Organocatalyzed Oxidative *N*-Annulation for Diverse and Polyfunctionalized Pyridines

Hari Datta Khanal and Yong Rok Lee*

School of Chemical Engineering, Yeungnam University, Gyeongsan 712-749, Korea

yrlee@yu.ac.kr
Phone: 82-53-810-2529. Fax: 82-53-810-4631

Supplementary Information

Contents

General Remarks

All the experiments were carried out under nitrogen atmosphere. Merck precoated silica gel plates (Art. 5554) with fluorescent indicator were used for analytical TLC. Flash column chromatography was performed using silica gel 9385 (Merck). Melting points are uncorrected and were determined on Fisher-Johns Melting Point Apparatus. ^{1}H NMR and ^{13}C NMR spectra were recorded on a Varian VNS or DPX (600 or 300 and 150 or 75 MHz, respectively) spectrometer in $CDCl_3$ using δ = 7.24 and 77.00 ppm as solvent chemical shift. Chemical shifts (δ) are expressed in units of ppm and J values are given in Hz. Multiplicities are abbreviated as follows; s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet and dd = doublet of doublets. IR spectra were recorded on a FTIR (BIO-RAD) and high-resolution mass spectra were obtained with a JEOL JMS-700 spectrometer at the Korea Basic Science Institute.

General experimental procedure for the synthesis of substituted pyridines and characterization data for synthesized compounds (4, 5, 6, 7 and 8)

To a solution of ketones **1** (1 mmol), enals **2** (1 mmol) and ammonium acetate **3** (1.1 mmol) in toluene (5 mL), L-proline (40 mol%) was added. Unless otherwise mentioned, the reaction mixture was stirred at room temperature for 10 h-20 h until completion of reaction as indicated by TLC. The volatiles were removed *in vacuo* and the residue was purified by silica gel column chromatography (hexane: ethyl acetate = 10:1) to give desired products.

2-Benzyl-3,4-diphenylpyridine (4a): Prepared from 1,3-diphenylpropan-2-one **1a** (210 mg, 1 mmol), cinnamaldehyde **2a** (132 mg, 1 mmol) and ammonium acetate **3** (85 mg, 1.1 mmol) according to general procedure in 12 h. The product was obtained as a liquid (225 mg, 70%). ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.62 (1H, d, J = 5.1Hz), 7.22-7.11 (10H, m), 7.05-7.02 (2H, m), 7.0-6.94 (4H, m), 4.09 (2H, s); ^{13}C NMR (75 MHz, $CDCl_3$) δ 158.8, 149.4, 148.1, 139.9, 139.2, 137.6, 135.5, 130.4, 129.1, 128.8, 128.0, 127.8, 127.7, 127.2, 127.0, 125.8, 122.5, 42.1; IR (neat) 3045, 2928, 1573, 1445, 1264, 1077, 847, 747, 702, 570 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{24}H_{19}N$: 321.1517. Found: 321.1514.

2-Benzyl-4-(2-methoxyphenyl)-3-phenylpyridine (4b): Prepared from 1,3-diphenylpropan-2-one **1a** (210 mg, 1 mmol), 2-methoxycinnamaldehyde **2b** (162 mg, 1 mmol) and ammonium acetate **3** (85 mg, 1.1 mmol) according to general procedure in 12 h. The product was obtained as a solid (256 mg, 73%); mp 110-112 ^{o}C. ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.6 (1H, d, J = 5.1 Hz), 7.19-7.08 (8H, m), 7.02-6.95 (5H, m), 6.79 (1H, t, J = 7.5 Hz), 6.63 (1H, d, J = 8.1 Hz), 4.09 (2H, s), 3.48 (3H, s); ^{13}C NMR (75 MHz, $CDCl_3$) δ 158.0, 155.5, 147.7, 147.3, 139.9, 137.8, 136.8, 130.5, 129.9, 129.0, 128.8, 128.3, 127.9, 127.1, 126.7, 125.7, 123.2, 119.8, 110.1, 54.7, 41.9; IR (KBr) 3464, 2975, 2347, 1734, 1589, 1462, 1300, 1247, 1044, 755, 704, 614 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{25}H_{21}NO$: 351.1623. Found: 351.1620.

2-Benzyl-4-(4-methoxyphenyl)-3-phenylpyridine (4c): Prepared from 1,3-diphenylpropan-2-one **1a** (210 mg, 1 mmol), 4-methoxycinnamaldehyde **2c** (162 mg, 1 mmol) and ammonium acetate **3** (85 mg, 1.1 mmol)

according to general procedure in 12 h. The product was obtained as a liquid (253 mg, 72%). ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.58 (1H, d, J = 5.4 Hz), 7.21-7.11 (7H, m), 6.97-6.94 (6H, m), 6.67 (2H, d, J = 9.0 Hz), 4.06 (2H, s), 3.7 (3H, s); ^{13}C NMR (75 MHz, $CDCl_3$) δ 158.8, 158.7, 149.0, 148.1, 139.9, 137.9, 135.4, 131.5, 130.5, 130.4, 128.8, 128.0, 127.9, 126.9, 125.7, 122.6, 113.2, 55.0, 42.1; IR (neat) 3040, 2944, 1599, 1513, 1448, 1255, 1178, 1030, 825, 739, 568 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{25}H_{21}NO$: 351.1623. Found: 351.1620.

4-(2-Benzyl-3-phenylpyridin-4-yl)-N,N-dimethyl aniline (4d): Prepared from 1,3-diphenylpropan-2-one **1a** (210 mg, 1 mmol), 4-dimethylaminocinnamaldehyde **2d** (175 mg, 1 mmol) and ammonium acetate **3** (85 mg, 1.1 mmol) according to general procedure in 12 h. The product was obtained as a solid (277 mg, 76%); mp 78-80 ^{o}C. ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.47 (1H, d, J = 5.1 Hz), 7.14-7.11 (4H, m), 7.08-7.00 (3H, m), 6.91-6.82 (6H, m), 6.38 (2H, d, J = 9.0 Hz), 3.97 (2H, s), 2.77 (6H, s); ^{13}C NMR (75 MHz, $CDCl_3$) δ 158.5, 149.4, 149.4, 147.8, 140.0, 138.2, 135.1, 130.5, 130.2, 128.7, 127.9, 127.9, 126.8, 126.5, 125.7, 122.5, 111.4, 42.0, 40.1; IR (KBr) 3040, 2919, 1604, 1527, 1448, 1356, 1203, 815, 742, 561 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{26}H_{24}N_2$: 364.1939. Found: 364.1937.

2-Benzyl-4-(4-fluorophenyl)-3-phenylpyridine (4e): Prepared from 1,3-diphenylpropan-2-one **1a** (210 mg, 1 mmol), 4-fluorocinnamaldehyde **2e** (150 mg, 1 mmol) and ammonium acetate **3** (85 mg, 1.1 mmol) according to general procedure in 12 h. The product was obtained as a liquid (237 mg, 70%). ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.60 (1H, d, J = 4.8 Hz), 7.20-7.09 (7H, m), 7.01-6.93 (6H, m), 6.82 (2H, t, J = 8.7 Hz), 4.06 (2H, s); ^{13}C NMR (75 MHz, $CDCl_3$) δ 158.9, 148.5, 148.1, 139.7, 137.4, 135.5, 135.1, 130.9, 130.4, 128.8, 128.0, 128.0, 127.2, 125.8, 122.5, 114.9, 114.6, 42.1; IR (neat) 3050, 2932, 1598, 1510, 1447, 1405, 1230, 831, 703, 561 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{24}H_{18}FN$: 339.1423. Found: 339.1420.

2-Benzyl-4-(4-nitrophenyl)-3-phenylpyridine (4f): Prepared from 1,3-diphenylpropan-2-one **1a** (210 mg, 1 mmol), 4-nitrocinnamaldehyde **2f** (177 mg, 1 mmol) and ammonium acetate **3** (85 mg, 1.1 mmol) according to general procedure in 14 h. The product was obtained as a liquid (238 mg, 65%). ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.59 (1H, d, J = 5.1 Hz), 7.92 (2H, d, J = 8.7 Hz), 7.17-7.03 (9H, m), 6.89-6.83 (4H, m), 4.01 (2H, s); ^{13}C NMR (75 MHz, $CDCl_3$) δ 159.3, 148.3, 147.1, 145.8, 139.3, 136.6, 135.2, 130.2, 130.0, 129.4, 128.7, 128.1, 128.0, 127.5, 125.9, 122.9, 121.9, 42.0; IR (neat) 3051, 2929, 1723, 1520, 1346, 1105, 848, 740, 567 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{24}H_{18}N_2O_2$: 366.1368. Found: 366.1365.

2-(4-Methoxybenzyl)-4-(2-methoxyphenyl)-3-(4-methoxyphenyl)pyridine (4g): Prepared from 1,3-bis(4-methoxyphenyl)propan-2-one **1b** (270 mg, 1 mmol), 2-methoxycinnamaldehyde **2b** (162 mg, 1 mmol) and ammonium acetate **3** (85 mg, 1.1 mmol) according to general procedure in 20 h. The product was obtained as a solid (300 mg, 73%); mp 48-50 ^{o}C. ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.57 (1H, d, J = 5.1 Hz), 7.16-7.10 (2H, m), 6.97-6.94 (3H, m), 6.85-6.77 (3H, m), 6.74-6.62 (5H, m), 4.03 (2H, s), 3.71 (6H, s), 3.48 (3H, s); ^{13}C NMR (150 MHz, $CDCl_3$) δ 158.6, 158.1, 157.6, 155.4, 147.4, 147.4, 136.2, 132.1, 130.9, 130.4, 130.1, 129.6, 128.8, 128.4, 123.0, 119.8, 113.3, 112.5, 110.1, 54.9, 54.8, 54.7, 41.0; IR (KBr) 3038, 2939, 2840, 2346, 1676, 1601, 1509, 1249, 1176, 1033, 824, 749, 570 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{27}H_{25}NO_3$: 411.1834. Found: 411.1832.

2-(4-Methoxybenzyl)-3-(4-methoxyphenyl)-4-(4-nitrophenyl)pyridine (4h): Prepared from 1,3-bis(4-methoxyphenyl)propan-2-one **1b** (270 mg, 1 mmol), 4-nitrocinnamaldehyde **2f** (177 mg, 1 mmol) and ammonium acetate **3** (85 mg, 1.1 mmol) according to general procedure in 20 h. The product was obtained as

a liquid (298 mg, 70%). ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.63 (1H, d, J = 4.8 Hz), 8.0 (2H, d, J = 8.7 Hz), 7.20-7.14 (3H, m), 6.88 (2H, d, J = 8.7 Hz), 6.81 (2H, d, J = 8.7 Hz), 6.75-6.68 (4H, m), 4.01 (2H, s), 3.76 (3H, s), 3.72 (3H, s); ^{13}C NMR (75 MHz, $CDCl_3$) δ 160.2, 158.9, 157.9, 148.1, 147.4, 146.9, 146.2, 134.8, 131.6, 131.4, 130.1, 129.7, 128.8, 123.0, 121.8, 113.7, 113.6, 55.1, 41.1; IR (neat) 2941, 2349, 1517, 1348, 1250, 1177, 1035, 837, 754 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{26}H_{22}N_2O_4$: 426.1580. Found: 426.1579.

2-(4-Chlorobenzyl)-3-(4-chlorophenyl)-4-(2-methoxyphenyl)pyridine (4i): Prepared from 1,3-bis(4-chlorophenyl)propan-2-one **1c** (279 mg, 1 mmol), 2-methoxycinnamaldehyde **2b** (162 mg, 1 mmol) and ammonium acetate **3** (85 mg, 1.1 mmol) according to general procedure in 10 h. The product was obtained as a liquid (328 mg, 78%). ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.58 (1H, d, J = 4.8 Hz), 7.19-7.08 (6H, m), 6.95-6.88 (3H, m), 6.83-6.78 (3H, m), 6.63 (1H, d, J = 8.1 Hz), 3.99 (2H, s), 3.48 (3H, s); ^{13}C NMR (75 MHz, $CDCl_3$) δ 157.3, 155.3, 148.1, 147.6, 138.1, 136.3, 135.7, 132.9, 131.7, 131.2, 130.4, 130.1, 129.4, 128.2, 127.8, 127.5, 123.4, 120.1, 110.3, 54.8, 41.4; IR (neat) 3050, 2935, 2348, 1584, 1492, 1253, 1093, 1021, 821, 748, 569 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{25}H_{19}Cl_2NO$: 419.0844. Found: 419.0840.

3-(2-Methoxyphenyl)-2-methyl-4-phenylpyridine (5a): Prepared from 1-(2-methoxyphenyl) propan-2-one **1d** (164 mg, 1 mmol), cinnamaldehyde **2a** (132 mg, 1 mmol) and ammonium acetate **3** (85 mg, 1.1 mmol) according to general procedure in 20 h. The product was obtained as a liquid (165 mg, 60%). ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.50 (1H, d, J = 5.1 Hz), 7.21-7.13 (5H, m), 7.06-7.05 (2H, m), 6.88-6.78 (3H, m), 3.6 (3H, s), 2.34 (3H, s); ^{13}C NMR (75 MHz, $CDCl_3$) δ 157.5, 156.8, 149.6, 147.4, 139.6, 131.9, 131.2, 128.9, 128.5, 127.6, 127.2, 127.1, 121.9, 120.4, 110.5, 55.1, 23.2; IR (neat) 3422, 3051, 2939, 1717, 1582, 1452, 1258, 1033, 753, 610 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{19}H_{17}NO$: 275.1310. Found: 275.1307.

3,4-Bis(2-methoxyphenyl)-2-methylpyridine (5b): Prepared from 1-(2-methoxyphenyl) propan-2-one **1d** (164 mg, 1 mmol), 2-methoxycinnamaldehyde **2b** (162 mg, 1 mmol) and ammonium acetate **3** (85 mg, 1.1 mmol) according to general procedure in 20 h. The product was obtained as a liquid (159 mg, 52%). ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.48 (1H, d, J = 5.1 Hz), 7.16-7.09 (3H, m), 6.95-6.92 (1H, m), 6.88-6.85 (1H, m), 6.77-6.71 (3H, m), 6.66 (1H, d, J = 8.1 Hz), 3.62 (3H, s), 3.53 (3H, s), 2.35 (3H, s); ^{13}C NMR (75 MHz, $CDCl_3$) δ 157.0, 156.5, 155.8, 147.4, 146.8, 133.1, 130.9, 130.3, 128.9, 128.6, 128.5, 127.2, 122.9, 119.8, 119.7, 110.1, 110.0, 54.9, 54.9, 23.0; IR (neat) 3497, 2949, 2346, 1681, 1594, 1491, 1254, 1117, 1033, 753 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{20}H_{19}NO_2$: 305.1416. Found: 305.1412.

3-(4-Methoxyphenyl)-2-methyl-4-phenylpyridine (5c): Prepared from 1-(4-methoxyphenyl) propan-2-one **1e** (164 mg, 1 mmol), cinnamaldehyde **2a** (132 mg, 1 mmol) and ammonium acetate **3** (85 mg, 1.1 mmol) according to general procedure in 18 h. The product was obtained as a liquid (209 mg, 76%). ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.48 (1H, d, J = 5.1 Hz), 7.16-7.15 (4H, m), 7.05-7.02 (2H, m), 6.93 (2H, d, J = 8.4 Hz), 6.76 (2H, d, J = 8.4 Hz), 3.75 (3H, s), 2.41 (3H, s); ^{13}C NMR (75 MHz, $CDCl_3$) δ 158.4, 157.2, 149.1, 147.3, 139.3, 134.8, 131.1, 130.2, 129.2, 127.8, 127.2, 122.3, 113.5, 55.0, 23.9; IR (neat) 3400, 3045, 2950, 2842, 1577, 1514, 1454, 1249, 1177, 1032, 833, 752, 573 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{19}H_{17}NO$: 275.1310. Found: 275.1309.

4-(2-Methoxyphenyl)-3-(4-methoxyphenyl)-2-methylpyridine (5d): Prepared from 1-(4-methoxyphenyl) propan-2-one **1e** (164 mg, 1 mmol), 2-methoxycinnamaldehyde **2b** (162 mg, 1 mmol) and ammonium acetate **3** (85 mg, 1.1 mmol) according to general procedure in 20 h. The product was obtained as a liquid (226 mg, 74%). ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.46 (1H, d, J = 5.1 Hz), 7.17-7.08 (2H, m), 6.96-6.91 (3H, m), 6.82-

6.77 (1H, m), 6.71-6.64 (3H, m), 3.71 (3H, s), 3.49 (3H, s), 2.40 (3H, s); ^{13}C NMR (75 MHz, $CDCl_3$) δ 158.1, 156.5, 155.6, 146.9, 146.9, 136.1, 130.7, 130.6, 130.5, 128.9, 128.5, 122.9, 119.9, 112.8, 110.3, 55.0, 54.9, 23.7; IR (neat) 3043, 2946, 2840, 1600, 1506, 1459, 1249, 1176, 1032, 832, 751, 571 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{20}H_{19}NO_2$: 305.1416. Found: 305.1412.

3,4-Bis(4-methoxyphenyl)-2-methylpyridine (5e): Prepared from 1-(4-methoxyphenyl) propan-2-one **1e** (164 mg, 1 mmol), 4-methoxycinnamaldehyde **2c** (162 mg, 1 mmol) and ammonium acetate **3** (85 mg, 1.1 mmol) according to general procedure in 20 h. The product was obtained as a liquid (220 mg, 72%). ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.45 (1H, d, J = 5.1 Hz), 7.15 (1H, d, J = 5.1 Hz), 6.97-6.92 (4H, m), 6.79 (2H, d, J = 8.4 Hz), 6.69 (2H, d, J = 8.4 Hz), 3.76 (3H, s), 3.70 (3H, s), 2.39 (3H, s); ^{13}C NMR (75 MHz, $CDCl_3$) δ 158.8, 158.4, 157.0, 148.9, 147.0, 134.9, 131.5, 131.2, 130.4, 122.3, 113.6, 113.3, 113.3, 55.1, 23.7; IR (neat) 2938, 2844, 2347, 1605, 1514, 1458, 1251, 1177, 1032, 826, 569 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{20}H_{19}NO_2$: 305.1416. Found: 305.1413.

4-(3-(4-Methoxyphenyl)-2-methylpyridin-4-yl)-N,N-dimethylaniline (5f): Prepared from 1-(4-methoxyphenyl)propan-2-one **1e** (164 mg, 1 mmol), 4-dimethylaminocinnamaldehyde **2d** (175 mg, 1 mmol) and ammonium acetate **3** (85 mg, 1.1 mmol) according to general procedure in 18 h. The product was obtained as a solid (248 mg, 78%); mp 138-140 ^{o}C. ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.42 (1H, d, J = 5.1 Hz), 7.16 (1H, d, J = 5.1 Hz), 6.98 (2H, d, J = 9.0 Hz), 6.92 (2H, d, J = 9.0 Hz), 6.81 (2H, d, J = 9.0 Hz), 6.50 (2H, d, J = 9.0 Hz), 3.78 (3H, s), 2.88 (6H, s), 2.37 (3H, s); ^{13}C NMR (75 MHz, $CDCl_3$) δ 158.3, 156.9, 149.5, 149.1, 147.0, 134.5, 131.2, 131.0, 130.2, 126.6, 122.2, 113.6, 111.5, 55.1, 40.1, 23.8; IR (KBr) 3042, 2928, 2349, 1607, 1526, 1456, 1359, 1248, 1039, 818, 565 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{21}H_{22}N_2O$: 318.1732. Found: 318.1732.

3-(4-Methoxyphenyl)-2-methyl-4-(4-nitrophenyl) pyridine (5g): Prepared from 1-(4-methoxyphenyl) propan-2-one **1e** (164 mg, 1 mmol), 4-nitrocinnamaldehyde **2f** (177 mg, 1 mmol) and ammonium acetate **3** (85 mg, 1.1 mmol) according to general procedure in 20 h. The product was obtained as a liquid (256 mg, 80%). ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.52 (1H, d, J = 5.1 Hz), 8.0 (2H, d, J = 8.7 Hz), 7.19 (2H, d, J = 8.7 Hz), 7.14 (1H, d, J = 5.1 Hz), 6.90 (2H, d, J = 8.7 Hz), 6.77 (2H, d, J = 8.7 Hz), 3.74 (3H, s), 2.41 (3H, s); ^{13}C NMR (75 MHz, $CDCl_3$) δ 158.8, 157.8, 147.5, 146.9, 146.8, 146.1, 134.7, 131.0, 130.0, 129.1, 123.0, 121.6, 113.8, 55.0, 23.6; IR (neat) 3053, 2949, 2845, 1597, 1520, 1454, 1345, 1252, 1178, 1109, 1030, 837, 738, 571 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{19}H_{16}N_2O_3$: 320.1161. Found: 320.1161.

3-(3,4-Dimethoxyphenyl)-2-methyl-4-phenylpyridine (5h): Prepared from 1-(3,4-dimethoxyphenyl)propan-2-one **1f** (194 mg, 1 mmol), cinnamaldehyde **2a** (132 mg, 1 mmol) and ammonium acetate **3** (85 mg, 1.1 mmol) according to general procedure in 18 h. The product was obtained as a liquid (220 mg, 72%). ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.48 (1H, d, J = 5.1 Hz), 7.15-7.14 (4H, m), 7.04-7.01 (2H, m), 6.74 (1H, d, J = 8.1 Hz), 6.62 (1H, dd, J = 1.8, 8.1 Hz), 6.45 (1H, d, J = 1.5 Hz), 3.82 (3H, s), 3.61 (3H, s), 2.43 (3H, s); ^{13}C NMR (75 MHz, $CDCl_3$) δ 157.0, 149.1, 148.4, 147.9, 147.4, 139.4, 134.9, 130.5, 129.0, 127.8, 127.2, 122.6, 122.2, 113.6, 110.7, 55.7, 55.6, 23.8; IR (neat) 3051, 2942, 2843, 1726, 1579, 1515, 1454, 1252, 1145, 1028, 847, 754 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{20}H_{19}NO_2$: 305.1416. Found: 305.1412.

3-(3,4-Dimethoxyphenyl)-4-(2-methoxyphenyl)-2-methylpyridine (5i): Prepared from 1-(3,4-dimethoxyphenyl)propan-2-one **1f** (194 mg, 1 mmol), 2-methoxycinnamaldehyde **2b** (162 mg, 1 mmol) and ammonium acetate **3** (85 mg, 1.1 mmol) according to general procedure in 16 h. The product was obtained as

a liquid (255 mg, 76%). ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.45 (1H, d, J = 5.1 Hz), 7.15-7.06 (2H, m), 6.93 (1H, d, J = 6.3 Hz), 6.78 (1H, t, J = 7.5 Hz), 6.70-6.59 (3H, m), 6.47 (1H, s), 3.77 (3H, s), 3.66 (3H, s), 3.48 (3H, s), 2.42 (3H, s); ^{13}C NMR (75 MHz, $CDCl_3$) δ 156.3, 155.6, 147.8, 147.5, 147.0, 146.7, 135.9, 130.9, 130.3, 128.9, 128.6, 122.7, 122.0, 119.9, 113.0, 110.2, 110.1, 55.5, 55.5, 54.8, 23.7; IR (neat) 3052, 2945, 2840, 1680, 1588, 1509, 1457, 1251, 1145, 1029, 746, 570 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{21}H_{21}NO_3$: 335.1521. Found: 335.1519.

3-(3,4-Dimethoxyphenyl)-2-methyl-4-(4-nitrophenyl) pyridine (5j): Prepared from 1-(3,4-dimethoxyphenyl)propan-2-one **1f** (194 mg, 1 mmol), 4-nitrocinnamaldehyde **2f** (177 mg, 1 mmol) and ammonium acetate **3** (85 mg, 1.1 mmol) according to general procedure in 18 h. The product was obtained as a solid (252 mg, 72%); mp 66-68 ^{o}C. ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.49 (1H, d, J = 4.8 Hz), 7.98 (2H, d, J = 9.0 Hz), 7.18 (2H, d, J = 9.0 Hz), 7.09 (1H, d, J = 1.5 Hz), 6.71 (1H, d, J = 8.1 Hz), 6.53 (1H, dd, J = 1.8, 8.1 Hz), 6.45 (1H, d, J = 5.1 Hz), 3.79 (3H, s), 3.62 (3H, s), 2.40 (3H, s); ^{13}C NMR (75 MHz, $CDCl_3$) δ 157.8, 148.7, 148.2, 147.8, 146.8, 146.6, 146.2, 134.6, 129.9, 129.5, 123.0, 122.5, 121.5, 113.1, 110.9, 55.8, 55.6, 23.8; IR (KBr) 2936, 2854, 2348, 1588, 1518, 1345, 1253, 1138, 1026, 844, 742 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{20}H_{18}N_2O_4$: 350.1267. Found: 350.1267.

2-Methyl-4-phenyl-3-(3-(trifluoromethyl)phenyl) pyridine (5k): Prepared from 1-(3-(trifluoromethyl) phenyl)propan-2-one **1g** (202 mg, 1 mmol), cinnamaldehyde **2a** (132 mg, 1 mmol) and ammonium acetate **3** (85 mg, 1.1 mmol) according to general procedure in 12 h. The product was obtained as a liquid (257 mg, 82%). ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.52 (1H, d, J = 5.1 Hz), 7.41 (1H, d, J = 7.5 Hz), 7.32-7.25 (2H, m), 7.16 (2H, d, J = 5.4 Hz), 7.10-7.09 (3H, m), 6.93-6.90 (2H, m), 2.36 (3H, s); ^{13}C NMR (75 MHz, $CDCl_3$) δ 156.3, 149.7, 147.8, 138.8, 138.5, 134.0, 133.4, 129.0, 128.6, 128.0, 127.6, 127.1, 127.0, 123.9, 123.9, 122.5, 23.4; IR (neat) 3054, 2928, 2491, 1952, 1703, 1579, 1443, 1326, 1252, 1165, 1131, 810, 750, 699 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{19}H_{14}F_3N$: 313.1078. Found: 313.1075.

4-(2-Methoxyphenyl)-2-methyl-3-(3-(trifluoromethyl) phenyl)pyridine (5l): Prepared from 1-(3-(trifluoromethyl)phenyl)propan-2-one **1g** (202 mg, 1 mmol), 2-methoxycinnamaldehyde **2b** (162 mg, 1 mmol) and ammonium acetate **3** (85 mg, 1.1 mmol) according to general procedure in 12 h. The product was obtained as a solid (274 mg, 80%); mp 120-122 ^{o}C. ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.48 (1H, d, J = 5.1 Hz), 7.32 (2H, d, J = 7.5 Hz), 7.21-7.17 (1H, m), 7.10-7.07 (3H, m), 6.92 (1H, dd, J = 1.5, 7.5 Hz), 6.76 (1H, t, J = 7.5 Hz), 6.52 (1H, d, J = 8.1 Hz), 3.37 (3H, s), 2.34 (3H, s); ^{13}C NMR (75 MHz, $CDCl_3$) δ 155.5, 155.3, 147.7, 147.2, 139.3, 135.2, 132.8, 130.3, 129.6, 129.5, 127.8, 127.7, 126.6, 123.5, 123.4, 122.9, 120.1, 110.1, 54.5, 23.4; IR (KBr) 3055, 2936, 2854, 1709, 1587, 1456, 1327, 1251, 1166, 1128, 754, 572 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{20}H_{16}F_3NO$: 343.1184. Found: 343.1183.

3-(4-Bromophenyl)-2-methyl-4-phenylpyridine (5m): Prepared from 1-(4-bromophenyl)propan-2-one **1h** (213 mg, 1 mmol), cinnamaldehyde **2a** (132 mg, 1 mmol) and ammonium acetate **3** (85 mg, 1.1 mmol) according to general procedure in 10 h. The product was obtained as a solid (246 mg, 76%); mp 115-117 ^{o}C. ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.52 (1H, d, J = 5.1 Hz), 7.36 (2H, d, J = 8.4 Hz), 7.18-7.17 (4H, m), 7.02-7.0 (2H, m), 6.91 (2H, d, J = 8.1 Hz), 2.39 (3H, s); ^{13}C NMR (75 MHz, $CDCl_3$) δ 156.6, 149.0, 147.8, 138.8, 137.1, 134.0, 131.7, 131.3, 129.1, 127.9, 127.5, 122.3, 121.2, 23.8; IR (KBr) 3405, 3047, 2346, 1695, 1575, 1453, 1396, 1265, 1074, 1005, 830, 749, 709, 558 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{18}H_{14}BrN$: 323.0310. Found: 323.0307.

3-(4-Bromophenyl)-4-(4-methoxyphenyl)-2-methyl pyridine (5n): Prepared from 1-(4-bromophenyl) propan-2-one **1h** (213 mg, 1 mmol), 4-methoxycinnamaldehyde **2c** (162 mg, 1 mmol) and ammonium acetate **3** (85 mg, 1.1 mmol) according to general procedure in 12 h. The product was obtained as a solid (283 mg, 80%); mp 71-73 ^{o}C. ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.47 (1H, d, J = 5.1 Hz), 7.38 (2H, d, J = 8.4 Hz), 7.13 (1H, d, J = 5.1 Hz), 6.94-6.90 (4H, m), 6.7 (2H, d, J = 8.4 Hz), 3.72 (3H, s), 2.36 (3H, s); ^{13}C NMR (75 MHz, $CDCl_3$) δ 158.9, 156.6, 148.5, 147.9, 137.4, 133.8, 131.8, 131.3, 131.0, 130.4, 122.3, 121.1, 113.4, 55.1, 23.9; IR (KBr) 3039, 2958, 2843, 2346, 1732, 1599, 1512, 1458, 1250, 1178, 1034, 824, 752, 567 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{19}H_{16}BrNO$: 353.0415. Found: 353.0413

4-(3-(4-Bromophenyl)-2-methylpyridin-4-yl)-N,N-dimethylaniline (5o): Prepared from 1-(4-bromophenyl)propan-2-one **1h** (213 mg, 1 mmol), 4-dimethylaminocinnamaldehyde **2d** (175 mg, 1 mmol) and ammonium acetate **3** (85 mg, 1.1 mmol) according to general procedure in 16 h. The product was obtained as a solid (272 mg, 74%); mp 137-139 ^{o}C. ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.45 (1H, d, J = 5.1 Hz), 7.4 (2H, d, J = 8.4 Hz), 7.15 (1H, d, J = 5.1 Hz), 6.95 (2H, d, J = 8.4 Hz), 6.89 (2H, d, J = 9.0 Hz), 6.5 (2H, d, J = 9.0 Hz), 2.89 (6H, s), 2.35 (3H, s); ^{13}C NMR (75 MHz, $CDCl_3$) δ 156.4, 149.6, 148.8, 147.7, 137.9, 133.5, 131.9, 131.3, 130.2, 126.0, 122.2, 120.9, 111.5, 40.1, 23.9; IR (KBr) 3041, 2920, 2814, 2348, 1730, 1604, 1528, 1456, 1360, 1236, 1071, 818, 740, 557 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{20}H_{19}BrN_2$: 366.0732. Found: 366.0733.

3-(4-Bromophenyl)-2-methyl-4-(4-nitrophenyl) pyridine (5p): Prepared from 1-(4-bromophenyl)propan-2-one **1h** (213 mg, 1 mmol), 4-nitrocinnamaldehyde **2f** (177 mg, 1 mmol) and ammonium acetate **3** (85 mg, 1.1 mmol) according to general procedure in 14 h. The product was obtained as a solid (288 mg, 78%); mp 133-135 ^{o}C. ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.56 (1H, d, J = 5.1 Hz), 8.04 (2H, d, J = 8.7 Hz), 7.39 (2H, d, J = 8.4 Hz), 7.19 (2H, d, J = 9.0 Hz), 7.14 (1H, d, J = 4.8 Hz), 6.9 (2H, d, J = 8.4 Hz), 2.39 (3H, s); ^{13}C NMR (75 MHz, $CDCl_3$) δ 157.3, 148.3, 147.0, 146.5, 145.6, 136.2, 133.6, 131.7, 131.5, 130.0, 123.2, 121.8, 121.6, 23.8; IR (KBr) 3451, 3062, 2957, 2346, 1520, 1347, 1083, 834, 735, 559 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{18}H_{13}BrN_2O_2$: 368.0160. Found: 368.0160.

2-Benzyl-4-(furan-2-yl)-3-phenylpyridine (6a): Prepared from 1,3-diphenylpropan-2-one **1a** (210 mg, 1 mmol), (*E*)-3-(furan-2-yl)acrylaldehyde **2g** (122 mg, 1 mmol) and ammonium acetate **3** (85 mg, 1.1 mmol) according to general procedure in 10 h. The product was obtained as a liquid (255 mg, 82%). ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.52 (1H, d, J = 5.4 Hz), 7.61 (1H, d, J = 5.4 Hz), 7.32-7.27 (4H, m), 7.09-7.01 (3H, m), 6.98-6.94 (2H, m), 6.87-6.84 (2H, m), 6.07-6.05 (1H, m), 5.08 (1H, d, J = 3.6 Hz), 3.87 (2H, s); ^{13}C NMR (75 MHz, $CDCl_3$) δ 158.9, 150.2, 148.4, 142.6, 139.6, 138.2, 137.1, 132.0, 129.4, 128.9, 128.7, 127.9, 127.9, 125.8, 117.4, 112.5, 111.8, 42.0; IR (neat) 3429, 3044, 2928, 1958, 1698, 1576, 1492, 1407, 1266, 1174, 1022, 746, 702, 581 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{22}H_{17}NO$: 311.1310. Found: 311.1306.

2'-Benzyl-3'-phenyl-3,4'-bipyridine (6b): Prepared from 1,3-diphenylpropan-2-one **1a** (210 mg, 1 mmol), (*E*)-3-(pyridin-3-yl)acrylaldehyde **2h** (133 mg, 1 mmol) and ammonium acetate **3** (85 mg, 1.1 mmol) according to general procedure in 10 h. The product was obtained as a liquid (251 mg, 78%). ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.65 (1H, d, J = 4.8 Hz), 8.37 (1H, dd, J = 1.5, 4.8 Hz), 8.34 (1H, d, J = 1.5 Hz), 7.29-7.25 (1H, m), 7.21-7.18 (4H, m), 7.14-7.08 (3H, m), 7.05-7.01 (1H, m), 6.96-6.90 (4H, m), 4.07 (2H, s); ^{13}C NMR (75 MHz, $CDCl_3$) δ 159.1, 149.4, 148.4, 148.3, 145.8, 139.4, 136.7, 136.3, 135.6, 134.9, 130.3, 128.7, 128.1, 128.0, 127.4, 125.9, 122.4, 122.2, 42.0; IR (neat) 3414, 3040, 2927, 2274, 1682, 1576, 1406, 1267, 1187, 1022, 710, 574 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{23}H_{18}N_2$: 322.1470. Found: 322.1467.

4-(Anthracen-9-yl)-2-benzyl-3-phenylpyridine (6c): Prepared from 1,3-diphenylpropan-2-one **1a** (210 mg, 1 mmol), (*E*)-3-(anthracen-9-yl)acrylaldehyde **2i** (232 mg, 1 mmol) and ammonium acetate **3** (85 mg, 1.1 mmol) according to general procedure in 10 h. The product was obtained as a solid (287 mg, 68%); mp 161-163 ^{o}C. ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.7 (1H, d, J = 4.8 Hz), 8.19 (1H, s), 7.80-7.77 (2H, m), 7.42 (2H, d, J = 9.3 Hz), 7.31-7.23 (4H, m), 7.19-7.07 (4H, m), 6.98 (2H, d, J = 6.9 Hz), 6.74-6.61 (5H, m), 4.07 (2H, s); ^{13}C NMR (75 MHz, $CDCl_3$) δ 159.1, 148.0, 147.4, 139.8, 138.1, 136.8, 133.2, 130.7, 129.5, 129.3, 128.9, 128.7, 128.3, 128.1, 127.0, 126.9, 126.1, 125.9, 125.5, 124.9, 124.4, 42.1; IR (KBr) 3048, 2929, 2346, 1723, 1673, 1581, 1446, 1266, 1076, 1024, 739, 544 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{32}H_{23}N$: 421.1830. Found: 421.1829.

4-(Furan-2-yl)-3-(4-methoxyphenyl)-2-methyl pyridine (6d): Prepared from 1-(4-methoxyphenyl) propan-2-one **1e** (164 mg, 1 mmol), (*E*)-3-(furan-2-yl)acrylaldehyde **2g** (122 mg, 1 mmol) and ammonium acetate **3** (85 mg, 1.1 mmol) according to general procedure in 10 h. The product was obtained as a liquid (175 mg, 66%). ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.47 (1H, d, J = 5.4 Hz), 7.64 (1H, d, J = 5.4 Hz), 7.39 (1H, d, J = 1.8 Hz), 7.07 (2H, dd, J = 1.8, 6.6 Hz), 7.01 (2H, dd, J = 1.8, 6.6 Hz), 6.20-6.19 (1H, m), 5.30 (1H, d, J = 3.6 Hz), 3.87 (3H, s), 2.29 (3H, s); ^{13}C NMR (75 MHz, $CDCl_3$) δ 159.2, 157.6, 150.4, 147.9, 142.5, 136.8, 131.5, 131.2, 130.0, 117.0, 114.7, 112.4, 111.8, 55.2, 23.7; IR (neat) 3408, 2931, 1581, 1508, 1459, 1252, 1029, 746, 585 cm^{-1}; HRMS m/z (M+) calcd for $C_{17}H_{15}NO_2$: 265.1103. Found: 265.1102.

3-(3,4-Dimethoxyphenyl)-4-(furan-2-yl)-2-methyl pyridine (6e): Prepared from 1-(3,4-dimethoxyphenyl) propan-2-one **1f** (194 mg, 1 mmol), (*E*)-3-(furan-2-yl)acrylaldehyde **2g** (122 mg, 1 mmol) and ammonium acetate **3** (85 mg, 1.1 mmol) according to general procedure in 10 h. The product was obtained as a solid (183 mg, 62%); mp 95-97 ^{o}C. ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.47 (1H, d, J = 5.4 Hz), 7.64 (1H, d, J = 5.4 Hz), 7.39 (1H, d, J = 1.2 Hz), 6.97 (1H, d, J = 8.4 Hz), 6.72 (1H, dd, J = 1.8, 8.4 Hz), 6.66 (1H, d, J = 1.2 Hz), 6.20-6.19 (1H, m), 5.35 (1H, d, J = 3.6 Hz), 3.94 (3H, s), 3.81 (3H, s), 2.31 (3H, s); ^{13}C NMR (150 MHz, $CDCl_3$) δ 157.5, 150.2, 149.7, 148.6, 147.8, 142.7, 136.9, 131.6, 131.3, 121.1, 117.0, 112.7, 111.9, 111.8, 111.8, 55.9, 55.8, 23.5; IR (KBr) 3586, 3396, 3136, 2937, 1721, 1580, 1511, 1458, 1252, 1141, 1026, 743 cm^{-1}; HRMS m/z (M+) calcd for $C_{18}H_{17}NO_3$: 295.1208. Found: 295.1209.

4-(Furan-2-yl)-2-methyl-3-(3-(trifluoromethyl) phenyl)pyridine (6f): Prepared from 1-(3-(trifluoromethyl) phenyl)propan-2-one **1g** (202 mg, 1 mmol), (*E*)-3-(furan-2-yl)acrylaldehyde **2g** (122 mg, 1 mmol) and ammonium acetate **3** (85 mg, 1.1 mmol) according to general procedure in 10 h. The product was obtained as a liquid (121 mg, 40%). ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.52 (1H, d, J = 4.8 Hz), 7.71 (1H, d, J = 7.2 Hz), 7.65 (1H, d, J = 5.4 Hz), 7.62 (1H, t, J = 7.2 Hz), 7.48 (1H, s), 7.40-7.38 (2H, m), 6.20 (1H, q, J = 1.2 Hz), 5.22 (1H, d, J = 3.0 Hz), 2.27 (3H, s); ^{13}C NMR (150 MHz, $CDCl_3$) δ 156.8, 149.8, 148.4, 143.1, 139.8, 136.7, 132.6, 131.7 ($J_{C\text{-}F}$ = 33.4 Hz), 130.3, 129.8, 126.05 ($J_{C\text{-}F}$ = 3.4 Hz), 124.8 ($J_{C\text{-}F}$ = 3.4 Hz), 122.9, 117.4, 112.5, 111.9, 23.7; IR (neat) 3555, 2928, 1580, 1430, 1329, 1253, 1129, 911, 752, 589 cm^{-1}; HRMS m/z (M+) calcd for $C_{17}H_{12}F_3NO$: 303.0871. Found: 303.0872.

4-Phenyl-5,6,7,8-tetrahydroquinoline (7a): Prepared from cyclohexanone **1i** (98 mg, 1 mmol), cinnamaldehyde **2a** (132 mg, 1 mmol) and ammonium acetate **3** (85 mg, 1.1 mmol) according to general procedure in 12 h. The product was obtained as a liquid (88 mg, 42%). ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.37 (1H, d, J = 4.8 Hz), 7.40 (2H, t, J = 7.2 Hz), 7.36 (1H, d, J = 7.2 Hz), 7.26 (2H, d, J = 6.6 Hz), 6.94 (1H, d, J = 4.2 Hz), 2.99 (2H, t, J = 6.6 Hz), 2.60 (2H, t, J = 6.6 Hz), 1.90-1.86 (2H, m), 1.72-1.68 (2H, m); ^{13}C NMR (150 MHz, $CDCl_3$) δ 157.5, 149.6, 146.2, 139.2, 129.9, 128.4, 128.2, 127.7, 121.9, 32.9, 27.3, 22.8, 22.8; IR

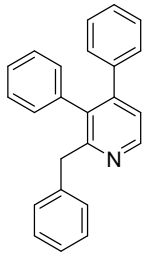
(neat) 3415, 3050, 2932, 1577, 1444, 1080, 760, 702, 589 cm^{-1}; HRMS m/z (M+) calcd for $C_{15}H_{15}N$: 209.1204. Found: 209.1203.

4-(2-Methoxyphenyl)-5,6,7,8-tetrahydroquinoline (7b): Prepared from cyclohexanone **1i** (98 mg, 1 mmol), 2-methoxycinnamaldehyde **2b** (162 mg, 1 mmol) and ammonium acetate **3** (85 mg, 1.1 mmol) according to general procedure in 12 h. The product was obtained as a liquid (96 mg, 40%). ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.35 (1H, d, J = 4.8 Hz), 7.36-7.33 (1H, m), 7.05 (1H, dd, J = 1.8, 7.2 Hz), 6.99 (1H, t, J = 7.2 Hz), 6.94 (1H, d, J = 7.8 Hz), 6.91 (1H, d, J = 4.8 Hz), 3.74 (3H, s), 3.01-2.94 (2H, m), 2.56-2.38 (2H, m), 1.89-1.85 (2H, m), 1.72-1.65 (2H, m); ^{13}C NMR (150 MHz, $CDCl_3$) δ 156.9, 156.1, 147.1, 145.9, 131.3, 130.0, 129.3, 128.2, 122.4, 120.5, 110.7, 55.3, 32.8, 26.4, 22.9, 22.6; IR (neat) 3415, 3056, 2932, 1855, 1452, 1249, 1032, 838, 752, 571 cm^{-1}; HRMS m/z (M+) calcd for $C_{16}H_{17}NO$: 239.1310. Found: 239.1308.

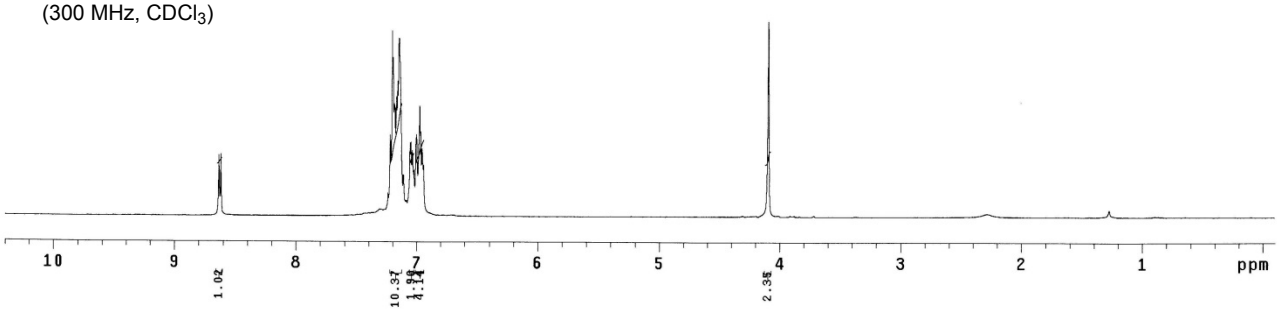
4-(4-Methoxyphenyl)-5,6,7,8-tetrahydroquinoline (7c): Prepared from cyclohexanone **1i** (98 mg, 1 mmol), 4-methoxycinnamaldehyde **2c** (162 mg, 1 mmol) and ammonium acetate **3** (85 mg, 1.1 mmol) according to general procedure in 12 h. The product was obtained as a solid (98 mg, 41%); mp 70-72 ^{o}C. ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.34 (1H, d, J = 4.8 Hz), 7.20-7.18 (2H, m), 6.93-6.90 (3H, m), 3.81 (3H, s), 2.97 (2H, t, J = 7.2 Hz), 2.61 (2H, t, J = 6.6 Hz), 1.89-1.84 (2H, m), 1.70-1.66 (2H, m); ^{13}C NMR (150 MHz, $CDCl_3$) δ 159.1, 157.4, 149.2, 146.2, 131.5, 129.9, 129.7, 122.0, 113.6, 55.2, 32.9, 27.4, 22.9, 22.9; IR (KBr) 3391, 2930, 1599, 1515, 1450, 1251, 1176, 1032, 828, 737, 564 cm^{-1}; HRMS m/z (M+) calcd for $C_{16}H_{17}NO$: 239.1310. Found: 239.1308.

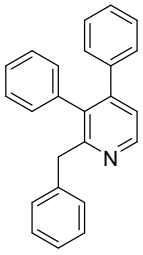
2-Methyl-4-phenyl-3-(p-tolylthio)pyridine (8a): Prepared from 1-(*p*-tolylthio)propan-2-one **1j** (180 mg, 1 mmol), cinnamaldehyde **2a** (132 mg, 1 mmol) and ammonium acetate **3** (85 mg, 1.1 mmol) according to general procedure in 8 h. The product was obtained as a liquid (198 mg, 68%). ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.50 (1H, d, J = 5.1 Hz), 7.33-7.31 (3H, m), 7.28-7.25 (2H, m), 7.16 (1H, d, J = 5.1 Hz), 6.94 (2H, d, J = 7.8 Hz), 6.76 (2H, d, J = 8.4 Hz), 2.66 (3H, s), 2.23 (3H, s); ^{13}C NMR (75 MHz, $CDCl_3$) δ 163.4, 155.5, 148.4, 139.3, 135.3, 133.4, 129.7, 128.7, 128.1, 127.8, 127.3, 127.2, 123.2, 24.4, 20.8; IR (neat) 3048, 2931, 2350, 1707, 1573, 1493, 1448, 1267, 1086, 756, 698, 584 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{19}H_{17}NS$: 291.1082. Found: 291.1082.

4-(4-Methoxyphenyl)-2-methyl-3-(p-tolylthio) pyridine (8b): Prepared from 1-(*p*-tolylthio) propan-2-one **1j** (180 mg, 1 mmol), 4-methoxycinnamaldehyde **2c** (162 mg, 1 mmol) and ammonium acetate **3** (85 mg, 1.1 mmol) according to general procedure in 8 h. The product was obtained as a solid (212 mg, 66%); mp 83-85 ^{o}C. ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.40 (1H, d, J = 5.1 Hz), 7.19-7.16 (2H, m), 7.10 (1H, d, J = 5.1 Hz), 6.89 (2H, d, J = 7.8 Hz), 6.8 (2H, d, J = 8.7 Hz), 6.71 (2H, d, J = 7.8 Hz), 3.73 (3H, s), 2.58 (3H, s), 2.18 (3H, s); ^{13}C NMR (75 MHz, $CDCl_3$) δ 163.5, 159.6, 155.3, 148.3, 135.3, 133.6, 131.6, 130.1, 129.7, 127.1, 126.9, 123.2, 113.3, 55.2, 24.3, 20.8; IR (KBr) 3022, 2935, 2847, 2351, 1604, 1511, 1451, 1252, 1178, 1033, 817, 745, 557 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{20}H_{19}NOS$: 321.1187. Found: 321.1188.

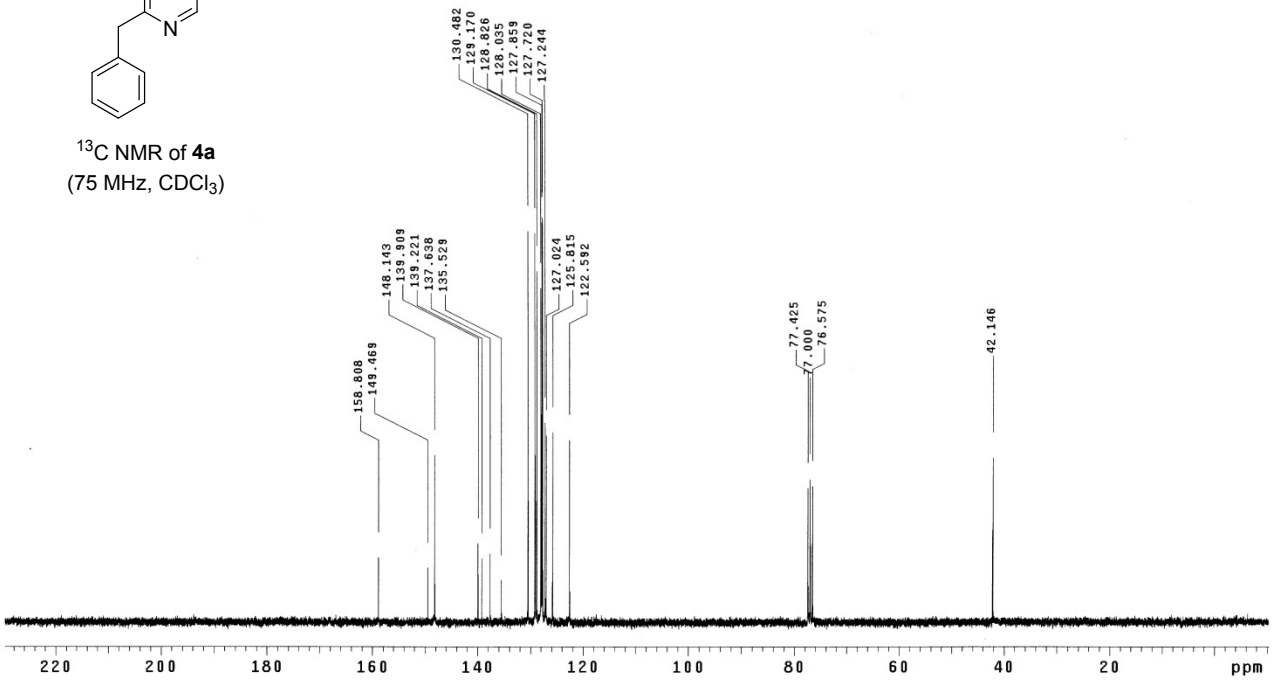


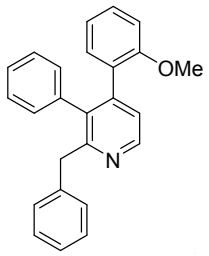
^{1}H NMR of **4a**
(300 MHz, $CDCl_3$)



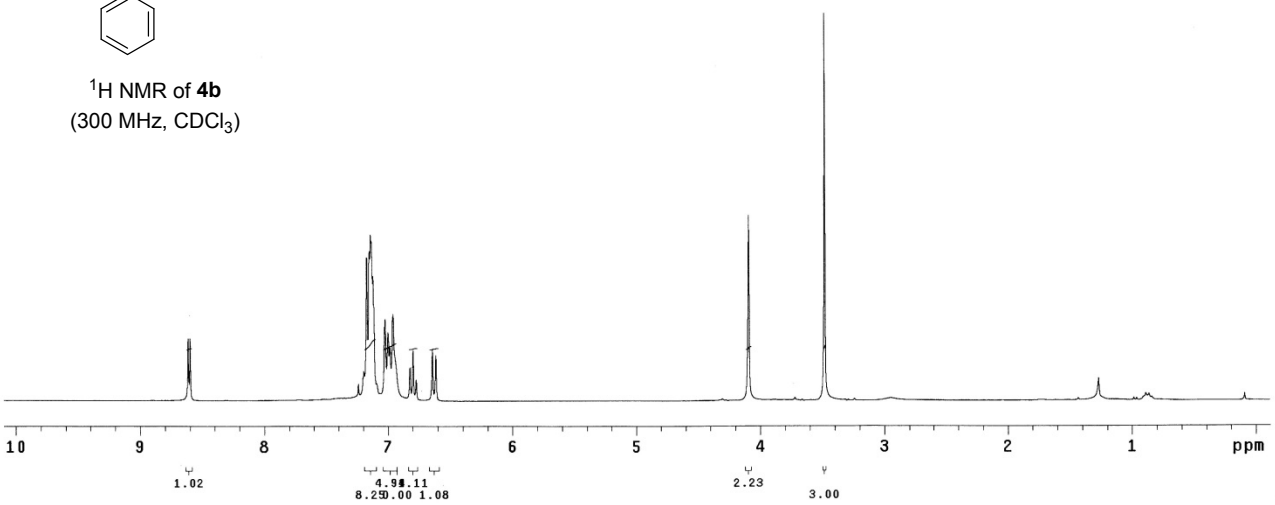


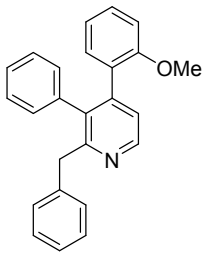
^{13}C NMR of **4a**
(75 MHz, $CDCl_3$)



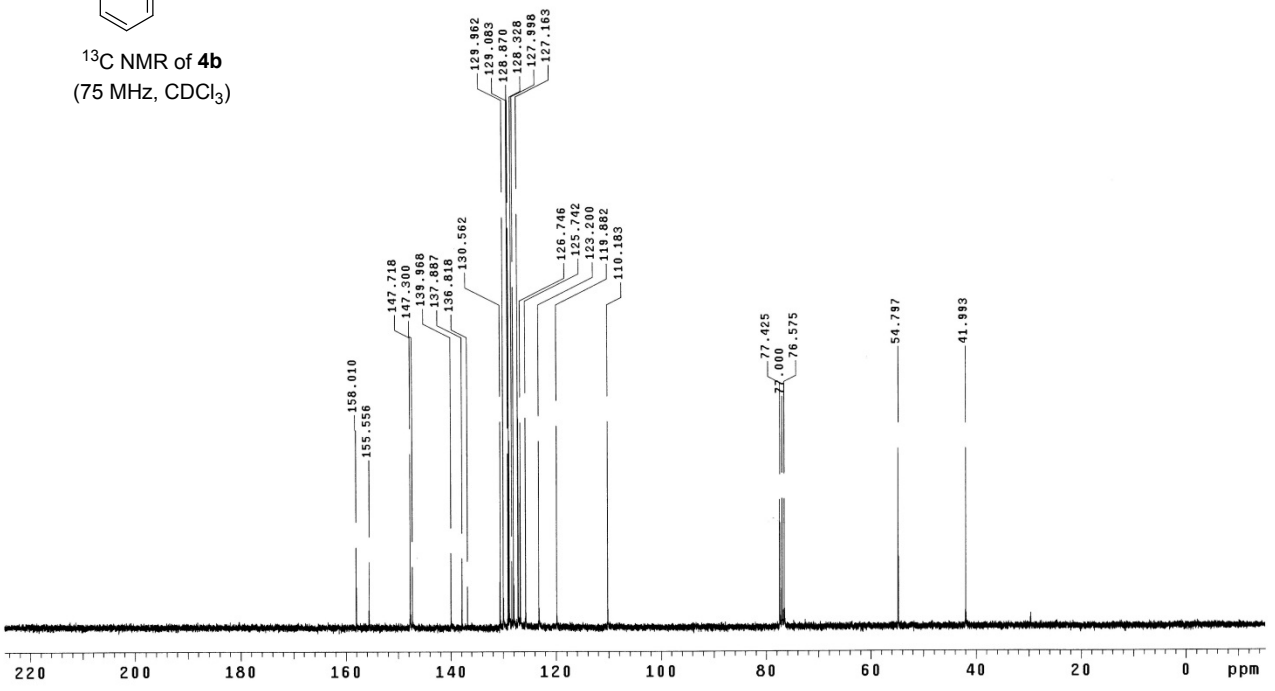


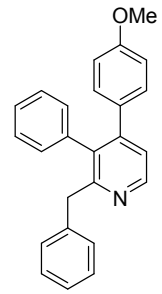
^{1}H NMR of **4b**
(300 MHz, $CDCl_3$)



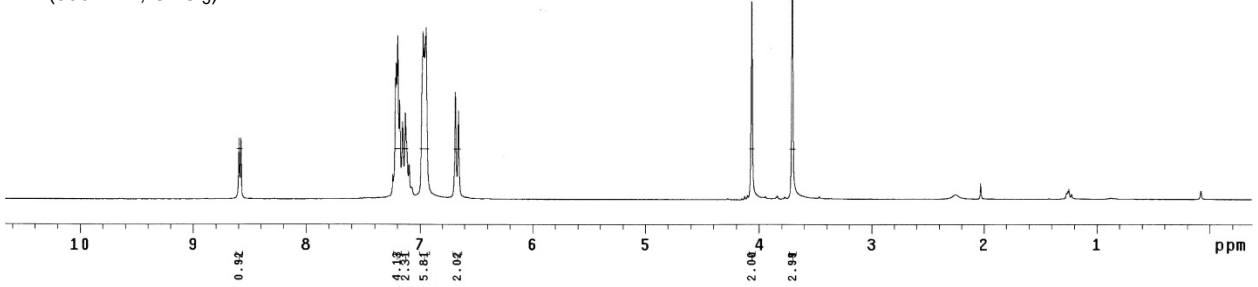


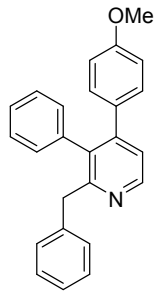
^{13}C NMR of **4b**
(75 MHz, $CDCl_3$)



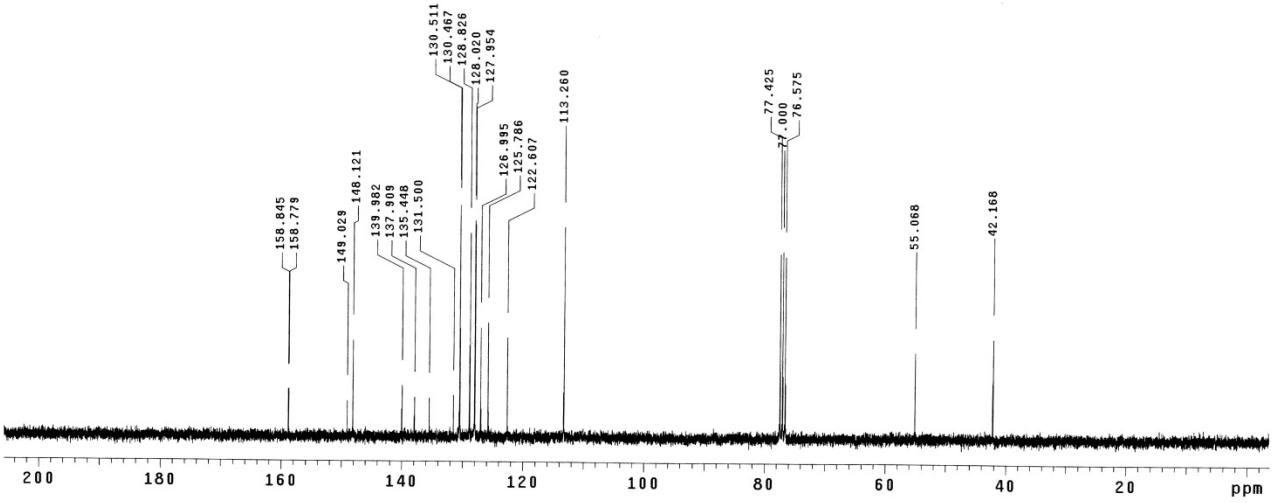


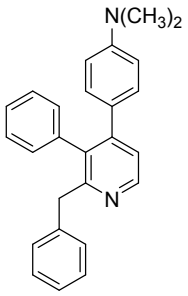
^{1}H NMR of **4c**
(300 MHz, $CDCl_3$)



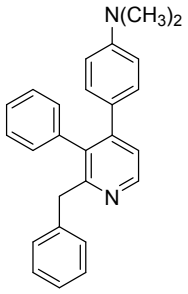


^{13}C NMR of **4c**
(75 MHz, $CDCl_3$)

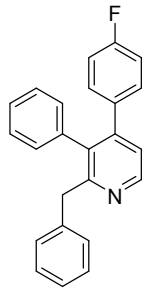




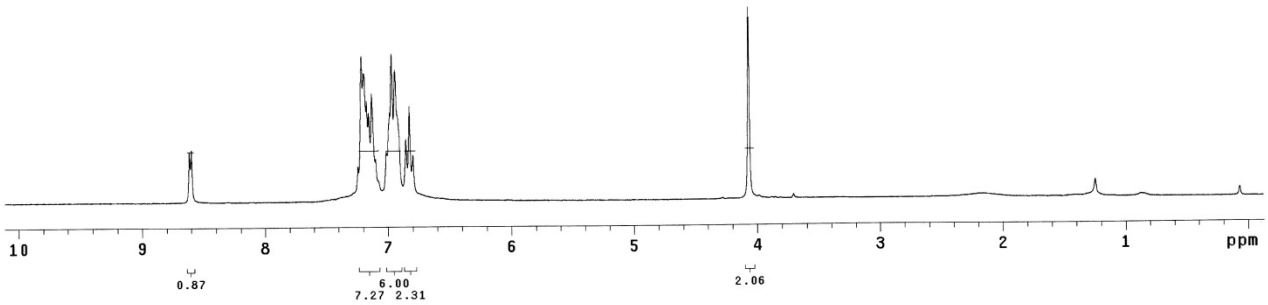
^{1}H NMR of **4d**
(300 MHz, $CDCl_3$)

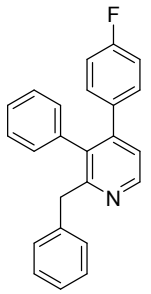


^{13}C NMR of **4d**
(75 MHz, $CDCl_3$)

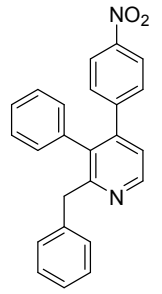


^{1}H NMR of **4e**
(300 MHz, $CDCl_3$)

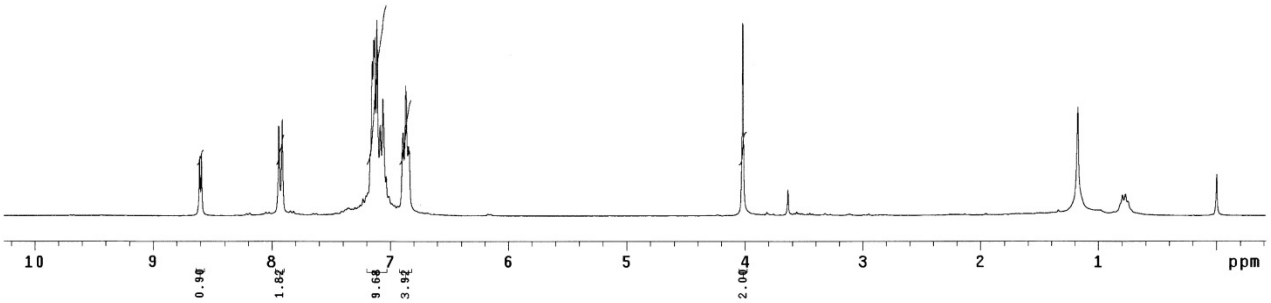


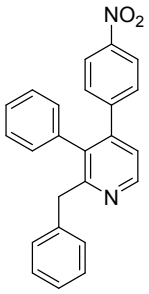


^{13}C NMR of **4e**
(75 MHz, $CDCl_3$)



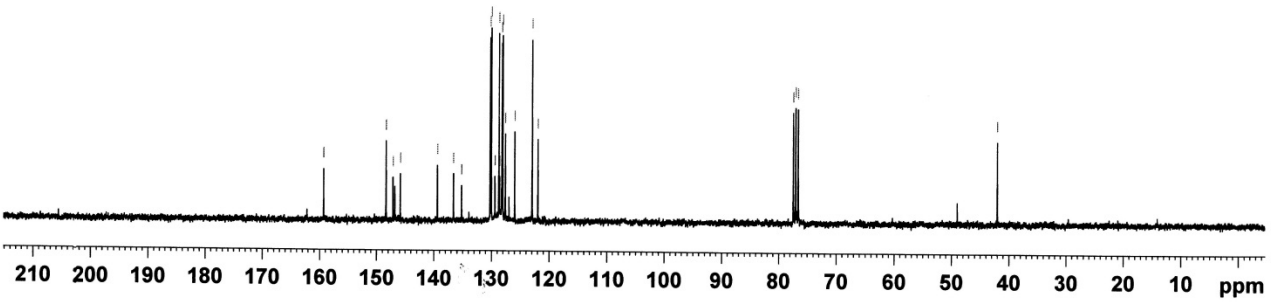
^{1}H NMR of **4f**
(300 MHz, $CDCl_3$)

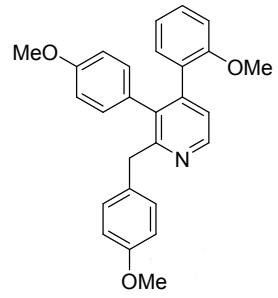




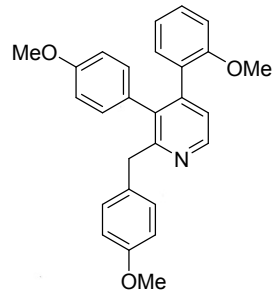
^{13}C NMR of **4f**
(75 MHz, $CDCl_3$)

159.32
148.37
147.14
145.85
139.39
136.61
135.20
130.22
130.04
129.40
128.73
128.60
128.19
128.06
127.59
125.94
122.96
121.93
77.43
77.00
76.58
42.00

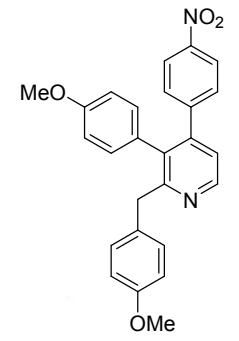




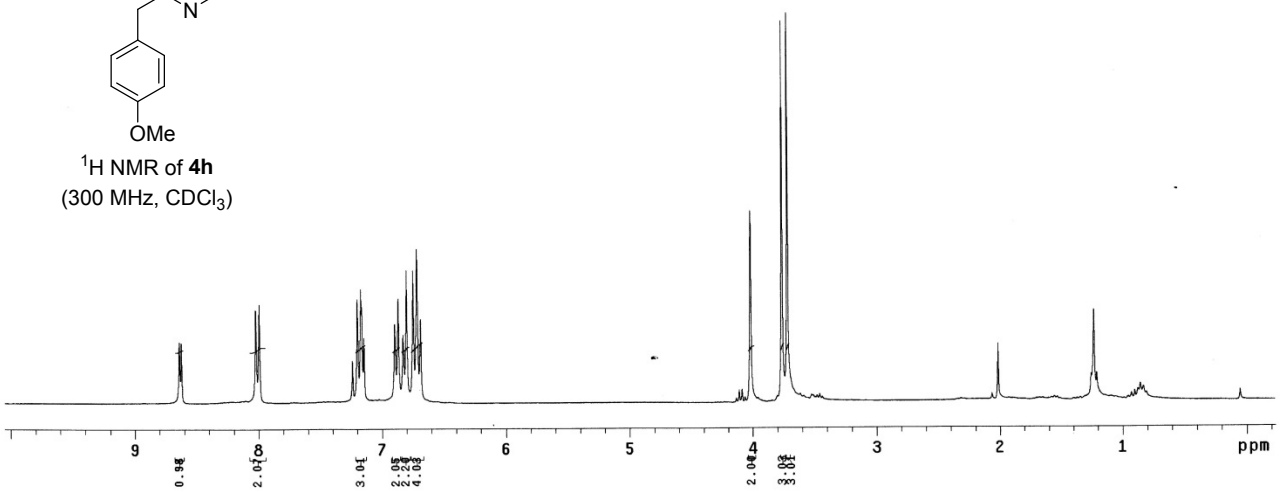
^{1}H NMR of **4g**
(300 MHz, $CDCl_3$)

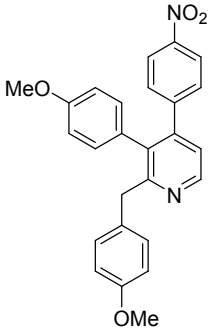


^{13}C NMR of **4g**
(150 MHz, $CDCl_3$)

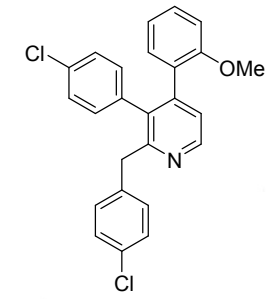


^{1}H NMR of **4h**
(300 MHz, $CDCl_3$)

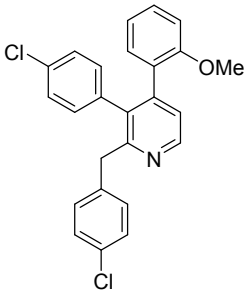




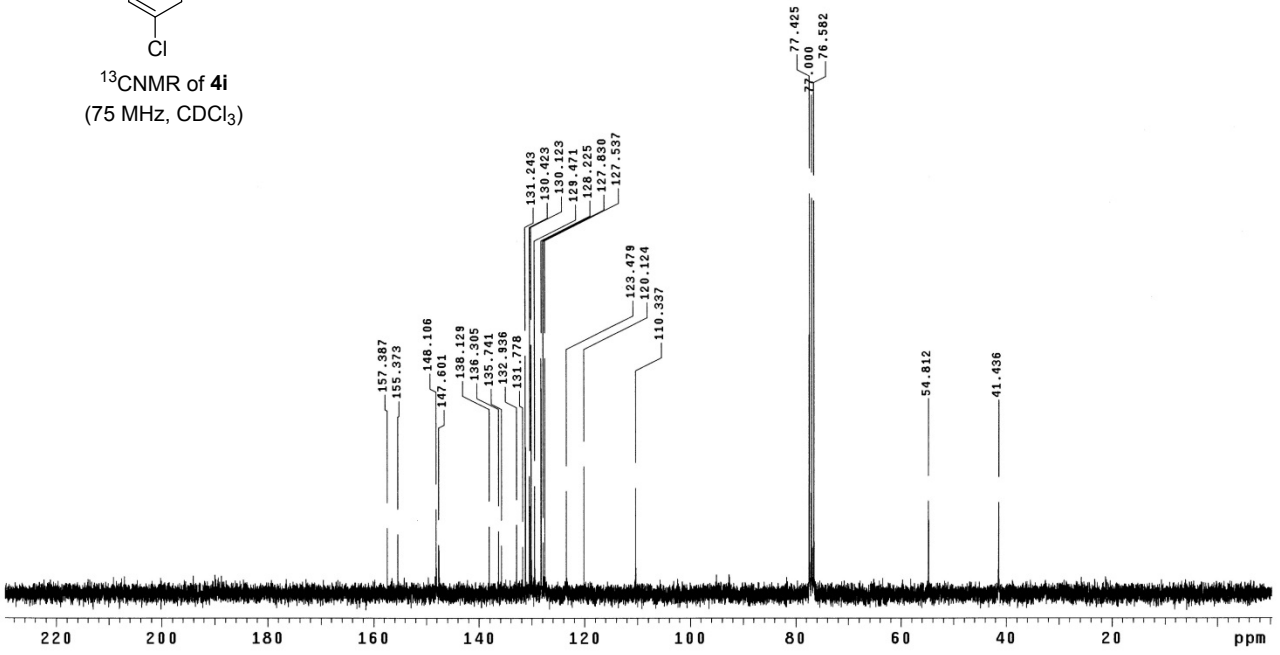
^{13}C NMR of **4h**
(75 MHz, $CDCl_3$)

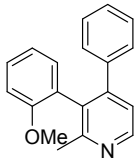


^{1}HNMR of **4i**
(300 MHz, $CDCl_3$)

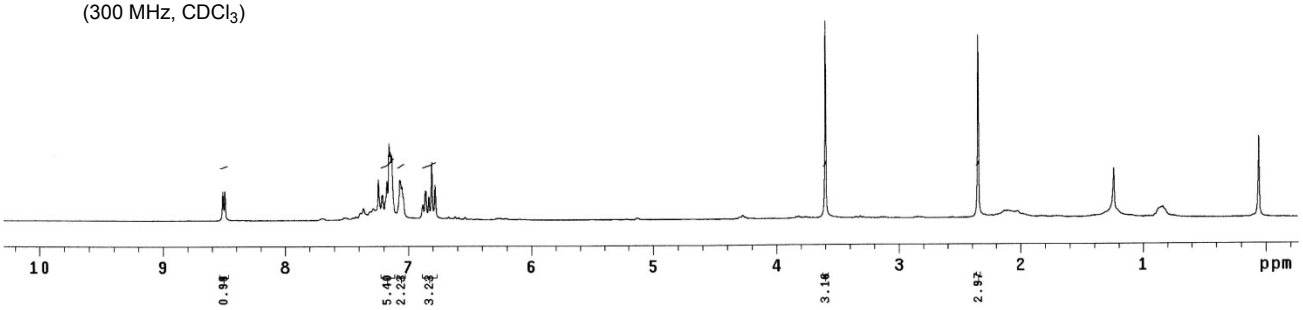


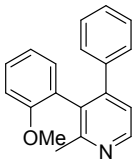
^{13}CNMR of **4i**
(75 MHz, $CDCl_3$)



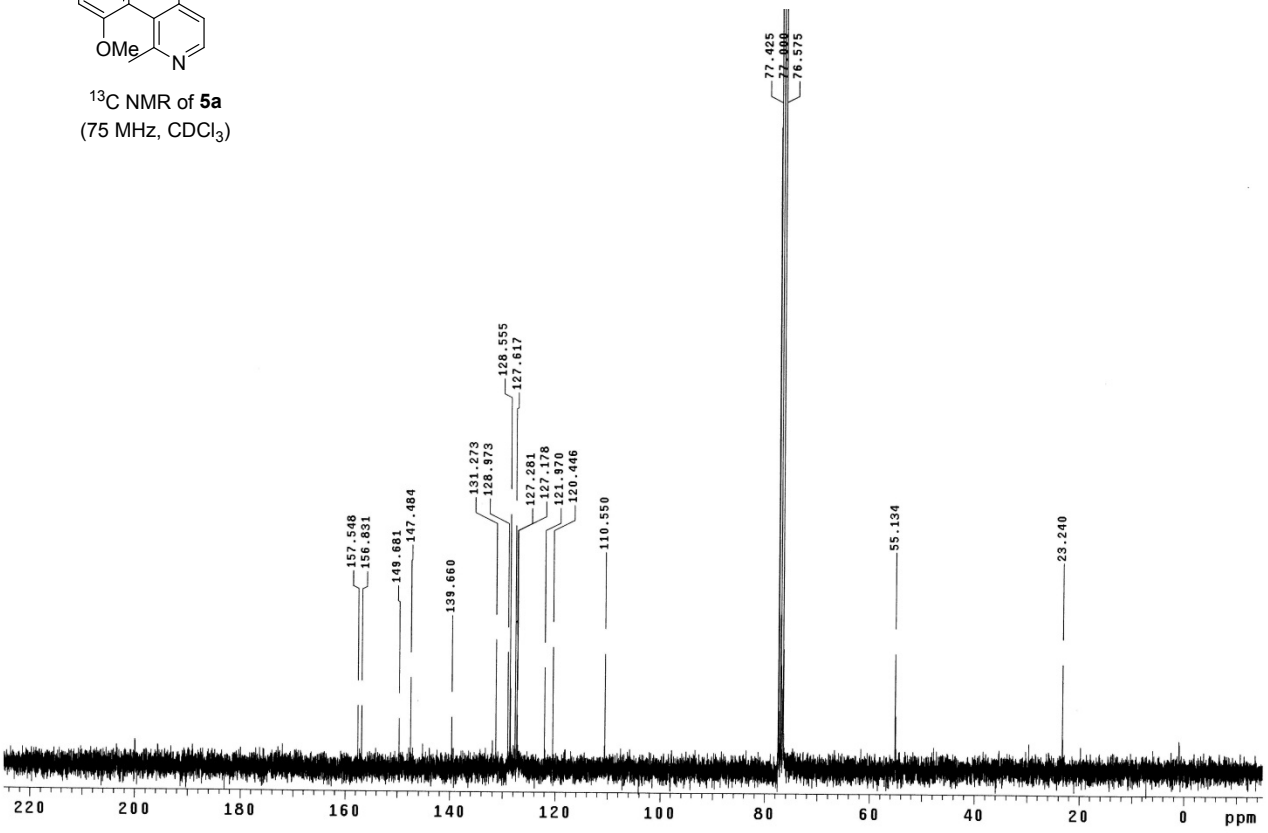


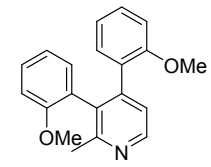
^{1}H NMR of **5a**
(300 MHz, $CDCl_3$)



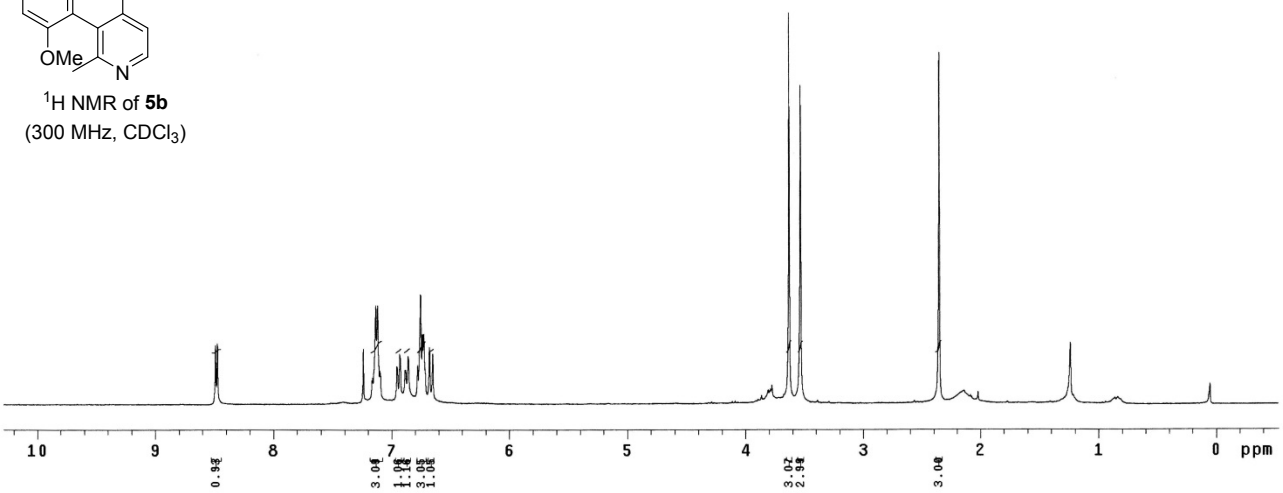


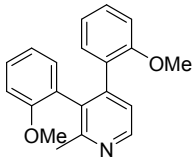
^{13}C NMR of **5a**
(75 MHz, $CDCl_3$)



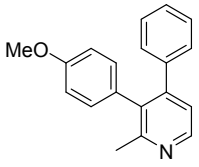


^{1}H NMR of **5b**
(300 MHz, $CDCl_3$)

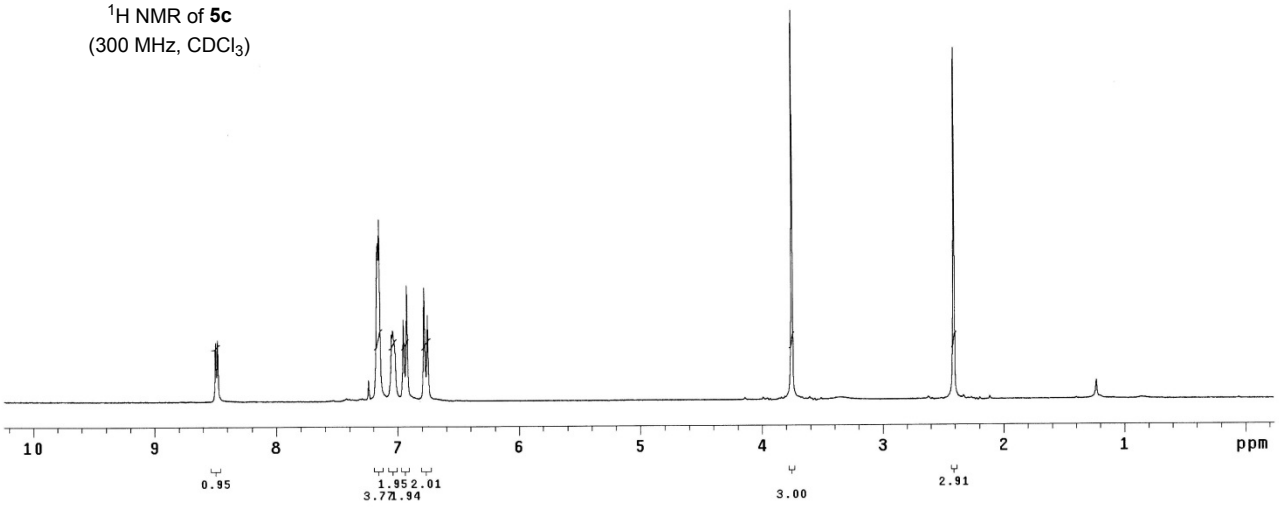


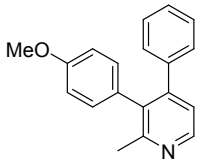


^{13}C NMR of **5b**
(75 MHz, $CDCl_3$)

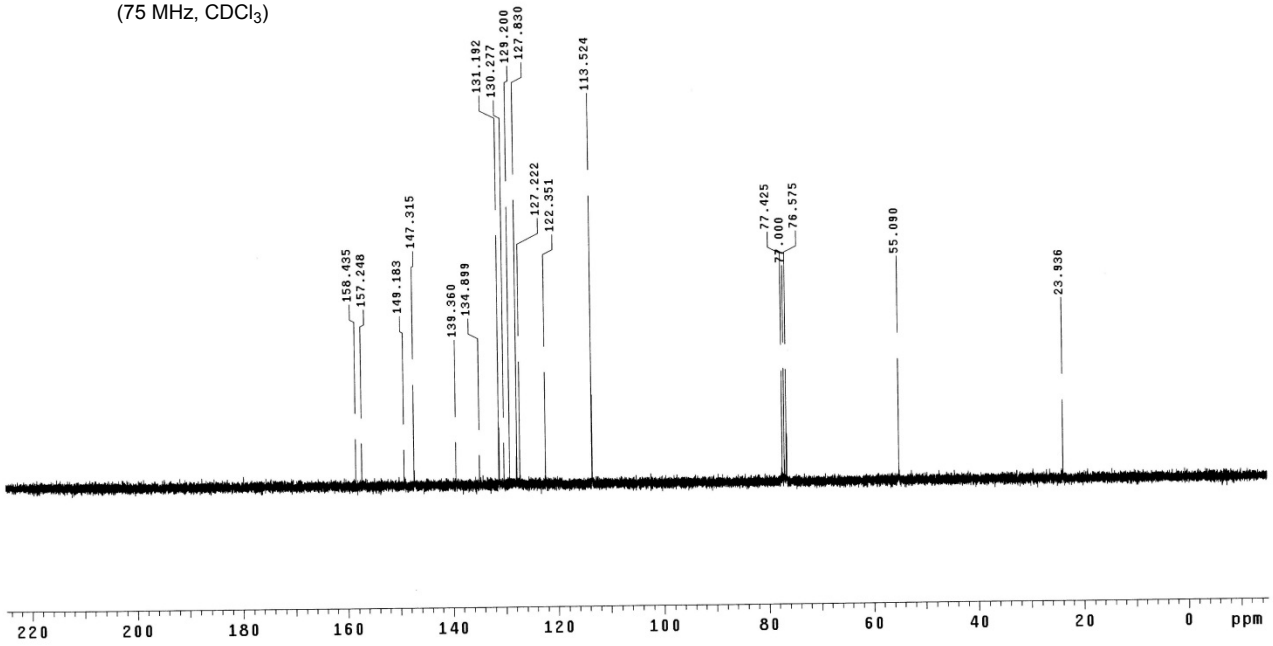


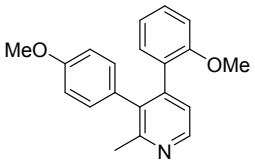
^{1}H NMR of **5c**
(300 MHz, $CDCl_3$)



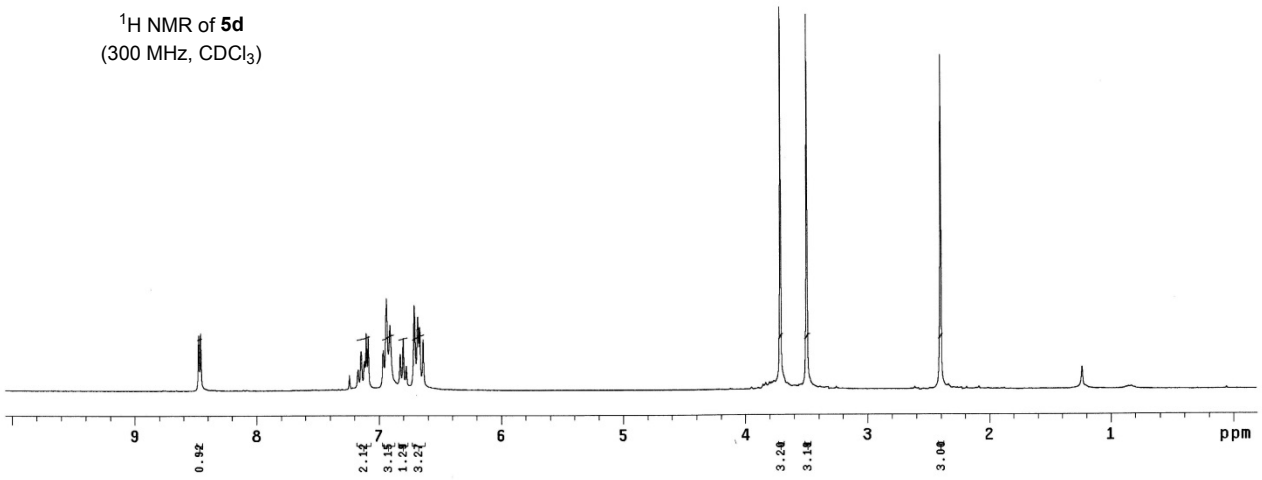


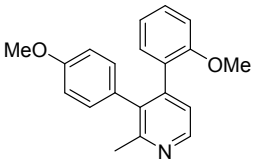
^{13}C NMR of **5c**
(75 MHz, $CDCl_3$)



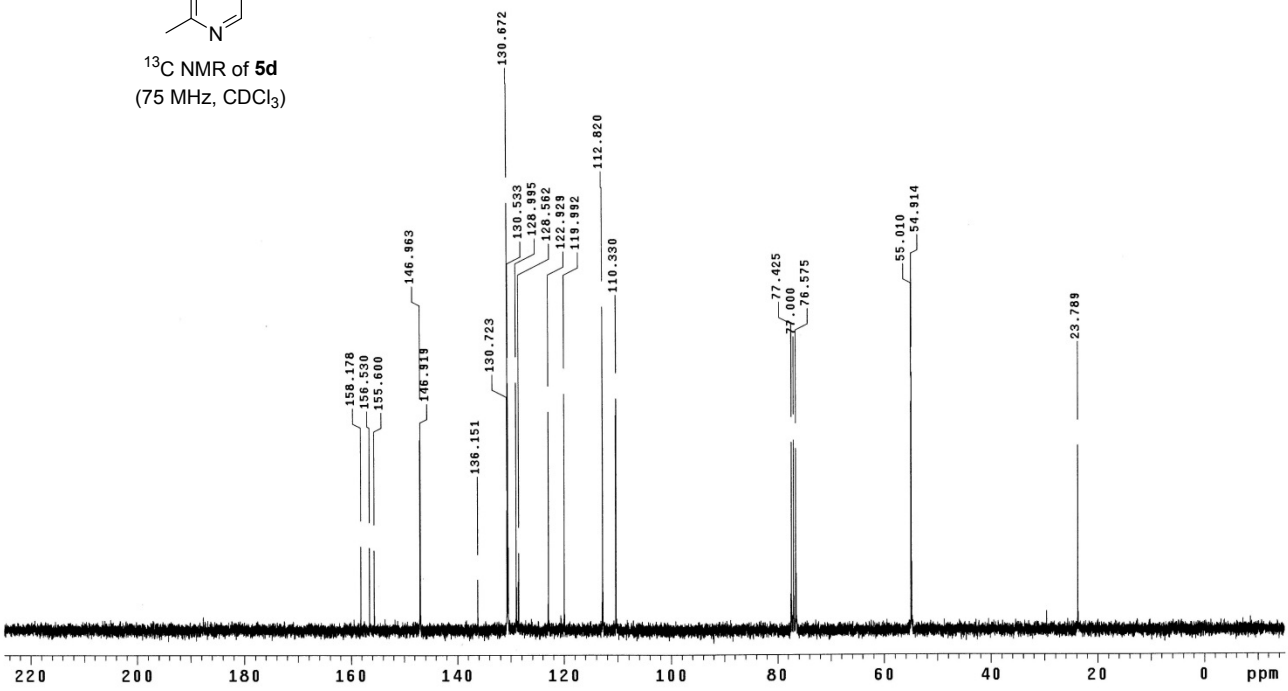


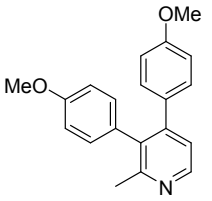
^{1}H NMR of **5d**
(300 MHz, $CDCl_3$)



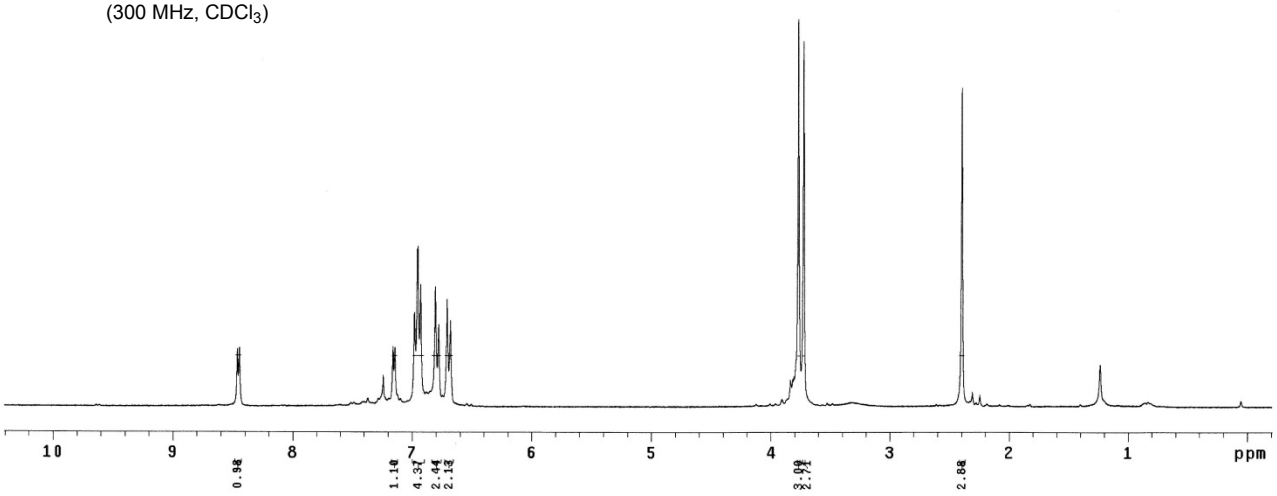


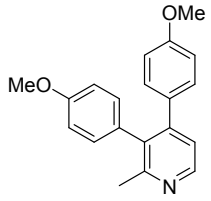
^{13}C NMR of **5d**
(75 MHz, $CDCl_3$)



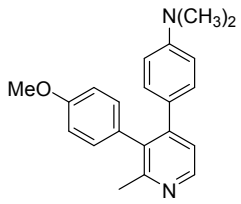


^{1}H NMR of **5e**
(300 MHz, $CDCl_3$)

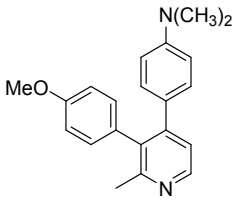




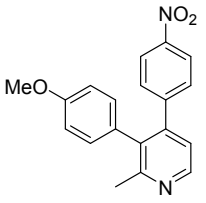
^{13}C NMR of **5e**
(75 MHz, $CDCl_3$)



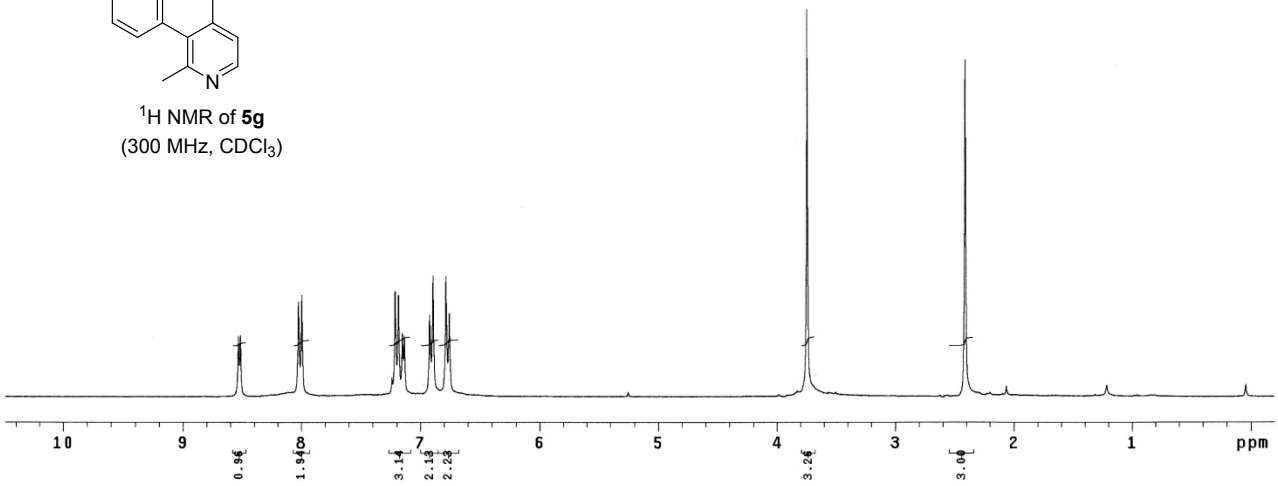
^{1}H NMR of **5f**
(300 MHz, $CDCl_3$)

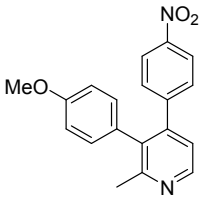


^{13}C NMR of **5f**
(75 MHz, $CDCl_3$)

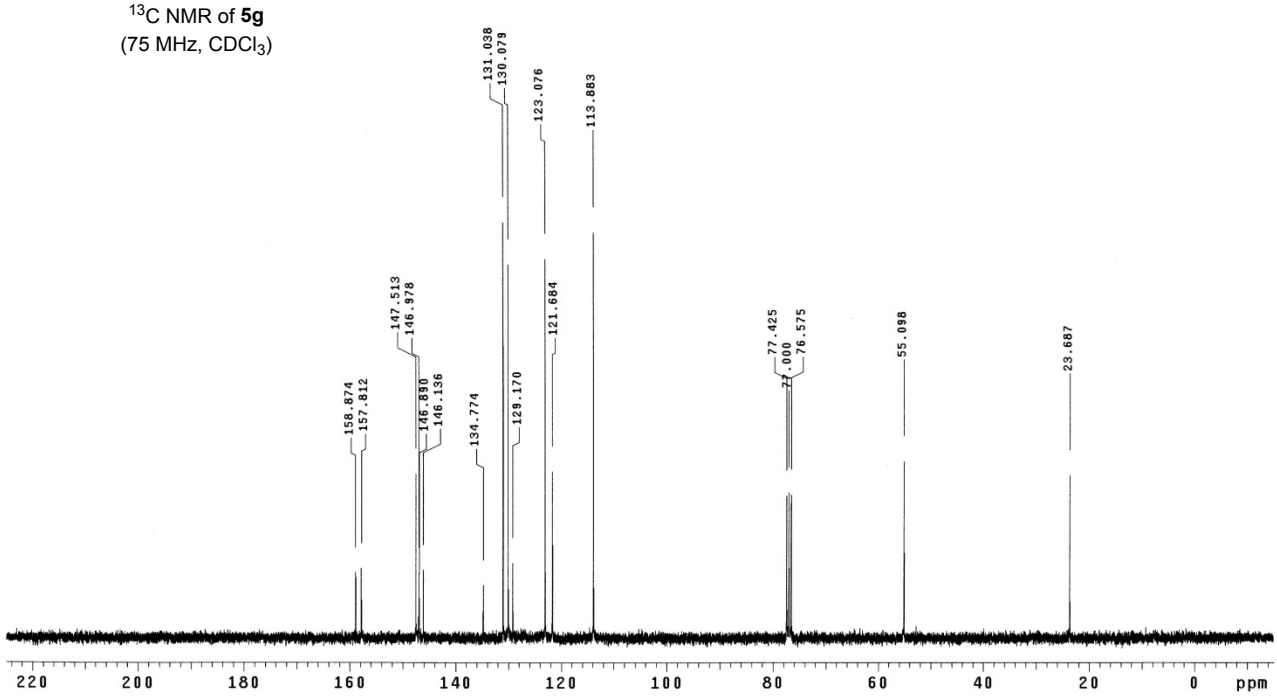


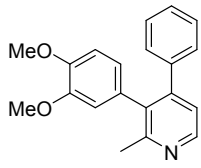
^{1}H NMR of **5g**
(300 MHz, $CDCl_3$)



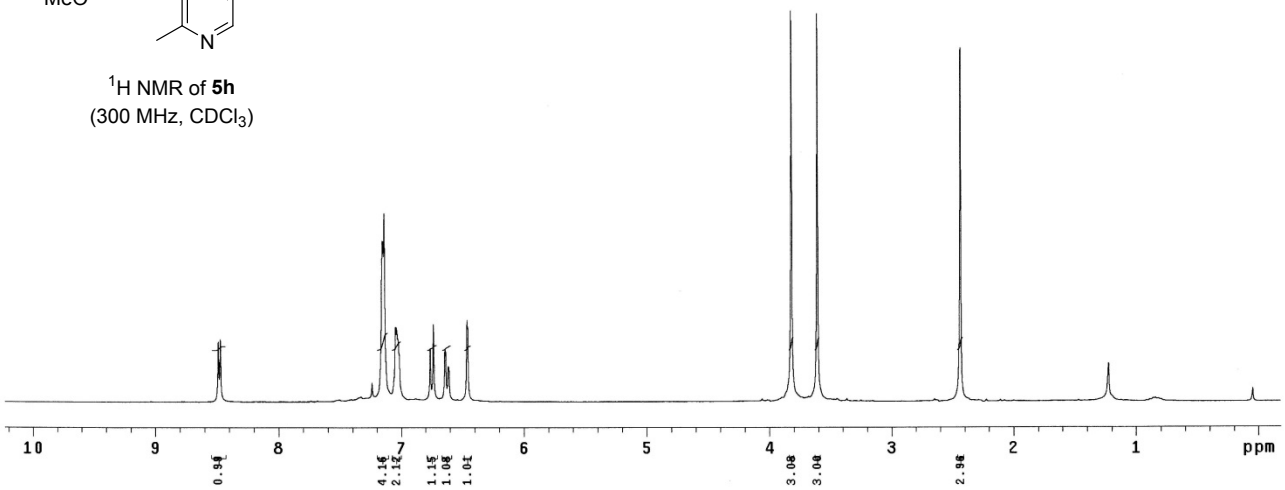


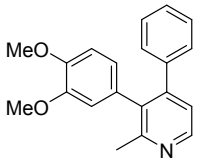
^{13}C NMR of **5g**
(75 MHz, $CDCl_3$)



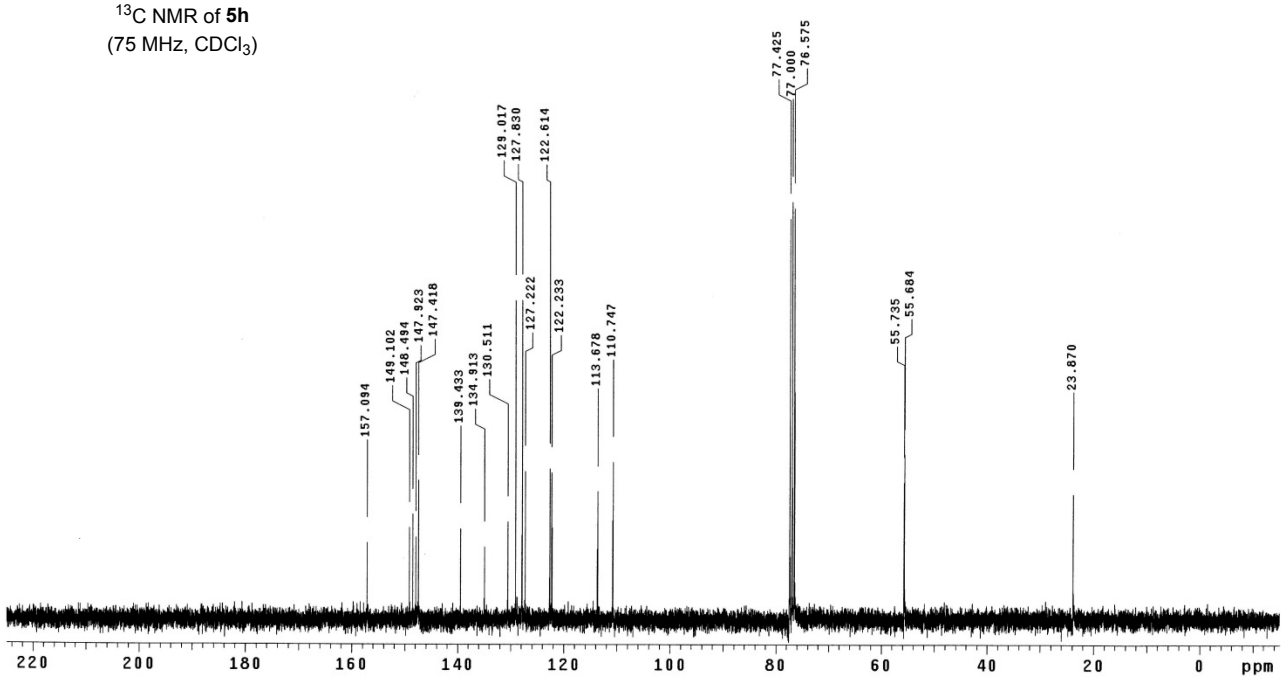


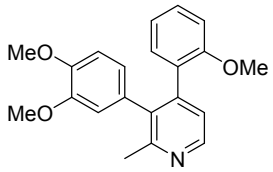
^{1}H NMR of **5h**
(300 MHz, $CDCl_3$)



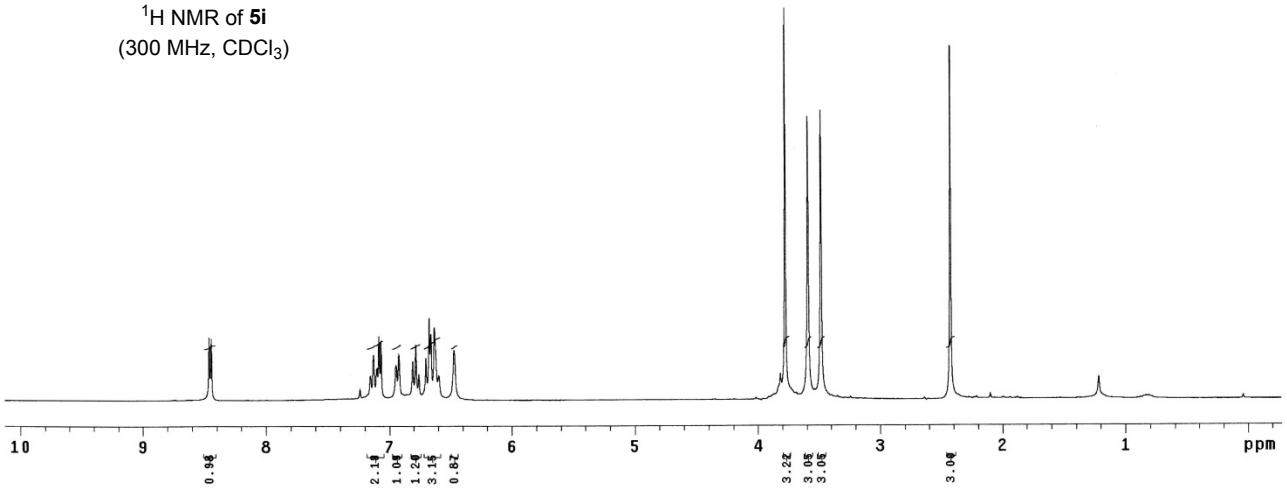


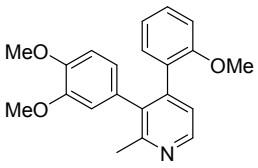
^{13}C NMR of **5h**
(75 MHz, $CDCl_3$)



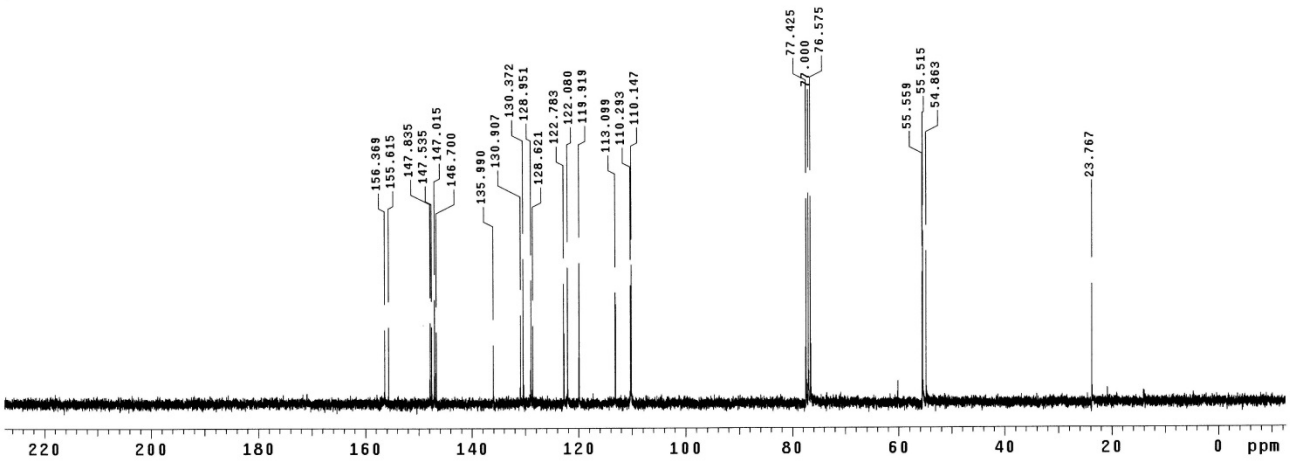


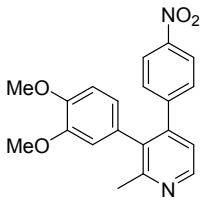
^{1}H NMR of **5i**
(300 MHz, $CDCl_3$)



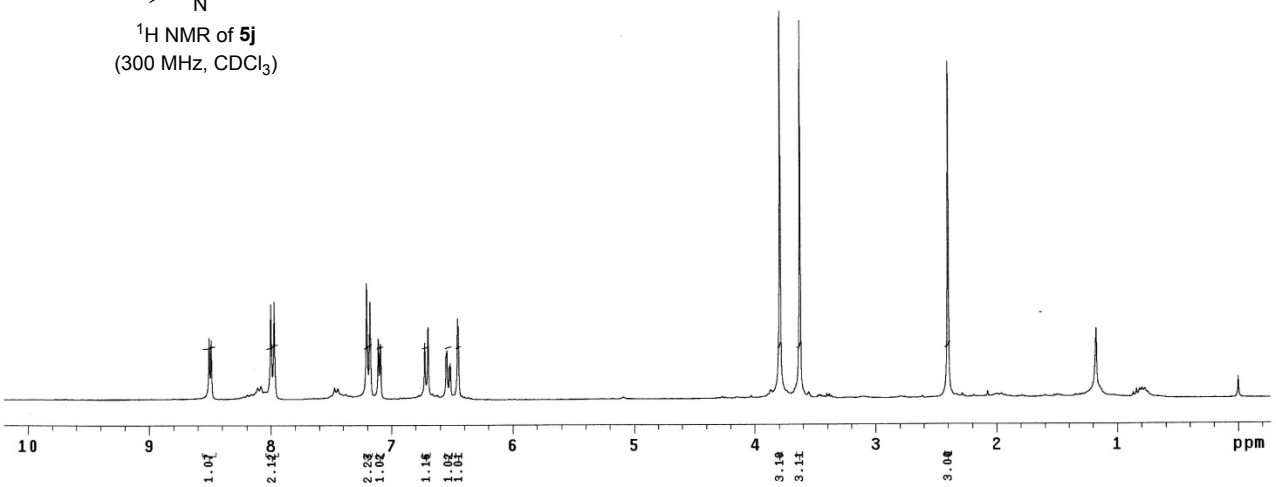


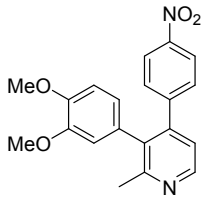
^{13}C NMR of **5i**
(75 MHz, $CDCl_3$)



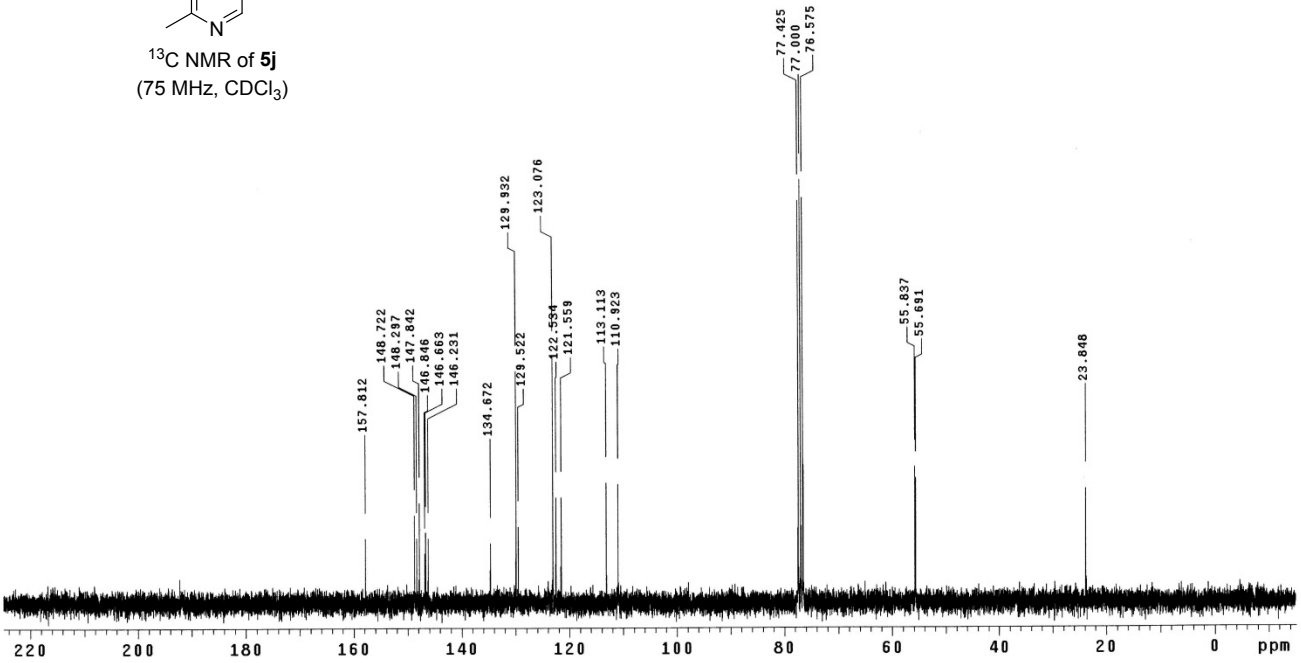


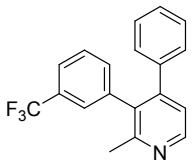
^{1}H NMR of **5j**
(300 MHz, $CDCl_3$)



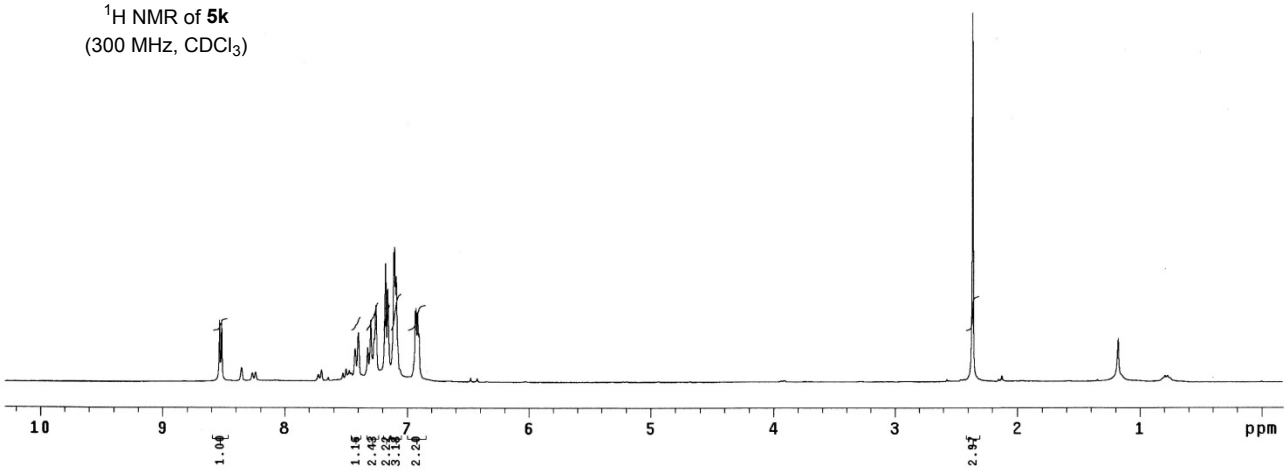


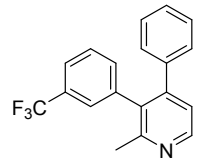
^{13}C NMR of **5j**
(75 MHz, $CDCl_3$)



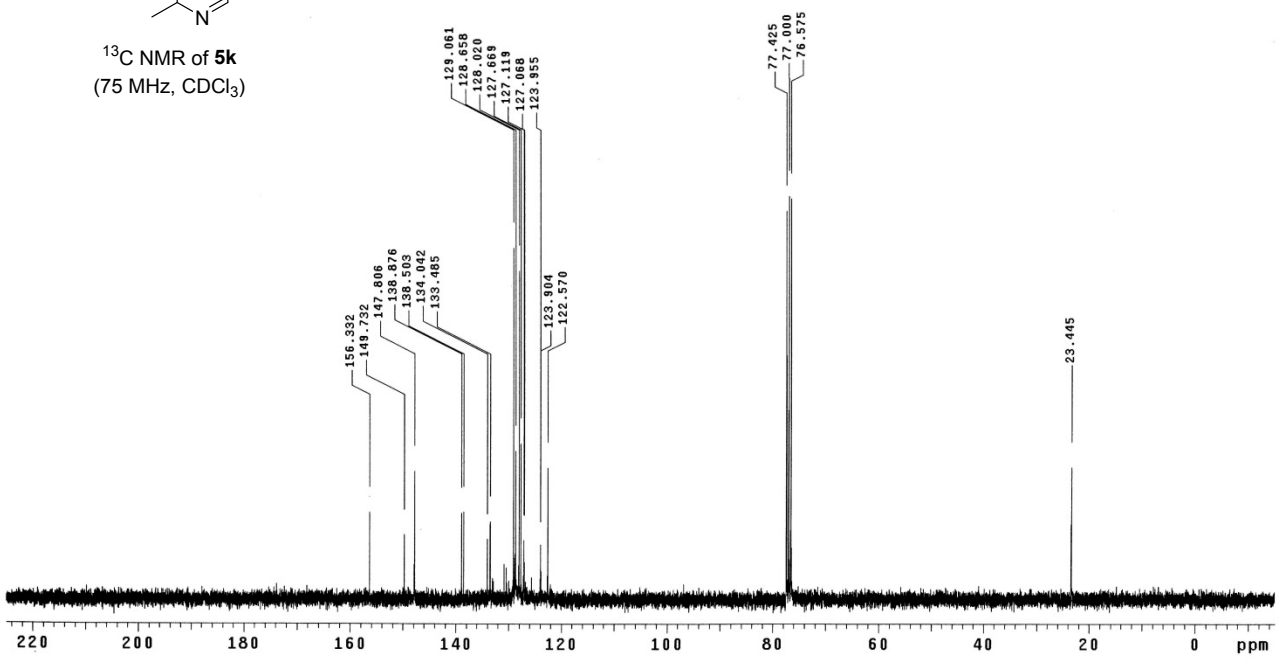


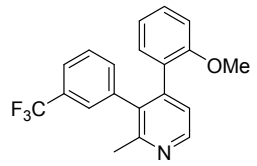
^{1}H NMR of **5k**
(300 MHz, $CDCl_3$)



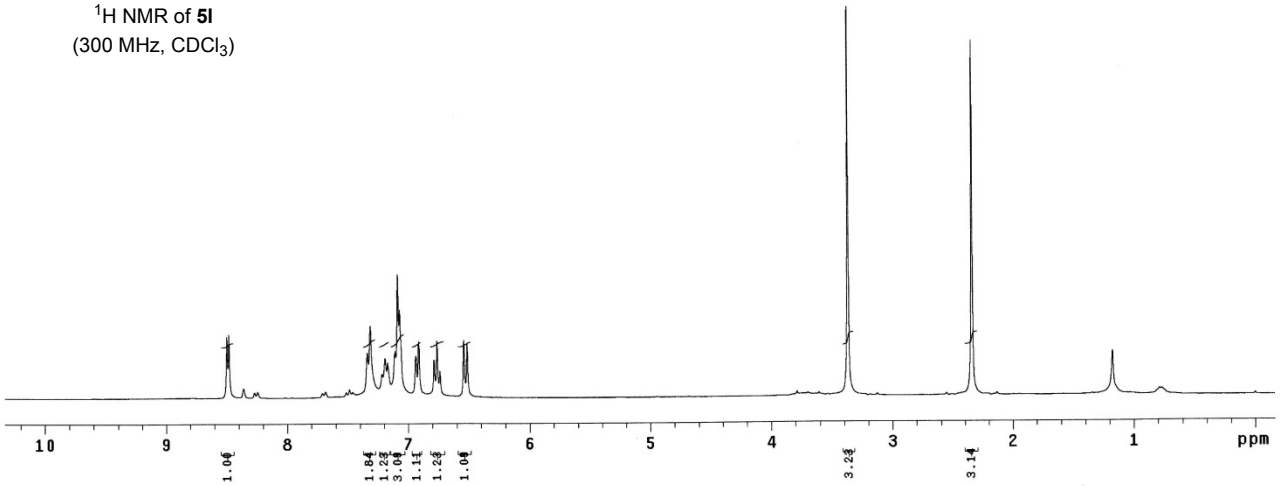


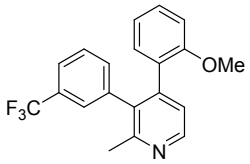
^{13}C NMR of **5k**
(75 MHz, $CDCl_3$)



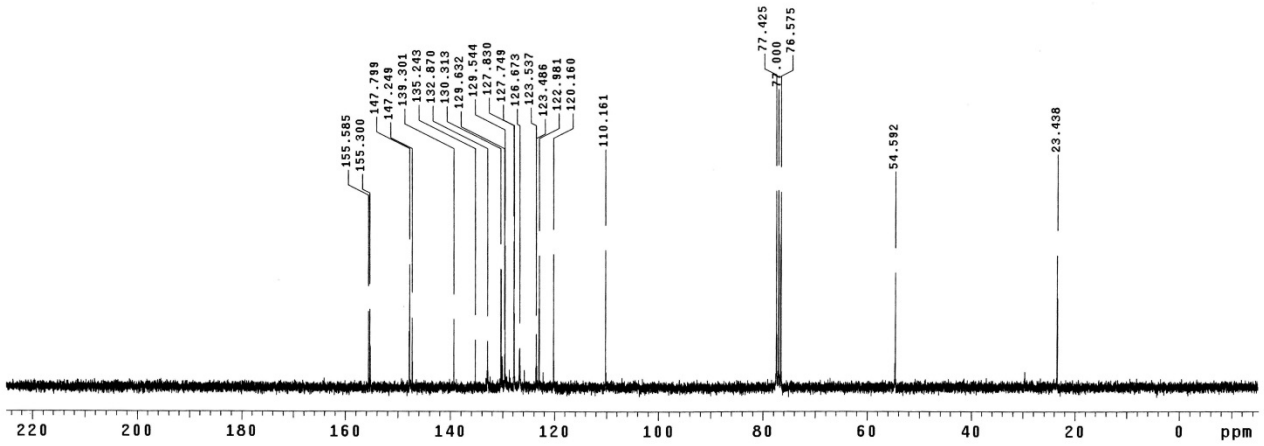


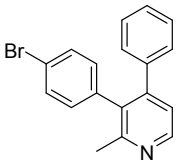
^{1}H NMR of **5l**
(300 MHz, $CDCl_3$)



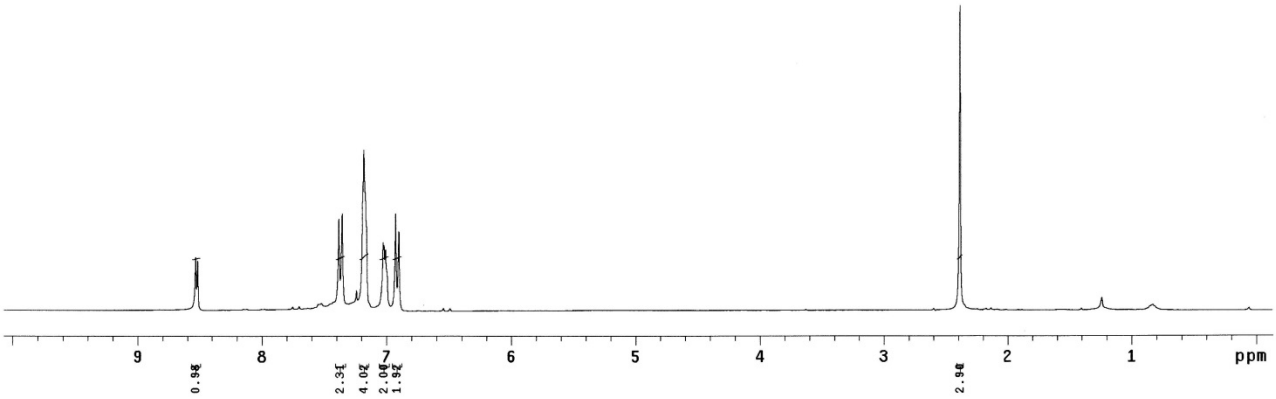


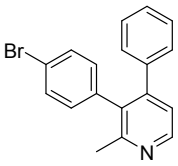
^{13}C NMR of **5l**
(75 MHz, $CDCl_3$)



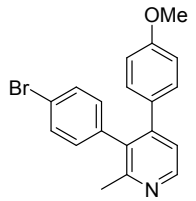


^{1}H NMR of **5m**
(300 MHz, $CDCl_3$)

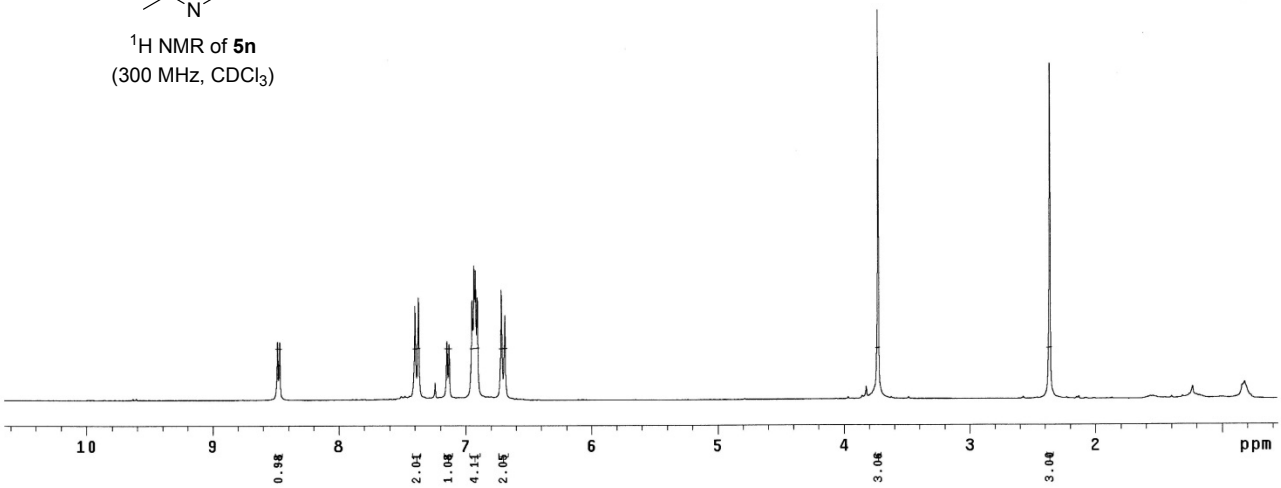


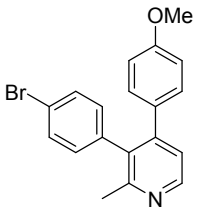


^{13}C NMR of **5m**
(75 MHz, $CDCl_3$)

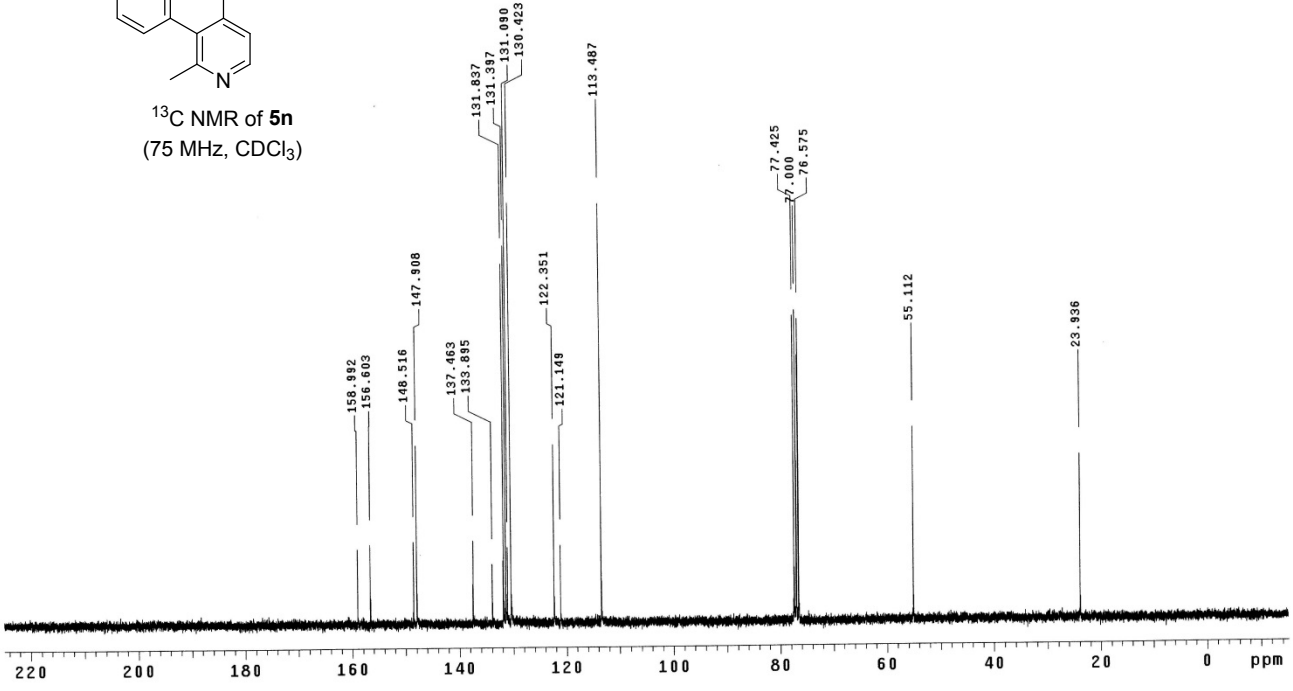


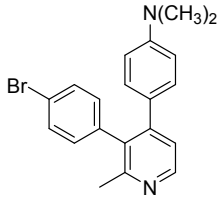
^{1}H NMR of **5n**
(300 MHz, $CDCl_3$)



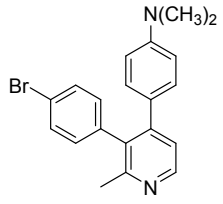


^{13}C NMR of **5n**
(75 MHz, $CDCl_3$)

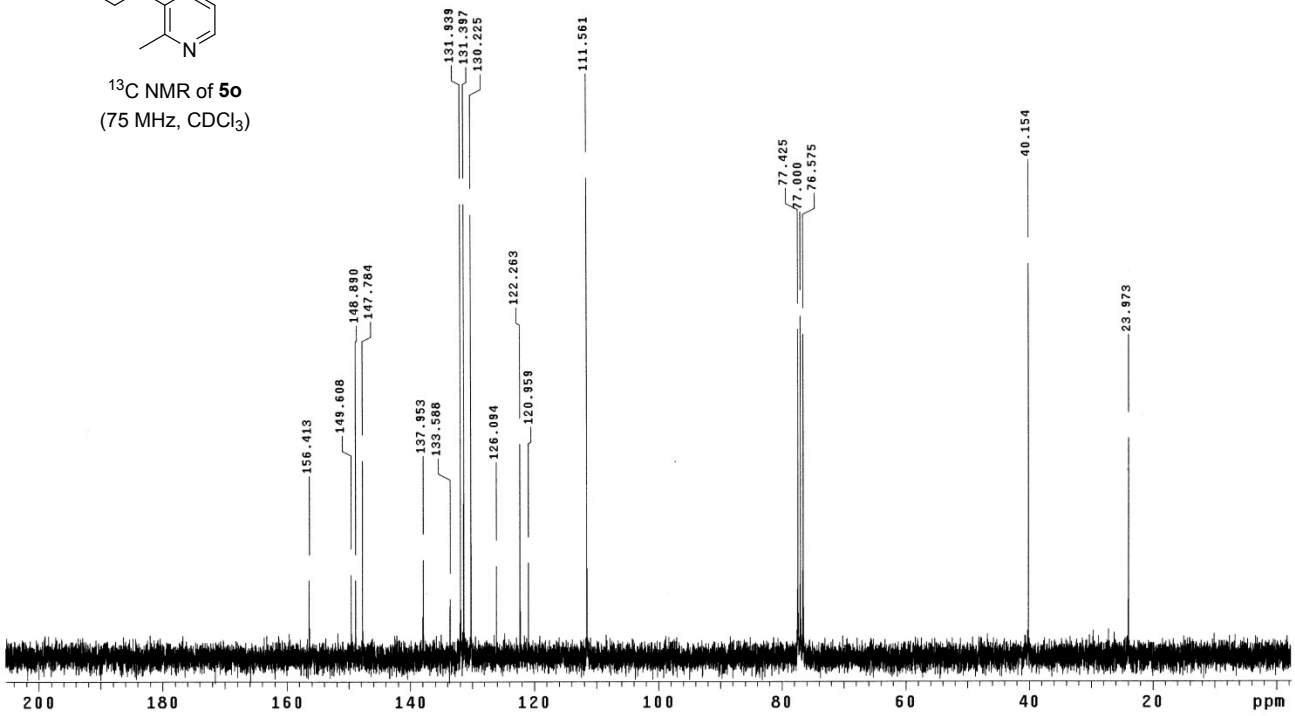


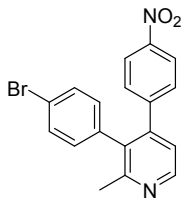


^{1}H NMR of **5o**
(300 MHz, $CDCl_3$)

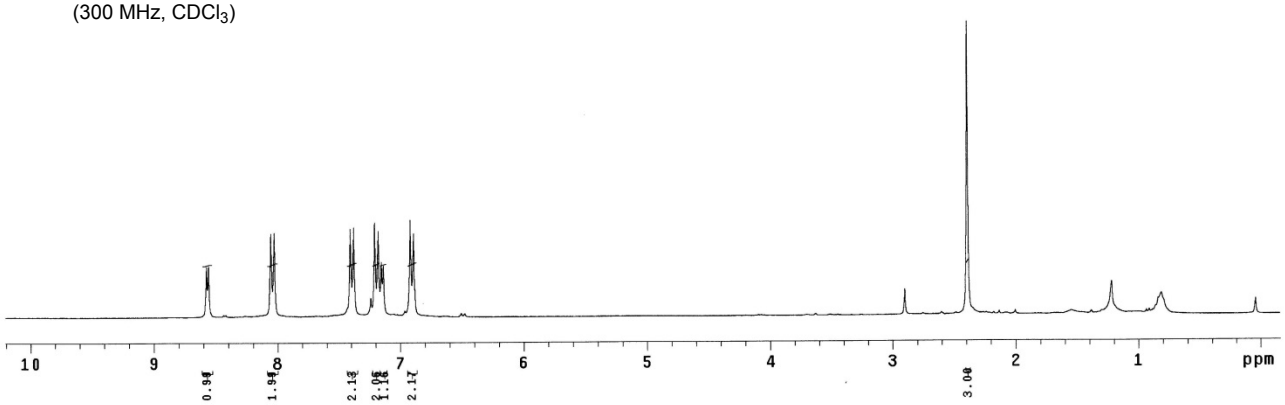


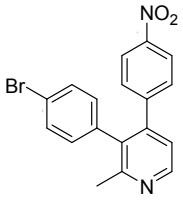
^{13}C NMR of **5o**
(75 MHz, $CDCl_3$)



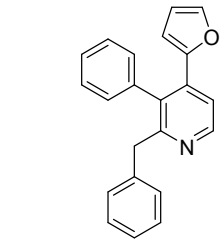


^{1}H NMR of **5p**
(300 MHz, $CDCl_3$)

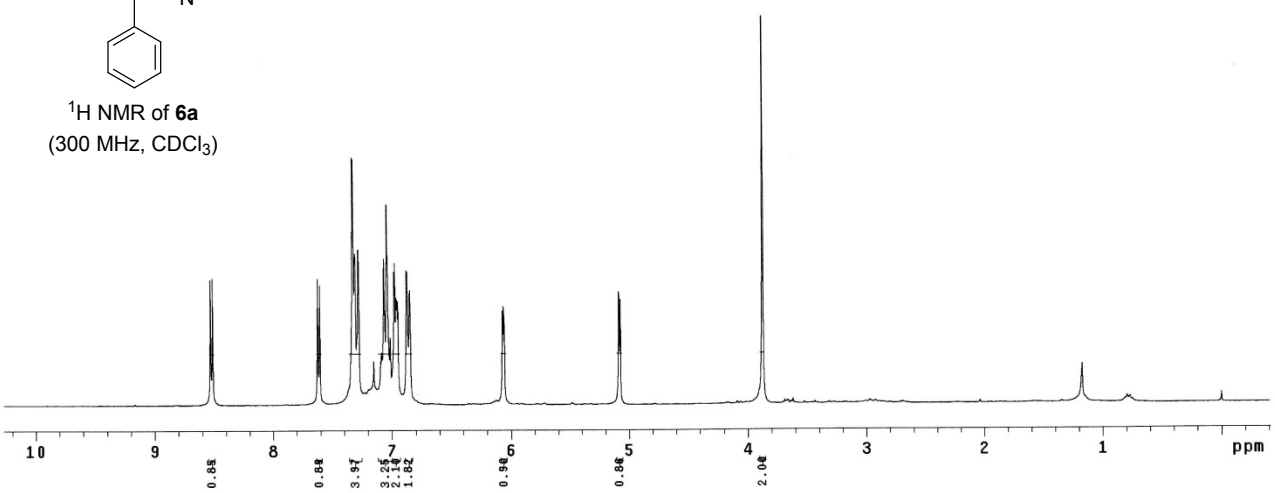


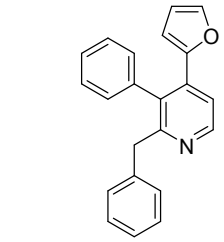


^{13}C NMR of **5p**
(75 MHz, $CDCl_3$)

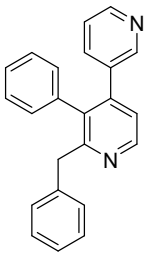


^{1}H NMR of **6a**
(300 MHz, $CDCl_3$)

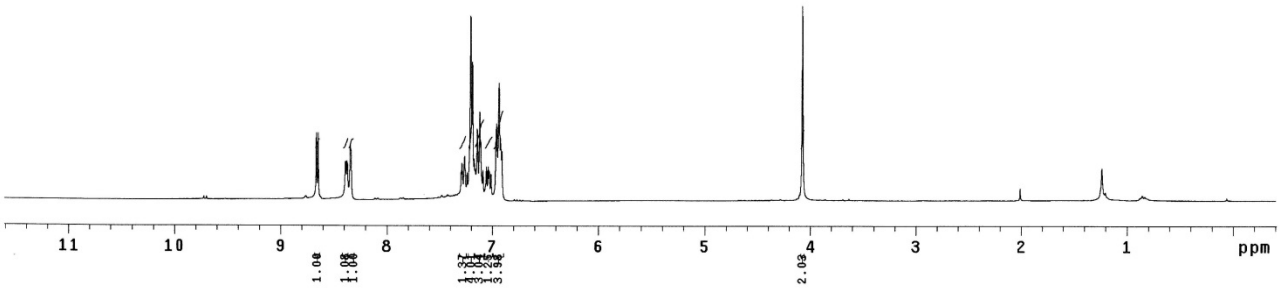


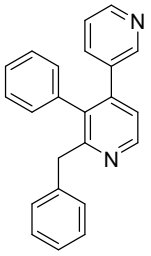


^{13}C NMR of **6a**
(75 MHz, $CDCl_3$)

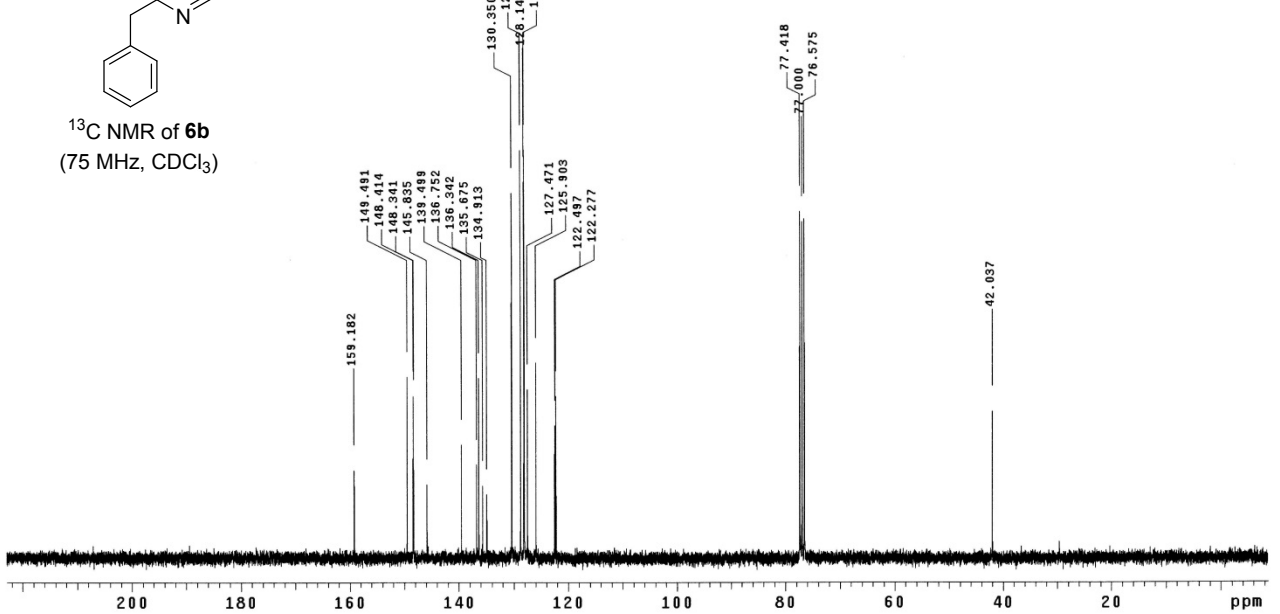


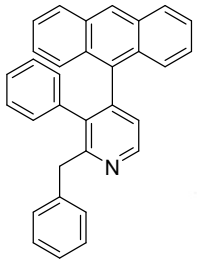
^{1}H NMR of **6b**
(300 MHz, $CDCl_3$)



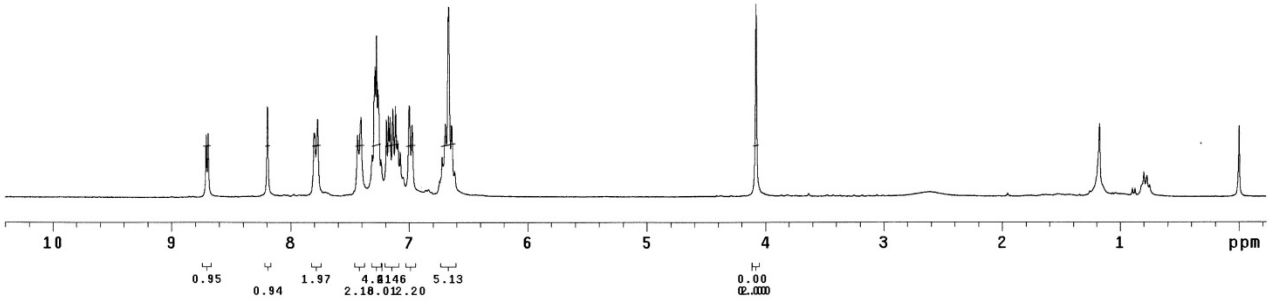


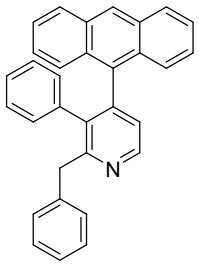
^{13}C NMR of **6b**
(75 MHz, $CDCl_3$)



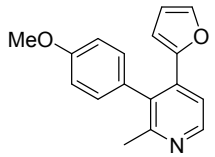


^{1}H NMR of **6c**
(300 MHz, $CDCl_3$)

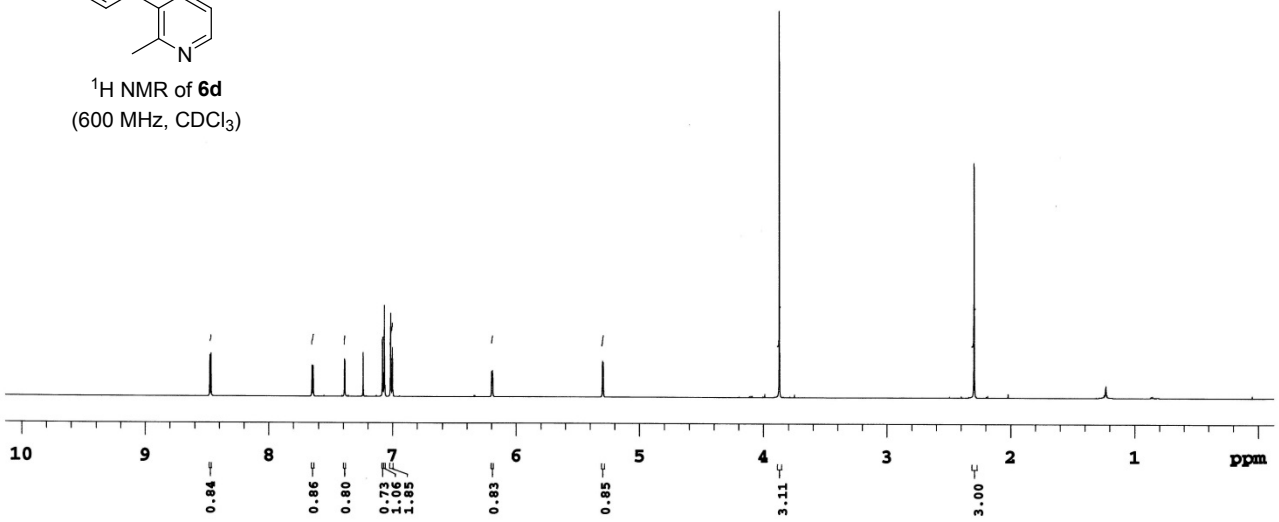


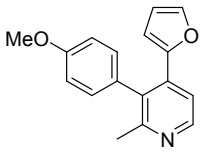


^{13}C NMR of **6c**
(75 MHz, $CDCl_3$)

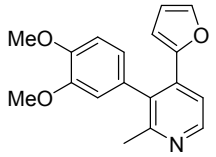


^{1}H NMR of **6d**
(600 MHz, $CDCl_3$)

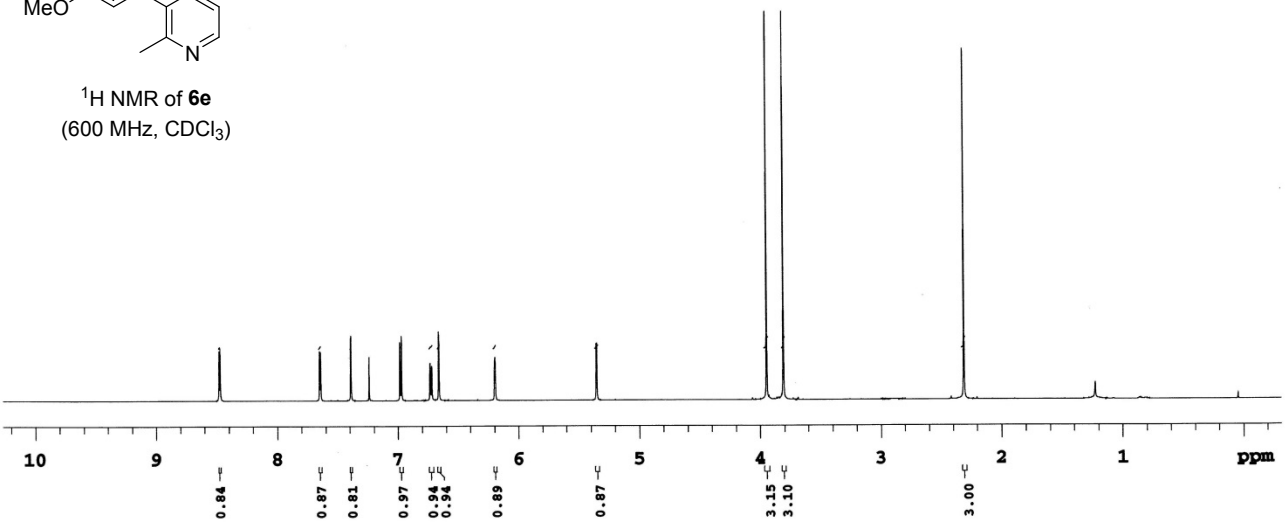


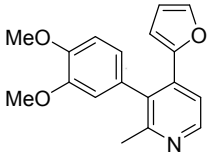


^{13}C NMR of **6d**
(75 MHz, $CDCl_3$)

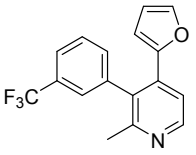


^{1}H NMR of **6e**
(600 MHz, $CDCl_3$)

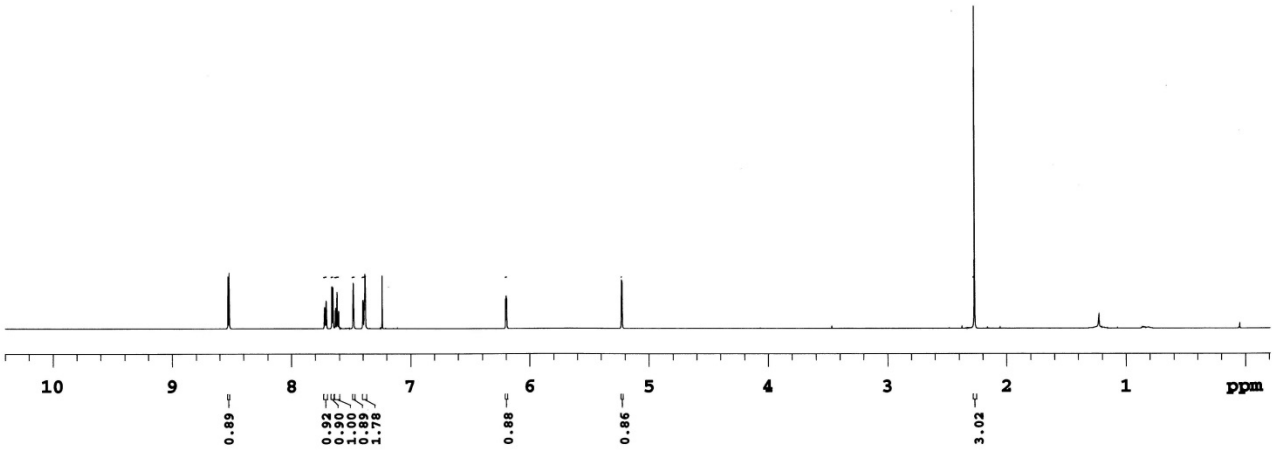


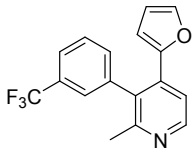


^{13}C NMR of **6e**
(150 MHz, $CDCl_3$)

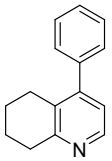


^{1}H NMR of **6f**
(600 MHz, $CDCl_3$)

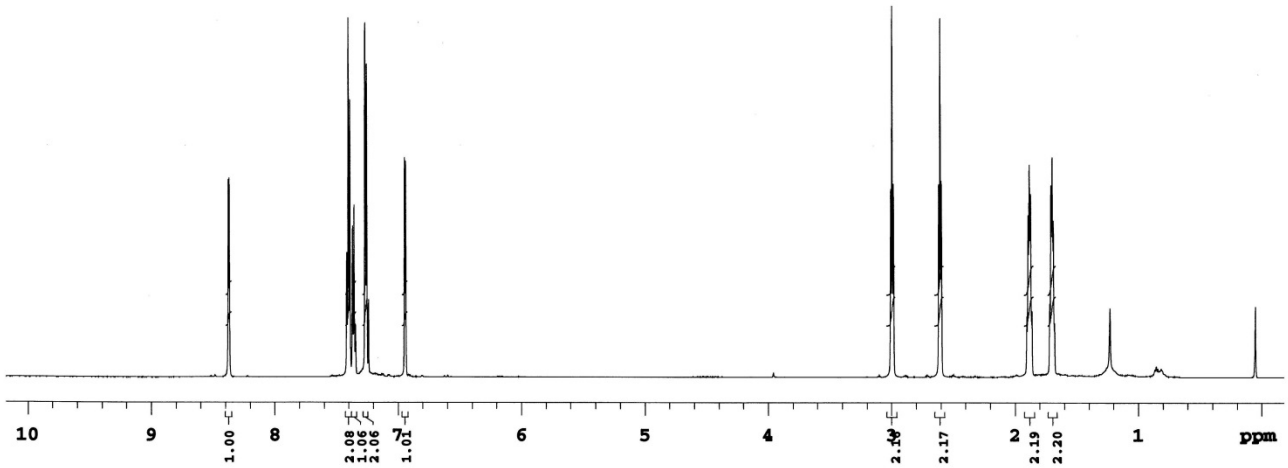


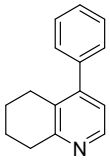


^{13}C NMR of **6f**
(150 MHz, $CDCl_3$)

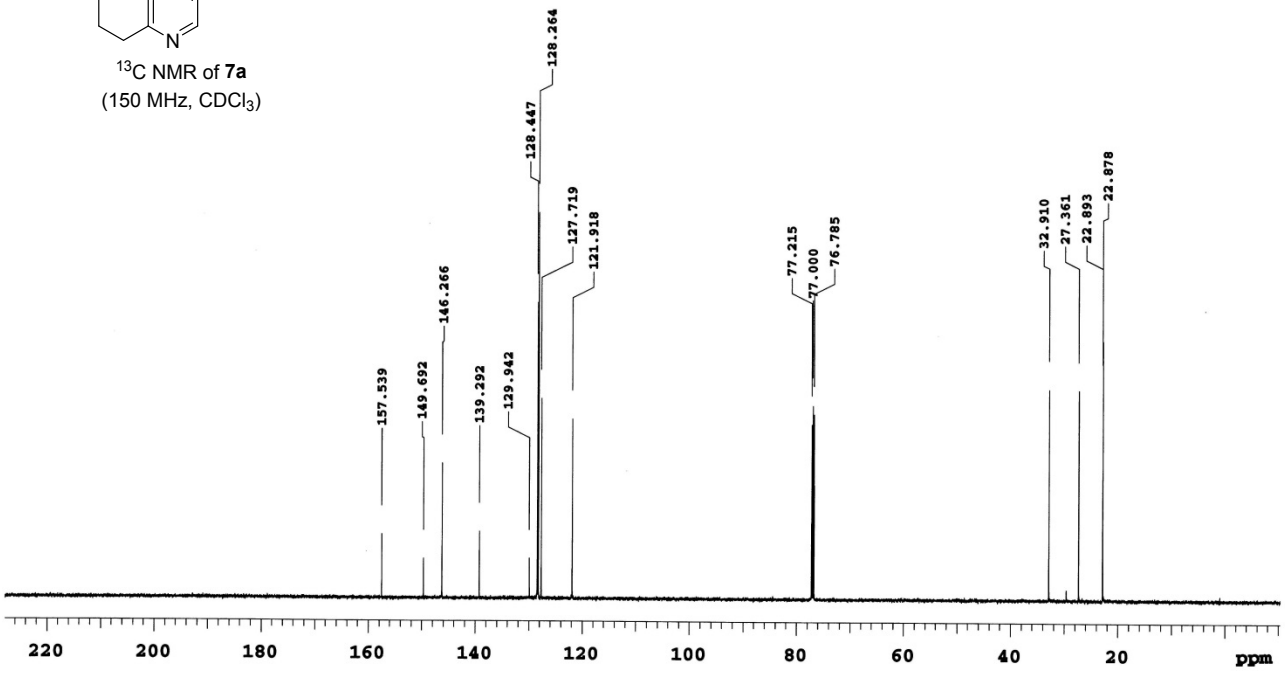


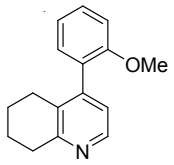
^{1}H NMR of **7a**
(600 MHz, $CDCl_3$)



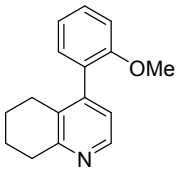


^{13}C NMR of **7a**
(150 MHz, $CDCl_3$)

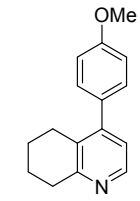




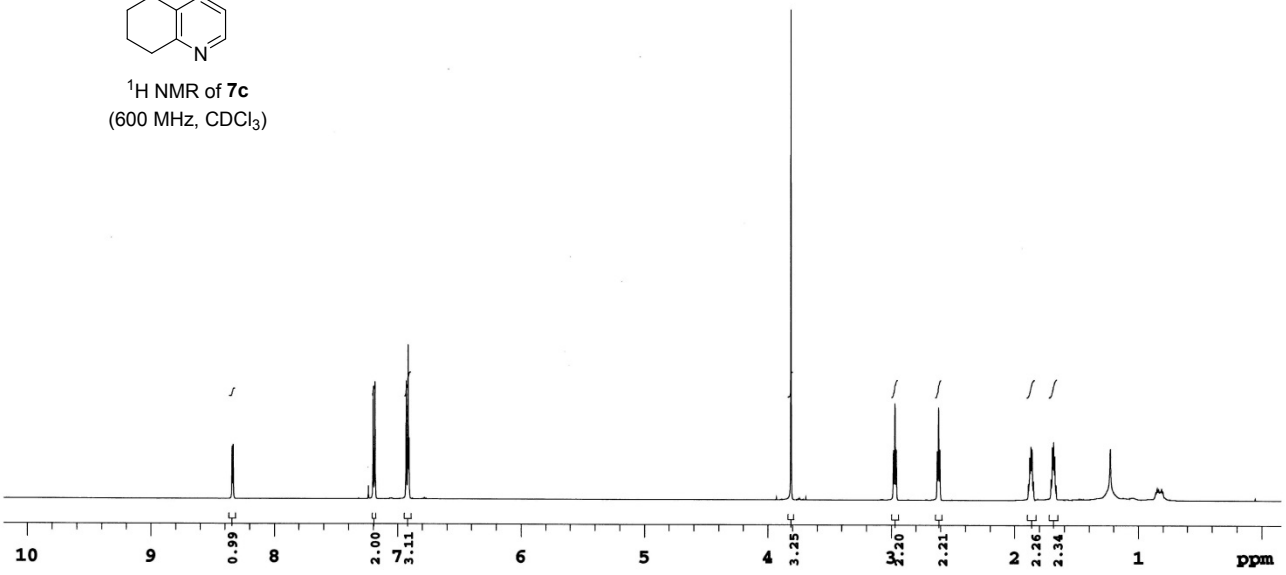
^{1}H NMR of **7b**
(600 MHz, $CDCl_3$)

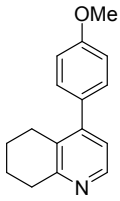


^{13}C NMR of **7b**
(150 MHz, $CDCl_3$)

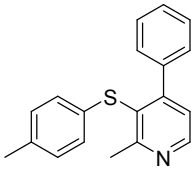


^{1}H NMR of **7c**
(600 MHz, $CDCl_3$)

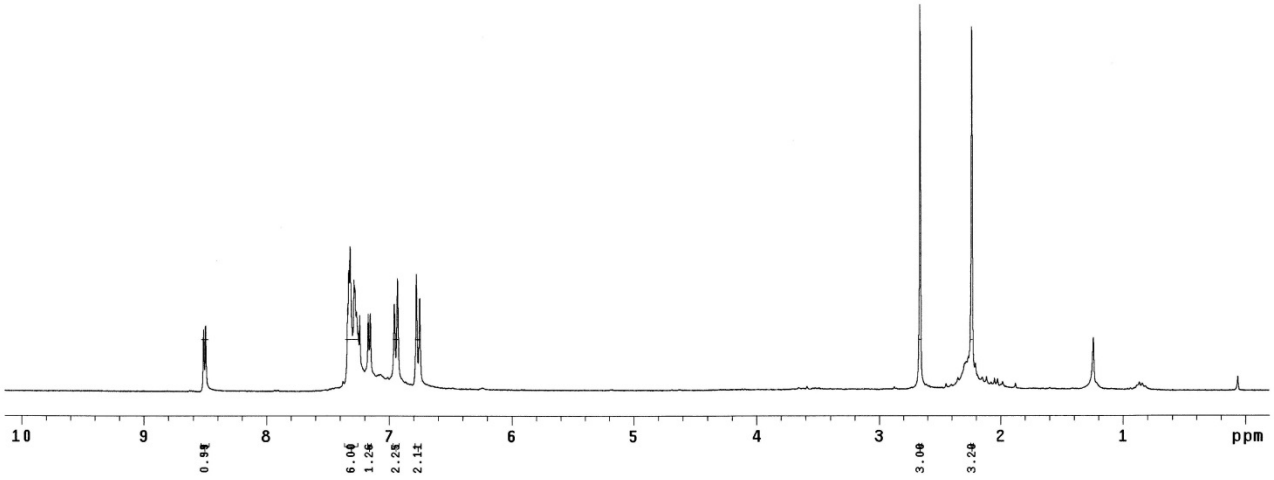


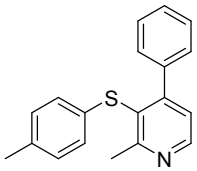


^{13}C NMR of **7c**
(150 MHz, $CDCl_3$)

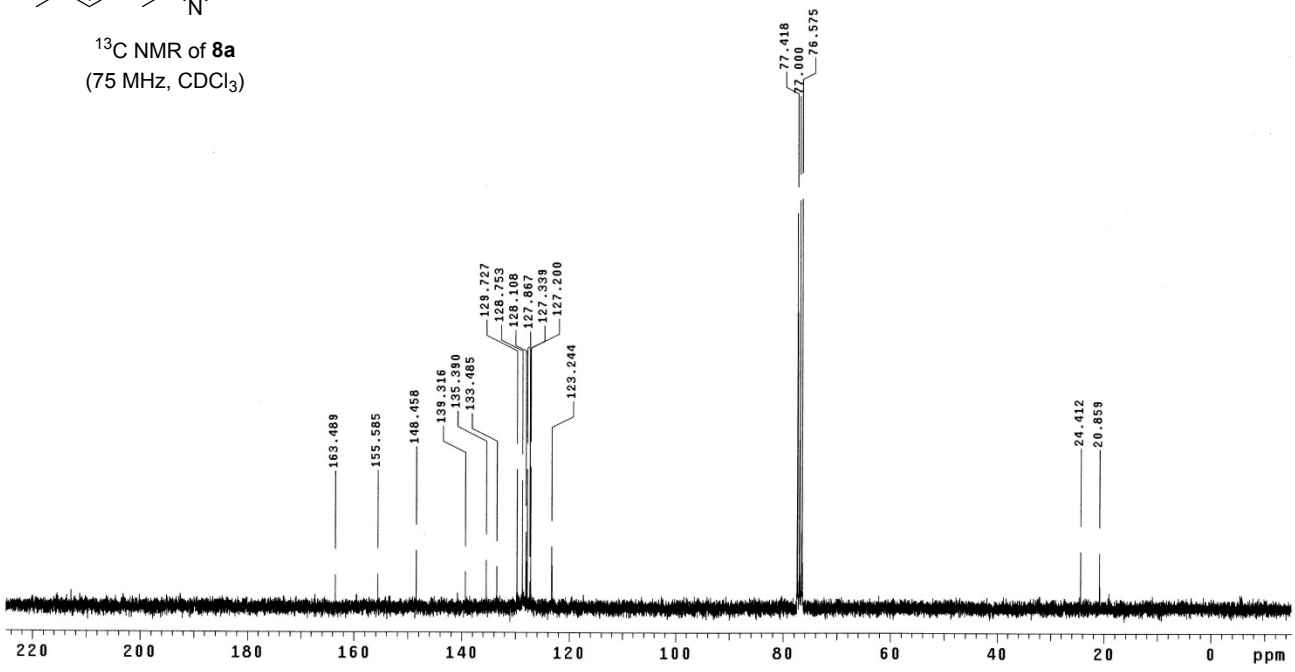


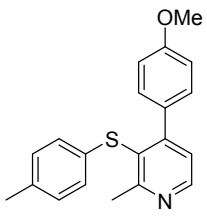
^{1}H NMR of **8a**
(300 MHz, $CDCl_3$)



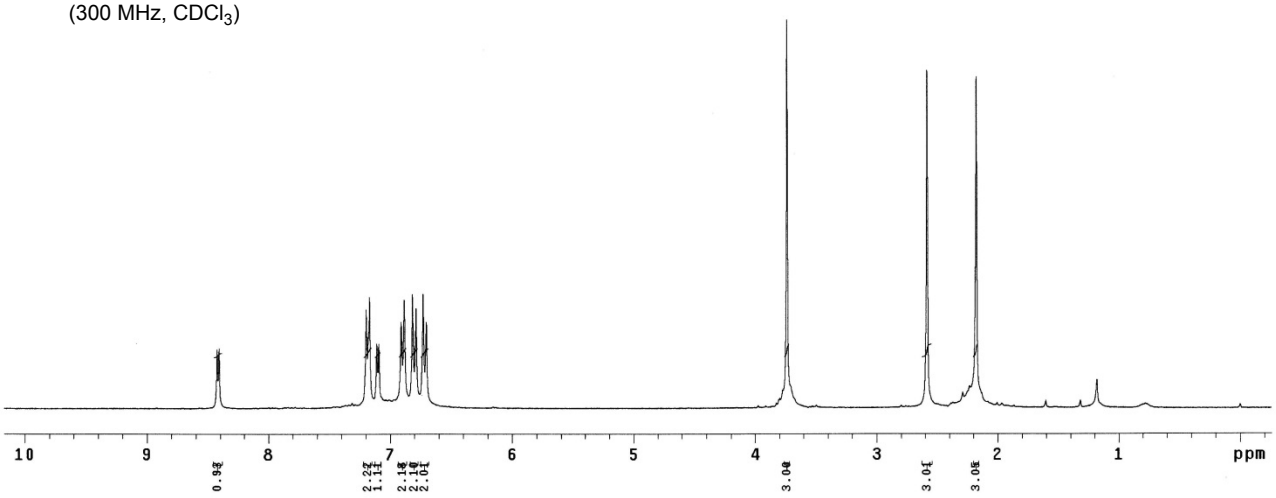


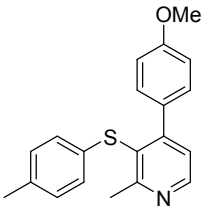
^{13}C NMR of **8a**
(75 MHz, $CDCl_3$)



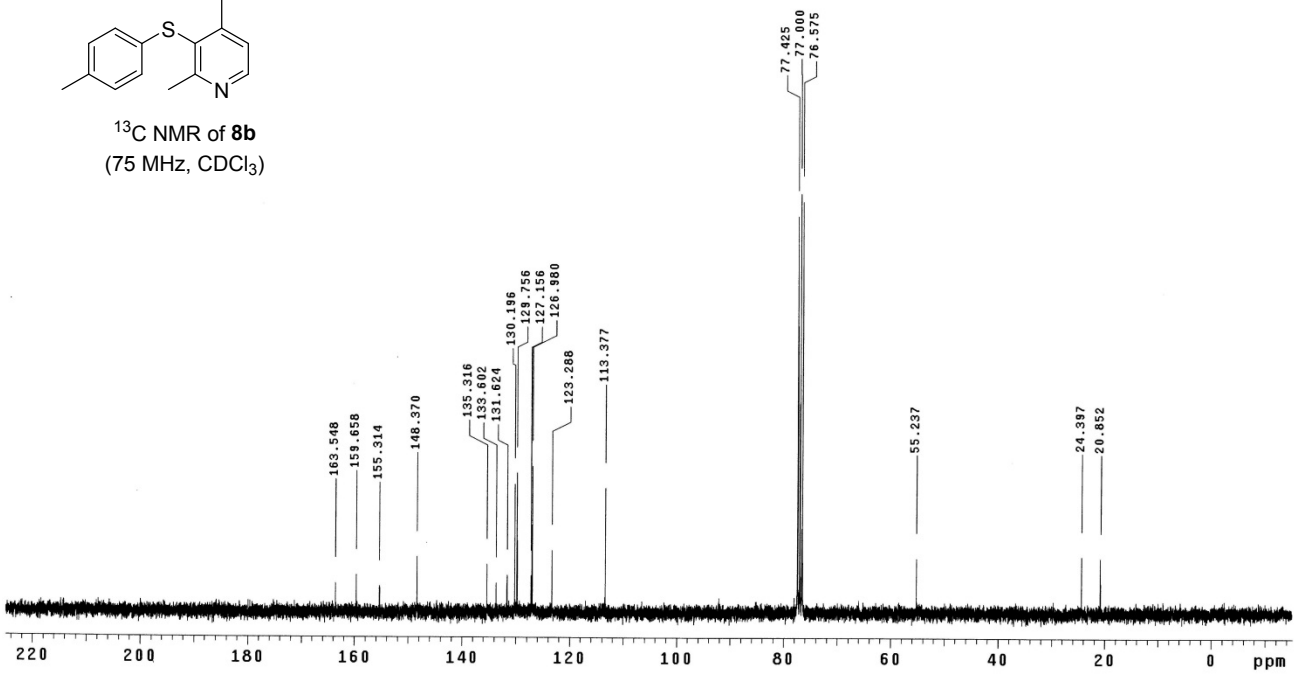


^{1}H NMR of **8b**
(300 MHz, $CDCl_3$)





^{13}C NMR of **8b**
(75 MHz, $CDCl_3$)



General remarks for antibacterial activity

The antibacterial activities of synthesized compounds were determined using a modified Kirby-Bauer disc diffusion method. Briefly, the test bacteria were grown in 10 mL of fresh Difco™ nutrient broth for 24 h. Optical density of test bacteria was measured using an Optizer 3220 (Double beam) UV-Vis spectrophotometer and found to be 0.7 at 595 nm. Aliquots of above bacterial suspension (100 μL) were then spread on Difco™ nutrient broth agar, which corresponded to the broth in which they were maintained. Gram-negative *E. coli* (KCTC-1924) and Gram-positive *S. aureus* (KCTC-1916), both obtained from the Korean Collection for Type Cultures (KCTC), were incubated at 37 °C for 20-36 h, and then the diameters of the inhibition zones were measured in millimeters. A 2 mg of each test compound was dissolved in DMSO and further diluted to 100 μg/ mL. Standard discs of ciprofloxacin served as positive controls and filter discs impregnated with DMSO as negative controls. Further, the depth of the agar in the plate is a factor to be considered in the disc diffusion method. Blank paper discs of diameter of 8.0 mm were impregnated with 10 μL of above diluted sample solutions. When a filter disc impregnated with a tested chemical is placed on agar, the chemical diffuses from the disc into the agar. The solubility of the chemical and its molecular size determines the size of the area of infiltration. When an organism is placed on the agar, and if the chemical is active, it will not grow in the area around the disc. This area of no growth around the disc is known as the zone of inhibition.

General Remarks for Sensing Cu^{2+}

A Hitachi F-7000 FL spectrofluorophotometer equipped with a 150-W xenon lamp and intensities with the slits (E_x/E_m) of 5.0/5.0 nm and the PMT voltage of 400 V was used for recording the fluorescence spectra. A 1.5 mL of compound **6c** (0.07 μM) was taken in a typical fluorescence quartz cuvette and titrated against different concentrations of $CuCl_2$ solution in acetonitrile (12.5 μM-250.0 μM). The fluorescence response of sample solution was recorded upon addition of various concentrations of Cu^{2+}.

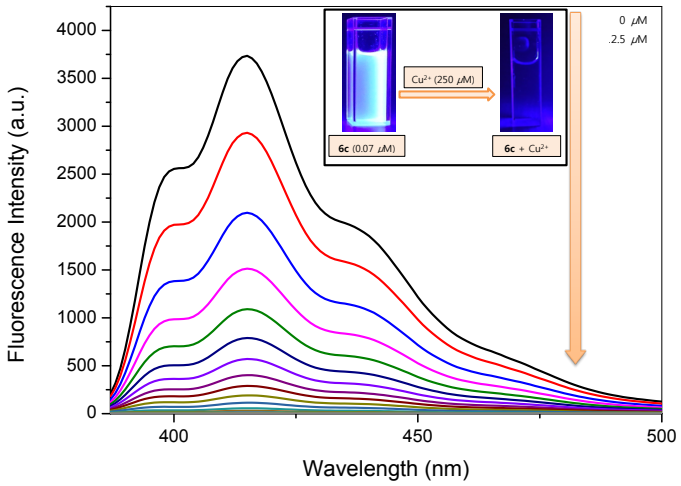


Figure S1. Fluorescence response of **6c** (0.07 μM) upon addition of various concentrations of Cu^{2+} in acetonitrile solution. Inset: **6c** (0.07 μM) before and after addition of Cu^{2+}.

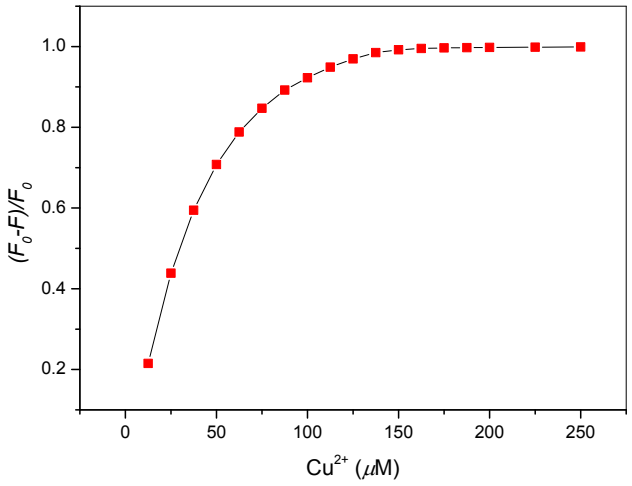


Figure S2. Relationship between quenching efficiency ($(F_0-F)/F_0$) and concentration of Cu^{2+} ions.

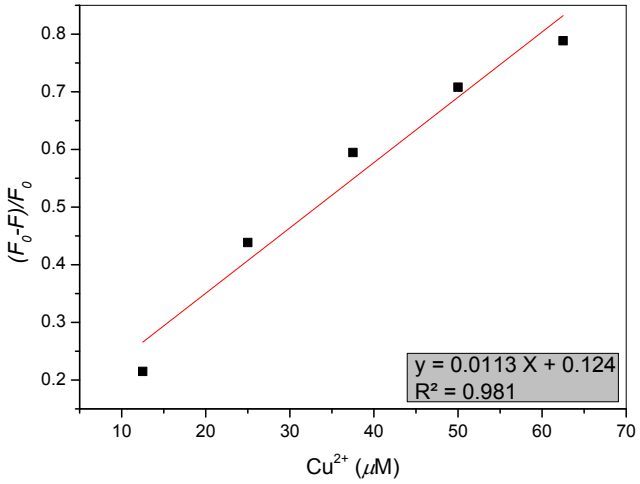


Figure S3. Linear plot of quenching efficiency versus the concentration of Cu^{2+} ions.