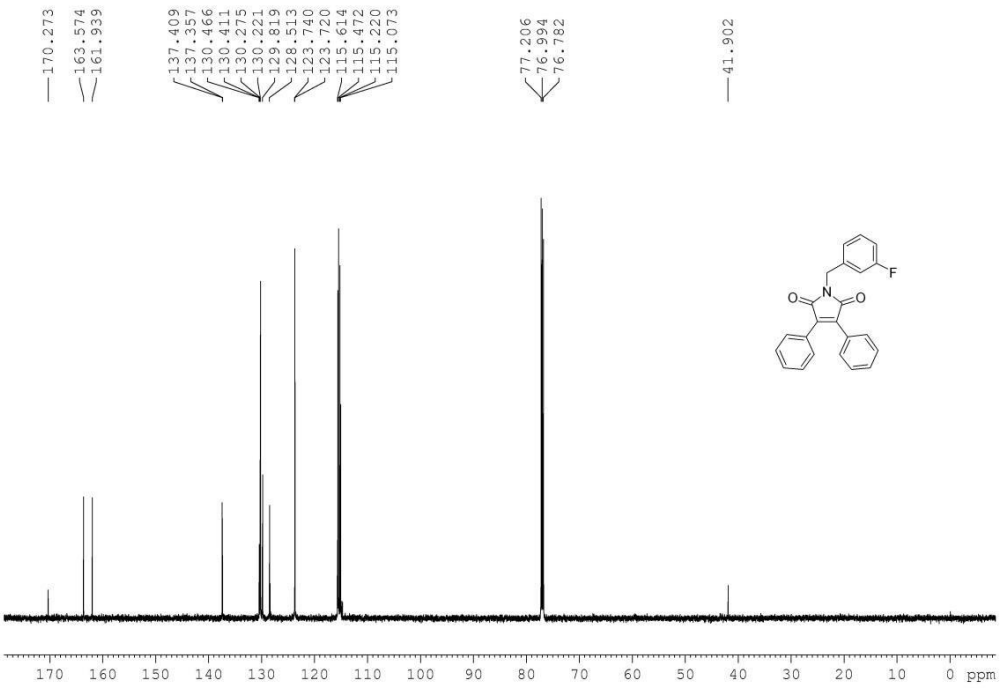


^{13}C NMR ($CDCl_3$, 100 MHz)

1-(3-fluorobenzyl)-3,4-diphenyl-1*H*-pyrrole-2,5-dione (3h)

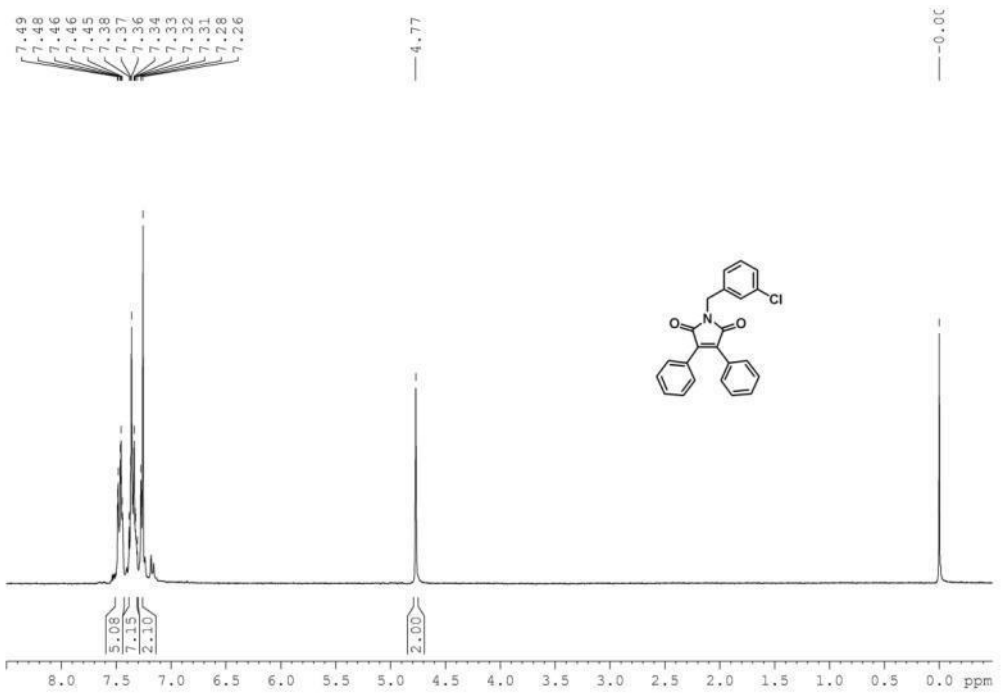


^{1}H NMR ($CDCl_3$, 400 MHz)

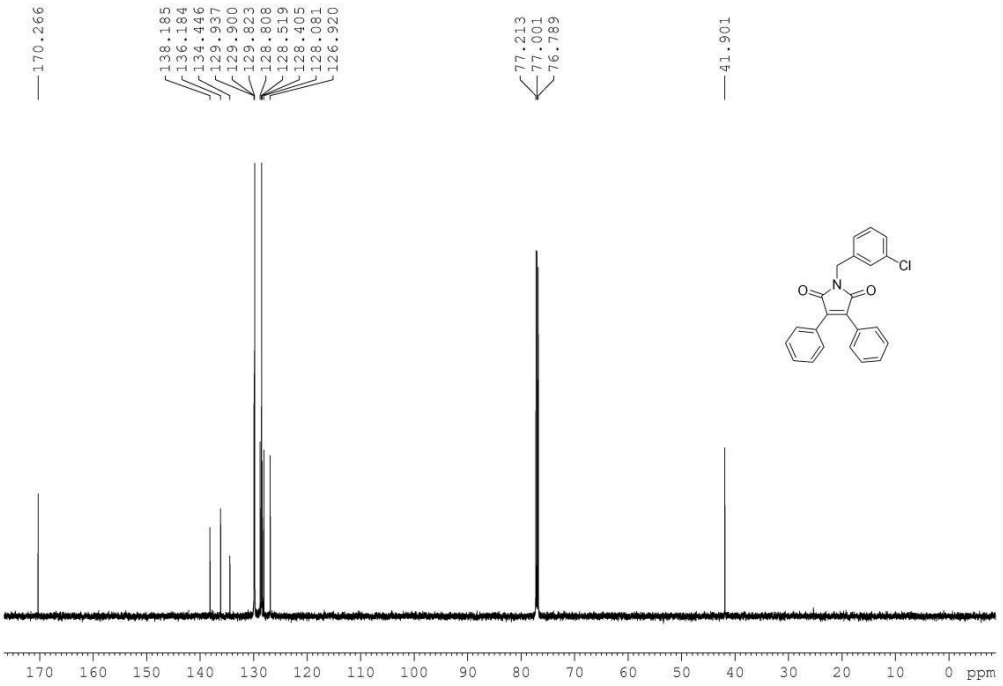


^{13}C NMR ($CDCl_3$, 100 MHz)

1-(3-chlorobenzyl)-3,4-diphenyl-1*H*-pyrrole-2,5-dione (3i)

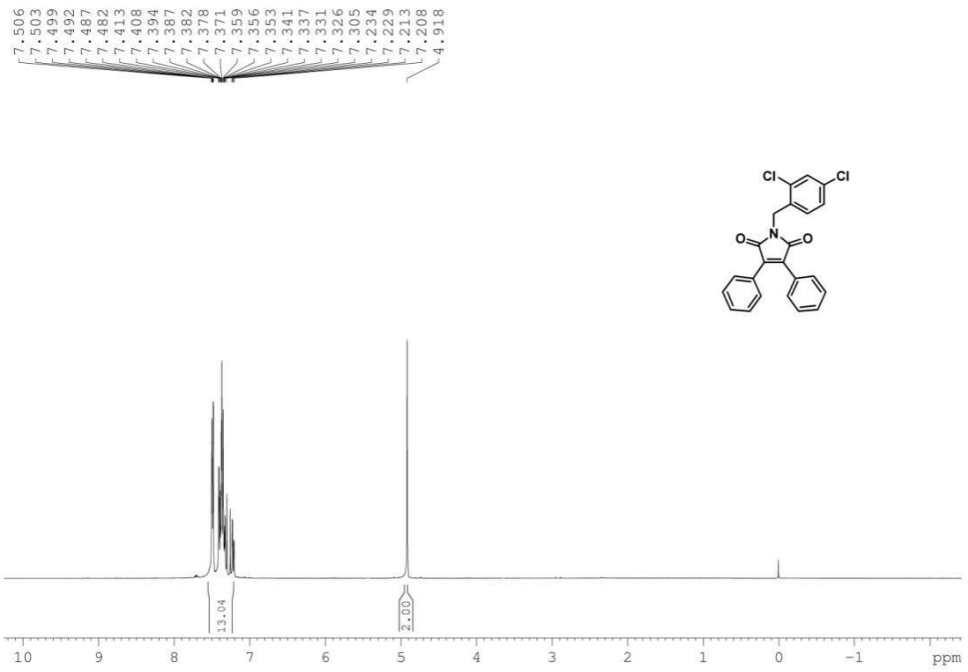


^{1}H NMR ($CDCl_3$, 400 MHz)

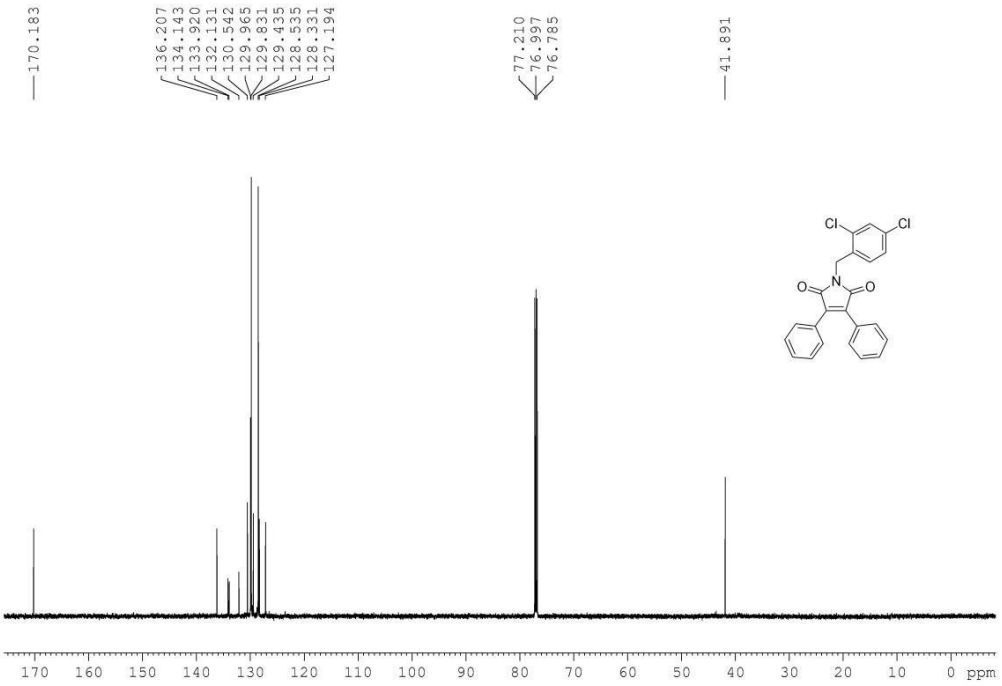


^{13}C NMR ($CDCl_3$, 100 MHz)

1-(2,4-dichlorobenzyl)-3,4-diphenyl-1*H*-pyrrole-2,5-dione (3j)

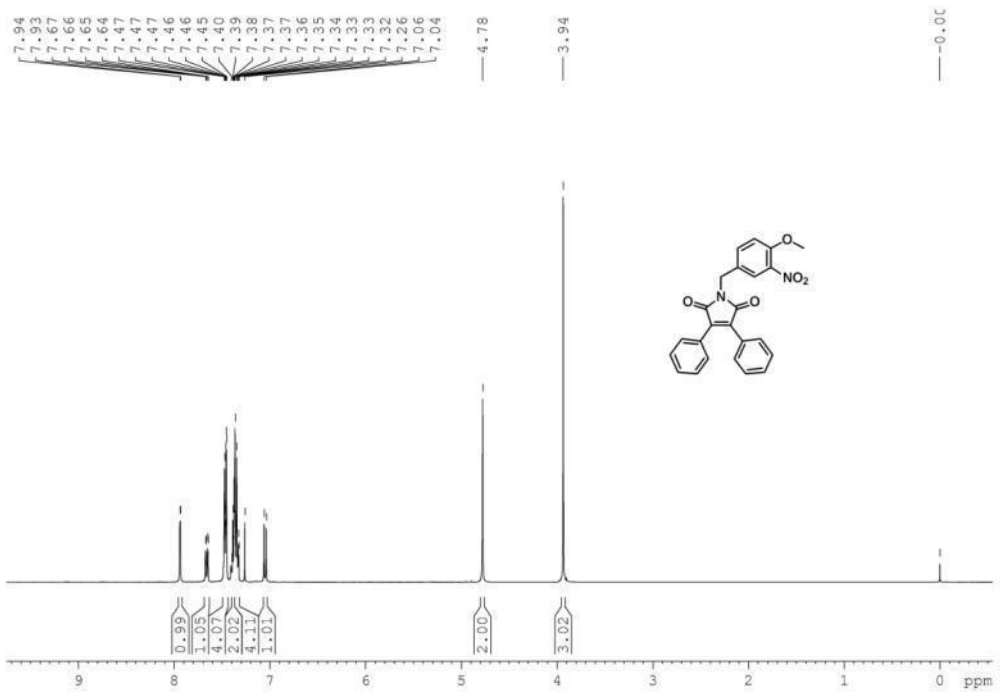


^{1}H NMR ($CDCl_3$, 400 MHz)

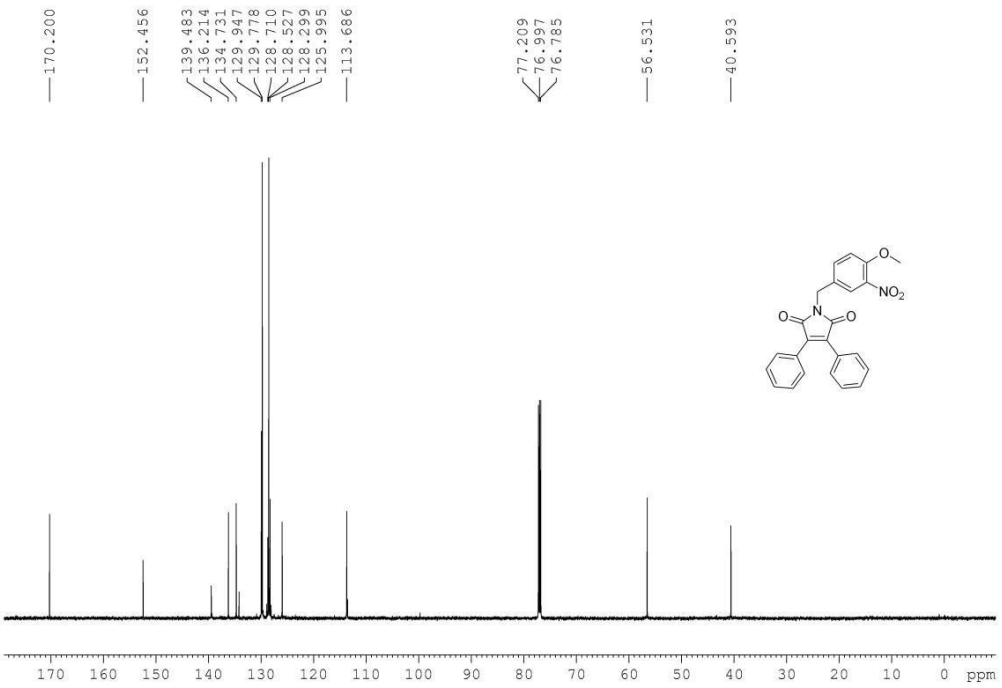


^{13}C NMR ($CDCl_3$, 100 MHz)

1-(4-methoxy-3-nitrobenzyl)-3,4-diphenyl-1*H*-pyrrole-2,5-dione (3k)

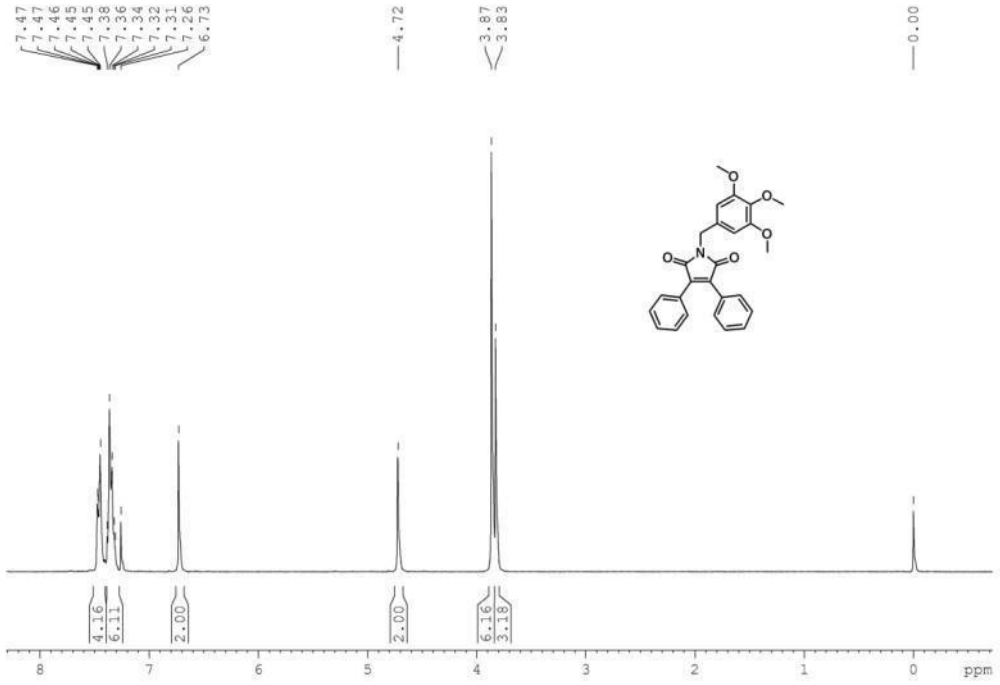


^{1}H NMR ($CDCl_3$, 400 MHz)

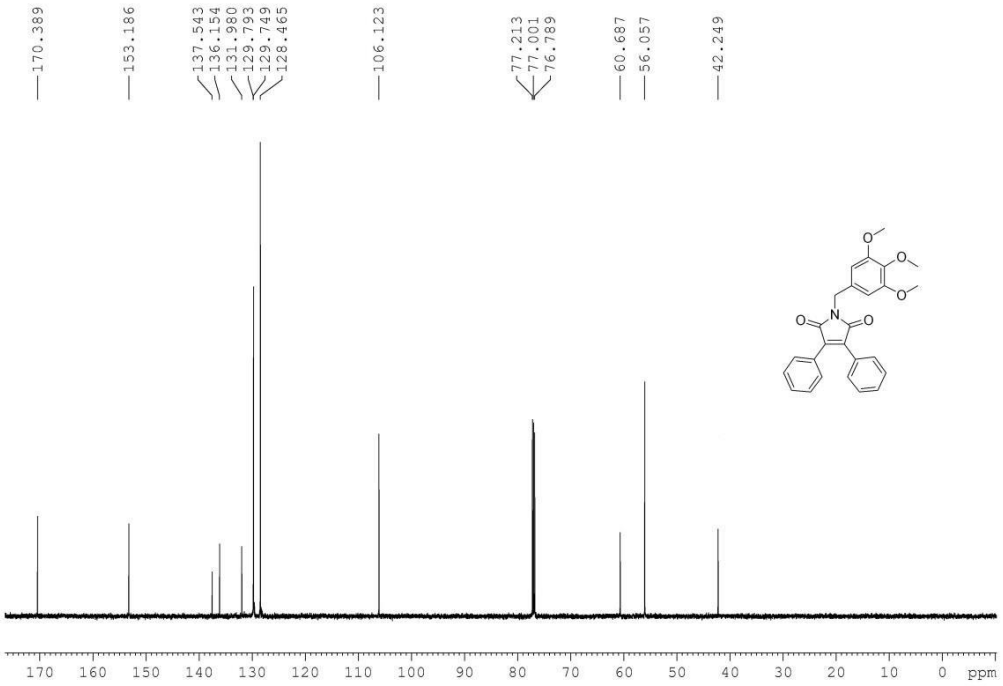


^{13}C NMR ($CDCl_3$, 100 MHz)

1-(3,4,5-trimethoxybenzyl)-3,4-diphenyl-1*H*-pyrrole-2,5-dione (3l)

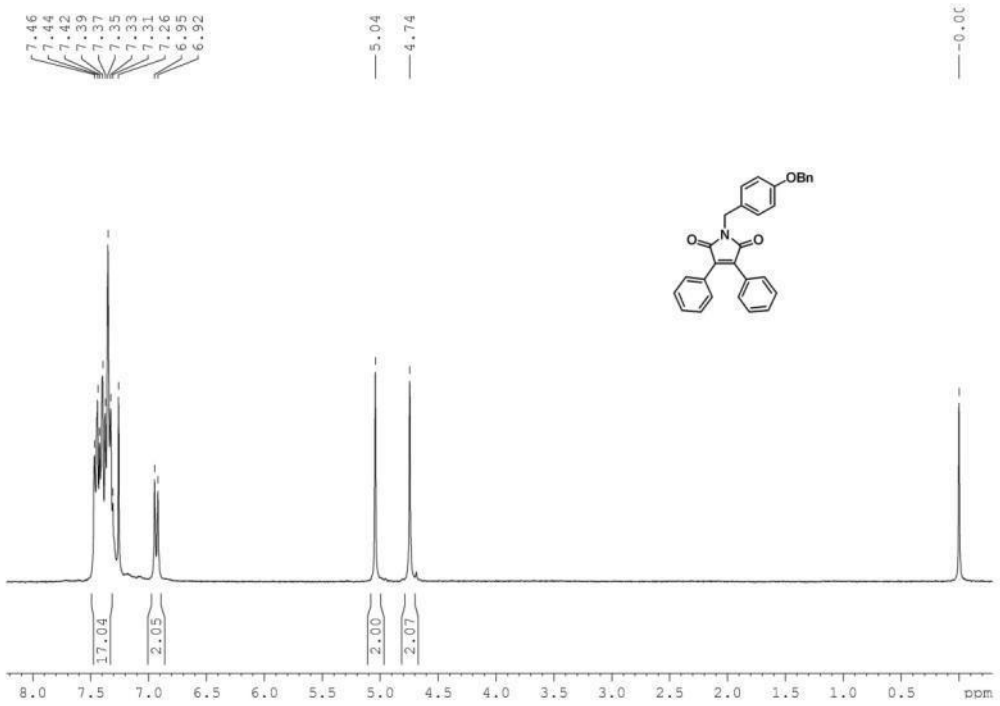


^{1}H NMR ($CDCl_3$, 400 MHz)

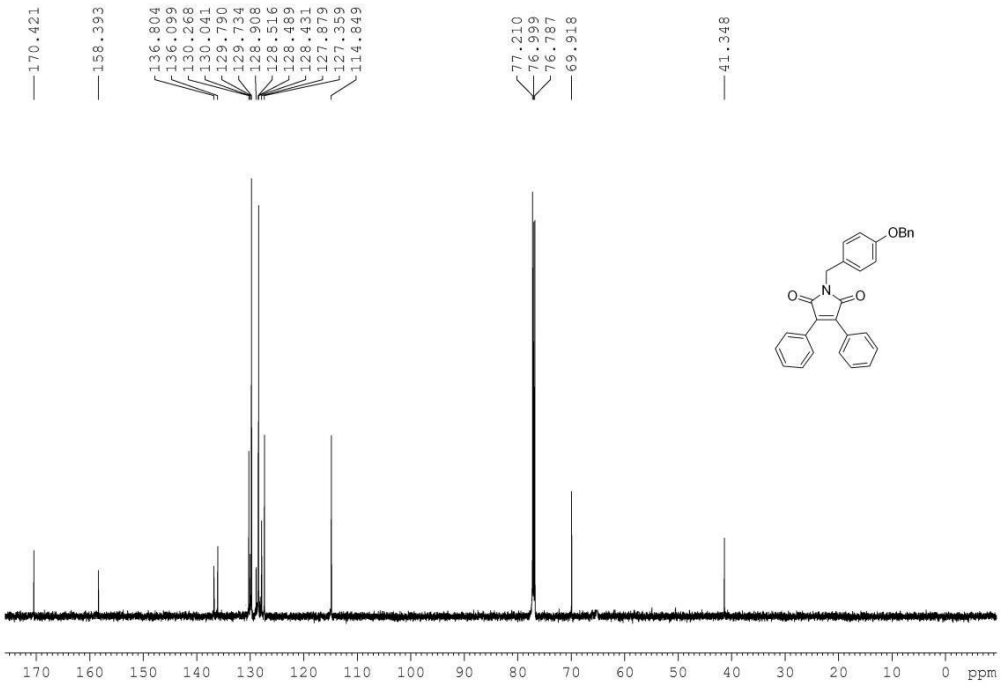


^{13}C NMR ($CDCl_3$, 100 MHz)

1-(4-benzyloxybenzyl)-3,4-diphenyl-1*H*-pyrrole-2,5-dione (3m)

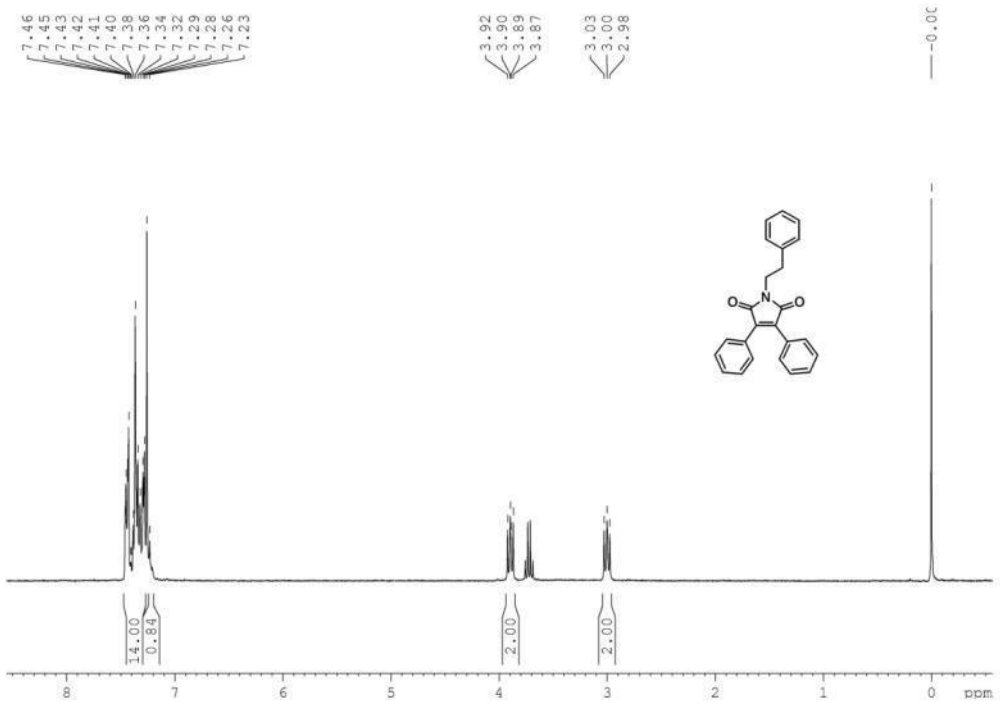


^{1}H NMR ($CDCl_3$, 400 MHz)



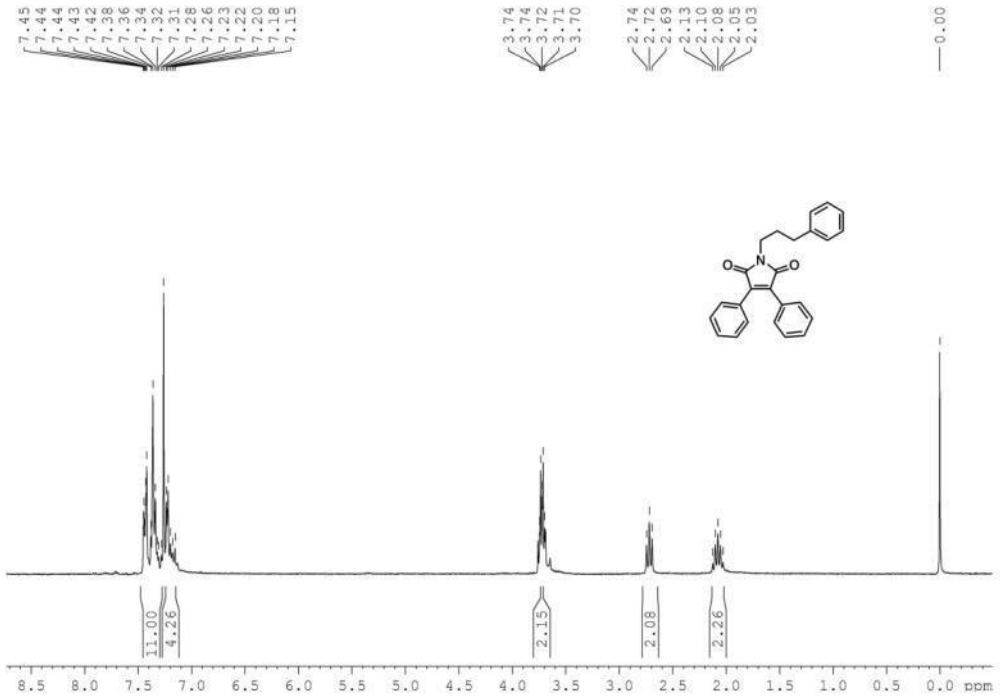
^{13}C NMR ($CDCl_3$, 100 MHz)

1-phenethyl-3,4-diphenyl-1*H*-pyrrole-2,5-dione (3n)



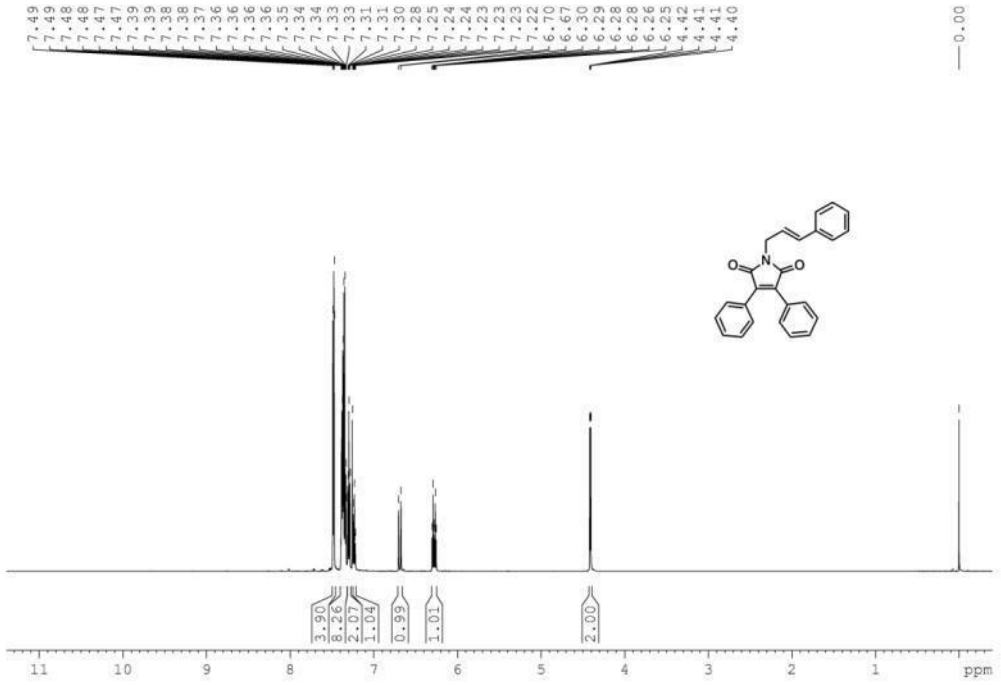
^{1}H NMR ($CDCl_3$, 400 MHz)

1-(3-phenylpropyl)-3,4-diphenyl-1*H*-pyrrole-2,5-dione (3o)

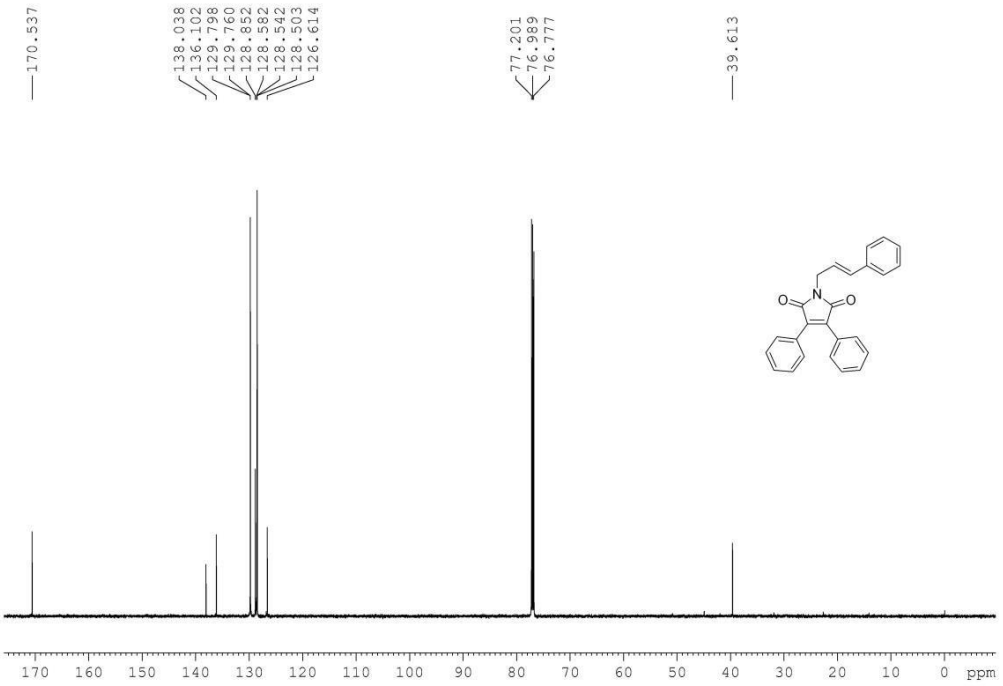


^{1}H NMR ($CDCl_3$, 400 MHz)

(*Z*)-1-cinnamyl-3,4-diphenyl-1*H*-pyrrole-2,5-dione (3p)

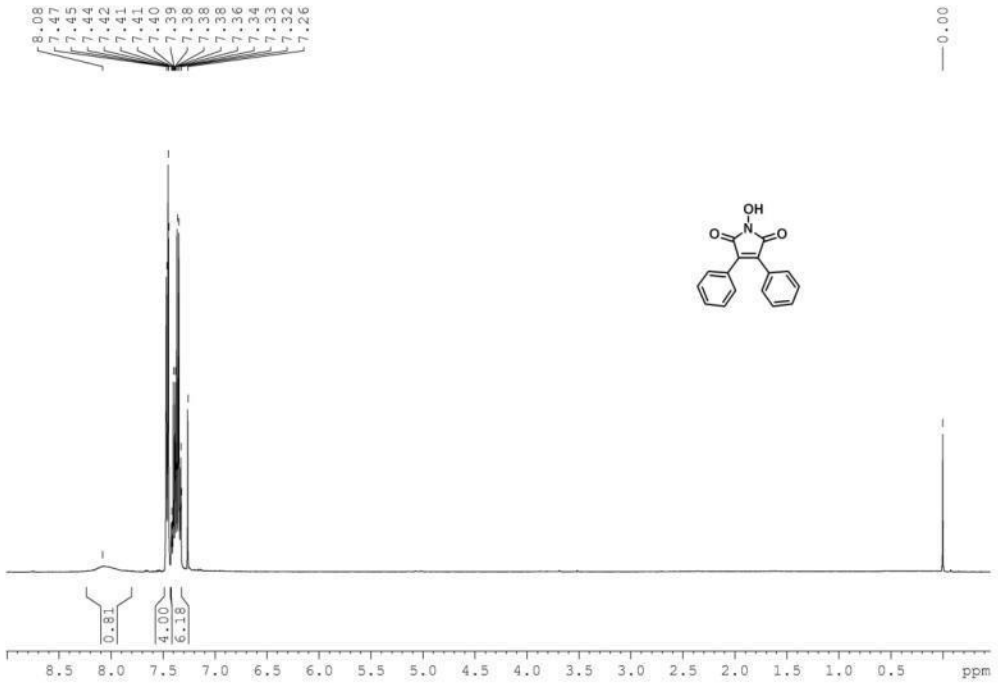


^{1}H NMR ($CDCl_3$, 400 MHz)



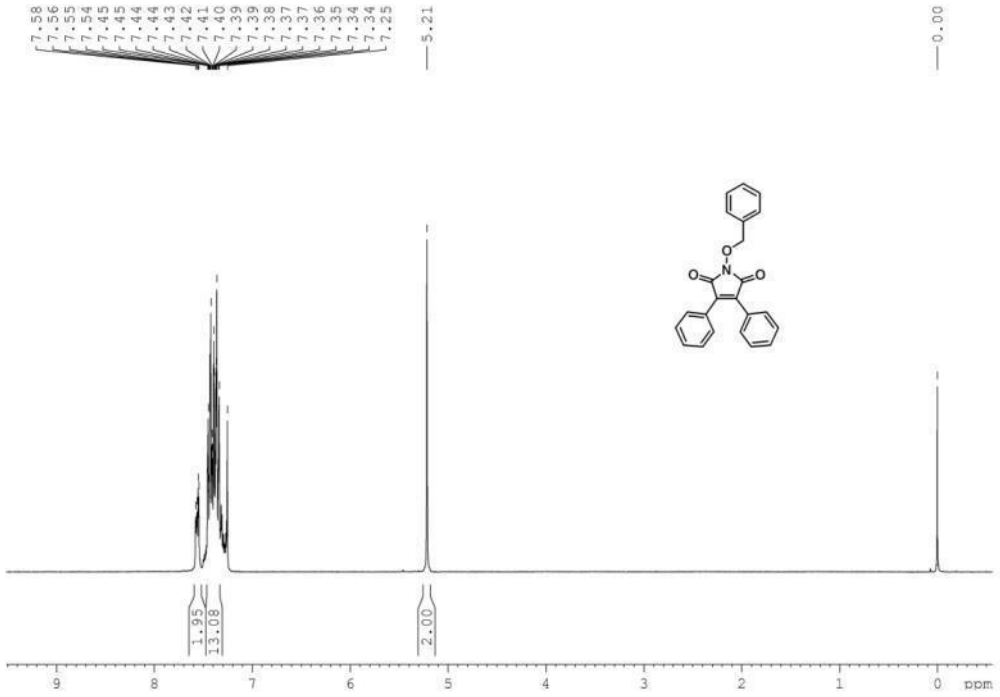
^{13}C NMR ($CDCl_3$, 100 MHz)

1-hydroxy-3,4-diphenyl-1*H*-pyrrole-2,5-dione (5)

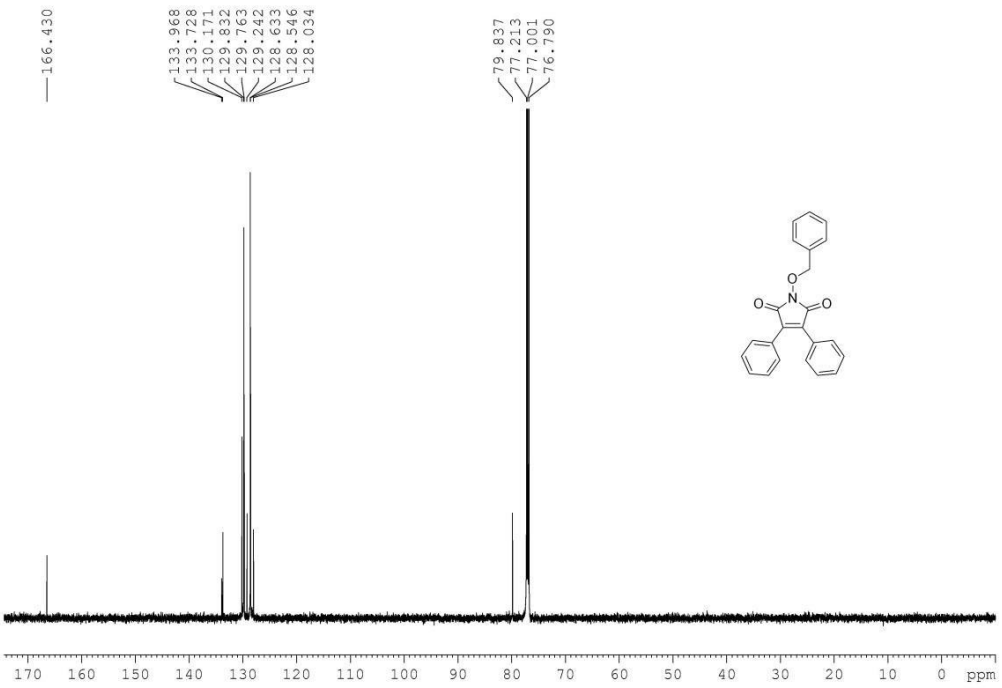


^{1}H NMR ($CDCl_3$, 400 MHz)

1-(benzyloxy)-3,4-diphenyl-1*H*-pyrrole-2,5-dione (6a)

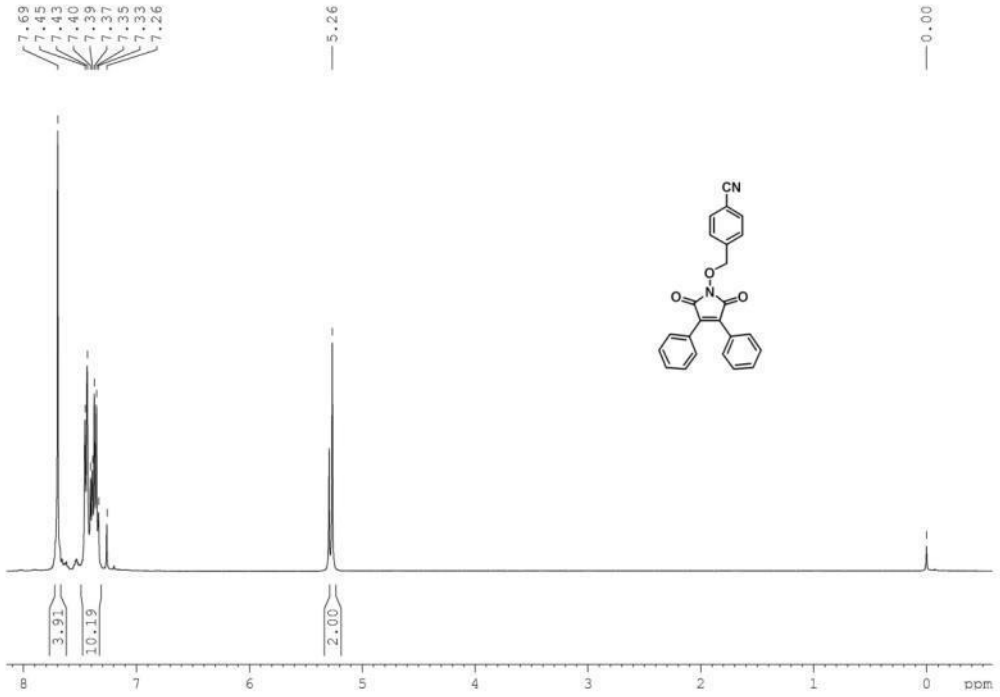


^{1}H NMR ($CDCl_3$, 400 MHz)

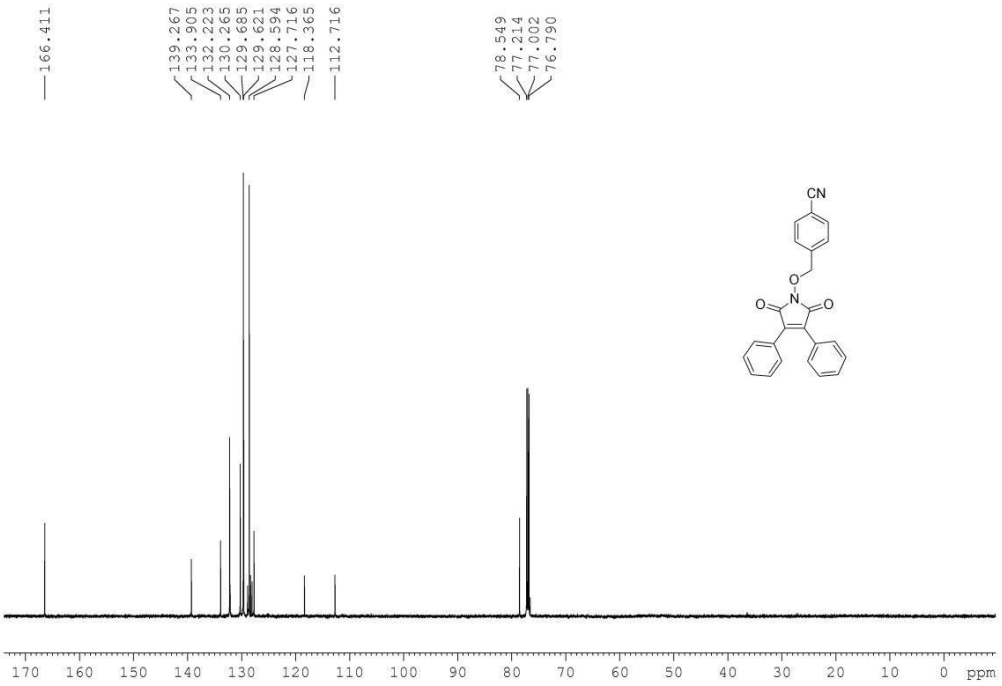


^{13}C NMR ($CDCl_3$, 100 MHz)

1-(4-cyanobenzyloxy)-3,4-diphenyl-1*H*-pyrrole-2,5-dione (6b)

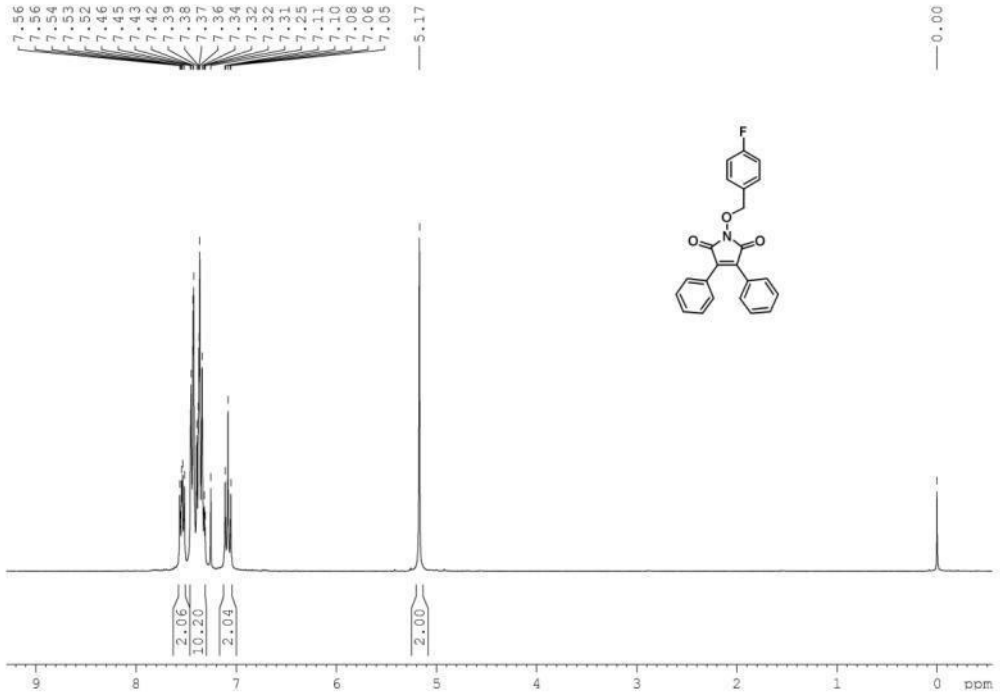


^{1}H NMR ($CDCl_3$, 400 MHz)

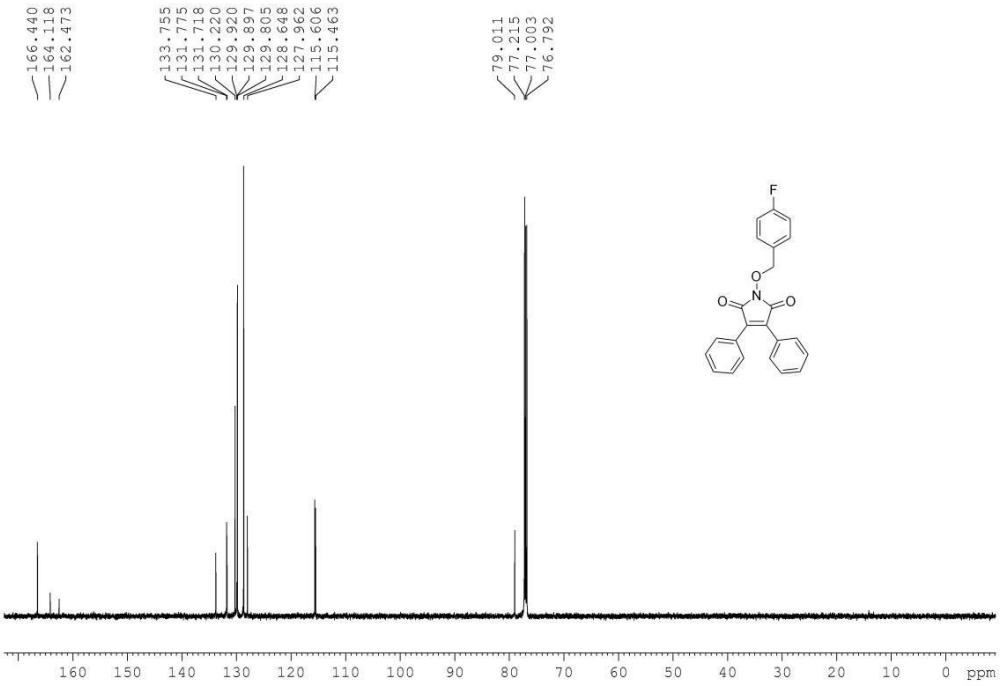


^{13}C NMR ($CDCl_3$, 100 MHz)

1-(4-fluorobenzyloxy)-3,4-diphenyl-1*H*-pyrrole-2,5-dione (6c)

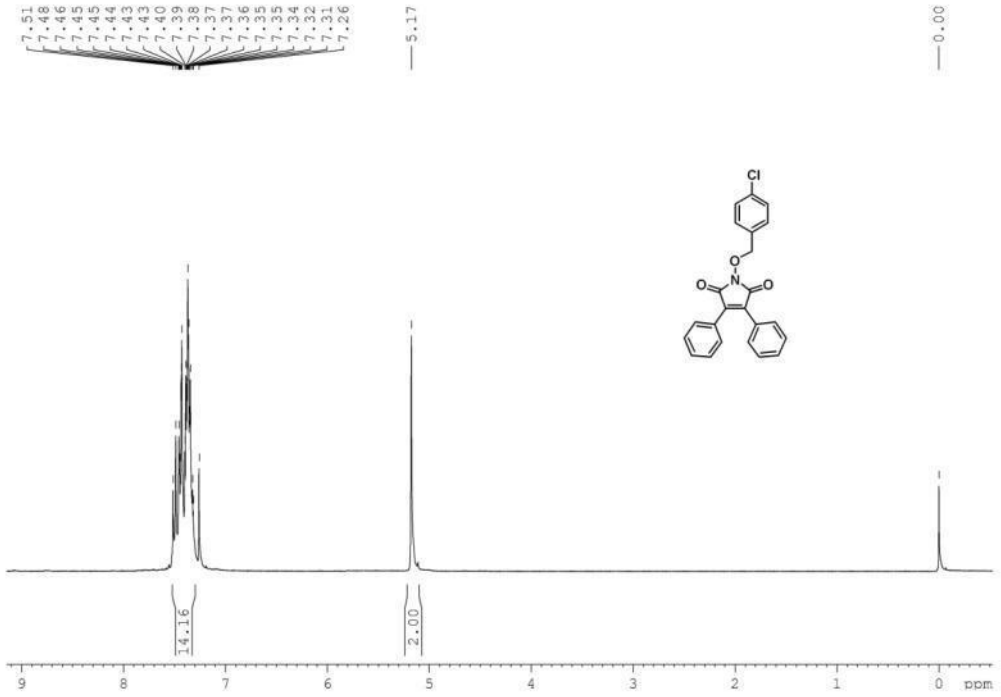


^{1}H NMR ($CDCl_3$, 400 MHz)

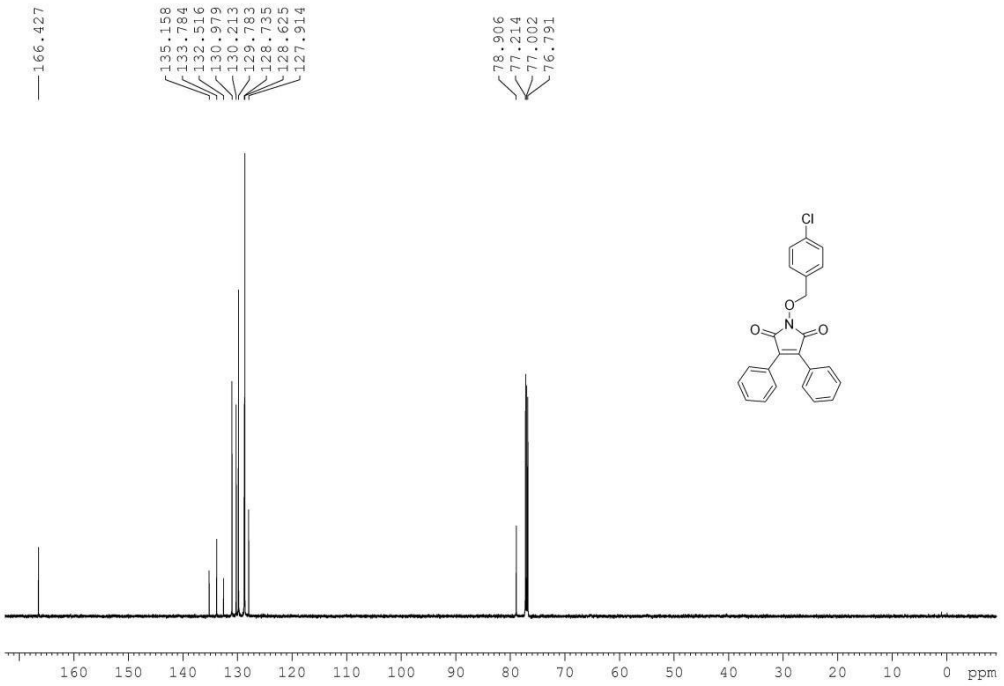


^{13}C NMR ($CDCl_3$, 100 MHz)

1-(4-chlorobenzyloxy)-3,4-diphenyl-1*H*-pyrrole-2,5-dione (6d)



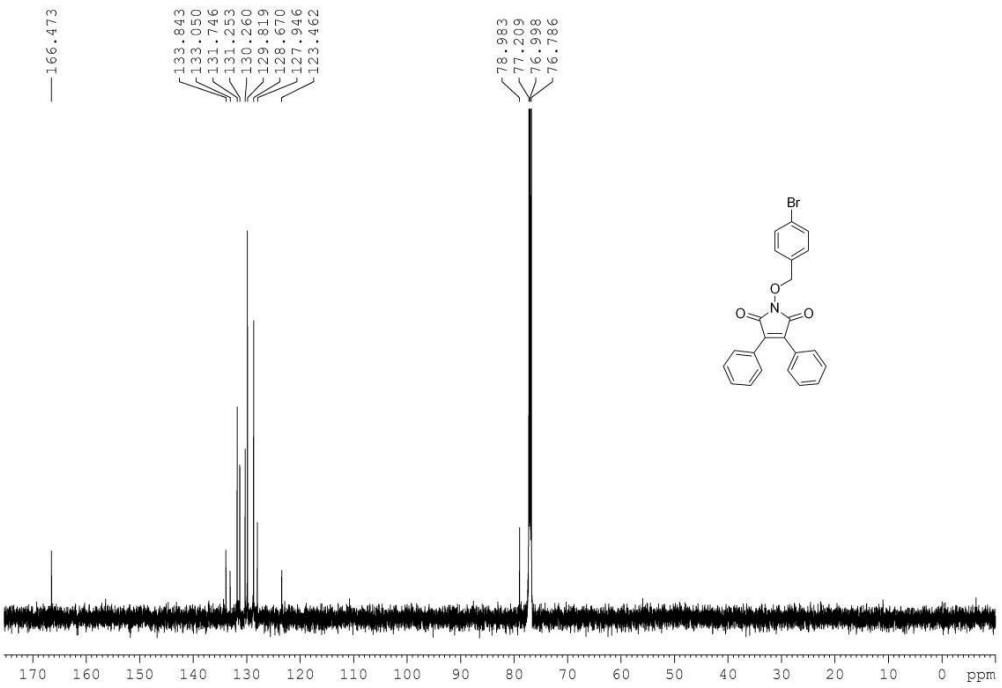
^{1}H NMR ($CDCl_3$, 400 MHz)



^{13}C NMR ($CDCl_3$, 100 MHz)

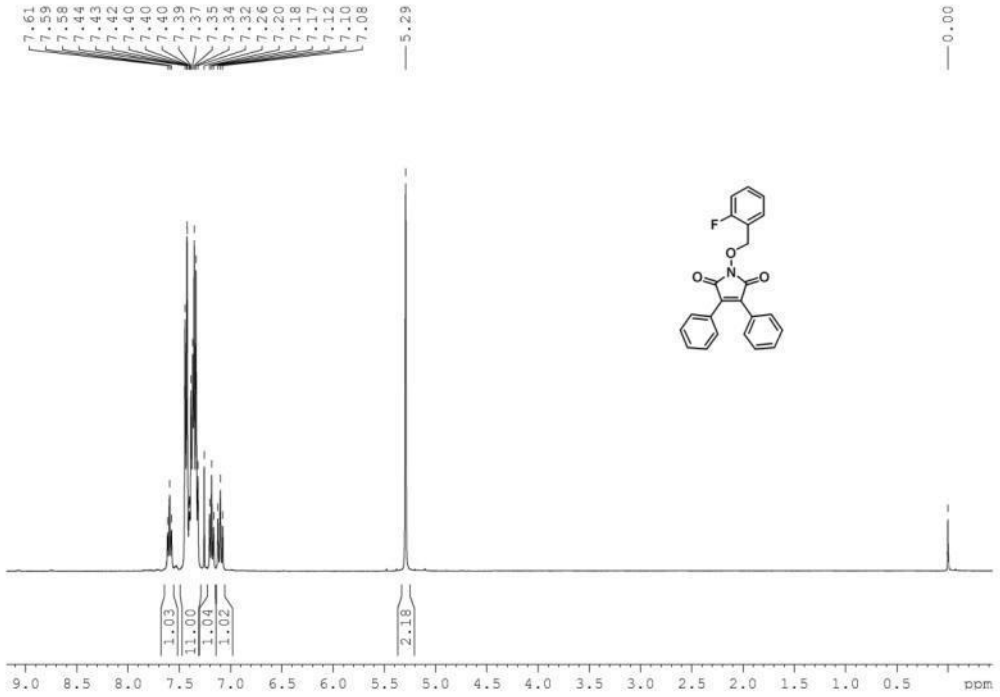
1-(4-bromobenzyloxy)-3,4-diphenyl-1*H*-pyrrole-2,5-dione (6e)

^{1}H NMR ($CDCl_3$, 400 MHz)

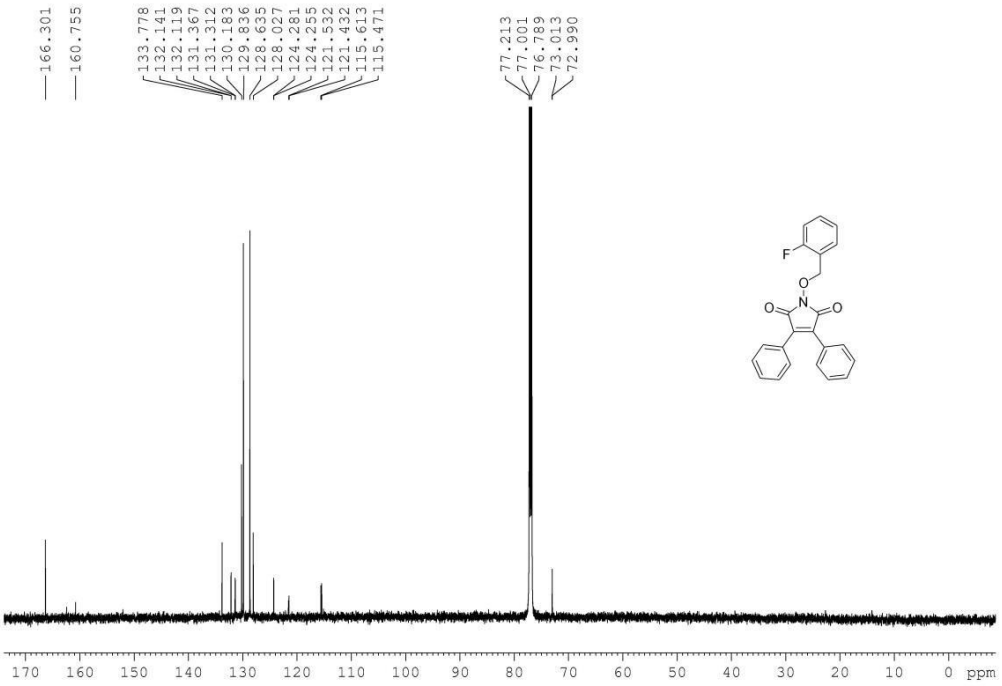


^{13}C NMR ($CDCl_3$, 100 MHz)

1-(2-fluorobenzyloxy)-3,4-diphenyl-1*H*-pyrrole-2,5-dione (6f)

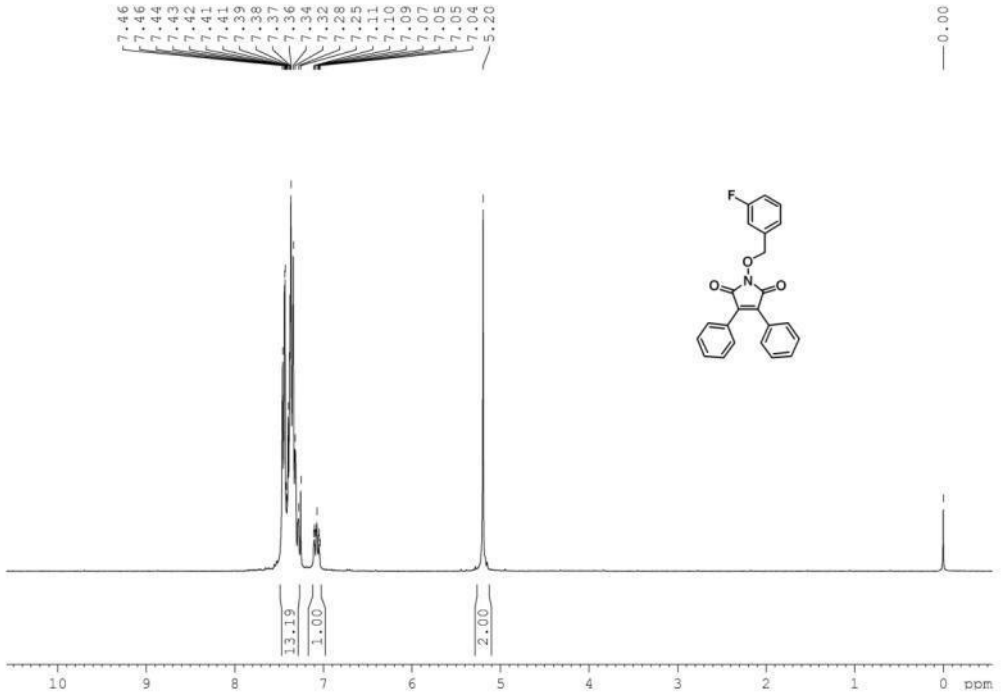


^{1}H NMR ($CDCl_3$, 400 MHz)

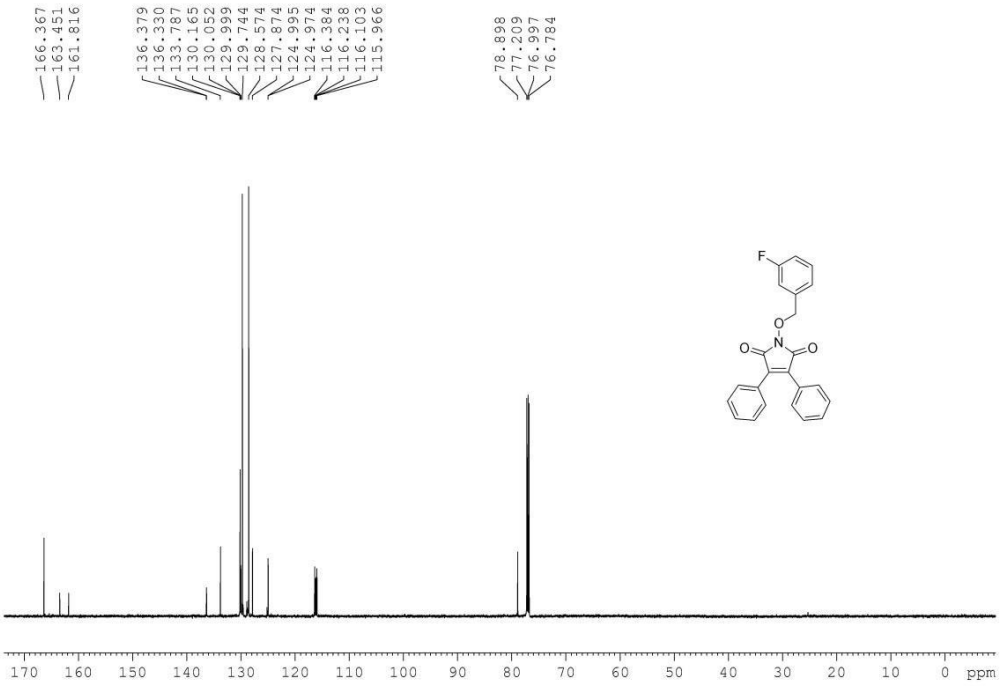


^{13}C NMR ($CDCl_3$, 100 MHz)

1-(3-fluorobenzyloxy)-3,4-diphenyl-1*H*-pyrrole-2,5-dione (6g)

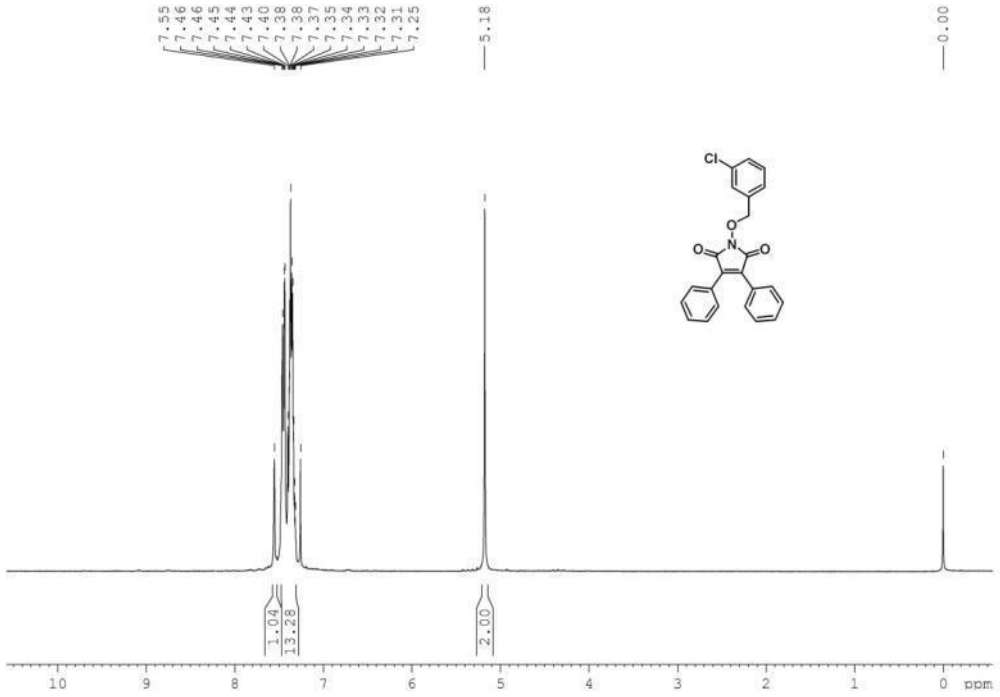


^{1}H NMR ($CDCl_3$, 400 MHz)

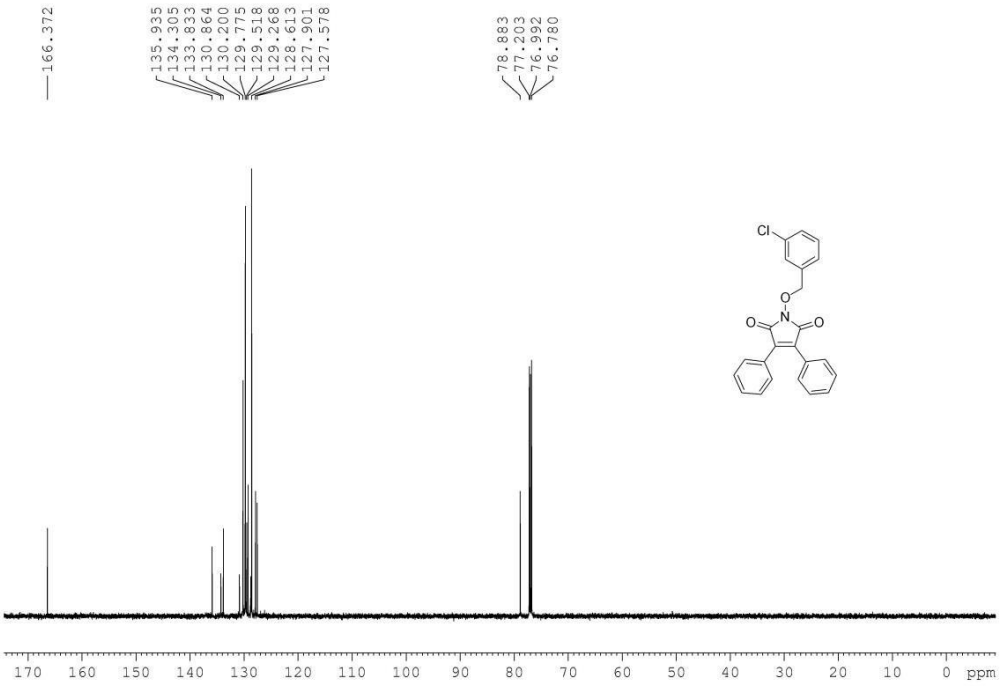


^{13}C NMR ($CDCl_3$, 100 MHz)

1-(3-chlorobenzyloxy)-3,4-diphenyl-1*H*-pyrrole-2,5-dione (6h)

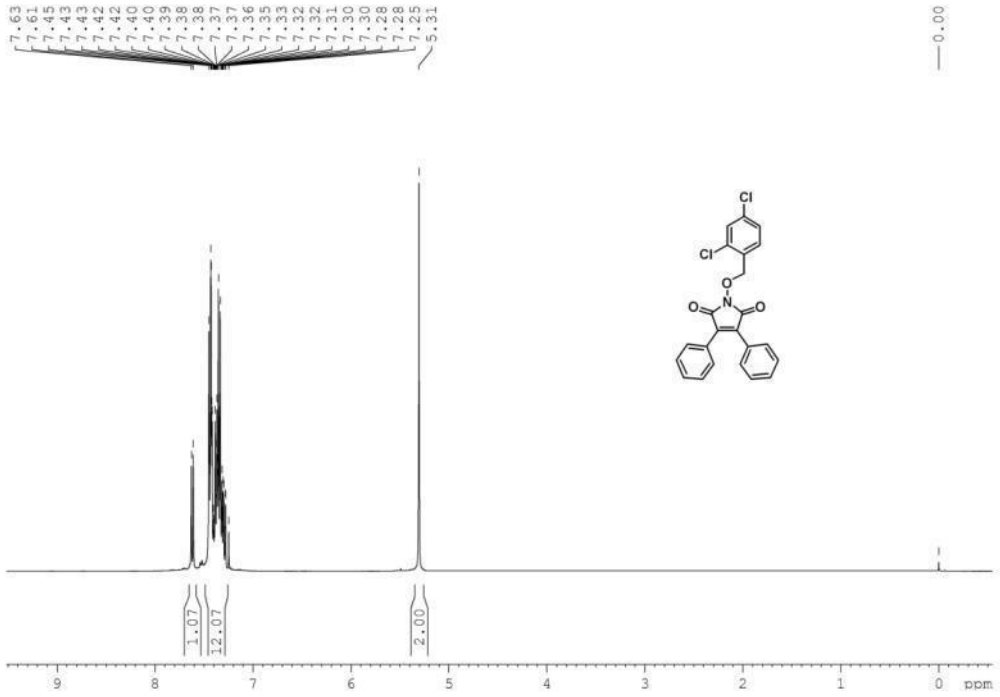


^{1}H NMR ($CDCl_3$, 400 MHz)

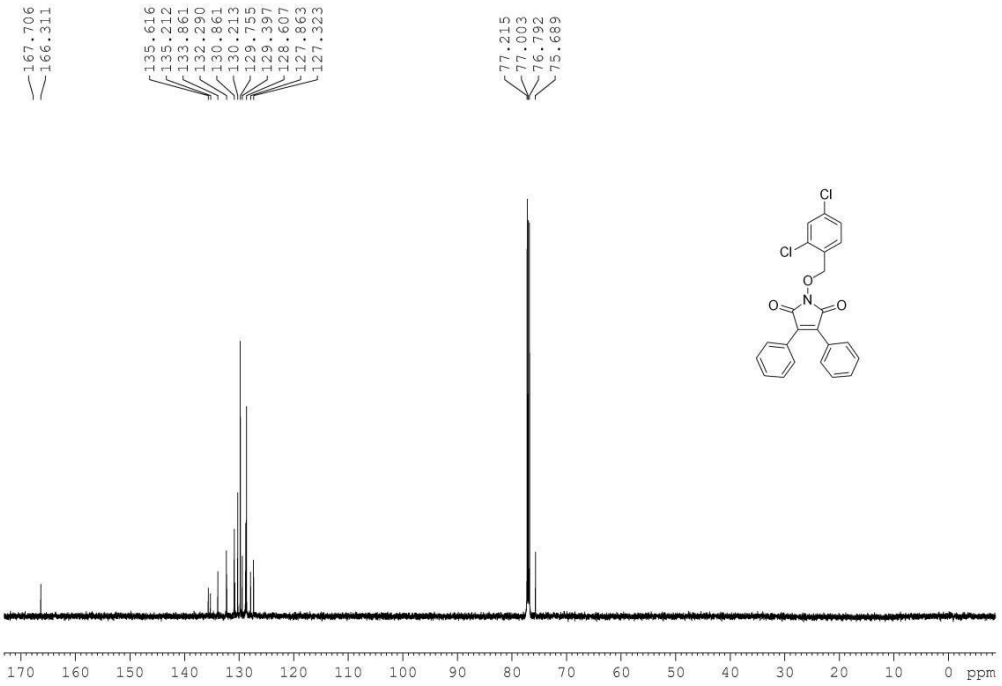


^{13}C NMR ($CDCl_3$, 100 MHz)

1-(2,4-dichlorobenzyloxy)-3,4-diphenyl-1*H*-pyrrole-2,5-dione (6i)

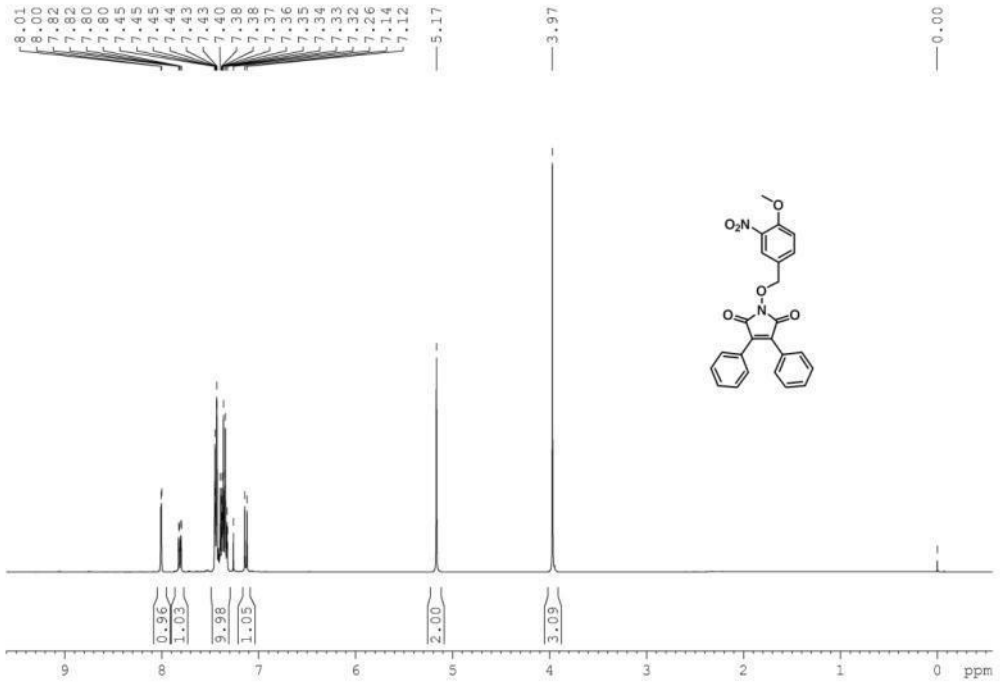


^{1}H NMR ($CDCl_3$, 400 MHz)

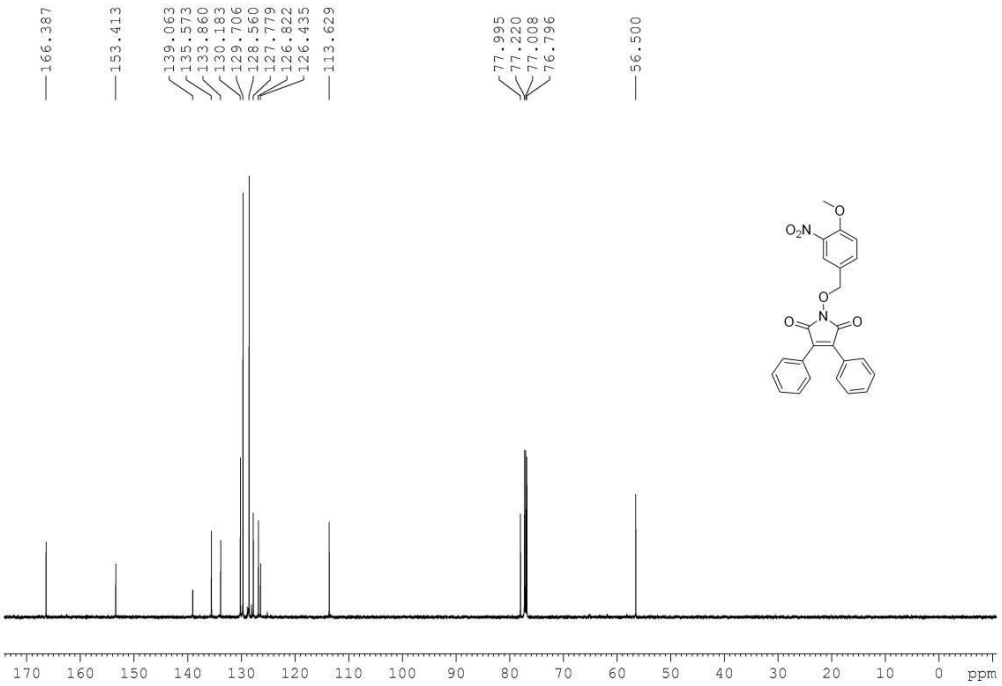


^{13}C NMR ($CDCl_3$, 100 MHz)

1-(4-methoxy-3-nitrobenzyloxy)-3,4-diphenyl-1*H*-pyrrole-2,5-dione (6j)

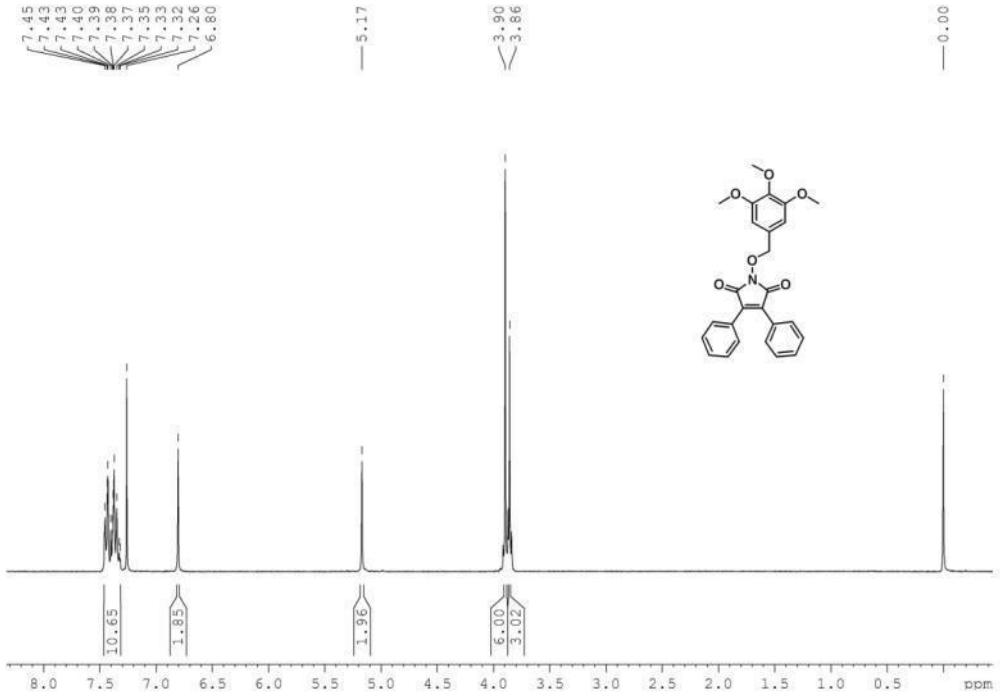


^{1}H NMR ($CDCl_3$, 400 MHz)

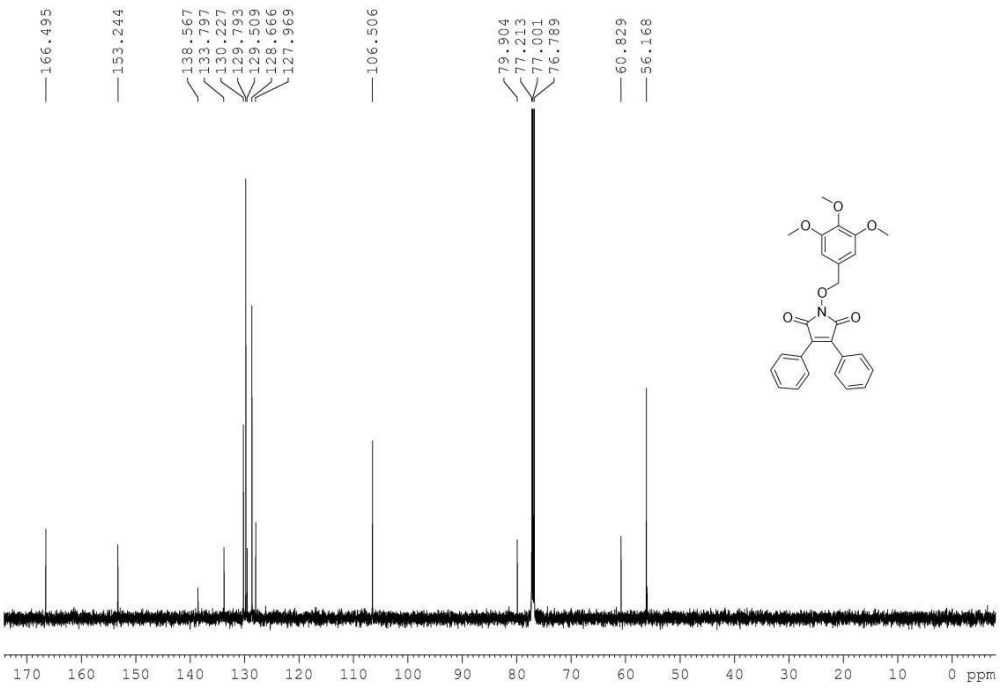


^{13}C NMR ($CDCl_3$, 100 MHz)

1-(3,4,5-trimethoxybenzyloxy)-3,4-diphenyl-1*H*-pyrrole-2,5-dione (6k)

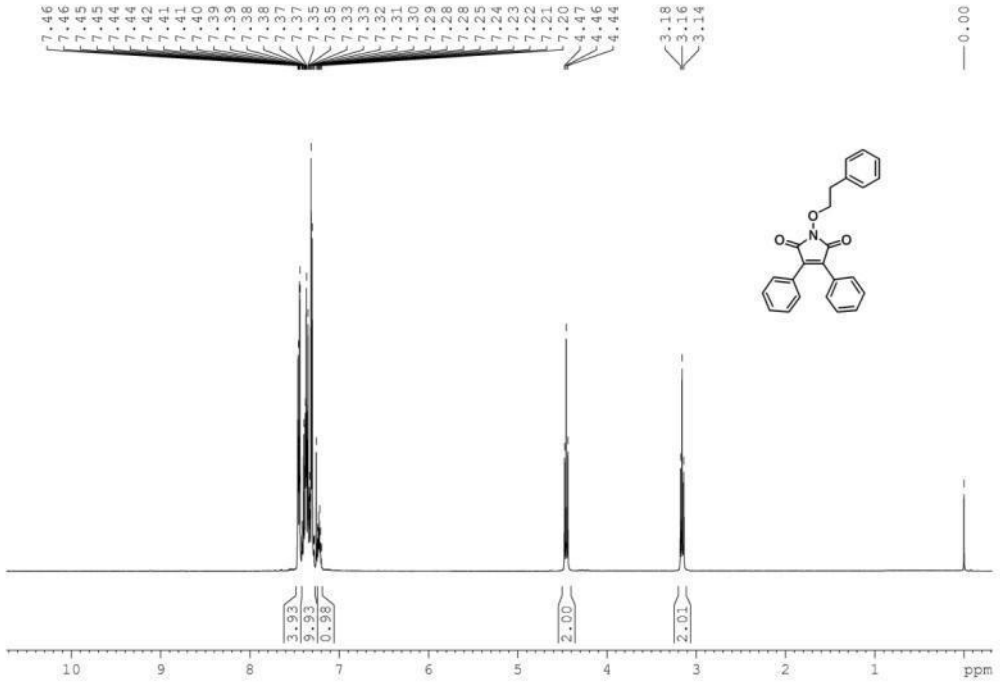


^{1}H NMR ($CDCl_3$, 400 MHz)

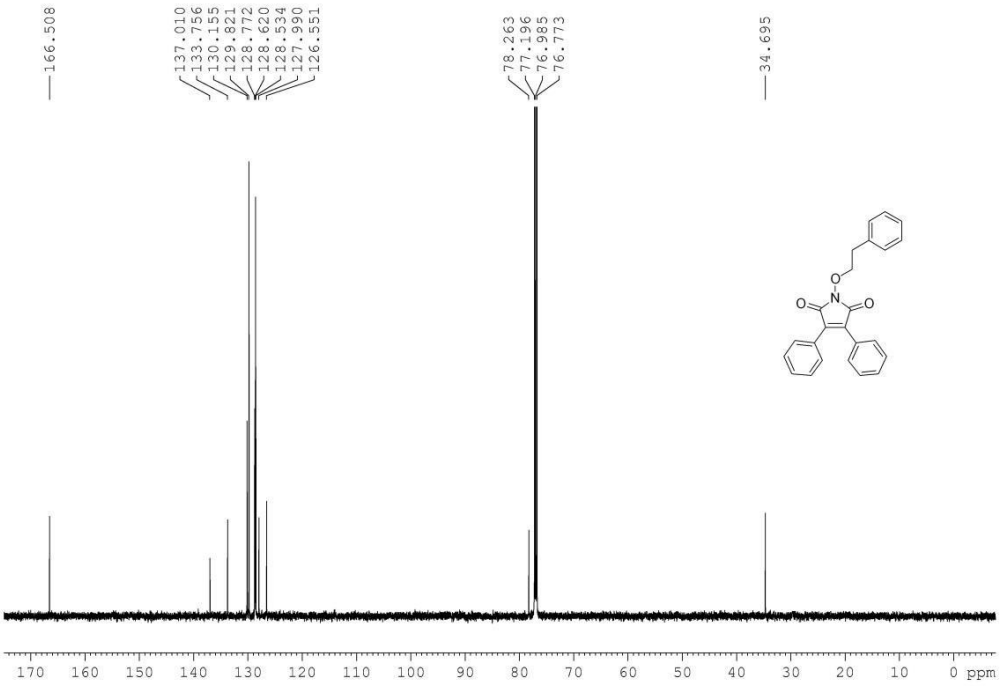


^{13}C NMR ($CDCl_3$, 100 MHz)

1-phenethoxy-3,4-diphenyl-1*H*-pyrrole-2,5-dione (6l)

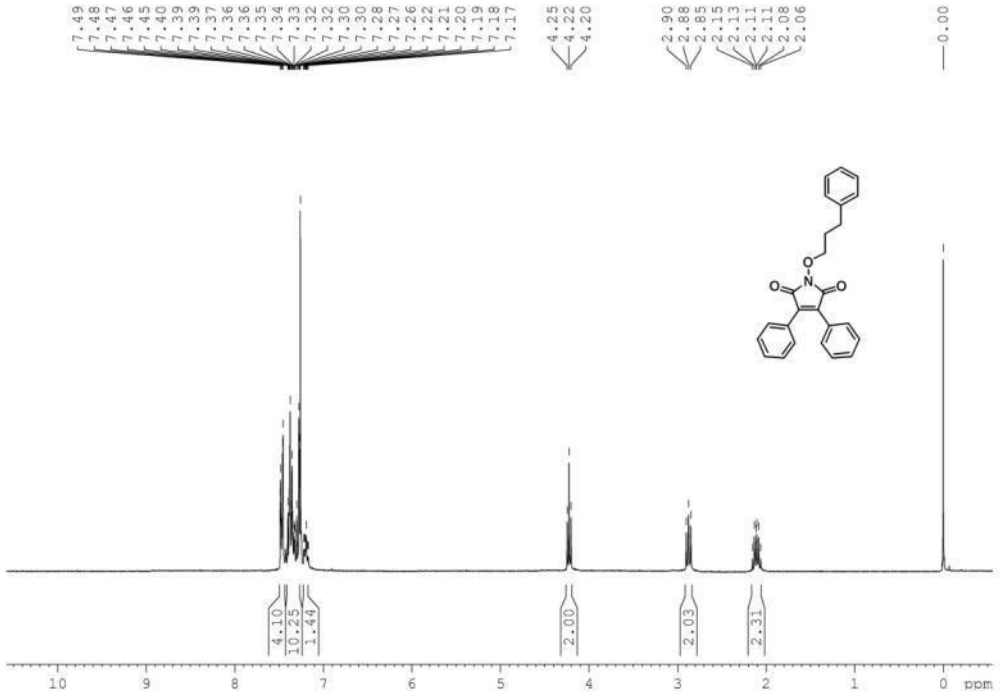


^{1}H NMR ($CDCl_3$, 400 MHz)

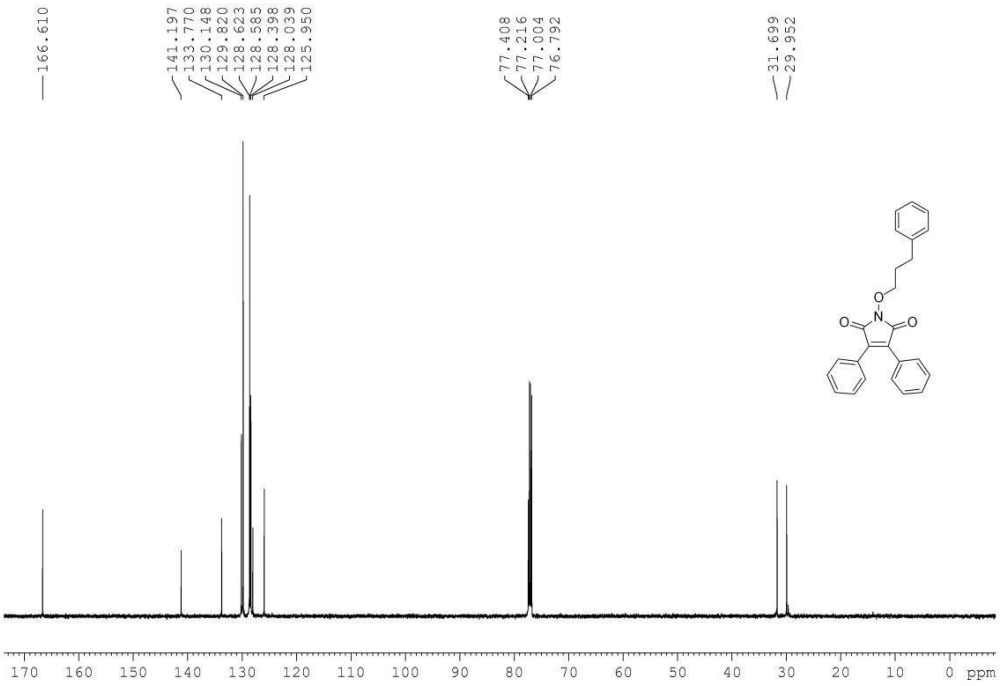


^{13}C NMR ($CDCl_3$, 100 MHz)

1-(3-phenylpropoxy)-3,4-diphenyl-1*H*-pyrrole-2,5-dione (6m)

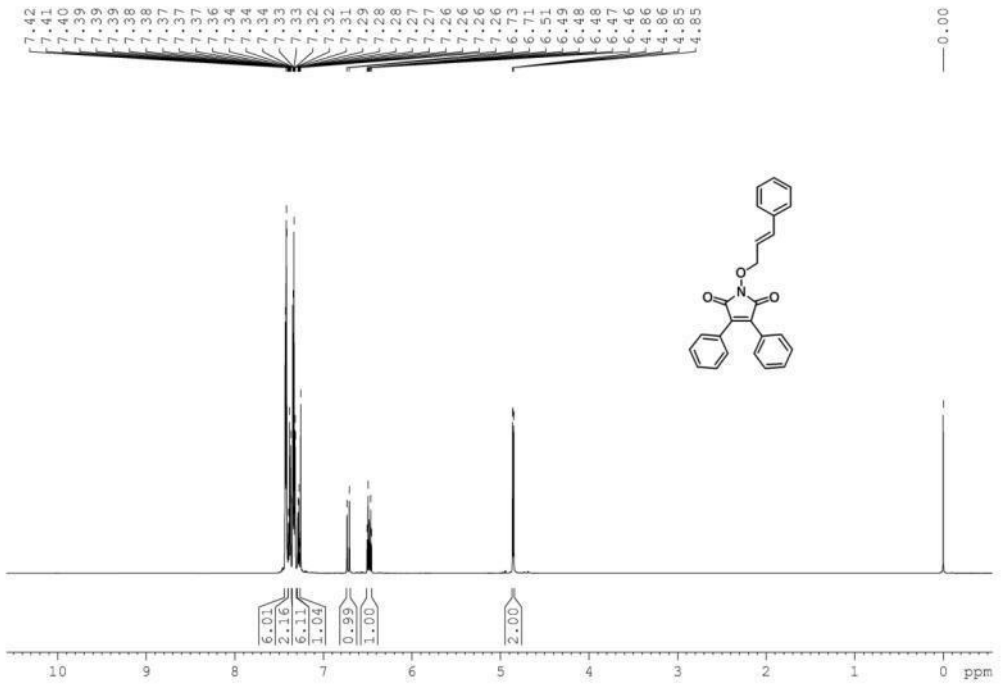


^{1}H NMR ($CDCl_3$, 400 MHz)

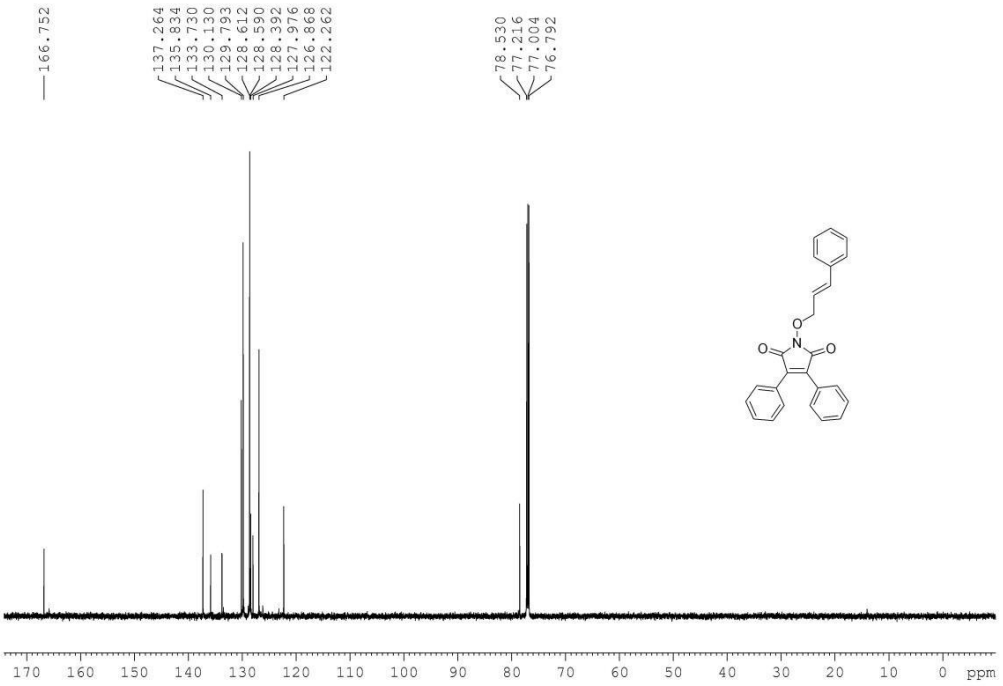


^{13}C NMR ($CDCl_3$, 100 MHz)

(*Z*)-1-(cinnamyloxy)-3,4-diphenyl-1*H*-pyrrole-2,5-dione (6n)

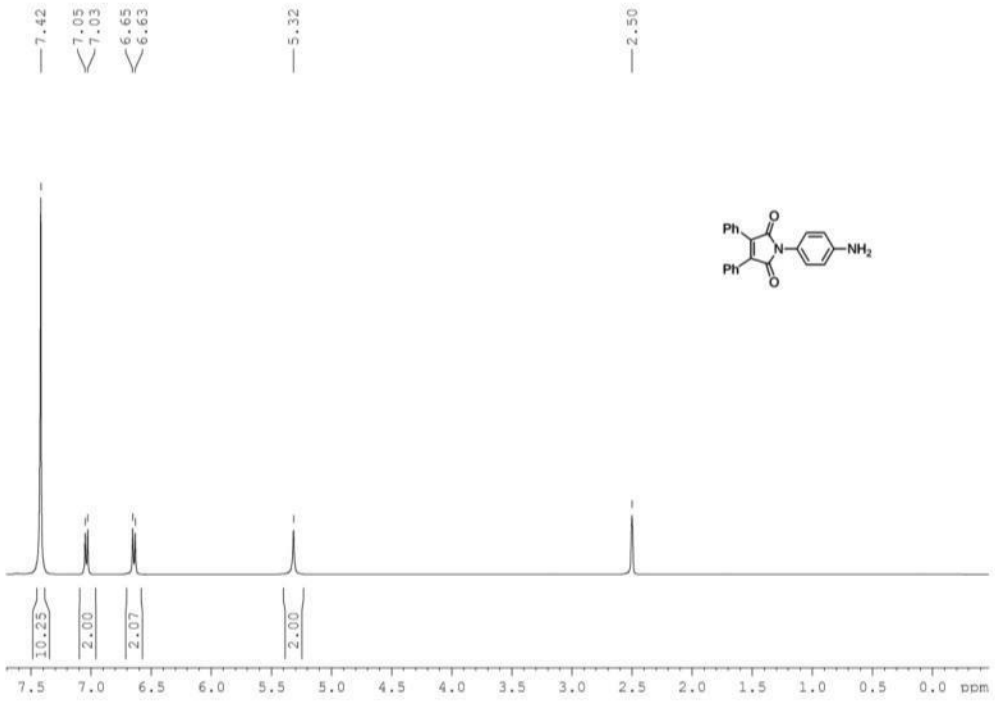


^{1}H NMR ($CDCl_3$, 400 MHz)

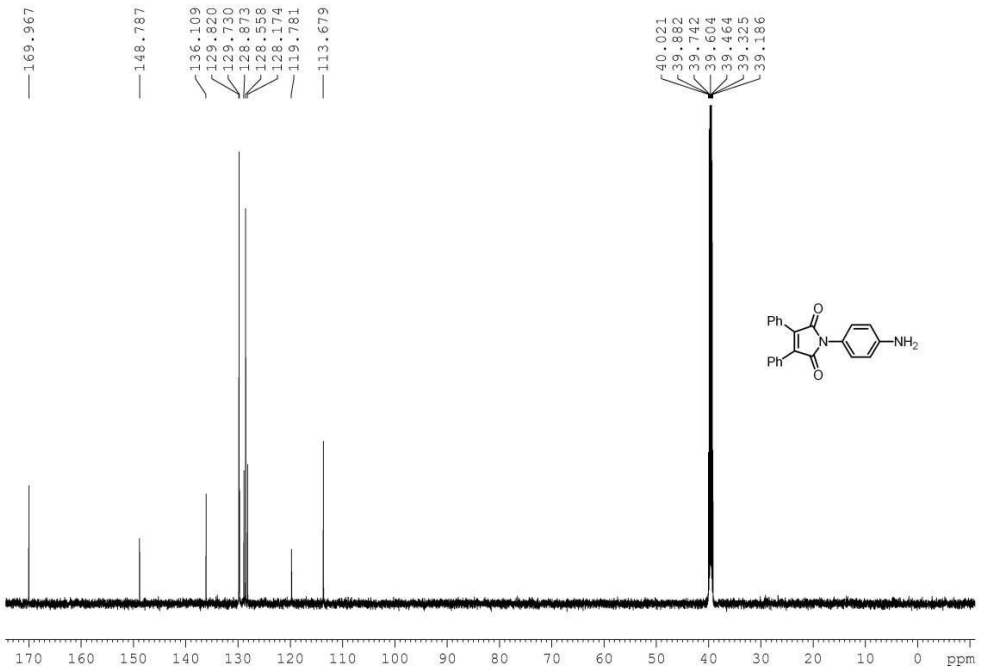


^{13}C NMR ($CDCl_3$, 100 MHz)

1-(4-aminophenyl)-3,4-diphenyl-1*H*-pyrrole-2,5-dione (8a)

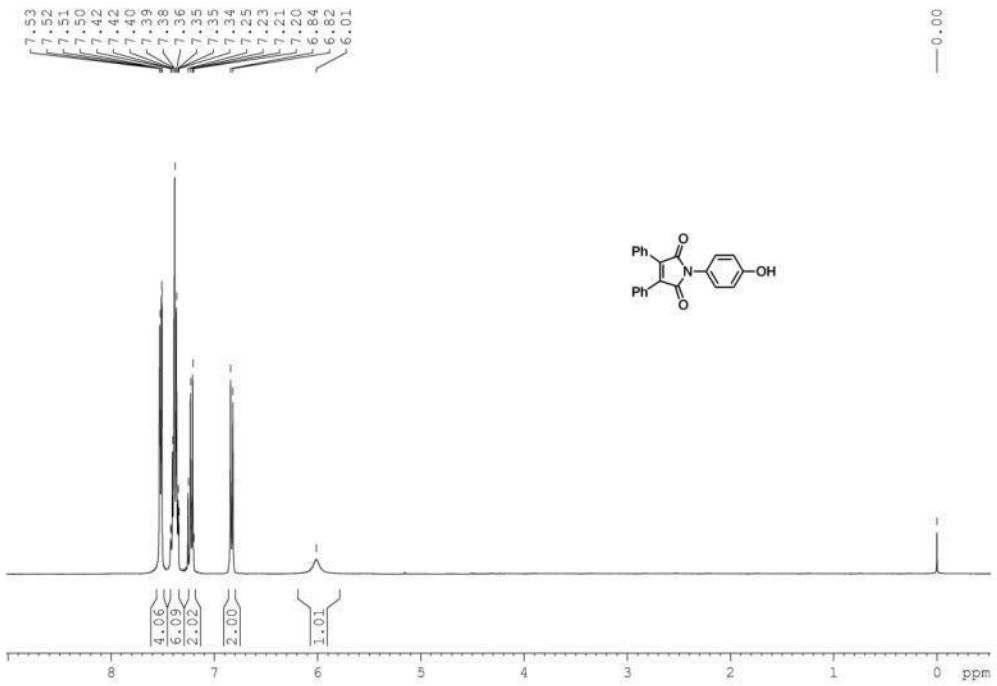


^{1}H NMR (DMSO-d_6, 400 MHz)

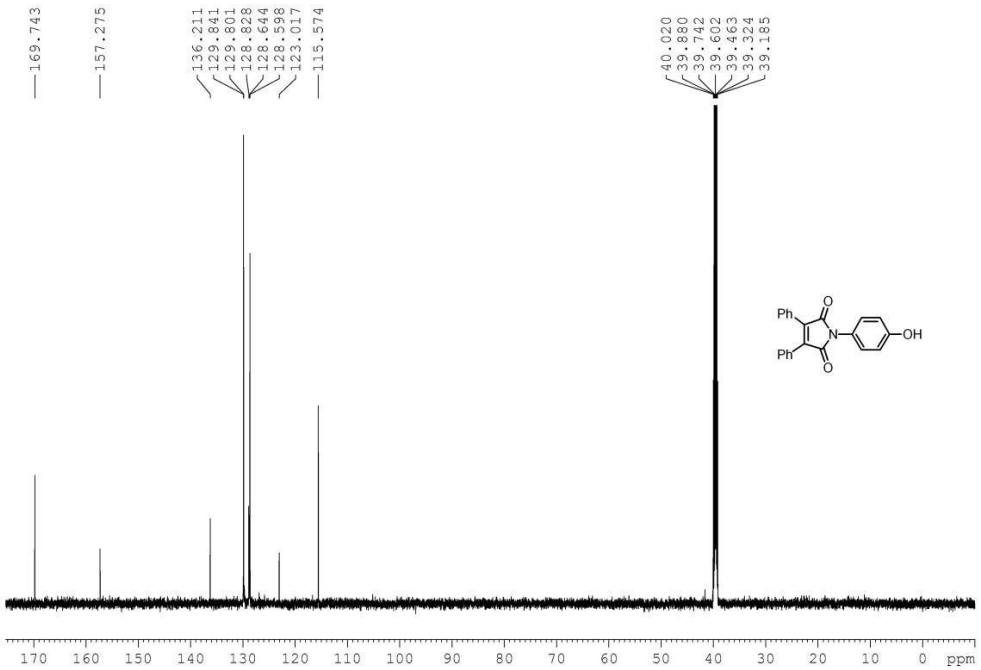


^{13}C NMR (DMSO-d_6, 100 MHz)

1-(4-hydroxyphenyl)-3,4-diphenyl-1*H*-pyrrole-2,5-dione (8b)

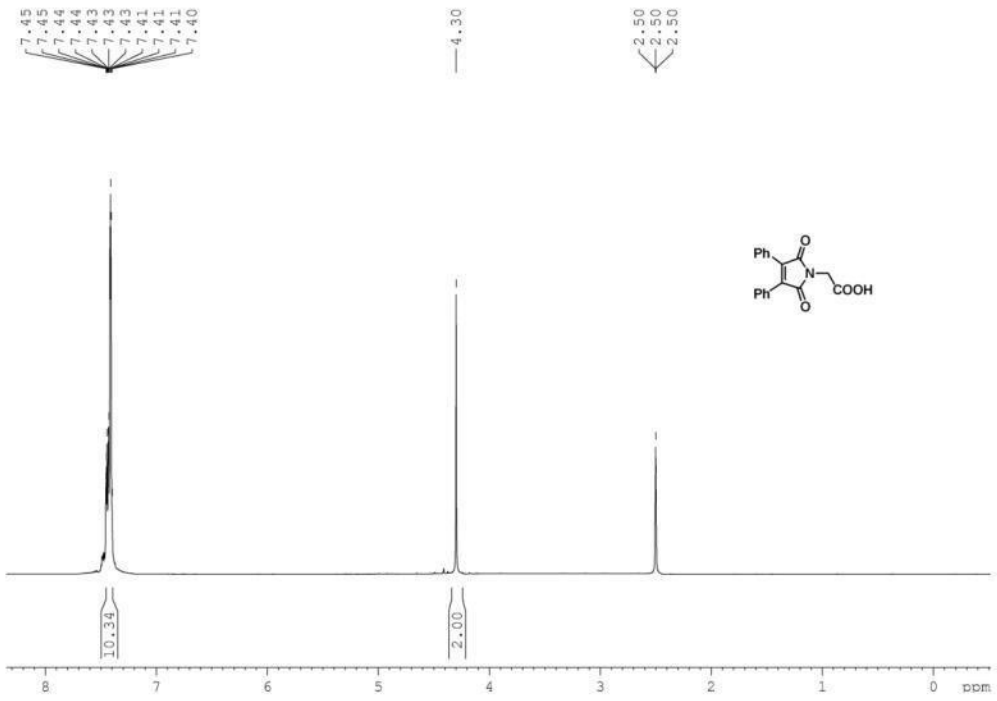


^{1}H NMR (CDCl$_3$, 400 MHz)

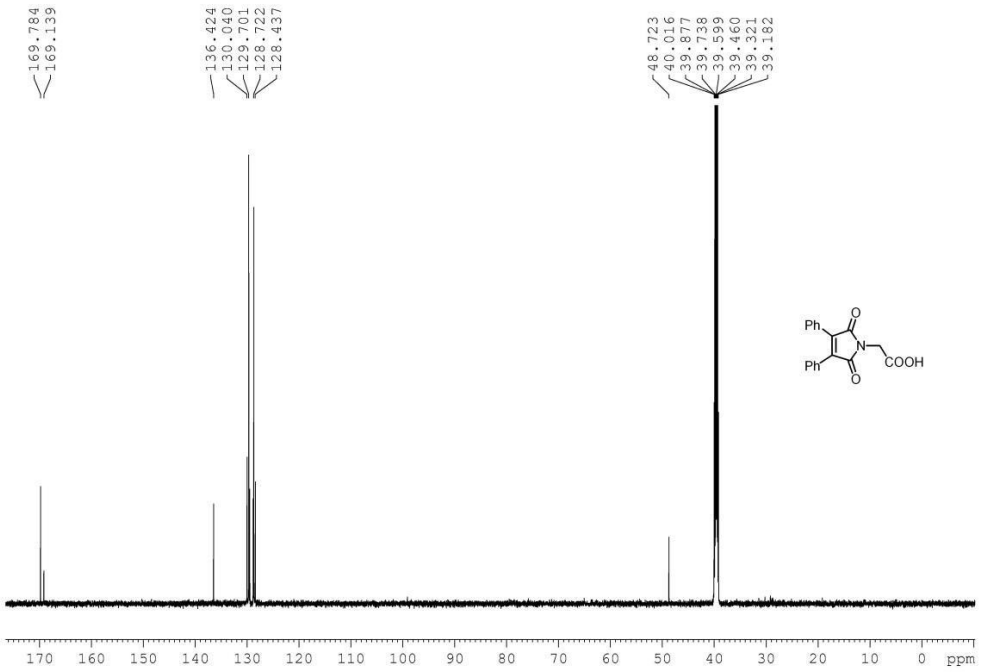


^{13}C NMR (DMSO-*d*$_6$, 100 MHz)

2-(2,5-dioxo-3,4-diphenyl-2,5-dihydro-1*H*-pyrrol-1-yl)acetic acid (8c)

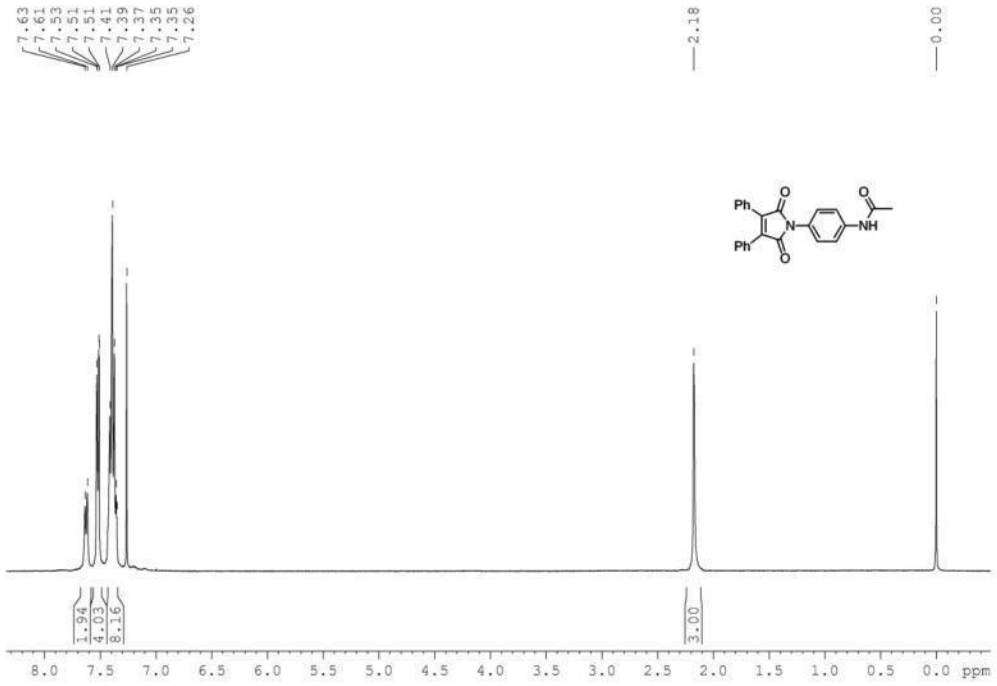


^{1}H NMR (DMSO-d_6, 400 MHz)

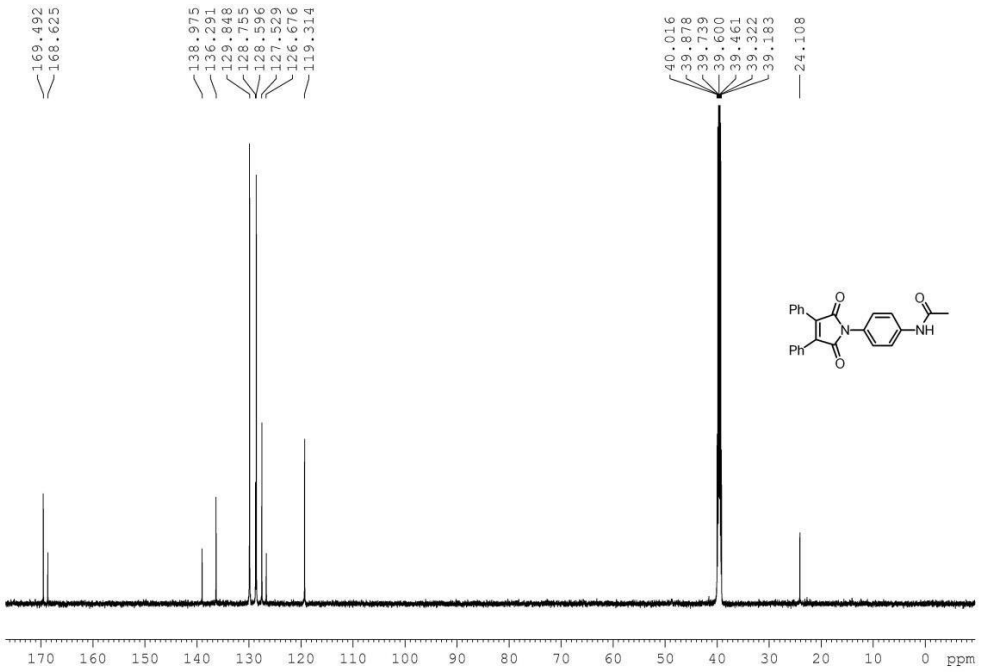


^{13}C NMR (DMSO-d_6, 100 MHz)

***N*-[4-(2,5-dioxo-3,4-diphenyl-2,5-dihydro-1*H*-pyrrol-1-yl)phenyl]acetamide (9a)**

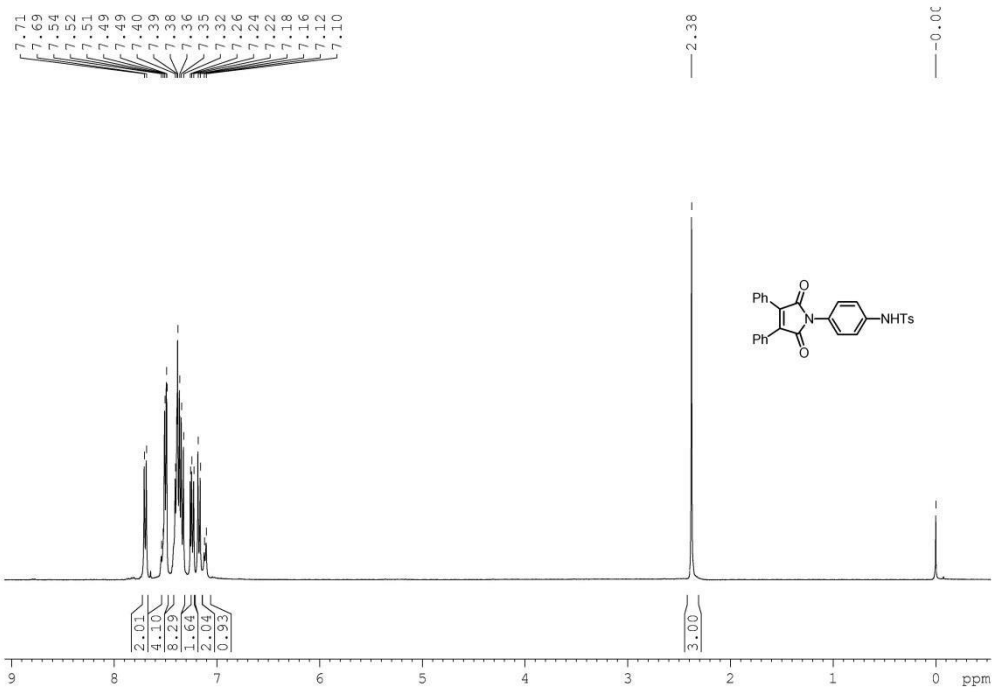


^{1}H NMR ($CDCl_3$, 400 MHz)

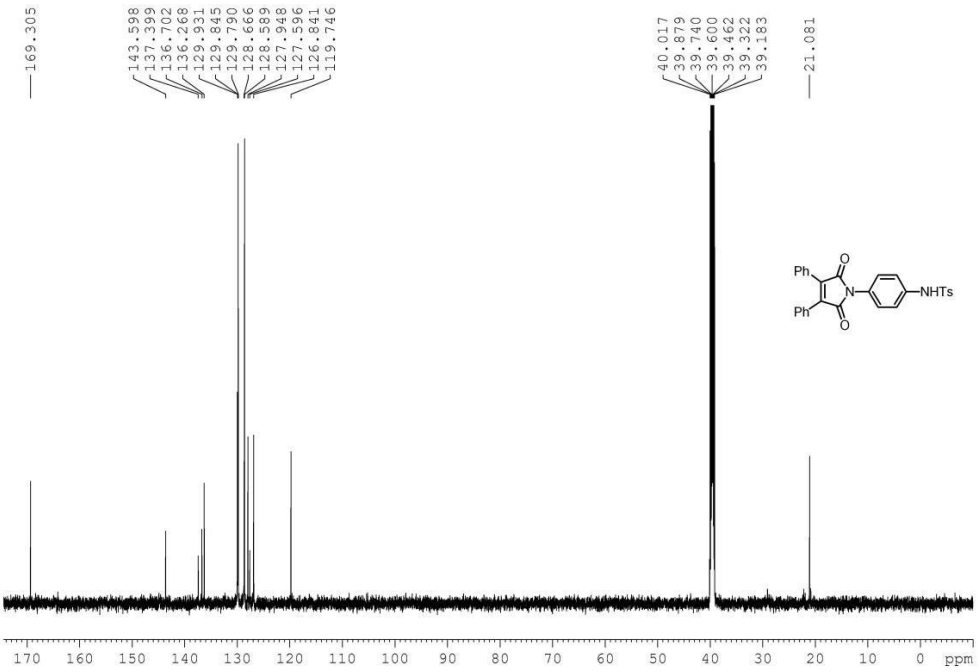


^{13}C NMR (DMSO-d_6, 100 MHz)

***N*-(4-(2,5-dioxo-3,4-diphenyl-2,5-dihydro-1*H*-pyrrol-1-yl)phenyl)-4-methylbenze nesulfonamide (9b)**

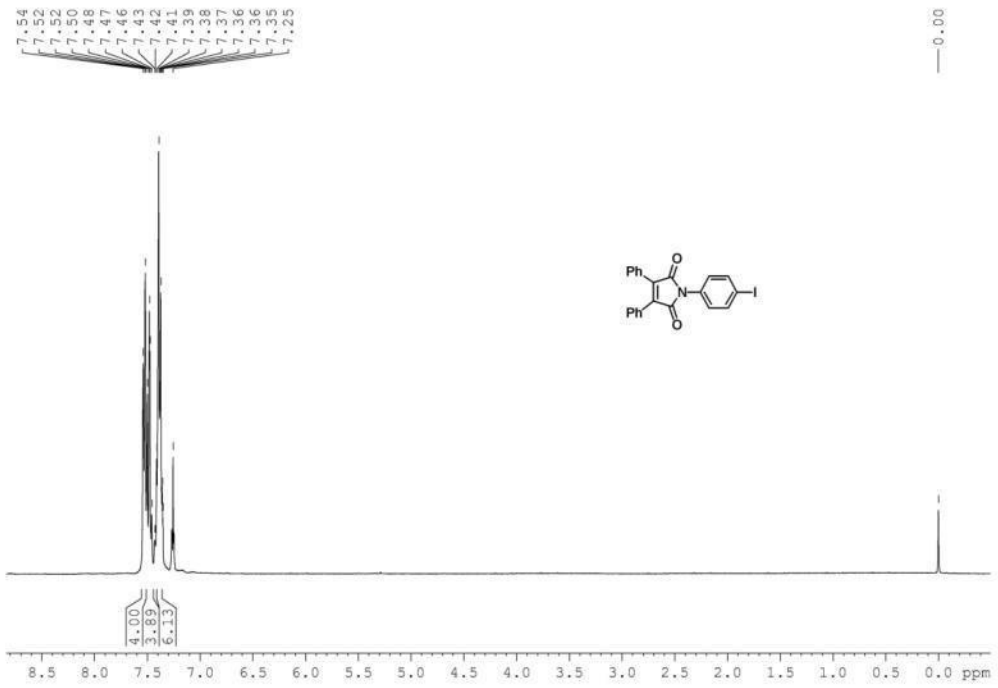


^{1}H NMR ($CDCl_3$, 400 MHz)

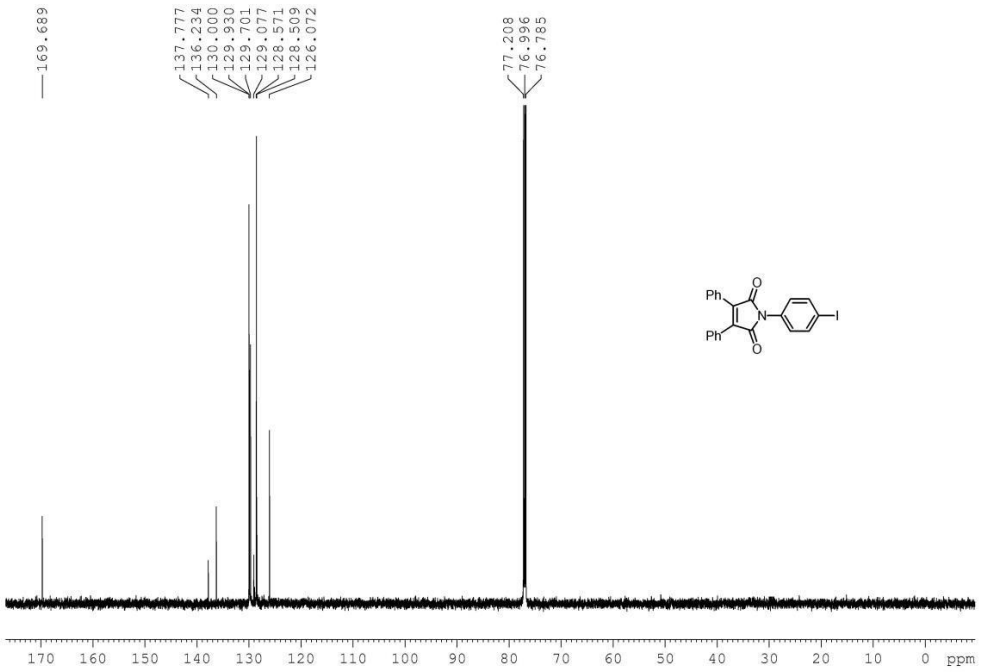


^{13}C NMR (DMSO-d_6, 100 MHz)

1-(4-iodophenyl)-3,4-diphenyl-1*H*-pyrrole-2,5-dione (9c)

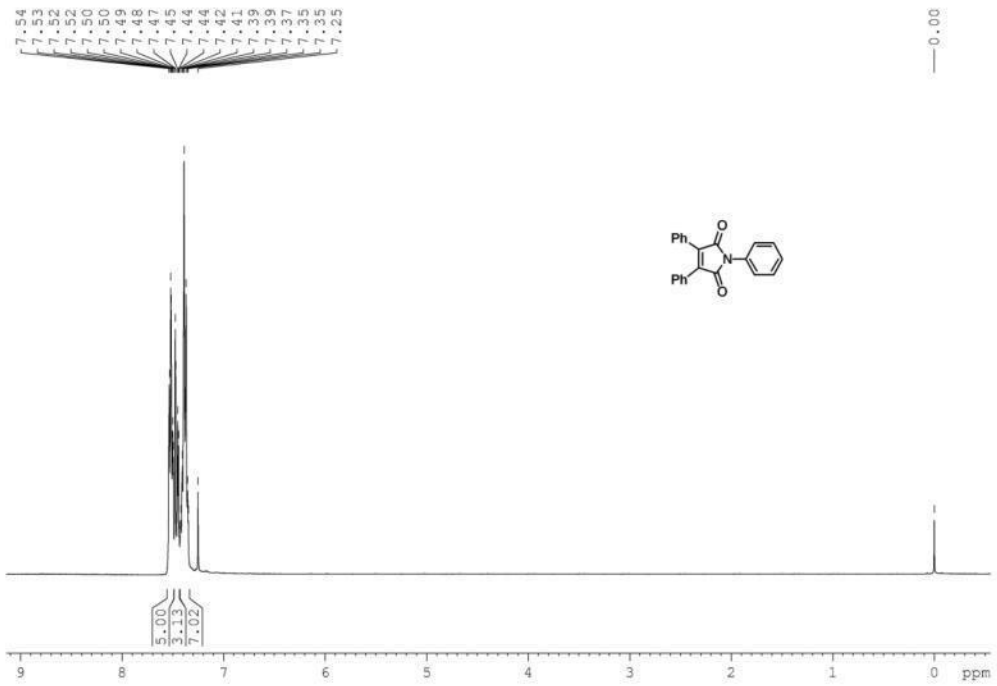


^{1}H NMR ($CDCl_3$, 400 MHz)



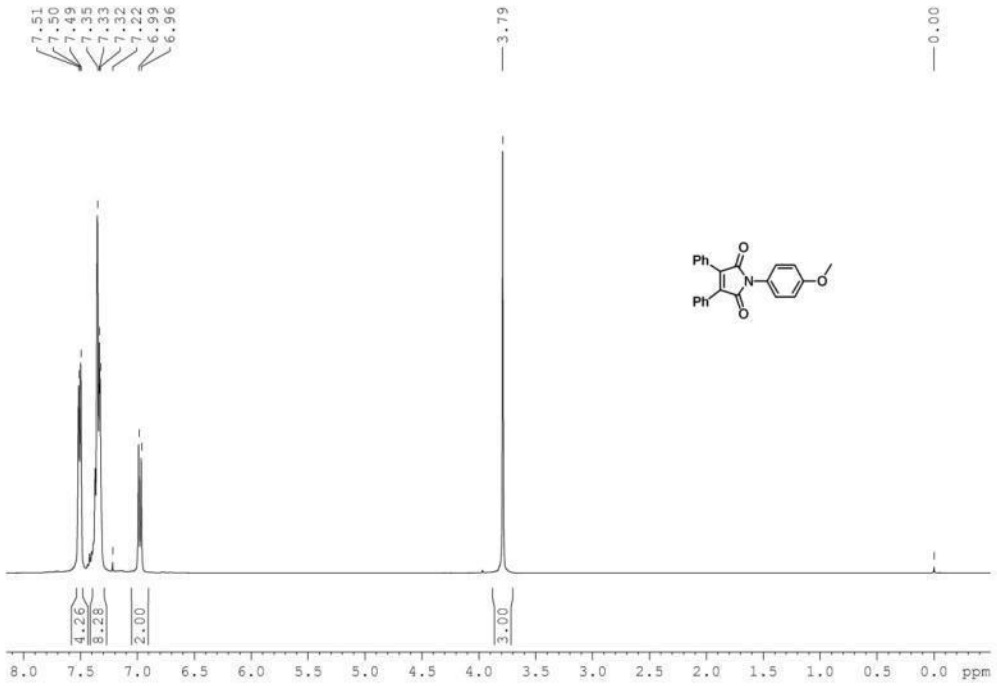
^{13}C NMR ($CDCl_3$, 100 MHz)

1,3,4-triphenyl-1*H*-pyrrole-2,5-dione (9d)



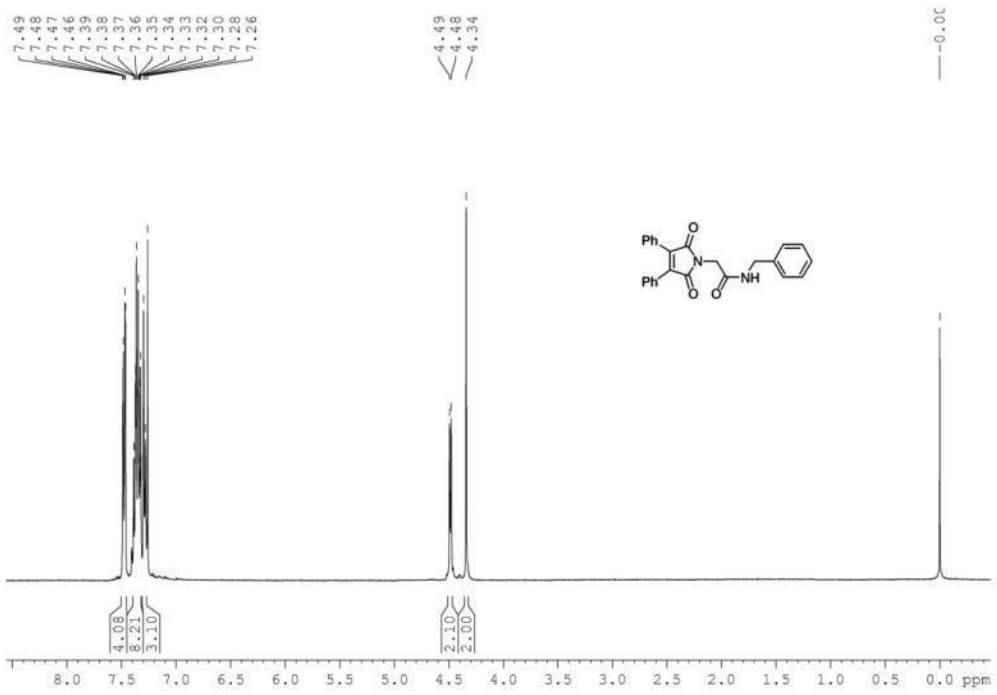
^{1}H NMR ($CDCl_3$, 400 MHz)

1-(4-methoxyphenyl)-3,4-diphenyl-1*H*-pyrrole-2,5-dione (9e)



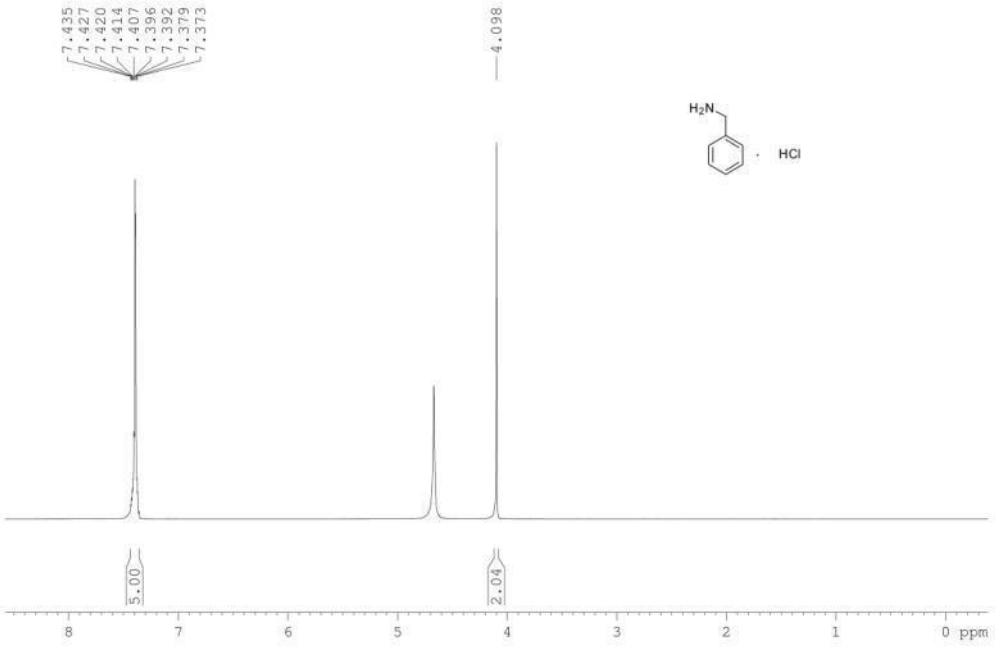
^{1}H NMR ($CDCl_3$, 400 MHz)

***N*-benzyl-2-(2,5-dioxo-3,4-diphenyl-2,5-dihydro-1*H*-pyrrol-1-yl)acetamide (9f)**

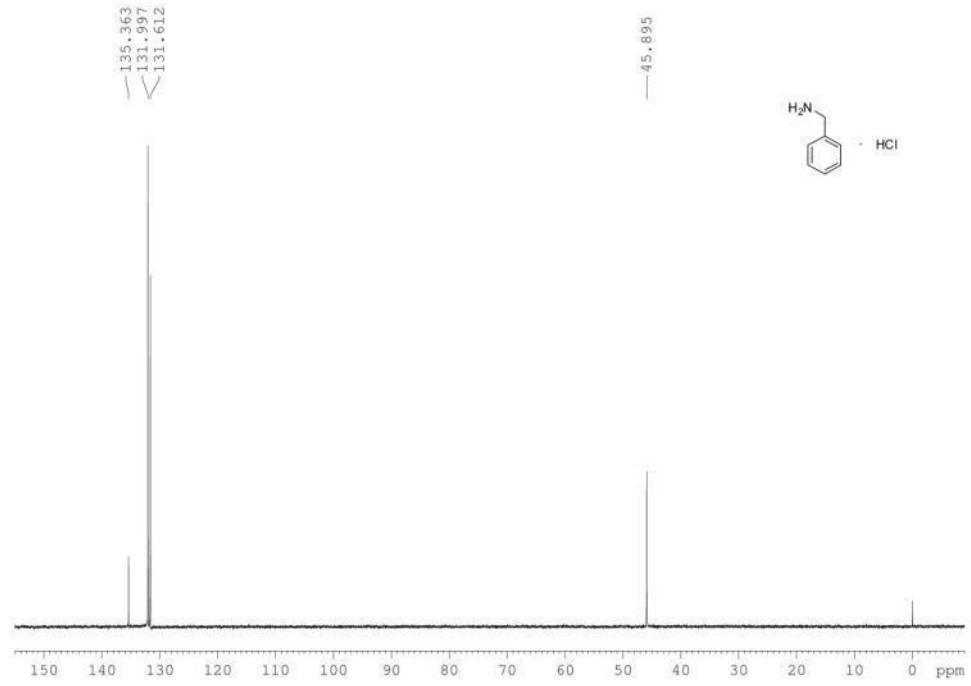


^{1}H NMR ($CDCl_3$, 400 MHz)

Phenylmethanamine hydrochloride (4a)

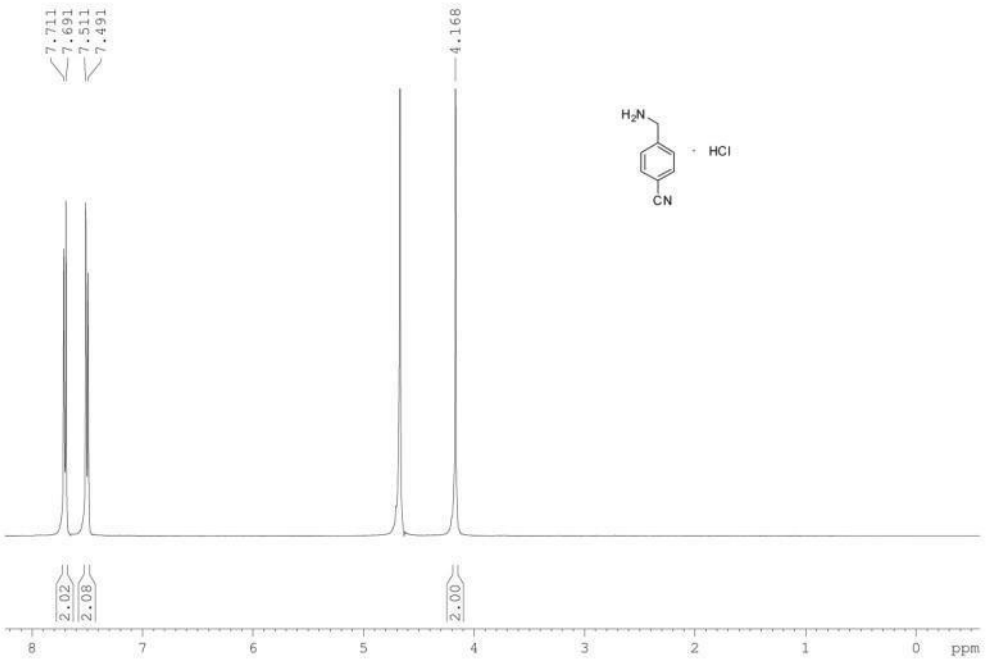


^{1}H NMR (D_2O, 400 MHz)

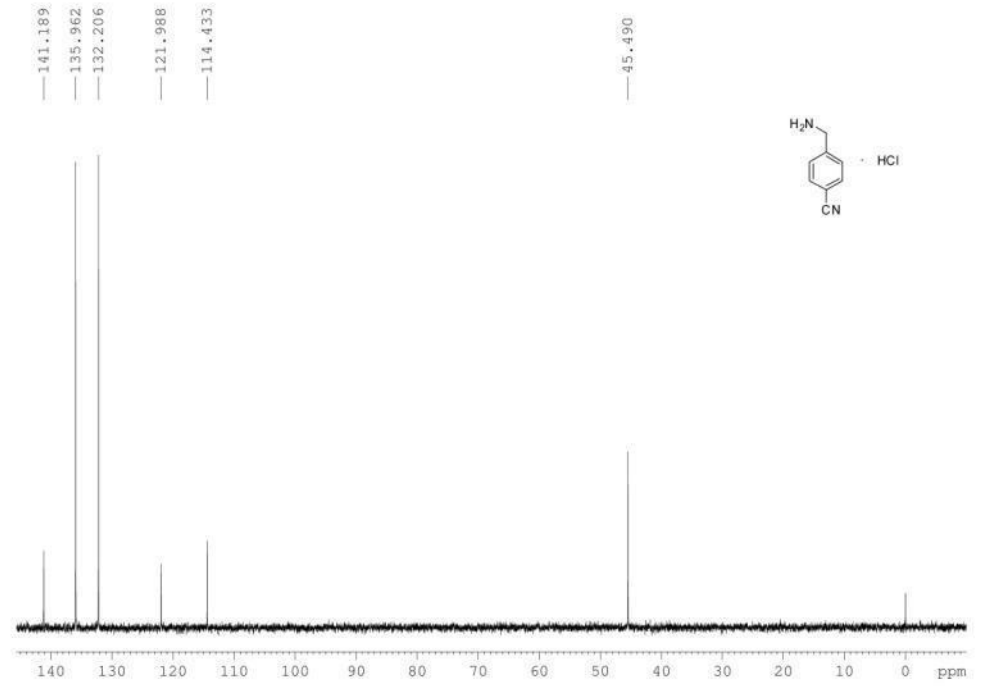


^{13}C NMR (D_2O, 100 MHz)

(4-cyanophenyl)methanamine hydrochloride (4b)

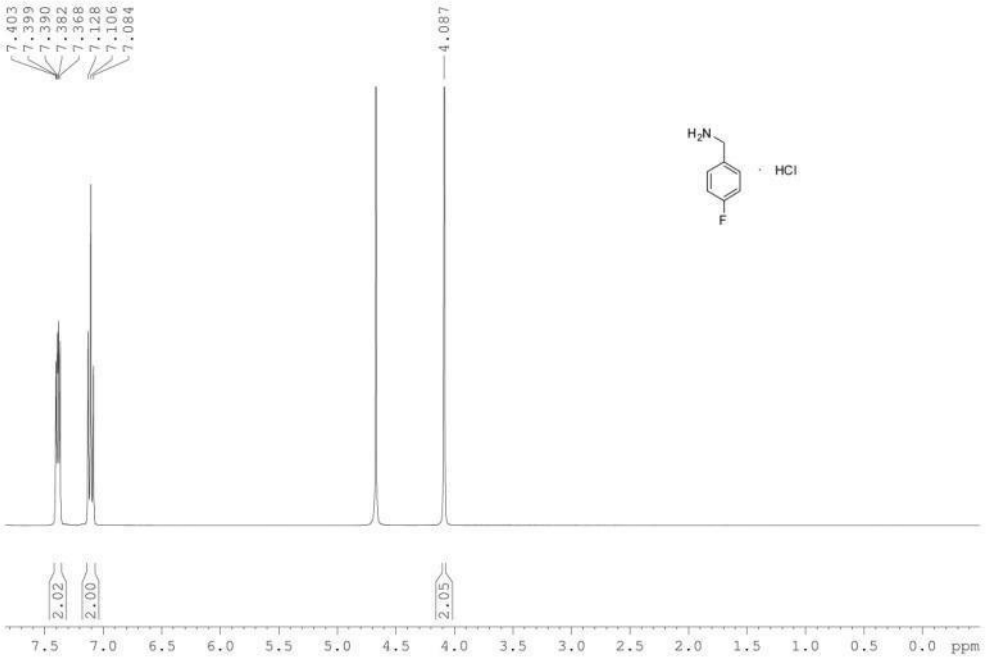


^{1}H NMR (D_2O, 400 MHz)

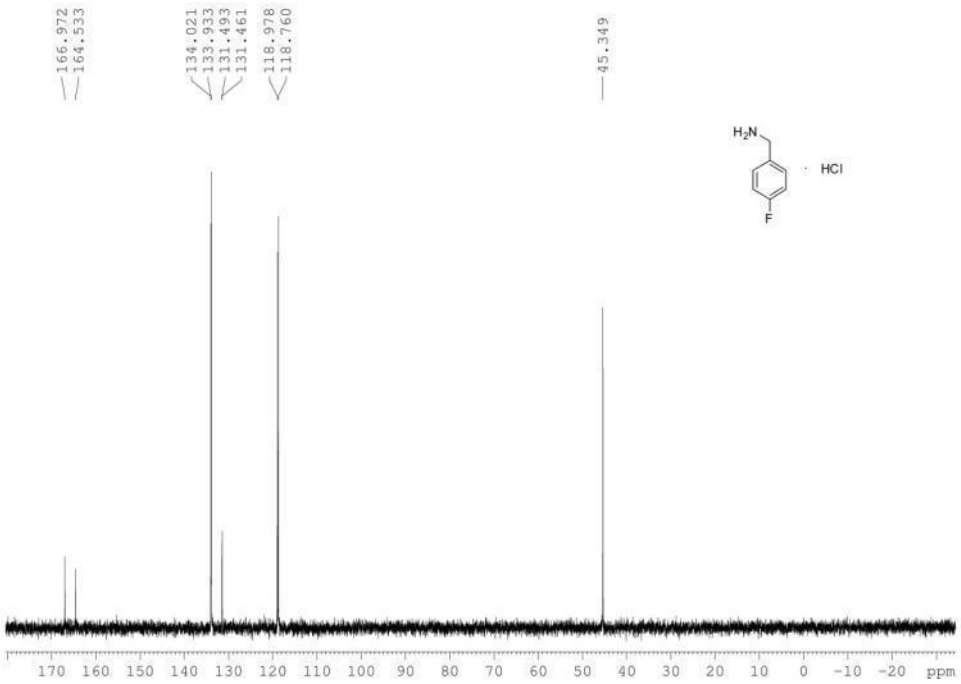


^{13}C NMR (D_2O, 100 MHz)

(4-fluorophenyl)methanamine hydrochloride (4c)

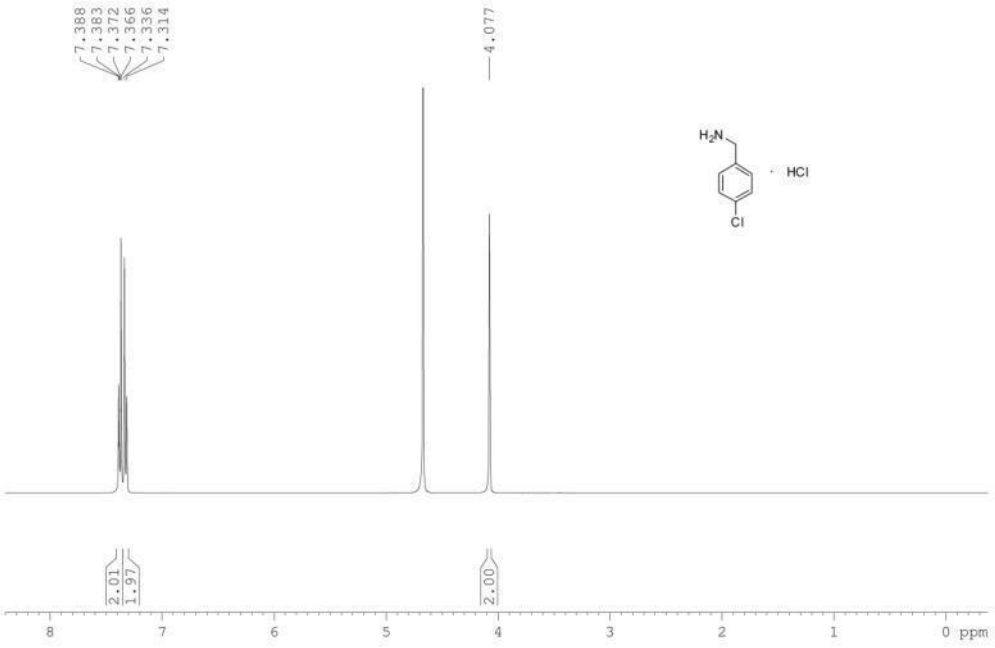


^{1}H NMR (D_2O, 400 MHz)

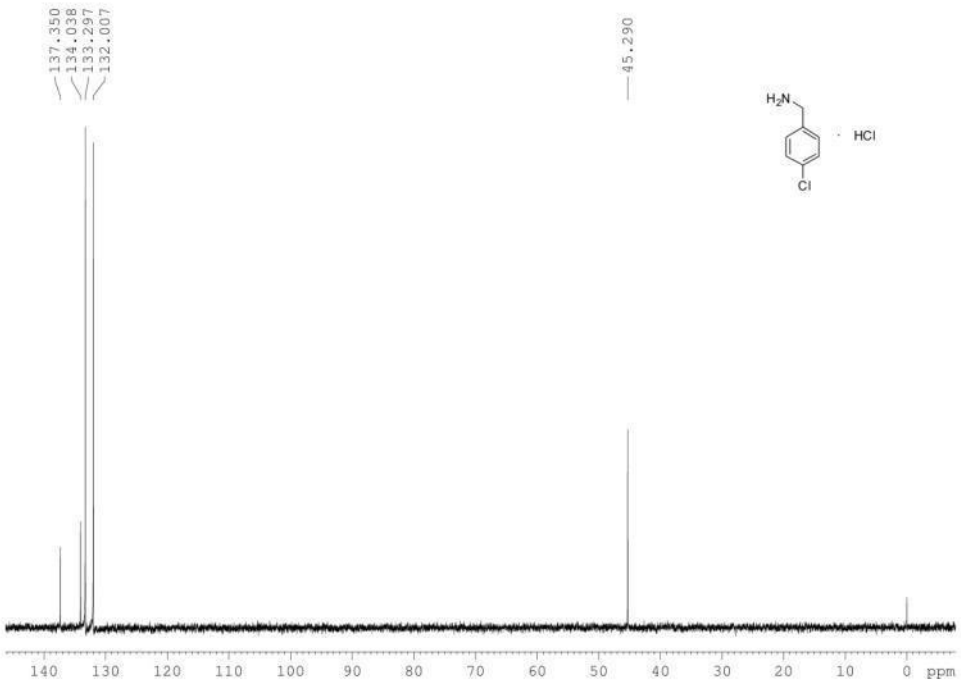


^{13}C NMR (D_2O, 100 MHz)

(4-chlorophenyl)methanamine hydrochloride (4d)

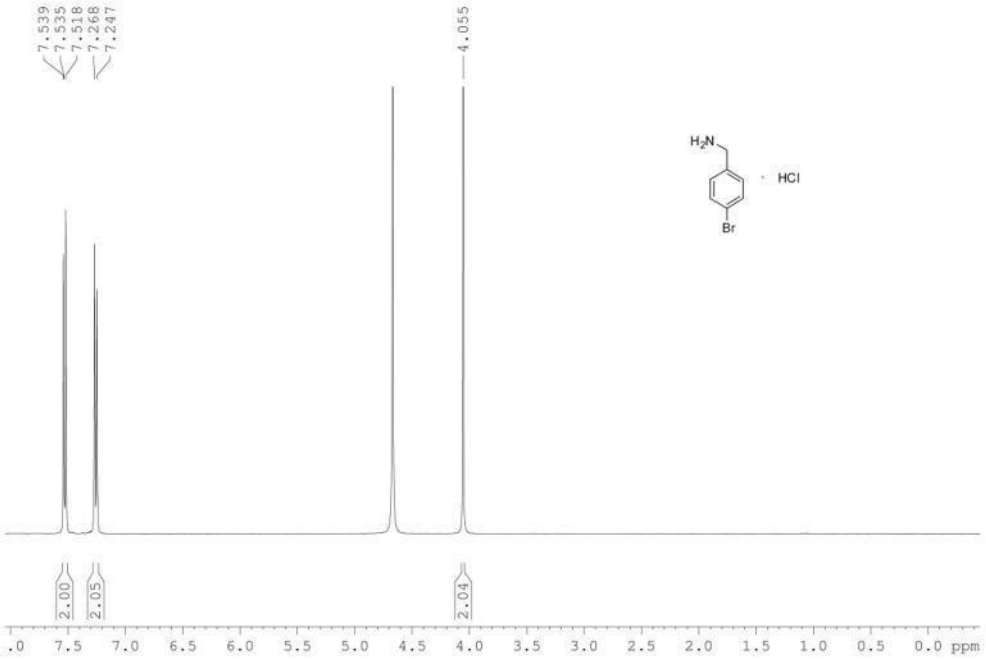


^{1}H NMR (D_2O, 400 MHz)

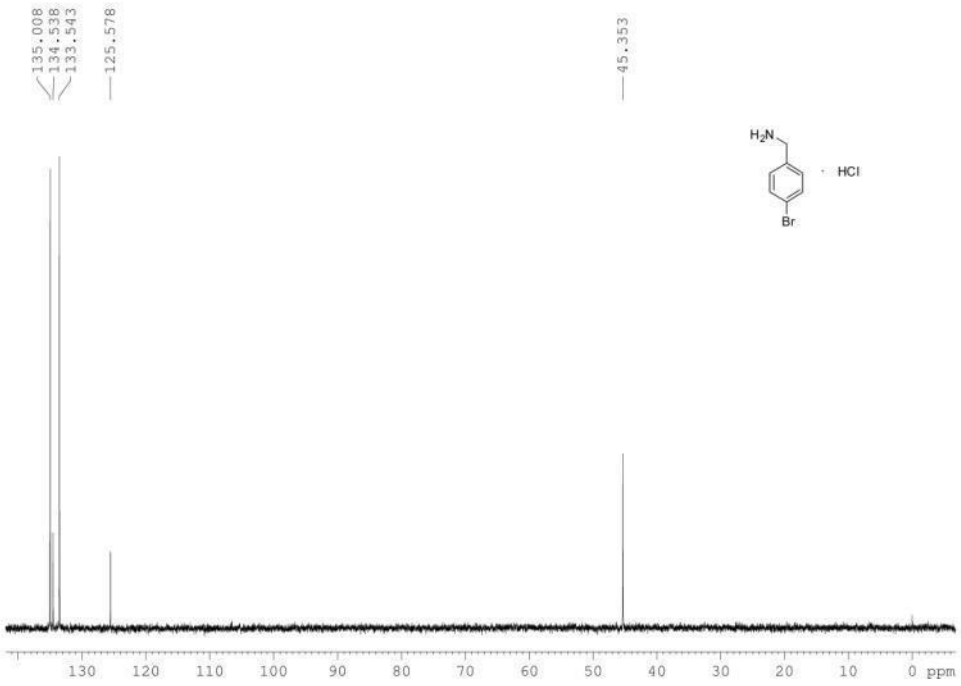


^{13}C NMR (D_2O, 100 MHz)

(4-bromophenyl)methanamine hydrochloride (4e)

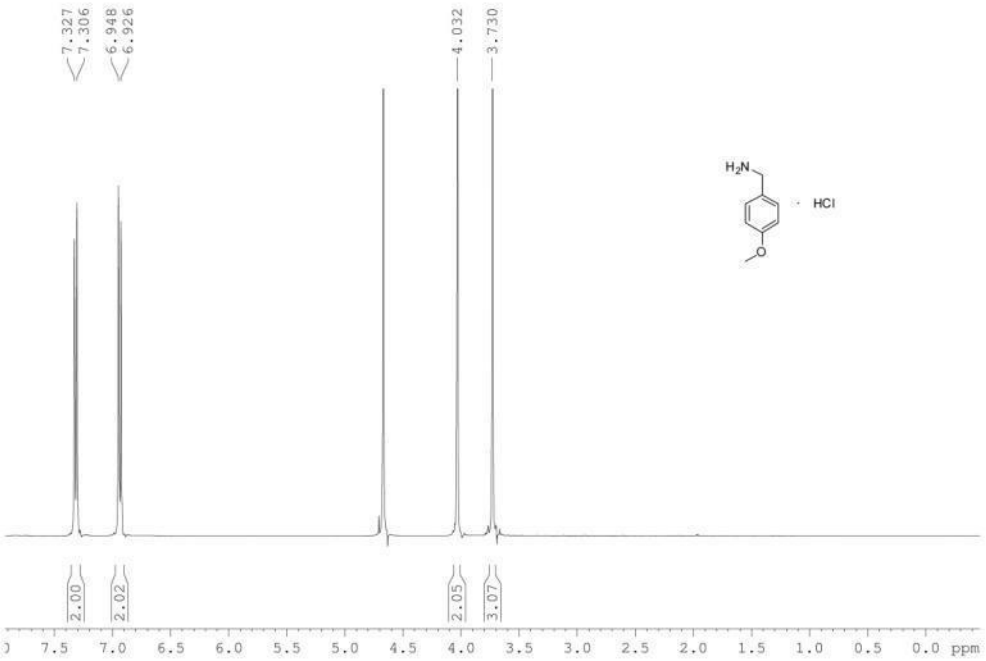


^{1}H NMR (D_2O, 400 MHz)

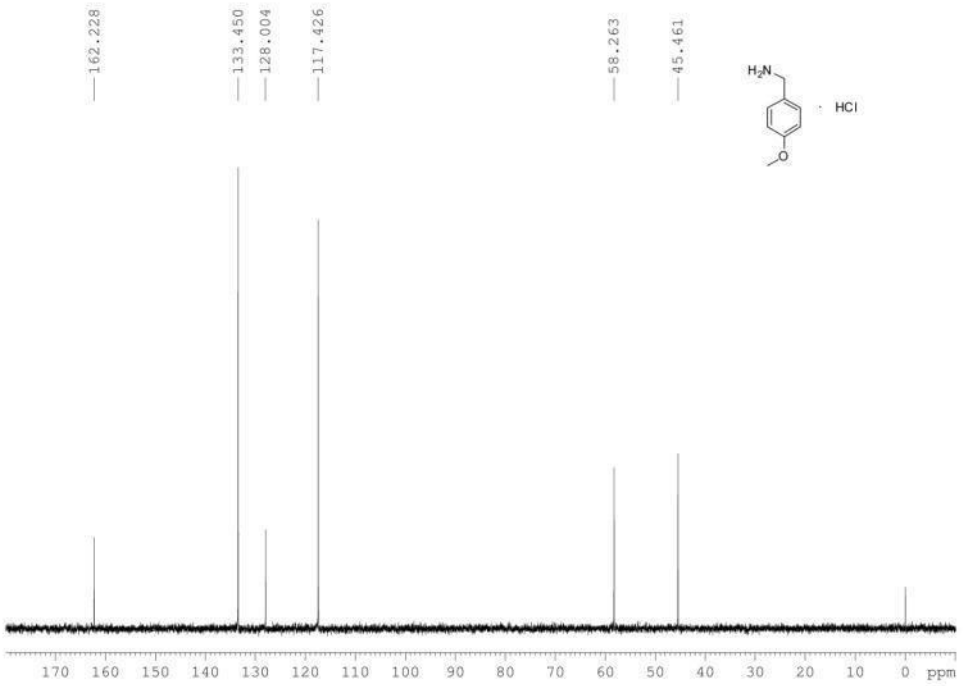


^{13}C NMR (D_2O, 100 MHz)

(4-methoxyphenyl)methanamine hydrochloride (4f)

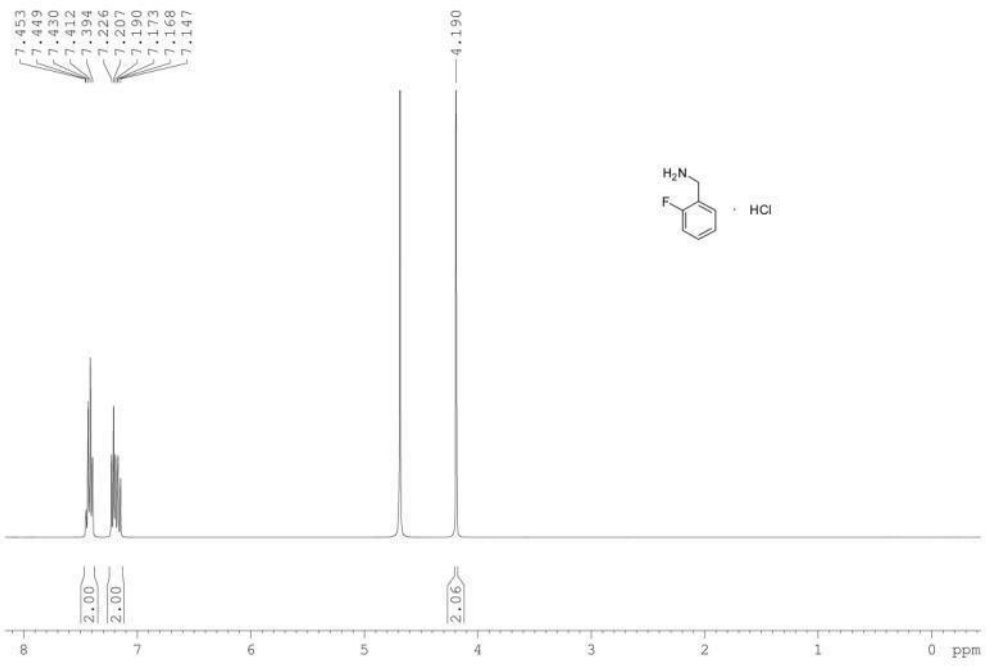


^{1}H NMR (D_2O, 400 MHz)

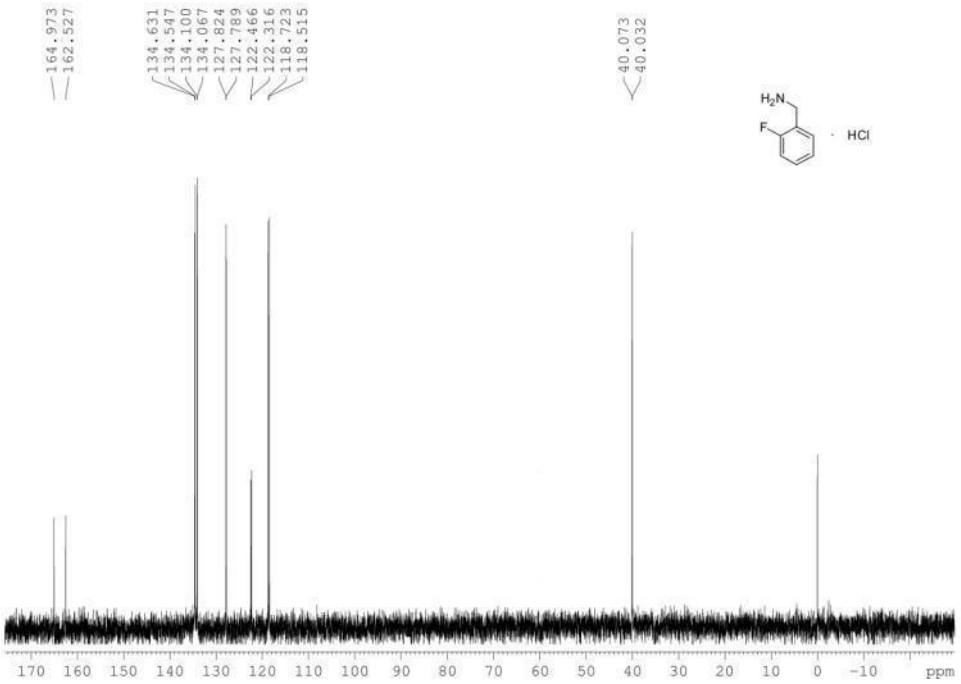


^{13}C NMR (D_2O, 100 MHz)

(2-fluorophenyl)methanamine hydrochloride (4g)

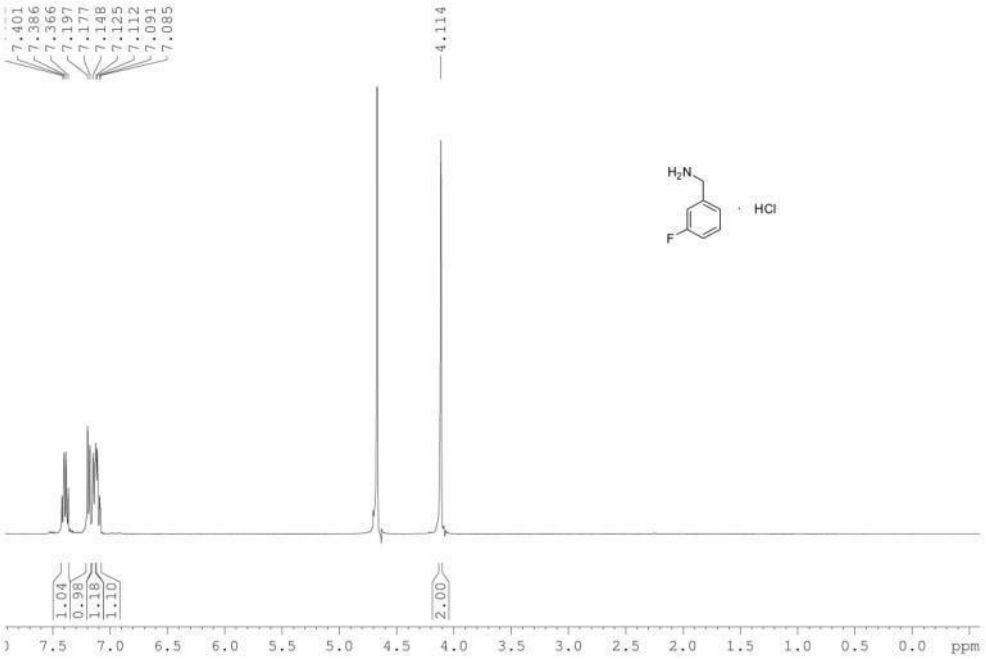


^{1}H NMR (D_2O, 400 MHz)

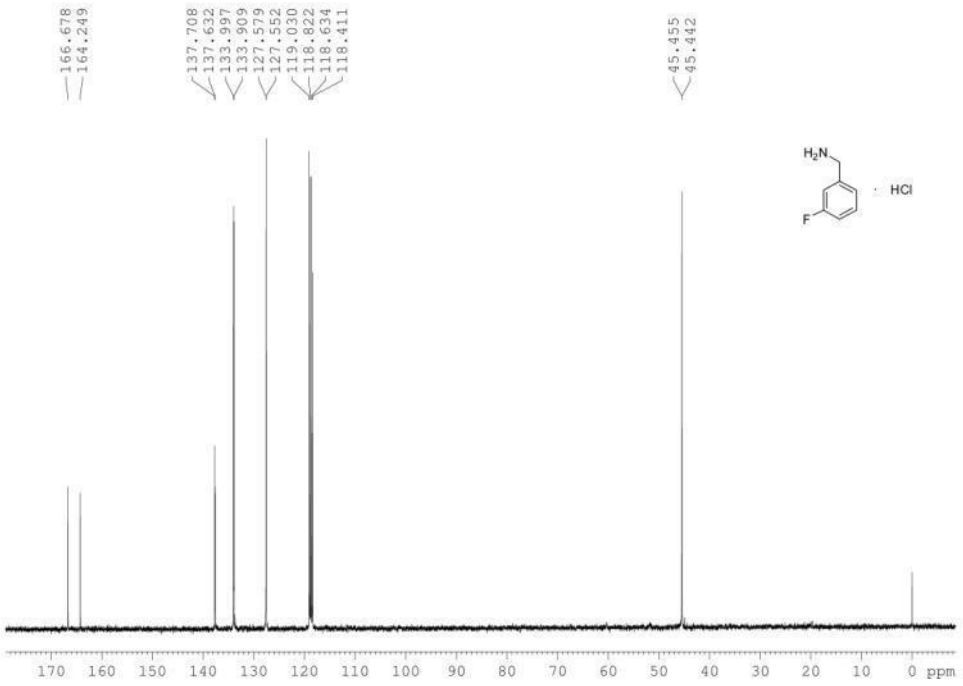


^{13}C NMR (D_2O, 100 MHz)

(3-fluorophenyl)methanamine hydrochloride (4h)

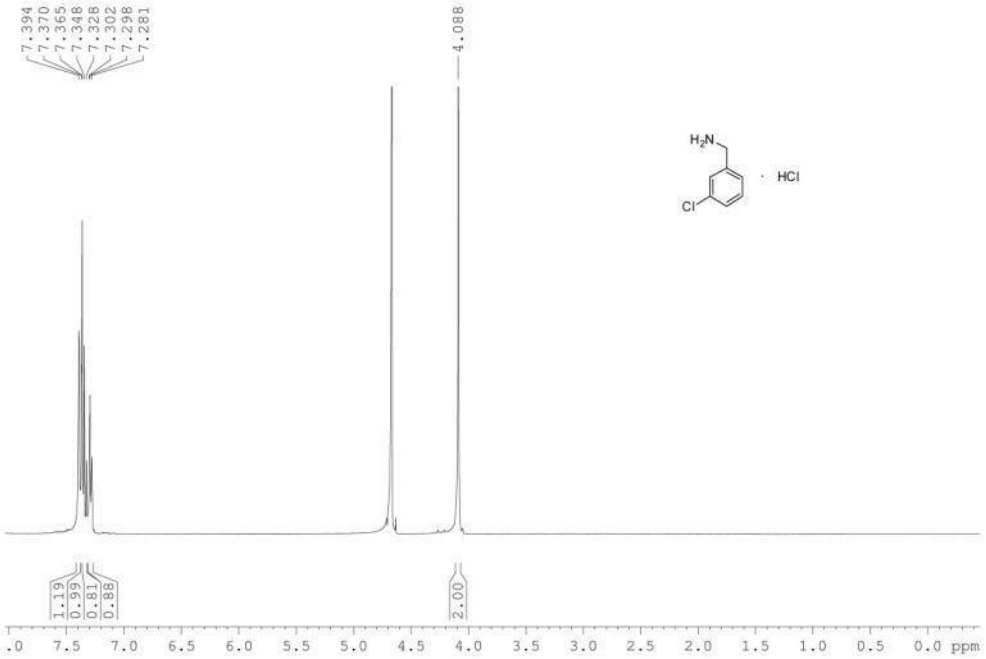


^{1}H NMR (D_2O, 400 MHz)

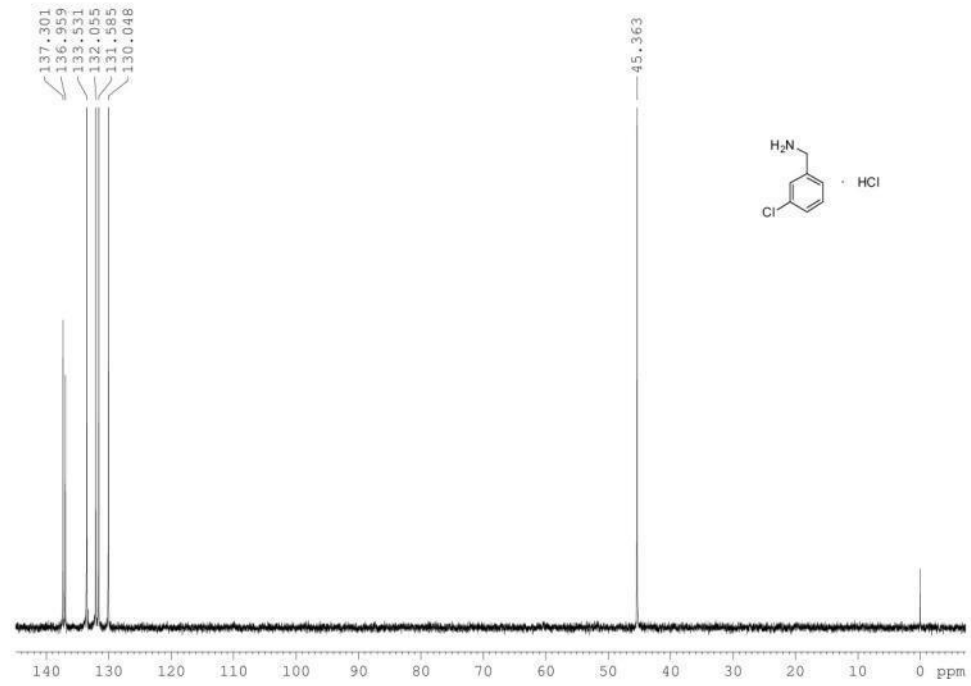


^{13}C NMR (D_2O, 100 MHz)

(3-chlorophenyl)methanamine hydrochloride (4i)

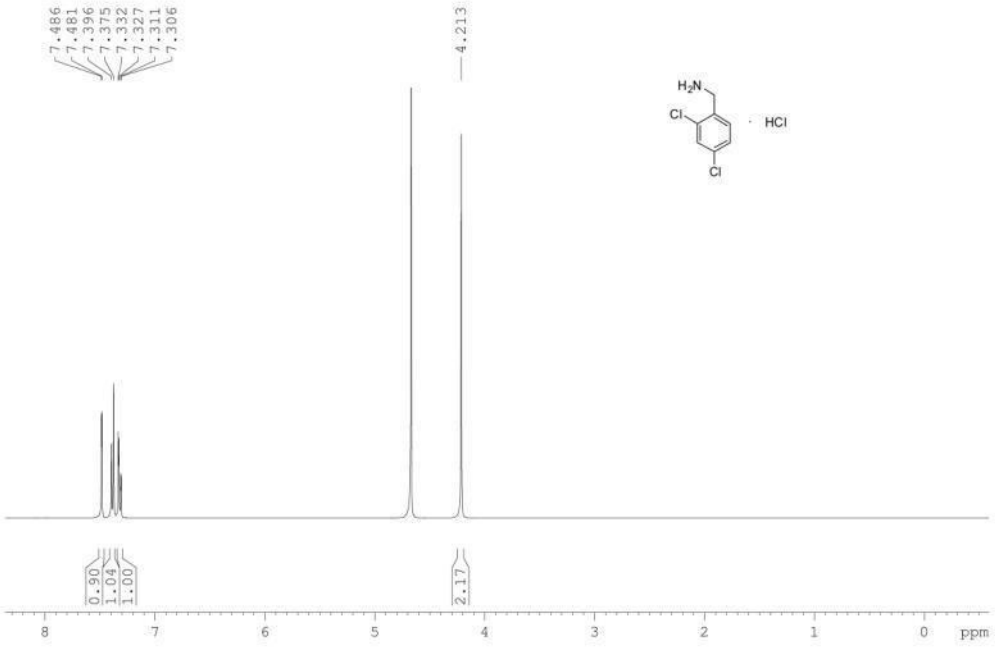


^{1}H NMR (D_2O, 400 MHz)

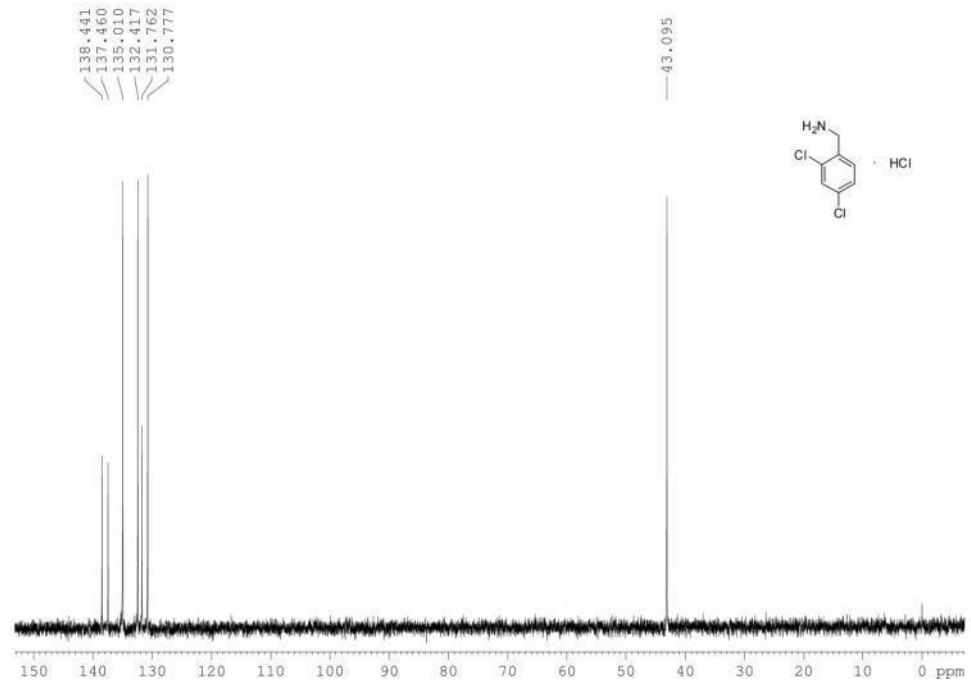


^{13}C NMR (D_2O, 100 MHz)

(2,4-dichlorophenyl)methanamine hydrochloride (4j)

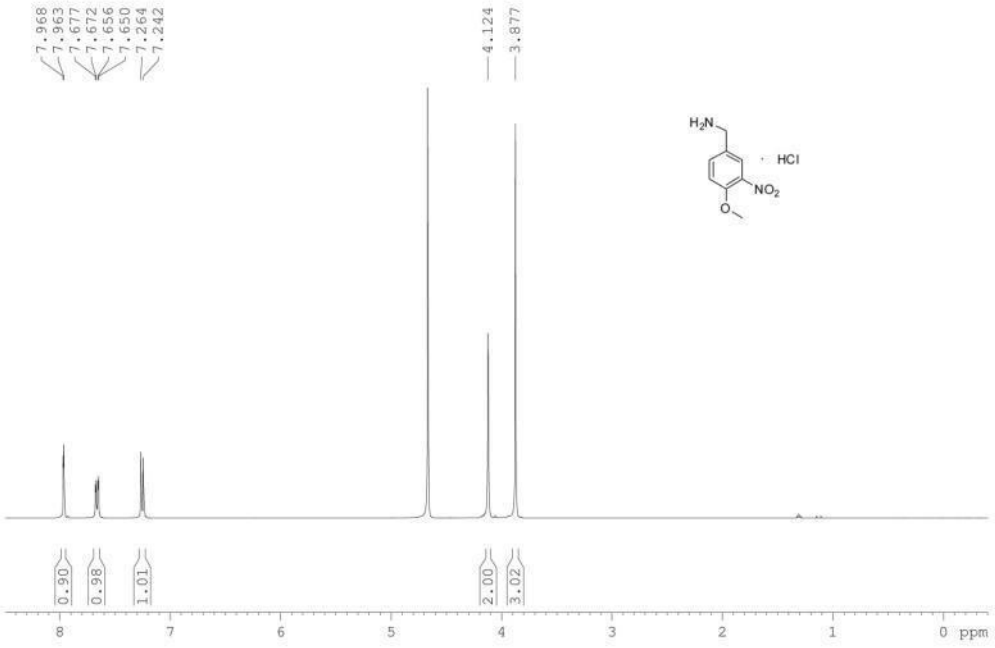


^{1}H NMR (D_2O, 400 MHz)

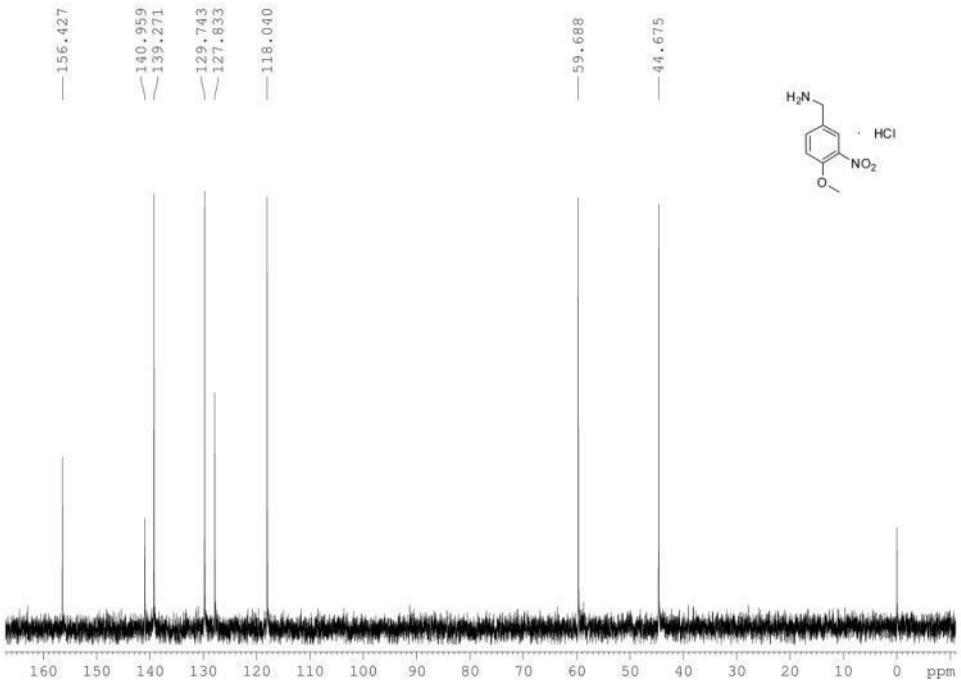


^{13}C NMR (D_2O, 100 MHz)

(4-methoxy-3-nitrophenyl)methanamine hydrochloride (4k)

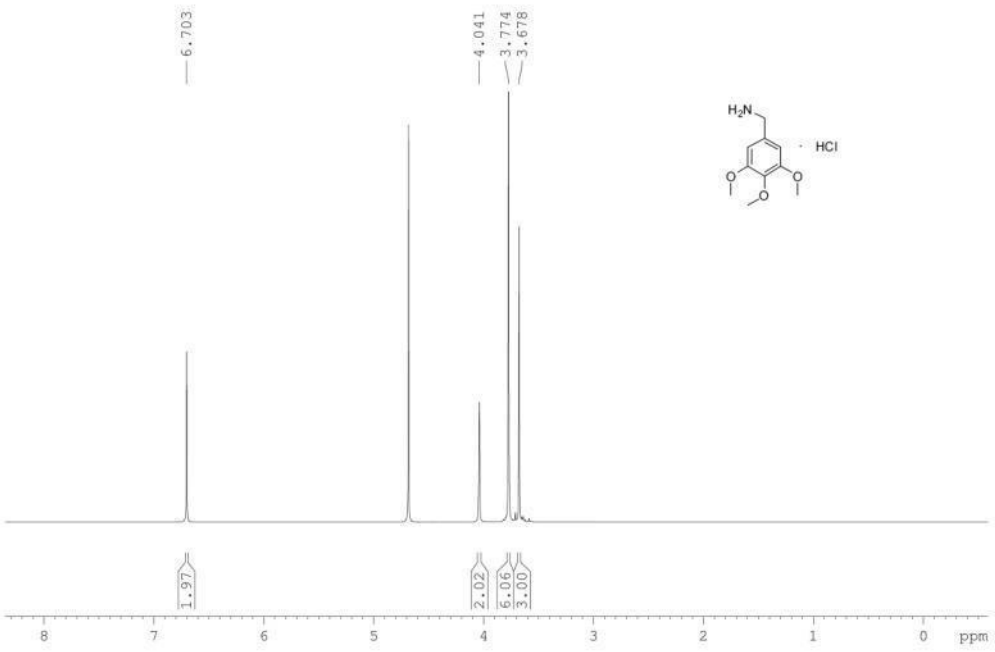


^{1}H NMR (D_2O, 400 MHz)

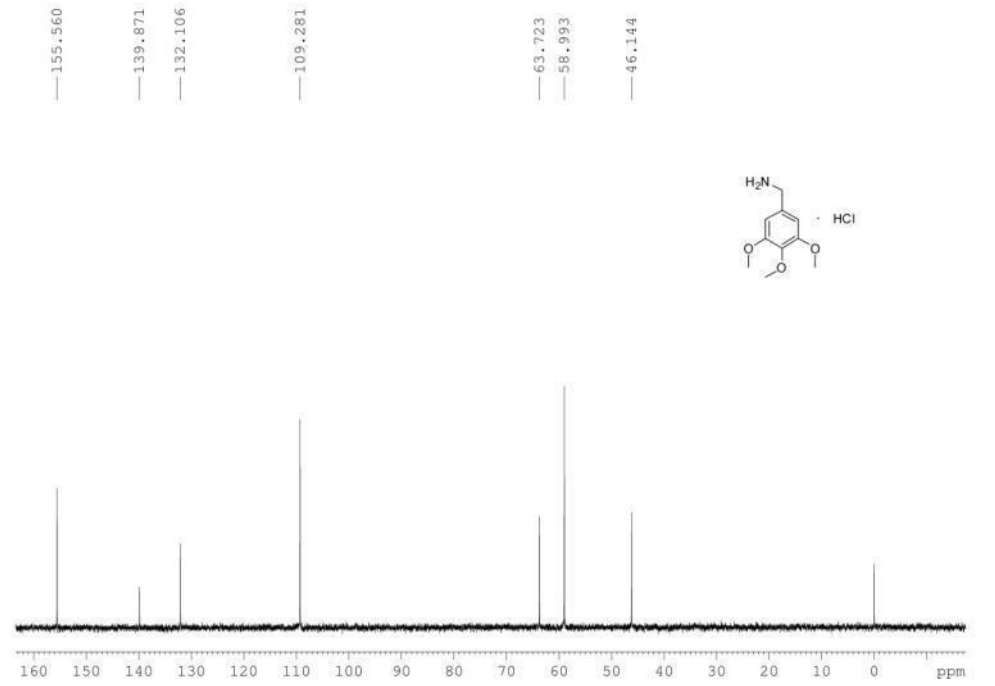


^{13}C NMR (D_2O, 100 MHz)

(3,4,5-trimethoxyphenyl)methanamine hydrochloride (4l)

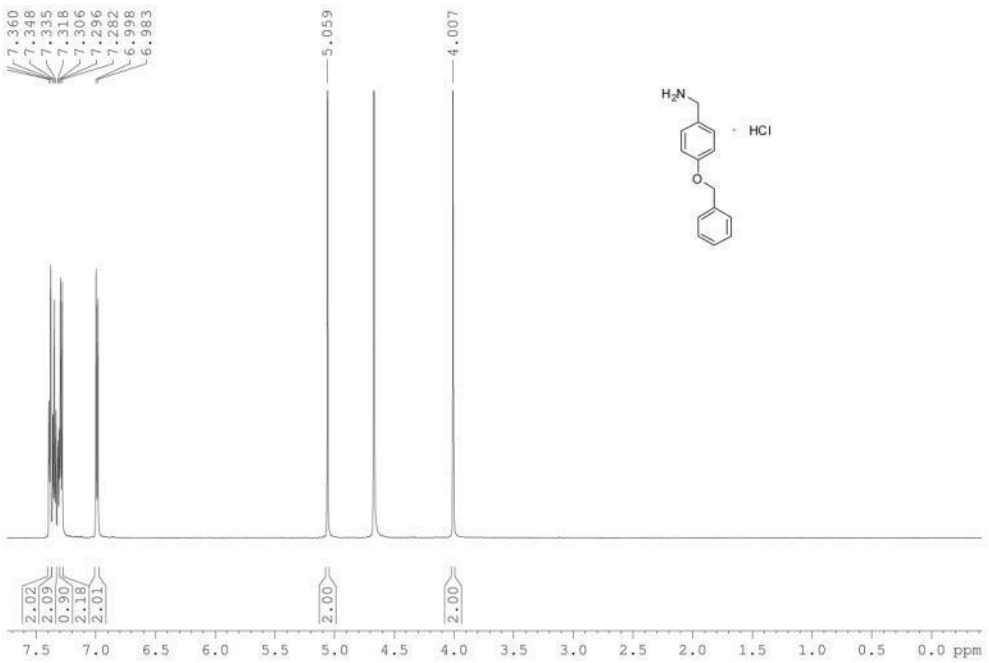


^{1}H NMR (D_2O, 400 MHz)

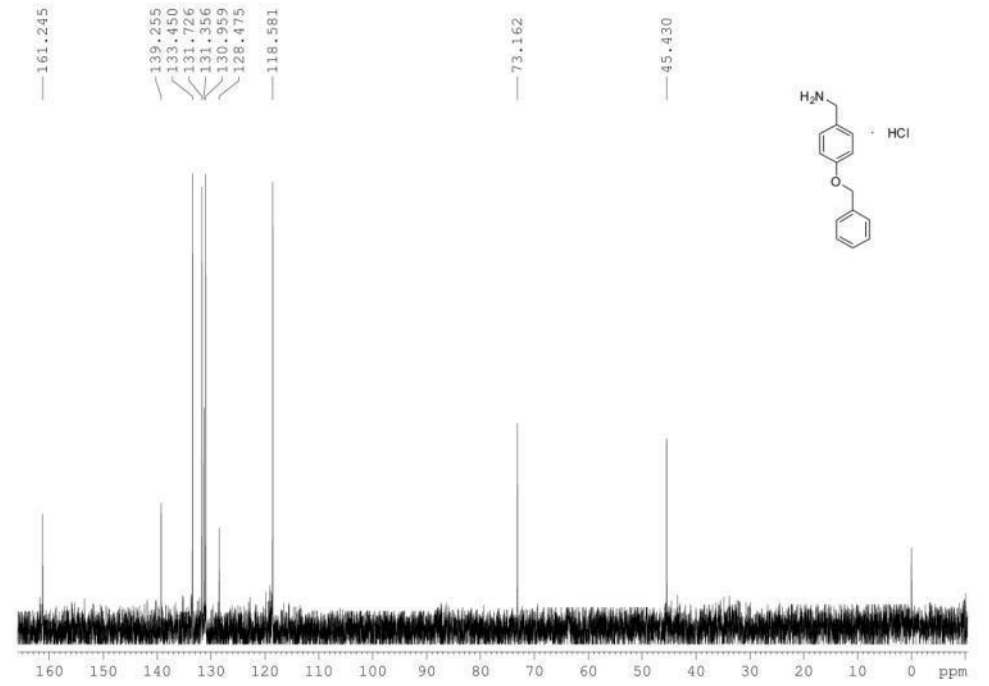


^{13}C NMR (D_2O, 100 MHz)

(4-benzyloxyphenyl)methanamine hydrochloride (4m)

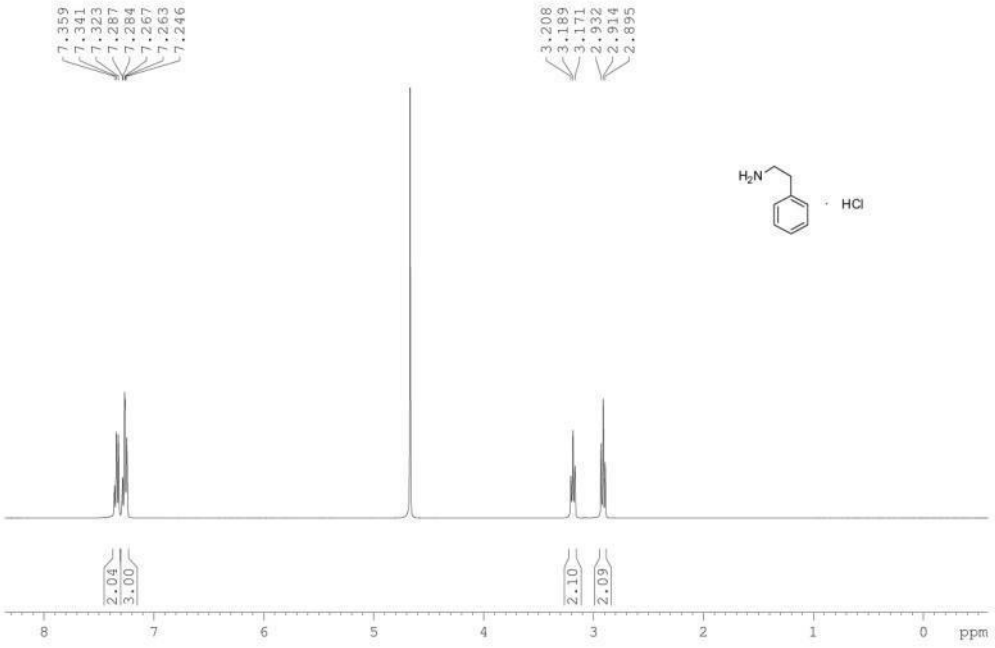


^{1}H NMR (D_2O, 400 MHz)

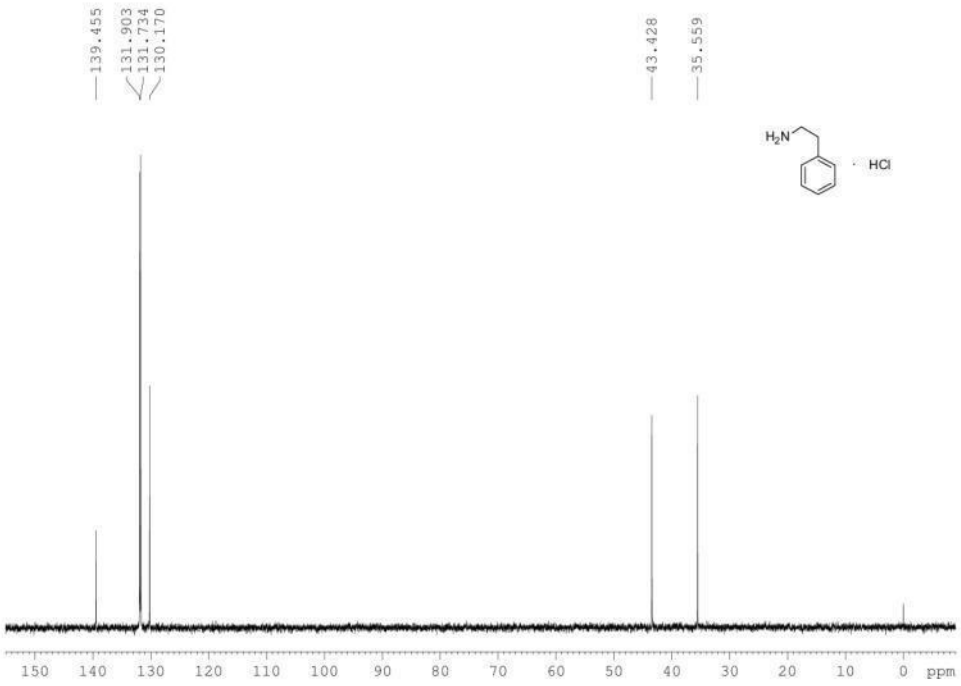


^{13}C NMR (D_2O, 100 MHz)

2-phenylethan-1-amine hydrochloride (4n)

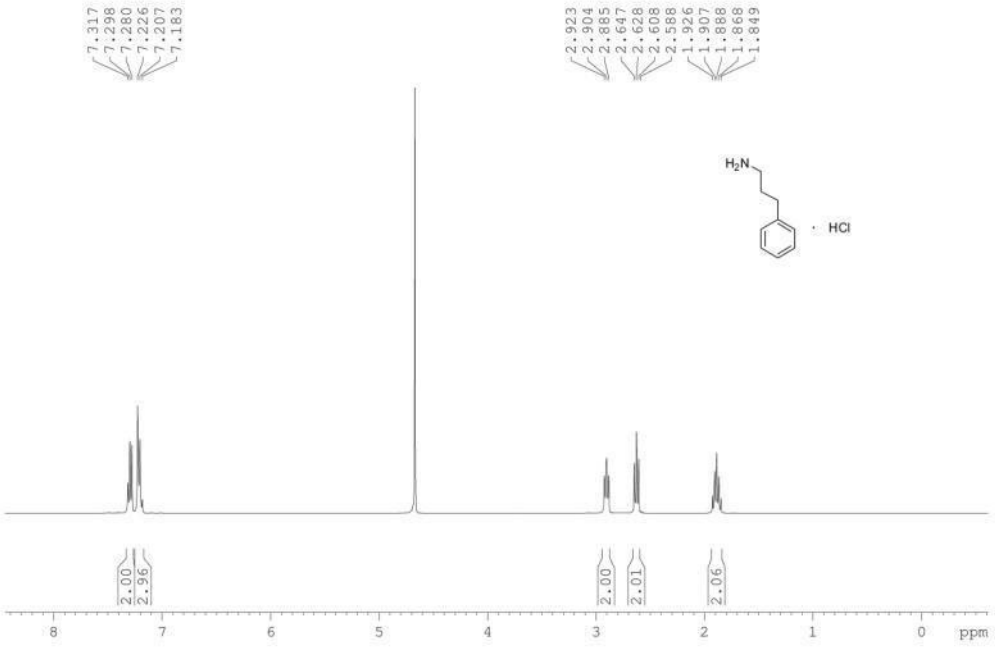


^{1}H NMR (D_2O, 400 MHz)

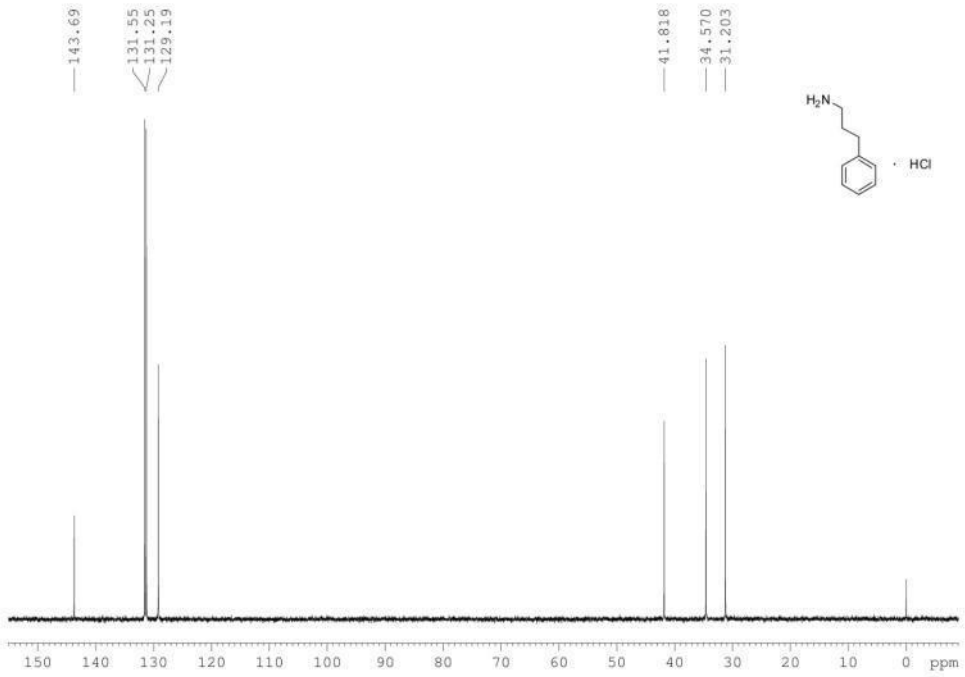


^{13}C NMR (D_2O, 100 MHz)

3-phenylpropan-1-amine hydrochloride (4o)

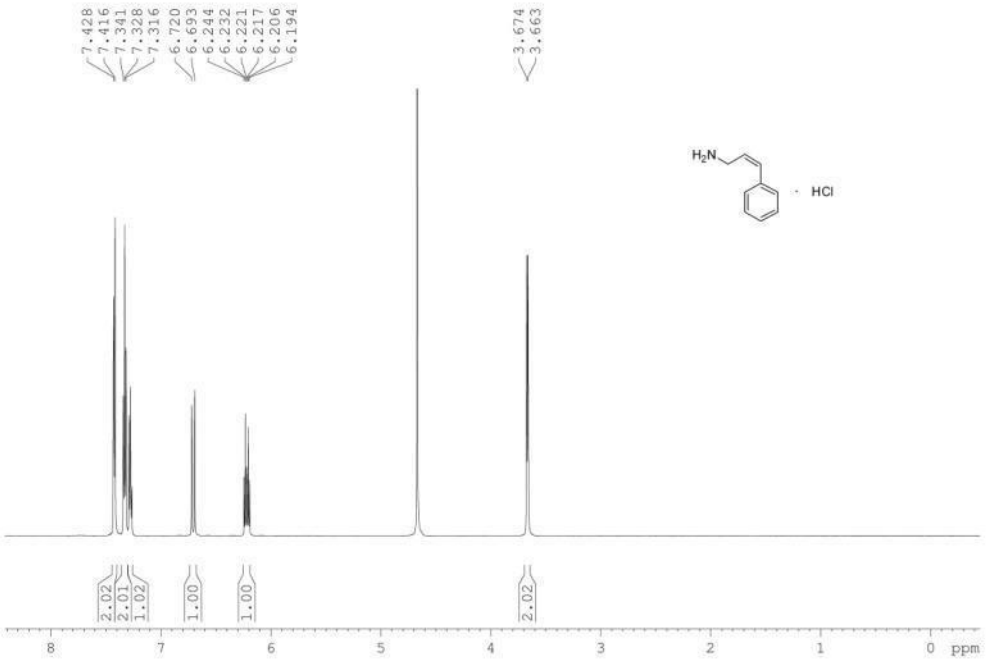


^{1}H NMR (D_2O, 400 MHz)

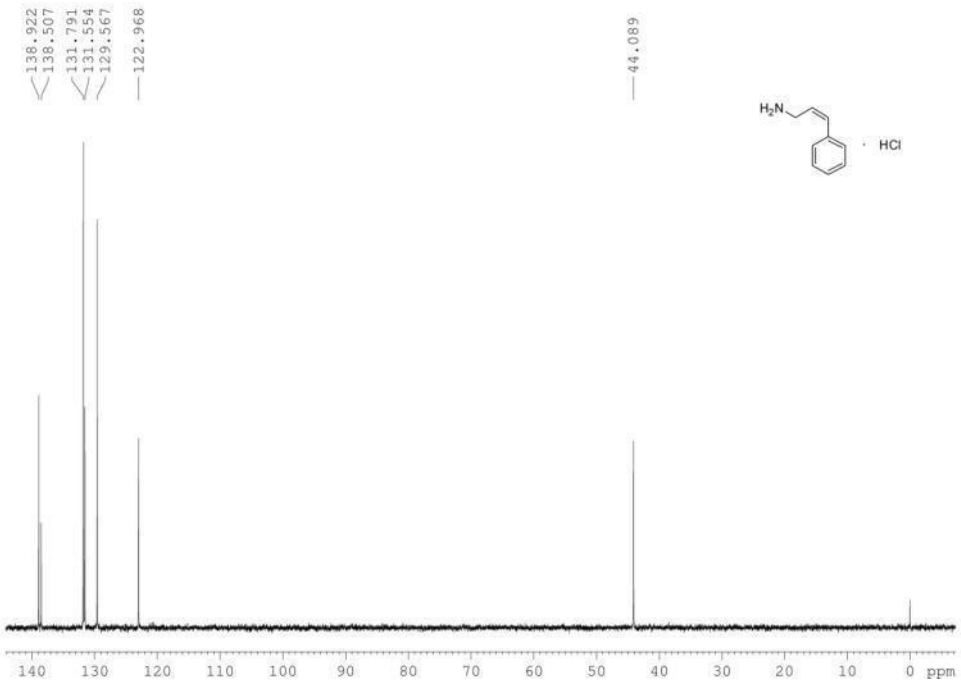


^{13}C NMR (D_2O, 100 MHz)

(*Z*)-3-phenylprop-2-en-1-amine hydrochloride (4p)

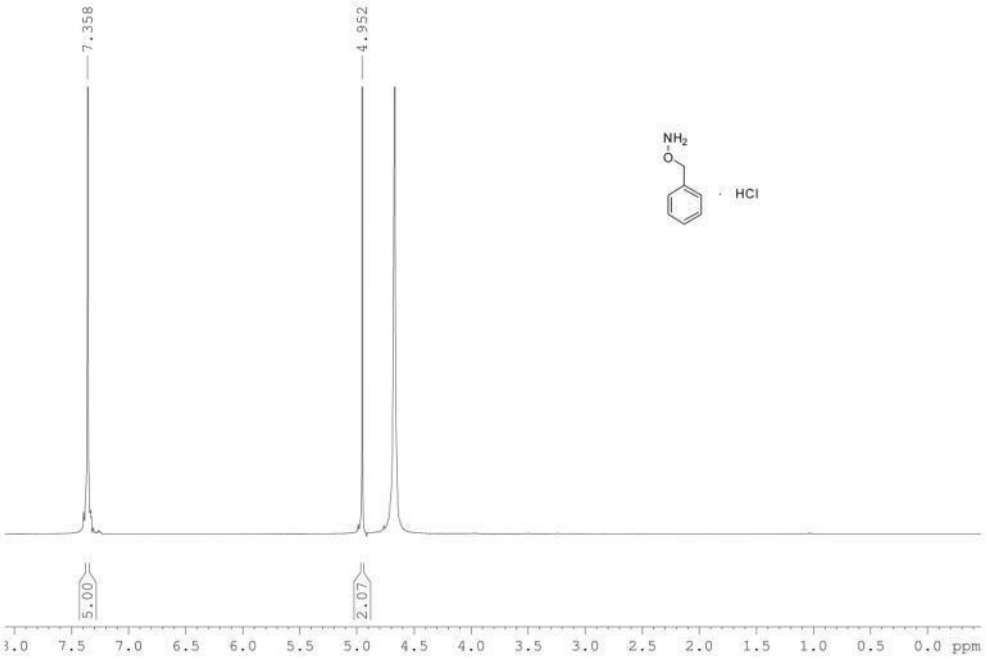


^{1}H NMR (D_2O, 400 MHz)

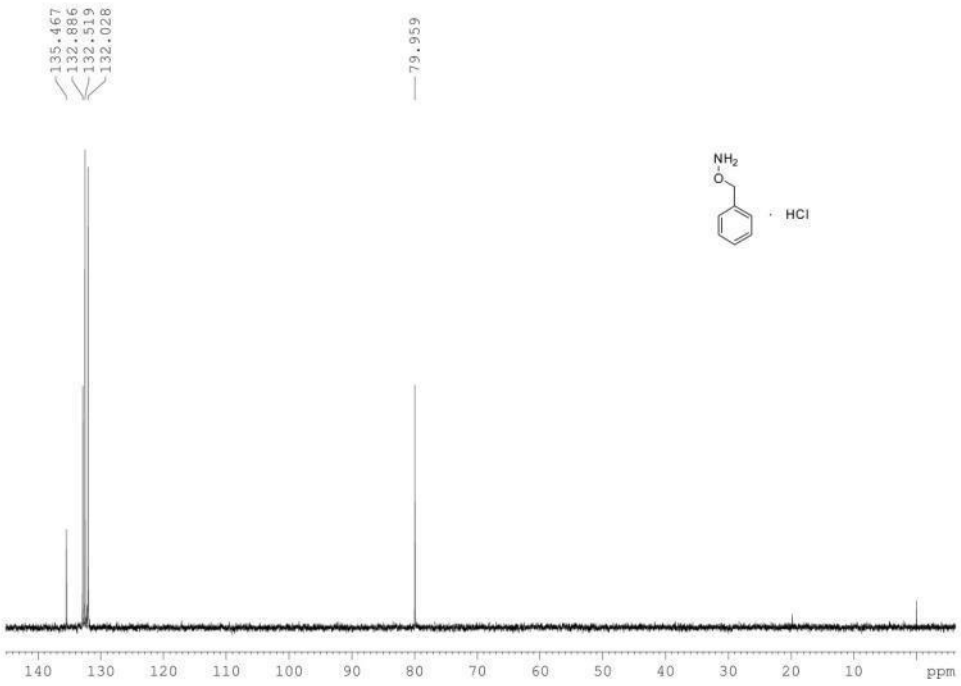


^{13}C NMR (D_2O, 100 MHz)

O-benzylhydroxylamine hydrochloride (7a)

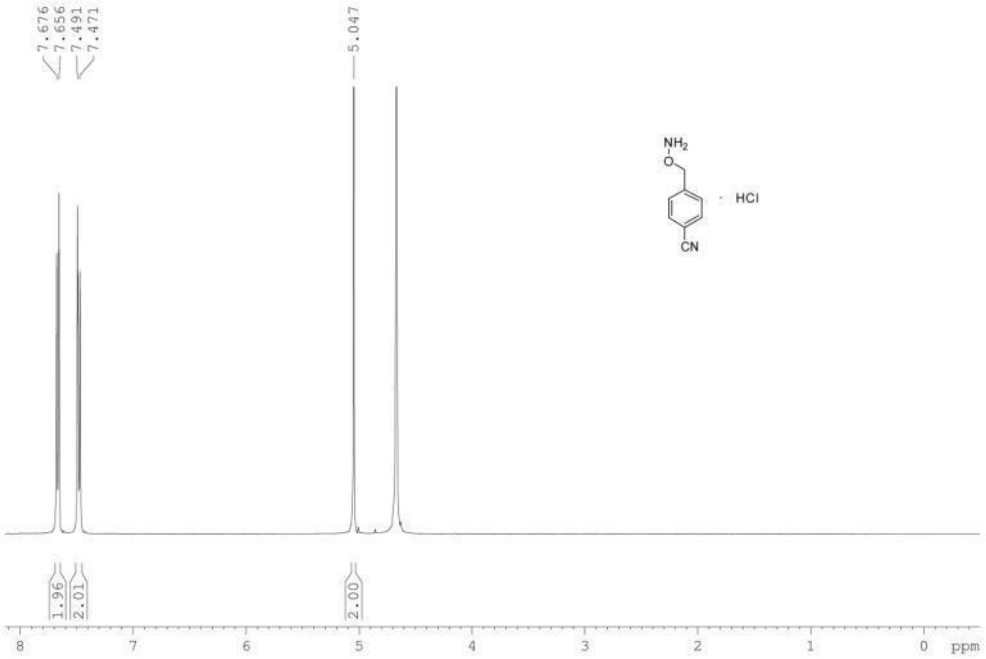


^{1}H NMR (D_2O, 400 MHz)

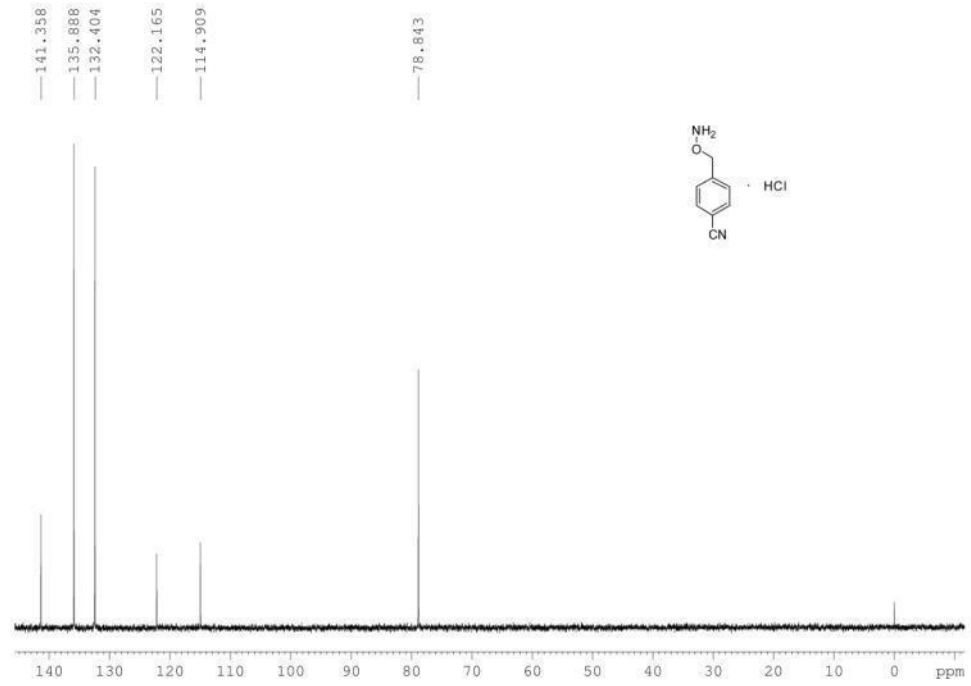


^{13}C NMR (D_2O, 100 MHz)

O-(4-cyanobenzyl)hydroxylamine hydrochloride (7b)

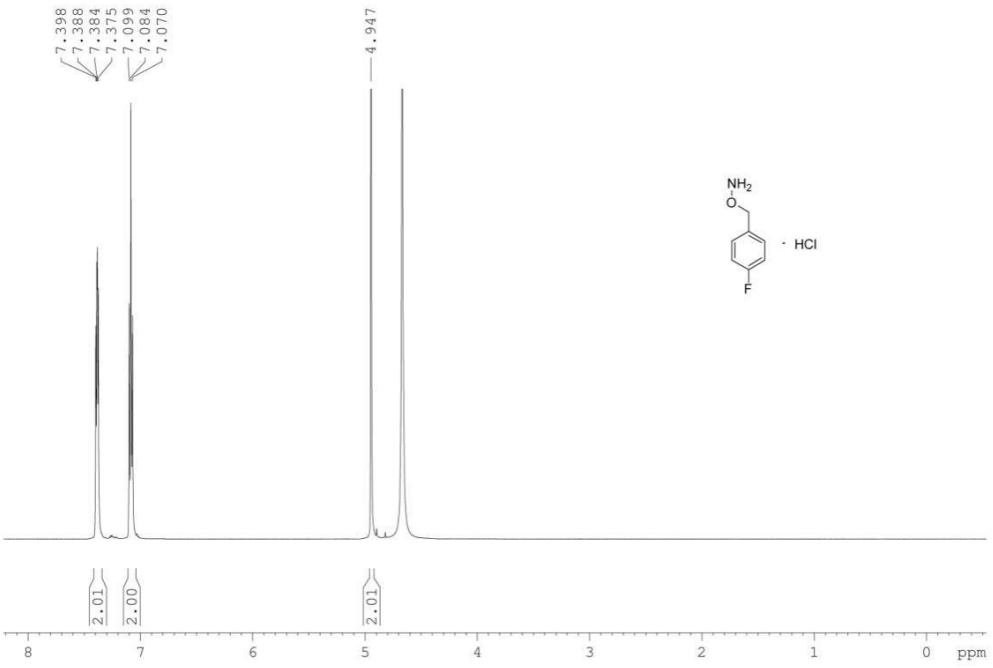


^{1}H NMR (D_2O, 400 MHz)

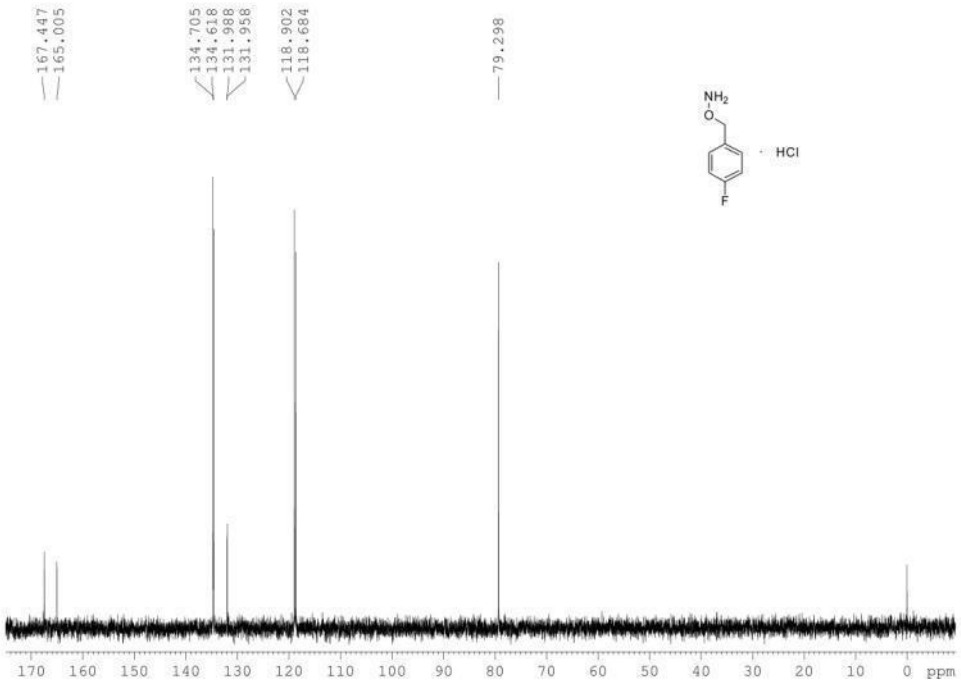


^{13}C NMR (D_2O, 100 MHz)

O-(4-fluorobenzyl)hydroxylamine hydrochloride (7c)

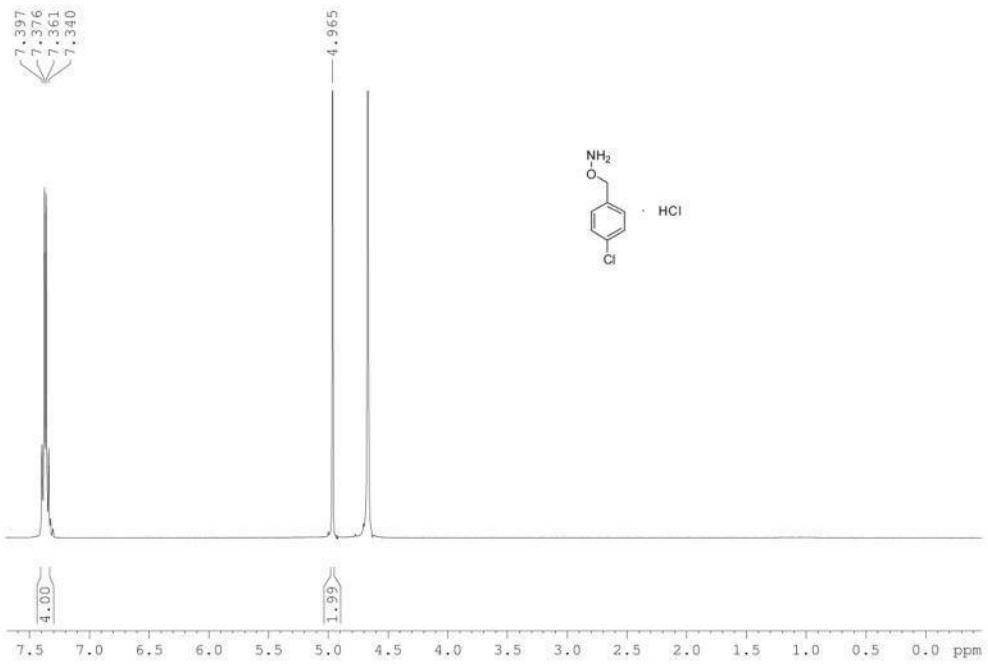


^{1}H NMR (D_2O, 400 MHz)

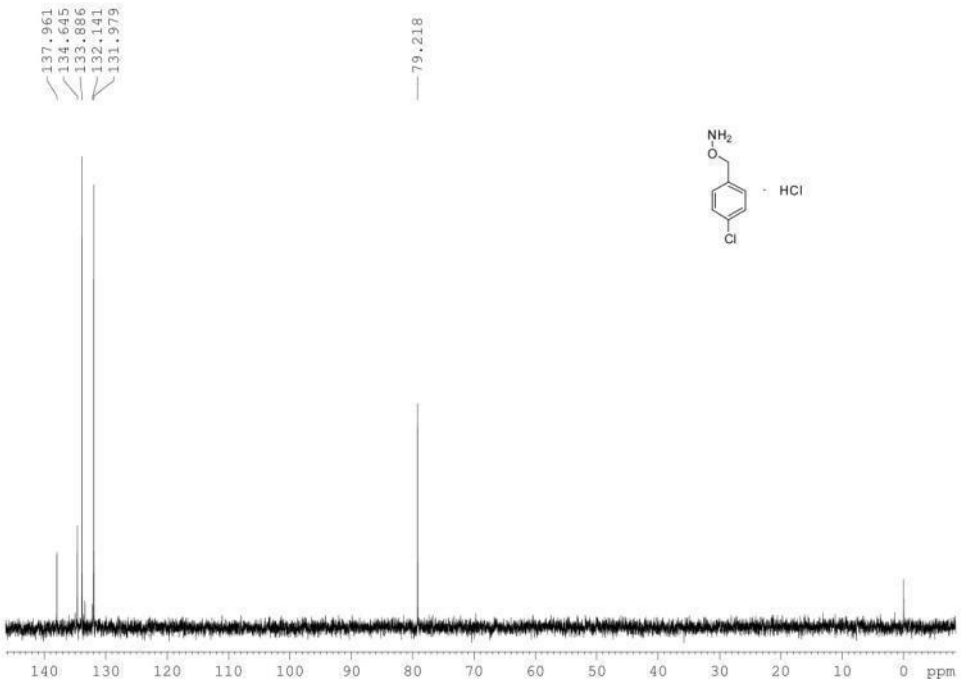


^{13}C NMR (D_2O, 100 MHz)

O-(4-chlorobenzyl)hydroxylamine hydrochloride (7d)

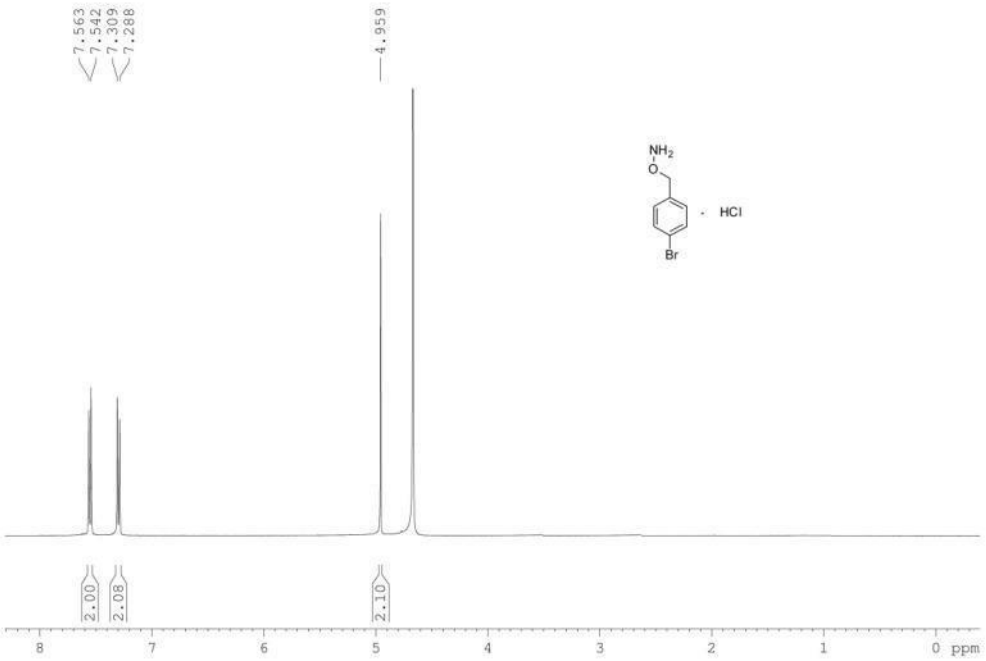


^{1}H NMR (D_2O, 400 MHz)

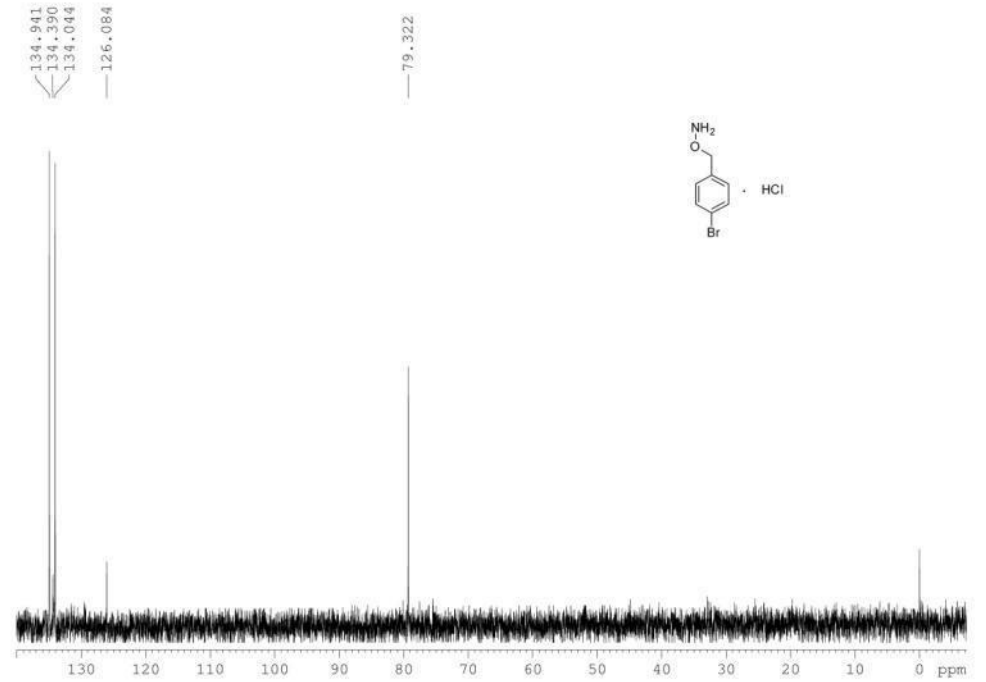


^{13}C NMR (D_2O, 100 MHz)

O-(4-bromobenzyl)hydroxylamine hydrochloride (7e)

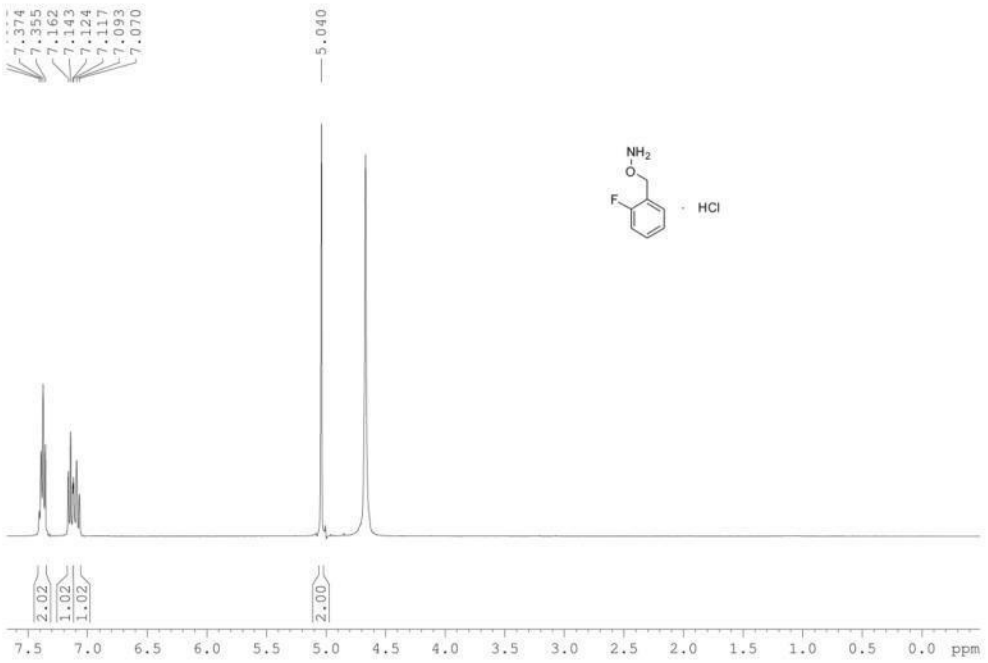


^{1}H NMR (D_2O, 400 MHz)

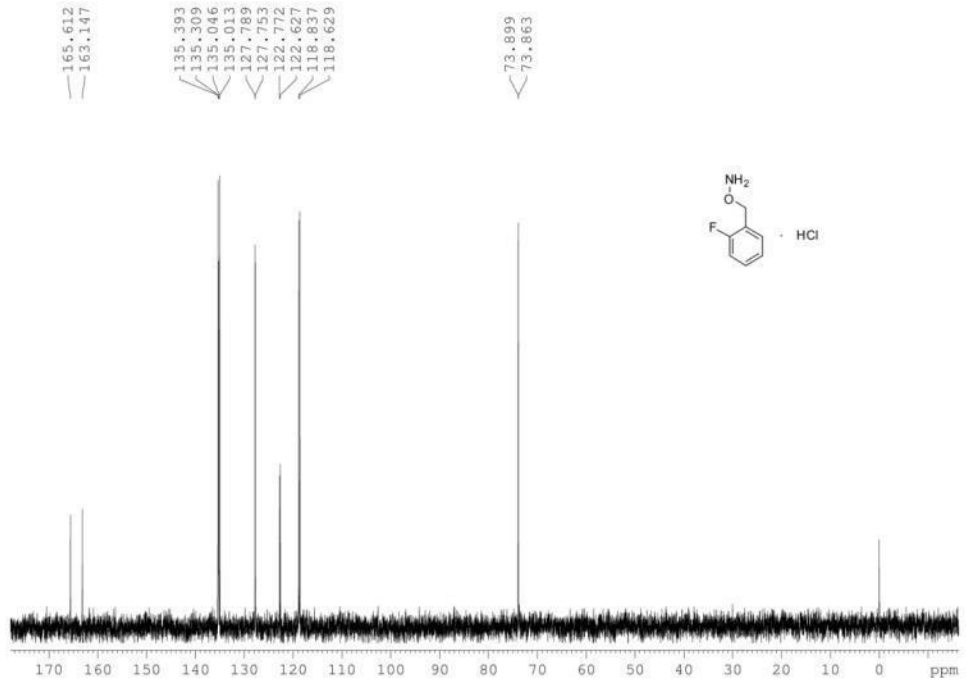


^{13}C NMR (D_2O, 100 MHz)

O-(2-fluorobenzyl)hydroxylamine hydrochloride (7f)

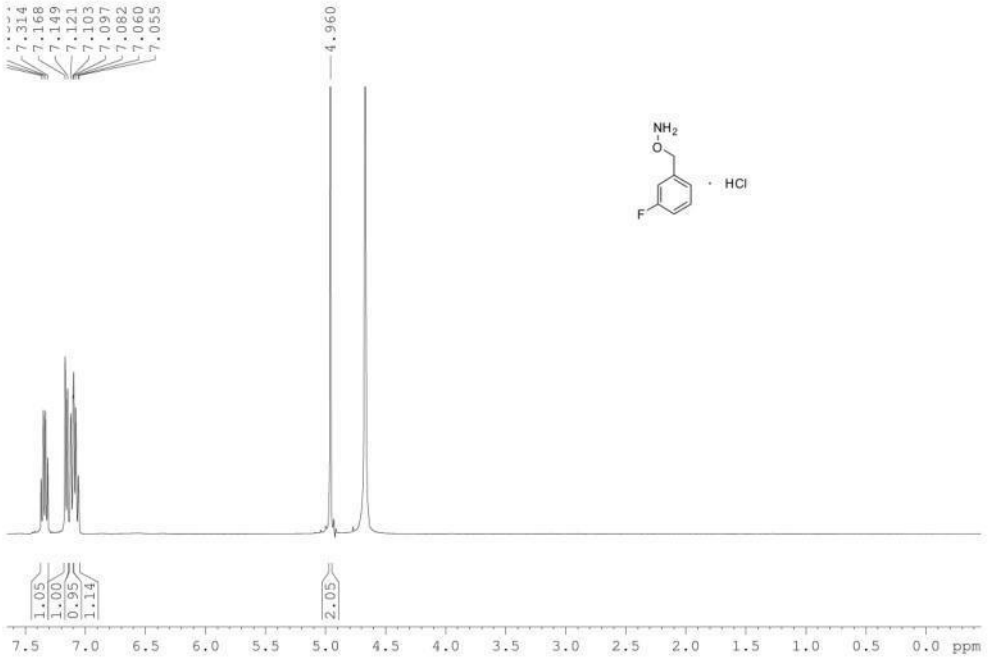


^{1}H NMR (D_2O, 400 MHz)

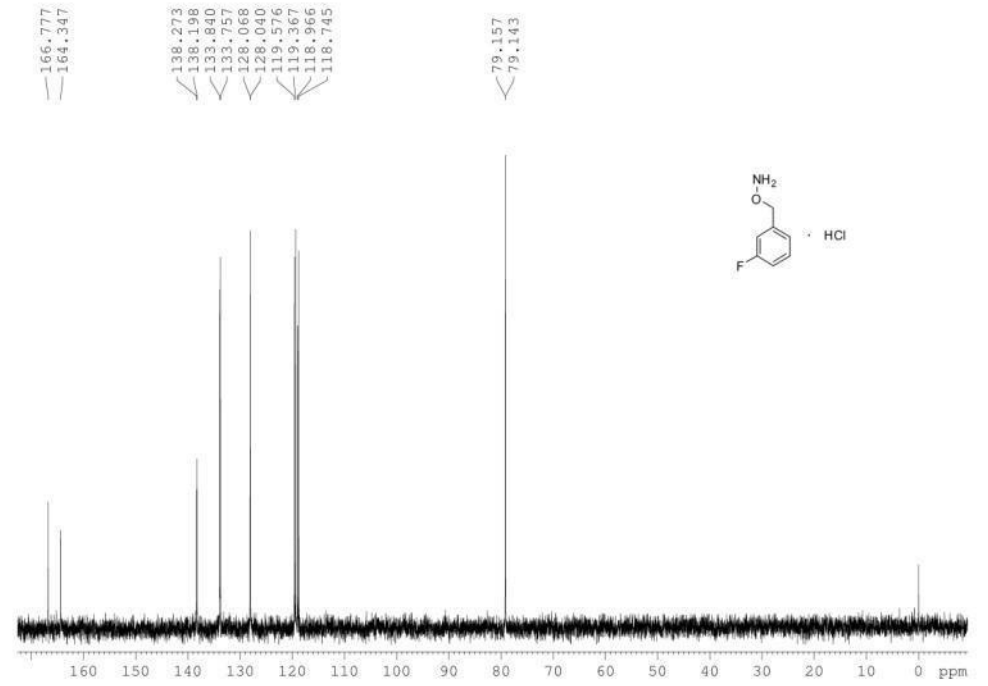


^{13}C NMR (D_2O, 100 MHz)

O-(3-fluorobenzyl)hydroxylamine hydrochloride (7g)

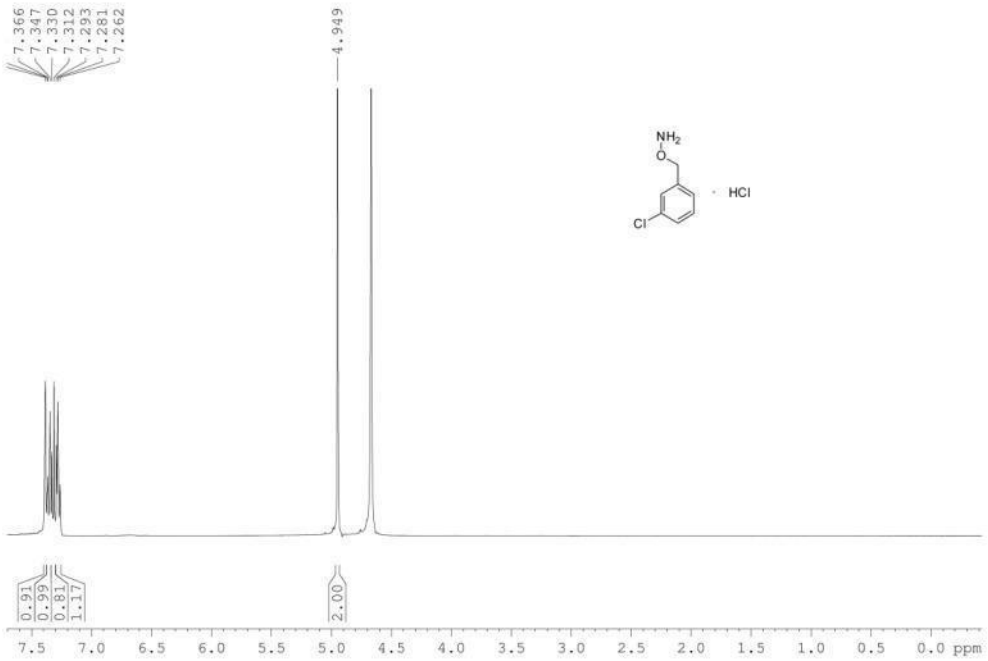


^{1}H NMR (D_2O, 400 MHz)

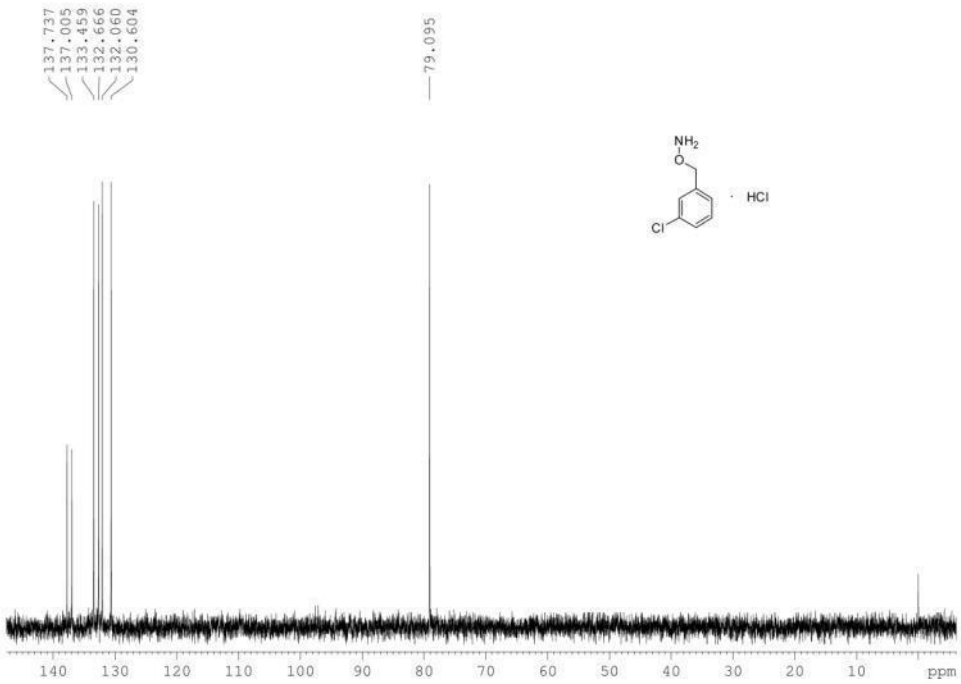


^{13}C NMR (D_2O, 100 MHz)

O-(3-chlorobenzyl)hydroxylamine hydrochloride (7h)

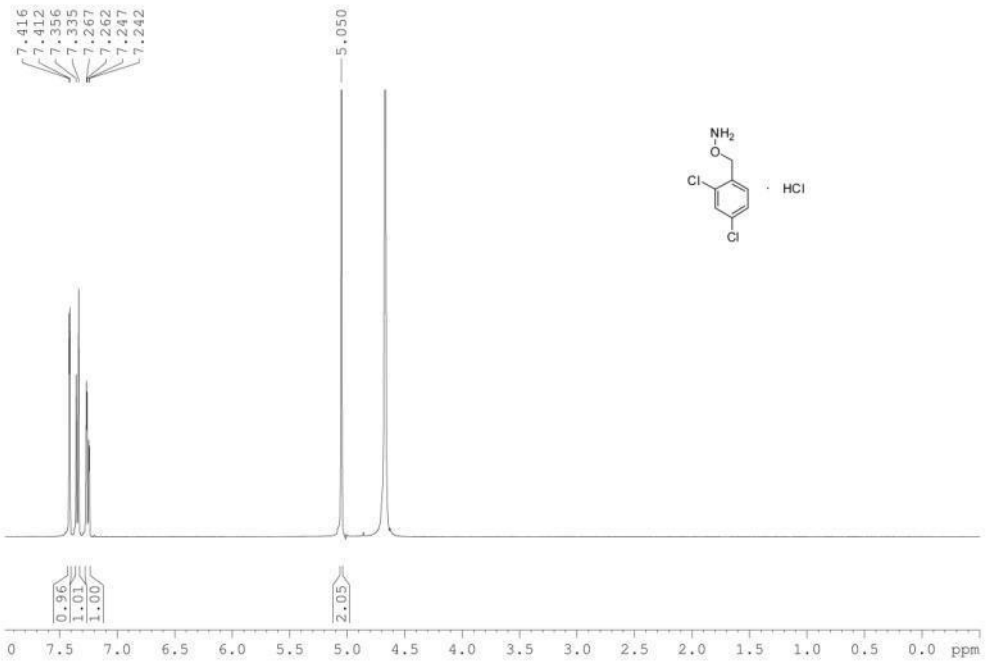


^{1}H NMR (D_2O, 400 MHz)

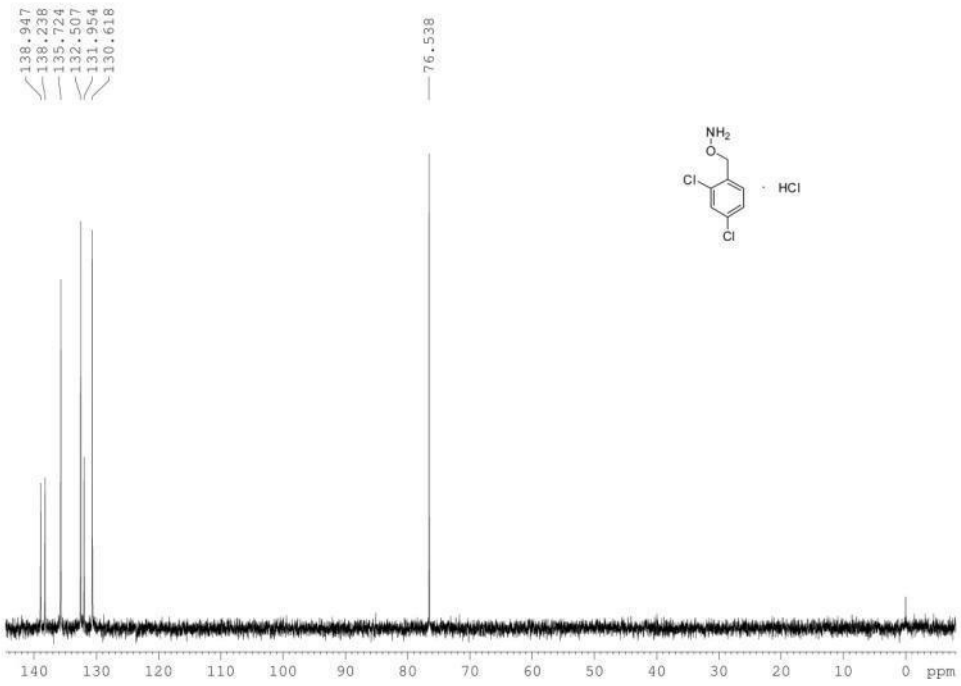


^{13}C NMR (D_2O, 100 MHz)

O-(2,4-dichlorobenzyl)hydroxylamine hydrochloride (7i)

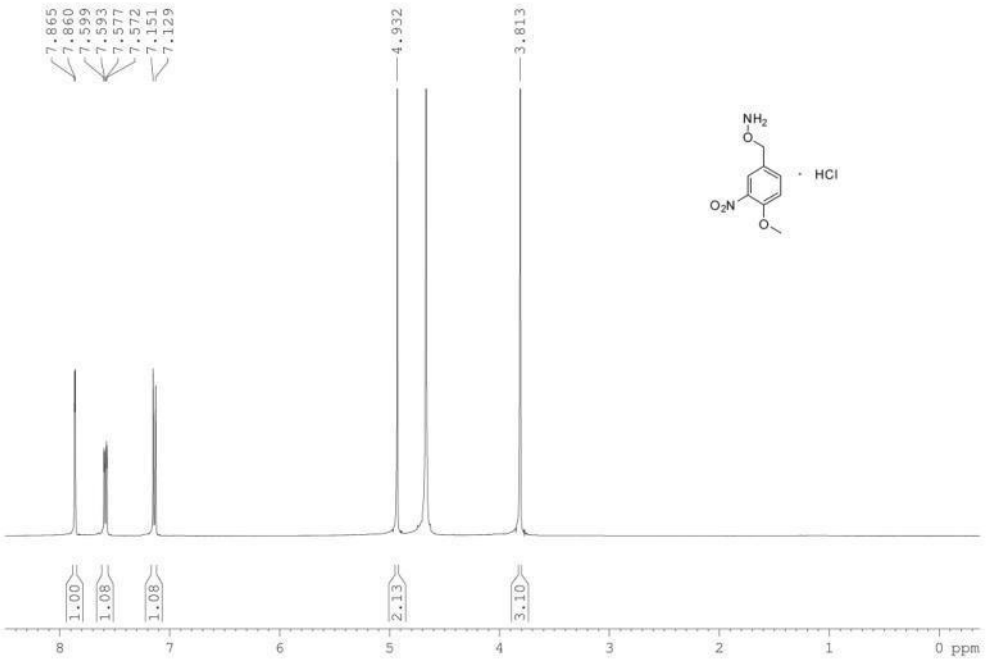


^{1}H NMR (D_2O, 400 MHz)

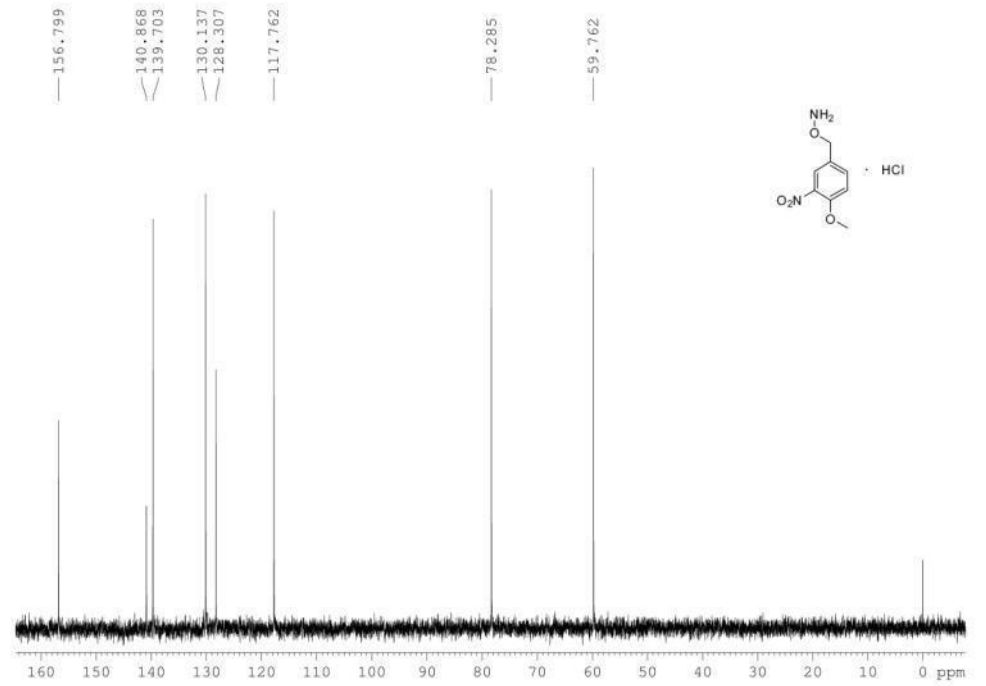


^{13}C NMR (D_2O, 100 MHz)

O-(4-methoxy-3-nitrobenzyl)hydroxylamine hydrochloride (7j)

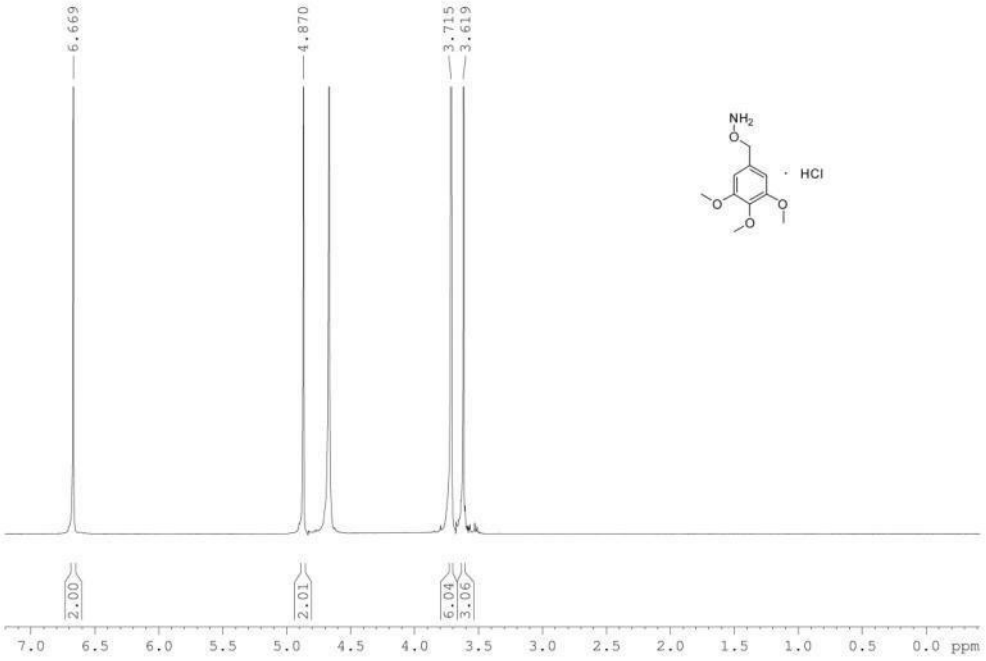


^{1}H NMR (D_2O, 400 MHz)

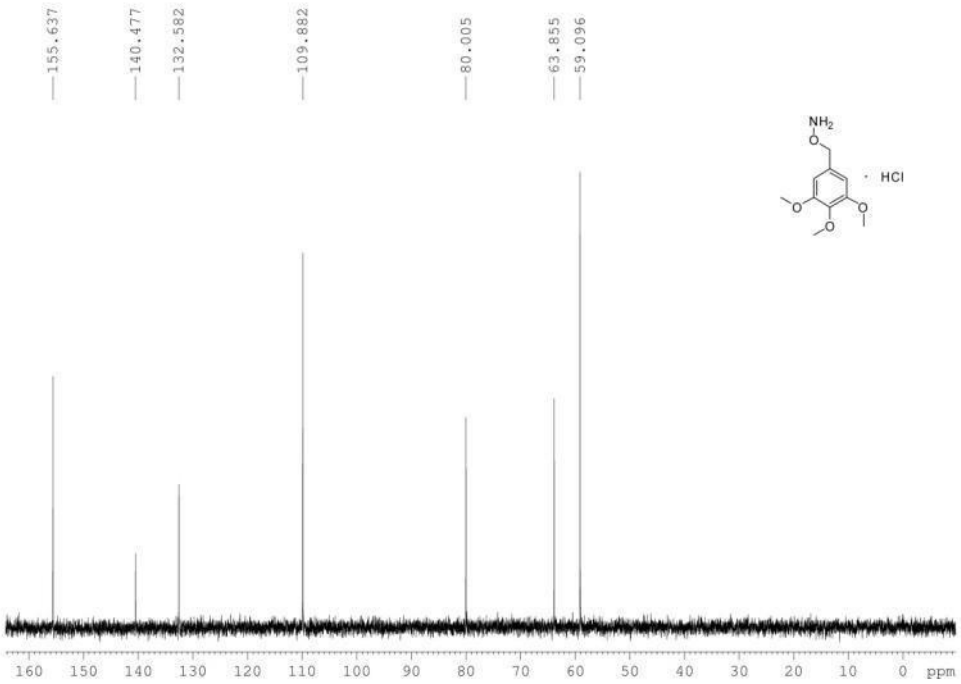


^{13}C NMR (D_2O, 100 MHz)

O-(3,4,5-trimethoxybenzyl)hydroxylamine hydrochloride (7k)

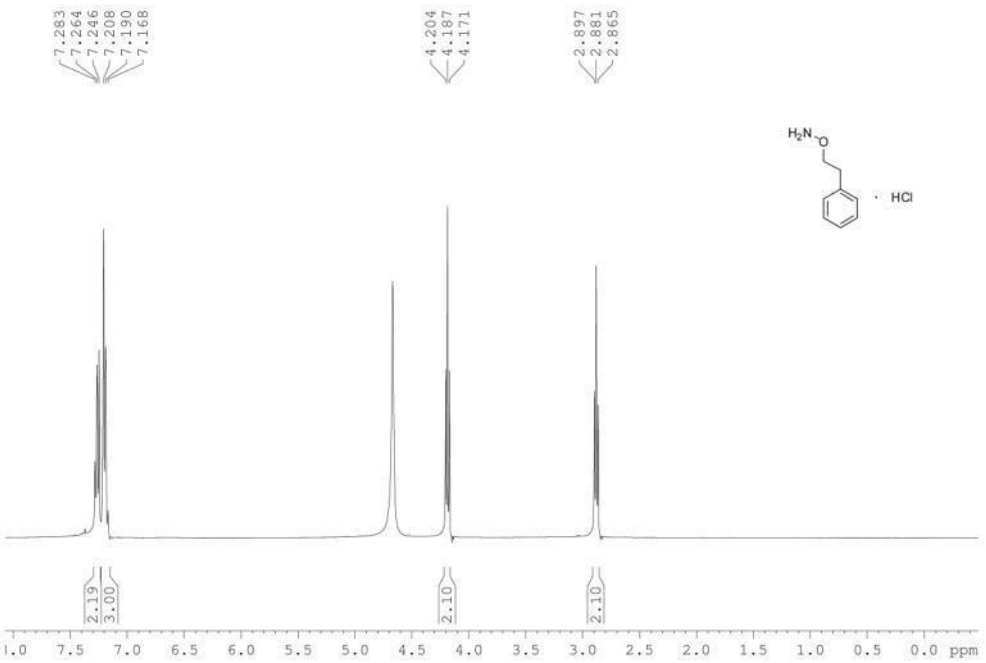


^{1}H NMR (D_2O, 400 MHz)

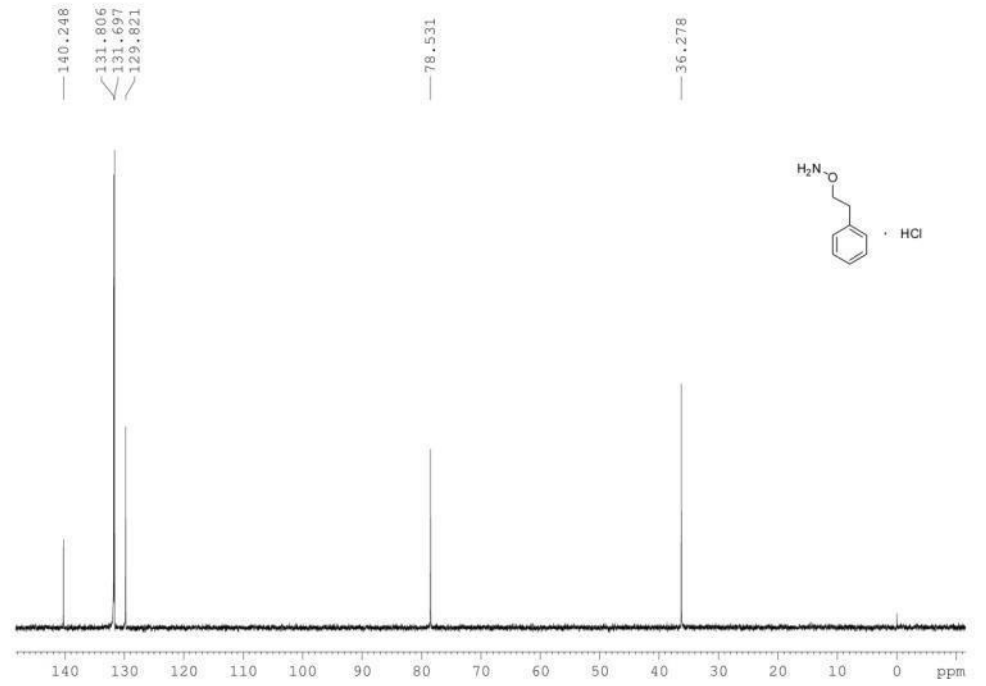


^{13}C NMR (D_2O, 100 MHz)

O-phenethylhydroxylamine hydrochloride (7l)

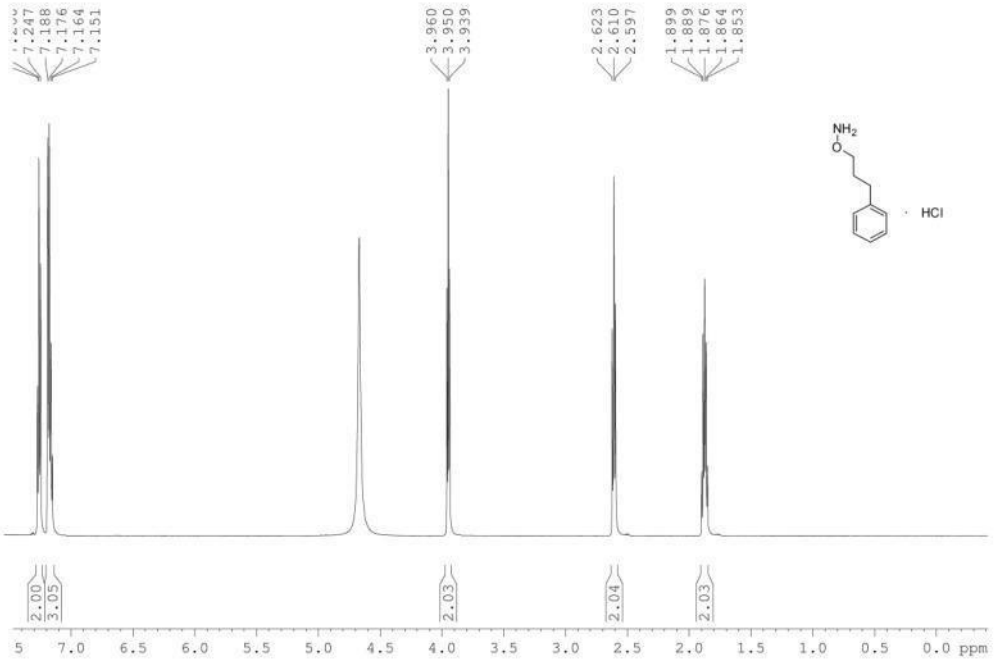


^{1}H NMR (D_2O, 400 MHz)

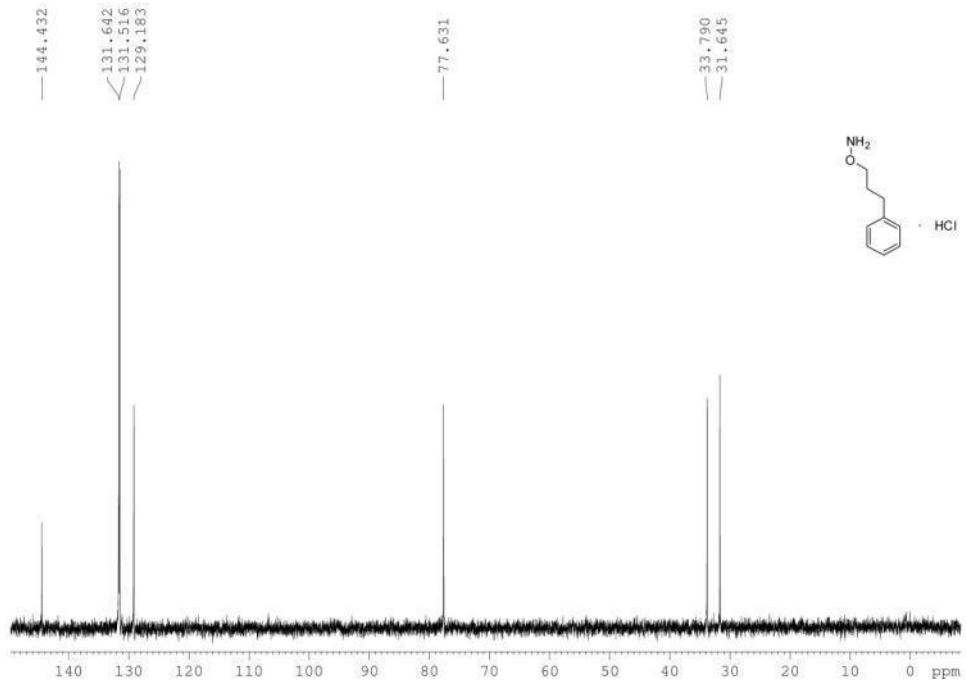


^{13}C NMR (D_2O, 100 MHz)

O-(3-phenylpropyl)hydroxylamine hydrochloride (7m)

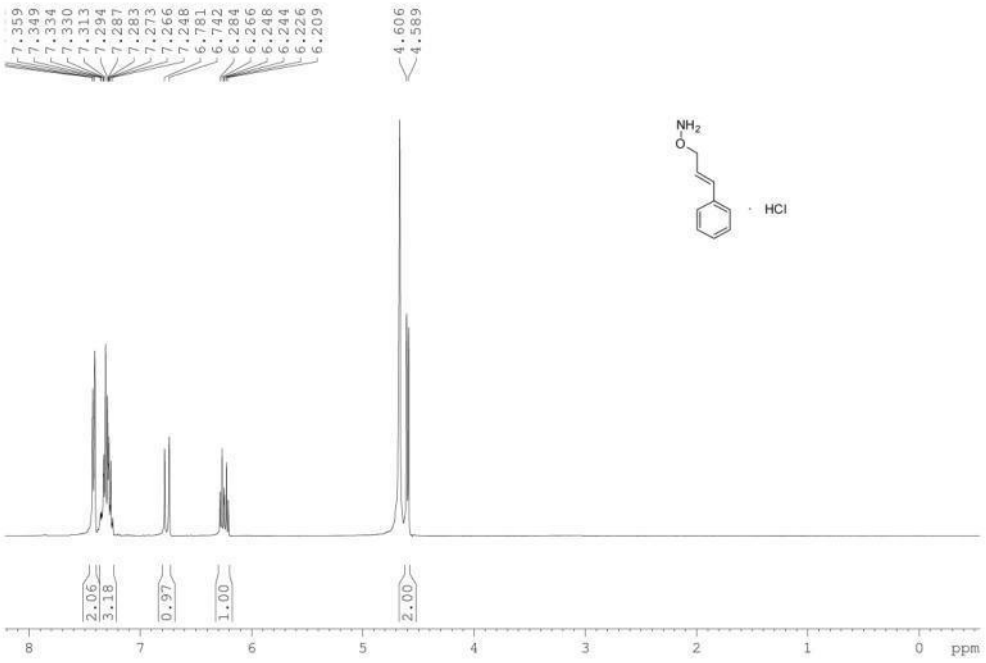


^{1}H NMR (D_2O, 400 MHz)

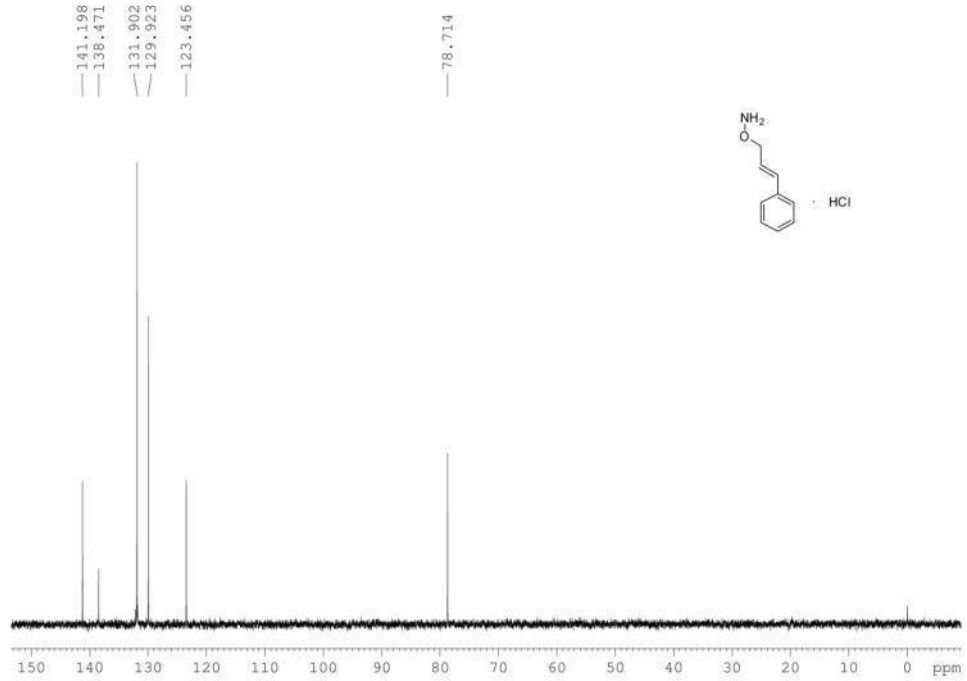


^{13}C NMR (D_2O, 100 MHz)

(*Z*)-O-cinnamylhydroxylamine hydrochloride (7n)

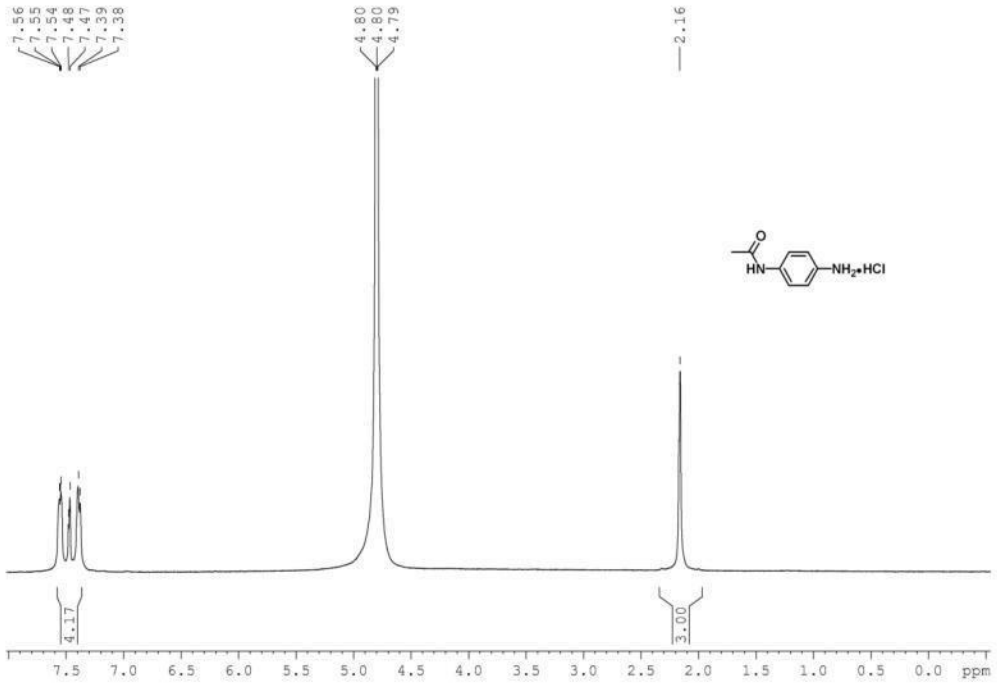


^{1}H NMR (D_2O, 400 MHz)



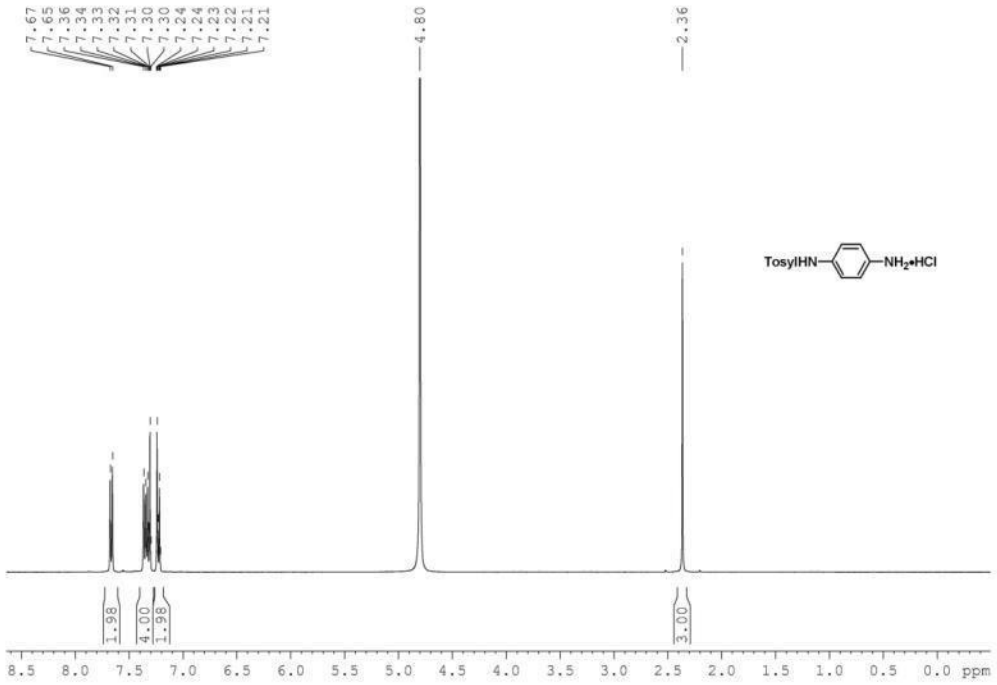
^{13}C NMR (D_2O, 100 MHz)

***N*-(4-aminophenyl)acetamide hydrochloride (10a)**

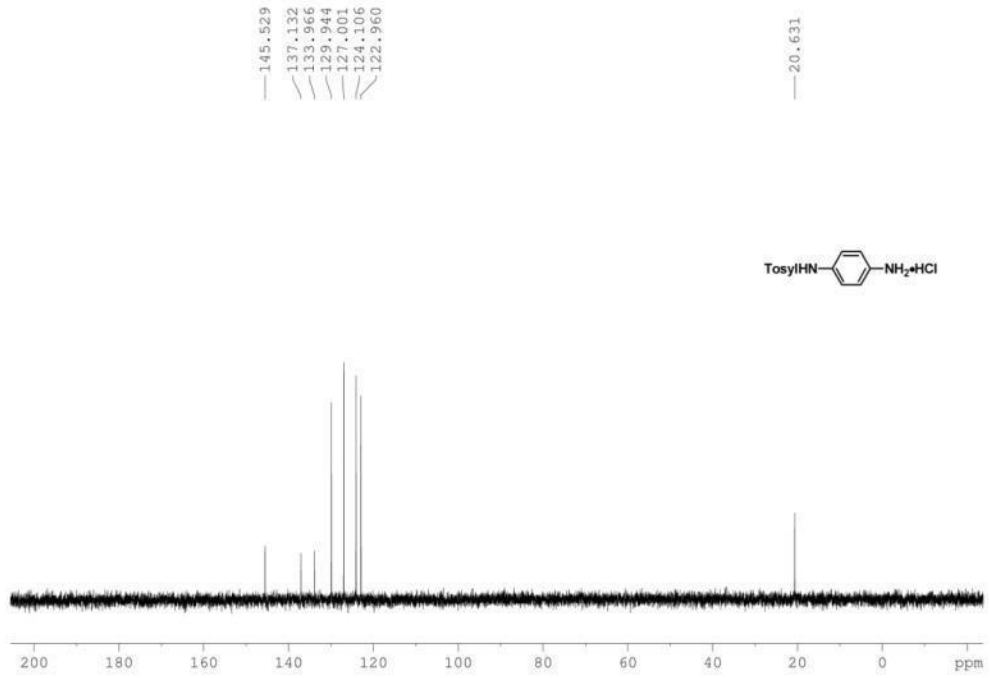


^{1}H NMR (D_2O, 400 MHz)

***N*-(4-aminophenyl)-4-methylbenzenesulfonamide hydrochloride (10b)**

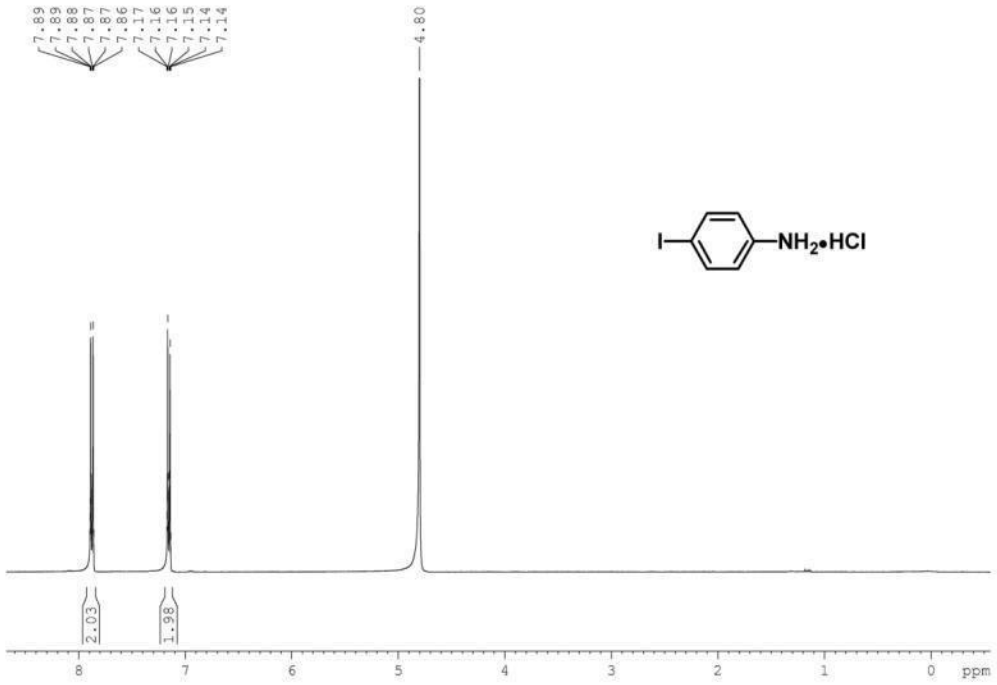


^{1}H NMR (D_2O, 400 MHz)

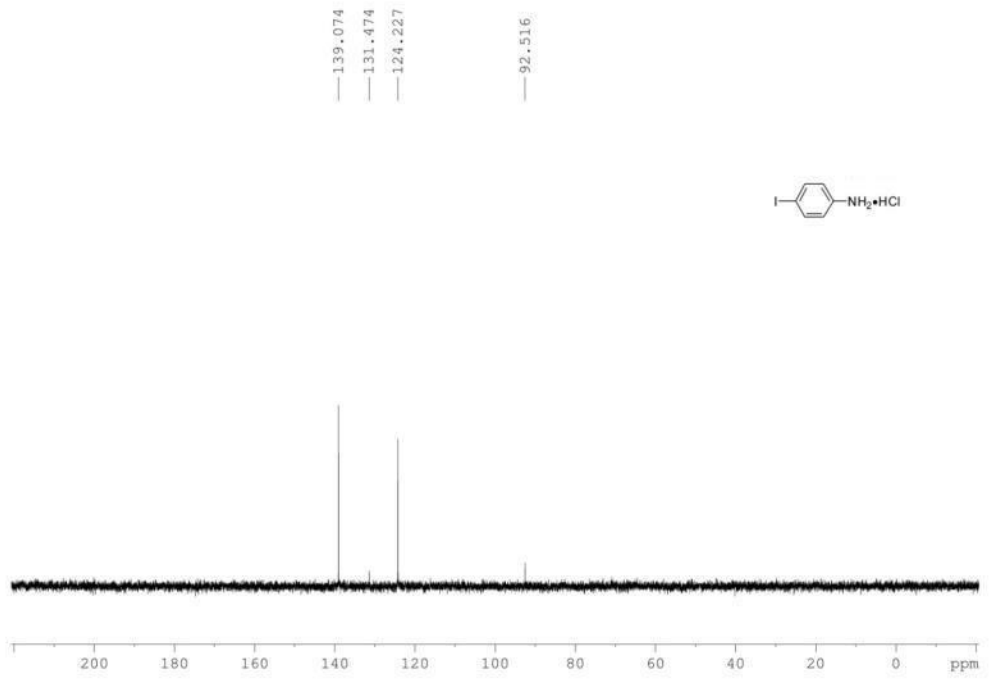


^{13}C NMR (D_2O, 100 MHz)

4-iodoaniline hydrochloride (10c)

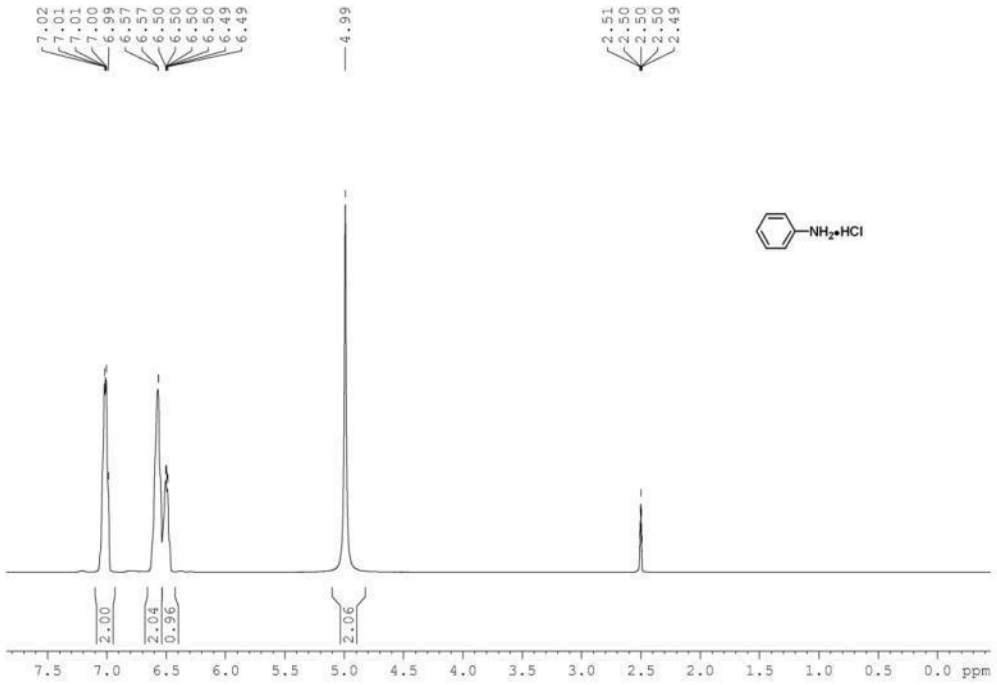


^{1}H NMR (D_2O, 400 MHz)

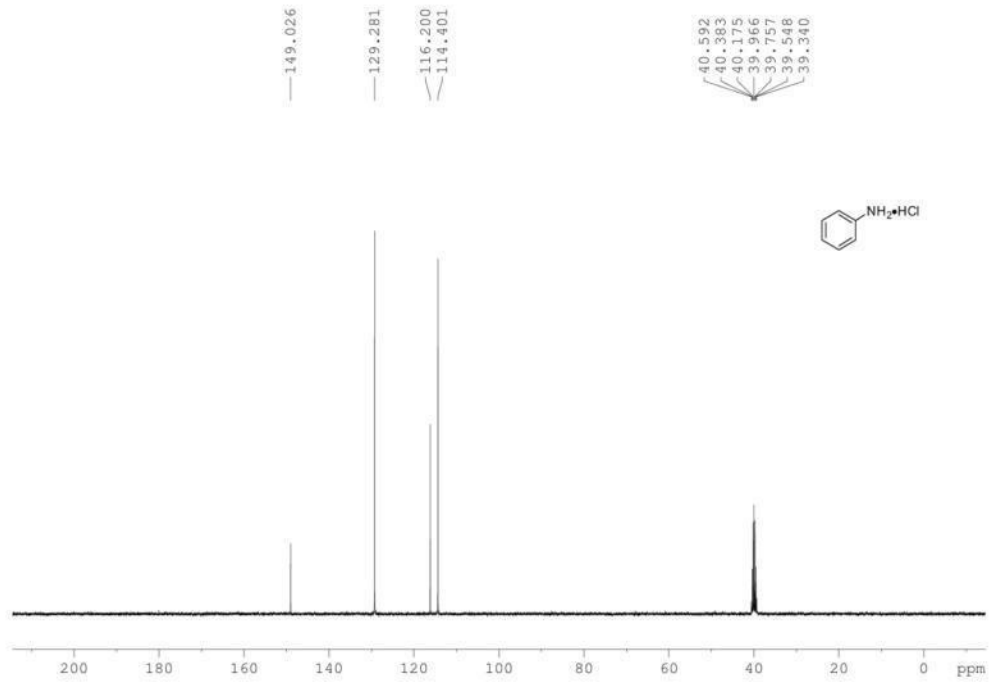


^{13}C NMR (D_2O, 100 MHz)

Aniline hydrochloride (10d)

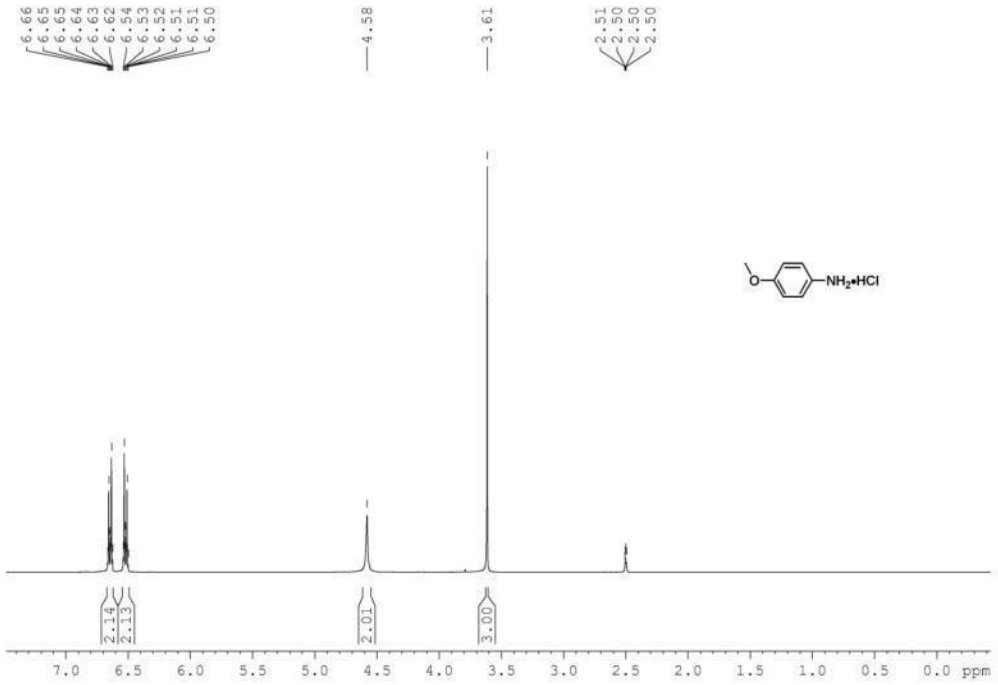


^{1}H NMR (DMSO-d_6, 400 MHz)

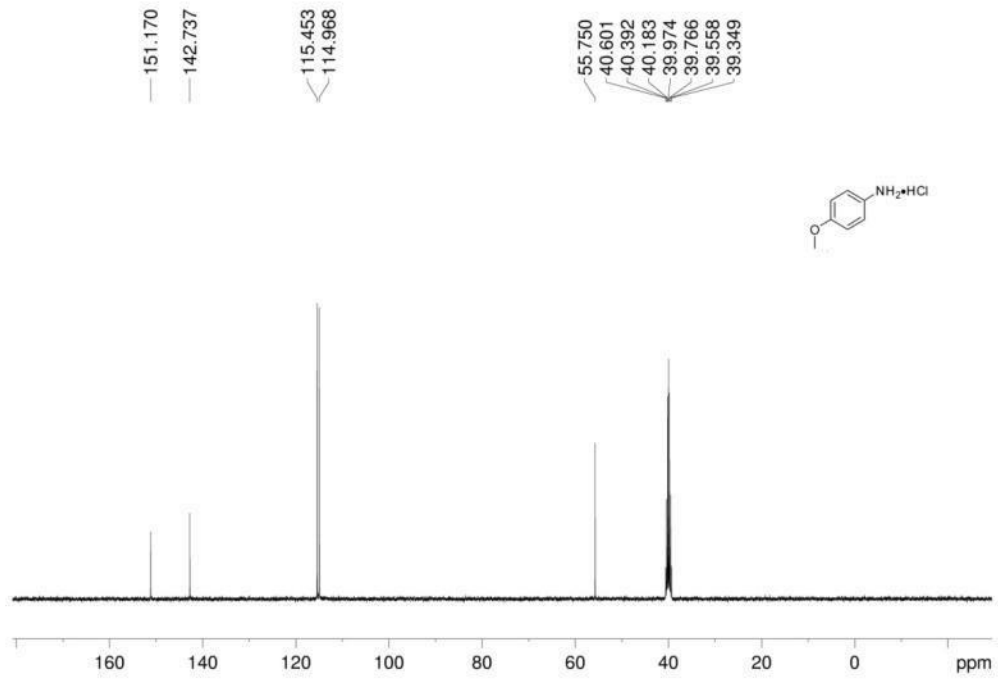


^{13}C NMR (DMSO-d_6, 100 MHz)

4-methoxyaniline hydrochloride (10e)

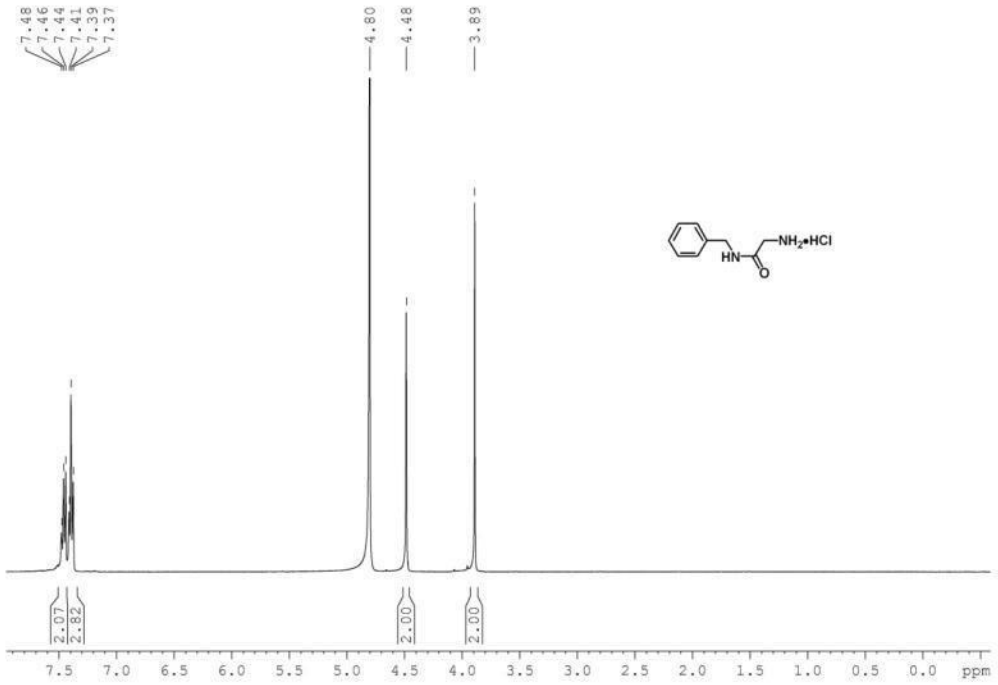


^{1}H NMR (DMSO-d_6, 400 MHz)

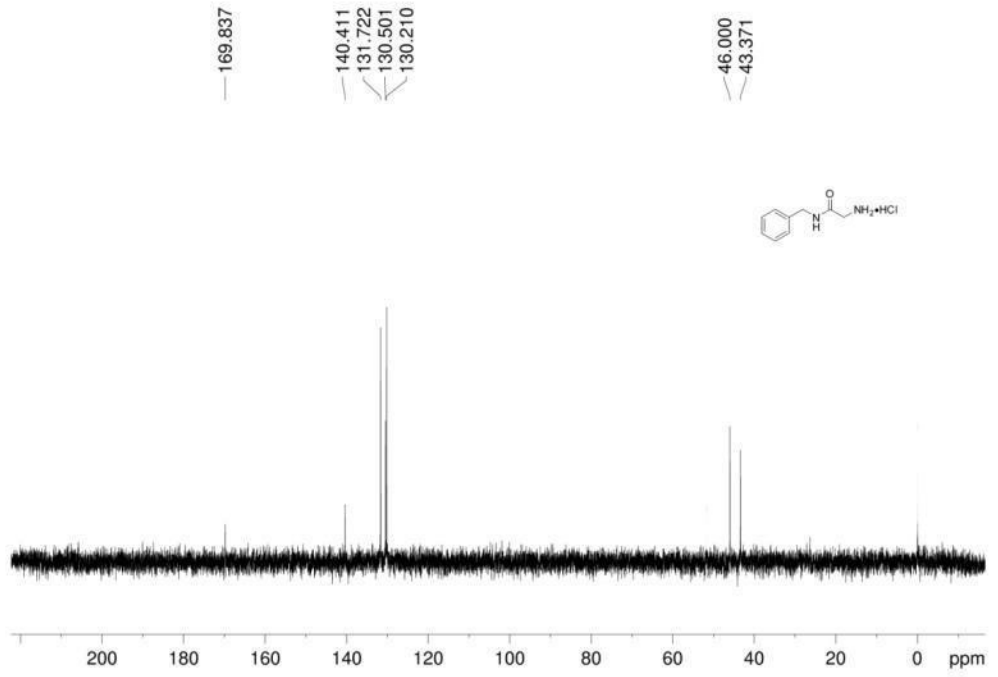


^{13}C NMR (DMSO-d_6, 100 MHz)

2-amino-*N*-benzylacetamide hydrochloride (10f)



^{1}H NMR (D_2O, 400 MHz)



^{13}C NMR (D_2O, 100 MHz)