Electronic Supplementary Material (ESI) for Organic Chemistry Frontiers.

Supporting Information

Amine Hydrochloride Salts as Bifunctional Reagents for Maleimides Radical Aminochlorination

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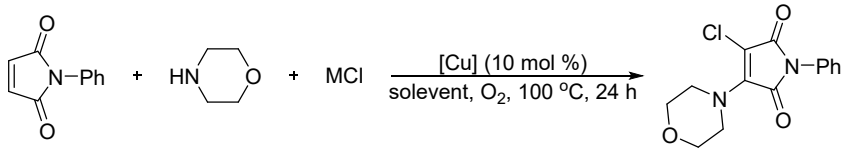
General Information

N-substituent Maleimides[1] were prepared according to the reported procedures. ^{1}H and ^{13}C spectra of known compounds were in accordance with those described in the literatures. All other reagents were purchased from TCI, Sigma-Aldrich, Alfa Aesar, Acros, and Meryer and used without further purification. ^{1}H NMR (500 MHz), ^{13}C NMR (125 MHz) and ^{19}F NMR (470 MHz) spectra were recorded in $CDCl_3$ and DMSO-D6 solutions using a Burker AVANCE 500 spectrometer. High-resolution mass spectra were recorded on an ESI-Q-TOF mass spectrometer. Analysis of crude reaction mixture was done on the Varian 4000 GC/MS and 1200 LC. All reactions were conducted using standard Schlenk techniques. Column chromatography was performed using EM silica gel 60 (300−400 m).

Detailed optimization of reaction conditions:



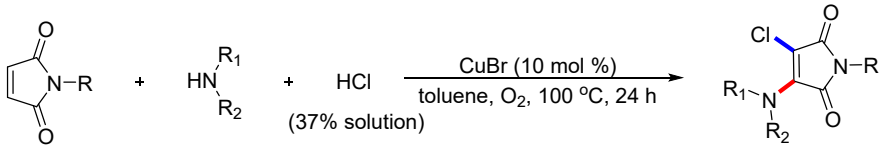
1a **2a** **3a**

entry	catalyst	Cl^- source	solvent	yield (%)[b]
1	CuBr	HCl	toluene	88
2	CuBr	n-Bu_4NCl	toluene	0
3	CuBr	LiCl	toluene	0
4	CuBr	NaCl	toluene	0
5	CuBr	KCl	toluene	0
6	CuBr	TMSCl	toluene	80
7	$Pd(OAc)_2$	HCl	toluene	0
8	$Ni(PPh_3)_2Cl_2$	HCl	toluene	0
9	$[Ru(p\text{-cymene})Cl_2]_2$	HCl	toluene	0
10	$FeCl_3$	HCl	toluene	0
11	$AgNO_3$	HCl	toluene	0
12	CuBr	HCl	THF	0
13	CuBr	HCl	dioxane	0
14	CuBr	HCl	DMSO	0
15	CuBr	HCl	DMF	0
16	CuBr	HCl	CH_3CN	0
17	CuBr	HCl	EtOAc	0
18	$CuBr_2$	HCl	toluene	62
19	CuCl	HCl	toluene	82
20	CuI	HCl	toluene	85
21	$Cu(OAc)_2$	HCl	toluene	80
22		HCl	toluene	0
23[c]	CuBr	HCl	toluene	16

24[d]	CuBr	HCl	toluene	81

[a] Reaction conditions unless specified otherwise: **1a** (0.2 mmol), **2a** (0.6 mmol), MCl (0.6 mmol) and catalyst (0.02 mmol) in solvent (2.0 mL) at 100 °C for 24 h. [b] Isolated yield. [c] Under N_2 atmosphere. [d] Under air atmosphere.

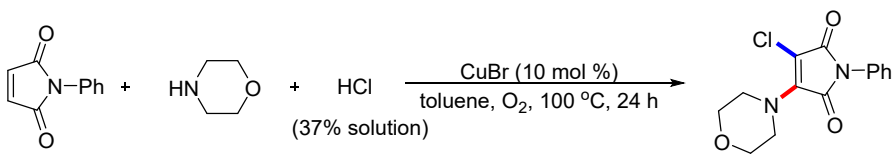
General Procedure of Amine Hydrochloride Salts as Bifunctional Reagents for Electron-Deficient Alkenes Aminochlorination：



1 **2** **3-4**

A 25 mL Schlenk tube equipped with a stir bar was charged with maleimide (0.2 mmol), alkylamines (0.6 mmol), CuBr (0.02 mol) and 2 mL toluene, then, the addition of aqueous hydrochloric acid (37%, 0.6 mmol) using a pipette, the tube was fitted with a rubber septum, and then it was evacuated and refilled with dioxygen three times, then the septum was replaced by a Teflon screwcap under oxygen flow. The reaction mixture was stirred 100 ℃ (aluminium block heating mantle) for 24 h. After cooling down, the reaction mixture was diluted with 10 mL of ethyl ether, filtered through a pad of silica gel, followed by washing the pad of the silica gel with the same solvent (20 mL), concentrated under reduced pressure. The residue was then purified by flash chromatography on silica gel to provide the corresponding product.

5mmol scale-up reaction:



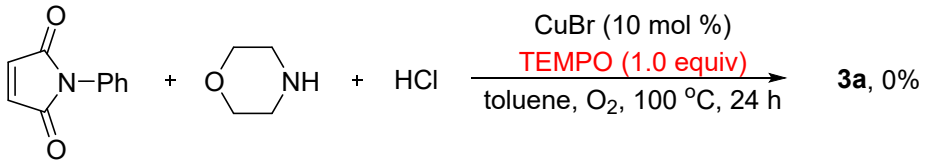
1a **2a** **3a**

A 150 mL Schlenk tube equipped with a stir bar was charged with *N*-Phenylmaleimide (5.0 mmol), morpholine (15 mmol), CuBr (0.5 mol) and 50 mL toluene, then, the addition of aqueous hydrochloric acid (37%, 15 mmol) using a pipette, the tube was fitted with a rubber septum, and then it was evacuated and refilled with dioxygen three times, then the septum was replaced by a

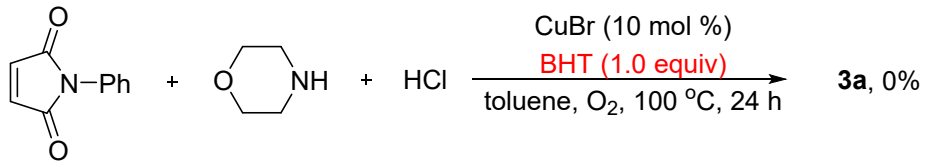
Teflon screwcap under oxygen flow. The reaction mixture was stirred at 100 ℃ (oil bath) for 24 h. After cooling down, the reaction mixture was diluted with 10 mL of ethyl ether, filtered through a pad of silica gel, followed by washing the pad of the silica gel with the same solvent (20 mL), concentrated under reduced pressure. The residue was then purified by flash chromatography on silica gel to provide the corresponding product **3a** (isolated 79% yield).

Mechanism investigation:

(a) Radical scavenger



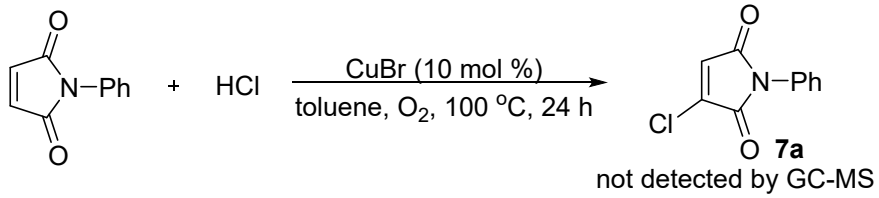
A 25 mL Schlenk tube equipped with a stir bar was charged with *N*-Phenylmaleimide (0.2 mmol), morpholine (0.6 mmol), CuBr (0.02 mol), TEMPO (0.2 mmol) and 2 mL toluene, then, the addition of aqueous hydrochloric acid (37%, 0.6 mmol) using a pipette, the tube was fitted with a rubber septum, and then it was evacuated and refilled with dioxygen three times, then the septum was replaced by a Teflon screwcap under oxygen flow. The reaction mixture was stirred at room temperature for 5 minutes, the mixture reacted at 100 ℃ (aluminium block heating mantle). After stirring for 24 h, the reaction mixture was cooled to room temperature and the reaction was filtered through a pad of Celite and diluted with ethyl acetate (10 mL), no corresponding product was detected by GC-MS, which suggest radical process was involved in current multi-component reactions.



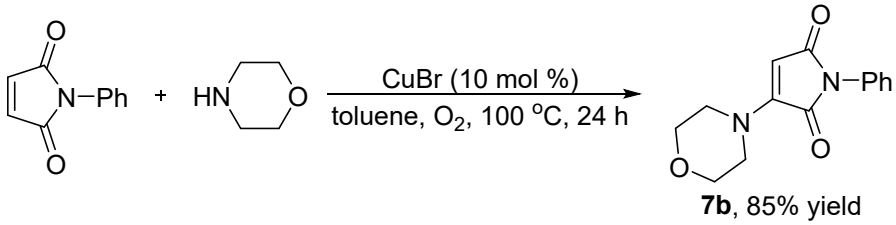
A 25 mL Schlenk tube equipped with a stir bar was charged with *N*-Phenylmaleimide (0.2 mmol), morpholine (0.6 mmol), CuBr (0.02 mol), BHT (0.2 mmol) and 2 mL toluene, then, the addition of aqueous hydrochloric acid (37%, 0.6 mmol) using a pipette, the tube was fitted with a rubber septum, and then it was evacuated and refilled with dioxygen three times, then the septum was replaced by a Teflon screwcap under oxygen flow. The reaction mixture was stirred at room

temperature for 5 minutes, the mixture reacted at 100 ℃ (aluminium block heating mantle). After stirring for 24 h, the reaction mixture was cooled to room temperature and the reaction was filtered through a pad of Celite and diluted with ethyl acetate (10 mL), no corresponding product was detected by GC-MS, which suggest radical process was involved in current multi-component reactions.

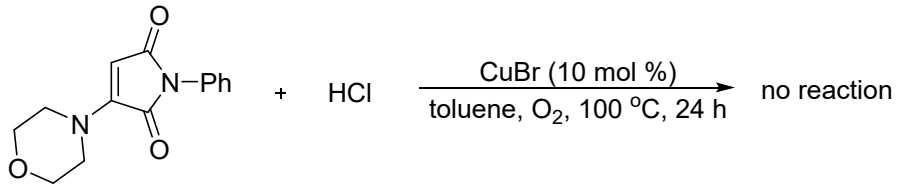
(b) Competent intermediate identification



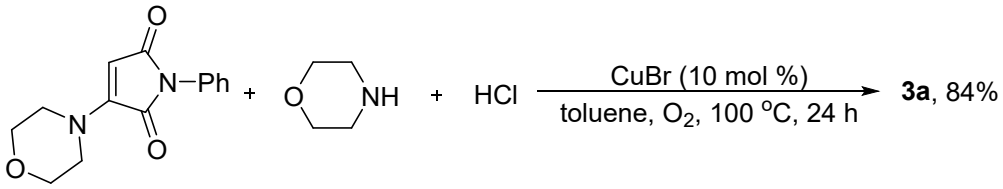
A 25 mL Schlenk tube equipped with a stir bar was charged with *N*-Phenylmaleimide (0.2 mmol), CuBr (0.02 mol), aqueous hydrochloric acid (37%, 0.6 mmol) and 2 mL toluene, the tube was fitted with a rubber septum, and then it was evacuated and refilled with dioxygen three times, then the septum was replaced by a Teflon screwcap under oxygen flow. The reaction mixture was reacted at 100 ℃ (aluminium block heating mantle). After stirring for 24 h, the reaction mixture was cooled to room temperature and the reaction was filtered through a pad of Celite and diluted with ethyl acetate (10 mL), no corresponding product was detected by GC-MS.



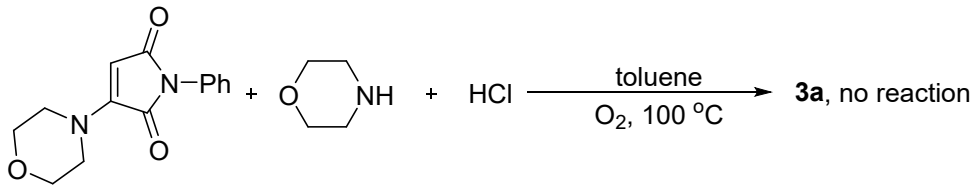
A 25 mL Schlenk tube equipped with a stir bar was charged with *N*-Phenylmaleimide (0.2 mmol), CuBr (0.02 mol), morpholine (0.6 mmol) and 2 mL toluene, the tube was fitted with a rubber septum, and then it was evacuated and refilled with dioxygen three times, then the septum was replaced by a Teflon screwcap under oxygen flow. The reaction mixture was reacted at 100 ℃ (aluminium block heating mantle). After stirring for 24 h, the reaction mixture was cooled to room temperature and the reaction was filtered through a pad of Celite and diluted with ethyl acetate (10 mL), and the corresponding product was isolated in 85% yield.



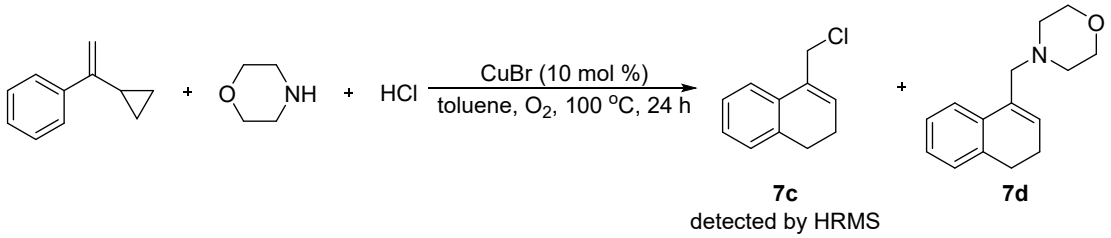
A 25 mL Schlenk tube equipped with a stir bar was charged with 3-morpholino-1-phenyl-1H-pyrrole-2,5-dione (0.2 mmol), CuBr (0.02 mol), aqueous hydrochloric acid (37%, 0.6 mmol) and 2 mL toluene, the tube was fitted with a rubber septum, and then it was evacuated and refilled with dioxygen three times, then the septum was replaced by a Teflon screwcap under oxygen flow. The reaction mixture was reacted at 100 ℃ (aluminium block heating mantle). After stirring for 24 h, the reaction mixture was cooled to room temperature and the reaction was filtered through a pad of Celite and diluted with ethyl acetate (10 mL), no corresponding product was detected by GC-MS.



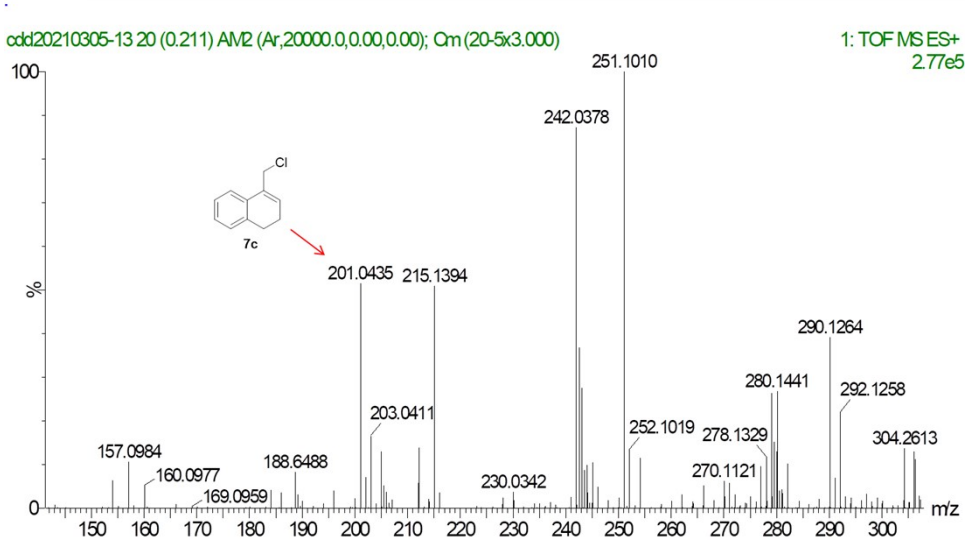
A 25 mL Schlenk tube equipped with a stir bar was charged with 3-morpholino-1-phenyl-1H-pyrrole-2,5-dione (0.2 mmol), CuBr (0.02 mol), and 2 mL toluene, then, the addition of morpholine (0.6 mmol) and aqueous hydrochloric acid (37%, 0.6 mmol) using a pipette, the tube was fitted with a rubber septum, and then it was evacuated and refilled with dioxygen three times, then the septum was replaced by a Teflon screwcap under oxygen flow. The reaction mixture was stirred at room temperature for 5 minutes, the mixture reacted at 100 ℃ (aluminium block heating mantle). After stirring for 24 h, the reaction mixture was cooled to room temperature and the reaction was filtered through a pad of Celite and diluted with ethyl acetate (10 mL), the desired product was isolated in 84% yield.



A 25 mL Schlenk tube equipped with a stir bar was charged with 3-morpholino-1-phenyl-1H-pyrrole-2,5-dione (0.2 mmol) and 2 mL toluene, then, the addition of morpholine (0.6 mmol) and aqueous hydrochloric acid (37%, 0.6 mmol) using a pipette, the tube was fitted with a rubber septum, and then it was evacuated and refilled with dioxygen three times, then the septum was replaced by a Teflon screwcap under oxygen flow. The reaction mixture was stirred at room temperature for 5 minutes, the mixture reacted at 100 ℃ (aluminium block heating mantle). After stirring for 24 h, the reaction mixture was cooled to room temperature and the reaction was filtered through a pad of Celite and diluted with ethyl acetate (10 mL), no new product was observed on TLC and GC-MS.

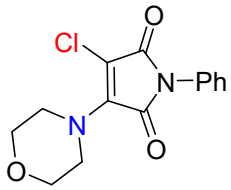


A 25 mL Schlenk tube equipped with a stir bar was charged with (1-cyclopropylvinyl)benzene (0.2 mmol), CuBr (0.02 mol), and 2 mL toluene, then, the addition of morpholine (0.6 mmol) and aqueous hydrochloric acid (37%, 0.6 mmol) using a pipette, the tube was fitted with a rubber septum, and then it was evacuated and refilled with dioxygen three times, then the septum was replaced by a Teflon screwcap under oxygen flow. The reaction mixture was stirred at room temperature for 5 minutes, the mixture reacted at 100 ℃ (aluminium block heating mantle). After stirring for 24 h, the reaction mixture was cooled to room temperature and the reaction was filtered through a pad of Celite and diluted with ethyl acetate (10 mL), it was found that **7c** was detected by HRMS, which suggesting that chlorine radical was generated in reaction mixture.



Characterization of Products in Details:

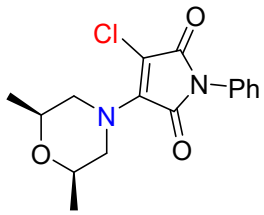
3-chloro-4-morpholino-1-phenyl-1H-pyrrole-2,5-dione[2]



3a

Following the general procedure, using (petroleum ether : EtOAc = 9 : 1) as the eluant afforded a yellow solid (51.4 mg, 88% yield), Mp = 145-146℃. **^{1}H NMR** (500 MHz, $CDCl_3$): δ 7.43 (t, *J*=7.85 Hz, 2H), 7.35-7.30 (m, 3H), 4.01 (t, *J*=4.60 Hz, 4H), 3.81 (t, *J*=4.60 Hz, 4H); **^{13}C NMR** (125MHz, $CDCl_3$): δ 165.2, 164.7, 140.8, 131.3, 129.1, 127.9, 126.3, 96.0, 67.1, 48.5; **HRMS** (ESI): calcd for $C_{14}H_{14}ClN_2O_3$ $[M + H]^+$ 293.0693, found 293.0699.

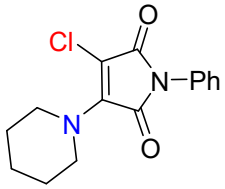
3-chloro-4-((2S,6R)-2,6-dimethylmorpholino)-1-phenyl-1H-pyrrole-2,5-dione



3b

Following the general procedure, using (petroleum ether : EtOAc = 9 : 1) as the eluant afforded a yellow solid (53.7 mg, 84% yield). yield), Mp = 145-146℃. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.46-7.42 (m, 2H), 7.36-7.30 (m, 3H), 4.65 (d, *J* = 13.4 Hz, 2H), 3.76 (dtd, *J* = 12.4, 6.2, 2.1 Hz, 2H), 2.85 (dd, *J* = 13.3, 10.4 Hz, 2H), 1.23 (s, *3*H), 1.21 (s, *3*H); **^{13}C NMR** (125MHz, $CDCl_3$): δ 165.4, 164.8, 140.7, 131.4, 129.3, 129.1, 128.0, 126.4, 120.0, 95.6, 72.4, 53.4, 18.7; **HRMS** (ESI): calcd for $C_{16}H_{17}N_2O_3NaCl$ $[M + Na]^+$ 343.0825, found343.0827.

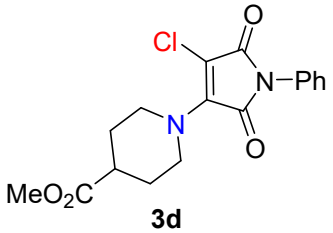
3-chloro-1-phenyl-4-(piperidin-1-yl)-1H-pyrrole-2,5-dione



3c

Following the general procedure, using (petroleum ether : EtOAc = 9 : 1) as the eluant afforded a yellow liquid (49.9 mg, 86% yield). **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.45-7.40 (m, 2H), 7.35-7.31 (m, 3H), 3.94-3.92 (m, 4H), 1.74-1.72 (m, 6H); **^{13}C NMR** (125MHz, $CDCl_3$): δ 165.7, 164.8, 141.6, 131.6, 129.1, 127.8, 126.4, 94.2, 49.9, 26.9, 24.2; **HRMS** (ESI): calcd for $C_{15}H_{16}ClN_2O_2$ $[M + H]^+$ 291.0900, found 291.0899.

Methyl 1-(4-chloro-2,5-dioxo-1-phenyl-2,5-dihydro-1H-pyrrol-3-yl)piperidine-4-carboxylate[2]

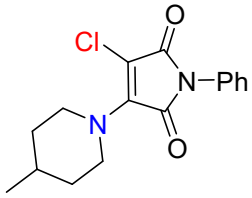


3d

Following the general procedure, using (petroleum ether : EtOAc = 9 : 1) as the eluant afforded a yellow liquid (54.3 mg, 78% yield). **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.45-7.41 (m, 2H), 7.36-7.30

(m, 3H), 4.59 (dt, *J* = 13.6, 4.2 Hz, 2H), 3.71 (s, 3H), 3.39-3.32 (m, 2H), 2.68-2.61 (m, 1H), 2.08-2.02 (m, 2H), 1.94-1.85 (m, 2H); **^{13}C NMR** (100 MHz, $CDCl_3$): δ 174.3, 165.4, 164.7, 141.3, 131.4, 129.2, 129.1, 127.8, 126.3, 126.2, 95.5, 52.1, 47.9, 40.3, 28.7; **HRMS** (ESI): calcd for $C_{17}H_{18}ClN_2O_4$ $[M + H]^+$ 349.0955, found 349.0954.

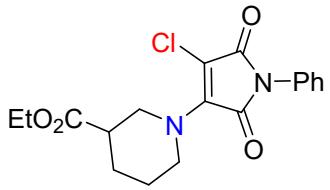
3-chloro-4-(4-methylpiperidin-1-yl)-1-phenyl-1H-pyrrole-2,5-dione[2]



3e

Following the general procedure, using (petroleum ether : EtOAc = 9 : 1) as the eluant afforded a yellow liquid (51.6 mg, 85% yield). **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.45-7.41 (m, 2H), 7.35-7.31 (m, 3H), 4.76 (dt, *J* = 13.5, 2.4 Hz, 2H), 3.10 (td, *J* = 12.9, 2.5 Hz, 2H), 1.82-1.65 (m, 3H), 1.40-1.30 (m, 2H), 0.99 (d, *J* = 6.5 Hz, 3H); **^{13}C NMR** (100 MHz, $CDCl_3$): δ 165.7, 164.8, 141.6, 131.6, 129.1, 127.8, 126.4, 94.3, 49.1, 35.0, 30.8, 21.8; **HRMS** (ESI): calcd for $C_{16}H_{17}ClN_2NaO_2$ $[M + Na]^+$ 327.0876, found 327.0881.

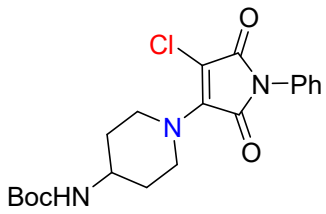
ethyl 1-(4-chloro-2,5-dioxo-1-phenyl-2,5-dihydro-1H-pyrrol-3-yl)piperidine-3-carboxylate



3f

Following the general procedure, using (petroleum ether : EtOAc = 9 : 1) as the eluant afforded a yellow liquid (55.7 mg, 77% yield). **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.44-7.40 (m, 2H), 7.34-7.30 (m, 3H), 4.60-4.55 (m, 1H), 4.39-4.33 (m, 1H), 4.15 (q, *J* = 7.1 Hz, 2H), 3.62 (dd, *J* = 13.6, 9.4 Hz, 1H), 3.40 (ddd, *J* = 13.3, 10.1, 2.9 Hz, 1H), 2.69 (tt, *J* = 9.7, 4.0 Hz, 1H), 2.14-2.08 (m, 1H), 1.91-1.78 (m, 1H), 1.75-1.66 (m, 1H), 1.25 (t, *J* = 7.1 Hz, 3H); **^{13}C NMR** (125 MHz, $CDCl_3$): δ 172.7, 165.4, 164.7, 141.5, 131.5, 129.1, 127.8, 126.3, 95.7, 60.9, 50.2, 49.1, 42.0, 27.0, 25.1, 14.2; **HRMS** (ESI): calcd for $C_{18}H_{19}N_2O_4NaCl$ $[M + Na]^+$ 385.0931, found 385.0936.

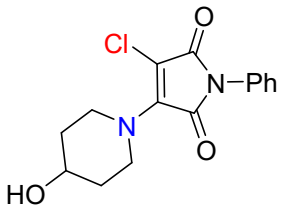
tert-butyl (1-(4-chloro-2,5-dioxo-1-phenyl-2,5-dihydro-1H-pyrrol-3-yl)piperidin-4-yl)carbamate[2]



3g

Following the general procedure, using (petroleum ether : EtOAc = 9 : 1) as the eluant afforded a yellow solid (56.7 mg, 70% yield), Mp = 158-159℃. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.45-7.41 (m, 2H), 7.36-7.29 (m, 3H), 4.67 (d, *J* = 13.5 Hz, 2H), 4.51 (d, *J* = 8.0 Hz, 1H), 3.78 (brs, 1H), 3.26 (ddd, *J* = 14.2, 11.6, 2.3 Hz, 2H), 2.09 (dd, *J* = 13.2, 3.8 Hz, 2H), 1.51 (dt, *J* = 4.4, 2.5 Hz, 2H), 1.45 (s, 9H); **^{13}C NMR** (125 MHz, $CDCl_3$): δ 165.5, 164.7, 155.2, 141.3, 131.5, 129.1, 127.9, 126.3, 79.9, 47.6, 47.4, 33.2, 28.5; **HRMS** (ESI): calcd for $C_{20}H_{24}ClN_3NaO_4$ $[M + Na]^+$ 428.1353, found 428.1353.

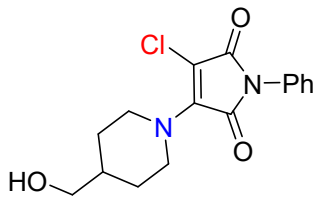
3-chloro-4-(4-hydroxypiperidin-1-yl)-1-phenyl-1H-pyrrole-2,5-dione



3h

Following the general procedure, using (petroleum ether : EtOAc = 9 : 1) as the eluant afforded a yellow liquid (50.8 mg, 83% yield). **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.47-7.42 (m, 2H), 7.36-7.30 (m, 3H), 4.31 (ddd, *J* = 13.4, 7.1, 3.7 Hz, 2H), 4.02 (tt, *J* = 7.8, 3.8 Hz, 1H), 3.71 (ddd, *J* = 13.7, 8.5, 3.4 Hz, 2H), 2.07-2.00 (m, 2H), 1.71 (dtd, *J* = 12.2, 8.1, 3.6 Hz, 3H); **^{13}C NMR** (125 MHz, $CDCl_3$): δ 165.6, 164.8, 141.4, 131.5, 129.1, 127.9, 126.4, 95.2, 66.3, 45.8, 34.9; **HRMS** (ESI): calcd for $C_{15}H_{15}N_2O_3NaCl$ $[M + Na]^+$ 329.0669, found 329.0673.

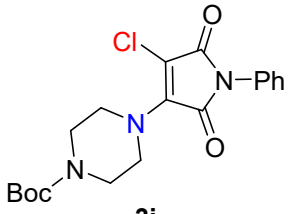
3-chloro-4-(4-(hydroxymethyl)piperidin-1-yl)-1-phenyl-1H-pyrrole-2,5-dione



3i

Following the general procedure, using (petroleum ether : EtOAc = 9 : 1) as the eluant afforded a yellow liquid (51.8 mg, 81% yield). **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.46-7.41 (m, 2H), 7.36-7.30 (m, 3H), 4.83 (dt, *J* = 13.4, 2.4 Hz, 2H), 3.55 (d, *J* = 6.1 Hz, 2H), 3.16-3.09 (m, 2H), 1.92-1.87 (m, 2H), 1.66 (brs, 2H), 1.48-1.38 (m, 2H); **^{13}C NMR** (125 MHz, $CDCl_3$): δ 165.7, 164.8, 141.5, 131.5, 129.1, 127.8, 126.4, 94.8, 67.3, 48.8, 38.3, 29.6; **HRMS** (ESI): calcd for $C_{16}H_{17}N_2O_3NaCl$ $[M + Na]^+$ 343.0825, found 343.0828.

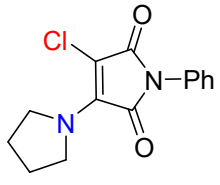
tert-butyl 4-(4-chloro-2,5-dioxo-1-phenyl-2,5-dihydro-1H-pyrrol-3-yl)piperazine-1-carboxylate[2]



3j

Following the general procedure, using (petroleum ether : EtOAc = 9 : 1) as the eluant afforded a yellow solid (61.8 mg, 79% yield), Mp = 202-203℃. **^{1}H NMR** (500 MHz, $CDCl_3$): δ 7.46-7.42 (m, 2H), 7.37-7.30 (m, 3H), 3.96 (t, *J* = 5.2 Hz, 4H), 3.58 (t, *J* = 5.2 Hz, 4H), 1.49 (s, 9H); **^{13}C NMR** (100 MHz, $CDCl_3$): δ 165.3, 164.7, 154.5, 141.0, 131.3, 129.2, 128.0, 126.4, 96.5, 80.7, 55.8, 48.1, 28.5; **HRMS** (ESI): calcd for $C_{19}H_{22}ClN_3NaO_4$ $[M + Na]^+$ 414.1197, found 414.1190.

3-chloro-1-phenyl-4-(pyrrolidin-1-yl)-1H-pyrrole-2,5-dione[2]

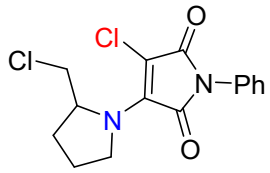


3k

Following the general procedure, using (petroleum ether : EtOAc = 9 : 1) as the eluant afforded a yellow solid (50.2 mg, 91% yield), Mp = 117-118℃. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.45-7.41 (m, 2H), 7.34-7.30 (m, 3H), 4.01-3.97 (m, 4H), 1.97-1.94 (m, 4H); **^{13}C NMR** (125 MHz, $CDCl_3$):

δ 166.3, 164.2, 140.4, 131.8, 129.0, 127.6, 126.3, 90.7, 50.7, 25.3; **HRMS** (ESI): calcd for $C_{14}H_{14}ClN_2O_2$ $[M + H]^+$ 277.0744, found 277.0742.

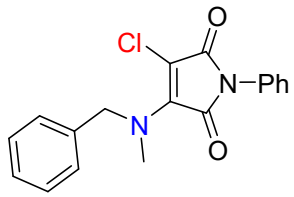
3-chloro-4-(2-(chloromethyl)pyrrolidin-1-yl)-1-phenyl-1H-pyrrole-2,5-dione



3l

Following the general procedure, using (petroleum ether : EtOAc = 9 : 1) as the eluant afforded a yellow solid (53.1 mg, 82% yield), Mp = 117-118℃. **^{1}H NMR** (500 MHz, $CDCl_3$): δ 7.46-7.42 (m, 2H), 7.36-7.32 (m, 3H), 5.02-4.98 (m, 1H), 4.19 (ddd, *J* = 10.6, 6.9, 3.6 Hz, 1H), 3.95-3.90 (m, 1H), 3.71 (dd, *J* = 10.9, 3.1 Hz, 1H), 3.48 (dd, *J* = 10.9, 8.5 Hz, 1H), 2.22-2.16 (m, 1H), 2.09-1.99 (m, 3H), 1.61 (brs, 1H); **^{13}C NMR** (125 MHz, $CDCl_3$): δ 165.8, 164.3, 139.5, 131.5, 129.1, 127.9, 126.3, 93.4, 60.7, 51.4, 45.7, 28.1, 22.9; **HRMS** (ESI): calcd for $C_{15}H_{14}N_2O_2NaCl_2$ $[M + Na]^+$ 347.0330, found 347.0333.

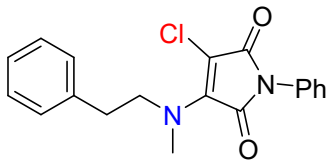
3-(benzyl(methyl)amino)-4-chloro-1-phenyl-1H-pyrrole-2,5-dione[2]



3m

Following the general procedure, using (petroleum ether : EtOAc = 9 : 1) as the eluant afforded a yellow liquid (54.7 mg, 84% yield). **^{1}H NMR** (500 MHz, $CDCl_3$): δ 7.46-7.43 (m, 2H), 7.41-7.38 (m, 2H), 7.36-7.33 (m, 4H), 7.32-7.30 (m, 2H), 5.02 (s, 2H), 3.36 (s, 3H); **^{13}C NMR** (125 MHz, $CDCl_3$): δ 165.6, 164.5, 141.7, 136.3, 131.4, 129.0, 128.9, 127.9, 127.7, 127.6, 126.3, 94.1, 56.4, 39.3; **HRMS** (ESI): calcd for $C_{18}H_{16}ClN_2O_2$ $[M + H]^+$ 327.0900, found 327.0907

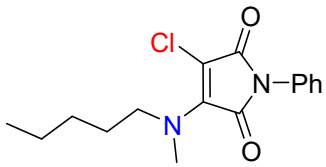
3-chloro-4-(methyl(phenethyl)amino)-1-phenyl-1H-pyrrole-2,5-dione



3n

Following the general procedure, using (petroleum ether : EtOAc = 9 : 1) as the eluant afforded a yellow solid (52.3 mg, 77% yield), Mp = 117-118℃. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.46-7.42 (m, 2H), 7.35-7.24 (m, 8H), 4.00 (t, *J* = 7.5 Hz, 2H), 3.41 (s, 3H), 2.99 (t, *J* = 7.7 Hz, 2H); **^{13}C NMR** (125 MHz, $CDCl_3$): δ 165.7, 164.5, 141.5, 137.9, 131.6, 129.1, 128.8, 127.8, 127.0, 126.4, 93.4, 55.5, 40.5, 35.2; **HRMS** (ESI): calcd for $C_{19}H_{17}N_2O_2NaCl$ $[M + Na]^+$ 363.0876, found 363.0881.

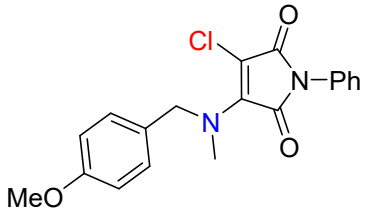
3-chloro-4-(methyl(pentyl)amino)-1-phenyl-1H-pyrrole-2,5-dione[2]



3o

Following the general procedure, using (petroleum ether : EtOAc = 9 : 1) as the eluant afforded a yellow liquid (54.4 mg, 89% yield). **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.45-7.41 (m, 2H), 7.35-7.31 (m, 3H), 3.73 (t, *J* = 7.84 Hz, 2H), 3.43 (s, 3H), 1.73-1.67 (m, 2H), 1.38-1.30 (m, 4H), 0.92 (t, *J* = 6.9 Hz, 3H); **^{13}C NMR** (125 MHz, $CDCl_3$): δ 165.9, 164.5, 141.5, 131.6, 129.1, 127.8, 126.4, 92.3, 54.0, 40.1, 28.7, 28.4, 22.6, 14.1; **HRMS** (ESI): calcd for $C_{16}H_{20}ClN_2O_2$ $[M + H]^+$ 307.1213, found 307.1219.

3-chloro-4-((4-methoxybenzyl)(methyl)amino)-1-phenyl-1H-pyrrole-2,5-dione

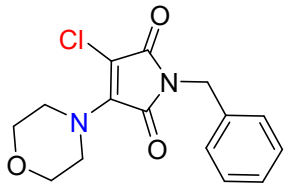


3p

Following the general procedure, using (petroleum ether : EtOAc = 9 : 1) as the eluant afforded a yellow liquid (53.4 mg, 75% yield). **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.46-7.42 (m, 2H), 7.36-7.31

(m, 3H), 7.26-7.22 (m, 2H), 6.91 (d, *J* = 8.6 Hz, 2H), 4.94 (s, 2H), 3.81 (s, 3H), 3.32 (s, 3H); **^{13}C NMR** (125 MHz, $CDCl_3$): δ 165.7, 164.7, 159.5, 141.8, 131.6, 129.2, 129.1, 128.3, 127.8, 126.4, 114.4, 93.9, 55.9, 55.4, 39.1; **HRMS** (ESI): calcd for $C_{19}H_{17}N_2O_3NaCl$ $[M + Na]^+$ 379.0825, found 379.0828.

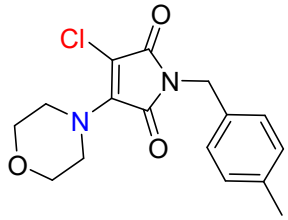
1-benzyl-3-chloro-4-morpholino-1H-pyrrole-2,5-dione[2]



4a

Following the general procedure, using (petroleum ether : EtOAc = 9 : 1) as the eluant afforded a yellow liquid (52.0 mg, 85% yield). **^{1}H NMR** (500 MHz, $CDCl_3$): δ 7.35-7.25 (m, 5H), 4.64 (s, 2H), 3.95 (t, *J* = 4.45 Hz, 4H), 3.77 (t, *J* = 4.65 Hz, 4H); **^{13}C NMR** (125 MHz, $CDCl_3$): δ 166.2, 165.5, 141.0, 136.3, 128.8, 128.7, 128.0, 95.3, 67.1, 48.3, 41.9; **HRMS** (ESI): calcd for $C_{15}H_{15}ClN_2NaO_3$ $[M + Na]^+$ 329.0669, found 329.0667.

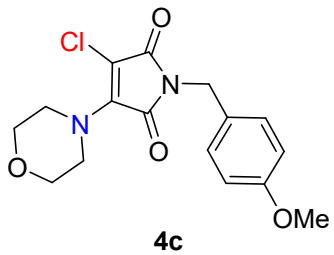
3-chloro-1-(4-methylbenzyl)-4-morpholino-1H-pyrrole-2,5-dione[2]



4b

Following the general procedure, using (petroleum ether : EtOAc = 9 : 1) as the eluant afforded a yellow solid (55.7 mg, 87% yield), Mp = 128-129℃. **^{1}H NMR** (500 MHz, $CDCl_3$): δ 7.24 (d, *J* = 7.8 Hz, 2H), 7.12 (d, *J* = 7.8 Hz, 2H), 4.59 (s, 2H), 3.94 (t, *J* = 4.45 Hz, 4H), 3.76 (t, *J* = 4.65 Hz, 4H), 2.31 (s, 3H); **^{13}C NMR** (125 MHz, $CDCl_3$): δ 166.2, 165.5, 141.0, 137.7, 133.3, 129.4, 128.7, 95.2, 67.0, 48.3, 41.6, 21.2; **HRMS** (ESI): calcd for $C_{16}H_{17}ClN_2NaO_3$ $[M + Na]^+$ 343.0825, found 343.0822.

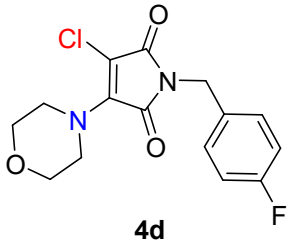
3-chloro-1-(4-methoxybenzyl)-4-morpholino-1H-pyrrole-2,5-dione[2]



4c

Following the general procedure, using (petroleum ether : EtOAc = 9 : 1) as the eluant afforded a yellow liquid (53.8 mg, 80% yield). **^{1}H NMR** (500 MHz, $CDCl_3$): δ 7.29 (d, *J* = 8.7 Hz, 2H), 6.83 (d, *J* = 7.7 Hz, 2H), 4.57 (s, 2H), 3.94 (t, *J* = 4.80 Hz, 4H), 3.77-3.75 (m, 7H); **^{13}C NMR** (125 MHz, $CDCl_3$): δ 166.2, 165.5, 159.3, 141.0, 130.2, 128.5, 114.1, 95.2, 67.0, 55.4, 48.3, 41.3; **HRMS** (ESI): calcd for $C_{16}H_{17}ClN_2NaO_4$ $[M + Na]^+$ 379.0837, found 379.0827.

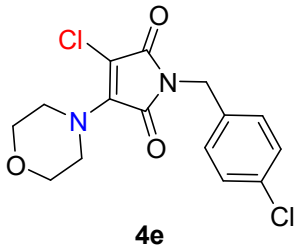
3-chloro-1-(4-fluorobenzyl)-4-morpholino-1H-pyrrole-2,5-dione[2]



4d

Following the general procedure, using (petroleum ether : EtOAc = 9 : 1) as the eluant afforded a yellow liquid (53.1 mg, 82% yield). **^{1}H NMR** (500 MHz, $CDCl_3$): δ 7.35-7.32 (m, 2H), 6.99 (t, *J* = 8.6 Hz, 2H), 4.60 (s, 2H), 3.96 (t, *J* = 4.70 Hz, 4H), 3.78 (t, *J* = 4.85 Hz, 4H); **^{13}C NMR** (125 MHz, $CDCl_3$): δ 166.1, 165.4, 162.5 (d, *J* = 246.5 Hz), 141.0, 132.1 (d, *J* = 3.4 Hz), 130.6 (d, *J* = 8.1 Hz), 115.6 (d, *J* = 21.8 Hz), 95.2, 67.1, 48.3, 41.2; **^{19}F NMR** (375 MHz, $CDCl_3$): δ -114.2 (s, 1F); **HRMS** (ESI): calcd for $C_{15}H_{14}ClFN_2NaO_3$ $[M + Na]^+$ 347.0575, found 347.0572.

3-chloro-1-(4-chlorobenzyl)-4-morpholino-1H-pyrrole-2,5-dione[2]

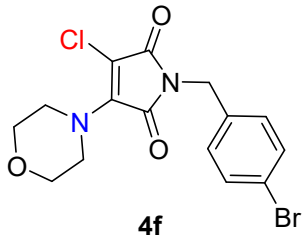


4e

Following the general procedure, using (petroleum ether : EtOAc = 9 : 1) as the eluant afforded a yellow solid (53.7 mg, 79% yield), Mp = 76-77℃. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.29-7.26 (m,

4H), 4.60 (s, 2H), 3.96 (t, *J* = 4.70 Hz, 4H), 3.78 (t, *J* = 4.85 Hz, 4H); **^{13}C NMR** (100 MHz, $CDCl_3$): δ 166.1, 165.4, 141.0, 134.7, 134.0, 130.2, 129.0, 95.2, 67.1, 48.3, 41.2; **HRMS** (ESI): calcd for $C_{15}H_{15}Cl_2N_2O_3$ $[M + H]^+$ 341.0460, found 341.0458.

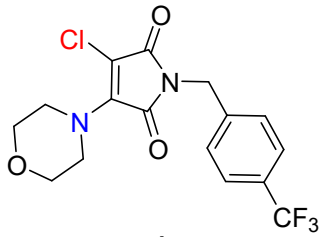
1-(4-bromobenzyl)-3-chloro-4-morpholino-1H-pyrrole-2,5-dione[2]



4f

Following the general procedure, using (petroleum ether : EtOAc = 9 : 1) as the eluant afforded a yellow solid (59.1 mg, 77% yield), Mp = 130-131℃. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.43 (d, *J* = 8.5 Hz, 2H), 7.23 (d, *J* = 8.4 Hz, 2H), 4.58 (s, 2H), 3.96 (t, J = 4.70 Hz, 4H), 3.78 (t, J = 4.85 Hz, 4H); **^{13}C NMR** (125 MHz, $CDCl_3$): δ 166.0, 165.4, 141.0, 135.2, 131.9, 130.6, 130.5, 122.1, 95.2, 67.1, 48.4, 41.3; **HRMS** (ESI): calcd for $C_{15}H_{14}BrClN_2NaO_3$ $[M + Na]^+$ 406.9774, found 406.9774.

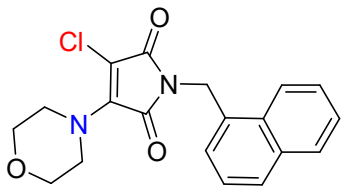
3-chloro-4-morpholino-1-(4-(trifluoromethyl)benzyl)-1H-pyrrole-2,5-dione[2]



4g

Following the general procedure, using (petroleum ether : EtOAc = 9 : 1) as the eluant afforded a yellow solid (53.8 mg, 72% yield), Mp = 110-111℃. **^{1}H NMR** (500 MHz, $CDCl_3$): δ 7.58 (d, *J* = 8.0 Hz, 2H), 7.46 (d, *J* = 8.0 Hz, 2H), 4.69 (s, 2H), 3.97 (t, J = 4.75 Hz, 4H), 3.78 (t, J = 4.85 Hz, 4H); **^{13}C NMR** (125 MHz, $CDCl_3$): δ 166.0, 165.4, 141.1, 140.1, 130.3 (q, *J* = 32.4 Hz), 129.0, 125.8 (q, *J* = 3.9 Hz), 124.1 (q, *J* = 272.2 Hz), 95.2, 67.1, 48.4, 41.4; **^{19}F NMR** (375 MHz, $CDCl_3$): δ -62.7; **HRMS** (ESI): calcd for $C_{16}H_{14}ClF_3N_2NaO_3$ $[M + Na]^+$ 397.0543, found 397.0537.

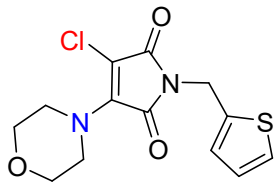
3-chloro-4-morpholino-1-(naphthalen-1-ylmethyl)-1H-pyrrole-2,5-dione[2]



4h

Following the general procedure, using (petroleum ether : EtOAc = 9 : 1) as the eluant afforded a yellow liquid (59.1 mg, 83% yield). **^{1}H NMR** (500 MHz, $CDCl_3$): δ 8.28 (d, *J* = 8.5 Hz, 1H), 7.85 (d, *J* = 8.1 Hz, 1H), 7.80 (d, *J* = 8.2 Hz, 1H), 7.59-7.55 (m, 2H), 7.50 (t, *J* = 7.5 Hz, 1H), 7.43 (t, *J* = 7.6 Hz, 1H), 5.10 (s, 2H), 3.91-3.89 (m, 4H), 3.74-3.71 (m, 4H); **^{13}C NMR** (125 MHz, $CDCl_3$): δ 166.2, 165.6, 140.9, 133.8, 131.4, 131.2, 128.8, 127.7, 126.6, 125.9, 125.3, 123.5, 95.1, 66.9, 48.2, 39.8; **HRMS** (ESI): calcd for $C_{19}H_{17}ClN_2NaO_3$ $[M + Na]^+$ 379.0825, found 379.0826.

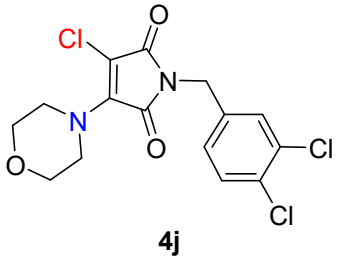
3-chloro-4-morpholino-1-(thiophen-2-ylmethyl)-1H-pyrrole-2,5-dione[2]



4i

Following the general procedure, using (petroleum ether : EtOAc = 9 : 1) as the eluant afforded a yellow solid (49.9 mg, 80% yield), Mp = 129-130℃. **^{1}H NMR** (500 MHz, $CDCl_3$): δ 7.20 (d, *J* = 5.2 Hz, 1H), 7.05 (d, *J* = 3.5 Hz, 1H), 6.91 (t, *J* = 4.4 Hz, 1H), 4.80 (s, 2H), 3.94 (t, J = 4.75 Hz, 4H), 3.76 (t, J = 4.85 Hz, 4H); **^{13}C NMR** (125 MHz, $CDCl_3$): δ 165.6, 165.1, 141.0, 137.9, 127.8, 126.9, 125.9, 95.2, 67.0, 48.3, 35.9; **HRMS** (ESI): calcd for $C_{13}H_{13}ClN_2NaO_3S$ $[M + Na]^+$ 335.0233, found 335.0242.

3-chloro-1-(3,4-dichlorobenzyl)-4-morpholino-1H-pyrrole-2,5-dione[2]

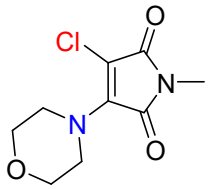


4j

Following the general procedure, using (petroleum ether : EtOAc = 9 : 1) as the eluant afforded a yellow solid (53.1 mg, 71% yield), Mp = 99-100℃. **^{1}H NMR** (500 MHz, $CDCl_3$): δ 7.42 (d, *J* =

2.1 Hz, 1H), 7.37 (d, *J* = 8.2 Hz, 1H), 7.19 (dd, *J* = 8.3, 2.1 Hz, 1H), 4.57 (s, 2H), 3.96 (t, J = 4.75 Hz, 4H), 3.78 (t, J = 4.85 Hz, 4H); **^{13}C NMR** (125 MHz, $CDCl_3$): δ 165.9, 165.3, 141.0, 136.3, 132.8, 132.3, 130.8, 130.7, 128.2, 95.1, 67.0, 48.4, 40.8; **HRMS** (ESI): calcd for $C_{15}H_{13}Cl_3N_2NaO_3$ $[M + Na]^+$ 396.9889, found 396.9885.

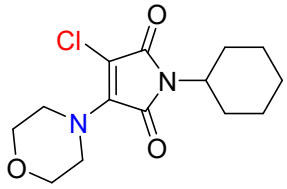
3-chloro-1-methyl-4-morpholino-1H-pyrrole-2,5-dione[2]



4k

Following the general procedure, using (petroleum ether : EtOAc = 9 : 1) as the eluant afforded a yellow liquid (38.6 mg, 84% yield). **^{1}H NMR** (500 MHz, $CDCl_3$): δ 3.93 (t, *J* = 4.65 Hz, 4H), 3.75 (t, *J* = 4.65 Hz, 4H), 2.95 (s, 3H); **^{13}C NMR** (125 MHz, $CDCl_3$): δ 166.5, 165.9, 141.1, 95.1, 67.0, 48.3, 24.1; **HRMS** (ESI): calcd for $C_9H_{12}ClN_2O_3$ $[M + H]^+$ 231.0536, found 231.0528.

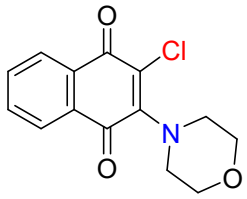
3-chloro-1-cyclohexyl-4-morpholino-1H-pyrrole-2,5-dione[2]



4l

Following the general procedure, using (petroleum ether : EtOAc = 9 : 1) as the eluant afforded a yellow solid (49.4 mg, 83% yield), Mp = 130-131℃. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 3.96-3.93 (m, 4H), 3.92-3.85 (m, 1H), 3.80-3.78 (m, 4H), 2.01 (qd, *J* = 12.4, 3.4 Hz, 2H), 1.84-1.78 (m, 2H), 1.68-1.62 (m, 3H), 1.36-1.13 (m, 3H); **^{13}C NMR** (100 MHz, $CDCl_3$): δ 166.4, 165.7, 140.6, 95.5, 67.1, 51.3, 48.3, 30.1, 26.1, 25.2; **HRMS** (ESI): calcd for $C_{14}H_{19}ClN_2NaO_3$ $[M + Na]^+$ 321.0982, found 321.0980.

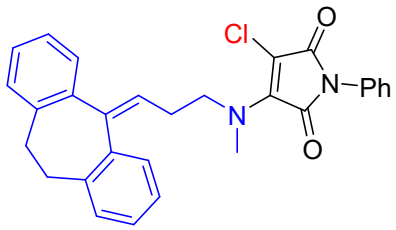
2-chloro-3-morpholinonaphthalene-1,4-dione



4m

Following the general procedure, using (petroleum ether : EtOAc = 9 : 1) as the eluant afforded a yellow liquid (47.1 mg, 85% yield). **^{1}H NMR** (400 MHz, $CDCl_3$): δ 8.08 (dd, *J* = 7.3, 1.7 Hz, 1H), 7.97 (dd, *J* = 7.3, 1.7 Hz, 1H), 7.71-7.63 (m, 2H), 3.85 (t, *J* = 4.4 Hz, 4H), 3.61 (t, *J* = 4.4 Hz, 4H); **^{13}C NMR** (125 MHz, $CDCl_3$): δ 181.8, 178.1, 149.7, 134.2, 133.3, 131.5, 131.4, 126.9, 126.7, 123.3, 67.6, 51.8; **HRMS** (ESI): calcd for $C_{14}H_{13}NO_3Cl$ $[M + H]^+$ 278.0584, found 278.0580.

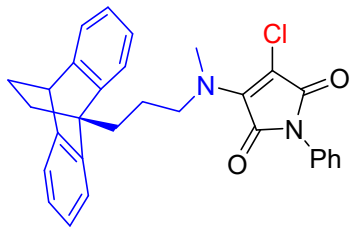
3-chloro-4-((3-(10,11-dihydro-5H-dibenzo[a,d][7]annulen-5-ylidene)propyl)(methyl)amino)-1-phenyl-1H-pyrrole-2,5-dione



5a

Following the general procedure, using (petroleum ether : EtOAc = 9 : 1) as the eluant afforded a yellow liquid (83.3 mg, 89% yield). **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.49-7.45 (m, 2H), 7.40-7.35 (m, 1H), 7.33-7.29 (m, 3H), 7.27-7.17 (m, 6H), 7.11-7.08 (m, 1H), 5.92 (t, *J* = 7.6 Hz, 1H), 3.88 (t, *J* = 7.3 Hz, 2H), 3.52-3.32 (m, 5H), 3.04-2.97 (m, 1H), 2.86-2.82 (m, 1H), 2.68-2.53 (m, 2H); **^{13}C NMR** (125 MHz, $CDCl_3$): δ 165.6, 164.4, 146.1, 141.3, 140.8, 139.6, 139.5, 137.2, 131.6, 130.2, 129.0, 128.5, 128.3, 128.1, 127.9, 127.7, 127.5, 126.4, 126.3, 126.2, 125.9, 93.0, 53.3, 40.1, 33.8, 32.1, 29.0, 27.0; **HRMS** (ESI): calcd for $C_{29}H_{25}N_2O_2NaCl$ $[M + Na]^+$ 491.1502, found 491.1503.

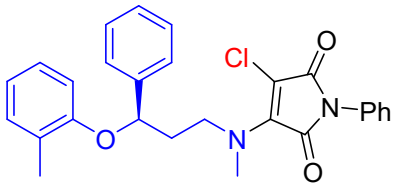
3-((3-((9r,10r)-9,10-ethanoanthracen-9(10H)-yl)propyl)(methyl)amino)-4-chloro-1-phenyl-1H-pyrrole-2,5-dione



5b

Following the general procedure, using (petroleum ether : EtOAc = 9 : 1) as the eluant afforded a yellow liquid (81.9 mg, 85% yield). **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.48-7.44 (m, 2H), 7.37-7.33 (m, 3H), 7.29-7.25 (m, 4H), 7.15-7.07 (m, 4H), 4.30 (t, *J* = 2.7 Hz, 1H), 4.06 (t, *J* = 7.8 Hz, 2H), 3.56 (s, 3H), 2.53-2.48 (m, 2H), 2.23-2.19 (m, 2H), 1.87-1.83 (m, 2H), 1.63-1.59 (m, 2H); **^{13}C NMR** (125 MHz, $CDCl_3$): δ 165.7, 164.4, 144.9, 144.9, 141.4, 131.5, 129.0, 127.8, 126.4, 125.4, 125.3, 123.5, 121.0, 92.8, 54.6, 44.6, 44.5, 40.2, 29.7, 27.6, 27.6, 24.3; **HRMS** (ESI): calcd for $C_{30}H_{27}N_2O_2NaCl$ $[M + Na]^+$ 505.1659, found 505.1663.

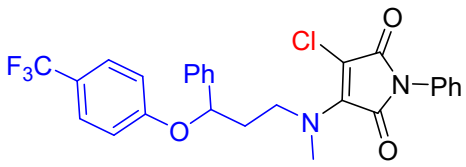
(R)-3-chloro-4-(methyl(3-phenyl-3-(o-tolyloxy)propyl)amino)-1-phenyl-1H-pyrrole-2,5-dione[2]



5c

Following the general procedure, using (petroleum ether : EtOAc = 9 : 1) as the eluant afforded a yellow liquid (75.4 mg, 82% yield). **^{1}H NMR** (500 MHz, $CDCl_3$): δ 7.44-7.40 (m, 2H), 7.37-7.32 (m, 5H), 7.28-7.24 (m, 3H), 7.13 (d, *J* = 7.8 Hz, 1H), 6.96 (t, *J* = 7.8 Hz, 1H), 6.80 (t, *J* = 7.4 Hz, 1H), 6.58 (d, *J* = 8.1 Hz, 6H), 5.28 (dd, *J* = 8.9, 3.8 Hz, 1H), 4.14-3.96 (m, 2H), 3.44 (s, 3H), 2.45-2.37 (m, 1H), 2.35 (s, 3H), 2.32-2.22 (m, 1H); **^{13}C NMR** (125 MHz, $CDCl_3$): δ 165.6, 164.4, 155.6, 141.5, 141.1, 131.5, 130.9, 129.0, 128.9, 127.9, 127.8, 126.9, 126.8, 126.4, 125.7, 120.7, 112.6, 93.3, 51.0, 40.2, 37.7, 16.7; **HRMS** (ESI): calcd for $C_{27}H_{25}ClN_2NaO_3$ $[M + Na]^+$ 483.1451, found 483.1447.

3-chloro-4-(methyl(3-phenyl-3-(4-(trifluoromethyl)phenoxy)propyl)amino)-1-phenyl-1H-pyrrole-2,5-dione[2]

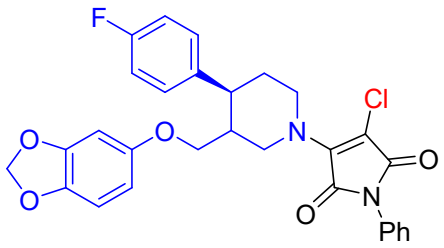


5d

Following the general procedure, using (petroleum ether : EtOAc = 9 : 1) as the eluant afforded a yellow liquid (77.1 mg, 75% yield). **^{1}H NMR** (500 MHz, $CDCl_3$): δ 7.43-7.39 (m, 4H), 7.35-7.32(m, 5H), 7.31-7.28 (m, 1H), 7.17 (d, *J* = 8.3 Hz, 2H), 6.88 (d, *J* = 8.5 Hz, 2H), 5.28 (dd, *J* = 9.2, 3.6 Hz, 1H), 4.09-3.99 (m, 2H), 3.45 (s, 3H), 2.43-2.36 (m, 1H), 2.28-2.19 (m, 1H); **^{13}C NMR** (125

MHz, $CDCl_3$): δ 165.5, 164.5, 160.1, 149.1, 141.5, 140.2, 131.4, 131.3, 129.1, 129.1, 128.4, 127.9, 127.0, 127.0, 126.4, 125.7, 115.7, 93.5, 78.1, 50.8, 40.2, 37.5, 27.1; **^{19}F NMR** (375 MHz, $CDCl_3$): δ -61.6 (s, 3F); **HRMS** (ESI): calcd for $C_{27}H_{22}ClF_3N_2NaO_3$ $[M + Na]^+$ 537.1169, found 537.1177.

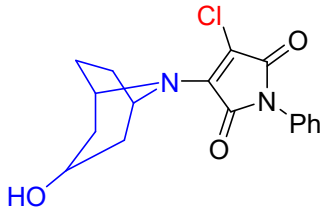
3-((4S)-3-((benzo[d][1,3]dioxol-5-yloxy)methyl)-4-(4-fluorophenyl)piperidin-1-yl)-4-chloro-1-phenyl-1H-pyrrole-2,5-dione



5e

Following the general procedure, using (petroleum ether : EtOAc = 9 : 1) as the eluant afforded a yellow liquid (84.4 mg, 79% yield). **^{1}H NMR** (500 MHz, $CDCl_3$): δ 7.49 (t, *J* = 7.8 Hz, 2H), 7.39 (dt, *J* = 6.2, 1.5 Hz, 3H), 7.22 (dd, *J* = 8.5, 5.4 Hz, 2H), 7.04 (t, *J* = 8.7 Hz, 2H), 6.68 (d, *J* = 8.4 Hz, 1H), 6.41 (d, *J* = 2.5 Hz, 1H), 6.19 (dd, *J* = 8.5, 2.5 Hz, 1H), 5.93 (s, 2H), 5.15 (ddd, *J* = 13.5, 3.9, 2.1 Hz, 1H), 5.06-5.00 (m, 1H), 3.71 (dd, *J* = 9.6, 2.7 Hz, 1H), 3.55 (dd, *J* = 9.6, 6.1 Hz, 1H), 3.27 (dd, *J* = 13.6, 11.1 Hz, 2H), 2.93 (td, *J* = 11.3, 5.0 Hz, 1H), 2.34-2.26 (m, 1H), 2.04-1.95 (m, 2H); **^{13}C NMR** (125 MHz, $CDCl_3$): δ 165.5, 164.7, 163.1, 160.6, 154.1, 148.3, 141.9, 141.2, 138.2, 138.2, 134.3, 131.5, 129.1, 128.9, 128.9, 127.8, 126.3, 126.1, 115.9, 115.7, 107.9, 105.6, 101.2, 98.1, 95.4, 68.3, 51.9, 49.3, 43.7, 43.1, 34.6; **^{19}F NMR** (375 MHz, $CDCl_3$): δ -115.5 (s, 1F); **HRMS** (ESI): calcd for $C_{29}H_{24}N_2O_5NaClF$ $[M + Na]^+$ 557.1255, found 557.1252.

3-chloro-4-((1R,5S)-3-hydroxy-8-azabicyclo[3.2.1]octan-8-yl)-1-phenyl-1H-pyrrole-2,5-dione



5f

Following the general procedure, using (petroleum ether : EtOAc = 9 : 1) as the eluant afforded a yellow liquid (58.4 mg, 88% yield). **^{1}H NMR** (500 MHz, $CDCl_3$): δ 7.48-7.44 (m, 2H), 7.37-7.34 (m, 3H), 5.42-5.30 (brs, 2H), 4.15-4.12 (m, 1H), 2.39-2.36 (m, 2H), 2.23-2.18 (m, 2H), 2.07-2.00

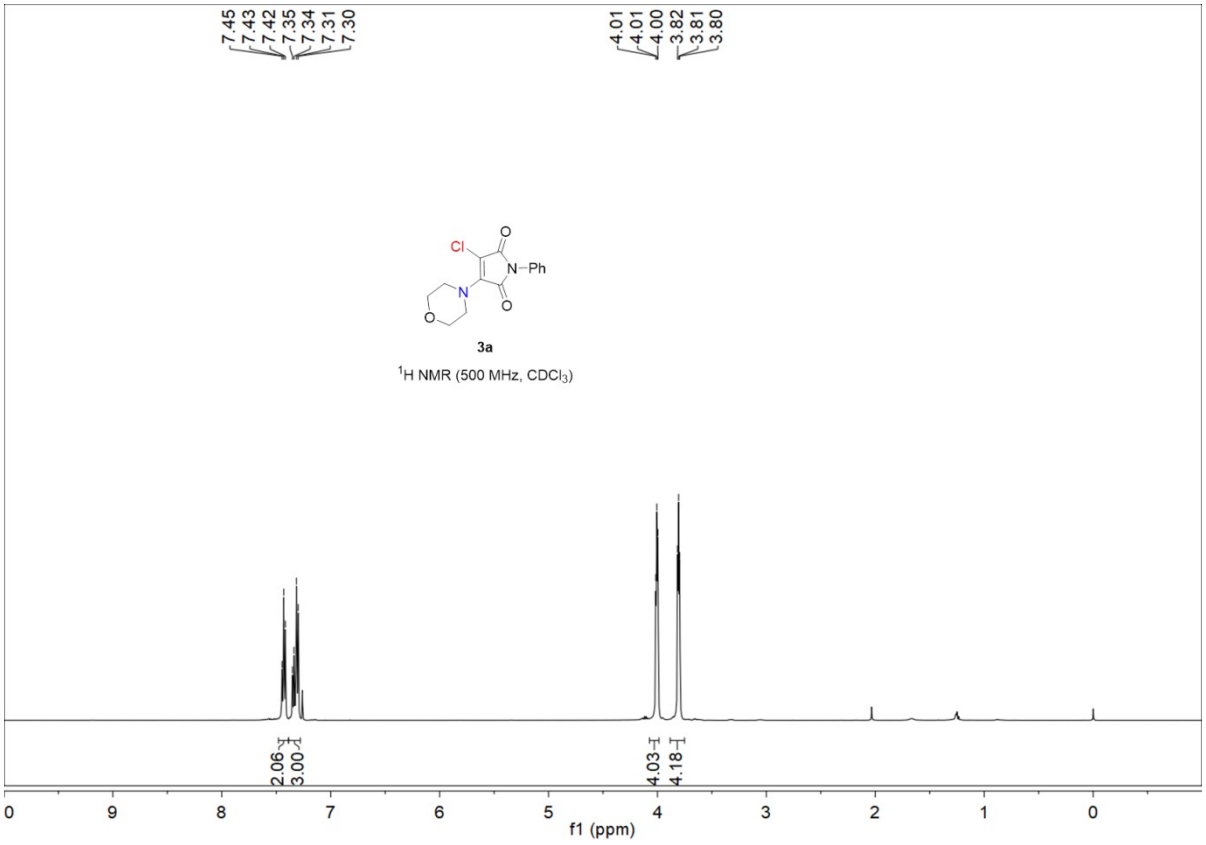
(m, 3H), 1.91 (d, J = 14.7 Hz, 2H); **^{13}C NMR** (125 MHz, $CDCl_3$): δ 166.1, 164.2, 138.4, 131.6, 129.0, 127.7, 126.3, 91.2, 64.4, 60.5, 55.5, 40.5, 27.2, 21.1, 14.3; **HRMS** (ESI): calcd for $C_{17}H_{17}N_2O_3NaCl$ $[M + Na]^+$ 355.0829, found 355.0825.

References:

(1) Galvis, C. E. P.; Kouznetsov, V. V. *Org. Biomol. Chem.* **2013**, *11*, 407-411.

(2) Zhou, X.; Yao, Y.; Wang, C.; Xu, Y.; Zhang, W.; Ma, Y.; Wu, G. *Org. Lett.* **2021**, *23*, 3669-3673.

^{1}H, ^{13}C and ^{19}F NMR spectra of product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7.43
7.42
7.35
7.34
7.31
7.30
4.01
4.01
4.00
3.82
3.81
3.80
Cl
O
N–Ph
N
O
O
3a
^{1}H NMR (500 MHz, $CDCl_3$)
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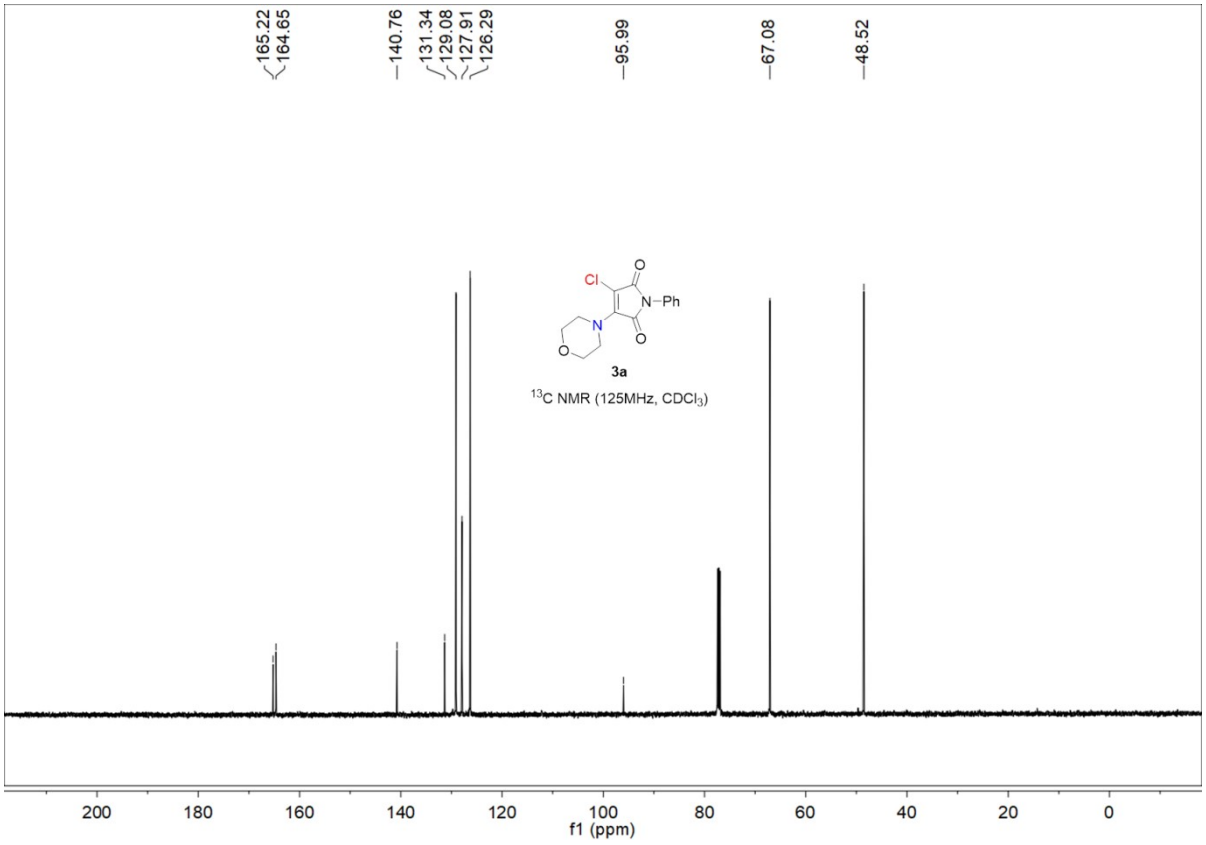
3.00
4.03
4.18
0
9
8
7
6
5
4
3
2
1
0
f1 (ppm)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95.99
67.08
48.52
Cl
O
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N
O
O
3a
^{13}C NMR (125MHz, $CDCl_3$)
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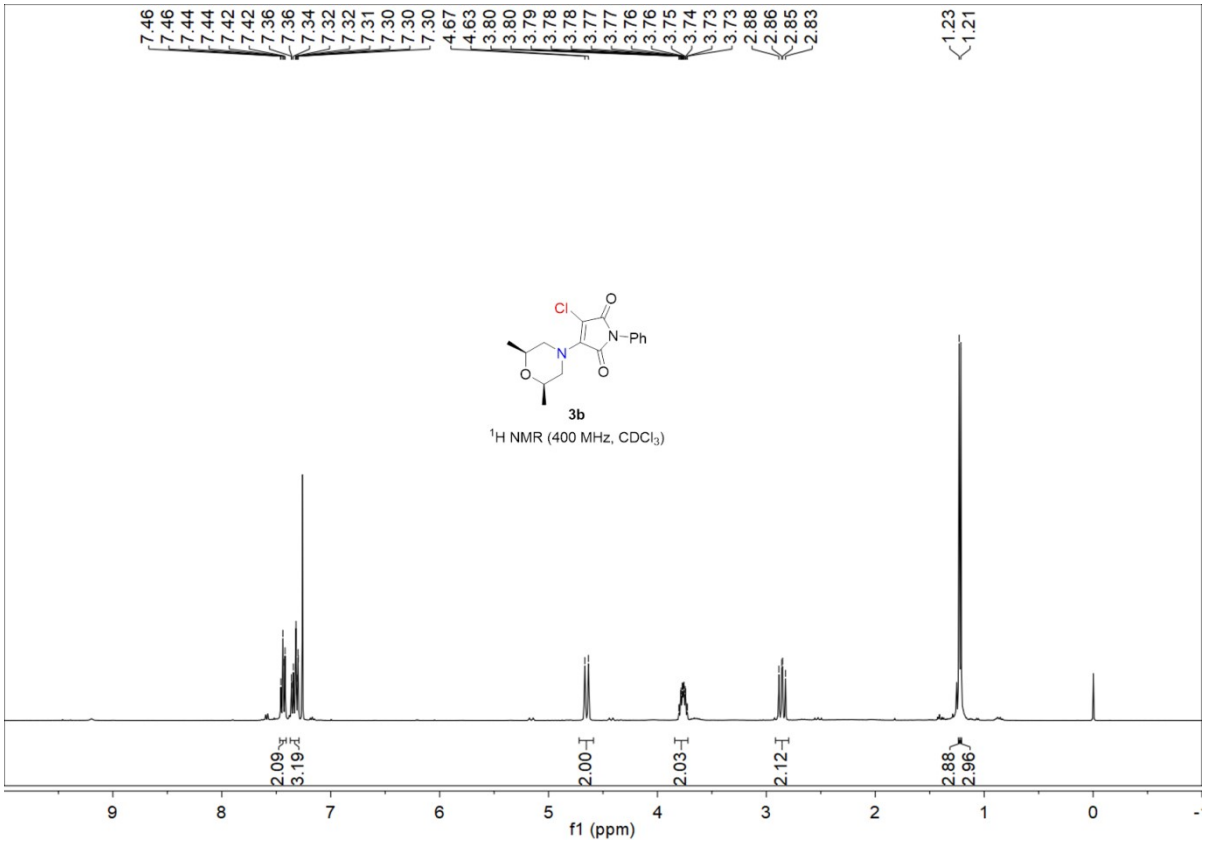
180
160
140
120
100
80
60
40
20
0
f1 (ppm)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7.46
7.44
7.44
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7.36
7.36
7.34
7.32
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7.31
7.30
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3.76
3.75
3.74
3.73
3.73
2.88
2.86
2.85
2.83
1.23
1.21
Cl
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N–Ph
N
O
O
3b
1H NMR (400 MHz, CDCl3)
2.09
3.19
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2.88
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5
4
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2
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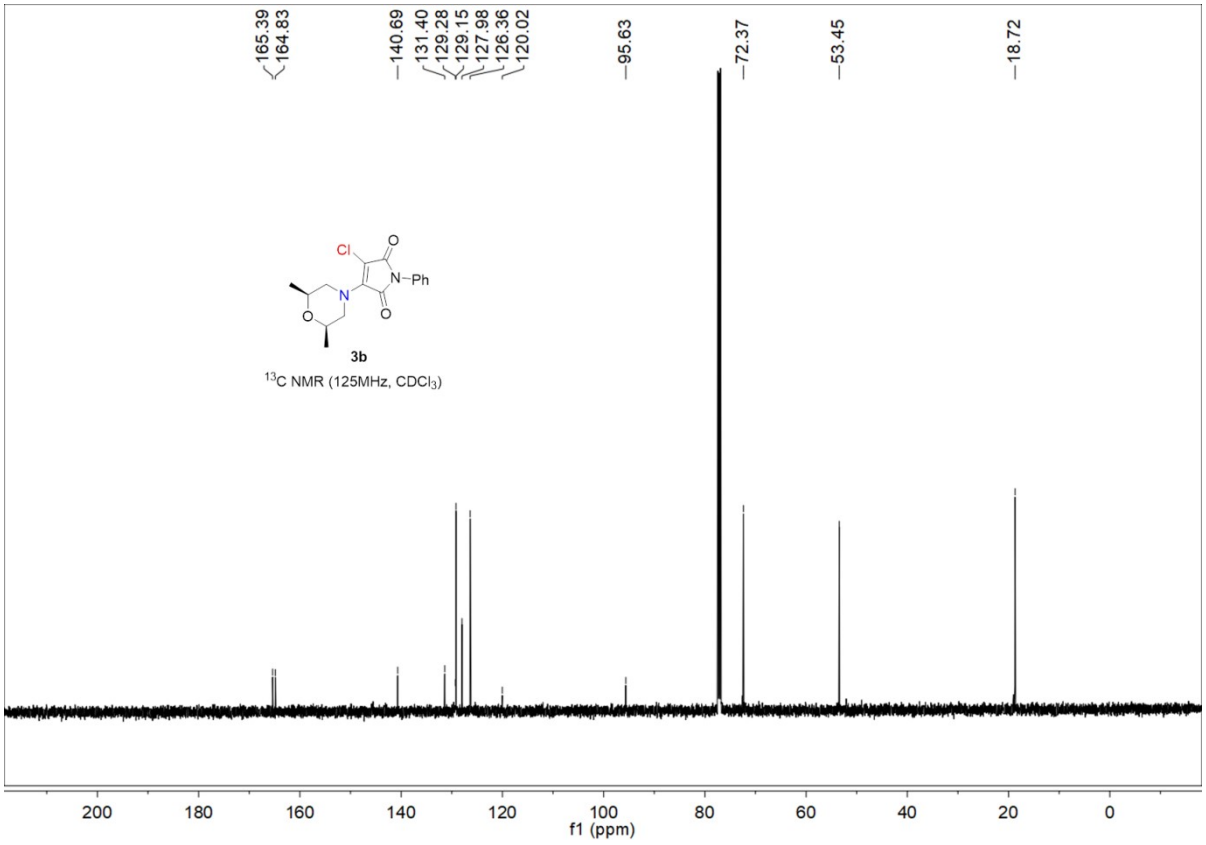
f1 (ppm)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140.69
131.40
129.28
129.15
127.98
126.36
120.02
95.63
72.37
53.45
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Cl
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N–Ph
N
O
O
3b
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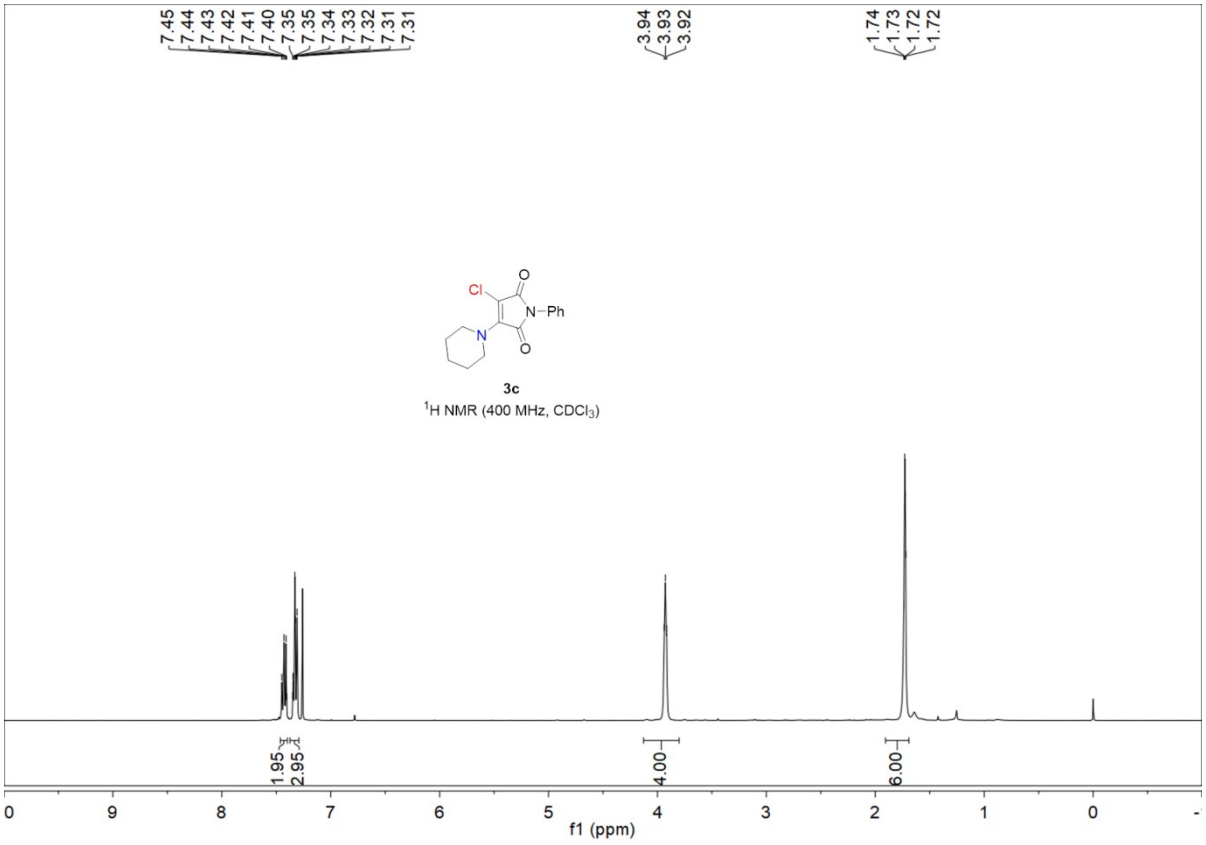
180
160
140
120
100
80
60
40
20
0
f1 (ppm)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7.44
7.43
7.42
7.41
7.40
7.35
7.35
7.34
7.33
7.32
7.31
7.31
3.94
3.93
3.92
1.74
1.73
1.72
1.72
Cl
O
N–Ph
N
O
3c
^{1}H NMR (400 MHz, $CDCl_3$)
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2.95
4.00
6.00
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9
8
7
6
5
4
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2
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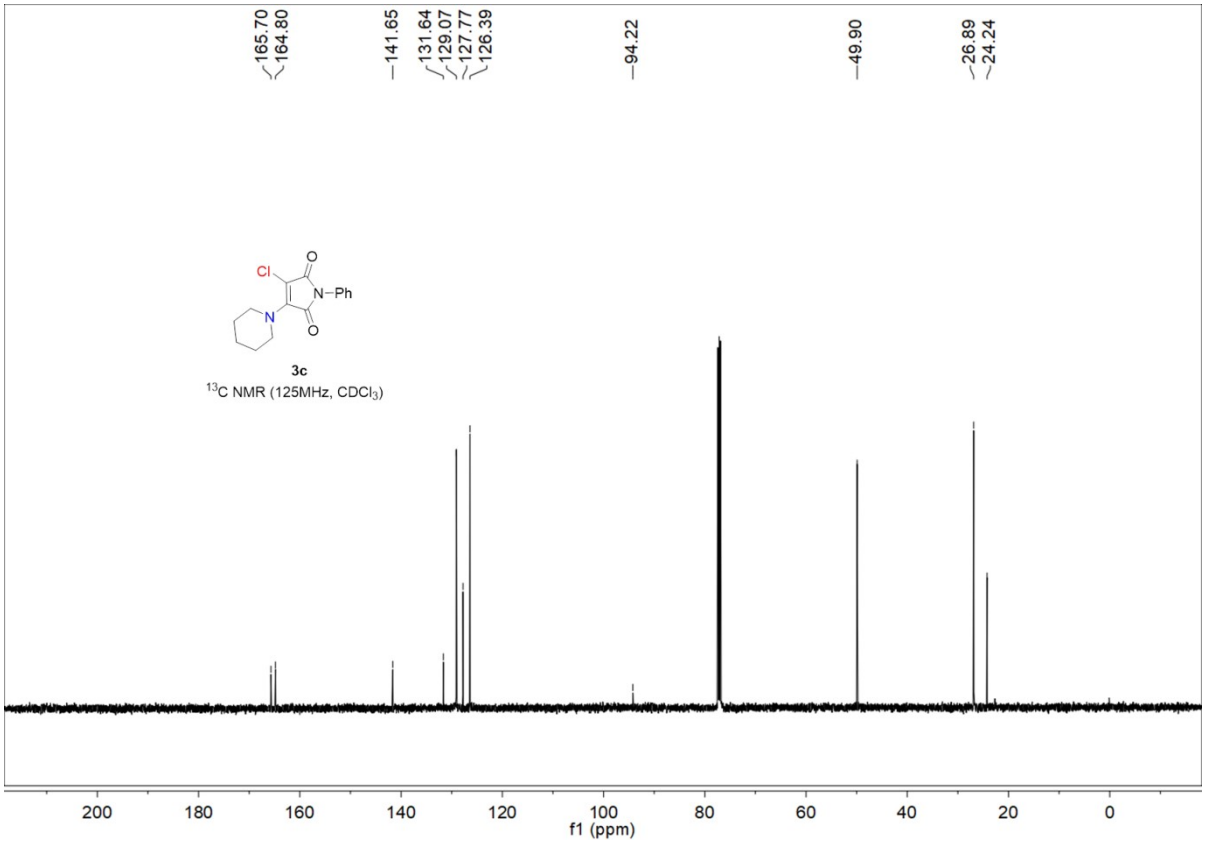
0
f1 (ppm)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141.65
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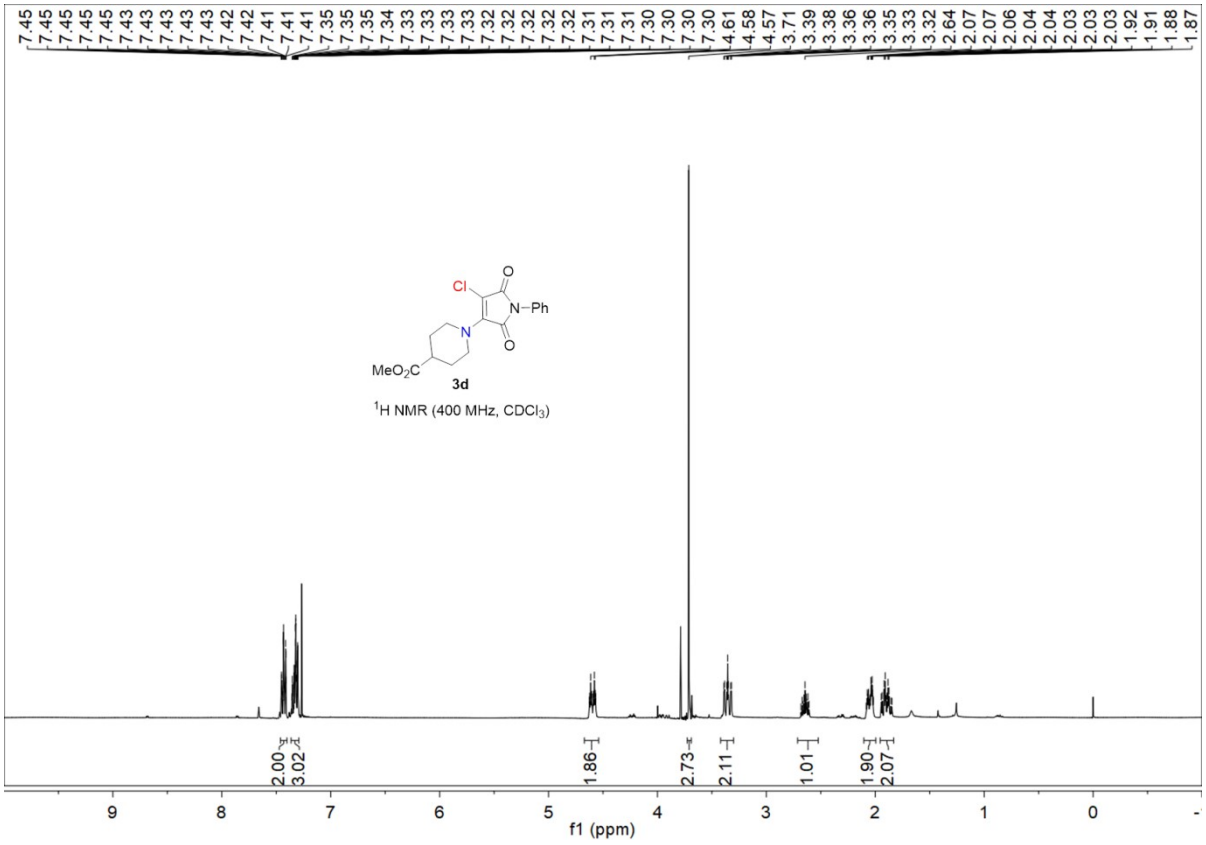
129.07
127.77
126.39
94.22
49.90
26.89
24.24
Cl
O
N–Ph
N
O
3c
^{13}C NMR (125MHz, $CDCl_3$)
200
180
160
140
120
100
80
60
40
20
0
f1 (ppm)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Cl
O
N–Ph
N
O
MeO2C
3d
1H NMR (400 MHz, CDCl3)
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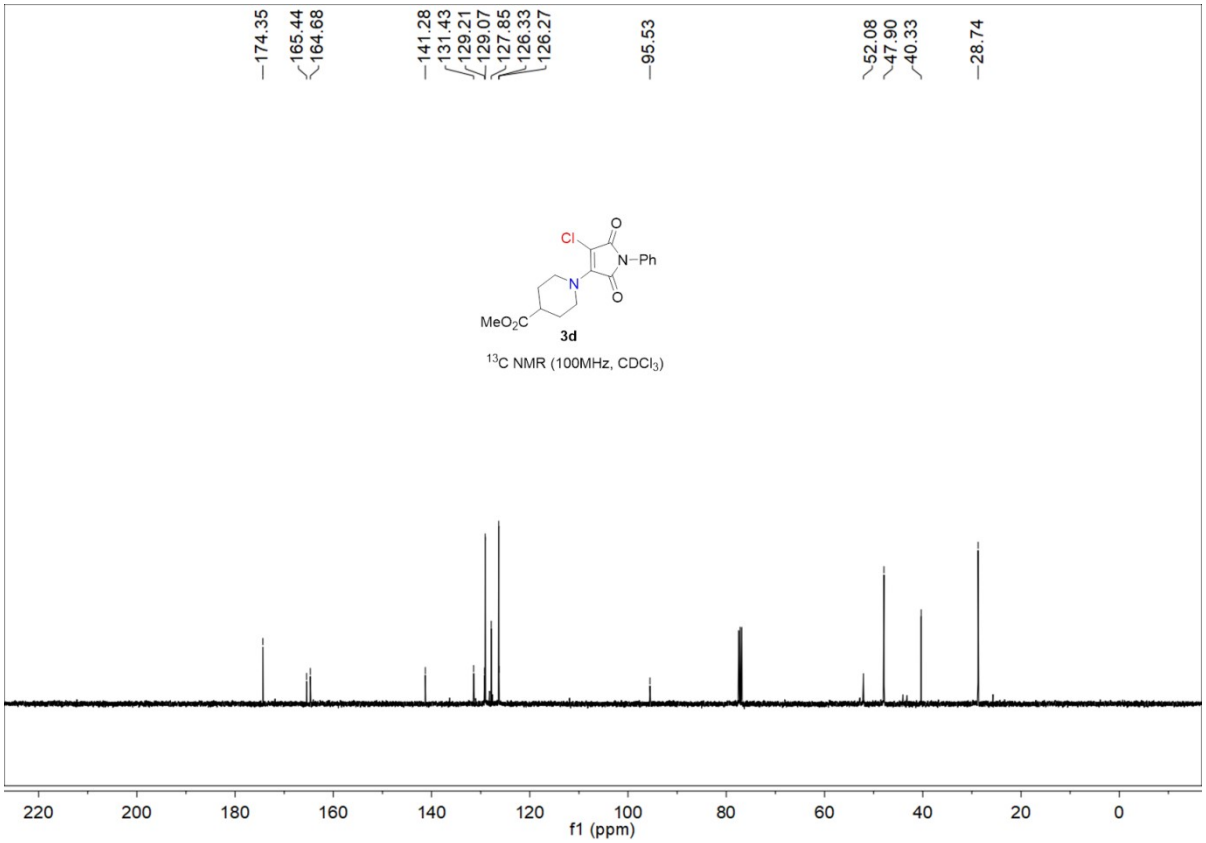
1.86
2.73
2.11
1.01
1.90
2.07
9 8 7 6 5 4 3 2 1 0
f1 (ppm)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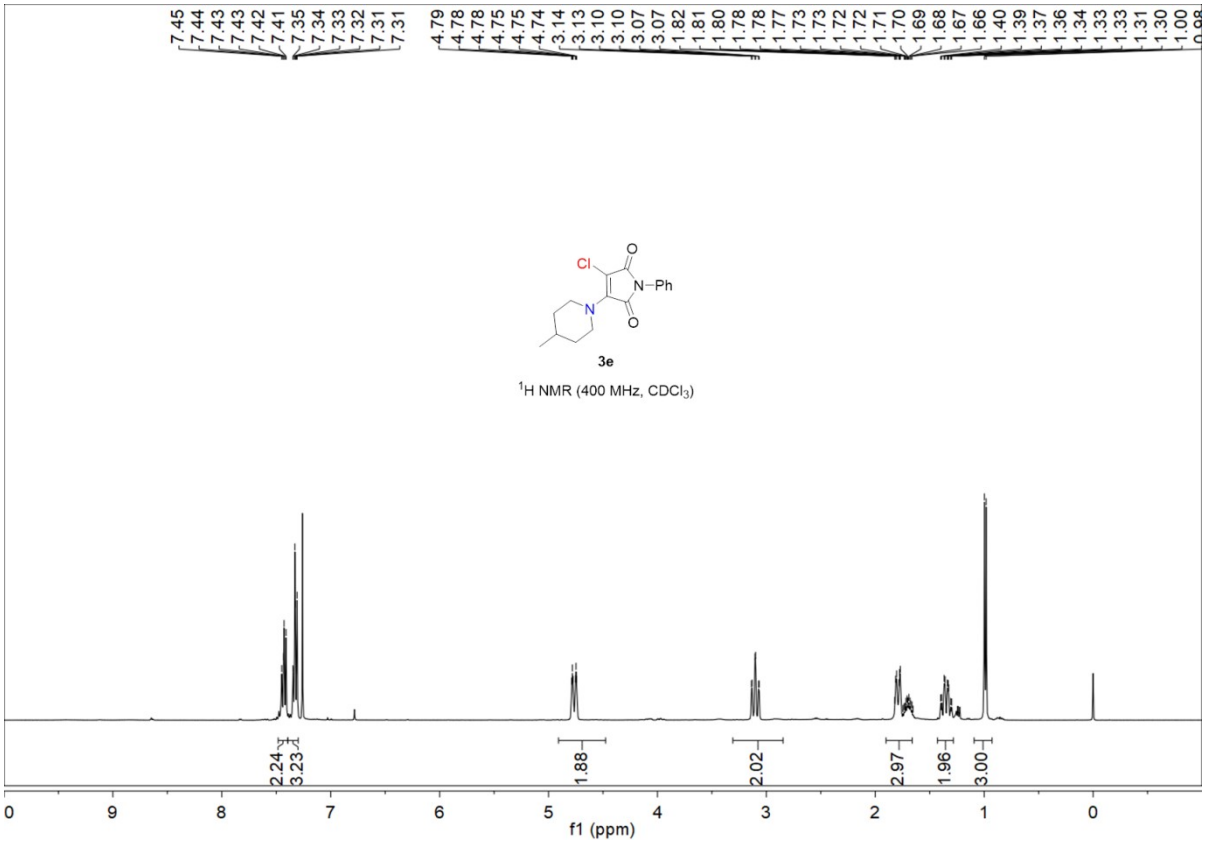
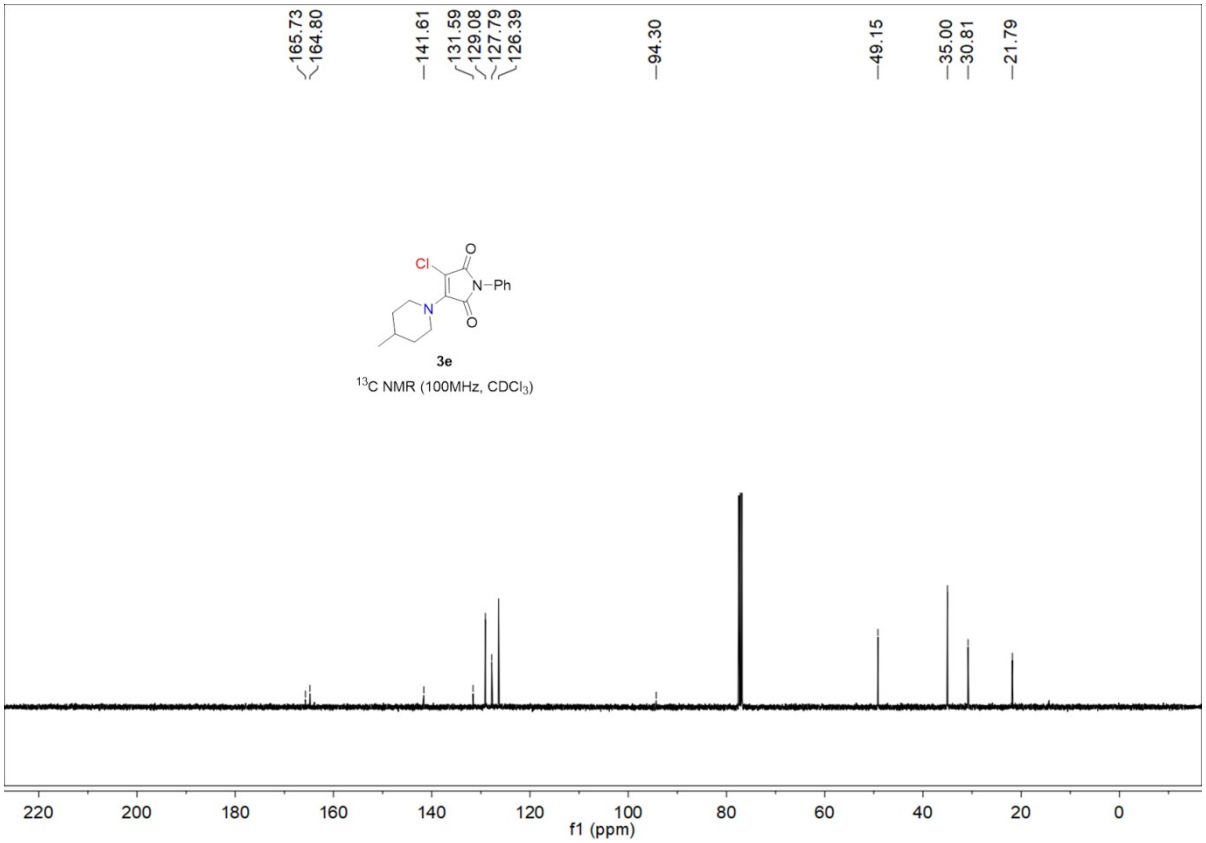
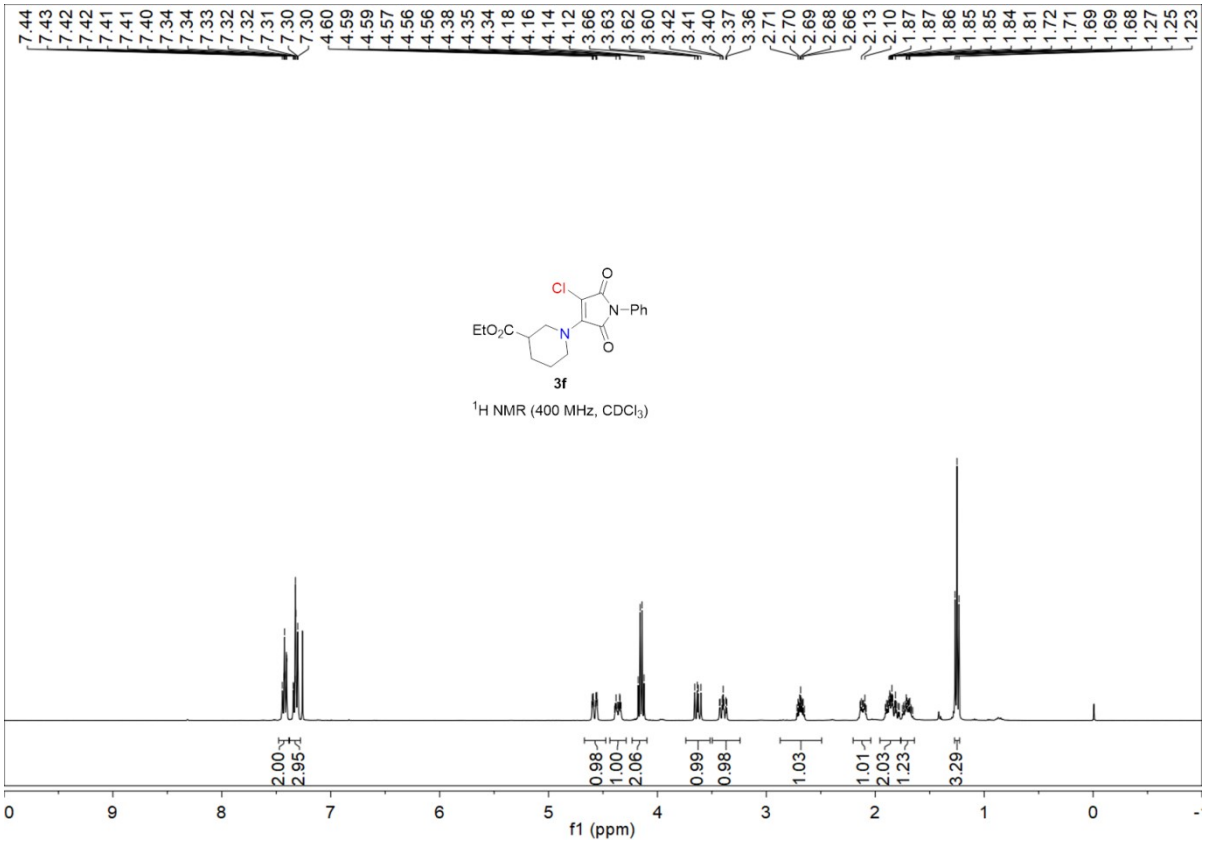
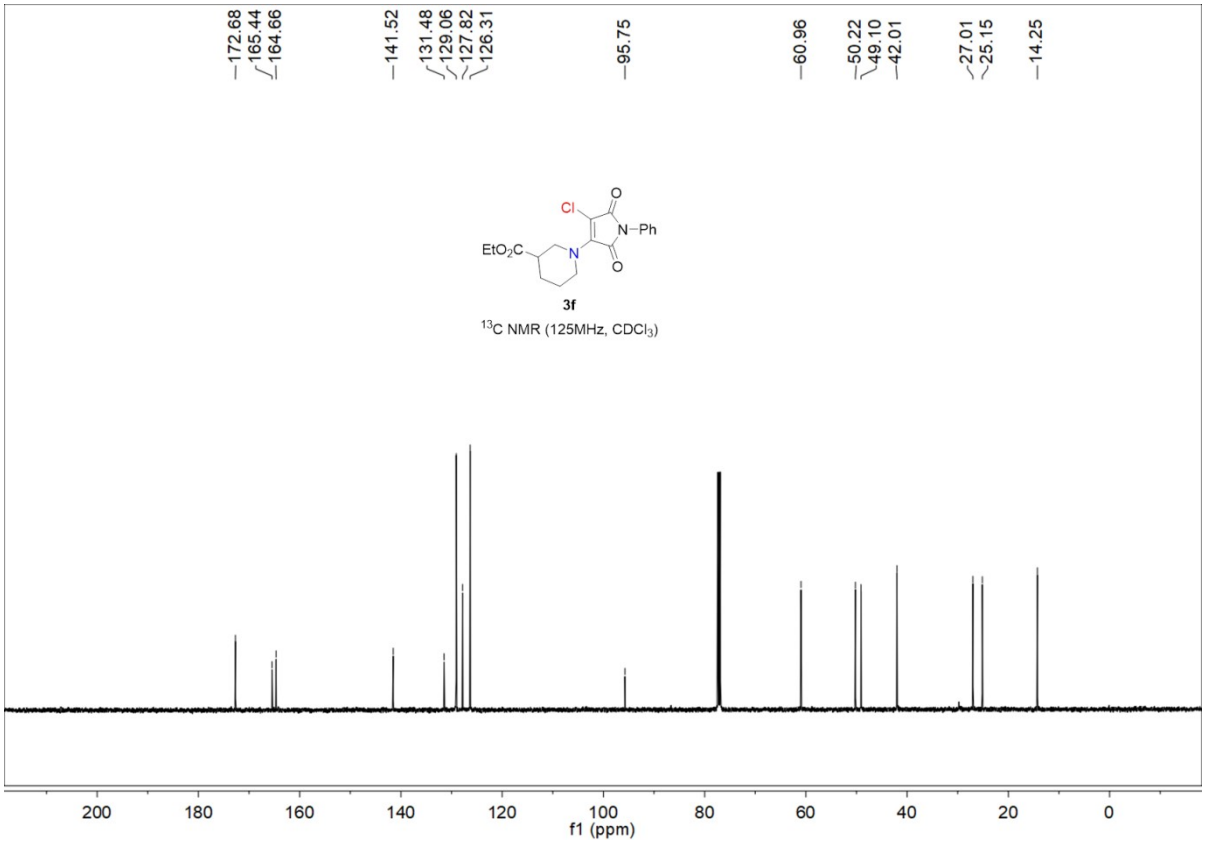
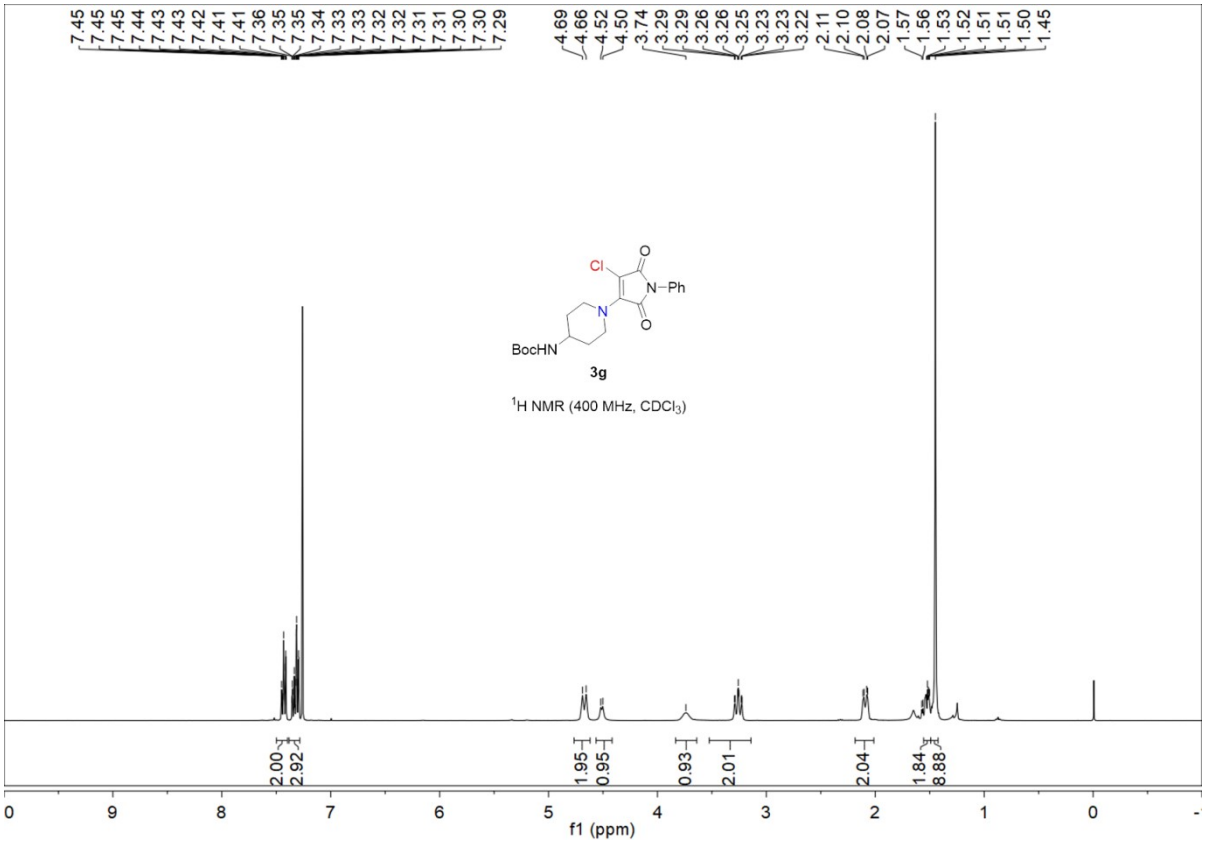
131.43
129.21
129.07
127.85
126.33
126.27
95.53
52.08
47.90
40.33
28.74
Cl
O
N–Ph
N
O
MeO2C
3d
13C NMR (100MHz, CDCl3)
220 200 180 160 140 120 100 80 60 40 20 0
f1 (ppm)

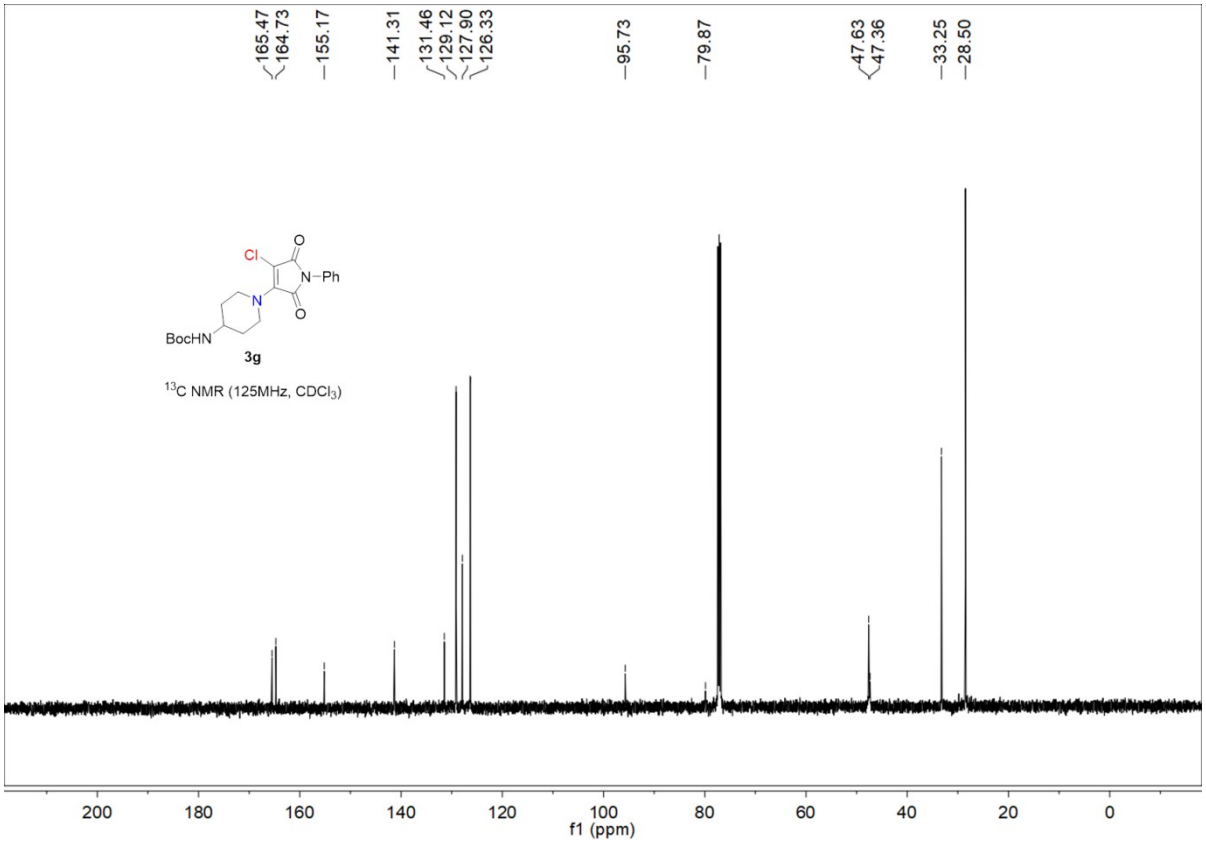

7.45
7.44
7.43
7.43
7.42
7.41
7.35
7.34
7.33
7.32
7.31
7.31
4.79
4.78
4.78
4.75
4.75
4.74
3.14
3.13
3.10
3.10
3.07
3.07
1.82
1.81
1.80
1.78
1.78
1.77
1.73
1.73
1.72
1.72
1.71
1.70
1.69
1.68
1.67
1.66
1.40
1.39
1.37
1.36
1.34
1.33
1.33
1.31
1.30
1.00
Cl
O
N–Ph
N
O
3e
^{1}H NMR (400 MHz, CDCl$_3$)
2.24
3.23
1.88
2.02
2.97
1.96
3.00
0
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

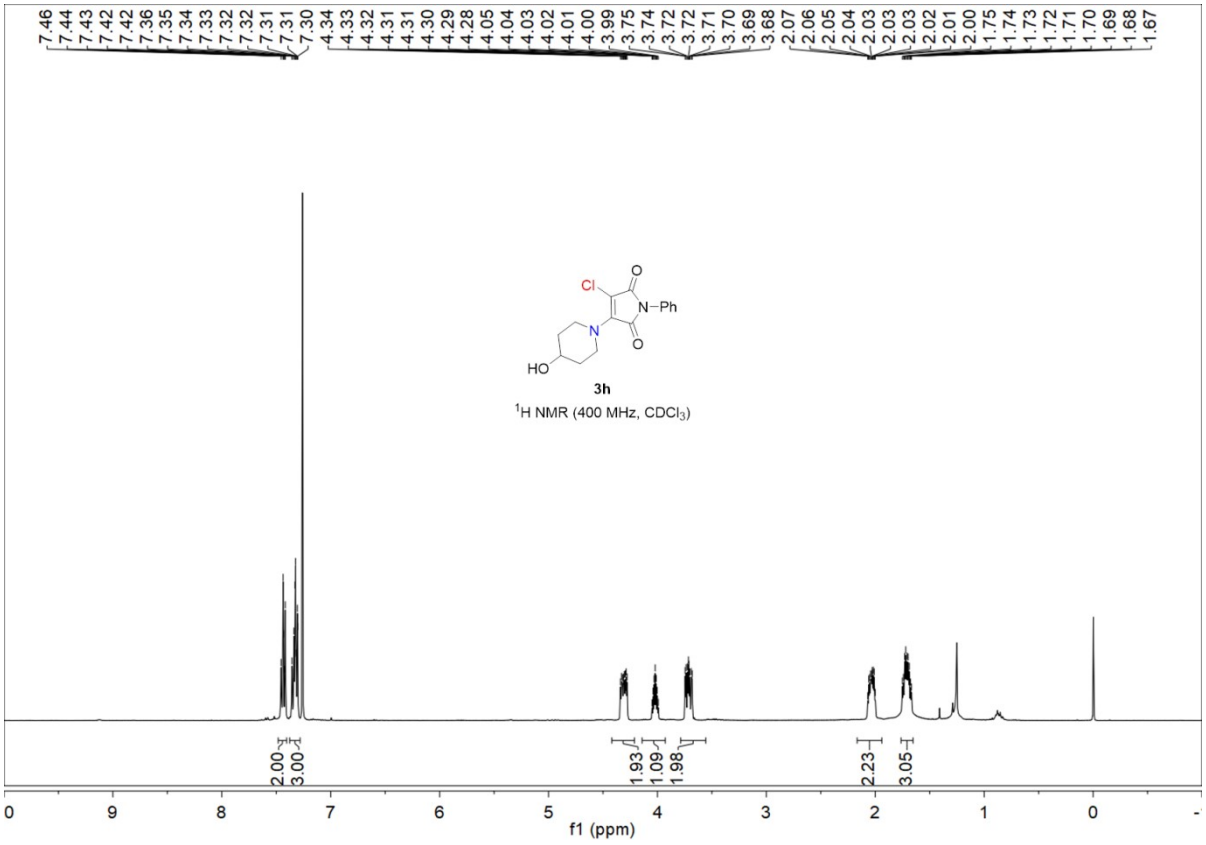

165.73
164.80
141.61
131.59
129.08
127.79
126.39
94.30
49.15
35.00
30.81
21.79
Cl
O
N–Ph
N
O
3e
^{13}C NMR (100MHz, CDCl$_3$)
220
200
180
160
140
120
100
80
60
40
20
0
f1 (ppm)


7.44 7.43 7.42 7.42 7.41 7.41 7.40 7.34 7.34 7.33 7.32 7.32 7.31 7.30 7.30
4.60 4.59 4.59 4.57 4.56 4.56 4.38 4.35 4.34 4.18 4.16 4.14 4.12 3.66 3.63 3.62 3.60 3.42 3.41 3.40 3.37 3.36
2.71 2.70 2.69 2.68 2.66 2.13 2.10 1.87 1.87 1.86 1.85 1.85 1.84 1.81 1.72 1.71 1.69 1.69 1.68 1.27 1.25 1.23
Cl
O
N–Ph
EtO2C
N
O
3f
1H NMR (400 MHz, CDCl3)
2.00
2.95
0.98
1.00
2.06
0.99
0.98
1.03
1.01
2.03
1.23
3.29
f1 (ppm)


172.68
165.44
164.66
141.52
131.48
129.06
127.82
126.31
95.75
60.96
50.22
49.10
42.01
27.01
25.15
14.25
Cl
O
N–Ph
EtO2C
N
O
3f
13C NMR (125MHz, CDCl3)
f1 (ppm)

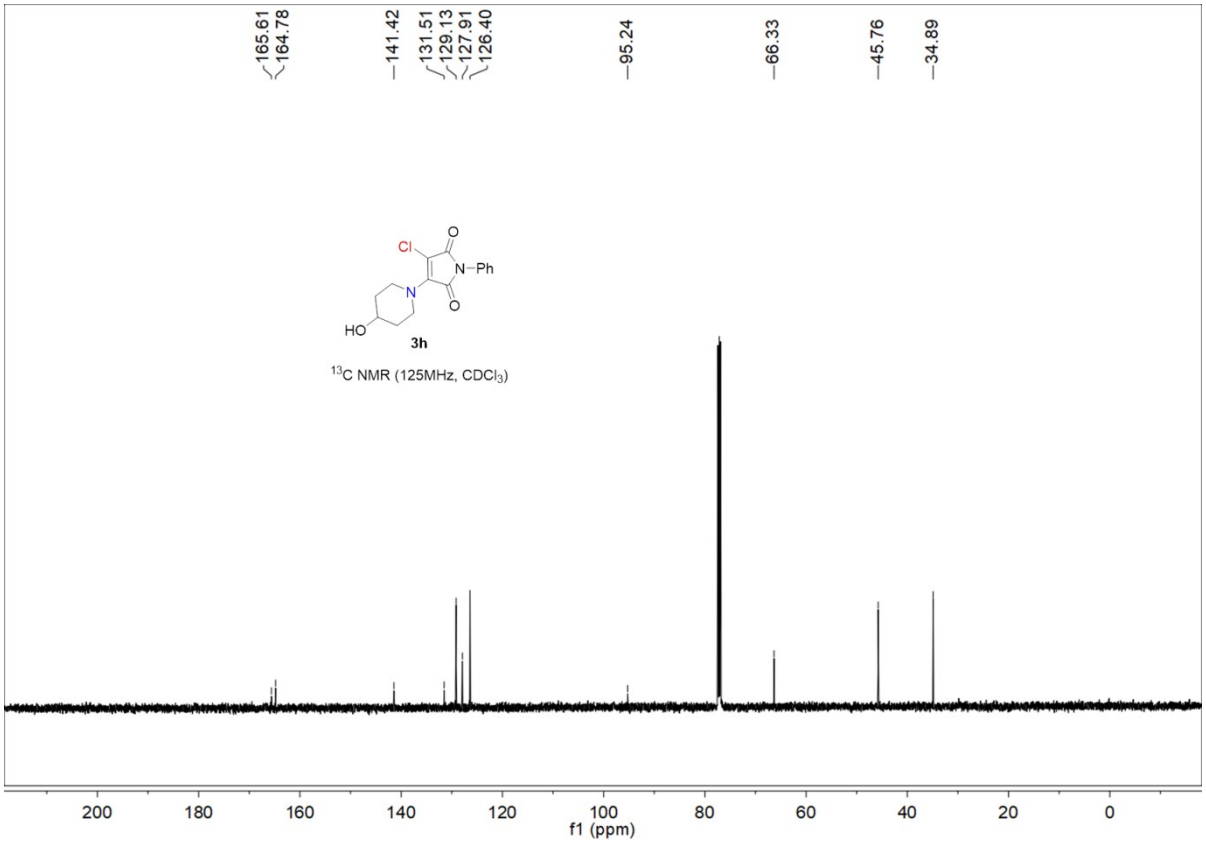

7.45 7.45 7.45 7.44 7.43 7.43 7.42 7.41 7.41 7.36 7.35 7.35 7.34 7.33 7.33 7.32 7.32 7.31 7.31 7.30 7.30 7.29
4.69 4.66 4.52 4.50 3.74 3.29 3.29 3.26 3.26 3.25 3.23 3.23 3.22 2.11 2.10 2.08 2.07 1.57 1.56 1.53 1.52 1.51 1.51 1.50 1.45
Cl
O
N–Ph
N
O
BocHN
3g
^{1}H NMR (400 MHz, CDCl$_3$)
2.00 2.92 1.95 0.95 0.93 2.01 2.04 1.84 8.88
0 9 8 7 6 5 4 3 2 1 0
f1 (ppm)


165.47 164.73 155.17 141.31 131.46 129.12 127.90 126.33 95.73 79.87 47.63 47.36 33.25 28.50
Cl
O
N–Ph
N
O
BocHN
3g
^{13}C NMR (125MHz, CDCl$_3$)
200 180 160 140 120 100 80 60 40 20 0
f1 (ppm)



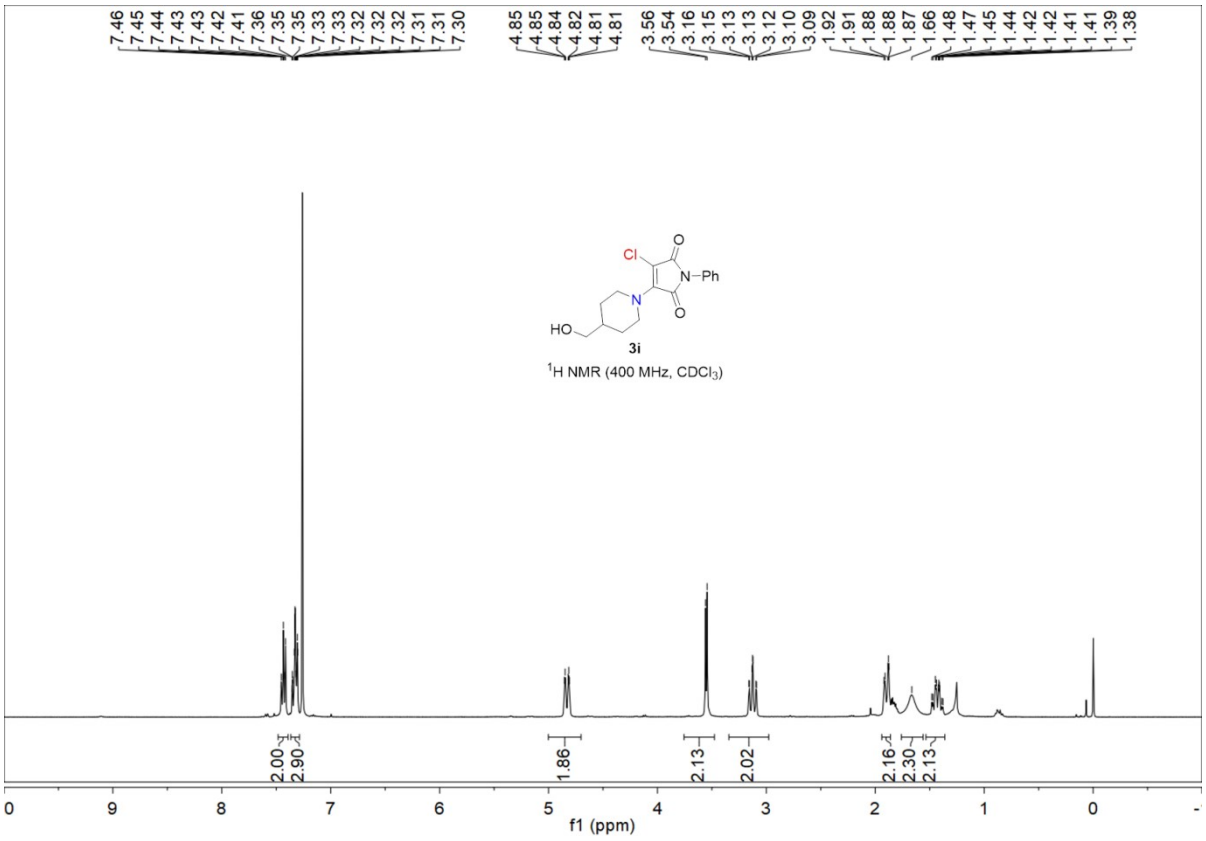
3h

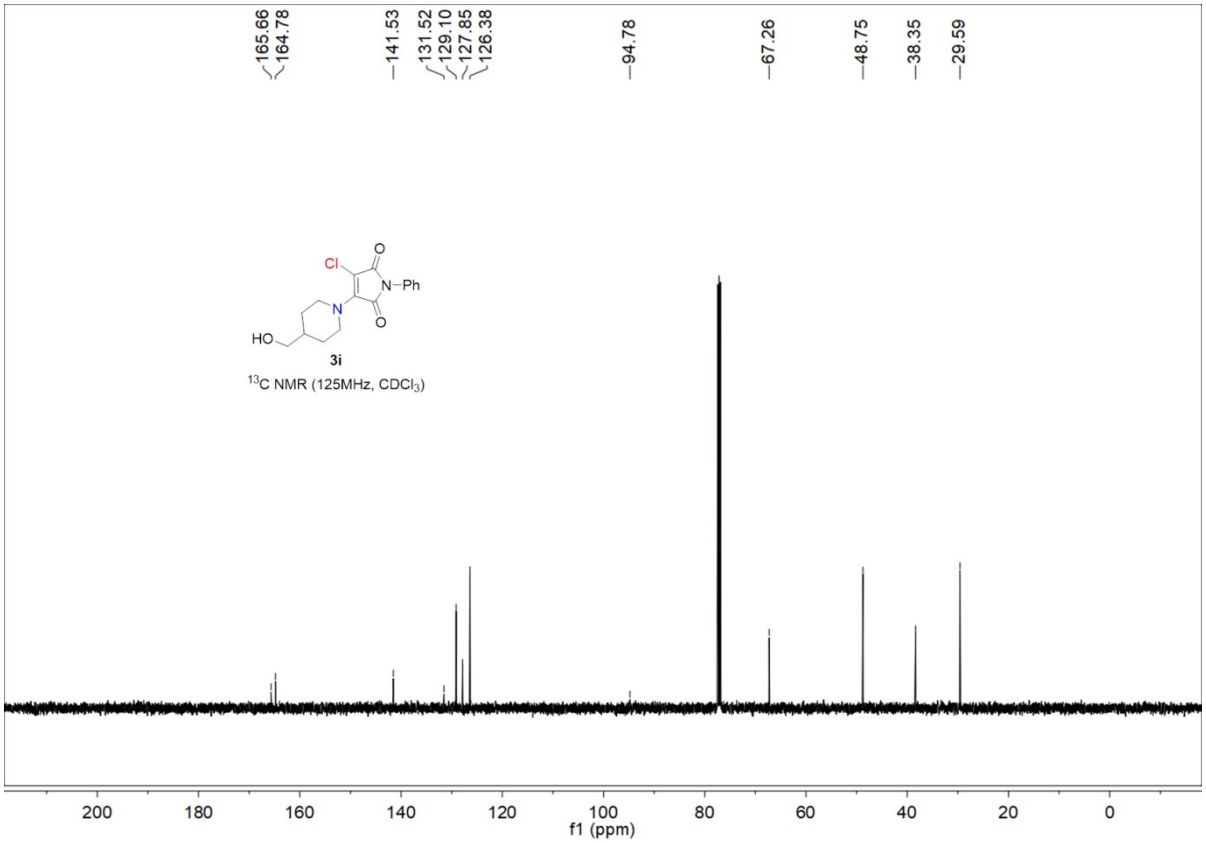
^{1}H NMR (400 MHz, $CDCl_3$)

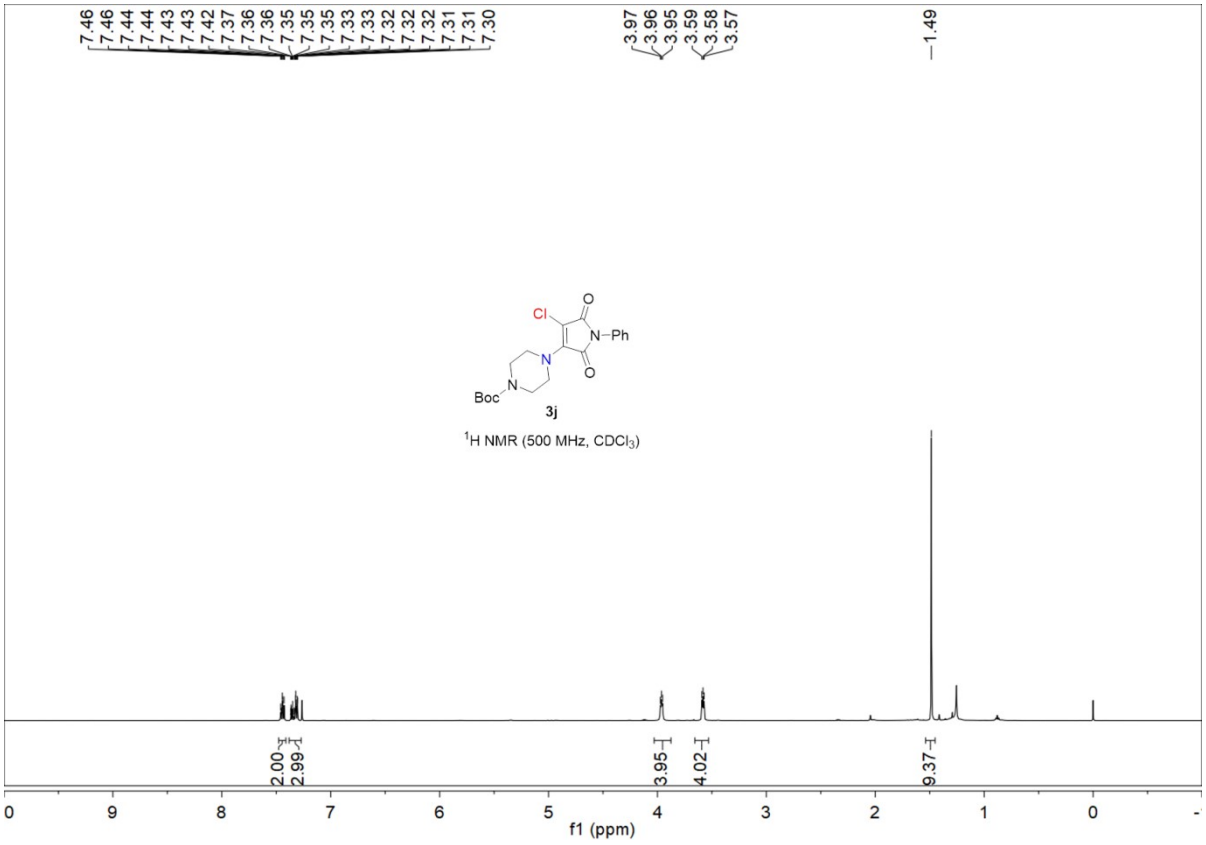


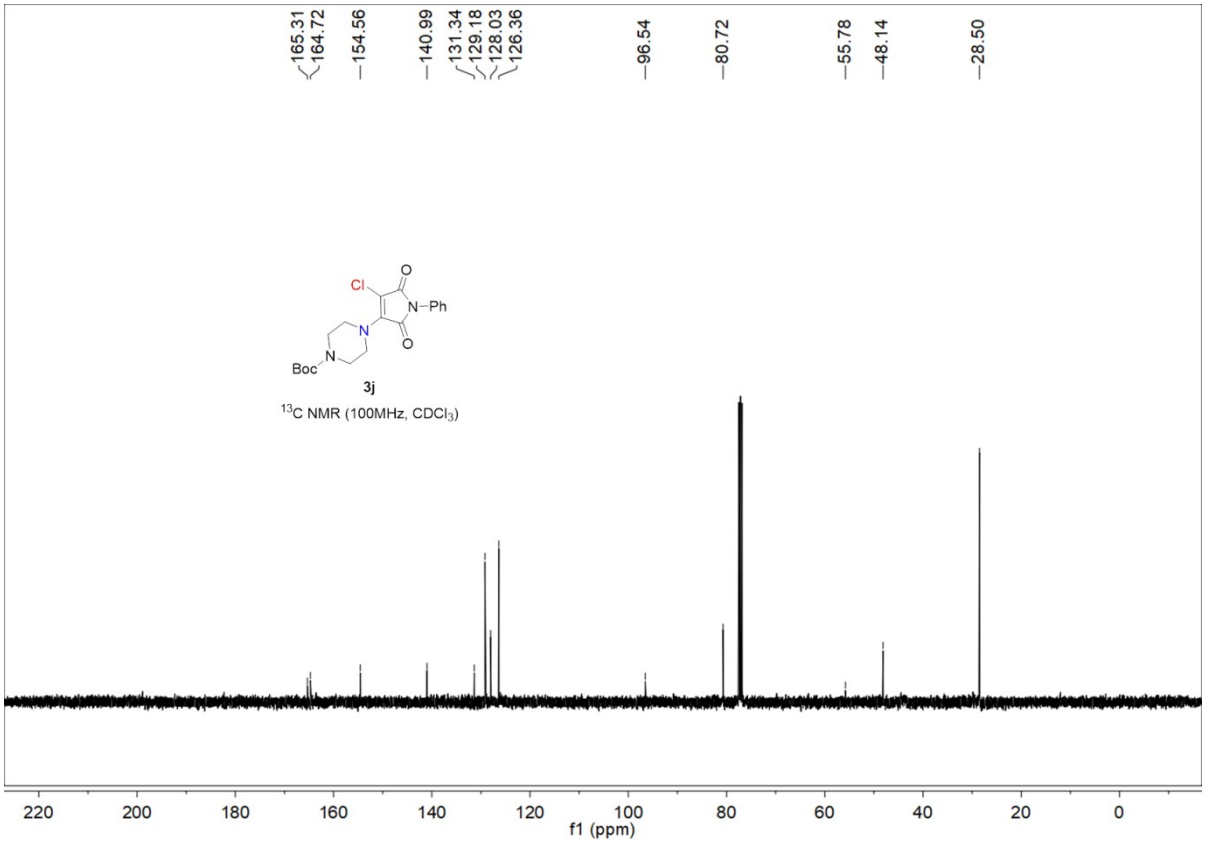
3h

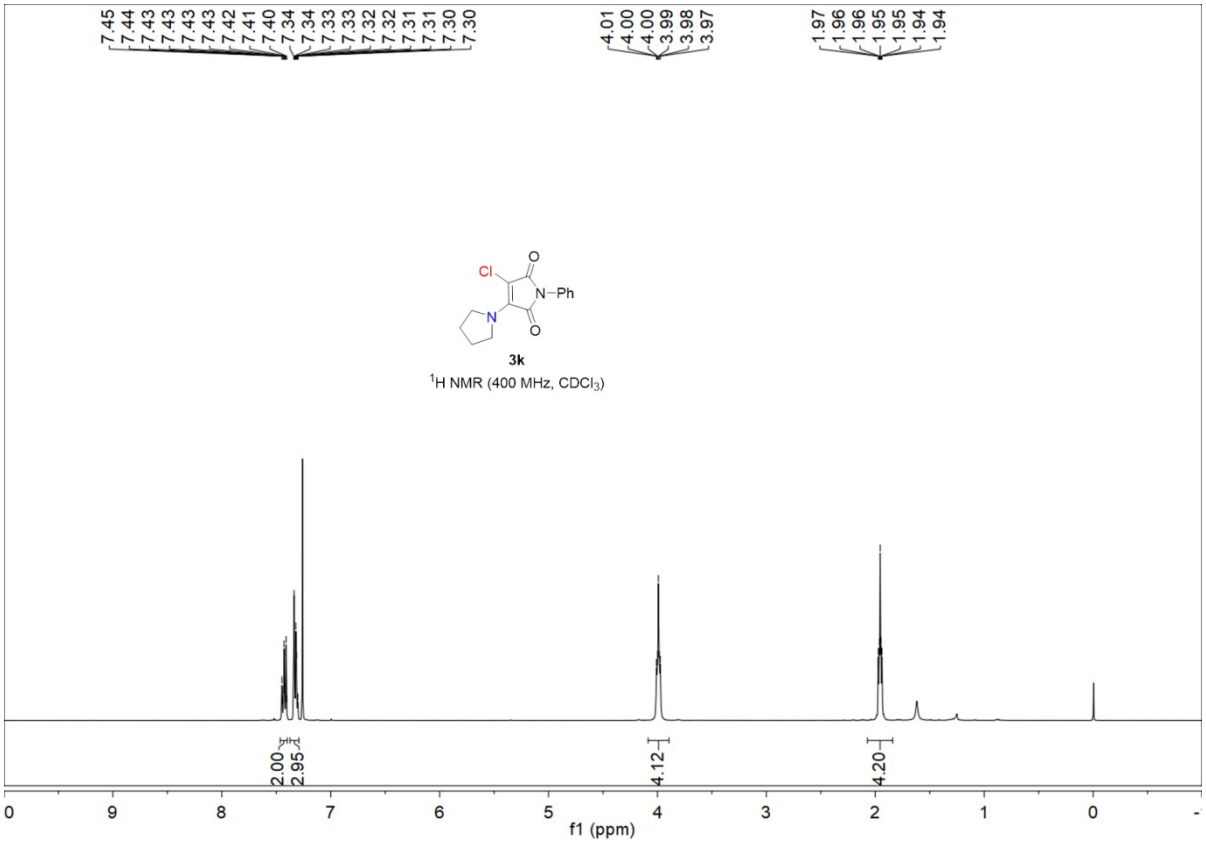
^{13}C NMR (125MHz, $CDCl_3$)

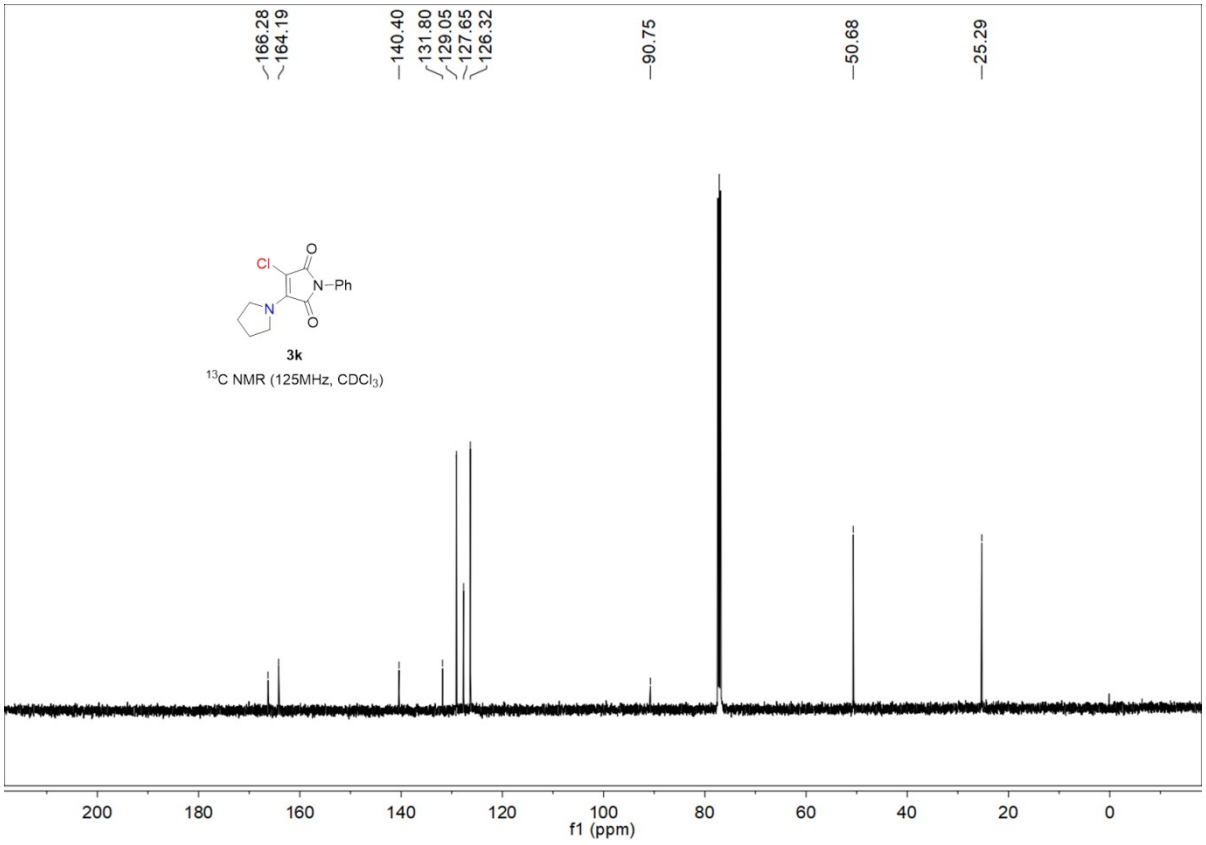

7.46 7.45 7.44 7.43 7.43 7.42 7.41 7.36 7.35 7.35 7.33 7.33 7.32 7.32 7.32 7.31 7.31 7.30
4.85 4.85 4.84 4.82 4.81 4.81
3.56 3.54 3.16 3.15 3.13 3.13 3.12 3.10 3.09
1.92 1.91 1.88 1.88 1.87 1.66 1.48 1.47 1.45 1.44 1.42 1.42 1.41 1.41 1.39 1.38
Cl
O
N–Ph
N
O
HO
3i
^{1}H NMR (400 MHz, CDCl$_3$)
2.00 2.90 1.86 2.13 2.02 2.16 2.30 2.13
0 9 8 7 6 5 4 3 2 1 0
f1 (ppm)

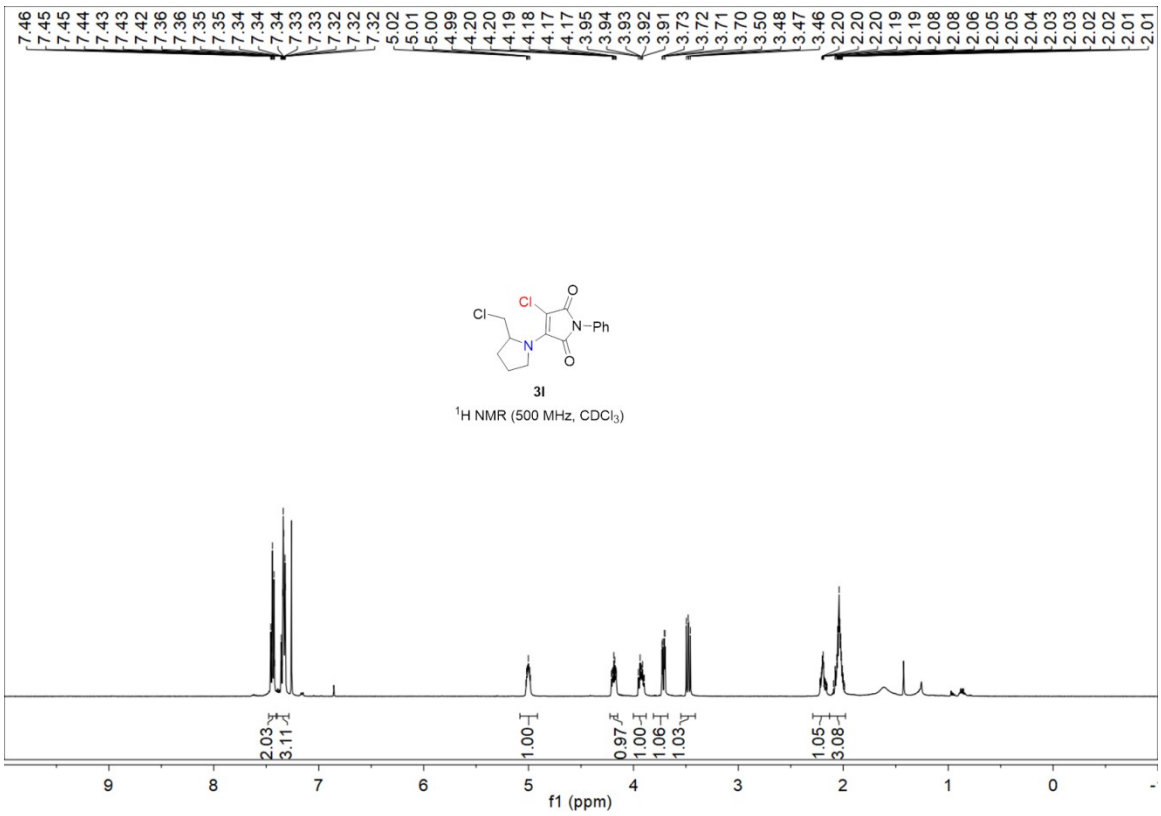

165.66 164.78 141.53 131.52 129.10 127.85 126.38 94.78 67.26 48.75 38.35 29.59
Cl
O
N–Ph
N
O
HO
3i
^{13}C NMR (125MHz, CDCl$_3$)
200 180 160 140 120 100 80 60 40 20 0
f1 (ppm)

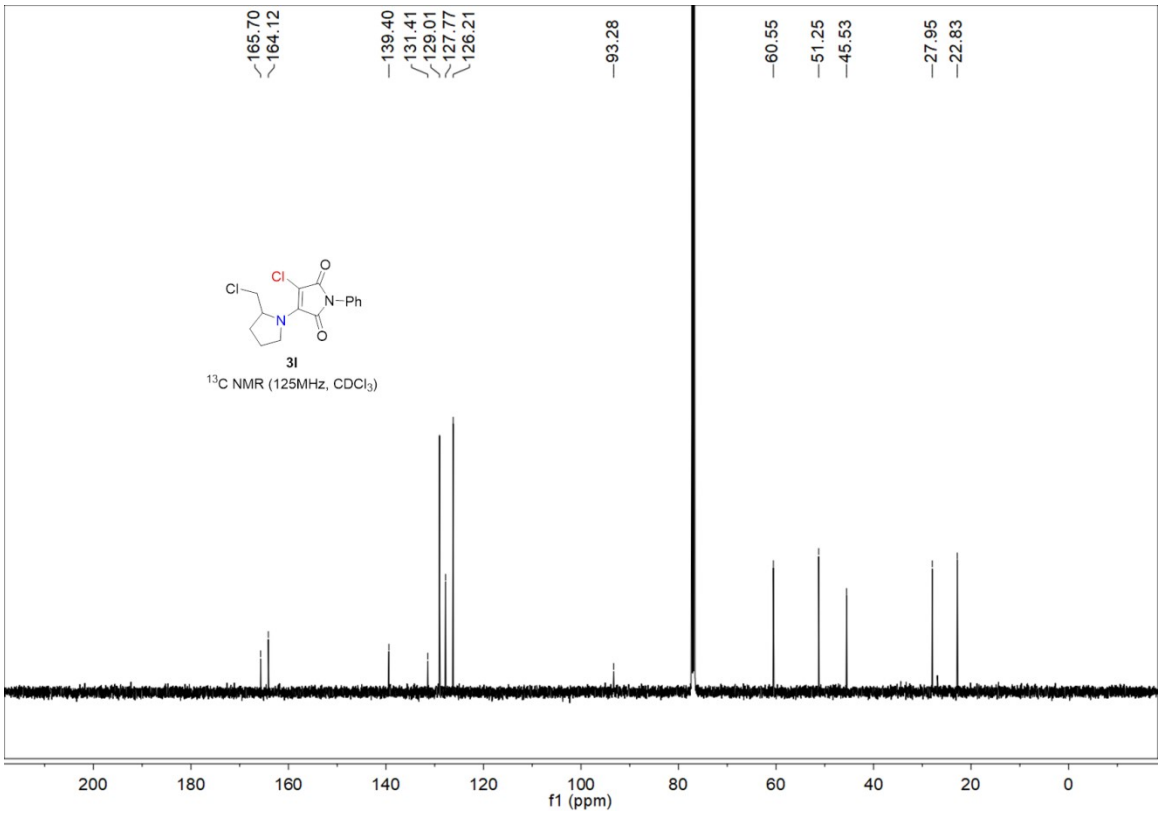

7.46
7.46
7.44
7.44
7.43
7.43
7.42
7.37
7.36
7.36
7.35
7.35
7.35
7.33
7.33
7.32
7.32
7.32
7.31
7.30
3.97
3.96
3.95
3.59
3.58
3.57
1.49
Cl
N–Ph
O
O
N
N
Boc
3j
^{1}H NMR (500 MHz, $CDCl_3$)
2.00
2.99
3.95
4.02
9.37
f1 (ppm)

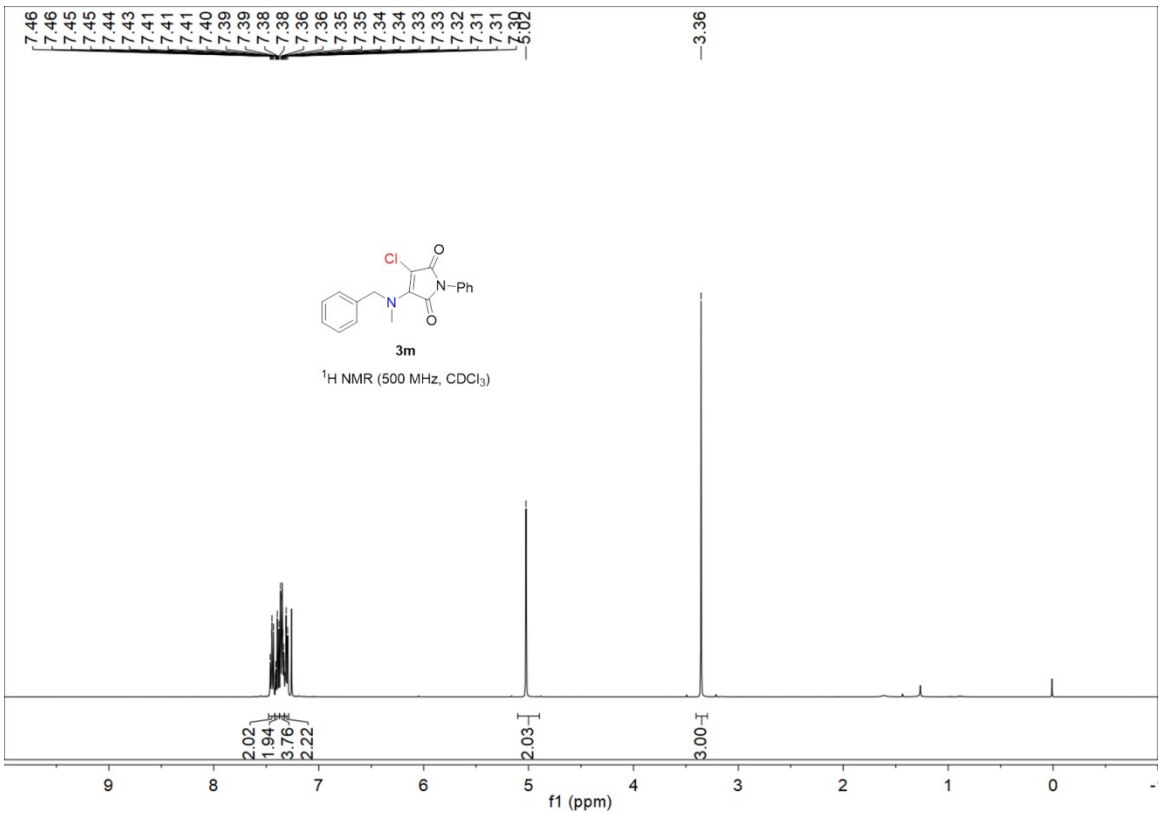

165.31
164.72
154.56
140.99
131.34
129.18
128.03
126.36
96.54
80.72
55.78
48.14
28.50
Cl
N–Ph
O
O
N
N
Boc
3j
^{13}C NMR (100MHz, $CDCl_3$)
f1 (ppm)

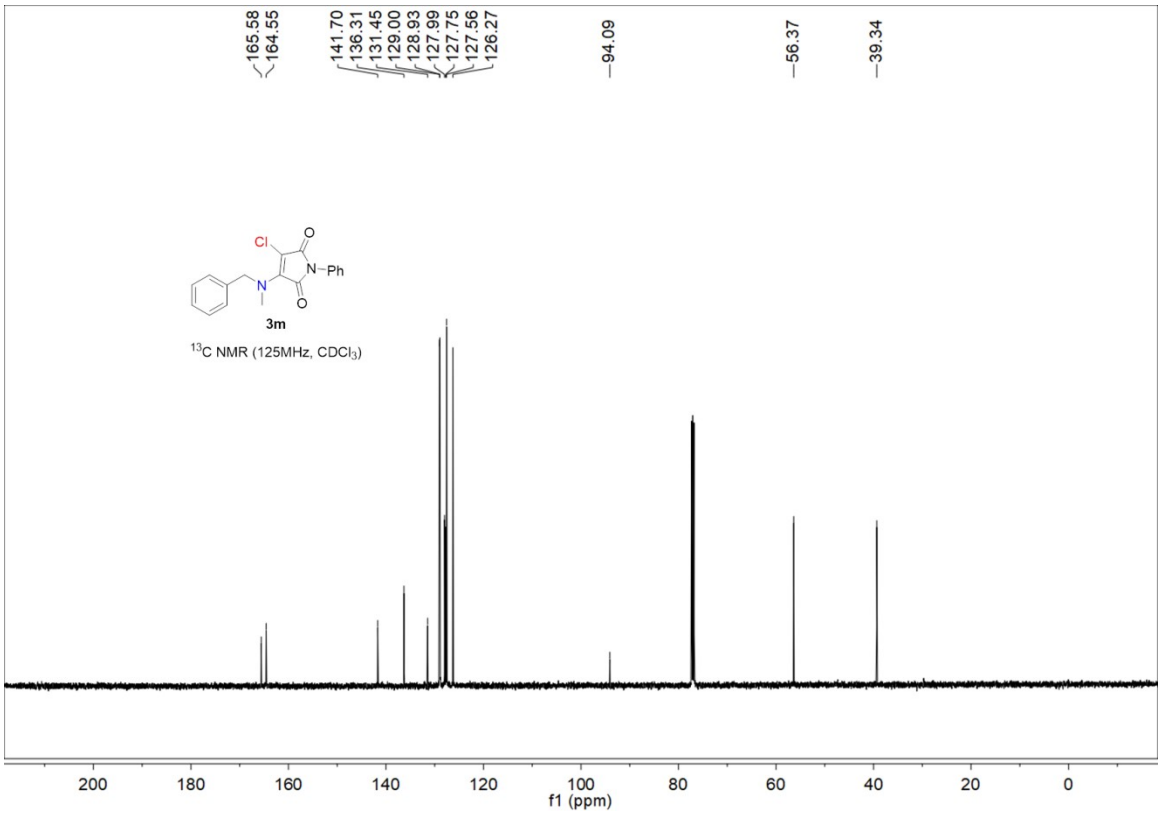

7.45
7.44
7.43
7.43
7.43
7.43
7.42
7.41
7.40
7.34
7.34
7.33
7.33
7.32
7.32
7.31
7.31
7.30
7.30
4.01
4.00
4.00
3.99
3.98
3.97
1.97
1.96
1.96
1.95
1.95
1.94
1.94
Cl
O
N–Ph
N
O
3k
1H NMR (400 MHz, CDCl3)
2.00
2.95
4.12
4.20
0
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

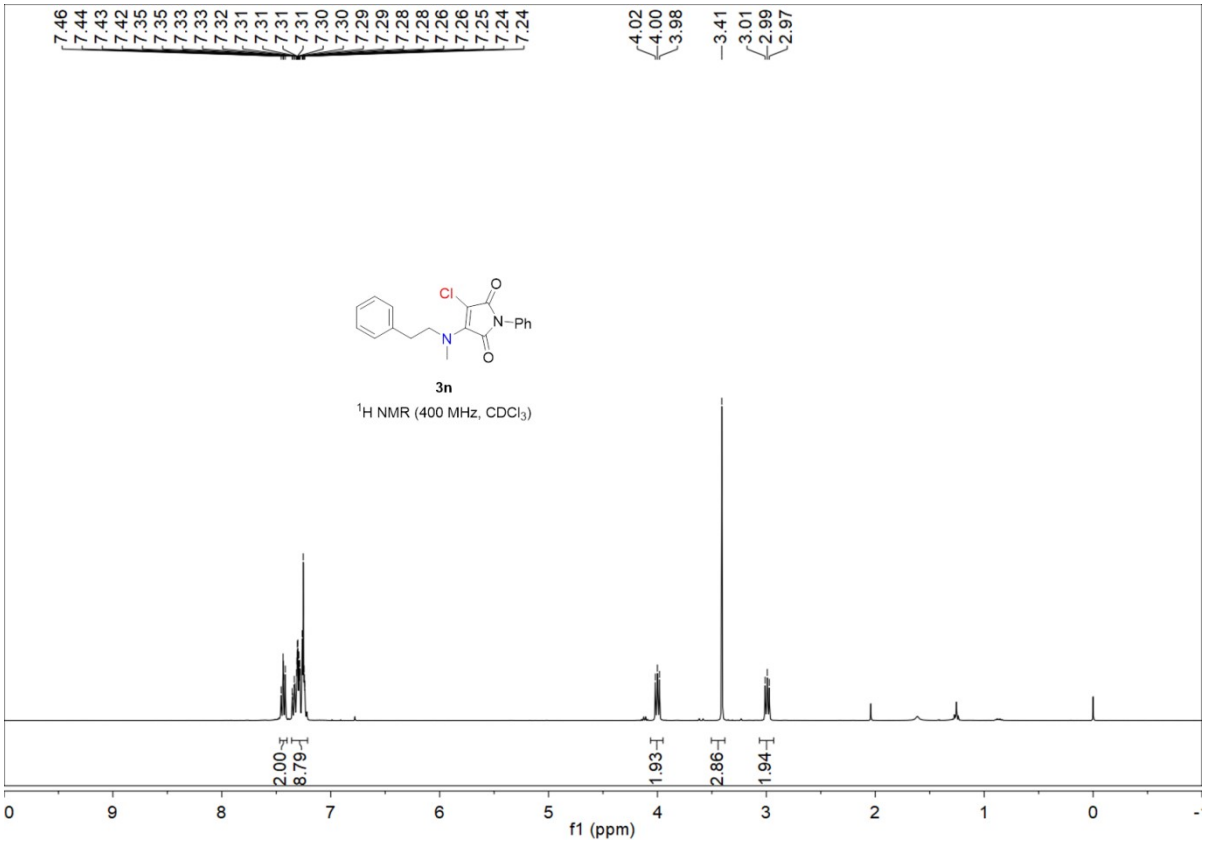

166.28
164.19
140.40
131.80
129.05
127.65
126.32
90.75
50.68
25.29
Cl
O
N–Ph
N
O
3k
13C NMR (125MHz, CDCl3)
200
180
160
140
120
100
80
60
40
20
0
f1 (ppm)

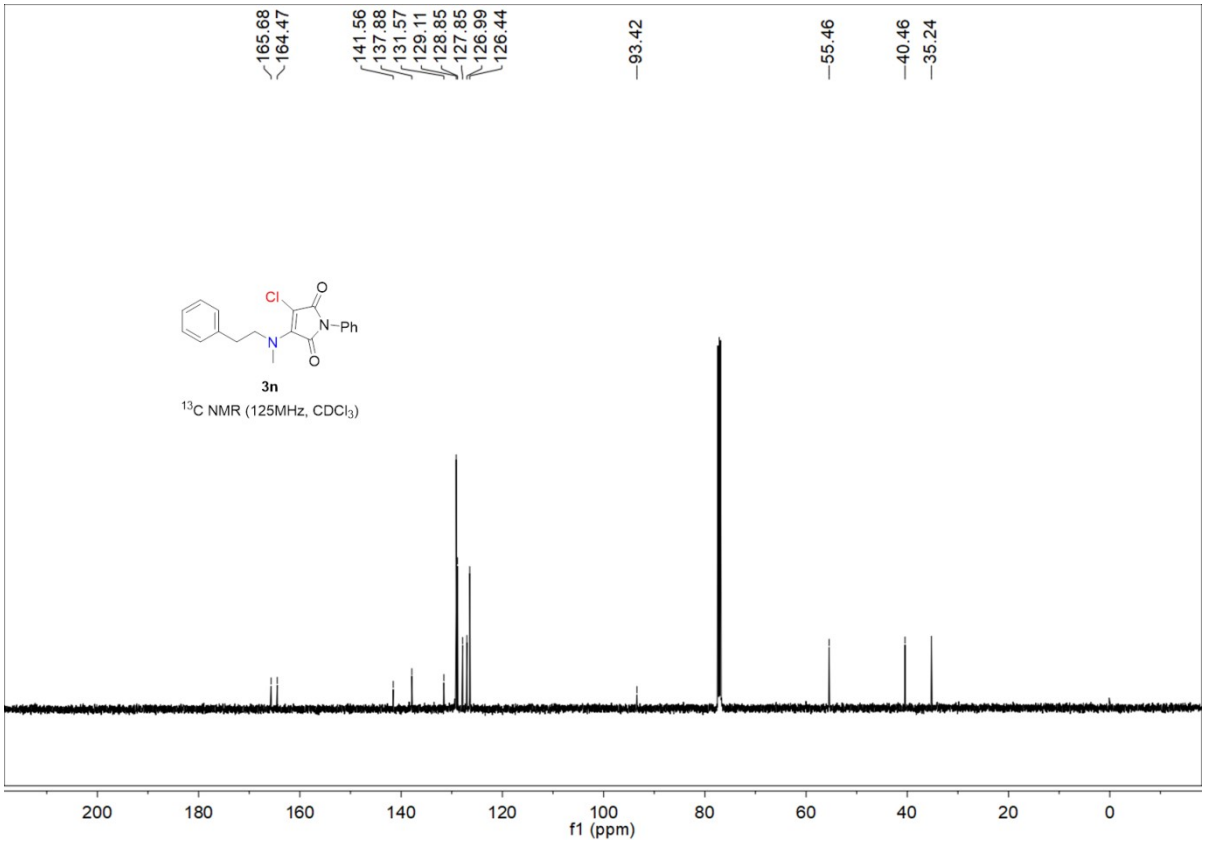

7.46 7.45 7.45 7.44 7.43 7.43 7.42 7.36 7.36 7.35 7.35 7.34 7.34 7.34 7.33 7.33 7.32 7.32 7.32
5.02 5.01 5.00 4.99 4.20 4.20 4.19 4.18 4.17 4.17 3.95 3.94 3.93 3.92 3.91 3.73 3.72 3.71 3.70 3.50 3.48 3.47 3.46
2.20 2.20 2.20 2.19 2.08 2.08 2.06 2.05 2.05 2.04 2.03 2.03 2.02 2.02 2.01 2.01
Cl
N
N–Ph
O
O
3l
1H NMR (500 MHz, CDCl3)
2.03
3.11
1.00
0.97
1.00
1.06
1.03
1.05
3.08
9 8 7 6 5 4 3 2 1 0
f1 (ppm)

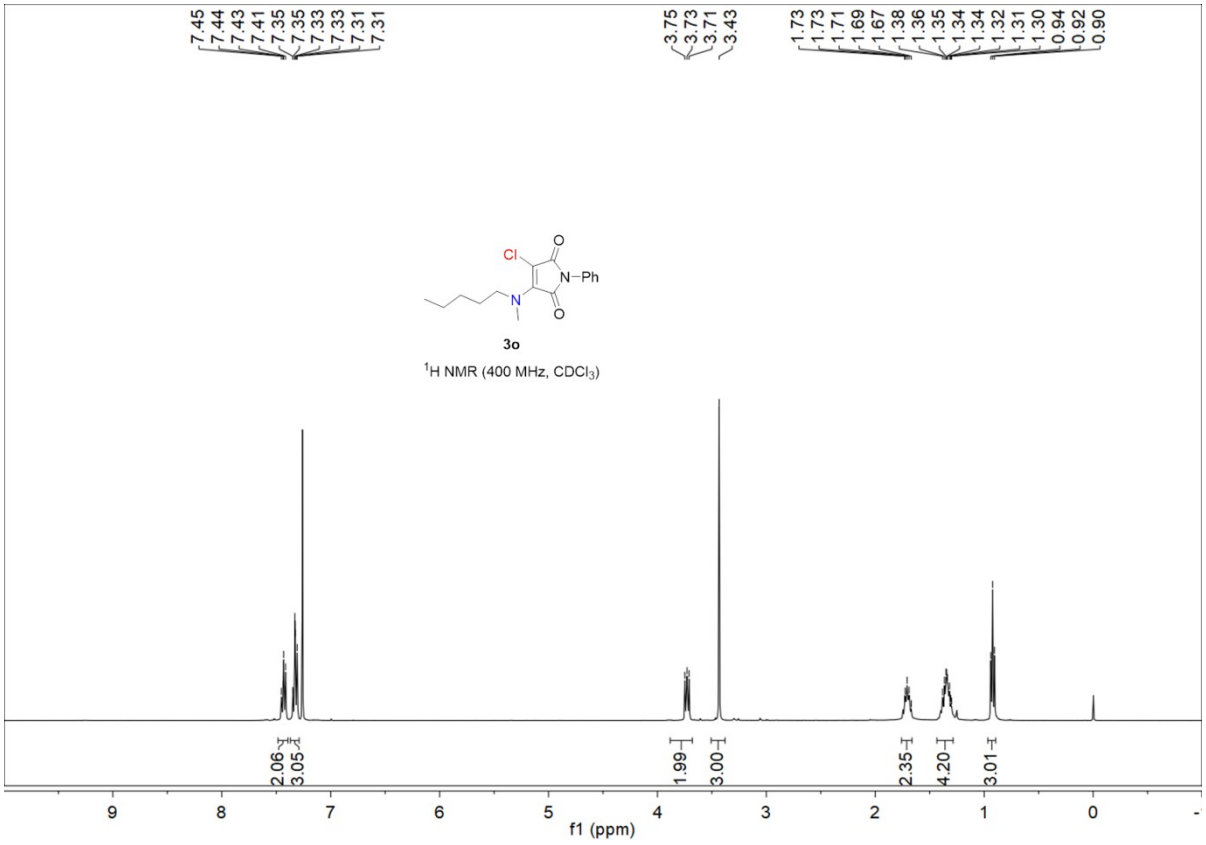

165.70
164.12
139.40
131.41
129.01
127.77
126.21
93.28
60.55
51.25
45.53
27.95
22.83
Cl
N
N–Ph
O
O
3l
13C NMR (125MHz, CDCl3)
200 180 160 140 120 100 80 60 40 20 0
f1 (ppm)

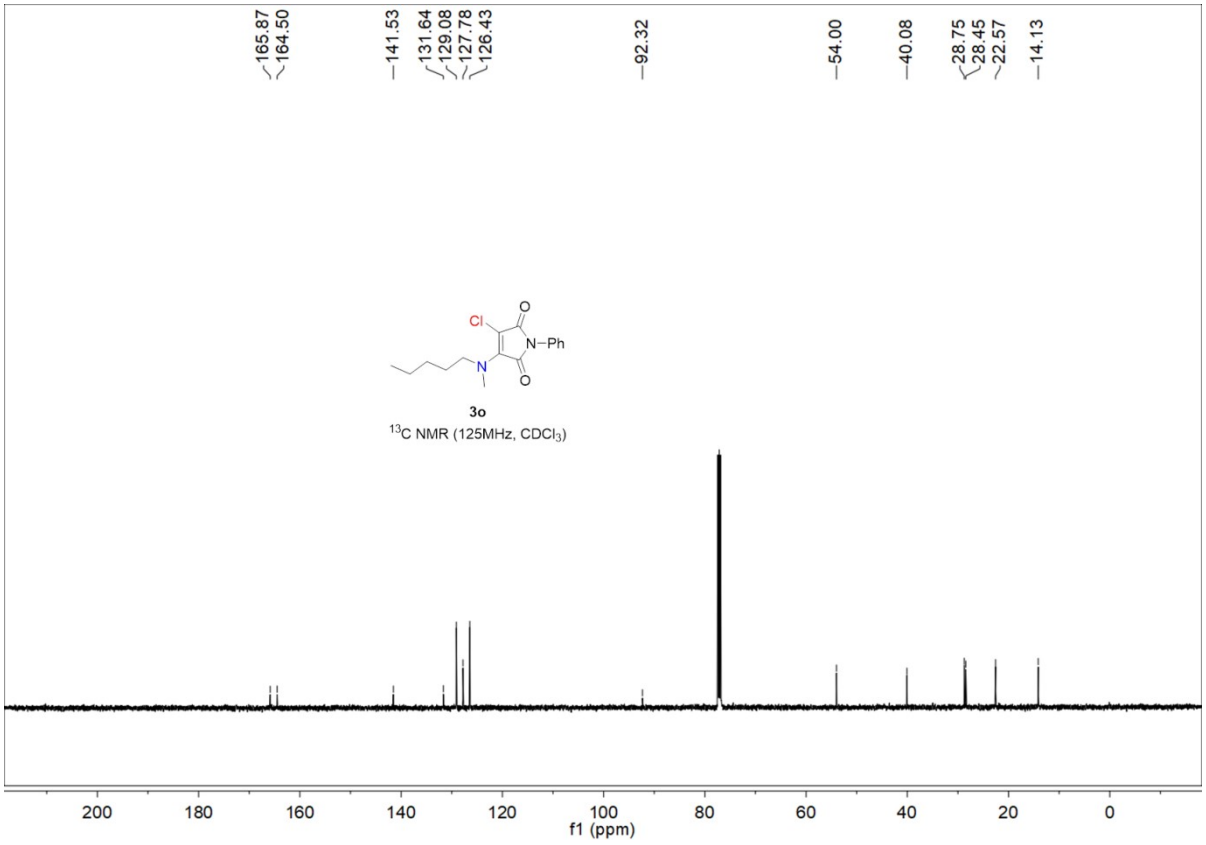

7.46
7.46
7.45
7.45
7.44
7.43
7.41
7.41
7.41
7.40
7.39
7.39
7.38
7.38
7.36
7.36
7.35
7.35
7.34
7.34
7.33
7.33
7.32
7.31
7.31
7.30
5.02
3.36
Cl
O
N–Ph
N
O
3m
1H NMR (500 MHz, CDCl3)
2.02
1.94
3.76
2.22
2.03
3.00
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

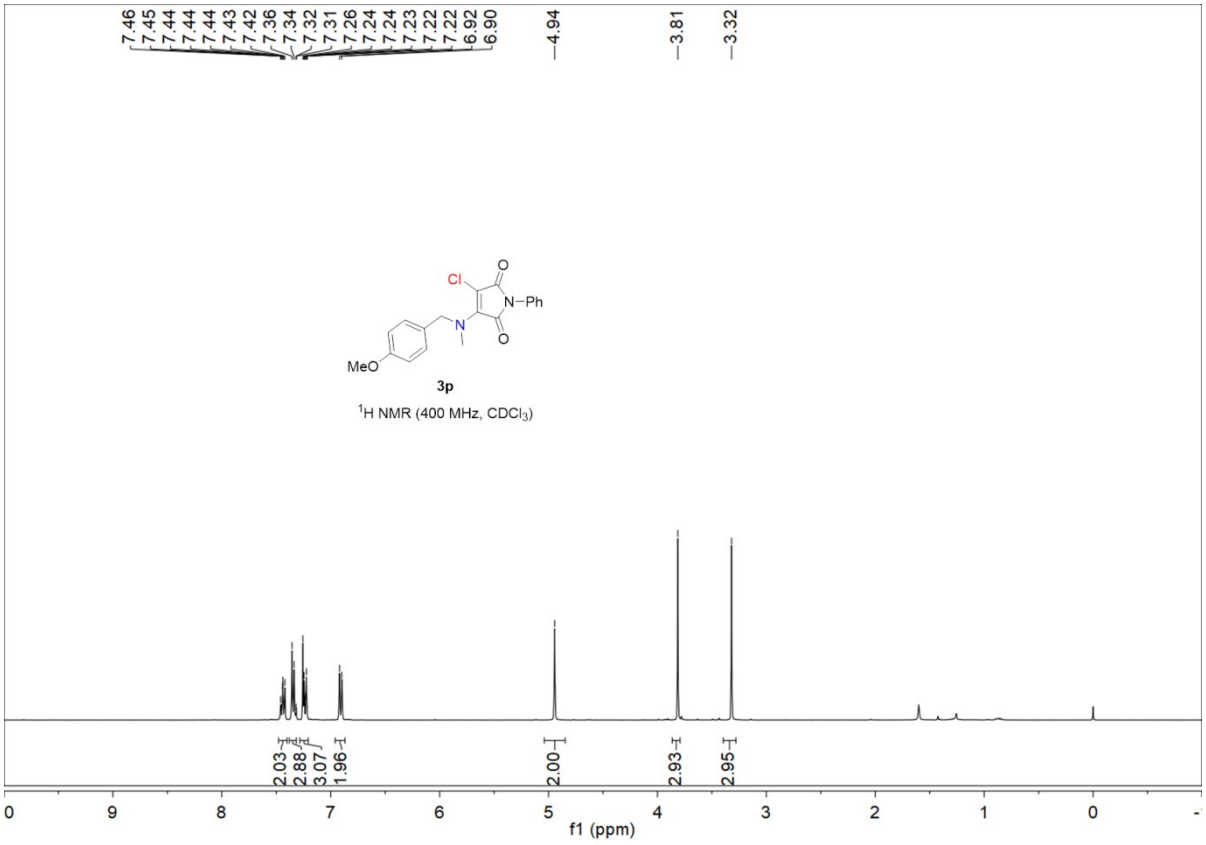

165.58
164.55
141.70
136.31
131.45
129.00
128.93
127.99
127.75
127.56
126.27
94.09
56.37
39.34
Cl
O
N–Ph
N
O
3m
13C NMR (125MHz, CDCl3)
200
180
160
140
120
100
80
60
40
20
0
f1 (ppm)


7.46
7.44
7.43
7.42
7.35
7.33
7.33
7.32
7.31
7.31
7.31
7.30
7.30
7.29
7.29
7.28
7.28
7.26
7.26
7.25
7.24
7.24
4.02
4.00
3.98
3.41
3.01
2.99
2.97
Cl
O
N–Ph
N
O
3n
1H NMR (400 MHz, CDCl3)
2.00
8.79
1.93
2.86
1.94
0
9
8
7
6
5
4
3
2
1
0
f1 (ppm)


165.68
164.47
141.56
137.88
131.57
129.11
128.85
127.85
126.99
126.44
93.42
55.46
40.46
35.24
Cl
O
N–Ph
N
O
3n
13C NMR (125MHz, CDCl3)
200
180
160
140
120
100
80
60
40
20
0
f1 (ppm)

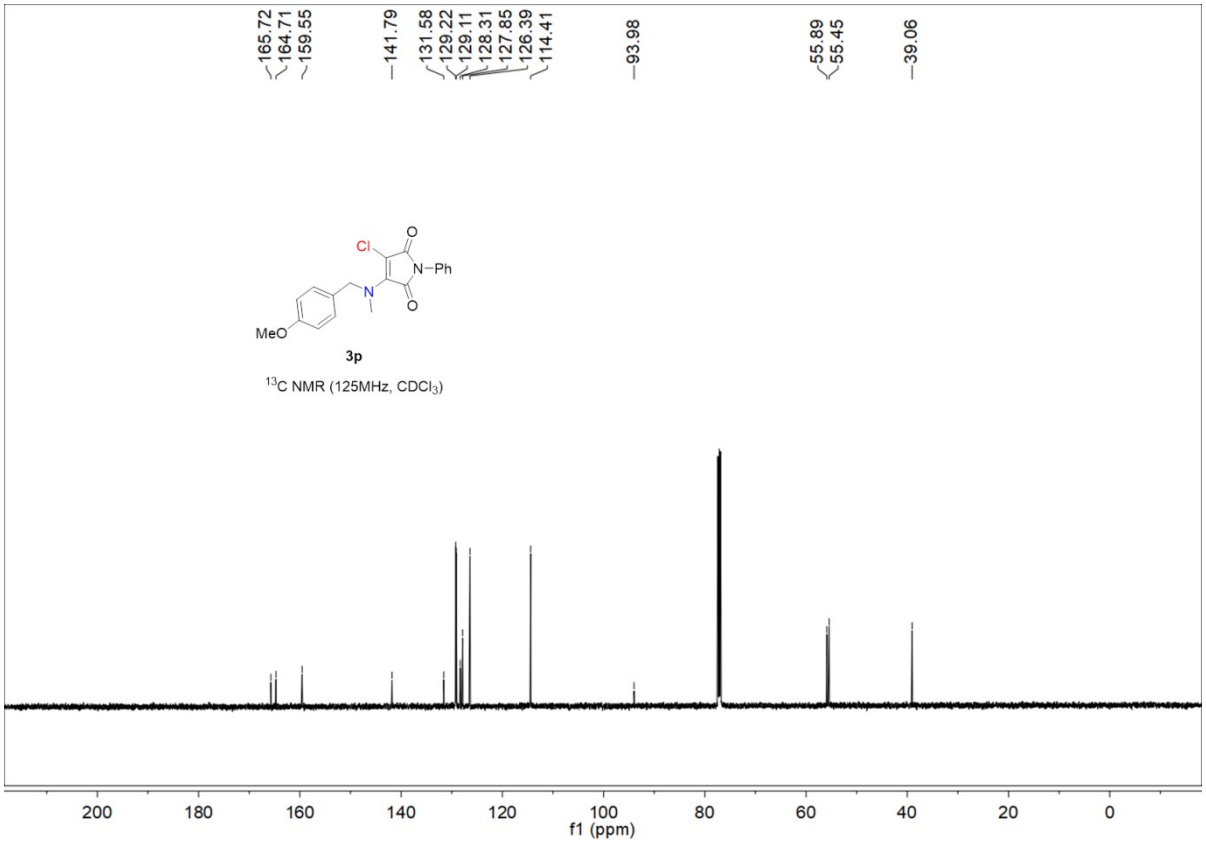

7.45
7.44
7.43
7.41
7.35
7.35
7.33
7.33
7.31
7.31
3.75
3.73
3.71
3.43
1.73
1.73
1.71
1.69
1.67
1.38
1.36
1.35
1.34
1.34
1.32
1.31
1.30
0.94
0.92
0.90
Cl
O
N–Ph
N
O
3o
1H NMR (400 MHz, CDCl3)
2.06
3.05
1.99
3.00
2.35
4.20
3.01
9
8
7
6
5
4
3
2
1
0
f1 (ppm)


165.87
164.50
141.53
131.64
129.08
127.78
126.43
92.32
54.00
40.08
28.75
28.45
22.57
14.13
Cl
O
N–Ph
N
O
3o
13C NMR (125MHz, CDCl3)
200
180
160
140
120
100
80
60
40
20
0
f1 (ppm)



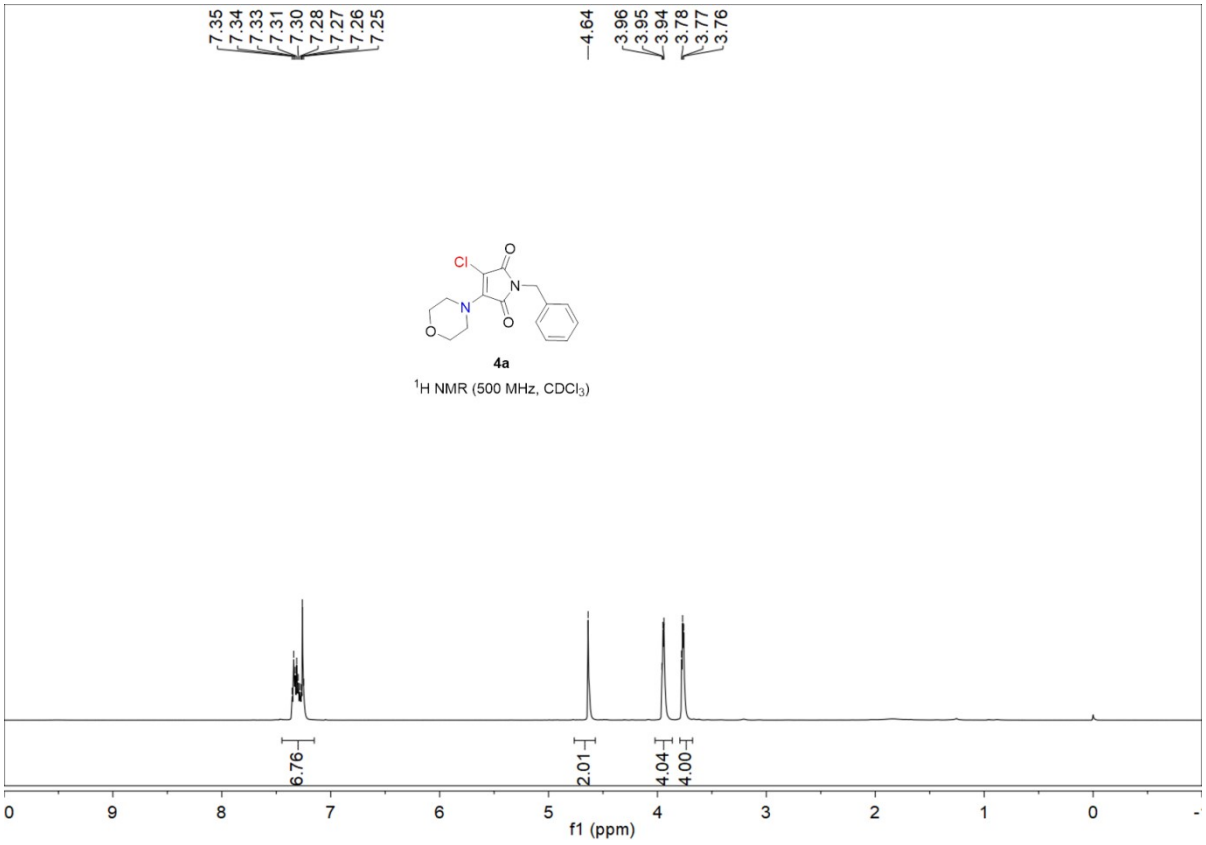
3p

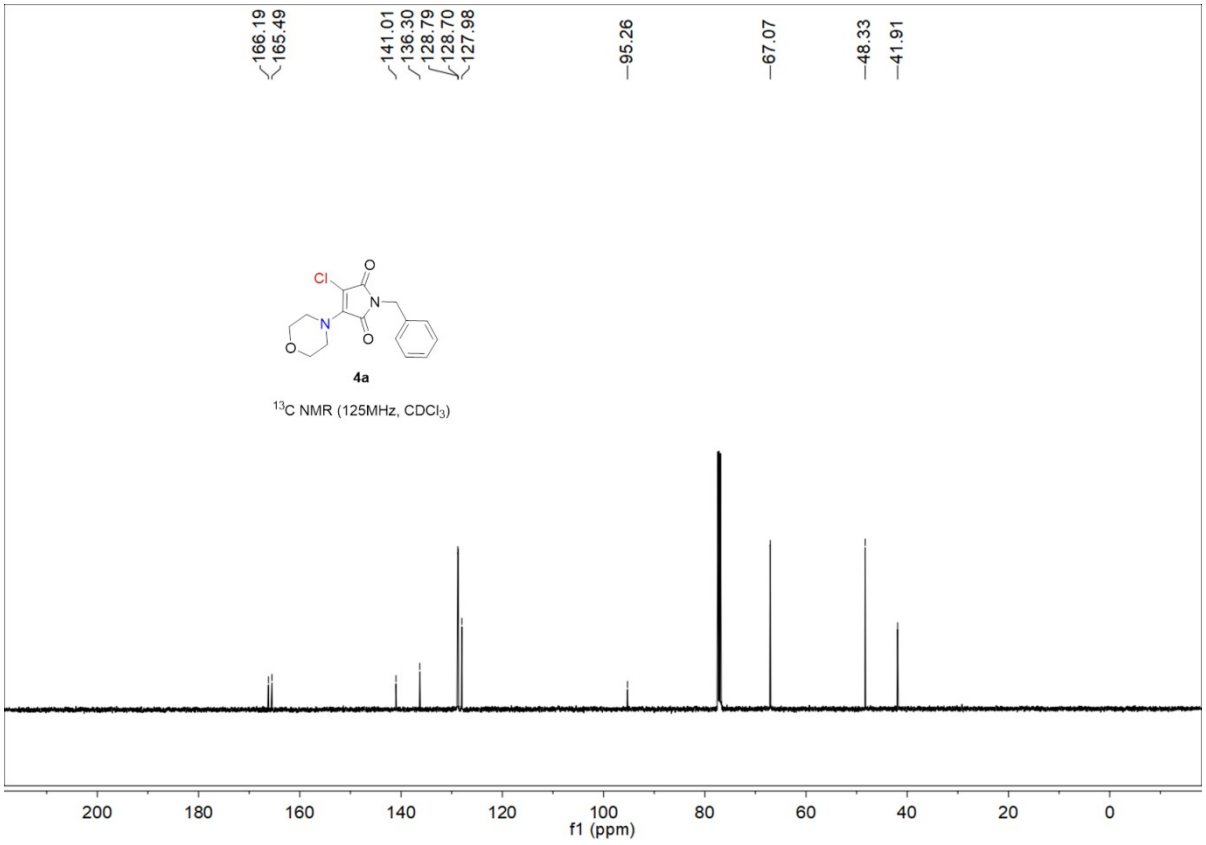
^{1}H NMR (400 MHz, $CDCl_3$)

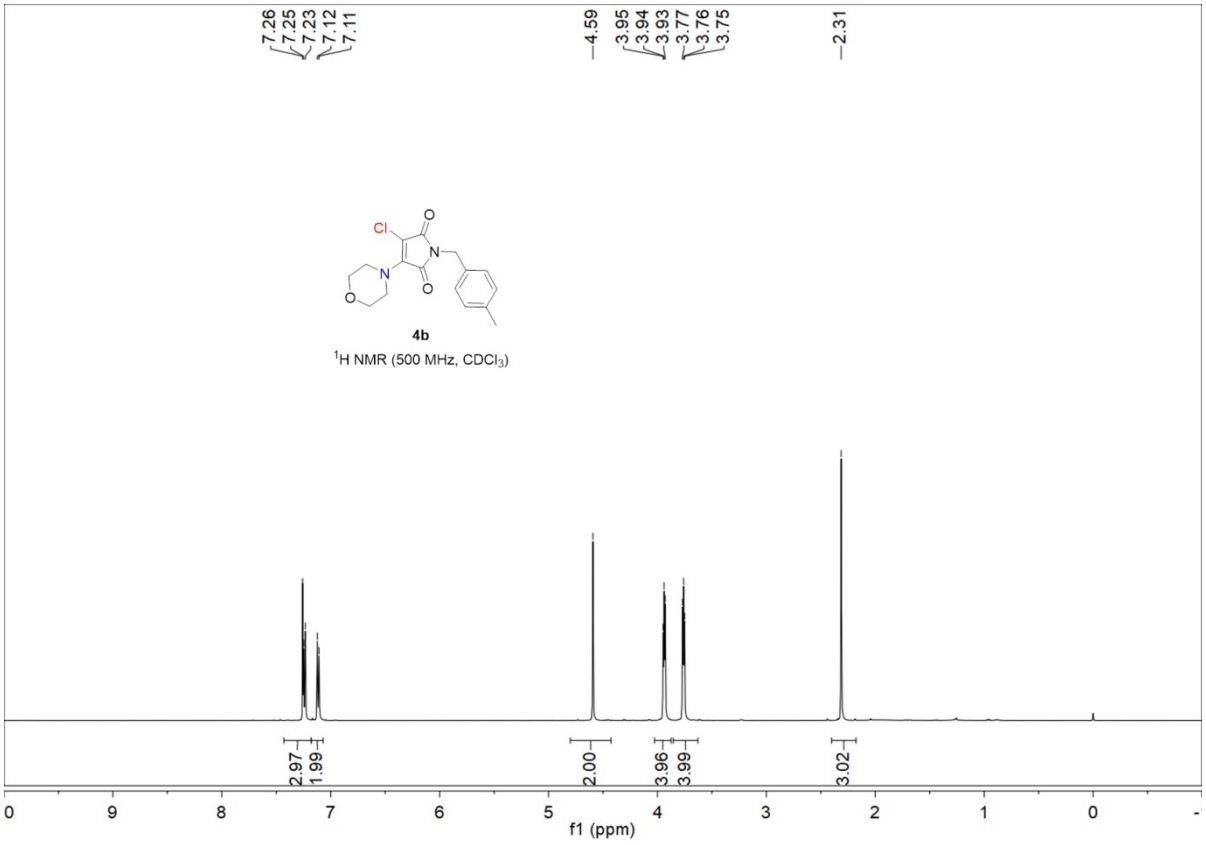


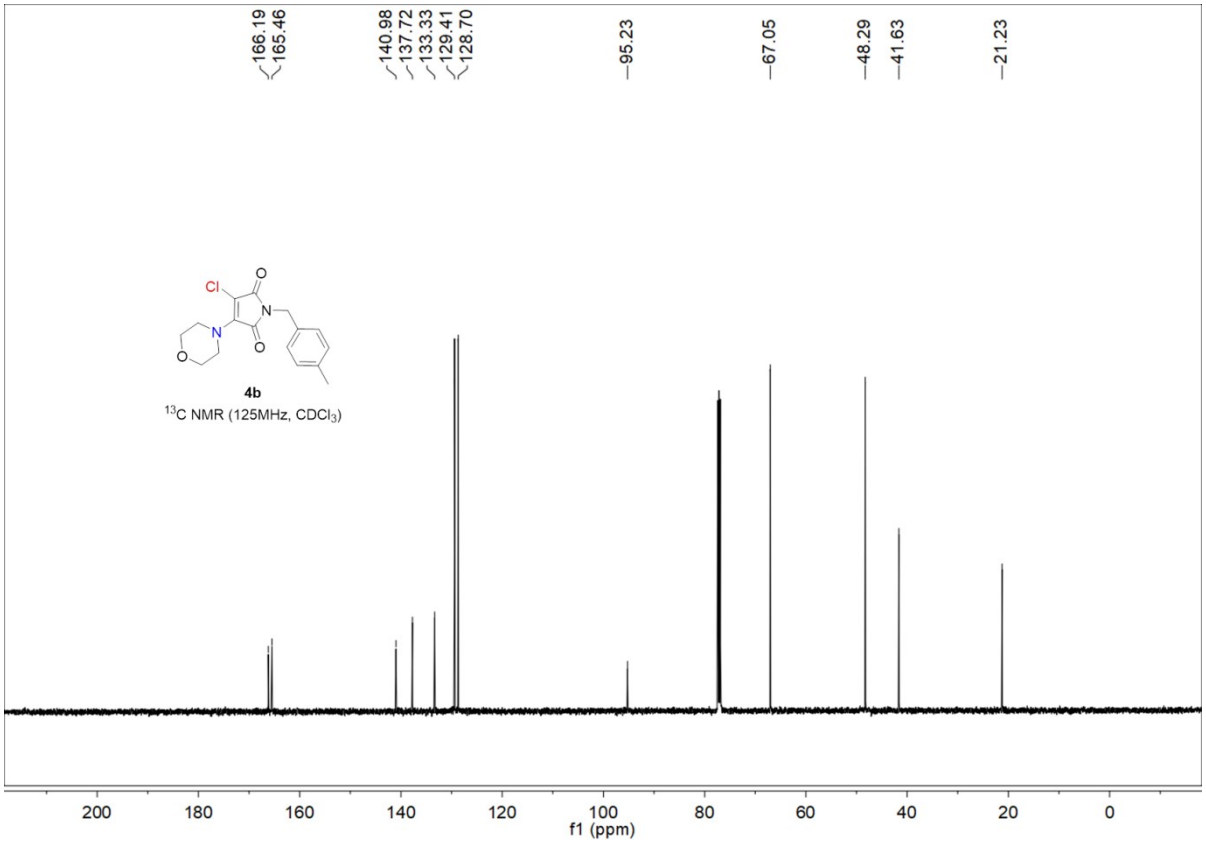
3p

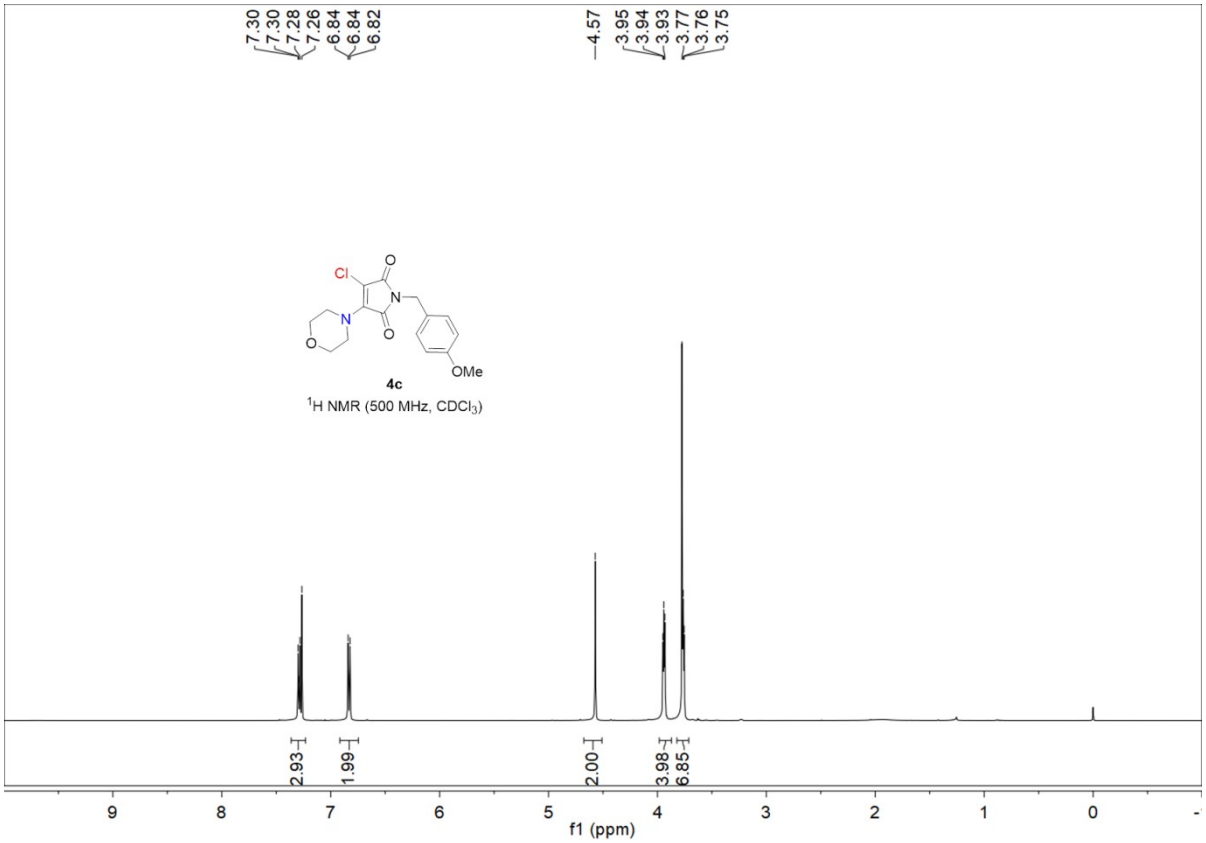
^{13}C NMR (125MHz, $CDCl_3$)

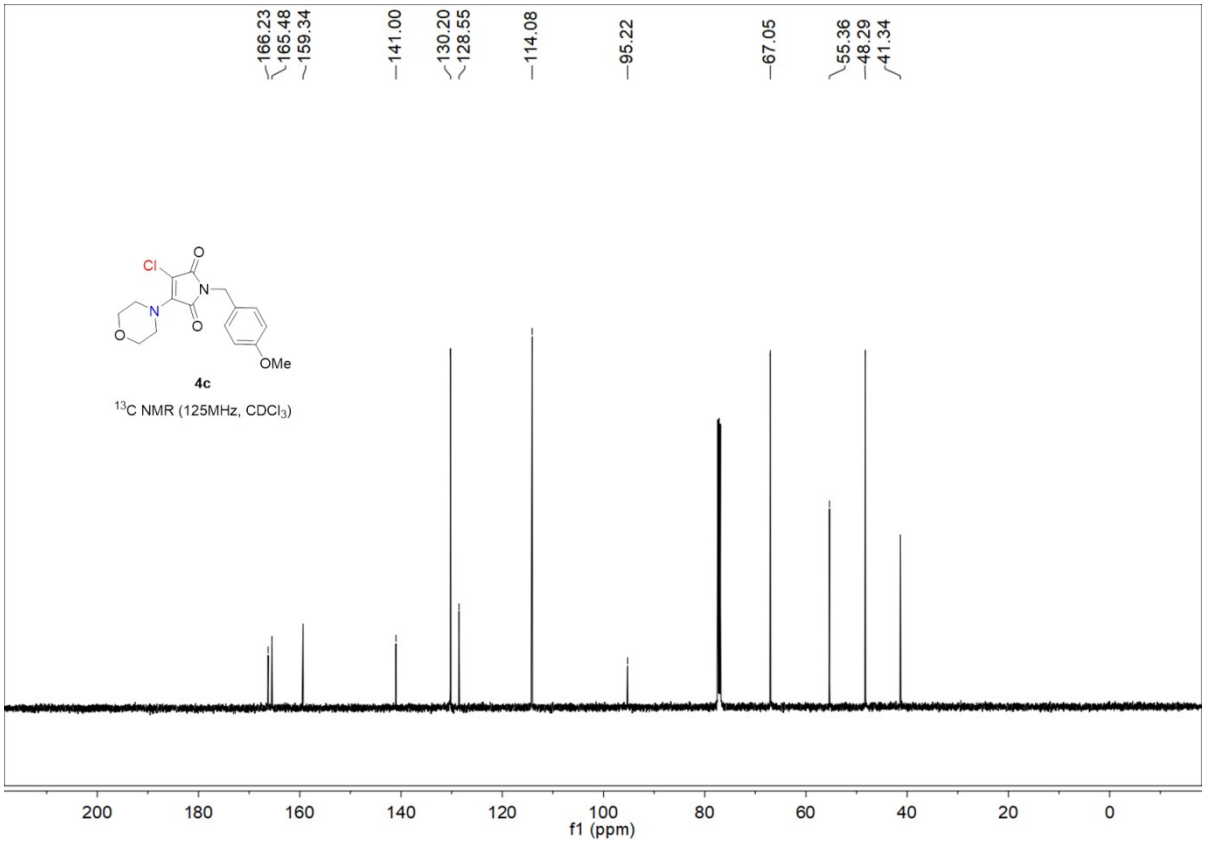

7.35
7.34
7.33
7.31
7.30
7.28
7.27
7.26
7.25
4.64
3.96
3.95
3.94
3.78
3.77
3.76
Cl
O
N
O
N
O
4a
1H NMR (500 MHz, CDCl3)
6.76
2.01
4.04
4.00
0
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

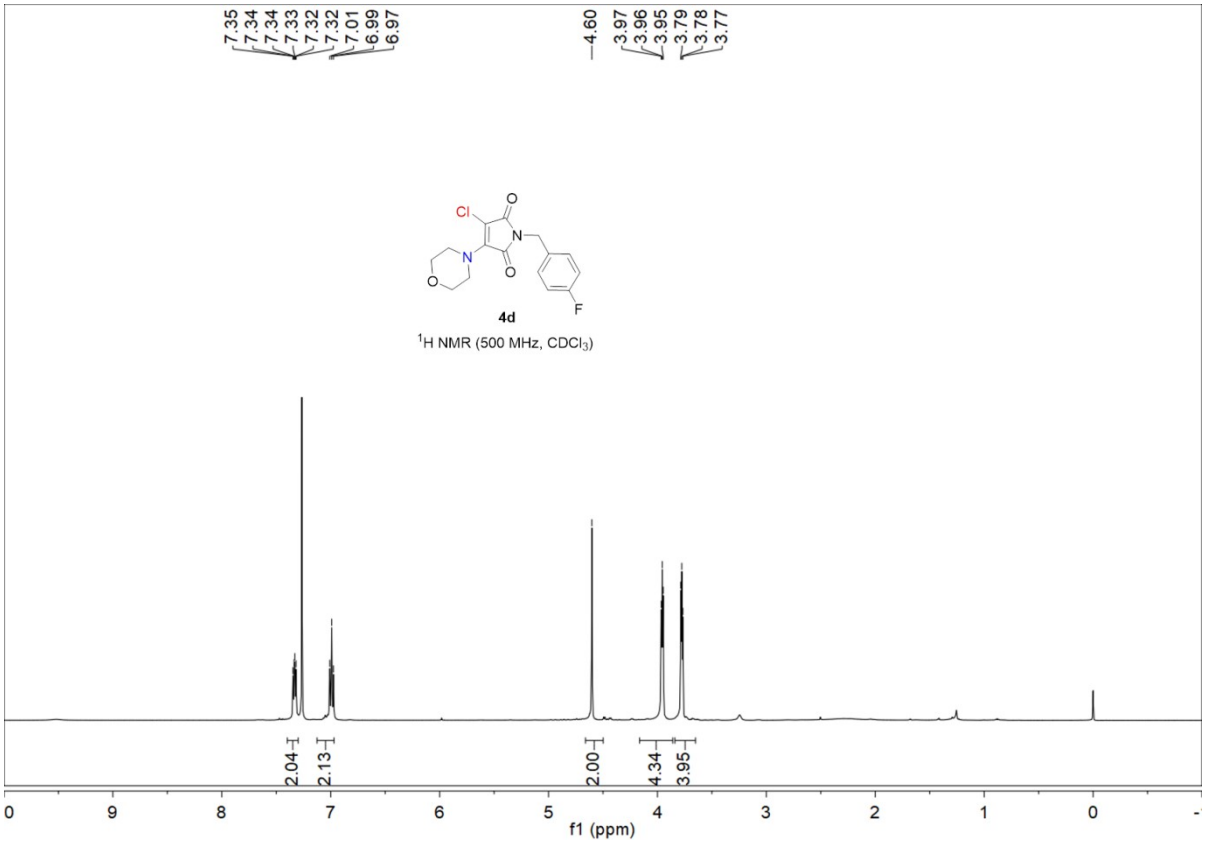

166.19
165.49
141.01
136.30
128.79
128.70
127.98
95.26
67.07
48.33
41.91
Cl
O
N
O
N
O
4a
13C NMR (125MHz, CDCl3)
200
180
160
140
120
100
80
60
40
20
0
f1 (ppm)

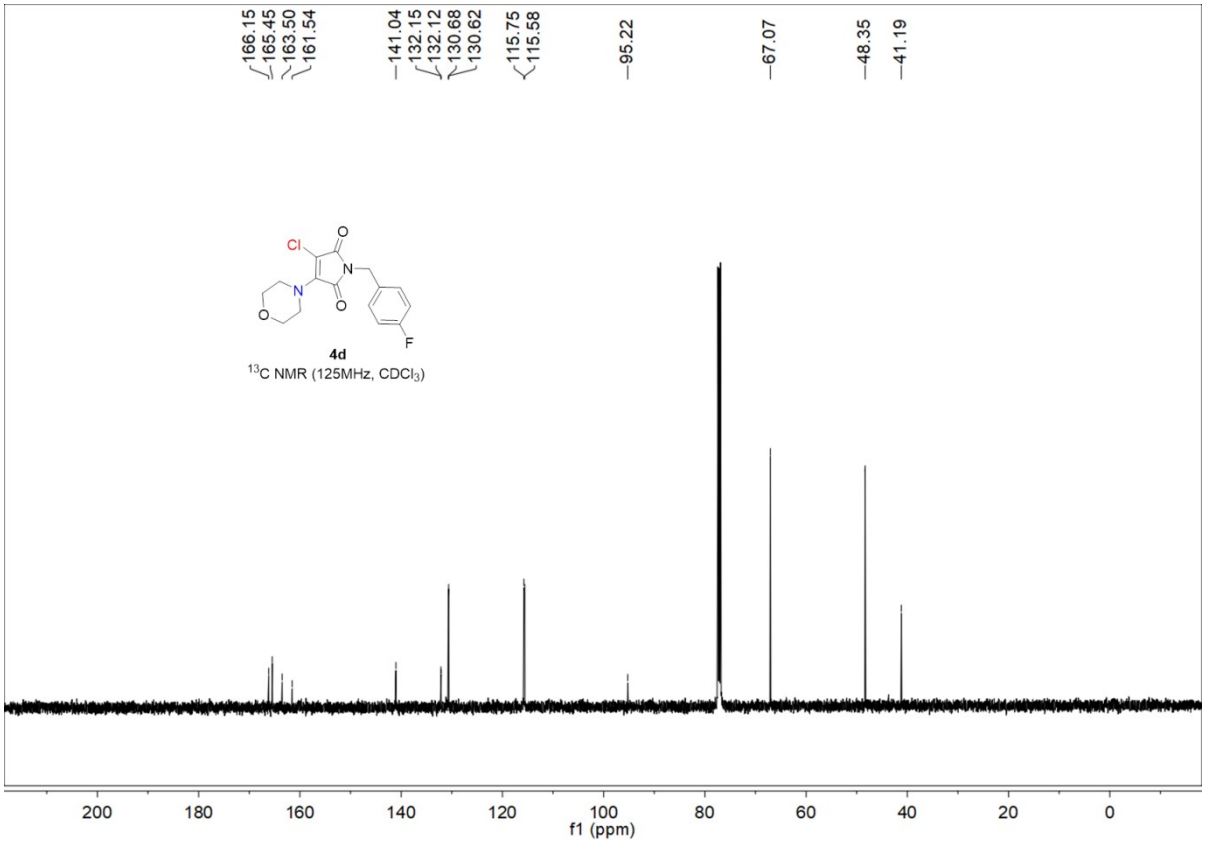

7.26
7.25
7.23
7.12
7.11
4.59
3.95
3.94
3.93
3.77
3.76
3.75
2.31
Cl
O
N
O
N
O
4b
^{1}H NMR (500 MHz, $CDCl_3$)
2.97
1.99
2.00
3.96
3.99
3.02
0
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

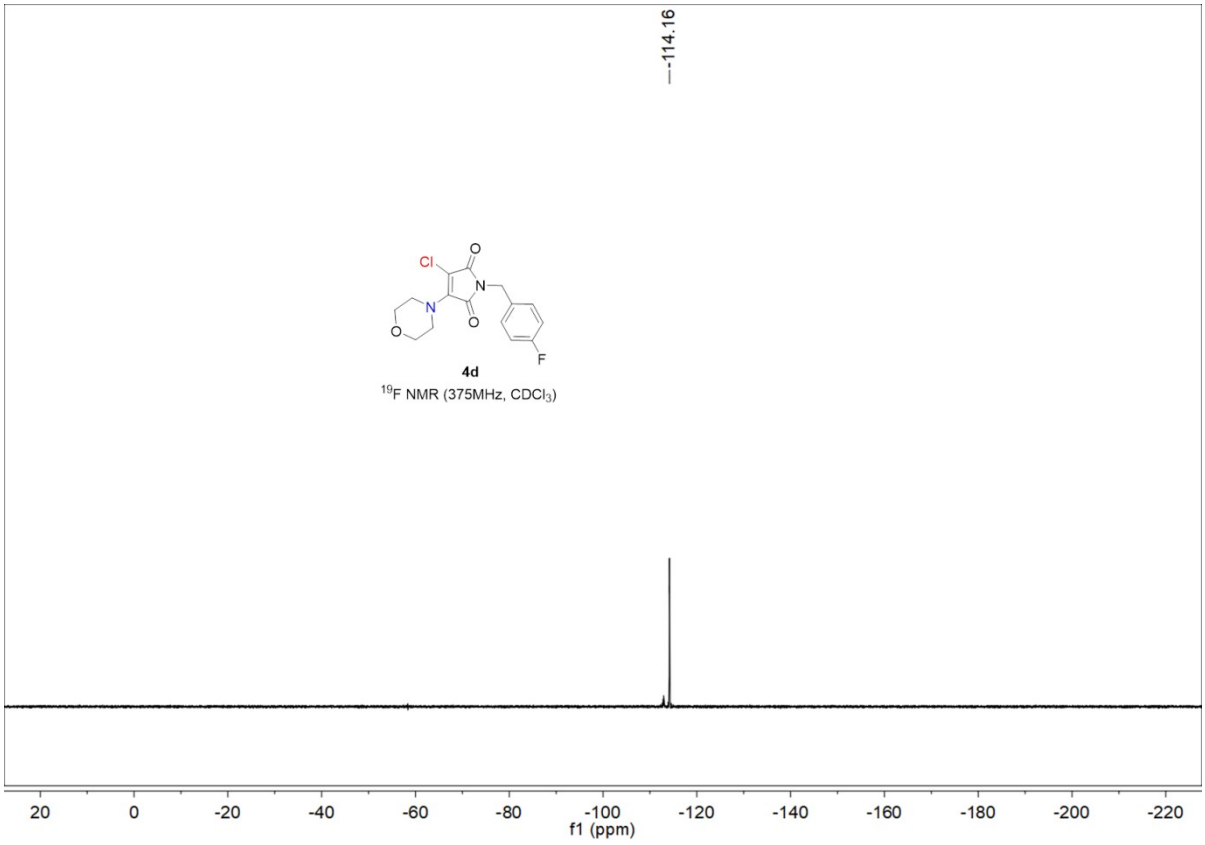

166.19
165.46
140.98
137.72
133.33
129.41
128.70
95.23
67.05
48.29
41.63
21.23
Cl
O
N
O
N
O
4b
^{13}C NMR (125MHz, $CDCl_3$)
200
180
160
140
120
100
80
60
40
20
0
f1 (ppm)

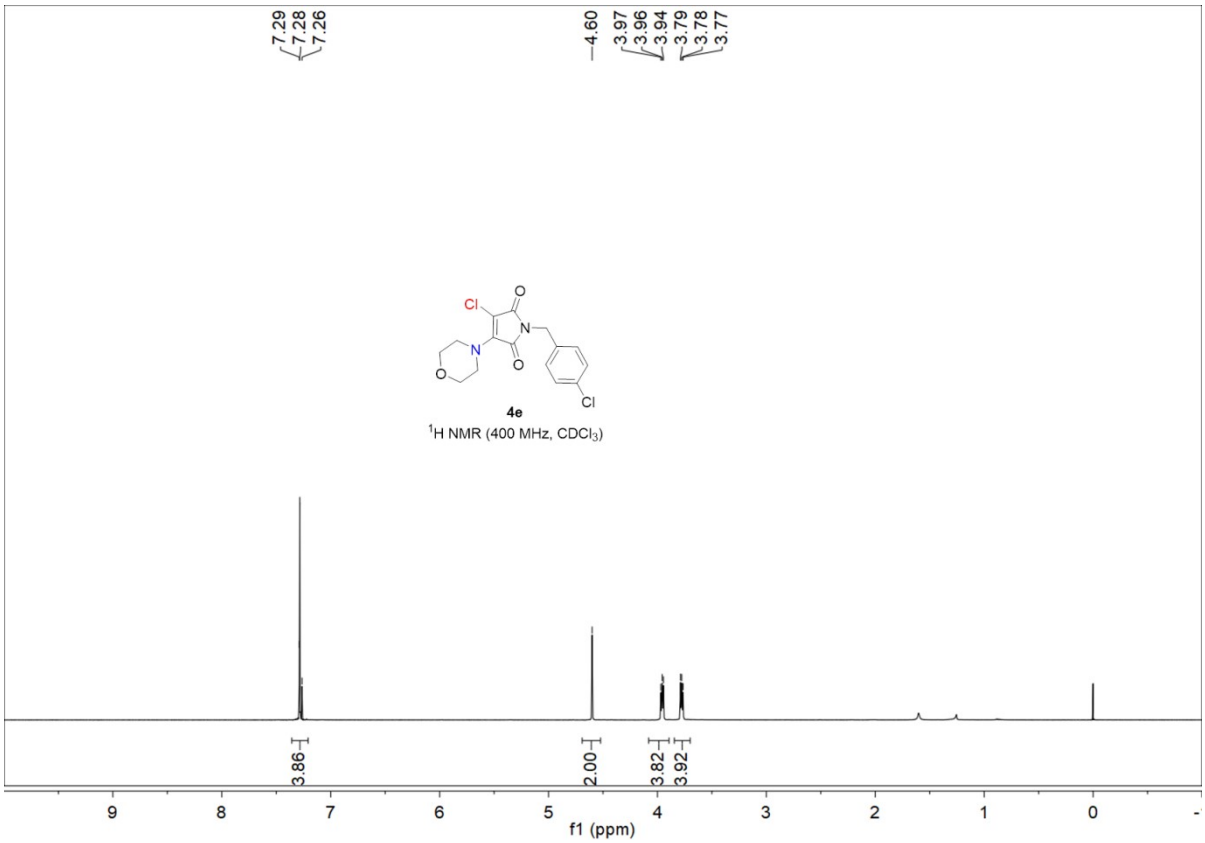

7.30
7.30
7.28
7.26
6.84
6.84
6.82
4.57
3.95
3.94
3.93
3.77
3.76
3.75
Cl
O
N
O
N
O
OMe
4c
^{1}H NMR (500 MHz, $CDCl_3$)
2.93
1.99
2.00
3.98
6.85
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

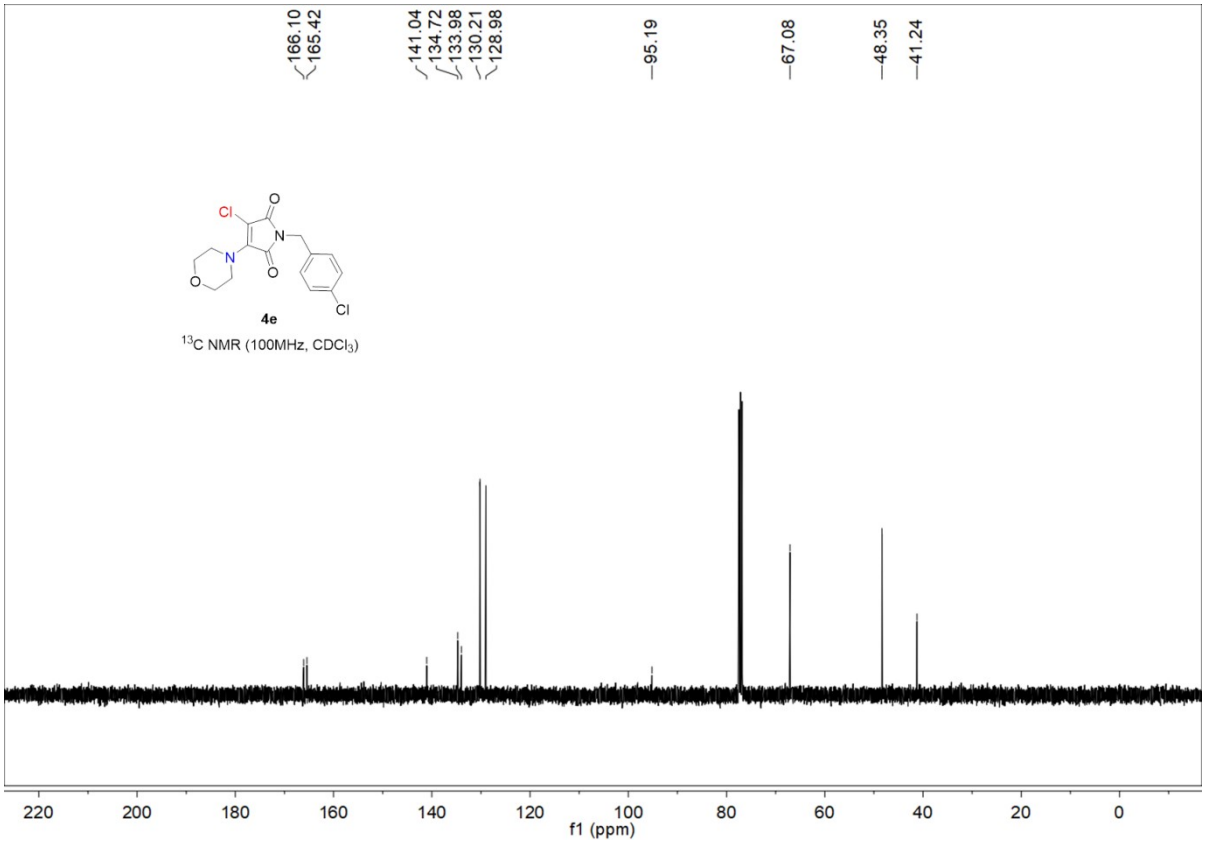

166.23
165.48
159.34
141.00
130.20
128.55
114.08
95.22
67.05
55.36
48.29
41.34
Cl
O
N
O
N
O
OMe
4c
^{13}C NMR (125MHz, $CDCl_3$)
200
180
160
140
120
100
80
60
40
20
0
f1 (ppm)

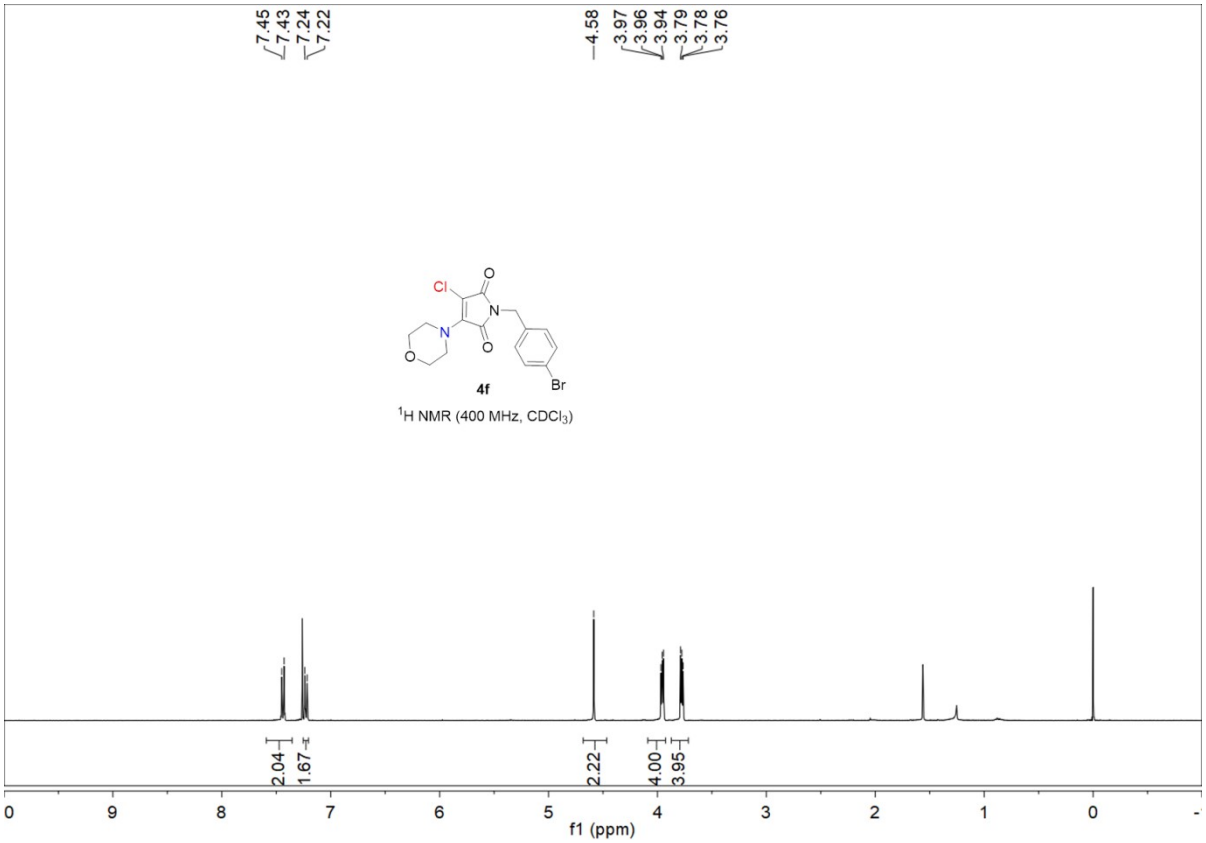

7.35
7.34
7.34
7.33
7.32
7.32
7.01
6.99
6.97
4.60
3.97
3.96
3.95
3.79
3.78
3.77
Cl
O
N
O
N
O
F
4d
1H NMR (500 MHz, CDCl3)
2.04
2.13
2.00
4.34
3.95
0
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

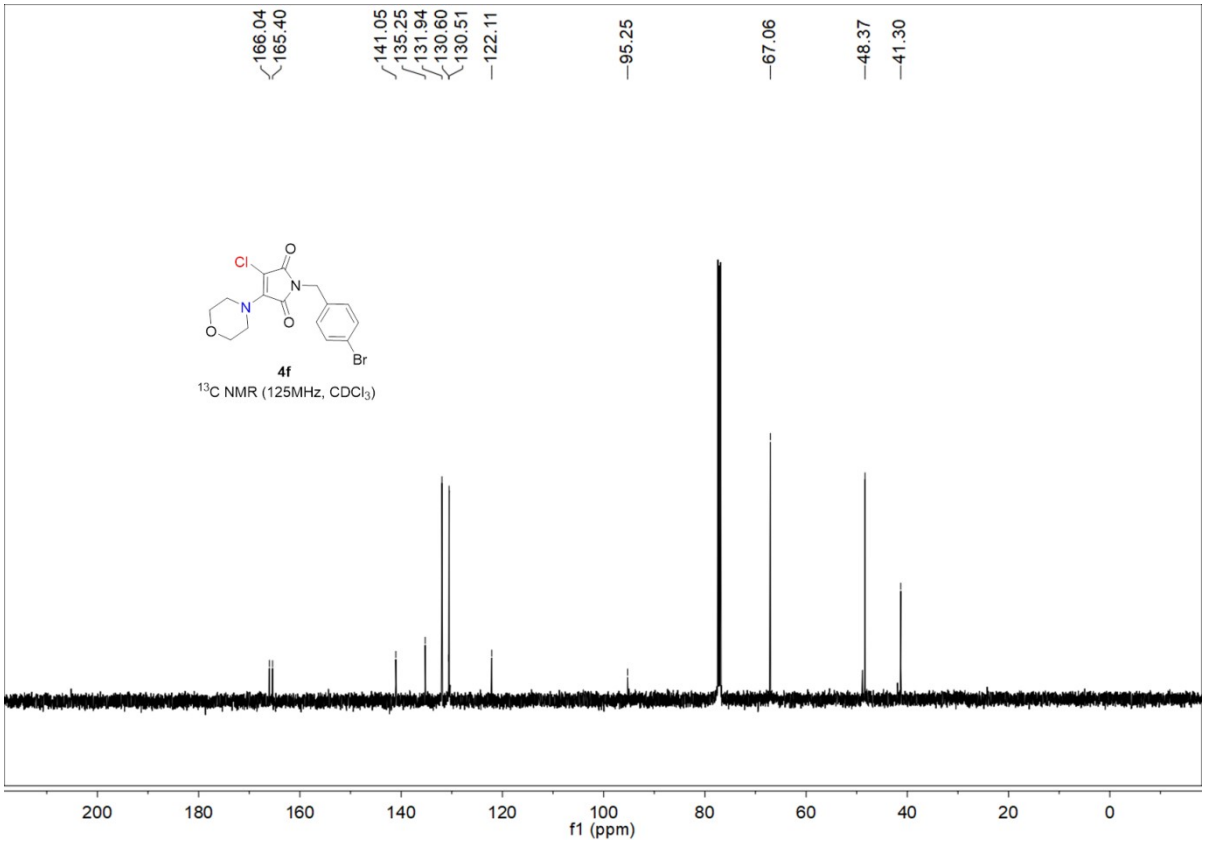

166.15
165.45
163.50
161.54
141.04
132.15
132.12
130.68
130.62
115.75
115.58
95.22
67.07
48.35
41.19
Cl
O
N
O
N
O
F
4d
13C NMR (125MHz, CDCl3)
200
180
160
140
120
100
80
60
40
20
0
f1 (ppm)


-114.16
Cl
O
N
O
N
O
F
4d
19F NMR (375MHz, CDCl3)
20
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
f1 (ppm)


7.29
7.28
7.26
4.60
3.97
3.96
3.94
3.79
3.78
3.77
Cl
O
N
O
N
O
Cl
4e
1H NMR (400 MHz, CDCl3)
3.86
2.00
3.82
3.92
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

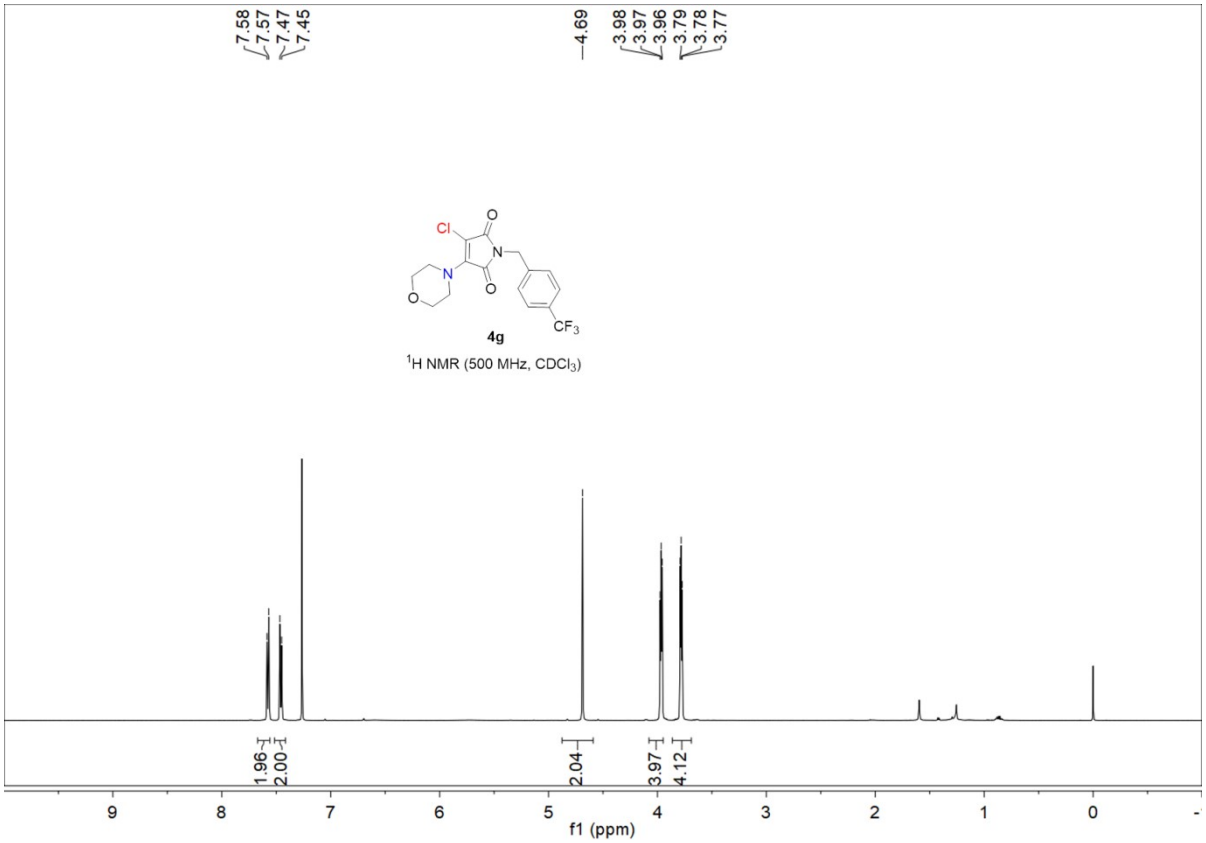

166.10
165.42
141.04
134.72
133.98
130.21
128.98
95.19
67.08
48.35
41.24
Cl
O
N
O
N
O
Cl
4e
13C NMR (100MHz, CDCl3)
220
200
180
160
140
120
100
80
60
40
20
0
f1 (ppm)


7.45
7.43
7.24
7.22
4.58
3.97
3.96
3.94
3.79
3.78
3.76
Cl
O
N
O
N
O
Br
4f
1H NMR (400 MHz, CDCl3)
2.04
1.67
2.22
4.00
3.95
0
9
8
7
6
5
4
3
2
1
0
f1 (ppm)



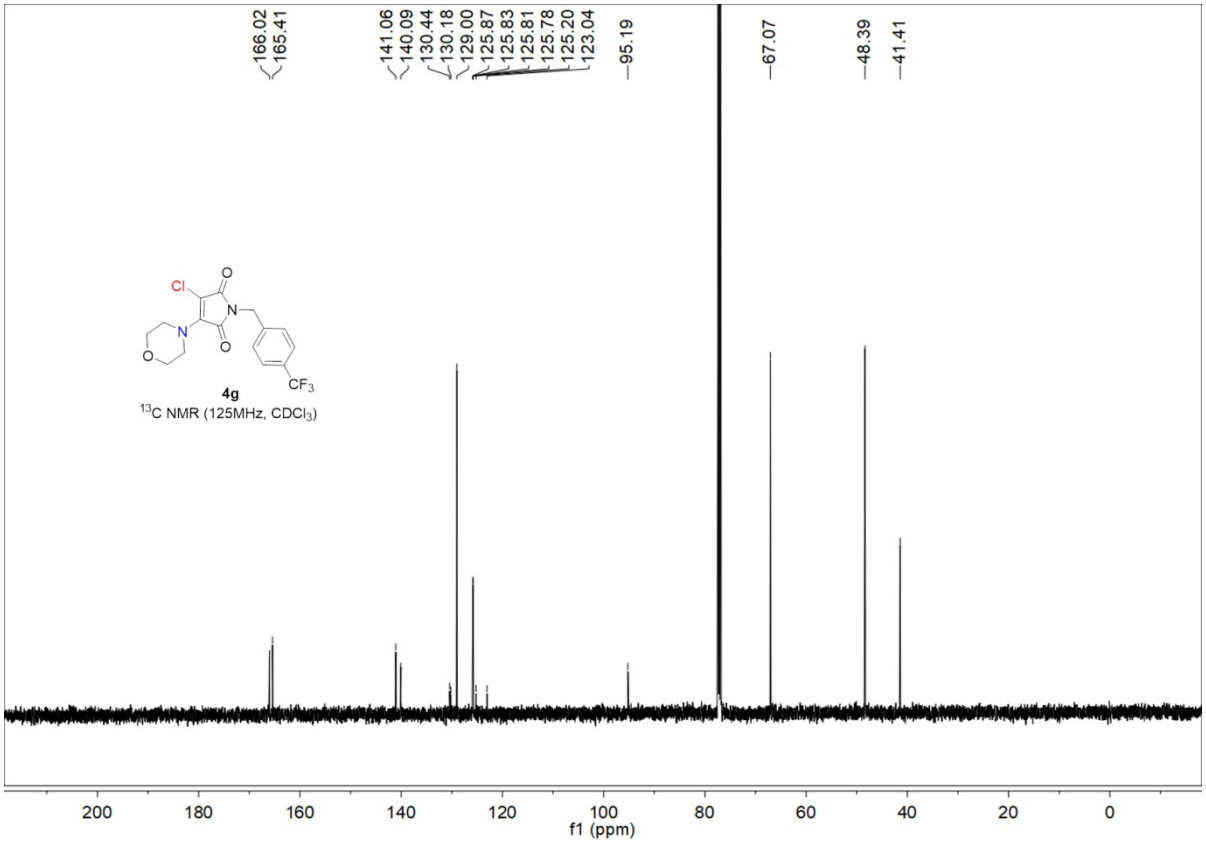
4f

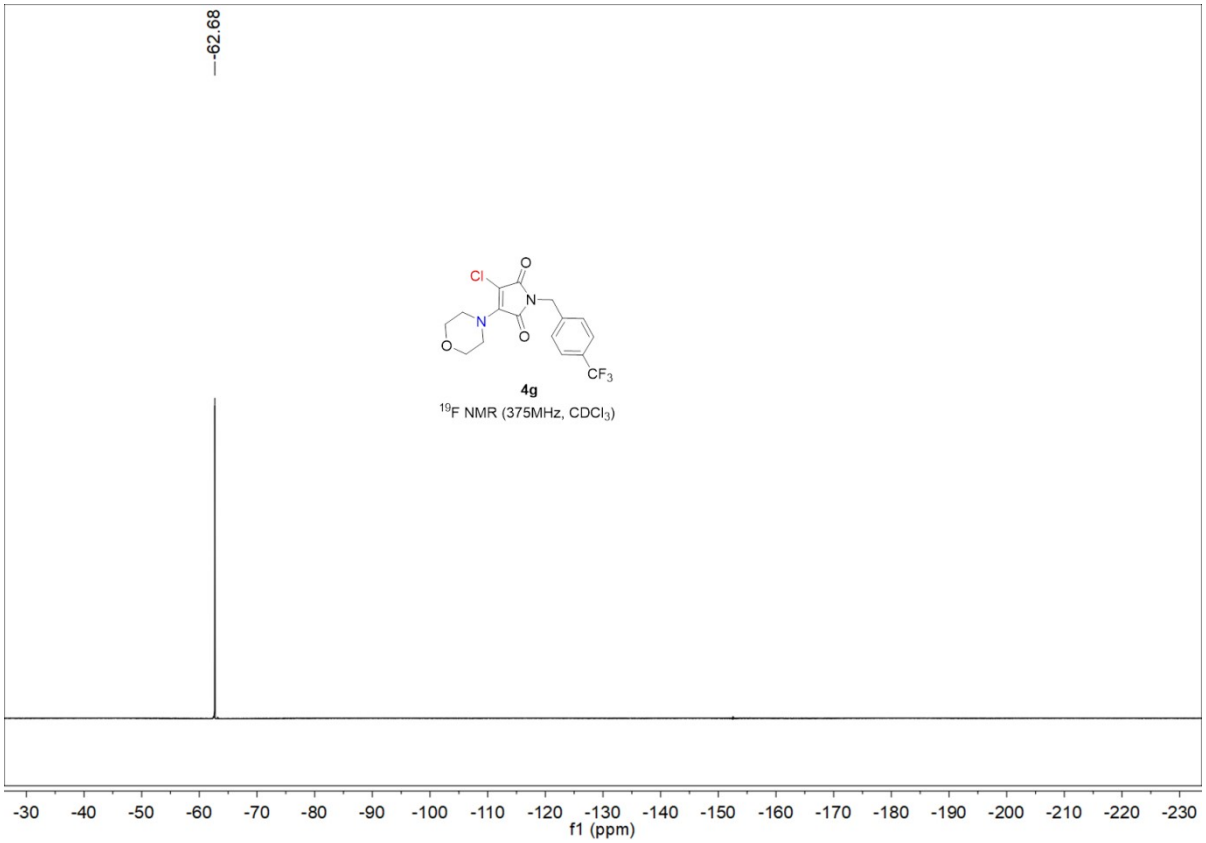
^{13}C NMR (125MHz, $CDCl_3$)

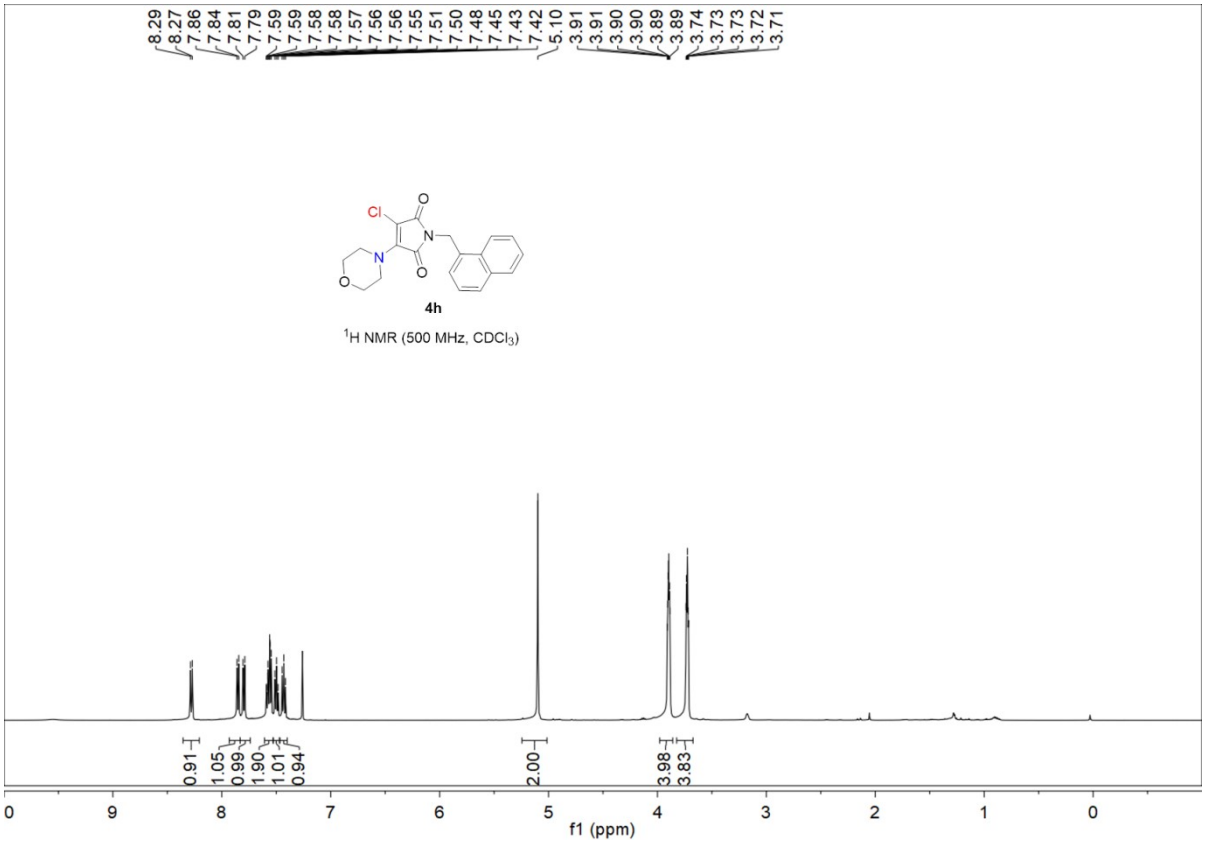


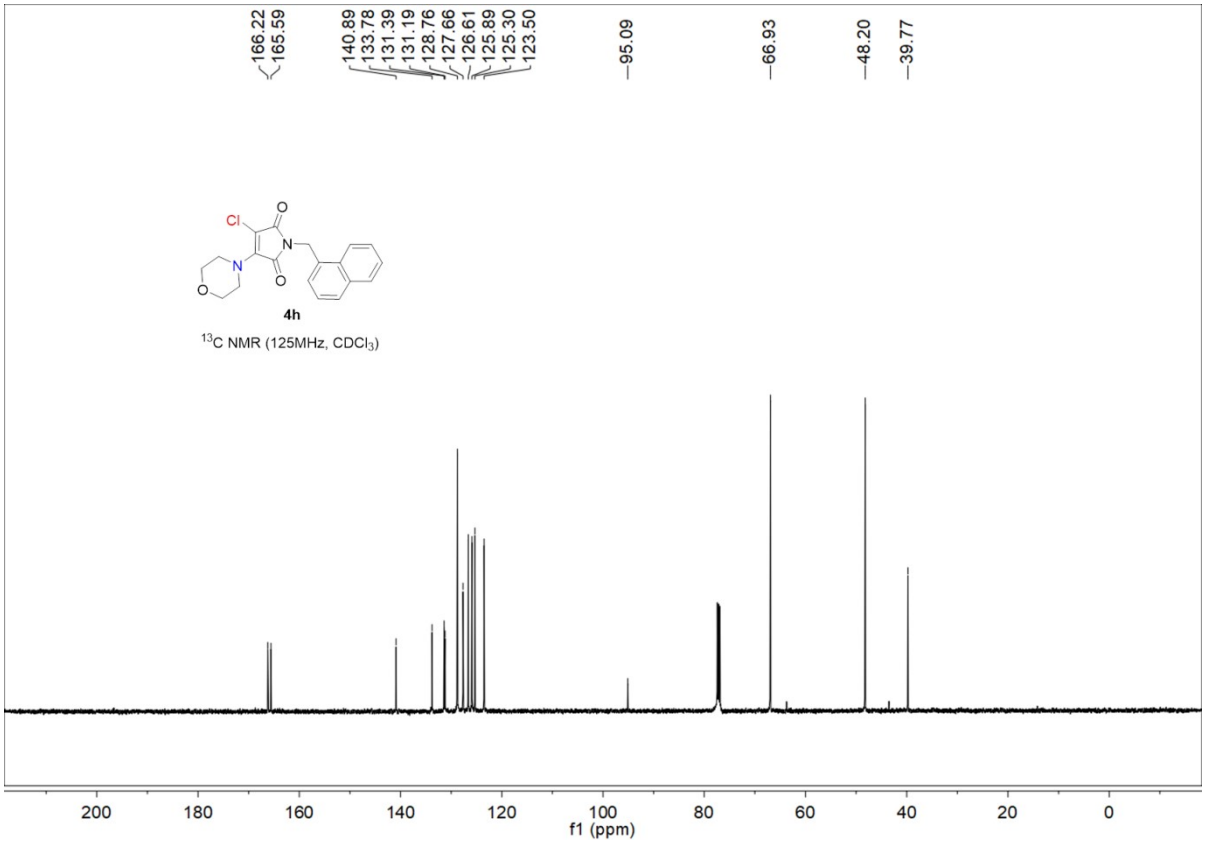
4g

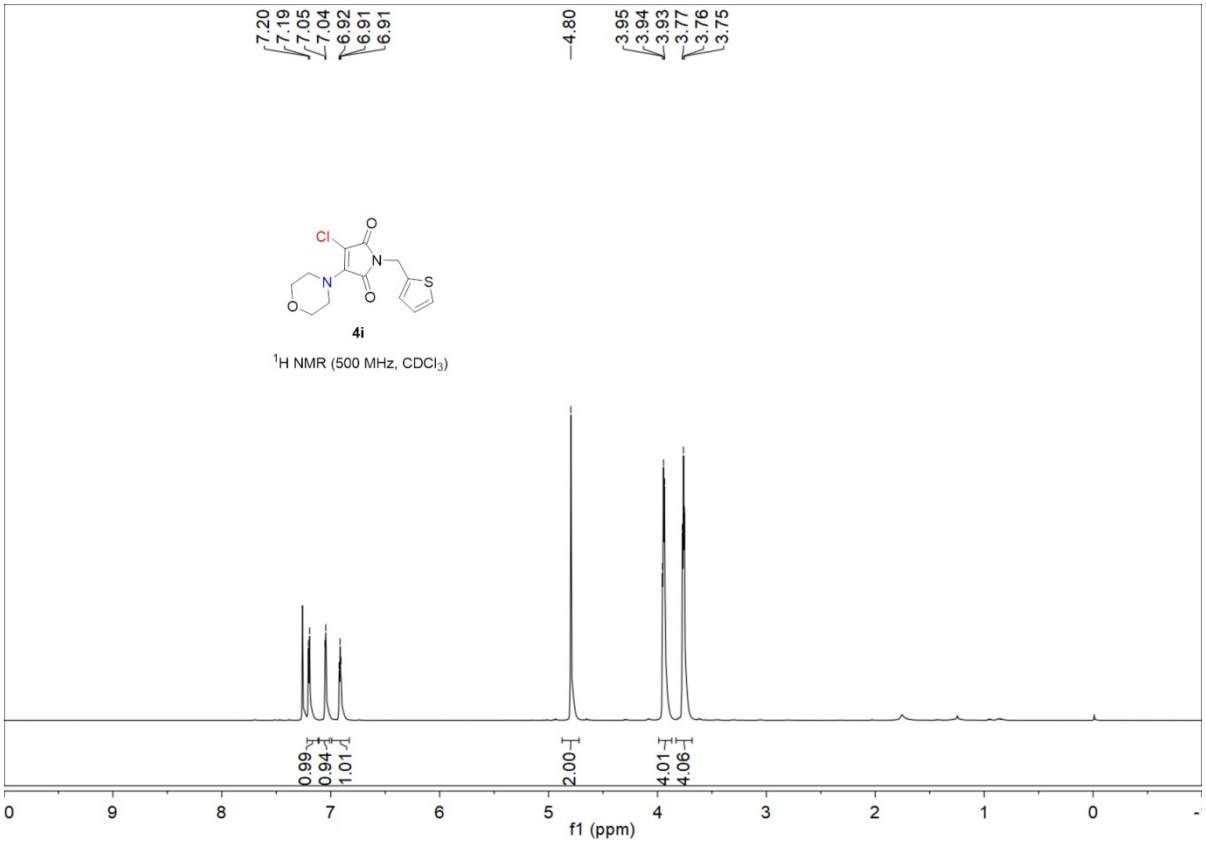
^{1}H NMR (500 MHz, $CDCl_3$)

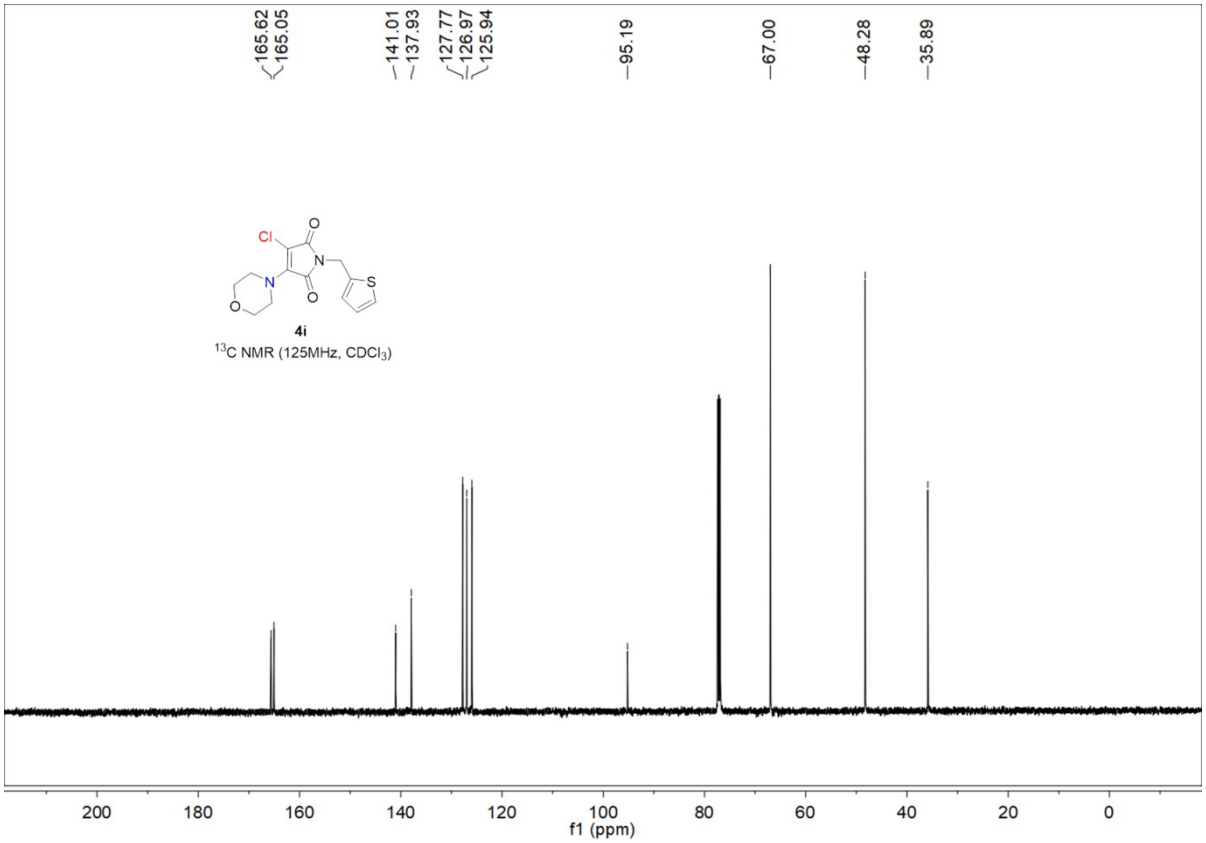

166.02
165.41
141.06
140.09
130.44
130.18
129.00
125.87
125.83
125.81
125.78
125.20
123.04
95.19
67.07
48.39
41.41
Cl
O
N
O
N
O
CF3
4g
13C NMR (125MHz, CDCl3)
200
180
160
140
120
100
80
60
40
20
0
f1 (ppm)

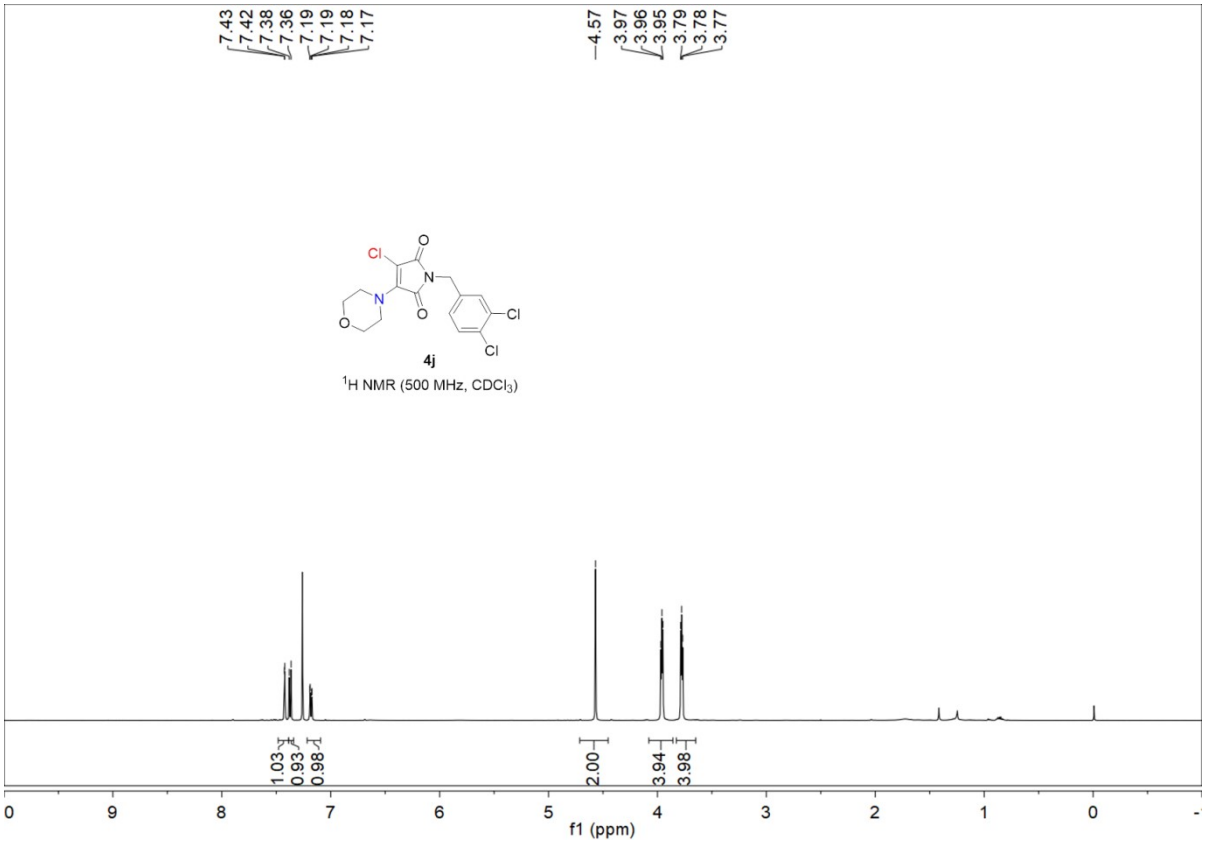

-62.68
Cl
O
N
O
N
O
CF3
4g
19F NMR (375MHz, CDCl3)
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
-210
-220
-230
f1 (ppm)

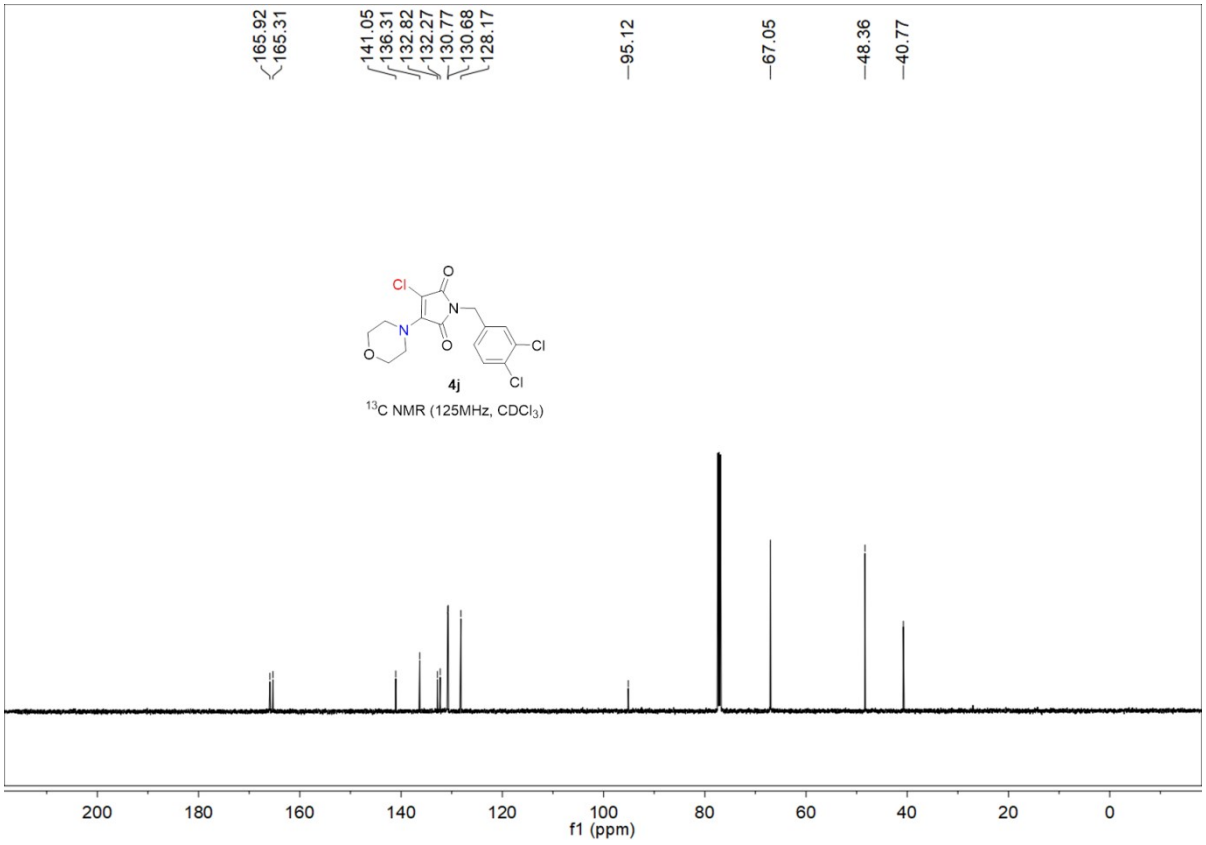

8.29
8.27
7.86
7.84
7.81
7.79
7.59
7.59
7.58
7.58
7.57
7.56
7.56
7.55
7.51
7.50
7.48
7.45
7.43
7.42
5.10
3.91
3.91
3.90
3.90
3.89
3.89
3.74
3.73
3.73
3.72
3.71
Cl
O
N
N
O
O
4h
1H NMR (500 MHz, CDCl3)
0.91
1.05
0.99
1.90
1.01
0.94
2.00
3.98
3.83
0
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

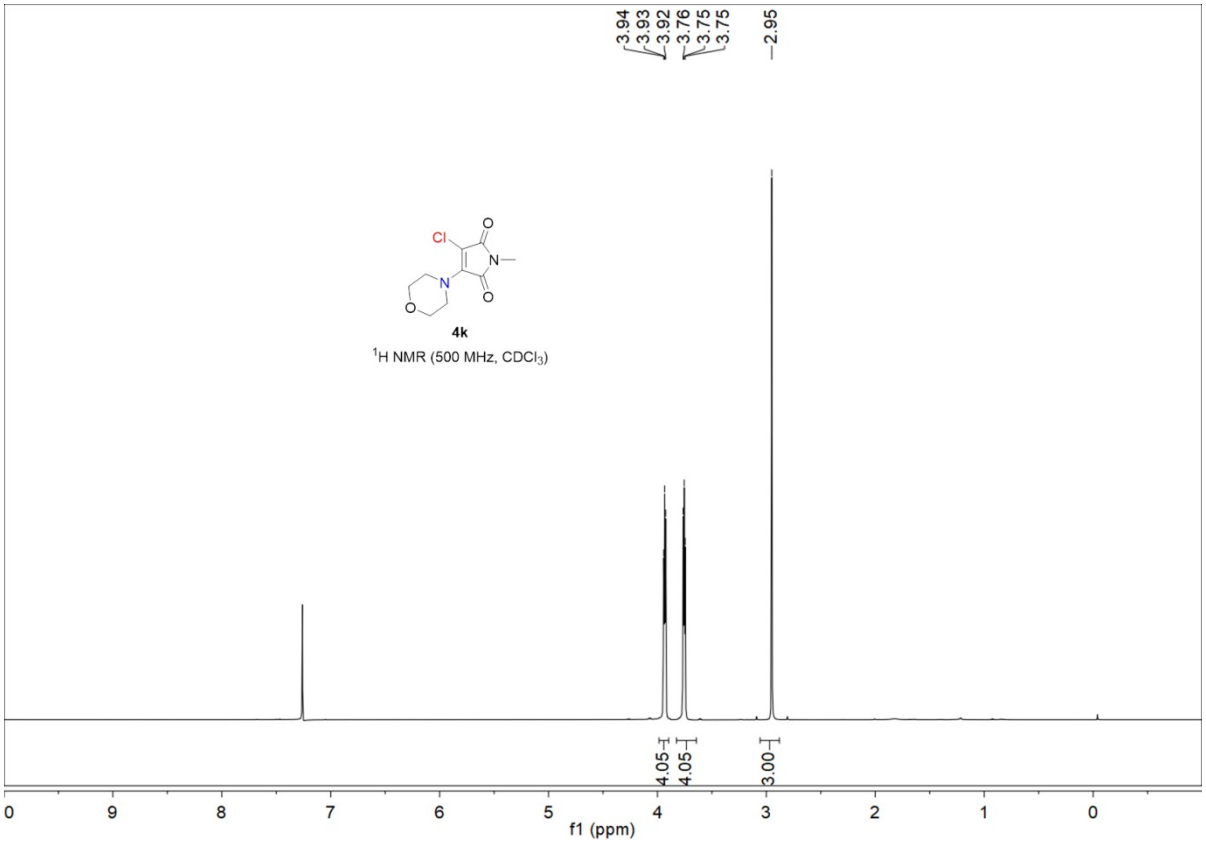

166.22
165.59
140.89
133.78
131.39
131.19
128.76
127.66
126.61
125.89
125.30
123.50
95.09
66.93
48.20
39.77
Cl
O
N
N
O
O
4h
13C NMR (125MHz, CDCl3)
200
180
160
140
120
100
80
60
40
20
0
f1 (ppm)

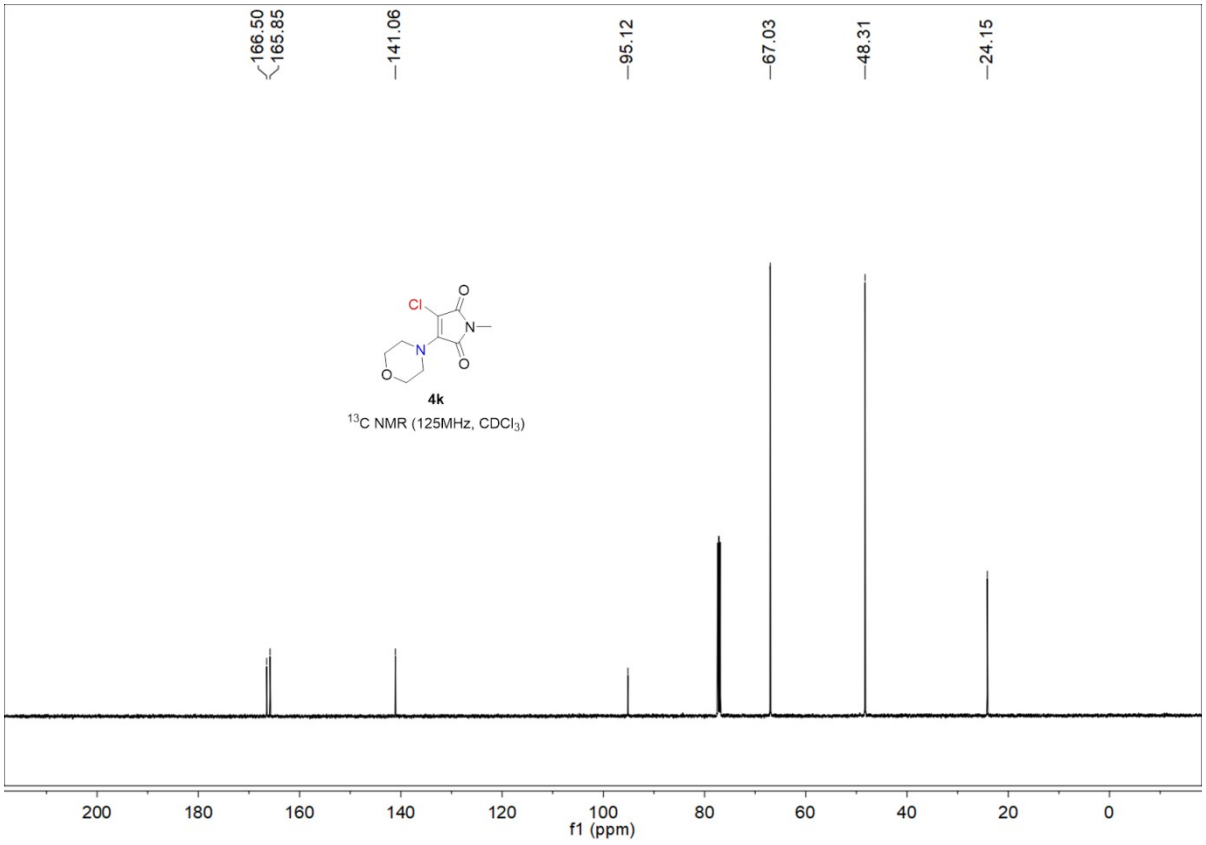

7.20
7.19
7.05
7.04
6.92
6.91
6.91
4.80
3.95
3.94
3.93
3.77
3.76
3.75
Cl
O
N
S
O
N
O
4i
^{1}H NMR (500 MHz, CDCl$_3$)
0.99
0.94
1.01
2.00
4.01
4.06
0
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

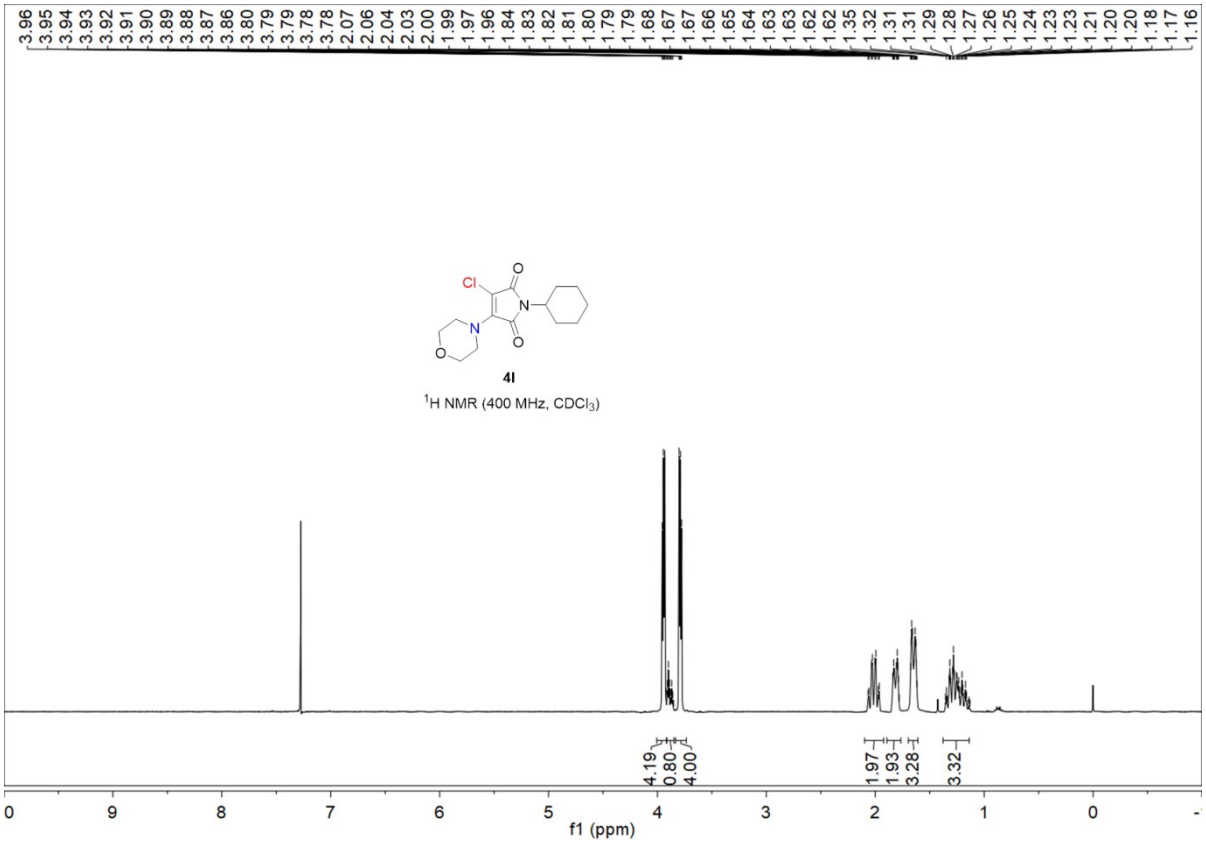

165.62
165.05
141.01
137.93
127.77
126.97
125.94
95.19
67.00
48.28
35.89
Cl
O
N
S
O
N
O
4i
^{13}C NMR (125MHz, CDCl$_3$)
200
180
160
140
120
100
80
60
40
20
0
f1 (ppm)

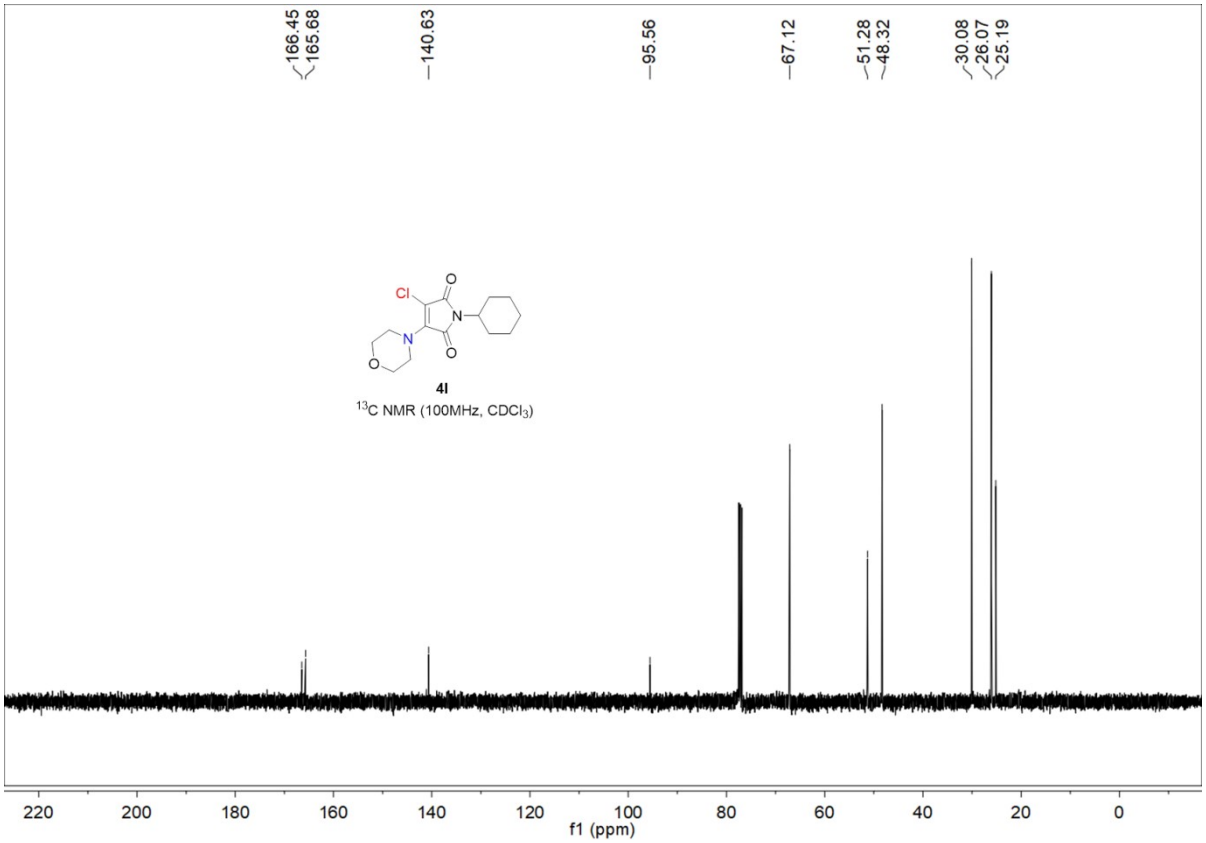

7.43
7.42
7.38
7.36
7.19
7.19
7.18
7.17
4.57
3.97
3.96
3.95
3.79
3.78
3.77
Cl
O
N
O
N
O
Cl
Cl
4j
1H NMR (500 MHz, CDCl3)
1.03
0.93
0.98
2.00
3.94
3.98
0
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

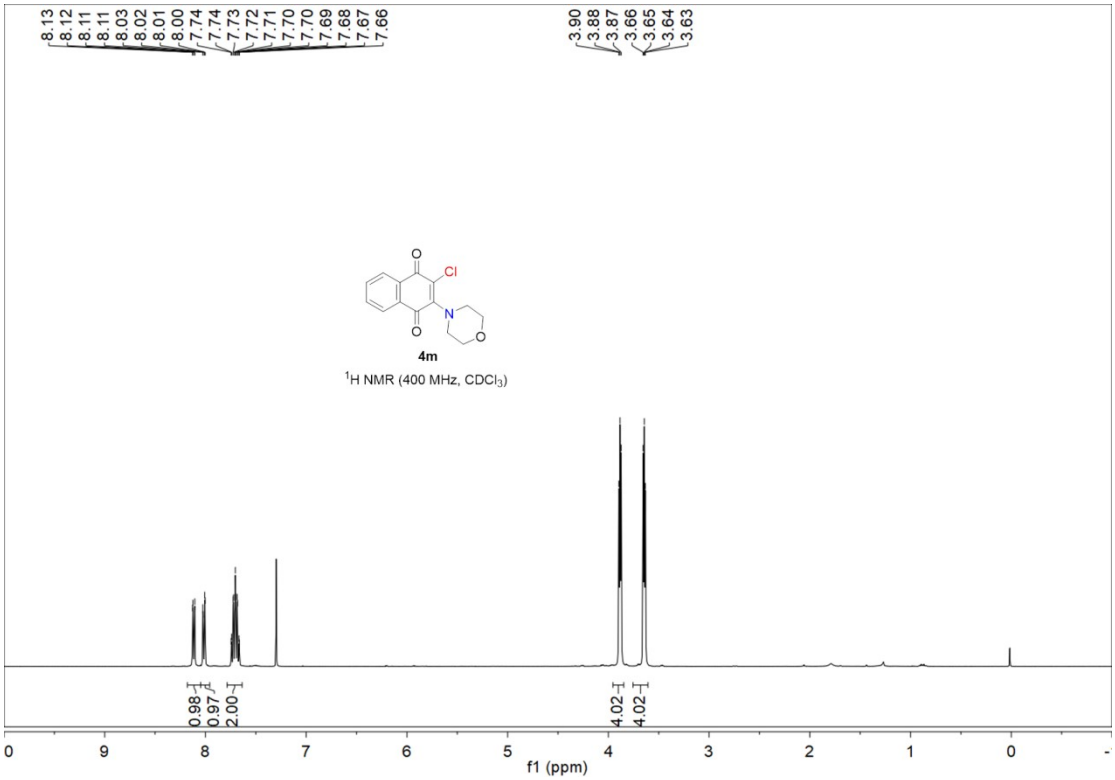

165.92
165.31
141.05
136.31
132.82
132.27
130.77
130.68
128.17
95.12
67.05
48.36
40.77
Cl
O
N
O
N
O
Cl
Cl
4j
13C NMR (125MHz, CDCl3)
200
180
160
140
120
100
80
60
40
20
0
f1 (ppm)

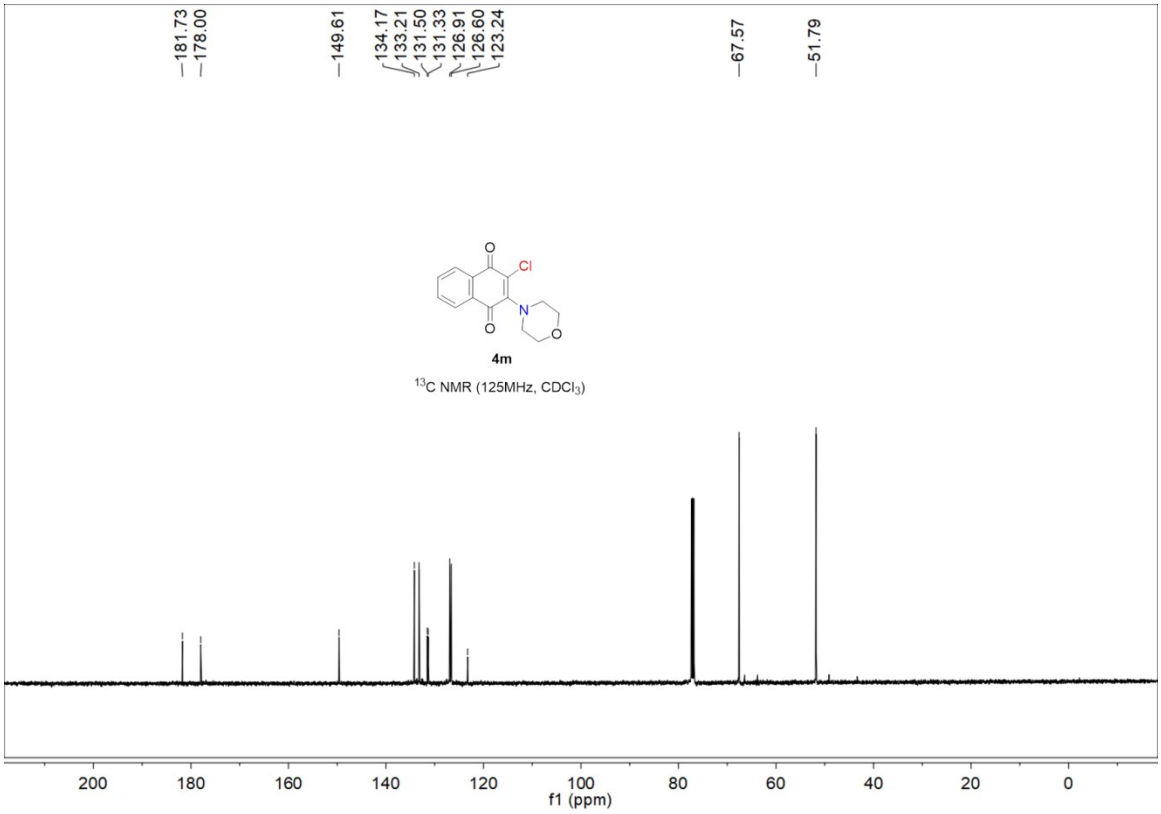

3.94
3.93
3.92
3.76
3.75
3.75
2.95
Cl
O
N
N
O
O
4k
1H NMR (500 MHz, CDCl3)
4.05
4.05
3.00
0
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

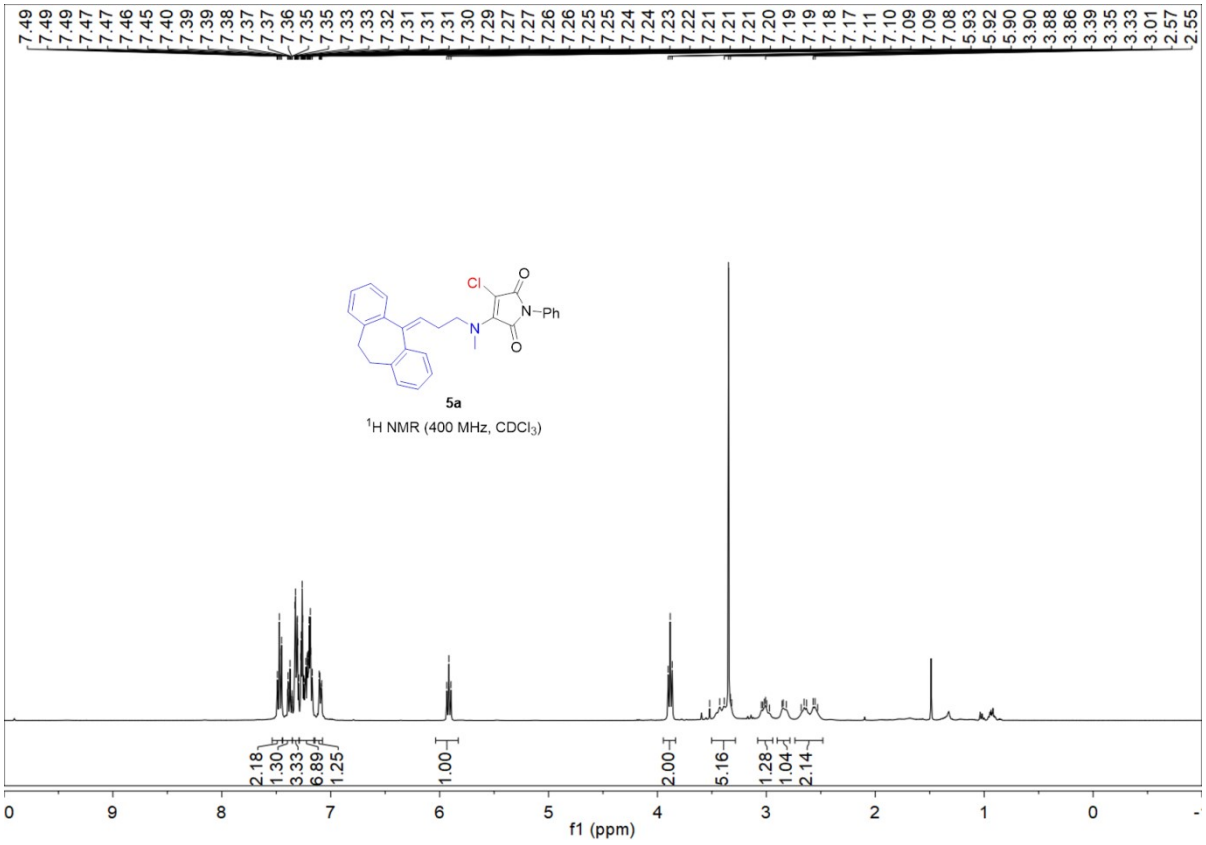

166.50
165.85
141.06
95.12
67.03
48.31
24.15
Cl
O
N
N
O
O
4k
13C NMR (125MHz, CDCl3)
200
180
160
140
120
100
80
60
40
20
0
f1 (ppm)

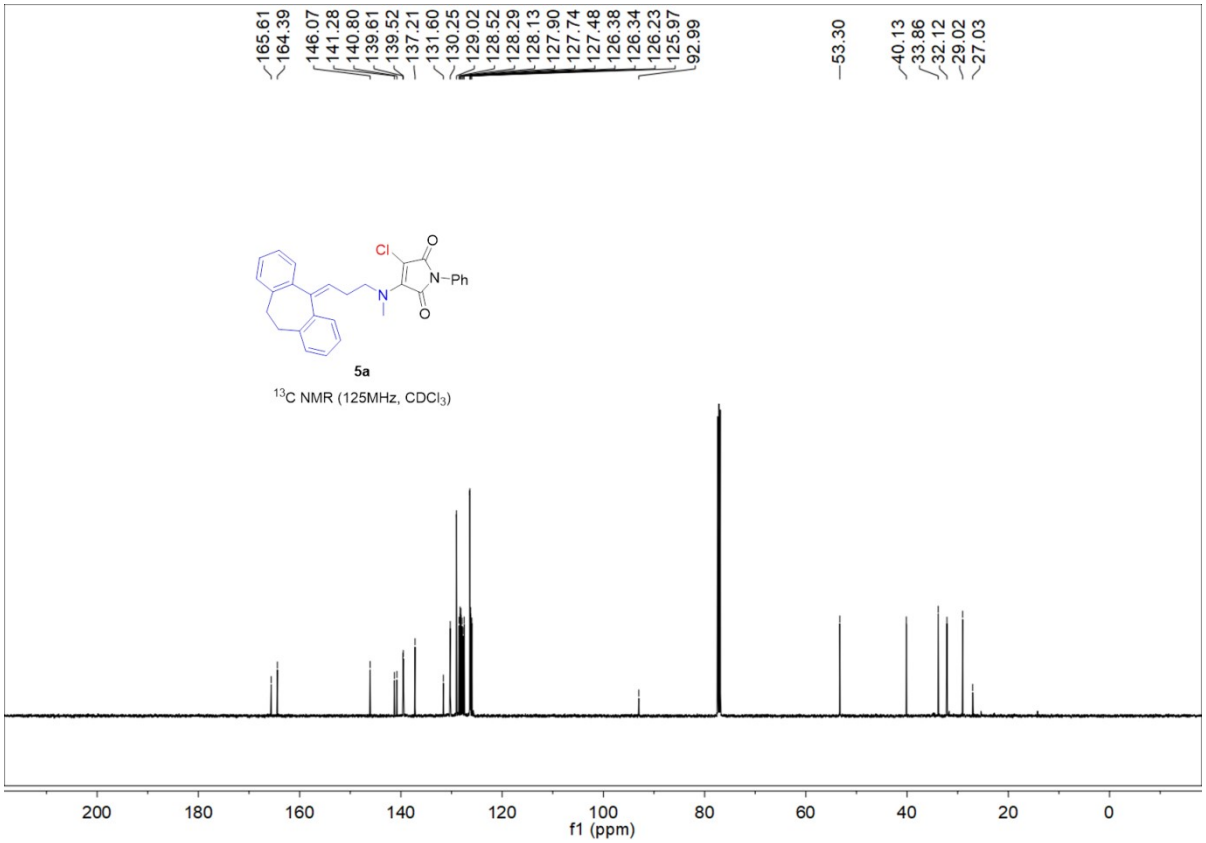

3.96 3.95 3.94 3.93 3.92 3.91 3.90 3.89 3.88 3.87 3.86 3.80 3.79 3.79 3.78 3.78 2.07 2.06 2.04 2.03 2.00 1.99 1.97 1.96 1.84 1.83 1.82 1.81 1.80 1.79 1.79 1.68 1.67 1.67 1.66 1.65 1.64 1.63 1.63 1.62 1.62 1.35 1.32 1.31 1.31 1.29 1.28 1.27 1.26 1.25 1.24 1.23 1.23 1.21 1.20 1.20 1.18 1.17 1.16
Cl
O
N
N
O
O
4l
^{1}H NMR (400 MHz, CDCl$_3$)
4.19
0.80
4.00
1.97
1.93
3.28
3.32
0
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

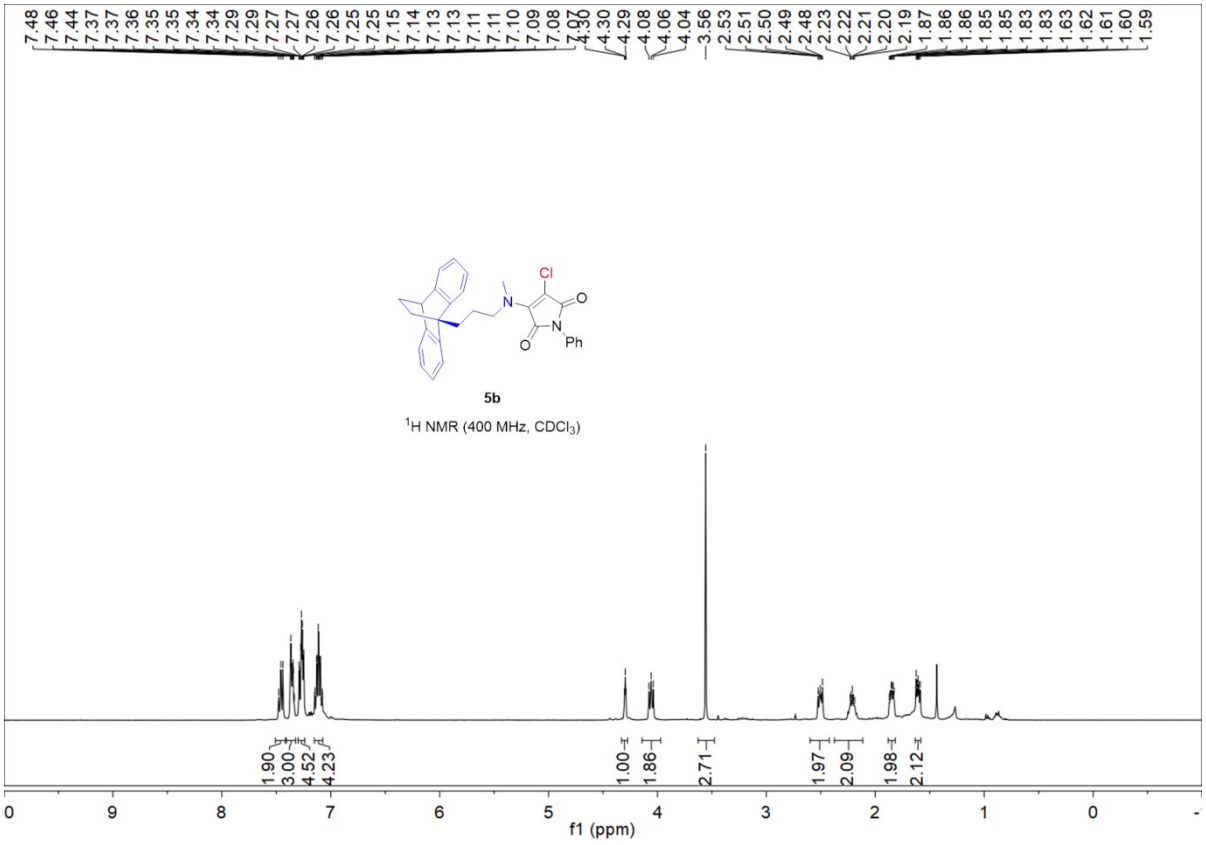

166.45
165.68
140.63
95.56
67.12
51.28
48.32
30.08
26.07
25.19
Cl
O
N
N
O
O
4l
^{13}C NMR (100MHz, CDCl$_3$)
220
200
180
160
140
120
100
80
60
40
20
0
f1 (ppm)

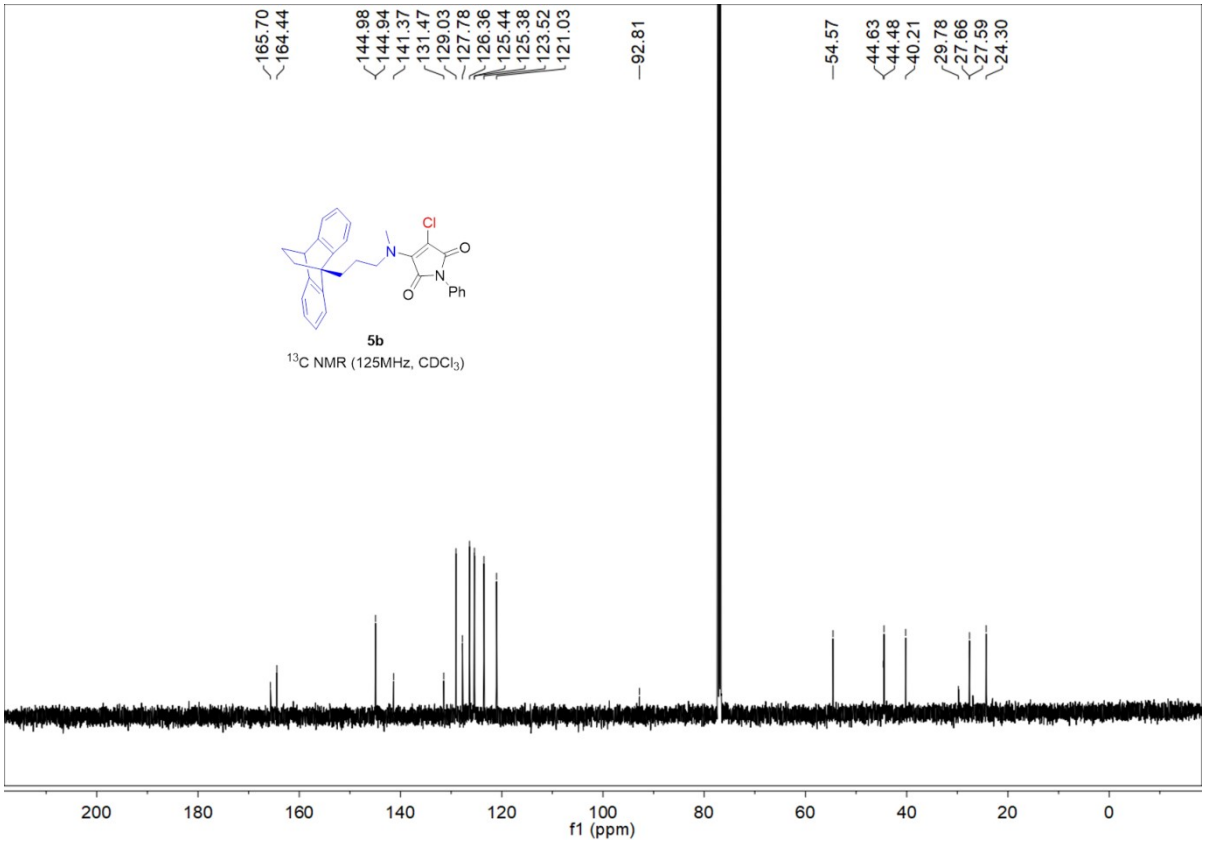

8.13
8.12
8.11
8.11
8.03
8.02
8.01
8.00
7.74
7.74
7.73
7.72
7.71
7.70
7.70
7.69
7.68
7.67
7.66
3.90
3.88
3.87
3.66
3.65
3.64
3.63
Cl
O
N
O
O
4m
1H NMR (400 MHz, CDCl3)
0.98
0.97
2.00
4.02
4.02
0
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

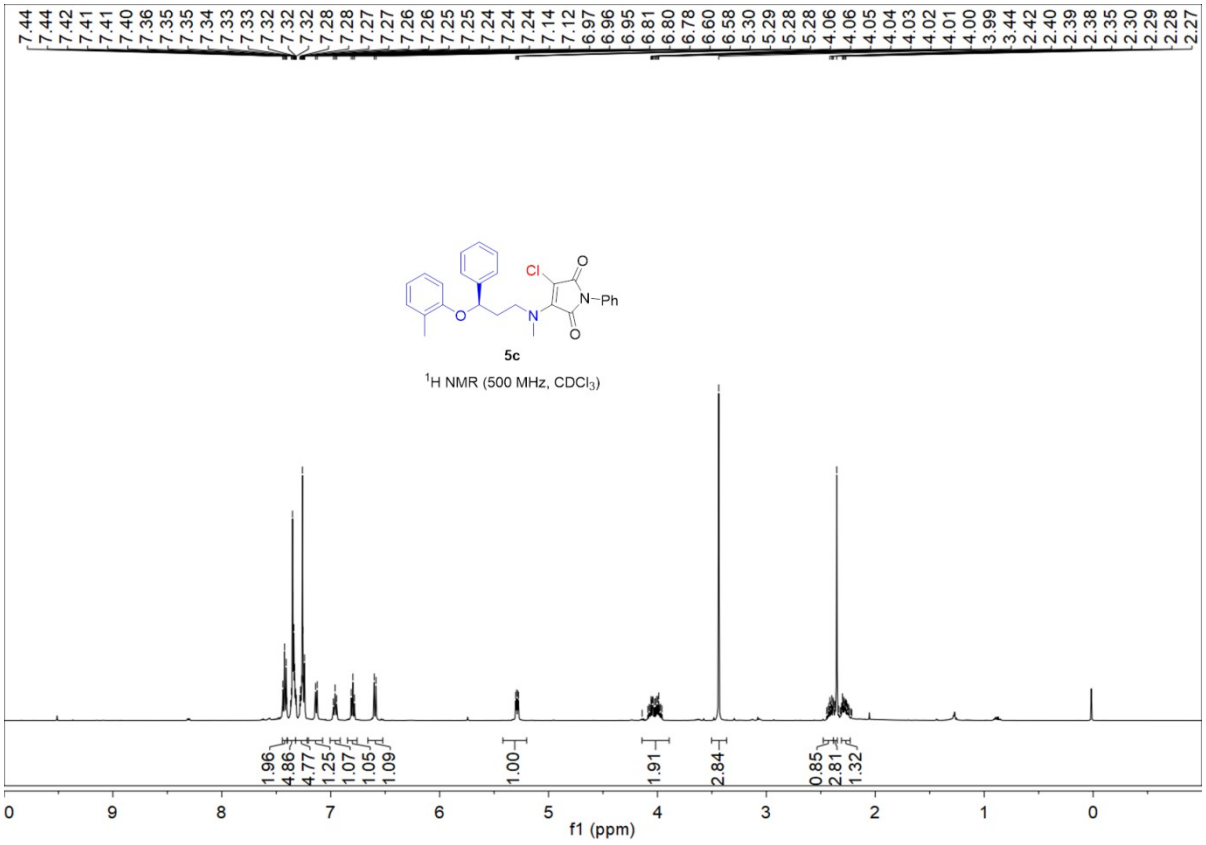

181.73
178.00
149.61
134.17
133.21
131.50
131.33
126.91
126.60
123.24
67.57
51.79
Cl
O
N
O
O
4m
13C NMR (125MHz, CDCl3)
200
180
160
140
120
100
80
60
40
20
0
f1 (ppm)

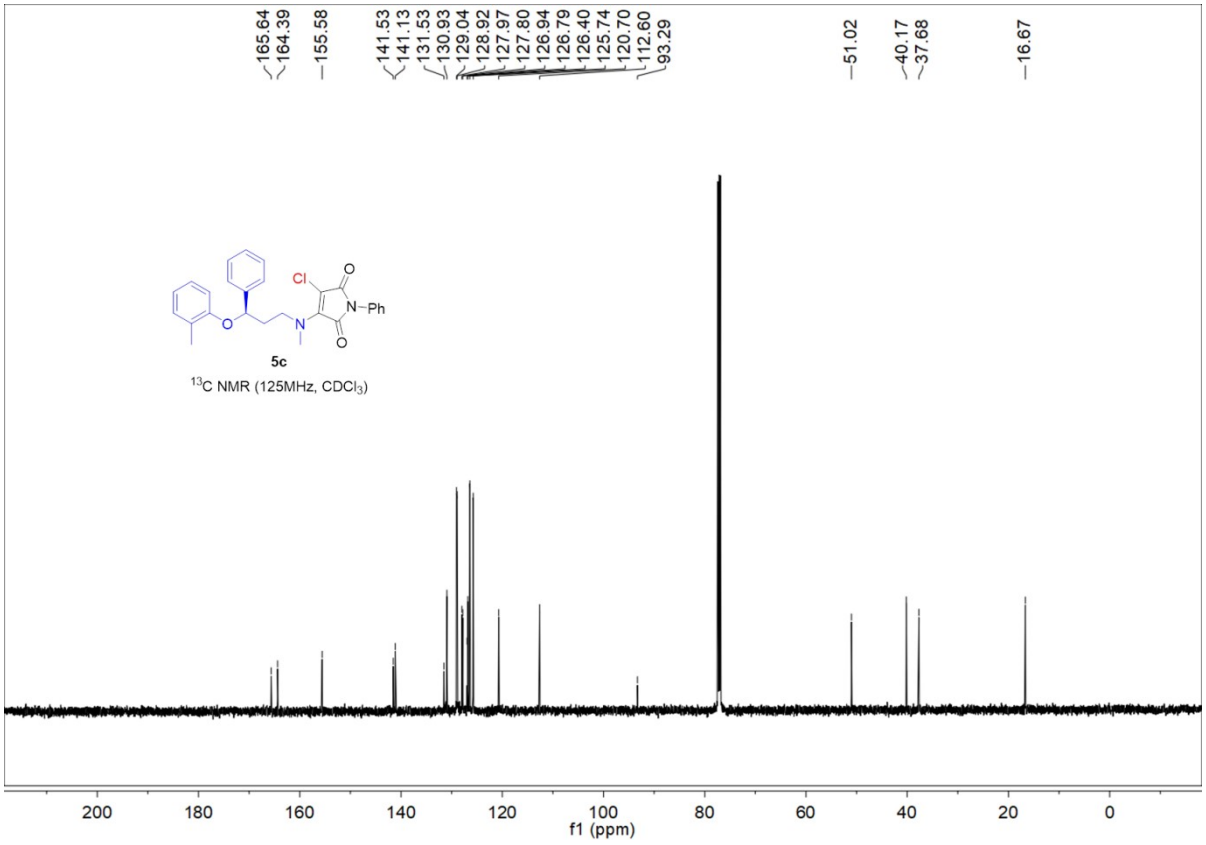

7.49 7.49 7.49 7.47 7.47 7.46 7.45 7.40 7.39 7.39 7.38 7.37 7.37 7.36 7.35 7.35 7.33 7.33 7.32 7.31 7.31 7.31 7.30 7.29 7.27 7.27 7.26 7.26 7.25 7.25 7.24 7.24 7.23 7.22 7.21 7.21 7.21 7.20 7.19 7.19 7.18 7.17 7.11 7.10 7.09 7.09 7.08 5.93 5.92 5.90 3.90 3.88 3.86 3.39 3.35 3.33 3.01 2.57 2.55
Cl
O
N–Ph
N
O
5a
1H NMR (400 MHz, CDCl3)
2.18 1.30 3.33 6.89 1.25 1.00 2.00 5.16 1.28 1.04 2.14
0 9 8 7 6 5 4 3 2 1 0
f1 (ppm)

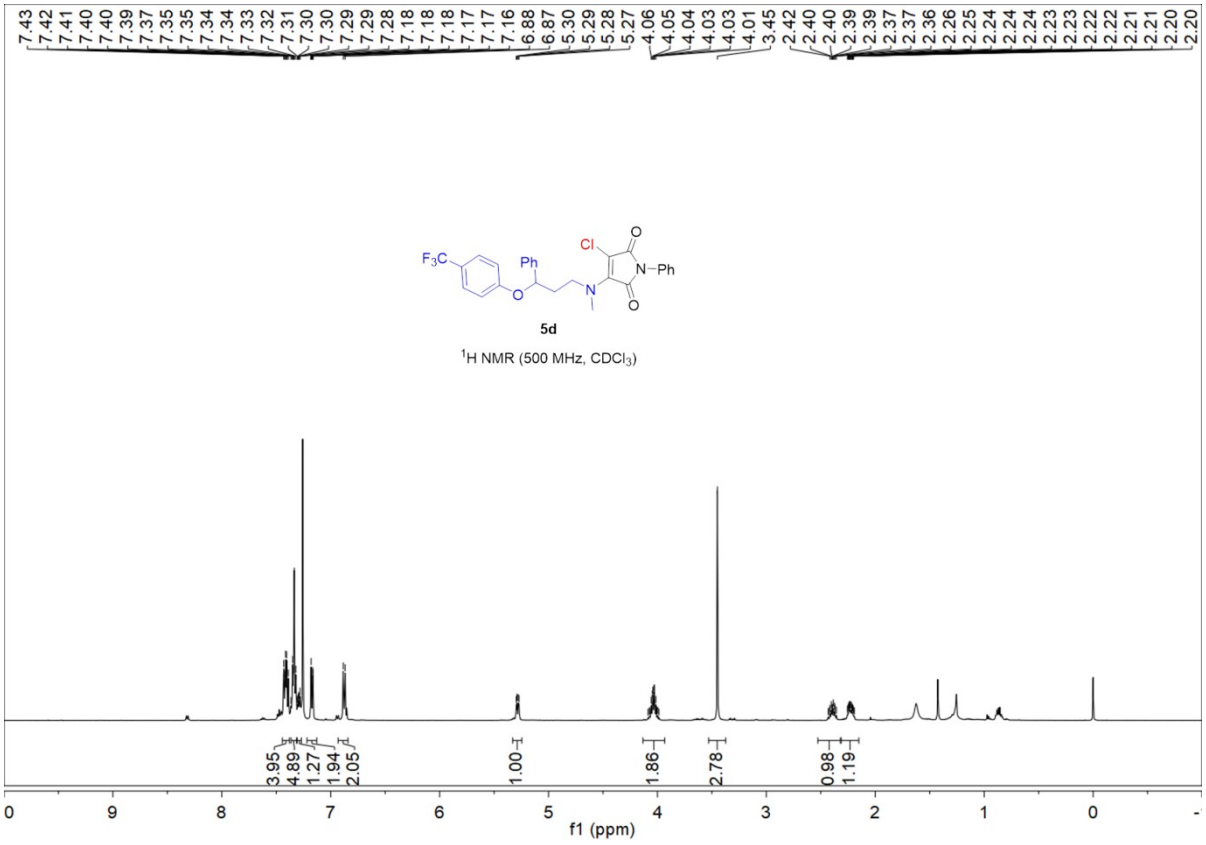

165.61 164.39 146.07 141.28 140.80 139.61 139.52 137.21 131.60 130.25 129.02 128.52 128.29 128.13 127.90 127.74 127.48 126.38 126.34 126.23 125.97 92.99 53.30 40.13 33.86 32.12 29.02 27.03
Cl
O
N–Ph
N
O
5a
13C NMR (125MHz, CDCl3)
200 180 160 140 120 100 80 60 40 20 0
f1 (ppm)

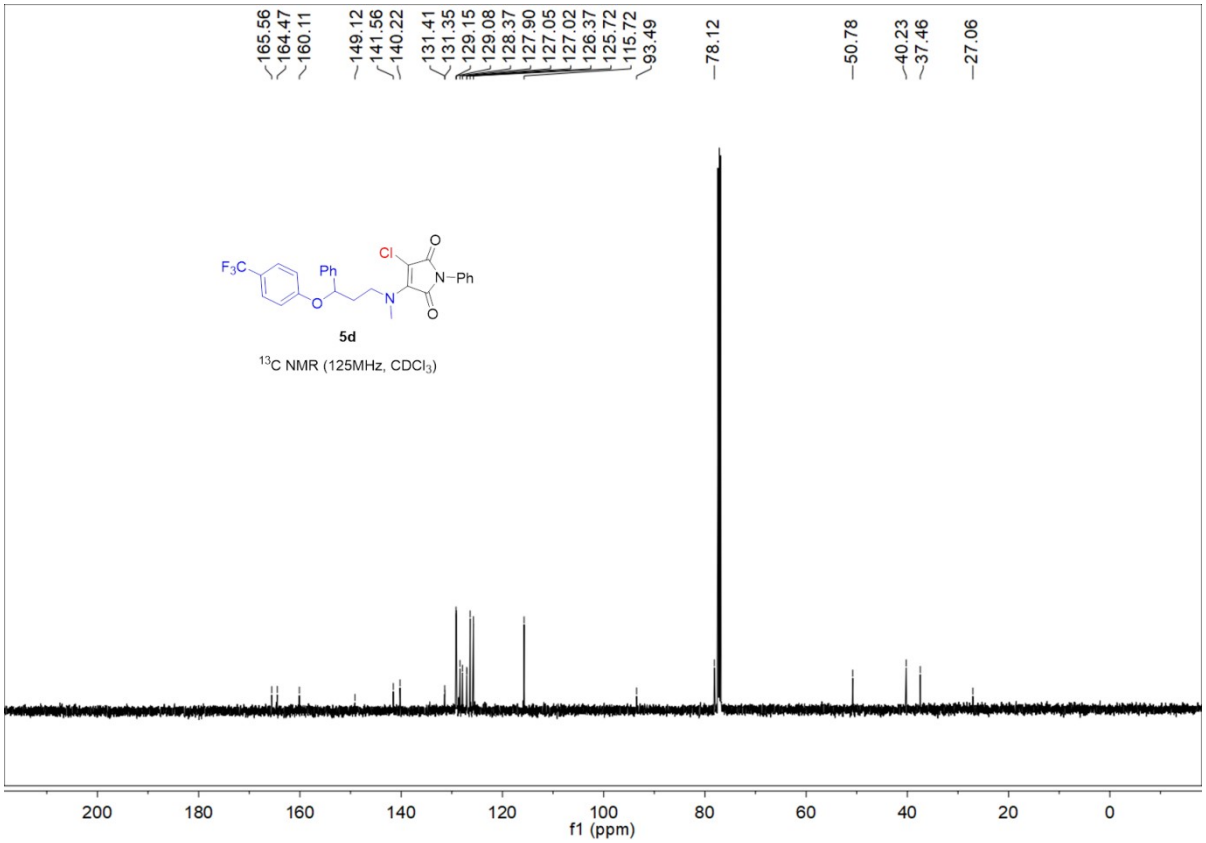

7.48 7.46 7.44 7.37 7.37 7.36 7.35 7.35 7.34 7.34 7.29 7.29 7.27 7.27 7.26 7.26 7.25 7.25 7.15 7.14 7.13 7.13 7.11 7.11 7.10 7.09 7.08 7.07 4.30 4.30 4.29 4.08 4.06 4.04 3.56 2.53 2.51 2.50 2.49 2.48 2.23 2.22 2.21 2.20 2.19 1.87 1.86 1.86 1.85 1.85 1.83 1.83 1.63 1.62 1.61 1.60 1.59
Cl
N
O
O
N
Ph
5b
1H NMR (400 MHz, CDCl3)
1.90
3.00
4.52
4.23
1.00
1.86
2.71
1.97
2.09
1.98
2.12
0
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

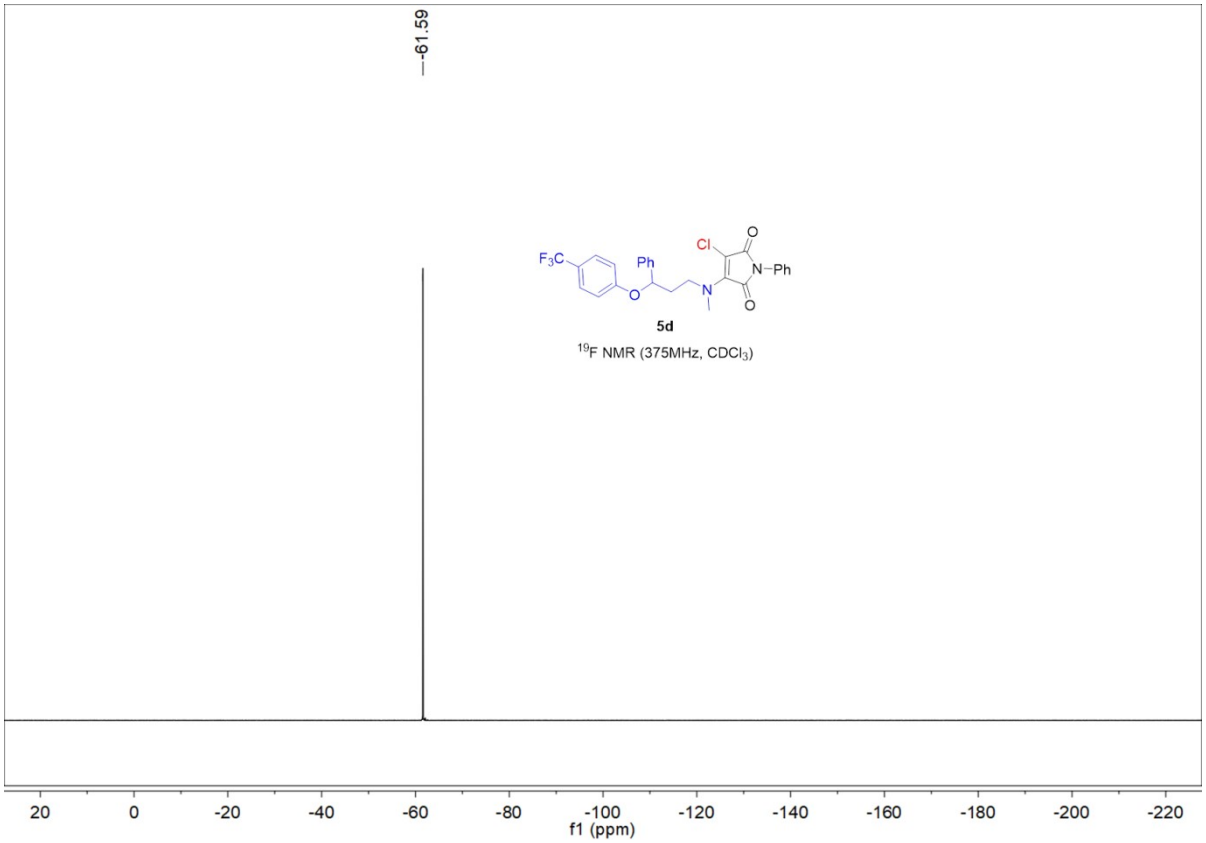

165.70 164.44 144.98 144.94 141.37 131.47 129.03 127.78 126.36 125.44 125.38 123.52 121.03 92.81 54.57 44.63 44.48 40.21 29.78 27.66 27.59 24.30
Cl
N
O
O
N
Ph
5b
13C NMR (125MHz, CDCl3)
200
180
160
140
120
100
80
60
40
20
0
f1 (ppm)


7.44 7.44 7.42 7.41 7.41 7.40 7.36 7.35 7.35 7.34 7.33 7.33 7.32 7.32 7.32 7.28 7.28 7.27 7.27 7.26 7.26 7.25 7.24 7.24 7.24 7.14 7.12 6.97 6.96 6.95 6.81 6.80 6.78 6.60 6.58 5.30 5.29 5.28 4.06 4.06 4.05 4.04 4.03 4.02 4.01 4.00 3.99 3.44 2.42 2.40 2.39 2.38 2.35 2.30 2.29 2.28 2.27
Cl
O
N–Ph
O
O
N
5c
1H NMR (500 MHz, CDCl3)
1.96 4.86 4.77 1.25 1.07 1.05 1.09 1.00 1.91 2.84 0.85 2.81 1.32
0 9 8 7 6 5 4 3 2 1 0
f1 (ppm)


165.64 164.39 155.58 141.53 141.13 131.53 130.93 129.04 128.92 127.97 127.80 126.94 126.79 126.40 125.74 120.70 112.60 93.29 51.02 40.17 37.68 16.67
Cl
O
N–Ph
O
O
N
5c
13C NMR (125MHz, CDCl3)
200 180 160 140 120 100 80 60 40 20 0
f1 (ppm)

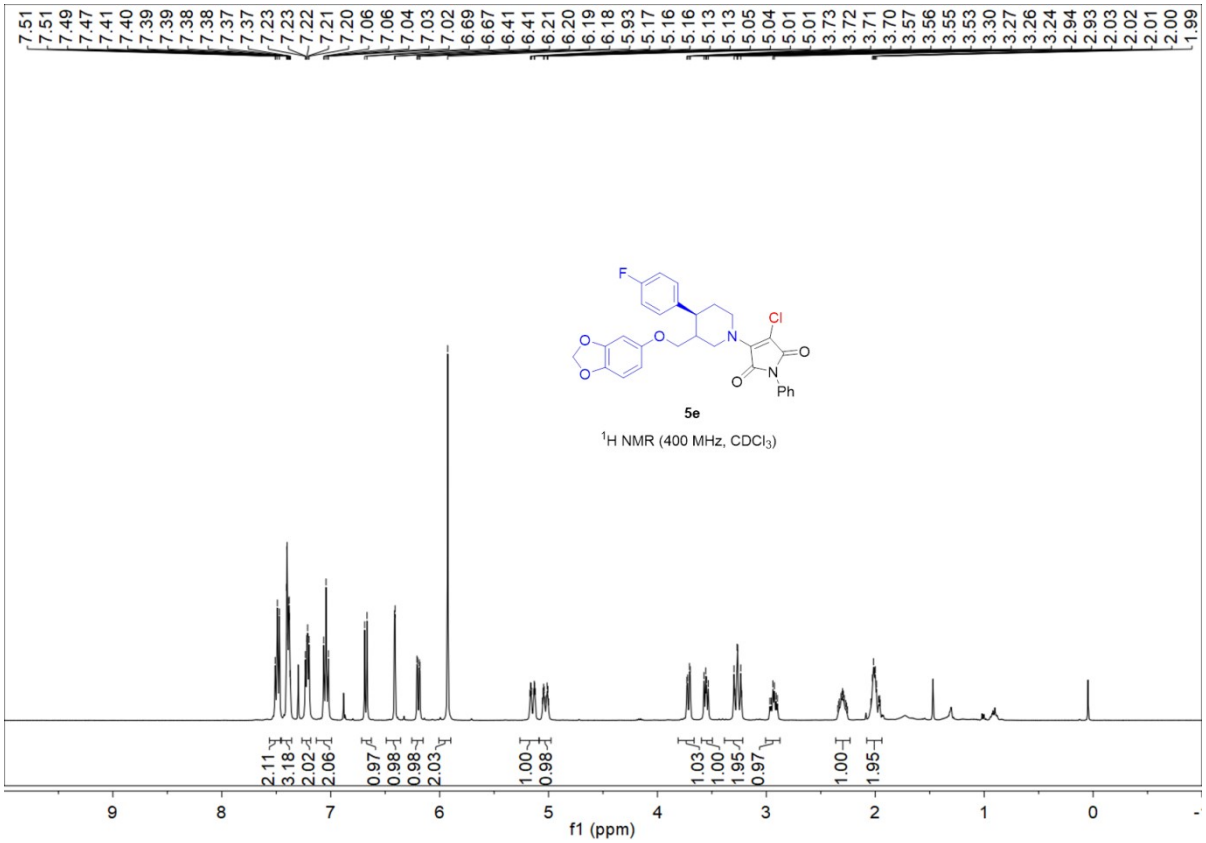

7.43 7.42 7.41 7.40 7.40 7.39 7.37 7.35 7.35 7.34 7.34 7.33 7.32 7.31 7.30 7.30 7.29 7.29 7.28 7.18 7.18 7.18 7.17 7.17 7.16 6.88 6.87 5.30 5.29 5.28 5.27 4.06 4.05 4.04 4.03 4.03 4.01 3.45 2.42 2.40 2.40 2.39 2.39 2.37 2.37 2.36 2.26 2.25 2.24 2.24 2.24 2.23 2.23 2.22 2.22 2.21 2.21 2.20 2.20
F3C
Ph
O
N
Cl
N–Ph
O
O
5d
1H NMR (500 MHz, CDCl3)
3.95
4.89
1.27
1.94
2.05
1.00
1.86
2.78
0.98
1.19
0 9 8 7 6 5 4 3 2 1 0 -
f1 (ppm)


165.56
164.47
160.11
149.12
141.56
140.22
131.41
131.35
129.15
129.08
128.37
127.90
127.05
127.02
126.37
125.72
115.72
93.49
78.12
50.78
40.23
37.46
27.06
F3C
Ph
O
N
Cl
N–Ph
O
O
5d
13C NMR (125MHz, CDCl3)
200 180 160 140 120 100 80 60 40 20 0
f1 (ppm)



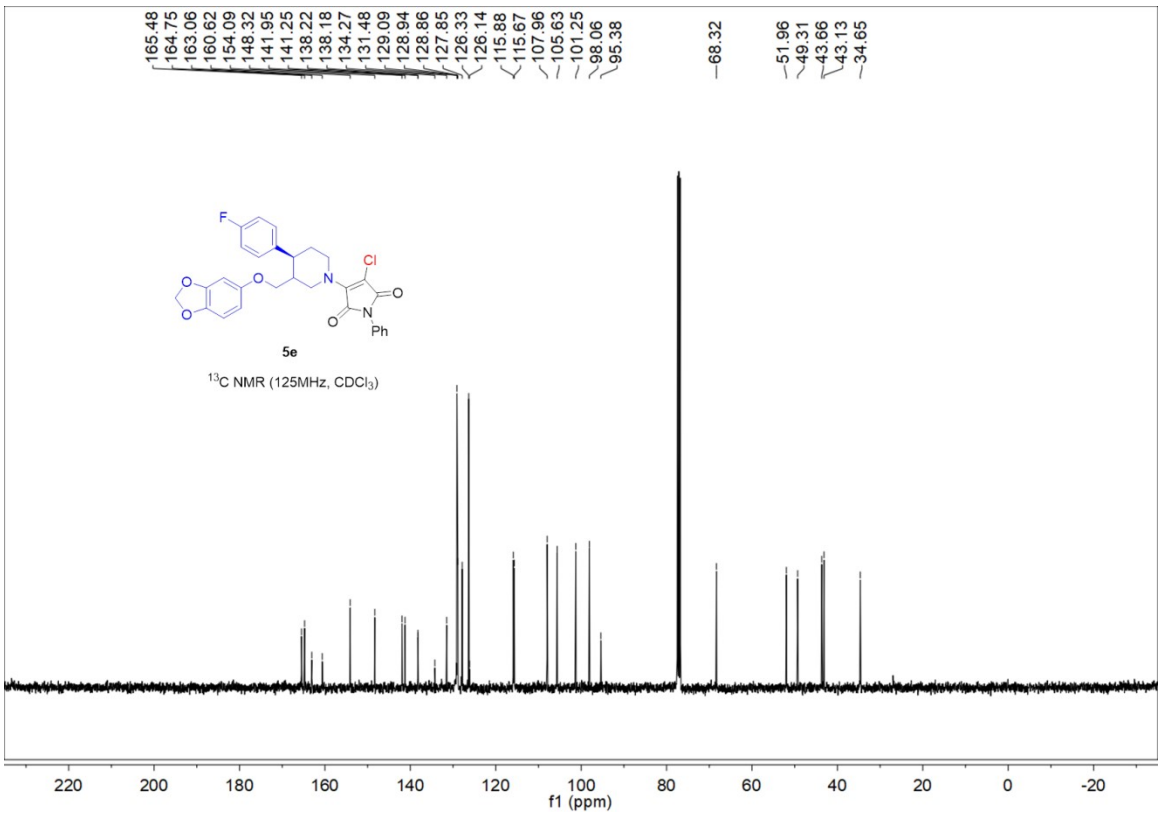
5d

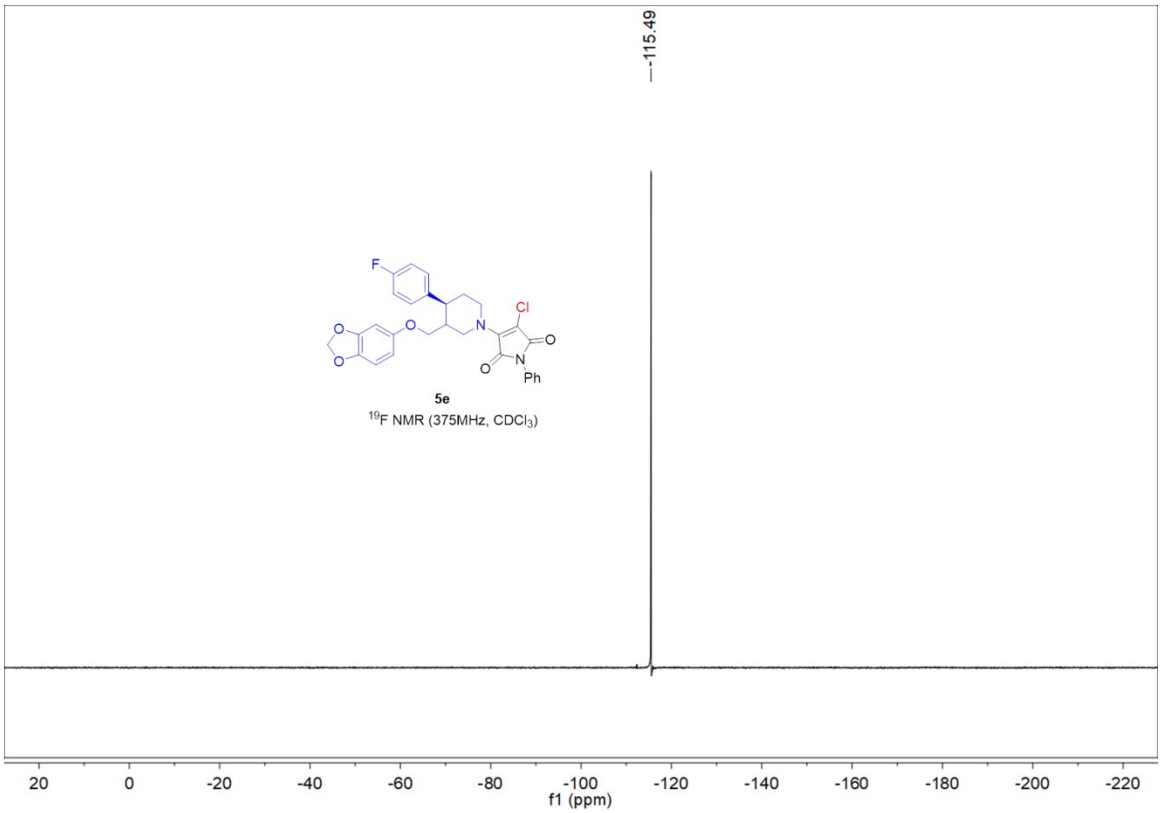
^{19}F NMR (375MHz, $CDCl_3$)

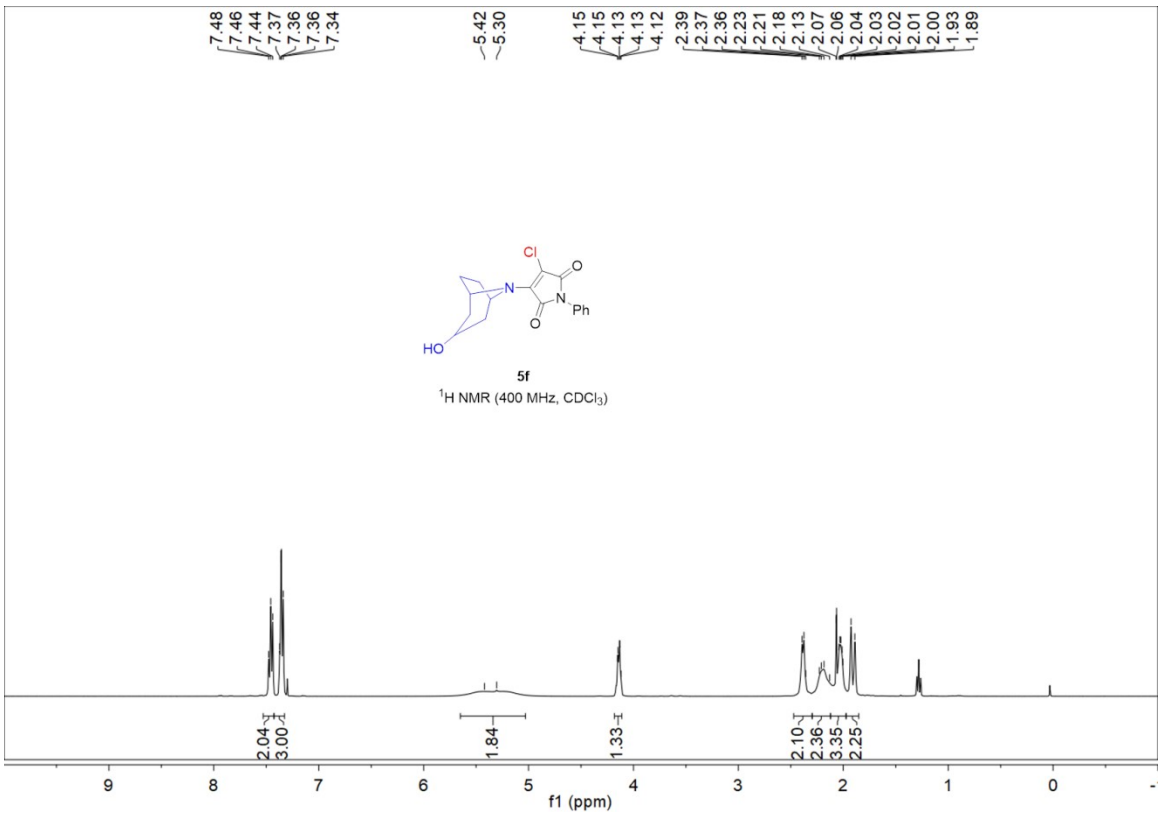


5e

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

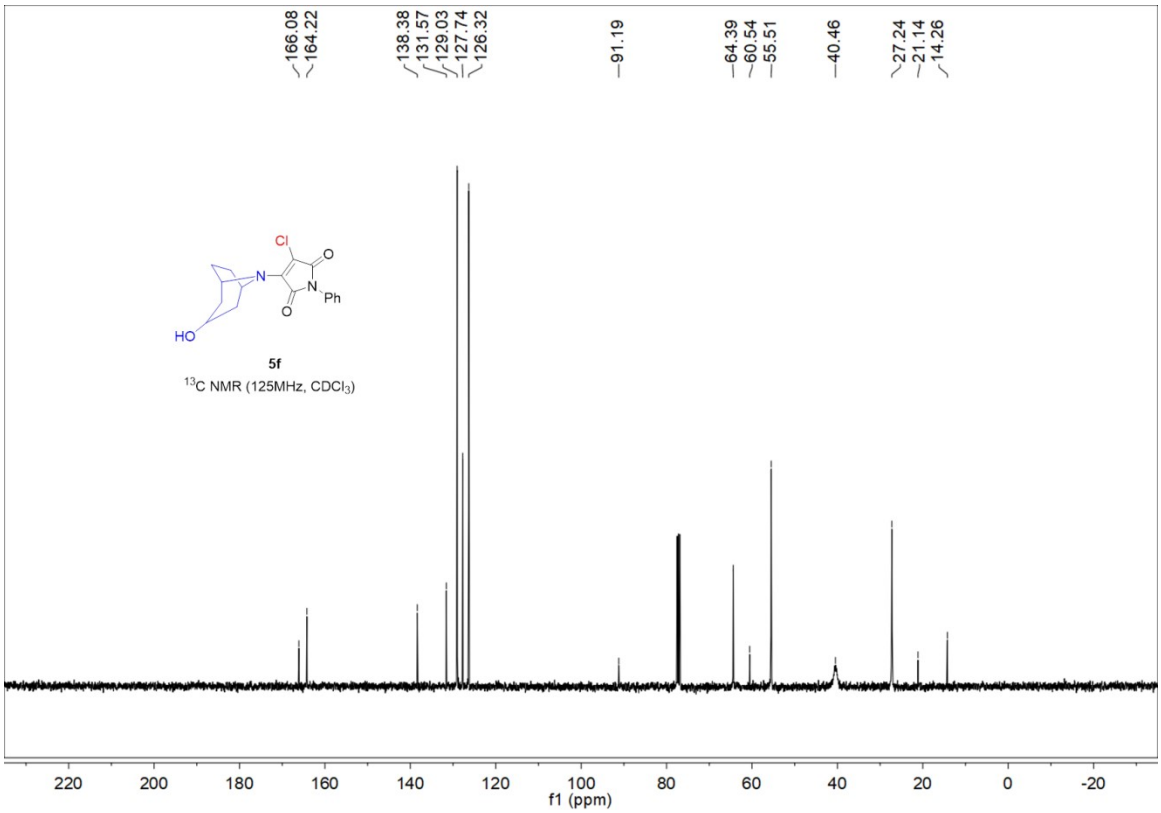

165.48
164.75
163.06
160.62
154.09
148.32
141.95
141.25
138.22
138.18
134.27
131.48
129.09
128.94
128.86
127.85
126.33
126.14
115.88
115.67
107.96
105.63
101.25
98.06
95.38
68.32
51.96
49.31
43.66
43.13
34.65
F
Cl
O
N
Ph
5e
13C NMR (125MHz, CDCl3)
220
200
180
160
140
120
100
80
60
40
20
0
-20
f1 (ppm)


-115.49
F
Cl
O
N
Ph
5e
19F NMR (375MHz, CDCl3)
20
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
f1 (ppm)



5f

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



5f

^{13}C NMR (125MHz, $CDCl_3$)