Supporting Information

I_2-Promoted oxidative annulation of three different amines to access diverse biheteroaryls

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1. General

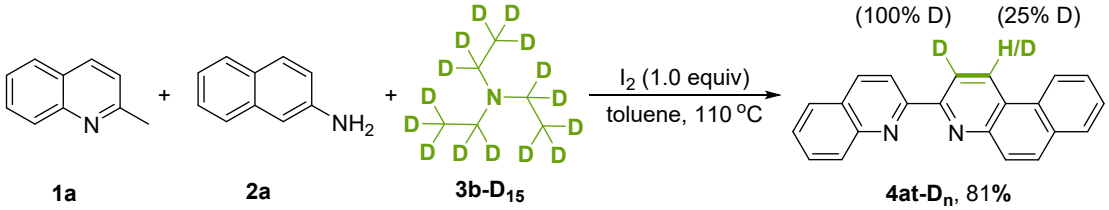
All substrates methylazaarenes (**1**), arylamines (**2**), tertiary alkylamines (**3**) and reagents were commercially available and used without further purification. All methylazaarenes (**1**), arylamines (**2**) and tertiary alkylamines (**3**) are known compounds. TLC analysis was performed using pre-coated glass plates. Column chromatography was performed using silica gel (200–300 mesh). ^{1}H spectra were recorded in $CDCl_3$ on 400 MHz NMR spectrometers and resonances (δ) are given in parts per million relative to tetramethylsilane. Data are reported as follows: chemical shift, multiplicity (s = singlet, d = doublet, t = triplet, m = multiplet), coupling constants (Hz) and integration. ^{13}C spectra were recorded in $CDCl_3$ on 100 MHz NMR spectrometers and resonances (δ) are given in ppm. HRMS analysis of compounds was performed with a time-of-flight mass spectrometer (micrOTOF-Q, Bruker Daltonik, Germany) equipped with an electrospray ionization source. The X-ray crystal-structure determinations of **4an** were obtained on a Bruker SMART APEX CCD system. Melting points were determined using XT-4 apparatus and not corrected. All reactions were heated by a metal sand bath (WATTCAS, LAB-500, https://www.wattcas.com).

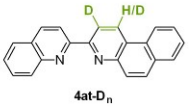
2. General procedure for the synthesis of compounds 4 (4a as an example)

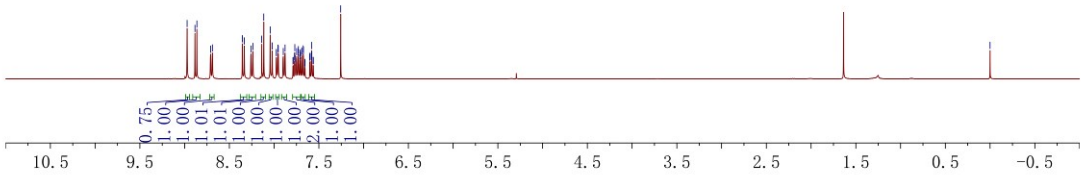
2-Methyl quinoline **1a** (43.0 mg, 0.3 mmol), naphthalen-2-amine **2a** (28.7 mg, 0.2 mmol), tripropylamine **3a** (28.7 mg, 0.2 mmol), I_2 (50.8 mg, 0.2 mmol) and toluene (2.0 mL) were charged into a pressure tube (35 mL) and were stirred at 110 ^{o}C for 20 h. After disappearance of the reactant (monitored by TLC), and added 50 mL water to the mixture, then extracted with EtOAc 3 times (3 × 50 mL). The extract was washed with 10% $Na_2S_2O_3$ solution (w/w), dried over anhydrous Na_2SO_4 and evaporation. The residue was purified by column chromatography on silica gel (petroleum ether/EtOAc = 12:1) to afford the product **4a** as a light yellow solid (54.5 mg, 85% yield).

3. The D-labeling experiments and the spectrogram

2-Methyl quinoline **1a** (43.0 mg, 0.3 mmol), naphthalen-2-amine **2a** (28.7 mg, 0.2 mmol), **3b-D$_{15}$** (23.2 mg, 0.2 mmol), I_2 (50.8 mg, 0.2 mmol) and toluene (2.0 mL) were charged into a pressure tube (35 mL) and were stirred at 110 °C for 20 h. After disappearance of the reactant (monitored by TLC), and added 50 mL water to the mixture, then extracted with EtOAc 3 times (3 × 50 mL). The extract was washed with 10% $Na_2S_2O_3$ solution (w/w), dried over anhydrous Na_2SO_4 and evaporation. The residue was purified by column chromatography on silica gel (petroleum ether/EtOAc = 10:1) to afford the product **4at-D$_n$**. Then, the product was monitored by ^{1}H NMR (400 MHz), the spectral copies of ^{1}H NMR was listed in the following. This result reveals that deuteration grade at the *β*-position and *γ*-position of 3-(quinolin-2-yl)benzo[*f*]quinoline scaffold was 100% and 25%, respectively.

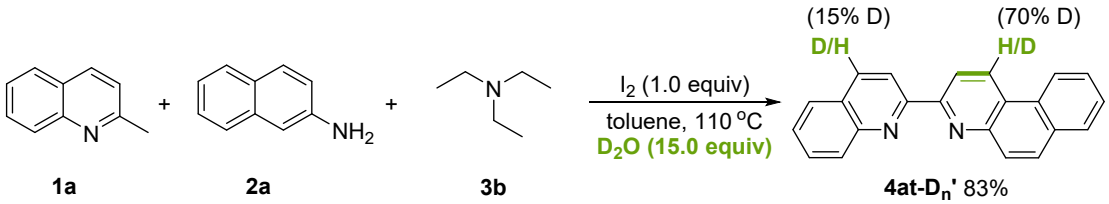


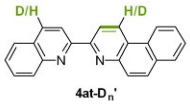


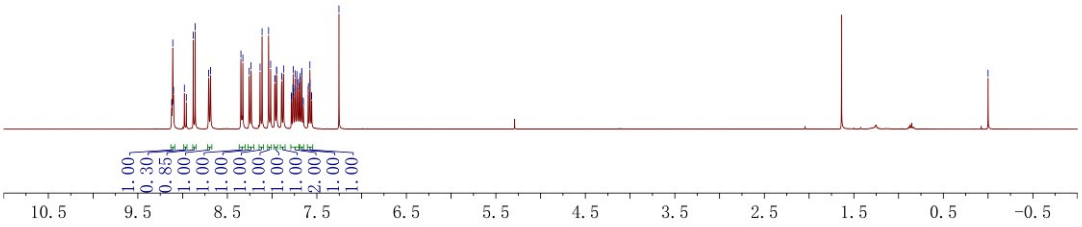


4. The H/D exchange experiment and the spectrogram

2-Methyl quinoline **1a** (43.0 mg, 0.3 mmol), naphthalen-2-amine **2a** (28.7 mg, 0.2 mmol), triethylamine **3b** (20.2 mg, 0.2 mmol), I_2 (50.8 mg, 0.2 mmol), D_2O (60.1 mg, 3.0 mmol) and toluene (2.0 mL) were charged into a pressure tube (35 mL) and were stirred at 110 °C for 20 h. After disappearance of the reactant (monitored by TLC), and added 50 mL water to the mixture, then extracted with EtOAc 3 times (3 × 50 mL). The extract was washed with 10% $Na_2S_2O_3$ solution (w/w), dried over anhydrous Na_2SO_4 and evaporation. The residue was purified by column chromatography on silica gel (petroleum ether/EtOAc = 10:1) to afford the product **4at-D$_n$'**. Then, the product was monitored by ^{1}H NMR (400 MHz), the spectral copies of ^{1}H NMR was listed in the following. NMR analysis of the isolated product revealed that significant H/D exchange was detected at the γ-selective deuteration reactions of two pyridine rings.







5. Experimental details

(1) The scale-up synthesis (**4a** as an example)

2-Methyl quinoline **1a** (214.8 mg, 1.5 mmol), naphthalen-2-amine **2a** (143.2 mg, 1.0 mmol), tripropylamine **3a** (143.3 mg, 1.0 mmol), I_2 (253.8 mg, 1.0 mmol) and toluene (10.0 mL) were charged into a pressure tube (150 mL) and were stirred at 110 °C for 20 h. After disappearance of the reactant (monitored by TLC), and added 50 mL water to the mixture, then extracted with EtOAc 3 times (3 × 50 mL). The extract was washed with 10% $Na_2S_2O_3$ solution (w/w), dried over anhydrous Na_2SO_4 and evaporation. The residue was purified by column chromatography on silica gel (petroleum ether/EtOAc = 12:1) to afford the product **4a** as a light yellow solid (249.9 mg, 78% yield).

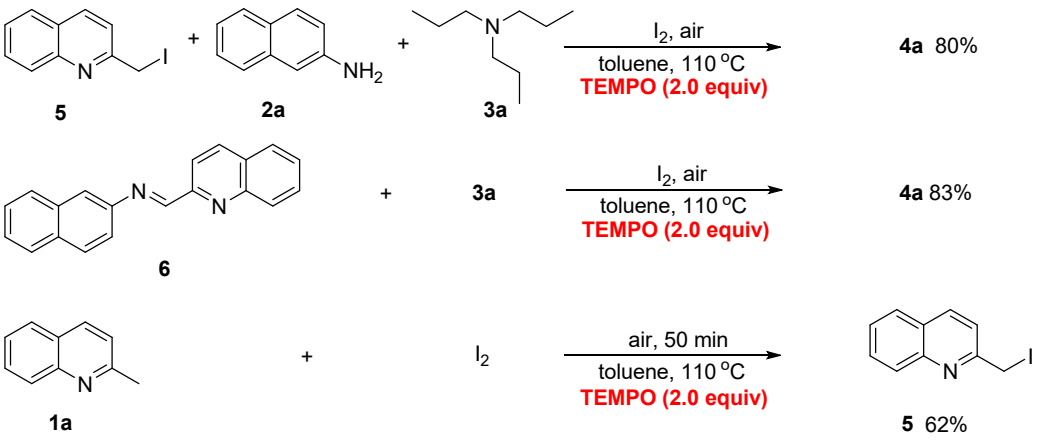
(2) Experimental procedure for the synthesis of compound **6**

A round bottom flask equipped with stir bar was charged with quinoline-2-carbaldehyde (377.2 mg, 2.4 mmol), naphthalen-2-amine (286.4 mg, 2.0 mmol) and anhydrous DCM (5.0 mL), followed by addition of anhydrous $MgSO_4$ (1820.0 mg, 15.1 mmol). The mixture was stirred at room temperature overnight. After filtration of $MgSO_4$, the filtrate was concentrated under reduced pressure, and the crude product was purified by column chromatography to obtain the corresponding imines **6**.[1]

(3) Experimental procedure for the synthesis of compound **7**

Phenylacetaldehyde (600.8 mg, 5.0 mmol, commercial sources) was charged into a 50 mL RB flask containing 35.0 mL THF at room temperature. Diethylamine (731.4 mg,10.0 mmol), $MgSO_4$ (9g, 74.8 mmol) were added sequentially, and the reaction was stirred at room tempture for 24 h. The solution was diluted with EtOAc (50 mL), filtration, then concentrated in vacuo to give the product **7**.[2]

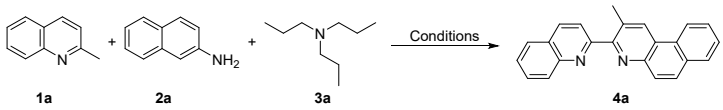
(4) Radical inhibition experiments



Scheme S1

When adding TEMPO in the reaction of 2-(iodomethyl)quinoline (**5**) with naphthalen-2-amine (**2a**) and tripropylamine (**3a**), the yield of **4a** was obtained in 80%; Also, adding TEMPO in the reaction of imine (**6**) and **3a** under the standard conditions did not inhibit the production of **4a**; Ultimately, the iodination reaction of **1a** went smoothly with TEMPO. These results ruled out the possibility of a free-radical pathway in this reaction.

6. Optimization of the reaction conditions[a]

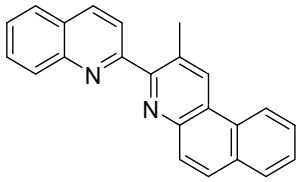


1a 2a 3a 4a

entry	[I]	oxidant	acid	solvent	temp .(°C)	yield (%)[b]
1	I_2	—	—	toluene	110	85
2	KI	—	—	toluene	110	0
3	TBAI	—	—	toluene	110	25
4	NIS	—	—	toluene	110	37
5	NH_4I	—	—	toluene	110	52
6	—	—	—	toluene	110	0
7	I_2	CHP	—	toluene	110	26
8	I_2	TBHP	—	toluene	110	35
9	I_2	TBPB	—	toluene	110	40
10	I_2	DCP	—	toluene	110	47
11	I_2	$K_2S_2O_8$	—	toluene	110	53
12	I_2	DMSO	—	toluene	110	66
13	I_2	DTBP	—	toluene	110	70
14	I_2	—	CF_3SO_3H	toluene	110	55
15	I_2	—	CH_3SO_3H	toluene	110	71
16	I_2	—	CH_3COOH	toluene	110	77
17	I_2	—	PhCOOH	toluene	110	79
18	I_2	—	—	*o*-DCB	110	63
19	I_2	—	—	PhCl	110	74
20	I_2	—	—	*o*-Xylene	110	81
21	I_2	—	—	DCE	110	18
22	I_2	—	—	THF	110	23
23	I_2	—	—	DMSO	110	27
24	I_2	—	—	CH_3CN	110	33
25	I_2	—	—	DMF	110	37
26	I_2	—	—	NMP	110	43
27	I_2	—	—	toluene	120	71
28	I_2	—	—	toluene	100	78
29	I_2	—	—	toluene	80	62
30	I_2	Ar	—	toluene	110	45
31	I_2	O_2	—	toluene	110	87
32[c]	I_2	—	—	toluene	110	50
33[d]	I_2	—	—	toluene	110	86
34[e]	I_2	—	—	toluene	110	64
35[f]	I_2	—	—	toluene	110	77
36[g]	I_2	—	—	toluene	110	45

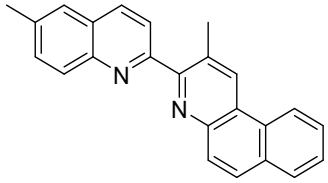
[a]Reaction conditions: **1a** (0.3 mmol), **2a** (0.2 mmol), **3a** (0.2 mmol), [I] (0.2 mmol), oxidant (0.6 mmol), acid (0.2 mmol), solvent (2.0 mL) in the 35 mL sealed tube at 110 °C for 20 h. [b]Isolated yields. [c]**3a** (0.4 mmol). [d]**1a** (0.4 mmol). [e]**1a** (0.2 mmol). [f]I_2 (0.3 mmol). [g]I_2 (0.1 mmol).

7. Characterization data for compounds



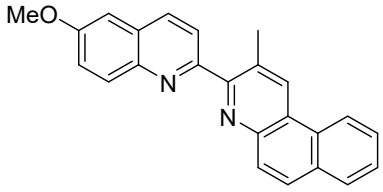
2-methyl-3-(quinolin-2-yl)benzo[*f*]quinoline (4a):

Yield 85% (54.5 mg; petroleum ether/EtOAc = 12:1); light yellow solid; mp 174–176 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 8.90 (s, 1H), 8.70 (d, J = 8.0 Hz, 1H), 8.36 (d, J = 8.8 Hz, 1H), 8.21 (d, J = 8.4 Hz, 1H), 8.17 (d, J = 8.4 Hz, 1H), 8.06 (d, J = 9.2 Hz, 1H), 7.98–7.94 (m, 2H), 7.91 (d, J = 8.0 Hz, 1H), 7.77–7.75 (m, 1H), 7.75–7.70 (m, 1H), 7.69–7.64 (m, 1H), 7.61 (t, J = 7.6 Hz, 1H), 2.88 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 158.8, 156.6, 147.3, 146.1, 136.6, 133.2, 132.0, 130.8, 130.1, 129.7, 129.6, 129.2, 128.7, 128.2, 127.6, 127.4, 127.3, 126.9, 126.8, 125.1, 122.9, 122.2, 21.1; HRMS (ESI): m/z $[M + H]^+$ calcd for $C_{23}H_{17}N_2$: 321.1386; found: 321.1390.



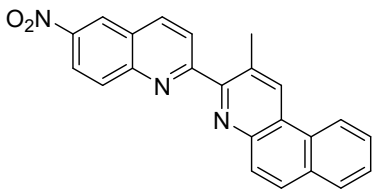
2-methyl-3-(6-methylquinolin-2-yl)benzo[*f*]quinoline (4b):

Yield 80% (53.5 mg; petroleum ether/EtOAc = 12:1); white solid; mp 179–181 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 8.86 (s, 1H), 8.67 (d, J = 8.0 Hz, 1H), 8.24 (d, J = 8.8 Hz, 1H), 8.13–8.07 (m, 2H), 8.05 (d, J = 9.2 Hz, 1H), 7.96–7.91 (m, 2H), 7.72–7.67 (m, 1H), 7.67–7.62 (m, 2H), 7.58 (dd, J = 8.4, 2.0 Hz, 1H), 2.85 (s, 3H), 2.57 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 157.9, 156.7, 146.0, 145.9, 136.8, 135.9, 133.1, 132.0, 131.8, 130.8, 130.0, 129.4, 129.2, 128.7, 128.2, 127.4, 127.2, 126.9, 126.4, 125.0, 122.8, 122.1, 21.6, 21.0; HRMS (ESI): m/z $[M + H]^+$ calcd for $C_{24}H_{19}N_2$: 335.1543; found: 335.1549.



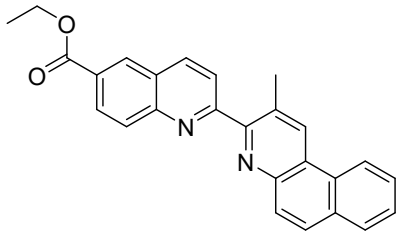
3-(6-methoxyquinolin-2-yl)-2-methylbenzo[*f*]quinoline (4c):

Yield 83% (58.2 mg; petroleum ether/EtOAc = 12:1); white solid; mp 181–183 °C; ^{1}H NMR (400 MHz, $CDCl_3$): 8.86 (s, 1H), 8.67 (d, J = 8.0 Hz, 1H), 8.22 (d, J = 8.4 Hz, 1H), 8.12 (d, J = 8.4 Hz, 1H), 8.09 (d, J = 9.2 Hz, 1H), 8.05 (d, J = 9.2 Hz, 1H), 7.96–7.91 (m, 2H), 7.72–7.67 (m, 1H), 7.67–7.61 (m, 1H), 7.41 (dd, J = 9.2, 2.8 Hz, 1H), 7.15 (d, J = 2.4 Hz, 1H), 3.96 (s, 3H), 2.86 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 158.1, 156.7, 156.4, 146.0, 143.4, 135.3, 133.1, 131.9, 131.1, 130.7, 130.0, 129.2, 128.6, 128.4, 128.1, 127.2, 126.9, 124.9, 122.8, 122.4, 122.3, 105.0, 55.5, 21.1; HRMS (ESI): m/z $[M + H]^+$ calcd for $C_{24}H_{19}N_2O$: 351.1492; found: 351.1496.



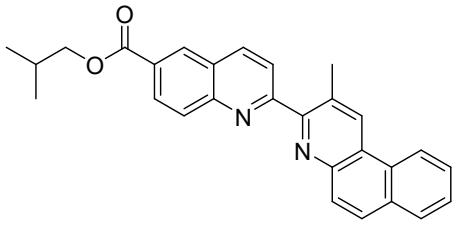
2-methyl-3-(6-nitroquinolin-2-yl)benzo[*f*]quinoline (4d):

Yield 71% (51.9 mg; petroleum ether/EtOAc = 10:1); white solid; mp 237–239 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 8.92 (s, 1H), 8.87 (d, J = 2.4 Hz, 1H), 8.70 (d, J = 8.0 Hz, 1H), 8.54–8.51 (m, 1H), 8.50 (s, 1H), 8.46 (d, J = 8.8 Hz, 1H), 8.31 (d, J = 9.2 Hz, 1H), 8.04 (d, J = 9.2 Hz, 1H), 7.99 (s, 1H), 7.97–7.94 (m, 1H), 7.77–7.71 (m, 1H), 7.69 (td, J = 7.6, 1.2 Hz, 1H), 2.95 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 162.2, 154.9, 149.3, 146.2, 145.6, 138.1, 133.6, 132.2, 131.4, 131.1, 130.5, 129.0, 128.8, 128.0, 127.6, 127.1, 126.2, 125.4, 124.4, 124.2, 123.0, 21.4. HRMS (ESI): m/z [M + H]$^+$ calcd for $C_{23}H_{16}N_3O_2$: 366.1237; found: 366.1244.



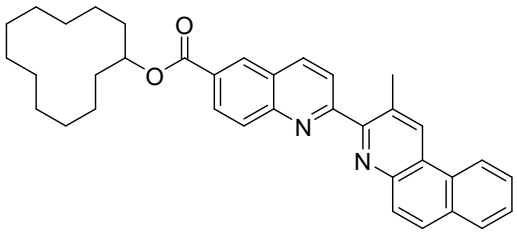
ethyl 2-(2-methylbenzo[*f*]quinolin-3-yl)quinoline-6-carboxylate (4e):

Yield 82% (64.4 mg; petroleum ether/EtOAc = 15:1); white solid; mp 193–195 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 8.88 (s, 1H), 8.68 (d, J = 8.0 Hz, 1H), 8.66 (d, J = 2.0 Hz, 1H), 8.43 (d, J = 8.4 Hz, 1H), 8.35 (dd, J = 8.8, 2.0 Hz, 1H), 8.28 (d, J = 8.8 Hz, 1H), 8.22 (d, J = 8.8 Hz, 1H), 8.04 (d, J = 9.2 Hz, 1H), 7.97–7.92 (m, 2H), 7.74–7.69 (m, 1H), 7.69–7.64 (m, 1H), 4.48 (q, J = 7.2 Hz, 2H), 2.90 (s, 3H), 1.48 (t, J = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 166.2, 160.8, 155.8, 149.1, 146.1, 137.8, 133.3, 132.1, 130.9, 130.6, 130.3, 129.9, 129.1(0), 129.0(8), 128.7, 128.6, 128.1, 127.4, 127.0, 126.5, 125.2, 123.0, 122.9, 61.4, 21.2, 14.4; HRMS (ESI): m/z [M + H]$^+$ calcd for $C_{26}H_{21}N_2O_2$: 393.1598; found: 393.1603.



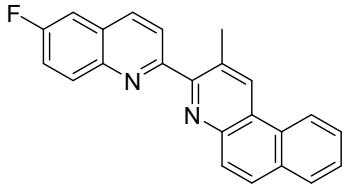
isobutyl 2-(2-methylbenzo[*f*]quinolin-3-yl)quinoline-6-carboxylate (4f):

Yield 88% (74.0 mg; petroleum ether/EtOAc = 15:1); white solid; mp 146–148 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 8.88 (s, 1H), 8.71–8.64 (m, 2H), 8.44 (d, J = 8.4 Hz, 1H), 8.36 (dd, J = 8.8, 2.0 Hz, 1H), 8.28 (d, J = 8.8 Hz, 1H), 8.23 (d, J = 8.8 Hz, 1H), 8.04 (d, J = 9.2 Hz, 1H), 7.98–7.91 (m, 2H), 7.75–7.69 (m, 1H), 7.69–7.63 (m, 1H), 4.21 (d, J = 6.8 Hz, 2H), 2.90 (s, 3H), 2.22–2.12 (m, 1H), 1.09 (d, J = 6.8 Hz, 6H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 166.3, 160.8, 155.9, 149.2, 146.2, 137.8, 133.4, 132.1, 131.0, 130.6, 130.3, 130.0, 129.2, 129.1, 128.8, 128.7, 128.1, 127.5, 127.0, 126.6, 125.3, 123.0(2), 122.9(8), 71.5, 28.0, 21.2, 19.3; HRMS (ESI): m/z [M + H]$^+$ calcd for $C_{28}H_{25}N_2O_2$: 421.1911; found: 421.1903.



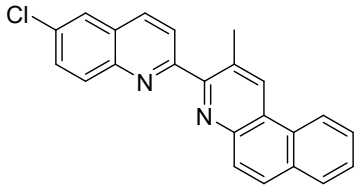
cyclododecyl 2-(2-methylbenzo[*f*]quinolin-3-yl)quinoline-6-carboxylate (4g):

Yield 81% (86.0 mg; petroleum ether/EtOAc = 8:1); light yellow solid; mp 170–172 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 8.89 (s, 1H), 8.69 (d, J = 8.0 Hz, 1H), 8.64 (d, J = 1.6 Hz, 1H), 8.44 (d, J = 8.4 Hz, 1H), 8.35 (dd, J = 8.8, 1.6 Hz, 1H), 8.28 (d, J = 8.8 Hz, 1H), 8.22 (d, J = 8.8 Hz, 1H), 8.05 (d, J = 9.2 Hz, 1H), 7.98–7.93 (m, 2H), 7.75–7.69 (m, 1H), 7.69–7.64 (m, 1H), 5.39–5.32 (m, 1H), 2.90 (s, 3H), 1.96–1.86 (m, 2H), 1.77–1.70 (m, 2H), 1.56–1.45 (m, 8H), 1.44–1.33 (m, 10H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 165.8, 160.7, 155.9, 149.1, 146.1, 137.8, 133.3, 132.0, 130.9, 130.5, 130.3, 129.8, 129.2, 129.1, 129.0, 128.7, 128.1, 127.4, 127.0, 126.5, 125.2, 122.9(2), 122.8(9), 73.5, 29.1, 24.2, 24.0, 23.3, 23.1, 21.2, 20.9; HRMS (ESI): m/z $[M + H]^+$ calcd for $C_{36}H_{39}N_2O_2$: 531.3006; found: 531.3002.



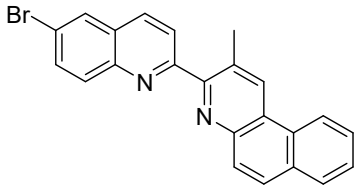
3-(6-fluoroquinolin-2-yl)-2-methylbenzo[*f*]quinoline (4h):

Yield 80% (54.1 mg; petroleum ether/EtOAc = 20:1); white solid; mp 212–214 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 8.88 (s, 1H), 8.69 (d, J = 8.0 Hz, 1H), 8.29 (d, J = 8.8 Hz, 1H), 8.23–8.16 (m, 2H), 8.04 (d, J = 9.2 Hz, 1H), 7.98–7.93 (m, 2H), 7.74–7.69 (m, 1H), 7.69–7.63 (m, 1H), 7.56–7.49 (m, 2H), 2.88 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 161.9, 159.5, 158.1(9), 158.1(6), 156.1, 146.1, 144.4, 136.0, 135.9, 133.2, 132.2, 132.1, 132.0, 130.8, 130.2, 129.2, 128.7, 128.1, 128.0, 127.3, 127.0, 125.1, 122.9(2), 122.8(9), 119.9, 119.6, 110.7, 110.5, 21.1; HRMS (ESI): m/z $[M + H]^+$ calcd for $C_{23}H_{16}FN_2$: 339.1292; found: 339.1299.



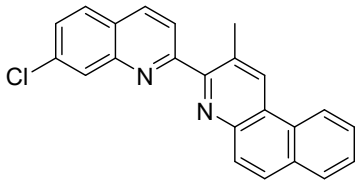
3-(6-chloroquinolin-2-yl)-2-methylbenzo[*f*]quinoline (4i):

Yield 82% (58.2 mg; petroleum ether/EtOAc = 20:1); white solid; mp 229–231 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 8.90 (s, 1H), 8.69 (d, J = 8.4 Hz, 1H), 8.28–8.21 (m, 2H), 8.13 (d, J = 8.8 Hz, 1H), 8.04 (d, J = 9.2 Hz, 1H), 7.99–7.93 (m, 2H), 7.89 (d, J = 2.0 Hz, 1H), 7.75–7.65 (m, 3H), 2.88 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 159.0, 156.0, 146.1, 145.7, 135.7, 133.3, 132.6, 132.0, 131.3, 130.8, 130.5, 130.3, 129.1, 128.7, 128.1, 128.0, 127.4, 127.0, 126.3, 125.2, 123.1, 122.9, 21.1; HRMS (ESI): m/z $[M + H]^+$ calcd for $C_{23}H_{16}ClN_2$: 355.0997; found: 355.0999.



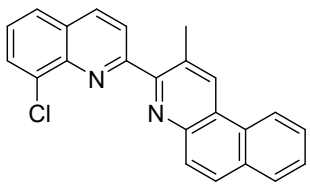
3-(6-bromoquinolin-2-yl)-2-methylbenzo[*f*]quinoline (4j):

Yield 78% (62.3 mg; petroleum ether/EtOAc = 20:1); white solid; mp 216–218 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 8.90 (s, 1H), 8.70 (d, J = 8.0 Hz, 1H), 8.28–8.21 (m, 2H), 8.08–8.02 (m, 3H), 7.99–7.94 (m, 2H), 7.85–7.81 (m, 1H), 7.75–7.70 (m, 1H), 7.70–7.65 (m, 1H), 2.89 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 159.2, 156.0, 146.1, 145.9, 135.6, 133.3, 133.0, 132.0, 131.4, 130.8, 130.3, 129.6, 129.1, 128.7, 128.5, 128.1, 127.4, 127.0, 125.2, 123.1, 122.9, 120.8, 21.1; HRMS (ESI): m/z $[M + H]^+$ calcd for $C_{23}H_{16}BrN_2$: 399.0491; found: 399.0485.



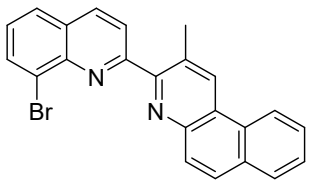
3-(7-chloroquinolin-2-yl)-2-methylbenzo[*f*]quinoline (4k):

Yield 82% (58.2 mg; petroleum ether/EtOAc = 20:1); white solid; mp 209–211 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 8.88 (s, 1H), 8.69 (d, J = 8.0 Hz, 1H), 8.32 (d, J = 8.8 Hz, 1H), 8.26–8.16 (m, 2H), 8.04 (d, J = 8.8 Hz, 1H), 7.98–7.92 (m, 2H), 7.83 (d, J = 8.8 Hz, 1H), 7.74–7.64 (m, 2H), 7.58–7.51 (m, 1H), 2.88 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 159.7, 155.9, 147.6, 146.1, 136.4, 135.4, 133.3, 132.0, 130.9, 130.2, 129.1, 128.8, 128.7(1), 128.6(6), 128.0, 127.9, 127.4, 127.0, 125.8, 125.2, 122.9, 122.4, 21.2; HRMS (ESI): m/z $[M + H]^+$ calcd for $C_{23}H_{16}ClN_2$: 355.0997; found: 355.0999.



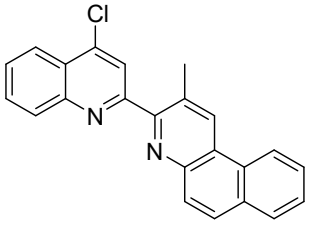
3-(8-chloroquinolin-2-yl)-2-methylbenzo[*f*]quinoline (4l):

Yield 80% (56.8 mg; petroleum ether/EtOAc = 20:1); white solid; mp 219–221 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 8.89 (s, 1H), 8.70 (d, J = 8.4 Hz, 1H), 8.55 (d, J = 8.8 Hz, 1H), 8.35 (d, J = 8.4 Hz, 1H), 8.05 (d, J = 8.8 Hz, 1H), 7.98–7.91 (m, 2H), 7.90–7.85 (m, 1H), 7.83–7.78 (m, 1H), 7.74–7.64 (m, 2H), 7.52–7.46 (m, 1H), 3.13 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 159.1, 155.0, 146.0, 143.4, 136.9, 134.2, 133.7, 132.1, 131.9, 130.1, 129.5, 129.2, 128.8, 128.7, 128.1, 127.4, 127.0, 126.7, 126.6, 125.2, 123.0(0), 122.9(7), 22.3; HRMS (ESI): m/z $[M + H]^+$ calcd for $C_{23}H_{16}ClN_2$: 355.0997; found:355.0995.



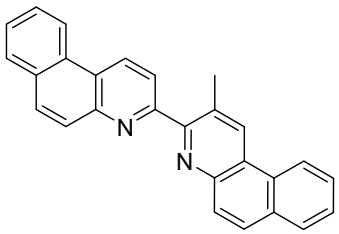
3-(8-bromoquinolin-2-yl)-2-methylbenzo[*f*]quinoline (4m):

Yield 78% (62.3 mg; petroleum ether/EtOAc = 30:1); white solid; mp 225–227 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 8.91 (s, 1H), 8.71 (d, J = 8.0 Hz, 1H), 8.57 (d, J = 8.4 Hz, 1H), 8.34 (d, J = 8.4 Hz, 1H), 8.10 (d, J = 7.2 Hz, 1H), 8.06 (d, J = 8.4 Hz, 1H), 8.01–7.92 (m, 2H), 7.86 (d, J = 7.6 Hz, 1H), 7.75–7.64 (m, 2H), 7.44 (t, J = 7.6 Hz, 1H), 3.18 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 159.3, 154.9, 146.0, 144.3, 137.0, 133.7, 133.1, 132.1, 132.0, 130.1, 129.2, 128.8, 128.7, 128.1, 127.4(1), 127.3(9), 127.2, 127.0, 125.6, 125.2, 123.0, 22.7; HRMS (ESI): m/z $[M + H]^+$ calcd for $C_{23}H_{16}BrN_2$: 399.0491; found: 399.0497.



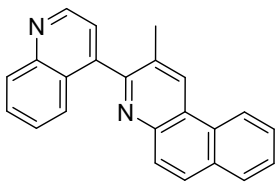
3-(4-chloroquinolin-2-yl)-2-methylbenzo[*f*]quinoline (4n):

Yield 43% (30.5 mg; petroleum ether/EtOAc = 30:1); white solid; mp 189–191 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 8.91 (s, 1H), 8.71 (d, J = 8.0 Hz, 1H), 8.38 (s, 1H), 8.33 (dd, J = 8.4, 0.8 Hz, 1H), 8.22 (d, J = 8.4 Hz, 1H), 8.06 (d, J = 9.2 Hz, 1H), 8.00–7.94 (m, 2H), 7.85–7.80 (m, 1H), 7.76–7.72 (m, 1H), 7.72–7.70 (m, 1H), 7.70–7.65 (m, 1H), 2.93 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 158.6, 155.1, 148.1, 146.1, 143.0, 133.5, 132.1, 131.0, 130.4(2), 130.3(6), 130.0, 129.1, 128.8, 128.0, 127.8, 127.5, 127.0, 125.7, 125.3, 124.0, 123.0, 122.3, 21.2; HRMS (ESI): m/z $[M + H]^+$ calcd for $C_{23}H_{16}ClN_2$: 355.0997; found: 355.1006.



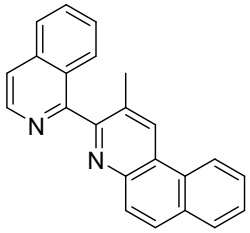
2-methyl-3,3'-bibenzo[*f*]quinoline (4o):

Yield 85% (63.0 mg; petroleum ether/EtOAc = 10:1); white solid; mp 245–247 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 9.15 (d, J = 8.8 Hz, 1H), 8.91 (s, 1H), 8.75–8.68 (m, 2H), 8.34 (d, J = 8.8 Hz, 1H), 8.12–8.02 (m, 3H), 8.00–7.93 (m, 3H), 7.77–7.65 (m, 4H), 2.91 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 158.4, 156.5, 147.2, 146.2, 133.2, 132.0(1), 131.9(5), 131.4, 131.0, 130.8, 130.2, 129.6, 129.2, 128.7(3), 128.7(2), 128.5, 128.2, 127.4, 127.3, 127.1, 126.9, 125.1, 124.6, 122.9(1), 122.8(8), 122.3, 21.2; HRMS (ESI): m/z $[M + H]^+$ calcd for $C_{27}H_{19}N_2$: 371.1543; found: 371.1538.



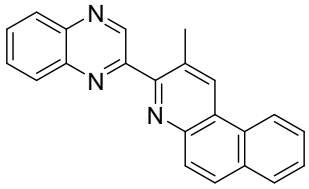
2-methyl-3-(quinolin-4-yl)benzo[*f*]quinoline (4p):

Yield 88% (56.4 mg; petroleum ether/EtOAc = 5:1); white solid; mp 212–214 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 9.06 (d, J = 4.4 Hz, 1H), 8.89 (s, 1H), 8.68 (d, J = 8.0 Hz, 1H), 8.23 (d, J = 8.8 Hz, 1H), 8.03–7.96 (m, 2H), 7.96–7.93 (m, 1H), 7.75–7.70 (m, 2H), 7.69–7.65 (m, 1H), 7.49–7.42 (m, 3H), 2.31 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 156.3, 150.1, 148.5, 146.6, 146.1, 131.9, 131.8, 130.6, 129.8, 129.5, 129.0, 128.7, 127.8, 127.4, 127.1, 127.0, 126.4, 125.4, 125.0, 122.6, 120.9, 19.6; HRMS (ESI): m/z $[M + H]^+$ calcd for $C_{23}H_{17}N_2$: 321.1386; found: 321.1376.



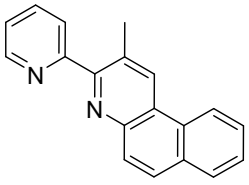
3-(isoquinolin-1-yl)-2-methylbenzo[*f*]quinoline (4q):

Yield 83% (53.2 mg; petroleum ether/EtOAc = 8:1); white solid; mp 98–100 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 8.92 (s, 1H), 8.68 (d, J = 6.0 Hz, 2H), 8.04 (d, J = 8.8 Hz, 1H), 7.97–7.91 (m, 2H), 7.91–7.87 (m, 1H), 7.75 (d, J = 5.6 Hz, 1H), 7.72–7.63 (m, 4H), 7.49–7.44 (m, 1H), 2.40 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 159.0, 157.0, 145.8, 142.0, 136.7, 132.2, 131.9, 130.5, 130.23(X2), 129.1, 128.6, 128.0, 127.5, 127.2, 127.0, 126.9(0), 126.8(9), 126.8, 125.1, 122.7, 120.8, 19.4; HRMS (ESI): m/z $[M + H]^+$ calcd for $C_{23}H_{17}N_2$: 321.1386; found: 321.1390.



2-methyl-3-(quinoxalin-2-yl)benzo[*f*]quinoline (4r):

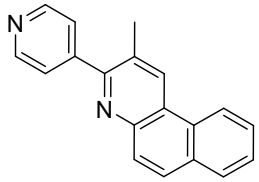
Yield 70% (45.0 mg; petroleum ether/EtOAc = 8:1); white solid; mp 174–176 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 9.73 (s, 1H), 8.89 (s, 1H), 8.69 (d, J = 8.0 Hz, 1H), 8.23–8.16 (m, 2H), 8.07 (d, J = 8.8 Hz, 1H), 8.00–7.94 (m, 2H), 7.85–7.79 (m, 2H), 7.75–7.70 (m, 1H), 7.70–7.65 (m, 1H), 2.95 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 153.4, 153.1, 146.6, 146.2, 141.5, 141.0, 133.5, 132.2, 131.5, 130.5, 130.1(4), 130.0(6), 129.6, 129.2, 129.0, 128.8, 128.0, 127.6, 127.1, 125.3, 123.0, 21.2; HRMS (ESI): m/z $[M + H]^+$ calcd for $C_{22}H_{16}N_3$: 322.1339; found: 322.1338.



2-methyl-3-(pyridin-2-yl)benzo[*f*]quinoline (4s):

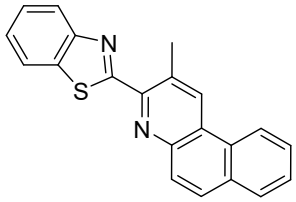
Yield 85% (46.0 mg; petroleum ether/EtOAc = 5:1); brownish-yellow solid; mp 124–126 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 8.79 (s, 1H), 8.74 (d, J = 4.4 Hz, 1H), 8.62 (d, J = 8.0 Hz, 1H), 8.01 (d, J = 9.2 Hz, 1H), 7.94 (d, J = 7.6 Hz, 1H), 7.93–7.88 (m, 2H), 7.88–7.83 (m, 1H), 7.69–7.64 (m, 1H), 7.64–7.59 (m, 1H), 7.33 (ddd, J = 7.6, 4.8, 1.2 Hz, 1H), 2.72 (s, 3H);

^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 158.9, 156.7, 148.5, 145.9, 136.7, 132.9, 131.8, 130.2, 130.0, 129.1, 128.6, 128.0, 127.2, 126.8, 124.9, 124.4, 122.8, 122.7, 20.6; HRMS (ESI): m/z $[M + H]^+$ calcd for $C_{19}H_{15}N_2$: 271.1230; found: 271.1222.



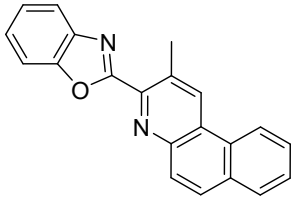
2-methyl-3-(pyridin-4-yl)benzo[*f*]quinoline (4t):

Yield 87% (47.0 mg; petroleum ether/EtOAc = 2:1); white solid; mp 190–192 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 8.82 (s, 1H), 8.77 (dd, J = 4.4, 1.6 Hz, 2H), 8.63 (d, J = 8.4 Hz, 1H), 8.01–7.94 (m, 2H), 7.94–7.91 (m, 1H), 7.73–7.68 (m, 1H), 7.68–7.64 (m, 1H), 7.59 (dd, J = 4.4, 1.6 Hz, 2H), 2.59 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 156.3, 149.9, 148.2, 146.3, 132.7, 131.9, 130.6, 129.0, 128.72(X2), 127.8, 127.4, 127.1, 124.9, 123.8, 122.7, 20.5; HRMS (ESI): m/z $[M + H]^+$ calcd for $C_{19}H_{15}N_2$: 271.1230; found: 271.1236.



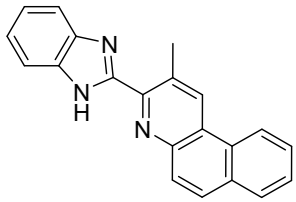
2-(2-methylbenzo[*f*]quinolin-3-yl)benzo[*d*]thiazole (4u):

Yield 74% (48.3 mg; petroleum ether/EtOAc = 50:1); white solid; mp 183–185 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 8.84 (s, 1H), 8.65 (d, J = 8.0 Hz, 1H), 8.13 (d, J = 8.0 Hz, 1H), 8.02 (d, J = 9.2 Hz, 1H), 7.99 (d, J = 8.0 Hz, 1H), 7.97–7.90 (m, 2H), 7.73–7.64 (m, 2H), 7.53–7.48 (m, 1H), 7.46–7.40 (m, 1H), 3.17 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 171.1, 154.9, 149.0, 145.9, 136.2, 133.7, 132.2, 130.8, 130.6, 129.0, 128.8, 127.7(4), 127.7(0), 127.1, 125.8, 125.7, 125.6, 124.0, 123.0, 121.6, 21.9; HRMS (ESI): m/z $[M + H]^+$ calcd for $C_{21}H_{15}N_2S$: 327.0950; found: 327.0944.



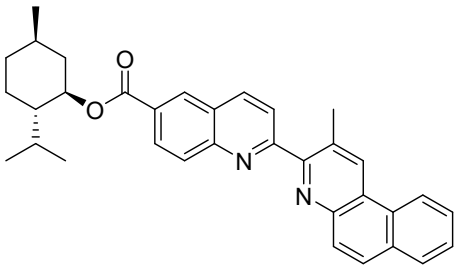
2-(2-methylbenzo[*f*]quinolin-3-yl)benzo[*d*]oxazole (4v):

Yield 49% (30.4 mg; petroleum ether/EtOAc = 15:1); light brown solid; mp 187–189 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 8.92 (s, 1H), 8.67 (d, J = 8.0 Hz, 1H), 8.16 (d, J = 9.2 Hz, 1H), 8.00 (d, J = 9.2 Hz, 1H), 7.97–7.89 (m, 2H), 7.78–7.67 (m, 3H), 7.48–7.40 (m, 2H), 3.11 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 161.4, 150.5, 146.3, 144.4, 142.0, 133.8, 132.3, 132.2, 131.0, 128.8(1), 128.7(8), 128.0(3), 128.0(1), 127.2, 126.1, 126.0, 124.7, 123.1, 120.8, 111.4, 21.9; HRMS (ESI): m/z $[M + H]^+$ calcd for $C_{21}H_{15}N_2O$: 311.1179; found: 311.1186.



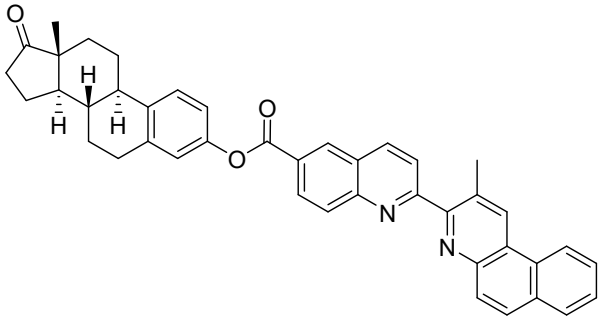
3-(1*H*-benzo[*d*]imidazol-2-yl)-2-methylbenzo[*f*]quinoline (4w):

Yield 78% (48.3 mg; petroleum ether/EtOAc = 3:1); light brown solid; mp 178–180 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 11.02 (s, 1H), 8.70 (s, 1H), 8.53 (d, J = 8.0 Hz, 1H), 7.94–7.88 (m, 1H), 7.87–7.82 (m, 3H), 7.67–7.62 (m, 1H), 7.62–7.57 (m, 1H), 7.44 (s, 1H), 7.30–7.25 (m, 2H), 3.16 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 151.6, 145.8, 145.5, 133.6, 131.9, 131.4, 130.6, 129.5, 128.9, 128.6, 127.5, 127.3, 127.1, 125.7, 125.4, 124.0, 122.8, 122.2, 120.5, 110.9, 21.8; HRMS (ESI): m/z $[M + H]^+$ calcd for $C_{21}H_{16}N_3$: 310.1339; found: 310.1344.



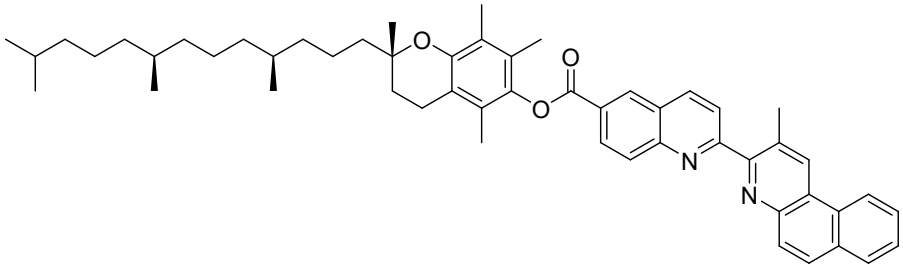
(1*R*,2*S*,5*R*)-2-isopropyl-5-methylcyclohexyl 2-(2-methylbenzo[*f*]quinolin-3-yl)quinoline-6-carboxylate (4x):

Yield 81% (81.4 mg; petroleum ether/EtOAc = 20:1); white solid; mp 125–127 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 8.92 (s, 1H), 8.71 (d, J = 8.0 Hz, 1H), 8.66 (d, J = 1.6 Hz, 1H), 8.47 (d, J = 8.4 Hz, 1H), 8.36 (dd, J = 8.8, 2.0 Hz, 1H), 8.29 (d, J = 8.4 Hz, 1H), 8.23 (d, J = 8.8 Hz, 1H), 8.06 (d, J = 9.2 Hz, 1H), 8.00–7.94 (m, 2H), 7.76–7.71 (m, 1H), 7.71–7.66 (m, 1H), 5.05 (td, J = 10.8, 4.4 Hz, 1H), 2.91 (s, 3H), 2.24–2.17 (m, 1H), 2.09–2.01 (m, 1H), 1.81–1.73 (m, 2H), 1.69–1.62 (m, 2H), 1.21–1.14 (m, 2H), 0.97 (d, J = 6.8 Hz, 7H), 0.85 (d, J = 6.8 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 165.7, 160.7, 155.9, 149.1, 146.1, 137.8, 133.4, 132.1, 131.0, 130.6, 130.3, 129.9, 129.2, 129.1, 129.0, 128.7, 128.1, 127.4, 127.0, 126.6, 125.2, 123.0, 122.9, 75.3, 47.3, 41.0, 34.3, 31.5, 26.5, 23.6, 22.1, 21.2, 20.8, 16.5; HRMS (ESI): m/z $[M + H]^+$ calcd for $C_{34}H_{35}N_2O_2$: 503.2693; found: 503.2682.



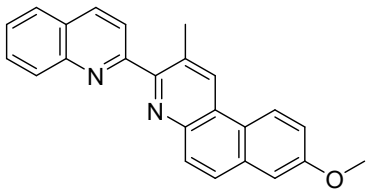
(8*S*,9*R*,13*R*,14*R*)-13-methyl-17-oxo-7,8,9,11,12,13,14,15,16,17-decahydro-6*H*-cyclopenta[*a*]phenanthren-3-yl 2-(2-methylbenzo[*f*]quinolin-3-yl)quinoline-6-carboxylate (4y):

Yield 80% (98.7 mg; petroleum ether/EtOAc = 10:1); white solid; mp 277–279 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 8.92 (s, 1H), 8.84 (d, J = 2.0 Hz, 1H), 8.71 (d, J = 8.0 Hz, 1H), 8.51–8.46 (m, 2H), 8.33 (d, J = 8.4 Hz, 1H), 8.29 (d, J = 8.8 Hz, 1H), 8.06 (d, J = 9.2 Hz, 1H), 8.00–7.94 (m, 2H), 7.76–7.71 (m, 1H), 7.71–7.66 (m, 1H), 7.38 (d, J = 8.4 Hz, 1H), 7.09–7.02 (m, 2H), 3.01–2.95 (m, 2H), 2.94 (s, 3H), 2.51–2.49 (m, 1H), 2.49–2.42 (m, 1H), 2.38–2.31 (m, 1H), 2.22–2.14 (m, 1H), 2.10–1.96 (m, 3H), 1.71–1.67 (m, 1H), 1.63–1.56 (m, 2H), 1.56–1.44 (m, 3H), 0.94 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 220.9, 165.1, 161.2, 155.7, 149.4, 148.8, 146.2, 138.2, 137.9, 137.6, 133.4, 132.1, 131.5, 131.0, 130.4, 130.2, 129.3, 129.1, 128.8, 128.1, 127.7, 127.5, 127.0, 126.58(X2), 125.3, 123.2, 123.0, 121.7, 118.8, 50.4, 48.0, 44.2, 38.0, 35.9, 31.5, 29.4, 26.4, 25.8, 21.6, 21.2, 13.8; HRMS (ESI): m/z $[M + H]^+$ calcd for $C_{42}H_{37}N_2O_3$: 617.2799; found: 617.2798.



(*S*)-2,5,7,8-tetramethyl-2-((4*S*,8*S*)-4,8,12-trimethyltridecyl)chroman-6-yl 2-(2-methylbenzo[*f*]quinolin-3-yl)quinoline-6-carboxylate (4z):

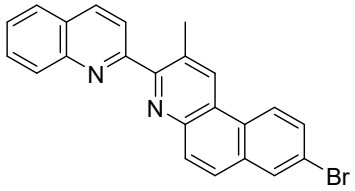
Yield 78% (121.2 mg; petroleum ether/EtOAc = 30:1); white solid; mp 111–113 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 8.93 (s, 1H), 8.89 (d, J = 2.0 Hz, 1H), 8.72 (d, J = 8.0 Hz, 1H), 8.57–8.52 (m, 1H), 8.52–8.48 (m, 1H), 8.34 (d, J = 8.4 Hz, 1H), 8.31 (d, J = 8.8 Hz, 1H), 8.07 (d, J = 9.2 Hz, 1H), 8.00–7.95 (m, 2H), 7.77–7.72 (m, 1H), 7.71–7.67 (m, 1H), 2.94 (s, 3H), 2.68–2.62 (m, 2H), 2.16 (s, 3H), 2.13 (s, 3H), 2.09 (s, 3H), 1.89–1.78 (m, 2H), 1.58–1.48 (m, 3H), 1.46–1.35 (m, 4H), 1.32–1.22 (m, 10H), 1.18–0.99 (m, 7H), 0.89–0.84 (m, 12H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 164.9, 161.1, 155.8, 149.6, 149.4, 146.2, 140.6, 137.9, 133.4, 132.1, 131.4, 131.0, 130.4, 130.2, 129.5, 129.1, 128.8, 128.1, 127.7, 127.5, 127.0, 126.9, 126.7, 125.3, 125.1, 123.2(3), 123.1(5), 123.0, 117.6, 75.1, 39.4, 37.4(4), 37.3(8), 37.3, 32.7(9), 32.7(8), 28.0, 24.8(2), 24.8(1), 24.4, 22.7, 22.6, 21.2, 21.0, 20.6, 19.8, 19.6(9), 19.6(7), 19.6(4), 19.6(0), 13.2, 12.3, 11.9; HRMS (ESI): m/z $[M + H]^+$ calcd for $C_{53}H_{65}N_2O_3$: 777.4990; found: 777.4985.



8-methoxy-2-methyl-3-(quinolin-2-yl)benzo[*f*]quinoline (4aa):

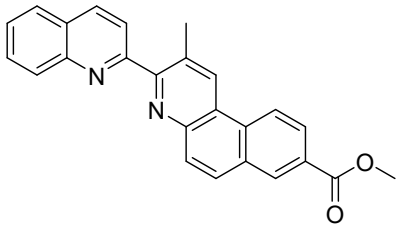
Yield 90% (63.1 mg; petroleum ether/EtOAc = 10:1); yellow solid; mp 182–184 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 8.76 (s, 1H), 8.56 (d, J = 9.2 Hz, 1H), 8.33 (d, J = 8.4 Hz, 1H), 8.20 (d, J = 8.4 Hz, 1H), 8.15 (d, J = 8.4 Hz, 1H), 8.03 (d, J = 9.2 Hz, 1H), 7.91–7.85 (m, 2H), 7.78–7.73 (m, 1H), 7.61–7.56 (m, 1H), 7.35–7.28 (m, 2H), 3.98 (s, 3H), 2.85 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 158.9, 158.8, 155.7, 147.3, 145.2, 136.6, 133.5, 132.6, 130.9, 129.7, 129.6, 129.5, 128.7, 127.6, 127.4, 126.8, 125.2, 124.5, 123.3, 122.1, 117.5,

108.7, 55.5, 21.1; HRMS (ESI): m/z [M + H]$^+$ calcd for $C_{24}H_{19}N_2O$: 351.1492; found: 351.1487.



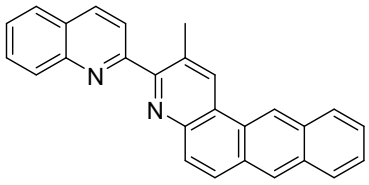
8-bromo-2-methyl-3-(quinolin-2-yl)benzo[*f*]quinoline (4ab):

Yield 78% (62.3 mg; petroleum ether/EtOAc = 20:1); light yellow solid; mp 234–236 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 8.84 (s, 1H), 8.55 (d, J = 8.8 Hz, 1H), 8.36 (d, J = 8.4 Hz, 1H), 8.20 (d, J = 8.4 Hz, 1H), 8.17 (d, J = 8.4 Hz, 1H), 8.10 (d, J = 2.0 Hz, 1H), 8.08 (d, J = 9.2 Hz, 1H), 7.92 (d, J = 8.4 Hz, 1H), 7.86 (d, J = 9.2 Hz, 1H), 7.81–7.75 (m, 2H), 7.64–7.59 (m, 1H), 2.88 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 158.5, 157.0, 147.3, 145.9, 136.7, 133.4, 133.0, 131.4, 130.9, 130.0, 129.7, 129.6, 129.5, 128.9, 127.9, 127.6, 127.4, 127.0, 124.8, 124.6, 122.1, 121.4, 21.1; HRMS (ESI): m/z [M + H]$^+$ calcd for $C_{23}H_{16}BrN_2$: 399.0491; found: 399.0482.



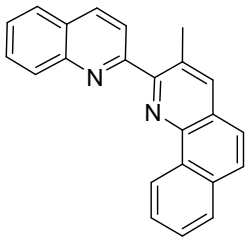
methyl 2-methyl-3-(quinolin-2-yl)benzo[*f*]quinoline-8-carboxylate (4ac):

Yield 75% (56.8 mg; petroleum ether/EtOAc = 12:1); white solid; mp 256–258 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 8.91 (s, 1H), 8.74 (d, J = 8.8 Hz, 1H), 8.67 (d, J = 1.6 Hz, 1H), 8.36 (d, J = 8.8 Hz, 1H), 8.33–8.29 (m, 1H), 8.22–8.16 (m, 2H), 8.11 (d, J = 8.8 Hz, 1H), 8.03 (d, J = 9.2 Hz, 1H), 7.92 (d, J = 8.0 Hz, 1H), 7.80–7.75 (m, 1H), 7.64–7.59 (m, 1H), 4.03 (s, 3H), 2.90 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 167.0, 158.5, 157.6, 147.3, 146.8, 136.7, 133.7, 132.3, 131.4(2), 131.3(9), 130.9, 130.4, 129.7(4), 129.6(5), 129.1, 128.6, 127.6, 127.5, 127.0, 126.8, 124.6, 123.2, 122.1, 52.4, 21.1; HRMS (ESI): m/z [M + H]$^+$ calcd for $C_{25}H_{19}N_2O_2$: 379.1441; found: 379.1450.



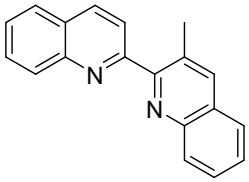
2-methyl-3-(quinolin-2-yl)naphtho[2,3-*f*]quinoline (4ad):

Yield 55% (40.8 mg; petroleum ether/EtOAc = 20:1); light yellow solid; mp 258–260 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 9.20 (s, 1H), 9.05 (s, 1H), 8.45 (s, 1H), 8.38 (d, J = 8.4 Hz, 1H), 8.26–8.17 (m, 3H), 8.13–8.09 (m, 1H), 8.05 (d, J = 9.2 Hz, 1H), 7.98–7.92 (m, 2H), 7.83–7.77 (m, 1H), 7.67–7.59 (m, 3H), 2.94 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 158.8, 156.2, 147.4, 146.6, 136.6, 133.4, 132.3, 132.0, 131.0, 130.7, 130.2, 129.7, 129.6, 128.4, 128.3, 127.9, 127.6(1), 127.5(9), 127.4, 127.2, 126.8, 126.3, 126.2, 125.6, 122.2, 122.1, 21.0; HRMS (ESI): m/z [M + H]$^+$ calcd for $C_{27}H_{19}N_2$: 371.1543; found: 371.1547.



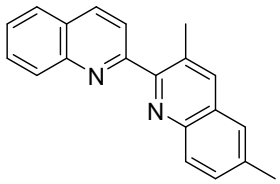
3-methyl-2-(quinolin-2-yl)benzo[*h*]quinoline (4ae):

Yield 82% (52.5 mg; petroleum ether/EtOAc = 30:1); white solid; mp 130–132 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 9.41–9.35 (m, 1H), 8.43 (d, J = 8.4 Hz, 1H), 8.36 (d, J = 8.4 Hz, 1H), 8.19 (d, J = 8.4 Hz, 1H), 8.11 (s, 1H), 7.94–7.89 (m, 2H), 7.82 (d, J = 8.8 Hz, 1H), 7.79–7.74 (m, 1H), 7.74–7.65 (m, 3H), 7.62–7.57 (m, 1H), 2.91 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 159.2, 155.0, 147.2, 144.2, 138.2, 136.3, 133.4, 131.61(X2), 129.7, 129.4, 128.2, 127.7(8), 127.7(6), 127.6, 127.4, 126.9, 126.8, 126.1, 124.8, 124.4, 122.6, 21.0; HRMS (ESI): m/z $[M + H]^+$ calcd for $C_{23}H_{17}N_2$: 321.1386; found: 321.1384.



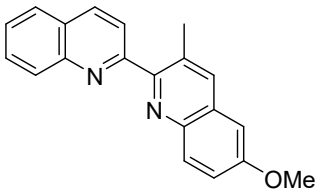
3-methyl-2,2'-biquinoline (4af):

Yield 74% (40.0 mg; petroleum ether/EtOAc = 20:1); white solid; mp 133–135 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 8.34 (d, J = 8.4 Hz, 1H), 8.20–8.14 (m, 2H), 8.10 (s, 1H), 8.08 (d, J = 8.4 Hz, 1H), 7.90 (d, J = 8.4 Hz, 1H), 7.82 (d, J = 8.0 Hz, 1H), 7.79–7.74 (m, 1H), 7.71–7.66 (m, 1H), 7.62–7.57 (m, 1H), 7.57–7.53 (m, 1H), 2.74 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 158.8, 157.8, 147.3, 146.4, 137.6, 136.7, 130.5, 129.7, 129.6, 129.4, 128.8, 128.1, 127.6, 127.4, 126.8(9), 126.8(6), 126.8, 122.0, 20.7; HRMS (ESI): m/z $[M + H]^+$ calcd for $C_{19}H_{15}N_2$: 271.1230; found: 271.1233.



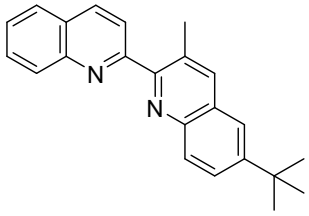
3,6-dimethyl-2,2'-biquinoline (4ag):

Yield 83% (47.2 mg; petroleum ether/EtOAc = 50:1); light yellow solid; mp 121–123 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 8.26 (d, J = 8.4 Hz, 1H), 8.11 (d, J = 8.8 Hz, 1H), 8.00 (d, J = 8.8 Hz, 1H), 7.97 (d, J = 8.8 Hz, 1H), 7.93 (s, 1H), 7.83 (d, J = 8.4 Hz, 1H), 7.71–7.66 (m, 1H), 7.55–7.49 (m, 2H), 7.46–7.42 (m, 1H), 2.65 (s, 3H), 2.49 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 158.9, 156.9, 147.3, 145.1, 137.0, 136.8, 136.6, 131.1, 130.4, 129.7, 129.5, 129.0, 128.1, 127.6, 127.4, 126.8, 125.6, 122.1, 21.7, 20.7; HRMS (ESI): m/z $[M + H]^+$ calcd for $C_{20}H_{17}N_2$: 285.1386; found: 285.1382.



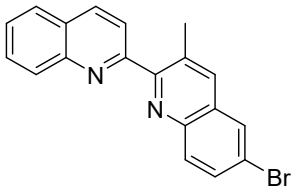
6-methoxy-3-methyl-2,2'-biquinoline (4ah):

Yield 72% (43.3 mg; petroleum ether/EtOAc = 20:1); light yellow solid; mp 124–126 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 8.26 (d, J = 8.4 Hz, 1H), 8.11 (d, J = 8.4 Hz, 1H), 8.04–7.98 (m, 2H), 7.93 (s, 1H), 7.82 (d, J = 8.0 Hz, 1H), 7.71–7.66 (m, 1H), 7.54–7.49 (m, 1H), 7.27 (dd, J = 9.2, 2.8 Hz, 1H), 7.01 (d, J = 2.8 Hz, 1H), 3.89 (s, 3H), 2.66 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 158.2, 155.1, 147.2, 142.4, 136.7, 130.8, 130.7, 129.6(3), 129.5(6), 129.2, 127.6, 127.4, 126.8, 122.1, 121.7, 104.1, 55.5, 20.7; HRMS (ESI): m/z [M + H]$^+$ calcd for $C_{20}H_{17}N_2O$: 301.1335; found: 301.1333.



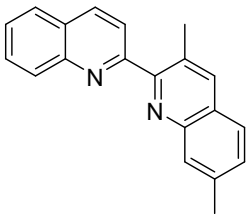
6-(*tert*-butyl)-3-methyl-2,2'-biquinoline (4ai):

Yield 80% (52.2 mg; petroleum ether/EtOAc = 30:1); light yellow solid; mp 135–137 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 8.31 (d, J = 8.4 Hz, 1H), 8.18 (d, J = 8.4 Hz, 1H), 8.10 (d, J = 8.8 Hz, 1H), 8.06 (d, J = 8.4 Hz, 2H), 7.88 (d, J = 7.6 Hz, 1H), 7.79–7.71 (m, 3H), 7.60–7.55 (m, 1H), 2.72 (s, 3H), 1.44 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 158.9, 157.0, 149.7, 147.2, 145.0, 137.6, 136.6, 130.3, 129.6, 129.5, 128.8, 127.8, 127.6, 127.4, 126.7, 122.1, 121.7, 34.9, 31.2, 20.6; HRMS (ESI): m/z [M + H]$^+$ calcd for $C_{23}H_{23}N_2$: 327.1856; found: 327.1858.



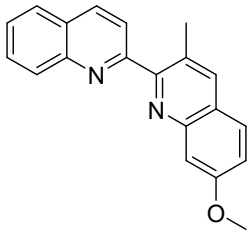
6-bromo-3-methyl-2,2'-biquinoline (4aj):

Yield 53% (37.0 mg; petroleum ether/EtOAc = 30:1); white solid; mp 167–169 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 8.35 (d, J = 8.4 Hz, 1H), 8.19 (d, J = 8.8 Hz, 1H), 8.08 (d, J = 8.8 Hz, 1H), 8.03 (d, J = 9.2 Hz, 1H), 8.01 (s, 1H), 7.98 (d, J = 2.4 Hz, 1H), 7.93–7.89 (m, 1H), 7.80–7.73 (m, 2H), 7.64–7.59 (m, 1H), 2.75 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 158.2, 158.0, 147.2, 144.9, 136.9, 136.6, 132.3, 131.7, 131.1, 129.8, 129.6, 129.1, 128.8, 127.6, 127.5, 127.1, 121.9, 120.9, 20.8; HRMS (ESI): m/z [M + H]$^+$ calcd for $C_{19}H_{14}BrN_2$: 349.0335; found: 349.0337.



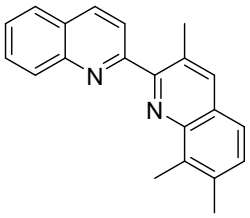
3,7-dimethyl-2,2'-biquinoline (4ak):

Yield 82% (46.5 mg; petroleum ether/EtOAc = 30:1); white solid; mp 123–125 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 8.32 (d, J = 8.4 Hz, 1H), 8.18 (d, J = 8.4 Hz, 1H), 8.07 (d, J = 8.4 Hz, 1H), 8.04 (s, 1H), 7.94 (s, 1H), 7.89 (d, J = 8.4 Hz, 1H), 7.75 (t, J = 7.2 Hz, 1H), 7.70 (d, J = 8.0 Hz, 1H), 7.61–7.56 (m, 1H), 7.38 (d, J = 8.4 Hz, 1H), 2.72 (s, 3H), 2.57 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 159.0, 157.7, 147.3, 146.7, 138.9, 137.3, 136.6, 129.7, 129.6, 129.5, 129.2, 128.4, 127.6, 127.4, 126.8, 126.4, 126.2, 122.1, 21.9, 20.6; HRMS (ESI): m/z $[M + H]^+$ calcd for $C_{20}H_{17}N_2$: 285.1386; found: 285.1389.



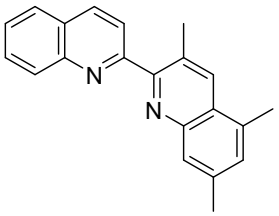
7-methoxy-3-methyl-2,2'-biquinoline (4al):

Yield 50% (30 mg; petroleum ether/EtOAc = 15:1); light yellow solid; mp 126–128 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 8.33 (d, J = 8.4 Hz, 1H), 8.18 (d, J = 8.4 Hz, 1H), 8.04 (d, J = 8.8 Hz, 1H), 8.03 (s, 1H), 7.90 (d, J = 7.6 Hz, 1H), 7.79–7.73 (m, 1H), 7.70 (d, J = 8.8 Hz, 1H), 7.62–7.57 (m, 1H), 7.49 (d, J = 2.0 Hz, 1H), 7.22 (dd, J = 8.8, 2.4 Hz, 1H), 3.95 (s, 3H), 2.68 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 160.2, 159.0, 157.9, 148.0, 147.3, 137.5, 136.7, 129.7, 129.6, 128.0, 127.8, 127.6, 127.4, 126.8, 123.4, 122.0, 120.3, 107.2, 55.5, 20.3; HRMS (ESI): m/z $[M + H]^+$ calcd for $C_{20}H_{17}N_2O$: 301.1335; found: 301.1328.



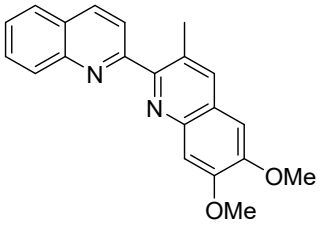
3,7,8-trimethyl-2,2'-biquinoline (4am):

Yield 83% (49.5 mg; petroleum ether/EtOAc = 50:1); light yellow solid; mp 128–130 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 8.29 (s, 2H), 8.17 (d, J = 8.4 Hz, 1H), 7.99 (s, 1H), 7.89–7.85 (m, 1H), 7.76–7.71 (m, 1H), 7.59–7.53 (m, 2H), 7.35 (d, J = 8.4 Hz, 1H), 2.82 (s, 3H), 2.81 (s, 3H), 2.50 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 159.5, 155.6, 147.1, 145.4, 137.9, 136.2, 136.1, 134.5, 129.8, 129.7, 129.3, 127.5, 127.4, 126.6, 126.3, 123.6, 122.6, 20.9, 20.6, 13.3; HRMS (ESI): m/z $[M + H]^+$ calcd for $C_{21}H_{19}N_2$: 299.1543; found: 299.1549.



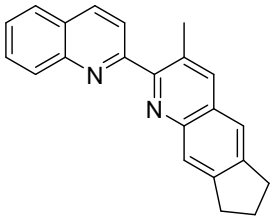
3,5,7-trimethyl-2,2'-biquinoline (4an):

Yield 85% (50.7 mg; petroleum ether/EtOAc = 30:1); light yellow solid; mp 104–106 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 8.31 (d, J = 8.4 Hz, 1H), 8.18 (d, J = 5.6 Hz, 2H), 8.08 (d, J = 8.8 Hz, 1H), 7.88 (d, J = 8.0 Hz, 1H), 7.80 (s, 1H), 7.77–7.72 (m, 1H), 7.60–7.55 (m, 1H), 7.21 (s, 1H), 2.75 (s, 3H), 2.67 (s, 3H), 2.51 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 159.0, 157.0, 147.2, 146.9, 138.4, 136.6, 134.1, 133.2, 129.7, 129.6, 129.5, 129.0, 127.5, 127.4, 126.7, 126.5, 125.4, 122.1, 21.7, 20.8, 18.5; HRMS (ESI): m/z [M + H]$^+$ calcd for $C_{21}H_{19}N_2$: 299.1543; found: 299.1547.



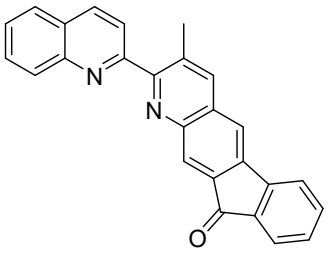
6,7-dimethoxy-3-methyl-2,2'-biquinoline (4ao):

Yield 76% (50.2 mg; petroleum ether/EtOAc = 5:1); white solid; mp 152–154 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 8.32 (d, J = 8.4 Hz, 1H), 8.18 (d, J = 8.4 Hz, 1H), 8.04 (d, J = 8.4 Hz, 1H), 7.95 (s, 1H), 7.89 (d, J = 8.0 Hz, 1H), 7.78–7.73 (m, 1H), 7.62–7.56 (m, 1H), 7.50 (s, 1H), 7.05 (s, 1H), 4.05 (s, 3H), 4.03 (s, 3H), 2.69 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 159.0, 155.4, 152.0, 150.2, 147.3, 143.3, 136.6, 136.2, 129.7, 129.5, 128.5, 127.6, 127.3, 126.7, 123.8, 122.0, 108.0, 104.1, 56.1, 56.0, 20.4; HRMS (ESI): m/z [M + H]$^+$ calcd for $C_{21}H_{19}N_2O_2$: 331.1441; found: 331.1435.



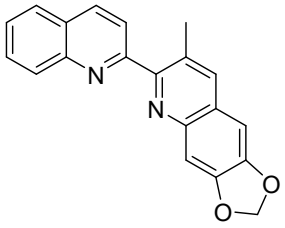
3-methyl-2-(quinolin-2-yl)-7,8-dihydro-6*H*-cyclopenta[*g*]quinoline (4ap):

Yield 79% (49.0 mg; petroleum ether/EtOAc = 15:1); white solid; mp 146–148 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 8.31 (d, J = 8.4 Hz, 1H), 8.18 (d, J = 8.4 Hz, 1H), 8.07 (d, J = 8.4 Hz, 1H), 7.97 (d, J = 16.8 Hz, 2H), 7.88 (d, J = 8.0 Hz, 1H), 7.78–7.72 (m, 1H), 7.61–7.55 (m, 2H), 3.14–3.09 (m, 2H), 3.08–3.04 (m, 2H), 2.70 (s, 3H), 2.21–2.13 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 159.1, 156.5, 147.2, 146.9, 146.3, 144.6, 137.2, 136.6, 129.6, 129.5, 129.2, 127.6, 127.4, 127.3, 126.7, 123.5, 122.2, 120.7, 32.8, 32.6, 26.1, 20.6; HRMS (ESI): m/z [M + H]$^+$ calcd for $C_{22}H_{19}N_2$: 311.1543; found: 311.1545.



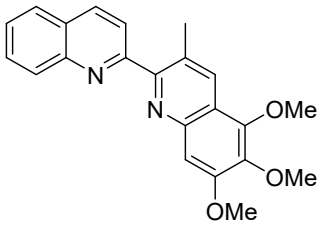
3-methyl-2-(quinolin-2-yl)-10*H*-indeno[1,2-*g*]quinolin-10-one (4aq):

Yield 67% (49.9 mg; petroleum ether/EtOAc = 12:1); yellow solid; mp 246–248 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 8.42 (s, 1H), 8.35 (d, J = 8.4 Hz, 1H), 8.18–8.14 (m, 2H), 8.05 (s, 1H), 7.91 (d, J = 8.0 Hz, 1H), 7.83 (s, 1H), 7.80–7.75 (m, 2H), 7.74 (d, J = 7.2 Hz, 1H), 7.63–7.60 (m, 1H), 7.60–7.56 (m, 1H), 7.40–7.35 (m, 1H), 2.79 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 192.5, 158.1, 157.8, 147.3, 147.2, 144.3, 139.4, 138.2, 136.7, 136.2, 135.5, 135.2, 133.5, 132.0, 129.7, 129.64, 129.56, 127.6, 127.5, 127.0, 126.8, 124.6, 122.0, 121.2, 117.7, 21.1; HRMS (ESI): m/z $[M + H]^+$ calcd for $C_{26}H_{17}N_2O$: 373.1335; found: 373.1340.



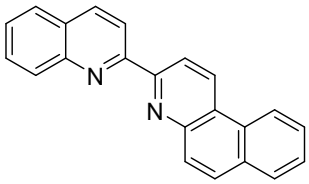
7-methyl-6-(quinolin-2-yl)-[1,3]dioxolo[4,5-*g*]quinoline (4ar):

Yield 75% (47.2 mg; petroleum ether/EtOAc = 8:1); white solid; mp 153–155 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 8.31 (d, J = 8.8 Hz, 1H), 8.17 (d, J = 8.4 Hz, 1H), 8.04 (d, J = 8.4 Hz, 1H), 7.91 (s, 1H), 7.90–7.87 (m, 1H), 7.78–7.72 (m, 1H), 7.61–7.56 (m, 1H), 7.44 (s, 1H), 7.06 (s, 1H), 6.11 (s, 2H), 2.68 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 159.0, 155.3, 150.2, 148.2, 147.3, 144.5, 136.8, 136.6, 129.7, 129.5, 128.7, 127.6, 127.3, 126.7, 125.2, 122.1, 105.8, 101.8, 101.6, 20.3; HRMS (ESI): m/z $[M + H]^+$ calcd for $C_{20}H_{15}N_2O_2$: 315.1128; found: 315.1118.



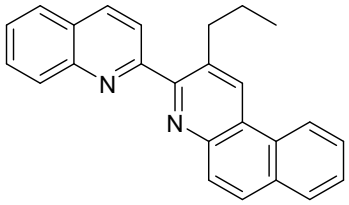
5,6,7-trimethoxy-3-methyl-2,2'-biquinoline (4as):

Yield 62% (44.7 mg; petroleum ether/EtOAc = 8:1); light yellow solid; mp 121–123 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 8.32 (d, J = 8.4 Hz, 1H), 8.28 (s, 1H), 8.18 (d, J = 8.4 Hz, 1H), 8.02 (d, J = 8.8 Hz, 1H), 7.90 (d, J = 8.0 Hz, 1H), 7.78–7.73 (m, 1H), 7.62–7.57 (m, 1H), 7.32 (s, 1H), 4.09 (s, 3H), 4.02 (s, 3H), 4.00 (s, 3H), 2.70 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 159.0, 157.1, 155.4, 147.4, 146.3, 144.2, 141.3, 136.7, 132.0, 129.8, 129.6, 128.0, 127.6, 127.4, 126.8, 122.0, 119.2, 104.3, 61.7, 61.3, 56.1, 20.5; HRMS (ESI): m/z $[M + H]^+$ calcd for $C_{22}H_{21}N_2O_3$: 361.1547; found: 361.1555.



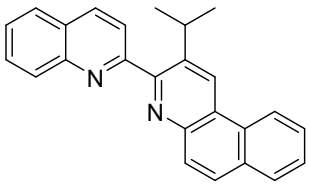
3-(quinolin-2-yl)benzo[*f*]quinoline (4at):

Yield 88% (53.9 mg; petroleum ether/EtOAc = 10:1); white solid; mp 205–207 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 9.14 (d, J = 8.4 Hz, 1H), 8.99 (d, J = 8.4 Hz, 1H), 8.89 (d, J = 8.8 Hz, 1H), 8.73 (d, J = 8.4 Hz, 1H), 8.36 (d, J = 8.4 Hz, 1H), 8.26 (d, J = 8.4 Hz, 1H), 8.14 (d, J = 8.8 Hz, 1H), 8.05 (d, J = 9.2 Hz, 1H), 7.98 (d, J = 7.6 Hz, 1H), 7.90 (d, J = 8.0 Hz, 1H), 7.80–7.72 (m, 2H), 7.71–7.66 (m, 1H), 7.63–7.56 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 156.2, 155.7, 148.0, 147.8, 136.8, 132.0, 131.6, 131.0, 129.9, 129.7, 129.6, 128.7, 128.6, 128.4, 127.7, 127.4, 127.1, 126.9, 125.7, 123.0, 119.6, 119.3; HRMS (ESI): m/z [M + H]$^+$ calcd for $C_{22}H_{15}N_2$: 307.1230; found: 307.1232.



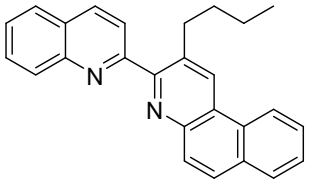
2-propyl-3-(quinolin-2-yl)benzo[*f*]quinoline (4au):

Yield 85% (59.2 mg; petroleum ether/EtOAc = 20:1); white solid; mp 130–132 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 8.89 (s, 1H), 8.70 (d, J = 8.0 Hz, 1H), 8.33 (d, J = 8.4 Hz, 1H), 8.19 (d, J = 8.4 Hz, 1H), 8.12 (d, J = 8.4 Hz, 1H), 8.05 (d, J = 9.2 Hz, 1H), 7.99–7.92 (m, 2H), 7.91–7.87 (m, 1H), 7.79–7.73 (m, 1H), 7.73–7.68 (m, 1H), 7.68–7.63 (m, 1H), 7.62–7.56 (m, 1H), 3.28–3.20 (m, 2H), 1.78–1.68 (m, 2H), 0.93 (t, J = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 158.8, 156.6, 147.3, 146.0, 136.6, 135.3, 132.4, 132.0, 130.2, 129.8, 129.5, 129.3, 128.7, 128.1, 127.6, 127.4, 127.2, 126.9, 126.8, 125.0, 122.9, 122.2, 35.5, 24.6, 14.1; HRMS (ESI): m/z [M + H]$^+$ calcd for $C_{25}H_{21}N_2$: 349.1699; found: 349.1701.



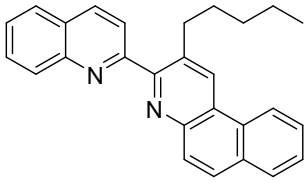
2-isopropyl-3-(quinolin-2-yl)benzo[*f*]quinoline (4av):

Yield 77% (53.7 mg; petroleum ether/EtOAc = 30:1); white solid; mp 117–119 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 9.04 (s, 1H), 8.75 (d, J = 8.0 Hz, 1H), 8.35 (d, J = 8.8 Hz, 1H), 8.20 (d, J = 8.4 Hz, 1H), 8.05 (d, J = 9.2 Hz, 1H), 8.00–7.93 (m, 3H), 7.92 (d, J = 8.0 Hz, 1H), 7.80–7.71 (m, 2H), 7.70–7.64 (m, 1H), 7.63–7.57 (m, 1H), 3.88–3.77 (m, 1H), 1.41 (s, 3H), 1.40 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 158.9, 156.9, 147.4, 145.7, 141.1, 136.6, 132.0, 130.3, 129.8, 129.6, 129.4, 128.8, 128.4, 128.1, 127.6, 127.4, 127.3, 126.9, 126.8, 125.2, 122.8, 122.3, 29.1, 24.1; HRMS (ESI): m/z [M + H]$^+$ calcd for $C_{25}H_{21}N_2$: 349.1699; found: 349.1702.



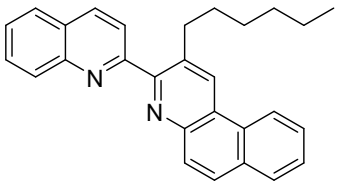
2-butyl-3-(quinolin-2-yl)benzo[*f*]quinoline (4aw):

Yield 82% (59.4 mg; petroleum ether/EtOAc = 20:1); white solid; mp 111–113 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 8.90 (s, 1H), 8.71 (d, J = 8.0 Hz, 1H), 8.34 (d, J = 8.4 Hz, 1H), 8.18 (d, J = 8.4 Hz, 1H), 8.12 (d, J = 8.8 Hz, 1H), 8.05 (d, J = 8.8 Hz, 1H), 7.98–7.92 (m, 2H), 7.90 (d, J = 7.6 Hz, 1H), 7.79–7.74 (m, 1H), 7.74–7.69 (m, 1H), 7.69–7.63 (m, 1H), 7.63–7.56 (m, 1H), 3.30–3.22 (m, 2H), 1.73–1.64 (m, 2H), 1.40–1.30 (m, 2H), 0.89–0.81 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 158.8, 156.6, 147.3, 146.0, 136.6, 135.6, 132.3, 132.0, 130.2, 129.7, 129.5, 129.3, 128.7, 128.1, 127.6, 127.4, 127.3, 126.9, 126.8, 125.1, 122.9, 122.2, 33.6, 33.1, 22.6, 13.9; HRMS (ESI): m/z $[M + H]^+$ calcd for $C_{26}H_{23}N_2$: 363.1856; found: 363.1864.



2-pentyl-3-(quinolin-2-yl)benzo[*f*]quinoline (4ax):

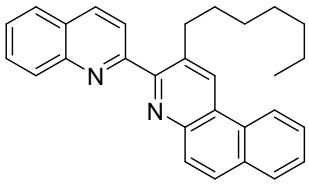
Yield 81% (61.0 mg; petroleum ether/EtOAc = 20:1); white solid; mp 88–90 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 8.88 (s, 1H), 8.70 (d, J = 8.0 Hz, 1H), 8.33 (d, J = 8.8 Hz, 1H), 8.18 (d, J = 8.4 Hz, 1H), 8.11 (d, J = 8.4 Hz, 1H), 8.05 (d, J = 9.2 Hz, 1H), 7.96–7.91 (m, 2H), 7.89 (d, J = 8.0 Hz, 1H), 7.78–7.73 (m, 1H), 7.73–7.68 (m, 1H), 7.67–7.62 (m, 1H), 7.61–7.55 (m, 1H), 3.28–3.21 (m, 2H), 1.75–1.65 (m, 2H), 1.30–1.24 (m, 4H), 0.83–0.75 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 158.8, 156.6, 147.3, 146.0, 136.6, 135.6, 132.3, 131.9, 130.1, 129.7, 129.5, 129.2, 128.7, 128.1, 127.6, 127.4, 127.2, 126.9, 126.8, 125.0, 122.9, 122.2, 33.4, 31.8, 31.1, 22.4, 13.9; HRMS (ESI): m/z $[M + H]^+$ calcd for $C_{27}H_{25}N_2$: 377.2012; found: 377.2013.



2-hexyl-3-(quinolin-2-yl)benzo[*f*]quinoline (4ay):

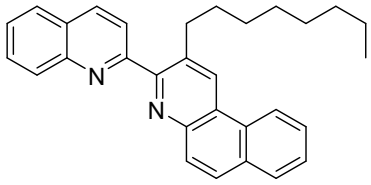
Yield 82% (64.0 mg; petroleum ether/EtOAc = 20:1); white solid; mp 85–87 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 8.90 (s, 1H), 8.71 (d, J = 8.0 Hz, 1H), 8.34 (d, J = 8.8 Hz, 1H), 8.18 (d, J = 8.4 Hz, 1H), 8.11 (d, J = 8.4 Hz, 1H), 8.05 (d, J = 9.2 Hz, 1H), 7.97–7.92 (m, 2H), 7.90 (d, J = 8.4 Hz, 1H), 7.79–7.74 (m, 1H), 7.74–7.69 (m, 1H), 7.68–7.64 (m, 1H), 7.62–7.57 (m, 1H), 3.28–3.22 (m, 2H), 1.73–1.64 (m, 2H), 1.35–1.27 (m, 6H), 0.82–0.75 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 158.8, 156.7, 147.3, 146.0, 136.6, 135.6, 132.3, 132.0, 130.2, 129.7, 129.5, 129.3, 128.7, 128.2, 127.6, 127.4, 127.2, 126.9, 126.8, 125.1, 122.9,

122.2, 33.4, 31.6, 31.4, 29.2, 22.5, 14.0; HRMS (ESI): m/z $[M + H]^+$ calcd for $C_{28}H_{27}N_2$: 391.2169; found: 391.2169.



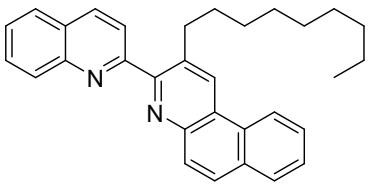
2-heptyl-3-(quinolin-2-yl)benzo[*f*]quinoline (4az):

Yield 80% (64.7 mg; petroleum ether/EtOAc = 20:1); white solid; mp 79–81 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 8.91 (s, 1H), 8.72 (d, J = 8.0 Hz, 1H), 8.35 (d, J = 8.4 Hz, 1H), 8.18 (d, J = 8.4 Hz, 1H), 8.11 (d, J = 8.4 Hz, 1H), 8.05 (d, J = 9.2 Hz, 1H), 7.98–7.94 (m, 2H), 7.92 (dd, J = 8.0, 0.8 Hz, 1H), 7.80–7.75 (m, 1H), 7.75–7.70 (m, 1H), 7.69–7.65 (m, 1H), 7.63 – 7.58 (m, 1H), 3.28–3.22 (m, 2H), 1.71–1.64 (m, 2H), 1.33–1.26 (m, 2H), 1.25–1.13 (m, 6H), 0.83–0.77 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 158.9, 156.8, 147.4, 146.0, 136.7, 135.7, 132.4, 132.0, 130.2, 129.8, 129.6, 129.3, 128.8, 128.2, 127.6, 127.5, 127.3, 127.0, 126.8, 125.1, 123.0, 122.3, 33.4, 31.7, 31.5, 29.6, 29.0, 22.6, 14.1; HRMS (ESI): m/z $[M + H]^+$ calcd for $C_{29}H_{29}N_2$: 405.2325; found: 405.2320.



2-octyl-3-(quinolin-2-yl)benzo[*f*]quinoline (4aaa):

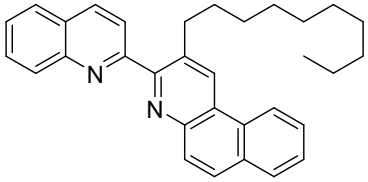
Yield 82% (68.6 mg; petroleum ether/EtOAc = 20:1); white solid; mp 85–87 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 8.89 (s, 1H), 8.70 (d, J = 8.0 Hz, 1H), 8.33 (d, J = 8.4 Hz, 1H), 8.18 (d, J = 8.4 Hz, 1H), 8.11 (d, J = 8.4 Hz, 1H), 8.05 (d, J = 8.8 Hz, 1H), 7.98–7.91 (m, 2H), 7.91–7.87 (m, 1H), 7.79–7.73 (m, 1H), 7.73–7.68 (m, 1H), 7.68–7.62 (m, 1H), 7.62–7.56 (m, 1H), 3.30–3.19 (m, 2H), 1.74–1.62 (m, 2H), 1.34–1.26 (m, 2H), 1.24–1.09 (m, 8H), 0.88–0.77 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 158.9, 156.7, 147.4, 146.0, 136.7, 135.7, 132.4, 132.0, 130.2, 129.8, 129.6, 129.3, 128.8, 128.2, 127.6, 127.5, 127.3, 127.0, 126.8, 125.2, 123.0, 122.3, 33.4, 31.8, 31.5, 29.6, 29.4, 29.2, 22.6, 14.2; HRMS (ESI): m/z $[M + H]^+$ calcd for $C_{30}H_{31}N_2$: 419.2482; found: 419.2478.



2-nonyl-3-(quinolin-2-yl)benzo[*f*]quinoline (4aab):

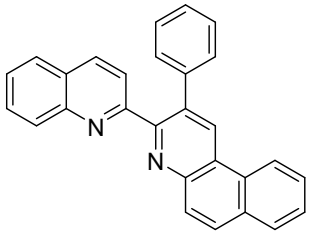
Yield 80% (69.2 mg; petroleum ether/EtOAc = 20:1); white solid; mp 82–84 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 8.90 (s, 1H), 8.71 (d, J = 8.0 Hz, 1H), 8.34 (d, J = 8.4 Hz, 1H), 8.18 (d, J = 8.4 Hz, 1H), 8.11 (d, J = 8.4 Hz, 1H), 8.05 (d, J = 9.2 Hz, 1H), 7.98–7.92 (m, 2H), 7.92–7.88 (m, 1H), 7.79–7.74 (m, 1H), 7.74–7.69 (m, 1H), 7.68–7.63 (m, 1H), 7.62–7.57 (m, 1H), 3.29–3.21 (m, 2H), 1.72–1.64 (m, 2H), 1.35–1.27 (m, 2H), 1.25–1.12 (m, 10H), 0.85 (t, J = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 158.8, 156.7, 147.3, 146.0, 136.6, 135.6,

132.3, 132.0, 130.2, 129.7, 129.5, 129.3, 128.7, 128.1, 127.6, 127.4, 127.3, 126.9, 126.8, 125.1, 122.9, 122.2, 33.4, 31.8, 31.4, 29.5, 29.4, 29.3, 29.2, 22.6, 14.1; HRMS (ESI): m/z [M + H]$^+$ calcd for $C_{31}H_{33}N_2$: 433.2638; found: 433.2635.



2-decyl-3-(quinolin-2-yl)benzo[f]quinoline (4aac):

Yield 78% (69.7 mg; petroleum ether/EtOAc = 20:1); white solid; mp 68–70 ^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 8.90 (s, 1H), 8.72 (d, J = 8.4 Hz, 1H), 8.35 (d, J = 8.4 Hz, 1H), 8.18 (d, J = 8.4 Hz, 1H), 8.11 (d, J = 8.8 Hz, 1H), 8.05 (d, J = 9.2 Hz, 1H), 7.98–7.93 (m, 2H), 7.91 (d, J = 8.0 Hz, 1H), 7.79–7.70 (m, 2H), 7.69–7.64 (m, 1H), 7.63–7.58 (m, 1H), 3.30–3.20 (m, 2H), 1.73–1.67 (m, 2H), 1.35–1.24 (m, 4H), 1.22–1.10 (m, 10H), 0.89–0.83 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 158.8, 156.7, 147.4, 146.0, 136.6, 135.6, 132.4, 132.0, 130.2, 129.8, 129.6, 129.3, 128.7, 128.2, 127.6, 127.4, 127.3, 126.9, 126.8, 125.1, 122.9, 122.2, 33.4, 31.9, 31.4, 29.52(X2), 29.5, 29.3(3), 29.2(6), 22.6, 14.1; HRMS (ESI): m/z [M + H]$^+$ calcd for $C_{32}H_{35}N_2$: 447.2795; found: 447.2803.



2-phenyl-3-(quinolin-2-yl)benzo[*f*]quinoline (8):

Yield 65% (49.7 mg; petroleum ether/EtOAc = 12:1); white solid; mp 197–199 ^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 9.07 (s, 1H), 8.72 (d, J = 7.6 Hz, 1H), 8.20 (d, J = 9.2 Hz, 1H), 8.10 (d, J = 8.4 Hz, 1H), 8.06 (d, J = 2.8 Hz, 1H), 8.04 (d, J = 3.2 Hz, 1H), 8.00–7.97 (m, 1H), 7.79 (d, J = 8.4 Hz, 1H), 7.76–7.72 (m, 1H), 7.71–7.67 (m, 2H), 7.57–7.51 (m, 2H), 7.39–7.34 (m, 2H), 7.31–7.27 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 158.2, 156.1, 147.9, 147.2, 139.9, 135.8, 134.9, 133.1, 132.1, 131.2, 130.0, 129.8, 129.4, 128.8, 128.4, 128.3, 127.6, 127.4, 127.2(3), 127.1(7), 126.8, 125.0, 123.0, 122.6; HRMS (ESI): m/z [M + H]$^+$ calcd for $C_{28}H_{19}N_2$: 383.1543; found: 383.1535.

8. Crystallographic data and molecular structure of 4ap

The crystal of **4ap** for X-ray diffraction study has been obtained through the dissolving of compound in $CHCl_3$, followed by slow evaporation of the solvent at room temperature. The crystal was kept at 296(2) during data collection. CCDC 2384037 contains the supplementary crystallographic data for this paper. This data can be obtained free of charge from the Cambridge Crystallographic Data Centre via www.ccdc.cam.ac.uk/data_request/cif.

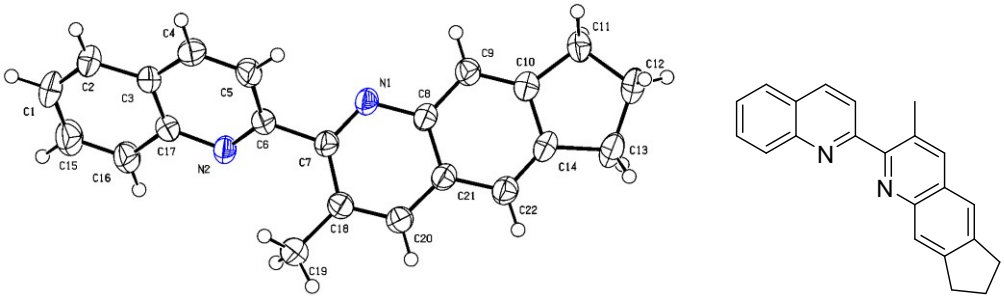


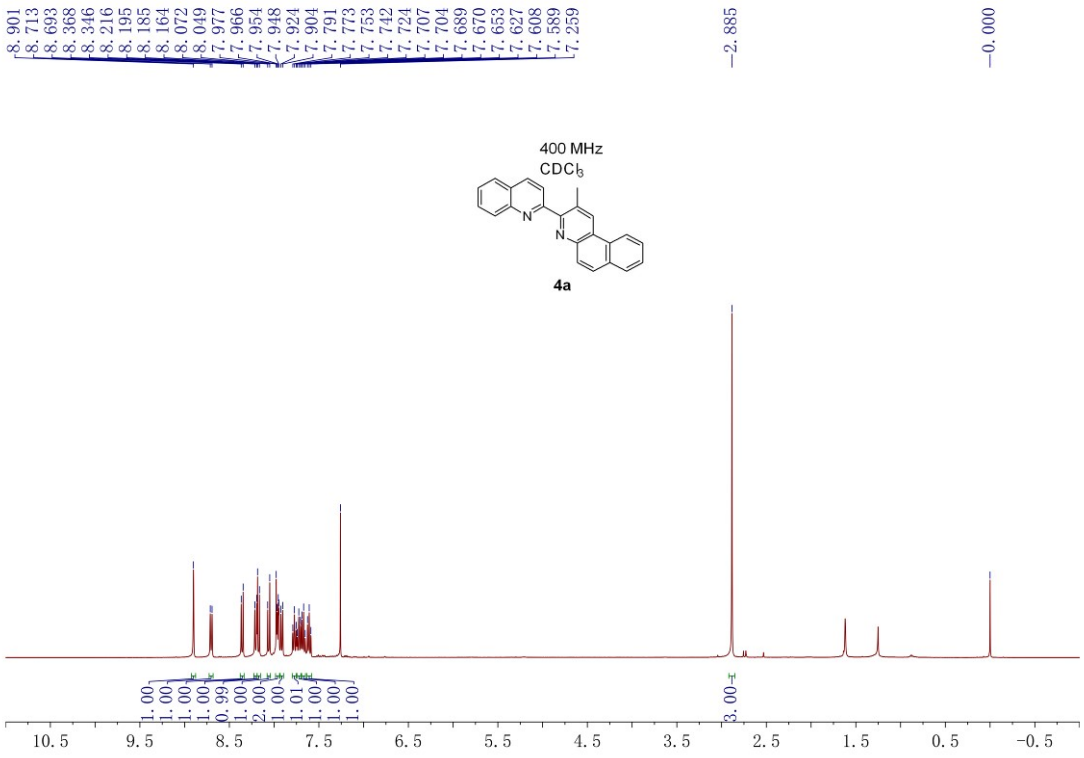
Figure S1. X-ray crystal structure of **4ap**; the ellipsoids depicted at the 50% probability level.

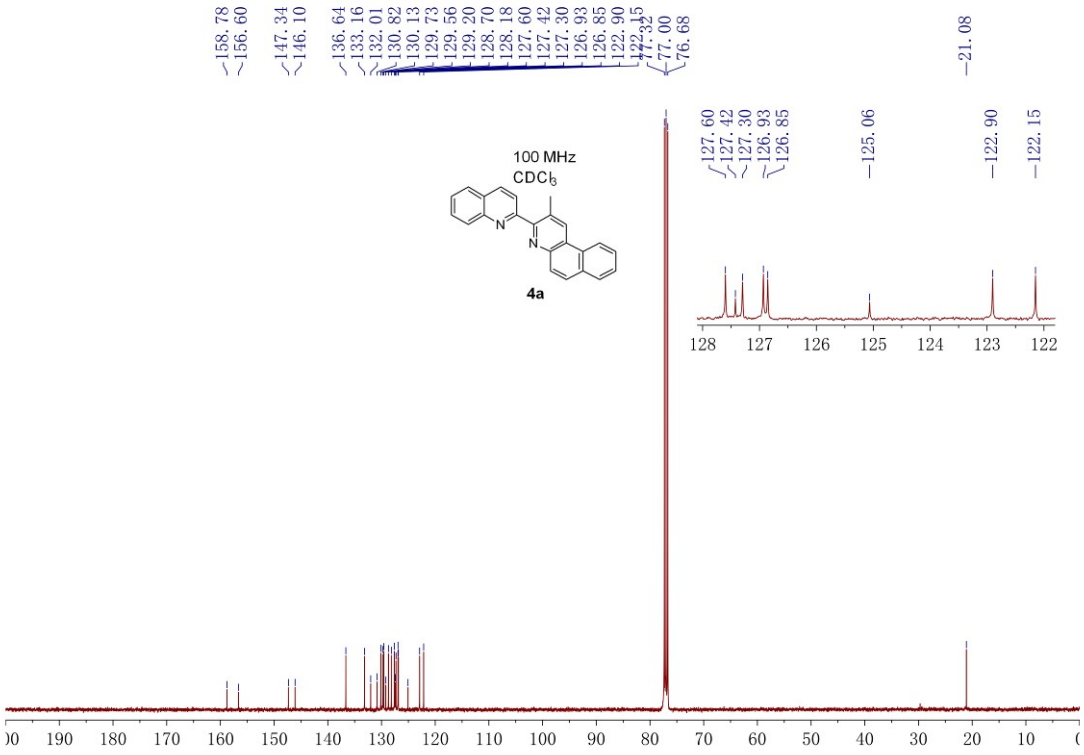
Empirical formula	$C_{22}H_{18}N_2$		Density (calculated)	1.312 g/cm^3
Formula weight	310.38		Absorption coefficient	0.077 mm^{-1}
Temperature	296(2) K		F(000)	656.0
Crystal system	monoclinic		Crystal size	0.19 × 0.16 × 0.1 mm^3
Space group	$P2_1/c$		Theta range for data collection	2.526 to 55.196°
Unit cell dimensions	a = 3.989(3) Å	α = 90°	Reflections collected	3510
	b = 12.220(9) Å	β = 92.740(11)°	Data / restraints / parameters	3510/0/219
	c = 32.27(2) Å	γ = 90°	Goodness-of-fit on F^2	1.182
Volume	1571(2) Å^3		Final R indices [I>2sigma(I)]	R_1 = 0.1161, wR_2 = 0.3128
Z	4		R indices (all data)	R_1 = 0.1590, wR_2 = 0.3406

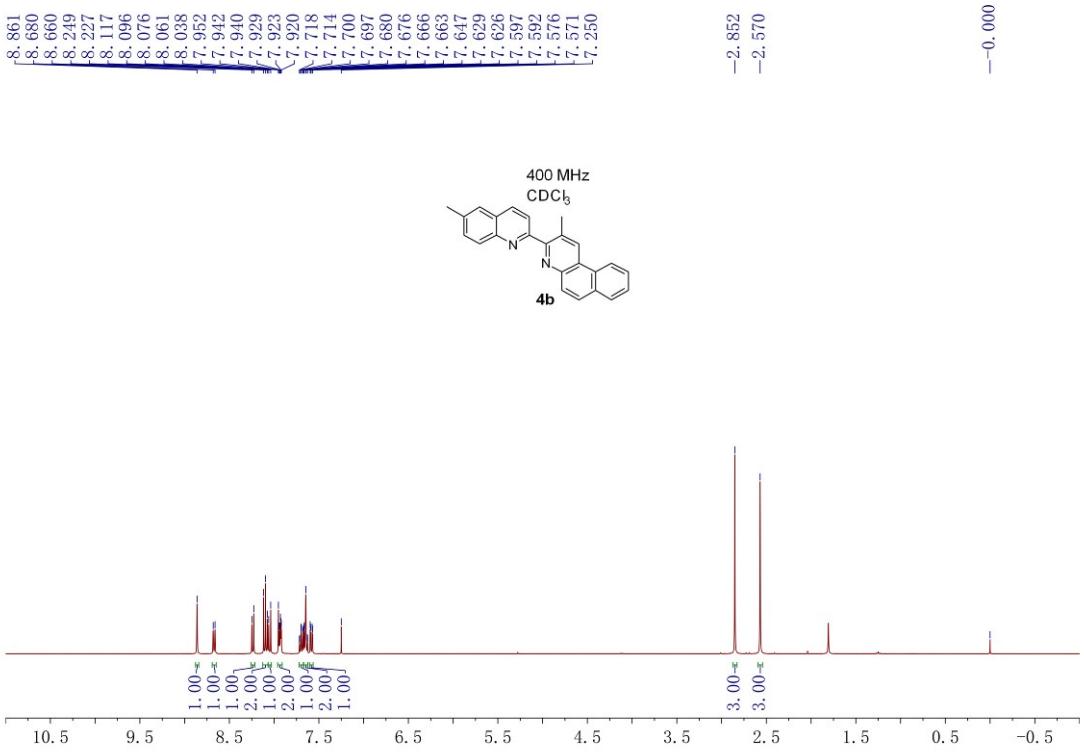
9. References

1. Hu,Y.; Nan, J.; Yin, J.; Huang, G.; Ren, X.; Ma, Y. Rhodium-Catalyzed Dehydrogenative Annulation of N-Arylmethanimines with Vinylene Carbonate for Synthesizing Quinolines. *Org. Lett*. **2021**, *23*, 8527–8532.
2. Wang, L.-C.; Geng, H.-Q.; Peng, J.-B.; Wu, X.-F. Iron-Catalyzed Synthesis of 2-Aminofurans from 2-Haloketones and Tertiary Amines or Enamines. *Eur. J. Org. Chem.* **2020**, *2020,* 2605−2616.

10. NMR spectra



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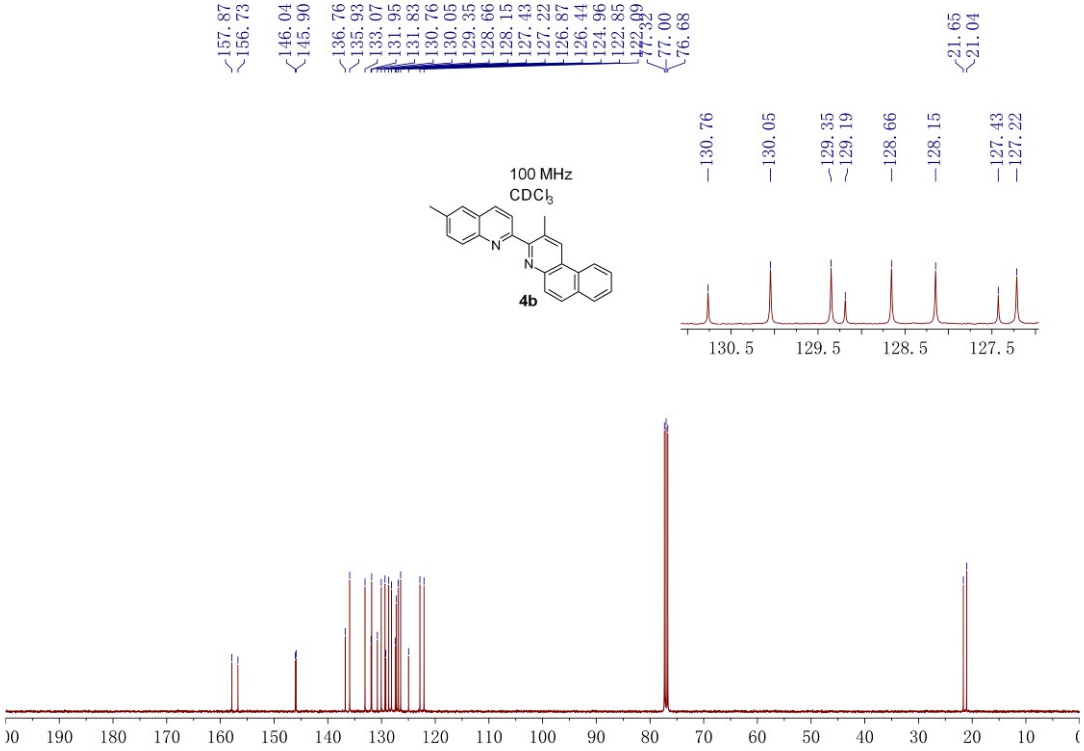
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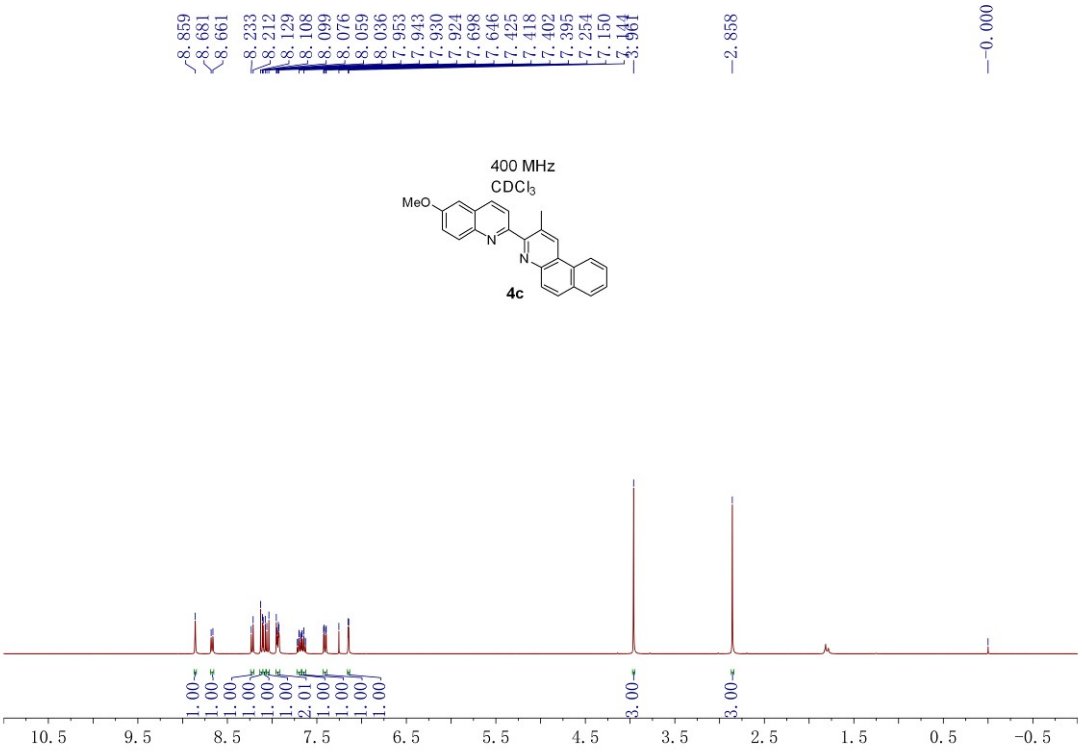
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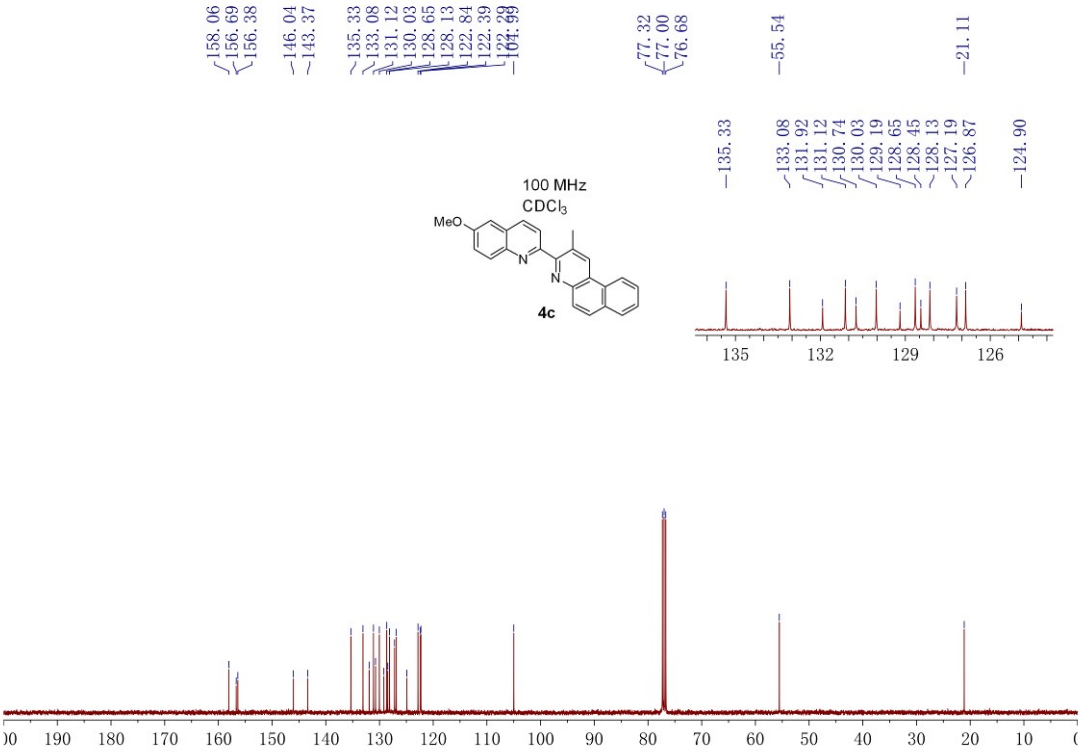
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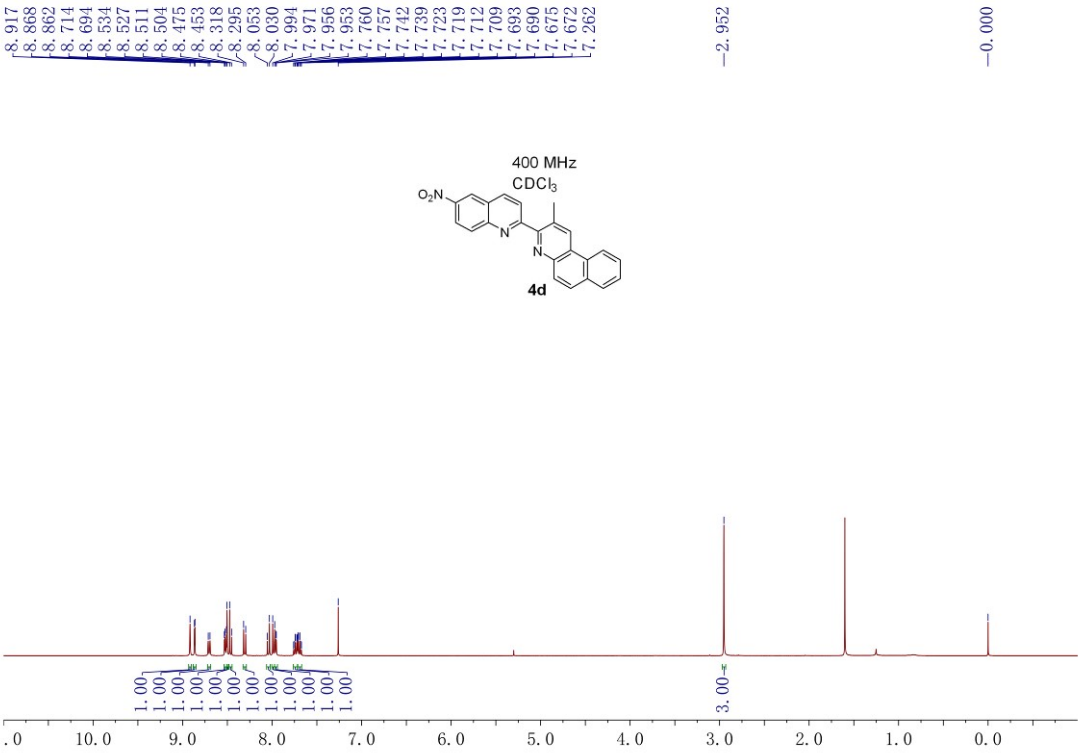
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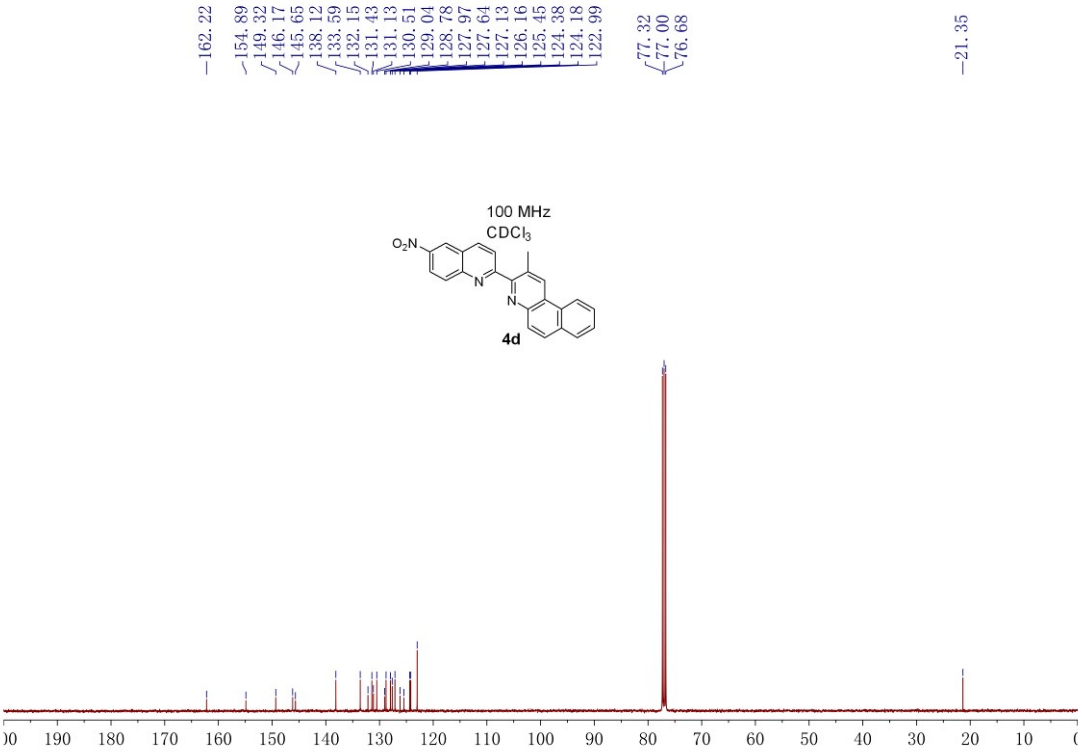
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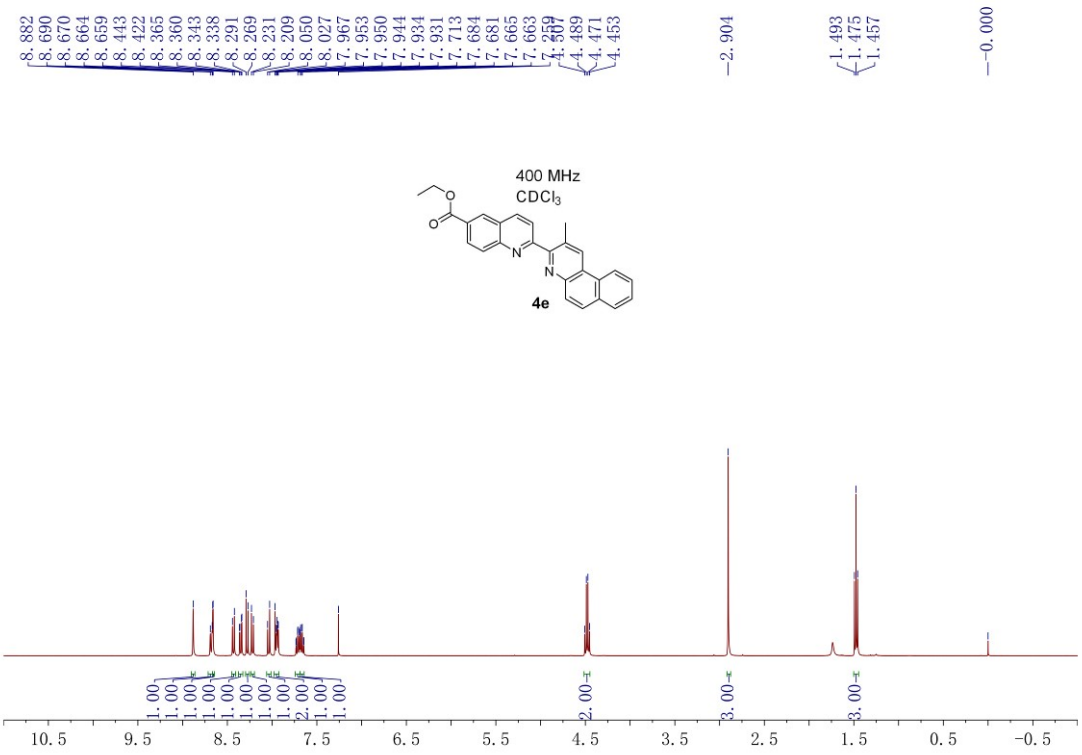
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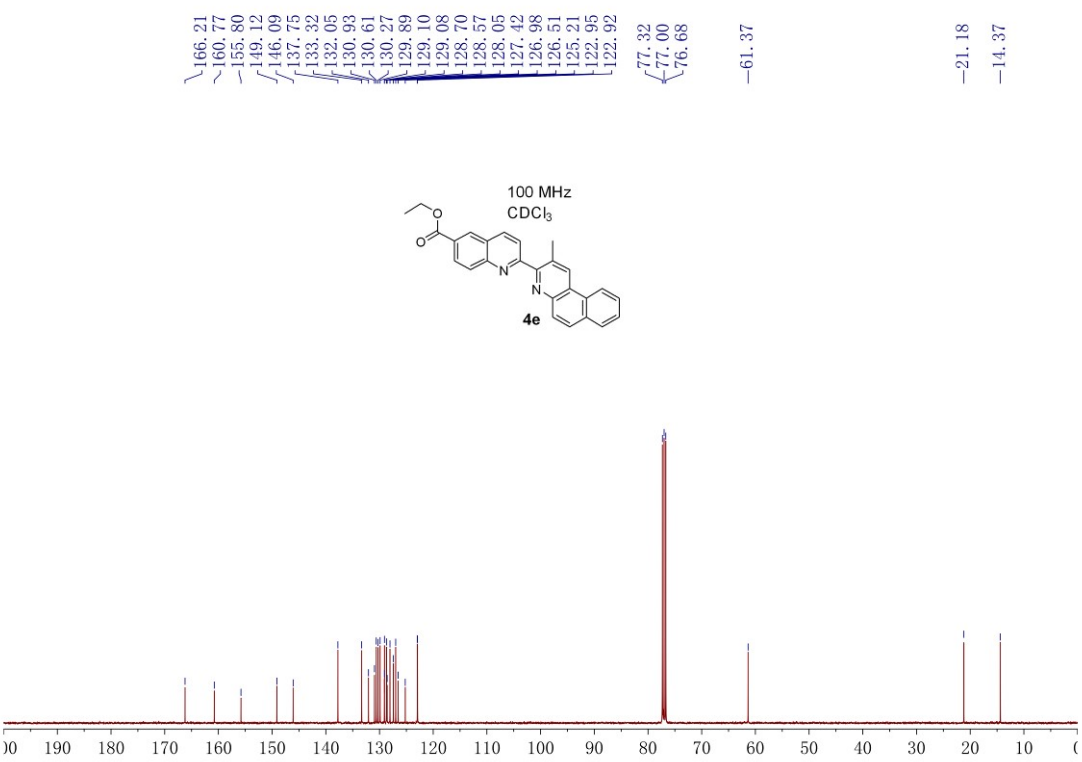
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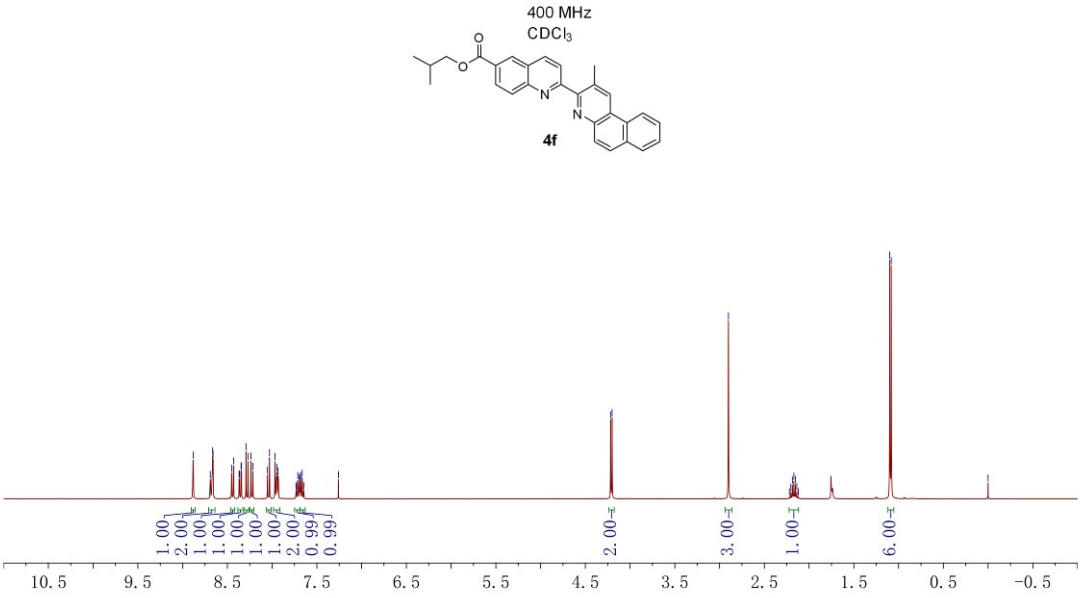
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1.00
6.00
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166.22
160.77
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146.09
137.76
133.32
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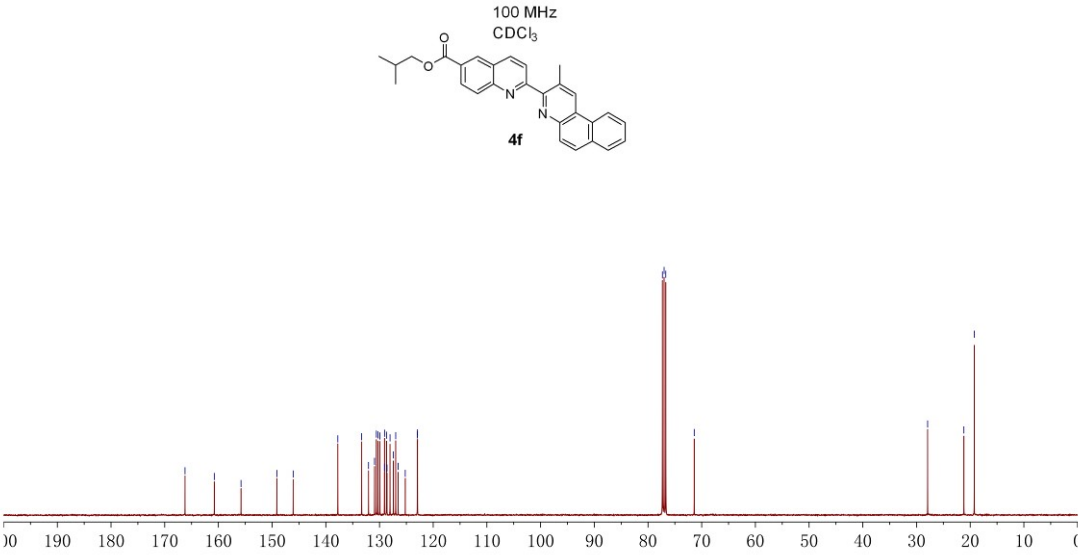
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180
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150
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120
110
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70
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50
40
30
20
10


8.890
8.698
8.678
8.647
8.643
8.452
8.431
8.361
8.357
8.339
8.335
8.289
8.267
8.228
8.206
8.057
8.034
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7.950
7.938
7.935
7.737
7.734
7.719
7.716
7.700
7.696
7.687
7.684
7.667
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7.648
7.259
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5.360
5.348
5.342
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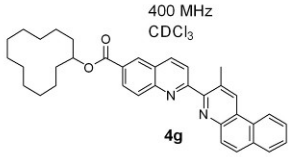
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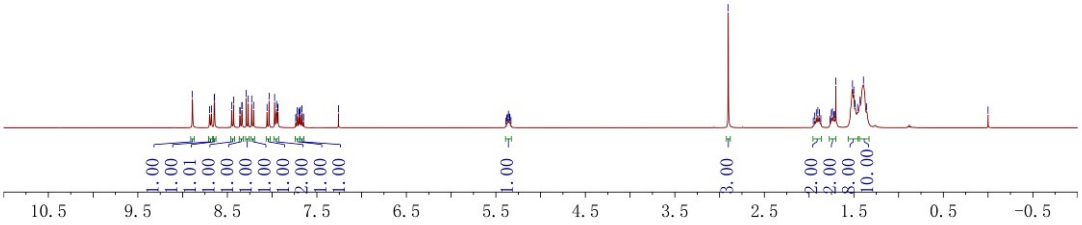
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8.00
10.00
10.5
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7.5
6.5
5.5
4.5
3.5
2.5
1.5
0.5
-0.5


165.84
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155.86
149.09
146.10
137.77
133.32
132.04
130.94
130.48
130.27
129.84
129.15
129.11
129.05
128.70
128.06
127.41
126.98
126.52
125.20
122.92
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76.68
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23.96
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23.11
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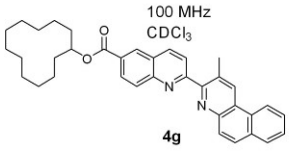
20.88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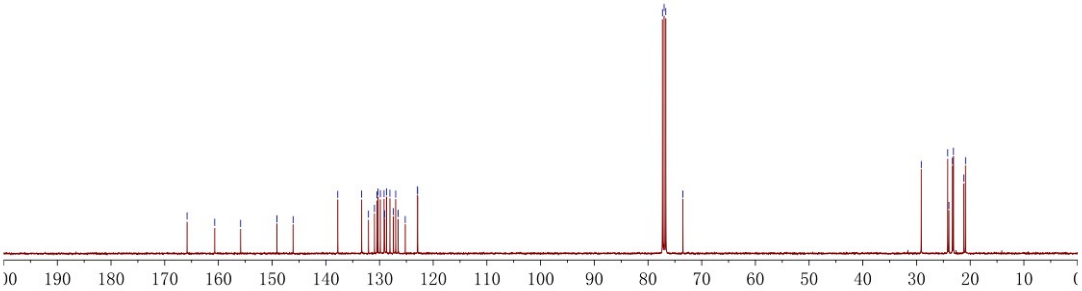
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80
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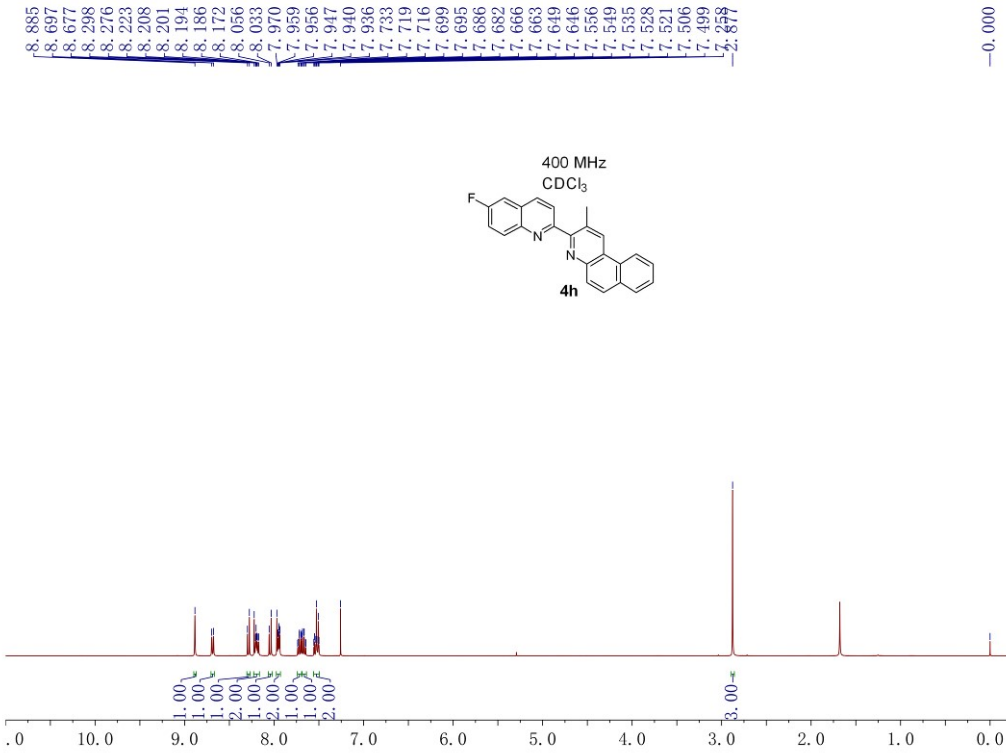
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7.959
7.956
7.947
7.940
7.936
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7.719
7.716
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7.695
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7.682
7.666
7.663
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7.646
7.556
7.549
7.535
7.528
7.521
7.506
7.499
2.877
0.000
400 MHz
CDCl3
F
N
N
4h
1.00
1.00
1.00
2.00
1.00
2.00
1.00
1.00
2.00
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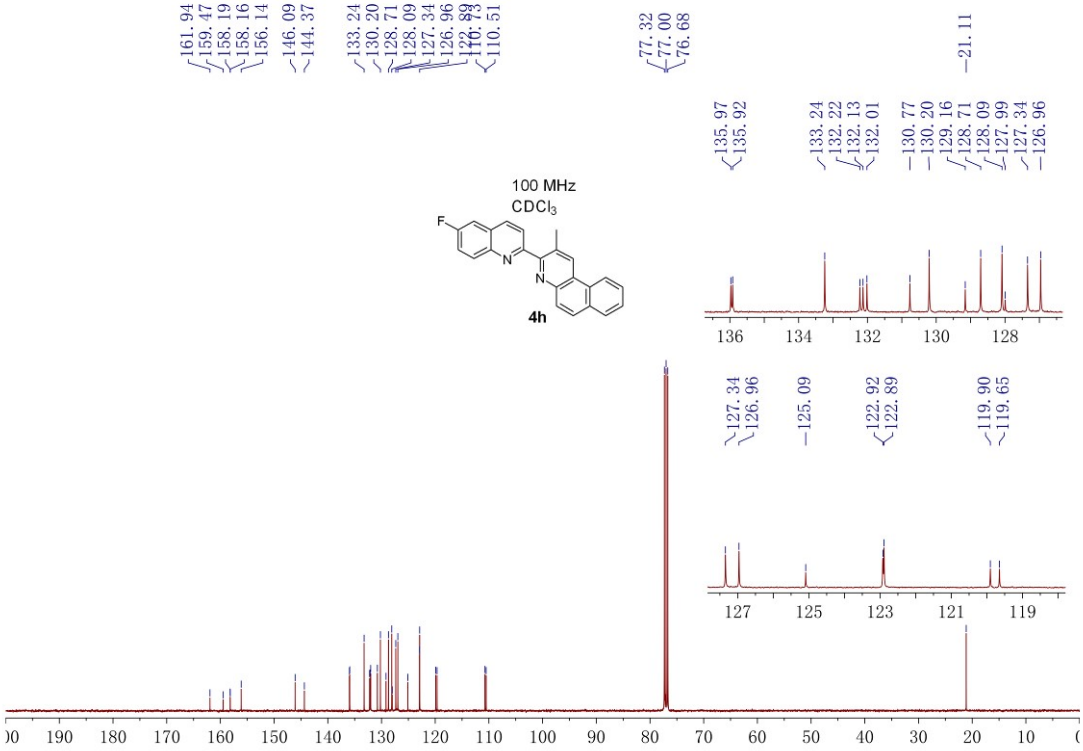
0.0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126.96
110.51
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77.00
76.68
21.11
135.97
135.92
133.24
132.22
132.13
132.01
130.77
130.20
129.16
128.71
128.09
127.99
127.34
126.96
127.34
126.96
125.09
122.92
122.89
119.90
119.65
100 MHz
CDCl3
F
N
N
4h
136
134
132
130
128
127
125
123
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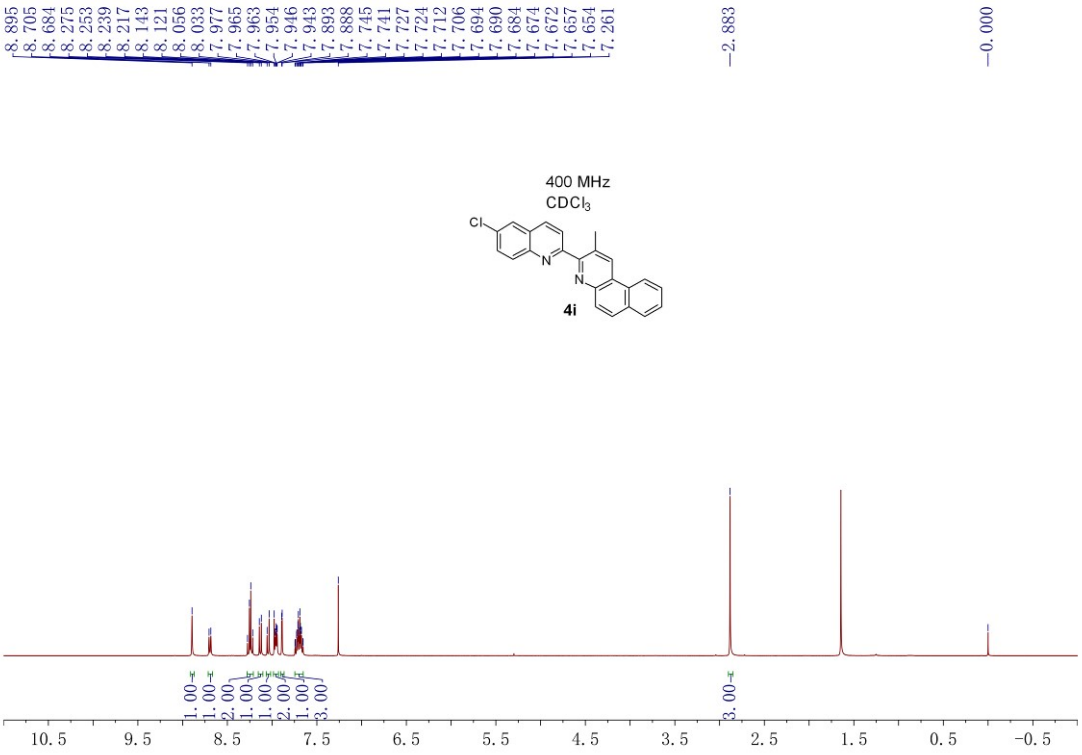
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8.143
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8.056
8.033
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7.965
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7.954
7.946
7.943
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7.888
7.745
7.741
7.727
7.724
7.712
7.706
7.694
7.690
7.684
7.674
7.672
7.657
7.654
7.261
2.883
0.000
400 MHz
CDCl3
Cl
N
N
4i
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1.00
2.00
1.00
1.00
2.00
1.00
3.00
3.00
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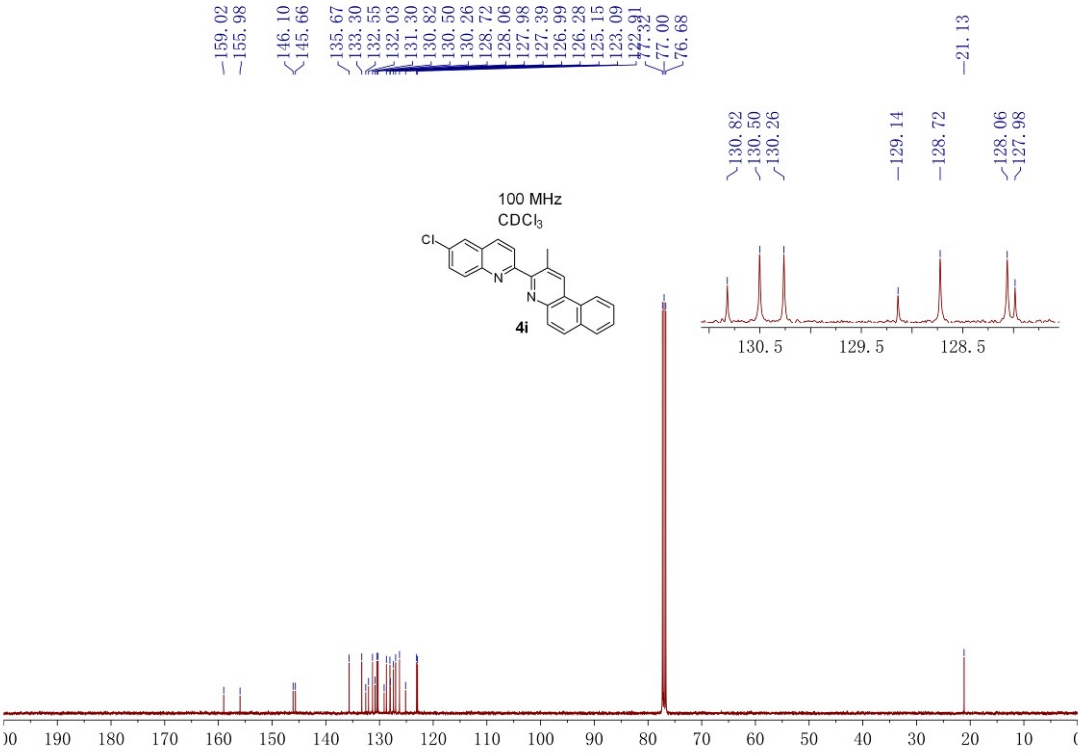
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132.03
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128.72
128.06
127.98
127.39
126.99
126.28
125.15
123.09
122.91
77.32
77.00
76.68
21.13
130.82
130.50
130.26
129.14
128.72
128.06
127.98
100 MHz
CDCl3
Cl
N
N
4i
130.5
129.5
128.5
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160
150
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120
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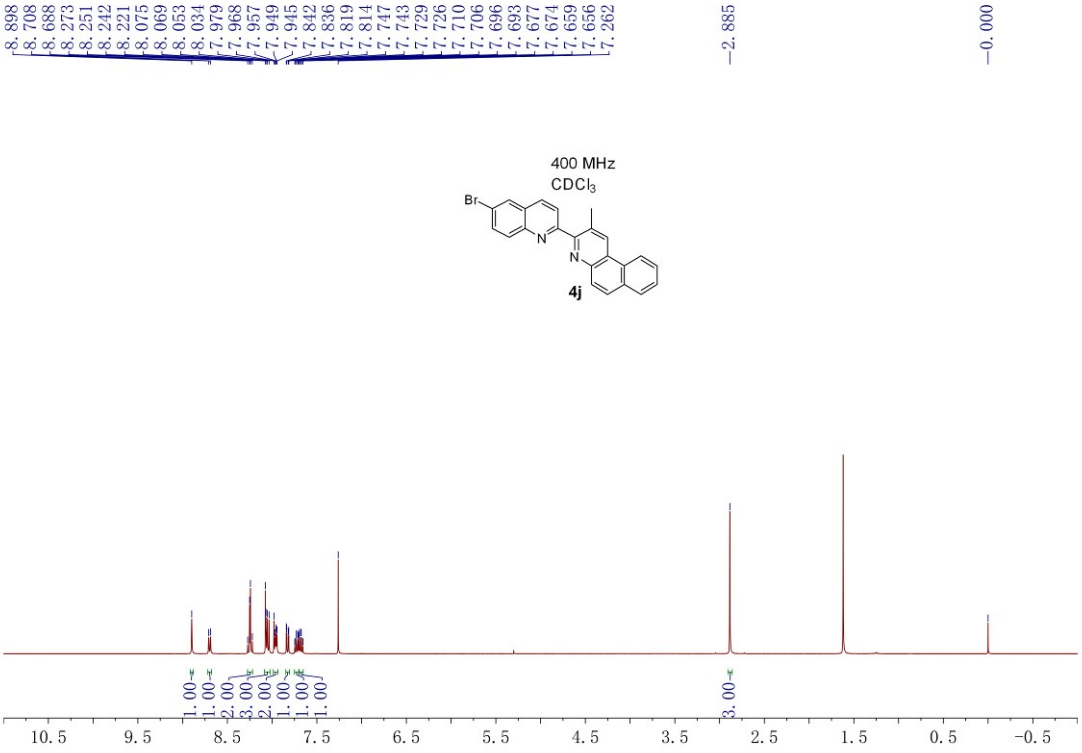
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7.968
7.957
7.949
7.945
7.842
7.836
7.819
7.814
7.747
7.743
7.729
7.726
7.710
7.706
7.696
7.693
7.677
7.674
7.659
7.656
7.262
2.885
0.000
400 MHz
CDCl3
Br
N
N
4j
1.00
1.00
2.00
3.00
2.00
1.00
1.00
1.00
3.00
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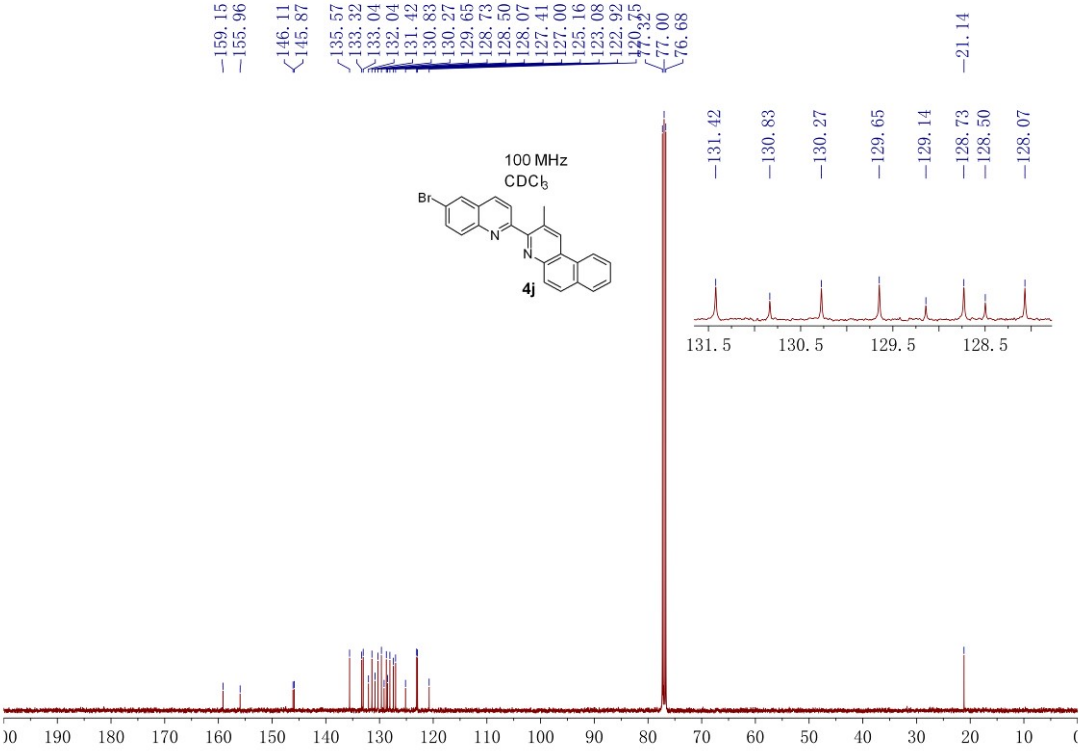
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77.32
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131.42
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128.07
100 MHz
CDCl3
Br
N
N
4j
131.5
130.5
129.5
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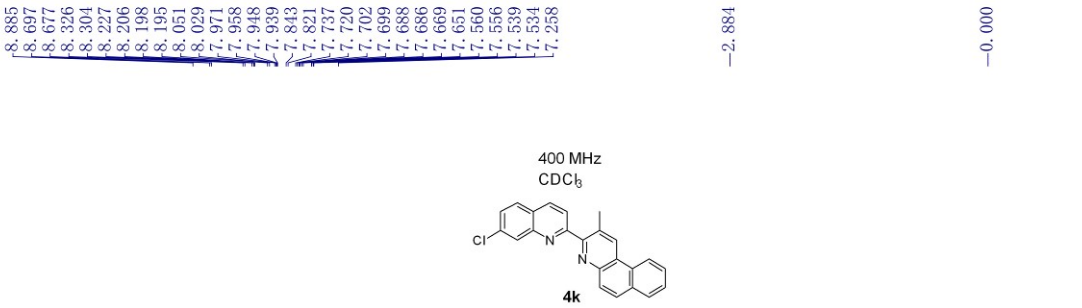
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8.051
8.029
7.971
7.958
7.948
7.939
7.843
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7.737
7.720
7.702
7.699
7.688
7.686
7.669
7.651
7.560
7.556
7.539
7.534
7.258
2.884
0.000

400 MHz
CDCl3
Cl
N
N
4k
1.00
1.00
1.00
2.00
1.00
2.00
1.00
2.00
1.00
3.00
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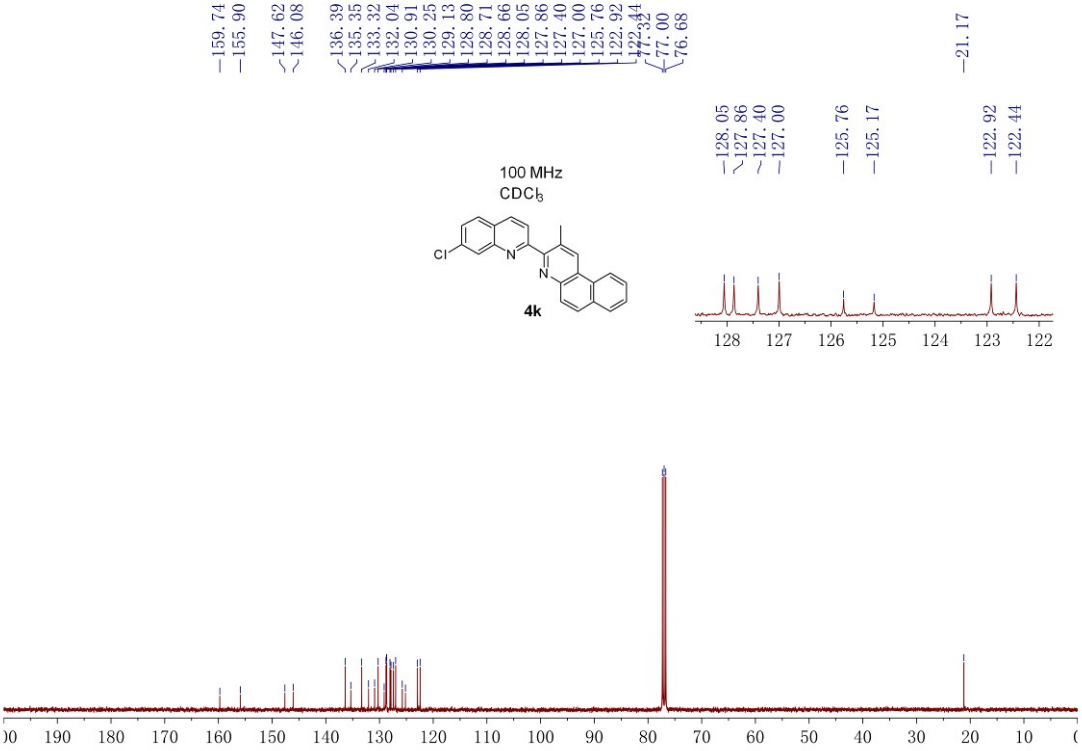
-0.5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127.40
127.00
125.76
122.92
122.44
77.32
77.00
76.68
21.17
128.05
127.86
127.40
127.00
125.76
125.17
122.92
122.44
100 MHz
CDCl3
Cl
N
N
4k
128
127
126
125
124
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20
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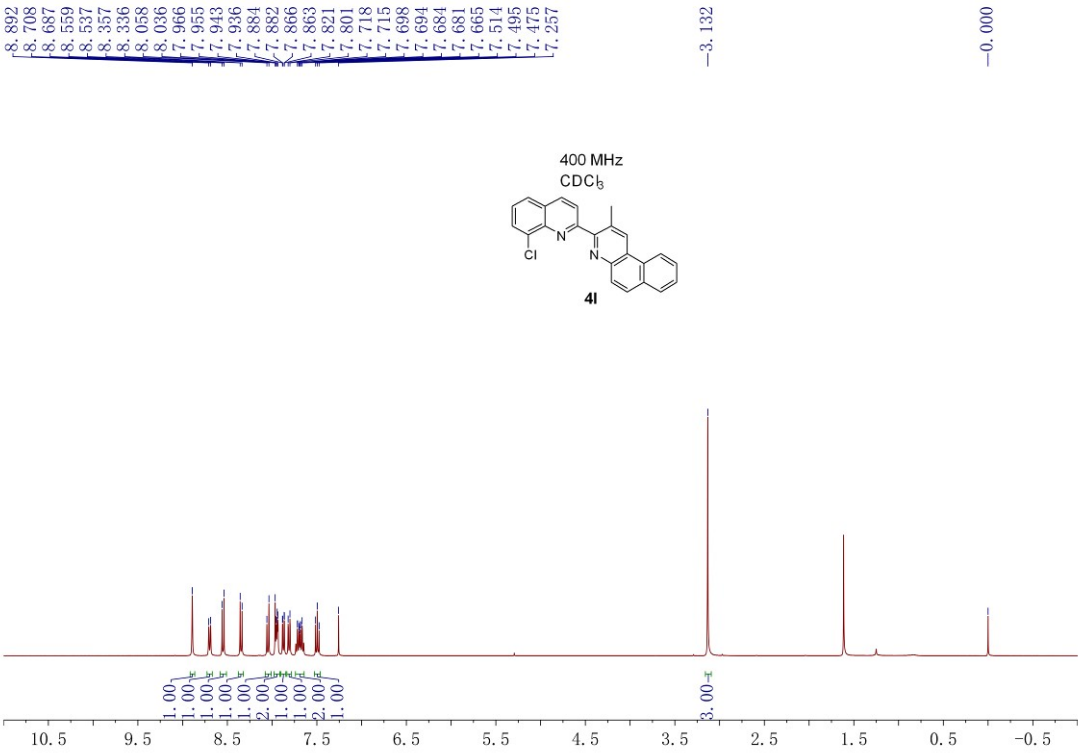
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7.821
7.801
7.718
7.715
7.698
7.694
7.684
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7.665
7.514
7.495
7.475
7.257
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Cl
N
N
4l
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2.00
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1.00
3.00
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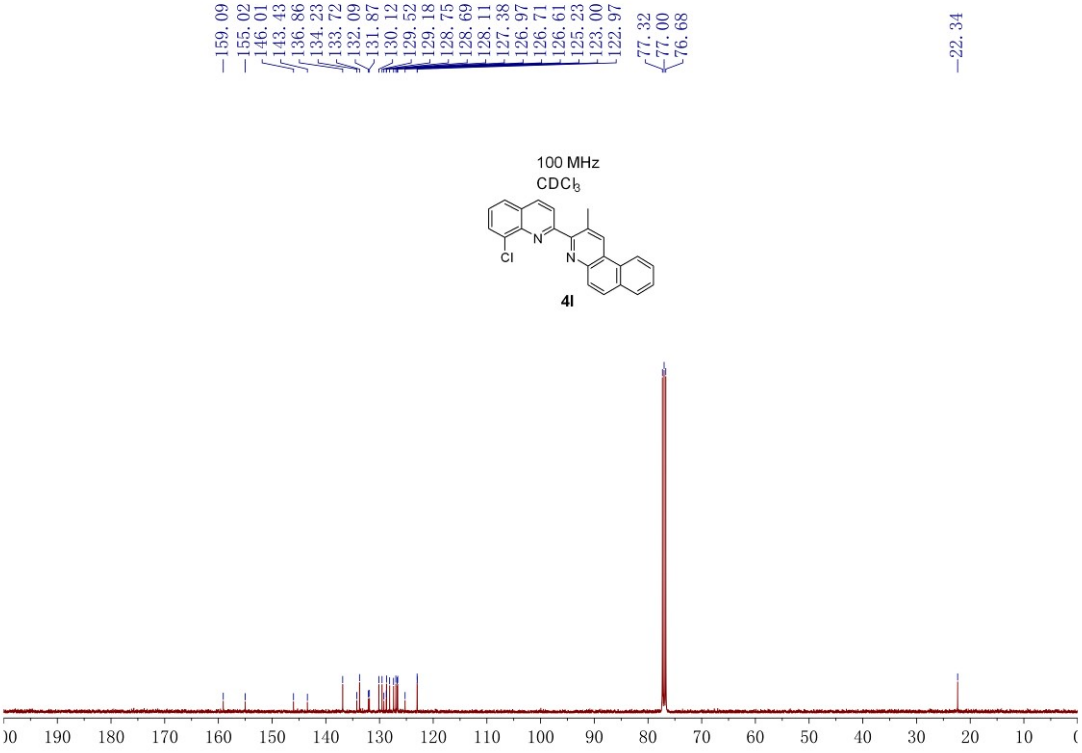
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128.11
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126.71
126.61
125.23
123.00
122.97
77.32
77.00
76.68
22.34
100 MHz
CDCl3
Cl
N
N
4l
190
180
170
160
150
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100
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80
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20
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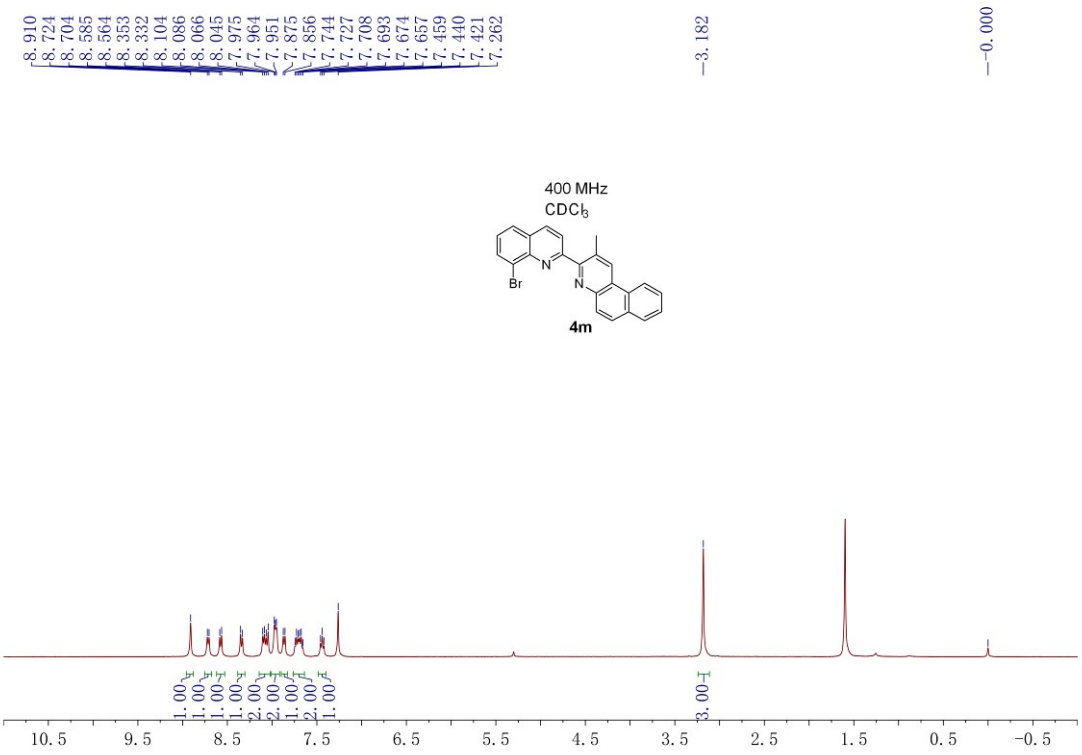
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8.066
8.045
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7.951
7.875
7.856
7.744
7.727
7.708
7.693
7.674
7.657
7.459
7.440
7.421
7.262
3.182
0.000
400 MHz
CDCl3
Br
N
N
4m
1.00
1.00
1.00
1.00
2.00
2.00
1.00
2.00
1.00
3.00
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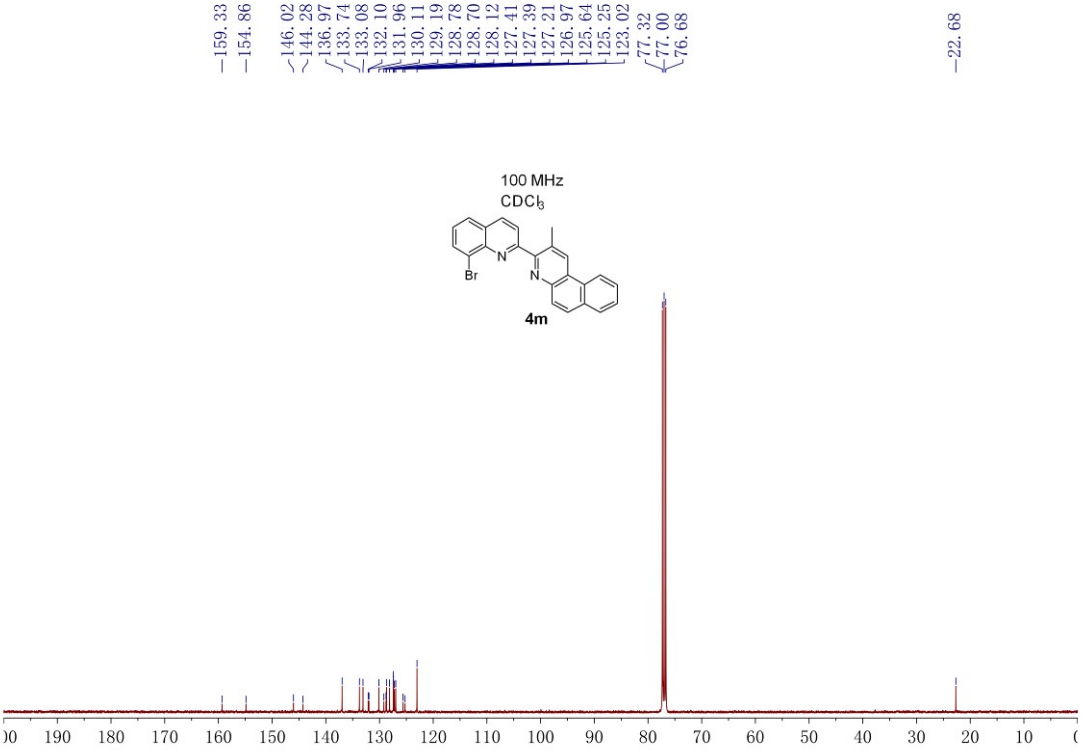
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128.12
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127.39
127.21
126.97
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125.25
123.02
77.32
77.00
76.68
22.68
100 MHz
CDCl3
Br
N
N
4m
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80
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40
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20
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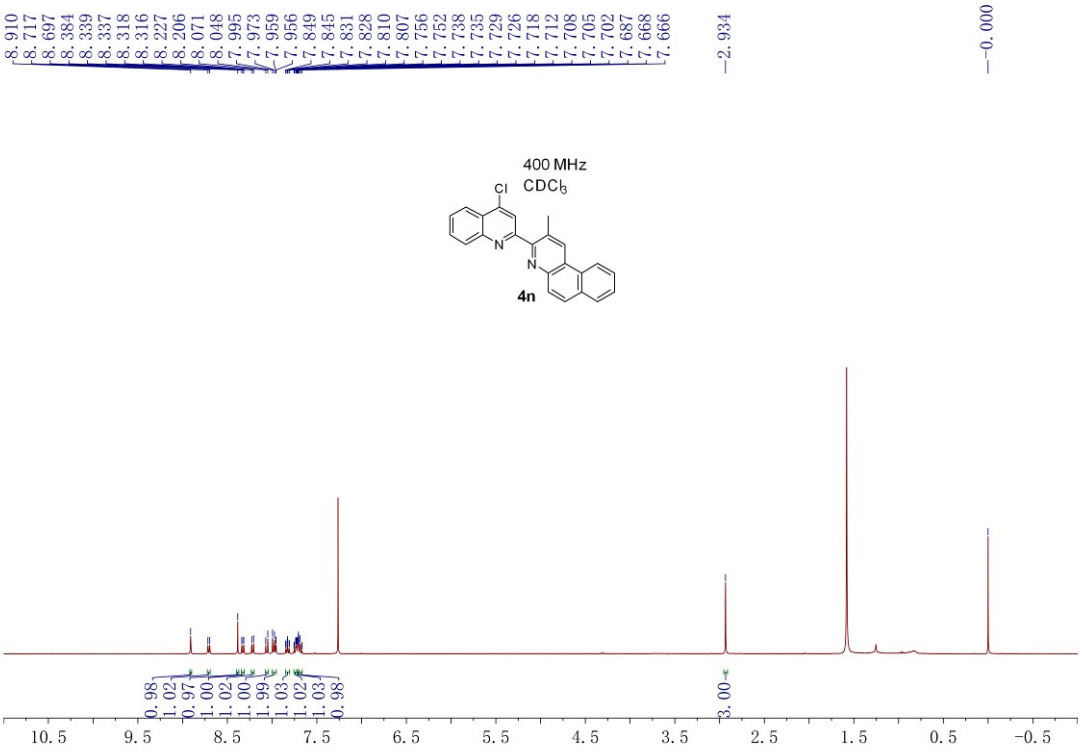
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7.729
7.726
7.718
7.712
7.708
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7.668
7.666
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0.000
400 MHz
CDCl3
Cl
N
N
4n
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1.02
1.00
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1.02
1.03
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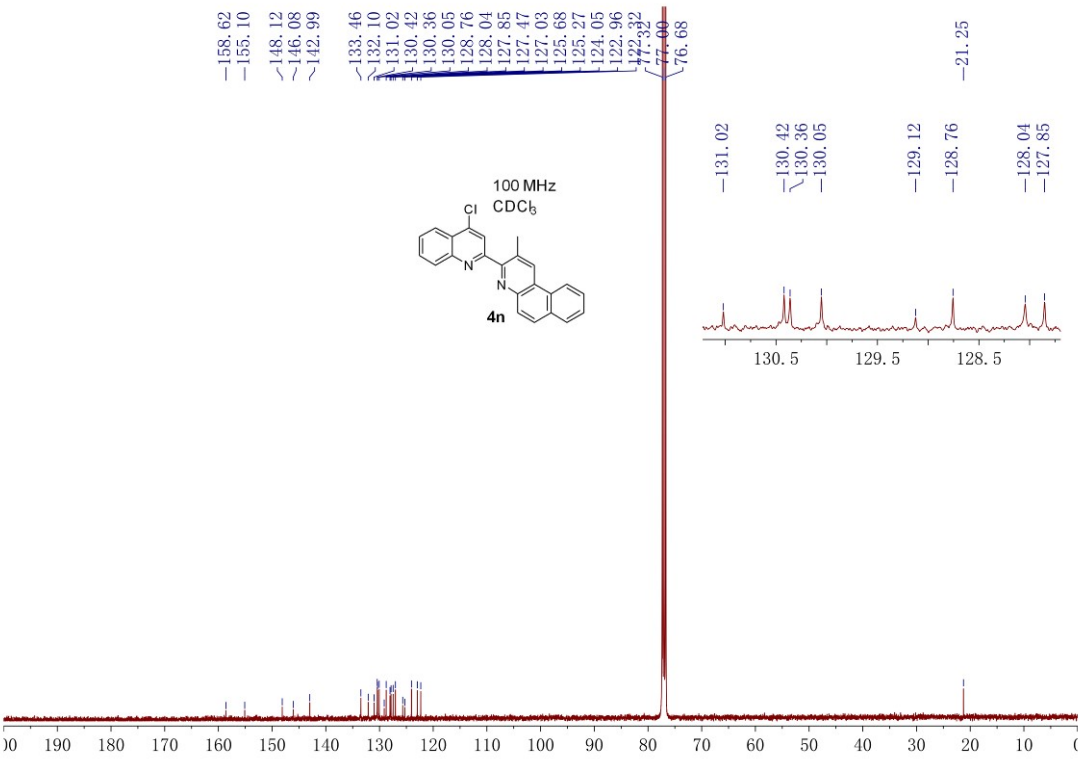
-0.5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127.47
127.03
125.68
125.27
124.05
122.96
122.32
77.00
76.68
21.25
131.02
130.42
130.36
130.05
129.12
128.76
128.04
127.85
100 MHz
CDCl3
Cl
N
N
4n
130.5
129.5
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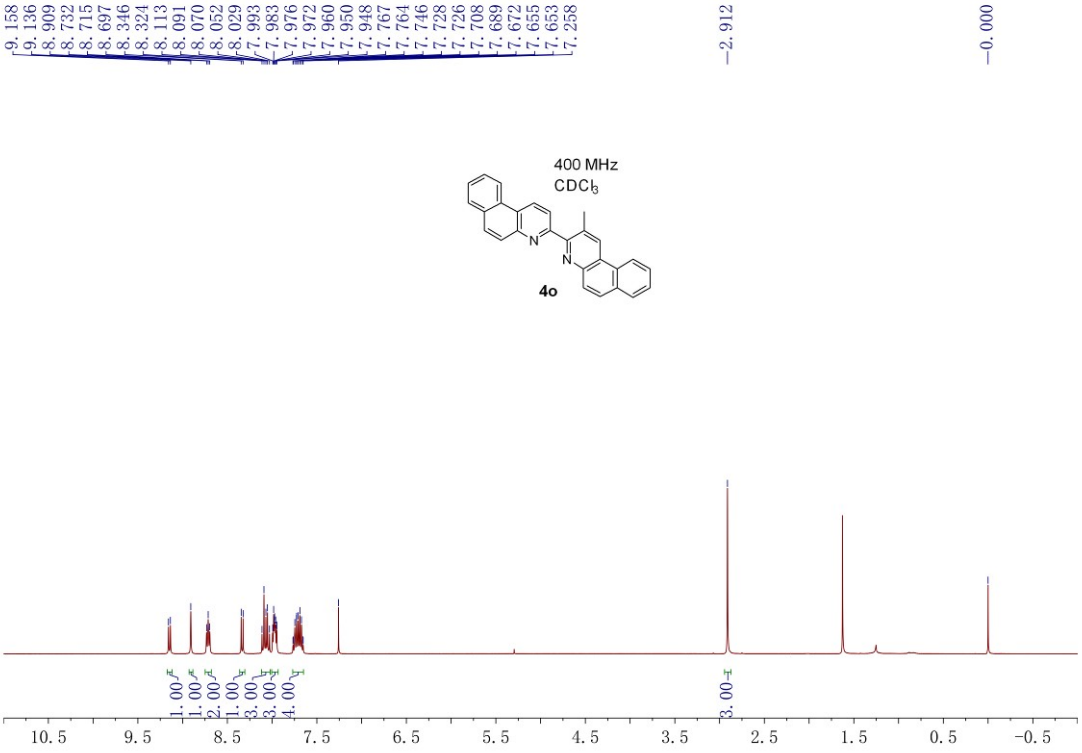
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8.052
8.029
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7.983
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7.972
7.960
7.950
7.948
7.767
7.764
7.746
7.728
7.726
7.708
7.689
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7.653
7.258
2.912
0.000
400 MHz
CDCl3
4o
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1.00
2.00
1.00
3.00
3.00
4.00
3.00
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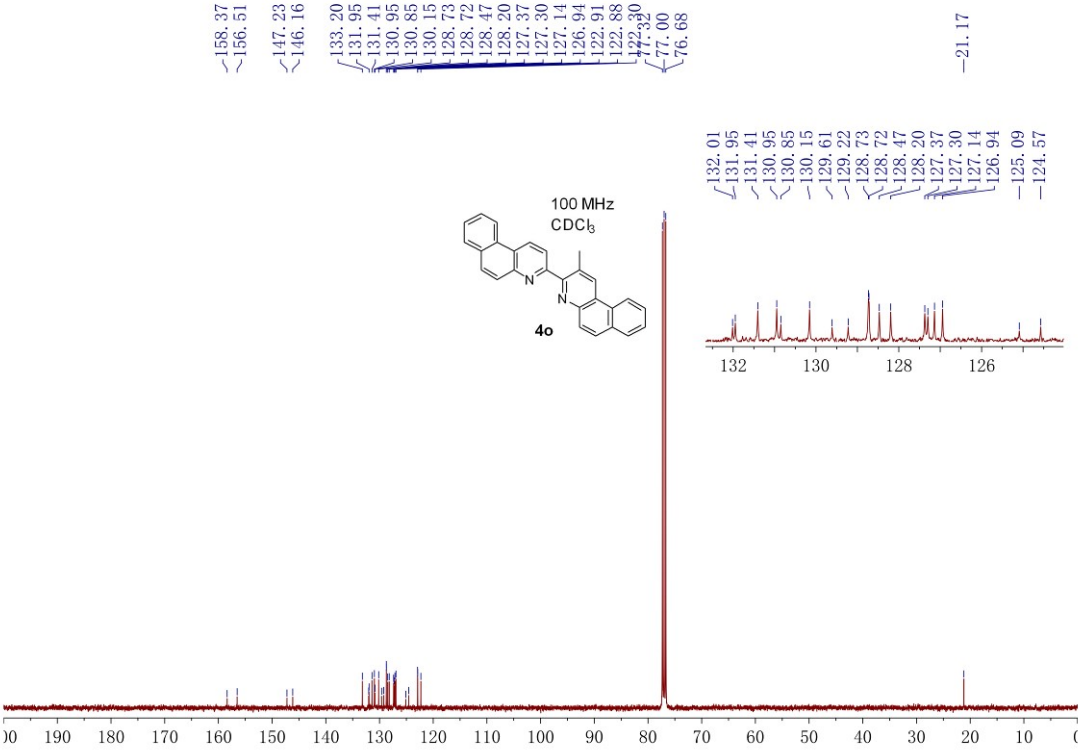
-0.5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127.37
127.30
127.14
126.94
122.91
122.88
77.32
77.00
76.68
21.17
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128.72
128.47
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127.37
127.30
127.14
126.94
125.09
124.57
100 MHz
CDCl3
4o
132
130
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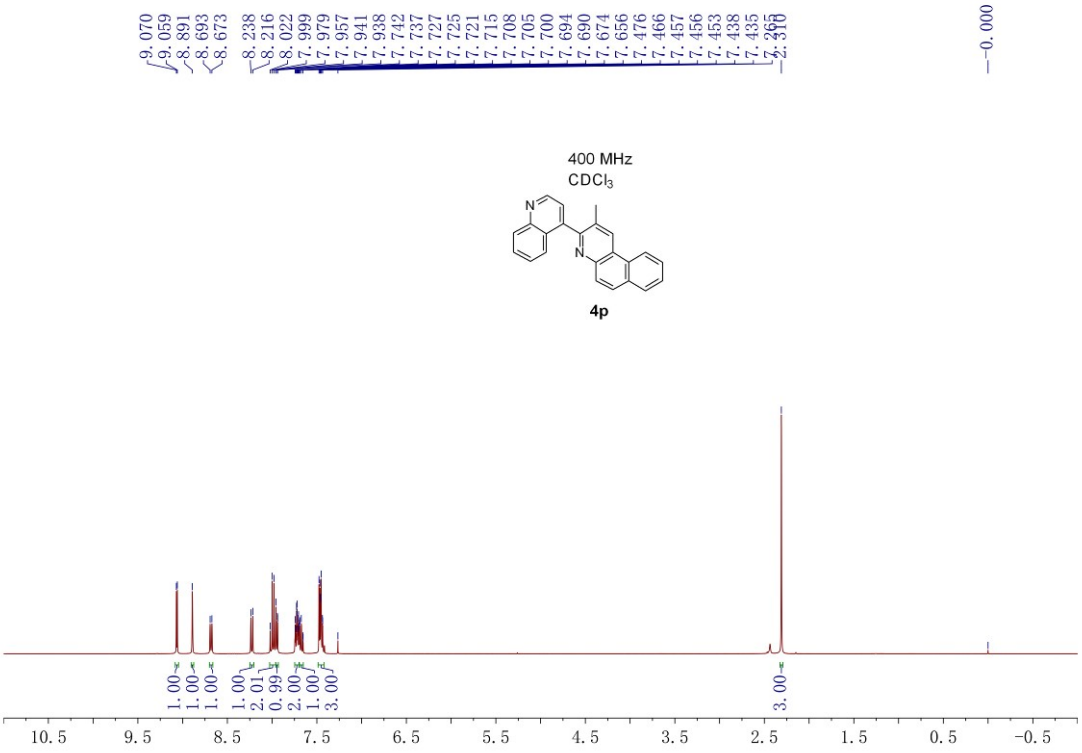
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7.938
7.742
7.737
7.727
7.725
7.721
7.715
7.708
7.705
7.700
7.694
7.690
7.674
7.656
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7.466
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7.456
7.453
7.438
7.435
2.310
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CDCl3
4p
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1.00
1.00
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0.99
2.00
1.00
3.00
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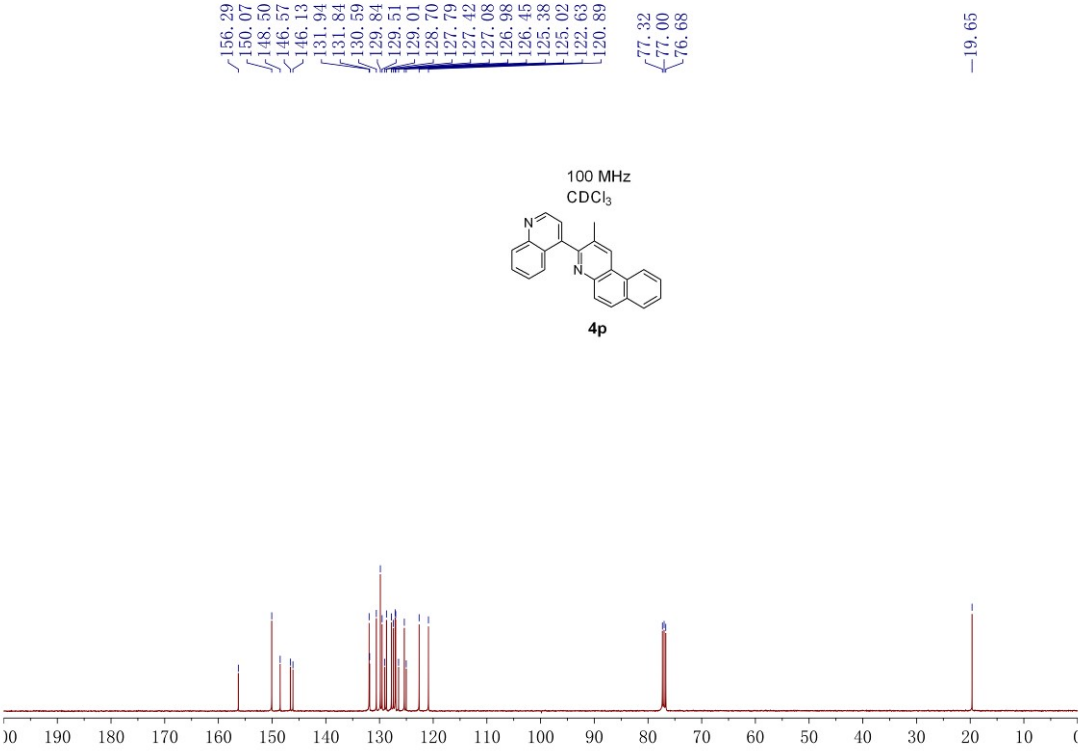
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125.38
125.02
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120.89
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77.00
76.68
19.65
100 MHz
CDCl3
4p
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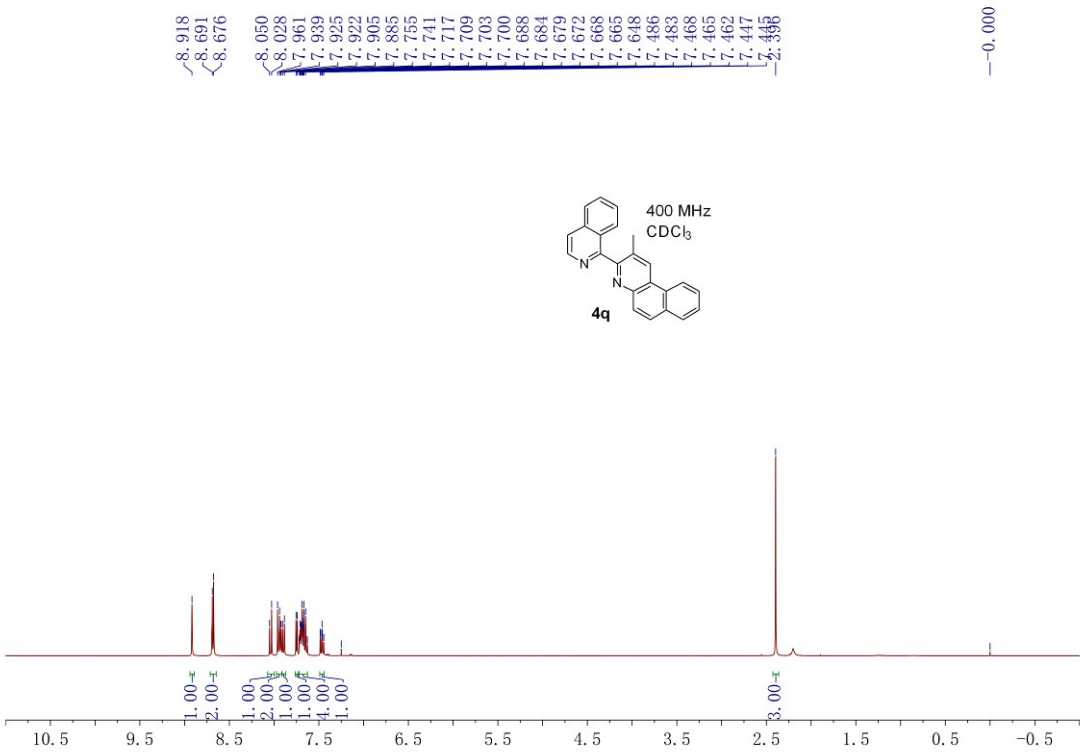
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7.905
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7.755
7.741
7.717
7.709
7.703
7.700
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7.684
7.679
7.672
7.668
7.665
7.648
7.486
7.483
7.468
7.465
7.462
7.447
7.445
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CDCl3
4q
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2.00
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3.00
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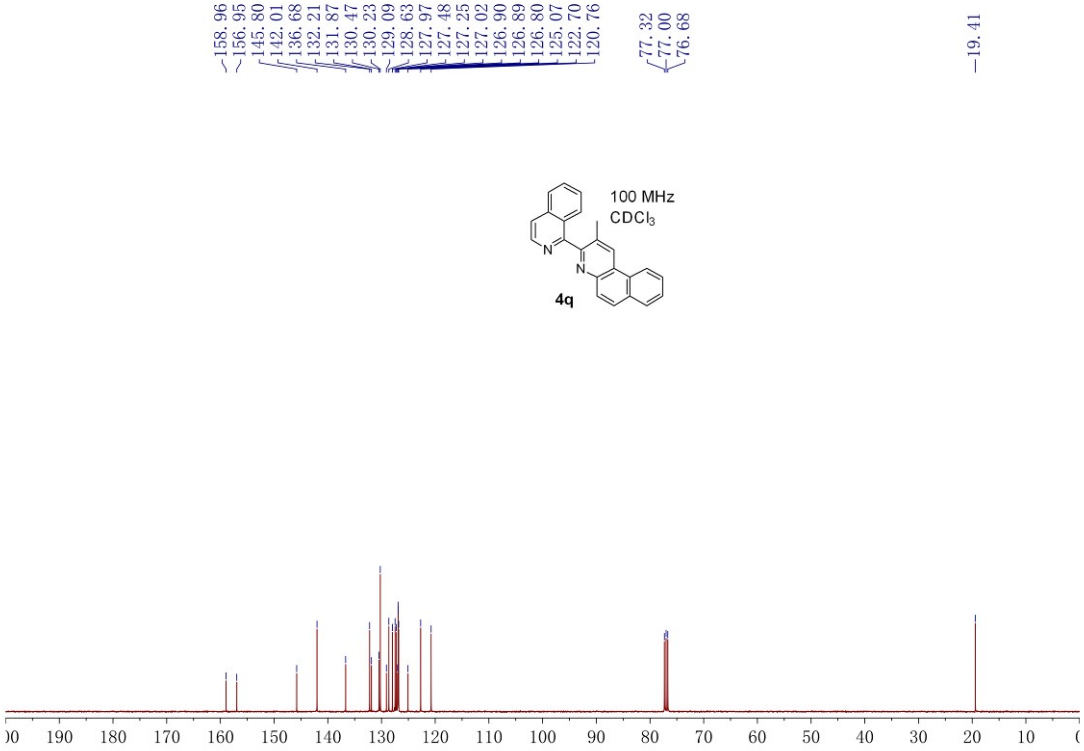
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127.25
127.02
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126.89
126.80
125.07
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120.76
77.32
77.00
76.68
19.41
100 MHz
CDCl3
4q
190
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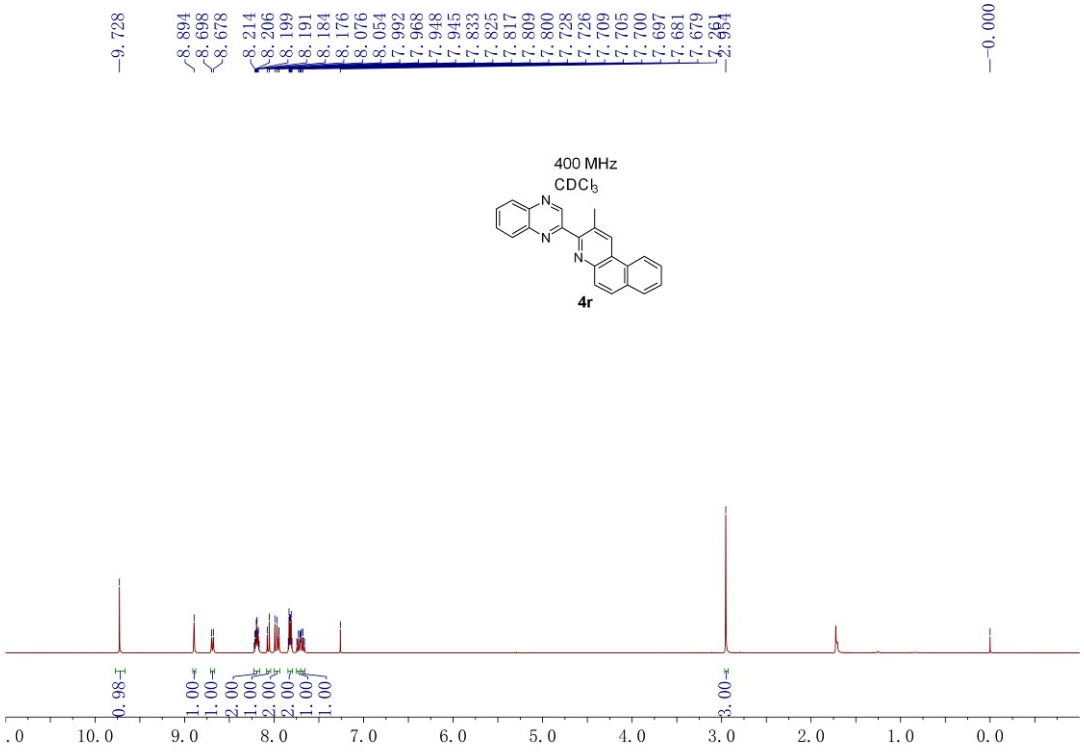
10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8.191
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8.176
8.076
8.054
7.992
7.968
7.948
7.945
7.833
7.825
7.817
7.809
7.800
7.728
7.726
7.709
7.705
7.700
7.697
7.681
7.679
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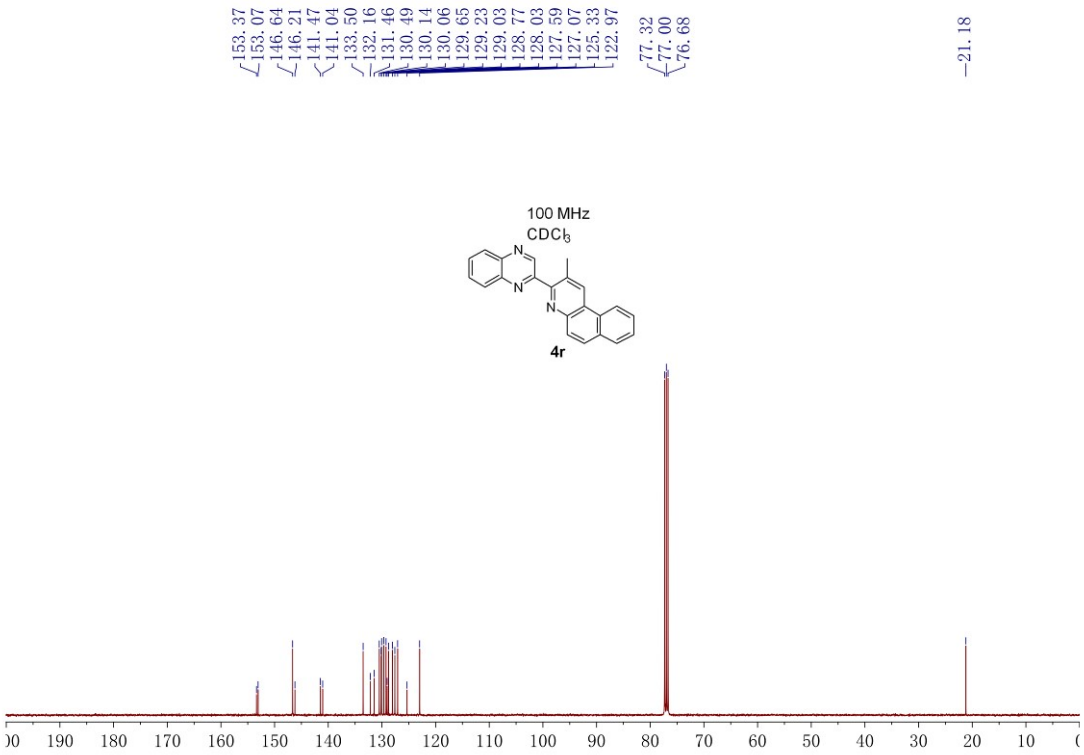
3.00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132.16
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130.49
130.14
130.06
129.65
129.23
129.03
128.77
128.03
127.59
127.07
125.33
122.97
77.32
77.00
76.68
21.18
100 MHz
CDCl3
4r


8.794
8.744
8.733
8.629
8.609
8.025
8.002
7.952
7.933
7.923
7.910
7.900
7.892
7.889
7.877
7.872
7.857
7.853
7.668
7.665
7.648
7.644
7.638
7.634
7.618
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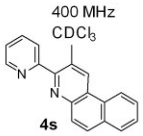
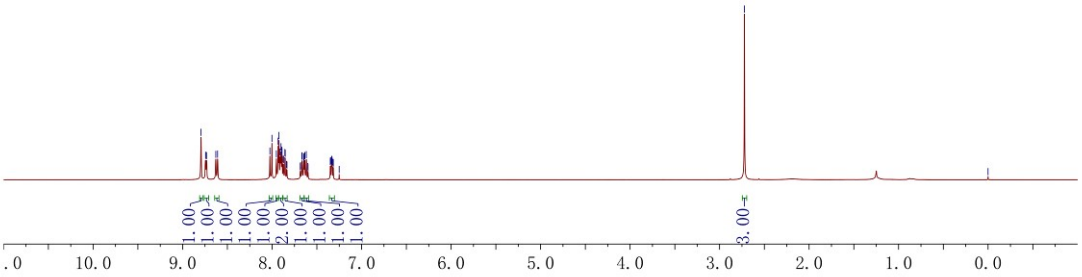
7.338
7.335
7.331
2.722
0.000


400 MHz
CDCl3
4s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1.00
1.00
2.00
1.00
1.00
1.00
3.00
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0


158.87
156.68
148.53
145.93
136.67
132.86
131.83
130.16
130.01
129.08
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127.15
126.82
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124.40
122.84
122.74
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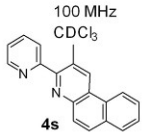
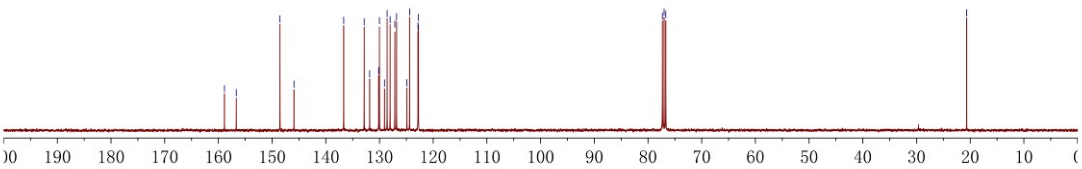
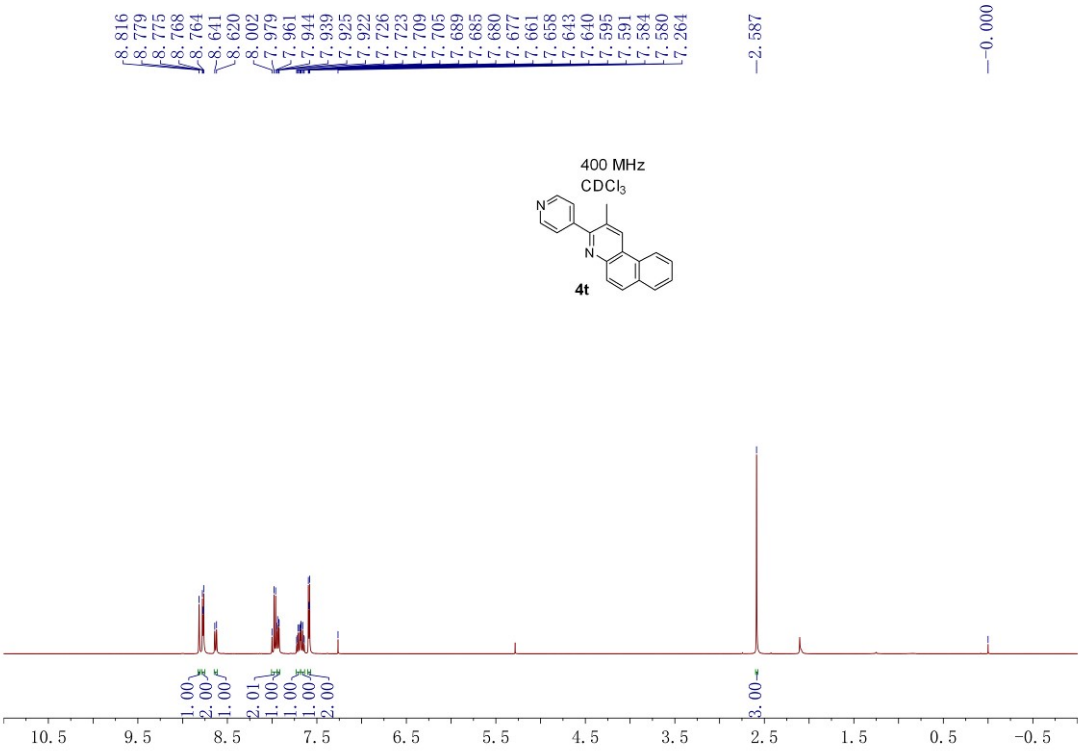
77.00
76.68
20.65


100 MHz
CDCl3
4s


190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10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8.002
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7.961
7.944
7.939
7.925
7.922
7.726
7.723
7.709
7.705
7.689
7.685
7.680
7.677
7.661
7.658
7.643
7.640
7.595
7.591
7.584
7.580
7.264
2.587
0.000
400 MHz
CDCl3
4t
1.00
2.00
1.00
2.01
1.00
1.00
1.00
2.00
3.00
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7.5
6.5
5.5
4.5
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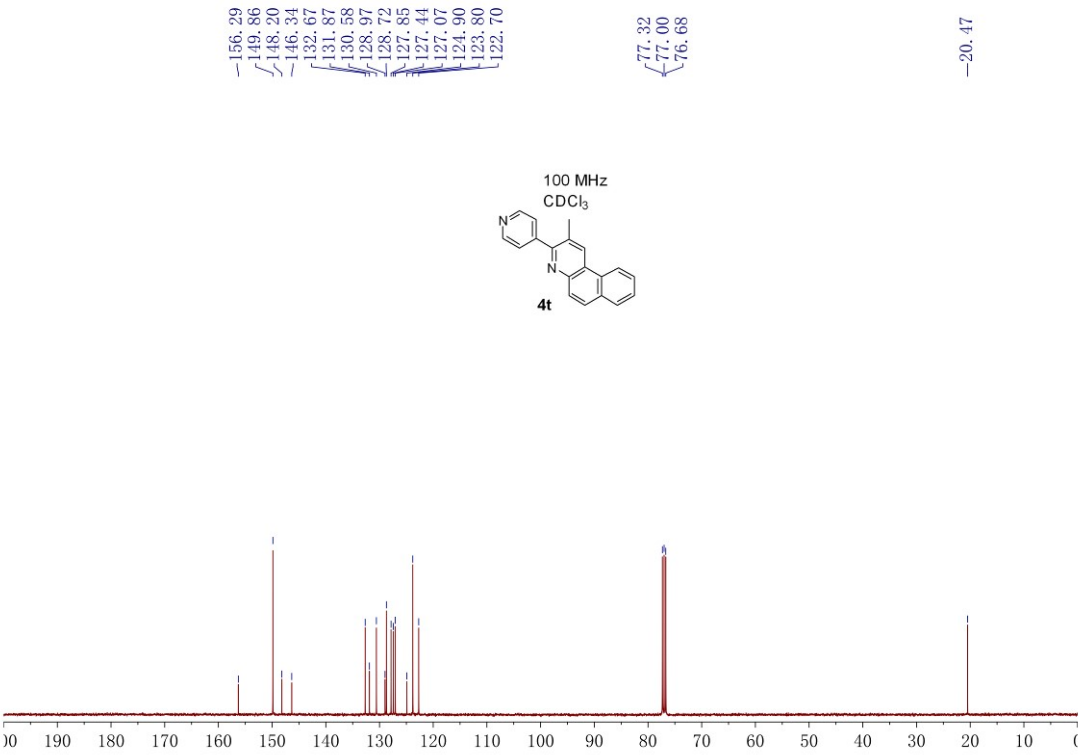
0.5
-0.5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128.97
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127.85
127.44
127.07
124.90
123.80
122.70
77.32
77.00
76.68
20.47
100 MHz
CDCl3
4t
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180
170
160
150
140
130
120
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100
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80
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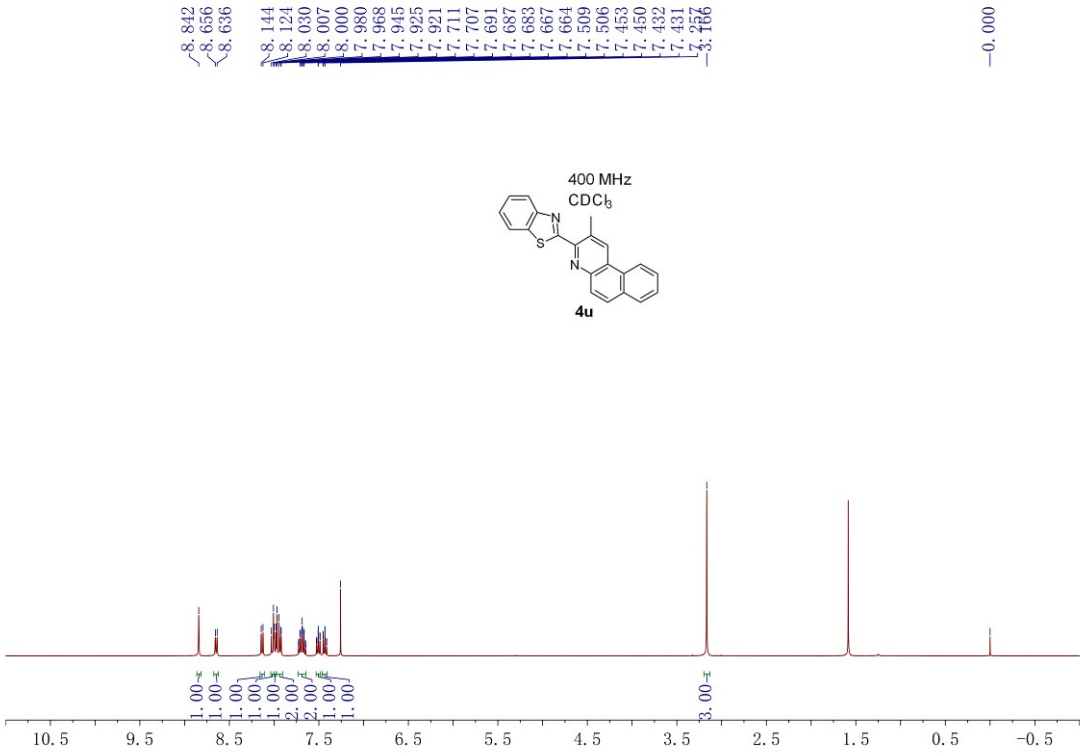
20
10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8.000
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7.968
7.945
7.925
7.921
7.711
7.707
7.691
7.687
7.683
7.667
7.664
7.509
7.506
7.453
7.450
7.432
7.431
7.257
7.166
0.000
400 MHz
CDCl3
4u
1.00
1.00
1.00
1.00
2.00
2.00
1.00
1.00
3.00
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7.5
6.5
5.5
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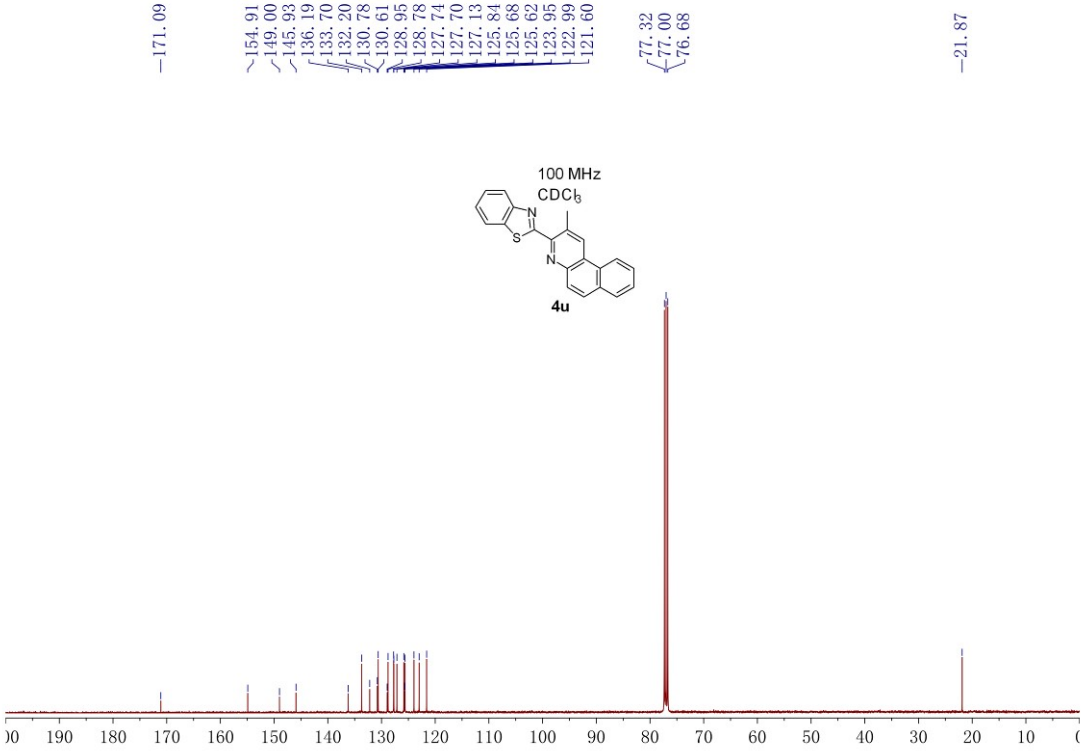
-0.5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127.70
127.13
125.84
125.68
125.62
123.95
122.99
121.60
77.32
77.00
76.68
21.87
100 MHz
CDCl3
4u
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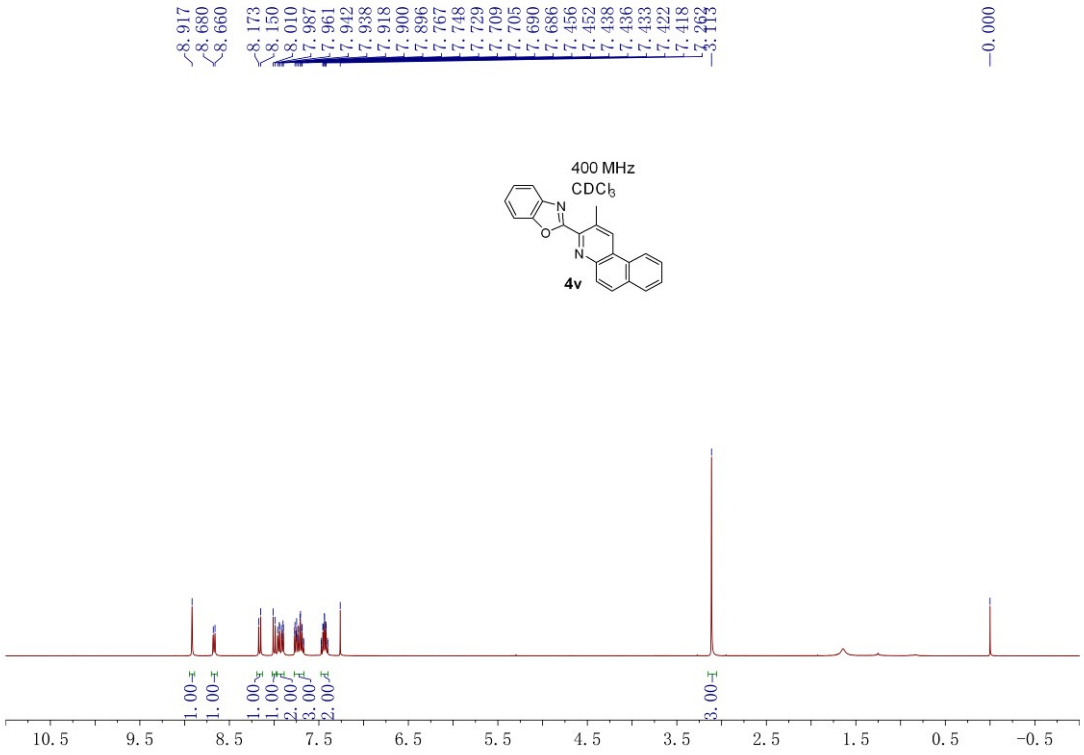
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7.961
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7.938
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7.705
7.690
7.686
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7.452
7.438
7.436
7.433
7.422
7.418
7.263
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CDCl3
4v
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1.00
1.00
1.00
2.00
3.00
2.00
3.00
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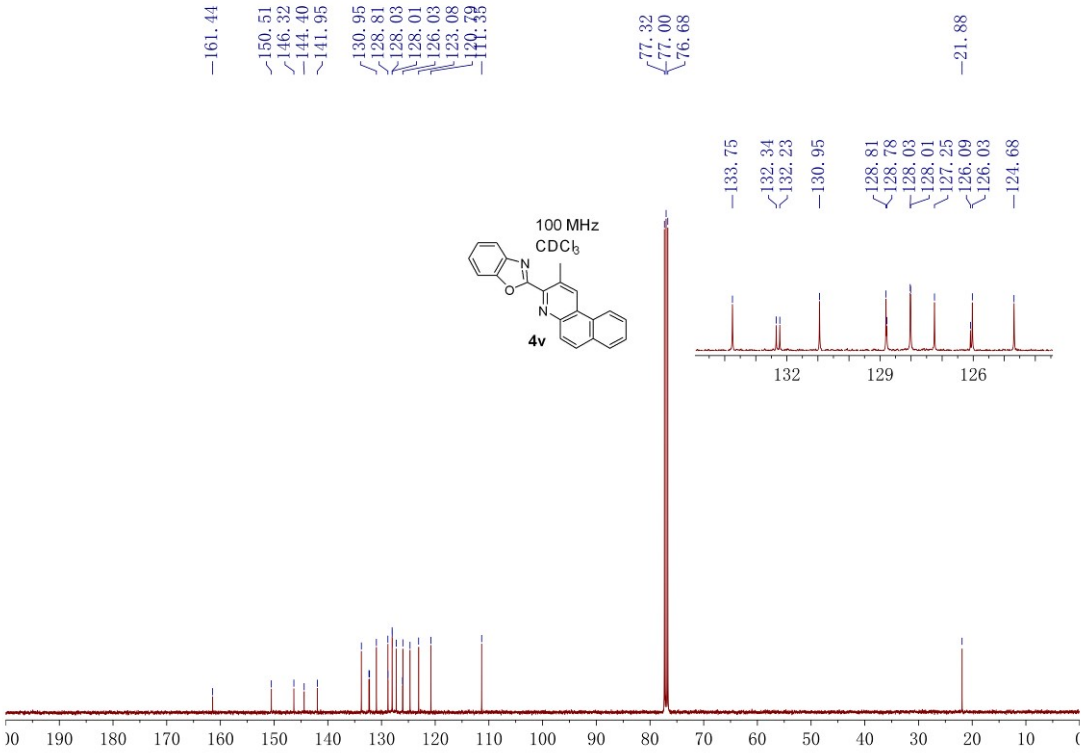
-0.5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126.03
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111.35
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77.00
76.68
21.88
133.75
132.34
132.23
130.95
128.81
128.78
128.03
128.01
127.25
126.09
126.03
124.68
100 MHz
CDCl3
4v
132
129
126
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170
160
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20
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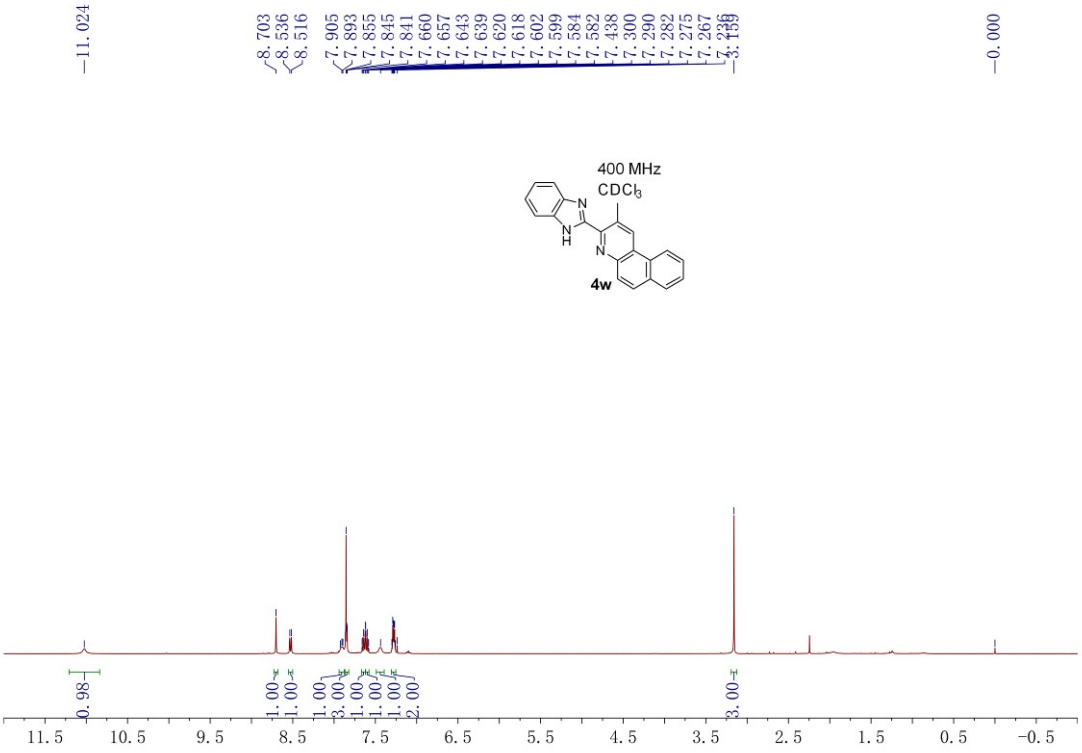
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7.660
7.657
7.643
7.639
7.620
7.618
7.602
7.599
7.584
7.582
7.438
7.300
7.290
7.282
7.275
7.267
7.236
3.159
0.000
400 MHz
CDCl3
4w
0.98
1.00
1.00
1.00
3.00
1.00
1.00
1.00
2.00
3.00
11.5
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5.5
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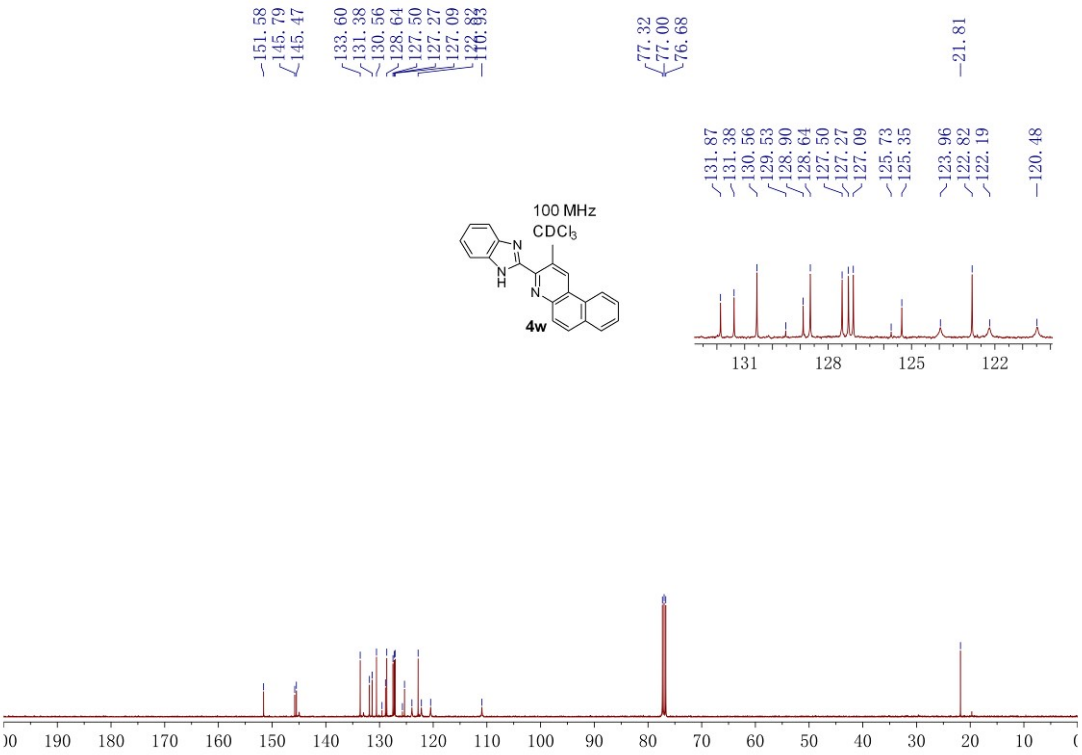
0.5
-0.5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127.09
122.82
116.93
77.32
77.00
76.68
21.81
131.87
131.38
130.56
129.53
128.90
128.64
127.50
127.27
127.09
125.73
125.35
123.96
122.82
122.19
120.48
100 MHz
CDCl3
4w
131
128
125
122
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10


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8.700
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8.661
8.477
8.456
8.372
8.367
8.350
8.345
8.298
8.277
8.241
8.219
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7.717
7.713
7.703
7.700
7.683
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2.043
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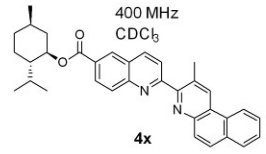
0.000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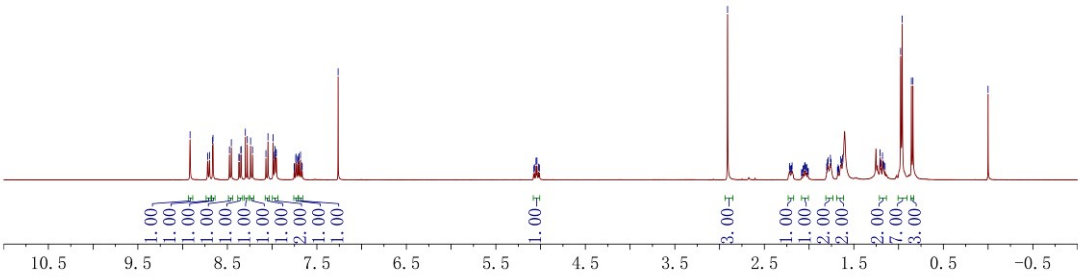
CDCl3
4x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3.00
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7.00
3.00
10.5
9.5
8.5
7.5
6.5
5.5
4.5
3.5
2.5
1.5
0.5
-0.5


165.73
160.73
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129.88
129.19
129.14
128.98
128.74
128.08
127.45
127.02
126.56
125.25
122.95
122.93
77.32
77.00
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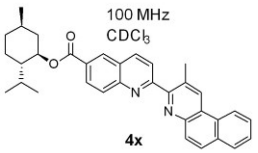
16.49


100 MHz
CDCl3
4x

190
180
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160
150
140
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120
110
100
90
80
70
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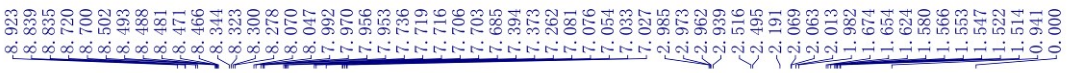
50
40
30
20
10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8.502
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8.471
8.466
8.344
8.323
8.300
8.278
8.070
8.047
7.992
7.970
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7.953
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7.706
7.703
7.685
7.394
7.373
7.262
7.081
7.076
7.054
7.033
7.027
2.985
2.973
2.962
2.939
2.516
2.495
2.191
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2.063
2.013
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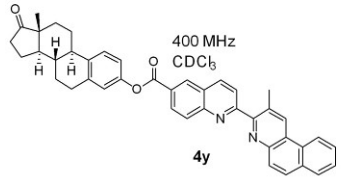
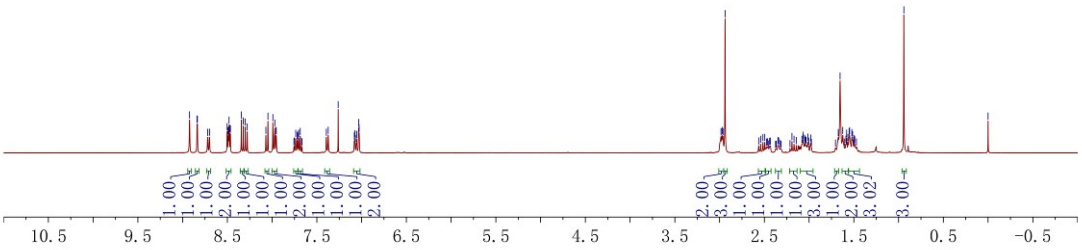

400 MHz
CDCl3
4y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1.00
1.00
2.00
1.00
1.00
2.00
2.00
3.00
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3.02
3.00
10.5
9.5
8.5
7.5
6.5
5.5
4.5
3.5
2.5
1.5
0.5
-0.5


220.87
165.11
161.19
155.71
149.42
148.79
146.15
138.20
137.88
137.63
133.42
132.10
131.53
130.99
130.36
130.20
129.34
129.12
128.75
128.06
127.72
127.50
127.05
126.58
125.29
123.20
122.96
121.69
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77.00
76.68
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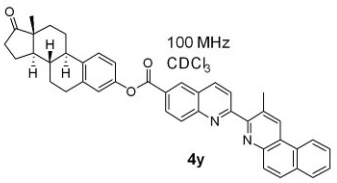
13.84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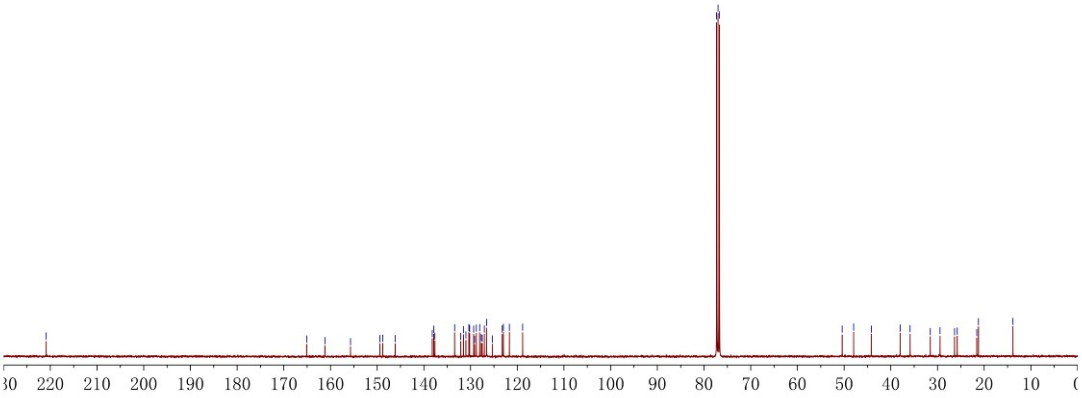
CDCl3
4y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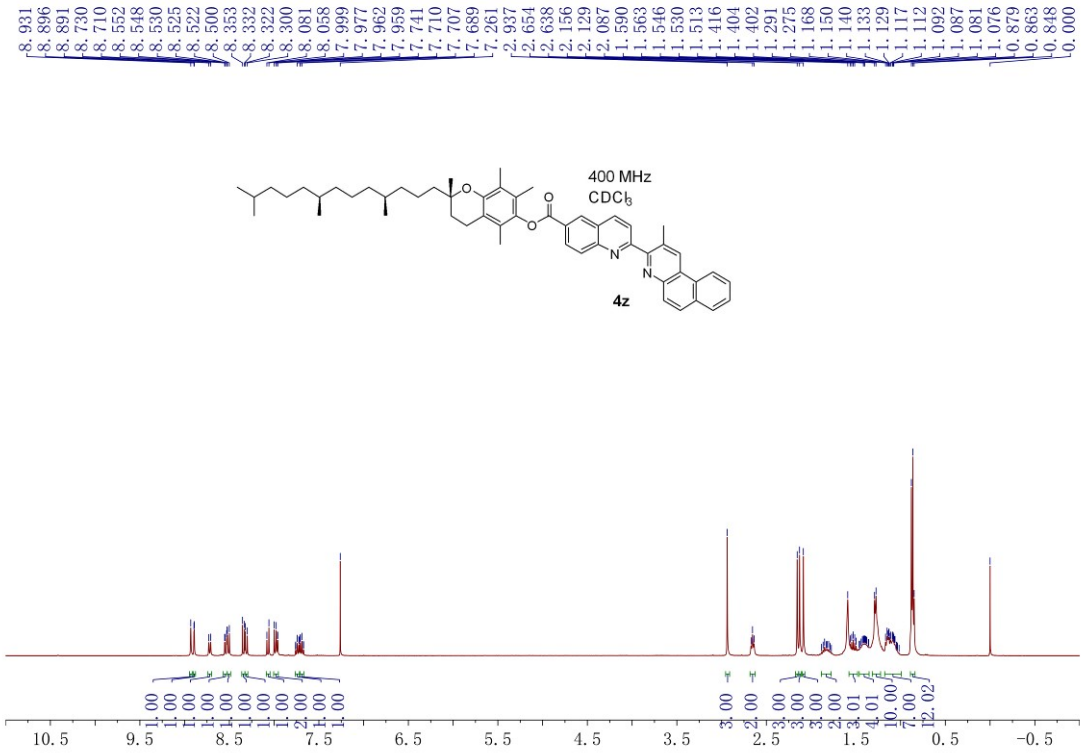
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8.332
8.322
8.300
8.081
8.058
7.999
7.977
7.962
7.959
7.741
7.710
7.707
7.689
7.261
2.937
2.654
2.638
2.156
2.129
2.087
1.590
1.563
1.546
1.530
1.513
1.416
1.404
1.402
1.291
1.275
1.168
1.150
1.140
1.133
1.129
1.117
1.112
1.092
1.087
1.081
1.076
0.879
0.863
0.848
0.000
400 MHz
CDCl3
4z
1.00
1.00
1.00
1.00
1.00
1.00
1.00
1.00
2.00
1.00
1.00
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2.00
3.00
3.00
2.00
3.01
4.01
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7.00
12.02
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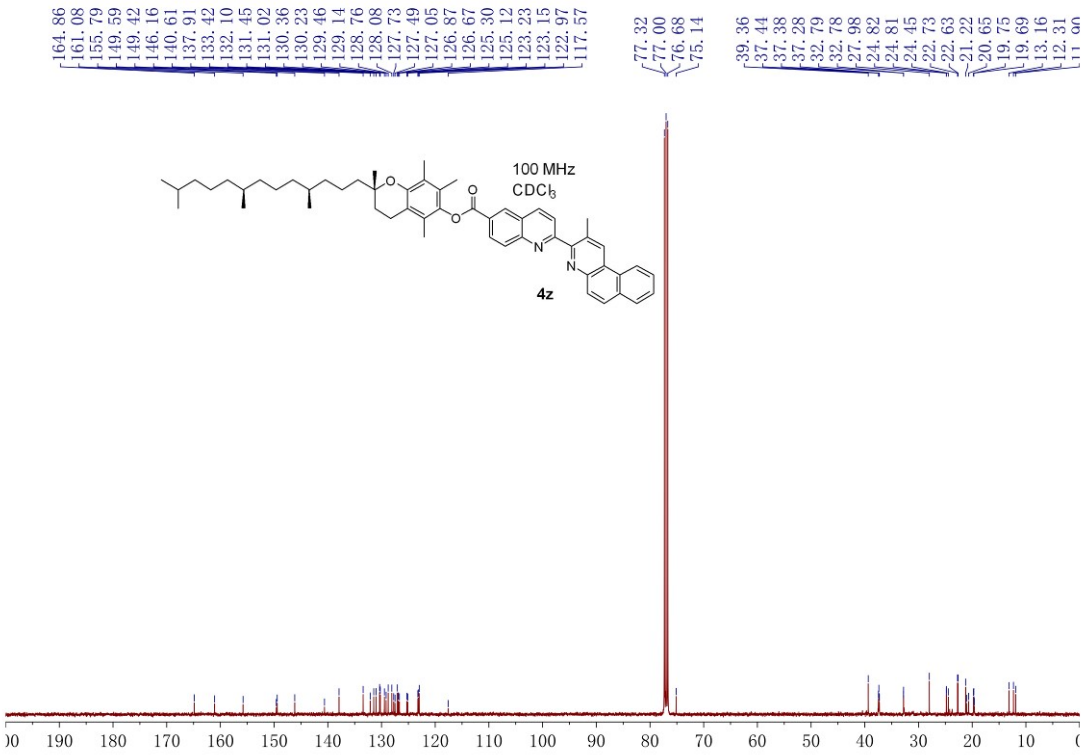
0.5
-0.5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128.08
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127.49
127.05
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126.67
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125.12
123.23
123.15
122.97
117.57
77.32
77.00
76.68
75.14
39.36
37.44
37.38
37.28
32.79
32.78
27.98
24.82
24.81
24.45
22.73
22.63
21.22
20.65
19.75
19.69
13.16
12.31
100 MHz
CDCl3
4z
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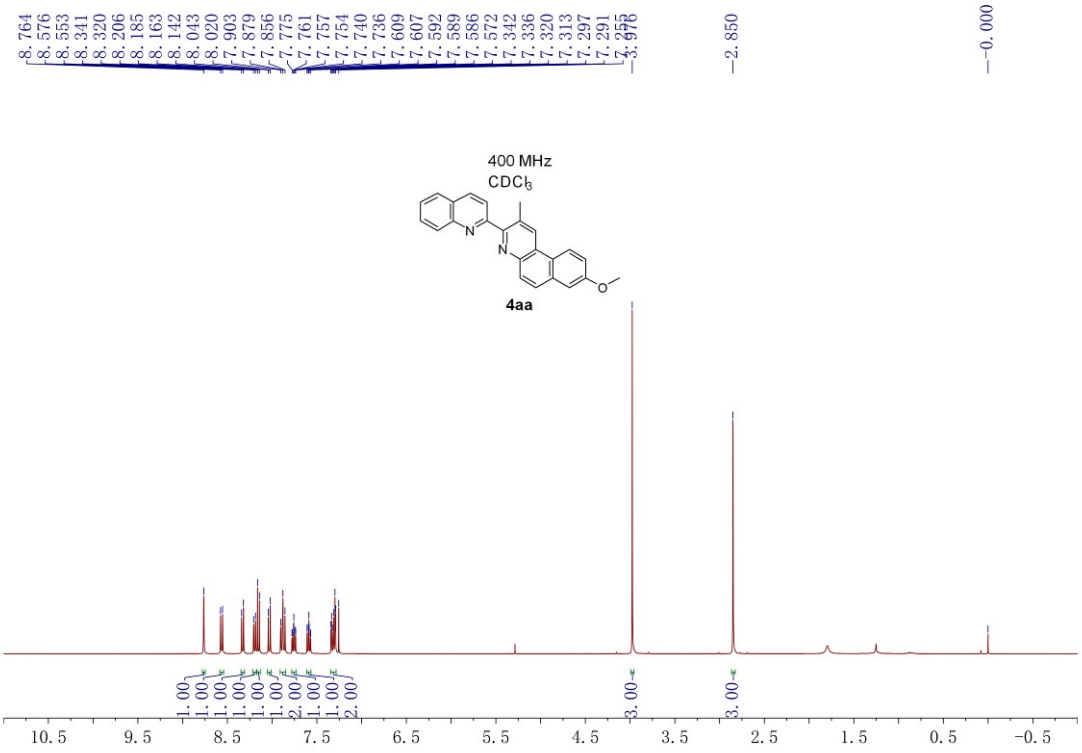
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7.879
7.856
7.775
7.761
7.757
7.754
7.740
7.736
7.609
7.607
7.592
7.589
7.586
7.572
7.342
7.336
7.320
7.313
7.297
7.291
3.978
2.850
0.000
400 MHz
CDCl3
4aa
1.00
1.00
1.00
1.00
1.00
2.00
1.00
2.00
3.00
3.00
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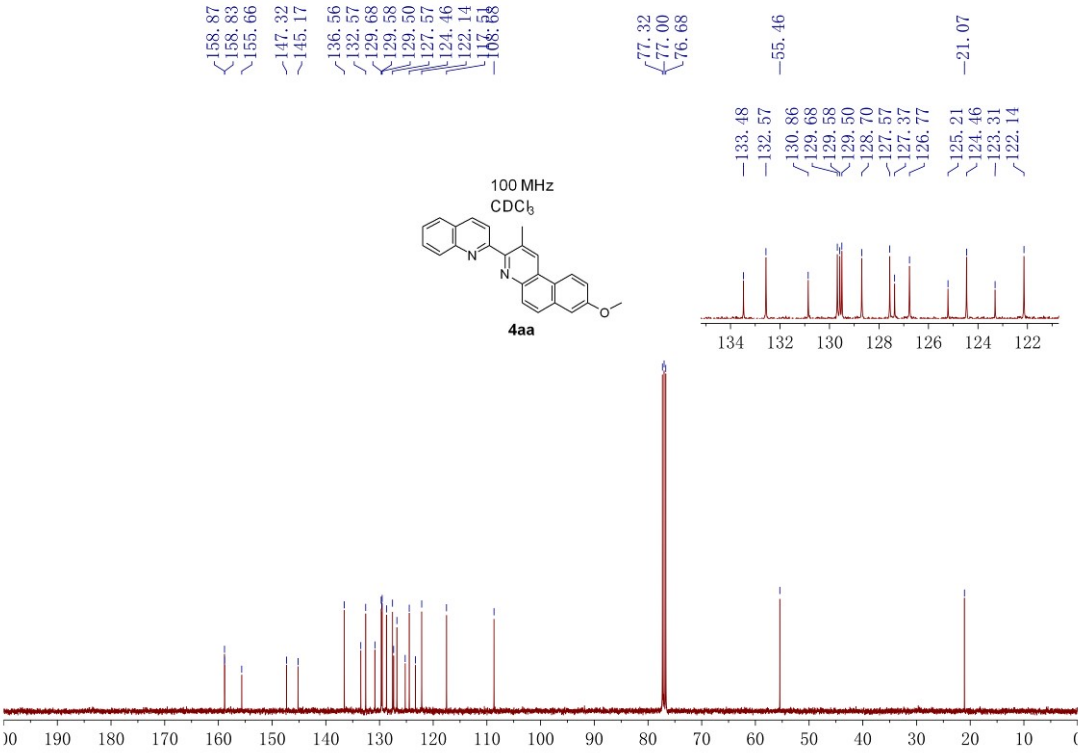
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77.32
77.00
76.68
55.46
21.07
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130.86
129.68
129.58
129.50
128.70
127.57
127.37
126.77
125.21
124.46
123.31
122.14
100 MHz
CDCl3
4aa
134
132
130
128
126
124
122
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80
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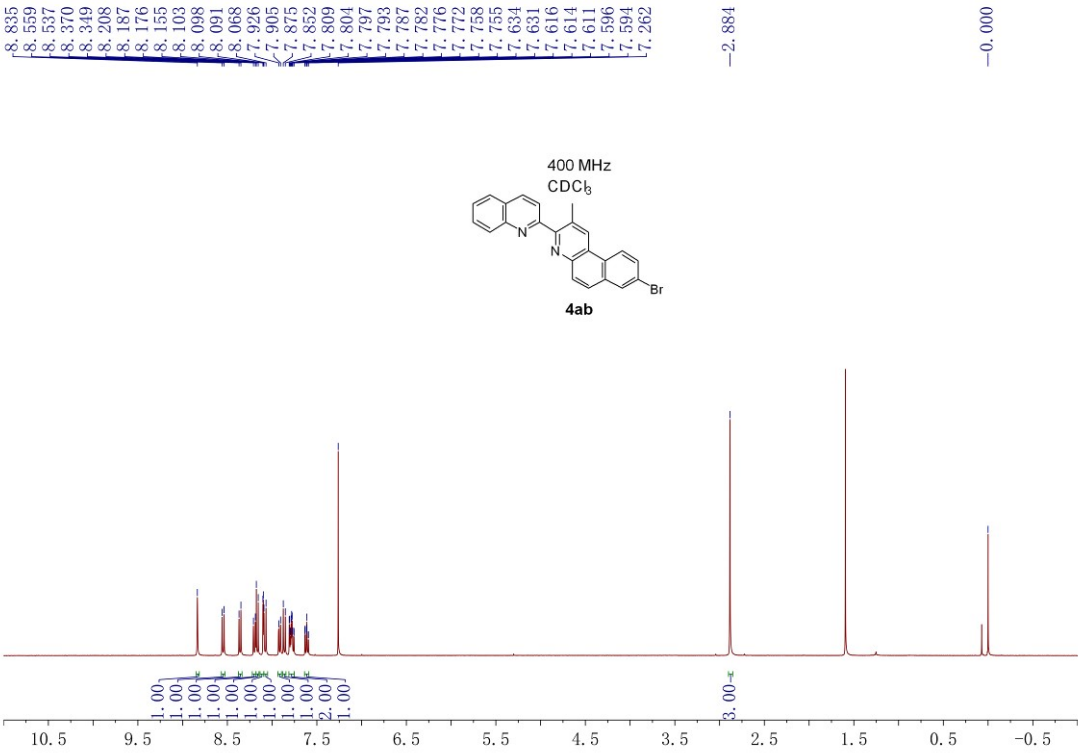
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8.537
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8.187
8.176
8.155
8.103
8.098
8.091
8.068
7.926
7.905
7.875
7.852
7.809
7.804
7.797
7.793
7.787
7.782
7.776
7.772
7.758
7.755
7.634
7.631
7.616
7.614
7.611
7.596
7.594
7.262
2.884
0.000
400 MHz
CDCl3
4ab
1.00
1.00
1.00
1.00
1.00
1.00
1.00
1.00
2.00
1.00
3.00
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2.5
1.5
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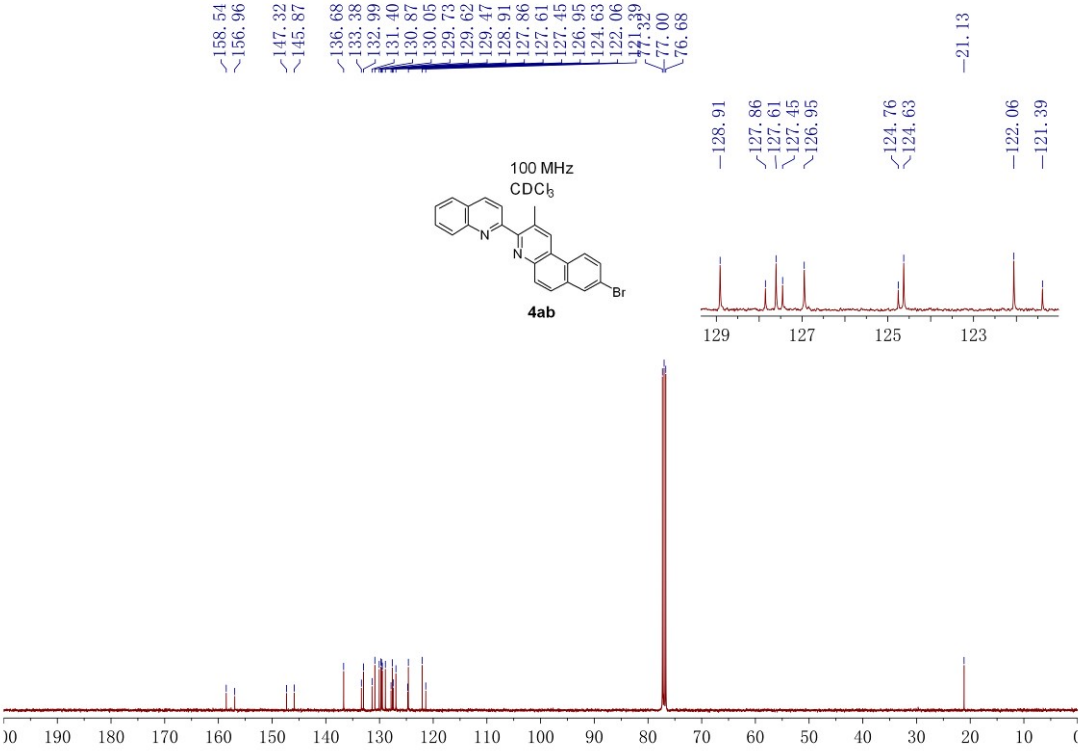
-0.5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127.86
127.61
127.45
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124.63
122.06
121.39
77.32
77.00
76.68
21.13
128.91
127.86
127.61
127.45
126.95
124.76
124.63
122.06
121.39
100 MHz
CDCl3
4ab
129
127
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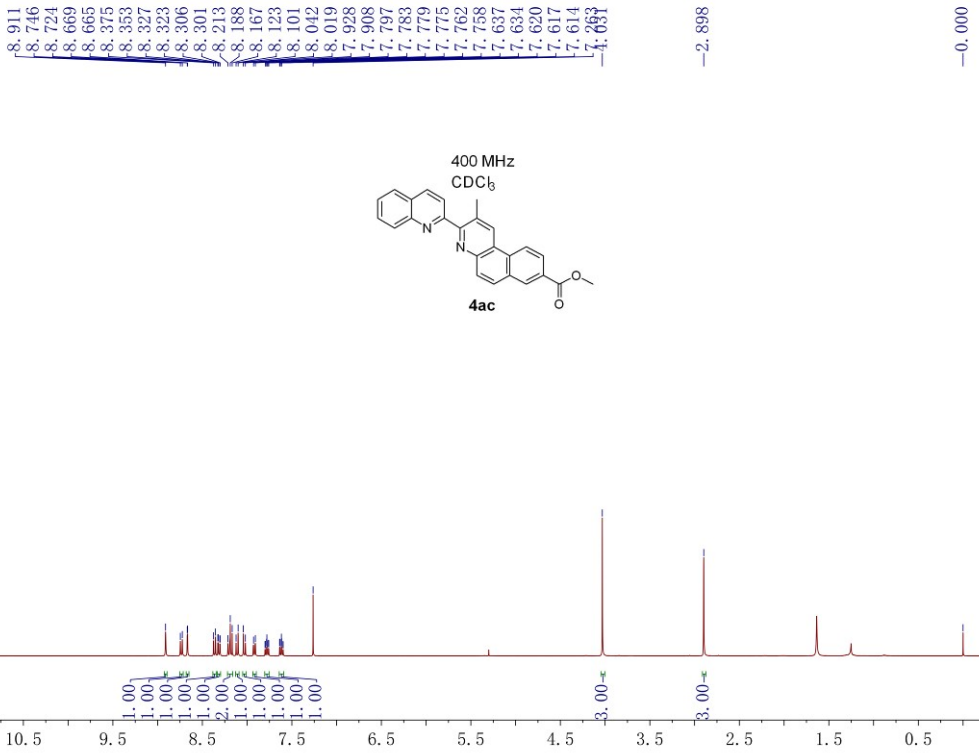
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8.213
8.188
8.167
8.123
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8.042
8.019
7.928
7.908
7.797
7.783
7.779
7.775
7.762
7.758
7.637
7.634
7.620
7.617
7.614
7.263
7.031
2.898
0.000
400 MHz
CDCl3
4ac
1.00
1.00
1.00
1.00
2.00
1.00
1.00
1.00
1.00
3.00
3.00
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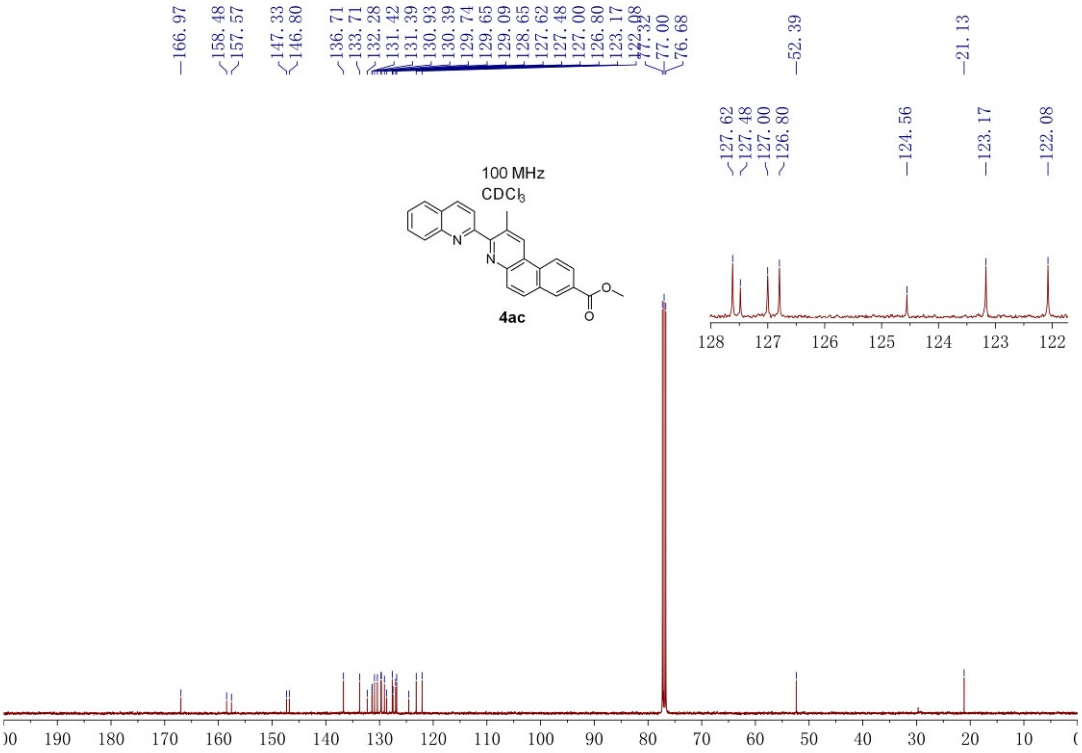
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129.09
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127.62
127.48
127.00
126.80
123.17
122.08
77.32
77.00
76.68
52.39
21.13
127.62
127.48
127.00
126.80
124.56
123.17
122.08
100 MHz
CDCl3
4ac
128
127
126
125
124
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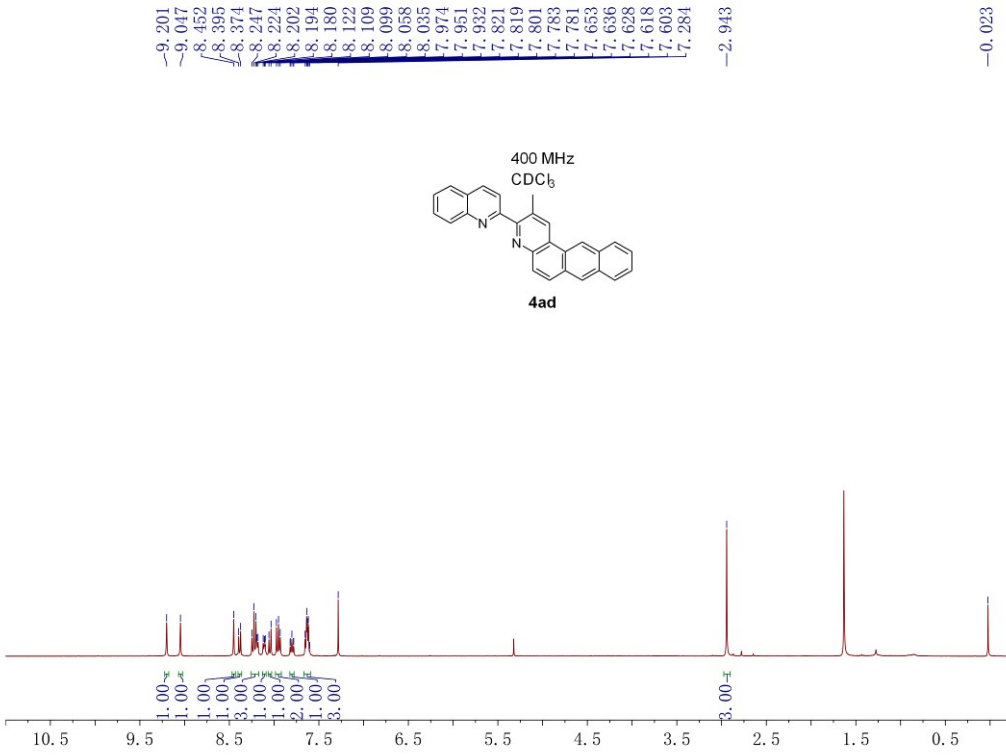
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8.109
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8.058
8.035
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7.932
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7.819
7.801
7.783
7.781
7.653
7.636
7.628
7.618
7.603
7.284
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0.023
400 MHz
CDCl3
4ad
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1.00
1.00
3.00
1.00
1.00
2.00
1.00
3.00
3.00
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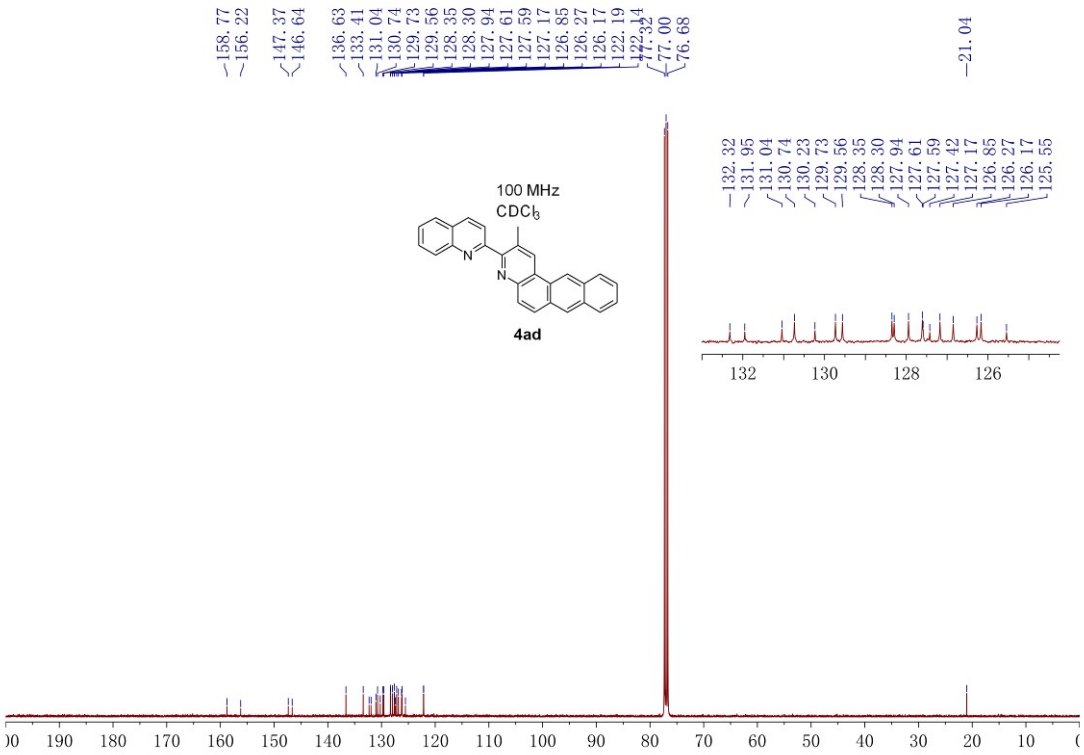
-0.5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127.17
126.85
126.27
126.17
122.19
77.32
77.00
76.68
21.04
100 MHz
CDCl3
4ad
132.32
131.95
131.04
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130.23
129.73
129.56
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128.30
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127.61
127.59
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126.17
125.55
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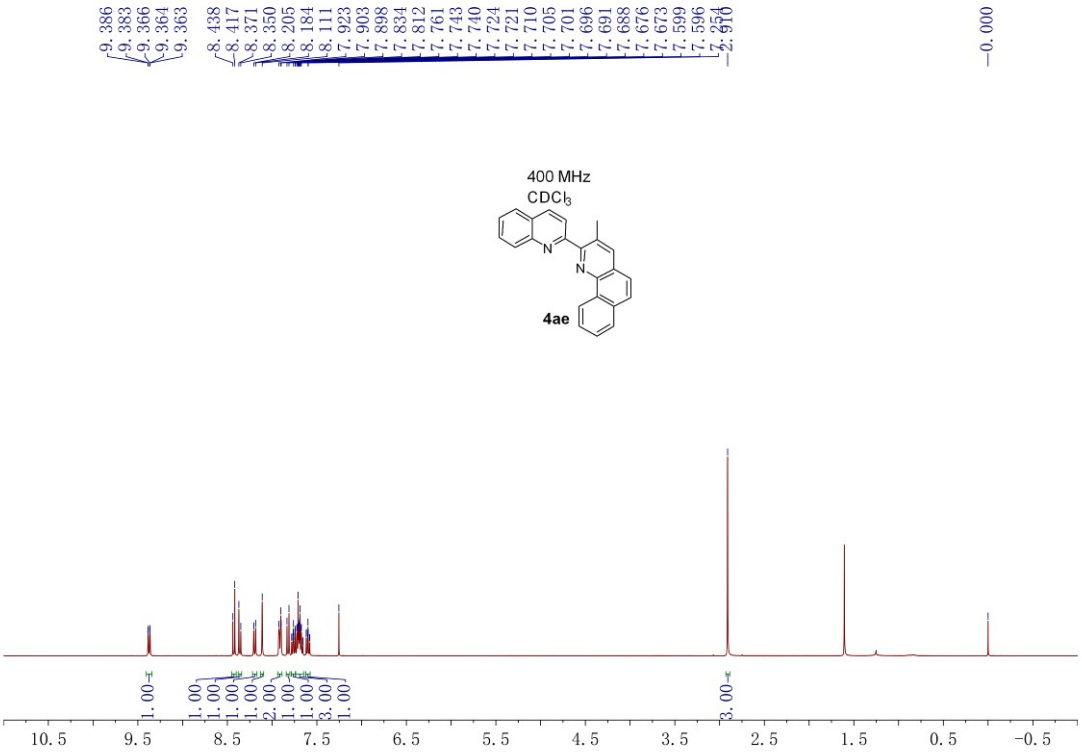
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7.923
7.903
7.898
7.834
7.812
7.761
7.743
7.740
7.724
7.721
7.710
7.705
7.701
7.696
7.691
7.688
7.676
7.673
7.599
7.596
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CDCl3
4ae
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1.00
1.00
1.00
2.00
1.00
1.00
3.00
1.00
3.00
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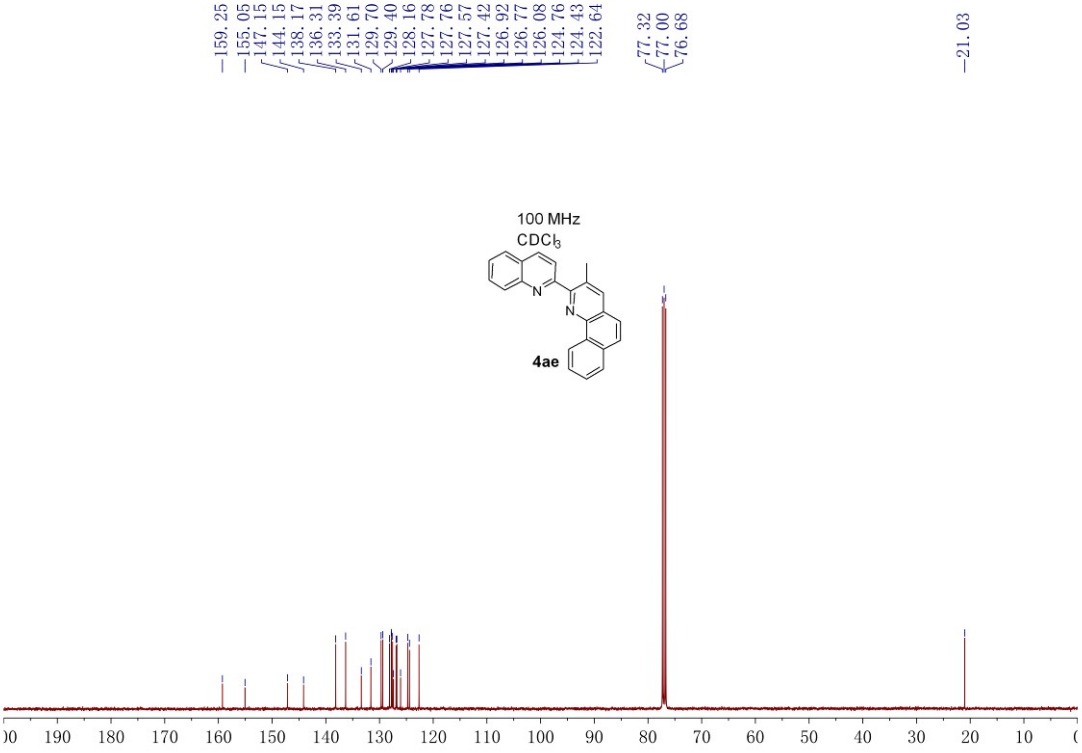
-0.5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127.57
127.42
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126.77
126.08
124.76
124.43
122.64
77.32
77.00
76.68
21.03
100 MHz
CDCl3
4ae
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180
170
160
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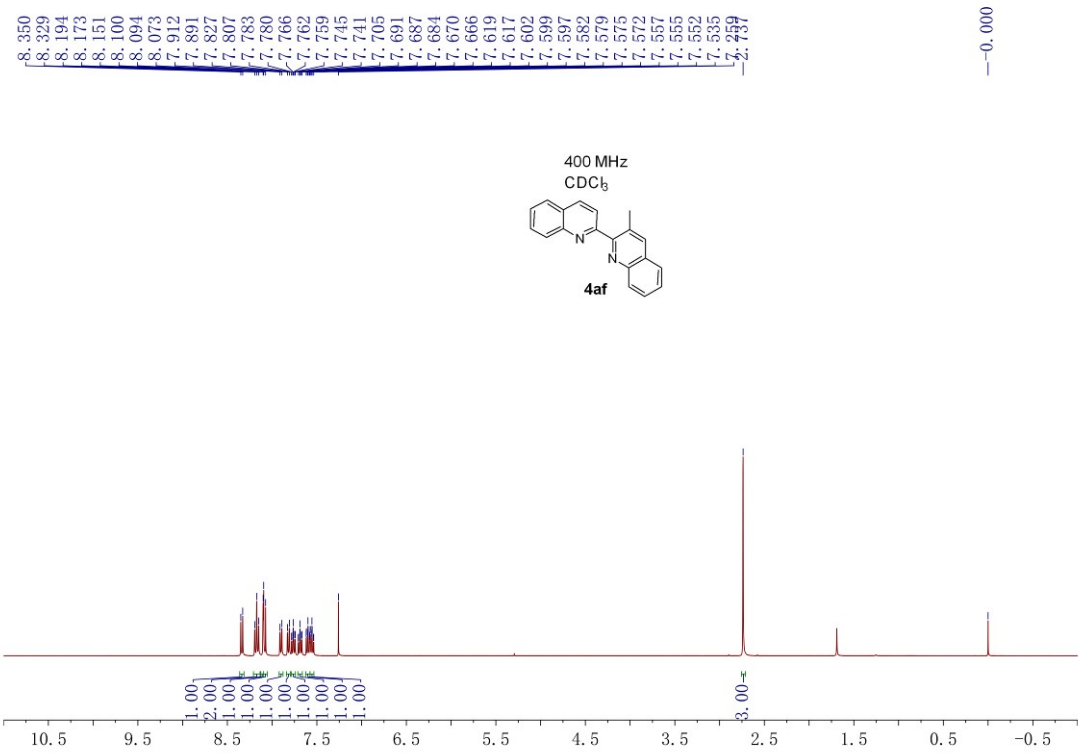
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7.827
7.807
7.783
7.780
7.766
7.762
7.759
7.745
7.741
7.705
7.691
7.687
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7.602
7.599
7.597
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7.555
7.552
7.535
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CDCl3
4af
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2.00
1.00
1.00
1.00
1.00
1.00
1.00
3.00
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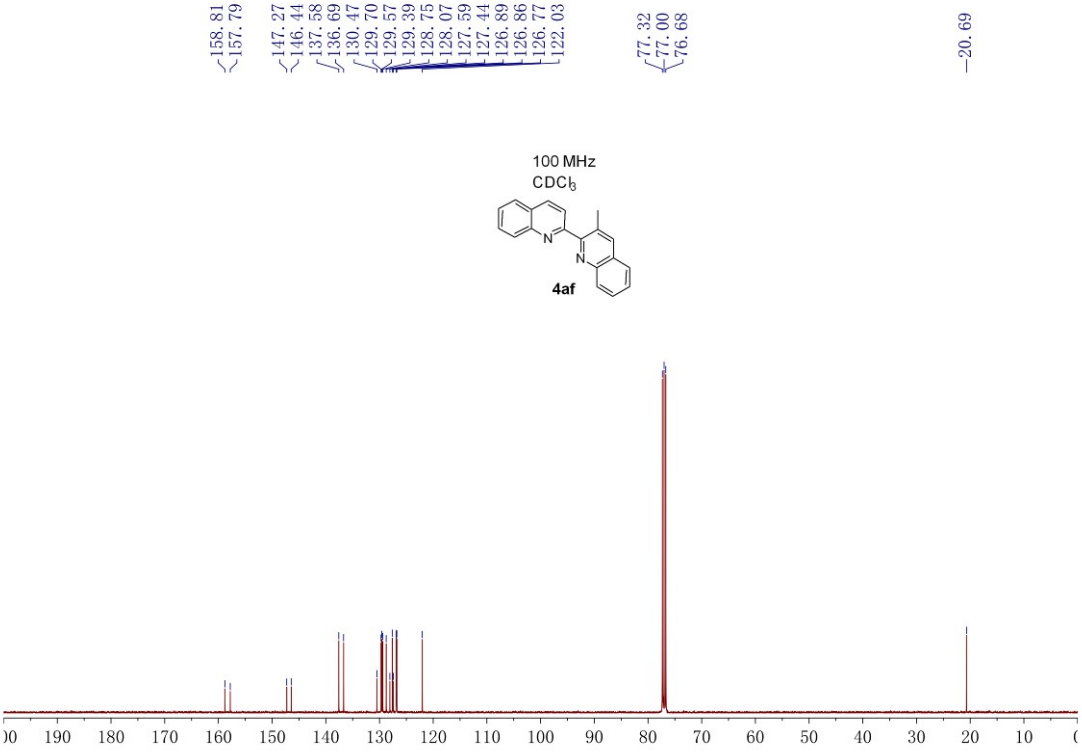
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127.44
126.89
126.86
126.77
122.03
77.32
77.00
76.68
20.69
100 MHz
CDCl3
4af
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170
160
150
140
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100
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80
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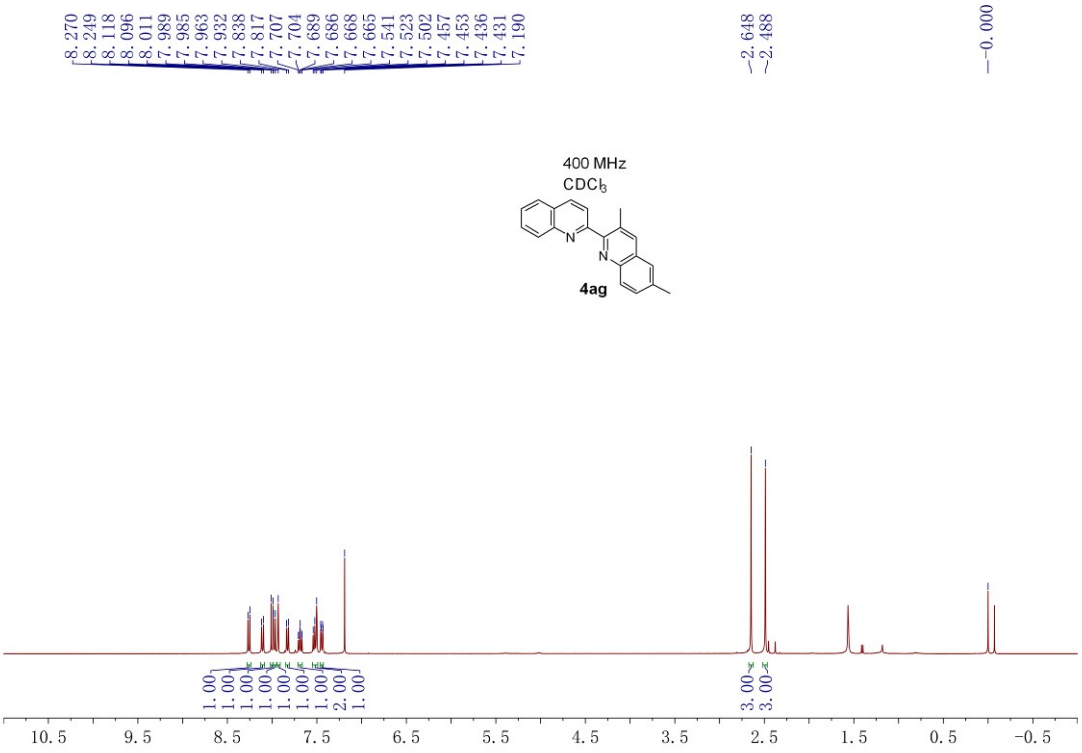
30
20
10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7.704
7.689
7.686
7.668
7.665
7.541
7.523
7.502
7.457
7.453
7.436
7.431
7.190
2.648
2.488
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CDCl3
4ag
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1.00
1.00
1.00
1.00
1.00
2.00
1.00
3.00
3.00
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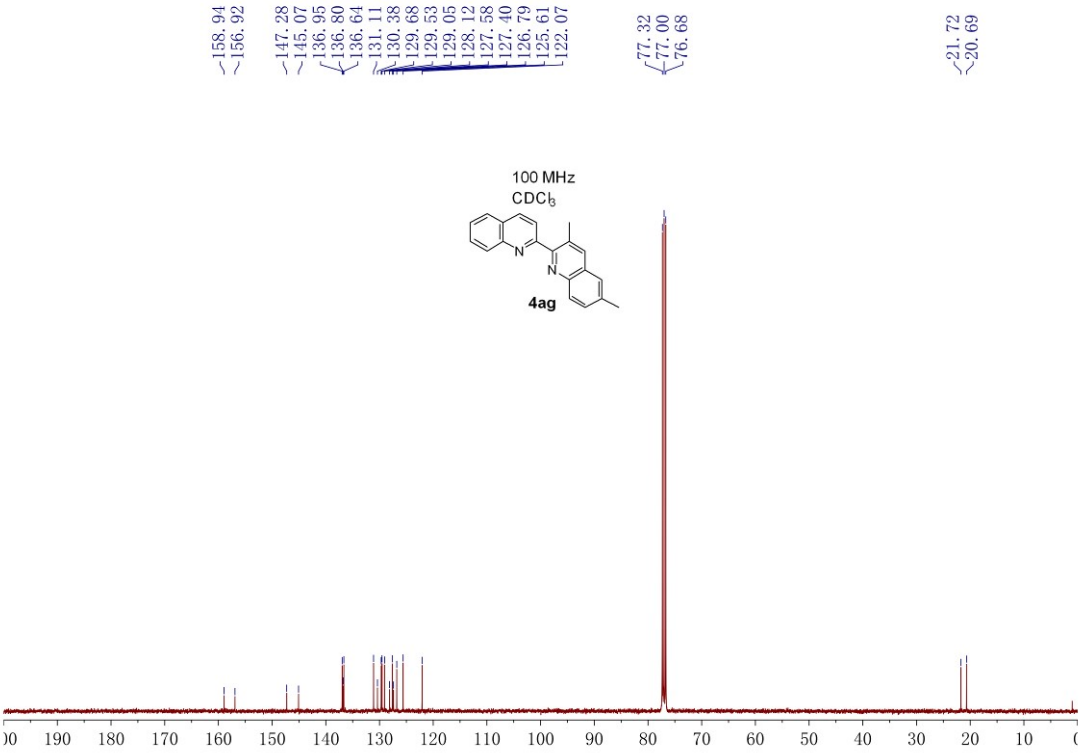
-0.5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129.05
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127.58
127.40
126.79
125.61
122.07
77.32
77.00
76.68
21.72
20.69
100 MHz
CDCl3
4ag
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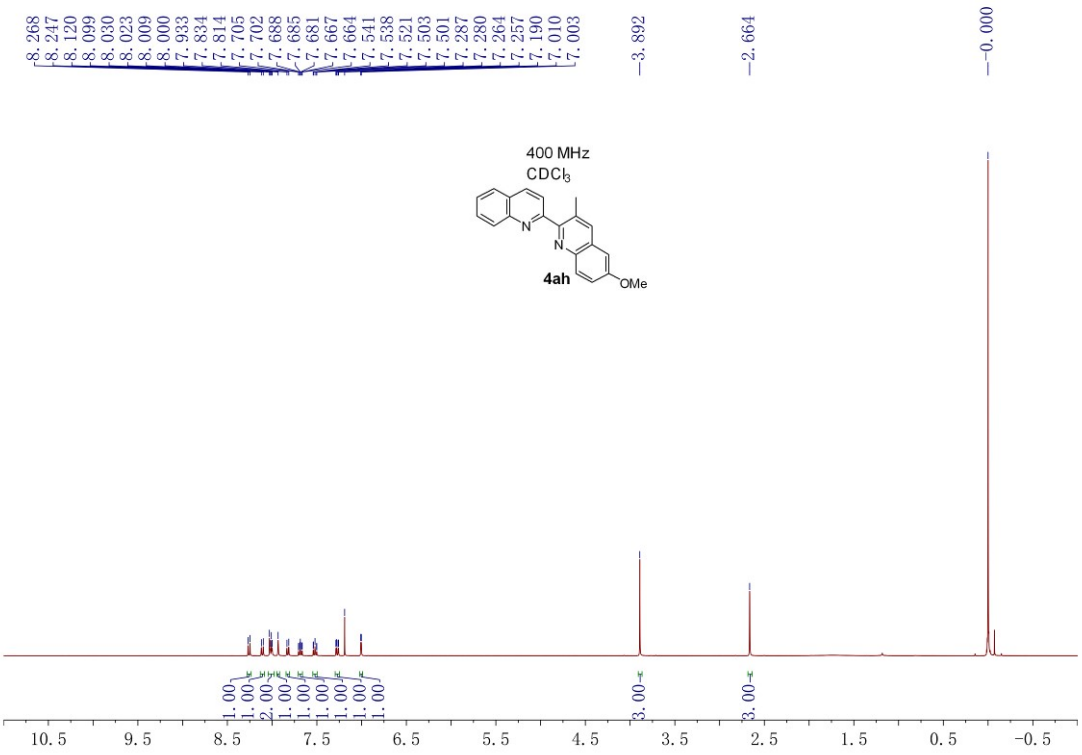
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7.702
7.688
7.685
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7.667
7.664
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7.538
7.521
7.503
7.501
7.287
7.280
7.264
7.257
7.190
7.010
7.003
3.892
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0.000
400 MHz
CDCl3
4ah
OMe
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1.00
2.00
1.00
1.00
1.00
1.00
1.00
3.00
3.00
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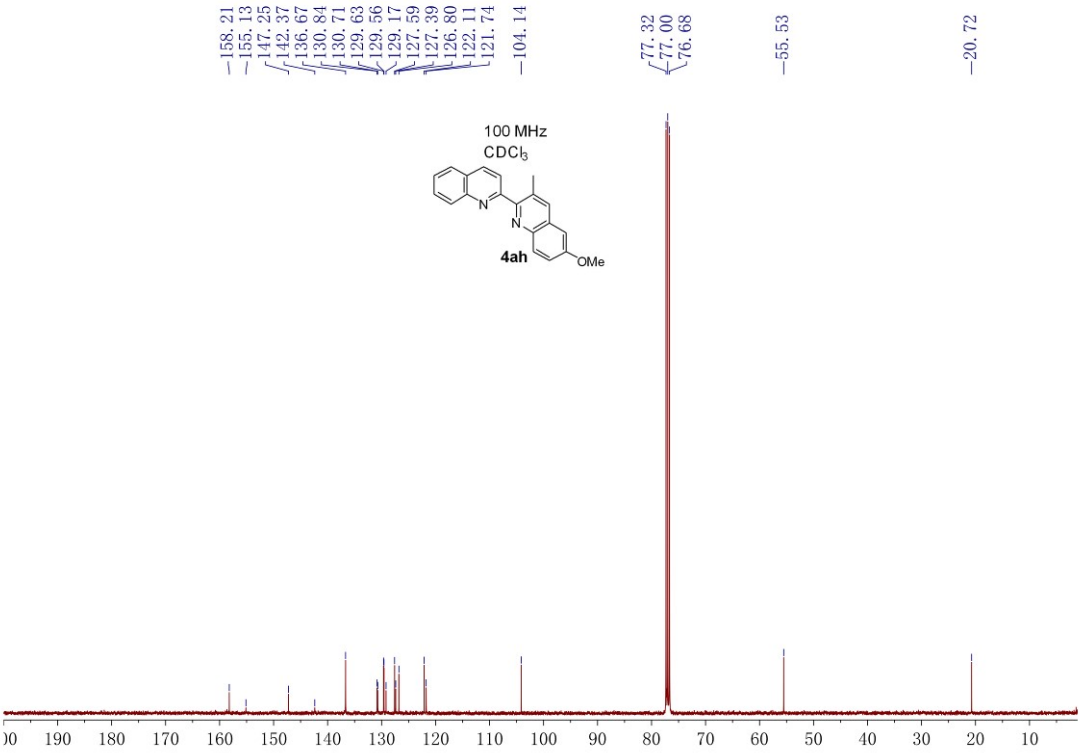
-0.5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127.39
126.80
122.11
121.74
104.14
77.32
77.00
76.68
55.53
20.72
100 MHz
CDCl3
4ah
OMe
190
180
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150
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80
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20
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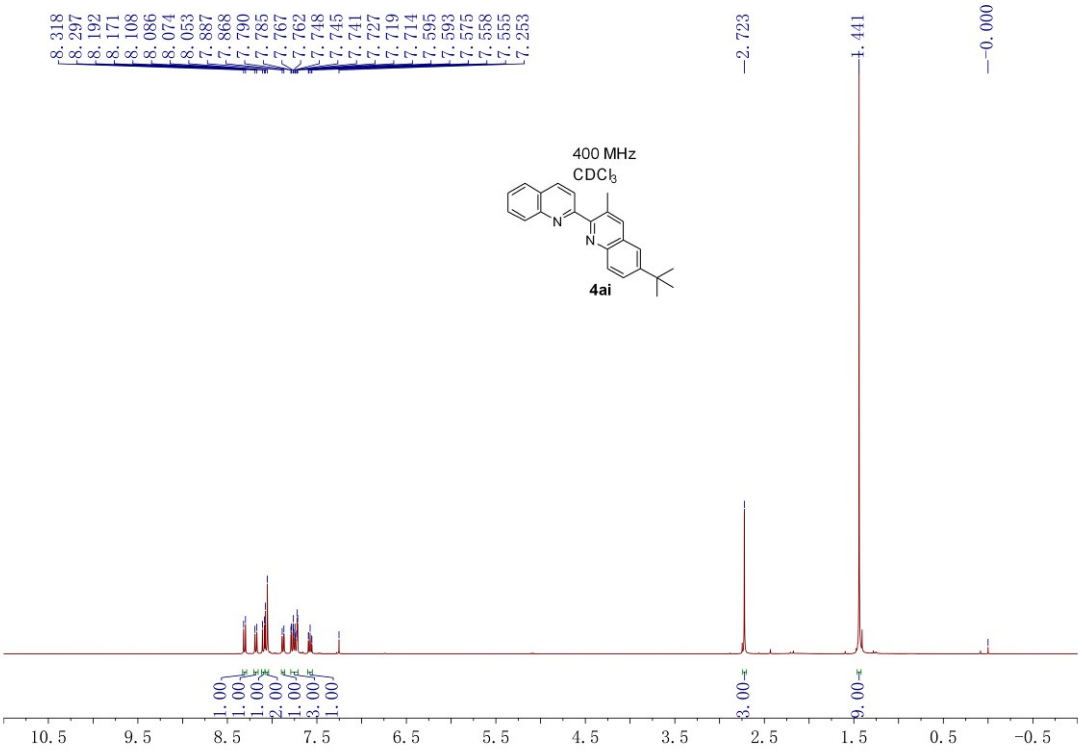
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7.767
7.762
7.748
7.745
7.741
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7.719
7.714
7.595
7.593
7.575
7.558
7.555
7.253
2.723
1.441
0.000
400 MHz
CDCl3
4ai
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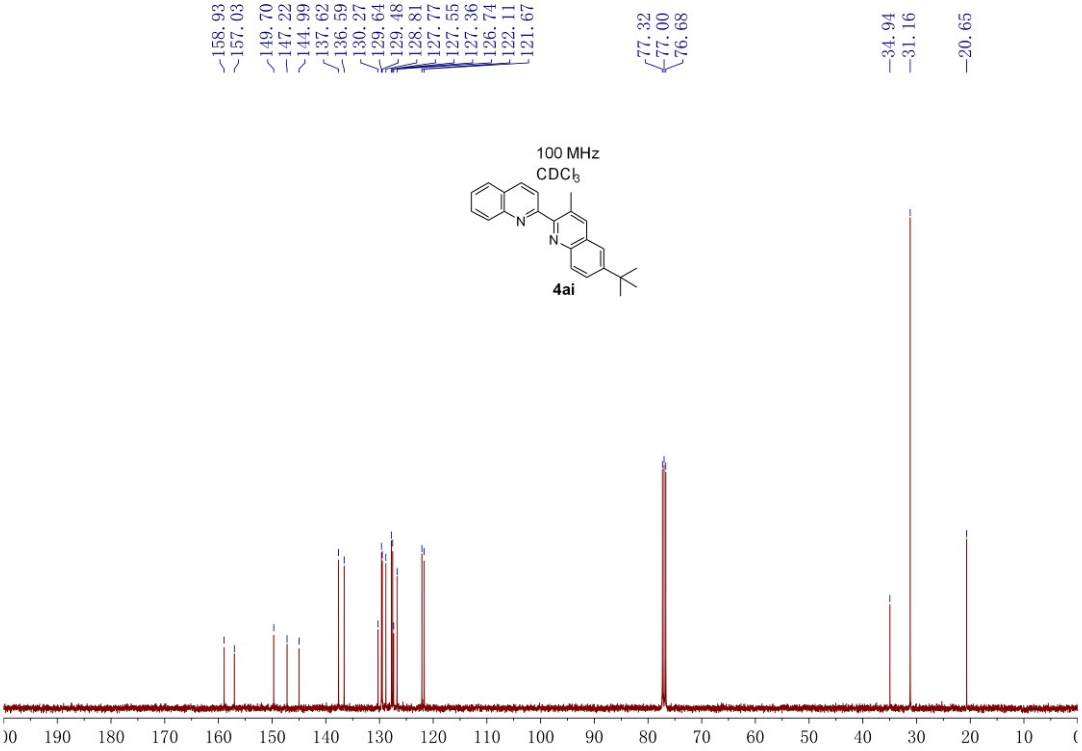
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76.68
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31.16
20.65
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CDCl3
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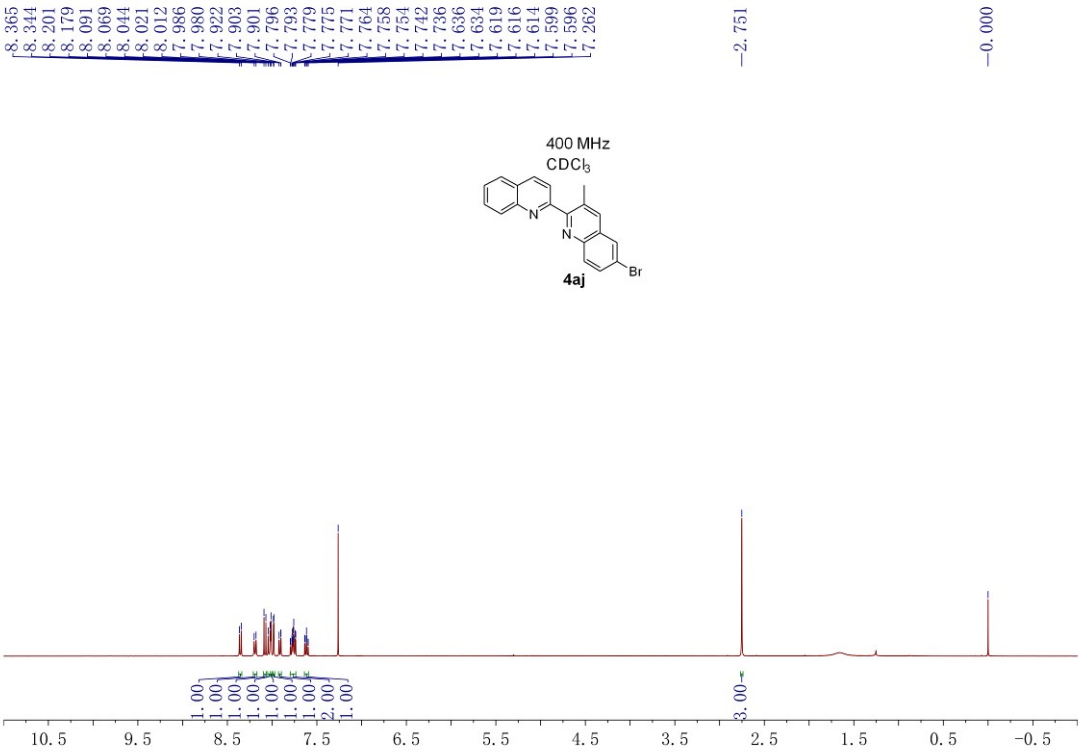
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7.903
7.901
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4aj
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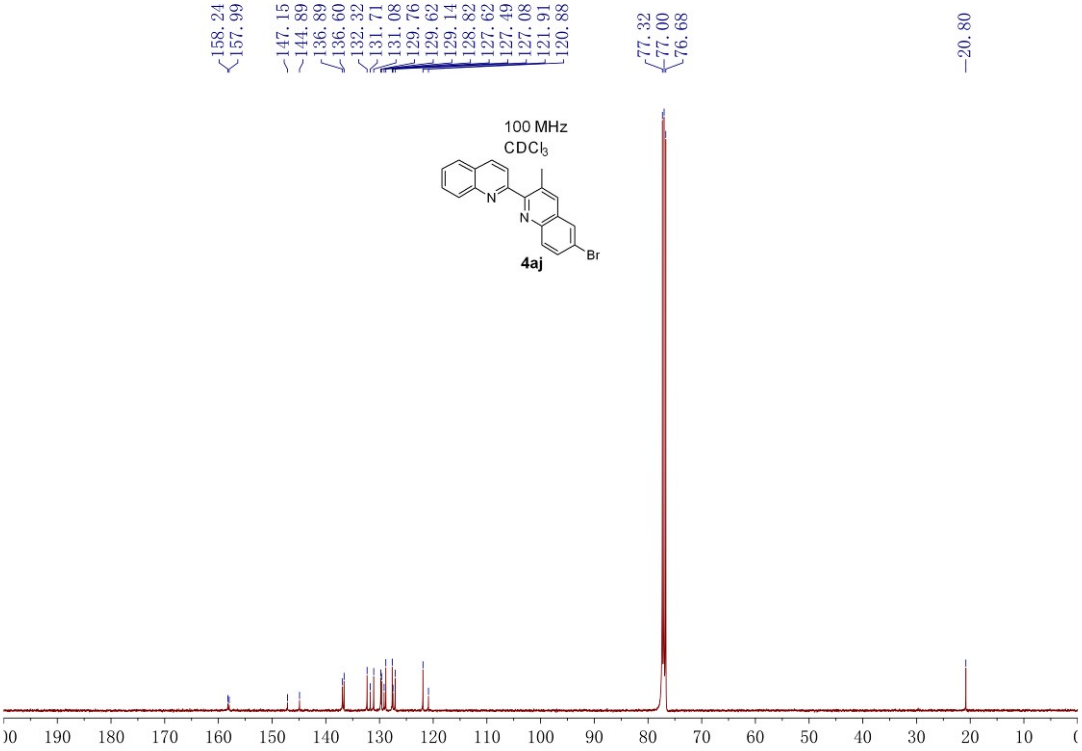
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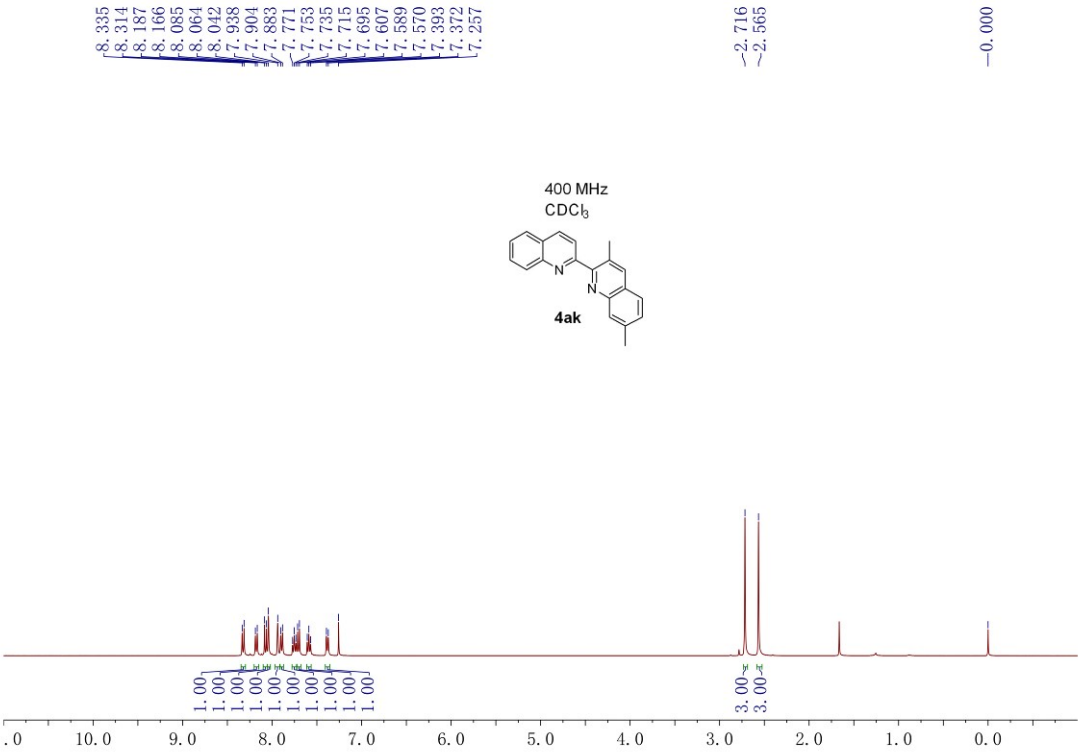
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7.735
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7.589
7.570
7.393
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7.257
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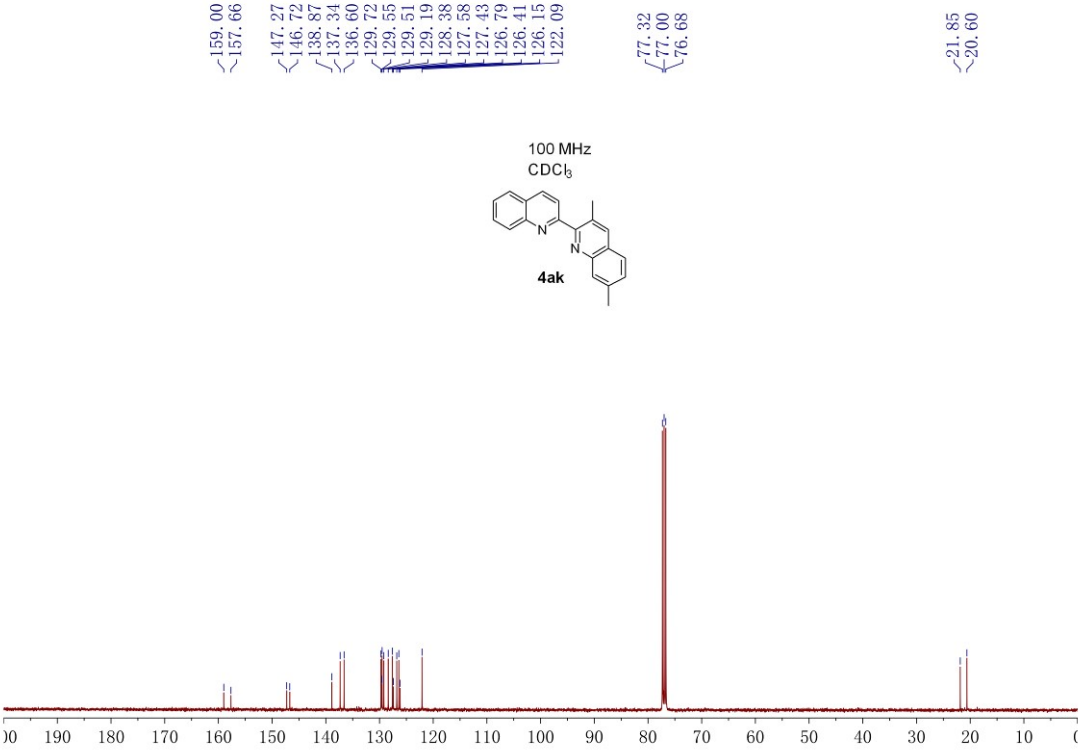
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77.00
76.68
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20.60
100 MHz
CDCl3
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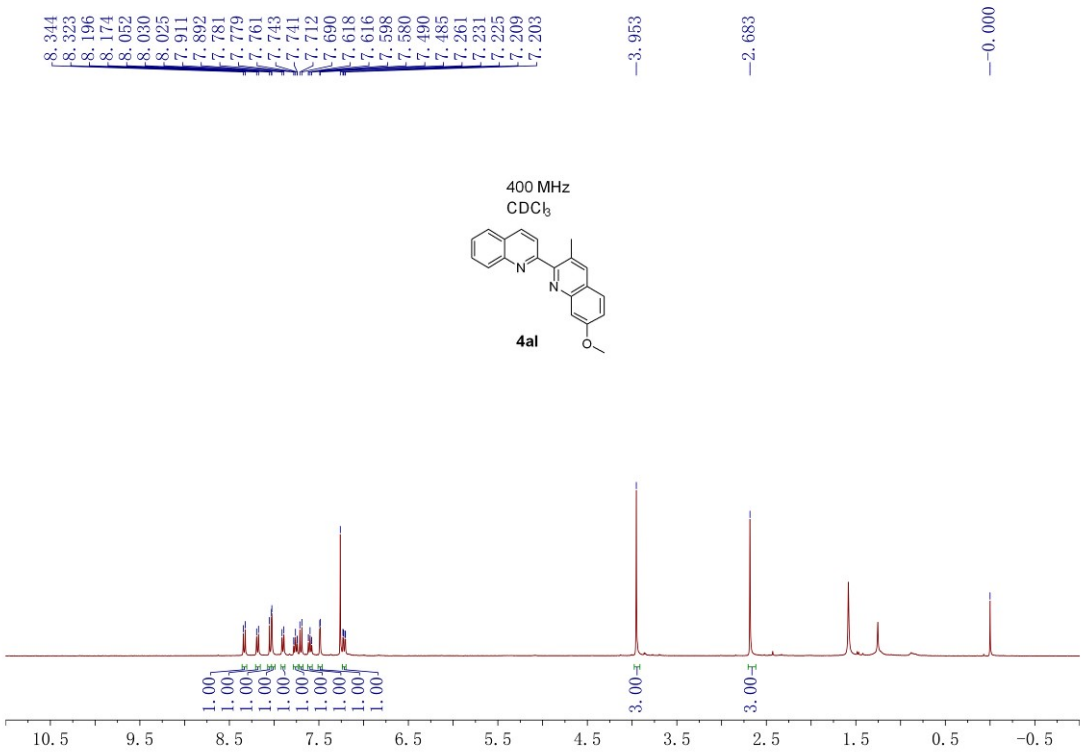
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7.741
7.712
7.690
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7.598
7.580
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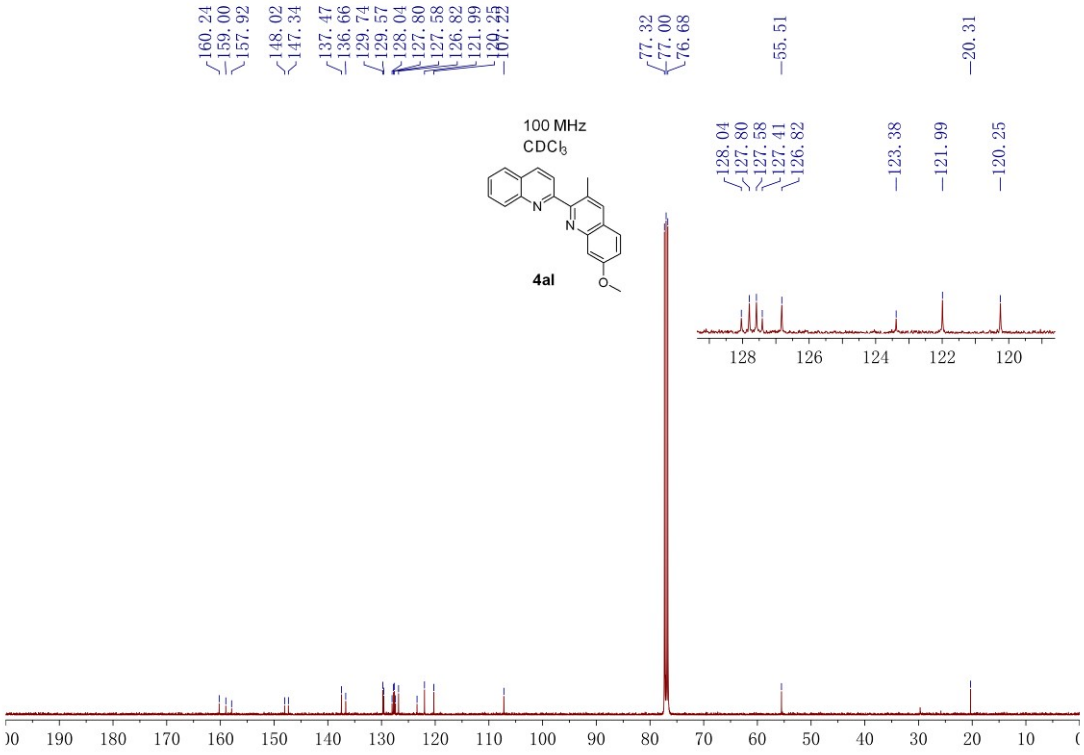
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126.82
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77.32
77.00
76.68
55.51
20.31
100 MHz
CDCl3
4al
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127.80
127.58
127.41
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123.38
121.99
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50
40
30
20
10


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7.866
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7.734
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7.588
7.586
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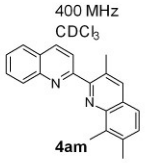
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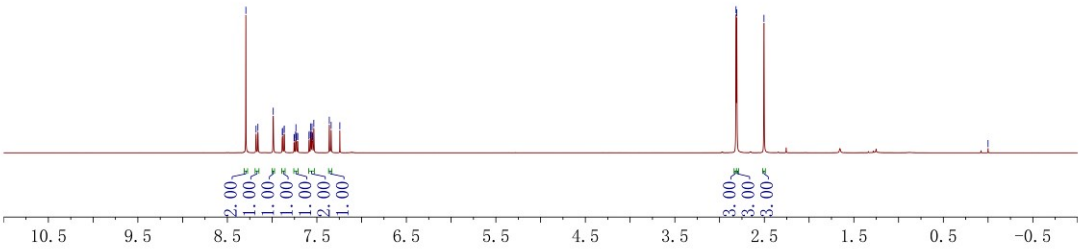
4am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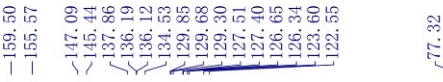
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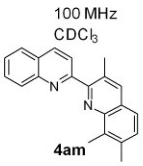
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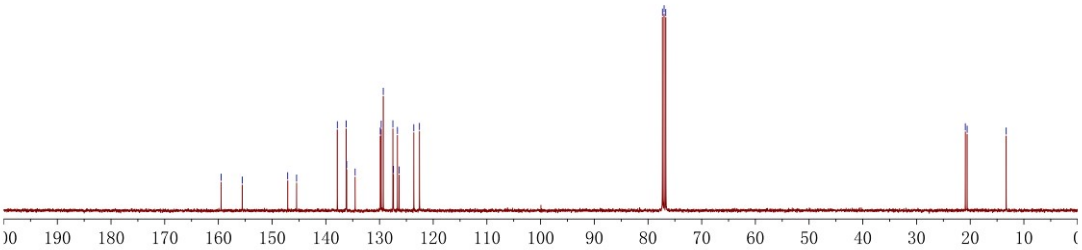
4am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80
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20
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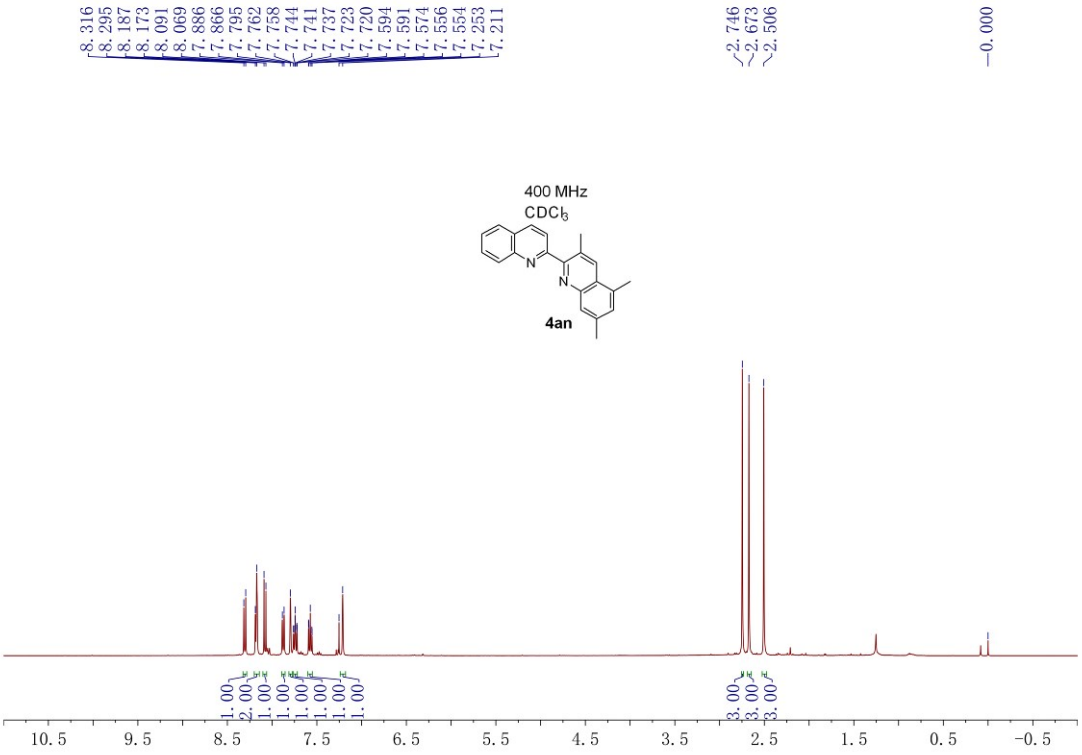
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7.741
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7.720
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7.591
7.574
7.556
7.554
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7.211
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2.673
2.506
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400 MHz
CDCl3
4an
1.00
2.00
1.00
1.00
1.00
1.00
1.00
3.00
3.00
3.00
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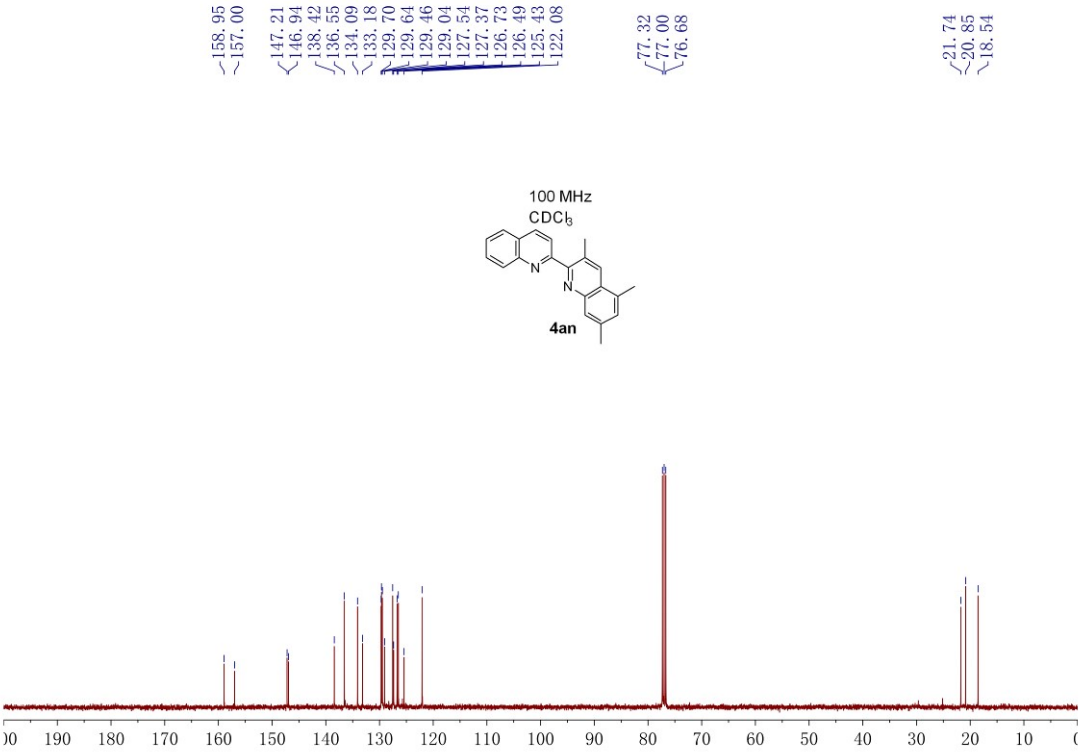
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126.49
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122.08
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77.00
76.68
21.74
20.85
18.54
100 MHz
CDCl3
4an
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180
170
160
150
140
130
120
110
100
90
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30
20
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8.192
8.171
8.053
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7.949
7.903
7.883
7.776
7.772
7.758
7.755
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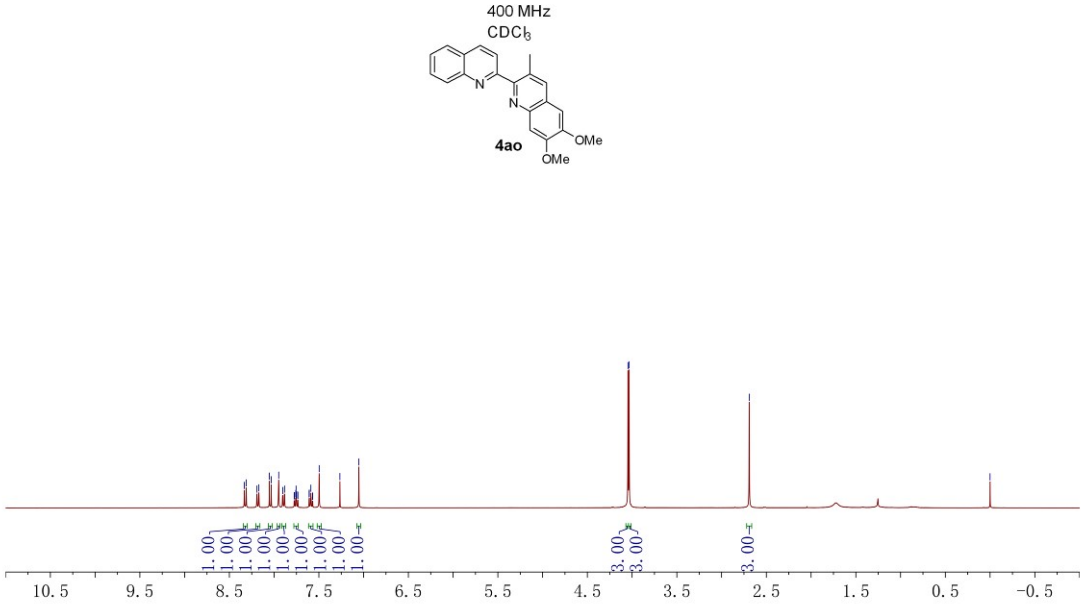
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4ao
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OMe
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3.00
3.00
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7.5
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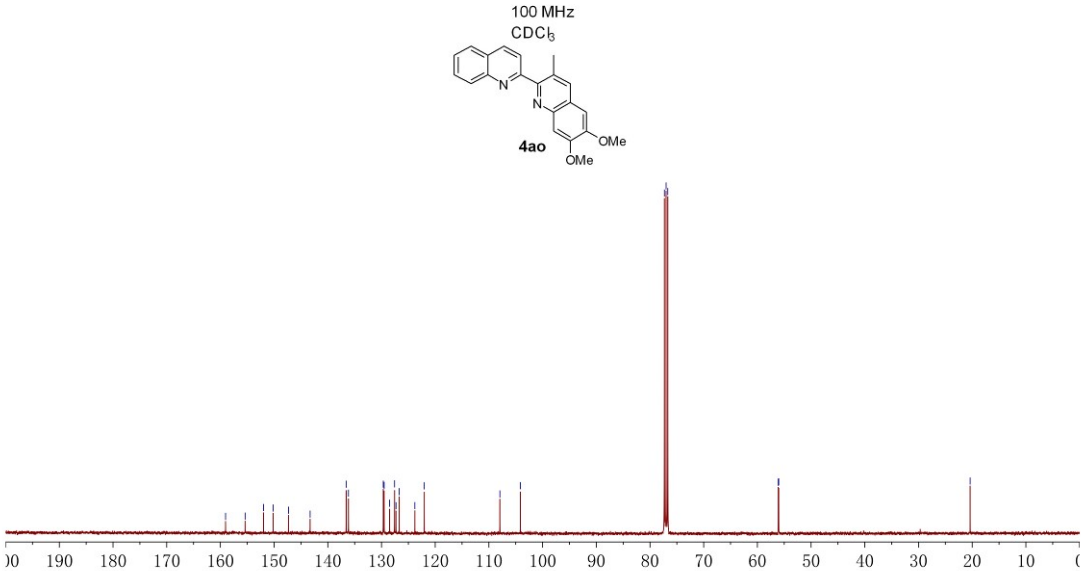
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4ao
OMe
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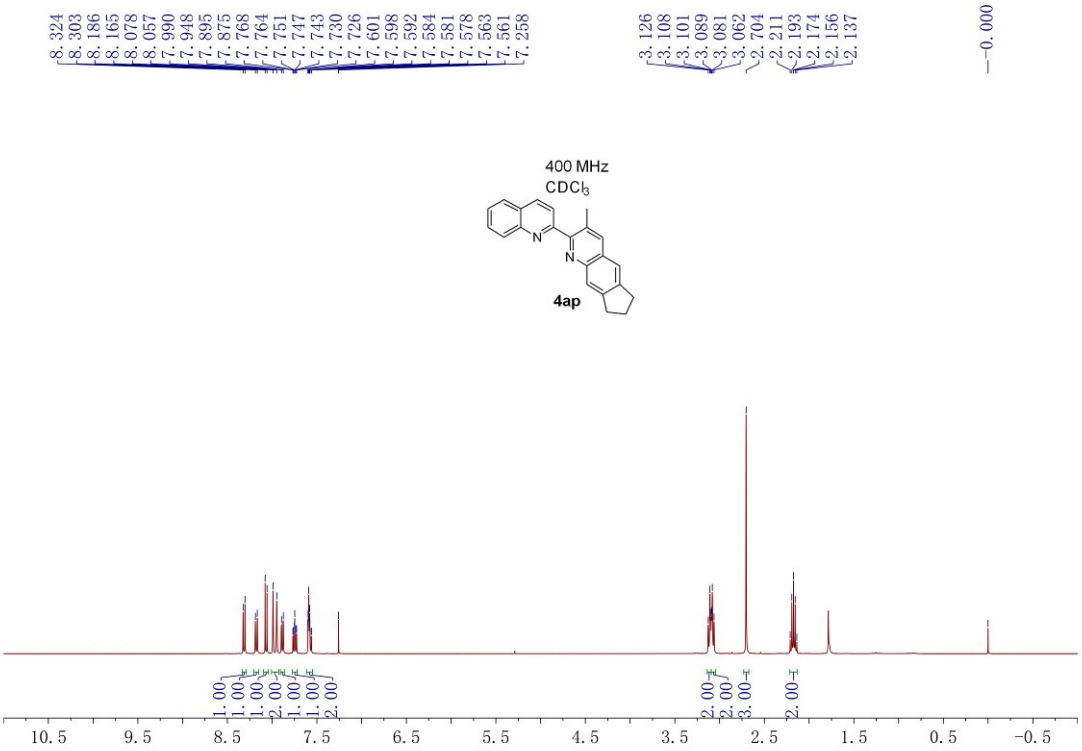
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7.730
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7.601
7.598
7.592
7.584
7.581
7.578
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7.561
7.258
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3.108
3.101
3.089
3.081
3.062
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2.174
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4ap
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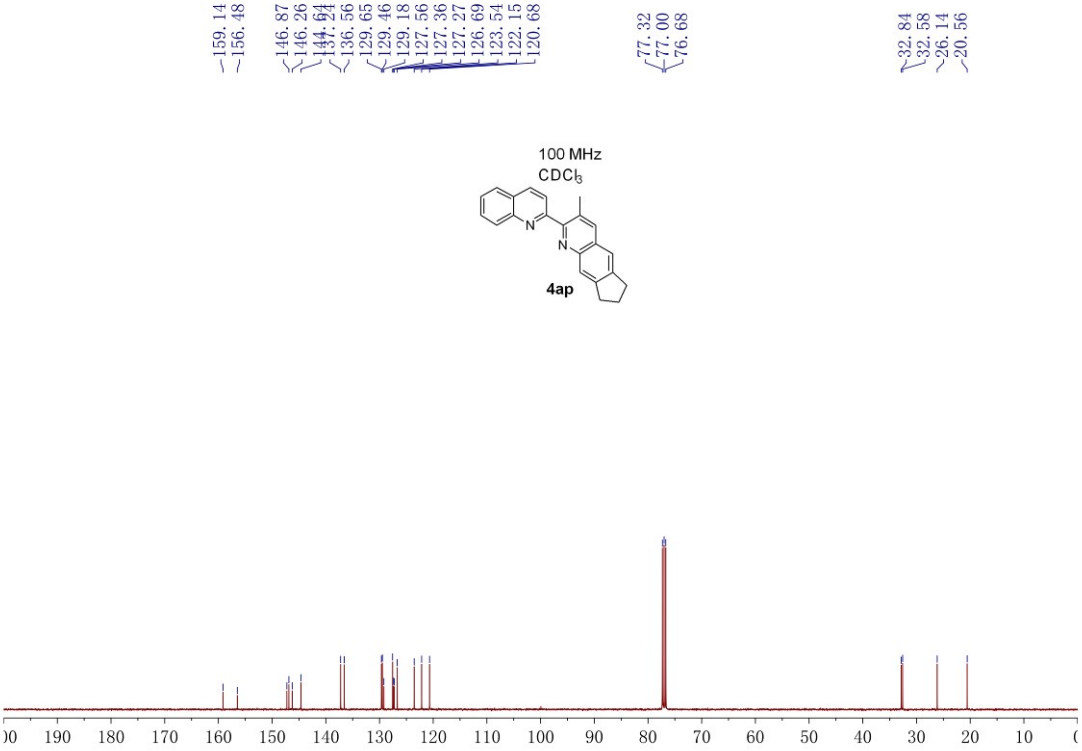
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123.54
122.15
120.68
77.32
77.00
76.68
32.84
32.58
26.14
20.56
100 MHz
CDCl3
4ap
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150
140
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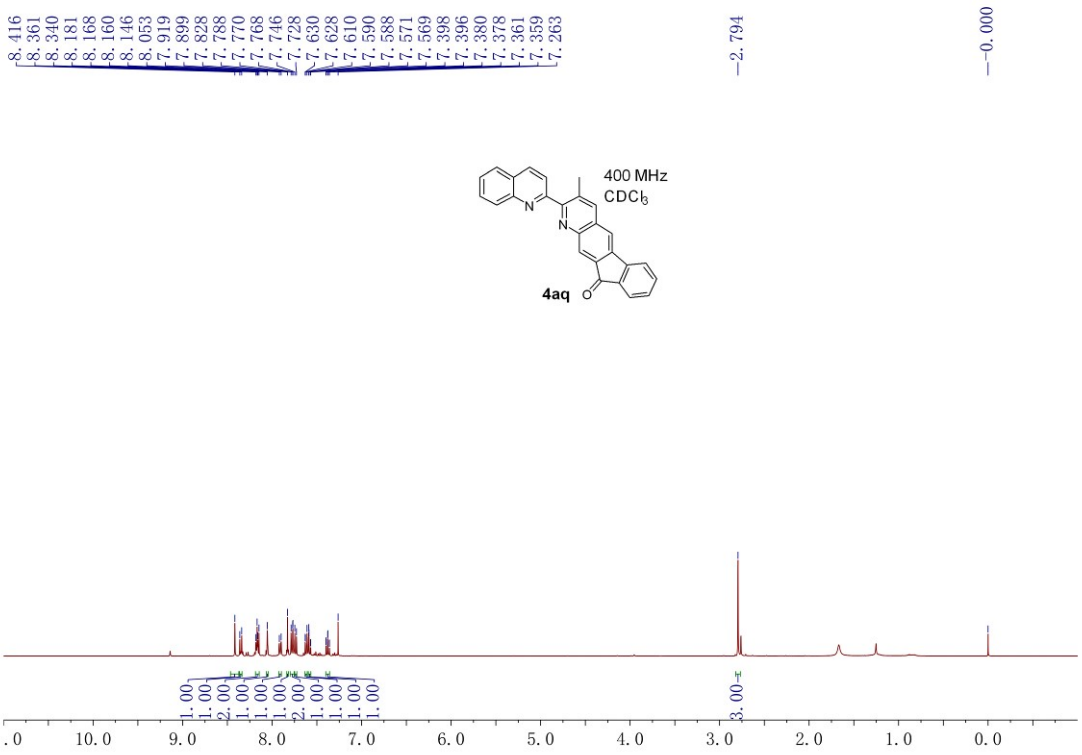
20
10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7.768
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7.628
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7.590
7.588
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7.396
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400 MHz
CDCl3
4aq
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1.00
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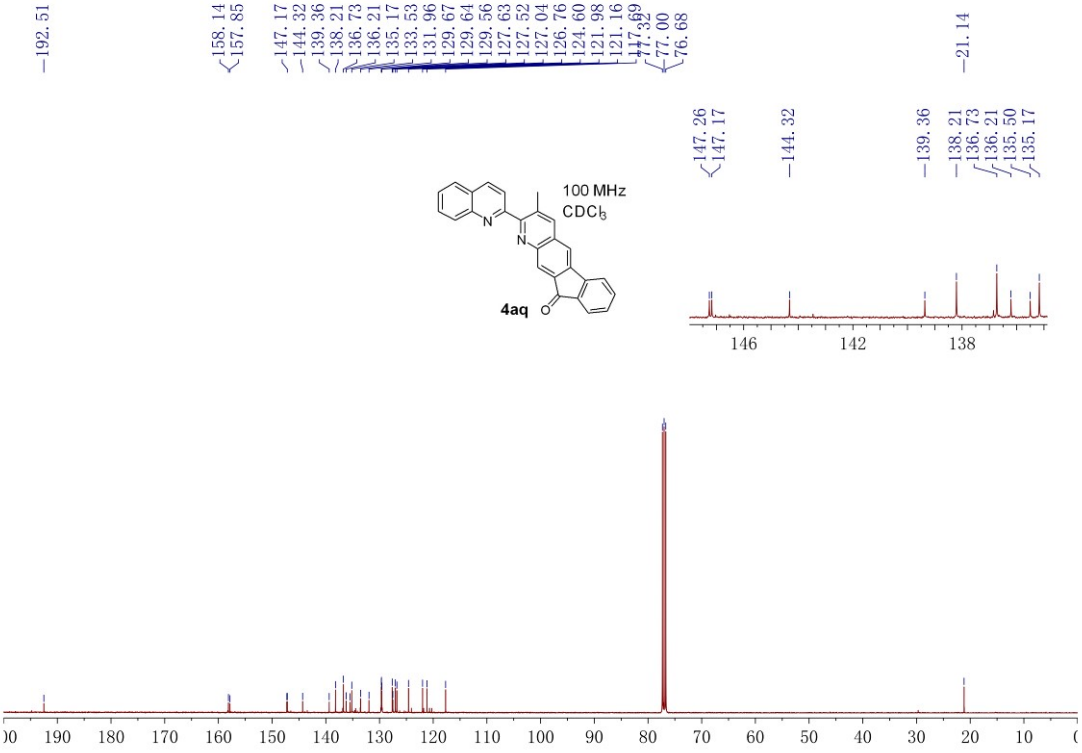
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77.00
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147.26
147.17
144.32
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138.21
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135.50
135.17
100 MHz
CDCl3
4aq
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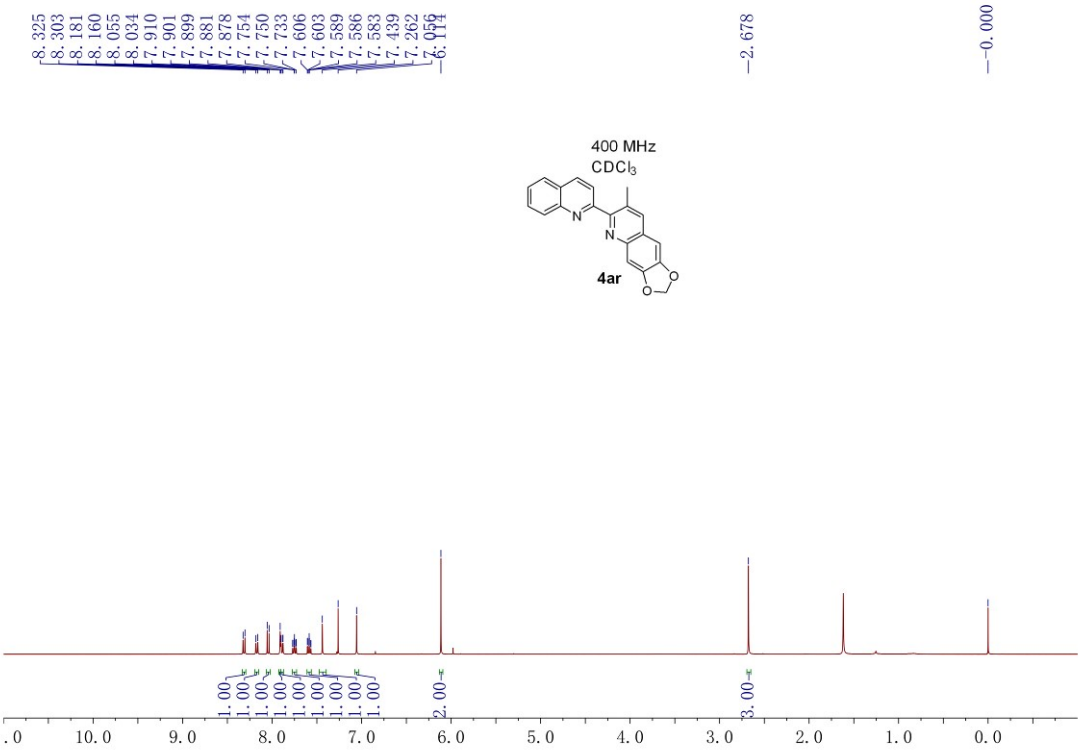
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7.750
7.733
7.606
7.603
7.589
7.586
7.583
7.439
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7.056
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4ar
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1.00
1.00
1.00
1.00
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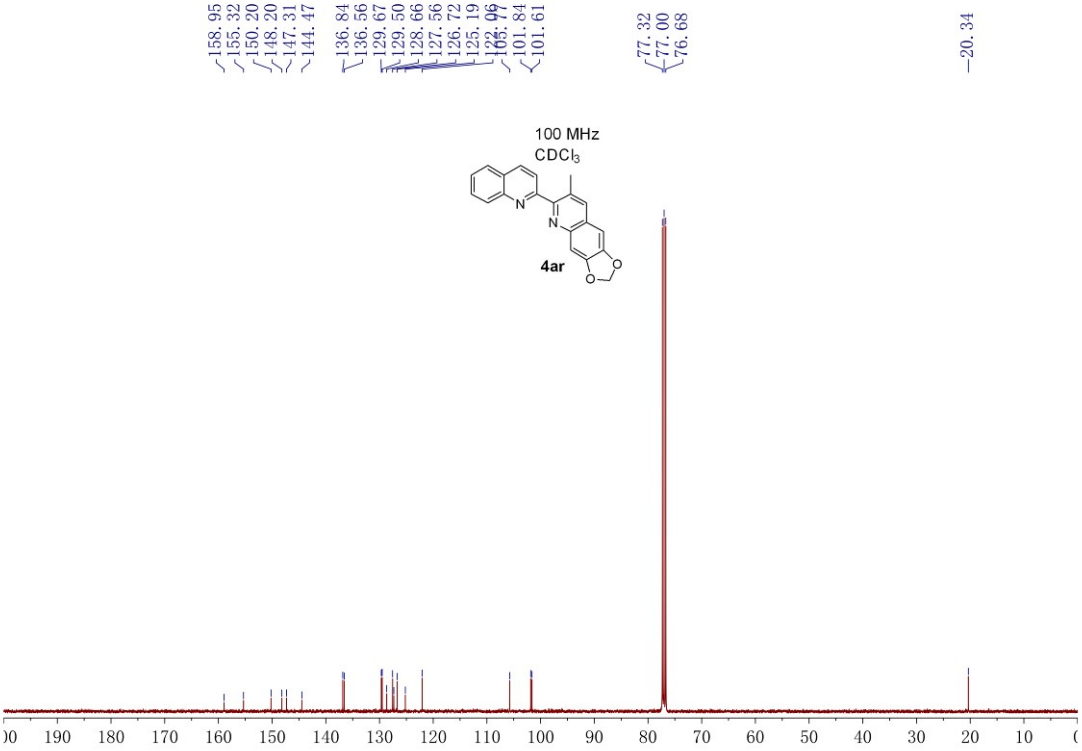
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125.19
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77.00
76.68
20.34
100 MHz
CDCl3
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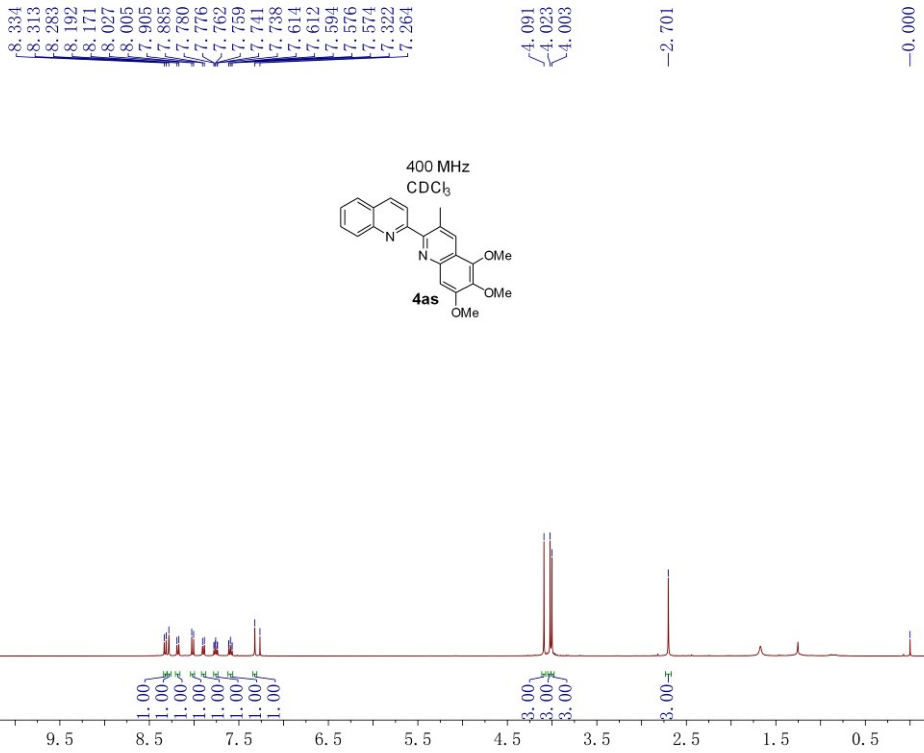
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7.738
7.614
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7.574
7.322
7.264
4.091
4.023
4.003
2.701
0.000
400 MHz
CDCl3
OMe
OMe
4as
OMe
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1.00
1.00
1.00
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3.00
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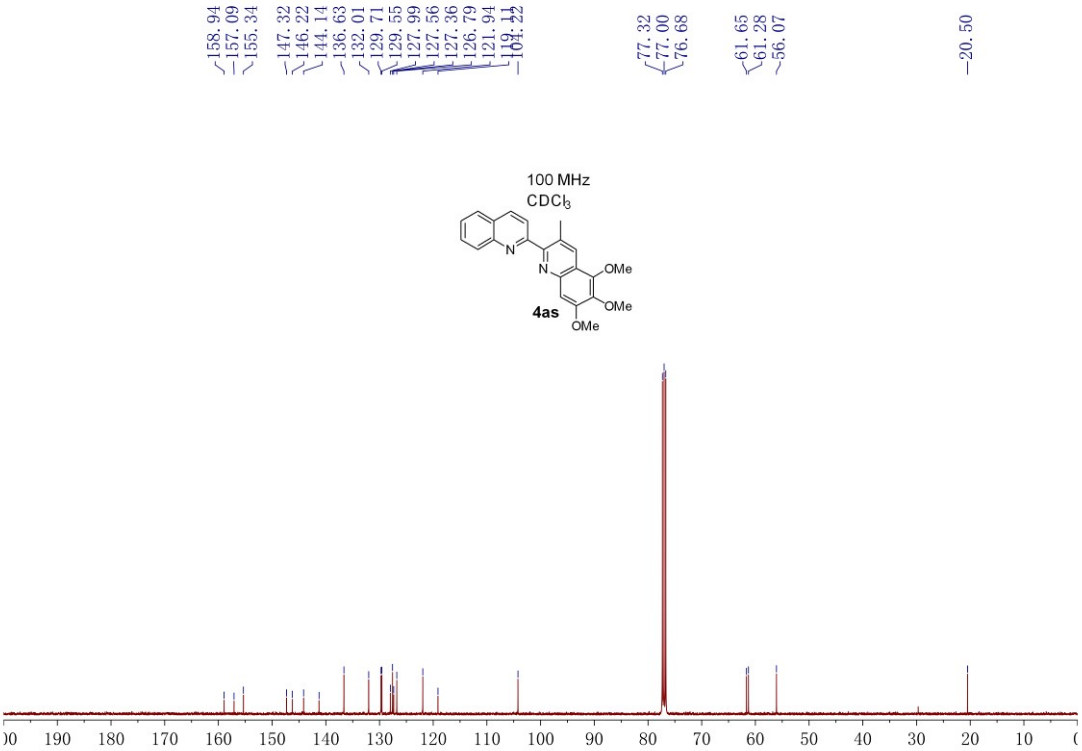
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100 MHz
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OMe
OMe
4as
OMe
190
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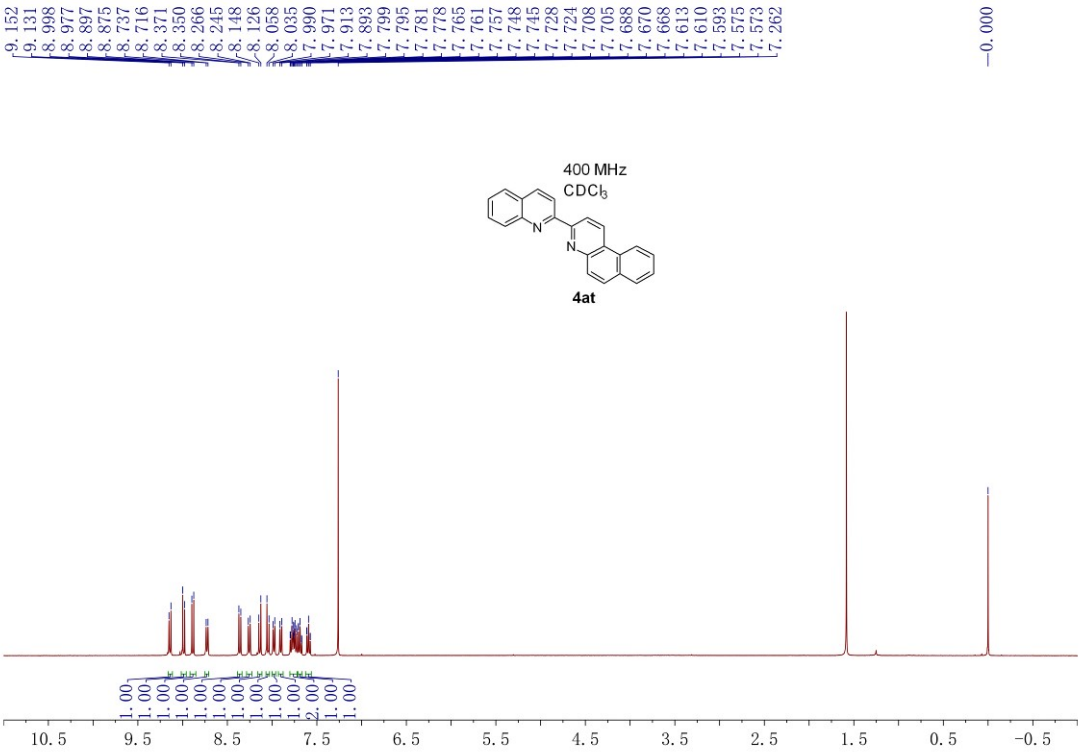
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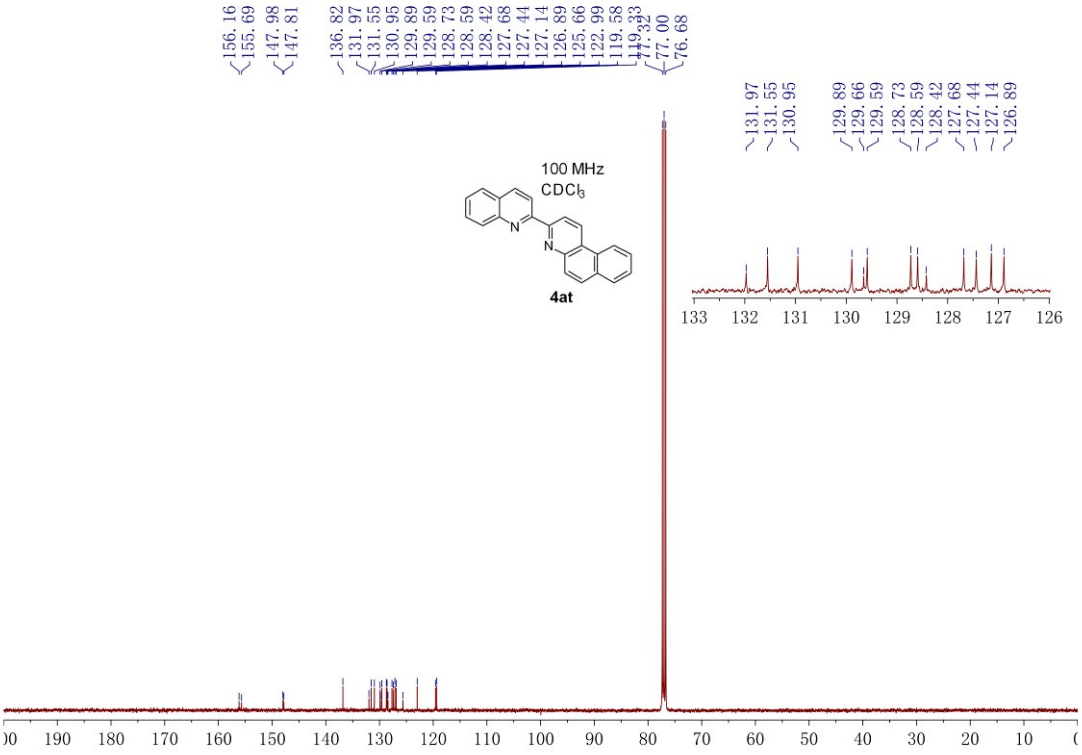
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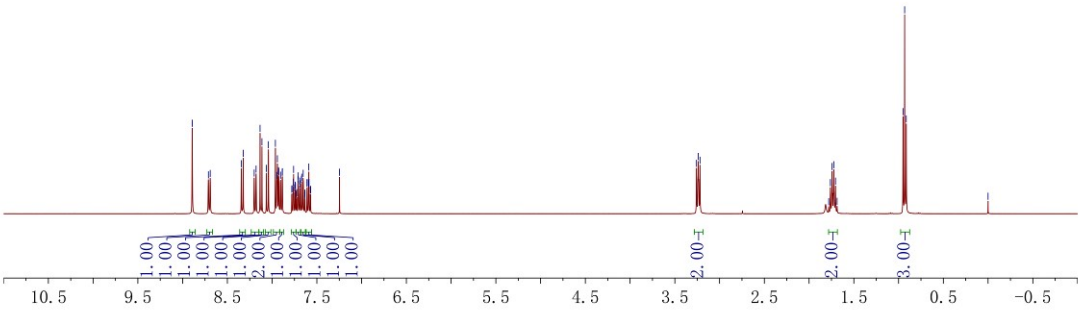
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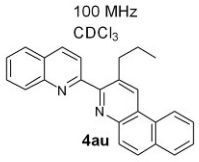
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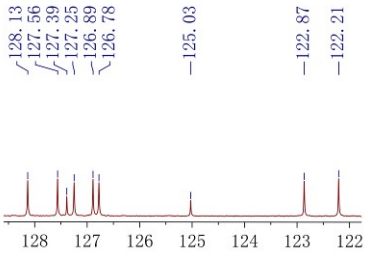
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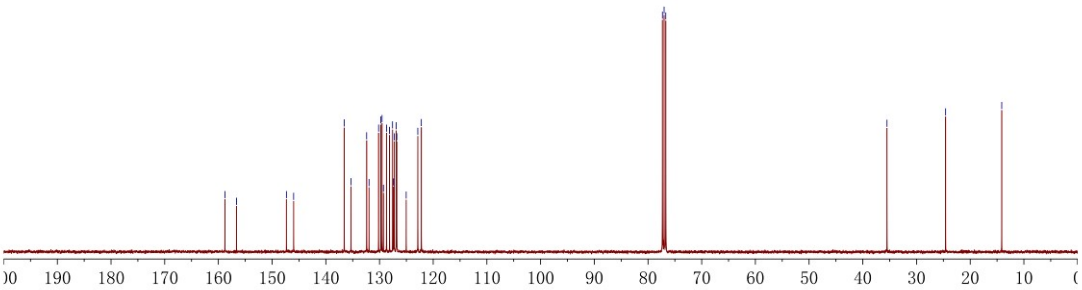
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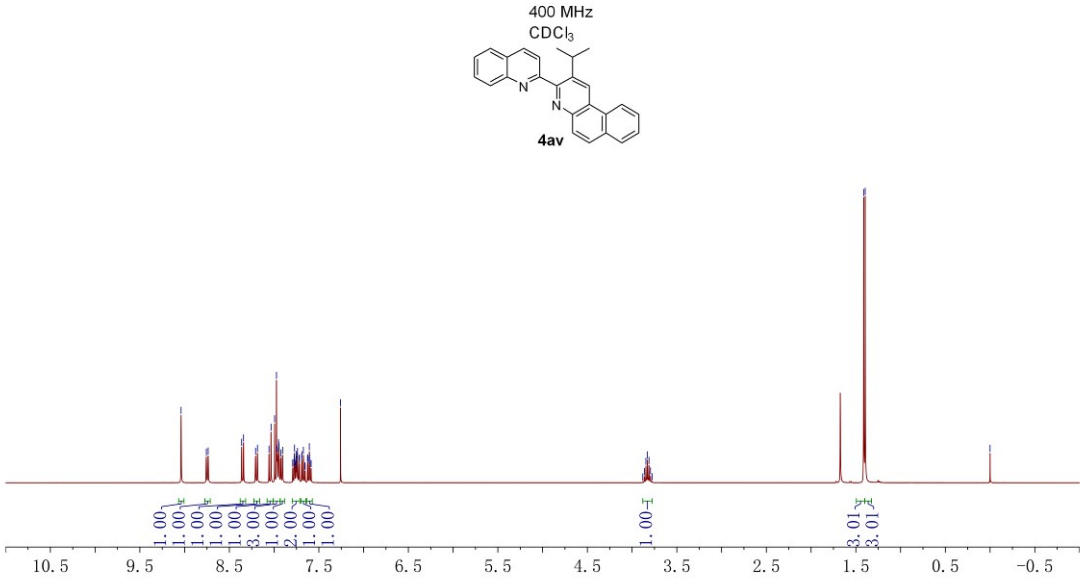
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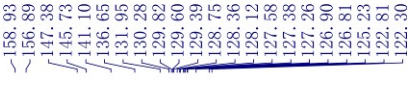
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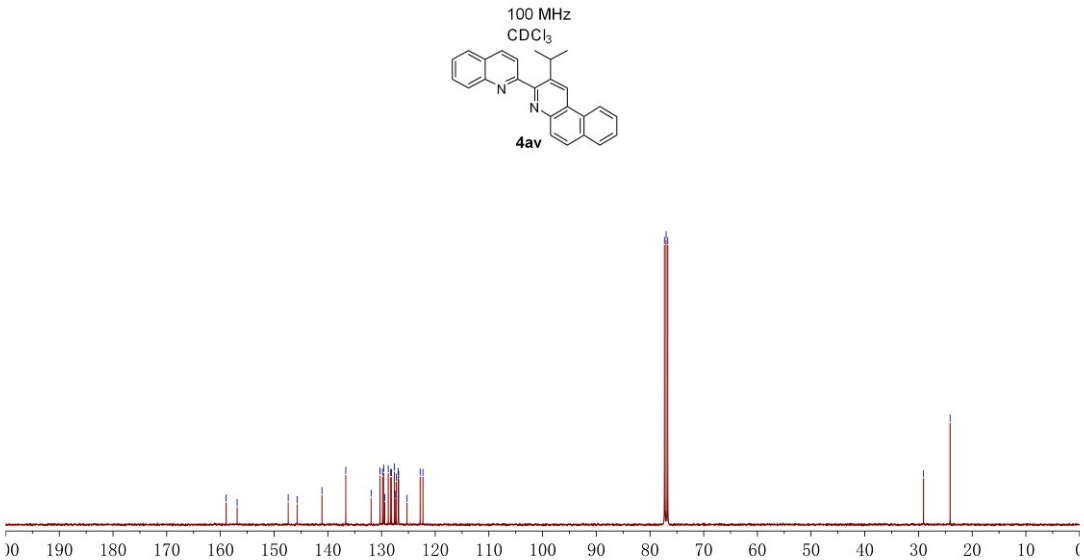
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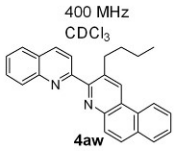
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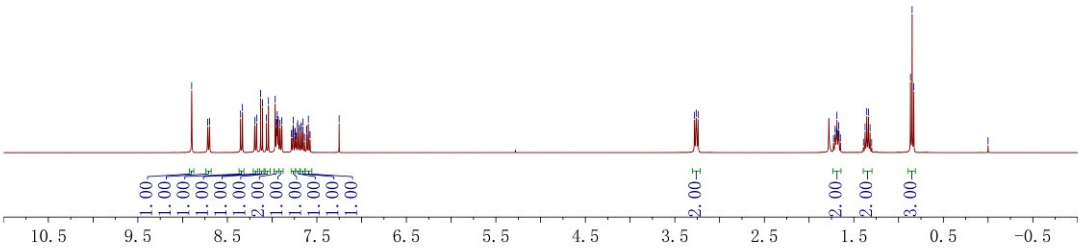
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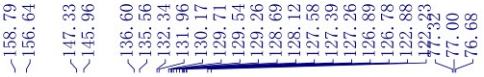
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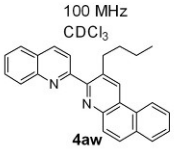
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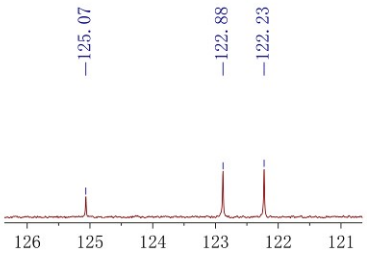
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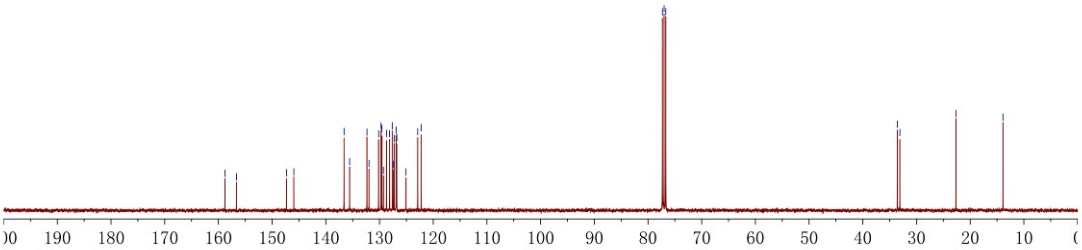
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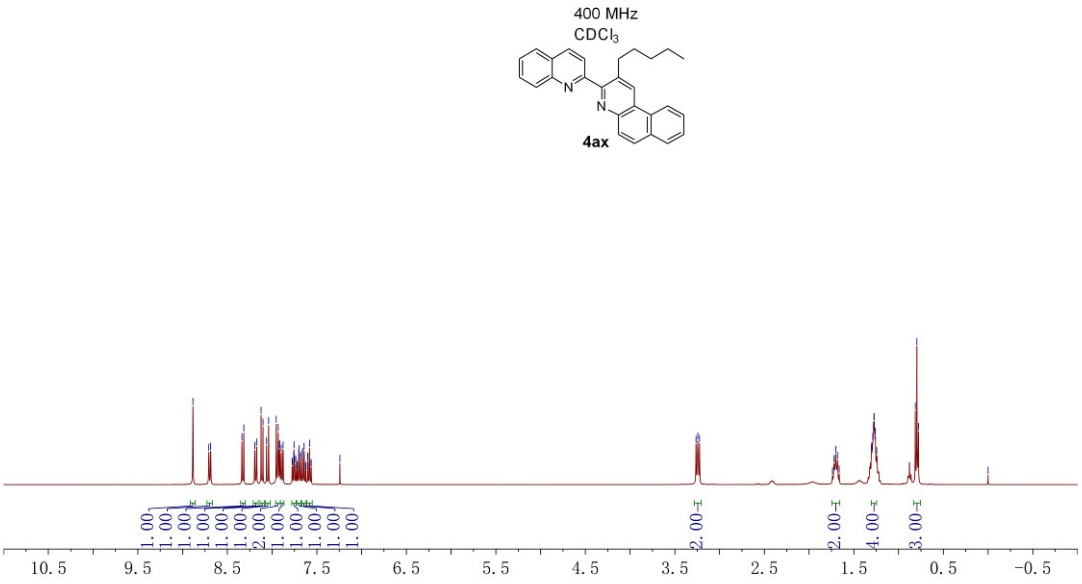
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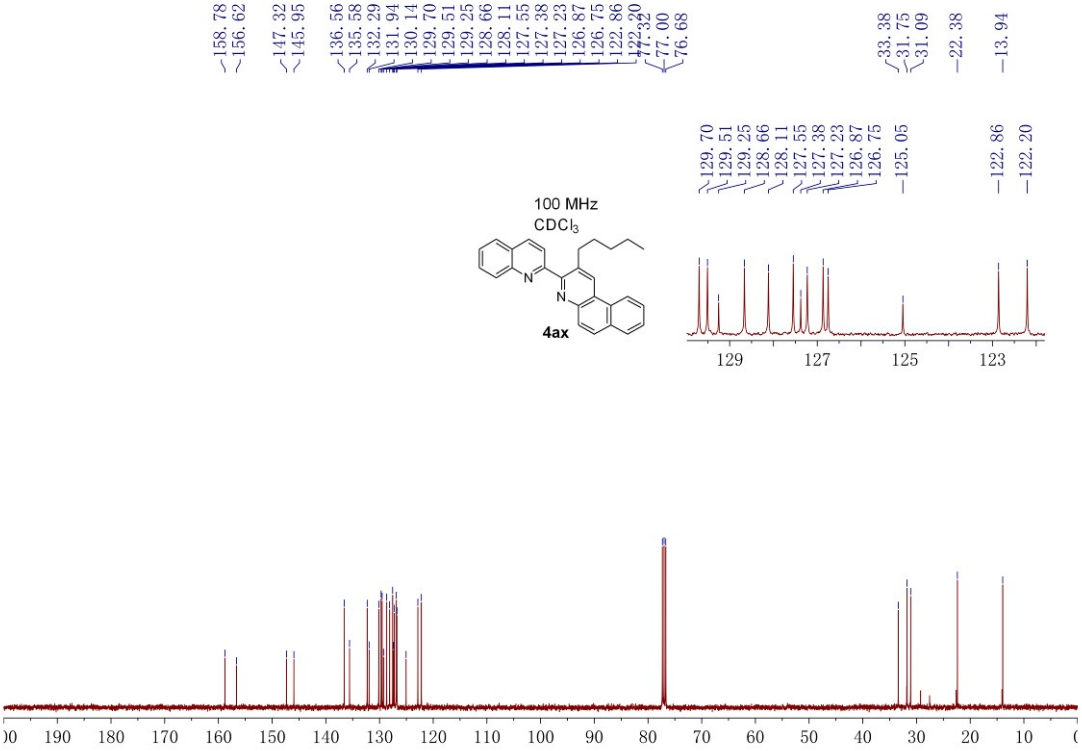
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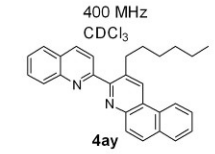
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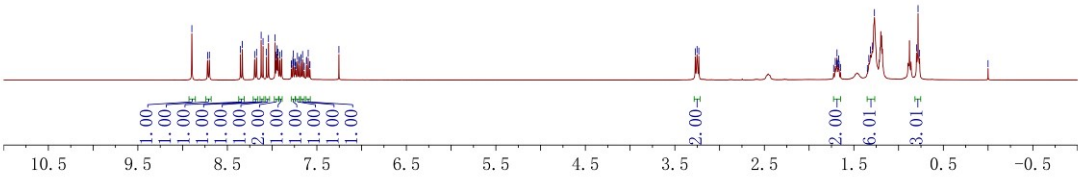
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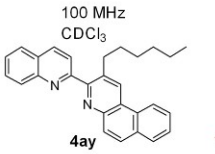
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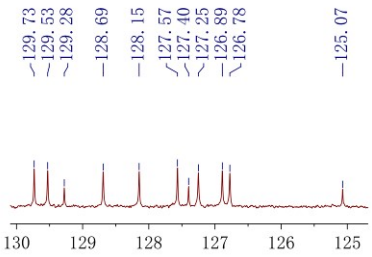
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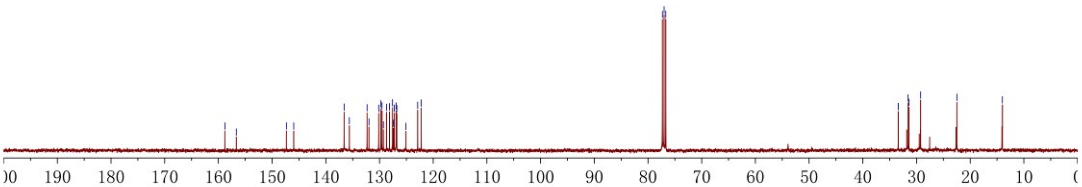
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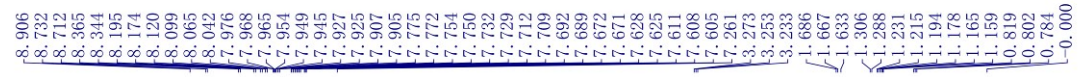

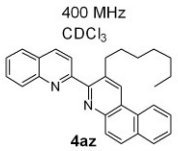
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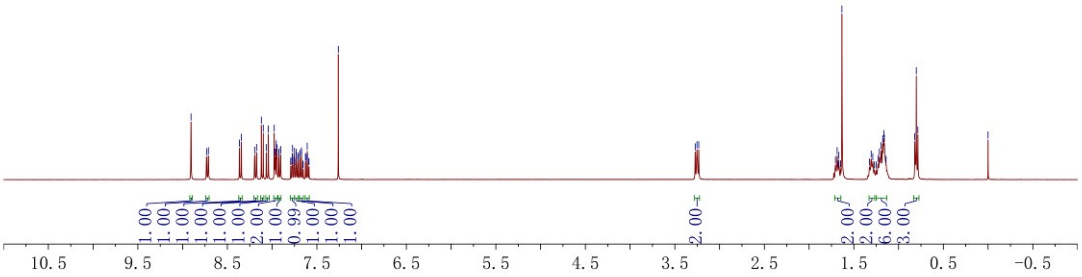

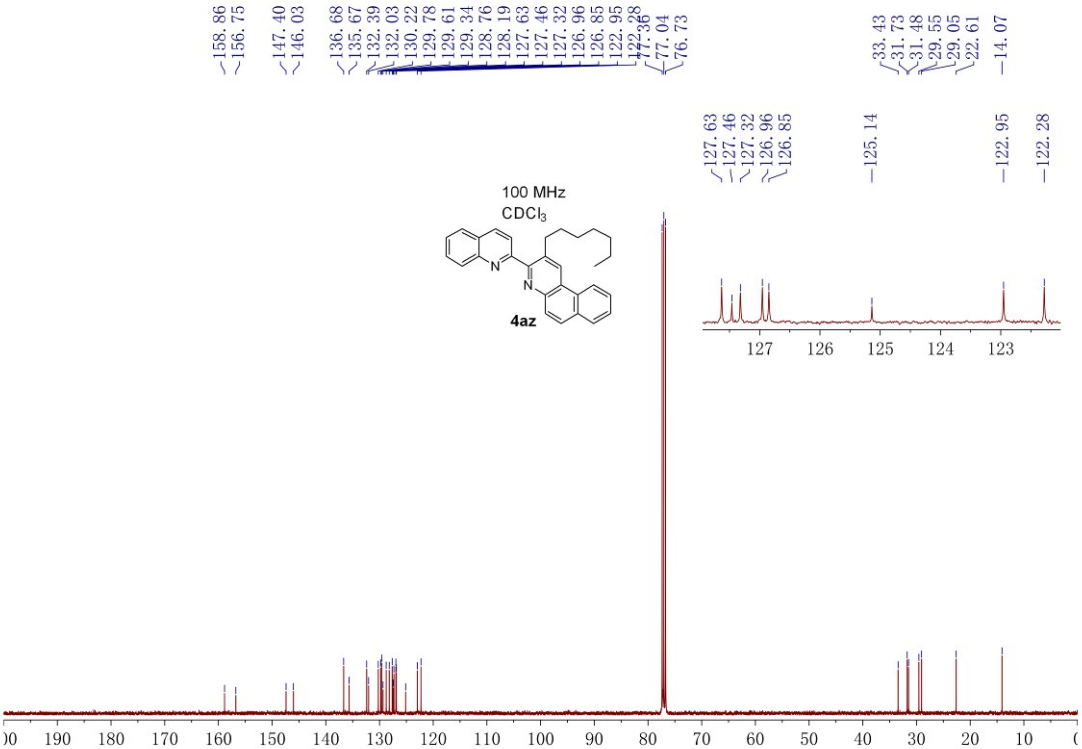

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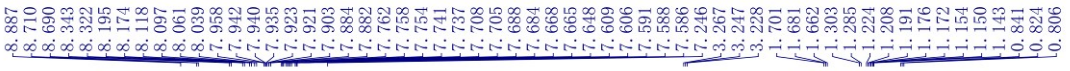
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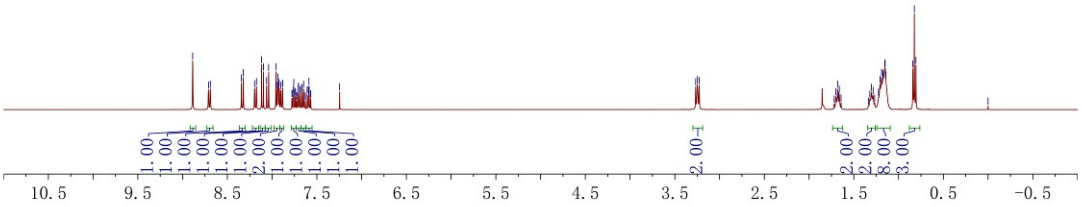
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0.5
-0.5


158.87
156.73
147.41
146.04
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135.69
132.40
132.03
130.23
129.80
129.61
129.34
128.76
128.20
127.64
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127.32
126.96
126.85
122.96
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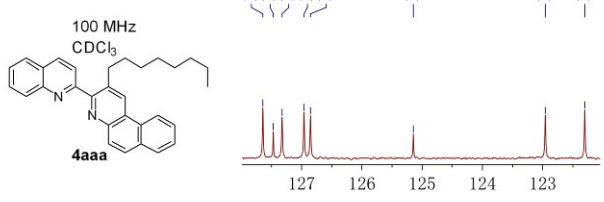
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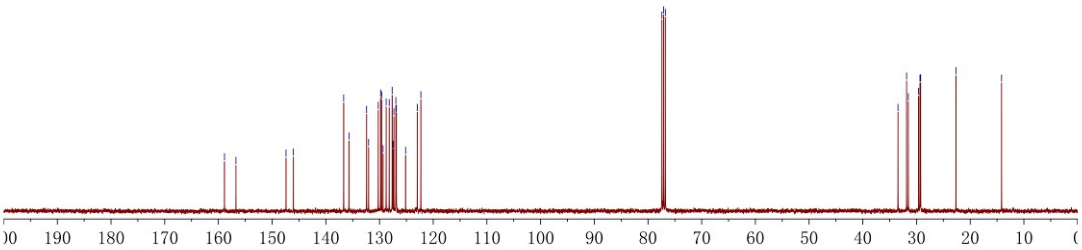
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8.701
8.354
8.333
8.195
8.174
8.119
8.098
8.063
8.040
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7.956
7.953
7.944
7.936
7.933
7.914
7.894
7.785
7.782
7.768
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7.760
7.747
7.743
7.720
7.717
7.700
7.697
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7.677
7.661
7.619
7.616
7.601
7.598
7.596
7.581
7.578
7.253
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3.250
3.230
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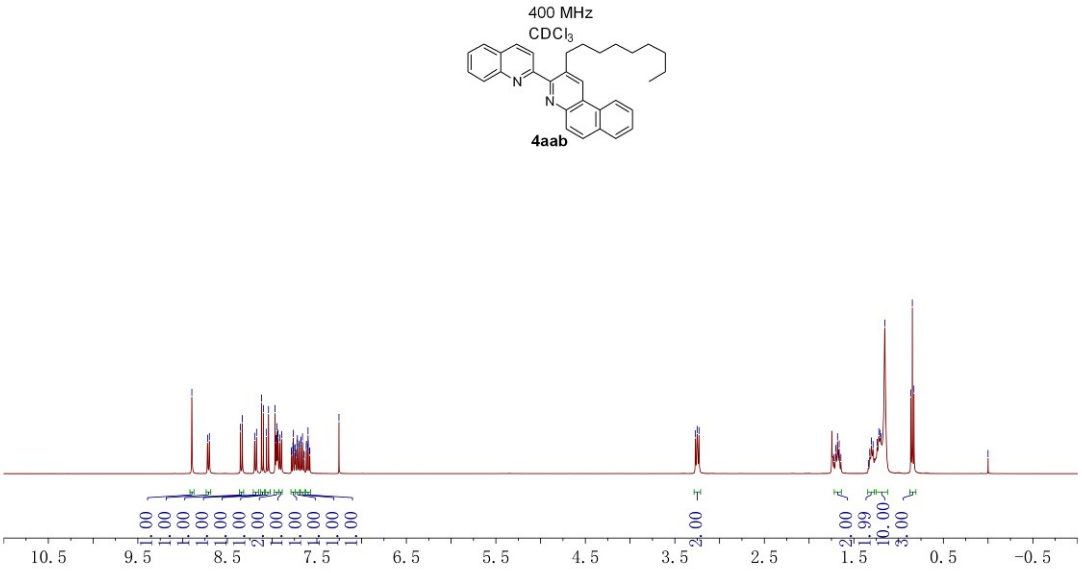
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10.00
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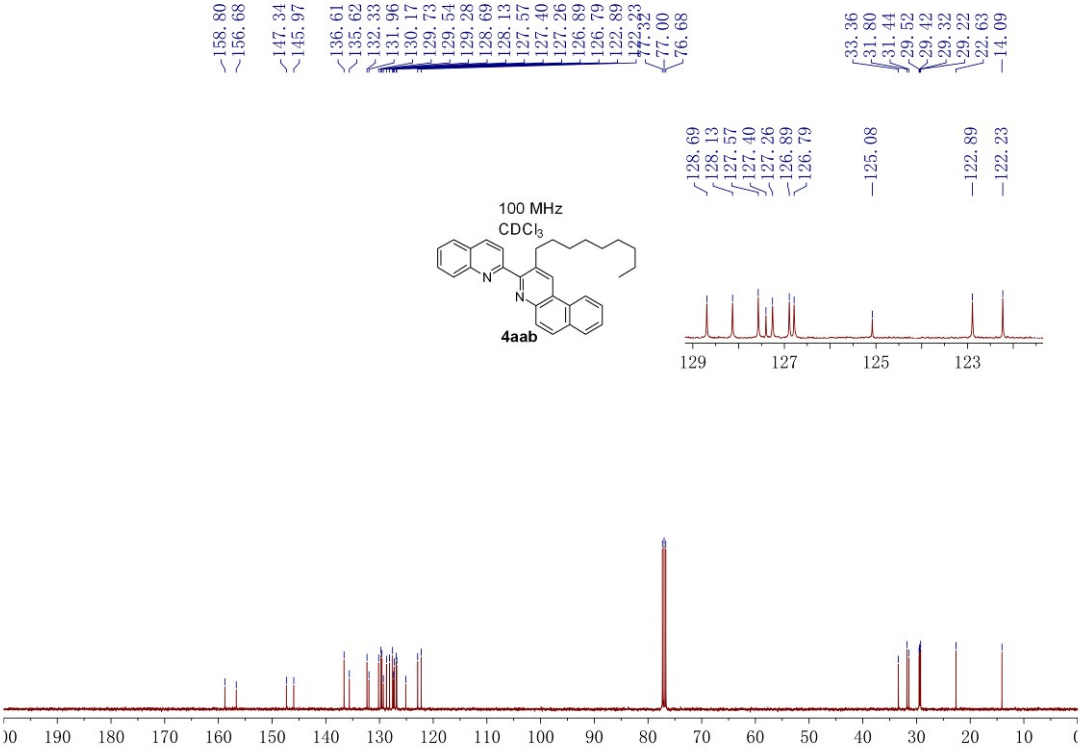
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122.89
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76.68
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22.63
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CDCl3
4aab
129
127
125
123
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140
130
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100
90
80
70
60
50
40
30
20
10


8.902
8.728
8.707
8.359
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8.195
8.174
8.122
8.100
8.064
8.041
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7.961
7.949
7.943
7.920
7.900
7.788
7.785
7.767
7.749
7.746
7.742
7.724
7.707
7.703
7.687
7.684
7.667
7.648
7.622
7.604
7.586
7.584
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1.704
1.676
1.666
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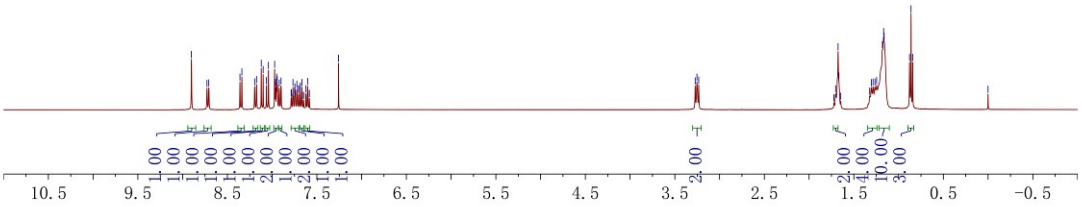
400 MHz
CDCl3
4aac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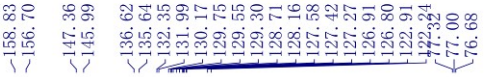
-0.5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128.71
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126.80
122.91
122.24
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29.26
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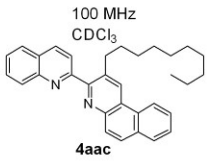
14.11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CDCl3
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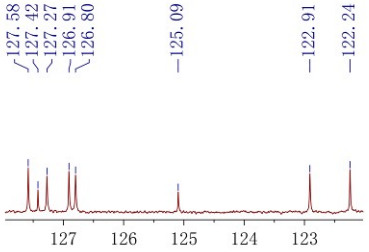
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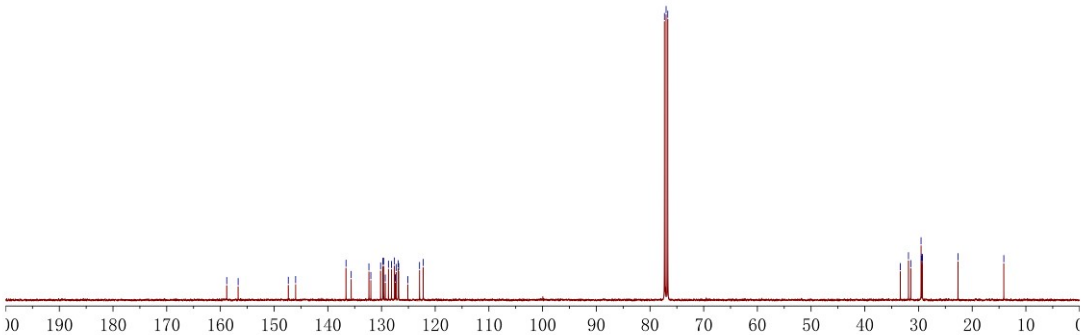
123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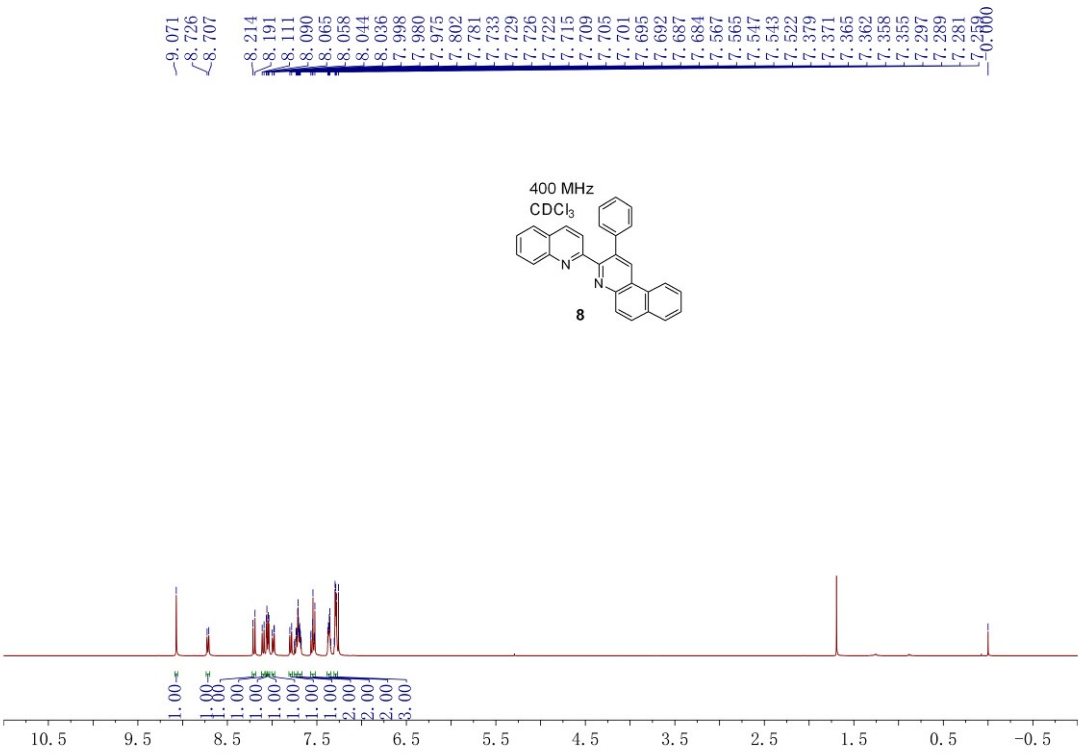
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7.802
7.781
7.733
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7.726
7.722
7.715
7.709
7.705
7.701
7.695
7.692
7.687
7.684
7.567
7.565
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7.543
7.522
7.379
7.371
7.365
7.362
7.358
7.355
7.297
7.289
7.281
7.259
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400 MHz
CDCl3
8
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1.00
1.00
1.00
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1.00
1.00
2.00
2.00
2.00
3.00
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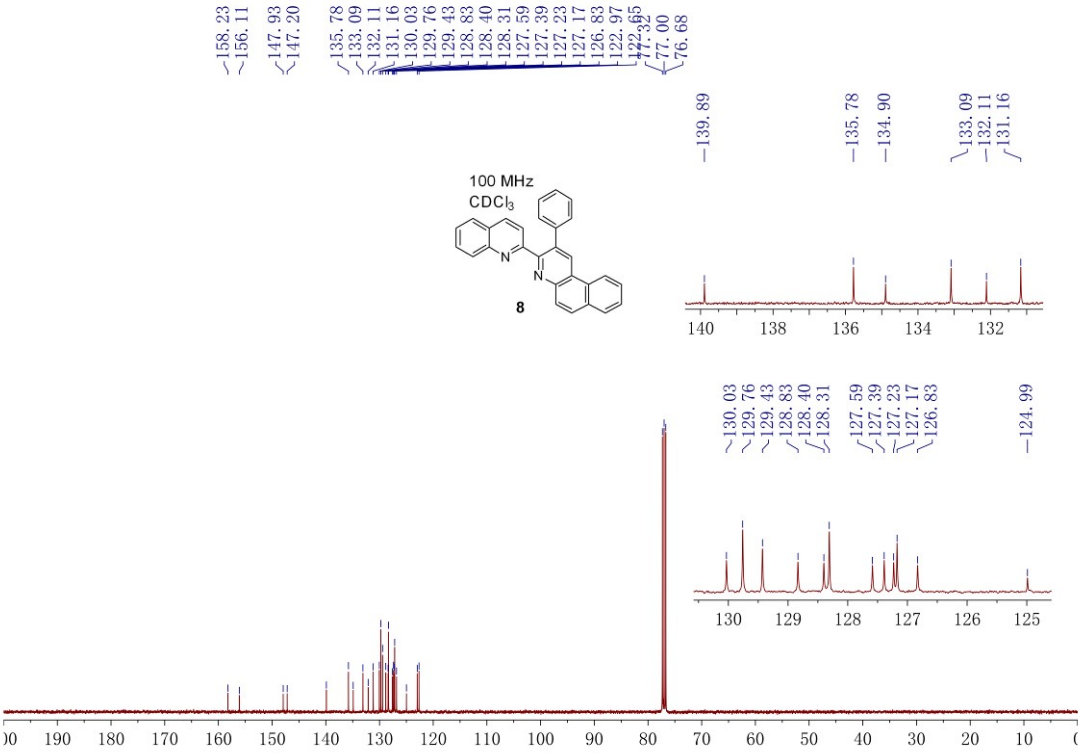
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122.97
77.32
77.00
76.68
139.89
135.78
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133.09
132.11
131.16
100 MHz
CDCl3
8
140
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136
134
132
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