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Visible light-Induced Aerobic C–N bond activation: A Photocatalytic Strategy for the preparation of 2-arylpyridines and 2-arylquinolines

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Content

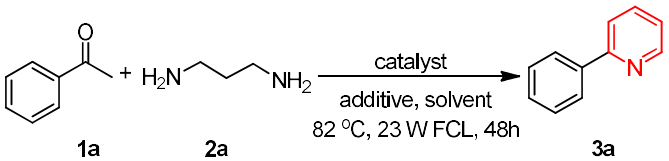
1. General Information

Unless otherwise noted, all reactions were carried out under an atmosphere of O_2 using standard Schlenk techniques. Materials (including various ketones) were purchased from commercial source and were used without further purification. Anhydrous DMF, DMA, NMP, DCE, CH_3CN, DCM were freshly distilled from calcium hydride, ^1H NMR and ^{13}C NMR spectra were recorded on a 400 MHz spectrometer (400 MHz for ^1H and 100 MHz for ^{13}C NMR spectroscopy). The chemical shifts for ^1H NMR were recorded in ppm downfield from the solvent [using $CDCl_3$ (for ^1H, $\delta = 7.26$) resonance as the internal standard. The chemical shifts for ^{13}C NMR were recorded in ppm downfield using the central peak of deuterochloroform (77.00 ppm) as the internal standard. Coupling constants (*J*) are reported in Hz and refer to apparent peak multiplications. HRMS were performed under ESI ionization technique on a Q-TOF Premier Mass Spectrometer. Flash column chromatography was performed on silica gel (300-400 mesh).

2. Typical Procedure for the Synthesis of 2-Phenylpyridine

A mixture of acetophenone (**1a,** 0.5 mmol, c = 0.25 mol/L), 1,3-diaminopropane (**2a,** 1.5 mmol), 4-methylbenzenesulfonic acid (0.5 mmol) and $Ru(bpy)_3Cl_2{\cdot}6H_2O$ (0.01 mmol) in CH_3CN (2 mL) in a sealed 25mL Schlenk tube was irradiated with a 23W household fluorescent lamp at 82°C under oxygen atmosphere for 48h. After the reaction was finished, the reaction mixture was cooled to room temperature. The resulting mixture was concentrated and taken up by dichloromethane (3 x 20 mL). The combined organic phases were dried over anhydrous Na_2SO_4, concentrated under vacuum. And the resulting residue was purified by flash column chromatography on silica gel with EtOAc/petroleum (1/50) to afford the desired product **3a**.

3. Additional data[a]



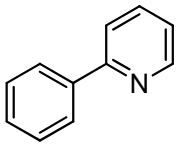
1a **2a** **3a**

entry	catalyst	**2a** (eq.)	additive (eq.)	solvent	yield (%)[b]
1	$Ru(bpy)_3Cl_2$	3	TsOH (0.6)	CH_3CN	37
2	$Ru(bpy)_3Cl_2$	3	TsOH (1)	CH_3CN	52
3	$Ru(bpy)_3Cl_2$	3	TsOH (2)	CH_3CN	39
4	$Ru(bpy)_3Cl_2$	2	TsOH (1)	CH_3CN	32
5	$Ru(bpy)_3Cl_2$	4	TsOH (1)	CH_3CN	40
6	$Ru(bpy)_3Cl_2$	5	TsOH (1)	CH_3CN	36
7	$Ru(bpy)_3Cl_2$	6	TsOH (1)	CH_3CN	35
8	$Ru(bpy)_3Cl_2$	3	TsOH (1)	$MeNO_2$	8
9	$Ru(bpy)_3Cl_2$	3	TsOH (1)	NMP	34
10	$Ru(bpy)_3Cl_2$	3	TsOH (1)	Toluene	32
11	$Ru(bpy)_3Cl_2$	3	TsOH (1)	benzene	27
12	$Ru(bpy)_3Cl_2$	3	TsOH (1)	Dioxane	19
13	$Ru(bpy)_3Cl_2$	3	2-Pyridinesulfonic acid	CH_3CN	51
14	$Ru(bpy)_3Cl_2$	3	2-Naphthalene sulfonic acid	CH_3CN	40
15	$Ru(bpy)_3Cl_2$	3	Methylsulphonicacid	CH_3CN	50
16	$Ru(bpy)_3Cl_2$	3	Benzenesulfonic acid	CH_3CN	48
17	$Ru(bpy)_3Cl_2$	3	Trifluoromethanesulfonic acid	CH_3CN	52
18	$Ru(bpy)_3(PF_6)_2$	3	TsOH (1)	CH_3CN	52
19	$Ir(ppy)_2(dtbpy)PF_6$	3	TsOH (1)	CH_3CN	49
20	*fac*-$Ir(ppy)_3$	3	TsOH (1)	CH_3CN	52
21	$Ir(ppy)_2(bpy)PF_6$	3	TsOH (1)	CH_3CN	33
22	$Ir(tb\text{-}ppy)_2(bpy)PF_6$	3	TsOH (1)	CH_3CN	29
23[c]	$Ru(bpy)_3Cl_2$	3	TsOH (1)	CH_3CN	15
24[d]	$Ru(bpy)_3Cl_2$	3	TsOH (1)	CH_3CN	50

[a] Conditions: **1a** (0.5 mmol), **2a**, $Ru(bpy)_3Cl_2$ (0.01 mmol), additive, solvent (2 mL), O_2 balloon, irradiation with a 23 W household light bulb at about 82 °C for 48 h. [b] GC yield based on dibenzyl ether as an internal standard. [c] 60 °C. [d] 80 °C.

3. Spectra Data of the Products

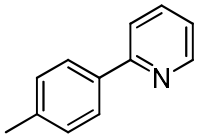
2-Phenylpyridine (3a)[1]



3a

Colorless liquid, 51% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.72 – 8.68 (m, 1H), 8.01 – 7.96 (m, 2H), 7.78 – 7.72 (m, 2H), 7.51 – 7.41 (m, 3H), 7.26 – 7.21 (m, 1H).
^{13}C NMR (100 MHz, $CDCl_3$) δ = 157.1, 149.4, 139.1, 136.5, 128.7, 128.5, 126.6, 121.8, 120.2.

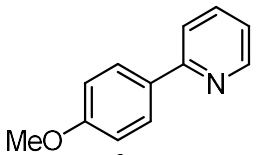
2-(*p*-Tolyl)pyridine (3b)[1]



3b

Pale yellow liquid, 50% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.70 – 8.65 (m, 1H), 7.90 – 7.86 (m, 2H), 7.75 – 7.69 (m, 2H), 7.29 (d, *J* = 8.4 Hz, 2H), 7.22 – 7.19 (m, 1H), 2.41 (s, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 157.4, 149.5, 138.9, 136.6, 136.5, 129.4, 126.7, 121.7, 120.2, 21.20.

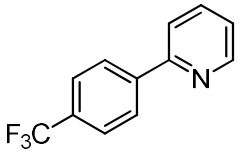
2-(4-Methoxyphenyl)pyridine (3c)[1]



3c

White solid, 48% yield, mp: 51 - 52 ºC. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.66 – 8.64 (m, 1H), 7.97 – 7.93 (m, 2H), 7.73 – 7.64 (m, 2H), 7.19 – 7.15 (m, 1H), 7.02 – 6.98 (m, 2H), 3.86 (s, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 160.4, 157.0, 149.4, 136.6, 131.9, 128.1, 121.3, 119.7, 114.0, 55.3.

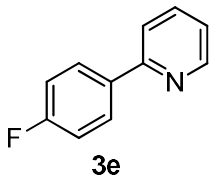
2-(4-(Trifluoromethyl)phenyl)pyridine (3d)[1]



3d

White solid, 14% yield, mp: 71 - 73 ºC. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.75 – 8.72 (m, 1H), 8.11 (d, *J* = 8.0 Hz, 2H), 7.82 – 7.72 (m, 4H), 7.33 – 7.28 (m, 1H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 156.1, 150.2, 142.9, 137.2, 130.9 (q, *J* = 32.2 Hz), 127.4, 125.9, 125.9, 123.2, 121.1.
^{19}F NMR (376 MHz, $CDCl_3$) δ -62.54.

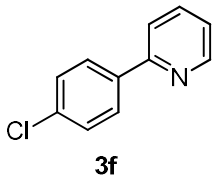
2-(4-Fluorophenyl)pyridine (3e)[1]



3e

White solid, 39% yield, mp: 39 - 41 ºC. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.69 – 8.67 (m, 1H), 8.00 – 7.95 (m, 2H), 7.77 – 7.73 (m, 1H), 7.69 – 7.67 (m, 1H), 7.25 – 7.21 (m, 1H), 7.19 – 7.13 (m, 2H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 164.3 (d, J = 250.0 Hz), 156.4, 149.6, 136.8, 135.5, 128.7 (d, J =8.2 Hz), 122.0, 120.2, 115.7 (d, J = 21.4 Hz).
^{19}F NMR (376 MHz, $CDCl_3$) δ -113.16.

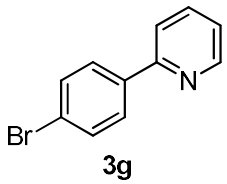
2-(4-Chlorophenyl)pyridine (3f)[1]



3f

Pale yellow solid, 40% yield, mp: 50 - 52 ºC. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.69 – 8.67 (m, 1H), 7.96 – 7.91 (m, 2H), 7.77 – 7.68 (m, 2H), 7.47 – 7.42 (m, 2H), 7.26 – 7.22 (m, 1H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 156.1, 149.7, 137.7, 136.8, 135.0, 128.9, 128.1, 122.3, 120.3.

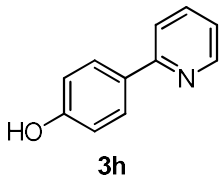
2-(4-Bromophenyl)pyridine (3g)[1]



3g

Pale yellow solid, 44% yield, mp: 60 - 62 ºC. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.70 – 8.68 (m, 1H), 7.90 – 7.85 (m, 2H), 7.78 – 7.69 (m, 2H), 7.62 – 7.58 (m, 2H), 7.24 – 7.27 (m, 1H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 156.1, 149.7, 138.2, 136.8, 131.8, 128.4, 123.4, 122.4, 120.2.

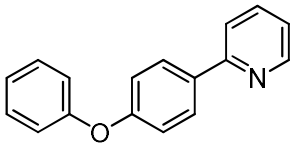
4-(Pyridin-2-yl)phenol (3h)[1]



3h

White solid, 43% yield, mp: 157 - 160 ºC. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.62 – 8.61 (m, 1H), 7.78 – 7.71 (m, 3H), 7.65 – 7.63 (m, 1H), 7.26 – 7.19 (m, 1H), 6.80 – 6.75 (m, 2H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 158.1, 157.6, 148.7, 137.5, 130.3, 128.6, 121.5, 120.9, 116.0.

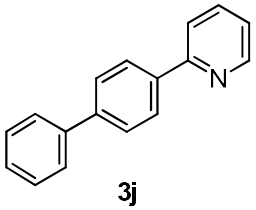
2-(4-Phenoxyphenyl)pyridine (3i)[9]



3i

White solid, 51% yield, mp: 52 - 53 ºC. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.69 – 8.67 (m, 1H), 7.99 – 7.95 (m, 2H), 7.77 – 7.66 (m, 2H), 7.40 – 7.33 (m, 2H), 7.21 – 7.19 (m, 1H), 7.16 – 7.06 (m, 5H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 158.2, 156.7, 149.6, 136.7, 134.3, 129.8, 128.3, 123.5, 121.7, 120.0, 119.1, 118.7.

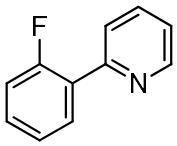
2-([1,1'-Biphenyl]-4-yl)pyridine (3j)[1]



3j

White solid, 47% yield, mp: 137 - 138 ºC. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.73 – 8.70 (m, 1H), 8.10 – 8.07 (m, 2H), 7.79 – 7.76 (m, 2H), 7.74 – 7.71 (m, 2H), 7.68 – 7.65 (m, 2H), 7.49 – 7.44 (m, 2H), 7.40 – 7.35 (m, 1H), 7.26 – 7.23 (m, 1H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 156.9, 149.6, 141.6, 140.5, 138.2, 136.9, 128.8, 127.4, 127.4, 127.2, 127.0, 122.0, 120.4.

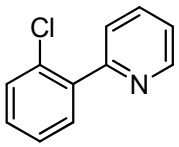
2-(2-Fluorophenyl)pyridine (3k)[10]



3k

Pale yellow liquid, 28% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.75 – 8.72 (m, 1H), 7.99 – 7.95 (m, 1H), 7.83 – 7.73 (m, 2H), 7.41 – 7.36 (m, 1H), 7.31 – 7.24 (m, 2H), 7.19 – 7.14 (m, 1H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 161.4 (d, J = 247.9 Hz), 153.3, 149.7, 136.3, 130.9, 130.4 (d, J = 8.4 Hz), 127.4 (d, J = 11.6 Hz), 124.5, 124.4, 122.3, 116.1 (d, J = 22.8 Hz).
^{19}F NMR (376 MHz, $CDCl_3$) δ -117.49.

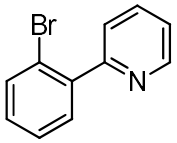
2-(2-Chlorophenyl)pyridine(3l)[11]



3l

Pale yellow liquid, 22% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.74 – 8.72 (m, 1H), 7.79 – 7.74 (m, 1H), 7.66 – 7.64 (m, 1H), 7.62 – 7.58 (m, 1H), 7.49 – 7.46 (m, 1H), 7.39 – 7.28 (m, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 156.8, 149.5, 139.1, 135.8, 132.0, 131.4, 130.0, 129.5, 126.9, 124.8, 122.3.

2-(2-Bromophenyl)pyridine (3m)[11]

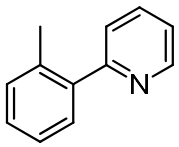


3m

Pale yellow liquid, 18% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.73 – 8.71 (m, 1H), 7.79 – 7.74 (m, 1H), 7.69 – 7.66 (m, 1H), 7.62 – 7.59 (m, 1H), 7.55 – 7.52 (m, 1H), 7.43 – 7.39 (m, 1H), 7.32 – 7.27 (m, 1H), 7.26 – 7.23 (m, 1H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 158.2, 149.3, 141.1, 135.8, 133.2, 131.3, 129.6, 127.5, 124.7, 122.4, 121.7.

2-(*o*-Tolyl)pyridine (3n)[1]

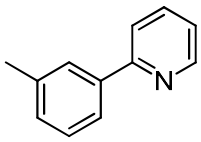


3n

Pale yellow liquid, 41% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.74 – 8.64 (m, 1H), 7.78 – 7.73 (m, 1H), 7.44 – 7.36 (m, 2H), 7.33 – 7.23 (m, 4H), 2.36 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 159.9, 149.0, 140.2, 136.2, 135.7, 130.6, 129.5, 128.2, 125.8, 124.1, 121.6, 20.2.

2-(*m*-Tolyl)pyridine (3o)[3]

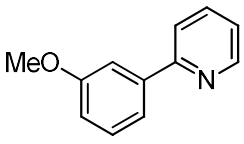


3o

Pale yellow liquid, 36% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.69 (d, J = 4.8 Hz, 1H), 7.84 (s, 1H), 7.77 – 7.70 (m, 3H), 7.37 (t, J = 7.6 Hz, 1H), 7.26 – 7.21 (m, 2H), 2.44 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 157.8, 149.8, 139.6, 138.6, 137.0, 130.0, 128.9, 127.9, 124.2, 122.3, 120.9, 21.8.

2-(3-Methoxyphenyl)pyridine (3p)[1]

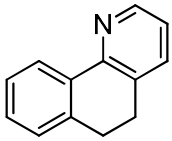


3p

Pale yellow liquid, 40% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.71 – 8.69 (m, 1H), 7.78 – 7.70 (m, 2H), 7.59 – 7.51 (m, 2H), 7.39 (t, J = 8.0 Hz, 1H), 7.26 – 7.23 (m, 1H), 6.99 – 6.96 (m, 1H), 3.90 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 160.0, 157.2, 149.5, 140.8, 136.7, 129.7, 122.2, 120.7, 119.2, 115.0, 112.0, 55.3.

5,6-Dihydrobenzo[h]quinoline (3q)[8]

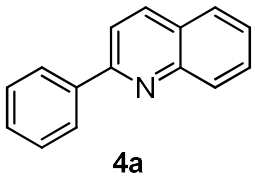


3q

Yellow liquid, 57% yield.^{1}H NMR (400 MHz, $CDCl_3$) δ 8.54 (dd, *J* = 4.8, 1.6 Hz, 1H), 8.31 (dd, *J* = 7.6, 1.6 Hz, 1H), 7.50 (dd, *J* = 7.6, 1.6 Hz, 1H), 7.39 – 7.29 (m, 2H), 7.24 – 7.22 (m, 1H), 7.13 (dd, *J* = 7.6, 4.8 Hz, 1H), 2.94 (s, 4H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 152.4, 147.6, 138.0, 135.5, 134.4, 131.8, 129.0, 127.7, 127.1, 124.9, 122.1, 28.0, 27.9.

2-Phenylquinoline (4a)[2]

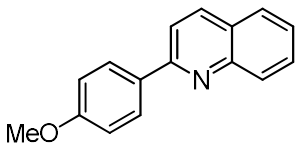


4a

White solid, 65% yield, mp: 77 - 78 ºC. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.26 – 8.13 (m, 4H), 7.89 (d, *J* = 8.4 Hz, 1H), 7.84 (dd, *J* = 8.4, 1.2 Hz, 1H), 7.76 – 7.72 (m, 1H), 7.56 – 7.45 (m, 4H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 157.2, 148.2, 139.5, 136.6, 129.6, 129.5, 129.2, 128.7, 127.4, 127.4, 127.0, 126.1, 118.8.

2-(4-Methoxyphenyl)quinoline (4b)[2]

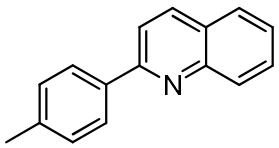


4b

Pale yellow solid, 73% yield, mp: 118 - 119 ºC. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.20 – 8.10 (m, 4H), 7.85 – 7.79 (m, 2H), 7.73 – 7.69 (m, 1H), 7.52 – 7.48 (m, 1H), 7.08 – 7.02 (m, 2H), 3.89 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 160.7, 156.8, 148.2, 136.6, 132.1, 129.5, 129.4, 128.8, 127.4, 126.8, 125.8, 118.5, 114.1, 55.3.

2-(*p*-Tolyl)quinoline (4c)[2]

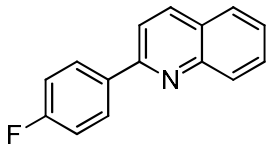


4c

White solid, 59% yield, mp: 79 - 80 ºC. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.20 (d, *J* = 8.6 Hz, 1H), 8.17 (d, *J* = 8.5 Hz, 1H), 8.08 (d, *J* = 8.1 Hz, 2H), 7.87 (d, *J* = 8.6 Hz, 1H), 7.82 (d, *J* = 8.1 Hz, 1H), 7.75 – 7.69 (m, 1H), 7.51 (dd, *J* = 11.0, 4.0 Hz, 1H), 7.34 (d, *J* = 7.9 Hz, 2H), 2.44 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 157.1, 148.2, 139.2, 136.7, 136.5, 129.5, 129.4, 127.3, 127.0, 125.9, 118.7, 21.2.

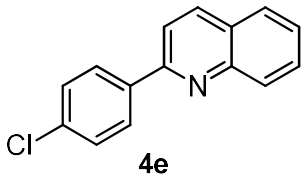
2-(4-Fluorophenyl)quinoline (4d)[2]



4d

White solid, 90% yield, mp: 90 - 91 ºC. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.22 (d, *J* = 8.4 Hz, 1H), 8.19 – 8.12 (m, 3H), 7.86 – 7.81 (m, 2H), 7.72 – 7.76 (m, 1H), 7.56 – 7.52 (m, 1H), 7.25 – 7.18 (m, 2H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 163.7 (d, *J* = 247.4 Hz), 156.1, 148.1, 136.8, 135.7 (d, *J* = 3.0 Hz), 129.7, 129.5, 129.4, 129.3, 127.4, 127.0, 126.2, 118.5, 115.7 (d, *J* = 21.5 Hz).
^{19}F NMR (376 MHz, $CDCl_3$) δ -113.16.

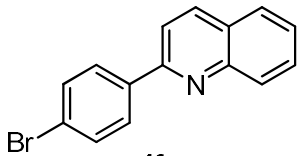
2-(4-Chlorophenyl)quinoline (4e)[2]



4e

White solid, 60% yield, mp: 109 - 110 ºC. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.24 (d, *J* = 8.4 Hz, 1H), 8.19 – 8.10 (m, 3H), 7.86 – 7.83 (m, 2H), 7.76 – 7.72 (m, 1H), 7.58 – 7.46 (m, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 155.8, 148.1, 137.9, 136.8, 135.4, 129.7, 129.6, 128.9, 128.7, 127.4, 127.1, 126.4, 118.4.

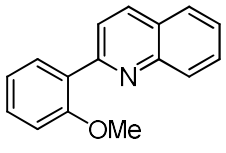
2-(4-Bromophenyl)quinoline (4f)[2]



4f

White solid, 62% yield, mp: 113 - 115 ºC. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.24 (d, *J* = 8.4 Hz, 1H), 8.16 (d, *J* = 8.4 Hz, 1H), 8.09 – 8.04 (m, 2H), 7.86 – 7.83 (m, 2H), 7.76 – 7.72 (m, 1H), 7.69 – 7.63 (m, 2H), 7.58 – 7.52 (m, 1H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 155.8, 148.1, 138.3, 136.8, 131.8, 129.7, 129.6, 128.9, 127.4, 127.1, 126.4, 123.8, 118.3.

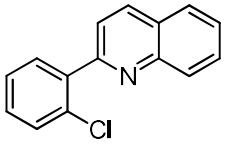
2-(2-Methoxyphenyl)quinoline (4g)[2]



4g

Yellow liquid, 70% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.20 – 8.13 (m, 2H), 7.91 – 7.80 (m, 3H), 7.73 – 7.69 (m, 1H), 7.55 – 7.51 (m, 1H), 7.45 – 7.41 (m, 1H), 7.6 – 7.12(m, 1H), 7.04 (d, *J* = 8.4 Hz, 1H), 3.87 (s, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 157.0, 156.9, 148.1, 134.9, 131.3, 130.2, 129.5, 129.37, 129.1, 127.2, 126.8, 126.0, 123.3, 121.1, 111.2, 55.4.

2-(2-Chlorophenyl)quinoline (4h)[5]

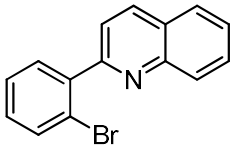


4h

White solid, 65% yield, mp: 74 - 75 ºC. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.22 (d, *J* = 8.4 Hz, 1H), 8.18 (d, *J* = 8.4 Hz, 1H), 7.88 (dd, *J* = 8.0, 1.2 Hz, 1H), 7.79 – 7.72 (m, 2H), 7.72 – 7.68 (m, 1H), 7.60 – 7.56 (m, 1H), 7.54 – 7.49 (m, 1H), 7.44 – 7.36 (m, 2H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 157.2, 147.9, 139.5, 135.5, 132.2, 131.6, 130.0, 129.8, 129.6, 129.5, 127.4, 127.0, 127.0, 126.6, 122.6.

2-(2-Bromophenyl)quinoline (4i)[6]

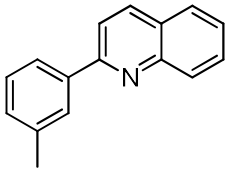


4i

White solid, 49% yield, mp: 67 - 69 ºC. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.23 (d, *J* = 8.4 Hz, 1H), 8.20 – 8.16 (m, 1H), 7.88 (dd, *J* = 8.4, 1.2 Hz, 1H), 7.78 – 7.74 (m, 1H), 7.73 – 7.68 (m, 2H), 7.64 (dd, *J* = 7.6, 2.0 Hz, 1H), 7.61 – 7.57 (m, 1H), 7.48 – 7.44 (m, 1H), 7.33 – 7.28 (m, 1H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 158.6, 147.8, 141.5, 135.5, 133.1, 131.4, 129.9, 129.6, 129.5, 127.6, 127.4, 127.0, 126.7, 122.6, 121.7.

2-(*m*-Tolyl)quinoline (4j)[4]

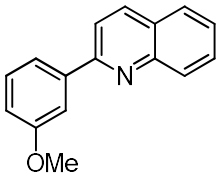


4j

White solid, 75% yield, mp: 41 - 42 ºC. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.22 (d, *J* = 8.4 Hz, 1H), 8.20 – 8.17 (m, 1H), 8.01 (s, 1H), 7.92 (d, *J* = 7.6 Hz, 1H), 7.87 (d, *J* = 8.4 Hz, 1H), 7.83 (dd, *J* = 8.0, 1.2 Hz, 1H), 7.75 – 7.71 (m 1H), 7.55 – 7.51 (m, 1H), 7.42 (t, *J* = 7.6 Hz, 1H), 7.30 – 7.28 (m, 1H), 2.49 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 157.4, 148.1, 139.5, 138.3, 136.6, 133.7, 130.0, 129.5, 129.5, 128.6, 128.1, 127.3, 127.0, 126.0, 124.6, 119.0, 21.5.

2-(3-Methoxyphenyl)quinoline (4k)[2]

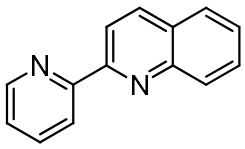


4k

Brown liquid, 78% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.24 – 8.16 (m, 2H), 7.87 (d, *J* = 8.4 Hz, 1H), 7.83 (dd, *J* = 8.0, 1.2 Hz, 1H), 7.79 – 7.69 (m, 3H), 7.55 – 7.51 (m, 1H), 7.48 – 7.41 (m, 1H), 7.04 – 7.01 (m, 1H), 3.94 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 159.9, 156.8, 148.0, 140.9, 136.6, 129.6, 129.5, 129.4, 127.3, 127.0, 126.1, 119.8, 118.9, 115.2, 112.5, 55.2.

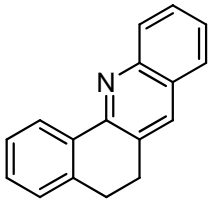
2-(Pyridin-2-yl)quinoline (4l)[6]



4l

Yellow solid, 77% yield, mp: 92 - 93 ºC.^{1}H NMR (400 MHz, $CDCl_3$) δ 8.76 – 8.74 (m, 1H), 8.67 – 8.65 (m, 1H), 8.56 (d, *J* = 8.4 Hz, 1H), 8.29 (d, *J* = 8.4 Hz, 1H), 8.20 – 8.17 (m, 1H), 7.91 – 7.85 (m, 2H), 7.76 – 7.72 m, 1H), 7.58 – 7.53 (m, 1H), 7.39 – 7.33 (m, 1H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 156.2, 156.1, 149.1, 147.8, 136.8, 136.7, 129.7, 129.5, 128.2, 127.5, 126.7, 123.9, 121.8, 118.9.

5,6-Dihydrobenzo[c]acridine (4m)[7]



4m

Yellow solid, 76% yield, mp: 54 - 57 ºC. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.62 – 8.57 (m, 1H), 8.15 (d, *J* = 8.4 Hz, 1H), 7.92 (s, 1H), 7.79 – 7.71 (m, 1H), 7.66 – 7.64 (m, 1H), 7.50 – 7.36 (m, 3H), 7.28 (dd, *J* = 7.2, 0.8 Hz, 1H), 3.15 – 3.10 (m, 2H), 3.03 – 3.00 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 153.2, 147.4, 139.2, 134.5, 133.5, 130.4, 129.5, 129.2, 128.5, 127.8, 127.7, 127.2, 126.8, 125.9, 28.6, 28.2.

4. Reference:

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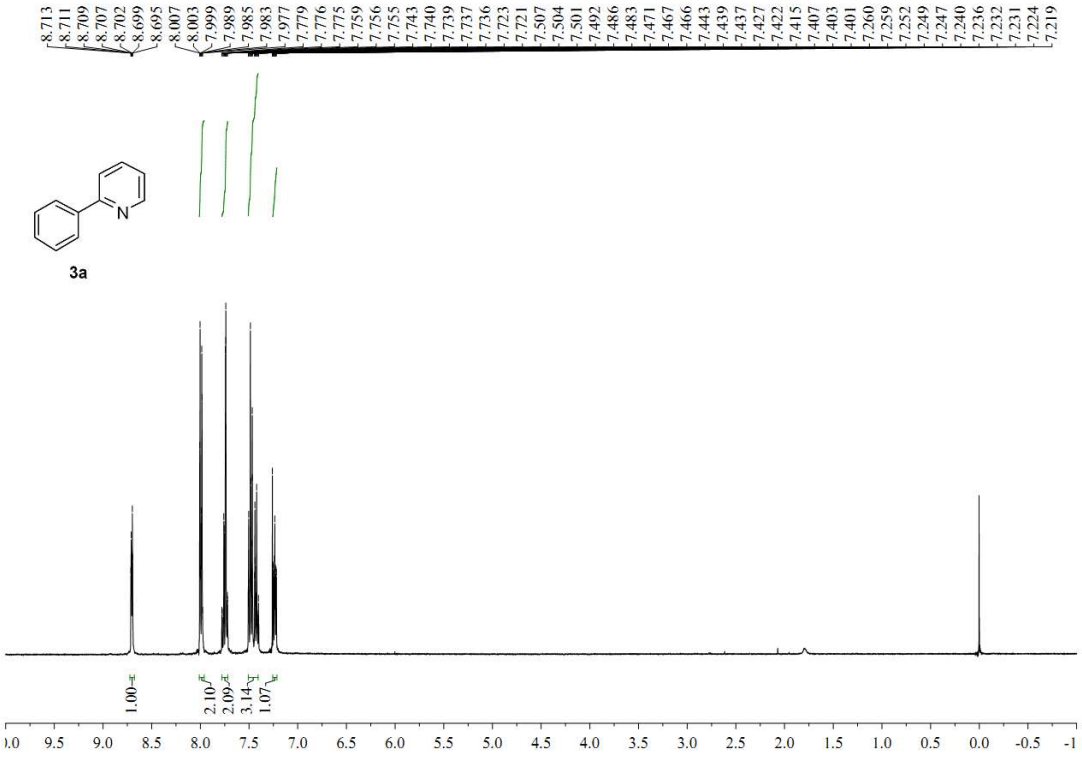
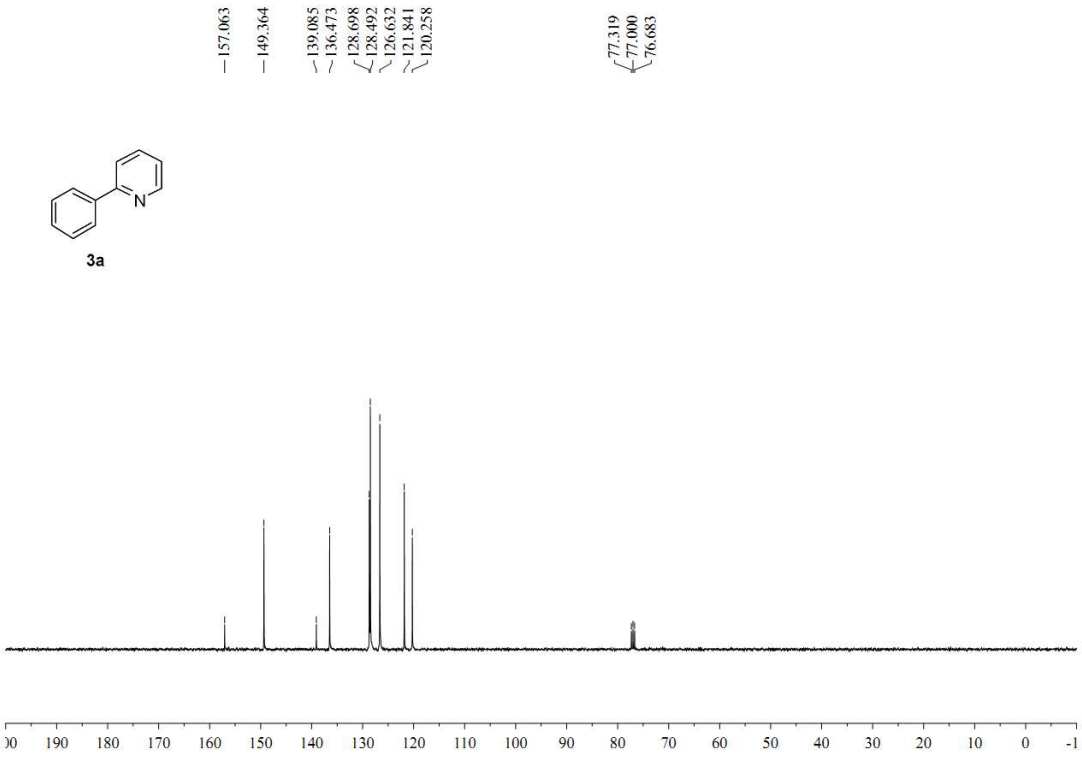
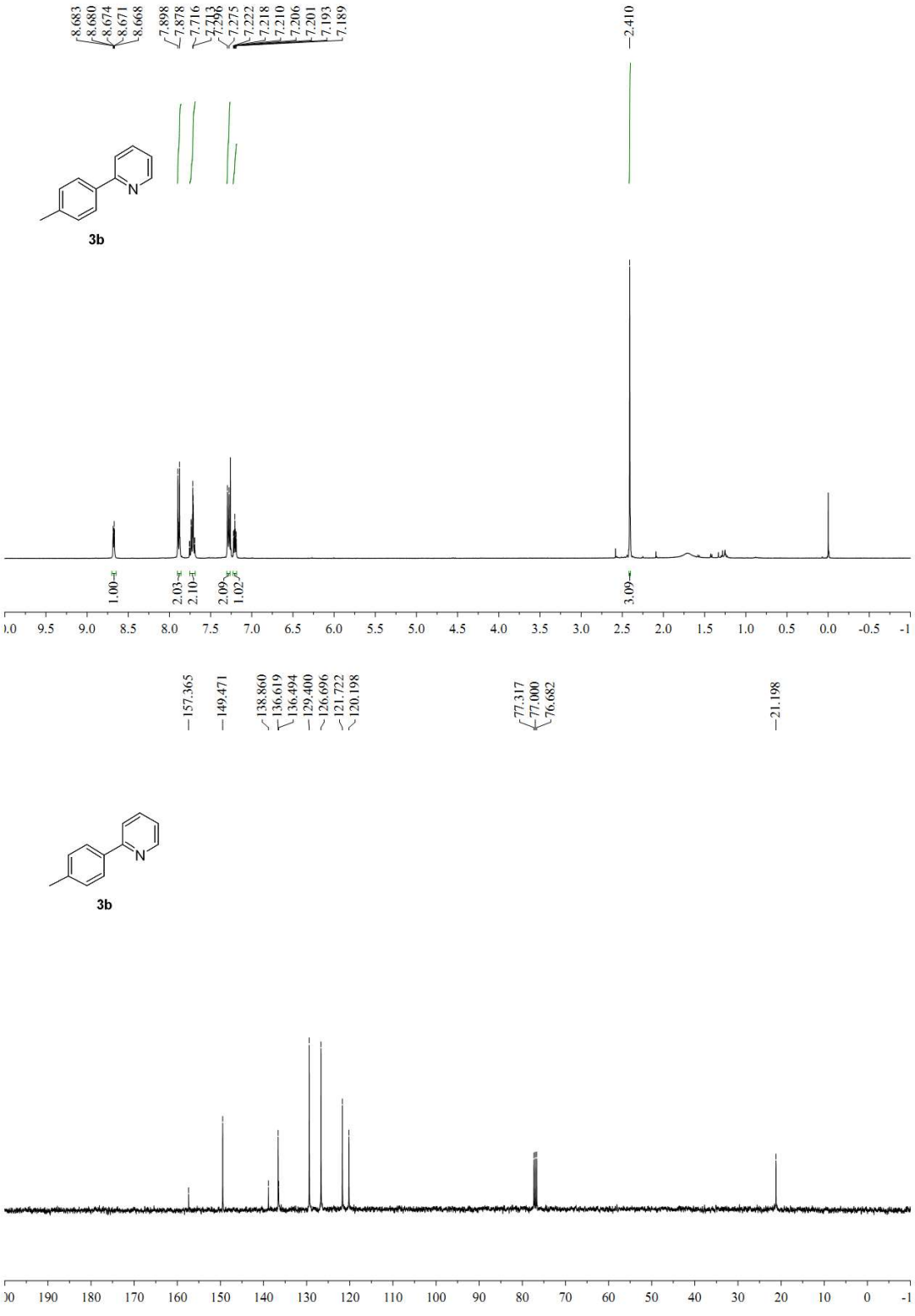
5. NMR spectra of the products

2-Phenylpyridine (3a)

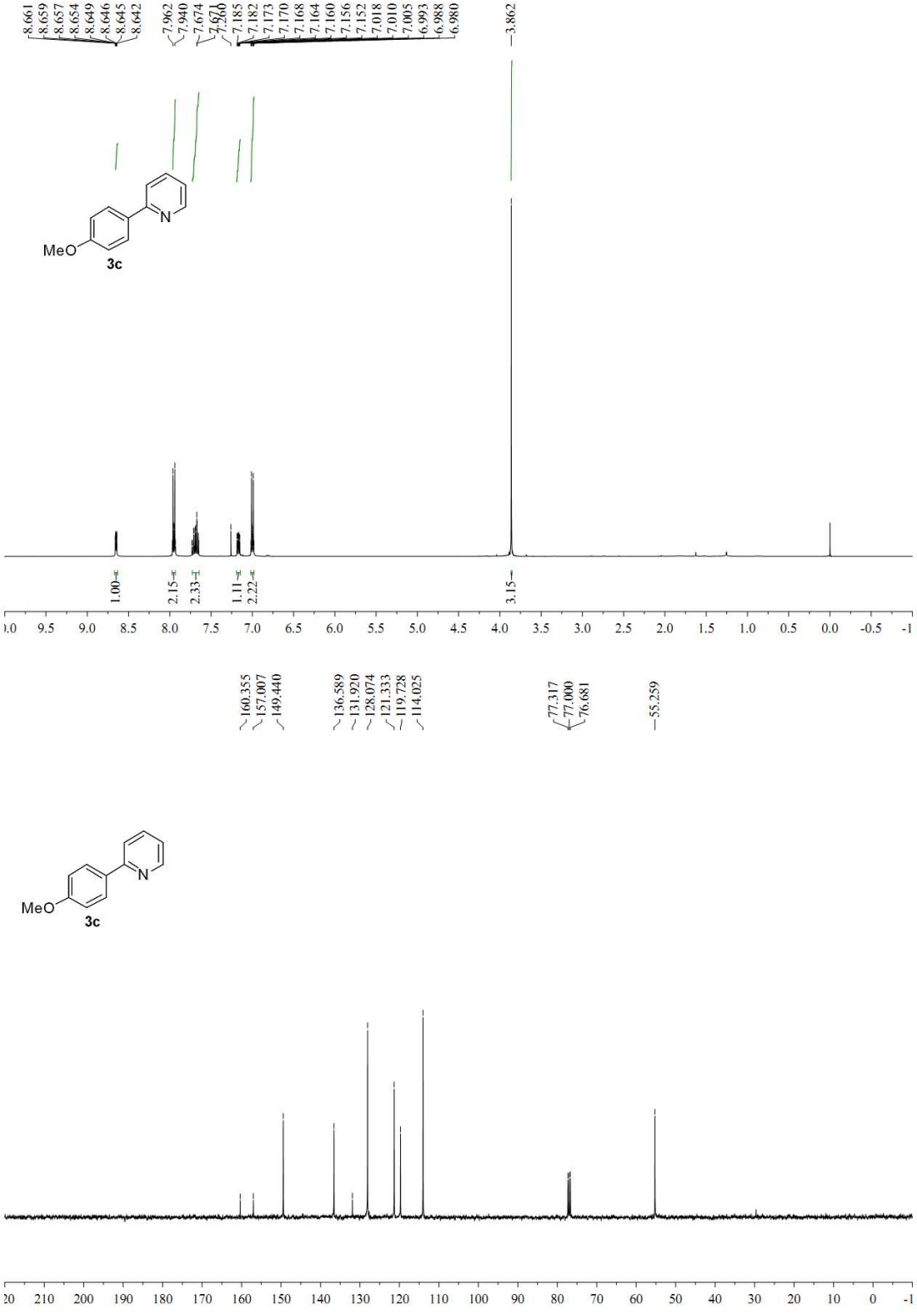




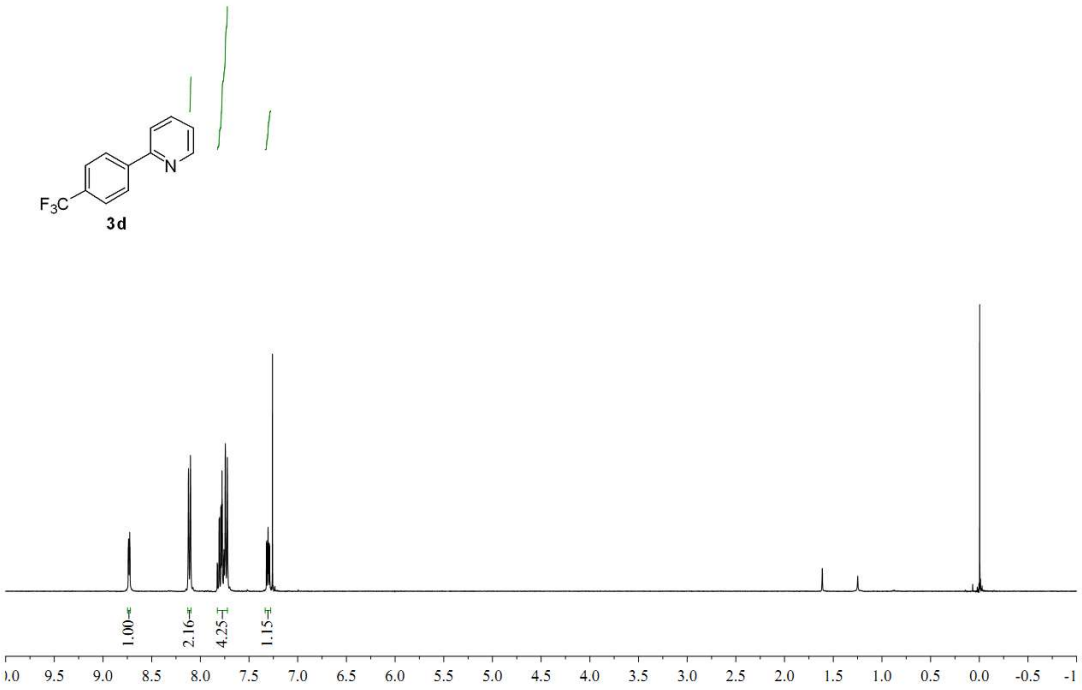
2-(*p*-Tolyl)pyridine (3b)

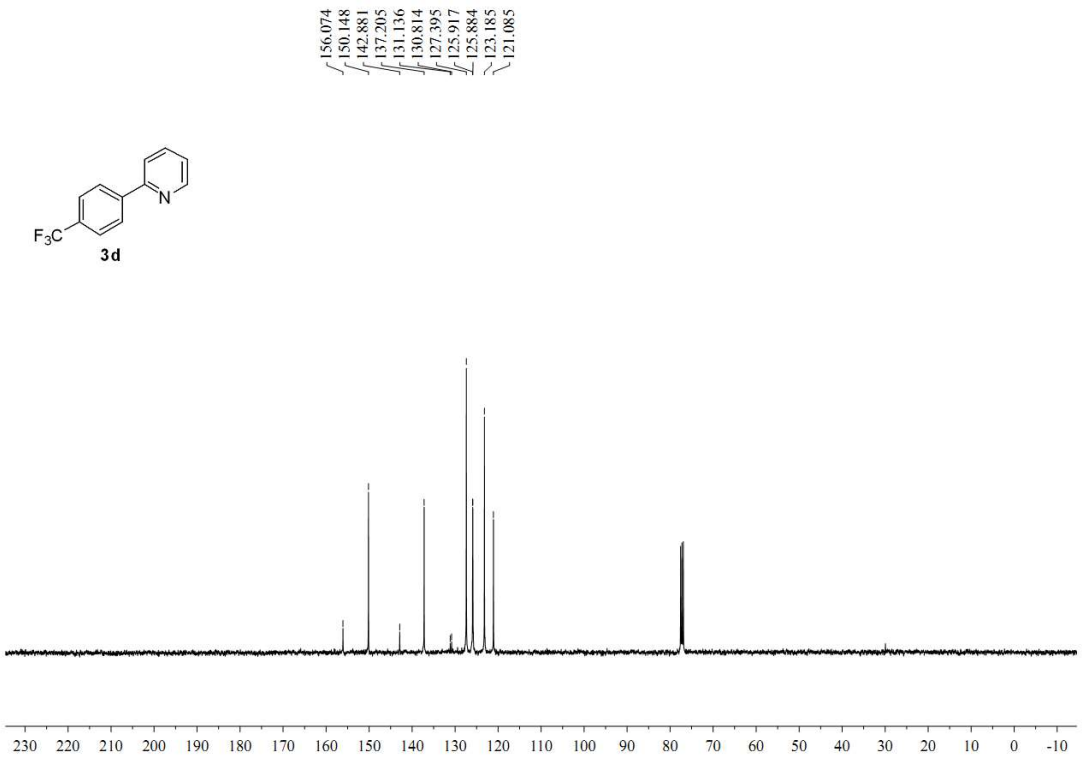


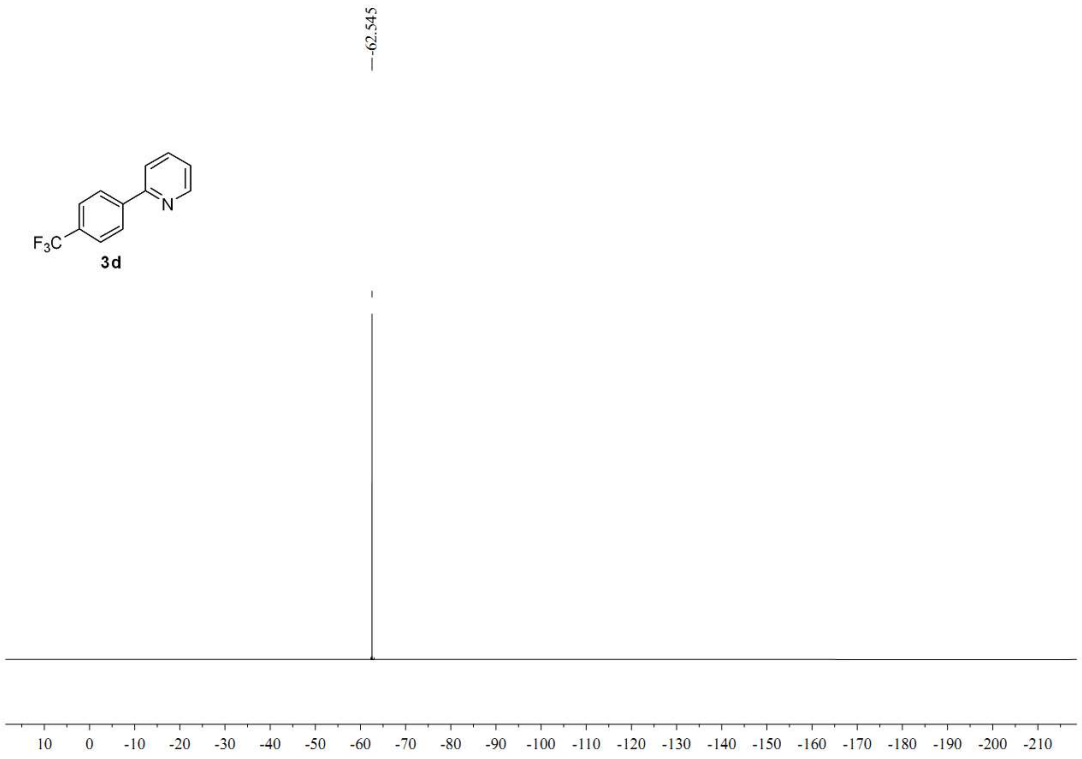
2-(4-Methoxyphenyl)pyridine (3c)



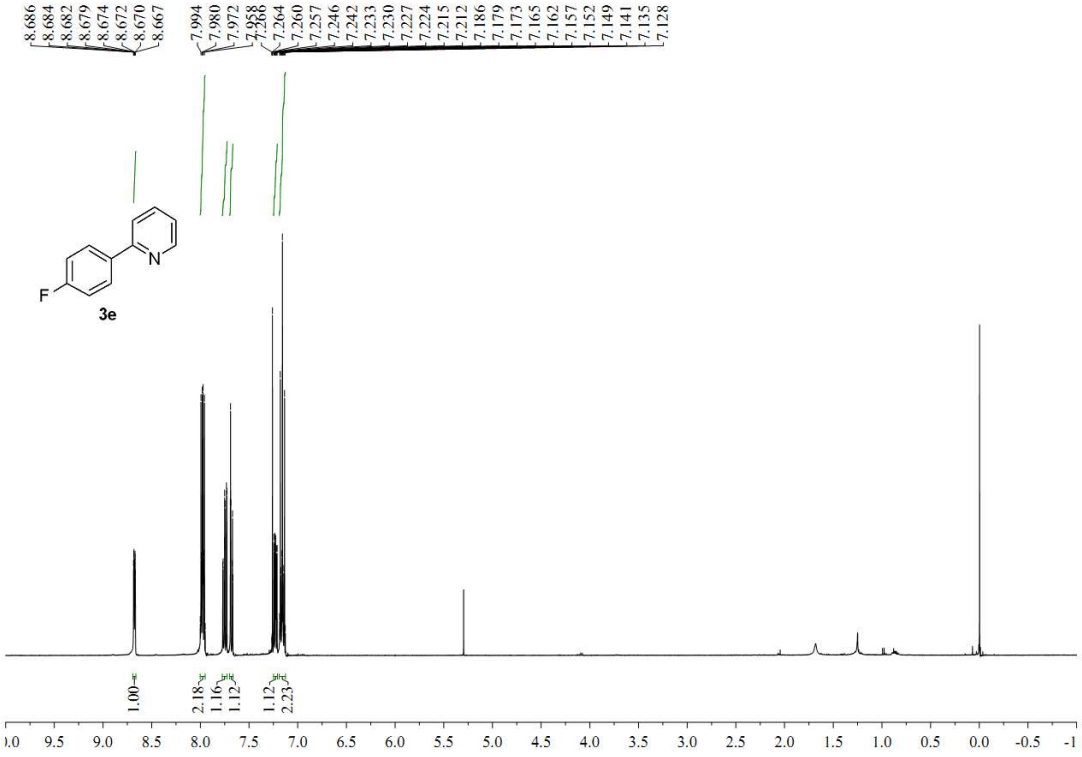
2-(4-(Trifluoromethyl)phenyl)pyridine (3d)

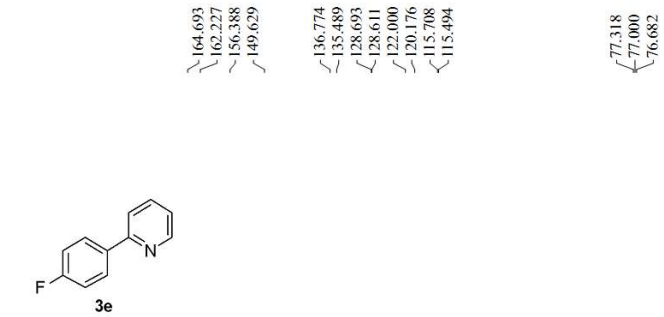






2-(4-Fluorophenyl)pyridine (3e)

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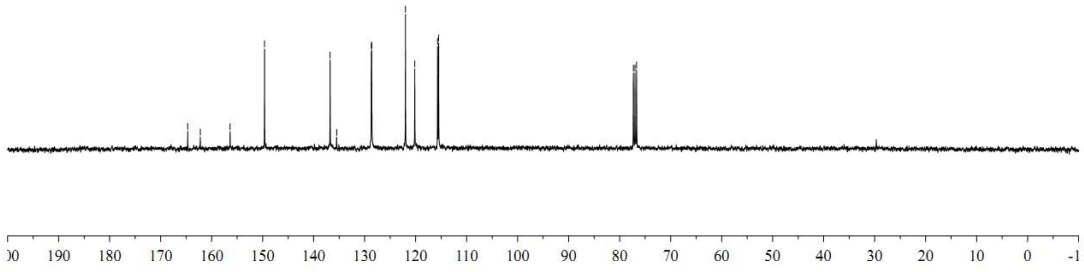
77.000
76.682
N
F
3e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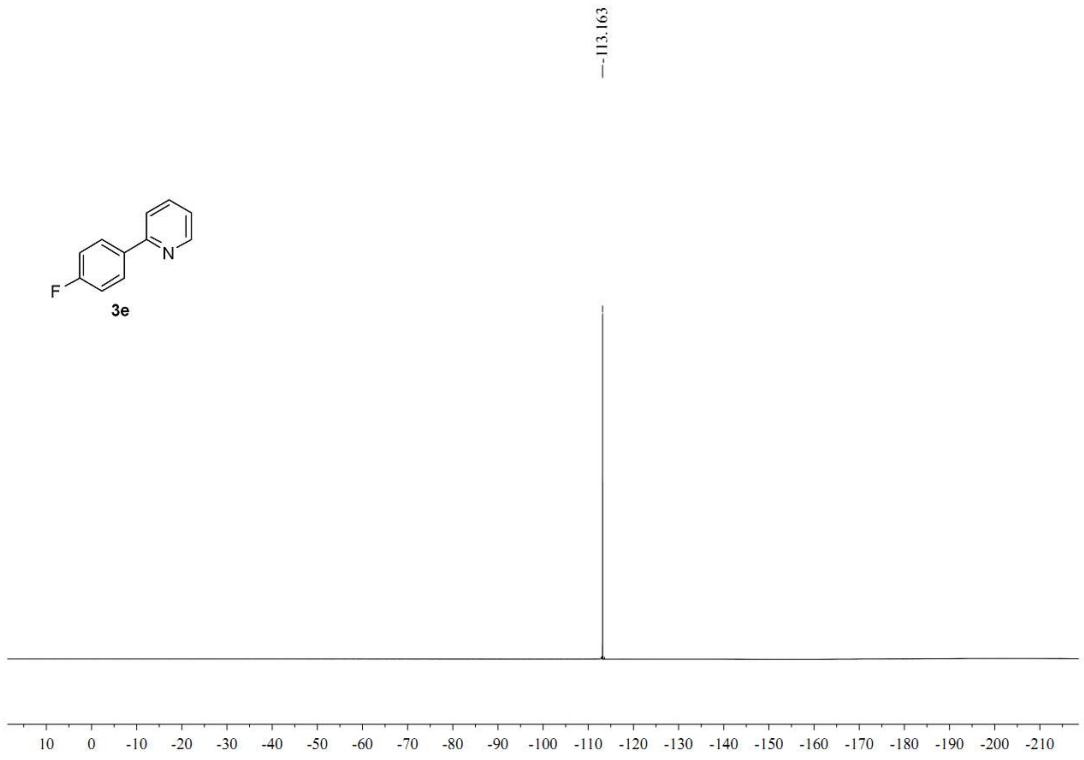
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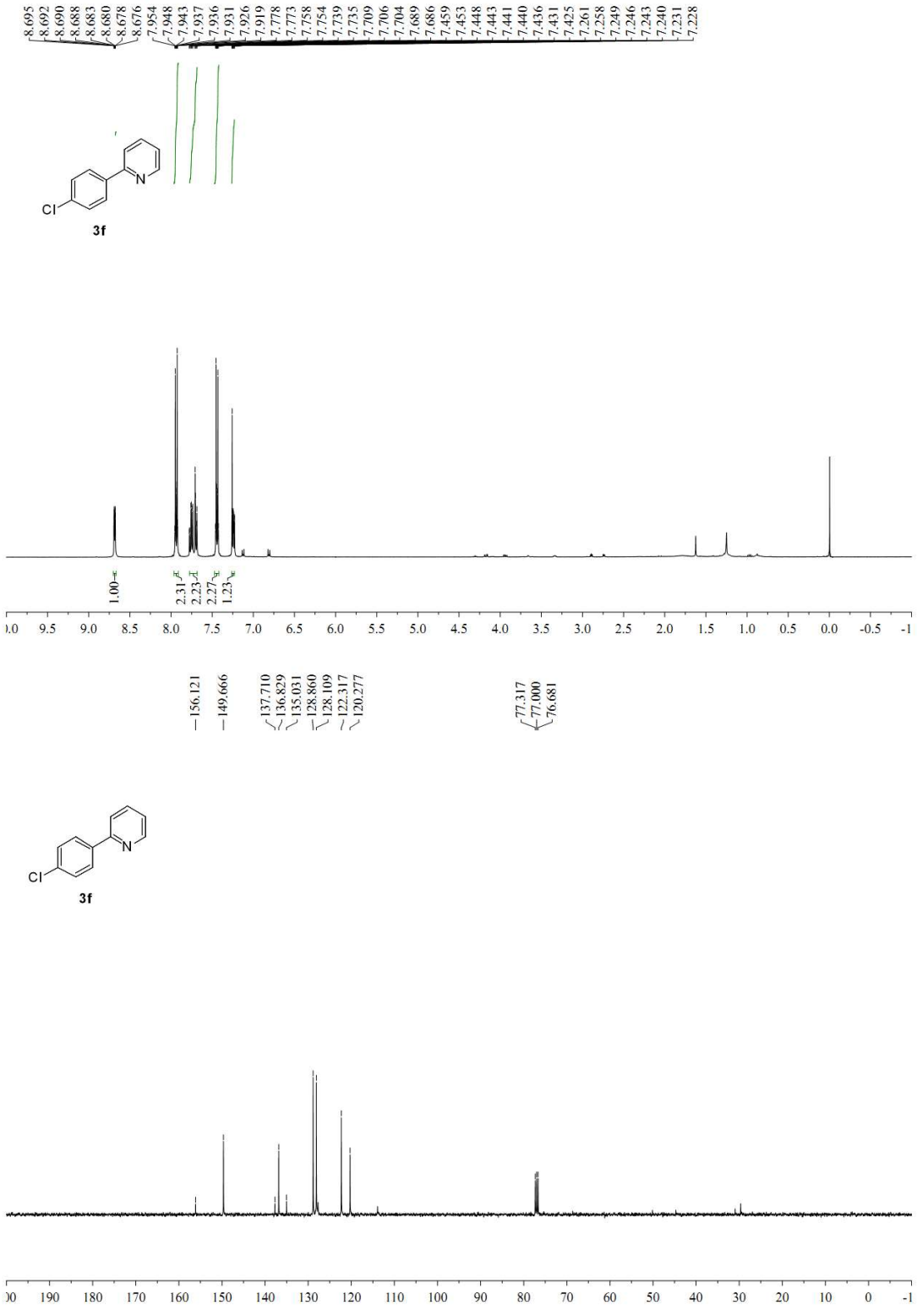
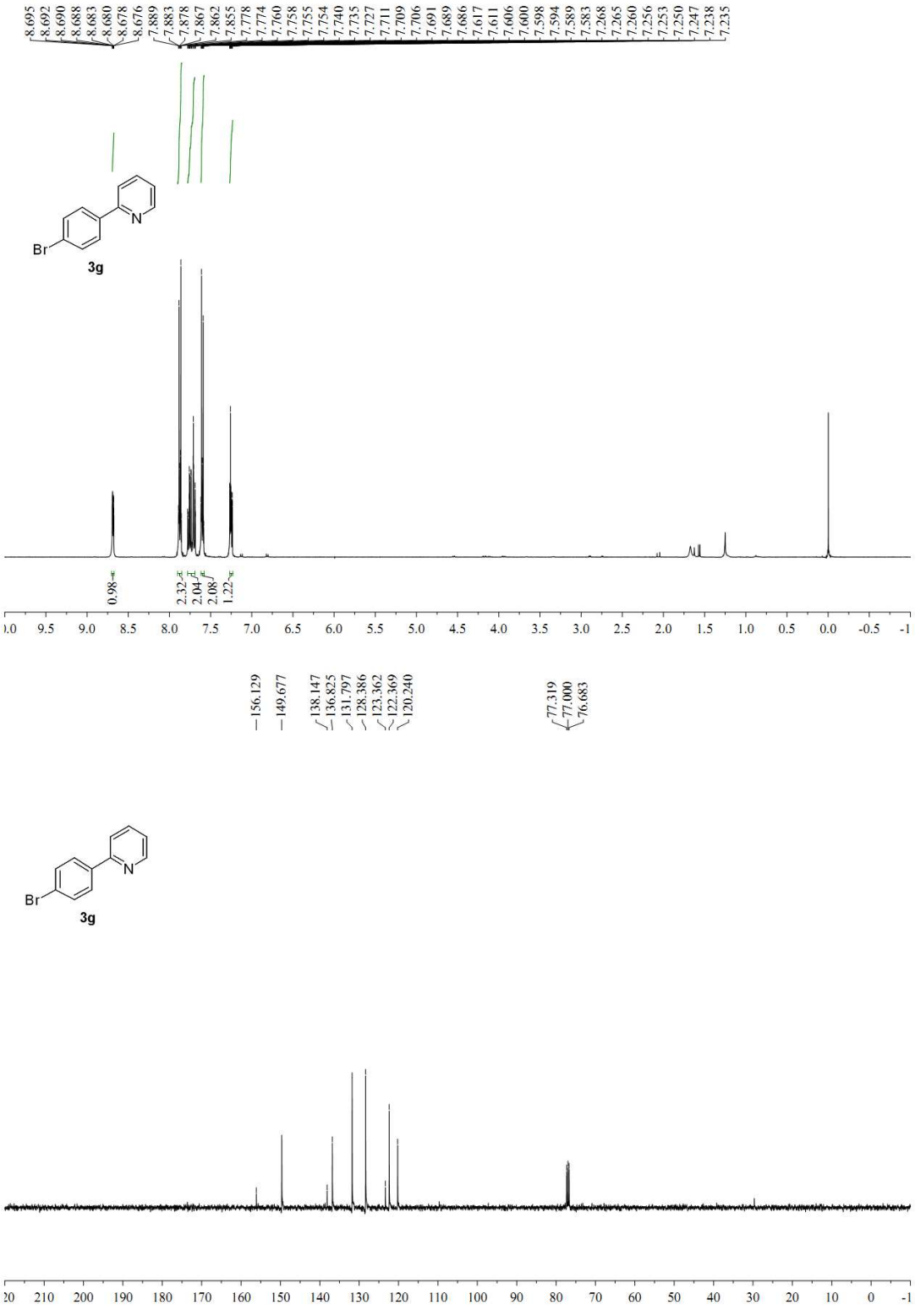
-200
-210

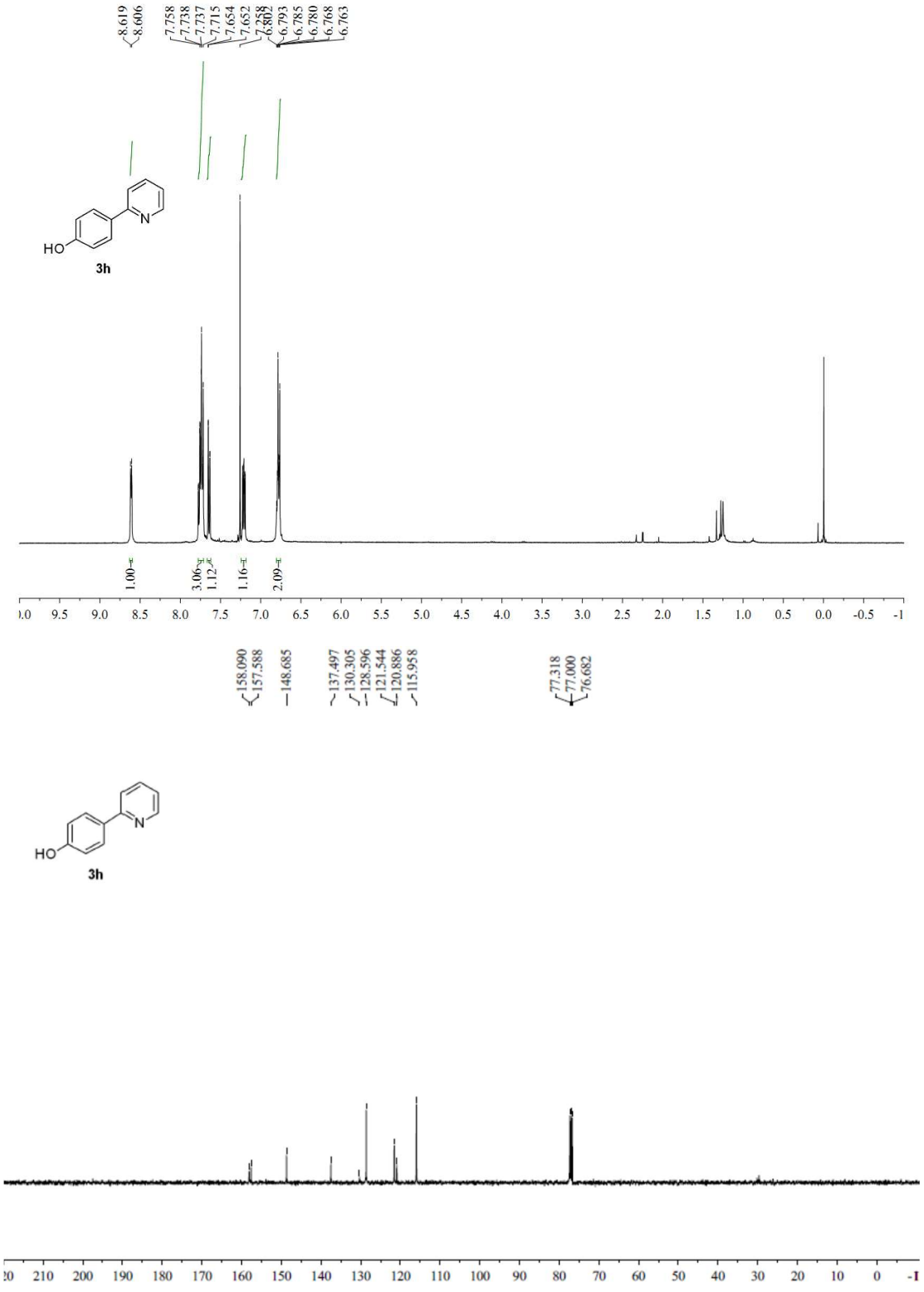
2-(4-Chlorophenyl)pyridine (3f)



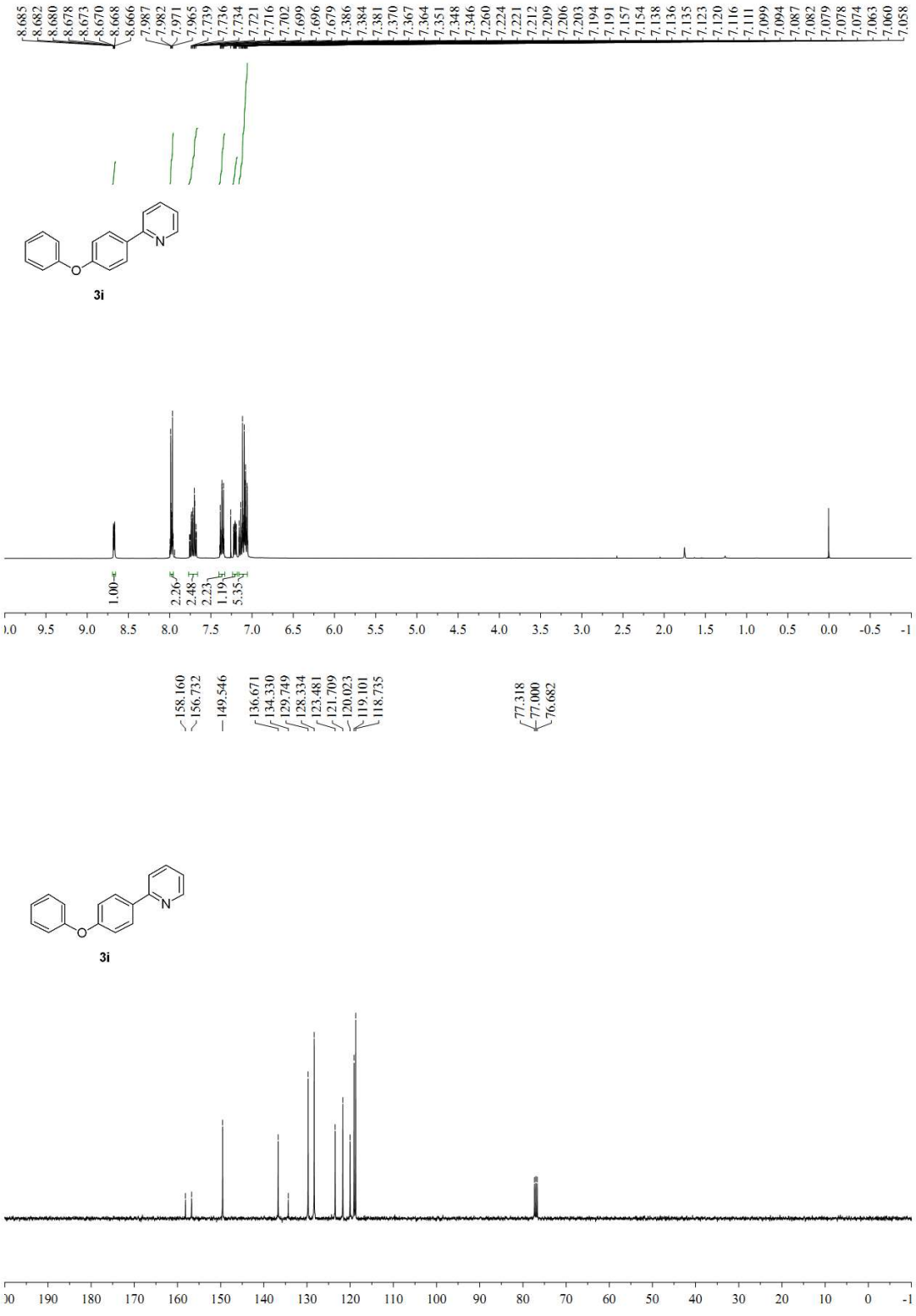
2-(4-Bromophenyl)pyridine (3g)



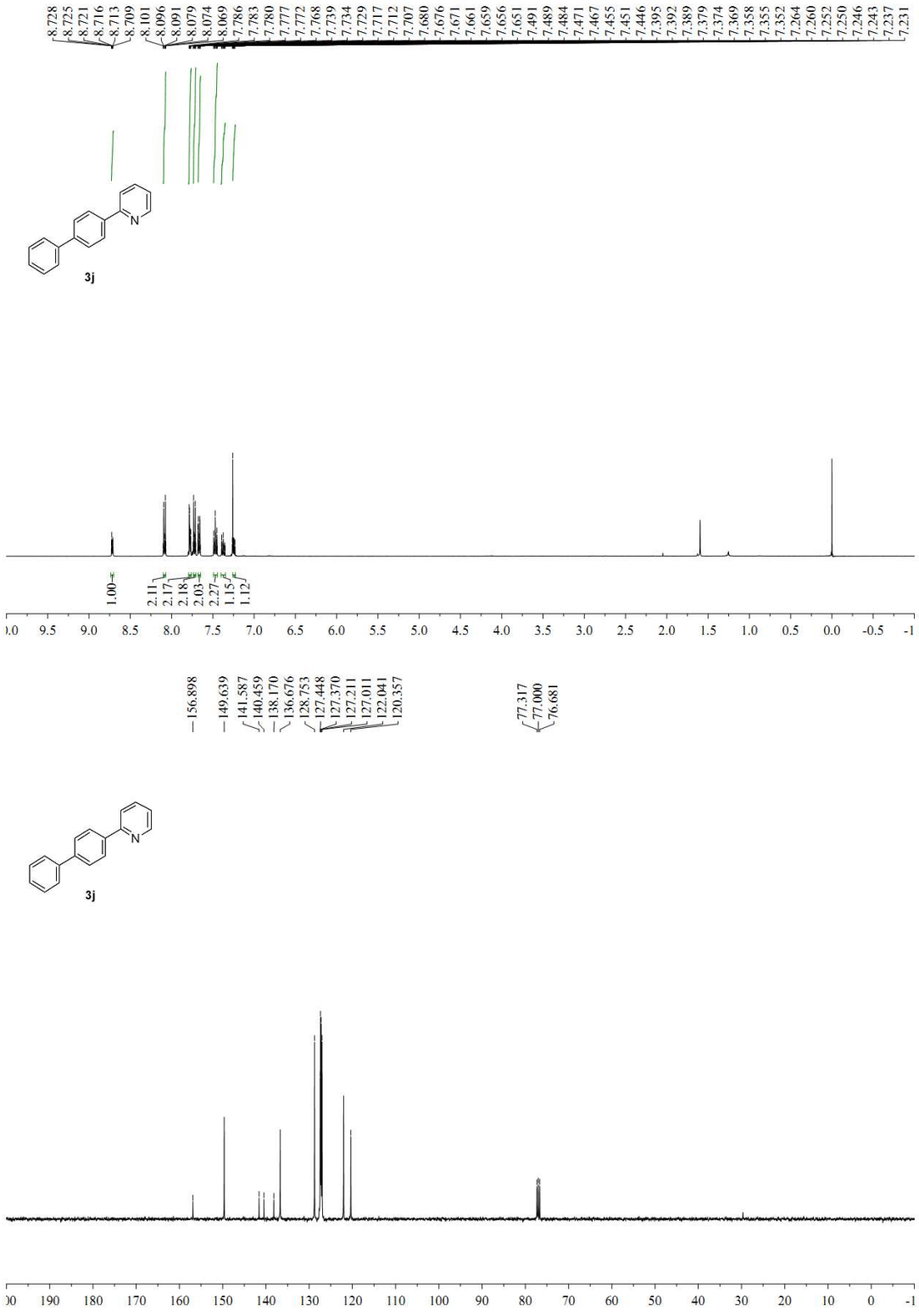
4-(Pyridin-2-yl)phenol (3h)



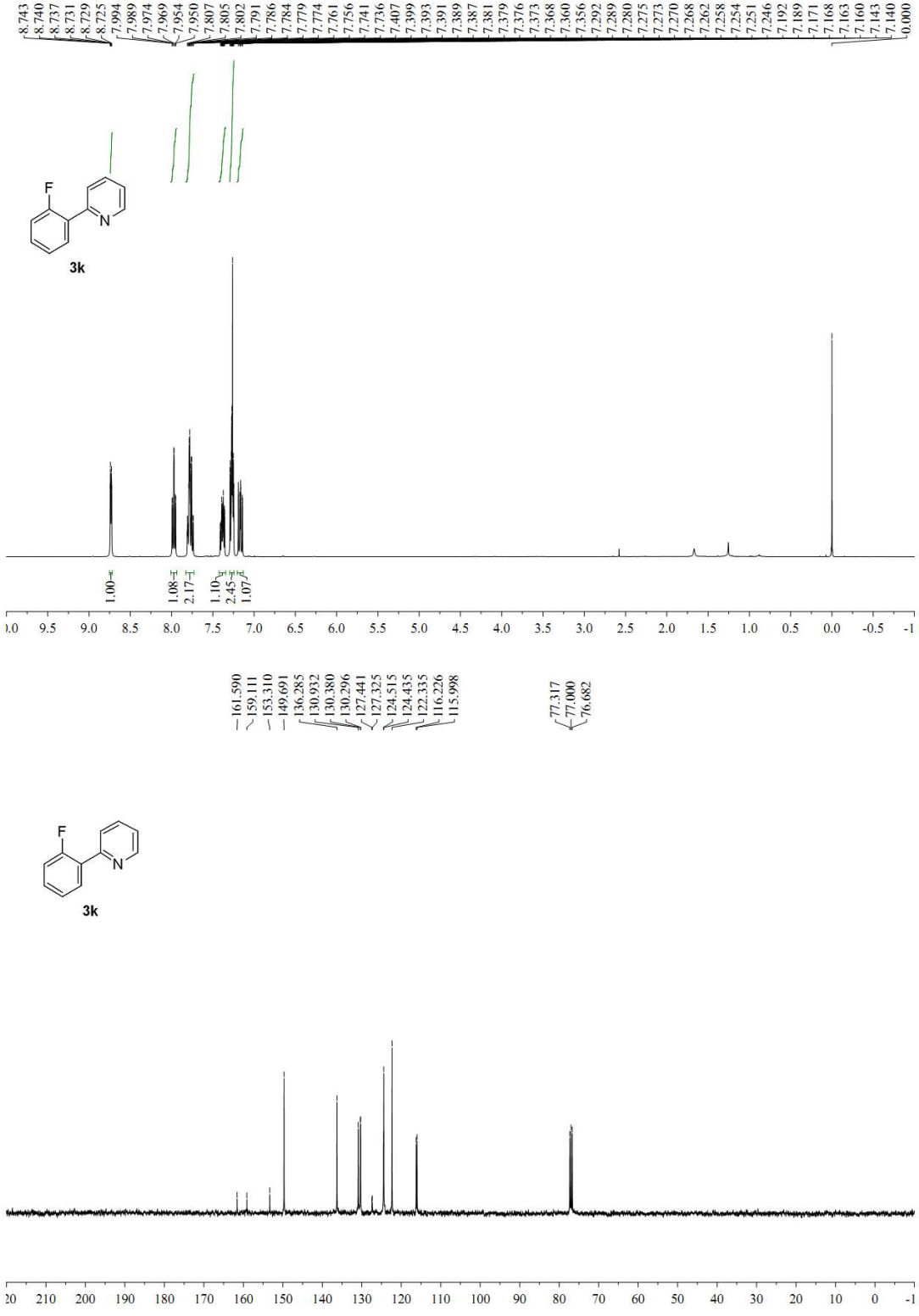
2-(4-Phenoxyphenyl)pyridine (3i)

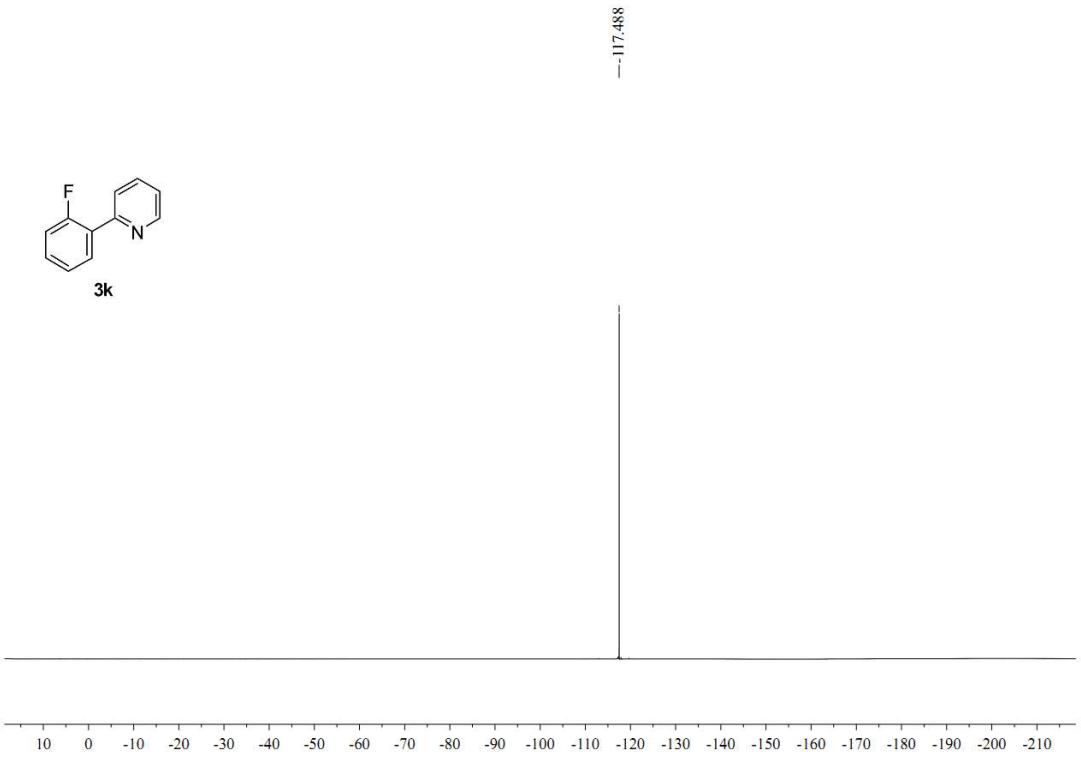


2-([1,1'-Biphenyl]-4-yl)pyridine (3j)

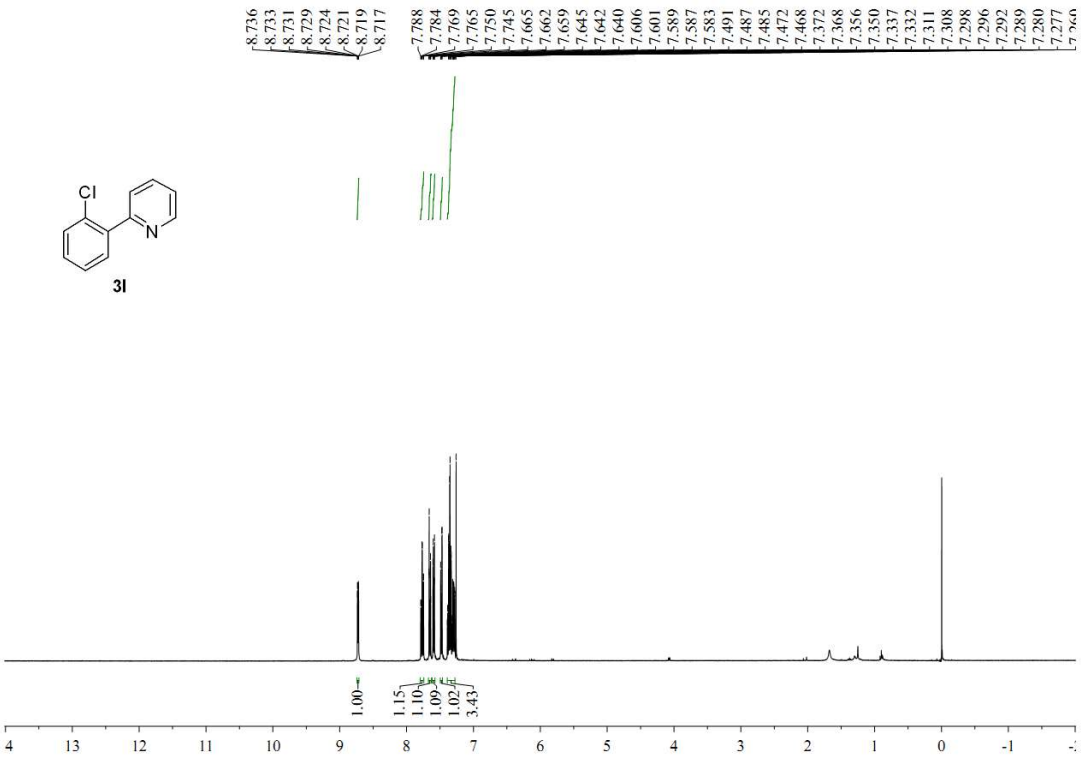


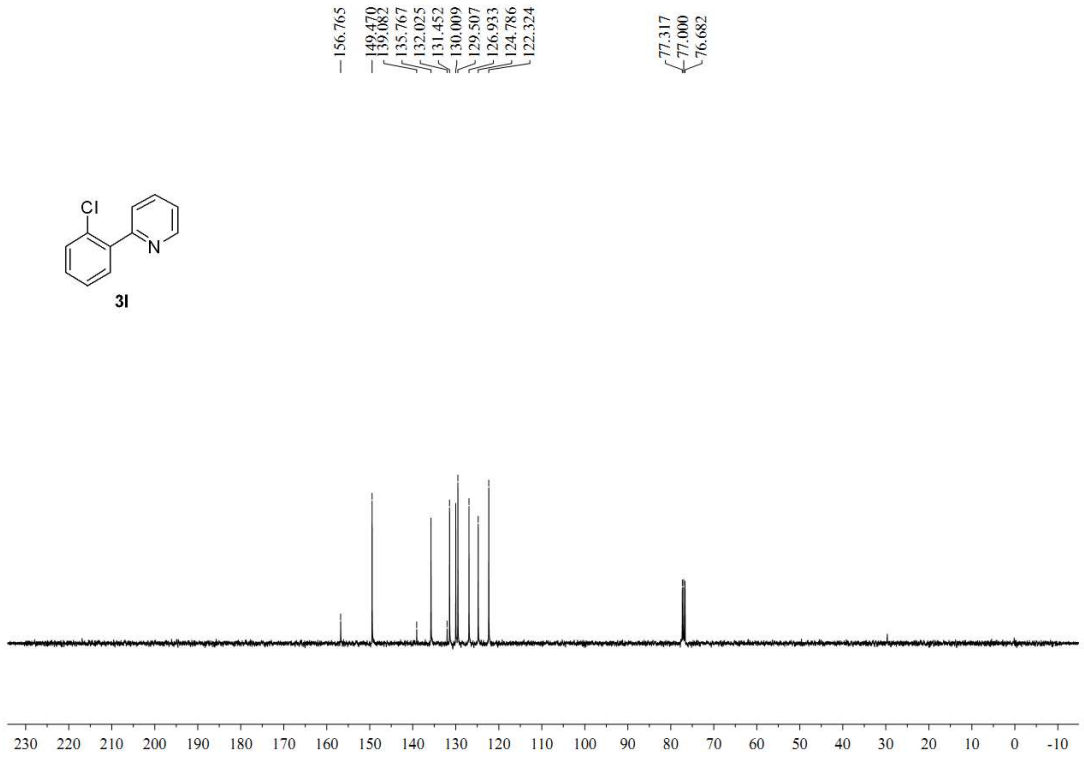
2-(2-Fluorophenyl)pyridine (3k)



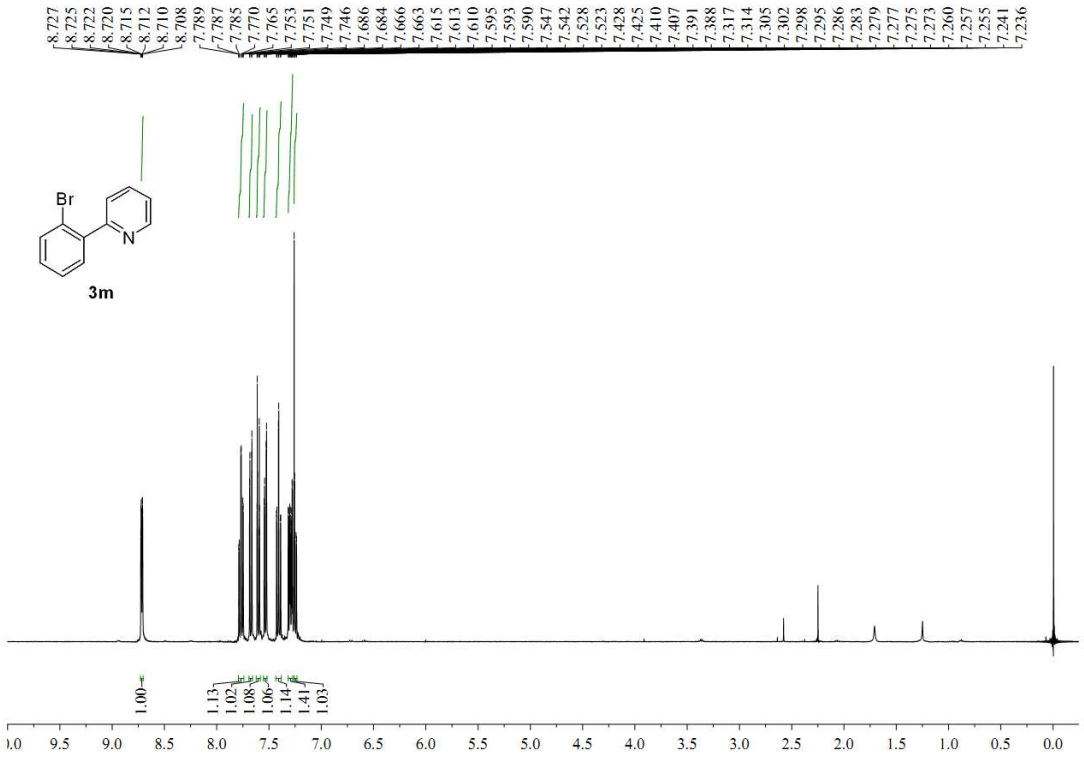


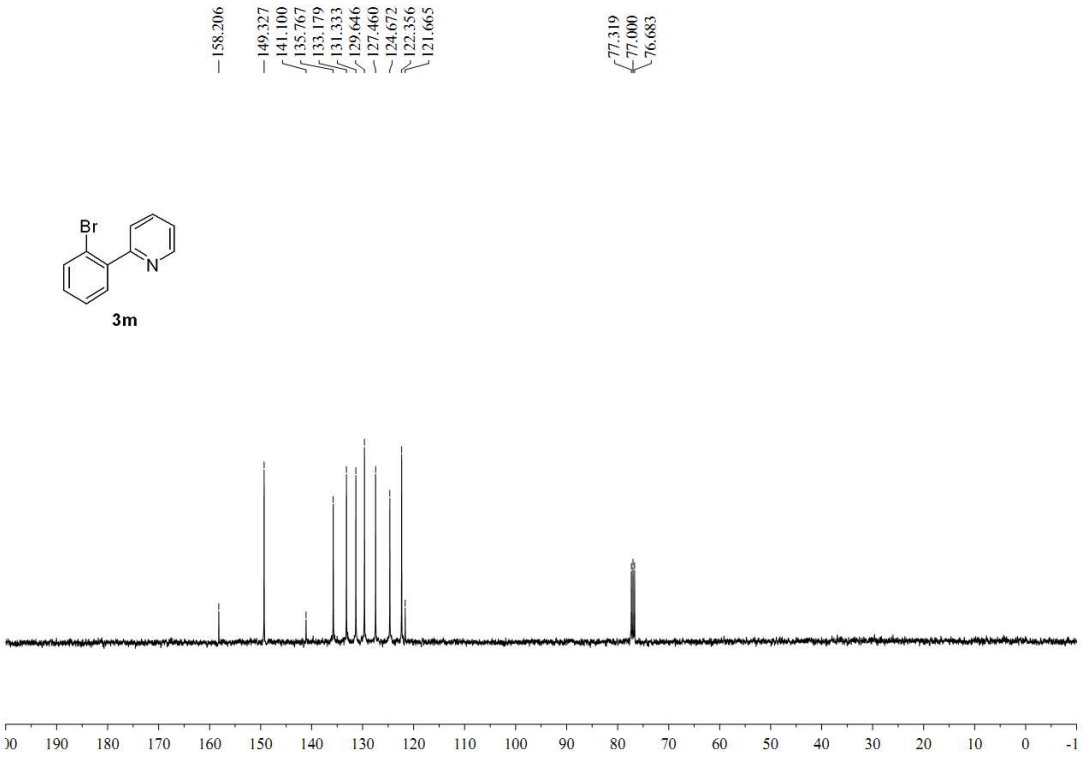
2-(2-Chlorophenyl)pyridine (3l)



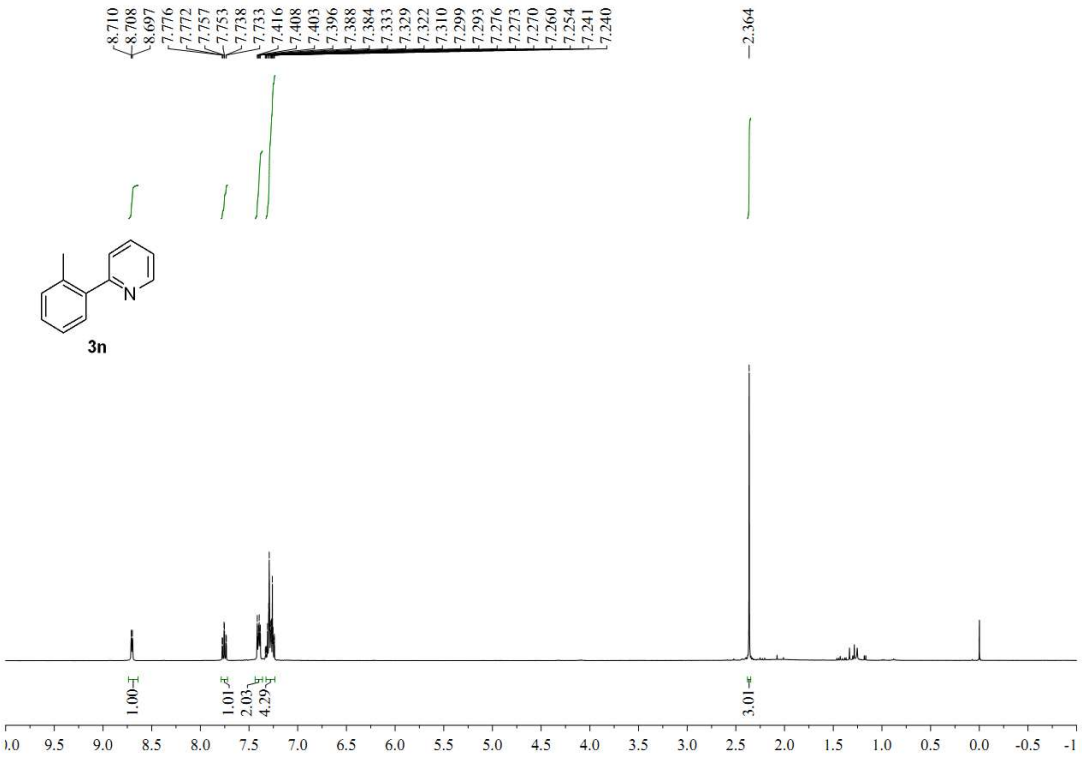


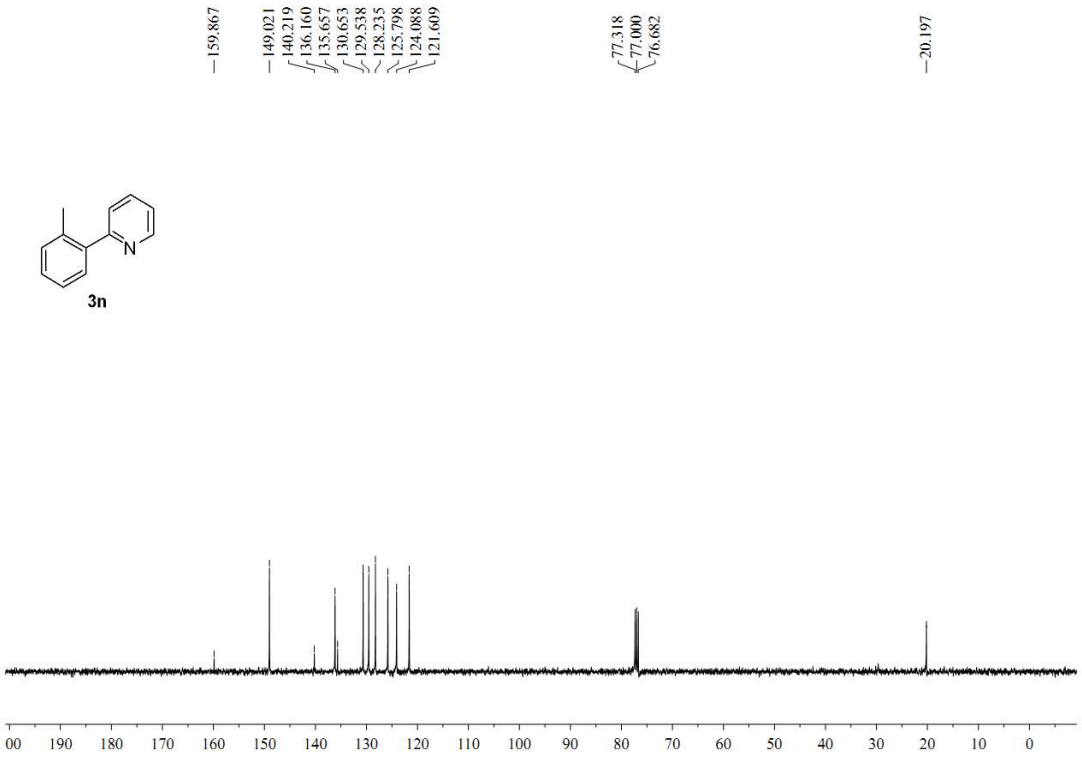
2-(2-Bromophenyl)pyridine (3m)





2-(*o*-Tolyl)pyridine (3n)





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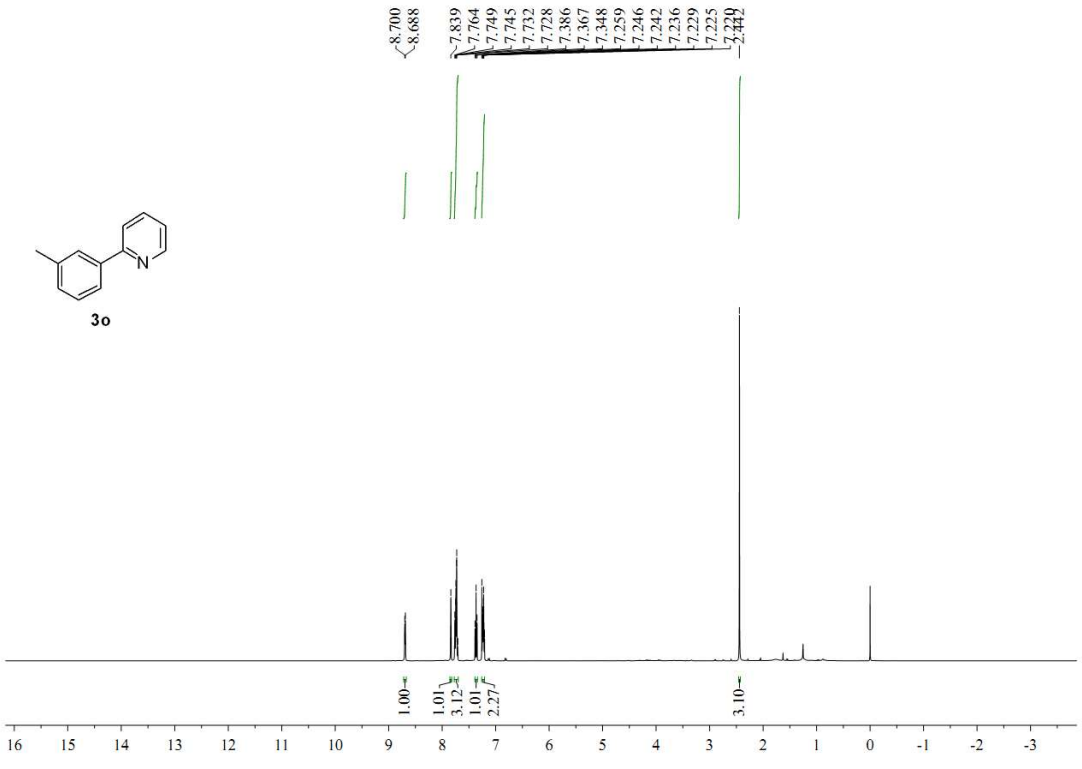
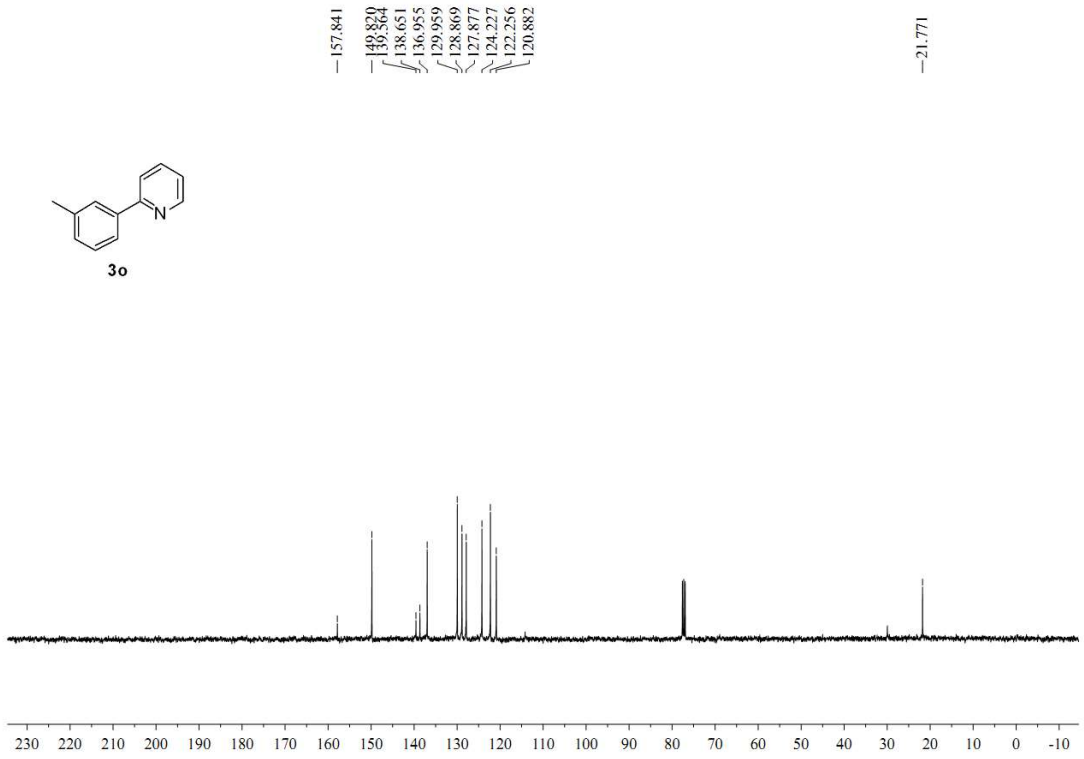
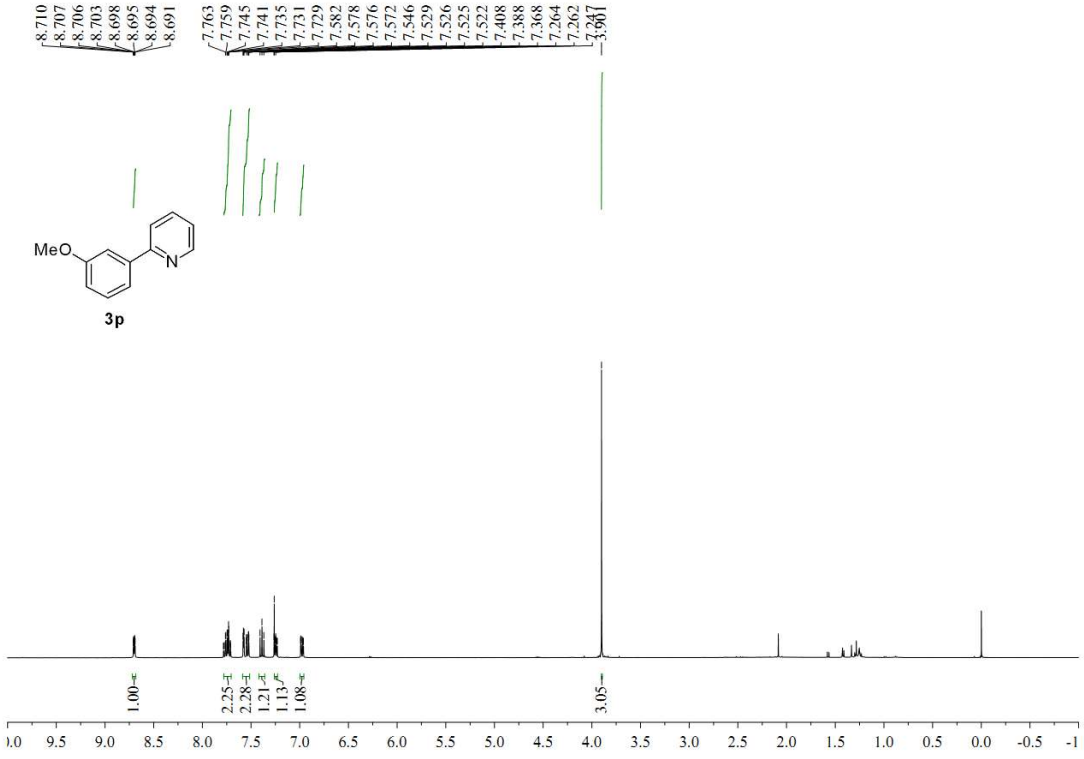
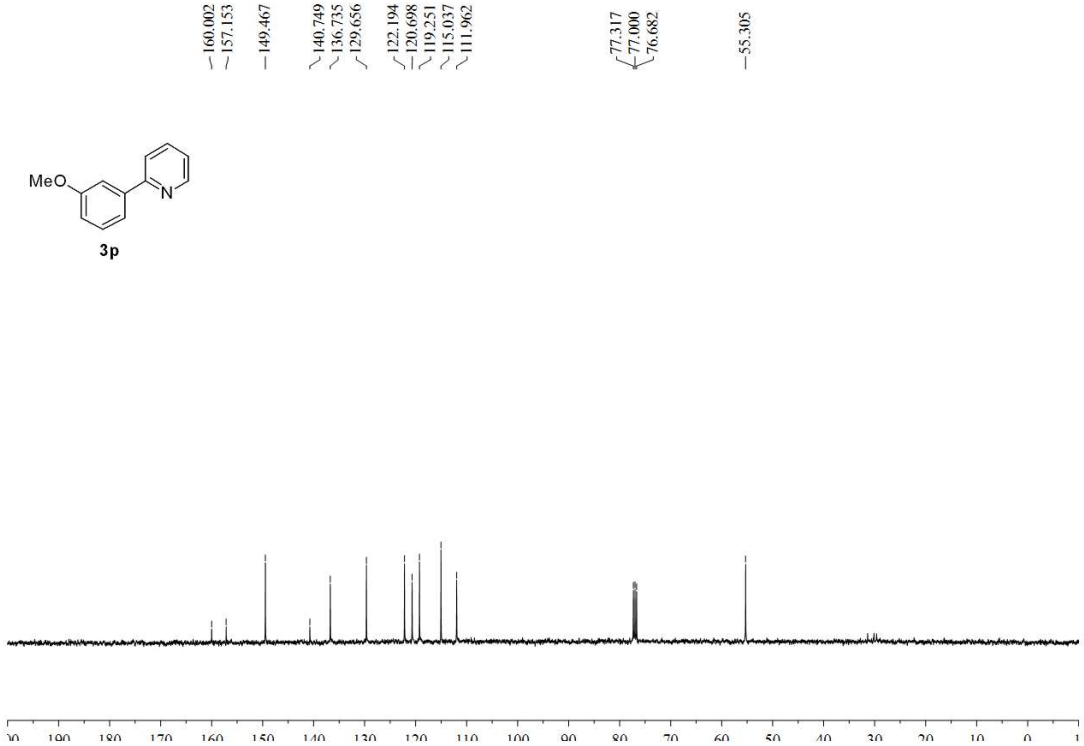


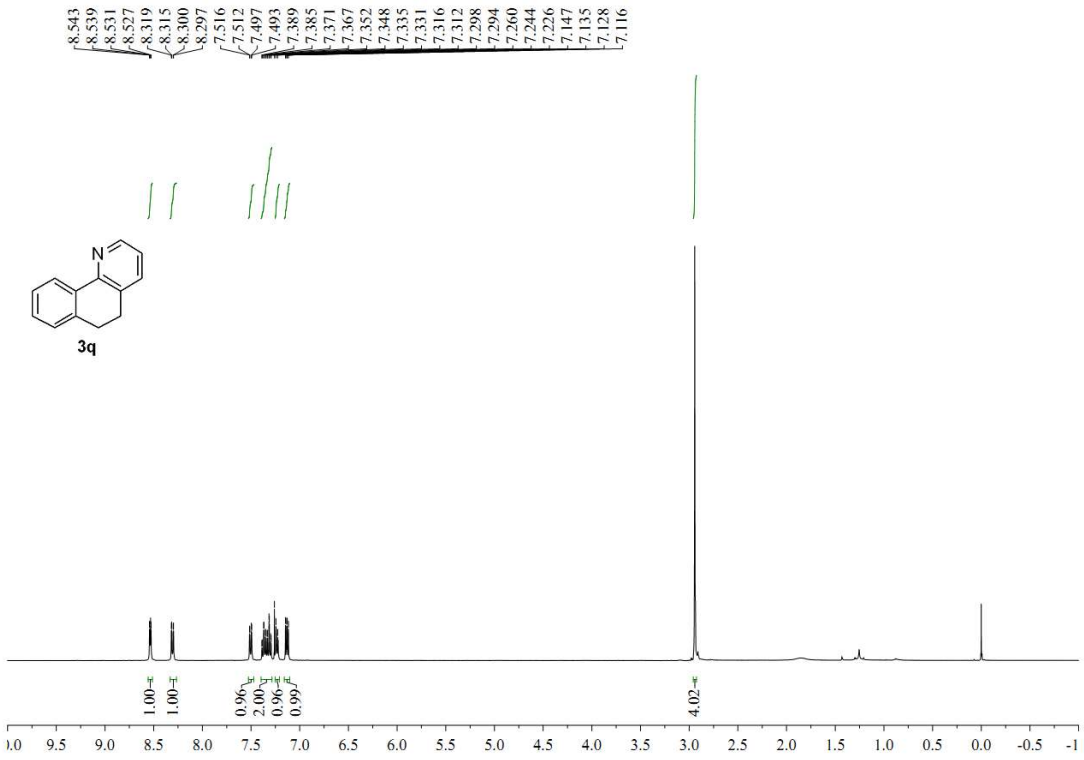


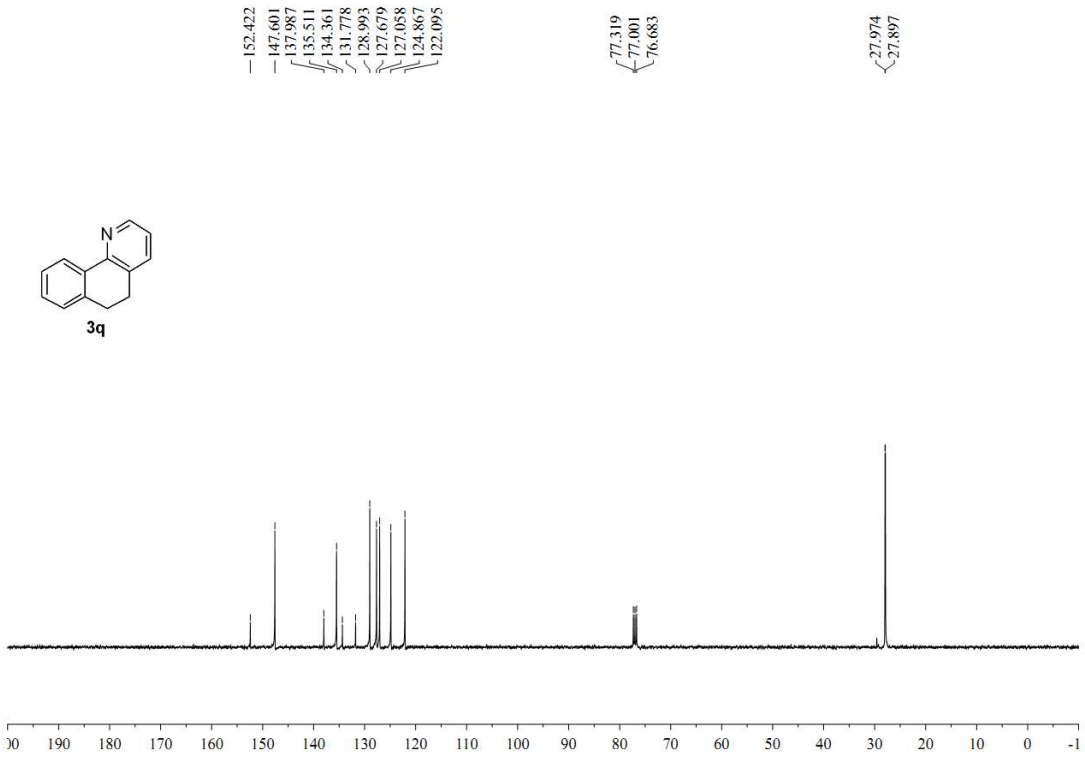
2-(3-Methoxyphenyl)pyridine (3p)



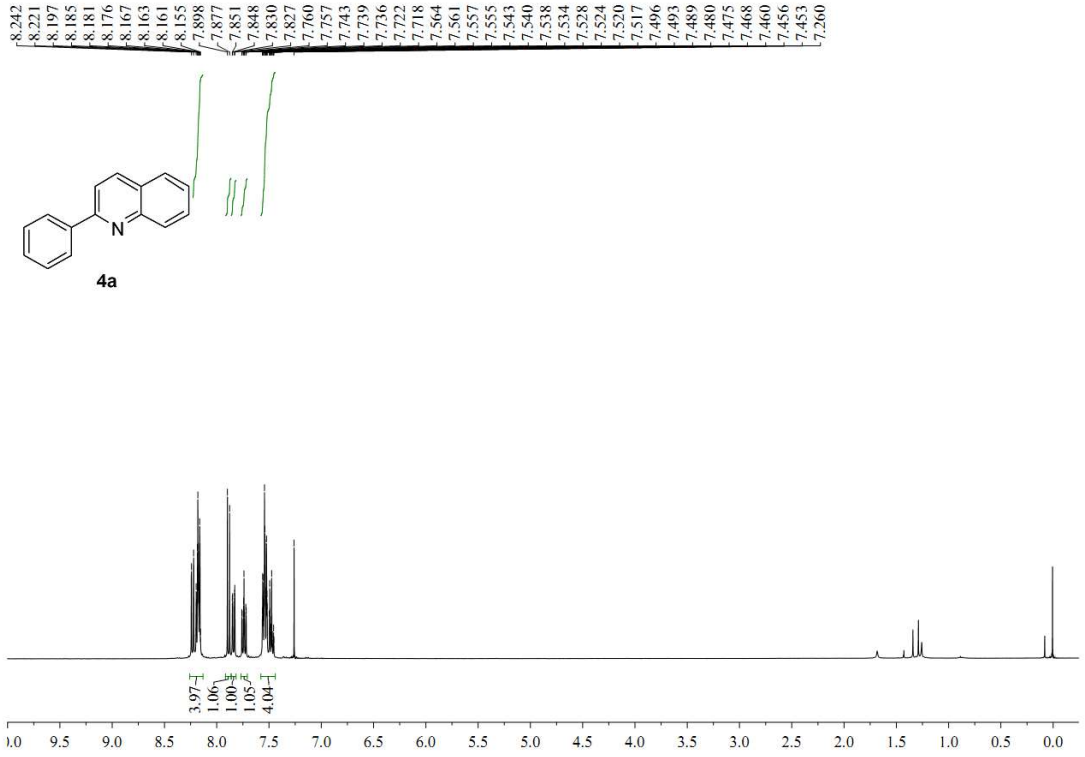


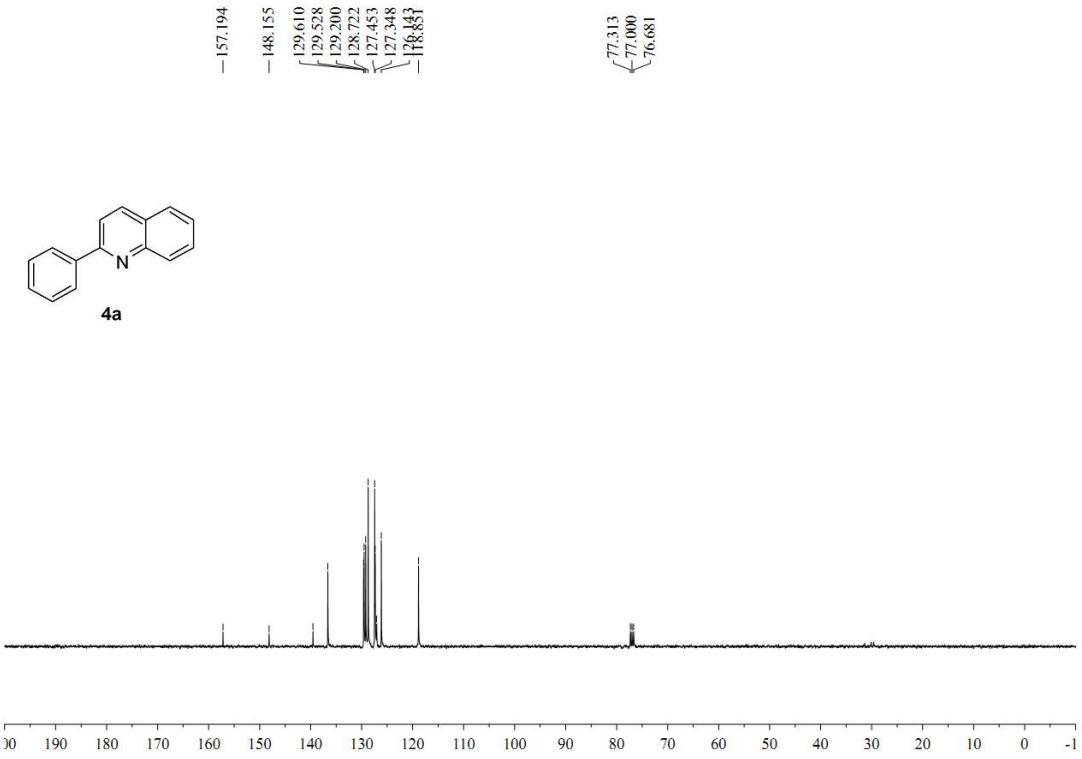
5,6-Dihydrobenzo[h]quinoline (3q)



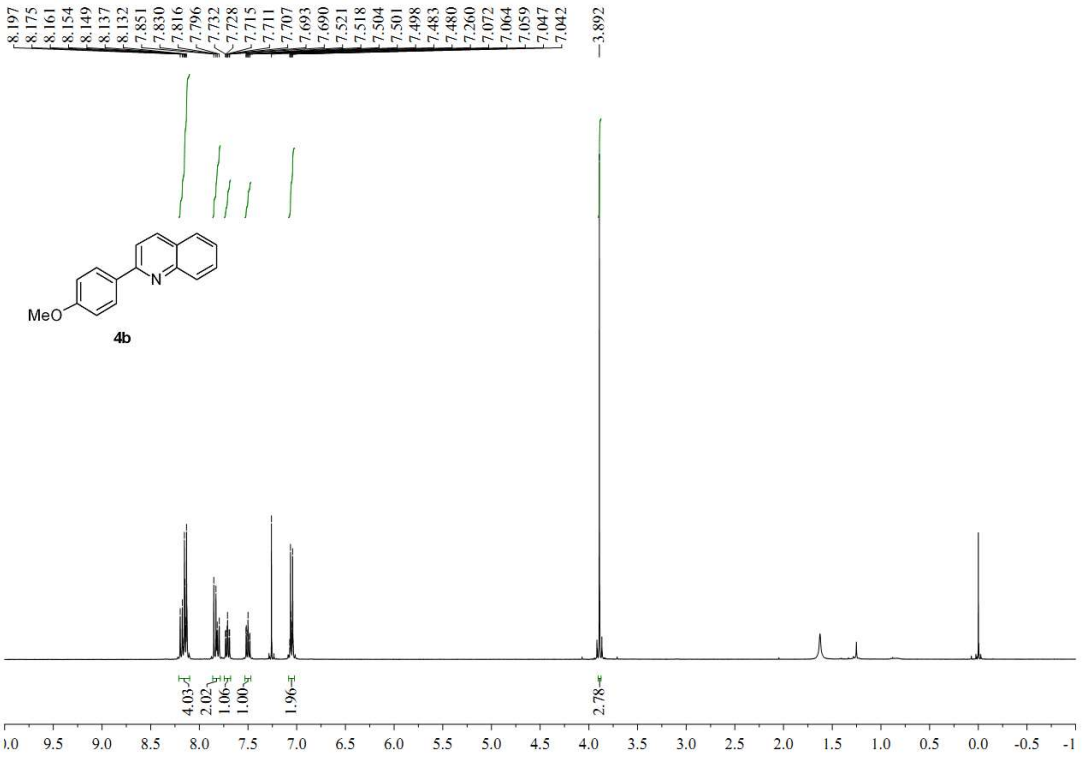


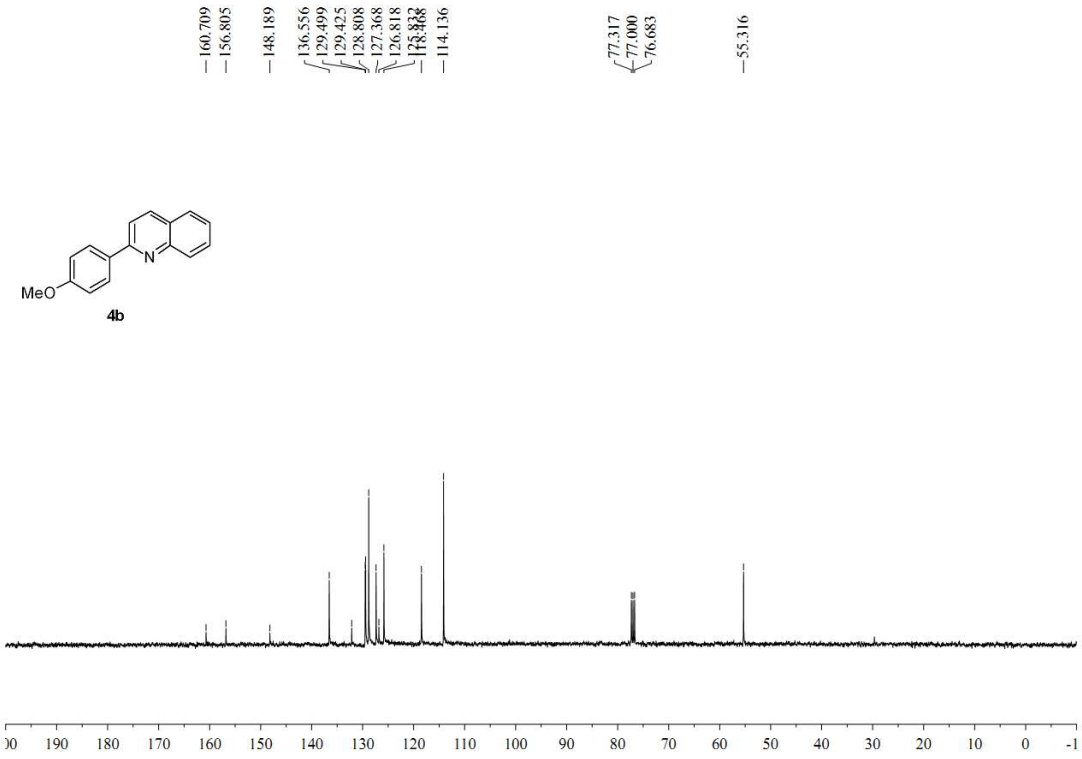
2-Phenylquinoline (4a)



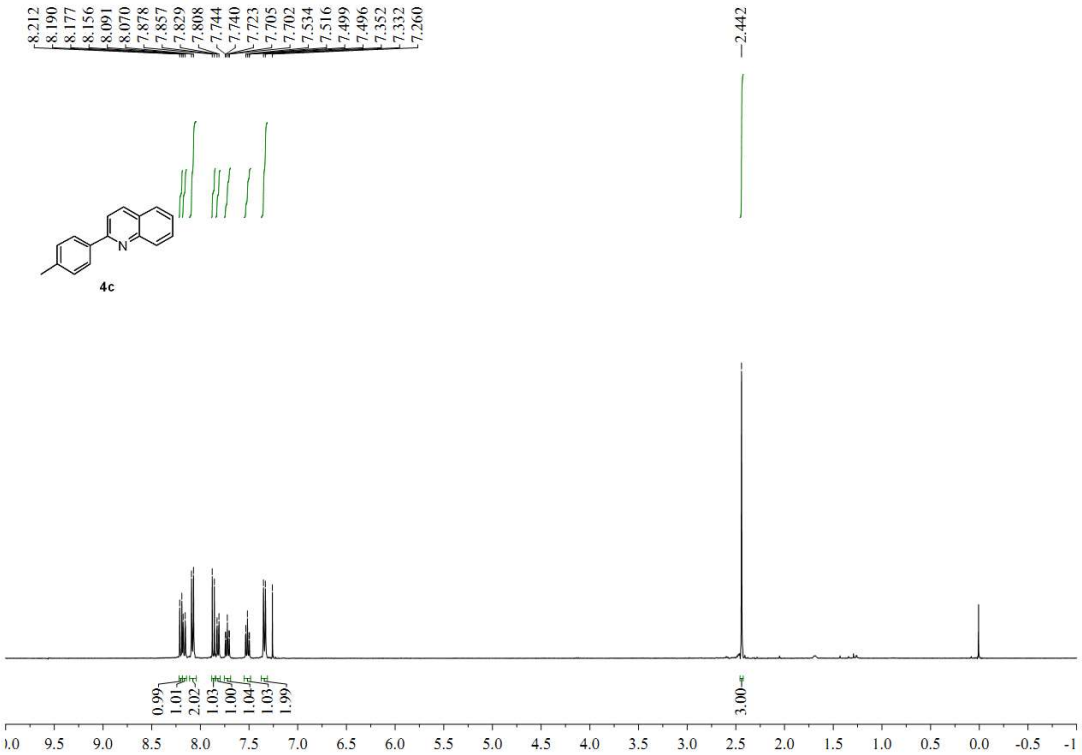


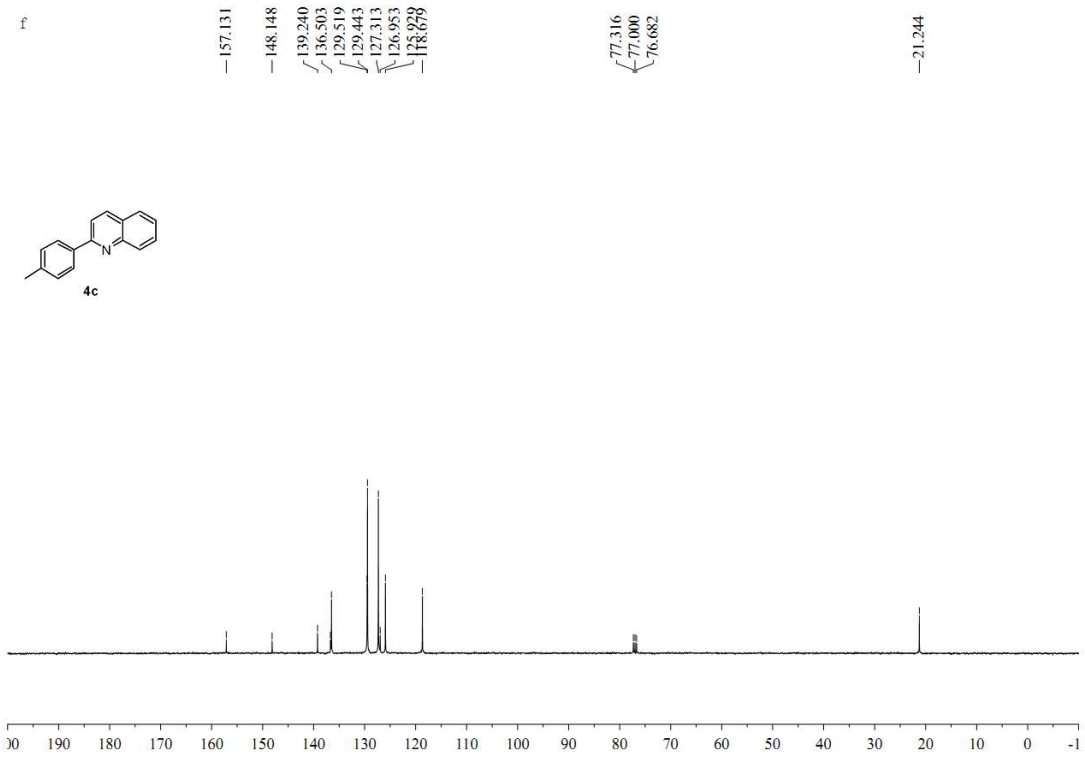
2-(4-Methoxyphenyl)quinoline (4b)



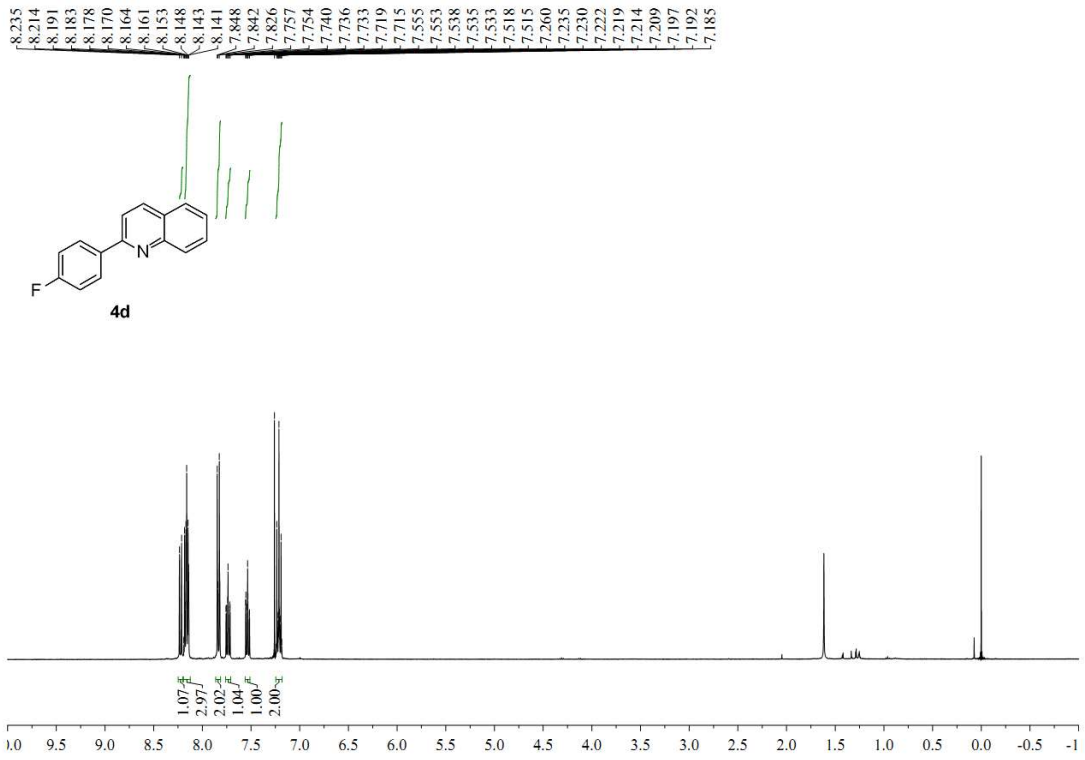


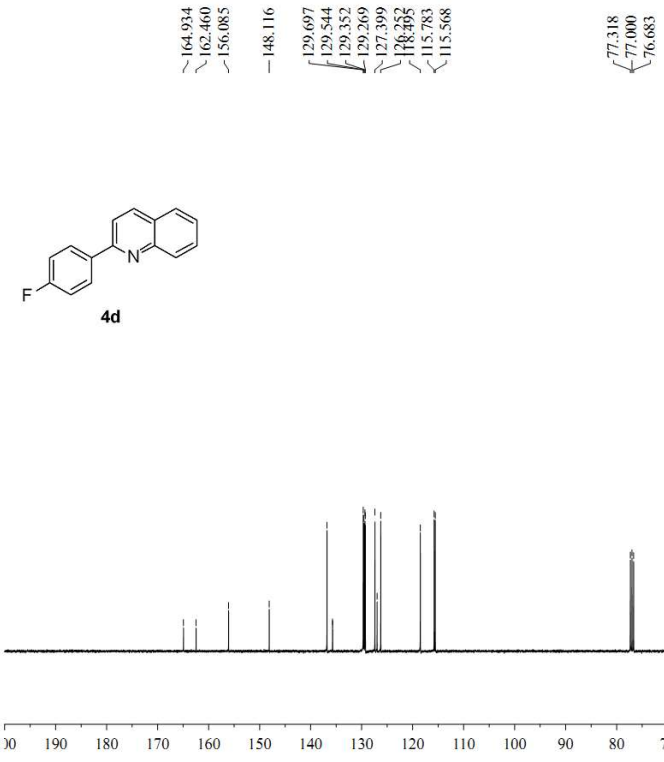
2-(*p*-Tolyl)quinoline (4c)





2-(4-Fluorophenyl)quinoline (4d)

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126.252
118.495
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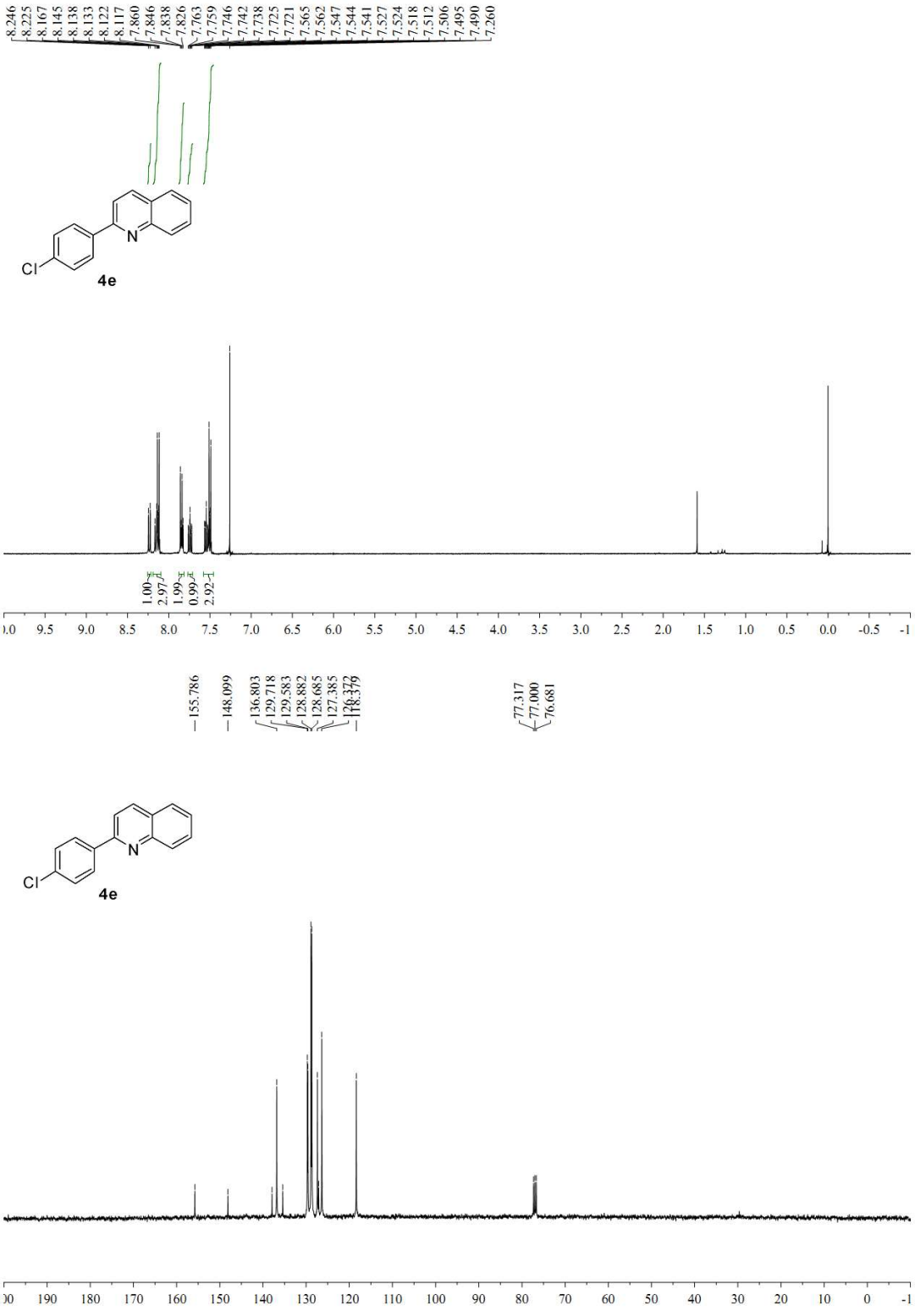
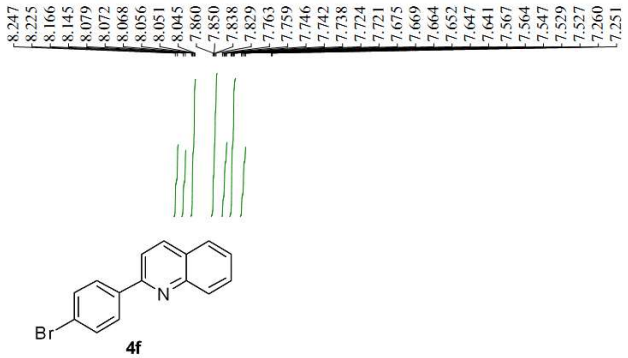
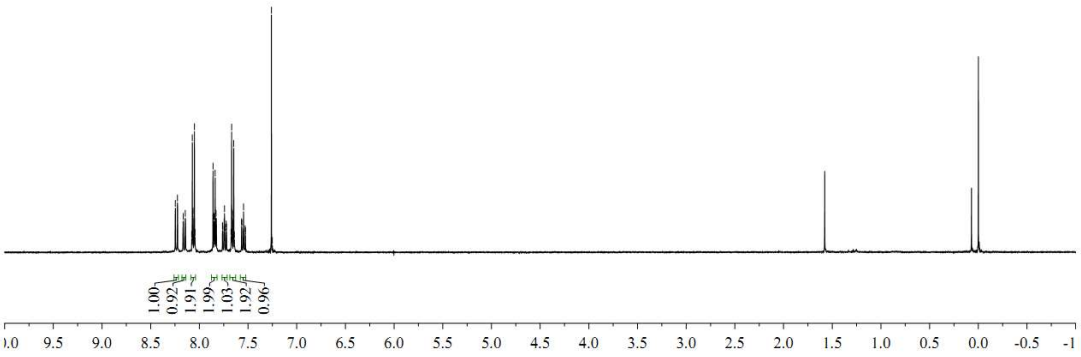
115.568
77.318
77.000
76.683
F
4d
-113.163
F
4d

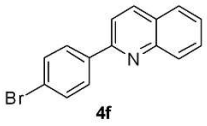
2-(4-Chlorophenyl)quinoline (4e)

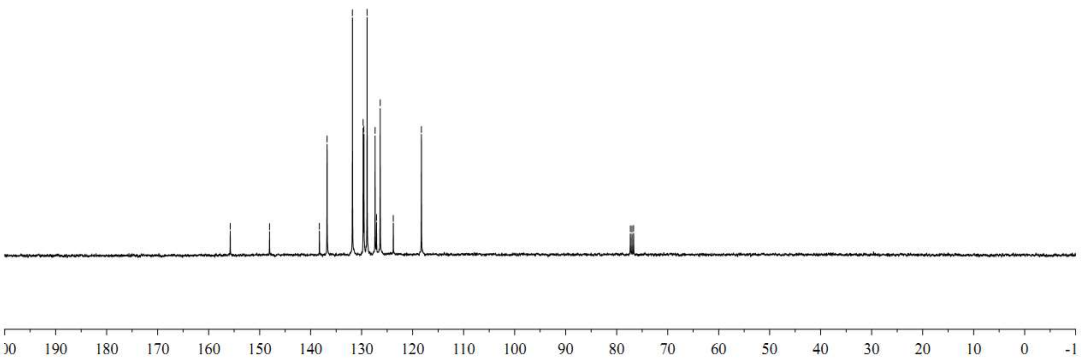


2-(4-Bromophenyl)quinoline (4f)

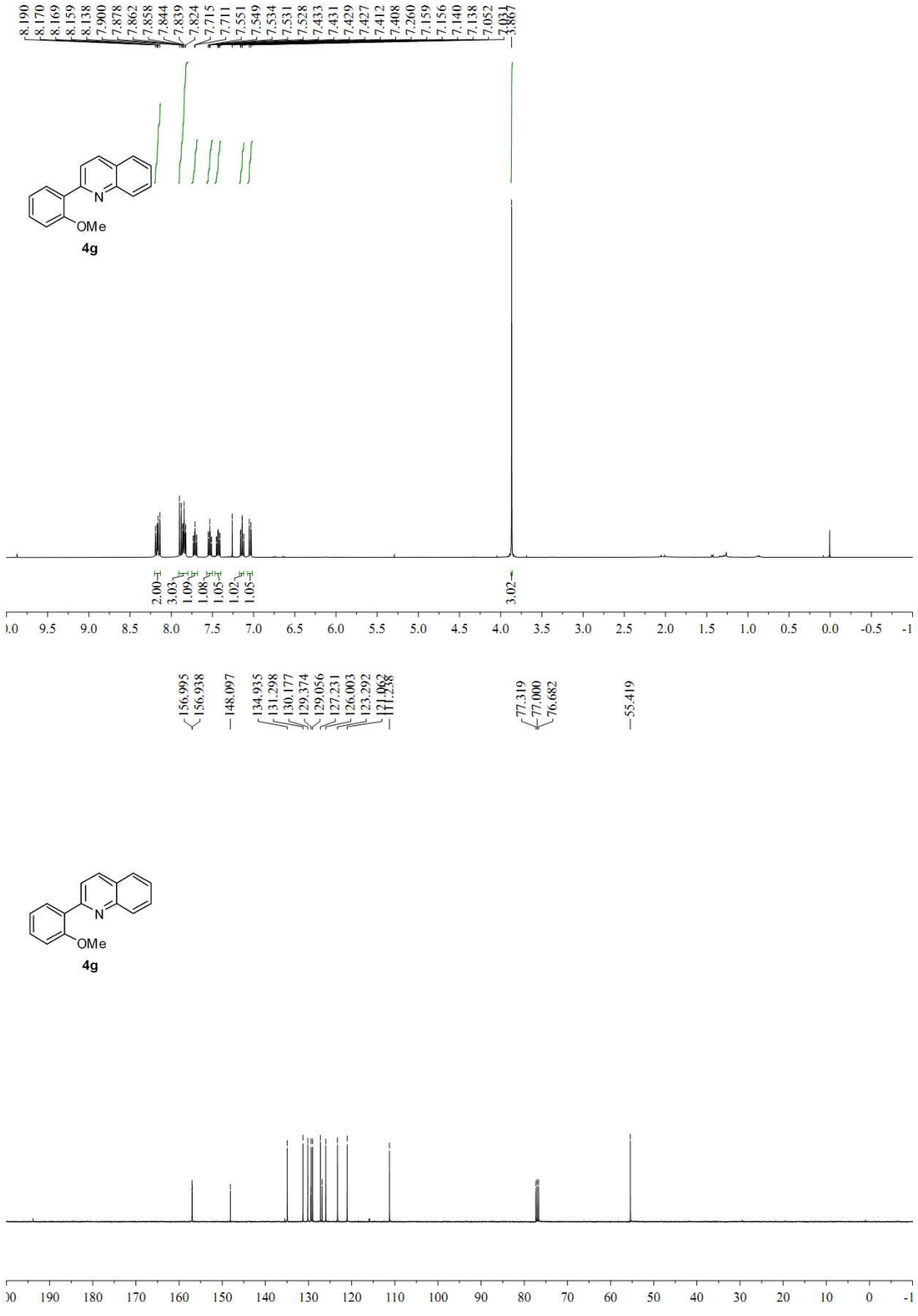




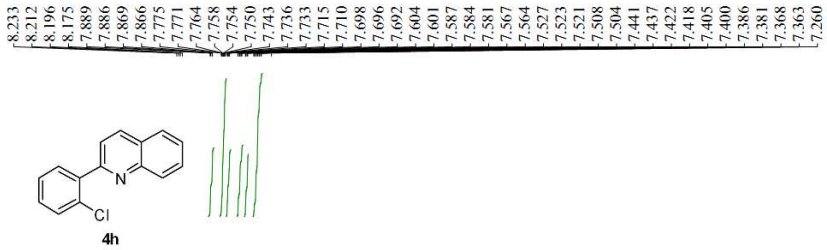


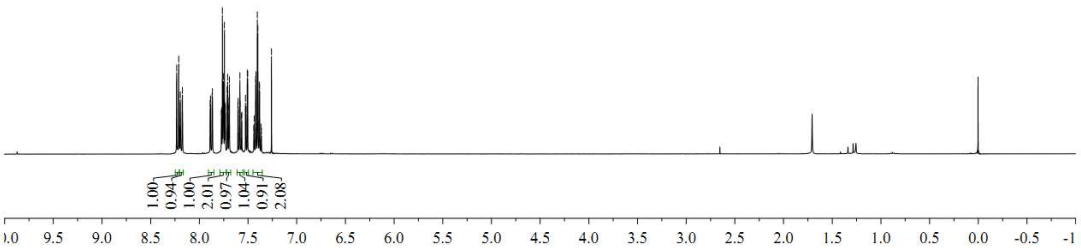


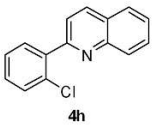
2-(2-Methoxyphenyl)quinoline

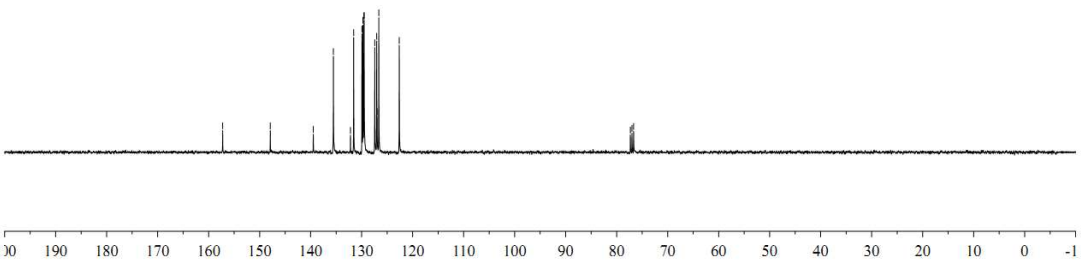


2-(2-Chlorophenyl)quinoline (4h)

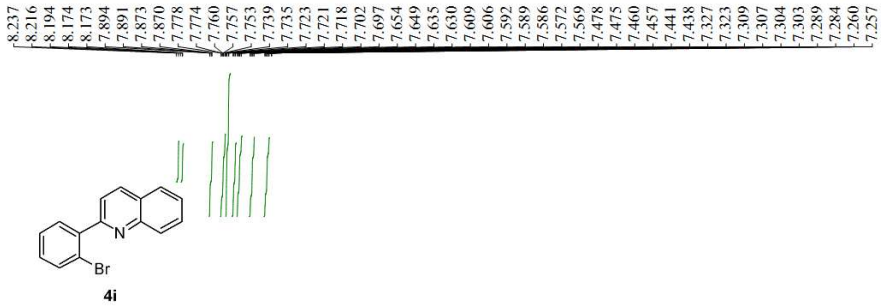


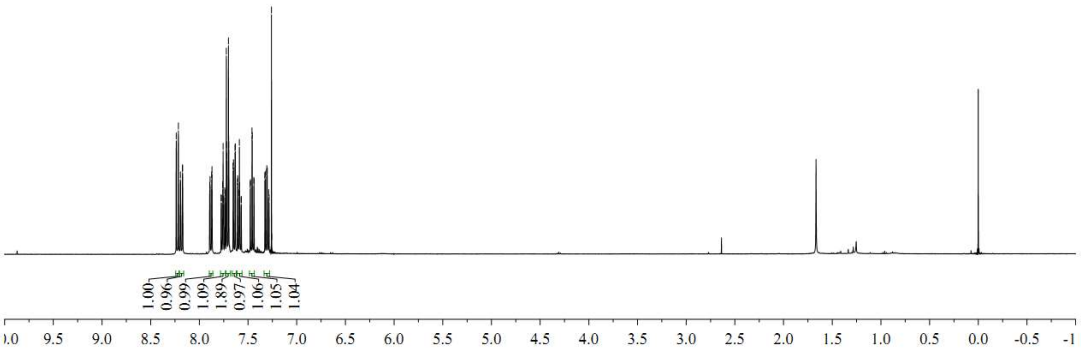


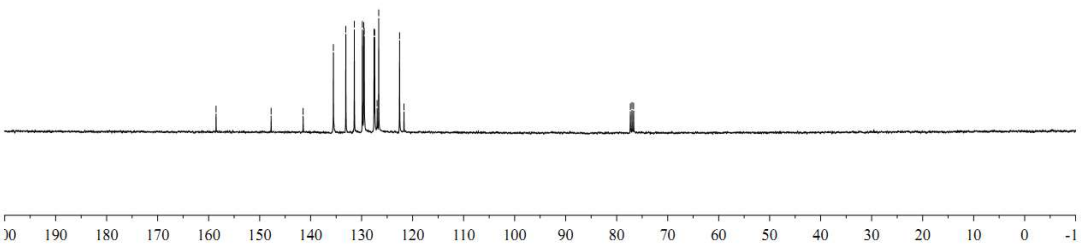




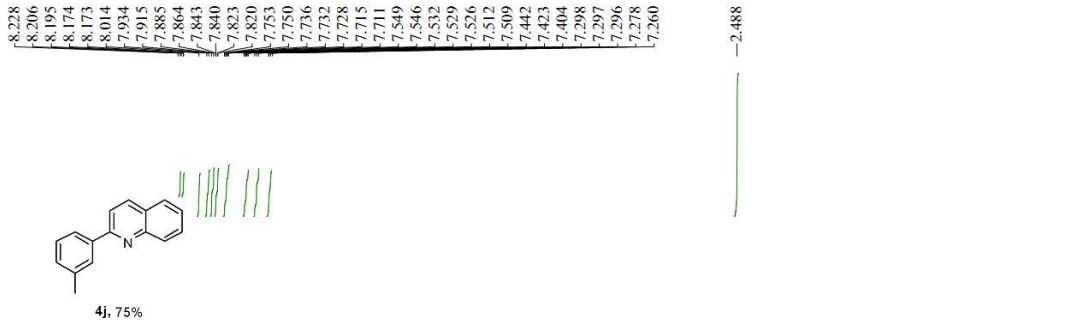
2-(2-Bromophenyl)quinoline (4i)

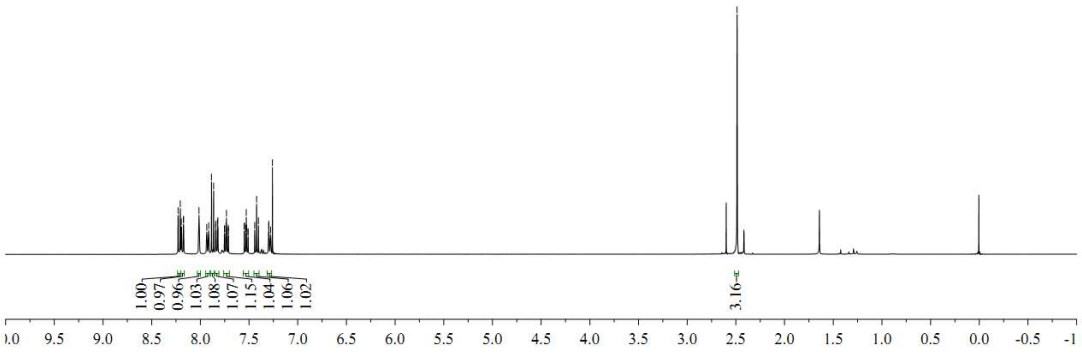


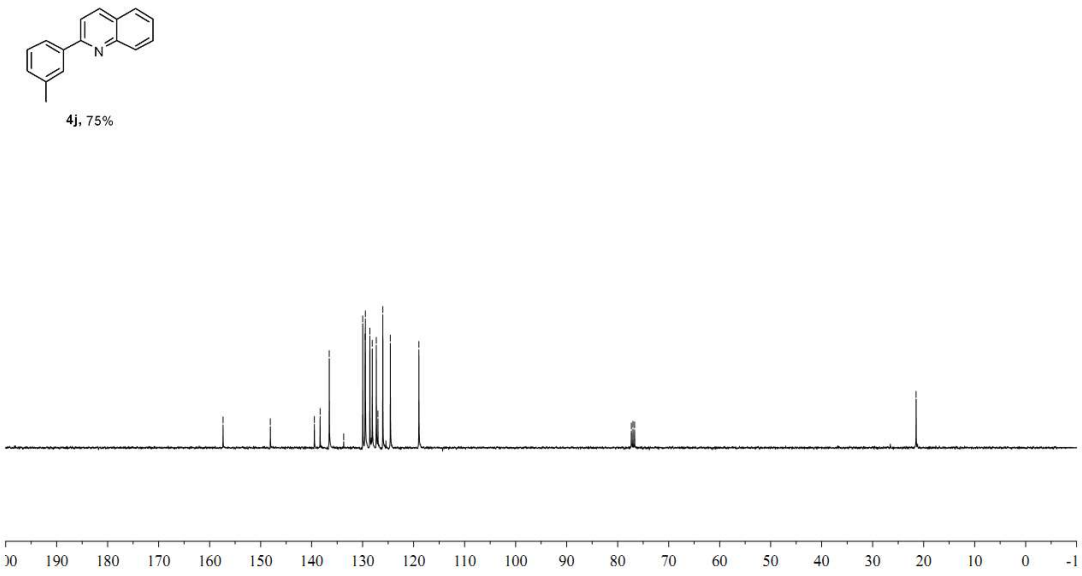




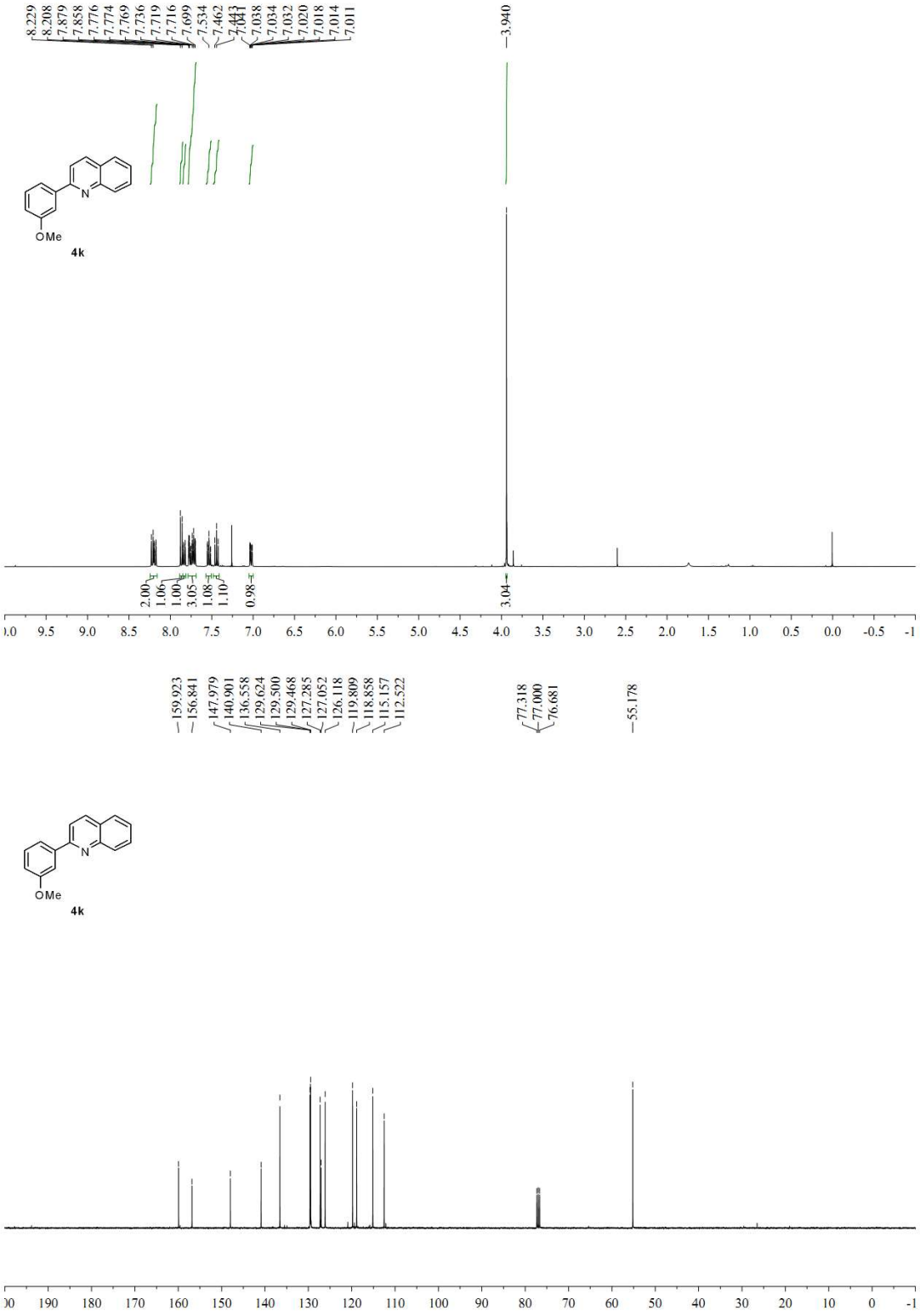
2-(*m*-Tolyl)quinoline (4j)



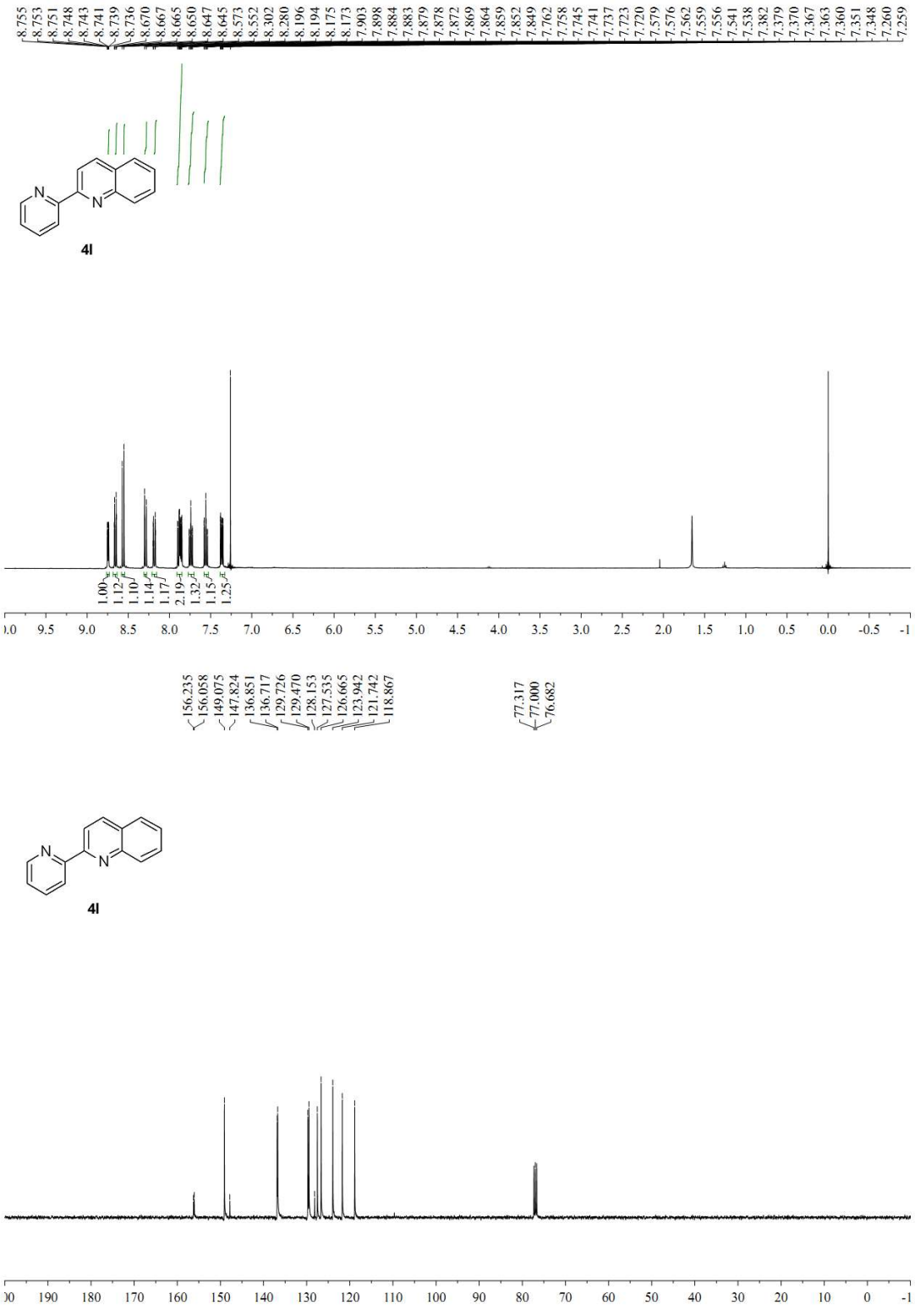




2-(3-Methoxyphenyl)quinoline (4k)



2-(Pyridin-2-yl)quinoline (4l)



5,6-Dihydrobenzo[c]acridine (4m)