Supporting Information

Transfer Hydrogenative *Para*-Selective Aminoalkylation of Aniline Derivatives with N-Heteroarenes by a Ruthenium/Acid Dual Catalysis

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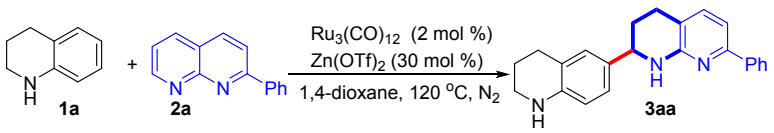
1. General information

All the obtained products were characterized by melting points (m.p), ^{1}H-NMR, ^{13}C-NMR and infrared spectra (IR). Melting points were measured on an Electrothemal SGW-X4 microscopy digital melting point apparatus and are uncorrected; IR spectra were recorded on a FTLA2000 spectrometer; ^{1}H-NMR and ^{13}C-NMR spectra were obtained on Bruker-400 and referenced to 7.26 ppm for chloroform solvent with TMS as internal standard (0 ppm). Chemical shifts were reported in parts per million (ppm, δ) downfield from tetramethylsilane. Proton coupling patterns are described as singlet (s), doublet (d), triplet (t), multiplet (m); TLC was performed using commercially prepared 100-400 mesh silica gel plates (GF254), and visualization was effected at 254 nm; Unless otherwise stated, all the reagents were purchased from commercial sources (J&KChemic, TCI, Fluka, Acros, SCRC), used without further purification.

2. Optimization of reaction conditions

Our initial studies focused on developing an efficient catalyst system for the coupling of excess 1,2,3,4-tetrahydroquinoline (THQ, 1.5 eq) 1a with 2-phenyl-1,8-naphthyridine 2a as a model system. First, in the presence of 30 mol % $Zn(OTf)_2$, the reaction was performed at 120 ^{o}C for 16 h by testing 4 transition metal catalysts used frequently for dehydrogenation reactions (Table 1, entries 1-4). $Ru_3(CO)_{12}$ exhibited the best catalytic performance and afforded the coupling product 3aa in 36% yield. Then, a series of Lewis acids (entries 5-6) and Brønsted acids (entries 7-12) were evaluated. The results indicated that TsOH was the best choice (entry 11). Thus, we chose $Ru_3(CO)_{12}$/TsOH as a preferred combination. Among several solvents tested (entries 13-16), the apolar toluene improved the product yield to 73%. Further investigations revealed that change of reaction temperatures or the THQ (1a) loadings was unsuccessful in further improving the yields (entries 17-18), and both $Ru_3(CO)_{12}$ and TsOH were essential to give product 3aa (entry 19). Thus, the optimal conditions are as indicated in entry 13 of Table 1.

Table S1. Screening of optimal reaction conditions[a]



Entry	Condition deviation	**3aa** (yield%)[b]
1	None	36
2	$[RuCl_2(p\text{-cymene})]_2$ instead of $Ru_3(CO)_{12}$	32
3	$Pd(OAc)_2$ instead of $Ru_3(CO)_{12}$	12
4	$[Cp^*IrCl_2]_2$ instead of $Ru_3(CO)_{12}$	34
5	$Cu(OTf)_2$ instead of $Zn(OTf)_2$	38
6	$Yb(OTf)_3$ instead of $Zn(OTf)_2$	42
7	H_2SO_4 instead of $Zn(OTf)_2$	Trace
8	Benzoic acid instead of $Zn(OTf)_2$	16
9	CF_3COOH instead of $Zn(OTf)_2$	32
10	CH_3CO_2H instead of $Zn(OTf)_2$	NR
11	TsOH instead of $Zn(OTf)_2$	46
12	PivOH instead of $Zn(OTf)_2$	Trace
13	acid: TsOH, solvent: toluene	73
14	acid: TsOH, solvent: *p*-xylene	72
15	acid: TsOH, solvent: *t*-AmOH	63
16	acid: TsOH, solvent: DMSO	Trace
17	acid: TsOH, solvent: toluene	(68, 73)[c]
18	acid: TsOH, solvent: toluene	72[d]
19	absence of $Ru_3(CO)_{12}$ or TsOH	(-, -)[e]

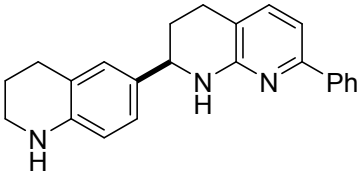
[a] Reaction conditions: Unless otherwise stated, all the reactions were performed with **1a** (0.3 mmol), **2a** (0.2 mmol), Cat. (2 mol %), acid (30 mol %), solvent (1.0 mL) at 120 °C for 16 h under N_2 protection. [b] Isolated yield. [c] Yields are with respect to the temperatures at 110 °C and 130 °C, respectively. [d] **1a**: 0.4 mmol. [e] Yields are with to the absence of $Ru_3(CO)_{12}$ and TsOH, respectively.

3. Typical procedure for the synthesis of 3aa

Under N_2 atmosphere, tetrahydroquinoline **1a** (0.3 mmol), 2-phenyl-1,8-naphthyridine **2a** (0.2 mmol), $Ru_3(CO)_{12}$ (2 mol %), TsOH (30 mol %) and toluene (1.0 mL) were introduced into a Schlenk tube (25 mL), successively. Then, the Schlenk tube was closed and the resulting mixture was stirred at 120 °C for 16 h. After cooling down to room temperature, the reaction mixture was concentrated by removing the solvent under vacuum, and the residue was purified by preparative TLC on silica, eluting with petroleum ether (60-90 °C): ethyl acetate (5:1) to give **3aa** (48.5 mg, 71% yield).

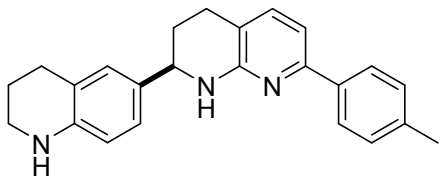
4. Analytical data of the obtained compounds

7-phenyl-2-(1,2,3,4-tetrahydroquinolin-6-yl)-1,2,3,4-tetrahydro-1,8-naphthyridine (3aa)



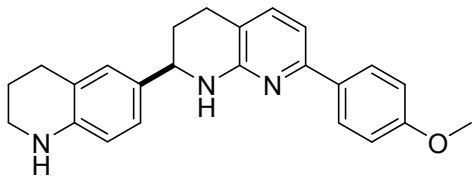
Yellow oil (48.5 mg, 71% yield); R_f = 0.4 (petroleum ether/ethyl acetate = 5/1, v/v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.91 (d, *J* = 7.6 Hz, 2H), 7.40 (t, *J* = 7.6 Hz, 2H), 7.33 (d, *J* = 7.2 Hz, 1H), 7.25 (d, *J* = 7.6 Hz, 1H), 7.08 – 6.91 (m, 3H), 6.43 (d, *J* = 7.8 Hz, 1H), 5.09 (s, 1H), 4.45 (dd, *J* = 9.1, 3.0 Hz, 1H), 3.81 (s, 1H), 3.36 – 3.18 (m, 2H), 2.90 – 2.79 (m, 1H), 2.78 – 2.65 (m, 3H), 2.13 – 2.04 (m, 1H), 1.97 – 1.86 (m, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 156.2, 154.1, 144.3, 140.0, 136.7, 132.2, 128.5, 128.2, 127.5, 126.6, 124.9, 121.5, 114.6, 114.2, 109.7, 55.8, 42.0, 30.7, 27.1, 25.7, 22.2. IR (KBr): 2925, 1595, 1459, 1302, 1124, 815, 754, 695 cm^{-1}. HRMS (ESI): Calcd. for $C_{23}H_{24}N_3$ $[M+H]^+$: 342.1965; found: 342.1969.

2-(1,2,3,4-tetrahydroquinolin-6-yl)-7-(*p*-tolyl)-1,2,3,4-tetrahydro-1,8-naphthyridine (3ab)



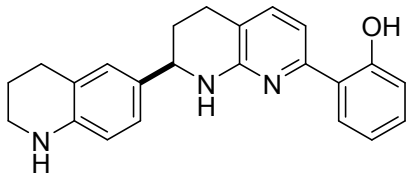
Yellow solid (42.6 mg, 60% yield); R_f = 0.4 (petroleum ether/ethyl acetate = 5/1, v/v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.86 (d, *J* = 7.7 Hz, 2H), 7.32 – 7.23 (m, 3H), 7.10 – 6.94 (m, 3H), 6.48 (d, *J* = 7.8 Hz, 1H), 5.14 (s, 1H), 4.49 (dd, *J* = 9.0, 2.8 Hz, 1H), 3.38 – 3.27 (m, 2H), 2.94 – 2.84 (m, 1H), 2.77 (dt, *J* = 9.6, 5.6 Hz, 3H), 2.42 (s, 3H), 2.17 – 2.08 (m, 1H), 2.05 – 1.91 (m, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 156.1, 154.0, 144.3, 138.0, 137.2, 136.7, 132.2, 129.2, 127.6, 126.5, 124.9, 121.5, 114.3, 114.2, 109.4, 55.8, 42.0, 30.8, 27.1, 25.7, 22.2, 21.3. IR (KBr): 2923, 2852, 1594, 1499, 1460, 1323, 1298, 1179, 1123, 805, 758 cm^{-1}. HRMS (ESI): Calcd. for $C_{24}H_{26}N_3$ $[M+H]^+$: 356.2121; found: 356.2128.

7-(4-methoxyphenyl)-2-(1,2,3,4-tetrahydroquinolin-6-yl)-1,2,3,4-tetrahydro-1,8-naphthyridine (3ac)



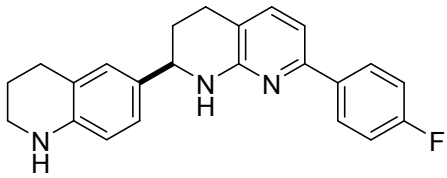
Gray oil (40.8 mg, 55% yield); R_f = 0.3 (petroleum ether/ethyl acetate = 5/1, v/v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.89 (d, *J* = 8.7 Hz, 2H), 7.25 (s, 1H), 7.02 – 6.92 (m, 5H), 6.45 (d, *J* = 7.8 Hz, 1H), 5.10 (s, 1H), 4.46 (dd, *J* = 9.1, 3.0 Hz, 1H), 3.84 (s, 3H), 3.33 – 3.26 (m, 2H), 2.89 – 2.80 (m, 1H), 2.78 – 2.65 (m, 3H), 2.13 – 2.06 (m, 1H), 1.99 – 1.88 (m, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 159.9, 156.1, 153.7, 144.3, 136.7, 132.7, 132.2, 127.8, 127.5, 124.9, 121.5, 114.2, 113.9, 113.8, 109.0, 55.8, 55.3, 42.0, 30.8, 27.1, 25.7, 22.2. IR (KBr): 2927, 2836, 1592, 1513, 1460, 1247, 1125, 840, 807, 735 cm^{-1}. HRMS (ESI): Calcd. for $C_{24}H_{26}N_3O$ $[M+H]^+$: 372.2070; found: 372.2074.

2-(7-(1,2,3,4-tetrahydroquinolin-6-yl)-5,6,7,8-tetrahydro-1,8-naphthyridin-2-yl)phenol (3ad)



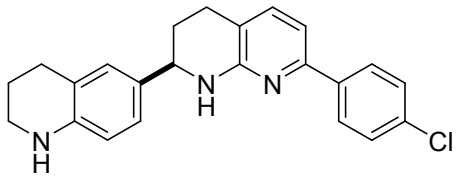
Yellow oil (52.2 mg, 73% yield); R_f = 0.3 (petroleum ether/ethyl acetate = 5/1, v/v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.70 (d, *J* = 8.0 Hz, 1H), 7.28 (d, *J* = 7.8 Hz, 1H), 7.25 – 7.17 (m, 1H), 7.08 (d, *J* = 7.8 Hz, 1H), 6.99 – 6.87 (m, 3H), 6.83 (t, *J* = 7.5 Hz, 1H), 6.53 – 6.38 (m, 1H), 4.97 (s, 1H), 4.39 (dd, *J* = 9.1, 3.0 Hz, 1H), 3.39 – 3.22 (m, 2H), 2.84 – 2.64 (m, 4H), 2.10 – 2.01 (m, 1H), 1.98 – 1.79 (m, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 159.4, 153.9, 153.3, 144.5, 137.5, 131.3, 130.4, 127.5, 126.2, 124.9, 121.6, 119.8, 118.6, 118.2, 114.3, 107.9, 55.8, 42.0, 30.3, 27.1, 25.6, 22.1. IR (KBr): 2925, 1628, 1596, 1511, 1469, 1281, 812, 751 cm^{-1}. HRMS (ESI): Calcd. for $C_{23}H_{24}N_3O$ $[M+H]^+$: 358.1914; found: 358.1913.

7-(4-fluorophenyl)-2-(1,2,3,4-tetrahydroquinolin-6-yl)-1,2,3,4-tetrahydro-1,8-naphthyridine (3ae)



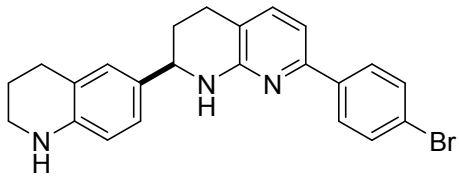
Reddish brown solid (45.3 mg, 63% yield); m.p: 146-148°C; R_f = 0.4 (petroleum ether/ethyl acetate = 5/1, v/v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.89 (dd, *J* = 8.1, 5.9 Hz, 2H), 7.24 (d, *J* = 6.2 Hz, 1H), 7.07 (t, *J* = 8.6 Hz, 2H), 6.96 (d, *J* = 7.6 Hz, 2H), 6.91 (d, *J* = 7.5 Hz, 1H), 6.44 (d, *J* = 7.9 Hz, 1H), 5.07 (s, 1H), 4.45 (dd, *J* = 9.0, 2.8 Hz, 1H), 3.82 (s, 1H), 3.37 – 3.24 (m, 2H), 2.89 – 2.79 (m, 1H), 2.77 – 2.67 (m, 3H), 2.13 – 2.04 (m, 1H), 1.97 – 1.87 (m, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 163.1 (d, *J* = 246.9 Hz), 156.2, 152.99, 144.3, 136.7, 136.1, 132.1, 128.3 (d, *J* = 8.1 Hz), 127.5, 124.9, 121.5, 115.3 (d, *J* = 21.4 Hz), 114.6, 114.2, 109.3, 55.8, 42.0, 30.7, 27.1, 25.6, 22.2. IR (KBr): 2925, 2841, 1598, 1510, 1460, 1323, 1299, 1198, 1155, 1009, 845, 808 cm^{-1}. HRMS (ESI): Calcd. for $C_{23}H_{23}FN_3$ $[M+H]^+$: 360.1871; found: 360.1875.

7-(4-chlorophenyl)-2-(1,2,3,4-tetrahydroquinolin-6-yl)-1,2,3,4-tetrahydro-1,8-naphthyridine (3af)



Brown solid (51.0 mg, 68% yield); m.p: 138-139 °C; R_f = 0.4 (petroleum ether/ethyl acetate = 5/1, v/v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.86 (d, *J* = 8.5 Hz, 2H), 7.36 (d, *J* = 8.5 Hz, 2H), 7.25 (t, *J* = 3.7 Hz, 1H), 7.04 – 6.90 (m, 3H), 6.45 (d, *J* = 8.4 Hz, 1H), 5.13 (s, 1H), 4.46 (dd, *J* = 9.1, 3.0 Hz, 1H), 3.83 (s, 1H), 3.37 – 3.23 (m, 2H), 2.80 – 2.91 (m, 1H), 2.78 – 2.66 (m, 3H), 2.14 – 2.05 (m, 1H), 1.97 – 1.88 (m, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 156.2, 152.6, 144.3, 138.3, 136.8, 134.1, 132.0, 128.6, 127.9, 127.5, 124.9, 121.5, 115.1, 114.2, 109.4, 55.8, 42.0, 30.6, 27.1, 25.7, 22.2. IR (KBr): 2923, 2851, 1660, 1629, 1592, 1459, 1300, 1090, 804, 756 cm^{-1}. HRMS (ESI): Calcd. for $C_{23}H_{23}ClN_3$ $[M+H]^+$: 376.1575; found: 376.1578.

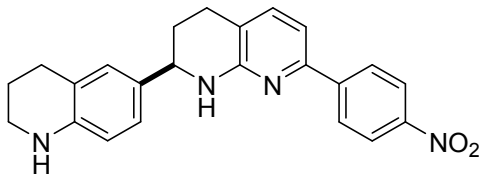
7-(4-bromophenyl)-2-(1,2,3,4-tetrahydroquinolin-6-yl)-1,2,3,4-tetrahydro-1,8-naphthyridine (3ag)



Yellow solid (55.3 mg, 66% yield); m.p: 171-173 °C; R_f = 0.5 (petroleum ether/ethyl acetate = 5/1, v/v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.83 (d, *J* = 8.3 Hz, 2H), 7.55 (d, *J* = 8.4 Hz, 2H), 7.27 (d, *J* = 2.6 Hz, 1H), 7.09 – 6.86 (m, 3H), 6.46 (d, *J* = 8.1 Hz, 1H), 5.18 (s, 1H), 4.64 – 4.32 (m, 1H), 3.38 – 3.23 (m, 2H), 2.90 – 2.81 (m, 1H), 2.80 – 2.67 (m, 3H), 2.16 – 2.07 (m, 1H), 2.00 – 1.86 (m, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 156.3, 152.6, 144.3, 138.9, 136.8, 131.9, 131.6, 128.2, 127.5, 124.9, 122.4, 121.5, 115.1, 114.2, 109.4, 55.8, 42.0, 30.6, 27.1, 25.7, 22.2. IR (KBr): 2924, 1628, 1594, 1499, 1458, 1323, 806 cm^{-1}. HRMS (ESI): Calcd. for $C_{23}H_{23}BrN_3$ $[M+H]^+$: 420.1070; found: 420.1072.

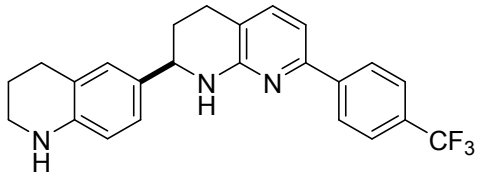
7-(4-nitrophenyl)-2-(1,2,3,4-tetrahydroquinolin-6-yl)-1,2,3,4-tetrahydro-1,8-naphthyridine

(3ah)



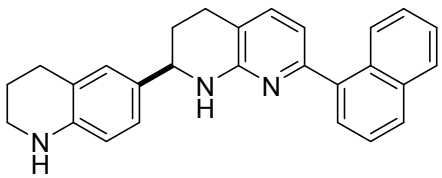
Brown solid (48.0 mg, 62% yield); m.p: 136-138 °C; R_f = 0.3 (petroleum ether/ethyl acetate = 4/1, v/v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.22 (d, *J* = 8.8 Hz, 2H), 8.07 (d, *J* = 8.8 Hz, 2H), 7.28 (d, *J* = 7.5 Hz, 1H), 7.03 (d, *J* = 7.5 Hz, 1H), 6.94 (d, *J* = 6.9 Hz, 2H), 6.43 (d, *J* = 8.7 Hz, 1H), 5.21 (s, 1H), 4.45 (dd, *J* = 9.0, 2.7 Hz, 1H), 3.85 (s, 1H), 3.33 – 3.24 (m, 2H), 2.91 – 2.81 (m, 1H), 2.78 – 2.64 (m, 3H), 2.12 – 2.04 (m, 1H), 1.96 – 1.87 (m, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 156.4, 151.1, 147.5, 150.0, 144.4, 136.7, 131.7, 127.5, 127.1, 124.9, 123.8, 121.5, 116.7, 114.2, 110.4, 55.8, 42.0, 30.4, 27.1, 25.8, 22.1. IR (KBr): 2927, 2840, 1595, 1513, 1460, 1340, 1300, 1125, 1008, 896, 851, 810, 751 cm^{-1}. HRMS (ESI): Calcd. for $C_{23}H_{23}N_4O_2$ $[M+H]^+$: 387.1816; found: 387.1815.

2-(1,2,3,4-tetrahydroquinolin-6-yl)-7-(4-(trifluoromethyl)phenyl)-1,2,3,4-tetrahydro-1,8-naphthyridine (3ai)



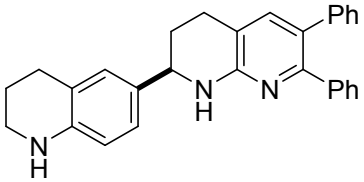
Reddish brown solid (61.4 mg, 75% yield); m.p: 148-150 °C; R_f = 0.4 (petroleum ether/ethyl acetate = 5/1, v/v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.02 (d, *J* = 8.1 Hz, 2H), 7.64 (d, *J* = 8.2 Hz, 2H), 7.26 (d, *J* = 7.5 Hz, 1H), 7.03 – 6.91 (m, 3H), 6.42 (d, *J* = 8.0 Hz, 1H), 5.19 (s, 1H), 4.44 (dd, *J* = 9.0, 2.9 Hz, 1H), 3.80 (s, 1H), 3.32 – 3.19 (m, 2H), 2.88 – 2.79 (m, 1H), 2.78 – 2.66 (m, 3H), 2.12 – 2.04 (m, 1H), 1.96 – 1.84 (m, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 156.3, 152.2, 144.4 , 143.3, 136.8, 131.8, 129.9 (q, *J* = 32.4 Hz), 127.5, 126.8, 125.4 (q, *J* = 3.7 Hz), 124.9, 121.5, 115.8, 114.2, 110.0, 55.8, 42.0, 30.5, 27.1, 25.7, 22.2. ^{19}F NMR (376 MHz, $CDCl_3$) δ -62.37. IR (KBr): 2926, 2849, 1615, 1597, 1511, 1462, 1325, 1163, 1122, 1072, 1013, 854, 808, 740 cm^{-1}. HRMS (ESI): Calcd. for $C_{24}H_{23}F_3N_3$ $[M+H]^+$: 410.1839; found: 410.1842.

7-(4-(naphthalen-1-yl)phenyl)-2-(1,2,3,4-tetrahydroquinolin-6-yl)-1,2,3,4-tetrahydro-1,8-naphthyridine (3aj)



Yellow solid (65.4 mg, 70% yield); m.p: 142-144 °C; R_f = 0.4 (petroleum ether/ethyl acetate = 4/1, v/v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.41 (s, 1H), 8.07 (d, *J* = 8.5 Hz, 1H), 7.92 – 7.80 (m, 3H), 7.50 – 7.42 (m, 2H), 7.28 (d, *J* = 7.5 Hz, 1H), 7.11 (d, *J* = 7.5 Hz, 1H), 6.97 (d, *J* = 7.9 Hz, 2H), 6.43 (d, *J* = 7.8 Hz, 1H), 5.17 (s, 1H), 4.46 (dd, *J* = 9.0, 2.8 Hz, 1H), 3.37 – 3.22 (m, 2H), 2.90 – 2.81 (m, 1H), 2.81 – 2.65 (m, 3H), 2.12 – 2.04 (m, 1H), 2.00 – 1.88 (m, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 156.3, 153.8, 144.3, 137.3, 136.8, 133.6, 133.4, 132.1, 128.7, 128.1, 127.6, 127.6, 126.0, 125.7, 124.9, 124.8, 121.5, 114.8, 114.2, 110.0, 55.9, 42.0, 30.7, 27.1, 25.7, 22.2. IR (KBr): 2924, 2852, 1612, 1591, 1492, 1457, 1321, 1158, 1126, 1010, 874, 805, 738 cm^{-1}. HRMS (ESI): Calcd. for $C_{27}H_{26}N_3$ $[M+H]^+$: 392.2121; found: 392.2124.

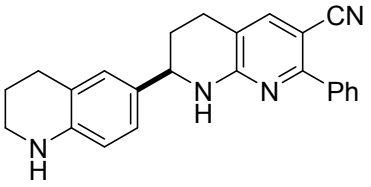
6,7-diphenyl-2-(1,2,3,4-tetrahydroquinolin-6-yl)-1,2,3,4-tetrahydro-1,8-naphthyridine (3ak)



Yellow solid (63.4 mg, 76% yield); m.p: 207-209 °C; R_f = 0.4 (petroleum ether/ethyl acetate = 4/1, v/v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.45 – 7.38 (m, 2H), 7.35 (s, 1H), 7.32 – 7.22 (m, 6H), 7.19 (d, *J* = 7.7 Hz, 2H), 7.04 (d, *J* = 7.8 Hz, 2H), 6.50 (d, *J* = 7.9 Hz, 1H), 5.27 (s, 1H), 4.64 – 4.48 (m, 1H), 3.86 (s, 1H), 3.42 – 3.26 (m, 2H), 2.99 – 2.80 (m,, 1H), 2.83 (dt, *J* = 12.3, 5.5 Hz, 3H), 2.24 – 2.13 (m, 1H), 2.08 – 1.93 (m, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 155.3, 153.4, 144.3, 140.9, 140.8, 138.9, 132.0, 129.9, 129.7, 128.1, 127.8, 127.5, 127.2, 126.0, 125.4, 124.9, 121.5, 114.6, 114.2, 55.9, 42.0, 30.8, 27.1, 25.6, 22.2. IR (KBr): 2926, 2841, 1615, 1565, 1509, 1448,

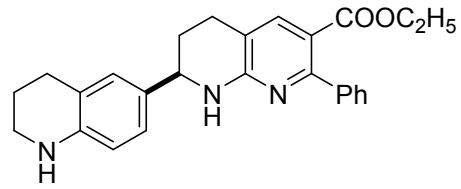
1421, 1302, 1176, 1073, 874, 767, 736, 701 cm^{-1}. HRMS (ESI): Calcd. for $C_{29}H_{28}N_3$ $[M+H]^+$: 418.2278; found: 418.2275.

2-phenyl-7-(1,2,3,4-tetrahydroquinolin-6-yl)-5,6,7,8-tetrahydro-1,8-naphthyridine-3-carbonitrile (3al)



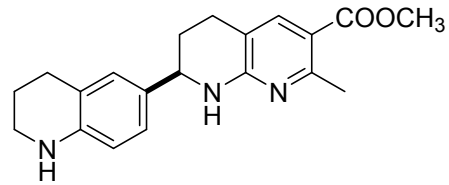
Pale yellow oil (53.5 mg, 73% yield); R_f = 0.3 (petroleum ether/ethyl acetate = 4/1, v/v); ^1H NMR (400 MHz, $CDCl_3$) δ 7.90 – 7.83 (m, 2H), 7.50 – 7.42 (m, 5H), 6.89 (s, 1H), 6.45 (d, *J* = 8.7 Hz, 1H), 5.94 (s, 1H), 4.48 (d, *J* = 6.5 Hz, 1H), 3.33 – 3.30 (m, 2H), 2.85 – 2.70 (m, 4H), 2.17 – 2.08 (m, 1H), 2.04 – 1.80 (m, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 159.7, 157.4, 144.5, 139.7, 137.9, 130.4, 129.5, 128.6, 128.4, 127.3, 124.7, 121.6, 119.9, 114.6, 114.2, 94.1, 55.8, 41.9, 29.6, 27.06, 24.9, 22.0. IR (KBr): 2927, 1615, 1547, 1437, 1302, 1168, 1015, 918, 874, 817, 757, 736, 700 cm^{-1}. HRMS (ESI): Calcd. for $C_{24}H_{23}N_4$ $[M+H]^+$: 367.1917; found: 367.1915.

Ethyl 2-phenyl-7-(1,2,3,4-tetrahydroquinolin-6-yl)-5,6,7,8-tetrahydro-1,8-naphthyridine -3-carboxylate (3am)



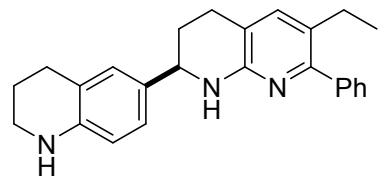
Yellow oil (57.5 mg, 72% yield); R_f = 0.3 (petroleum ether/ethyl acetate = 4/1, v/v); ^1H NMR (400 MHz, $CDCl_3$) δ 7.80 (s, 1H), 7.43 (d, *J* = 6.5 Hz, 2H), 7.39 – 7.34 (m, 3H), 6.90 (d, *J* = 5.8 Hz, 2H), 6.42 (d, *J* = 8.7 Hz, 1H), 5.59 (s, 1H), 4.48 (d, *J* = 5.9 Hz, 1H), 4.08 (q, *J* = 7.2 Hz, 2H), 3.36 – 3.22 (m, 2H), 2.91 – 2.76 (m, 2H), 2.73 (t, *J* = 6.4 Hz, 2H), 2.17 – 2.06 (m, 1H), 1.97 – 1.84 (m, 3H), 1.02 (t, *J* = 7.1 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 167.7, 158.8, 156.96, 144.4, 141.6, 138.3, 131.1, 128.4, 127.8, 127.7, 127.4, 124.7, 121.5, 114.8, 114.2, 113.8, 60.3, 55.8, 42.0, 30.1, 27.1, 25.1, 22.1, 13.8. IR (KBr): 2928, 2842, 1689, 1615, 1511, 1400, 1257, 1178, 1094, 798, 771, 735, 701 cm^{-1}. HRMS (ESI): Calcd. for $C_{26}H_{28}N_3O_2$ $[M+H]^+$: 414.2176; found: 414.2176.

Methyl 2-methyl-7-(1,2,3,4-tetrahydroquinolin-6-yl)-5,6,7,8-tetrahydro-1,8-naphthyridine -3-carboxylate (3an)



Yellow solid (29.0 mg, 43% yield); m.p: 161-163 °C; R_f = 0.3 (petroleum ether/ethyl acetate = 3/1, v/v); ^1H NMR (400 MHz, $CDCl_3$) δ 7.78 (s, 1H), 6.89 (d, *J* = 6.0 Hz, 2H), 6.43 (d, *J* = 8.7 Hz, 1H), 5.50 (s, 1H), 4.47 (dd, *J* = 8.8, 3.2 Hz, 1H), 3.83 (s, 3H), 3.36 – 3.24 (m, 2H), 2.72 (dd, *J* = 11.3, 5.2 Hz, 4H), 2.66 (s, 3H), 2.11 – 2.04 (m, 1H), 1.96 – 1.89 (m, 2H), 1.88 – 1.79 (m, 1H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 167.3, 159.2, 157.3, 144.4, 138.42, 131.1, 127.3, 124.7, 121.5, 114.1, 113.2, 112.4, 55.8, 51.3, 41.9, 30.3, 27.0, 25.0, 24.6, 22.1. IR (KBr): 2925, 1707, 1614, 1511, 1388, 1252, 1167, 1072, 873, 782 cm^{-1}. HRMS (ESI): Calcd. for $C_{20}H_{24}N_3O_2$ $[M+H]^+$: 338.1863; found: 338.1864.

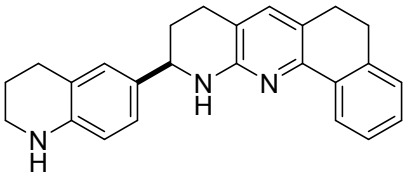
6-ethyl-7-phenyl-2-(1,2,3,4-tetrahydroquinolin-6-yl)-1,2,3,4-tetrahydro-1,8-naphthyridine (3ao)



Yellow oil (34.7 mg, 47% yield); R_f = 0.3 (petroleum ether/ethyl acetate = 4/1, v/v); ^1H NMR (400 MHz, $CDCl_3$) δ 7.46 (d, *J* = 7.1 Hz, 2H), 7.40 (t, *J* = 7.3 Hz, 2H), 7.36 – 7.31 (m, 1H), 7.18 (s, 1H), 6.97 (d, *J* = 8.0 Hz, 2H), 6.44 (d, *J* = 7.8 Hz, 1H), 5.02 (s, 1H), 4.58 – 4.28 (m, 1H), 3.40 – 3.19 (m, 2H), 2.93 – 2.83 (m, 1H), 2.80 – 2.71 (m, 3H), 2.50 (q, *J* = 7.4 Hz, 2H), 2.15 – 2.07 (m, 1H), 1.97 – 1.87 (m, 3H), 1.10 (t, *J* = 7.5 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 154.1, 144.2, 141.2, 137.4, 132.3, 128.9, 128.0, 127.4, 127.3, 125.5, 124.8, 121.4, 115.0, 114.2, 55.8, 42.0,

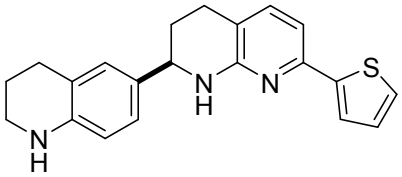
31.0, 27.0, 25.7, 24.6, 22.2, 15.9. IR (KBr): 2926, 1616, 1442, 1165, 1017, 873, 754, 702 cm^{-1}. HRMS (ESI): Calcd. for $C_{25}H_{28}N_3$ $[M+H]^+$: 370.2278; found: 370.2277.

10-(1,2,3,4-tetrahydroquinolin-6-yl)-5,6,8,9,10,11-hexahydronaphtho[1,2-b][1,8]naphthyridine (3ap)



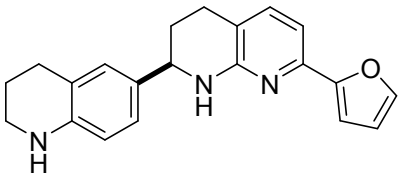
Yellow solid (30.8 mg, 42% yield); m.p: 119-121 °C; R_f = 0.4 (petroleum ether/ethyl acetate = 5/1, v/v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.16 (d, *J* = 7.5 Hz, 1H), 7.28 (t, *J* = 7.3 Hz, 1H), 7.25 – 7.15 (m, 3H), 7.05 (s, 1H), 6.97 (d, *J* = 8.9 Hz, 2H), 6.43 (d, *J* = 7.9 Hz, 1H), 4.98 (s, 1H), 4.43 (d, *J* = 6.8 Hz, 1H), 3.36 – 3.19 (m, 2H), 2.91 – 2.80 (m, 3H), 2.78 – 2.67 (m, 5H), 2.11 – 2.03 (m, 1H), 1.97 – 1.85 (m, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 155.2, 144.2, 138.0, 136.3, 132.4, 128.0, 127.6, 126.8, 125.0 124.4, 121.5, 120.9, 115.0, 114.2, 55.9, 42.0, 30.9, 28.9, 27.1, 27.1, 25.8, 22.2. IR (KBr): 2924, 1615, 1562, 1440, 1153, 873, 752 cm^{-1}. HRMS (ESI): Calcd. for $C_{25}H_{26}N_3$ $[M+H]^+$: 368.2121; found: 368.2120.

2-(1,2,3,4-tetrahydroquinolin-6-yl)-7-(thiophen-2-yl)-1,2,3,4-tetrahydro-1,8-naphthyridine (3aq)



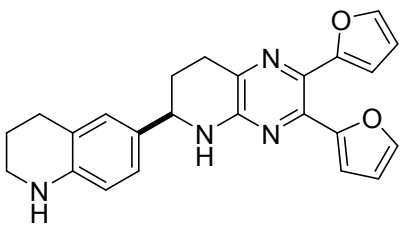
Brownish solid; (42.4 mg, 61% yield); m.p: 116-118 °C; R_f = 0.3 (petroleum ether/ethyl acetate = 5/1, v/v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.60 – 7.45 (m, 1H), 7.28 (d, *J* = 5.0 Hz, 1H), 7.20 (d, *J* = 7.5 Hz, 1H), 7.10 – 7.03 (m, 1H), 7.02 – 6.88 (m, 3H), 6.45 (d, *J* = 7.8 Hz, 1H), 5.08 (s, 1H), 4.44 (dd, *J* = 9.0, 2.8 Hz, 1H), 3.36 – 3.16 (m, 2H), 2.87 – 2.66 (m, 4H), 2.12 – 2.03 (m, 1H), 1.99 – 1.87 (m, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 156.0, 149.0, 145.8, 144.3, 136.6, 132.0, 127.7, 127.6, 126.0, 125.0, 123.5, 121.5, 114.6, 114.2, 108.2, 55.8, 42.0, 30.6, 27.1, 25.78, 22.2. IR (KBr): 2924, 2849, 1616, 1592, 1461, 1352, 1297, 1119, 804, 735, 702 cm^{-1}. HRMS (ESI): Calcd. for $C_{21}H_{22}N_3S$ $[M+H]^+$: 348.1529; found: 348.1528.

7-(furan-2-yl)-2-(1,2,3,4-tetrahydroquinolin-6-yl)-1,2,3,4-tetrahydro-1,8-naphthyridine (3ar)



Gray solid (38.4 mg, 58% yield); m.p: 114-116 °C; R_f = 0.2 (petroleum ether/ethyl acetate = 4/1, v/v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.49 (s, 1H), 7.25 (d, *J* = 7.5 Hz, 1H), 7.03 – 6.94 (m, 3H), 6.89 (s, 1H), 6.54 – 6.43 (m, 2H), 5.14 (s, 1H), 4.48 (dd, *J* = 8.9, 3.0 Hz, 1H), 3.39 – 3.19 (m, 2H), 2.88 – 2.69 (m, 4H), 2.18 – 2.03 (m, 1H), 1.99 – 1.87 (m, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 156.0, 154.1, 145.7, 144.2, 142.5, 136.5, 132.0, 127.5, 124.9, 121.5, 114.9, 114.2, 111.7, 108.0, 107.2, 55.7, 42.0, 30.6, 27.0, 25.8, 22.2. IR (KBr): 2924, 1594, 1471, 1452, 1384, 1122, 874, 805, 747 cm^{-1}. HRMS (ESI): Calcd. for $C_{21}H_{22}N_3O$ $[M+H]^+$: 332.1757; found: 332.1756.

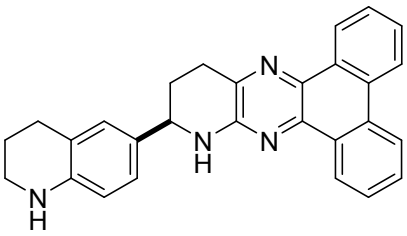
2,3-di(furan-2-yl)-6-(1,2,3,4-tetrahydroquinolin-6-yl)-5,6,7,8-tetrahydropyrido[2,3-b]pyrazine (3as)



Gray oil (40.6 mg, 51% yield); R_f = 0.2 (petroleum ether/ethyl acetate = 4/1, v/v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.48 (s, 2H), 6.92 (d, *J* = 6.6 Hz, 2H), 6.49 – 6.46 (m, 1H), 6.45 – 6.40 (m, 3H), 6.28 (d, *J* = 3.4 Hz, 1H), 5.41 (s, 1H), 4.61 – 4.48 (m, 1H), 3.33 – 3.25 (m, 2H), 3.06 – 2.97 (m, 2H), 2.74 (t, *J* = 6.3 Hz, 2H), 2.28 – 2.17 (m, 1H), 2.08 – 1.99 (m, 1H), 1.96 – 1.89 (m, 2H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 151.7, 151.0, 150.4, 144.5, 143.1, 142.1, 139.0, 137.4, 130.6, 130.3, 127.3, 124.7, 121.5, 114.2, 111.5, 111.3, 111.1, 109.1,

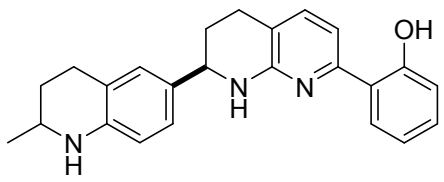
55.7, 41.9, 30.3, 29.0, 27.0, 22.1. IR (KBr): 2922, 1638, 1617, 1421, 1158, 874 cm^{-1}. HRMS (ESI): Calcd. for $C_{24}H_{23}N_4O_2$ $[M+H]^+$: 399.1816; found: 399.1823.

11-(1,2,3,4-tetrahydroquinolin-6-yl)-10,11,12,13-tetrahydrodibenzo[f,h]pyrido[2,3-b]quinoxaline (3at)



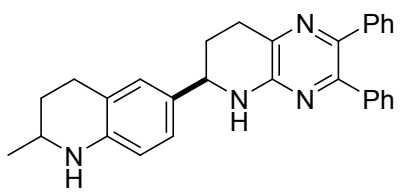
Reddish brown solid (54.9 mg, 66% yield); R_f = 0.3 (petroleum ether/ethyl acetate = 3/1, v/v); m.p: 167-169 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.03 (d, *J* = 8.0 Hz, 1H), 9.00 (d, *J* = 8.0 Hz, 1H), 8.58 (t, *J* = 8.1 Hz, 2H), 7.71 – 7.59 (m, 4H), 6.92 (d, *J* = 6.6 Hz, 2H), 6.37 (d, *J* = 8.6 Hz, 1H), 5.69 (s, 1H), 4.69 – 4.50 (m, 1H), 3.32 – 3.11 (m, 4H), 2.69 (t, *J* = 6.3 Hz, 2H), 2.36 – 2.25 (m, 1H), 2.17 – 2.07 (m, 1H), 1.95 – 1.85 (m, 2H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 150.9, 144.5, 140.9, 138.2, 132.1, 131.2, 130.8, 130.7, 129.8, 128.8, 128.2, 127.5, 127.2, 126.9, 126.5, 124.9, 124.9, 123.5, 122.6, 122.6, 121.5, 114.2, 56.1, 41.9, 30.4, 30.2, 27.0, 22.1. IR (KBr): 2924, 1638, 1617, 1570, 1469, 1158, 873, 762, 727 cm^{-1}. HRMS (ESI): Calcd. for $C_{28}H_{25}N_4$ $[M+H]^+$: 417.2074; found: 417.2077.

2-(7-(2-methyl-1,2,3,4-tetrahydroquinolin-6-yl)-5,6,7,8-tetrahydro-1,8-naphthyridin-2-yl)phenol (3bd)



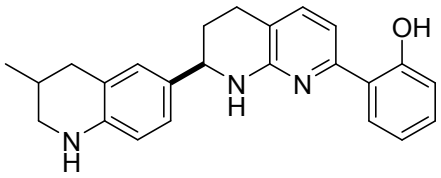
Yellow solid (52.7 mg, 71% yield); m.p: 166-168 °C; R_f = 0.3 (petroleum ether/ethyl acetate = 4/1, v/v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.70 (d, *J* = 8.0 Hz, 1H), 7.28 (d, *J* = 7.7 Hz, 1H), 7.25 – 7.17 (m, 2H), 7.08 (d, *J* = 7.7 Hz, 1H), 6.92 (t, *J* = 9.4 Hz, 3H), 6.83 (t, *J* = 7.5 Hz, 1H), 6.43 (d, *J* = 7.9 Hz, 1H), 4.97 (s, 1H), 4.41 (d, *J* = 7.3 Hz, 1H), 3.38 (s, 1H), 2.91 – 2.74 (m, 2H), 2.69 (d, *J* = 16.1 Hz, 2H), 2.15 – 2.01 (m, 1H), 1.96 – 1.85 (m, 2H), 1.64 – 1.50 (m, 1H), 1.19 (d, *J* = 6.2 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 159.4, 153.9, 153.3, 144.5, 137.5, 131.4, 130.4, 127.2, 126.1, 124.9, 121.3, 119.8, 118.6, 118.2, 114.2, 114.1, 107.9, 55.8, 47.2, 30.3, 30.1, 26.7, 25.5, 22.6. IR (KBr): 3414, 2924, 1638, 1616, 1469, 1281, 1133, 874, 752 cm^{-1}. HRMS (ESI): Calcd. for $C_{24}H_{26}N_3O$ $[M+H]^+$: 372.2070; found: 372.2069.

6-(2-methyl-1,2,3,4-tetrahydroquinolin-6-yl)-2,3-diphenyl-5,6,7,8-tetrahydropyrido[2,3-b]pyrazine (3bu)



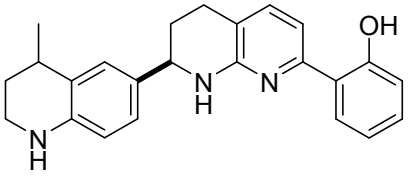
Yellow solid (62.2 mg, 72% yield); m.p: 157-159 °C;R_f = 0.3 (petroleum ether/ethyl acetate = 4/1, v/v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.39 – 7.32 (m, 4H), 7.27 – 7.20 (m, 6H), 6.94 (d, *J* = 8.8 Hz, 2H), 6.43 (d, *J* = 7.9 Hz, 1H), 5.31 (s, 1H), 4.49 (d, *J* = 6.6 Hz, 1H), 3.41 – 3.34 (m, 1H), 3.07 – 2.99 (m, 2H), 2.79 (d, *J* = 9.8 Hz, 1H), 2.73 – 2.65 (m, 1H), 2.30 – 2.17 (m, 1H), 2.09 – 2.02 (m, 1H), 1.95 – 1.87 (m, 1H), 1.63 – 1.51 (m, 1H), 1.19 (d, *J* = 6.1 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 150.4, 148.1, 144.5, 140.5, 139.7, 139.5, 137.1, 131.1, 129.7, 129.6, 128.1, 128.0, 127.9, 127.2, 127.0, 124.7, 121.2, 114.1, 55.8, 47.2, 30.6, 30.1, 29.1, 26.7, 22.6. IR (KBr): 2923, 1638, 1617, 1478, 1447, 1414, 1331, 1173, 874, 769, 698 cm^{-1}. HRMS (ESI): Calcd. for $C_{29}H_{29}N_4$ $[M+H]^+$: 433.2387; found: 433.2386.

2-(7-(3-methyl-1,2,3,4-tetrahydroquinolin-6-yl)-5,6,7,8-tetrahydro-1,8-naphthyridin-2-yl)phenol (3cd)



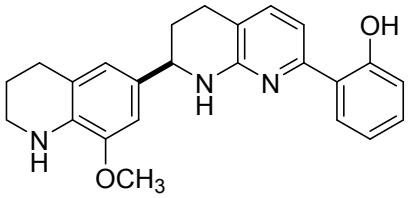
Brownish oil (53.4 mg, 72% yield); R_f = 0.3 (petroleum ether/ethyl acetate = 4/1, v/v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.72 (d, *J* = 7.4 Hz, 1H), 7.31 (d, *J* = 7.7 Hz, 1H), 7.23 (d, *J* = 6.5 Hz, 1H), 7.09 (d, *J* = 7.7 Hz, 1H), 6.93 (d, *J* = 7.0 Hz, 3H), 6.83 (t, *J* = 7.0 Hz, 1H), 6.46 (d, *J* = 8.3 Hz, 1H), 5.03 (s, 1H), 4.44 (dd, *J* = 8.9, 2.8 Hz, 1H), 3.29 – 3.23 (m, 1H), 2.93 – 2.66 (m, 4H), 2.46 – 2.33 (m, 1H), 2.15 – 2.00 (m, 2H), 1.95 – 1.84 (m, 1H), 1.04 (d, *J* = 6.6 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 159.4, 153.8, 153.3, 144.0, 137.5, 131.3, 130.4, 127.5, 126.1, 124.9, 121.3, 119.7, 118.6, 118.2, 114.2, 113.9, 107.9, 55.8, 48.8, 35.5, 30.2, 27.1, 25.5, 19.0. IR (KBr): 3414, 2921, 1616, 1598, 1512, 1469, 1354, 1281, 1130, 873, 813, 752 cm^{-1}. HRMS (ESI): Calcd. for $C_{24}H_{26}N_3O$ $[M+H]^+$: 372.2070; found: 372.2069.

2-(7-(4-methyl-1,2,3,4-tetrahydroquinolin-6-yl)-5,6,7,8-tetrahydro-1,8-naphthyridin-2-yl)phenol (3dd)



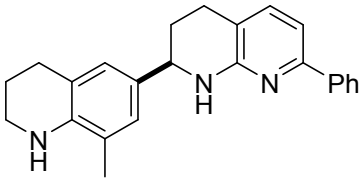
Brownish oil (51.9 mg, 70% yield); R_f = 0.3 (petroleum ether/ethyl acetate = 4/1, v/v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.77 (d, *J* = 7.9 Hz, 1H), 7.36 (d, *J* = 7.7 Hz, 1H), 7.31 – 7.23 (m, 1H), 7.15 (d, *J* = 7.7 Hz, 1H), 7.07 (s, 1H), 6.99 (d, *J* = 8.1 Hz, 2H), 6.89 (t, *J* = 7.5 Hz, 1H), 6.50 (d, *J* = 8.1 Hz, 1H), 5.05 (s, 1H), 4.49 (d, *J* = 9.1 Hz, 1H), 3.45 – 3.22 (m, 2H), 3.02 – 2.83 (m, 2H), 2.81 – 2.73 (m, 1H), 2.23 – 2.09 (m, 1H), 2.05 – 1.91 (m, 2H), 1.77 – 1.67 (m, 1H), 1.32 (d, *J* = 6.0 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 159.4, 153.9, 153.4, 144.0, 137.5, 131.3, 131.2, 130.4, 126.7, 126.5, 126.2, 124.9, 119.8, 118.6, 118.2, 114.3, 107.9, 56.0, 39.0, 30.4, 30.3, 29.8, 25.7, 22.7. IR (KBr): 3416, 2923, 1638, 1617, 1511, 1468, 1281, 874, 752 cm^{-1}. HRMS (ESI): Calcd. for $C_{24}H_{26}N_3O$ $[M+H]^+$: 372.2070; found: 372.2067.

2-(7-(8-methoxy-1,2,3,4-tetrahydroquinolin-6-yl)-5,6,7,8-tetrahydro-1,8-naphthyridin-2-yl)phenol (3ed)



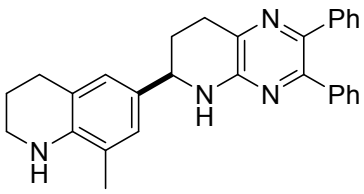
Brownish solid (51.1 mg, 66% yield); m.p: 158-190 °C; R_f = 0.3 (petroleum ether/ethyl acetate = 3/1, v/v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.71 (d, *J* = 7.9 Hz, 1H), 7.32 (d, *J* = 7.8 Hz, 1H), 7.23 (d, *J* = 9.6 Hz, 1H), 7.10 (d, *J* = 7.8 Hz, 1H), 6.94 (d, *J* = 8.2 Hz, 1H), 6.85 (t, *J* = 7.6 Hz, 1H), 6.60 (s, 2H), 5.07 (s, 1H), 4.45 (d, *J* = 6.7 Hz, 1H), 3.81 (s, 3H), 3.45 – 3.25 (m, 2H), 2.89 – 2.80 (m, 1H), 2.78 – 2.66 (m, 3H), 2.18 – 2.07 (m, 1H), 2.00 – 1.85 (m, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 159.3, 153.8, 153.3, 146.5, 137.5, 134.2, 130.4, 130.4, 126.2, 121.2, 119.7, 119.7, 118.6, 118.2, 114.3, 108.0, 105.5, 56.3, 55.5, 41.5, 30.5, 26.8, 25.7, 22.1. IR (KBr): 3415, 1638, 1617, 1464, 1111, 874 cm^{-1}. HRMS (ESI): Calcd. for $C_{24}H_{26}N_3O_2$ $[M+H]^+$: 388.2020; found: 388.2016.

2-(8-methyl-1,2,3,4-tetrahydroquinolin-6-yl)-7-phenyl-1,2,3,4-tetrahydro-1,8-naphthyridine (3fa)



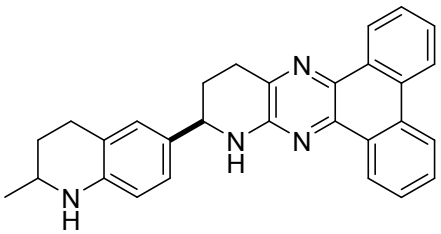
Yellow oil (43.3 mg, 61% yield); R_f = 0.4 (petroleum ether/ethyl acetate = 5/1, v/v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.92 (d, *J* = 7.4 Hz, 2H), 7.40 (t, *J* = 7.5 Hz, 2H), 7.32 (t, *J* = 7.1 Hz, 1H), 7.24 (d, *J* = 4.1 Hz, 1H), 6.97 (d, *J* = 7.5 Hz, 1H), 6.90 (s, 1H), 6.87 (s, 1H), 5.12 (s, 1H), 4.56 – 4.36 (m, 1H), 3.41 – 3.31 (m, 2H), 2.88 – 2.70 (m, 4H), 2.19 – 2.08 (m, 1H), 2.06 (s, 3H), 2.03 – 1.81 (m, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 156.2, 154.0, 142.2, 140.0, 136.7, 131.6, 128.5, 128.2, 126.7, 126.0, 125.4, 121.3, 120.9, 114.7, 109.7, 55.9, 42.4, 30.9, 27.4, 25.8, 22.2, 17.2. IR (KBr): 3417, 2924, 1638, 1617, 1494, 1460, 1330, 1124, 874, 755, 695 cm^{-1}. HRMS (ESI): Calcd. for $C_{24}H_{26}N_3$ $[M+H]^+$: 356.2121; found: 356.2115.

6-(8-methyl-1,2,3,4-tetrahydroquinolin-6-yl)-2,3-diphenyl-5,6,7,8-tetrahydropyrido[2,3-b]pyrazine (3fu)



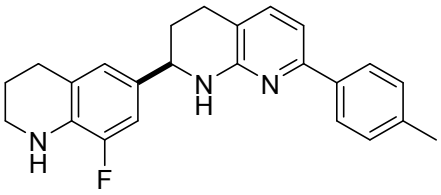
Brownish solid (50.1 mg, 58% yield); m.p: 120-122 °C; R_f = 0.3 (petroleum ether/ethyl acetate = 4/1, v/v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.46 – 7.39 (m, 4H), 7.33 – 7.26 (m, 6H), 6.92 (d, *J* = 10.3 Hz, 2H), 5.37 (s, 1H), 4.62 – 4.48 (m, 1H), 3.45 – 3.39 (m, 2H), 3.14 – 3.05 (m, 2H), 2.82 (t, *J* = 6.3 Hz, 2H), 2.32 – 2.25 (m, 1H), 2.18 – 2.12 (m, 1H), 2.12 (s, 3H), 2.04 – 1.90 (m, 2H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 150.4, 148.1, 142.4, 140.5, 139.7, 139.5, 137.1, 130.5, 129.7, 129.6, 128.1, 128.0, 127.9, 127.0, 125.9, 125.2, 121.4, 121.0, 55.8, 42.3, 30.8, 29.3, 27.4, 22.1, 17.2. IR (KBr): 2925, 1638, 1617, 1495, 1447, 1331, 1174, 874, 769, 735, 698 cm^{-1}. HRMS (ESI): Calcd. for $C_{29}H_{29}N_4$ $[M+H]^+$: 433.2387; found: 433.2392.

11-(2-methyl-1,2,3,4-tetrahydroquinolin-6-yl)-10,11,12,13-tetrahydrodibenzo[f,h]pyrido[2,3-b]quinoxaline (3bt)



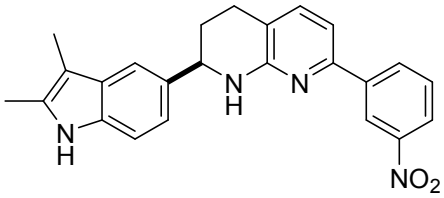
Reddish brown solid (48.2 mg, 56% yield); m.p: 110-112 °C; R_f = 0.3 (petroleum ether/ethyl acetate = 4/1, v/v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.02 (d, *J* = 7.9 Hz, 1H), 8.98 (d, *J* = 7.9 Hz, 1H), 8.56 (t, *J* = 7.6 Hz, 2H), 7.70 – 7.56 (m, 4H), 7.02 – 6.75 (m, 2H), 6.43 – 6.17 (m, 1H), 5.87 (s, 1H), 4.51 (d, *J* = 6.7 Hz, 1H), 3.31 – 3.10 (m, 3H), 2.79 – 2.55 (m, 2H), 2.34 – 2.20 (m, 1H), 2.17 – 2.05 (m, 1H), 1.90 – 1.78 (m, 1H), 1.56 – 1.42 (m, 1H), 1.12 (d, *J* = 6.2 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 150.9, 144.5, 140.9, 138.1, 132.0, 131.2, 130.8, 130.7, 129.9, 128.8, 128.1, 127.3, 127.2, 126.8, 126.5, 125.0, 124.9, 124.8, 123.5, 122.6, 122.6, 121.1, 121.1, 113.9, 113.9, 56.1, 47.1, 30.4, 30.2, 30.0, 26.7, 22.5. IR (KBr): 2922, 2361, 2340, 1638, 1617, 1470, 1157, 873, 761 cm^{-1}. HRMS (ESI): Calcd. for $C_{29}H_{27}N_4$ $[M+H]^+$: 431.2230; found: 431.2235.

2-(8-fluoro-1,2,3,4-tetrahydroquinolin-6-yl)-7-(p-tolyl)-1,2,3,4-tetrahydro-1,8-naphthyridine (3gb)



Yellow oil (5.2 mg, 7% yield); R_f = 0.3 (petroleum ether/ethyl acetate = 5/1, v/v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.89 (dd, *J* = 8.5, 5.6 Hz, 2H), 7.23 (d, *J* = 2.6 Hz, 1H), 7.07 (t, *J* = 8.7 Hz, 2H), 7.01 – 6.78 (m, 3H), 5.11 (s, 1H), 4.43 (dd, *J* = 9.2, 3.0 Hz, 1H), 3.40 – 3.30 (m, 2H), 2.87 – 2.69 (m, 4H), 2.14 – 2.07 (m, 1H), 2.06 (s, 3H), 1.97 – 1.88 (m, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 163.1 (d, *J* = 246.9 Hz), 156.2, 152.9, 142.2, 136.7, 136.1 (d, *J* = 3.0 Hz), 131.5, 128.3 (d, *J* = 8.1 Hz), 126.0, 125.7 (d, *J* = 63.0 Hz), 121.3, 120.9, 115.3 (d, *J* = 21.4 Hz), 114.6, 109.3, 55.9, 42.4, 30.8, 27.4, 25.8, 22.2, 17.2. IR (KBr): 2931, 1622, 1599, 1488, 1444, 1341, 801 cm^{-1}. HRMS (ESI): Calcd. for $C_{24}H_{25}FN_3$ $[M+H]^+$: 374.2027; found: 374.2025.

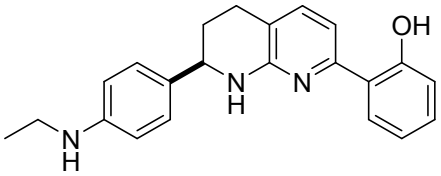
2-(2,3-dimethyl-*1H*-indol-5-yl)-7-(3-nitrophenyl)-1,2,3,4-tetrahydro-1,8-naphthyridine (3hv)



Yellow solid (30.3 mg, 38% yield); m.p: 207-209 °C; R_f = 0.3 (petroleum ether/ethyl acetate = 4/1, v/v); ^{1}H NMR (400 MHz, DMSO) δ 10.67 (s, 1H), 8.84 (s, 1H), 8.41 (d, *J* = 7.9 Hz, 1H), 8.18 (dd, *J* = 7.8, 1.7 Hz, 1H), 7.70 (t, *J* = 8.0 Hz, 1H), 7.39 (d, *J* = 7.5 Hz, 1H), 7.28 (s, 1H), 7.21 (d, *J* = 7.5 Hz, 1H), 7.15 (d, *J* = 8.1 Hz, 1H), 6.81 (d, *J* = 8.2 Hz, 1H), 6.57 (s, 1H), 4.86 (dd, *J* = 9.4, 2.9 Hz, 1H), 2.89 – 2.95 (m, 1H), 2.83 – 2.72 (m, 1H), 2.36 (s, 3H), 2.29 (s, 3H), 2.26 – 2.13 (m, 1H), 2.01 – 1.90 (m, 1H). ^{13}C NMR (101 MHz, DMSO) δ 157.2, 150.1, 148.8, 141.6, 137.1, 134.1, 132.6, 132.6, 130.4, 127.5, 126.9, 123.1, 121.9, 120.9, 118.6, 116.6, 111.8, 110.7, 109.0, 49.0, 28.6, 26.4, 21.8, 12.2. IR (KBr): 3415, 1638, 1618, 1527, 1442, 1348, 1121, 870, 792, 734 cm^{-1}. HRMS (ESI): Calcd. for $C_{24}H_{23}N_4O_2$ $[M+H]^+$: 399.1816;

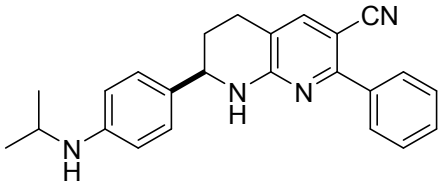
found: 399.1820.

2-(7-(4-(ethylamino)phenyl)-5,6,7,8-tetrahydro-1,8-naphthyridin-2-yl)phenol (3id)



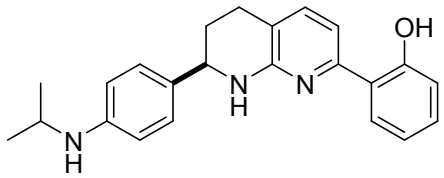
Yellow solid (45.6 mg, 44% yield); m.p: 133-135 °C; R_f = 0.3 (petroleum ether/ethyl acetate = 4/1, v/v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.76 (d, *J* = 7.9 Hz, 1H), 7.36 (d, *J* = 7.8 Hz, 1H), 7.27 (d, *J* = 10.6 Hz, 1H), 7.19 (d, *J* = 8.4 Hz, 2H), 7.15 (d, *J* = 7.8 Hz, 1H), 6.98 (d, *J* = 8.2 Hz, 1H), 6.89 (t, *J* = 7.5 Hz, 1H), 6.63 (d, *J* = 8.4 Hz, 2H), 5.03 (s, 1H), 4.54 (dd, *J* = 8.8, 3.0 Hz, 1H), 3.19 (q, *J* = 7.1 Hz, 2H), 2.93 – 2.82 (m, 1H), 2.75 (dt, *J* = 16.5, 4.8 Hz, 1H), 2.23 – 2.05 (m, 1H), 2.02 – 1.92 (m, 1H), 1.30 (d, *J* = 7.1 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 159.3, 153.9, 153.3, 148.2, 137.5, 131.6, 130.4, 127.3, 126.1, 119.7, 118.6, 118.2, 114.2, 112.9, 108.0, 55.7, 38.6, 30.2, 25.4, 14.9. IR (KBr): 3416, 2925, 1638, 1616, 1517, 1469, 1280, 1168, 874, 815, 751 cm^{-1}. HRMS (ESI): Calcd. for $C_{22}H_{24}N_3O$ $[M+H]^+$: 346.1914; found: 346.1908.

7-(4-(isopropylamino)phenyl)-2-phenyl-5,6,7,8-tetrahydro-1,8-naphthyridine-3-carbonitrile (3jl)



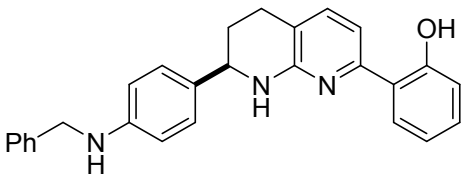
Yellow oil (42.0 mg, 38% yield); R_f = 0.3 (petroleum ether/ethyl acetate = 4/1, v/v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.90 – 7.78 (m, 2H), 7.46 (d, *J* = 7.2 Hz, 4H), 7.11 (d, *J* = 8.4 Hz, 2H), 6.57 (d, *J* = 8.4 Hz, 2H), 5.70 (s, 1H), 4.55 (d, *J* = 5.6 Hz, 1H), 3.62 (dt, *J* = 12.6, 6.3 Hz, 1H), 2.87 – 2.71 (m, 2H), 2.17 – 2.10 (m, 1H), 1.97 – 1.88 (m, 1H), 1.21 (d, *J* = 6.3 Hz, 6H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 159.9, 157.3, 147.2, 139.8, 137.9, 129.5, 128.6, 128.5, 127.3, 119.8, 114.5, 113.3, 94.3, 55.7, 44.4, 29.5, 24.8, 23.0. IR (KBr): 3412, 1624, 1617, 1466, 1279, 1167, 867, 815 cm^{-1}. HRMS (ESI): Calcd. for $C_{24}H_{25}N_4$ $[M+H]^+$: 369.2074; found: 369.2079.

2-(7-(4-(isopropylamino)phenyl)-5,6,7,8-tetrahydro-1,8-naphthyridin-2-yl)phenol (3jd)



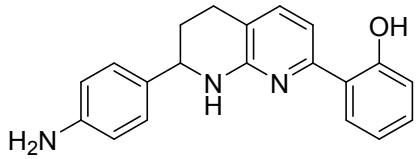
Yellow solid (43.1 mg, 40% yield); m.p: 117-119 °C; R_f = 0.3 (petroleum ether/ethyl acetate = 4/1, v/v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.72 (dd, *J* = 8.0, 1.3 Hz, 1H), 7.32 (d, *J* = 7.8 Hz, 1H), 7.24 – 7.19 (m, 1H), 7.17 – 7.09 (m, 3H), 6.94 (d, *J* = 7.5 Hz, 1H), 6.85 (t, *J* = 7.5 Hz, 1H), 6.57 (d, *J* = 8.5 Hz, 2H), 4.99 (s, 1H), 4.50 (dd, *J* = 9.0, 3.0 Hz, 1H), 3.67 – 3.58 (m, 1H), 2.91 – 2.78 (m, 1H), 2.72 (dt, *J* = 16.3, 4.9 Hz, 1H), 2.16 – 2.07 (m, 1H), 1.99 – 1.90 (m, 1H), 1.21 (d, *J* = 6.3 Hz, 6H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 159.3, 153.9, 153.3, 147.2, 137.5, 131.3, 130.4, 127.4, 126.1, 119.7, 118.6, 118.2, 114.2, 113.3, 108.0, 55.6, 44.3, 30.2, 25.4, 23.0. IR (KBr): 3416, 1636, 1617, 1466, 1279, 1167, 874 cm^{-1}. HRMS (ESI): Calcd. for $C_{23}H_{26}N_3O$ $[M+H]^+$: 360.2070; found: 360.2066.

2-(7-(4-(benzylamino)phenyl)-5,6,7,8-tetrahydro-1,8-naphthyridin-2-yl)phenol (3kd)



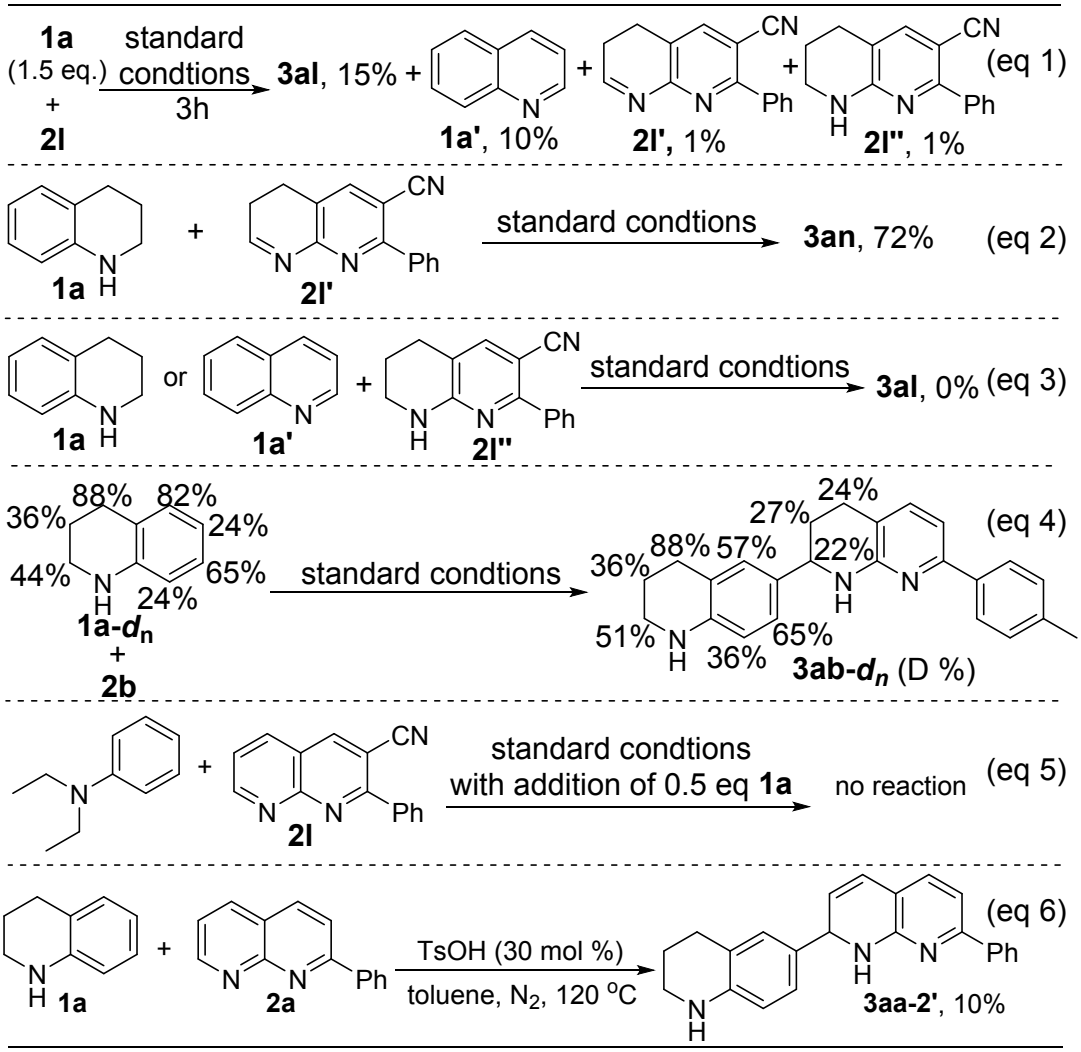
Yellow oil (56.2 mg, 46% yield); R_f = 0.3 (petroleum ether/ethyl acetate = 4/1, v/v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.72 (d, *J* = 8.0 Hz, 1H), 7.38 – 7.28 (m, 6H), 7.21 (d, *J* = 7.2 Hz, 1H), 7.16 – 7.09 (m, 3H), 6.94 (d, *J* = 8.2 Hz, 1H), 6.85 (t, *J* = 7.5 Hz, 1H), 6.62 (d, *J* = 8.4 Hz, 2H), 4.99 (s, 1H), 4.50 (dd, *J* = 8.9, 2.9 Hz, 1H), 4.33 (s, 2H), 2.94 – 2.78 (m, 1H), 2.73 – 2.70 (m, 1H), 2.23 – 1.98 (m, 1H), 2.03 – 1.84 (m, 1H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 159.3, 153.9, 153.2, 147.9, 139.3, 137.6, 132.0, 130.4, 128.7, 127.5, 127.4, 127.3, 126.2, 119.7, 118.6, 118.2, 114.2, 113.0, 108.1, 55.6, 48.4, 30.1, 25.3. IR (KBr): 3416, 1638, 1617, 1443, 1128, 874 cm^{-1}. HRMS (ESI): Calcd. for $C_{27}H_{26}N_3O$ $[M+H]^+$: 408.2070; found: 408.2075.

2-(7-(4-aminophenyl)-5,6,7,8-tetrahydro-1,8-naphthyridin-2-yl)phenol (3kd')

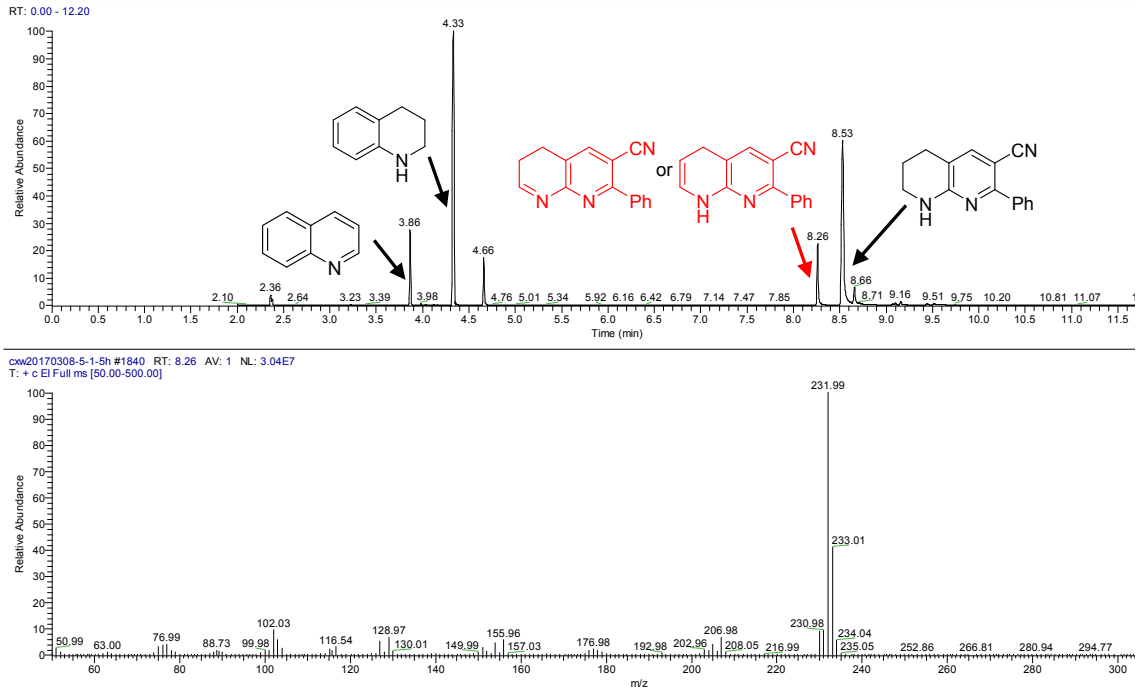


Yellow oil; R_f = 0.2 (petroleum ether/ethyl acetate = 3/1, v/v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.73 (d, *J* = 8.0 Hz, 1H), 7.34 (d, *J* = 7.7 Hz, 1H), 7.22 (d, *J* = 7.2 Hz, 1H), 7.14 (t, *J* = 8.1 Hz, 3H), 6.95 (d, *J* = 8.1 Hz, 1H), 6.86 (t, *J* = 7.5 Hz, 1H), 6.68 (d, *J* = 8.3 Hz, 2H), 5.07 (s, 1H), 4.53 (dd, *J* = 8.9, 3.1 Hz, 1H), 2.91 – 2.79 (m, 1H), 2.72 (dt, *J* = 16.2, 5.0 Hz, 1H), 2.17 – 2.08 (m, 1H), 1.98 – 1.90 (m, 1H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 159.3, 153.9, 153.2, 146.1, 137.6, 133.1, 130.4, 127.4, 126.2, 119.7, 118.6, 118.2, 115.3, 114.2, 108.1, 55.6, 30.2, 25.3. HRMS (ESI): Calcd. for $C_{20}H_{20}N_3O$ $[M+H]^+$: 318.1601; found: 318.1605.

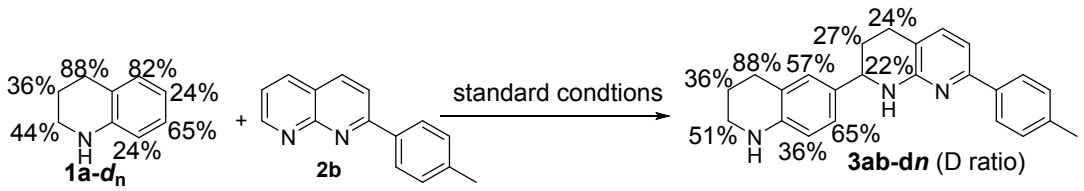
5. Control experiments



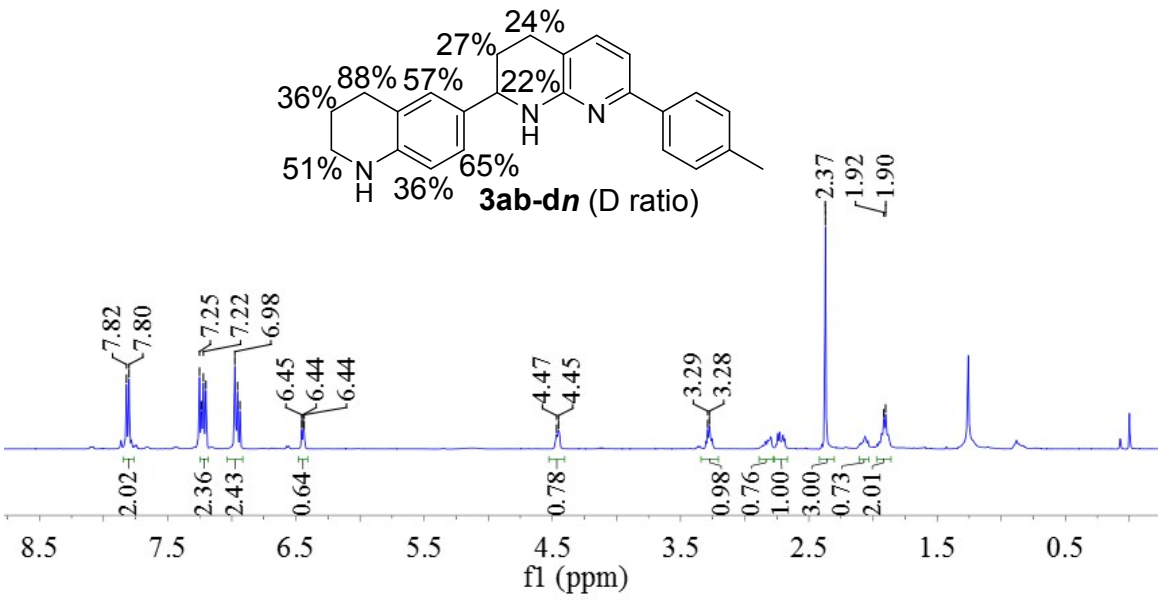
Detection of reaction intermediates by GC-MS analysis (eq 1)



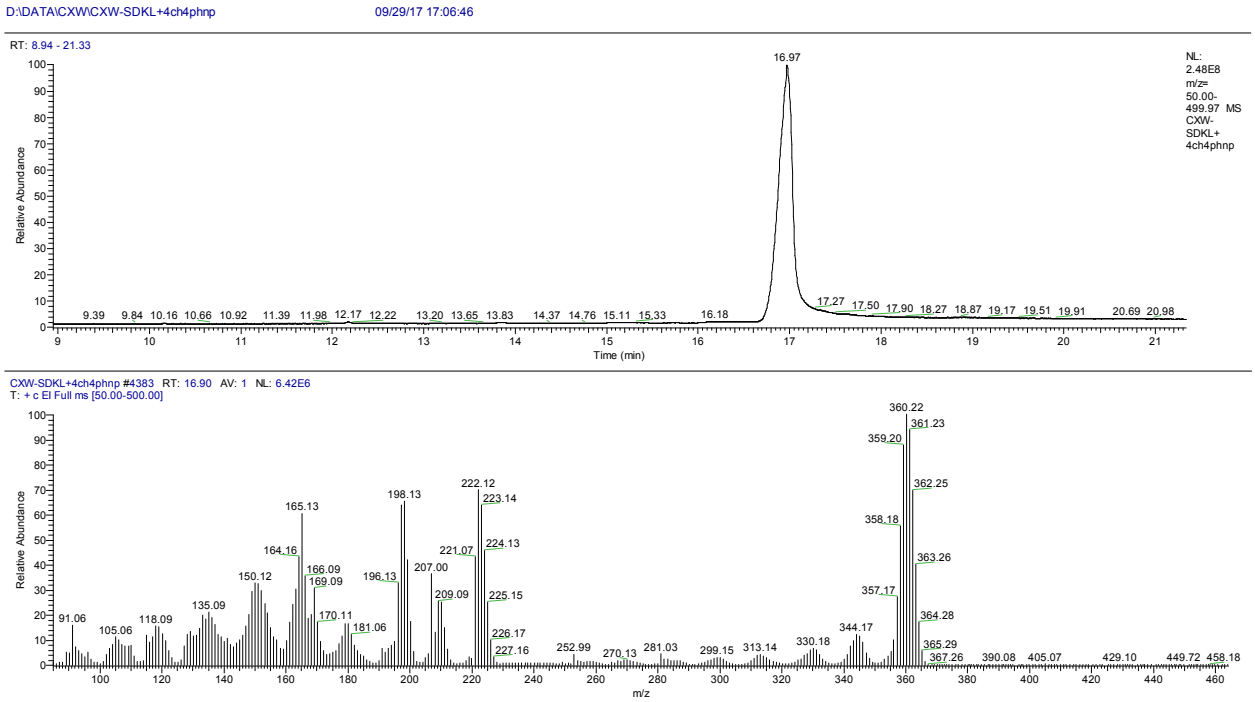
6. Deuterium labeling experiment



^{1}H- NMR spectrum of deuterated product

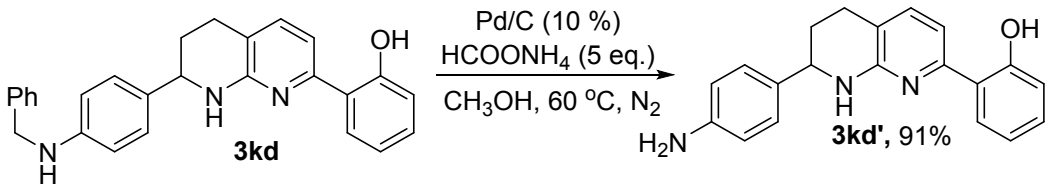


GC-MS of deuterated product



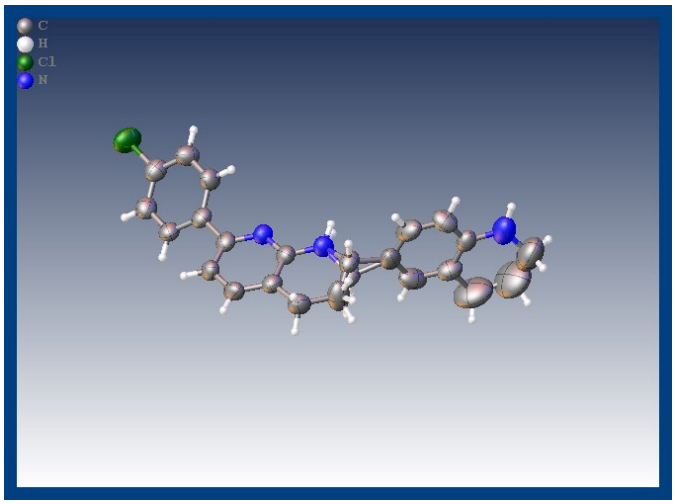
7. The application of the obtained compound

Compound **3kd** in methanol was treated with Pd/C catalyst (10%) and $HCOONH_4$ (5 equiv.) at 60 ^oC for 5 h, which underwent effective debenzylation and produced the synthetically useful primary amine **3kd'** in almost quantitative yield (91%). Noteworthy, the preparation of such structural anilines is quite challenging with conventional methods.



8. Single crystal X-ray diffraction of 3af

Crystal Data and Experimental



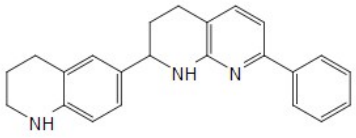
Experimental. Single yellow block-shaped crystals of (**4.3af**) were obtained by recrystallisation from dichlormethane. A suitable crystal (0.32×0.29×0.24) mm^3 was selected and collected on a Bruker APEX-II CCD diffractometer. The crystal was kept at T = 296(2) K during data collection. Using Olex2 (Dolomanov et al., 2009), the structure was solved with the ShelXS (Sheldrick, 2008) structure solution program, using the Direct Methods solution method. The model was refined with version of XL (Sheldrick, 2008) using Least Squares minimisation. (CCDC 1814853)

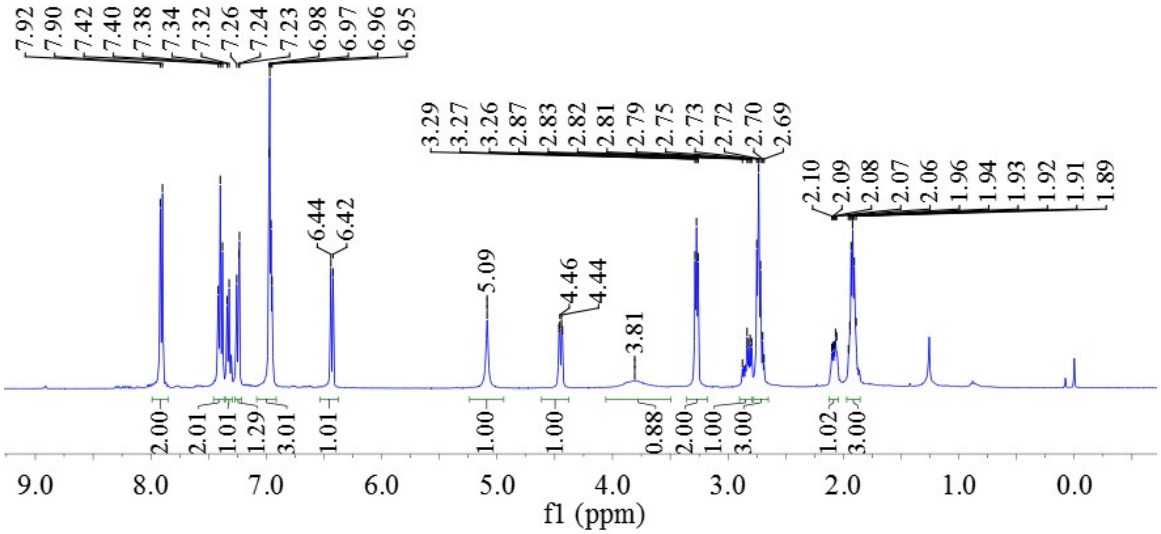
Crystal Data. $C_{23}H_{22}ClN_3$, M_r = 375.89, monoclinic, $C2/c$ (No. 15), a = 33.350(13) Å, b = 5.917(2) Å, c = 21.754(10) Å, α = 90.00°, β = 119.191(9)°, γ = 90.00°, V = 3747(3) Å^3, T = 296(2) K, Z = 8, Z' = 1, μ(MoK$_\alpha$) = 0.217, 19411 reflections measured, 4195 unique (R_{int} = 0.0967) which were used in all calculations. The final wR_2 was 0.3013 (all data) and R_1 was 0.0936 (>2σ(I)).

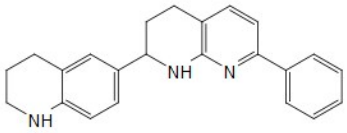
Compound	**3af**
Formula	$C_{23}H_{22}ClN_3$
$D_{calc.}$/ g cm^{-3}	1.333
μ/mm^{-1}	0.217
Formula Weight	375.89
Colour	yellow
Shape	block
Size/mm^3	0.32×0.29×0.24
T/K	296(2)
Crystal System	monoclinic
Space Group	$C2/c$
a/Å	33.350(13)
b/Å	5.917(2)
c/Å	21.754(10)
α/°	90.00
β/°	119.191(9)
γ/°	90.00
V/Å^3	3747(3)
Z	8
Z'	1
Wavelength/Å	0.710730
Radiation type	MoK□
Θ_{min}/°	1.91
Θ_{max}/°	27.62
Measured Refl.	19411
Independent Refl.	4195
Reflections Used	1690
R_{int}	0.0967
Parameters	251
Restraints	31
Largest Peak	0.619
Deepest Hole	-0.322
GooF	0.997
wR_2 (all data)	0.3013
wR_2	0.2339
R_1 (all data)	0.2094
R_1	0.0936

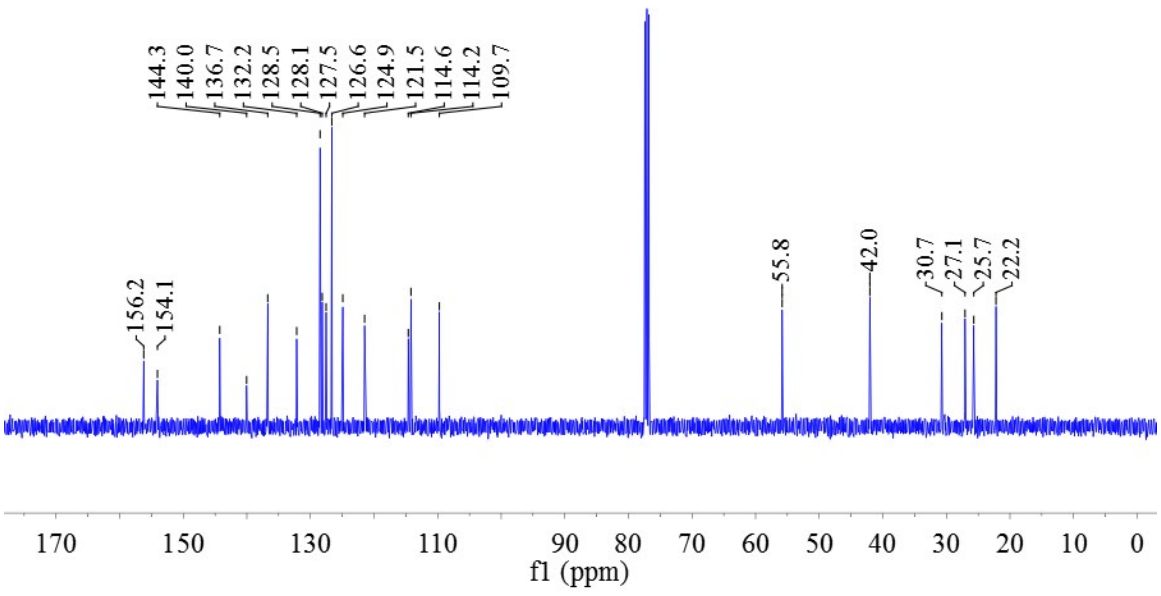
9. NMR spectra of products

NMR spectra of 7-phenyl-2-(1,2,3,4-tetrahydroquinolin-6-yl)-1,2,3,4 -tetrahydro-1,8 -naphthyridine (3aa)

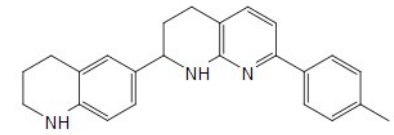


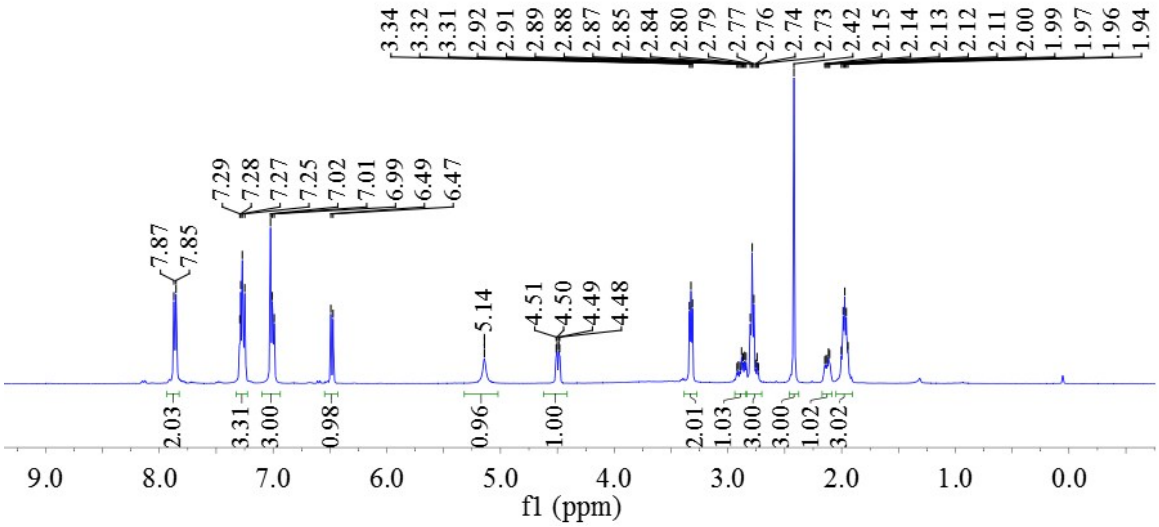


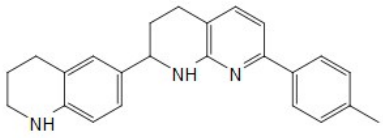


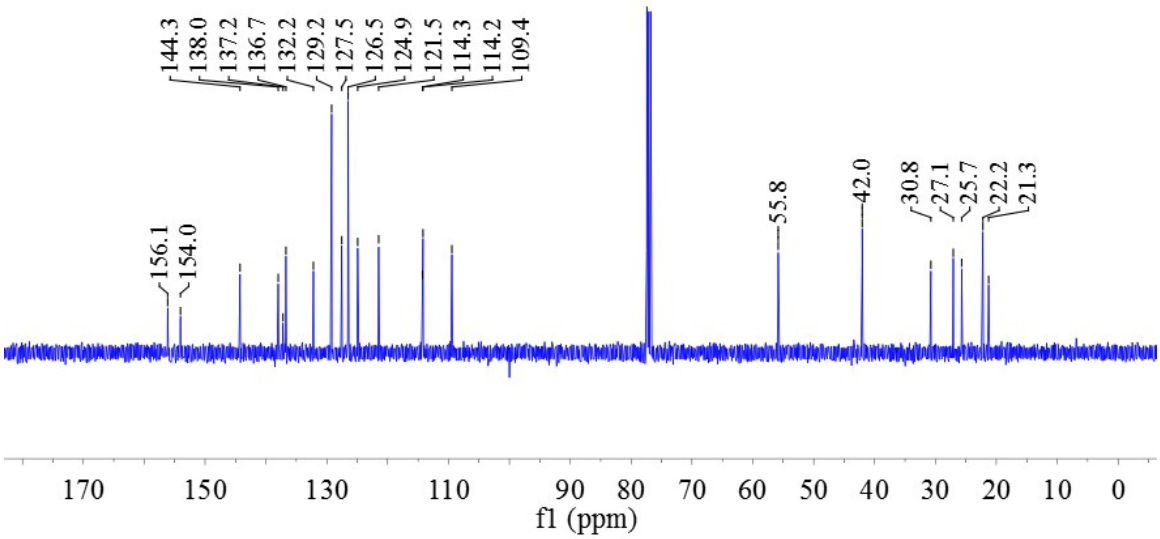


NMR spectra of 2-(1,2,3,4-tetrahydroquinolin-6-yl)-7-(p-tolyl)-1,2,3,4-tetrahydro-1,8-naphthyridine (3ab)

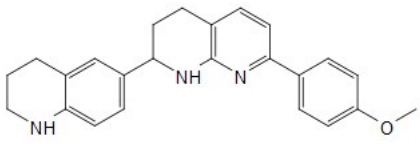


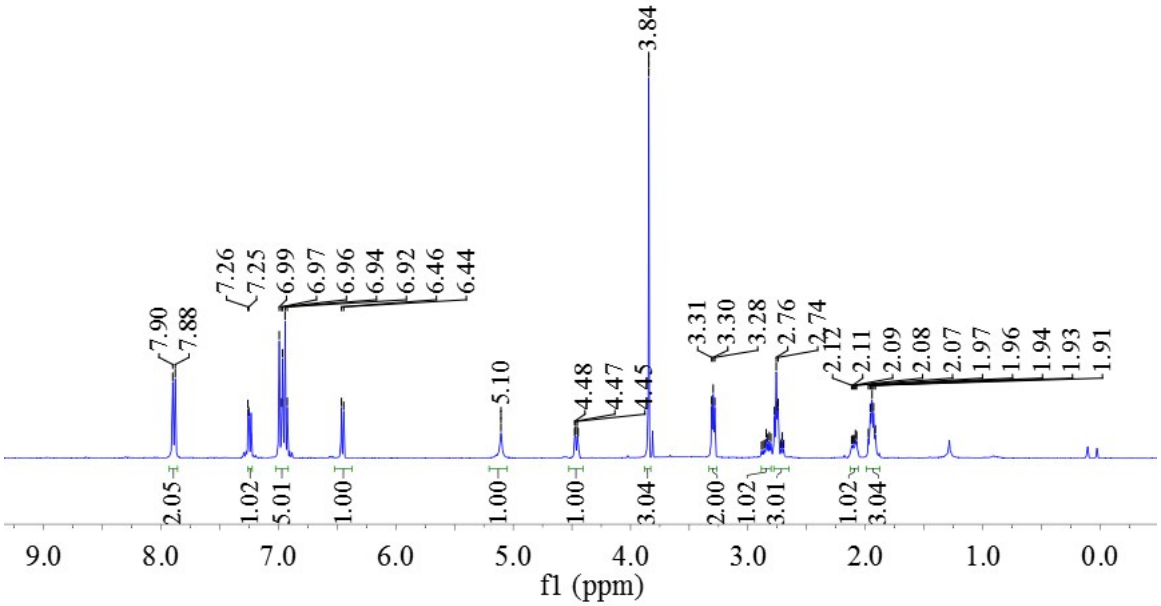


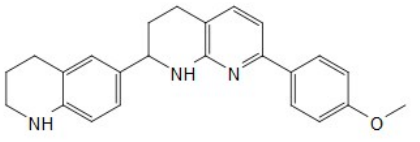


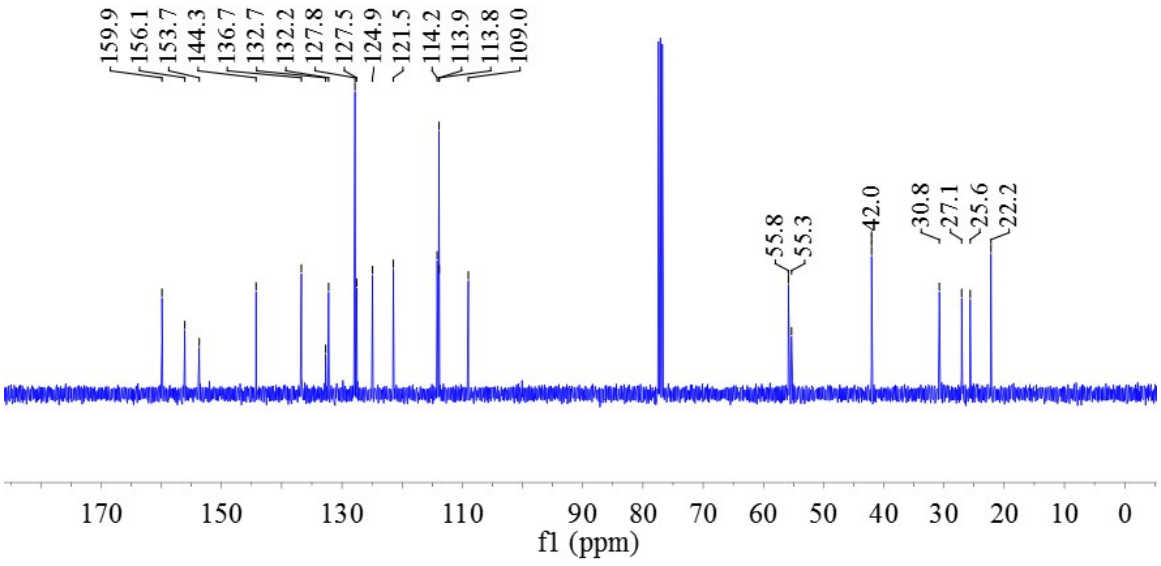


NMR spectra of 7-(4-methoxyphenyl)-2-(1,2,3,4-tetrahydroquinolin-6-yl)- 1,2,3,4-tetrahydro-1,8-naphthyridine (3ac)

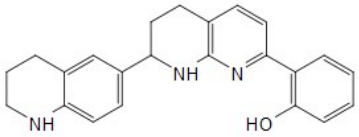


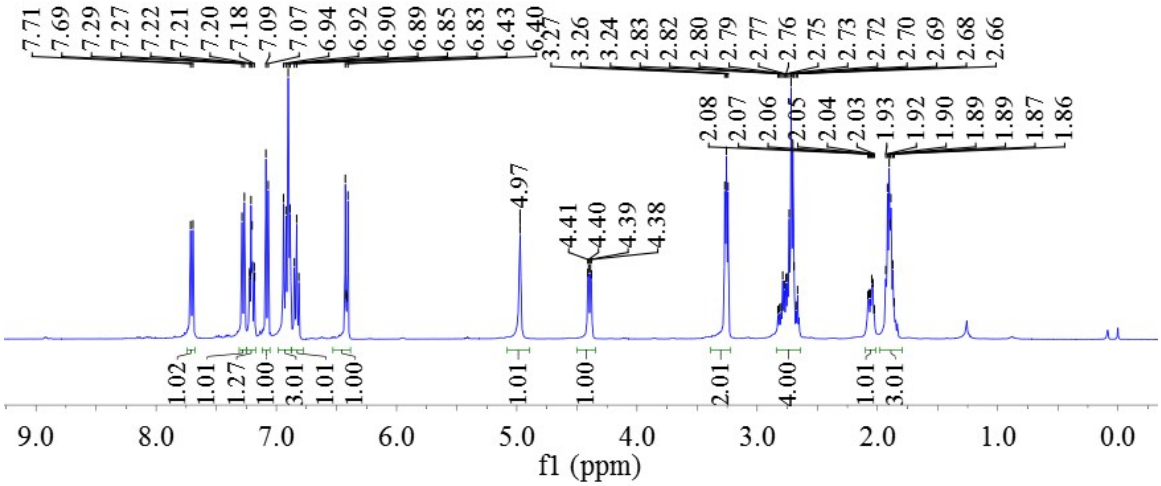


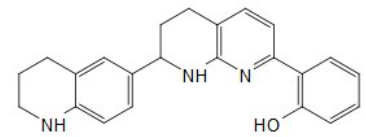


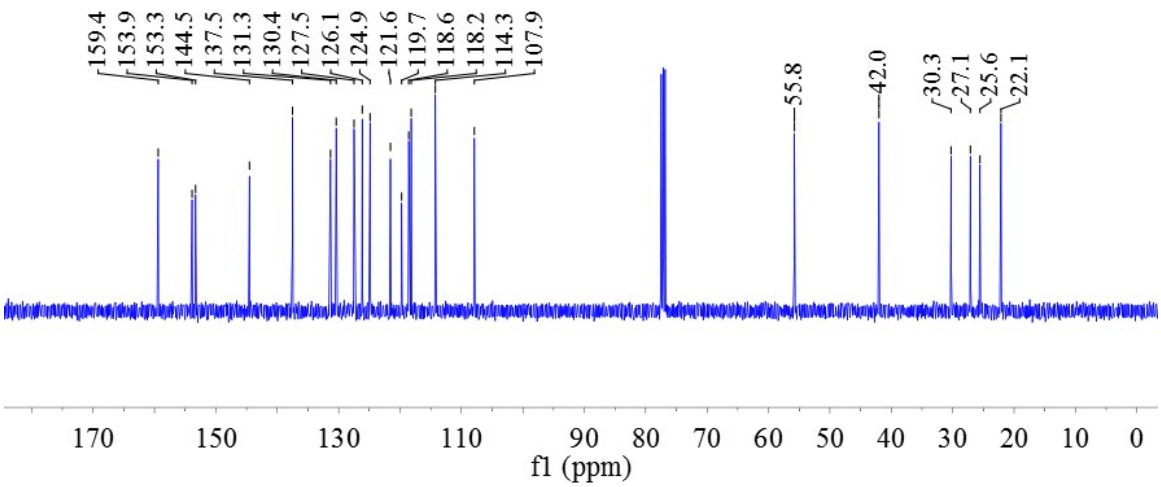


NMR spectra of 2-(7-(1,2,3,4-tetrahydroquinolin-6-yl)-5,6,7,8-tetrahydro- 1,8-naphthyridin-2-yl)phenol (3ad)

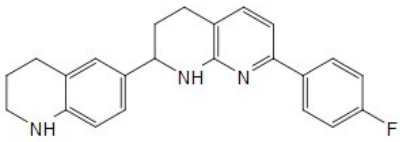


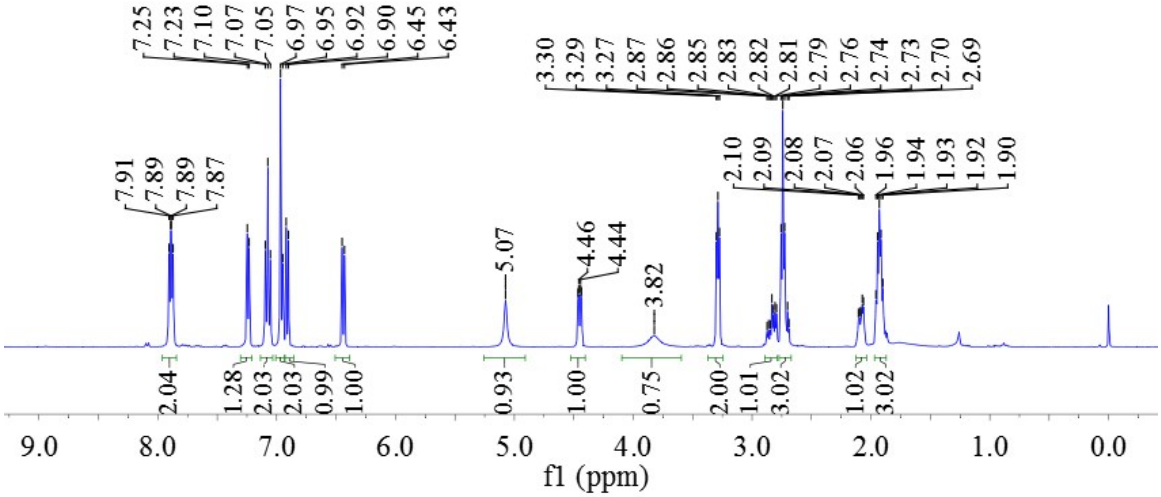


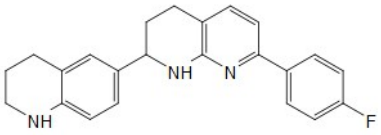




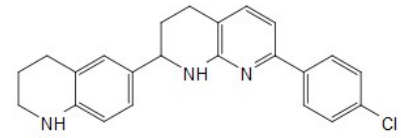
NMR spectra of 7-(4-fluorophenyl)-2-(1,2,3,4-tetrahydroquinolin-6-yl)- 1,2,3,4-tetrahydro-1,8-naphthyridine (3ae)

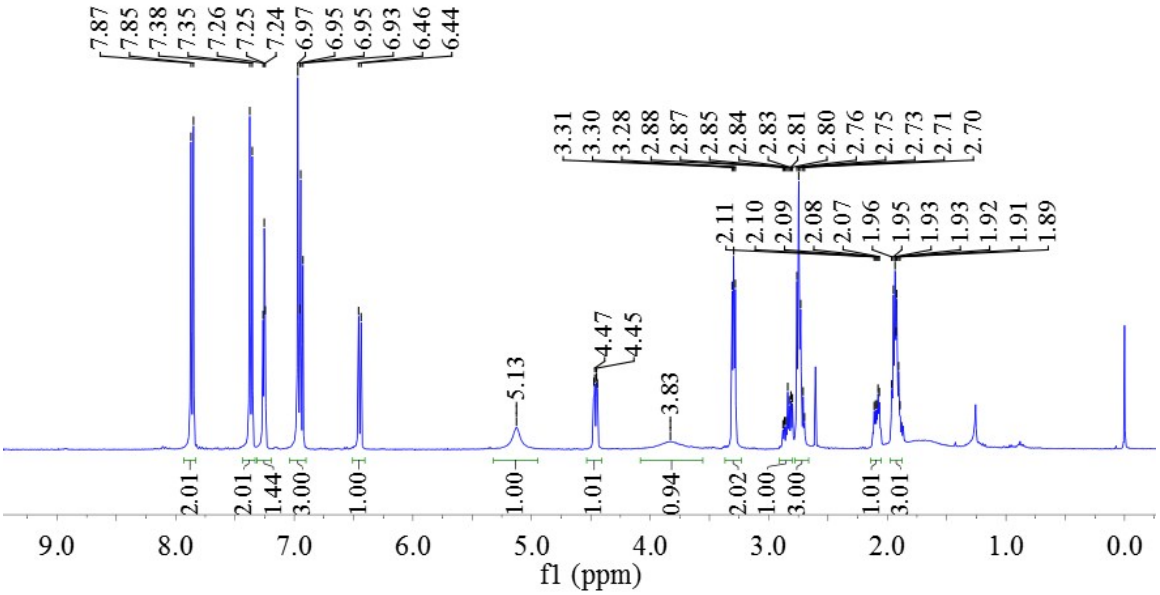


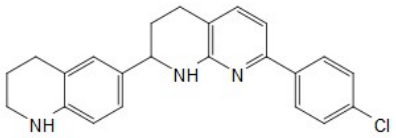


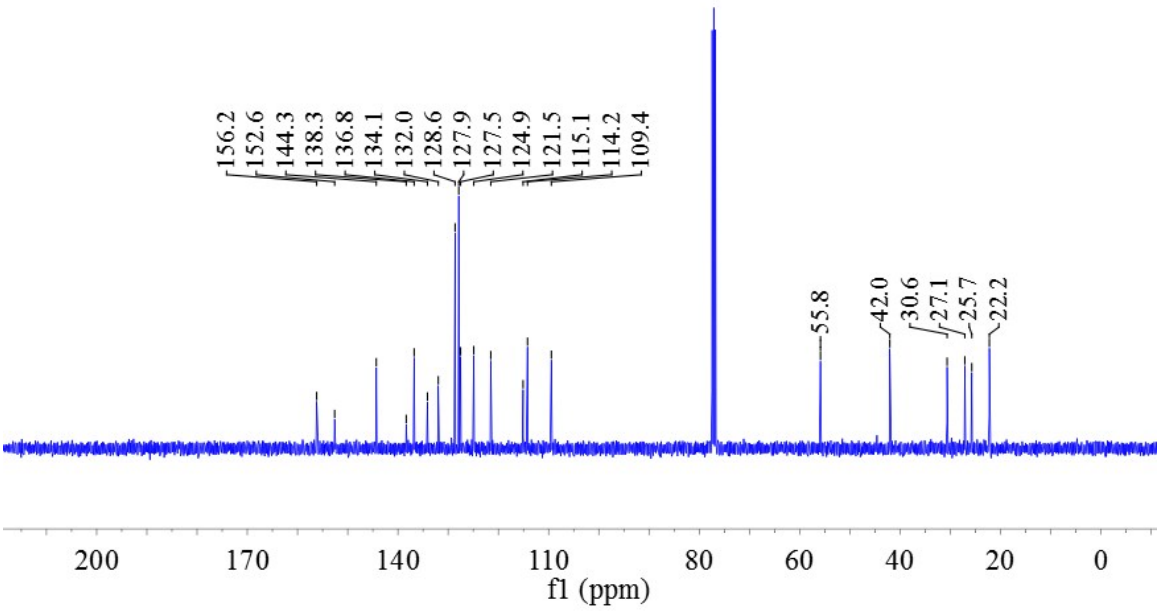


NMR spectra of 7-(4-chlorophenyl)-2-(1,2,3,4-tetrahydroquinolin-6-yl)-1,2,3,4-tetrahydro-1,8-naphthyridine (3af)

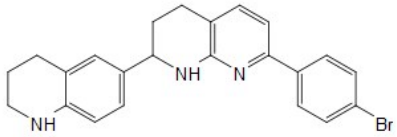


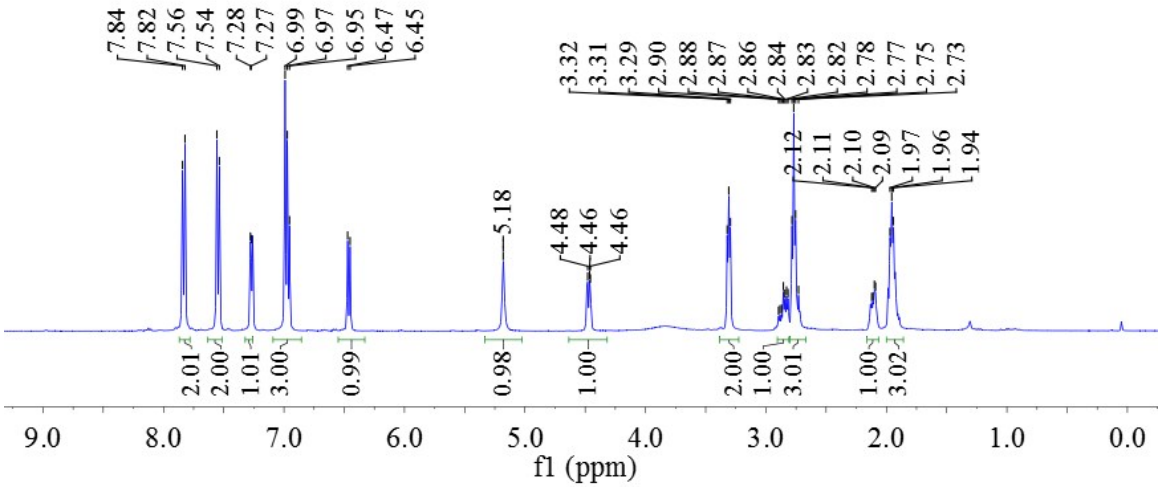


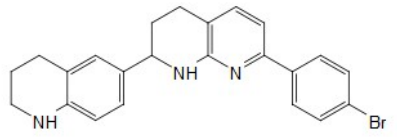


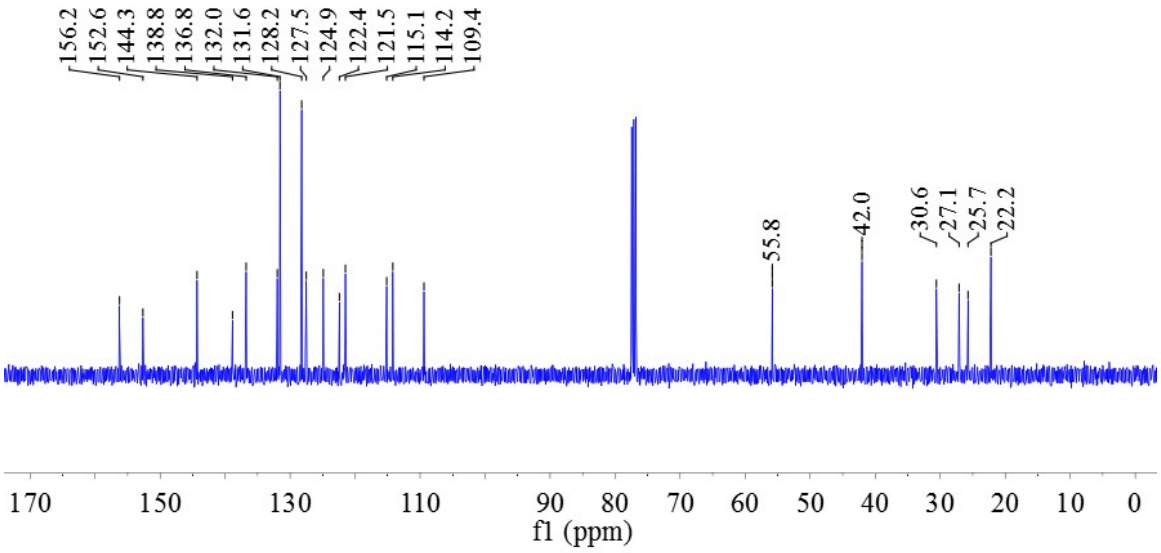


NMR spectra of 7-(4-bromophenyl)-2-(1,2,3,4-tetrahydroquinolin-6-yl)-1,2,3,4-tetrahydro-1,8-naphthyridine (3ag)

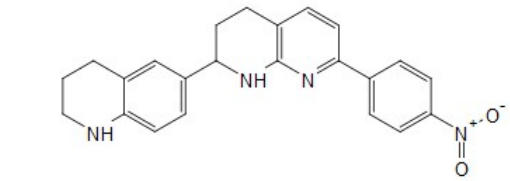


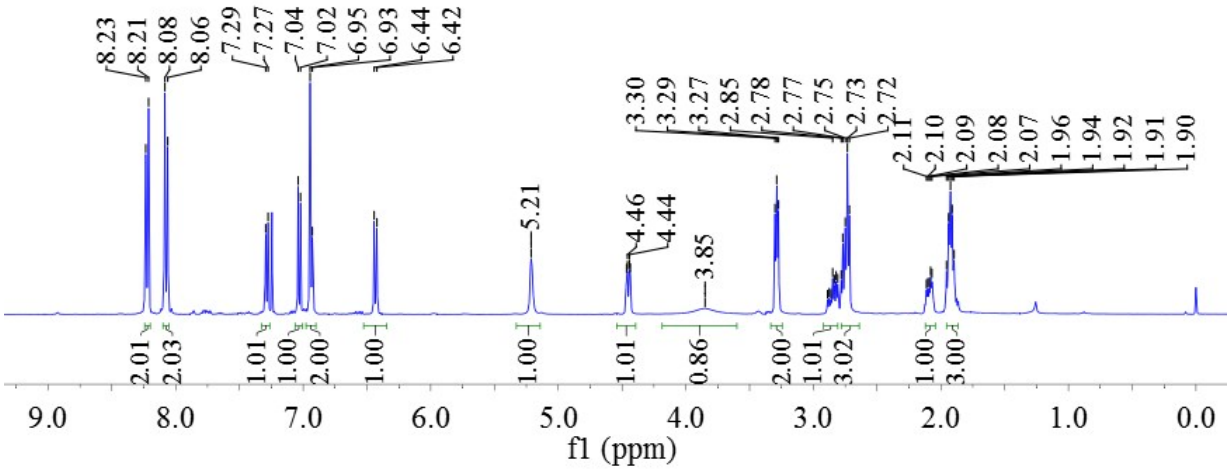


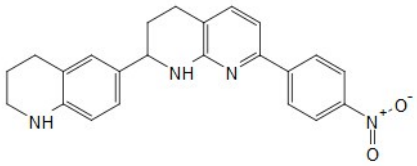


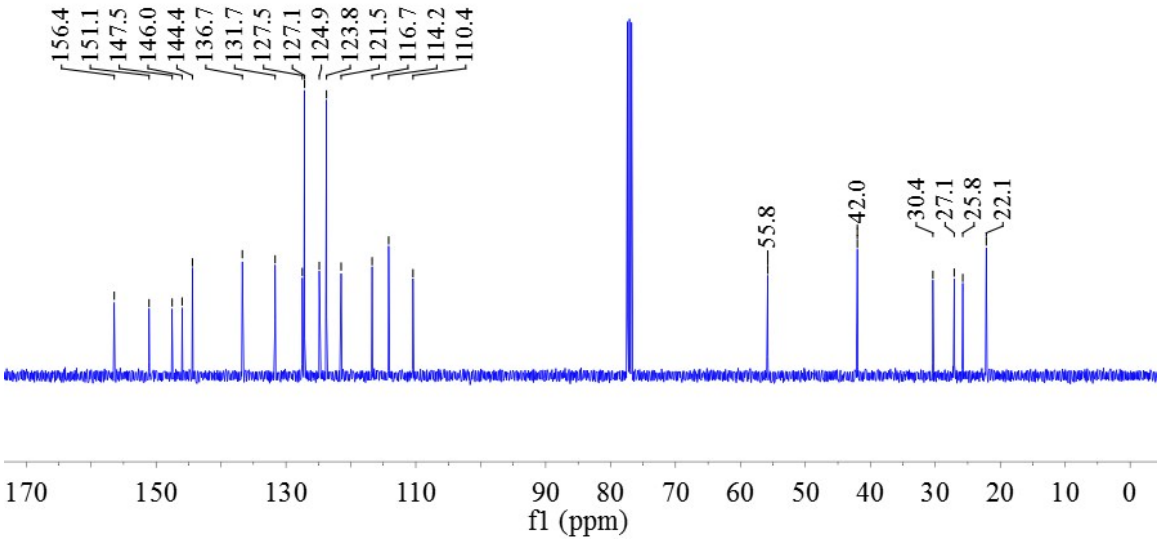


NMR spectra of 7-(4-nitrophenyl)-2-(1,2,3,4-tetrahydroquinolin-6-yl)-1,2,3,4-tetrahydro-1,8-naphthyridine (3ah)

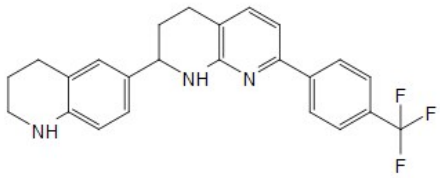


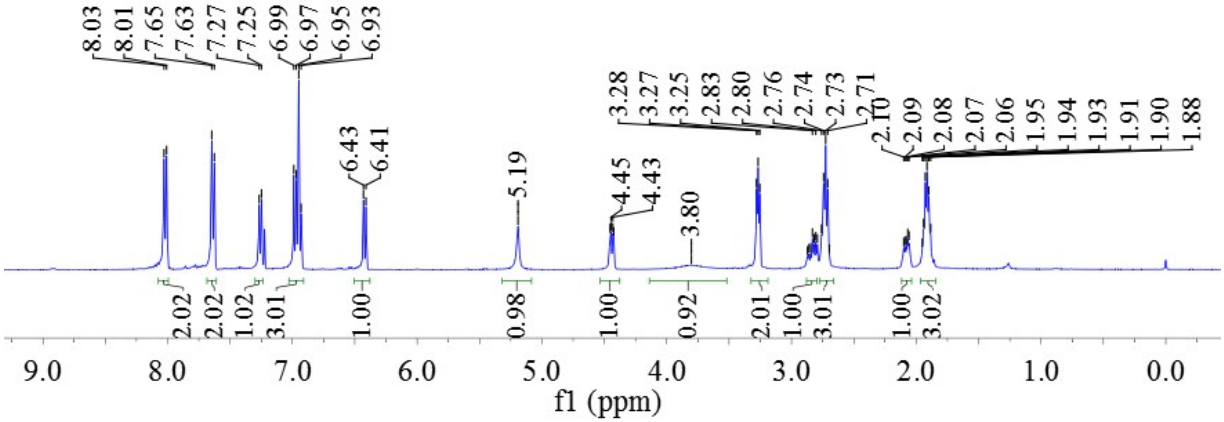


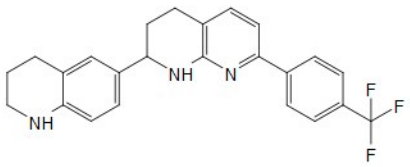


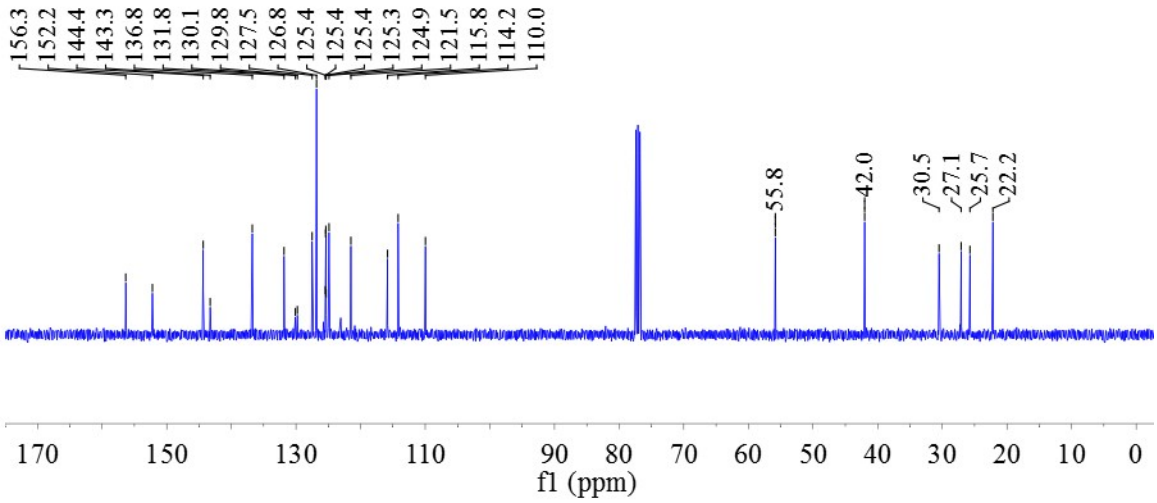


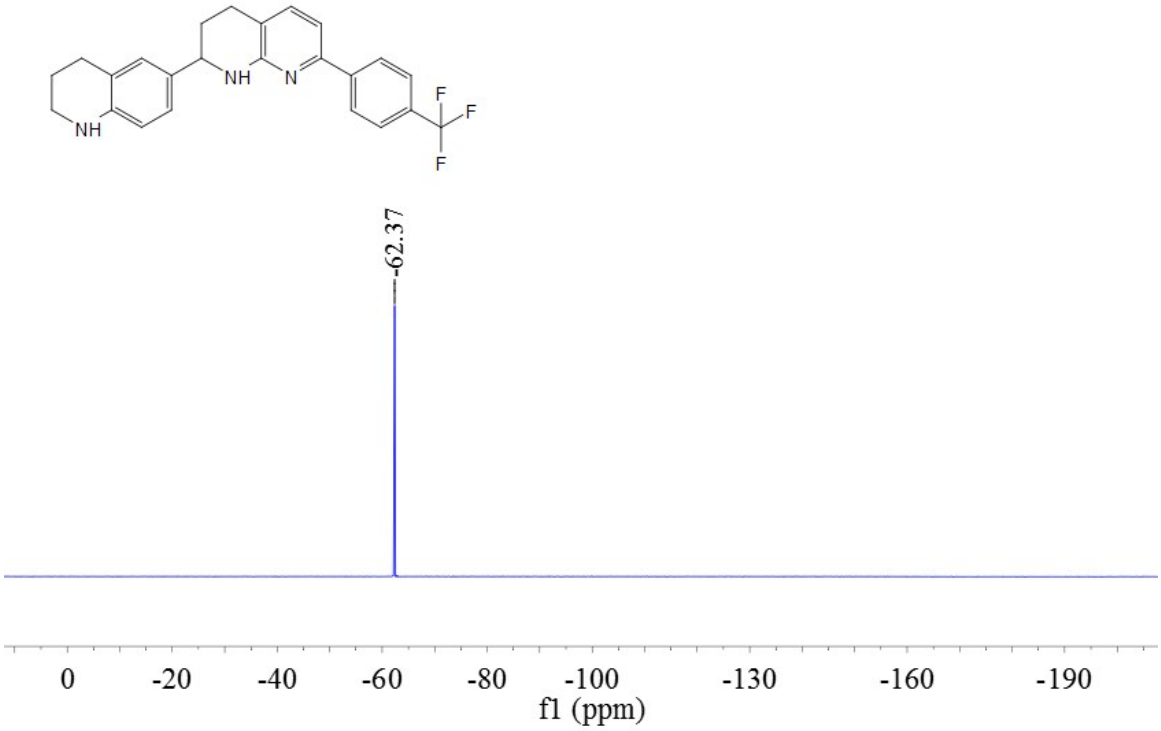
NMR spectra of 2-(1,2,3,4-tetrahydroquinolin-6-yl)-7-(4-(trifluoromethyl)phenyl) -1,2,3,4-tetrahydro-1,8-naphthyridine (3ai)



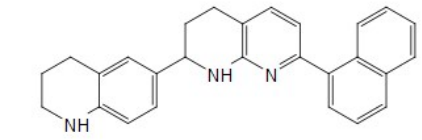


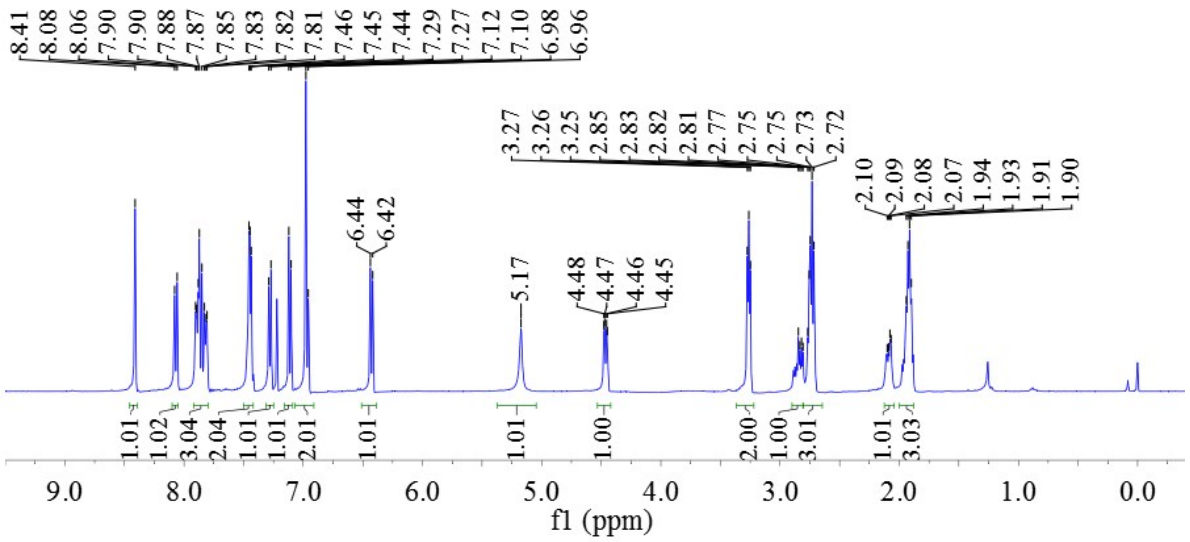


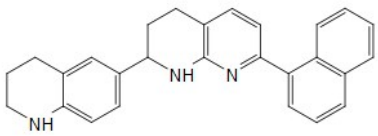


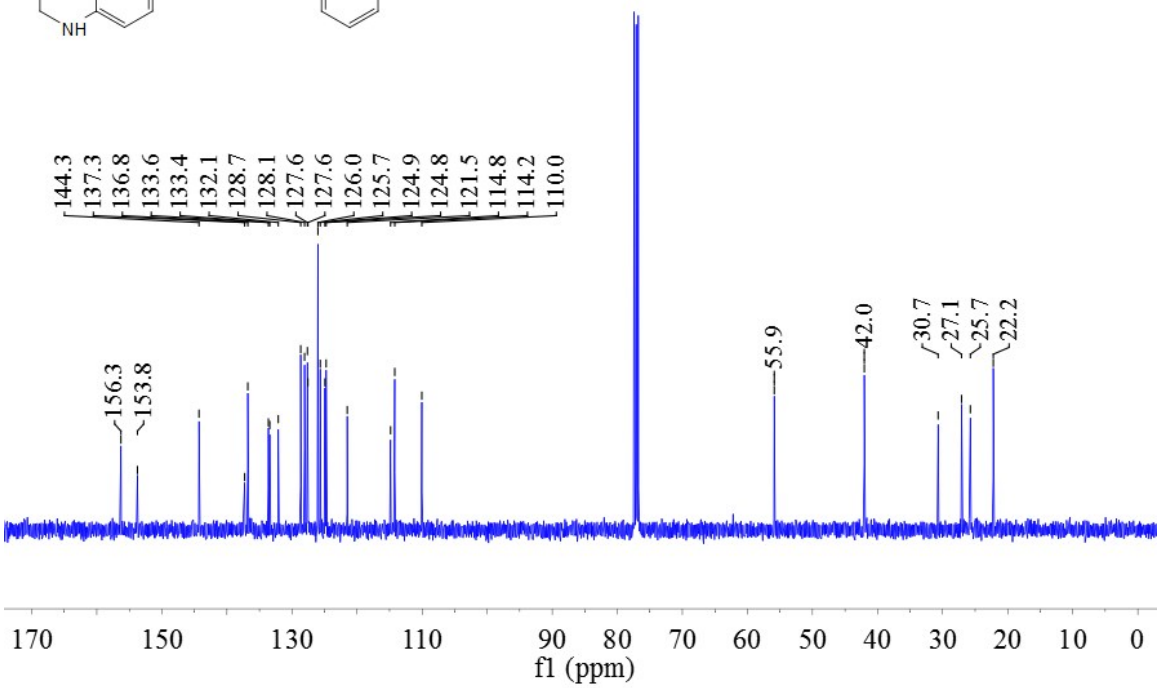

NH
NH
N
F
F
F
-62.37
0
-20
-40
-60
-80
-100
-130
-160
-190
f1 (ppm)

NMR spectra of 7-(4-(naphthalen-1-yl)phenyl)-2-(1,2,3,4-tetrahydroquinolin-6-yl) -1,2,3,4-tetrahydro-1,8-naphthyridine (3aj)

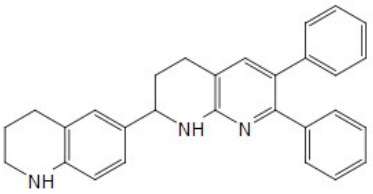


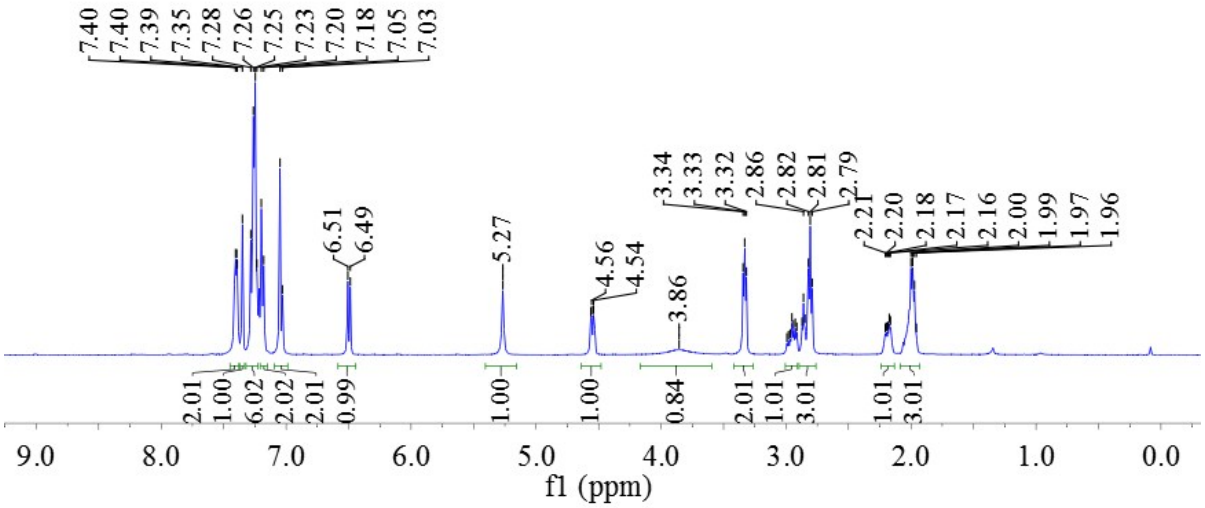


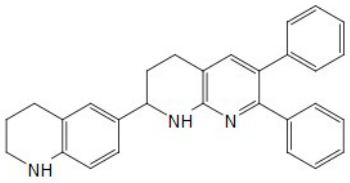


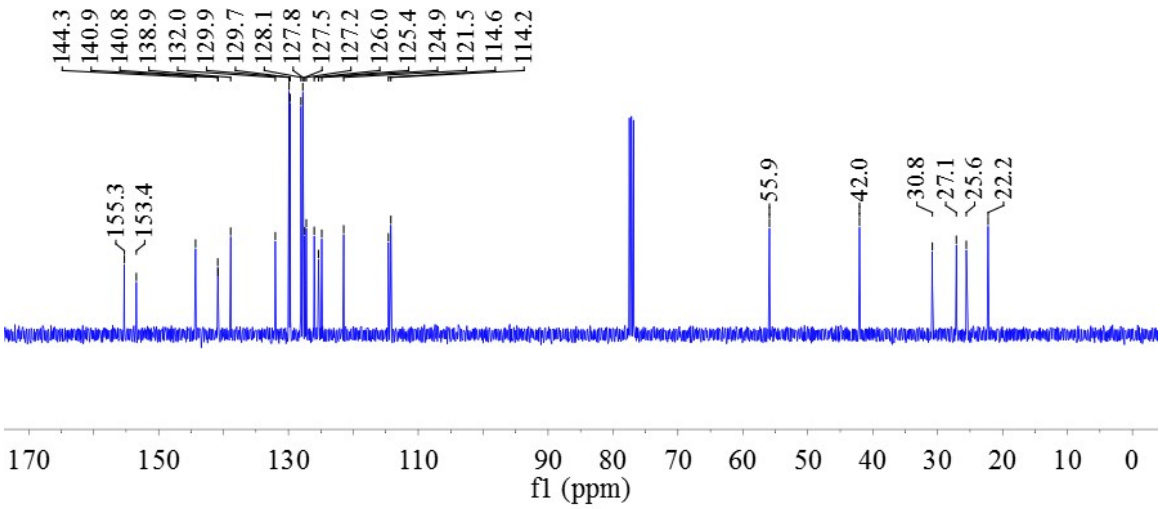


NMR spectra of 6,7-diphenyl-2-(1,2,3,4-tetrahydroquinolin-6-yl)-1,2,3,4-tetrahydro-1,8-naphthyridine (3ak)

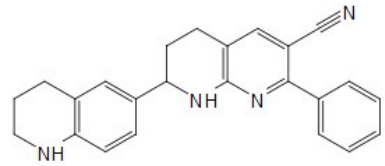


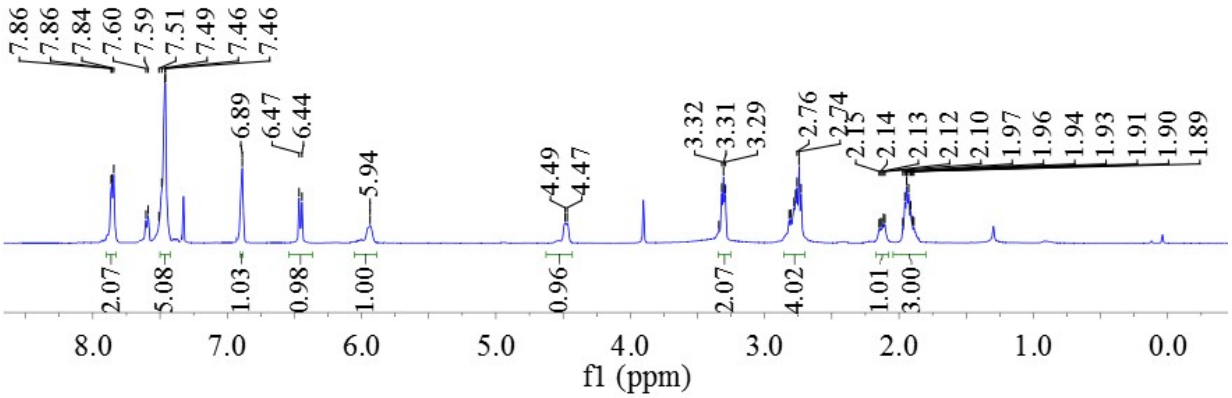


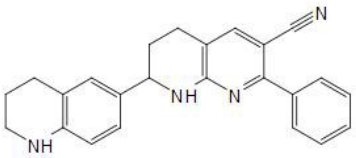


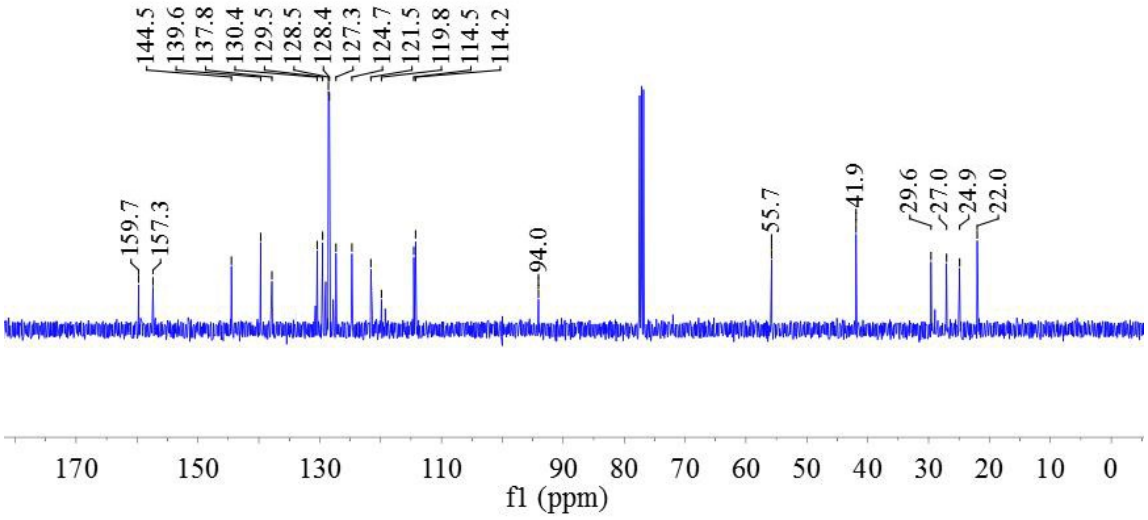


NMR spectra of 2-phenyl-7-(1,2,3,4-tetrahydroquinolin-6-yl)-5,6,7,8- tetrahydro-1,8-naphthyridine-3-carbonitrile (3al)

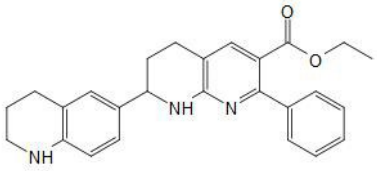


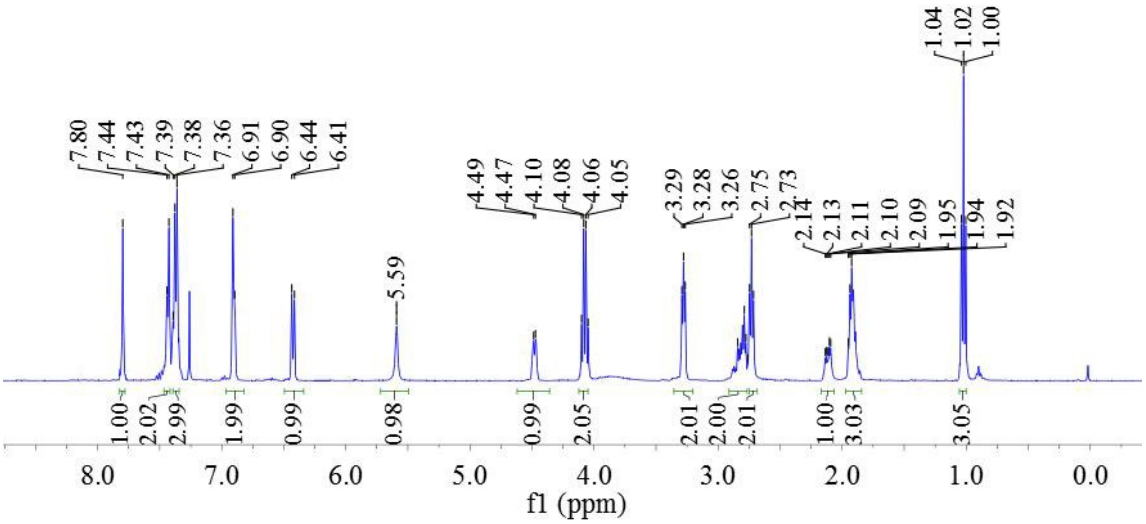


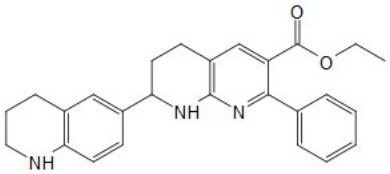


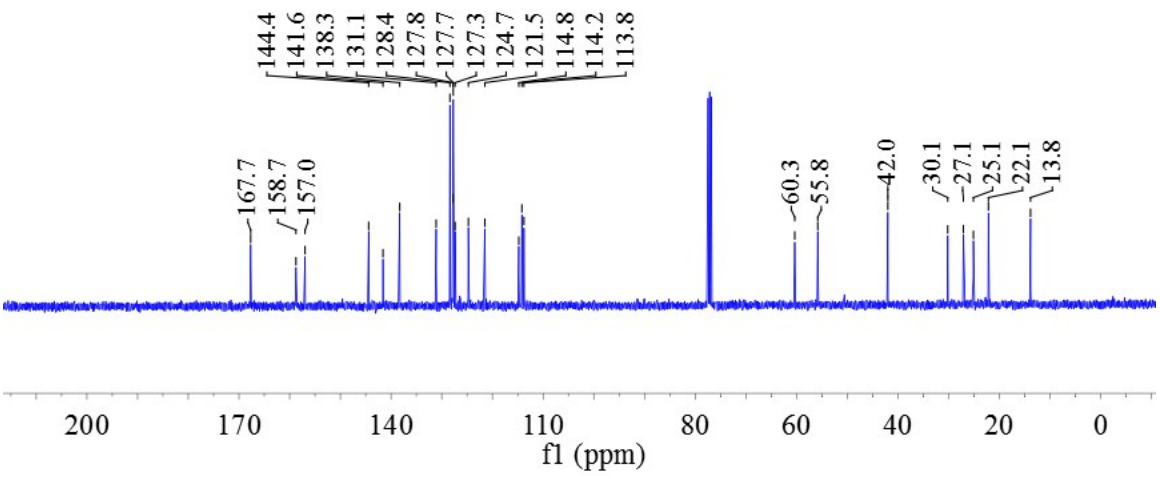


NMR spectra of ethyl 2-phenyl-7-(1,2,3,4-tetrahydroquinolin-6-yl)-5,6,7,8-tetrahydro-1,8-naphthyridine -3-carboxylate (3am)

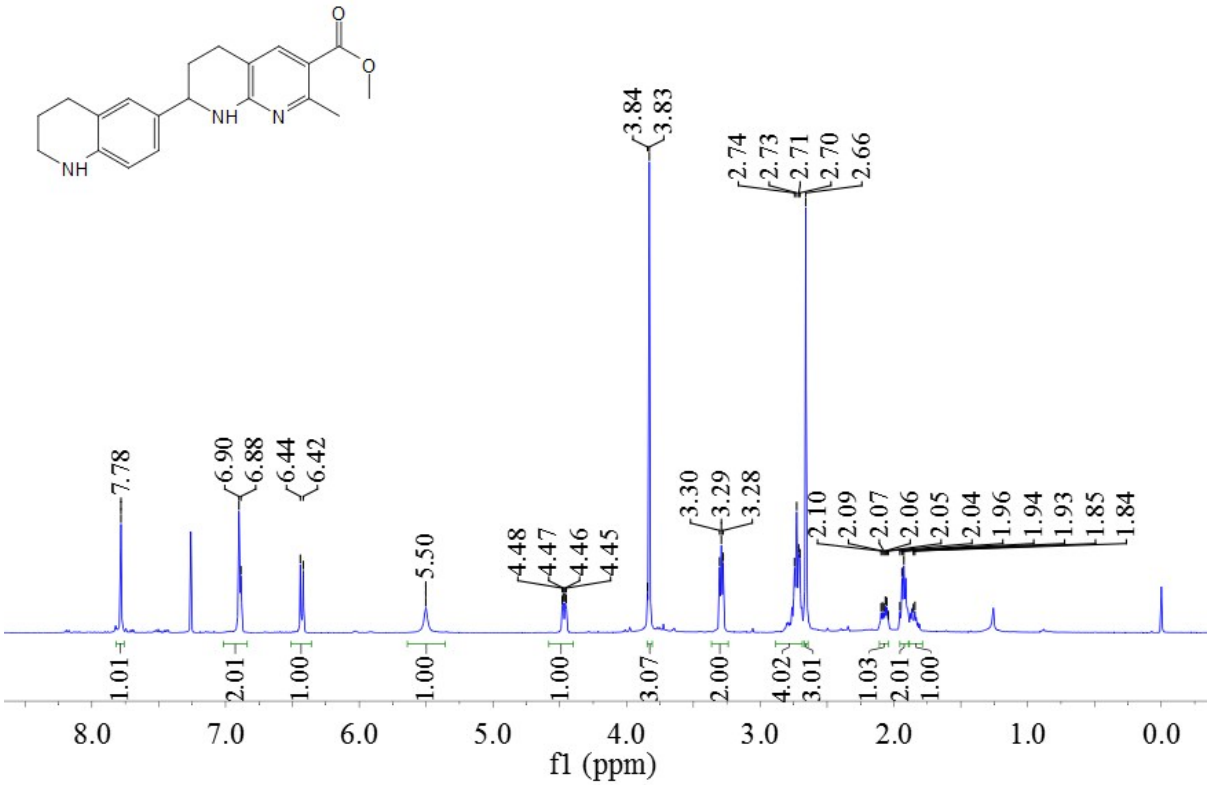


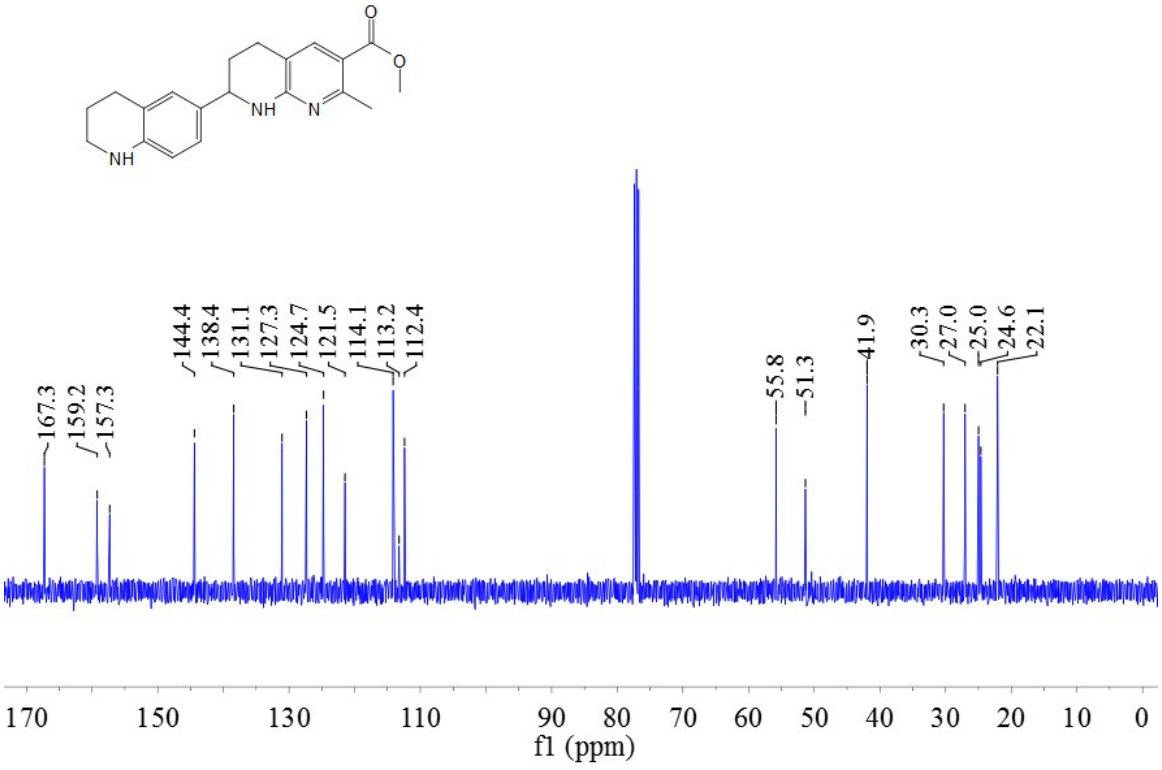




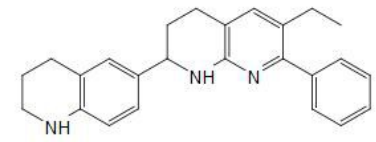


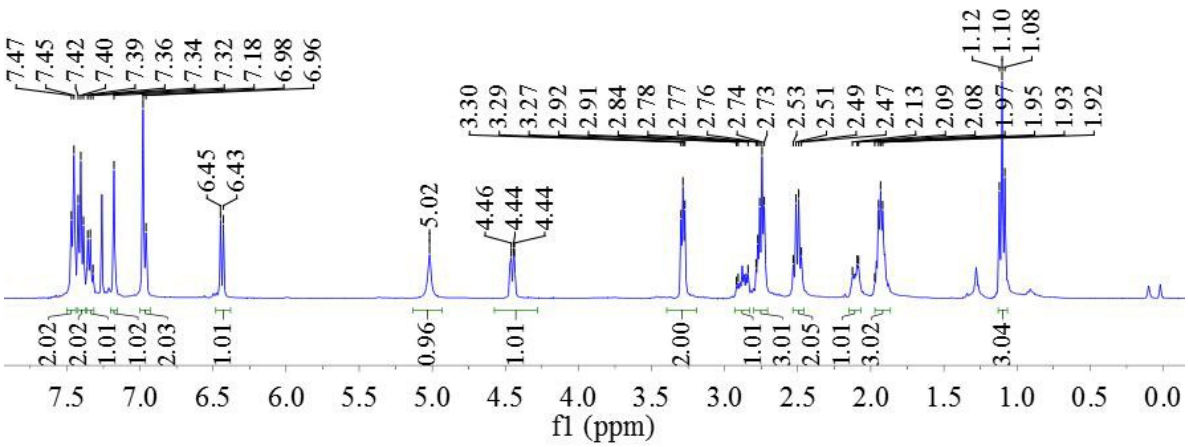
NMR spectra of methyl 2-methyl-7-(1,2,3,4-tetrahydroquinolin-6-yl)-5,6,7,8-tetrahydro-1,8-naphthyridine -3-carboxylate (3an)

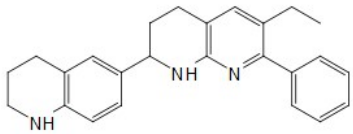


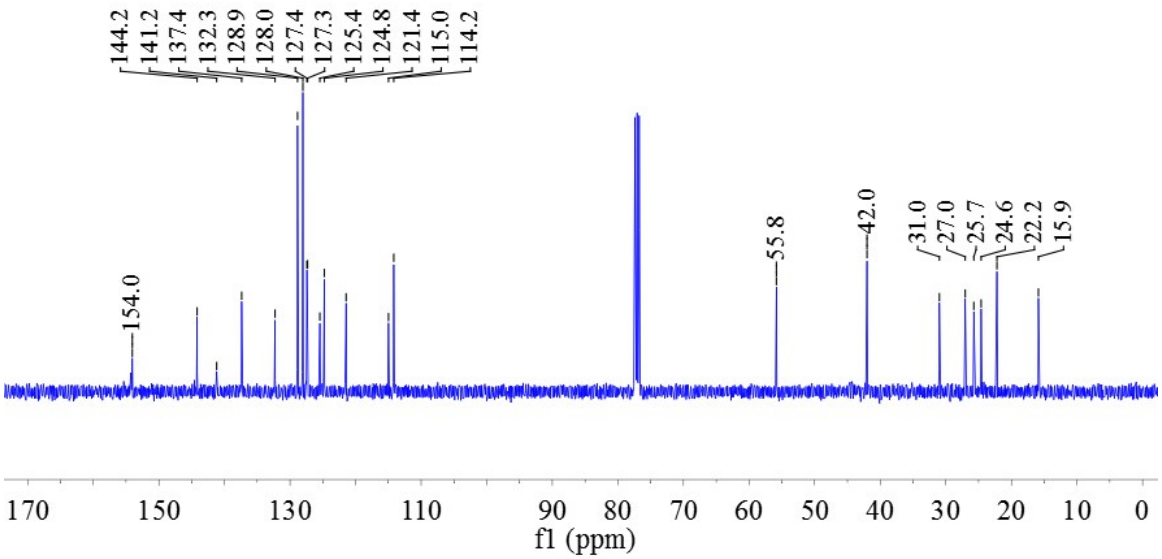


NMR spectra of 6-ethyl-7-phenyl-2-(1,2,3,4-tetrahydroquinolin-6-yl)-1,2,3,4-tetrahydro-1,8-naphthyridine (3ao)

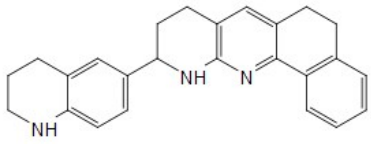


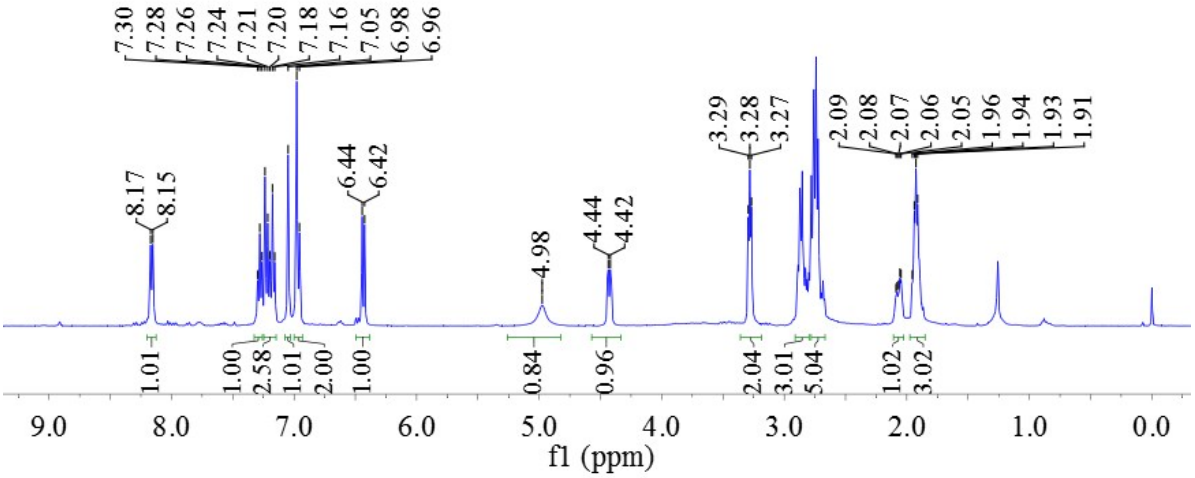


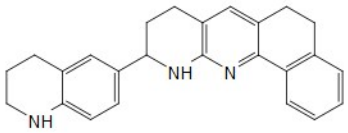




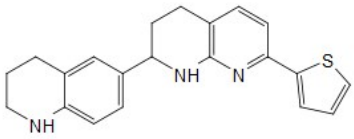
NMR spectra of 10-(1,2,3,4-tetrahydroquinolin-6-yl)-5,6,8,9,10,11-hexahydronaphtho[1,2-b][1,8]naphthyridine (3ap)

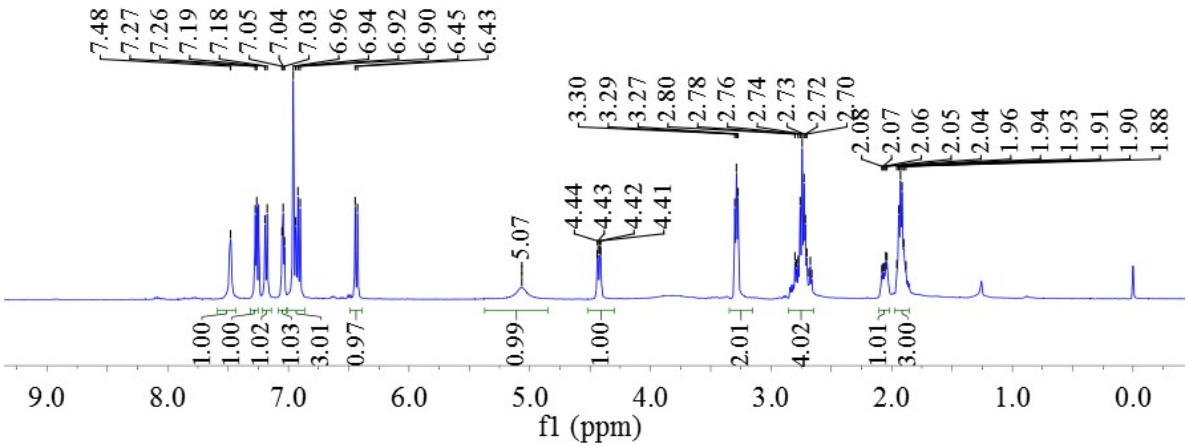


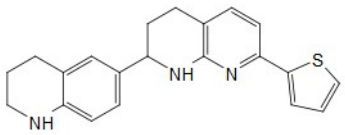


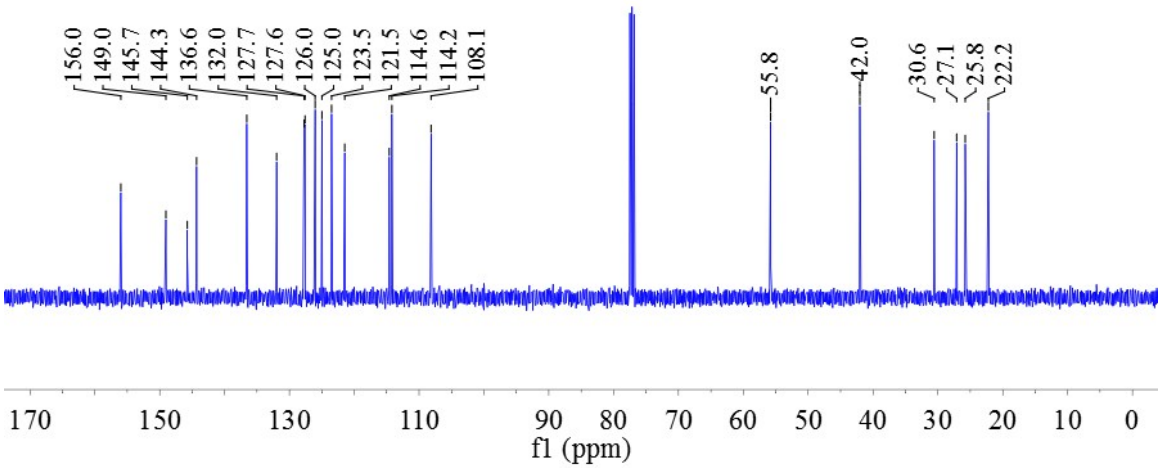


NMR spectra of 2-(1,2,3,4-tetrahydroquinolin-6-yl)-7-(thiophen-2-yl)-1,2,3,4-tetrahydro-1,8-naphthyridine (3aq)

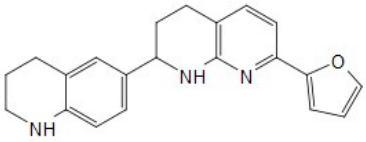


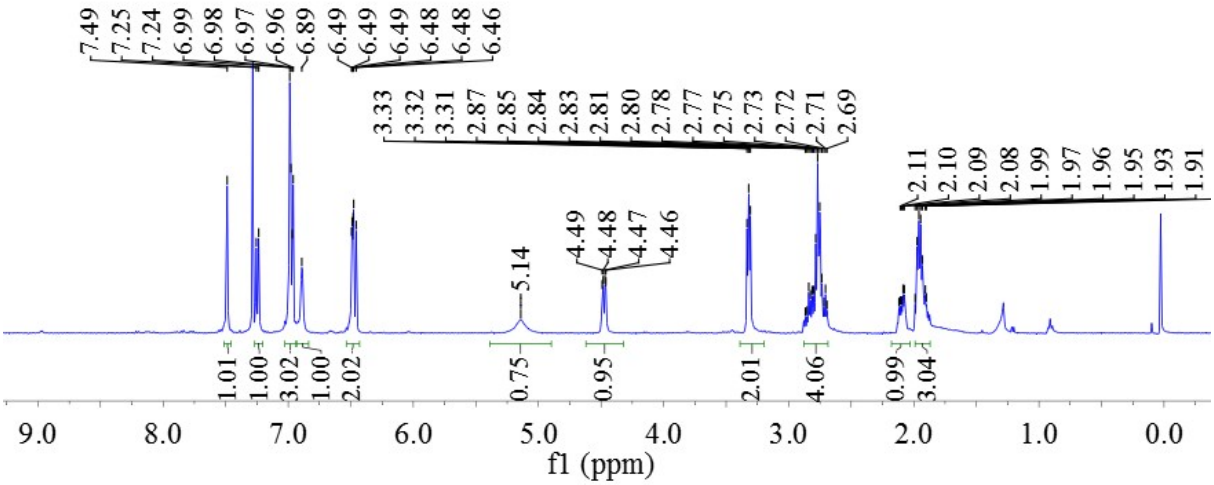


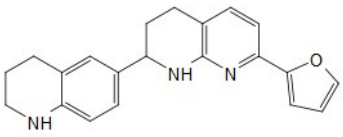




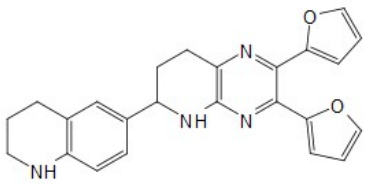
NMR spectra of 7-(furan-2-yl)-2-(1,2,3,4-tetrahydroquinolin-6-yl)-1,2,3,4-tetrahydro-1,8-naphthyridine (3ar)

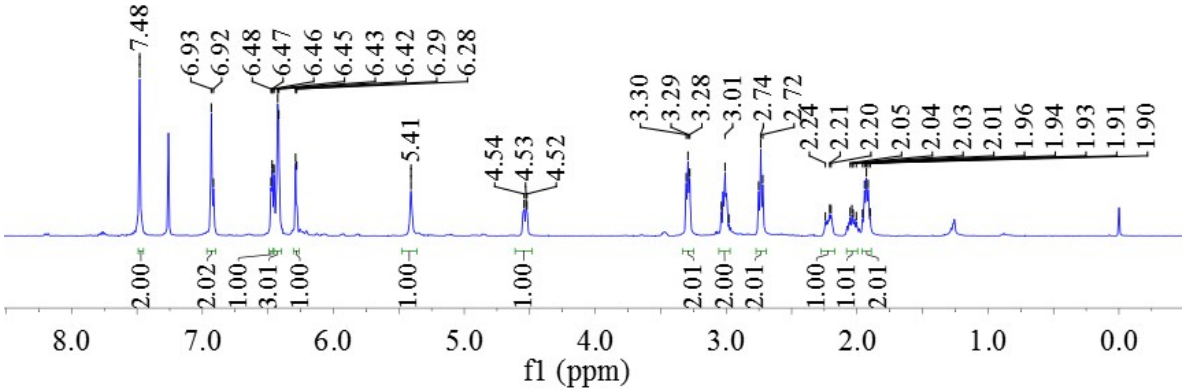


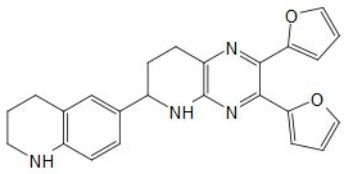


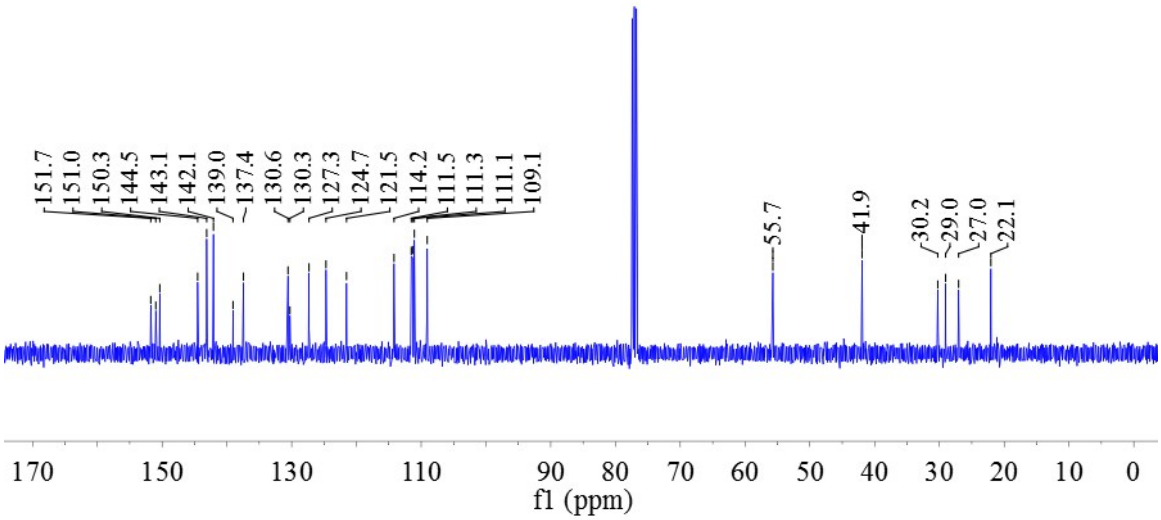


NMR spectra of 2,3-di(furan-2-yl)-6-(1,2,3,4-tetrahydroquinolin-6-yl)-5,6,7,8-tetrahydropyrido[2,3-b]pyrazine (3as)

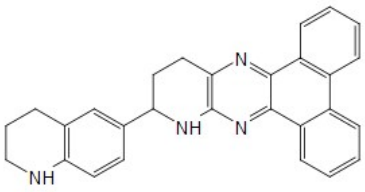


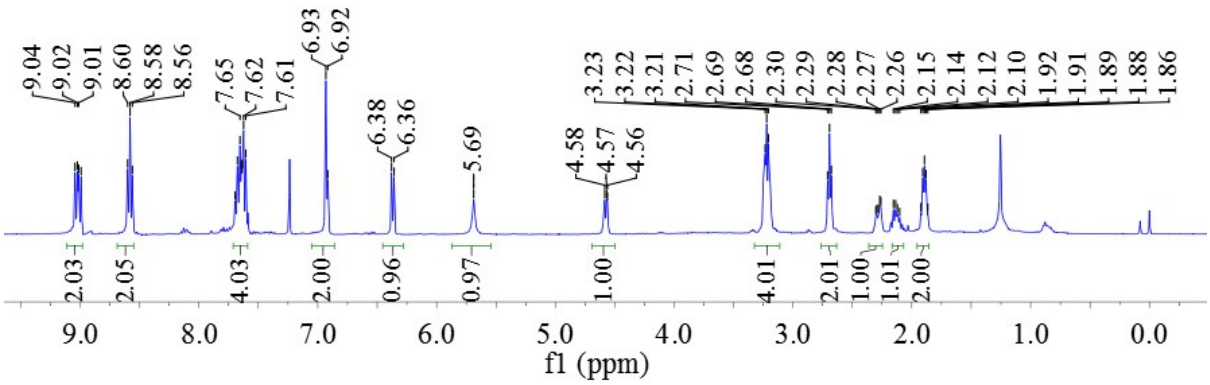


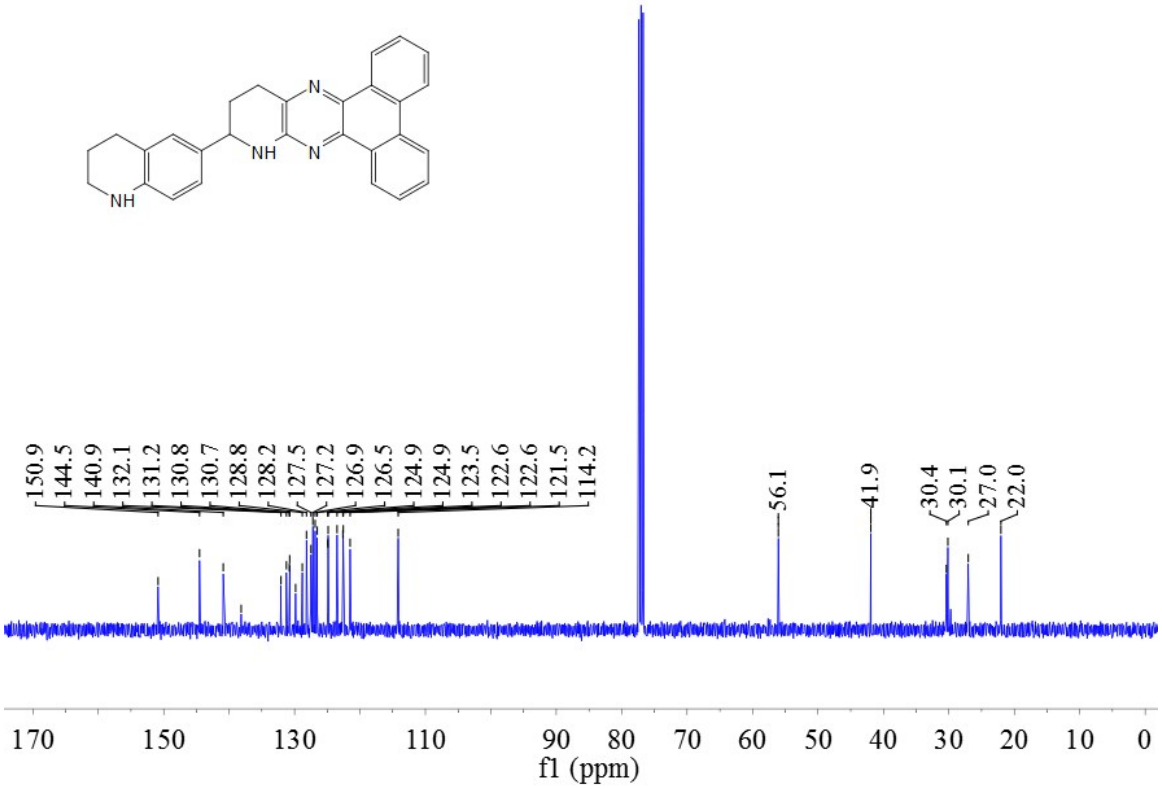




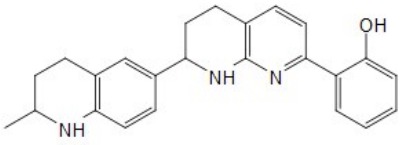
NMR spectra of 11-(1,2,3,4-tetrahydroquinolin-6-yl)-10,11,12,13-tetrahydrodibenzo[f,h]pyrido[2,3-b]quinoxaline (3at)

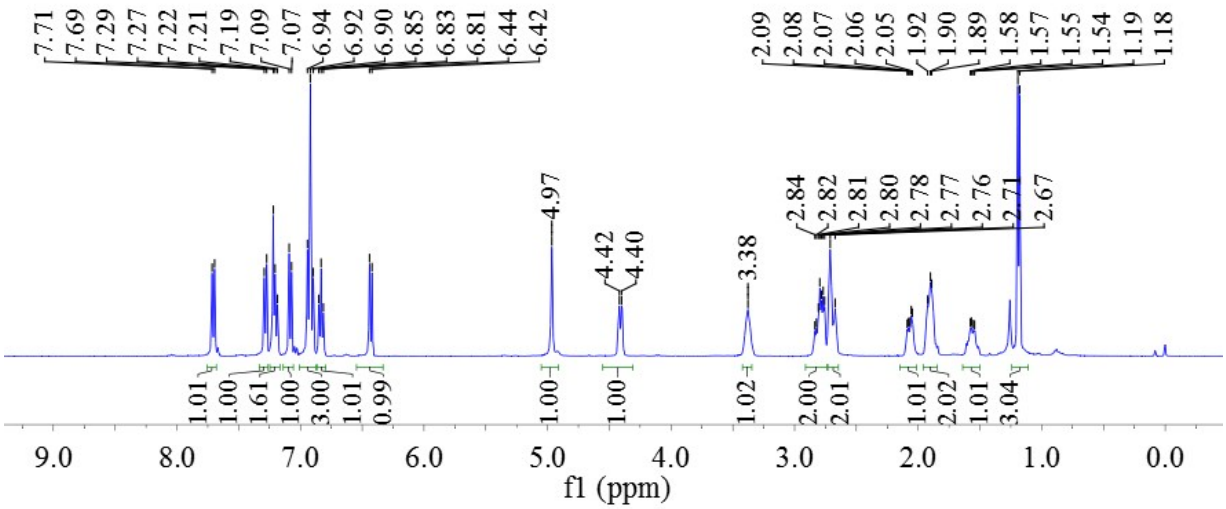


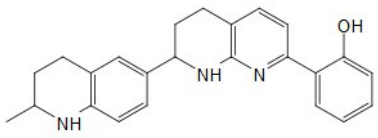


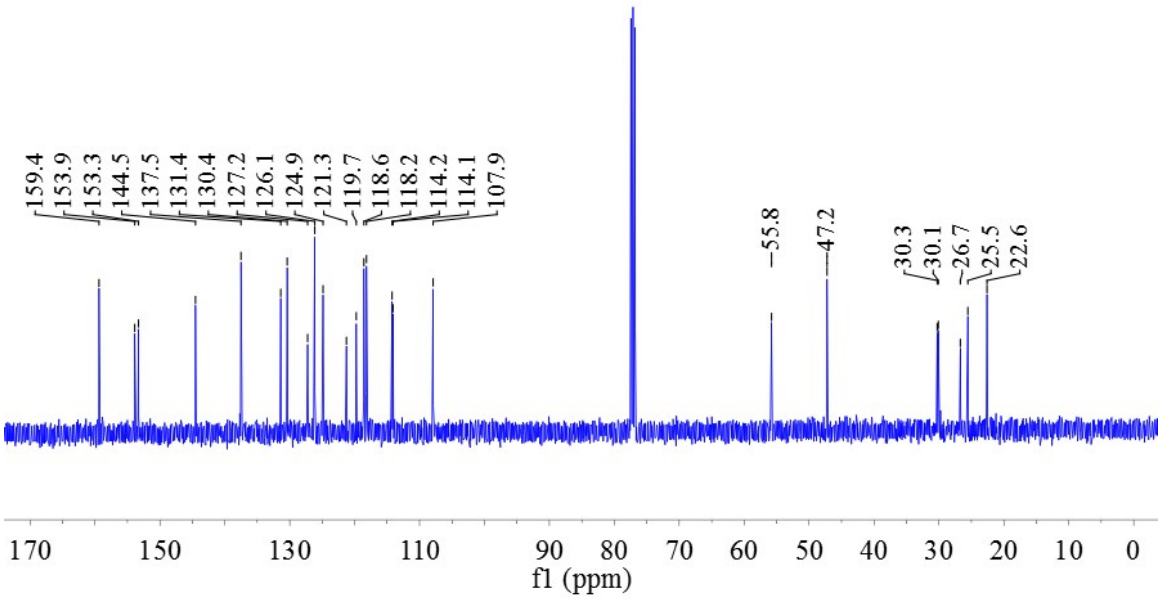


NMR spectra of 2-(7-(2-methyl-1,2,3,4-tetrahydroquinolin-6-yl)-5,6,7,8-tetrahydro-1,8-naphthyridin-2-yl)phenol (3bd)

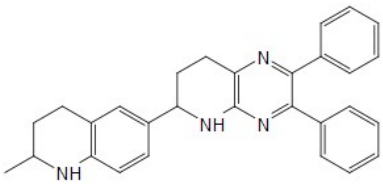


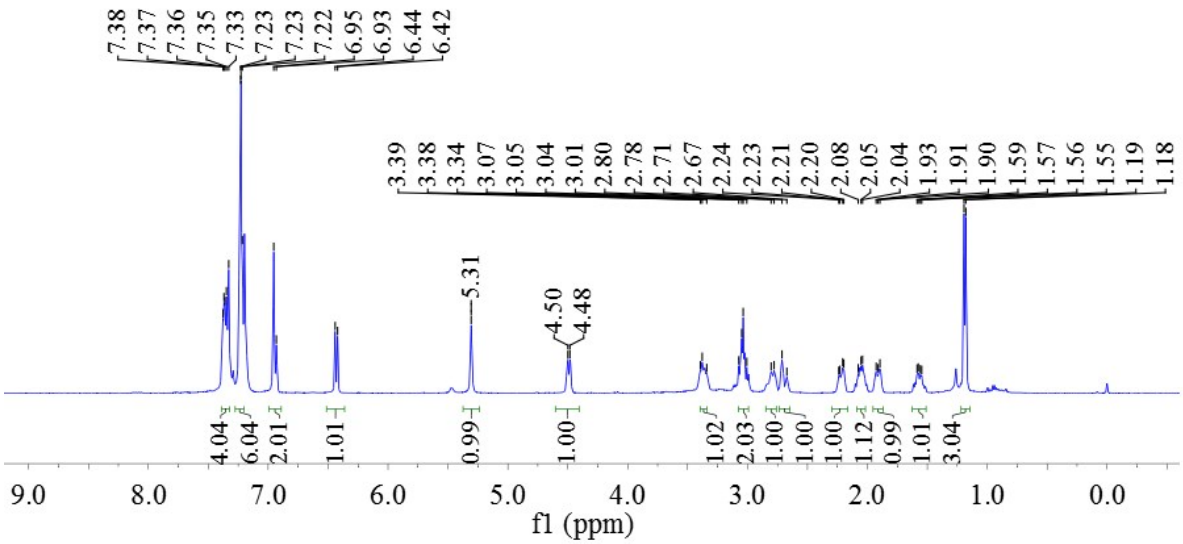


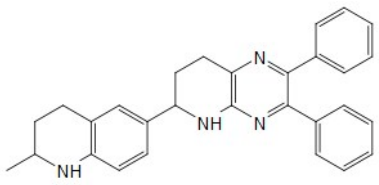


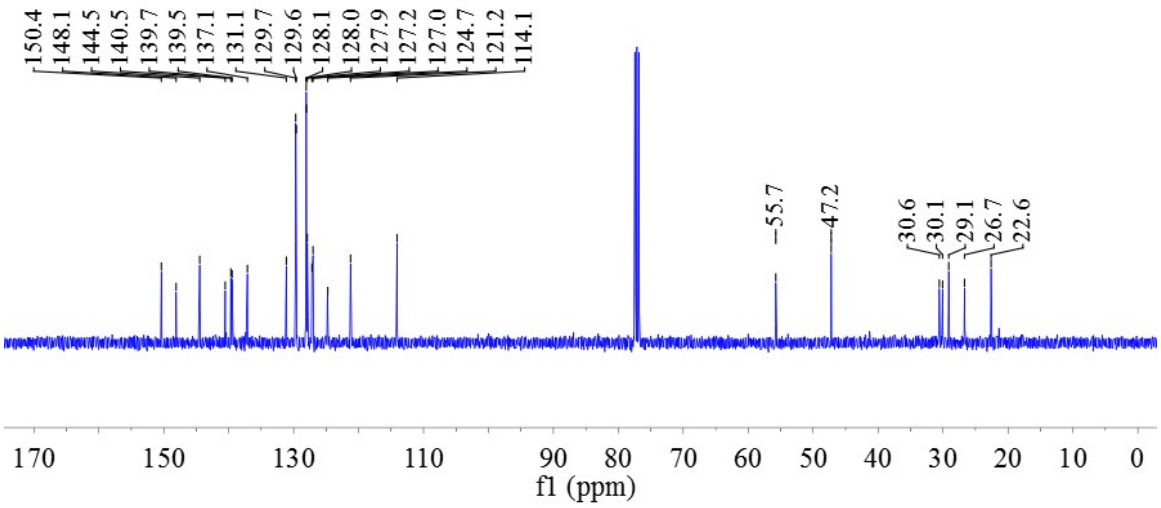


NMR spectra of 6-(2-methyl-1,2,3,4-tetrahydroquinolin-6-yl)-2,3-diphenyl-5,6,7,8-tetrahydropyrido[2,3-b]pyrazine (3bu)

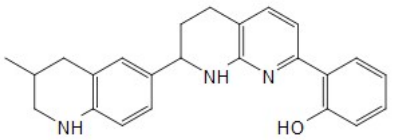


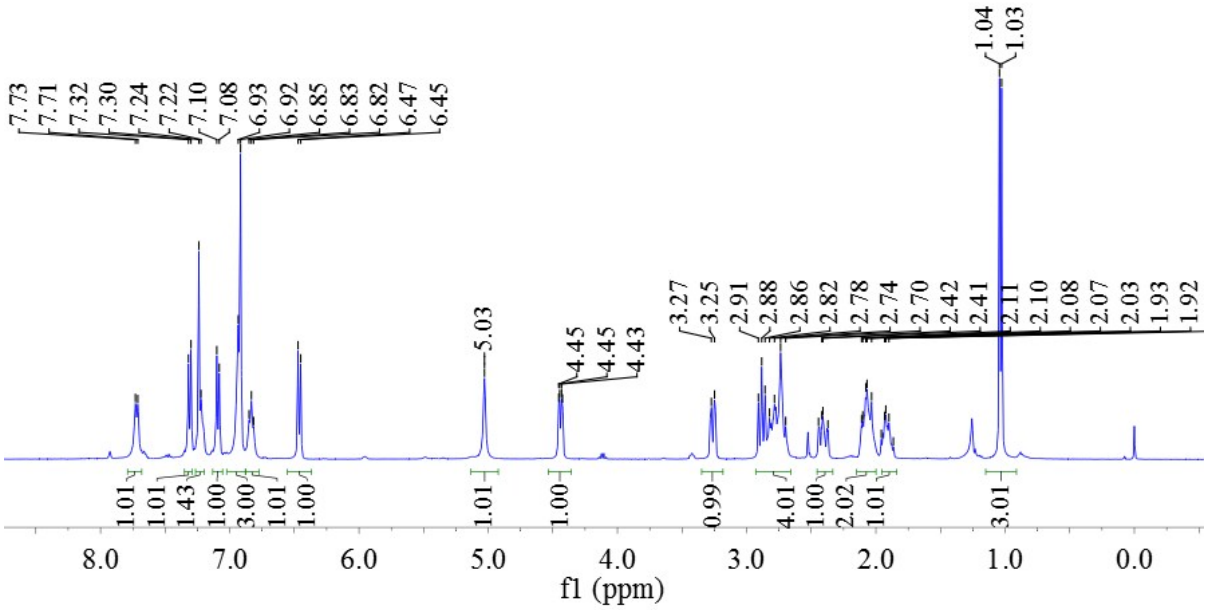


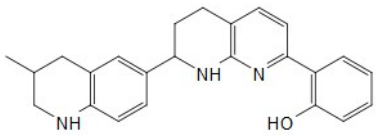


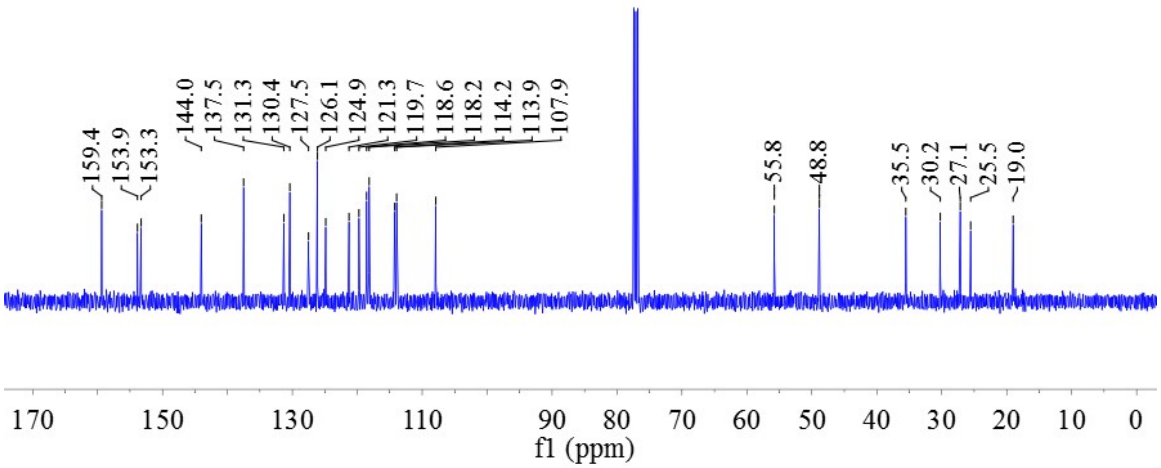


NMR spectra of 2-(7-(3-methyl-1,2,3,4-tetrahydroquinolin-6-yl)-5,6,7,8-tetrahydro-1,8-naphthyridin-2-yl)phenol (3cd)

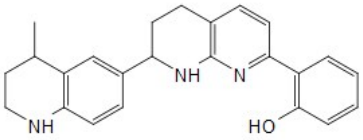


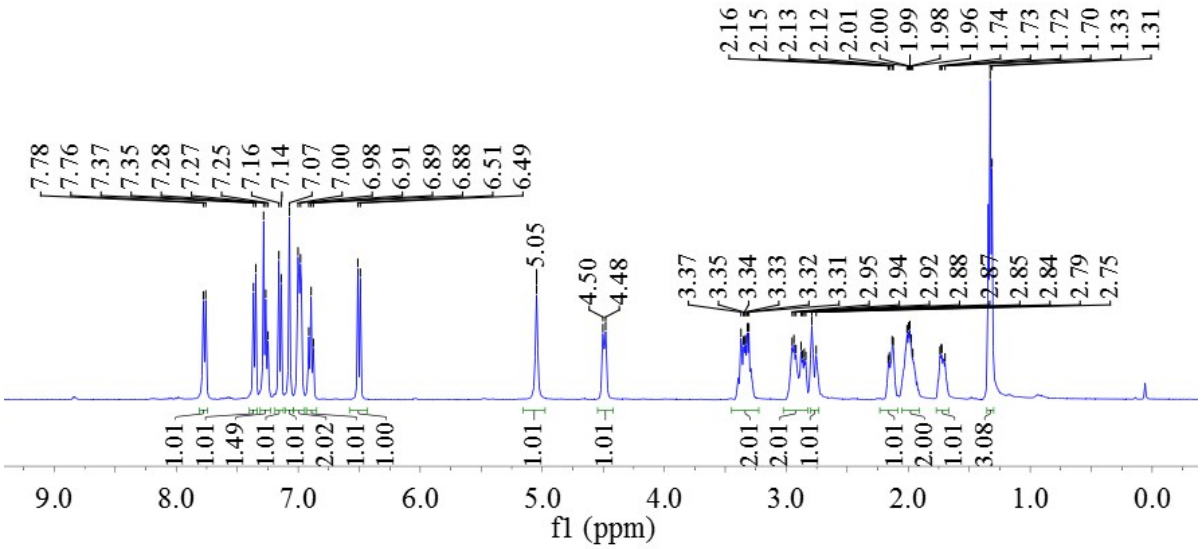


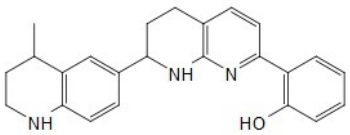


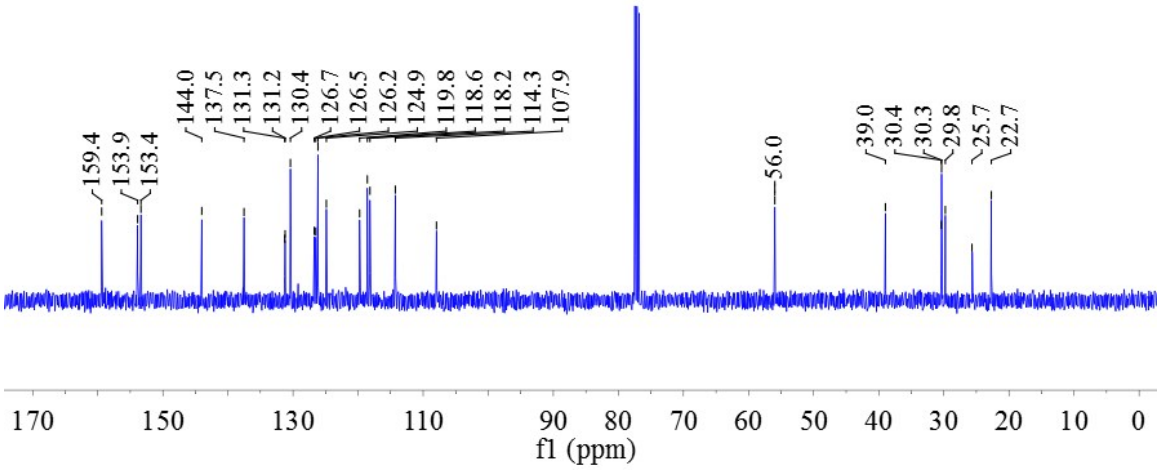


NMR spectra of 2-(7-(4-methyl-1,2,3,4-tetrahydroquinolin-6-yl)-5,6,7,8-tetrahydro-1,8-naphthyridin-2-yl)phenol (3dd)

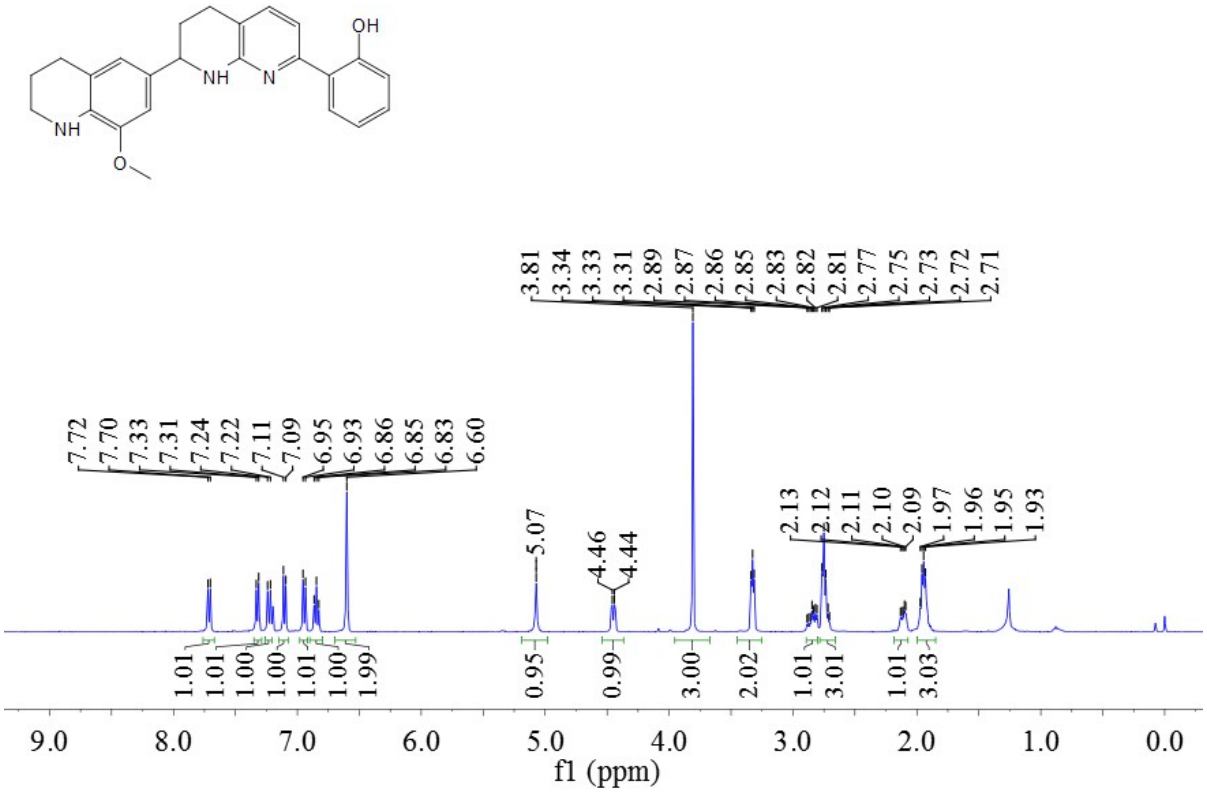


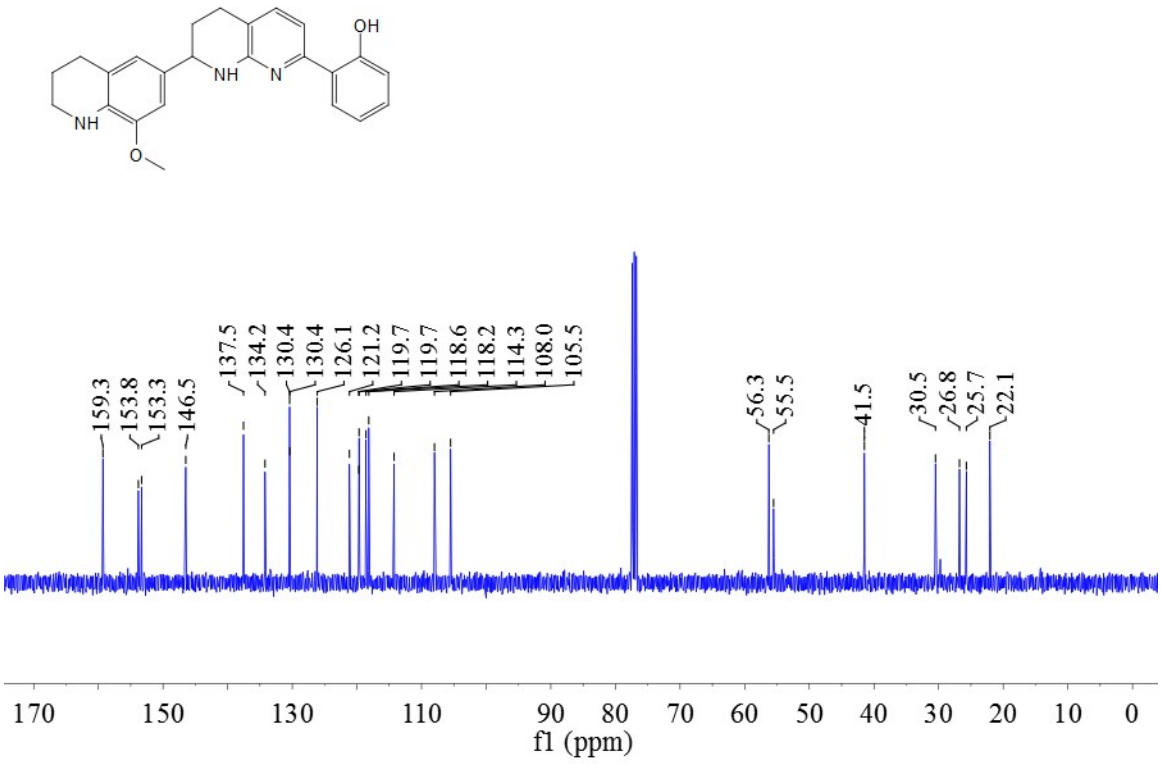




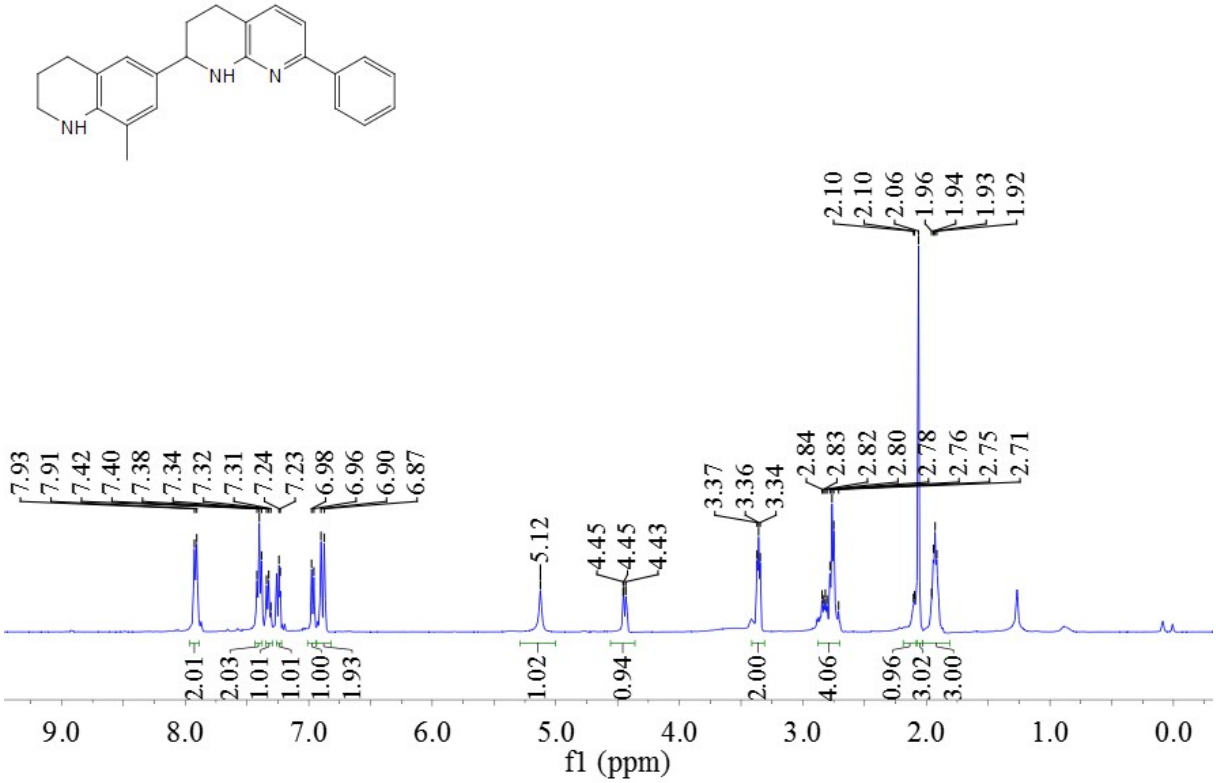


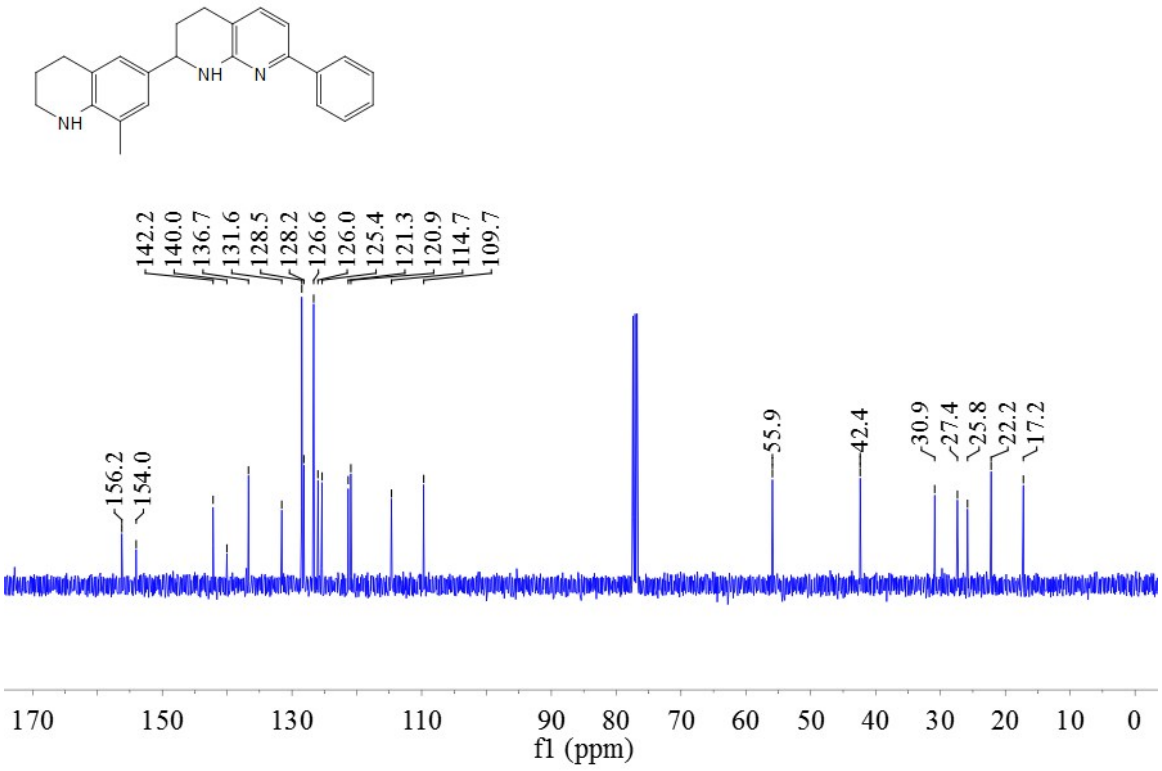
NMR spectra of 2-(7-(8-methoxy-1,2,3,4-tetrahydroquinolin-6-yl)-5,6,7,8-tetrahydro-1,8-naphthyridin-2-yl)phenol (3ed)



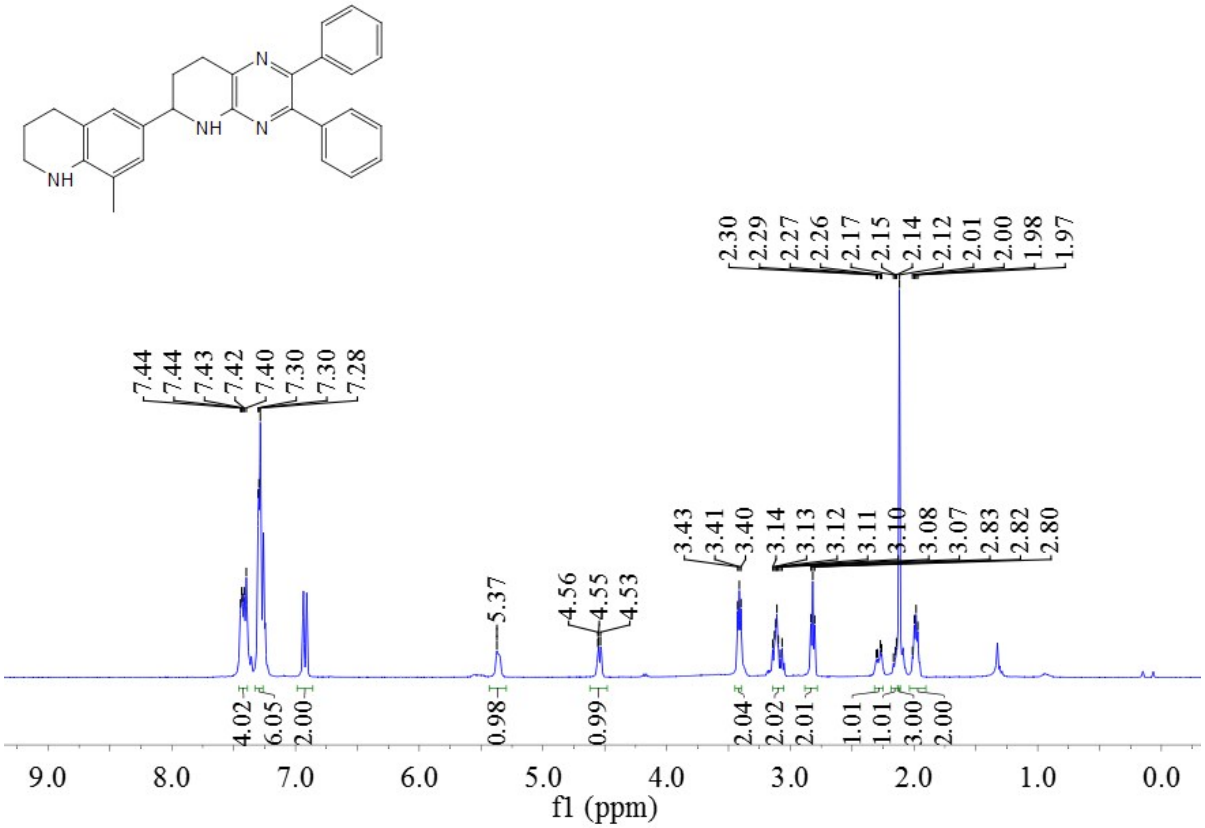


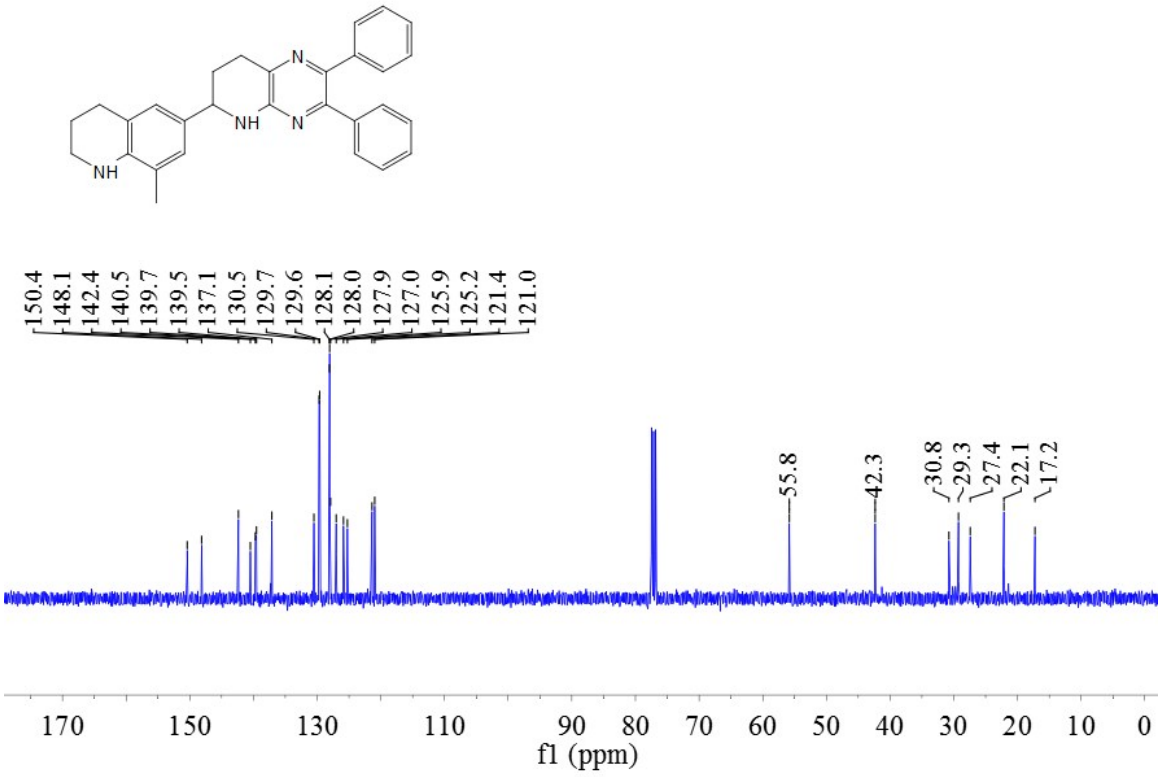
NMR spectra of 2-(8-methyl-1,2,3,4-tetrahydroquinolin-6-yl)-7-phenyl-1,2,3,4-tetrahydro-1,8-naphthyridine (3fa)



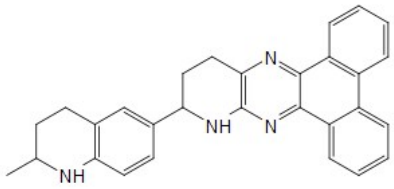


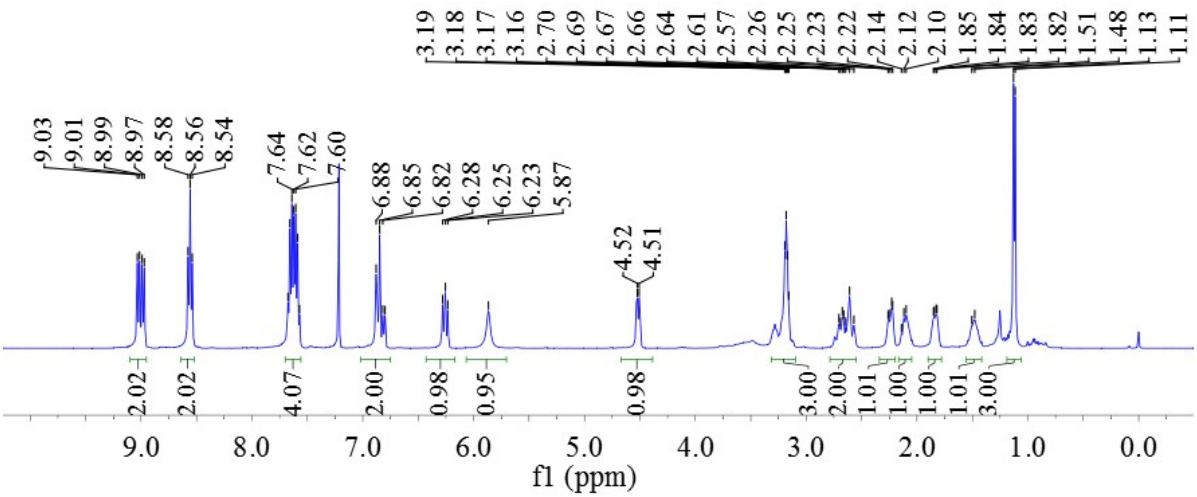
NMR spectra of 6-(8-methyl-1,2,3,4-tetrahydroquinolin-6-yl)-2,3-diphenyl-5,6,7,8-tetrahydropyrido[2,3-b]pyrazine (3fu)

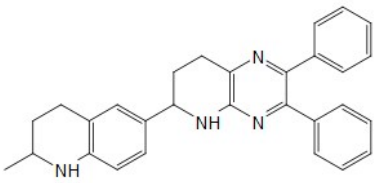


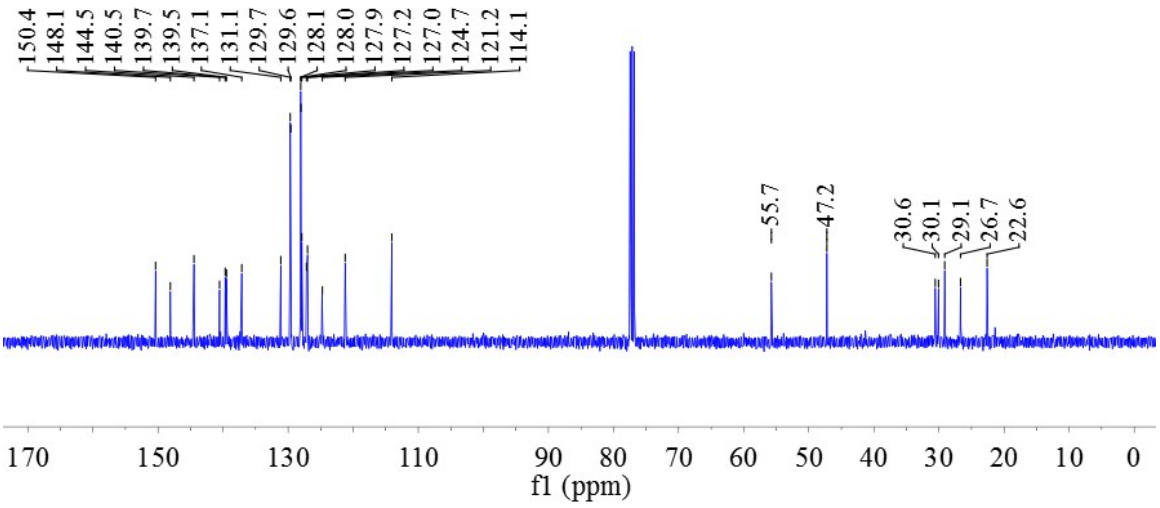


NMR spectra of 11-(2-methyl-1,2,3,4-tetrahydroquinolin-6-yl)-10,11,12,13-tetrahydrodibenzo[f,h]pyrido[2,3-b]quinoxaline (3bt)

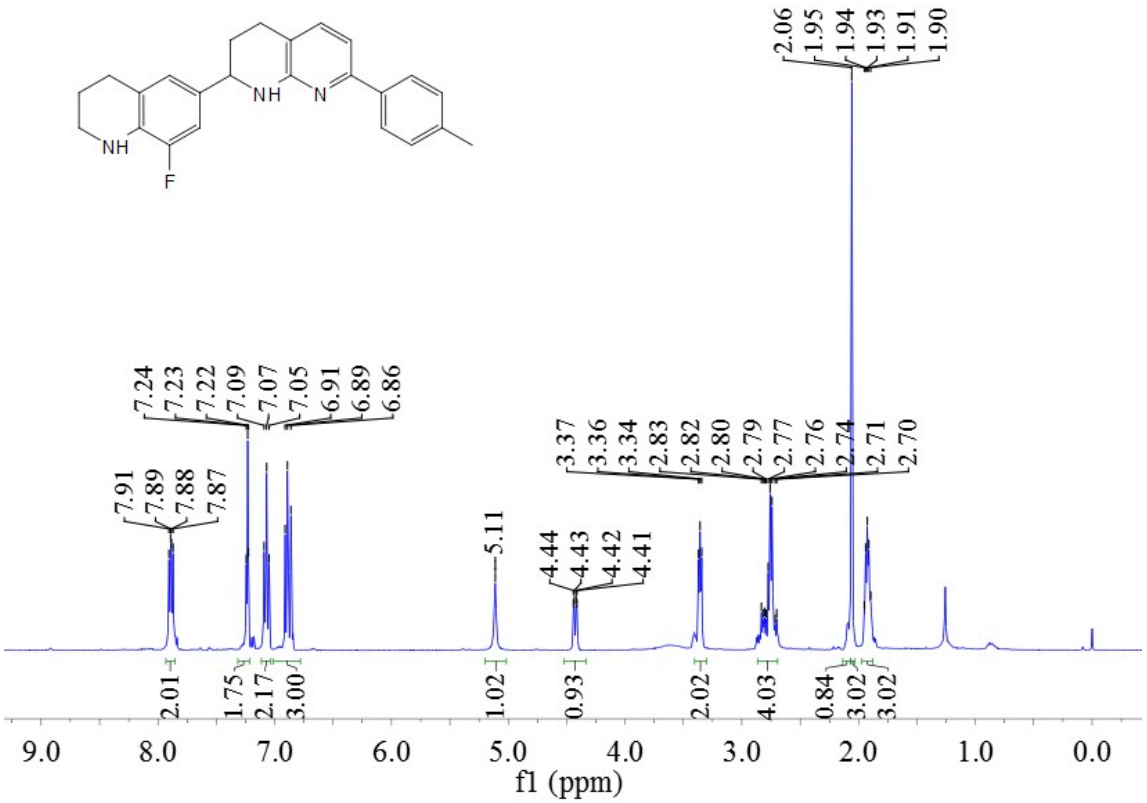


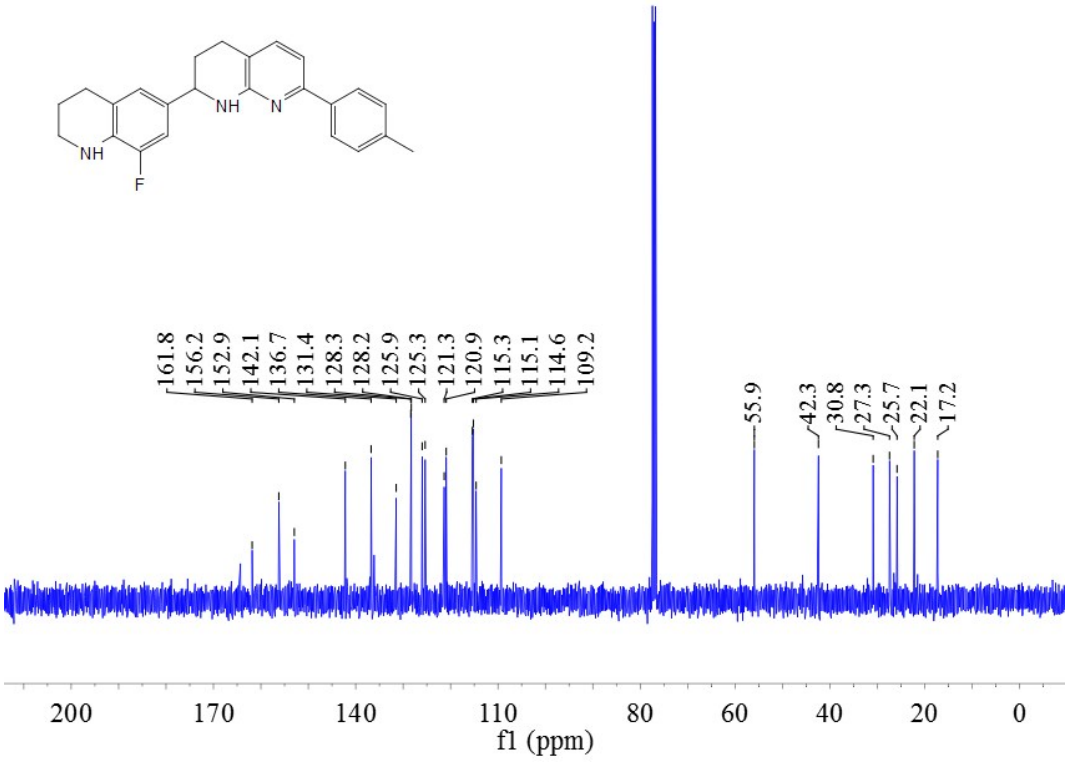


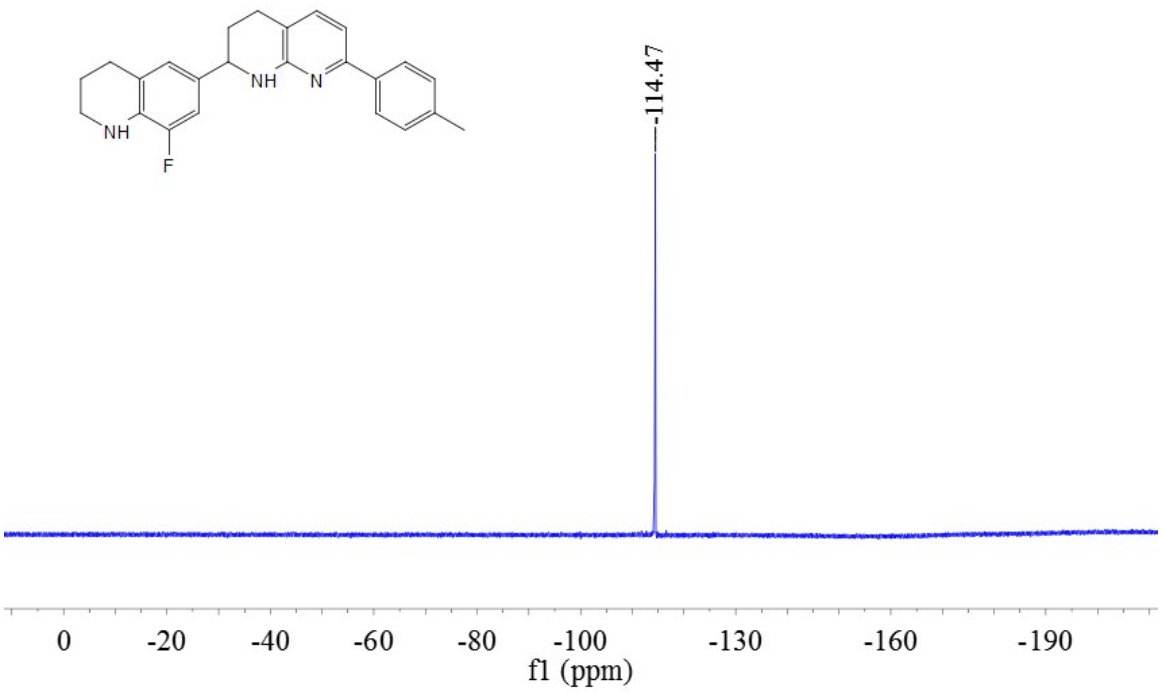




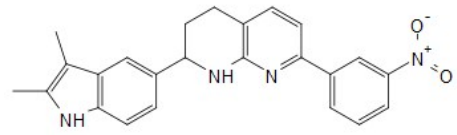
NMR spectra of 2-(8-fluoro-1,2,3,4-tetrahydroquinolin-6-yl)-7-(p-tolyl)-1,2,3,4-tetrahydro-1,8-naphthyridine (3gb)

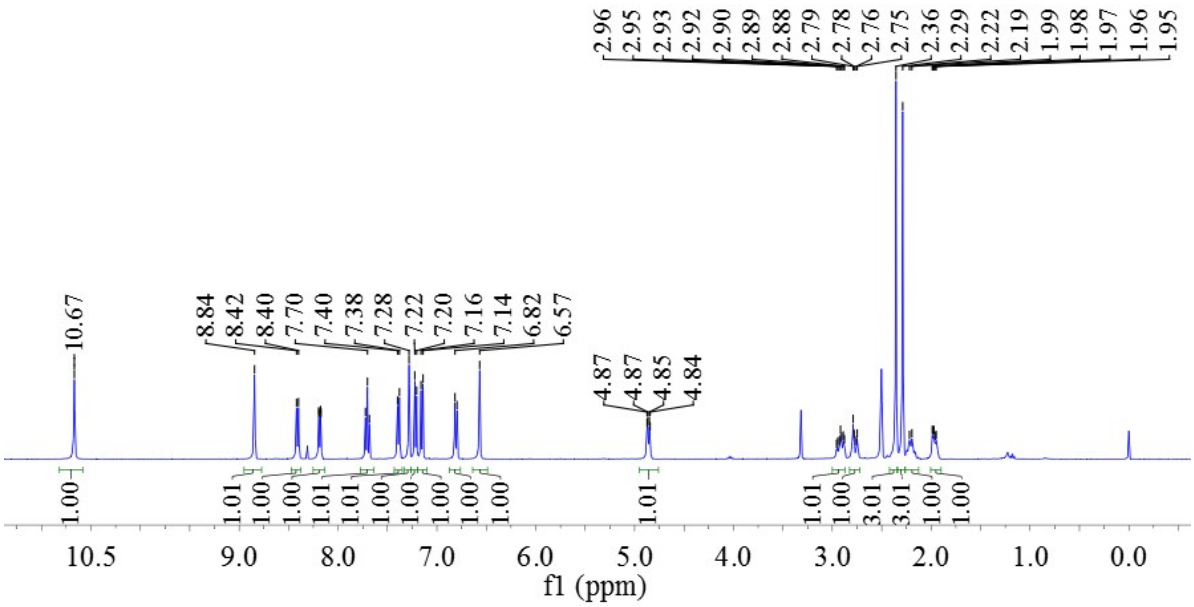


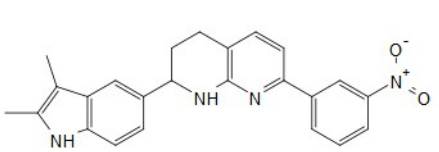



NH
N
NH
F
-114.47
0
-20
-40
-60
-80
-100
-130
-160
-190
f1 (ppm)

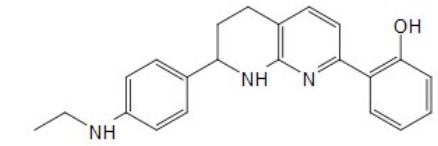
NMR spectra of 2-(2,3-dimethyl-1H-indol-5-yl)-7-(3-nitrophenyl)-1,2,3,4-tetrahydro-1,8-naphthyridine (3hv)

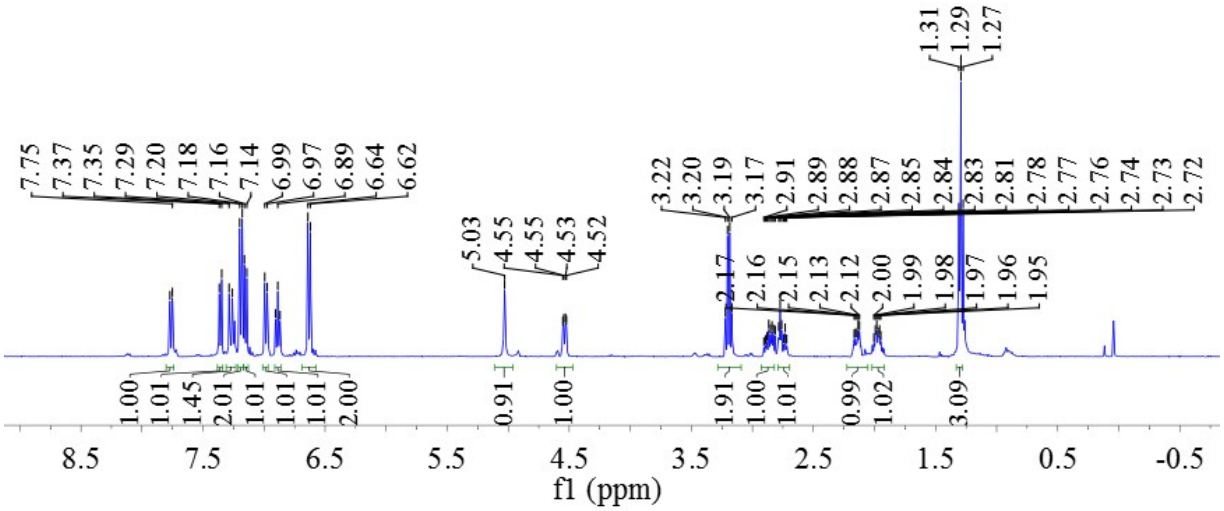


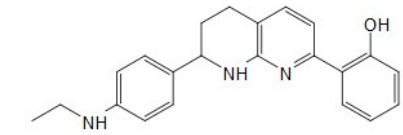


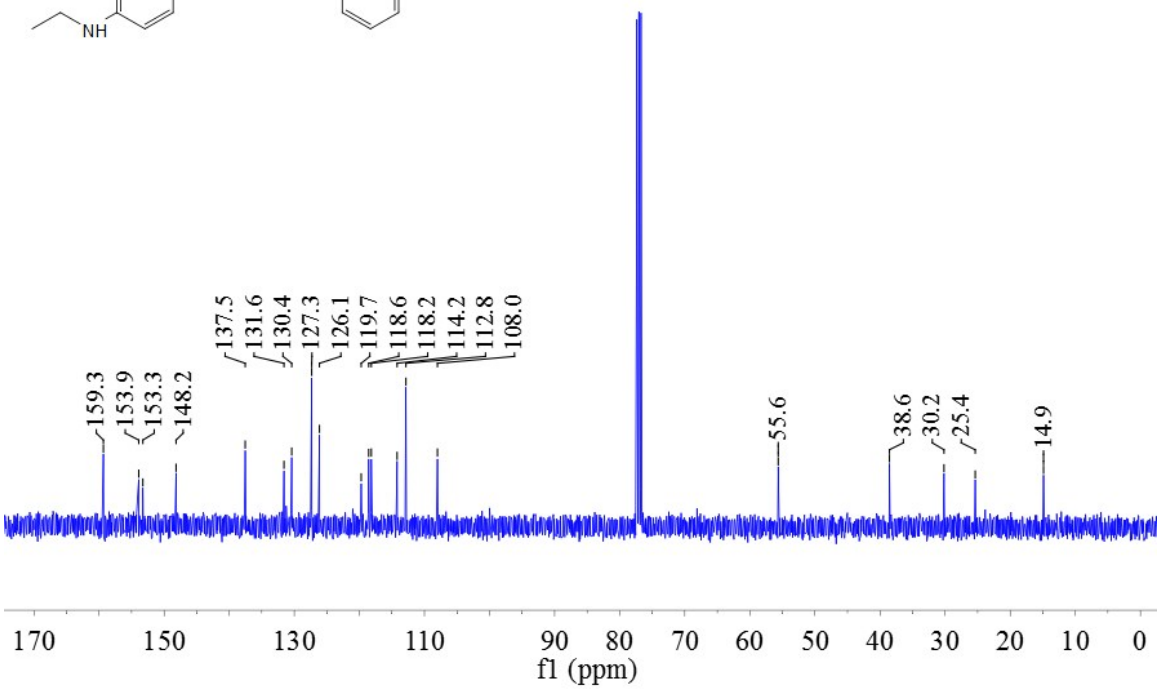


NMR spectra of 2-(7-(4-(ethylamino)phenyl)-5,6,7,8-tetrahydro-1,8-naphthyridin-2-yl)phenol (3id)

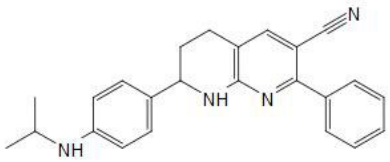


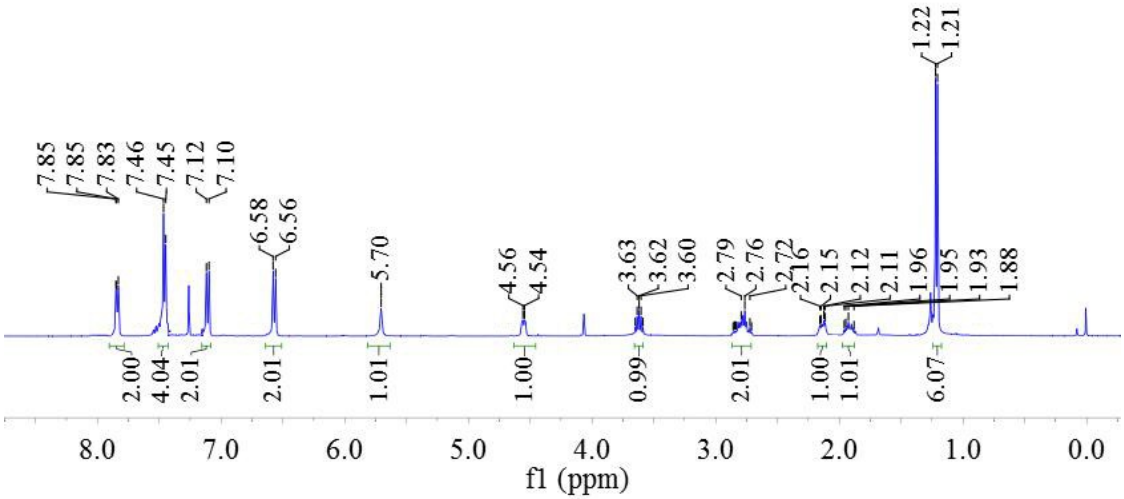


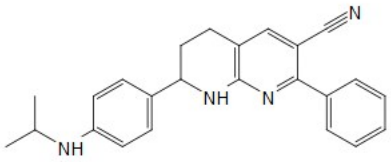


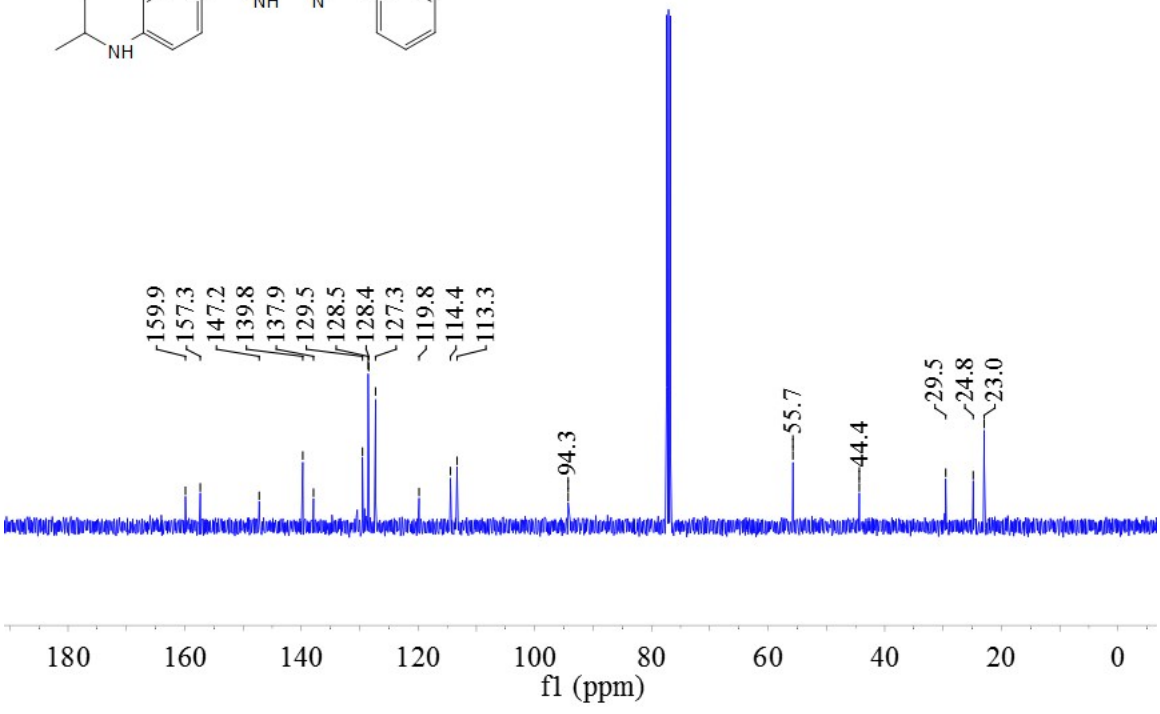


NMR spectra of 7-(4-(isopropylamino)phenyl)-2-phenyl-5,6,7,8-tetrahydro- 1,8-naphthyridine-3-carbonitrile (3jl)

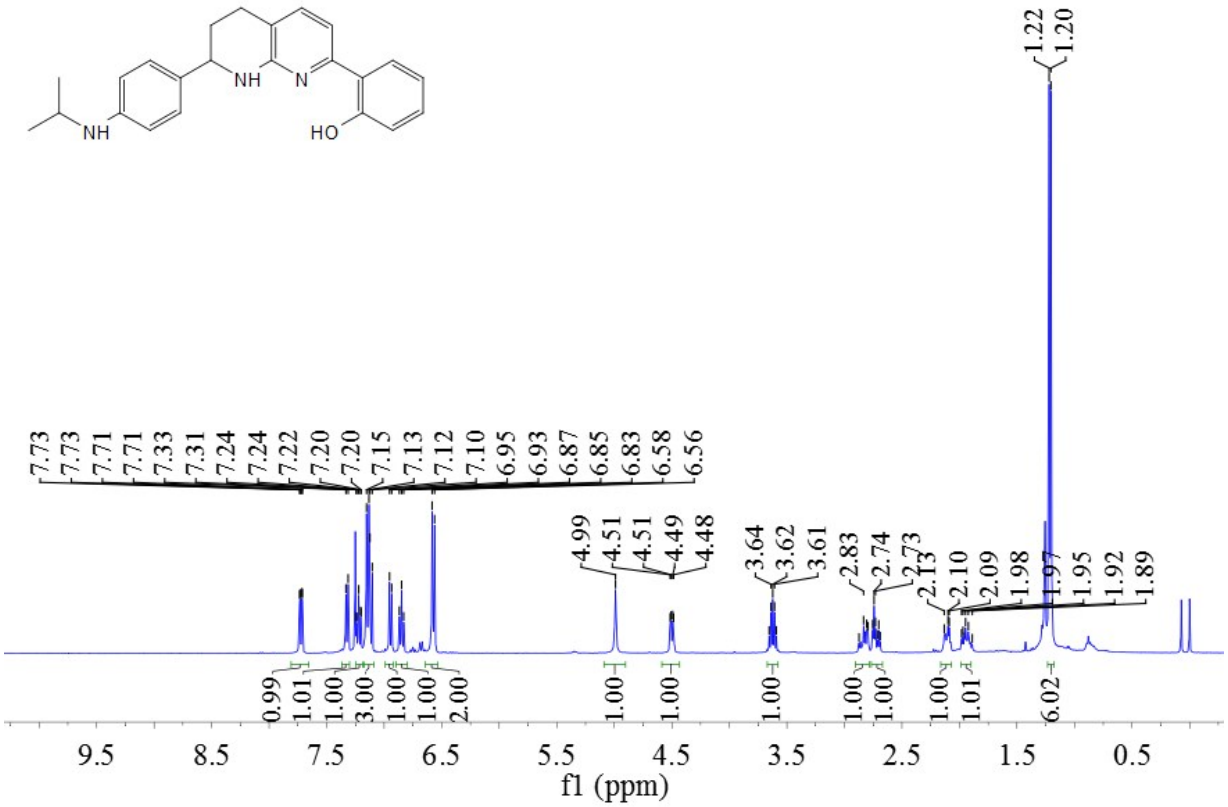


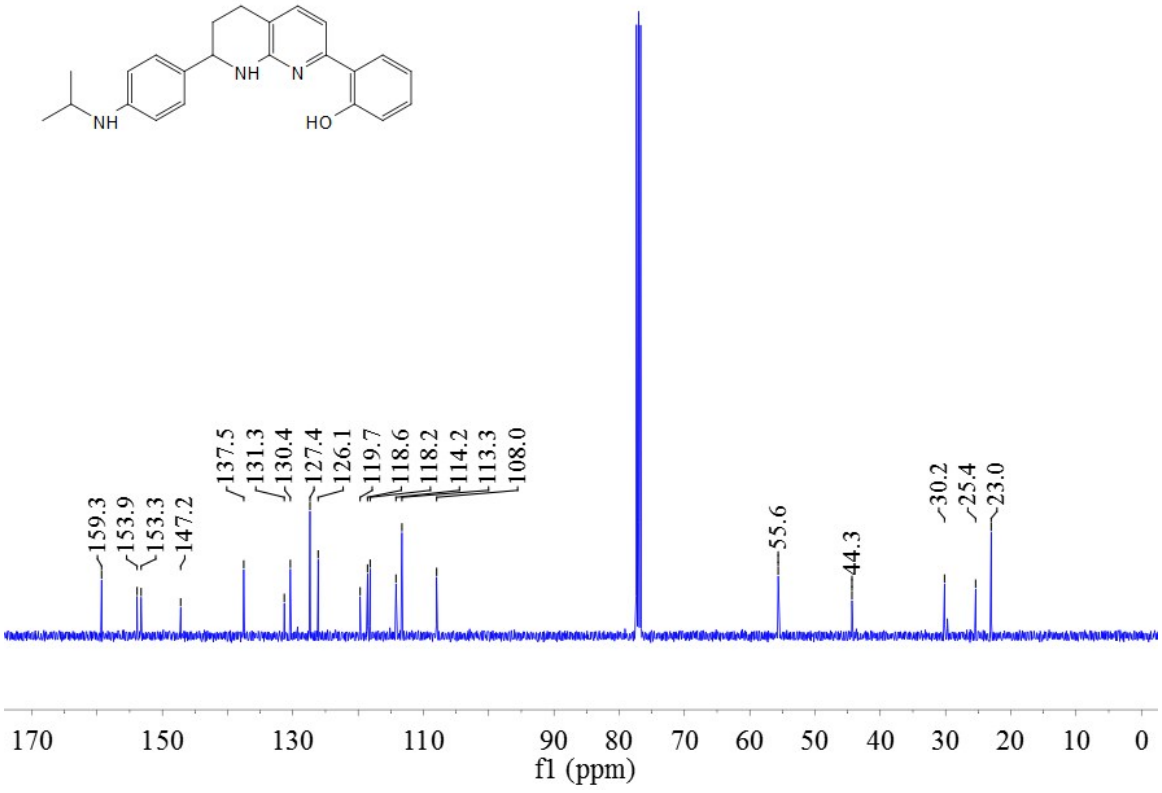




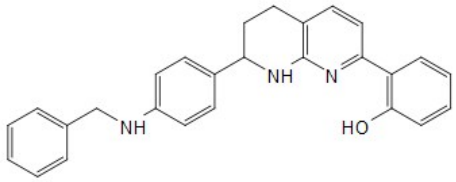


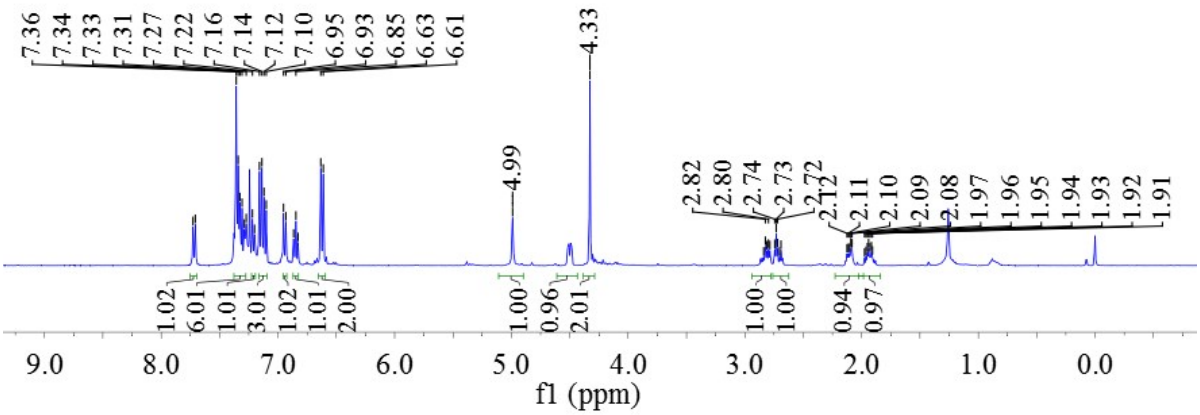
NMR spectra of 2-(7-(4-(isopropylamino)phenyl)-5,6,7,8-tetrahydro-1,8-naphthyridin-2-yl)phenol (3jd)

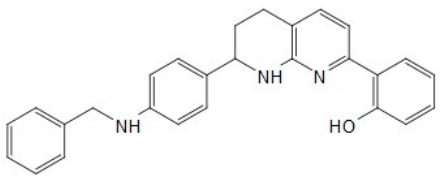




NMR spectra of 2-(7-(4-(benzylamino)phenyl)-5,6,7,8-tetrahydro-1,8-naphthyridin-2-yl)phenol (3kd)







NMR spectra of 2-(7-(4-aminophenyl)-5,6,7,8-tetrahydro-1,8-naphthyridin- 2-yl)phenol (3kd')