

Copper-catalyzed Aromatic C—H Bond Halogenation with Lithium Halide under Aerobic Conditions

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Supporting Information

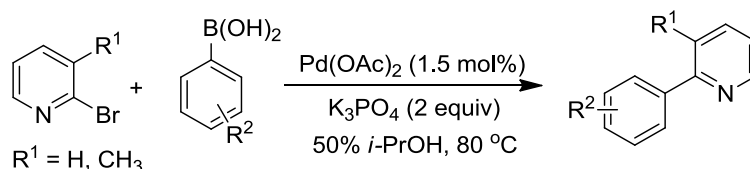
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I. General Procedure

All experiments were carried out under an oxygen atmosphere unless otherwise noted. Reactions were monitored using thin-layer chromatography (TLC). All solvents were dried and distilled before use according to the standard methods. Substrates **1a**, **1k**, **1w** and **1x** are commercially available. Other Substrates **1b-1j**,^[1] **1l-1q**,^[1] and **1r-1v**^[2] were synthesized according to the reported methods. ¹H and ¹³C NMR spectra were obtained on a Mercury Plus-400 at 400 and 100 MHz, respectively. Mass spectra were in general recorded on an AMD 402/3 or a HP 5989A mass selective detector. Infrared spectra were recorded on an AVATAR 370 spectrometer.

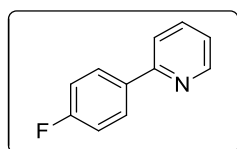
II. Preparation and Characterization of Starting Materials

(i) **General procedure for the preparation of arylpyridine substrates through Suzuki-coupling reaction:** ^[1]



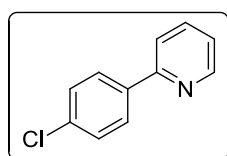
A mixture of heteroaryl bromide (4 mmol), phenylboronic acid (6 mmol), Pd(OAc)₂ (1.5 mol%), K₃PO₄·7H₂O (8 mmol) and 50% isopropanol (40 mL) was stirred at 80 °C under oxygen. After the reaction finished, the mixture was added to brine (10 mL) and extracted four times with ethylacetate (4 × 15 mL), the solvent was evaporated under reduced pressure and the product was isolated by short column chromatography.

(4-Fluorophenyl)pyridine (1b)^[4]



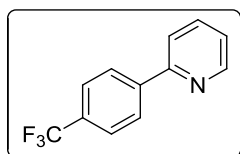
White solid, m.p. 39-41 °C, yield: 94%. ¹H NMR (400 MHz, CDCl₃) δ 7.14-7.18 (t, *J* = 8.8 Hz, 2H), 7.22-7.25 (m, 1H), 7.68 (dd, *J* = 0.8, 7.6 Hz, 1H), 7.75 (dt, *J* = 0.8, 8.0 Hz, 1H), 7.96-8.00 (m, 2H), 8.67-8.69 (m, 1H); IR (KBr): 1667, 1589, 1462, 1153 cm⁻¹; MS (ESI) *m/z*: 174 (M+1)⁺

2-(4-Chlorophenyl)pyridine (1c)^[5]



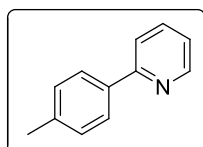
White solid, m.p. 48-49 °C, yield: 55%. ¹H NMR (400 MHz, CDCl₃) δ 7.24-7.25 (m, 1H), 7.44-7.46 (m, 2H), 7.69-7.71 (m, 1H), 7.74-7.78 (m, 1H), 7.93-7.95 (m, 2H), 8.68-8.70 (m, 1H); IR (KBr): 3046, 1666, 1586, 1462, 1154, 1086 cm⁻¹; MS (ESI) *m/z*: 190 [(M+1)⁺ (³⁵Cl)], 192 [(M+1)⁺ (³⁷Cl)].

2-(4-(Trifluoromethyl)phenyl)pyridine (1d)^[6]



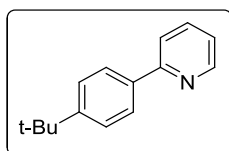
White solid, m.p. 72-74 °C, yield: 32%. ¹H NMR (400 MHz, CDCl₃) δ 7.28-7.32 (m, 1H), 7.72 (s, 1H), 7.74-7.75 (m, 1H), 7.77-7.82 (m, 2H), 8.11 (d, *J* = 8.0 Hz, 1H), 8.72-8.74 (m, 1H); IR (KBr): 3056, 2963, 1614, 1587, 1156, 1013 cm⁻¹; MS (ESI) *m/z*: 224 (M+1)⁺.

2-(*p*-Tolyl)pyridine (1e)^[7]



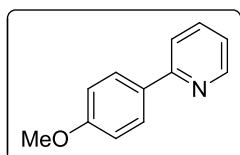
Yellow oil, yield: 95%. ¹H NMR (400 MHz, CDCl₃) δ 2.41 (s, 3H), 7.20-7.22(m, 1H), 7.28 (d, *J* = 8.0 Hz, 2H), 7.69-7.74 (m, 2H), 7.90 (d, *J* = 8.0 Hz, 2H), 8.67-8.68 (m, 1H); IR (KBr): 2920, 1588, 1467, 1152 cm⁻¹; MS (ESI) *m/z*:170 (M+1)⁺.

2-(4-(*tert*-Butyl)phenyl)pyridine (1f)^[8]



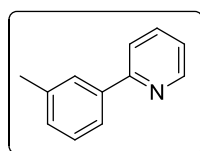
Yellow oil, yield: 80%. ¹H NMR (400 MHz, CDCl₃) δ 1.36 (s, 9H), 7.18-7.22(m, 1H), 7.50 (d, *J* = 8.4 Hz, 2H), 7.71-7.73 (m, 2H), 7.93 (d, *J* = 8.4 Hz, 2H), 8.67-8.68 (m, 1H); IR (KBr): 2962, 1609, 1587, 1466, 1153 cm⁻¹; MS (ESI) *m/z*: 212 (M+1)⁺.

2-(4-Methoxyphenyl)pyridine (1g)^[9]



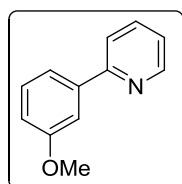
White solid, m.p. 53-54 °C, yield: 82%; ¹H NMR (400 MHz, CDCl₃) δ 3.87 (s, 3H), 7.00 (d, *J* = 8.8 Hz, 2H), 7.16-7.19 (m, 1H), 7.66-7.74 (m, 2H), 7.95(d, *J* = 8.8 Hz, 2H), 8.64-8.66 (m, 1H); IR (KBr): 3046, 2920, 1589, 1462, 1096 cm⁻¹; MS (ESI) *m/z*: 186 (M+1)⁺.

2-(*m*-Tolyl)pyridine (1h)^[5]



Yellow oil, yield: 85%; ¹H NMR (400 MHz, CDCl₃) δ 2.41 (s, 3H), 7.18-7.24(m, 2H), 7.35 (t, *J* = 7.6 Hz, 1H), 7.68-7.75 (m, 3H), 7.83 (s, 1H), 8.67-8.68(m, 1H); IR (KBr): 2920, 1615, 1590, 1460 cm⁻¹; MS (ESI) *m/z*: 170 (M+1)⁺.

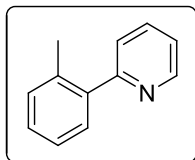
2-(3-Methoxyphenyl)pyridine (1i)^[10]



Colorless oil, yield: 88%; ¹H NMR (400 MHz, CDCl₃) δ 3.89 (s, 3H), 6.96-6.99 (m, 1H), 7.21-7.24 (m, 1H), 7.38 (t, *J* = 8.0 Hz, 1H), 7.53-7.55 (m, 1H), 7.59 (s, 1H), 7.70-7.75 (m, 2H),

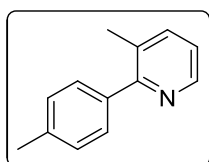
8.68-8.70 (m, 1H); IR (KBr): ν 2920, 1614, 1560, 1503, 1156 cm^{-1} ; MS (ESI) m/z : 186 ($M+1$)⁺.

2-(*o*-Tolyl)pyridine (1j)^[11]



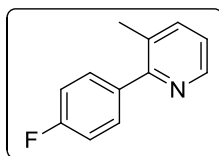
Yellow oil, yield: 71%; ¹H NMR (400 MHz, CDCl₃) δ 2.37 (s, 3H), 7.22-7.25(m, 2H), 7.27-7.30 (m, 2H), 7.39-7.41 (m, 2H), 7.74 (dt, $J = 1.6, 7.6$ Hz, 1H), 8.69-8.70 (m, 1H); IR (KBr): ν 3060, 2958, 1605, 1586, 1562, 1470, 1425, 795, 751, 728, 620 cm^{-1} ; MS (ESI) m/z : 170 ($M+1$)⁺.

3-Methyl-2-(*p*-tolyl)pyridine (1l)^[12]



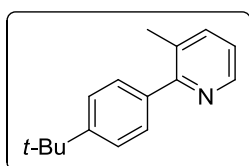
Colorless oil, yield: 80%; ¹H NMR (400 MHz, CDCl₃) δ 2.37 (s, 3H), 2.41 (s, 3H), 7.16 (dd, $J = 4.8, 7.6$ Hz, 1H), 7.25 (d, $J = 8.0$ Hz, 2H), 7.43 (d, $J = 8.0$ Hz, 2H), 7.57 (d, $J = 7.6$ Hz, 1H), 8.51-8.52 (m, 1H); IR (KBr): 2926, 1768, 1624, 1188 cm^{-1} ; MS (ESI) m/z : 184 ($M+1$)⁺.

2-(4-Fluorophenyl)-3-methylpyridine (1m)



Yellow oil, yield: 52%; ¹H NMR (400 MHz, CDCl₃): δ 8.51 (d, $J = 4.8$ Hz, 1H), 7.58 (d, $J = 7.6$ Hz, 1H), 7.52-7.47 (m, 2H), 7.17 (dd, $J = 4.8, 7.6$ Hz, 1H), 7.14-7.10 (m, 2H), 2.33 (s, 3H); ¹³C NMR (100 MHz, CDCl₃): δ 162.5 (d, $J_{C-F} = 245.5$ Hz, 1C), 157.5, 146.9, 146.7, 138.6, 136.4 (d, $J_{C-F} = 2.7$ Hz, 1C), 130.6 (d, $J_{C-F} = 7.8$ Hz, 1C), 122.1, 115.0 (d, $J_{C-F} = 21.3$ Hz, 1C), 20.0; IR (KBr): ν 2962, 2918, 1637, 1384, 1260, 800, 609, 513 cm^{-1} ; MS (EI) m/z : 187 (M^+), 186 ($M-1$)⁺, 185, 166, 159, 133, 92; HRMS (EI) Calcd for C₁₂H₁₀FN: 187.0797, Found: 187.0793.

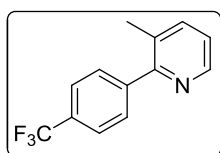
2-(4-(*tert*-Butyl)phenyl)-3-methylpyridine (1n)



Colorless oil, yield: 80%; ¹H NMR (400 MHz, CDCl₃): δ 8.51 (d, $J = 4.8$ Hz, 1H), 7.56 (d, $J = 7.6$ Hz, 1H), 7.46 (s, 4H), 7.15 (dd, $J = 4.8, 7.6$ Hz, 1H), 2.38 (s, 3H), 1.34 (s, 9H); ¹³C NMR (100 MHz, CDCl₃): δ 158.6, 150.8, 146.9, 138.4, 137.7, 130.7, 128.6, 125.0, 121.8, 34.6, 31.3, 20.1; IR (KBr): ν 2962, 1584, 1573, 1468, 1446, 1424, 841, 789 cm^{-1} ;

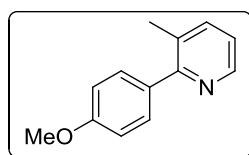
MS (EI) m/z : 225 (M^+), 224 ($M-1$)⁺, 210, 195, 181, 168; HRMS (EI) Calcd for $C_{16}H_{19}N$: 225.1517, Found: 225.1515.

3-Methyl-2-(4-(trifluoromethyl)phenyl)pyridine (1o)



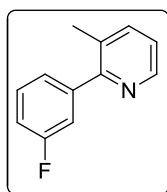
Colorless oil, yield: 24%; ¹H NMR (400 MHz, $CDCl_3$): δ 8.53 (d, $J = 4.8$ Hz, 1H), 7.71 (d, $J = 8.4$ Hz, 2H), 7.64 (d, $J = 8.4$ Hz, 2H), 7.61 (d, $J = 7.6$ Hz, 1H), 7.22 (dd, $J = 4.8, 7.6$ Hz, 1H), 2.35 (s, 3H); ¹³C NMR (100 MHz, $CDCl_3$): δ 157.1, 147.2, 144.0, 138.7, 130.9, 130.0 (q, $J_{C-F} = 31.9$ Hz, 1C), 129.3, 125.1, 124.2 (q, $J_{C-F} = 270.4$ Hz, 1C), 122.7, 19.9; IR (KBr): ν 1674, 1405, 1325, 1163, 1124, 850 cm^{-1} ; MS (EI) m/z : 237 (M^+), 236 ($M-1$)⁺, 218, 216, 167, 166; HRMS (EI) Calcd for $C_{13}H_{10}F_3N$: 237.0765, Found: 237.0762.

2-(4-Methoxyphenyl)-3-methylpyridine (1p)^[13]



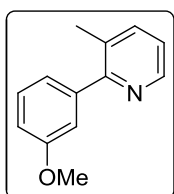
Yellow oil, yield: 52%; ¹H NMR (400 MHz, $CDCl_3$): δ 8.51 (d, $J = 4.8$ Hz, 1H), 7.56 (d, $J = 7.6$ Hz, 1H), 7.49 (d, $J = 8.4$ Hz, 2H), 7.14 (dd, $J = 4.8, 7.6$ Hz, 1H), 6.97 (d, $J = 8.4$ Hz, 2H), 3.86 (s, 3H), 2.37 (s, 3H); IR (KBr): ν 2956, 1610, 1580, 1514, 1447, 1422, 1247, 837, 791, 773, 591 cm^{-1} ; MS (EI) m/z : 199 (M^+), 198 ($M-1$)⁺, 183, 154.

2-(3-Fluorophenyl)-3-methylpyridine (1h)



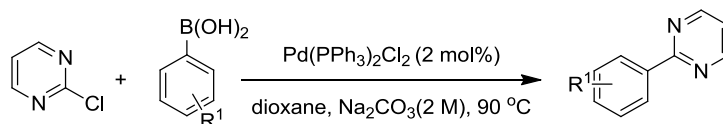
Yellow oil, yield: 44%; ¹H NMR (400 MHz, $CDCl_3$): δ 8.51 (d, $J = 4.8$ Hz, 1H), 7.59-7.57 (m, 1H), 7.41 (dt, $J = 6.0, 8.0$ Hz, 1H), 7.30 (dt, $J = 1.2, 8.0$ Hz, 1H), 7.26-7.22 (m, 1H), 7.19 (dd, $J = 4.8, 7.6$ Hz, 1H), 7.09 (dt, $J = 2.8, 8.8$ Hz, 1H), 2.35 (s, 3H); ¹³C NMR (100 MHz, $CDCl_3$): δ 162.6 (d, $J_{C-F} = 244.4$ Hz, 1C), 157.3, 147.0, 142.9 (d, $J_{C-F} = 7.6$ Hz, 1C), 138.6, 130.8, 129.6 (d, $J_{C-F} = 8.3$ Hz, 1C), 124.7, 122.5, 116.0 (d, $J_{C-F} = 21.9$ Hz, 1C), 114.8 (d, $J_{C-F} = 20.9$ Hz, 1C), 19.9; IR (KBr): ν 2975, 1613, 1583, 1567, 1486, 1455, 1433, 1273, 1258, 891, 787, 766 cm^{-1} ; HRMS (EI) Calcd for $C_{12}H_{11}FN$ ($M+H$)⁺: 188.0876, Found: 188.0900.

2-(3-Methoxyphenyl)-3-methylpyridine (1q)



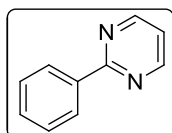
Yellow oil, yield: 63%; ^1H NMR (400 MHz, CDCl_3): δ 8.51 (d, $J = 4.8$ Hz, 1H), 7.57 (d, $J = 7.6$ Hz, 1H), 7.35 (t, $J = 8.0$ Hz, 1H), 7.17 (dd, $J = 4.8, 7.6$ Hz, 1H), 7.08 (d, $J = 7.6$ Hz, 1H), 7.06 (t, $J = 2.4$ Hz, 1H), 6.94 (dd, $J = 2.4, 8.4$ Hz, 1H), 3.85 (s, 3H), 2.35 (s, 3H); ^{13}C NMR (100 MHz, CDCl_3): δ 159.7, 158.8, 147.1, 142.2, 138.7, 131.1, 129.2, 122.4, 121.6, 114.5, 114.1, 55.5, 20.3; IR (KBr): ν 2936, 1582, 1488, 1459, 1427, 1287, 1229, 879, 788, 766, 701 cm^{-1} ; HRMS (EI) Calcd for $\text{C}_{13}\text{H}_{14}\text{NO}$ ($\text{M}+\text{H}$) $^+$: 200.1075; Found: 200.1082.

(ii) General procedure for the preparation of arylpyrimidine substrates through Suzuki-coupling reaction^[2]



To a round-bottom flask was added 2-chloropyrimidine (2.0 mmol), arylboronic acid (1.2-2.5 equiv), $\text{PdCl}_2(\text{PPh}_3)_2$ (1.0-4.0 mol%) and Na_2CO_3 (2 M, 5 mL) in dioxane (5 mL). The reaction mixture was heated to 90 °C until the 2-chloropyrimidine was consumed completely (monitored by TLC). The heterogeneous aqueous was concentrated under reduced pressure and the residue was diluted with EtOAc (30 mL), washed by H_2O (30 mL) and brine (30 mL). The organic layer was dried over Na_2SO_4 , concentrated and purified by column chromatography on silica gel (eluant: PE / EtOAc) to afford the arylpyrimidines.

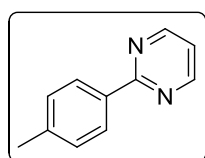
2-Phenylpyrimidine (1r)^[2]



White solid, 36-38 °C, yield: 93%; ^1H NMR (400 MHz, CDCl_3): δ

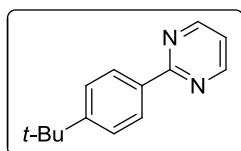
8.82 (d, $J = 4.8$ Hz, 2H), 8.45-8.43 (m, 2H), 7.51-7.48 (m, 3H), 7.20 (t, $J = 4.8$ Hz, 1H); IR (KBr): ν 2960, 1677, 1626, 1583, 1543, 825, 809, 689, 639, 615, 553 cm^{-1} ; MS (EI) m/z : 156 (M^+), 155 ($M-1$)⁺, 129, 103, 76.

2-(p-Tolyl)pyrimidine (1s)^[2]



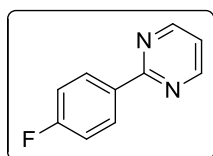
White solid, 86-88°C, yield: 93%; ¹H NMR (400 MHz, CDCl₃): δ 8.78 (d, $J = 4.8$ Hz, 2H), 8.34 (d, $J = 8.0$ Hz, 2H), 7.31 (d, $J = 8.8$ Hz, 2H), 7.16 (t, $J = 4.8$ Hz, 1H), 2.42 (s, 3H); IR (KBr): ν 2918, 1609, 1574, 1564, 1412, 1179, 785, 628, 545 cm^{-1} ; MS (EI) m/z : 170 (M^+), 169 ($M-1$)⁺, 117, 89, 75.

2-(4-(tert-Butyl)phenyl)pyrimidine (1t)



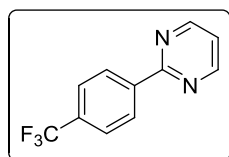
White solid, 46-48 °C, yield: 78%; ¹H NMR (400 MHz, CDCl₃): δ 8.79 (d, $J = 4.0$ Hz, 2H), 8.38-8.34 (m, 2H), 7.53-7.50 (m, 2H), 7.15 (t, $J = 4.8$ Hz, 1H), 1.36 (s, 9H); ¹³C NMR (100 MHz, CDCl₃): δ 164.7, 157.2, 157.1, 154.1, 134.8, 127.9, 125.5, 118.7, 34.8, 31.2; IR (KBr): ν 2969, 1606, 1568, 1551, 1417, 808, 800, 575 cm^{-1} ; MS (EI) m/z : 212 (M^+), 211 ($M-1$)⁺, 197, 169; HRMS (EI) Calcd for C₁₄H₁₆N₂: 212.1313, Found: 212.1315.

2-(4-Fluorophenyl)pyrimidine (1u)^[2]



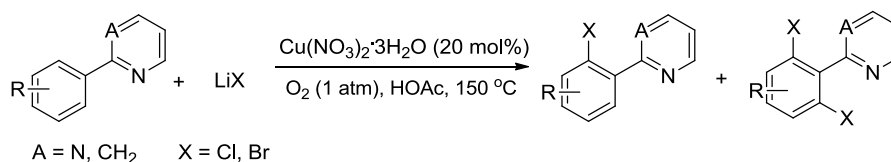
White solid, 61-62 °C, yield: 40%; ¹H NMR (400 MHz, CDCl₃): δ 8.78 (d, $J = 4.8$ Hz, 2H), 8.47-8.43 (m, 2H), 7.19-7.14 (m, 3H); IR (KBr): ν 2923, 1603, 1565, 1419, 1215, 794, 581 cm^{-1} ; MS (EI) m/z : 175 ($M+1$)⁺.

2-(4-(Trifluoromethyl)phenyl)pyrimidine (1v)^[2]



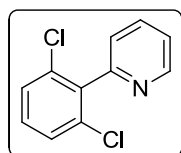
White solid, 104-105 °C, yield: 23%; ¹H NMR (400 MHz, CDCl₃): δ 8.85 (d, $J = 4.8$ Hz, 2H), 8.56 (d, $J = 8.4$ Hz, 2H), 7.74 (d, $J = 8.4$ Hz, 2H), 7.26 (t, $J = 4.8$ Hz, 1H); IR (KBr): ν 2929, 1617, 1560, 1426, 1316, 864, 804, 793, 734, 599 cm^{-1} ; MS (ESI) m/z : 225 ($M+1$)⁺.

III. General Procedure for the Cu-Catalyzed Halogenation



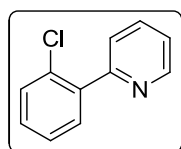
In a sealed tube, a solution of heterocycle (0.3 mmol), LiX (X = Cl, Br) (0.9 mmol), Cu(NO₃)₂·3H₂O (15 mg, 0.06 mmol) in HOAc (2 mL) under O₂ (1 atm) was stirred at 150 °C. Reactions were monitored by thin-layer chromatography (TLC). When the starting material disappeared, the mixture was neutralized with NaHCO₃ (saturated solution) and extracted with EtOAc (3 x 15 mL). The extract was washed with brine (2 x 15 mL) and dried over Na₂SO₄. After evaporation, the residue was purified via chromatography on silica gel with petroleum ether/Et₂O (2/1 (v/v)) to provide the corresponding product.

2-(2,6-dichlorophenyl)pyridine(3a)^[14]



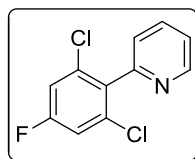
Yellow oil, yield: 70%; ¹H NMR (400 MHz, CDCl₃) δ 7.26-7.28 (m, 1H), 7.34-7.37 (m, 2H), 7.41 (d, *J* = 8.8 Hz, 2H), 7.82 (td, *J* = 2.0, 8.0 Hz, 1H), 8.76-8.75 (m, 1H); IR (KBr): ν 3054, 1593, 1560, 1427, 1191, 1116, 773, 747 cm⁻¹; MS (EI) *m/z*: 227 [M⁺ (³⁷Cl³⁷Cl)], 225 [(M-1)⁺ (³⁷Cl³⁵Cl)], 223 [M⁺ (³⁵Cl³⁵Cl)], 190, 188, 161, 153, 152.

2-(2-chlorophenyl)pyridine(2a)^[14]



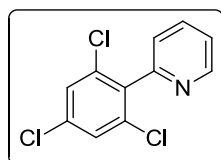
Yellow oil, yield: 3%; ¹H NMR (400 MHz, CDCl₃) δ 7.29-7.32 (m, 1H), 7.32-7.39 (m, 2H), 7.48 (dd, *J* = 1.6, 7.2 Hz, 1H), 7.60 (dd, *J* = 2.0, 7.6 Hz, 1H), 7.65 (d, *J* = 8.0 Hz, 1H), 7.77 (td, *J* = 1.6, 7.6 Hz, 1H), 8.73 (d, *J* = 4.8 Hz, 1H); IR (KBr): ν 3057, 1585, 1459, 1422, 1035, 750 cm⁻¹; MS (EI) *m/z*: 191 [M⁺ (³⁷Cl)] (19.72), 189 [M⁺ (³⁵Cl)] (51.25), 188, 154, 127, 77, 51.

2-(2,6-Dichloro-4-fluorophenyl)pyridine (3b)



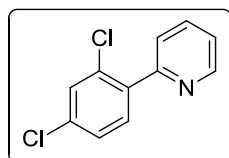
Yellow oil, yield: 63%; ^1H NMR (400 MHz, CDCl_3): δ 8.76-8.74 (m, 1H), 7.82 (td, $J = 1.2, 7.6$, 1H), 7.35 (ddd, $J = 1.6, 4.8, 7.6$ Hz, 1H), 7.32 (td, $J = 1.2, 7.6$ Hz, 1H), 7.18 (d, $J = 8.0$ Hz, 2H); ^{13}C NMR (100 MHz, CDCl_3): δ 162.4 (q, $^1J_{\text{C-F}} = 251.5$ Hz), 154.7, 149.7, 136.5, 135.4 (q, $^3J_{\text{C-F}} = 11.4$ Hz), 134.9 (q, $^4J_{\text{C-F}} = 3.7$ Hz), 125.2, 123.1, 115.8 (q, $^2J_{\text{C-F}} = 24.3$ Hz); IR (KBr): ν 2925, 1599, 1573, 1449, 1426, 1392, 941, 855, 810, 787, 566 cm^{-1} ; MS (EI) m/z : 245 [M^+ ($^{37}\text{Cl}^{37}\text{Cl}$)] (3.12), 243 [M^+ ($^{37}\text{Cl}^{35}\text{Cl}$)] (18.47), 241 [M^+ ($^{35}\text{Cl}^{35}\text{Cl}$)] (29.10), 208.0, 206.0, 171.0; HRMS (EI) Calcd for $\text{C}_{11}\text{H}_6\text{Cl}_2(^{35}\text{Cl})\text{FN}$: 240.9861, Found: 240.9865.

2-(2,4,6-Trichlorophenyl)pyridine (3c)



White solid, m.p.: 100-101 $^\circ\text{C}$, yield: 81%; ^1H NMR (400 MHz, CDCl_3): δ 8.75 (d, $J = 4.8$ Hz, 1H), 7.81 (td, $J = 1.6, 7.6$ Hz, 1H), 7.42 (s, 2H), 7.35-7.29 (m, 1H), 7.31 (dt, $J = 1.2, 7.6$ Hz, 1H); ^{13}C NMR (100 MHz, CDCl_3): δ 154.5, 149.7, 137.0, 136.5, 135.2, 134.7, 128.1, 125.0, 123.2; IR (KBr): ν 3039, 3003, 1590, 1539, 1422, 1371, 1107, 780, 745, 575 cm^{-1} ; MS (EI) m/z : 263 [M^+ ($^{37}\text{Cl}^{37}\text{Cl}^{37}\text{Cl}$)] (1.03), 261 [M^+ ($^{37}\text{Cl}^{37}\text{Cl}^{35}\text{Cl}$)] (8.54), 259 [M^+ ($^{37}\text{Cl}^{35}\text{Cl}^{35}\text{Cl}$)] (27.34), 257 [M^+ ($^{35}\text{Cl}^{35}\text{Cl}^{35}\text{Cl}$)] (29.32), 224, 222, 189, 187; HRMS (EI) Calcd for $\text{C}_{11}\text{H}_6\text{Cl}_3(^{35}\text{Cl})\text{N}$: 256.9566, Found: 256.9571.

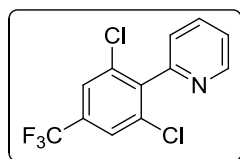
2-(2,4-Dichlorophenyl)pyridine (2c)



White solid, m.p. 75-76 $^\circ\text{C}$, yield: 9%; ^1H NMR (400 MHz, CDCl_3): δ 8.73-8.71 (m, 1H), 7.77 (dt, $J = 2.0, 7.6$ Hz, 1H), 7.64 (d, $J = 8.0$ Hz, 1H), 7.56 (d, $J = 8.4$ Hz, 1H), 7.50 (d, $J = 2.0$ Hz, 1H), 7.36 (dd, $J = 2.0, 8.4$ Hz, 1H), 7.31 (ddd, $J = 1.2, 4.8, 7.6$ Hz, 1H); ^{13}C NMR (100 MHz, CDCl_3): 155.7, 149.7, 137.7, 135.9, 134.8, 132.8, 132.4, 129.8, 127.4, 124.8, 122.6; IR (KBr): ν 3069, 2924, 1592, 1571, 1459, 1376, 818, 778, 744 cm^{-1} ; MS (EI) m/z : 223 [M^+ ($^{35}\text{Cl}^{35}\text{Cl}$)] (49.72), 225 [M^+ ($^{35}\text{Cl}^{37}\text{Cl}$)] (31.31), 227 [M^+ ($^{37}\text{Cl}^{37}\text{Cl}$)] (5.07), 190, 188, 153, 74; HRMS (EI) Calcd for $\text{C}_{11}\text{H}_7\text{Cl}_2(^{35}\text{Cl})\text{N}$:

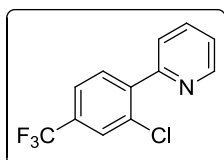
222.9956, Found: 222.9954.

2-(2,6-Dichloro-4-(trifluoromethyl)phenyl)pyridine (3d)^[15]



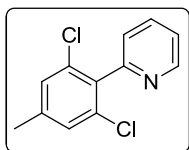
Colorless oil, yield: 78%; ¹H NMR (400 MHz, CDCl₃): 8.77 (d, *J* = 4.8 Hz, 1H), 7.79 (td, *J* = 2.0, 7.6 Hz, 1H), 7.68 (s, 2H), 7.38 (ddd, *J* = 1.2, 4.8, 7.6 Hz, 1H), 7.34 (d, *J* = 7.6, 1H); IR (KBr): 3054, 2928, 1587, 1568, 1560, 1485, 1428, 880, 857, 814, 787, 747, 738, 486 cm⁻¹; MS (EI) *m/z*: 291 [M⁺ (³⁵Cl³⁵Cl)] (24.03), 293 [M⁺ (³⁵Cl³⁷Cl)] (14.29), 295 [M⁺ (³⁷Cl³⁷Cl)] (2.26), 238.0, 236.0, 221.0, 152.1.

2-(2-Chloro-4-(trifluoromethyl)phenyl)pyridine (2d)^[15]



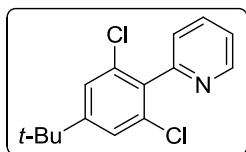
White solid, m.p. 42-43 °C, yield: 3%; ¹H NMR (400 MHz, CDCl₃): δ 8.75 (d, *J* = 4.8 Hz, 1H), 7.81 (td, *J* = 2.0, 7.6 Hz, 1H), 7.76 (s, 1H), 7.74 (d, *J* = 8.0 Hz, 1H), 7.67 (d, *J* = 7.6 Hz, 1H), 7.63 (d, *J* = 8.0 Hz, 1H), 7.38 (ddd, *J* = 1.2, 4.8, 7.6 Hz, 1H); IR (KBr): ν 1590, 1465, 1434, 1391, 1338, 887, 861, 833, 783 cm⁻¹; MS (EI) *m/z*: 259 [M⁺ (³⁷Cl)] (13.65), 257 [M⁺ (³⁵Cl)] (43.92), 223, 222, 191, 91, 71.

2-(2,6-Dichloro-4-methylphenyl)pyridine (3e)^[15]



Yellow oil, yield: 76%; ¹H NMR (400 MHz, CDCl₃): δ 8.74 (td, *J* = 1.6, 4.4 Hz, 1H), 7.79 (dt, *J* = 1.6, 7.6 Hz, 1H), 7.34-7.31 (m, 2H), 7.23 (s, 2H), 2.37 (s, 3H); IR (KBr): ν 2923, 1600, 1566, 1453, 1390, 849, 801, 782, 745, 578 cm⁻¹; MS (EI) *m/z*: 237 [M⁺ (³⁵Cl³⁵Cl)] (31.23), 239 [M⁺ (³⁵Cl³⁷Cl)] (19.40), 241 [M⁺ (³⁷Cl³⁷Cl)] (3.17), 204, 202, 167, 139.

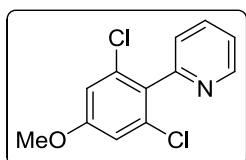
2-(4-(tert-Butyl)-2,6-dichlorophenyl)pyridine (3f)



Yellow solid, m.p. 64-66 °C, yield: 67%; ¹H NMR (400 MHz, CDCl₃): δ 8.75-8.73 (m, 1H), 7.79 (td, *J* = 1.6, 7.6 Hz, 1H), 7.40 (s, 2H), 7.34-7.30 (m, 2H), 1.33 (s, 9H); ¹³C NMR (100 MHz, CDCl₃): δ 155.6, 153.8, 149.5, 136.2, 135.4, 134.0, 125.4, 125.0, 122.7, 34.9, 30.9; IR

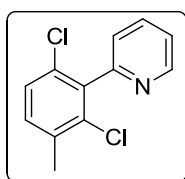
(KBr): ν 2965, 1597, 1567, 1542, 1454, 1426, 1379, 1262, 803, 746, 588 cm^{-1} ; MS (EI) m/z : 283 [M^+ ($^{37}\text{Cl}^{37}\text{Cl}$)] (2.18), 281 [M^+ ($^{35}\text{Cl}^{37}\text{Cl}$)] (13.0), 279 [M^+ ($^{35}\text{Cl}^{35}\text{Cl}$)] (19.69), 264, 236, 228, 192, 115, 78; HRMS (EI) Calcd for $\text{C}_{15}\text{H}_{15}\text{Cl}_2\text{N}$: 279.0582, Found:279.0581.

2-(2,6-Dichloro-4-methoxyphenyl)pyridine (3g)^[15]



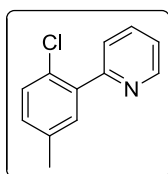
White solid, m.p. 65-67 °C, yield: 46%; ^1H NMR (400 MHz, CDCl_3): δ 8.75-8.73 (m, 1H), 7.78 (td, $J = 1.6, 7.6$ Hz, 1H), 7.33-7.30 (m, 2H), 6.96 (s, 2H), 3.83 (s, 3H); IR (KBr): ν 2942, 1602, 1554, 1462, 1425, 1397, 833, 787, 747, 570 cm^{-1} ; MS (EI) m/z : 257 [M^+ ($^{37}\text{Cl}^{37}\text{Cl}$)] (4.67), 255 [M^+ ($^{35}\text{Cl}^{37}\text{Cl}$)] (28.89), 253 [M^+ ($^{35}\text{Cl}^{35}\text{Cl}$)] (47.67), 219, 218, 203, 175, 140, 78.

2-(2,6-Dichloro-3-methylphenyl)pyridine (3h)



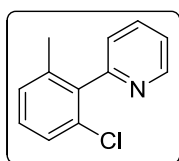
Yellow oil, yield: 25%; ^1H NMR (400 MHz, CDCl_3): δ 8.76-8.74 (m, 1H), 7.81 (td, $J = 2.0, 8.0$ Hz, 1H), 7.35-7.30 (m, 3H), 7.22 (d, $J = 8.0$ Hz, 1H), 2.39 (s, 3H); ^{13}C NMR (100 MHz, CDCl_3): δ 158.0, 149.6, 149.5, 137.3, 136.0, 131.1, 129.3, 129.2, 126.6, 125.1, 122.5, 21.1; IR (KBr): ν 2924, 1593, 1566, 1445, 1428, 1382, 810, 773, 747, 692, 581 cm^{-1} ; MS (EI) m/z : 241 [M^+ ($^{37}\text{Cl}^{37}\text{Cl}$)] (2.38), 239 [M^+ ($^{35}\text{Cl}^{37}\text{Cl}$)] (15.25), 237 [M^+ ($^{35}\text{Cl}^{35}\text{Cl}$)] (25.67), 204, 202, 167, 139, 83; HRMS (EI) Calcd for $\text{C}_{12}\text{H}_9\text{Cl}_2\text{N}$: 237.0112, Found: 237.0113.

2-(2-Chloro-5-methylphenyl)pyridine (2h)^[16]



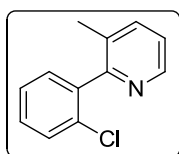
Yellow oil, yield: 58%; ^1H NMR (400 MHz, CDCl_3): δ 8.72-8.70 (m, 1H), 7.75 (td, $J = 2.0, 8.0$ Hz, 1H), 7.65 (d, $J = 8.0$ Hz, 1H), 7.42 (d, $J = 2.0$ Hz, 1H), 7.35 (d, $J = 8.4$ Hz, 1H), 7.28-7.25 (m, 1H), 7.13 (dd, $J = 2.0, 8.0$ Hz, 1H), 2.37 (s, 3H); IR (KBr): ν 2924, 2855, 1587, 1565, 1457, 1428, 1383, 812, 787, 747, 692, 581 cm^{-1} ; MS (EI) m/z : 202 [$(\text{M}-1)^+$ (^{35}Cl)] (100.0), 204 [$(\text{M}-1)^+$ (^{37}Cl)] (23.06), 167, 166, 139, 87, 74.

2-(2-chloro-6-methylphenyl)pyridine (2j)^[15]



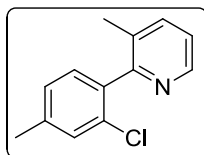
Colorless oil, yield: 55%; ¹H NMR (400 MHz, CDCl₃): δ 8.74-8.73 (m, 1H), 7.79 (dt, *J* = 2.0, 7.6 Hz, 1H), 7.32-7.29 (m, 3H), 7.22 (t, *J* = 7.6 Hz, 1H), 7.19-7.17 (m, 1H), 2.09 (s, 3H); IR (KBr): ν 2956, 2925, 1596, 1586, 1566, 1453, 1422, 860, 787, 774, 749, 669, 530 cm⁻¹; MS (EI) *m/z*: 204 [(*M*-1)⁺ (³⁷Cl)] (31.13), 202 [(*M*-1)⁺ (³⁵Cl)] (100.0), 191, 167, 166, 139, 76.

2-(2-Chlorophenyl)-3-methylpyridine (2k)^[15]



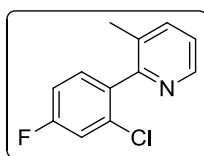
Colorless oil, yield: 57%; ¹H NMR (400 MHz, CDCl₃): δ 8.52-8.51 (m, 1H), 7.59-7.56 (m, 1H), 7.47-7.44 (m, 1H), 7.36-7.29 (m, 3H), 7.23 (dd, *J* = 4.8, 7.6 Hz, 1H), 2.16 (s, 3H); IR (KBr): ν 3054, 2926, 1596, 1570, 1445, 1431, 792, 777, 756, 738, 622 cm⁻¹; MS (EI) *m/z*: 205 [*M*⁺ (³⁷Cl)] (15.37), 203 [*M*⁺ (³⁵Cl)] (50.23), 202, 204, 168, 167, 75.

2-(2-Chloro-4-methylphenyl)-3-methylpyridine (2l)



Yellow oil, yield: 62%; ¹H NMR (400 MHz, CDCl₃): δ 8.51-8.50 (m, 1H), 7.59-7.57 (m, 1H), 7.29 (s, 1H), 7.24-7.14 (m, 3H), 2.39 (s, 3H), 2.16 (s, 3H); ¹³C NMR (100 MHz, CDCl₃): 157.0, 146.4, 139.6, 137.9, 136.3, 132.4, 132.3, 130.1, 129.8, 127.7, 122.8, 21.0, 18.9; IR (KBr): ν 2924, 1610, 1583, 1571, 1445, 1425, 1081, 874, 824, 791, 588 cm⁻¹; MS (EI) *m/z*: 219 [*M*⁺ (³⁷Cl)] (16.36), 217 [*M*⁺ (³⁵Cl)] (52.08), 216, 218, 182, 167, 152, 77; HRMS (EI) Calcd for C₁₃H₁₂ClN: 217.0658, Found: 217.0656.

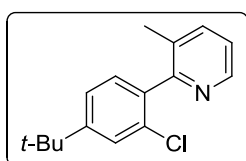
2-(2-Chloro-4-fluorophenyl)-3-methylpyridine (2m)



Yellow oil, yield: 61%; ¹H NMR (400 MHz, CDCl₃): δ 8.52-8.51 (m, 1H), 7.59 (d, *J* = 7.6 Hz, 1H), 7.31-7.21 (m, 3H), 7.02 (dt, *J* = 2.4, 8.4 Hz, 1H), 2.16 (s, 3H); ¹³C NMR (100 MHz, CDCl₃): δ 162.2 (d, ¹*J*_{C-F} = 248.5 Hz, 1C), 156.2, 146.8, 137.8, 135.7 (d, ⁴*J*_{C-F} = 3.3 Hz, 1C), 133.6 (d, ³*J*_{C-F} = 10.1 Hz, 1C), 132.3, 131.5 (d, ³*J*_{C-F} = 8.8 Hz, 1C), 123.0, 116.7 (d,

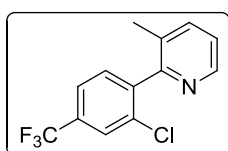
$^2J_{C-F} = 24.6$ Hz, 1C), 114.2 (d, $^2J_{C-F} = 21.0$ Hz, 1C), 18.7; IR (KBr): ν 2925, 1600, 1574, 1496, 1446, 1424, 1384, 898, 858, 791, 579 cm^{-1} ; MS (EI) m/z : 223 [M^+ (^{37}Cl)] (15.91), 221 [M^+ (^{35}Cl)] (56.02), 222 [($M-1$) $^+$ (^{37}Cl)] (30.12), 220 [($M-1$) $^+$ (^{35}Cl)] (100), 186, 185, 157, 75; HRMS (EI) Calcd for $\text{C}_{12}\text{H}_8\text{ClFN}$ [($M+H$) $^+$ (^{35}Cl)]: 222.0486, Found: 222.0453.

2-(4-(*tert*-Butyl)-2-chlorophenyl)-3-methylpyridine (2n)



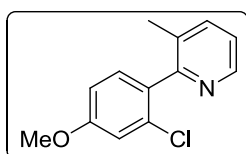
Yellow oil, yield: 60%; ^1H NMR (400 MHz, CDCl_3): δ 8.50 (d, $J = 4.8$ Hz, 1H), 7.57 (d, $J = 7.6$ Hz, 1H), 7.45 (d, $J = 2.0$ Hz, 1H), 7.35 (dd, $J = 1.6, 8.0$ Hz, 1H), 7.23 (d, $J = 8.0$ Hz, 1H), 7.20 (dd, $J = 4.8, 7.6$ Hz, 1H), 2.18 (s, 3H), 1.34 (s, 9H); ^{13}C NMR (100 MHz, CDCl_3): δ 157.5, 153.2, 146.9, 137.8, 136.8, 132.6, 132.5, 130.2, 126.7, 124.3, 122.9, 35.0, 31.4, 19.1; IR (KBr): ν 2962, 1606, 1570, 1445, 1385, 868, 832, 790, 632, 573 cm^{-1} ; MS (EI) m/z : 259 [M^+ (^{35}Cl)] (25.5), 261 [M^+ (^{37}Cl)] (7.84), 246, 244, 216, 167, 92; HRMS (EI) Calcd for $\text{C}_{16}\text{H}_{18}\text{ClN}$: 259.1128, Found: 259.1127.

2-(2-Chloro-4-(trifluoromethyl)phenyl)-3-methylpyridine (2o)



Yellow oil, yield: 72%; ^1H NMR (400 MHz, CDCl_3): δ 8.53 (dd, $J = 1.2, 4.8$ Hz, 1H), 7.75 (s, 1H), 7.64-7.62 (m, 2H), 7.46 (d, $J = 8.0$ Hz, 1H), 7.27 (dd, $J = 4.8, 8.0$ Hz, 1H), 2.16 (s, 3H); ^{13}C NMR (100 MHz, CDCl_3): 155.7, 146.9, 143.1, 137.9, 133.6, 132.0, 131.8 (q, $^2J_{C-F} = 33.0$ Hz), 131.2, 126.6, 124.5 (q, $^1J_{C-F} = 270.8$ Hz), 123.7, 123.3, 18.6; IR (KBr): ν 2929, 1572, 1448, 1388, 1323, 1132, 888, 845, 792, 721, 481 cm^{-1} ; MS (EI) m/z : 273 [M^+ (^{37}Cl)] (15.36), 271 [M^+ (^{35}Cl)] (46.53), 270, 272, 236, 235, 167, 166; HRMS (EI) Calcd for $\text{C}_{13}\text{H}_9\text{ClNF}_3$: 271.0376, Found: 271.0377.

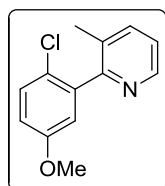
2-(2-Chloro-4-methoxyphenyl)-3-methylpyridine (2p)^[17]



Yellow oil, yield: 52%; ^1H NMR (400 MHz, CDCl_3): δ 8.54 (d, $J = 4.4$ Hz, 1H), 7.63 (d, $J = 8.0$ Hz, 1H), 7.27 (dd, $J = 4.8, 7.6$

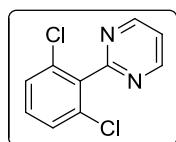
Hz, 1H), 7.22 (d, $J = 8.4$ Hz, 1H), 7.02 (d, $J = 2.4$ Hz, 1H), 6.90 (dd, $J = 2.4, 8.4$ Hz, 1H), 3.84 (s, 3H), 2.17 (s, 3H); IR (KBr): ν 2931, 1607, 1503, 1424, 1287, 792, 592, 571 cm^{-1} ; MS (EI) m/z : 233 [M^+ (^{35}Cl)] (68.05), 235 [M^+ (^{37}Cl)] (17.42), 232, 234, 199, 198, 183, 154, 127.

2-(2-Chloro-5-methoxyphenyl)-3-methylpyridine (2q)



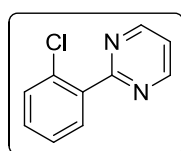
Yellow oil, yield: 72%; ^1H NMR (400 MHz, CDCl_3) δ 8.50 (d, $J = 4.8$ Hz, 1H), 7.57 (d, $J = 7.6$ Hz, 1H), 7.24-7.20 (m, 2H), 7.00 (d, $J = 2.4$ Hz, 1H), 6.89 (dd, $J = 2.4$ Hz, 8.4 Hz, 1H), 3.84 (s, 3H), 2.17 (s, 3H); ^{13}C NMR (100 MHz, CDCl_3) δ 160.1, 157.3, 146.9, 137.9, 133.6, 132.7, 132.3, 131.2, 122.9, 114.9, 113.3, 55.8, 19.1; IR (KBr): ν 3049, 2930, 1607, 1503, 1424, 1287, 879, 792, 592 cm^{-1} ; MS (EI) m/z : 235 [M^+ (^{37}Cl)] (19.51), 233 [M^+ (^{35}Cl)] (68.20), 232, 217, 198, 183, 155, 154, 77; HRMS (EI) Calcd for $\text{C}_{13}\text{H}_{12}\text{ClNO}$: 233.0607, Found: 233.0608.

2-(2,6-Dichlorophenyl)pyrimidine (3r)^[2]



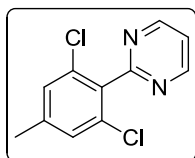
White solid, m.p.: 128-130 °C, yield: 39%; ^1H NMR (400 MHz, CDCl_3) δ 8.92 (d, $J = 4.8$ Hz, 2H), 7.43-7.27 (m, 4H); IR (KBr): ν 2922, 1588, 1562, 1467, 1429, 1407, 781, 737, 558 cm^{-1} ; MS (EI) m/z : 228 [M^+ ($^{37}\text{Cl}^{37}\text{Cl}$)] (4.39), 226 [M^+ ($^{37}\text{Cl}^{35}\text{Cl}$)] (27.54), 224 [M^+ ($^{35}\text{Cl}^{35}\text{Cl}$)] (46.25), 191, 189, 173, 171, 136, 75.

2-(2-Chlorophenyl)pyrimidine (2r)^[2]



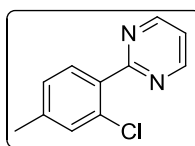
Yellow oil, yield: 58%; ^1H NMR (400 MHz, CDCl_3) δ 8.88 (dd, $J = 1.2, 4.8$ Hz, 2H), 7.75-7.73 (m, 1H), 7.52-7.50 (m, 1H), 7.41-7.37 (m, 2H), 7.29 (t, $J = 4.8$ Hz, 1H); IR (KBr): ν 1595, 1566, 1441, 1413, 1037, 817, 754, 696, 631 cm^{-1} ; MS (EI) m/z : 192 [M^+ (^{37}Cl)] (22.8), 190 [M^+ (^{35}Cl)] (100.0), 156, 155, 139, 137, 102, 75.

2-(2,6-Dichloro-4-methylphenyl)pyrimidine (3s)^[2]



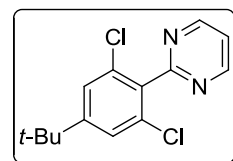
White solid, m.p.: 119-121 °C, yield: 56%; ¹H NMR (400 MHz, CDCl₃) δ 8.91 (d, *J* = 5.2 Hz, 2H), 7.34 (t, *J* = 4.8 Hz, 1H), 7.23 (s, 2H), 2.37 (s, 3H); IR (KBr): ν 2924, 1600, 1557, 1410, 853, 792, 736, 576 cm⁻¹; MS (EI) *m/z*: 242 [M⁺ (³⁷Cl³⁷Cl)] (4.7), 240 [M⁺ (³⁷Cl³⁵Cl)] (32.3), 238 [M⁺ (³⁵Cl³⁵Cl)] (62.2), 205, 203, 187, 185, 150, 114.

2-(2-Chloro-4-methylphenyl)pyrimidine (2s) ^[2]



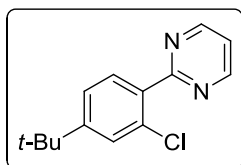
Colorless oil, yield: 30%; ¹H NMR (400 MHz, CDCl₃) δ 8.87 (d, *J* = 4.8 Hz, 2H), 7.65 (d, *J* = 8.0 Hz, 1H), 7.33 (s, 1H), 7.25 (t, *J* = 4.8 Hz, 1H), 7.19-7.17 (m, 1H); IR (KBr): ν 2924, 1673, 1607, 1563, 1415, 802, 742, 633 cm⁻¹; MS (EI) *m/z*: 206 [M⁺ (³⁷Cl)] (22.1), 204 [M⁺ (³⁵Cl)] (100.0), 169, 151, 116, 89, 63.

2-(4-(*tert*-Butyl)-2,6-dichlorophenyl)pyrimidine (3t)



White solid, m.p.: 154-156 °C, yield: 54%; ¹H NMR (400 MHz, CDCl₃) δ 8.91 (d, *J* = 4.8 Hz, 2H), 7.40 (s, 2H), 7.34 (t, *J* = 4.8 Hz, 1H), 1.34 (s, 9H); ¹³C NMR (100 MHz, CDCl₃) δ 164.4, 157.3, 154.3, 134.5, 133.3, 125.3, 119.9, 35.0, 30.9; IR (KBr): ν 2965, 1600, 1559, 1534, 1413, 1379, 870, 799, 584 cm⁻¹; MS (EI) *m/z*: 284 [M⁺ (³⁷Cl³⁷Cl)] (1.71), 282 [M⁺ (³⁷Cl³⁵Cl)] (8.82), 280 [M⁺ (³⁵Cl³⁵Cl)] (13.07), 267, 265, 237, 225, 183, 141, 115; HRMS (EI) Calcd for C₁₄H₁₄Cl₂N₂: 280.0534, Found: 280.0532.

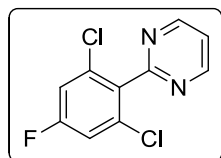
2-(4-(*tert*-Butyl)-2-chlorophenyl)pyrimidine (2t)



Yellow solid, m.p.: 154-156 °C, yield: 22%; ¹H NMR (400 MHz, CDCl₃): δ 8.87 (d, *J* = 4.8 Hz, 2H), 7.68 (d, *J* = 8.0 Hz, 1H), 7.50 (d, *J* = 2.0 Hz, 1H), 7.39 (dd, *J* = 2.0, 8.0 Hz, 1H), 7.27 (t, *J* = 4.8 Hz, 1H), 1.34 (s, 9H); ¹³C NMR (100 MHz, CDCl₃): δ 165.6, 157.0, 154.2, 134.6, 132.2, 131.3, 127.6, 124.0, 119.1, 34.8, 31.0; IR (KBr): ν 2965, 1601, 1559, 1413, 1379, 870, 1262, 799, 653, 584 cm⁻¹; MS (EI) *m/z*: 248 [M⁺ (³⁷Cl)] (6.91), 246 [M⁺ (³⁵Cl)] (20.24), 233, 231, 216, 203, 63; HRMS (EI) Calcd for C₁₄H₁₅ClN₂: 246.0924,

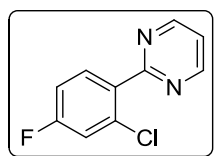
Found: 246.0932.

2-(2,6-Dichloro-4-fluorophenyl)pyrimidine (3u) ^[2]



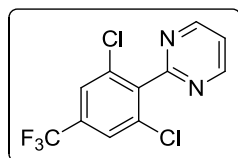
White solid, m.p.: 98-100 °C, yield: 33%; ¹H NMR (400 MHz, CDCl₃): δ 8.92 (d, *J* = 4.8 Hz, 2H), 7.37 (t, *J* = 4.8 Hz, 1H), 7.19 (d, *J*_{F-H} = 8.0 Hz, 2H); IR (KBr): ν 3091, 1598, 1559, 1409, 1396, 942, 858, 804, 578 cm⁻¹; MS (EI) m/z: 246 [M⁺ (³⁷Cl³⁷Cl)] (6.36), 244 [M⁺ (³⁷Cl³⁵Cl)] (44.55), 242 [M⁺ (³⁵Cl³⁵Cl)] (83.40), 209, 207, 191, 189, 154.

2-(2-Chloro-4-fluorophenyl)pyrimidine (2u) ^[2]



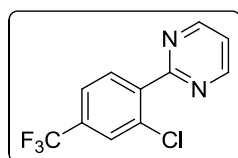
White solid, m.p.: 101-103 °C, yield: 33%; ¹H NMR (400 MHz, CDCl₃): δ 8.88 (d, *J* = 4.8 Hz, 2H), 7.78 (dd, *J* = 6.4, 8.8 Hz, 1H), 7.31-7.25 (m, 2H), 7.10 (td, *J* = 2.4, 8.4 Hz, 1H); IR (KBr): ν 2922, 1597, 1558, 1418, 1384, 902, 883, 793, 581 cm⁻¹; MS (EI) m/z: 210 [M⁺ (³⁷Cl)] (25.19), 208 [M⁺ (³⁵Cl)] (100.00), 173, 157, 155, 120, 75.

2-(2,6-Dichloro-4-(trifluoromethyl)phenyl)pyrimidine (3v) ^[2]



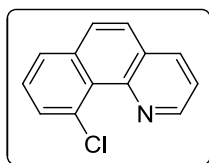
White solid, m.p.: 106-108 °C, yield: 64%; ¹H NMR (400 MHz, CDCl₃): δ 8.93 (d, *J* = 5.2 Hz, 2H), 7.69 (s, 2H), 7.40 (t, *J* = 4.8 Hz, 1H); IR (KBr): ν 2924, 1564, 1415, 1400, 1164, 1135, 873, 798, 664 cm⁻¹; MS (EI) m/z: 296 [M⁺ (³⁷Cl³⁷Cl)] (4.28), 294 [M⁺ (³⁷Cl³⁵Cl)] (28.07), 292 [M⁺ (³⁵Cl³⁵Cl)] (48.62), 259, 257, 241, 239, 204, 75.

2-(2-Chloro-4-(trifluoromethyl)phenyl)pyrimidine (2v) ^[2]



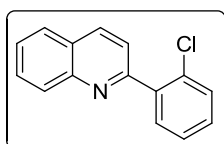
Colorless oil, yield: 36%; ¹H NMR (400 MHz, CDCl₃): δ 8.91 (d, *J* = 4.8 Hz, 2H), 7.88 (d, *J* = 8.0 Hz, 1H), 7.77 (s, 1H), 7.62 (d, *J* = 8.0 Hz, 1H), 7.33 (t, *J* = 4.8 Hz, 1H); IR (KBr): ν 1567, 1559, 1421, 1318, 1180, 1122, 841, 806, 709 cm⁻¹; MS (EI) m/z: 258 [M⁺ (³⁷Cl)] (6.53), 256 [M⁺ (³⁵Cl)] (6.40), 243, 236, 241, 215, 213, 186, 143.

10-Chlorobenzo[*h*]quinoline (2w)^[15]



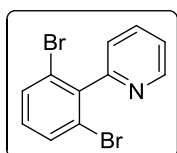
White solid, m.p.: 81-82 °C, yield: 78%; ¹H NMR (400 MHz, CDCl₃): δ 9.11 (dd, *J* = 2.0, 4.4 Hz, 1H), 8.13 (dd, *J* = 2.0, 8.4 Hz, 1H), 7.80 (t, *J* = 6.0 Hz, 2H), 7.74 (d, *J* = 8.8 Hz, 1H), 7.65 (d, *J* = 8.8 Hz, 1H), 7.55-7.51 (m, 2H); IR (KBr): ν 3043, 1622, 1590, 1553, 1493, 1437, 925, 833, 714, 646 cm⁻¹; MS (EI) *m/z*: 215 [M⁺(³⁷Cl)](22.8), 213 [M⁺(³⁵Cl)] (100.0), 178, 177, 150, 75.

2-(2-Chlorophenyl)quinoline (2x)^[14]



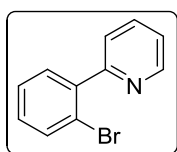
White solid, m.p.: 73-75 °C, yield: 27%; ¹H NMR (400 MHz, CDCl₃): δ 8.21 (d, *J* = 8.8 Hz, 1H), 8.19 (d, *J* = 8.4 Hz, 1H), 7.87 (dd, *J* = 1.2, 8.0 Hz, 1H), 7.77-7.73 (m, 2H), 7.71-7.69 (m, 1H), 7.60-7.58 (m, 1H), 7.53-7.50 (m, 1H), 7.42-7.38 (m, 2H); IR (KBr): ν 3059, 1598, 1503, 1436, 1312, 1038, 831, 761 cm⁻¹; MS (EI) *m/z*: 241 [M⁺(³⁷Cl)](10.99), 239 [M⁺(³⁵Cl)] (38.88), 204, 203, 176, 151, 102, 75.

2-(2,6-Dibromophenyl)pyridine (5a)^[15]



White solid, m.p.: 120-130 °C, yield: 27%; ¹H NMR (400 MHz, CDCl₃): δ 8.75 (d, *J* = 4.8 Hz, 1H), 7.82 (td, *J* = 2.0, 7.6 Hz, 1H), 7.63 (d, *J* = 8.0 Hz, 1H), 7.37-7.30 (m, 2H), 7.13 (t, *J* = 8.0 Hz, 1H); IR (KBr): ν 1562, 1467, 1407, 1130, 781 cm⁻¹; MS (ESI) *m/z*: 316 [(M+H⁺) (⁸¹Br⁸¹Br)], 314 [(M+H⁺) (⁷⁹Br⁸¹Br)], 312 [(M+H⁺) (⁷⁹Br⁷⁹Br)].

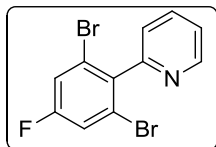
2-(2-Bromophenyl)pyridine (4a)^[15]



Yellow oil, yield: 44%. ¹H NMR (400 MHz, CDCl₃): δ 8.72-8.70 (m, 1H), 7.76 (td, *J* = 2.0, 7.6 Hz, 1H), 7.67 (dd, *J* = 1.2, 8.0 Hz, 1H), 7.59 (dt, *J* = 1.2, 8.0 Hz, 1H), 7.53 (dd, *J* = 1.2, 7.2 Hz, 1H), 7.39 (td, *J* = 1.2, 7.2 Hz, 1H), 7.31-7.23 (m, 2H); IR (KBr): ν 3053, 1592, 1583, 1458, 1420, 1016, 750 cm⁻¹; MS (EI) *m/z*: 235 [M⁺(⁸¹Br)] (23.53), 233 [M⁺(⁷⁹Br)] (24.63), 232,

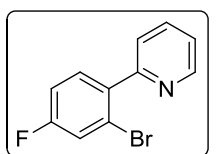
154, 127, 77, 43.

2-(2,6-Dibromo-4-fluorophenyl)pyridine (5b)



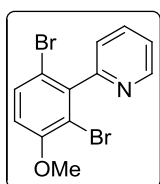
White solid, m.p.: 64-65 °C, yield: 51%; ^1H NMR (400 MHz, CDCl_3): δ 8.74 (d, $J = 4.8$ Hz, 1H), 7.80 (td, $J = 1.6, 8.0$ Hz, 1H), 7.40 (d, $J_{F-H} = 7.6$ Hz, 2H), 7.35 (ddd, $J = 1.6, 4.8, 7.6$ Hz, 1H), 7.28 (d, $J = 7.6$ Hz, 1H); ^{13}C NMR (100 MHz, CDCl_3): δ 161.7 (d, $^1J_{C-F} = 253.7$ Hz, 1C), 158.2, 149.8, 138.6, 136.8, 125.1, 124.0 (d, $^3J_{C-F} = 10.1$ Hz, 1C), 123.4, 119.7 (d, $^2J_{C-F} = 23.9$ Hz, 1C); IR (KBr): ν 1594, 1562, 1446, 1423, 910, 856, 745, 566 cm^{-1} ; MS (EI) m/z : 333 [M^+ ($^{81}\text{Br}^{81}\text{Br}$)] (10.66), 331 [M^+ ($^{79}\text{Br}^{81}\text{Br}$)] (24.26), 329 [M^+ ($^{79}\text{Br}^{79}\text{Br}$)] (12.22), 252, 250, 171, 144, 118; HRMS (EI) Calcd for $\text{C}_{11}\text{H}_6\text{Br}_2\text{FN}$: 328.8851, Found: 328.8848.

2-(2-Bromo-4-fluorophenyl)pyridine (4b)



Colorless oil, yield: 7%; ^1H NMR (400 MHz, CDCl_3): δ 8.70 (d, $J = 4.8$ Hz, 1H), 7.76 (td, $J = 2.0, 8.0$ Hz, 1H), 7.58 (d, $J = 8.0$ Hz, 1H), 7.53 (dd, $J = 6.0, 8.4$ Hz, 1H), 7.42 (dd, $J = 2.8, 8.4$ Hz, 1H), 7.30 (ddd, $J = 1.2, 4.8, 7.6$ Hz, 1H), 7.13 (td, $J = 2.8, 8.0$ Hz, 1H); ^{13}C NMR (100 MHz, CDCl_3): δ 162.0 (d, $^1J_{C-F} = 250.3$ Hz), 157.2, 149.3, 137.3 (d, $^4J_{C-F} = 3.0$ Hz, 1C), 136.0, 132.5 (d, $^3J_{C-F} = 8.5$ Hz, 1C), 124.8, 122.5, 121.9 (d, $^3J_{C-F} = 9.7$ Hz, 1C), 120.3 (d, $^2J_{C-F} = 24.3$ Hz, 1C), 114.7 (d, $^2J_{C-F} = 20.9$ Hz, 1C); IR (KBr): ν 1651, 1589, 1568, 1456, 1429, 1370, 1098, 797, 777, 744 cm^{-1} ; HRMS (ESI) Calcd for ($\text{C}_{11}\text{H}_7\text{BrFN} + \text{H}^+$): 251.9824, Found: 251.9820.

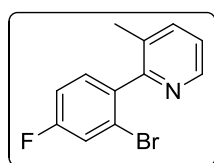
2-(2,6-Dibromo-3-methoxyphenyl)pyridine (5i)



Yellow solid, m.p.: 104-105 °C, yield: 54%; ^1H NMR (400 MHz, CDCl_3): δ 8.72-8.71 (m, 1H), 8.77 (td, $J = 1.6, 7.6$ Hz, 1H), δ 7.54 (d, $J = 8.8$ Hz, 1H), 7.31 (ddd, $J = 1.2, 4.8, 7.6$ Hz, 1H), 7.25 (d, $J = 7.6$ Hz, 1H), 6.84 (d, $J = 8.8$ Hz, 1H), 3.90 (s, 3H); ^{13}C NMR (100 MHz, CDCl_3): δ 159.1, 155.9, 150.0, 143.1, 136.7, 132.2, 124.8, 123.2, 114.1, 144.0, 113.0, 56.9; IR (KBr): ν

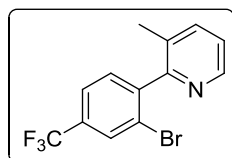
2964, 1557, 1452, 1294, 1091, 801 cm^{-1} ; MS (EI) m/z : 345 [M^+ ($^{81}\text{Br}^{81}\text{Br}$)] (15.03), 343 [M^+ ($^{81}\text{Br}^{79}\text{Br}$)] (34.00), 341 [M^+ ($^{79}\text{Br}^{79}\text{Br}$)] (16.08), 264, 262, 247, 221, 140, 113; HRMS (EI) Calcd for $\text{C}_{12}\text{H}_9\text{Br}_2\text{NO}$: 340.9051, Found: 340.9054.

2-(2-Bromo-4-fluorophenyl)-3-methylpyridine (4m)



Yellow oil, yield: 30%; ^1H NMR (400 MHz, CDCl_3): δ 8.52-8.51 (m, 1H), 7.61-7.60 (m, 1H), 7.40 (dd, $J = 2.4, 8.4$ Hz, 1H), 7.29-7.23 (m, 2H), 7.12 (td, $J = 2.4, 8.4$ Hz, 1H), 2.15 (s, 3H); ^{13}C NMR (100 MHz, CDCl_3): δ 162.0 (d, $^1J_{\text{C-F}} = 249.6$ Hz, 1C), 157.6, 146.7, 138.2, 137.9, 137.7, 132.1, 131.2 (d, $^3J_{\text{C-F}} = 8.5$ Hz, 1C), 123.1, 119.8 (d, $^2J_{\text{C-F}} = 24.3$ Hz, 1C), 114.7 (d, $^2J_{\text{C-F}} = 21.9$ Hz, 1C), 18.9; IR (KBr): ν 2925, 2854, 1601, 1581, 1494, 1446, 1384, 909, 877, 859, 733, 592 cm^{-1} ; MS (EI) m/z : 267 [M^+ (^{81}Br)] (16.04), 265 [M^+ (^{79}Br)] (17.64), 186, 185, 166, 157, 93, 75; HRMS (EI) Calcd for $\text{C}_{12}\text{H}_9\text{BrFN}$: 264.9902, Found: 264.9906.

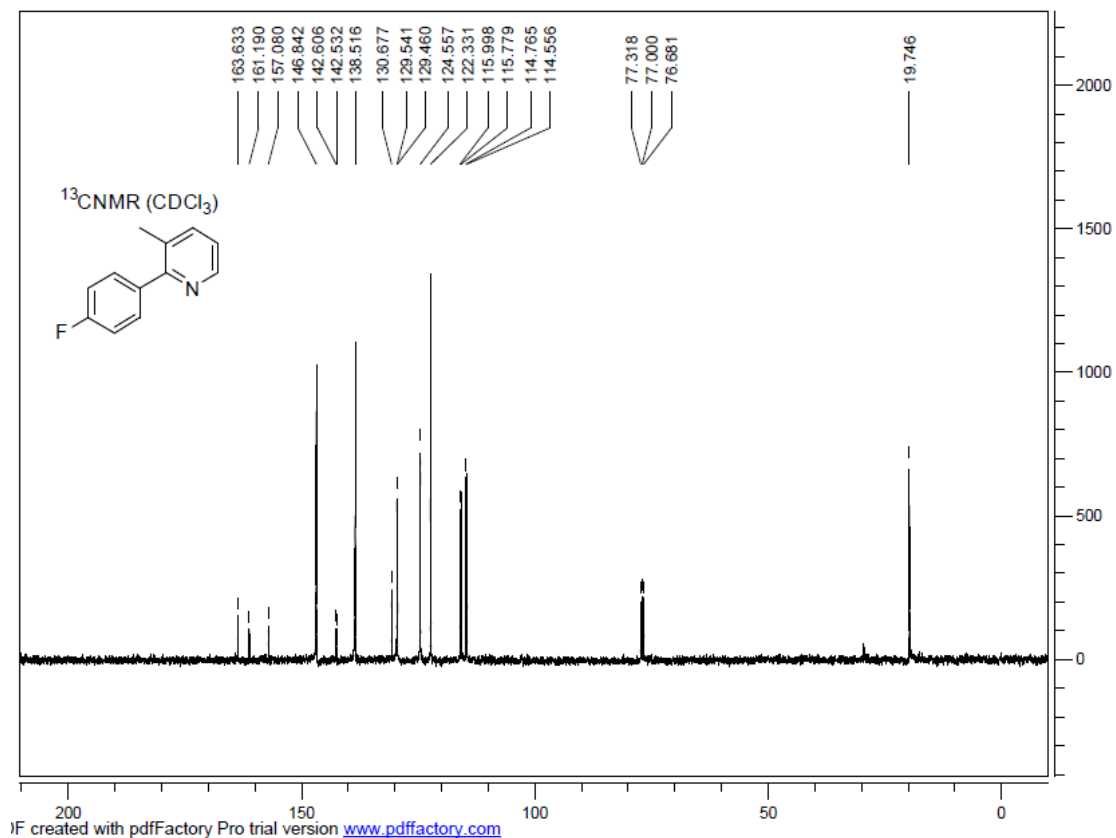
2-(2-Bromo-4-(trifluoromethyl)phenyl)-3-methylpyridine (4o)



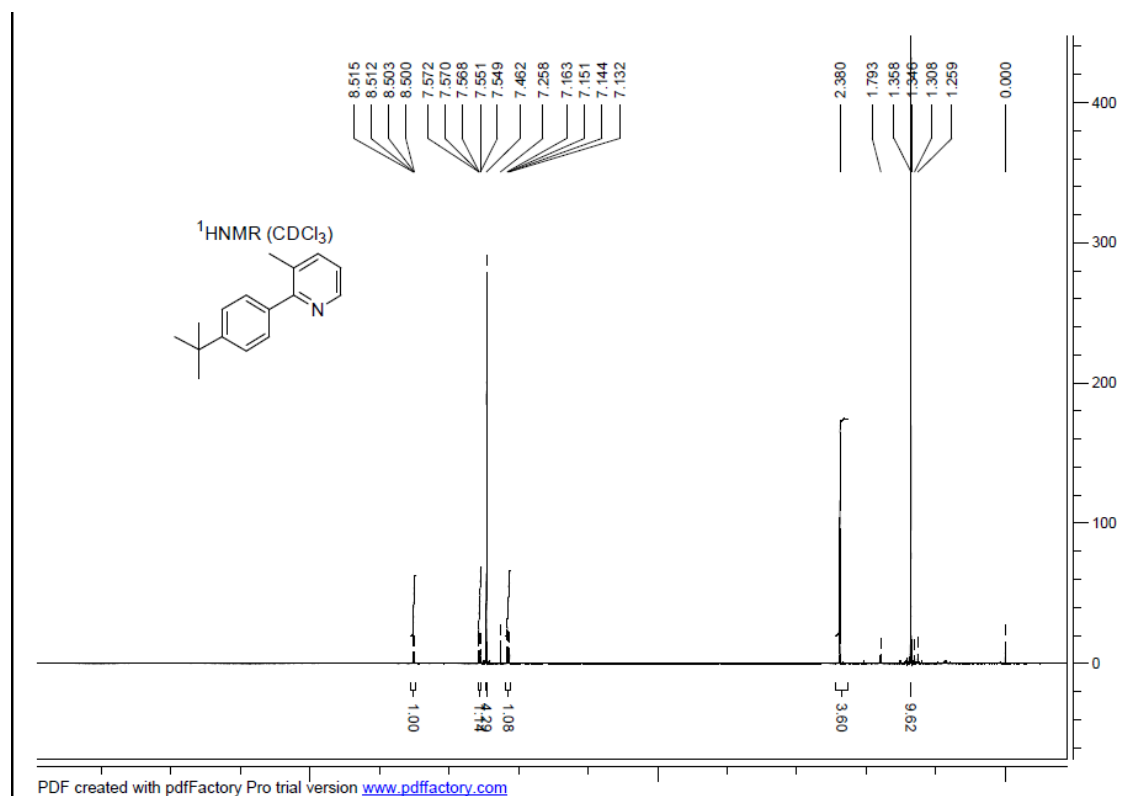
Colorless oil, yield: 46%; ^1H NMR (400 MHz, CDCl_3): δ 8.53 (d, $J = 4.8$ Hz, 1H), 7.93 (s, 1H), 7.67-7.61 (m 2H), 7.42 (d, $J = 8.0$ Hz, 1H), 7.28 (dd, $J = 4.8, 7.6$ Hz, 1H), 2.15 (s, 3H); ^{13}C NMR (100 MHz, CDCl_3): δ 157.4, 147.1, 145.3, 138.3, 131.9, 131.8 (q, $^2J_{\text{C-F}} = 32.9$ Hz, 1C), 131.0, 129.9, 123.3 (q, $^1J_{\text{C-F}} = 270.9$ Hz, 1C), 124.6, 123.7, 123.2, 19.0; IR (KBr): ν 2926, 1321, 1131, 1080, 792 cm^{-1} ; MS (EI) m/z : 317 [M^+ (^{81}Br)](17.46), 315 [M^+ (^{79}Br)](16.94), 237, 236, 216, 167, 139, 75; HRMS (EI) Calcd for $\text{C}_{13}\text{H}_9\text{BrF}_3\text{N}$: 314.9870, Found: 314.9876.

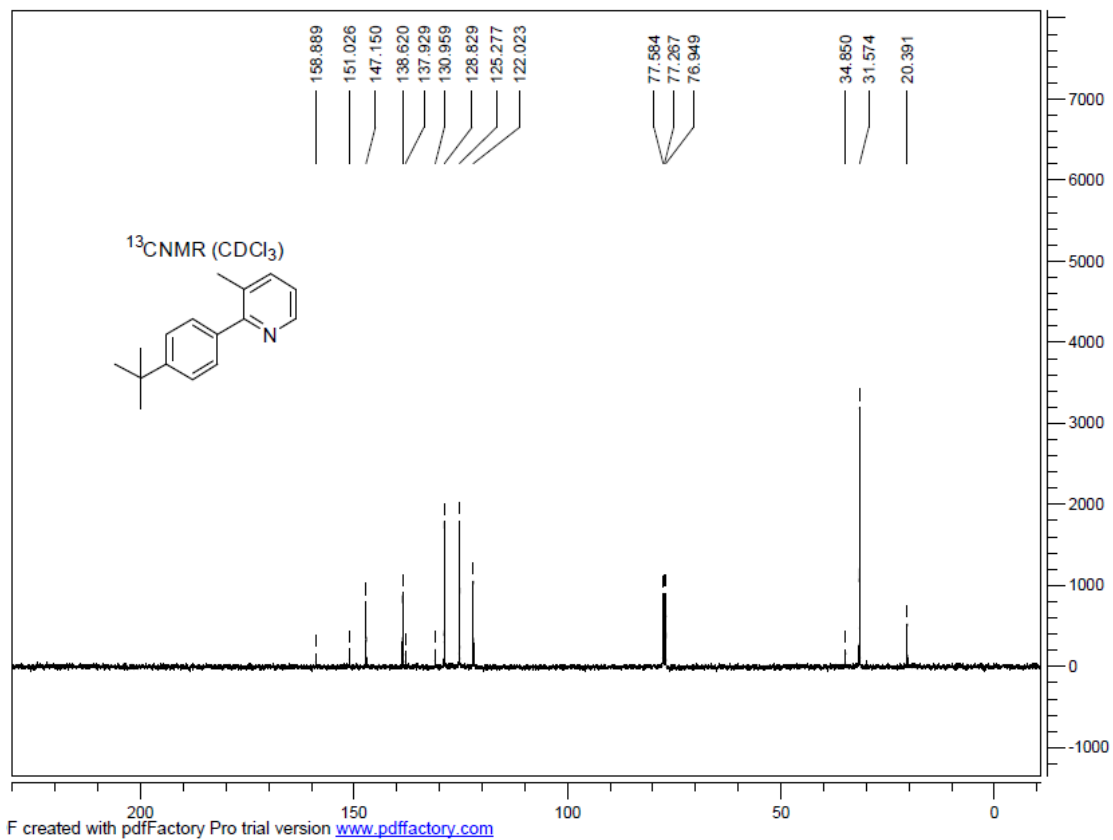
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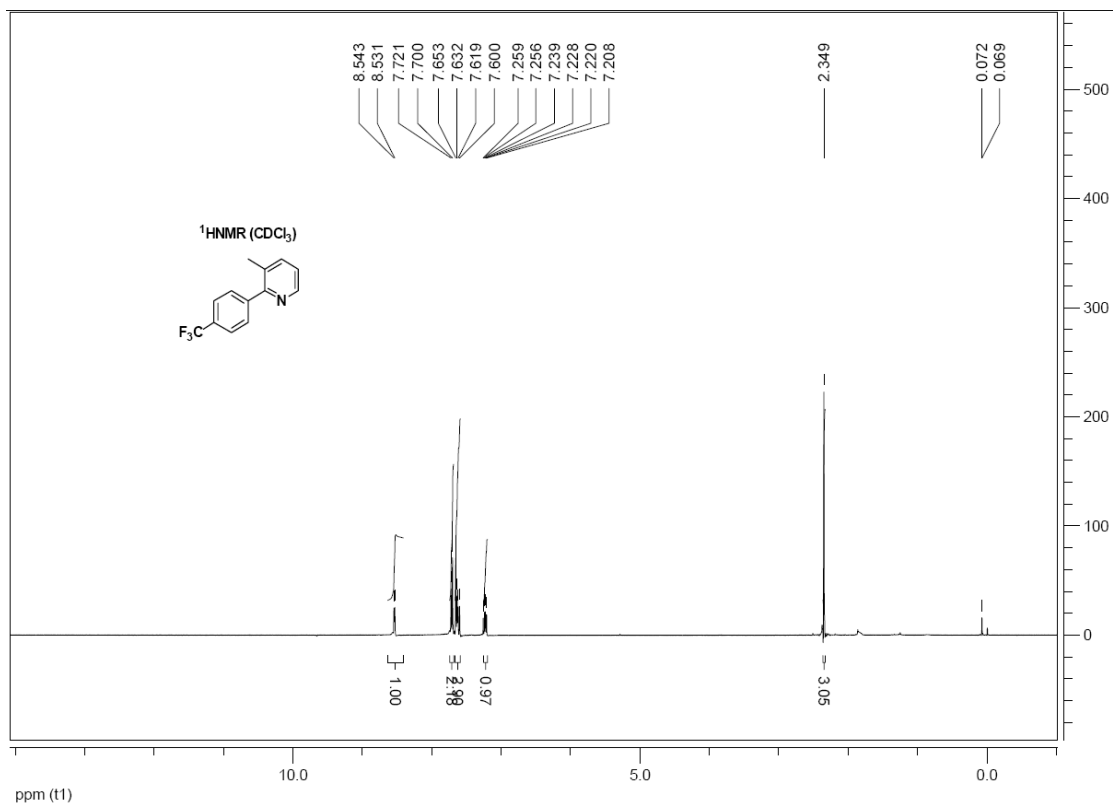


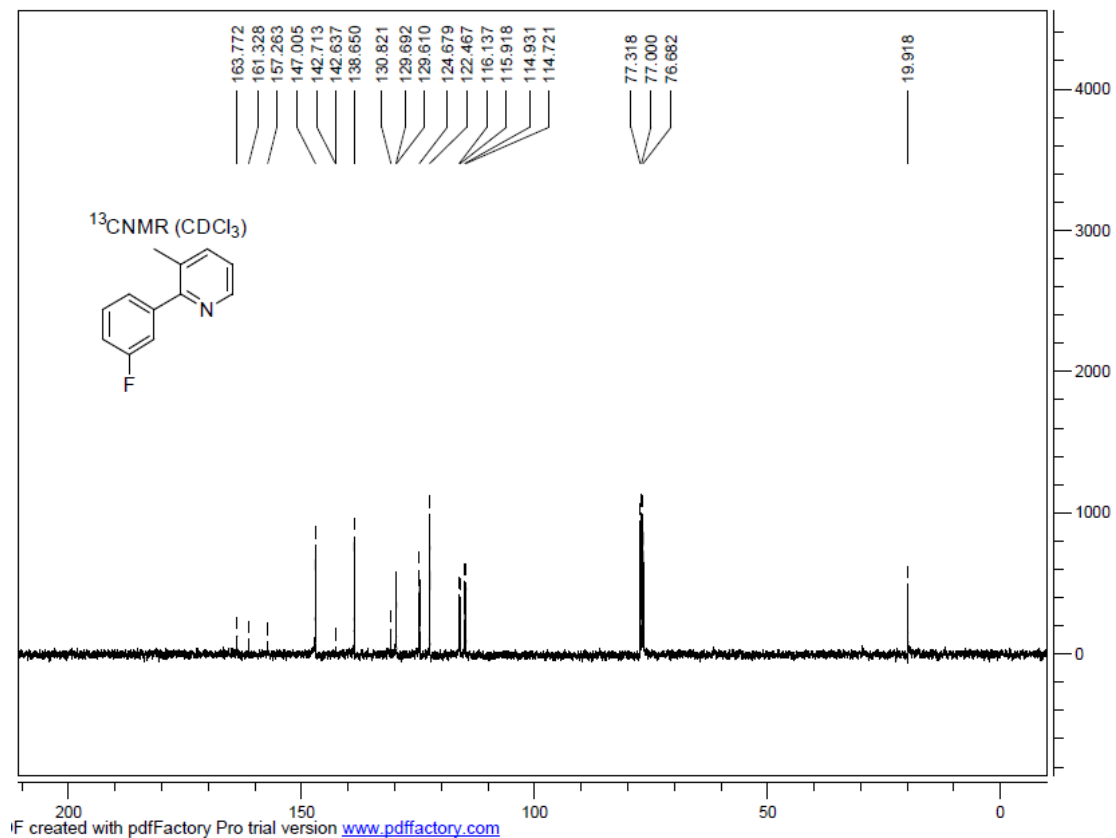
NMR spectra of compound **1n**



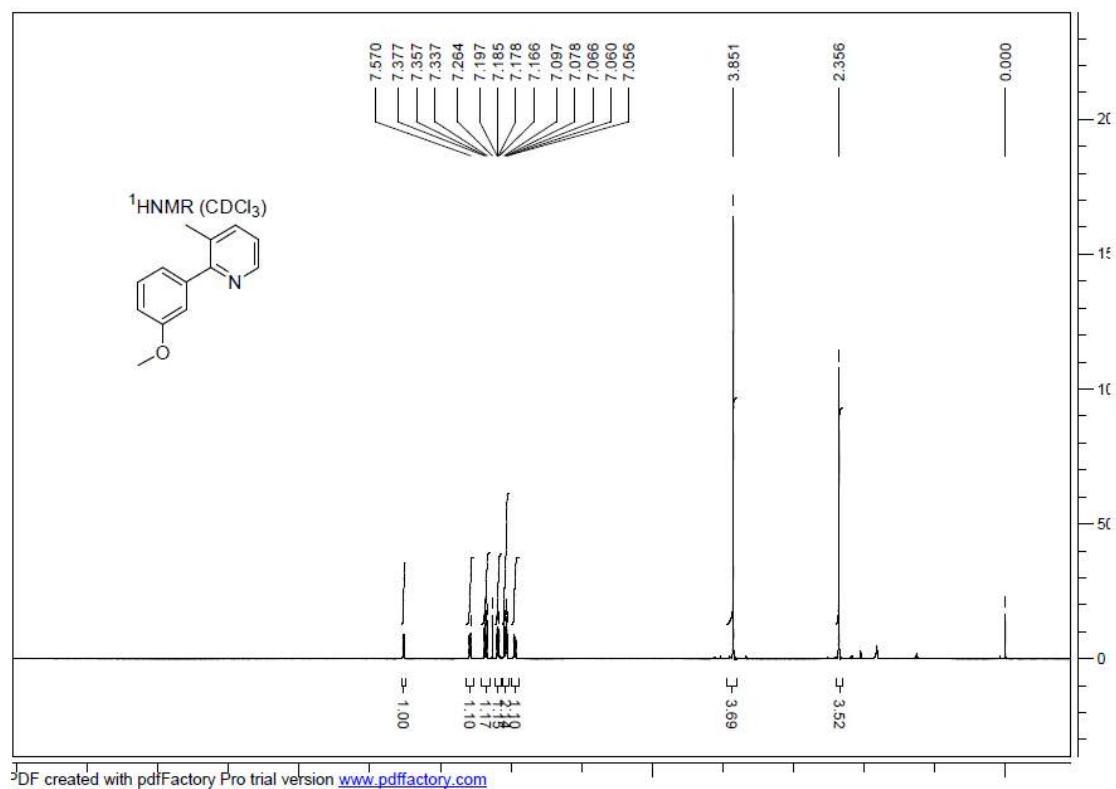


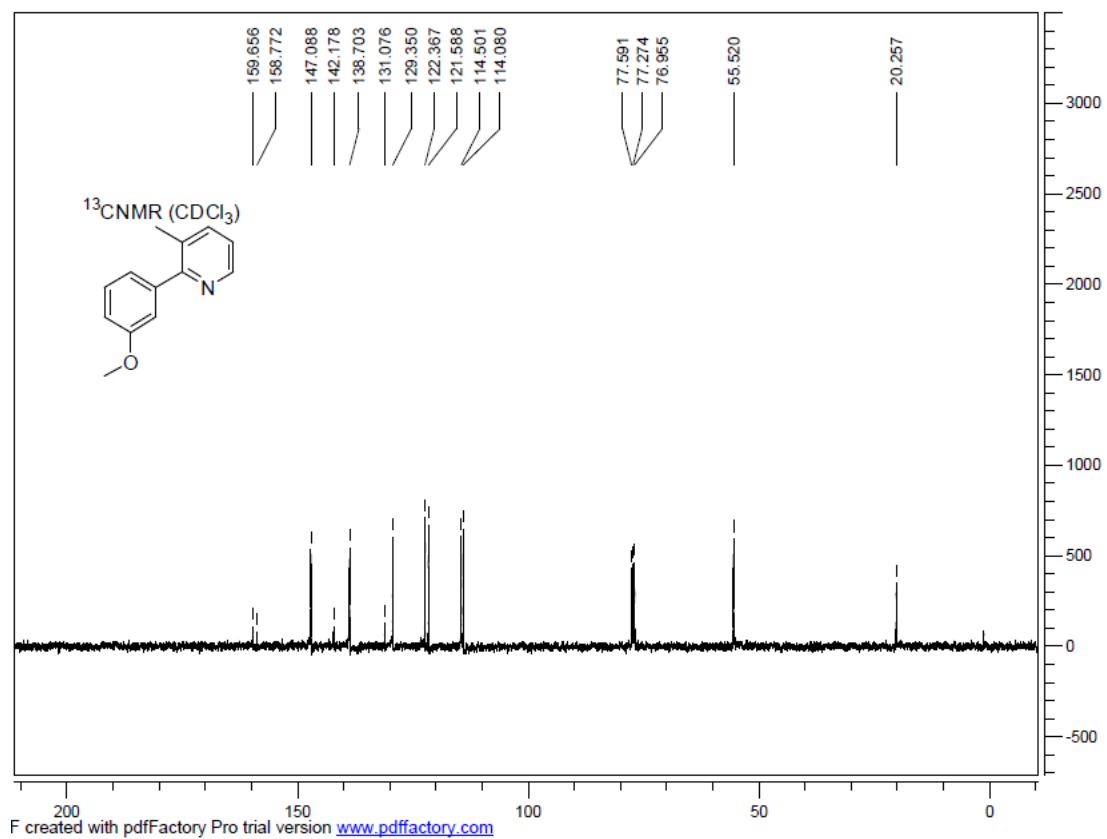
NMR spectra of compound **10**



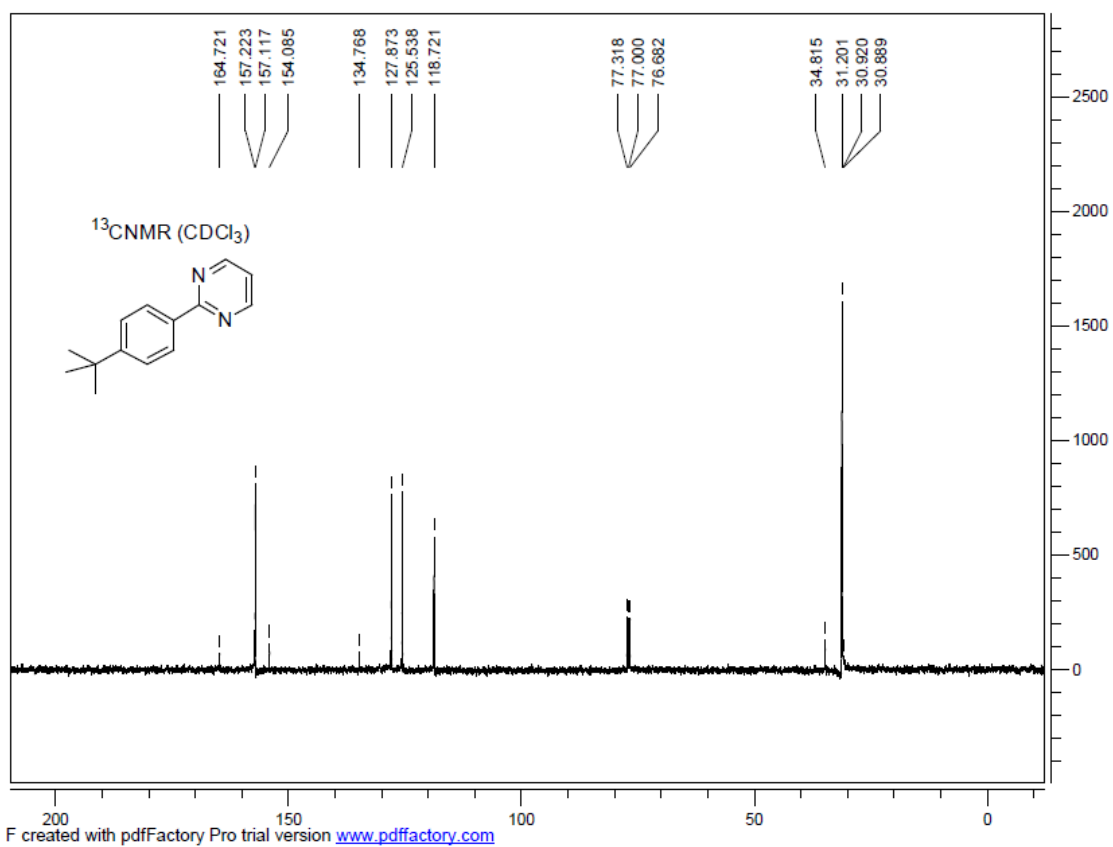
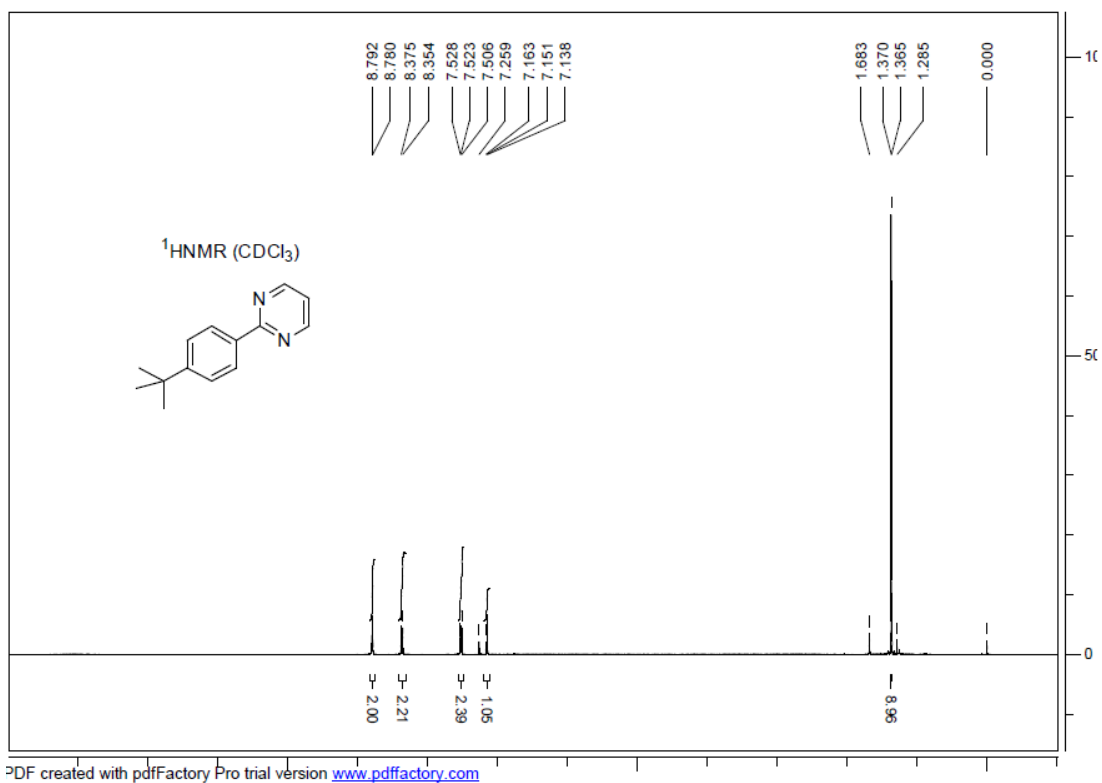


NMR spectra of compound **1r**

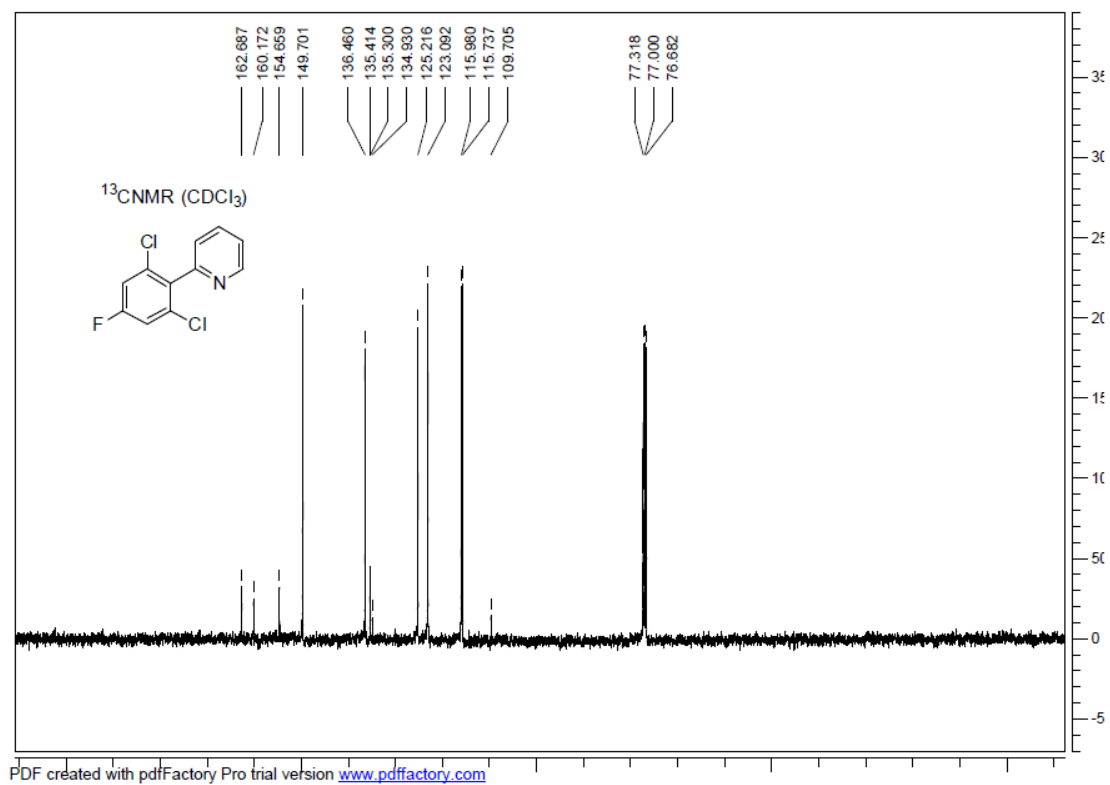
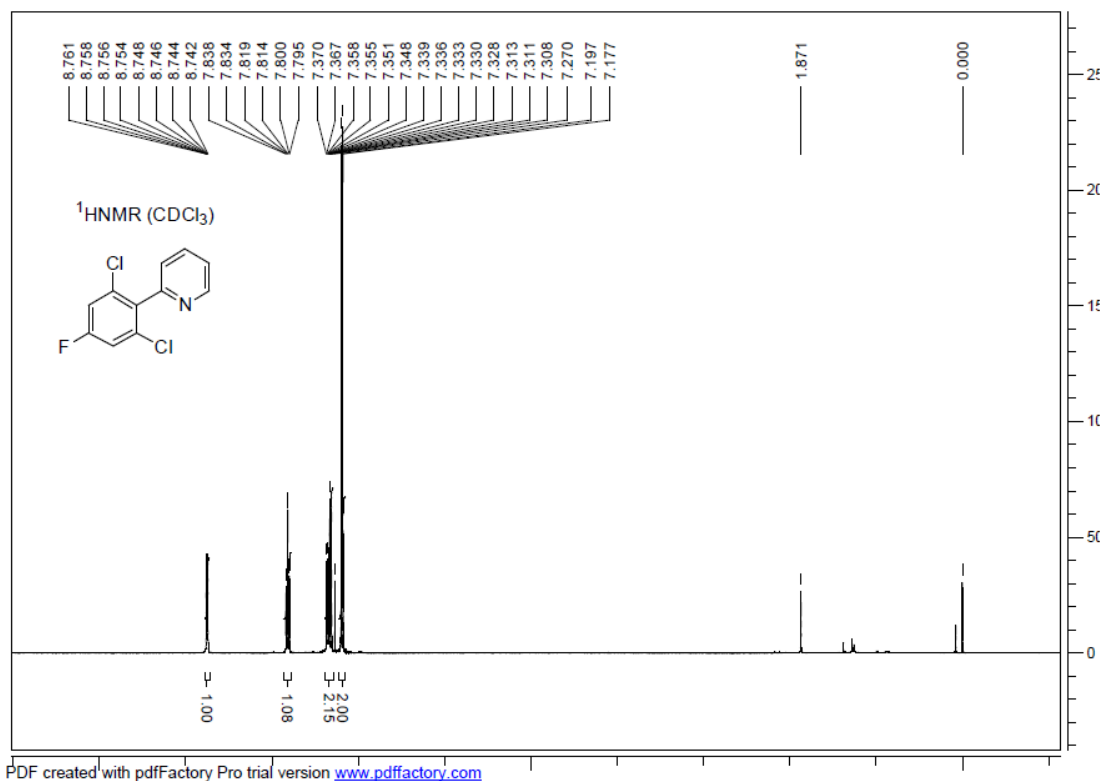




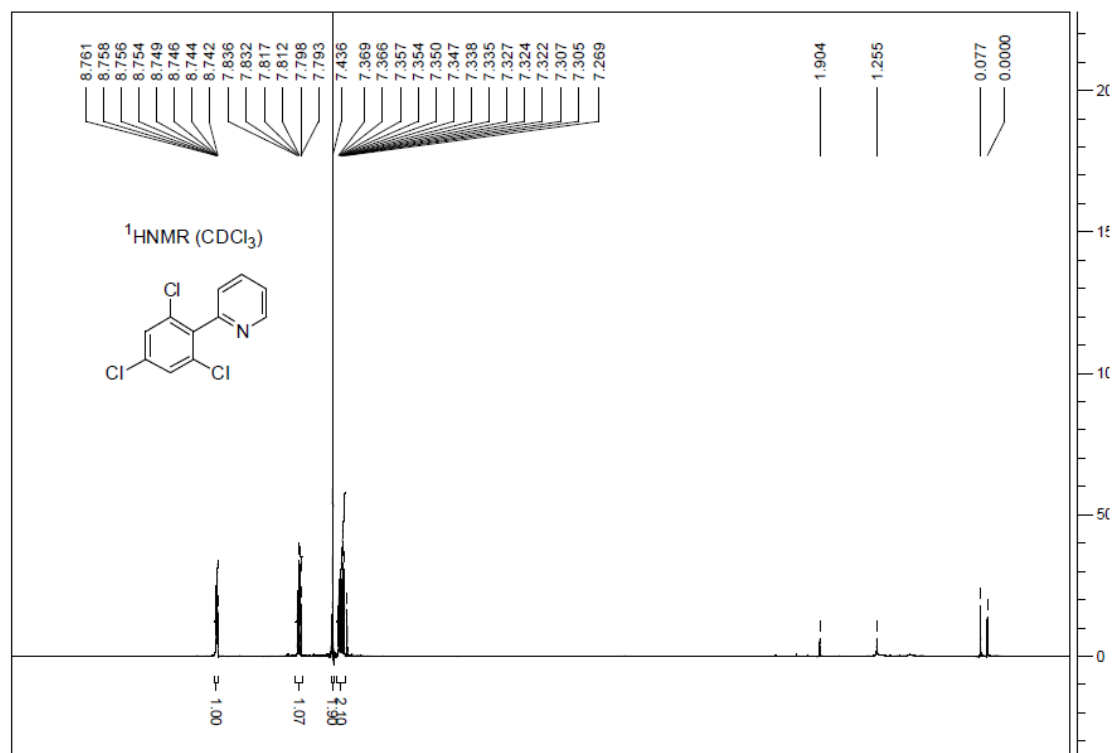
NMR spectra of compound **1t**



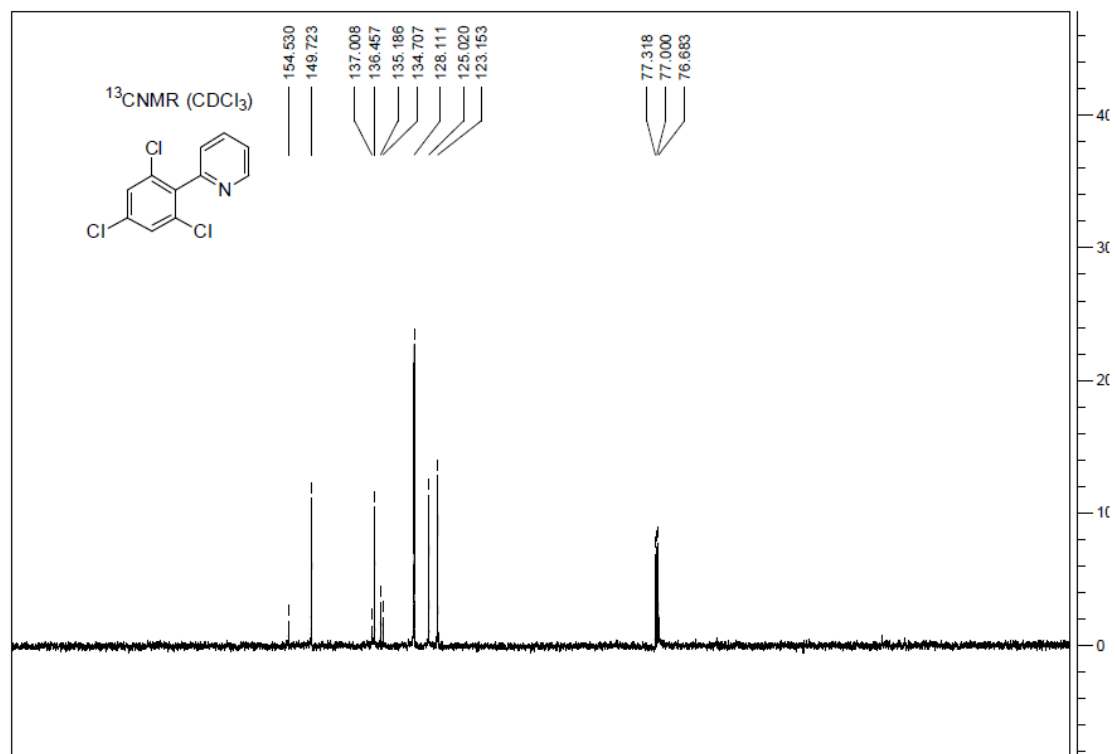
NMR spectra of compound **3b**



NMR spectra of compound **3c**

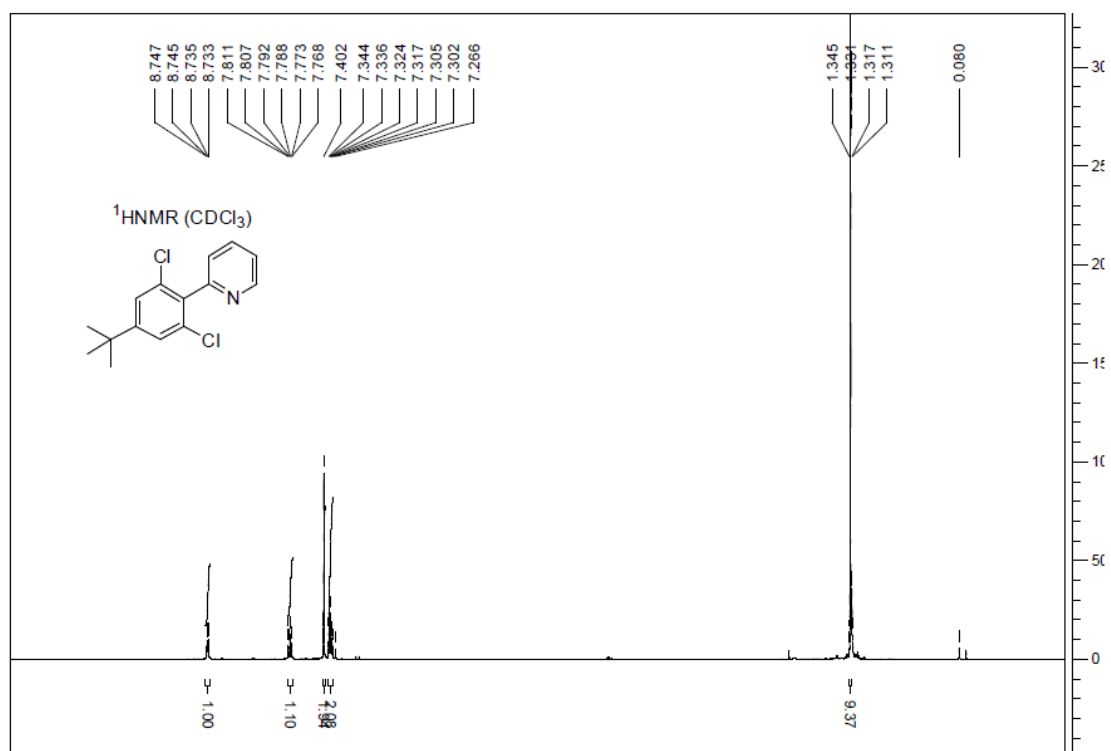


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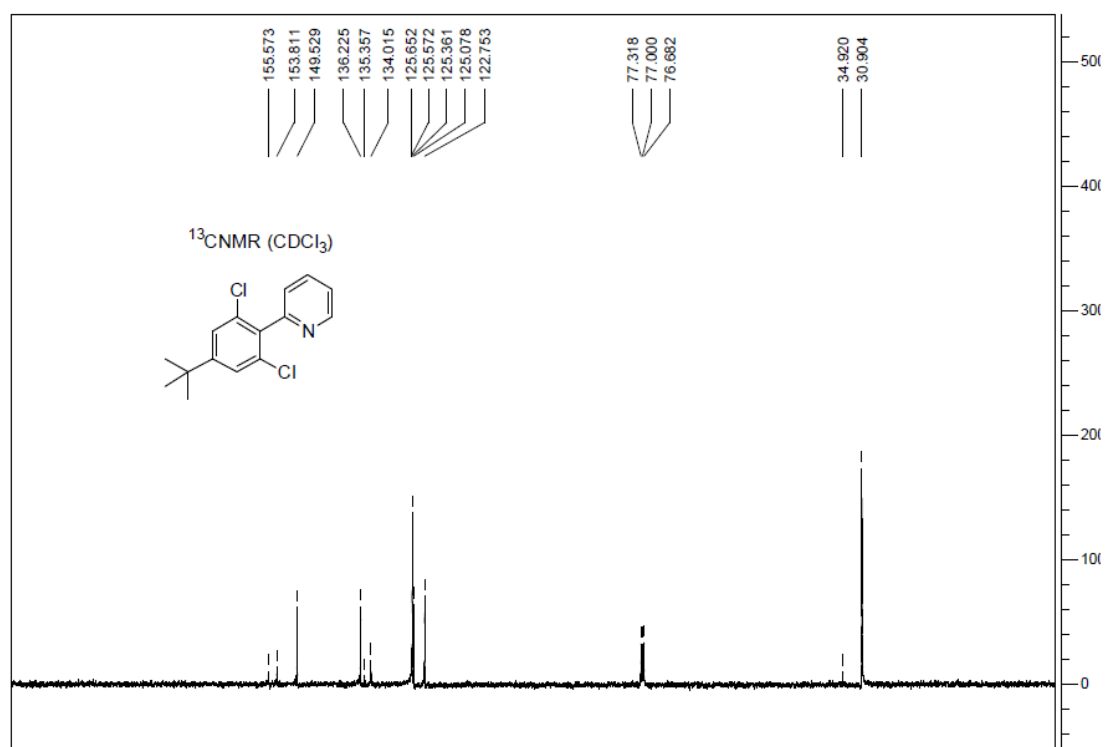


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NMR spectra of compound **2c**

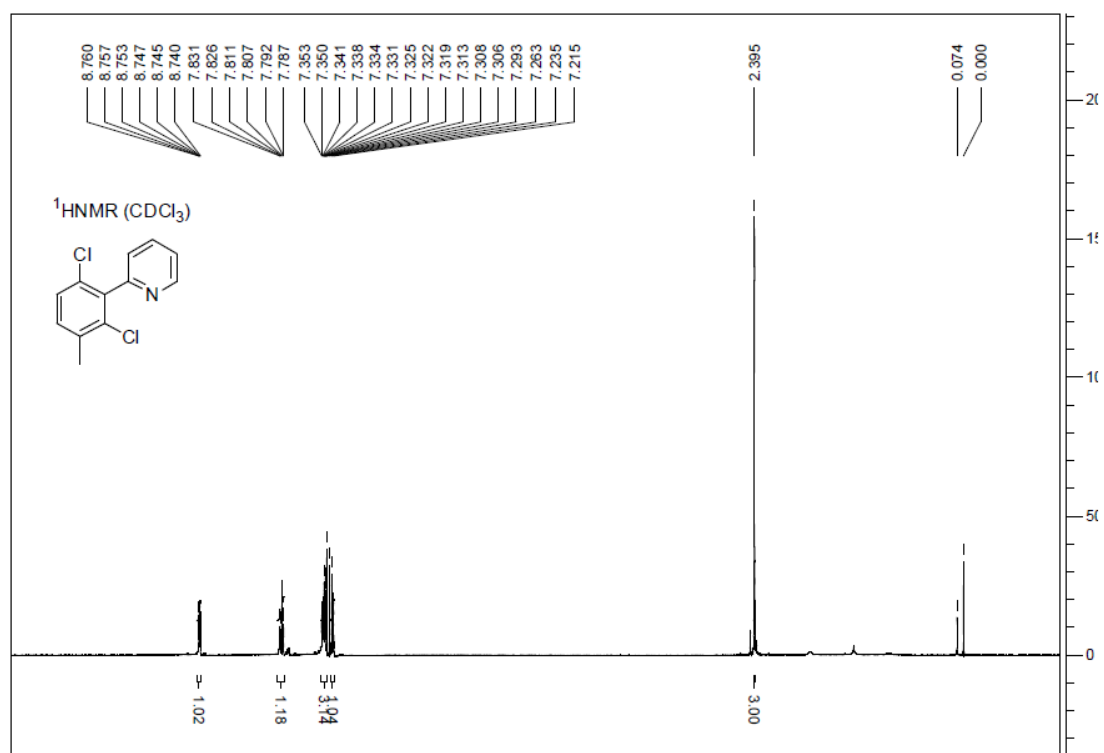


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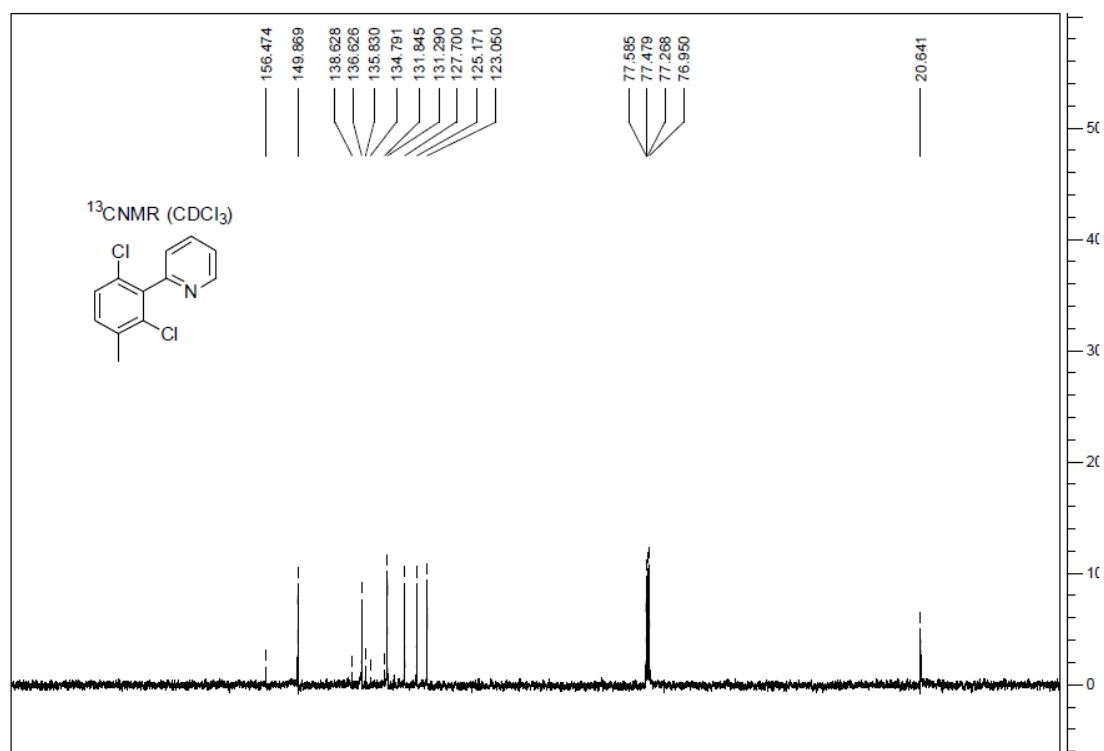


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NMR spectra of compound **3h**

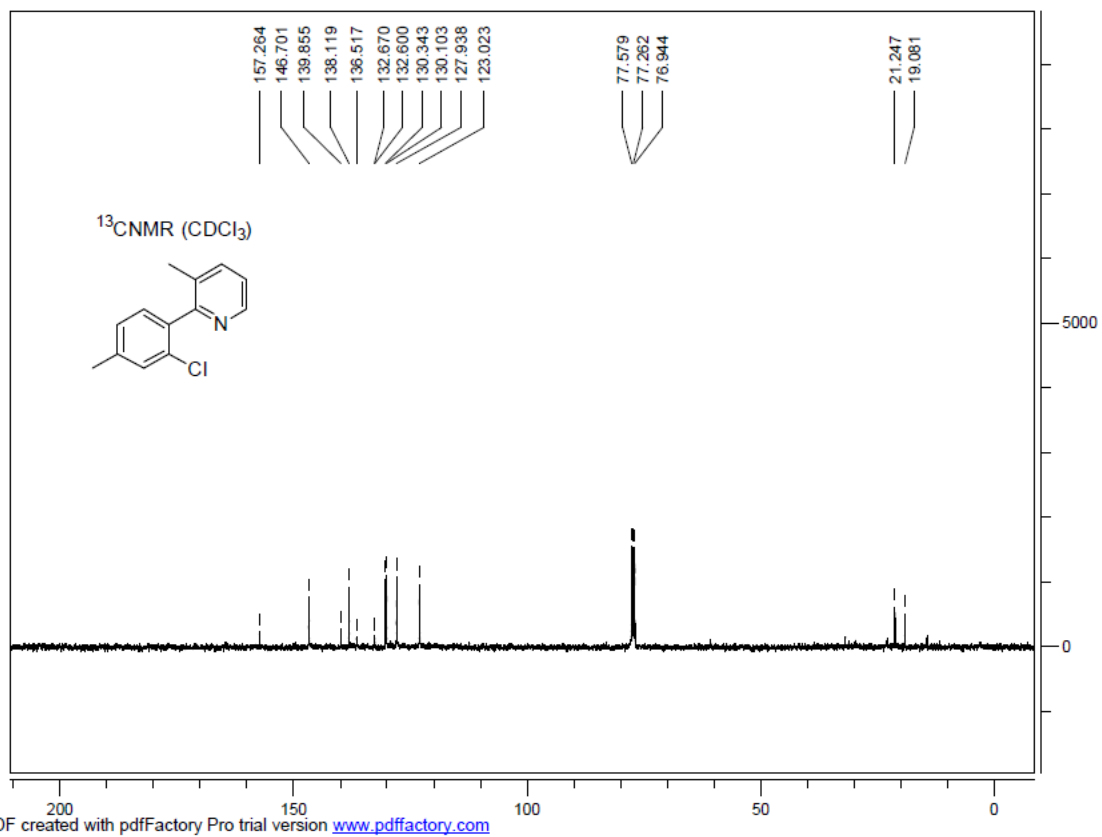
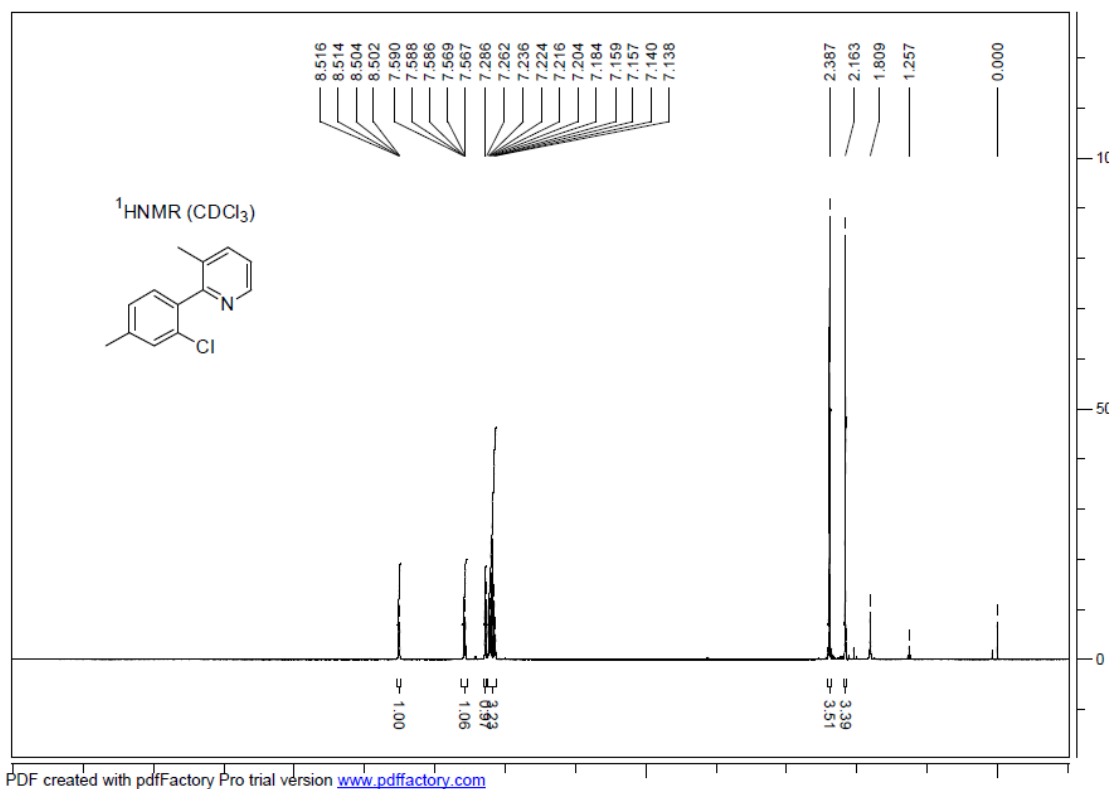


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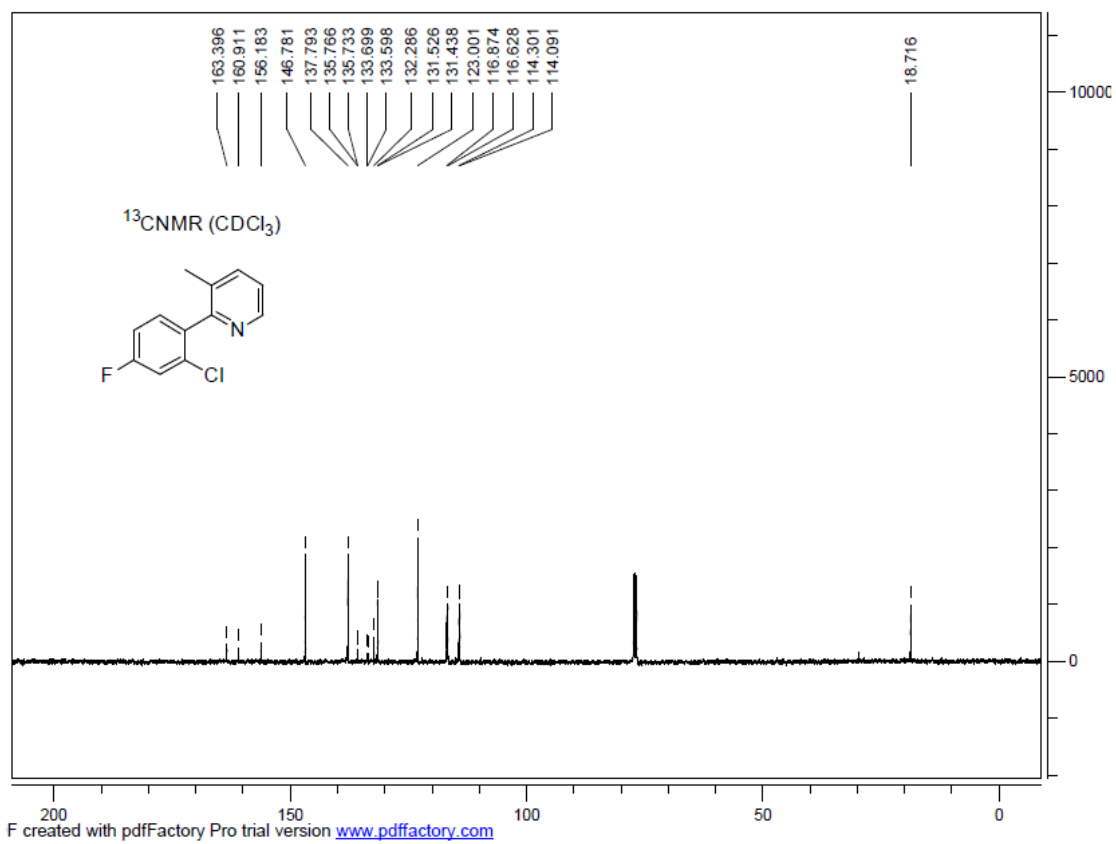
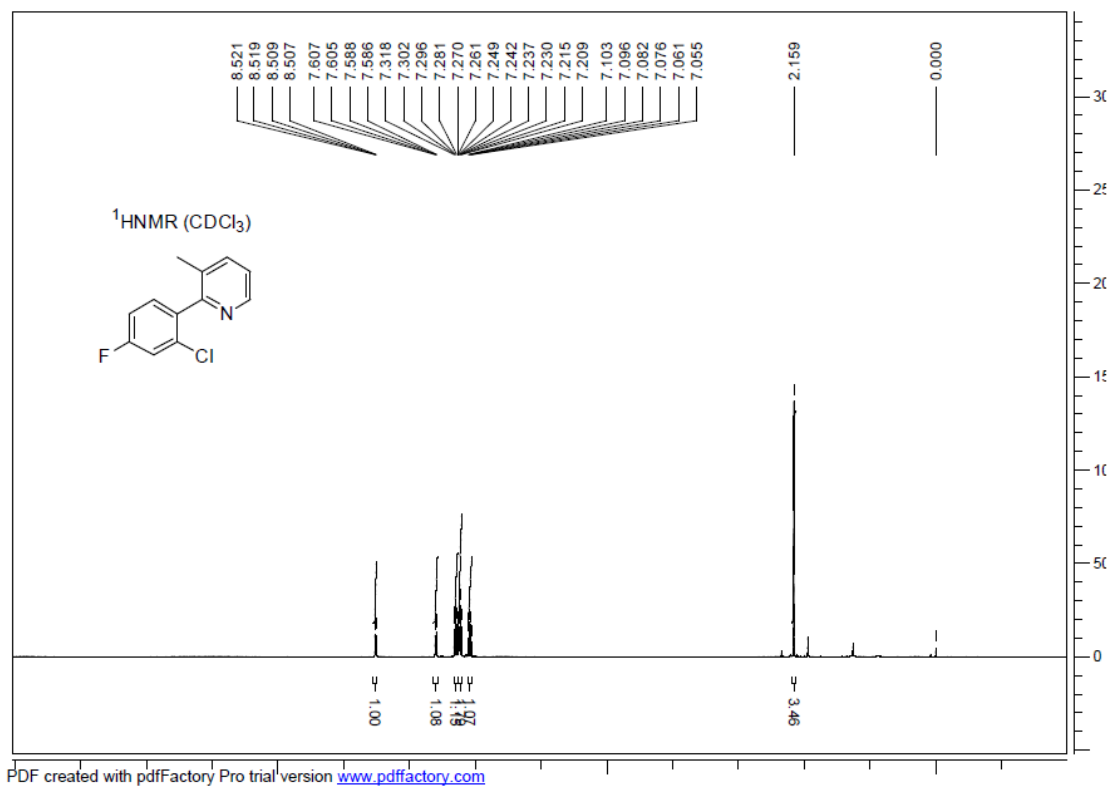


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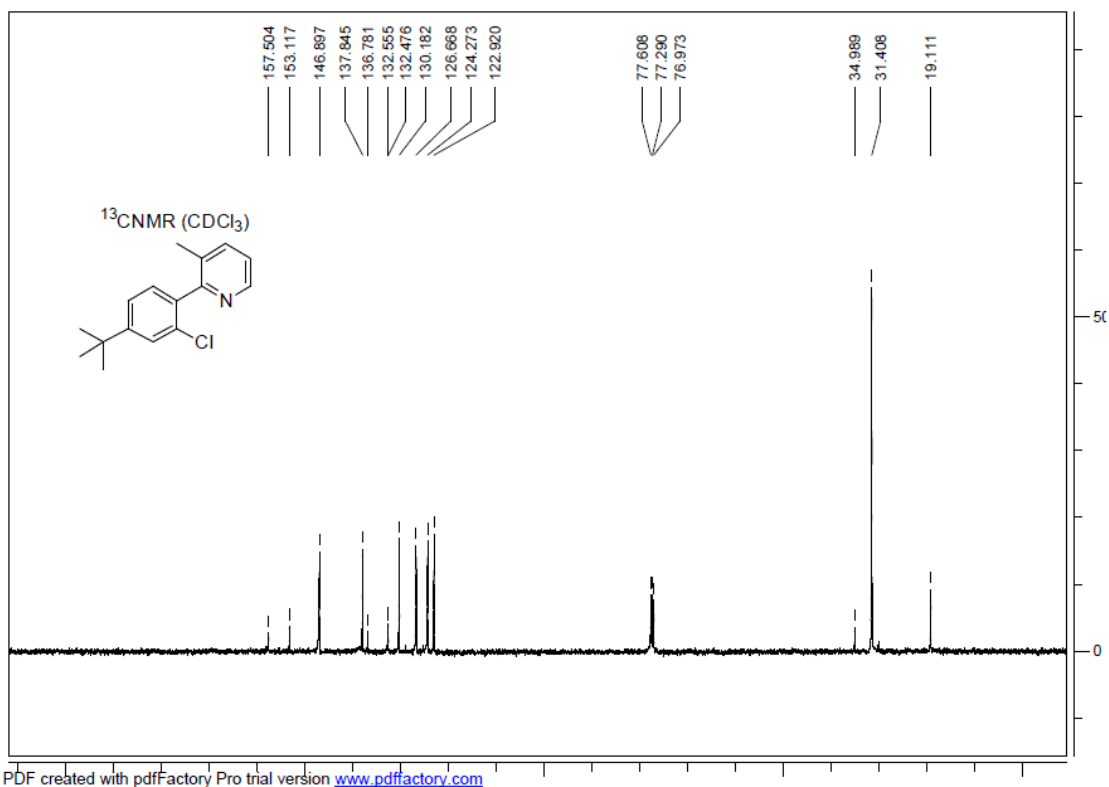
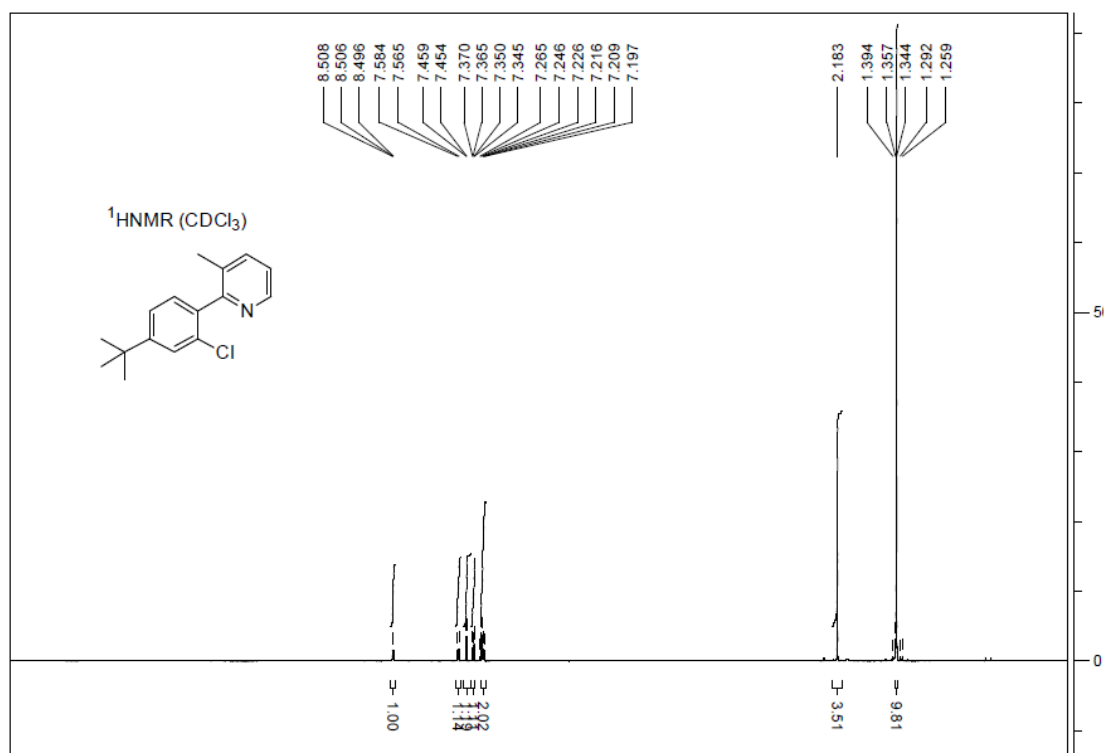
NMR spectra of compound **21**



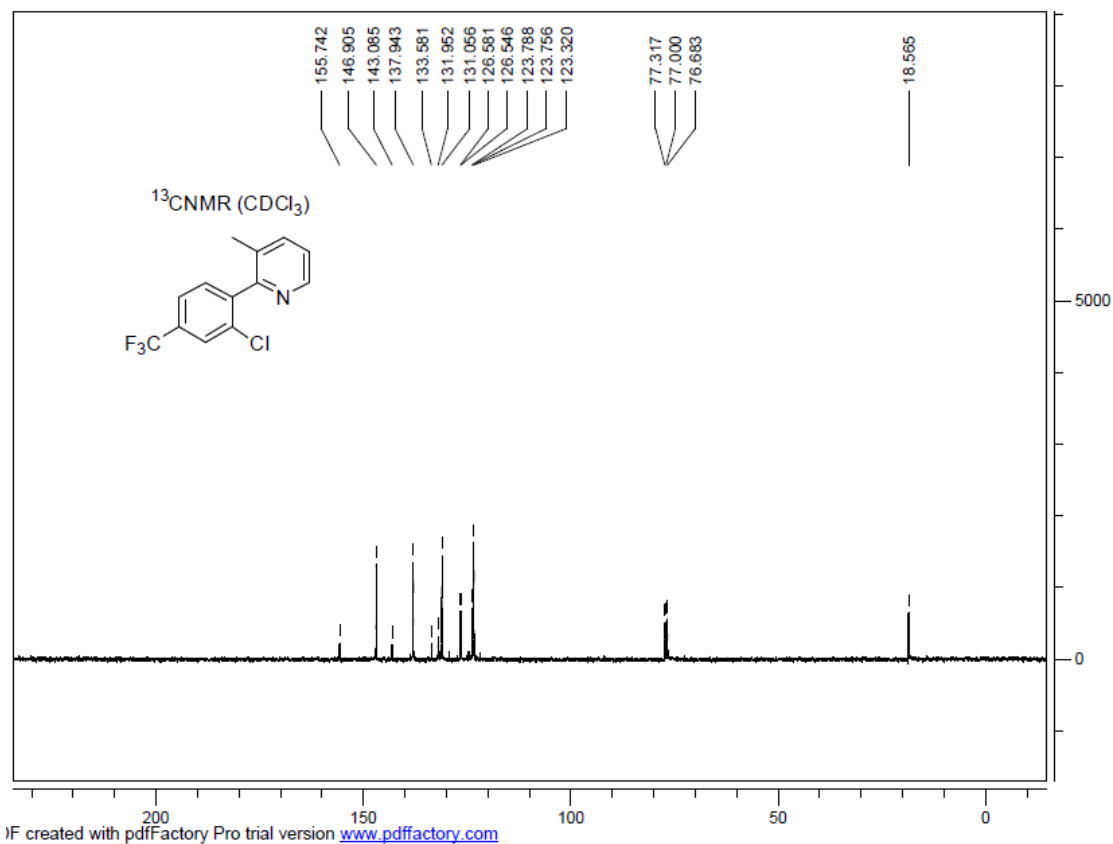
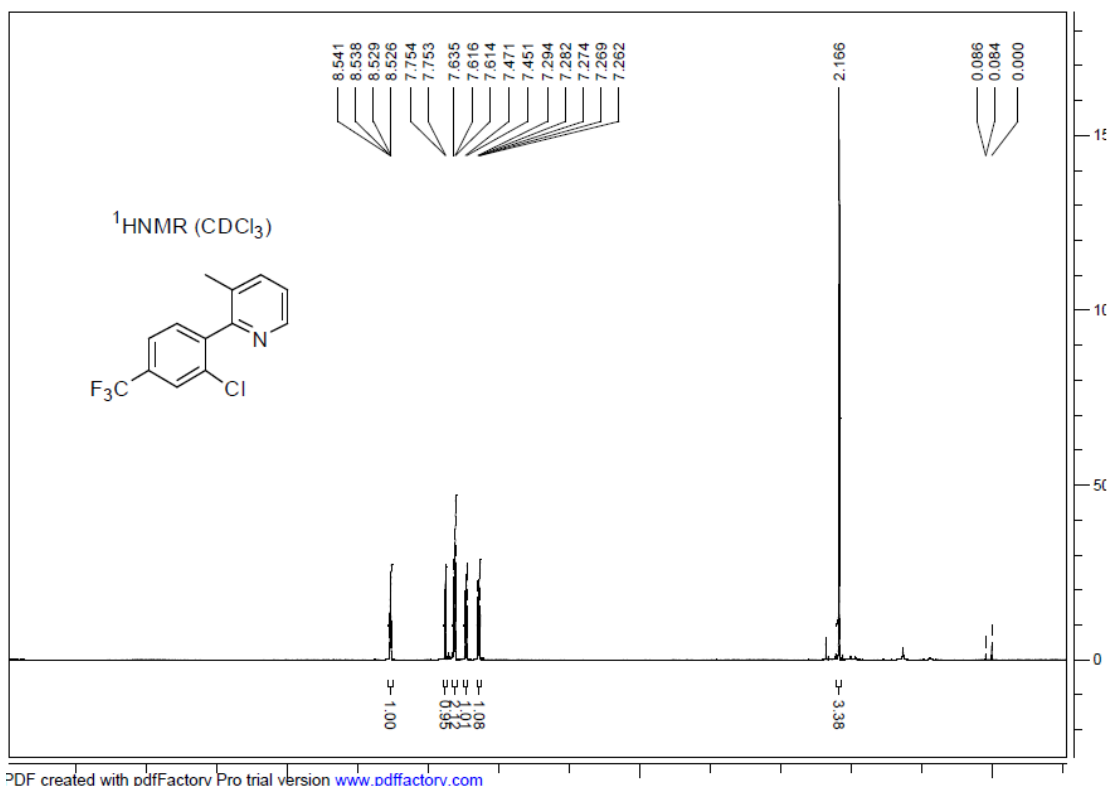
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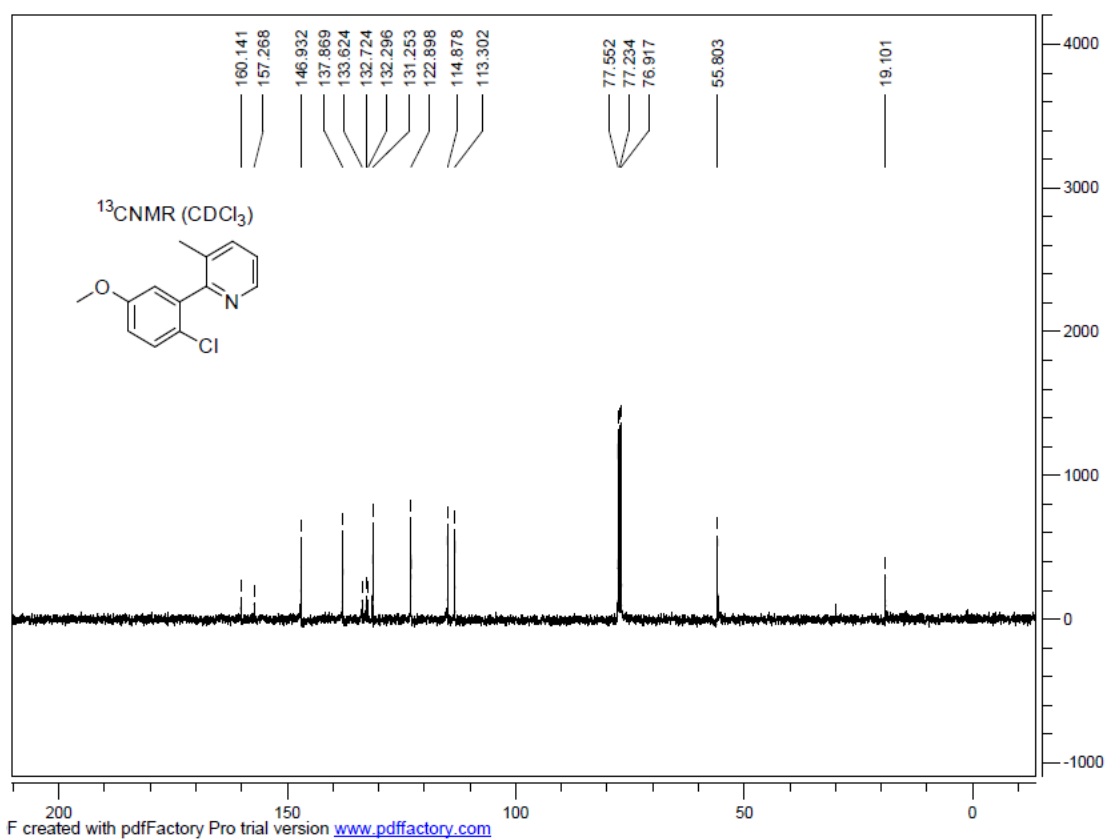
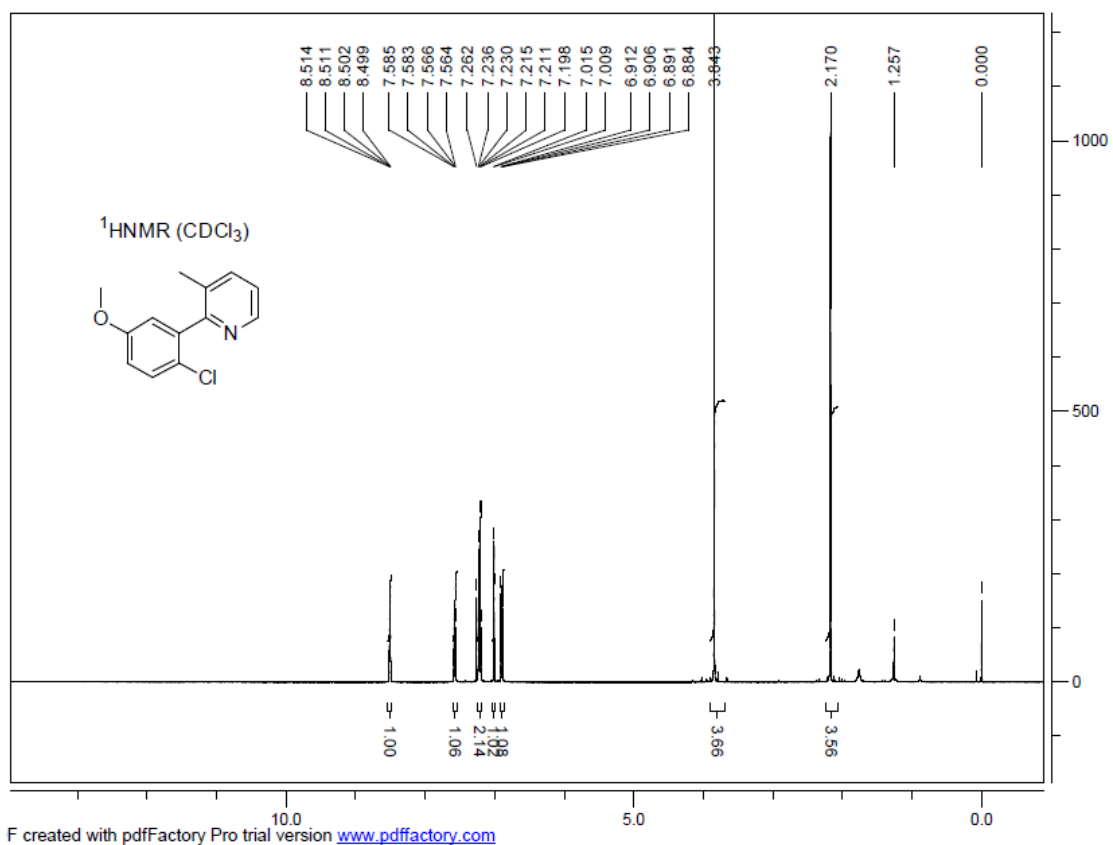
NMR spectra of compound **2n**



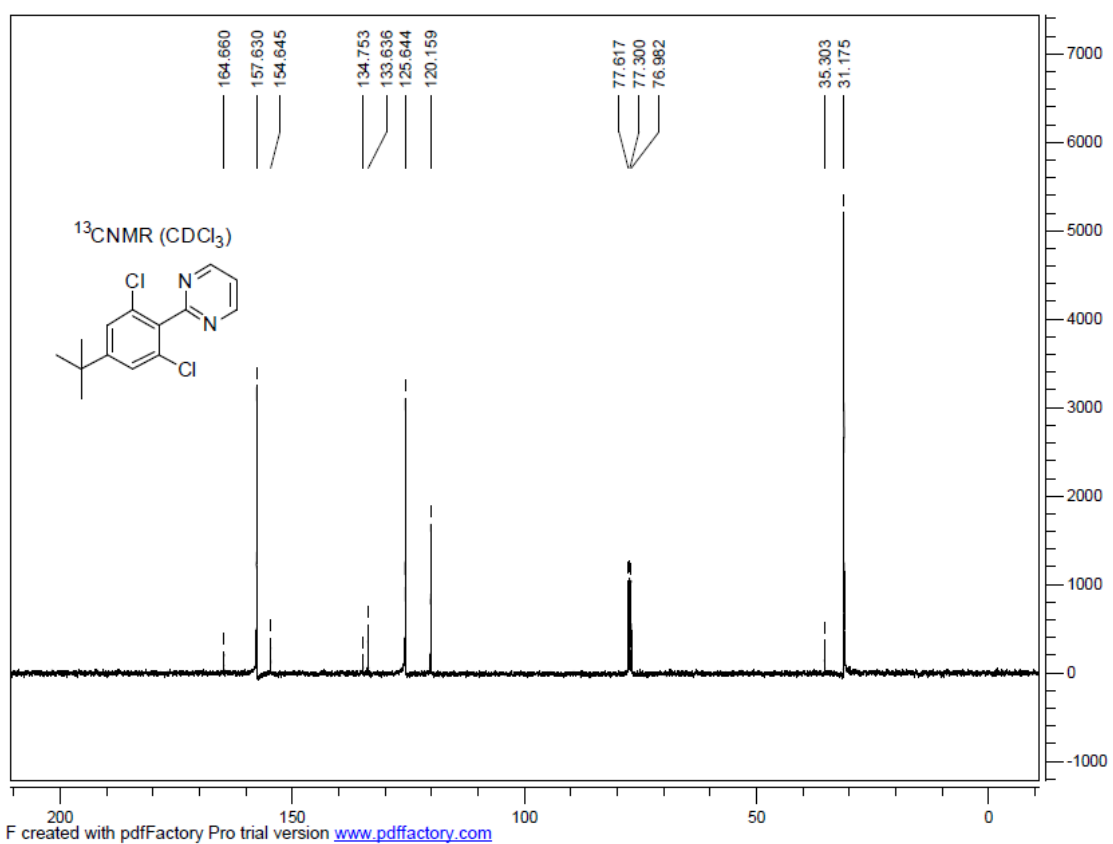
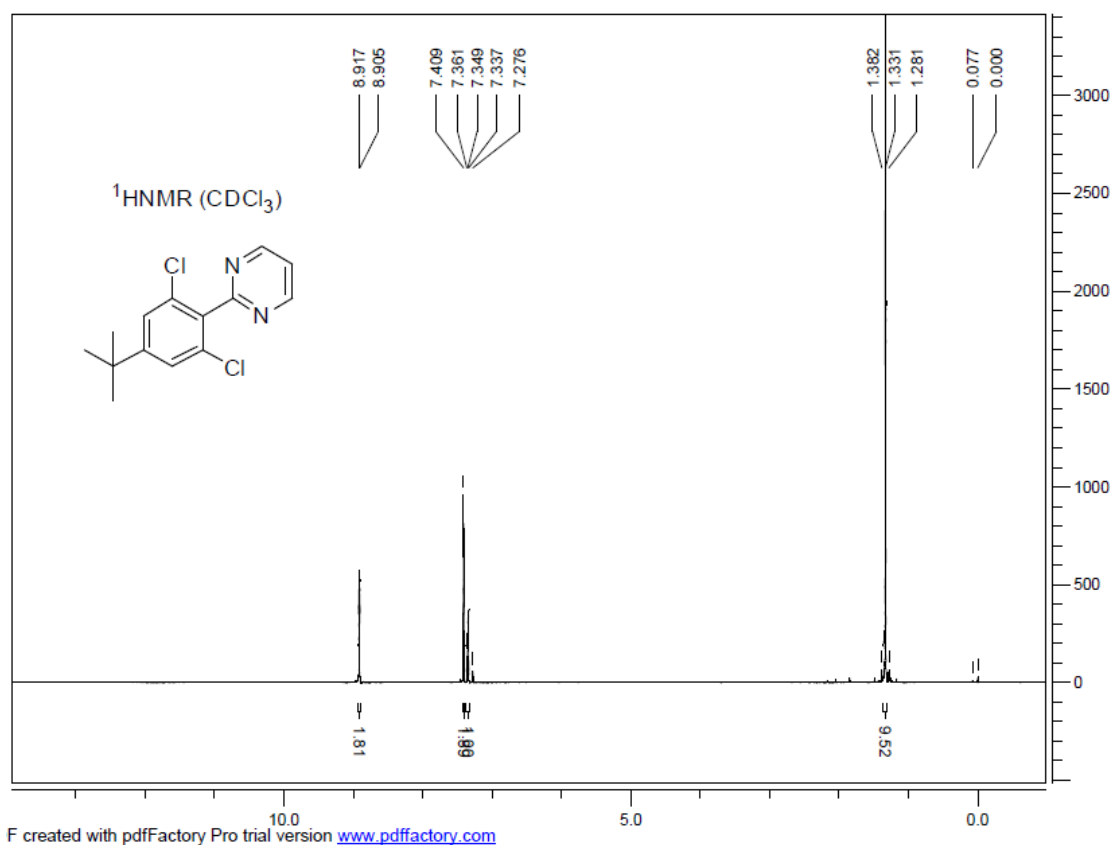
NMR spectra of compound **2o**



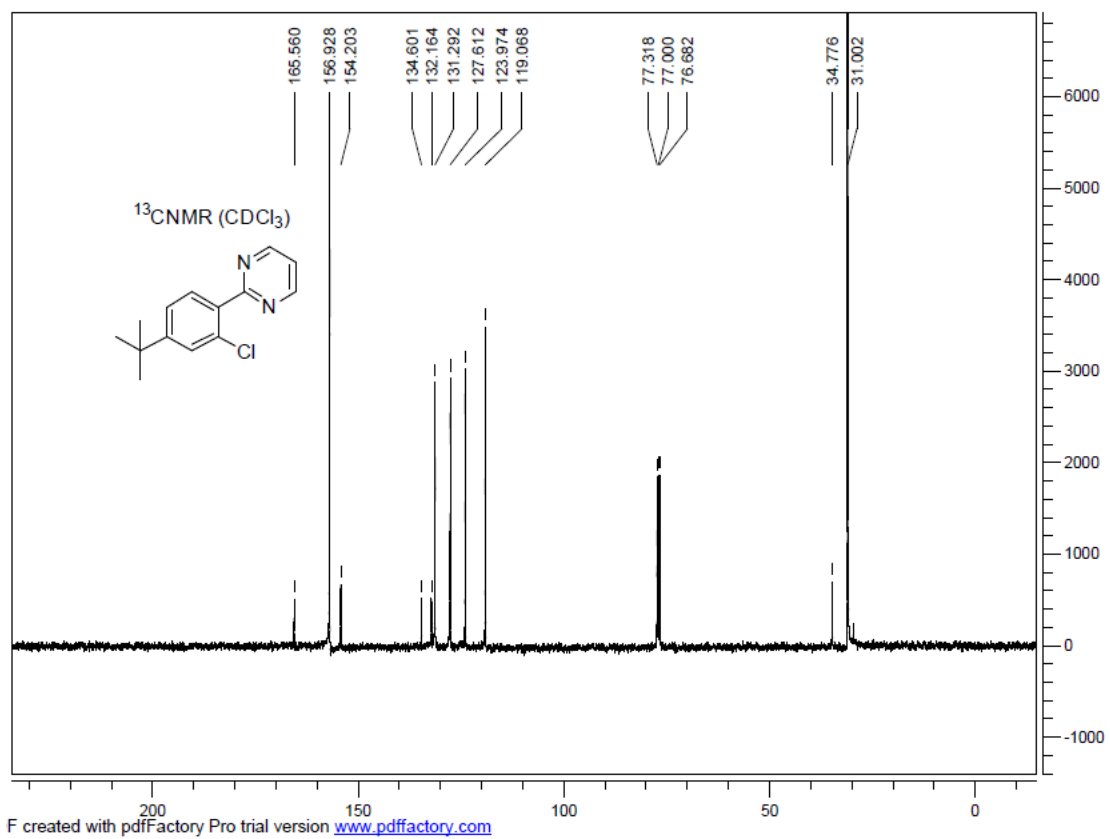
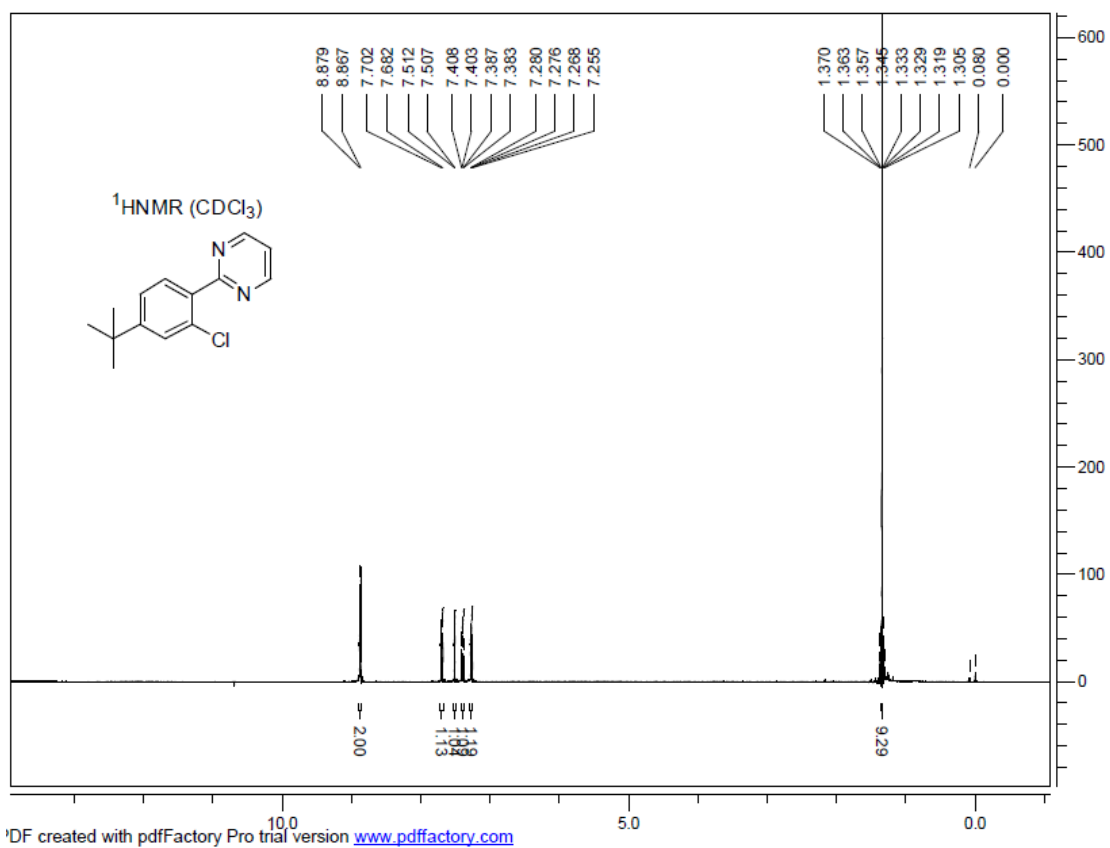
NMR spectra of compound **2q**



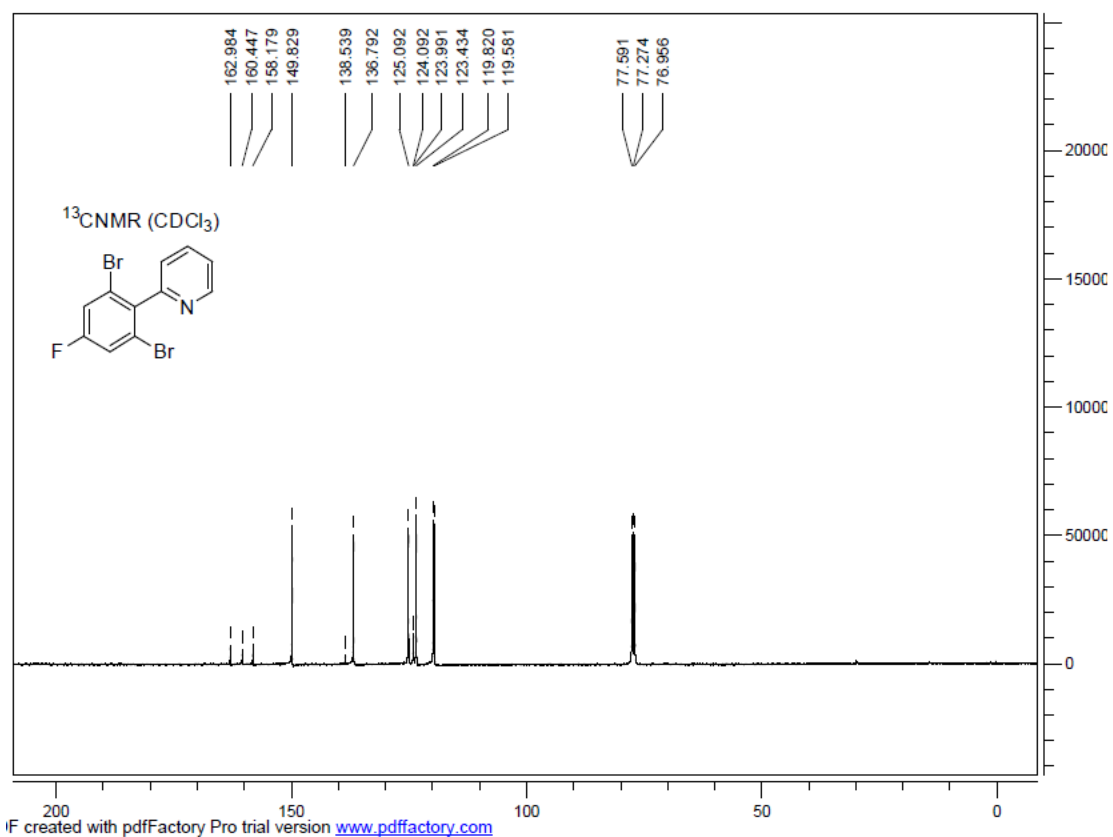
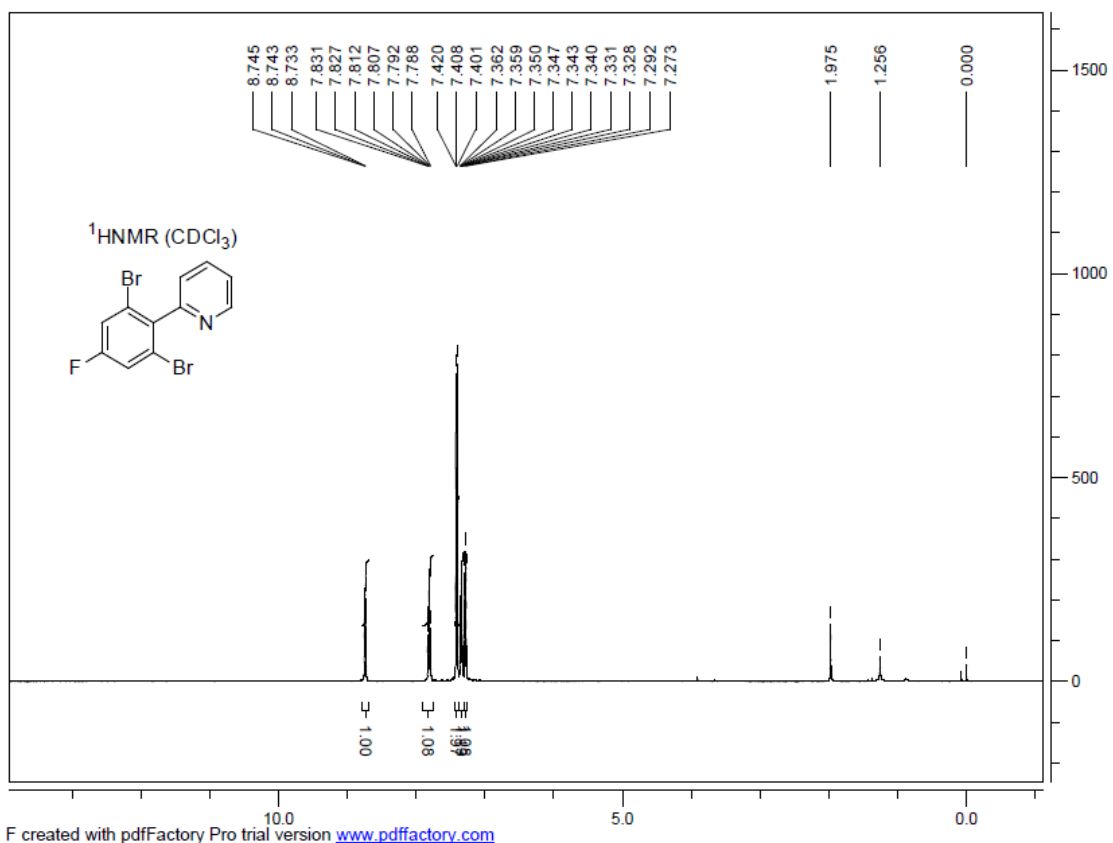
NMR spectra of compound **3t**



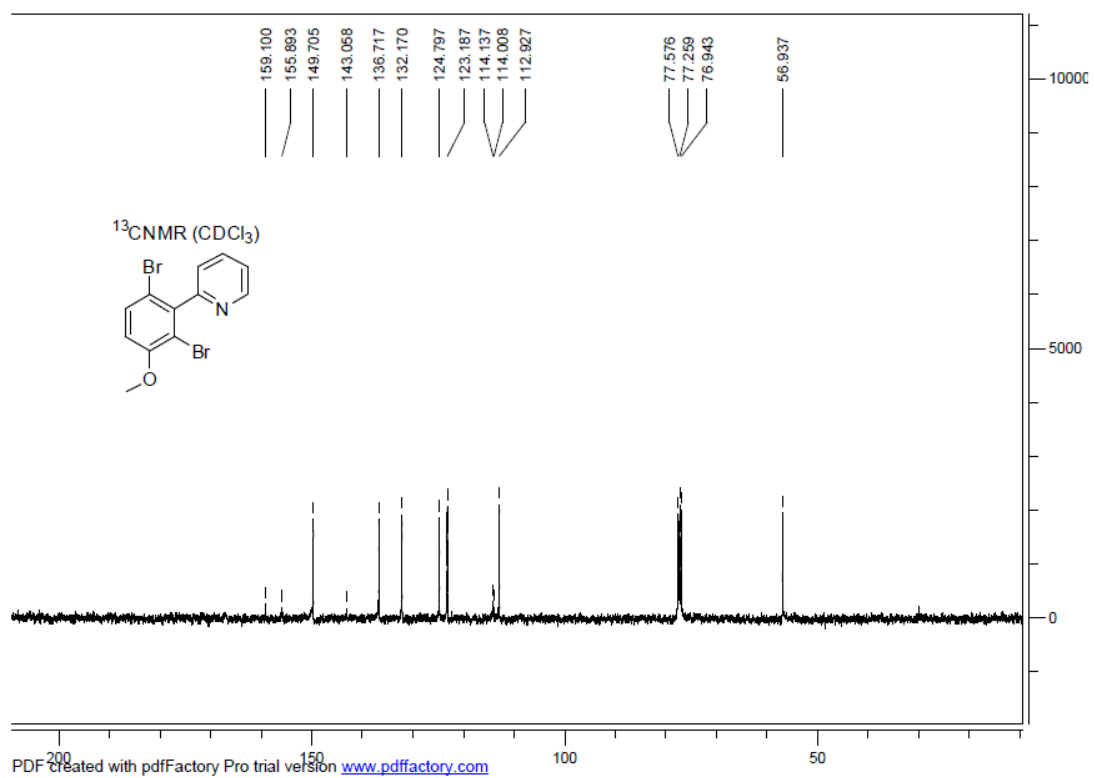
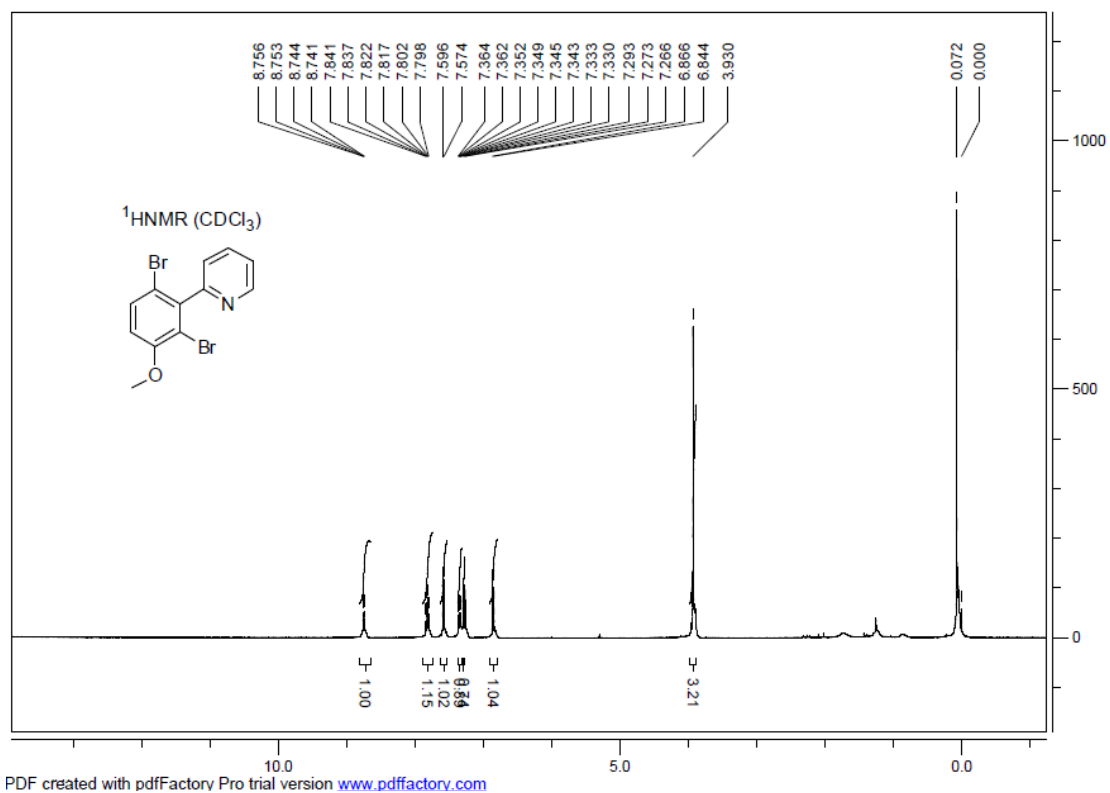
NMR spectra of compound **2u**



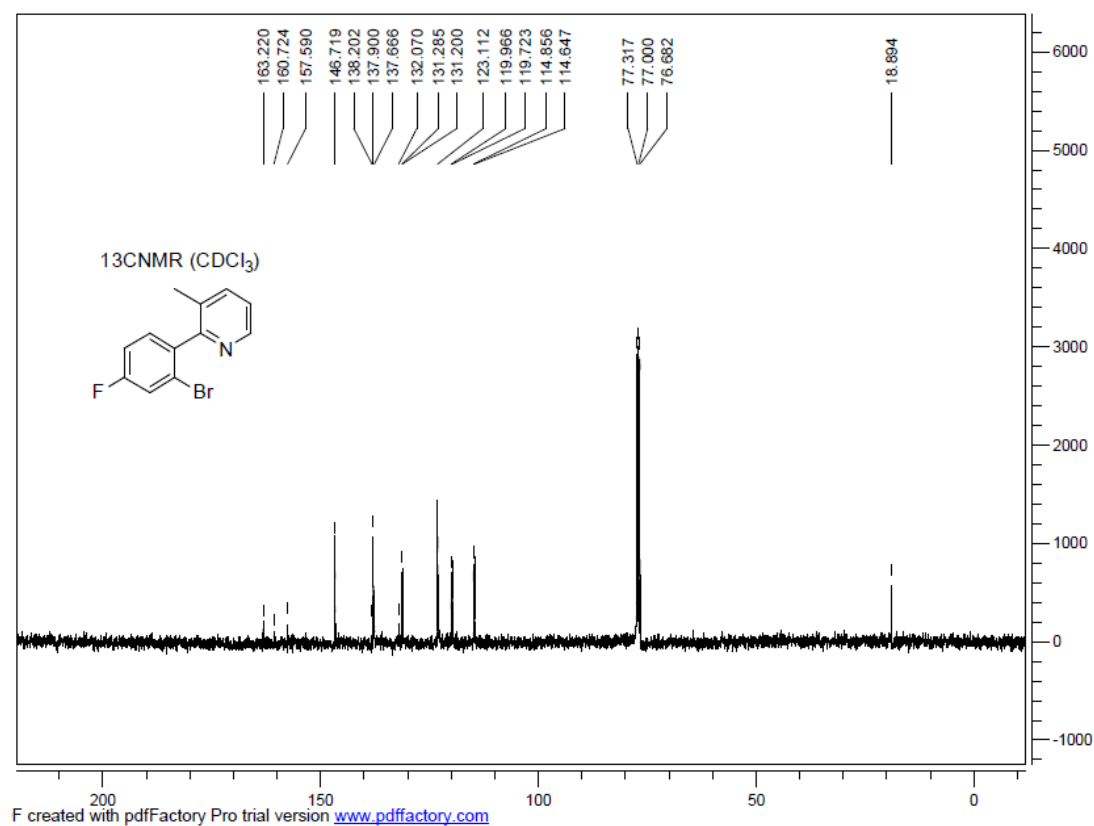
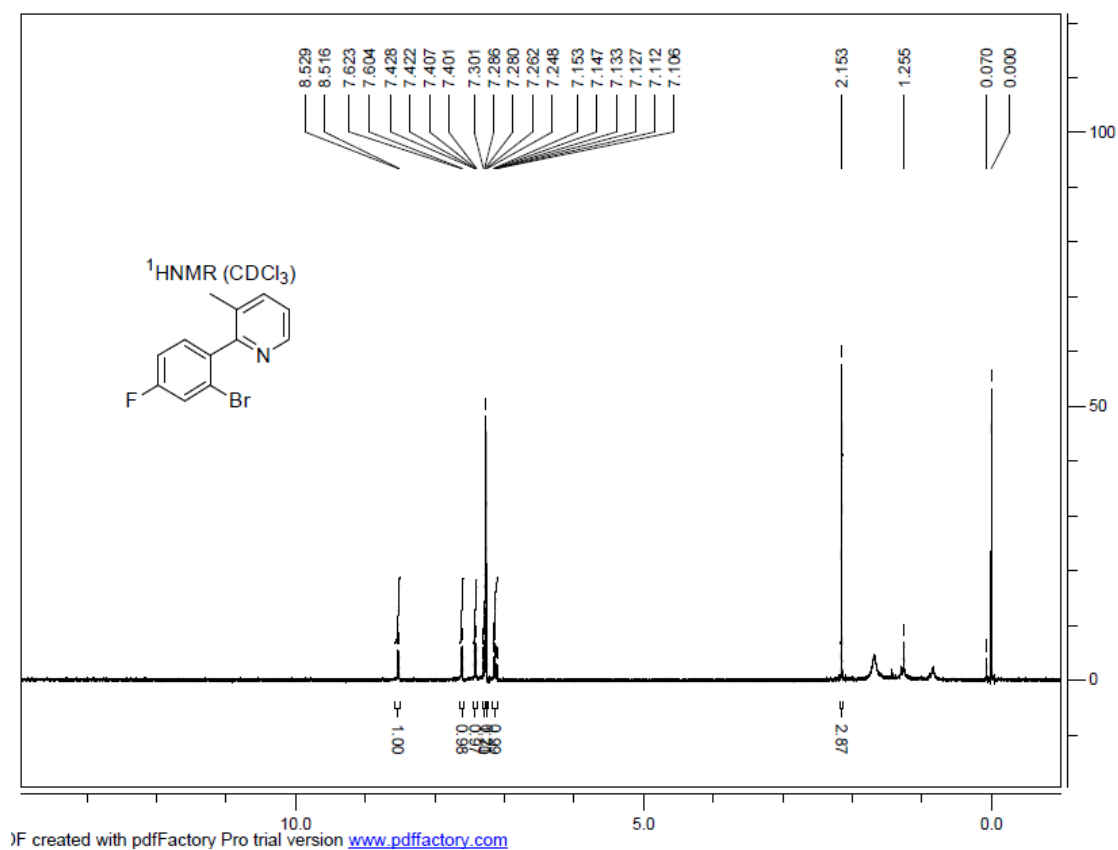
NMR spectra of compound **5b**



NMR spectra of compound **4b**



NMR spectra of compound **4m**



NMR spectra of compound **4o**

