Supporting Information

Synthesis of Polysubstituted Pyridines via a One-Pot Metal-Free Strategy

Hongbo Wei,[†] Yun Li,[*,†] Ke Xiao,[†] Bin Cheng,[†] Huifei Wang,[‡] Lin Hu,[$] and Hongbin Zhai[*,†,‡,⊥]

[†] The State Key Laboratory of Applied Organic Chemistry, College of Chemistry and Chemical Engeneering, Lanzhou University, Lanzhou 730000, China

[‡] Laboratory of Chemical Genomics, School of Chemical Biology and Biotechnology, Shenzhen Graduate School of Peking University, Shenzhen 518055, China.

[$] Department of Chemistry, Brandeis University, Waltham, Massachusetts 02454-9110, United States

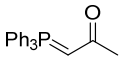
[⊥] Collaborative Innovation Center of Chemical Science and Engineering (Tianjin), Tianjin 300071, China

CONTENTS

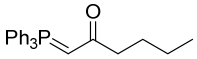
Part 1. Experimental Procedures and Analytical Data

General Methods. Melting points are uncorrected. NMR spectra were recorded in $CDCl_3$, and (^1H NMR at 400 MHz and ^{13}C NMR at 100 MHz) using TMS as the internal standard. Column chromatography was performed on silica gel. Anhydrous THF, PhMe and PhH were distilled over sodium benzophenone ketyl under argon gas. Anhydrous DCE and CH_3CN were distilled over calcium hydride under argon gas. All other solvents and reagents were used as obtained from commercial sources without further purification.

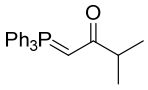
Synthesis of phosphoranes 2a-2h[1]



1-(Triphenylphosphoranylidene)propan-2-one 2a.[1, 2] A solution of the 1-bromopropan-2-one (1.0 g, 7.3 mmol) and triphenylphosphine (1.9 g, 7.3 mmol) were refluxed in dry PhMe (6 mL) for 4 h. After completion, the reaction mixture was allowed to cool to room temperature and the phosphonium salt was filtered and washed with Et_2O (3×100 mL). The phosponium salt was then dissolved in H_2O:DCM (1.5:1) and 2 M. aq. NaOH (100 mL) was added. The mixture was stirred for 2 h and then extracted with DCM (3×100 mL). The combined organic phases were washed with brine, dried ($MgSO_4$) and concentrated in vacuo to afford **2a** as a white solid (2.0 g, 89%): mp 212-214 ^oC; δ_H ($CDCl_3$, 400 MHz) 7.64-7.62 (m, 6H), 7.54-7.50 (m, 3H), 7.46-7.41 (m, 6H), 3.70 (d, J = 26.4 Hz, 1H), 2.09 (s, 3H); δ_c ($CDCl_3$, 100 MHz) 190.8, 133.1 (d, J = 10 Hz), 132.0 (d, J = 3 Hz), 128.8 (d, J = 12 Hz), 127.3 (d, J = 90 Hz), 51.5 (d, J = 107 Hz), 28.5 (d, J = 15 Hz).

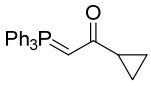


1-(Triphenylphosphoranylidene)-2-hexanone 2c.[3] Compound **2c** was prepared according to the same procedure for the synthesis of **2a** by employing 1-bromohexan-2-one (1.3 g, 7.3 mmol), triphenylphosphine (1.9 g, 7.3 mmol) and dry PhMe (6 mL), gave **2c** as a white solid (1.9 g, 73%): mp 90-92 ^oC; δ_H ($CDCl_3$, 400 MHz) 7.66-7.61 (m, 6H), 7.53-7.50 (m, 3H), 7.45-7.41 (m, 6H), 3.67 (brs, 1H), 2.30 (t, J = 7.2 Hz, 2H), 2.09 (m, 2H), 1.64 (m, 2H), 0.91(t, J = 7.2 Hz, 3H); δ_c ($CDCl_3$, 100 MHz) 194.1, 133.0 (d, J = 10 Hz), 131.9 (d, J = 2 Hz), 128.8 (d, J = 13 Hz), 127.4 (d, J = 90 Hz), 51.0 (d, J = 103 Hz), 41.5 (d, J = 5 Hz), 29.4, 22.8, 14.1.

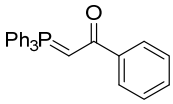


3-Methyl-1-(triphenylphosphoranylidene)-2-butanoe 2d.[4] Compound **2d** was prepared according to the same procedure for the synthesis of **2a** by employing 1-bromo-3-methylbutan-2-one (2.0 g, 12.1 mmol), triphenylphosphine (3.2 g, 12.1 mmol) and dry PhMe (10 mL), gave **2d** as a white solid (3.5 g, 83%): mp 171-172 ^oC; δ_H ($CDCl_3$, 400 MHz) 7.69-7.60 (m, 6H), 7.53-7.49 (m, 3H),

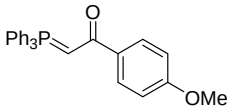
7.44-7.40 (m, 6H), 3.67 (d, J = 20.0 Hz, 1H), 2.49 (m, 1H), 1.16 (d, J = 6.8 Hz, 6H); δ_c ($CDCl_3$, 100 MHz) 198.6, 133.0 (d, J = 10 Hz), 131.8 (d, J = 3 Hz), 128.8 (d, J = 12 Hz), 127.6 (d, J = 90 Hz), 48.4 (d, J = 108 Hz), 39.4 (d, J = 14 Hz), 21.0.



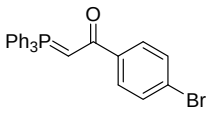
1-Cyclopropyl-2-(triphenylphosphoranylidene)ethanone 2e.[5] Compound **2e** was prepared according to the same procedure for the synthesis of **2a** by employing 2-bromo-1-cyclopropylethan-1-one (1.5 g, 9.2 mmol), triphenylphosphine (2.4 g, 9.2 mmol) and dry PhMe (15 mL), gave **2e** as a white solid (2.3 g, 74%): mp 181-182 ^oC; δ_H ($CDCl_3$, 400 MHz) 7.66-7.61 (m, 6H), 7.54-7.50 (m, 3H), 7.45-7.41 (m, 6H), 3.81 (s, 1H), 1.78 (m, 1H), 0.88 (m, 2H), 0.59 (m, 2H); δ_c ($CDCl_3$, 100 MHz) 192.5, 133.1 (d, J = 10 Hz), 131.9 (d, J = 3 Hz), 128.8 (d, J = 12 Hz), 127.6 (d, J = 90 Hz), 49.4 (d, J = 109 Hz), 19.4 (d, J = 19 Hz), 7.0.



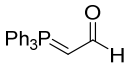
1-Phenyl-2-(triphenylphosphoranylidene)ethanone 2f.[6] Compound **2f w**as prepared according to the same procedure for the synthesis of **2a** by employing 2-bromo-1-phenylethanone (2.0 g, 10.0 mmol), triphenylphosphine (2.6 g, 10.0 mmol) and dry THF (30 mL), gave **2f** as an orange solid (2.8 g, 74%): mp 182-184 ^oC; δ_H ($CDCl_3$, 400 MHz) 7.99-7.97 (m, 2H), 7.70-7.62 (m, 6H), 7.54-7.50 (m, 3H), 7.45-7.41 (m, 6H), 7.33-7.31 (m, 3H), 4.42 (s, 1H); δ_c ($CDCl_3$, 100 MHz) 184.9, 141.3 (d, J = 14 Hz), 133.2 (d, J = 10 Hz), 132.1, 129.4, 129.0, 128.9 (d, J = 12 Hz), 127.8, 127.1 (d, J = 91 Hz), 127.0, 50.7 (d, J = 109 Hz).



1-(4-Methoxyphenyl)-2-(triphenylphosphoranylidene)ethanone 2g.[1] Compound **2g** was prepared according to the same procedure for the synthesis of **2a** by employing 2-bromo-1-(4-methoxy)phenylethanone (1.2 g, 5.2 mmol), triphenylphosphine (1.4 g, 5.2 mmol) and dry THF (5 mL), gave **2g** as an orange solid (2.0 g, 95%): mp 160-161 ^oC; δ_H ($CDCl_3$, 400 MHz) 7.90 (*d*, J = 8.4 Hz, 2H), 7.71-7.66 (m, 6H), 7.53-7.49 (m, 3H), 7.44-7.40 (m, 6H), 6.82 (d, J = 8.8 Hz 2H), 4.33 (s, 1H), 3.78 (s, 3H); δ_c (100 MHz, $CDCl_3$) 184.4, 160.8, 134.1 (d, J = 14 Hz), 133.2 (d, J = 10 Hz), 132.0 (d, J = 2 Hz),128.9 (d, J = 12 Hz), 128.6, 127.3 (d, J = 91 Hz), 112.9, 55.3, 49.5 (d, J = 113 Hz).



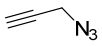
1-(4-Bromophenyl)-2-(triphenylphosphoranylidene)ethanone 2h.[7] Compound **2h** was prepared according to the same procedure for the synthesis of **2a** by employing 2, 4′-dibromoacetophenone (1.9 g, 6.8 mmol), triphenylphosphine (1.8 g, 6.8 mmol) and dry THF (6 mL), gave **2h** as an orange solid (2.5 g, 81%): mp 199-201 ^{o}C; δ_H ($CDCl_3$, 400 MHz) 7.85 (*d*, *J* = 8.4 Hz, 2H), 7.74-7.69 (m, 6H), 7.58-7.54 (m, 3H), 7.49-7.45 (m, 8H), 4.42 (s, 1H); δ_c ($CDCl_3$, 100 MHz) 183.2, 140.1 (d, *J* = 14 Hz), 132.9 (d, *J* = 10 Hz), 132.0, 130.6, 128.8 (d, *J* = 12 Hz), 126.6 (d, *J* = 90 Hz), 123.4, 51.0 (d, *J* = 111 Hz).



2-(Triphenylphosphoranylidene)-acetaldehyde 2b.[8] A mixture of $CHCl_3$ (50 mL) and 50% aqueous solution of chloroethanal (4.0 g, 0.026 mol) was refluxed using a Dean–Stark trap at 55 ^{o}C. After destillation of about 40 mL of the azeotrope, triphenylphosphine (6.7 g, 0.026 mol) was added to the yellow solution and the mixture was refluxed for 24 h. The solvent was evaporated under reduced pressure, the residual phosphonium salt was dissolved in 35 mL of H_2O, and the organic phases were separated and discarded. After addition of activated charcoal, the mixture was stirred for 30 min at room temperature, and filtered. Under vigrous stirring, 36 mL of 1N NaOH solution were added dropwise to the filtrate until the pH became 7-8. The resulting precipitate was filtered and dried to give **2b** as a brown solid (4.1 g, 51%): mp 176-178 ^{o}C;

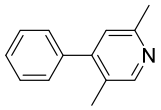
Synthesis of azidoprop-1-yne[9]

Warning. This compound is known to be potentially explosive and appropriate caution should be applied!

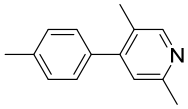


The 3-bromo-1-propyne (2.0 g, 16.8 mmol) was added to a 30% aqueous solution of sodium azide (4.36 g, 67.2 mmol) in a flask with reflux condenser. The flask was immersed 1-2 cm under the surface in an ultrasonic cleaner at 50 ^{o}C for 2 h. Then the product was extract four times with ether (4×60 mL). After drying the solution with $MgSO_4$, the ether was removed and azidoprop-1-yne (2.17 g, 80%) was obtained as a yellow oil. δ_H ($CDCl_3$, 400 MHz) 3.91 (d, *J* = 2.8 Hz, 2H), 2.56 (d, *J* = 3.2 Hz, 1H).

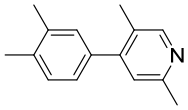
Synthesis of 3a-3ac



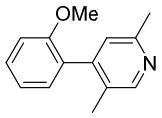
2,5-Dimethyl-4-phenylpyridine (3a).[10] To a sealed-tube containing dry PhMe (7 mL), benzaldehyde **1a** (100 mg, 0.942 mmol) and phosphorus ylides **2a** (315 mg, 0.989 mmol) were added. The sealed-tube was evacuated and back filled with argon. The reaction mixture was heated to 90 ^{o}C. After stirred for 5 h, substrate **1a** was consumed and the intermediate **4** was formed as indicated by TLC. Then the mixture was cooled down to room temperature. A solution of azidoprop-1-yne (305 mg, 3.769 mmol) in 2 mL of PhMe and triphenylphosphine (1.091 g, 4.159 mmol) were added and stirred for 30 min. Then the mixture was warmed to 120 ^{o}C for 24 h. After the removal of toluene, the residue was subjected to flash chromatography (silica, PE/AcOEt 50:1 and 10:1) to give compound **3a** (138 mg, 80%) as a colorless oil. δ_H ($CDCl_3$, 400 MHz) 8.39 (s, 1H), 7.46-7.39 (m, 3H), 7.31 (d, J = 7.2 Hz 2H), 7.03 (s, 1H), 2.56 (s, 3H), 2.23 (s, 3H); δ_c ($CDCl_3$, 100 MHz) 155.8, 150.5, 149.5, 139.4, 128.5, 128.4, 127.8, 127.4, 123.5, 23.8, 16.8. MS (ESI) 184.1 (M + H).



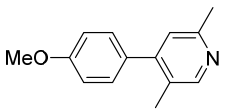
2,5-Dimethyl-4-(p-tolyl)pyridine (3b).[11] Compound **3b** was prepared according to the same procedure for the synthesis of **3a** by employing dry PhMe (6 mL), **1b** (100 mg, 0.832 mmol), **2a** (278 mg, 0.874 mmol), azidoprop-1-yne (270 mg, 3.329 mmol) and triphenylphosphine (895 mg, 3.142 mmol). The residue was purified by chromatography (silica, PE/AcOEt 50:1 and 10:1) to give compound **3b** (164 mg, 87%) as a colorless oil. δ_H ($CDCl_3$, 400 MHz) 8.39 (s, 1H), 7.25 (d, J = 8.8 Hz, 2H), 7.21 (d, J = 8.0 Hz 2H), 7.04 (s, 1H), 2.57 (s, 3H), 2.41 (s, 3H), 2.24 (s, 3H); δ_c ($CDCl_3$, 100 MHz) 155.2, 150.2, 149.7, 137.8, 136.1, 129.1, 128.3, 127.8, 123.8, 23.4, 21.1, 16.8. MS (ESI) 198.6 (M + H).



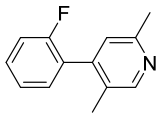
4-(3,4-Dimethylphenyl)-2,5-dimethylpyridine (3c).[12] Compound **3c** was prepared according to the same procedure for the synthesis of **3a** by employing dry PhMe (5 mL), **1c** (100 mg, 0.745 mmol), **2a** (249 mg, 0.783 mmol), azidoprop-1-yne (241 mg, 2.981 mmol) and triphenylphosphine (801 mg, 3.056 mmol). The residue was purified by chromatography (silica, PE/AcOEt 50:1 and 10:1) to give compound **3c** (133 mg, 85%) as a colorless oil. δ_H ($CDCl_3$, 400 MHz) 8.35 (s, 1H), 7.17 (d, J = 7.6 Hz, 1H), 7.07 (s, 1H), 7.03 (d, J = 7.6 Hz, 1H), 6.99 (s, 1H), 2.52 (s, 3H), 2.29 (s, 6H), 2.21 (s, 3H); δ_c (100 MHz, $CDCl_3$) δ 155.4, 150.2, 149.3, 136.7, 136.3, 136.0, 129.5, 129.3, 127.2, 125.7, 123.3, 23.6, 19.5, 19.2, 16.6. MS (ESI) 212.1 (M + H).



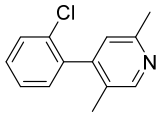
4-(2-Methoxyphenyl)-2,5-dimethylpyridine (3d). Compound **3d** was prepared according to the same procedure for the synthesis of **3a** by employing dry PhMe (5 mL), **1d** (100 mg, 0.735 mmol), **2a** (245 mg, 0.771 mmol), azidoprop-1-yne (238 mg, 2.938 mmol) and triphenylphosphine (790 mg, 3.012 mmol). The residue was purified by chromatography (silica, PE/AcOEt 50:1 and 10:1) to give compound **3d** (136 mg, 87%) as a yellow oil. δ_H ($CDCl_3$, 400 MHz) 8.37 (s, 1H), 7.38 (ddd, J = 7.6, 7.6, 2.0 Hz, 1H), 7.09 (dd, J = 7.6, 2.0 Hz, 1H), 7.04 (dd, J = 7.6, 0.8 Hz, 1H), 7.01-6.97 (m, 2H), 3.77 (s, 3H), 2.55 (s, 3H), 2.08 (s, 3H). δ_c ($CDCl_3$, 100 MHz) 156.1, 155.1, 149.3, 147.4, 130.1, 129.5, 129.3, 128.1, 124.2, 120.6, 110.7, 55.3, 23.6, 16.3. HRMS (ESI): m/z calcd for $C_{14}H_{15}NO$ $[M+H]^+$: 214.1226, found: 214.1223.



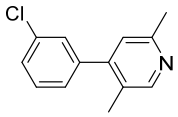
4-(4-Methoxyphenyl)-2,5-dimethylpyridine (3e).[13] Compound **3e** was prepared according to the same procedure for the synthesis of **3a** by employing dry PhMe (5 mL), **1e** (100 mg, 0.735 mmol), **2a** (245 mg, 0.771 mmol), azidoprop-1-yne (238 mg, 2.938 mmol) and triphenylphosphine (790 mg, 3.012 mmol). The residue was purified by chromatography (silica, PE/AcOEt 50:1 and 10:1) to give compound **3e** (130 mg, 83%) as a yellow oil. δ_H ($CDCl_3$, 400 MHz) 8.37 (s, 1H), 7.26 (dd, J = 6.4, 2.0 Hz, 2H), 7.02 (s, 1H), 6.97 (dd, J = 6.8, 2.0 Hz, 2H), 3.86 (s, 3H), 2.55 (s, 3H), 2.25 (s, 3H); δ_c ($CDCl_3$, 100 MHz) 159.3, 155.5, 150.2, 149.4, 131.5, 129.8, 127.6, 123.7, 113.8, 55.3, 23.7, 16.9. MS (ESI) 214.5 (M + H).



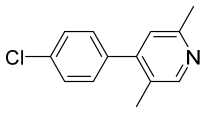
4-(2-Fluorophenyl)-2,5-dimethylpyridine (3f). Compound **3f** was prepared according to the same procedure for the synthesis of **3a** by employing dry PhMe (5 mL), **1f** (100 mg, 0.806 mmol), **2a** (269 mg, 0.846 mmol), azidoprop-1-yne (261 mg, 3.322 mmol) and triphenylphosphine (866 mg, 3.303 mmol). The residue was purified by chromatography (silica, PE/AcOEt 50:1 and 10:1) to give compound **3f** (146 mg, 83%) as a yellow oil. δ_H ($CDCl_3$, 400 MHz) 8.41 (s, 1H), 7.41-7.35 (m, 1H), 7.22-7.19 (m, 2H), 7.15 (dd, J = 9.2, 9.2 Hz, 1H), 7.01 (s, 1H), 2.55 (s, 3H), 2.15 (s, 3H); δ_c ($CDCl_3$, 100 MHz) 159.1 (d, J = 246 Hz), 155.5, 150.1, 143.9, 130.7 (d, J = 3 Hz), 129.9 (d, J = 8 Hz), 128.7, 126.7 (d, J = 16 Hz), 124.1 (d, J = 3 Hz), 123.8, 115.6 (d, J = 22 Hz), 23.8, 16.2 (d, J = 3 Hz). HRMS (ESI): m/z calcd for $C_{13}H_{12}FN$ $[M+H]^+$: 202.1027, found: 202.1032.



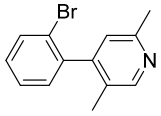
4-(2-Chlorophenyl)-2,5-dimethylpyridine (3g). Compound **3g** was prepared according to the same procedure for the synthesis of **3a** by employing dry PhMe (5 mL), **1g** (100 mg, 0.711 mmol), **2a** (237 mg, 0.747 mmol), azidoprop-1-yne (230 mg, 2.846 mmol) and triphenylphosphine (765 mg, 2.917 mmol). The residue was purified by chromatography (silica, PE/AcOEt 50:1 and 10:1) to give compound **3g** (131 mg, 85%) as a yellow oil. δ_H ($CDCl_3$, 400 MHz) 8.39 (s, 1H), 7.46-7.44 (m, 1H), 7.32-7.30 (m, 2H), 7.15-7.13 (m, 1H), 6.93 (s, 1H), 2.53 (s, 3H), 2.05 (s, 3H); δ_c ($CDCl_3$, 100 MHz) 155.6, 150.1, 147.3, 138.2, 132.5, 130.2, 129.6, 129.3, 128.5, 126.8, 123.3, 23.9, 16.1. HRMS (ESI): m/z calcd for $C_{13}H_{12}ClN$ $[M+H]^+$: 218.0737, found: 218.0731.



4-(3-Chlorophenyl)-2,5-dimethylpyridine (3h). Compound **3g** was prepared according to the same procedure for the synthesis of **3a** by employing dry PhMe (5 mL), **1h** (100 mg, 0.711 mmol), **2a** (237 mg, 0.747 mmol), azidoprop-1-yne (230 mg, 2.846 mmol) and triphenylphosphine (765 mg, 2.917 mmol). The residue was purified by chromatography (silica, PE/AcOEt 50:1 and 10:1) to give compound **3h** (133 mg, 87%) as a yellow oil. δ_H ($CDCl_3$, 400 MHz) 8.39 (s, 1H), 7.37 (d, J = 5.2 Hz, 2H), 7.31 (d, J = 0.8 Hz, 1H), 7.21-7.18 (m, 1H), 7.00 (s, 1H), 2.55 (s, 3H), 2.22 (s, 3H); δ_c ($CDCl_3$, 100 MHz) 155.9, 150.6, 148.0, 141.0, 134.2, 129.6, 128.5, 127.9, 127.2, 126.6, 123.2, 23.8, 16.6. HRMS (ESI): m/z calcd for $C_{13}H_{12}ClN$ $[M+H]^+$: 218.0731, found: 218.0735.

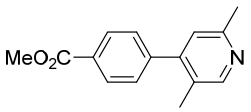


4-(4-Chlorophenyl)-2,5-dimethylpyridine (3i). Compound **3i** was prepared according to the same procedure for the synthesis of **3a** by employing dry PhMe (5 mL), **1i** (100 mg, 0.711 mmol),**2a** (237 mg, 0.747 mmol), azidoprop-1-yne (230 mg, 2.846 mmol) and triphenylphosphine (765 mg, 2.917 mmol). The residue was purified by chromatography (silica, PE/AcOEt 50:1 and 10:1) to give compound **3i** (137 mg, 89%) as a yellow oil. δ_H ($CDCl_3$, 400 MHz) 8.38 (s, 1H), 7.40 (d, J = 8.0 Hz, 2H), 7.23 (d, J = 8.0 Hz, 2H), 7.00 (s, 1H), 2.54 (s, 3H), 2.20 (s, 3H); δ_c ($CDCl_3$, 100 MHz) 155.9, 150.6, 148.2, 137.7, 133.9, 129.8, 128.6, 127.2, 123.2, 23.8, 16.6. HRMS (ESI): m/z calcd for $C_{13}H_{12}ClN$ $[M+H]^+$: 218.0731, found: 218.0728.

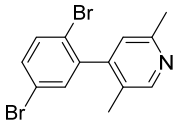


4-(2-Bromophenyl)-2,5-dimethylpyridine (3j). Compound **3j** was prepared according to the same

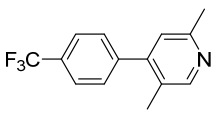
procedure for the synthesis of **3a** by employing dry PhMe (4 mL), **1j** (100 mg, 0.541 mmol), **2a** (181 mg, 0.568 mmol), azidoprop-1-yne (175 mg, 2.162 mmol) and triphenylphosphine (518 mg, 2.216 mmol). The residue was purified by chromatography (silica, PE/AcOEt 50:1 and 10:1) to give compound **3j** (125 mg, 88%) as a yellow oil. δ_H ($CDCl_3$, 400 MHz) 8.47 (s, 1H), 7.68 (d, J = 8.0 Hz, 1H), 7.40 (ddd, J = 7.6, 7.6, 1.2 Hz, 1H), 7.29 (ddd, J = 7.6, 7.6, 1.2 Hz, 1H), 7.15 (dd, J = 7.6, 1.6 Hz, 1H), 7.01 (s, 1H), 2.62 (s, 3H), 2.10 (s, 3H); δ_c ($CDCl_3$, 100 MHz) 155.3, 149.6, 149.3, 139.9, 132.7, 129.9, 129.4, 128.4, 127.3, 123.4, 122.2, 23.6, 16.2. HRMS (ESI): m/z calcd for $C_{13}H_{12}BrN$ $[M+H]^+$: 262.0226, found: 262.0229.



Methyl 4-(2,5-dimethylpyridin-4-yl)benzoate (3k). Compound **3k** was prepared according to the same procedure for the synthesis of **3a** by employing dry PhMe (4 mL), **1k** (100 mg, 0.541 mmol), **2a** (181 mg, 0.568 mmol), azidoprop-1-yne (175 mg, 2.162 mmol) and triphenylphosphine (518 mg, 2.216 mmol). The residue was purified by chromatography (silica, PE/AcOEt 50:1 and 10:1) to give compound **3k** (125 mg, 88%) as a yellow solid: mp 70-71 ^oC; δ_H ($CDCl_3$, 400 MHz) 8.41 (s, 1H), 8.11 (d, J = 6.8 Hz, 2H), 7.38 (d, J = 6.8 Hz, 2H), 7.02 (s, 1H), 3.94 (s, 3H), 2.57 (s, 3H), 2.21 (s, 3H); δ_c ($CDCl_3$, 100 MHz) 166.4, 155.7, 150.5, 148.2, 143.7, 129.4, 128.4, 126.9, 122.9, 51.9, 23.6, 16.4. HRMS (ESI): m/z calcd for $C_{15}H_{15}NO_2$ $[M+H]^+$: 242.1176, found: 242.1173.

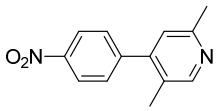


4-(2,5-Dibromophenyl)-2,5-dimethylpyridine (3l). Compound **3l** was prepared according to the same procedure for the synthesis of **3a** by employing dry PhMe (3 mL), **1l** (100 mg, 0.379 mmol), **2a** (127 mg, 0.398 mmol), azidoprop-1-yne (123 mg, 1.515 mmol) and triphenylphosphine (407 mg, 1.553 mmol). The residue was purified by chromatography (silica, PE/AcOEt 50:1 and 10:1) to give compound **3l** (83 mg, 65%) as a white solid: mp 91-92 ^oC; δ_H ($CDCl_3$, 400 MHz) 8.47 (s, 1H), 7.53 (d, J = 8.4 Hz, 1H), 7.39 (dd, J = 8.4, 2.0 Hz, 1H), 7.31 (d, J = 2.0 Hz, 1H), 6.93 (s, 1H), 2.57 (s, 3H), 2.09 (s, 3H); δ_c ($CDCl_3$, 100 MHz) 155.8, 150.3, 147.5, 142.0, 134.1, 132.7, 132.4, 128.0, 122.8, 121.2, 121.1, 23.9, 16.1. HRMS (ESI): m/z calcd for $C_{13}H_{11}Br_2N$ $[M+H]^+$: 339.9331, found: 339.9330.

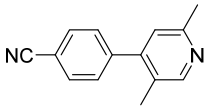


2,5-Dimethyl-4-(4-(trifluoromethyl)phenyl)pyridine (3m). Compound **3m** was prepared according to the same procedure for the synthesis of **3a** by employing dry PhMe (4 mL), **1m** (100

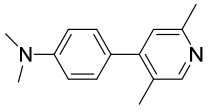
mg, 0.574 mmol), **2a** (192 mg, 0.603 mmol), azidoprop-1-yne (186 mg, 2.297 mmol) and triphenylphosphine (617 mg, 2.355 mmol). The residue was purified by chromatography (silica, PE/AcOEt 50:1 and 10:1) to give compound **3m** (106 mg, 74%) as a brown oil. δ_H ($CDCl_3$, 400 MHz) 8.48 (s, 1H), 7.70 (d, J = 8.4 Hz, 2H), 7.43 (d, J = 8.0 Hz, 2H), 7.02 (s, 1H), 2.57 (s, 3H), 2.22 (s, 3H); δ_c ($CDCl_3$, 100 MHz) 155.9, 150.4, 148.5, 142.9, 130.3, 128.9, 128.7 (d, J = 257 Hz), 125.5(q, J = 4 Hz), 123.4, 122.7, 23.7, 16.7. HRMS (ESI): m/z calcd for $C_{14}H_{12}F_3N$ $[M+H]^+$: 252.0995, found: 252.0998.



2,5-Dimethyl-4-(4-nitrophenyl)pyridine (3n).[14] Compound **3n** was prepared according to the same procedure for the synthesis of **3a** by employing dry PhMe (5 mL), **1n** (100 mg, 0.662 mmol), **2a** (221 mg, 0.695 mmol), azidoprop-1-yne (214 mg, 2.647 mmol) and triphenylphosphine (712 mg, 2.713 mmol). The residue was purified by chromatography (silica, PE/AcOEt 50:1 and 10:1) to give compound **3n** (99 mg, 66%) as a yellow solid: mp 89-90 ^oC;. δ_H ($CDCl_3$, 400 MHz) 8.45 (s, 1H), 8.32 (d, J = 8.4 Hz, 2H), 7.51 (d, J = 8.8 Hz, 2H), 7.04 (s, 1H), 2.59 (s, 3H), 2.24 (s, 3H); δ_c ($CDCl_3$, 100 MHz) 156.1, 150.6, 147.4, 147.3, 145.8, 129.5, 127.1, 123.6, 122.9, 23.7, 16.6. MS (ESI) 229.5 (M + H).

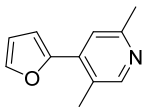


4-(2,5-Dimethylpyridin-4-yl)benzonitrile (3o). Compound **3o** was prepared according to the same procedure for the synthesis of **3a** by employing dry PhMe (5 mL), **1o** (100 mg, 0.723 mmol), **2a** (255 mg, 0.801 mmol), azidoprop-1-yne (234 mg, 2.890 mmol) and triphenylphosphine (777 mg, 2.963 mmol). The residue was purified by chromatography (silica, PE/AcOEt 50:1 and 10:1) to give compound **3o** (98 mg, 65%) as a white solid: mp 98-99 ^oC; δ_H ($CDCl_3$, 400 MHz) 8.43 (s, 1H), 7.75 (d, J = 8.4 Hz, 2H), 7.43 (d, J = 8.4 Hz, 2H), 7.01 (s, 1H), 2.57 (s, 3H), 2.21 (s, 3H); δ_c ($CDCl_3$, 100 MHz) 156.0, 150.6, 147.7, 143.9, 132.2, 129.3, 127.1, 123.0, 118.4, 111.9, 23.7, 16.6. HRMS (ESI): m/z calcd for $C_{14}H_{12}N_2$ $[M+H]^+$: 209.1073, found: 209.1075.

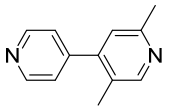


4-(2,5-Dimethylpyridin-4-yl)-*N, N*-dimethylaniline (3p). Compound **3p** was prepared according to the same procedure for the synthesis of **3a** by employing dry PhMe (5 mL), **1p** (100 mg, 0.670 mmol), **2a** (224 mg, 0.801 mmol), azidoprop-1-yne (217 mg, 2.681 mmol) and triphenylphosphine (721 mg, 2.748 mmol). The residue was purified by chromatography (silica, PE/AcOEt 50:1 and

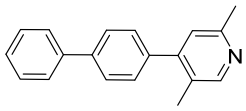
10:1) to give compound **3p** (118 mg, 78%) as a yellow solid: mp 77-78 ^{o}C; δ_H ($CDCl_3$, 400 MHz) 8.35 (s, 1H), 7.23 (dd, J = 8.4, 4.0 Hz, 2H), 7.04 (s, 1H), 6.76 (d, J = 8.8 Hz, 2H), 3.00 (s, 6H), 2.55 (s, 3H), 2.28 (s, 3H); δ_c ($CDCl_3$, 100 MHz) 154.9, 150.4, 150.1, 149.5, 129.5, 127.7, 126.4, 123.7, 111.9, 40.3, 23.3, 17.2. HRMS (ESI): m/z calcd for $C_{15}H_{18}N_2$ $[M+H]^+$: 227.1543, found: 227.1548.



4-(Furan-2-yl)-2,5-dimethylpyridine (3q). Compound **3q** was prepared according to the same procedure for the synthesis of **3a** by employing dry PhMe (7 mL), **1q** (100 mg, 1.041 mmol), **2a** (348 mg, 1.093 mmol), azidoprop-1-yne (337 mg, 4.163 mmol) and triphenylphosphine (1.119 g, 4.267 mmol). The residue was purified by chromatography (silica, PE/AcOEt 50:1 and 10:1) to give compound **3q** (117 mg, 65%) as a colorless oil. δ_H ($CDCl_3$, 400 MHz) 8.39 (s, 1H), 7.57 (d, J = 1.2 Hz, 1H), 7.50 (s, 1H), 6.78 (d, J = 3.2 Hz, 1H), 6.56 (dd, J = 3.2, 1.6 Hz, 1H), 2.56 (s, 3H), 2.46 (s, 3H); δ_c ($CDCl_3$, 100 MHz) 156.0, 151.3, 151.1, 143.2, 137.1, 125.3, 119.1, 111.9, 111.8, 23.9, 18.6. HRMS (ESI): m/z calcd for $C_{11}H_{11}NO$ $[M+H]^+$: 174.0913, found: 174.0910.

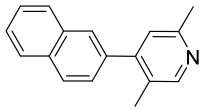


2,5-Dimethyl-4,4'-bipyridine (3r). Compound **3r** was prepared according to the same procedure for the synthesis of **3a** by employing dry PhMe (6 mL), **1r** (100 mg, 0.934 mmol), **2a** (312 mg, 0.980 mmol), azidoprop-1-yne (302 mg, 3.734 mmol) and triphenylphosphine (1.003 g, 3.828 mmol). The residue was purified by chromatography (silica, PE/AcOEt 50:1 and 10:1) to give compound **3r** (128 mg, 75%) as a colorless oil. δ_H ($CDCl_3$, 400 MHz) 8.76 (d, J = 5.6 Hz, 2H), 8.47 (s, 1H), 7.32 (d, J = 6.0 Hz, 2H), 7.02 (s, 1H), 2.58 (s, 3H), 2.24 (s, 3H); δ_c ($CDCl_3$, 100 MHz) 156.2, 150.8, 149.6, 147.9, 146.4, 126.9, 123.7, 122.7, 23.7, 16.4. HRMS (ESI): m/z calcd for $C_{12}H_{12}N_2$ $[M+H]^+$: 185.1073, found: 185.1071.

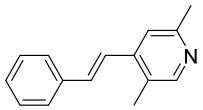


4-([1,1'-Biphenyl]-4-yl)-2,5-dimethylpyridine (3s). Compound **3s** was prepared according to the same procedure for the synthesis of **3a** by employing dry PhMe (4 mL), **1s** (100 mg, 0.549 mmol), **2a** (183 mg, 0.576 mmol), azidoprop-1-yne (178 mg, 2.195 mmol) and triphenylphosphine (590 mg, 2.250 mmol). The residue was purified by chromatography (silica, PE/AcOEt 50:1 and 10:1) to give compound **3s** (128 mg, 75%) as a white solid: mp 94-95 ^{o}C; δ_H ($CDCl_3$, 400 MHz) 8.40 (s, 1H), 7.66-7.61 (m, 4H), 7.44 (t, J = 8.0 Hz, 2H), 7.36 (m, 3H), 7.05 (s, 1H), 2.57 (s, 3H), 2.26 (s, 3H); δ_c ($CDCl_3$, 100 MHz) 155.6, 150.3, 149.1, 140.6, 140.3, 138.1, 128.9, 128.7, 127.4, 127.4,

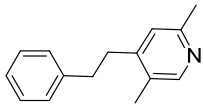
126.9, 123.4, 23.7, 16.8. HRMS (ESI): m/z calcd for $C_{19}H_{17}N$ $[M+H]^+$: 260.1434, found: 260.1439.



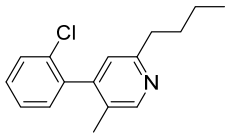
2,5-Dimethyl-4-(naphthalen-2-yl)pyridine (3t). Compound **3t** was prepared according to the same procedure for the synthesis of **3a** by employing dry PhMe (4 mL), **1t** (100 mg, 0.641 mmol), **2a** (214 mg, 0.673 mmol), azidoprop-1-yne (208 mg, 2.563 mmol) and triphenylphosphine (690 mg, 2.627 mmol). The residue was purified by chromatography (silica, PE/AcOEt 50:1 and 10:1) to give compound **3t** (131 mg, 88%) as a white solid: mp 95-96 ^oC;. δ_H ($CDCl_3$, 400 MHz) 8.43 (s, 1H), 7.88-7.83 (m, 3H), 7.74 (s, 1H), 7.51-7.49 (m, 2H), 7.39 (d, J = 8.4 Hz, 1H), 7.10 (s, 1H), 2.57 (s, 3H), 2.24 (s, 3H); δ_c ($CDCl_3$, 100 MHz) 155.5, 150.1, 149.6, 136.6, 133.0, 132.5, 127.9, 127.8, 127.7, 127.6, 127.4, 126.4, 126.3, 126.3, 123.7, 23.6, 16.7. HRMS (ESI): m/z calcd for $C_{17}H_{15}N$ $[M+H]^+$: 234.1277, found: 234.1282.



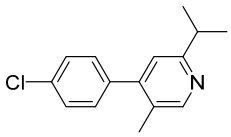
(*E*)-2,5-dimethyl-4-styrylpyridine (3u).[15] Compound **3u** was prepared according to the same procedure for the synthesis of **3a** by employing dry PhMe (4 mL), **1u** (50 mg, 0.378 mmol), **2a** (151 mg, 0.397 mmol), azidoprop-1-yne (123 mg, 1.513 mmol) and triphenylphosphine (496 mg, 1.551 mmol). The residue was purified by chromatography (silica, PE/AcOEt 50:1 and 10:1) to give compound **3u** (67 mg, 85%) as a white solid: mp 90-91^oC; δ_H ($CDCl_3$, 400 MHz) 8.35 (s, 1H), 7.53 (d, J = 7.6 Hz, 2H), 7.39 (dd, J = 7.6 Hz, 2H), 7.34-7.30 (m, 2H), 7.18 (s, 2H), 2.55 (s, 3H), 2.35 (s, 3H); δ_c ($CDCl_3$, 100 MHz) 155.9, 150.5, 143.8, 136.6, 133.3, 128.8, 128.5, 127.3, 126.9, 124.0, 118.3, 24.0, 16.2. MS (ESI) 210.6 (M + H).



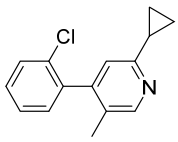
2,5-Dimethyl-4-phenethylpyridine (**3v**).[15, 16] Compound **3v** was prepared according to the same procedure for the synthesis of **3a** by employing dry PhMe (5 mL), **1v** (100 mg, 0.745 mmol), **2a** (260 mg, 0.820 mmol), azidoprop-1-yne (241 mg, 2.981 mmol) and triphenylphosphine (821 mg, 3.130 mmol). The residue was purified by chromatography (silica, PE/AcOEt 50:1 and 10:1) to give compound **3v** (80 mg, 51%) as a colorless oil; δ_H ($CDCl_3$, 400 MHz) 8.37 (s, 1H), 7.32-7.27 (m, 2H), 7.24-7.21 (m, 1H), 7.18-7.16 (m, 2H), 6.96 (s, 1H), 2.88 (s, 4H), 2.50 (s, 3H), 2.12 (s, 3H); δ_c ($CDCl_3$, 100 MHz) 155.7, 149.6, 140.7 132.1, 132.0, 131.9, 128.5, 128.3, 126.3, 35.5, 34.5, 23.6, 15.6. MS (ESI) 212.2 (M + H).



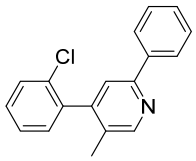
2-Butyl-4-(2-chlorophenyl)-5-methylpyridine (3w). Compound **3w** was prepared according to the same procedure for the synthesis of **3a** by employing dry PhMe (5 mL), **1g** (100 mg, 0.711 mmol), **2c** (269 mg, 0.747 mmol), azidoprop-1-yne (231 mg, 2.846 mmol) and triphenylphosphine (765 mg, 2.917 mmol). The residue was purified by chromatography (silica, PE/AcOEt 50:1 and 20:1) to give compound **3w** (139 mg, 76%) as a colorless oil. δ_H ($CDCl_3$, 400 MHz) 8.44 (s, 1H), 7.49-7.47 (m, 1H), 7.36-7.31 (m, 2H), 7.19-7.17 (m, 1H), 6.95 (s, 1H), 2.80 (t, J = 7.6 Hz, 2H), 2.08 (s, 3H), 1.74 (tt, J = 7.6, 7.6 Hz, 2H), 1.39 (dt, J = 7.6, 7.6 Hz, 2H), 0.94 (t, J = 7.6 Hz, 3H); δ_c ($CDCl_3$, 100 MHz) 159.7, 150.0, 147.3, 138.2, 132.5, 130.1, 129.6, 129.2, 128.6, 126.7, 122.8, 37.5, 32.0, 22.4, 16.1, 13.9. HRMS (ESI): m/z calcd for $C_{16}H_{18}ClN$ $[M+H]^+$: 260.1201, found: 260.1206.



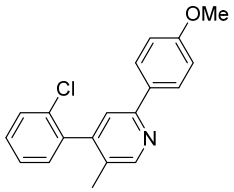
4-(4-Chlorophenyl)-2-isopropyl-5-methylpyridine (3x). Compound **3x** was prepared according to the same procedure for the synthesis of **3a** by employing dry PhMe (5 mL), **1i** (100 mg, 0.711 mmol), **2d** (246 mg, 0.747 mmol), azidoprop-1-yne (231 mg, 2.846 mmol) and triphenylphosphine (765 mg, 2.917 mmol). The residue was purified by chromatography (silica, PE/AcOEt 50:1 and 20:1) to give compound **3x** (106 mg, 61%) as a colorless oil. δ_H ($CDCl_3$, 400 MHz) 8.43 (s, 1H), 7.42 (d, J = 8.4 Hz, 2H), 7.26 (d, J = 8.4 Hz, 2H), 7.00 (s, 1H), 3.07 (m, 1H), 2.22 (s, 3H), 1.31 (d, J = 7.2 Hz, 6H); δ_c ($CDCl_3$, 100 MHz) 165.0, 150.5, 148.4, 138.0, 133.9, 129.9, 128.6, 127.6, 120.7, 35.8, 22.6, 16.7. HRMS (ESI): m/z calcd for $C_{15}H_{16}ClN$ $[M+H]^+$: 246.1044, found: 246.1050.



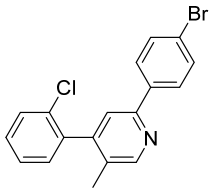
4-(2-Chlorophenyl)-2-cyclopropyl-5-methylpyridine (3y). Compound **3y** was prepared according to the same procedure for the synthesis of **3a** by employing dry PhMe (5 mL), **1g** (100 mg, 0.711 mmol), **2e** (257 mg, 0.747 mmol), azidoprop-1-yne (231 mg, 2.846 mmol) and triphenylphosphine (765 mg, 2.917 mmol). The residue was purified by chromatography (silica, PE/AcOEt 50:1 and 20:1) to give compound **3y** (103 mg, 60%) as a colorless oil. δ_H ($CDCl_3$, 400 MHz) 8.35 (s, 1H), 7.48-7.46 (m, 1H), 7.35-7.30 (m, 2H), 7.18-7.16 (m, 1H), 6.92 (s, 1H), 2.05 (s, 3H), 2.04-2.00 (m, 1H), 1.05-0.97 (m, 4H); δ_c ($CDCl_3$, 100 MHz) 160.1, 150.1, 147.0, 138.2, 132.5, 130.1, 129.6, 129.2, 128.1, 126.8, 121.3, 16.6, 16.1, 9.7, 9.5. HRMS (ESI): m/z calcd for $C_{15}H_{14}ClN$ $[M+H]^+$: 244.0888, found: 244.0893.



4-(2-Chlorophenyl)-5-methyl-2-phenylpyridine (3z). Compound **3z** was prepared according to the same procedure for the synthesis of **3a** by employing dry PhMe (5 mL), **1g** (100 mg, 0.711 mmol), **2f** (284 mg, 0.747 mmol), azidoprop-1-yne (231 mg, 2.846 mmol) and triphenylphosphine (765 mg, 2.917 mmol). The residue was purified by chromatography (silica, PE/AcOEt 50:1 and 20:1) to give compound **3z** (143 mg, 72%) as a yellow oil. δ_H ($CDCl_3$, 400 MHz) 8.61 (s, 1H), 8.00 (d, J = 7.6 Hz, 2H), 7.54 (s, 1H), 7.51-7.49 (m, 1H), 7.45 (t, J = 7.2 Hz, 2H), 7.40-7.33 (m, 3H), 7.24-7.21 (m, 1H), 2.16 (s, 3H); δ_c ($CDCl_3$, 100 MHz) 155.0, 150.7, 147.7, 139.1, 138.1, 132.5, 130.2, 130.1, 129.6, 129.4, 128.6, 128.6, 126.8, 126.7, 120.8, 16.3. HRMS (ESI): m/z calcd for $C_{18}H_{14}ClN$ $[M+H]^+$: 280.0888, found: 280.0984.

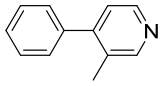


4-(2-Chlorophenyl)-2-(4-methoxyphenyl)-5-methylpyridine (3aa). Compound **3aa** was prepared according to the same procedure for the synthesis of **3a** by employing dry PhMe (5 mL), **1g** (100 mg, 0.711 mmol), **2g** (342 mg, 0.747 mmol), azidoprop-1-yne (231 mg, 2.846 mmol) and triphenylphosphine (765 mg, 2.917 mmol). The residue was purified by chromatography (silica, PE/AcOEt 50:1 and 20:1) to give compound **3aa** (88 mg, 40%) as a yellow solid: mp 112-114 ^oC; δ_H ($CDCl_3$, 400 MHz) 8.53 (s, 1H), 7.94 (d, J = 8.8 Hz, 2H), 7.49 (s, 1H), 7.44 (d, J = 8.4 Hz, 2H), 7.30 (d, J = 8.4 Hz, 2H), 6.98 (d, J = 8.8 Hz, 2H), 3.85 (s, 3H), 2.27 (s, 3H); δ_c ($CDCl_3$, 100 MHz) 160.3, 154.8, 150.7, 147.7, 138.3, 132.6, 131.9, 131.0, 130.3, 129.7, 129.4, 128.0, 126.9, 120.1, 114.1, 55.3, 16.3. HRMS (ESI): m/z calcd for $C_{19}H_{16}ClNO$ $[M+H]^+$: 310.0993, found: 310.0992.



2-(4-Bromophenyl)-4-(2-chlorophenyl)-5-methylpyridine (3ab). Compound **3ab** was prepared according to the same procedure for the synthesis of **3a** by employing dry PhMe (5 mL), **1g** (100 mg, 0.711 mmol), **2h** (342 mg, 0.747 mmol), azidoprop-1-yne (231 mg, 2.846 mmol) and triphenylphosphine (765 mg, 2.917 mmol). The residue was purified by chromatography (silica,

PE/AcOEt 50:1 and 20:1) to give compound **3ab** (103 mg, 41%) as a white solid: mp 87-88 ^{o}C; δ_H ($CDCl_3$, 400MHz) 8.59 (s, 1H), 7.87 (d, J = 8.4 Hz, 2H), 7.57 (d, J = 8.4 Hz, 2H), 7.51 (s, 2H), 7.37-7.35 (m, 2H), 7.23-7.21 (m, 1H), 2.15 (s, 3H); δ_c ($CDCl_3$, 100 MHz) 153.8, 150.9, 147.9, 138.0, 137.9, 132.6, 131.8, 130.6, 130.2, 129.7, 129.5, 128.3, 126.9, 123.1, 120.6, 16.4. HRMS (ESI): m/z calcd for $C_{18}H_{13}BrClN$ $[M+H]^+$: 359.9970, found: 359.9977.



3-Methyl-4-phenylpyridine (3ac).[17] Cinnamaldehyde (100 mg, 0.757 mmol) was dissolved in 5 mL of dry PhCl. To this solution, propargylamine (0.073 mL, 1.135 mmol) was added at room temperature and the resulting mixture was stirred for 2 h. Then DBU (0.103 mL, 0.757 mmol) was added, and the mixture was heated to 100 ^{o}C. The reaction was monitored on TLC. After the completion of the reaction , the solvent was evaporated and the residue was subjected to flash chromatography (silica, PE/AcOEt 50:1 and 10:1) to give compound **3ac** (90 mg, 70%) as a colorless oil. δ_H ($CDCl_3$, 400 MHz) 8.50 (s, 1H), 8.45 (d, J = 4.2 Hz, 1H), 7.46-7.38 (m, 3H), 7.31(s, 1H), 7.30 (d, J = 8.0 Hz, 1H), 7.12 (d, J = 8.4 Hz, 1H), 2.26 (s, 3H); δ_c ($CDCl_3$, 100 MHz) 151.2, 149.0, 147.2, 138.9, 130.4, 128.4, 128.3, 127.8, 123.8, 17.0. MS (ESI) 170.6 (M + H).

Part 2. References

(1) Belmessieri, D.; Cordes, D. B.; Slawin, A. M. Z.; Smith, A. D. *Org. Lett.* **2013**, *15*, 3472-3475.

(2) Abraham, A. W.; Antje, H.; Christina, T.; Martina, B.; Manfred, K.; Rudolf, B.; Franz, B. *Bioorg. Med. Chem.* **2011**, *19*, 567-579.

(3) Dawid, Ł.; Krzysztof, D.; Piotr, K. *Org. Lett*. **2012**, *14*, 1540-1543.

(4) David, A. O.; Mark, A. H.; Mark, A. S.; Clayton, H. H. *J. Org. Chem.* **1990**, *55*, 132-157.

(5) Martin, J. C. *Tetrahedron* **1987**, *43*, 4609-4619.

(6) Belmessieri, D.; Morrill, L. C.; Simal, C.; Slawin, A. M. Z.; Smith, A. D. *J. Am. Chem. Soc.* **2011**, *133*, 2714-2720.

(7) Seyyed, J. S.; Fateme, A. B.; Asghar D.; Janusz, L.; Mehdi K. *J. Organomet. Chem*. **2011**, *696*, 3521-3526.

(8) Wube, A. A.; Hüfner, A.; Thomaschitz, C.; Blunder, M.; Manfred, K.; Rudolf, B.; Franz, B. *Bioorg. Med. Chem*. **2011,** *19*, 567-579.

(9) Hanno, P. *Acta Chemica Scandinavica, Series B: Organic Chemistry and Biochemistry*, **1984**, *B38*, 895-898.

(10) Prostakov, N. S.; Gaivoronskaya, L. A. *Zhurnal Obshchei Khimii* **1962**, *32*, 76-81.

(11) Prostakov, N. S.; Mikheeva, N. N.; Igumnova, A. V.; Zimina, G. I. *Zhurnal Obshchei Khimii* **1960**, *30*, 2294-2297.

(12) Prostakov, N. S.; Obynochnyi, A. A.; Dorogov, V. V.; Zvolinskii, V. P.; Zakharov, V. F.; Savina, A. A. *Khimiya Geterotsiklicheskikh Soedinenii* **1977**, *6*, 814-818.

(13) Prostakov, N. S.; Gaivoronskaya, L. A.; Mikhailova, N. M.; Kirillova, L. M. *Zhurnal Obshchei Khimii* **1963**, *33*, 2573-2576.

(14) Prostakov, N. S.; Krapivko, A. P.; Soldatenkov, A. T.; Furnaris, K.; Savina, A. A.; Zvolinskii, V. P. *Khimiya Geterotsiklicheskikh Soedinenii* **1976**, *3*, 365-368.

(15) Prostakov, N. S.; Kurichev, V. A. *Khimiya Geterotsiklicheskik Soedinenii* **196**7, *4*, 679-681.

(16) (a) Fankhauser, R.; Grob, C. A.; Krasnobajew, V. *Helvetica Chimica Acta* **1966**, *49*, 690-695. (b) Prostakov, N. S.; Kurichev, V. A. *Khimiya Geterotsiklicheskik Soedinenii* **196**5, *6*, 850-857.

(17) Chiba, S.; Xu Y. J.; Wang, Y. F. *J. Am. Chem. Soc.* **2009**, *131*, 12886-12887.

Part 3. NMR Spectra

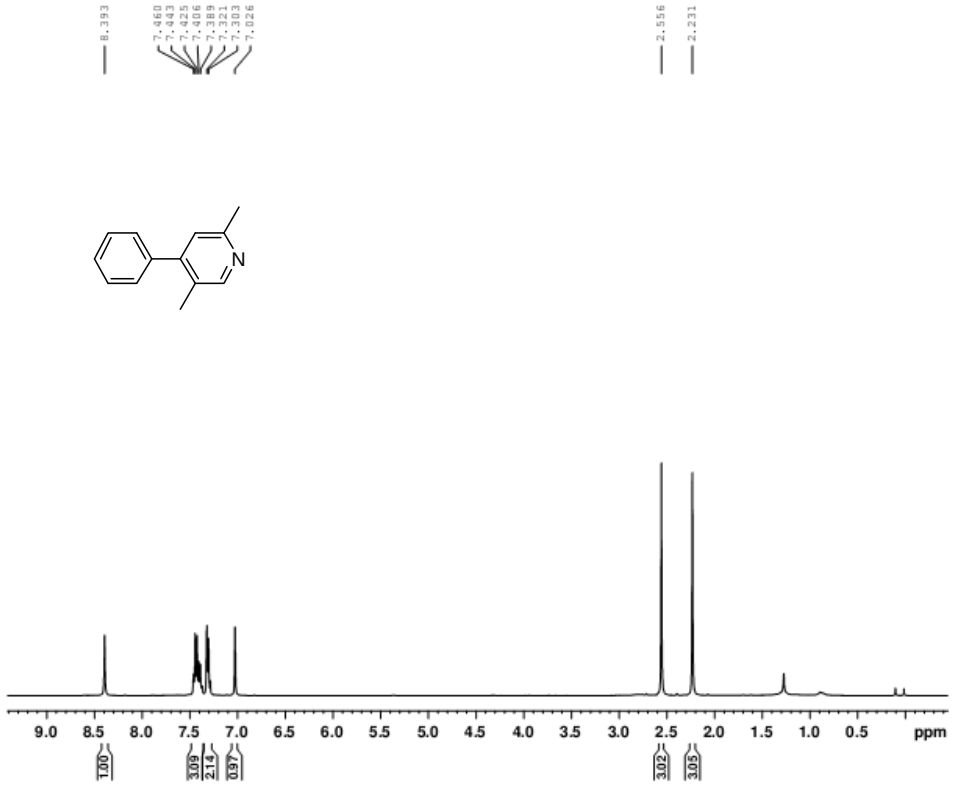


Fig. S1. ^{1}H NMR of compound **3a** (400 MHz, $CDCl_3$).

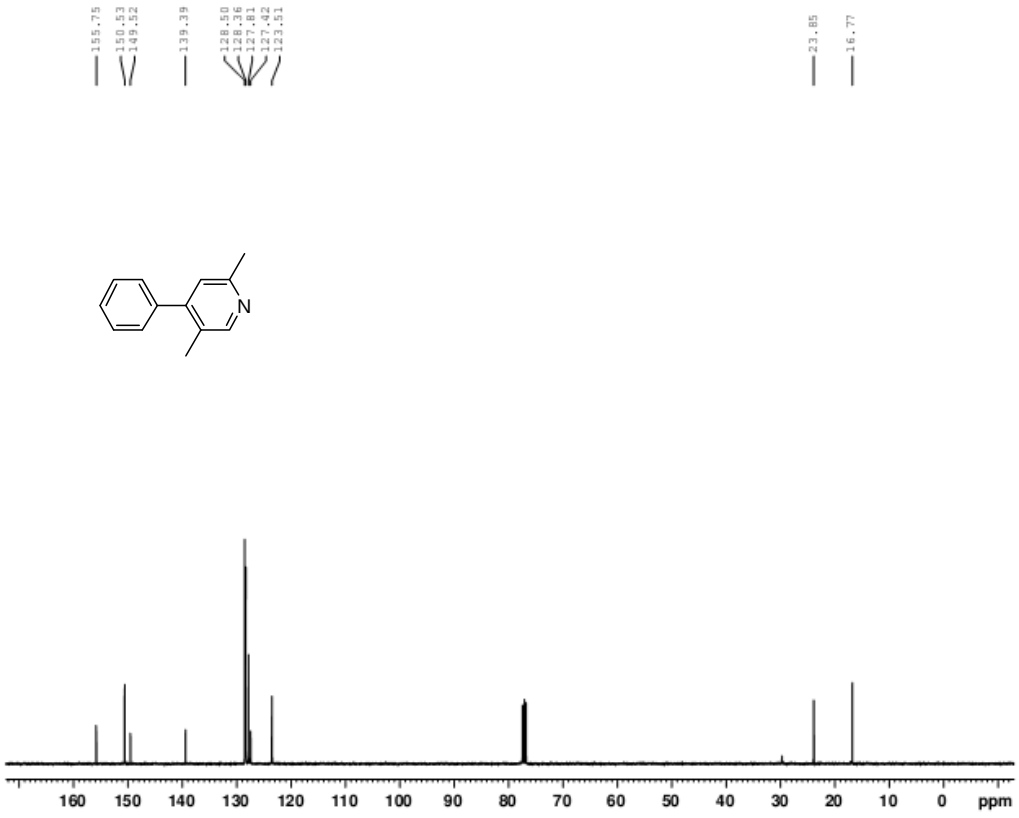


Fig. S2. ^{13}C NMR of compound **3a** (100 MHz, $CDCl_3$).

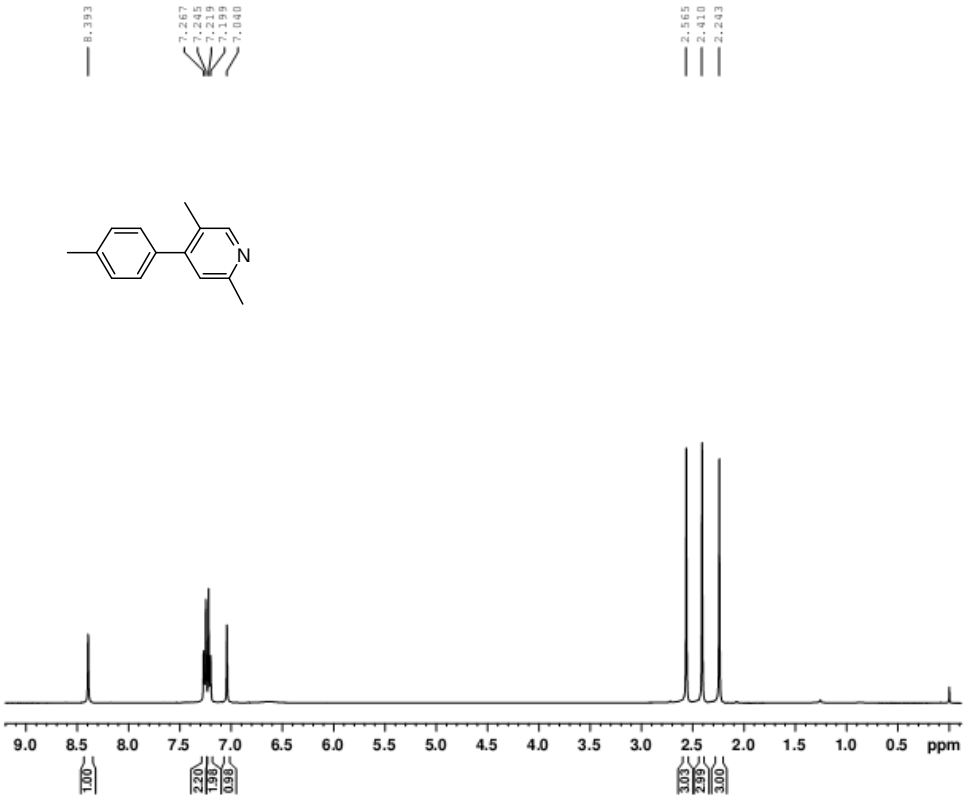


Fig. S3. ^{1}H NMR of compound **3b** (400 MHz, $CDCl_3$).

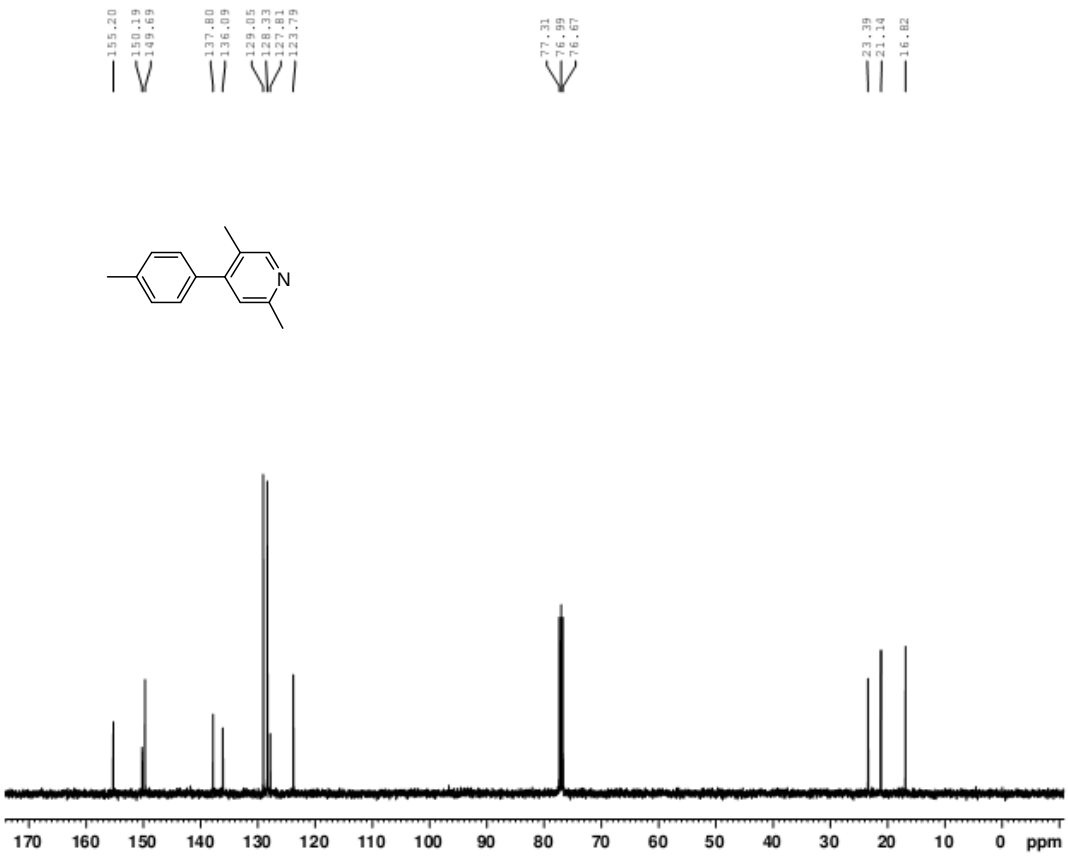


Fig. S4. ^{13}C NMR of compound **3b** (100 MHz, $CDCl_3$).

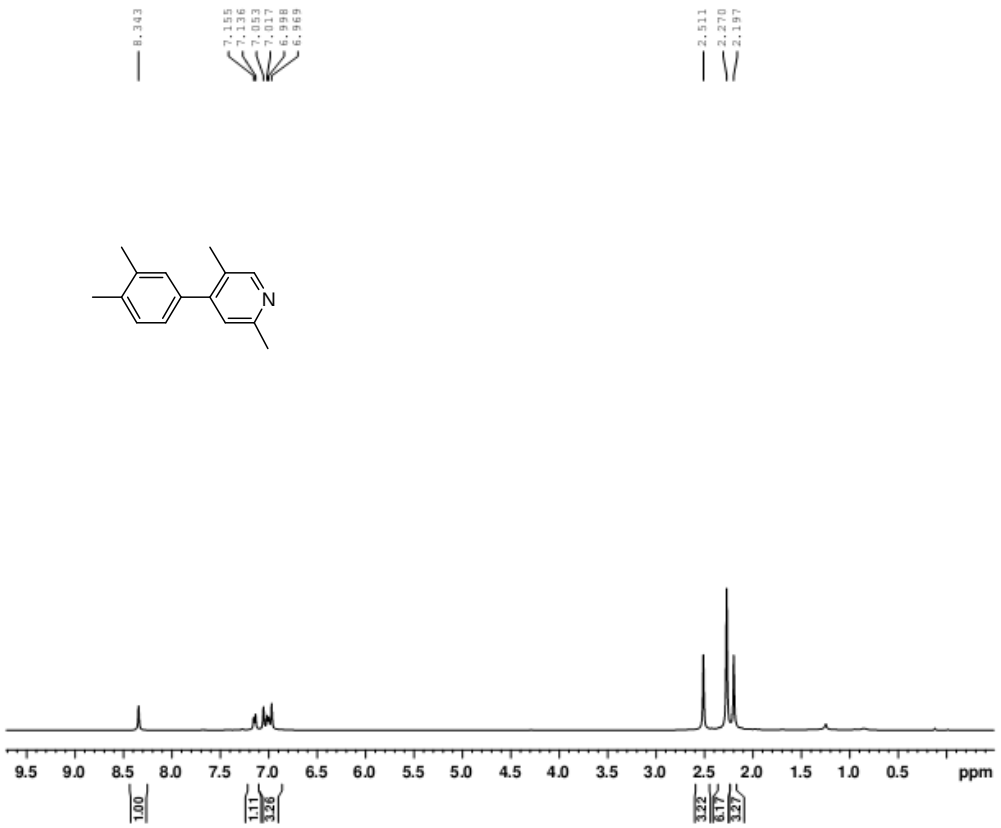


Fig. S5. ^{1}H NMR of compound **3c** (400 MHz, $CDCl_3$).

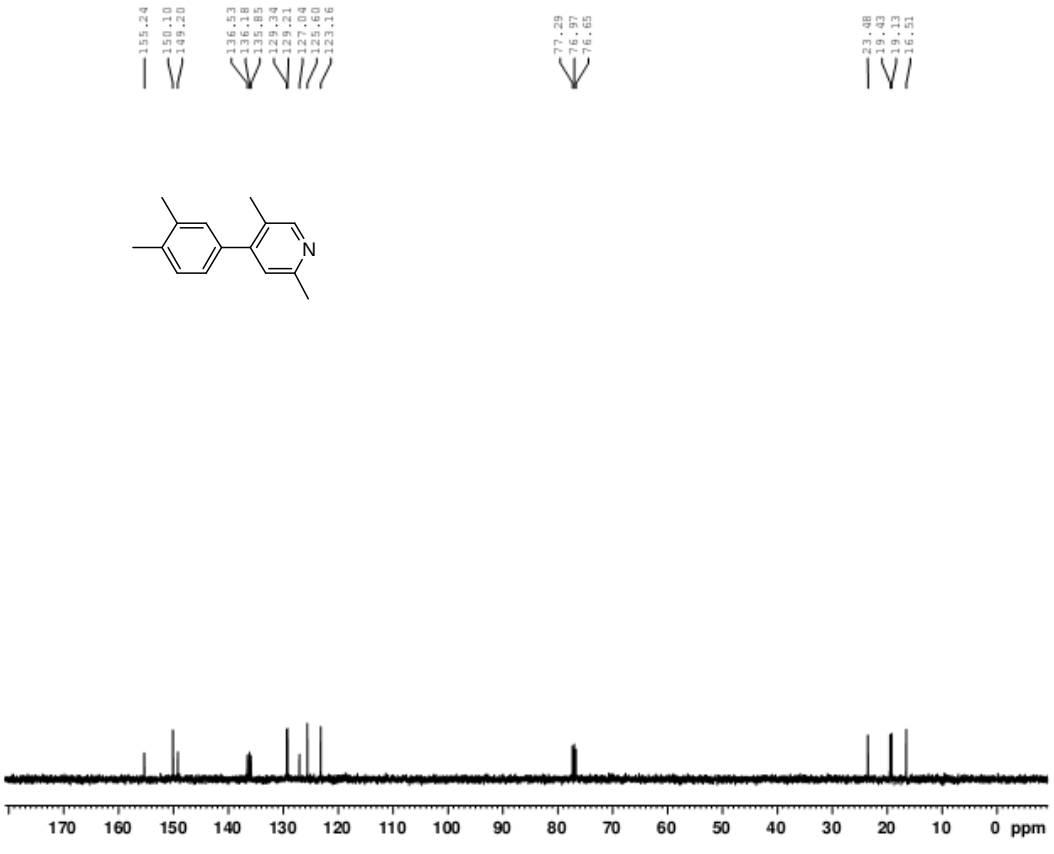


Fig. S6. ^{13}C NMR of compound **3c** (100 MHz, $CDCl_3$).

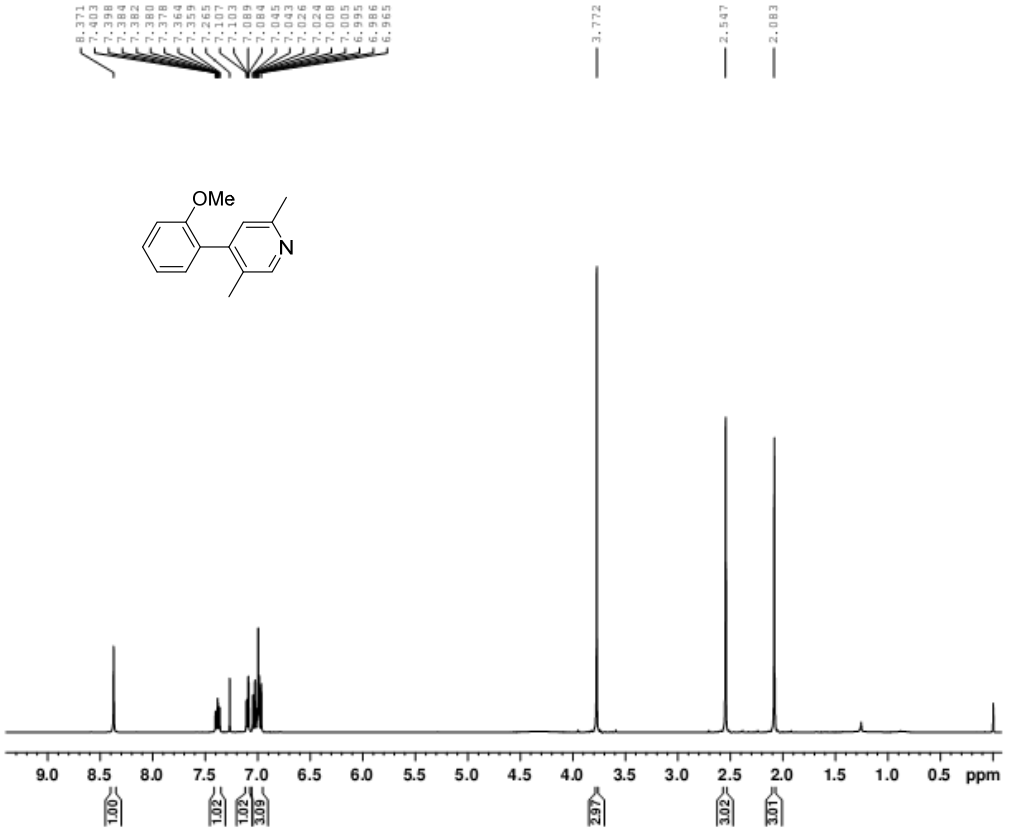


Fig. S7. ^{1}H NMR of compound **3d** (400 MHz, $CDCl_3$).

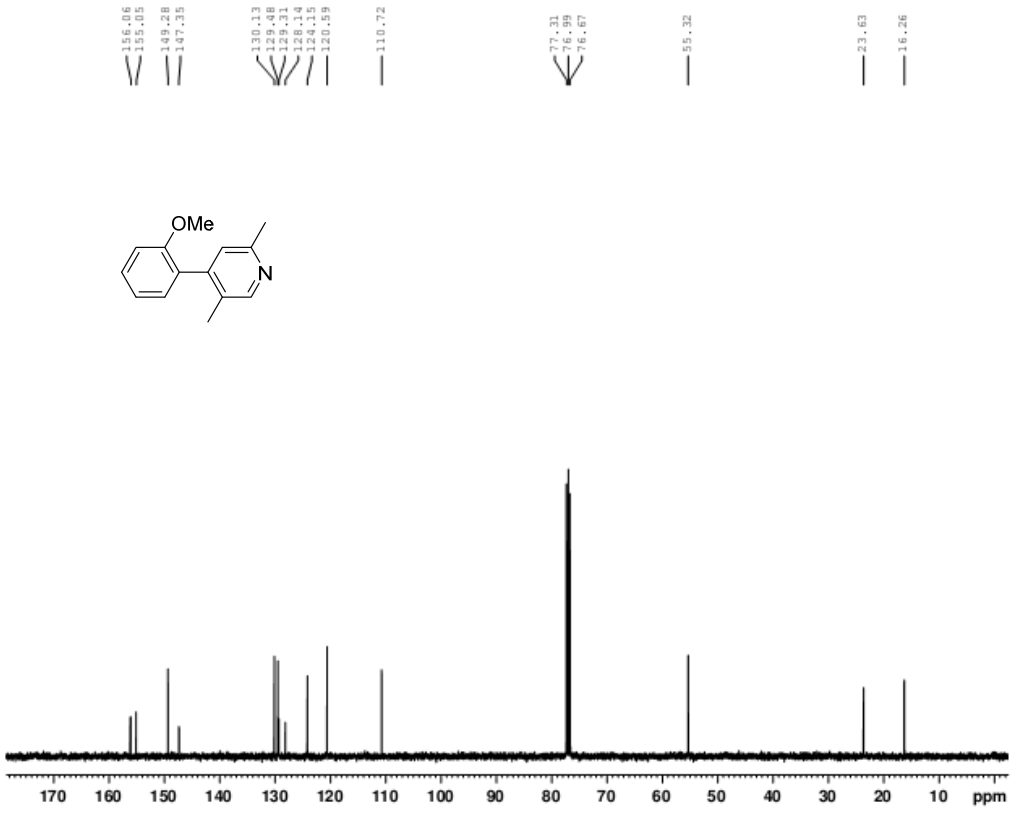


Fig. S8. ^{13}C NMR of compound **3d** (100 MHz, $CDCl_3$).

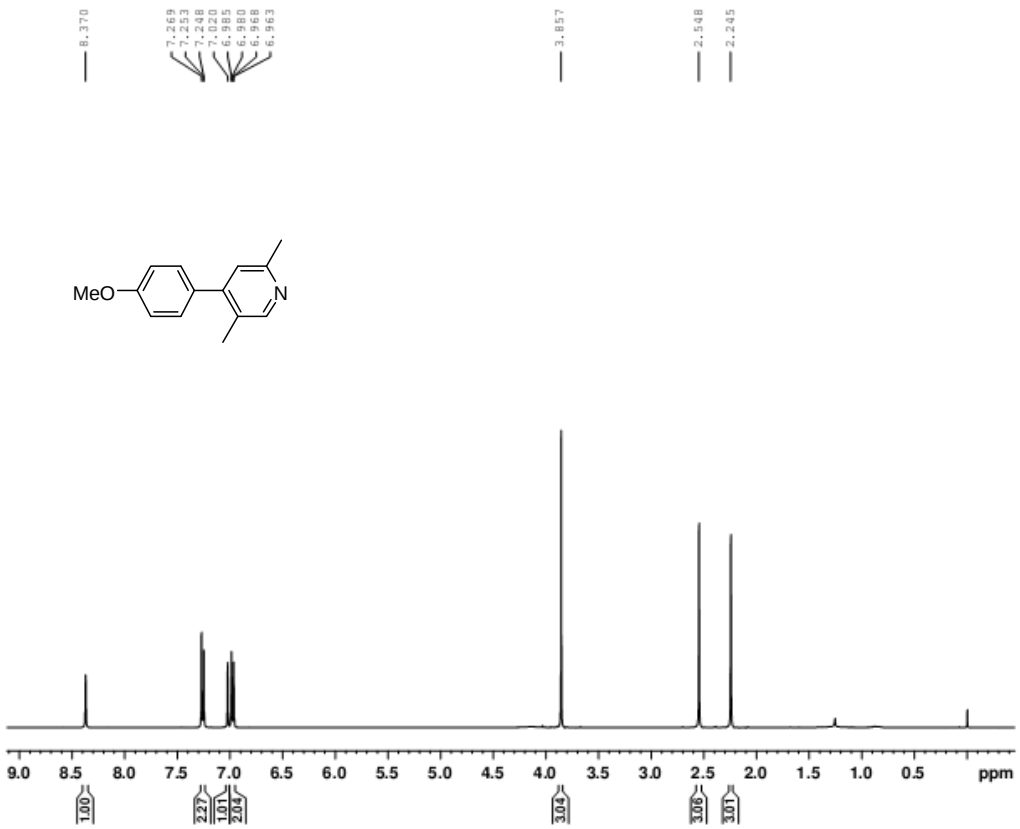


Fig. S9. ^{1}H NMR of compound **3e** (400 MHz, $CDCl_3$).

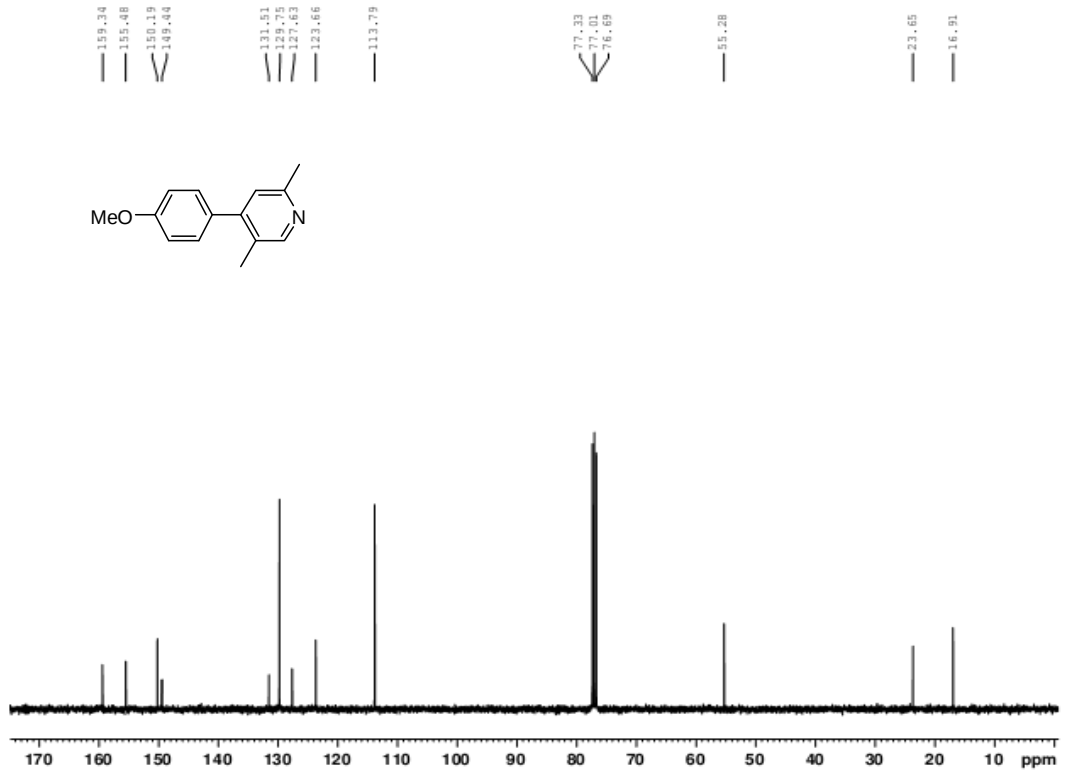


Fig. S10. ^{13}C NMR of compound **3e** (100 MHz, $CDCl_3$).

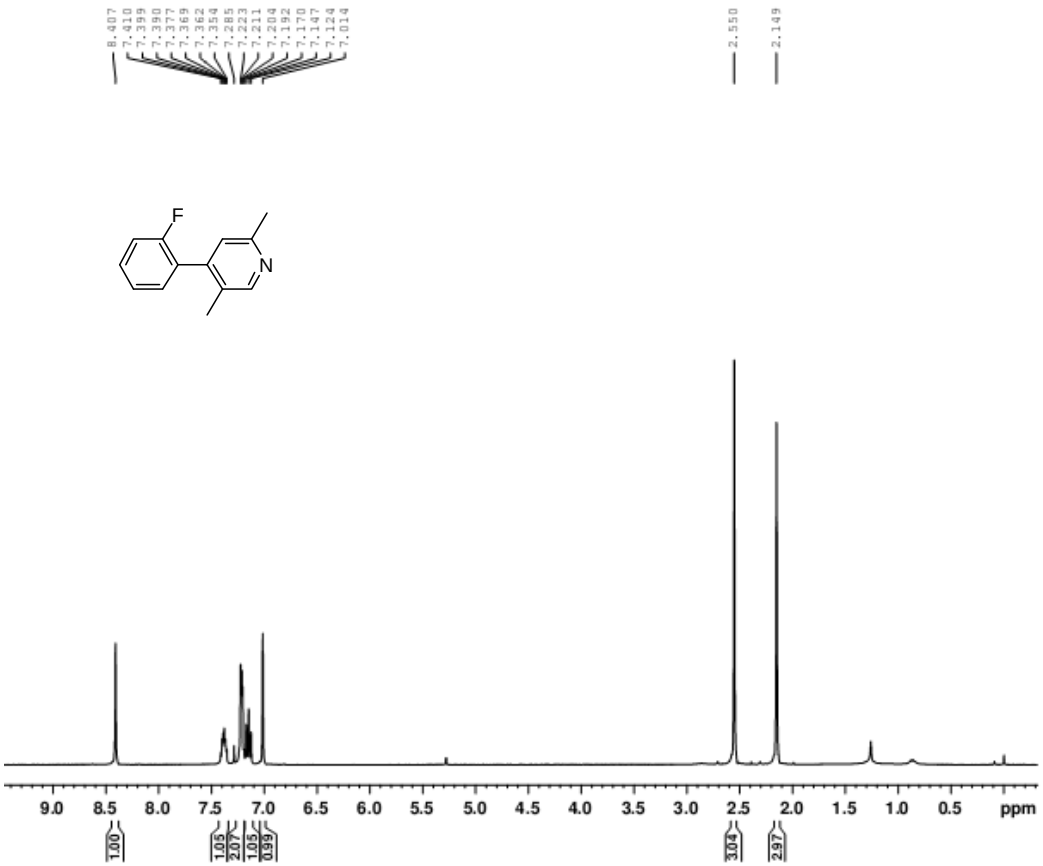


Fig. S11. ^{1}H NMR of compound **3f** (400 MHz, $CDCl_3$).

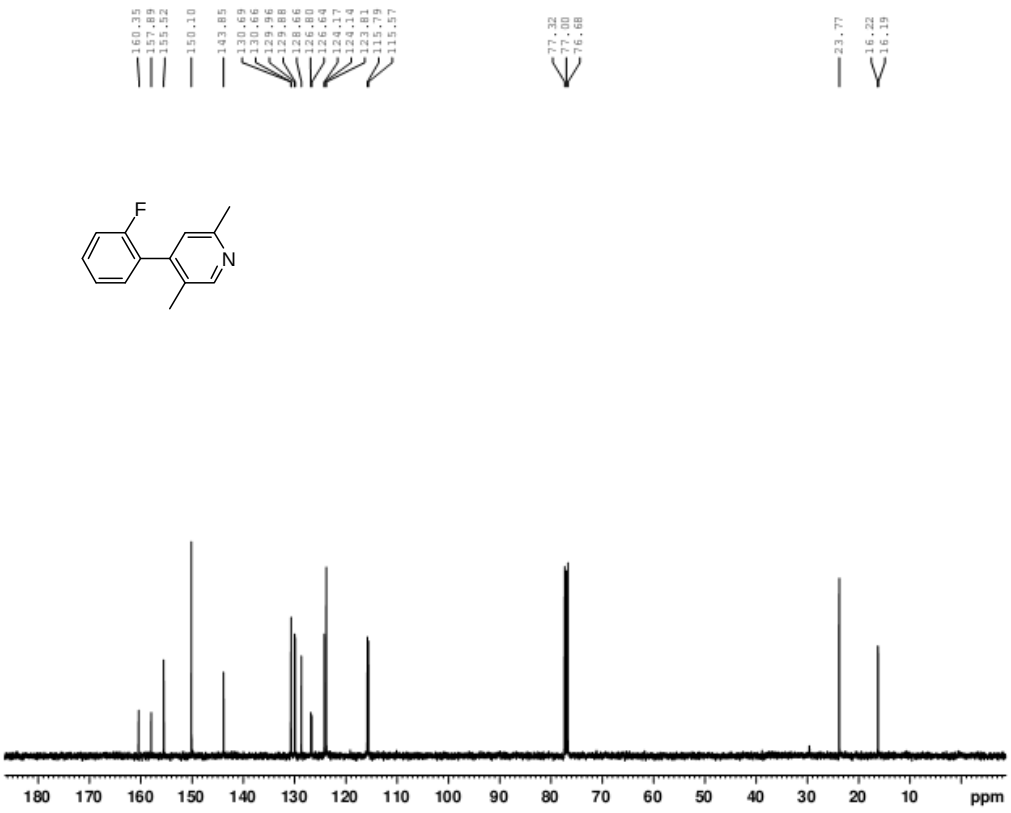


Fig. S12. ^{13}C NMR of compound **3f** (100 MHz, $CDCl_3$).

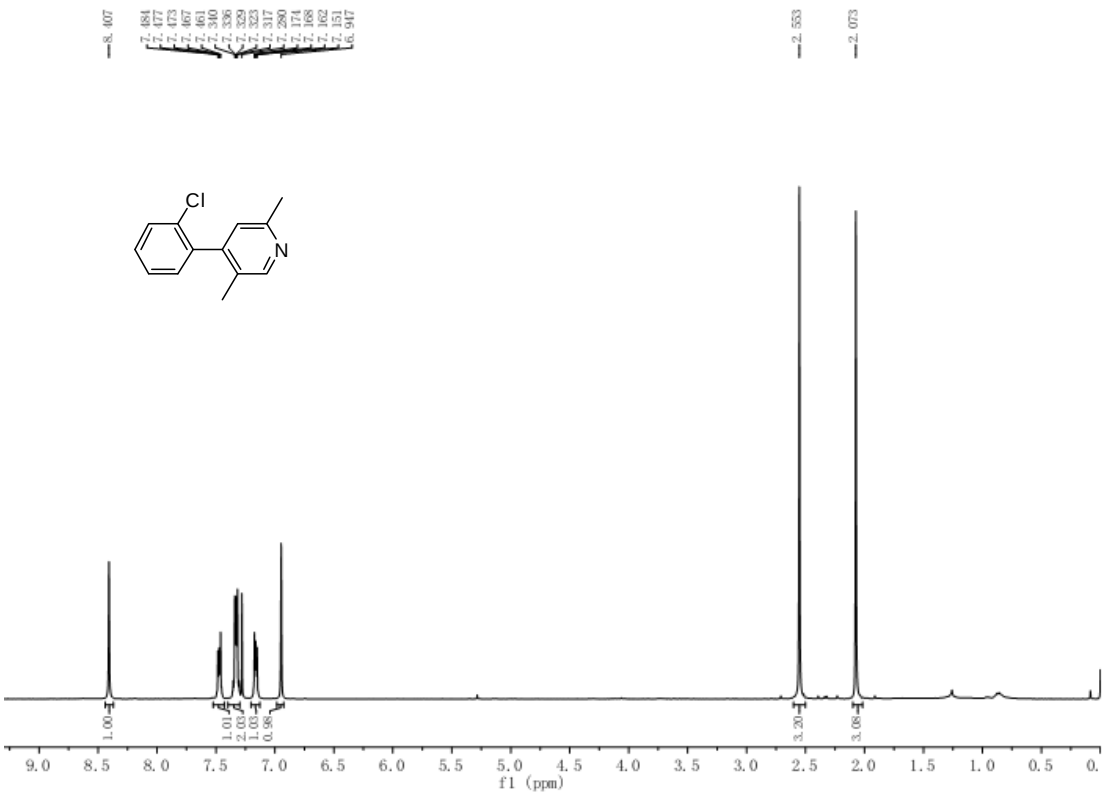


Fig. S13. ^{1}H NMR of compound **3g** (400 MHz, $CDCl_3$).

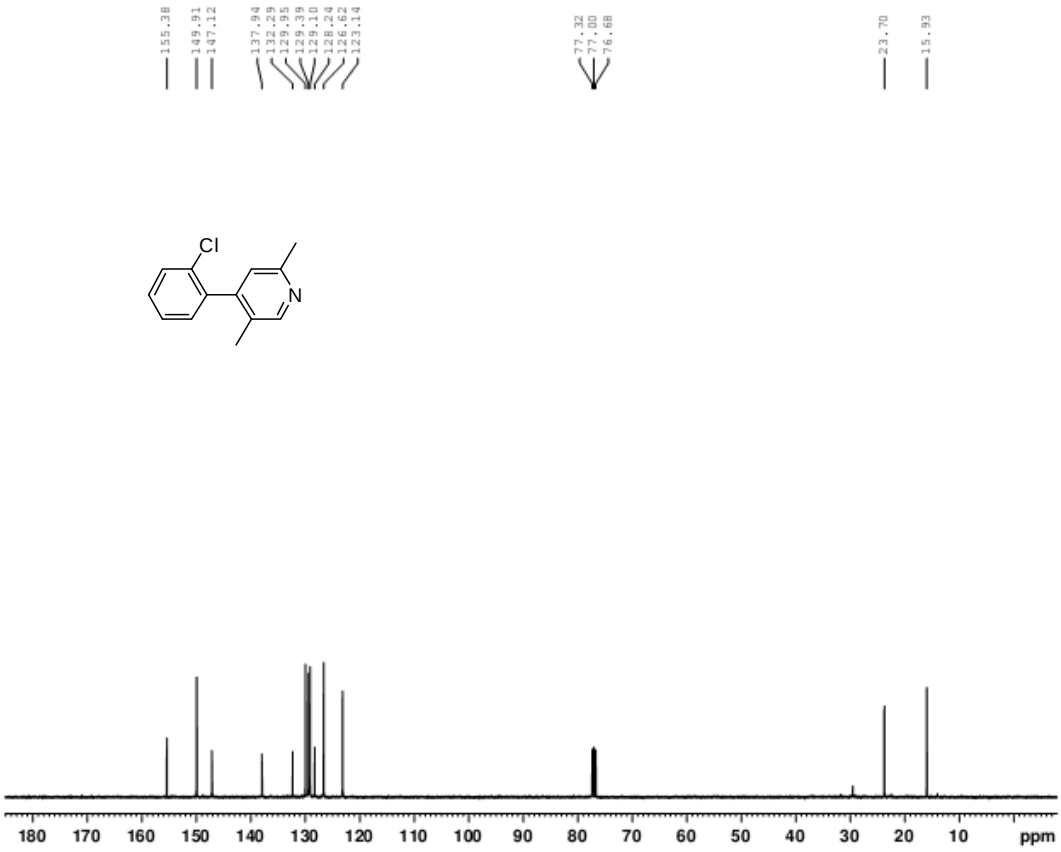


Fig. S14. ^{13}C NMR of compound **3g** (100 MHz, $CDCl_3$).

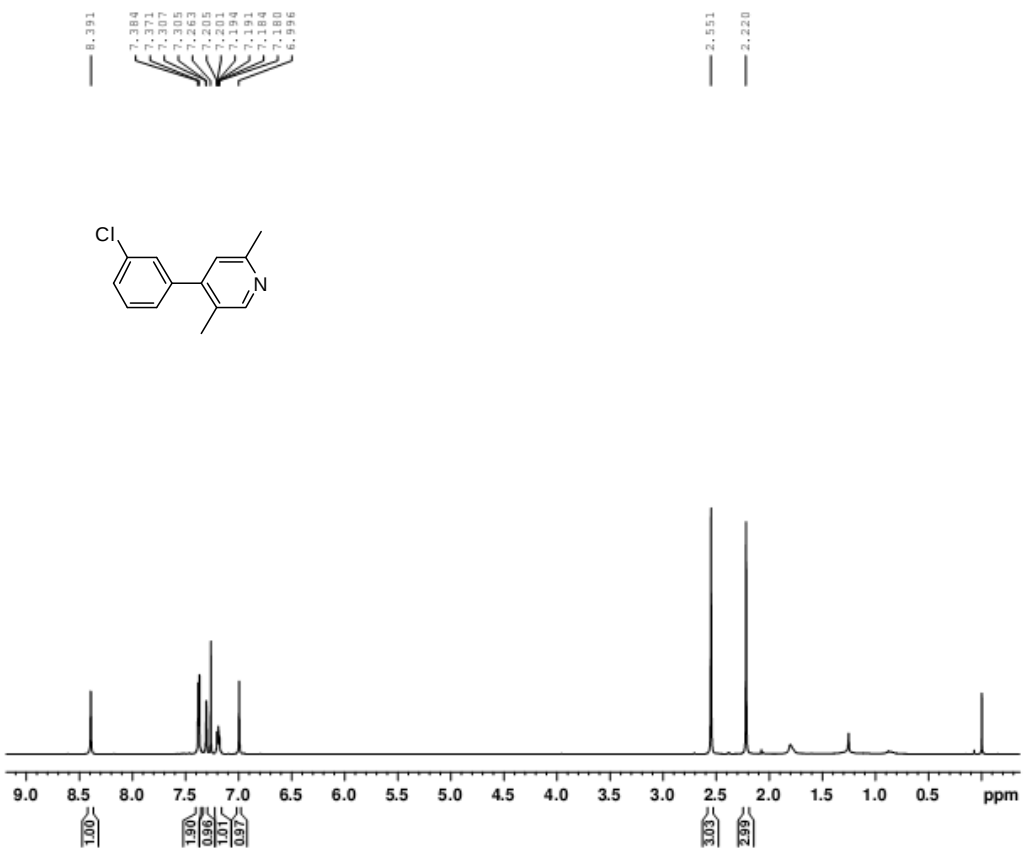


Fig. S15. ^{1}H NMR of compound **3h** (400 MHz, $CDCl_3$).

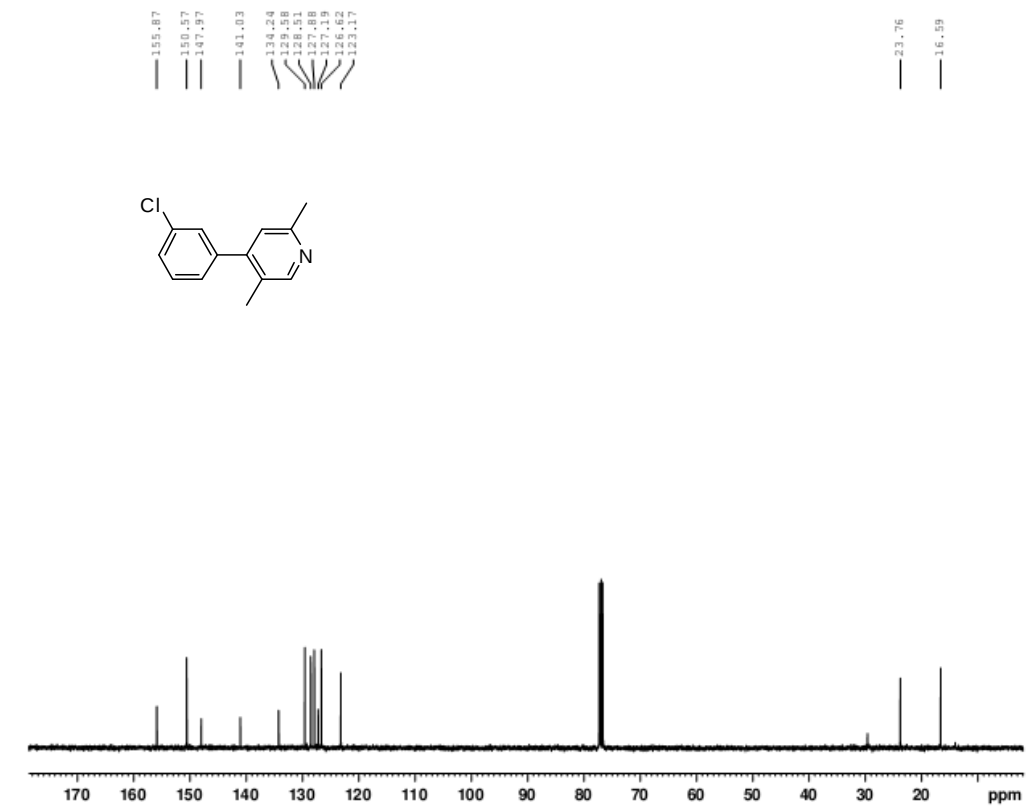


Fig. S16. ^{13}C NMR of compound **3h** (100 MHz, $CDCl_3$).

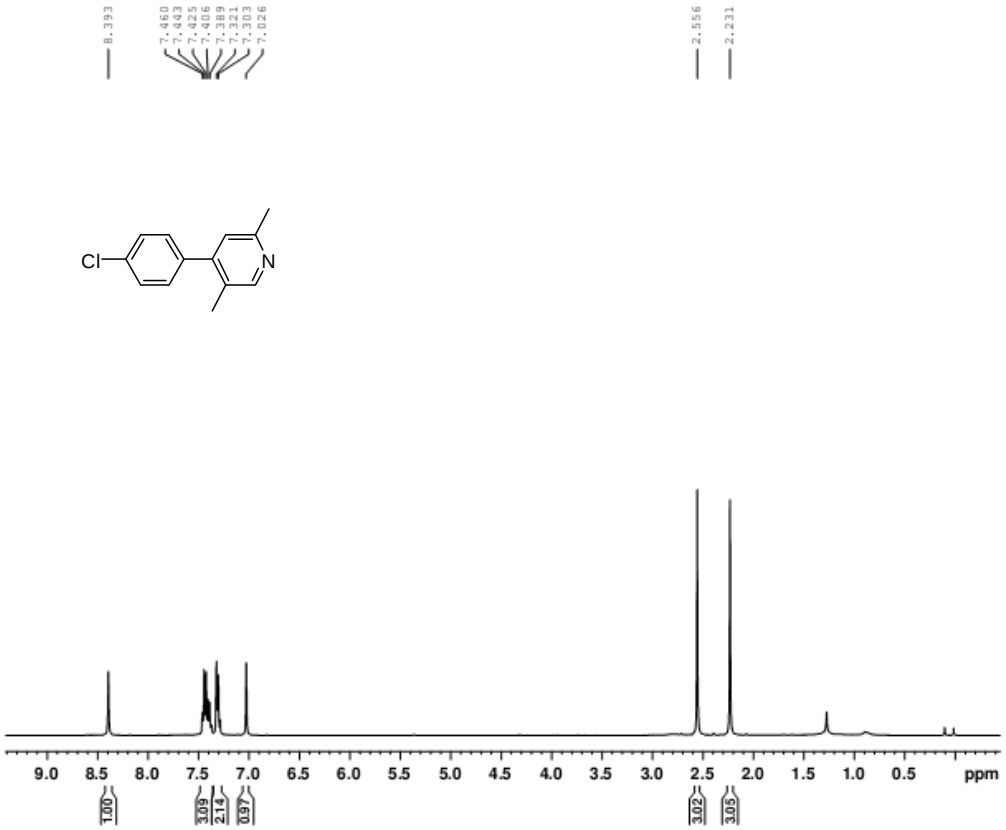


Fig. S17. ^{1}H NMR of compound **3i** (400 MHz, $CDCl_3$).

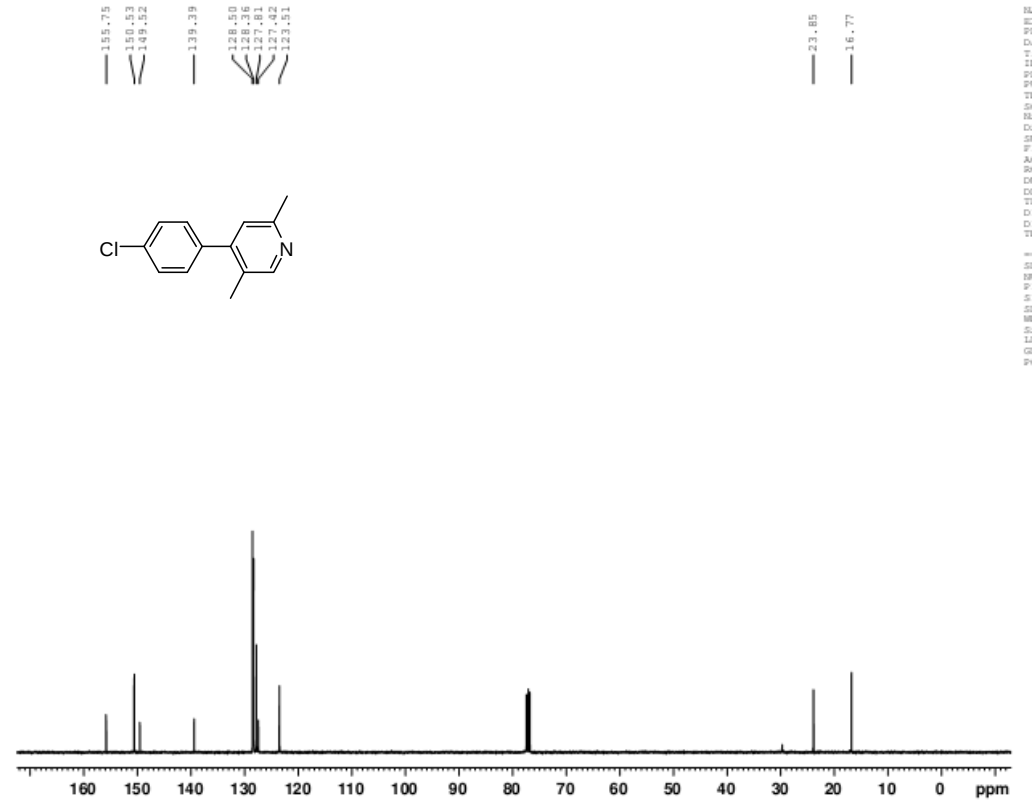


Fig. S18. ^{13}C NMR of compound **3i** (100 MHz, $CDCl_3$).

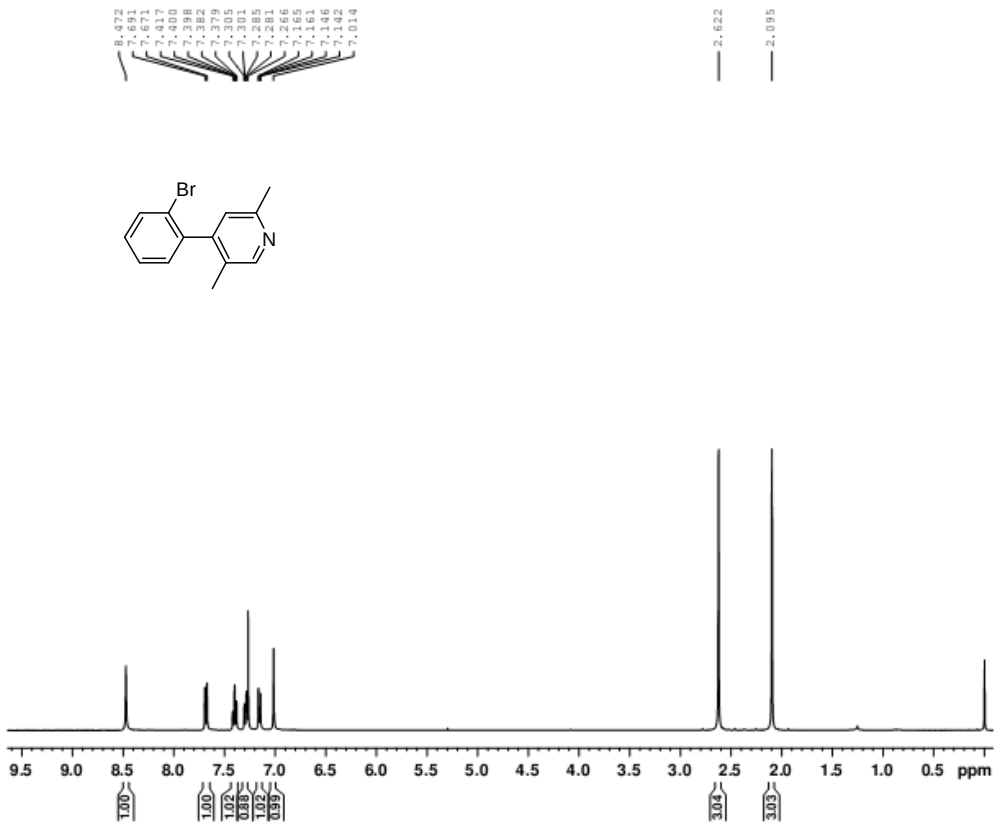


Fig. S19. ^{1}H NMR of compound **3j** (400 MHz, $CDCl_3$).

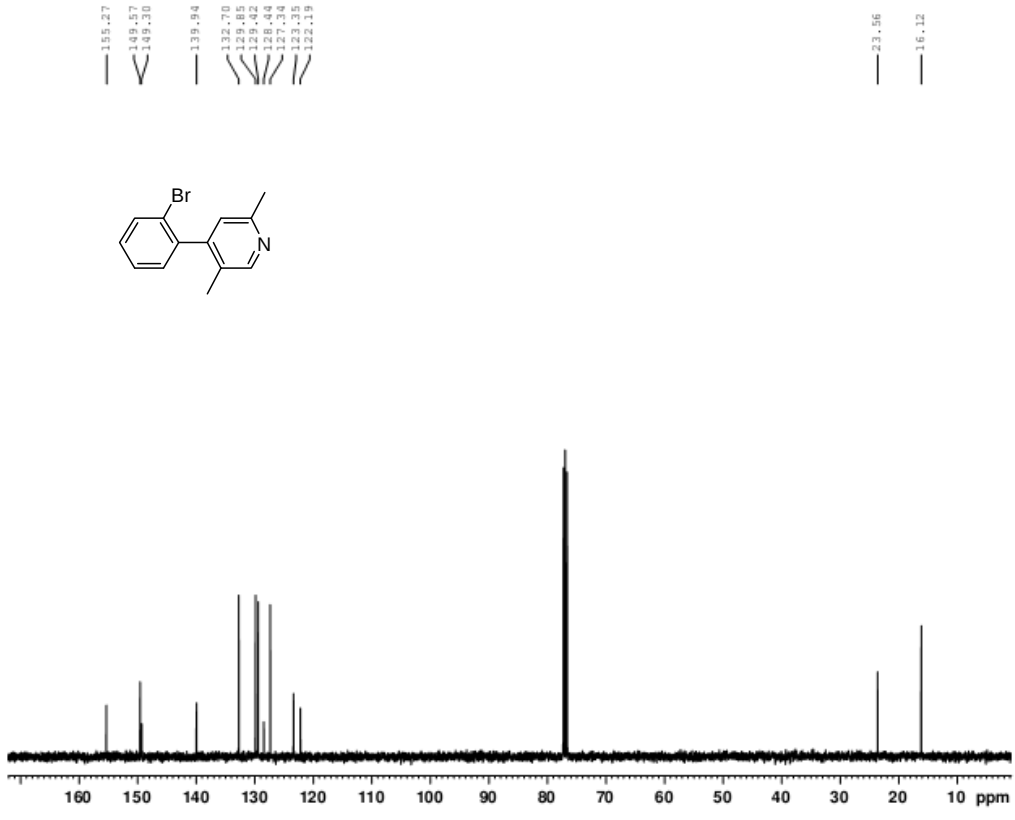


Fig. S20. ^{13}C NMR of compound **3j** (100 MHz, $CDCl_3$).

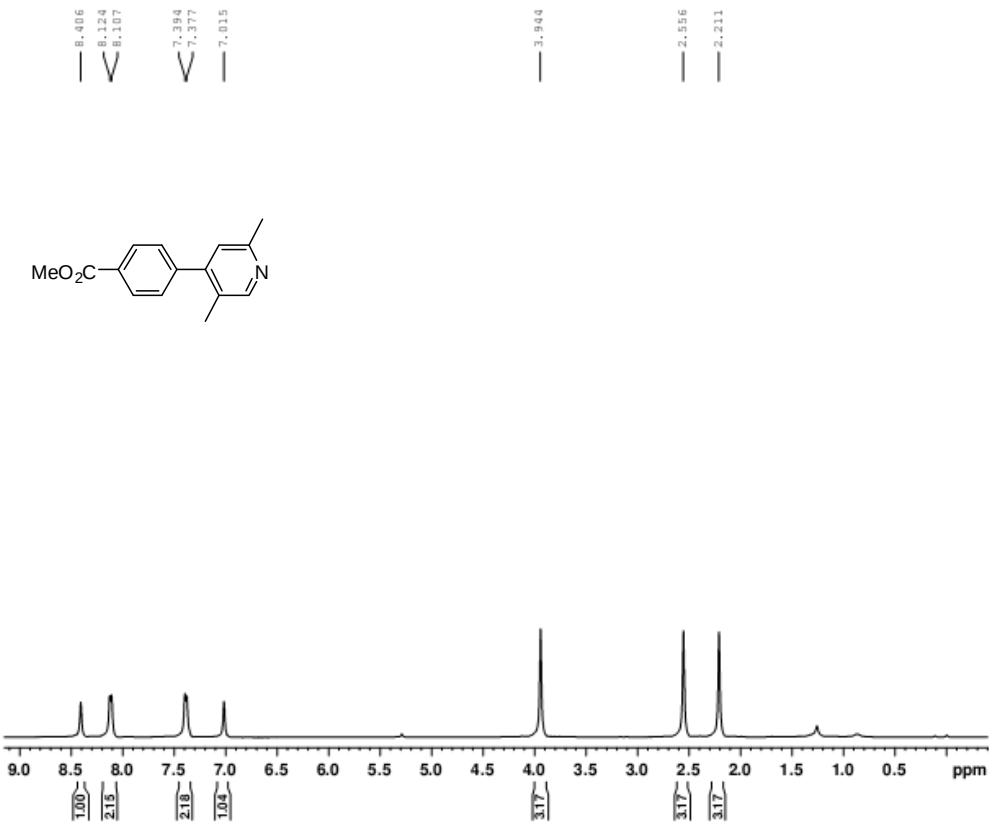


Fig. S21. ^{1}H NMR of compound **3k** (400 MHz, $CDCl_3$).

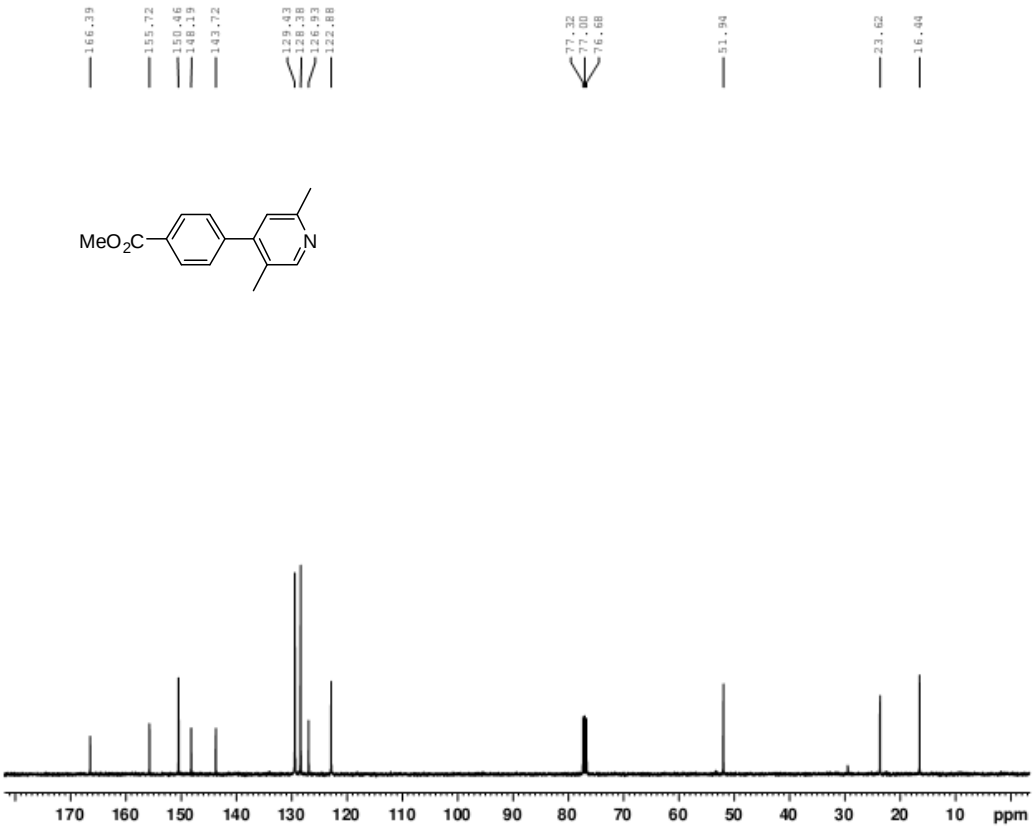


Fig. S22. ^{13}C NMR of compound **3k** (100 MHz, $CDCl_3$).

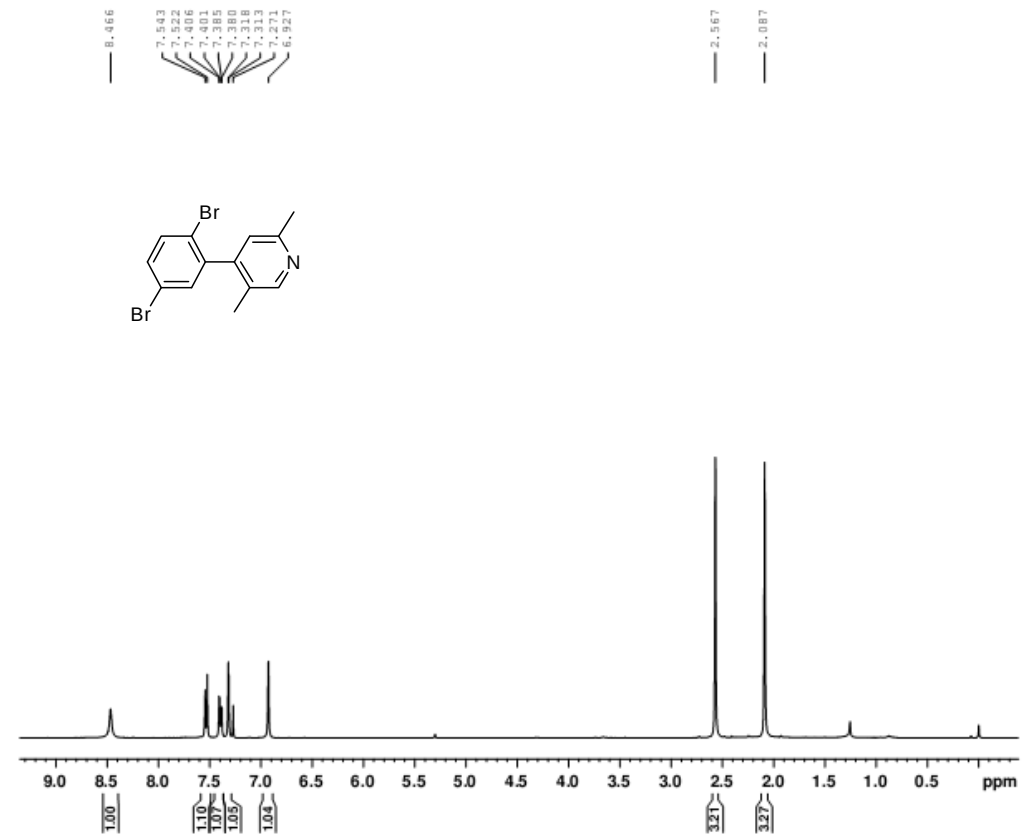


Fig. S23. ^{1}H NMR of compound **3l** (400 MHz, $CDCl_3$).

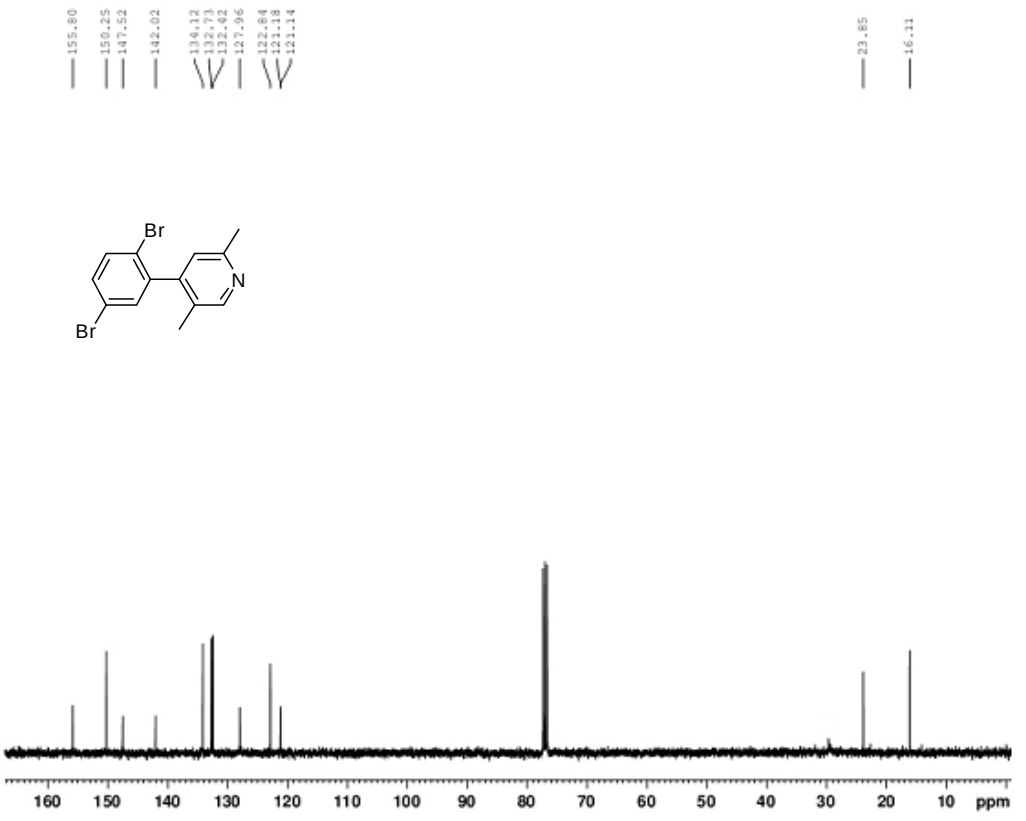


Fig. S24. ^{13}C NMR of compound **3l** (100 MHz, $CDCl_3$).

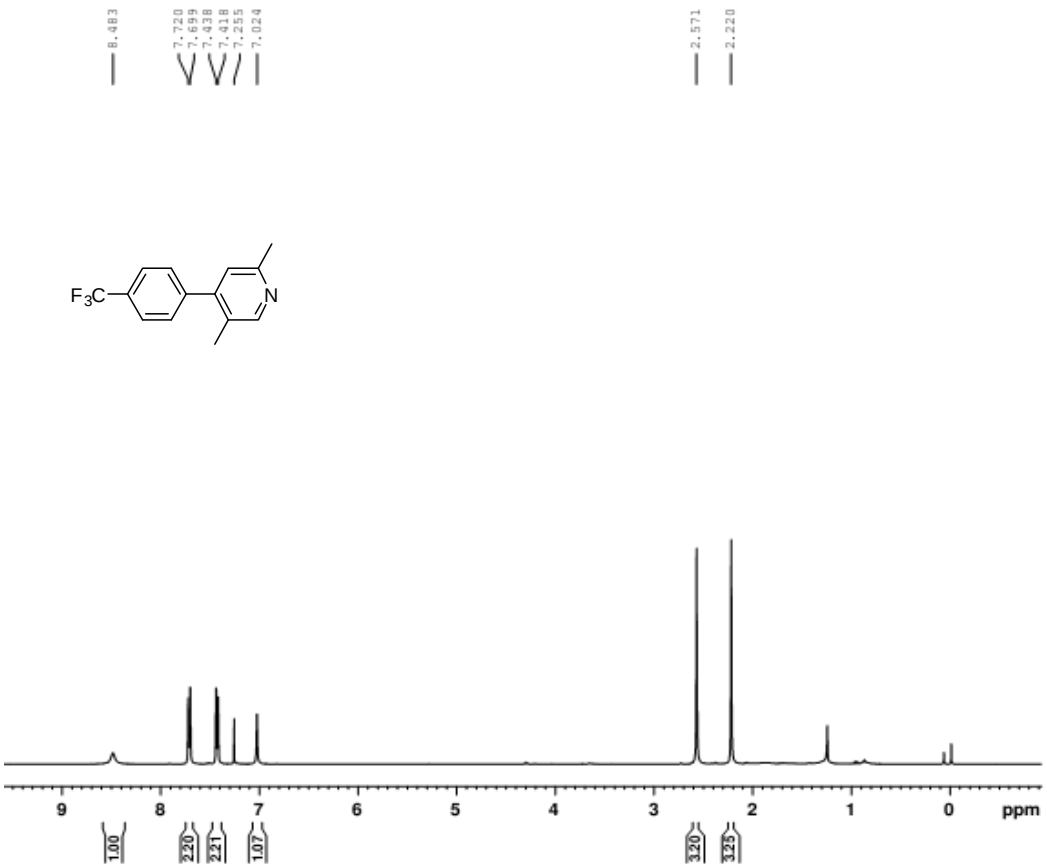


Fig. S25. ^{1}H NMR of compound **3m** (400 MHz, $CDCl_3$).

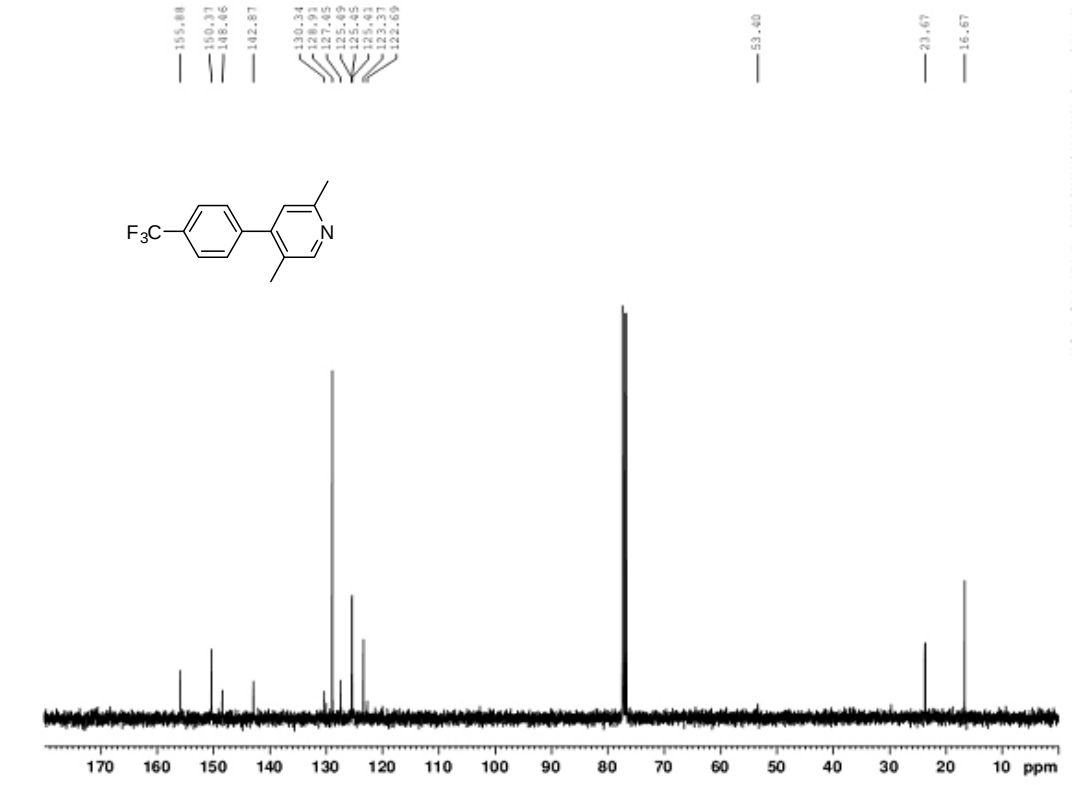


Fig. S26. ^{13}C NMR of compound **3m** (100 MHz, $CDCl_3$).

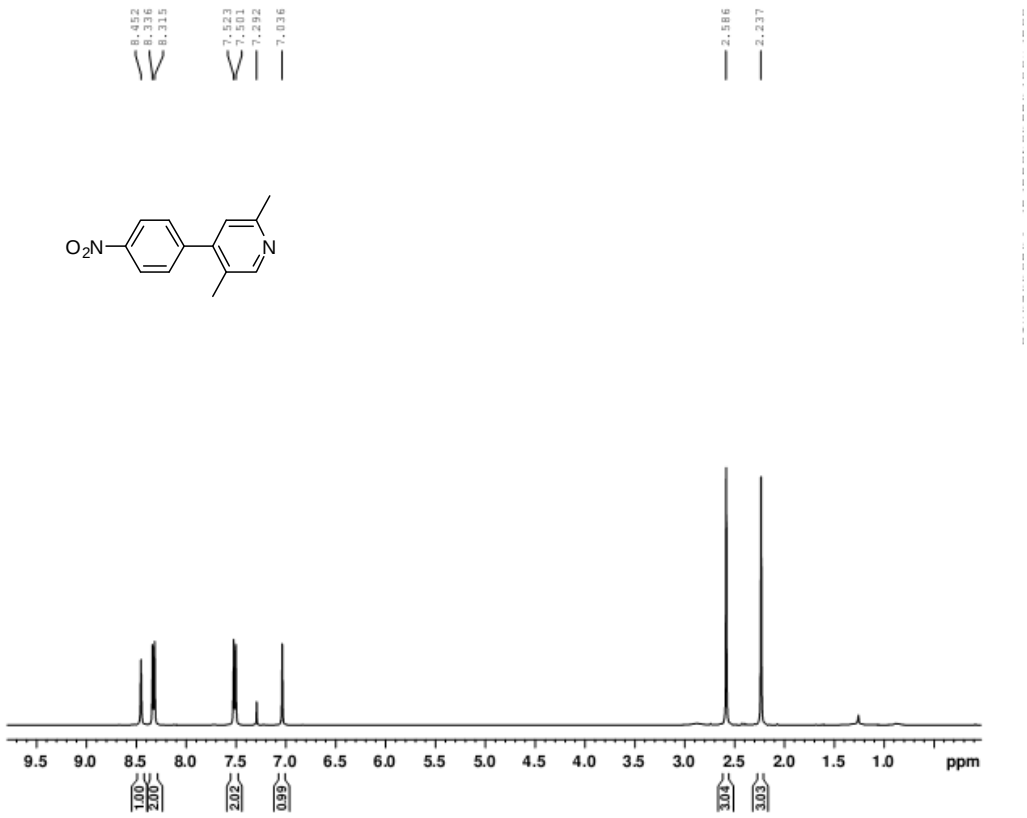


Fig. S27. ^{1}H NMR of compound **3n** (400 MHz, $CDCl_3$).

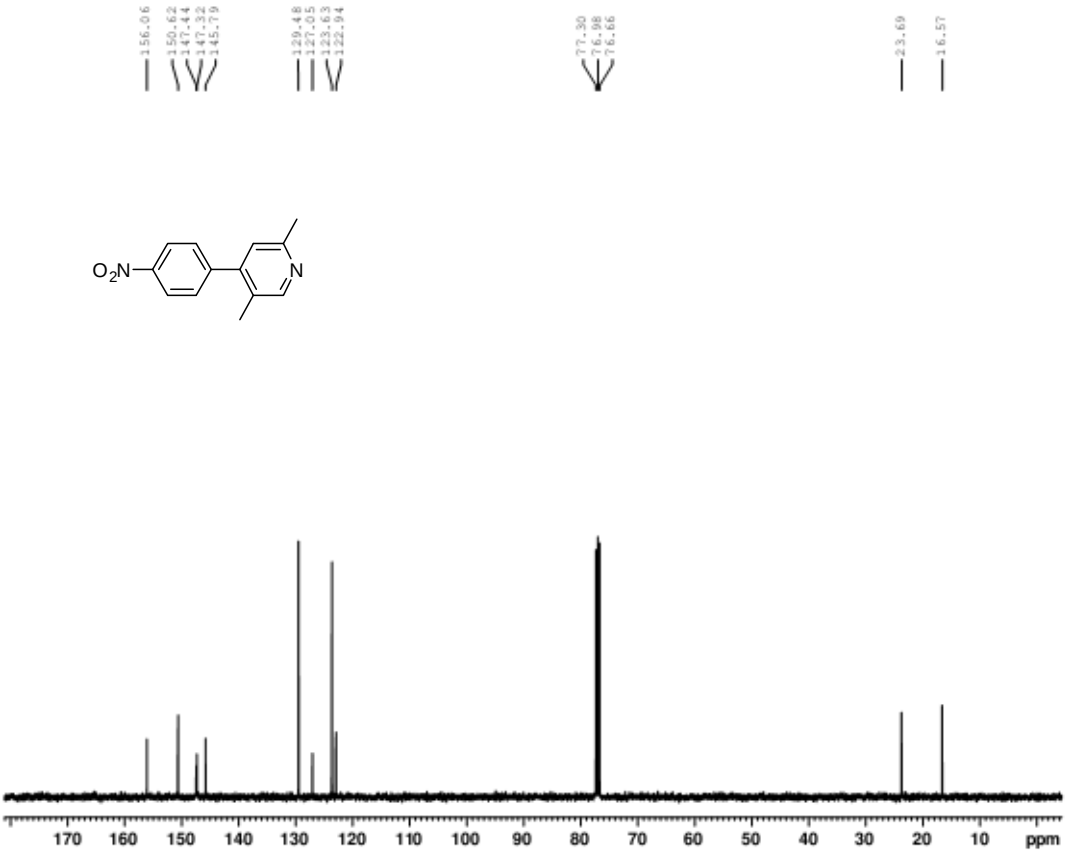


Fig. S28. ^{13}C NMR of compound **3n** (100 MHz, $CDCl_3$).

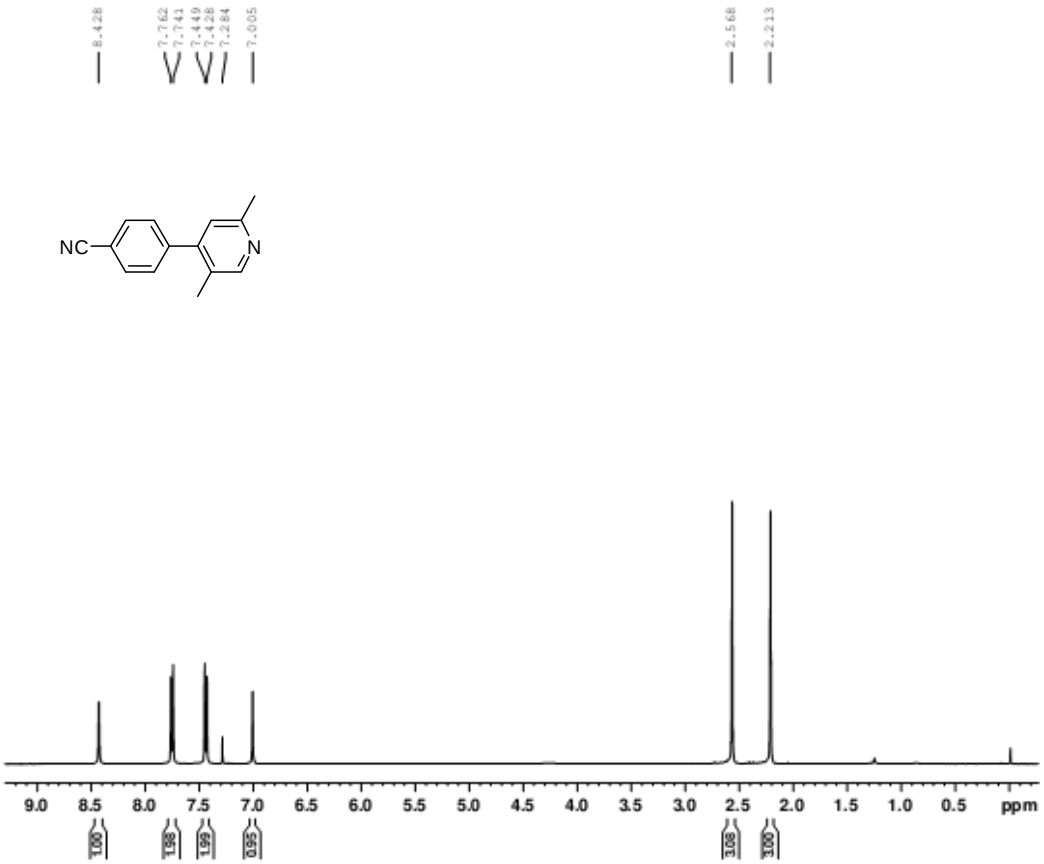


Fig. S29. ^{1}H NMR of compound **3o** (400 MHz, $CDCl_3$).

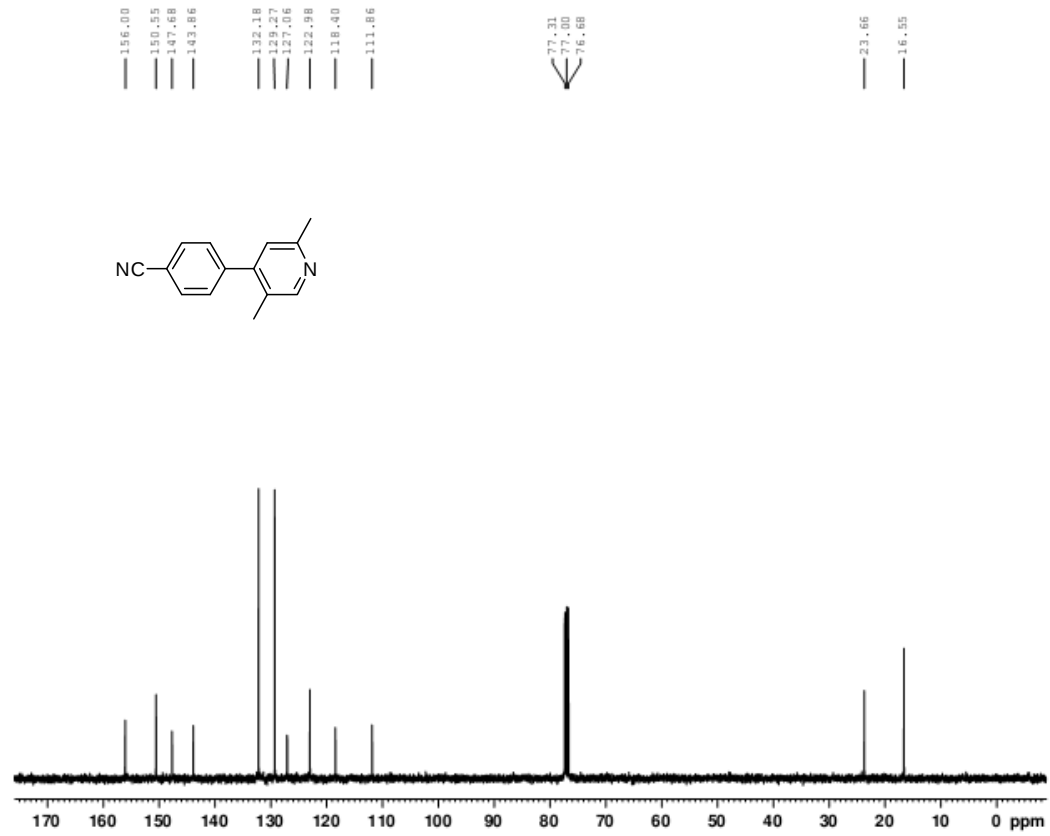


Fig. S30. ^{13}C NMR of compound **3o** (100 MHz, $CDCl_3$).

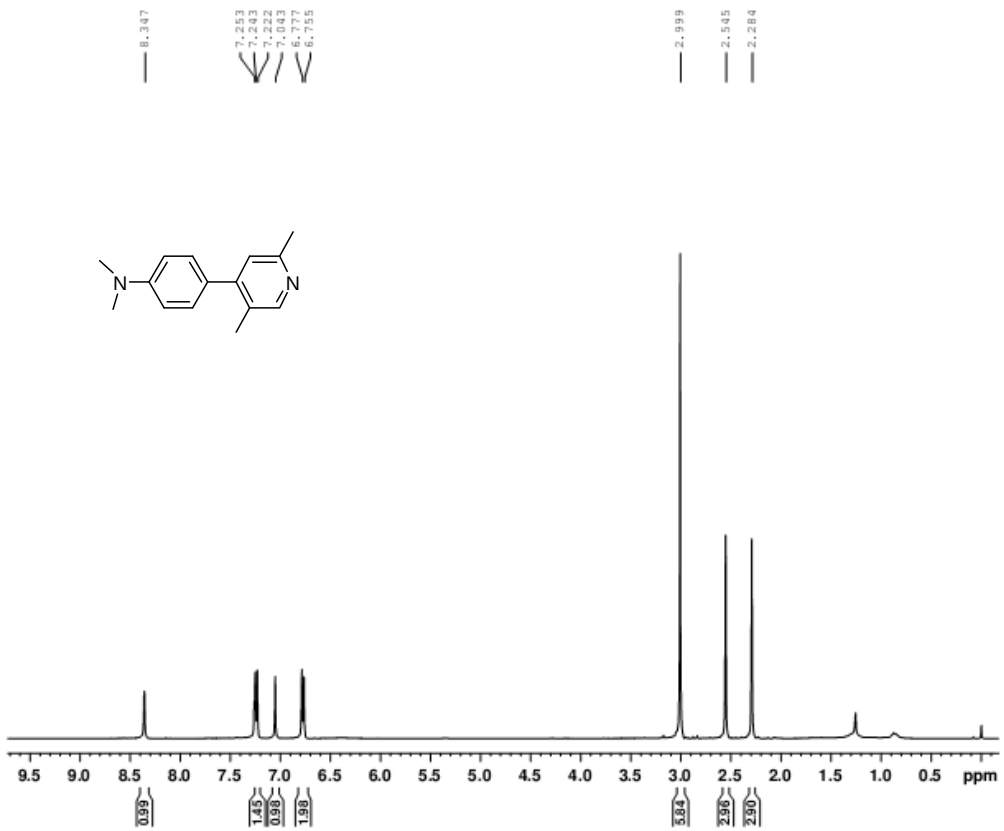


Fig. S31. ^{1}H NMR of compound **3p** (400 MHz, $CDCl_3$).

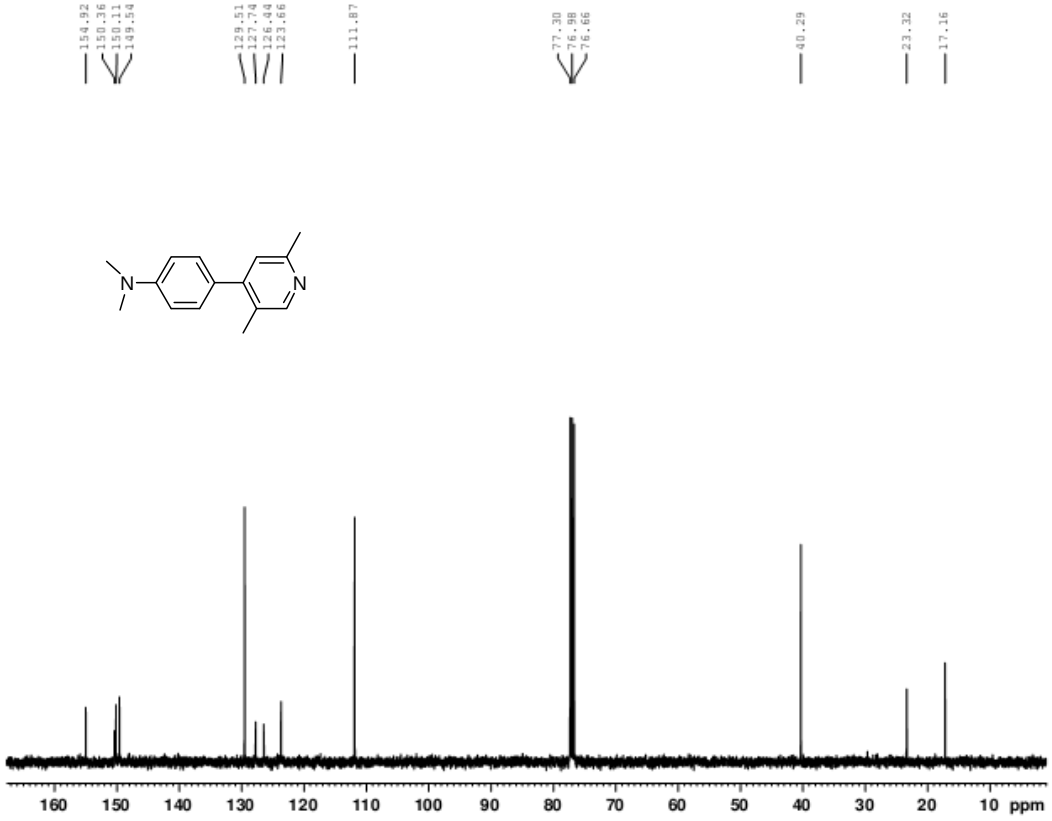


Fig. S32. ^{13}C NMR of compound **3p** (100 MHz, $CDCl_3$).

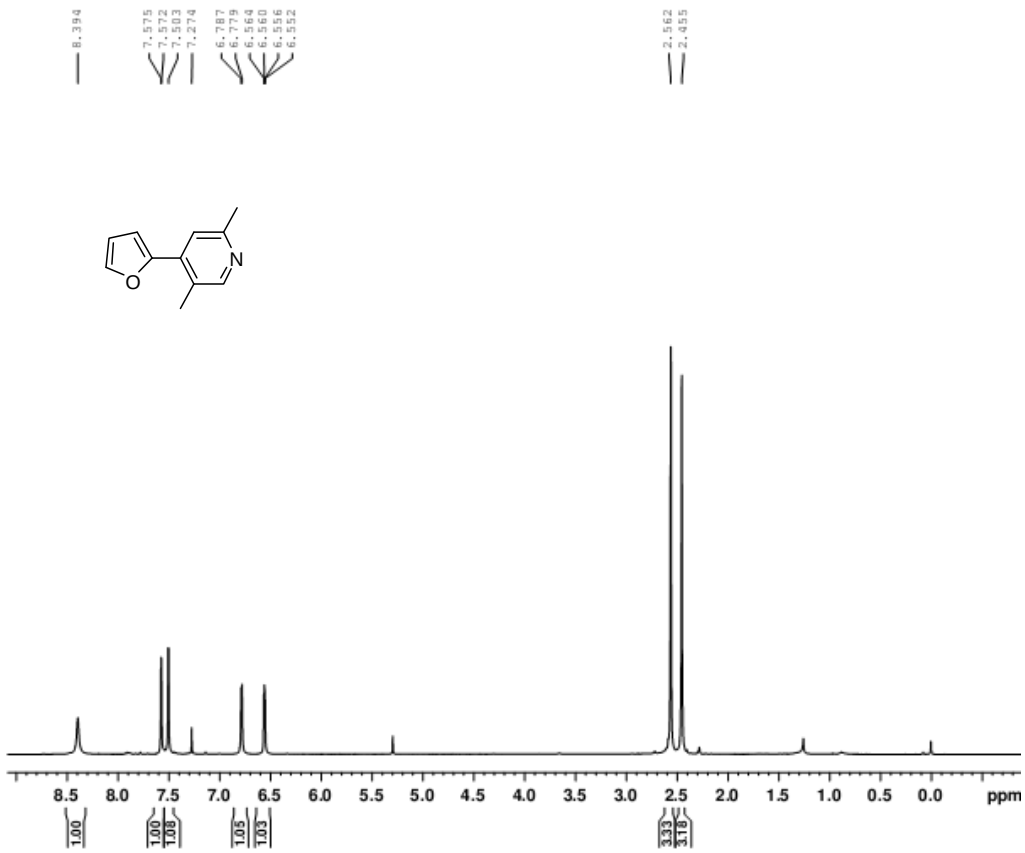


Fig. S33. ^{1}H NMR of compound **3q** (400 MHz, $CDCl_3$).

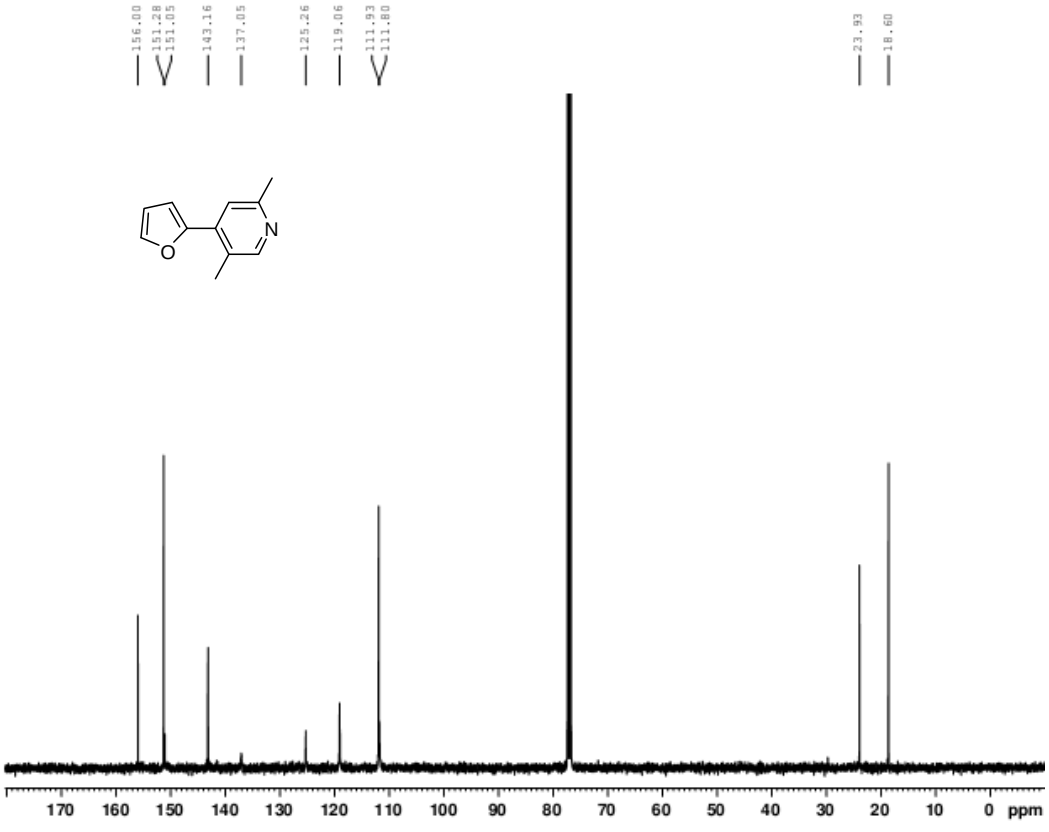


Fig. S34. ^{13}C NMR of compound **3q** (100 MHz, $CDCl_3$).

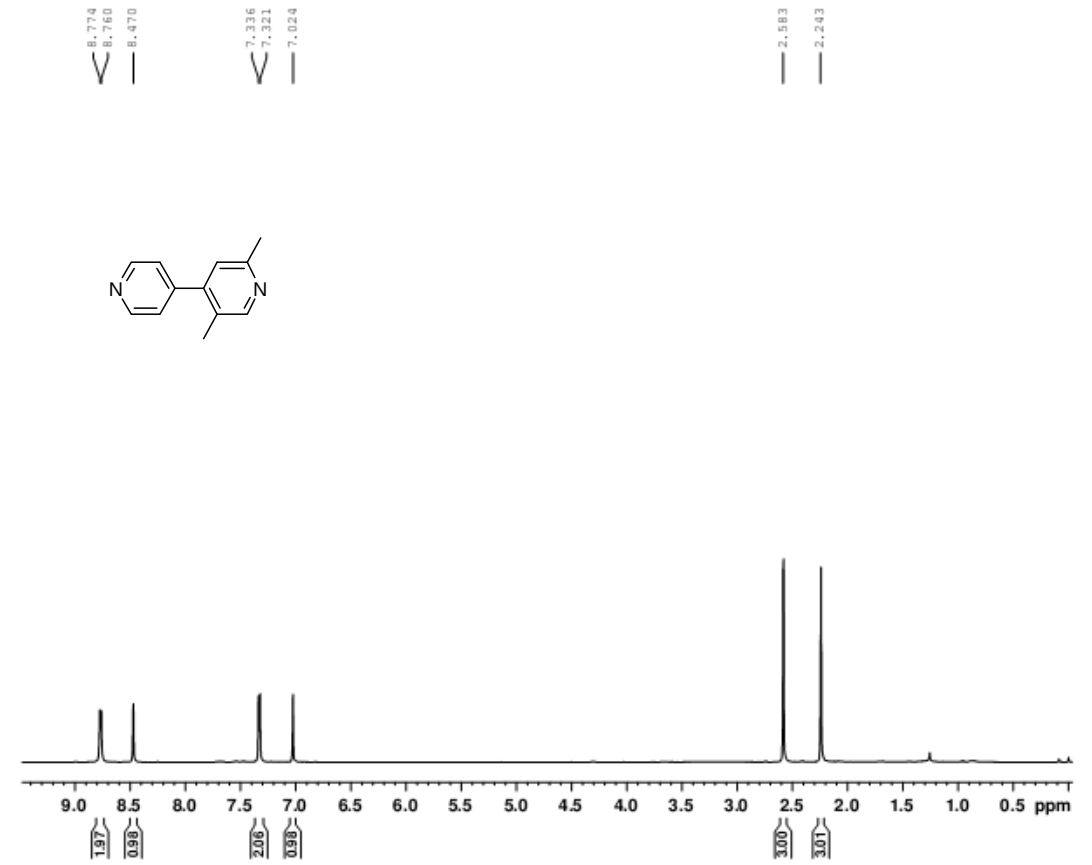


Fig. S35. ^{1}H NMR of compound **3r** (400 MHz, $CDCl_3$).

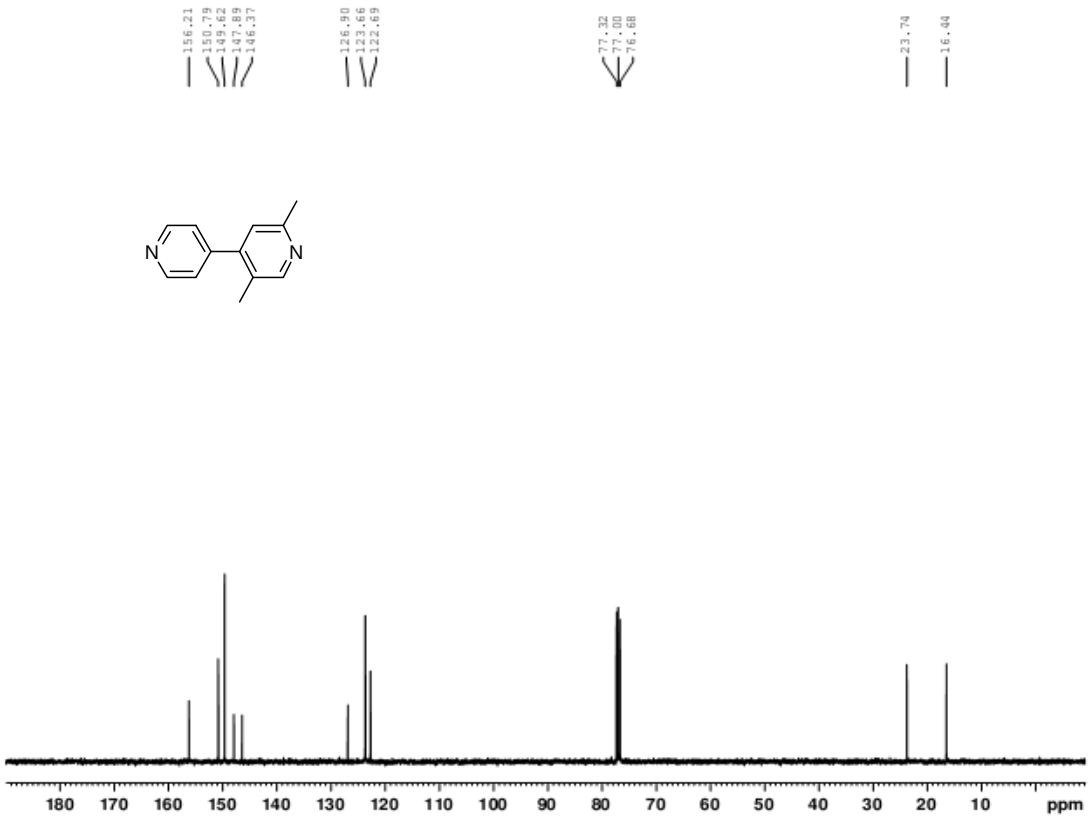


Fig. S36. ^{13}C NMR of compound **3r** (100 MHz, $CDCl_3$).

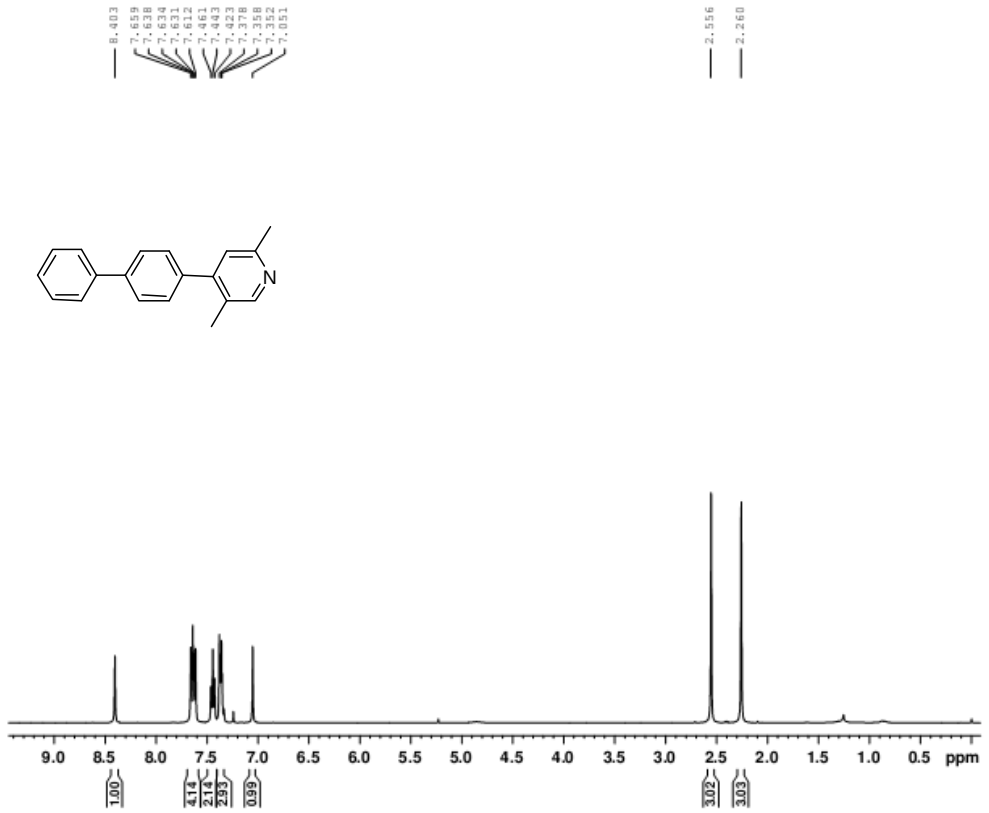


Fig. S37. ^{1}H NMR of compound **3s** (400 MHz, $CDCl_3$).

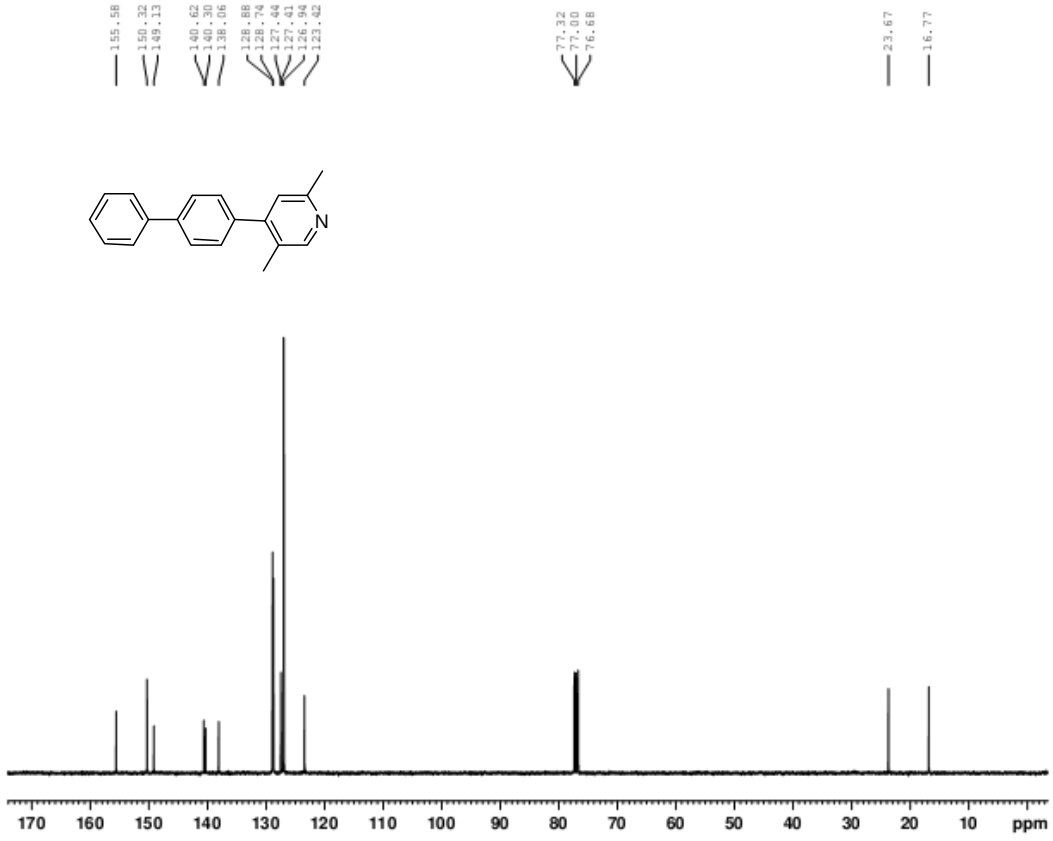


Fig. S38. ^{13}C NMR of compound **3s** (100 MHz, $CDCl_3$).

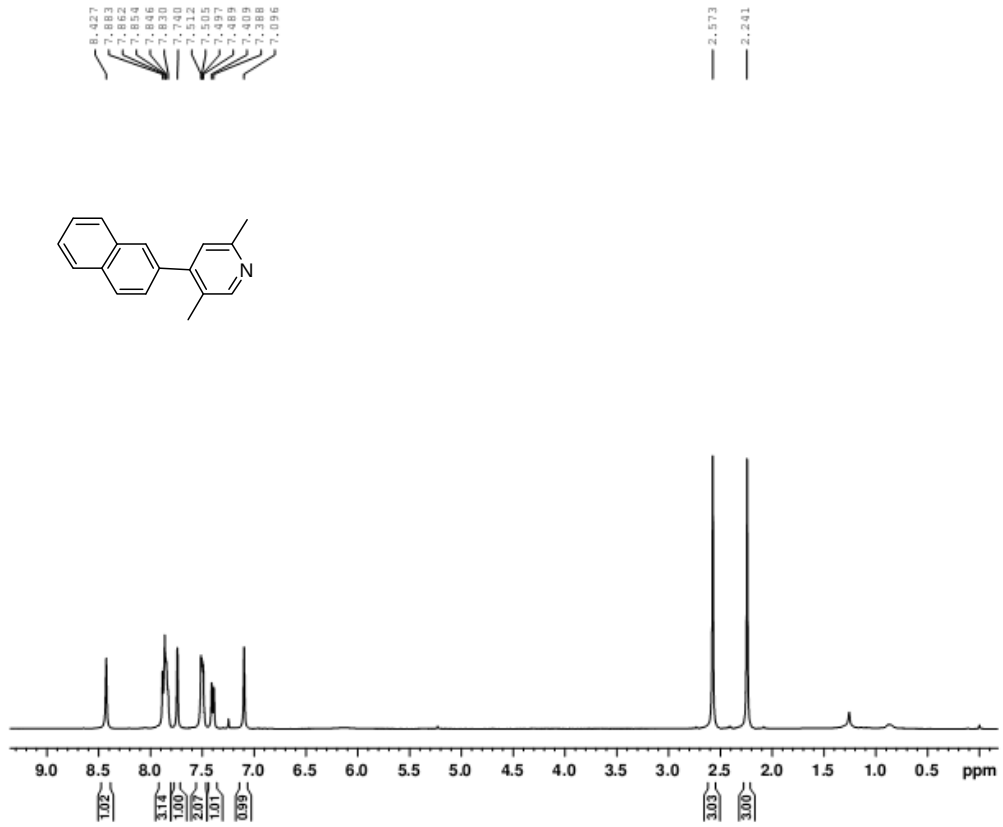


Fig. S39. ^{1}H NMR of compound **3t** (400 MHz, $CDCl_3$).

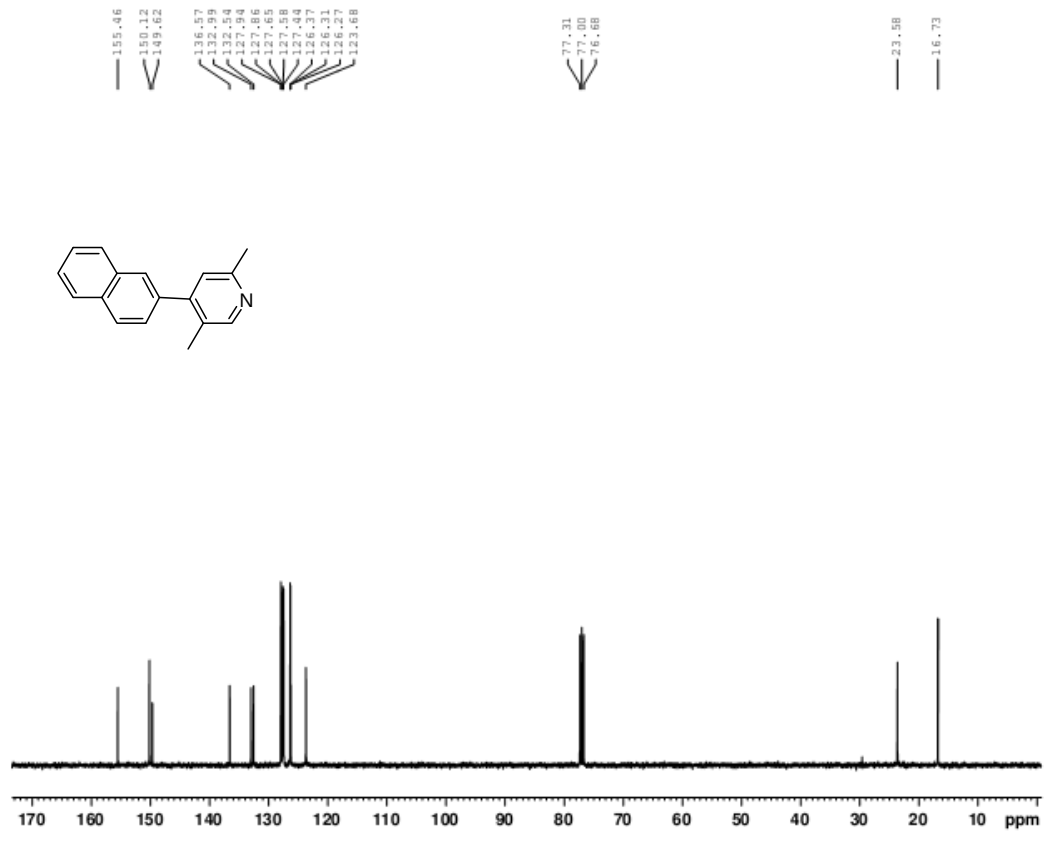


Fig. S40. ^{13}C NMR of compound **3t** (100 MHz, $CDCl_3$).

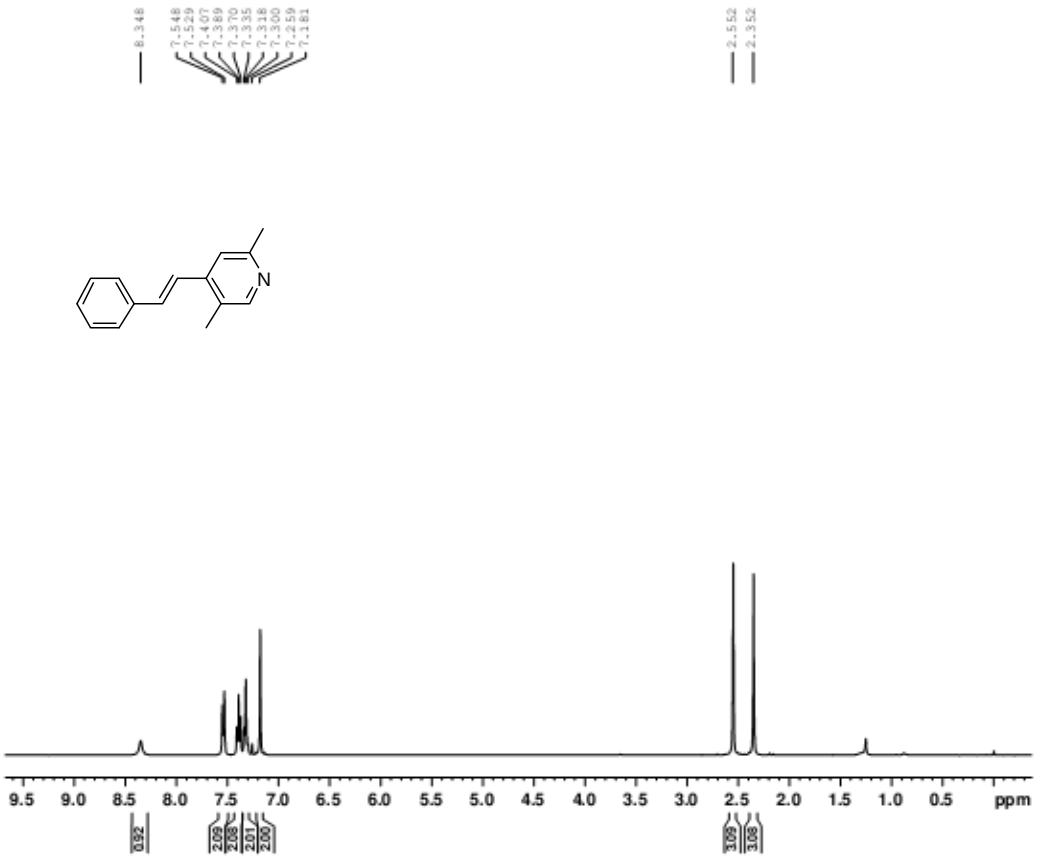


Fig. S41. ^{1}H NMR of compound **3u** (400 MHz, $CDCl_3$).

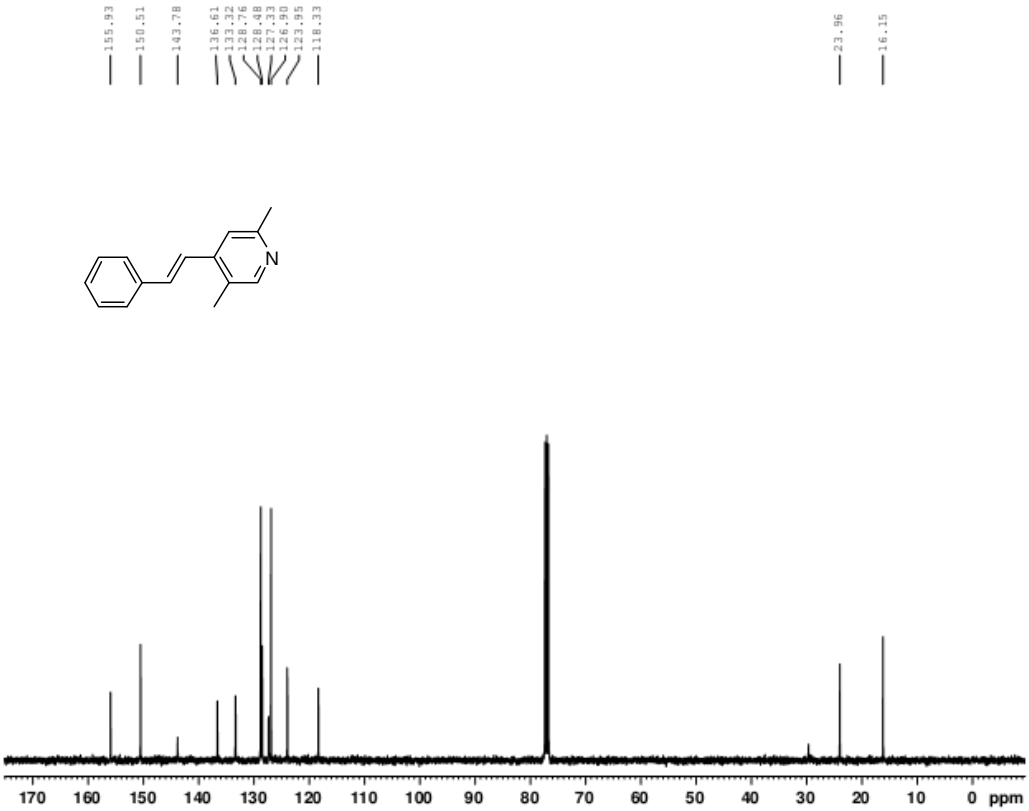


Fig. S42. ^{13}C NMR of compound **3u** (100 MHz, $CDCl_3$).

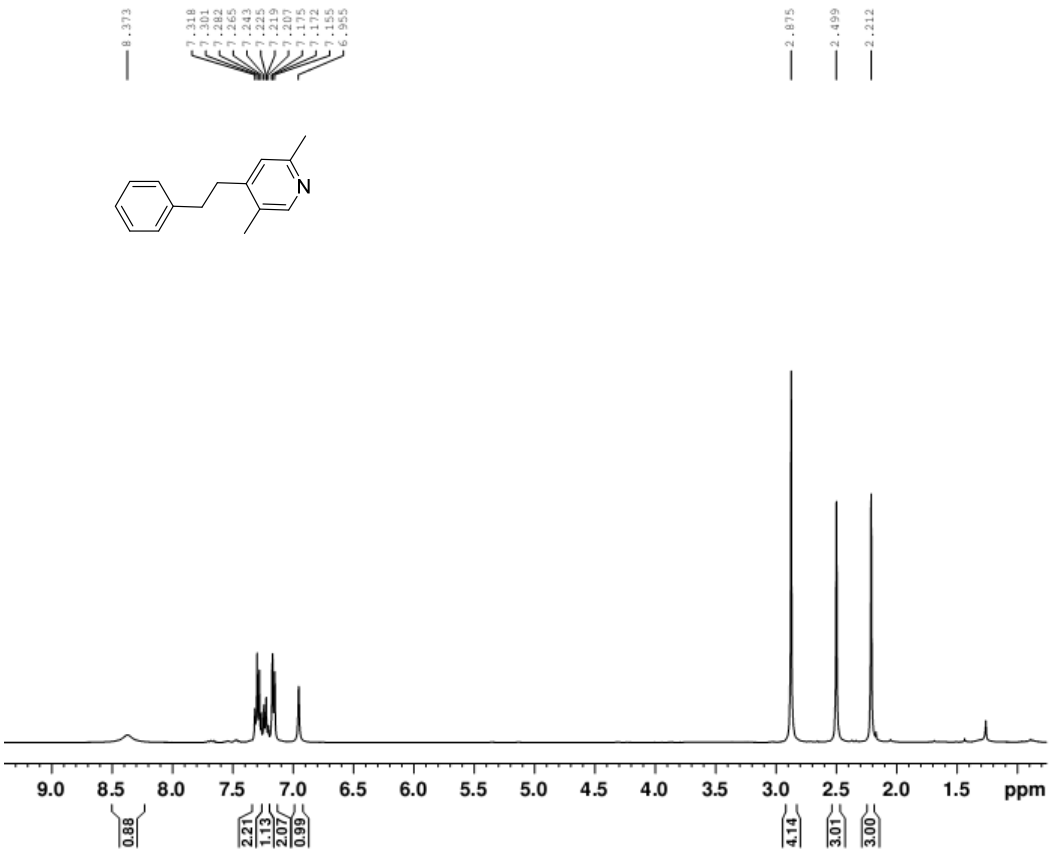


Fig. S43. ^{1}H NMR of compound **3v** (400 MHz, $CDCl_3$).

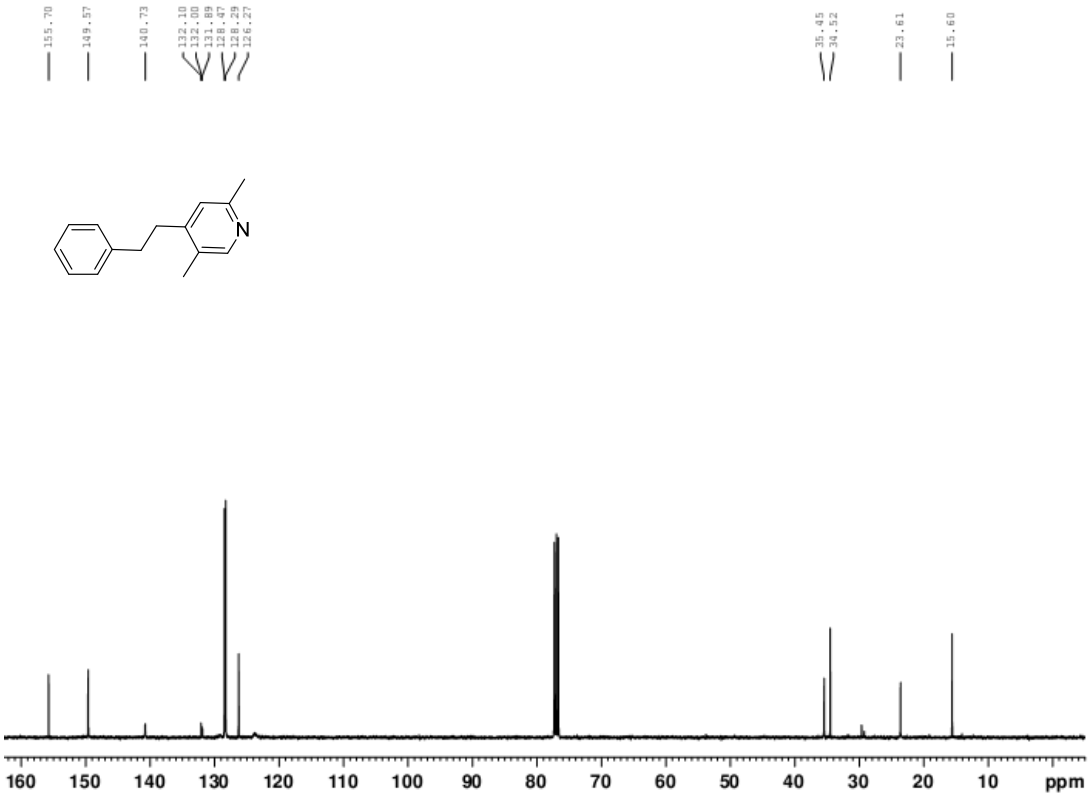


Fig. S44. ^{13}C NMR of compound **3v** (100 MHz, $CDCl_3$).

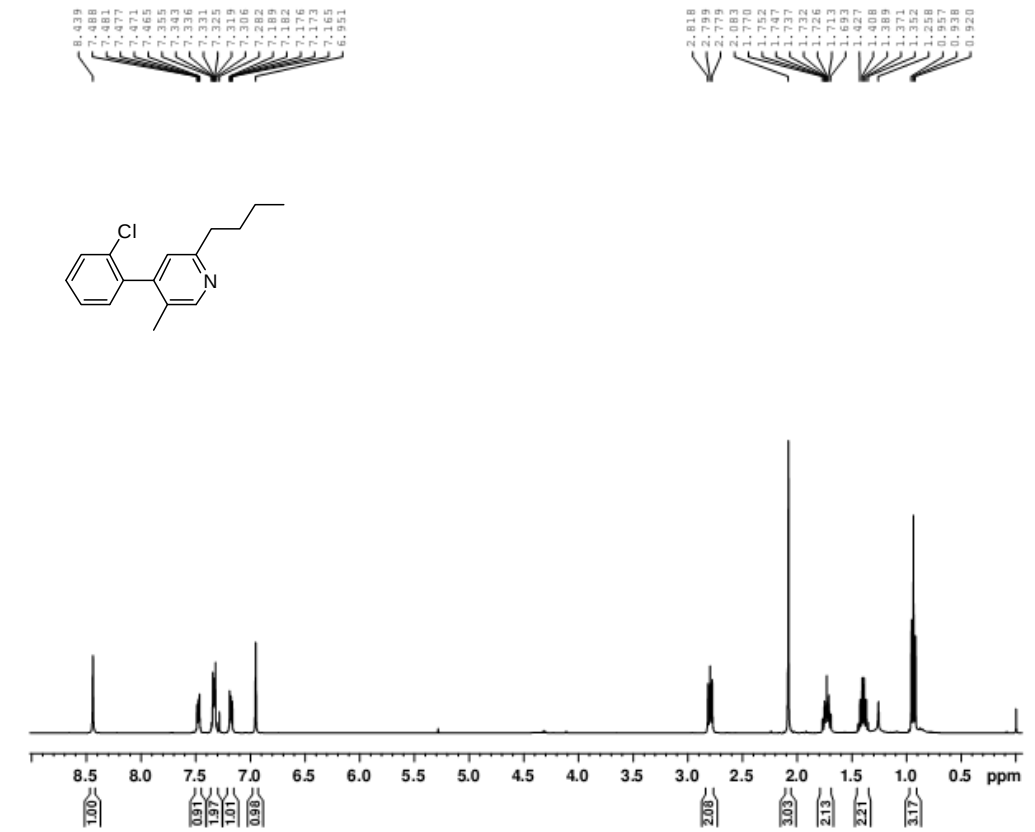


Fig. S45. ^{1}H NMR of compound **3w** (400 MHz, $CDCl_3$).

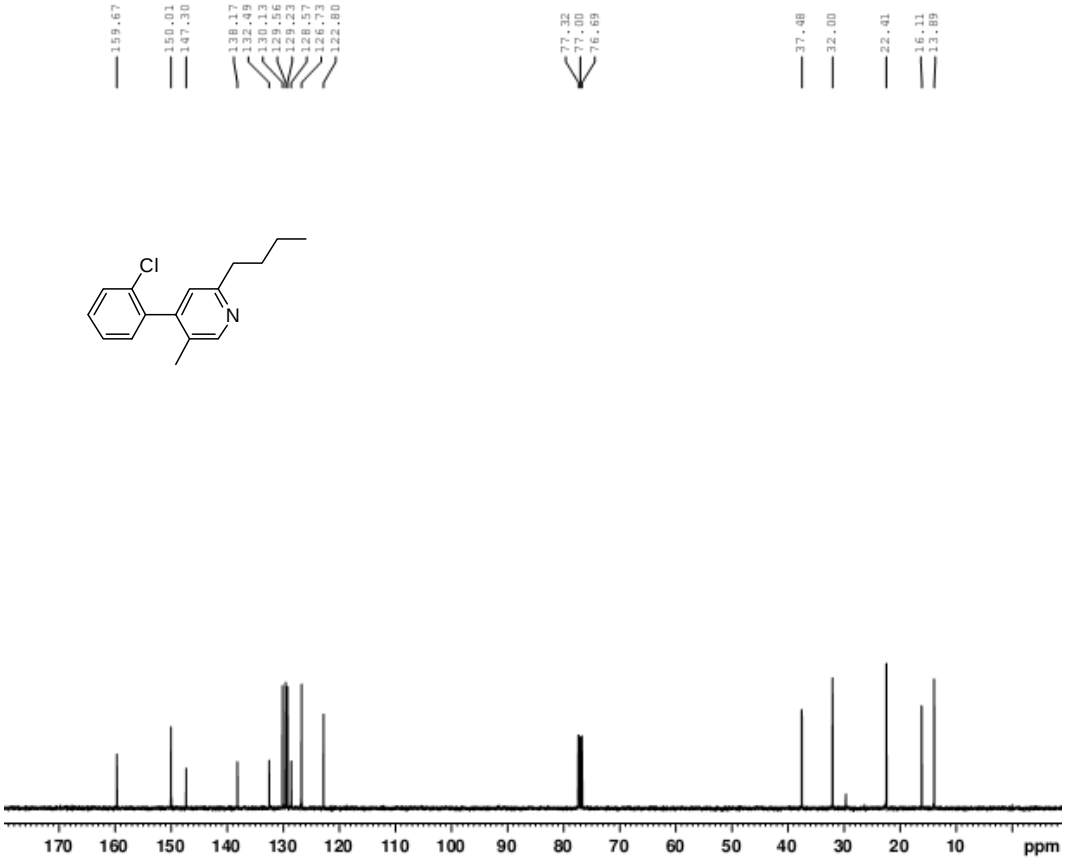


Fig. S46. ^{13}C NMR of compound **3w** (100 MHz, $CDCl_3$).

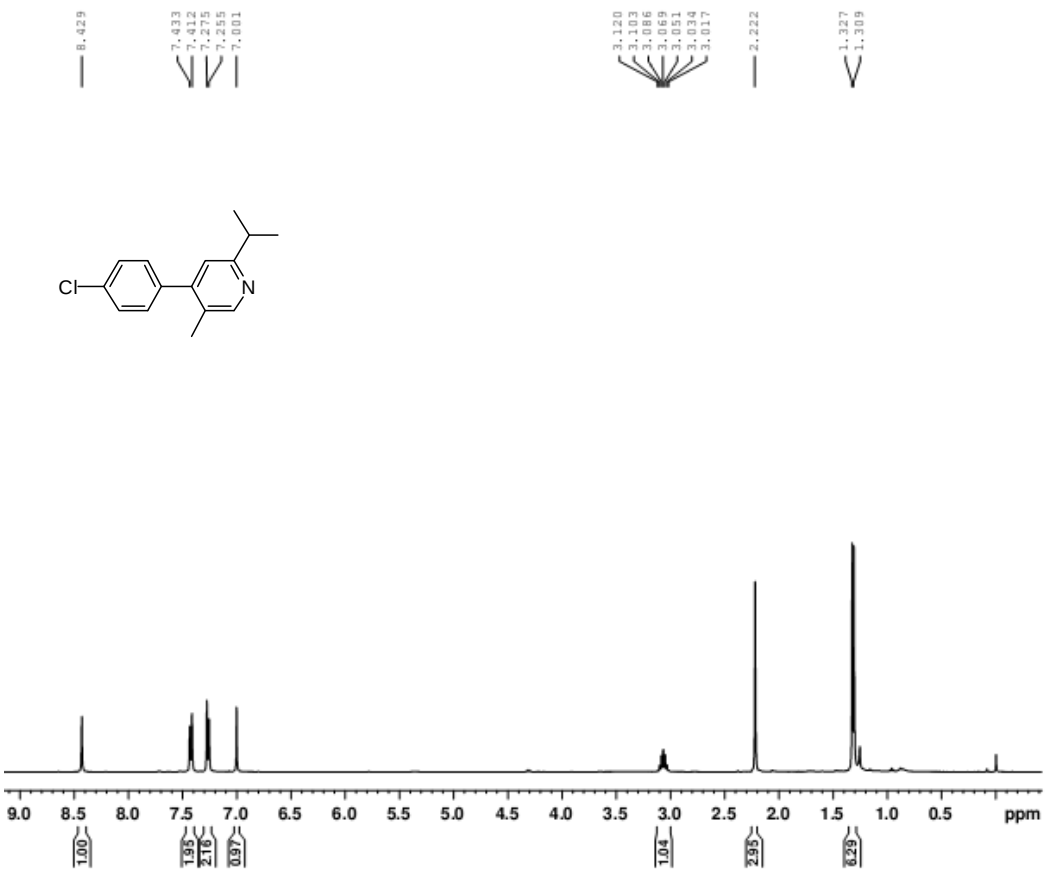


Fig. S47. ^{1}H NMR of compound **3x** (400 MHz, $CDCl_3$).

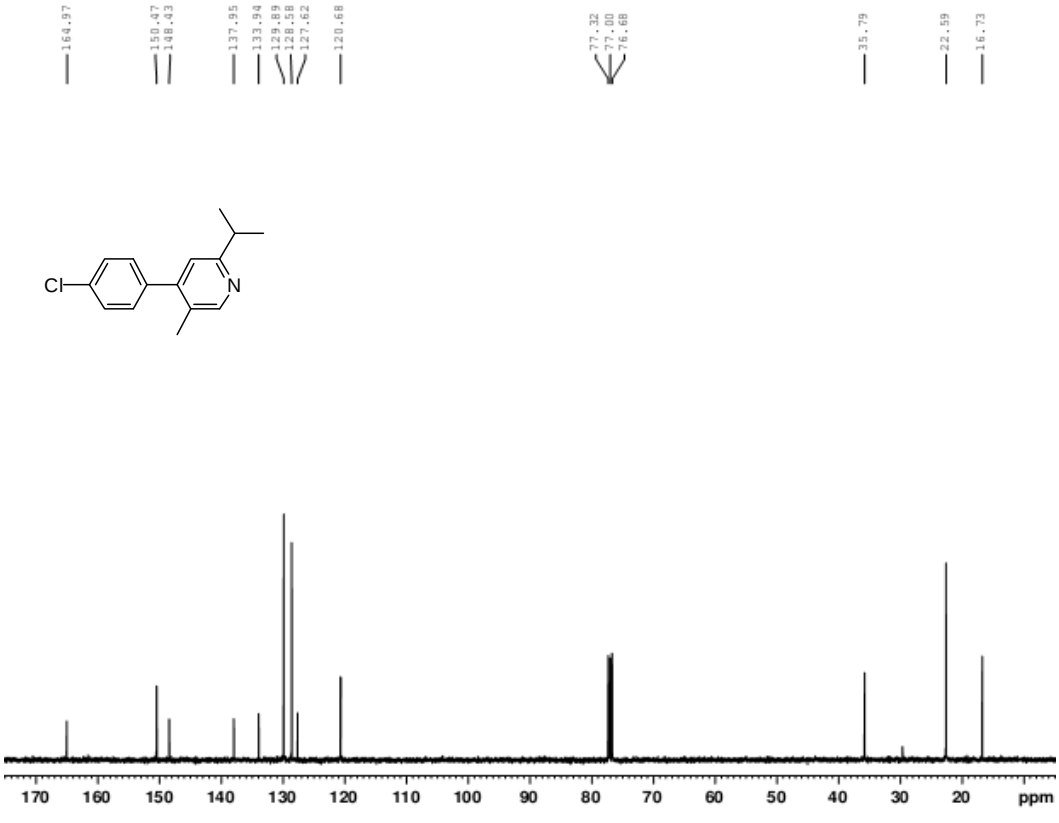


Fig. S48. ^{13}C NMR of compound **3x** (100 MHz, $CDCl_3$).

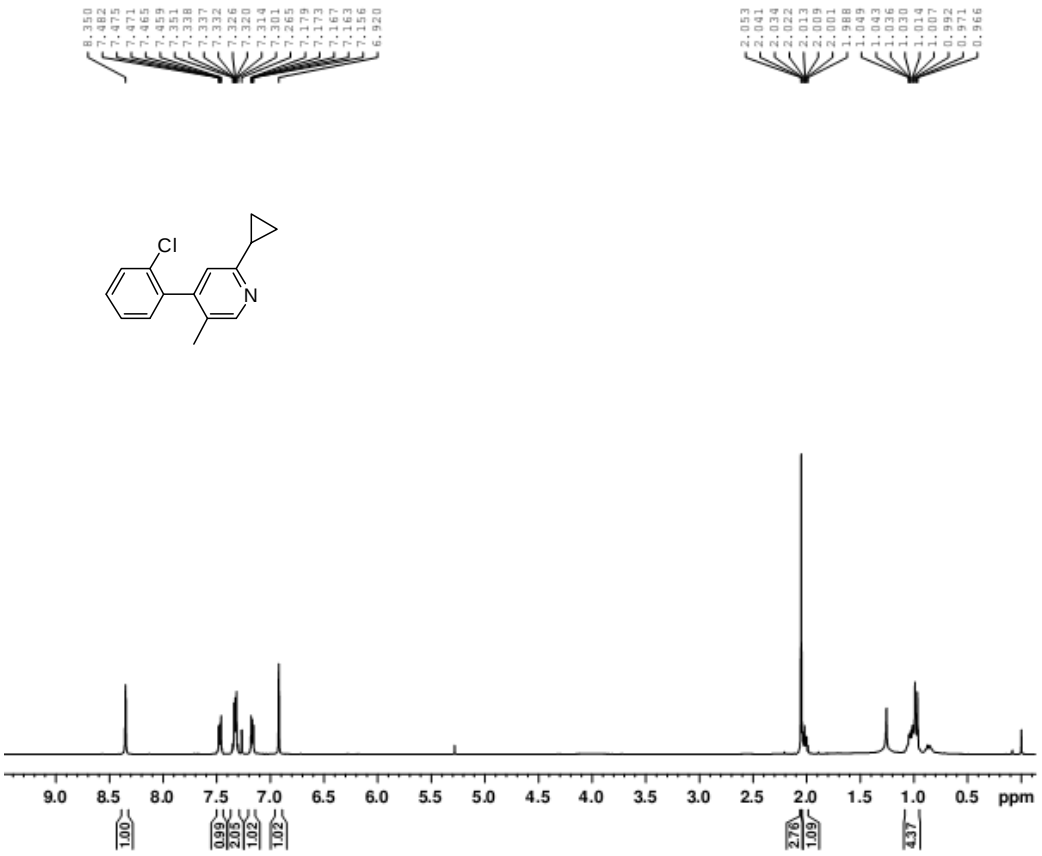


Fig. S49. ^{1}H NMR of compound **3y** (400 MHz, $CDCl_3$).

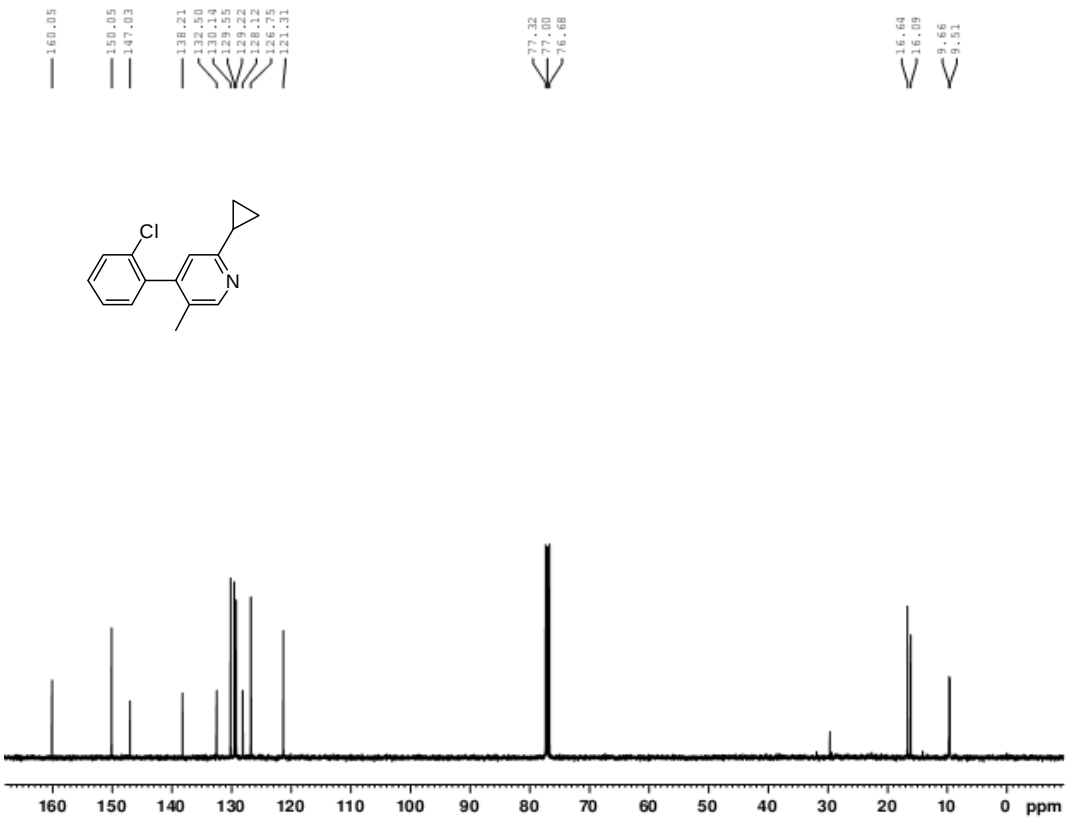


Fig. S50. ^{13}C NMR of compound **3y** (100 MHz, $CDCl_3$).

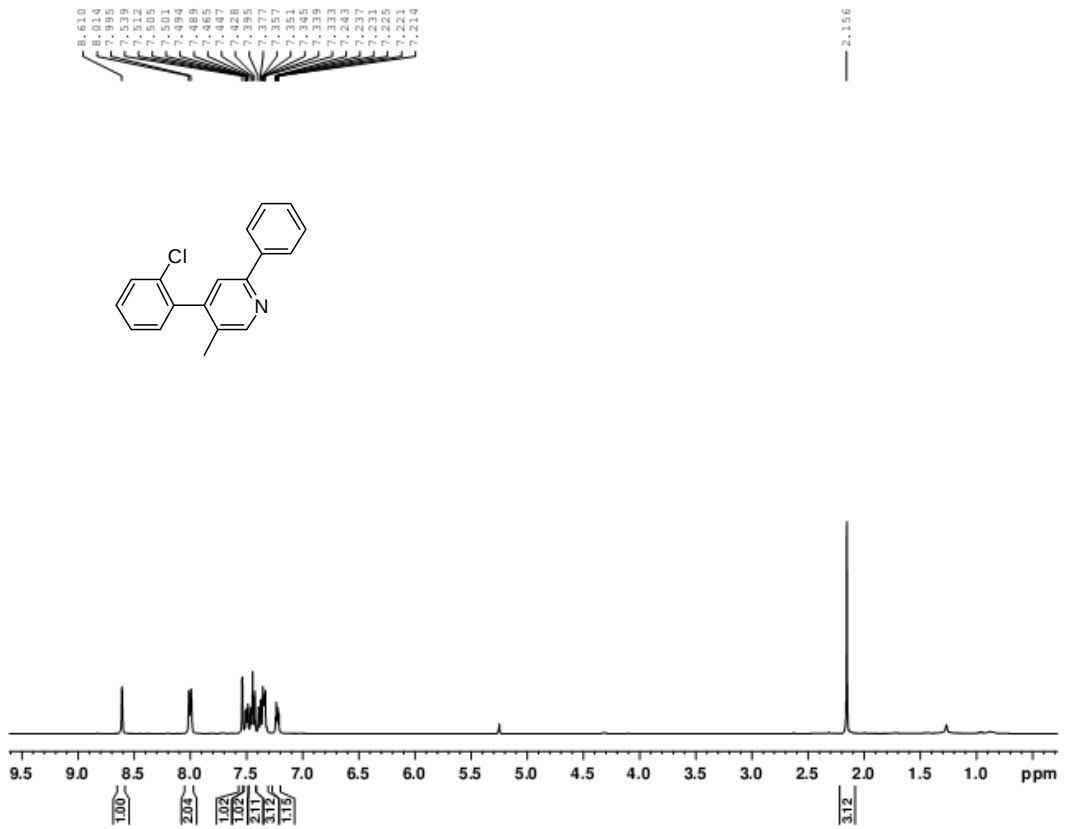


Fig. S51. ^{1}H NMR of compound **3z** (400 MHz, $CDCl_3$).

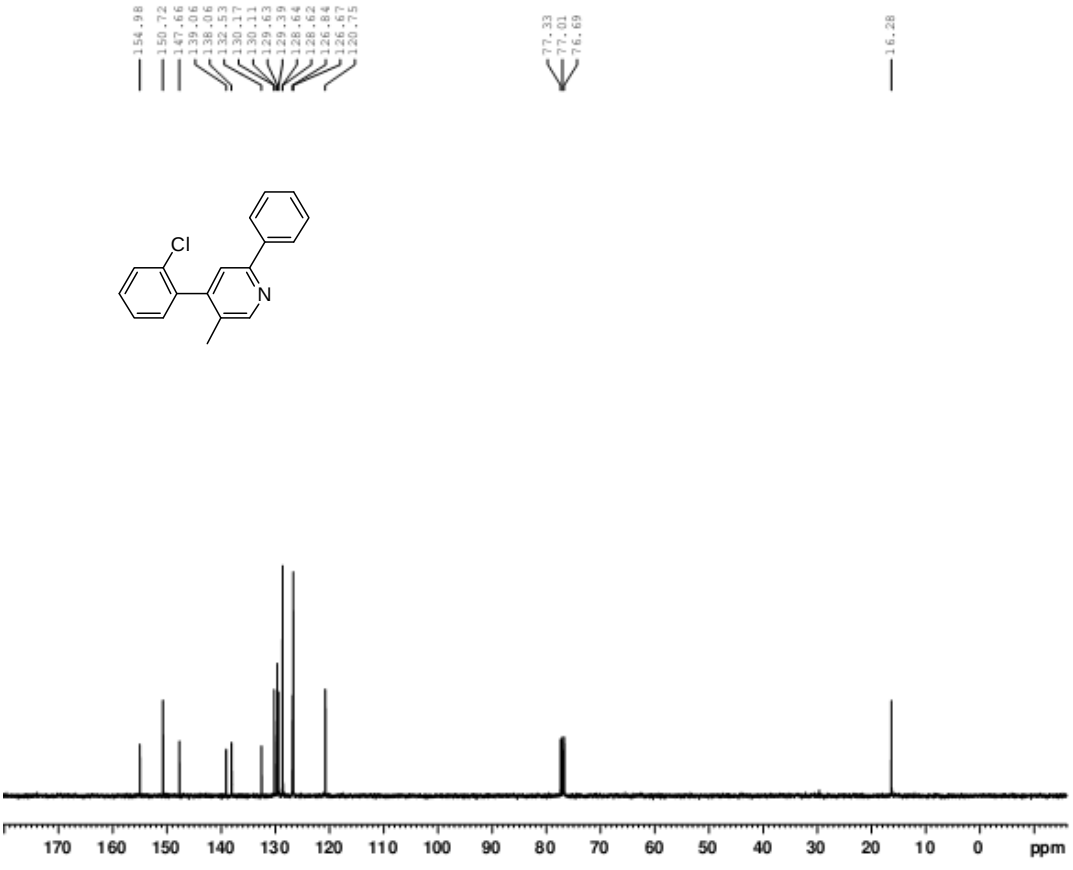


Fig. S52. ^{13}C NMR of compound **3z** (100 MHz, $CDCl_3$).

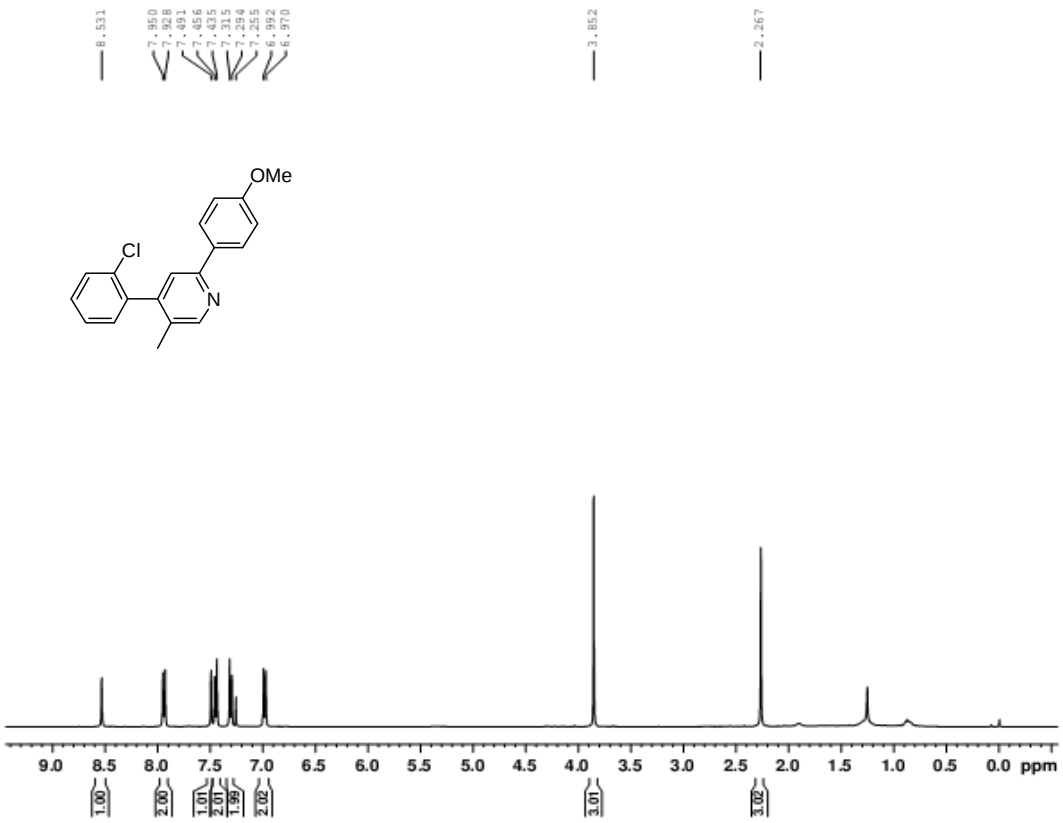


Fig. S53. ^{1}H NMR of compound **3aa** (400 MHz, $CDCl_3$).

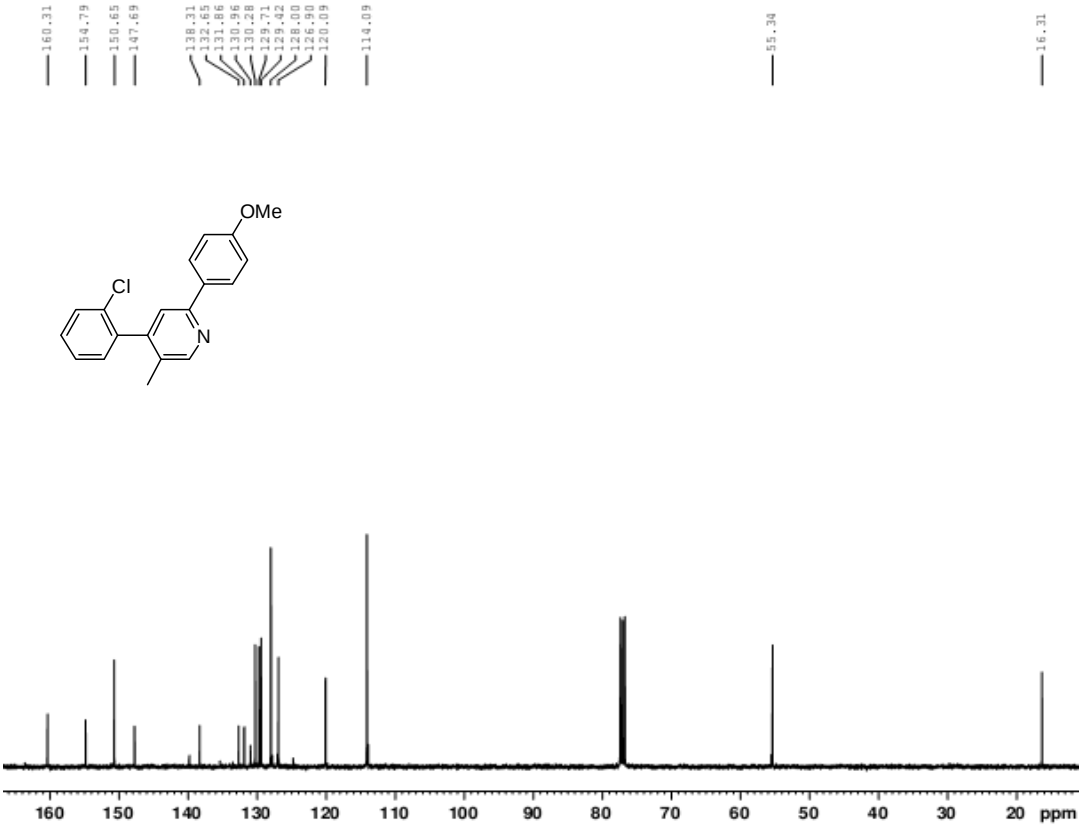


Fig. S54. ^{13}C NMR of compound **3aa** (100 MHz, $CDCl_3$).

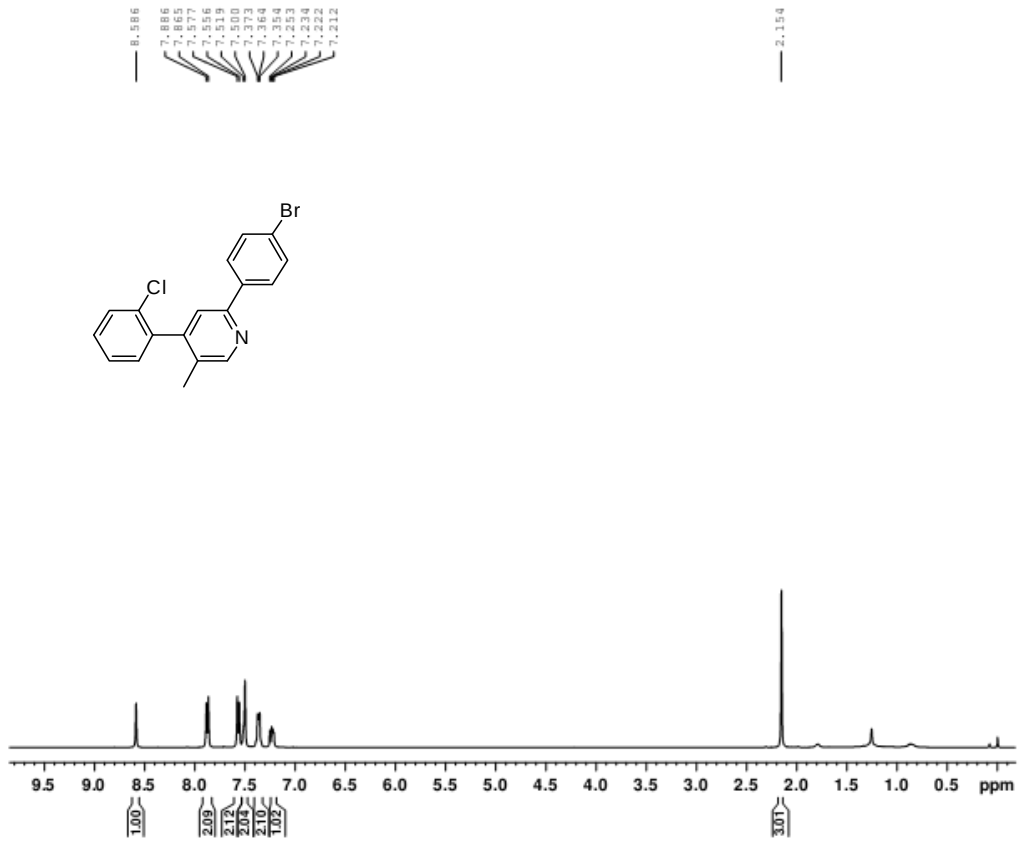


Fig. S55. ^{1}H NMR of compound **3ab** (400 MHz, $CDCl_3$).

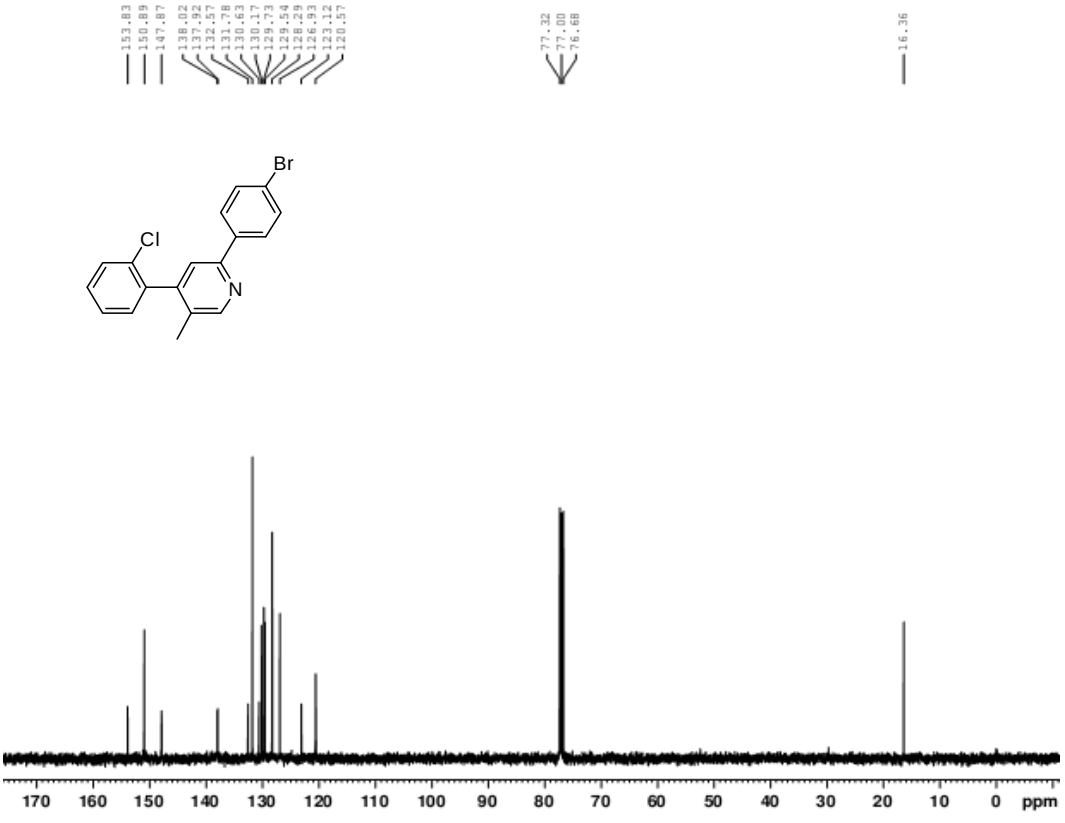


Fig. S56. ^{13}C NMR of compound **3ab** (100 MHz, $CDCl_3$).

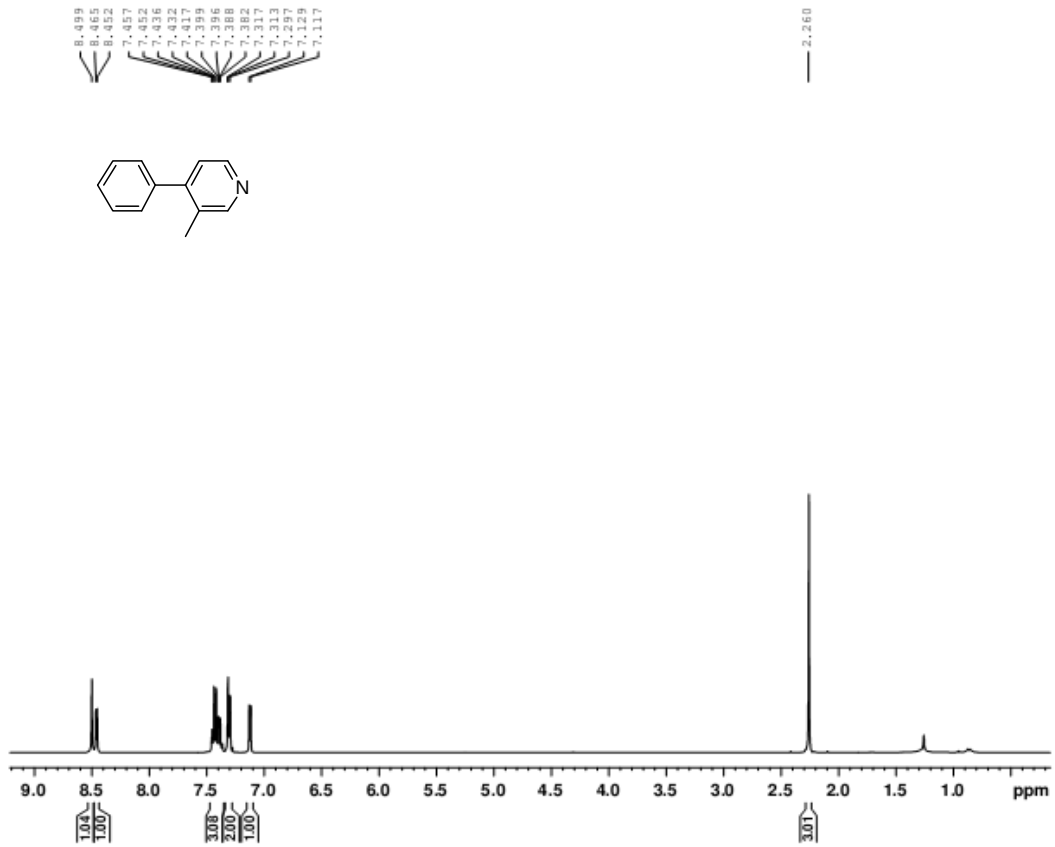


Fig. S57. ^{1}H NMR of compound **3ac** (400 MHz, $CDCl_3$).

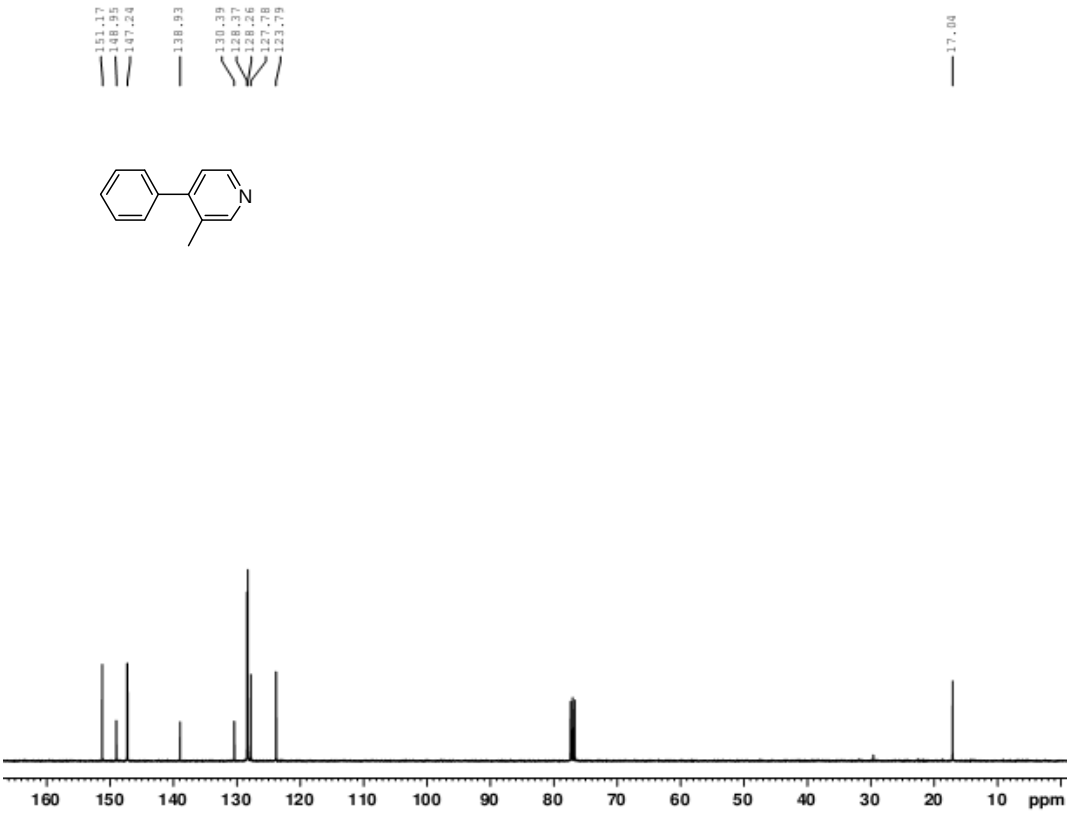


Fig. S58. ^{13}C NMR of compound **3ac** (100 MHz, $CDCl_3$).