Supporting Information

Palladium-Catalyzed C–H Alkylation of 2-Phenylpyridines with Alkyl Iodides

Xiaoling Wang, Xiaoming Ji, Changdong Shao, Yu Zhang, and Yanghui Zhang*

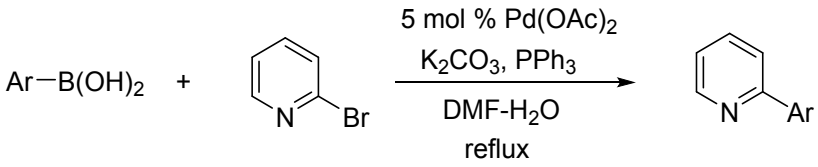
School of Chemical Science and Engineering, and Shanghai Key Lab of Chemical Assessment and Sustainability, Tongji University, 1239 Siping Road, Shanghai, 200092, P. R. China.

*To whom correspondence should be addressed. Email: zhangyanghui@tongji.edu.cn

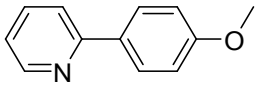
Table of contents

I. Synthesis of starting materials

1. General procedure for the preparation of 2-arylpyridines[1]

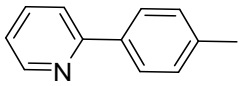


2-Bromopyridine (476.6 uL, 5 mmol, 1.0 equiv), phenylboronic acids (6 mmol, 1.2 equiv), potassium carbonate (2.07 g, 15 mmol, 3.0 equiv), $Pd(OAc)_2$ (56.1 mg, 0.25mmol, 5 mol %) and PPh_3 (1.05 g, 4 mmol, 0.8 equiv) were added in a round bottom flask containing 30 mL DMF:H_2O (25 mL : 25 mL = 1:1). The reaction mixture was stirred for 12 hours at 130 °C. After completion of the reaction, the reaction mixture was washed with brine three times and extracted with ethyl acetate. Then the filtrates were dried over Na_2SO_4 and concentrated under reduced pressure. The residue was purified through column chromatography on silica gel with petroleum ether and ethyl acetate to give the product. Arylpyridine **1b**, **1g**, **1r**, **1s** was purchased from commercial source. The rest of 2-arylpyridines were prepared from corresponding arylboronic acids and 2-bromopyridine.



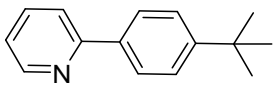
2-(4-methoxyphenyl)pyridine (1a)

White solid: (786 mg, 85%). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.70 (d, *J* = 5.4 Hz, 1H), 8.15 – 7.82 (m, 2H), 7.74 (ddd, *J* = 20.9, 10.9, 4.8 Hz, 2H), 7.21 (ddd, *J* = 7.0, 4.8, 1.4 Hz, 1H), 7.14 – 6.96 (m, 2H), 3.91 (s, 3H). ^{13}C NMR (101 MHz, CDCl3) δ 160.50, 157.17, 149.56, 136.67, 132.08, 128.19, 121.42, 119.83, 114.16, 55.38. HRMS (ESI-TOF) m/z: calcd for $C_{12}H_{11}NNaO^+$: 208.0733$(M + Na)^+$, found: 208.0732.



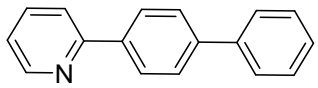
2-(*p*-tolyl)pyridine (1c)

Colorless liquid: (676 mg, 80%). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.73 (d, *J* = 4.8 Hz, 1H), 7.96 (d, *J* = 8.2 Hz, 2H), 7.73 (d, *J* = 3.6 Hz, 2H), 7.33 (d, *J* = 8.0 Hz, 2H), 7.21 (dd, *J* = 8.7, 4.6 Hz, 1H), 2.45 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 157.47, 149.61, 138.95, 136.70, 136.65, 129.53, 126.82, 121.83, 120.27, 21.31. HRMS (ESI-TOF) m/z: calcd for $C_{12}H_{11}NNa^+$: 192.0784 $(M + Na)^+$, found: 192.0788.



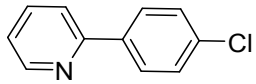
2-(4-(*tert*-butyl)phenyl)pyridine (1d)

Colorless liquid: (591 mg, 56%). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.74 (d, *J* = 4.5 Hz, 1H), 8.00 (d, *J* = 7.9 Hz, 2H), 7.77 (d, *J* = 3.5 Hz, 2H), 7.57 (d, *J* = 8.2 Hz, 2H), 7.25 (dd, *J* = 8.4, 5.0 Hz, 1H), 1.43 (s, 9H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 157.48, 152.17, 149.61, 136.77, 136.58, 126.68, 125.78, 121.89, 120.44, 34.74, 31.37. HRMS (ESI-TOF) m/z: calcd for $C_{15}H_{17}NNa^+$: 234.1253 $(M + Na)^+$, found: 234.1258.



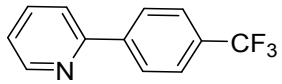
2-([1,1'-biphenyl]-4-yl)pyridine (1e)

White solid: (751 mg, 65%). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.76 (d, *J* = 4.7 Hz, 1H), 8.13 (d, *J* = 8.4 Hz, 2H), 7.85 – 7.79 (m, 2H), 7.77 (d, *J* = 8.3 Hz, 2H), 7.74 – 7.68 (m, 2H), 7.52 (t, *J* = 7.6 Hz, 2H), 7.42 (t, *J* = 7.3 Hz, 1H), 7.34 – 7.24 (m, 1H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 157.09, 149.76, 141.75, 140.63, 138.31, 136.76, 128.84, 127.54, 127.48, 127.32, 127.12, 122.12, 120.47. HRMS (ESI-TOF) m/z: calcd for $C_{17}H_{13}NNa^+$: 254.0940 $(M + Na)^+$, found: 254.0942.



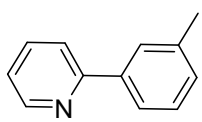
2-(4-chlorophenyl)pyridine (1f)

Colorless solid：(463 mg, 49%). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.72 (d, *J* = 4.5 Hz, 1H), 7.97 (d, *J* = 8.5 Hz, 2H), 7.79 (ddd, *J* = 7.8, 7.8, 1.5 Hz, 1H), 7.73 (d, *J* = 7.9 Hz, 1H), 7.48 (d, *J* = 8.5 Hz, 2H), 7.32 – 7.24 (m, 1H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 156.31, 149.77, 136.89, 136.47 , 133.39, 128.95, 128.20, 122.40, 120.35. HRMS (ESI-TOF) m/z: calcd for $C_{11}H_9ClN^+$: 190.0418 $(M + H)^+$, found: 190.0419.



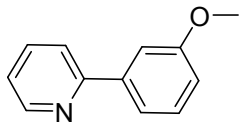
2-(4-(trifluoromethyl)phenyl)pyridine (1h)

White solid: (529 mg, 43%). ^{1}H NMR (400 MHz, CDCl3) δ 8.76 (d, J = 4.7 Hz, 1H), 8.15 (d, J = 8.2 Hz, 2H), 7.89 – 7.66 (m, 4H), 7.33 (t, J = 6.6 Hz, 1H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 155.87, 149.93, 142.70, 136.96, 130.80 (q, *J* = 32.4 Hz), 127.20, 125.67 (q, *J* = 3.9 Hz), 124.23 (q, *J* = 272.0 Hz), 122.96, 120.84. HRMS (ESI-TOF) m/z: calcd for $C_{12}H_8F_3NNa^+$: 246.0501$(M + Na)^+$, found: 246.0498.



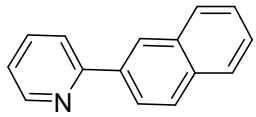
2-(*m*-tolyl)pyridine (1i)

Colorless liquid: (650 mg, 77%). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.73 (t, *J* = 7.1 Hz, 1H), 7.89 (s, 1H), 7.84 – 7.73 (m, 3H), 7.42 (t, *J* = 7.6 Hz, 1H), 7.33 – 7.22 (m, 2H), 2.49 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 157.66, 149.65, 139.39, 138.47, 136.77, 129.77, 128.68, 127.69, 124.04, 122.07, 120.70, 21.59. HRMS (ESI-TOF) m/z: calcd for $C_{12}H_{11}NNa^+$: 192.0784 $(M + Na)^+$, found: 192.0797.



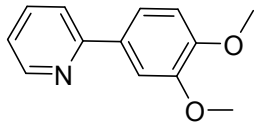
2-(3-methoxyphenyl)pyridine (1j)

White solid: (814 mg, 88%). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.74 (d, *J* = 4.5 Hz, 1H), 7.79 (q, *J* = 8.1 Hz, 2H), 7.67 – 7.54 (m, 2H), 7.43 (t, *J* = 7.9 Hz, 1H), 7.33 – 7.25 (m, 1H), 7.02 (dd, *J* = 8.1, 1.9 Hz, 1H), 3.94 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 160.10, 157.27, 149.63, 140.92, 136.78, 129.76, 122.28, 120.76, 119.34, 115.13, 112.01, 55.42. HRMS (ESI-TOF) m/z: calcd for $C_{12}H_{11}NNaO^+$: 208.0733 $(M + Na)^+$, found: 208.0740.



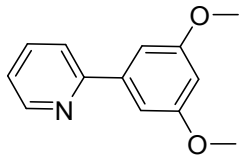
2-(naphthalen-2-yl)pyridine (1k)

White solid: (728 mg, 71%). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.80 (d, *J* = 4.1 Hz, 1H), 8.54 (s, 1H), 8.19 (d, *J* = 8.6 Hz, 1H), 8.00 (d, *J* = 8.1 Hz, 2H), 7.93 (t, *J* = 5.4 Hz, 2H), 7.88 – 7.80 (m, 1H), 7.56 (dd, *J* = 6.1, 3.4 Hz, 2H), 7.38 – 7.27 (m, 1H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 157.37, 149.82, 136.86, 136.71, 133.67, 133.55, 128.76, 128.49, 127.70, 126.56, 126.36, 126.34, 124.59, 122.20, 120.87. HRMS (ESI-TOF) m/z: calcd for $C_{15}H_{11}NNa^+$: 228.0784 $(M + Na)^+$, found: 228.0783.



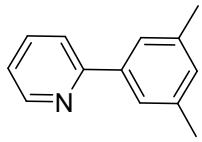
2-(3,4-dimethoxyphenyl)pyridine (1l)

White solid: (677 mg, 63%). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.70 (d, *J* = 4.5 Hz, 1H), 7.82 – 7.68 (m, 3H), 7.55 (dd, *J* = 8.4, 1.9 Hz, 1H), 7.26 – 7.17 (m, 1H), 7.00 (d, *J* = 8.4 Hz, 1H), 4.04 (s, 3H), 3.98 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 157.07, 149.97, 149.50, 149.29, 136.70, 132.37, 121.59, 120.00, 119.37, 111.07, 109.92, 56.33, 56.00. HRMS (ESI-TOF) m/z: calcd for $C_{13}H_{13}NNaO_2^+$: 238.0838 $(M + Na)^+$, found: 238.0841.



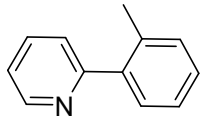
2-(3,5-dimethoxyphenyl)pyridine (1m)

White solid: (623 mg, 58%). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.73 (d, J = 4.7 Hz, 1H), 7.93 – 7.64 (m, 2H), 7.45 – 7.24 (m, 2H), 7.19 (d, J = 2.2 Hz, 2H), 3.90 (d, J = 11.9 Hz, 6H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 161.15, 157.23, 149.49, 141.55, 136.72, 122.43, 120.88, 104.99, 101.52, 55.54. HRMS (ESI-TOF) m/z: calcd for $C_{13}H_{13}NNaO_2^+$: 238.0838 $(M + Na)^+$, found: 238.0840.



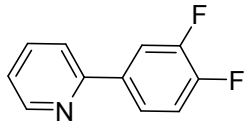
2-(3,5-dimethylphenyl)pyridine (1n)

Colorless liquid: (622 mg, 68%). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.73 (d, J = 4.7 Hz, 1H), 7.83 – 7.72 (m, 2H), 7.65 (s, 2H), 7.28 – 7.22 (m, 1H), 7.11 (s, 1H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 157.83, 149.56, 139.38, 138.31, 136.69, 130.65, 124.82, 121.97, 120.73, 21.43. HRMS (ESI-TOF) m/z: calcd for $C_{13}H_{13}NNa^+$: 206.0940 $(M + Na)^+$, found: 206.0941.



2-(o-tolyl)pyridine (1o)

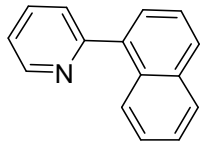
Colorless liquid: (743mg, 88%). ^{1}H NMR (400 MHz, CDCl3) δ 8.74 (d, J = 4.4 Hz, 1H), 7.79 (t, J = 8.5 Hz, 1H), 7.45 (d, J = 7.7 Hz, 2H), 7.39 – 7.27 (m, 4H), 2.41 (s, 3H). ^{13}C NMR (101 MHz, CDCl3) δ 160.06, 149.22, 140.46, 136.15, 135.76, 130.76, 129.64, 128.30, 125.90, 124.13, 121.66, 20.31. HRMS (ESI-TOF) m/z: calcd for $C_{12}H_{11}NNa^+$: 192.0784 $(M + Na)^+$, found: 192.0785.



2-(3,4-difluorophenyl)pyridine (1p)

White solid: (382 mg, 40%). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.75 (d, J = 4.8 Hz, 1H), 8.04 (td, J = 8.8, 6.7 Hz, 1H), 7.79 (d, J = 4.0 Hz, 2H), 7.30 (dd, J = 9.1, 4.3 Hz, 1H), 7.05 (td, J = 9.0, 2.4 Hz, 1H), 6.96 (ddd, J = 11.3, 8.8, 2.5 Hz, 1H). ^{13}C NMR (101 MHz, CDCl3) δ 164.52 (d, J_{CF} = 12.02 Hz), 162.02 (t, J_{CF} = 12.85 Hz), 159.40 (t, J_{CF} = 12.01 Hz), 152.57 (d, J_{CF} = 2.38 Hz), 149.80 (d, J_{CF} = 9.41Hz), 136.50, 132.22 (t,

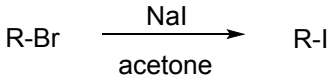
J_{CF} = 4.48 Hz), 124.28 (d, J_{CF} = 9.01 Hz) 122.45, 112.02(t, J_{CF} = 21.02 Hz) 104.64 (t, J_{CF} = 26.26 Hz), HRMS (ESI-TOF) m/z: calcd for $C_{11}H_7F_2NNa^+$: 214.0439 $(M + Na)^+$,found: 214.0851.



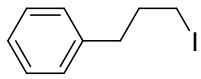
2-(naphthalen-1-yl)pyridine (1q)

White solid: (651 mg, 62%). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.86 (d, *J* = 4.7 Hz, 1H), 8.15 (d, *J* = 8.1 Hz, 1H), 7.97 (d, *J* = 8.3 Hz, 2H), 7.87 (td, *J* = 7.7, 1.2 Hz, 1H), 7.64 (dt, *J* = 15.4, 7.1 Hz, 3H), 7.59 – 7.50 (m, 2H), 7.39 (dd, *J* = 7.0, 5.4 Hz, 1H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 159.32, 149.54, 138.48, 136.51, 133.99, 131.21, 128.97, 128.42, 127.54, 126.54, 125.94, 125.63, 125.35, 125.16, 122.12. HRMS (ESI-TOF) m/z: calcd for $C_{15}H_{11}NNa^+$: 228.0784 $(M + Na)^+$, found: 228.0781.

2. General procedure for the synthesis of alkyl iodides[2]

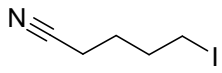


To a solution of corresponding alkyl bromide (5 mmol) in 15 mL acetone was added NaI (25 mmol, 4.15 g). The mixture was heated to reflux for 6 h. After being allowed to cool down to room temperature, the solvent was evaporated under reduced pressure, followed by the addition of 15 mL DCM. Then the mixture was filtered, and the filtrate was washed with aqueous Na_2S and brine, dried over Na_2SO_4, and concentrated in vacuo. The resulted residue was purified by short silica gel column chromatography to give the products. Alkyl iodide **2c**, **2d**, **2e** and **2g** were prepared from corresponding alkyl bromide. **2a**, **2b**, and **2f** were purchased from commercial source.



(3-iodopropyl)benzene (2c)

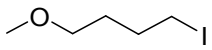
Colorless liquid (1.2 g, 100%). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.36 (t, *J* = 7.3 Hz, 2H), 7.28 (dd, *J* = 14.7, 7.4 Hz, 3H), 3.23 (t, *J* = 6.8 Hz, 2H), 2.79 (t, *J* = 7.3 Hz, 2H), 2.24 – 2.13 (m, 2H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 140.45, 128.61, 128.55, 126.23, 36.27, 34.95, 6.47.



5-iodopentanenitrile (2d)

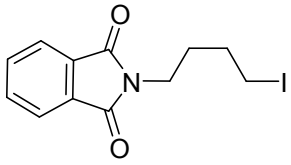
Colorless liquid (1.0 g, 100%). ^{1}H NMR (400 MHz, $CDCl_3$) δ 3.25 (t, *J* = 6.6 Hz, 2H), 2.44 (t, *J* = 7.0 Hz, 2H), 2.08 – 1.96 (m, 2H), 1.85 (dd, *J* = 14.6, 7.3 Hz, 2H). ^{13}C

NMR (101 MHz, $CDCl_3$) δ 119.16, 31.84, 26.21, 16.30, 4.54. HRMS (ESI-TOF) m/z: calcd for $C_5H_8INNa^+$: 231.9594 $(M + Na)^+$, found: 231.9589.



1-iodo-4-methoxybutane (2e)

Slightly brown liquid (1.0 g, 100%). ^1H NMR (400 MHz, $CDCl_3$) δ 3.42 (t, J = 6.2 Hz, 2H), 3.36 (s, 3H), 3.25 (t, J = 6.9 Hz, 2H), 2.02 – 1.89 (m, 2H), 1.74 – 1.65 (m, 2H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 71.44, 58.65, 30.51, 30.34, 6.88. HRMS (ESI-TOF) m/z: calcd for $C_5H_{11}INaO^+$: 236.9747 $(M + Na)^+$, found: 236.9715.

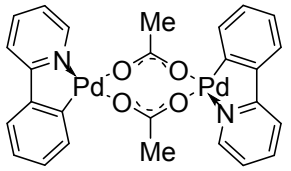


2-(4-iodobutyl)isoindoline-1,3-dione (2g)

White solid (1.6 g, 100%). ^1H NMR (400 MHz, $CDCl_3$) δ 7.88 (dd, J = 6.8, 3.4 Hz, 2H), 7.76 (dd, J = 5.4, 3.1 Hz, 2H), 3.75 (t, J = 6.7 Hz, 2H), 3.26 (t, J = 6.6 Hz, 2H), 1.99 – 1.78 (m, 4H). ^{13}C NMR (101 MHz, CDCl3) δ 168.37, 134.02, 132.06, 123.30, 36.76, 30.57, 29.55, 5.61. HRMS (ESI-TOF) m/z: calcd for $C_{12}H_{12}INNaO_2^+$: 351.9805 $(M + Na)^+$, found: 351.9801.

3. Synthesis of 2-phenylpyridyl palladium acetate dimer [3]

To a solution of 2-phenylpyridine (3.46 g, 22.3 mmol) in CH_2Cl_2 (220 mL) at room temperature was added palladium acetate (5.00 g, 22.3 mmol). After stirring for 3 h at room temperature, the orange solution was concentrated in vacuo and the solid residue was triturated with ethyl ether (70 mL). The solid was isolated by vacuum filtration and washed with ethyl ether (2 × 30 mL) to afford 6.40 g of the titled compound .



2-phenylpyridyl palladium acetate dimer (4b)

Orange-yellow solid (6.40 g, 90%). ^1H NMR (400 MHz, $CDCl_3$) δ 7.92 (d, J = 5.6 Hz, 1H), 7.42 (t, J = 8.5 Hz, 1H), 7.13 (d, J = 8.0 Hz, 1H), 6.97 (d, J = 6.4 Hz, 1H), 6.88 (dt, J = 15.5, 5.6 Hz, 3H), 6.49 (t, J = 6.6 Hz, 1H), 2.32 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 181.66, 164.15, 151.91, 150.08, 144.39, 137.45, 131.80, 128.36, 123.85, 122.30, 120.98, 117.06, 24.89.

II. References

1 C. Premi, A. Dixit and N. Jain, *Org. let.*, 2015, **17**, 2598−2601.

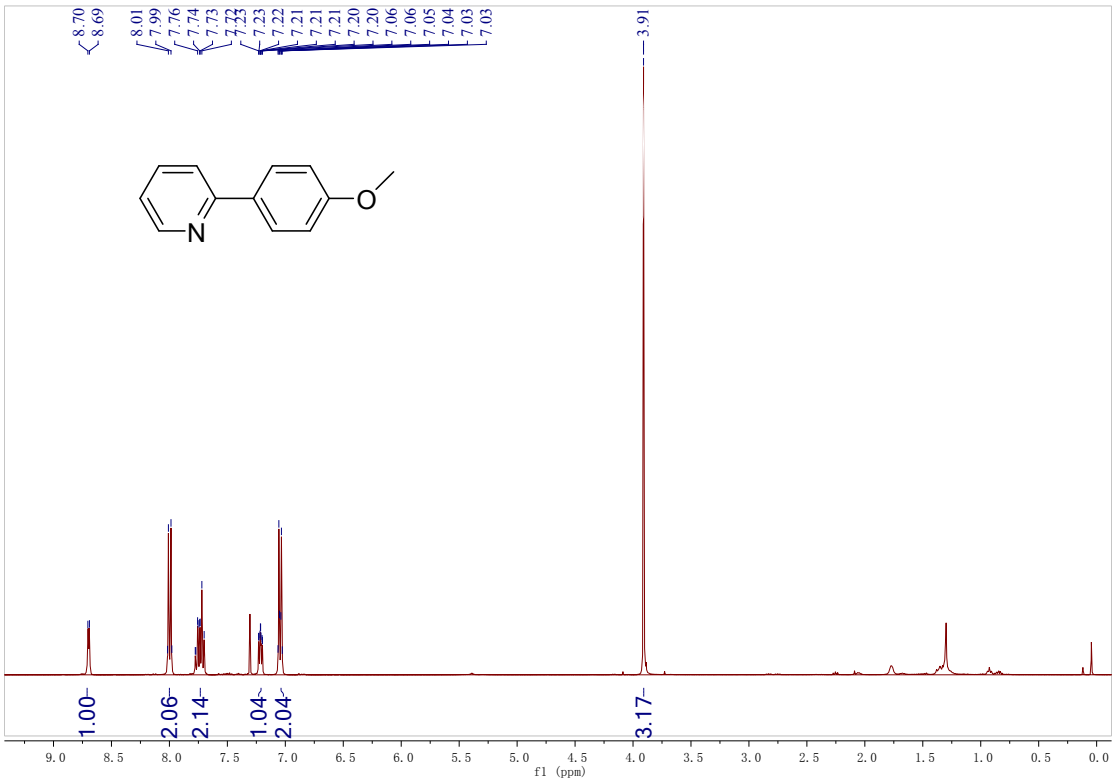
2 P. X. Shen, X. C. Wang, P. Wang, R. Y. Zhu and J. Q. Yu, *J. Am. Chem. Soc.*, 2015, **137**, 11574−11577.

3 C. Xu and Q. Shen, *Org, lett.*, 2014, **16**, 2046−2049.

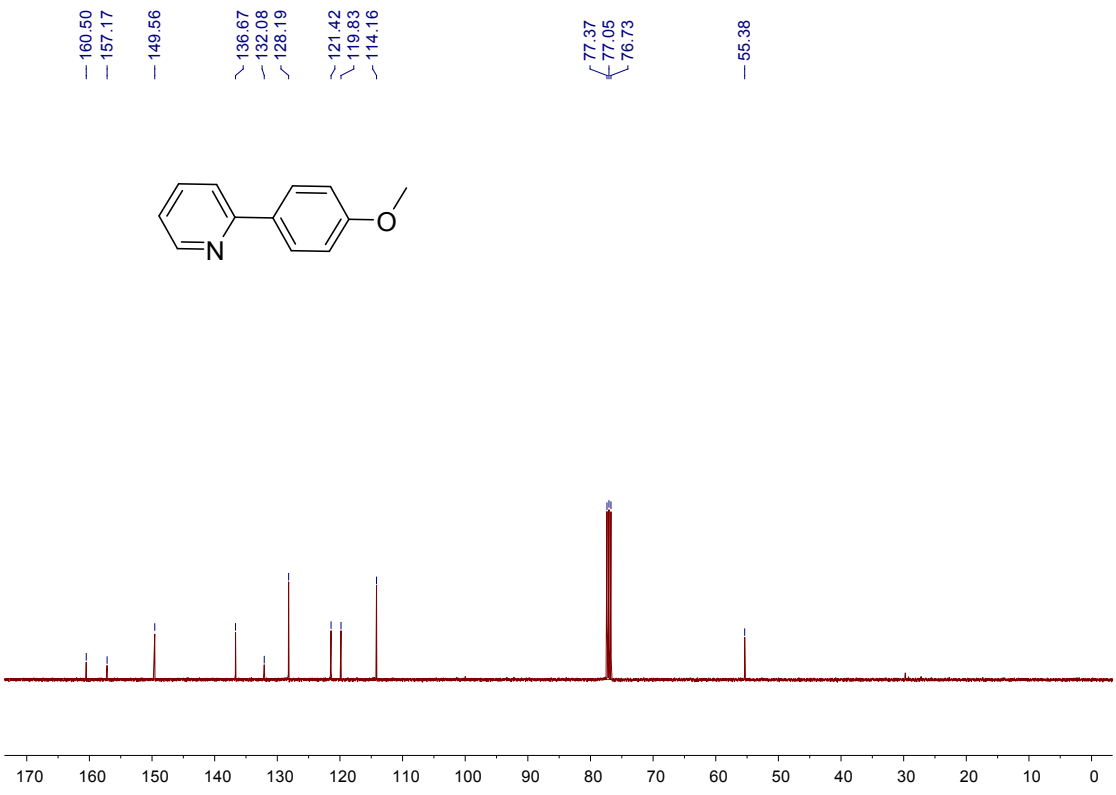
III. ^{1}H and ^{13}C NMR spectra of all compounds

2-(4-methoxyphenyl)pyridine (1a)

^{1}H NMR ($CDCl_3$)

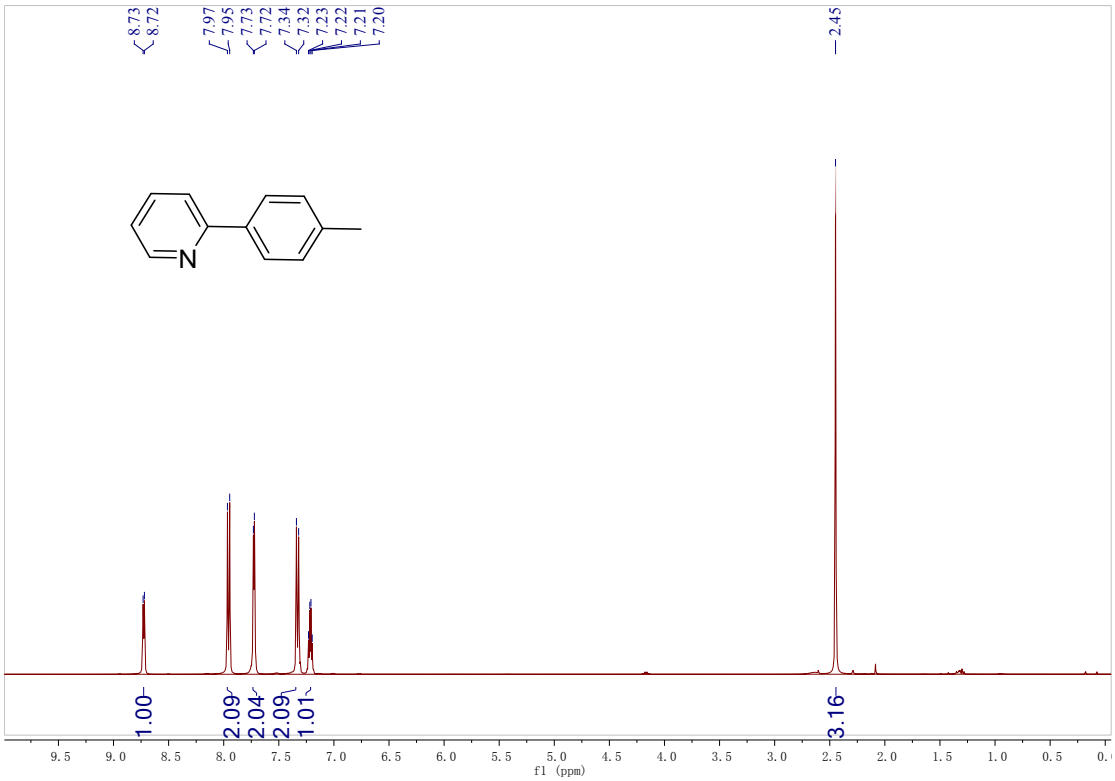


^{13}C NMR ($CDCl_3$)

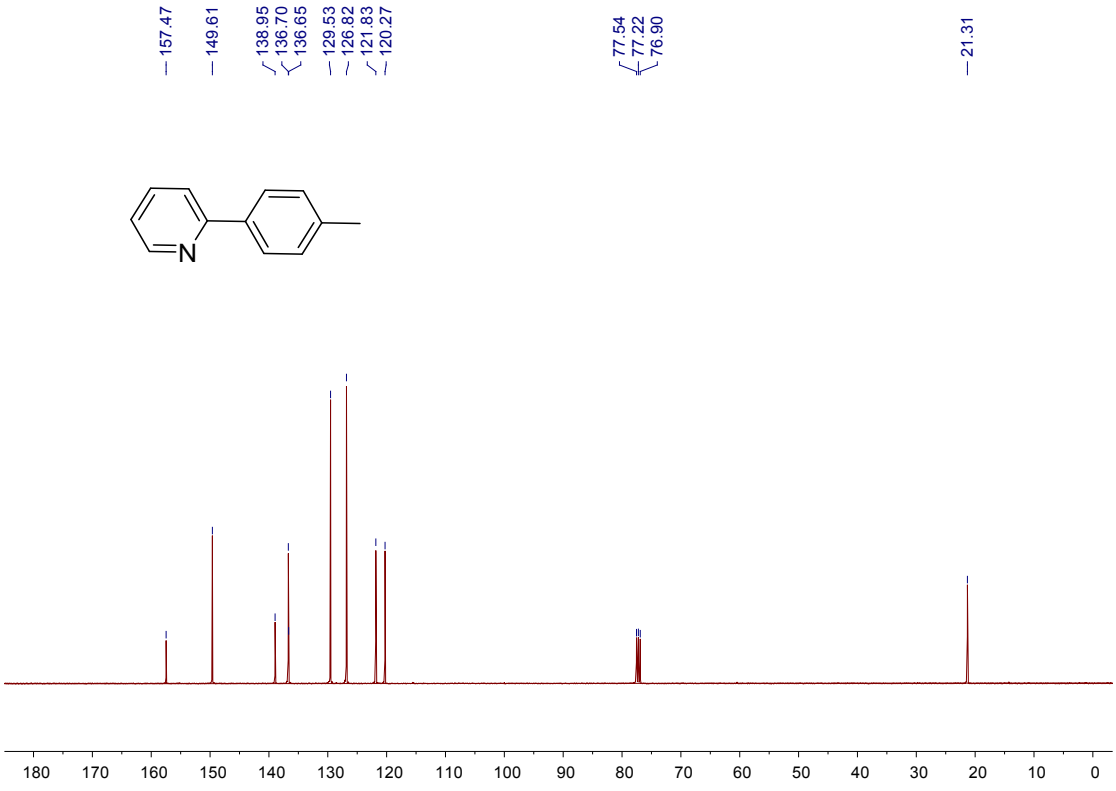


2-(*p*-tolyl)pyridine (1c)

^{1}H NMR ($CDCl_3$)

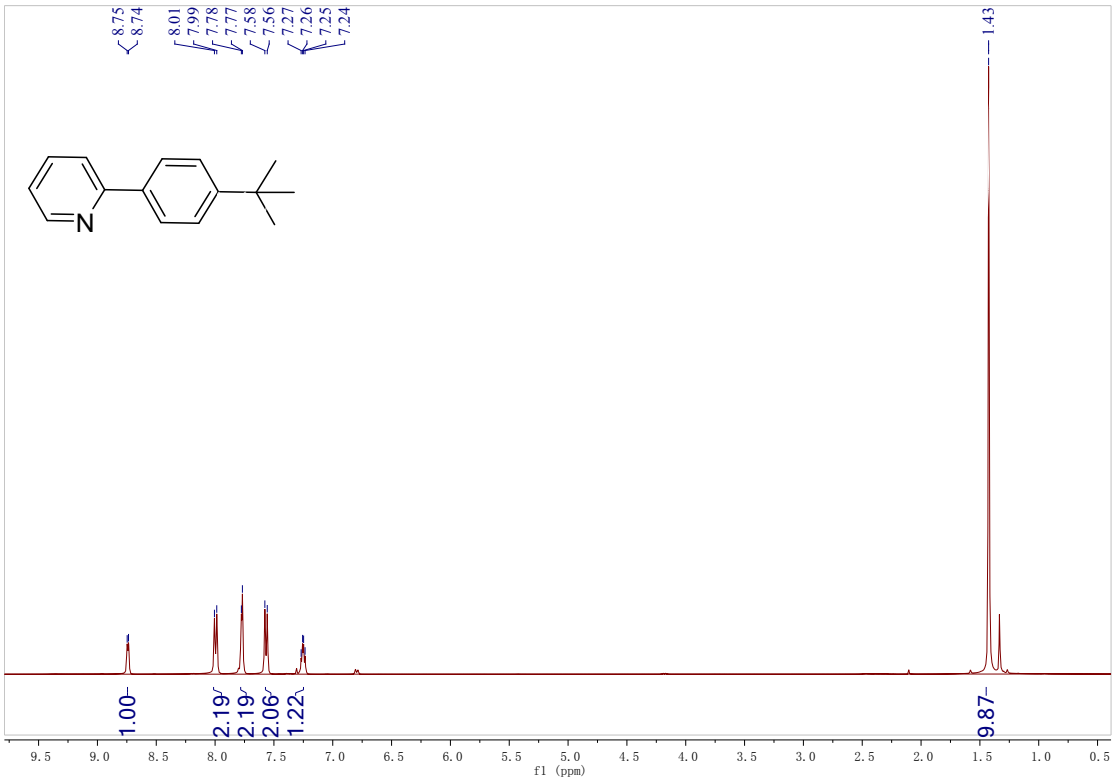


^{13}C NMR ($CDCl_3$)

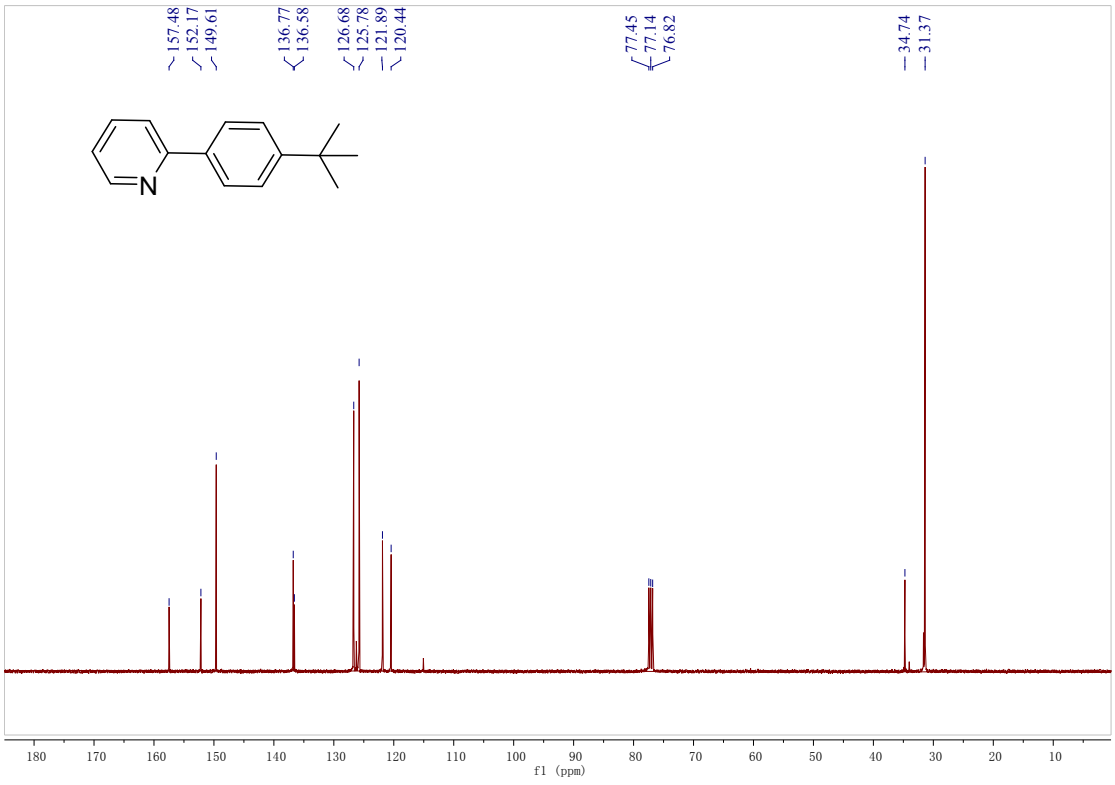


2-(4-(*tert*-butyl)phenyl)pyridine (1d)

^{1}H NMR ($CDCl_3$)

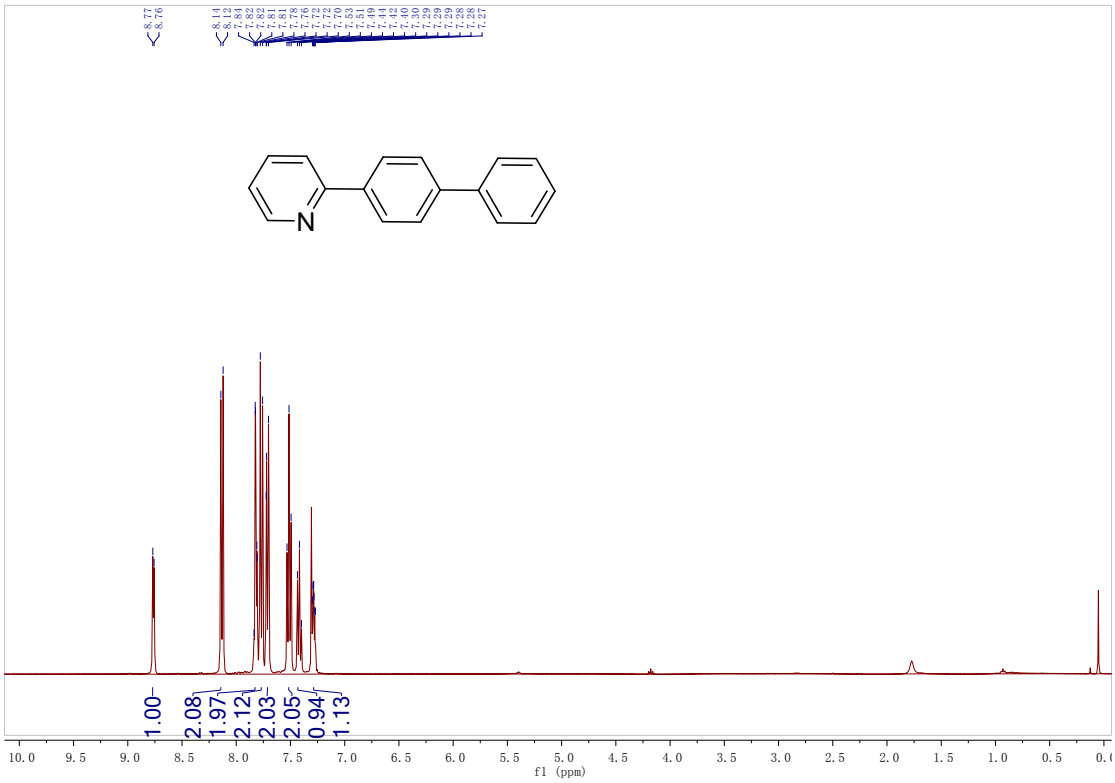


^{13}C NMR ($CDCl_3$)

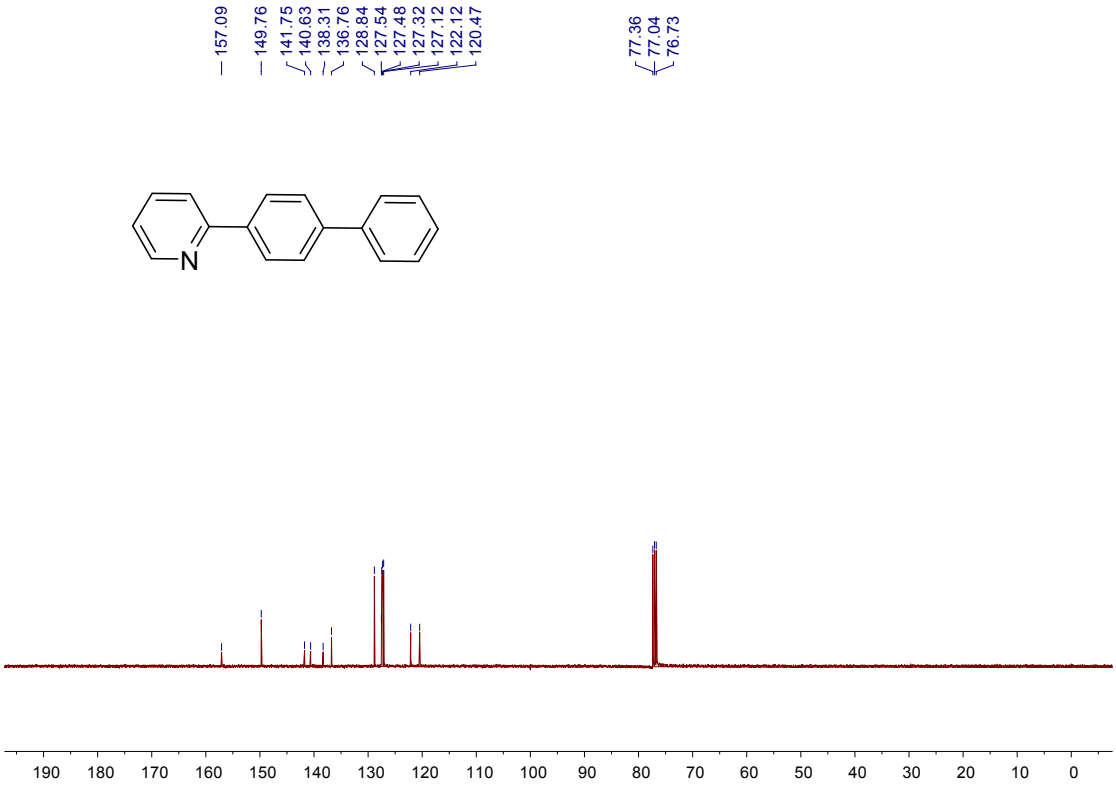


2-([1,1'-biphenyl]-4-yl)pyridine (1e)

^{1}H NMR ($CDCl_3$)

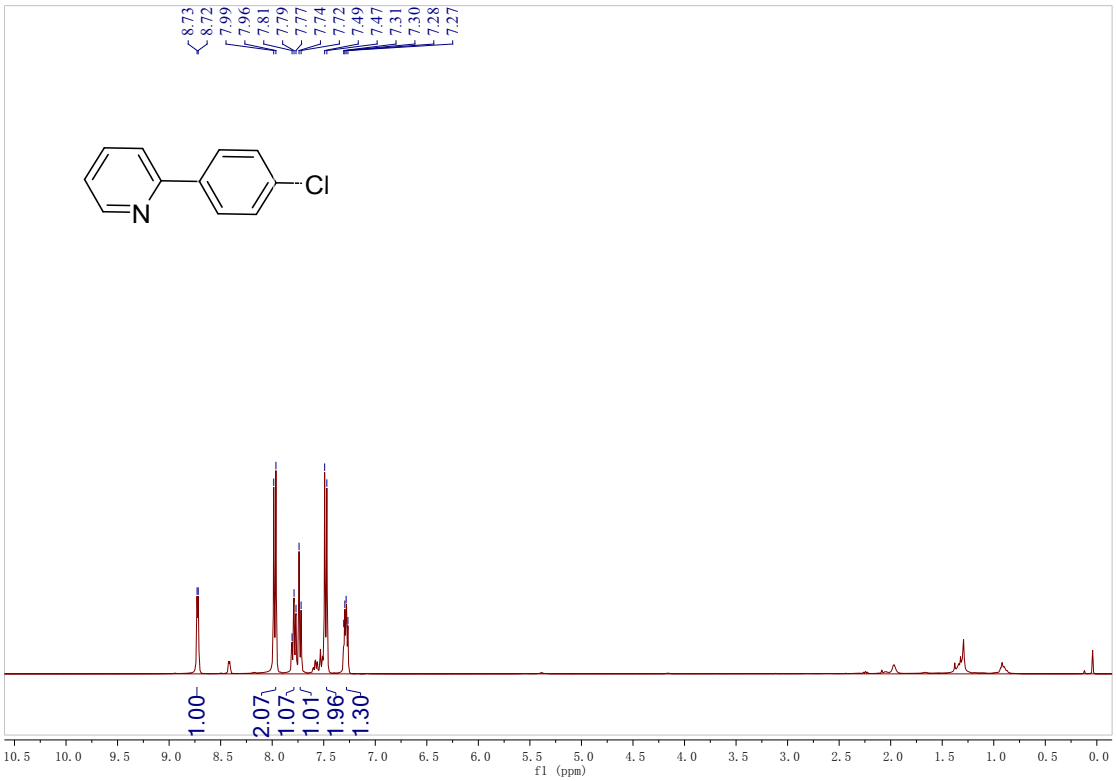


^{13}C NMR ($CDCl_3$)

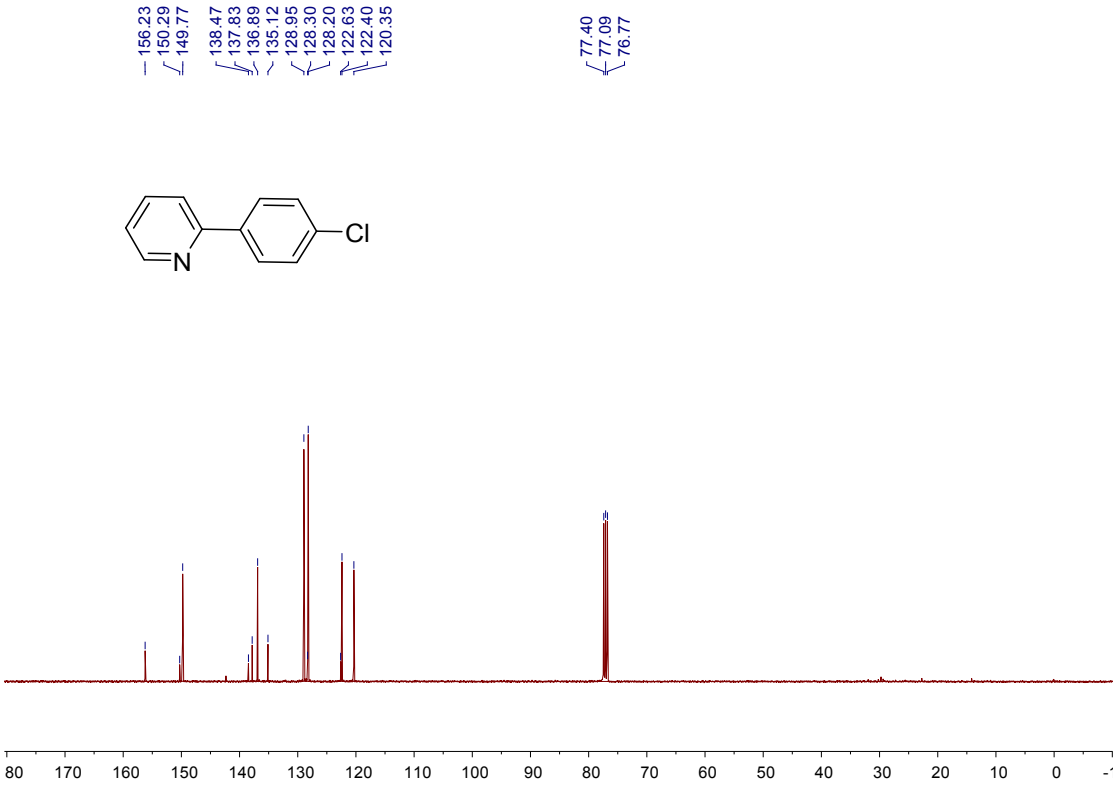


2-(4-chlorophenyl)pyridine (1f)

^{1}H NMR ($CDCl_3$)

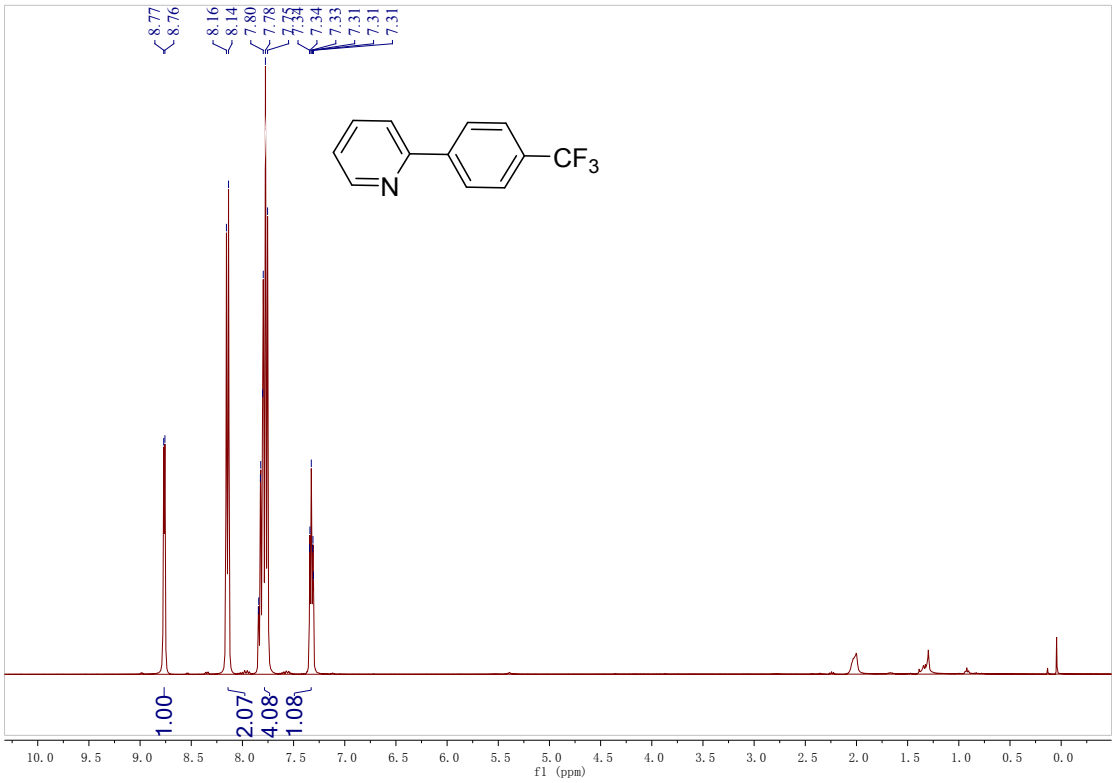


^{13}C NMR ($CDCl_3$)

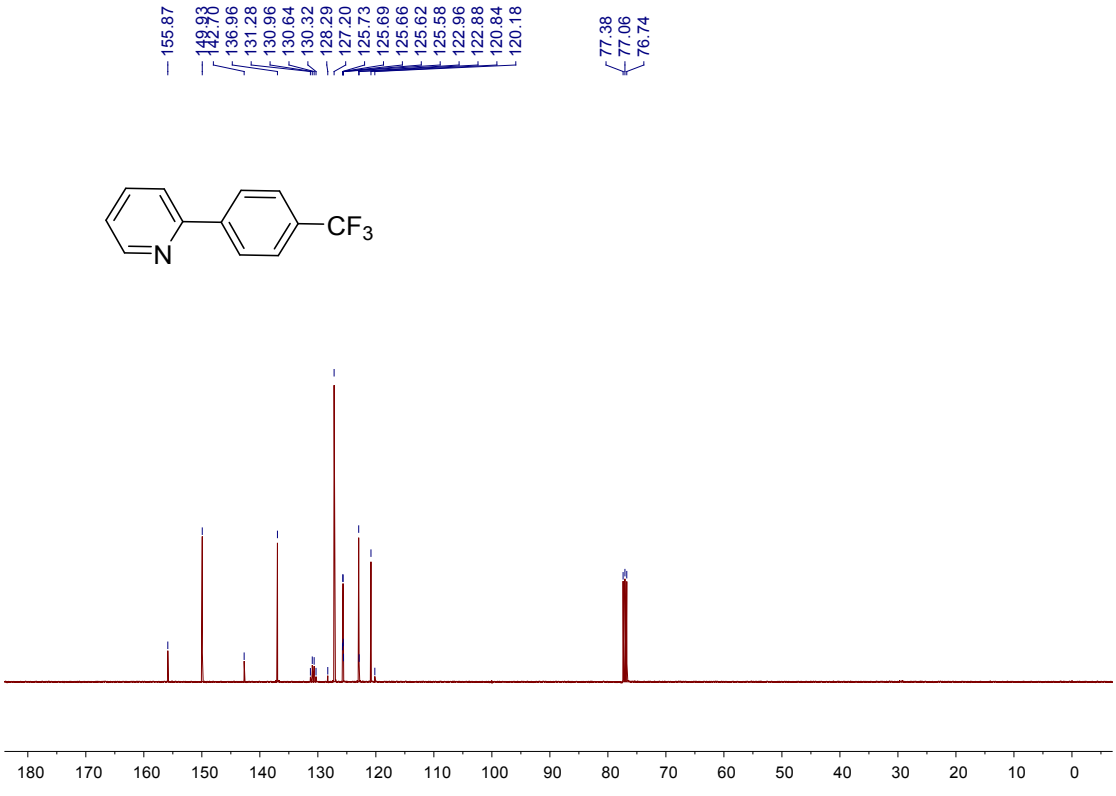


2-(4-(trifluoromethyl)phenyl)pyridine (1h)

^{1}H NMR ($CDCl_3$)

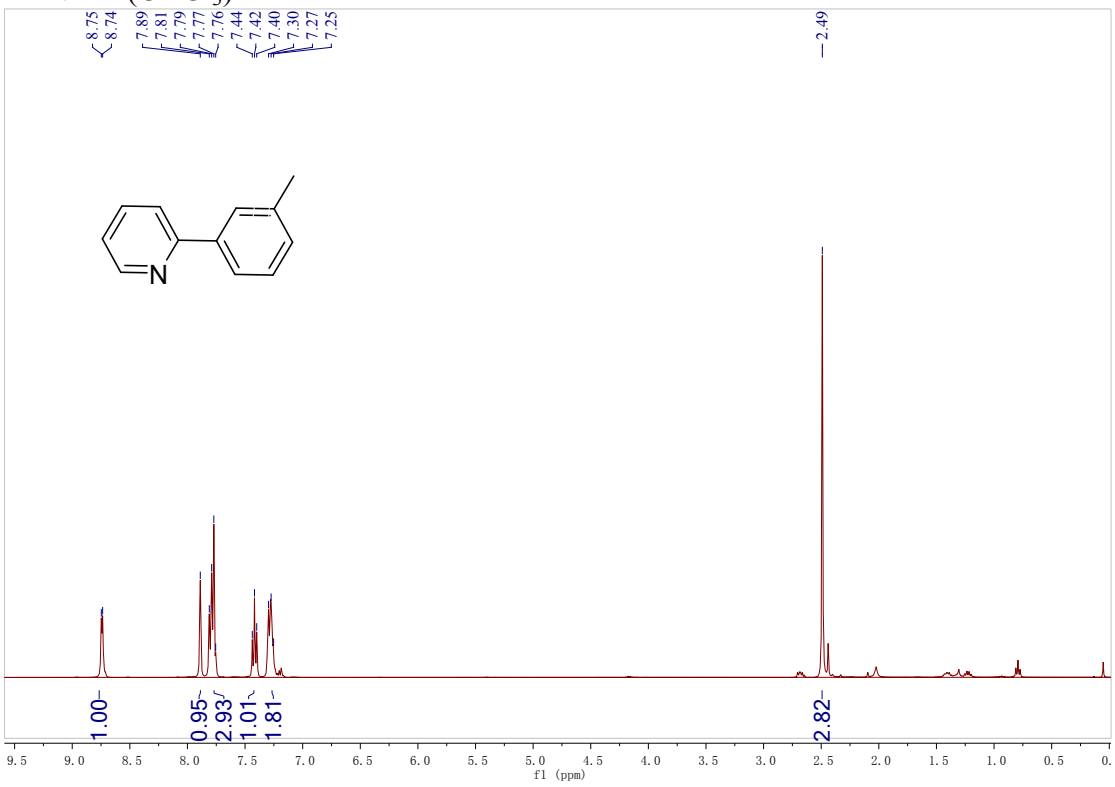


^{13}C NMR ($CDCl_3$)

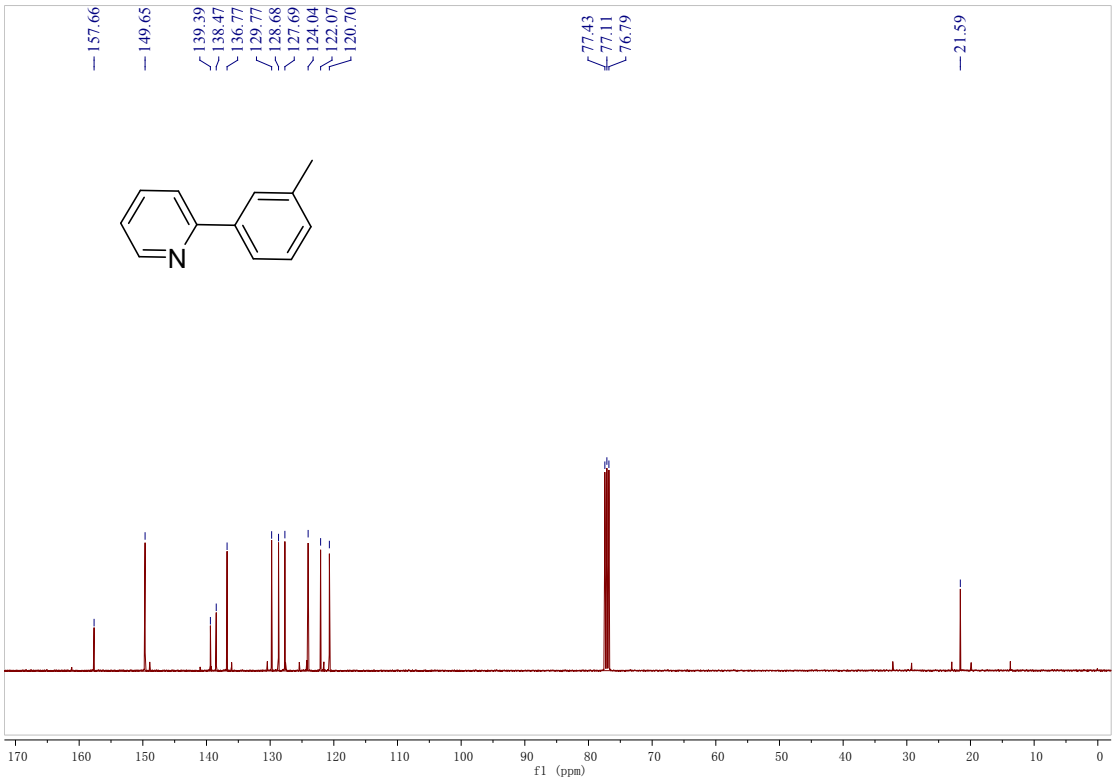


2-(*m*-tolyl)pyridine (1i)

^{1}H NMR ($CDCl_3$)

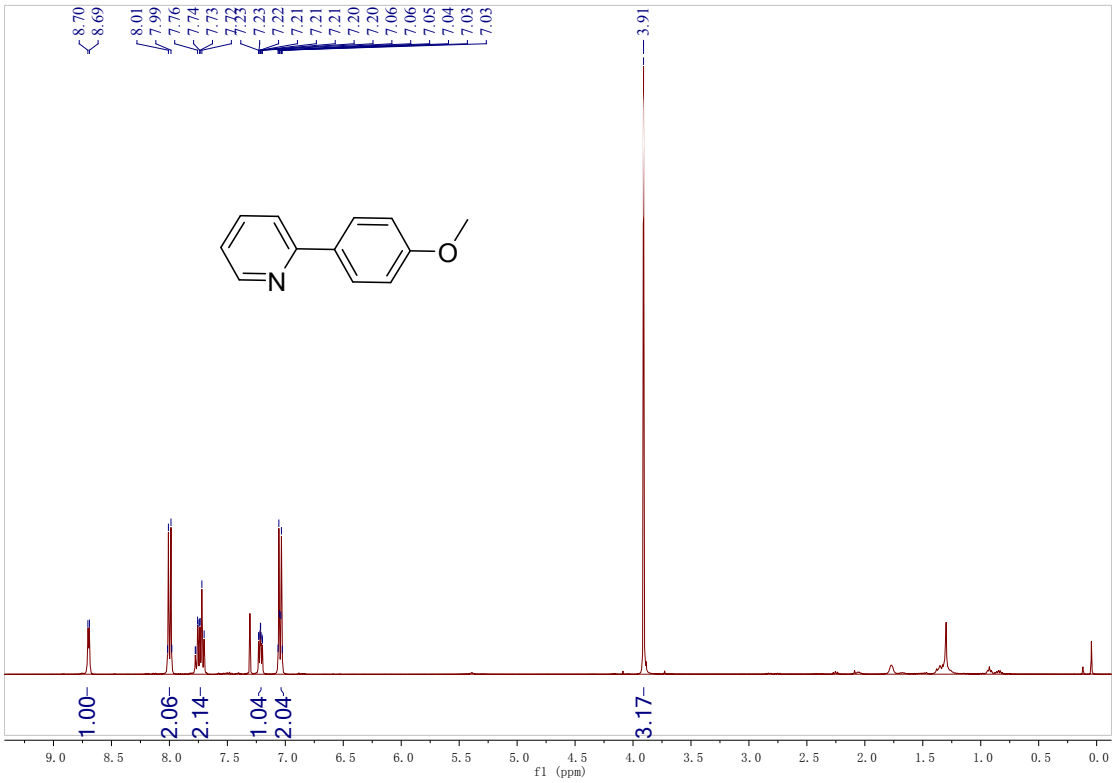


^{13}C NMR ($CDCl_3$)

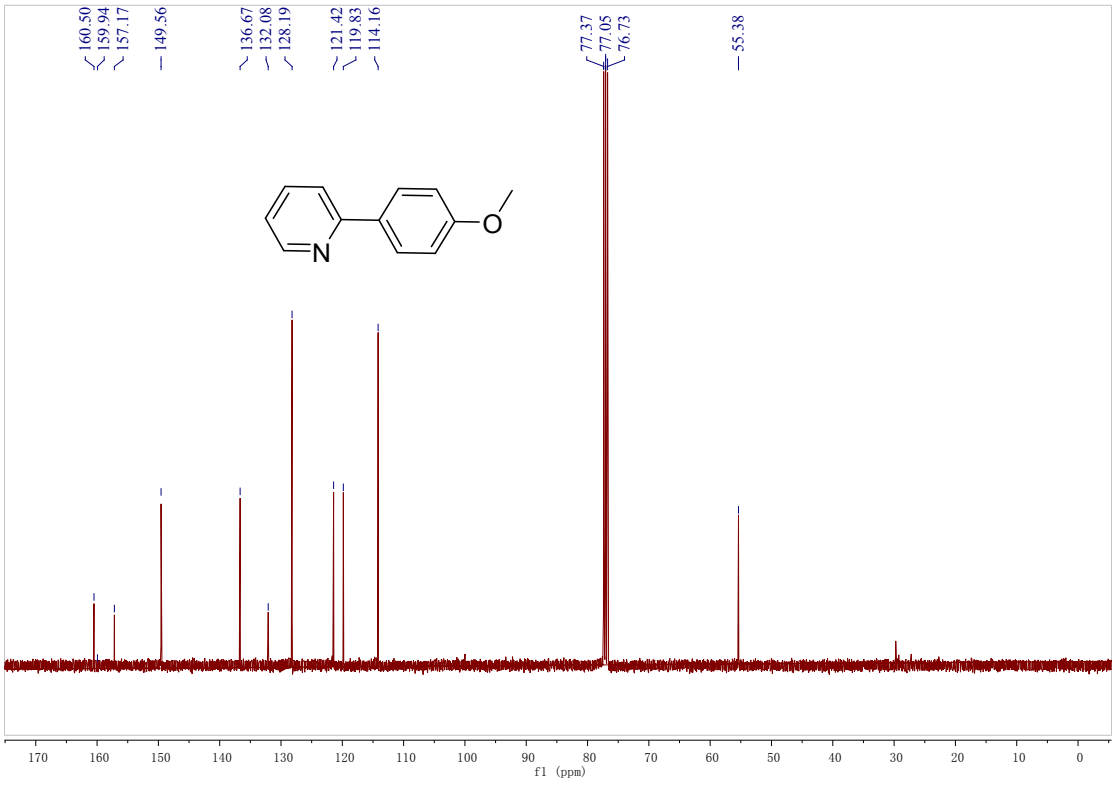


2-(4-methoxyphenyl)pyridine (1j)

^{1}H NMR ($CDCl_3$)

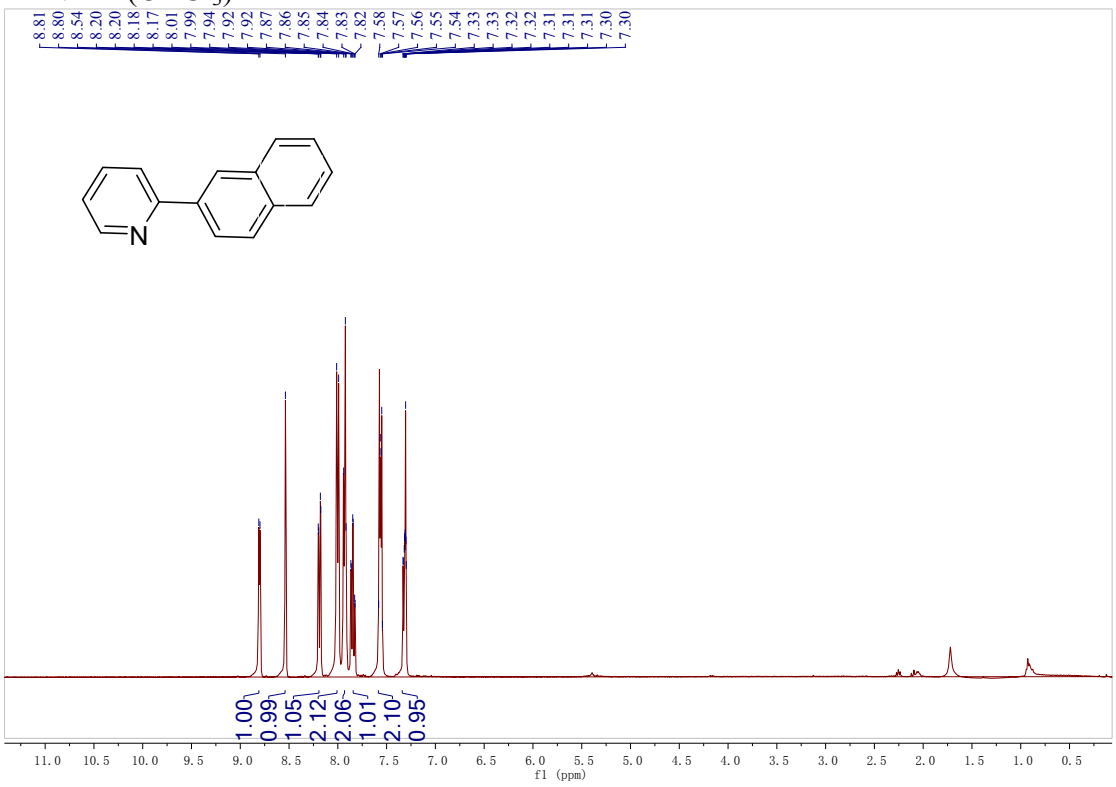


^{13}C NMR ($CDCl_3$)

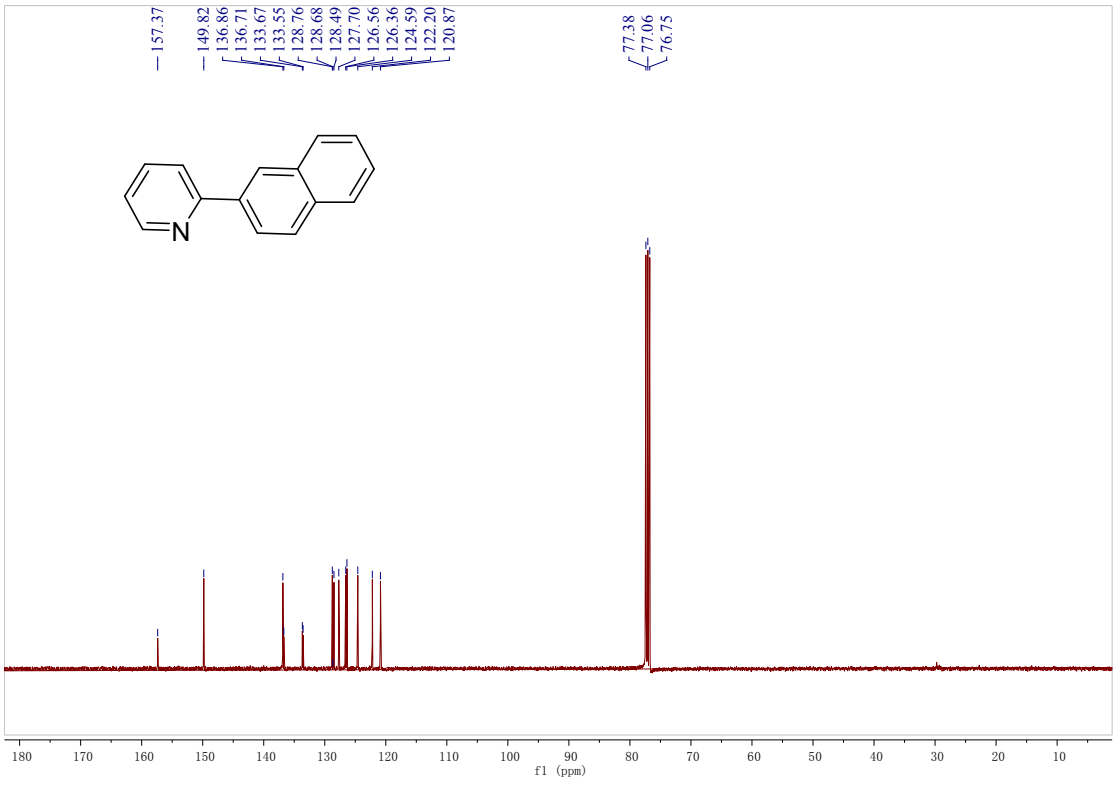


2-(naphthalen-2-yl)pyridine(1k)

^{1}H NMR ($CDCl_3$)

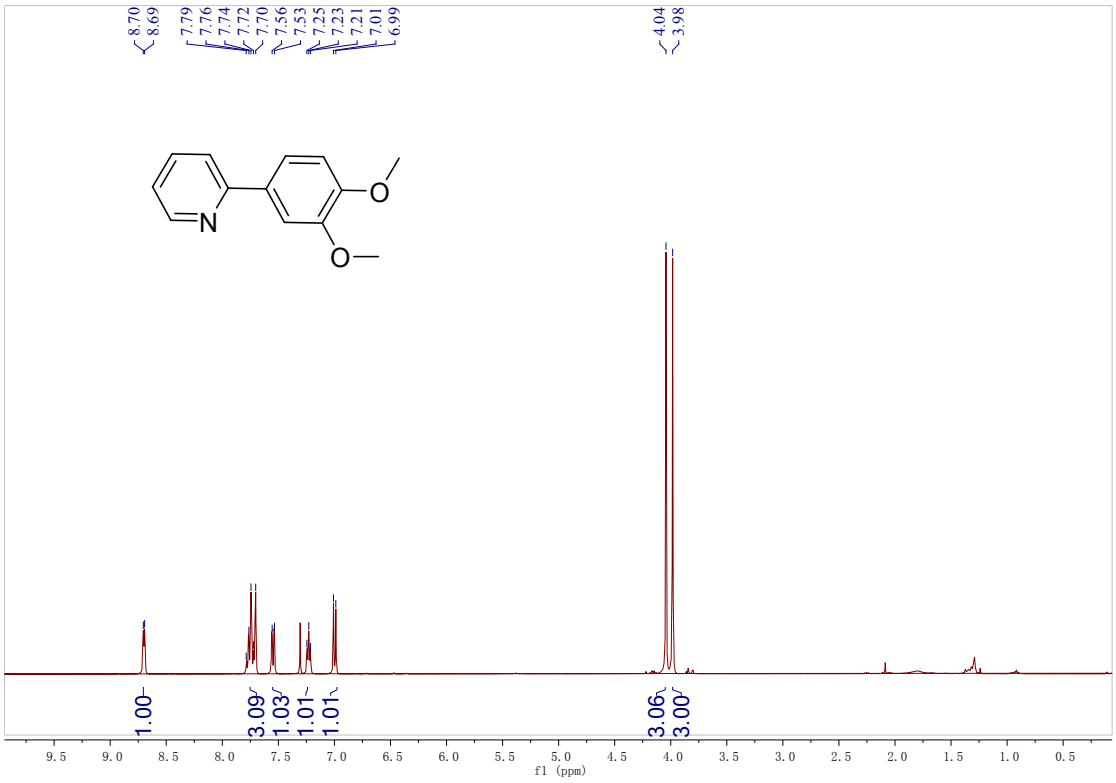


^{13}C NMR ($CDCl_3$)

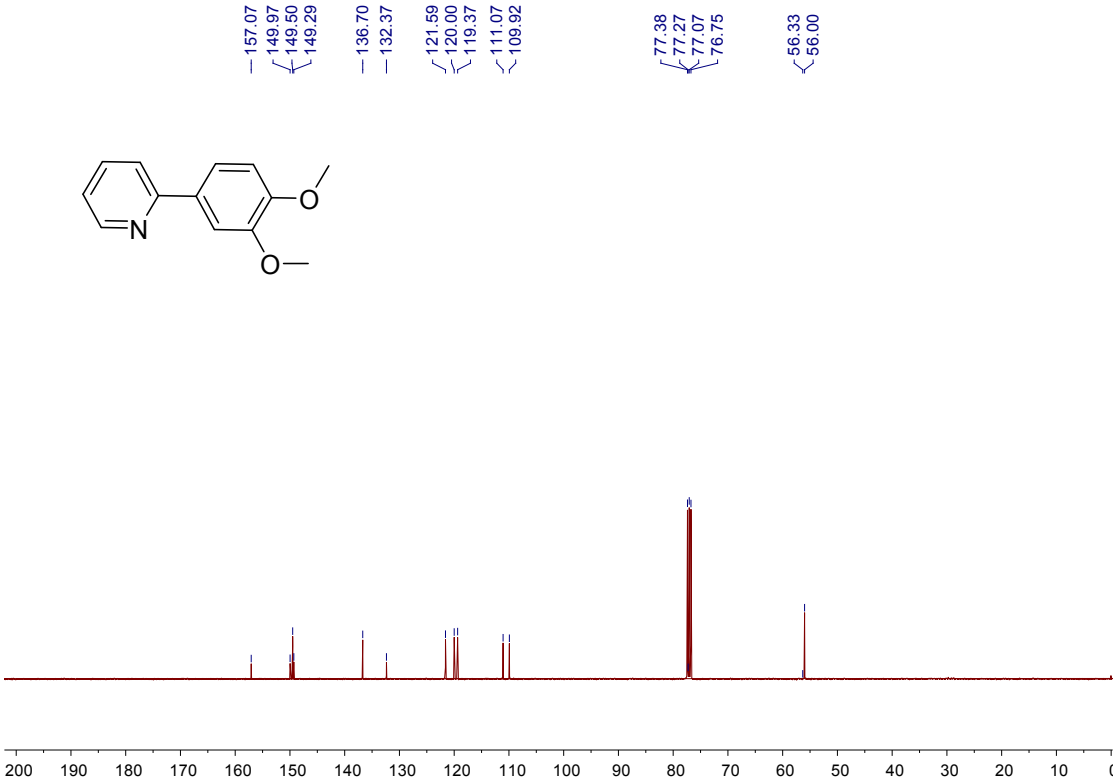


2-(3,4-dimethoxyphenyl)pyridine (1l)

^{1}H NMR ($CDCl_3$)

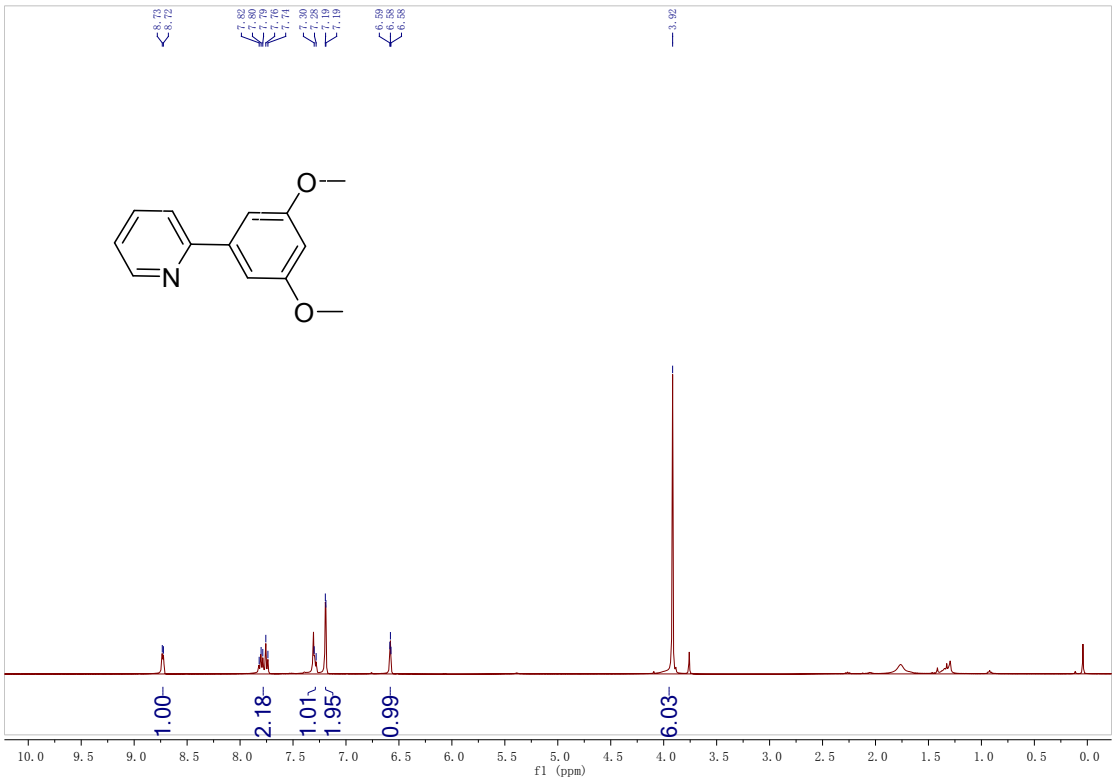


^{13}C NMR ($CDCl_3$)

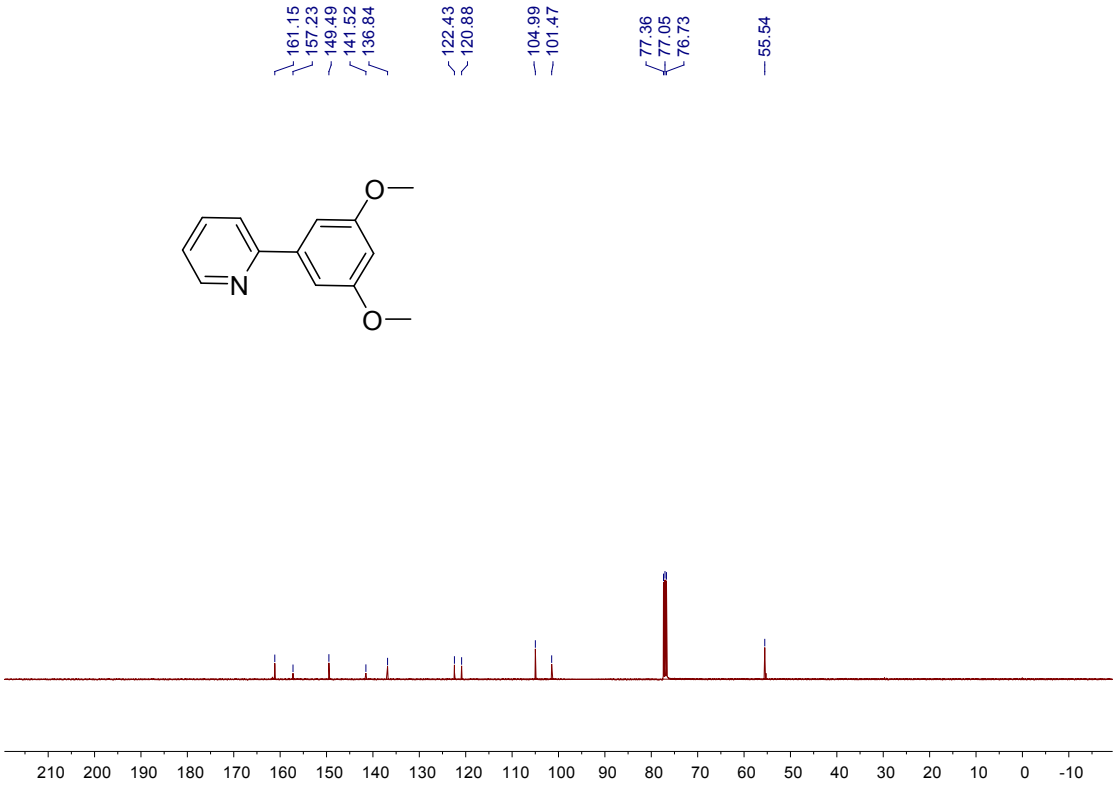


2-(3,5-dimethoxyphenyl)pyridine (1m)

^{1}H NMR ($CDCl_3$)

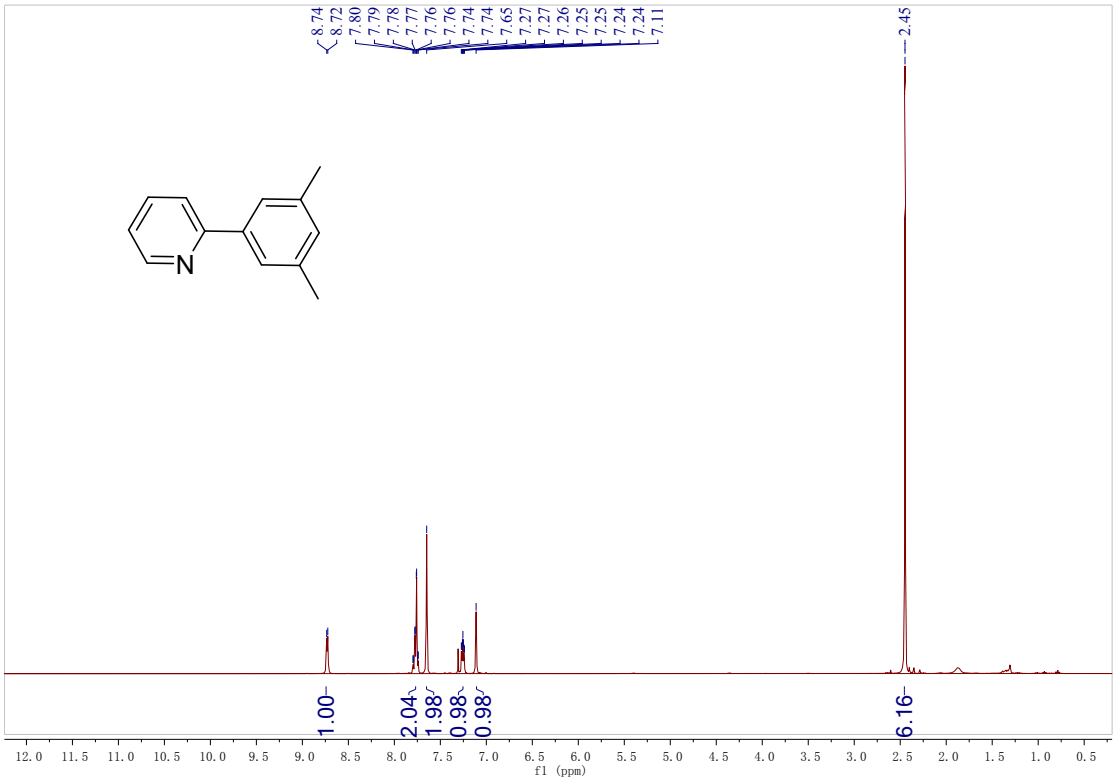


^{13}C NMR ($CDCl_3$)

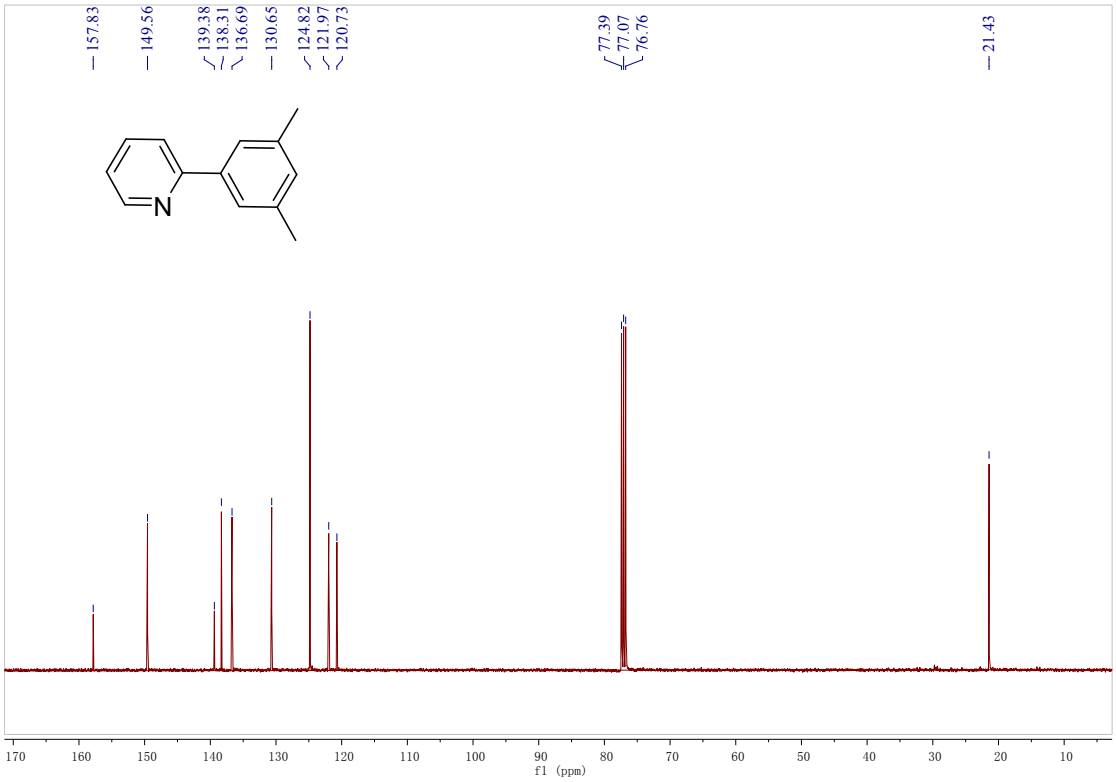


2-(3,5-dimethylphenyl)pyridine (1n)

^{1}H NMR ($CDCl_3$)

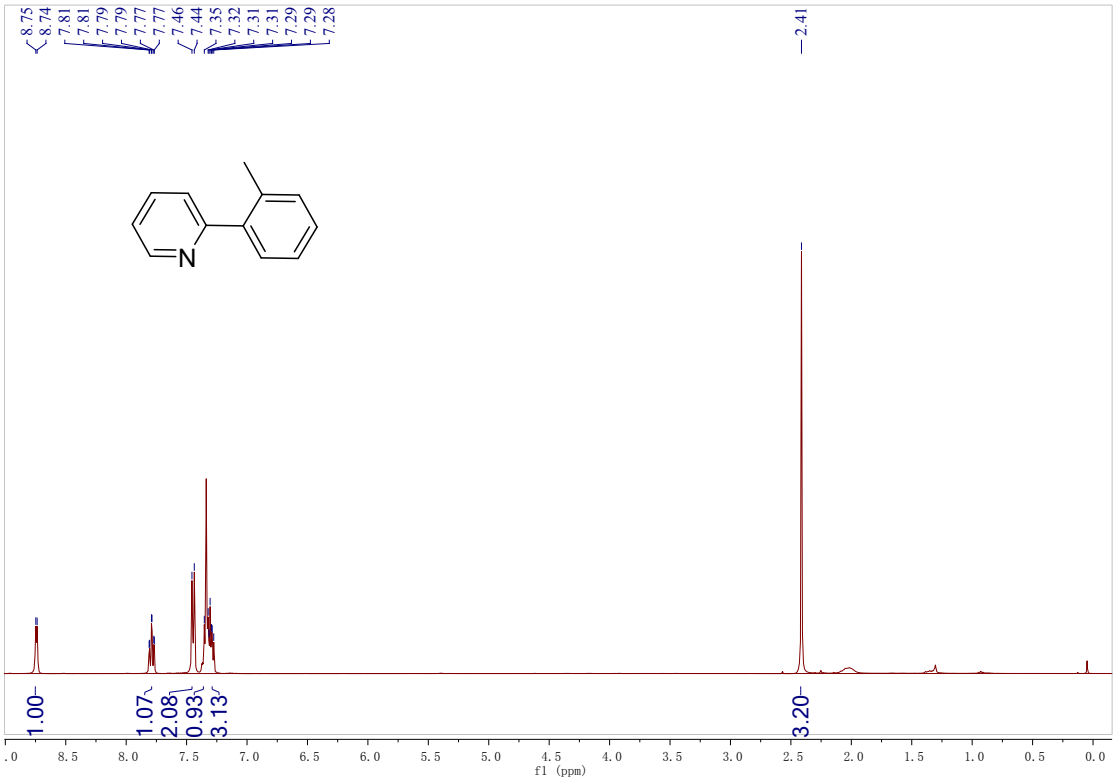


^{13}C NMR ($CDCl_3$)

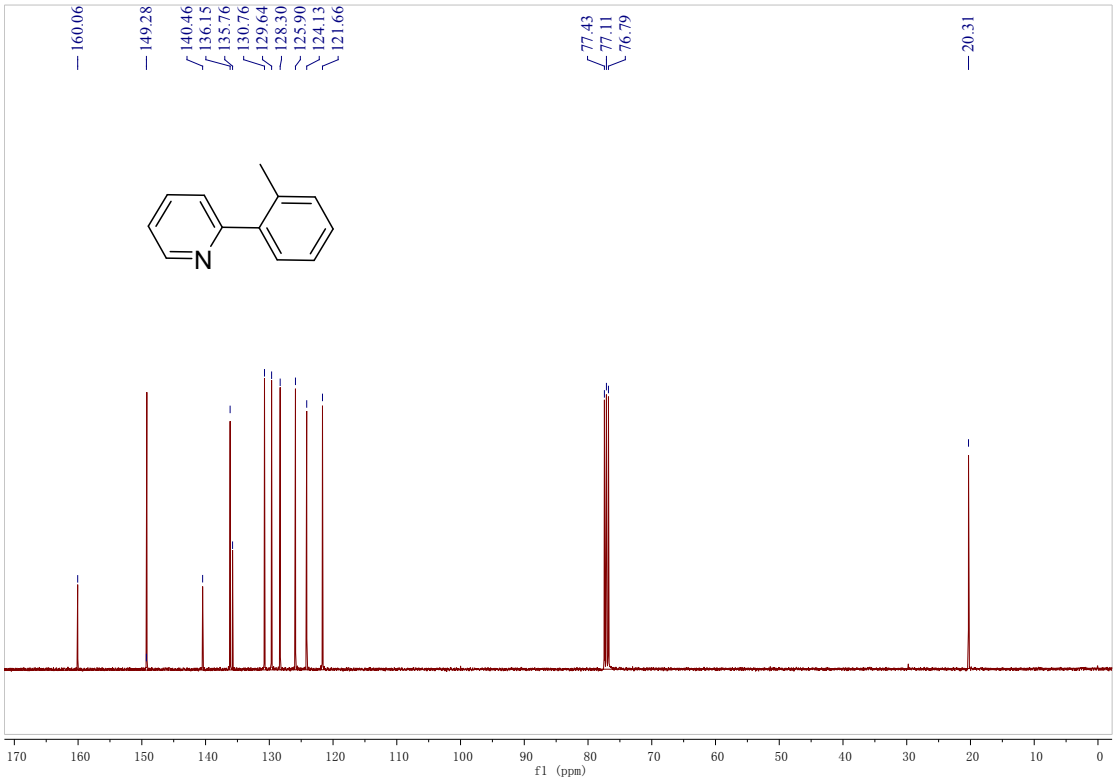


2-(o-tolyl)pyridine (1o)

^{1}H NMR ($CDCl_3$)

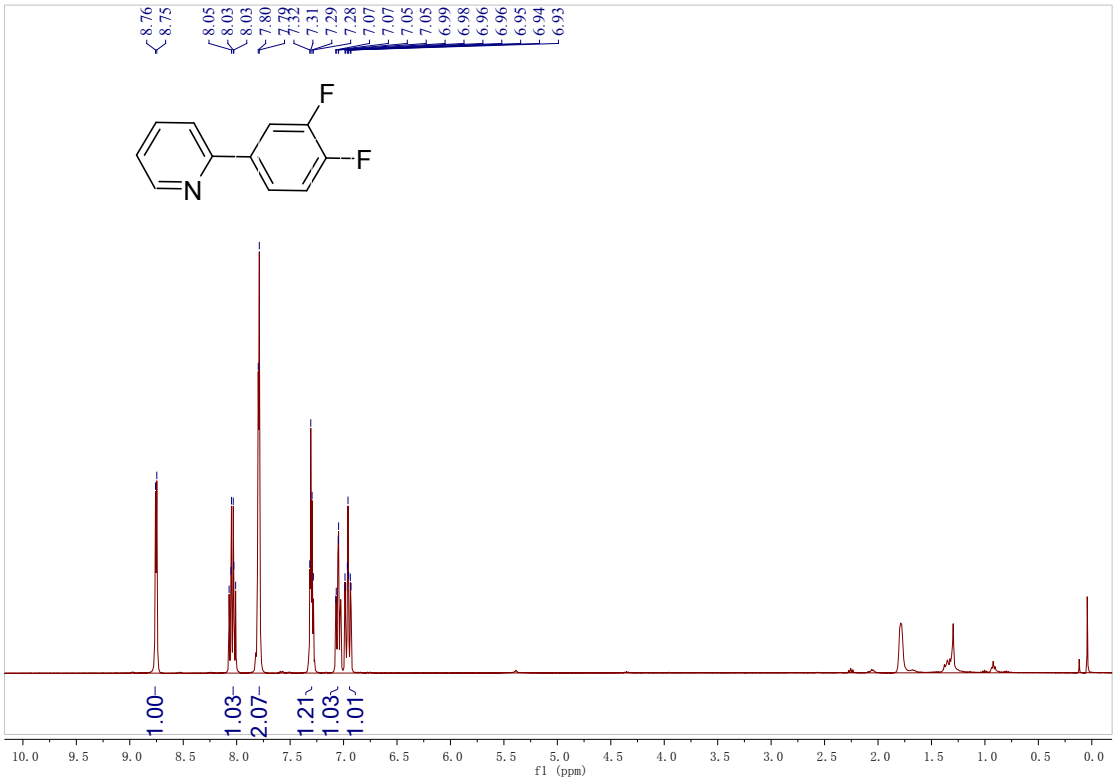


^{13}C NMR ($CDCl_3$)

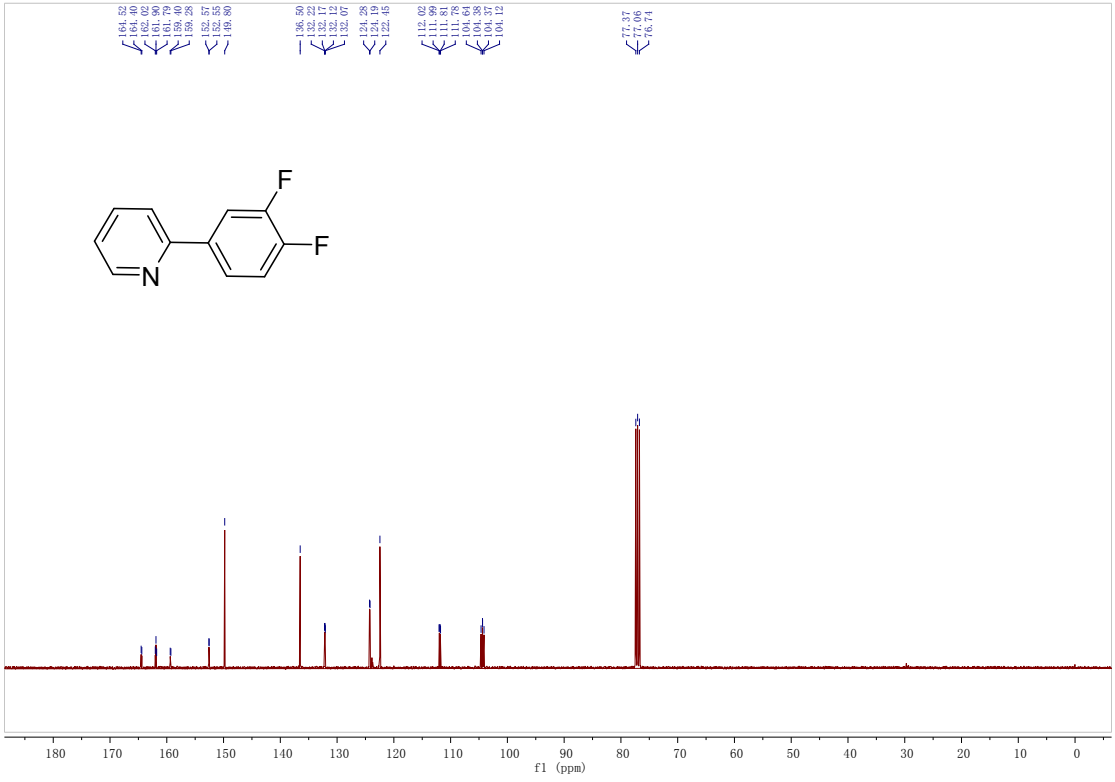


2-(3,4-difluorophenyl)pyridine (1p)

^{1}H NMR ($CDCl_3$)

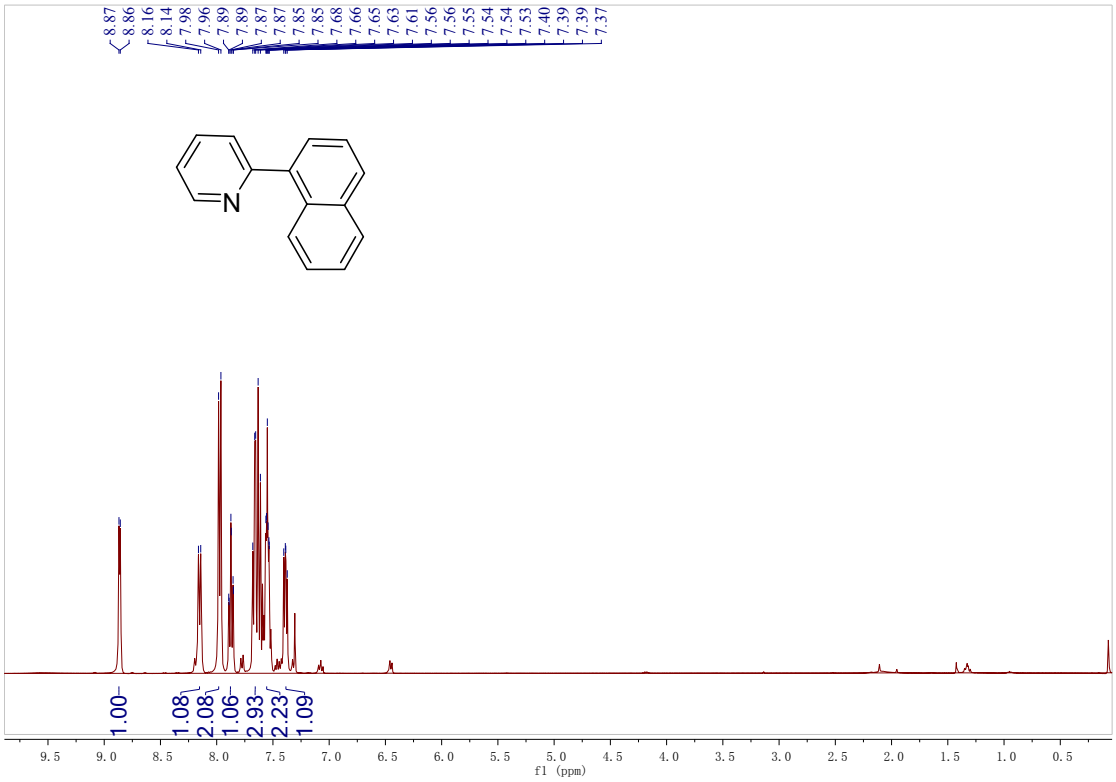


^{13}C NMR ($CDCl_3$)

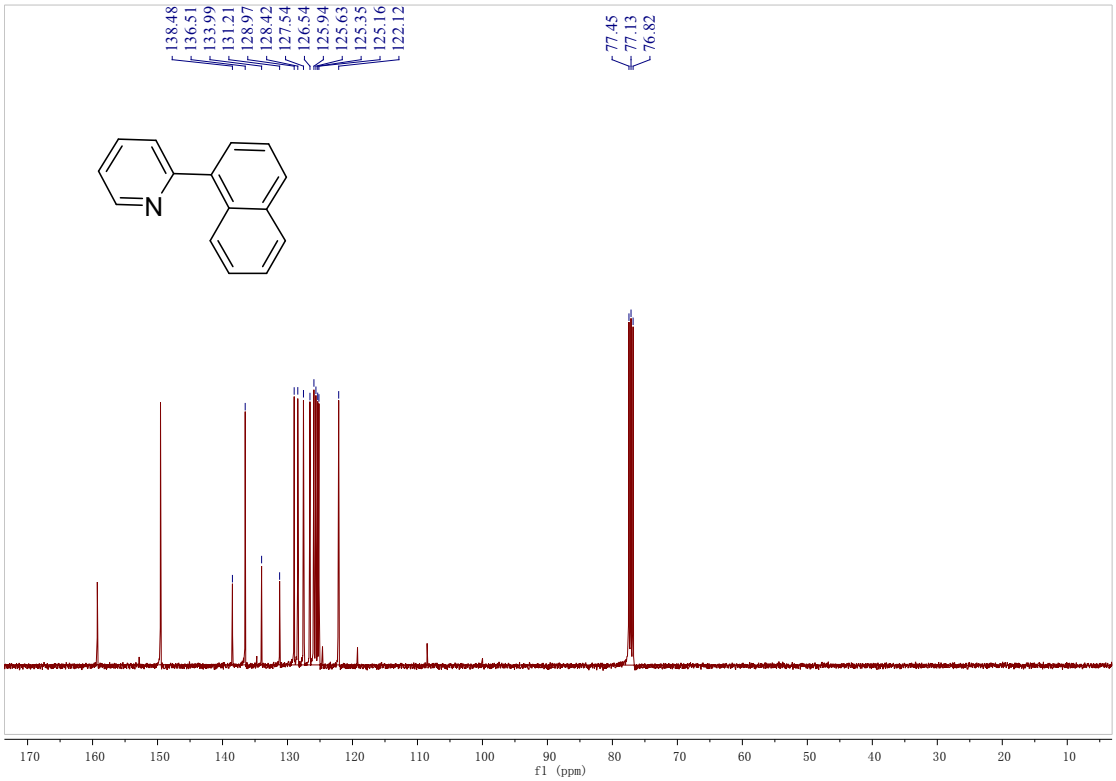


2-(naphthalen-1-yl)pyridine (1q)

^{1}H NMR ($CDCl_3$)

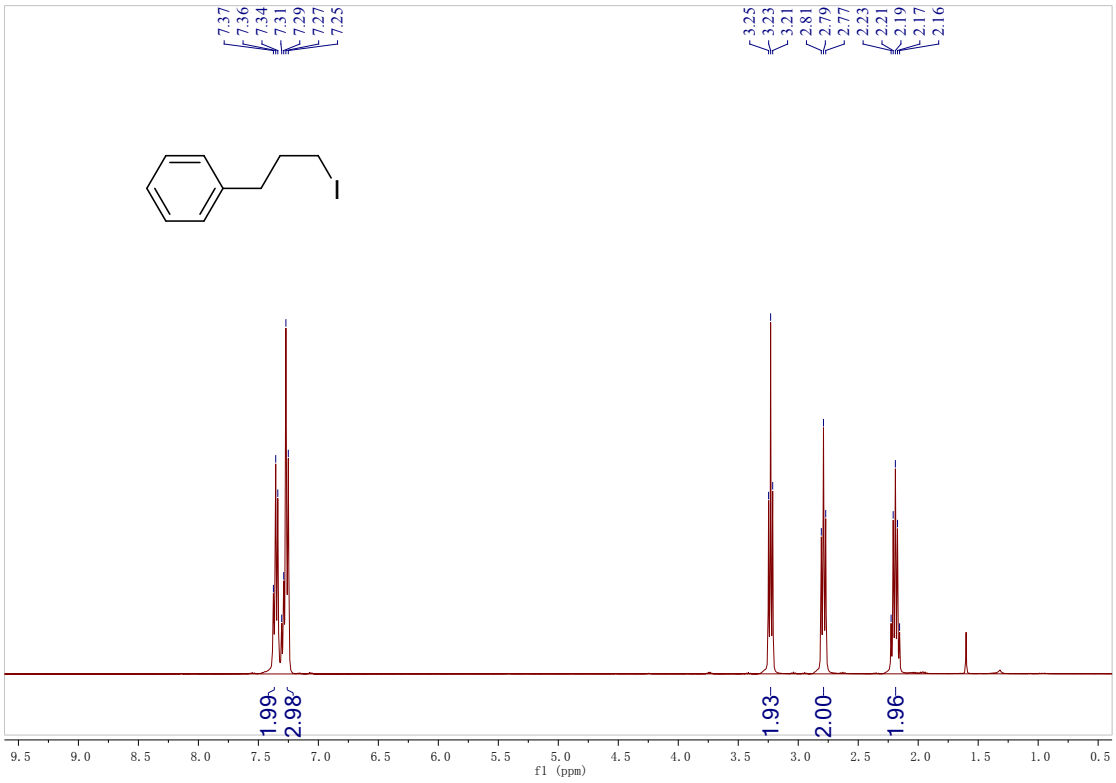


^{13}C NMR ($CDCl_3$)

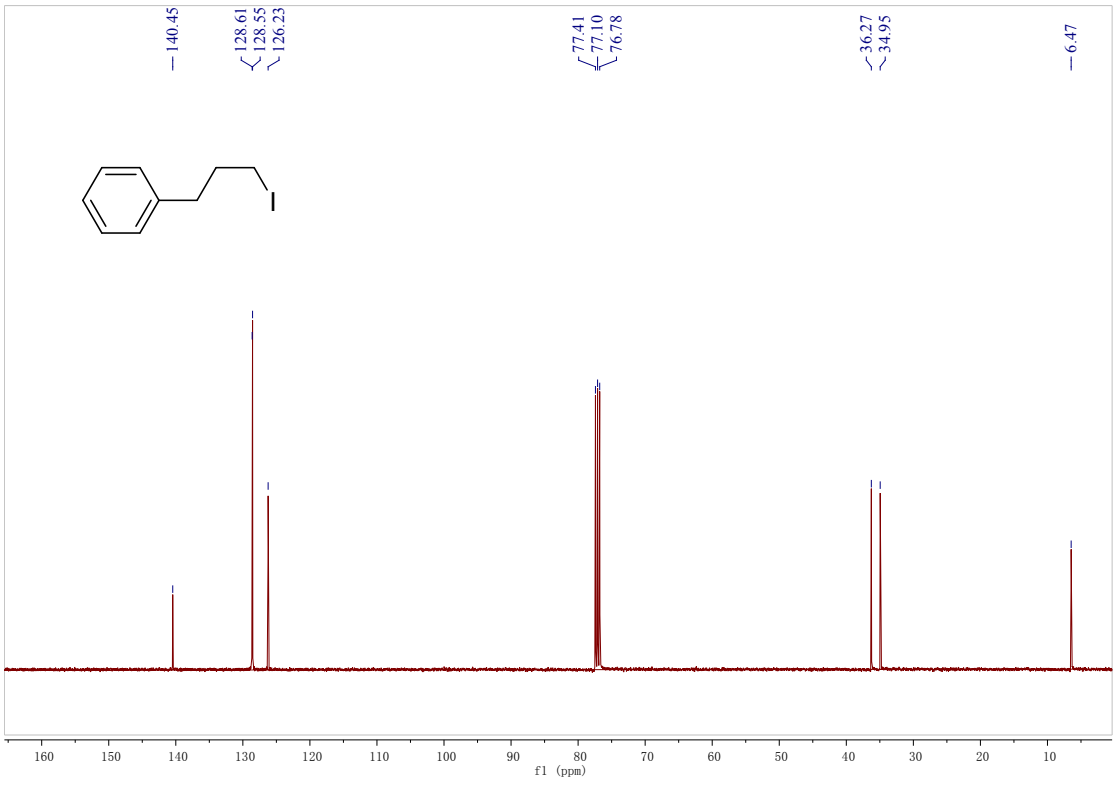


(3-iodopropyl)benzene (2c)

^{1}H NMR ($CDCl_3$)

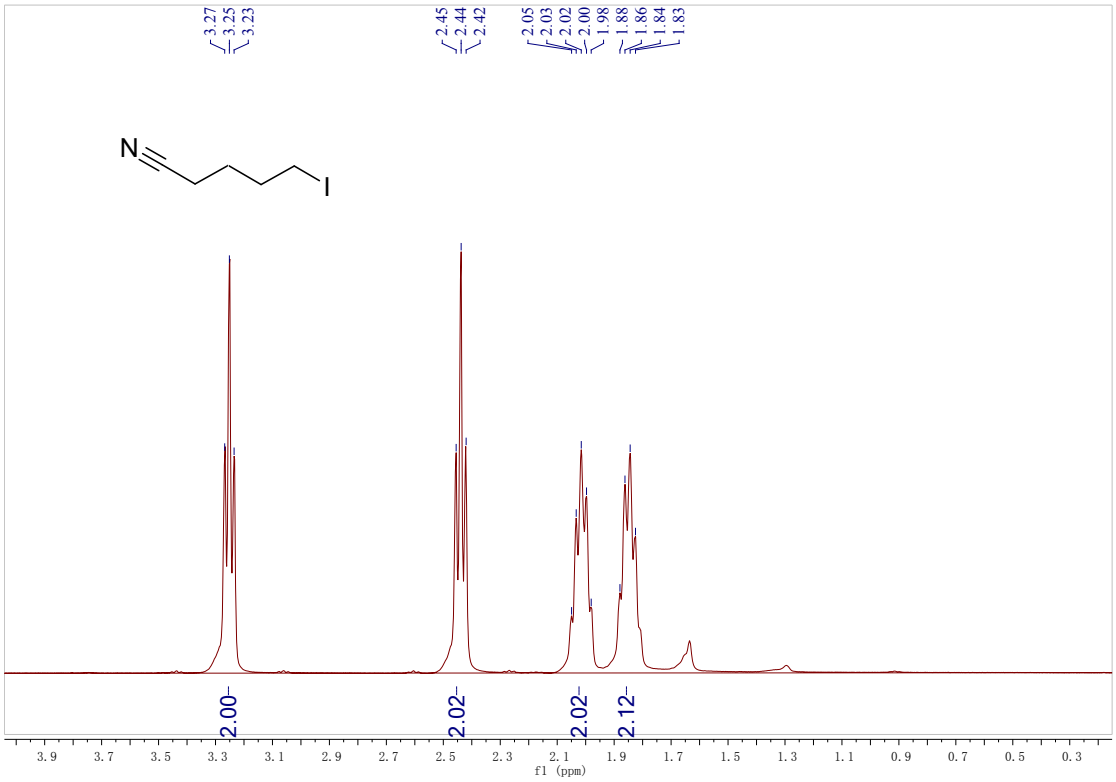


^{13}C NMR ($CDCl_3$)

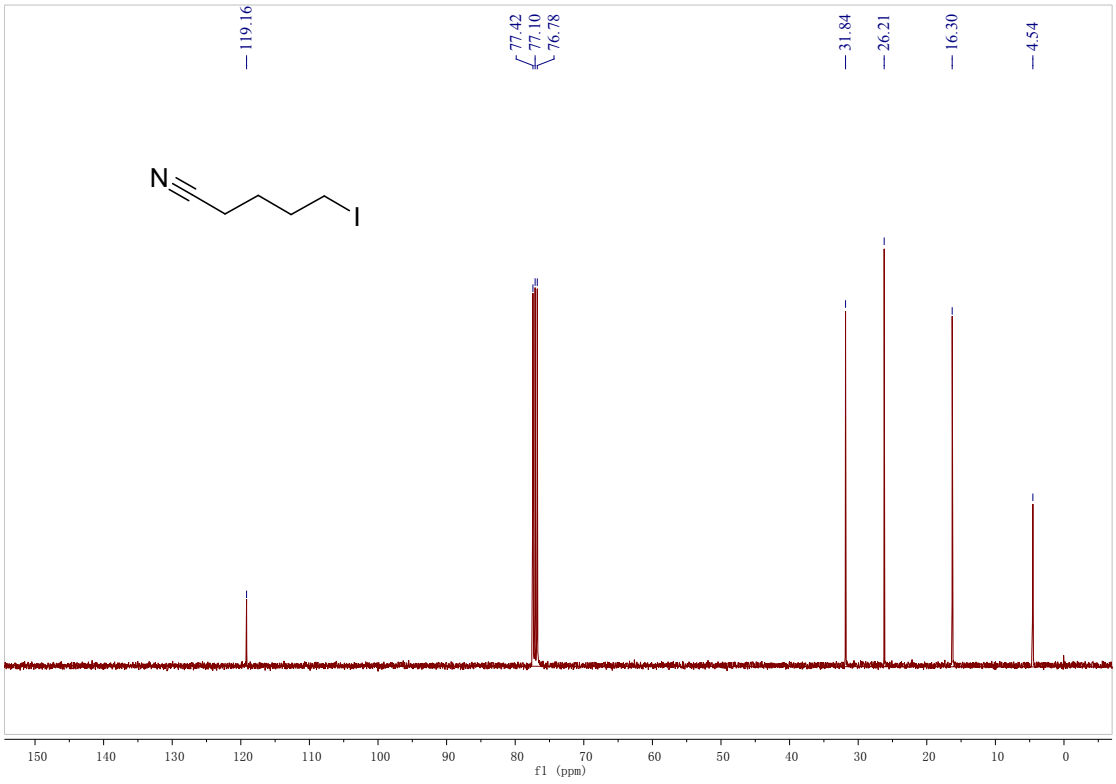


5-iodopentanenitrile (2d)

^{1}H NMR ($CDCl_3$)

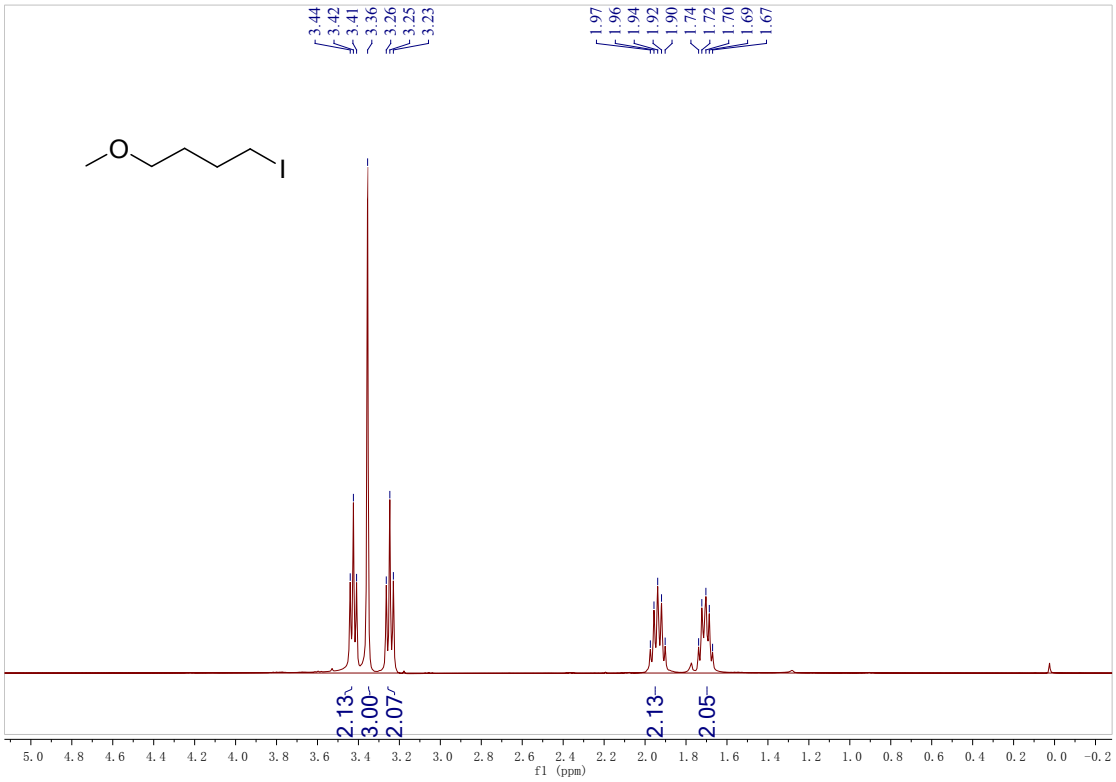


^{13}C NMR ($CDCl_3$)

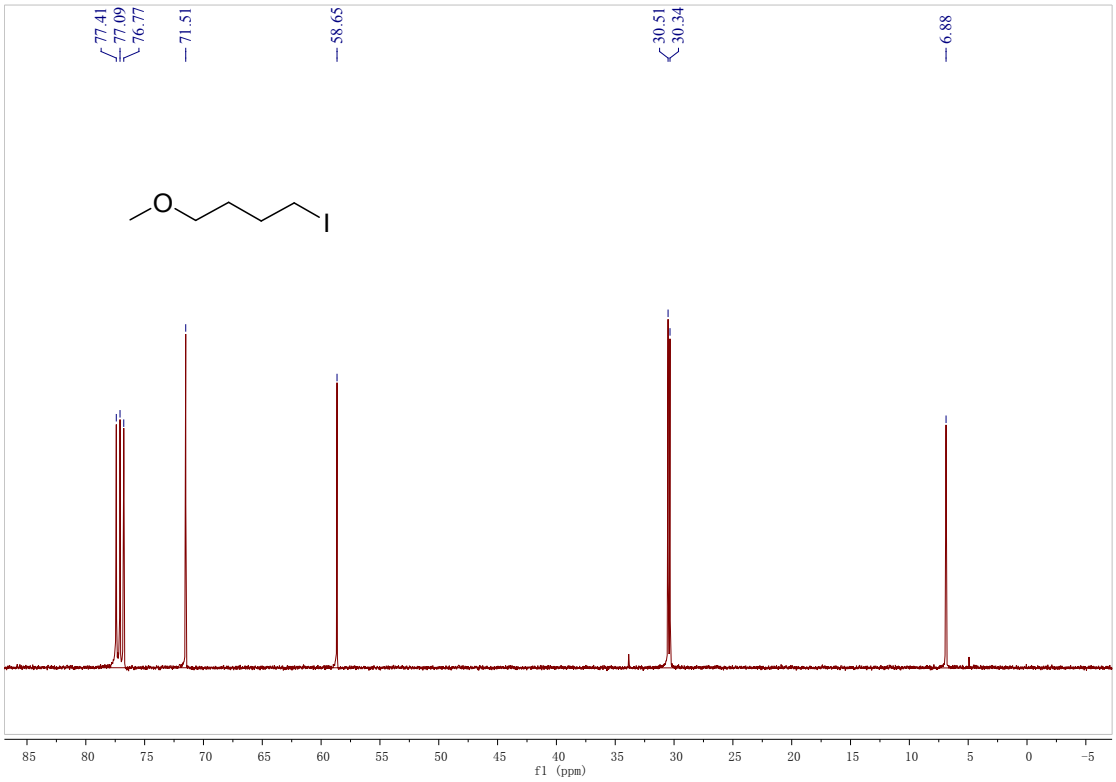


1-iodo-4-methoxybutane (2e)

^{1}H NMR ($CDCl_3$)

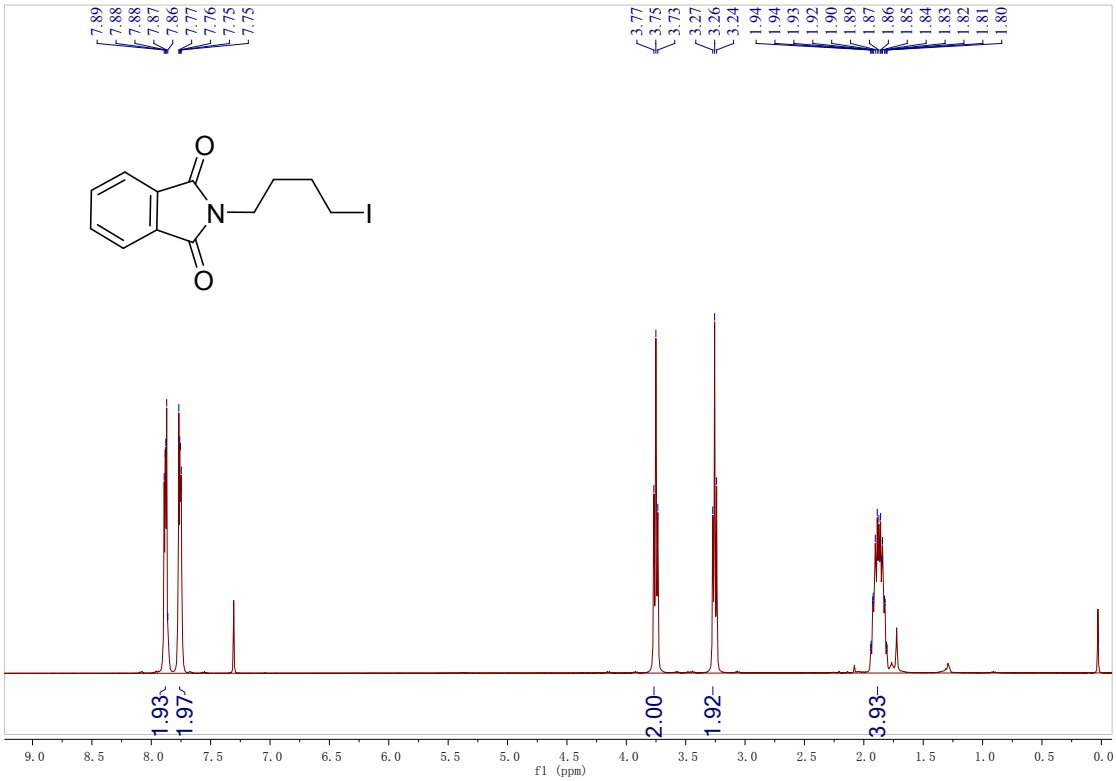


^{13}C NMR ($CDCl_3$)

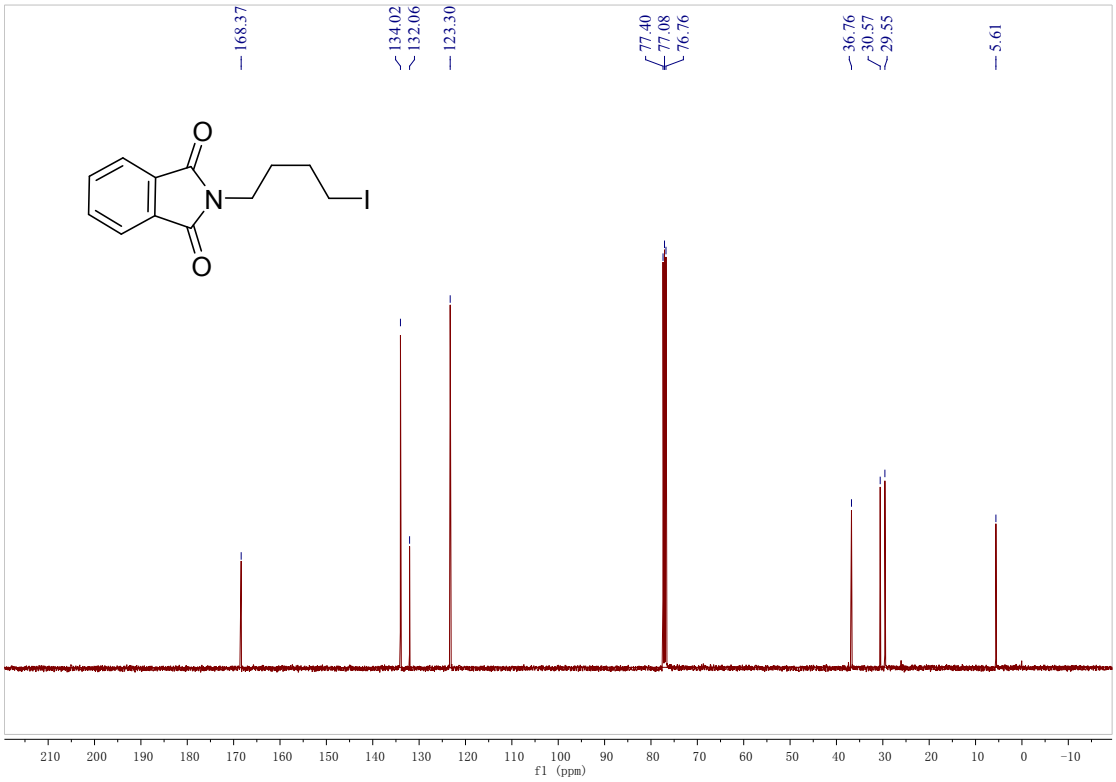


2-(4-iodobutyl)isoindoline-1,3-dione (2g)

^{1}H NMR ($CDCl_3$)

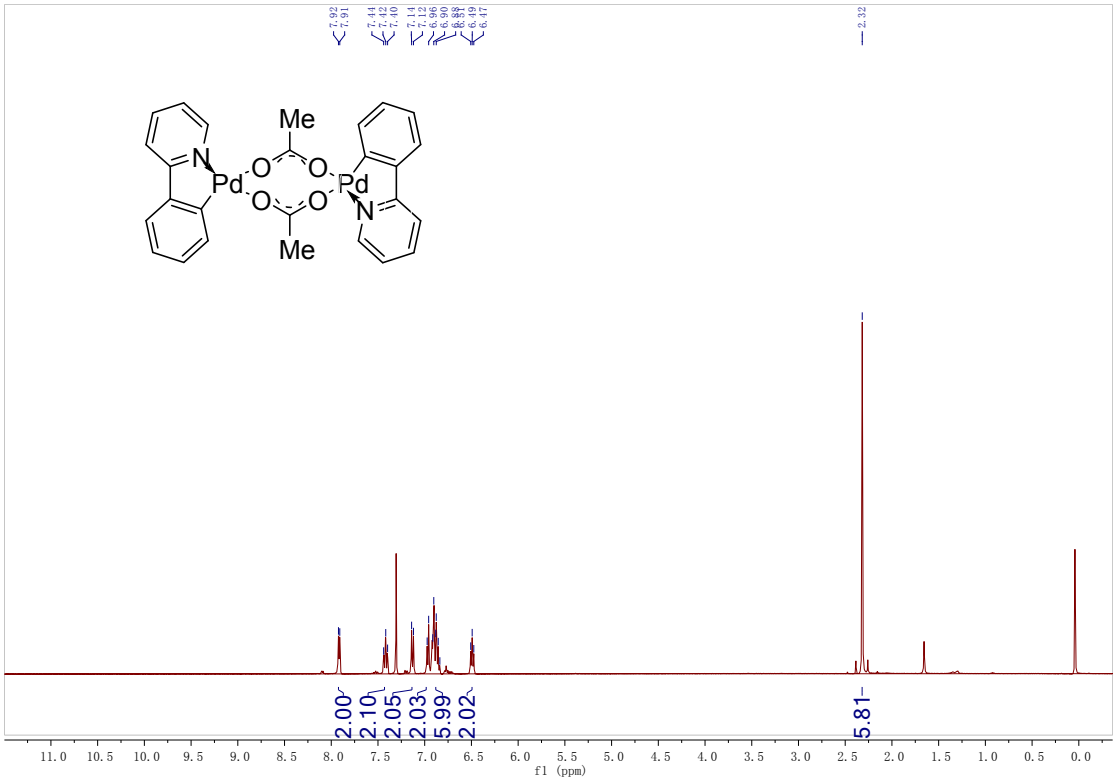


^{13}C NMR ($CDCl_3$)

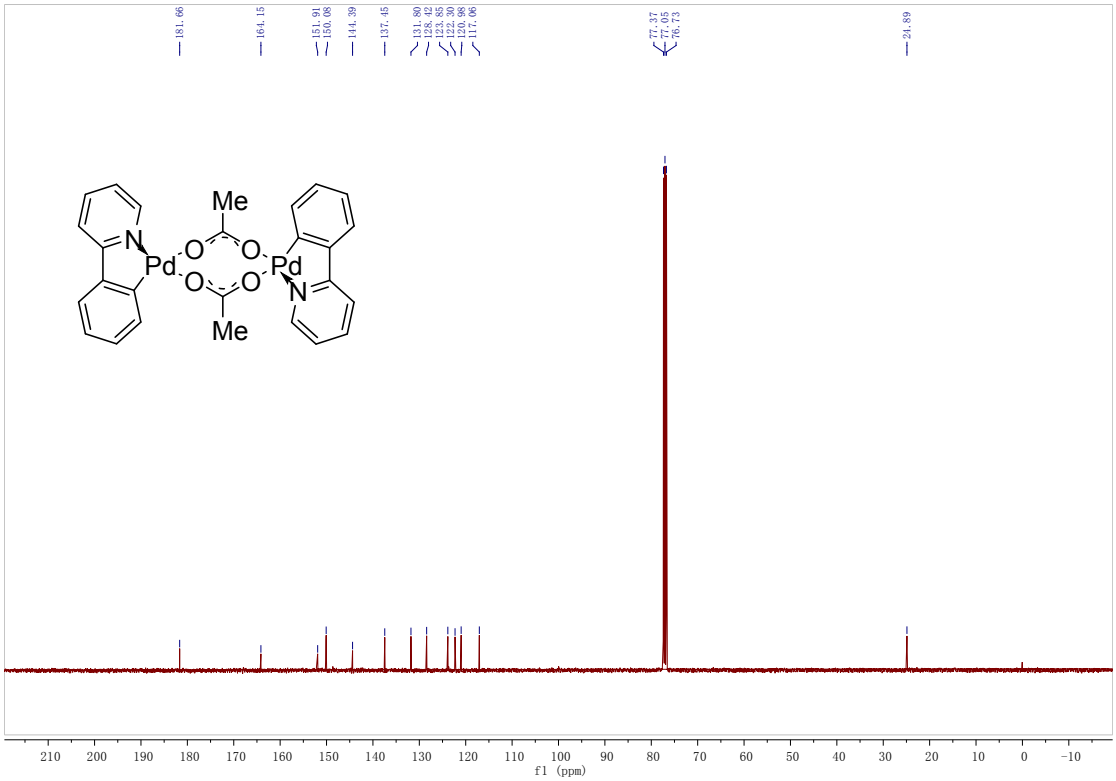


2-phenylpyridyl palladium acetate dimer (4b)

^{1}H NMR ($CDCl_3$)

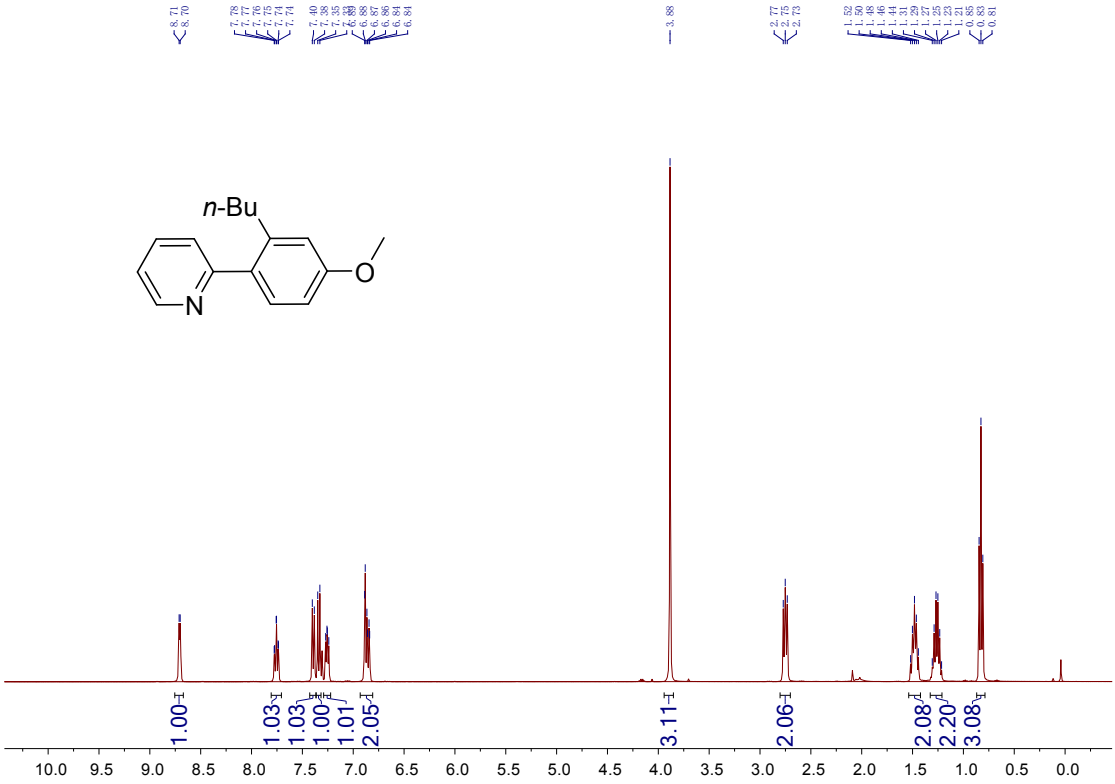


^{13}C N MR ($CDCl_3$)

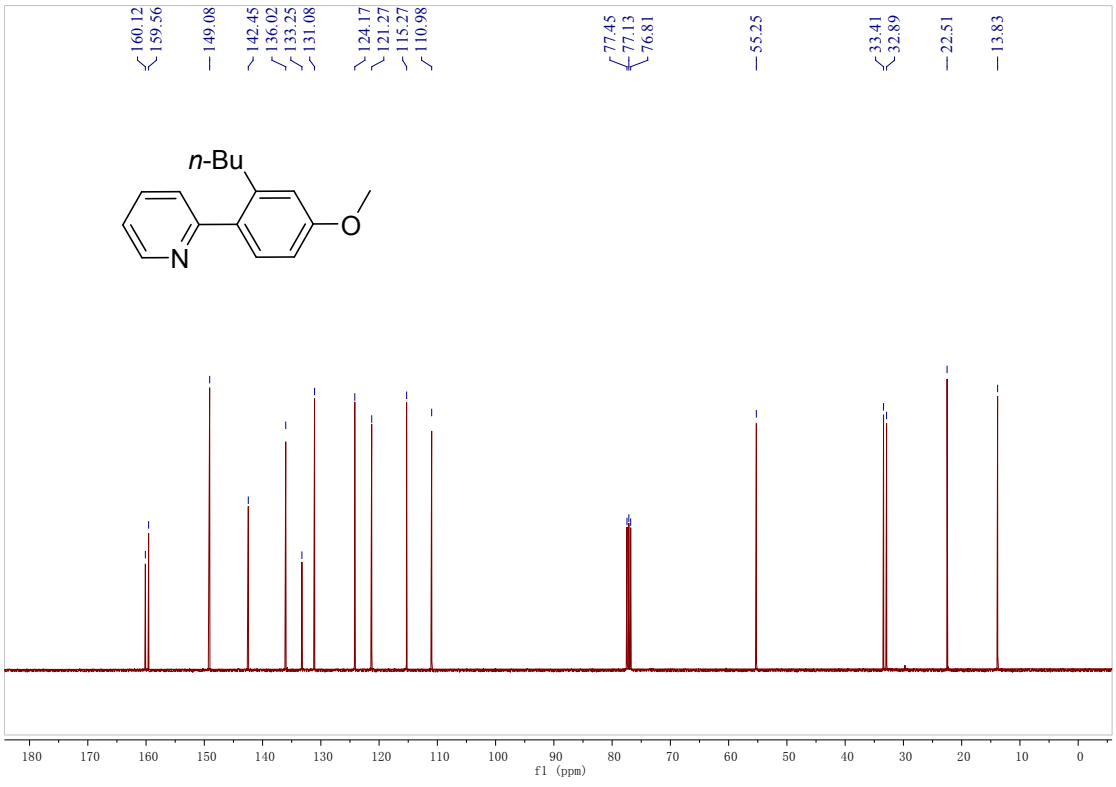


2-(2-butyl-4-methoxyphenyl)pyridine (3aa)

^{1}H NMR ($CDCl_3$)

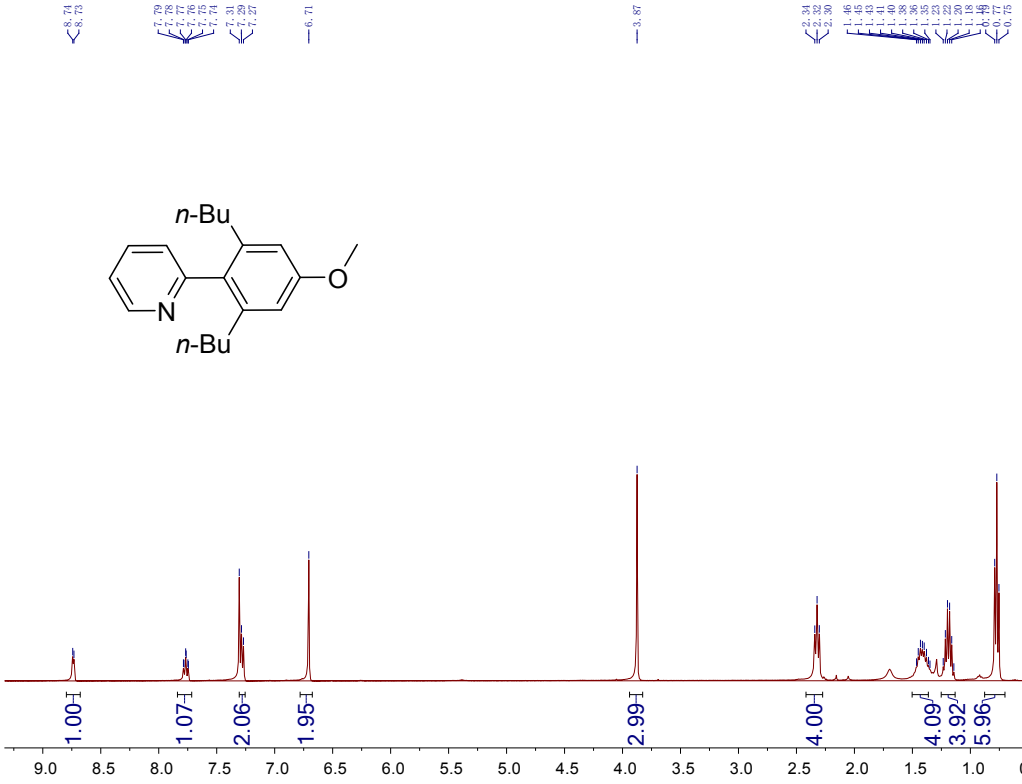


^{13}C NMR ($CDCl_3$)

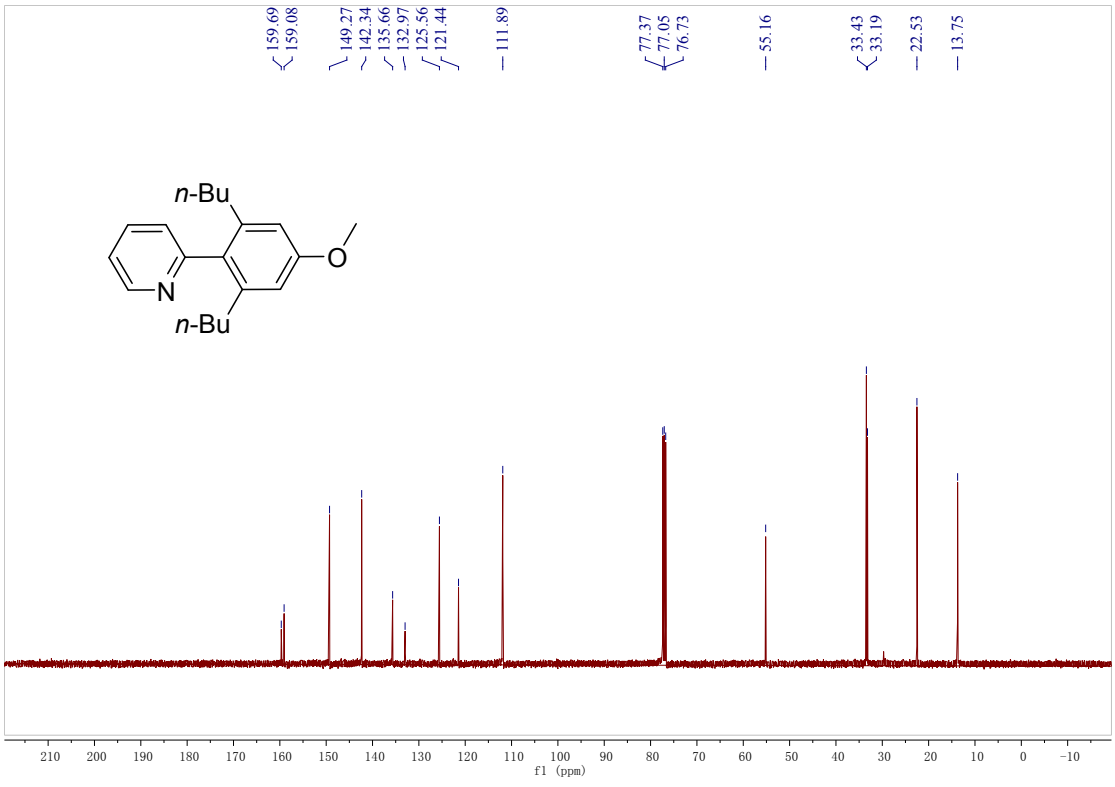


2-(2,6-dibutyl-4-methoxyphenyl)pyridine (3aa-di)

^{1}H NMR ($CDCl_3$)

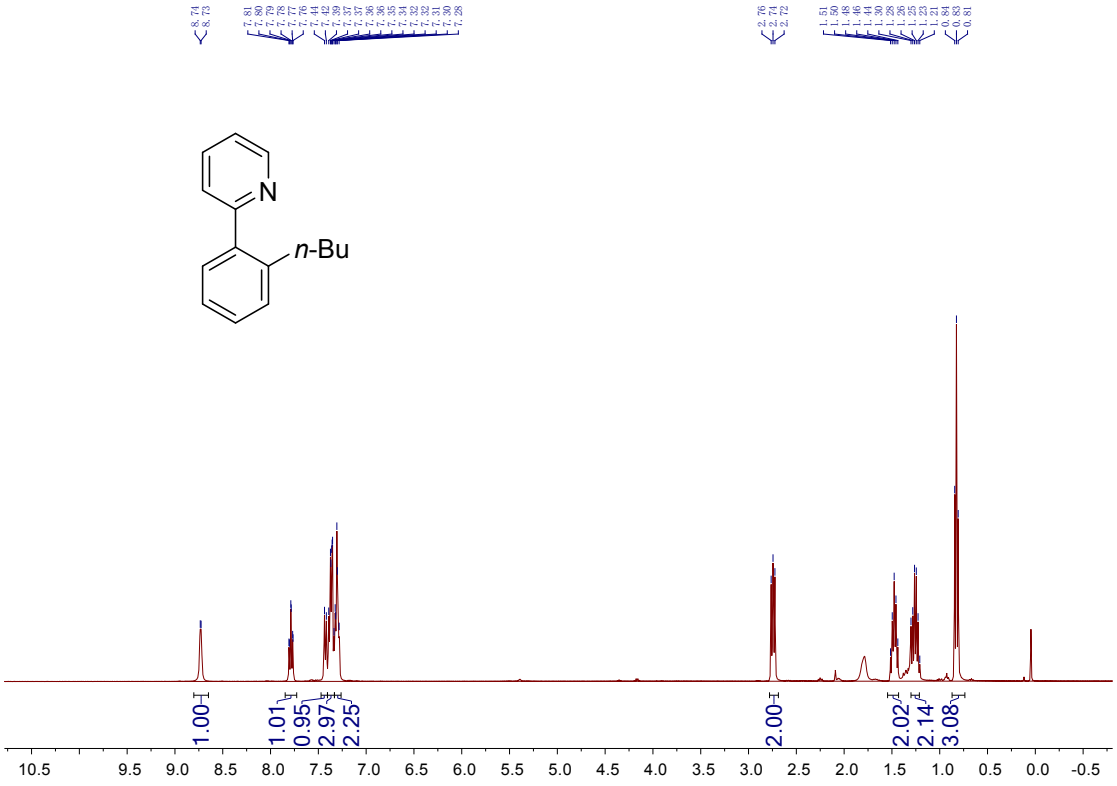


^{13}C NMR ($CDCl_3$)

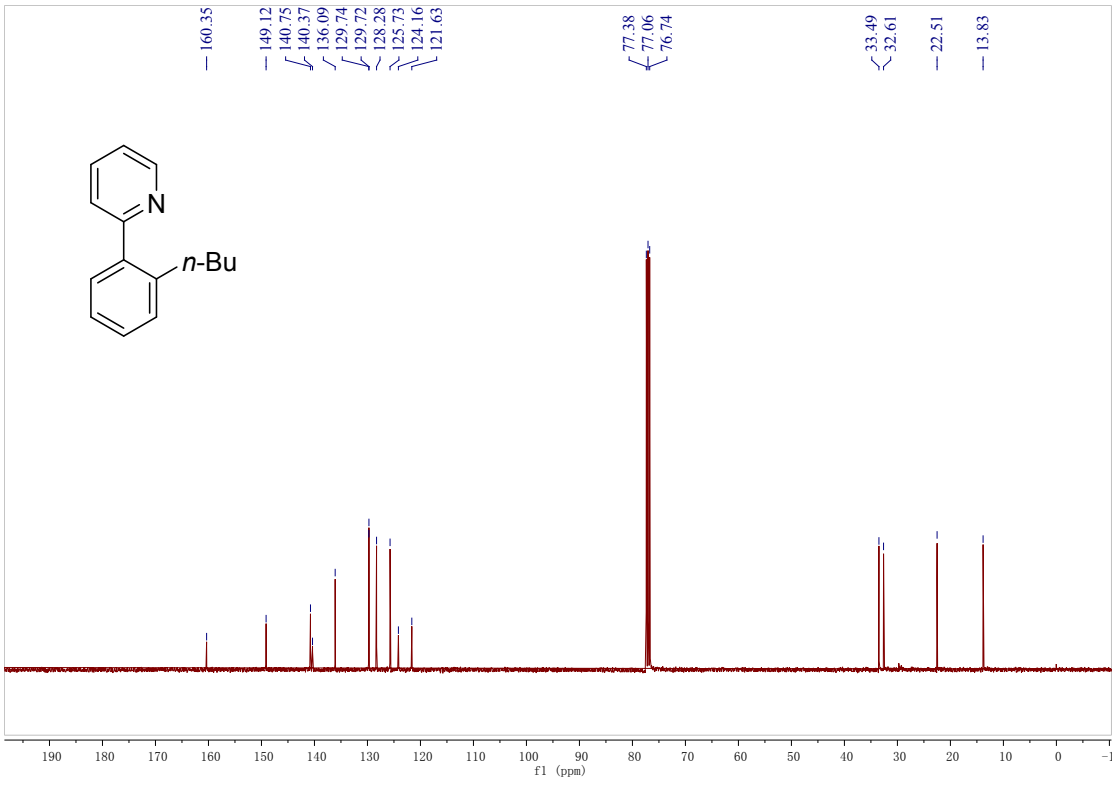


2-(2-butylphenyl)pyridine (3ba)

^{1}H NMR ($CDCl_3$)

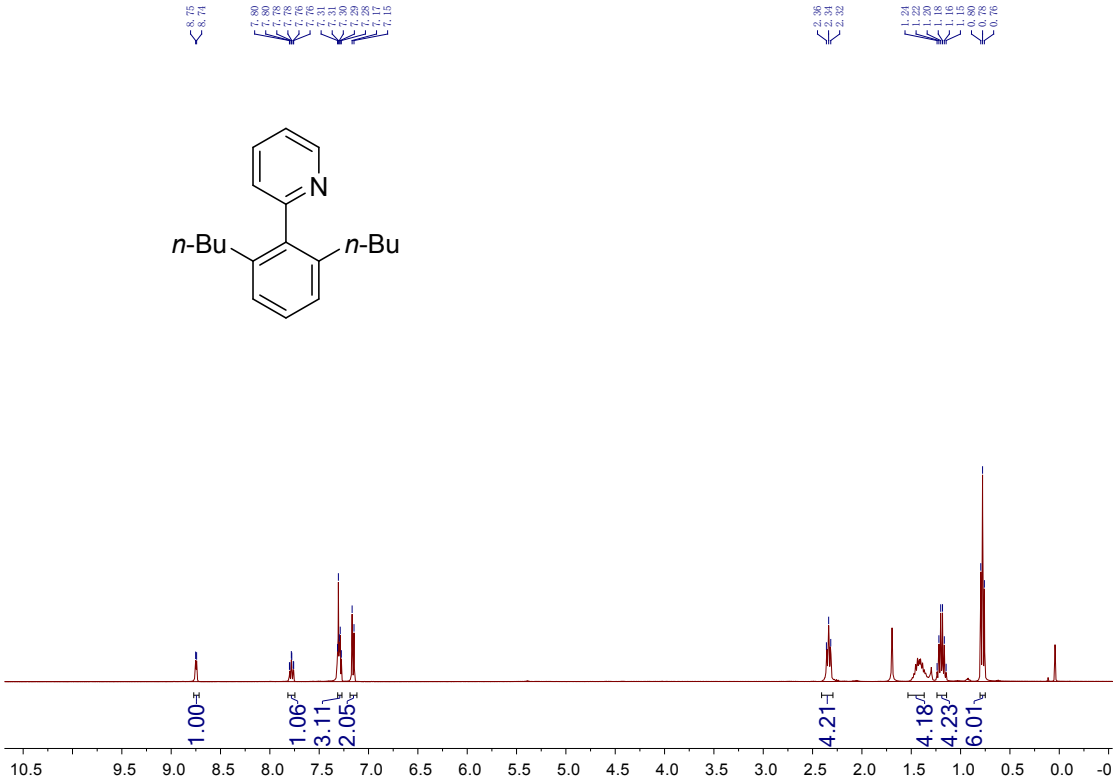


^{13}C NMR ($CDCl_3$)

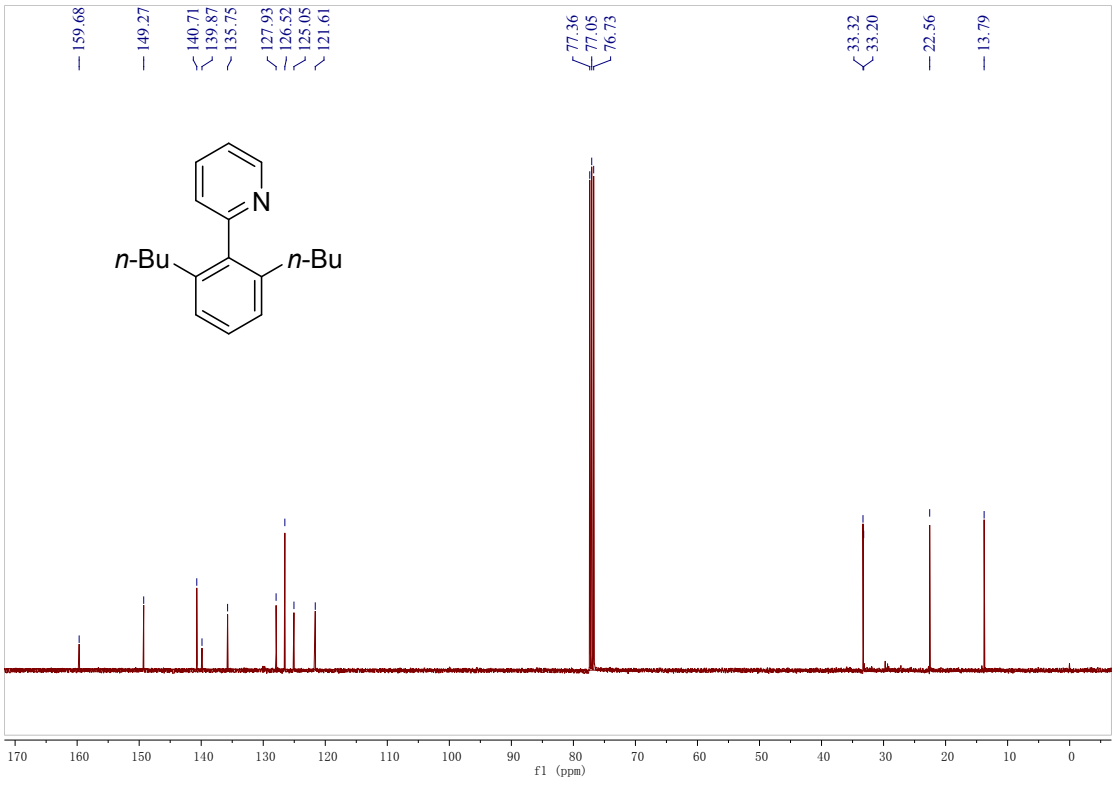


2-(2,6-dibutylphenyl)pyridine (3ba-di)

^{1}H NMR ($CDCl_3$)

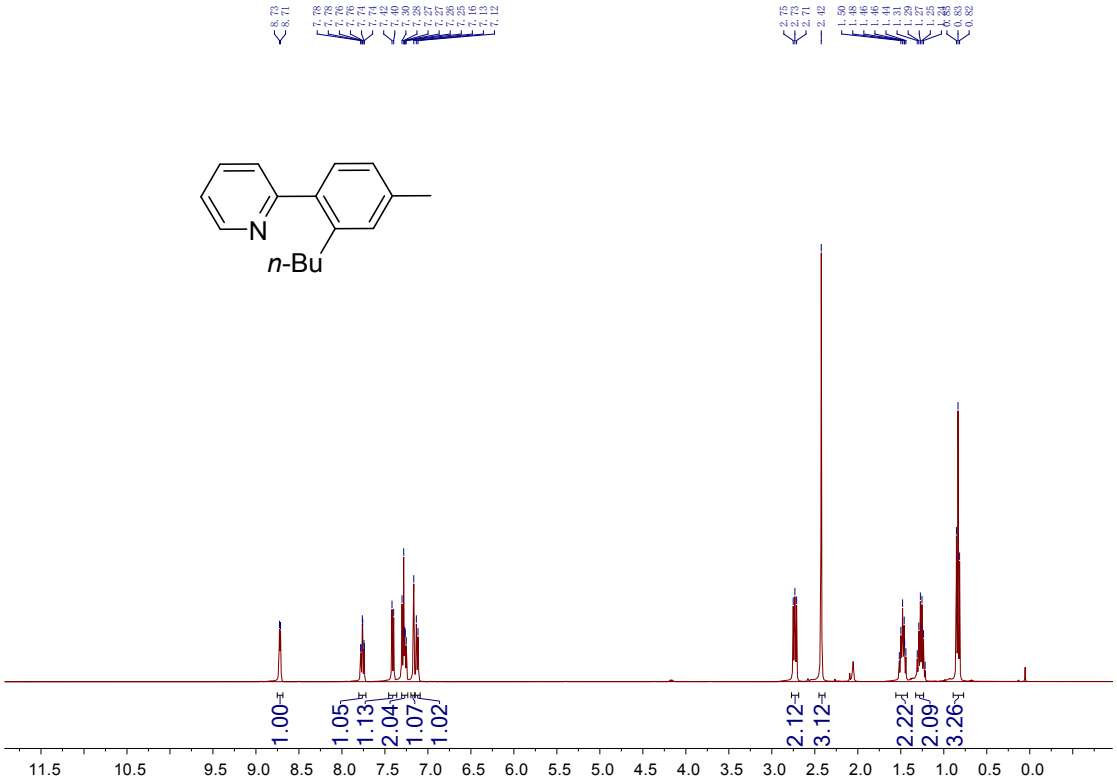


^{13}C NMR ($CDCl_3$)

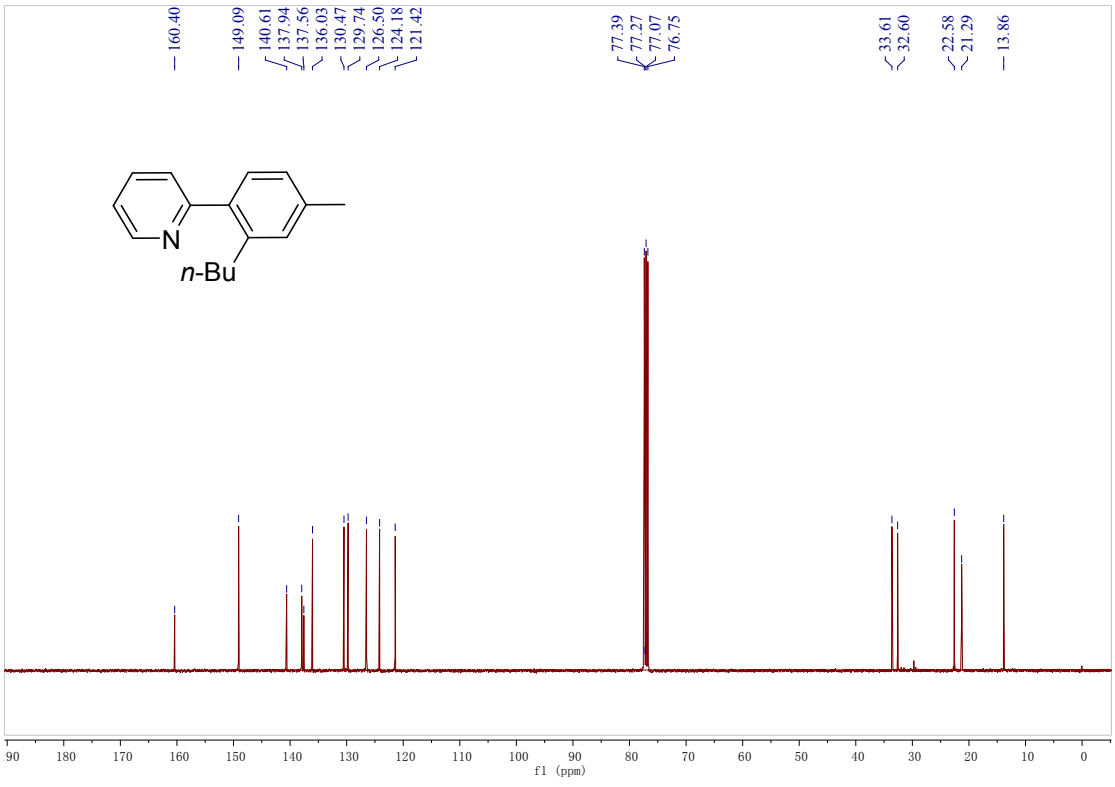


2-(2-butyl-4-methylphenyl)pyridine (3ca)

^{1}H NMR ($CDCl_3$)

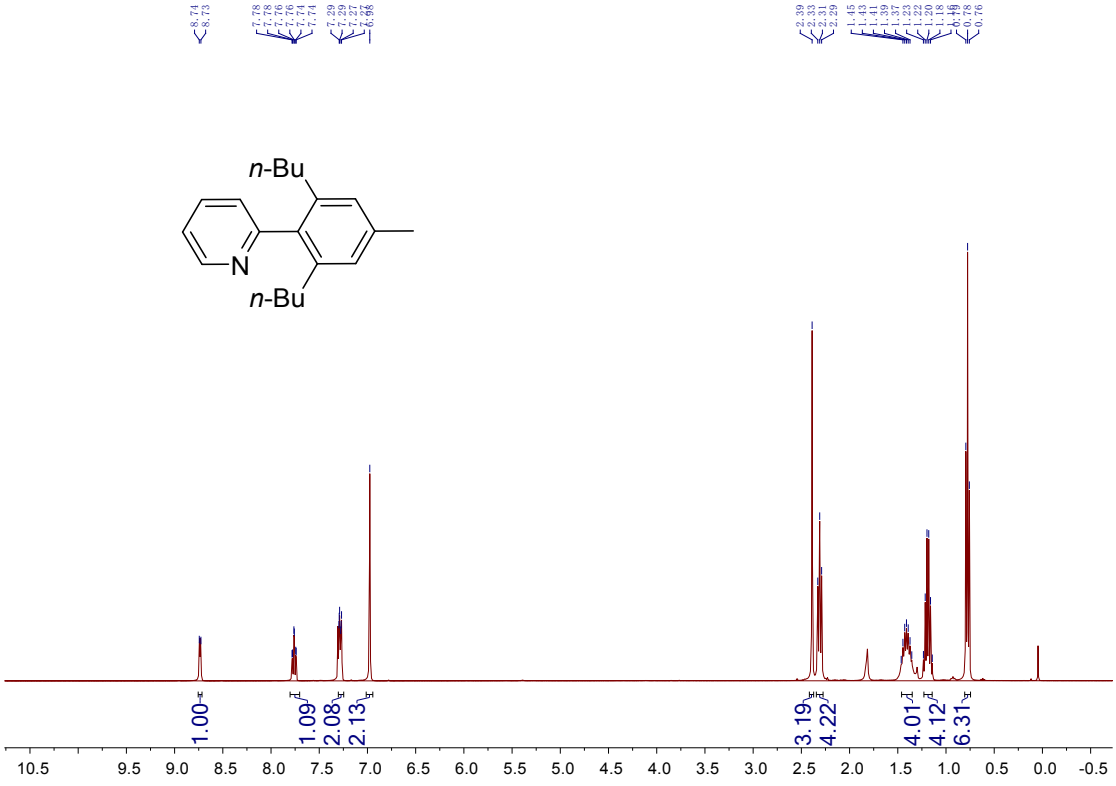


^{13}C NMR ($CDCl_3$)

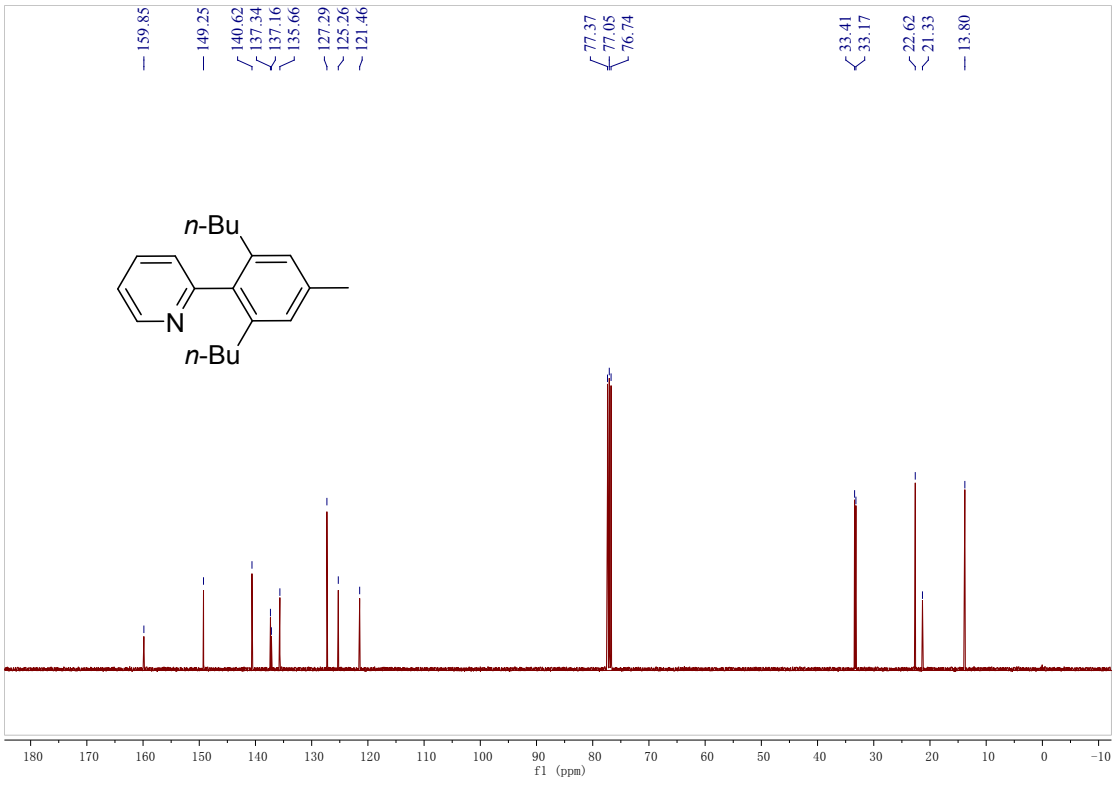


(2,6-dibutyl-4-methylphenyl)pyridine (3ca-di)

^{1}H NMR ($CDCl_3$)

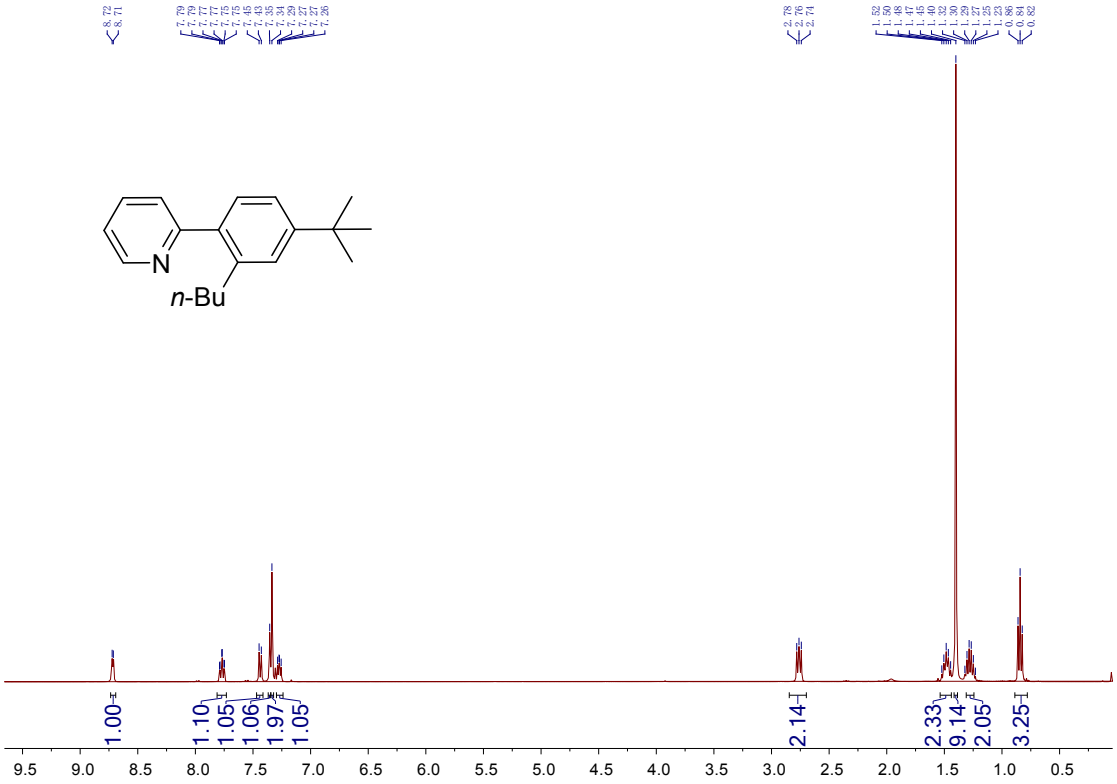


^{13}C NMR ($CDCl_3$)

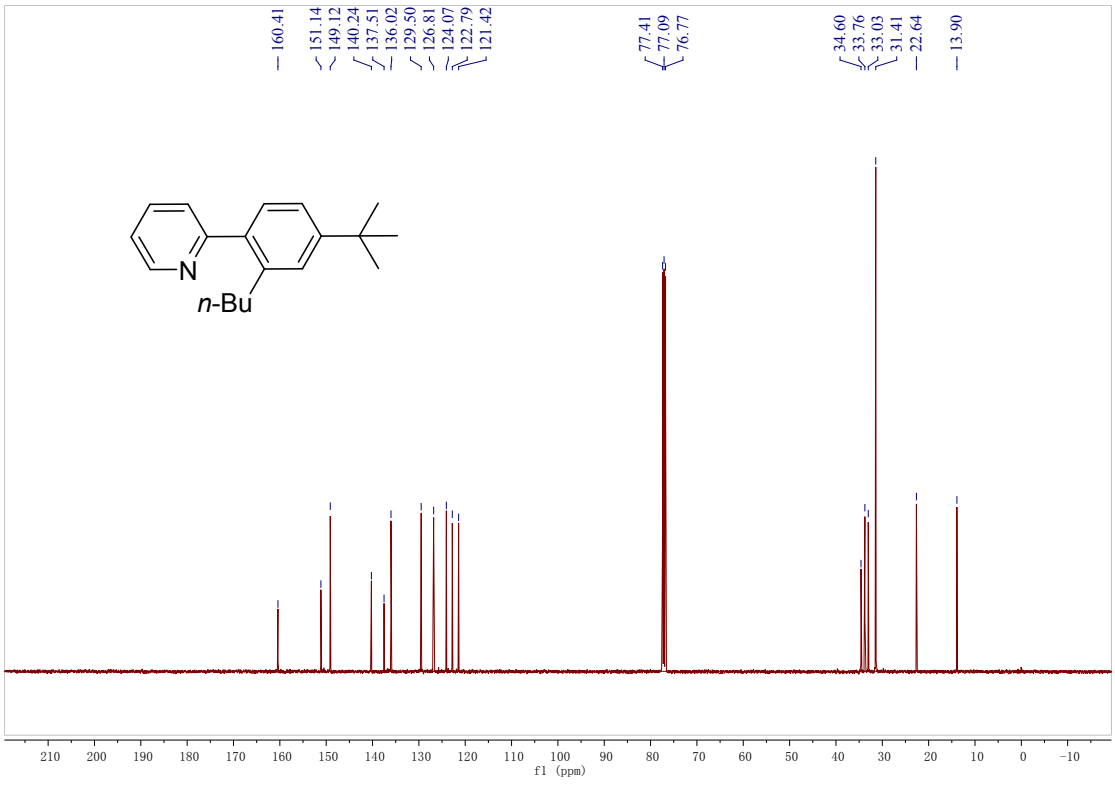


2-(4-(tert-butyl)-2-butylphenyl)pyridine (3da)

^{1}H NMR ($CDCl_3$)

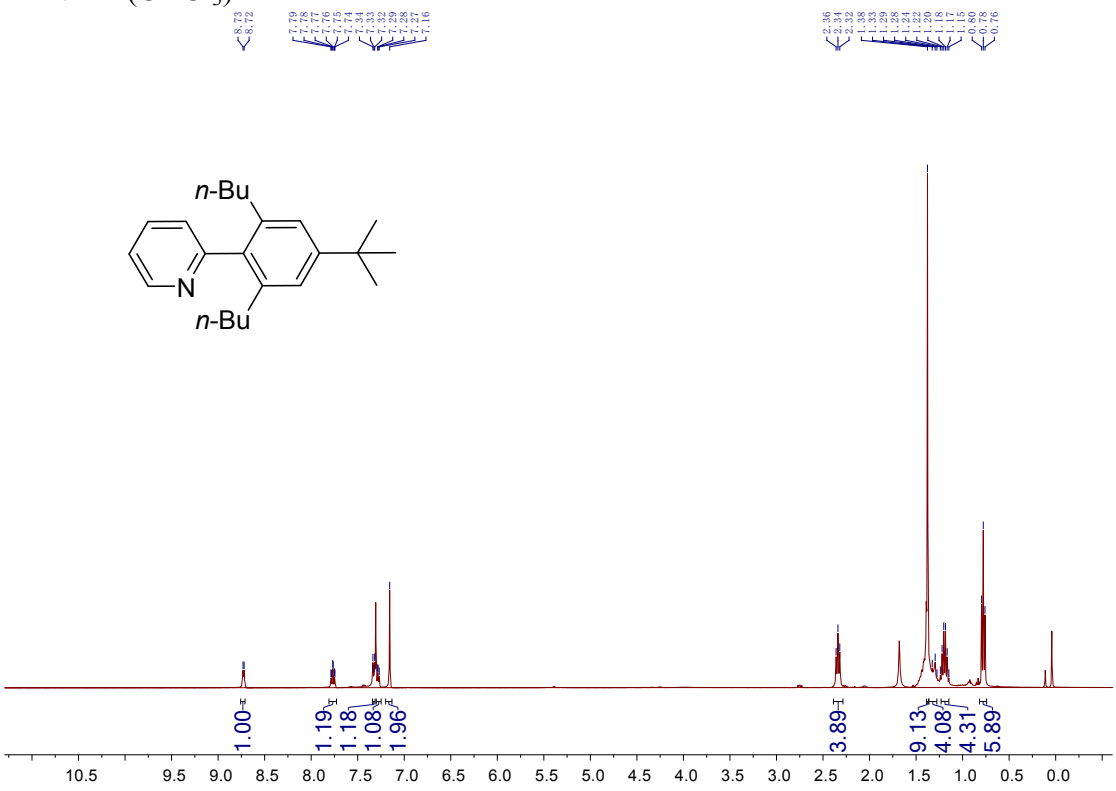


^{13}C NMR ($CDCl_3$)

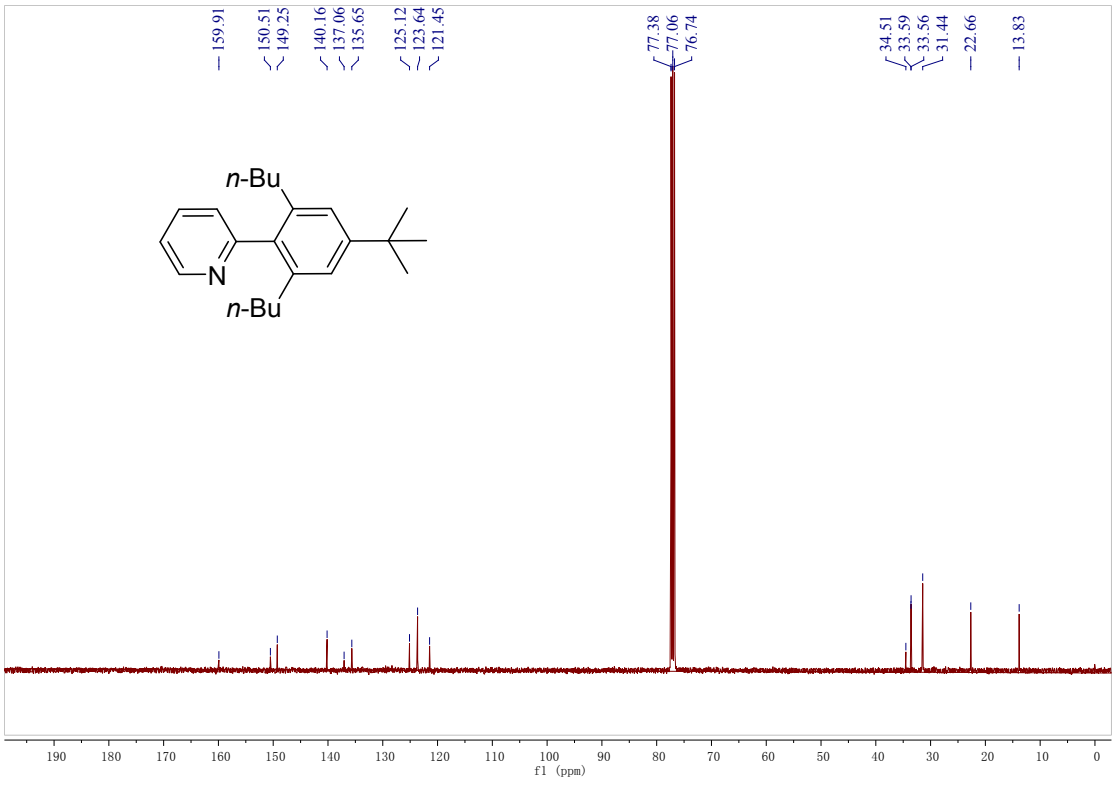


2-(4-(tert-butyl)-2,6-dibutylphenyl)pyridine (3da-di)

^{1}H NMR ($CDCl_3$)

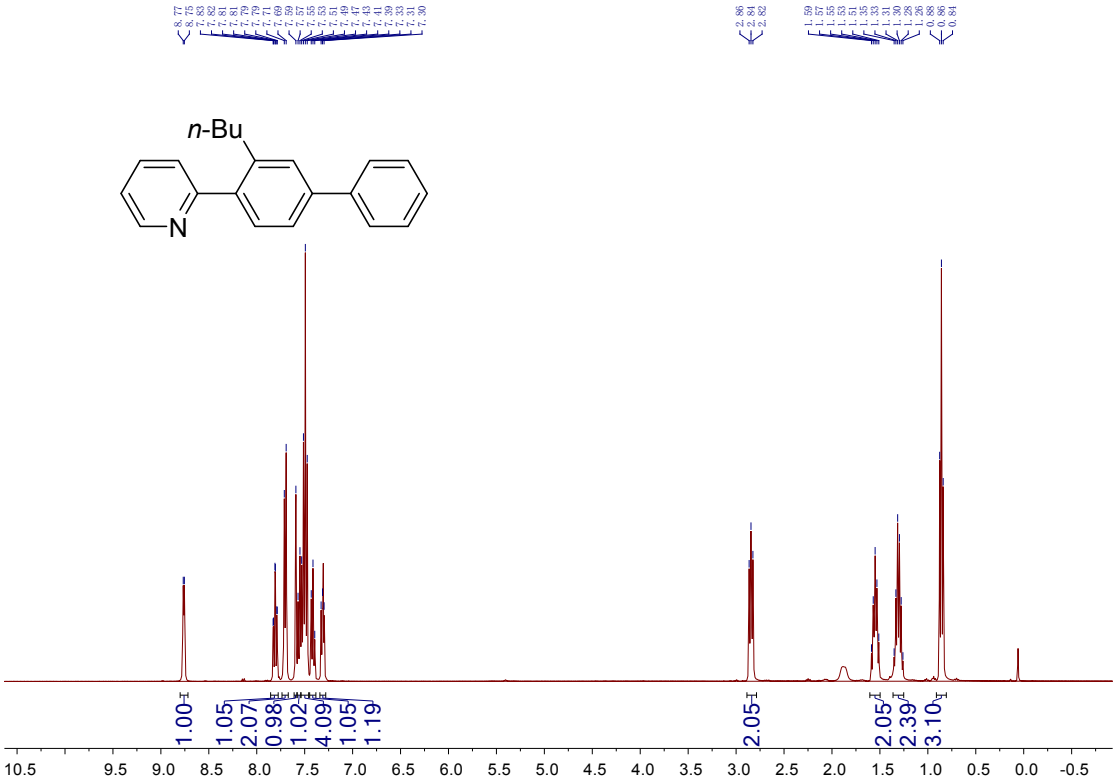


^{13}C NMR ($CDCl_3$)

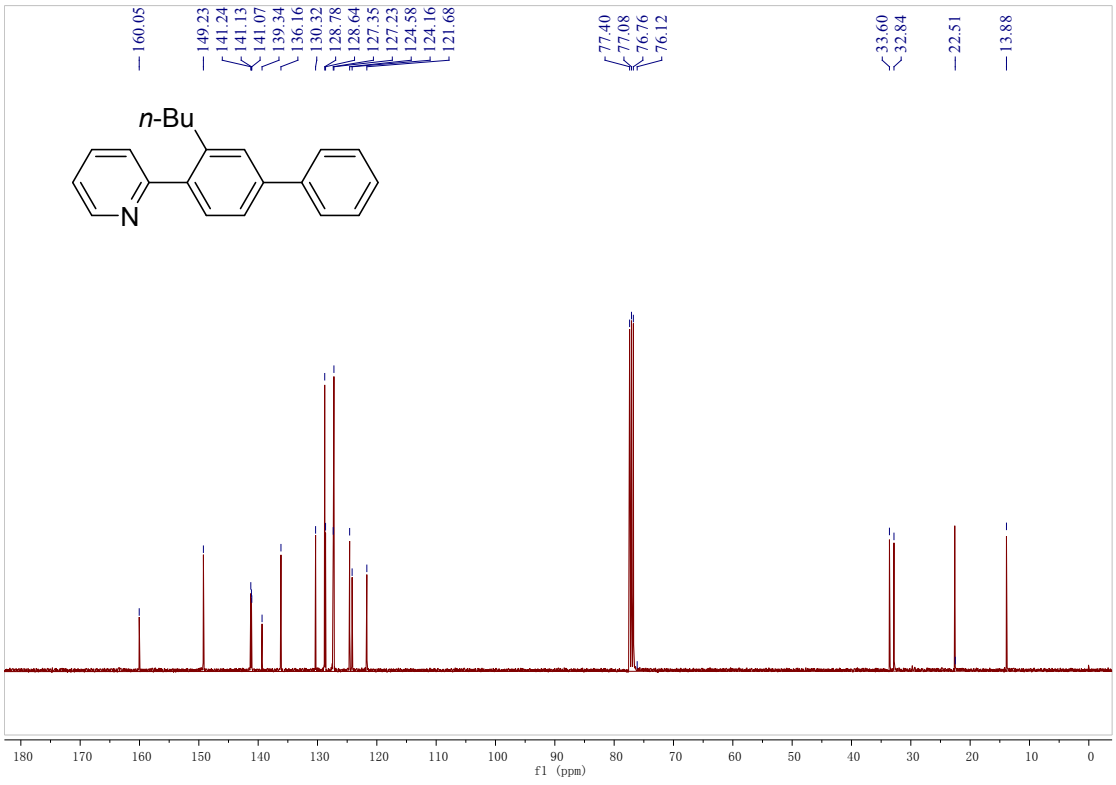


2-(3-butyl-[1,1'-biphenyl]-4-yl)pyridine (3ea)

^{1}H NMR ($CDCl_3$)



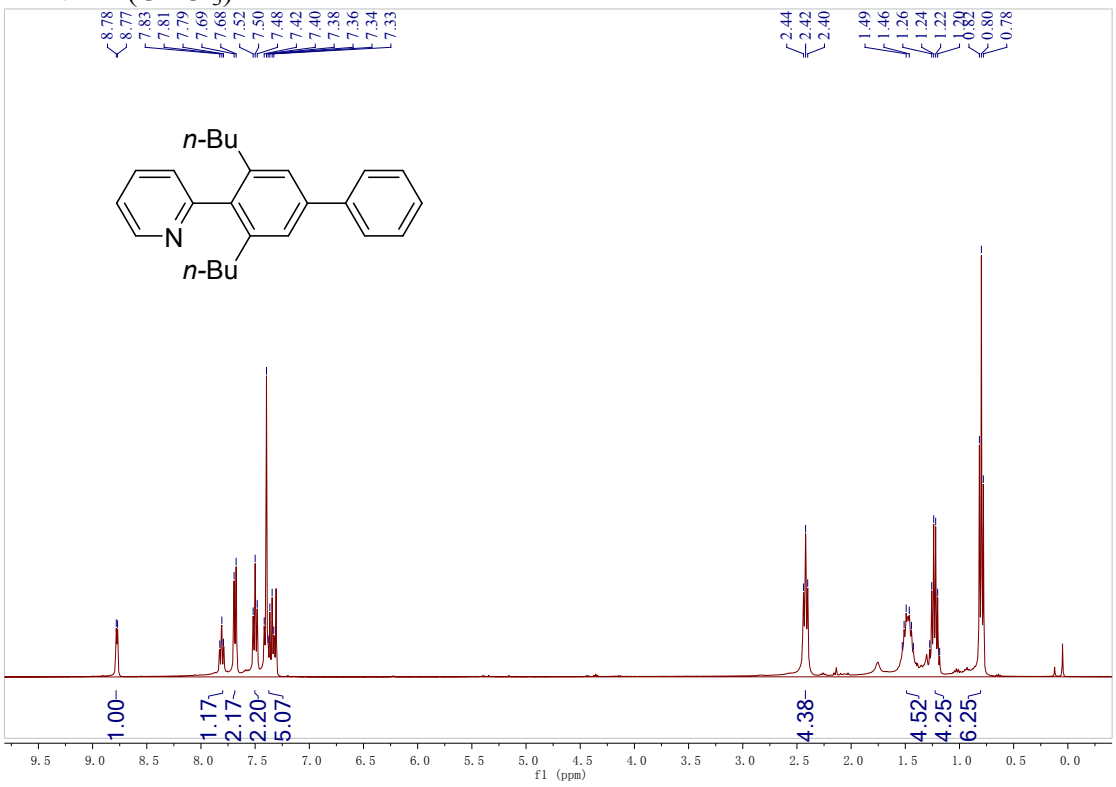
^{13}C NMR ($CDCl_3$)



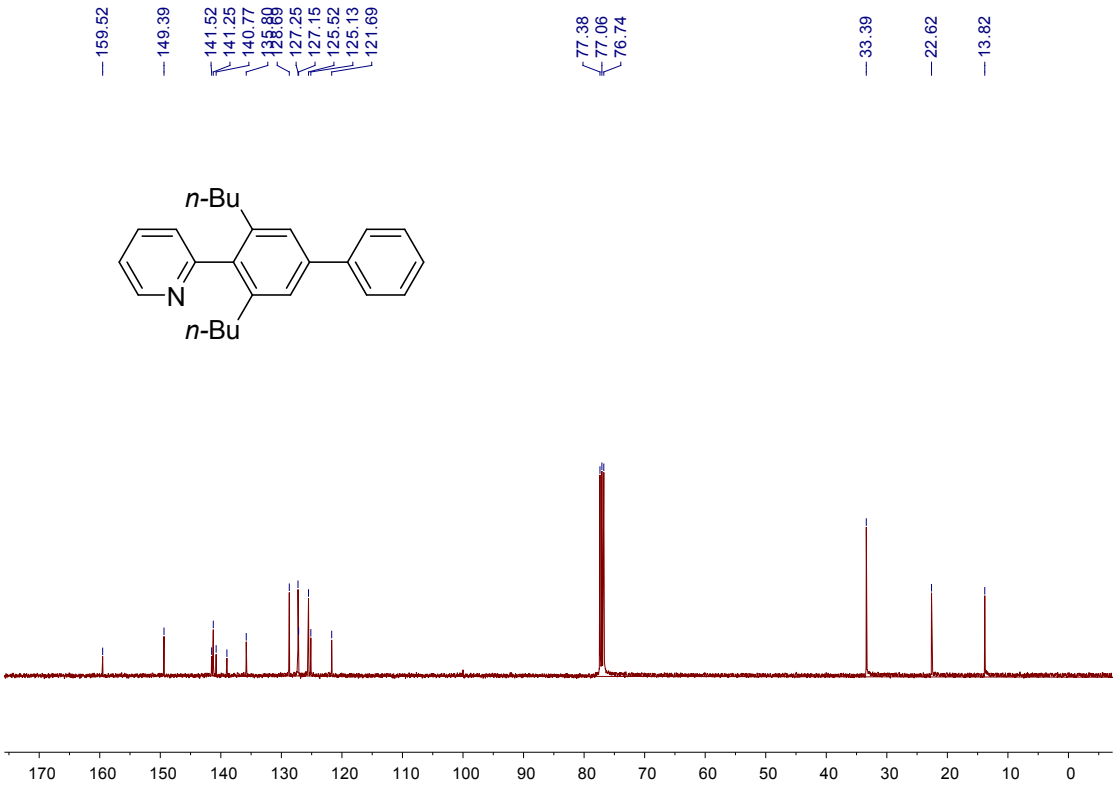
.

2-(3,5-dibutyl-[1,1'-biphenyl]-4-yl)pyridine (3ea-di)

^{1}H NMR ($CDCl_3$)

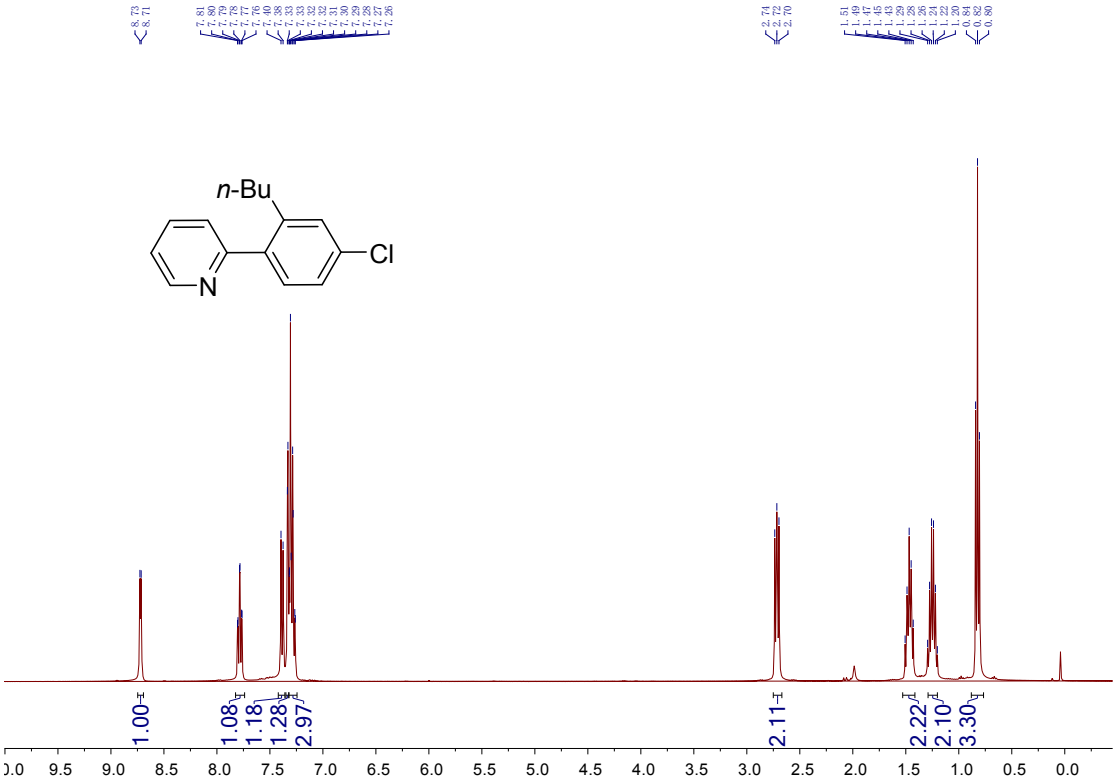


^{13}C NMR ($CDCl_3$)

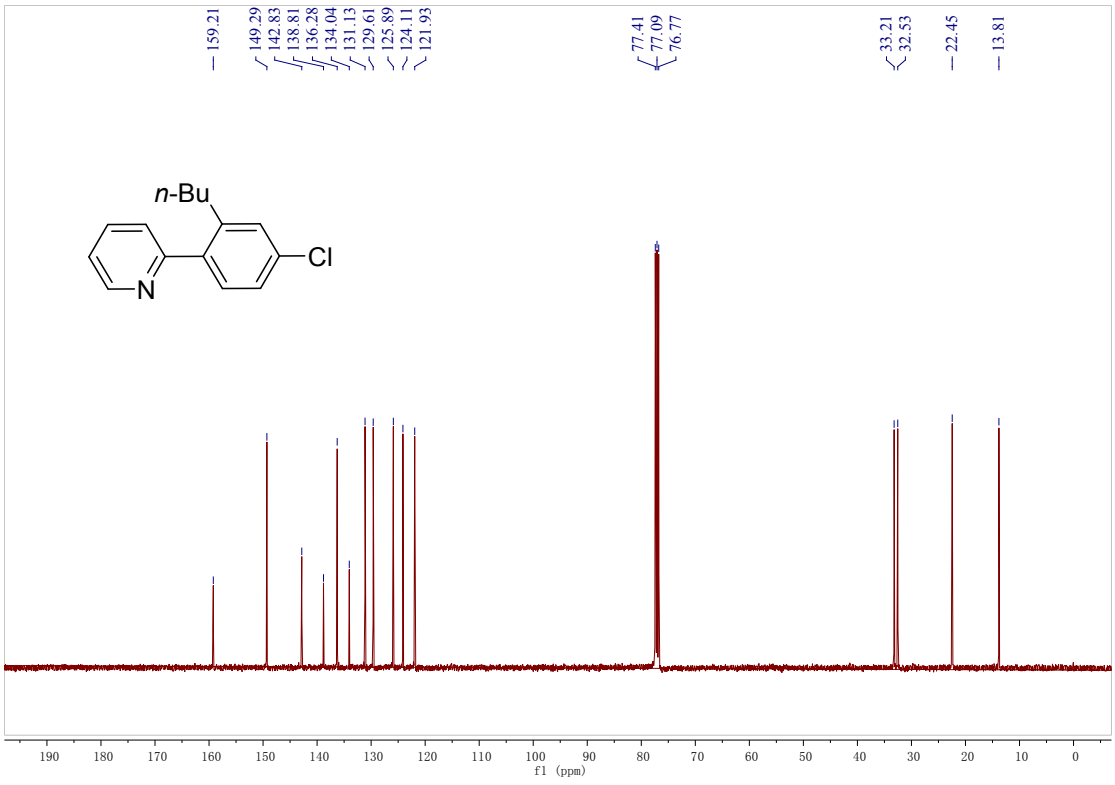


2-(2-butyl-4-chlorophenyl)pyridine (3fa)

^{1}H NMR ($CDCl_3$)

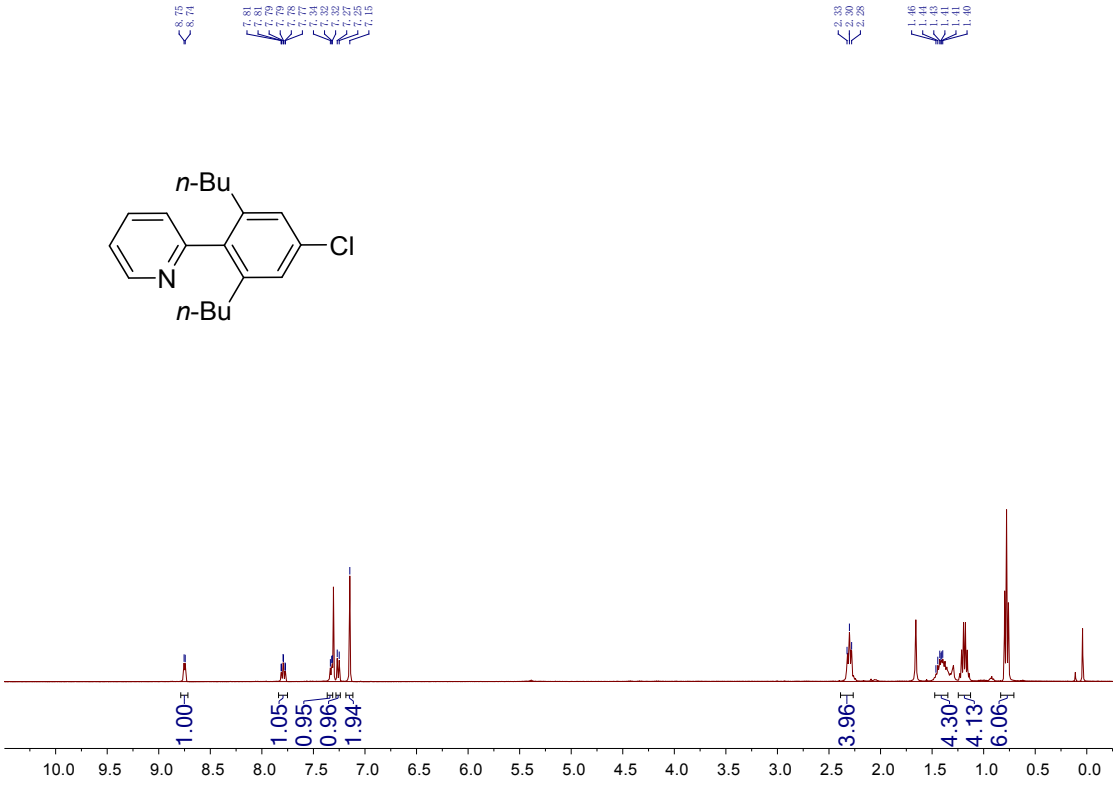


^{13}C NMR ($CDCl_3$)

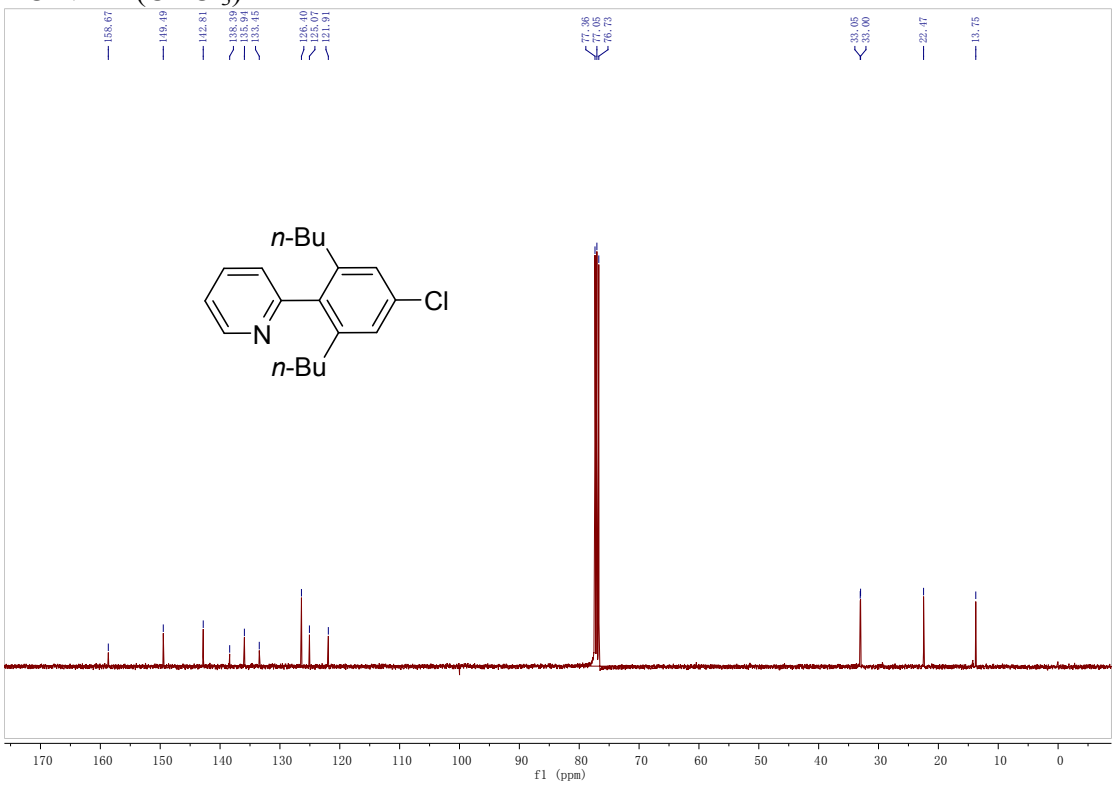


2-(2,6-dibutyl-4-chlorophenyl)pyridine（3fa-di）

^{1}H NMR ($CDCl_3$)

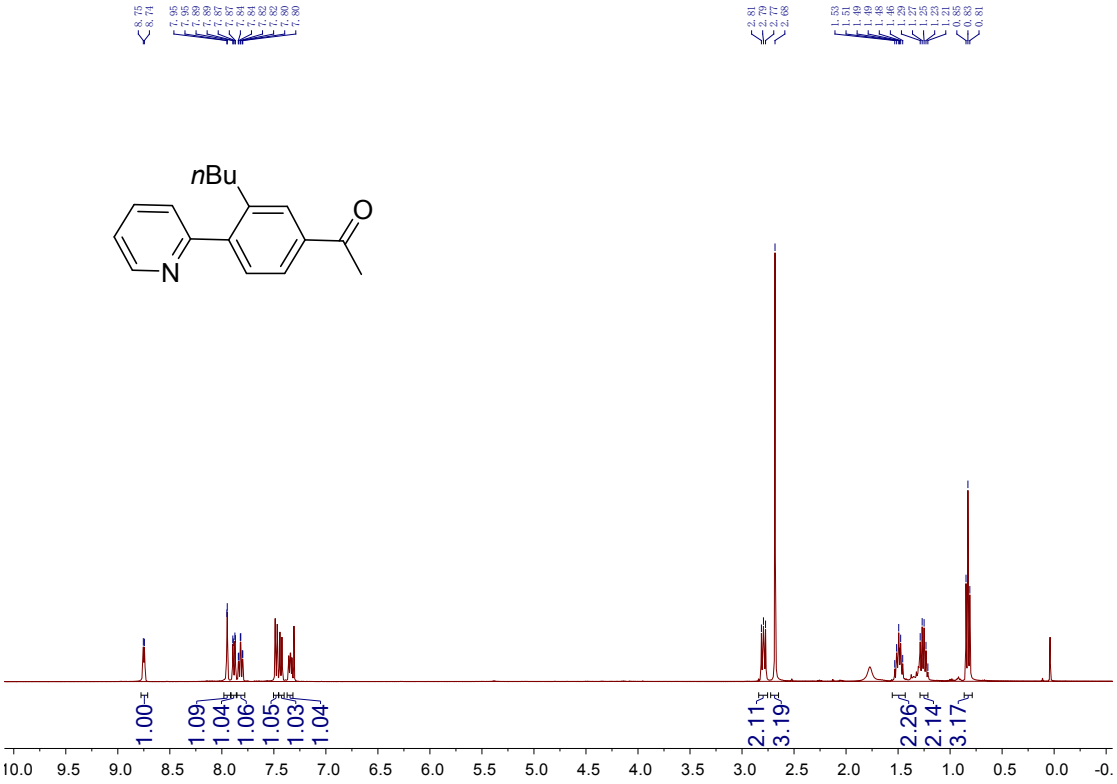


^{13}C NMR ($CDCl_3$)

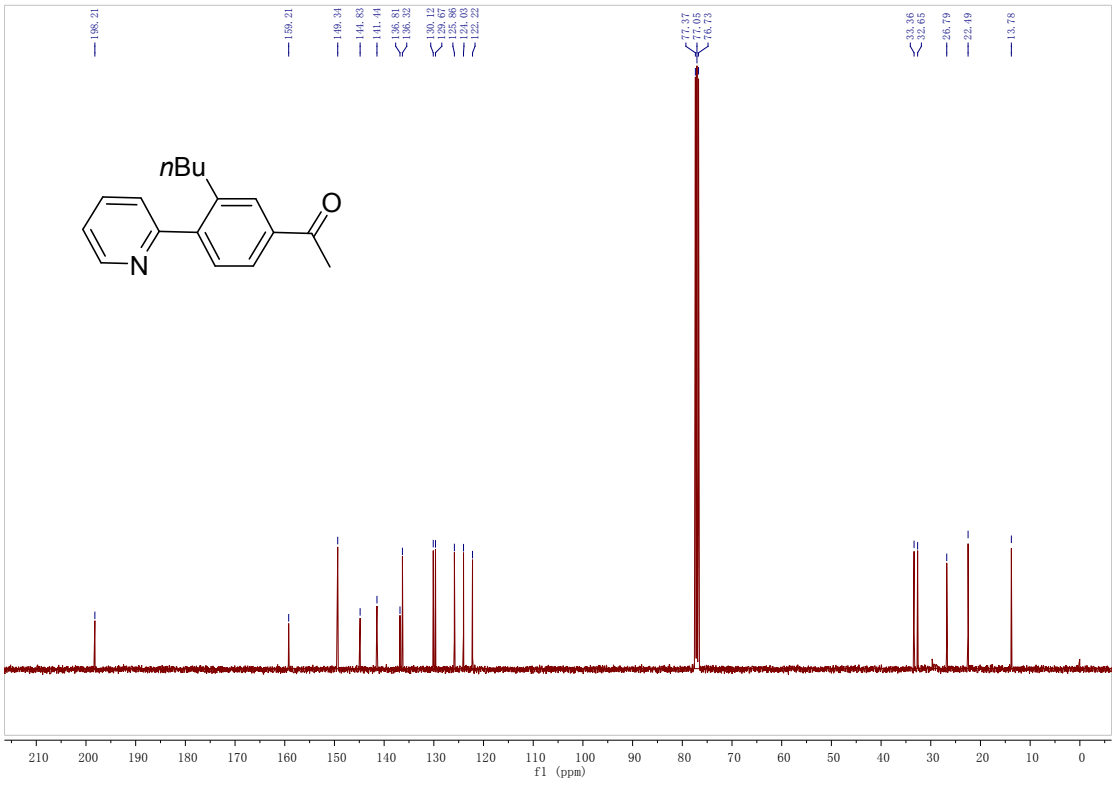


1-(3-butyl-4-(pyridin-2-yl)phenyl)ethan-1-one (3ga)

^{1}H NMR ($CDCl_3$)

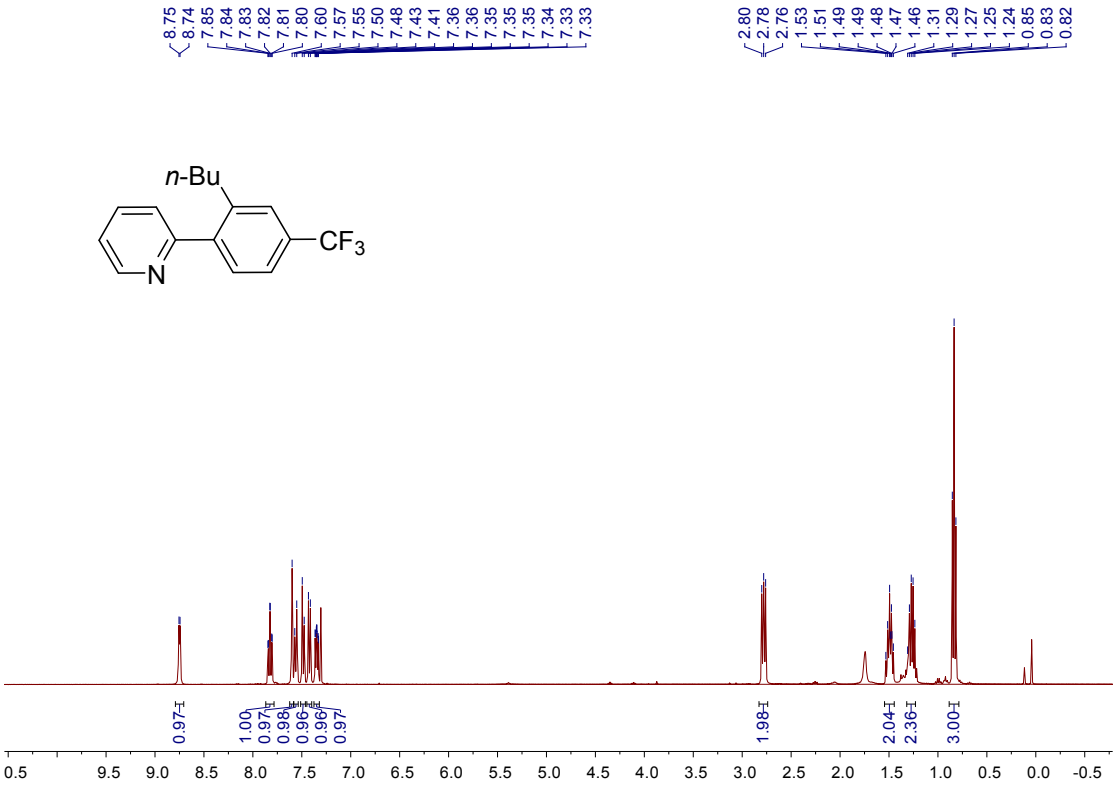


^{13}C NMR ($CDCl_3$)

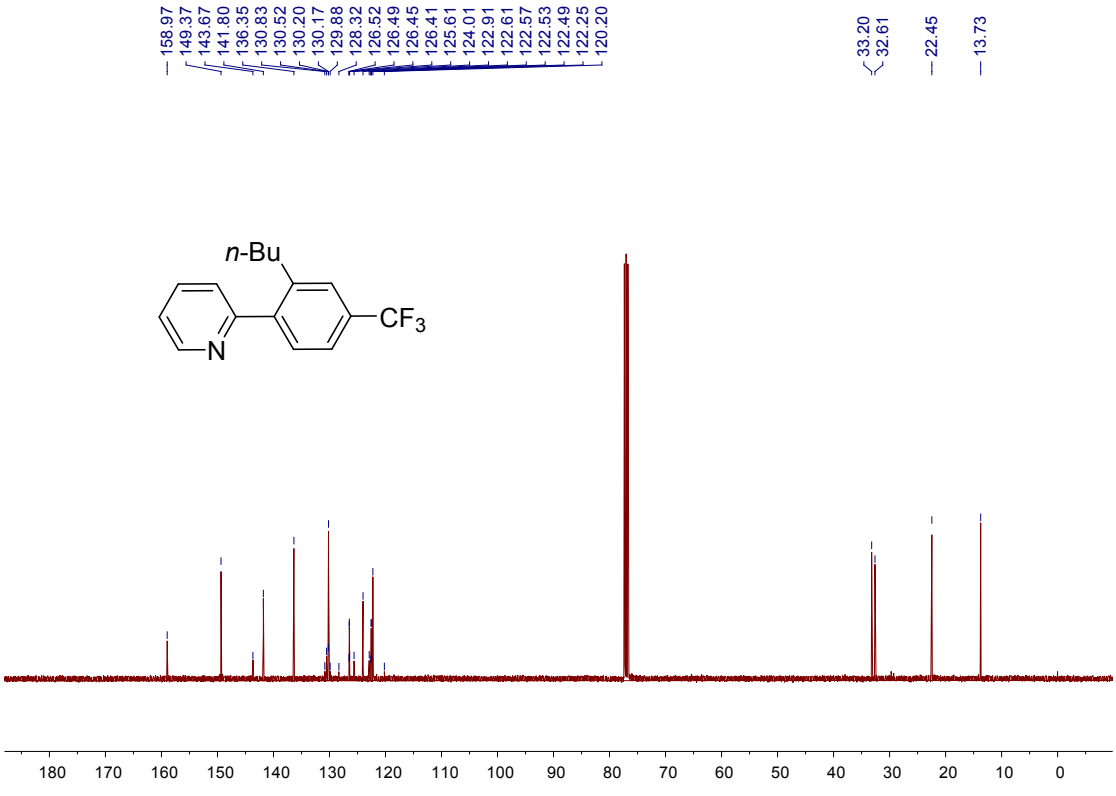


2-(2-butyl-4-(trifluoromethyl)phenyl)pyridine (3ha)

^{1}H NMR ($CDCl_3$)

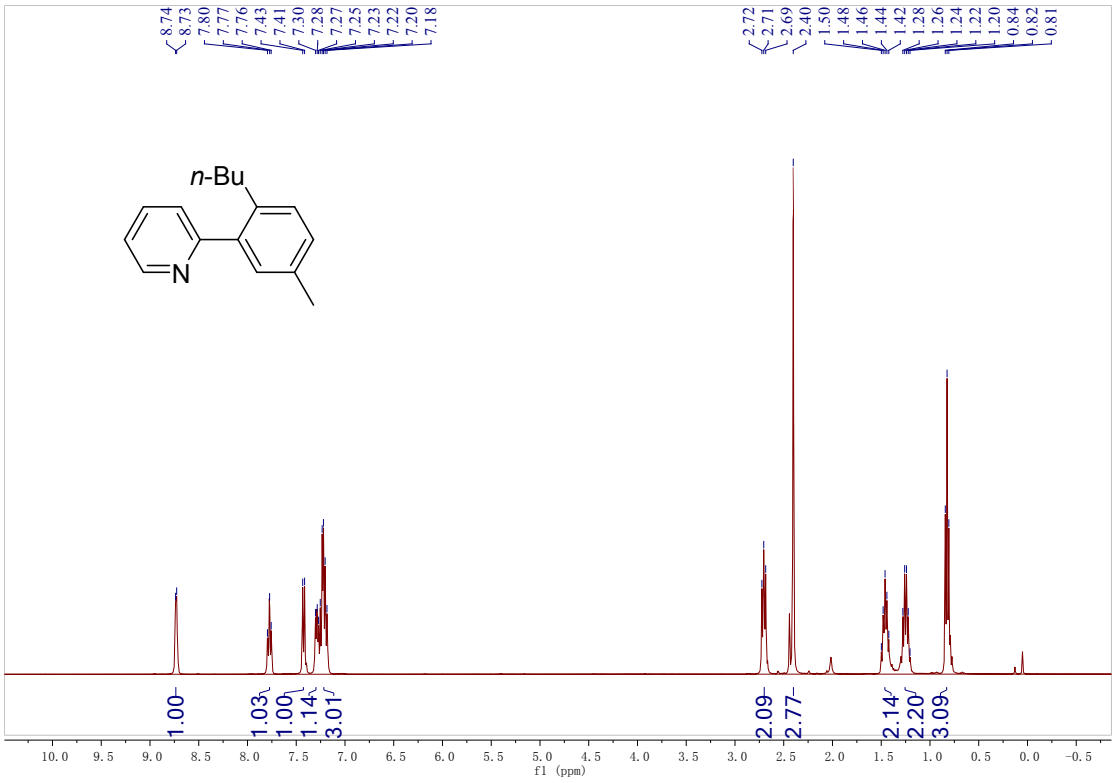


^{13}C NMR ($CDCl_3$)

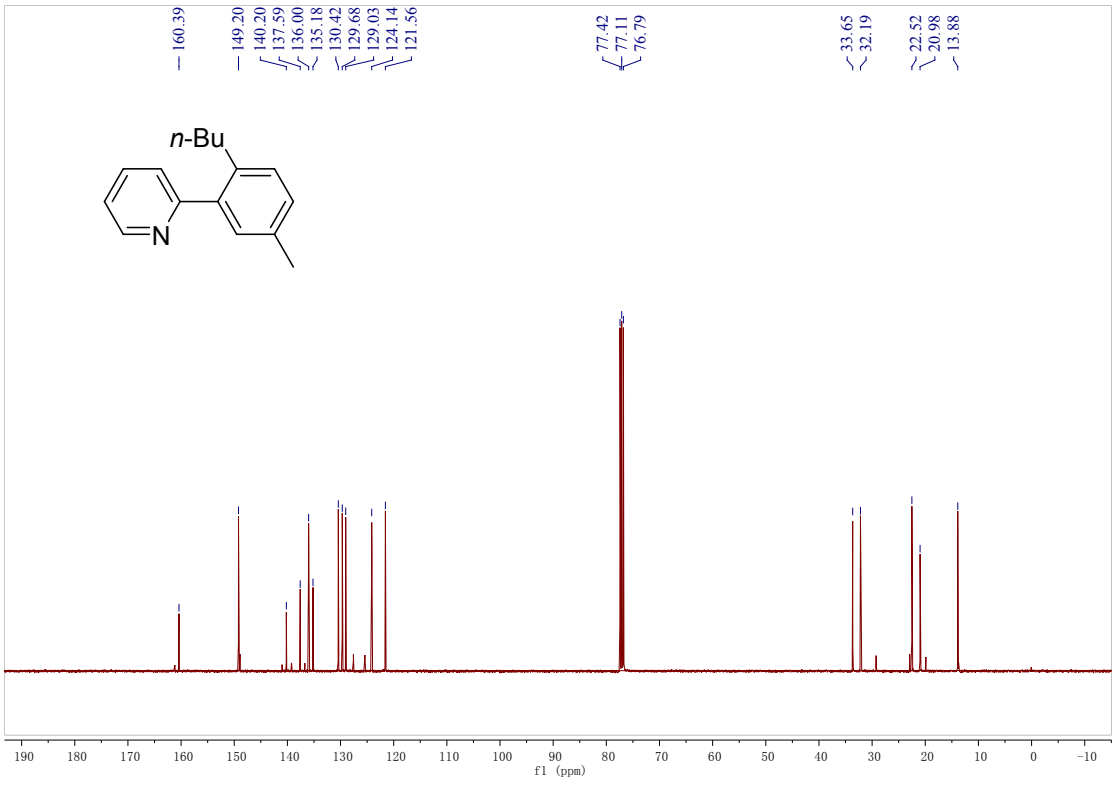


2-(2-butyl-5-methylphenyl)pyridine（3ia）

^{1}H NMR ($CDCl_3$)

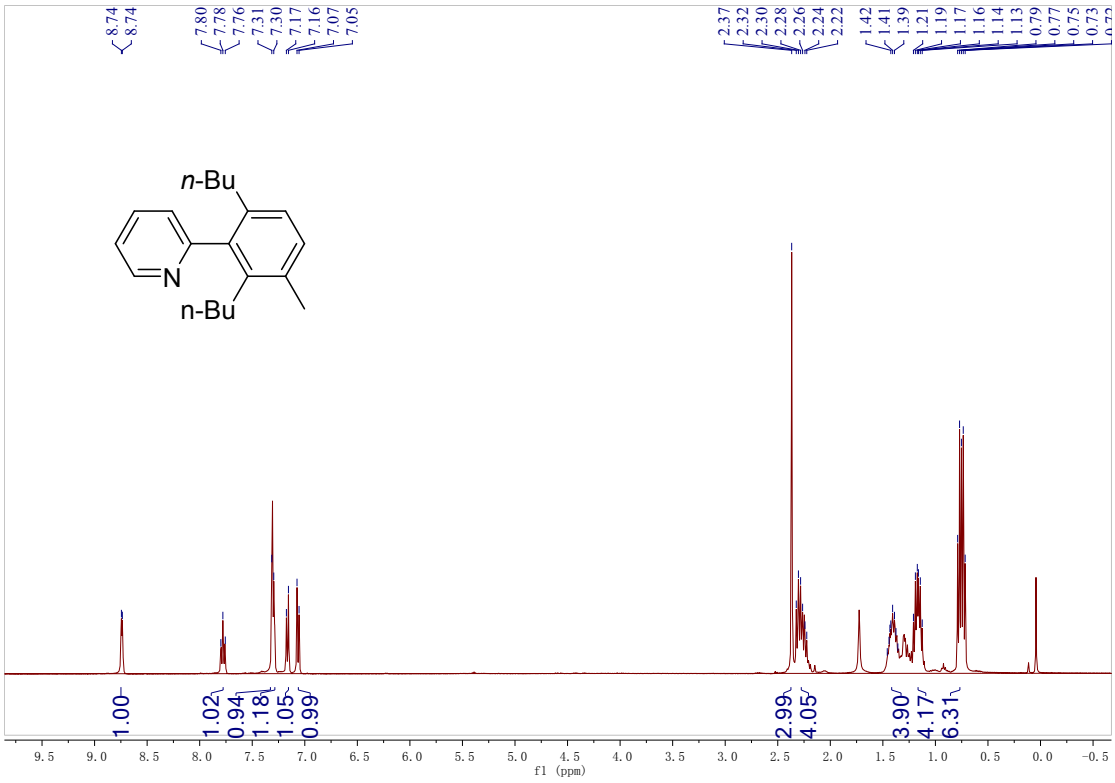


^{13}C NMR ($CDCl_3$)

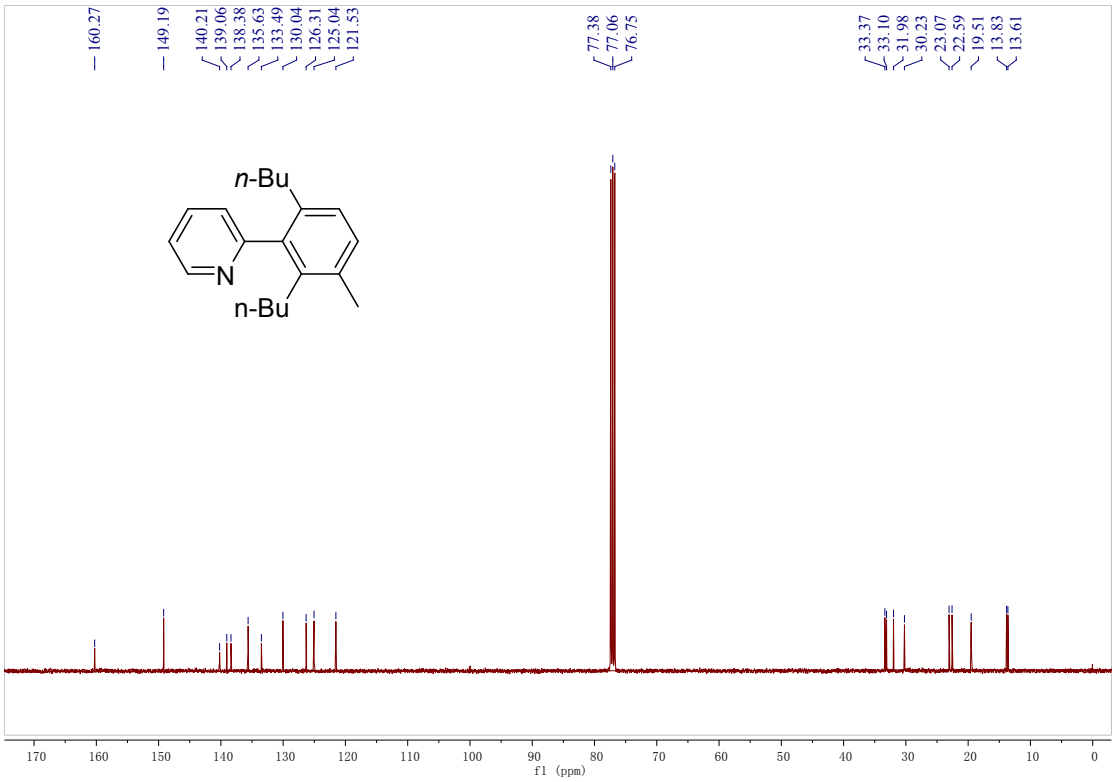


2-(2,6-dibutyl-3-methylphenyl)pyridine (3ia-di)

^{1}H NMR ($CDCl_3$)

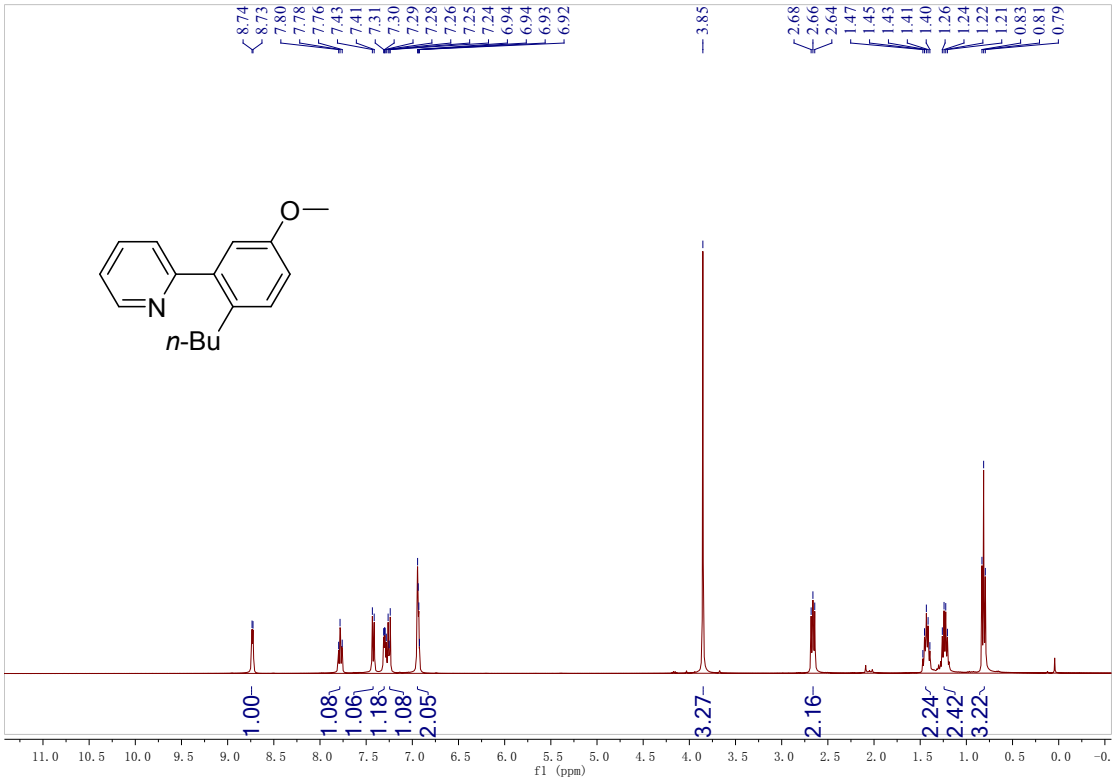


^{13}C NMR ($CDCl_3$)

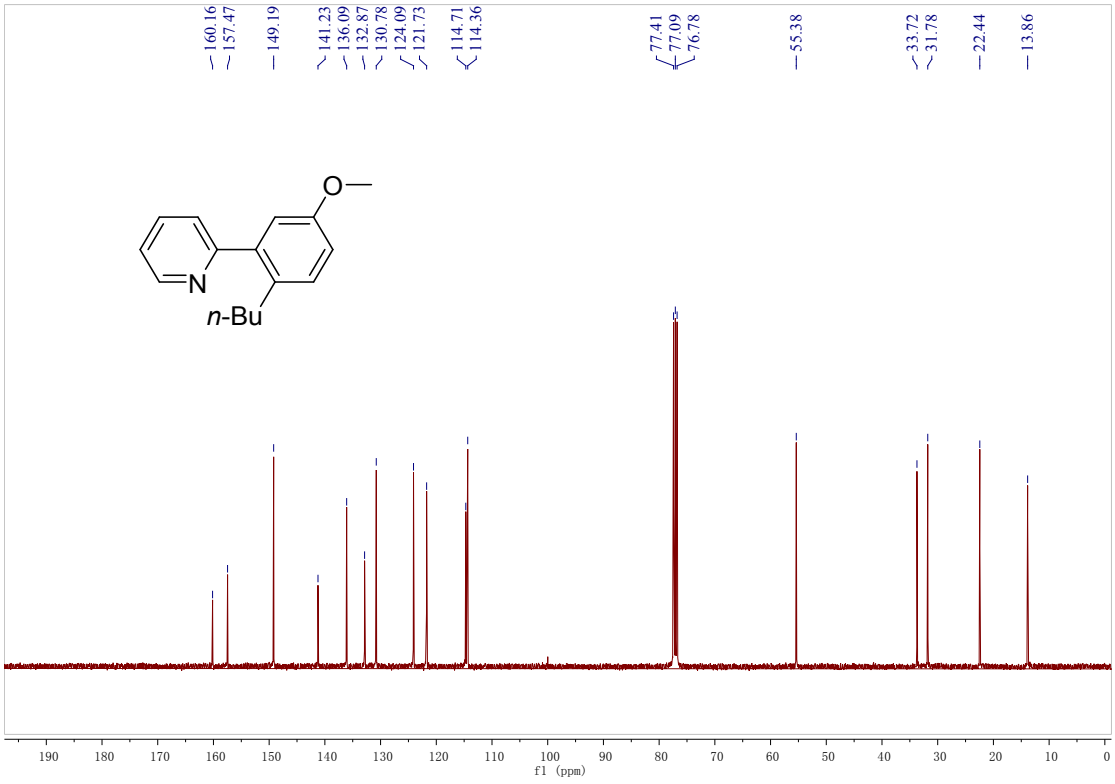


2-(2-butyl-5-methoxyphenyl)pyridine (3ja)

^{1}H NMR ($CDCl_3$)

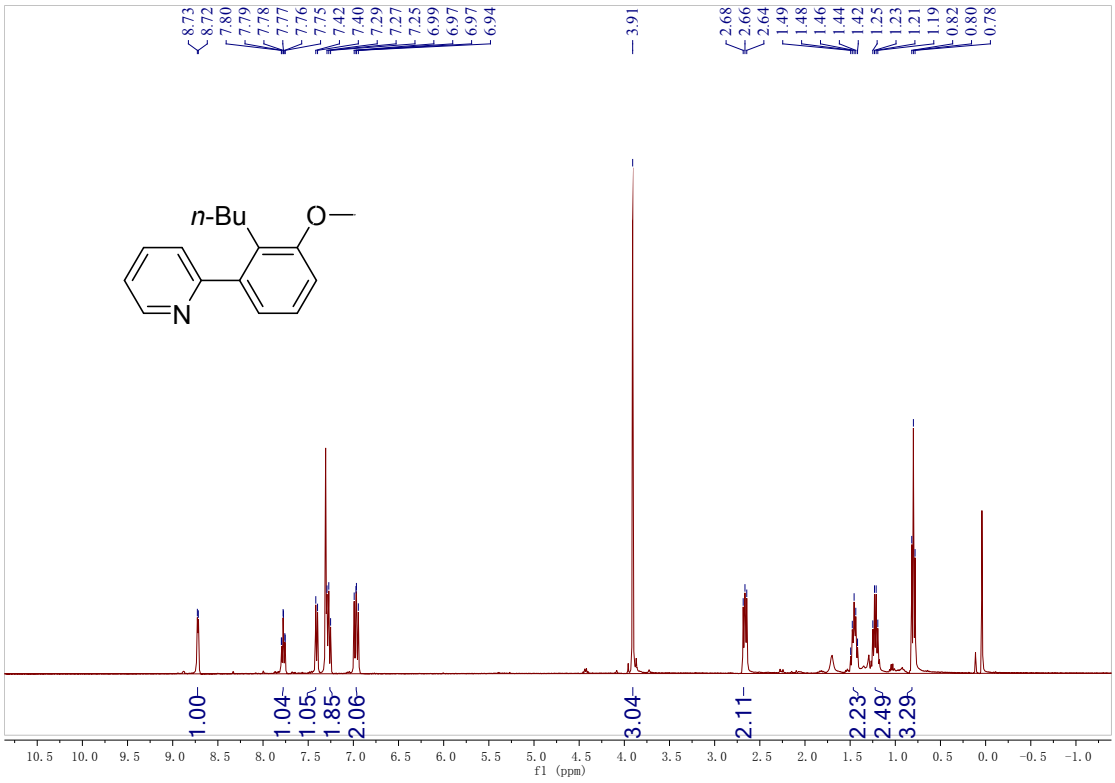


^{13}C NMR ($CDCl_3$)

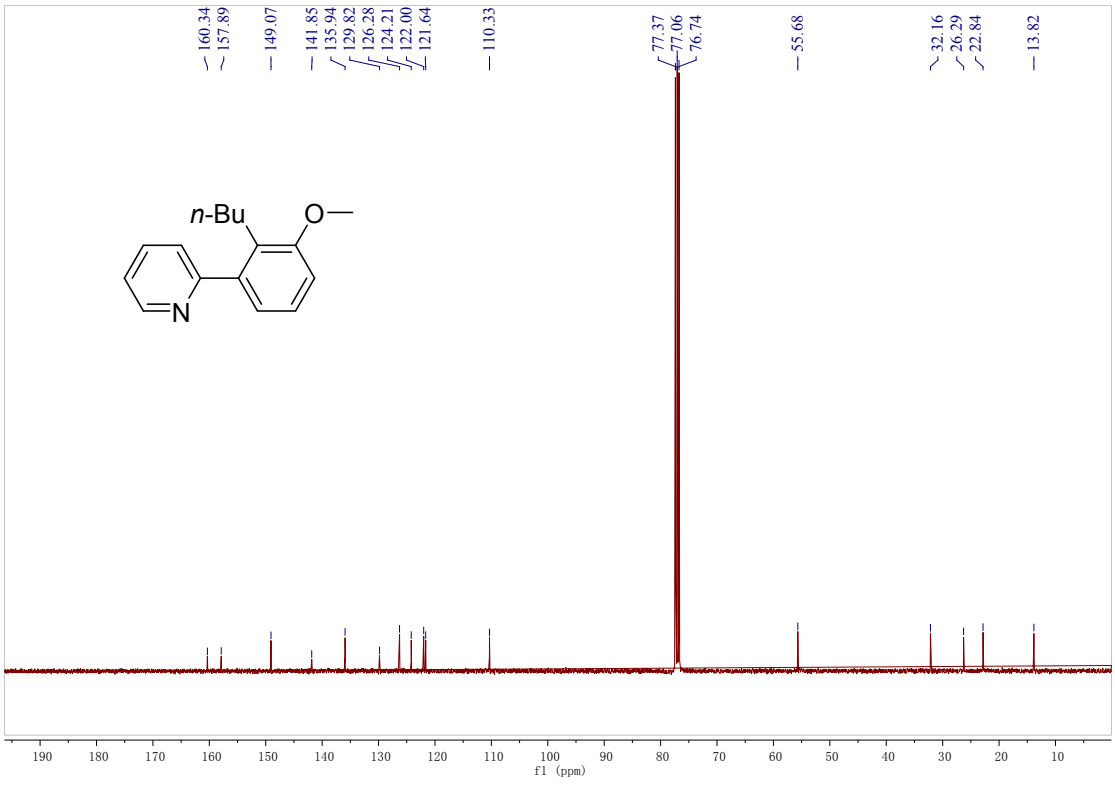


2-(2-butyl-3-methoxyphenyl)pyridine (3ja-iso)

^{1}H NMR ($CDCl_3$)

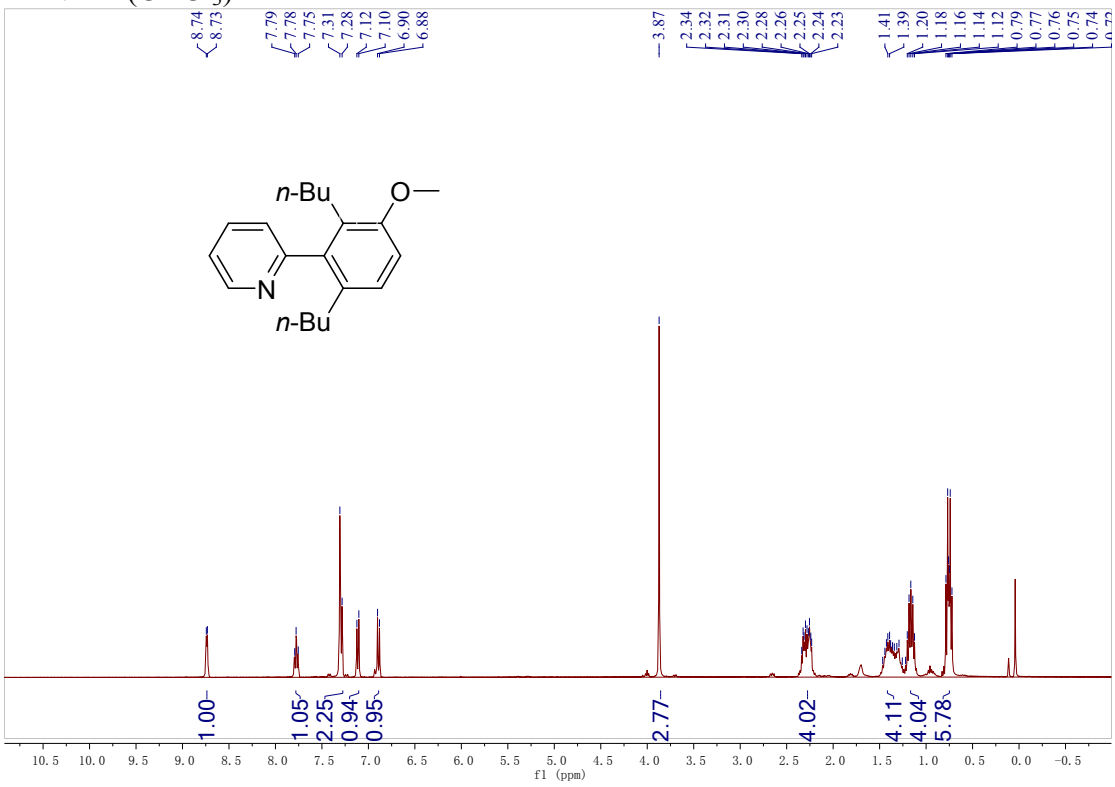


^{13}C NMR ($CDCl_3$)

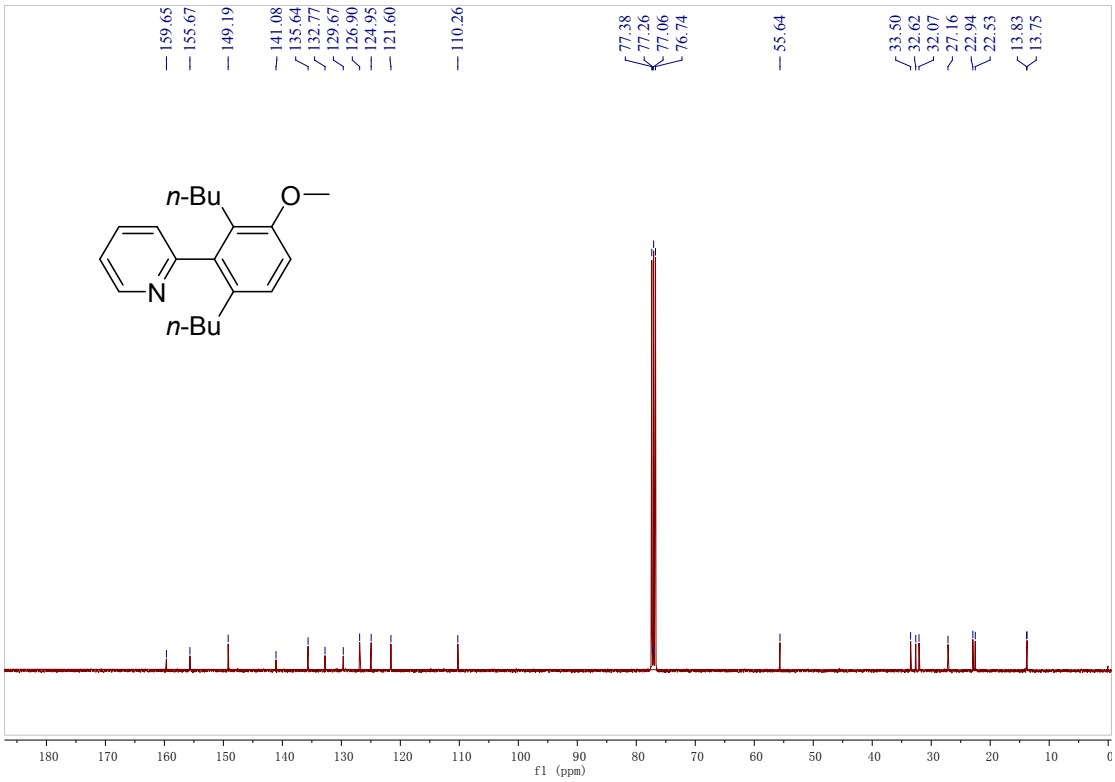


2-(2,6-dibutyl-3-methoxyphenyl)pyridine (3ja-di)

^{1}H NMR ($CDCl_3$)

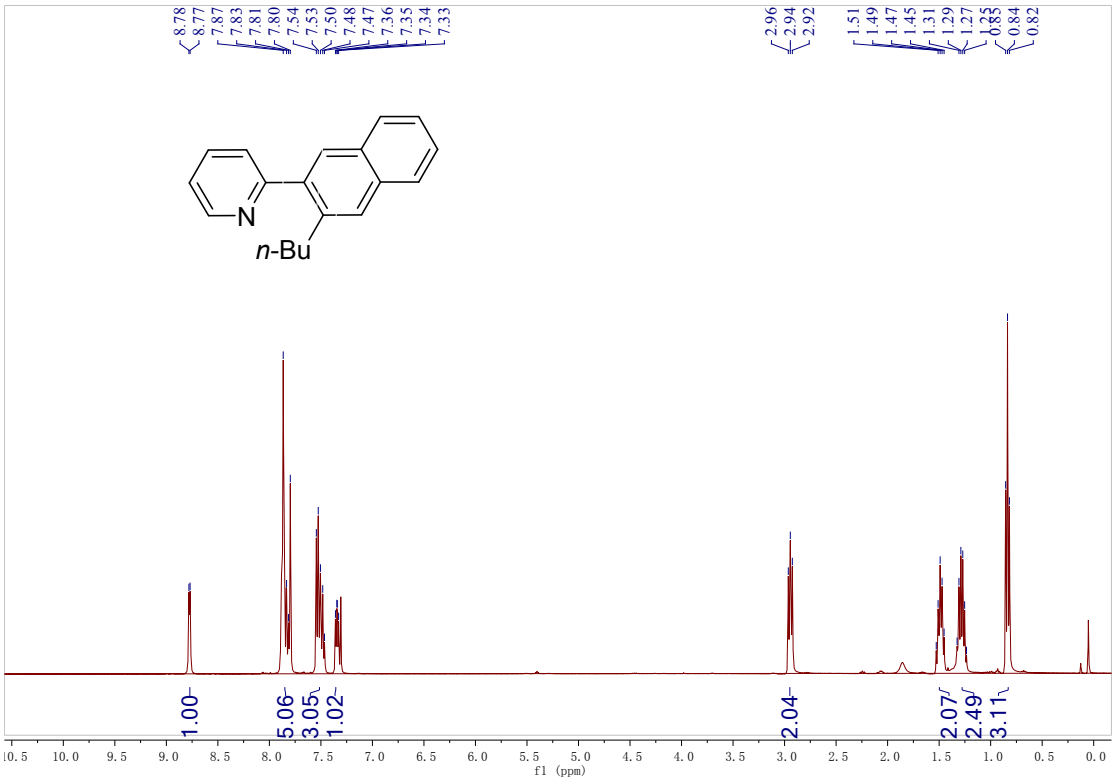


^{13}C NMR ($CDCl_3$)

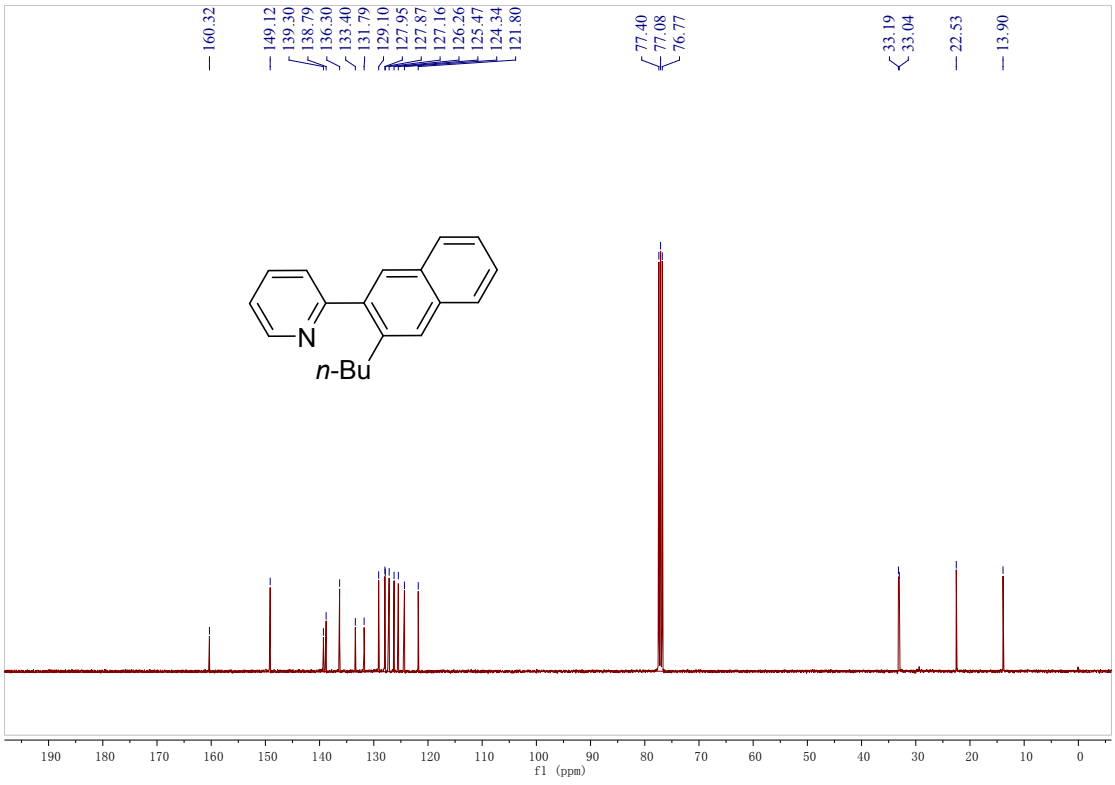


2-(3-butylnaphthalen-2-yl)pyridine (3ka)

^{1}H NMR ($CDCl_3$)

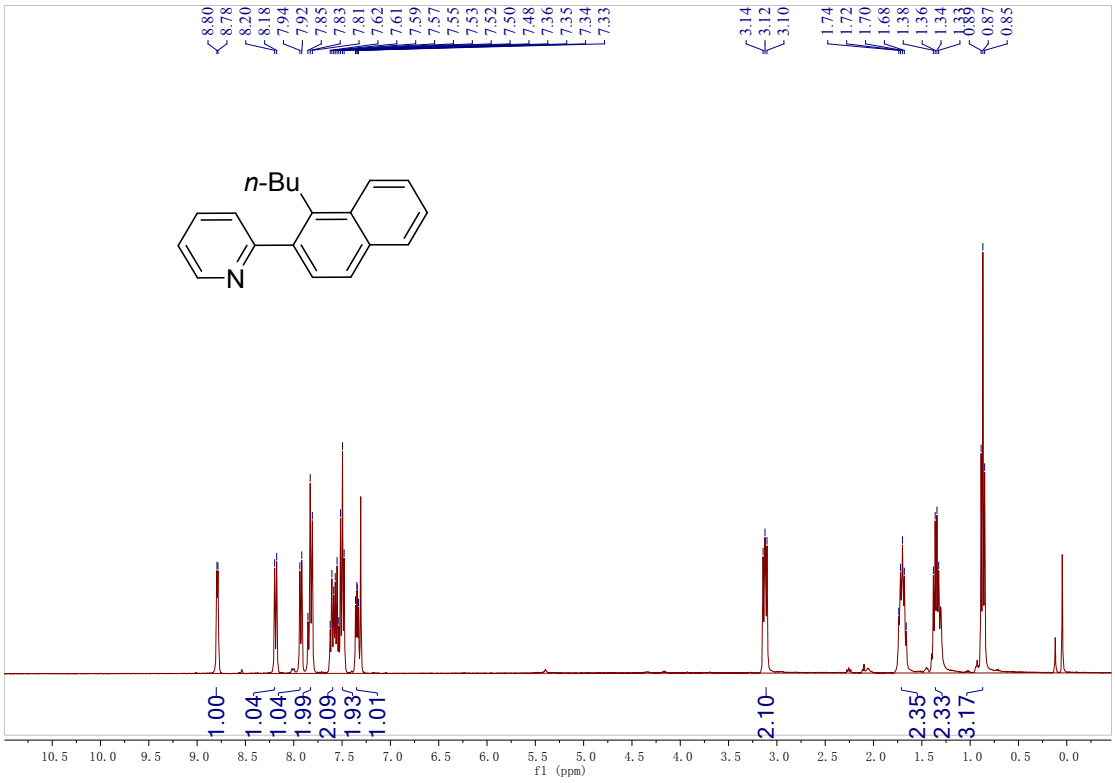


^{13}C NMR ($CDCl_3$)

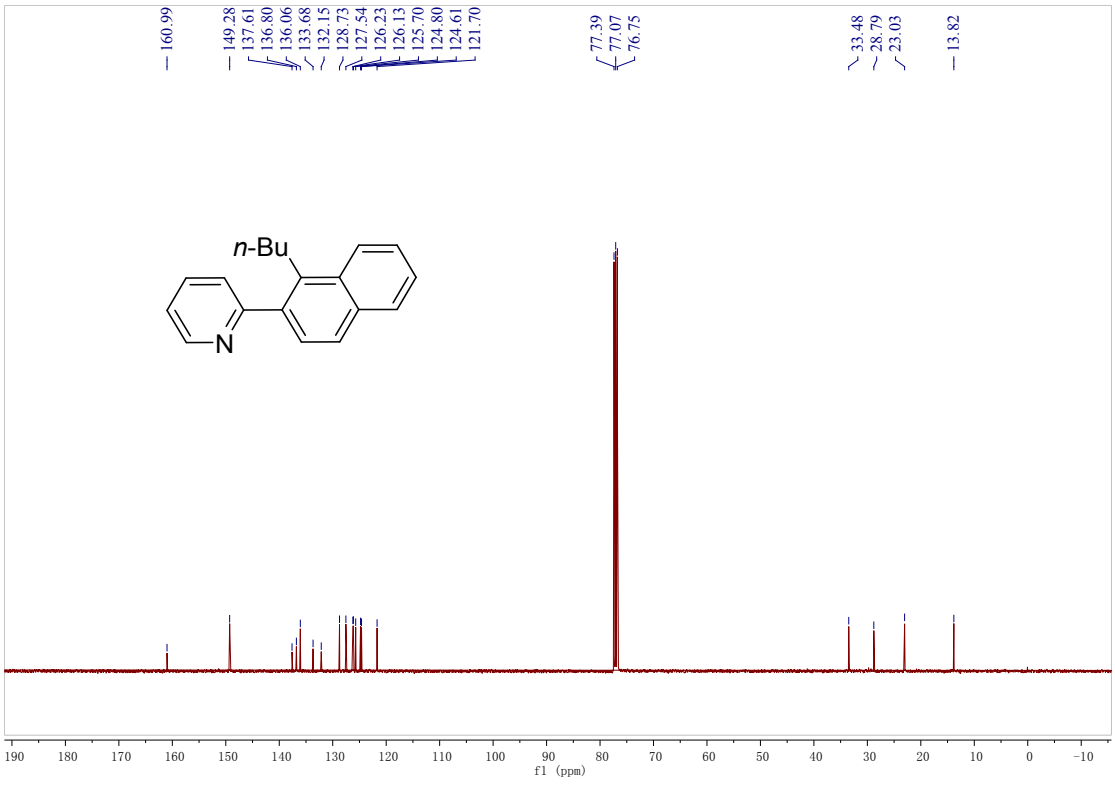


2-(1-butylnaphthalen-2-yl)pyridine (3ka-iso)

^{1}H NMR ($CDCl_3$)

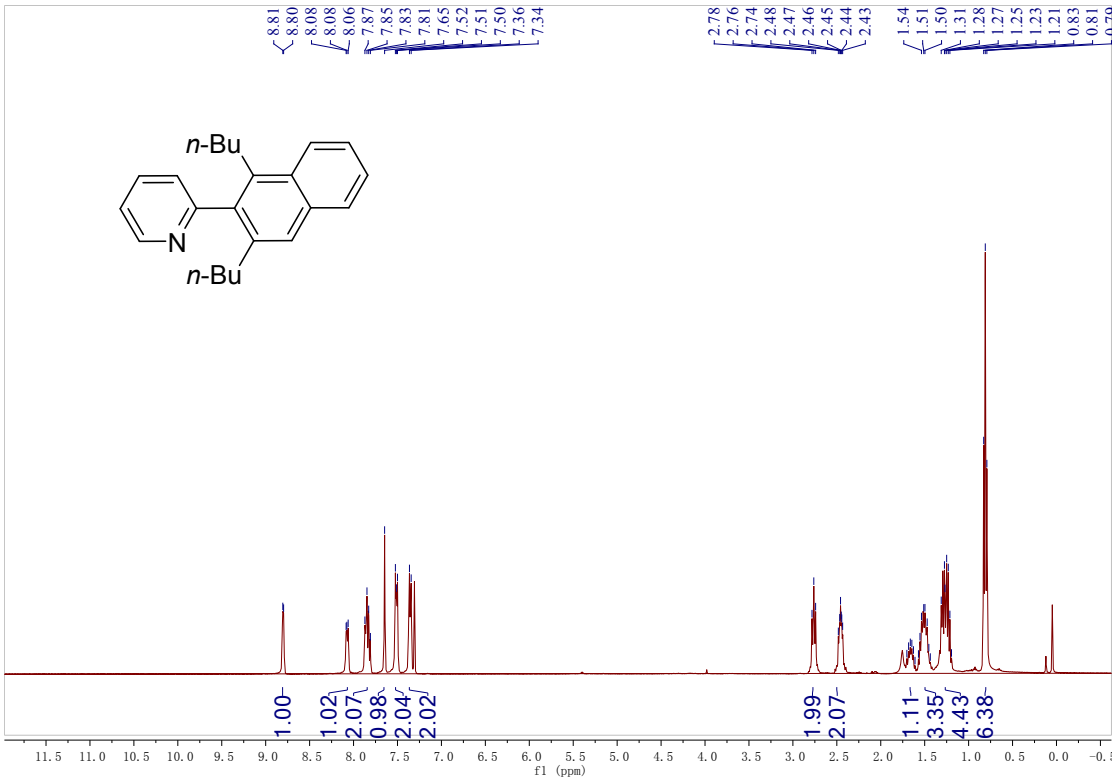


^{13}C NMR ($CDCl_3$)

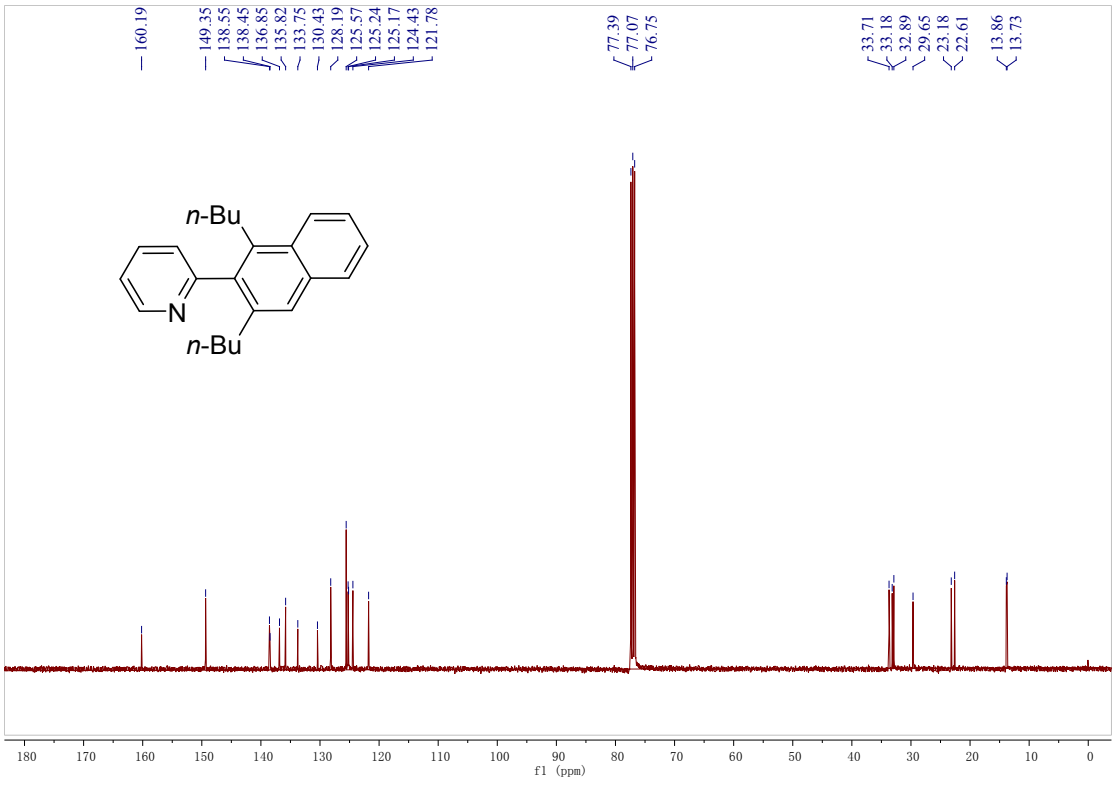


2-(1,3-dibutylnaphthalen-2-yl)pyridine (3ka-di)

^{1}H NMR ($CDCl_3$)

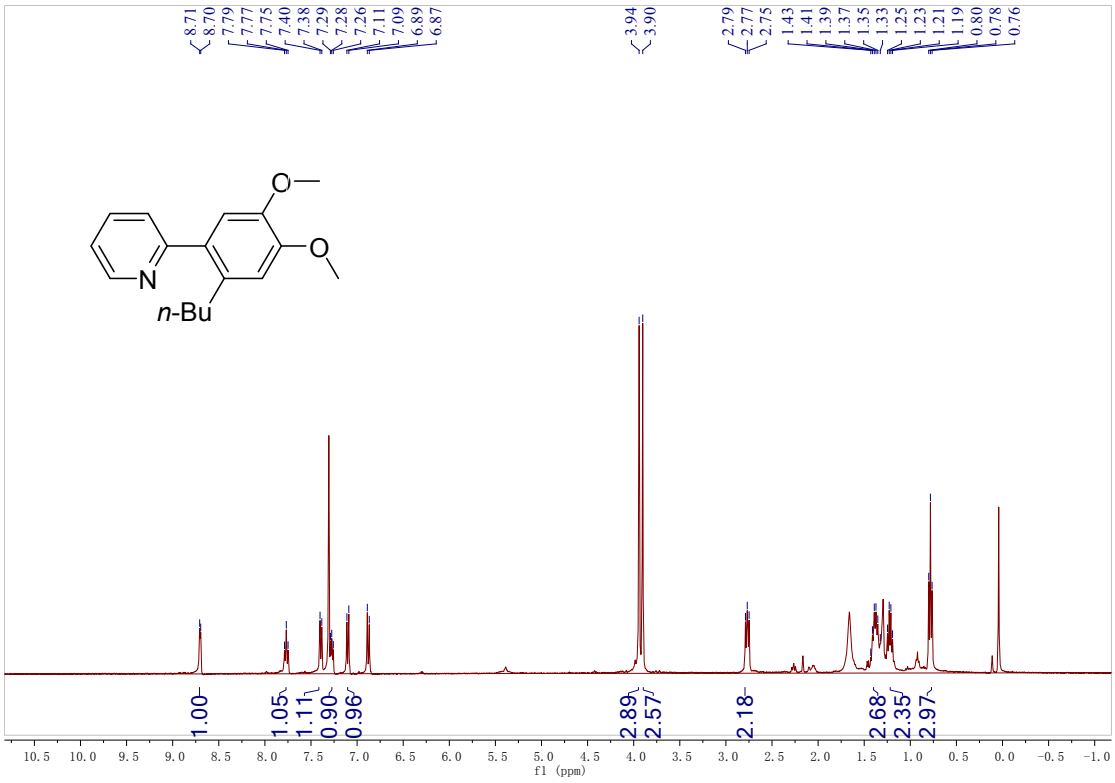


^{13}C NMR ($CDCl_3$)

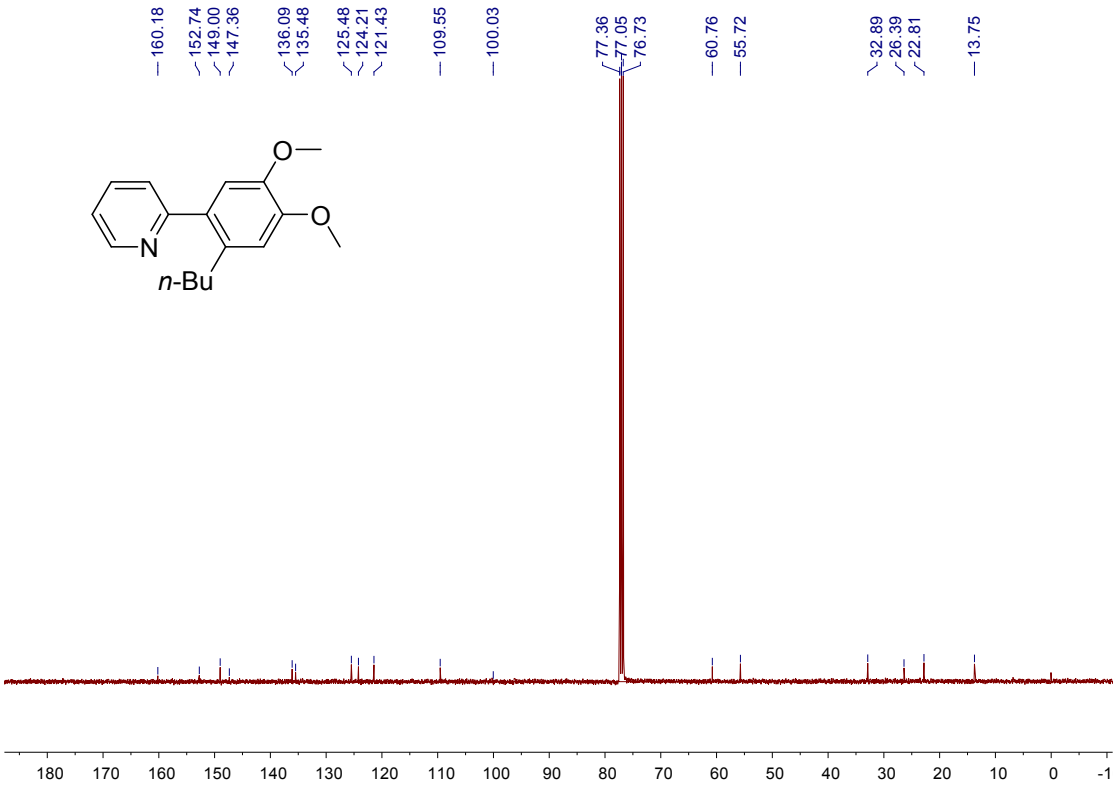


2-(2-butyl-3,4-dimethoxyphenyl)pyridine (3la)

^{1}H NMR ($CDCl_3$)

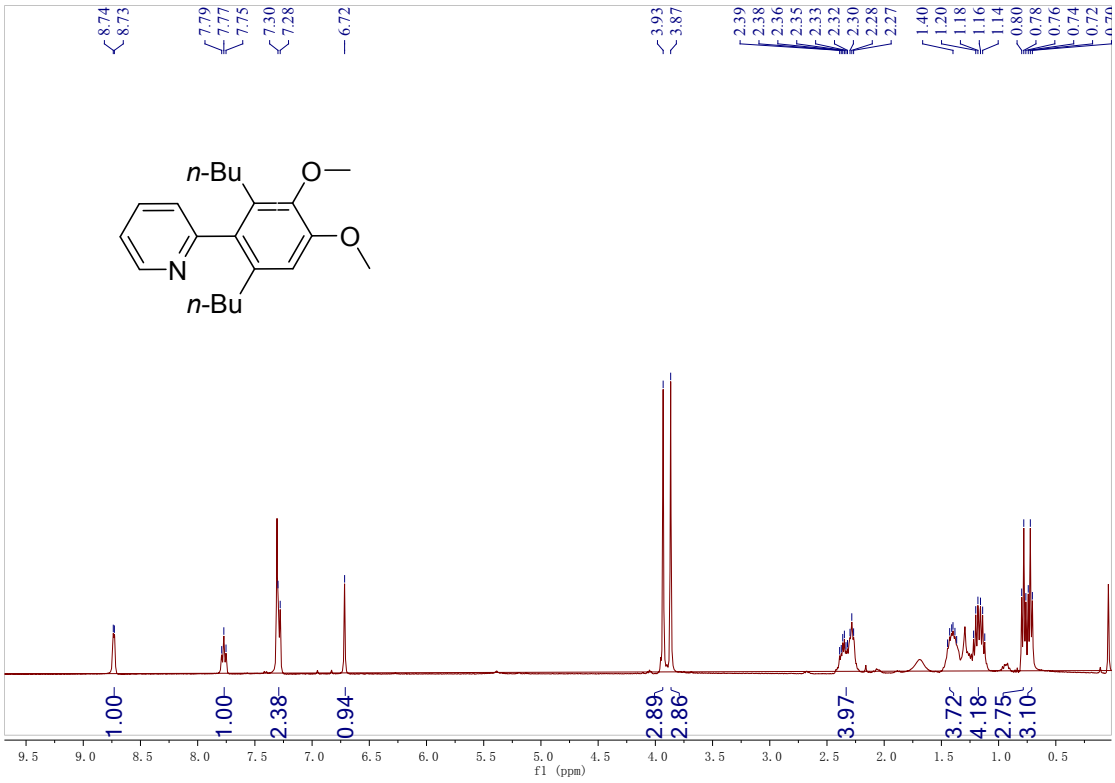


^{13}C NMR ($CDCl_3$)

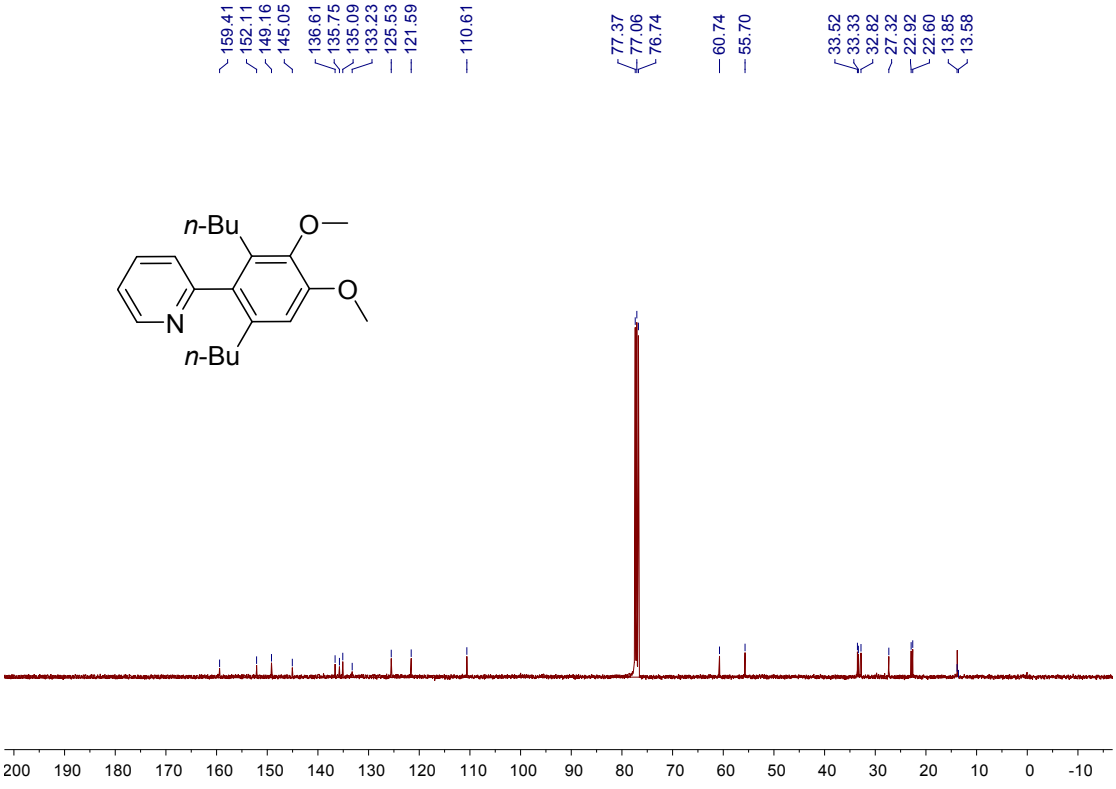


2-(2,6-dibutyl-3,4-dimethoxyphenyl)pyridine（3la-di）

^{1}H NMR ($CDCl_3$)

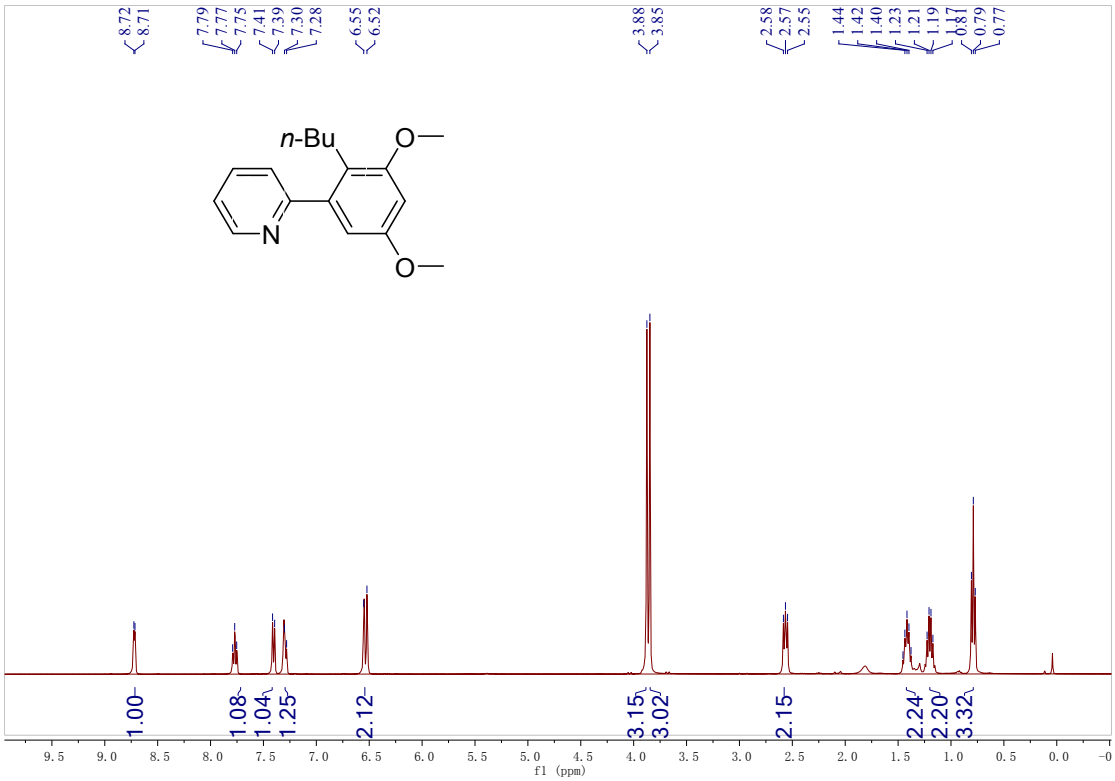


^{13}C NMR ($CDCl_3$)

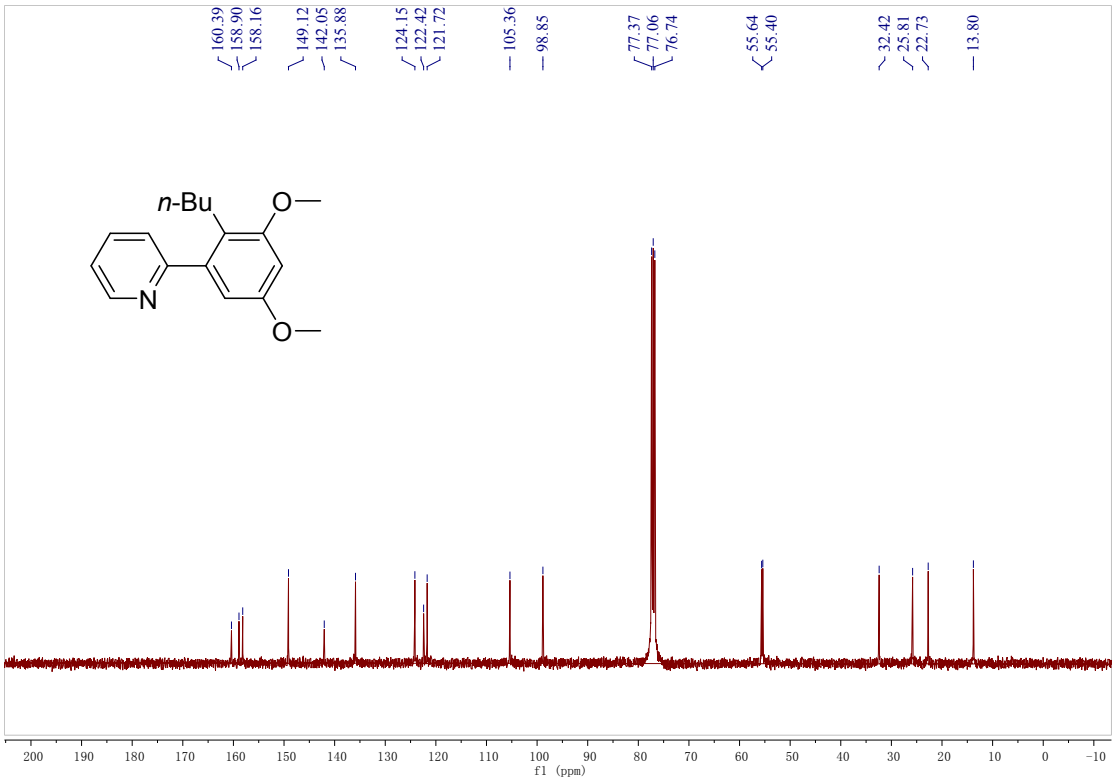


2-(2-butyl-3,5-dimethoxyphenyl)pyridine (3ma)

^{1}H NMR ($CDCl_3$)

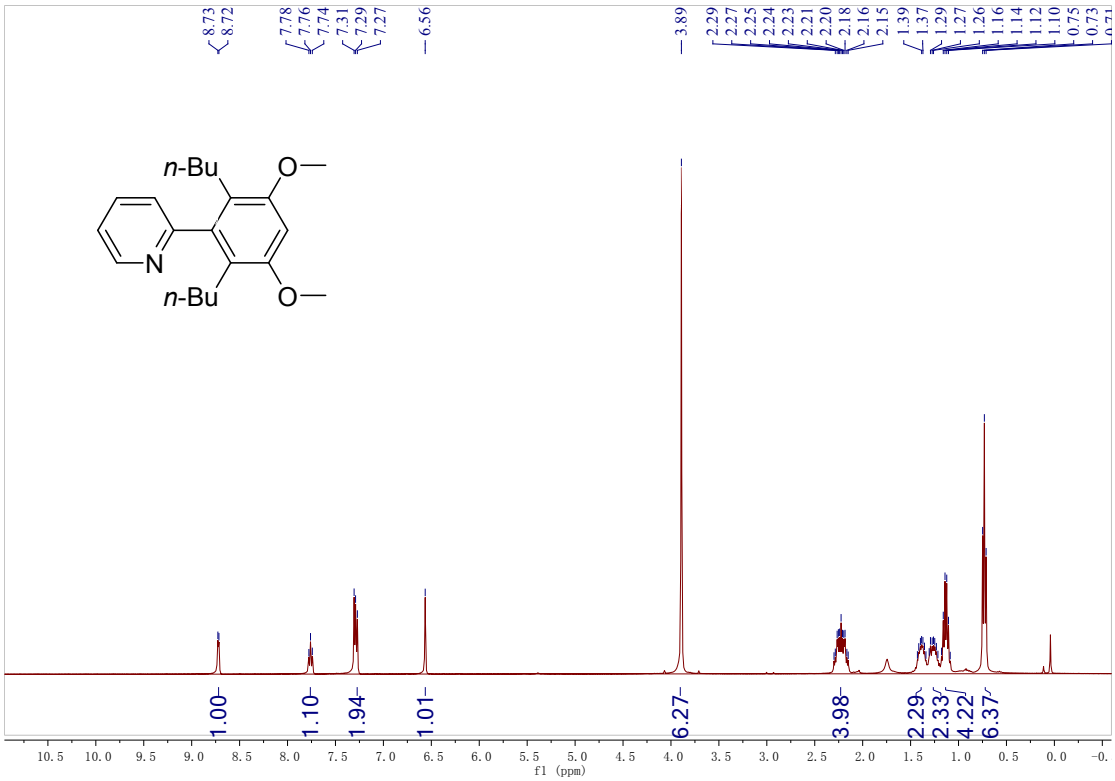


^{13}C NMR ($CDCl_3$)

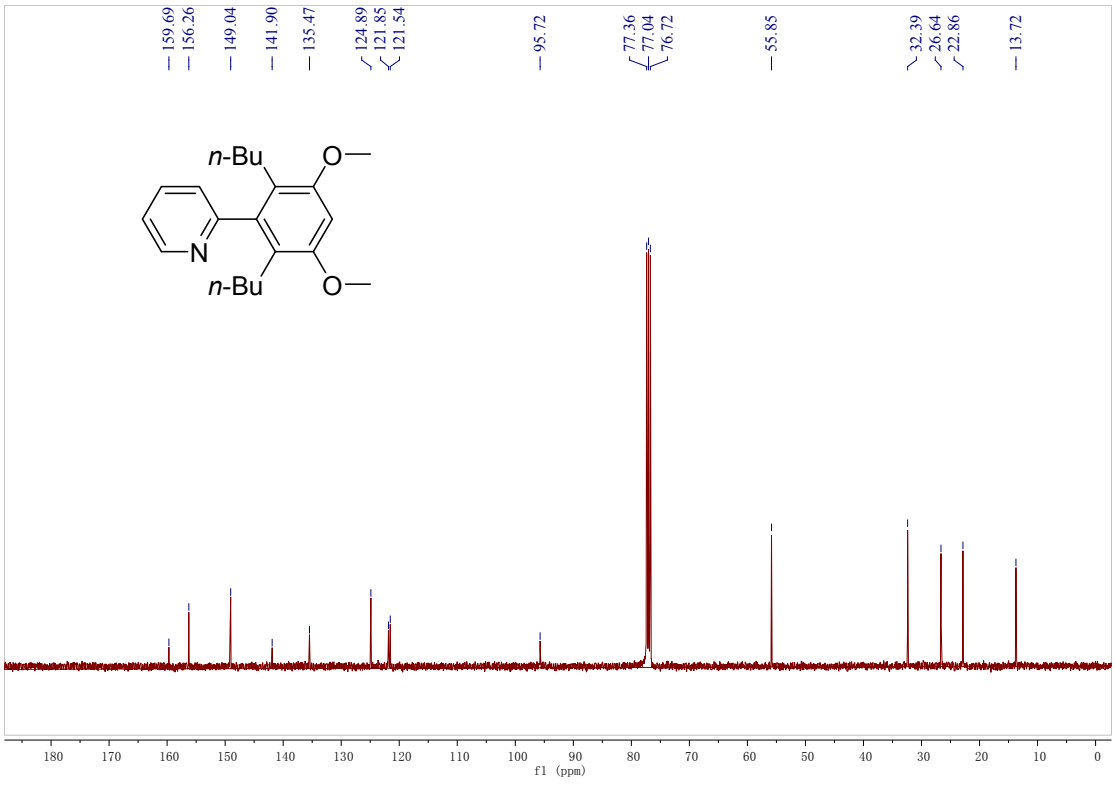


2-(2,6-dibutyl-3,5-dimethoxyphenyl)pyridine (3ma-di)

^{1}H NMR ($CDCl_3$)

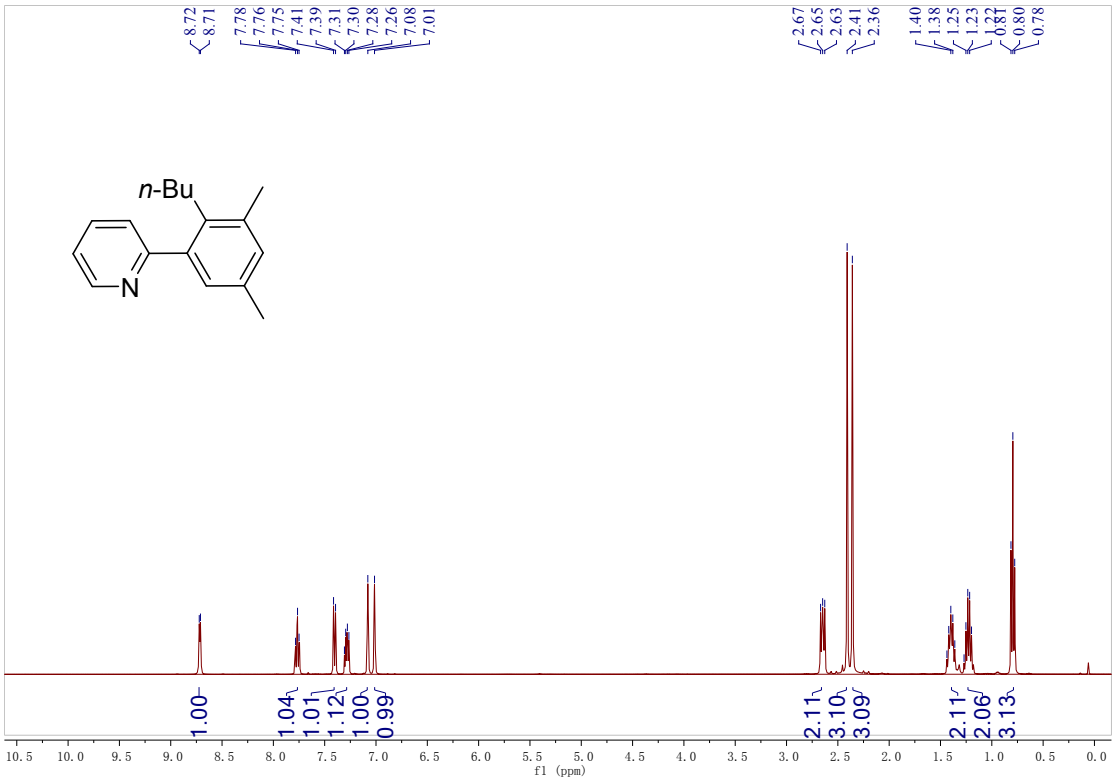


^{13}C NMR ($CDCl_3$)

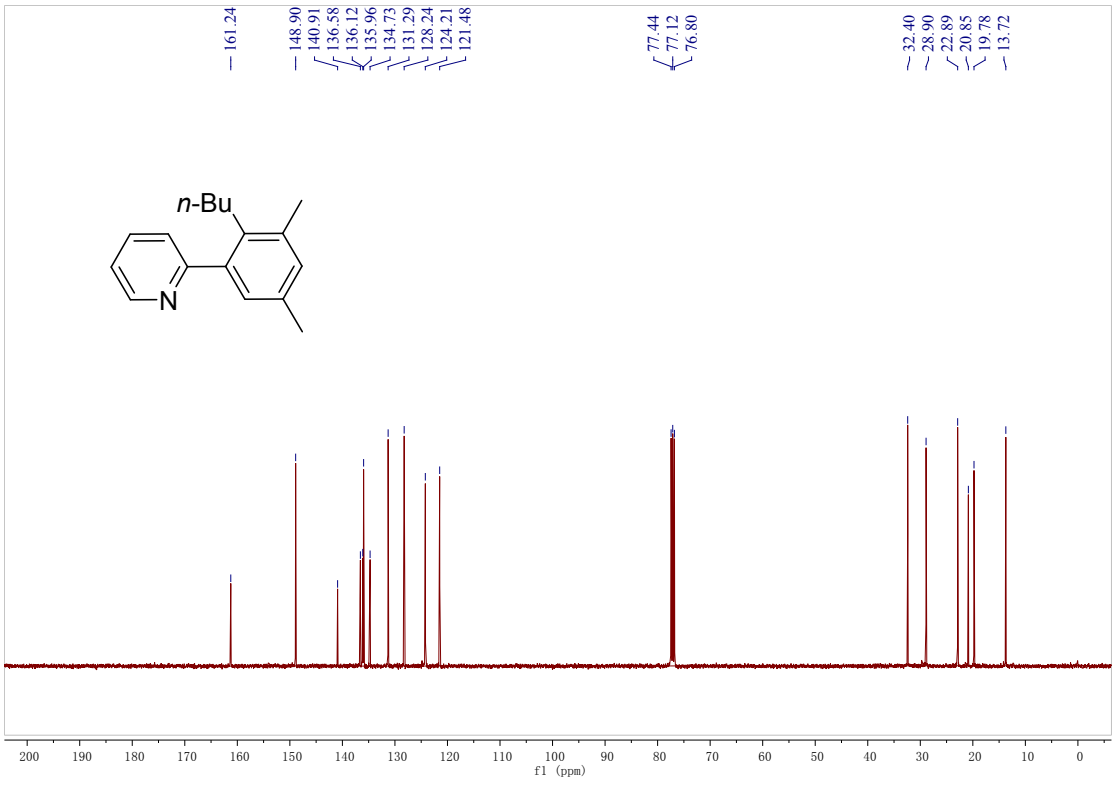


2-(2-butyl-3,5-dimethylphenyl)pyridine (3na)

^{1}H NMR ($CDCl_3$)

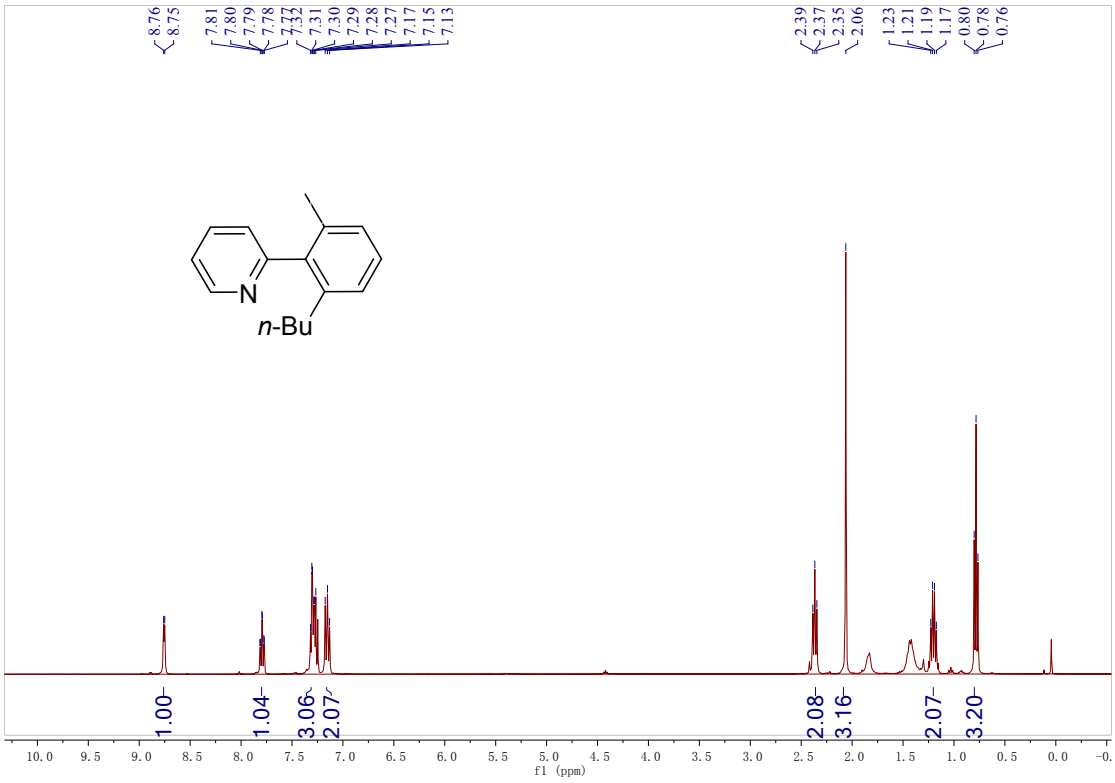


^{13}C NMR ($CDCl_3$)

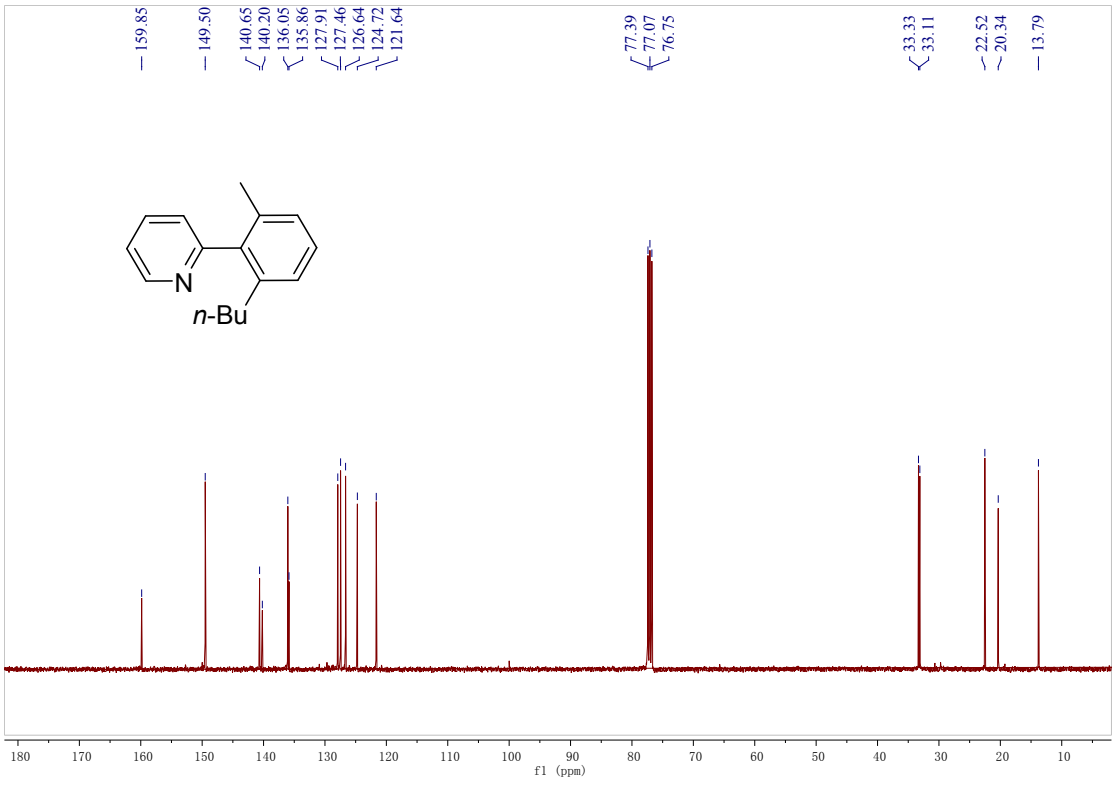


2-(2-butyl-6-methylphenyl)pyridine (3oa)

^{1}H NMR ($CDCl_3$)

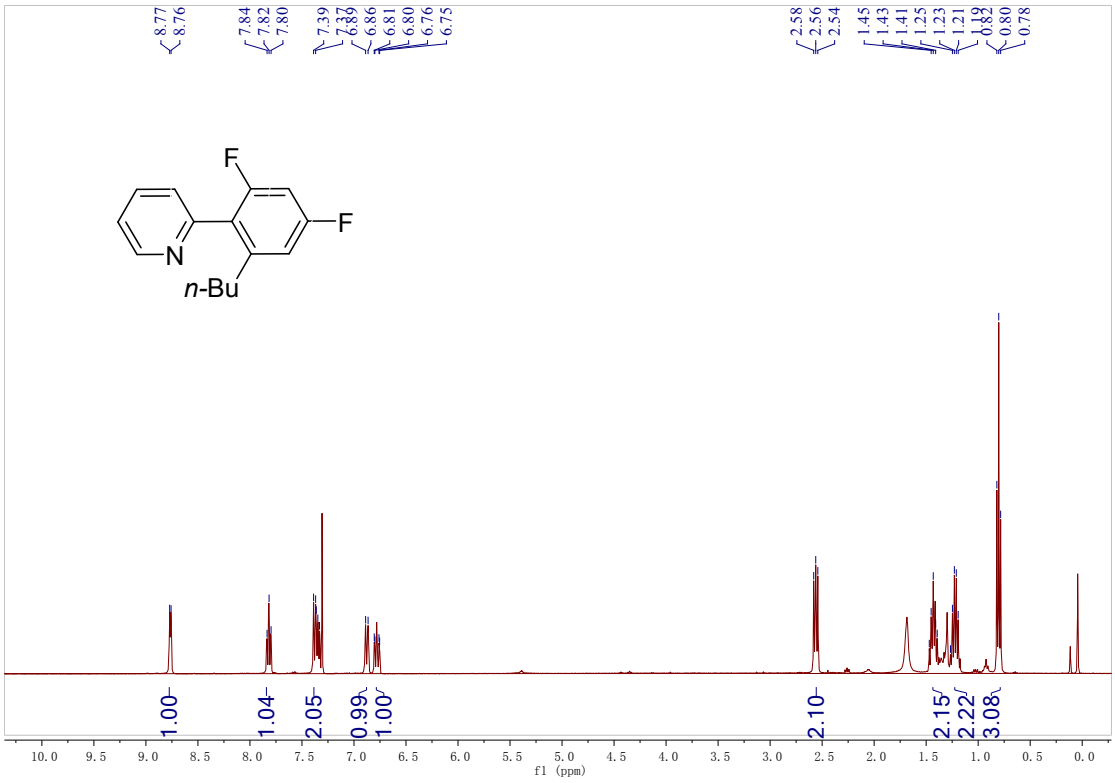


^{13}C NMR ($CDCl_3$)

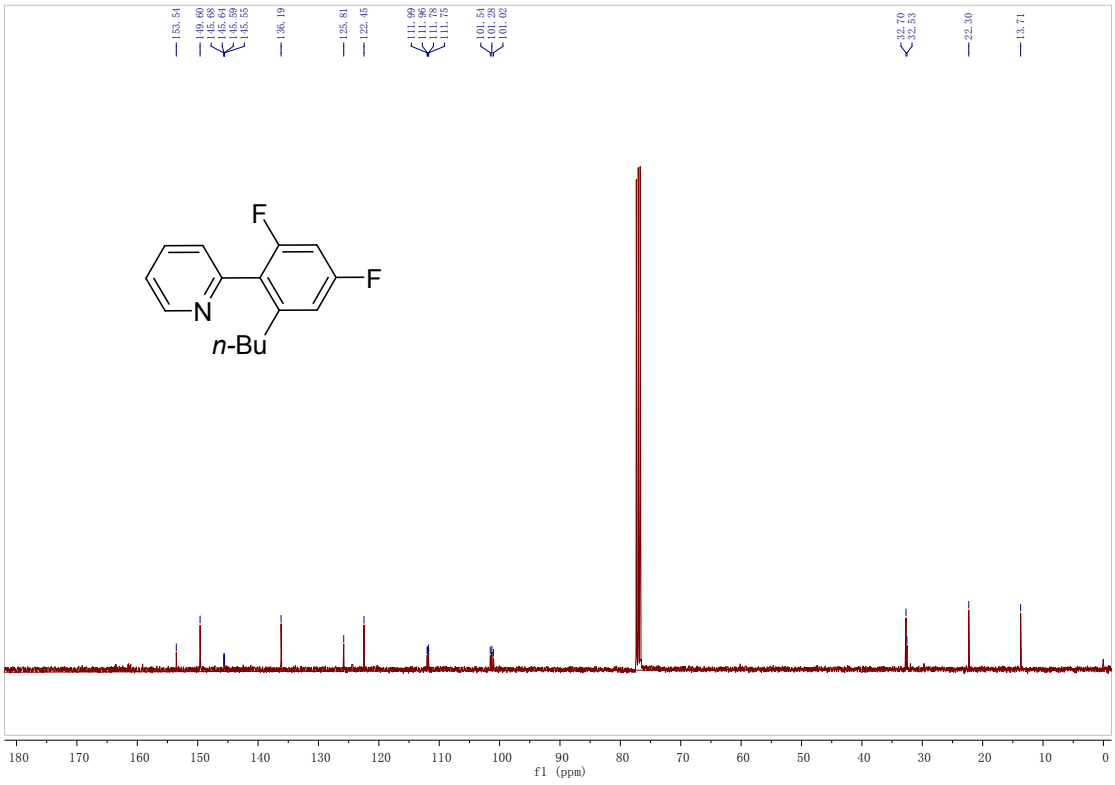


2-(2-butyl-4,6-difluorophenyl)pyridine (3pa)

^{1}H NMR ($CDCl_3$)

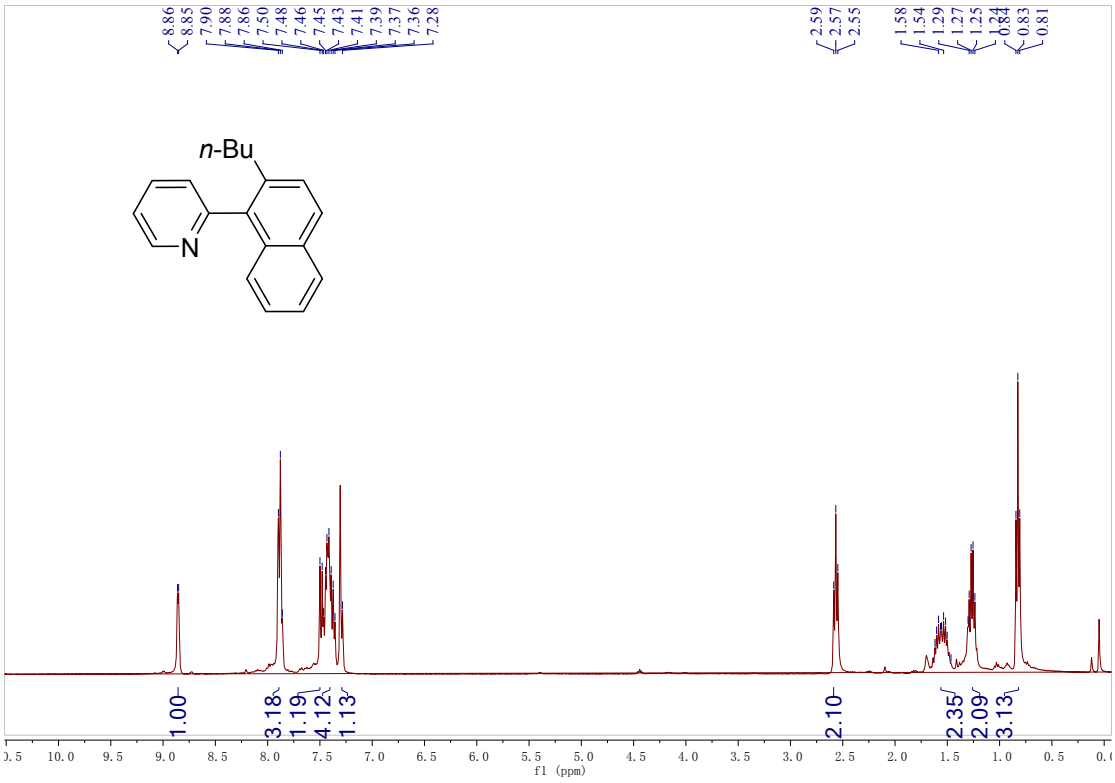


^{13}C NMR ($CDCl_3$)

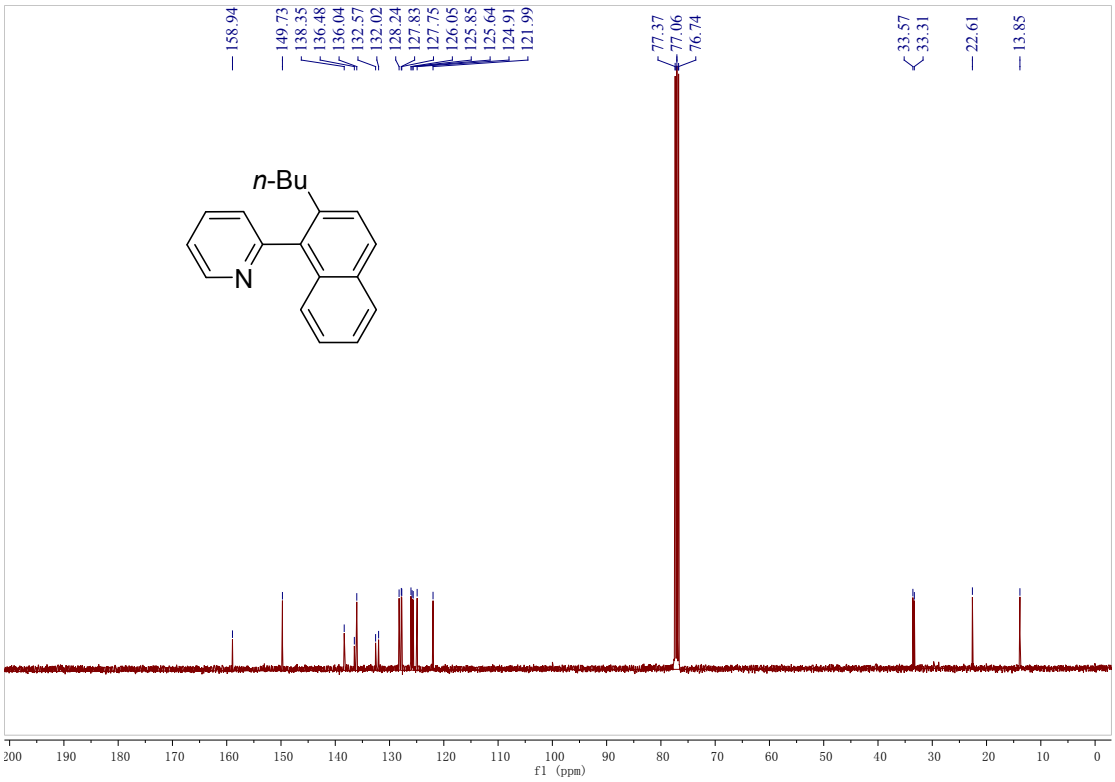


2-(2-butylnaphthalen-1-yl)pyridine (3qa)

^{1}H NMR ($CDCl_3$)

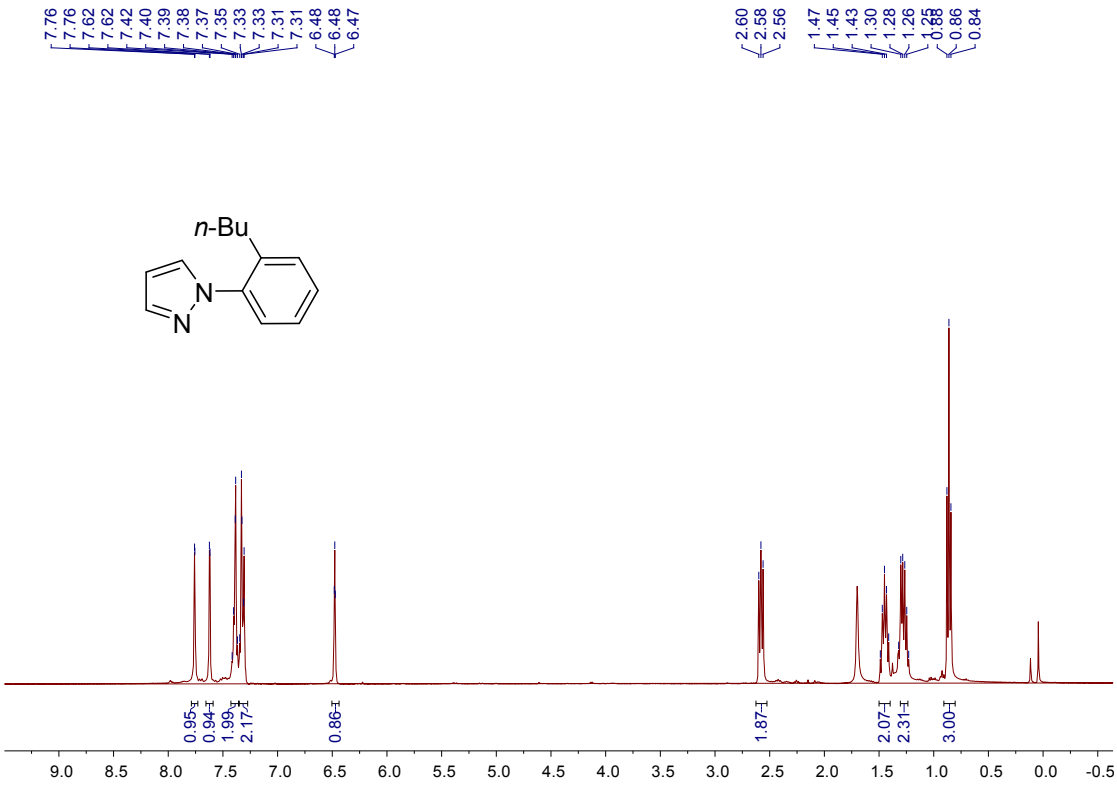


^{13}C NMR ($CDCl_3$)

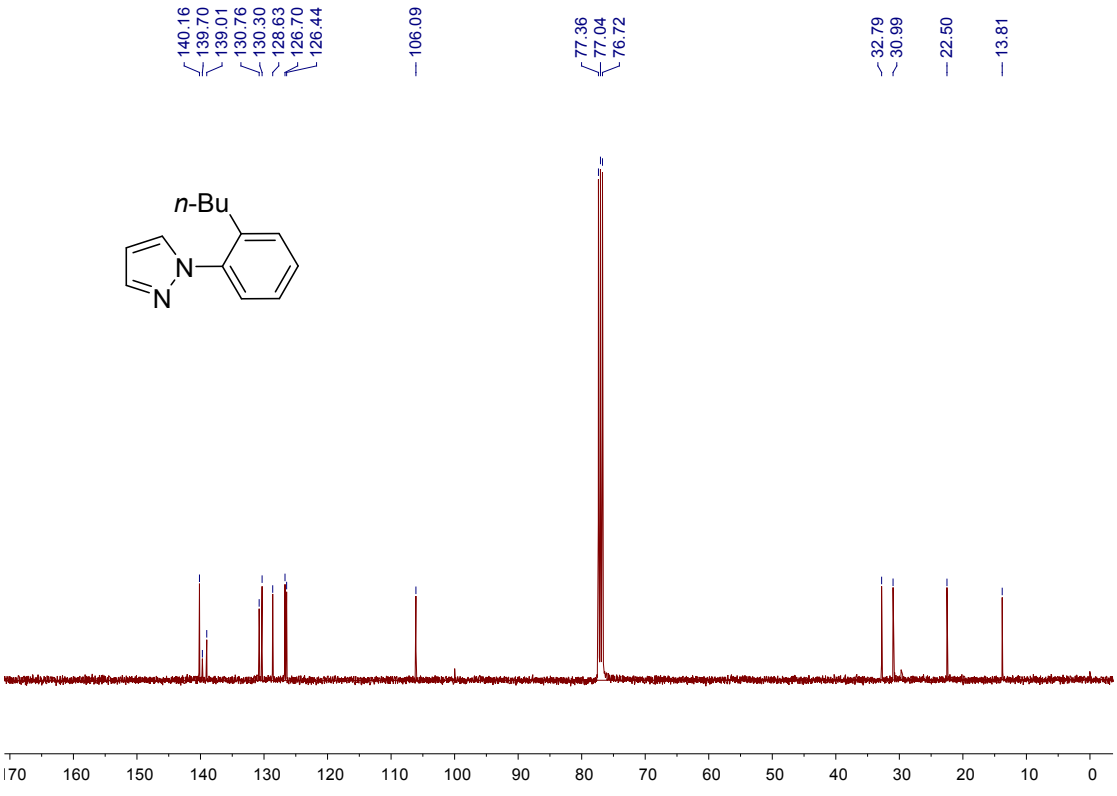


1-(2-butylphenyl)-1H-pyrazole(3ra)

^{1}H NMR ($CDCl_3$)

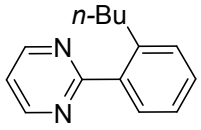


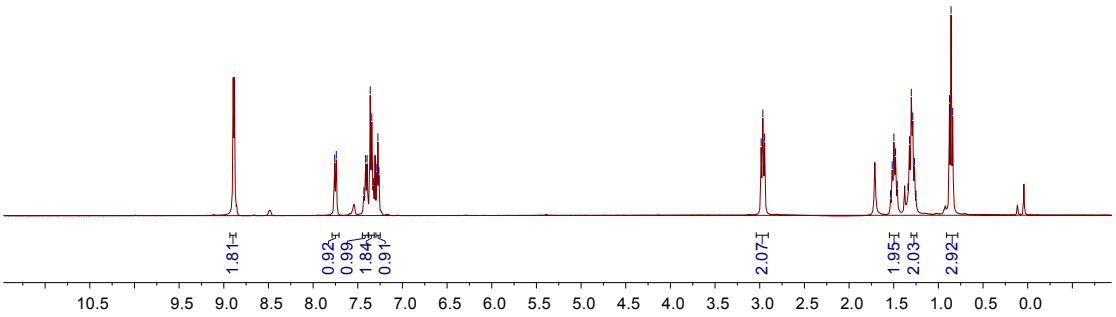
^{13}C NMR ($CDCl_3$)



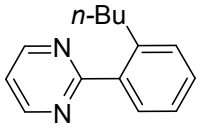
2-(2-butylphenyl)pyrimidine(3sa)

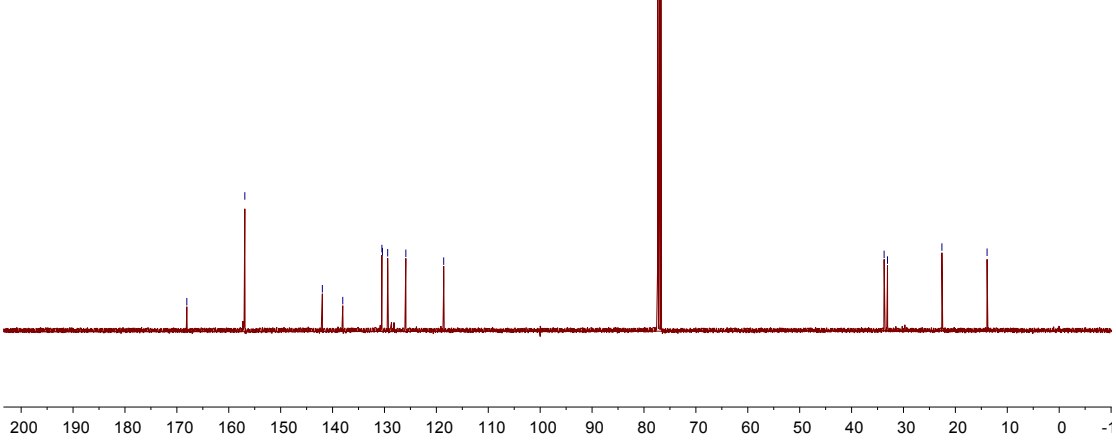
^{1}H NMR ($CDCl_3$)





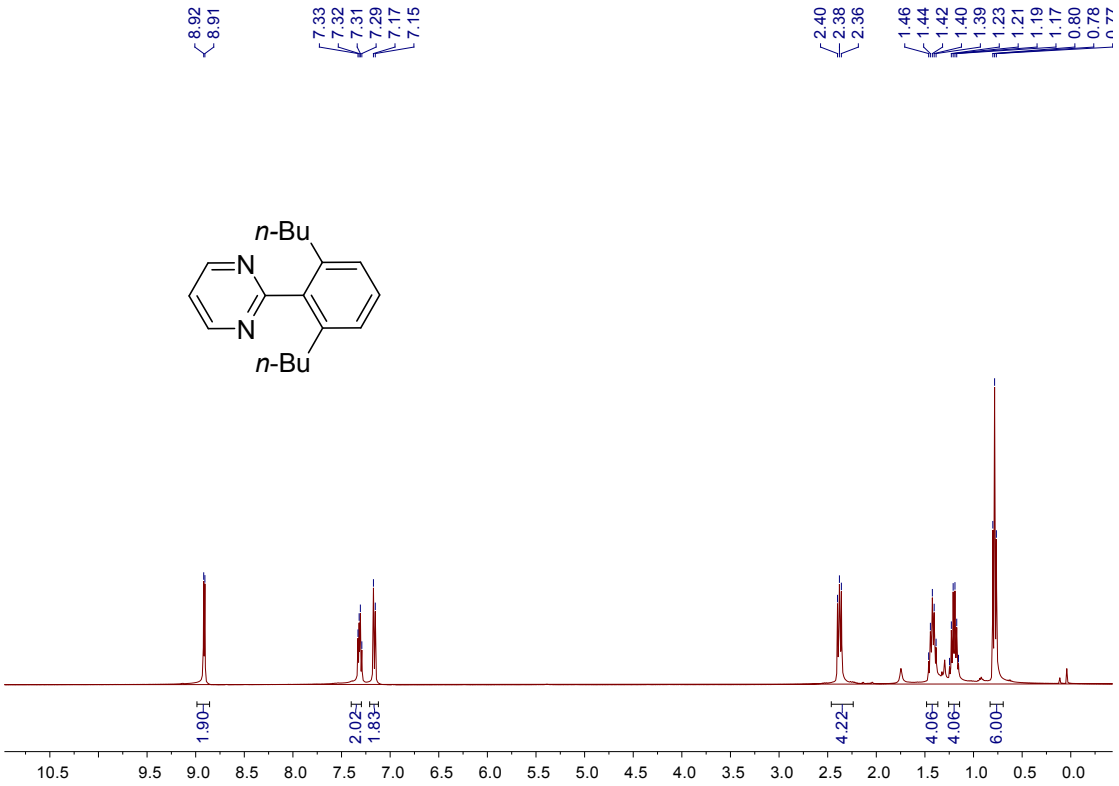
^{13}C NMR ($CDCl_3$)



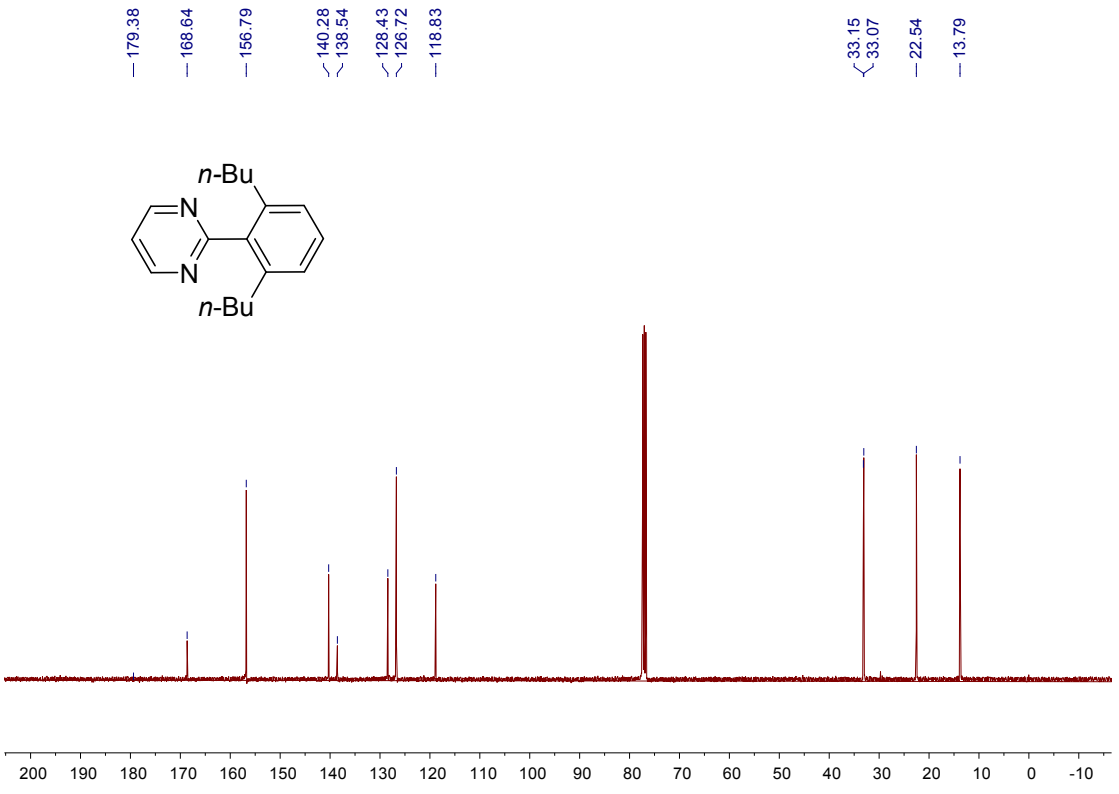


2-(2,6-dibutylphenyl)pyrimidine(3sa-di)

^{1}H NMR ($CDCl_3$)

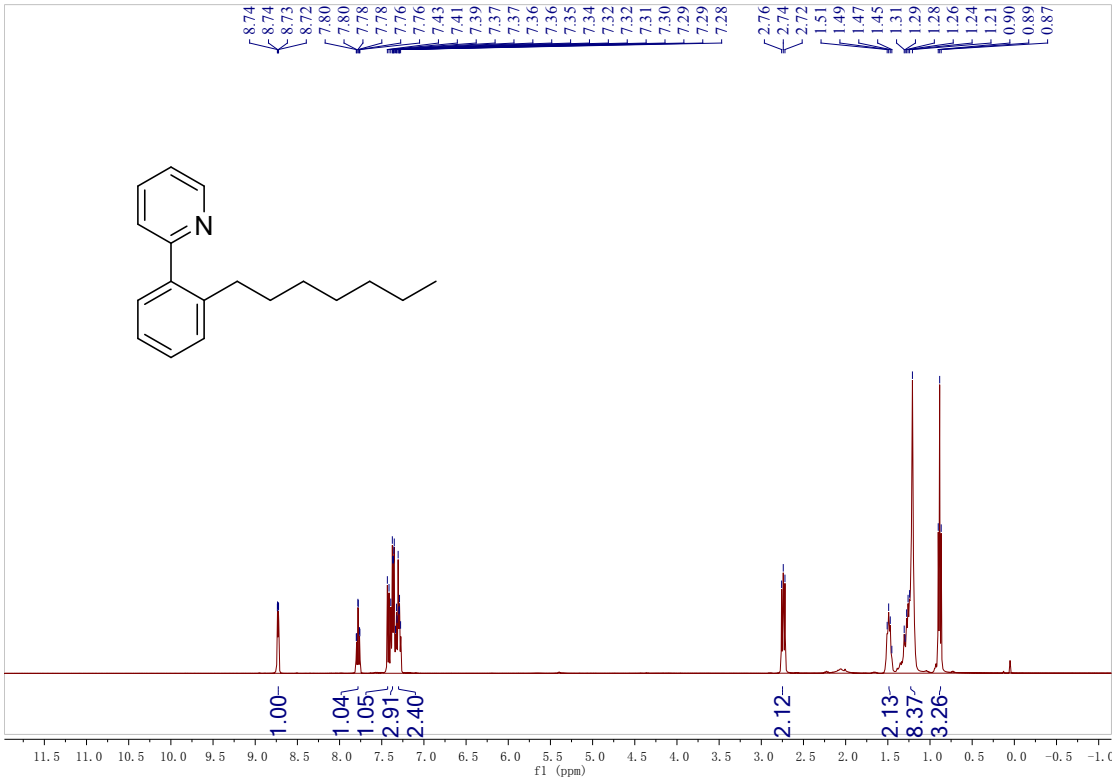


^{13}C NMR ($CDCl_3$)

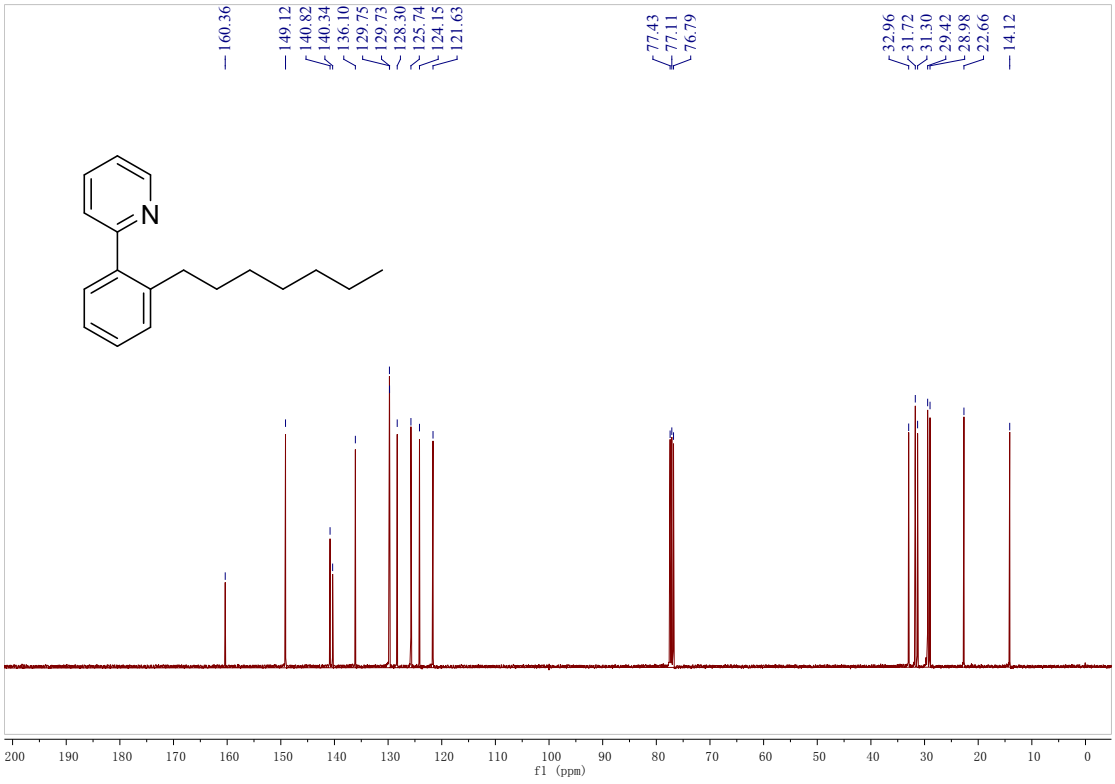


2-(2-heptylphenyl)pyridine (3bb)

^{1}H NMR ($CDCl_3$)

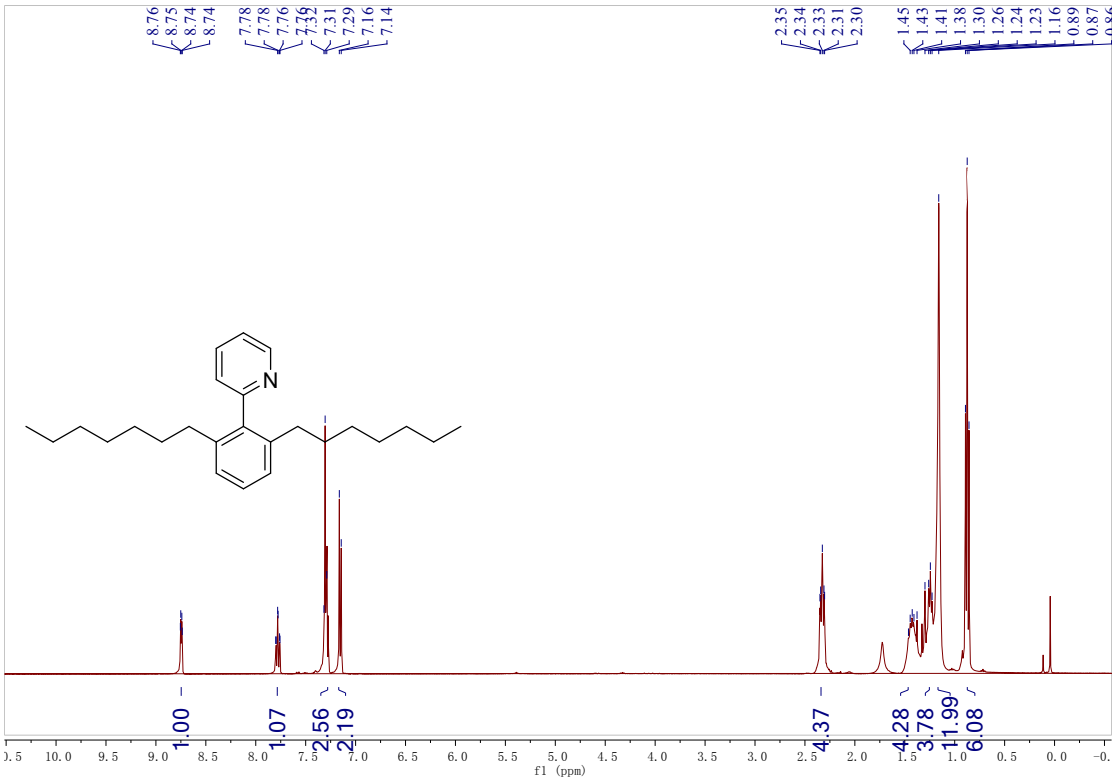


^{13}C NMR ($CDCl_3$)

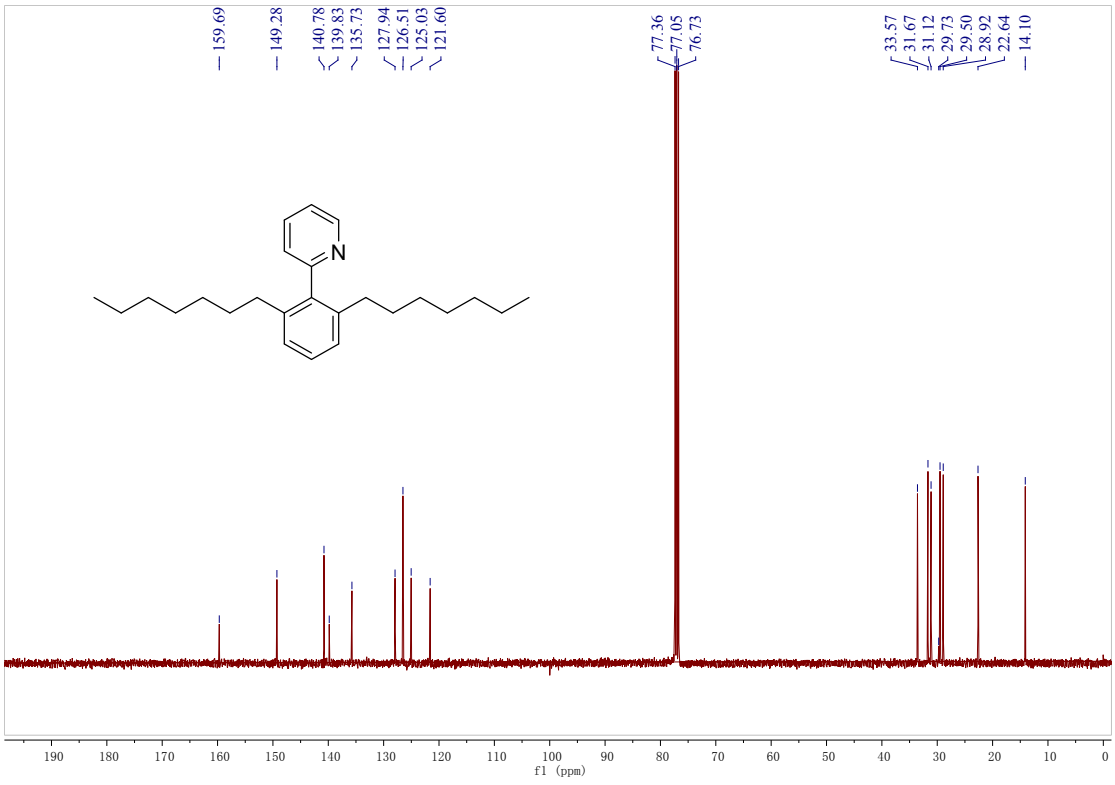


2-(2,6-diheptylphenyl)pyridine (3bb-di)

^{1}H NMR ($CDCl_3$)

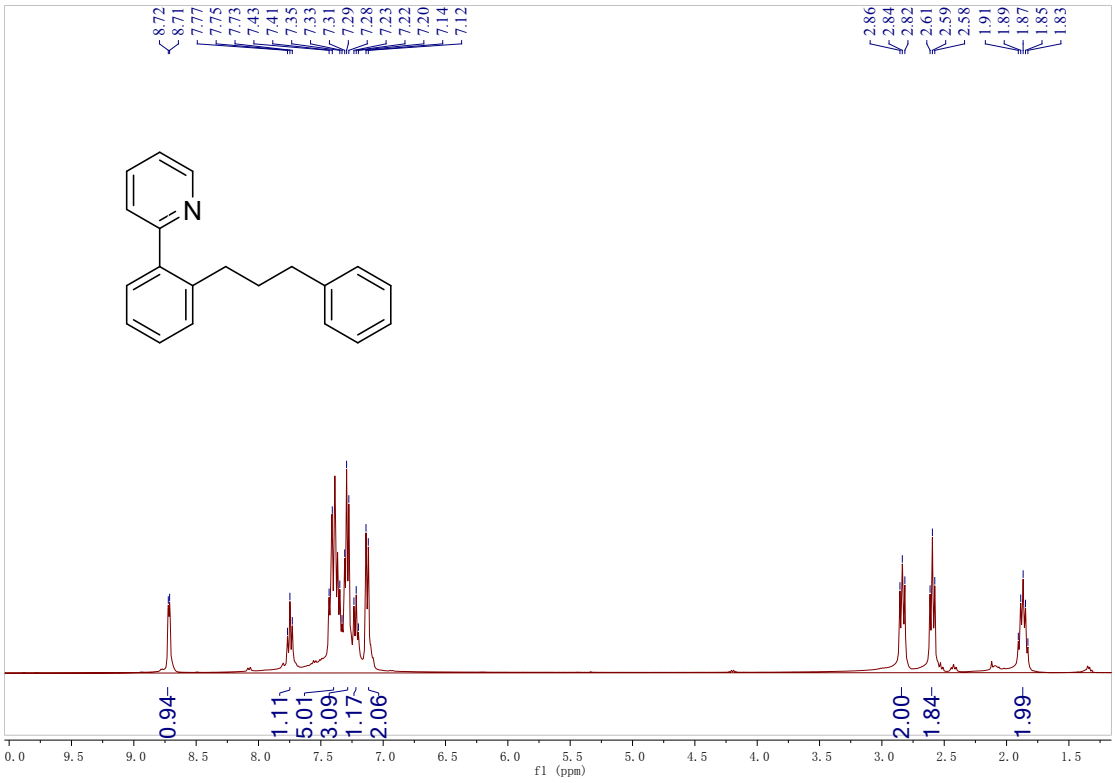


^{13}C NMR ($CDCl_3$)

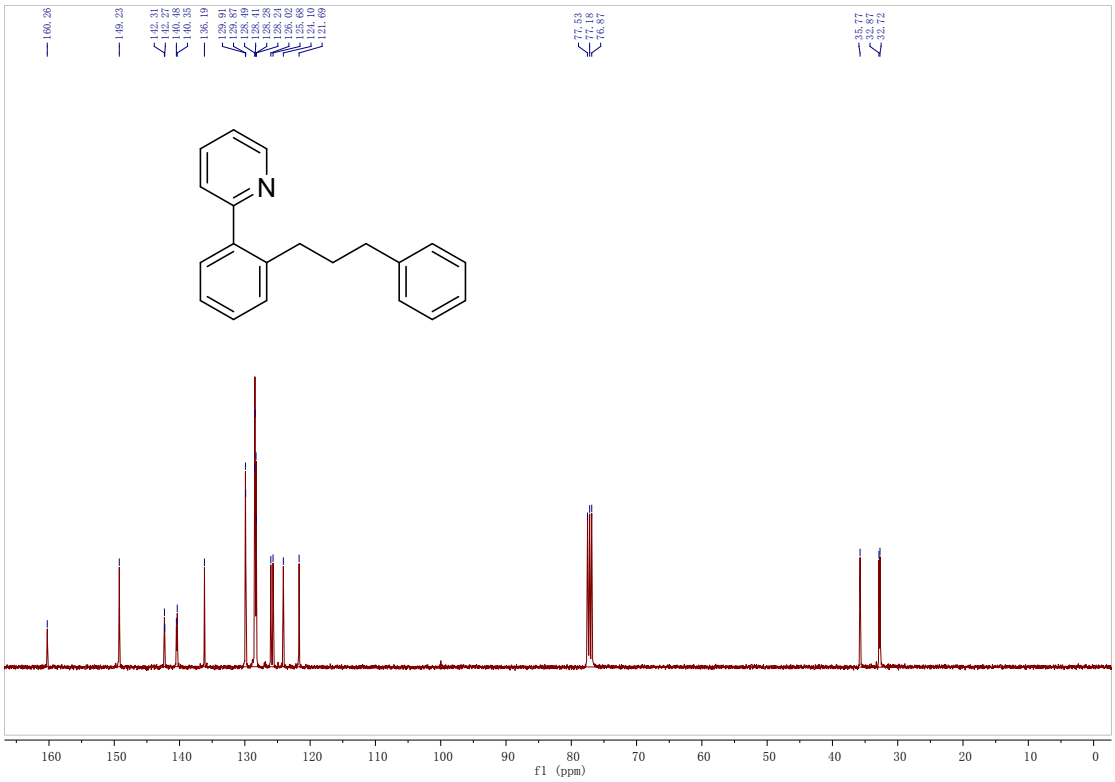


2-(2-(3-phenylpropyl)phenyl)pyridine (3bc)

^{1}H NMR ($CDCl_3$)

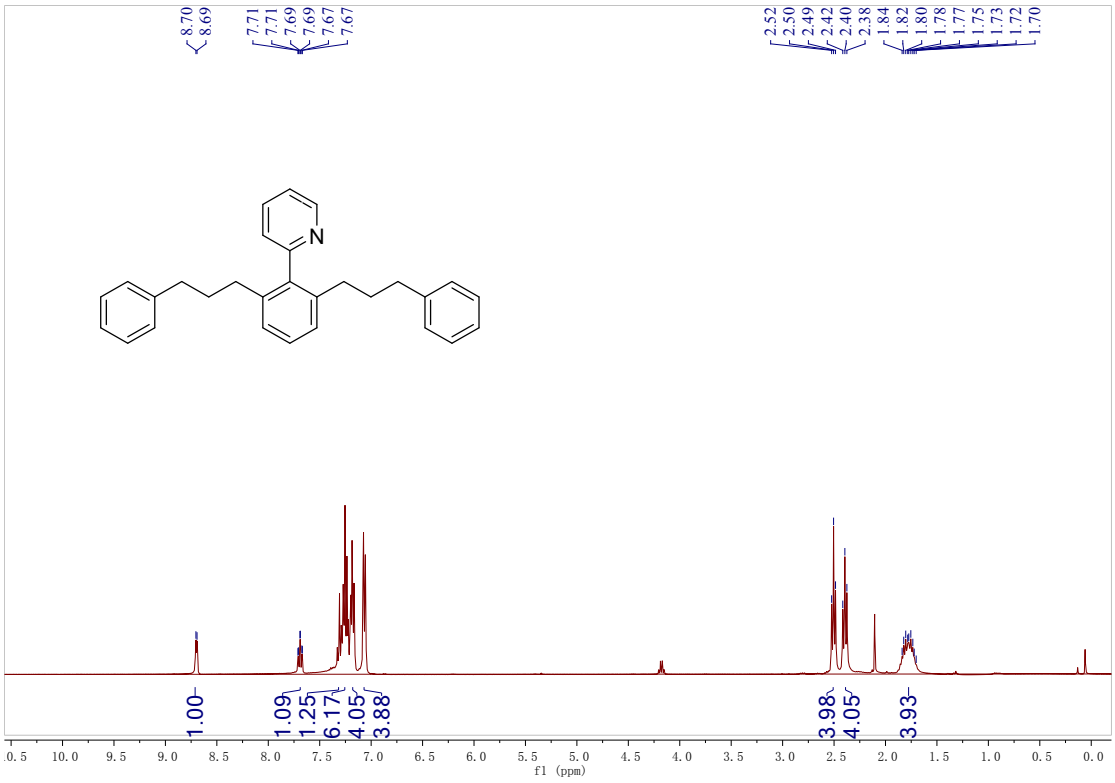


^{13}C NMR ($CDCl_3$)

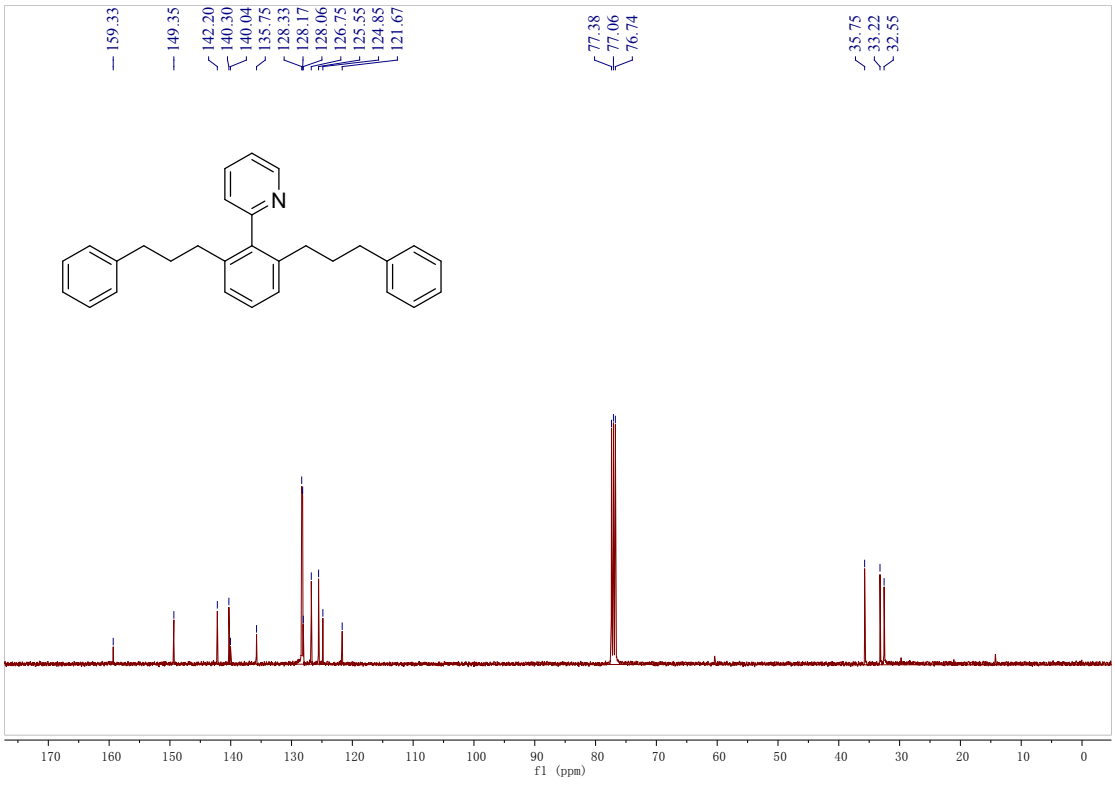


2-(2,6-bis(3-phenylpropyl)phenyl)pyridine (3bc-di)

^{1}H NMR ($CDCl_3$)

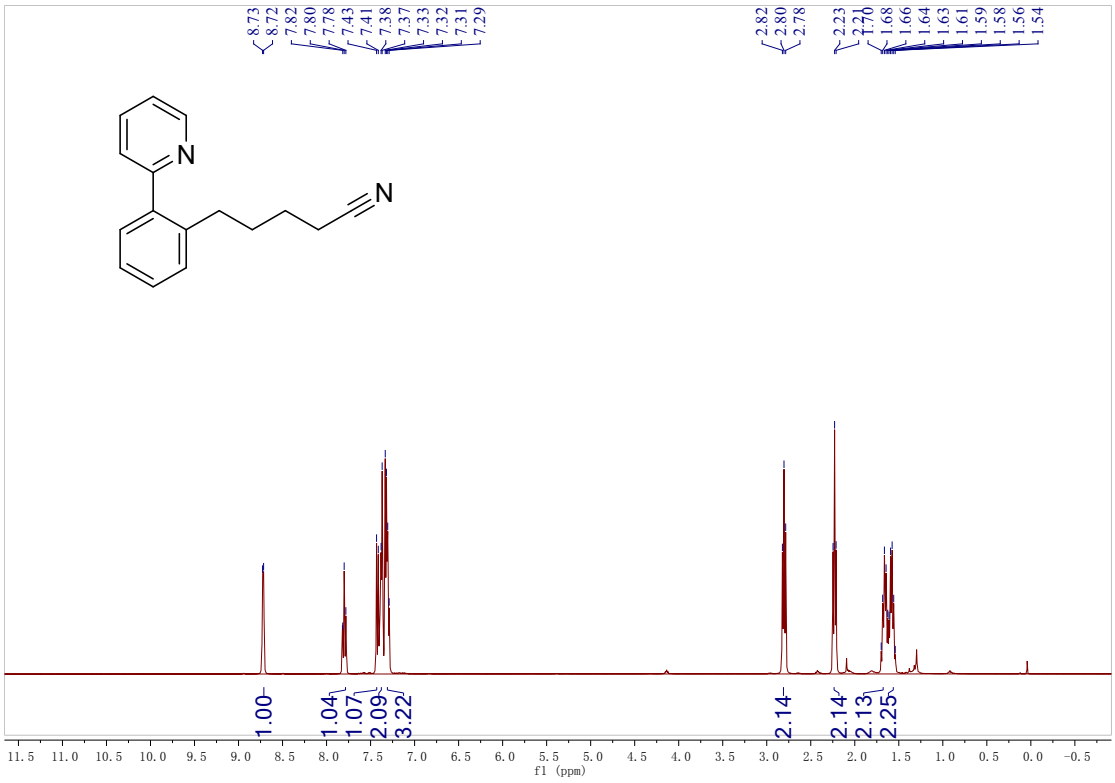


^{13}C NMR ($CDCl_3$)

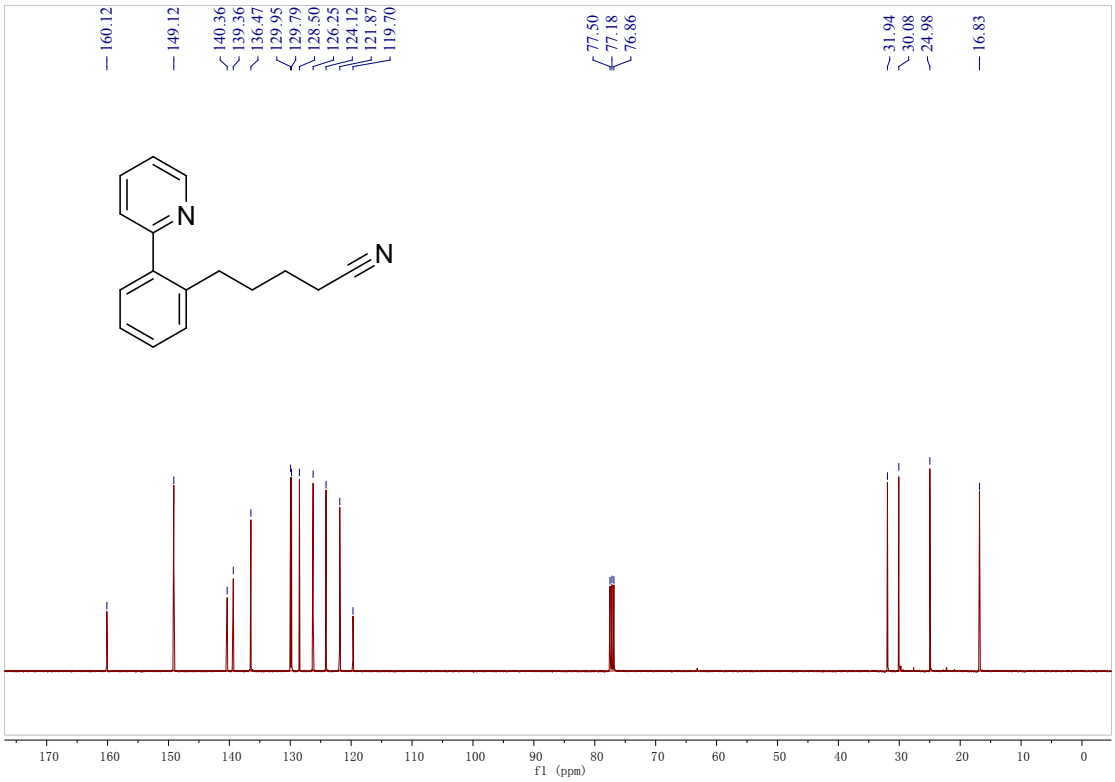


5-(2-(pyridin-2-yl)phenyl)pentanenitrile (3bd)

^{1}H NMR ($CDCl_3$)

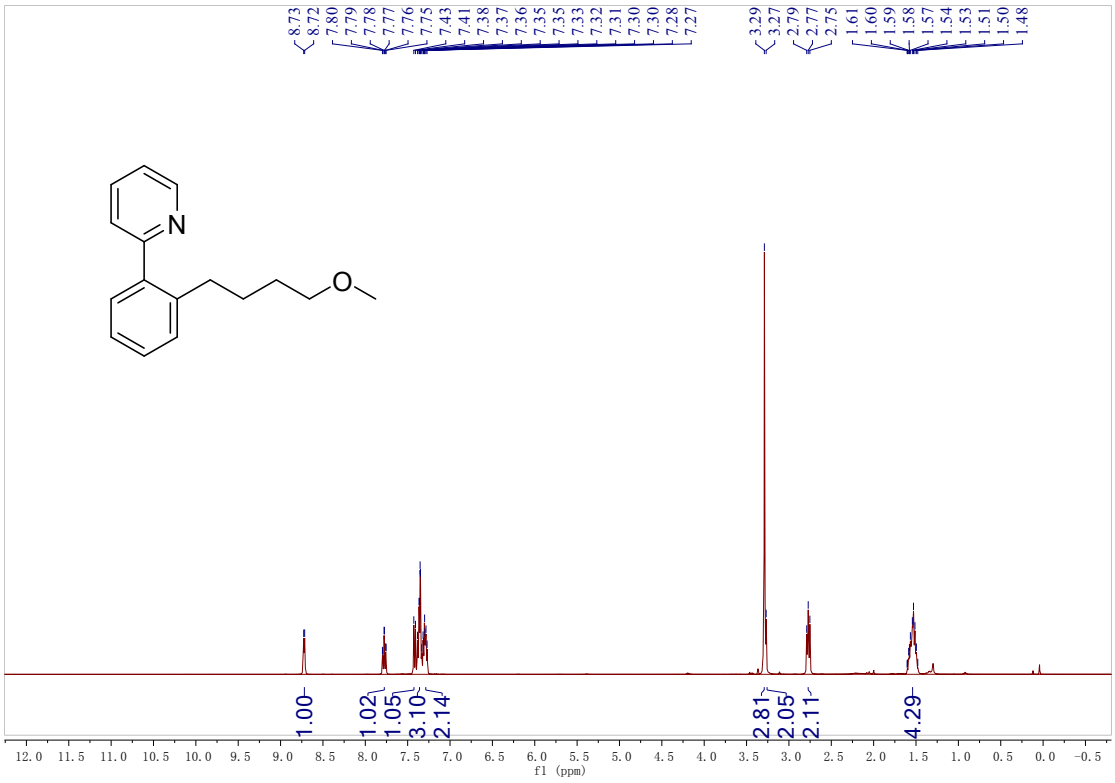


^{13}C NMR ($CDCl_3$)

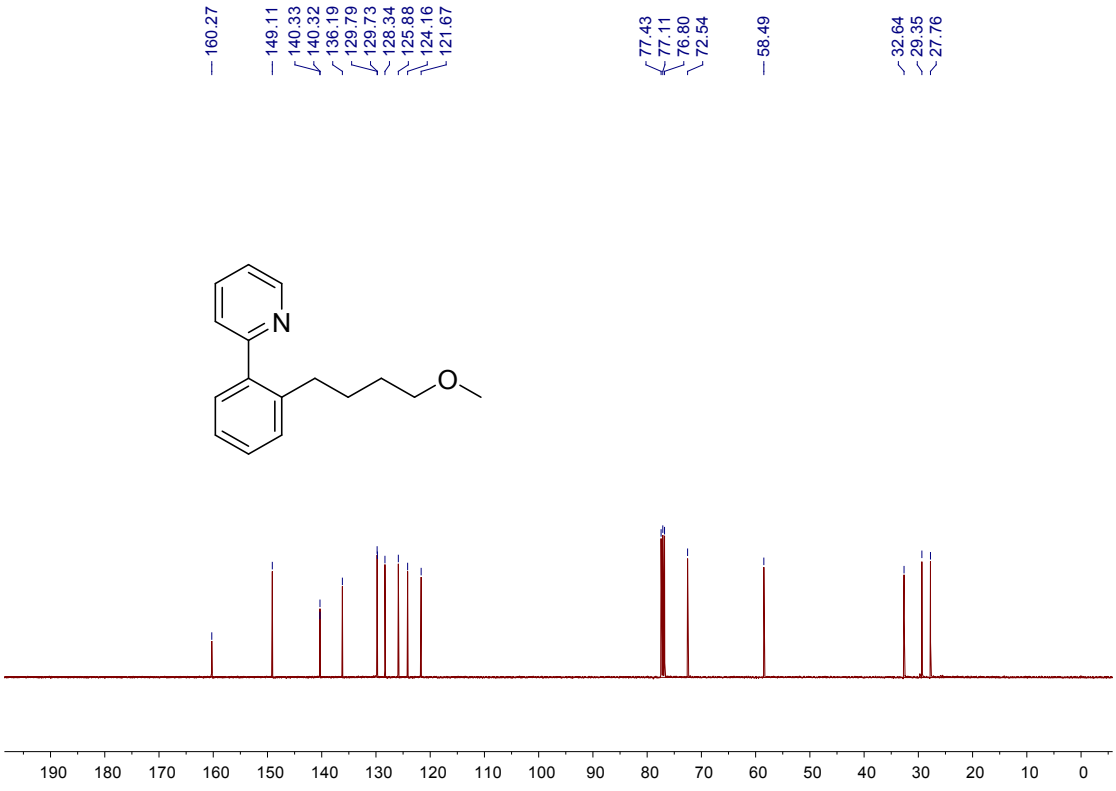


2-(2-(4-methoxybutyl)phenyl)pyridine (3be)

^{1}H NMR ($CDCl_3$)

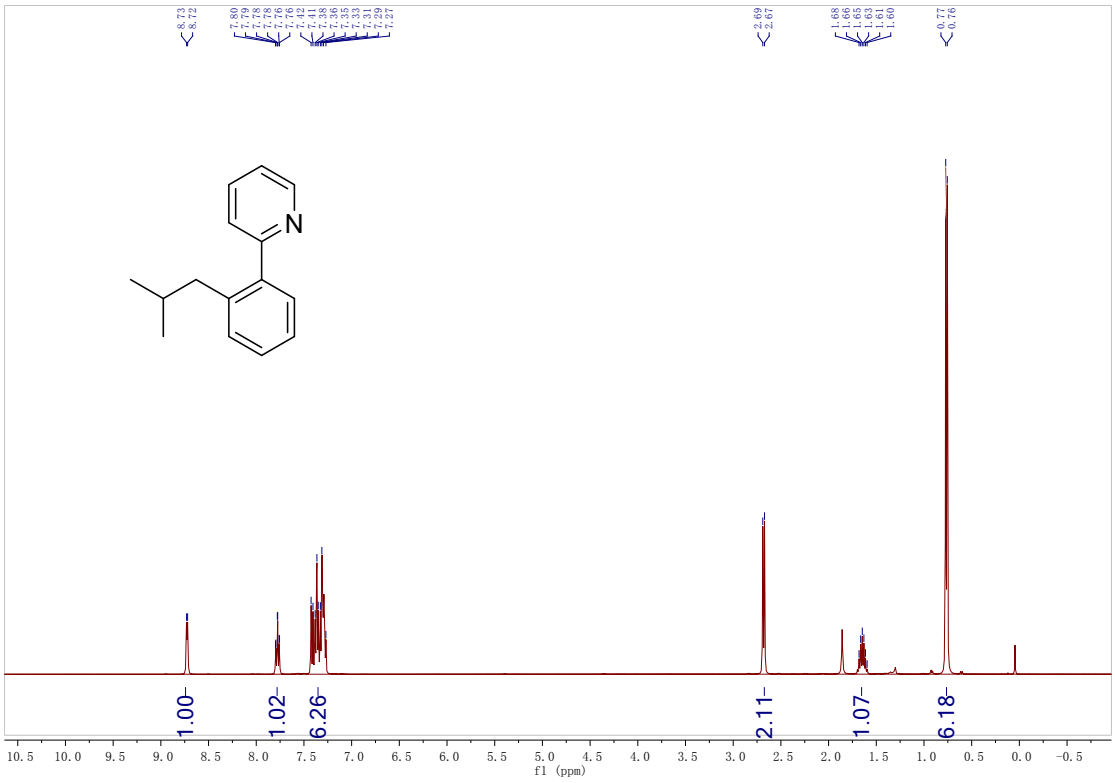


^{13}C NMR ($CDCl_3$)

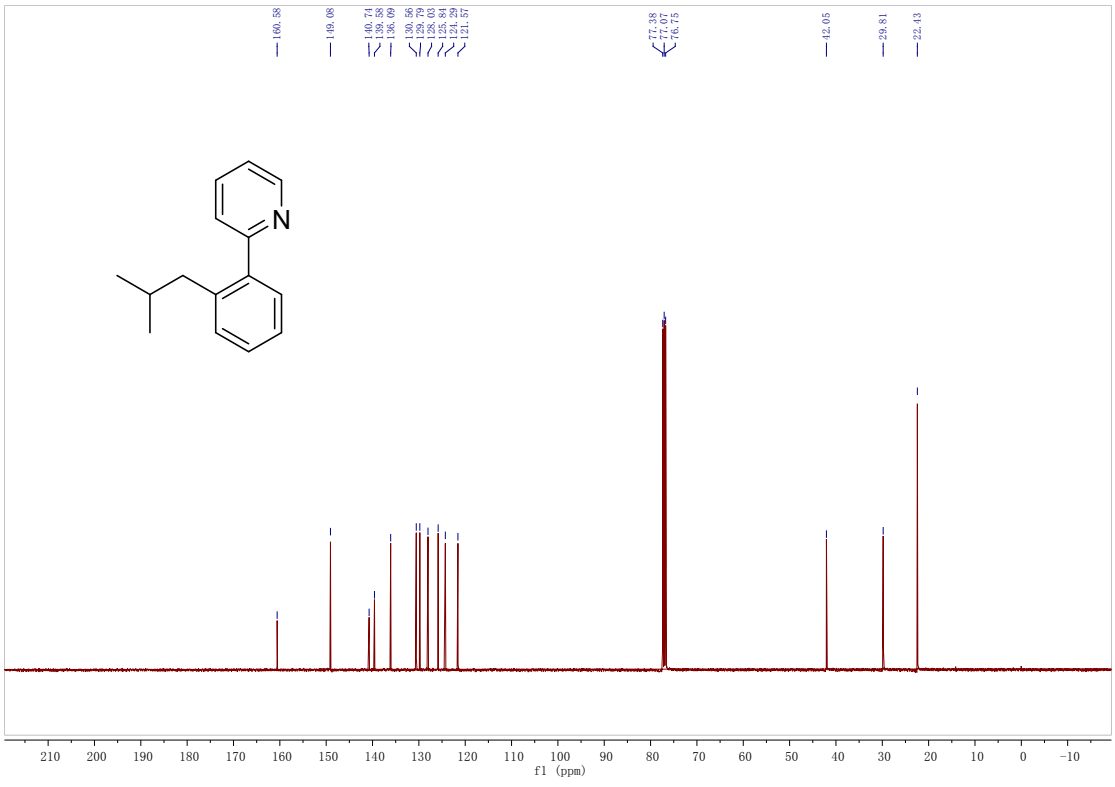


2-(2-isobutylphenyl)pyridine (3bf)

^{1}H NMR ($CDCl_3$)

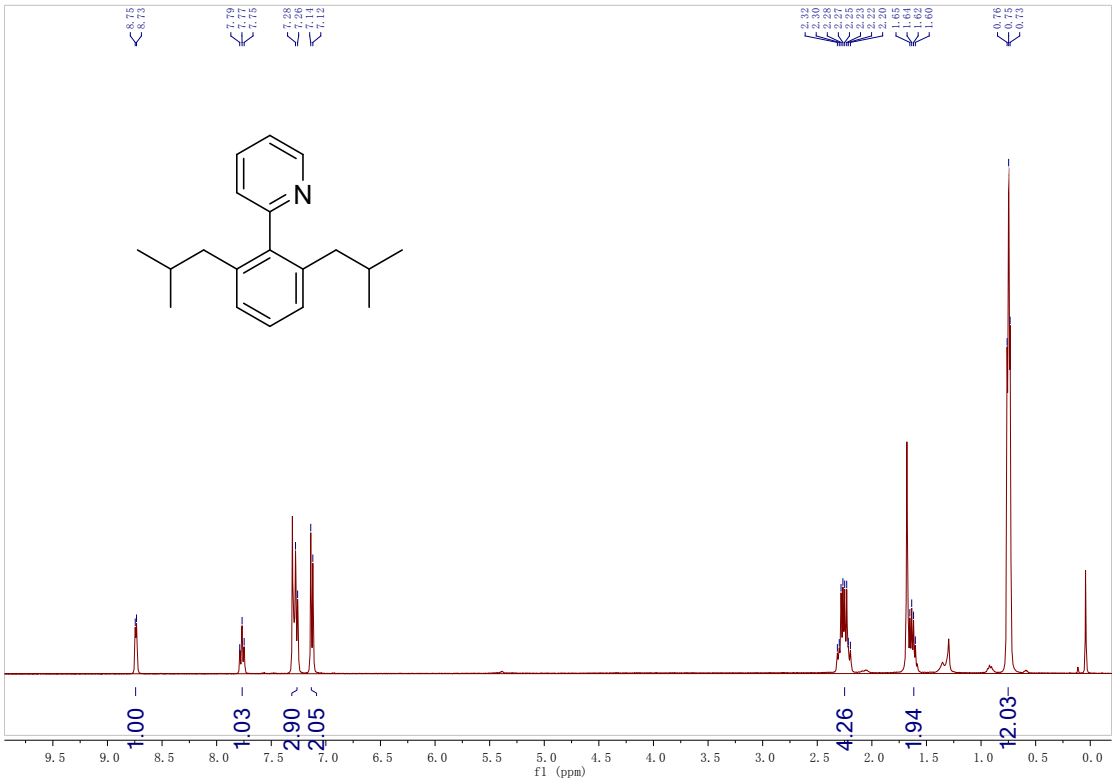


^{13}C NMR ($CDCl_3$)

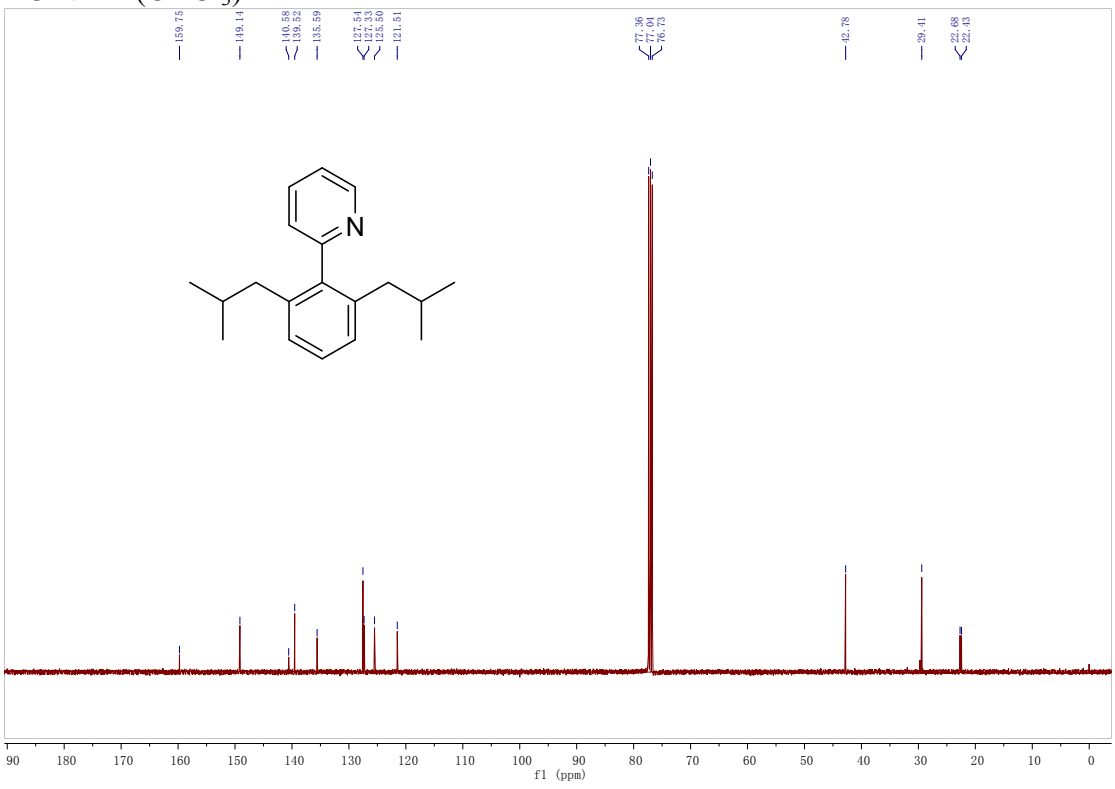


2-(2,6-diisobutylphenyl)pyridine (3bf-di)

^{1}H NMR ($CDCl_3$)

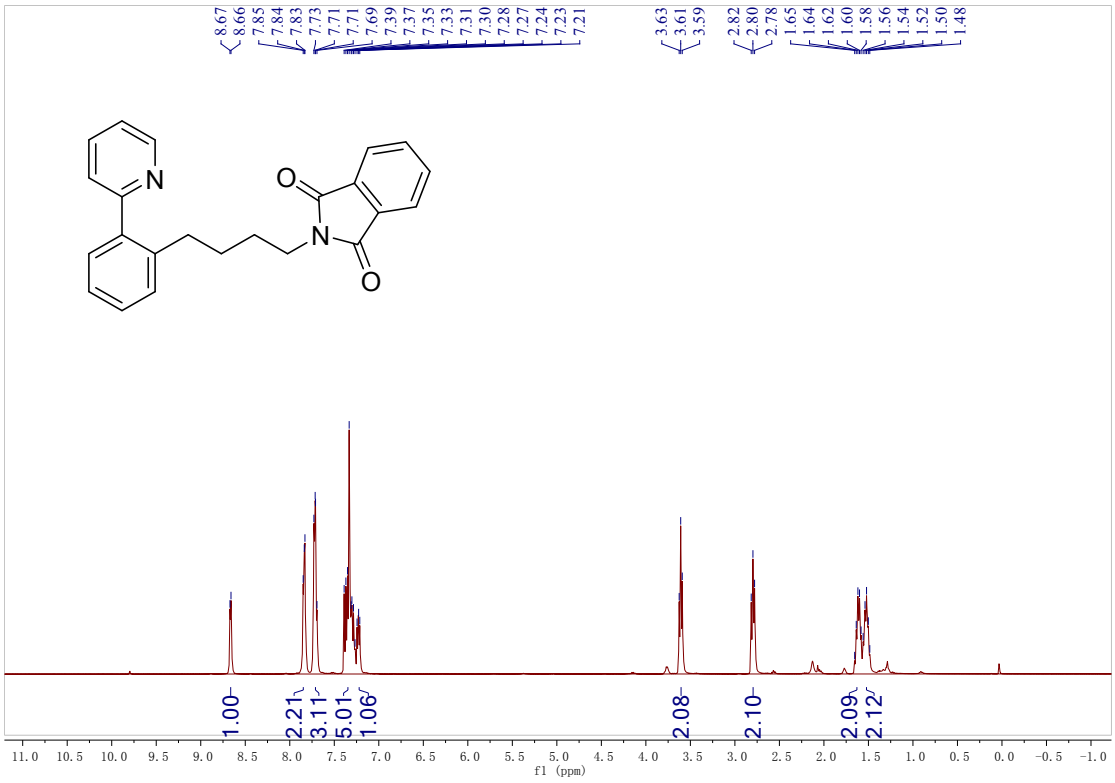


^{13}C NMR ($CDCl_3$)



2-(4-(2-(pyridin-2-yl)phenyl)butyl)isoindoline-1,3-dione (3bg)

^{1}H NMR ($CDCl_3$)



^{13}C NMR ($CDCl_3$)