Supporting Information

for

Palladium-Catalyzed C-H Bond Activation and Decarboxylation for the Assembly of Indolo[1,2-f]phenanthridine

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1. General information

All chemicals were purchased from Adamas Reagent, Ltd, Energy chemical company, J&K Scientific Ltd, Alfa Aesa chemical company and so forth. Unless otherwise stated, all experiments were conducted in a 25 mL Schlenk reaction tube under N_2 atmosphere. Reactions were monitored by TLC or GC-MS analysis. Flash column chromatography was performed over silica gel (200-300 mesh).

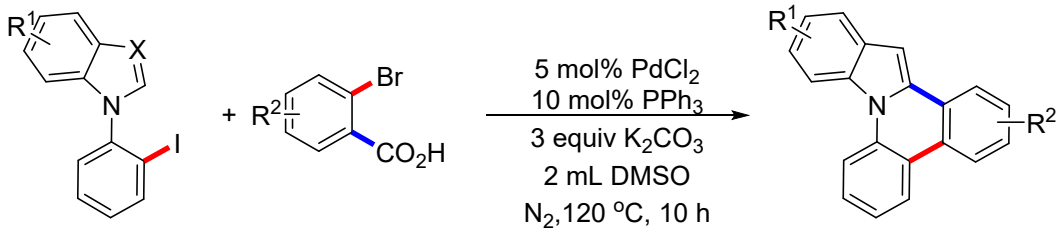
^{1}H-NMR and ^{13}C-NMR spectra were recorded in $CDCl_3$ on a Bruker Avance 500 spectrometer (500 MHz ^{1}H, 125 MHz ^{13}C) at room temperature. Chemical shifts were reported in ppm on the scale relative to $CDCl_3$ (δ = 7.26 for ^{1}H-NMR , δ = 77.00 for ^{13}C-NMR) or DMSO-d_6 (δ = 2.50 for ^{1}H-NMR, δ = 39.60 for ^{13}C-NMR) as an internal reference. High resolution mass spectra were recorded using Q-TOF time-of-flight mass spectrometer. Coupling constants (*J*) were reported in Hertz (Hz).

The starting materials **1** were synthetized according to methods reported previous literatures.[1,2]

[1] R. Liu, Q. Wang, Y. Wei and M. Shi, *Chem. Commun.,* **2018**, *54*, 1225.

[2] K. Naveen, S. Nikson, P. Perumal *Adv. Synth. Catal.*, **2017**, *359*, 2407.

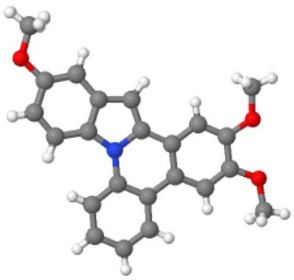
2. General procedure for the synthesis of 3 and 4



The mixture of **1** (0.2 mmol, 1.0 equiv), **2** (0.24 mmol, 1.2 equiv), $PdCl_2$ (1.7 mg, 0.01 mmol, 5 mol %), PPh_3 (5.2 mg, 0.02 mmol, 10 mol %) and K_3CO_3 (82.8 mg, 0.6 mmol, 3.0 equiv) in DMSO (2 mL) was stirred under nitrogen atmosphere at 120 °C for 10 h (oil bath temperature). After the completion of the reaction (monitored by TLC), the reaction mixture was washed by saturated NH_4Cl solution and then evaporated under reduced pressure, the crude product was purified by column chromatography to provide the desired product **3** or **4**.

3. Crystal data of 4e

Crystallographic data for compound **4e** (CCDC-2016614) has been deposited with the Cambridge Crystallographic Data Centre, Copies of the data can be obtained, free of charge, on application to CCDC (Email: deposit@ccdc.cam.ac.uk).



ORTEP view with ellipsoids (at the 30% probability level)

Bond precision: C-C = 0.0033 A Wavelength=0.71073

Cell: a=14.5848(15) b=8.7233(10) c=15.8098(18)
alpha=90 beta=115.796(13) gamma=90
Temperature: 300 K

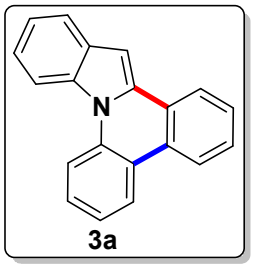
	Calculated	Reported
Volume	1811.0(4)	1811.0(4)
Space group	P 21/c	P 1 21/c 1
Hall group	-P 2ybc	-P 2ybc
Moiety formula	C23 H19 N O3	C23 H19 N O3
Sum formula	C23 H19 N O3	C23 H19 N O3
Mr	357.39	357.39
Dx,g cm-3	1.311	1.311
Z	4	4
Mu (mm-1)	0.087	0.087
F000	752.0	752.0
F000'	752.35	
h,k,lmax	20,11,21	19,11,21
Nref	4916	4122
Tmin,Tmax	0.990,0.991	0.783,1.000
Tmin'	0.990	

Correction method= # Reported T Limits: Tmin=0.783 Tmax=1.000
AbsCorr = MULTI-SCAN

Data completeness= 0.838 Theta(max)= 29.246

R(reflections)= 0.0644(2264) wR2(reflections)= 0.1626(4122)

S = 1.021 Npar= 258

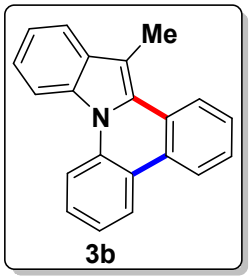


4. Characterization data for products

indolo[1,2-f]phenanthridine (3a) (CAS: 945472-69-5)

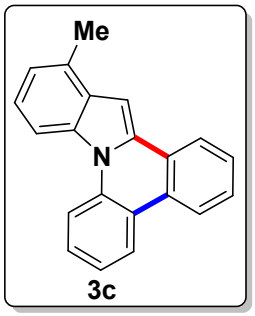
The reaction was performed following the general procedure. The residue was purified by flash column chromatograph (silica gel, 100% petroleum) to give the product as a pale yellow solid (50.2 mg, 94%). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.53 (d, *J* = 8.4 Hz, 1H), 8.39 (d, *J* = 8.3 Hz, 1H), 8.30 (dd, *J* = 8.1, 1.5 Hz, 1H), 8.25 – 8.16 (m, 1H), 8.15 – 8.08 (m, 1H), 7.86 (dd, *J* = 7.3, 1.6 Hz, 1H), 7.57 (ddd, *J* = 8.6, 7.2, 1.5 Hz, 1H), 7.52 – 7.45 (m, 2H), 7.44 – 7.30 (m, 3H), 7.26 (s, 1H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 136.0, 135.3, 133.9, 130.4, 128.8, 128.2, 127.8, 126.9, 126.2, 124.2, 124.0, 123.1, 122.4, 122.1, 122.1, 121.8, 121.1, 116.4, 114.3, 96.3.

14-methylindolo[1,2-f]phenanthridine (3b) (CAS: 2226086-29-7)



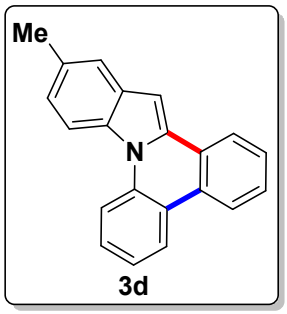
The reaction was performed following the general procedure. The residue was purified by flash column chromatograph (silica gel, 100% petroleum) to give the product as a pale yellow solid (50.1 mg, 89%). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.44 (dd, *J* = 8.5, 1.1 Hz, 1H), 8.31 (ddd, *J* = 22.6, 7.3, 1.6 Hz, 2H), 8.21 (ddd, *J* = 16.9, 8.1, 1.4 Hz, 2H), 7.90 – 7.78 (m, 1H), 7.55 – 7.47 (m, 2H), 7.47 – 7.36 (m, 3H), 7.28 (td, *J* = 7.6, 7.0, 1.1 Hz, 1H), 2.79 (s, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 136.01, 132.5, 131.3, 130.2, 128.6, 128.0, 127.8, 127.6, 126.8, 125.1, 123.8, 122.7, 122.3, 122.2, 122.1, 121.1, 118.8, 116.2, 114.0, 106.9, 11.9.

13-methylindolo[1,2-f]phenanthridine (3c) (CAS: 945472-68-4)



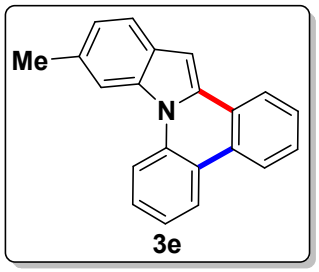
The reaction was performed following the general procedure. The residue was purified by flash column chromatograph (silica gel, 100% petroleum) to give the product as a pale yellow solid (47.8 mg, 85%). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.51 (dd, *J* = 8.5, 1.0 Hz, 1H), 8.27 (dd, *J* = 8.1, 1.5 Hz, 1H), 8.21 (d, *J* = 8.6 Hz, 1H), 8.17 (dd, *J* = 7.0, 2.1 Hz, 1H), 8.15 – 8.10 (m, 1H), 7.55 (ddd, *J* = 8.5, 7.0, 1.5 Hz, 1H), 7.46 (tt, *J* = 7.2, 5.4 Hz, 2H), 7.36 – 7.28 (m, 2H), 7.26 (s, 1H), 7.18 (d, *J* = 7.1 Hz, 1H), 2.73 (s, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 135.9, 134.6, 133.6, 130.2, 130.1, 128.6, 128.0, 127.5, 126.7, 126.2, 124.0, 123.8, 122.9, 122.3, 122.1, 122.1, 121.9, 116.3, 111.8, 94.6, 19.0.

12-methylindolo[1,2-f]phenanthridine (3d) (CAS: 945472-67-3)



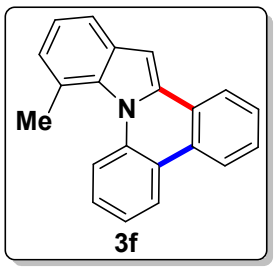
The reaction was performed following the general procedure. The residue was purified by flash column chromatograph (silica gel, 100% petroleum) to give the product as a pale yellow solid (49.5 mg, 88%). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.49 (d, *J* = 8.4 Hz, 1H), 8.29 (d, *J* = 7.9 Hz, 1H), 8.24 (d, *J* = 8.6 Hz, 1H), 8.22 – 8.16 (m, 1H), 8.15 – 8.05 (m, 1H), 7.61 (s, 1H), 7.59 – 7.53 (m, 1H), 7.48 (td, *J* = 6.3, 5.7, 3.5 Hz, 2H), 7.32 (t, *J* = 7.5 Hz, 1H), 7.24 – 7.12 (m, 2H), 2.56 (s, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 136.0, 135.2, 132.2, 131.12, 130.6, 128.6, 128.1, 127.6, 126.8, 126.2, 124.0, 123.9, 123.6, 122.7, 122.3, 121.9, 120.6, 116.1, 113.8, 95.7, 21.4.

11-methylindolo[1,2-f]phenanthridine (3e) (CAS: 2226086-21-9)

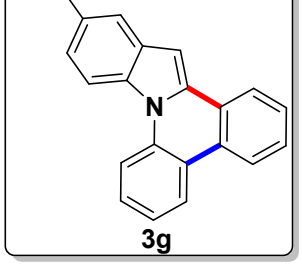


The reaction was performed following the general procedure. The residue was purified by flash column chromatograph (silica gel, 100% petroleum) to give the product as a pale yellow solid (46.6 mg, 83%). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.50 (d, *J* = 8.4 Hz, 1H), 8.26 (dd, *J* = 8.1, 1.5 Hz, 1H), 8.16 (q, *J* = 3.1, 2.2 Hz, 2H), 8.11 – 8.03 (m, 1H), 7.73 (d, *J* = 8.0 Hz, 1H), 7.56 (ddd, *J* = 8.4, 7.1, 1.5 Hz, 1H), 7.45 (tt, *J* = 7.2, 5.4 Hz, 2H), 7.35 – 7.28 (m, 1H), 7.21 (d, *J* = 8.0 Hz, 2H), 2.66 (s, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 136.0, 134.7, 134.3, 131.7, 128.5, 128.1, 128.0, 127.4, 126.6, 126.3, 123.9, 123.8, 123.4, 122.8, 122.3, 122.0, 120.5, 116.2, 114.2, 96.0, 22.4.

10-methylindolo[1,2-f]phenanthridine (3f)



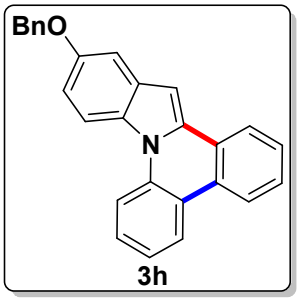
The reaction was performed following the general procedure. The residue was purified by flash column chromatograph (silica gel, 100% petroleum) to give the product as a pale yellow solid (48.9 mg, 87%).^{1}H NMR (500 MHz, $CDCl_3$) δ 8.27 – 8.15 (m, 2H), 8.12 – 8.02 (m, 1H), 7.69 (d, *J* = 7.8 Hz, 1H), 7.56 (dd, *J* = 8.3, 1.2 Hz, 1H), 7.54 – 7.44 (m, 3H), 7.38 – 7.28 (m, 2H), 7.25 – 7.17 (m, 2H), 2.63 (s, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 136.8, 135.6, 134.5, 131.7, 128.1, 128.1, 127.8, 127.2, 125.5, 124.3, 124.0, 122.9, 122.8, 122.7, 122.5, 120.8, 118.1, 97.4, 22.5. HRMS (ESI, m/z) calcd for $C_{22}H_{16}N$ $[M+H]^+$: 282.1277; found: 282.1281



12-methoxyindolo[1,2-f]phenanthridine (3g) (CAS: 945472-65-1)

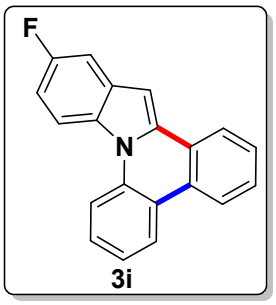
The reaction was performed following the general procedure. The residue was purified by flash column chromatograph (silica gel, petroleum ether : AcOEt = 10 : 1, v/v) to give the product as a pale yellow solid (48.1 mg, 81%). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.45 (d, *J* = 8.4 Hz, 1H), 8.30 (dd, *J* = 8.1, 1.5 Hz, 1H), 8.25 (d, *J* = 9.2 Hz, 1H), 8.23 – 8.18 (m, 1H), 8.13 – 8.06 (m, 1H), 7.56 (ddd, *J* = 8.6, 7.2, 1.5 Hz, 1H), 7.52 – 7.44 (m, 2H), 7.33 (t, *J* = 7.6 Hz, 1H), 7.24 (d, *J* = 2.6 Hz, 1H), 7.16 (s, 1H), 7.02 (dd, *J* = 9.1, 2.6 Hz, 1H), 3.94 (s, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 155.1, 135.8, 135.8, 131.3, 129.1, 128.7, 128.1, 127.7, 126.8, 126.0, 124.1, 124.0, 122.8, 122.4, 121.8, 115.9, 115.0, 111.9, 102.1, 95.8, 55.6.

12-(benzyloxy)indolo[1,2-f]phenanthridine (3h) (CAS: 2226086-24-2)



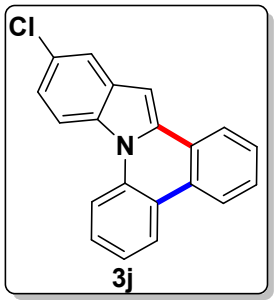
The reaction was performed following the general procedure. The residue was purified by flash column chromatograph (silica gel, petroleum ether : AcOEt = 8:1, v/v) to give the product as a pale yellow solid (56.0 mg, 75%). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.48 (dd, J = 8.5, 1.1 Hz, 1H), 8.34 (dd, J = 8.1, 1.5 Hz, 1H), 8.28 (d, J = 9.2 Hz, 1H), 8.26 – 8.21 (m, 1H), 8.15 – 8.09 (m, 1H), 7.61 – 7.48 (m, 5H), 7.42 (t, J = 7.6 Hz, 2H), 7.39 – 7.32 (m, 3H), 7.19 (s, 1H), 7.11 (dd, J = 9.2, 2.6 Hz, 1H), 5.20 (s, 2H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 154.4, 137.4, 135.9, 135.8, 131.3, 129.2, 128.8, 128.6, 128.2, 127.9, 127.75, 127.6, 126.8, 126.0, 124.1, 124.0, 122.9, 122.4, 121.9, 115.9, 115.1, 112.6, 103.6, 95.9, 70.6.

12-fluoroindolo[1,2-f]phenanthridine (3i) (CAS: 2226086-27-5)



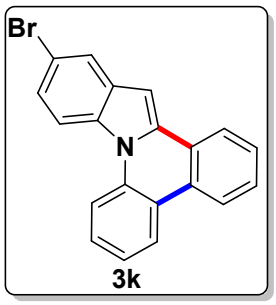
The reaction was performed following the general procedure. The residue was purified by flash column chromatograph (silica gel, 100% petroleum) to give the product as a pale yellow solid (46.7 mg, 82%).^{1}H NMR (500 MHz, $CDCl_3$) δ 8.35 (d, *J* = 8.4 Hz, 1H), 8.25 (dd, *J* = 8.1, 1.5 Hz, 1H), 8.20 (dd, *J* = 9.2, 4.3 Hz, 1H), 8.18 – 8.11 (m, 1H), 7.52 (ddd, *J* = 8.6, 7.1, 1.5 Hz, 1H), 7.46 (td, *J* = 5.5, 4.6, 3.2 Hz, 2H), 7.40 (dd, *J* = 9.1, 2.7 Hz, 1H), 7.34 – 7.27 (m, 1H), 7.15 – 7.02 (m, 2H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 158.5 (d, *J* = 236.3 Hz), 136.6, 135.5, 131.1(d, *J* = 11.3 Hz), 130.4, 128.7, 128.1 (d, *J* = 13.8 Hz), 126.8, 125.6, 124.0 (d, *J* = 18.8 Hz), 123.1, 122.3, 121.9, 115.8, 114.9 (d, *J* = 8.8 Hz), 110.1, 109.9, 105.6, 105.4, 95.9 (d, *J* = 3.8 Hz). ^{19}F NMR (471 MHz, $CDCl_3$) δ -121.7.

12-chloroindolo[1,2-f]phenanthridine (3j) (CAS: 2169291-29-4)



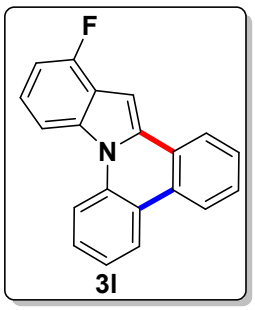
The reaction was performed following the general procedure. The residue was purified by flash column chromatograph (silica gel, 100% petroleum) to give the product as a pale yellow solid (51.8 mg, 86%).^{1}H NMR (500 MHz, $CDCl_3$) δ 8.38 (d, *J* = 8.4 Hz, 1H), 8.30 (dd, *J* = 8.1, 1.5 Hz, 1H), 8.25 – 8.15 (m, 2H), 8.12 – 8.01 (m, 1H), 7.74 (d, *J* = 2.2 Hz, 1H), 7.60 – 7.52 (m, 1H), 7.49 (td, *J* = 7.0, 6.3, 3.6 Hz, 2H), 7.35 (t, *J* = 7.6 Hz, 1H), 7.28 (dd, *J* = 9.0, 2.2 Hz, 1H), 7.12 (s, 1H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 136.4, 135.5, 132.2, 131.5, 128.8, 128.3, 128.2, 127.3, 126.9, 125.6, 124.2, 124.1, 123.4, 122.4, 122.1, 122.0, 120.1, 116.1, 115.1, 95.6.

12-bromoindolo[1,2-f]phenanthridine (3k)



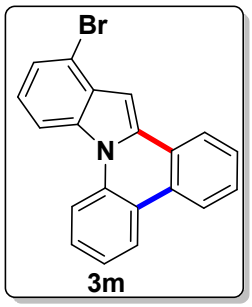
The reaction was performed following the general procedure. The residue was purified by flash column chromatograph (silica gel, 100% petroleum) to give the product as a pale yellow solid (49.0 mg, 71%).^{1}H NMR (500 MHz, $CDCl_3$) δ 8.38 (d, *J* = 8.4 Hz, 1H), 8.30 (d, *J* = 8.0 Hz, 1H), 8.25 – 8.14 (m, 2H), 8.13 – 8.01 (m, 1H), 7.90 (d, *J* = 2.0 Hz, 1H), 7.56 (t, *J* = 7.8 Hz, 1H), 7.52 – 7.45 (m, 2H), 7.45 – 7.30 (m, 2H), 7.12 (s, 1H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 136.3, 135.5, 132.5, 132.1, 128.9, 128.3, 128.3, 127.0, 125.7, 124.6, 124.3, 124.2, 123.5, 123.3, 122.5, 122.2, 116.2, 115.5, 115.1, 95.5. HRMS (ESI, m/z) calcd for $C_{20}H_{12}BrKN$ $[M+K]^+$: 383.9785; found: 383.9779.

13-fluoroindolo[1,2-f]phenanthridine (3l)



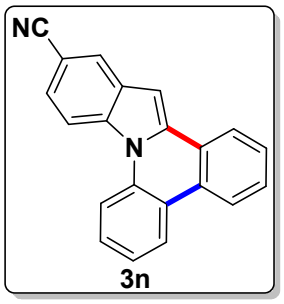
The reaction was performed following the general procedure. The residue was purified by flash column chromatograph (silica gel, 100% petroleum) to give the product as a pale yellow solid (44.5 mg, 78%).^{1}H NMR (500 MHz, $CDCl_3$) δ 8.43 (d, *J* = 8.4 Hz, 1H), 8.26 (dd, *J* = 8.1, 1.5 Hz, 1H), 8.16 (dt, *J* = 7.4, 3.7 Hz, 1H), 8.12 – 8.05 (m, 2H), 7.54 (ddd, *J* = 8.6, 7.2, 1.5 Hz, 1H), 7.47 (dt, *J* = 6.1, 3.5 Hz, 2H), 7.37 – 7.31 (m, 1H), 7.30 – 7.24 (m, 2H), 7.02 (dd, *J* = 9.7, 7.8 Hz, 1H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 156 .2 (d, *J* = 245.0 Hz), 136.0 (d, *J* = 10.0 Hz), 135.5, 135.2, 128.7, 128.3, 128.1, 126.8, 125.8, 124.1, 124.0, 123.4, 122.3, 122.2 (d, *J* = 7.5 Hz), 122.2, 119.7 (d, *J* = 22.5 Hz), 116.3, 110.3(d, *J* = 3.8 Hz), 106.4 (d, *J* = 18.8 Hz), 91.7. ^{19}F NMR (471 MHz, $CDCl_3$) δ -121.8. HRMS (ESI, m/z) calcd for $C_{23}H_{13}FN$ $[M+H]^+$: 286.1027; found: 286.1032.

13-bromoindolo[1,2-f]phenanthridine (3m) (CAS: 2226086-25-3)



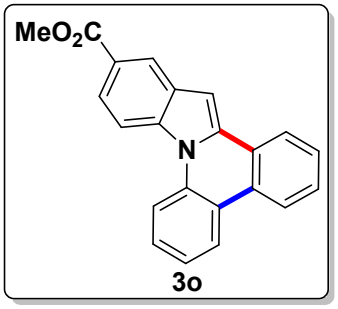
The reaction was performed following the general procedure. The residue was purified by flash column chromatograph (silica gel, 100% petroleum) to give the product as a pale yellow solid (48.3 mg, 70%).^{1}H NMR (500 MHz, $CDCl_3$) δ 8.41 (d, *J* = 8.4 Hz, 1H), 8.31 – 8.22 (m, 2H), 8.17 (dq, *J* = 7.3, 4.0 Hz, 1H), 8.12 (dt, *J* = 7.2, 3.7 Hz, 1H), 7.54 (ddd, *J* = 8.7, 7.3, 1.5 Hz, 1H), 7.52 – 7.43 (m, 3H), 7.35 (td, *J* = 7.6, 7.0, 1.1 Hz, 1H), 7.27 (s, 1H), 7.20 (t, *J* = 8.0 Hz, 1H).^{13}C NMR (125 MHz, $CDCl_3$) δ 135.7, 135.5, 133.9, 130.8, 128.8, 128.3, 128.3, 126.8, 125.6, 124.6, 124.3, 124.1, 123.5, 122.5, 122.4, 122.3, 116.3, 114.9, 113.2, 96.5.

indolo[1,2-f]phenanthridine-12-carbonitrile (3n) (CAS: 945472-71-9)



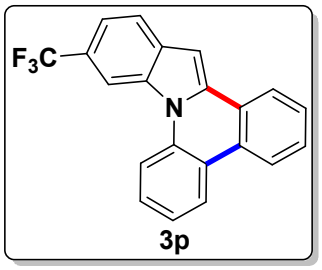
The reaction was performed following the general procedure. The residue was purified by flash column chromatograph (silica gel, petroleum ether : AcOEt = 5:1, v/v) to give the product as a pale yellow solid (32.7 mg, 56%).^{1}H NMR (500 MHz, $CDCl_3$) δ 8.37 (dd, J = 8.4, 1.2 Hz, 1H), 8.34 – 8.30 (m, 2H), 8.24 – 8.18 (m, 1H), 8.13 – 8.00 (m, 2H), 7.62 – 7.49 (m, 4H), 7.41 (ddd, J = 8.2, 7.2, 1.1 Hz, 1H), 7.19 (d, J = 0.8 Hz, 1H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 137.4, 137.2, 135.0, 135.0, 129.9, 129.0, 128.8, 128.5, 127.0, 125.9, 125.2, 124.4, 124.3, 124.2, 122.5, 122.4, 120.1, 116.5, 114.7, 104.8, 96.3.

methyl indolo[1,2-f]phenanthridine-12-carboxylate (3o)



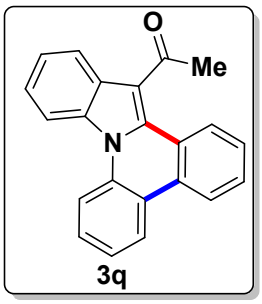
The reaction was performed following the general procedure. The residue was purified by flash column chromatograph (silica gel, petroleum ether : AcOEt = 5:1, v/v) to give the product as a pale yellow solid (47.5 mg, 73%).^{1}H NMR (500 MHz, $CDCl_3$) δ 8.48 (d, *J* = 1.8 Hz, 1H), 8.40 (dd, *J* = 8.4, 1.1 Hz, 1H), 8.30 – 8.20 (m, 2H), 8.18 – 8.10 (m, 1H), 8.01 (ddd, *J* = 22.1, 7.6, 3.3 Hz, 2H), 7.53 (ddd, *J* = 8.5, 7.2, 1.4 Hz, 1H), 7.50 – 7.41 (m, 2H), 7.33 (ddd, *J* = 8.2, 7.2, 1.1 Hz, 1H), 7.20 (s, 1H), 3.99 (s, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 167.7, 136.4, 135.9, 135.4, 129.8, 128.8, 128.3, 128.2, 126.8, 125.6, 124.2, 124.0, 123.7, 123.4, 123.4, 122.9, 122.4, 122.3, 116.4, 113.7, 97.1, 52.0. HRMS (ESI, m/z) calcd for $C_{22}H_{16}NO_2$ $[M+H]^+$: 326.1176; found: 326.1180.

11-(trifluoromethyl)indolo[1,2-f]phenanthridine (3p)



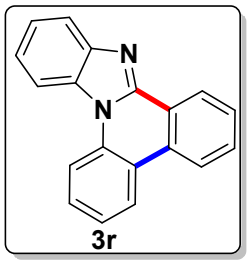
The reaction was performed following the general procedure. The residue was purified by flash column chromatograph (silica gel, 100% petroleum) to give the product as a pale yellow oil (58.3 mg, 87%). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.55 (s, 1H), 8.37 (d, *J* = 8.4 Hz, 1H), 8.26 (dd, *J* = 8.1, 1.5 Hz, 1H), 8.17 (dd, *J* = 7.1, 2.1 Hz, 1H), 8.10 – 7.99 (m, 1H), 7.83 (d, *J* = 8.3 Hz, 1H), 7.62 – 7.53 (m, 2H), 7.49 (tt, *J* = 7.2, 5.5 Hz, 2H), 7.39 – 7.32 (m, 1H), 7.17 (s, 1H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 137.6, 135.2, 132.6, 132.5, 129.0, 128.5, 128.3, 127.1, 125.3 (q, *J* = 270.0 Hz), 125.3, 124.3, 124.1, 123.7, 123.4 (q, *J* = 31.3 Hz), 122.4, 122.1, 121.1, 118.4, (q, *J* = 3.8 Hz), 116.23, 111.5 (q, *J* = 5.0 Hz) 96.1. ^{19}F NMR (471 MHz, $CDCl_3$) δ -60.0. HRMS (ESI, m/z) calcd for $C_{21}H_{13}F_3N$ $[M+H]^+$: 336.0995; found: 336.0995.

1-(indolo[1,2-f]phenanthridin-14-yl)ethan-1-one (3q)



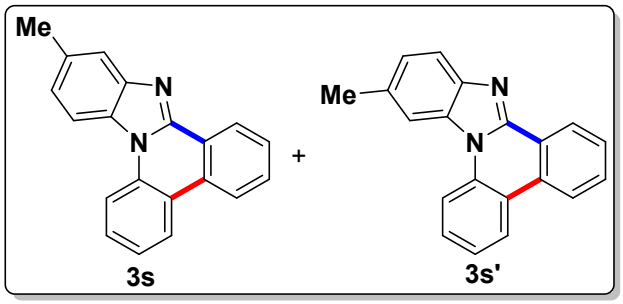
The reaction was performed following the general procedure. The residue was purified by flash column chromatograph (silica gel, petroleum ether : AcOEt = 10 : 1, v/v) to give the product as a yellow solid (26.6 mg, 43%).^{1}H NMR (500 MHz, $CDCl_3$) δ 8.62 (d, *J* = 8.4 Hz, 1H), 8.41 (dt, *J* = 7.0, 2.3 Hz, 2H), 8.35 (dd, *J* = 8.1, 1.2 Hz, 1H), 8.26 (dd, *J* = 8.1, 1.3 Hz, 1H), 8.22 – 8.11 (m, 1H), 7.65 (dddd, *J* = 8.4, 7.2, 5.7, 1.4 Hz, 2H), 7.59 – 7.54 (m, 1H), 7.48 (ddd, *J* = 7.7, 3.7, 1.9 Hz, 3H), 2.80 (s, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 199.4, 135.8, 134.7, 133.1, 129.3, 129.1, 128.8, 128.7, 128.4, 128.0, 124.7, 124.2, 124.2, 123.4, 123.3, 122.6, 122.5, 120.8, 117.0, 114.4, 114.2, 32.1. HRMS (ESI, m/z) calcd for $C_{22}H_{16}NO$ $[M+H]^+$: 310.1226; found: 310.1229.

benzo[4,5]imidazo[1,2-f]phenanthridine (3r) (CAS: 201-71-8)



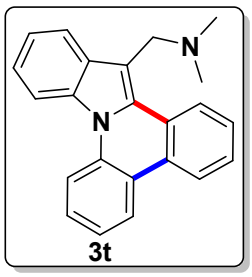
The reaction was performed following the general procedure. The residue was purified by flash column chromatograph (silica gel, petroleum ether : AcOEt = 4 : 1, v/v) to give the product as a pale yellow solid (28.4 mg, 53%).^{1}H NMR (500 MHz, $CDCl_3$) δ 8.84 (dd, *J* = 7.8, 1.6 Hz, 1H), 8.50 (d, *J* = 8.4 Hz, 1H), 8.42 (dd, *J* = 8.3, 1.5 Hz, 1H), 8.31 (dd, *J* = 11.0, 8.1 Hz, 2H), 8.10 – 7.99 (m, 1H), 7.74 – 7.60 (m, 3H), 7.54 – 7.40 (m, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 147.5, 144.5, 134.4, 131.8, 130.4, 129.5, 129.1, 128.6, 126.0, 124.4, 124.2, 124.1, 123.4, 122.9, 122.2, 121.7, 120.3, 116.0 113.9.

11-methylbenzo[4,5]imidazo[1,2-f]phenanthridine (3s) (CAS: 2376924-18-2) and 12-methylbenzo[4,5]imidazo[1,2-f]phenanthridine (3s') (CAS: 2376924-19-3)



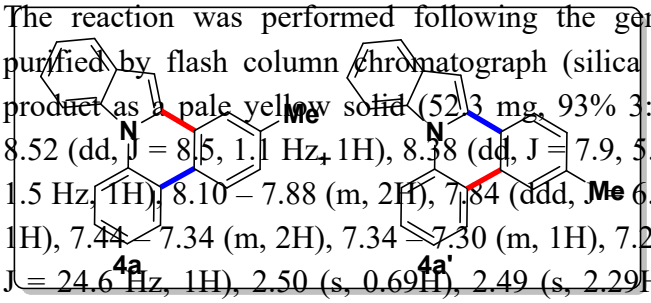
The reaction was performed following the general procedure. The residue was purified by flash column chromatograph (silica gel, petroleum ether : AcOEt = 4 : 1, v/v) to give the product as a White solid (27.6 mg, 49%). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.82 (ddd, *J* = 8.0, 4.5, 1.7 Hz, 1H), 8.47 (dd, *J* = 14.4, 8.4 Hz, 1H), 8.41 (dd, *J* = 8.2, 2.9 Hz, 1H), 8.32 (dd, *J* = 8.1, 3.7 Hz, 1H), 8.19 – 8.02 (m, 1H), 7.95 – 7.76 (m, 1H), 7.73 – 7.59 (m, 3H), 7.45 (t, *J* = 7.6 Hz, 1H), 7.32 (d, *J* = 8.2 Hz, 1H), 2.60 (d, *J* = 32.8 Hz, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 147.5, 147.1, 144.9, 142.6, 134.5, 134.4, 133.9, 132.8, 132.1, 130.2, 130.1, 129.9, 129.4, 129.3, 129.1, 129.0, 128.5, 128.5, 126.0, 125.9, 125.6, 124.4, 124.2, 124.2, 124.1, 123.6, 123.5, 122.2, 121.7, 121.6, 120.1, 119.8, 119.0, 115.99, 113.9, 113.3, 22.3, 21.6.

1-(indolo[1,2-f]phenanthridin-14-yl)-N,N-dimethylmethanamine (3t)



The reaction was performed following the general procedure. The residue was purified by flash column chromatograph (silica gel, DCM:EtOH = 100:1, v/v) to give the product as a pale yellow oil (47.3 mg, 73%).^{1}H NMR (500 MHz, $CDCl_3$) δ 8.72 (dd, *J* = 8.1, 1.4 Hz, 1H), 8.55 (d, *J* = 8.5 Hz, 1H), 8.41 (dd, *J* = 7.4, 1.9 Hz, 1H), 8.33 (dd, *J* = 8.1, 1.5 Hz, 1H), 8.28 (d, *J* = 8.0 Hz, 1H), 8.05 – 7.86 (m, 1H), 7.58 (tdd, *J* = 8.8, 7.2, 1.4 Hz, 2H), 7.52 (td, *J* = 7.7, 7.1, 1.3 Hz, 1H), 7.45 – 7.33 (m, 3H), 3.97 (s, 2H), 2.44 (s, 6H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 135.8, 132.8, 132.6, 131.8, 128.6, 128.4, 127.8, 127.5, 127.2, 127.1, 124.0, 123.1, 122.5, 122.2, 122.0, 121.5, 118.9, 116.7, 114.1, 108.8, 54.2, 45.4. HRMS (ESI, m/z) calcd for $C_{23}H_{21}N_2$ $[M+H]^+$: 325.1699; found: 325.1672.

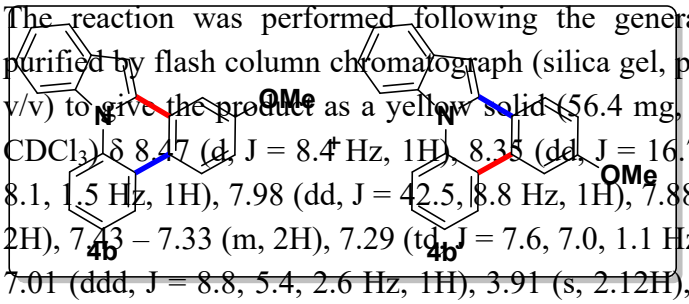
2-methylindolo[1,2-f]phenanthridine (4a) and 3-methylindolo[1,2-f]phenanthridine (4a') (CAS: 1658455-12-9)



The reaction was performed following the general procedure. The residue was purified by flash column chromatograph (silica gel, 100% petroleum) to give the product as a pale yellow solid (52.3 mg, 93% 3:1). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.52 (dd, J = 8.5, 1.1 Hz, 1H), 8.38 (dd, J = 7.9, 5.2 Hz, 1H), 8.27 (ddd, J = 16.3, 8.1, 1.5 Hz, 1H), 8.10 – 7.88 (m, 2H), 7.84 (ddd, J = 6.8, 3.7, 1.4 Hz, 1H), 7.62 – 7.49 (m, 1H), 7.44 – 7.34 (m, 2H), 7.34 – 7.30 (m, 1H), 7.27 (dd, J = 8.3, 1.9 Hz, 1H), 7.21 (d, J = 24.6 Hz, 1H), 2.50 (s, 0.69H), 2.49 (s, 2.29H). ^{13}C NMR (125 MHz, $CDCl_3$) δ

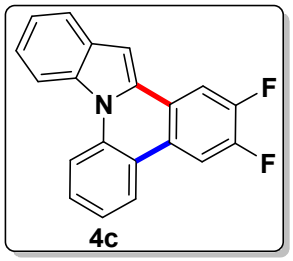
138.0, 137.6, 136.0, 135.6, 135.5, 135.3, 133.9, 133.8, 130.5, 130.4, 129.4, 129.1, 128.5, 128.2, 126.7, 126.0, 124.4, 124.1, 124.1, 123.9, 123.7, 123.6, 122.9, 122.9, 122.5, 122.3, 122.2, 122.1, 121.9, 121.7, 121.7, 121.0, 120.8, 116.3, 116.2, 114.2, 114.1, 96.0, 95.5, 21.8, 21.5.

2-methoxyindolo[1,2-f]phenanthridine (4b) and 3-methoxyindolo[1,2-f]phenanthridine (4b') (CAS: 1658455-26-5)



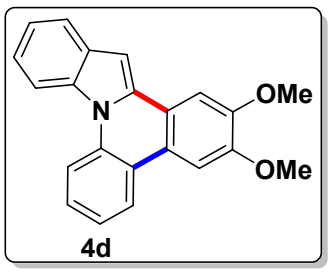
The reaction was performed following the general procedure. The residue was purified by flash column chromatograph (silica gel, petroleum ether : AcOEt = 10 : 1, v/v) to give the product as a yellow solid (56.4 mg, 95%, 3:1). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.47 (d, J = 8.4 Hz, 1H), 8.35 (dd, J = 16.7, 8.6 Hz, 1H), 8.14 (td, J = 8.9, 8.1, 1.5 Hz, 1H), 7.98 (dd, J = 42.5, 8.8 Hz, 1H), 7.88 – 7.75 (m, 1H), 7.59 – 7.43 (m, 2H), 7.43 – 7.33 (m, 2H), 7.29 (td, J = 7.6, 7.0, 1.1 Hz, 1H), 7.11 (d, J = 61.5 Hz, 1H), 7.01 (ddd, J = 8.8, 5.4, 2.6 Hz, 1H), 3.91 (s, 2.12H), 3.90 (s, 0.76H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 159.4, 159.4, 136.1, 135.4, 135.0, 135.0, 133.9, 133.6, 130.6, 130.2, 128.7, 128.2, 127.5, 127.2, 125.7, 124.0, 123.9, 123.3, 122.9, 122.7, 122.1, 122.0, 121.8, 121.7, 121.6, 121.4, 121.0, 120.6, 120.3, 119.7, 116.2, 116.1, 116.1, 115.9, 114.2, 114.1, 106.3, 105.6, 96.2, 94.6, 55.3.

2,3-difluoroindolo[1,2-f]phenanthridine (4c)



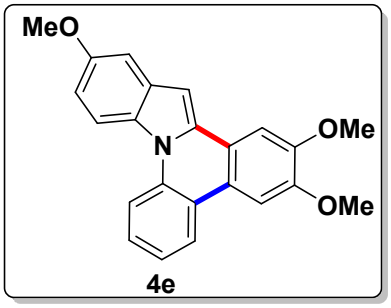
The reaction was performed following the general procedure. The residue was purified by flash column chromatograph (silica gel, 100% petroleum) to give the product as a pale yellow solid (50.9 mg, 84%). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.26 (dd, *J* = 10.3, 6.5 Hz, 1H), 8.17 (t, *J* = 7.7 Hz, 1H), 7.80 (dd, *J* = 11.7, 6.6 Hz, 1H), 7.72 (qd, *J* = 5.5, 3.6, 3.0 Hz, 1H), 7.62 (ddd, *J* = 19.1, 9.2, 5.9 Hz, 1H), 7.55 – 7.39 (m, 2H), 7.34 (p, *J* = 7.3 Hz, 2H), 7.18 (p, *J* = 6.0 Hz, 1H), 6.91 – 6.73 (m, 1H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 150.3 (dd, *J* = 250.0, 10.0 Hz), 150.1 (dd, *J* = 250.0, 10.0 Hz), 135.5, 133.6, 133.1, 129.9, 128.9, 123.7 (dd, *J* = 7.5, 3.8 Hz), 123.7, 122.9, 122.8 (dd, *J* = 7.5, 3.8 Hz), 122.3, 121.9, 121.0, 120.3, 116.0, 114.1, 111.7 (dd, *J* = 16.3, 3.8 Hz), 110.7 (d, *J* = 17.5 Hz), 96.5. ^{19}F NMR (471 MHz, $CDCl_3$) δ -136.75 – -136.79 (m), -136.80 – -136.87 (m), -136.88 – -136.92 (m). HRMS (ESI, m/z) calcd for $C_{20}H_{12}F_2N$ $[M+H]^+$: 304.0932; found: 304.0926.

2,3-dimethoxyindolo[1,2-f]phenanthridine (4d)



The reaction was performed following the general procedure. The residue was purified by flash column chromatograph (silica gel, petroleum ether:AcOEt = 8:1) to give the product as a pale yellow solid (55.6 mg, 85%).

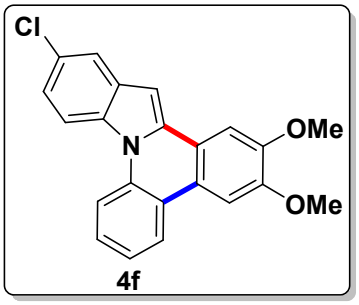
^{1}H NMR (500 MHz, $CDCl_3$) δ 8.32 (d, *J* = 8.3 Hz, 1H), 8.29 – 8.21 (m, 1H), 7.90 – 7.81 (m, 1H), 7.81 – 7.72 (m, 1H), 7.43 – 7.30 (m, 3H), 7.19 (t, *J* = 7.5 Hz, 1H), 7.11 (s, 1H), 7.01 (s, 1H), 6.85 (s, 1H), 3.82 (d, *J* = 7.5 Hz, 6H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 149.4, 149.2, 135.1, 135.0, 133.5, 130.3, 127.3, 122.9, 122.3, 121.6, 121.5, 121.2, 120.4, 120.3, 119.4, 115.9, 114.2, 104.7, 103.4, 94.2, 55.6, 55.6. HRMS (ESI, m/z) calcd for $C_{22}H_{18}NO_2$ $[M+H]^+$: 328.1332; found: 328.1334.



2,3,12-trimethoxyindolo[1,2-f]phenanthridine (4e)

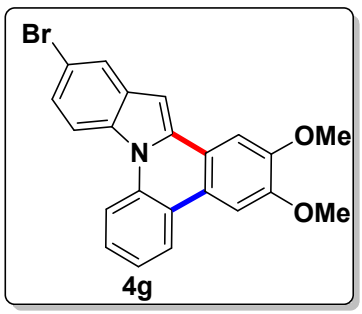
The reaction was performed following the general procedure. The residue was purified by flash column chromatograph (silica gel, petroleum ether : AcOEt = 5:1) to give the product as a pale yellow solid (59.3 mg, 83%). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.33 (d, *J* = 8.3 Hz, 1H), 8.17 (d, *J* = 9.1 Hz, 1H), 8.00 (dd, *J* = 8.2, 1.4 Hz, 1H), 7.44 (ddd, *J* = 8.5, 7.0, 1.5 Hz, 1H), 7.34 (s, 1H), 7.24 (d, *J* = 7.9 Hz, 1H), 7.22 – 7.15 (m, 2H), 6.97 (dd, *J* = 9.1, 2.6 Hz, 1H), 6.86 (s, 1H), 3.93 (s, 9H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 155.0, 149.7, 149.5, 135.7, 135.1, 131.4, 128.8, 127.5, 123.1, 122.4, 121.5, 120.4, 119.6, 115.7, 115.0, 111.0, 105.0, 103.7, 101.9, 94.0, 55.8, 55.6. HRMS (ESI, m/z) calcd for $C_{23}H_{20}NO_3$ $[M+H]^+$: 358.1438; found: 328.1443.

12-chloro-2,3-dimethoxyindolo[1,2-f]phenanthridine (4f)



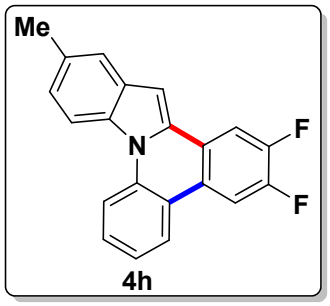
The reaction was performed following the general procedure. The residue was purified by flash column chromatograph (silica gel, petroleum ether : AcOEt = 5:1) to give the product as a pale yellow solid (47.7 mg, 66%). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.40 (dd, J = 8.4, 1.1 Hz, 1H), 8.23 (d, J = 9.0 Hz, 1H), 8.14 (dd, J = 8.3, 1.5 Hz, 1H), 7.72 (d, J = 2.2 Hz, 1H), 7.56 – 7.49 (m, 2H), 7.38 – 7.33 (m, 2H), 7.28 (d, J = 2.2 Hz, 1H), 6.95 (s, 1H), 4.03 (d, J = 6.0 Hz, 6H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 150.0, 150.0, 136.4, 134.9, 132.0, 131.6, 127.9, 127.3, 123.4, 123.2, 121.9, 121.4, 120.8, 119.7, 119.4, 116.1, 115.1, 105.3, 104.0, 93.9, 56.0, 56.0. HRMS (ESI, m/z) calcd for $C_{22}H_{17}ClNO_2$ $[M+H]^+$: 362.0942; found: 362.0950.

12-bromo-2,3-dimethoxyindolo[1,2-f]phenanthridine (4g)



The reaction was performed following the general procedure. The residue was purified by flash column chromatograph (silica gel, petroleum ether : AcOEt = 5:1) to give the product as a pale yellow solid (56.8 mg,

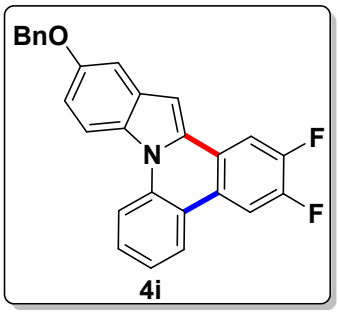
70%). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.40 (dd, *J* = 8.5, 1.1 Hz, 1H), 8.19 (d, *J* = 8.9 Hz, 1H), 8.15 (dd, *J* = 8.2, 1.5 Hz, 1H), 7.88 (d, *J* = 2.1 Hz, 1H), 7.57 – 7.50 (m, 2H), 7.40 (dd, *J* = 8.9, 2.1 Hz, 1H), 7.38 – 7.34 (m, 2H), 6.95 (s, 1H), 4.03 (d, *J* = 5.7 Hz, 6H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 150.1, 150.0, 136.3, 134.9, 132.3, 132.2, 127.9, 124.0, 123.4, 123.2, 122.9, 122.0, 120.8, 119.4, 116.2, 115.5, 115.0, 105.3, 104.0, 93.8, 56.0, 56.0. HRMS (ESI, m/z) calcd for $C_{22}H_{17}BrNO_2$ $[M+H]^+$: 406.0437; found: 406.0437.



2,3-difluoro-12-methylindolo[1,2-f]phenanthridine (4h)

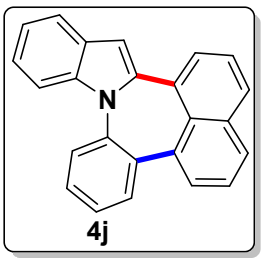
The reaction was performed following the general procedure. The residue was purified by flash column chromatograph (silica gel, 100% petroleum) to give the product as a pale yellow solid (52.6 mg, 83%). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.38 (dd, *J* = 8.5, 1.1 Hz, 1H), 8.14 (d, *J* = 8.7 Hz, 1H), 7.99 (dd, *J* = 8.1, 1.5 Hz, 1H), 7.82 (dd, *J* = 11.9, 7.8 Hz, 1H), 7.69 (dd, *J* = 10.9, 7.9 Hz, 1H), 7.58 – 7.48 (m, 2H), 7.28 (ddd, *J* = 8.3, 7.2, 1.2 Hz, 1H), 7.19 (dd, *J* = 8.7, 1.8 Hz, 1H), 6.92 (s, 1H), 2.53 (s, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 150.4 (dd, *J* = 251.3, 16.3 Hz), 150.3, (dd, *J* = 251.3, 17.5 Hz), 135.8, 133.4, 132.2, 131.5, 130.4, 129.1, 124.1, 124.0 (dd, *J* = 6.3, 2.5 Hz), 123.9, 123.2 (dd, *J* = 6.3, 2.5 Hz), 122.9, 120.8, 120.4, 116.2, 113.8, 111.9 (d, *J* = 17.5 Hz), 110.9, (d, *J* = 18.8 Hz), 96.2, 21.3. ^{19}F NMR (471 MHz, $CDCl_3$) δ -136.82, -136.87, -137.00, -137.05. HRMS (ESI, m/z) calcd for $C_{21}H_{14}F_2N$ $[M+H]^+$: 318.1089; found: 318.1092.

12-(benzyloxy)-2,3-difluoroindolo[1,2-f]phenanthridine (4i)



The reaction was performed following the general procedure. The residue was purified by flash column chromatograph (silica gel, petroleum ether : AcOEt = 8:1) to give the product as a pale yellow solid (70.3 mg, 86%). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.30 – 8.21 (m, 1H), 8.09 (d, *J* = 9.2 Hz, 1H), 7.91 (dd, *J* = 8.2, 1.5 Hz, 1H), 7.74 (dd, *J* = 11.8, 7.8 Hz, 1H), 7.66 – 7.51 (m, 3H), 7.51 – 7.41 (m, 3H), 7.41 – 7.32 (m, 1H), 7.26 – 7.22 (m, 1H), 7.21 (d, *J* = 2.6 Hz, 1H), 7.06 (dd, *J* = 9.2, 2.6 Hz, 1H), 6.80 (s, 1H), 5.17 (s, 2H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 154.4, 150.4 (dd, *J* = 250.0, 13.8 Hz), 150.2 (dd, *J* = 250.0, 13.8 Hz), 137.4, 135.5, 133.8, 130.9, 129.1, 129.0, 128.6, 127.9, 127.6, 123.8, 123.8 (dd, *J* = 7.5, 3.8 Hz), 122.9, 122.8 (dd, *J* = 7.5, 3.8 Hz), 120.2, 115.8, 115.0, 113.0, 111.8 (dd, *J* = 18.1, 2.5 Hz), 110.8 (d, *J* = 18.8 Hz), 103.5, 96.2, 70.5. ^{19}F NMR (471 MHz, $CDCl_3$) δ -136.75, -136.80, -136.87, -136.91. HRMS (ESI, m/z) calcd for $C_{27}H_{18}F_2NO$ $[M+H]^+$: 410.1351; found: 410.1357.

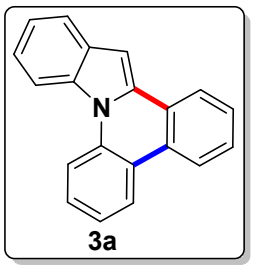
benzo[6,7]naphtho[1',8':3,4,5]azepino[1,2-a]indole (4j)

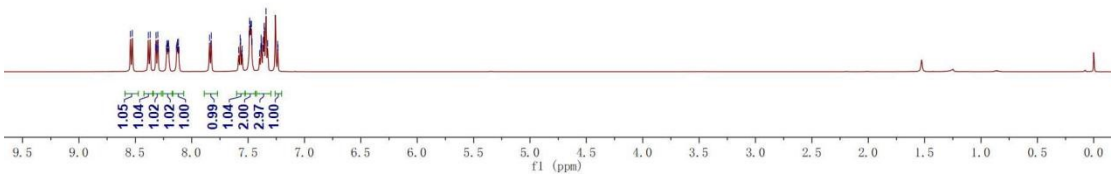


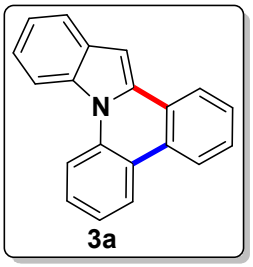
The reaction was performed following the general procedure. The residue was purified by flash column chromatograph (silica gel, 100% petroleum) to give the product as a bright yellow solid (29.1 mg, 46%).^{1}H NMR (500 MHz, $CDCl_3$) δ 8.04 (dd, *J* = 7.2, 1.2 Hz, 1H), 7.83 (dd, *J* = 8.1, 1.3 Hz, 1H), 7.80 – 7.68 (m, 4H), 7.59 (d, *J* = 7.7 Hz, 1H), 7.51 (t, *J* = 7.6 Hz, 1H), 7.45 (t, *J* = 7.6 Hz, 1H), 7.37 (td, *J* = 7.7, 1.7 Hz, 1H), 7.28 (td, *J* = 7.6, 1.3 Hz, 1H), 7.21 (ddd, *J* = 15.4, 8.1, 1.5 Hz, 2H), 7.14 (t, *J* = 7.4 Hz, 1H), 6.52 (s, 1H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 143.1, 137.6, 136.8, 135.7, 135.7, 135.0, 133.5, 133.40, 130.2, 128.8, 128.4, 128.1, 128.0, 127.2, 126.6, 126.1, 125.9, 124.6, 124.3, 122.4, 121.1, 120.7, 112.6, 107.4. HRMS (ESI, m/z) calcd for $C_{24}H_{16}N$ $[M+H]^+$: 318.1277; found: 318.1273.

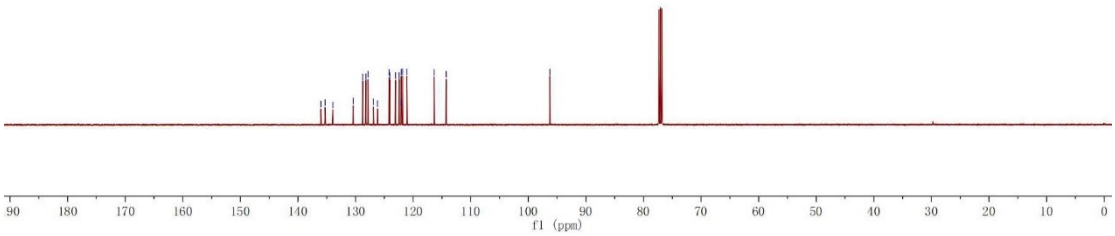
5. NMR spectroscopic data

indolo[1,2-f]phenanthridine (3a)

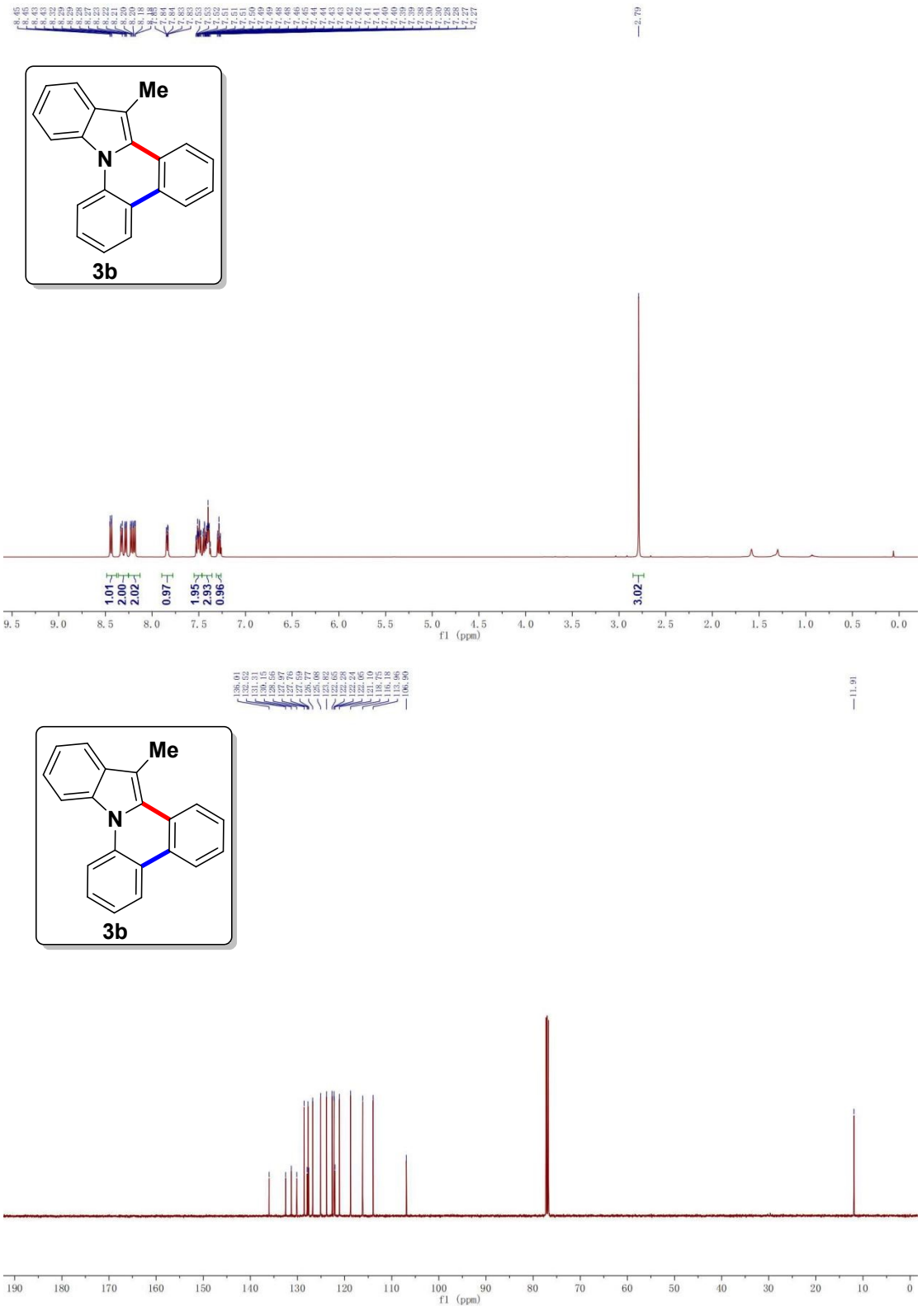




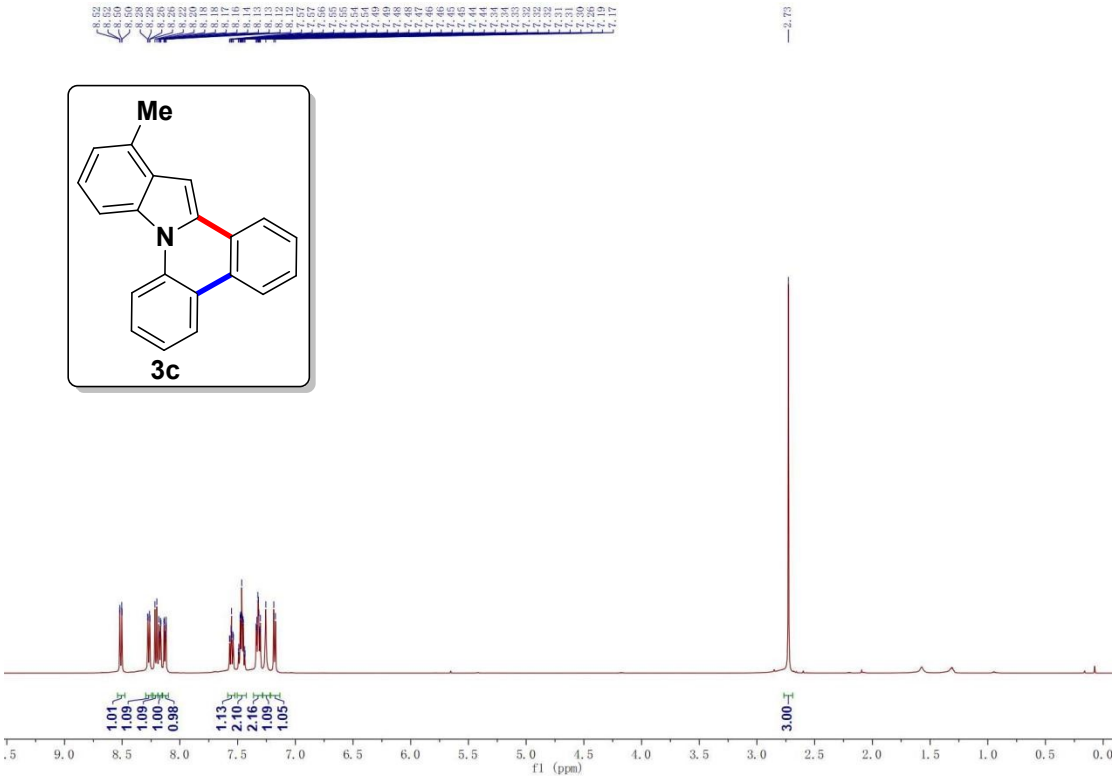


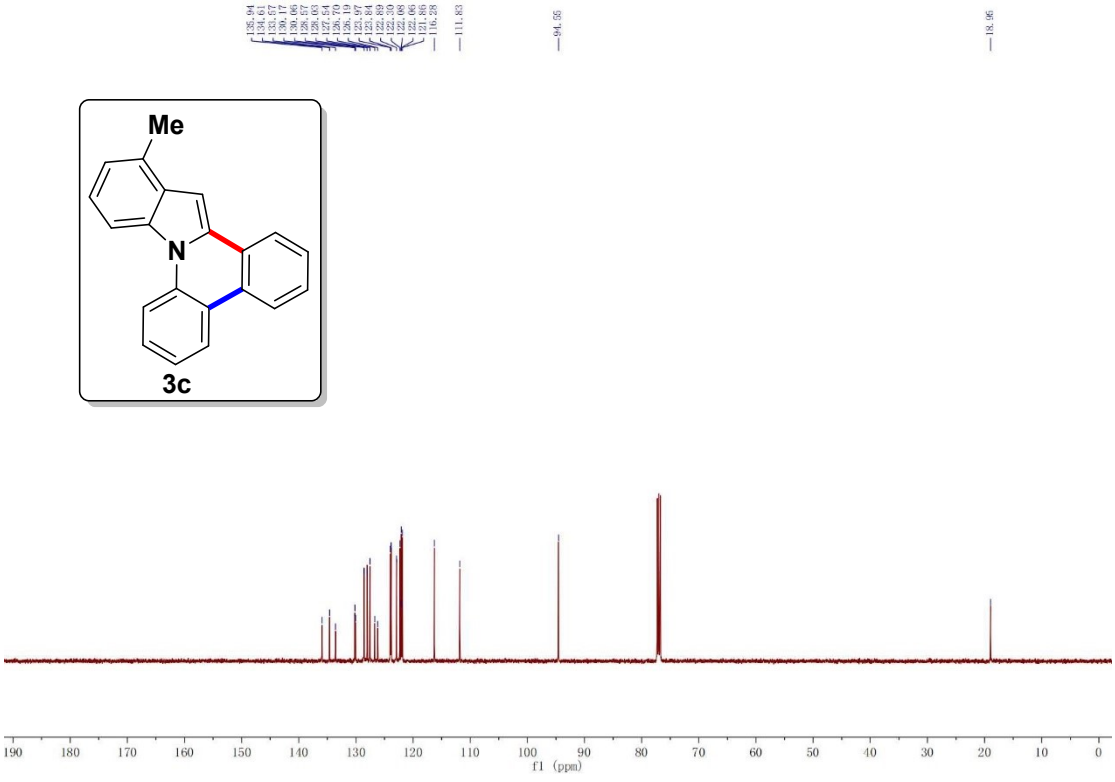


14-methylindolo[1,2-f]phenanthridine (3b)

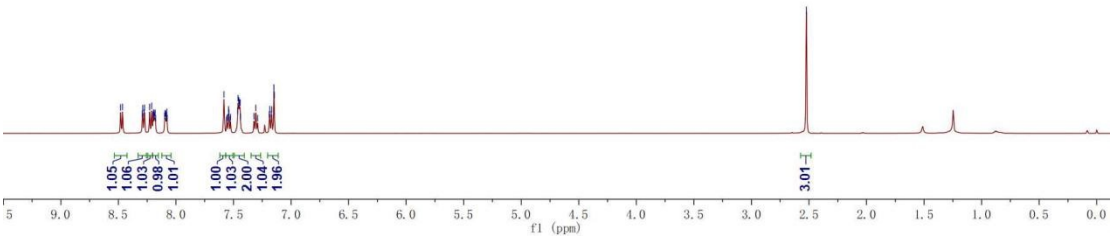


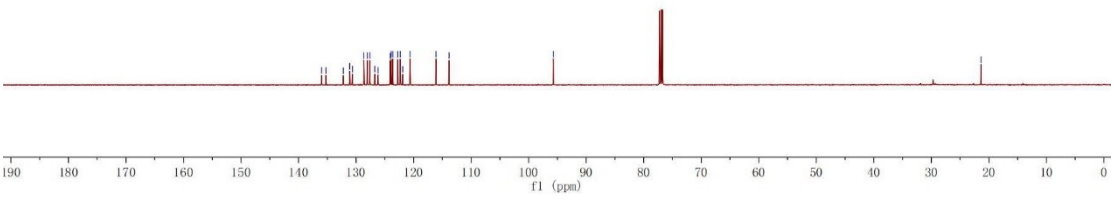
13-methylindolo[1,2-f]phenanthridine (3c)



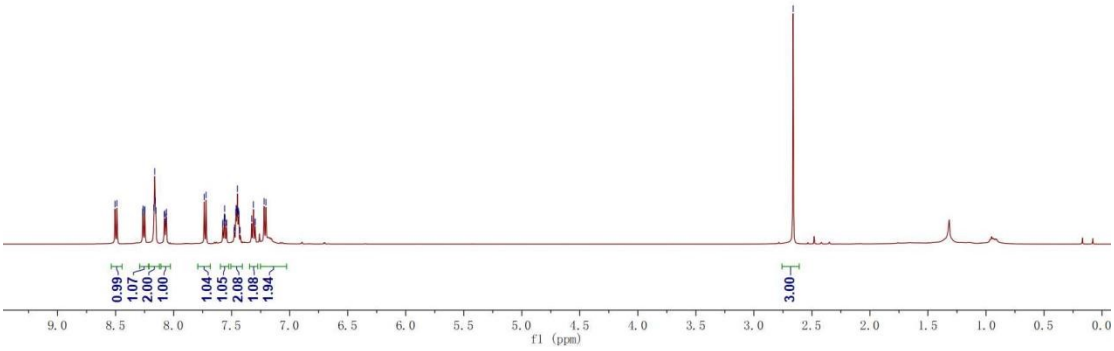


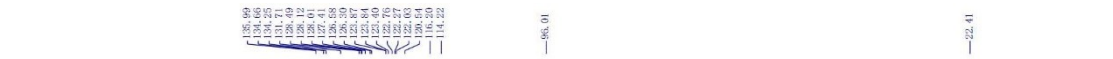
12-methylindolo[1,2-f]phenanthridine (3d)

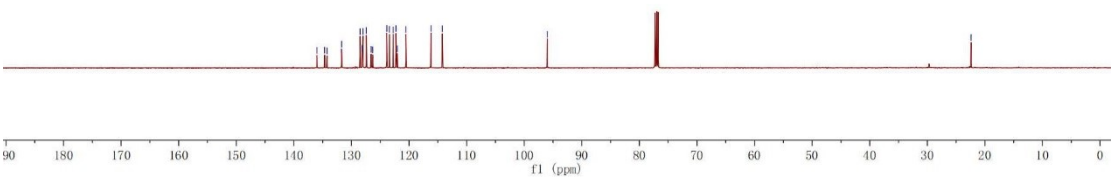




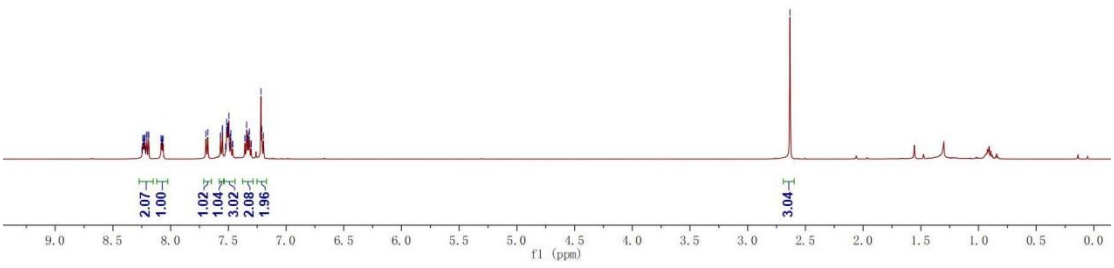
11-methylindolo[1,2-f]phenanthridine (3e)

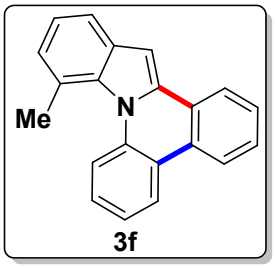


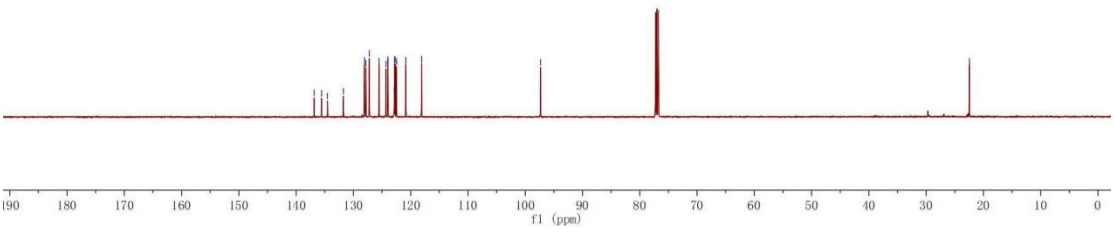




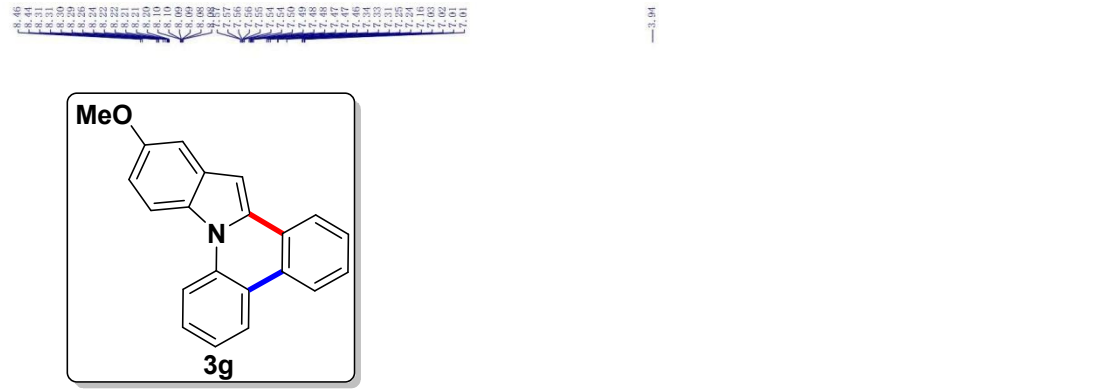
10-methylindolo[1,2-f]phenanthridine (3f)

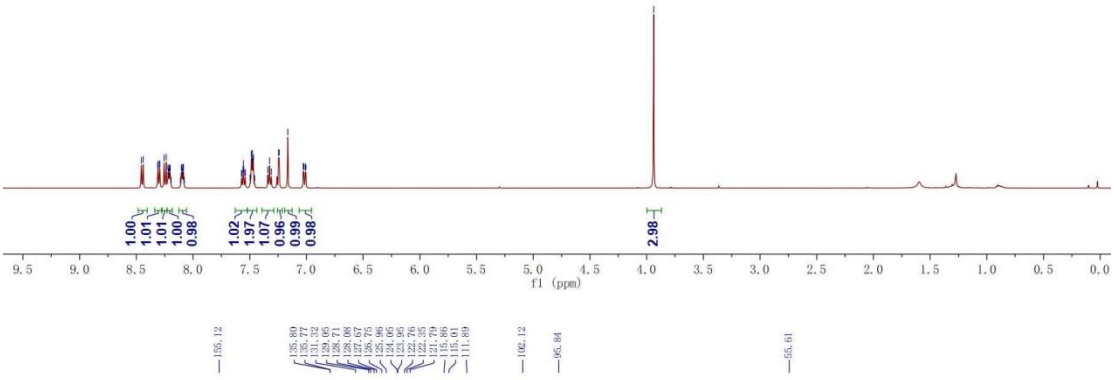


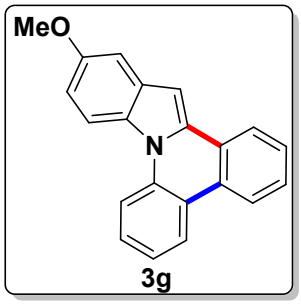


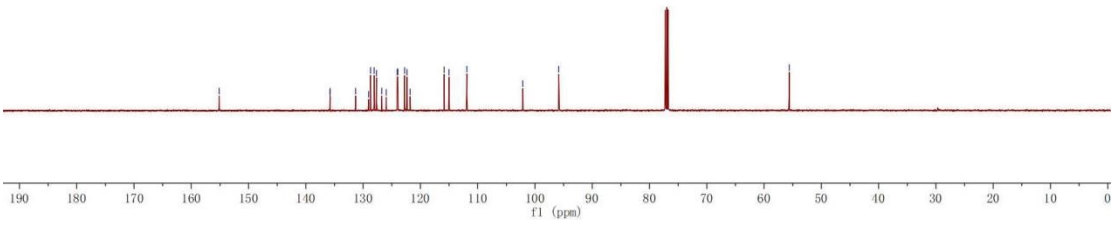


12-methoxyindolo[1,2-f]phenanthridine (3g)

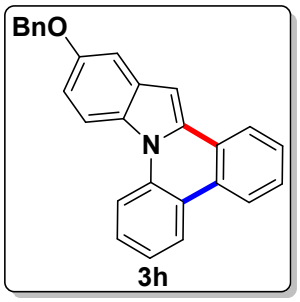


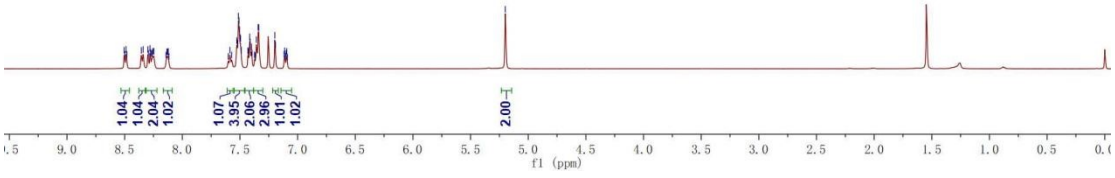


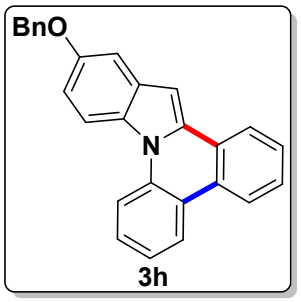


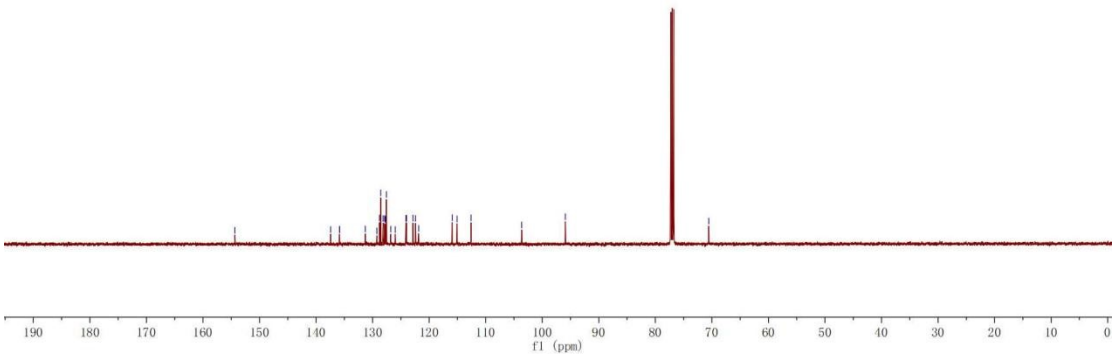


12-(benzyloxy)indolo[1,2-f]phenanthridine (3h)

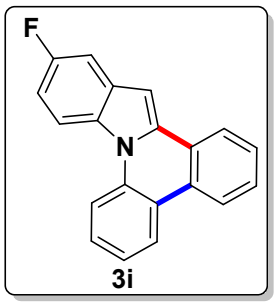


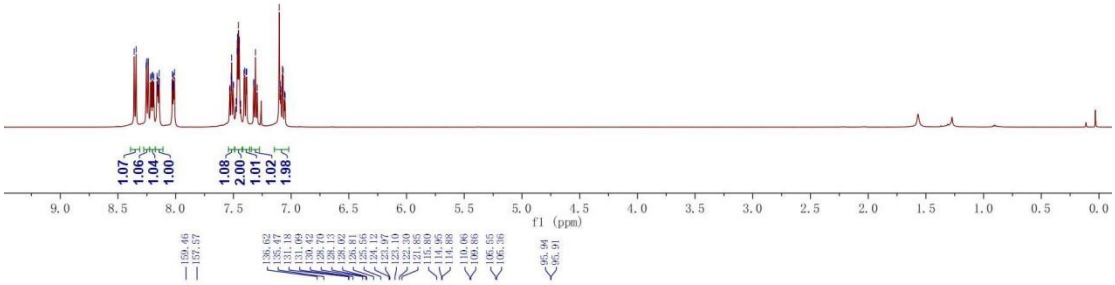


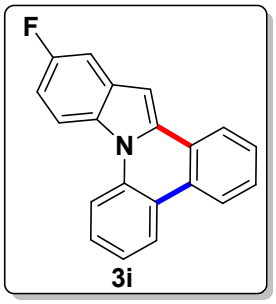


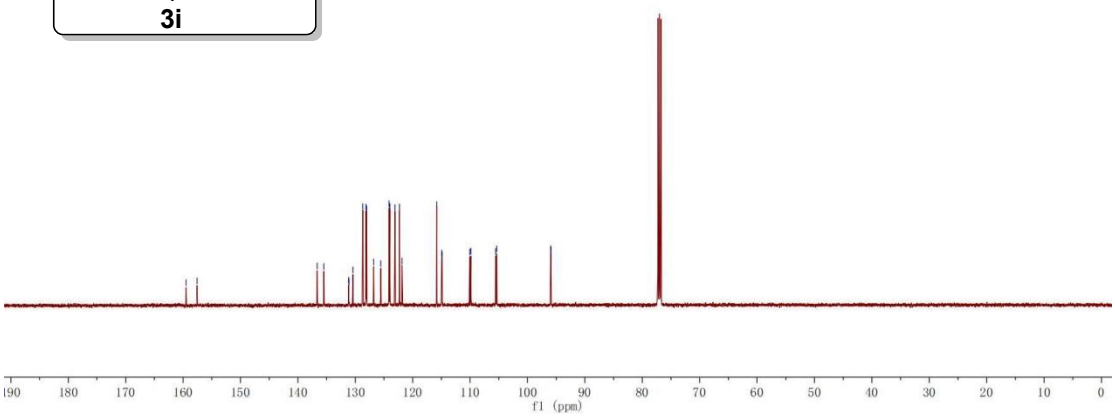


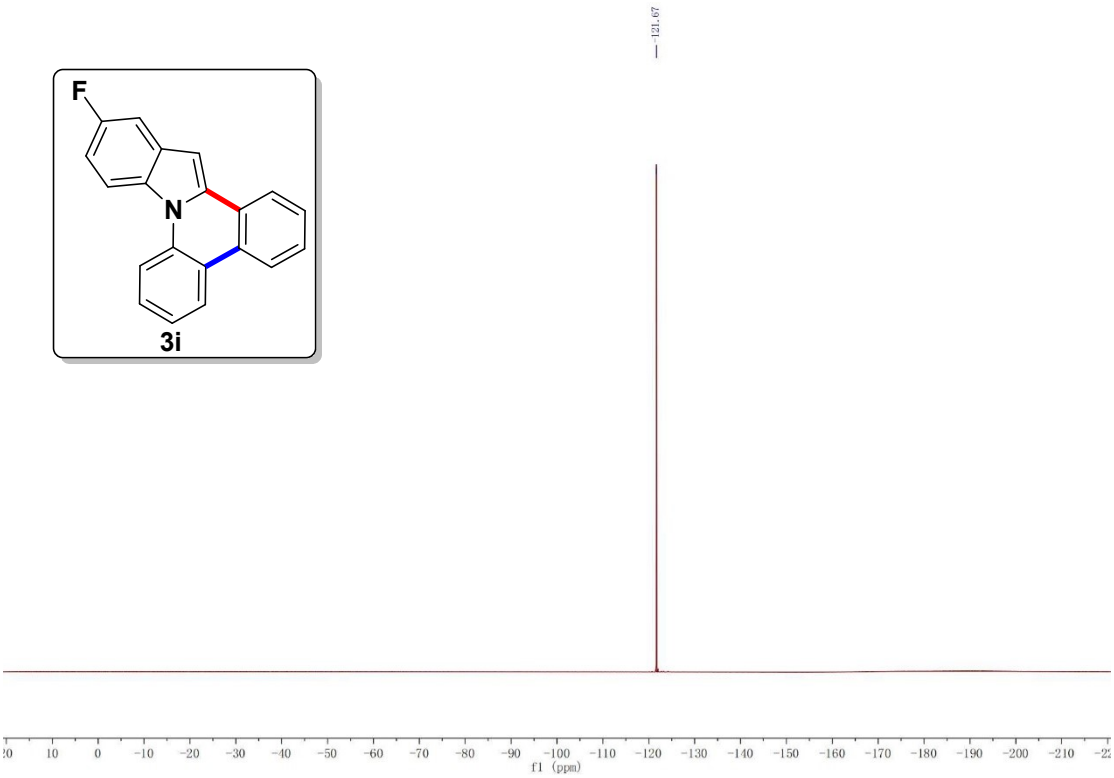
12-fluoroindolo[1,2-f]phenanthridine (3i)



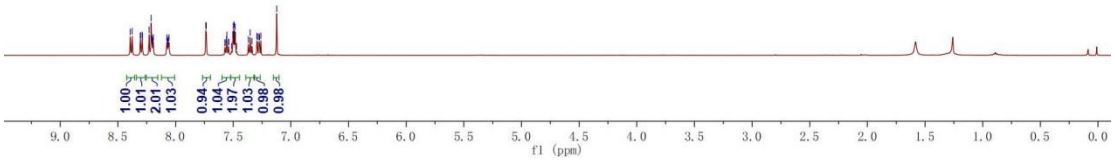


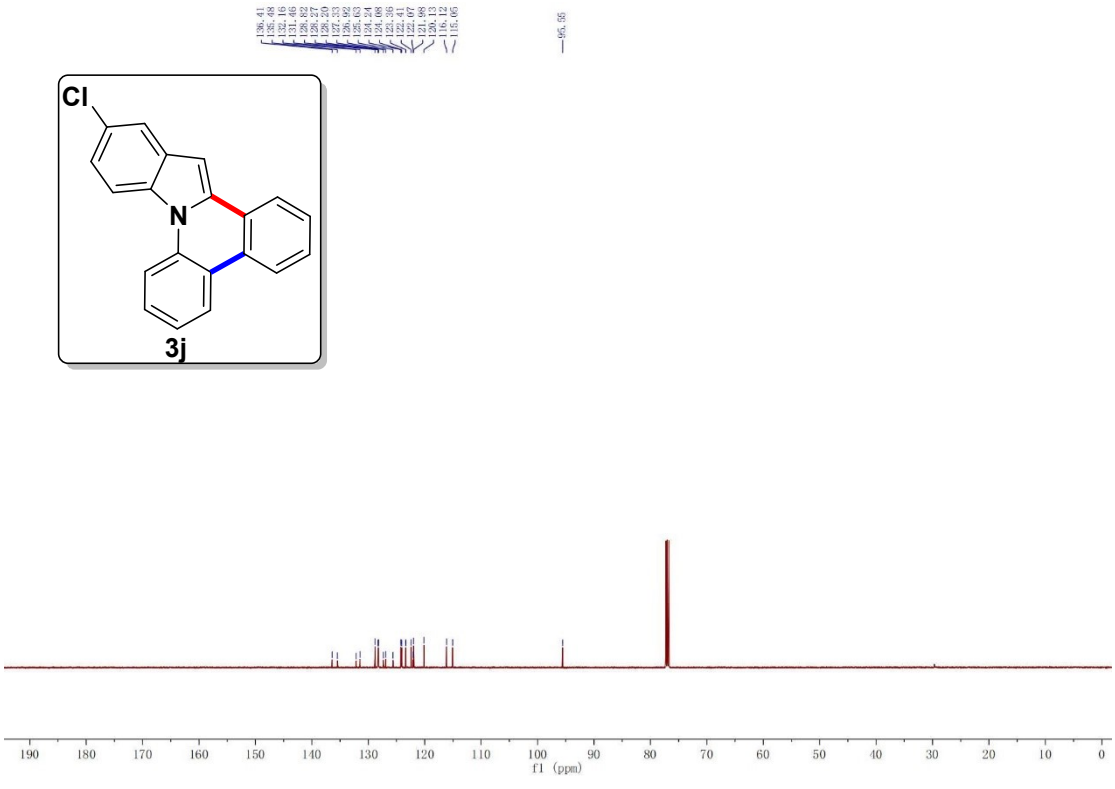




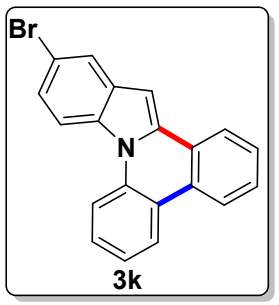

F
N
3i
-121.67
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
-210
f1 (ppm)

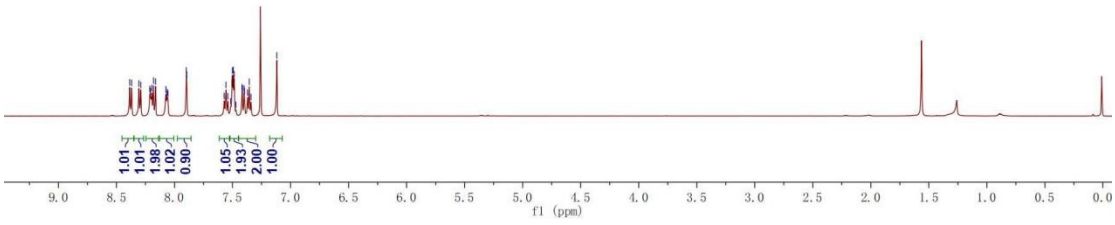
12-chloroindolo[1,2-f]phenanthridine (3j)

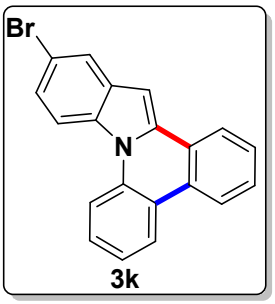


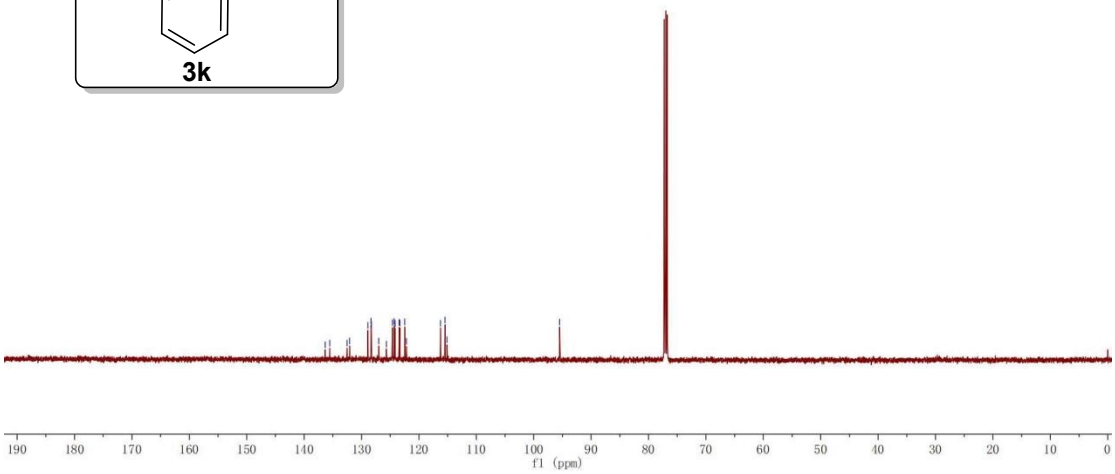


12-bromoindolo[1,2-f]phenanthridine (3k)

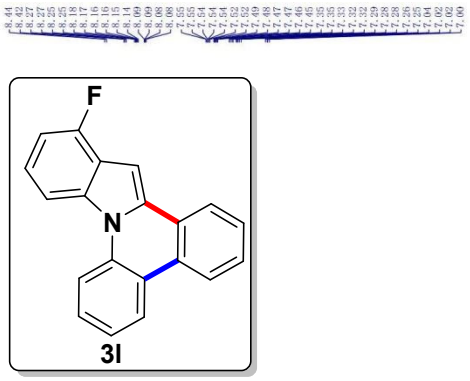


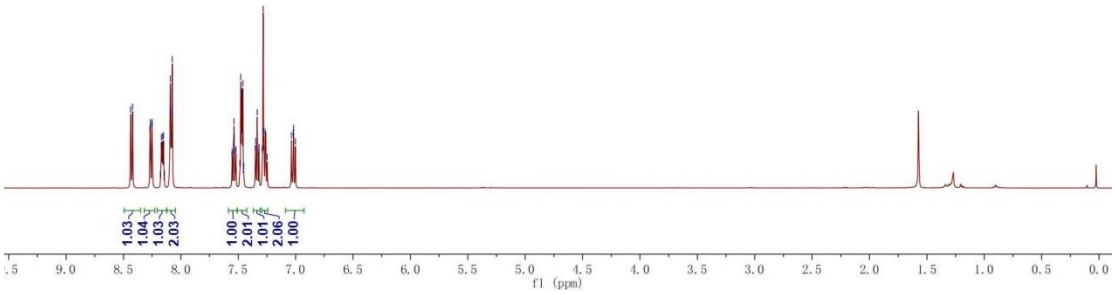


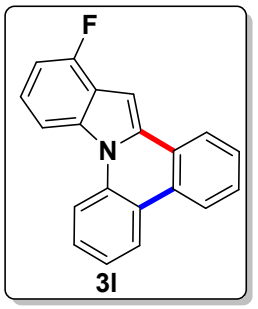


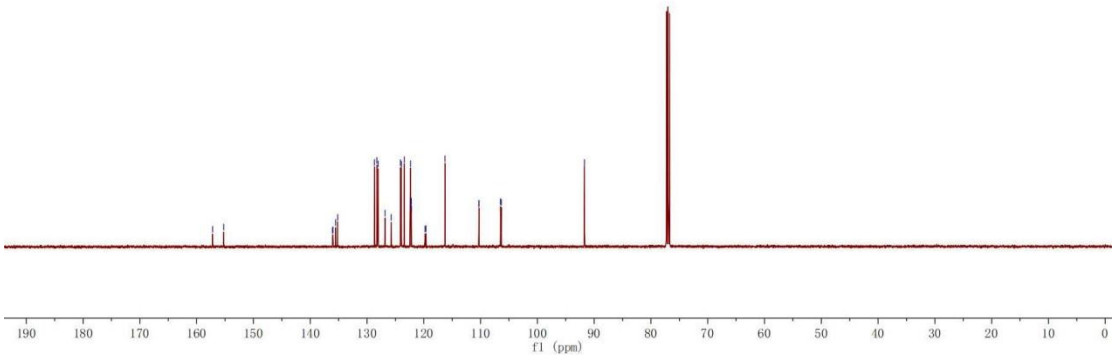


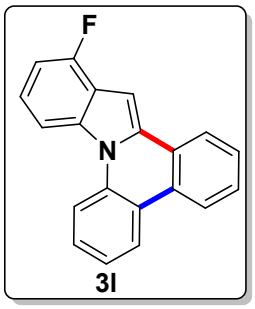
13-fluoroindolo[1,2-f]phenanthridine (3l)







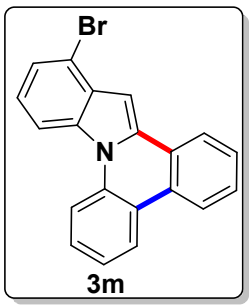


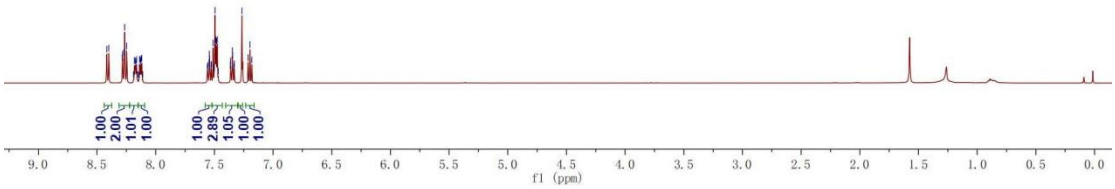

F
N

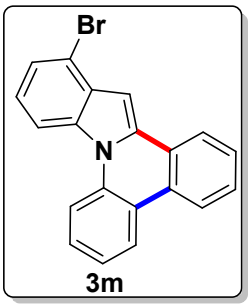
3l

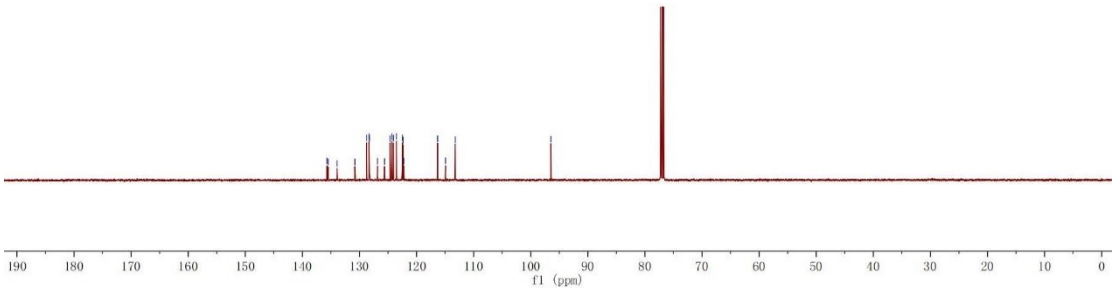
-121.77
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
-210
f1 (ppm)

13-bromoindolo[1,2-f]phenanthridine (3m)

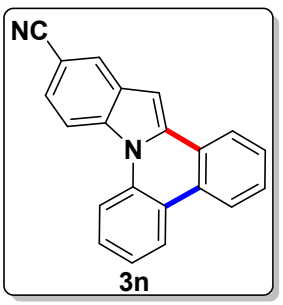


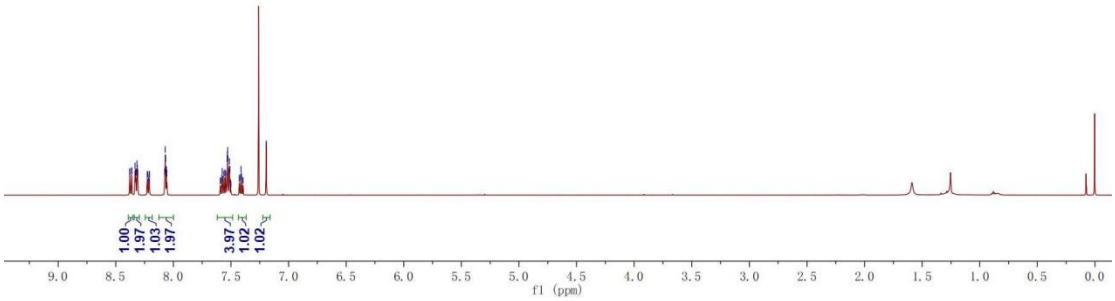


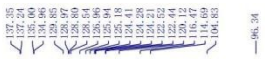


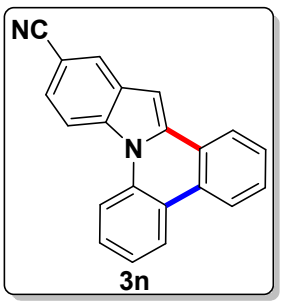


indolo[1,2-f]phenanthridine-12-carbonitrile (3n)

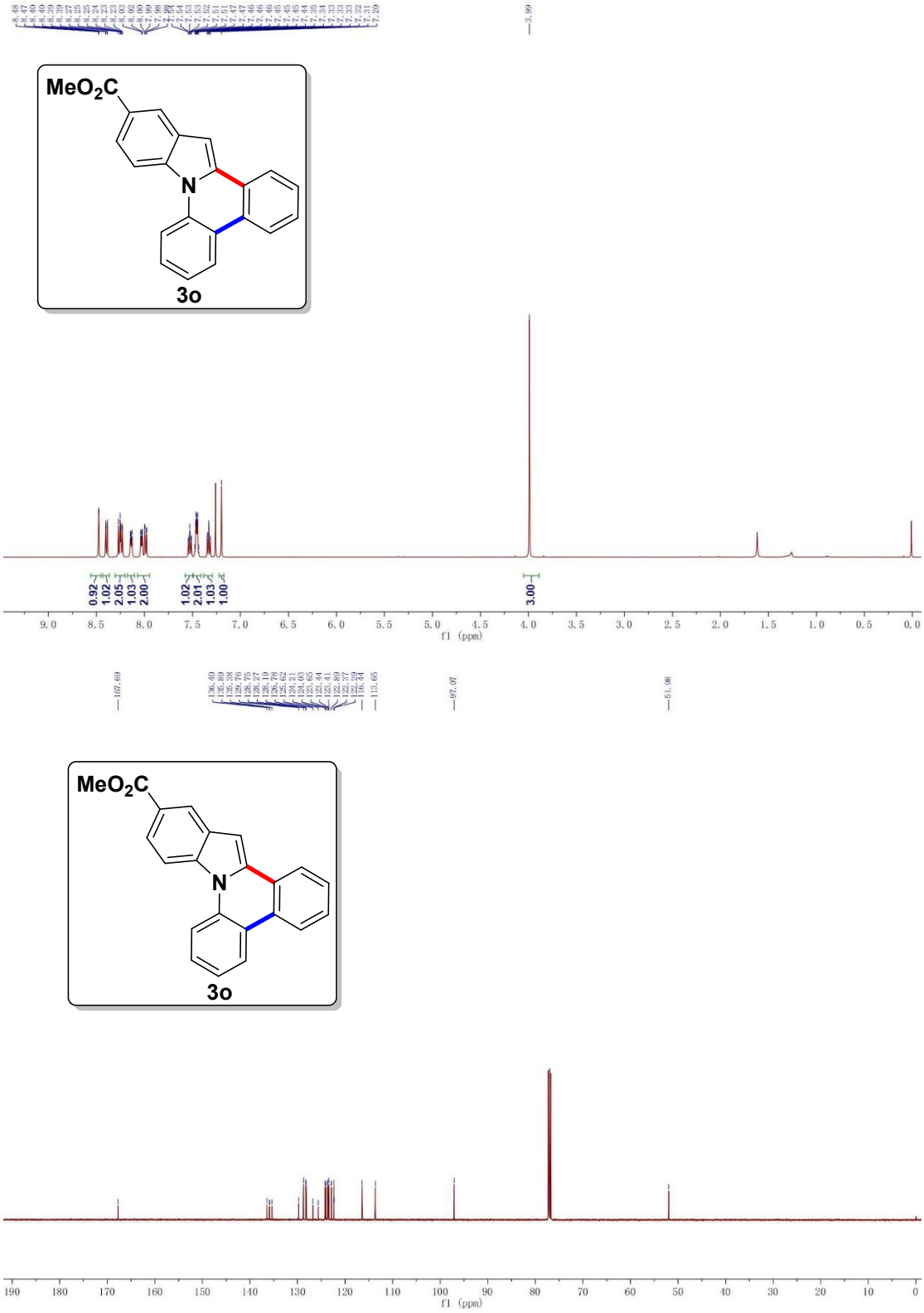




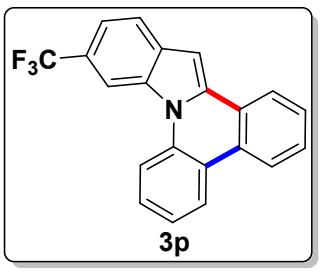


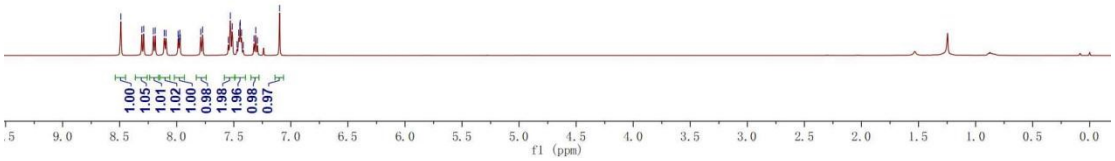


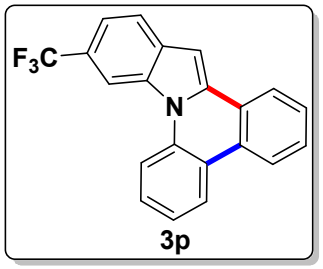
methyl indolo[1,2-f]phenanthridine-12-carboxylate (3o)

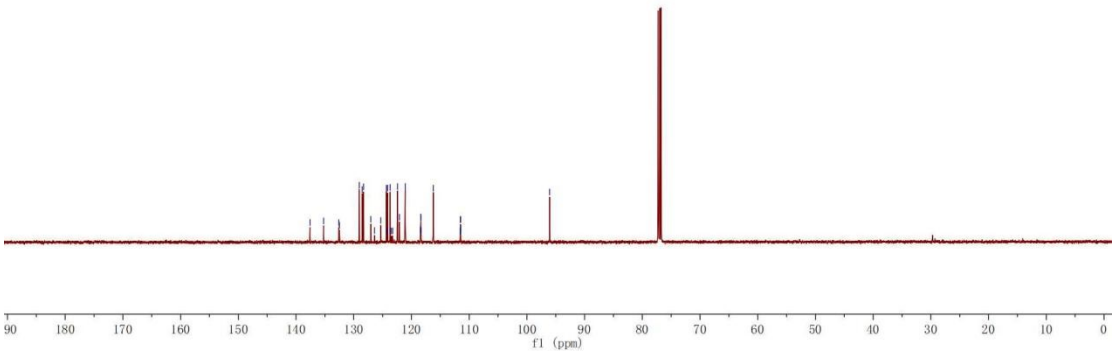


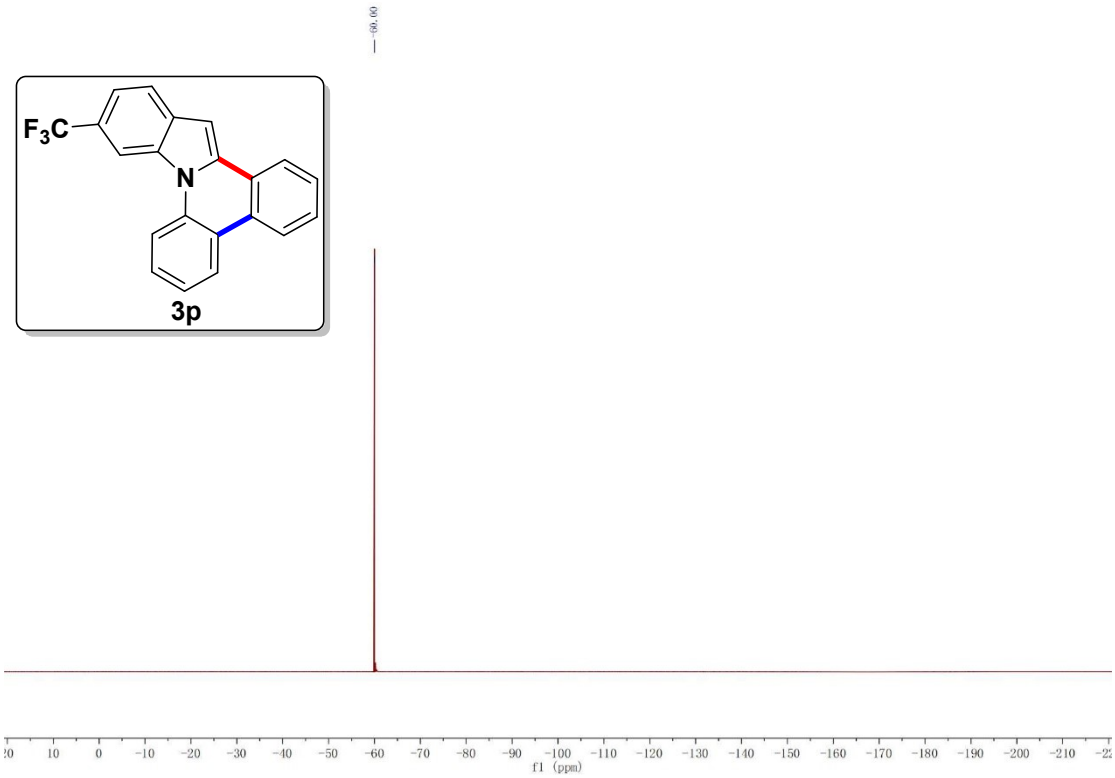
11-(trifluoromethyl)indolo[1,2-f]phenanthridine (3p)



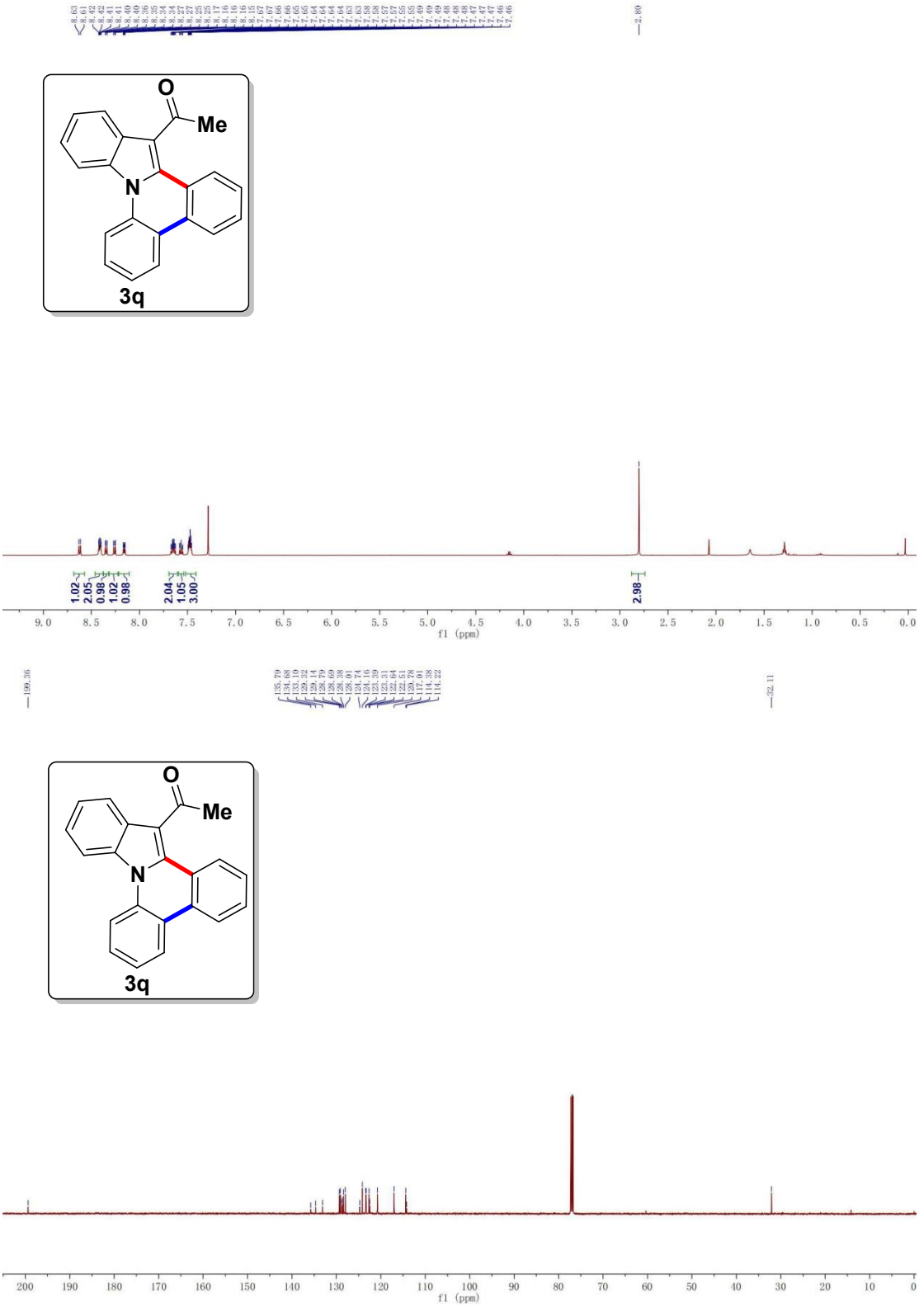




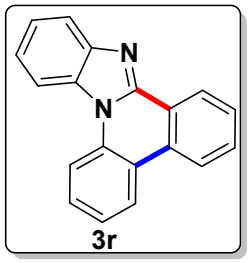


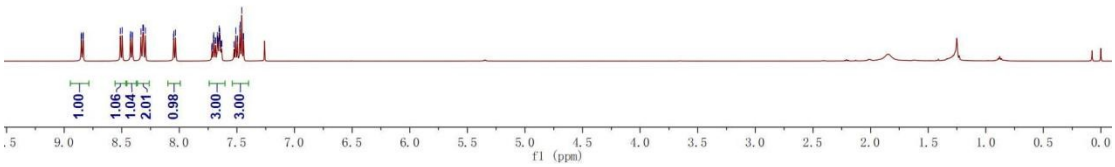

-60.60
F3C
N
3p
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
-210
f1 (ppm)

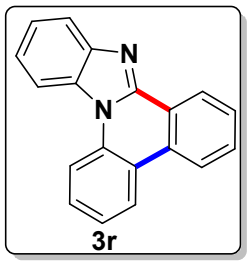
1-(indolo[1,2-f]phenanthridin-14-yl)ethan-1-one (3q)

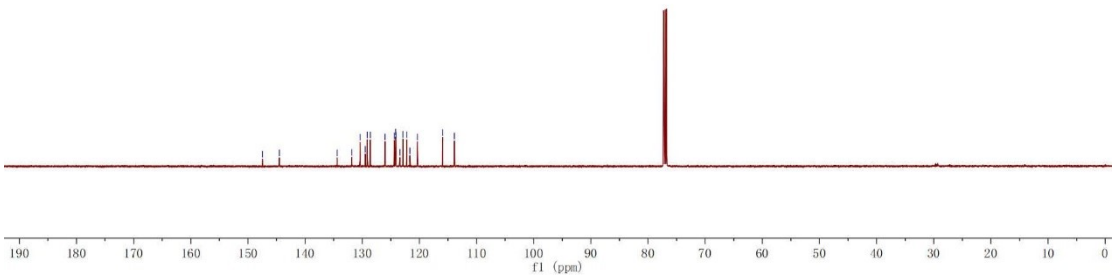


benzo[4,5]imidazo[1,2-f]phenanthridine (3r)

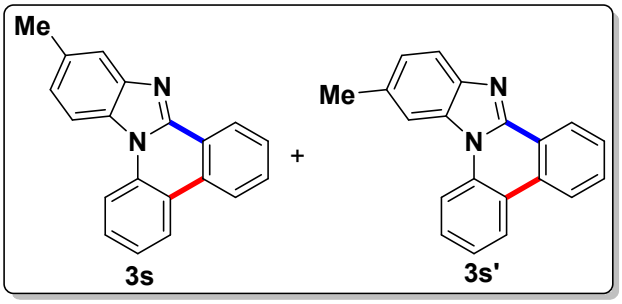


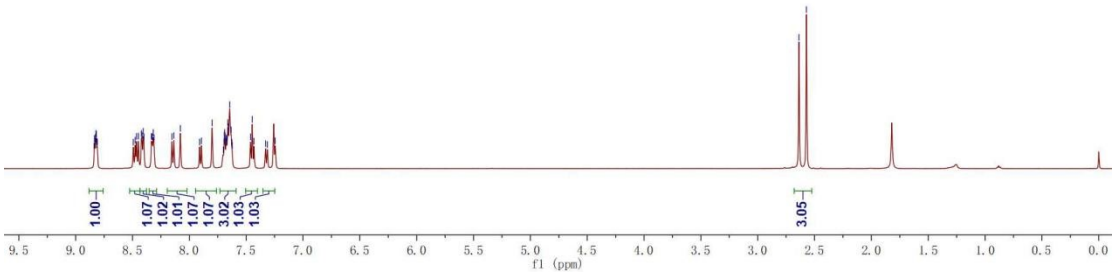


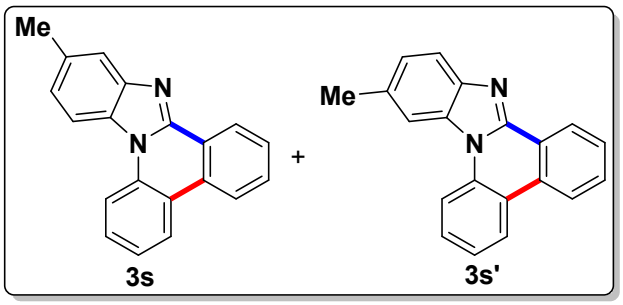


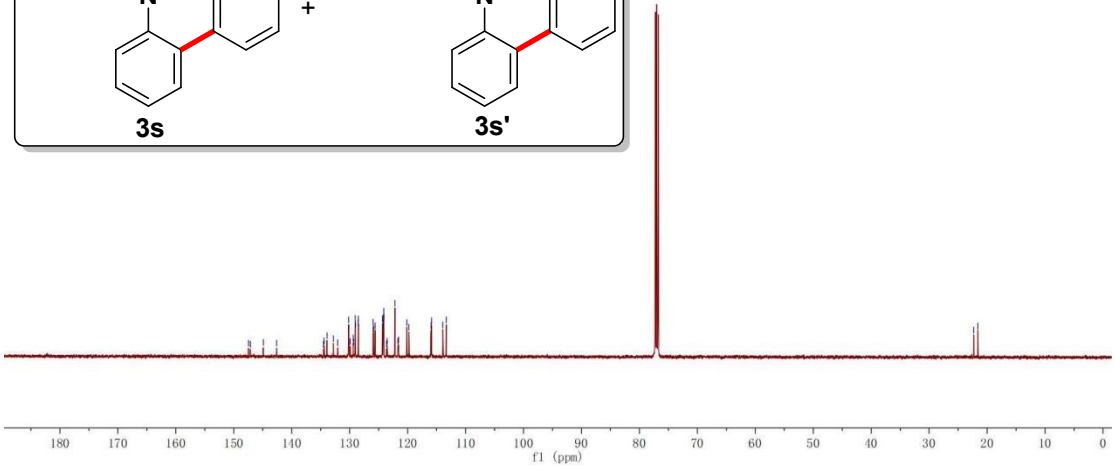


11-methylbenzo[4,5]imidazo[1,2-f]phenanthridine (3s) and 12-methylbenzo[4,5]imidazo[1,2-f]phenanthridine (3s')

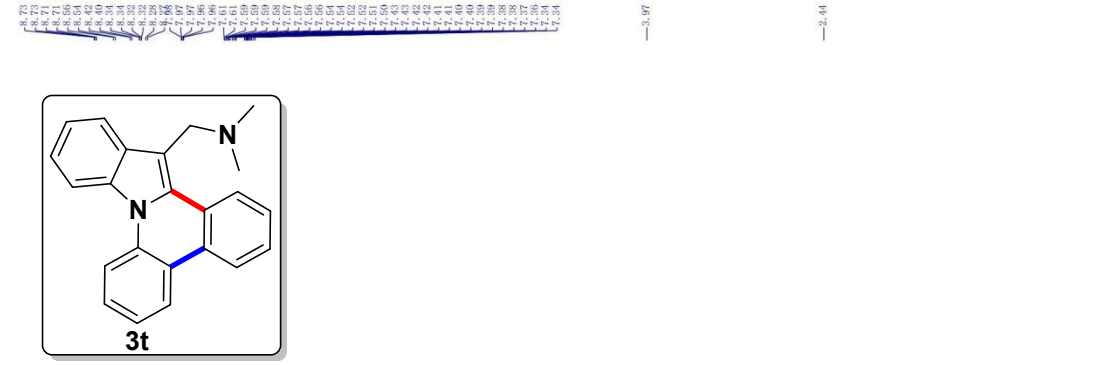


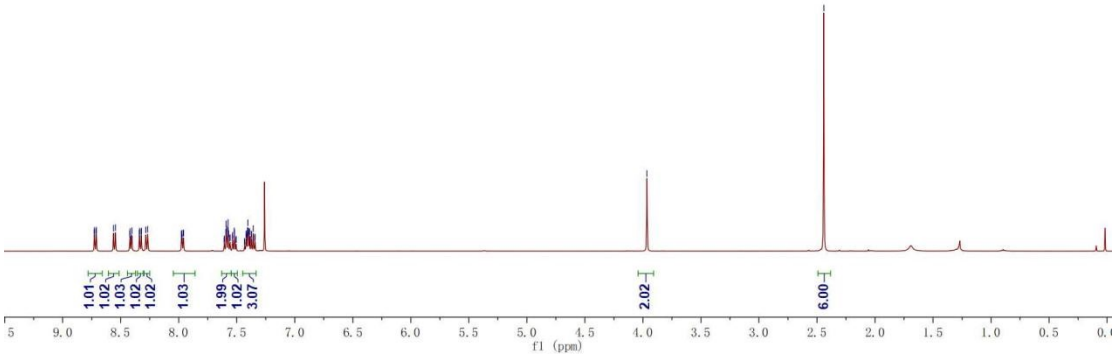


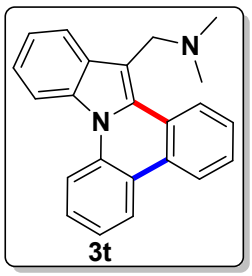


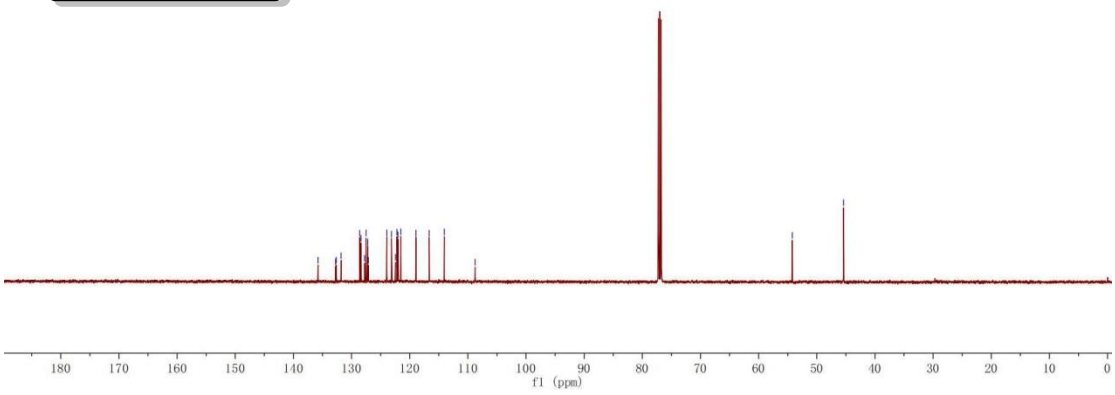


1-(indolo[1,2-f]phenanthridin-14-yl)-N,N-dimethylmethanamine (3t)

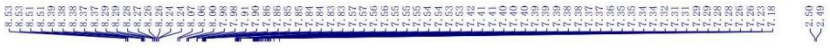


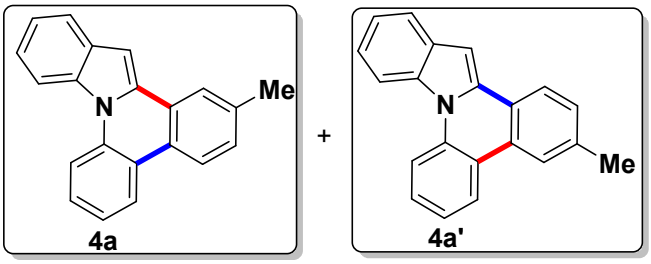


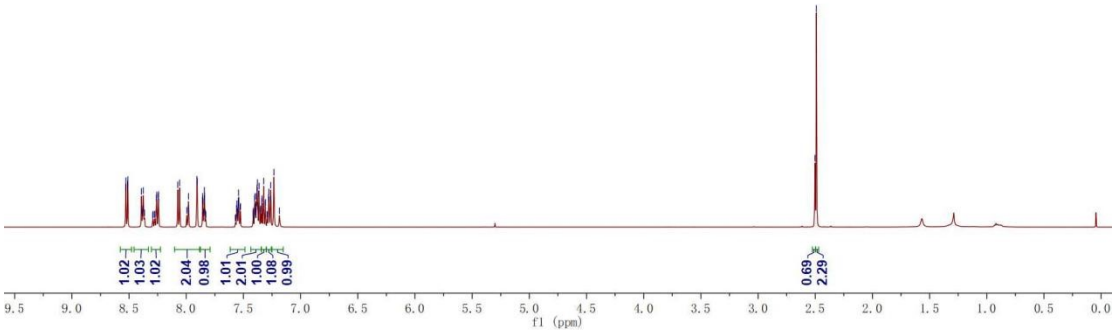


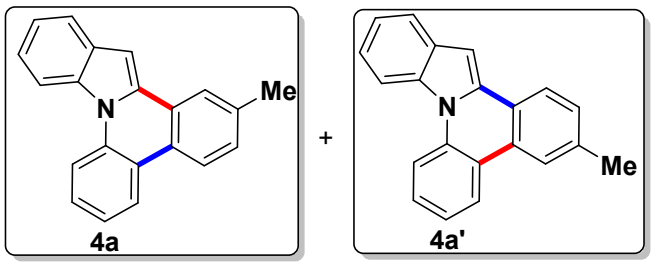


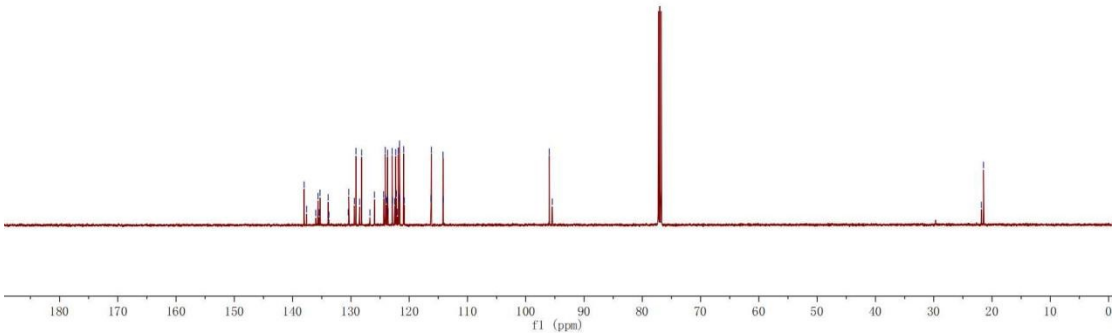
2-methylindolo[1,2-f]phenanthridine (4a) and 3-methylindolo[1,2-f]phenanthridine (4a')



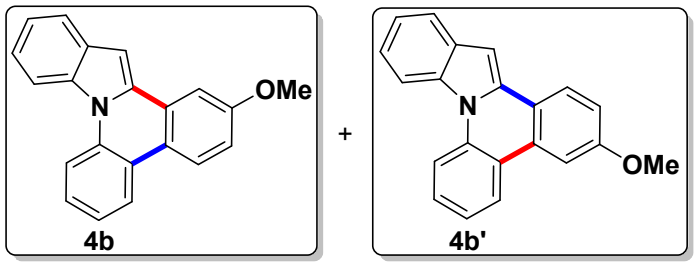


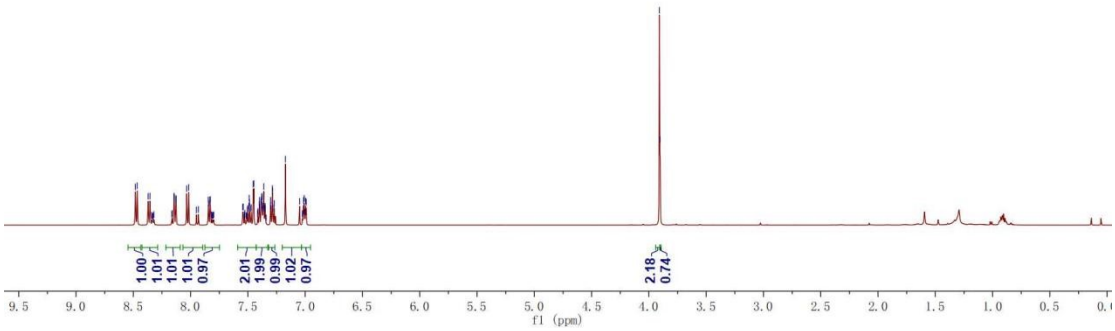


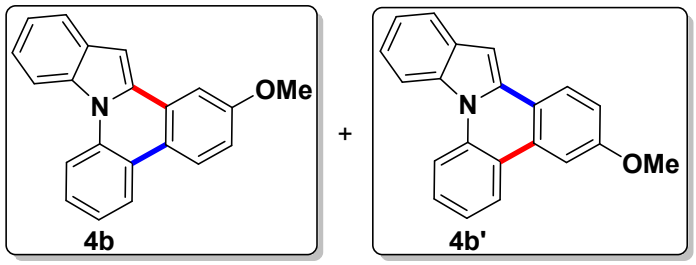


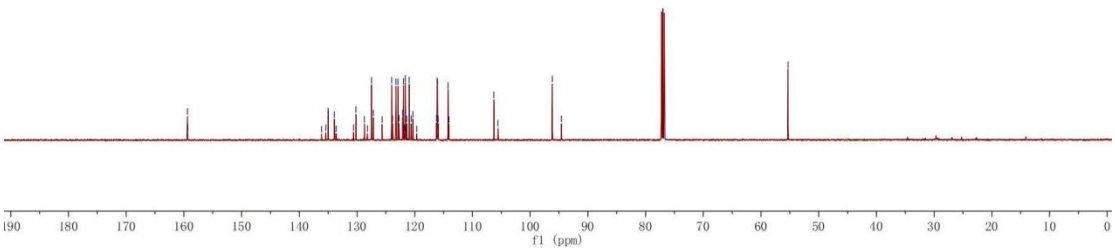


2-methoxyindolo[1,2-f]phenanthridine (4b) and 3-methoxyindolo[1,2-f]phenanthridine (4b')

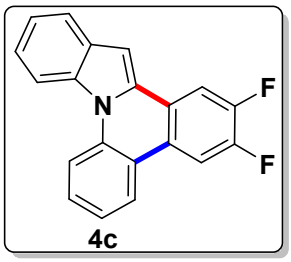


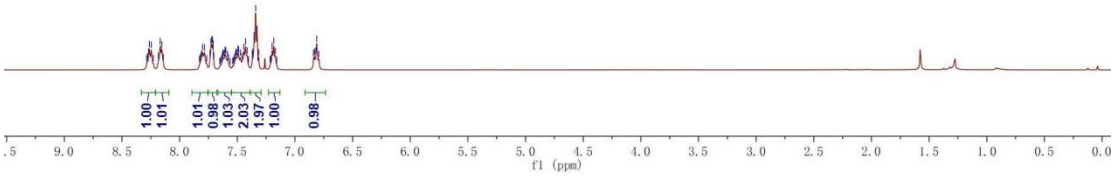


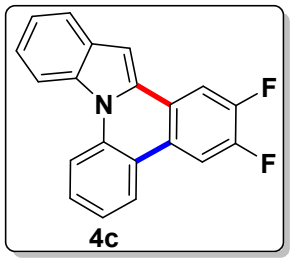


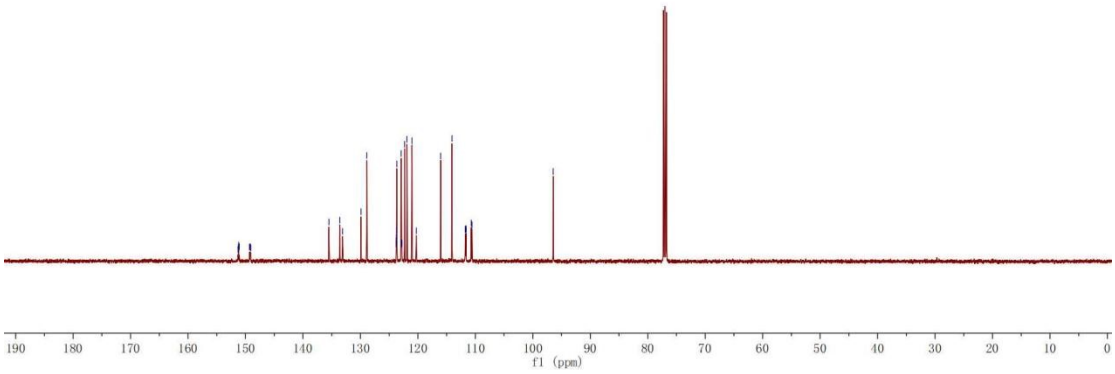


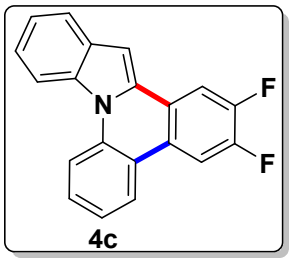
2,3-difluoroindolo[1,2-f]phenanthridine (4c)







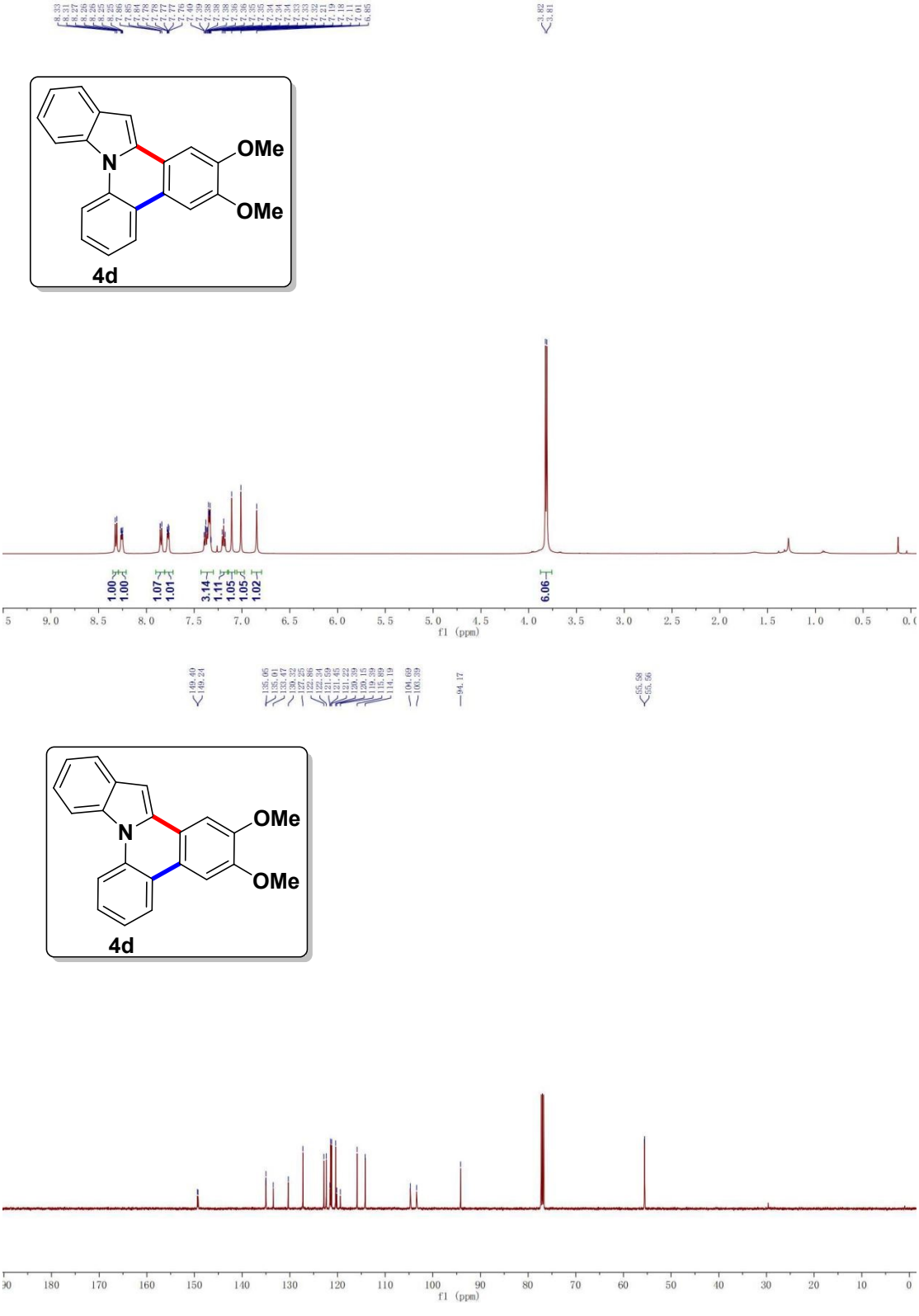



N
F
F

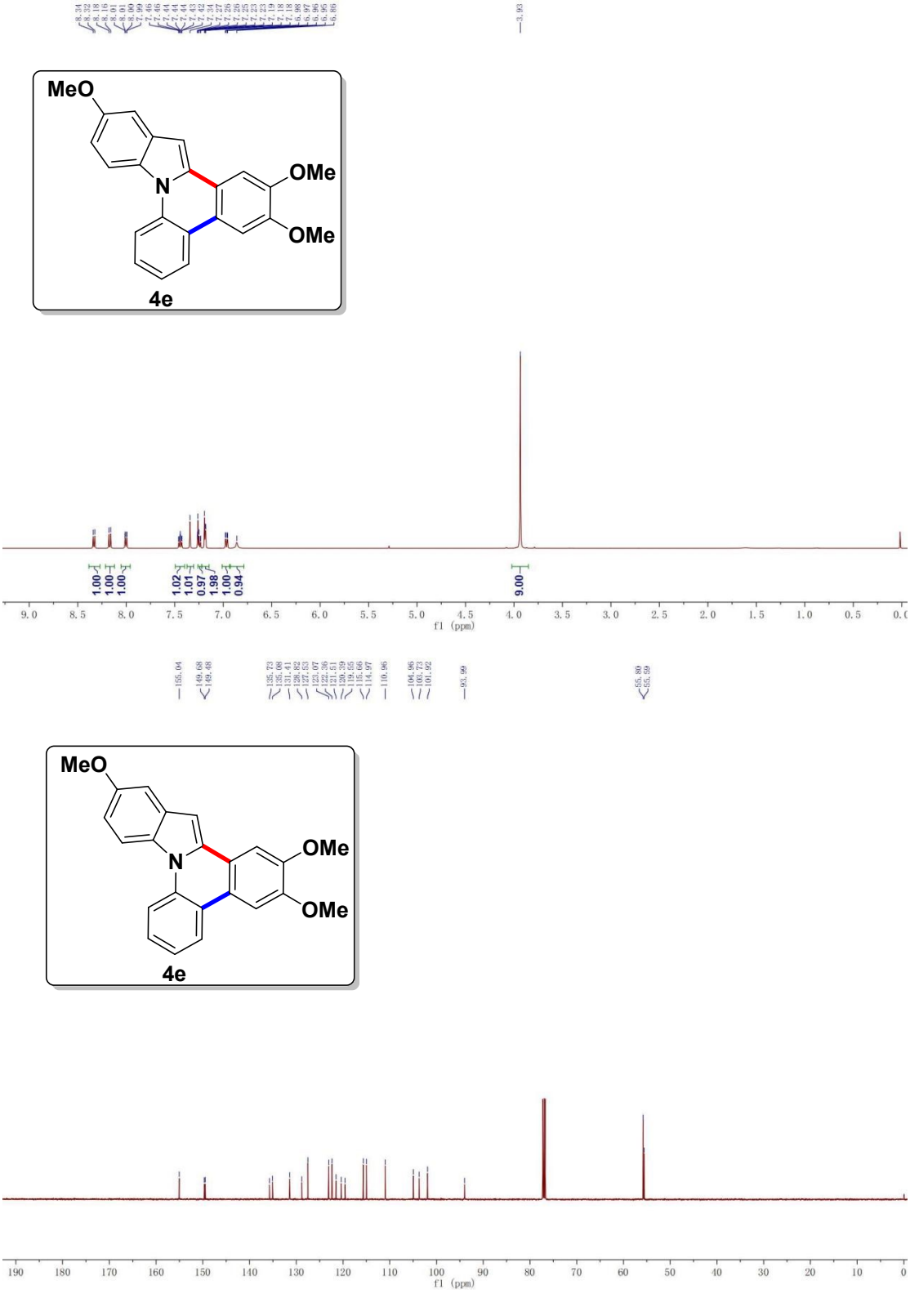
4c

-136.77
-136.82
-136.85
-136.90
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
-210
f1 (ppm)

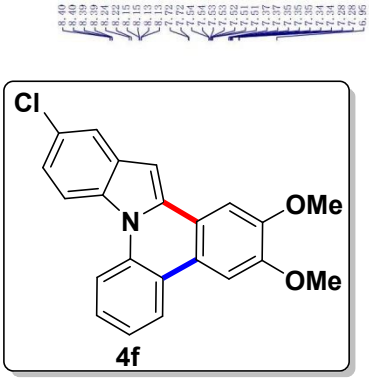
2,3-dimethoxyindolo[1,2-f]phenanthridine (4d)

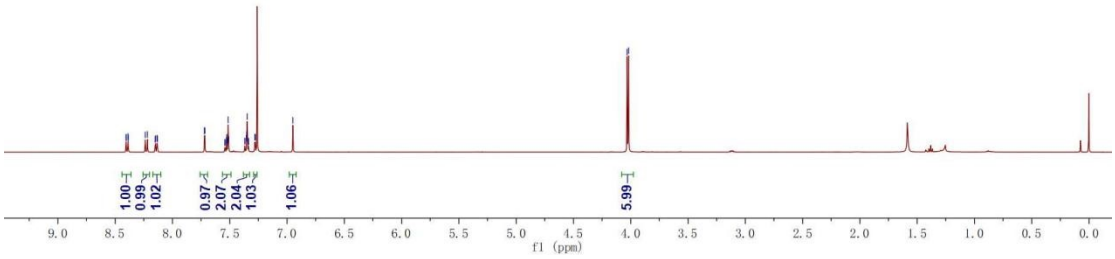


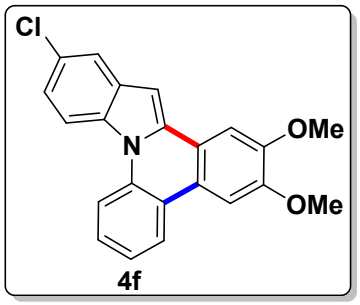
2,3,12-trimethoxyindolo[1,2-f]phenanthridine (4e)

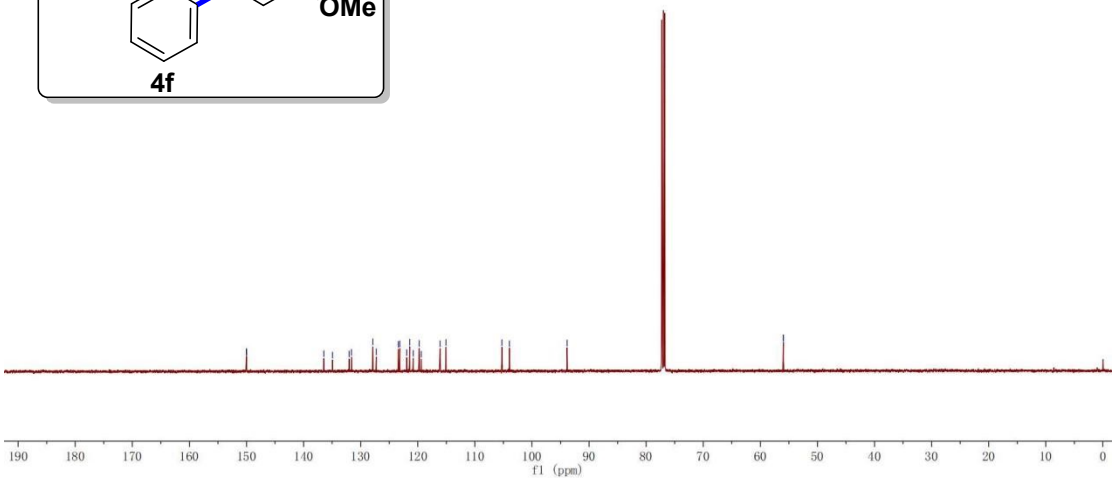


12-chloro-2,3-dimethoxyindolo[1,2-f]phenanthridine (4f)

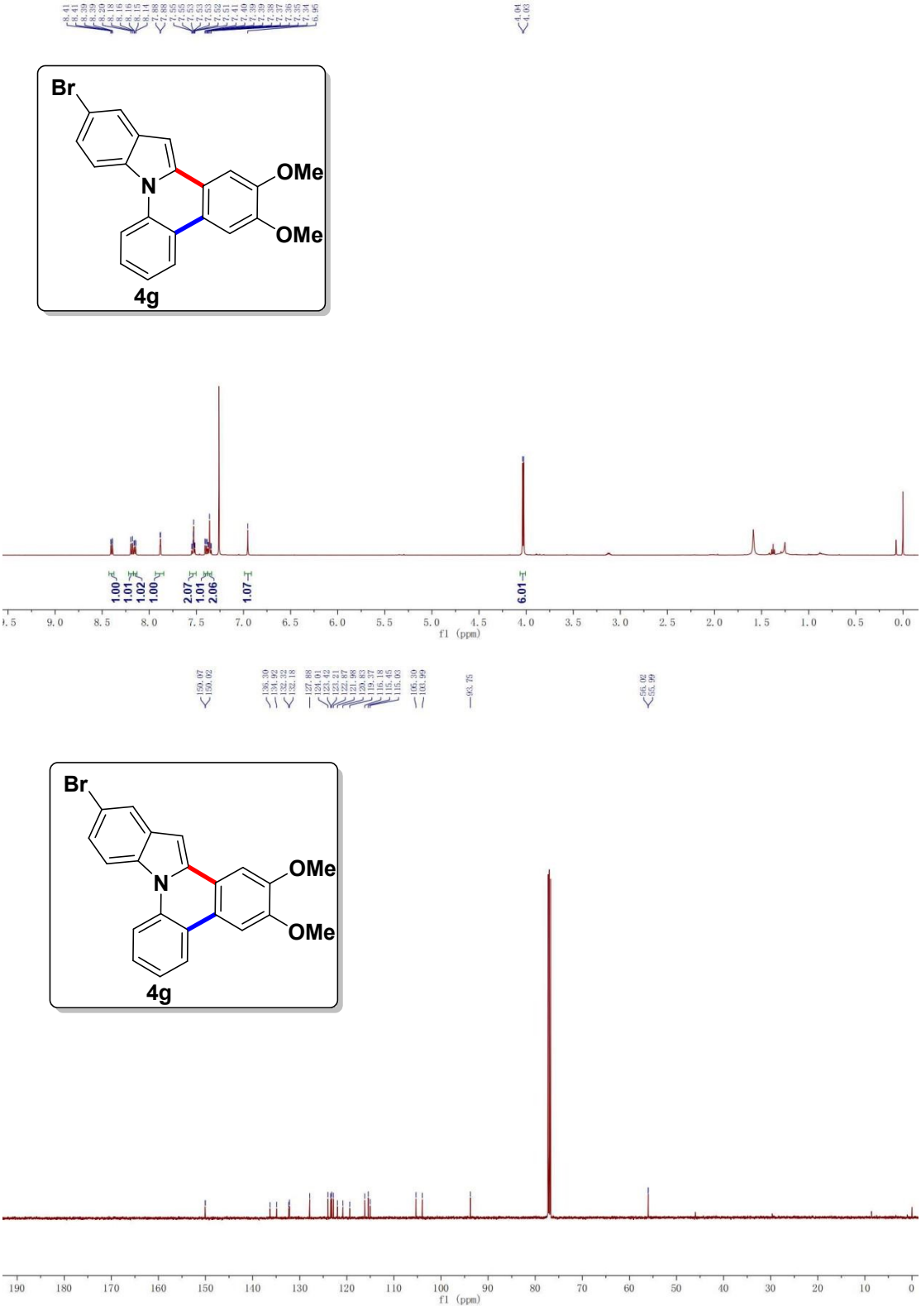




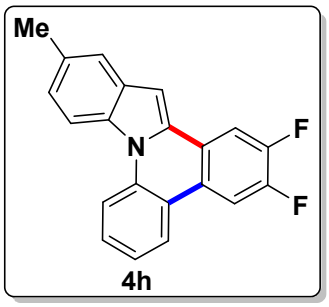


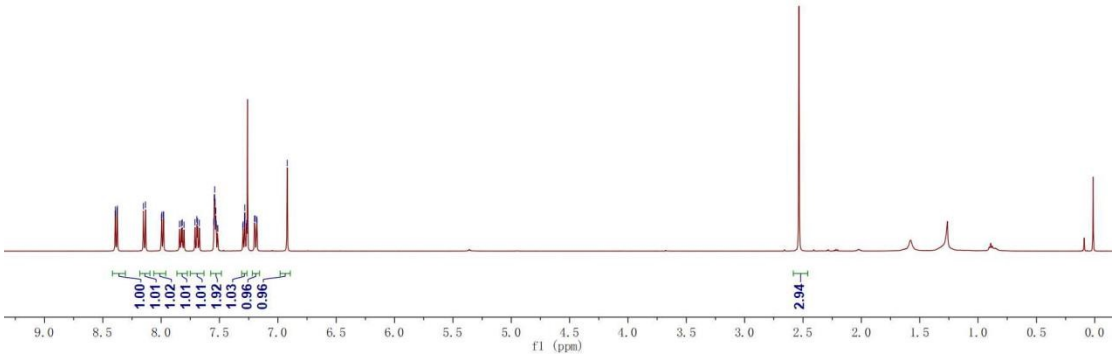


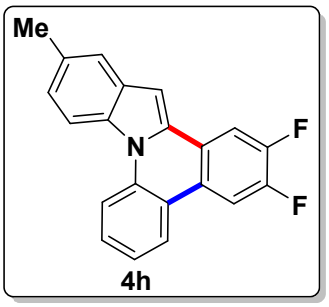
12-bromo-2,3-dimethoxyindolo[1,2-f]phenanthridine (4g)

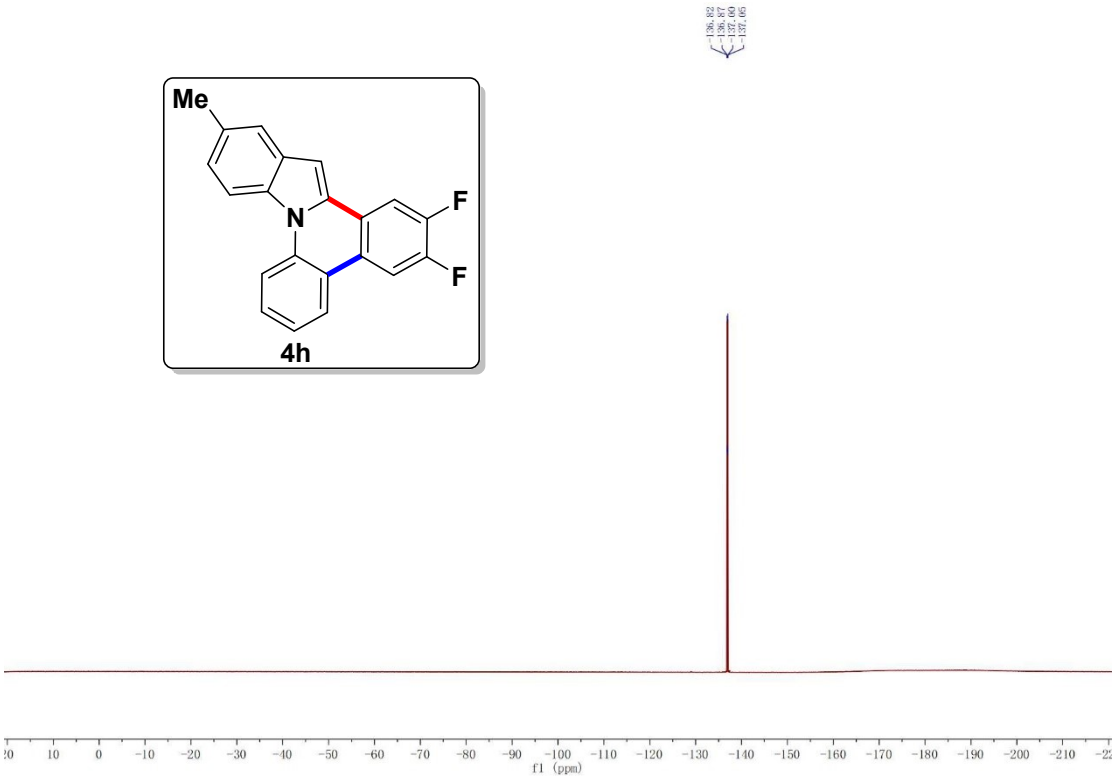


2,3-difluoro-12-methylindolo[1,2-f]phenanthridine (4h)

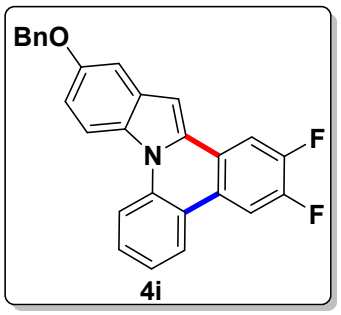


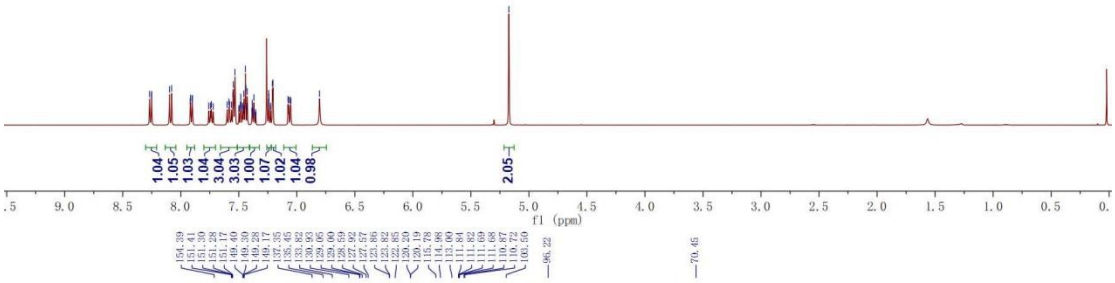


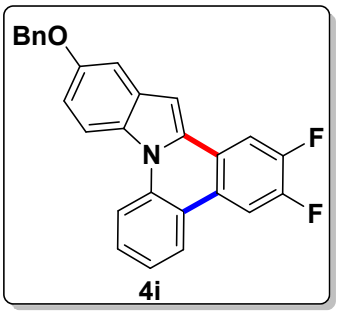


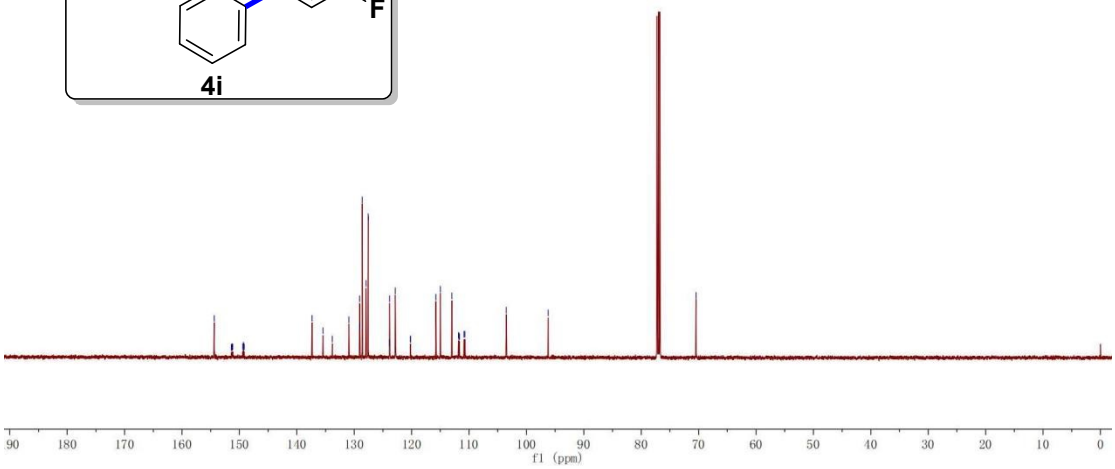

Me
N
F
F
4h
-136.82
-136.87
-137.60
-137.65
f1 (ppm)

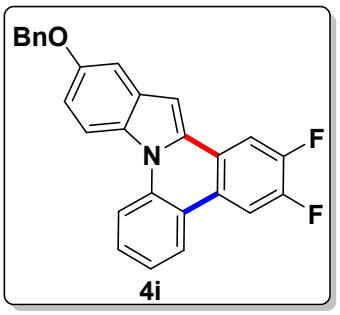
12-(benzyloxy)-2,3-difluoroindolo[1,2-f]phenanthridine (4i)










BnO
N
F
F

4i

-136.75
-136.89
-136.87
-136.91
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
-210
f1 (ppm)

benzo[6,7]naphtho[1',8':3,4,5]azepino[1,2-a]indole (4j)