Electronic Supplementary Material (ESI) for ChemComm.

Supporting Information

Expeditious Synthesis of Phenanthridines through Pd/MnO_2-Mediated C-H Arylation/Oxidative Annulation Cascade from Aldehydes, Aryl Iodides and Amino Acid

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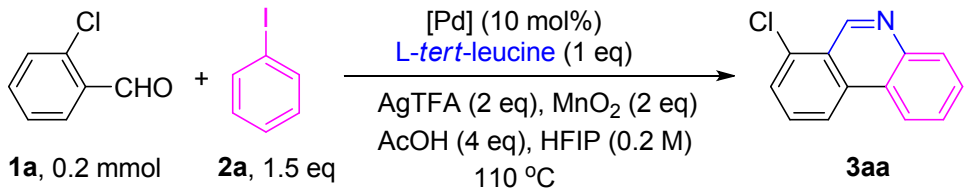
1. General information:

All commercial materials were used as received unless otherwise noted. Commercial reagents were purchased from Alfa Aesar, TCI, Energy Chemical, and used without further purification. ^{1}H NMR spectra were recorded at 400 MHz or 500 MHz NMR spectrometers using TMS as an internal standard, ^{13}C NMR spectra were recorded at 100 MHz or 125 MHz NMR spectrometers using $CDCl_3$ as an internal standard and were fully decoupled by broad band proton decoupling. The multiplicities are reported as follows: singlet (s), doublet (d), doublet of doublets (dd), multiplet (m), triplet (t) and broad resonances (br). Melting points were measured on a hot-stage microscope (XT4-A) and are uncorrected. High resolution mass spectra (HRMS) were obtained on an APEXM Fourier transform mass spectrometry (APCI). EPR spectra were obtained using Bruker EMX plus6/1 X-band variable-temperature apparatus.

2. Optimization of reaction conditions

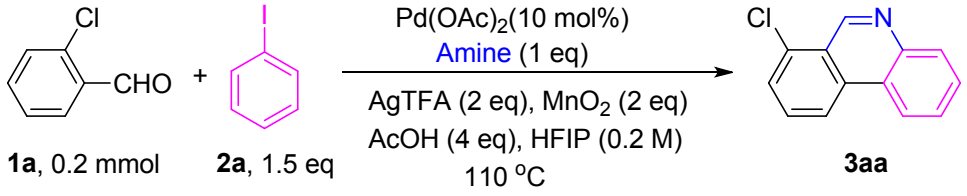
Screening of Catalyst



Entry[a]	[Pd]	Yield (%)[b]
1		N.R.
2	$Pd(OAc)_2$	66
3	$Pd(TFA)_2$	67
4	$Pd(acac)_2$	44
5	$PdCl_2$	63
6	$PdCl_2(CH_3CN)_2$	27
7[c]	$Pd(OAc)_2$	68

[a] Reactions conditons: 1 (0.2 mmol), 2 (0.3 mmol), L-*tert*-leucine (0.2 mmol), [Pd] (0.02 mmol), AgTFA (0.4 mmol), MnO_2 (0.4 mmol), AcOH (0.8 mmol), HFIP (1 mL), 110 °C, 24 h. [b] Isolated yield by flash column chromatography. [c] 15 mmol% of $Pd(OAc)_2$.

Screening of Amino Acid



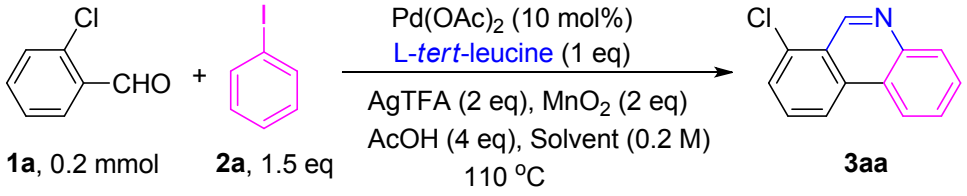
1a, 0.2 mmol **2a**, 1.5 eq **3aa**

Entry[a]	Amine	Yield (%)[b]
1		N.D.
2	L-*tert*-leucine	66
3	L-alanine	trace
4	L-aspartic acid	trace
5	L-valine instead	15
6	L-isoleucine	12[g]
7	Glycine	trace
8	D,L-*tert*-leucine	57
9	L-*tert*-leucine	65[c]
10	L-*tert*-leucine	57[d]
11	$AcNH_4$	36[e], 42[f]
12	*t*-$BuNH_2$	28[e], 34[f]
13	$BnNH_2$	19[e], 14[f]
14	$AcNH_4$	N.D.[h]
15	*t*-$BuNH_2$	N.D.[h]
16	$BnNH_2$	N.D.[h]

[a] Reactions conditons: **1** (0.2 mmol), **2** (0.3 mmol), Amino acid (0.2 mmol), $Pd(OAc)_2$ (0.02 mmol), AgTFA (0.4 mmol), MnO_2 (0.4 mmol), AcOH (0.8 mmol), HFIP (1 mL), 110 °C, 24 h. [b] Isolated yield by flash column chromatography. [c] 1.2 equiv of L-*tert*-leucine. [d] 1.5 equiv of L-*tert*-leucine. [e] 30 mol% of L-*tert*-leucine was used. [f] 1

equiv of L-*tert*-leucine was used. [g] 10% yield of **B** was obtained.[h] 0.2 mmol amine was used.

Screening of Solvent

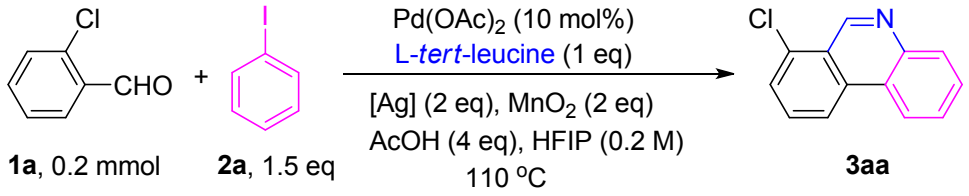


1a, 0.2 mmol **2a**, 1.5 eq **3aa**

Entry[a]	Sovent	Yield (%)[b]
1	HFIP	66
2	TFE	43
3	1,4-dioxane	N.D
4	toluene	N.D
5	DCE	trace
6	MeCN	N.D
7	MeOH	trace
8	AcOH	trace
9	THF	trace
10	DMSO	N.D.
11	HFIP/TFE (v/v = 1:1)	48

[a] Reactions conditons: **1** (0.2 mmol), **2** (0.3 mmol), L-*tert*-leucine (0.2 mmol), $Pd(OAc)_2$ (0.02 mmol), AgTFA (0.4 mmol), MnO_2 (0.4 mmol), AcOH (0.8 mmol), Solvent (1 mL), 110 °C, 24 h. [b] Isolated yield by flash column chromatography.

Screening of [Ag]

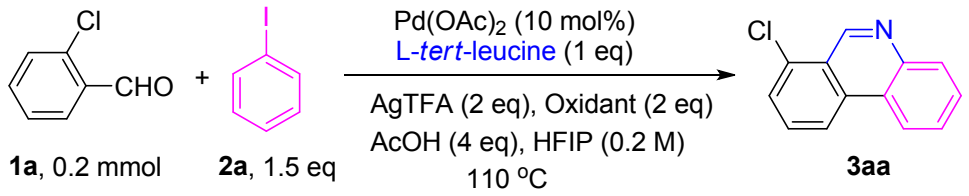


1a, 0.2 mmol **2a**, 1.5 eq **3aa**

Entry [a]	[Ag]	Yield (%) [b]
1		5
2	AgTFA	66
3	Ag_2CO_3	55
4	AgOAc	42
5	Ag_2O	21
6	$AgNO_3$	49
7	AgOTf	57
8	AgF	44
9	AgTFA	57[c]
10	AgTFA	50[d]

[a] Reactions conditons: **1** (0.2 mmol), **2** (0.3 mmol), L-*tert*-leucine (0.2 mmol), $Pd(OAc)_2$ (0.02 mmol), [Ag] (0.4 mmol), MnO_2 (0.4 mmol), AcOH (0.8 mmol), HFIP (1 mL), 110 °C, 24 h. [b] Isolated yield by flash column chromatography. [c] 1.2 equiv of AgTFA. [d] 1.5 equiv of AgTFA.

Screening of Oxidant



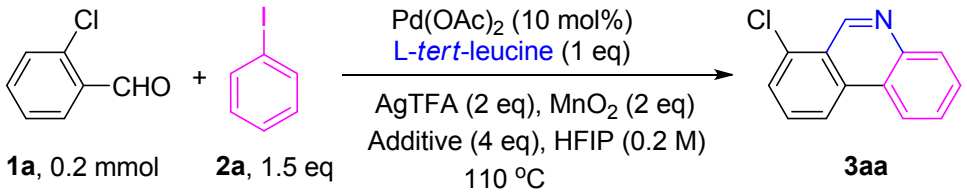
1a, 0.2 mmol **2a**, 1.5 eq **3aa**

Entry [a]	Oxidant	Yield (%) [b]
1	/	N.D.
2	$Mn(acac)_2$	N.D.
3	$Mn(OAc)_2{\cdot}4H_2O$	26
4	$Mn(OAc)_3{\cdot}2H_2O$	61

5	MnO_2	66
6	BQ	21
7	$PhI(OAc)_2$	N.D.
8	Selectflour	N.D.
9	DDQ	N.D.
10	$Na_2S_2O_8$	trace
11	$K_2S_2O_8$	trace
12	Oxone	N.D.
13	$Cu(OAc)_2$	23
14	CuO	21
15[c]	MnO_2	33
16[d]	MnO_2	64

[a] Reactions conditons: **1** (0.2 mmol), **2** (0.3 mmol), L-*tert*-leucine (0.2 mmol), $Pd(OAc)_2$ (0.02 mmol), AgTFA (0.4 mmol), Oxidant (0.4 mmol), AcOH (0.8 mmol), HFIP (1 mL), 110 °C, 24 h. [b] Isolated yield by flash column chromatography. [c] 1.0 equiv of MnO_2. [d] 4.0 equiv of MnO_2.

Screening of Additive



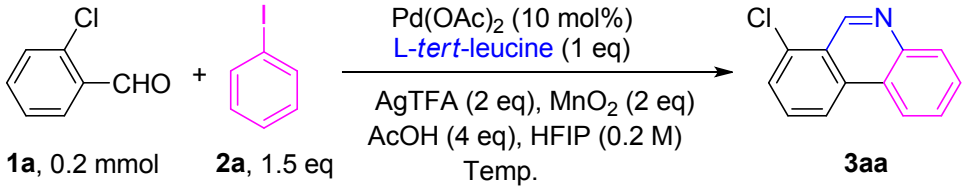
1a, 0.2 mmol **2a**, 1.5 eq **3aa**

Entry [a]	Additive	Yield (%) [b]
1	/	16
2	AcOH	66
3	PivOH	47
4	TFA	trace
5	$TsOH{\cdot}H_2O$	trace
6	*o*-ClC_6H_4COOH	52
7	*o*-$CH_3C_6H_4COOH$	52
8	PhCOOH	51

9	3,4-$F_2C_6H_3COOH$	46
10	2,4-$Cl_2C_6H_3COOH$	42
11	*m*-CPBA	trace
12	KH_2PO_4	trace
13	K_3PO_4	trace
14	AcOH	54[c]
15	AcOH	61[d]

[a] Reactions conditons: **1** (0.2 mmol), **2** (0.3 mmol), L-*tert*-leucine (0.2 mmol), $Pd(OAc)_2$ (0.02 mmol), AgTFA (0.4 mmol), MnO_2 (0.4 mmol), Additive (0.8 mmol), HFIP (1 mL), 110 °C, 24 h. [b] Isolated yield by flash column chromatography. [c] 2 equiv of AcOH. [d]. 6 equiv of AcOH.

Screening of Temperature

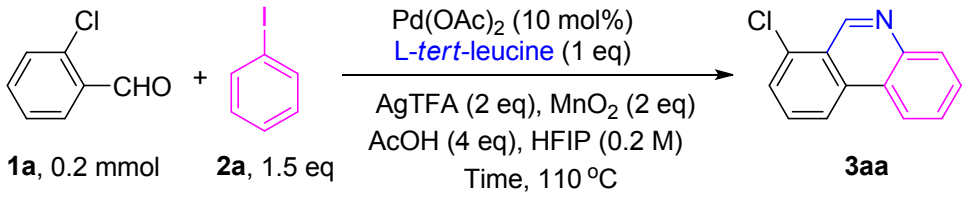


1a, 0.2 mmol **2a**, 1.5 eq **3aa**

Entry [a]	T (°C)	Yield (%) [b]
1	100	41
2	110	66
3	120	59

[a] Reactions conditons: **1** (0.2 mmol), **2** (0.3 mmol), L-*tert*-leucine (0.2 mmol), $Pd(OAc)_2$ (0.02 mmol), AgTFA (0.4 mmol), MnO_2 (0.4 mmol), AcOH (0.8 mmol), HFIP (1 mL), Temp., 24 h. [b] Isolated yield by flash column chromatography.

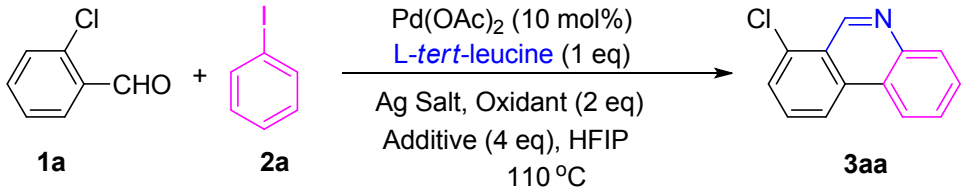
Screening of Reaction Time



Entry [a]	Time (h)	Yield (%) [b]
1	15	40
2	24	66
3	36	62
4	48	60

[a] Reactions conditons: **1** (0.2 mmol), **2** (0.3 mmol), L-*tert*-leucine (0.2 mmol), $Pd(OAc)_2$ (0.02 mmol), AgTFA (0.4 mmol), MnO_2 (0.4 mmol), AcOH (0.8 mmol), HFIP (1 mL), 110 °C, Time. [b] Isolated yield by flash column chromatography.

Table S1 Optimization of reaction conditions [a]



Entry	Ag Salt	Oxidant	Additive	Yield (%)[b]
1	AgOAc	MnO_2	AcOH	42
2	Ag_2CO_3	MnO_2	AcOH	55
3	Ag_2O	MnO_2	AcOH	21
4	$AgNO_3$	MnO_2	AcOH	49
5	AgOTf	MnO_2	AcOH	57
6	AgF	MnO_2	AcOH	44
7	AgTFA	MnO_2	AcOH	66
8	AgTFA	MnO_2	AcOH	64[c]
9	AgTFA	$Mn(acac)_2$	AcOH	N.D.
10	AgTFA	$Mn(OAc)_2{\cdot}4H_2O$	AcOH	26

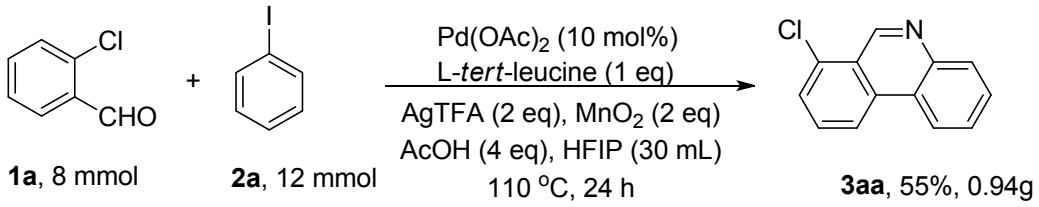
11	AgTFA	$Mn(OAc)_3{\cdot}2H_2O$	AcOH	61
12	AgTFA	BQ	AcOH	21
13	AgTFA	$PhI(OAc)_2$	AcOH	N.D.
14	AgTFA	$Na_2S_2O_8$	AcOH	Trace
15	AgTFA	$K_2S_2O_8$	AcOH	Trace
16	AgTFA	$Cu(OAc)_2$	AcOH	23
17	AgTFA	CuO	AcOH	21
18	AgTFA	MnO_2	TFA	Trace
19	AgTFA	MnO_2	$TsOH{\cdot}H_2O$	Trace
20	AgTFA	MnO_2	PivOH	47
21	AgTFA	MnO_2	$PhCO_2H$	51

[a] Reactions conditons: **1a** (0.2 mmol), **2a** (0.3 mmol), L-*tert*-leucine (0.2 mmol), $Pd(OAc)_2$ (0.02 mmol), Ag Sat (0.4 mmol), Oxidant (0.4 mmol), Additive (0.8 mmol), HFIP (1 mL), 110 °C, 24 h. [b] Isolated yield by flash column chromatography. [c] Under argon atmosphere.

3. General procedure for synthesis of phenanthridine

A mixture of aldehyde substrates (**1**, 0.2 mmol), aryl iodide (**2**, 0.3 mmol), L-*tert*-leucine (0.2 mmol), $Pd(OAc)_2$ (0.02 mmol), AgTFA(0.4 mmol), MnO_2 (fresh) (0.4 mmol), AcOH (0.8 mmol) and HFIP (1.0 mL) was added to a 15 mL sealed tube. The tube was stirred at 110 °C for 24 h. Then, the reaction mixture was cooled to room temperature. The mixture was filtered through Celite®, and the filter cake was rinsed with EtOAc. The combined organic was removed in vacuo. Then the mixture was subjected to column chromatography on silica gel to give the desired product.

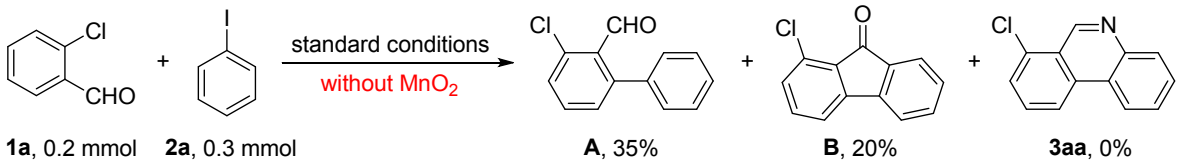
4. Gram-scale preparation of 3aa and competition experiment



1a, 8 mmol **2a**, 12 mmol **3aa**, 55%, 0.94g

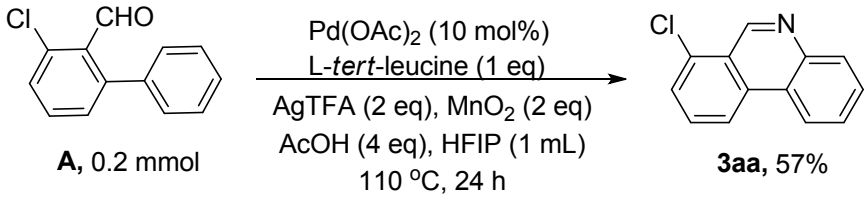
A 75 mL Schlenk tube was charged with *o*-chlorobenzaldehyde **1a** (8 mmol), **2a** (12 mmol), L-*tert*-leucine (8 mmol) and $Pd(OAc)_2$ (0.8 mmol), AgTFA (16 mmol), MnO_2 (fresh) (16 mmol). The mixture was dissolved in 30 mL HFIP followed by addition of AcOH (32 mmol). The reaction mixture was stirred for 24 hours at 110 °C. After that it was filtered through a short pad of Celite® and washed with ethyl acetate. The solvent was then evaporated under reduced pressure and the crude was purified by column chromatography on silica gel to afford the pure product **3aa** (0.94 g, 55% isolated yield).

5. Control experiments



1a, 0.2 mmol **2a**, 0.3 mmol **A**, 35% **B**, 20% **3aa**, 0%

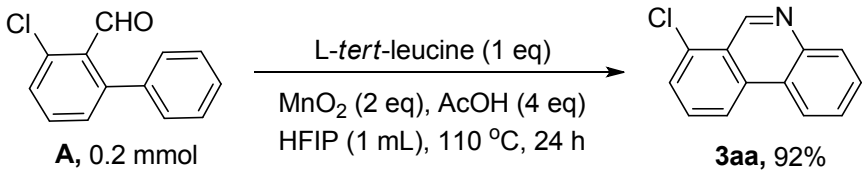
A 15 mL Schlenk tube was charged with *o*-chlorobenzaldehyde **1a** (0.2 mmol), **2a** (1.5 mmol), L-*tert*-leucine (1.0 mmol) and $Pd(OAc)_2$ (0.02 mmol), AgTFA (0.4 mmol). The mixture was dissolved in 1 mL HFIP followed by addition of AcOH (0.8 mmol). The reaction mixture was stirred for 24 hours at 110 °C. After that it was filtered through a short pad of Celite® and washed with ethyl acetate. The solvent was then evaporated under reduced pressure and the crude was purified by column chromatography on silica gel to afford the pure product **A** and **B**.



A, 0.2 mmol **3aa,** 57%

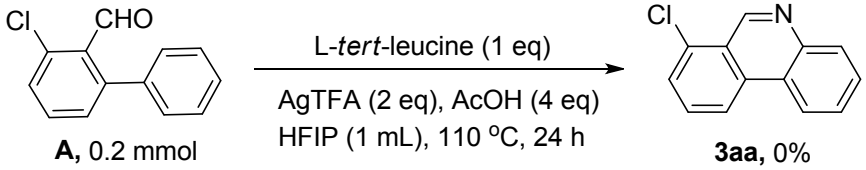
A 15 mL Schlenk tube was charged with biphenyl aldehyde **A** (0.2 mmol), L-*tert*-leucine (0.2 mmol) and $Pd(OAc)_2$ (0.02 mmol), AgTFA (0.4 mmol), MnO_2 (fresh) (0.4 mmol). The mixture was dissolved in 1 mL HFIP followed by addition of AcOH (0.8 mmol). The reaction mixture was stirred for 24 hours at 110 °C. After that it was filtered through a short pad of Celite® and washed with ethyl acetate. The solvent was then evaporated under reduced pressure and the crude was purified by column chromatography on silica gel to

afford the pure product **3aa** (57% isolated yield).



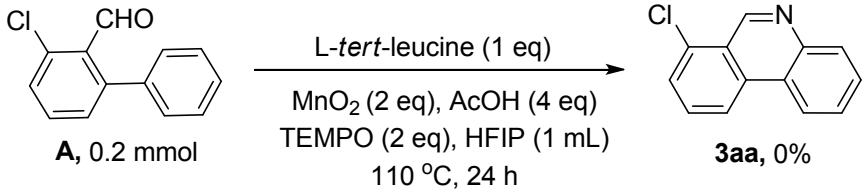
A, 0.2 mmol **3aa,** 92%

A mixture of biphenyl aldehyde **A** (0.2 mmol), L-*tert*-leucine (0.2 mmol), MnO_2 (fresh) (0.4 mmol), AcOH (0.8 mmol) and HFIP (1.0 mL) was added to a 15 mL sealed tube. The tube was stirred at 110 °C for 24 h. Then, the reaction mixture was cooled to room temperature. The mixture was filtered through Celite®, and the filter cake was rinsed with EtOAc. The solvent was then evaporated under reduced pressure and the crude was purified by column chromatography on silica gel to afford the pure product **3aa** (92% isolated yield).



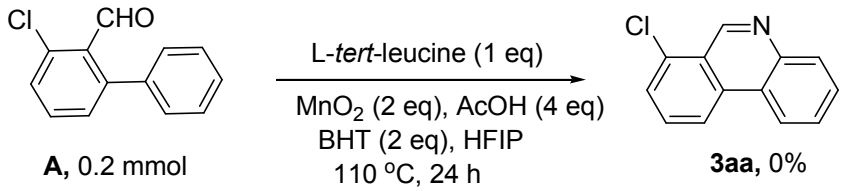
A, 0.2 mmol **3aa,** 0%

A mixture of biphenyl aldehyde **A** (0.2 mmol), L-*tert*-leucine (0.2 mmol), AgTFA (0.4 mmol), AcOH (0.8 mmol) and HFIP (1.0 mL) was added to a 15 mL sealed tube. The tube was stirred at 110 °C for 24 h. Then, the reaction mixture was cooled to room temperature. And no **3aa** was detected by TLC.

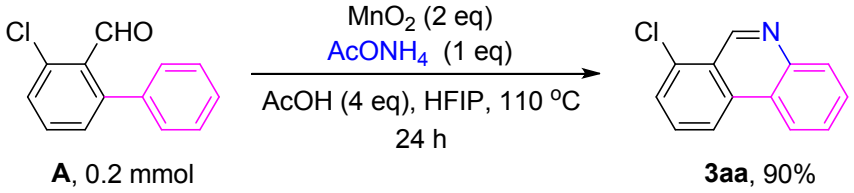


A, 0.2 mmol **3aa,** 0%

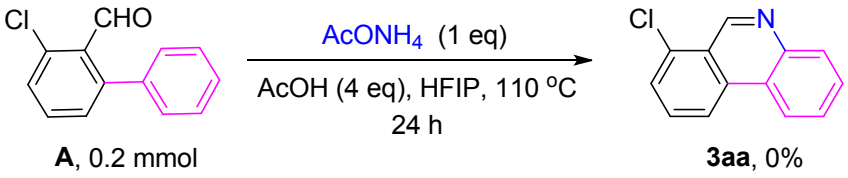
A mixture of biphenyl aldehyde **A** (0.2 mmol), L-*tert*-leucine (0.2 mmol), TEMPO (0.4 mmol), MnO_2 (fresh) (0.4 mmol), AcOH (0.8 mmol) and HFIP (1.0 mL) was added to a 15 mL sealed tube. The tube was stirred at 110 °C for 24 h. Then, the reaction mixture was cooled to room temperature. And no **3aa** was detected by TLC.



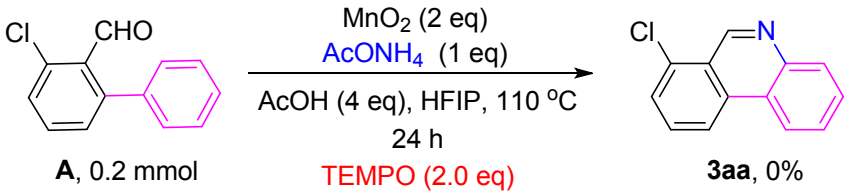
A mixture of biphenyl aldehyde **A** (0.2 mmol), L-*tert*-leucine (0.2 mmol), BHT (0.4 mmol), MnO_2 (fresh) (0.4 mmol), AcOH (0.8 mmol) and HFIP (1.0 mL) was added to a 15 mL sealed tube. The tube was stirred at 110 °C for 24 h. Then, the reaction mixture was cooled to room temperature. And no **3aa** was detected by TLC.



A mixture of biphenyl aldehyde **A** (0.2 mmol), $AcONH_4$ (0.2 mmol), MnO_2 (fresh) (0.4 mmol), AcOH (0.8 mmol) and HFIP (1.0 mL) was added to a 15 mL sealed tube. The tube was stirred at 110 °C for 24 h. Then, the reaction mixture was cooled to room temperature. The mixture was filtered through Celite®, and the filter cake was rinsed with EtOAc. The solvent was then evaporated under reduced pressure and the crude was purified by column chromatography on silica gel to afford the pure product **3aa** (90% isolated yield).



A mixture of biphenyl aldehyde **A** (0.2 mmol), $AcONH_4$ (0.2 mmol), AcOH (0.8 mmol) and HFIP (1.0 mL) was added to a 15 mL sealed tube. The tube was stirred at 110 °C for 24 h. Then, the reaction mixture was cooled to room temperature. And no **3aa** was detected by TLC.

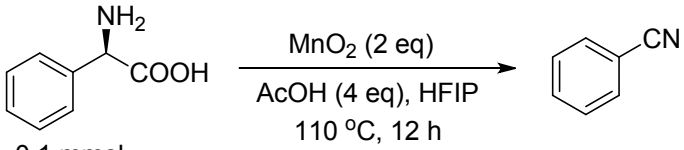


A, 0.2 mmol

3aa, 0%

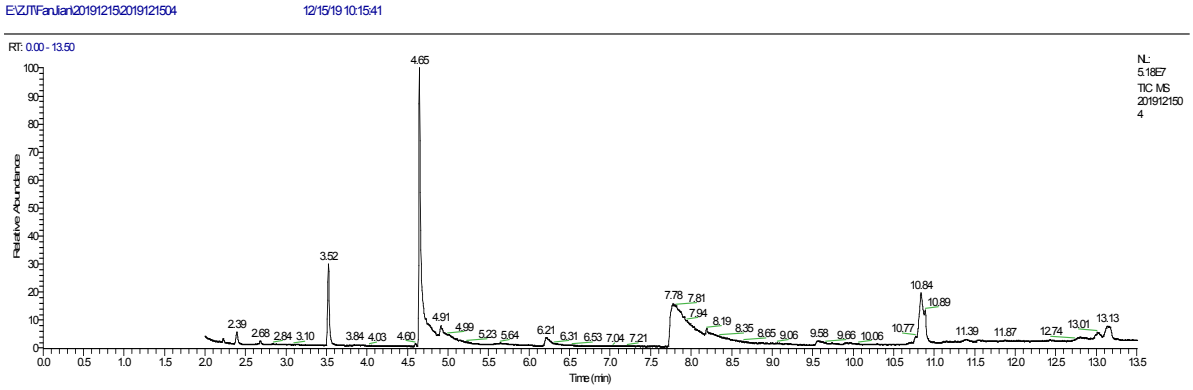
A mixture of biphenyl aldehyde **A** (0.2 mmol), $AcONH_4$ (0.2 mmol), TEMPO (0.4 mmol), MnO_2 (fresh) (0.4 mmol), AcOH (0.8 mmol) and HFIP (1.0 mL) was added to a 15 mL sealed tube. The tube was stirred at 110 °C for 24 h. Then, the reaction mixture was cooled to room temperature. And no **3aa** was detected by TLC.

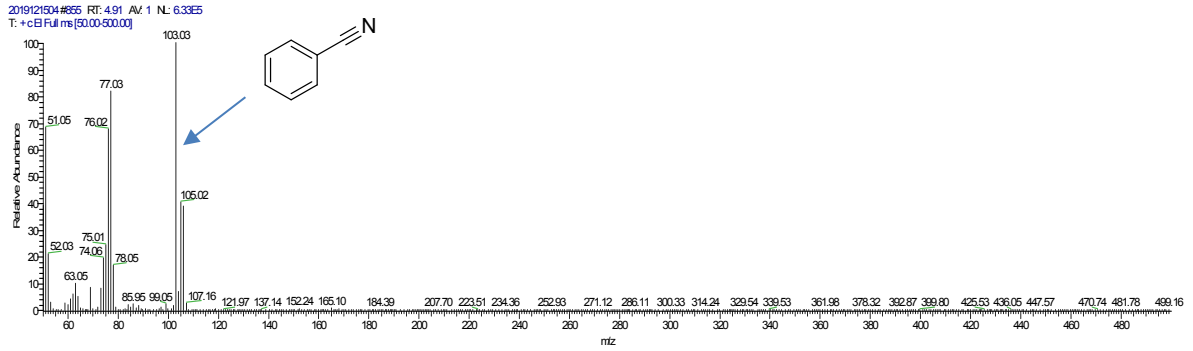
6. GC-MS analysis

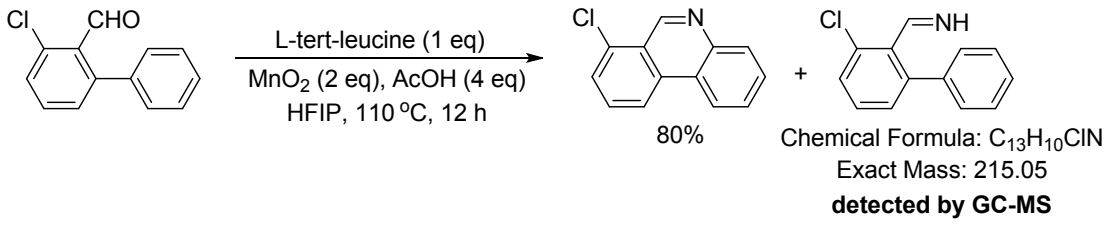


0.1 mmol

Chemical Formula: C_7H_5N
Exact Mass: 103.04
detecded by GC-MS





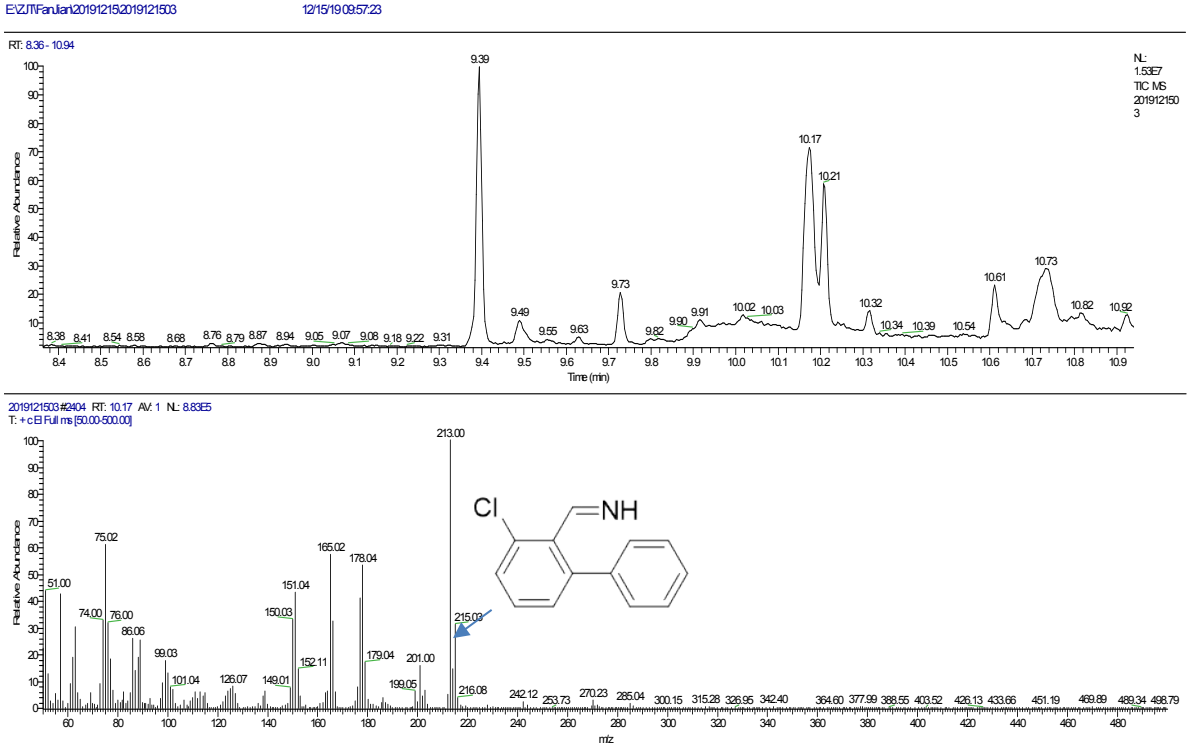


80%

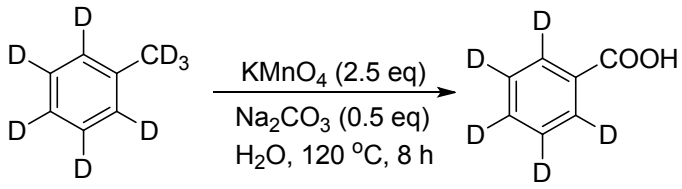
Chemical Formula: $C_{13}H_{10}ClN$

Exact Mass: 215.05

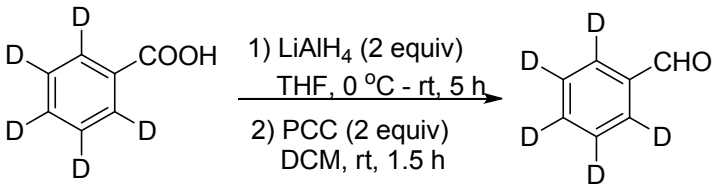
detected by GC-MS



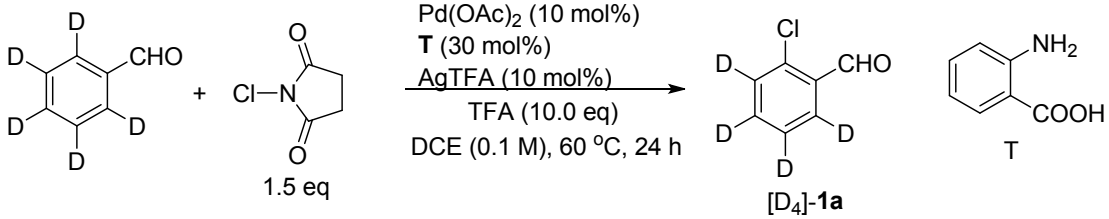
7. Deuteration Studies



A round-bottom flask equipped with a stir bar and a condenser was charged with d_8-tolune (99.9 atom % D) (1 g, 10 mmol), $KMnO_4$ (4 g, 25 mmol), Na_2CO_3 (0.26 g, 5 mmol), and H_2O (30 mL). The reaction mixture was refluxed for 8 h and then cooled to room temperature. The mixture was filtered through a pad of celite, and the filtrate was acidified with 12 M HCl and extracted with DCM (3 × 30 mL). The organic layer was washed with water and concentrated in vacuo. The crude product was recrystallized from water to give $C_6D_5CO_2H$ as white needle solid (0.64 g, 50% yield). Synthesis of $C_6D_5CO_2H$ was prepared using a similar procedure (P. Gandeepan, P. Rajamalli, C. Cheng, *Angew. Chem. Int. Ed*., 2016, **55**, 4308-4311).



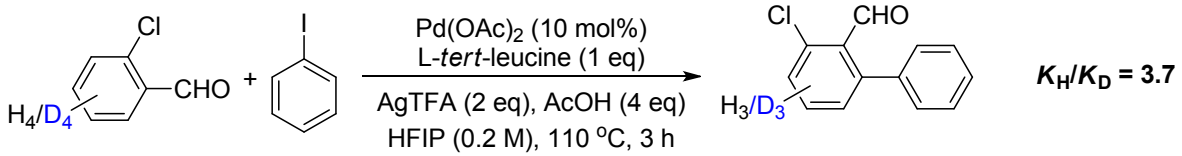
[$^2H_5$]-Benzyl alcohol (0.45 g; 4 mmol) in CH_2Cl_2 (2 mL) was slowly dropped into the solution of pyridinium chlorochromate (Sigma-Aldrich) (1.5 g; 6 mmol) and CH_2Cl_2 (12 mL). The mixture which turned quickly from orange to black was stirred for 1.5 h. Diethyl ether (20 mL) was added, and the residue was further extracted with diethyl ether (3 × 10 mL) until the gummy residue became granular solid. The combined extracts were passed through dry Florisil® (Sigma-Aldrich) (10 g), and the solvent was remove by N_2 gas to obtain [$^2H_5$]- benzaldehyde (80% yield, 85.1% purity) (L. Li, B. Zhou, Y.-H. Wang, C. Shu, Y.-F. Pan, X. Lu, L.-W. Ye, *Angew. Chem. Int. Ed.*, 2015, **54**, 8245 –8249).

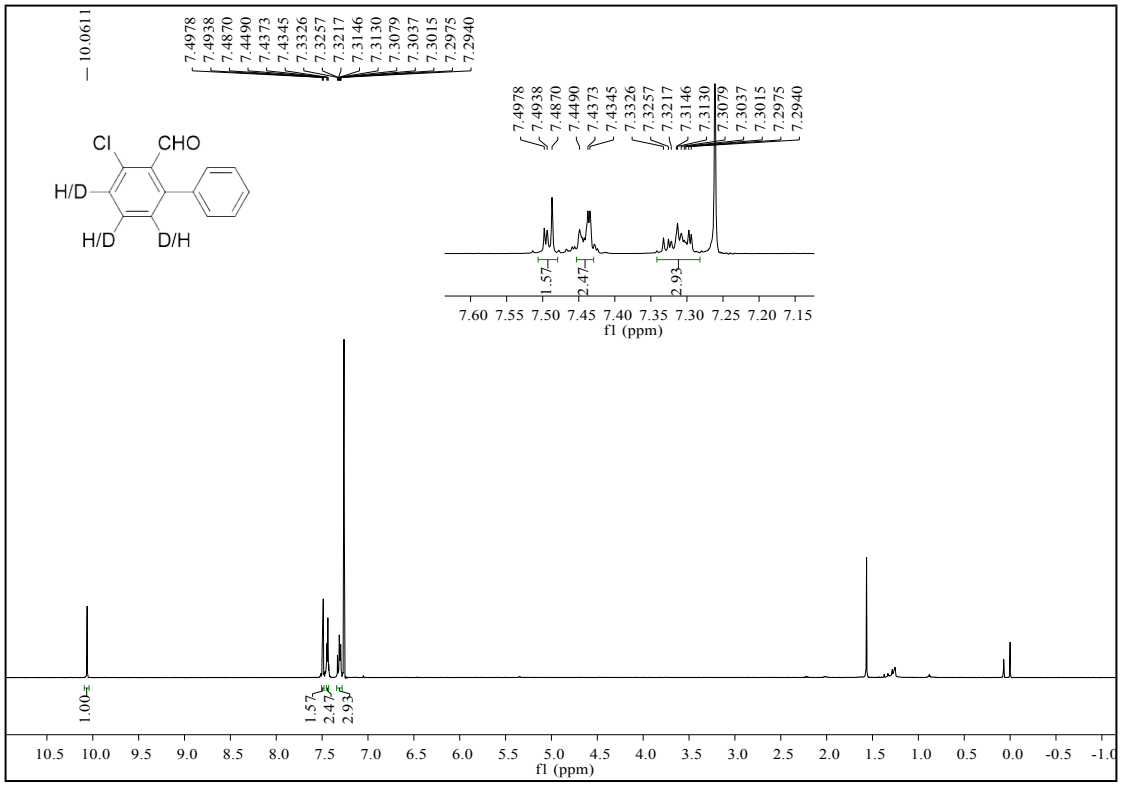


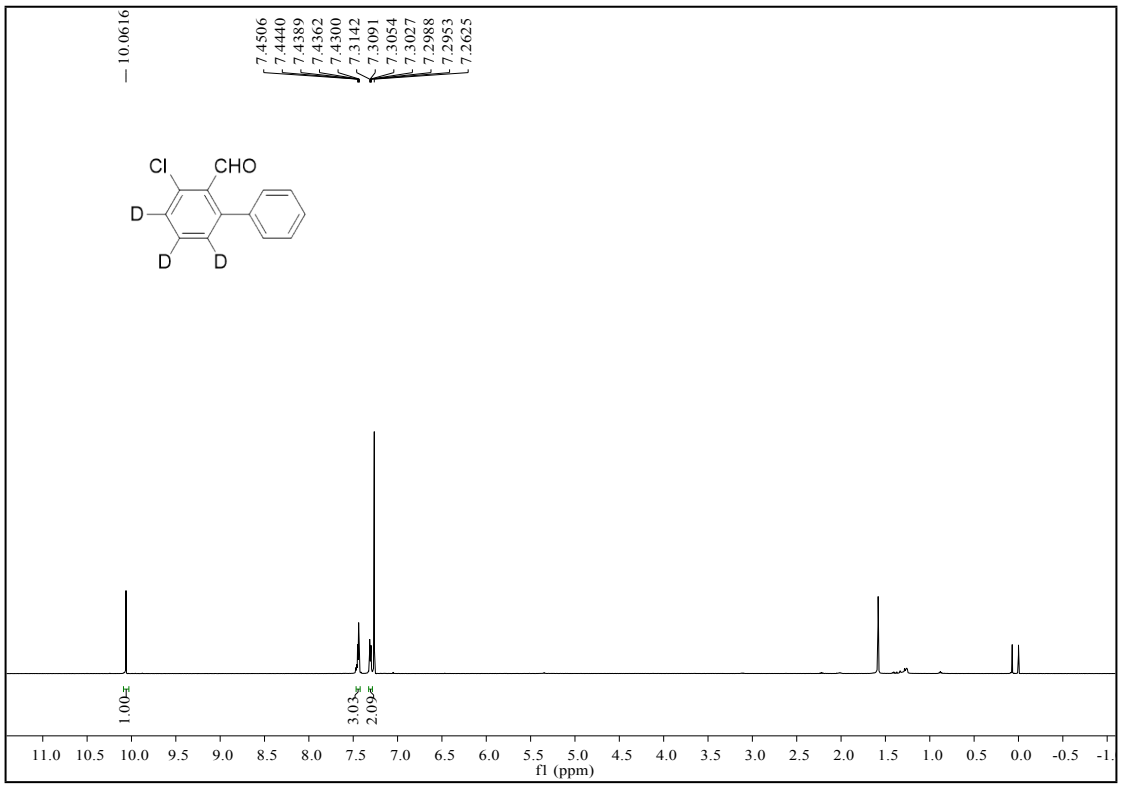
A sealed tube with magnetic stir bar was charged with [$^2H_5$]- benzaldehyde (0.3 mmol), NCS (0.45 mmol, 60.0 mg), $Pd(OAc)_2$ (0.03 mmol, 6.7 mg), **T** (0.09 mmol, 12.3 mg), and AgTFA (0.03 mmol, 6.6 mg) in air, followed by DCE (3.0 mL) and TFA (3.0 mmol, 342.0 mg). The reaction mixture was stirred at 60 °C for 24 hours. Upon completion, the reaction mixture was quenched by sat. $NaHCO_3$ (aq) (30 mL), and extracted with DCM for 3 times. The combined organic layers were washed with water (50 mL), dried over anhydrous Na_2SO_4, and concentrated in vacuo. The crude residue was purified by column

chromatography on silica gel using petroleum ether/EtOAc (50:1) as eluent to afford the [D_4]-**1a** (65% yield) (X.-H. Liu, H. Park, J.-H. Hu, Y. Hu, Q.-L. Zhang, B.-L. Wang, B. Sun, K.-S. Yeung, F.-L. Zhang, J.-Q. Yu, *J. Am. Chem. Soc.* 2017, **139**, 888−896).

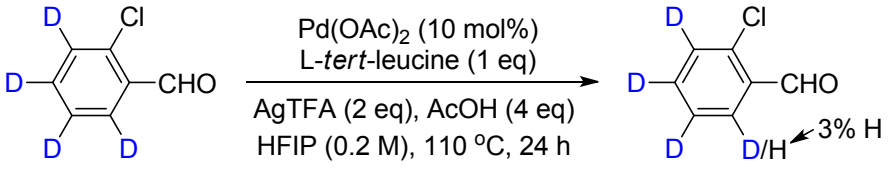
A 15 mL Schlenk tube was charged with *o*-chlorobenzaldehyde **1a** (0.1 mmol), [D_4]-**1a** (0.1 mmol), **2a** (1.5 mmol), L-*tert*-leucine (1.0 mmol) and $Pd(OAc)_2$ (0.02 mmol), AgTFA (0.4 mmol). The mixture was dissolved in 1 mL HFIP followed by addition of AcOH (0.8 mmol). The reaction mixture was stirred for 3 hours at 110 °C. After that it was filtered through a short pad of Celite® and washed with ethyl acetate. The solvent was then evaporated under reduced pressure and the crude was purified by column chromatography on silica gel to afford the pure arylation product, and the KIE was determined by ^{1}H NMR.





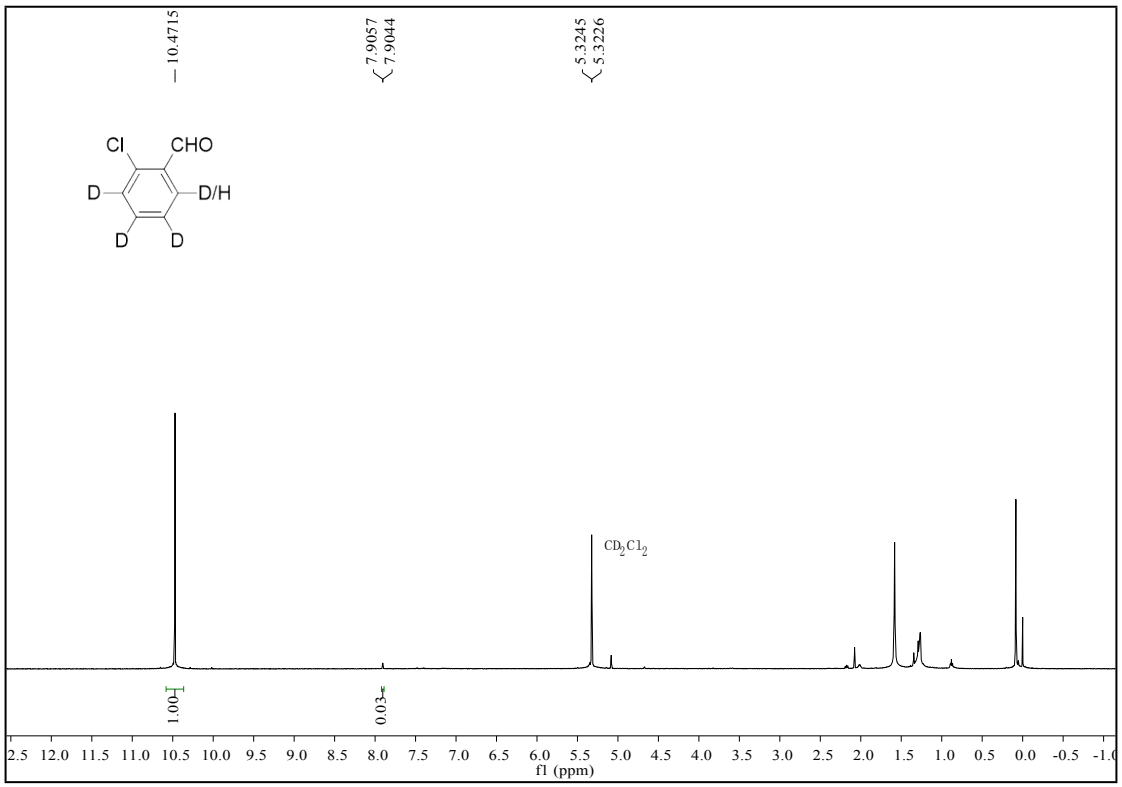


A 15 mL Schlenk tube was charged with [D_4]-**1a** (0.2 mmol), L-*tert*-leucine (1.0 mmol) and $Pd(OAc)_2$ (0.02 mmol), AgTFA (0.4 mmol). The mixture was dissolved in 1 mL HFIP followed by addition of AcOH (0.8 mmol). The reaction mixture was stirred for 24 hours at 110 °C. After that it was filtered through a short pad of Celite® and washed with ethyl acetate. The solvent was then evaporated under reduced pressure and the aldehyde was recovered by column chromatography on silica gel and characterized by ^{1}H NMR.

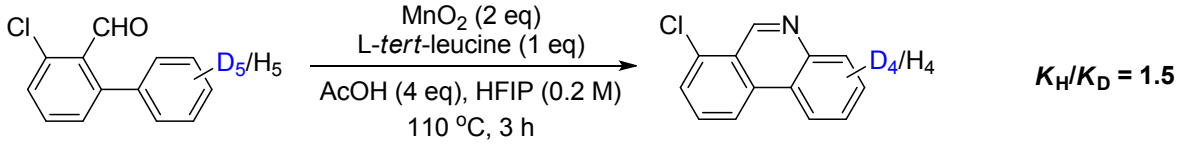


[D_4]-**1a**, > 99% D

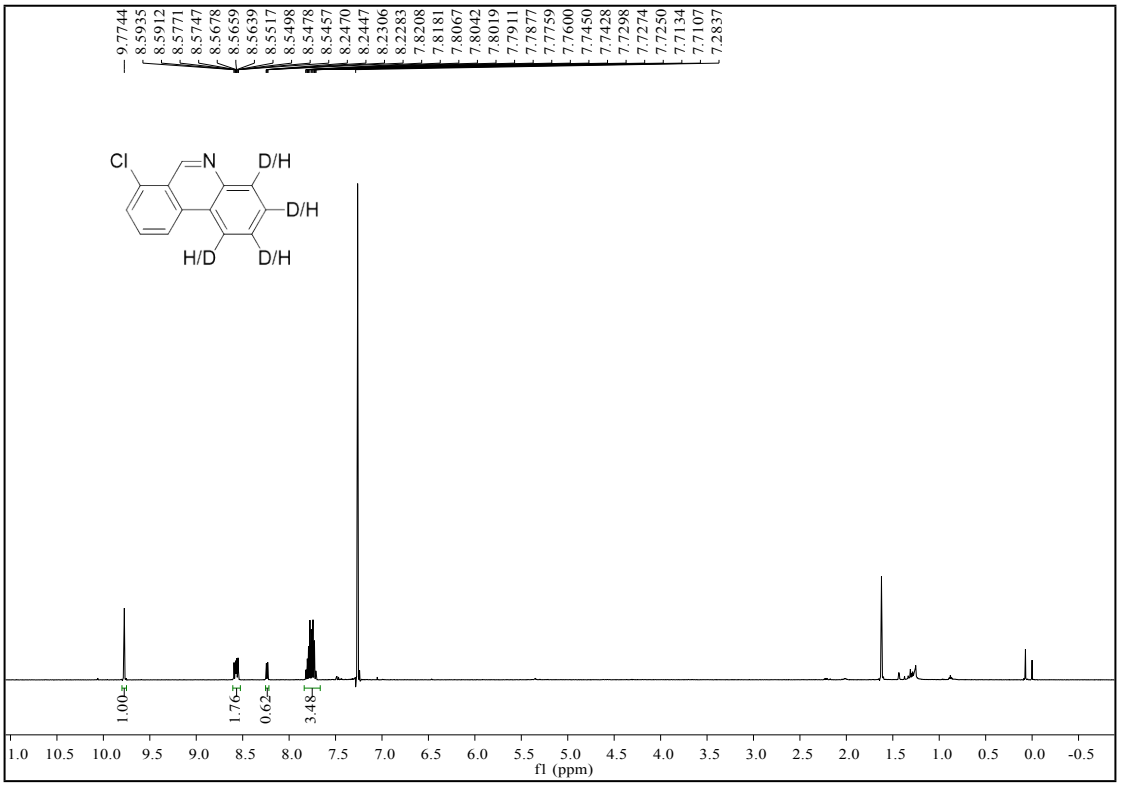
[D_4]-**1a**, 97% D

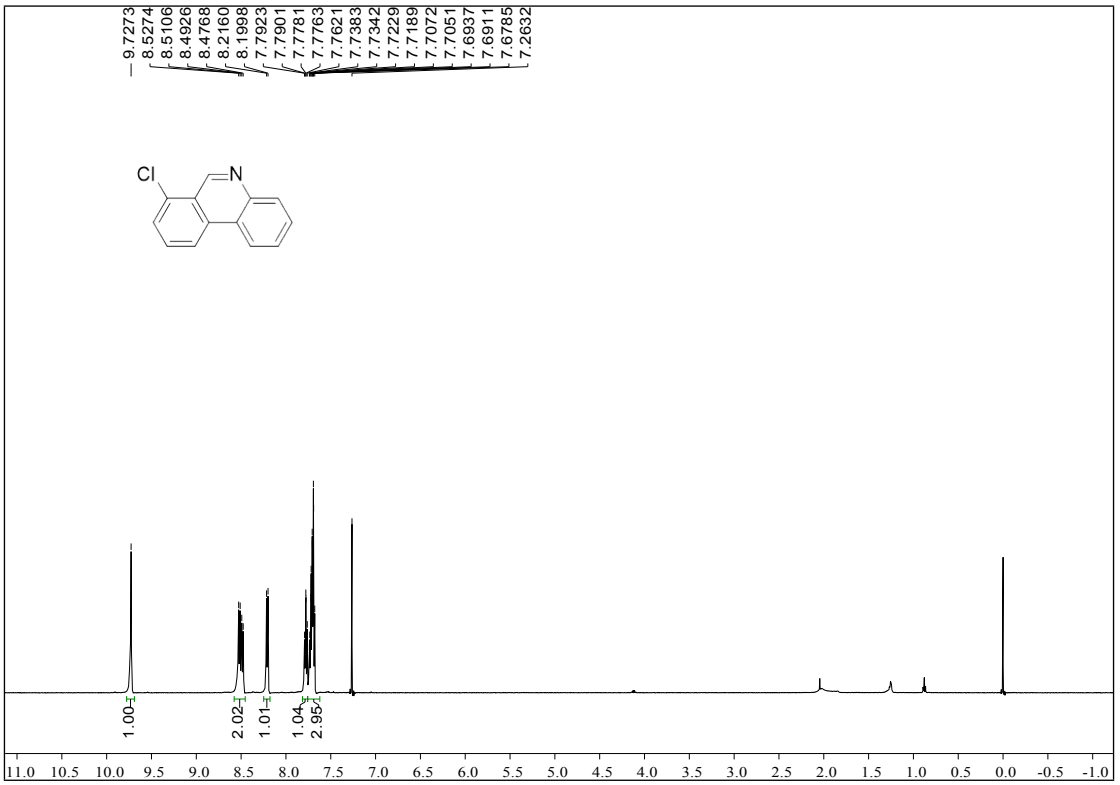


A mixture of biphenyl aldehyde **A** (0.1 mmol), [D_5]-**A** (0.1 mmol), L-*tert*-leucine (0.2 mmol), MnO_2 (fresh) (0.4 mmol), AcOH (0.8 mmol) and HFIP (1.0 mL) was added to a 15 mL sealed tube. The tube was stirred at 110 °C for 3 h. Then, the reaction mixture was cooled to room temperature. The mixture was filtered through Celite®, and the filter cake was rinsed with EtOAc. The solvent was then evaporated under reduced pressure and the crude was purified by column chromatography on silica gel to afford the pure phenanthridine product, and the KIE was determined by ^{1}H NMR.

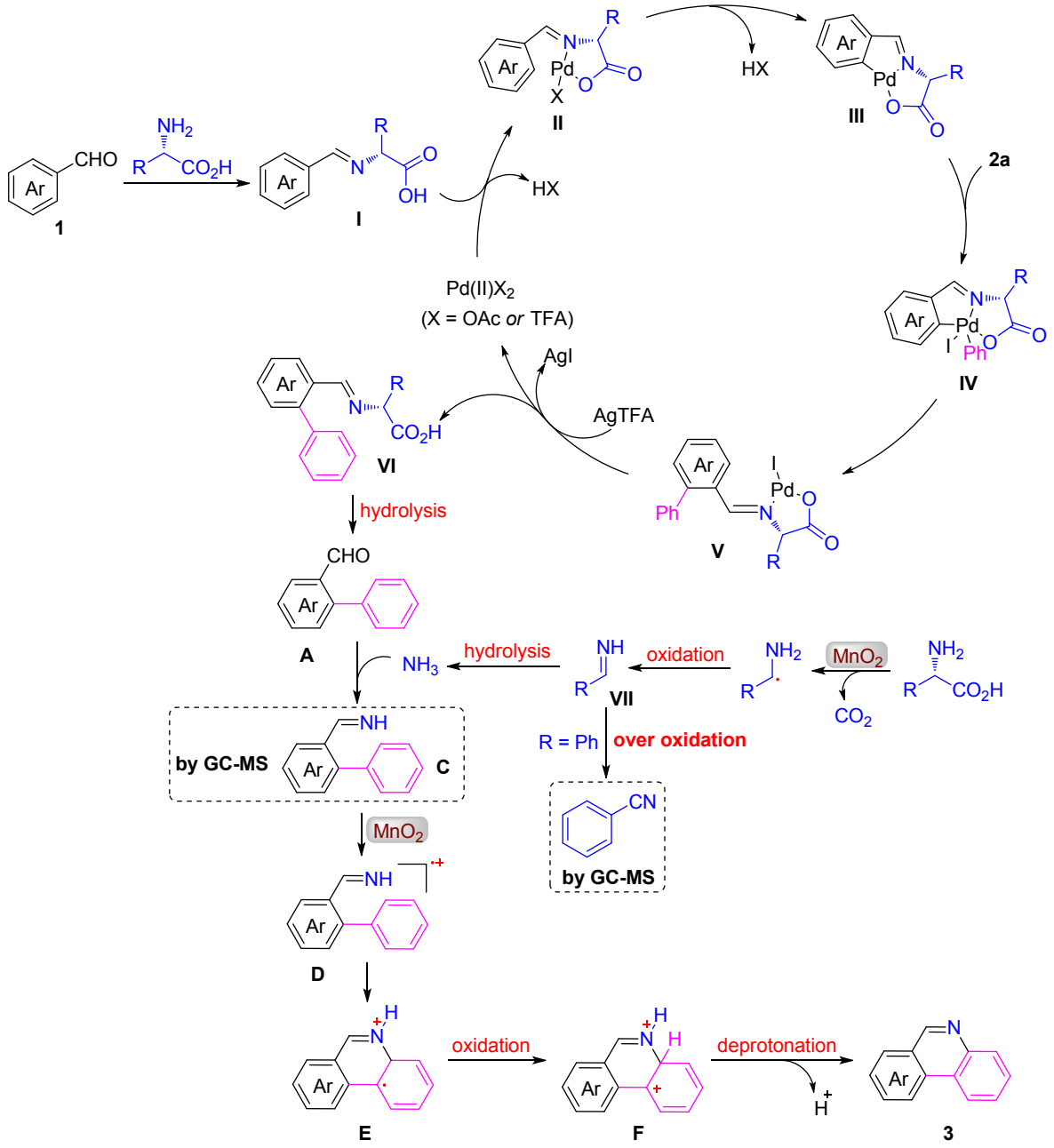


A/[D_5]-**A** **3aa**/[D_4]-**3aa** K_H/K_D = 1.5


9.7744
8.5935
8.5912
8.5771
8.5747
8.5678
8.5659
8.5639
8.5517
8.5498
8.5478
8.5457
8.2470
8.2447
8.2306
8.2283
8.8208
7.8181
7.8067
7.8042
7.8019
7.7911
7.7877
7.7759
7.7600
7.7450
7.7428
7.7298
7.7274
7.7250
7.7134
7.7107
7.2837
Cl
N
D/H
D/H
H/D
D/H
1.00
1.76
0.62
3.48
f1 (ppm)

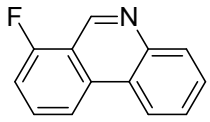

9.7273
8.5274
8.5106
8.4926
8.4768
8.2160
8.1998
7.7923
7.7901
7.7781
7.7763
7.7621
7.7383
7.7342
7.7229
7.7189
7.7072
7.7051
7.6937
7.6911
7.6785
7.2632
Cl
N
1.00
2.02
1.01
1.04
2.95

8. Proposed mechanism (Scheme S1)



Analytic Data of Products

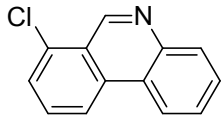
7-fluorophenanthridine (3ba)



White solid. Isolated yield: 66%. Melting point: 90-91 °C.

^{1}H NMR (500 MHz, $CDCl_3$, TMS as the internal standard): δ 9.61 (s, 1H), 8.57-8.55 (m, 1H), 8.39 (d, J = 8.5 Hz, 1H), 8.23 (d, J = 8.2 Hz, 1H), 7.83-7.78 (m, 2H), 7.73-7.70 (m, 1H), 7.38-7.34 (m, 1H). **^{13}C NMR** (125 MHz, $CDCl_3$, $CDCl_3$ as the internal standard): δ 160.6 ($J_{F\text{-}C}$ = 254.0 Hz), 146.8 ($J_{F\text{-}C}$ = 6.8 Hz), 144.9, 134.7 ($J_{F\text{-}C}$ = 3.2 Hz), 131.9 ($J_{F\text{-}C}$ = 8.9 Hz), 130.8, 129.7, 128.0, 123.5 ($J_{F\text{-}C}$ = 2.1 Hz), 122.9, 118.2 ($J_{F\text{-}C}$ = 4.3 Hz), 116.5 ($J_{F\text{-}C}$ = 13.9 Hz), 112.6 ($J_{F\text{-}C}$ = 19.4 Hz). **HRMS** (APCI) calcd for $C_{13}H_9FN$ ($M+H^+$): 198.0713, found: 198.0712.

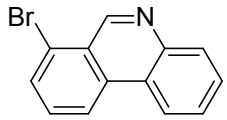
7-chlorophenanthridine (3aa)



White solid. Isolated yield: 66%. Melting point: 95-96 °C.

^{1}H NMR (500 MHz, $CDCl_3$, TMS as the internal standard): δ 9.73 (s, 1H), 8.53-8.48 (m, 2H), 8.21 (d, J = 8.1 Hz, 1H), 7.79-7.76 (m, 1H), 7.74-7.68 (m, 3H). **^{13}C NMR** (125 MHz, $CDCl_3$, $CDCl_3$ as the internal standard): δ 150.0, 144.8, 134.7, 134.2, 131.3, 130.7, 129.7, 128.4, 128.0, 123.5, 123.46, 122.8, 121.3. **HRMS** (APCI) calcd for $C_{13}H_9ClN$ ($M+H^+$): 214.0418, found: 214.0416.

7-bromophenanthridine (3ca)

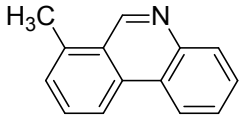


White solid. Isolated yield: 55%. Melting point: 151-152 °C.

^{1}H NMR (500 MHz, $CDCl_3$, TMS as the internal standard): δ 9.70 (s, 1H), 8.57 (t, J = 8.7 Hz, 2H), 8.39 (d, J = 8.1 Hz, 1H), 7.92 (d, J = 7.6 Hz, 1H), 7.80 (t, J = 7.2 Hz, 1H), 7.73-

7.66 (m, 2H). **^{13}C NMR** (125 MHz, $CDCl_3$, $CDCl_3$ as the internal standard): δ 152.6, 144.8, 135.0, 132.1, 131.7, 130.7, 129.8, 128.0, 124.7, 124.5, 123.4, 122.7, 122.0. **HRMS** (APCI) calcd for $C_{13}H_9BrN$ ($M+H^+$): 257.9912, found: 257.9910.

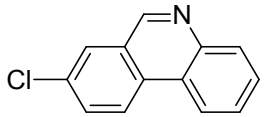
7-methylphenanthridine (3da)



White solid. Isolated yield: 31%. Melting point: 72-73 °C.

^{1}H NMR (500 MHz, $CDCl_3$, TMS as the internal standard): δ 9.57 (s, 1H), 8.60 (d, J = 8.1 Hz, 1H), 8.50 (d, J = 8.3 Hz, 1H), 8.21-8.19 (m, 1H), 7.77-7.73 (m, 2H), 7.70-7.67 (m, 1H), 7.51-7.50 (m, 1H), 2.89 (s, 3H). **^{13}C NMR** (125 MHz, $CDCl_3$, $CDCl_3$ as the internal standard): δ 150.7, 144.5, 137.0, 133.2, 131.1, 130.4, 129.2, 129.0, 127.4, 125.3, 124.7, 122.8, 120.4, 19.3. **HRMS** (APCI) calcd for $C_{14}H_{12}N$ ($M+H^+$): 194.0964, found: 194.0961.

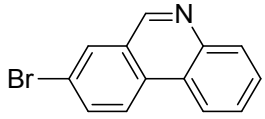
8-chlorophenanthridine (3ea)



White solid. Isolated yield: 57%. Melting point: 84-85 °C.

^{1}H NMR (500 MHz, $CDCl_3$, TMS as the internal standard): δ 9.21 (s, 1H), 8.53 (t, J = 8.0 Hz, 2H), 8.19 (d, J = 8.15 Hz, 1H), 8.03-8.02 (m, 1H), 7.81-7.75 (m, 2H), 7.72-7.69 (m, 1H). **^{13}C NMR** (125 MHz, $CDCl_3$, $CDCl_3$ as the internal standard): δ 152.7, 144.8, 133.7, 132.0, 131.3, 130.7, 129.5 128.2, 128.0, 127.6, 124.2, 124.0, 122.5. **HRMS** (APCI) calcd for $C_{13}H_9ClN$ ($M+H^+$): 214.0418, found: 214.0415.

8-bromophenanthridine (3fa)

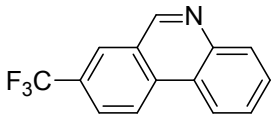


White solid. Isolated yield: 53%. Melting point: 72-73 °C.

^{1}H NMR (500 MHz, $CDCl_3$, TMS as the internal standard): δ 9.20 (s, 1H), 8.52 (d, J = 9.2 Hz, 1H), 8.46 (d, J = 8.8 Hz, 1H), 8.20-8.18 (m, 2H), 7.94-7.9 (m, 1H), 7.79-7.76 (m, 1H),

7.72-7.68 (m, 1H). **^{13}C NMR** (125 MHz, $CDCl_3$, $CDCl_3$ as the internal standard): δ 152.6, 144.7, 134.6, 131.6, 131.4, 130.7, 129.5, 128.0, 127.9, 124.2, 124.0, 122.5, 121.7. **HRMS** (APCI) calcd for $C_{13}H_9BrN$ ($M+H^+$): 257.9912, found: 257.9908.

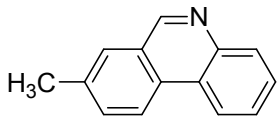
8-(trifluoromethyl)phenanthridine (3ga)



White solid. Isolated yield: 41%. Melting point: 118-119 °C.

^{1}H NMR (500 MHz, $CDCl_3$, TMS as the internal standard): δ 9.39 (s, 1H), 8.76 (d, J = 8.6 Hz, 1H), 8.63 (d, J = 8.1 Hz, 1H), 8.38 (s, 1H), 8.29 (d, J = 7.9 Hz, 1H), 8.09 (d, J = 8.7 Hz, 1H), 7.86 (t, J = 7.4 Hz, 1H), 7.78 (t, J = 7.6 Hz, 1H). **^{13}C NMR** (100 MHz, $CDCl_3$, $CDCl_3$ as the internal standard): δ 153.1, 145.2, 134.7, 130.4, 130.0, 129.5 ($J_{F\text{-}C}$ = 33.1 Hz), 127.8, 126.8 ($J_{F\text{-}C}$ = 3.1 Hz), 126.2 ($J_{F\text{-}C}$ = 4.2 Hz), 125.6, 125.3, 123.2, 123.1, 122.6. **HRMS** (APCI) calcd for $C_{14}H_9F_3N$ ($M+H^+$): 248.0681, found: 248.0678.

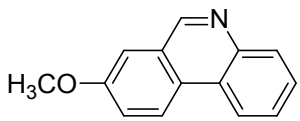
8-methylphenanthridine (3ha)



White solid. Isolated yield: 57%. Melting point: 139-140 °C.

^{1}H NMR (500 MHz, $CDCl_3$, TMS as the internal standard): δ 9.21 (s, 1H), 8.53 (d, J = 8.1 Hz, 1H), 8.48 (d, J = 8.35 Hz, 1H), 8.18-8.16 (m, 1H), 7.80 (s, 1H). 7.73-7.64 (m, 3H), 2.59 (s, 3H). **^{13}C NMR** (125 MHz, $CDCl_3$, $CDCl_3$ as the internal standard): δ 153.8, 144.5, 137.9, 133.2, 130.4, 128.6, 128.56, 127.4, 127.0, 124.6, 122.5, 122.2, 21.9. **HRMS** (APCI) calcd for $C_{14}H_{12}N$ ($M+H^+$): 194.0964, found: 194.0960.

8-methoxyphenanthridine (3ia)

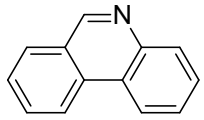


White solid. Isolated yield: 46%. Melting point: 92-93 °C.

^{1}H NMR (500 MHz, $CDCl_3$, TMS as the internal standard): δ 9.24 (s, 1H), 8.52 (t, J = 9.6

Hz, 2H), 8.17 (d, *J* = 7.85 Hz, 1H), 7.71-7.65 (m, 2H), 7.34 (d, *J* = 8.7 Hz, 1H), 7.39 (s, 1H), 4.00 (s, 3H). **^{13}C NMR** (125 MHz, $CDCl_3$, $CDCl_3$ as the internal standard): δ 159.3, 153.3, 144.0, 130.4, 128.1, 127.6, 127.4 124.7, 124.0, 122.5, 122.2, 108.3, 56.0. **HRMS** (APCI) calcd for $C_{14}H_{12}NO$ ($M+H^+$): 210.0913, found: 210.0911.

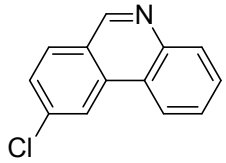
Phenanthridine (3ja)



White solid. Isolated yield: 36%. Melting point: 93-94 °C.

^{1}H NMR (500 MHz, $CDCl_3$, TMS as the internal standard): δ 9.29 (s, 1H), 8.61-8.57 (m, 2H), 8.20 (d, *J* = 8.0 Hz, 1H), 8.04 (d, *J* = 7.9 Hz, 1H), 7.86(t, *J* = 8.0 Hz, 1H), 7.77-7.67 (m, 3H); **^{13}C NMR** (125 MHz, $CDCl_3$, $CDCl_3$ as the internal standard): δ 153.6, 144.5, 132.6, 131.1, 130.2, 128.8, 128.7, 127.5, 127.1, 126.4, 124.1, 122.3, 121.9; **HRMS** (APCI) calcd for $C_{13}H_{10}N$ ($M+H^+$): 180.0807, found: 180.0804.

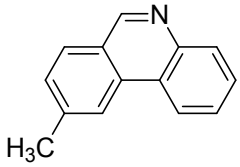
9-chlorophenanthridine (3ka)



White solid. Isolated yield: 30%. Melting point: 89-90 °C.

^{1}H NMR (500 MHz, $CDCl_3$, TMS as the internal standard): δ 9.27 (s, 1H), 8.59 (d, *J* = 1.5 Hz, 1H), 8.52-8.50 (m, 1H), 8.26 (d, *J* = 8.1 Hz, 1H), 8.04 (d, *J* = 8.5 Hz, 1H), 7.83-7.79 (m, 1H), 7.76-7.69 (m, 2H). **^{13}C NMR** (125 MHz, $CDCl_3$, $CDCl_3$ as the internal standard): δ 153.1, 145.1, 137.9, 134.1, 130.7, 130.6, 139.8, 128.6, 127.8, 125.0, 123.4, 122.6, 121.1. **HRMS** (APCI) calcd for $C_{13}H_9ClN$ ($M+H^+$): 214.0418, found: 214.0416.

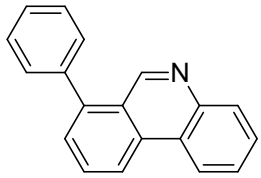
9-methylphenanthridine (3la)



White solid. Isolated yield: 30%. Melting point: 88-89 °C.

^{1}H NMR (500 MHz, $CDCl_3$, TMS as the internal standard): δ 9.24 (s, 1H), 8.58-8.56 (m, 1H), 8.40 (s, 1H), 8.18-8.16 (m, 1H), 7.95 (d, J = 8.1 Hz, 1H), 7.75-7.72 (m, 1H), 7.68-7.65 (m, 1H), 7.55-7.53 (m, 1H), 2.66 (s, 3H). **^{13}C NMR** (100 MHz, $CDCl_3$, $CDCl_3$ as the internal standard): δ 153.3, 144.6, 132.7, 130.1, 128.7, 128.6, 126.9, 124.6, 124.0, 122.2, 121.6, 22.5. **HRMS** (APCI) calcd for $C_{14}H_{12}N$ ($M+H^+$): 194.0964, found: 194.0961.

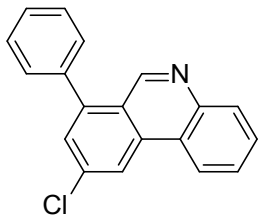
7-phenylphenanthridine (3jaa)



White solid. Isolated yield: 43%. Melting point: 195-196 °C.

^{1}H NMR (500 MHz, $CDCl_3$, TMS as the internal standard): δ 9.36 (s, 1H), 8.66-8.64 (m, 2H), 8.19-8.17 (m, 1H), 7.91-7.88 (m, 1H), 7.78-7.75 (m, 1H), 7.72-7.69 (m, 1H), 7.65-7.63 (m, 1H), 7.55-7.48 (m, 5H). **^{13}C NMR** (100 MHz, $CDCl_3$, $CDCl_3$ as the internal standard): δ 151.9, 144.1, 142.3, 138.9, 133.0, 130.4, 130.3, 130.1, 128.81, 128.8, 128.5, 128.0, 127.2, 124.0, 123.99, 122.4, 121.2. **HRMS** (APCI) calcd for $C_{19}H_{14}N$ ($M+H^+$): 256.1120, found: 256.1117.

9-chloro-7-phenylphenanthridine (3kaa)

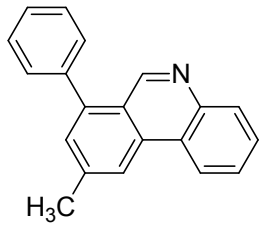


White solid. Isolated yield: 31%. Melting point: 120-121 °C.

^{1}H NMR (500 MHz, $CDCl_3$, TMS as the internal standard): δ 9.29 (s, 1H), 8.60 (d, J = 2.0 Hz, 1H), 8.55 (d, J = 7.9 Hz, 1H), 8.18-8.16 (m, 1H), 7.80-7.77 (m, 1H), 7.73-7.70 (m, 1H), 7.61 (d, J = 2.0 Hz, 1H), 7.57-7.50 (m, 5H). **^{13}C NMR** (100 MHz, $CDCl_3$, $CDCl_3$ as the internal standard): δ 151.3, 144.4, 144.1, 137.5, 136.7, 134.4, 130.2, 130.1, 129.5, 129.2,

128.7, 128.5, 127.5, 123.0, 122.5, 122.4, 120.8. **HRMS** (APCI) calcd for $C_{19}H_{13}ClN$ ($M+H^+$): 290.0731, found: 290.0728.

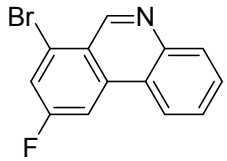
9-methyl-7-phenylphenanthridine (3laa)



White solid. Isolated yield: 36%. Melting point: 174-175 °C.

^{1}H NMR (500 MHz, $CDCl_3$, TMS as the internal standard): δ 9.30 (s, 1H), 8.63-8.61 (m, 1H), 8.43 (s, 1H), 8.17-8.15(m, 1H), 7.76-7.72 (m, 1H), 7.69-7.66 (m, 1H), 7.54-7.47 (m, 6H), 2.68 (s, 3H). **^{13}C NMR** (100 MHz, $CDCl_3$, $CDCl_3$ as the internal standard): δ 151.7, 144.3, 142.1, 140.8, 138.9, 133.2, 130.6, 130.3, 130.0, 128.7, 128.5, 127.9, 126.9, 123.9, 122.4, 122.2, 120.9, 22.4. **HRMS** (APCI) calcd for $C_{20}H_{16}N$ ($M+H^+$): 270.1277, found: 270.1274.

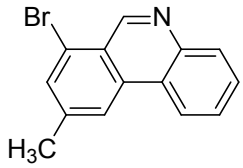
7-bromo-9-fluorophenanthridine (3ma)



White solid. Isolated yield: 42%. Melting point: 161-162 °C.

^{1}H NMR (500 MHz, $CDCl_3$, TMS as the internal standard): δ 9.64 (s, 1H), 8.45 (d, J = 9.0 Hz, 1H), 8.24-8.21 (m, 2H), 7.84-7.81 (m, 1H), 7.75-7.72 (m, 2H). **^{13}C NMR** (125 MHz, $CDCl_3$, $CDCl_3$ as the internal standard): δ 163.3 ($J_{F\text{-}C}$ = 253.9 Hz), 151.8, 144.9, 136.4 ($J_{F\text{-}C}$ = 9.6 Hz), 130.6 ($J_{F\text{-}C}$ = 42.8 Hz), 128.1, 125.8 ($J_{F\text{-}C}$ = 11.0 Hz), 122.9 ($J_{F\text{-}C}$ = 4.2 Hz), 122.8, 121.9, 121.7, 121.49, 107.3 ($J_{F\text{-}C}$ = 21.9 Hz). **HRMS** (APCI) calcd for $C_{13}H_8FBrN$ ($M+H^+$): 275.9818, found: 275.9815.

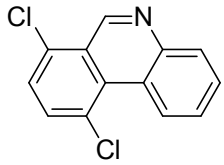
7-bromo-9-methylphenanthridine (3na)



White solid. Isolated yield: 43%. Melting point: 145-146 °C.

^{1}H NMR (500 MHz, $CDCl_3$, TMS as the internal standard): δ 9.60 (s, 1H), 8.50-8.49 (m, 1H), 8.29 (s, 1H), 8.19-8.17 (m, 1H), 7.77-7.73 (m, 2H), 7.68-7.65 (m, 1H), 2.59 (s, 3H). **^{13}C NMR** (125 MHz, $CDCl_3$, $CDCl_3$ as the internal standard): δ 152.2, 144.7, 142.6, 134.8, 133.6, 130.5, 129.6, 127.8, 124.2, 123.2, 122.8, 122.6, 121.7, 22.5. **HRMS** (APCI) calcd for $C_{14}H_{11}BrN$ ($M+H^+$): 272.0069, found: 272.0064.

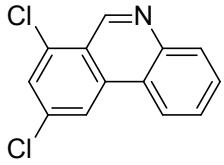
7,10-dichlorophenanthridine (3oa)



White solid. Isolated yield: 30%. Melting point: 188-189 °C.

^{1}H NMR (500 MHz, $CDCl_3$, TMS as the internal standard): δ 9.81 (d, *J* = 8.6 Hz, 1H), 9.78 (s, 1H), 8.26 (d, *J* = 8.1 Hz, 1H), 7.84 (t, *J* = 7.2 Hz, 2H), 7.73 (t, *J* = 8.2 Hz, 1H), 7.65 (d, *J* = 8.2 Hz, 1H). **^{13}C NMR** (125 MHz, $CDCl_3$, $CDCl_3$ as the internal standard): δ 150.0, 145.9, 134.7, 133.5, 131.4, 130.9, 130.3, 130.1, 128.5, 127.6, 126.6, 125.3, 122.8. **HRMS** (APCI) calcd for $C_{13}H_8Cl_2N$ ($M+H^+$): 248.0028, found: 248.0025.

7,9-dichlorophenanthridine (3pa)

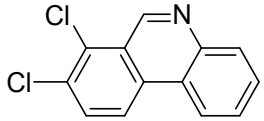


White solid. Isolated yield: 57%. Melting point: 157-158 °C.

^{1}H NMR (500 MHz, $CDCl_3$, TMS as the internal standard): δ 9.62 (s, 1H), 8.41-8.39 (m, 2H), 8.19 (d, *J* = 8.1 Hz, 1H), 7.79 (t, *J* = 7.4 Hz, 1H), 7.70-7.66 (m, 2H). **^{13}C NMR** (125 MHz, $CDCl_3$, $CDCl_3$ as the internal standard): δ 149.4, 145.1, 137.2, 135.4, 135.2, 130.8, 130.4, 128.7, 128.3, 122.8, 122.4, 121.9, 121.1. **HRMS** (APCI) calcd for $C_{13}H_8Cl_2N$

(M+H$^+$): 248.0028, found: 248.0024.

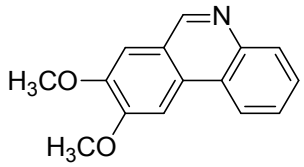
7,8-dichlorophenanthridine (3qa)



Yeiilow solid. Isolated yield: 60%. Melting point: 135-136 °C.

^{1}H NMR (500 MHz, $CDCl_3$, TMS as the internal standard): δ 9.77 (s, 1H), 8.55-8.53 (m, 1H), 8.49 (d, *J* = 8.8 Hz, 1H), 8.25-8.23 (m, 1H), 7.89 (d, *J* = 8.9 Hz, 1H), 7.83-7.80 (m, 1H), 7.76-7.72 (m, 1H). **^{13}C NMR** (125 MHz, $CDCl_3$, $CDCl_3$ as the internal standard): δ 149.7, 144.6, 133.0, 132.5, 132.0, 130.8, 130.0, 128.4, 124.7, 123.0, 122.6, 121.1. **HRMS** (APCI) calcd for $C_{13}H_8Cl_2N$ (M+H$^+$): 248.0028, found: 248.0025.

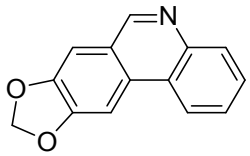
8,9-dimethoxyphenanthridine (3ra)



White solid. Isolated yield: 18%. Melting point: 172-173 °C.

^{1}H NMR (500 MHz, $CDCl_3$, TMS as the internal standard): δ 9.15 (s, 1H), 8.44 (d, *J* = 10.3 Hz, 1H), 8.17-8.15 (m, 1H), 7.88 (s, 1H), 7.72-7.62 (m, 2H), 7.35 (s, 1H), 4.14 (s, 3H), 4.07 (s, 3H). **^{13}C NMR** (125 MHz, $CDCl_3$, $CDCl_3$ as the internal standard): δ 153.3, 152.2, 150.4, 144.4, 130.5, 128.6, 128.2, 127.0, 124.2, 122.2, 122.1, 108.2, 102.2, 56.6, 56.5. **HRMS** (APCI) calcd for $C_{15}H_{14}NO_2$ (M+H$^+$): 240.1019, found: 240.0115.

[1,3]dioxolo[4,5-*j*]phenanthridine (3sa)

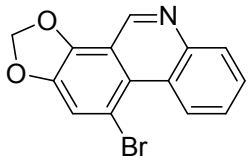


White solid. Isolated yield: 22%. Melting point: 144-145 °C.

^{1}H NMR (500 MHz, $CDCl_3$, TMS as the internal standard): δ 8.98 (s, 1H), 8.30 (d, *J* = 7.9 Hz, 1H), 8.15 (d, *J* = 7.9 Hz, 1H), 7.83 (s, 1H), 7.66-7.58 (m, 2H), 7.21 (s, 1H), 6.18 (s,

2H). **^{13}C NMR** (125 MHz, $CDCl_3$, $CDCl_3$ as the internal standard): δ 152.1, 151.6, 148.6, 143.5, 130.8, 129.6, 128.5, 127.2, 124.6, 123.2, 122.3, 105.9, 102.4, 100.2. **HRMS** (APCI) calcd for $C_{14}H_{10}NO_2$ ($M+H^+$): 224.0706, found: 224.0703.

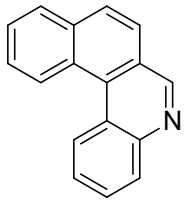
10-bromo-[1,3]dioxolo[4,5-*i*]phenanthridine (3ta)



Yellow solid. Isolated yield: 40%. Melting point: 225-226 °C.

^{1}H NMR (500 MHz, $CDCl_3$, TMS as the internal standard): δ 9.51 (s, 1H), 8.83 (d, J = 8.0 Hz, 1H), 8.16 (d, J = 8.2 Hz, 1H), 7.76 (t, J = 7.2 Hz, 1H), 7.66 (t, J = 7.2 Hz, 1H), 7.55 (s, 1H), 6.36 (s, 2H). **^{13}C NMR** (125 MHz, $CDCl_3$, $CDCl_3$ as the internal standard): δ 152.6, 149.3, 144.6, 143.0, 130.0, 129.8, 127.6, 127.0, 121.3, 120.5, 119.8, 116.7, 114.9, 103.1. **HRMS** (APCI) calcd for $C_{14}H_9BrNO_2$ ($M+H^+$): 301.9811, found: 301.9810.

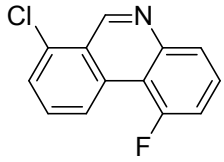
benzo[*k*]phenanthridine (3ua)



White solid. Isolated yield: 25%. Melting point: 75-76 °C.

^{1}H NMR (500 MHz, $CDCl_3$, TMS as the internal standard): δ 9.35 (s, 1H), 9.19 (d, J = 8.1 Hz, 1H), 9.10 (d, J = 8.3 Hz, 1H), 8.34-8.32 (m, 1H), 7.08-7.7.93 (m, 3H), 7.82-7.73 (m, 4H). **^{13}C NMR** (125 MHz, $CDCl_3$, $CDCl_3$ as the internal standard): δ 153.0, 147.0, 135.6, 131.6, 130.7, 129.41, 129.4, 129.2, 128.6, 128.5, 128.2, 127.4, 127.3, 127.2, 125.6, 125.5, 125.0. **HRMS** (APCI) calcd for $C_{17}H_{12}N$ ($M+H^+$): 230.0964, found: 230.0961.

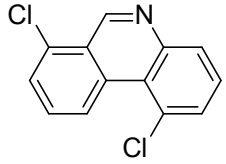
7-chloro-1-fluorophenanthridine (3ab)



White solid. Isolated yield: 45%. Melting point: 122-123 °C.

^{1}H NMR (500 MHz, $CDCl_3$, TMS as the internal standard): δ 9.79 (s, 1H), 8.97-8.95 (m, 1H), 8.06 (d, J = 8.2 Hz, 1H), 7.81-7.71 (m, 3H), 7.46-7.42 (m, 1H). **^{13}C NMR** (125 MHz, $CDCl_3$, $CDCl_3$ as the internal standard): δ 160.8 ($J_{F\text{-}C}$ = 253.7 Hz), 151.1, 146.7 ($J_{F\text{-}C}$ = 2.0 Hz), 134.1, 132.7 ($J_{F\text{-}C}$ = 4.8 Hz), 132.0 ($J_{F\text{-}C}$ = 1.7 Hz), 129.3 ($J_{F\text{-}C}$ = 10.6 Hz), 128.9, 126.8 ($J_{F\text{-}C}$ = 3.5 Hz), 126.2 ($J_{F\text{-}C}$ = 23.3 Hz), 123.9, 114.5 ($J_{F\text{-}C}$ = 23.9 Hz), 113.5 ($J_{F\text{-}C}$ = 9.1 Hz). **HRMS** (APCI) calcd for $C_{13}H_8ClFN$ ($M+H^+$): 232.0323, found: 232.0321.

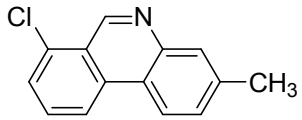
1,7-dichlorophenanthridine (3ac)



White solid. Isolated yield: 41%. Melting point: 145-146 °C.

^{1}H NMR (500 MHz, $CDCl_3$, TMS as the internal standard): δ 9.82-9.80 (m, 2H), 8.18-8.17 (m, 1H), 7.79-7.75 (m, 3H), 7.66 (t, J = 7.7 Hz, 1H). **^{13}C NMR** (100 MHz, $CDCl_3$, $CDCl_3$ as the internal standard): δ 150.5, 146.7, 133.7, 133.7, 131.4, 131.0, 130.4, 130.3, 128.7, 128.6, 125.3, 124.1, 121.1. HRMS (APCI) calcd for $C_{13}H_8Cl_2N$ ($M+H^+$): 248.0028, found: 248.0024.

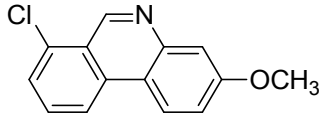
7-chloro-3-methylphenanthridine (3ad)



White solid. Isolated yield: 65%. Melting point: 115-116 °C.

^{1}H NMR (500 MHz, $CDCl_3$, TMS as the internal standard) δ 9.74 (s, 1H), 8.51 (d, J = 8.4 Hz, 1H), 8.46 (d, J = 8.4 Hz, 1H), 8.05 (s, 1H), 7.76 (t, J = 7.7 Hz, 1H), 7.71-7.69 (m, 1H), 7.57-7.55 (m, 1H), 2.62 (s, 3H). **^{13}C NMR** (125 MHz, $CDCl_3$, $CDCl_3$ as the internal standard) δ 149.2, 143.3, 140.7, 135.2, 134.6, 132.2, 130.3, 129.1 128.2, 123.0, 122.6, 121.4, 121.2, 22.0. **HRMS** (APCI) calcd for $C_{14}H_{11}ClN$ ($M+H^+$): 228.0574, found: 228.0571.

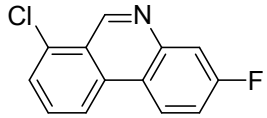
7-chloro-3-methoxyphenanthridine (3ae)



White solid. Isolated yield: 53%. Melting point: 149-150 °C.

^{1}H NMR (500 MHz, $CDCl_3$, TMS as the internal standard) δ 9.71 (s, 1H), 8.43 (t, *J* = 8.8 Hz, 2H), 7.71 (t, *J* = 8.0 Hz, 1H), 7.65-7.61 (m, 2H), 7.35-7.33 (m, 1H), 4.00 (s, 3H). **^{13}C NMR** (125 MHz, $CDCl_3$, $CDCl_3$ as the internal standard) δ 160.9, 150.5, 146.6, 135.0, 134.3, 131.4, 127.3 124.0, 122.8, 120.8, 119.2, 117.6, 110.3, 56.0. **HRMS** (APCI) calcd for $C_{14}H_{11}ClNO$ ($M+H^+$): 244.0523, found: 244.0522.

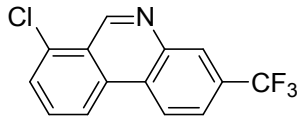
7-chloro-3-fluorophenanthridine (3af)



White solid. Isolated yield: 65%. Melting point: 84-85 °C.

^{1}H NMR (500 MHz, $CDCl_3$, TMS as the internal standard): δ 9.77 (s, 1H), 8.57-8.54 (m, 1H), 8.47 (d, *J* = 8.0 Hz, 1H), 7.92-7.89 (m, 1H), 7.79 (t, *J* = 7.9 Hz, 1H), 7.73 (d, J = 7.3 Hz, 1H), 7.51-7.47 (m, 1H). **^{13}C NMR** (125 MHz, $CDCl_3$, $CDCl_3$ as the internal standard): δ 163.4 (d, *J* = 248.5 Hz), 151.1, 134.7 ($J_{F\text{-}C}$ = 3.2 Hz), 132.1, 128.4 (2C), 124.9 ($J_{F\text{-}C}$ = 9.5 Hz), 123.2, 121.1 (2C), 120.3 ($J_{F\text{-}C}$ = 1.8 Hz), 117.4 ($J_{F\text{-}C}$ = 23.8 Hz), 114.9 ($J_{F\text{-}C}$ = 20.6 Hz). HRMS (APCI) calcd for $C_{13}H_8ClFN$ ($M+H^+$): 232.0323, found: 232.0320.

7-chloro-3-(trifluoromethyl)phenanthridine (3ag)

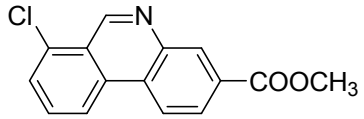


White solid. Isolated yield: 64%. Melting point: 224-225 °C.

^{1}H NMR (500 MHz, $CDCl_3$, TMS as the internal standard): δ 9.83 (s, 1H), 8.67 (d, *J* = 8.7 Hz, 1H), 8.56 (d, *J* = 7.8 Hz, 1H), 8.54 (s, 1H), 7.93-7.91 (m, 1H), 7.87-7.81 (m, 2H). **^{13}C NMR** (125 MHz, $CDCl_3$, $CDCl_3$ as the internal standard): δ 151.4, 144.1, 134.6, 133.9, 132.0, 131.5 ($J_{F\text{-}C}$ = 33.0 Hz), 129.6, 128.3 ($J_{F\text{-}C}$ = 4.1 Hz), 125.8, 125.4, 124.1, 123.9 ($J_{F\text{-}C}$ = 4.6 Hz), 123.2, 121.6. HRMS (APCI) calcd for $C_{14}H_8ClF_3N$ ($M+H^+$): 282.0291, found:

292.0288.

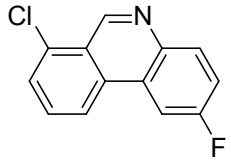
methyl 7-chlorophenanthridine-3-carboxylate (3ah)



White solid. Isolated yield: 57%. Melting point: 198-199 °C.

^{1}H NMR (500 MHz, $CDCl_3$, TMS as the internal standard): δ 9.81 (s, 1H), 8.89 (s, 1H), 8.61-8.55 (m, 2H), 8.31 (d, J = 8.5 Hz, 1H), 7.82-7.78 (m, 2H), 4.03 (s, 3H). **^{13}C NMR** (125 MHz, $CDCl_3$, $CDCl_3$ as the internal standard): δ 167.0, 151.0, 144.4, 134.5, 134.1, 132.8, 131.7, 131.2, 129.5, 127.9, 126.7, 124.2, 123.1, 121.8, 52.9. **HRMS** (APCI) calcd for $C_{15}H_{11}ClO_2N$ ($M+H^+$): 272.0472, found: 272.0468.

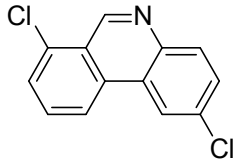
7-chloro-2-fluorophenanthridine (3ai)



White solid. Isolated yield: 36%. Melting point: 167-168 °C.

^{1}H NMR (500 MHz, $CDCl_3$, TMS as the internal standard): δ 9.78 (s, 1H), 8.51 (d, J = 7.8 Hz, 1H), 8.32 (d, J = 8.4 Hz, 1H), 7.81-7.75 (m, 2H), 7.68-7.63 (m, 1H), 7.51-7.48 (m, 1H). **^{13}C NMR** (125 MHz, $CDCl_3$, $CDCl_3$ as the internal standard): δ 159.2 (d, $J_{F\text{-}C}$ = 254.0 Hz), 150.3, 134.6, 134.5, 134.1 ($J_{F\text{-}C}$ = 2.8 Hz), 131.9, 129.1, 128.0 ($J_{F\text{-}C}$ = 8.5 Hz), 125.5, 123.8, 121.6, 118.4 (d, $J_{F\text{-}C}$ = 4.5 Hz), 114.7 (d, $J_{F\text{-}C}$ = 19.1 Hz). HRMS (APCI) calcd for $C_{13}H_8ClFN$ ($M+H^+$): 232.0323, found: 232.0325.

2,7-dichlorophenanthridine (3aj)

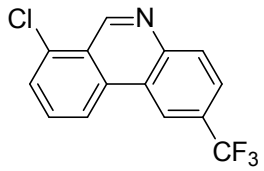


White solid. Isolated yield: 47%. Melting point: 161-162 °C.

^{1}H NMR (500 MHz, $CDCl_3$, TMS as the internal standard) δ 9.74 (s, 1H), 8.52 (d, J = 2.8

Hz, 1H), 8.48-8.45 (m, 1H), 8.16 (d, J = 10.9 Hz, 1H), 7.82-7.72 (m, 3H). **^{13}C NMR** (125 MHz, $CDCl_3$, $CDCl_3$ as the internal standard) δ 150.3, 143.2, 134.5, 134.0, 133.8, 132.2, 131.7, 130.3, 129.1, 124.6, 123.8, 122.5, 121.3. **HRMS** (APCI) calcd for $C_{13}H_8Cl_2N$ ($M+H^+$): 248.0028, found: 248.0025.

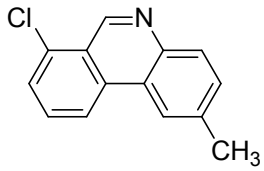
7-chloro-2-(trifluoromethyl)phenanthridine (3ak)



White solid. Isolated yield: 63%. Melting point: 136-137 °C.

^{1}H NMR (500 MHz, $CDCl_3$, TMS as the internal standard): δ 9.77 (s, 1H), 8.76 (s, 1H), 8.49 (d, J = 8.0 Hz, 1H), 8.29 (d, J = 8.5 Hz, 1H), 7.96 (d, J = 8.4 Hz, 1H), 7,81-7,75 (m, 2H). **^{13}C NMR** (125 MHz, $CDCl_3$, $CDCl_3$ as the internal standard): δ 152.1, 146.1, 134.6, 134.3, 132.1, 131.7, 129.6 ($J_{F\text{-}C}$ = 32.3 Hz), 129.3, 125.7 ($J_{F\text{-}C}$ = 3.4 Hz), 125.6, 123.8, 123.4, 123.1, 121.2, 120.6 ($J_{F\text{-}C}$ = 4.6 Hz). HRMS (APCI) calcd for $C_{14}H_8ClF_3N$ ($M+H^+$): 282.0291, found: 282.0289.

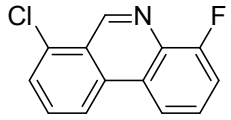
7-chloro-2-methylphenanthridine (3al)



White solid. Isolated yield: 58%. Melting point: 147-148 °C

^{1}H NMR (500 MHz, $CDCl_3$, TMS as the internal standard) δ 9.69 (s, 1H), 8.51 (d, J = 7.9 Hz, 1H), 8.33 (s, 1H), 8.11 (d, J = 8.3 Hz, 1H), 7.75-7.69 (m, 2H), 7.62-7.60 (m, 1H), 2.64 (s, 3H). **^{13}C NMR** (125 MHz, $CDCl_3$, $CDCl_3$ as the internal standard) δ 149.1, 143.1, 138.0, 134.5, 134.2, 131.5, 131.1 130.4, 128.3, 123.7, 123.3, 122.4, 121.3, 22.4. **HRMS** (APCI) calcd for $C_{14}H_{11}ClN$ ($M+H^+$): 228.0574, found: 228.0572.

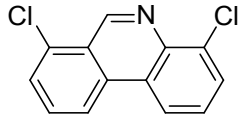
7-chloro-4-fluorophenanthridine (3ai')



White solid. Isolated yield: 37%. Melting point: 159-160 °C.

^{1}H NMR (500 MHz, $CDCl_3$, TMS as the internal standard): δ 9.72 (s, 1H), 8.43 (d, J = 7.9 Hz, 1H), 8.32-8.29 (m, 1H), 8.19-8.16 (m, 1H), 7.84-7.78 (m, 2H), 7.58-7.54 (m, 1H). **^{13}C NMR** (125 MHz, $CDCl_3$, $CDCl_3$ as the internal standard): δ 162.0 ($J_{F\text{-}C}$ = 247.3 Hz), 149.0, 141.1, 134.5, 134.2 ($J_{F\text{-}C}$ = 4.0 Hz), 132.7 ($J_{F\text{-}C}$ = 9.1 Hz), 131.7, 129.2, 125.0 ($J_{F\text{-}C}$ = 7.7 Hz), 123.6, 121.4, 118.9 ($J_{F\text{-}C}$ = 24.1 Hz), 107.8 ($J_{F\text{-}C}$ = 23.5 Hz). HRMS (APCI) calcd for $C_{13}H_8ClFN$ ($M+H^+$): 232.0323, found: 232.0322.

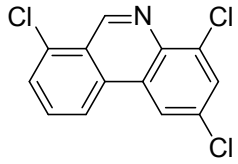
4,7-dichlorophenanthridine (3aj')



White solid. Isolated yield: 31%. Melting point: 167-168 °C.

^{1}H NMR (500 MHz, $CDCl_3$, TMS as the internal standard): δ 9.88 (s, 1H), 8.54-8.49 (m, 2H), 7.90 (d, J = 7.6 Hz, 1H), 7.82-7.76 (m, 2H), 7.63 (d, J = 7.8 Hz, 1H). **^{13}C NMR** (125 MHz, $CDCl_3$, $CDCl_3$ as the internal standard): δ 150.7, 141.1, 135.1, 134.6, 134.6, 131.9, 130.2, 129.1, 127.9, 125.3, 123.7, 121.8, 121.5; **HRMS** (APCI) calcd for $C_{13}H_8Cl_2N$ ($M+H^+$): 248.0028, found: 248.0026.

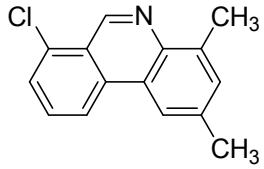
2,4,7-trichlorophenanthridine (3am)



White solid. Isolated yield: 76%. Melting point: 199-200 °C.

^{1}H NMR (500 MHz, $CDCl_3$, TMS as the internal standard): δ 9.86 (s, 1H), 8.46-8.45 (m, 2H), 7.89 (d, J = 2.2 Hz, 1H), 7.85-7.81 (m, 2H). **^{13}C NMR** (125 MHz, $CDCl_3$, $CDCl_3$ as the internal standard): δ 150.8, 139.6, 136.0, 134.8, 133.6, 132.3, 130.4, 129.8, 125.9, 123.9, 121.6, 121.5. HRMS (APCI) calcd for $C_{13}H_7Cl_3N$ ($M+H^+$): 281.9638, found: 281.9635.

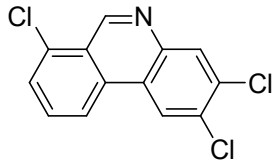
7-chloro-2,4-dimethylphenanthridine (3an)



White solid. Isolated yield: 46%. Melting point: 129-130 °C.

^{1}H NMR (500 MHz, $CDCl_3$, TMS as the internal standard): δ 9.73 (s, 1H), 8.51 (d, J = 7.6 Hz, 1H), 8.20 (s, 1H), 7.73-7.68 (m, 2H), 7.48 (s, 1H), 2.85 (s, 3H), 2.59 (s, 3H). **^{13}C NMR** (125 MHz, $CDCl_3$, $CDCl_3$ as the internal standard): δ 147.3, 141.6, 137.7, 137.0, 134.4, 133.8, 131.9, 130.4, 127.6, 123.0, 122.9, 121.1, 119.8, 22.0, 18.4. **HRMS** (APCI) calcd for $C_{15}H_{13}ClN$ ($M+H^+$): 242.0731, found: 242.0728.

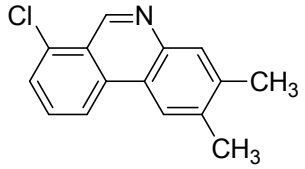
2,3,7-trichlorophenanthridine (3ao)



White solid. Isolated yield: 65%. Melting point: 184-185 °C.

^{1}H NMR (500 MHz, $CDCl_3$, TMS as the internal standard): δ 9.75 (s, 1H), 8.63 (s, 1H), 8.42 (d, J = 8.8 Hz, 1H), 8.33 (s, 1H), 7.82-7.77 (m, 2H). **^{13}C NMR** (125 MHz, $CDCl_3$, $CDCl_3$ as the internal standard): δ 151.4, 143.8, 134.7, 134.0, 133.4, 132.5, 132.0, 131.8, 129.3, 124.3, 123.7, 123.1, 121.2. **HRMS** (APCI) calcd for $C_{13}H_7Cl_3N$ ($M+H^+$): 281.9638, found: 281.9636.

7-chloro-2,3-dimethylphenanthridine (3ap)

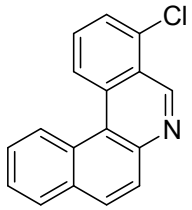


White solid. Isolated yield: 40%. Melting point: 162-163 °C.

^{1}H NMR (500 MHz, $CDCl_3$, TMS as the internal standard): δ 9.66 (s, 1H), 8.48 (d, J = 8.1 Hz, 1H), 8.28 (s, 1H), 7.96 (s, 1H), 7.72-7.65 (m, 2H), 2.53 (s, 3H), 2.51 (s, 3H). **^{13}C NMR**

(125 MHz, $CDCl_3$, $CDCl_3$ as the internal standard): δ 149.1, 143.7, 139.5, 137.6, 134.5, 134.2, 131.0, 130.5, 127.8, 123.3, 122.8, 121.5, 121.1, 20.9, 20.6. **HRMS** (APCI) calcd for $C_{15}H_{13}ClN$ ($M+H^+$): 242.0731, found: 242.0728.

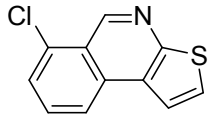
4-chlorobenzo[*a*]phenanthridine (3aq)



White solid. Isolated yield: 35%. Melting point: 147-148 °C

^{1}H NMR (500 MHz, $CDCl_3$, TMS as the internal standard): δ 9.86 (s, 1H), 9.00-8.97 (m, 2H), 8.14-8.12 (m, 1H), 8.07-8.05 (m, 2H), 7.79-7.67 (m, 4H). **^{13}C NMR** (125 MHz, $CDCl_3$, $CDCl_3$ as the internal standard): δ 149.4, 144.8, 134.7, 134.0, 133.9, 130.8, 130.7, 129.9, 129.3, 128.6, 128.1, 127.7, 127.2, 127.1, 126.0, 124.9, 120.4. **HRMS** (APCI) calcd for $C_{17}H_{11}ClN$ ($M+H^+$): 264.0574, found: 264.0571.

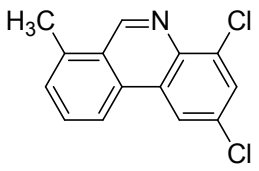
6-chlorothieno[2,3-*c*]isoquinoline (3ar)



Yellow solid. Isolated yield: 20%. Melting point: 94-95 °C.

^{1}H NMR (500 MHz, $CDCl_3$, TMS as the internal standard): δ 9.56 (s, 1H), 8.19-8.17 (m, 1H), 7.83 (d, J = 5.9 Hz, 1H), 7.70-7.64 (m, 3H). **^{13}C NMR** (100 MHz, $CDCl_3$, $CDCl_3$ as the internal standard): δ 156.9, 146.6, 133.7, 133.3, 130.7, 126.94, 126.9, 122.9, 121.9, 199.7. **HRMS** (APCI) calcd for $C_{11}H_7ClNS$ ($M+H^+$): 219.9982, found: 219.9978.

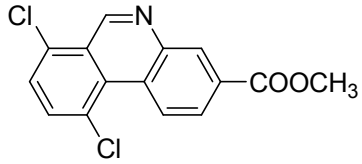
2,4-dichloro-7-methylphenanthridine (3dm)



White solid. Isolated yield: 55%. Melting point: 171-172 °C.

^{1}H NMR (500 MHz, $CDCl_3$, TMS as the internal standard): δ 9.63 (s, 1H), 8.43 (s, 1H), 8.35 (d, J = 8.3 Hz, 1H), 7.81 (d, J = 1.7 Hz, 1H), 7.77 (t, J = 7.6 Hz, 1H), 7.56 (d, J = 7.2 Hz, 1H), 2.87 (s, 3H). **^{13}C NMR** (125 MHz, $CDCl_3$, $CDCl_3$ as the internal standard): δ 151.4, 139.4, 137.4, 135.7, 132.8, 132.0, 131.9, 130.5, 129.5, 126.9, 125.5, 121.5, 120.6, 19.1. **HRMS** (APCI) calcd for $C_{14}H_{10}Cl_2N$ ($M+H^+$): 262.0184, found: 262.0182.

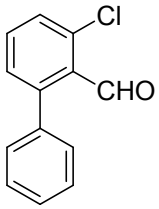
methyl 7,10-dichlorophenanthridine-3-carboxylate (3nh)



White solid. Isolated yield: 57%. Melting point: 177-178 °C.

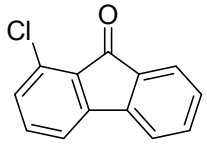
^{1}H NMR (500 MHz, $CDCl_3$, TMS as the internal standard): δ 9.86 (d, J = 9.0 Hz, 1 H), 9.83 (s, 1H), 8.90 (d, J = 2 Hz, 1H), 8.32-8.30 (m, 1H), 7.88 (d, J = 8.3 Hz, 1H), 7.72 (t, J = 8.3 Hz, 1H), 4.04 (s, 3H). **^{13}C NMR** (125 MHz, $CDCl_3$, $CDCl_3$ as the internal standard): δ 166.8, 150.9, 145.7, 135.0, 133.7, 132.6, 131.3, 131.0, 130.8, 129.5, 127.3, 126.9, 126.0, 125.9, 52.9. **HRMS** (APCI) calcd for $C_{15}H_{10}Cl_2O_2N$ ($M+H^+$): 306.0083, found: 306.0081.

3-chloro-[1,1'-biphenyl]-2-carbaldehyde (A)



^{1}H NMR (500 MHz, $CDCl_3$, TMS as the internal standard): δ 10.06 (s, 1H), 7.49-7.48 (m, 2H), 7.44-7.42 (m, 3H), 7.33-7.29 (m, 3H); **^{13}C NMR** (125 MHz, $CDCl_3$, $CDCl_3$ as the internal standard): δ 191.6, 147.0, 138.4, 134.9, 133.1, 132.3, 130.6, 128.9, 128.7.

1-chloro-9*H*-fluoren-9-one (B)

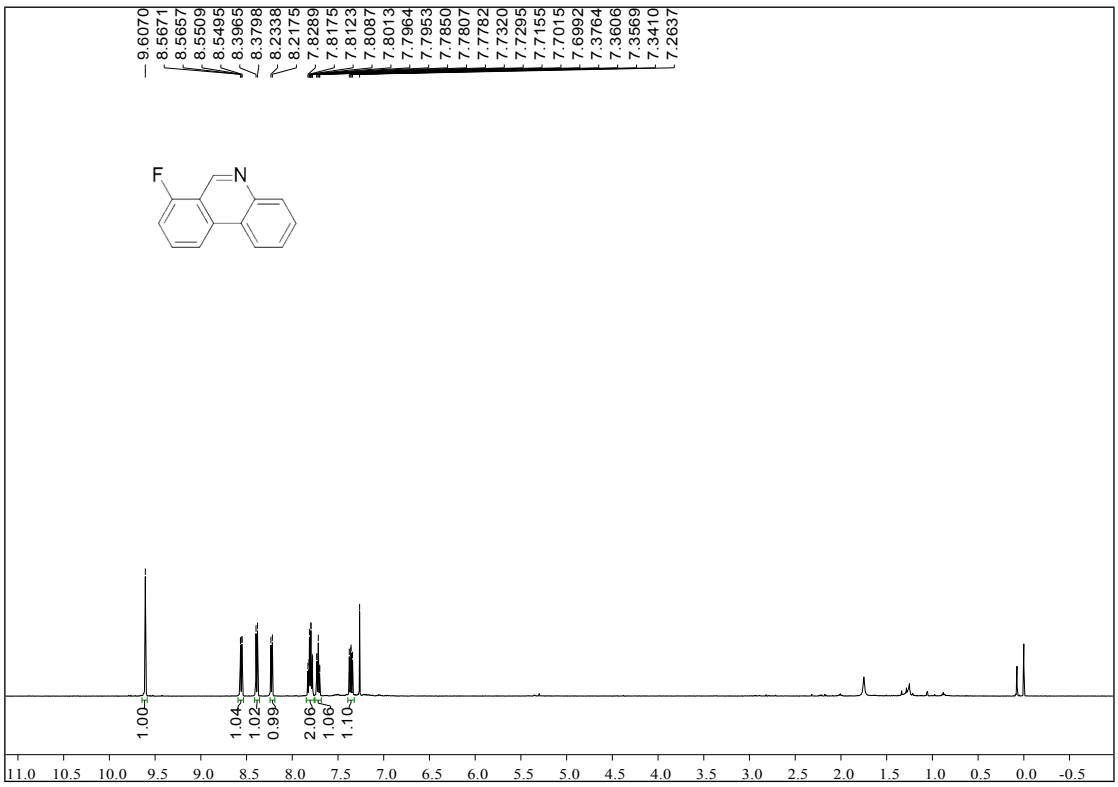


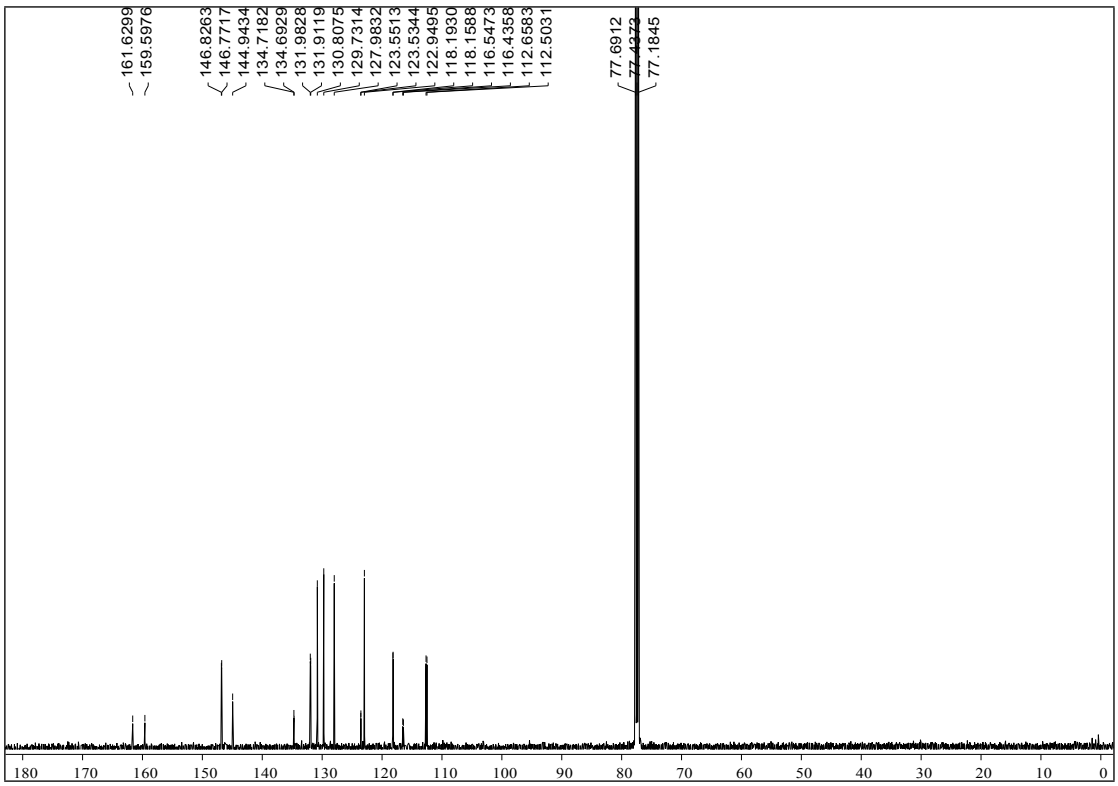
^{1}H NMR (500 MHz, $CDCl_3$, TMS as the internal standard): δ 7.69 (d, J = 7.4 Hz, 1H), 7.54-7.49 (m, 2H), 7.45-7.38 (m, 2H), 7.35-7.32 (m, 1H), 7.23-7.21 (m, 1H); **^{13}C NMR**

(125 MHz, $CDCl_3$, $CDCl_3$ as the internal standard): δ 191.2, 146.9, 143.0, 135.6, 135.1, 134.3, 133.2, 131.4, 130.1, 129.9, 124.9, 120.8, 119.1.

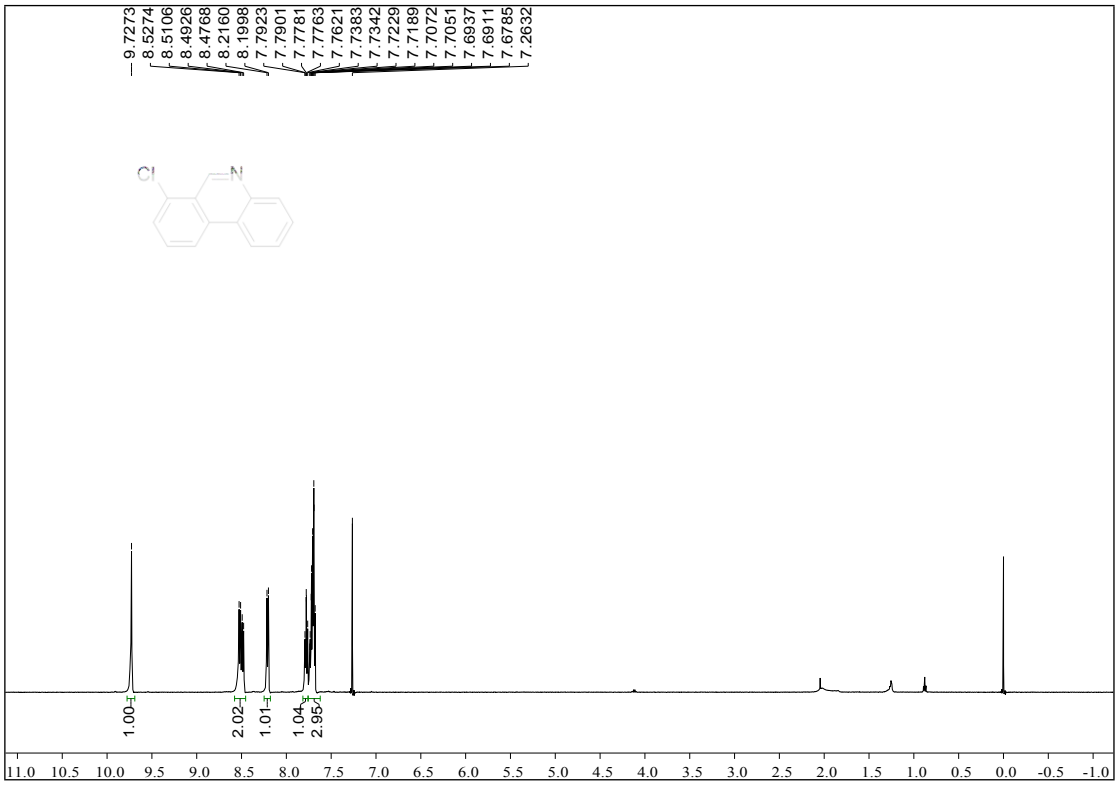
Copies of ^{1}H, ^{13}C Spectra

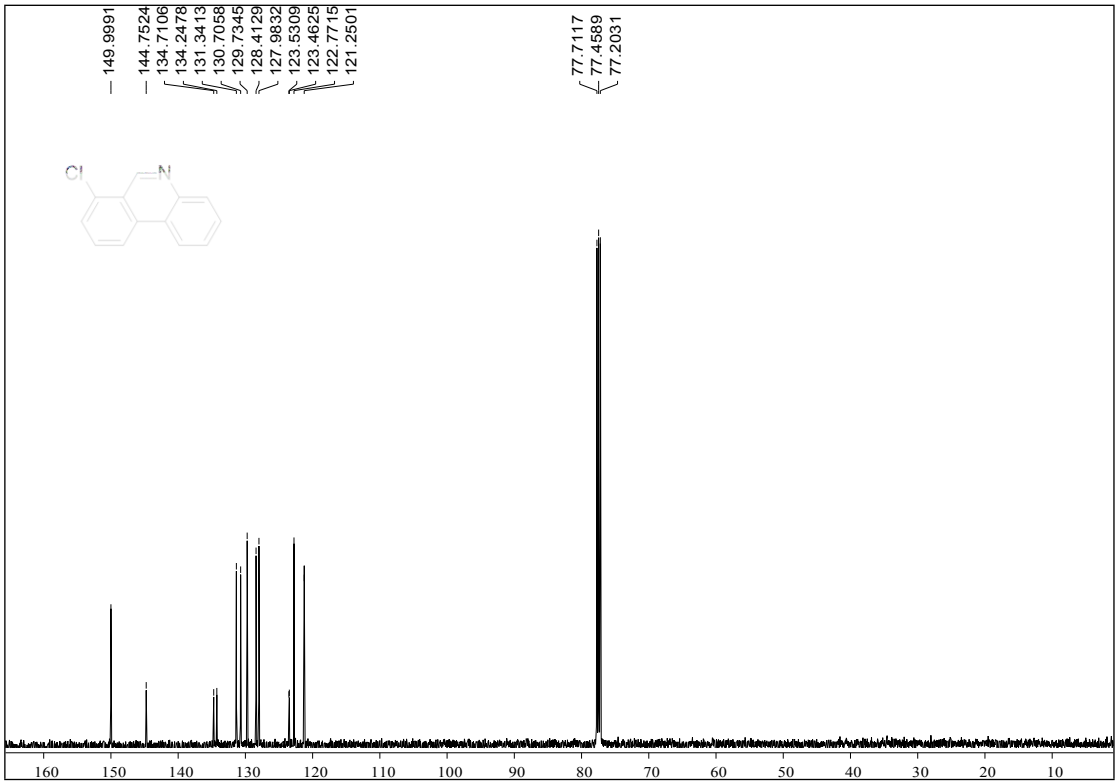
7-fluorophenanthridine (3ba)



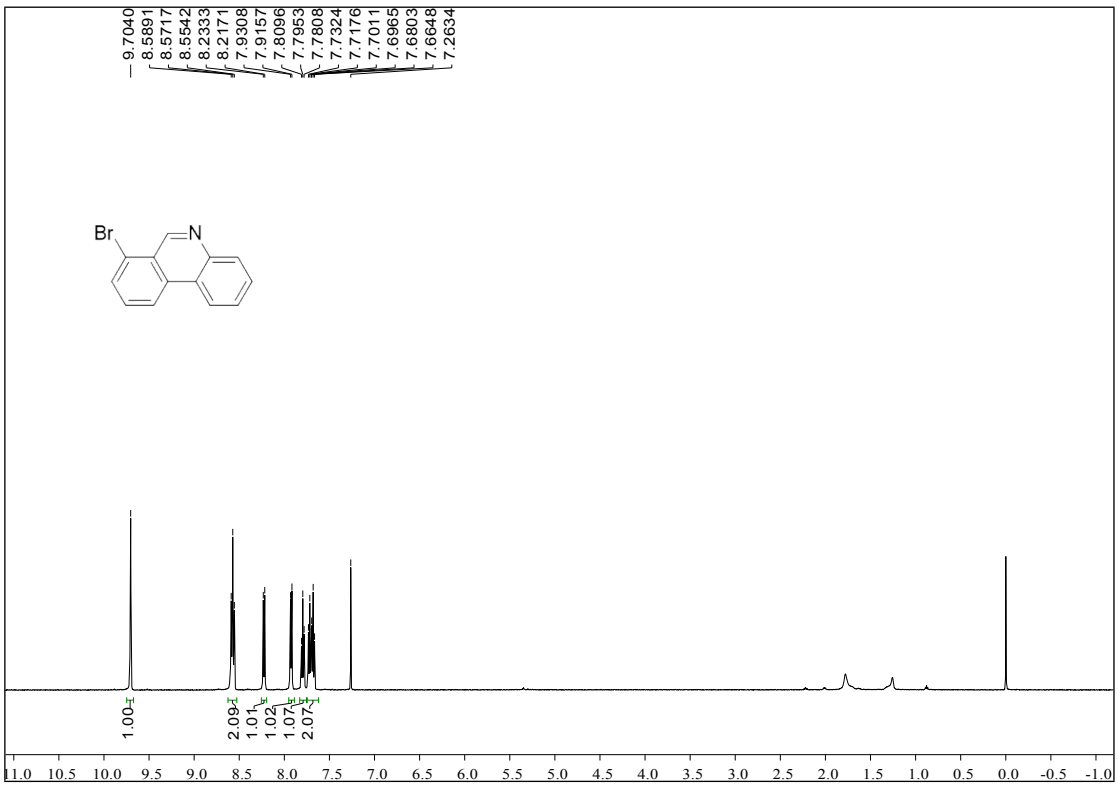


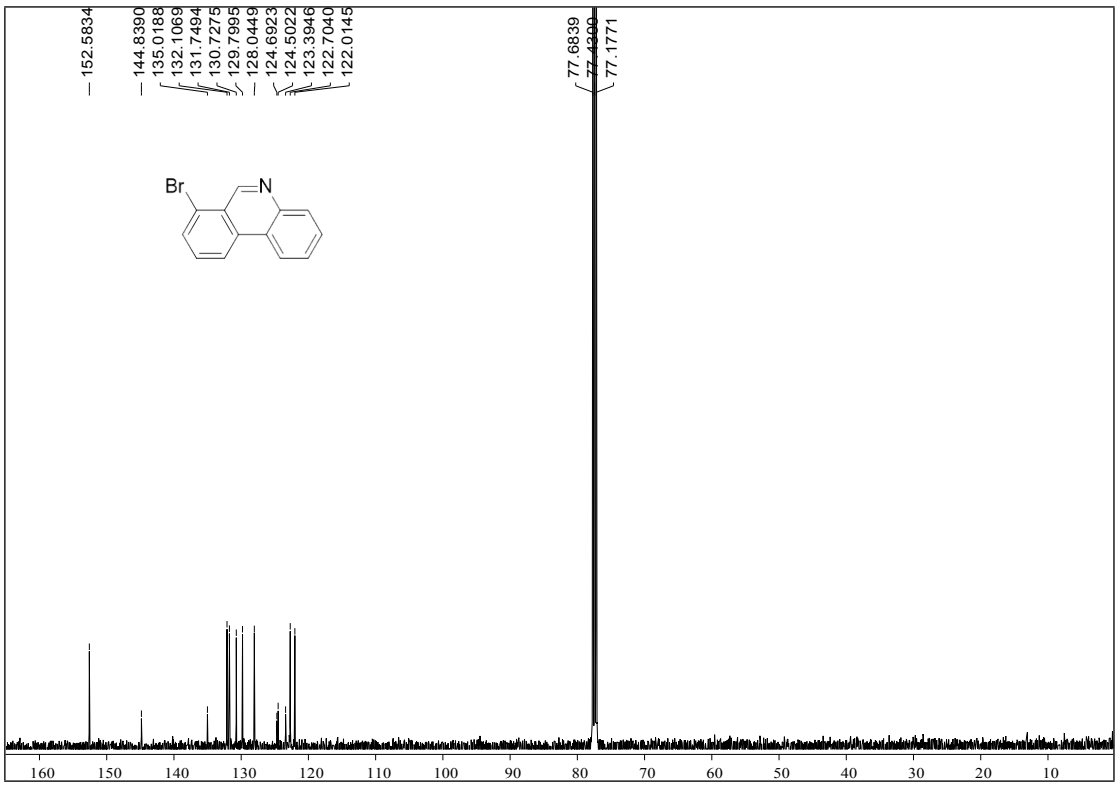
7-chlorophenanthridine (3aa)



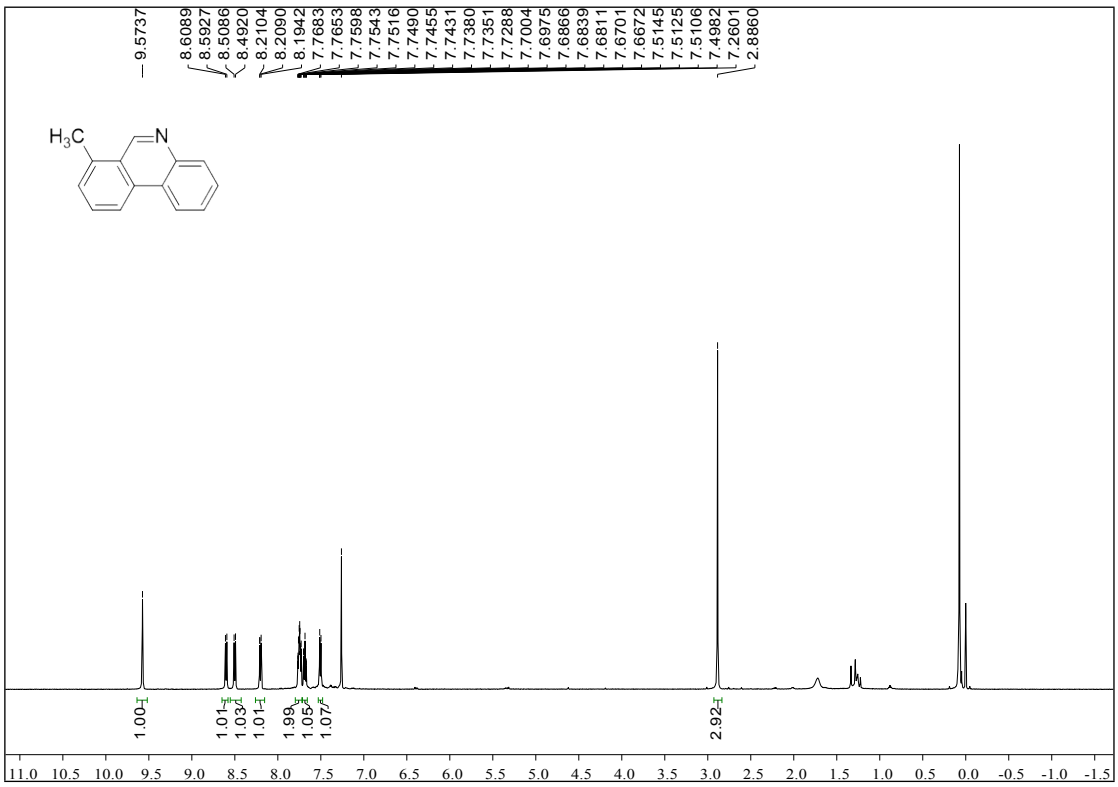


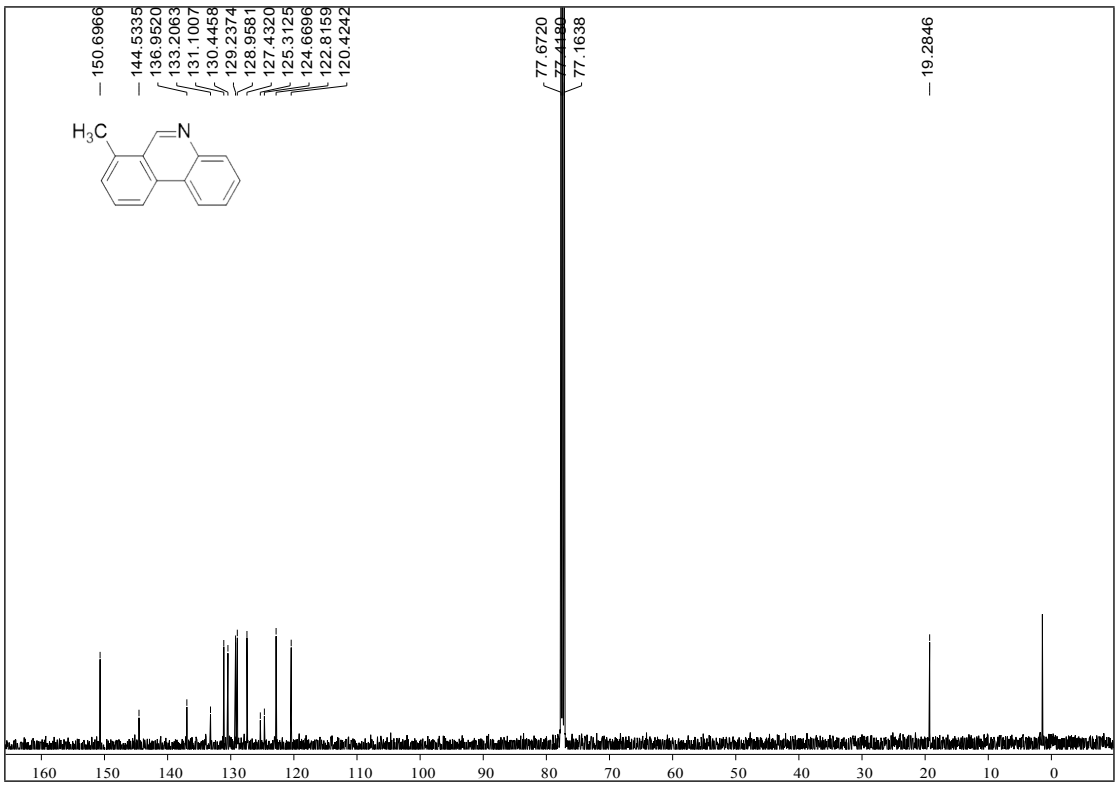
7-bromophenanthridine (3ca)



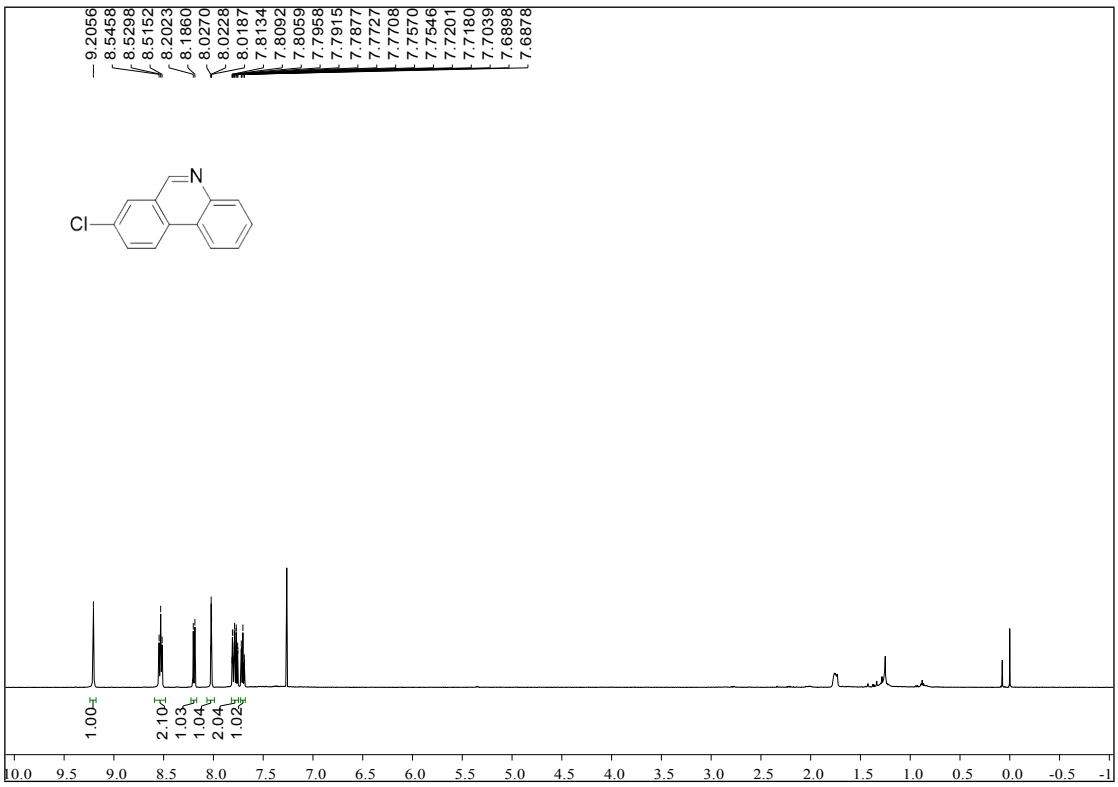


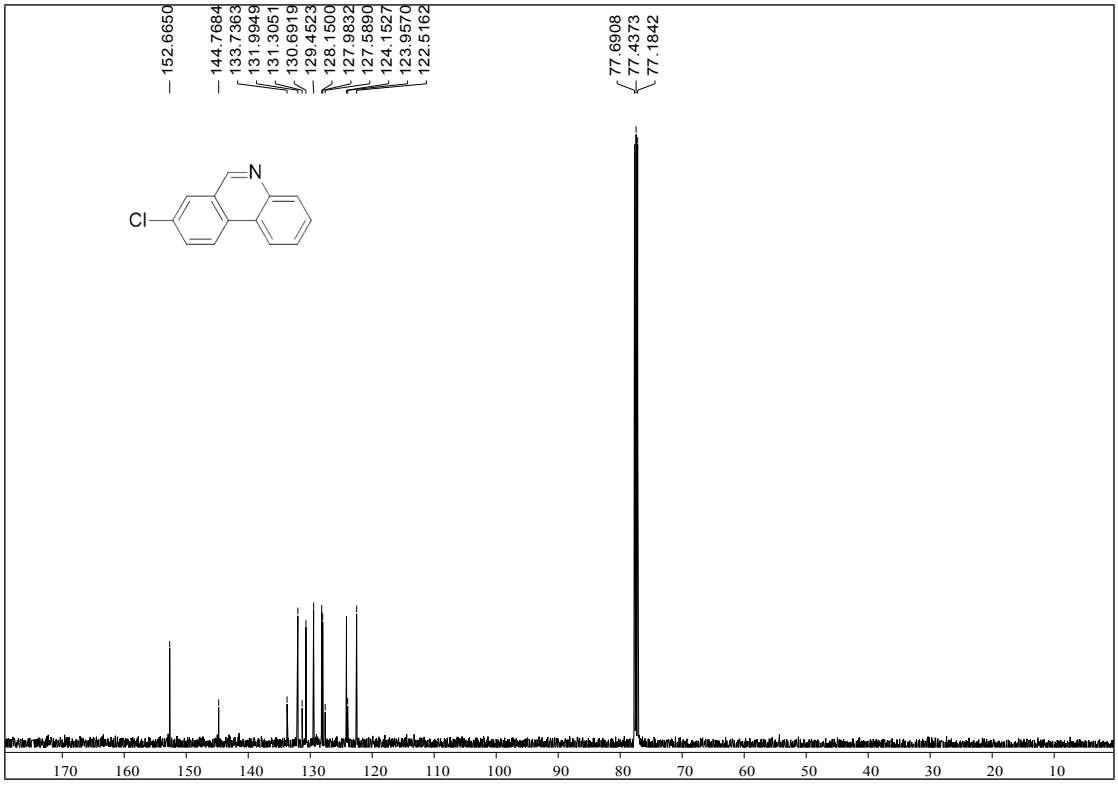
7-methylphenanthridine (3da)



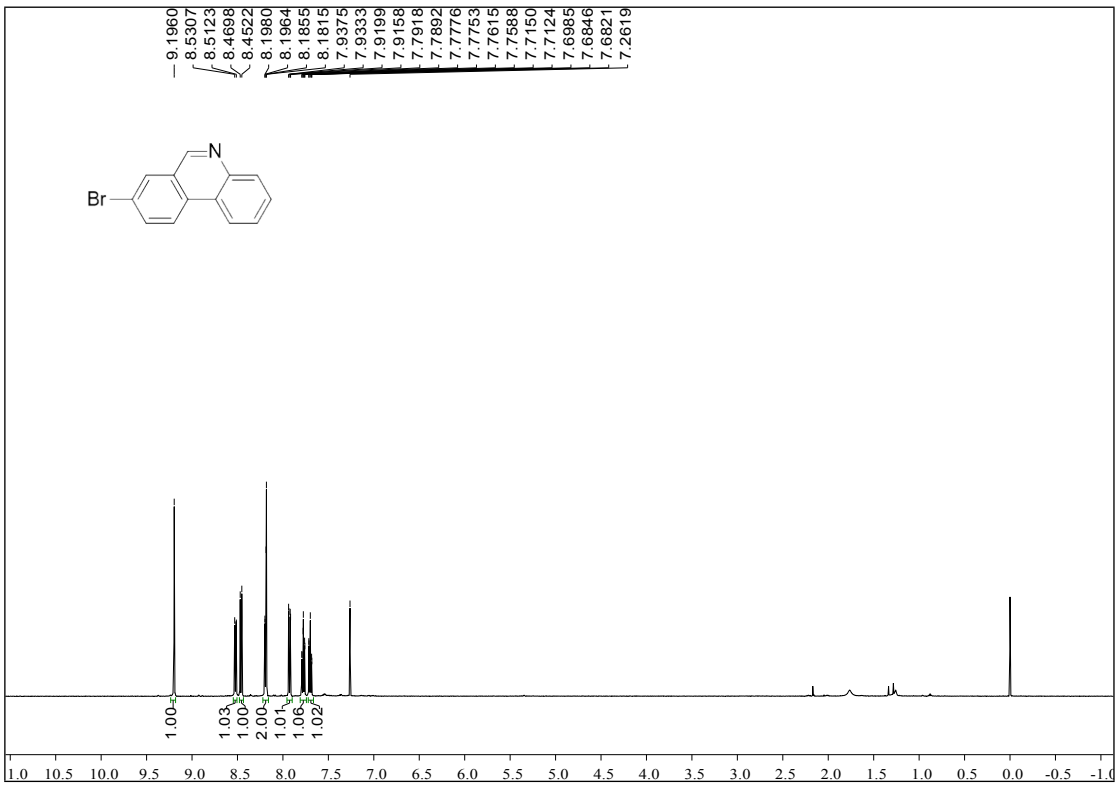


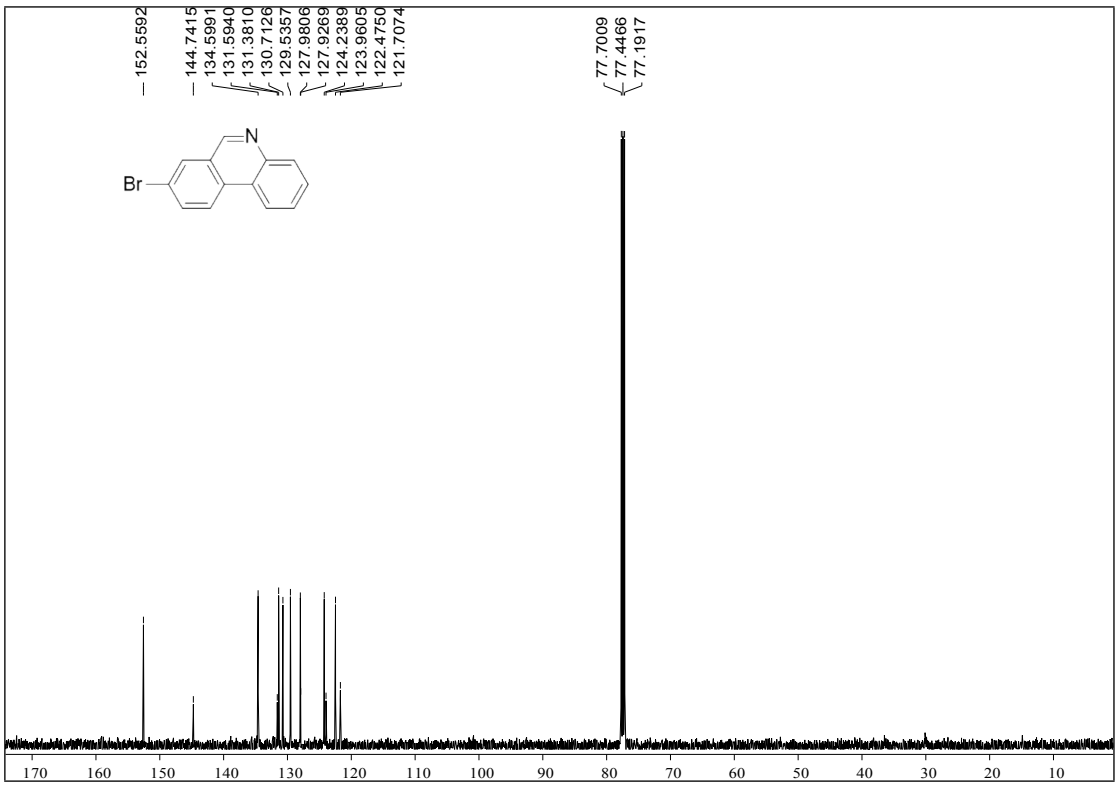
8-chlorophenanthridine (3ea)



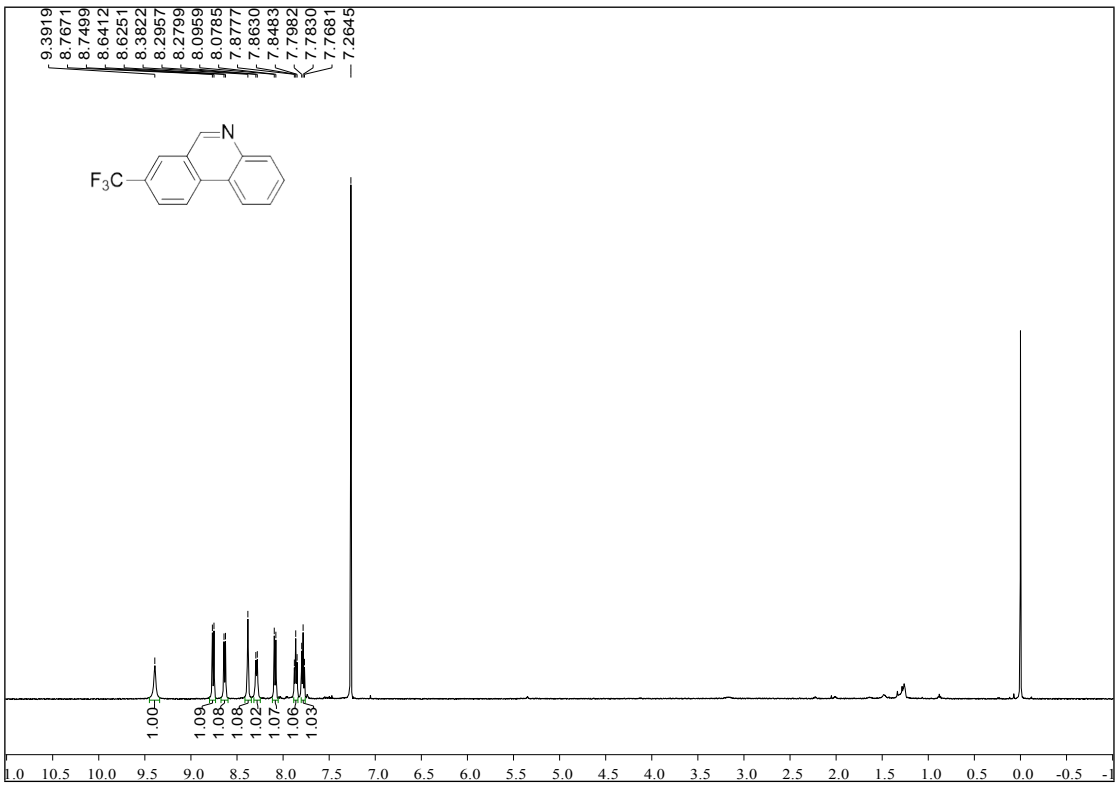


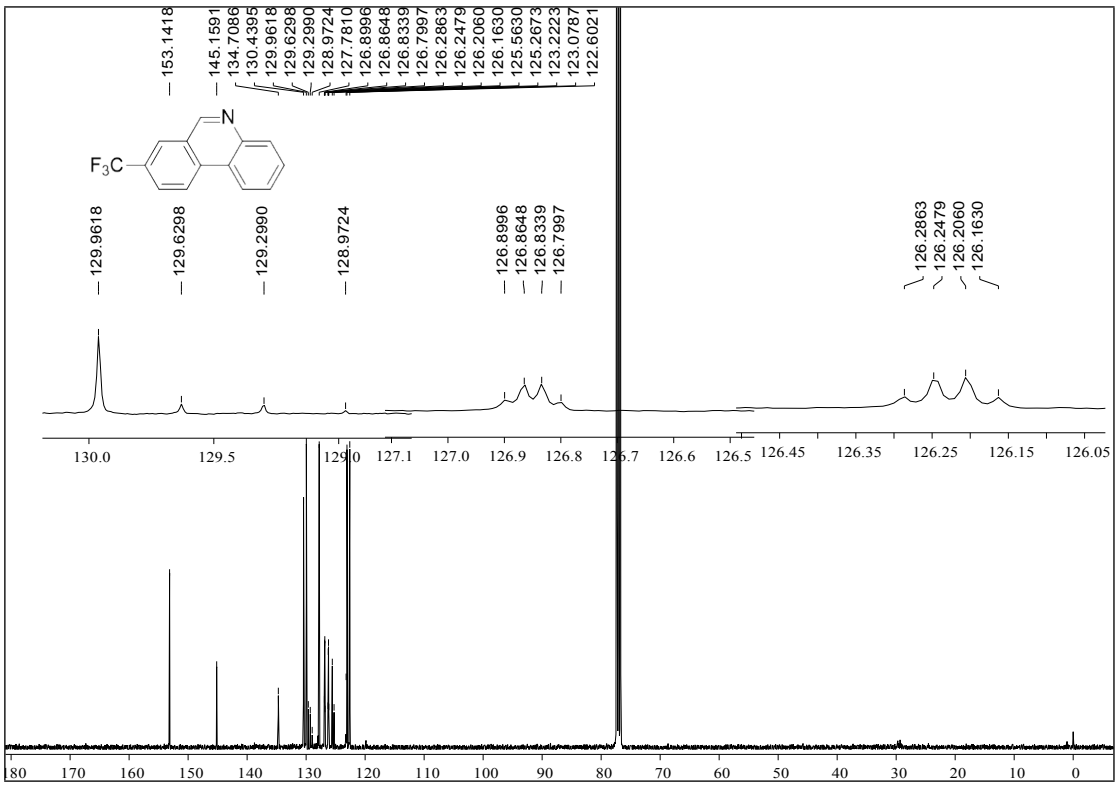
8-bromophenanthridine (3fa)



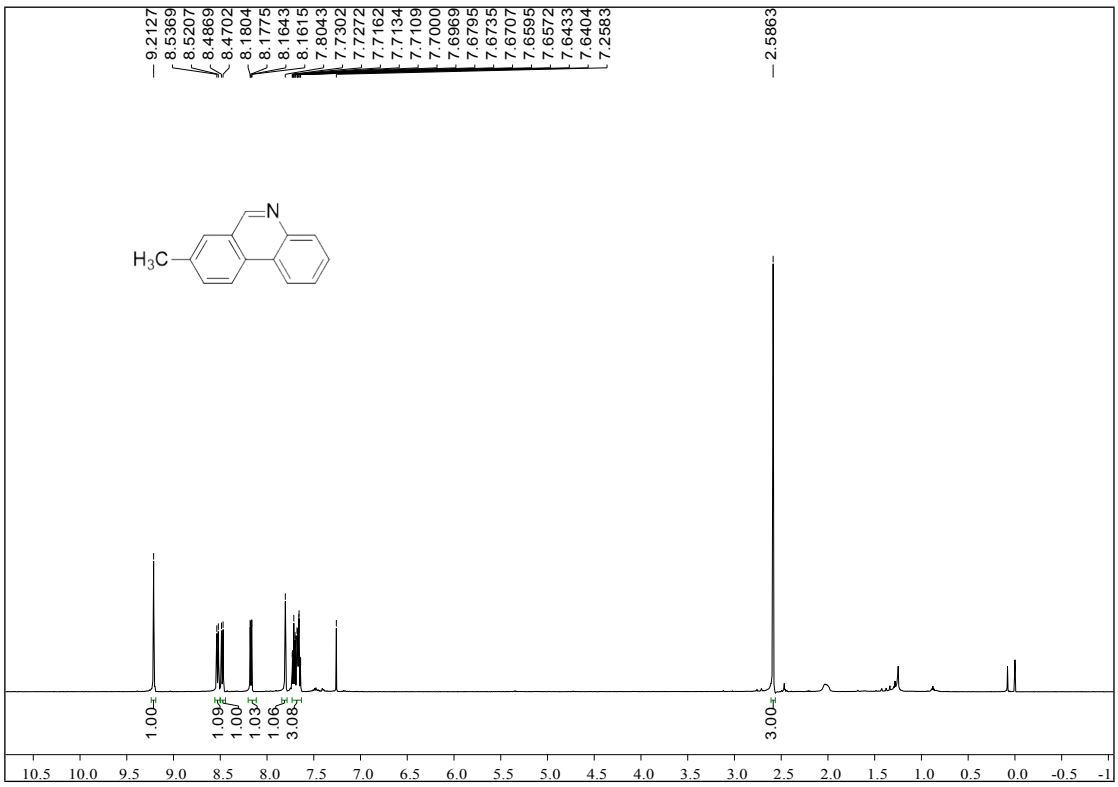


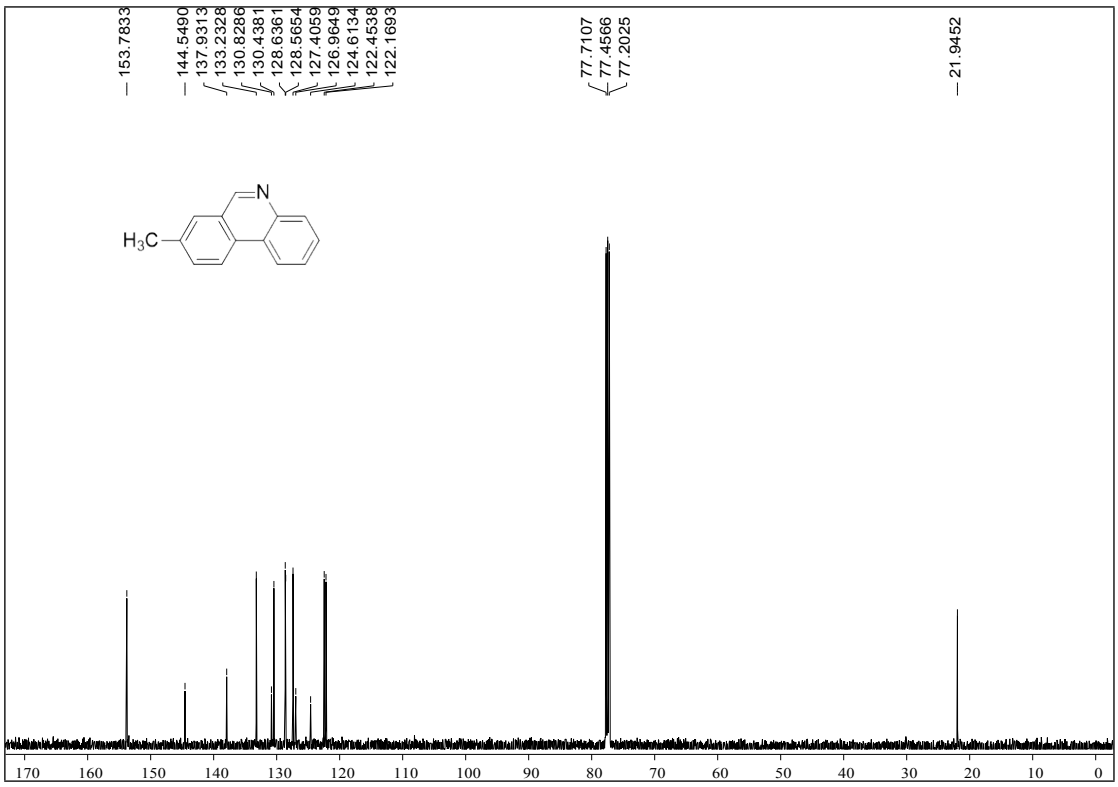
8-(trifluoromethyl)phenanthridine (3ga)



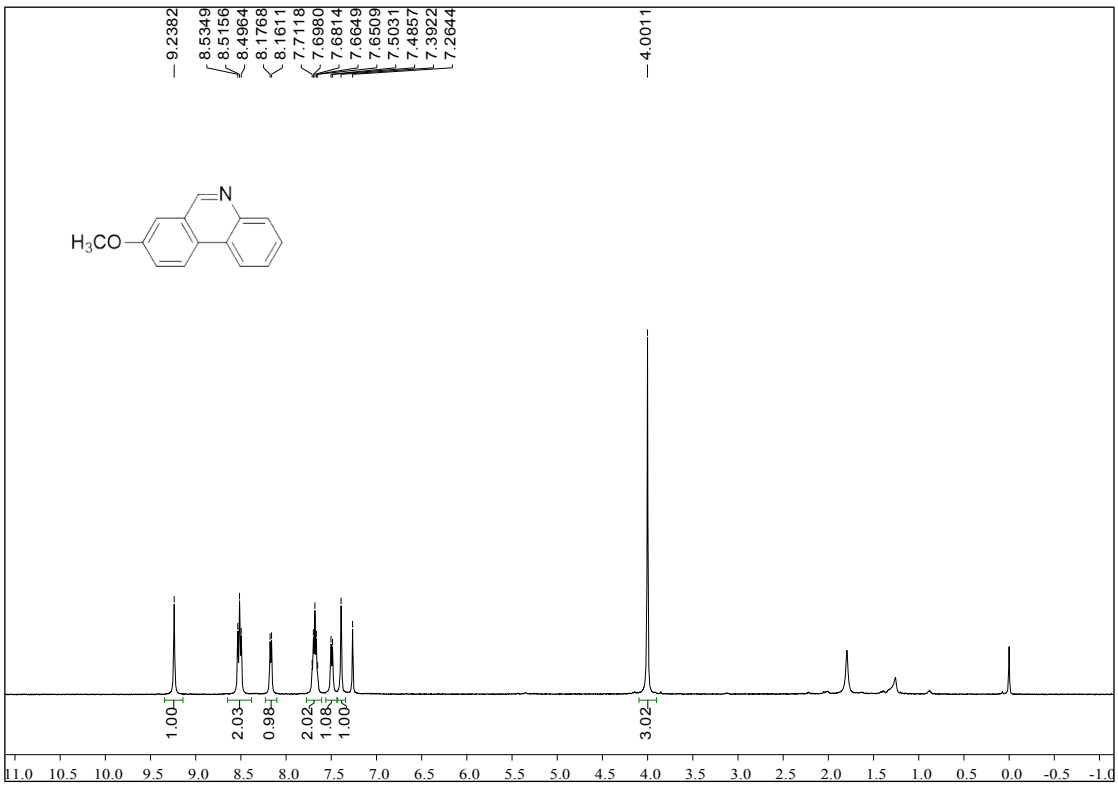


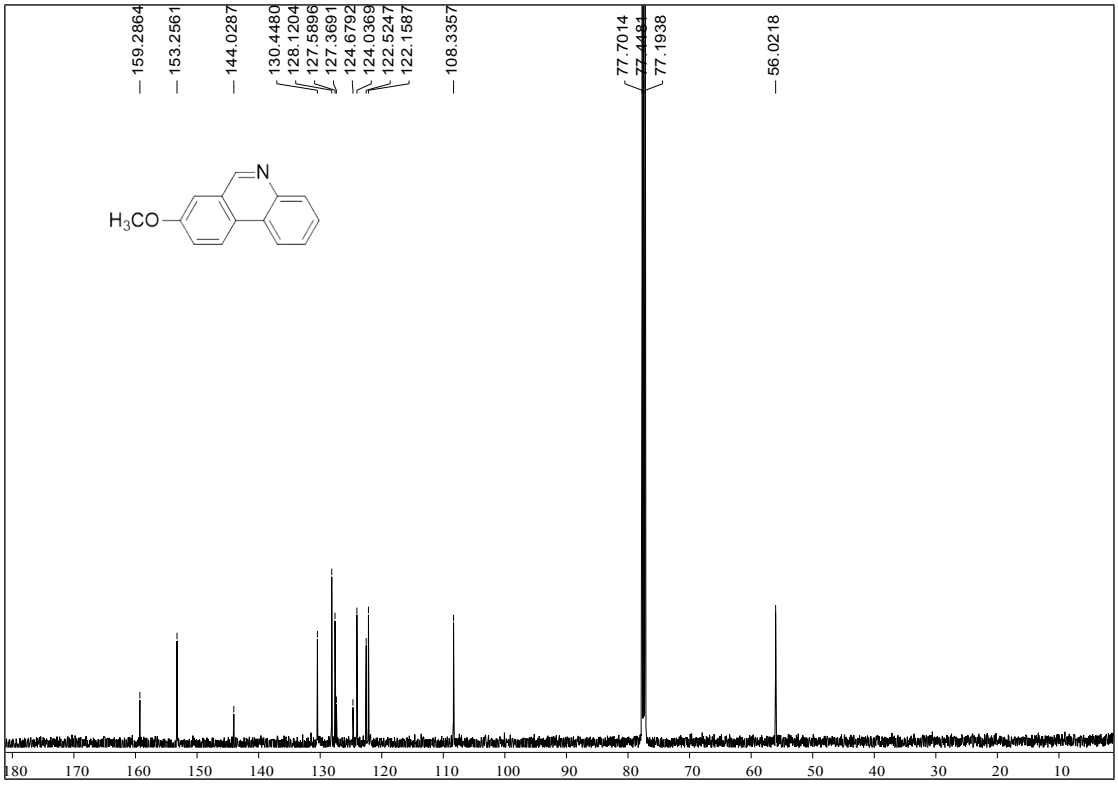
8-methylphenanthridine (3ha)



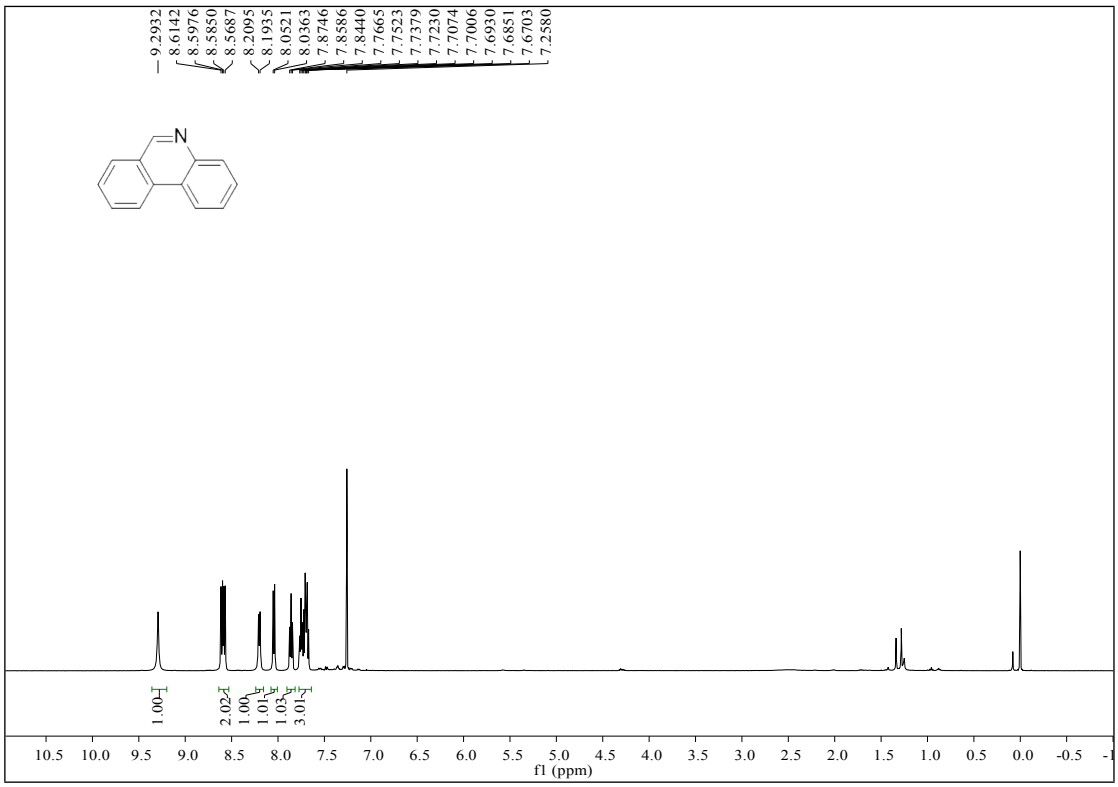


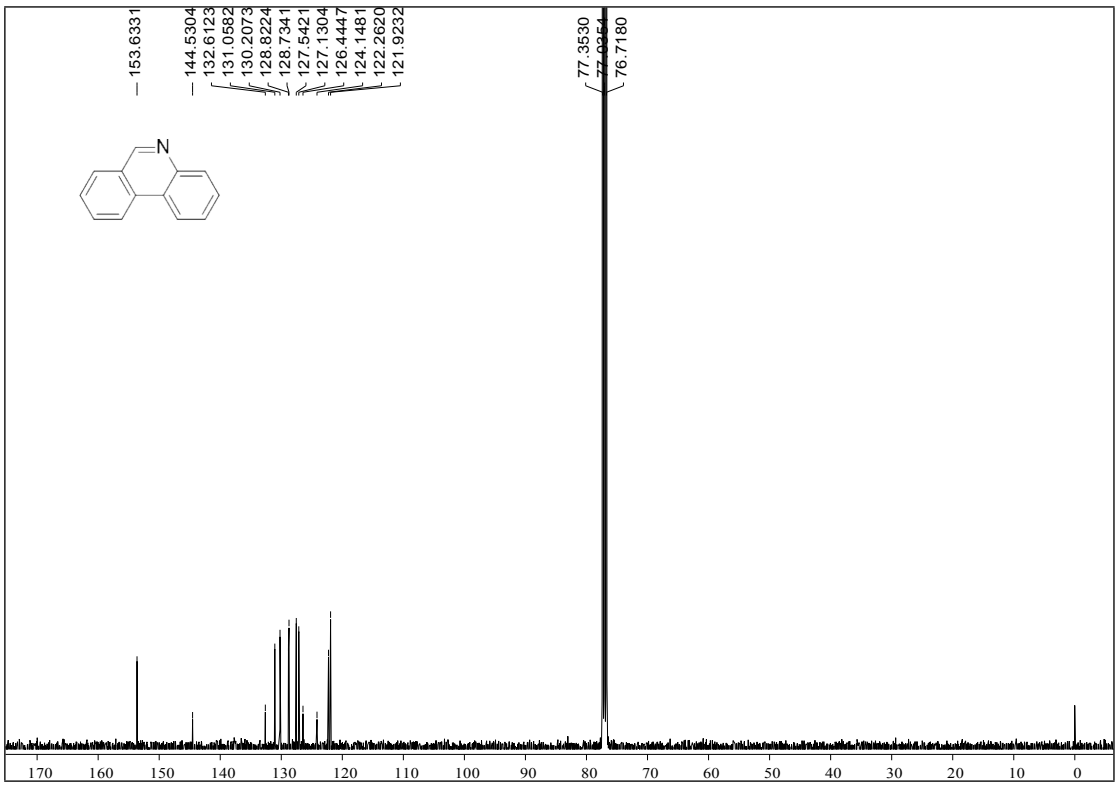
8-methoxyphenanthridine (3ia)



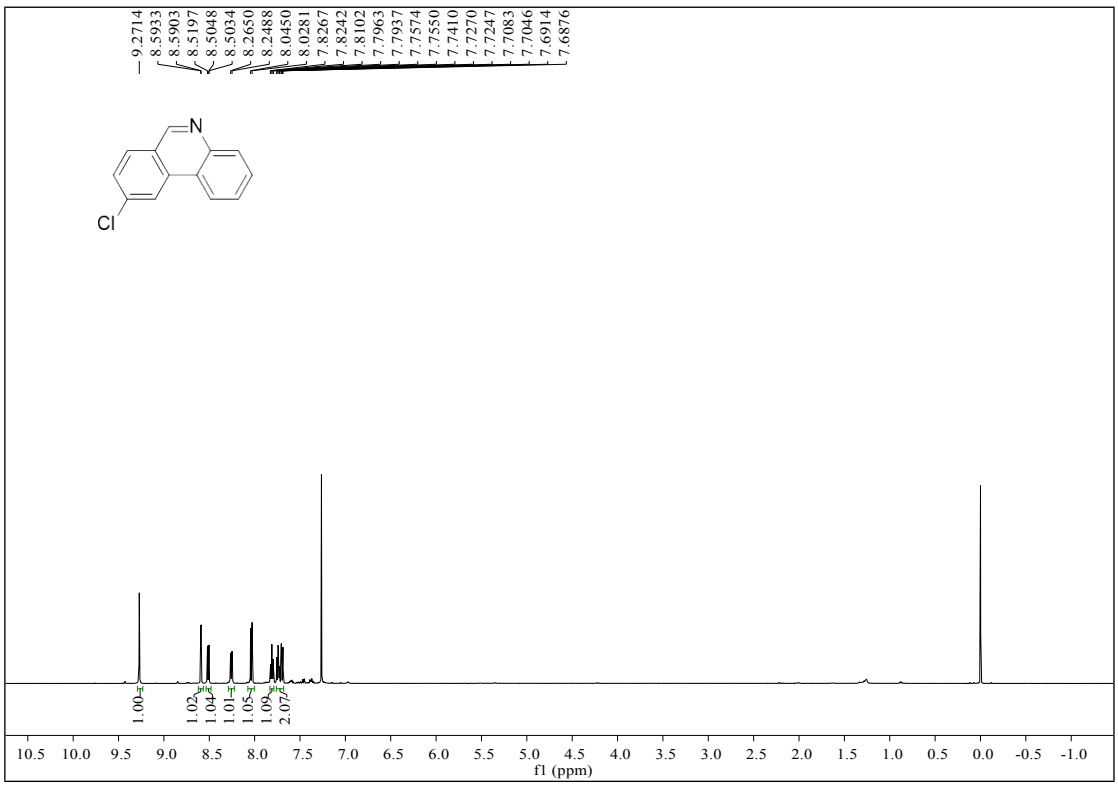


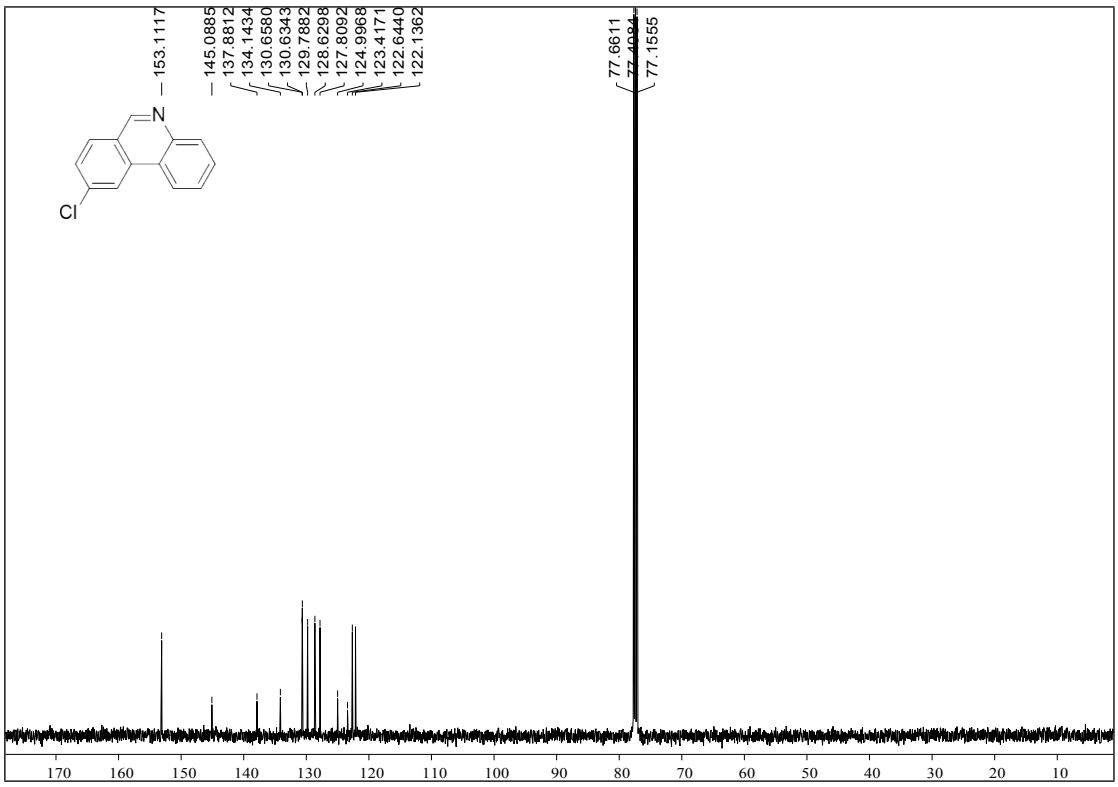
Phenanthridine (3ja)



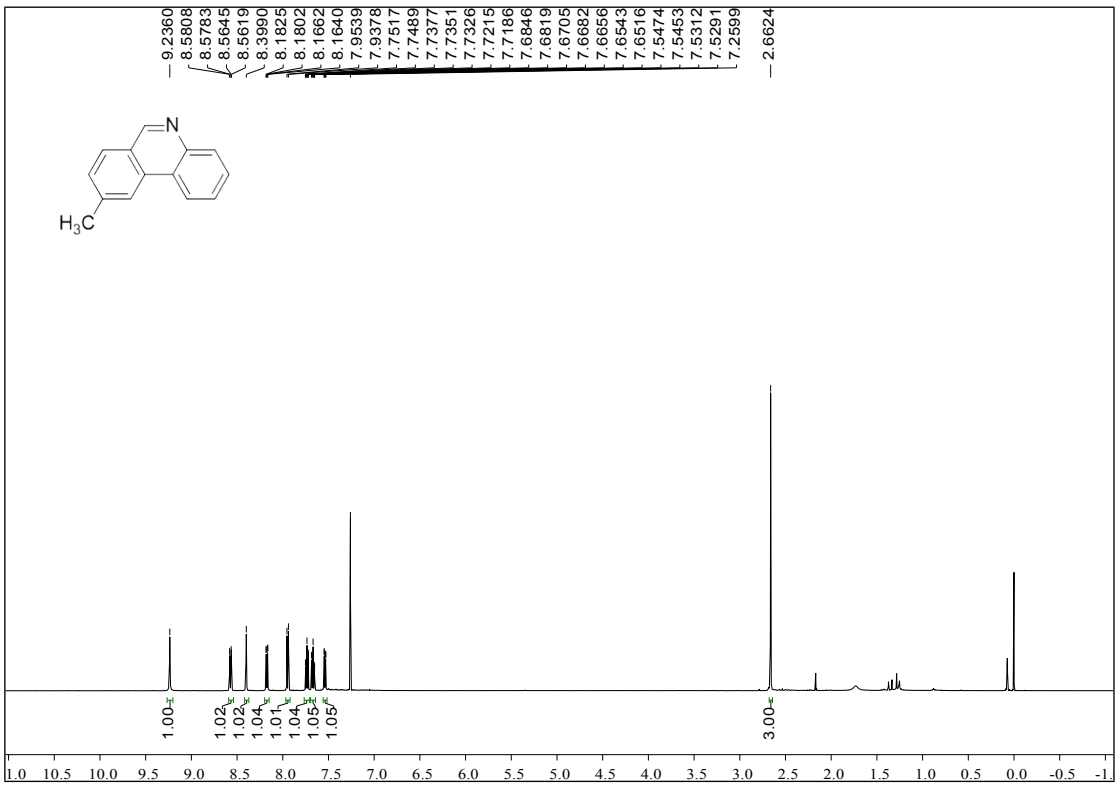


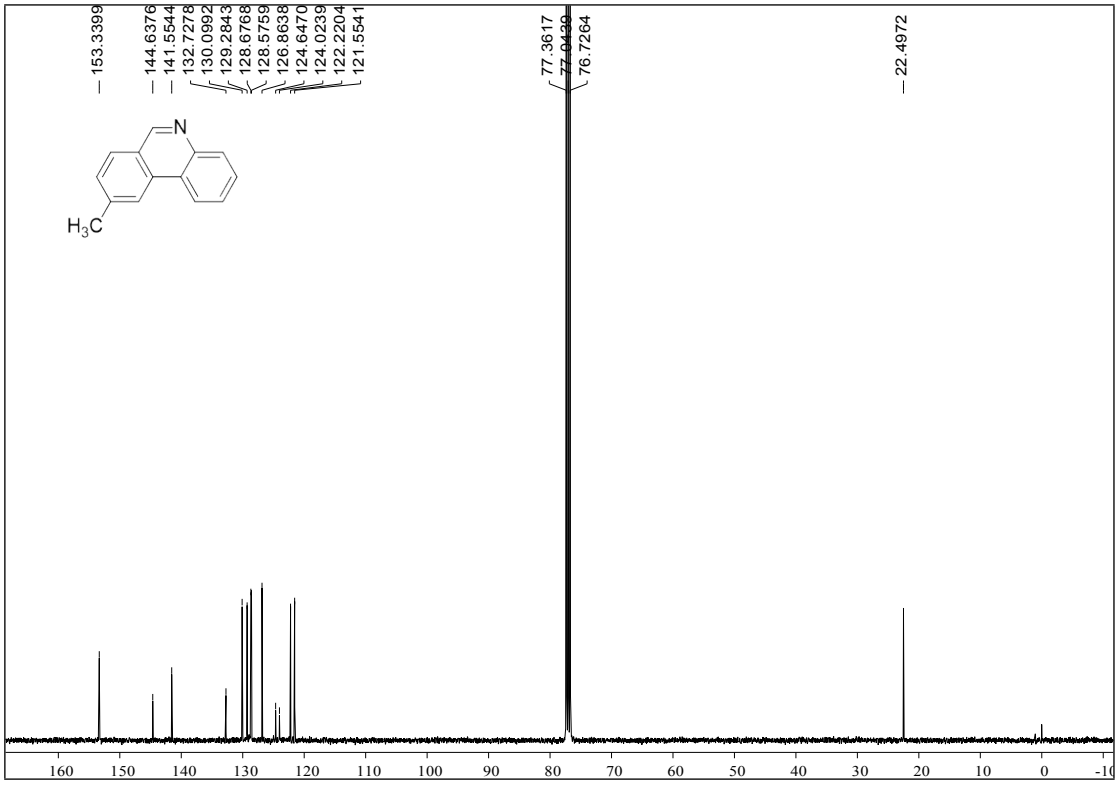
9-chlorophenanthridine (3ka)



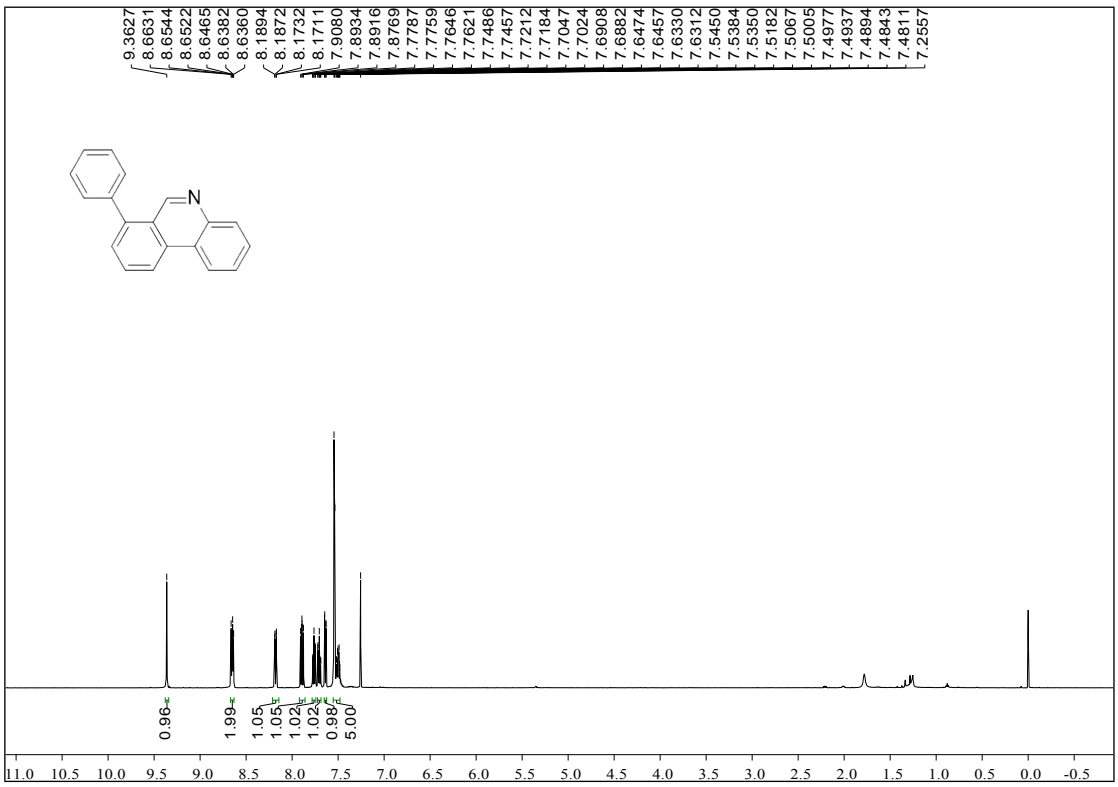


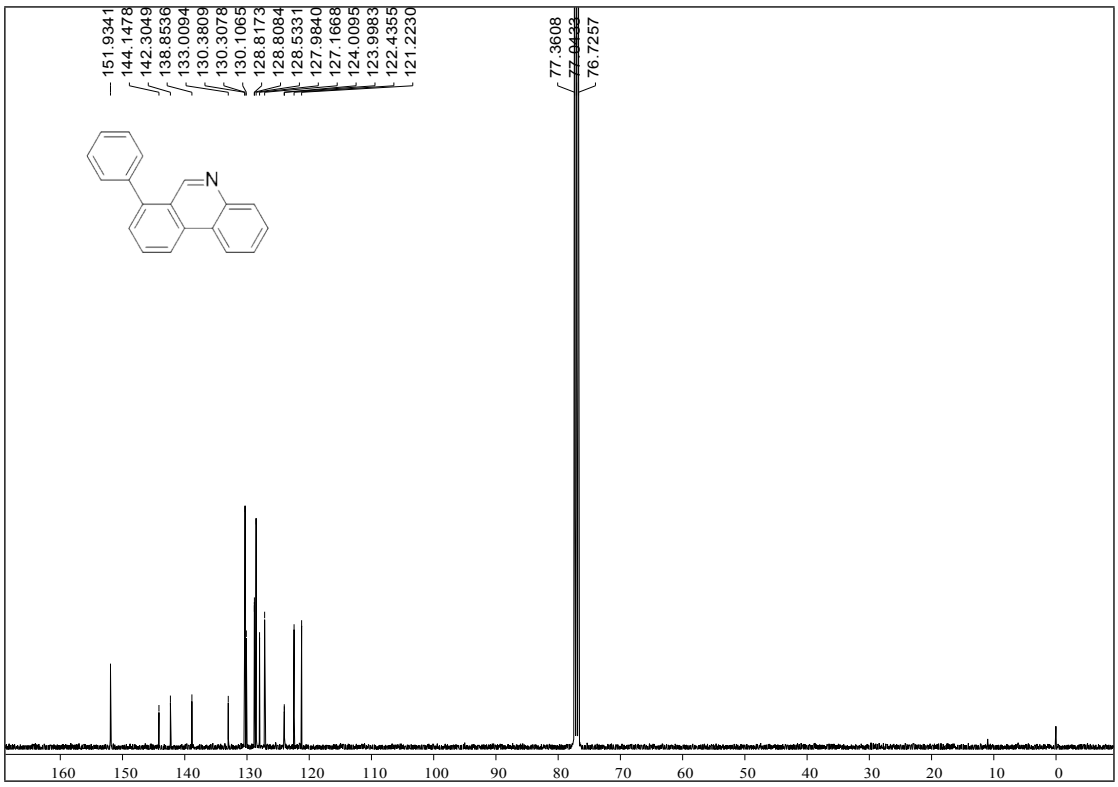
9-methylphenanthridine (3la)



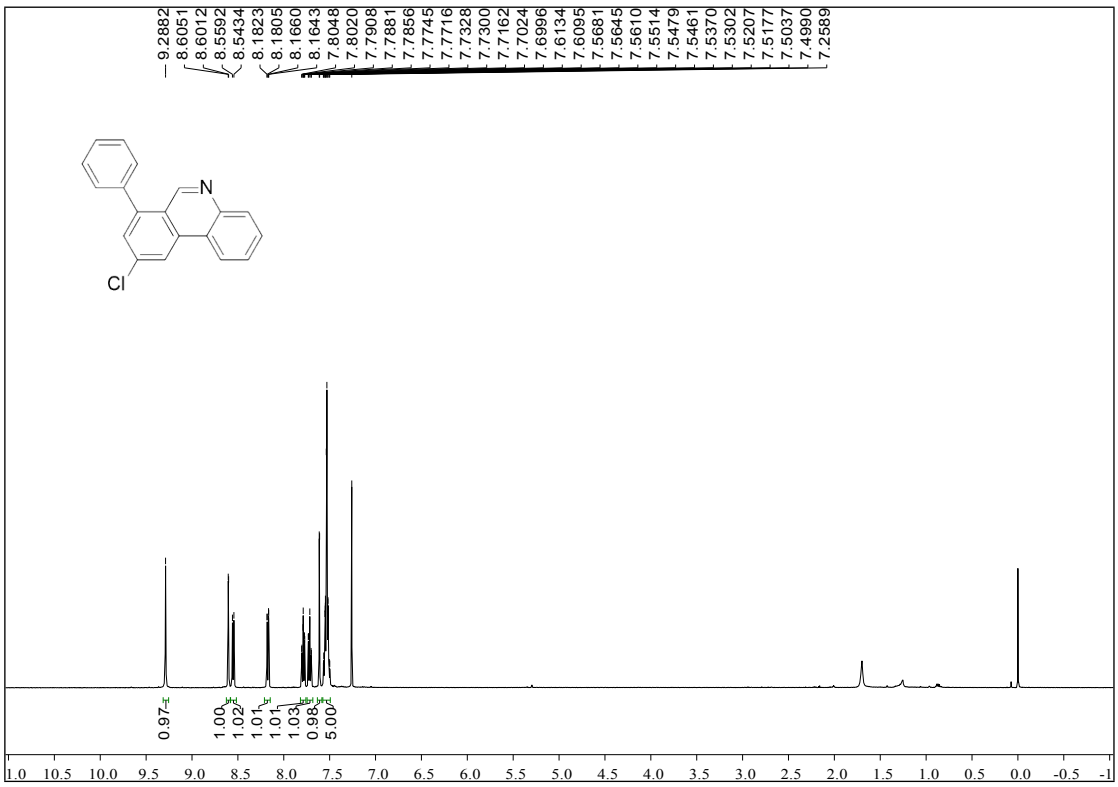


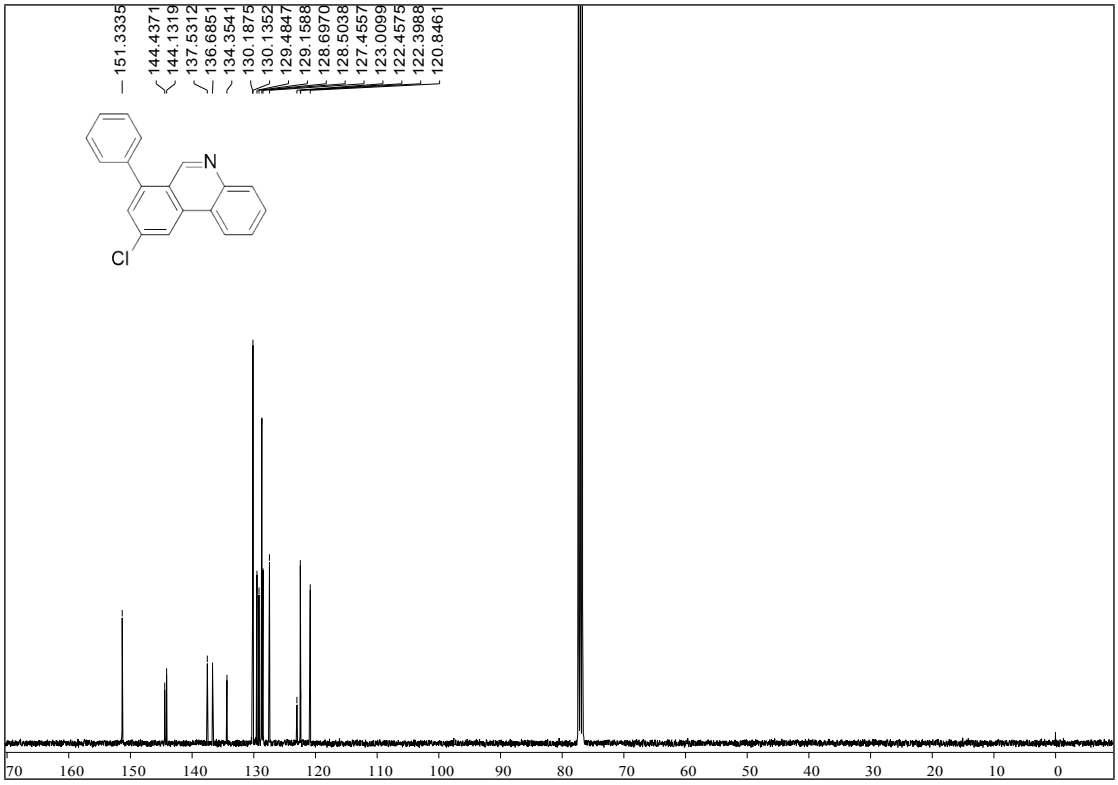
7-phenylphenanthridine (3jaa)



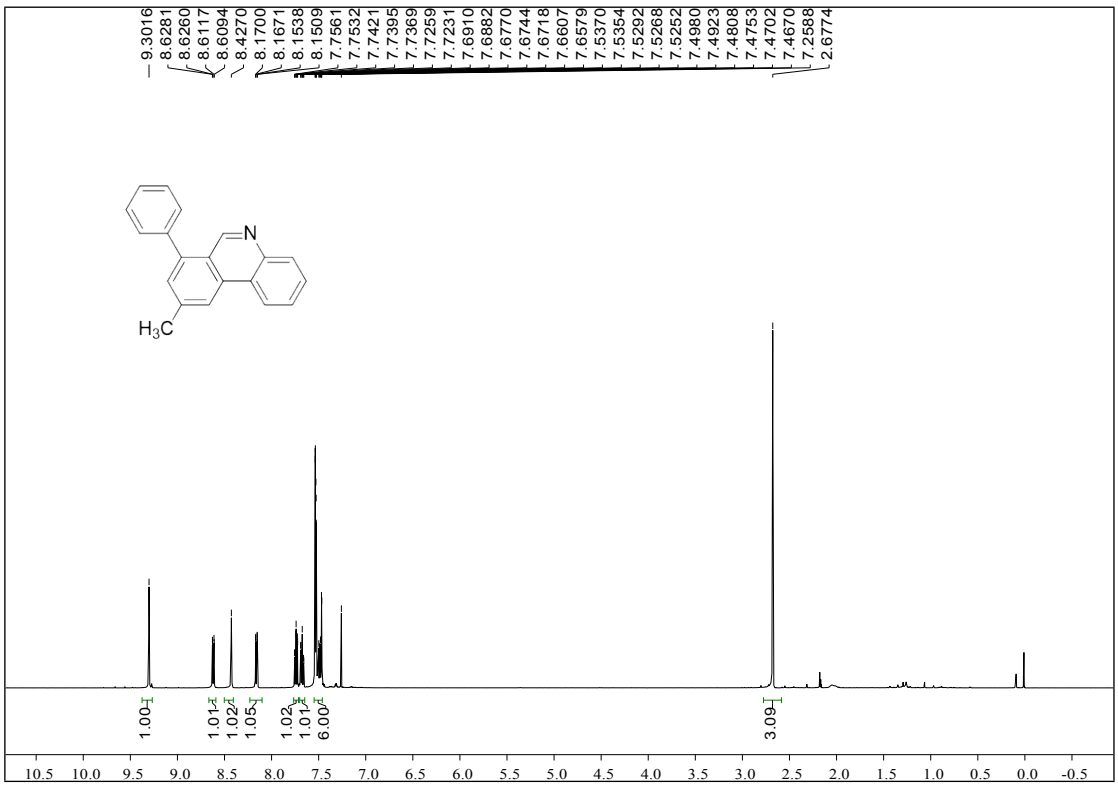


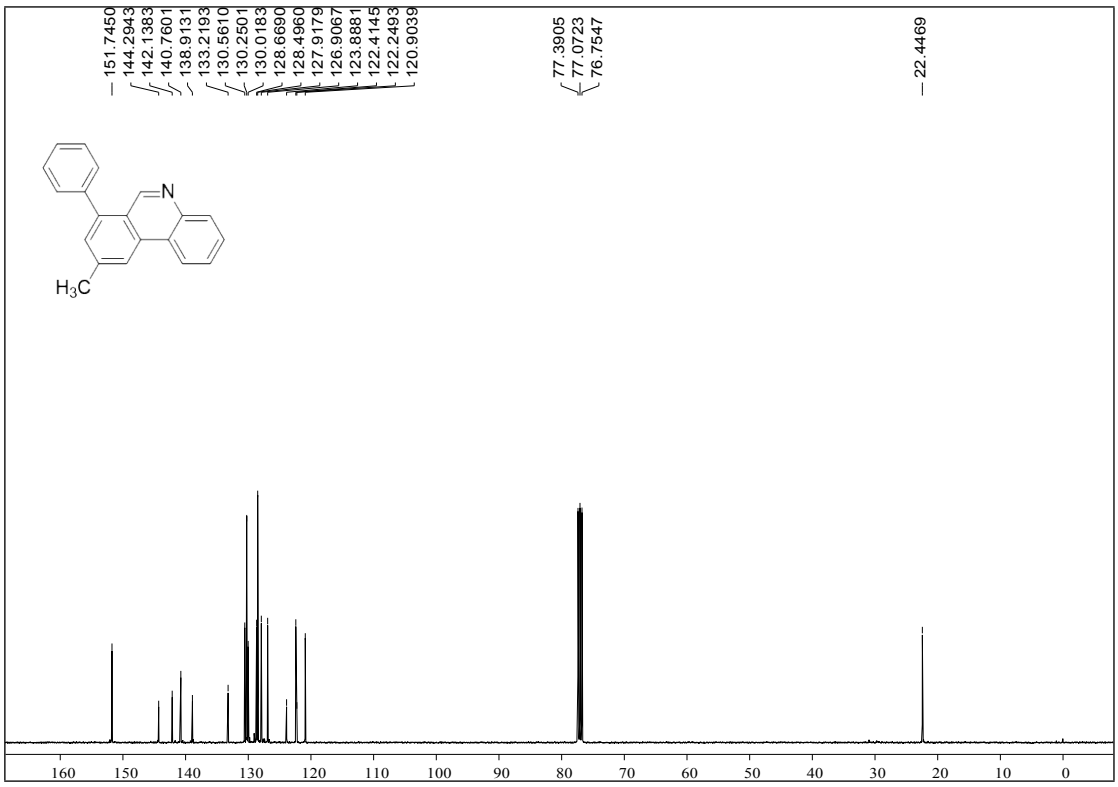
9-methyl-7-phenylphenanthridine (3kaa)



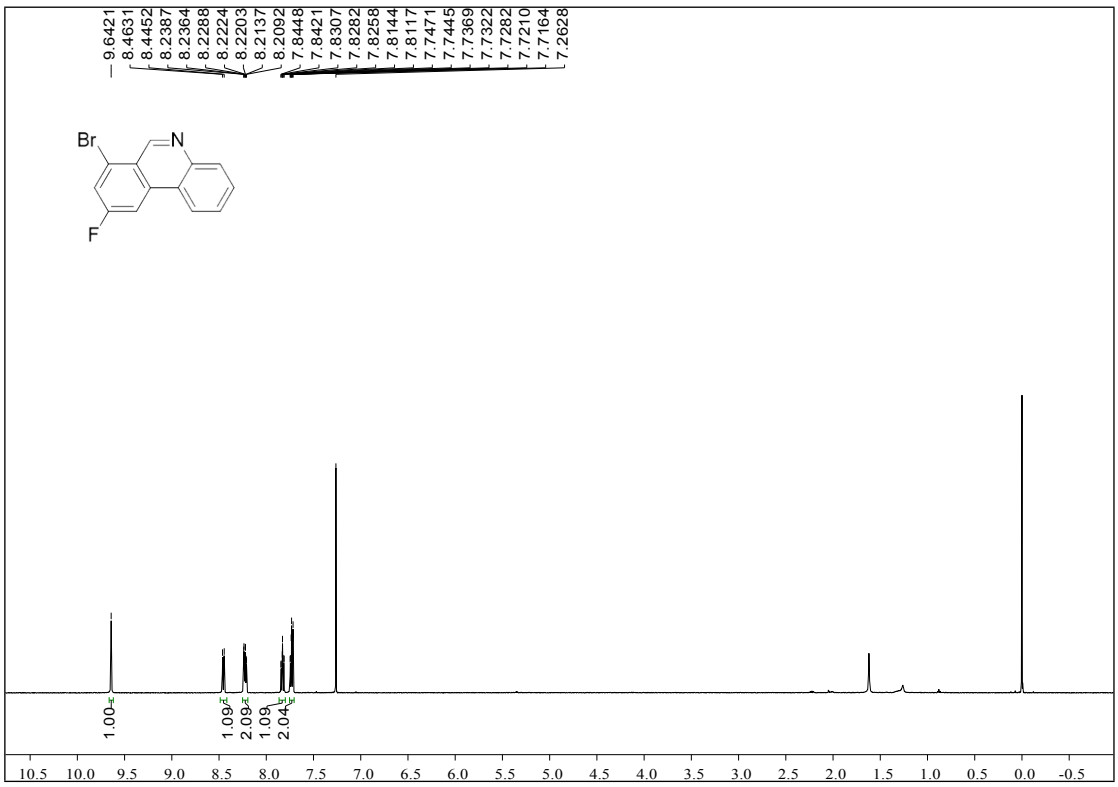


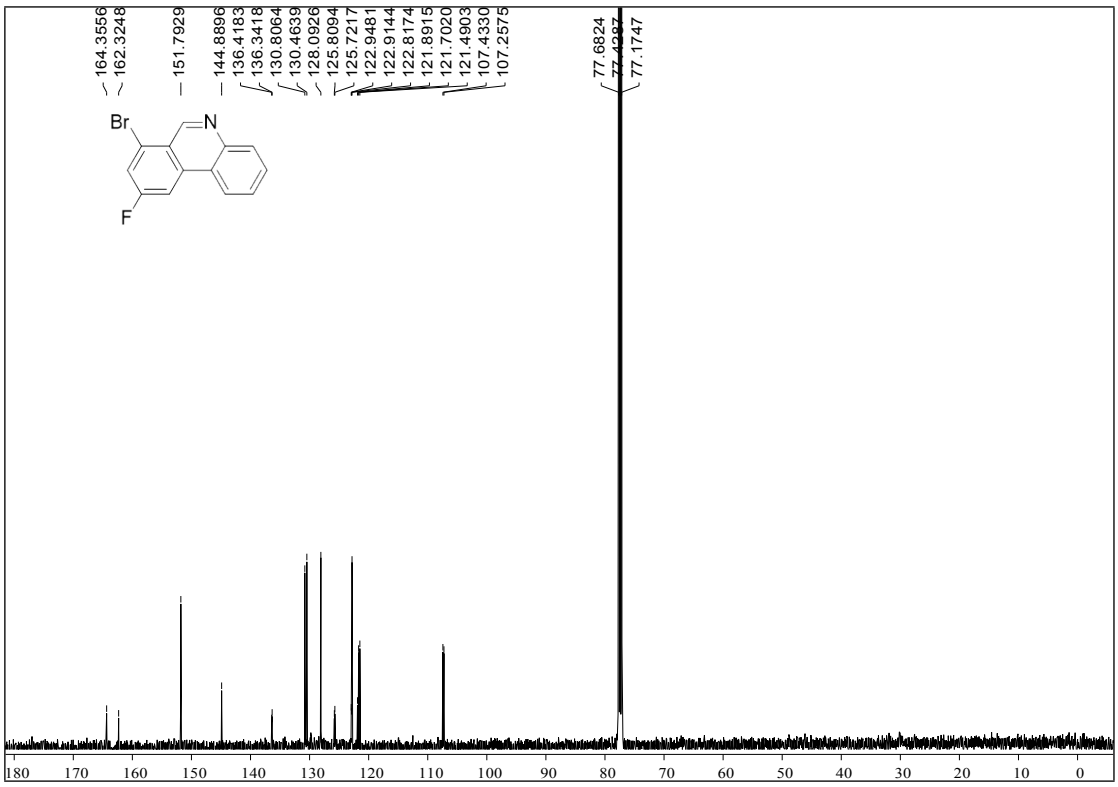
9-methyl-7-phenylphenanthridine (3laa)



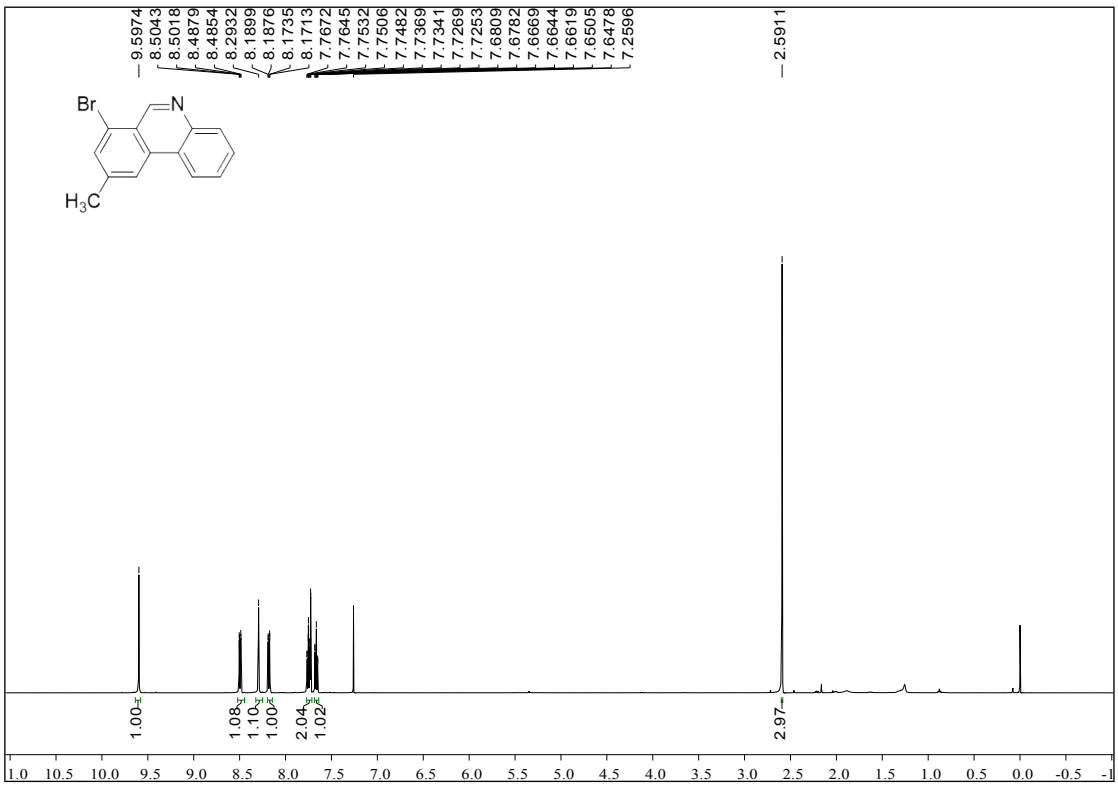


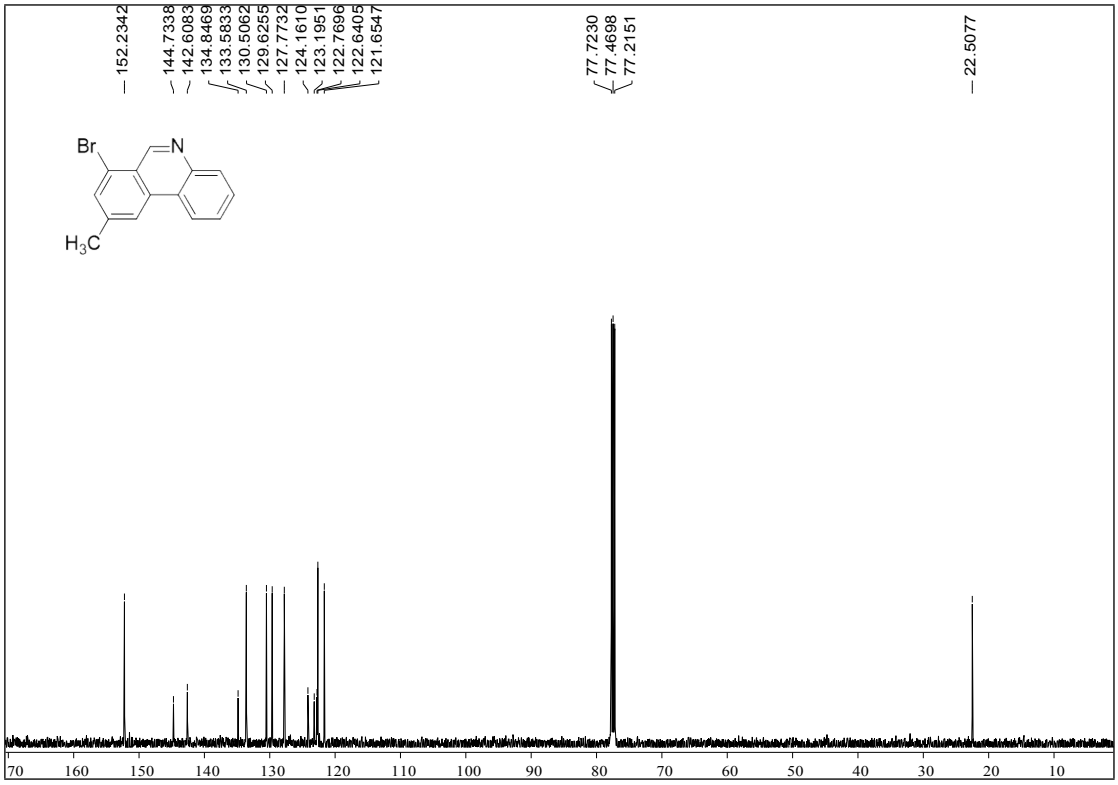
7-bromo-9-fluorophenanthridine (3ma)



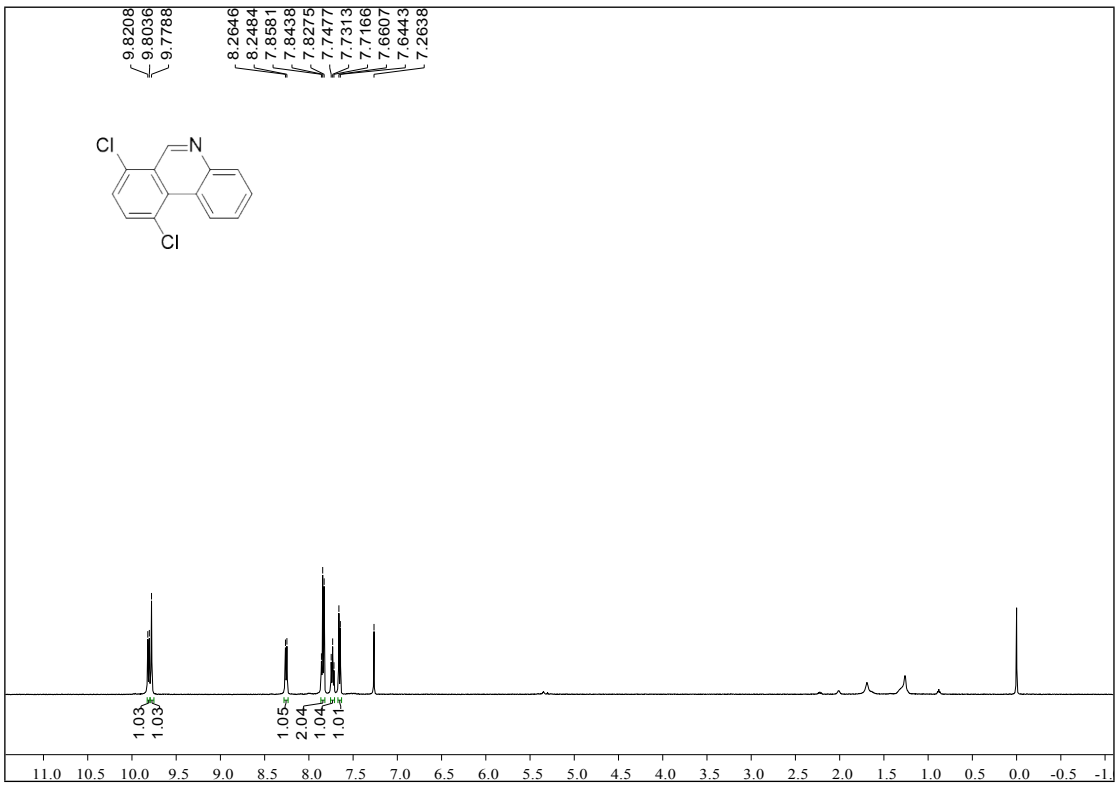


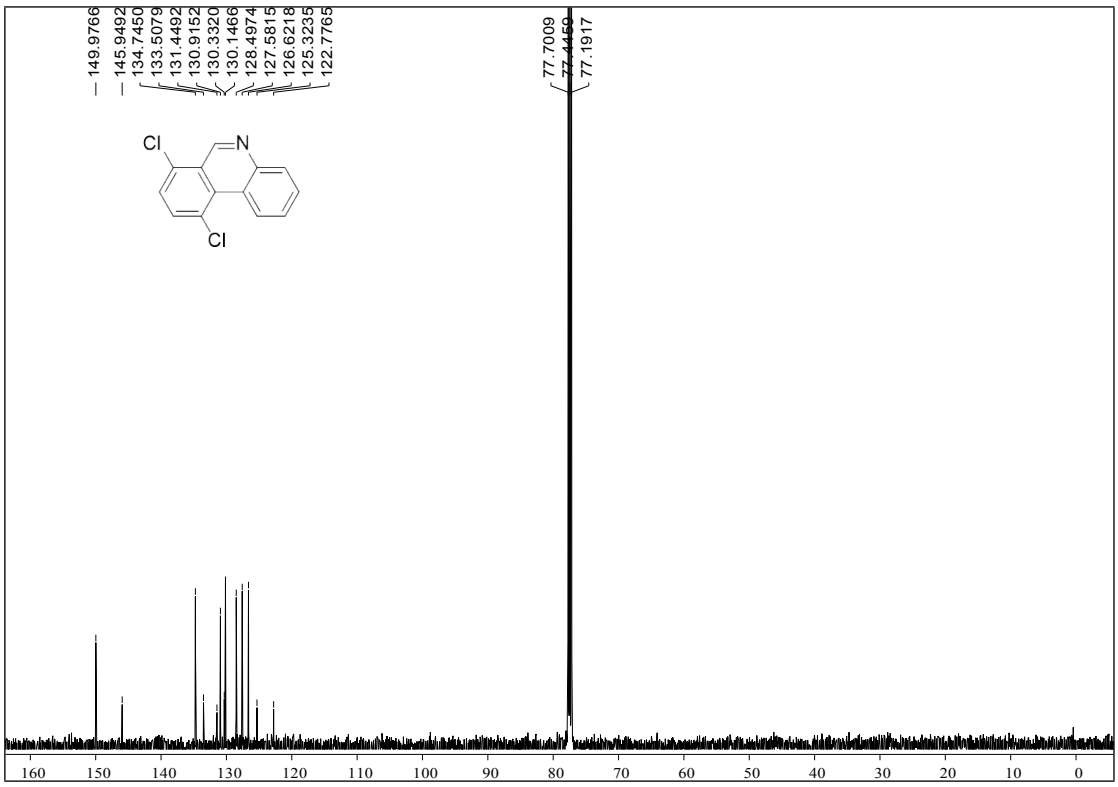
7-bromo-9-methylphenanthridine (3na)



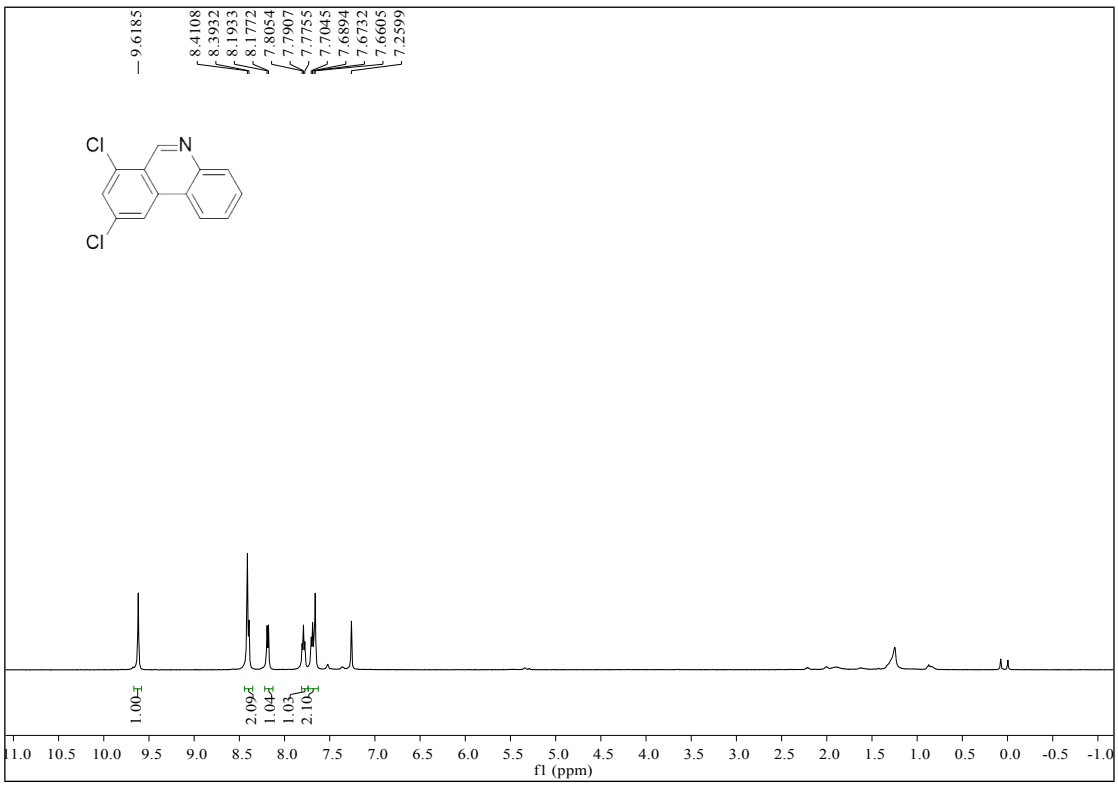


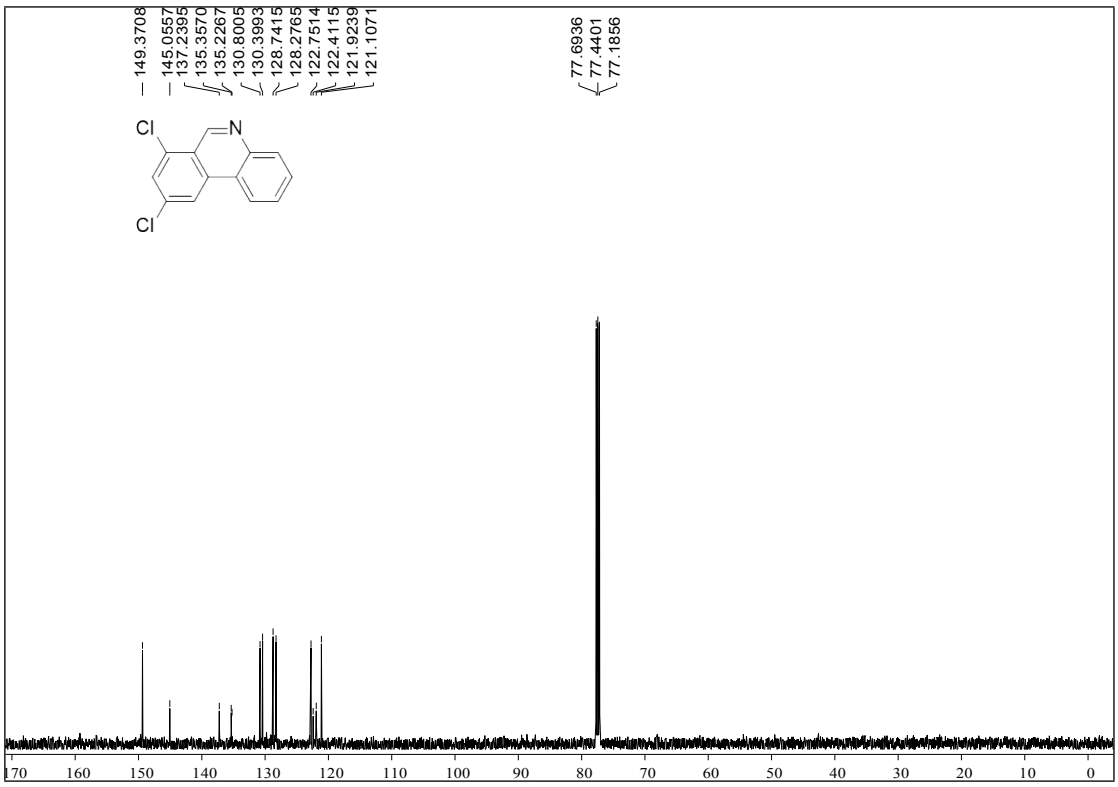
7,10-dichlorophenanthridine (3oa)



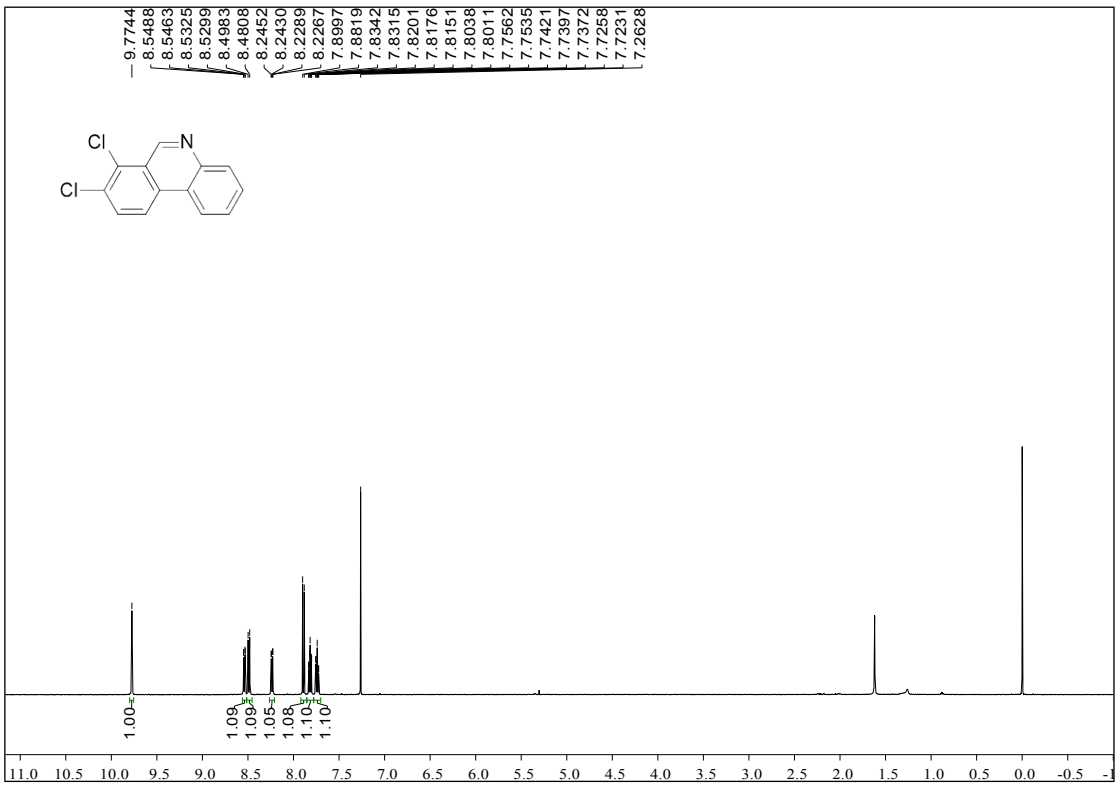


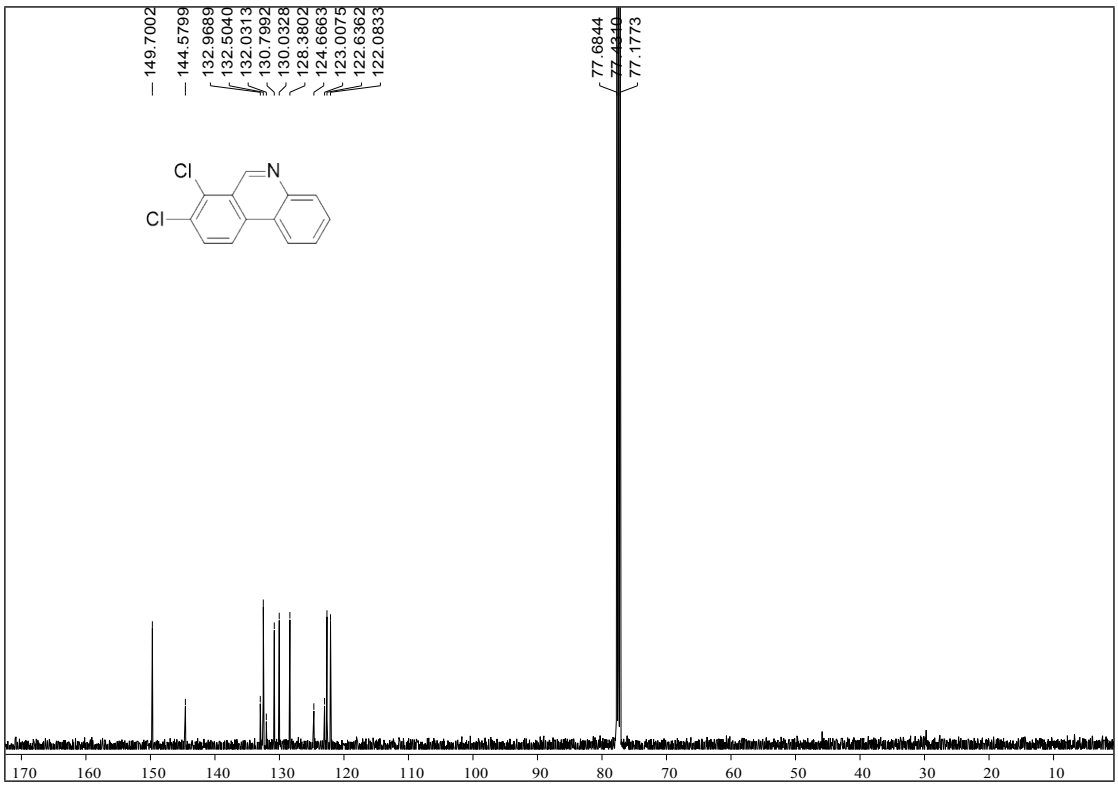
7,9-dichlorophenanthridine (3pa)



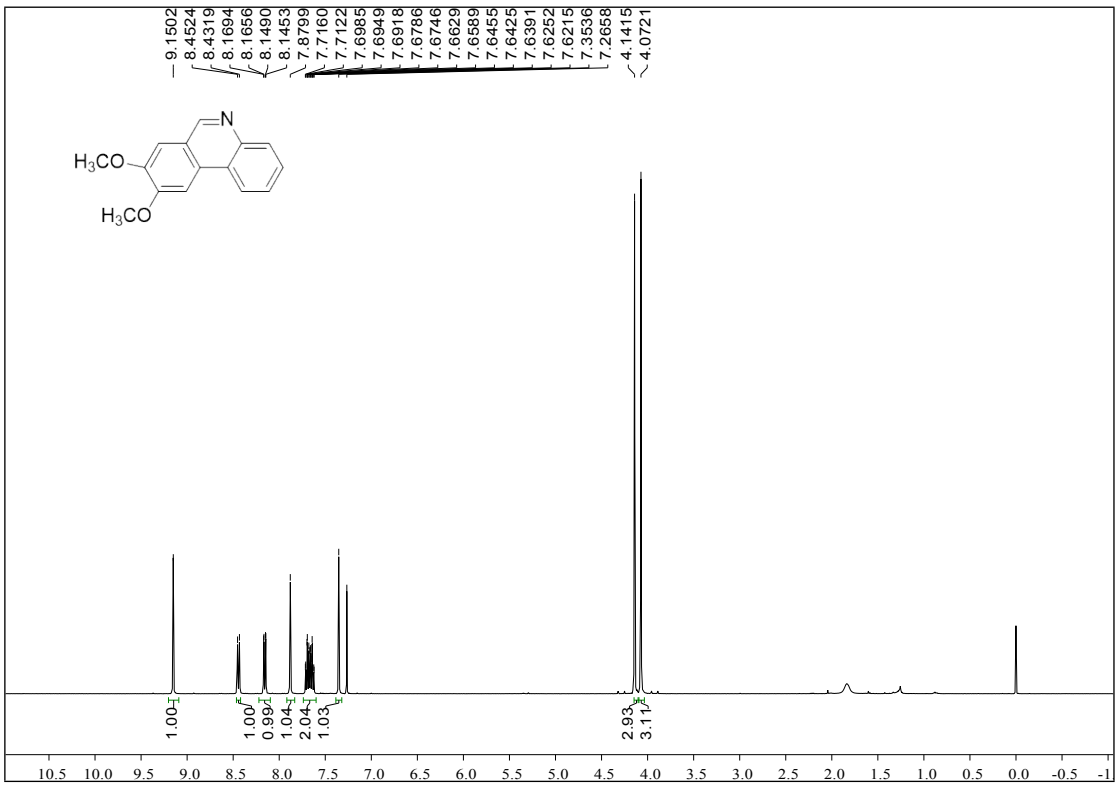


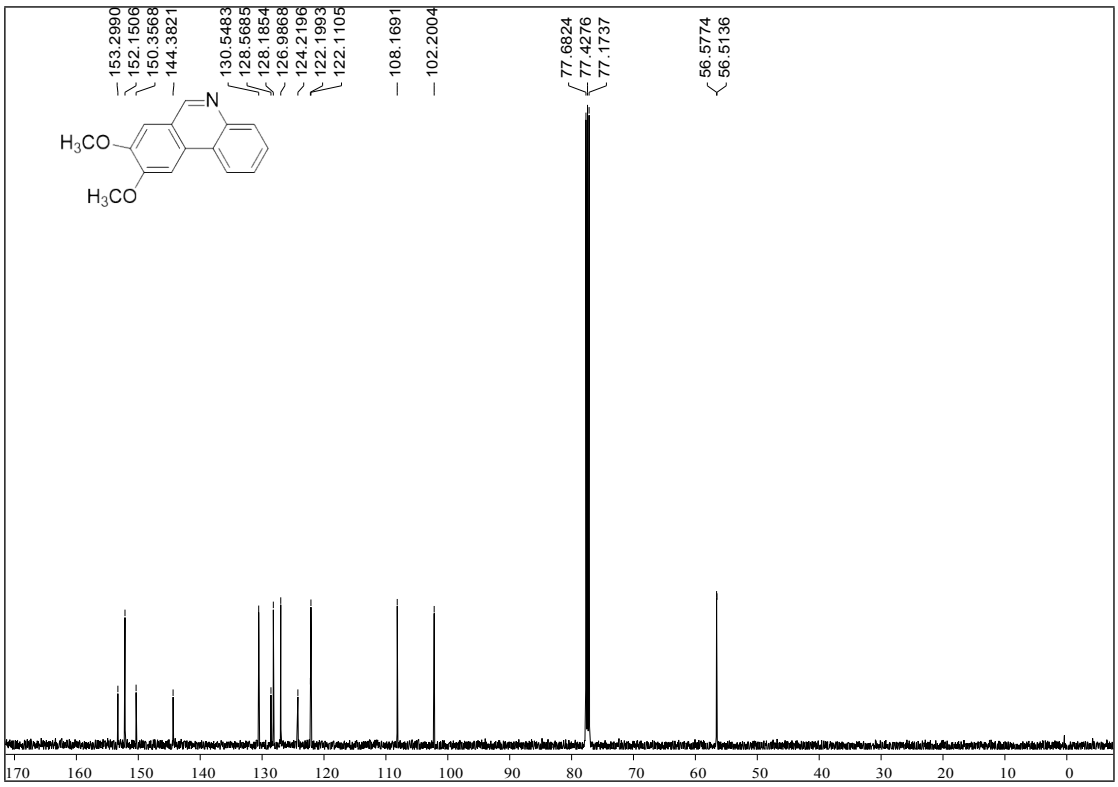
7,8-dichlorophenanthridine (3qa)



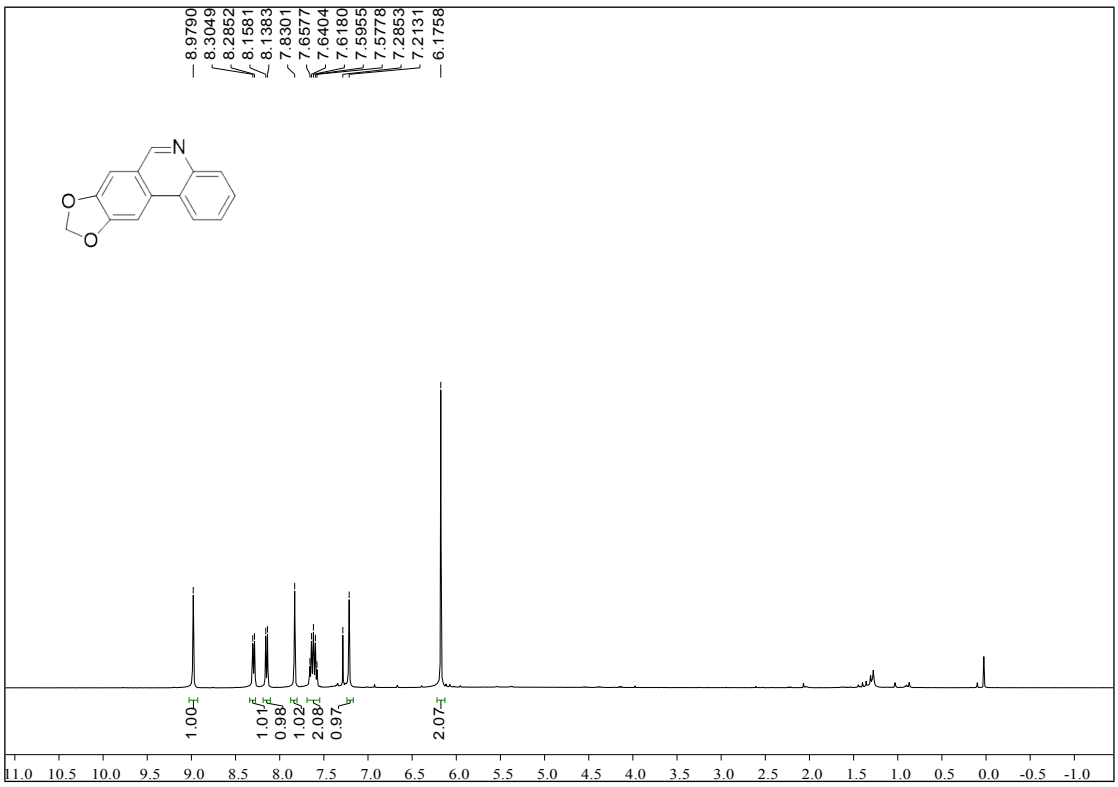


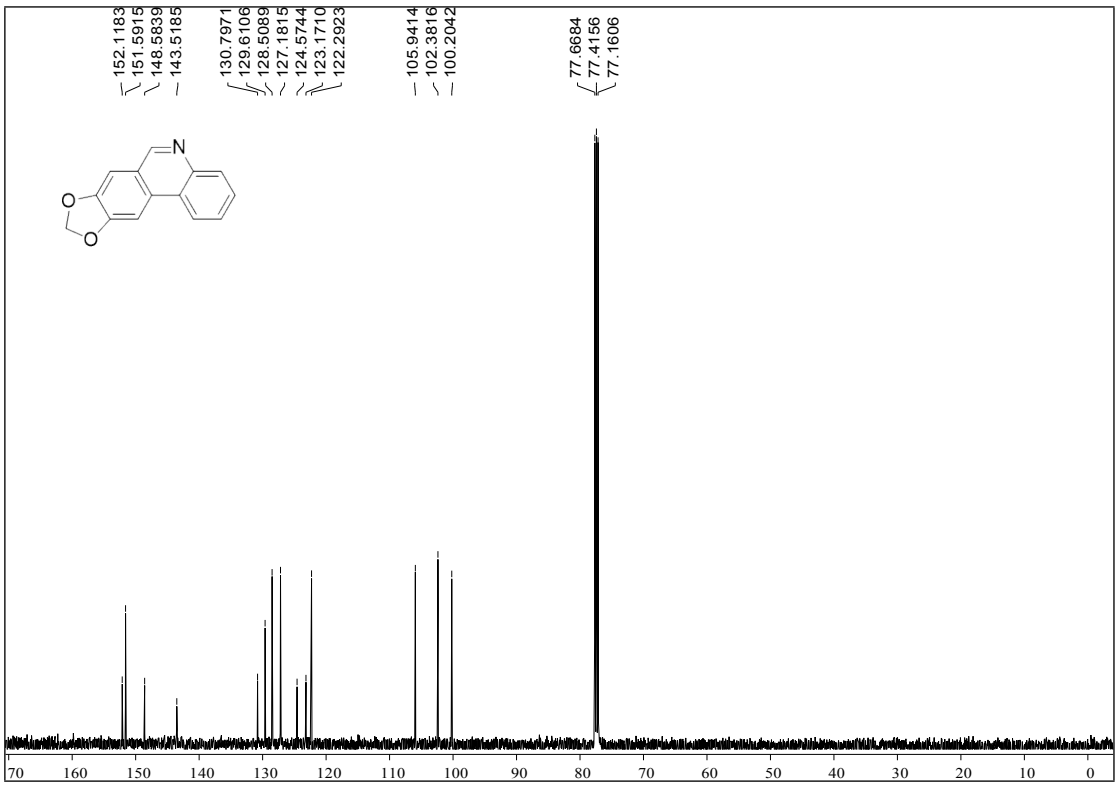
8,9-dimethoxyphenanthridine (3ra)



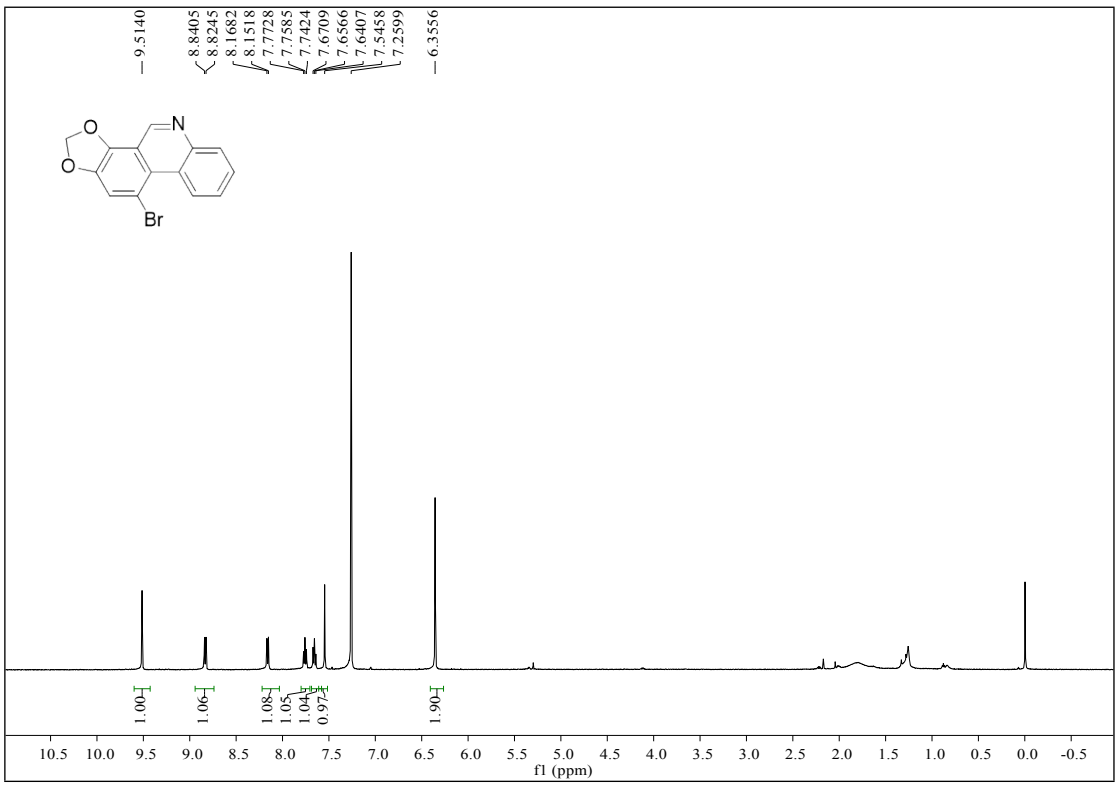


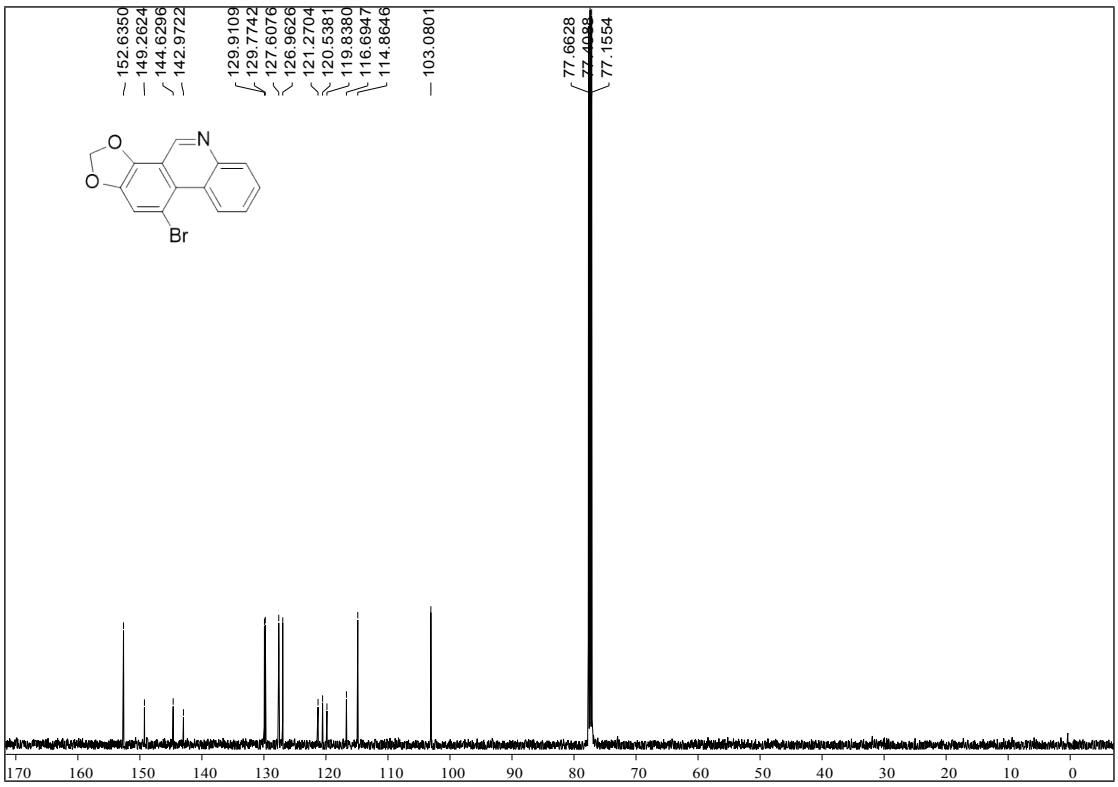
[1,3]dioxolo[4,5-j]phenanthridine (3sa)



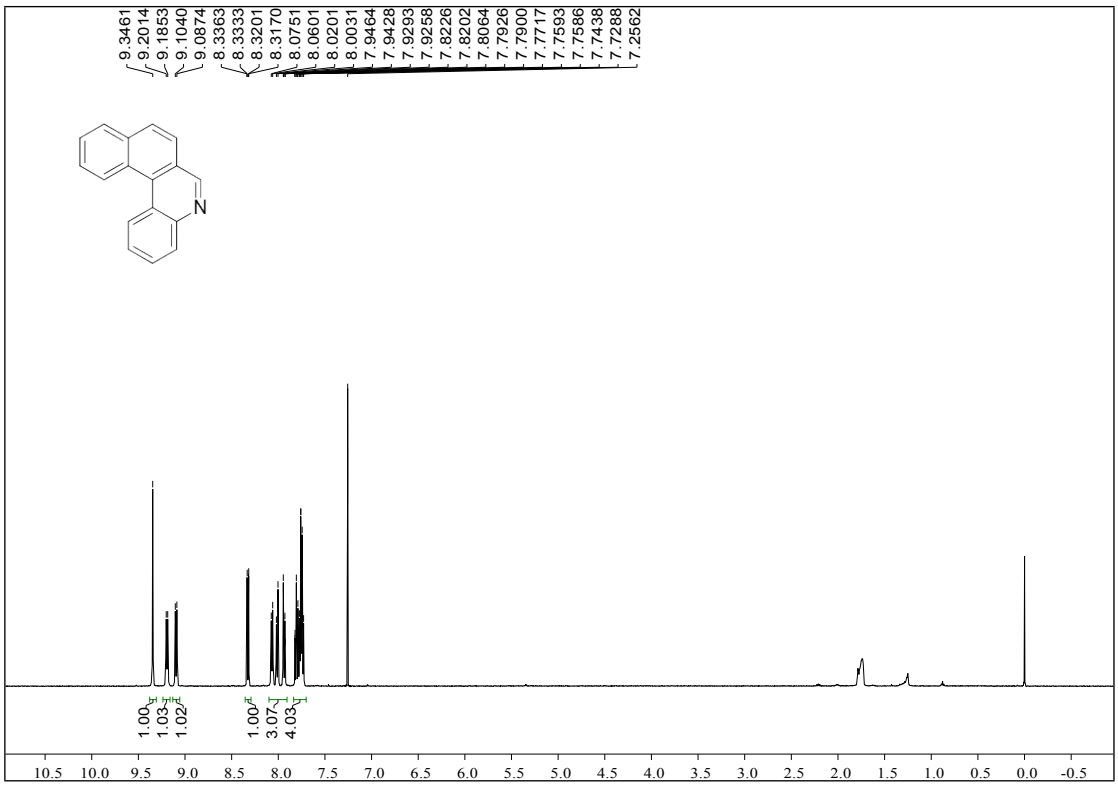


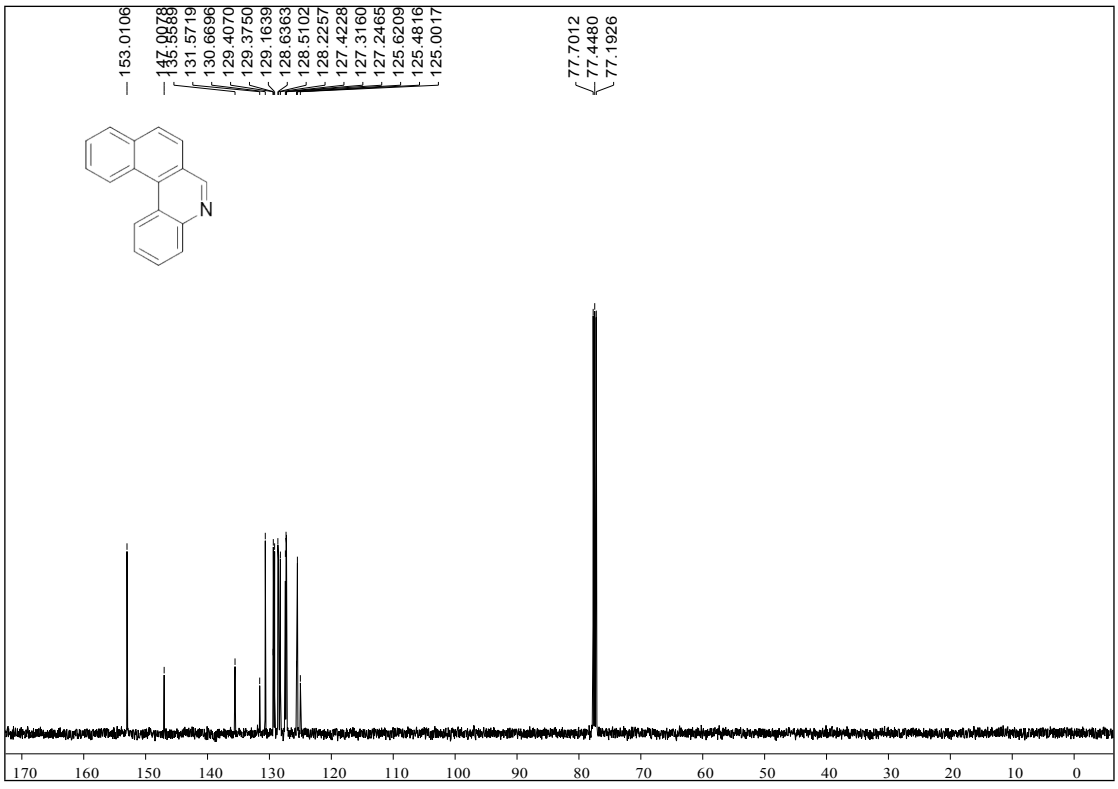
10-bromo-[1,3]dioxolo[4,5-i]phenanthridine (3ta)



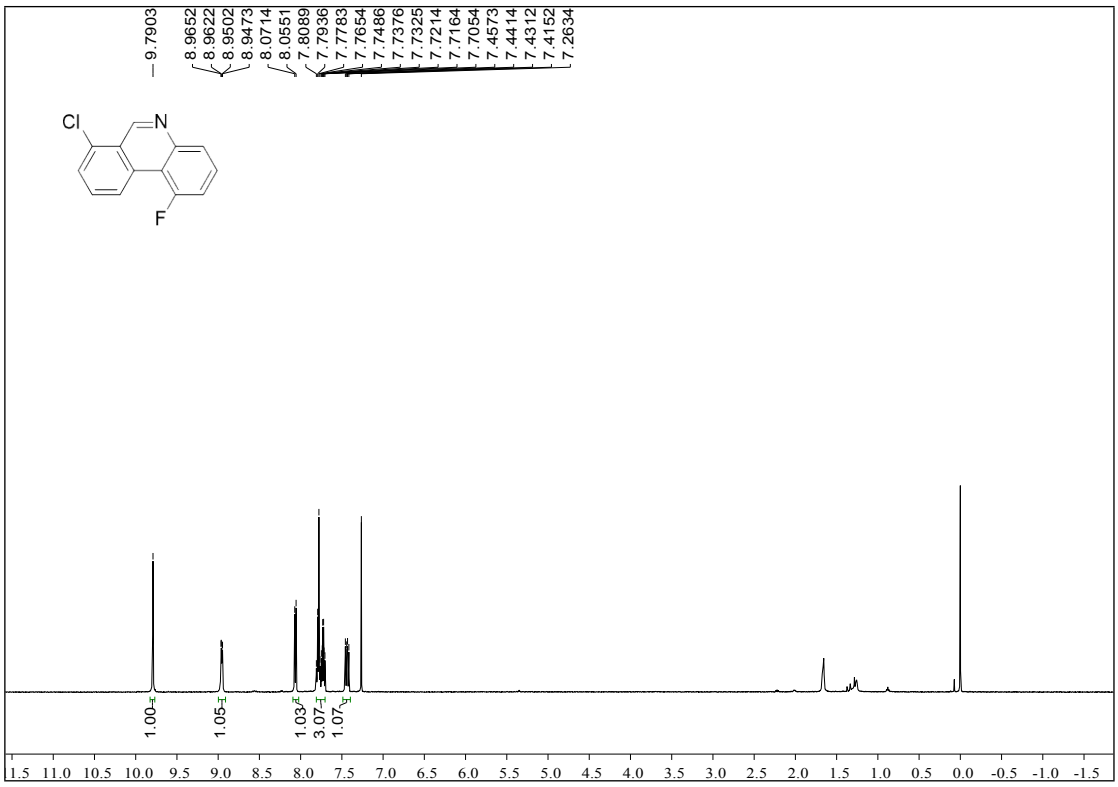


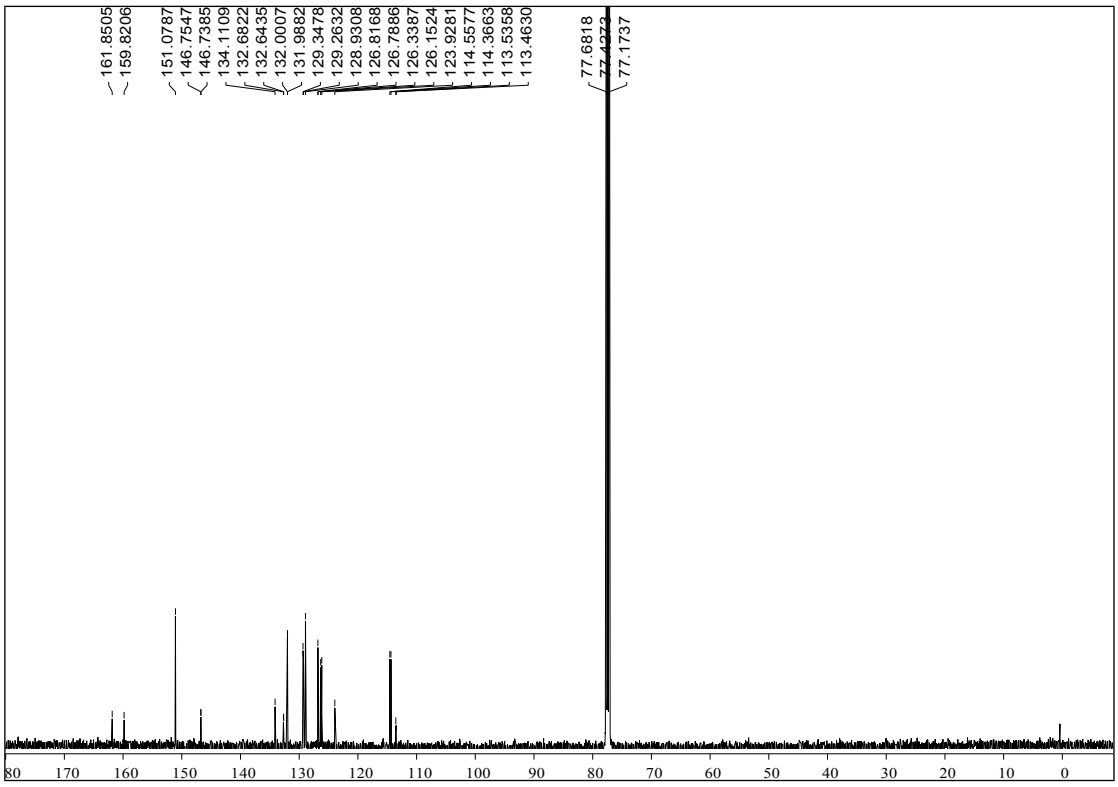
benzo[k]phenanthridine (3ua)



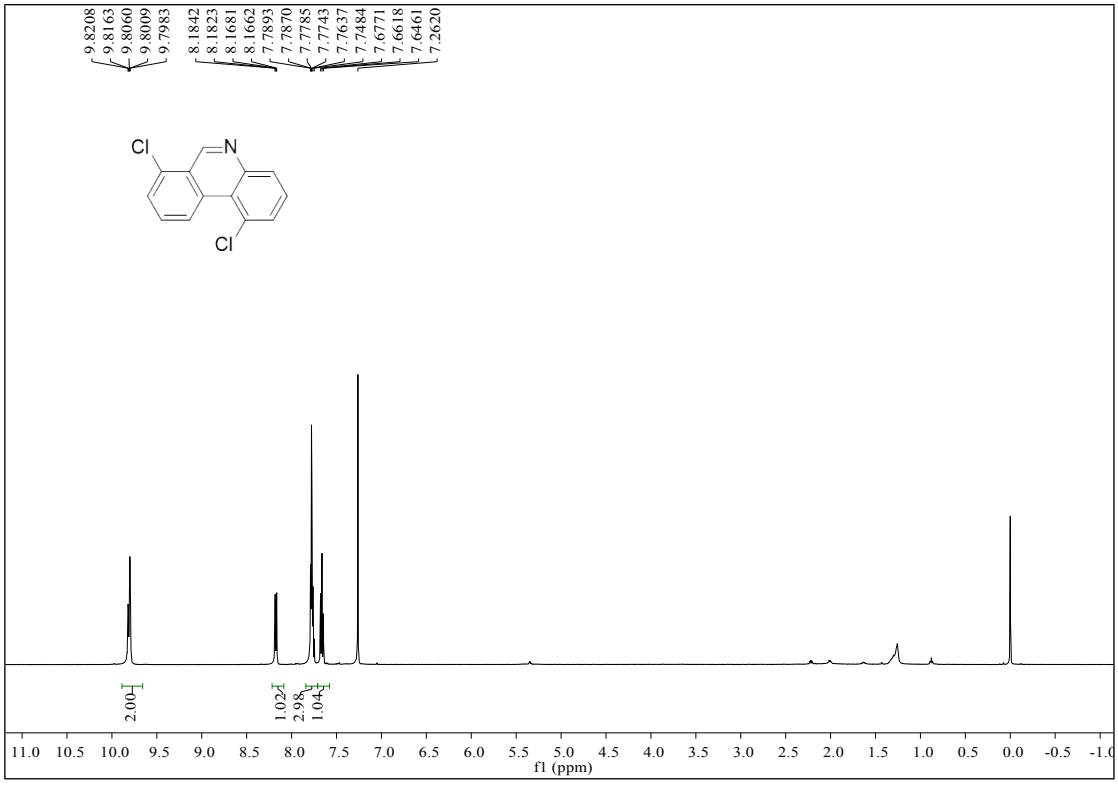


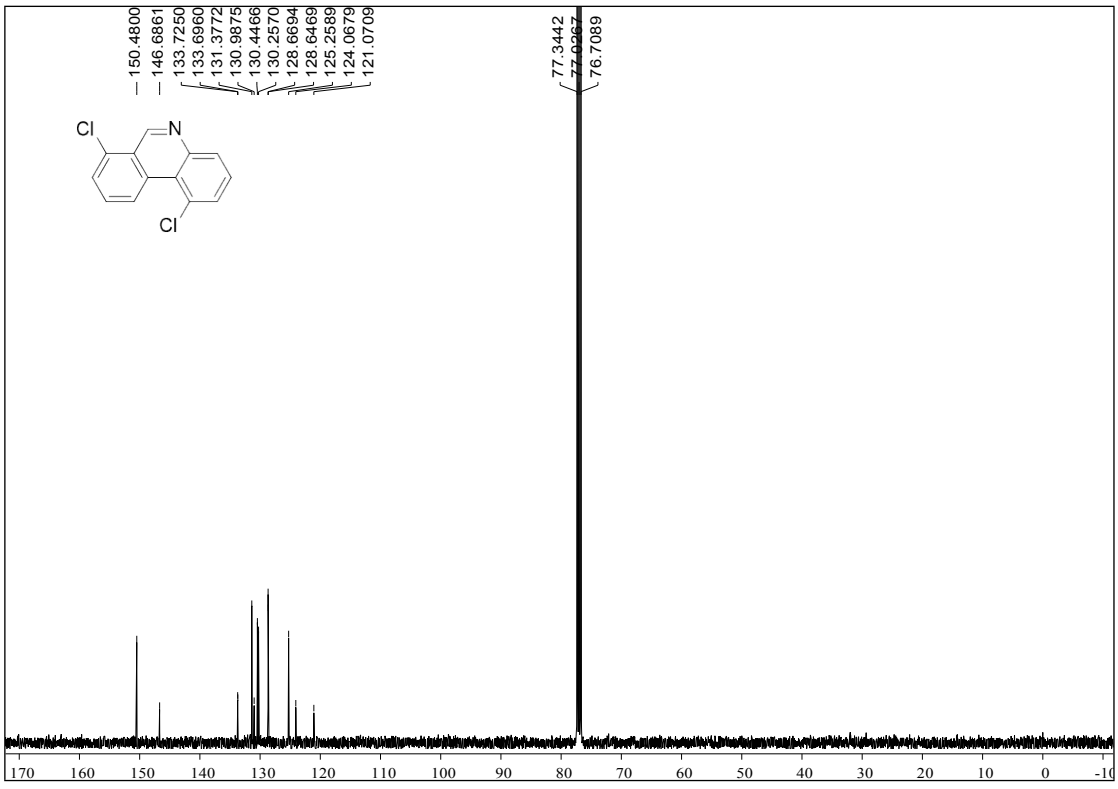
7-chloro-1-fluorophenanthridine (3ab)



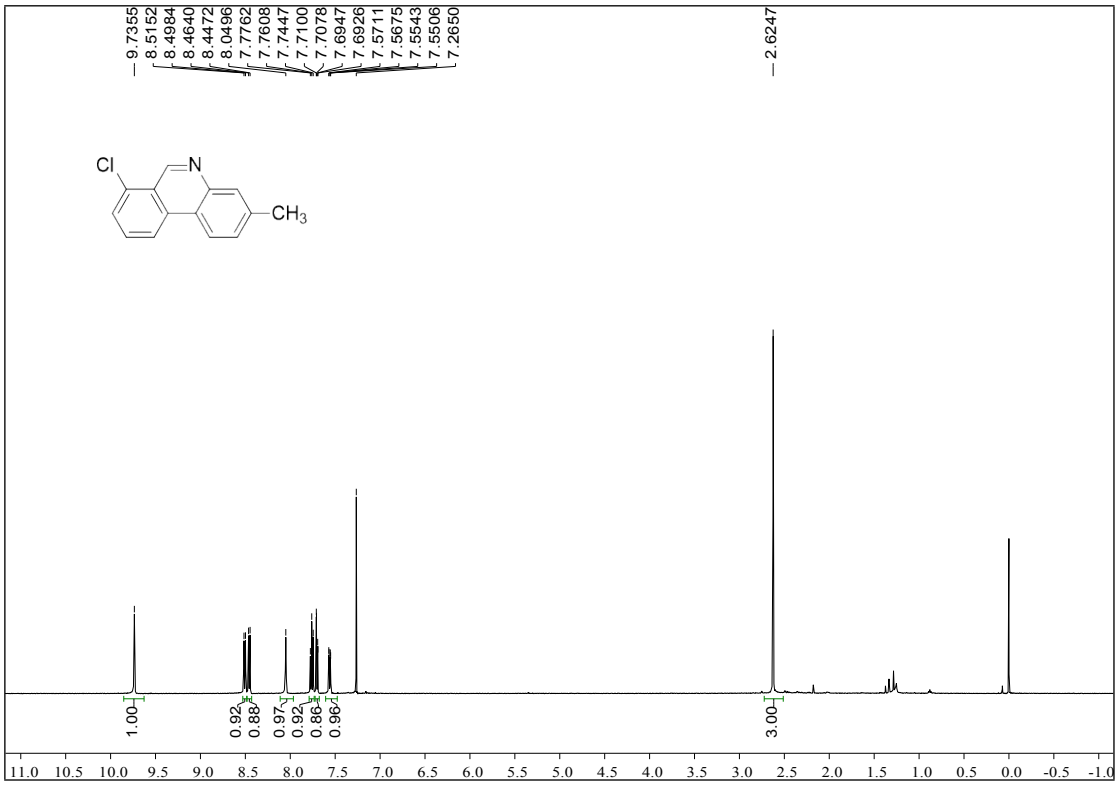


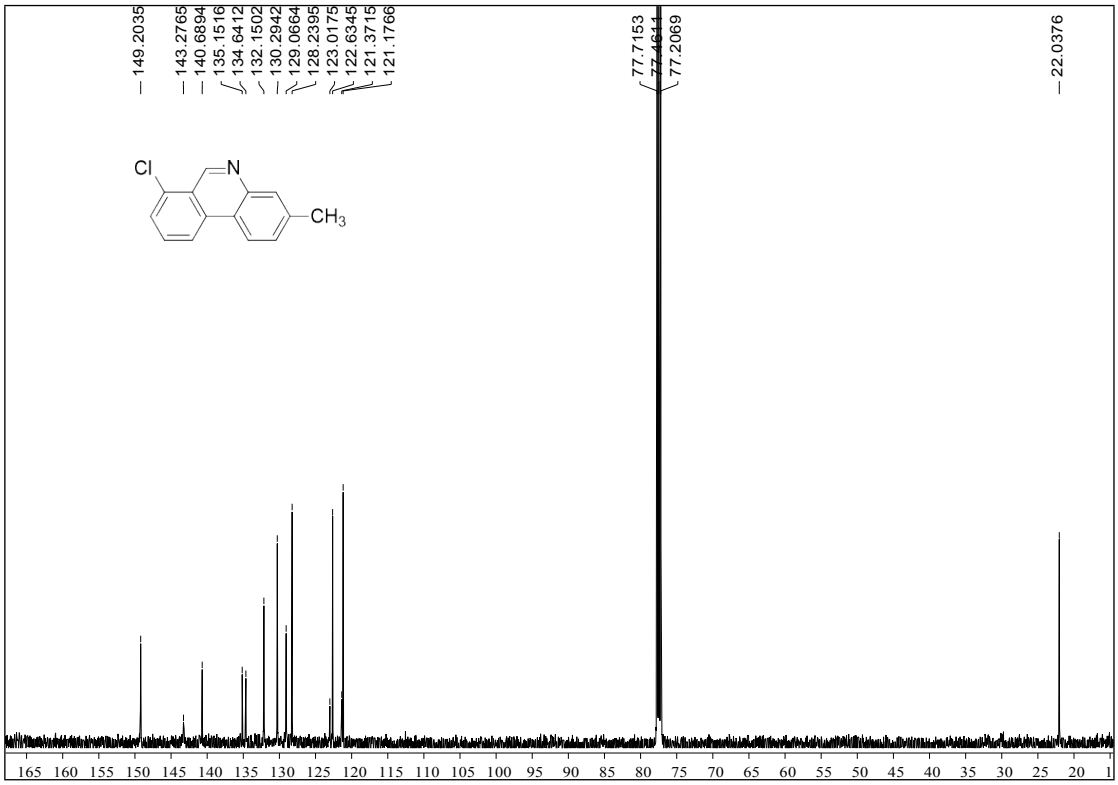
1,7-dichlorophenanthridine (3ac)



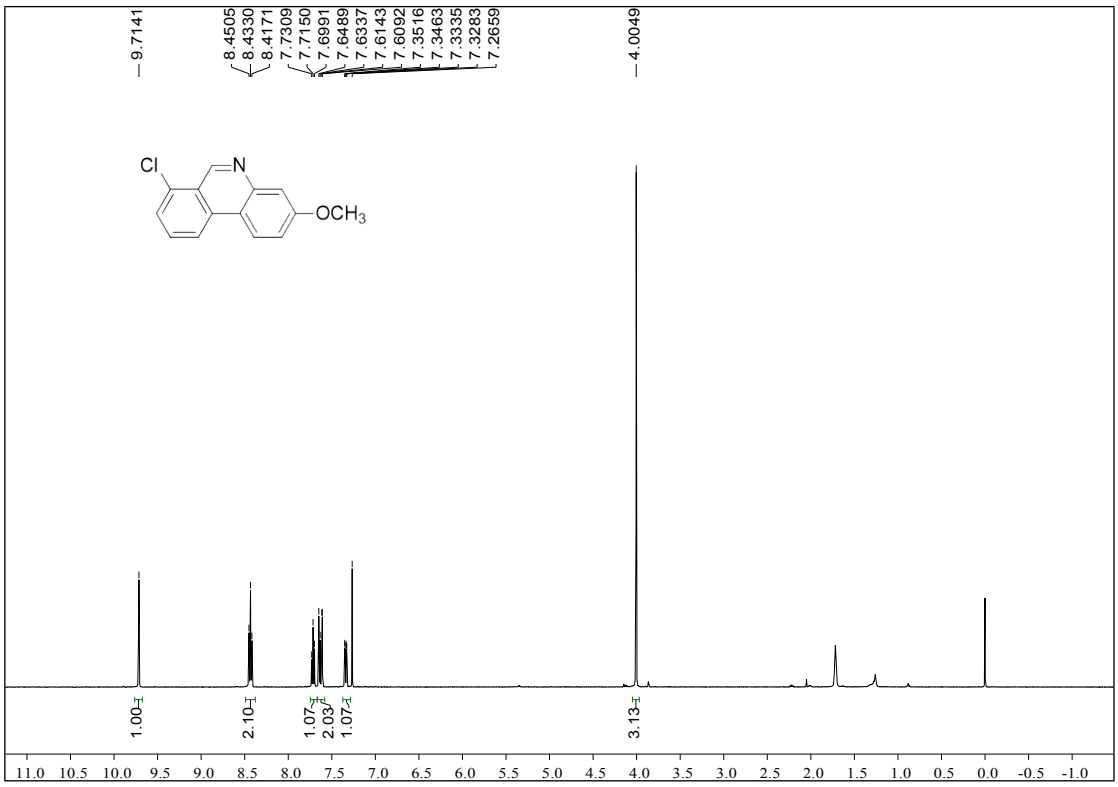


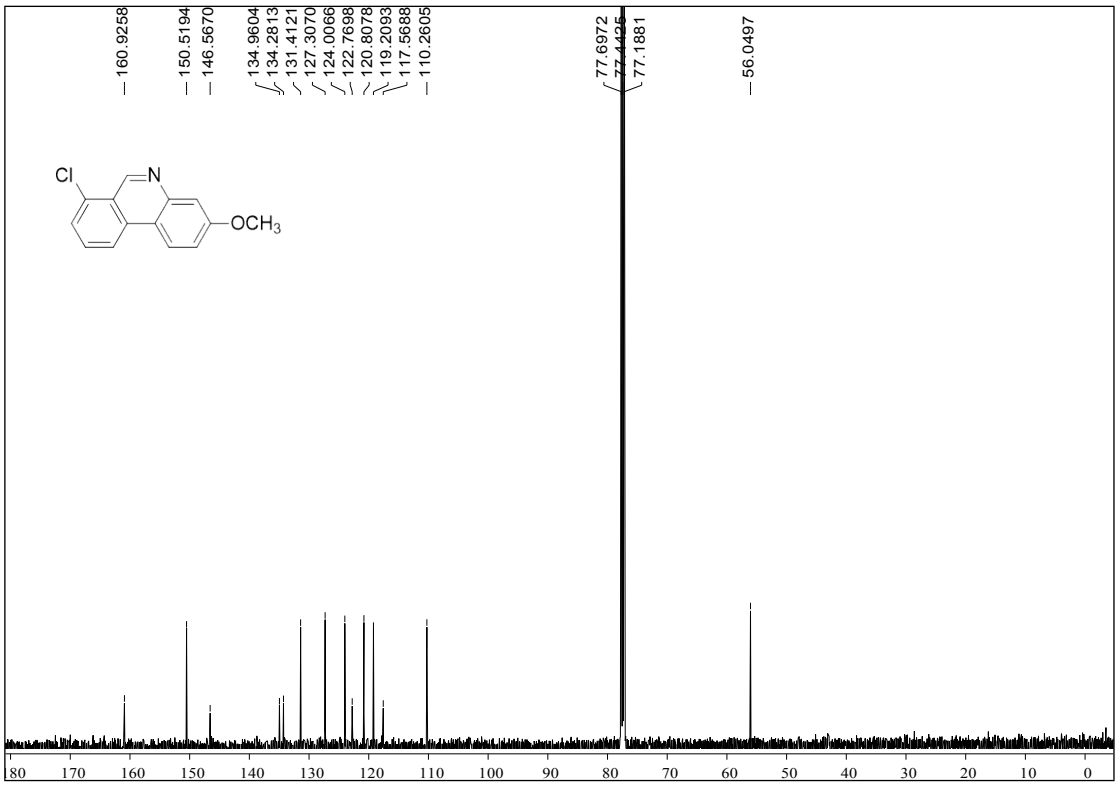
7-chloro-3-methylphenanthridine (3ad)



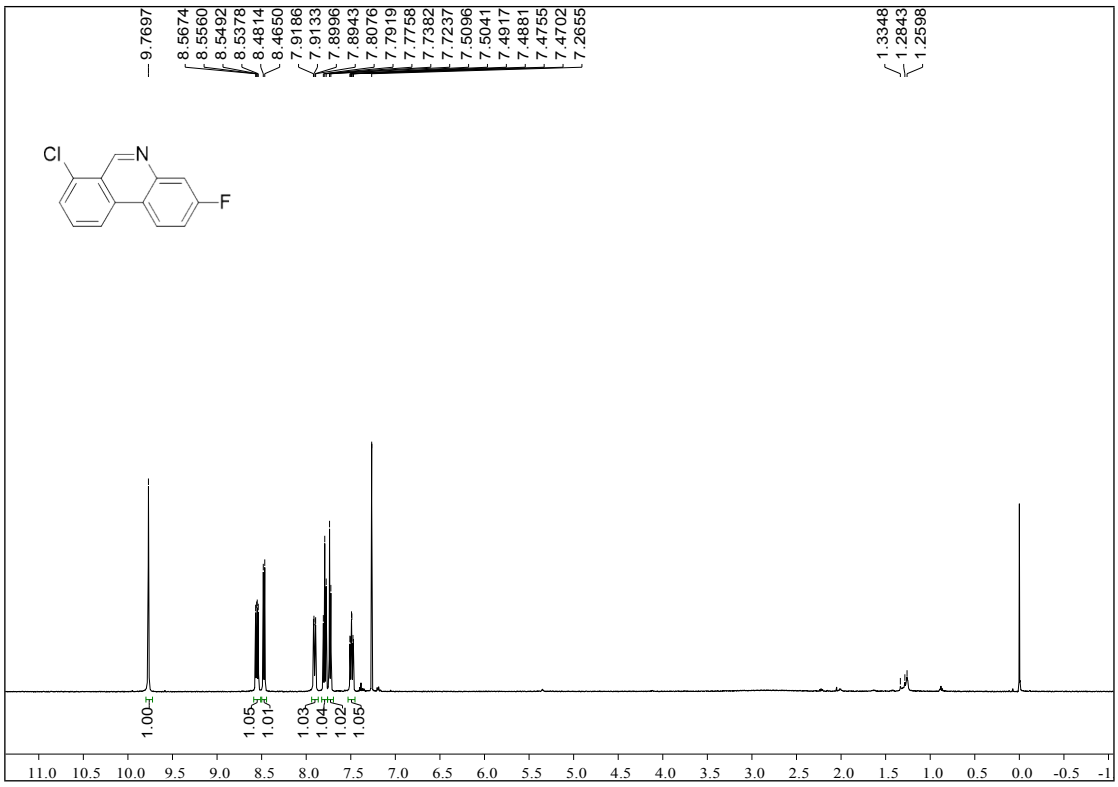


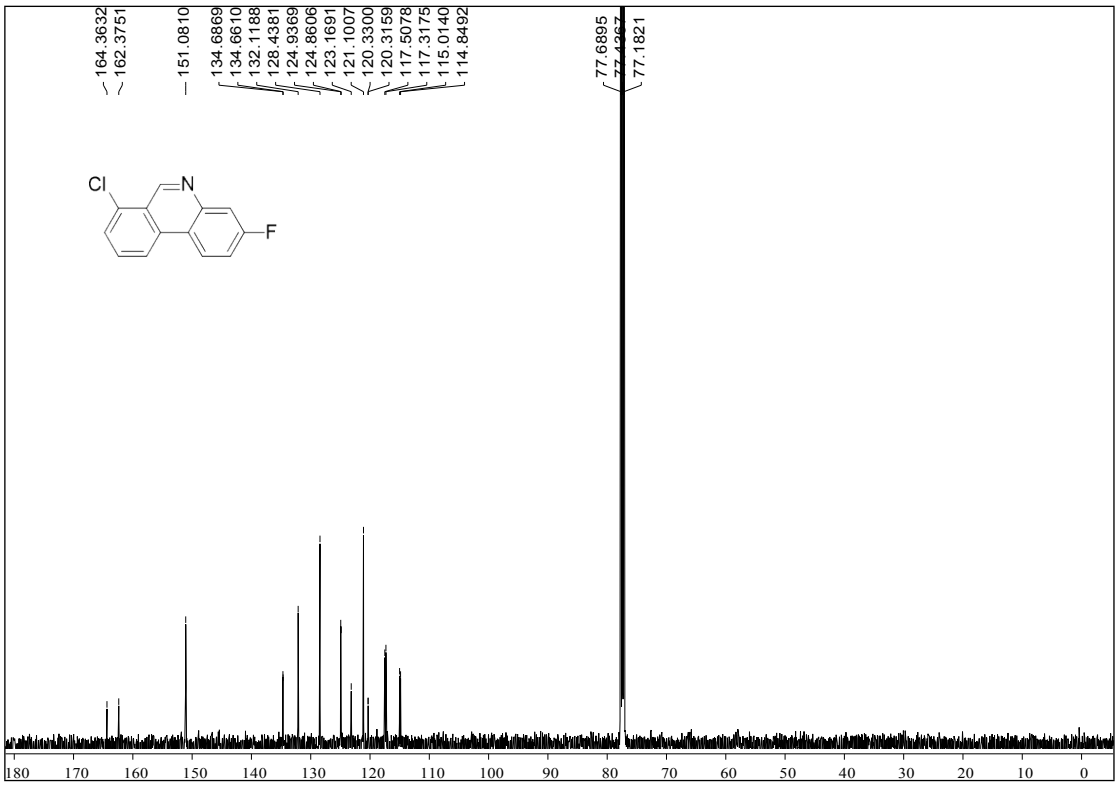
7-chloro-3-methoxyphenanthridine (3ae)



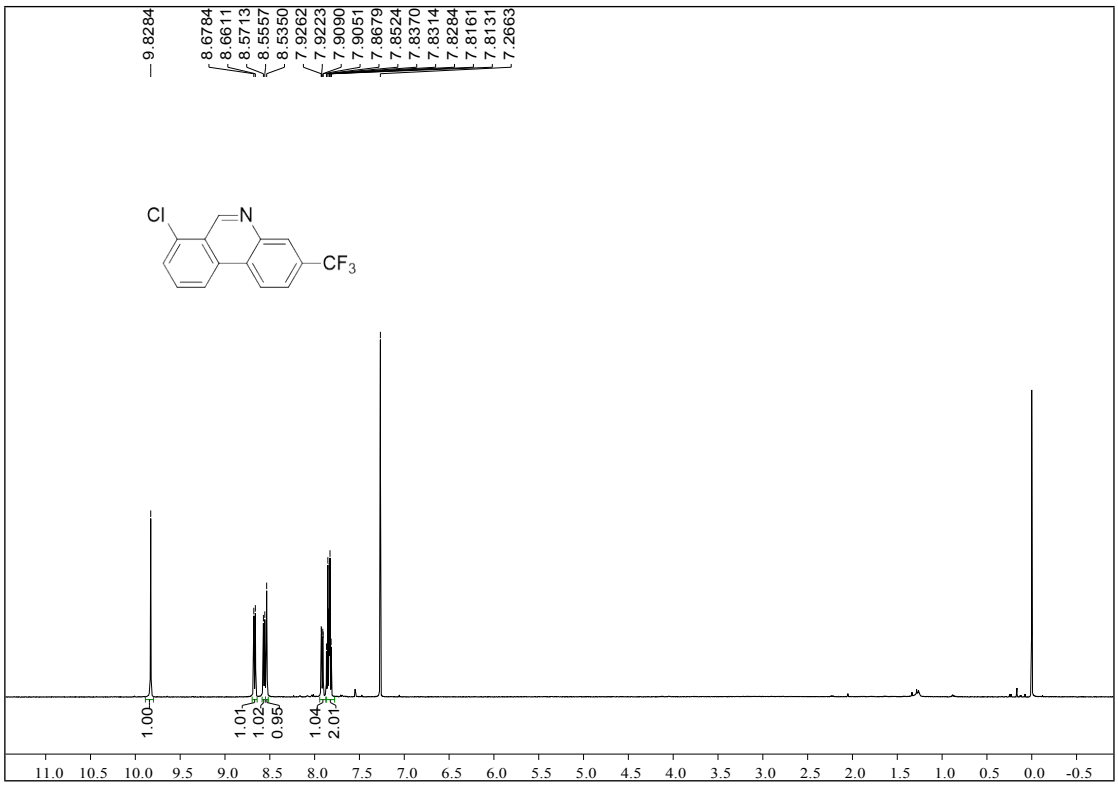


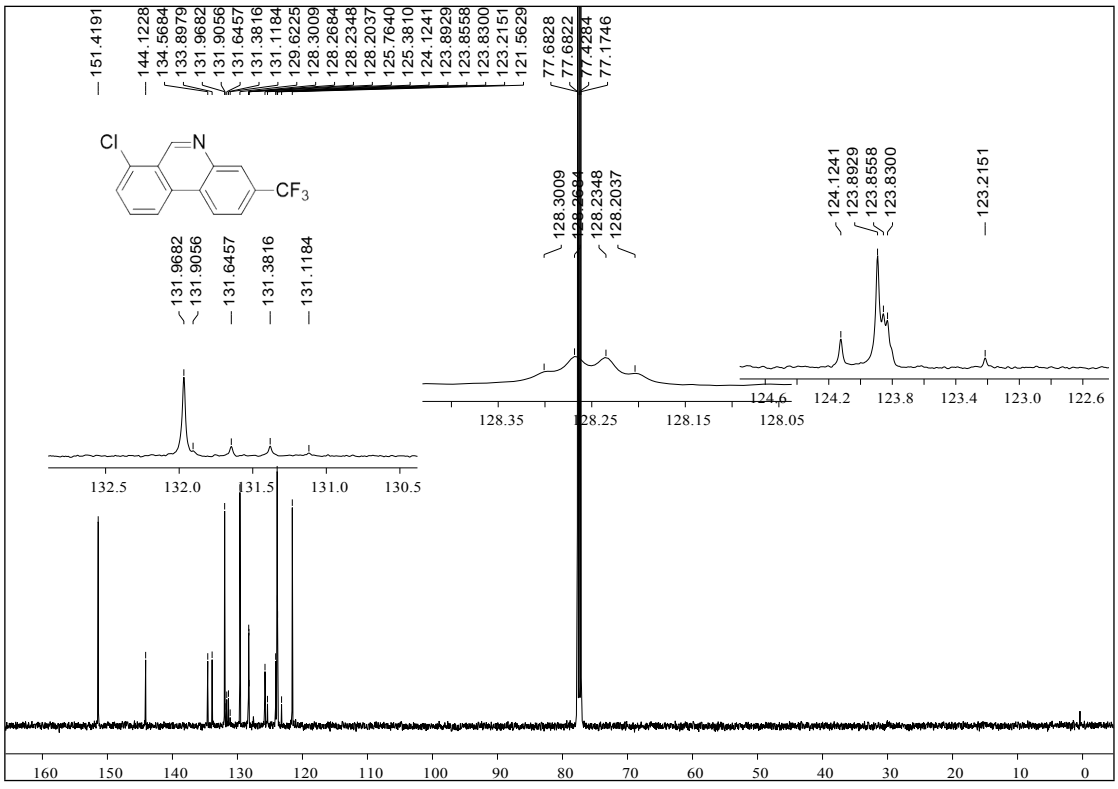
7-chloro-3-fluorophenanthridine (3af)



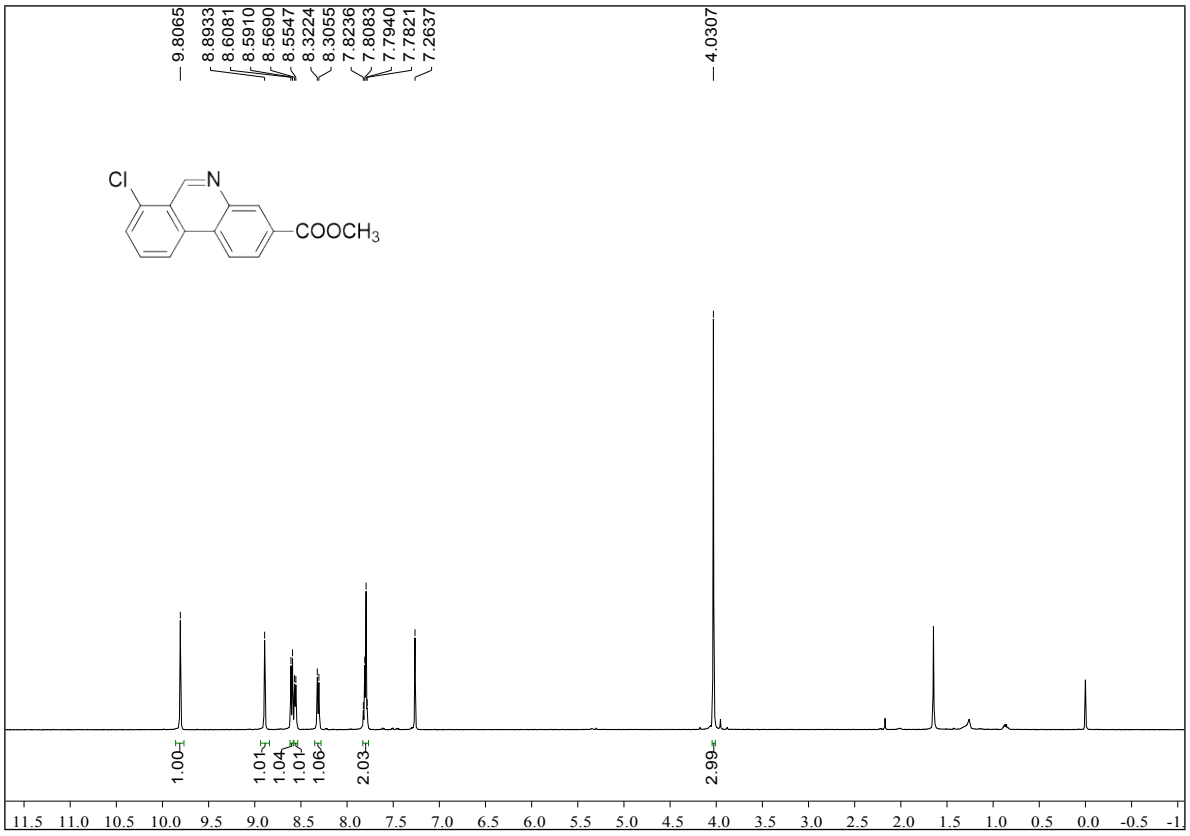


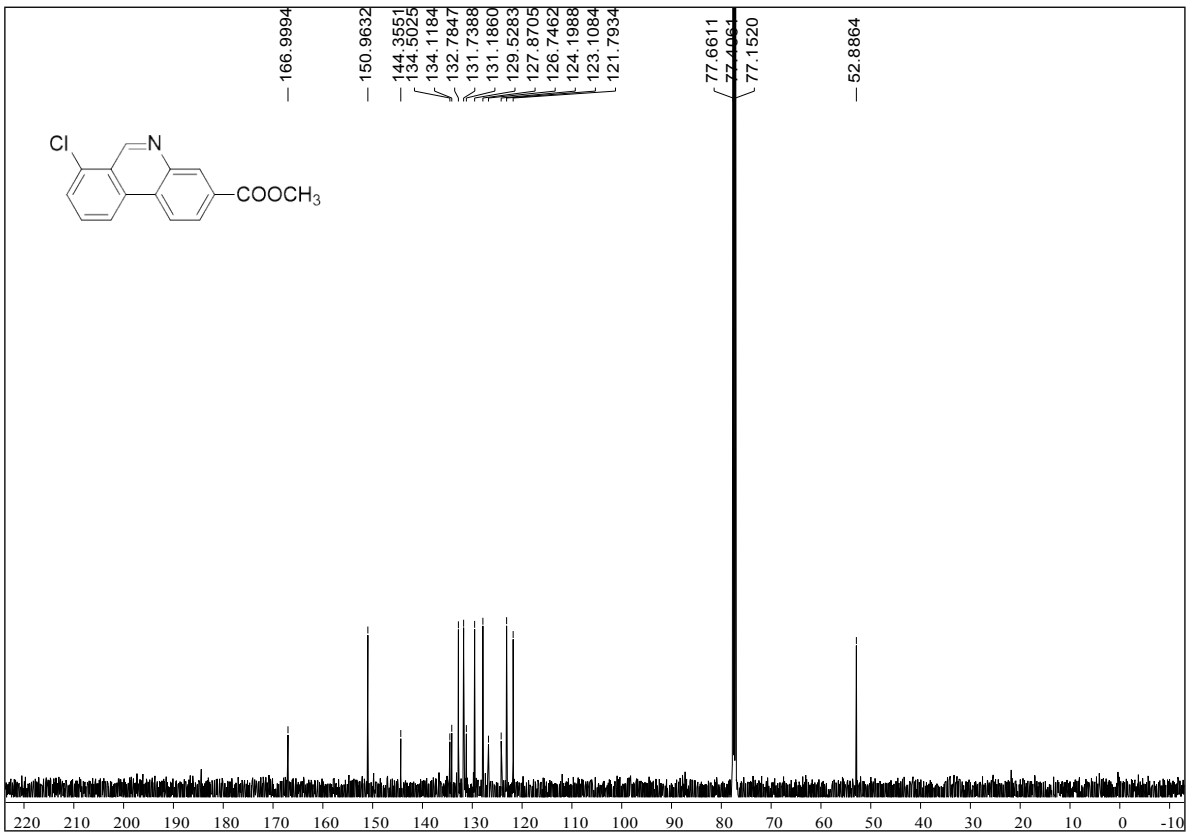
7-chloro-3-(trifluoromethyl)phenanthridine (3ag)



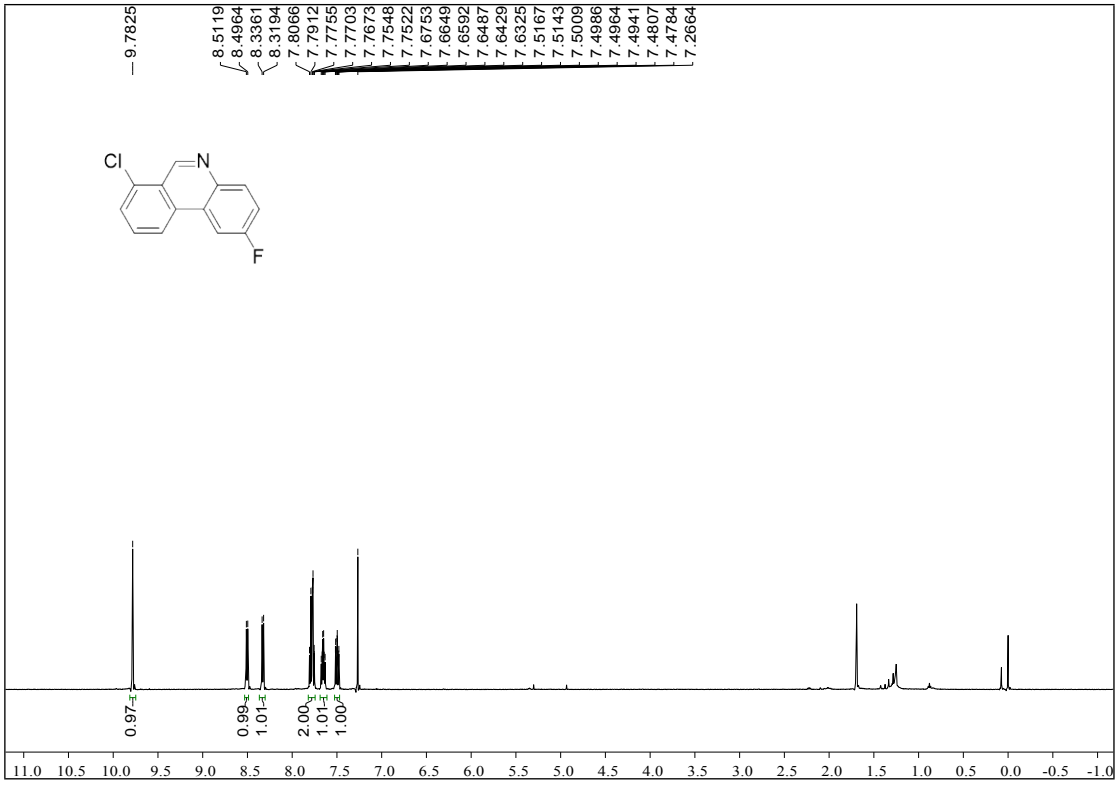


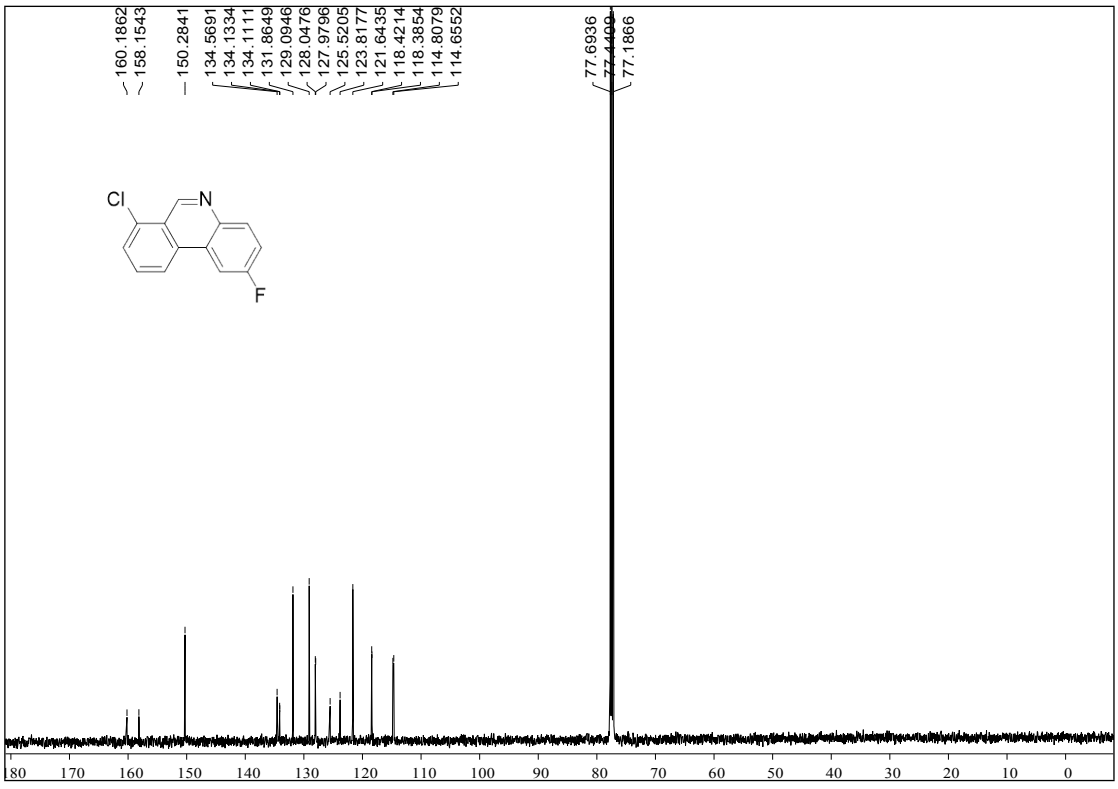
methyl 7-chlorophenanthridine-3-carboxylate (3ah)



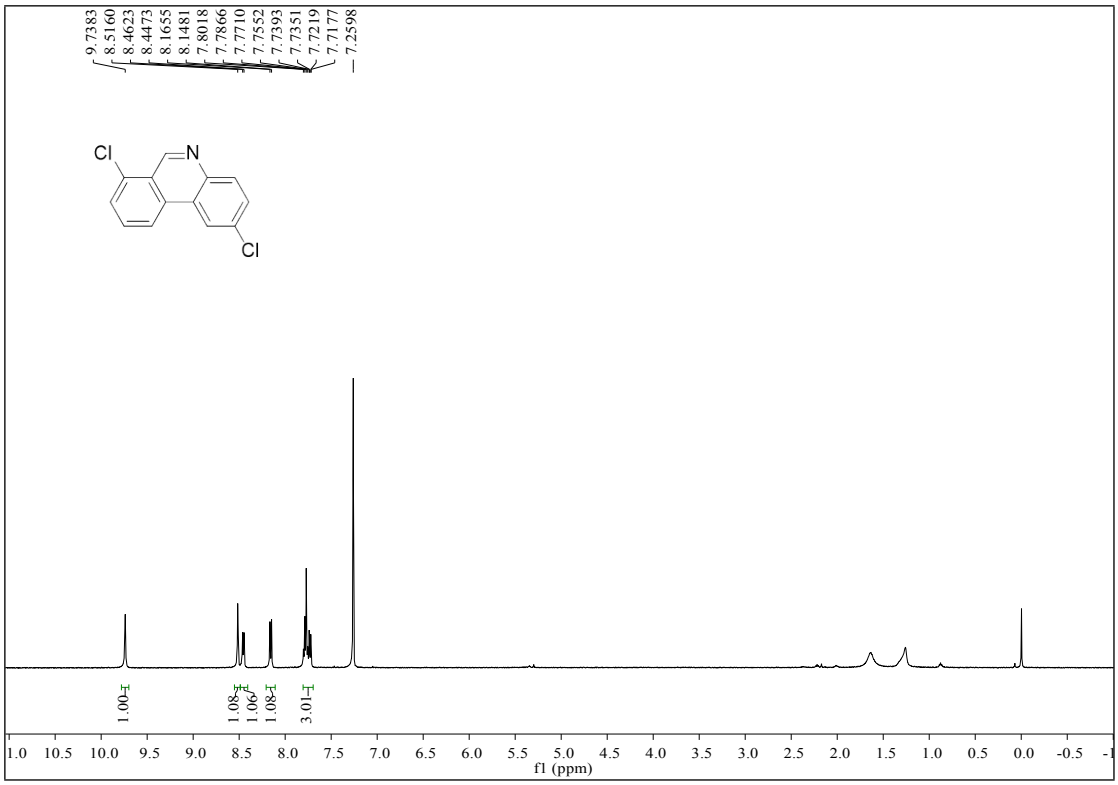


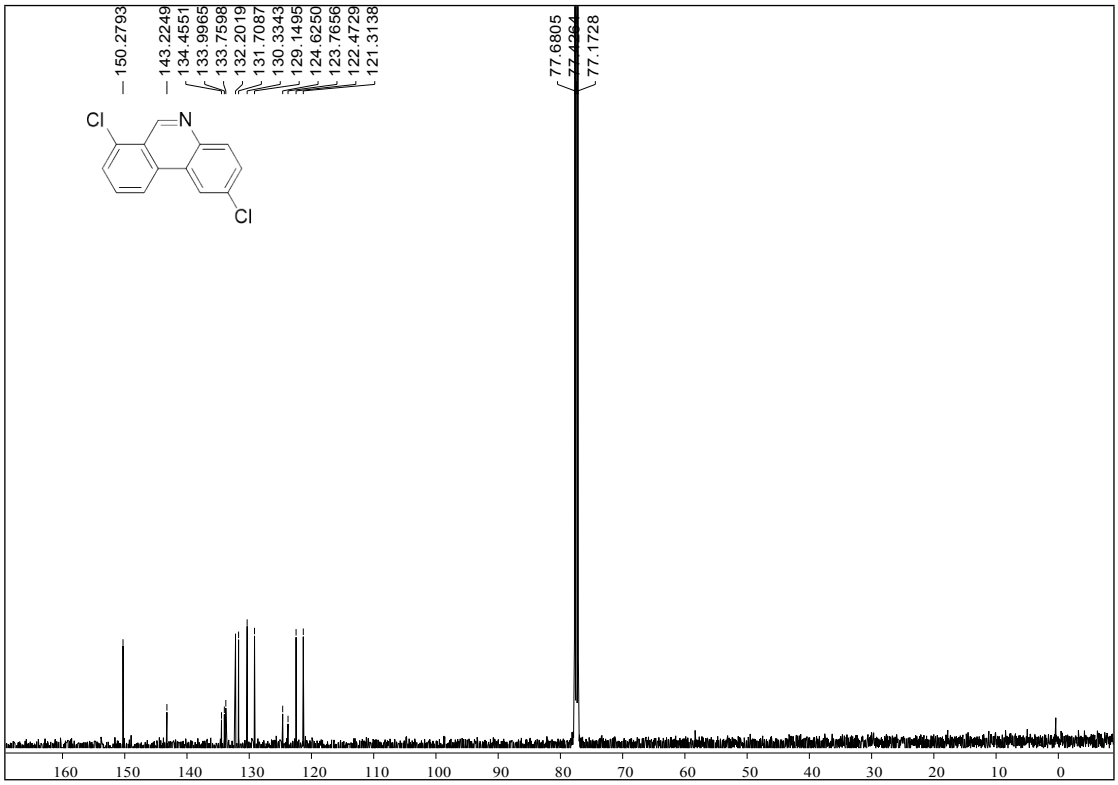
7-chloro-2-fluorophenanthridine (3ai)



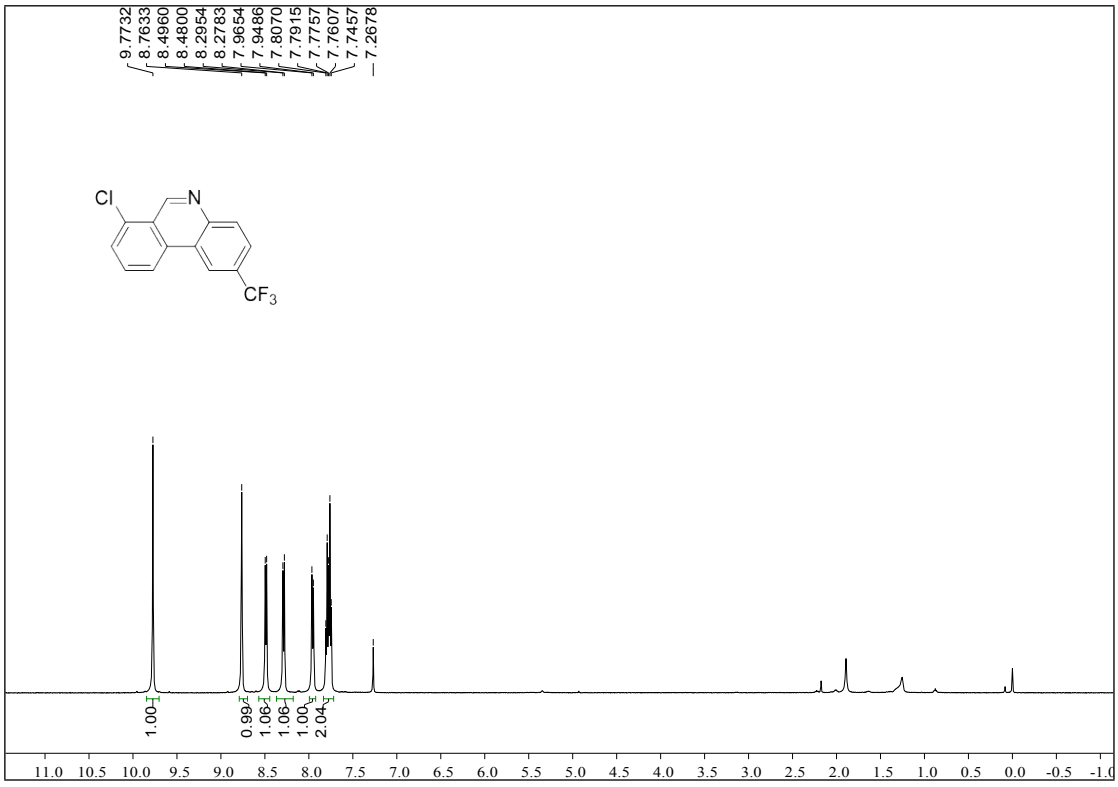


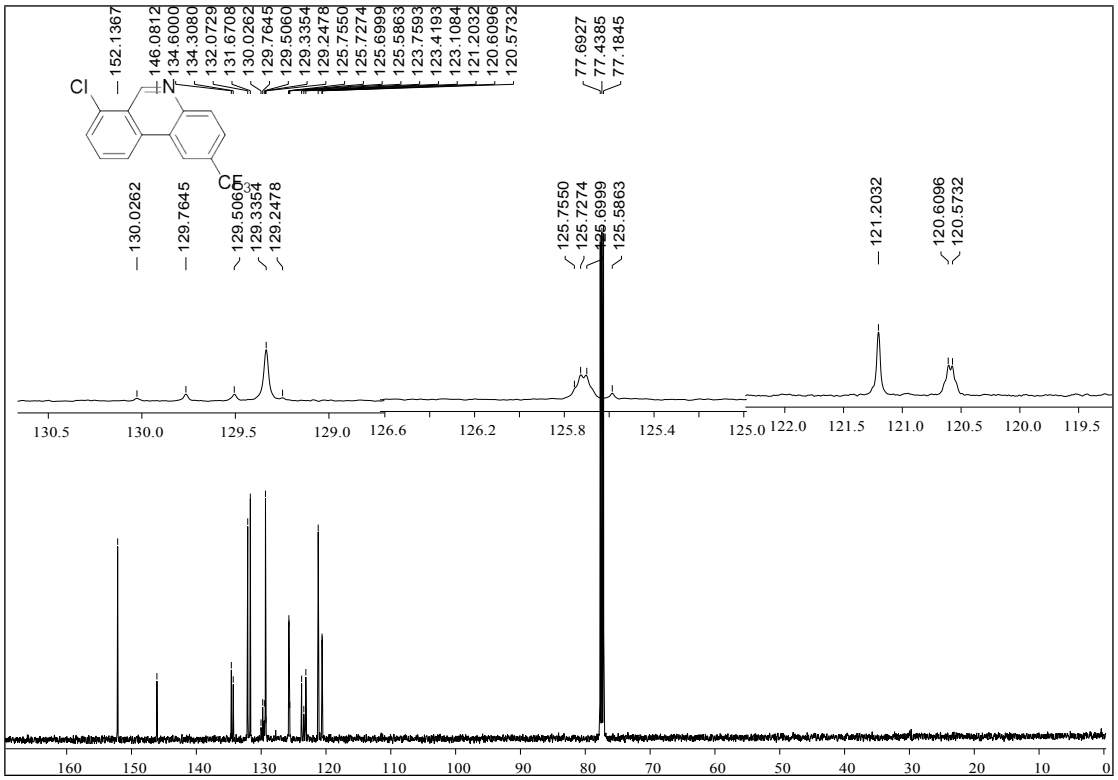
2,7-dichlorophenanthridine (3aj)



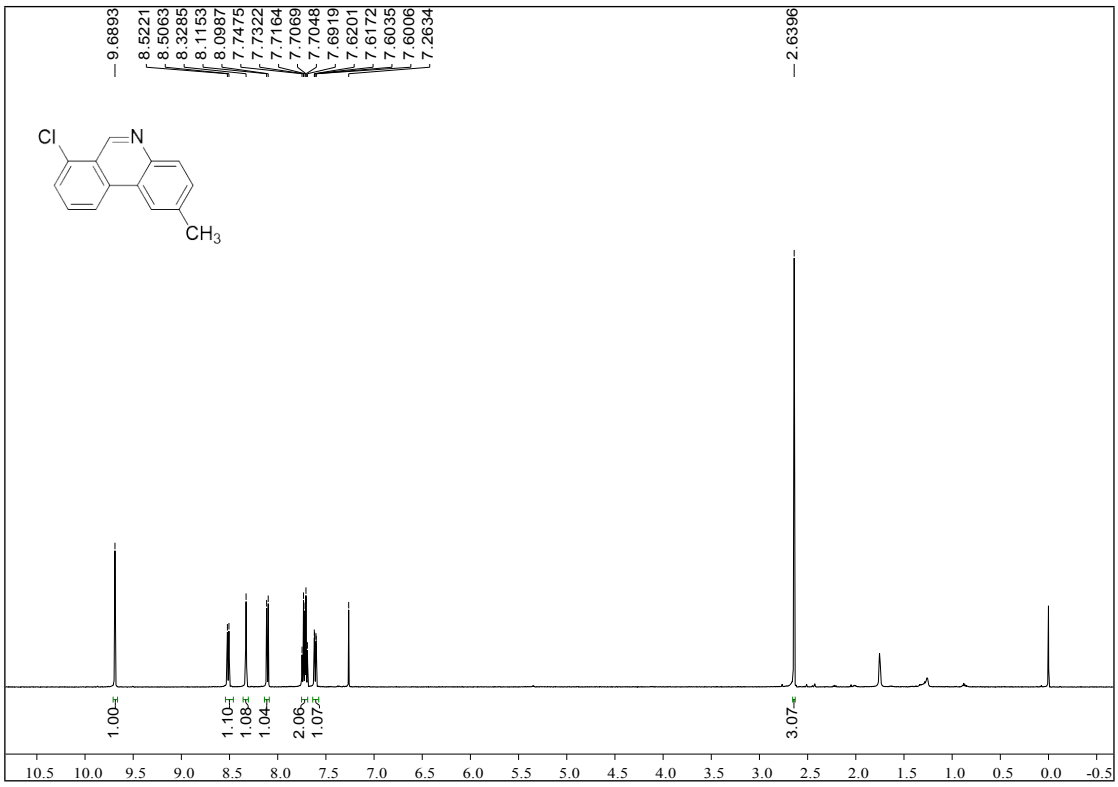


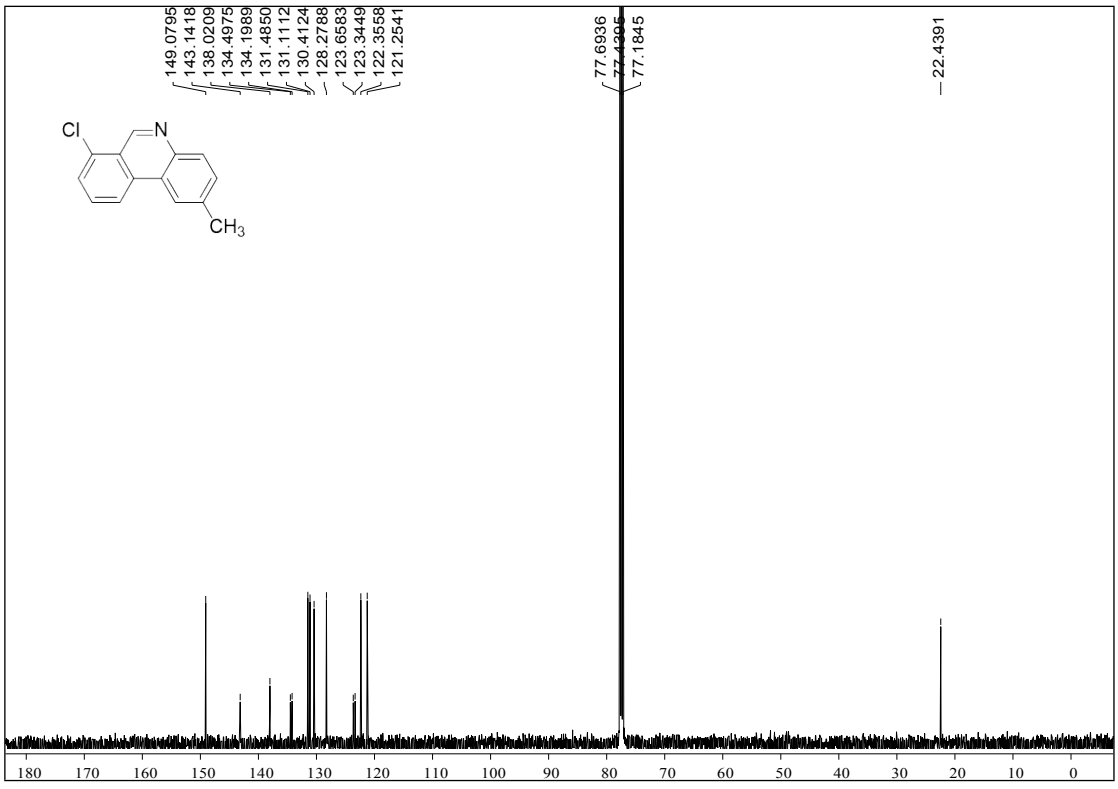
7-chloro-2-(trifluoromethyl)phenanthridine (3ak)



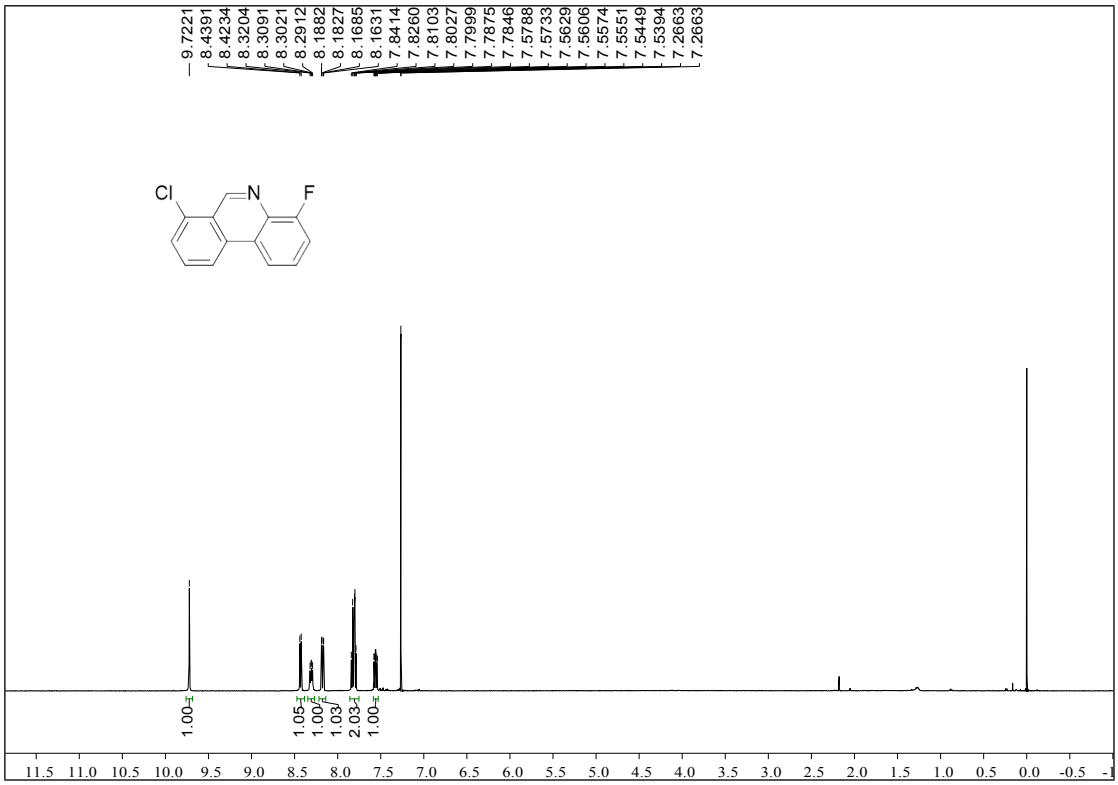


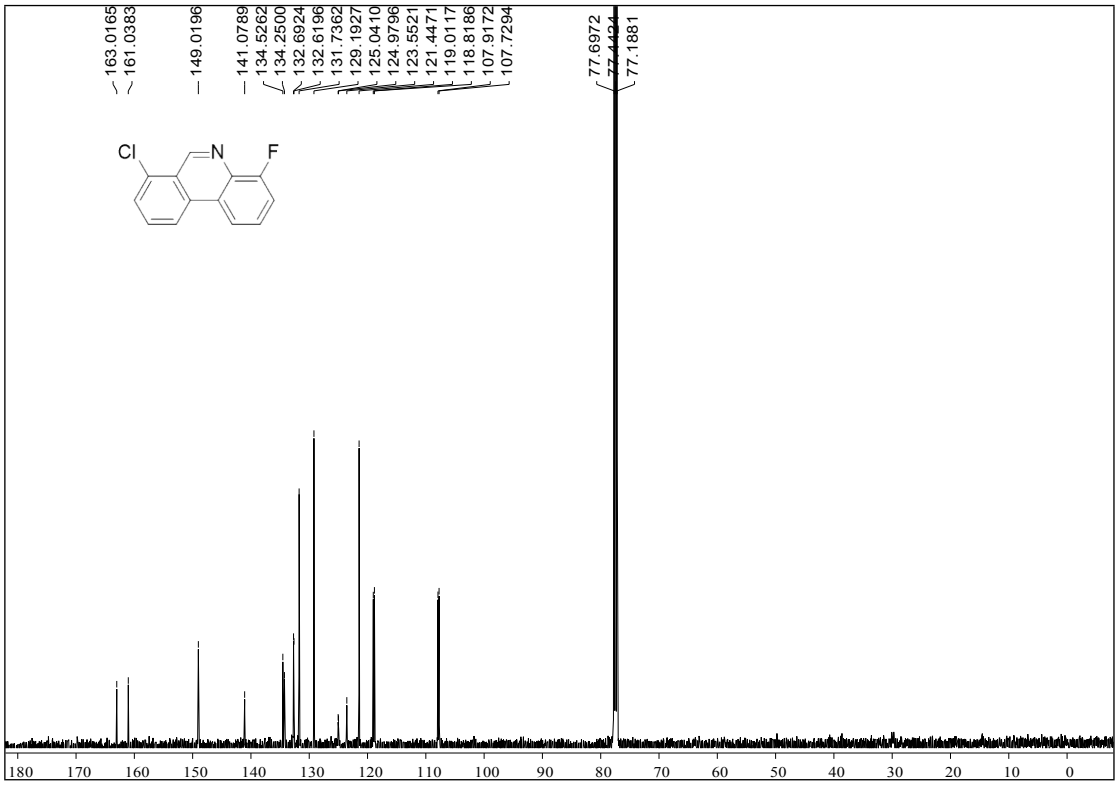
7-chloro-2-methylphenanthridine (3al)



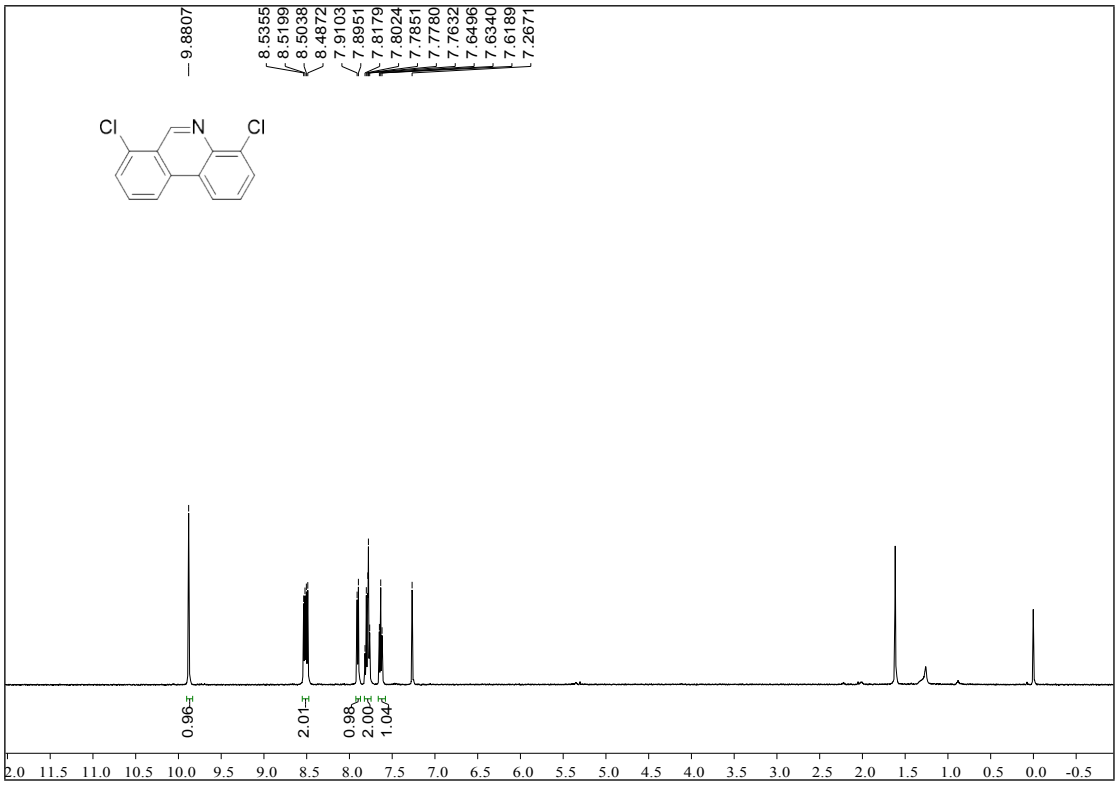


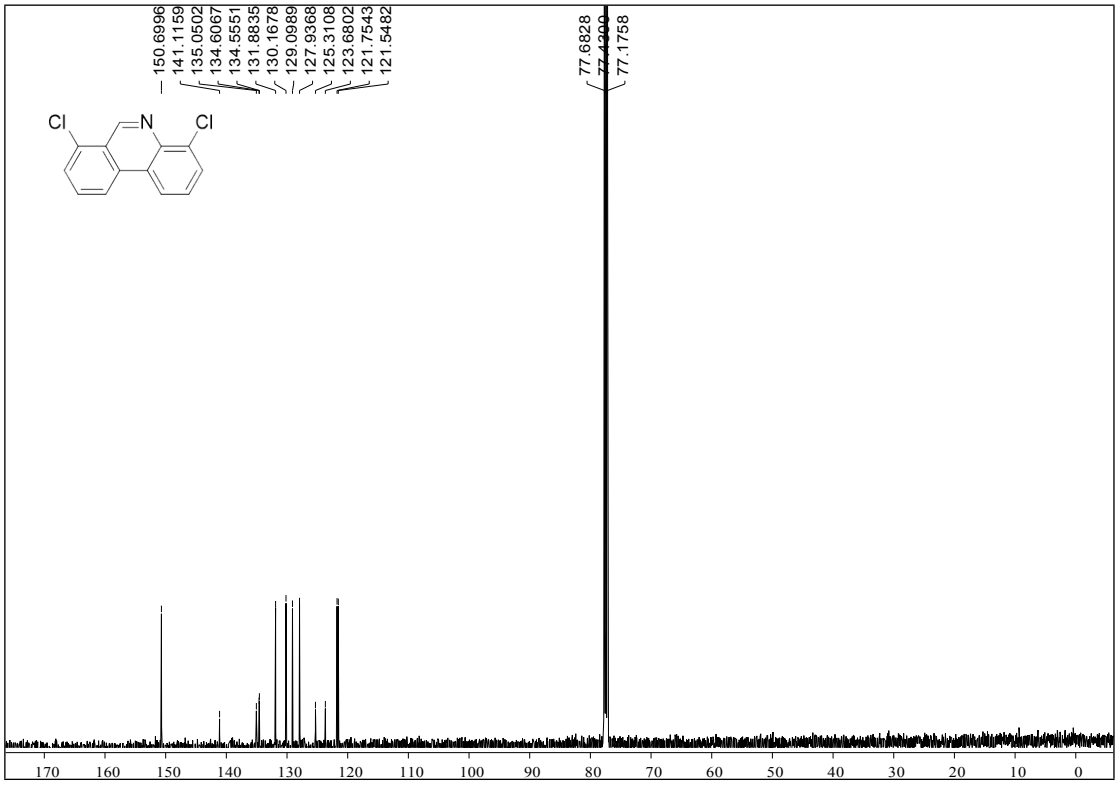
7-chloro-4-fluorophenanthridine (3ai')



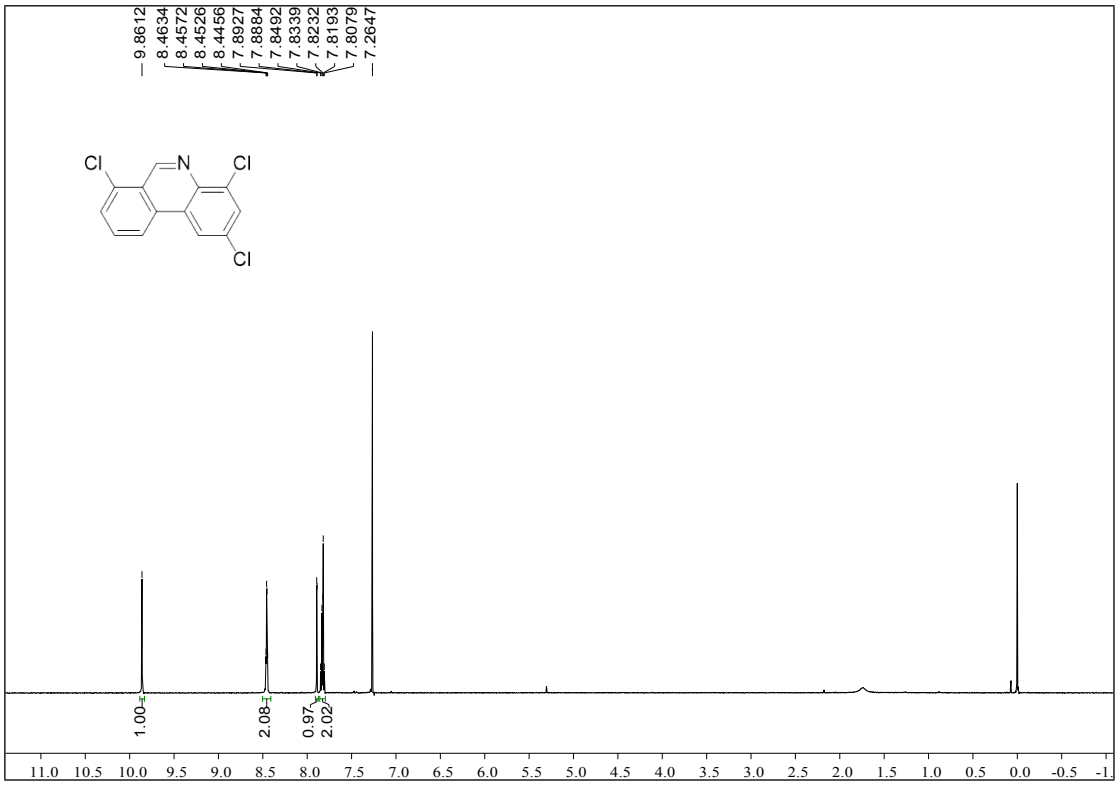


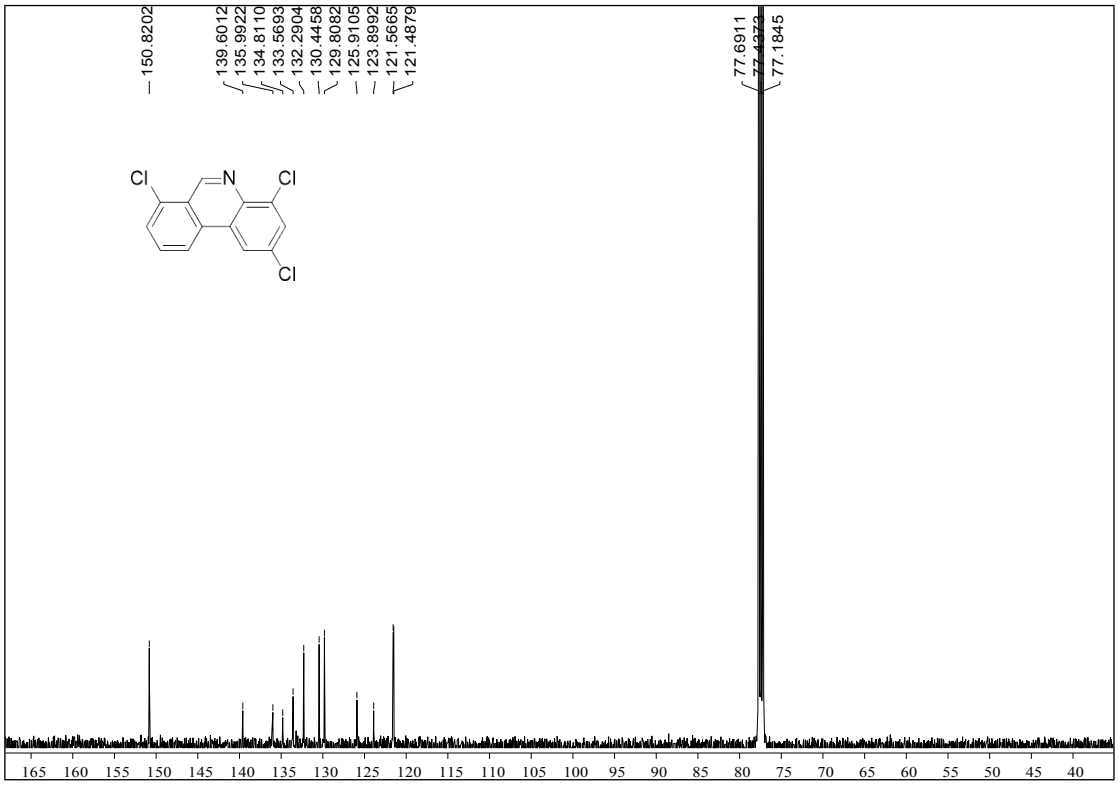
4,7-dichlorophenanthridine (3aj')



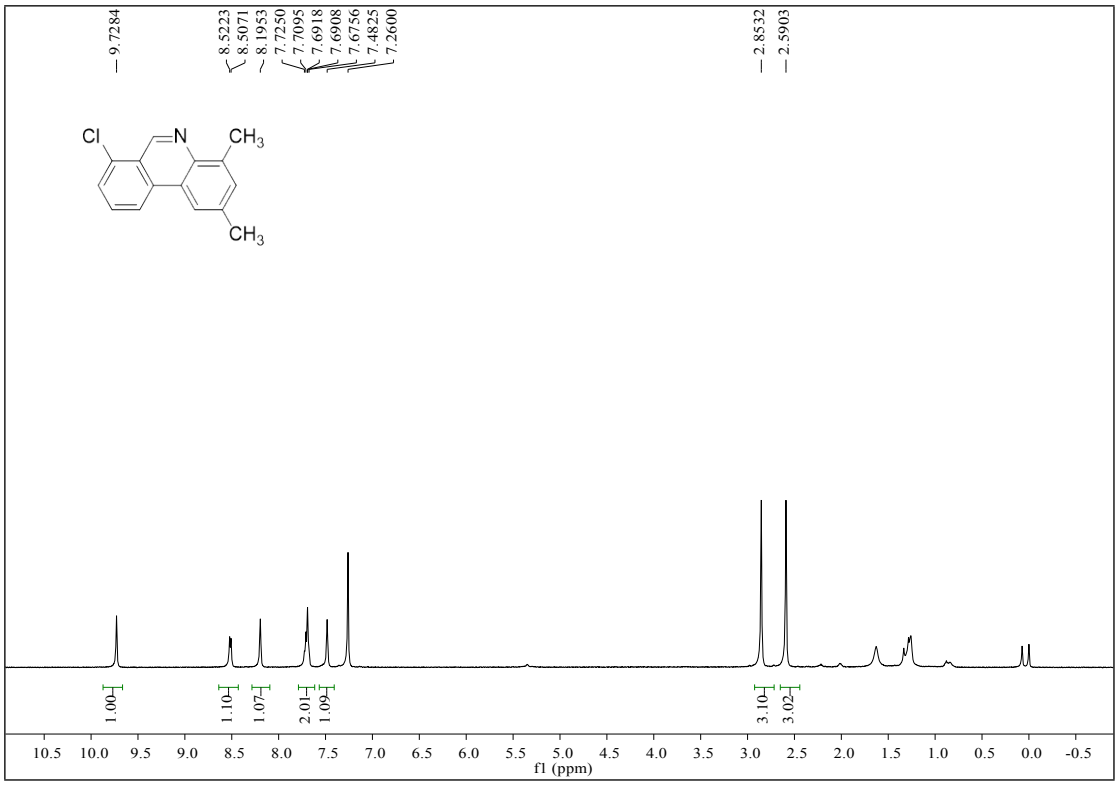


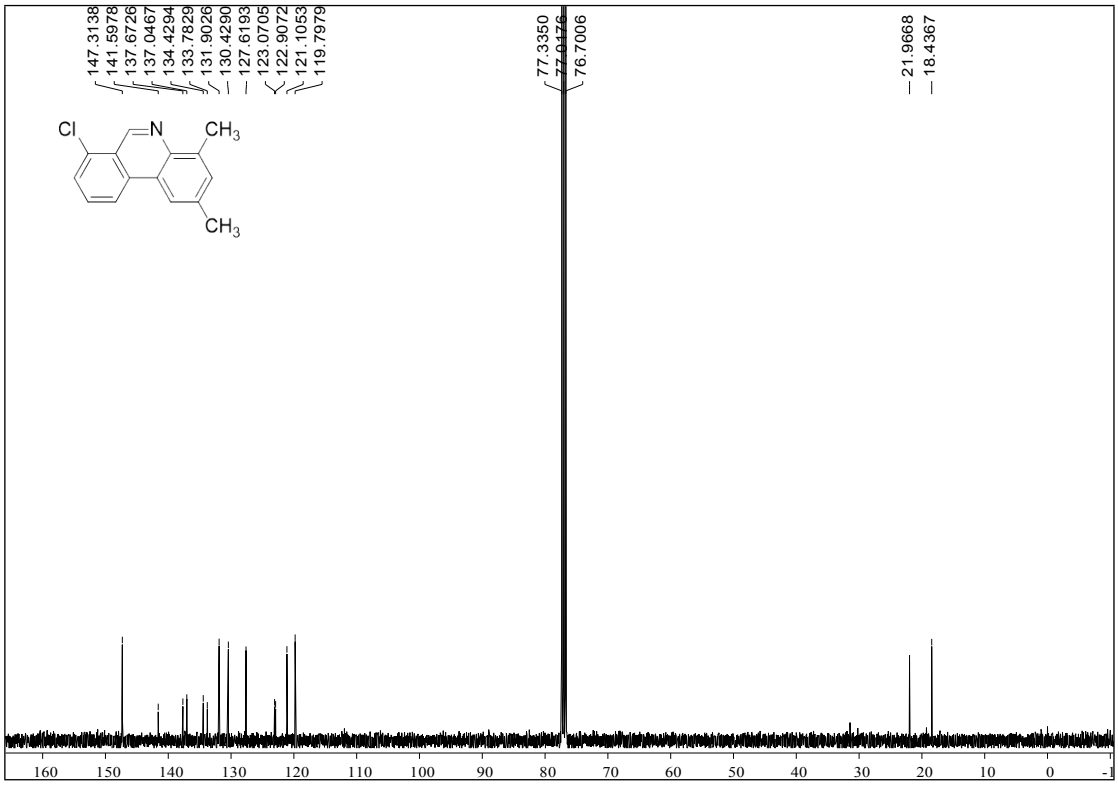
2,4,7-trichlorophenanthridine (3am)



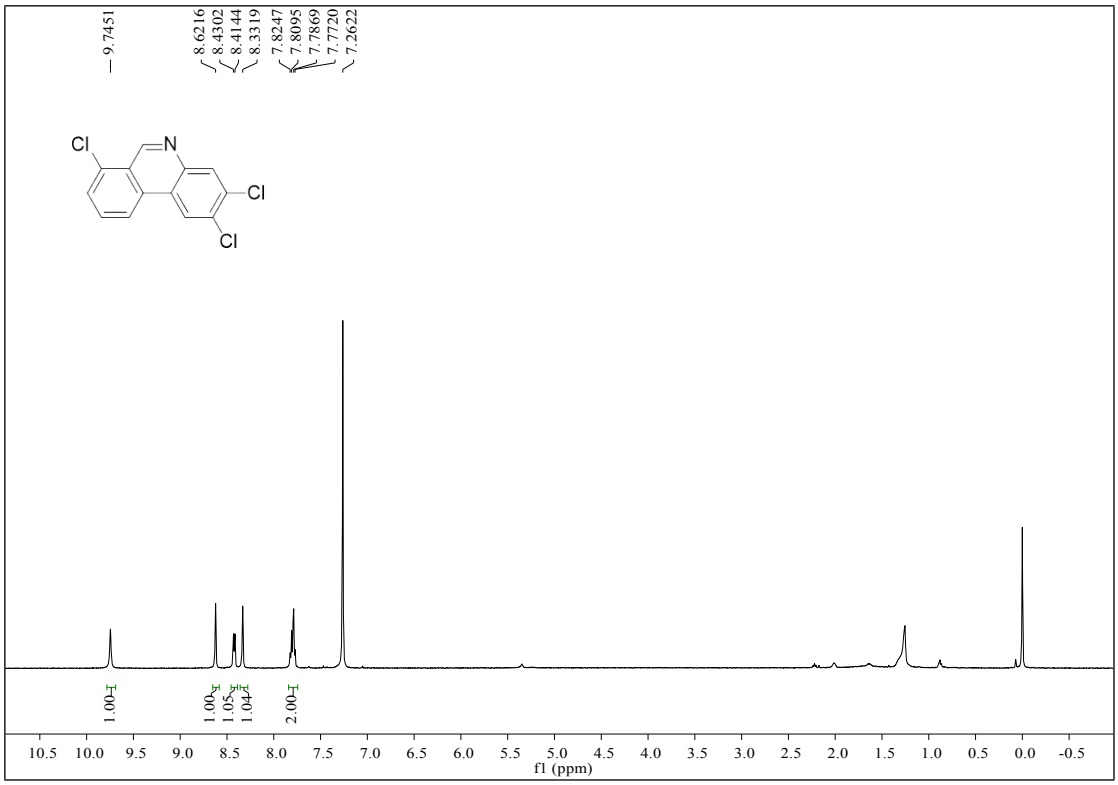


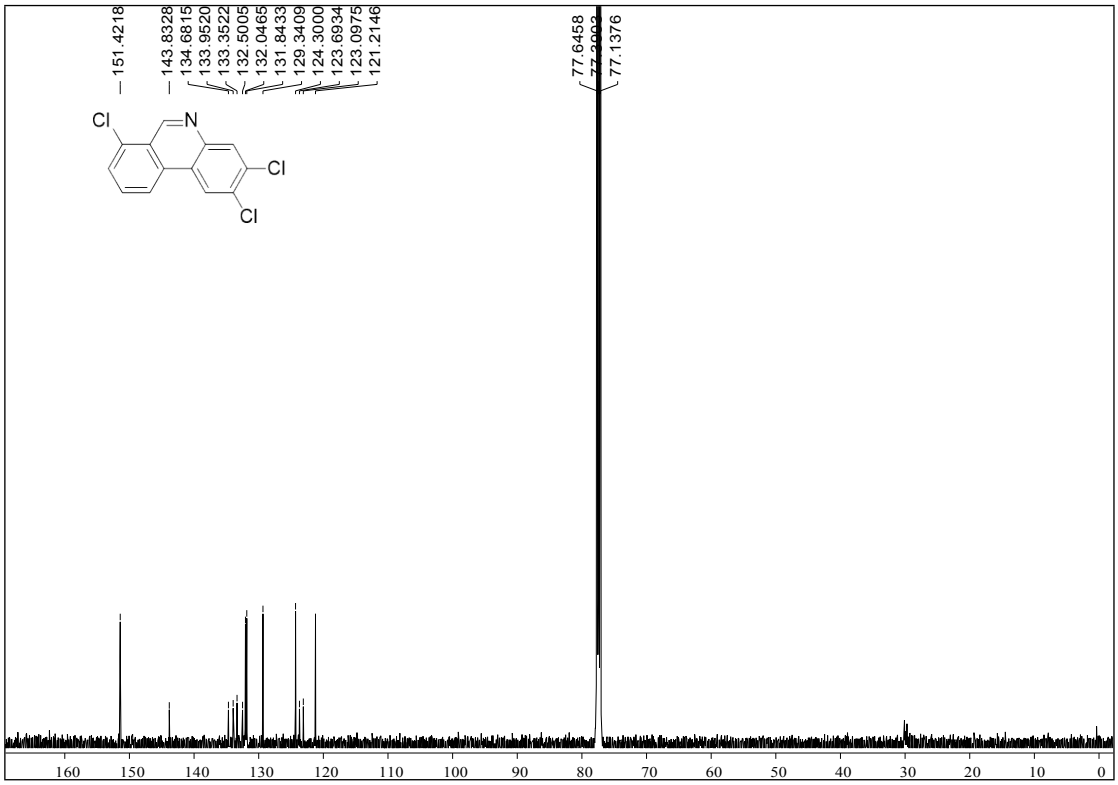
7-chloro-2,4-dimethylphenanthridine (3an)



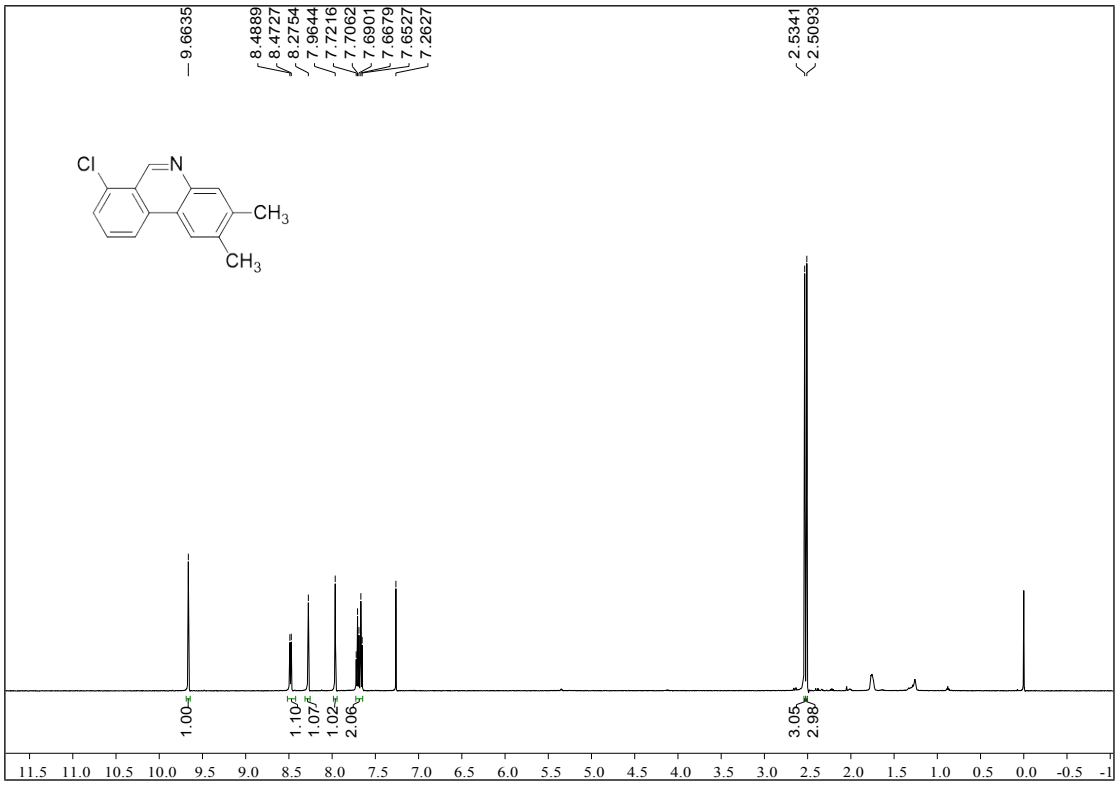


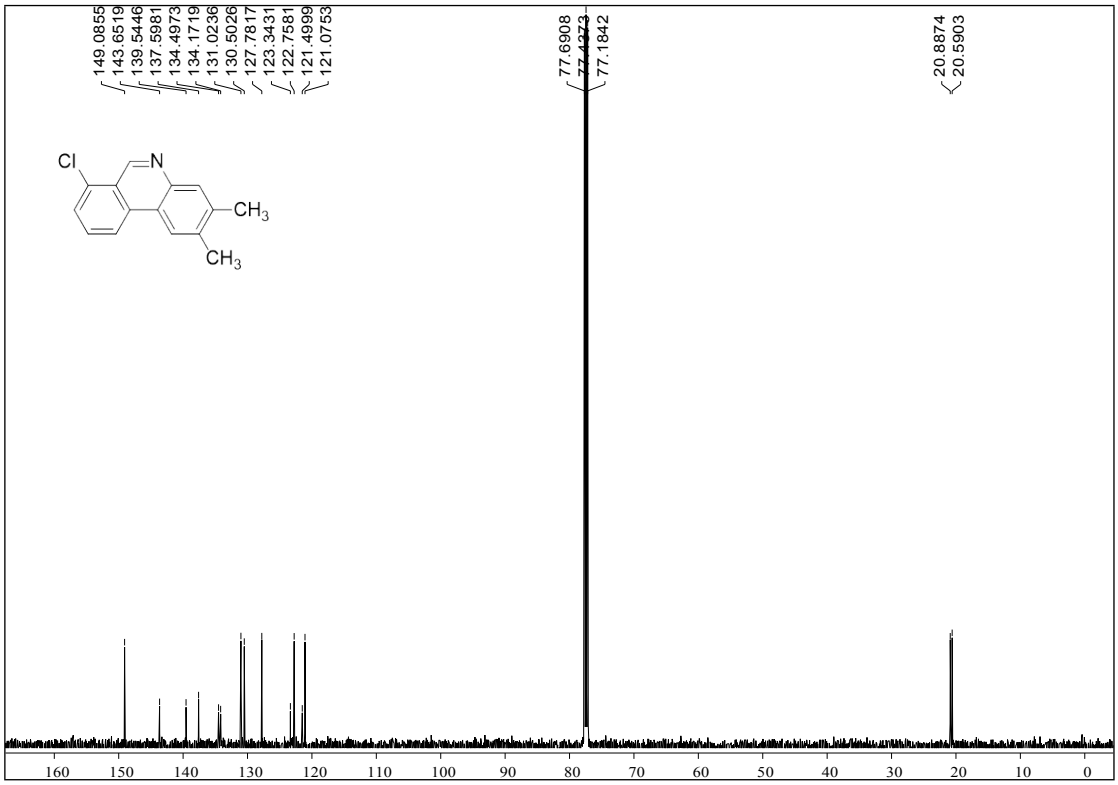
2,3,7-trichlorophenanthridine (3ao)



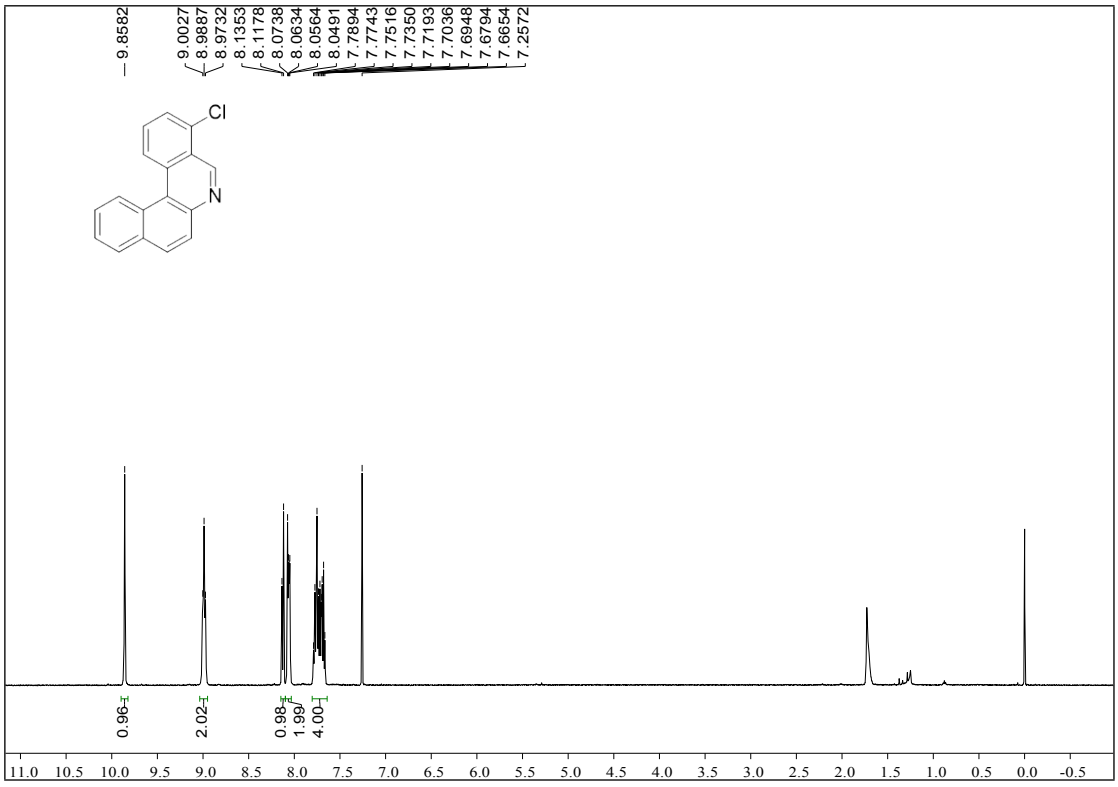


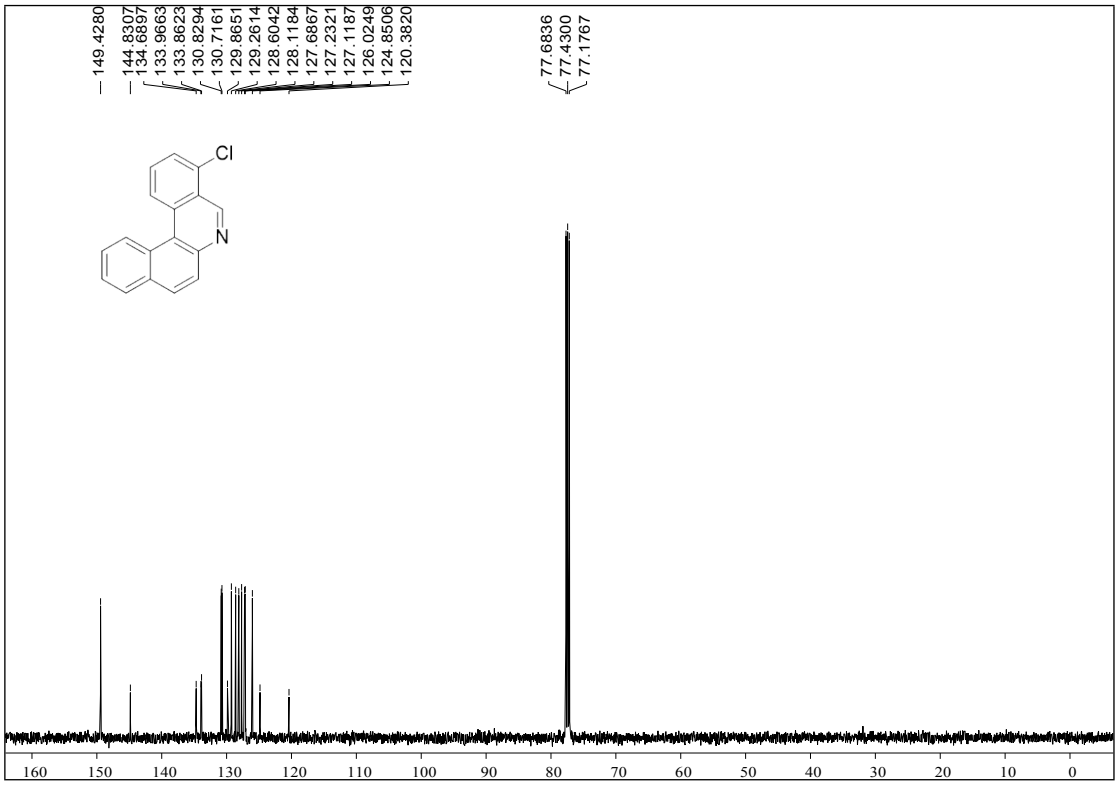
7-chloro-2,3-dimethylphenanthridine (3ap)



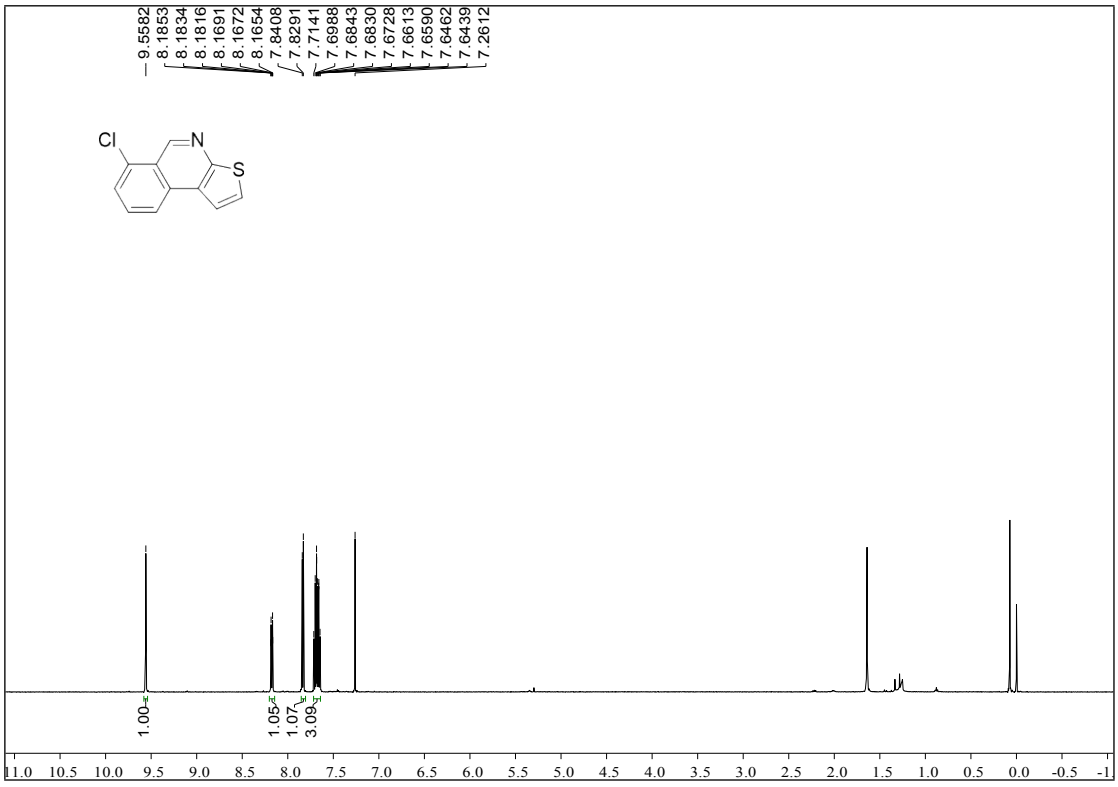


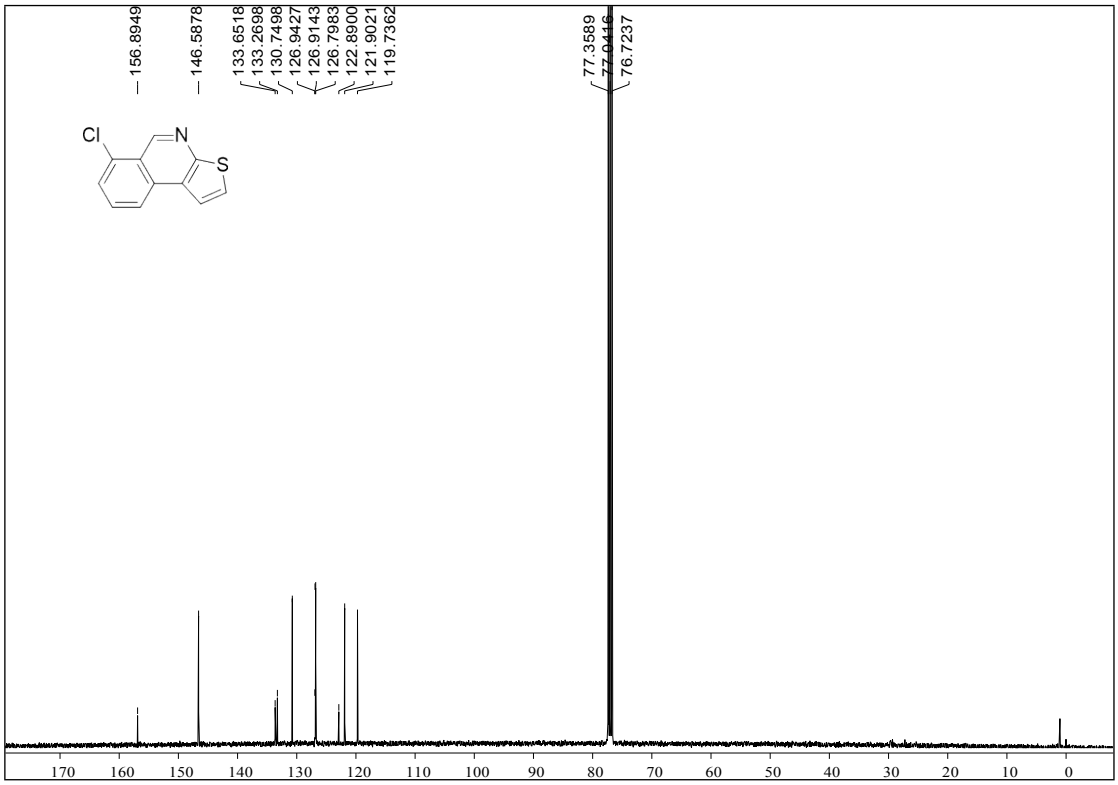
4-chlorobenzo[a]phenanthridine (3aq)



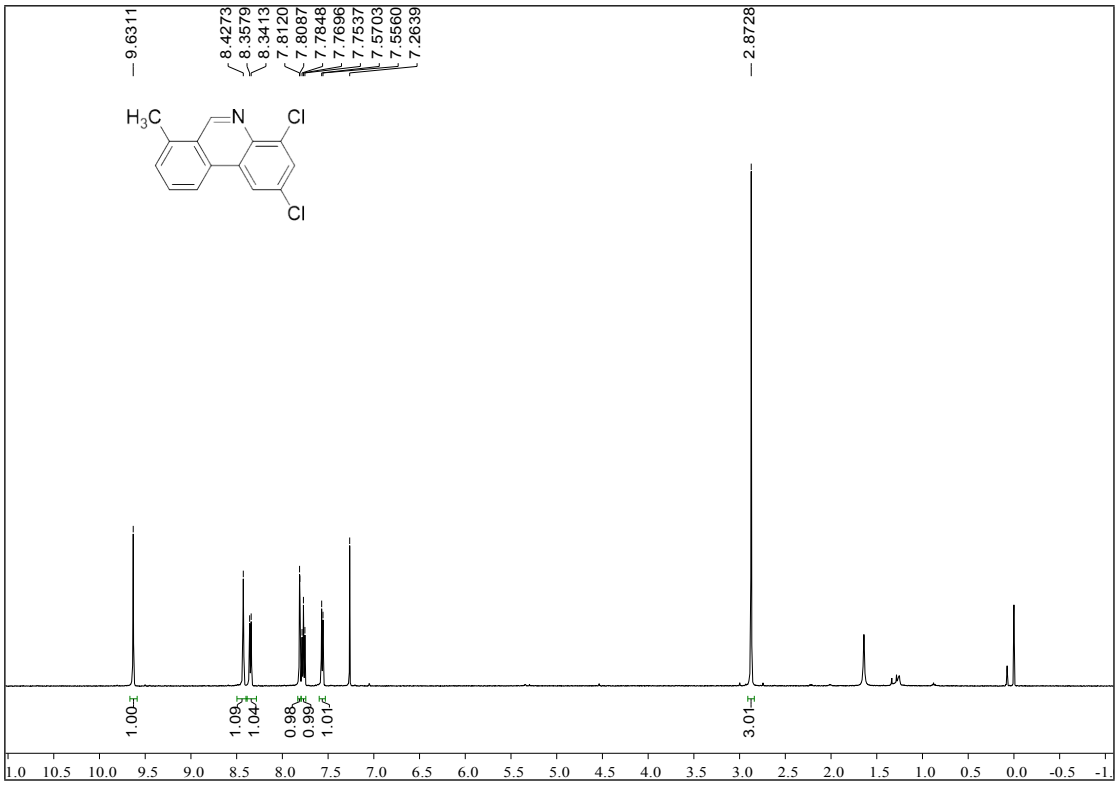


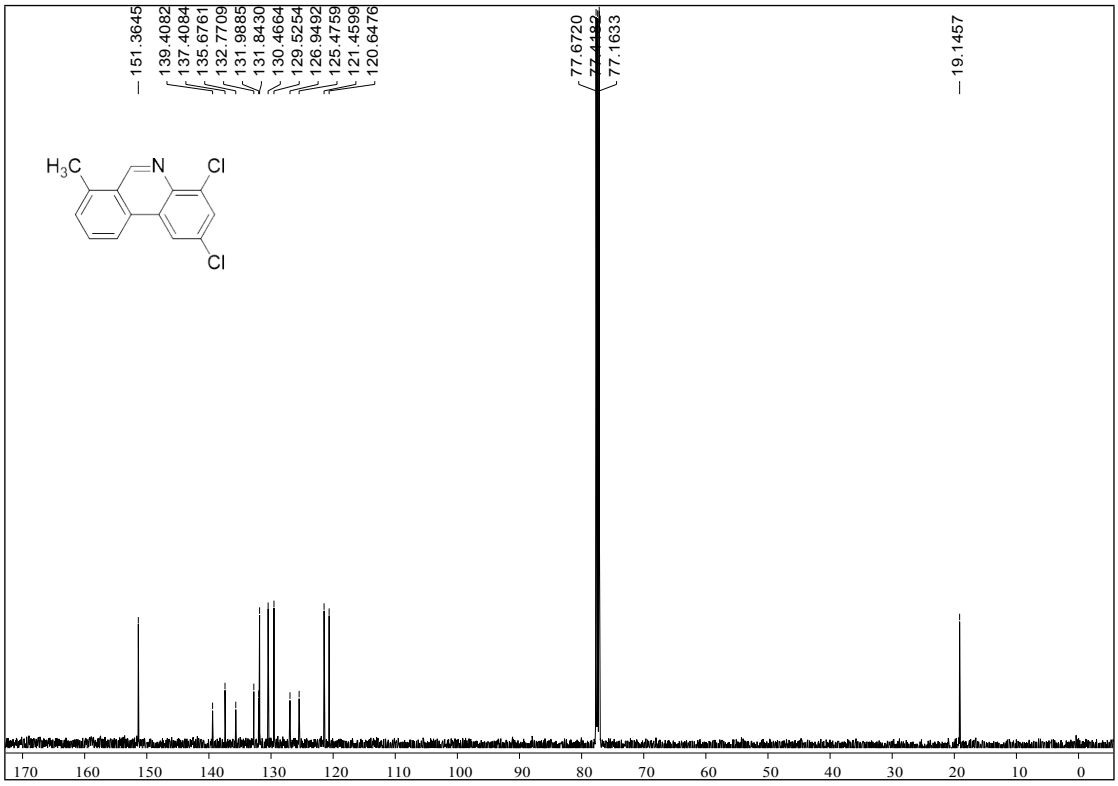
6-chlorothieno[2,3-c]isoquinoline (3ar)



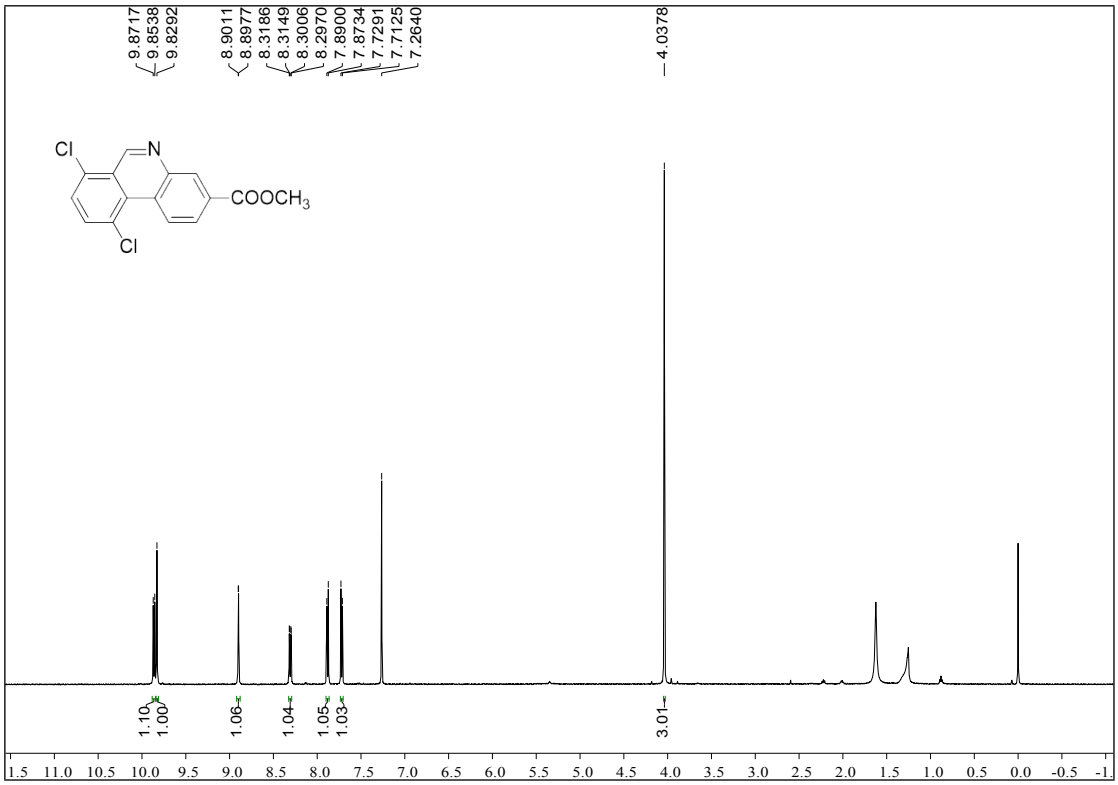


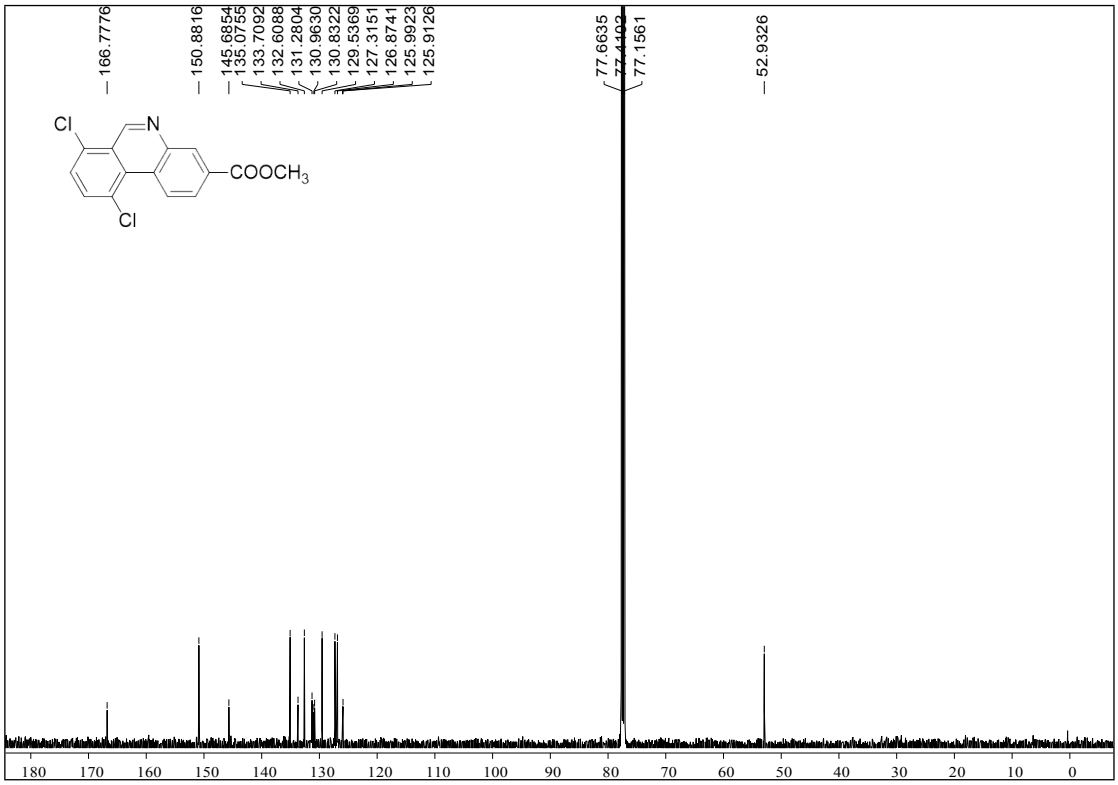
2,4-dichloro-7-methylphenanthridine (3dm)



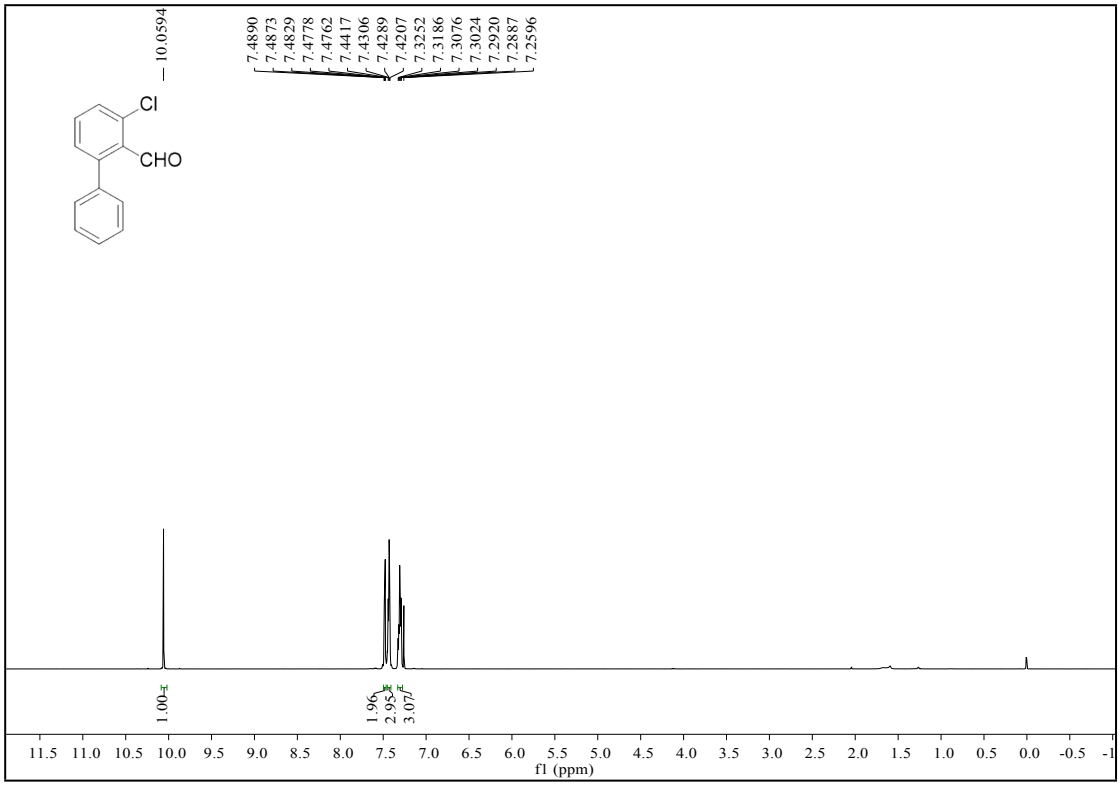


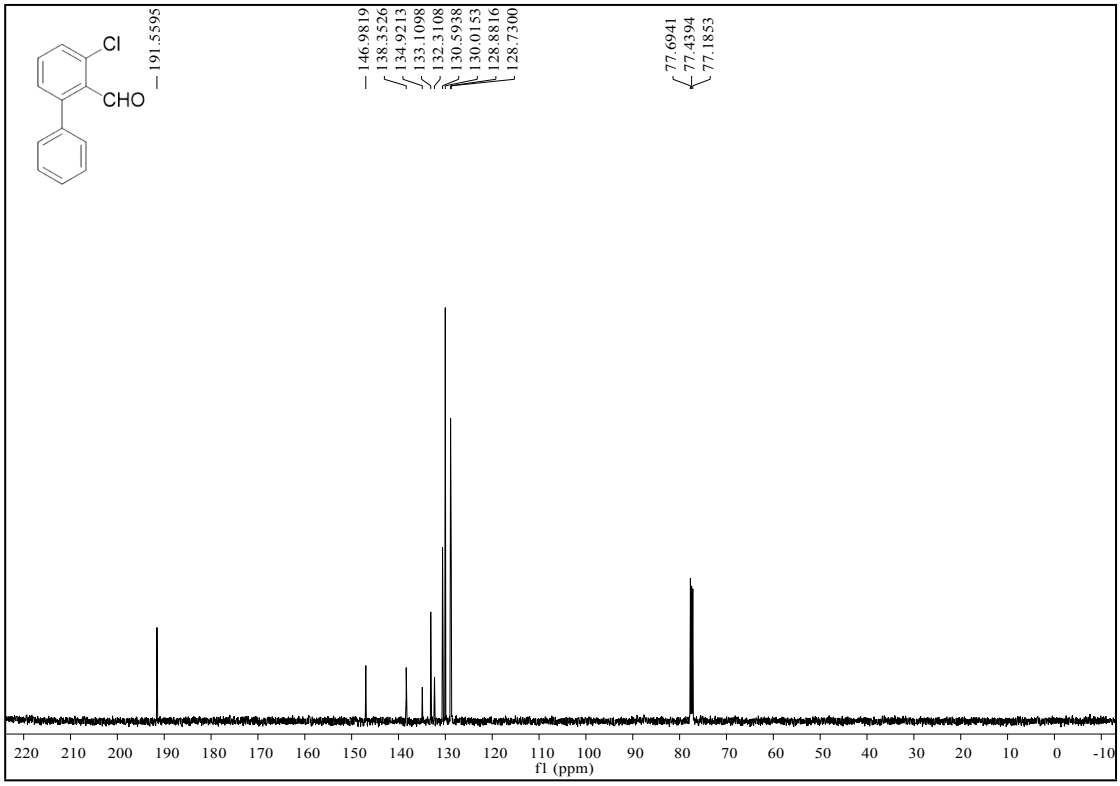
methyl 7,10-dichlorophenanthridine-3-carboxylate (3nh)





3-chloro-[1,1'-biphenyl]-2-carbaldehyde (A)





1- chloro-9*H*-fluoren-9-one (B)