Supporting information

Transition-metal catalyzed reactions of diazo compounds and *N,N*-dialkylnitrosoamines

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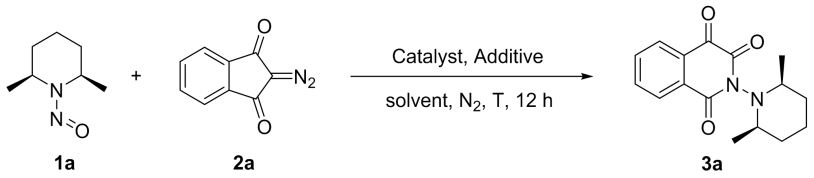
1. General information

^{1}H NMR and ^{13}C NMR spectra were recorded on Bruker AVANCE 400 MHz or 500 MHz spectrometer. Chemical shifts of protons are reported in parts per million downfield from tetramethylsilane. Chemical shifts of carbon are referenced to the center line of a triplet at 77.0 ppm of chloroform-d_3. Peaks are labeled as single (s), broad singlet (bs), doublet (d), triplet (t), quartet (q), double doublet (dd), triple doublet (td), multiplet (m). Melting points were determined with a commercially available melting point apparatus. High-resolution mass spectra (HRMS) were acquired using an electron spray ionization time of flight (ESI-TOF) mass spectrometer in positive mode. All reagents were used without further purification as received from commercial suppliers unless otherwise noted. All solvents were dried and distilled prior to use according to the standard protocols. Substrates **1k**, **2q** was purchased from commercial suppliers without further purification. Substrates **1a-1j**,[1] **1l-1y**,[1] **2a-2k**,[2] **2l-2p**,[3] **2r**[3] were synthesized according to the reported procedures. Their NMR data were identical to those reported in the literature.

2.Optimization of reaction conditions

2.1 Optimization of rearrangement reaction conditions

Table S1. Screening of catalyst and optimization of rearrangement reaction conditions[a]



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

Entry	**1a:2a**	Catalyst (mol%)	Additive (mol%)	solvent	T (°C)	Yield (%)
1	1:1.5	$[Cp^*RhCl_2]_2$ (2.5)	$AgSbF_6$ (15) AgOAc (15)	DCE	rt.	0
2	1:1.5	$[Cp^*RhCl_2]_2$ (2.5)	$AgSbF_6$ (15) AgOAc (15)	DCE	60	60
3	1:1.5	$[Cp^*RhCl_2]_2$ (2.5)	$AgSbF_6$ (15)	DCE	60	64
4	1:1.5	$Cu(OTf)_2$ (2.5)	none	DCE	rt.	0
5	1:1.5	$Rh_2(OAc)_4$ (2.5)	none	DCE	rt.	0
6	1:1.5	$Pd(OAc)_2$ (2.5)	none	DCE	80	0
7	1:1.5	[IPrAuCl] (2.5)	$AgSbF_6$ (15)	DCE	60	trace
8	1:1.5	$[Cp^*IrCl_2]_2$ (2.5)	$AgSbF_6$ (15)	DCE	60	20
9	1:1.5	$Cp^*Co(CO)I_2$ (2.5)	$AgSbF_6$ (15)	DCE	60	0
10	1:1.5	$[RuCl_2(p\text{-cymene})]_2$ (2.5)	$AgSbF_6$ (15)	DCE	60	81
11	1:1.5	none	$AgSbF_6$ (15)	DCE	60	0
12	1:1.5	$[RuCl_2(p\text{-cymene})]_2$ (2.5)	none	DCE	60	0
13	2:1	$[RuCl_2(p\text{-cymene})]_2$ (2.5)	$AgSbF_6$ (15)	DCE	60	82
14	1.5:1	$[RuCl_2(p\text{-cymene})]_2$ (2.5)	$AgSbF_6$ (15)	DCE	60	96 (96[b])
15	1:1	$[RuCl_2(p\text{-cymene})]_2$ (2.5)	$AgSbF_6$ (15)	DCE	60	68
16	1:2	$[RuCl_2(p\text{-cymene})]_2$ (2.5)	$AgSbF_6$ (15)	DCE	60	72
17	1.5:1	$[RuCl_2(p\text{-cymene})]_2$ (2.5)	AgOAc (15)	DCE	60	35
18	1.5:1	$[RuCl_2(p\text{-cymene})]_2$ (2.5)	$AgNTf_2$ (15)	DCE	60	78
19	1.5:1	$[RuCl_2(p\text{-cymene})]_2$ (2.5)	AgOTf (15)	DCE	60	87
20	1.5:1	$[RuCl_2(p\text{-cymene})]_2$ (2.5)	$AgBF_4$ (15)	DCE	60	72
21	1.5:1	$[RuCl_2(p\text{-cymene})]_2$ (2.5)	$AgSbF_6$ (15)	Toluene	60	60

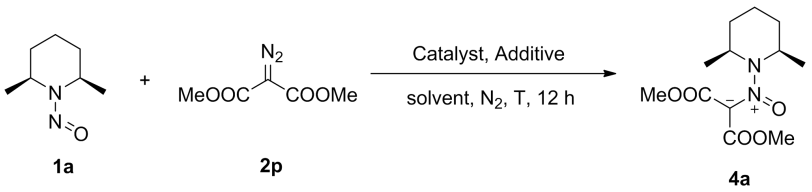
22	1.5:1	$[RuCl_2(p\text{-cymene})]_2$ (2.5)	$AgSbF_6$ (15)	MeOH	60	trace
23	1.5:1	$[RuCl_2(p\text{-cymene})]_2$ (2.5)	$AgSbF_6$ (15)	Dioxane	60	0
24	1.5:1	$[RuCl_2(p\text{-cymene})]_2$ (2.5)	$AgSbF_6$ (15)	THF	60	42
25	1.5:1	$[RuCl_2(p\text{-cymene})]_2$ (2.5)	$AgSbF_6$ (15)	CH_3CN	60	trace
26	1.5:1	$[RuCl_2(p\text{-cymene})]_2$ (2.5)	$AgSbF_6$ (15)	DMSO	60	0
27	1.5:1	$[RuCl_2(p\text{-cymene})]_2$ (2.5)	$AgSbF_6$ (15)	DCE	rt.	82
28	1.5:1	$[RuCl_2(p\text{-cymene})]_2$ (2.5)	$AgSbF_6$ (15)	DCE	80	76
29	1.5:1	$[RuCl_2(p\text{-cymene})]_2$ (1.25)	$AgSbF_6$ (7.5)	DCE	60	87
30	1.5:1	$[RuCl_2(p\text{-cymene})]_2$ (5)	$AgSbF_6$ (30)	DCE	60	67

[a]Reaction conditions: **1a**, **2a**, solvent (0.1 M) for 12 h under a N_2 atmosphere; Yield determined by ^1H NMR using dimethyl terephthalate as the internal standard.

[b]Isolated yield after column chromatography.

2.2 Optimization of ylide reaction conditions

Table S2. Screening of catalyst and optimization of ylide reaction conditions[a]



1a **2p** **4a**

Entry	**1a:2a**	Catalyst (mol%)	Additive (mol%)	solvent	T (°C)	Yield (%)
1	1.5:1	$[RuCl_2(p\text{-cymene})]_2$ (2.5)	$AgSbF_6$ (15)	DCE	60	38
2	1.5:1	$[Cp^*RhCl_2]_2$ (2.5)	$AgSbF_6$ (15)	DCE	60	51
3	1.5:1	$Cu(OTf)_2$ (2.5)	none	DCE	rt.	0
4	1.5:1	$Rh_2(OAc)_4$ (2.5)	none	DCE	rt.	0
5	1.5:1	$Pd(OAc)_2$ (2.5)	none	DCE	80	0
6	1.5:1	[IPrAuCl] (2.5)	$AgSbF_6$ (15)	DCE	60	0
7	1.5:1	$[Cp^*IrCl_2]_2$ (2.5)	$AgSbF_6$ (15)	DCE	60	10
8	1.5:1	$Cp^*Co(CO)I_2$ (2.5)	$AgSbF_6$ (15)	DCE	60	0
9	1.5:1	none	$AgSbF_6$ (15)	DCE	60	0
10	2:1	$[Cp^*RhCl_2]_2$ (2.5)	$AgSbF_6$ (15)	DCE	60	45
11	1:1	$[Cp^*RhCl_2]_2$ (2.5)	$AgSbF_6$ (15)	DCE	60	30
12	1:1.5	$[Cp^*RhCl_2]_2$ (2.5)	$AgSbF_6$ (15)	DCE	60	43
13	1:2	$[Cp^*RhCl_2]_2$ (2.5)	$AgSbF_6$ (15)	DCE	60	69 (67[b])
14	1:3	$[Cp^*RhCl_2]_2$ (2.5)	$AgSbF_6$ (15)	DCE	60	68
15	1:2	$[Cp^*RhCl_2]_2$ (2.5)	AgOAc (15)	DCE	60	trace
16	1:2	$[Cp^*RhCl_2]_2$ (2.5)	$AgNTf_2$ (15)	DCE	60	20
17	1:2	$[Cp^*RhCl_2]_2$ (2.5)	AgOTf (15)	DCE	60	trace
18	1:2	$[Cp^*RhCl_2]_2$ (2.5)	AgF (15)	DCE	60	trace
19	1:2	$[Cp^*RhCl_2]_2$ (2.5)	$AgBF_4$ (15)	DCE	60	10
20	1:2	$[Cp^*RhCl_2]_2$ (2.5)	$AgSbF_6$ (15)	Toluene	60	trace
21	1:2	$[Cp^*RhCl_2]_2$ (2.5)	$AgSbF_6$ (15)	MeOH	60	trace
22	1:2	$[Cp^*RhCl_2]_2$ (2.5)	$AgSbF_6$ (15)	Dioxane	60	trace
23	1:2	$[Cp^*RhCl_2]_2$ (2.5)	$AgSbF_6$ (15)	THF	60	trace

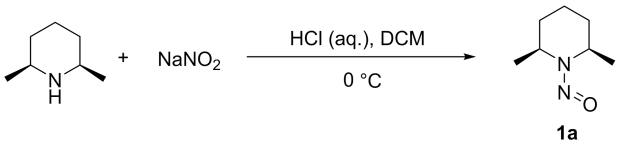
24	1:2	$[Cp^*RhCl_2]_2$ (2.5)	$AgSbF_6$ (15)	CH_3CN	60	0
25	1:2	$[Cp^*RhCl_2]_2$ (2.5)	$AgSbF_6$ (15)	DMSO	60	0
26	1:2	$[Cp^*RhCl_2]_2$ (2.5)	$AgSbF_6$ (15)	DCE	rt.	64
27	1:2	$[Cp^*RhCl_2]_2$ (2.5)	$AgSbF_6$ (15)	DCE	80	45
28	1:2	$[Cp^*RhCl_2]_2$ (1.25)	$AgSbF_6$ (7.5)	DCE	60	64
29	1:2	$[Cp^*RhCl_2]_2$ (5)	$AgSbF_6$ (30)	DCE	60	52

[a]Reaction conditions: **1a**, **2p**, solvent (0.1 M) for 12 h under a N_2 atmosphere; Yield determined by ^1H NMR using dimethyl terephthalate as the internal standard.

[b]Isolated yield after column chromatography.

3. General procedure for the preparation of substrates

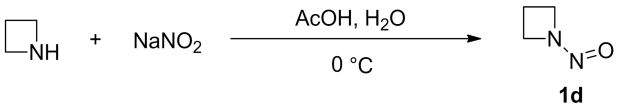
3.1 Preparation of nitrosoamines 1a-1c, 1e, 1g-1h, 1l-1o, 1q-1s, 1x-1y (taking 1a as an example)[1a]



Scheme S1. Preparation of **1a**

cis-2,6-Dimethylpiperidine (1.35 mL, 1.13 g, 10 mmol) and $NaNO_2$ (2.07 g, 30 mmol) were dissolved in DCM (50 mL, 0.2 M) at 0 °C in an ice bath and 2 M HCl (10 mL) was added dropwise to this solution. The solution was stirred at the same temperature for 3 h and quenched by adding water. The crude mixture was extracted with DCM and the combined organic layers were washed with brine, dried over anhydrous Na_2SO_4, filtered, and concentrated under reduced pressure. The residue was purified by flash column chromatography (*n*-hexane:ethyl acetate = 20:1) to give a yellow oil **1a** (1.25 g, 88%).

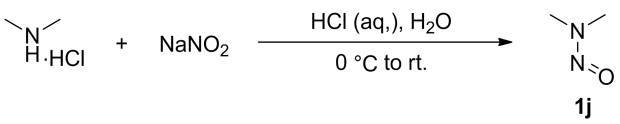
3.2 Preparation of nitrosoamines 1d, 1f, 1i, 1t, 1u-1w (taking 1d as an example)[1b]



Scheme S2. Preparation of **1d**

To a solution of azetidine (0.67 mL, 570.9 mg, 10 mmol) in a mixture of acetic acid (6 mL) and water (1.2 mL), an aqueous solution of $NaNO_2$ (1.04 g, 15 mmol) in water (3 mL) was added at 0°C in an ice-water bath. The reaction mixture was stirred for 3 h, then extracted with DCM. The organic layer was washed with brine, and dried over anhydrous Na_2SO_4. The solvent was evaporated to give a residue, which was purified by flash column chromatography (*n*-hexane:ethyl acetate = 2:1) to give a yellow oil **1d** (282.6 mg, 33%).

3.3 Preparation of *N,N*-dimethyl nitrosoamine 1j[1c]

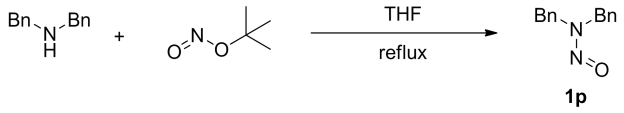


Scheme S3. Preparation of **1j**

Dimethylamine hydrochloride (815.4 mg, 10 mmol) was dissolved in 2 M HCl (3 mL) at 0 °C in

an ice bath. Next, $NaNO_2$ (1.04 g, 15 mmol) was dissolved in water (5 mL) and added dropwise to this solution. Following the complete addition of $NaNO_2$, the reaction mixture was stirred at 0 °C for 3 h and then at room temperature overnight. The crude mixture was extracted with DCM and the combined organic layers were dried over anhydrous Na_2CO_3 and Na_2SO_4, filtered, and concentrated under reduced pressure below 30 °C to give a yellow oil **1j** (253.7 mg, 34%).

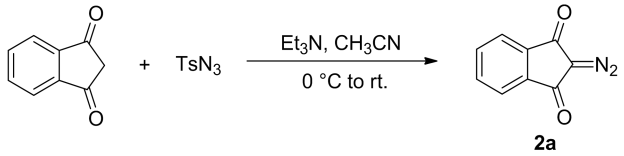
3.4 Preparation of *N,N*-dibenzyl nitrosoamine 1p[1d]



Scheme S4. Preparation of **1p**

Dibenzylamine (0.96 mL, 986.4 mg, 5 mmol) was dissolved in THF (10 mL) at room temperature and the tertbutyl nitrite (0.89 mL, 773.4 mg, 7.5 mmol) was added. The resulting cloudy mixture was refluxed for 17 h then cooled to room temperature. The solvent was evaporated to give a residue, which was purified by flash column chromatography (*n*-hexane:ethyl acetate = 20:1) to give a yellow crystal **1p** (998.4 mg, 88%).

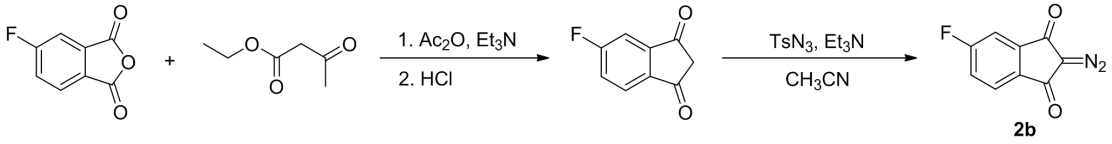
3.5 Preparation of diazoindandione 2a[2a]



Scheme S5. Preparation of **2a**

To a stirred solution of *1H*-indene-1,3(*2H*)-dione (1.46 g, 10 mmol) and TsN_3 (3.29 mL, 2.96 g, 15 mmol) in CH_3CN (20 mL) at 0 °C was added Et_3N (2.78 mL, 2.02 g, 20 mmol) dropwise. The reaction mixture was allowed to warm to room temperature and stirred overnight. Then the reaction mixture was purified by flash column chromatography (*n*-hexane:ethyl acetate = 100:1 to 10:1) to afford a yellow solid **2a** (1.58 g, 92%).

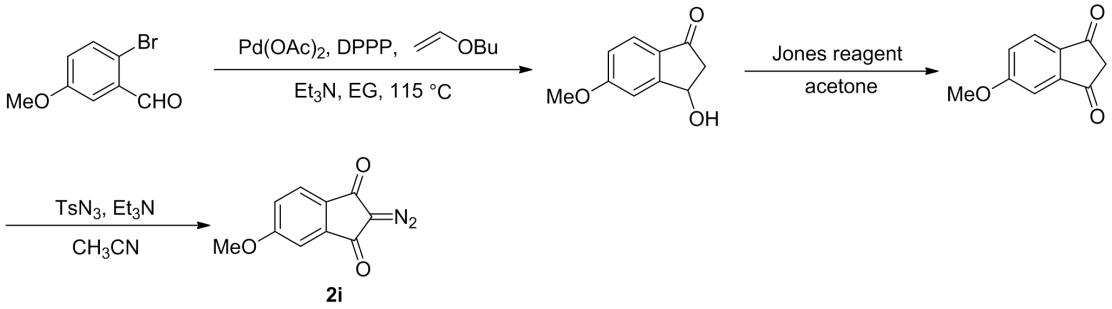
3.6 Preparation of diazoindandiones 2b-2h (taking 2b as an example)[2a]



Scheme S6. Preparation of **2b**

5-Fluoro-1,3-isobenzofurandione (732.5 mg, 4.41 mmol) was added to a solution of Ac_2O (2.4 mL) and Et_3N (1.3 mL). To the resulting orange suspension, ethyl acetoacetate (0.61 mL, 629.9 mg, 4.84 mmol) was added. The red solution was stirred at room temperature for 22 h. Ice (1.7 g) and concentrate HCl (1.6 mL) were added followed by the addition of 2 M HCl (17.5 mL). The resulting mixture was stirred at 80 °C for 15 min. After cooling down to room temperature, the mixture was extracted with DCM. The combined organic extract was washed with brine, dried over anhydrous Na_2SO_4 and the solvent was removed under reduced pressure. Then, to the solution of 5-fluoro-*1H*-indene-1,3(*2H*)-dione in CH_3CN (5 mL), TsN_3 (1.45 mL, 1.30 g, 6.6 mmol) and Et_3N (1.11 mL, 809.5 mg, 8 mmol) was added at 0 °C. The reaction mixture was allowed to warm to room temperature and stirred overnight. Afterwards, the reaction mixture was purified by flash column chromatography (*n*-hexane:ethyl acetate = 100:1 to 20:1) to afford a yellow powder **2b** (567.8 mg, 68%).

3.7 Preparation of diazoindandiones 2i, 2k (taking 2i as an example)[2b]



2i

Scheme S7. Preparation of **2i**

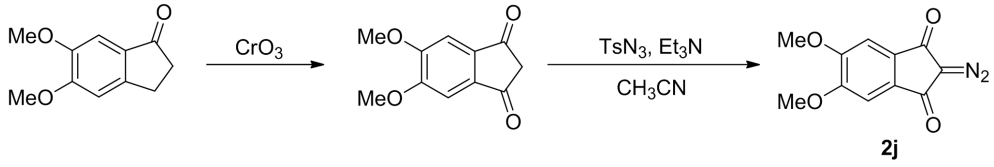
To a two-neck round bottom flask was successively added 2-bromo-5-methoxybenzaldehyde (2.15 g, 10 mmol), $Pd(OAc)_2$ (45.3 mg, 0.2 mmol), and 1,3-bis(diphenylphosphino)propane (dppp, 123.7 mg, 0.3 mmol). The mixture was evacuated and refilled with Ar for 3 times. To the resulting mixture was added ethylene glycol (40 mL), *n*-butyl vinyl ether (3.88 mL, 3.00 g, 30 mmol), and Et_3N (2.08 mL, 1.52 g, 15 mmol) under Ar and the reaction was vigorously stirred at 115 °C in an oil base for 16 h. After cooling down to room temperature, 2 M HCl (30 mL) and EtOAc (100 mL) were added; the mixture was stirred for 1 h. After separation of the EtOAc phase, the aqueous layer was extracted with EtOAc and the combined organic layers were washed with brine, dried over anhydrous Na_2SO_4, filtered, and concentrated under reduced pressure. The crude residue was

purified by flash column chromatography (*n*-hexane:ethyl acetate = 20:1 to 4:1) to afford the 3-hydroxy-5-methoxy-2,3-dihydro-*1H*-inden-1-one as an orange oil (1.15 g, 65%).

3-Hydroxy-5-methoxy-2,3-dihydro-*1H*-inden-1-one (1.15g, 6.5 mmol) was dissolved in acetone (20 mL) in around bottom flask, to the mixture was added 2 M Jones reagent (6.5 mL, 13 mmol) dropwise, and the reaction mixture was stirred at room temperature for 30 min. Afterwards, the mixture was diluted with EtOAc, the mixture was washed with water, dried over anhydrous Na_2SO_4 and removed under reduced pressure to get the 5-methoxy-*1H*-indene-1,3(*2H*)-dione as a yellow solid (1.13 g, 99%).

5-Methoxy-*1H*-indene-1,3(*2H*)-dione (1.13g, 6.4 mmol) was dissolved in CH_3CN (10 mL) in a round-bottom flask. To the mixture were added TsN_3 (2.10 mL, 1.89 g, 9.6 mmol) and Et_3N (3.56 mL, 2.59 g, 25.6 mmol) in an ice bath. After the addition, the ice bath was removed and the reaction mixture was stirred at room temperature overnight. Solvent was removed under reduced pressure, and the crude residue was further purified by flash column chromatography (*n*-hexane:ethyl acetate = 50:1 to 20:1) to afford the desired product **2i** as a yellow solid (728.8 mg, 56%).

3.8 Preparation of dimethoxy-diazoindandione 2j[2b]



2j

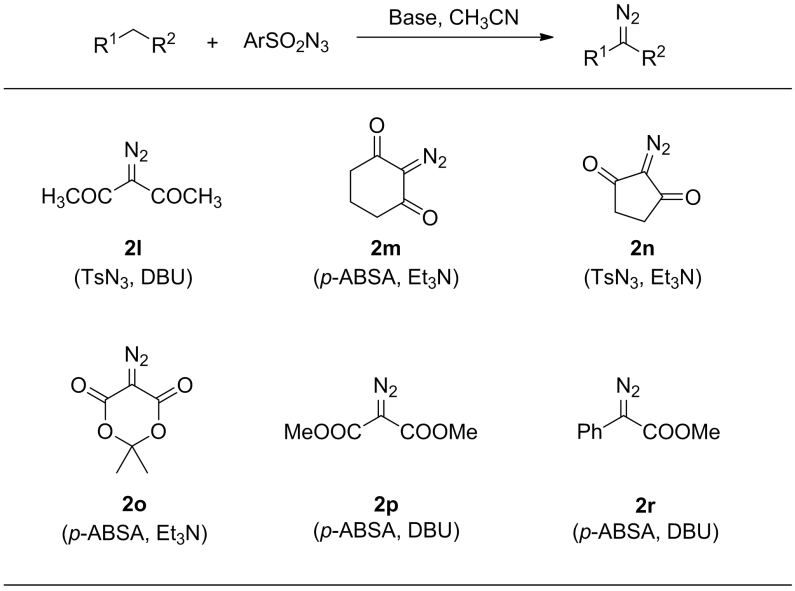
Scheme S8. Preparation of **2j**

5, 6-Dimethoxyindan-1-one (1.92 g, 10 mmol) was dissolved in a mixture of acetic acid (100 mL) and water (20 mL) in a round bottom flask. To the mixture was added chromium trioxide (5.00 g, 50 mmol) in small portions over 1 h in an ice bath. After the addition, ice bath was removed and the reaction mixture was stirred at room temperature for 24 h. 2-Propanol (20 mL) was added, and the mixture was stirred for an additional 30 min. The reaction mixture was poured into water and extracted with DCM. The combined organic layers were washed with brine, dried over anhydrous Na_2SO_4, filtered, and concentrated under reduced pressure to give 5,6-dimethoxy-*1H*-indene-1,3(*2H*)-dione as a pale green solid (872.6 mg, 42%).

5,6-Dimethoxy-*1H*-indene-1,3(*2H*)-dione (824.2 mg, 4 mmol) was dissolved in CH_3CN (10 mL)

in a round-bottom flask. To the mixture were added TsN_3 (1.31 mL, 1.18 g, 6 mmol) and Et_3N (2.22 mL, 1.62 g, 16 mmol) in an ice bath. After the addition, the ice bath was removed and the reaction mixture was stirred at room temperature overnight. Solvent was removed under reduced pressure, and the crude residue was further purified by flash column chromatography (*n*-hexane:ethyl acetate = 10:1 to 6:1) to afford the desired product **2j** as a yellow solid (778.3 mg, 84%).

3.9 Preparation of other diazo compounds 2l-2p, 2r[3]

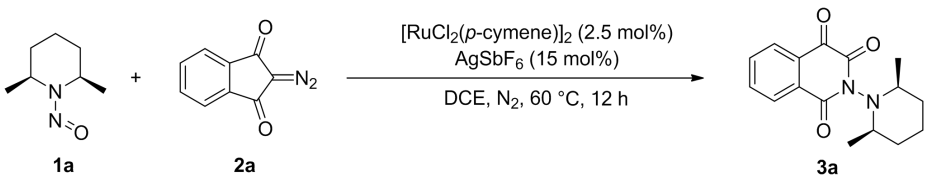


Scheme S9. Preparation of other diazo compounds

To a solution of the substrate (10 mmol) in anhydrous CH_3CN (20 mL) at 0 °C, were added the sulfonyl azide (12 mmol) and the base (15 mmol). The mixture was stirred at room temperature until full conversion of the starting material. After the solvent was evaporated under vacuum, the residue was purified through flash column chromatography to afford corresponding diazo compounds.

4. General procedure for the preparation of products

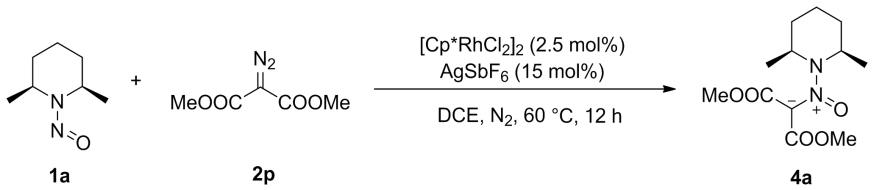
4.1 General procedure for the synthesis of 3 (taking 3a as an example)



Scheme S10. Preparation of **3a**

A 25 mL reaction tube equipped with a magnetic stirrer bar were charged with **2a** (34.4 mg, 0.2 mmol), $[RuCl_2(p\text{-cymene})]_2$ (3.1 mg, 2.5 mol%), $AgSbF_6$ (10.3 mg, 15 mol%). The mixture was evacuated and refilled with N_2 for 3 times. To the mixture was then added **1a** (42.6 mg, 0.3 mmol) in DCE (2 mL). The reaction mixture was stirred at 60 °C under a N_2 atmosphere for 12 h. The crude mixture was filtered through celite and concentrated under reduced pressure. The residue was then purified by flash column chromatography (*n*-hexane:ethyl acetate = 20:1) to give the desired product **3a** as an orange solid (54.7 mg, 96%).

4.2 General procedure for the synthesis of 4 (taking 4a as an example)

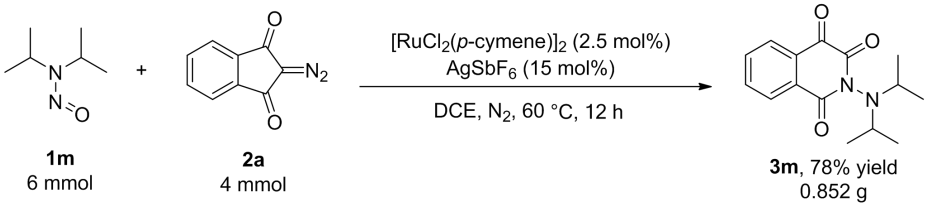


Scheme S11. Preparation of **4a**

A 25 mL reaction tube equipped with a magnetic stirrer bar were charged with $[Cp^*RhCl_2]_2$ (3.1 mg, 2.5 mol%), $AgSbF_6$ (10.3 mg, 15 mol%). The mixture was evacuated and refilled with N_2 for 3 times. To the mixture was then added **1a** (28.4 mg, 0.2 mmol) in DCE (1 mL) and **2p** (63.2 mg, 0.4 mmol) in DCE (1 mL). The reaction mixture was stirred at 60 °C under a N_2 atmosphere for 12 h. The crude mixture was filtered through celite and concentrated under reduced pressure. The residue was then purified by flash column chromatography (*n*-hexane:ethyl acetate = 30:1) to give the desired product **4a** as a pale yellow solid (36.2 mg, 67%).

5. Gram-scale synthesis and derivatizations of the products

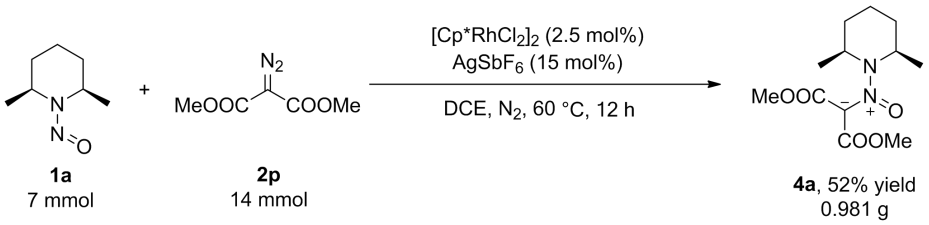
5.1 Gram-scale synthesis of 3m



Scheme S12. Gram-scale synthesis of **3m**

A 50 mL flask equipped with a magnetic stirrer bar were charged with **2a** (688.1 mg, 4 mmol), $[RuCl_2(p\text{-cymene})]_2$ (61.2 mg, 2.5 mol%), $AgSbF_6$ (206.2 mg, 15 mol%). The mixture was evacuated and refilled with N_2 for 3 times. To the mixture was then added **1a** (780.7 mg, 6 mmol) in DCE (20 mL). The reaction mixture was stirred at 60 °C under a N_2 atmosphere for 12 h. The crude mixture was filtered through celite and concentrated under reduced pressure. The residue was then purified by flash column chromatography (*n*-hexane:ethyl acetate = 20:1) to give the desired product **3m** as an orange solid (851.7 mg, 78%).

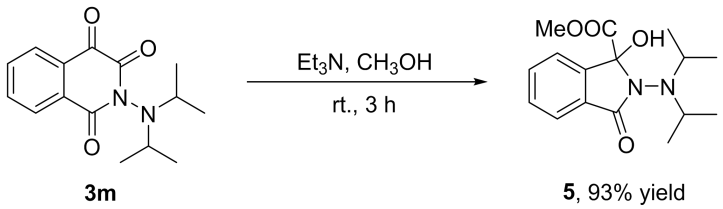
5.2 Gram-scale synthesis of 4a



Scheme S13. Gram-scale synthesis of **4a**

A 50 mL flask equipped with a magnetic stirrer bar were charged with $[Cp^*RhCl_2]_2$ (108.2 mg, 2.5 mol%), $AgSbF_6$ (360.8 mg, 15 mol%). The mixture was evacuated and refilled with N_2 for 3 times. To the mixture was then added **1a** (994.8 mg, 7 mmol) in DCE (5 mL) and **2p** (2.2 g, 14 mmol) in DCE (5 mL). The reaction mixture was stirred at 60 °C under a N_2 atmosphere for 12 h. The crude mixture was filtered through celite and concentrated under reduced pressure. The residue was then purified by flash column chromatography (*n*-hexane:ethyl acetate = 30:1) to give the desired product **4a** as a pale yellow solid (980.9 mg, 52%).

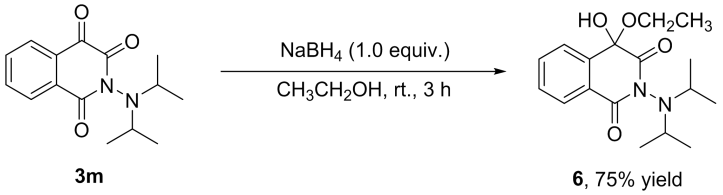
5.3 Transformation of 3m to compound 5[4]



Scheme S14. Preparation of **5**

To the stirred solution of **3m** (137.1 mg, 0.5 mmol) in CH_3OH (20 mL) was added catalytic amount of Et_3N (5 drops) at room temperature and the reaction mixture was further stirred for 3 h. The crude mixture was concentrated under reduced pressure. The residue was then purified by flash column chromatography (*n*-hexane:ethyl acetate = 20:1) to give the desired product **5** as a white solid (142.1 mg, 93%).

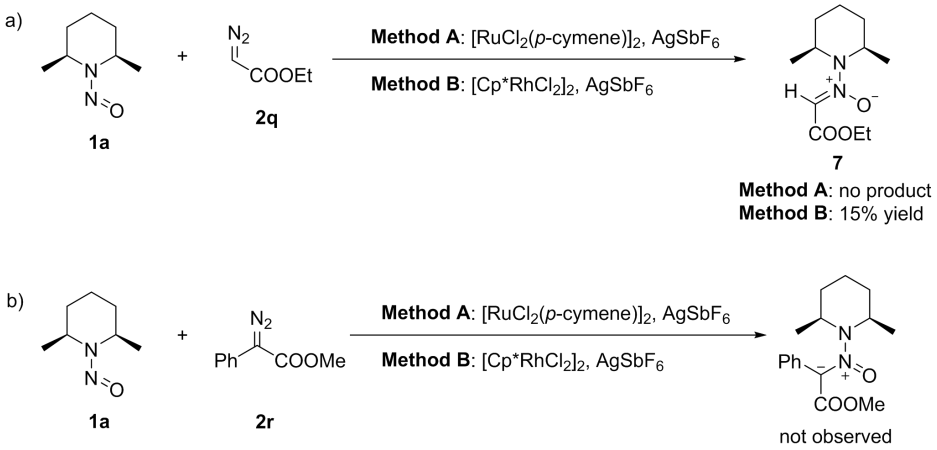
5.4 Transformation of 3m to compound 6[5]



Scheme S15. Preparation of **6**

To a solution of **3m** (54.8 mg, 0.2 mmol) in ethanol (30 mL) was added $NaBH_4$ (7.6 mg, 0.2 mmol). The mixture was stirred at room temperature until all the starting material is consumed, approximately 3 h. Then the reaction mixture was reduced under vacuum, diluted with DCM (50 mL) and neutralized with 2 M HCl. The reaction mixture was further washed with water and brine. Then, the organic layer was dried over anhydrous Na_2SO_4 and reduced under vacuum. The residue was then purified by flash column chromatography (*n*-hexane:ethyl acetate = 20:1) to give the desired product **6** as a yellow oil (47.8 mg, 75%).

6. Reaction of nitrosoamine with ethyl diazoacetate and methyl phenyldiazoacetate

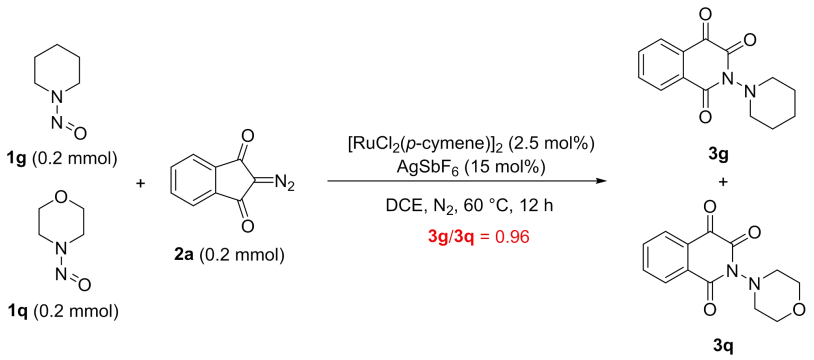


Scheme S16. Reaction of nitrosoamine **1a** with ethyl diazoacetate **2q** and methyl phenyldiazoacetate **2r**

A 25 mL reaction tube equipped with a magnetic stirrer bar were charged with $[Cp^*RhCl_2]_2$ (3.1 mg, 2.5 mol%), $AgSbF_6$ (10.3 mg, 15 mol%). The mixture was evacuated and refilled with N_2 for 3 times. To the mixture was then added **1a** (28.4 mg, 0.2 mmol) in DCE (1 mL) and **2q** (21 μL, 22.8 mg, 0.4 mmol) in DCE (1 mL). The reaction mixture was stirred at 60 °C under a N_2 atmosphere for 12 h. The crude mixture was filtered through celite and concentrated under reduced pressure. The residue was then purified by flash column chromatography (*n*-hexane:ethyl acetate = 50:1 to 20:1) to give the desired product **7** as a yellow liquid (6.8 mg, 15%).

7. Competition experiments

7.1 Electronic effect



Scheme S17. Competition experiment of **1g**, **1q** with **2a**

A 25 mL reaction tube equipped with a magnetic stirrer bar were charged with **2a** (34.4 mg, 0.2 mmol), $[RuCl_2(p\text{-cymene})]_2$ (3.1 mg, 2.5 mol%), $AgSbF_6$ (10.3 mg, 15 mol%). The mixture was evacuated and refilled with N_2 for 3 times. To the mixture was then added **1g** (22.8 mg, 0.2 mmol) in DCE (1 mL) and **1q** (23.2 mg, 0.2 mmol) in DCE (1 mL). The reaction mixture was stirred at 60 °C under a N_2 atmosphere for 12 h. The crude mixture was filtered through celite and concentrated under reduced pressure. The residue was then purified by flash column chromatography. The ratio of **3g** and **3q** was determined to be 0.96:1 by ^{1}H NMR analysis.

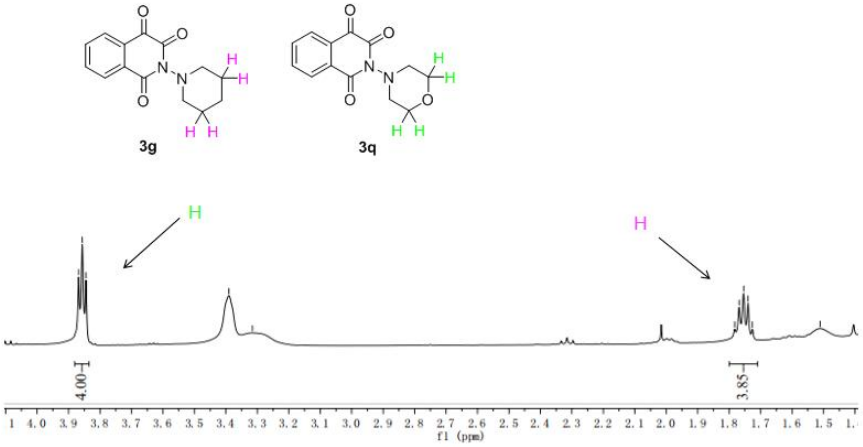
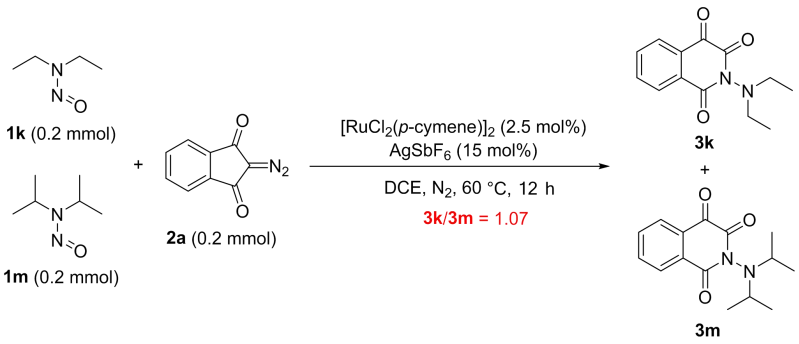


Figure S1. ^{1}H NMR spectra of the mixture of **3g** and **3q**

7.2 Steric effect



Scheme S18. Competition experiment of **1k**, **1m** with **2a**

A 25 mL reaction tube equipped with a magnetic stirrer bar were charged with **2a** (34.4 mg, 0.2 mmol), $[RuCl_2(p\text{-cymene})]_2$ (3.1 mg, 2.5 mol%), $AgSbF_6$ (10.3 mg, 15 mol%). The mixture was evacuated and refilled with N_2 for 3 times. To the mixture was then added **1k** (21.5μL, 20.4 mg, 0.2 mmol) in DCE (1 mL) and **1m** (26.0 mg, 0.2 mmol) in DCE (1 mL). The reaction mixture was stirred at 60 °C under a N_2 atmosphere for 12 h. The crude mixture was filtered through celite and concentrated under reduced pressure. The ratio of **3k** and **3m** was determined to be 1.07:1 by ^1H NMR analysis.

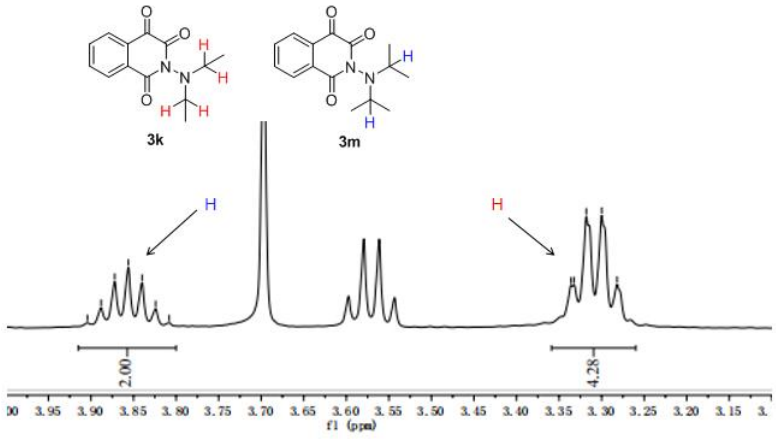
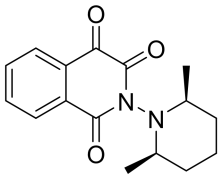


Figure S2. ^1H NMR spectra of the mixture of **3k** and **3m**

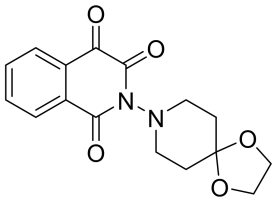
8. Characterization data for products

2-(*cis*-2,6-Dimethylpiperidin-1-yl)isoquinoline-1,3,4(2*H*)-trione (3a)



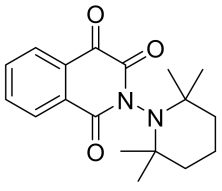
Orange solid (54.7 mg, 96% yield). By ^{13}C NMR, the ratio of stereoisomers was determined to be approximately 1:1. The ^{1}H NMR data listed here represent peak information only for the major isomer. The ^{13}C NMR data listed here represent peak information for the mixture. **Mp**: 132.9-133.7 °C; **^{1}H NMR** (400 MHz, $CDCl_3$): δ 8.42-8.32 (m, 1H), 8.21 (d, J = 7.6 Hz, 1H), 7.94-7.88 (m, 1H), 7.86-7.79 (m, 1H), 3.76-3.63 (m, 2H), 1.77-1.60 (m, 4H), 1.53-1.47 (m, 2H), 1.00-0.89 (m, 6H); **^{13}C NMR** (101 MHz, $CDCl_3$): δ 175.6, 175.0, 163.2, 162.4, 158.8, 157.2, 136.2, 136.0, 134.4, 134.2, 131.3, 131.1, 130.7, 129.8, 129.7(3), 129.6(7), 127.9, 127.6, 56.2, 55.4, 34.8, 34.7, 24.2, 24.0, 19.4; **HRMS** (ESI): calculated for $C_{16}H_{18}N_2O_3Na$ $[M+Na]^+$: 309.1210, found: 309.1204.

2-(1,4-Dioxa-8-azaspiro[4.5]decan-8-yl)isoquinoline-1,3,4(2*H*)-trione (3b)



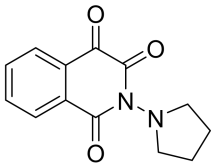
Yellow solid (36.4 mg, 58% yield). **Mp**: 123.5-124.0 °C; **^{1}H NMR** (500 MHz, $CDCl_3$): δ 8.34 (d, J = 7.8 Hz, 1H), 8.17 (d, J = 7.6 Hz, 1H), 7.89 (t, J = 7.5 Hz, 1H), 7.81 (t, J = 7.4 Hz, 1H), 3.98 (s, 4H), 3.48-3.40 (m, 4H), 1.91 (t, J = 5.2 Hz, 4H); **^{13}C NMR** (126 MHz, $CDCl_3$): δ 175.4, 161.6, 156.9, 136.1, 134.3, 130.8, 130.1, 130.0, 127.8, 106.2, 64.4, 49.2, 35.0; **HRMS** (ESI): calculated for $C_{16}H_{16}N_2O_5Na$ $[M+Na]^+$: 339.0951, found: 339.0949.

2-(2,2,6,6-Tetramethylpiperidin-1-yl)isoquinoline-1,3,4(2*H*)-trione (3c)



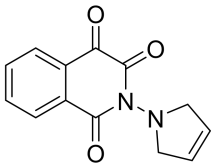
Red solid (47.1 mg, 75% yield). **Mp**: 121.0-121.5 °C; **^{1}H NMR** (400 MHz, $CDCl_3$): δ 8.38 (dd, J = 7.8, 0.8 Hz, 1H), 8.20 (dd, J = 7.7, 1.0 Hz, 1H), 7.91 (td, J = 7.6, 1.4 Hz, 1H), 7.82 (td, J = 7.6, 1.3 Hz, 1H), 1.85-1.77 (m, 2H), 1.68 (t, J = 5.9 Hz, 4H), 1.22 (s, 6H), 1.19 (s, 6H); **^{13}C NMR** (101 MHz, $CDCl_3$): δ 176.1, 165.4, 161.3, 136.0, 134.3, 131.2, 130.5, 130.0, 127.6, 58.3, 40.8, 28.8, 28.7, 18.3; **HRMS** (ESI): calculated for $C_{18}H_{22}N_2O_3Na$ $[M+Na]^+$: 337.1523, found: 337.1519.

2-(Pyrrolidin-1-yl)isoquinoline-1,3,4(2*H*)-trione (3e)



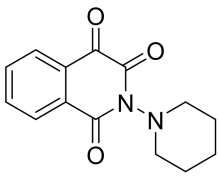
Yellow solid (27.5 mg, 56% yield). **Mp**: 157.3-158.0 °C; **^{1}H NMR** (500 MHz, $CDCl_3$): δ 8.35 (d, J = 7.8 Hz, 1H), 8.18 (d, J = 7.6 Hz, 1H), 7.89 (t, J = 7.6 Hz, 1H), 7.81 (t, J = 7.5 Hz, 1H), 3.34-3.29 (m, 4H), 2.05-2.01 (m, 4H); **^{13}C NMR** (126 MHz, $CDCl_3$): δ 175.4, 161.8, 157.1, 136.0, 134.3, 130.8, 130.1, 130.0, 127.8, 50.9, 24.5; **HRMS** (ESI): calculated for $C_{13}H_{12}N_2O_3Na$ $[M+Na]^+$: 267.0740, found: 267.0750.

2-(2,5-Dihydro-1*H*-pyrrol-1-yl)isoquinoline-1,3,4(2*H*)-trione (3f)



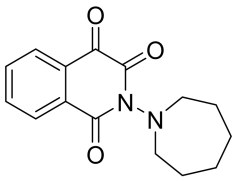
Orange solid (17.8 mg, 37% yield). **Mp**: 174.5-174.8 °C; **^{1}H NMR** (500 MHz, $CDCl_3$): δ 8.37 (dd, J = 7.8, 0.5 Hz, 1H), 8.20 (dd, J = 7.7, 0.8 Hz, 1H), 7.91 (td, J = 7.7, 1.2 Hz, 1H), 7.83 (td, J = 7.6, 1.1 Hz, 1H), 5.87-5.83 (m, 2H), 4.13-4.11 (m, 4H); **^{13}C NMR** (126 MHz, $CDCl_3$): δ 175.3, 161.8, 157.2, 136.1, 134.5, 130.9, 130.0(4), 129.9(7), 127.9, 126.1, 58.7; **HRMS** (ESI): calculated for $C_{13}H_{10}N_2O_3Na$ $[M+Na]^+$: 265.0584, found: 265.0587.

2-(Piperidin-1-yl)isoquinoline-1,3,4(2*H*)-trione (3g)



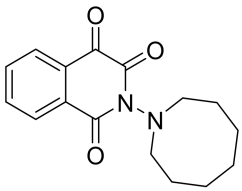
Yellow solid (24.8 mg, 48% yield). **Mp**: 114.9-115.6 °C; **^{1}H NMR** (400 MHz, $CDCl_3$): δ 8.34 (dd, J = 7.8, 0.6 Hz, 1H), 8.17 (dd, J = 7.7, 0.9 Hz, 1H), 7.89 (td, J = 7.7, 1.2 Hz, 1H), 7.80 (td, J = 7.6, 1.1 Hz, 1H), 3.39-3.21 (m, 4H), 1.79-1.71 (m, 4H), 1.56-1.45 (m, 2H); **^{13}C NMR** (101 MHz, $CDCl_3$): δ 175.6, 161.7, 157.0, 136.0, 134.2, 130.9, 130.3, 130.0, 127.7, 52.2, 26.3, 23.2; **HRMS** (ESI): calculated for $C_{14}H_{14}N_2O_3Na$ $[M+Na]^+$: 281.0897, found: 281.0901.

2-(Azepan-1-yl)isoquinoline-1,3,4(2*H*)-trione (3h)



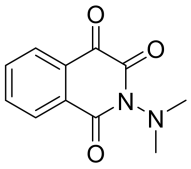
Orange solid (31.0 mg, 57% yield). **Mp**: 117.9-118.7 °C; **^{1}H NMR** (500 MHz, $CDCl_3$): δ 8.33 (d, J = 7.8 Hz, 1H), 8.16 (d, J = 7.7 Hz, 1H), 7.89 (t, J = 7.5 Hz, 1H), 7.80 (t, J = 7.4 Hz, 1H), 3.33-3.23 (m, 4H), 1.77-1.72 (m, 4H), 1.70-1.65 (m, 4H); **^{13}C NMR** (126 MHz, $CDCl_3$): δ 175.8, 161.7, 157.1, 136.0, 134.2, 130.9, 130.1, 129.9, 127.7, 55.0, 28.7, 27.5; **HRMS** (ESI): calculated for $C_{15}H_{16}N_2O_3Na$ $[M+Na]^+$: 295.1053, found: 295.1050.

2-(Azocan-1-yl)isoquinoline-1,3,4(2*H*)-trione (3i)



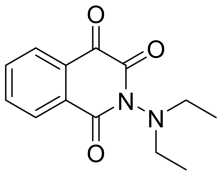
Yellow solid (39.5 mg, 69% yield). **Mp**: 117.5-118.1 °C; **^{1}H NMR** (500 MHz, $CDCl_3$): δ 8.35 (d, J = 7.8 Hz, 1H), 8.18 (d, J = 7.7 Hz, 1H), 7.89 (t, J = 7.6 Hz, 1H), 7.81 (t, J = 7.6 Hz, 1H), 3.29-3.24 (m, 2H), 3.23-3.16 (m, 2H), 1.97-1.88 (m, 2H), 1.73-1.68 (m, 4H), 1.67-1.61 (m, 4H); **^{13}C NMR** (126 MHz, $CDCl_3$): δ 175.8, 161.9, 157.3, 136.0, 134.2, 131.0, 130.2, 129.9, 127.8, 54.9, 27.8, 26.4, 25.7; **HRMS** (ESI): calculated for $C_{16}H_{18}N_2O_3Na$ $[M+Na]^+$: 309.1210, found: 309.1213.

2-(Dimethylamino)isoquinoline-1,3,4(2*H*)-trione (3j)



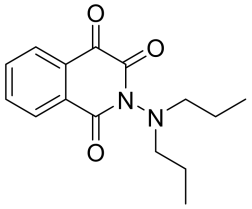
Yellow solid (16.7 mg, 38% yield). **Mp**: 175.6-176.1 °C; **^{1}H NMR** (400 MHz, $CDCl_3$): δ 8.35 (dd, J = 7.8, 0.6 Hz, 1H), 8.17 (dd, J = 7.7, 0.8 Hz, 1H), 7.89 (td, J = 7.6, 1.1 Hz, 1H), 7.81 (td, J = 7.6, 1.1 Hz, 1H), 3.01 (s, 6H); **^{13}C NMR** (101 MHz, $CDCl_3$): δ 175.3, 161.6, 156.8, 136.1, 134.4, 130.8, 130.0, 129.5, 127.8, 43.8; **HRMS** (ESI): calculated for $C_{11}H_{10}N_2O_3Na$ $[M+Na]^+$: 241.0584, found: 241.0590.

2-(Diethylamino)isoquinoline-1,3,4(2*H*)-trione (3k)



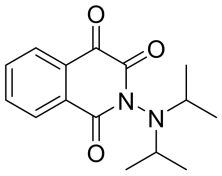
Orange solid (35.4 mg, 72% yield). **Mp**: 95.1-95.4 °C; **^{1}H NMR** (400 MHz, $CDCl_3$): δ 8.38 (dd, J = 7.8, 0.8 Hz, 1H), 8.22 (dd, J = 7.7, 0.9 Hz, 1H), 7.92 (td, J = 7.6, 1.3 Hz, 1H), 7.84 (td, J = 7.6, 1.2 Hz, 1H), 3.38-3.30 (m, 4H), 1.06 (t, J = 7.2 Hz, 6H); **^{13}C NMR** (101 MHz, $CDCl_3$): δ 175.2, 162.7, 157.8, 136.1, 134.4, 131.1, 130.2, 129.8, 127.8, 48.6, 12.5; **HRMS** (ESI): calculated for $C_{13}H_{14}N_2O_3Na$ $[M+Na]^+$: 269.0897, found: 269.0896.

2-(Dipropylamino)isoquinoline-1,3,4(2*H*)-trione (3l)



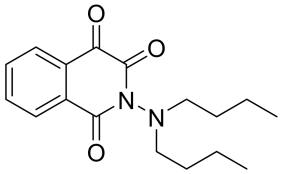
Orange liquid (49.8 mg, 91% yield). **^{1}H NMR** (400 MHz, $CDCl_3$): δ 8.35 (dd, J = 7.8, 0.8 Hz, 1H), 8.18 (dd, J = 7.7, 1.0 Hz, 1H), 7.90 (td, J = 7.6, 1.3 Hz, 1H), 7.81 (td, J = 7.6, 1.2 Hz, 1H), 3.21-3.14 (m, 4H), 1.45-1.38 (m, 4H), 0.89 (t, J = 7.4 Hz, 6H); **^{13}C NMR** (101 MHz, $CDCl_3$): δ 175.3, 162.4, 157.6, 136.1, 134.3, 131.0, 130.1, 129.9, 127.8, 56.7, 21.0, 11.5; **HRMS** (ESI): calculated for $C_{15}H_{18}N_2O_3Na$ $[M+Na]^+$: 297.1210, found: 297.1212.

2-(Diisopropylamino)isoquinoline-1,3,4(2*H*)-trione (3m)



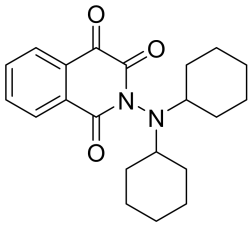
Yellow solid (54.4 mg, 99% yield). **Mp**: 93.6-94.3 °C; **^{1}H NMR** (500 MHz, $CDCl_3$): δ 8.36 (dd, J = 7.7, 0.4 Hz, 1H), 8.19 (dd, J = 7.7, 0.9 Hz, 1H), 7.89 (td, J = 7.6, 1.2 Hz, 1H), 7.81 (td, J = 7.6, 1.1 Hz, 1H), 3.90-3.83 (m, 2H), 1.13-1.09 (m, 12H); **^{13}C NMR** (126 MHz, $CDCl_3$): δ 175.8, 164.0, 159.7, 135.9, 134.2, 131.4, 130.3, 130.2, 127.7, 51.1, 21.3, 21.2; **HRMS** (ESI): calculated for $C_{15}H_{18}N_2O_3Na$ $[M+Na]^+$: 297.1210, found: 297.1206.

2-(Dibutylamino)isoquinoline-1,3,4(2*H*)-trione (3n)



Yellow liquid (59.7 mg, 99% yield). **^{1}H NMR** (500 MHz, $CDCl_3$): δ 8.37 (d, J = 7.8 Hz, 1H), 8.19 (dd, J = 7.7, 0.7 Hz, 1H), 7.89 (td, J = 7.7, 1.2 Hz, 1H), 7.81 (td, J = 7.6, 1.1 Hz, 1H), 3.26-3.20 (m, 4H), 1.43-1.34 (m, 8H), 0.86 (t, J = 7.1 Hz, 6H); **^{13}C NMR** (101 MHz, $CDCl_3$): δ 175.4, 162.5, 157.6, 136.1, 134.4, 131.1, 130.2, 129.9, 127.8, 54.7, 29.8, 20.2, 13.9; **HRMS** (ESI): calculated for $C_{17}H_{22}N_2O_3Na$ $[M+Na]^+$: 325.1523, found: 325.1523.

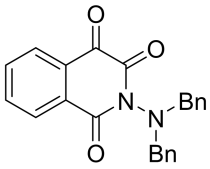
2-(Dicyclohexylamino)isoquinoline-1,3,4(2*H*)-trione (3o)



Orange solid (70.6 mg, 99% yield). **Mp**: 134.9-135.4 °C; **^{1}H NMR** (400 MHz, $CDCl_3$): δ 8.36 (dd, J = 7.8, 0.8 Hz, 1H), 8.20 (dd, J = 7.7, 1.0 Hz, 1H), 7.90 (td, J = 7.6, 1.3 Hz, 1H), 7.82 (td, J = 7.6, 1.2 Hz, 1H), 3.56-3.44 (m, 2H), 1.97-1.85 (m, 4H), 1.74-1.66 (m, 4H), 1.59-1.52 (m, 2H), 1.27-1.13 (m, 8H), 1.12-1.02 (m, 2H); **^{13}C NMR** (101 MHz, $CDCl_3$): δ 175.7, 164.1, 159.7, 136.0, 134.2, 131.2, 130.4, 130.0, 127.7, 58.6, 31.4, 31.3, 25.9, 25.5, 25.4; **HRMS** (ESI): calculated for

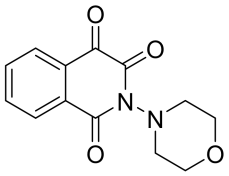
$C_{21}H_{26}N_2O_3Na$ [M+Na]$^+$: 377.1836, found: 377.1838.

2-(Dibenzylamino)isoquinoline-1,3,4(2*H*)-trione (3p)



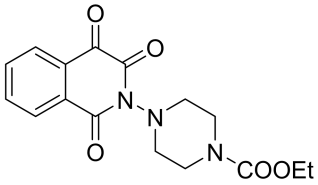
Yellow solid (57.7 mg, 78% yield). **Mp**: 131.5-132.2 °C; **^{1}H NMR** (500 MHz, $CDCl_3$): δ 8.24 (d, J = 7.7 Hz, 1H), 8.06 (d, J = 7.5 Hz, 1H), 7.82 (t, J = 7.4 Hz, 1H), 7.73 (t, J = 7.4 Hz, 1H), 7.48 (d, J = 7.3 Hz, 4H), 7.25 (t, J = 7.0 Hz, 4H), 7.19 (t, J = 7.0 Hz, 2H), 4.44 (s, 4H); **^{13}C NMR** (126 MHz, $CDCl_3$): δ 175.1, 162.1, 157.3, 136.6, 135.9, 134.2, 130.7, 129.8, 129.6, 129.2, 128.3, 127.7(0), 127.6(8), 58.1; **HRMS** (ESI): calculated for $C_{23}H_{18}N_2O_3Na$ [M+Na]$^+$: 393.1210, found: 393.1205.

2-Morpholinoisoquinoline-1,3,4(2*H*)-trione (3q)



Yellow solid (25.6 mg, 49% yield). **Mp**: 227.2-228.0 °C; **^{1}H NMR** (400 MHz, $CDCl_3$): δ 8.37 (dd, J = 7.7, 0.7 Hz, 1H), 8.20 (dd, J = 7.6, 1.0 Hz, 1H), 7.91 (td, J = 7.6, 1.3 Hz, 1H), 7.83 (td, J = 7.6, 1.1 Hz, 1H), 3.89-3.85 (m, 4H), 3.45-3.36 (m, 4H); **^{13}C NMR** (126 MHz, $CDCl_3$): δ 174.3, 160.6, 155.8, 135.2, 133.5, 129.9, 129.1, 129.0, 126.9, 66.2, 50.4; **HRMS** (ESI): calculated for $C_{13}H_{12}N_2O_4Na$ [M+Na]$^+$: 283.0689, found: 283.0688.

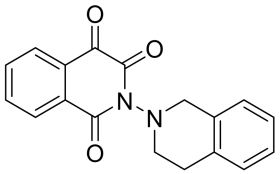
Ethyl 4-(1,3,4-trioxo-3,4-dihydroisoquinolin-2(1*H*)-yl)piperazine-1-carboxylate (3r)



Yellow solid (29.0 mg, 44% yield). **Mp**: 170.6-171.6 °C; **^{1}H NMR** (400 MHz, $CDCl_3$): δ 8.33 (d, J = 7.4 Hz, 1H), 8.18 (dd, J = 7.6, 0.7 Hz, 1H), 7.90 (td, J = 7.6, 1.2 Hz, 1H), 7.82 (td, J = 7.6, 1.0 Hz, 1H), 4.14 (q, J = 7.1 Hz, 2H), 3.80-3.52 (m, 4H), 3.44-3.20 (m, 4H), 1.26 (t, J = 7.1 Hz, 3H);

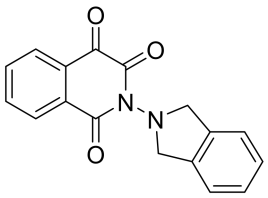
^{13}C NMR (101 MHz, $CDCl_3$): δ 175.2, 161.6, 156.8, 155.2, 136.1, 134.5, 130.8, 130.0, 129.9, 127.9, 61.5, 50.8, 44.0, 14.6; **HRMS** (ESI): calculated for $C_{16}H_{17}N_3O_5Na$ $[M+Na]^+$: 354.1060, found: 354.1044.

3',4'-Dihydro-1*H*,1'*H*-[2,2'-biisoquinoline]-1,3,4-trione (3s)



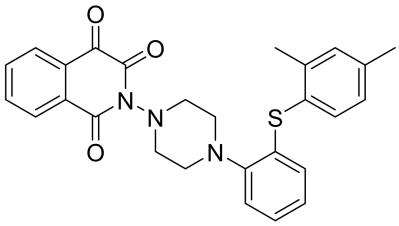
Yellow solid (25.3 mg, 41% yield). **Mp**: 214.6-215.3 °C; **^{1}H NMR** (400 MHz, $CDCl_3$): δ 8.37 (dd, J = 7.8, 0.8 Hz, 1H), 8.21 (dd, J = 7.7, 1.0 Hz, 1H), 7.91 (td, J = 7.6, 1.3 Hz, 1H), 7.83 (td, J = 7.6, 1.2 Hz, 1H), 7.17-7.12 (m, 3H), 7.01-6.97 (m, 1H), 4.53 (s, 2H), 3.75-3.57 (m, 2H), 3.14-3.05 (m, 2H); **^{13}C NMR** (101 MHz, $CDCl_3$): δ 175.4, 161.7, 157.0, 136.1, 134.4, 133.5, 133.4, 130.9, 130.1, 128.8, 127.9, 126.4, 126.3, 125.8, 52.1, 49.8, 30.5; **HRMS** (ESI): calculated for $C_{18}H_{14}N_2O_3Na$ $[M+Na]^+$: 329.0897, found: 329.0899.

2-(Isoindolin-2-yl)isoquinoline-1,3,4(2*H*)-trione (3t)



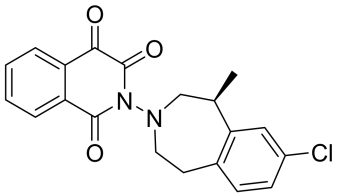
Orange solid (16.4 mg, 28% yield). The ^{1}H NMR data listed here represent peak information only for the major isomer. The ^{13}C NMR data listed here represent peak information for the mixture. **Mp**: 230.3-230.6 °C; **^{1}H NMR** (400 MHz, $CDCl_3$): δ 8.38 (d, J = 7.7 Hz, 1H), 8.23 (dd, J = 7.6, 0.9 Hz, 1H), 7.91 (td, J = 7.6, 1.3 Hz, 1H), 7.84 (td, J = 7.6, 1.2 Hz, 1H), 7.25-7.19 (m, 4H), 4.69 (s, 4H); **^{13}C NMR** (126 MHz, $CDCl_3$): δ 175.3, 175.1, 161.8, 161.6, 157.2, 155.8, 137.4, 136.2, 136.1, 134.9, 134.6, 131.4, 130.9, 130.2, 130.0, 129.5, 129.2, 128.3, 128.1, 127.2, 127.1, 122.5, 122.4, 57.2. **HRMS** (ESI): calculated for $C_{17}H_{12}N_2O_3Na$ $[M+Na]^+$: 315.0740, found: 315.0741.

2-(4-(2-((2,4-Dimethylphenyl)thio)phenyl)piperazin-1-yl)isoquinoline-1,3,4(2*H*)-trione (3x)



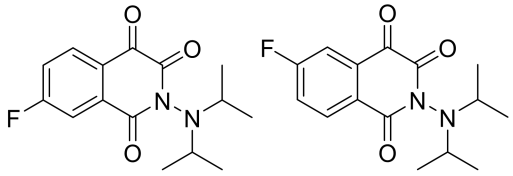
Yellow solid (39.3 mg, 42% yield). **Mp**: 122.6-123.1 °C; **^{1}H NMR** (400 MHz, $CDCl_3$): δ 8.39 (d, J = 7.7 Hz, 1H), 8.21 (d, J = 7.4 Hz, 1H), 7.95-7.90 (m, 1H), 7.86-7.80 (m, 1H), 7.40 (d, J = 7.8 Hz, 1H), 7.14 (d, J = 9.2 Hz, 2H), 7.10-7.02 (m, 2H), 6.91-6.85 (m, 1H), 6.54 (d, J = 7.8 Hz, 1H), 3.68-3.56 (m, 4H), 3.35-3.27 (m, 4H), 2.36 (s, 3H), 2.34 (s, 3H); **^{13}C NMR** (101 MHz, $CDCl_3$): δ 175.4, 161.8, 156.9, 148.7, 142.5, 139.2, 136.3, 136.1, 134.9, 134.4, 131.7, 130.9, 130.2, 130.0, 127.9, 127.8(4), 127.7(5), 126.1, 125.4, 124.6, 120.1, 51.9, 51.5, 21.2, 20.6; **HRMS** (ESI): calculated for $C_{27}H_{25}N_3O_3SNa$ $[M+Na]^+$: 494.1509, found: 494.1497.

(*S*)-2-(8-Chloro-1-methyl-1,2,4,5-tetrahydro-3*H*-benzo[*d*]azepin-3-yl)isoquinoline-1,3,4(2*H*)-trione (3y)



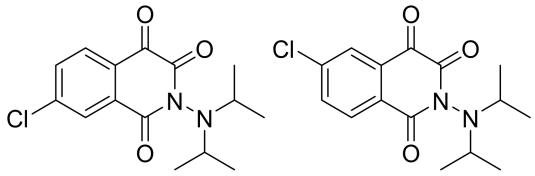
Yellow solid (43.1 mg, 59% yield). The ^{1}H NMR data listed here represent peak information only for the major isomer. The ^{13}C NMR data listed here represent peak information for the mixture. **Mp**: 184.2-185.0 °C; **^{1}H NMR** (400 MHz, $CDCl_3$): δ 8.39-8.29 (m, 1H), 8.18 (d, J = 7.7 Hz, 1H), 7.93-7.87 (m, 1H), 7.82 (t, J = 7.5 Hz, 1H), 7.15 (d, J = 1.7 Hz, 1H), 7.14-7.09 (m, 1H), 7.04 (d, J = 8.0 Hz, 1H), 3.47-3.28 (m, 4H), 3.25-3.17 (m, 1H), 3.15-2.98 (m, 2H), 1.44 (t, J = 7.7 Hz, 3H); **^{13}C NMR** (101 MHz, $CDCl_3$): δ 175.6, 175.5, 161.6, 161.5, 156.8, 156.7, 146.5(8), 146.5(6), 138.6(1), 138.5(9), 136.1, 134.4, 132.2, 131.2, 131.1, 130.9, 130.1, 129.9(9), 129.9(6), 127.9, 127.1, 126.9, 126.2, 61.4, 61.3, 55.0, 54.9, 39.6, 39.3, 35.6, 35.5, 17.8(4), 17.7(8); **HRMS** (ESI): calculated for $C_{20}H_{17}N_2O_3ClNa$ $[M+Na]^+$: 391.0820, found: 391.0821.

2-(Diisopropylamino)-7-fluoroisoquinoline-1,3,4(2*H*)-trione (3mb) and 2-(diisopropylamino)-6-fluoroisoquinoline-1,3,4(2*H*)-trione (3mb')



Orange solid (50.0 mg, 86% yield). By ^{1}H NMR, the ratio of two regioisomers was determined to be approximately 5:2. The NMR data listed here represent peak information for the mixture. **^{1}H NMR** (500 MHz, $CDCl_3$): δ 8.40 (dd, J = 8.7, 5.0 Hz, 1H), 8.25 (dd, J = 8.6, 5.2 Hz, 0.4H), 8.01 (dd, J = 8.5, 2.5 Hz, 0.4H), 7.82 (dd, J = 7.6, 2.6 Hz, 1H), 7.58 (td, J = 8.2, 2.6 Hz, 1H), 7.50 (td, J = 8.2, 2.5 Hz, 0.4H), 3.90-3.84 (m, 2.8H), 1.11-1.06 (m, 16.8H); **^{13}C NMR** (126 MHz, $CDCl_3$): δ 174.8, 174.1, 167.4 (J = 261.8 Hz), 166.0 (J = 260.1 Hz), 163.0, 162.9, 159.2, 159.1, 133.5 (J = 9.0 Hz), 133.4 (J = 8.2 Hz), 133.0 (J = 9.2 Hz), 131.1 (J = 9.6 Hz), 127.8 (J = 2.9 Hz), 126.3 (J = 3.1 Hz), 123.7 (J = 22.7 Hz), 122.1 (J = 22.9 Hz), 117.2 (J = 24.6 Hz), 114.0 (J = 23.5 Hz), 50.8, 21.1, 21.0(2), 20.9(9); **^{19}F NMR** (470 MHz, $CDCl_3$): δ -96.68, -100.82; **HRMS** (ESI): calculated for $C_{15}H_{17}N_2O_3FNa$ $[M+Na]^+$: 315.1115, found: 315.1110.

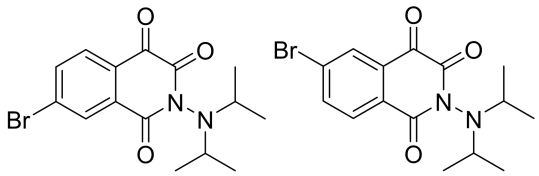
7-Chloro-2-(diisopropylamino)isoquinoline-1,3,4(2*H*)-trione (3mc) and 6-chloro-2-(diisopro pylamino)isoquinoline-1,3,4(2*H*)-trione (3mc')



Orange solid (50.7 mg, 82% yield). By ^{1}H NMR, the ratio of two regioisomers was determined to be approximately 2:1. The NMR data listed here represent peak information for the mixture. **^{1}H NMR** (500 MHz, $CDCl_3$): δ 8.32 (d, J = 2.0 Hz, 0.5H), 8.30 (d, J = 8.4 Hz, 1H), 8.17-8.11 (m, 1.5H), 7.85 (dd, J = 8.4, 2.1 Hz, 1H), 7.77 (dd, J = 8.3, 2.0 Hz, 0.5H), 3.90-3.83 (m, 3H), 1.11-1.06 (m, 18H); **^{13}C NMR** (126 MHz, $CDCl_3$): δ 174.8, 174.5, 163.1, 163.0, 159.1, 159.0, 143.5, 141.5, 136.2, 134.6, 132.1, 131.9, 131.3, 130.3, 129.3, 129.2, 128.1, 127.4, 50.8, 50.7, 21.0(9), 21.0(7), 21.0(1), 20.9(9); **HRMS** (ESI): calculated for $C_{15}H_{17}N_2O_3ClNa$ $[M+Na]^+$: 331.0820, found: 331.0821.

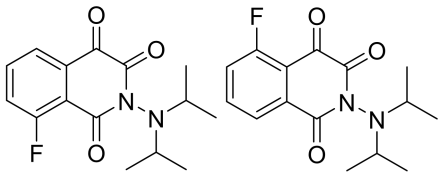
7-Bromo-2-(diisopropylamino)isoquinoline-1,3,4(2*H*)-trione (3md) and 6-bromo-2-(diisopr

opylamino)isoquinoline-1,3,4(2*H*)-trione (3md')



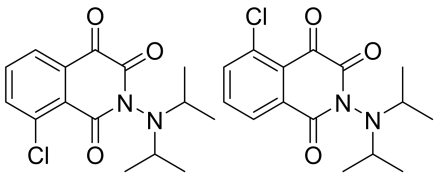
Orange solid (62.2 mg, 88% yield). By ^{1}H NMR, the ratio of two regioisomers was determined to be approximately 5:3. The NMR data listed here represent peak information for the mixture. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 8.50 (d, J = 1.5 Hz, 0.6H), 8.30 (d, J = 1.7 Hz, 1H), 8.22 (d, J = 8.4 Hz, 1H), 8.04 (d, J = 8.3 Hz, 0.6H), 8.01 (dd, J = 8.4, 1.8 Hz, 1H), 7.94 (dd, J = 8.2, 1.7 Hz, 0.6H), 3.90-3.83 (m, 3.2H), 1.11-1.06 (m, 19.2H); **^{13}C NMR** (101 MHz, $CDCl_3$): δ 174.8, 174.7, 163.3, 162.9, 159.1, 159.0, 139.1, 137.6, 133.3, 132.1, 132.0, 131.9, 131.1, 130.4, 129.9, 129.7, 129.0, 128.5, 50.8, 21.0(8), 21.0(6), 21.0; **HRMS** (ESI): calculated for $C_{15}H_{17}N_2O_3BrNa$ $[M+Na]^+$: 375.0315, found: 375.0322.

2-(Diisopropylamino)-8-fluoroisoquinoline-1,3,4(2*H*)-trione (3me) and 2-(diisopropylamino) -5-fluoroisoquinoline-1,3,4(2*H*)-trione (3me')



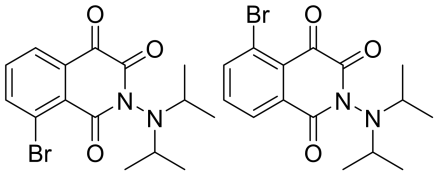
Orange solid (42.0 mg, 72% yield). By ^{1}H NMR, the ratio of two regioisomers was determined to be approximately 5:3. The NMR data listed here represent peak information for the mixture. **^{1}H NMR** (500 MHz, $CDCl_3$): δ 8.22 (d, J = 7.8 Hz, 0.6H), 8.05 (d, J = 7.7 Hz, 1H), 7.88 (td, J = 8.1, 4.9 Hz, 0.6H), 7.81 (td, J = 8.0, 4.4 Hz, 1H), 7.64-7.58 (m, 1H), 7.51 (t, J = 9.0 Hz, 0.6H), 3.89-3.83 (m, 3.2H), 1.11-1.06 (m, 19.2H); **^{13}C NMR** (126 MHz, $CDCl_3$): δ 175.2(2), 175.1(9), 163.1 (J = 3.3 Hz), 162.5 (J = 270.8 Hz), 161.4 (J = 272.5 Hz), 160.7 (J = 5.5 Hz), 158.9, 158.8, 137.4 (J = 9.9 Hz), 135.7 (J = 9.9 Hz), 132.4, 131.3, 126.6 (J = 3.6 Hz), 125.2 (J = 22.5 Hz), 124.2 (J = 3.9 Hz), 122.6 (J = 20.4 Hz), 119.5 (J = 7.2 Hz), 117.3 (J = 3.9 Hz), 50.8, 50.7, 21.1(4), 21.1(0), 21.0(8), 21.0; **^{19}F NMR** (376 MHz, $CDCl_3$): δ -106.69, -108.36; **HRMS** (ESI): calculated for $C_{15}H_{17}N_2O_3FNa$ $[M+Na]^+$: 315.1115, found: 315.1113.

8-Chloro-2-(diisopropylamino)isoquinoline-1,3,4(2*H*)-trione (3mf) and 5-chloro-2-(diisopropylamino)isoquinoline-1,3,4(2*H*)-trione (3mf')



Orange liquid (37.5 mg, 61% yield). By ^{1}H NMR, the ratio of two regioisomers was determined to be approximately 4:1. The NMR data listed here represent peak information for the mixture. **^{1}H NMR** (500 MHz, $CDCl_3$): δ 8.34 (dd, J = 7.5, 1.4 Hz, 0.25H), 8.16 (dd, J = 7.7, 1.0 Hz, 1H), 7.92 (dd, J = 8.0, 1.0 Hz, 1H), 7.81 (dd, J = 8.0, 1.4 Hz, 0.25H), 7.77 (t, J = 7.8 Hz, 0.25H), 7.71 (t, J = 7.9 Hz, 1H), 3.90-3.83 (m, 2.5H), 1.13-1.07 (m, 15H); **^{13}C NMR** (126 MHz, $CDCl_3$): δ 175.9, 174.0, 163.2, 161.9, 159.3, 158.6, 139.7, 137.5, 137.2, 136.0, 135.3, 133.9, 133.2, 132.4, 129.4, 127.9, 127.0, 126.4, 50.8, 50.7, 21.1(3), 21.0(5), 21.0; **HRMS** (ESI): calculated for $C_{15}H_{17}N_2O_3ClNa$ $[M+Na]^+$: 331.0820, found: 331.0814.

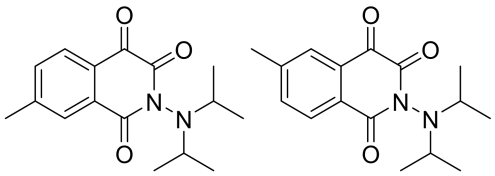
8-Bromo-2-(diisopropylamino)isoquinoline-1,3,4(2*H*)-trione (3mg) and 5-bromo-2-(diisopropylamino)isoquinoline-1,3,4(2*H*)-trione (3mg')



Orange liquid (48.7 mg, 69% yield). By ^{1}H NMR, the ratio of two regioisomers was determined to be approximately 4:1. The NMR data listed here represent peak information for the mixture. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 8.39 (dd, J = 7.8, 1.2 Hz, 0.25H), 8.19 (dd, J = 7.7, 1.3 Hz, 1H), 8.16 (dd, J = 8.0, 1.3 Hz, 1H), 8.03 (dd, J = 8.0, 1.2 Hz, 0.25H), 7.67 (t, J = 7.9 Hz, 0.25H), 7.61 (t, J = 7.8 Hz, 1H), 3.91-3.82 (m, 2.5H), 1.13-1.07 (m, 15H); **^{13}C NMR** (101 MHz, $CDCl_3$): δ 176.0, 174.4, 163.2, 162.2, 159.2, 158.6, 143.2, 140.8, 135.3, 133.9, 133.5, 132.8, 130.1, 129.2, 127.9, 127.6, 125.2, 123.5, 50.9, 50.8, 21.2, 21.1, 21.0; **HRMS** (ESI): calculated for $C_{15}H_{17}N_2O_3BrNa$ $[M+Na]^+$: 375.0315, found: 375.0317.

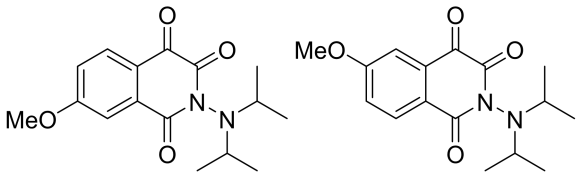
2-(Diisopropylamino)-7-methylisoquinoline-1,3,4(2*H*)-trione (3mh) and 2-(diisopropylamin

o)-6-methylisoquinoline-1,3,4(2*H*)-trione (3mh')



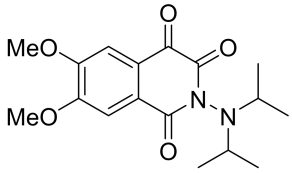
Orange solid (51.3 mg, 89% yield). By ^{1}H NMR, the ratio of two regioisomers was determined to be approximately 4:3. The NMR data listed here represent peak information for the mixture. **^{1}H NMR** (500 MHz, $CDCl_3$): δ 8.23 (d, J = 8.0 Hz, 1H), 8.16-8.13 (m, 0.75H), 8.08 (d, J = 7.9 Hz, 0.75H), 8.00-7.97 (m, 1H), 7.69 (d, J = 8.0 Hz, 1H), 7.61 (d, J = 7.9 Hz, 0.75H), 3.89-3.84 (m, 3.5H), 2.55 (s, 2.25H), 2.52 (s, 3H), 1.10-1.06 (m, 21H); **^{13}C NMR** (126 MHz, $CDCl_3$): δ 175.8, 175.2, 164.1, 163.9, 159.7(0), 159.6(6), 148.0, 145.7, 137.0, 135.1, 131.0, 130.6, 130.4, 129.9, 128.9, 127.9, 127.8, 127.5, 50.6(8), 50.6(6), 22.1, 21.6, 21.1, 21.0(2), 21.0(0); **HRMS** (ESI): calculated for $C_{16}H_{20}N_2O_3Na$ $[M+Na]^+$: 311.1366, found: 311.1369.

2-(Diisopropylamino)-7-methoxyisoquinoline-1,3,4(2*H*)-trione (3mi) and 2-(diisopropylamino)-6-methoxyisoquinoline-1,3,4(2*H*)-trione (3mi')



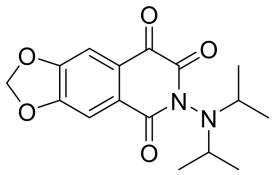
Orange solid (41.5 mg, 68% yield). By ^{1}H NMR, the ratio of two regioisomers was determined to be approximately 3:1. The NMR data listed here represent peak information for the mixture. **^{1}H NMR** (500 MHz, $CDCl_3$): δ 8.25 (d, J = 8.7 Hz, 1H), 8.13 (d, J = 8.7 Hz, 0.33H), 7.76 (d, J = 2.5 Hz, 0.33H), 7.57 (d, J = 2.6 Hz, 1H), 7.36 (dd, J = 8.7, 2.6 Hz, 1H), 7.27-7.25 (m, 0.33H), 3.99 (s, 1H), 3.95 (s, 3H), 3.89-3.83 (m, 2.66H), 1.10-1.06 (m, 15.96H); **^{13}C NMR** (126 MHz, $CDCl_3$): δ 175.7, 173.9, 166.0, 164.2, 164.0, 163.6, 159.9, 159.7, 132.8, 132.4, 132.3, 130.3, 124.6, 123.7, 122.8, 121.5, 113.3, 109.7, 56.2(3), 56.1(7), 50.6(9), 50.6(6), 21.0(8), 21.0(6), 21.0(3), 21.0(0); **HRMS** (ESI): calculated for $C_{16}H_{20}N_2O_4Na$ $[M+Na]^+$: 327.1315, found: 327.1317.

2-(Diisopropylamino)-6,7-dimethoxyisoquinoline-1,3,4(2*H*)-trione (3mj)



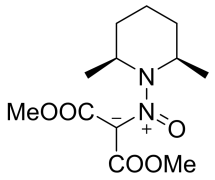
Yellow liquid (46.8 mg, 70% yield). **^{1}H NMR** (500 MHz, $CDCl_3$): δ 7.68 (s, 1H), 7.51 (s, 1H), 4.03 (s, 3H), 3.98 (s, 3H), 3.84-3.79 (m, 2H), 1.07-1.02 (m, 12H); **^{13}C NMR** (126 MHz, $CDCl_3$): δ 174.2, 163.8, 159.8, 155.6, 153.8, 125.5, 124.8, 111.0, 108.0, 56.7, 56.6, 50.6, 21.0, 20.9; **HRMS** (ESI): calculated for $C_{17}H_{22}N_2O_5Na$ $[M+Na]^+$: 357.1421, found: 357.1423.

6-(Diisopropylamino)-[1,3]dioxolo[4,5-*g*]isoquinoline-5,7,8(6*H*)-trione (3mk)



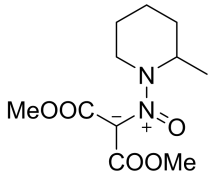
Yellow solid (35.1 mg, 55% yield). **Mp**: 122.8-123.6 °C; **^{1}H NMR** (500 MHz, $CDCl_3$): δ 7.68 (s, 1H), 7.50 (s, 1H), 6.21 (s, 2H), 3.88-3.82 (m, 2H), 1.10-1.05 (m, 12H); **^{13}C NMR** (126 MHz, $CDCl_3$): δ 173.9, 163.3, 159.4, 154.6, 152.9, 128.0, 127.5, 109.2, 106.0, 103.4, 50.7, 21.0(4), 20.9(8); **HRMS** (ESI): calculated for $C_{16}H_{18}N_2O_5Na$ $[M+Na]^+$: 341.1108, found: 341.1108.

2-((*cis*-2,6-Dimethylpiperidin-1-yl)(oxo)ammonio)-1,3-dimethoxy-1,3-dioxopropan-2-ide (4a)



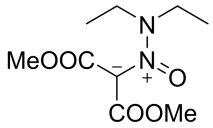
Pale Yellow solid (36.2 mg, 67% yield). **^{1}H NMR** (400 MHz, $CDCl_3$): δ 3.86 (s, 3H), 3.83 (s, 3H), 3.08-3.00 (m, 2H), 1.76-1.71 (m, 2H), 1.43-1.22 (m, 4H), 1.09 (d, J = 6.2 Hz, 6H); **^{13}C NMR** (101 MHz, $CDCl_3$): δ 160.9, 159.2, 128.3, 58.5, 52.8, 52.7, 33.5, 23.7, 18.5; **HRMS** (ESI): calculated for $C_{12}H_{20}N_2O_5Na$ $[M+Na]^+$: 295.1264, found: 295.1273.

1,3-Dimethoxy-2-((2-methylpiperidin-1-yl)(oxo)ammonio)-1,3-dioxopropan-2-ide (4b)



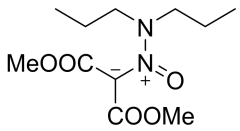
Yellow liquid (30.0 mg, 58% yield). **^{1}H NMR** (400 MHz, $CDCl_3$): δ 3.83 (s, 6H), 3.24-3.18 (m, 1H), 3.08-3.01 (m, 1H), 3.00-2.92 (m, 1H), 1.76-1.70 (m, 2H), 1.65-1.59 (m, 1H), 1.50-1.41 (m, 1H), 1.33-1.25 (m, 1H), 1.23-1.20 (m, 1H), 1.01 (d, J = 6.0 Hz, 3H); **^{13}C NMR** (101 MHz, $CDCl_3$): δ 160.0, 126.2, 55.6, 54.7, 52.7, 33.0, 25.2, 23.3, 18.0; **HRMS** (ESI): calculated for $C_{11}H_{18}N_2O_5Na$ $[M+Na]^+$: 281.1108, found: 281.1106.

2-(2,2-Diethyl-1-oxohydrazin-1-ium-1-yl)-1,3-dimethoxy-1,3-dioxopropan-2-ide (4c)



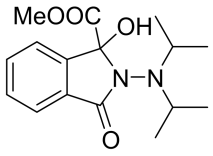
Yellow liquid (16.9 mg, 36% yield). **^{1}H NMR** (400 MHz, $CDCl_3$): δ 3.82 (s, 6H), 2.93 (q, J = 7.2 Hz, 4H), 1.04 (t, J = 7.2 Hz, 6H); **^{13}C NMR** (101 MHz, $CDCl_3$): δ 160.0, 126.8, 52.8, 49.1, 11.4; **HRMS** (ESI): calculated for $C_9H_{16}N_2O_5Na$ $[M+Na]^+$: 255.0951, found: 255.0951.

1,3-Dimethoxy-1,3-dioxo-2-(1-oxo-2,2-dipropylhydrazin-1-ium-1-yl)propan-2-ide (4d)



Yellow liquid (11.0 mg, 21% yield). **^{1}H NMR** (400 MHz, $CDCl_3$): δ 3.84 (s, 6H), 2.90-2.85 (m, 4H), 1.51-1.43 (m, 4H), 0.87 (t, J = 7.4 Hz, 6H); **^{13}C NMR** (101 MHz, $CDCl_3$): δ 159.9, 126.1, 56.3, 52.7, 19.5, 11.2; **HRMS** (ESI): calculated for $C_{11}H_{20}N_2O_5Na$ $[M+Na]^+$: 283.1264, found: 283.1264.

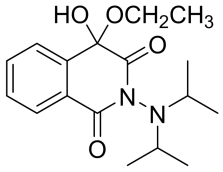
Methyl 2-(diisopropylamino)-1-hydroxy-3-oxoisoindoline-1-carboxylate (5)



White solid (142.1 mg, 93% yield). **Mp**: 127.6-128.3 °C; **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.78 (d, J = 6.7 Hz, 1H), 7.58 (td, J = 7.5, 1.3 Hz, 1H), 7.53 (td, J = 7.5, 1.2 Hz, 1H), 7.38 (d, J = 7.2 Hz,

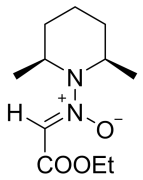
1H), 4.77 (s, 1H), 3.71 (s, 3H), 3.69-3.62 (m, 1H), 3.54-3.47 (m, 1H), 1.28 (d, J = 6.6 Hz, 3H), 1.21 (d, J = 6.4 Hz, 3H), 1.07-1.03 (m, 6H); **^{13}C NMR** (101 MHz, $CDCl_3$): δ 171.2, 168.3, 141.4, 132.7, 130.8, 130.2, 123.5, 122.2, 87.7, 55.8, 53.5, 52.3, 24.3, 22.9, 22.5, 21.6; **HRMS** (ESI): calculated for $C_{16}H_{22}N_2O_4Na$ $[M+Na]^+$: 329.1472, found: 329.1472.

2-(Diisopropylamino)-4-ethoxy-4-hydroxyisoquinoline-1,3(2*H*,4*H*)-dione (6)



Yellow liquid (47.8 mg, 75% yield). **^{1}H NMR** (500 MHz, $CDCl_3$): δ 7.77 (d, J = 7.4 Hz, 1H), 7.57 (t, J = 7.1 Hz, 1H), 7.52 (t, J = 7.3 Hz, 1H), 7.36 (d, J = 7.4 Hz, 1H), 4.79 (s, 1H), 4.28-4.20 (m, 1H), 4.15-4.08 (m, 1H), 3.70-3.63 (m, 1H), 3.55-3.48 (m, 1H), 1.29 (d, J = 6.6 Hz, 3H), 1.21 (d, J = 6.4 Hz, 3H), 1.12 (t, J = 7.1 Hz, 3H), 1.08-1.03 (m, 6H); **^{13}C NMR** (126 MHz, $CDCl_3$): δ 170.7, 168.4, 141.7, 132.6, 130.8, 130.1, 123.4, 122.0, 87.7, 63.1, 55.9, 52.2, 24.4, 23.1, 22.4, 21.6, 13.7; **HRMS** (ESI): calculated for $C_{17}H_{24}N_2O_4Na$ $[M+Na]^+$: 343.1628, found: 343.1628.

(*Z*)-*N*-(*cis*-2,6-Dimethylpiperidin-1-yl)-2-ethoxy-2-oxoethan-1-imine oxide (7)



Yellow liquid (6.8 mg, 15% yield). **^{1}H NMR** (500 MHz, $CDCl_3$): δ 7.16 (s, 1H), 4.29-4.24 (m, 2H), 3.11-3.03 (m, 2H), 1.77-1.72 (m, 2H), 1.37-1.29 (m, 7H), 1.02 (d, J = 6.0 Hz, 6H); **^{13}C NMR** (126 MHz, $CDCl_3$): δ 160.5, 122.2, 61.1, 56.3, 33.4, 23.5, 19.4, 14.1; **HRMS** (ESI): calculated for $C_{11}H_{20}N_2O_3Na$ $[M+Na]^+$: 251.1366, found: 251.1367.

9. X-ray structure of the products

9.1 X-ray structure of 3a

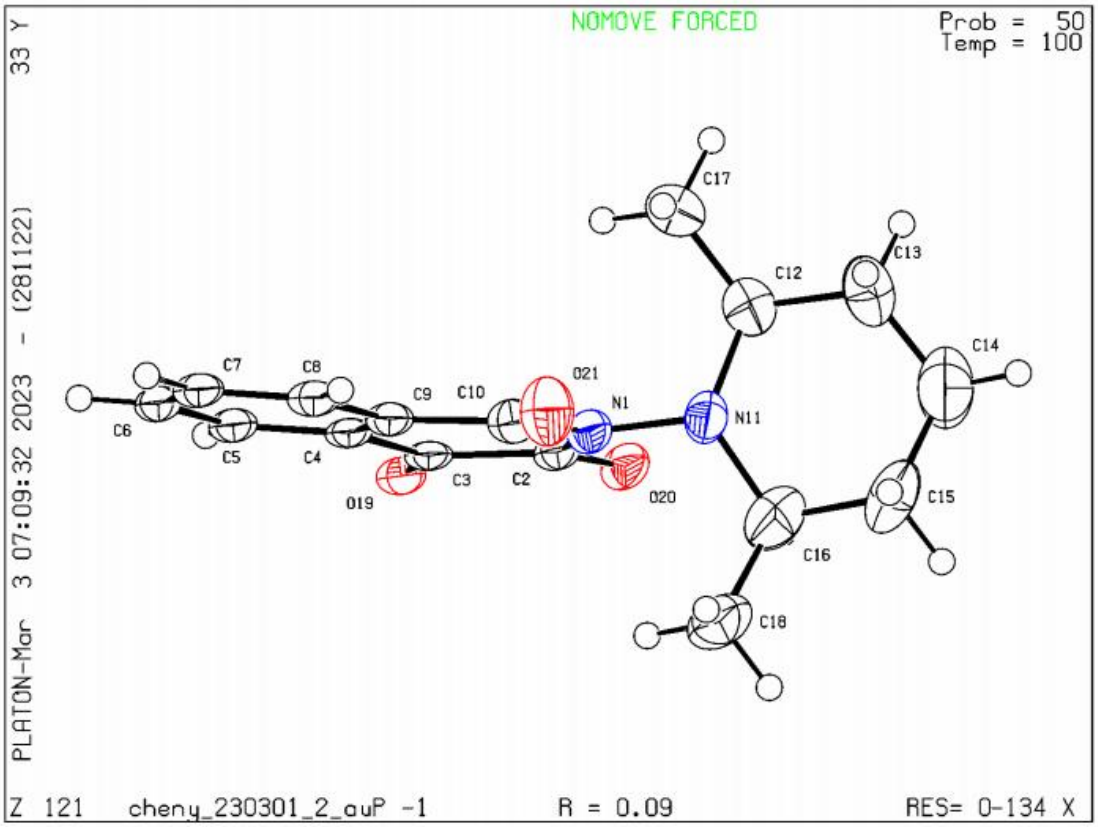
The structure of **3a** was determined by single crystal X-ray analysis (ellipsoid contour at 50% probability). **CCDC 2289572** contains the supplementary crystallographic data for this structure. These data can be obtained free of charge from The Cambridge Crystallographic Data Centre.

Experimental

Single crystals of **3a** ($C_{16}H_{18}N_2O_3$) were grown by slow evaporation in petroleum ether/CH_2Cl_2 under an air atmosphere. A suitable crystal was selected and mounted on a XtaLAB Synergy R, DW system, HyPix diffractometer. The crystal was kept at 100.00(10) K during data collection. Using Olex2, the structure was solved with the ShelXT structure solution program using Intrinsic Phasing and refined with the ShelXL refinement package using Least Squares minimisation.

Crystal structure determination of 3a

Crystal Data for $C_{16}H_{18}N_2O_3$ (M =286.32 g/mol): triclinic, space group P-1 (no. 2), a = 7.2046(3) Å, b = 7.9726(4) Å, c = 14.0906(6) Å, α = 94.512(4)°, β = 100.887(4)°, γ = 112.127(4)°, V = 726.20(6) Å^3, Z = 2, T = 100.00(10) K, μ(Cu Kα) = 0.746 mm^{-1}, *Dcalc* = 1.309 g/cm^3, 7556 reflections measured (6.476° ≤ 2Θ ≤ 150.518°), 2855 unique (R_{int} = 0.0287, R_{sigma} = 0.0361) which were used in all calculations. The final R_1 was 0.0850 (I > 2σ(I)) and wR_2 was 0.2466 (all data).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C3
C2
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C16
C18
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RES= 0-134 X

9.2 X-ray structure of 4a

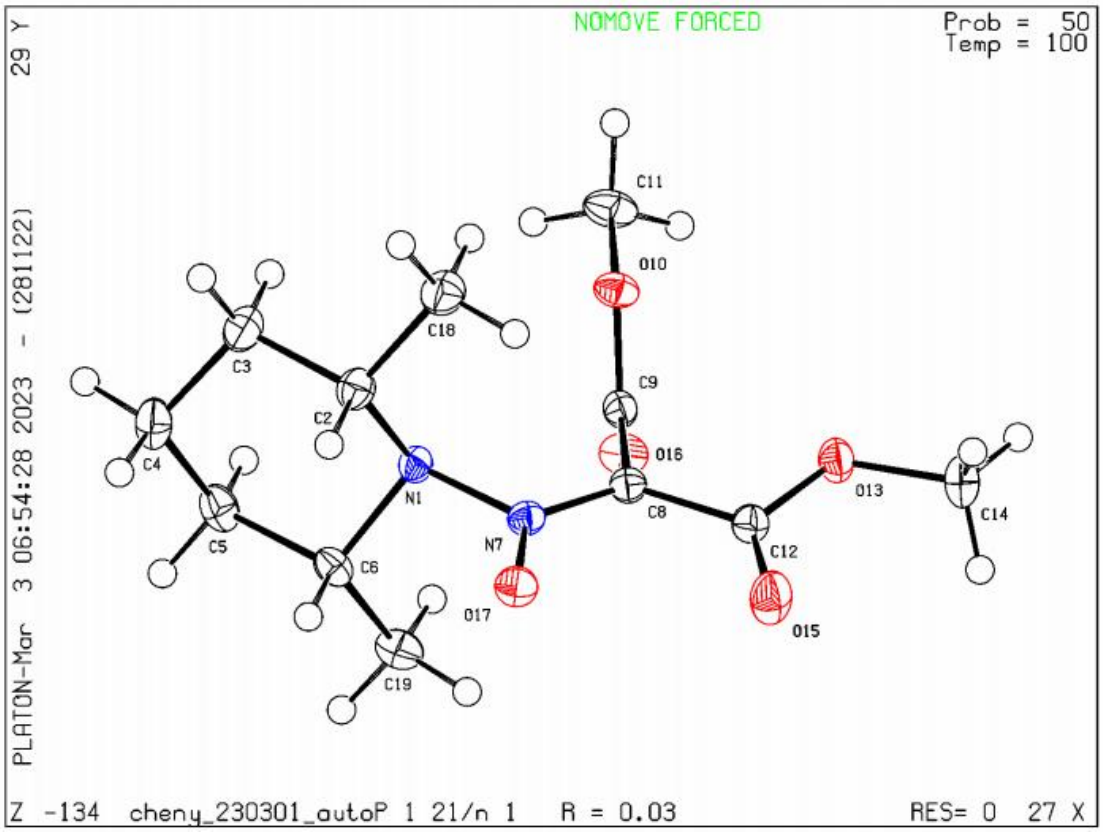
The structure of **4a** was determined by single crystal X-ray analysis (ellipsoid contour at 50% probability). **CCDC 2290196** contains the supplementary crystallographic data for this structure. These data can be obtained free of charge from The Cambridge Crystallographic Data Centre.

Experimental

Single crystals of **4a** ($C_{12}H_{20}N_2O_5$) were grown by slow evaporation in petroleum ether/CH_2Cl_2 under an air atmosphere. A suitable crystal was selected and mounted on a XtaLAB Synergy R, DW system, HyPix diffractometer. The crystal was kept at 100.00(10) K during data collection. Using Olex2, the structure was solved with the ShelXT structure solution program using Intrinsic Phasing and refined with the ShelXL refinement package using Least Squares minimisation.

Crystal structure determination of 4a

Crystal Data for $C_{12}H_{20}N_2O_5$ (M =272.30 g/mol): monoclinic, space group $P2_1/n$ (no. 14), a = 7.78740(10) Å, b = 21.7474(2) Å, c = 8.41450(10) Å, β = 100.6710(10)°, V = 1400.40(3) Å^3, Z = 4, T = 100.00(10) K, μ(Cu Kα) = 0.845 mm^{-1}, *Dcalc* = 1.292 g/cm^3, 28400 reflections measured (8.132° ≤ 2Θ ≤ 157.086°), 2992 unique (R_{int} = 0.0446, R_{sigma} = 0.0213) which were used in all calculations. The final R_1 was 0.0331 (I > 2σ(I)) and wR_2 was 0.0872 (all data).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O17
O15
C19
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RES= 0 27 X

10. References

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[4] P. B. Wakchaure, S. Easwar, V. G. Puranik and N. P. Argade, Facile air-oxidation of *N*-homopiperonyl-5,6-dimethoxyhomophthalimide: simple and effificient access to nuevamine, *Tetrahedron.*, 2008, **64**, 1786-1791.

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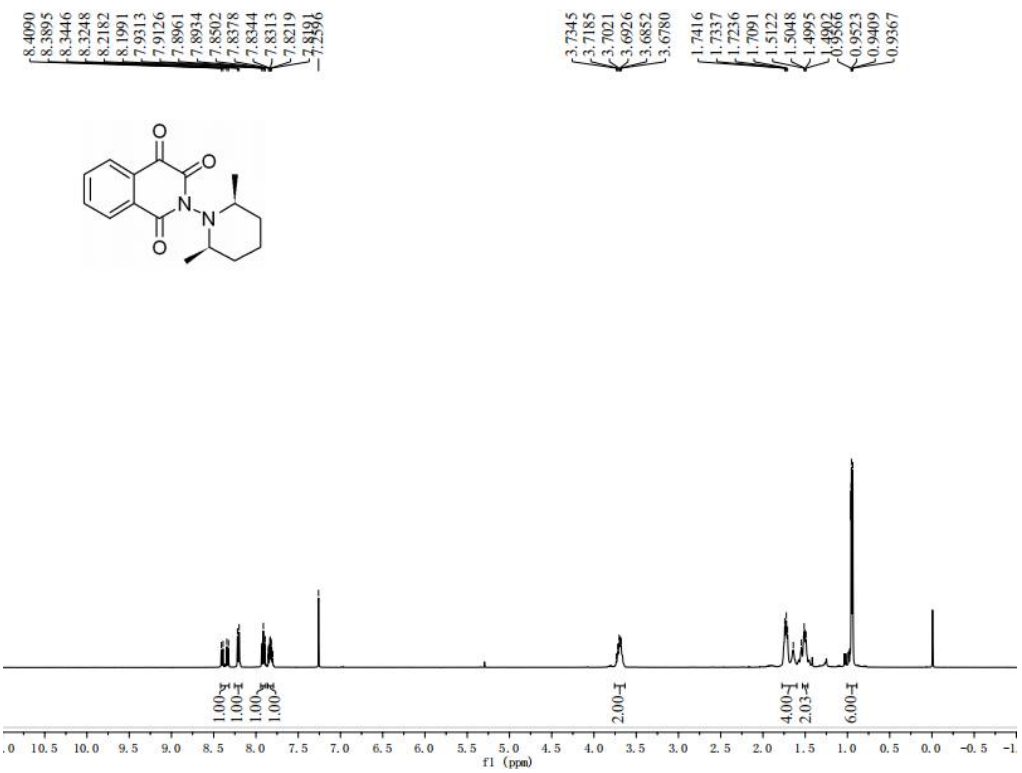
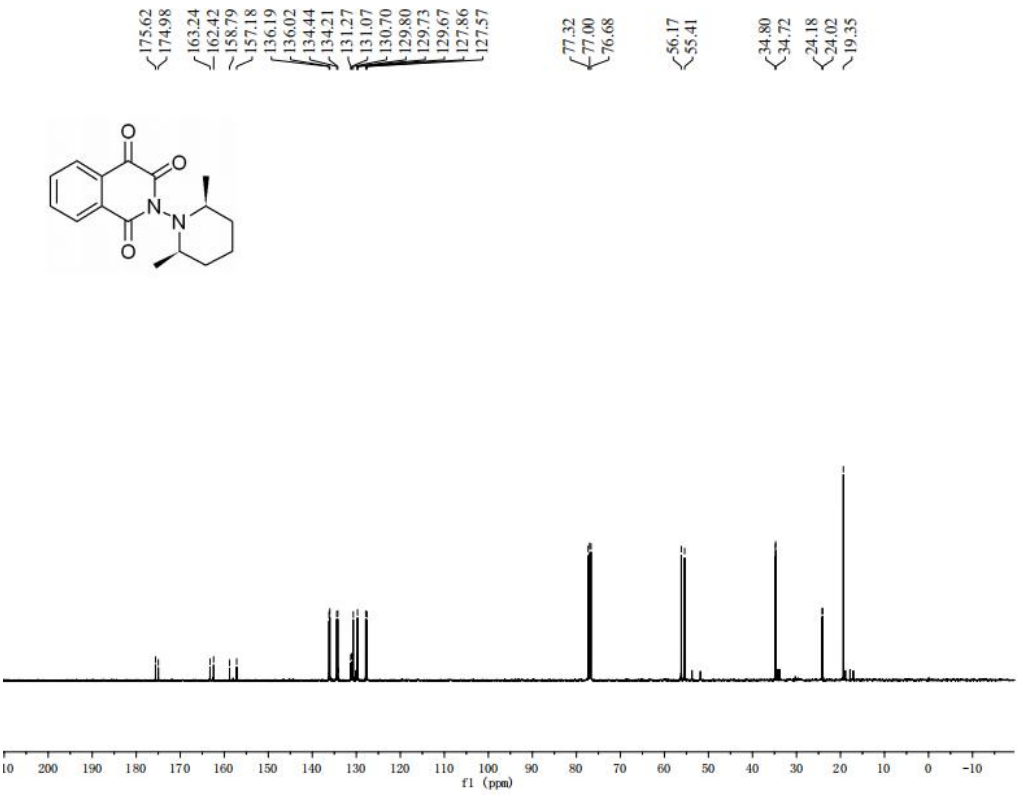
11. NMR spectra of products

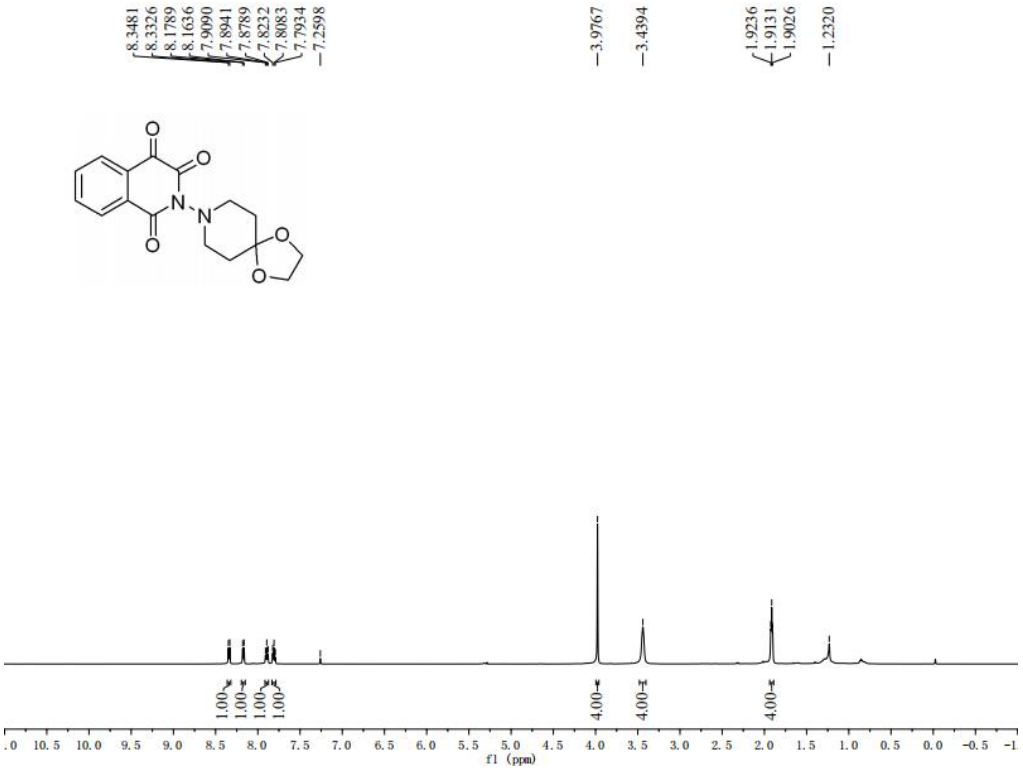
^{1}H NMR (400 MHz) Spectrum of 3a in $CDCl_3$



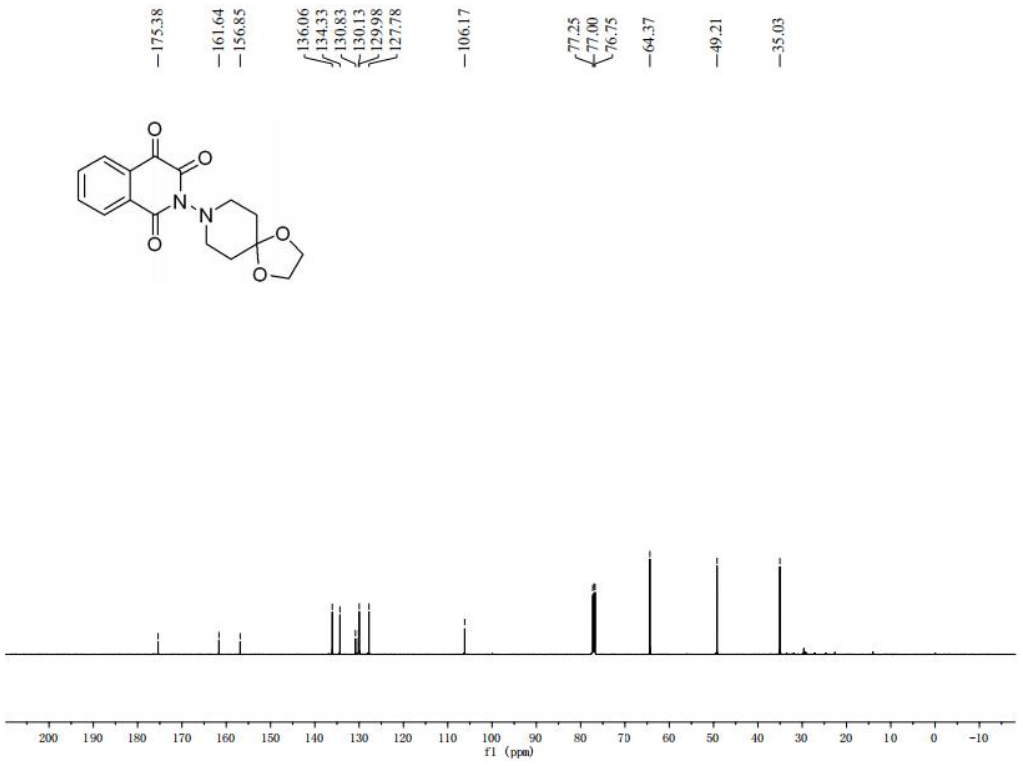
^{13}C NMR (101 MHz) Spectrum of 3a in $CDCl_3$



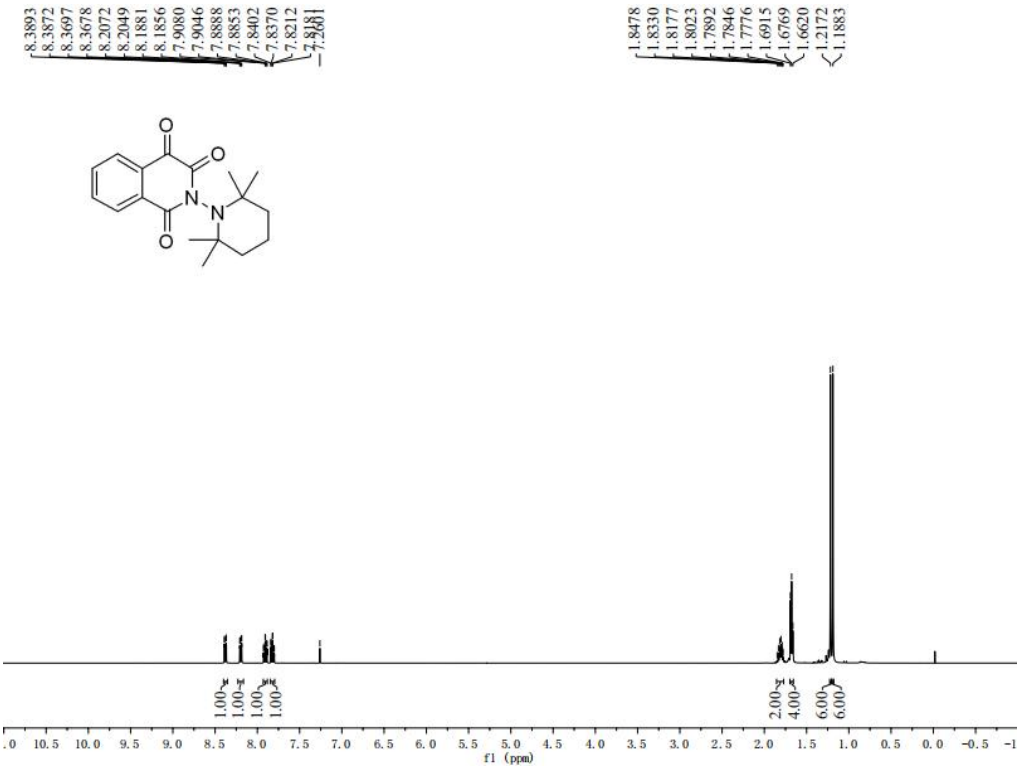
^{1}H NMR (500 MHz) Spectrum of 3b in $CDCl_3$



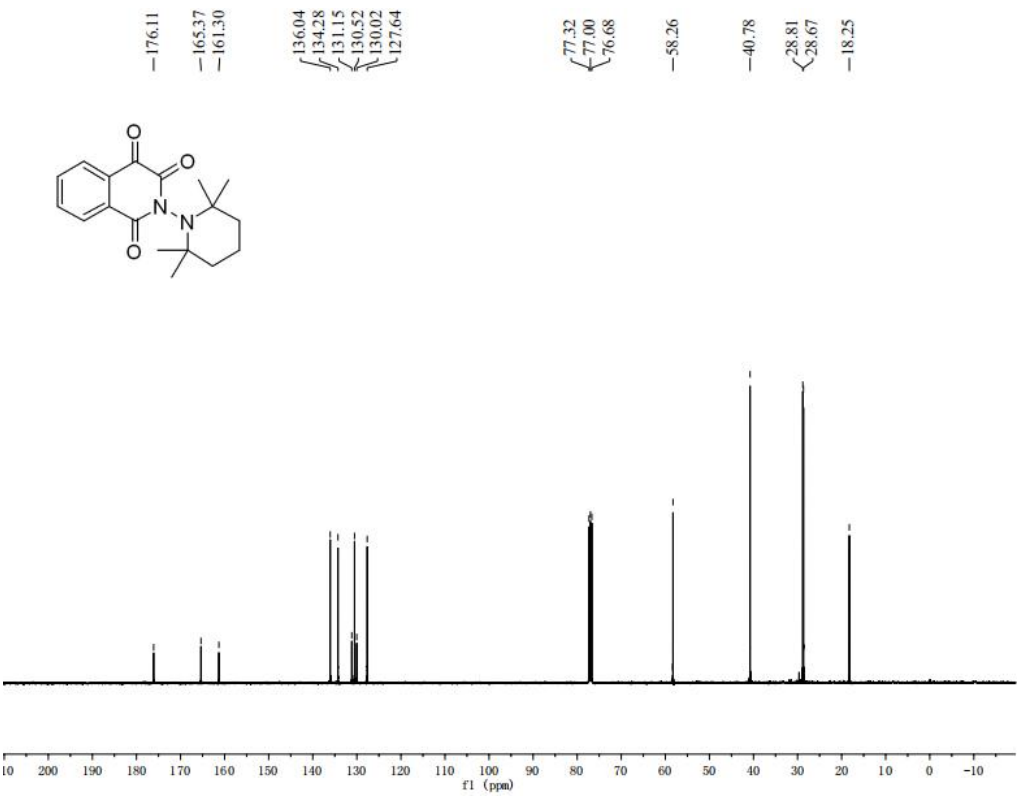
^{13}C NMR (126 MHz) Spectrum of 3b in $CDCl_3$



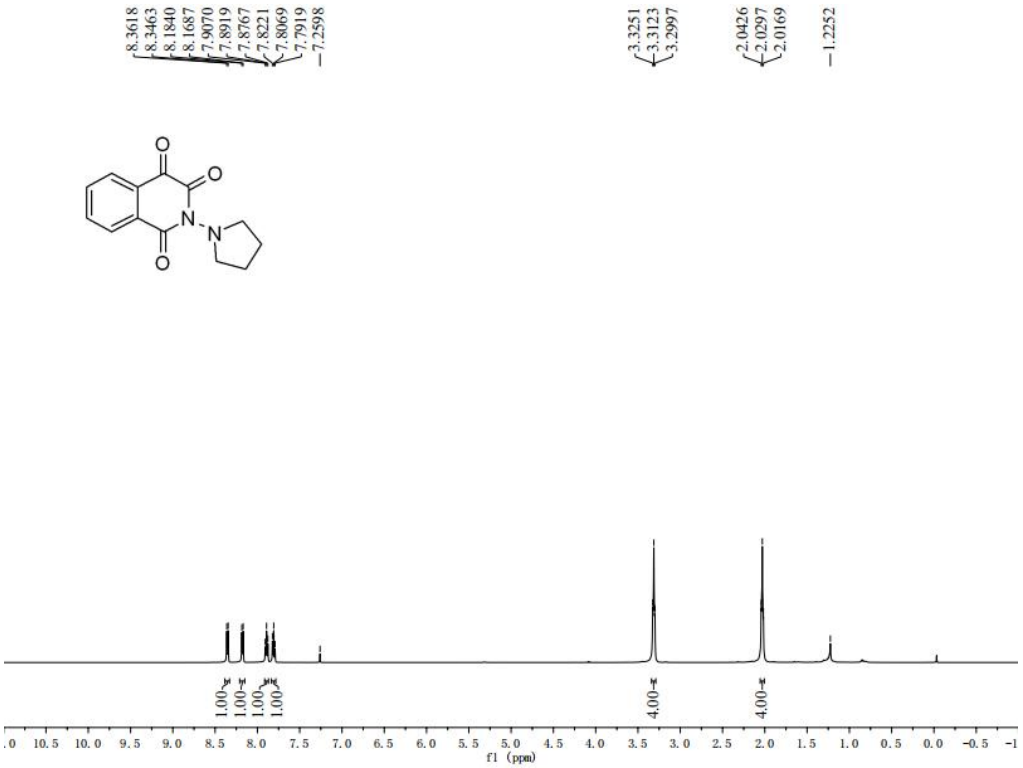
^{1}H NMR (400 MHz) Spectrum of 3c in $CDCl_3$



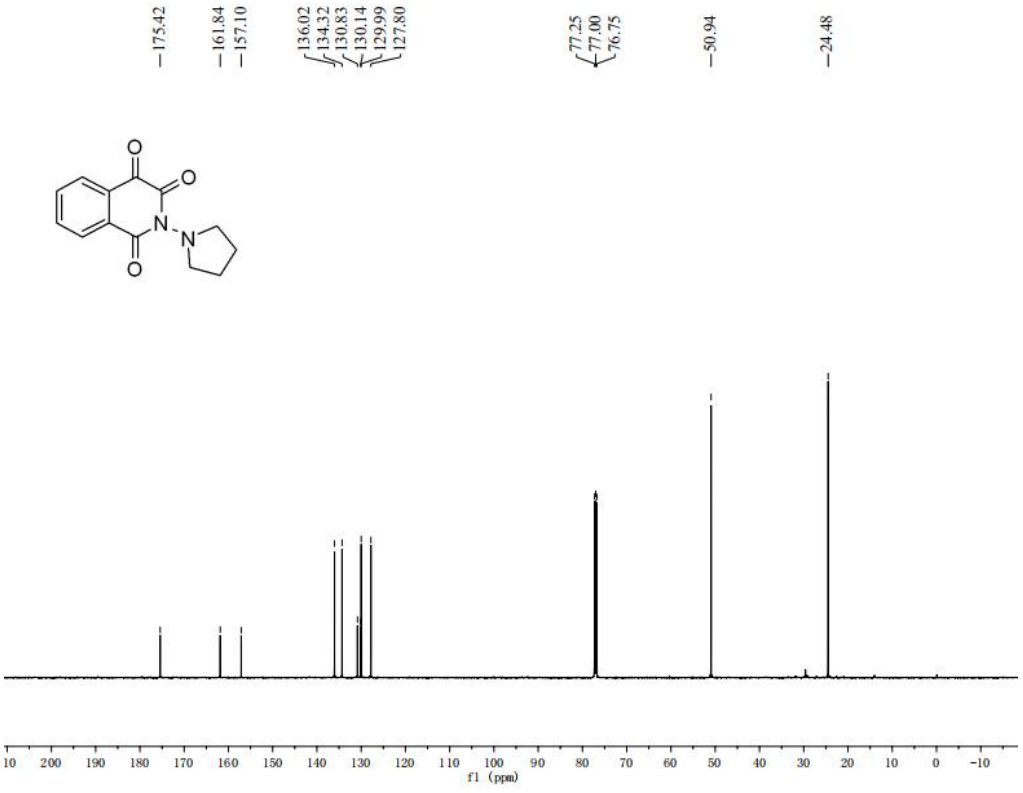
^{13}C NMR (101 MHz) Spectrum of 3c in $CDCl_3$



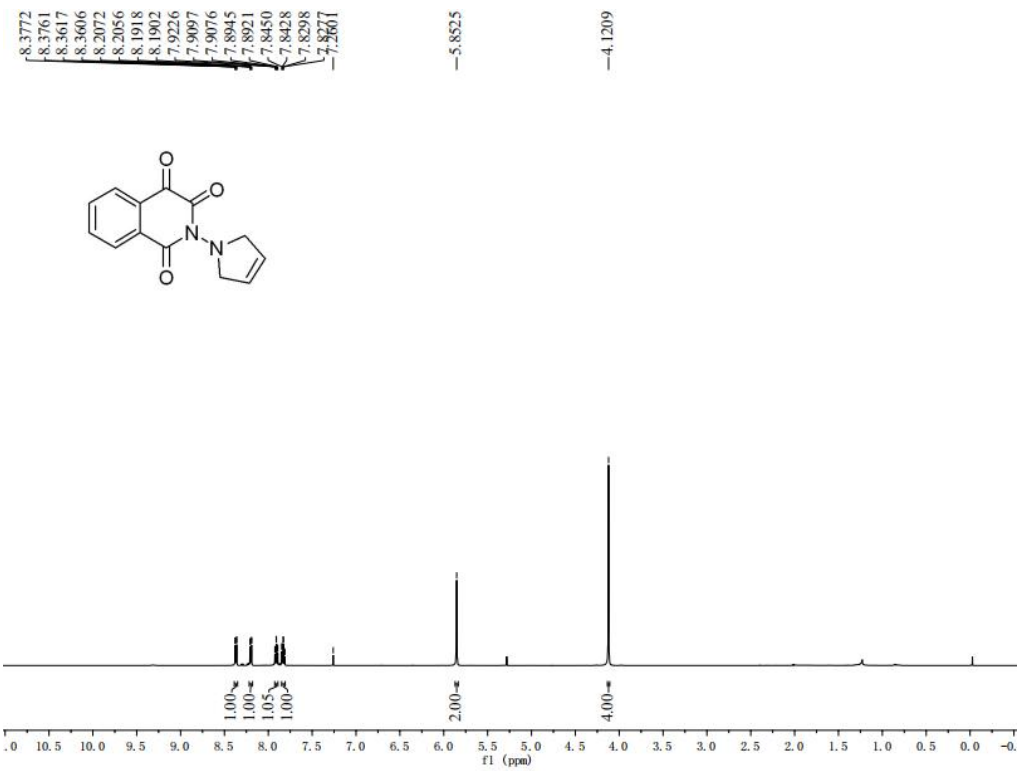
^{1}H NMR (500 MHz) Spectrum of 3e in $CDCl_3$



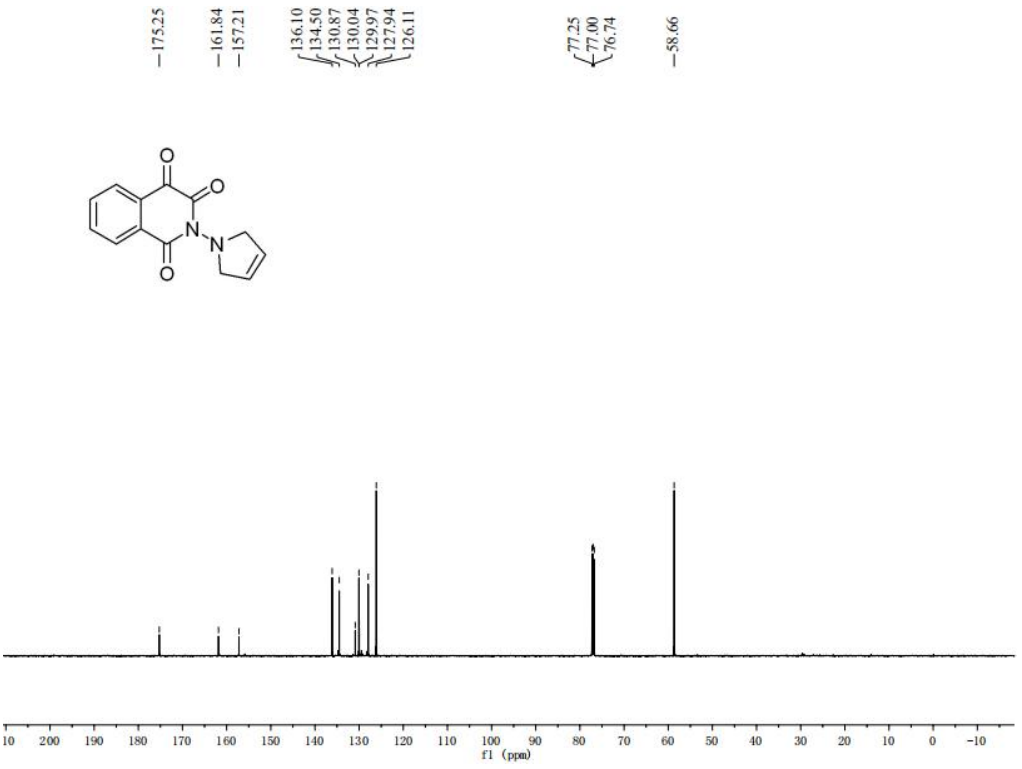
^{13}C NMR (126 MHz) Spectrum of 3e in $CDCl_3$



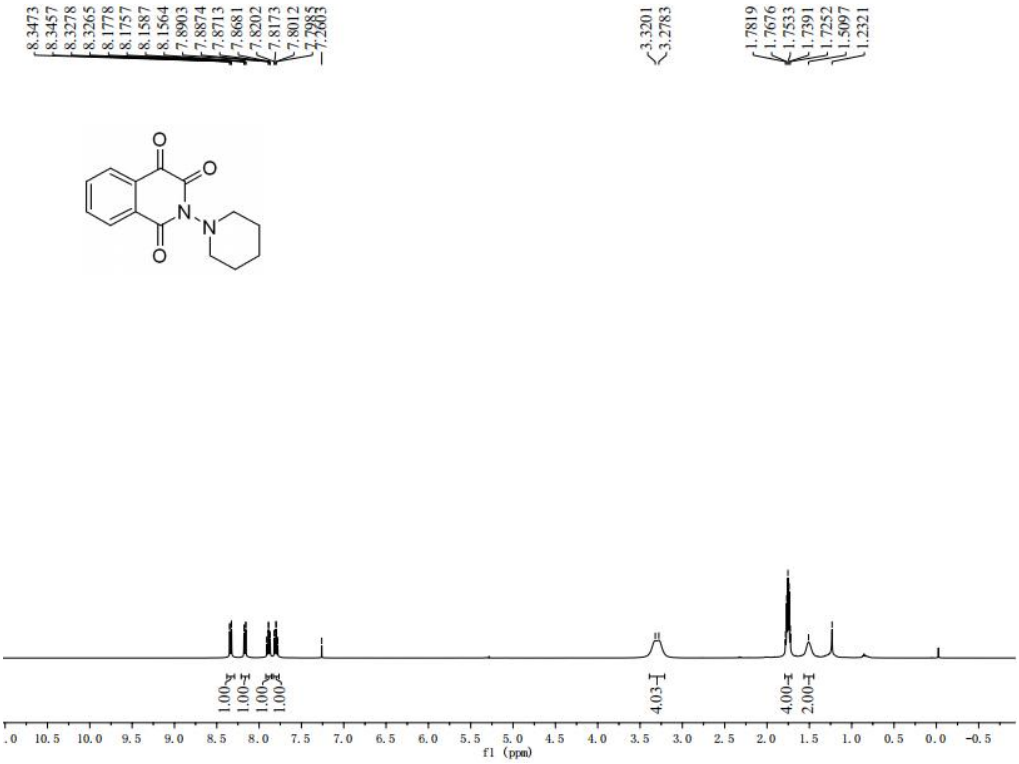
^{1}H NMR (500 MHz) Spectrum of 3f in $CDCl_3$



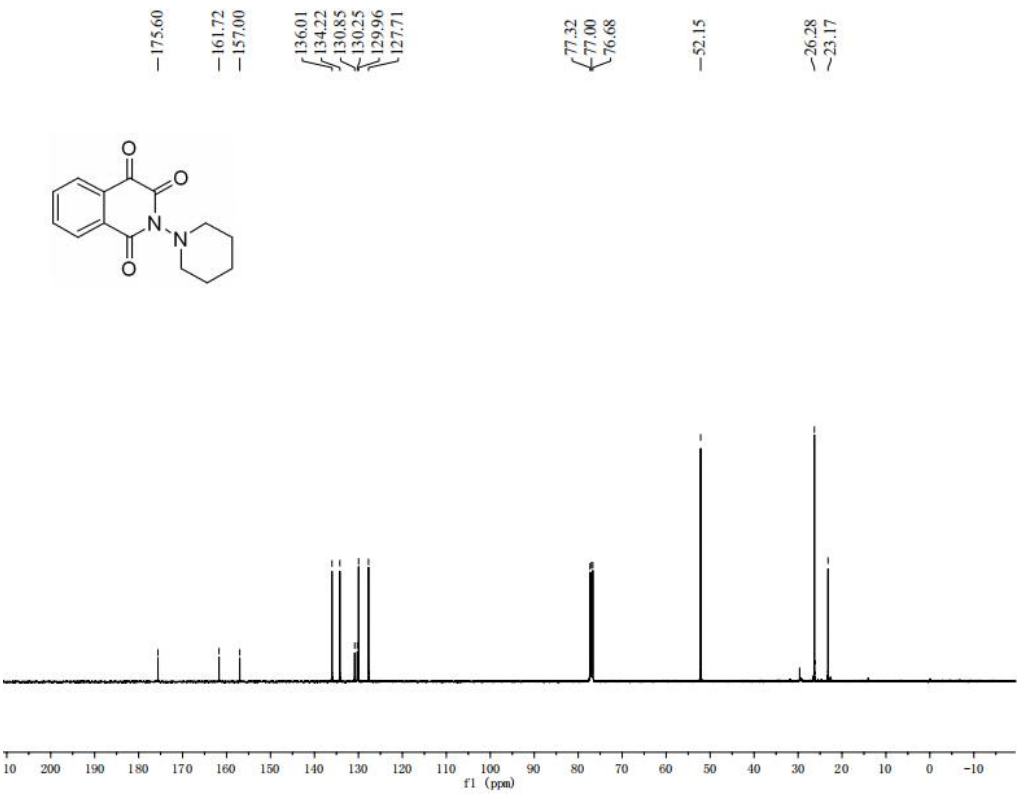
^{13}C NMR (126 MHz) Spectrum of 3f in $CDCl_3$



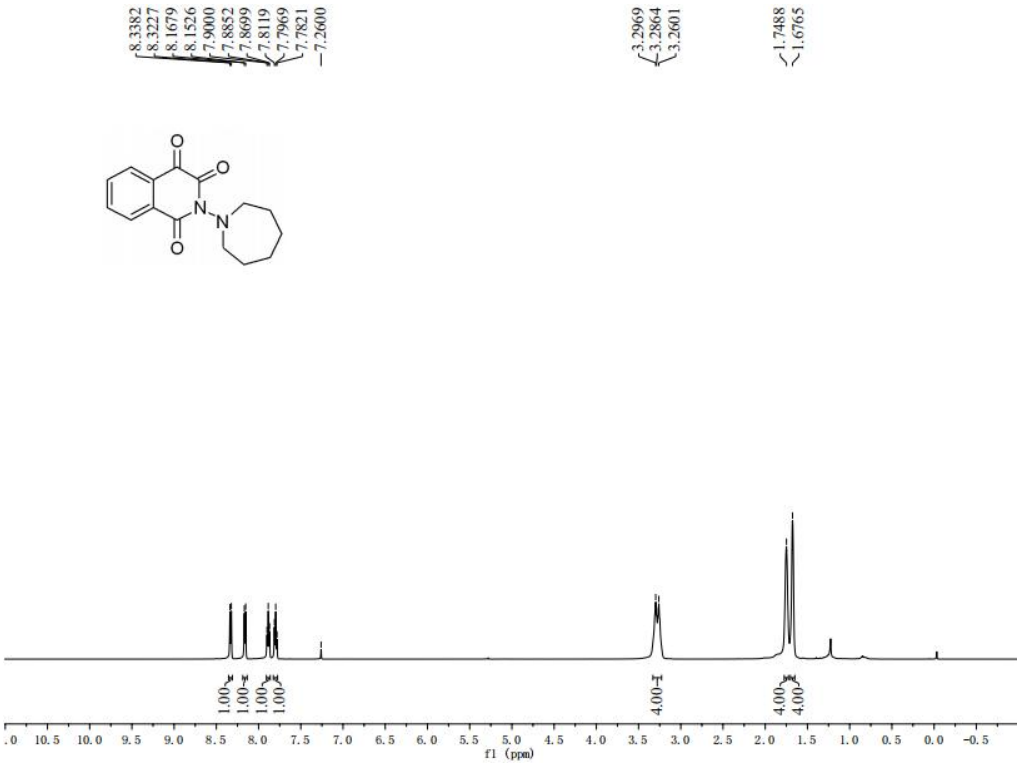
^{1}H NMR (400 MHz) Spectrum of 3g in $CDCl_3$



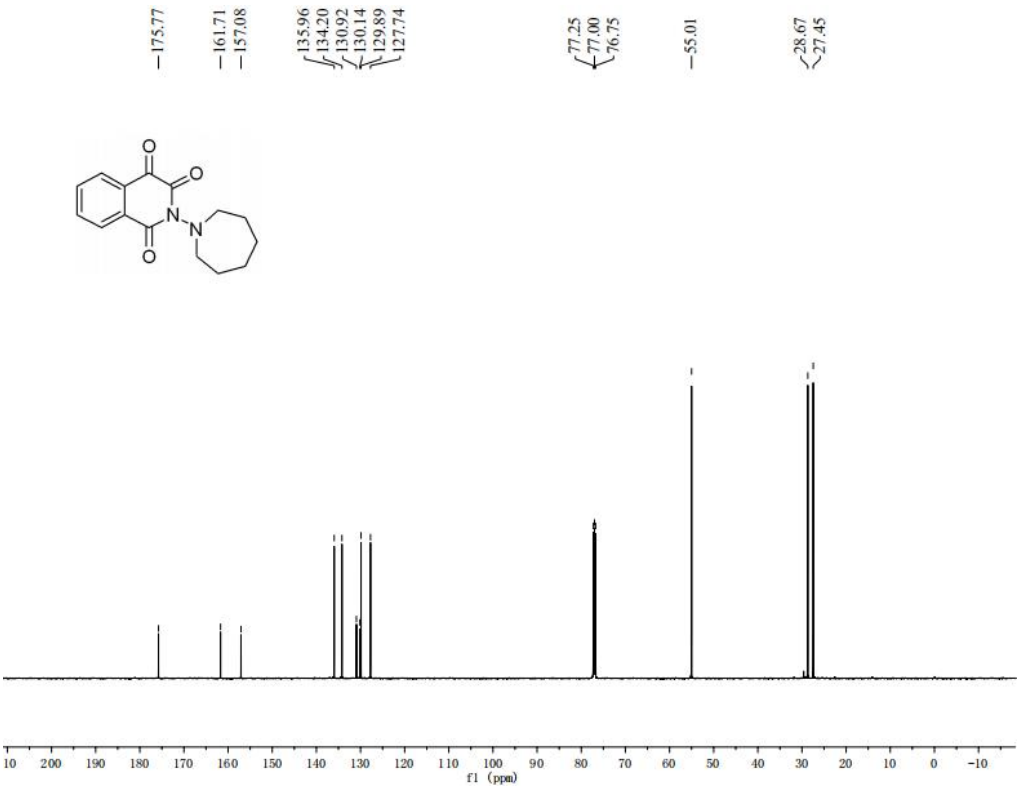
^{13}C NMR (101 MHz) Spectrum of 3g in $CDCl_3$



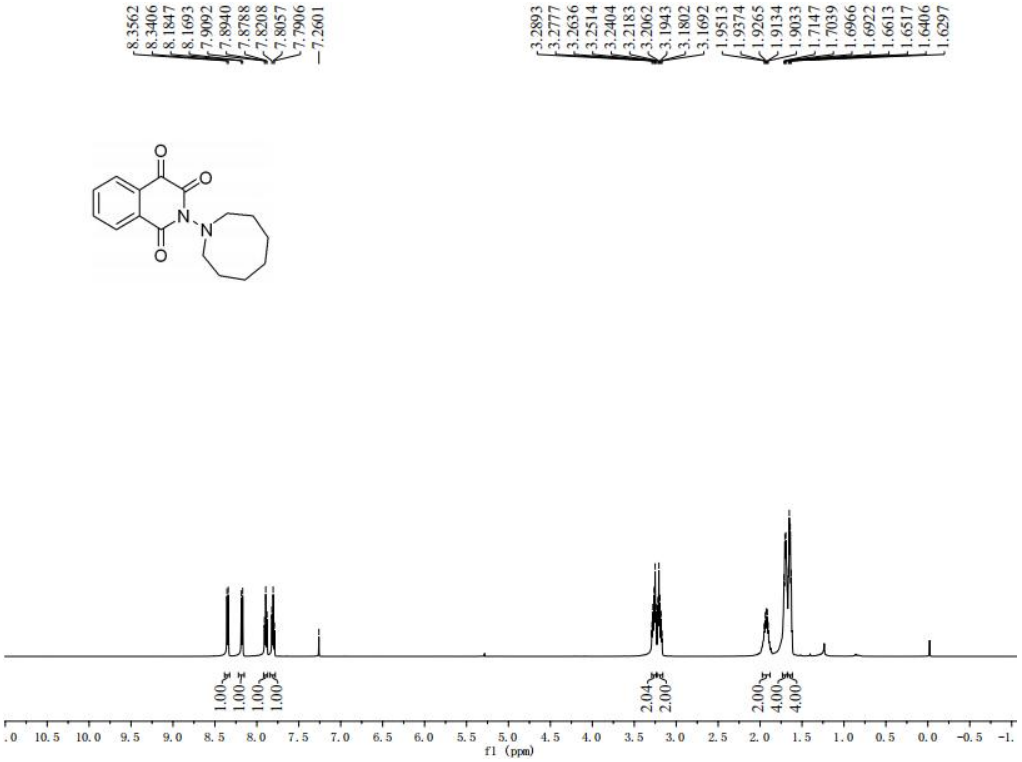
^{1}H NMR (500 MHz) Spectrum of 3h in $CDCl_3$



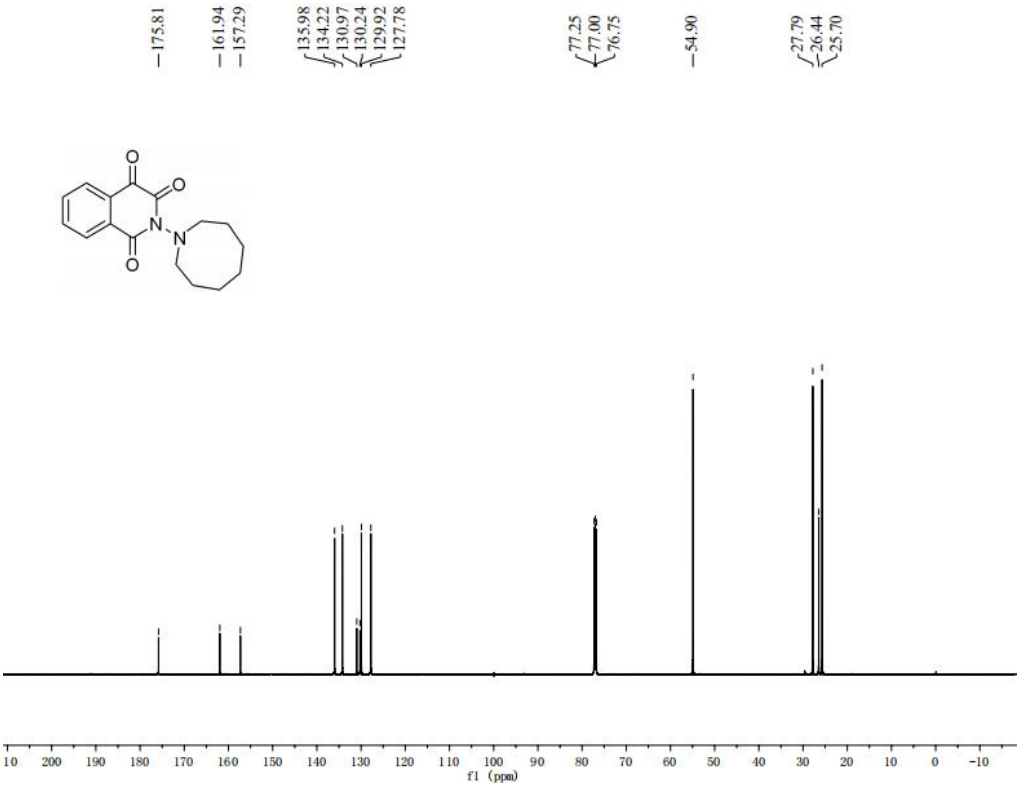
^{13}C NMR (126 MHz) Spectrum of 3h in $CDCl_3$



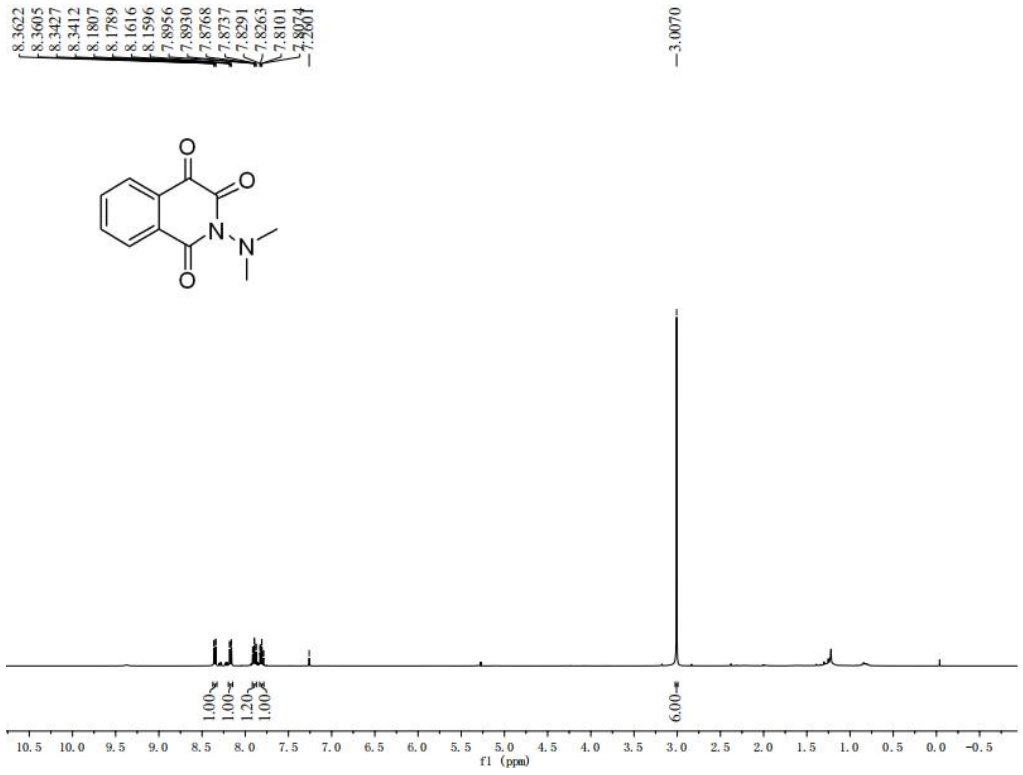
^{1}H NMR (500 MHz) Spectrum of 3i in $CDCl_3$



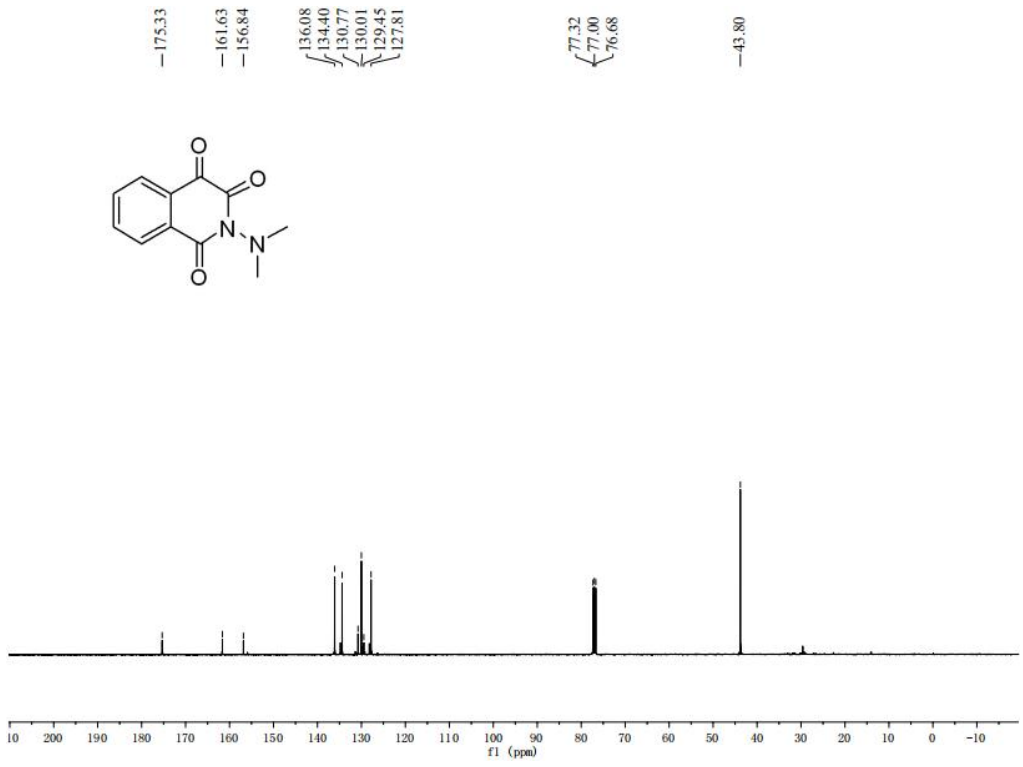
^{13}C NMR (126 MHz) Spectrum of 3i in $CDCl_3$



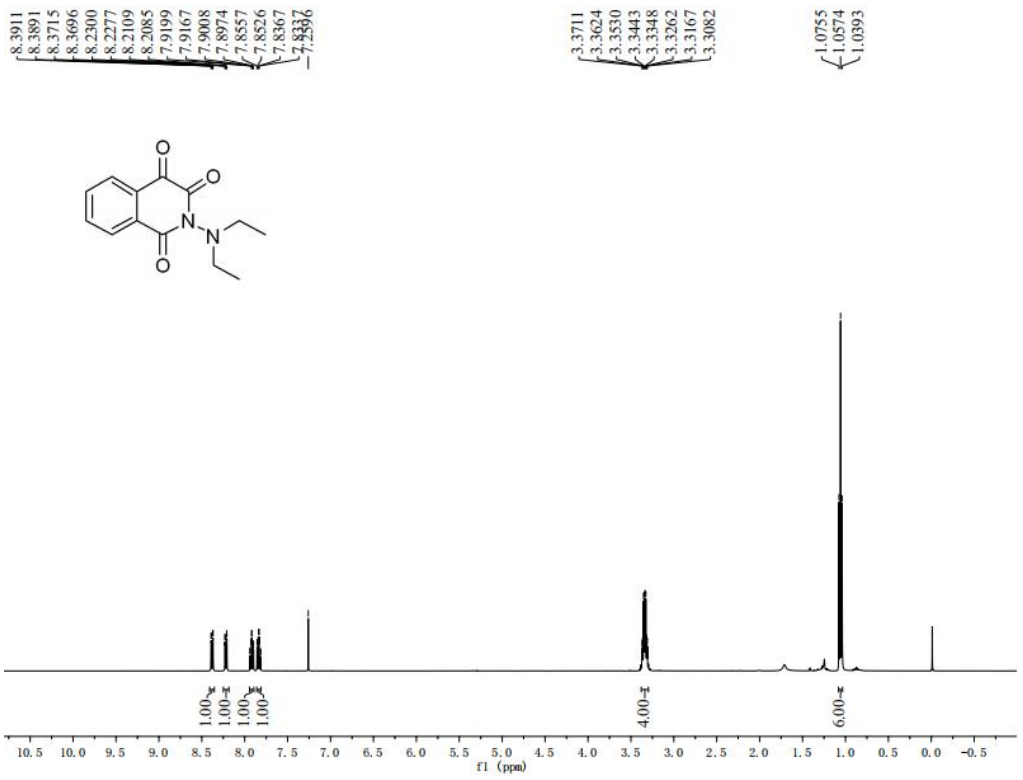
^{1}H NMR (400 MHz) Spectrum of 3j in $CDCl_3$



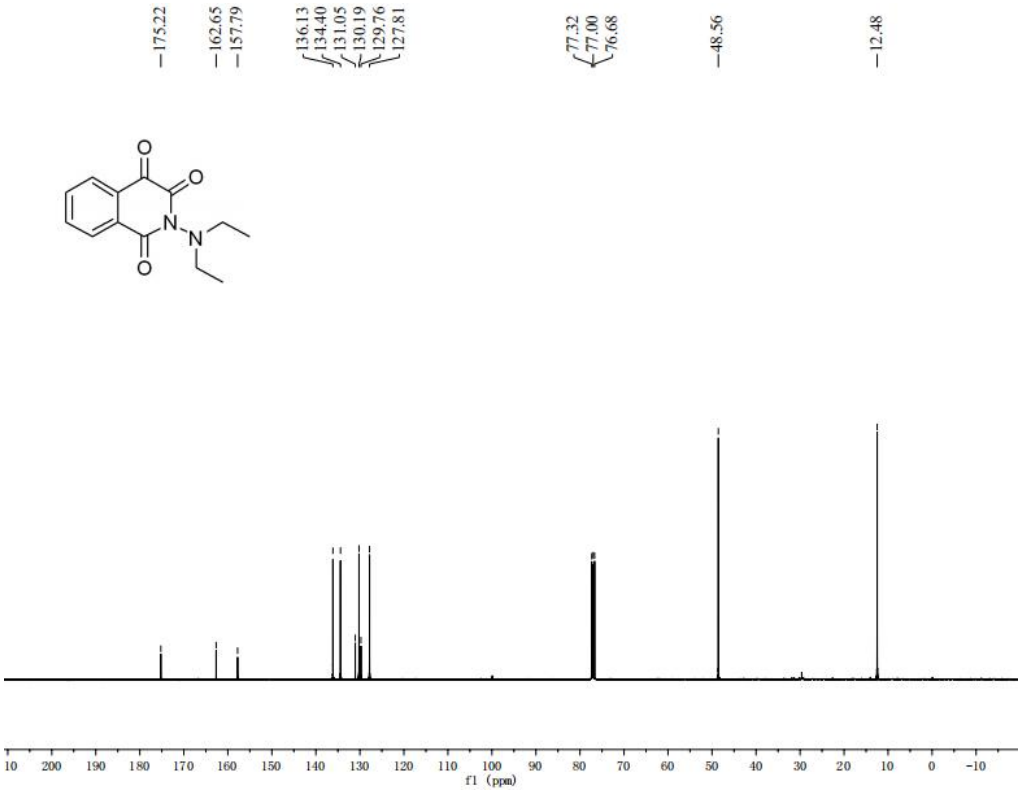
^{13}C NMR (101 MHz) Spectrum of 3j in $CDCl_3$



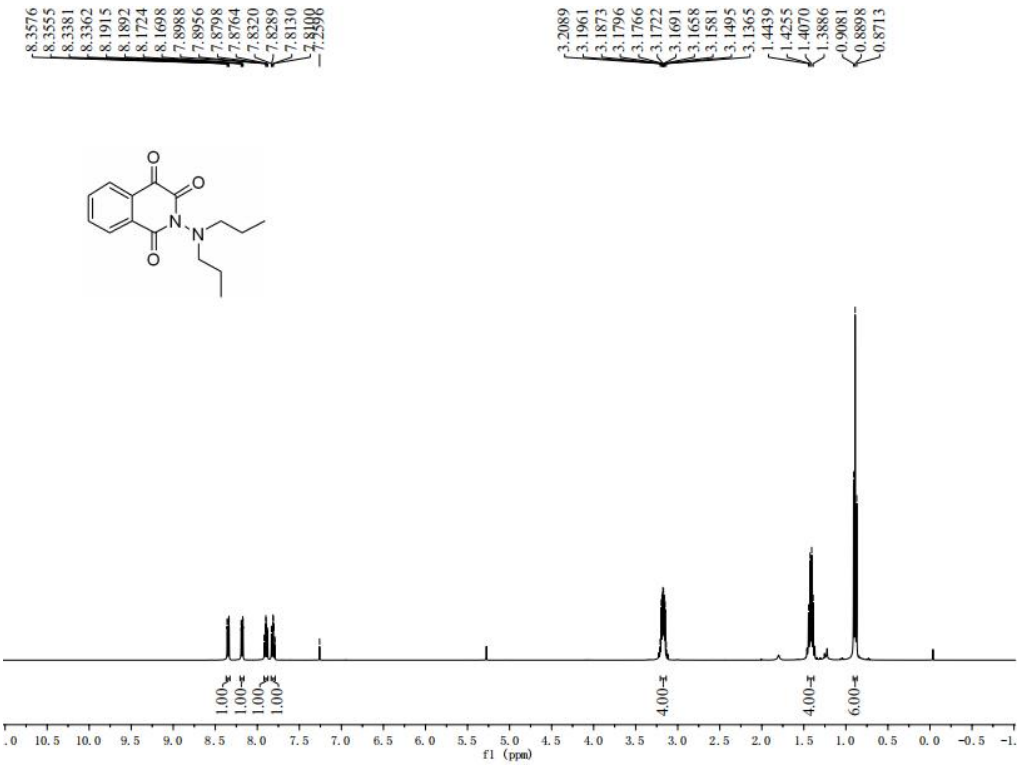
^{1}H NMR (400 MHz) Spectrum of 3k in $CDCl_3$



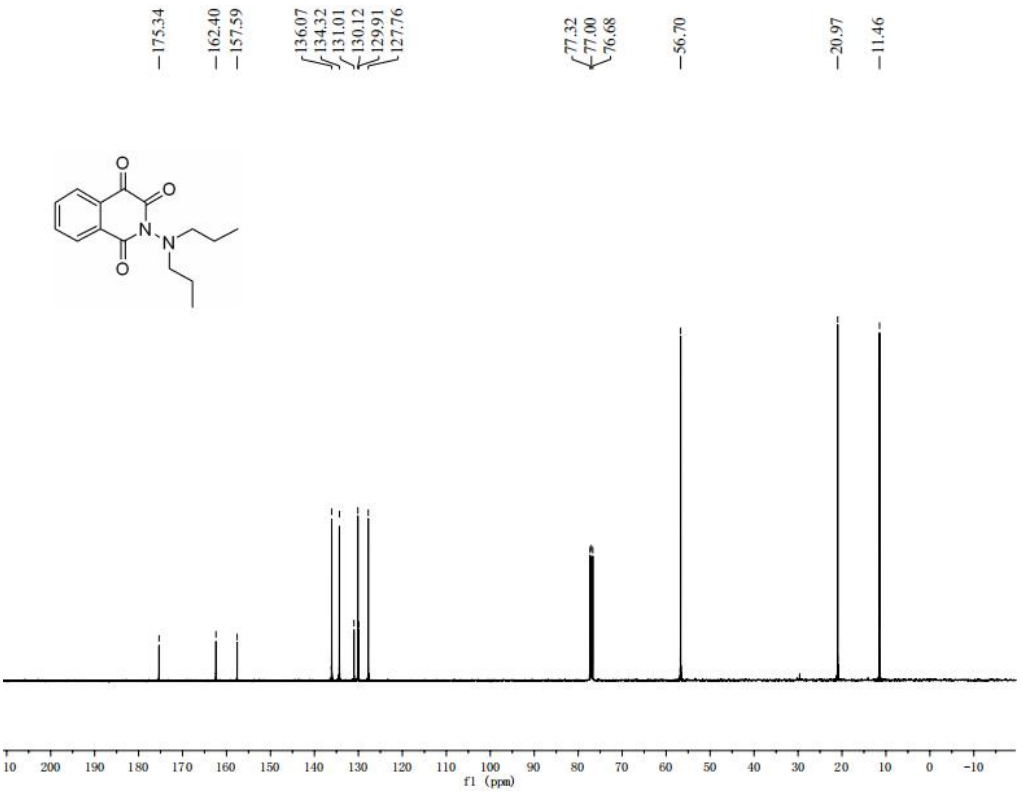
^{13}C NMR (101 MHz) Spectrum of 3k in $CDCl_3$



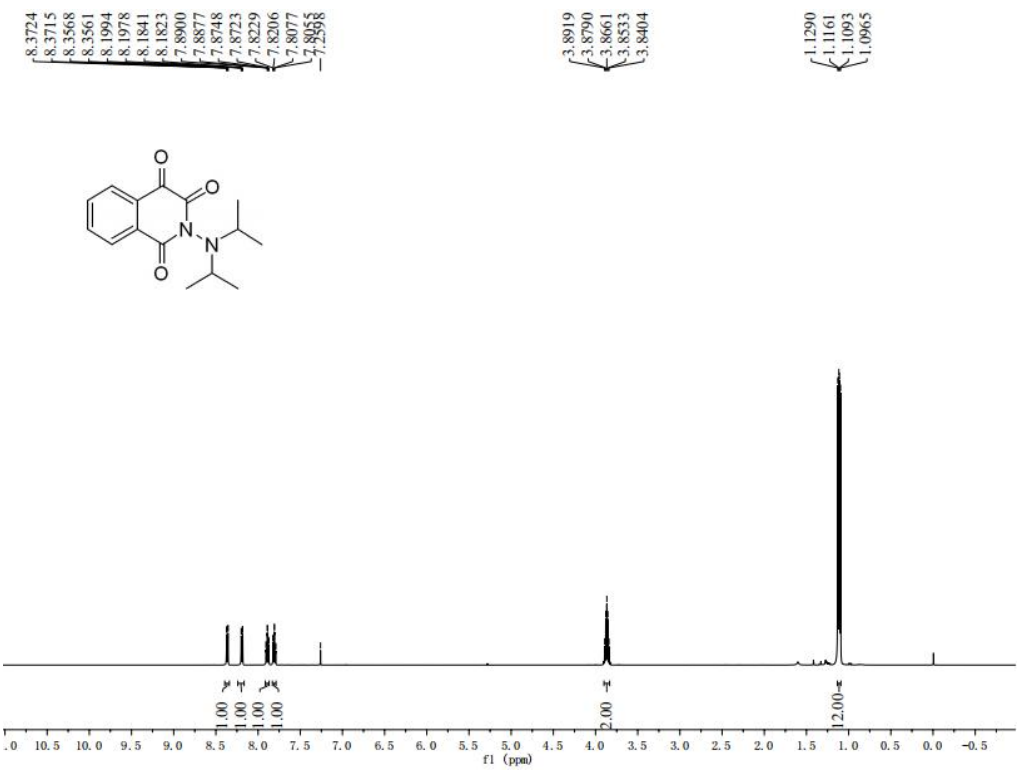
^{1}H NMR (400 MHz) Spectrum of 3l in $CDCl_3$



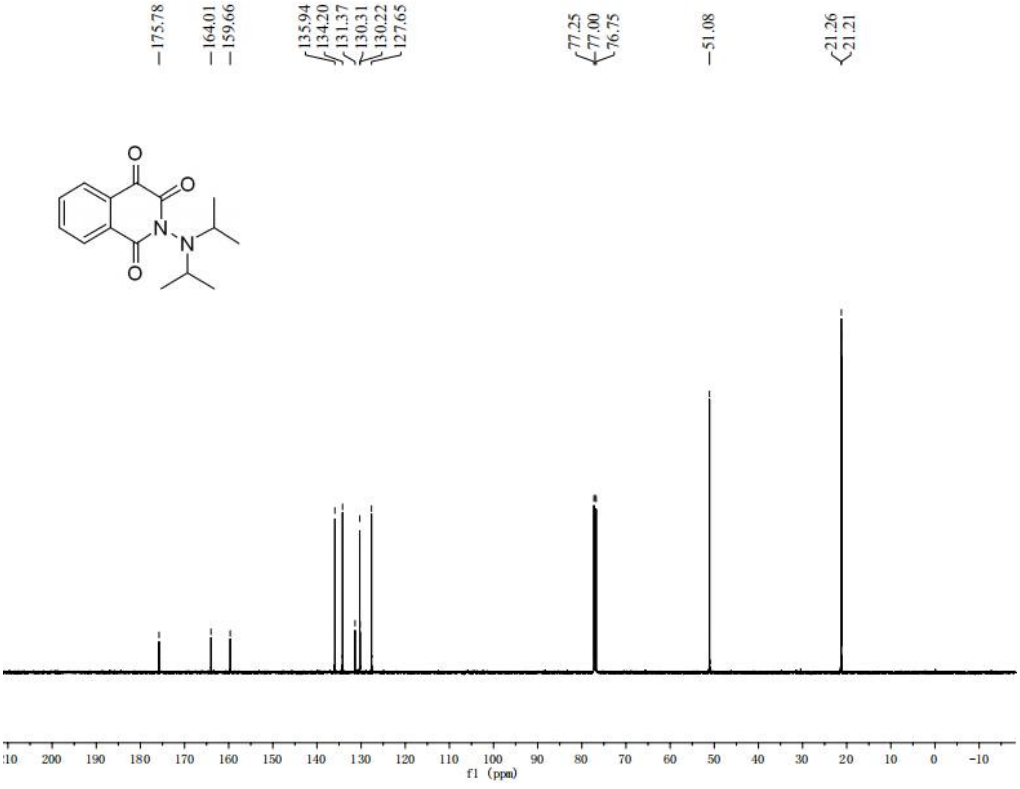
^{13}C NMR (101 MHz) Spectrum of 3l in $CDCl_3$



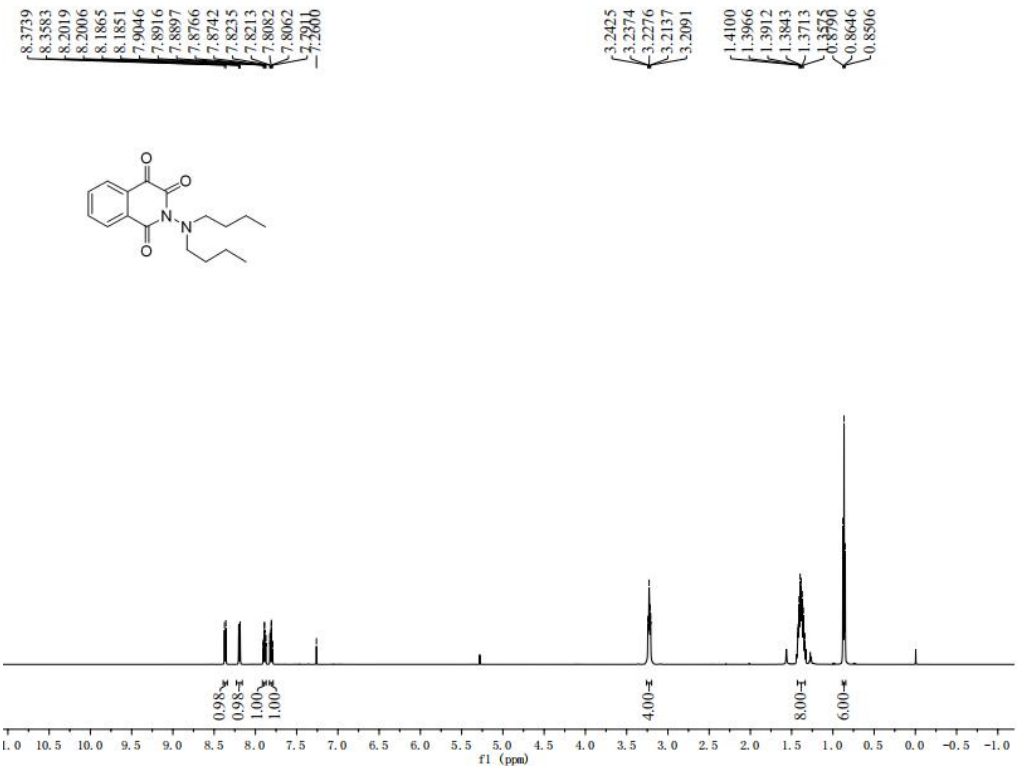
^{1}H NMR (500 MHz) Spectrum of 3m in $CDCl_3$



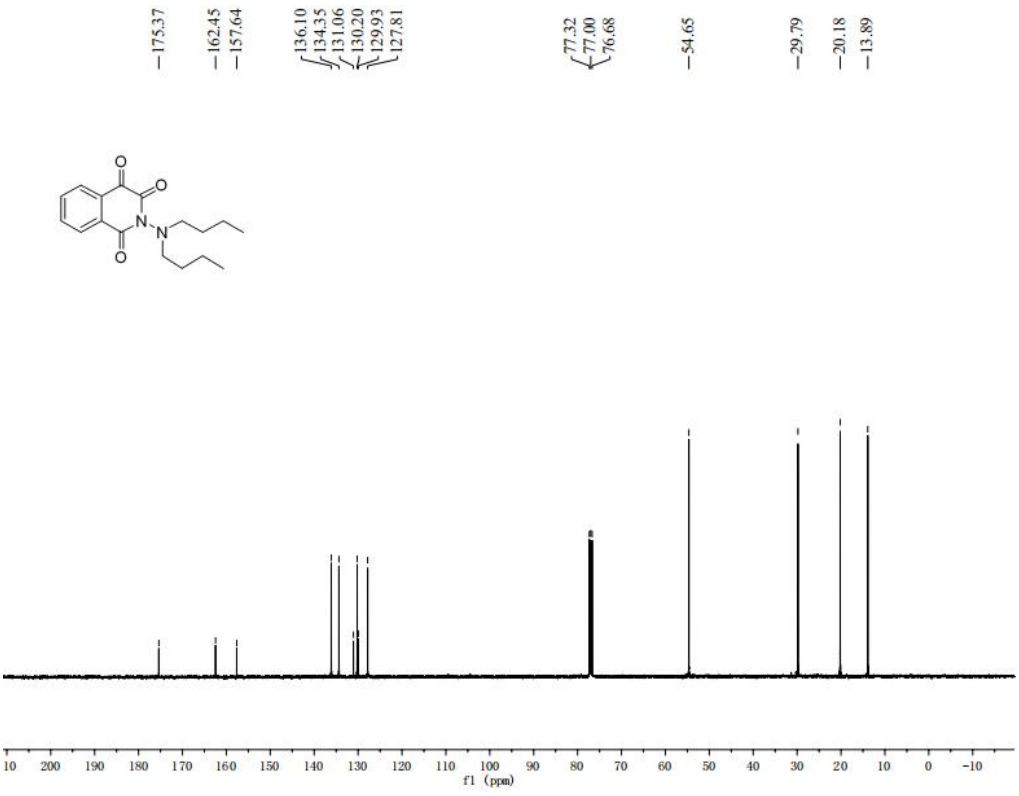
^{13}C NMR (126 MHz) Spectrum of 3m in $CDCl_3$



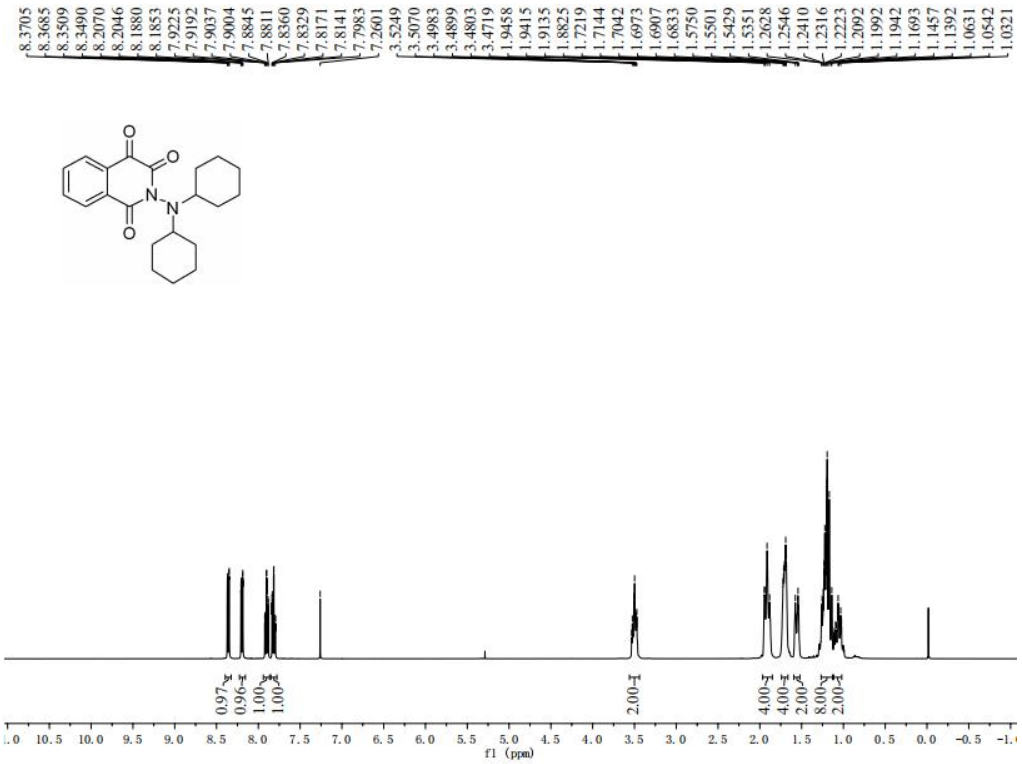
^{1}H NMR (500 MHz) Spectrum of 3n in $CDCl_3$



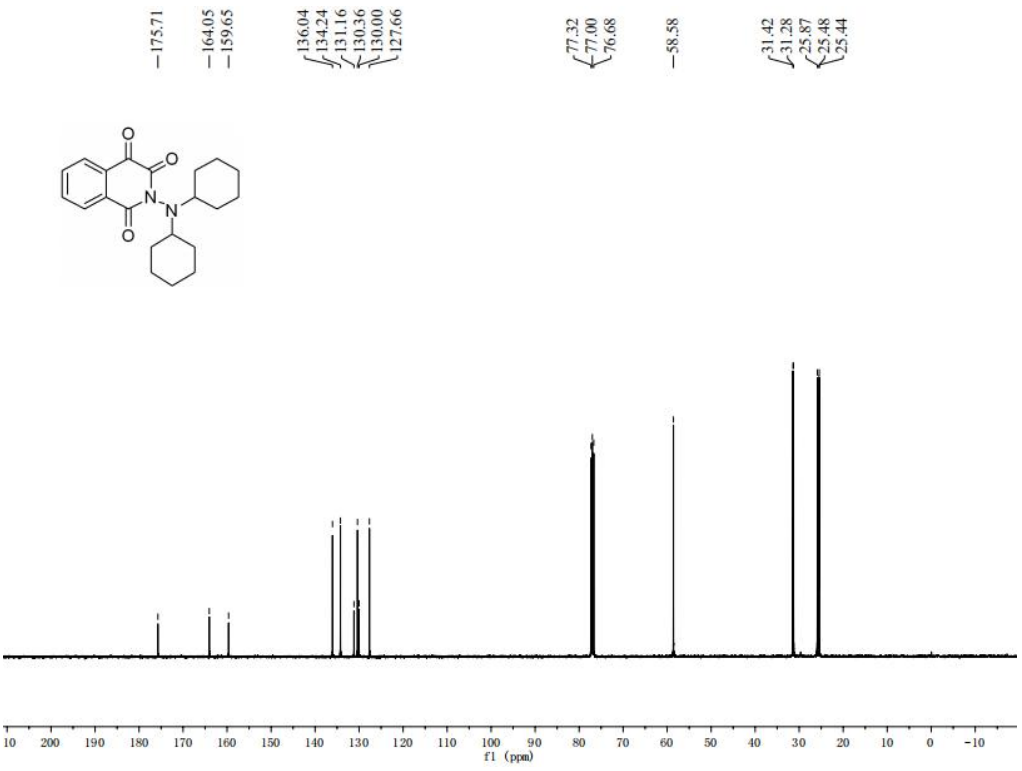
^{13}C NMR (101 MHz) Spectrum of 3n in $CDCl_3$



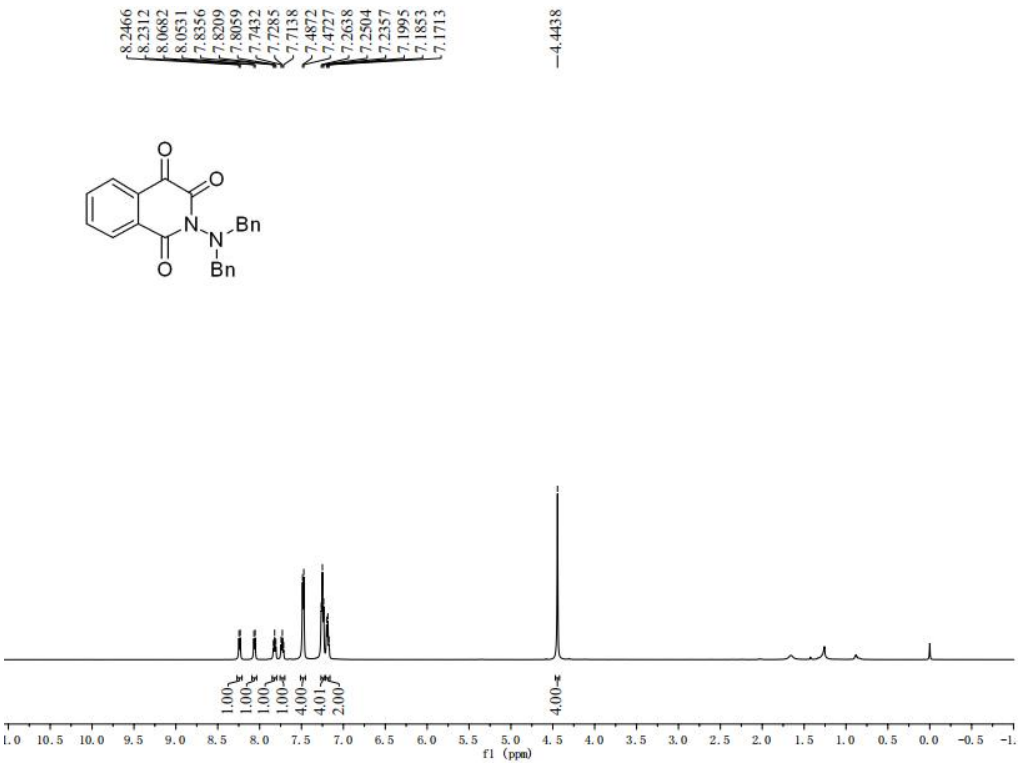
^{1}H NMR (400 MHz) Spectrum of 3o in $CDCl_3$



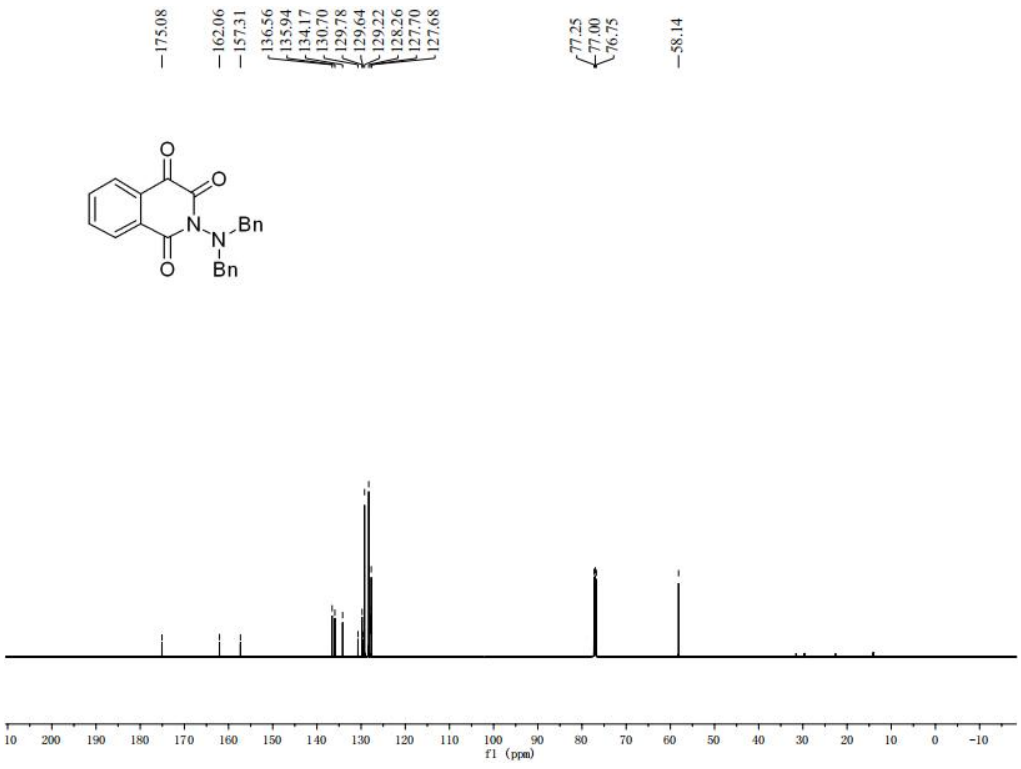
^{13}C NMR (101 MHz) Spectrum of 3o in $CDCl_3$



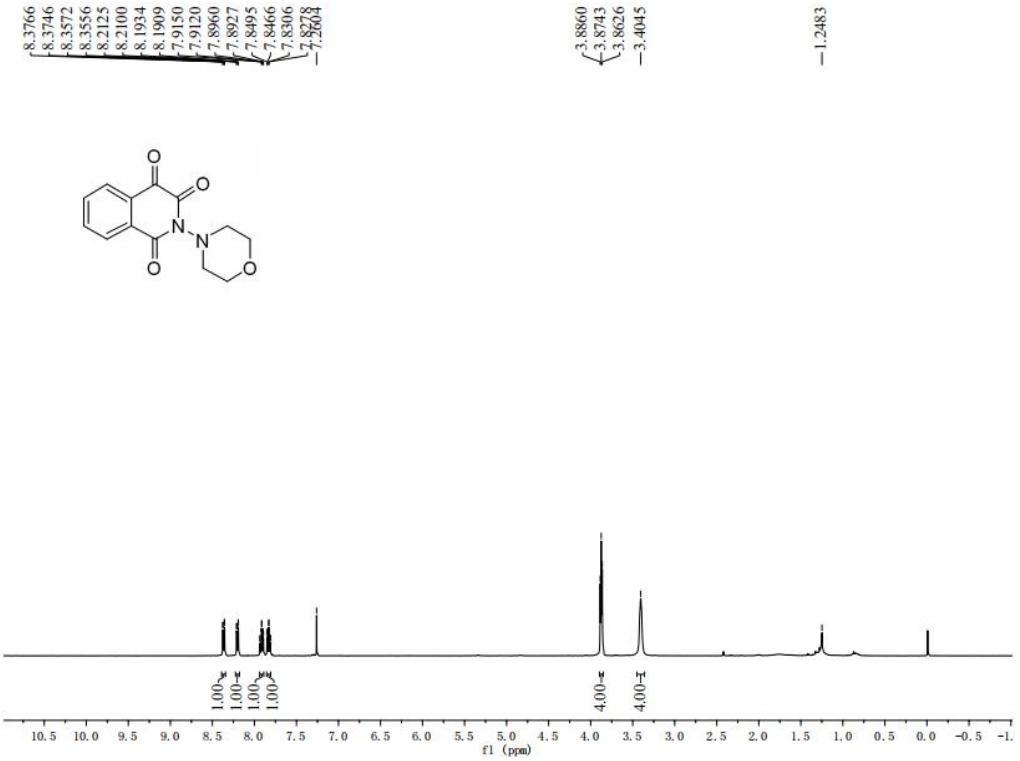
^{1}H NMR (500 MHz) Spectrum of 3p in $CDCl_3$



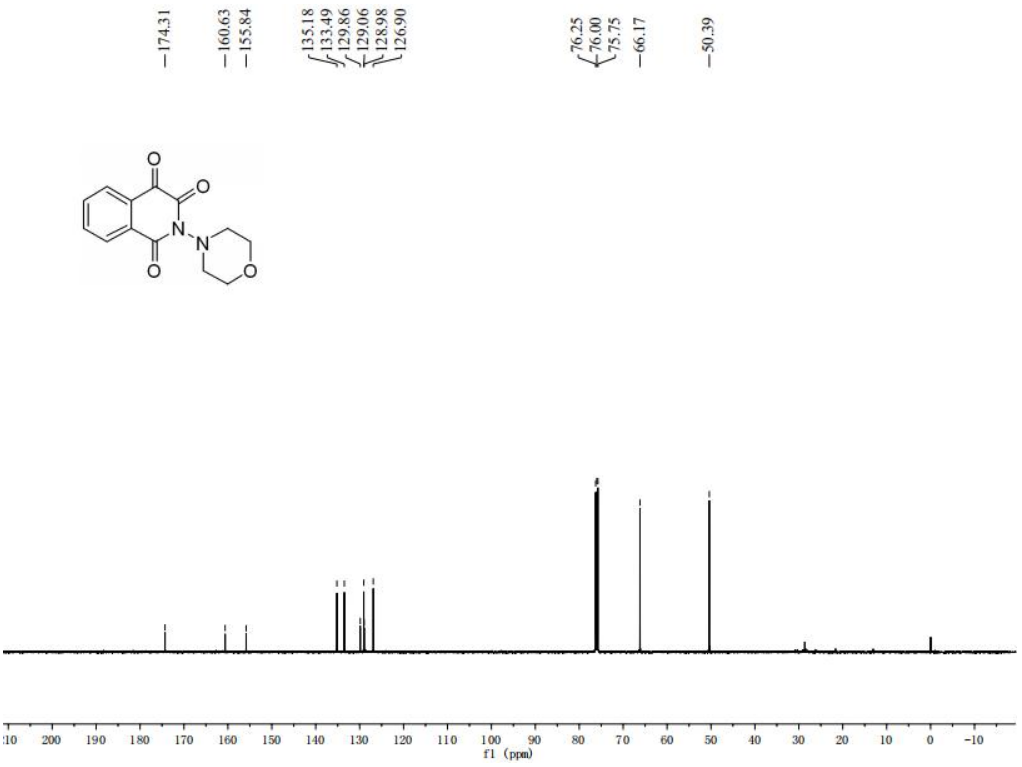
^{13}C NMR (126 MHz) Spectrum of 3p in $CDCl_3$



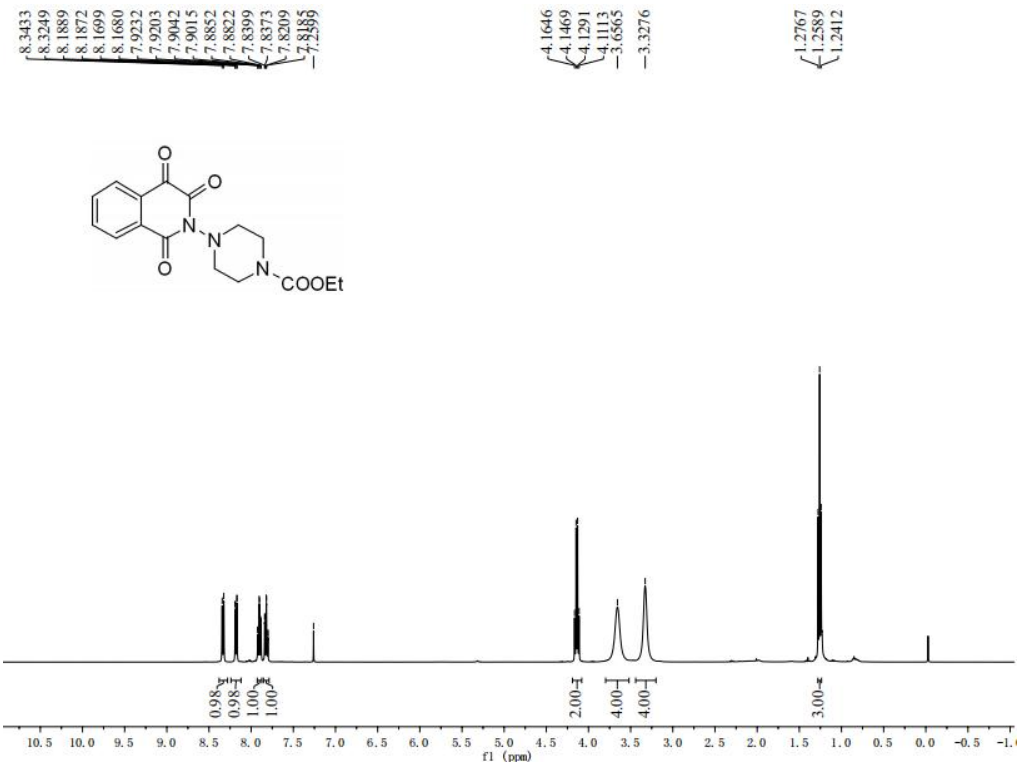
^{1}H NMR (400 MHz) Spectrum of 3q in $CDCl_3$



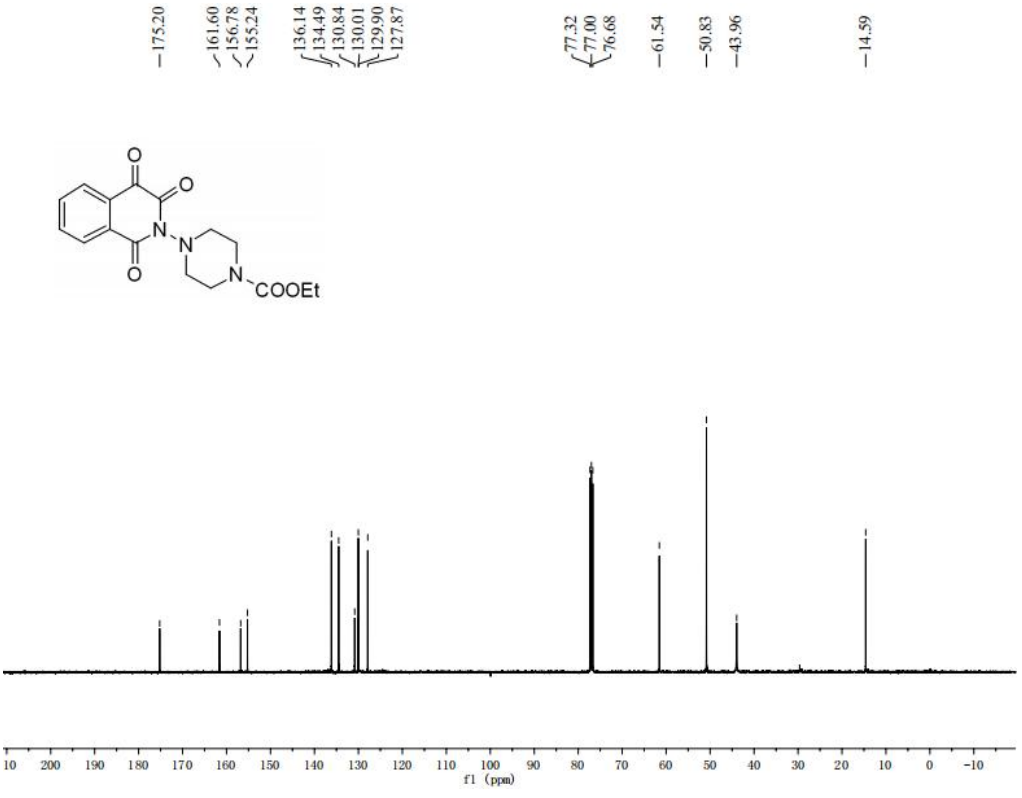
^{13}C NMR (126 MHz) Spectrum of 3q in $CDCl_3$



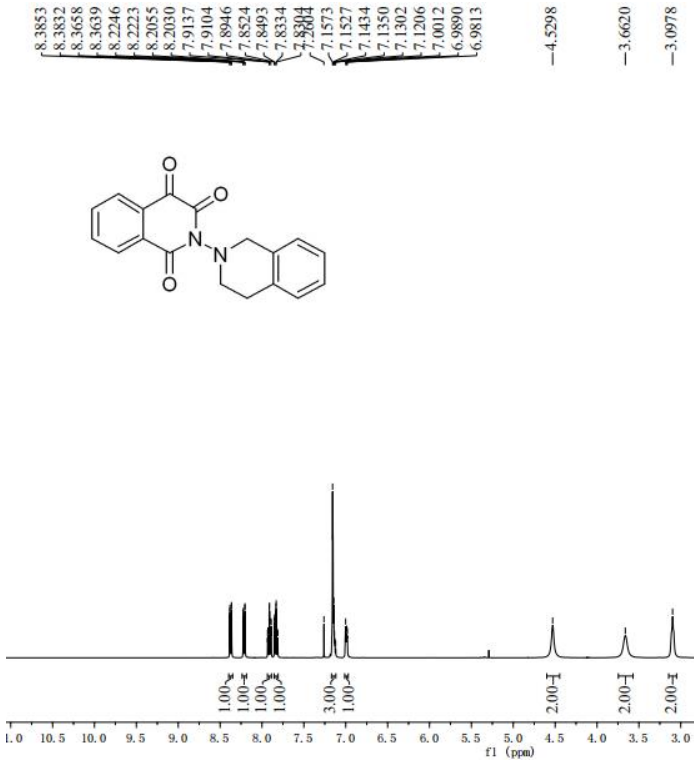
^{1}H NMR (400 MHz) Spectrum of 3r in $CDCl_3$



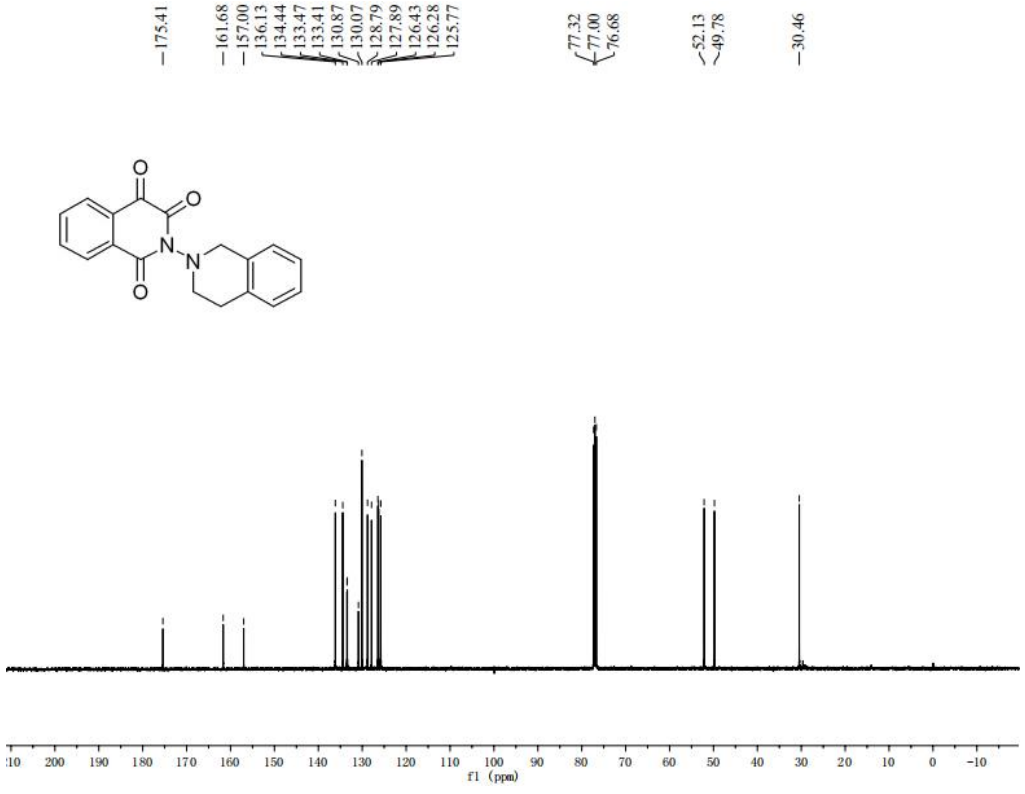
^{13}C NMR (101 MHz) Spectrum of 3r in $CDCl_3$



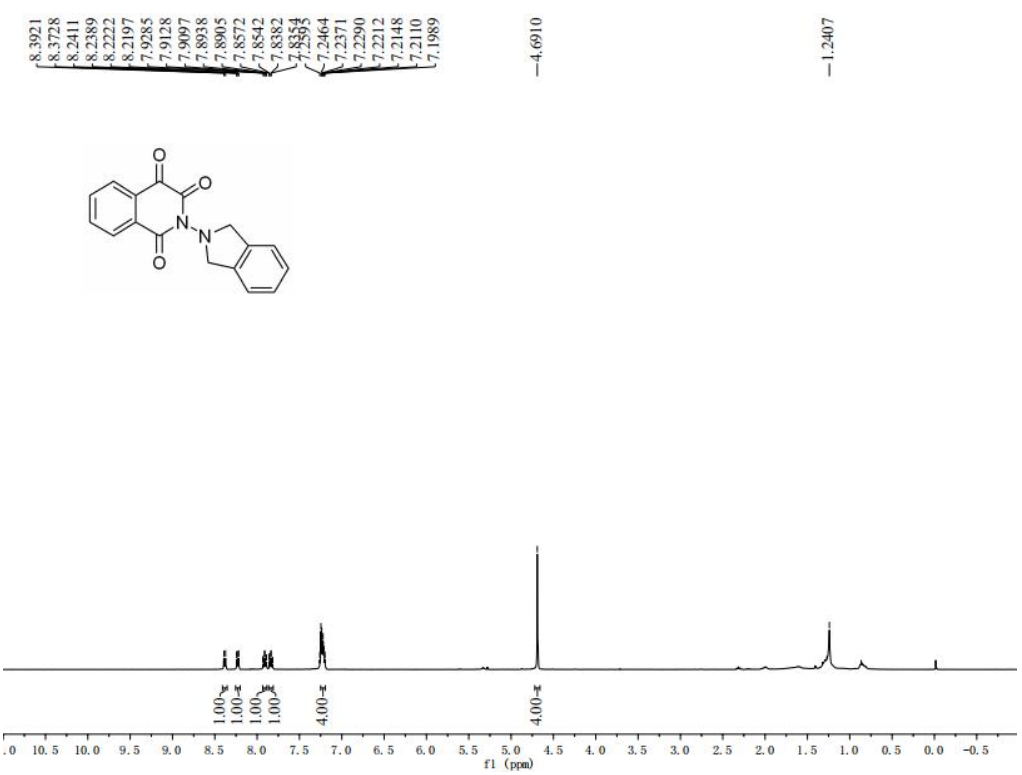
^{1}H NMR (400 MHz) Spectrum of 3s in $CDCl_3$



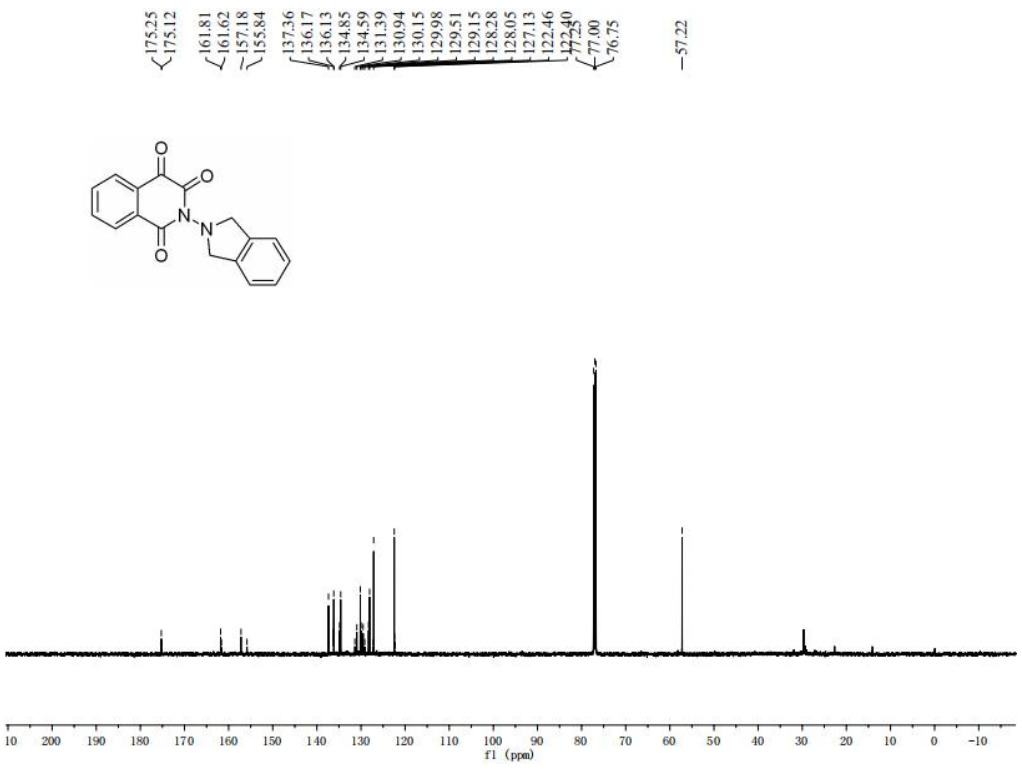
^{13}C NMR (101 MHz) Spectrum of 3s in $CDCl_3$



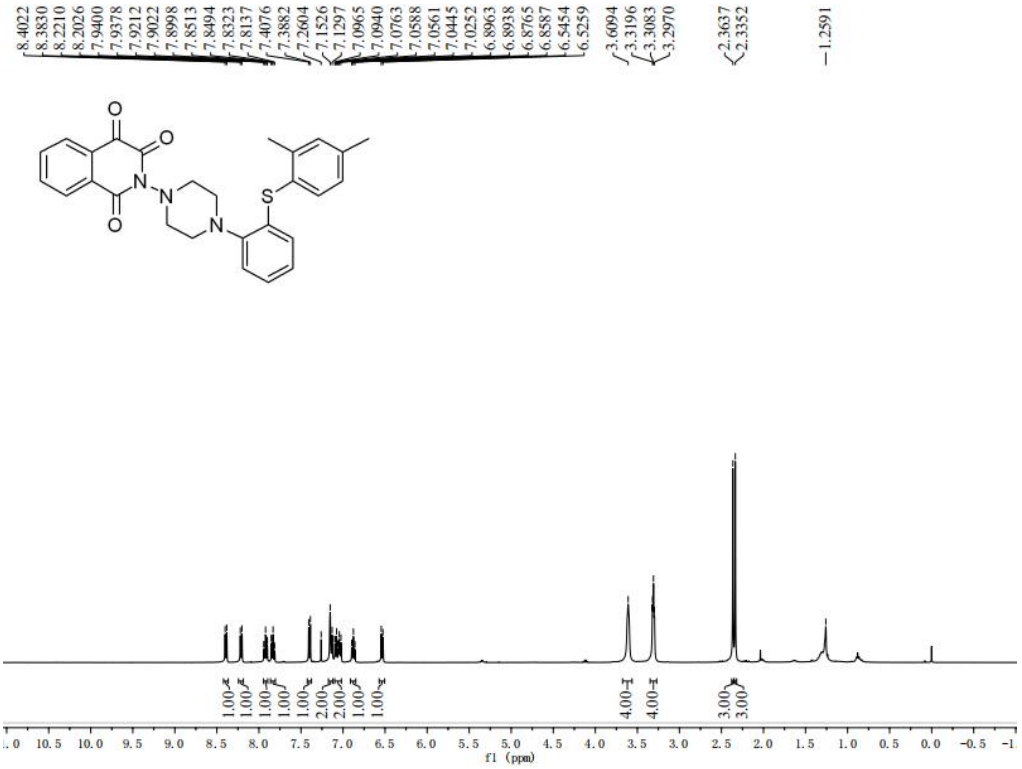
^{1}H NMR (400 MHz) Spectrum of 3t in $CDCl_3$



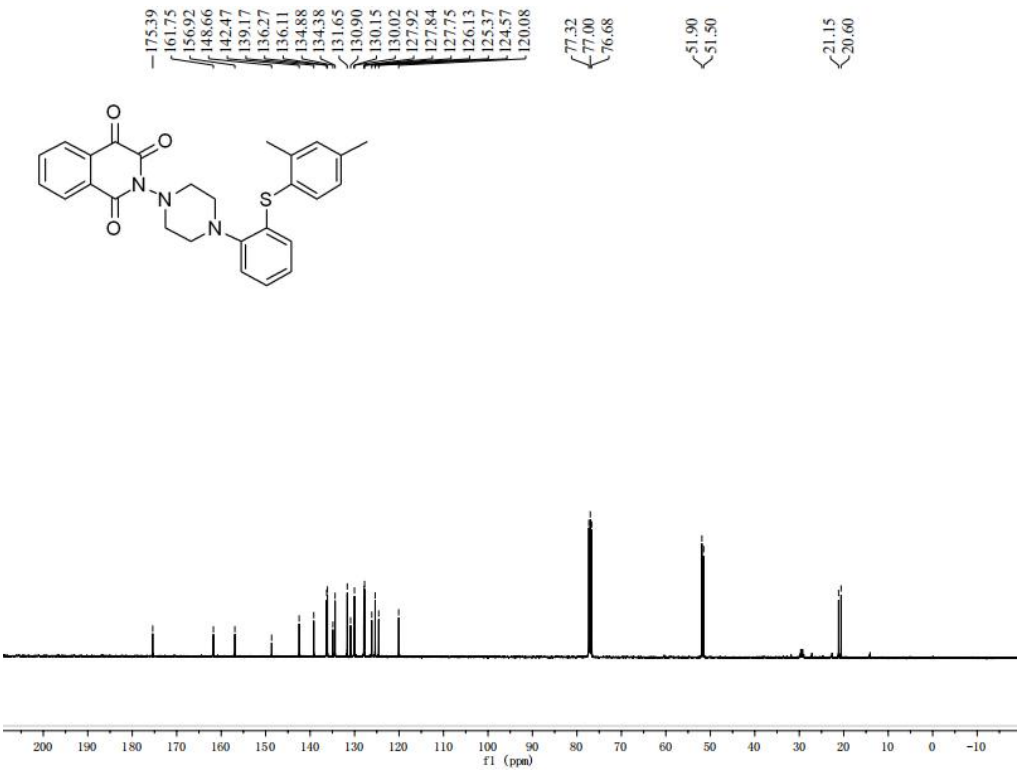
^{13}C NMR (126 MHz) Spectrum of 3t in $CDCl_3$



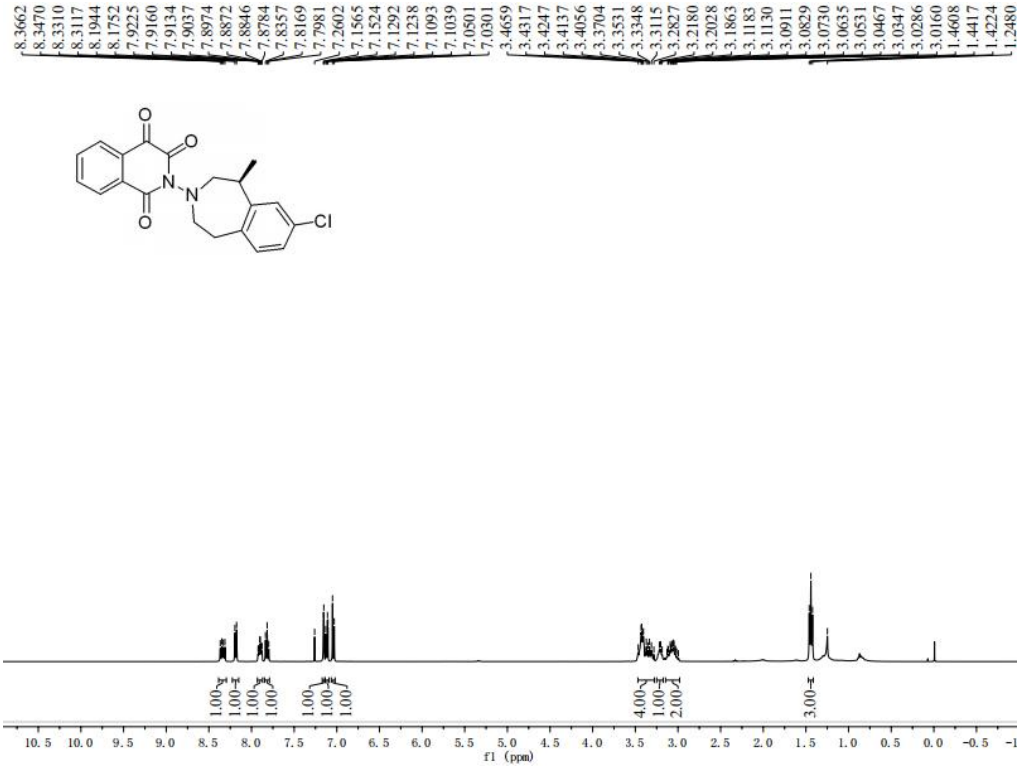
^{1}H NMR (400 MHz) Spectrum of 3x in $CDCl_3$



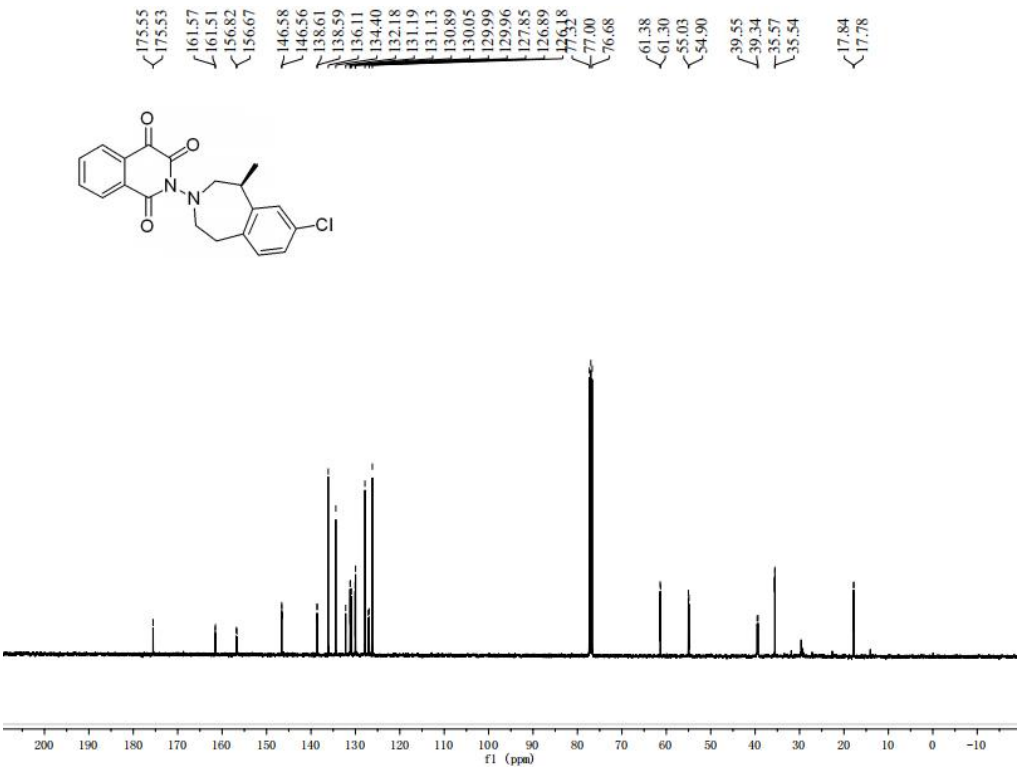
^{13}C NMR (101 MHz) Spectrum of 3x in $CDCl_3$



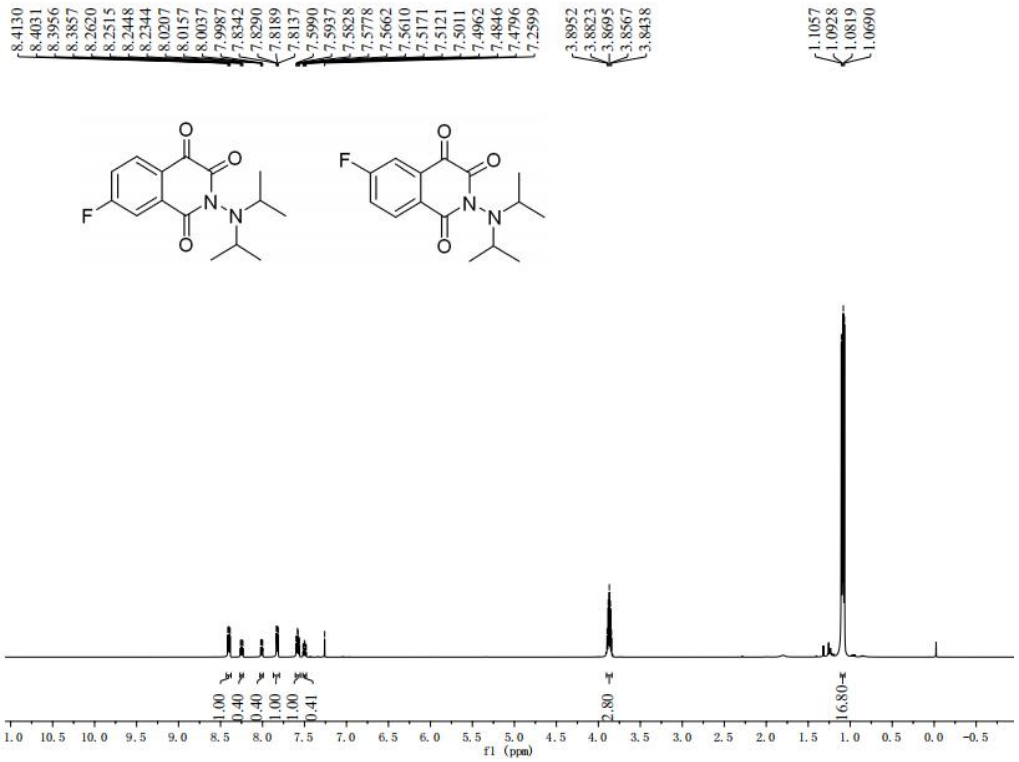
^{1}H NMR (400 MHz) Spectrum of 3y in $CDCl_3$



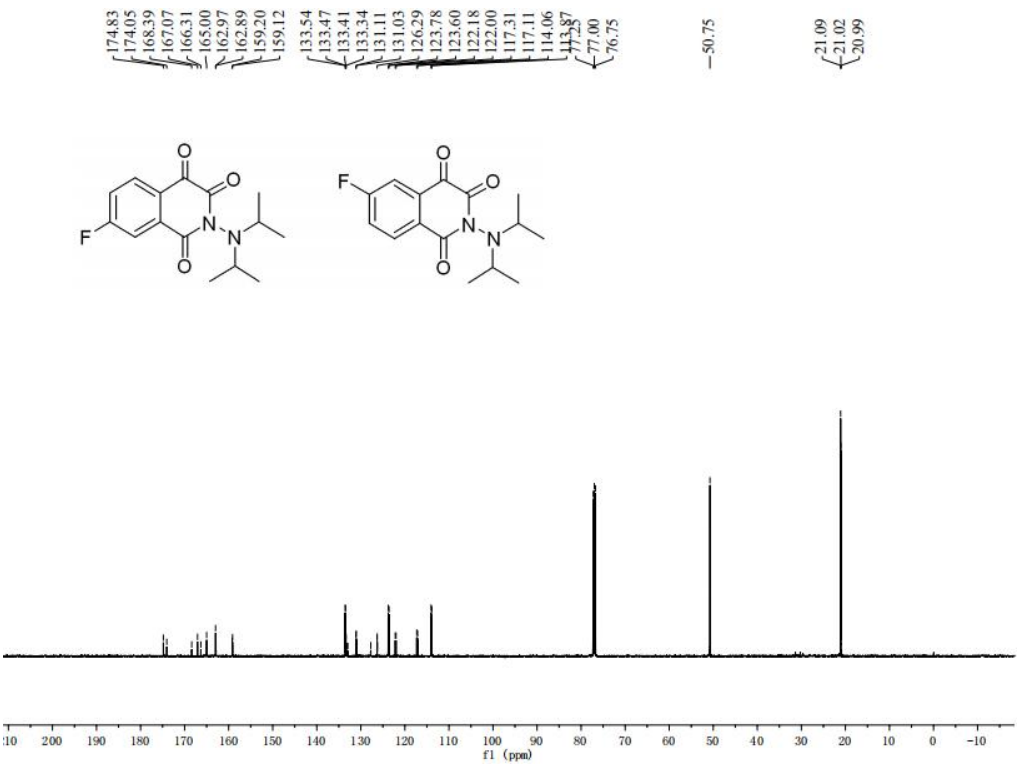
^{13}C NMR (101 MHz) Spectrum of 3y in $CDCl_3$



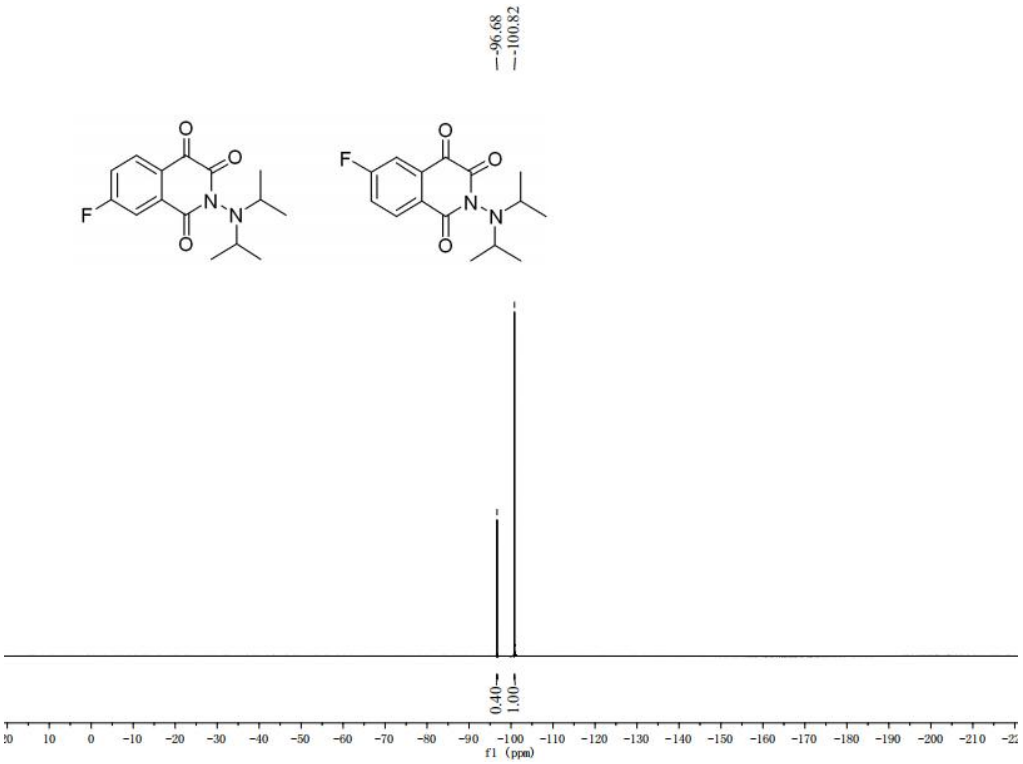
^{1}H NMR (500 MHz) Spectrum of 3mb and 3mb' in $CDCl_3$



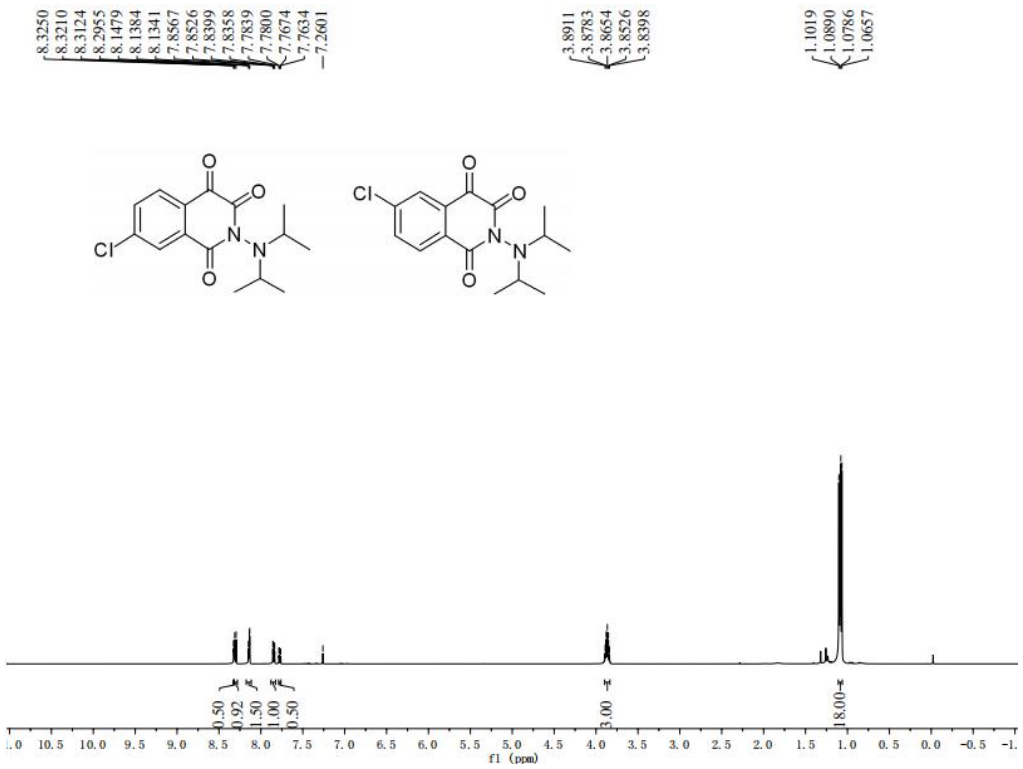
^{13}C NMR (126 MHz) Spectrum of 3mb and 3mb' in $CDCl_3$



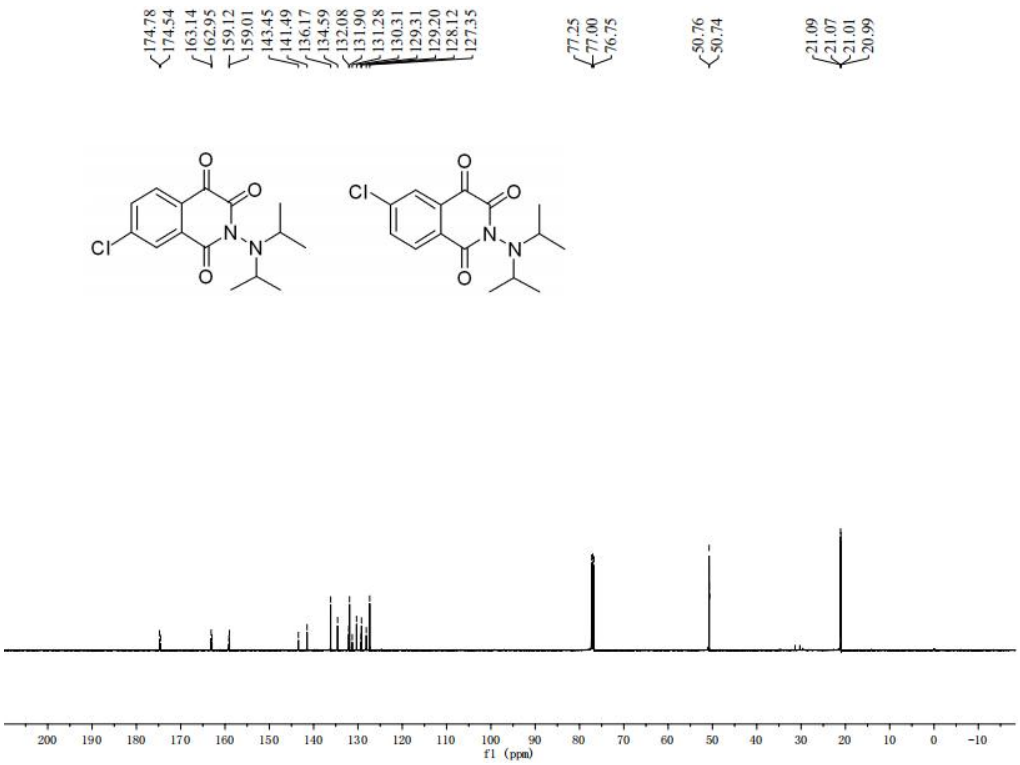
^{19}F NMR (470 MHz) Spectrum of 3mb and 3mb' in $CDCl_3$



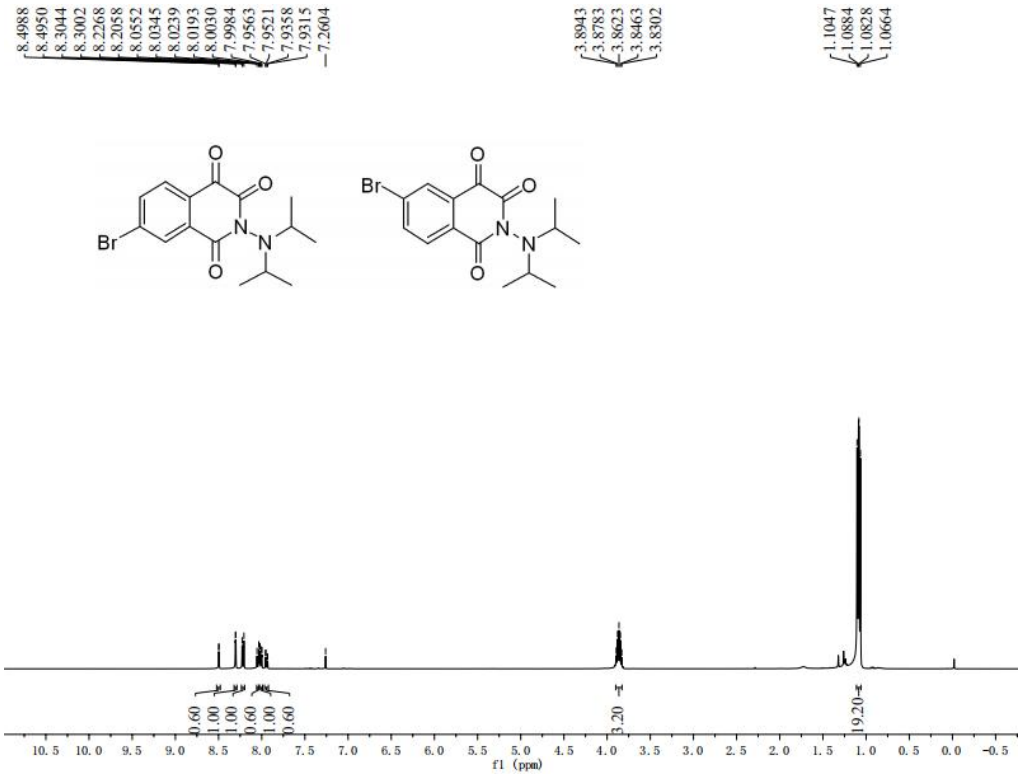
^{1}H NMR (500 MHz) Spectrum of 3mc and 3mc' in $CDCl_3$



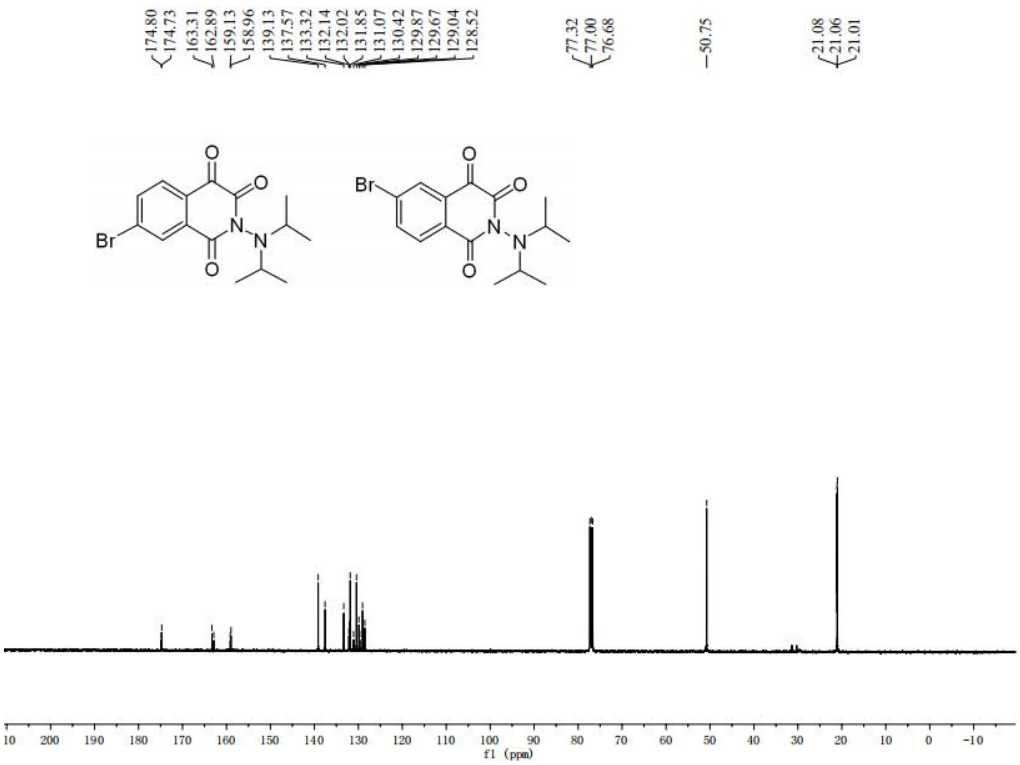
^{13}C NMR (126 MHz) Spectrum of 3mc and 3mc' in $CDCl_3$



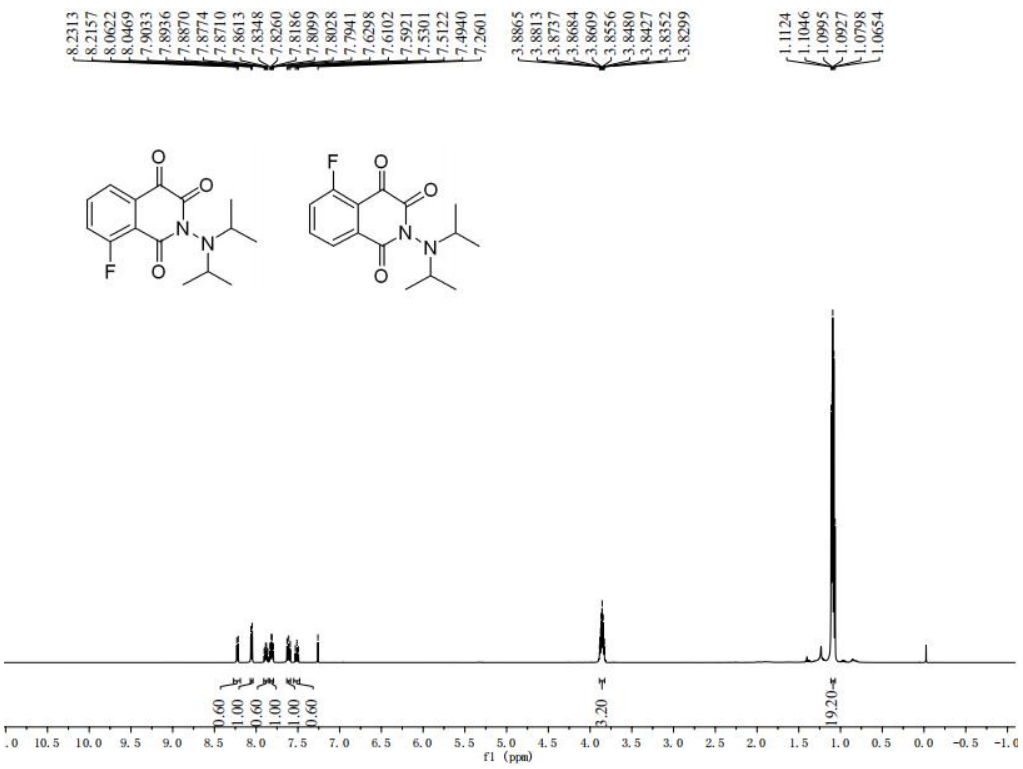
^{1}H NMR (400 MHz) Spectrum of 3md and 3md' in $CDCl_3$



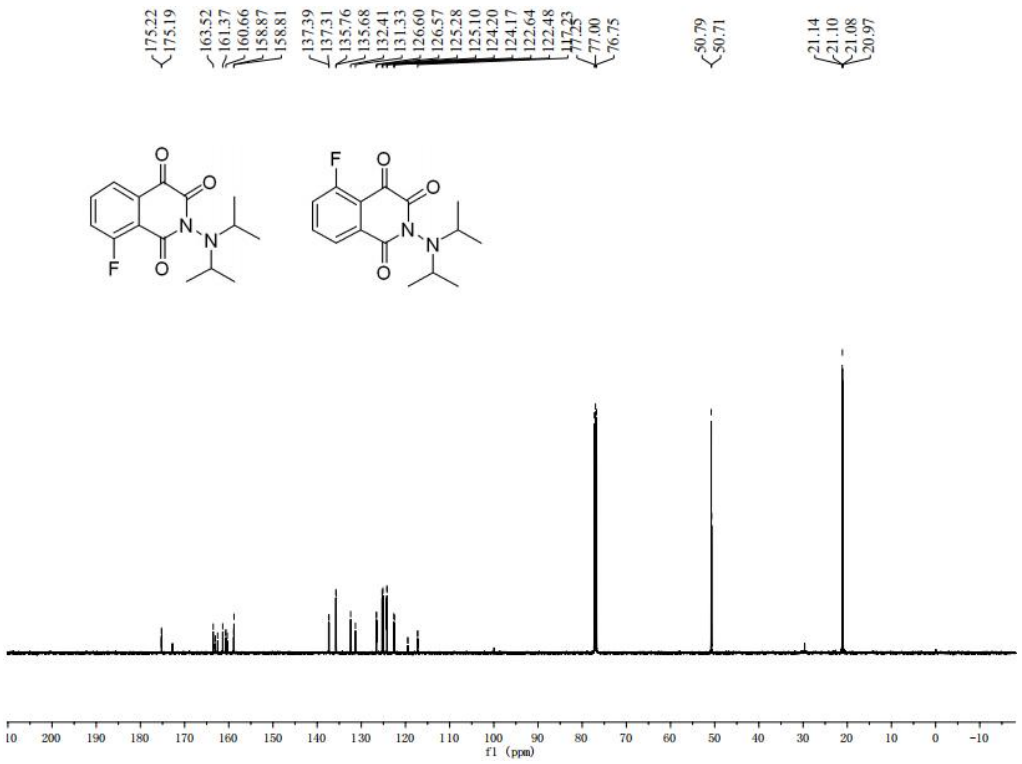
^{13}C NMR (101 MHz) Spectrum of 3md and 3md' in $CDCl_3$



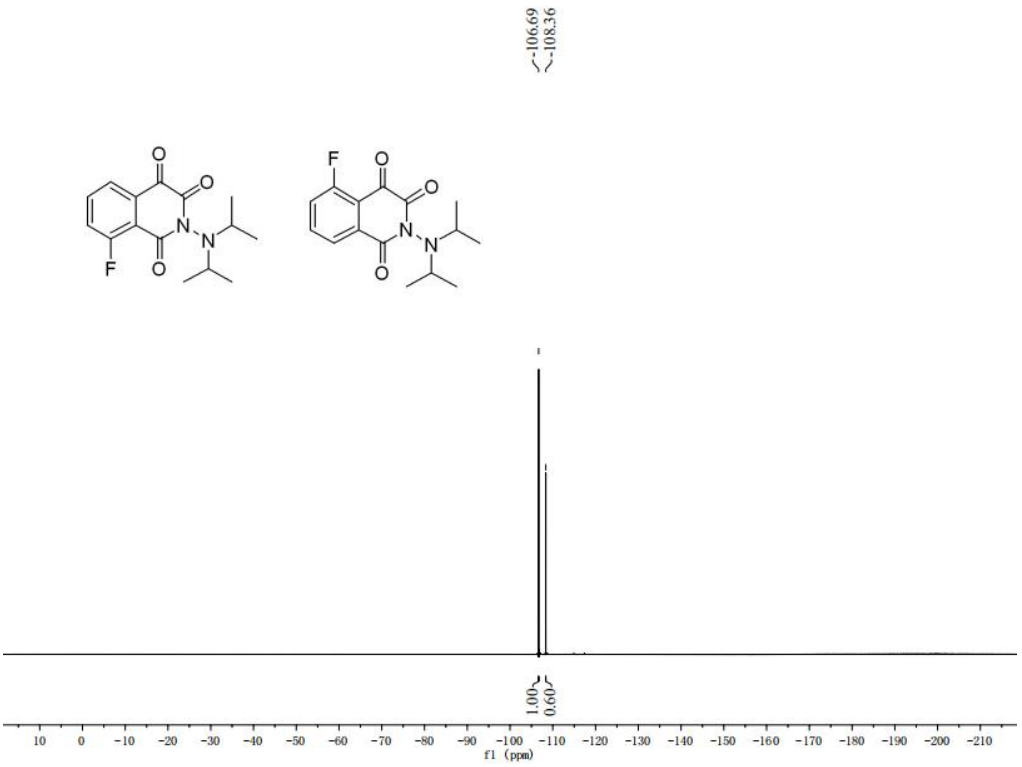
^{1}H NMR (500 MHz) Spectrum of 3me and 3me' in $CDCl_3$



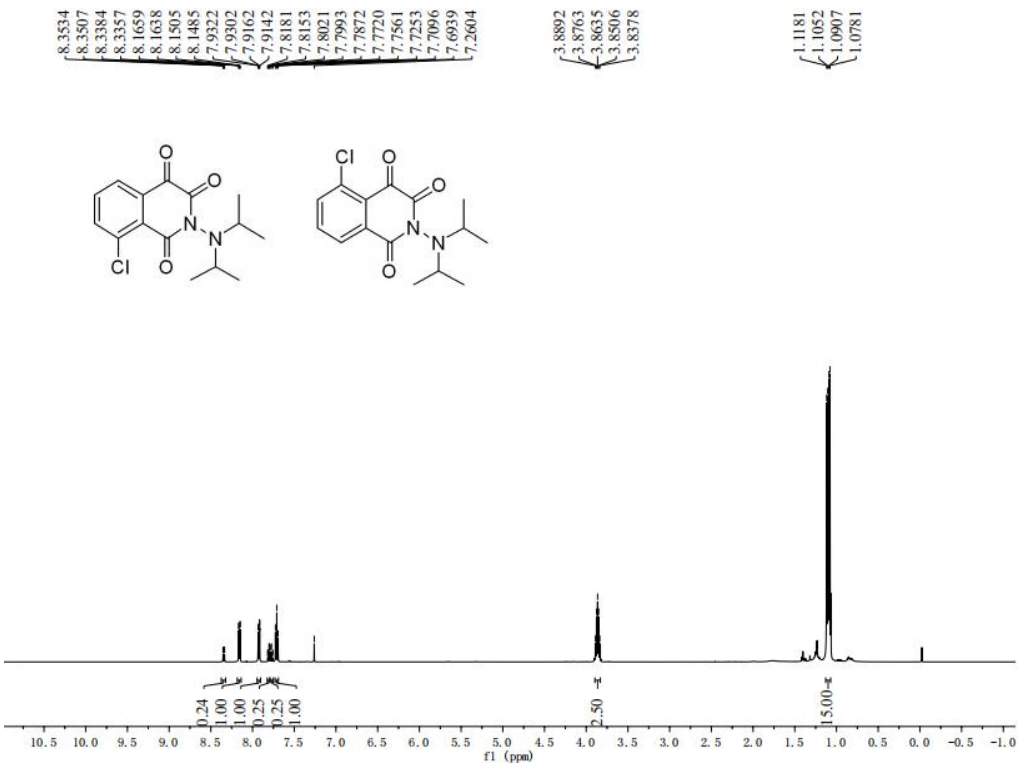
^{13}C NMR (126 MHz) Spectrum of 3me and 3me' in $CDCl_3$



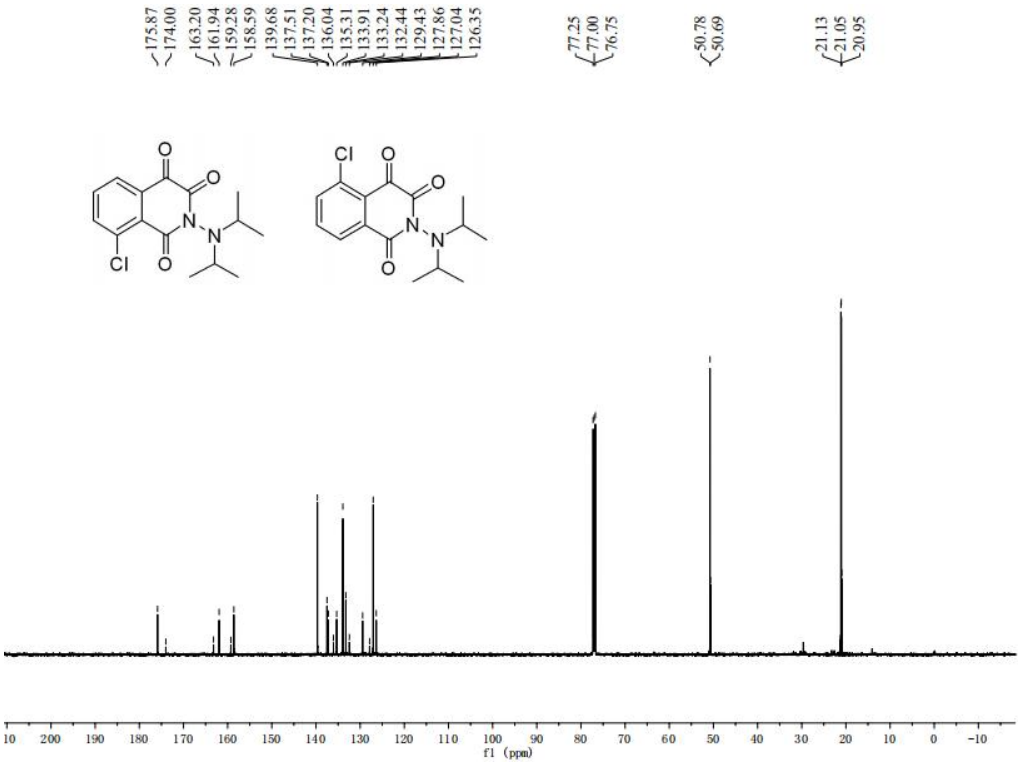
^{19}F NMR (376 MHz) Spectrum of 3me and 3me' in $CDCl_3$



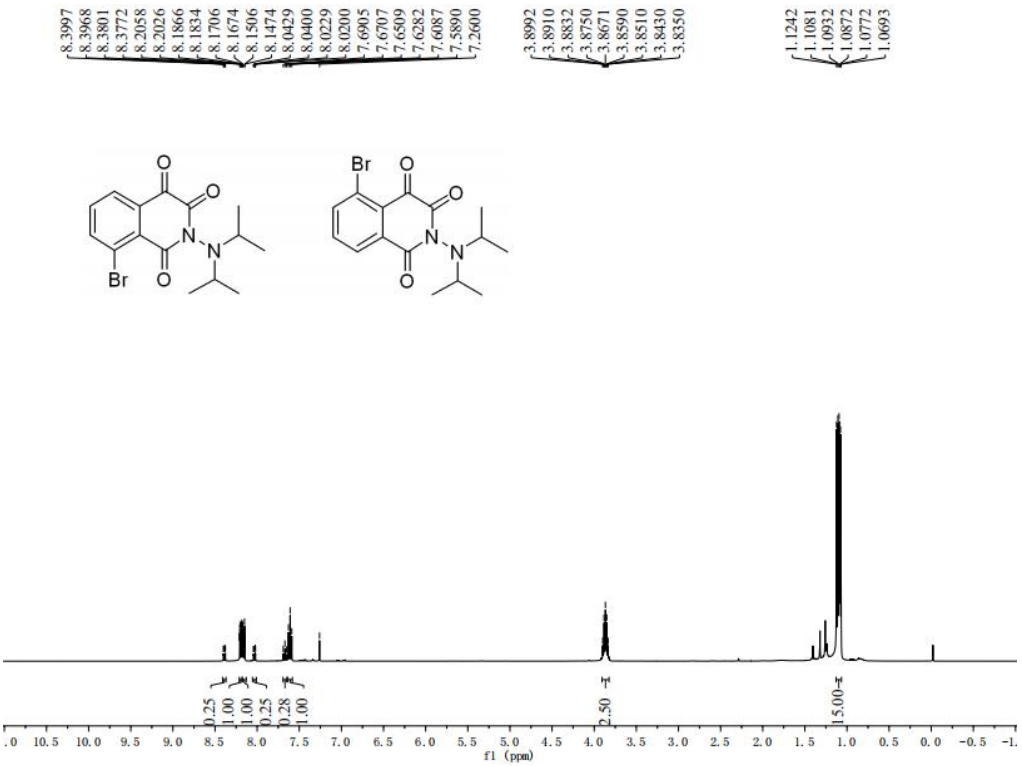
^{1}H NMR (500 MHz) Spectrum of 3mf and 3mf' in $CDCl_3$



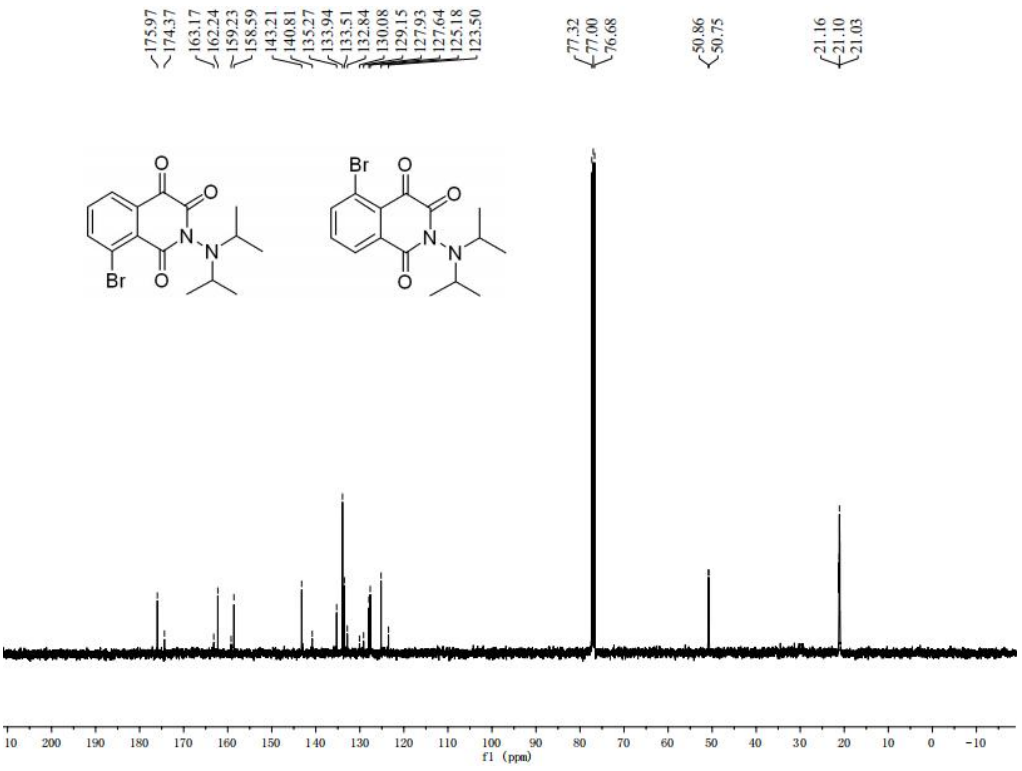
^{13}C NMR (126 MHz) Spectrum of 3mf and 3mf' in $CDCl_3$



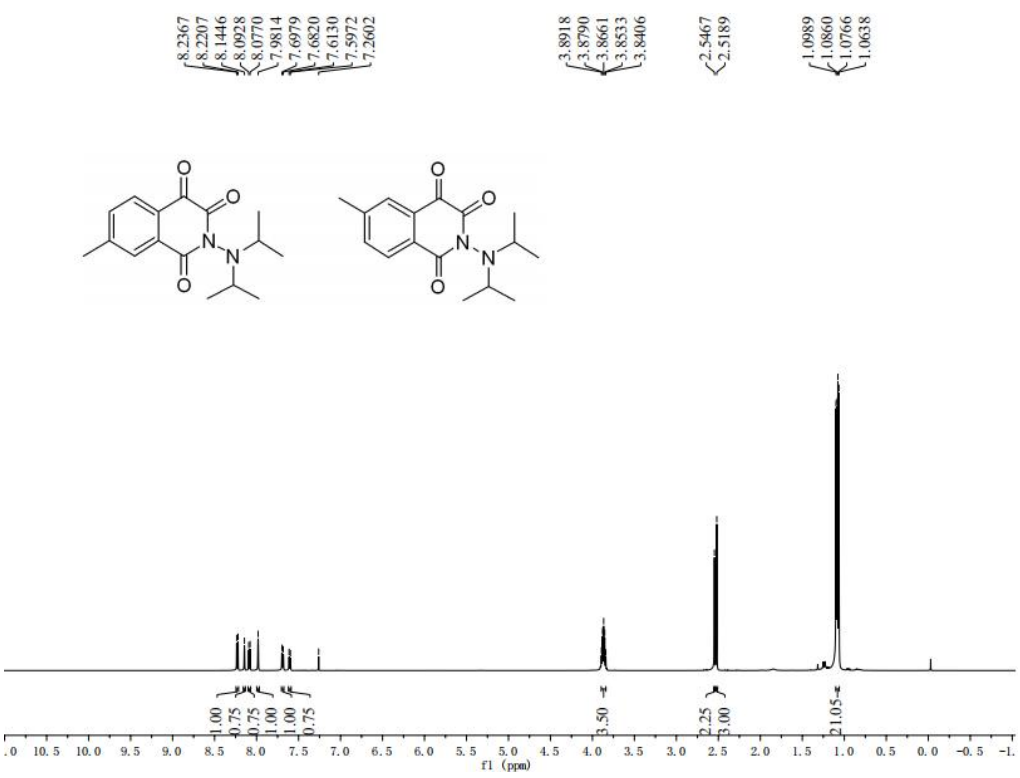
^{1}H NMR (400 MHz) Spectrum of 3mg and 3mg' in $CDCl_3$



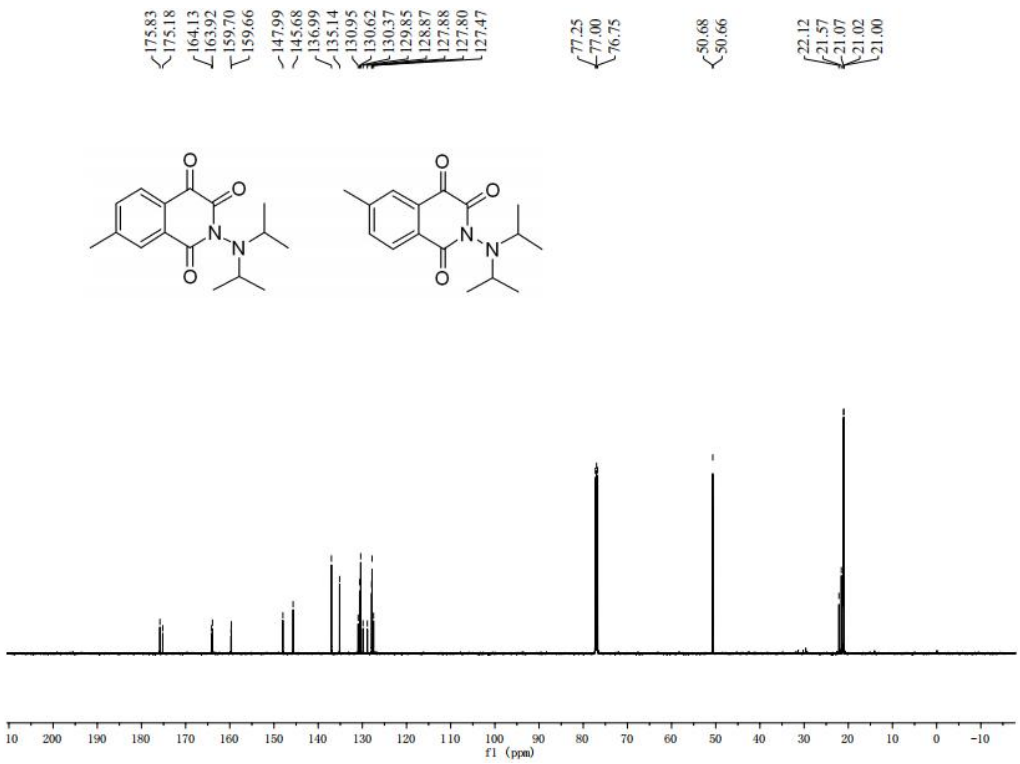
^{13}C NMR (101 MHz) Spectrum of 3mg and 3mg' in $CDCl_3$



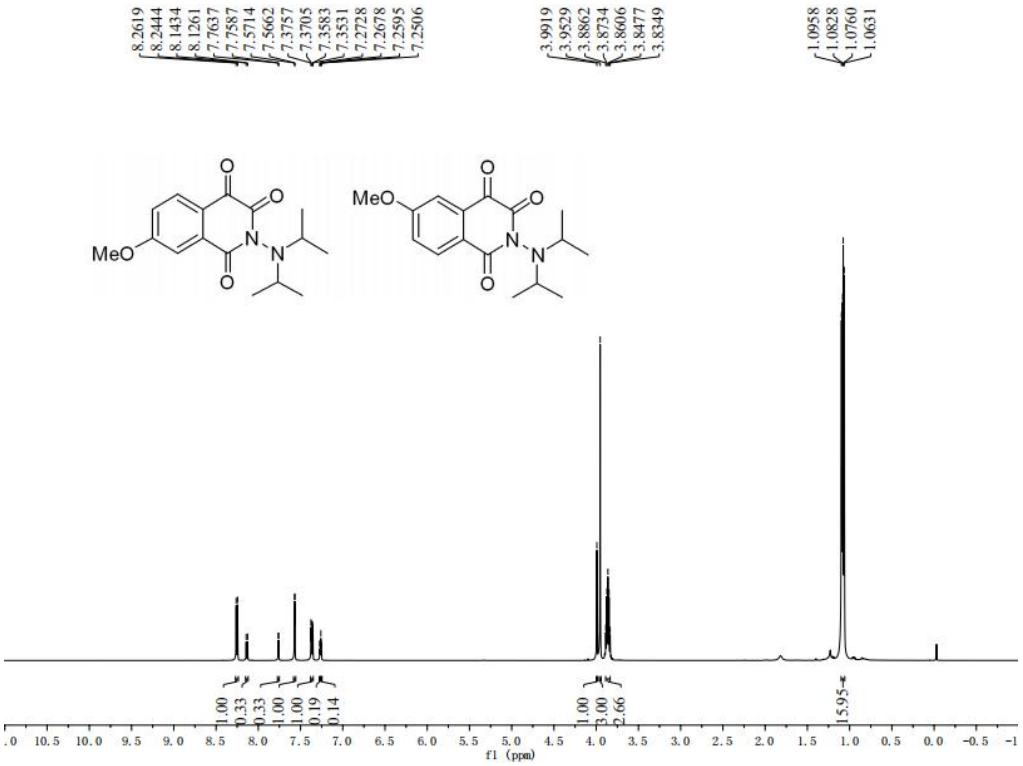
^{1}H NMR (500 MHz) Spectrum of 3mh and 3mh' in $CDCl_3$



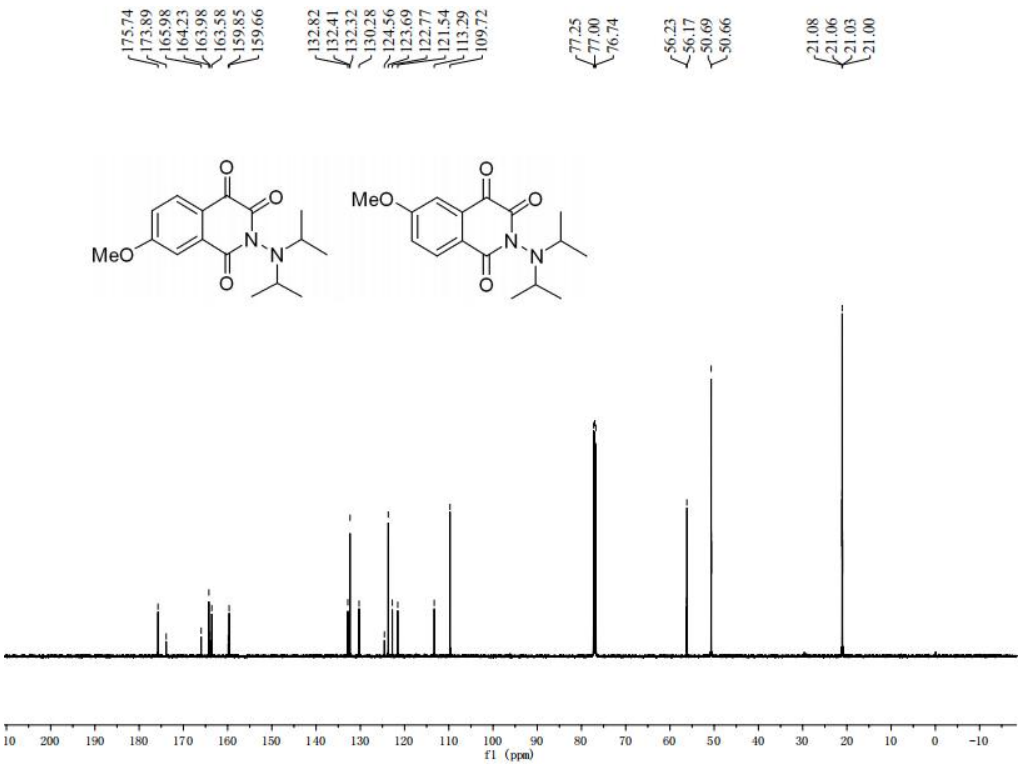
^{13}C NMR (126 MHz) Spectrum of 3mh and 3mh' in $CDCl_3$



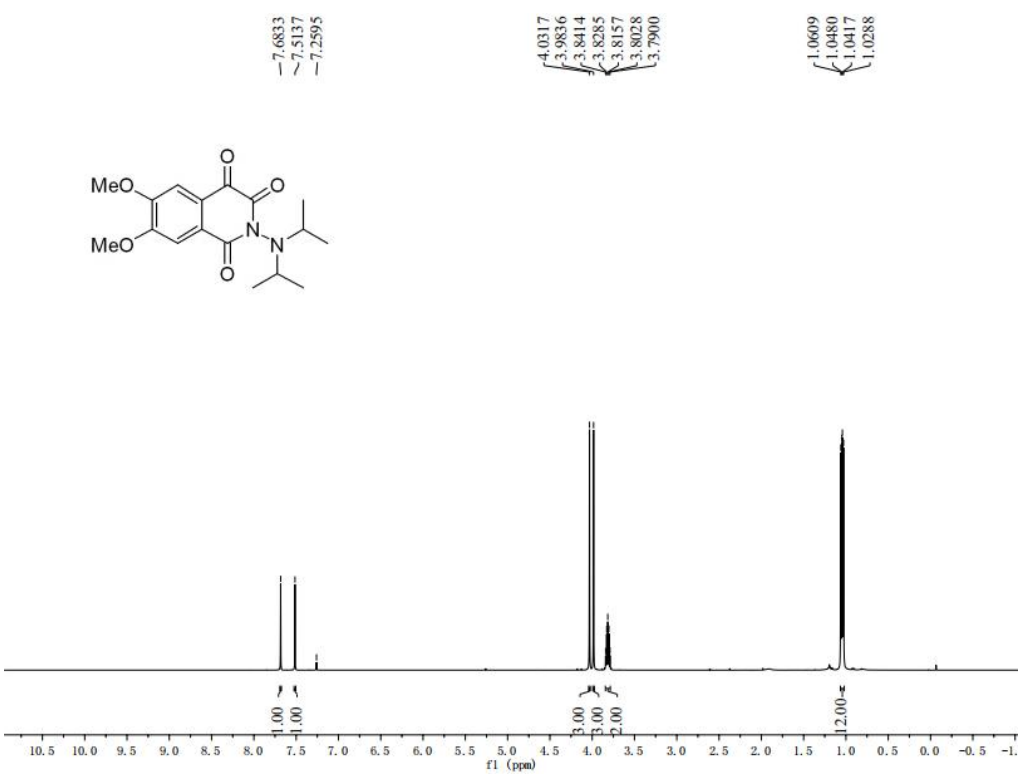
^{1}H NMR (500 MHz) Spectrum of 3mi and 3mi' in $CDCl_3$



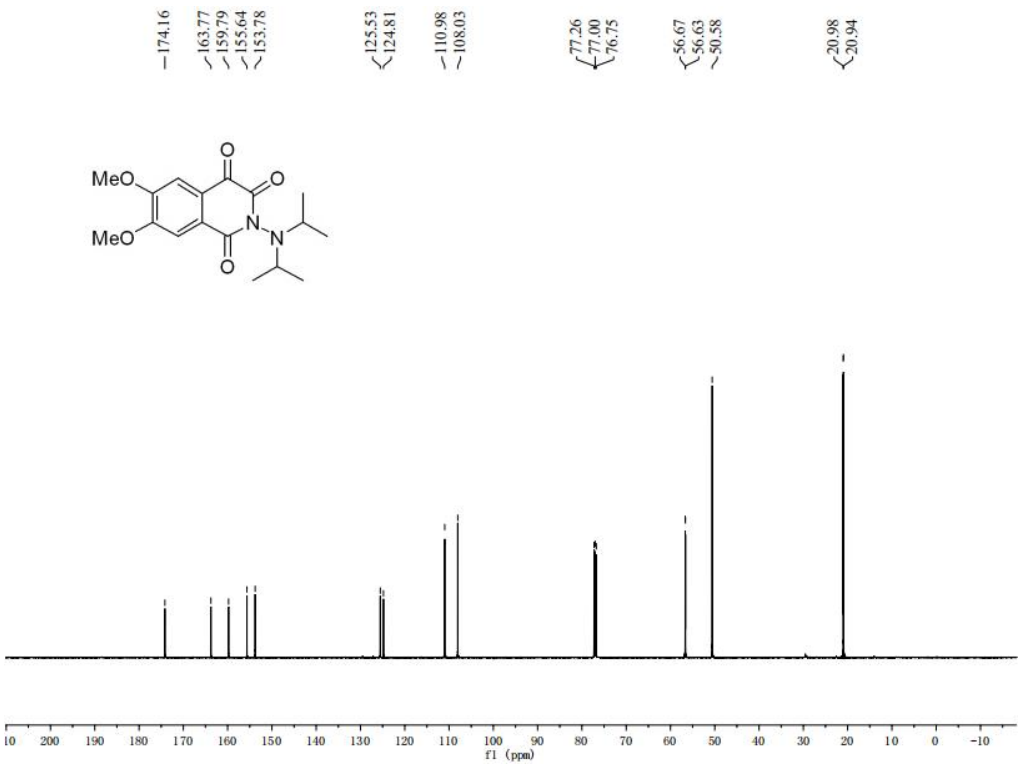
^{13}C NMR (126 MHz) Spectrum of 3mi and 3mi' in $CDCl_3$



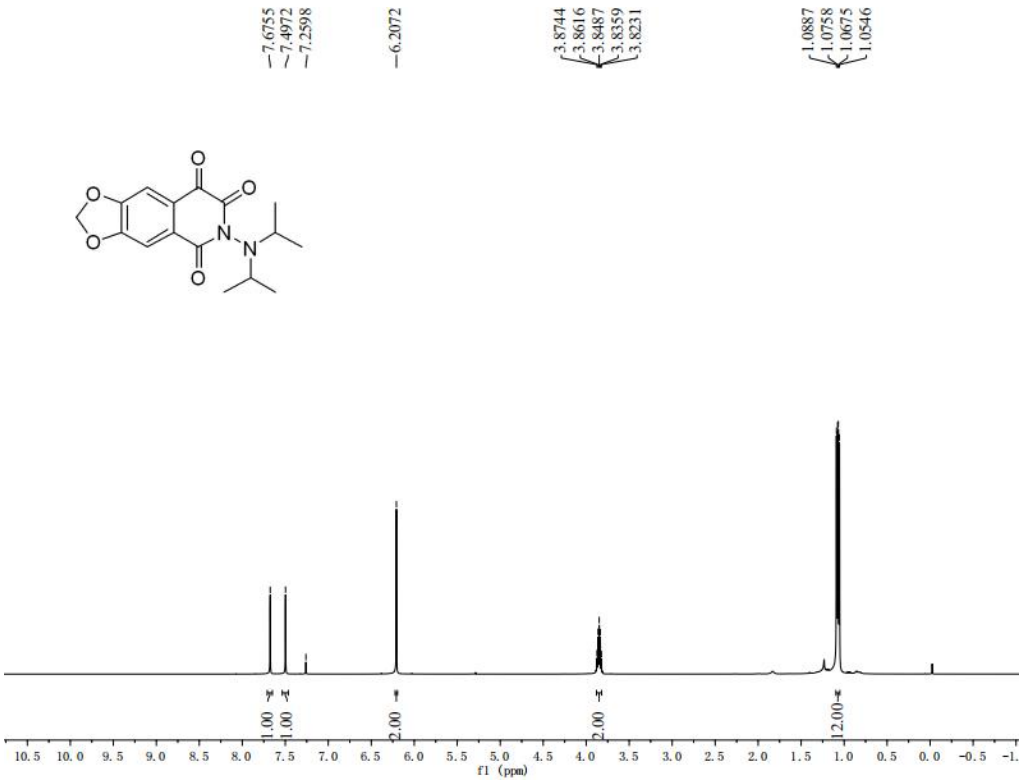
^{1}H NMR (500 MHz) Spectrum of 3mj in $CDCl_3$



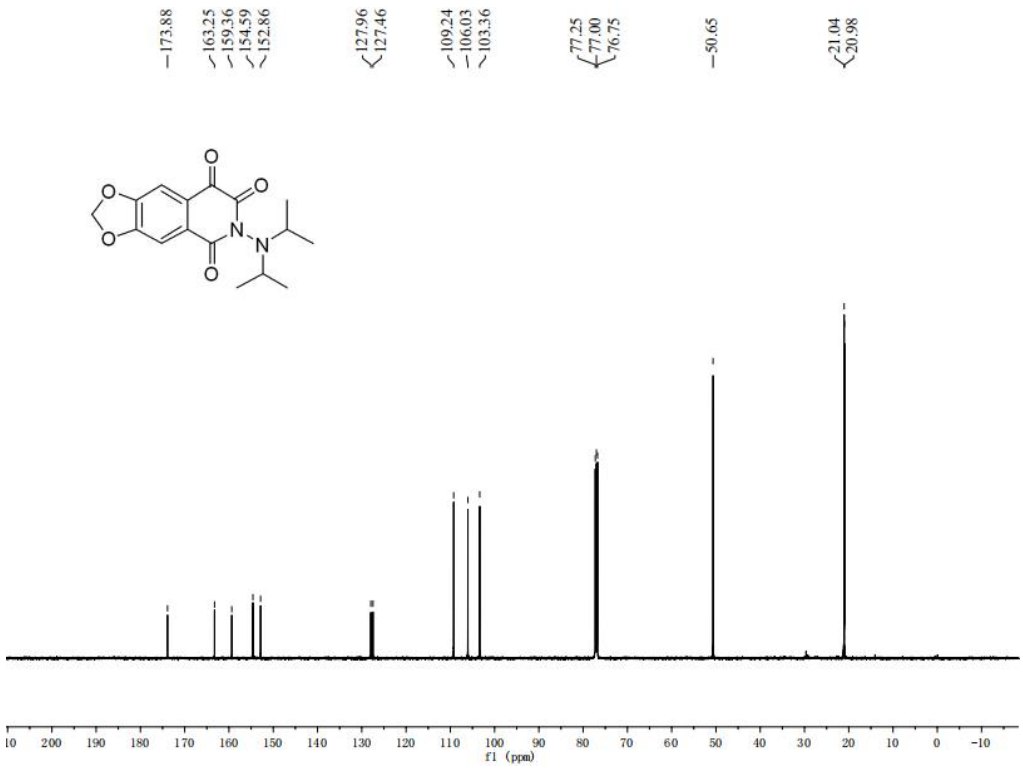
^{13}C NMR (126 MHz) Spectrum of 3mj in $CDCl_3$



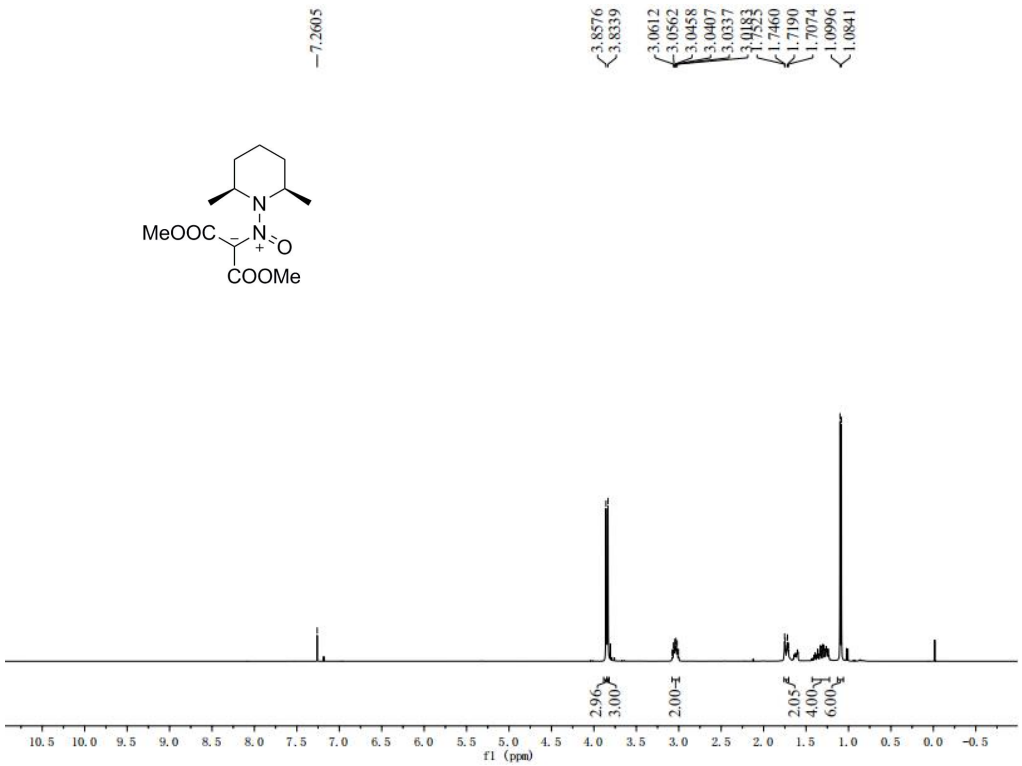
^{1}H NMR (500 MHz) Spectrum of 3mk in $CDCl_3$



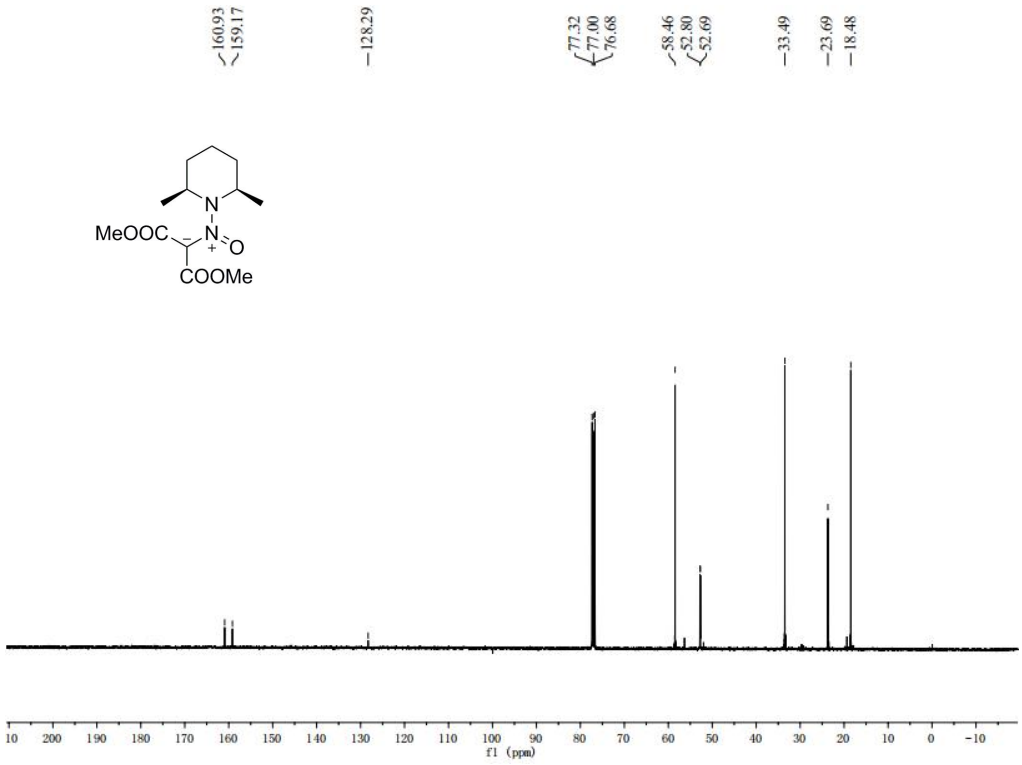
^{13}C NMR (126 MHz) Spectrum of 3mk in $CDCl_3$



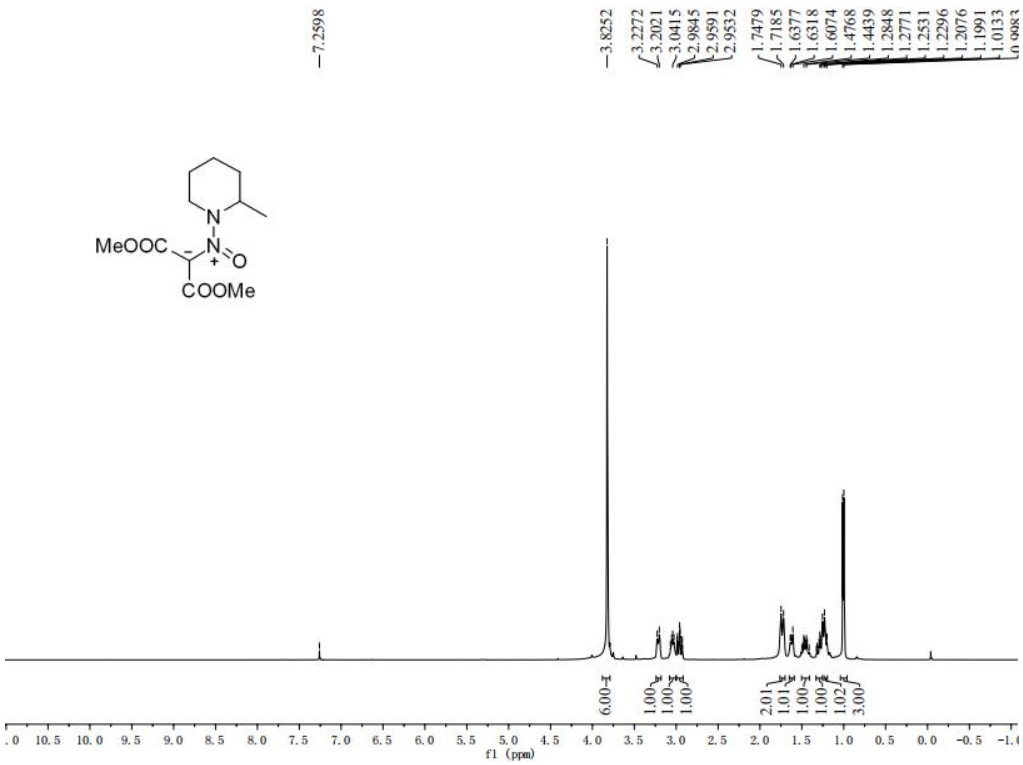
^{1}H NMR (400 MHz) Spectrum of 4a in $CDCl_3$



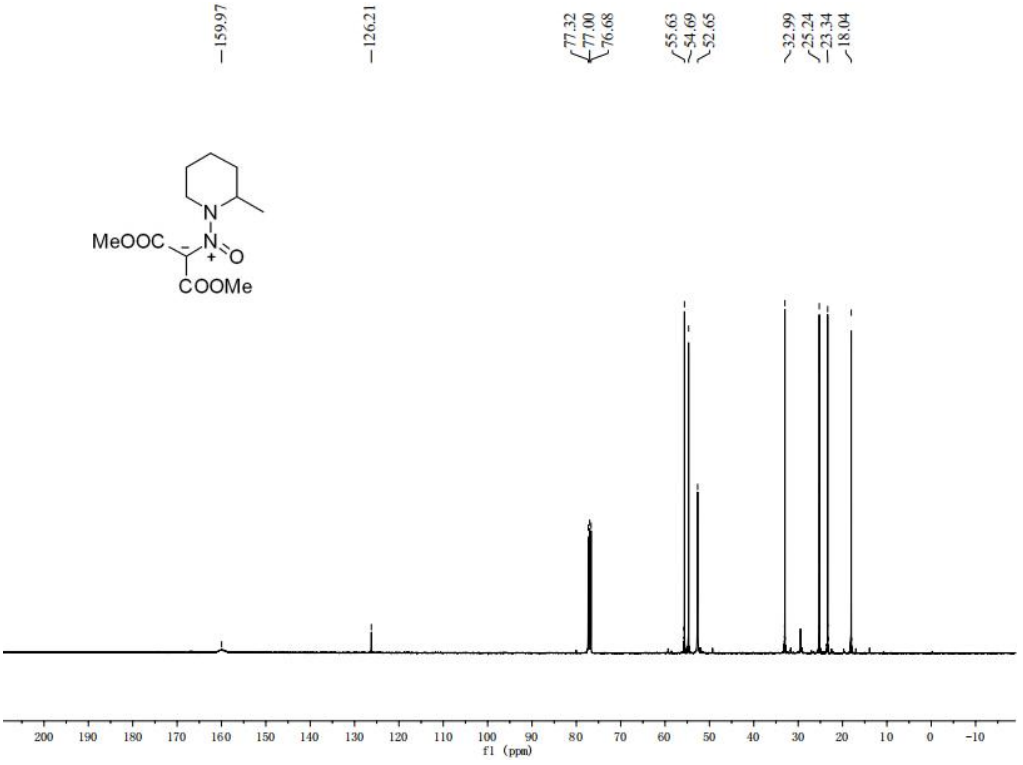
^{13}C NMR (101 MHz) Spectrum of 4a in $CDCl_3$



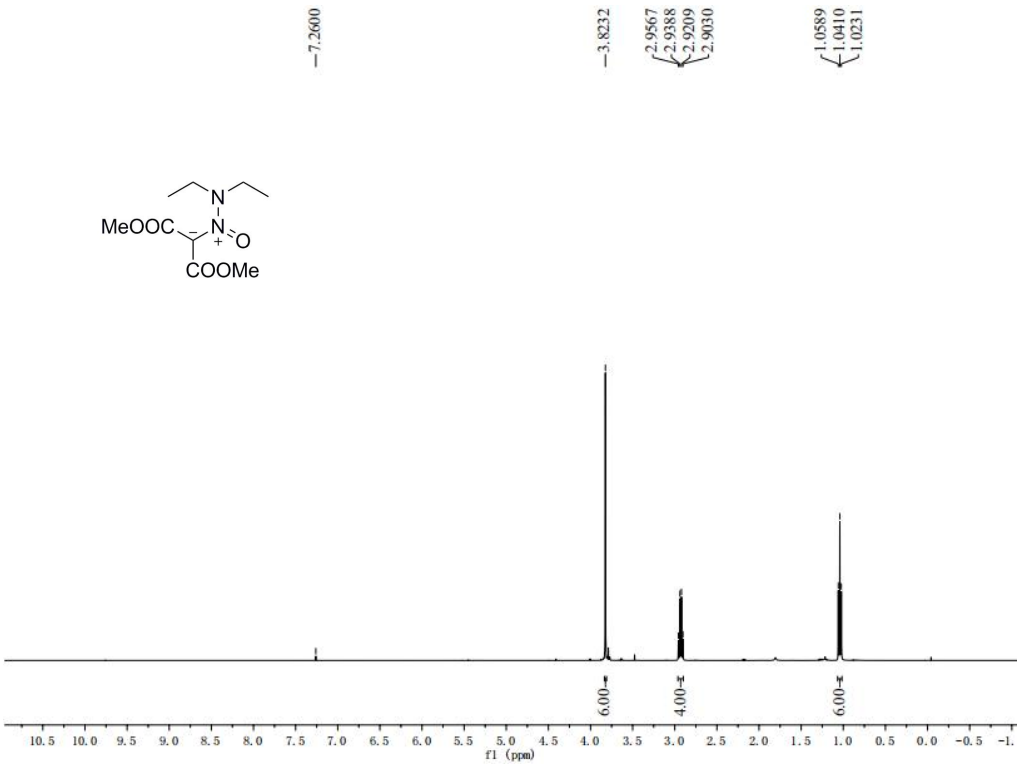
^{1}H NMR (400 MHz) Spectrum of 4b in $CDCl_3$



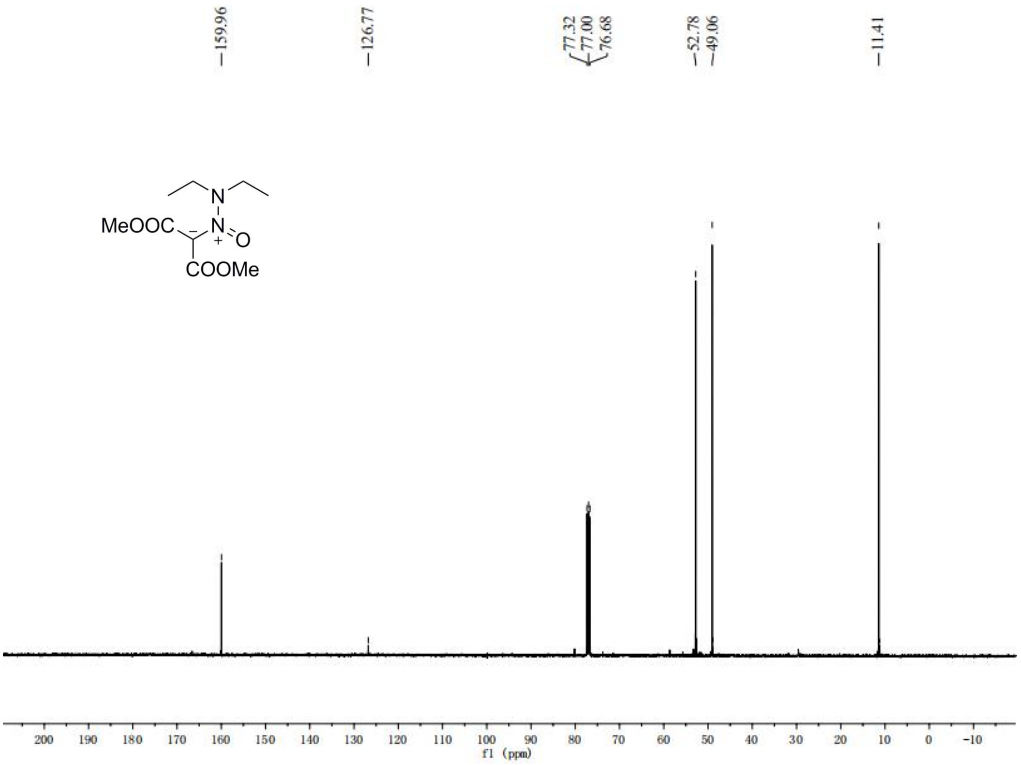
^{13}C NMR (101 MHz) Spectrum of 4b in $CDCl_3$



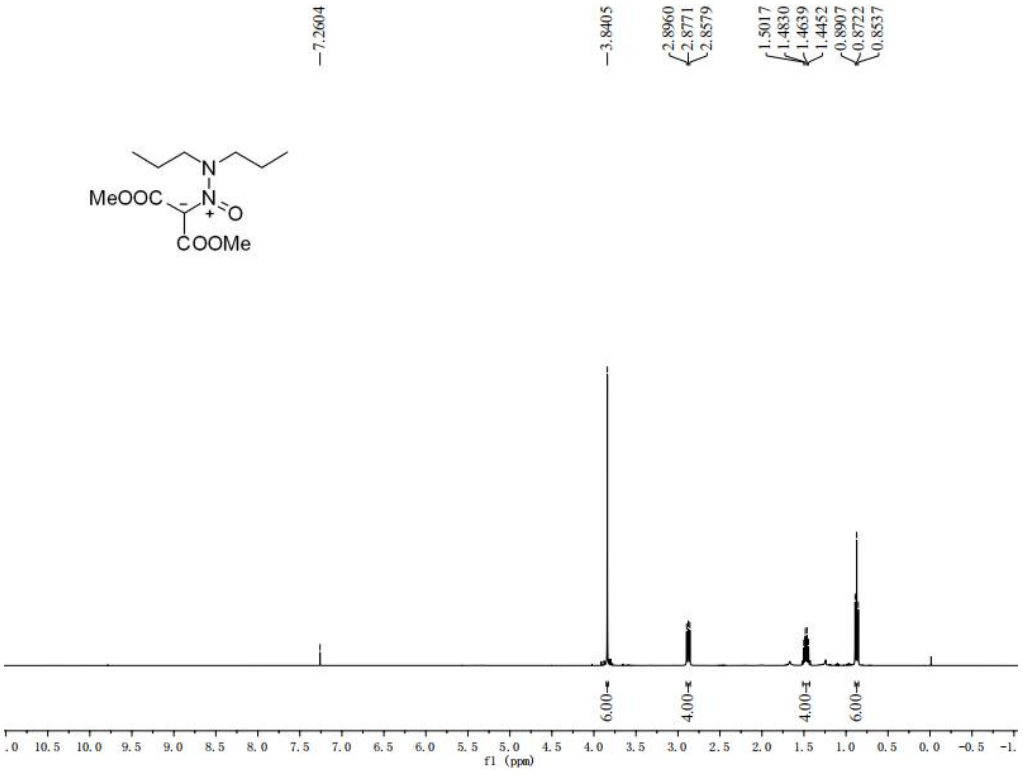
^{1}H NMR (400 MHz) Spectrum of 4c in $CDCl_3$



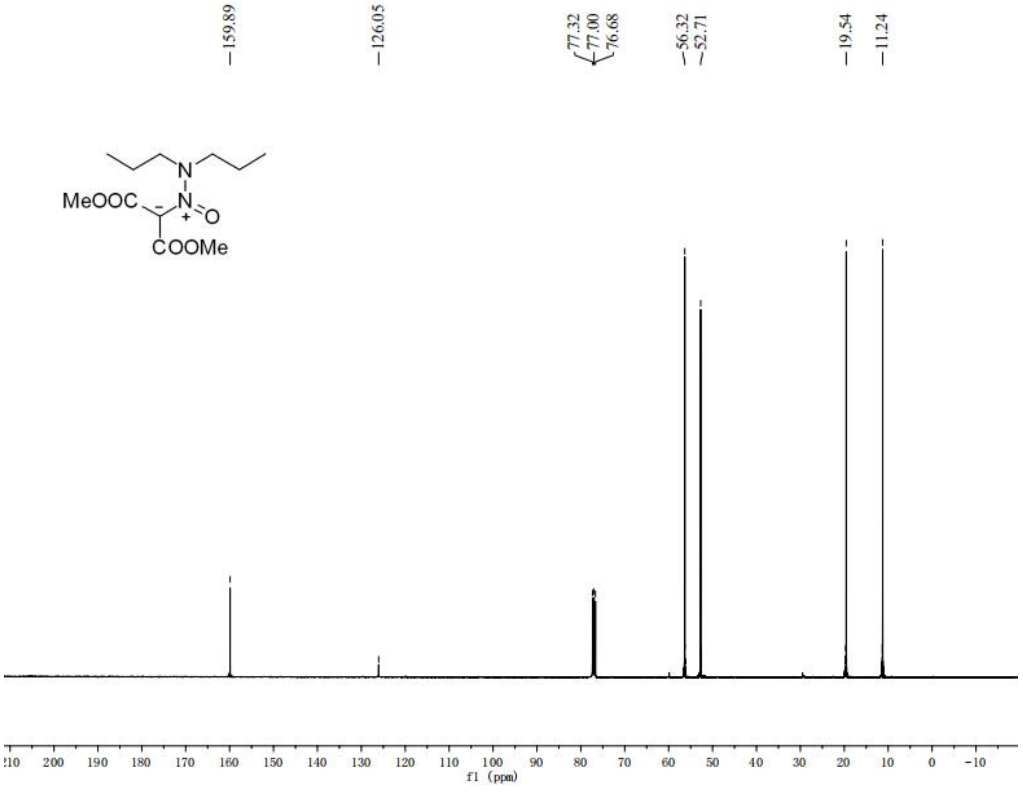
^{13}C NMR (101 MHz) Spectrum of 4c in $CDCl_3$



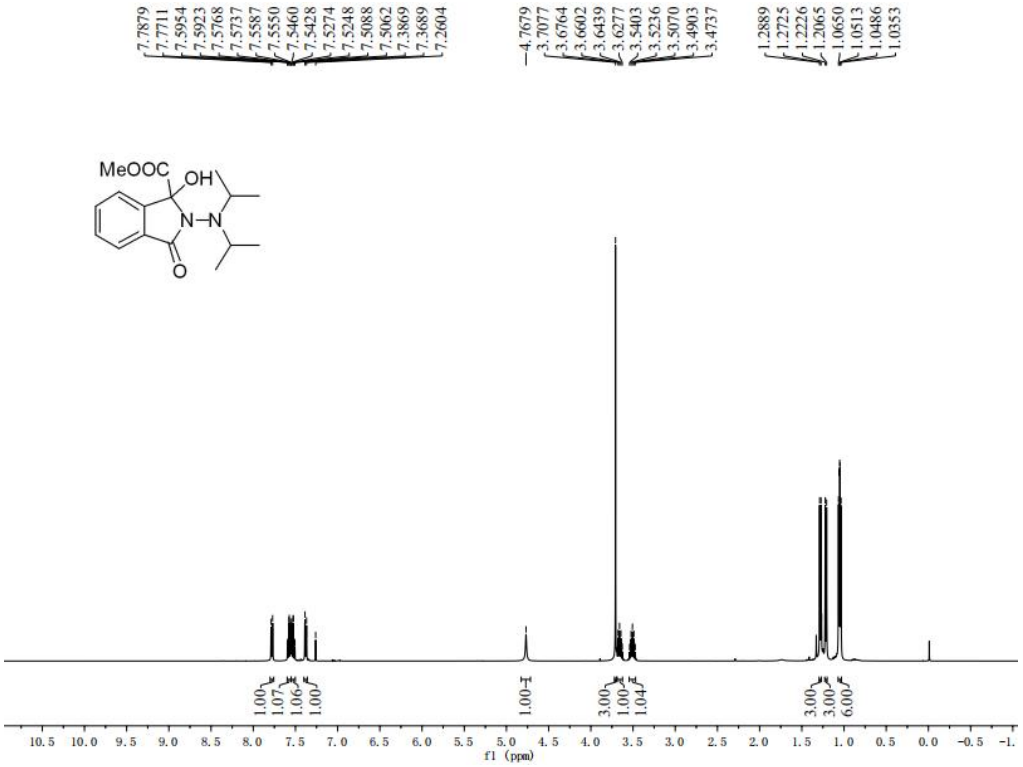
^{1}H NMR (400 MHz) Spectrum of 4d in $CDCl_3$



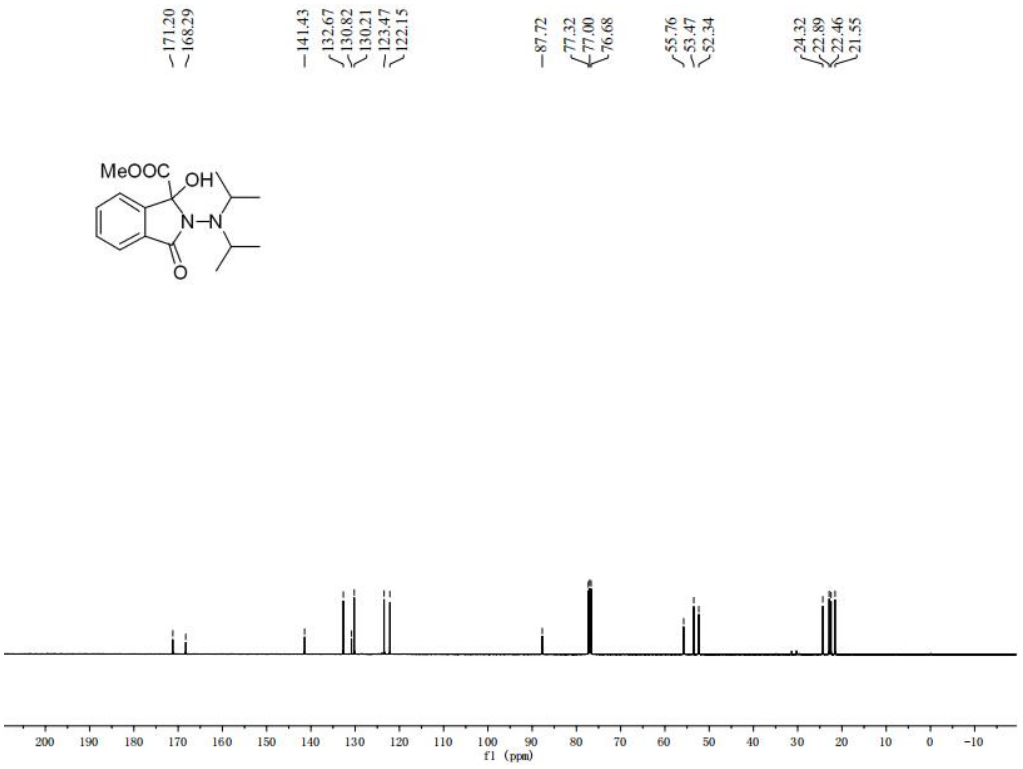
^{13}C NMR (101 MHz) Spectrum of 4d in $CDCl_3$



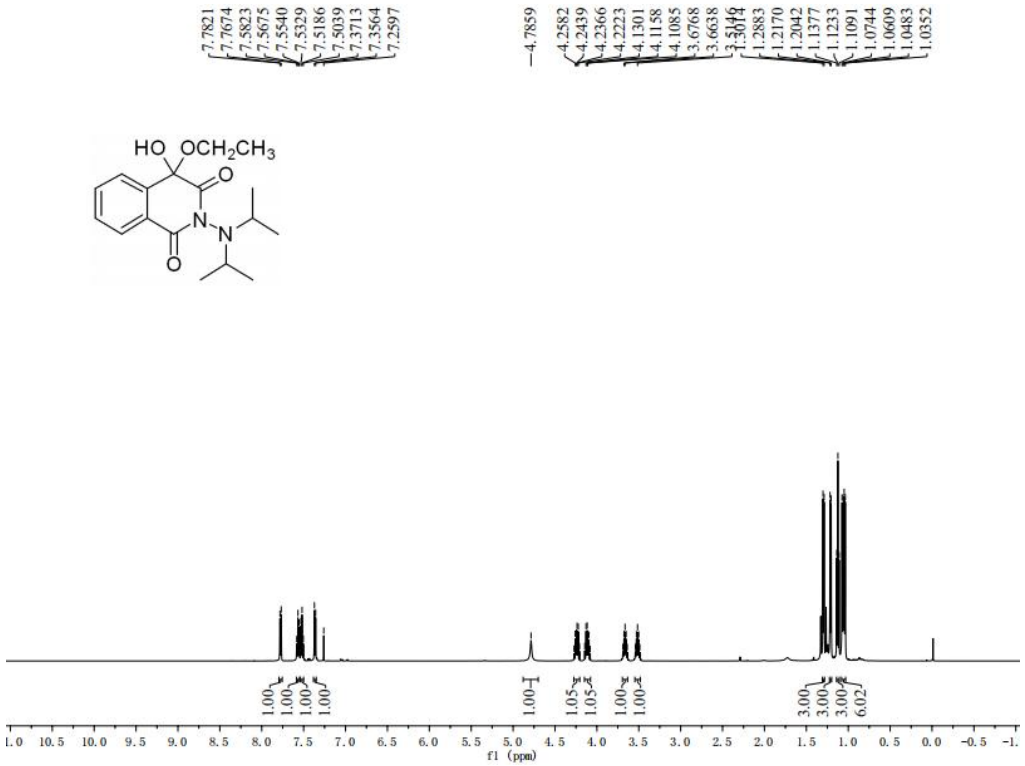
^{1}H NMR (400 MHz) Spectrum of 5 in $CDCl_3$



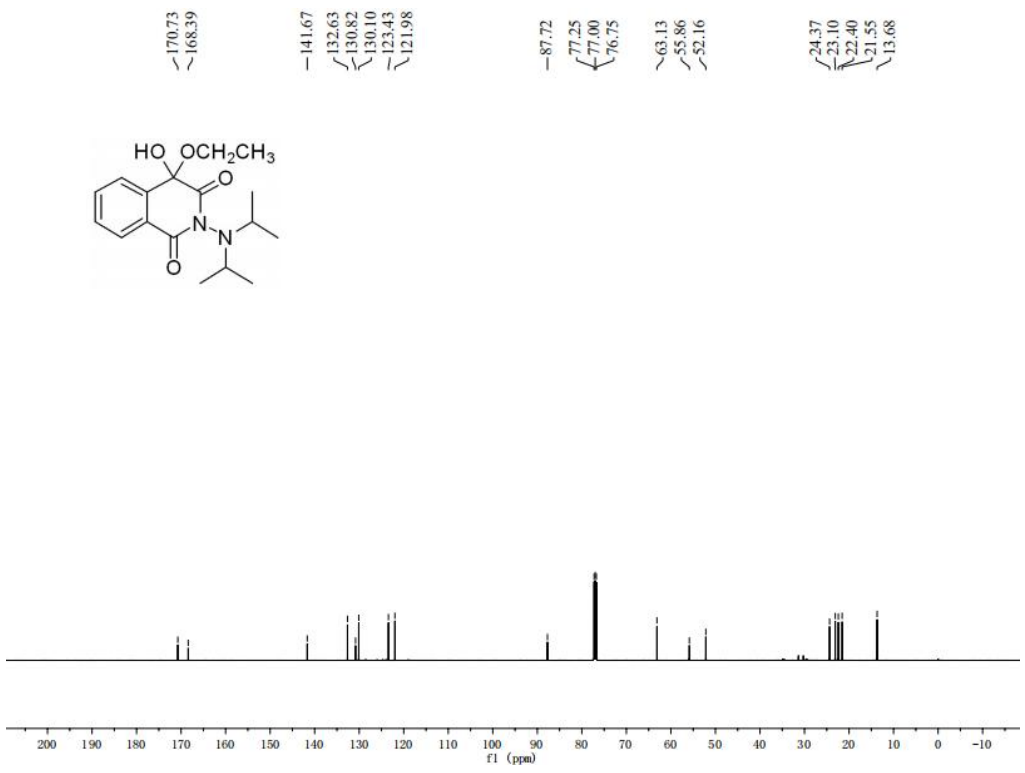
^{13}C NMR (101 MHz) Spectrum of 5 in $CDCl_3$



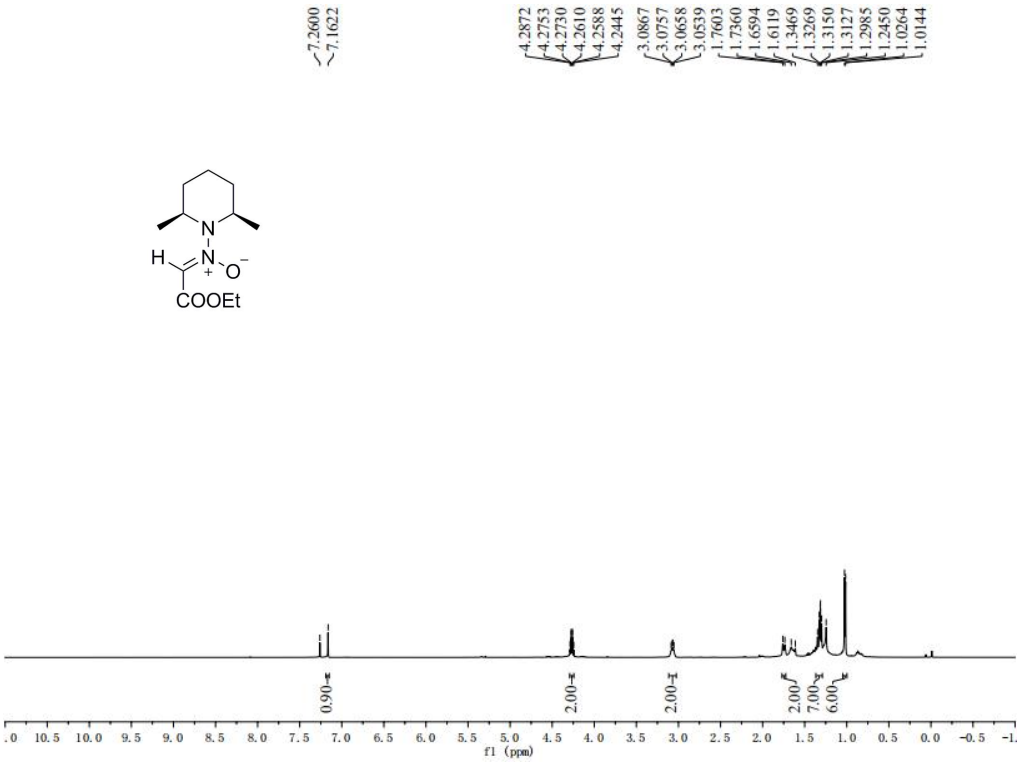
^{1}H NMR (500 MHz) Spectrum of 6 in $CDCl_3$



^{13}C NMR (126 MHz) Spectrum of 6 in $CDCl_3$



^{1}H NMR (500 MHz) Spectrum of 7 in $CDCl_3$



^{13}C NMR (126 MHz) Spectrum of 7 in $CDCl_3$