Electronic Supplementary Material (ESI) for Organic & Biomolecular Chemistry.

Ni *vs.* Pd in Suzuki-Miyaura sp^2-sp^2 cross-coupling:

A head-to-head study in a comparable precatalyst/ligand system

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Contents

1. General

All reagents and solvents were obtained from commercial suppliers and were used without further purification unless otherwise stated. Purification was carried out according to standard laboratory methods.[1]

1.1. Purification of solvents

All solvents used for dry reactions (PhMe, CH_2Cl_2, THF, and Et_2O) were obtained from a PureSolv SPS-400-5 solvent purification system. These solvents were transferred to and stored in a septum-sealed oven-dried flask over previously activated 4 Å molecular sieves and purged with and stored under N_2. All Ni and Pd precatalysts used are commercially available and can be sourced from Sigma Aldrich. Ni(dppf)(*o*-tol)Cl was also prepared *via* a known method.[2] Dry 1,4-dioxane was obtained by distillation over $LiAlH_4$ and transferred to and stored in a septum-sealed oven-dried flask over previously activated 4 Å molecular sieves and purged with and stored under N_2. EtOAc, Et_2O, MeOH, CH_2Cl_2, and petroleum ether 40–60 °C for purification purposes were used as obtained from suppliers without further purification.

1.2. Drying of inorganic bases

Inorganic bases were dried in a Heraeus Vacutherm oven at 60 °C under static vacuum for a minimum of 24 hours before use.

1.3. Experimental details

Reactions were carried out using conventional glassware (preparation of intermediates) or in 5 mL capped microwave vials (optimization reactions and substrates). The glassware was oven-dried (150 °C) and cooled under vacuum before use. Purging refers to a vacuum/N_2-refilling procedure. Room temperature was generally 20 °C. Reactions were carried out at elevated temperatures using a temperature-regulated hotplate/stirrer and a sandbath. Temperature quoted is a measurement of the sandbath heating block. Reactions were carried out at 0 °C using an ice bath. Reactions were carried out at –78 °C using an acetone/dry ice bath.

1.4. Purification of products

Thin layer chromatography (TLC) was carried out using Merck silica plates coated with fluorescent indicator UV254. These were analyzed under 254 nm UV light or developed using potassium permanganate, vanillin, or anisaldehyde solutions. Column chromatography was carried out using ZEOprep 60 HYD 40-63 μm silica gel.

1.5. Analysis of products

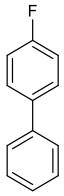
^{19}F NMR spectra were obtained on either a Bruker AV 400 spectrometer at 376 MHz or Bruker AV 500 at 470 MHz. ^{1}H and ^{13}C NMR spectra were obtained on either a Bruker AV 400 at 400 MHz and 125 MHz, Bruker AV 500 at 500 MHz and 126 MHz, respectively. Chemical shifts are reported in ppm and coupling constants are reported in Hz: $CDCl_3$ referenced at 7.26 (^{1}H) and 77.0 ppm (^{13}C); DMSO-d_6 referenced at 2.50 (^{1}H) and 39.5 ppm (^{13}C). For fluorine containing molecules NMR conversion was obtained through the addition of a known standard (trifluorotoluene (30.7 μL, 0.25 mmol)), referenced at –63.0 ppm). After 10 min of stirring, an aliquot of the mixture was filtered through celite and conversion against the internal standard was determined by ^{19}F NMR. NMR conversion was obtained through addition of a known standard (1,4-dinitrobenzene) to the crude reaction mixture. Solvent was removed under reduced pressure and conversion against the internal standard was determined by ^{1}H NMR.

Reverse phase HPLC data was obtained on an Agilent 1200 series HPLC using an Agilent Eclipse XDB-C18 column. Analysis was performed using a gradient method, eluting with 5–85% MeCN/H_2O over 8 minutes at a flow rate of 2 mL/min. Samples for HPLC analysis were prepared through the addition of 1.0 mL of naphthalene standard solution (0.03125 M) to the reaction mixture (0.25 mmol). The resulting solution was then stirred before the removal of a 200 μL aliquot. The aliquot was diluted to 1 mL with MeCN. A 200 μL aliquot of the diluted solution was then filtered through Celite and further diluted with 800 μL MeCN and 500 μL H_2O for HPLC analysis against established conversion factors.

2. General experimental procedures

2.1 General procedure: Ni-catalyzed Suzuki-Miyaura cross coupling optimization protocol.

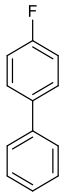
For example, synthesis of compound **3a**



To an oven-dried microwave vial was added 4-bromofluorobenzene (43.8 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(*o*-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), and K_3PO_4 (159 mg, 0.75 mmol, 3 equiv). The vial was capped and purged with N_2 before the addition of 1,4-dioxane (1 mL, 0.25 M). The reaction mixture was heated for 4 h at 80 °C. The reaction mixture was then allowed to cool to rt and trifluorotoluene (30.7 µL, 0.25 mmol) was added. The vial was then decapped, and the reaction mixture diluted with $CDCl_3$ and filtered through a layer of celite. Conversion to the desired product was measured by ^{19}F NMR against a known internal standard (trifluorotoluene).

2.2 Method A: Ni-catalyzed Suzuki-Miyaura cross coupling.

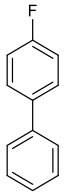
For example, synthesis of compound **3a**



To an oven-dried microwave vial was added 4-bromofluorobenzene (43.8 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(*o*-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), and K_3PO_4 (159 mg, 0.75 mmol, 3 equiv). The vial was capped and purged with N_2 before the addition of 1,4-dioxane (1 mL, 0.25 M). The reaction mixture was heated for 4 h at 80 °C. The vial was then allowed to cool to room temperature, decapped, diluted with EtOAc (10 mL) and filtered through a plug of celite, eluting with EtOAc. The resulting solution was washed with H_2O (3 x 10 mL) followed by brine (10 mL) and the organic phases collected. The organic phase was dried over Na_2SO_4, filtered, and concentrated under vacuum. The crude residue was purified by column chromatography (silica gel, petroleum ether 40-60°) to afford the desired product as a white solid (42.4 mg, 98%).

2.3 Method B: Pd-catalyzed Suzuki-Miyaura cross coupling.

For example, synthesis of compound **3a**



To an oven-dried microwave vial was added 4-bromofluorobenzene (43.8 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Pd(dppf)Cl_2 (7.3 mg, 0.01 mmol, 4 mol%), and K_3PO_4 (159 mg, 0.75 mmol, 3 equiv). The vial was capped and purged with N_2 before the addition of 1,4-dioxane (1 mL, 0.25 M), followed by H_2O (22.5 µL, 1.25 mmol, 5 equiv). The reaction mixture was heated for 4 h at 80 °C with stirring. The vial was then allowed to cool to room temperature, decapped, diluted with EtOAc (10 mL) and filtered through a plug of celite, eluting with EtOAc. The resulting solution was washed with H_2O (3 x 10 mL) followed by brine (10 mL) and the organic phases collected. The organic phase was dried over Na_2SO_4, filtered, and concentrated under vacuum. The crude residue was purified by column chromatography (silica gel, petroleum ether 40-60°) to afford the desired product as a white solid (42.1 mg, 98%).

3. Reaction optimization data

3.1 Time study

Reactions were carried out according to General Procedure using 4-bromofluorobenzene (43.8 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(*o*-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). The reaction was stirred for **x** h at 80 °C, before analysis by ^{19}F NMR against a known internal standard (trifluorotoluene).

Entry	Time (h)	Product conversion (%)
1	1	90
2	2	96
3	4	Quant.

3.2 Catalyst Loading study

Reactions were carried out according to General Procedure using 4-bromofluorobenzene (43.8 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(*o*-tol)Cl (**x** mg, **y** mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). The reaction was stirred for 4 h at 80 °C, before analysis by ^{19}F NMR against a known internal standard (trifluorotoluene).

Entry	Catalyst loading (x mg, y mol%)	Product conversion (%)
1	7.4 mg, 4 mol%	Quant.
2	3.8 mg, 2 mol%	Quant.
3	1.9 mg , 1 mol%	96

3.3 Base study

Reactions were carried out according to General Procedure using 4-bromofluorobenzene (43.8 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(*o*-tol)Cl (1.9 mg, 0.0025 mmol, 1 mol%), **Base** (**3** equiv, **x** mg), and 1,4-dioxane (1 mL, 0.25 M). The reaction was stirred for 4 h at 80 °C, before analysis by ^{19}F NMR against a known internal standard (trifluorotoluene).

Entry	Base (3 equiv, x mg)	Product conversion (%)
1	K_3PO_4 (159 mg)	Quant.
2	Cs_2CO_3 (244 mg)	18

3.4 Water study

Reactions were carried out according to General Procedure using 4-bromofluorobenzene (43.8 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(*o*-tol)Cl (1.9 mg, 0.0025 mmol, 1 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), 1,4-dioxane (1 mL, 0.25 M), and **H_2O** (**x** equiv, **y** µL). The reaction was stirred for 4 h at 80 °C, before analysis by ^{19}F NMR against a known internal standard (trifluorotoluene).

Entry	H_2O (x equiv, y µL)	Product conversion (%)
1	0 equiv, 0 µL	Quant.
2	1 equiv, 4.5 µL	99
3	2 equiv, 9 µL	93
4	3 equiv, 13.5 µL	92
5	5 equiv, 22.5 µL	68

3.5 Solvent study

Reactions were carried out according to General Procedure using 4-bromofluorobenzene (43.8 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(*o*-tol)Cl (1.9 mg, 0.0025 mmol, 1 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), and **solvent** (1 mL, 0.25 M). The reaction was stirred for 4 h at 80 °C, before analysis by ^{19}F NMR against a known internal standard (trifluorotoluene).

Entry	Solvent	Product conversion (%)
1	1,4-dioxane	Quant.
2	THF	91
3	PhMe	83

3.6 Temperature study

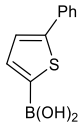
Reactions were carried out according to General Procedure using 4-bromofluorobenzene (43.8 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(*o*-tol)Cl (1.9 mg, 0.0025 mmol, 1 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). The reaction was stirred for 4 h at **x** °C, before analysis by ^{19}F NMR against a known internal standard (trifluorotoluene).

Entry	Temperature (°C)	Product conversion (%)
1	80	Quant.
2	50	93
3	room temperature	0

4. Compound characterization data

4.1. Preparation of starting materials

(5-Phenylthiophen-2-yl)boronic acid, **2v**



To an oven dried round bottom flask was added 2-phenylthiophene (2.04 g, 12.7 mmol), the flask was sealed and purged with N_2. Dry THF (40 mL) was added to the flask and the reaction mixture stirred under N_2 at 0 °C for 10 minutes. *n*-BuLi in THF (5.71 mL, 2.2 M, 1 equiv) was added to the reaction mixture dropwise and the reaction allowed to stir for 1 h at 0 °C. The reaction mixture was then added dropwise to a stirred solution of trimethyl borate (2.84 mL, 25.5 mL, 2 equiv) in THF (20 mL) at –78 °C *via* cannula, following addition the reaction was stirred overnight under N_2, allowing to warm to room temperature. The mixture was then acidified with HCl (2 M, 20 mL) and stirred for 1 h. The aqueous layer was extracted with diethyl ether (3 × 40 mL) and the organic layer was washed with water and dried over Na_2SO_4. The solvent was removed under vacuum and the resulting crude product was recrystallized from H_2O/EtOH (50/50) to give the product as a grey solid (1.63 g, 62%).

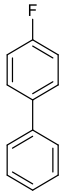
^{1}H NMR (500 MHz, DMSO-d_6) δ 8.28 (s, 2H), 7.70 – 7.63 (m, 3H), 7.53 (d, *J* = 3.6 Hz, 1H), 7.44 – 7.39 (m, 2H), 7.34 – 7.28 (m, 1H).

^{13}C NMR (126 MHz, DMSO-d_6) δ 148.8, 137.3, 133.9, 129.2, 127.8, 125.6, 124.8.

Spectroscopic data were in agreement with literature values.[3]

4.2 Products of bromide substrate survey

Compound 3a



Method A: According to the Method A, using 4-bromofluorobenzene (43.8 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(*o*-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), and K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, petroleum ether 40-60°) to afford the product as a white solid (42.4 mg, 98%).

Method B: According to the Method B, using 4-bromofluorobenzene (43.8 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Pd(dppf)Cl_2 (7.3 mg, 0.01 mmol, 4 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), H_2O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, petroleum ether 40-60°) to afford the product as a white solid (42.1 mg, 98%).

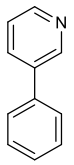
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.59 – 7.54 (m, 4H), 7.48 – 7.43 (m, 2H), 7.39 – 7.34 (m, 1H), 7.18 – 7.11 (m, 2H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 162.5 (d, $^1J_{CF}$ = 246.1 Hz), 140.3, 137.4, 128.8, 128.7 (d, $^3J_{CF}$ = 7.7 Hz), 127.2, 127.0, 115.6 (d, $^2J_{CF}$ = 21.5 Hz).

^{19}F NMR (376 MHz, $CDCl_3$) δ –115.80 – –115.88 (m).

Spectroscopic data were in agreement with literature values.[4]

Compound 3b



Method A: Prepared according to the Method A, using 3-bromopyridine (39.5 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(*o*-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 5-30% EtOAc in petroleum ether 40-60°) to afford the product as a colourless oil (33.4 mg, 86%).

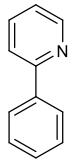
Method B: Prepared according to the Method B, using 3-bromopyridine (39.5 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), $Pd(dppf)Cl_2$ (7.3 mg, 0.01 mmol, 4 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), H_2O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 5-30% EtOAc in petroleum ether 40-60°) to afford the product as a colourless oil (33.0 mg, 85%).

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.86 – 8.85 (m, 1H), 8.59 (dd, *J* = 4.8, 1.7 Hz, 1H), 7.87 (ddd, *J* = 7.9, 2.4, 1.6 Hz, 1H), 7.60 – 7.56 (m, 2H), 7.50 – 7.45 (m, 2H), 7.43 – 7.38 (m, 1H), 7.36 (ddd, *J* = 7.9, 4.8, 0.9 Hz, 1H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 148.4, 148.3, 137.8, 136.6, 134.3, 129.0, 128.1, 127.1, 123.5.

Spectroscopic data were in agreement with literature values.[5]

Compound 3c



Method A: Prepared according to the Method A, using 2-bromopyridine (39.5 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(*o*-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 5-30% EtOAc in petroleum ether 40-60°) to afford the product as a colourless oil (3.5 mg, 9%).

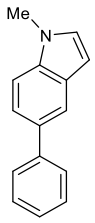
Method B: According to the Method B, using 2-bromopyridine (39.5 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), $Pd(dppf)Cl_2$ (7.3 mg, 0.01 mmol, 4 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), H_2O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 5-30% EtOAc in petroleum ether 40-60°) to afford the product as a colourless oil (22.3 mg, 57%).

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.75 – 7.99 (m, 1H), 8.04 – 7.97 (m, 2H), 7.77 – 7.70 (m, 2H), 7.52 – 7.45 (m, 2H), 7.44 – 7.39 (m, 1H), 7.25 – 7.20 (m, 1H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 157.5, 149.6, 139.4, 136.7, 128.9, 128.7, 126.9, 122.1, 120.5.

Spectroscopic data were in agreement with literature values.[5]

Compound 3d



Method A: According to the Method A, using 5-bromo-1-methyl-1*H*-indole (52.5 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(*o*-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, petroleum ether 40-60°) to afford the product as a white solid (49.9 mg, 96%).

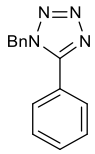
Method B: According to the Method B, using 5-bromo-1-methyl-1*H*-indole (52.5 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), $Pd(dppf)Cl_2$ (7.3 mg, 0.01 mmol, 4 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), H_2O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, petroleum ether 40-60°) to afford the product as a white solid (48.1 mg, 93%).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.97 – 7.88 (m, 1H), 7.77 – 7.70 (m, 2H), 7.59 – 7.48 (m, 3H), 7.47 – 7.41 (m, 1H), 7.41 – 7.35 (m, 1H), 7.12 (d, *J* = 3.1 Hz, 1H), 6.64 – 6.58 (m, 1H), 3.84 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 142.6, 136.2, 132.8, 129.4, 128.9, 128.6, 127.3, 126.2, 121.3, 119.4, 109.4, 101.3, 32.9.

Spectroscopic data were in agreement with literature values.[6]

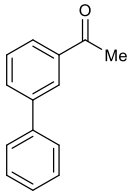
Compound 3e



Method A: According to the Method A, using 1-benzyl-5-bromo-1*H*-tetrazole (59.1 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(*o*-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). The reaction yielded no desired product.

Method B: According to the Method B, using 1-benzyl-5-bromo-1*H*-tetrazole (59.1 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), $Pd(dppf)Cl_2$ (7.3 mg, 0.01 mmol, 4 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), H_2O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). The reaction yielded no desired product.

Compound 3f



Method A: According to the Method A, using 1-(3-bromophenyl)ethan-1-one (49.8 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(*o*-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 5% EtOAc in petroleum ether 40-60°) to afford the product as a colourless oil (44.6 mg, 91%).

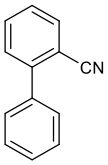
Method B: According to the Method B, using 1-(3-bromophenyl)ethan-1-one (49.8 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), $Pd(dppf)Cl_2$ (7.3 mg, 0.01 mmol, 4 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), H_2O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-2% EtOAc in petroleum ether 40-60°) to afford the product as a colourless oil (47.6 mg, 97%).

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.23 – 8.17 (m, 1H), 7.96 – 7.92 (m, 1H), 7.79 (ddd, *J* = 7.7, 1.9, 1.1 Hz, 1H), 7.65 – 7.61 (m, 2H), 7.56 – 7.51 (m, 1H), 7.50 – 7.45 (m, 2H), 7.44 – 7.35 (m, 1H), 2.66 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 198.0, 141.6, 140.1, 137.6, 131.6, 129.0, 128.8, 127.7, 127.1, 126.9, 26.7.

Spectroscopic data were in agreement with literature values.[7]

Compound 3g



Method A: According to the Method A, using 2-bromobenzonitrile (45.5 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(*o*-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-5% EtOAc in petroleum ether 40-60°) to afford the product as a colourless oil (45.1 mg, 100%).

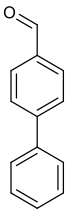
Method B: According to the Method B, using 2-bromobenzonitrile (45.5 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), $Pd(dppf)Cl_2$ (7.3 mg, 0.01 mmol, 4 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), H_2O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-5% EtOAc in petroleum ether 40-60°) to afford the product as white solid (42.8 mg, 96%).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.80 – 7.73 (m, 1H), 7.68 – 7.62 (m, 1H), 7.60 – 7.55 (m, 2H), 7.54 – 7.41 (m, 5H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 145.4, 138.0, 133.6, 132.7, 130.0, 128.7, 128.6, 127.5, 118.6, 111.2.

Spectroscopic data were in agreement with literature values.[8]

Compound 3h



Method A: According to the Method A, using 4-bromobenzaldehyde (46.3 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(*o*-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-5% EtOAc in petroleum ether 40-60°) to afford the product as a white solid (43.3 mg, 95%).

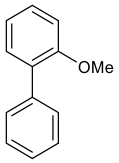
Method B: According to the Method B, using 4-bromobenzaldehyde (46.3 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), $Pd(dppf)Cl_2$ (7.3 mg, 0.01 mmol, 4 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), H_2O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-5% EtOAc in petroleum ether 40-60°) to afford the product as a white solid (42.9 mg, 94%).

1H NMR (500 MHz, $CDCl_3$) δ 10.06 (s, 1H), 7.98 – 7.92 (m, 2H), 7.78 – 7.73 (m, 2H), 7.67 – 7.61 (m, 2H), 7.52 – 7.45 (m, 2H), 7.46 – 7.39 (m, 1H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 192.0, 147.2, 139.7, 135.1, 130.3, 129.0, 128.5, 127.7 127.4.

Spectroscopic data were in agreement with literature values.[9]

Compound 3i



Method A: According to the Method A, using 1-bromo-2-methoxybenzene (46.8 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(*o*-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-2% EtOAc in petroleum ether 40-60°) to afford the product as a colourless oil (38.3 mg, 83%).

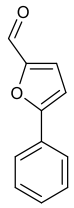
Method B: According to the Method B, using 1-bromo-2-methoxybenzene (46.8 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), $Pd(dppf)Cl_2$ (7.3 mg, 0.01 mmol, 4 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), H_2O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-2% EtOAc in petroleum ether 40-60°) to afford the product as a white solid (40.9 mg, 89%).

^1H NMR (400 MHz, $CDCl_3$) δ 7.59 – 7.55 (m, 2H), 7.49 – 7.41 (m, 2H), 7.41 – 7.33 (m, 3H), 7.12 – 7.03 (m, 1H), 7.04 – 7.01 (m, 1H), 3.84 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 156.4, 138.5, 130.9, 130.7, 129.5, 128.6, 127.9, 126.9, 120.8, 111.2, 55.5.

Spectroscopic data were in agreement with literature values.[10]

Compound 3j



Method A: According to the Method A, using 5-bromofuran-2-carbaldehyde (43.5 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(*o*-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-10% EtOAc in petroleum ether 40-60°) to afford the product as an orange oil (39.7 mg, 92%).

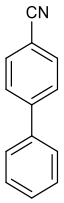
Method B: According to the Method B, using 5-bromofuran-2-carbaldehyde (43.5 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), $Pd(dppf)Cl_2$ (7.3 mg, 0.01 mmol, 4 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), H_2O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-10% EtOAc in petroleum ether 40-60°) to afford the product as an orange oil (29.6 mg, 69%).

^{1}H NMR (400 MHz, $CDCl_3$) δ 9.65 (s, 1H), 7.86 – 7.80 (m, 2H), 7.48 – 7.37 (m, 3H), 7.32 (d, *J* = 3.7 Hz, 1H), 6.85 (d, *J* = 3.7 Hz, 1H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 177.3, 159.4, 152.0, 129.7, 128.9, 125.3, 107.7.

Spectroscopic data were in agreement with literature values.[11]

Compound 3k



Method A: According to the Method A, using 4-bromobenzonitrile (45.5 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(*o*-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-6% EtOAc in petroleum ether 40-60°) to afford the product as a white solid (44.7 mg, 100%).

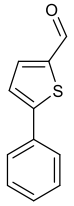
Method B: According to the Method B, using 4-bromobenzonitrile (45.5 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), $Pd(dppf)Cl_2$ (7.3 mg, 0.01 mmol, 4 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), H_2O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-5% EtOAc in petroleum ether 40-60°) to afford the product as white solid (43.8 mg, 98%).

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.75 – 7.66 (m, 4H), 7.61 – 7.57 (m, 2H), 7.52 – 7.46 (m, 2H), 7.46 – 7.41 (m, 1H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 145.5, 139.0, 132.5, 129.0, 128.6, 127.6, 127.1, 118.8, 110.7.

Spectroscopic data were in agreement with literature values.[4]

Compound 3l



Method A: According to the Method A, using 5-bromothiophene-2-carbaldehyde (47.8 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(*o*-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 10-20% EtOAc in petroleum ether 40-60°) to afford the product as a yellow solid (47.0 mg, 100%).

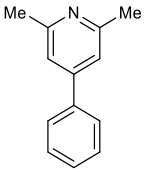
Method B: According to the Method B, using 5-bromothiophene-2-carbaldehyde (47.8 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), $Pd(dppf)Cl_2$ (7.3 mg, 0.01 mmol, 4 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), H_2O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 10-20% EtOAc in petroleum ether 40-60°) to afford the product as a yellow solid (35.0 mg, 74%).

^{1}H NMR (400 MHz, $CDCl_3$) δ 9.88 (s, 1H), 7.73 (d, *J* = 3.9 Hz, 1H), 7.68 – 7.64 (m, 2H), 7.45 – 7.36 (m, 4H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 182.7, 154.2, 142.4, 137.3, 133.0, 129.4, 129.1, 126.4, 124.0.

Spectroscopic data were in agreement with literature values.[12]

Compound 3m



Method A: According to the Method A, using 4-bromo-2,6-dimethylpyridine (46.2 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(*o*-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv) and 1,4-dioxane (1 mL, 0.25 M). The reaction mixture was then concentrated under vacuum and was determined to give a yield of 96%, determined by ^{1}H NMR assay.

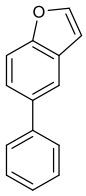
Method B: According to the Method B, using 4-bromo-2,6-dimethylpyridine (46.2 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), $Pd(dppf)Cl_2$ (7.3 mg, 0.01 mmol, 4 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), H_2O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). The reaction mixture was then concentrated under vacuum and was determined to give a yield of 70%, determined by ^{1}H NMR assay. For characterisation purposes, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-10% EtOAc in petroleum ether 40-60°) to afford the product as a yellow solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.65 – 7.58 (m, 2H), 7.49 – 7.38 (m, 3H), 7.19 – 7.16 (m, 2H), 2.59 (s, 6H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 158.1, 149.0, 138.7, 128.9, 128.7, 127.0, 118.4, 24.5.

Spectroscopic data were in agreement with literature values.[13]

Compound 3n



Method A: According to the Method A, using 5-bromobenzofuran (49.3 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(*o*-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, petroleum ether 40-60°) to afford the product as a white solid (44.8 mg, 92%).

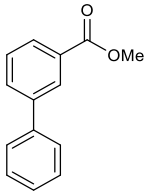
Method B: According to the Method B, using 5-bromobenzofuran (49.3 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), $Pd(dppf)Cl_2$ (7.3 mg, 0.01 mmol, 4 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), H_2O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, petroleum ether 40-60°) to afford the product as a white solid (46.8 mg, 96%).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.84 (dd, *J* = 1.8, 0.7 Hz, 1H), 7.70 – 7.65 (m, 3H), 7.63 – 7.55 (m, 2H), 7.52 – 7.47 (m, 2H), 7.41 – 7.36 (m, 1H), 6.85 (dd, *J* = 2.2, 0.9 Hz, 1H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 154.5, 145.5, 141.6, 136.5, 128.7, 127.9, 127.4, 126.8, 124.0, 119.7, 111.5, 106.8.

Spectroscopic data were in agreement with literature values.[14]

Compound 3o



Method A: According to the Method A, using methyl 3-bromobenzoate (53.8 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(*o*-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-10% EtOAc in petroleum ether 40-60°) to afford the product as a white solid (45.8 mg, 86%).

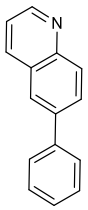
Method B: According to the Method B, using methyl 3-bromobenzoate (53.8 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), $Pd(dppf)Cl_2$ (7.3 mg, 0.01 mmol, 4 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), H_2O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-10% EtOAc in petroleum ether 40-60°) to afford the product as a white solid (48.4 mg, 91%).

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.31 – 8.29 (m, 1H), 8.06 – 8.02 (m, 1H), 7.79 (ddd, *J* = 7.7, 1.9, 1.2 Hz, 1H), 7.66 – 7.61 (m, 2H), 7.55 – 7.45 (m, 3H), 7.42 – 7.35 (m, 1H), 3.96 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 167.0, 141.4, 140.1, 131.5, 130.7, 128.8, 128.8, 128.3, 128.2, 127.7, 127.1, 52.1.

Spectroscopic data were in agreement with literature values.[12]

Compound 3p



Method A: According to the Method A, using 6-bromoquinoline (52.0 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(*o*-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 10-35% EtOAc in petroleum ether 40-60°) to afford the product as a yellow solid (49.2 mg, 96%).

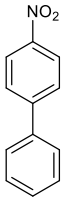
Method B: According to the Method B, using 6-bromoquinoline (52.0 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), $Pd(dppf)Cl_2$ (7.3 mg, 0.01 mmol, 4 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), H_2O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 10-30% EtOAc in petroleum ether 40-60°) to afford the product as a yellow solid (43.2 mg, 84%).

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.91 (dd, *J* = 4.3, 1.8 Hz, 1H), 8.22 – 8.15 (m, 2H), 8.03 – 7.95 (m, 2H), 7.75 – 7.67 (m, 2H), 7.55 – 7.46 (m, 2H), 7.43 – 7.37 (m, 2H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 150.3, 147.6, 140.2, 139.2, 136.1, 129.8, 129.1, 128.9, 128.4, 127.7, 127.4, 125.4, 121.4.

Spectroscopic data were in agreement with literature values.[15]

Compound 3q



Method A: According to the Method A, 1-bromo-4-nitrobenzene (50.5 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(*o*-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). The reaction yielded no desired product.

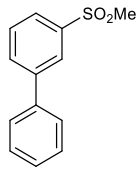
Method B: According to the Method B, using 1-bromo-4-nitrobenzene (50.5 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), $Pd(dppf)Cl_2$ (7.3 mg, 0.01 mmol, 4 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), H_2O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 20-30% EtOAc in petroleum ether 40-60°) to afford the product as a white solid (47.6 mg, 96%).

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.34 – 8.23 (m, 2H), 7.78 – 7.69 (m, 2H), 7.67 – 7.59 (m, 2H), 7.55 – 7.41 (m, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 147.6, 147.0, 138.7, 129.1, 128.9, 127.7, 127.3, 124.0.

Spectroscopic data were in agreement with literature values.[16]

Compound 3r



Method A: According to the Method A, using 1-bromo-3-(methylsulfonyl)benzene (58.8 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(*o*-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). The reaction mixture was then concentrated under vacuum and was determined to give a yield of 57%, determined by ^{1}H NMR assay.

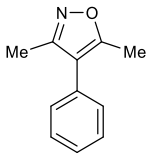
Method B: According to the Method B, using 1-bromo-3-(methylsulfonyl)benzene (58.8 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), $Pd(dppf)Cl_2$ (7.3 mg, 0.01 mmol, 4 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), H_2O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 20-30% EtOAc in petroleum ether 40-60°) to afford the product as a white solid (58.1 mg, 100%).

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.19 – 8.15 (m, 1H), 7.93 – 7.90 (m, 1H), 7.88 – 7.86 (m, 1H), 7.67 – 7.60 (m, 3H), 7.51 – 7.46 (m, 2H), 7.44 – 7.40 (m, 1H), 3.10 (s, 3H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 142.7, 141.1, 138.9, 132.2, 129.8, 129.1, 128.4, 127.2, 125.9, 125.8, 44.5.

Spectroscopic data were in agreement with literature values.[17]

Compound 3s



Method A: According to the Method A, using 4-bromo-3,5-dimethylisoxazole (44.0mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(*o*-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). The reaction yielded no desired product.

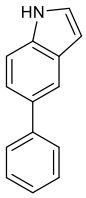
Method B: According to the Method B, using 4-bromo-3,5-dimethylisoxazole (44.0 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), $Pd(dppf)Cl_2$ (7.3 mg, 0.01 mmol, 4 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), H_2O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-10% EtOAc in petroleum ether 40-60°) to afford the product as a colourless oil (13.2 mg, 30%).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.49 – 7.42 (m, 2H), 7.41 – 7.35 (m, 1H), 7.30 – 7.25 (m, 2H), 2.42 (s, 3H), 2.29 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 165.2, 158.7, 130.5, 129.1, 128.8, 127.5, 116.6, 11.5, 10.8.

Spectroscopic data were in agreement with literature values.[18]

Compound 3t



Method A: According to the Method A, using 5-bromo-1H-indole (49.0 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(*o*-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-10% EtOAc in petroleum ether 40-60°) to afford the product as a white solid (46.8 mg, 97%).

Method B: According to the Method B, using 5-bromo-1H-indole (49.0 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), $Pd(dppf)Cl_2$ (7.3 mg, 0.01 mmol, 4 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), H_2O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-10% EtOAc in petroleum ether 40-60°) to afford the product as a white solid (44.0 mg, 91%).

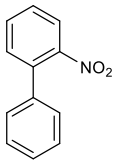
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.08 (s, 1H), 7.93 (d, *J* = 2.7 Hz, 1H), 7.76 – 7.68 (m, 2H), 7.55 – 7.44 (m, 4H), 7.42 – 7.34 (m, 1H), 7.23 (t, *J* = 2.8 Hz, 1H), 6.67 – 6.64 (m, 1H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 142.5, 135.3, 133.4, 128.6, 128.3, 127.4, 126.3, 124.8, 121.9, 119.2, 111.2, 103.0.

Spectroscopic data were in agreement with literature values.[19]

4.2 Products of boronic acid substrate survey

Compound 3u



Method A: According to the Method A, using bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), (2-nitrophenyl)boronic acid (46.7 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(*o*-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). The reaction yielded no desired product.

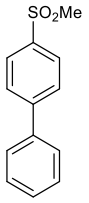
Method B: According to the Method B, using bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), (2-nitrophenyl)boronic acid (46.7 mg, 0.275 mmol, 1.1 equiv) $Pd(dppf)Cl_2$ (7.3 mg, 0.01 mmol, 4 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), H_2O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-10% EtOAc in petroleum ether 40-60°) to afford the product as a yellow oil (25.5 mg, 51%).

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.86 (dd, *J* = 8.1, 1.3 Hz, 1H), 7.62 (td, *J* = 7.6, 1.3 Hz, 1H), 7.49 (td, *J* = 7.8, 1.5 Hz, 1H), 7.47 – 7.39 (m, 4H), 7.36 – 7.31 (m, 2H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 149.2, 137.3, 136.3, 132.3, 131.9, 128.7, 128.2, 128.1, 127.8, 124.1.

Spectroscopic data were in agreement with literature values.[17]

Compound 3v



Method A: According to the Method A, using bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), (4-(methylsulfonyl)phenyl)boronic acid (55.0 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(*o*-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-15% EtOAc in petroleum ether 40-60°) to afford the product as a white solid (21.0 mg, 36%).

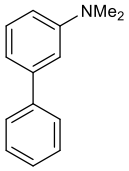
Method B: According to the Method B, using bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), (4-(methylsulfonyl)phenyl)boronic acid (55.0 mg, 0.275 mmol, 1.1 equiv), Pd(dppf)Cl_2 (7.3 mg, 0.01 mmol, 4 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), H_2O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-15% EtOAc in petroleum ether 40-60°) to afford the product as a white solid (45.0 mg, 78%).

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.04 – 7.97 (m, 2H), 7.79 – 7.75 (m, 2H), 7.63 – 7.59 (m, 2H), 7.51 – 7.46 (m, 2H), 7.45 – 7.40 (m, 1H), 3.09 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 146.6, 139.1, 129.0, 128.6, 127.9, 127.8, 127.3, 44.5.

Spectroscopic data were in agreement with literature values.[20]

Compound 3w



Method A: According to the Method A, using bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), (3-(dimethylamino)phenyl)boronic acid (45.4 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(*o*-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-5% EtOAc in petroleum ether 40-60°) to afford the product as a yellow oil (41.7 mg, 85%).

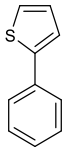
Method B: According to the Method B, using bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), (3-(dimethylamino)phenyl)boronic acid (45.4 mg, 0.275 mmol, 1.1 equiv), Pd(dppf)Cl_2 (7.3 mg, 0.01 mmol, 4 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), H_2O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-4% EtOAc in petroleum ether 40-60°) to afford the product as a yellow oil (47.7 mg, 97%).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.72 – 7.66 (m, 2H), 7.55 – 7.48 (m, 2H), 7.44 – 7.37 (m, 2H), 7.08 – 7.05 (m, 2H), 6.88 – 6.83 (m, 1H), 3.08 (s, 6H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 150.6, 142.3, 142.1, 129.4, 128.5, 127.3, 127.1, 116.2, 111.8, 111.7, 40.8.

Spectroscopic data were in agreement with literature values.[21]

Compound 3x



Method A: According to the Method A, using bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), thiophen-2-ylboronic acid (35.2 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(*o*-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, petroleum ether 40-60°) to afford the product as a white solid (20.0 mg, 50%).

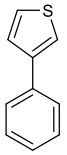
Method B: According to the Method B, using bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), thiophen-2-ylboronic acid (35.2 mg, 0.275 mmol, 1.1 equiv), $Pd(dppf)Cl_2$ (7.3 mg, 0.01 mmol, 4 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), H_2O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, petroleum ether 40-60°) to afford the product as a white solid (32.1 mg, 80%).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.66 – 7.63 (m, 2H), 7.43 – 7.37 (m, 2H), 7.35 – 7.28 (m, 3H), 7.14 – 7.07 (m, 1H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 144.4, 134.4, 128.9, 128.0, 127.4, 125.9, 124.8, 123.1.

Spectroscopic data were in agreement with literature values.[9]

Compound 3y



Method A: According to the Method A, using bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), thiophen-3-ylboronic acid (35.2 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(*o*-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, petroleum ether 40-60°) to afford the product as a white solid (22.6 mg, 56%).

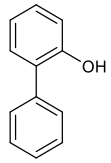
Method B: According to the Method B, using bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), thiophen-3-ylboronic acid (35.2 mg, 0.275 mmol, 1.1 equiv), $Pd(dppf)Cl_2$ (7.3 mg, 0.01 mmol, 4 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), H_2O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, petroleum ether 40-60°) to afford the product as a white solid (37.9 mg, 95%).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.67 – 7.62 (m, 2H), 7.50 – 7.47 (m, 1H), 7.47 – 7.39 (m, 4H), 7.38 – 7.31 (m, 1H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 142.3, 135.8, 128.8, 127.1, 126.4, 126.3, 126.2, 120.2.

Spectroscopic data were in agreement with literature values.[9]

Compound 3z



Method A: According to the Method A, bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), (2-hydroxyphenyl)boronic acid (37.9 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(*o*-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). The reaction yielded no desired product.

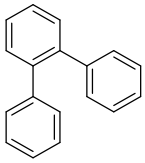
Method B: According to the Method B, bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), (2-hydroxyphenyl)boronic acid (37.9 mg, 0.275 mmol, 1.1 equiv), $Pd(dppf)Cl_2$ (7.3 mg, 0.01 mmol, 4 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), H_2O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-10% EtOAc in petroleum ether 40-60°) to afford the product as a white solid (28.9 mg, 68%).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.54 – 7.46 (m, 4H), 7.42 (d, *J* = 2.5 Hz, 1H), 7.33 – 7.24 (m, 2H), 7.09 – 6.94 (m, 2H), 5.25 (s, 1H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 152.4, 137.1, 130.2, 129.2, 129.1, 129.1, 128.1, 127.8, 120.8, 115.8.

Spectroscopic data were in agreement with literature values.[22]

Compound 3aa



Method A: According to the Method A, using bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), [1,1'-biphenyl]-2-ylboronic acid (54.5 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(*o*-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, petroleum ether 40-60°) to afford the product as a white solid (45.3 mg, 79%).

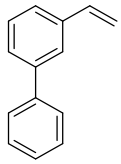
Method B: According to the Method B, using bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), [1,1'-biphenyl]-2-ylboronic acid (54.5 mg, 0.275 mmol, 1.1 equiv), $Pd(dppf)Cl_2$ (7.3 mg, 0.01 mmol, 4 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), H_2O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, petroleum ether 40-60°) to afford the product as a white solid (46.6 mg, 81%).

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.57 – 7.50 (m, 4H), 7.35 – 7.29 (m, 6H), 7.28 – 7.25 (m, 4H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 141.5, 140.5, 130.6, 129.9, 127.8, 127.5, 126.4.

Spectroscopic data were in agreement with literature values.[23]

Compound 3ab



Method A: According to the Method A, using bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), (3-vinylphenyl)boronic acid (40.7 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(*o*-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, petroleum ether 40-60°) to afford the product as a clear oil (20.0 mg, 40%).

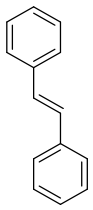
Method B: According to the Method B, using bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), (3-vinylphenyl)boronic acid (40.7 mg, 0.275 mmol, 1.1 equiv), $Pd(dppf)Cl_2$ (7.3 mg, 0.01 mmol, 4 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), H_2O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, petroleum ether 40-60°) to afford the product as a white solid (30.0 mg, 67%).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.64 – 7.58 (m, 3H), 7.55 – 7.40 (m, 5H), 7.39 – 7.34 (m, 1H), 6.80 (dd, *J* = 17.6, 10.9 Hz, 1H), 5.83 (dd, *J* = 17.6, 1.0 Hz, 1H), 5.30 (dd, *J* = 10.8, 1.0 Hz, 1H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 141.5, 141.1, 138.0, 136.8, 128.9, 128.7, 127.3, 127.2, 126.7, 125.2, 125.0, 114.2.

Spectroscopic data were in agreement with literature values.[24]

Compound 3ac



Method A: According to the Method A, bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), (*E*)-styrylboronic acid (40.7 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(*o*-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, petroleum ether 40-60°) to afford the product as a white solid (40.0 mg, 89%).

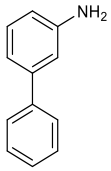
Method B: According to the Method B, bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), (E)-styrylboronic acid (40.7 mg, 0.275 mmol, 1.1 equiv), $Pd(dppf)Cl_2$ (7.3 mg, 0.01 mmol, 4 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), H_2O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, petroleum ether 40-60°) to afford the product as a white solid (41.2 mg, 91%).

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.59 – 7.55 (m, 4H), 7.41 (t, *J* = 7.7 Hz, 4H), 7.31 (td, *J* = 7.2, 1.4 Hz, 2H), 7.17 (s, 2H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 137.3, 128.7, 128.7, 127.6, 126.5.

Spectroscopic data were in agreement with literature values.[25]

Compound 3ad



Method A: According to the Method A, using bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), (3-aminophenyl)boronic acid (37.7 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(*o*-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-30% EtOAc in petroleum ether 40-60°) to afford the product as a clear oil (30.4 mg, 72%).

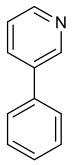
Method B: According to the Method B, bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), (3-aminophenyl)boronic acid (37.7 mg, 0.275 mmol, 1.1 equiv), $Pd(dppf)Cl_2$ (7.3 mg, 0.01 mmol, 4 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), H_2O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-30% EtOAc in petroleum ether 40-60°) to afford the product as an orange oil (41.8 mg, 99%).

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.61 – 7.57 (m, 2H), 7.47 – 7.42 (m, 2H), 7.38 – 7.33 (m, 1H), 7.29 – 7.23 (m, 1H), 7.03 – 6.98 (m, 1H), 6.91 (s, 1H), 6.70 – 6.66 (m, 1H), 3.73 (s, 2H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 146.8, 142.5, 141.5, 129.7, 128.7, 127.3, 127.2, 117.7, 114.1, 113.9.

Spectroscopic data were in agreement with literature values.[26]

Compound 3b



Method A: According to the Method A, bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), 3-pyridinylboronic acid (33.8 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(*o*-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). The reaction yielded no desired product.

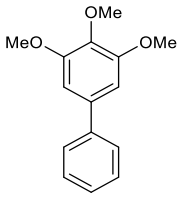
Method B: According to the Method B, bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), 3-pyridinylboronic acid (33.8 mg, 0.275 mmol, 1.1 equiv), $Pd(dppf)Cl_2$ (7.3 mg, 0.01 mmol, 4 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), H_2O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-40% EtOAc in petroleum ether 40-60°) to afford the product as a colourless oil (25.8 mg, 67%).

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.86 – 8.85 (m, 1H), 8.59 (dd, *J* = 4.8, 1.7 Hz, 1H), 7.87 (ddd, *J* = 7.9, 2.4, 1.6 Hz, 1H), 7.60 – 7.56 (m, 2H), 7.50 – 7.45 (m, 2H), 7.43 – 7.38 (m, 1H), 7.36 (ddd, *J* = 7.9, 4.8, 0.9 Hz, 1H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 148.4, 148.3, 137.8, 136.6, 134.3, 129.0, 128.1, 127.1, 123.5.

Spectroscopic data were in agreement with literature values.[5]

Compound 3ae



Method A: According to the Method A, using bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), (3,4,5-trimethoxyphenyl)boronic acid (58.3 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(*o*-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-5% EtOAc in petroleum ether 40-60°) to afford the product as a white solid (41.3 mg, 68%).

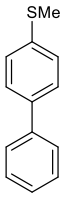
Method B: According to the Method B, bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), (3,4,5-trimethoxyphenyl)boronic acid (58.3 mg, 0.275 mmol, 1.1 equiv), $Pd(dppf)Cl_2$ (7.3 mg, 0.01 mmol, 4 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), H_2O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-5% EtOAc in petroleum ether 40-60°) to afford the product as a white solid (55.0 mg, 90%).

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.61 – 7.55 (m, 2H), 7.50 – 7.42 (m, 2H), 7.37 – 7.33 (m, 1H), 6.80 (s, 2H), 3.93 (s, 6H), 3.92 (s, 3H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 153.3, 141.2, 137.4, 137.1, 128.6, 127.2, 127.0, 104.2, 60.8, 56.0.

Spectroscopic data were in agreement with literature values.[27]

Compound 3af



Method A: According to the Method A, using bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), (4-(methylthio)phenyl)boronic acid (46.2 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(*o*-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-5% EtOAc in petroleum ether 40-60°) to afford the product as a white solid (9.0 mg, 18%).

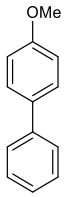
Method B: According to the Method B, using bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), (4-(methylthio)phenyl)boronic acid (46.2 mg, 0.275 mmol, 1.1 equiv), $Pd(dppf)Cl_2$ (7.3 mg, 0.01 mmol, 4 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), H_2O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-5% EtOAc in petroleum ether 40-60°) to afford the product as a white solid (42.0 mg, 84%).

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.61 – 7.57 (m, 2H), 7.56 – 7.53 (m, 2H), 7.47 – 7.43 (m, 2H), 7.38 – 7.32 (m, 3H), 2.54 (s, 3H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 140.5, 137.9, 137.5, 128.8, 127.4, 127.2, 126.8, 126.8, 15.8.

Spectroscopic data were in agreement with literature values.[28]

Compound 3ag



Method A: According to the Method A, using bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), 4-methoxyphenylboronic acid (41.8 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(*o*-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, petroleum ether 40-60°) to afford the product as a white solid (42.0 mg, 91%).

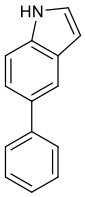
Method B: According to the Method B, using bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), 4-methoxyphenylboronic acid (41.8 mg, 0.275 mmol, 1.1 equiv), $Pd(dppf)Cl_2$ (7.3 mg, 0.01 mmol, 4 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), H_2O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, petroleum ether) to afford the product as a white solid (42.9 mg, 93%).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.61 – 7.51 (m, 4H), 7.47 – 7.40 (m, 2H), 7.36 – 7.29 (m, 1H), 7.04 – 6.97 (m, 2H), 3.87 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 159.1, 140.8, 133.8, 128.7, 128.1, 126.7, 126.6, 114.2, 55.3.

Spectroscopic data were in agreement with literature values.[29]

Compound 3t



Method A: According to the Method A, using bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), (1H-indol-5-yl)boronic acid (44.3 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(*o*-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). The reaction yielded no desired product.

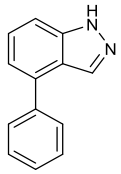
Method B: According to the Method B, using bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), (1H-indol-5-yl)boronic acid (44.3 mg, 0.275 mmol, 1.1 equiv), $Pd(dppf)Cl_2$ (7.3 mg, 0.01 mmol, 4 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), H_2O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-10% EtOAc in petroleum ether 40-60°) to afford the product as a colourless oil (43.5 mg, 90%).

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.08 (s, 1H), 7.93 (d, *J* = 2.7 Hz, 1H), 7.76 – 7.68 (m, 2H), 7.55 – 7.44 (m, 4H), 7.42 – 7.34 (m, 1H), 7.23 (t, *J* = 2.8 Hz, 1H), 6.67 – 6.64 (m, 1H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 142.5, 135.3, 133.4, 128.6, 128.3, 127.4, 126.3, 124.8, 121.9, 119.2, 111.2, 103.0.

Spectroscopic data were in agreement with literature values.[19]

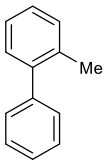
Compound 3ah



Method A: According to the Method A, using bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), (1H-indazol-4-yl)boronic acid hydrochloride (54.6 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(*o*-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K_3PO_4 (212 mg, 1.00 mmol, 4 equiv), and 1,4-dioxane (1 mL, 0.25 M). The reaction yielded no desired product.

Method B: According to the Method B, using bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), (1H-indazol-4-yl)boronic acid hydrochloride (54.6 mg, 0.275 mmol, 1.1 equiv), $Pd(dppf)Cl_2$ (7.3 mg, 0.01 mmol, 4 mol%), and K_3PO_4 (212 mg, 1.00 mmol, 4 equiv), H_2O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). The reaction yielded no desired product.

Compound 3ai



Method A: According to the Method A, using bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), 1 equiv), *o*-tolylboronic acid (37.4 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(*o*-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). The reaction mixture was then concentrated under vacuum and was determined to give a yield of 75%, determined by ^{1}H NMR assay.

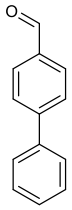
Method B: According to the Method B, using bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), *o*-tolylboronic acid (37.4 mg, 0.275 mmol, 1.1 equiv), $Pd(dppf)Cl_2$ (7.3 mg, 0.01 mmol, 4 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), H_2O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (petroleum ether 40-60°) to afford the product as a colourless oil (33.7 mg, 80%).

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.50 – 7.44 (m, 2H), 7.43 – 7.37 (m, 3H), 7.35 – 7.29 (m, 4H), 2.34 (s, 3H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 141.9, 141.9, 135.3, 130.3, 129.8, 129.2, 128.0, 127.2, 126.7, 125.7, 20.5.

Spectroscopic data were in agreement with literature values.[4]

Compound 3h



Method A: According to the Method A, using bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), (4-formylphenyl)boronic acid (41.2 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(*o*-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the

reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-1% EtOAc in petroleum ether 40-60°) to afford the product as a white solid (3.6 mg, 8%).

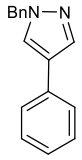
Method B: According to the Method B, using bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), (4-formylphenyl)boronic acid (41.2 mg, 0.275 mmol, 1.1 equiv), $Pd(dppf)Cl_2$ (7.3 mg, 0.01 mmol, 4 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), H_2O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). The reaction mixture was then concentrated under vacuum and was determined to give a yield of 51%, determined by ^1H NMR assay.

1H NMR (500 MHz, $CDCl_3$) δ 10.06 (s, 1H), 7.98 – 7.92 (m, 2H), 7.78 – 7.73 (m, 2H), 7.67 – 7.61 (m, 2H), 7.52 – 7.45 (m, 2H), 7.46 – 7.39 (m, 1H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 192.0, 147.2, 139.7, 135.1, 130.3, 129.0, 128.5, 127.7, 127.4.

Spectroscopic data were in agreement with literature values.[9]

Compound 3aj



Method A: According to the Method A, using bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), (1-benzyl-1H-pyrazol-4-yl)boronic acid (55.6 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(*o*-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 10-15% EtOAc in petroleum ether 40-60°) to afford the product as a pale brown soild (52.8 mg, 90%).

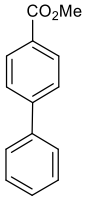
Method B: According to the Method B, using bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), (1-benzyl-1H-pyrazol-4-yl)boronic acid (55.6 mg, 0.275 mmol, 1.1 equiv), $Pd(dppf)Cl_2$ (7.3 mg, 0.01 mmol, 4 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), H_2O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 10-15% EtOAc in petroleum ether 40-60°) to afford the product as a pale brown solid (55.9 mg, 95%).

^1H NMR (500 MHz, $CDCl_3$) δ 7.87 (s, 1H), 7.63 (s, 1H), 7.51 – 7.47 (m, 2H), 7.41 – 7.32 (m, 5H), 7.30 – 7.26 (m, 2H), 7.24 (t, *J* = 7.7 Hz, 1H), 5.34 (s, 2H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 136.9, 136.3, 132.4, 128.8, 128.7, 128.0, 127.6, 126.3, 126.1, 125.4, 123.4, 56.1.

Spectroscopic data were in agreement with literature values.[30]

Compound 3ak



Method A: According to the Method A, using bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), (4-(methoxycarbonyl)phenyl)boronic acid (49.5 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(*o*-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete,

the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-5% EtOAc in petroleum ether 40-60°) to afford the product as a white soild (12.6 mg, 24%).

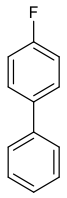
Method B: According to the Method B, using bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), (4-(methoxycarbonyl)phenyl)boronic acid (49.5 mg, 0.275 mmol, 1.1 equiv), $Pd(dppf)Cl_2$ (7.3 mg, 0.01 mmol, 4 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), H_2O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-5% EtOAc in petroleum ether 40-60°) to afford the product as a white solid (48.1 mg, 91%).

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.14 – 8.11 (m, 2H), 7.69 – 7.61 (m, 4H), 7.50 – 7.45 (m, 2H), 7.43 – 7.38 (m, 1H), 3.95 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 166.9, 145.5, 139.9, 130.0, 128.8, 128.8, 128.1, 127.2, 127.0, 52.0.

Spectroscopic data were in agreement with literature values.[31]

4.3 Scale-up procedure



[Ni]: To an oven-dried round-bottom flask was added 4-bromofluorobenzene (437.5 mg, 2.5 mmol, 1 equiv), phenylboronic acid (335.5 mg, 2.75 mmol, 1.1 equiv), Ni(dppf)(*o*-tol)Cl (37 mg, 0.05 mmol, 2 mol%), and K_3PO_4 (1.59 g, 7.5 mmol, 3 equiv). The vial was sealed and purged with N_2 before the addition of 1,4-dioxane (10 mL, 0.25 M). The reaction mixture was heated for 4 h at 80 °C. The flask was then allowed to cool to room temperature, the reaction mixture was then diluted with EtOAc (100 mL) and filtered through a plug of celite, eluting with EtOAc. The resulting solution was washed with H_2O (3 x 100 mL) followed by brine (100 mL) and the organic phases collected. The organic phase was dried over Na_2SO_4, filtered, and concentrated under vacuum. The crude residue was purified by column chromatography (silica gel, petroleum ether 40-60°) to afford the desired product as a white solid (390 mg, 91%).

[Pd]: To an oven-dried round-bottom flask was added 4-bromofluorobenzene (437.5 mg, 2.5 mmol, 1 equiv), phenylboronic acid (335.5 mg, 2.75 mmol, 1.1 equiv), $Pd(dppf)Cl_2$ (73.2 mg, 0.1 mmol, 4 mol%, and K_3PO_4 (1.59 g, 7.5 mmol, 3 equiv). The vial was sealed and purged with N_2 before the addition of 1,4-dioxane (10 mL, 0.25 M), followed by H_2O (225 µL, 12.5 mmol, 5 equiv). The reaction mixture was heated for 4 h at 80 °C. The flask was then allowed to cool to room temperature, the reaction mixture was then diluted with EtOAc (100 mL) and filtered through a plug of celite, eluting with EtOAc. The resulting solution was washed with H_2O (3 x 100 mL) followed by brine (100 mL) and the organic phases collected. The organic phase was dried over Na_2SO_4, filtered, and concentrated under vacuum. The crude residue was purified by column chromatography (silica gel, petroleum ether 40-60°) to afford the desired product as a white solid (415 mg, 96%).

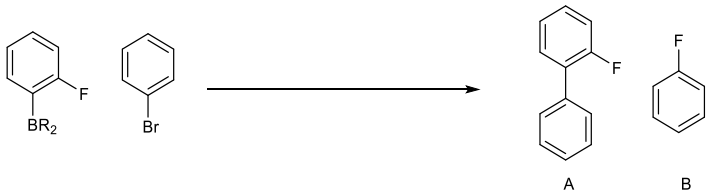
4.4 Quantification of Ni and Pd

Ni and Pd concentrations were determined using a Thermo Fisher Scientific ICP-OES iCAP 6000 Series, equipped with a CETAC ASX-520 autosampler. Compounds **3a**, **3r**, and **3aj** were tested for quantities of residual Pd and Ni (based on whether they had been prepared *via* the Ni or Pd method). The samples were prepared by acid digestion using 70% HNO_3, followed by filtration, and dilution with H_2O to give a 5% HNO_3 solution. It was found that the residual concentration for Ni samples was <100 ppm. Residual Pd was found to be consistently below the limit of detection for the instrument.

5.0 Protodeboronation study

5.1 Protodeboronation study for fluorine containing substrates

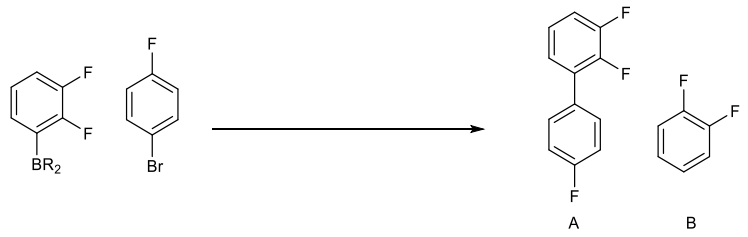
5.1.1 Protodeboronation study of 2-fluorophenyl boronic acid/2-(2-fluorophenyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane



To an oven-dried microwave vial was added bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), **boron reagent (1 equiv), catalyst**, and K_3PO_4 (159 mg, 0.75 mmol, 3 equiv). The vial was capped and purged with N_2 before the addition of 1,4-dioxane (1 mL, 0.25 M). The reaction mixture was heated for 0.5 h at 80 °C. The reaction mixture was then allowed to cool to room temperature and trifluorotoluene (30.7 µL, 0.25 mmol) was added. The vial was then decapped, and the reaction mixture diluted with $CDCl_3$ and filtered through a layer of celite. Conversion to the products was measured by ^{19}F NMR against a known internal standard (trifluorotoluene).

Entry	Catalyst	R-BR_2 (1 equiv)	H_2O	A(%)	B(%)
1	Ni(dppf)(*o*-tol)Cl (2 mol%)	2-fluorophenyl boronic acid	-	50	50
2	$Pd(dppf)Cl_2$ (4 mol%)	2-fluorophenyl boronic acid	5 equiv	100	3
3	No metal	2-fluorophenyl boronic acid	-	-	34
4	Ni(dppf)(*o*-tol)Cl (2 mol%)	2-(2-fluorophenyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane	-	83	18
5	$Pd(dppf)Cl_2$ (4 mol%)	2-(2-fluorophenyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane	5 equiv	88	trace
6	No metal	2-(2-fluorophenyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane	-	-	trace

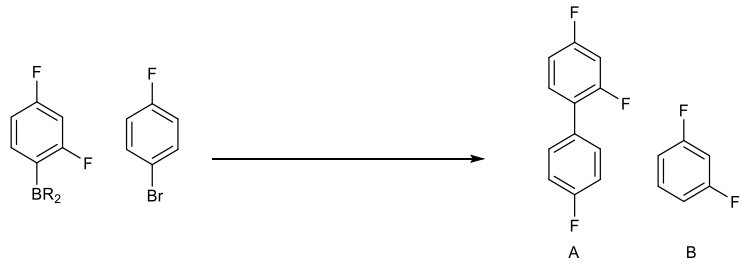
5.1.2 Protodeboronation study of 2,3-difluorophenylboronic acid/2-(2,3-difluorophenyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane



To an oven-dried microwave vial was added 4-fluorobromobenzene (43.8 mg, 0.25 mmol, 1 equiv), **boron reagent (1 equiv), catalyst**, and K_3PO_4 (159 mg, 0.75 mmol, 3 equiv). The vial was capped and purged with N_2 before the addition of 1,4-dioxane (1 mL, 0.25 M). The reaction mixture was heated for 0.5 h at 80 °C. The reaction mixture was then allowed to cool to room temperature and trifluorotoluene (30.7 µL, 0.25 mmol) was added. The vial was then decapped, and the reaction mixture diluted with $CDCl_3$ and filtered through a layer of celite. Conversion to the products was measured by ^{19}F NMR against a known internal standard (trifluorotoluene).

Entry	Catalyst	R-BR_2 (1 equiv)	H_2O	A(%)	B(%)
1	Ni(dppf)(*o*-tol)Cl (2 mol%)	2,3-difluorophenylboronic acid	-	9	89
2	$Pd(dppf)Cl_2$ (4 mol%)	2,3-difluorophenylboronic acid	5 equiv	81	10
3	No metal	2,3-difluorophenylboronic acid	-	-	98
4	Ni(dppf)(*o*-tol)Cl (2 mol%)	2-(2,3-difluorophenyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane	-	9	68
5	$Pd(dppf)Cl_2$ (4 mol%)	2-(2,3-difluorophenyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane	5 equiv	74	29
6	No metal	2-(2,3-difluorophenyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane	-	Trace	15

5.1.3 Protodeboronation study of 2,4-difluorophenylboronic acid/2-(2,4-difluorophenyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane

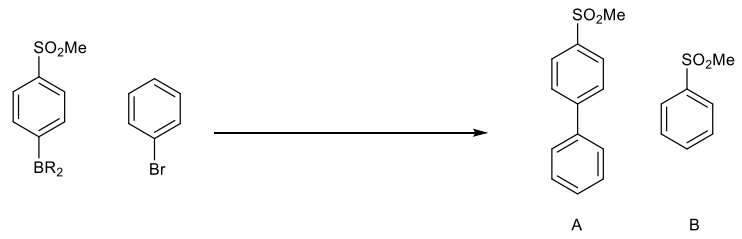


To an oven-dried microwave vial was added 4-fluorobromobenzene (43.8 mg, 0.25 mmol, 1 equiv), **boron reagent (1 equiv), catalyst**, and K_3PO_4 (159 mg, 0.75 mmol, 3 equiv). The vial was capped and purged with N_2 before the addition of 1,4-dioxane (1 mL, 0.25 M). The reaction mixture was heated for 0.5 h at 80 °C. The reaction mixture was then allowed to cool to room temperature and trifluorotoluene (30.7 µL, 0.25 mmol) was added. The vial was then decapped, and the reaction mixture diluted with $CDCl_3$ and filtered through a layer of celite. Conversion to the products was measured by ^{19}F NMR against a known internal standard (trifluorotoluene).

Entry	Catalyst	R-BR_2 (1 equiv)	H_2O	A(%)	B(%)
1	Ni(dppf)(*o*-tol)Cl (2 mol%)	2,4-difluorophenylboronic acid	-	43	48
2	$Pd(dppf)Cl_2$ (4 mol%)	2,4-difluorophenylboronic acid	5 equiv	75	5
3	No metal	2,4-difluorophenylboronic acid	-	-	87
4	Ni(dppf)(*o*-tol)Cl (2 mol%)	2-(2,4-difluorophenyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane	-	34	36
5	$Pd(dppf)Cl_2$ (4 mol%)	2-(2,4-difluorophenyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane	5 equiv	68	4
6	No metal	2-(2,4-difluorophenyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane	-	-	4

5.2 Protodeboronation study for non-fluorine containing substrates

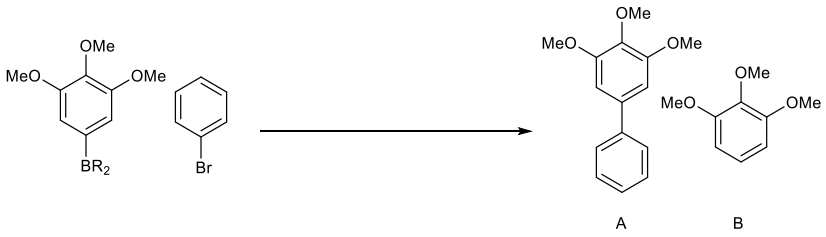
5.2.1 Protodeboronation study of (4-(methylsulfonyl)phenyl)boronic acid/4,4,5,5-tetramethyl-2-(4-(methylsulfonyl)phenyl)-1,3,2-dioxaborolane



To an oven-dried microwave vial was added bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), **boron reagent (1 equiv), catalyst**, and K_3PO_4 (159 mg, 0.75 mmol, 3 equiv). The vial was capped and purged with N_2 before the addition of 1,4-dioxane (1 mL, 0.25 M). The reaction mixture was heated for 0.5 h at 80 °C. The reaction mixture was then allowed to cool to room temperature and an aliquot was taken which was analysed by HPLC against an internal standard (naphthalene).

Entry	Catalyst	R-BR_2 (1 equiv)	H_2O	A(%)	B(%)
1	Ni(dppf)(*o*-tol)Cl (2 mol%)	(4-(methylsulfonyl)phenyl)boronic acid	-	7	0
2	$Pd(dppf)Cl_2$ (4 mol%)	(4-(methylsulfonyl)phenyl)boronic acid	5 equiv	20	0
3	No metal	(4-(methylsulfonyl)phenyl)boronic acid	-	-	0
4	Ni(dppf)(*o*-tol)Cl (2 mol%)	4,4,5,5-tetramethyl-2-(4-(methylsulfonyl)phenyl)-1,3,2-dioxaborolane	-	6	0
5	$Pd(dppf)Cl_2$ (4 mol%)	4,4,5,5-tetramethyl-2-(4-(methylsulfonyl)phenyl)-1,3,2-dioxaborolane	5 equiv	33	0
6	No metal	4,4,5,5-tetramethyl-2-(4-(methylsulfonyl)phenyl)-1,3,2-dioxaborolane	-	-	0

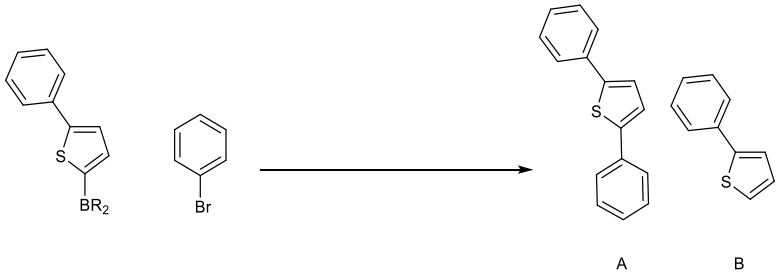
5.2.2 Protodeboronation study of (3,4,5-trimethoxyphenyl)boronic acid/4,4,5,5-tetramethyl-2-(3,4,5-trimethoxyphenyl)-1,3,2-dioxaborolane



To an oven-dried microwave vial was added bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), **boron reagent (1 equiv), catalyst**, and K_3PO_4 (159 mg, 0.75 mmol, 3 equiv). The vial was capped and purged with N_2 before the addition of 1,4-dioxane (1 mL, 0.25 M). The reaction mixture was heated for 0.5 h at 80 °C. The reaction mixture was then allowed to cool to room temperature and an aliquot was taken which was analysed by HPLC against an internal standard (naphthalene).

Entry	Catalyst	R-BR_2 (1 equiv)	H_2O	A(%)	B(%)
1	Ni(dppf)(*o*-tol)Cl (2 mol%)	(3,4,5-trimethoxyphenyl)boronic acid	-	34	5
2	$Pd(dppf)Cl_2$ (4 mol%)	(3,4,5-trimethoxyphenyl)boronic acid	5 equiv	47	0
3	No metal	(3,4,5-trimethoxyphenyl)boronic acid	-	-	0
4	Ni(dppf)(*o*-tol)Cl (2 mol%)	4,4,5,5-tetramethyl-2-(3,4,5-trimethoxyphenyl)-1,3,2-dioxaborolane	-	45	0
5	$Pd(dppf)Cl_2$ (4 mol%)	4,4,5,5-tetramethyl-2-(3,4,5-trimethoxyphenyl)-1,3,2-dioxaborolane	5 equiv	61	0
6	No metal	4,4,5,5-tetramethyl-2-(3,4,5-trimethoxyphenyl)-1,3,2-dioxaborolane	-	-	0

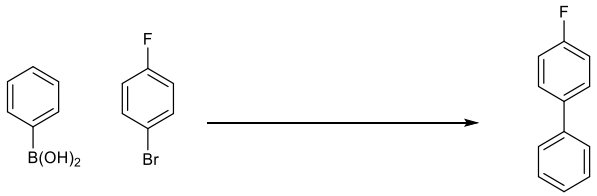
5.2.3 Protodeboronation study of (5-phenylthiophen-2-yl)boronic acid/4,4,5,5-tetramethyl-2-(5-phenylthiophen-2-yl)-1,3,2-dioxaborolane



To an oven-dried microwave vial was added bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), **boron reagent (1 equiv), catalyst**, and K_3PO_4 (159 mg, 0.75 mmol, 3 equiv). The vial was capped and purged with N_2 before the addition of 1,4-dioxane (1 mL, 0.25 M). The reaction mixture was heated for 0.5 h at 80 °C. The reaction mixture was then allowed to cool to room temperature and an aliquot was taken which was analysed by HPLC against an internal standard (naphthalene).

Entry	Catalyst	R-BR_2 (1 equiv)	H_2O	A(%)	B(%)
1	Ni(dppf)(*o*-tol)Cl (2 mol%)	(5-phenylthiophen-2-yl)boronic acid	-	46	6
2	$Pd(dppf)Cl_2$ (4 mol%)	(5-phenylthiophen-2-yl)boronic acid	5 equiv	22	41
3	No metal	(5-phenylthiophen-2-yl)boronic acid	-	-	58
4	Ni(dppf)(*o*-tol)Cl (2 mol%)	4,4,5,5-tetramethyl-2-(5-phenylthiophen-2-yl)-1,3,2-dioxaborolane	-	3	31
5	$Pd(dppf)Cl_2$ (4 mol%)	4,4,5,5-tetramethyl-2-(5-phenylthiophen-2-yl)-1,3,2-dioxaborolane	5 equiv	24	7
6	No metal	4,4,5,5-tetramethyl-2-(5-phenylthiophen-2-yl)-1,3,2-dioxaborolane	-	-	30

6.0 Robustness screen



[Ni]: To an oven-dried microwave vial was added 4-bromofluorobenzene (43.8 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(*o*-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), and **additive (1 equiv)**. The vial was capped and purged with N_2 before the addition of 1,4-dioxane (1 mL, 0.25 M). The reaction mixture was heated for 4 h at 80 °C. The reaction mixture was then allowed to cool to room temperature and trifluorotoluene (30.7 µL, 0.25 mmol) was added. The vial was then decapped, and the reaction mixture diluted with $CDCl_3$ and filtered through a layer of celite. Conversion to the desired product was measured by ^{19}F NMR against a known internal standard (trifluorotoluene).

[Pd]: To an oven-dried microwave vial was added 4-bromofluorobenzene (43.8 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Pd(dppf)Cl_2 (7.3 mg, 0.01 mmol, 4 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), and **additive (1 equiv)**. The vial was capped and purged with N_2 before the addition of 1,4-dioxane (1 mL, 0.25 M), and H_2O (22.5 µL, 1.25 mmol, 5 equiv). The reaction mixture was heated for 4 h at 80 °C. The reaction mixture was then allowed to cool to room temperature and trifluorotoluene (30.7 µL, 0.25 mmol) was added. The vial was then decapped, and the reaction mixture diluted with $CDCl_3$ and filtered through a layer of celite. Conversion to the desired product was measured by ^{19}F NMR against a known internal standard (trifluorotoluene).

Entry	additive	[Ni] Product yield (%)	[Pd] Product yield (%)	Entry	additive	[Ni] Product yield (%)	[Pd] Product yield (%)
1	No additive	>99	>99	**9**	Phenol	0	58
2	Pyridine	>99	73	**10**	Benzophenone	73	>99
3	DMAP	0	>99	**11**	Octanal	5	82
4	Pinacol	70	87	**12**	4-Methylstyrene	>99	72
5	Aniline	>99	90	**13**	Benzaldehyde	<99	<99
6	Benzonitrile	>99	96	**14**	4-Methoxybenzenethiol	0	1
7	Indole	>99	83	**15**	1,4-Dinitrobenzene	0	96
8	Methyl-indole	93	95	**16**	Benzoic acid	8	98

7.0 References

(1) W. L. F. Armarego, *Purification of Laboratory Chemicals*, 8th ed.; Elsevier: Oxford, 2017.

(2) E. A. Standley, S. J. Smith, P. Müller, T. F. Jamison, *Organometallics,* 2014, **33**, 2012.

(3) H. Kim, M. R. Reddy, H. Kim, D. Choi, C. Kim, S. Seo, *Chempluschem,* 2017, **82**, 742.

(4) F. Mäsing, H. Nüsse, J. Klingauf, A. Studer, *Org. Lett.,* 2018, **20**, 752.

(5) W. C. Chen, Y. C. Hsu, W. C. Shih, C. Y. Lee, W. H. Chuang, Y. F. Tsai, P. P. Y. Chen, T. G. Ong, *Chem. Commun.,* 2012, **48**, 6702.

(6) F. Zeng, H. Alper, *Org. Lett.,* 2013, **15**, 2034.

(7) M. Giannerini, C. Vila, V. Hornillos, B. L. Feringa, *Chem. Commun.,* 2016, **52**, 1206.

(8) C. Zhou,Q. Liu, Y. Li, R. Zhang, X. Fu, C. Duan, *J. Org. Chem.,* 2012, **77**, 10468.

(9) G. K. Rao, A. Kumar, J. Ahmed, A. K. Singh, *Chem. Commun.,* 2010, **46**, 5954.

(10) L. M. Castelló, V. Hornillos, C. Vila, M. Giannerini, M. Fañanás-Mastral, B. L. Feringa, *Org. Lett.,* 2015, **17**, 62.

(11) T. Y. Li, T. Meyer, Z. Ma, J. Benduhn, C. Korner, O. Zeika, K. Vandewal, K. Leo, *J. Am. Chem. Soc.,* 2017, **139**, 13636.

(12) G. A. Molander, L. Iannazzo, *J. Org. Chem.,* 2011, **76**, 9182.

(13) S. Yamamoto, K. Okamoto, M. Murakoso, Y. Kuninobu, K. Takai, *Org. Lett.,* 2012, **14**, 3182.

(14) A. Várela-Fernández, C. González-Rodríguez, J. A. Varela, L. Castedo, C. Saá, *Org. Lett.,* 2009, **11**, 5350.

(15) K. Okura, T. Teranishi, Y. Yoshida, E. Shirakawa, *Angew. Chem. Int. Ed.,* 2018*,* **57***,* 7186.

(16) G. M. Scheuermann, L. Rumi, P. Steurer, W. Bannwarth, R. Mülhaupt, *J. Am. Chem. Soc.,* 2009, **131**, 8262.

(17) J. Kan, S. Huang, J. Lin, M. Zhang, W. Su, *Angew. Chem. Int. Ed.,* 2015, **54**, 2199.

(18) Y. Zheng, C Yang, D. Zhang-Negrerie, Y. Du, K. Zhao, *Tetrahedron Lett.,* 2013, **54**, 6157.

(19) Y. Guan, J. W. Attard, M. D. Visco, T. J. Fisher, A. E. Mattson, *Chem. Eur.J.,* 2018*,* **24***,* 7123.

(20) G. Yuan, J. Zheng, X. Gao, X. Li, L. Huang, H. Chen, H. Jiang, *Chem. Commun.,* 2012, **48**, 7513.

(21) D. Martinez-Solorio, B. Melillo, L. Sanchez, Y. Liang, E. Lam, K. N. Houk, A. B. Smith, *J. Am. Chem. Soc.,* 2016, **138**, 1836.

(22) K. Yang, J. Zhang, Y. Li, B. Cheng, L. Zhao, H. Zhai, *Org. Lett.,* 2013, **15**, 808.

(23) D. Heijnen, J.-B. Gualtierotti, V. Hornillos, B. L. Feringa, *Chem. Eur. J,.* 2016*,* **22***,* 3991.

(24) L. R. Odell, J. Lindh, T. Gustafsson, M. Larhed, *Eur. J. Org. Chem.,* 2010*,* 2270.

(25) D.-J. Dong, H.-H. Li, S.-K. Tian, *J. Am. Chem. Soc.,* 2010, **132**, 5018.

(26) L. Chen, H. Lang, L. Fang, M. Zhu, J. Liu, J. Yu, L. Wang, *Eur. J. Org. Chem.,* 2014*,* 4953.

(27) S. K. Chittimalla, R. Kuppusamy, N. Akavaram, *Synlett,* 2015, **26**, 613.

(28) F. Luo, C. Pan, L. Li, F. Chen, *Chem. Commun.,* 2011, **47**, 5304.

(29) C. M. Boehner, E. C. Frye, K. M. G. O'Connell, W. R. J. D. Galloway, H. F. Sore, P. G. Dominguez, D. Norton, D. G. Hulcoop, M. Owen, G. Turner, *Chem. Eur. J.,* 2011*,* **17***,* 13230.

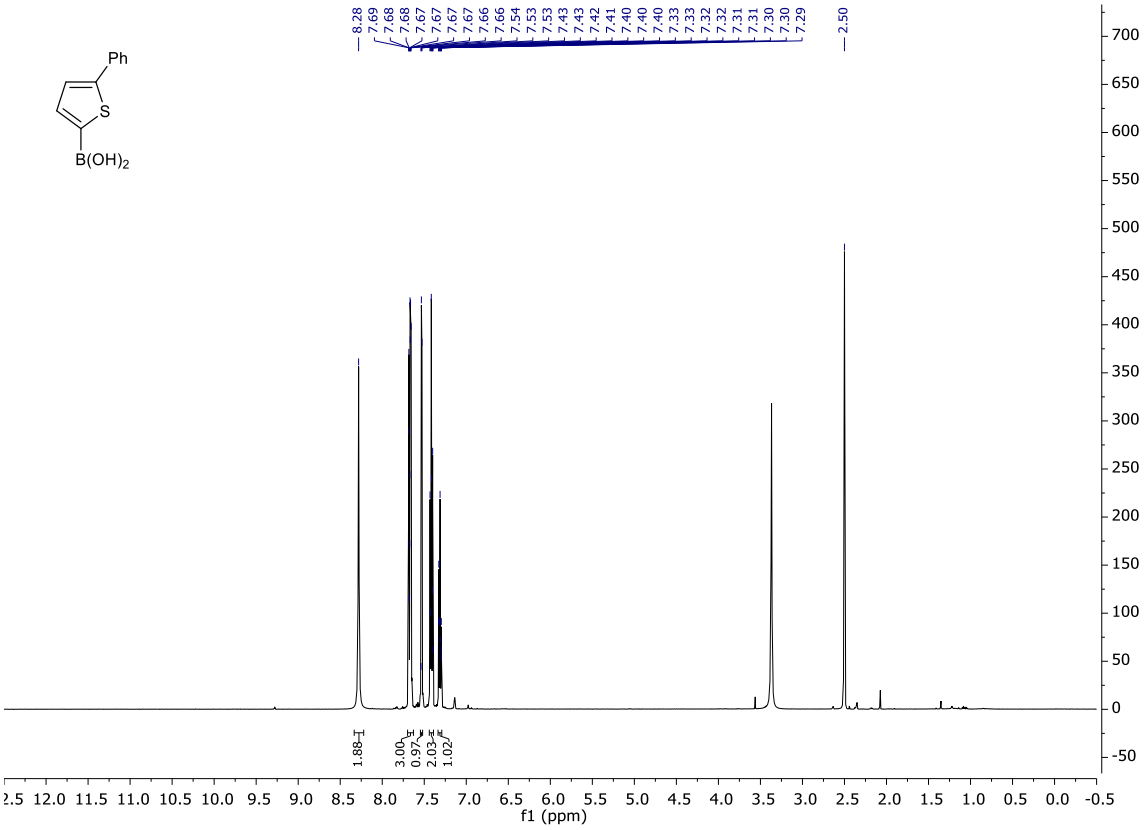
(30) J. W. B. Fyfe, N. J. Fazakerley, A. J. B. Watson, *Angew. Chem. Int. Ed.,* 2017, **56**, 1249.

(31) N. Zhang, C. Wang, G. Zou, J. Tang, *J. Organomet. Chem.,* 2017, **842**, 54.

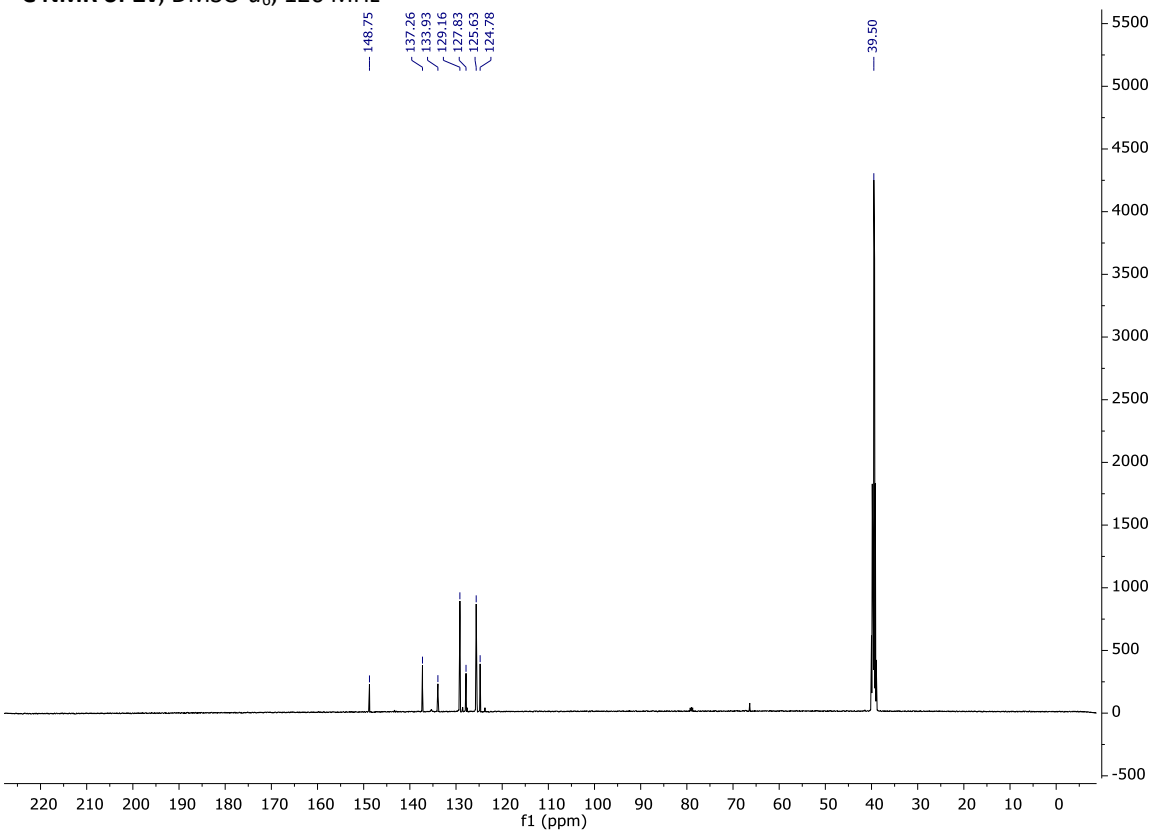
8.0 NMR spectra for intermediates and products

Compound 2v

^{1}H NMR of 2v, DMSO-d_6, 500 MHz

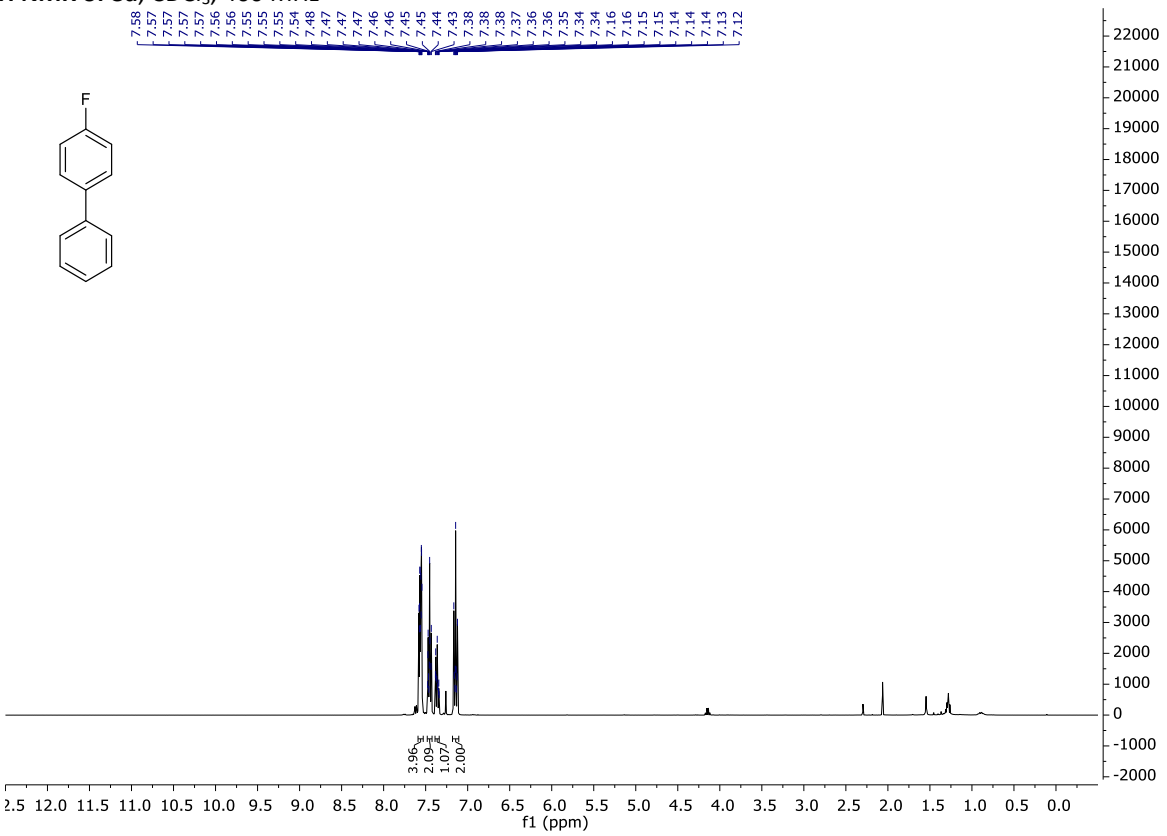


^{13}C NMR of 2v, DMSO-d_6, 126 MHz

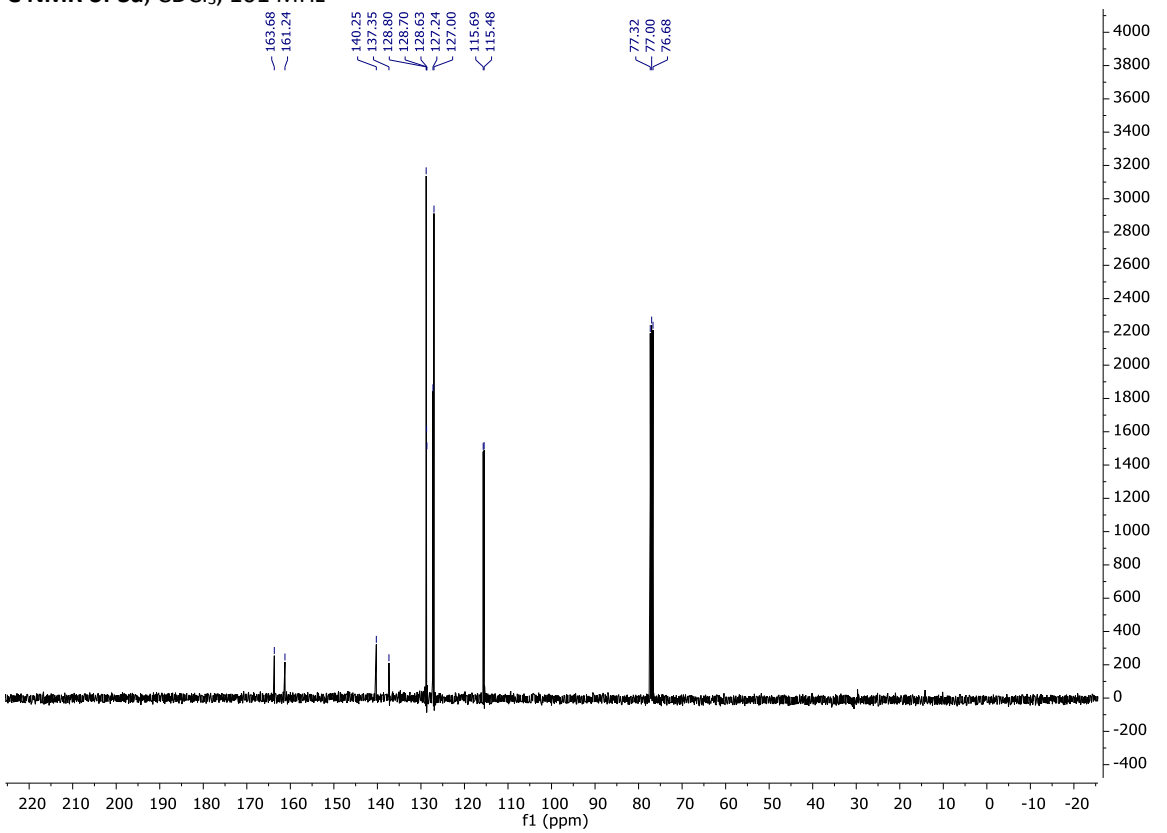


Compound 3a

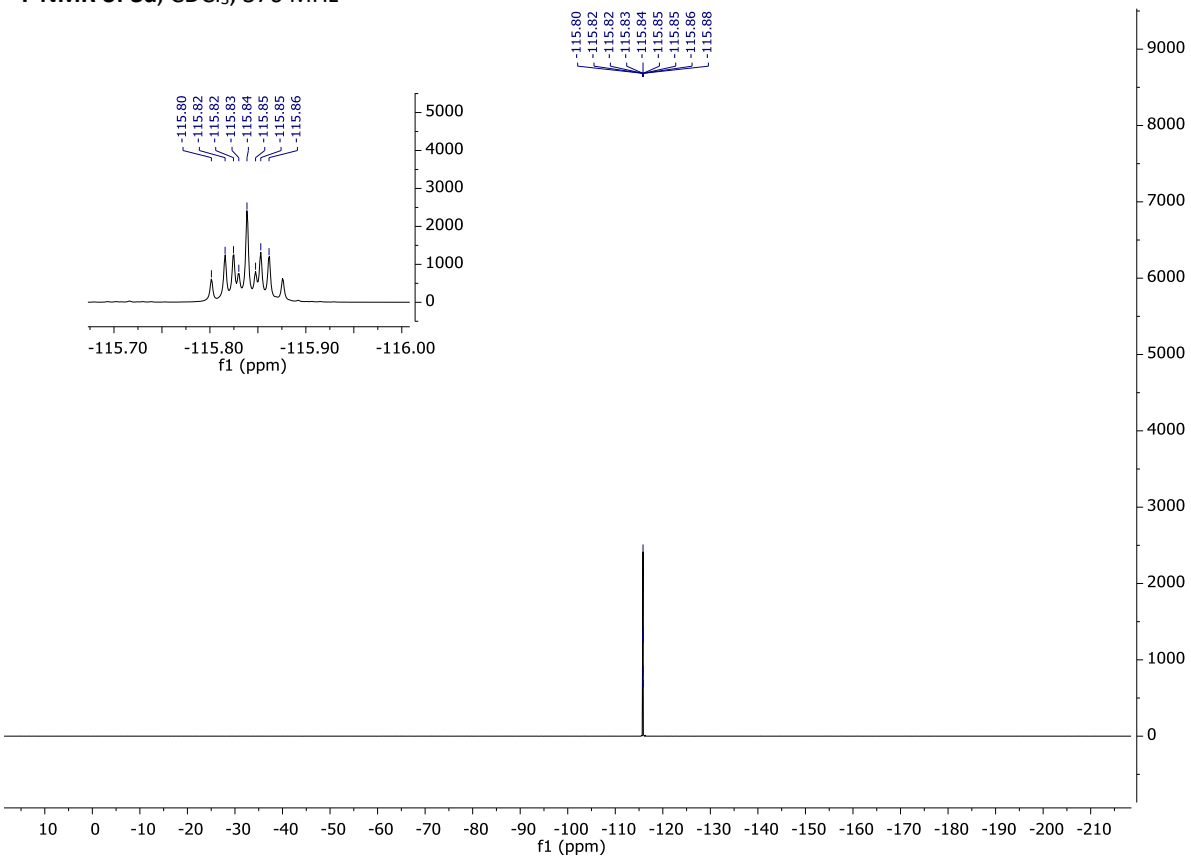
^{1}H NMR of 3a, $CDCl_3$, 400 MHz



^{13}C NMR of 3a, $CDCl_3$, 101 MHz

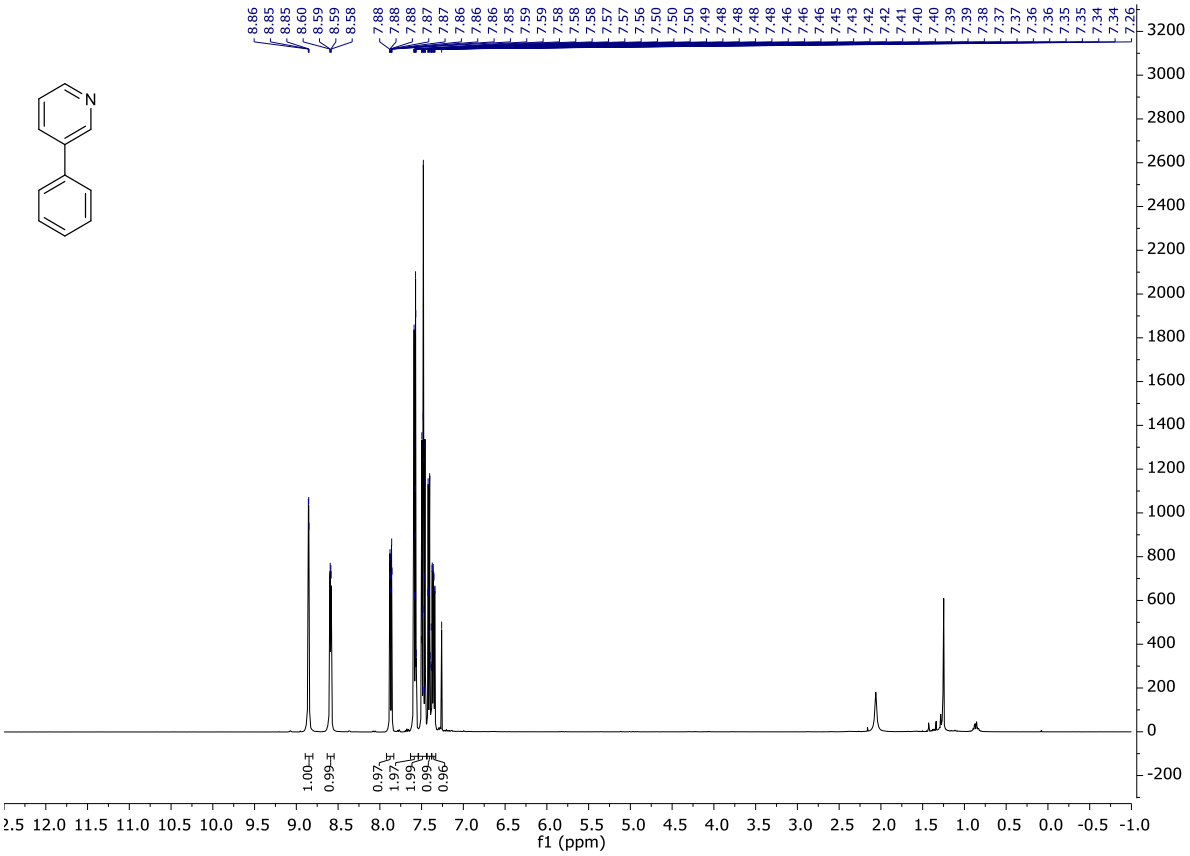


^{19}F NMR of 3a, $CDCl_3$, 376 MHz

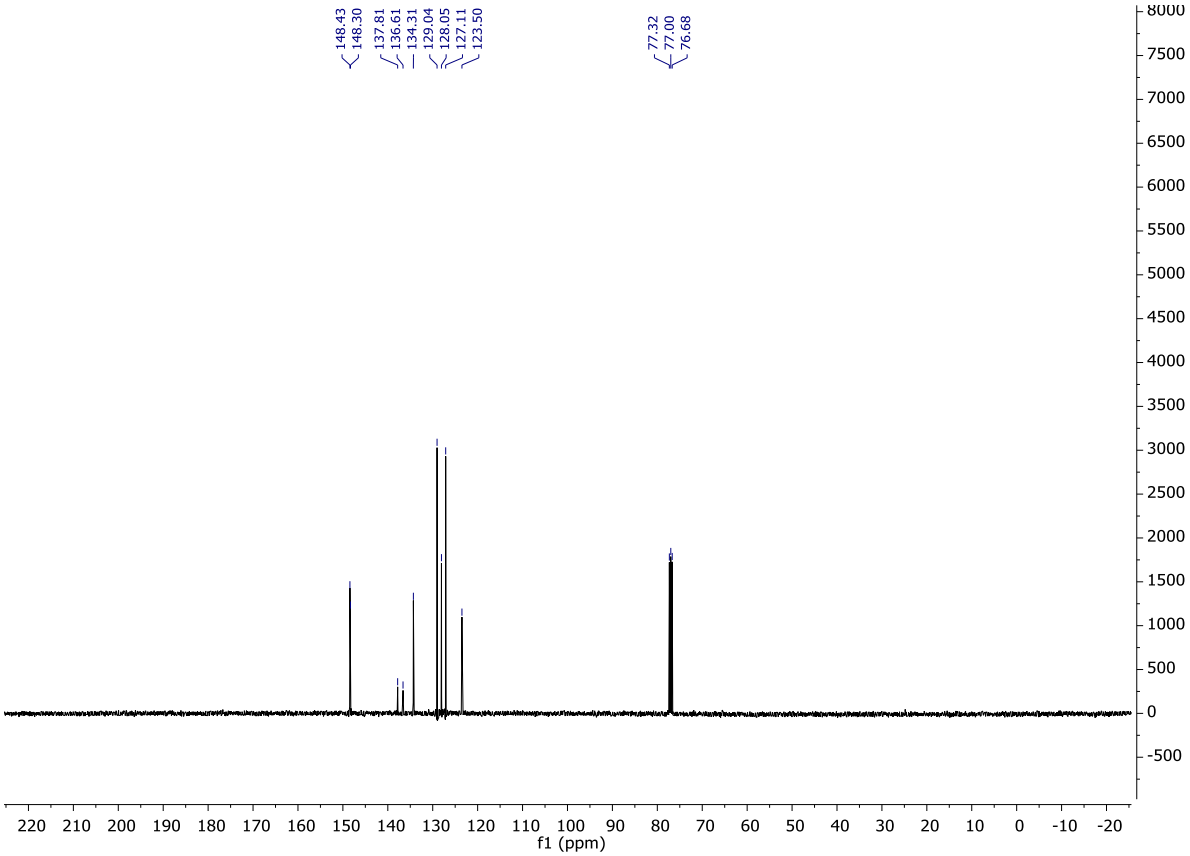


Compound 3b

^{1}H NMR of 3b, $CDCl_3$ 400 MHz.

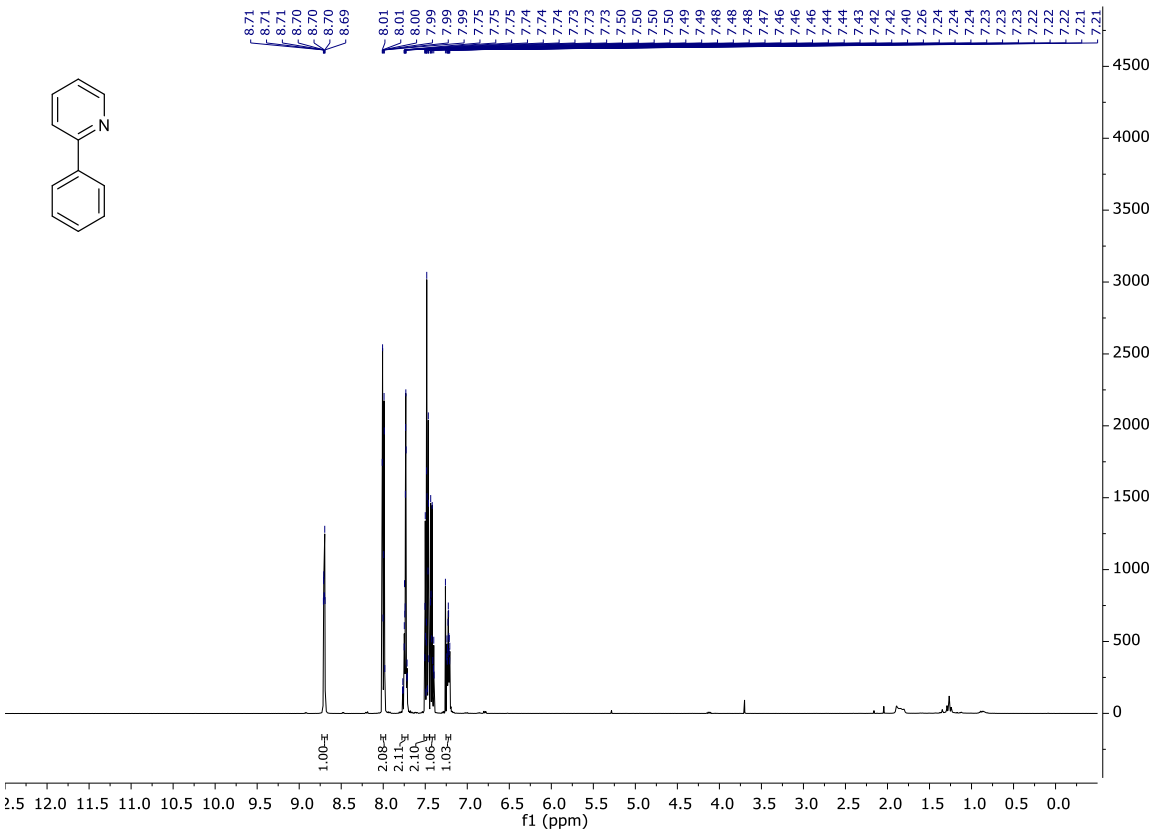


^{13}C NMR of 3b, $CDCl_3$, 101 MHz

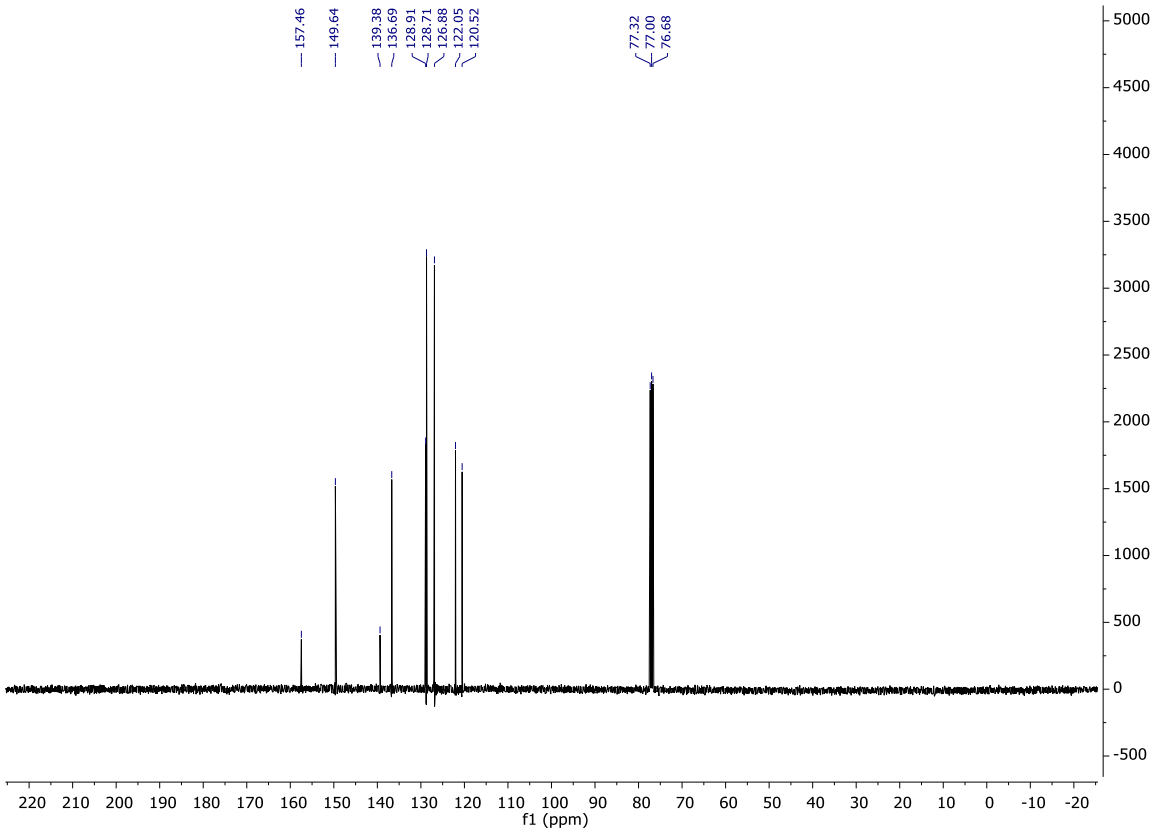


Compound 3c

^{1}H NMR of 3c, $CDCl_3$ 400 MHz.

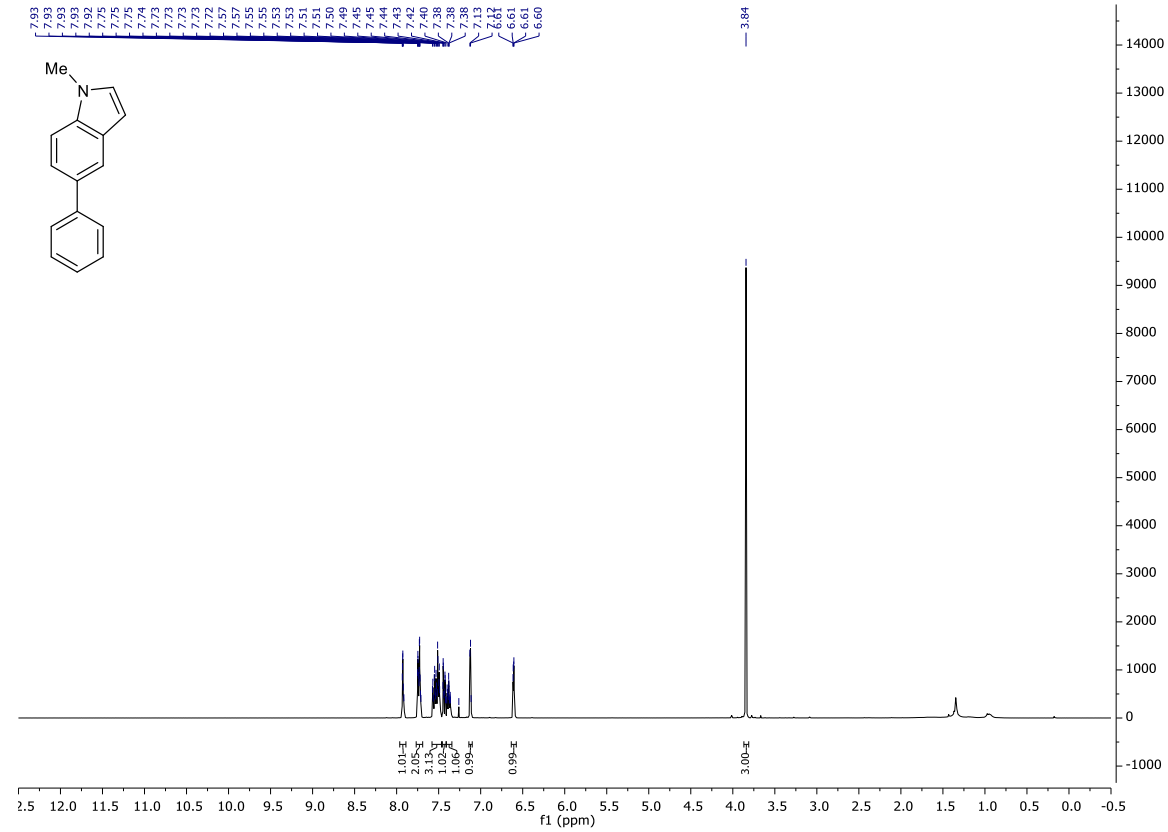


^{13}C NMR of 3c, $CDCl_3$, 101 MHz

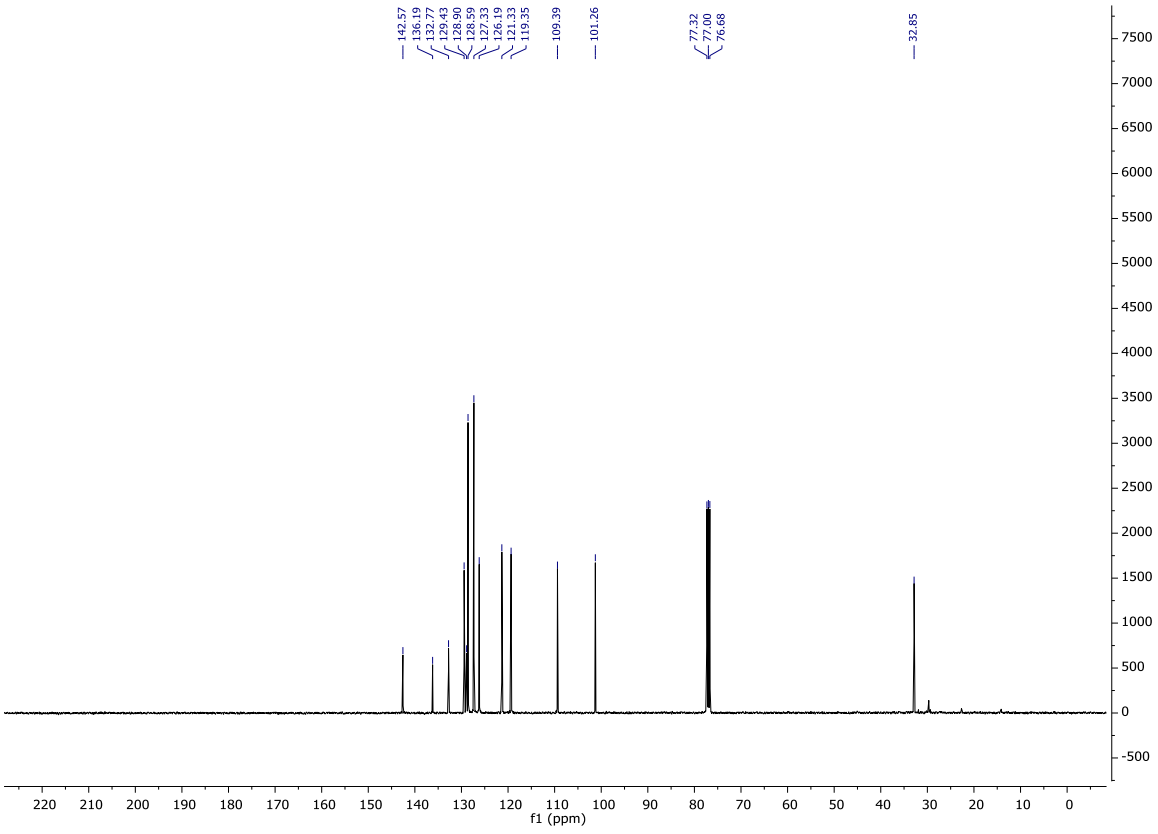


Compound 3d

^{1}H NMR of 3d, $CDCl_3$ 400 MHz.

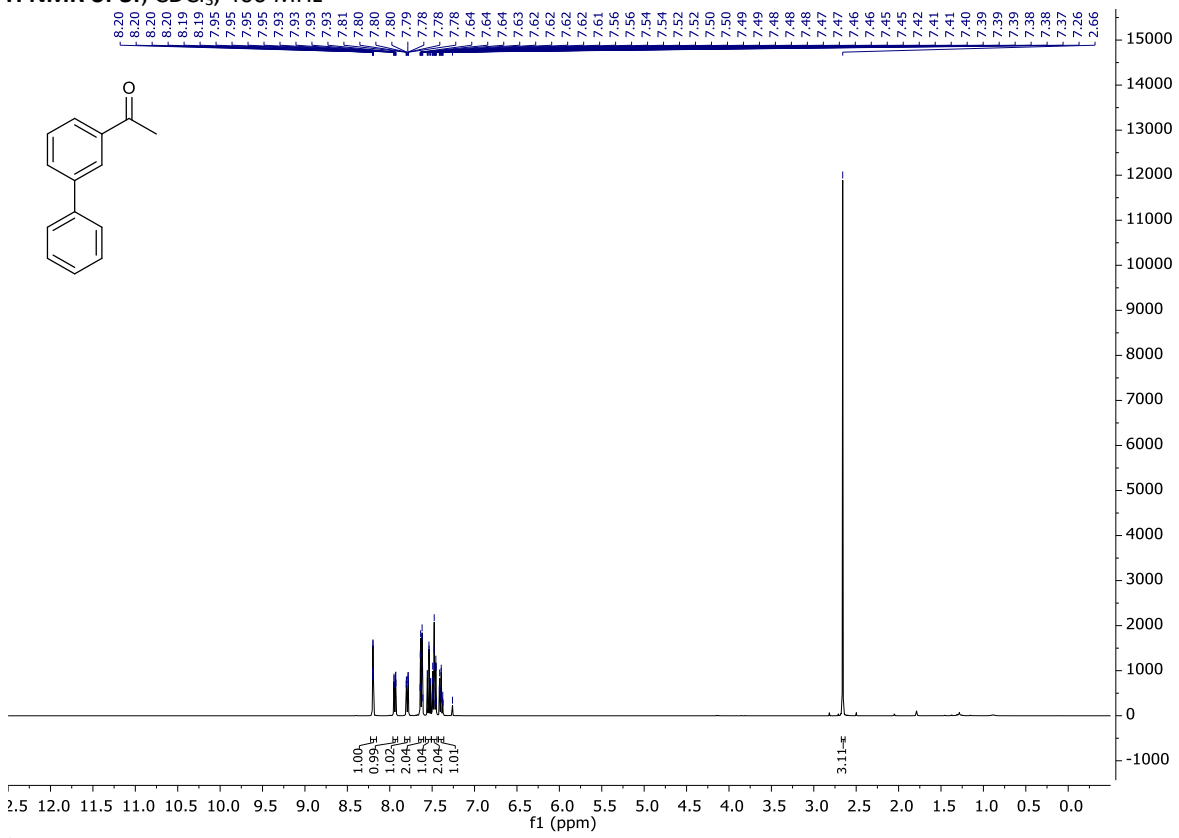


^{13}C NMR of 3d, $CDCl_3$, 101 MHz

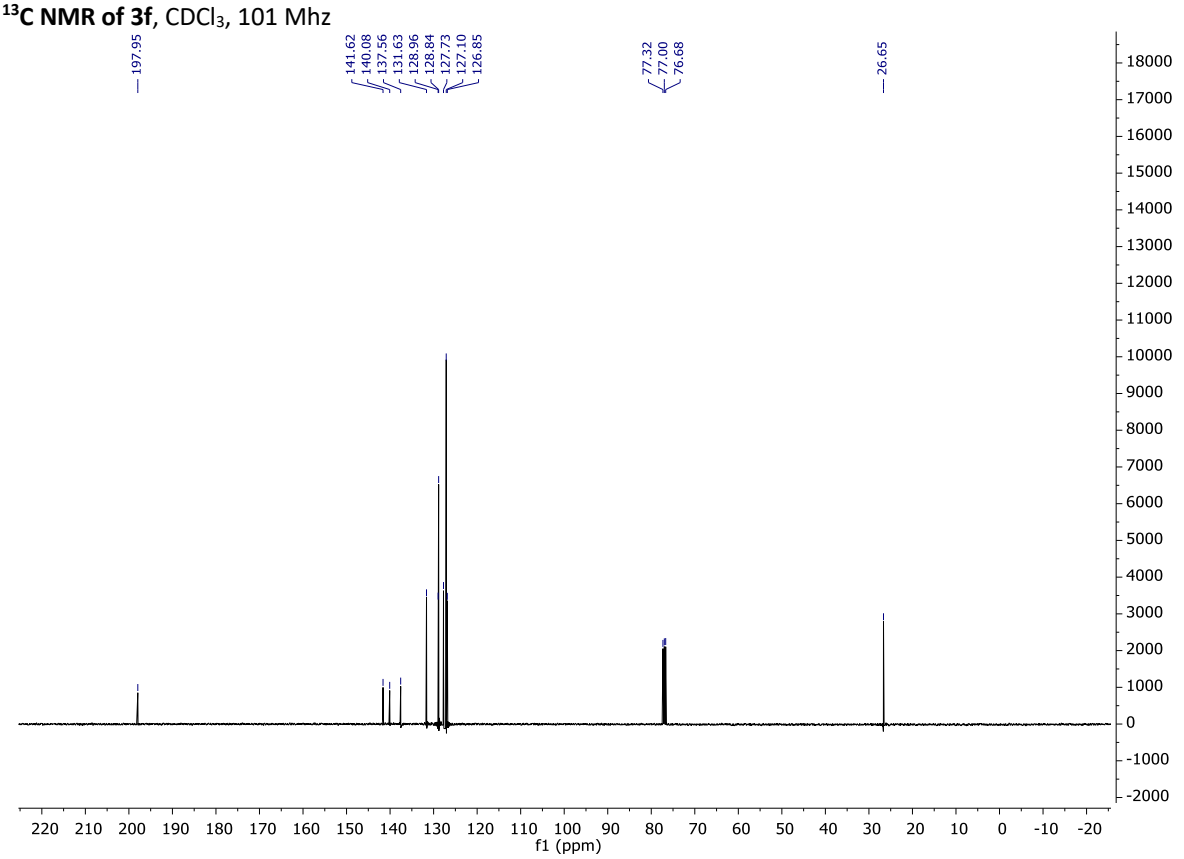


Compound 3f

^{1}H NMR of 3f, $CDCl_3$, 400 MHz

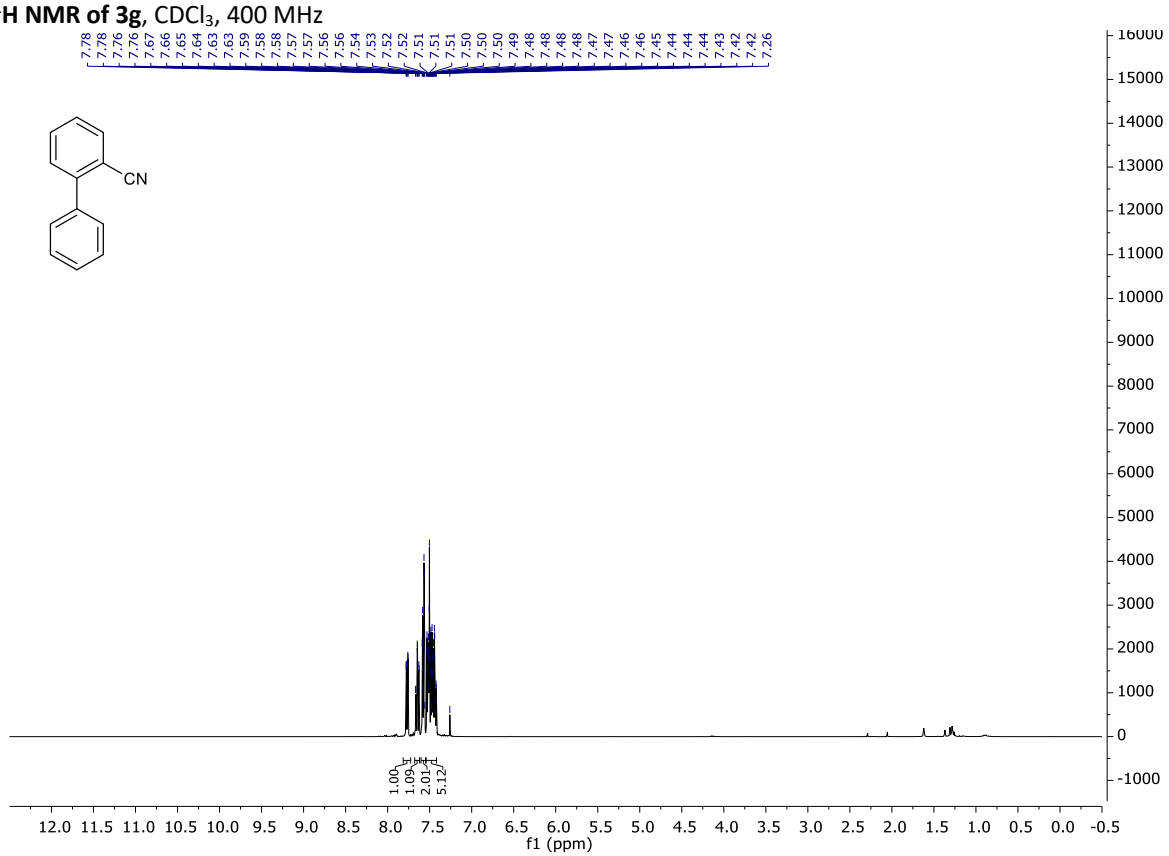


^{13}C NMR of 3f, $CDCl_3$, 101 Mhz

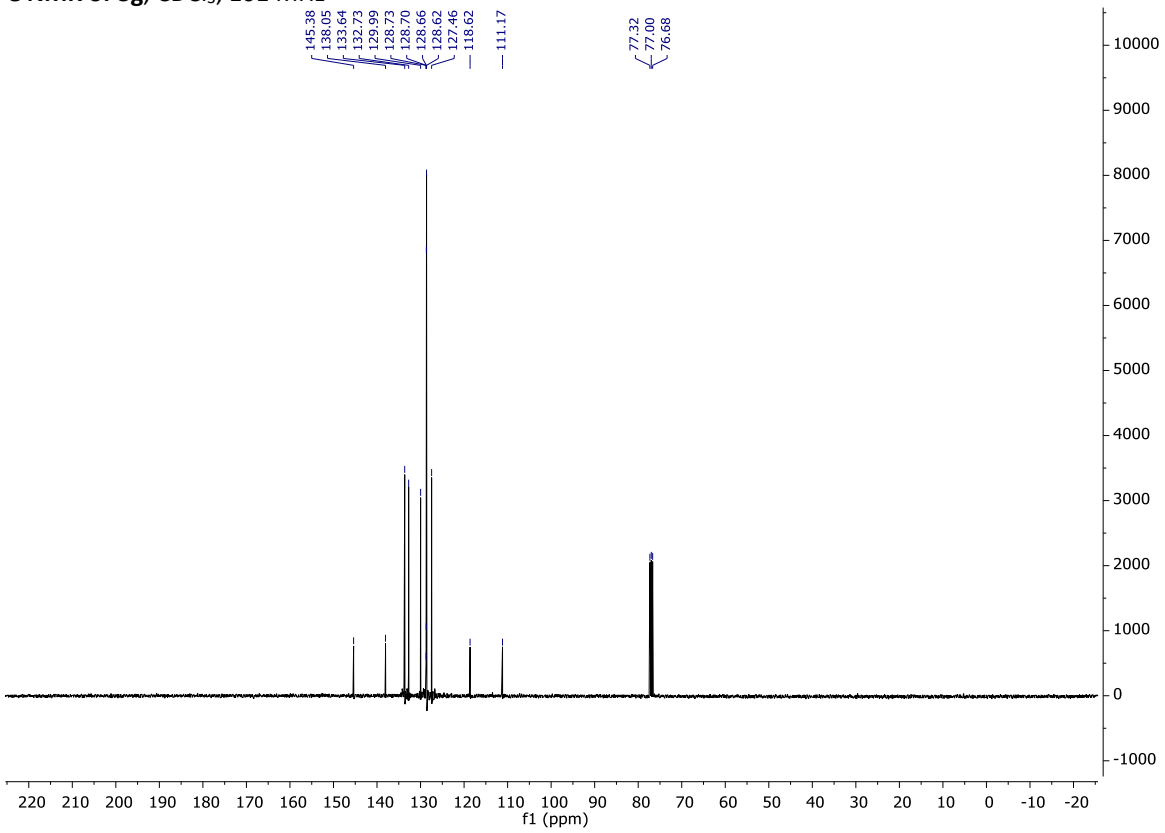


Compound 3g

^{1}H NMR of 3g, $CDCl_3$, 400 MHz

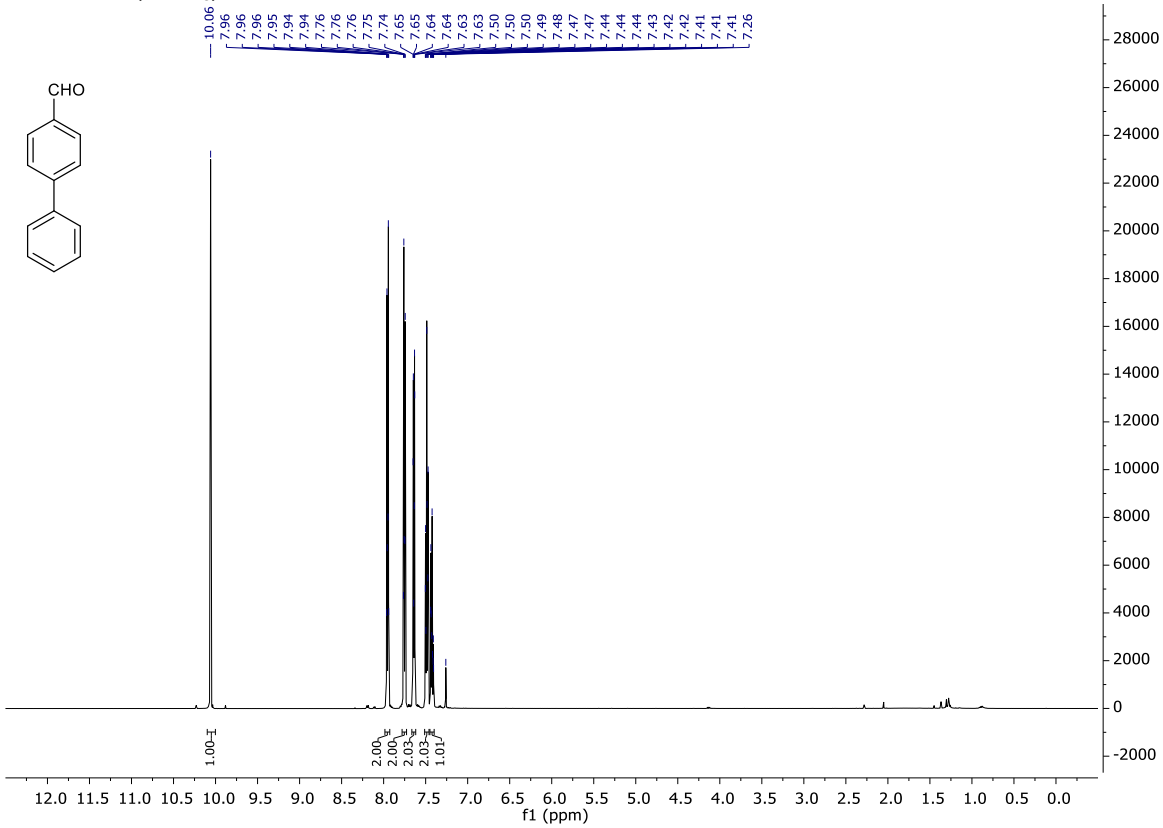


^{13}C NMR of 3g, $CDCl_3$, 101 MHz

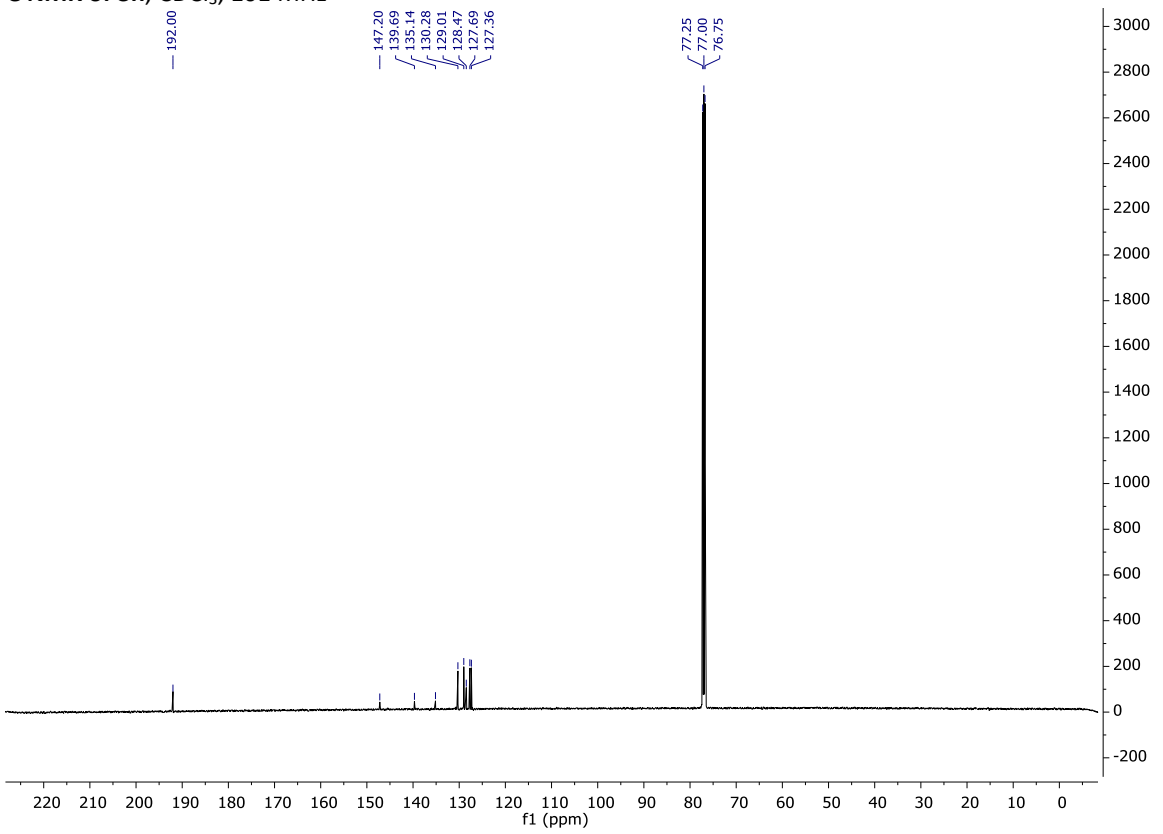


Compound 3h

^{1}H NMR of 3h, $CDCl_3$, 500 MHz

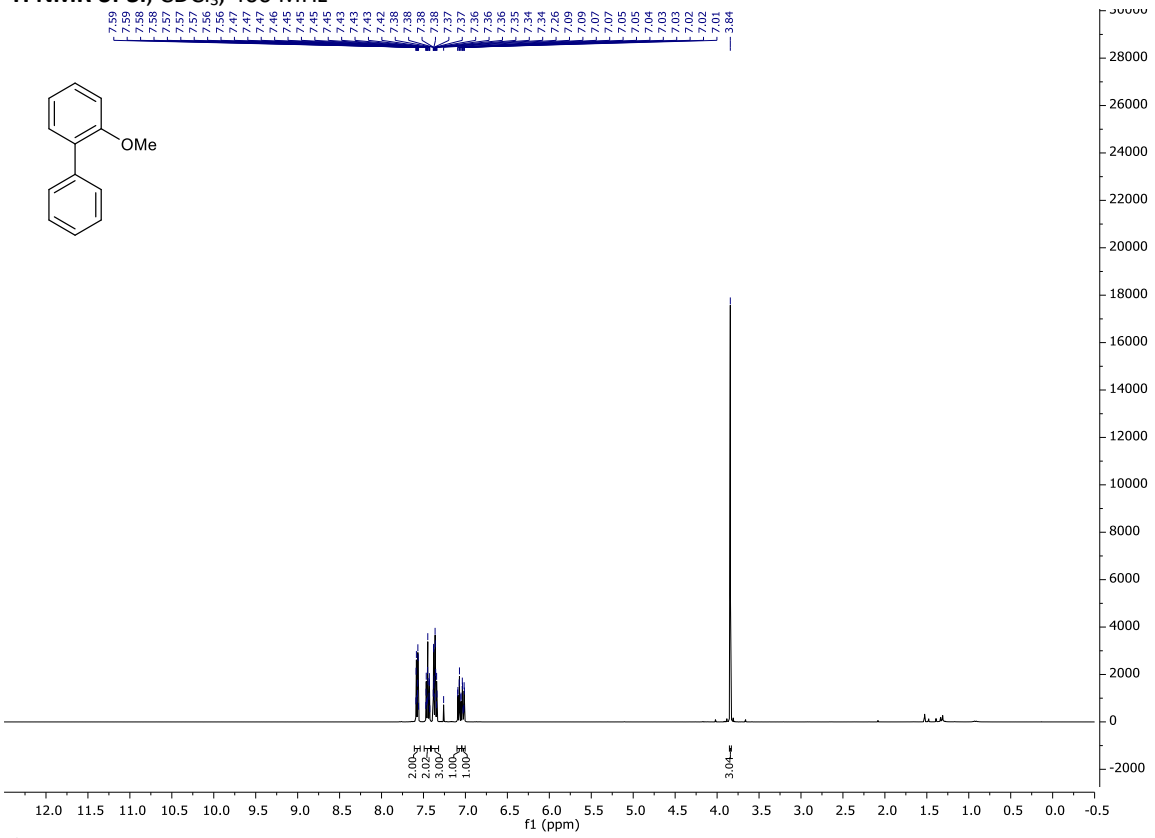


^{13}C NMR of 3h, $CDCl_3$, 101 MHz

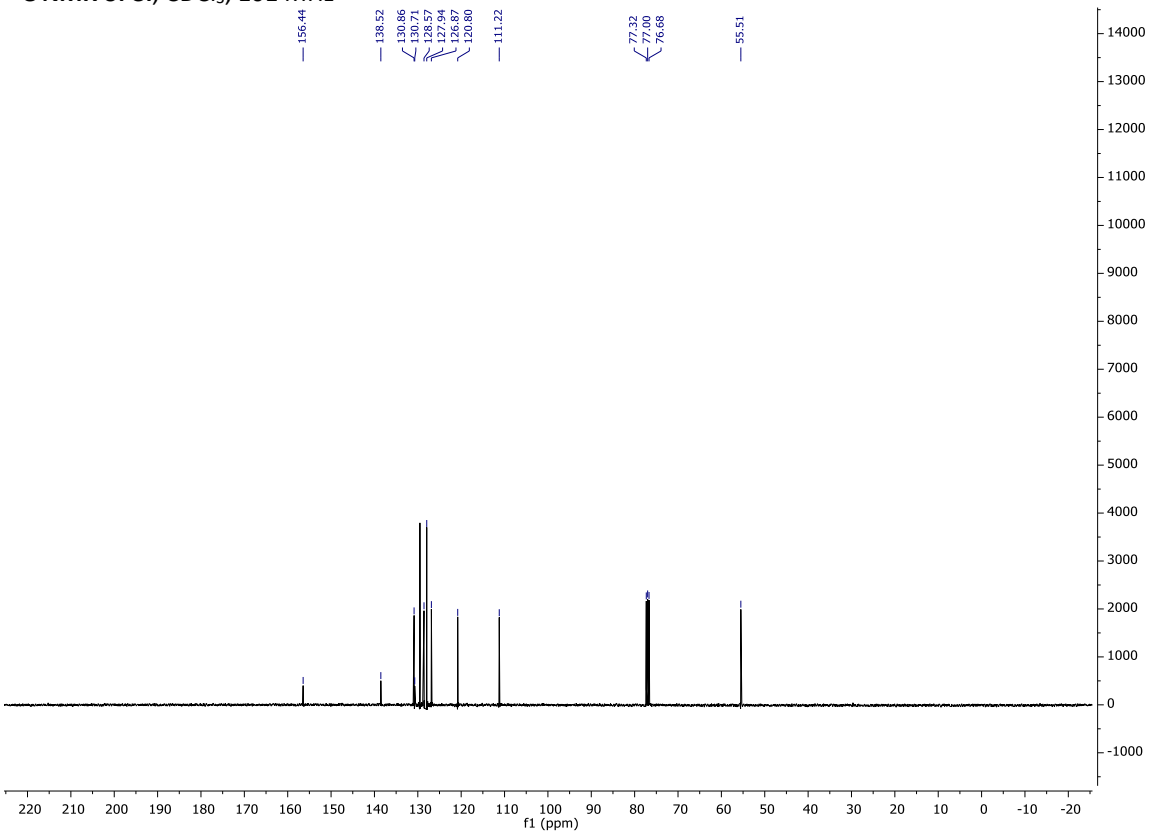


Compound 3i

^{1}H NMR of 3i, $CDCl_3$, 400 MHz

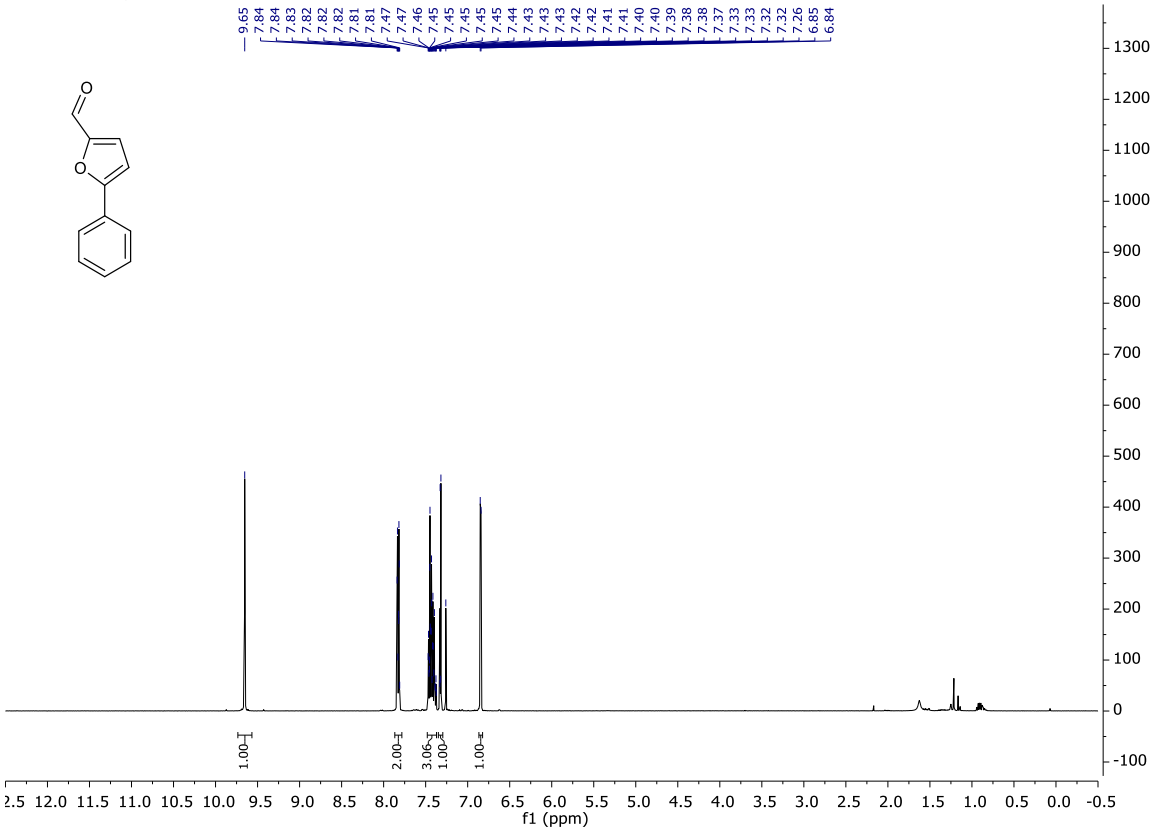


^{13}C NMR of 3i, $CDCl_3$, 101 MHz

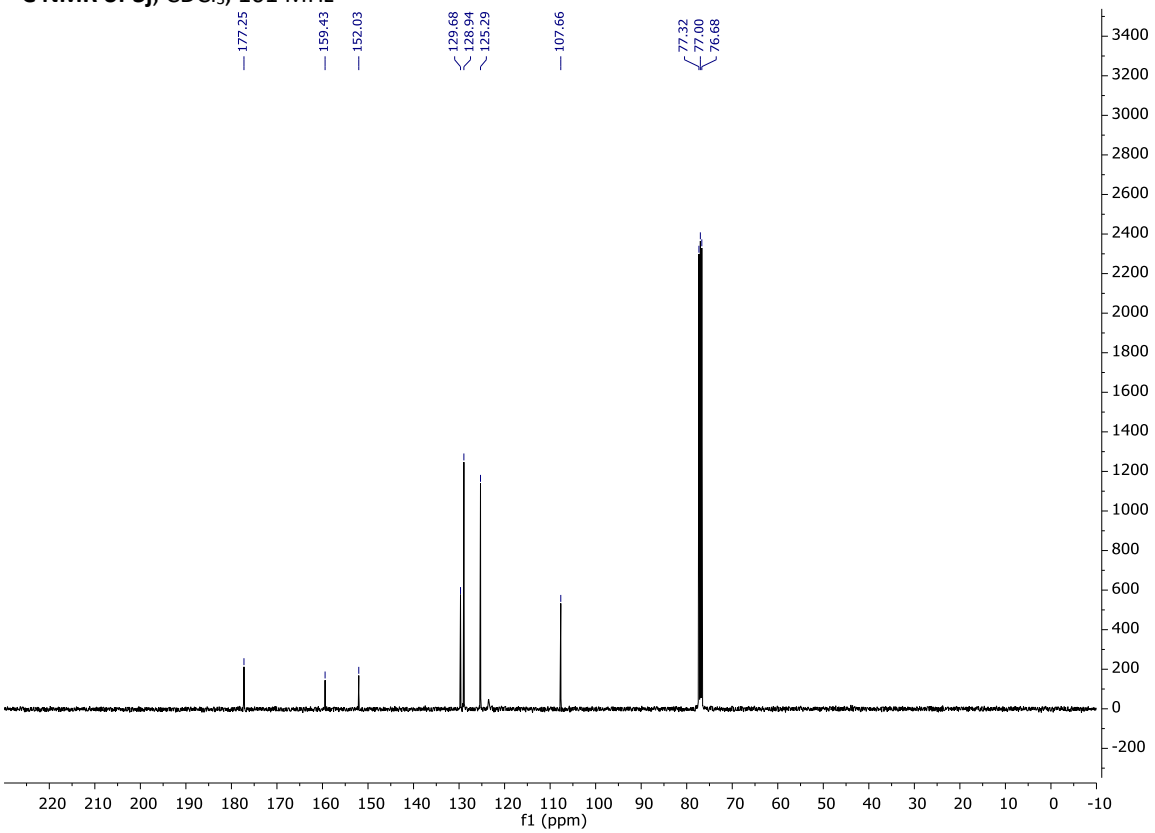


Compound 3j

^{1}H NMR of 3j, $CDCl_3$, 400 MHz

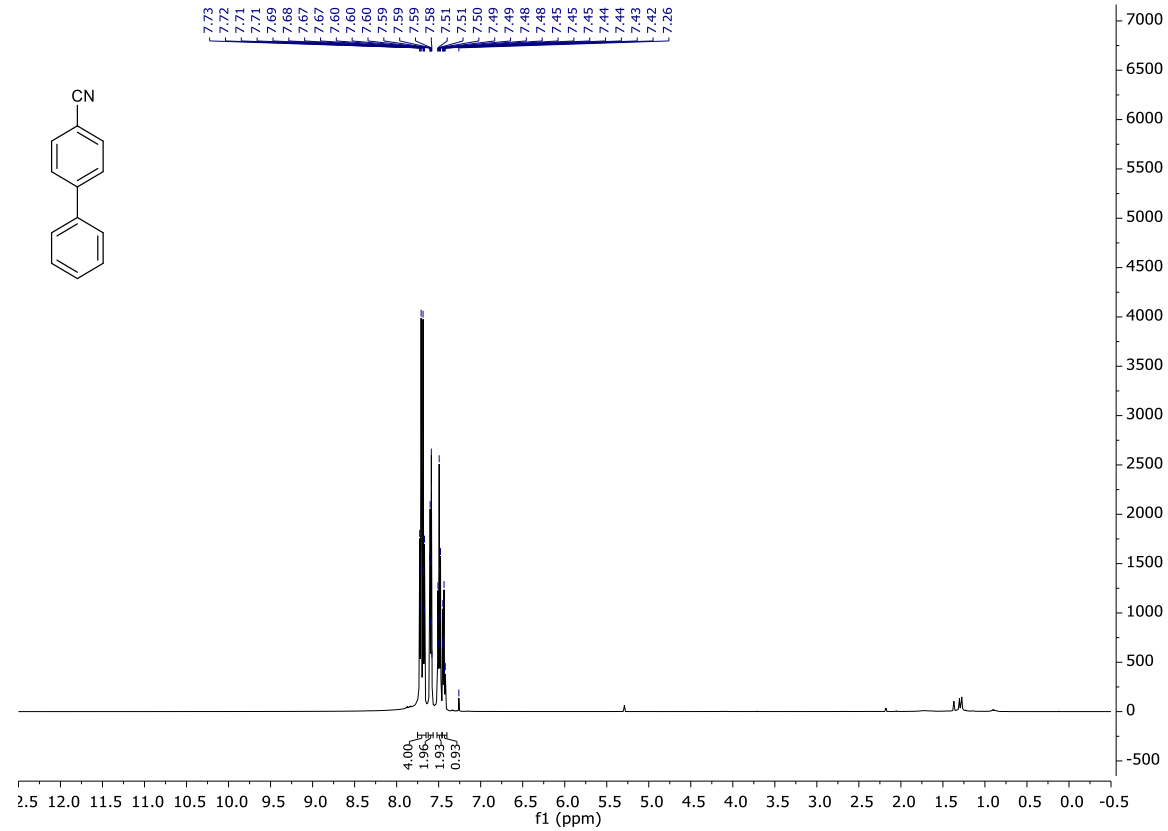


^{13}C NMR of 3j, $CDCl_3$, 101 MHz

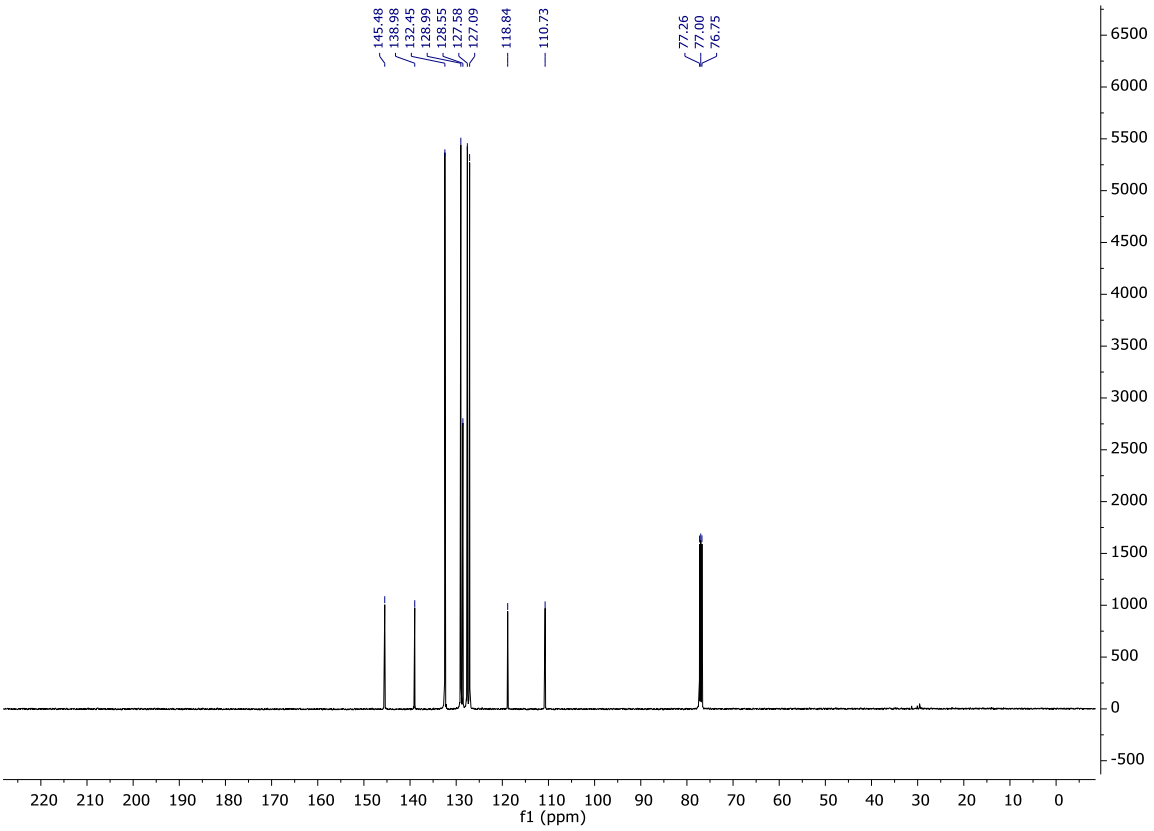


Compound 3k

^{1}H NMR of 3k, $CDCl_3$, 400 MHz

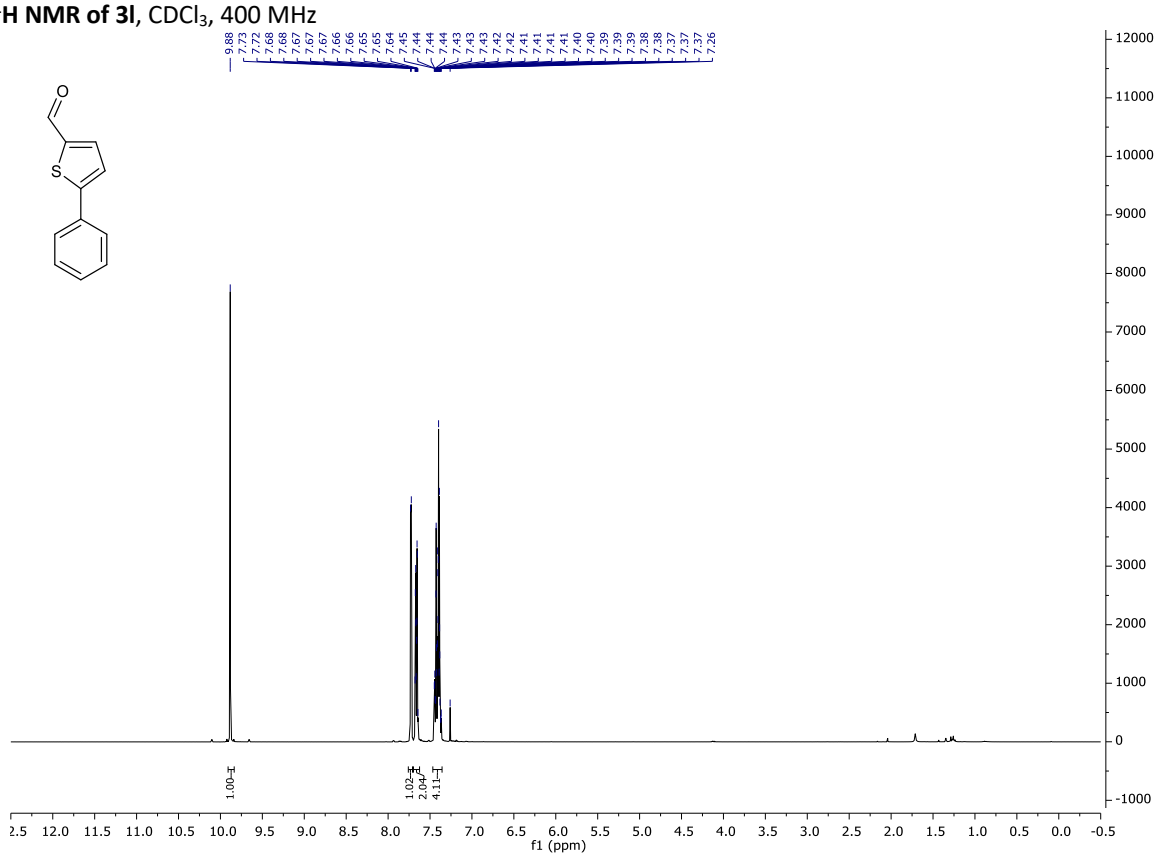


^{13}C NMR of 3k, $CDCl_3$, 101 MHz

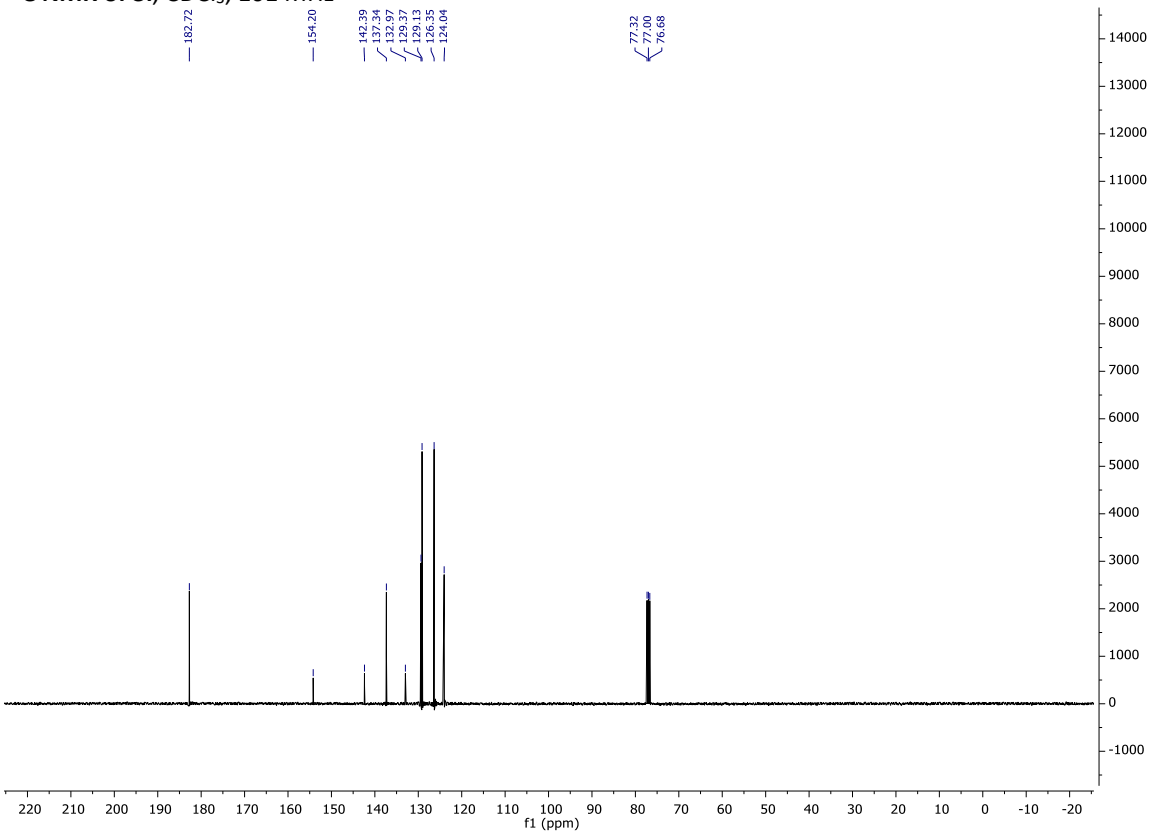


Compound 3l

^{1}H NMR of 3l, $CDCl_3$, 400 MHz

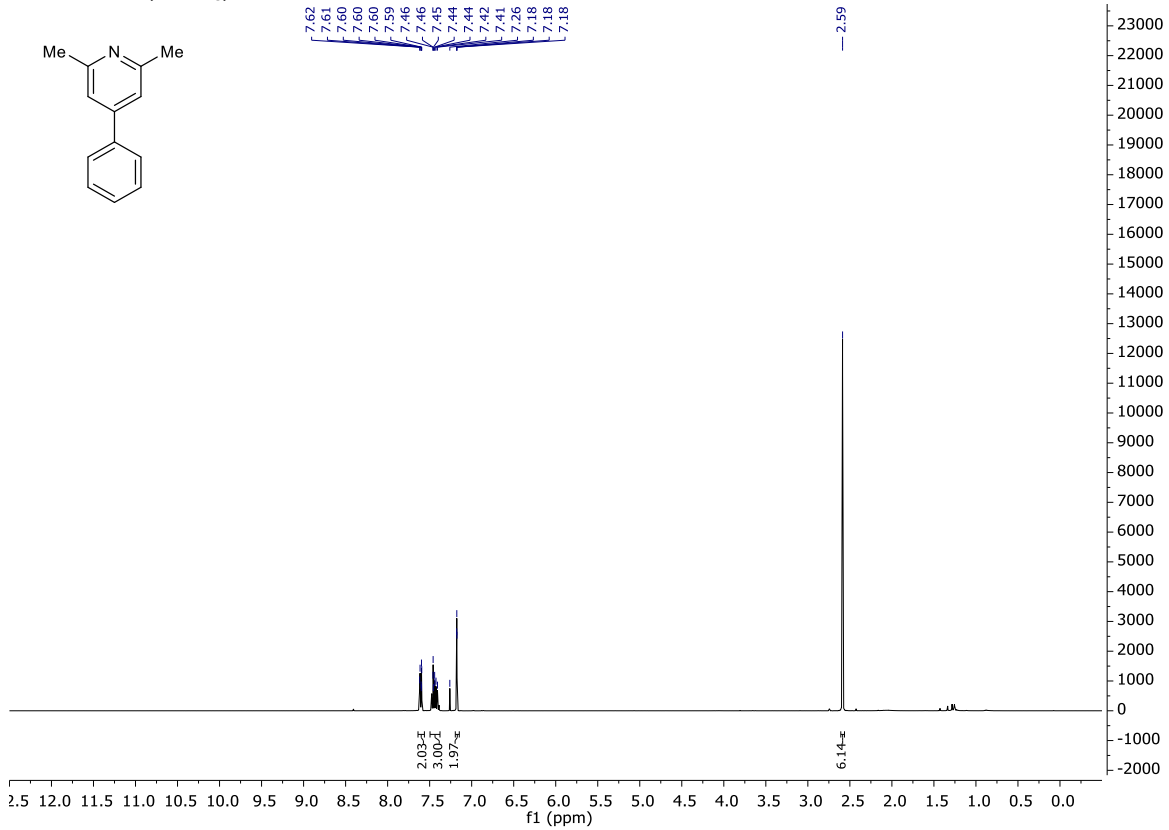


^{13}C NMR of 3l, $CDCl_3$, 101 MHz

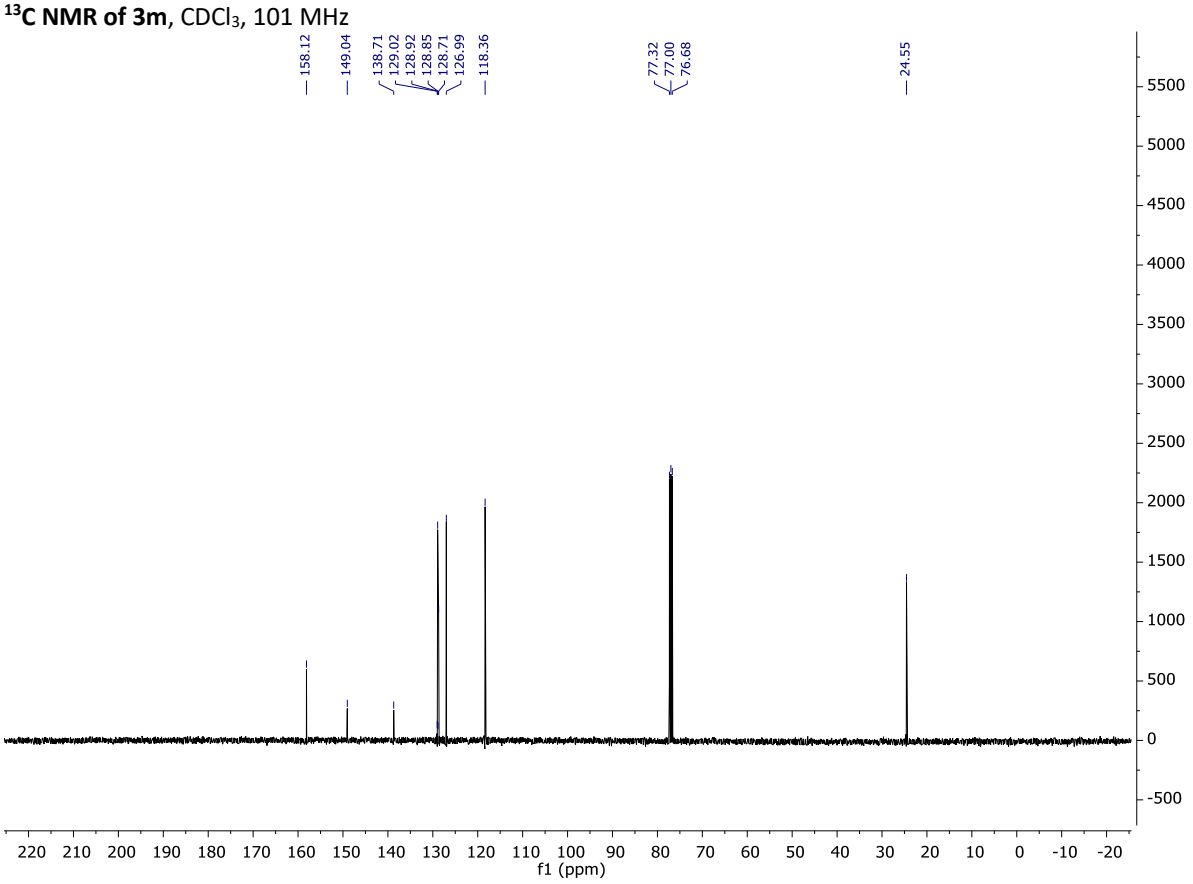


Compound 3m

^{1}H NMR of 3m, $CDCl_3$, 400 MHz

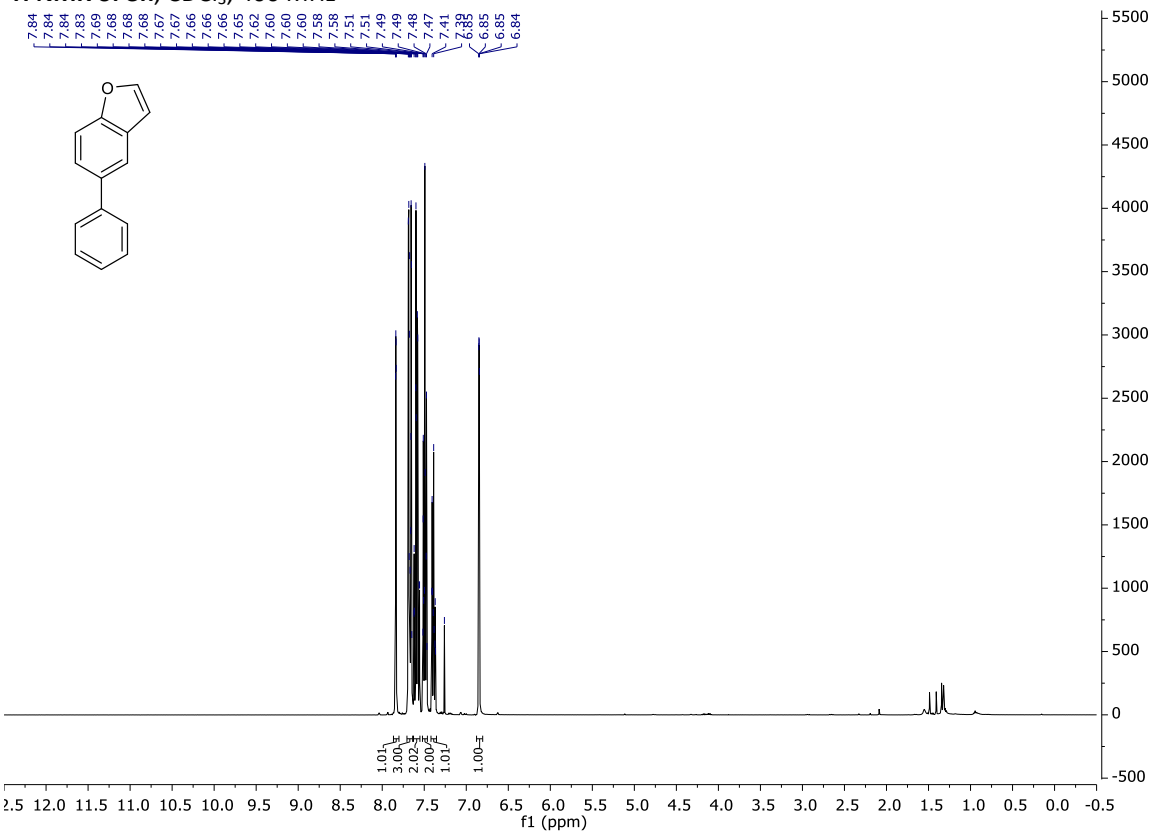


^{13}C NMR of 3m, $CDCl_3$, 101 MHz

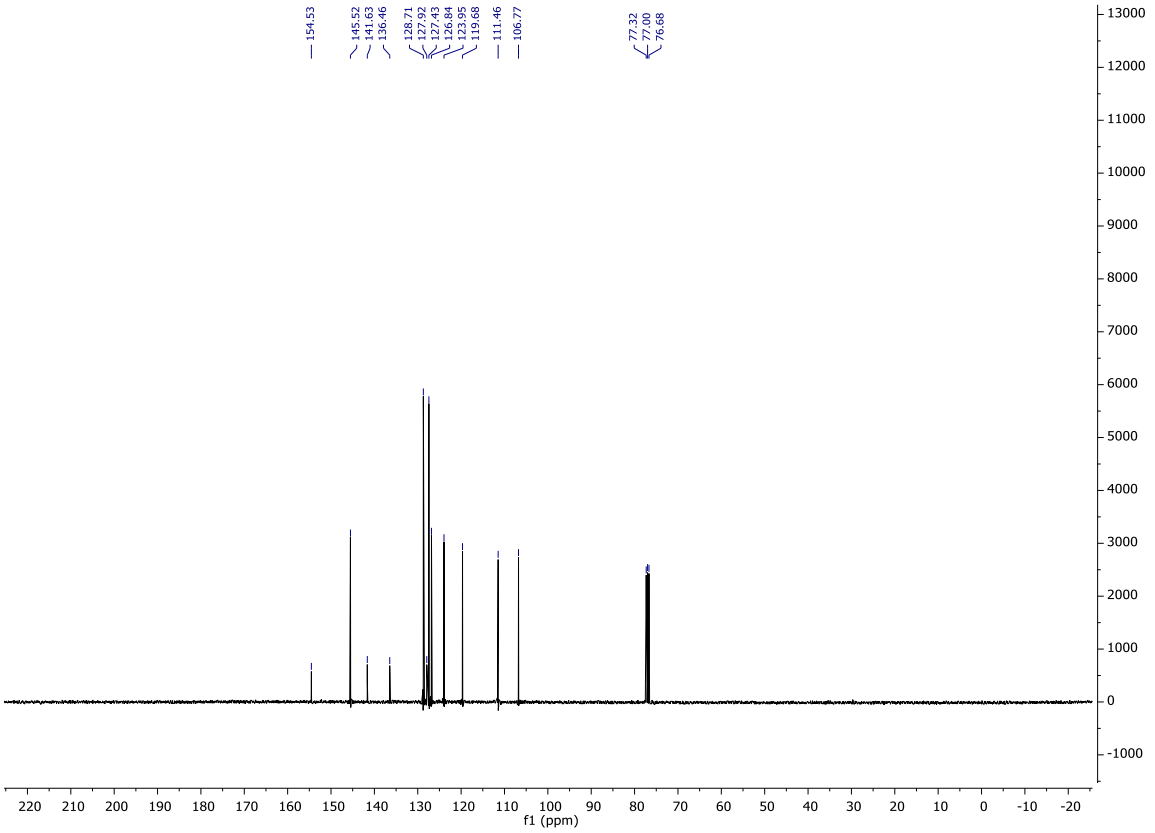


Compound 3n

^{1}H NMR of 3n, $CDCl_3$, 400 MHz

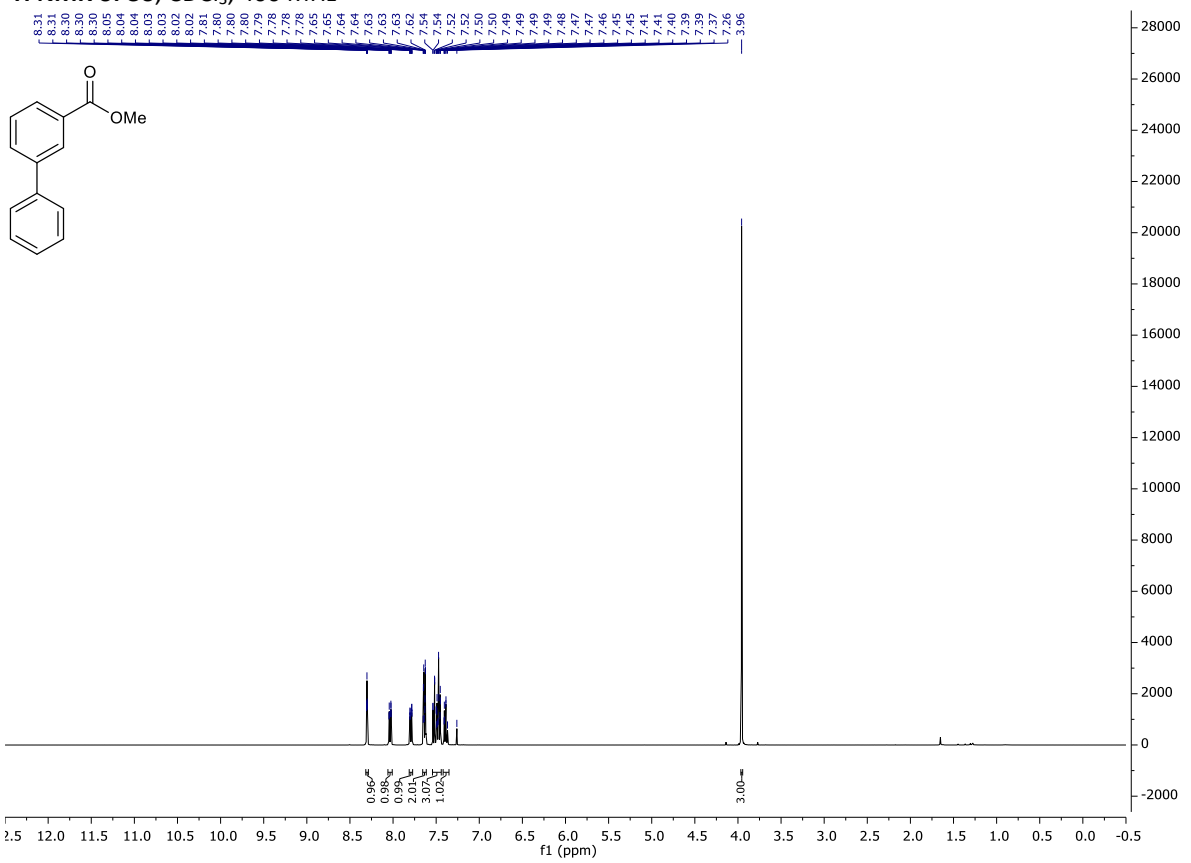


^{13}C NMR of 3n, $CDCl_3$, 101 MHz

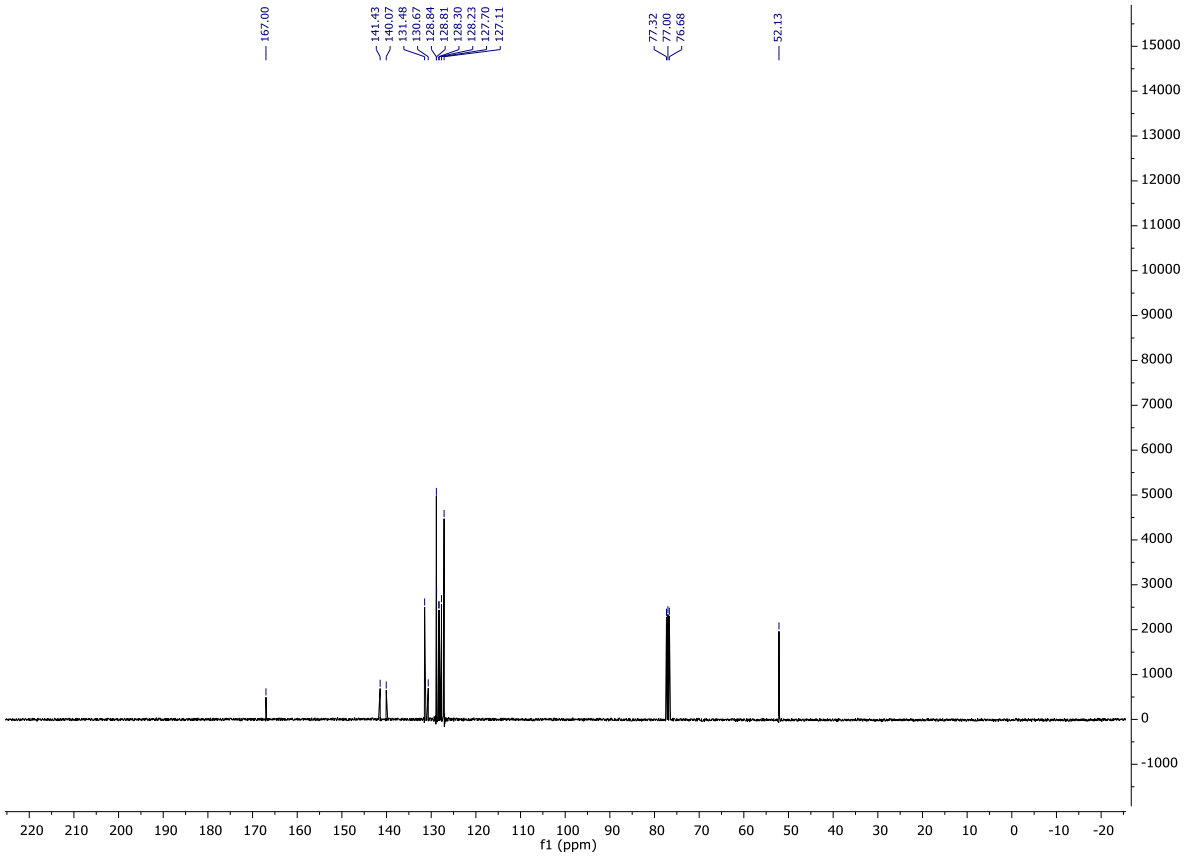


Compound 3o

^{1}H NMR of 3o, $CDCl_3$, 400 MHz

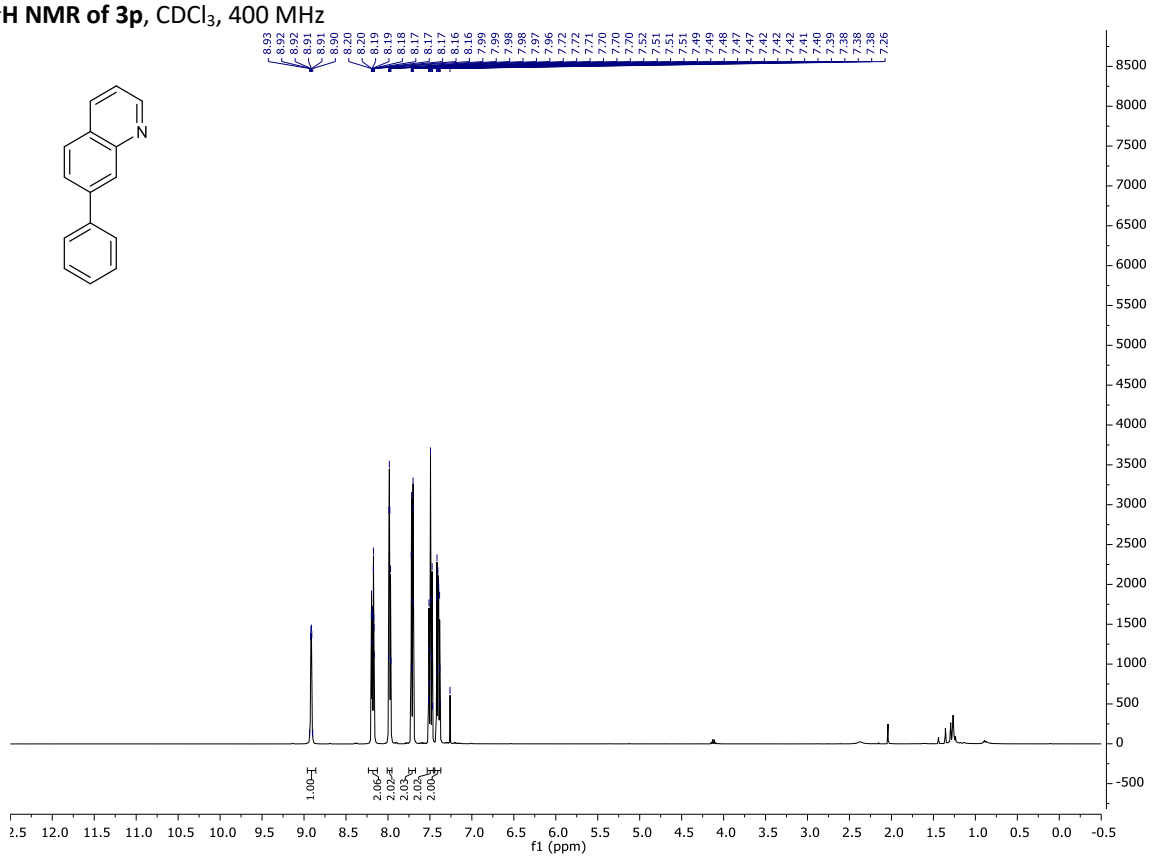


^{13}C NMR of 3o, $CDCl_3$, 101 MHz

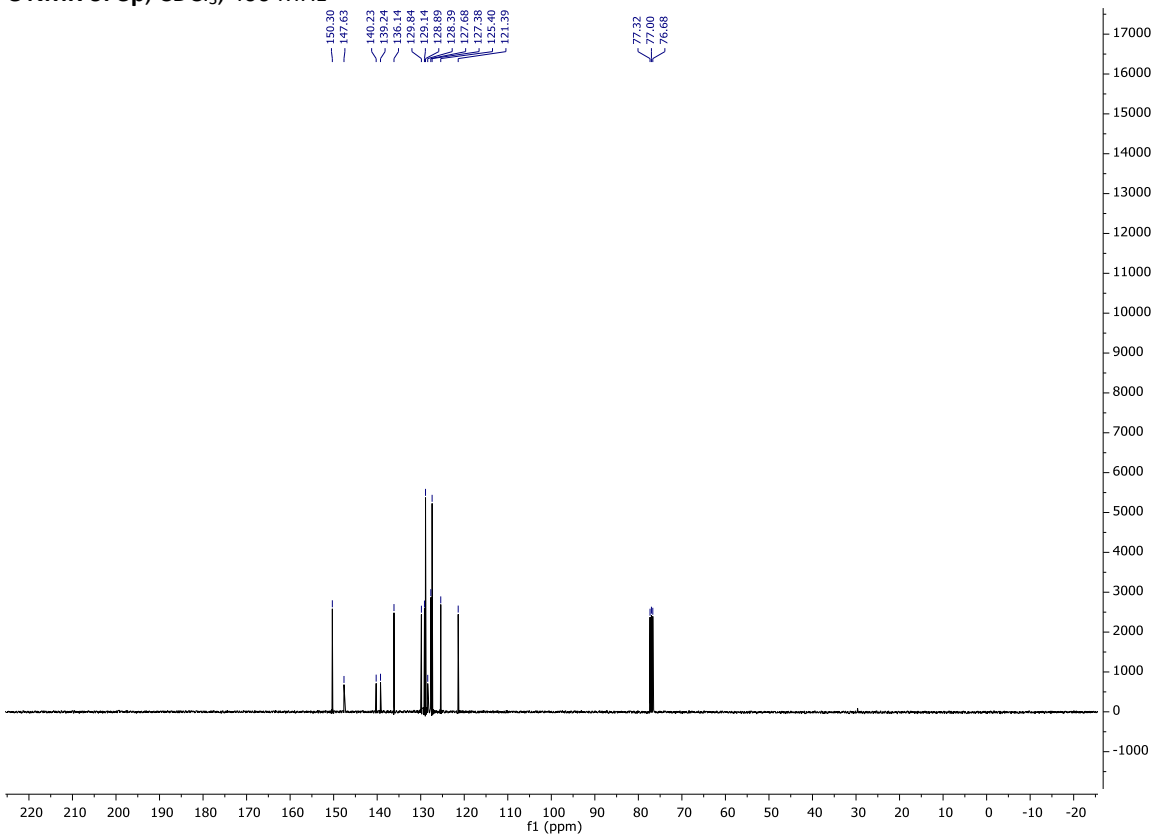


Compound 3p

^{1}H NMR of 3p, $CDCl_3$, 400 MHz

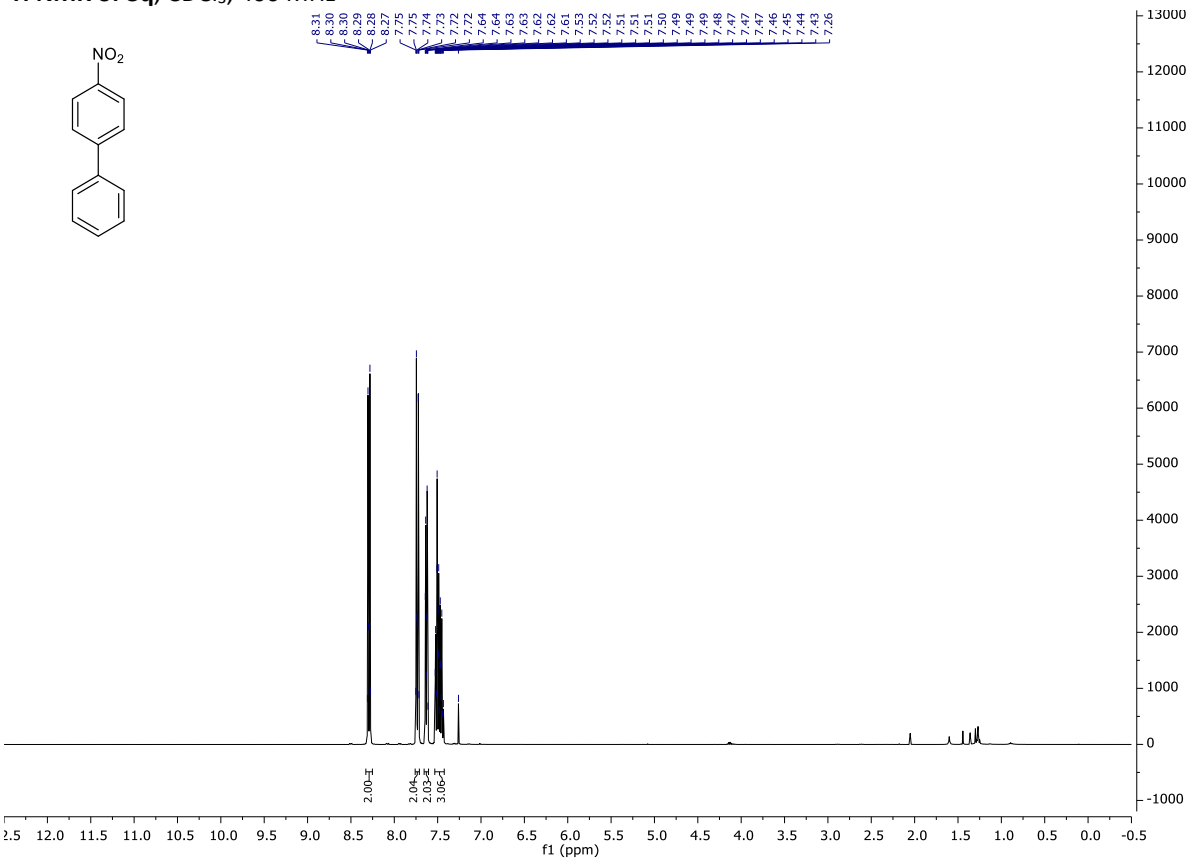


^{13}C NMR of 3p, $CDCl_3$, 400 MHz

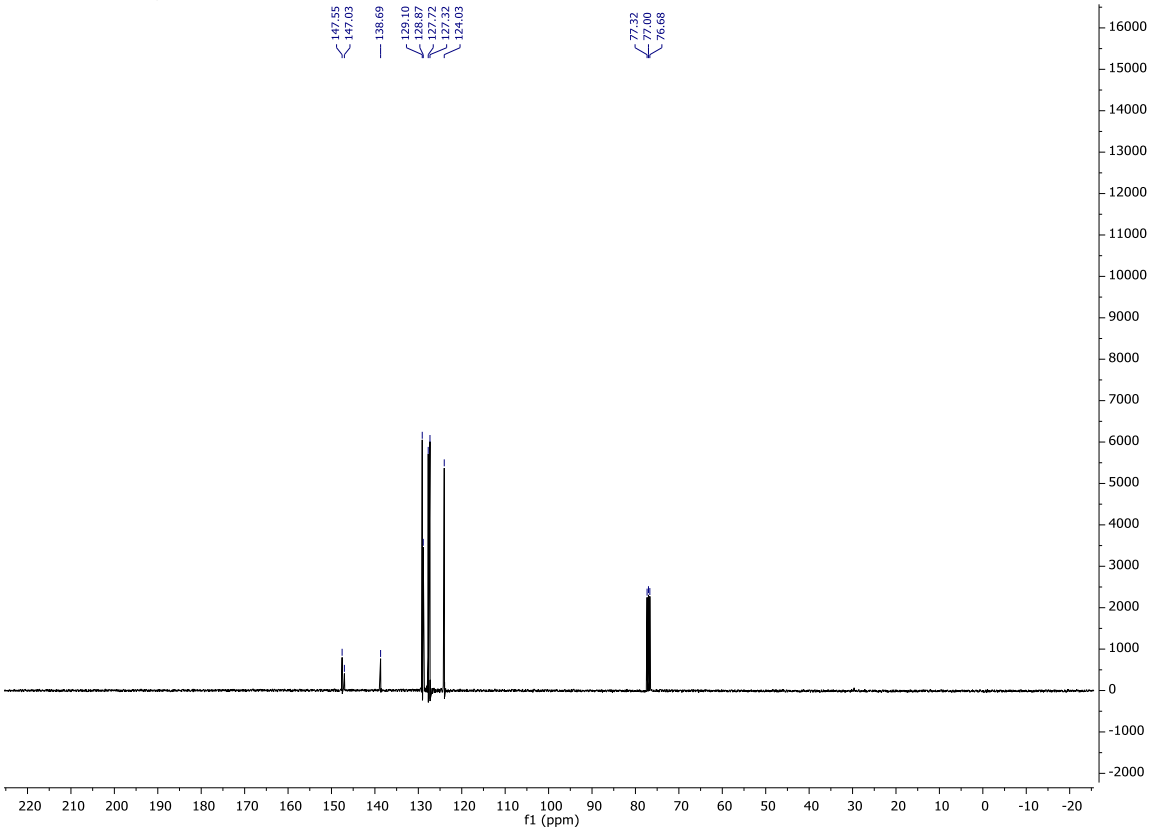


Compound 3q

^{1}H NMR of 3q, $CDCl_3$, 400 MHz

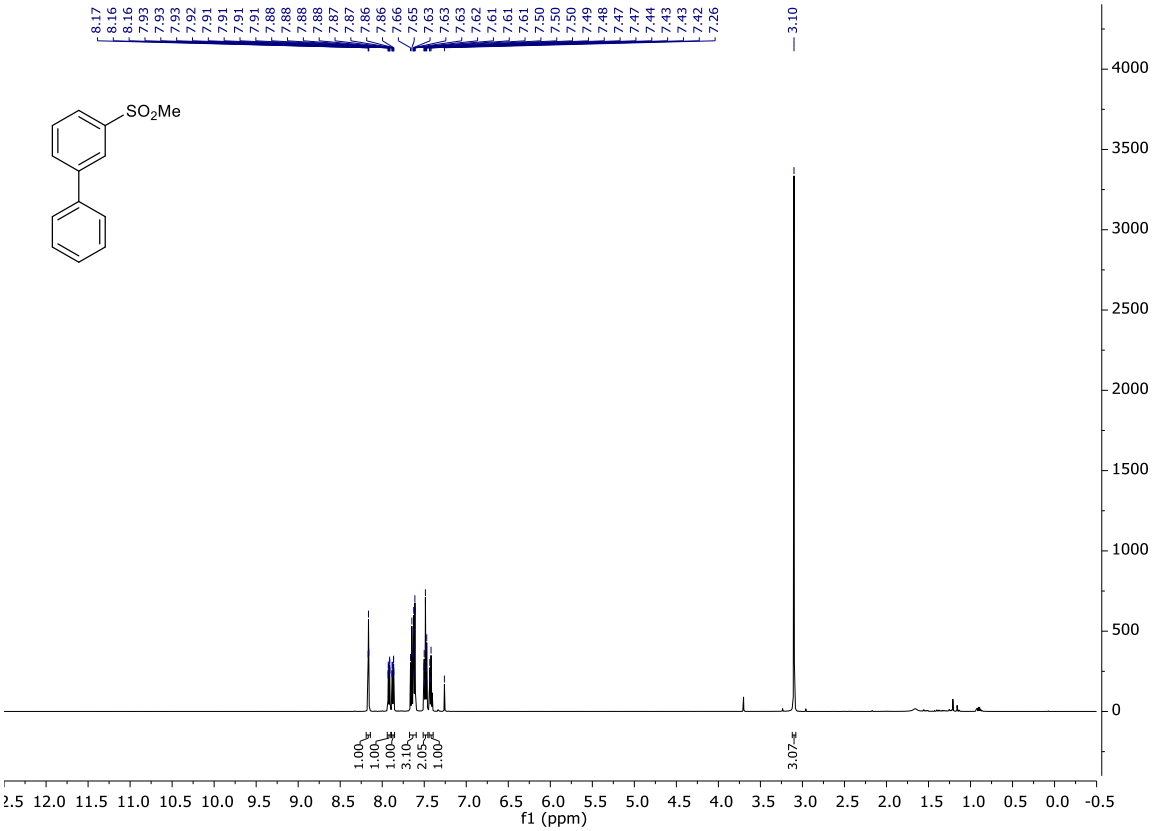


^{13}C NMR of 3q, $CDCl_3$, 101 MHz

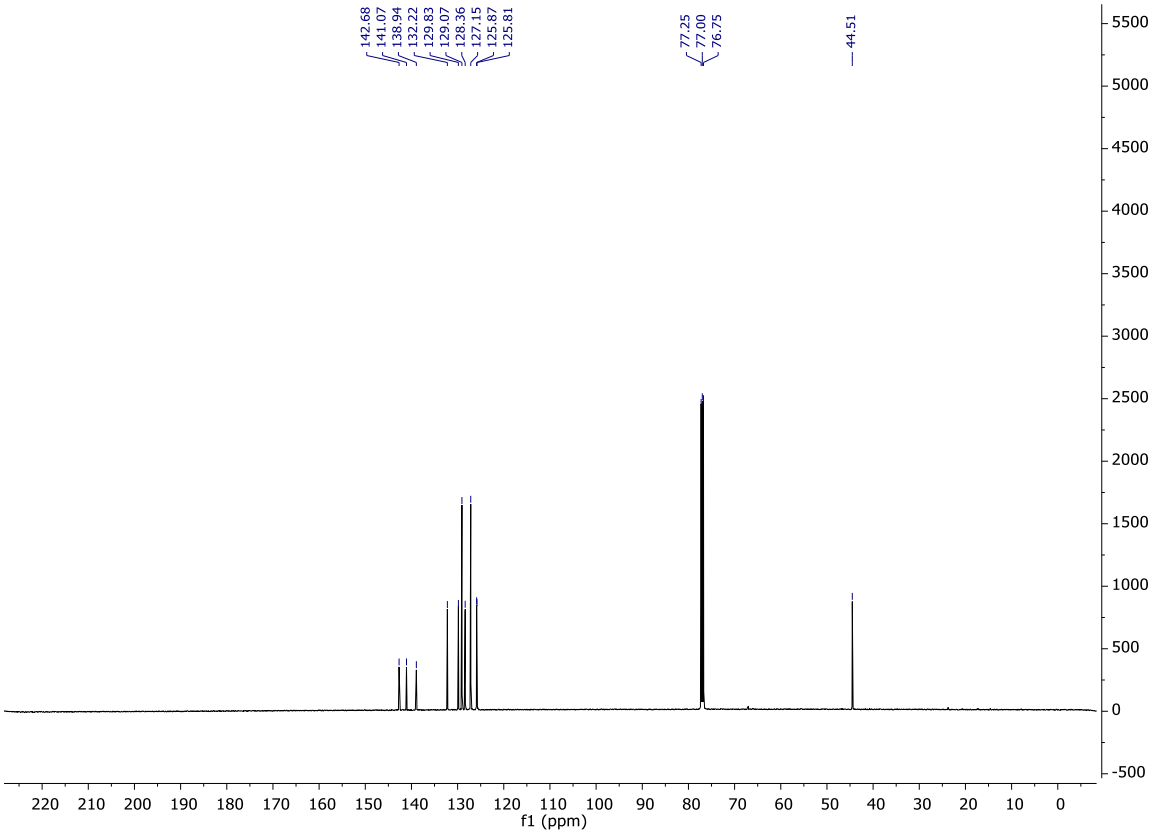


Compound 3r

^{1}H NMR of 3r, $CDCl_3$, 400 MHz

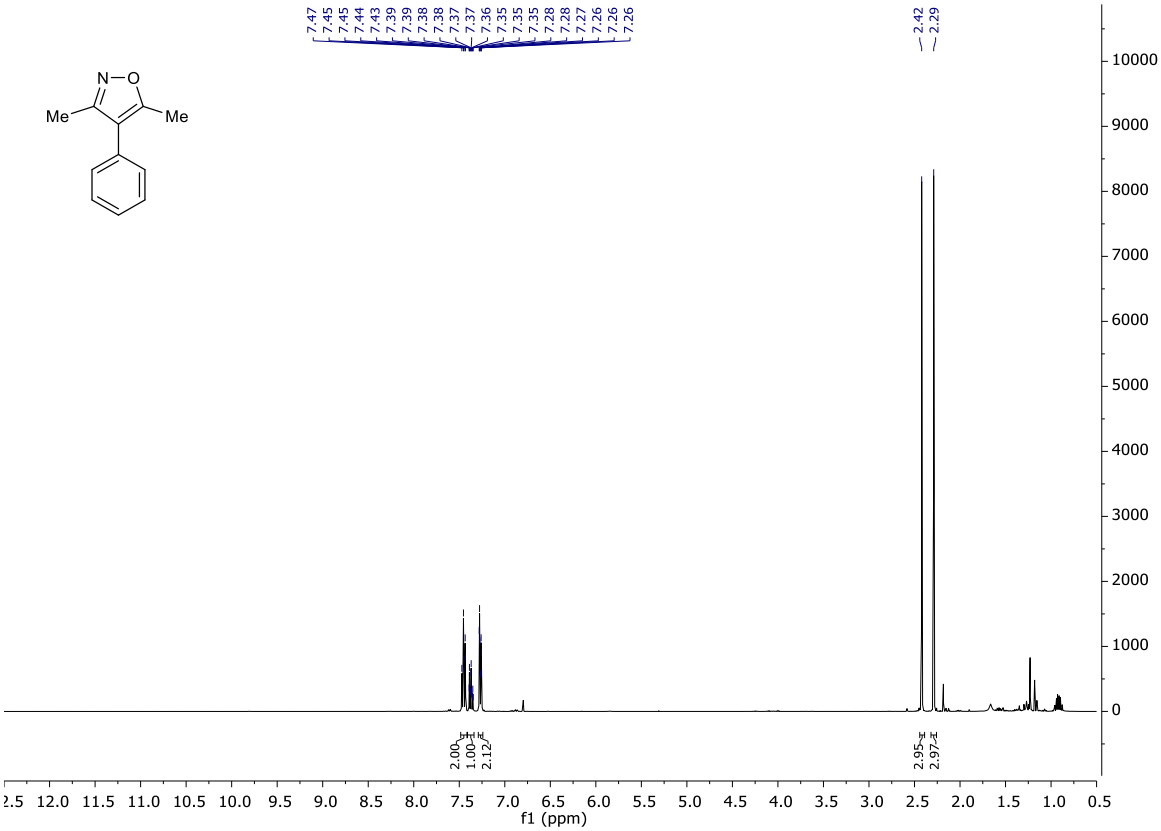


^{13}C NMR of 3r, $CDCl_3$, 101 MHz

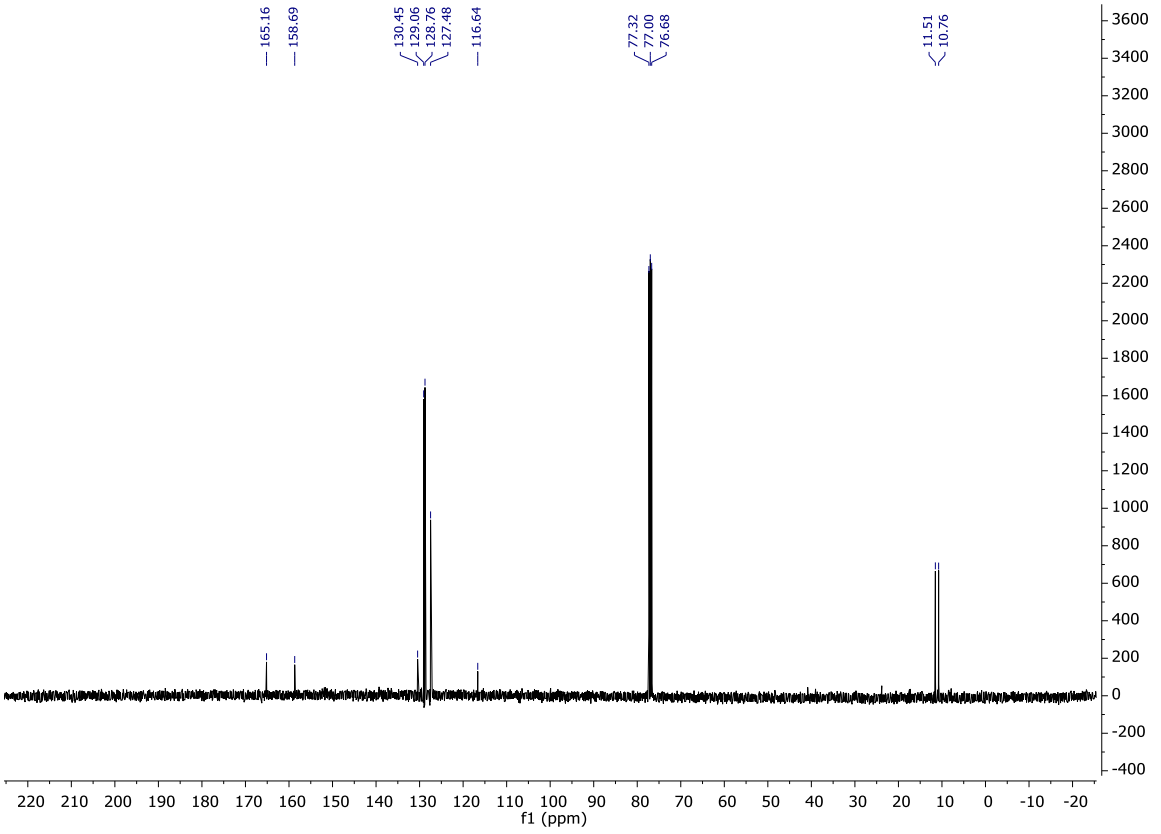


Compound 3s

^{1}H NMR of 3s, $CDCl_3$, 400 MHz

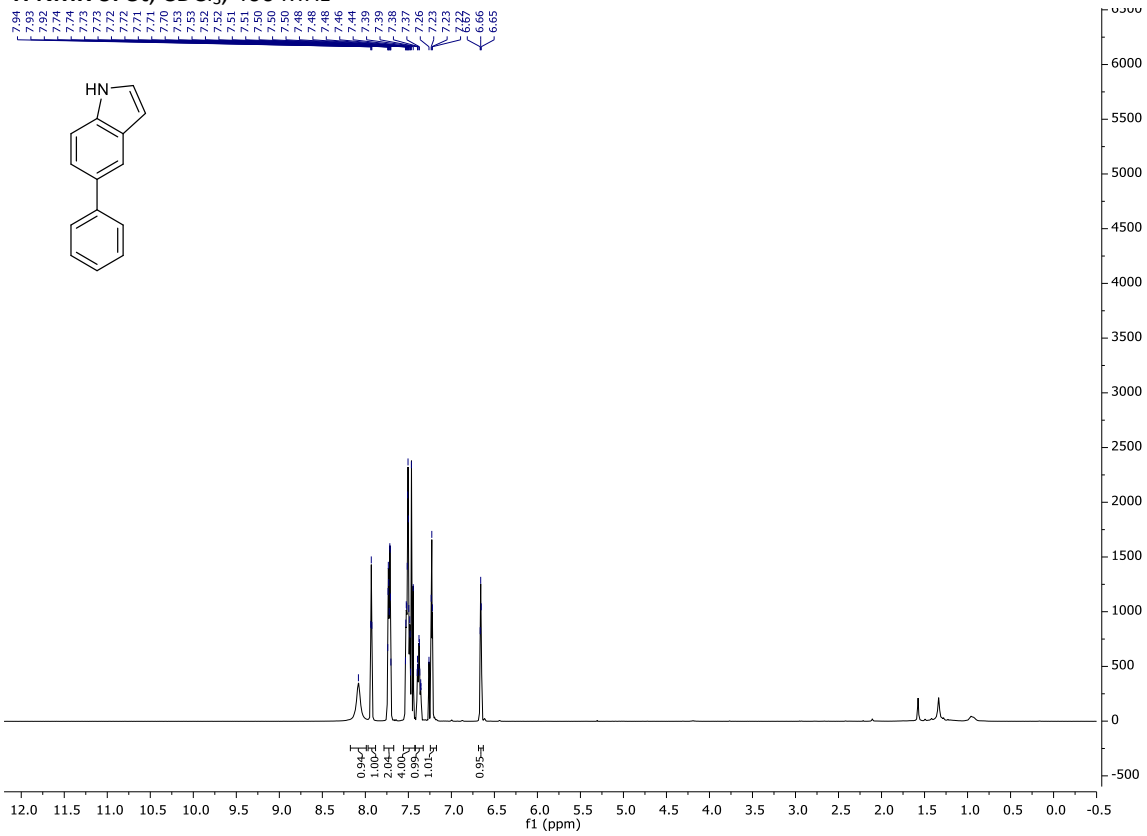


^{13}C NMR of 3s, $CDCl_3$, 101 MHz

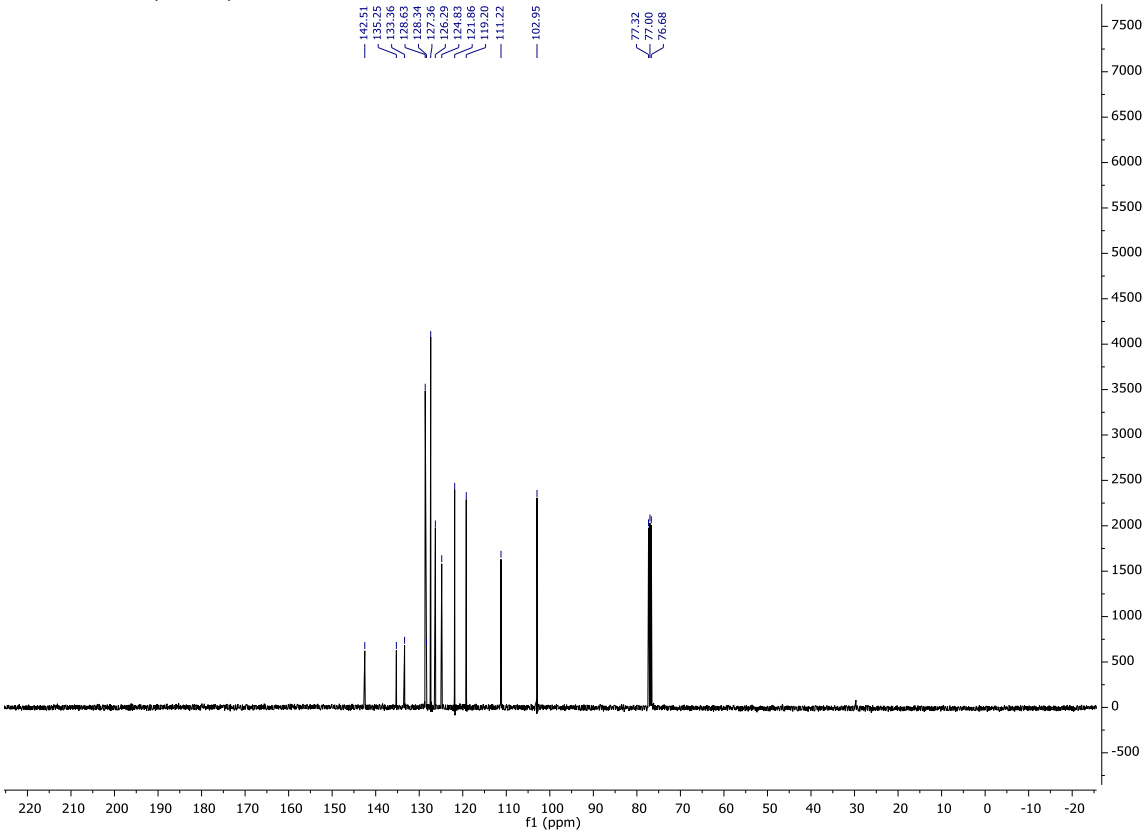


Compound 3t

^{1}H NMR of 3t, $CDCl_3$, 400 MHz

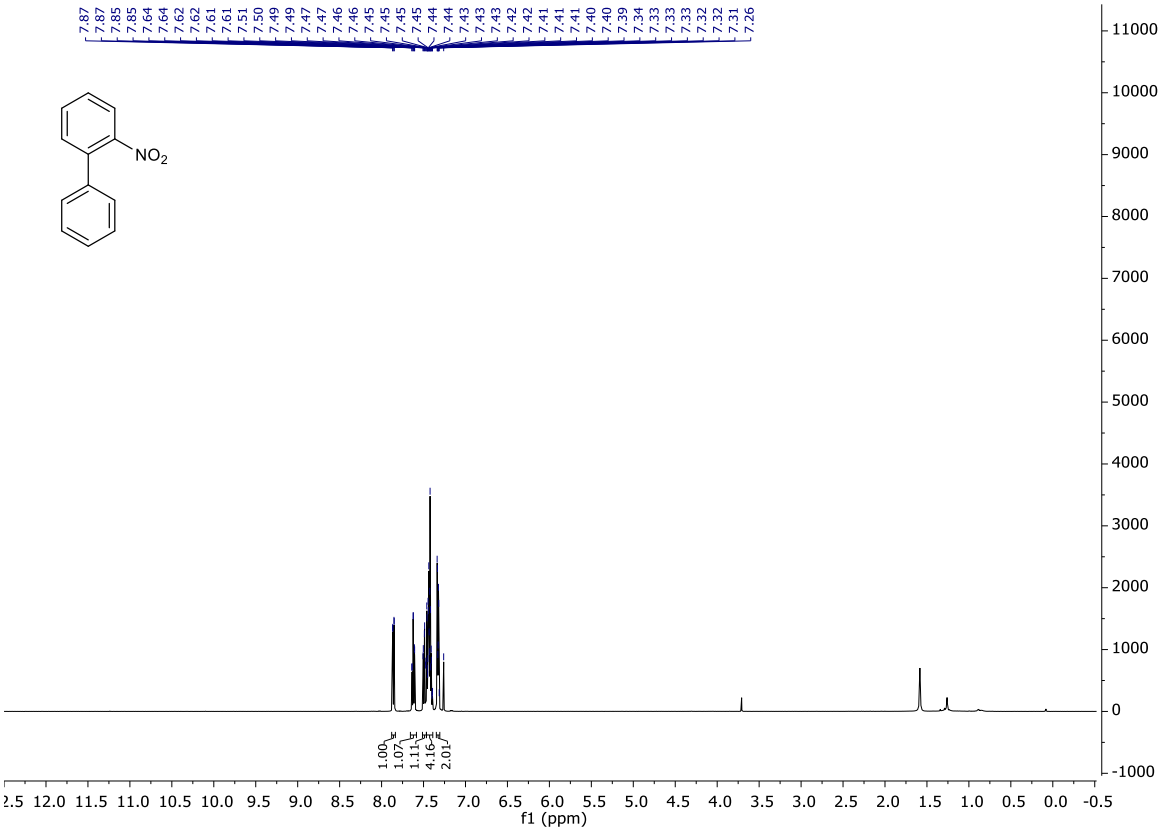


^{13}C NMR of 3t, $CDCl_3$, 101 MHz

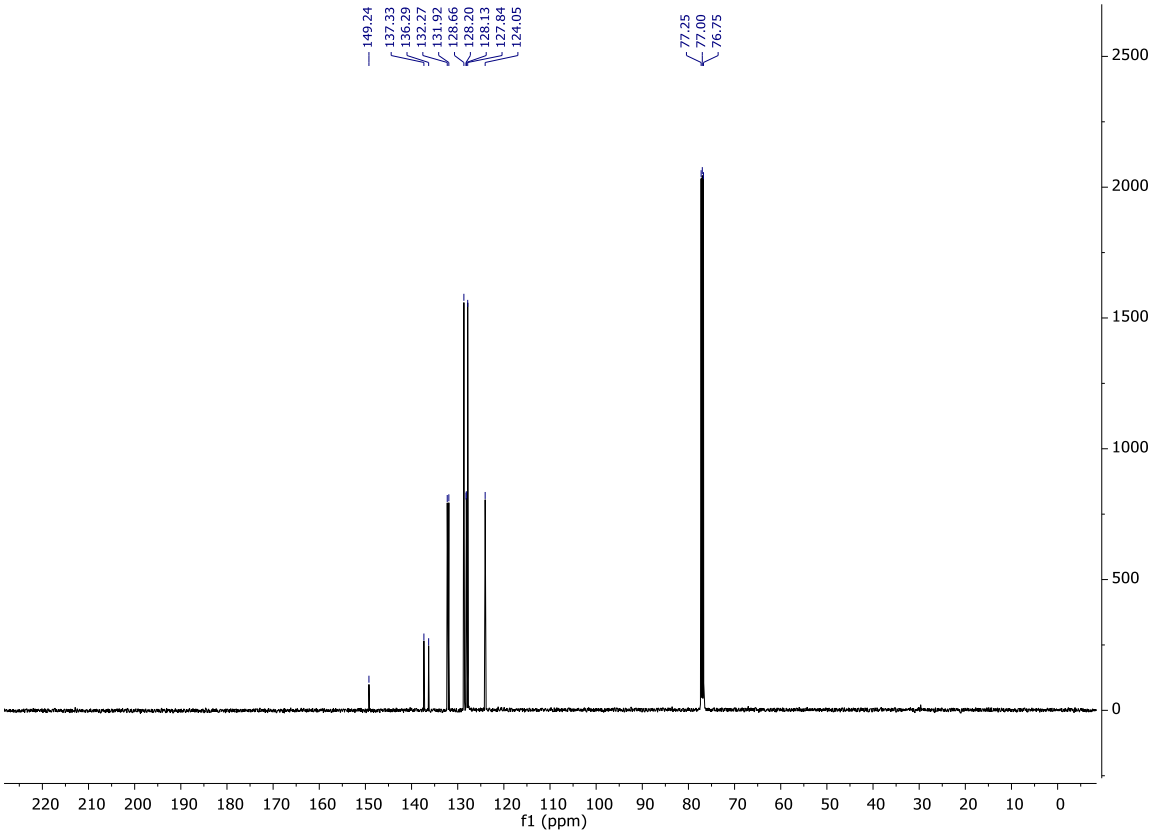


Compound 3u

^{1}H NMR of 3u, $CDCl_3$, 400 MHz

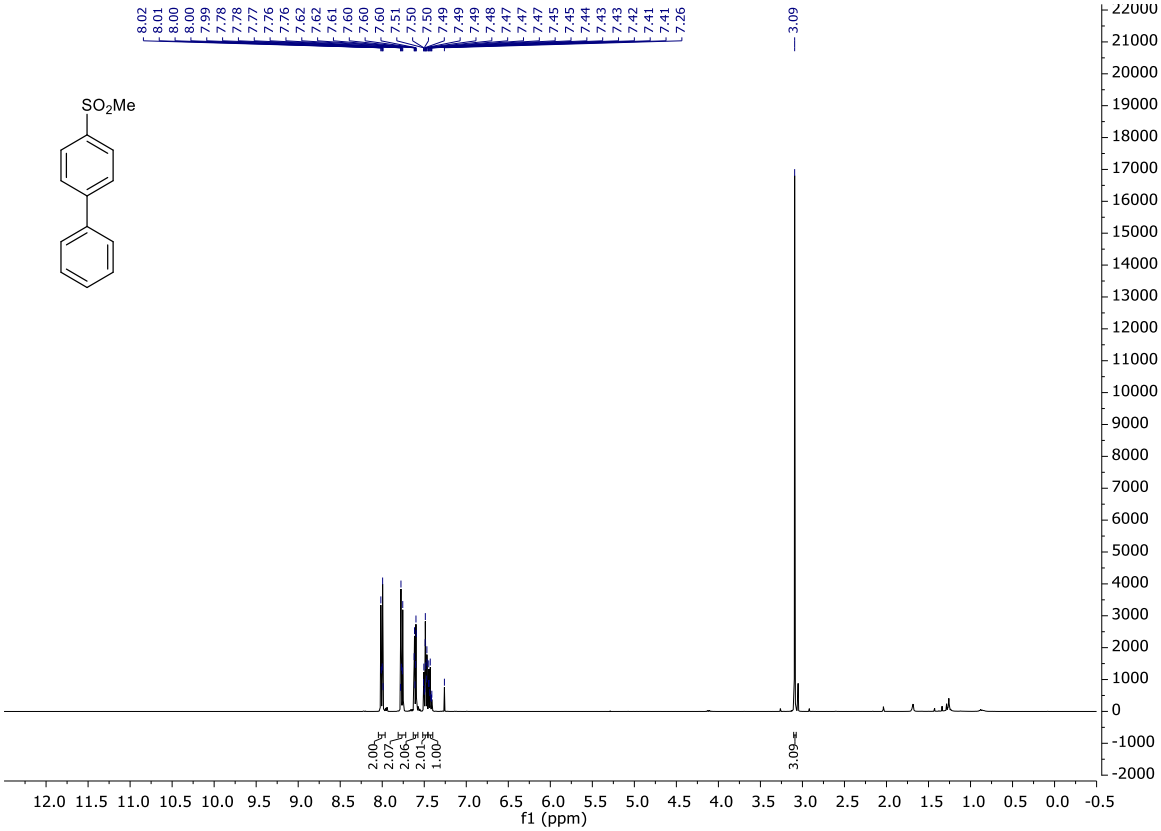


^{13}C NMR of 3u, $CDCl_3$, 101 MHz

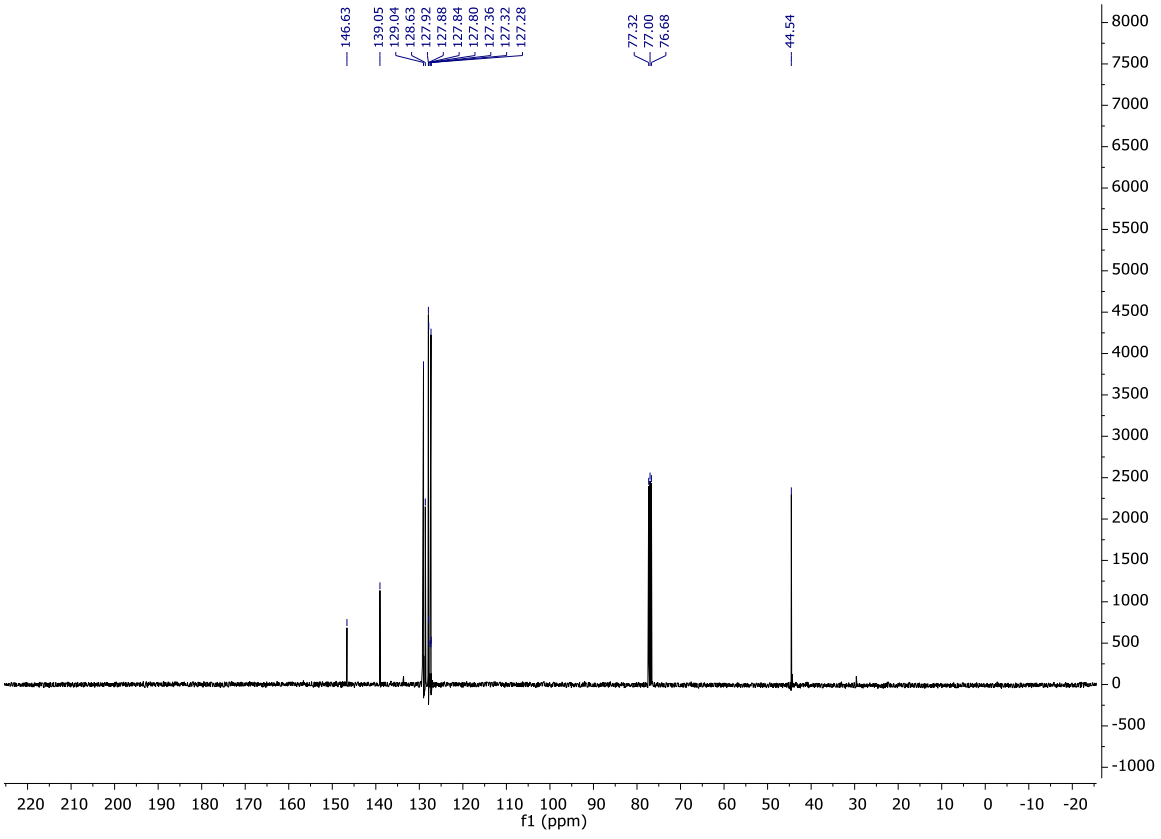


Compound 3v

^{1}H NMR of 3v, $CDCl_3$, 400 MHz

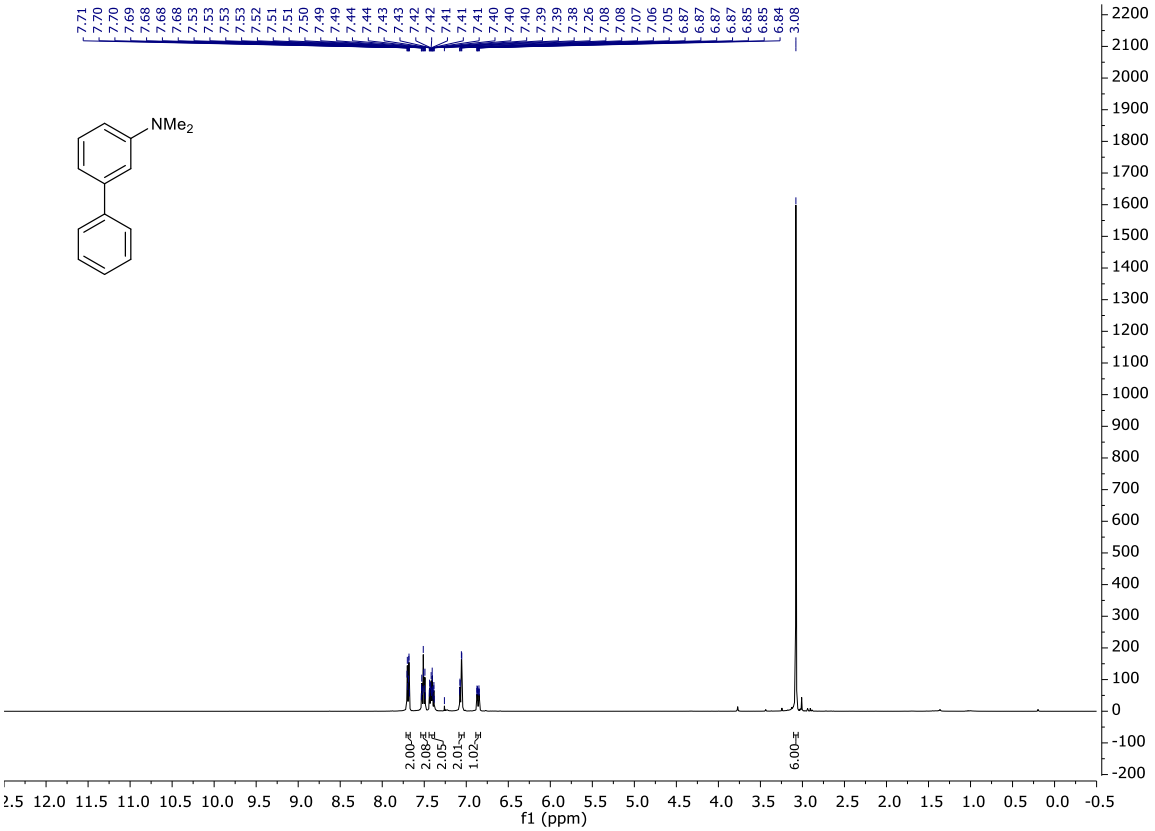


^{13}C NMR of 3v, $CDCl_3$, 101 MHz

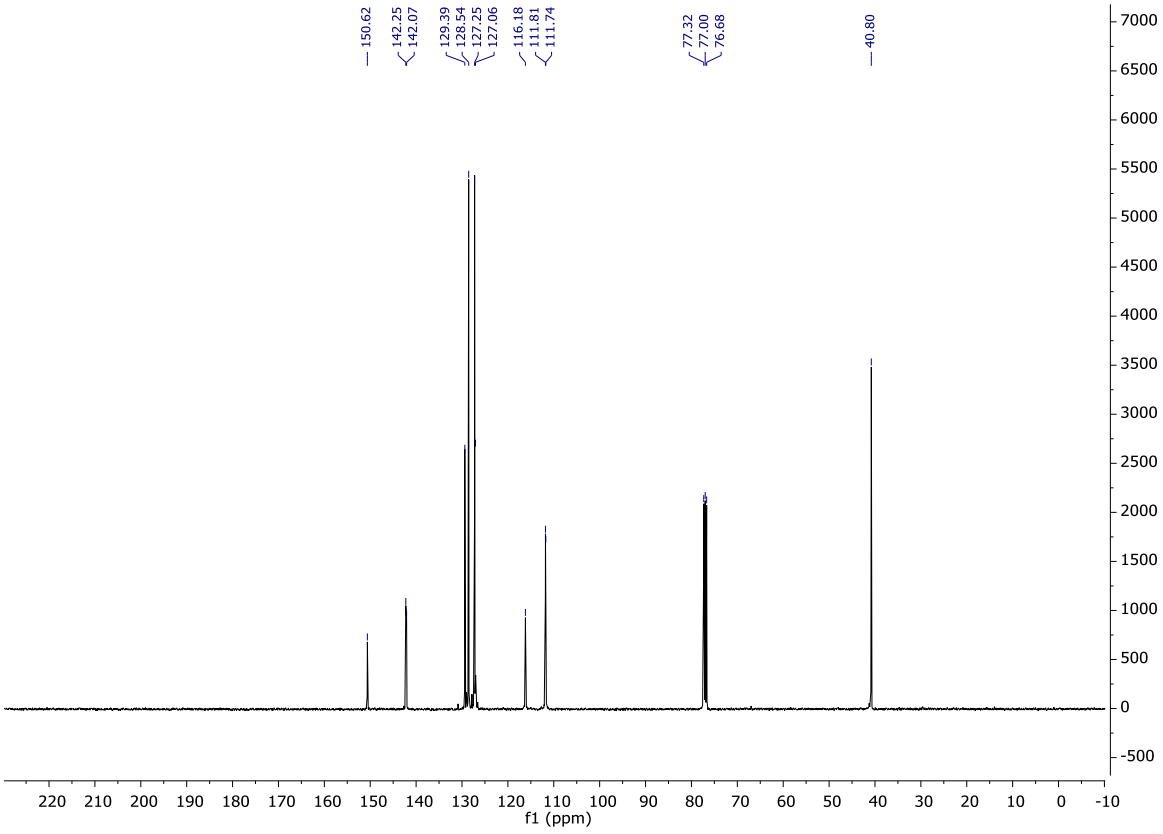


Compound 3w

^{1}H NMR of 3w, $CDCl_3$, 400 MHz

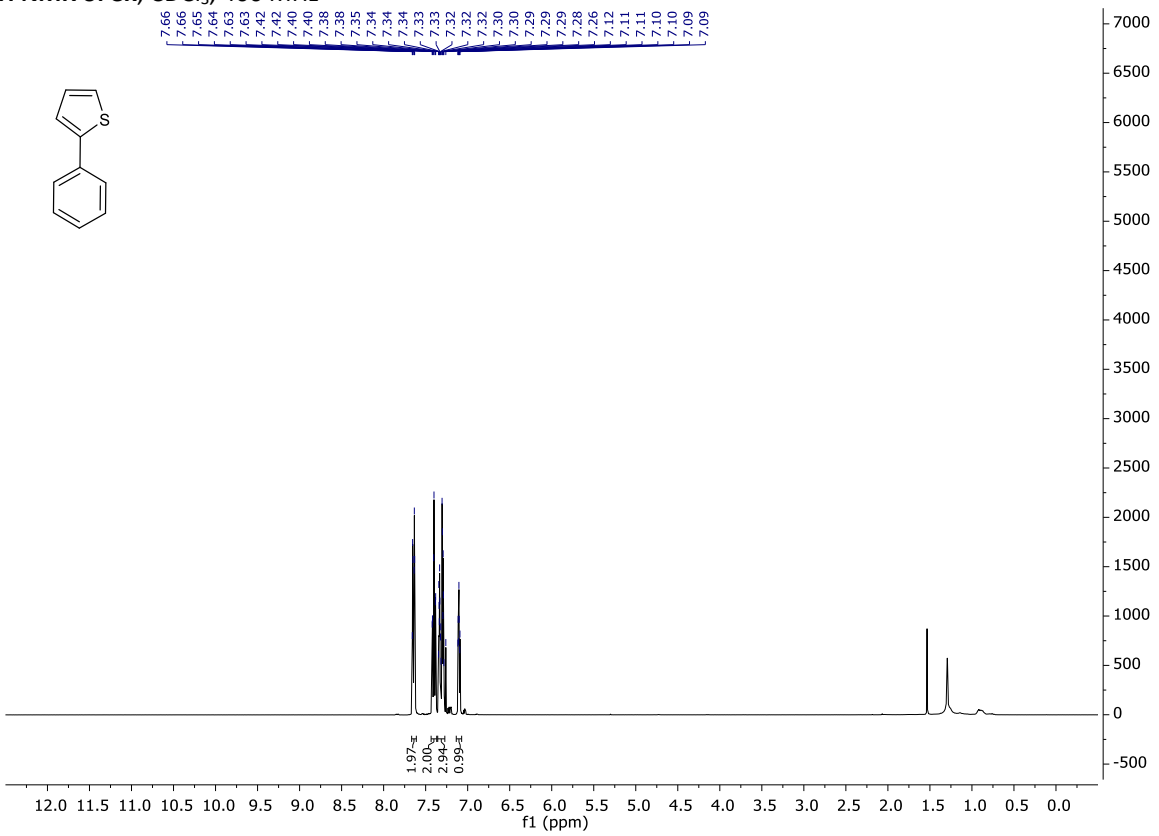


^{13}C NMR of 3w, $CDCl_3$, 101 MHz

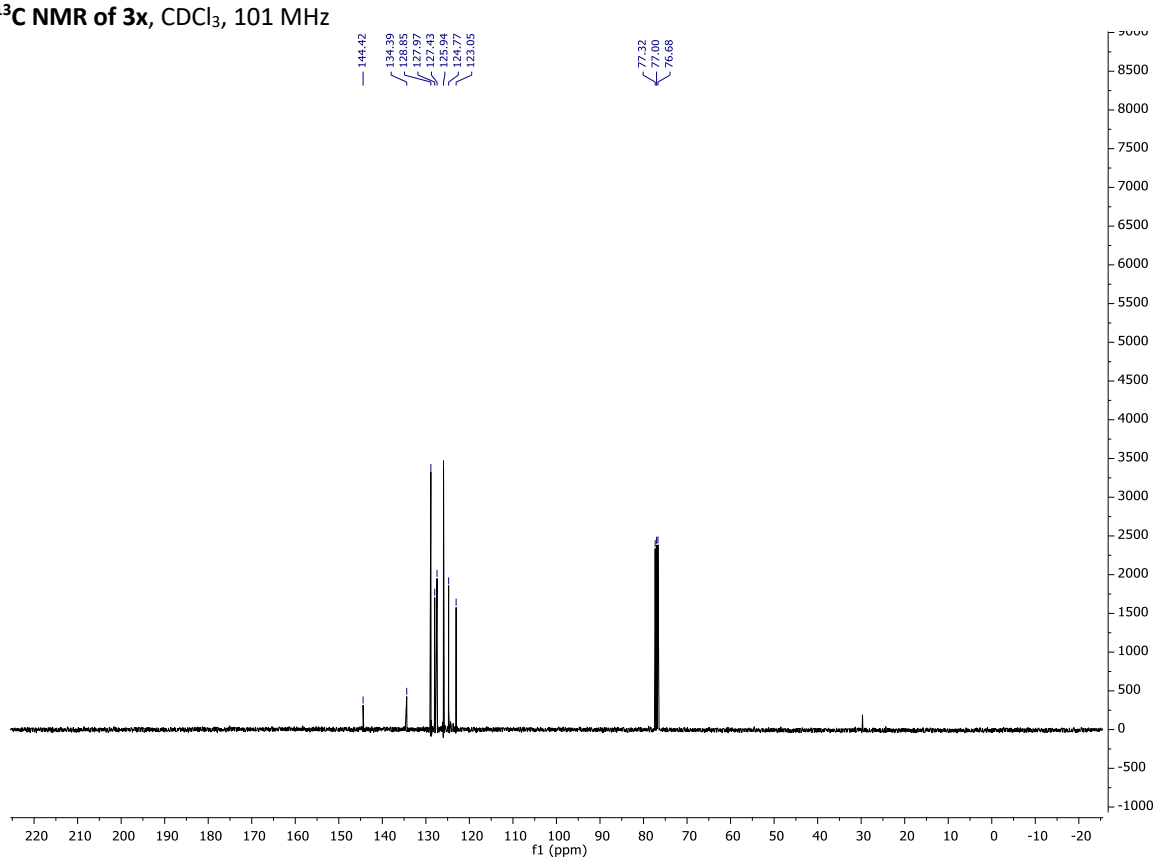


Compound 3x

^{1}H NMR of 3x, $CDCl_3$, 400 MHz

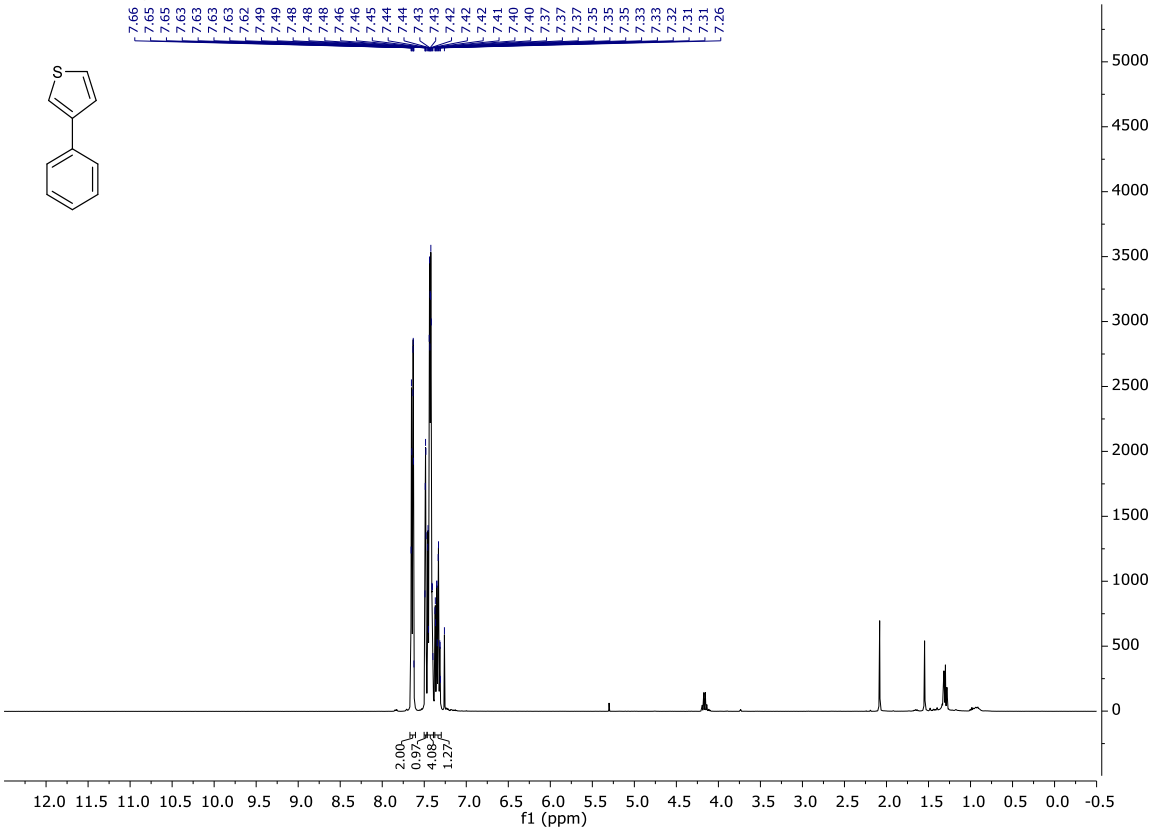


^{13}C NMR of 3x, $CDCl_3$, 101 MHz

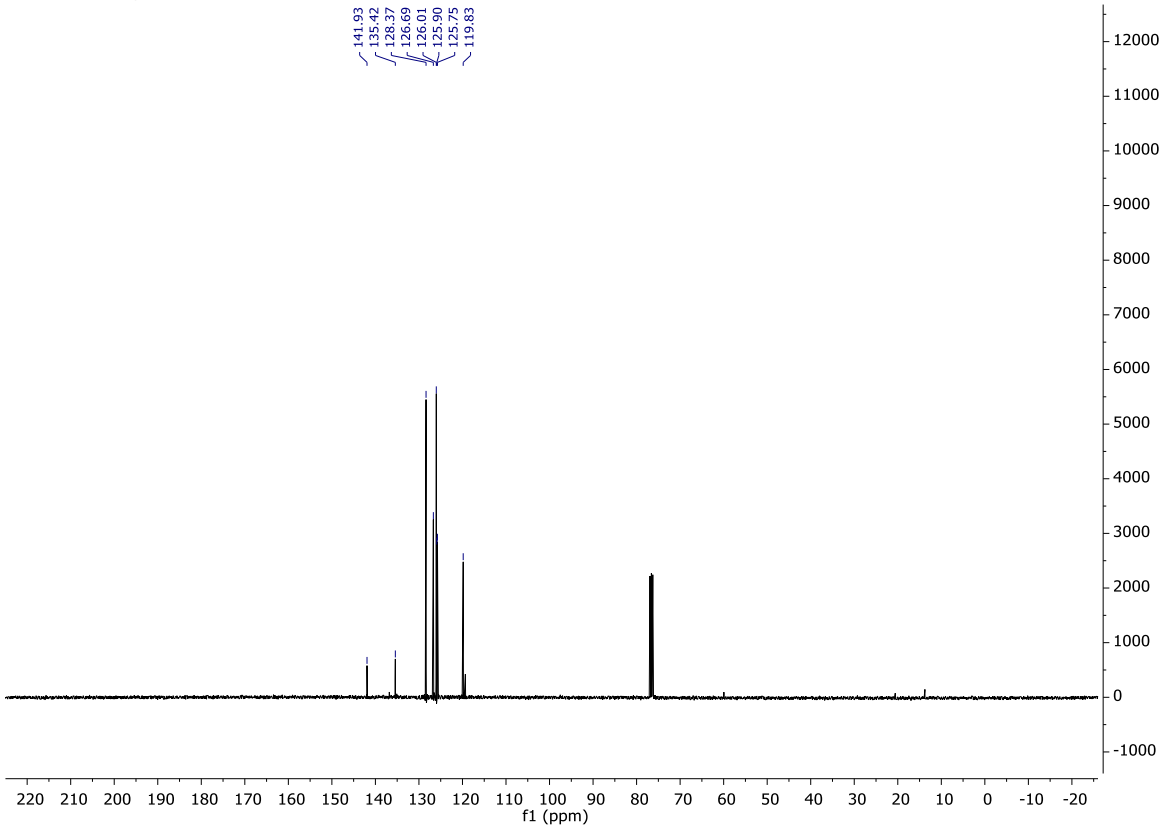


Compound 3y

^{1}H NMR of 3y, $CDCl_3$, 400 MHz

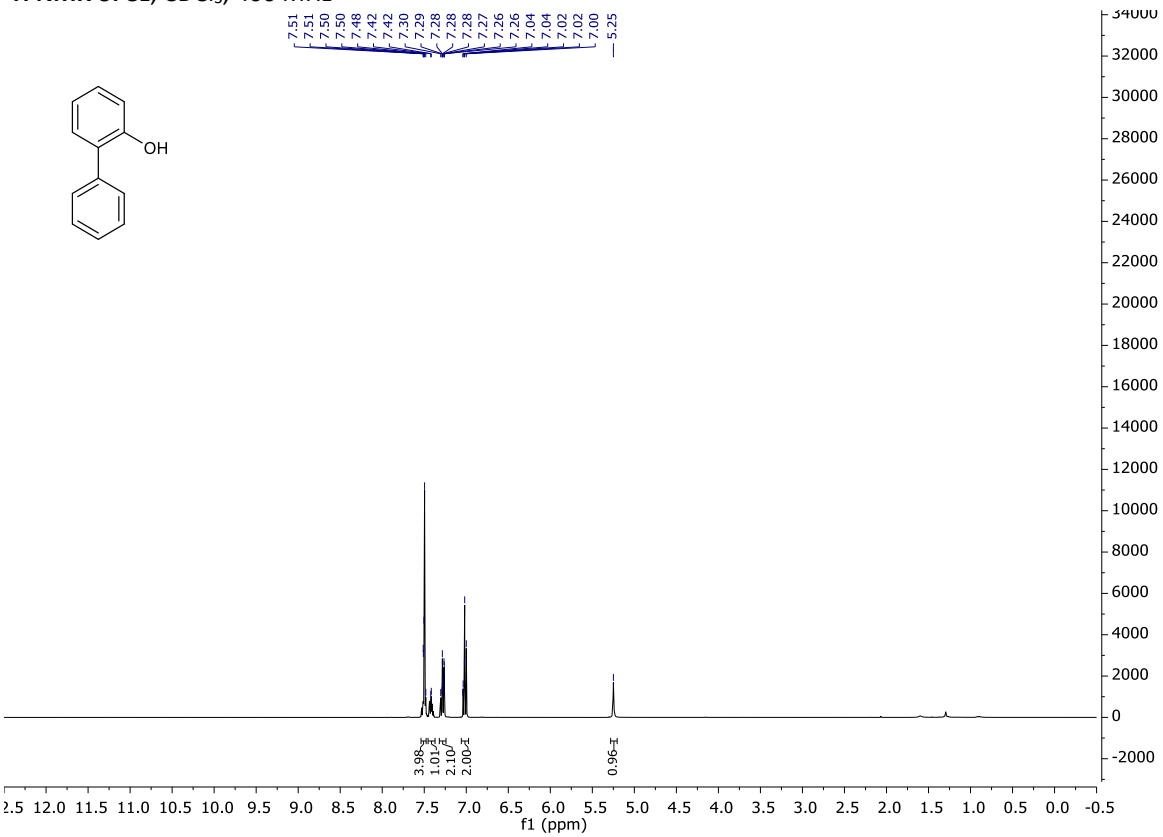


^{13}C NMR of 3y, $CDCl_3$, 101 MHz

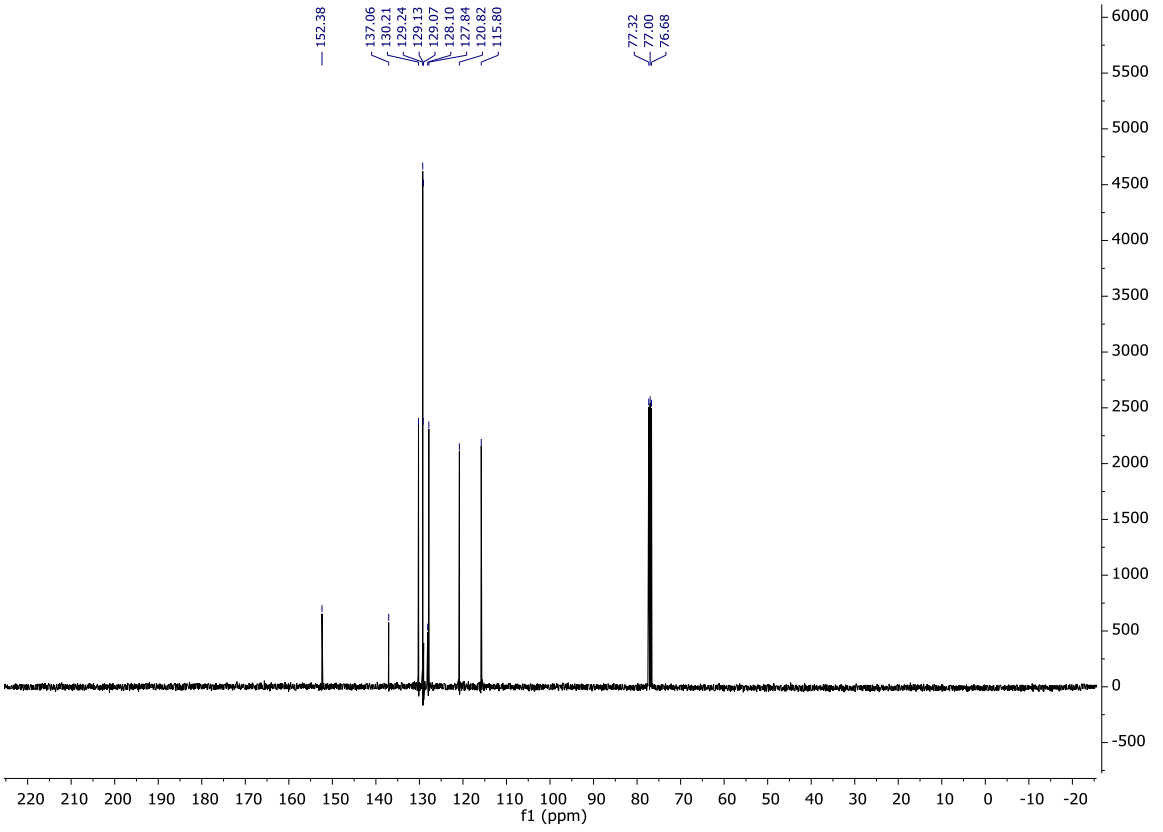


Compound 3z

^{1}H NMR of 3z, $CDCl_3$, 400 MHz

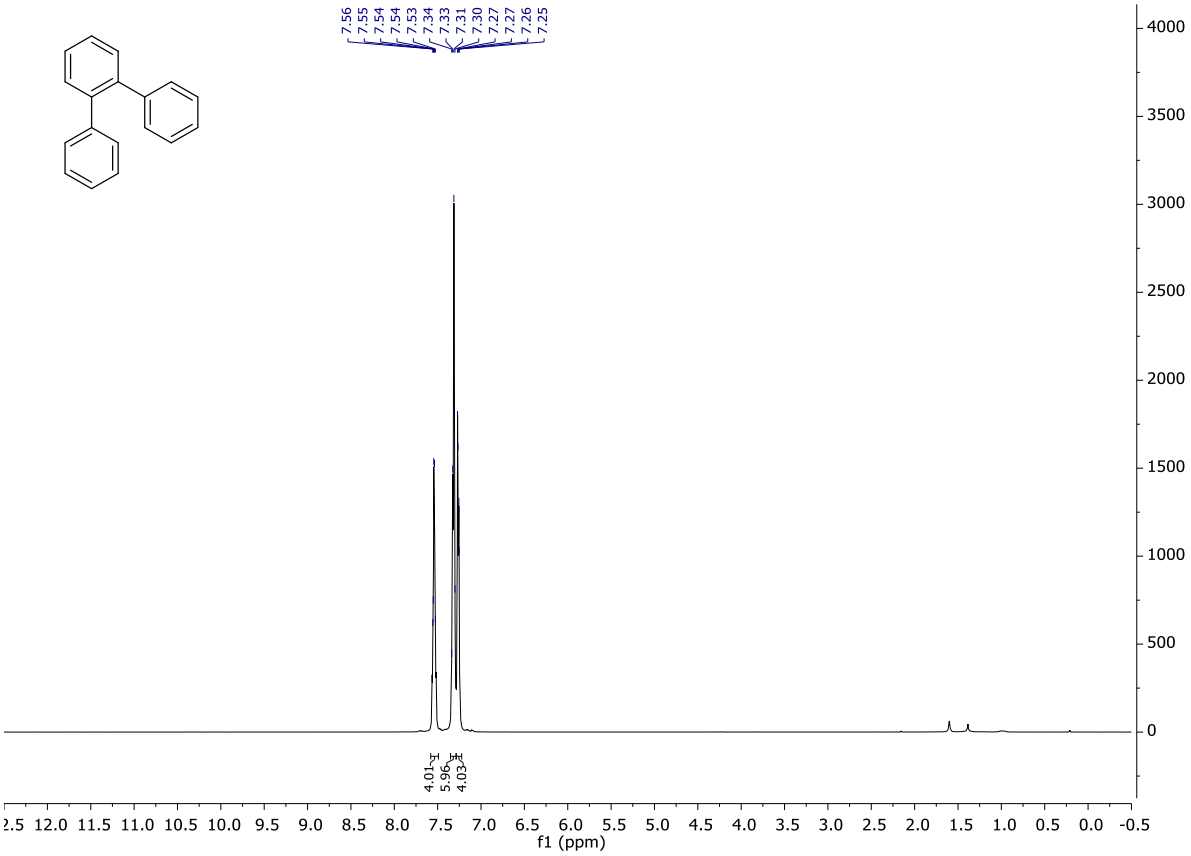


^{13}C NMR of 3z, $CDCl_3$, 101 MHz

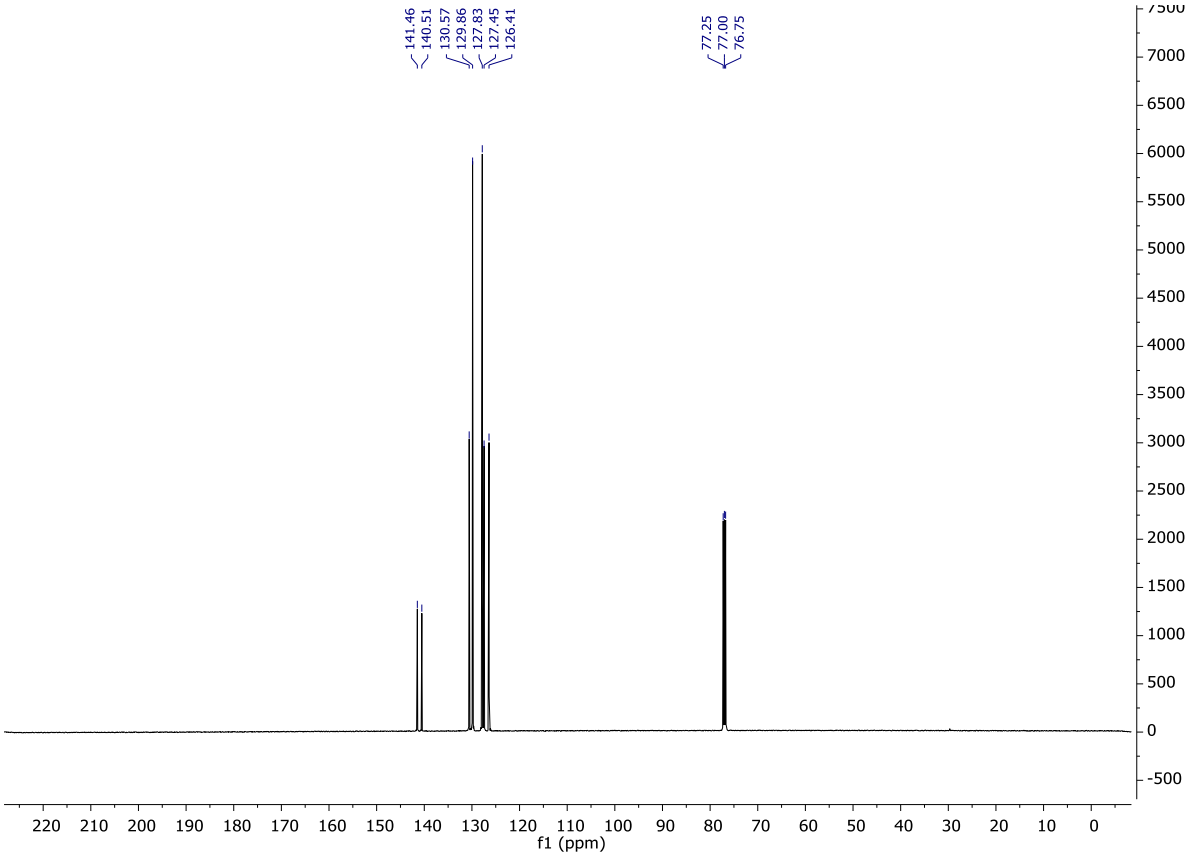


Compound 3aa

^{1}H NMR of 3aa, $CDCl_3$, 400 MHz

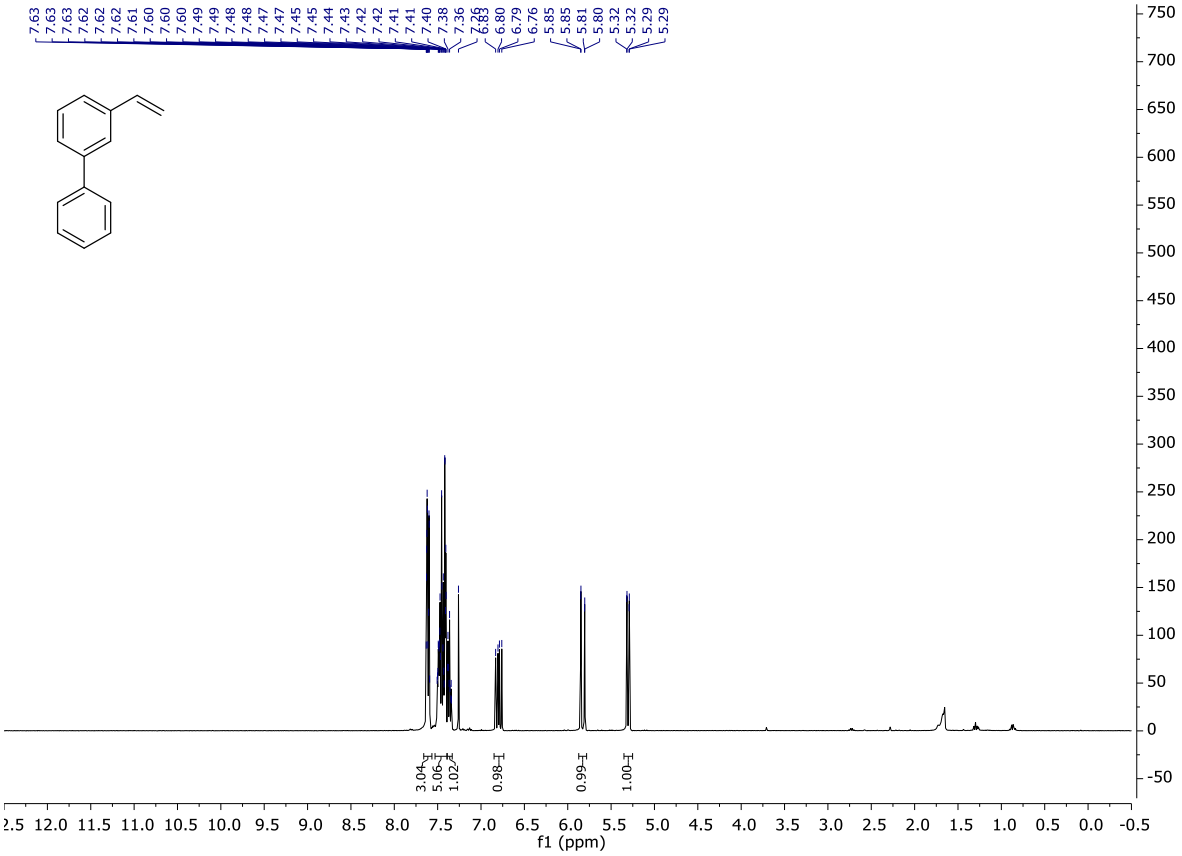


^{13}C NMR of 3aa, $CDCl_3$, 101 MHz

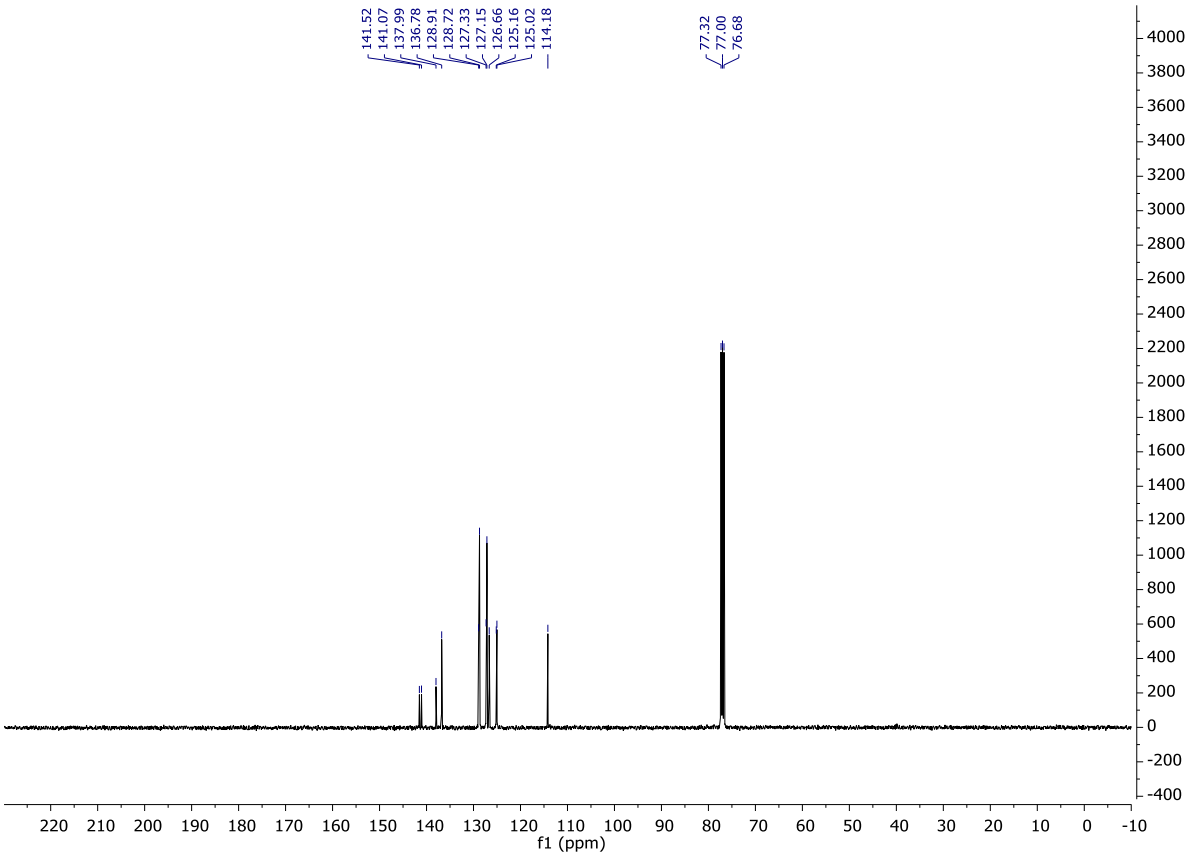


Compound 3ab

^{1}H NMR of 3ab, $CDCl_3$, 400 MHz

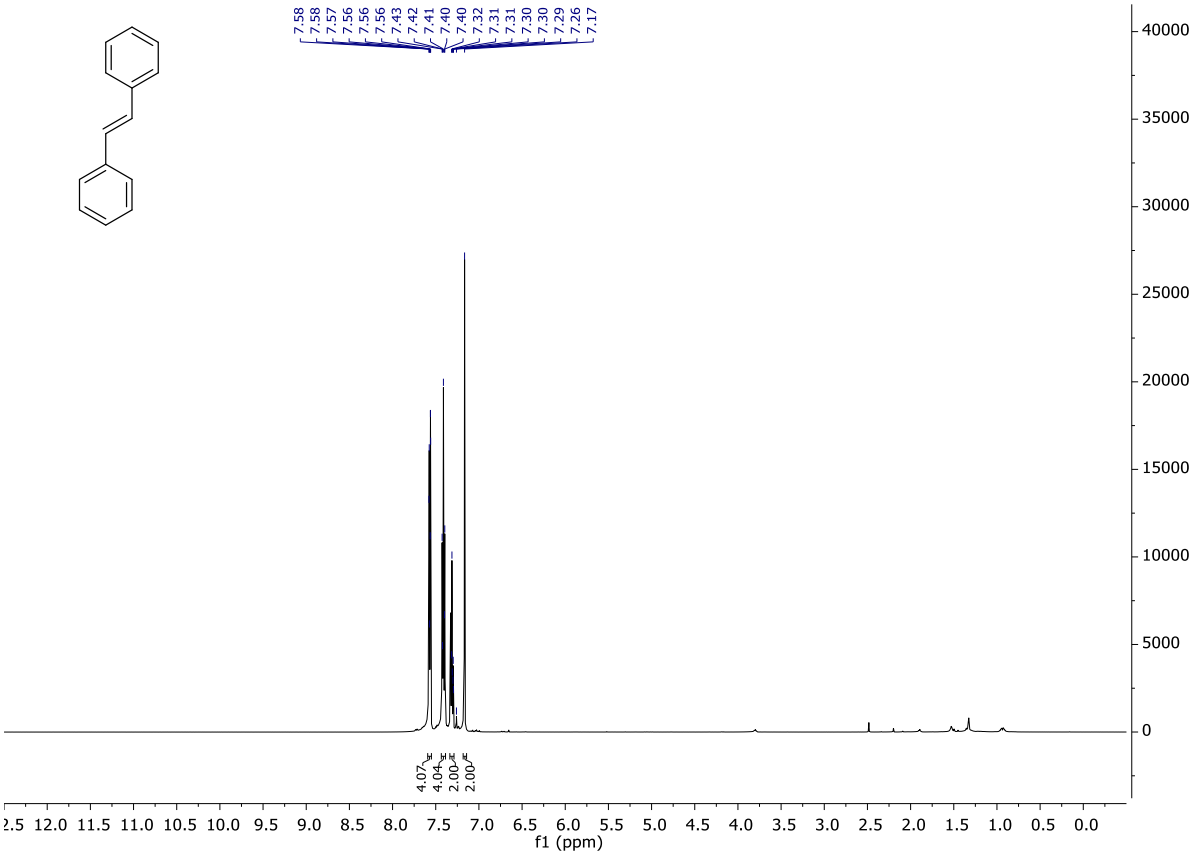


^{13}C NMR of 3ab, $CDCl_3$, 101 MHz

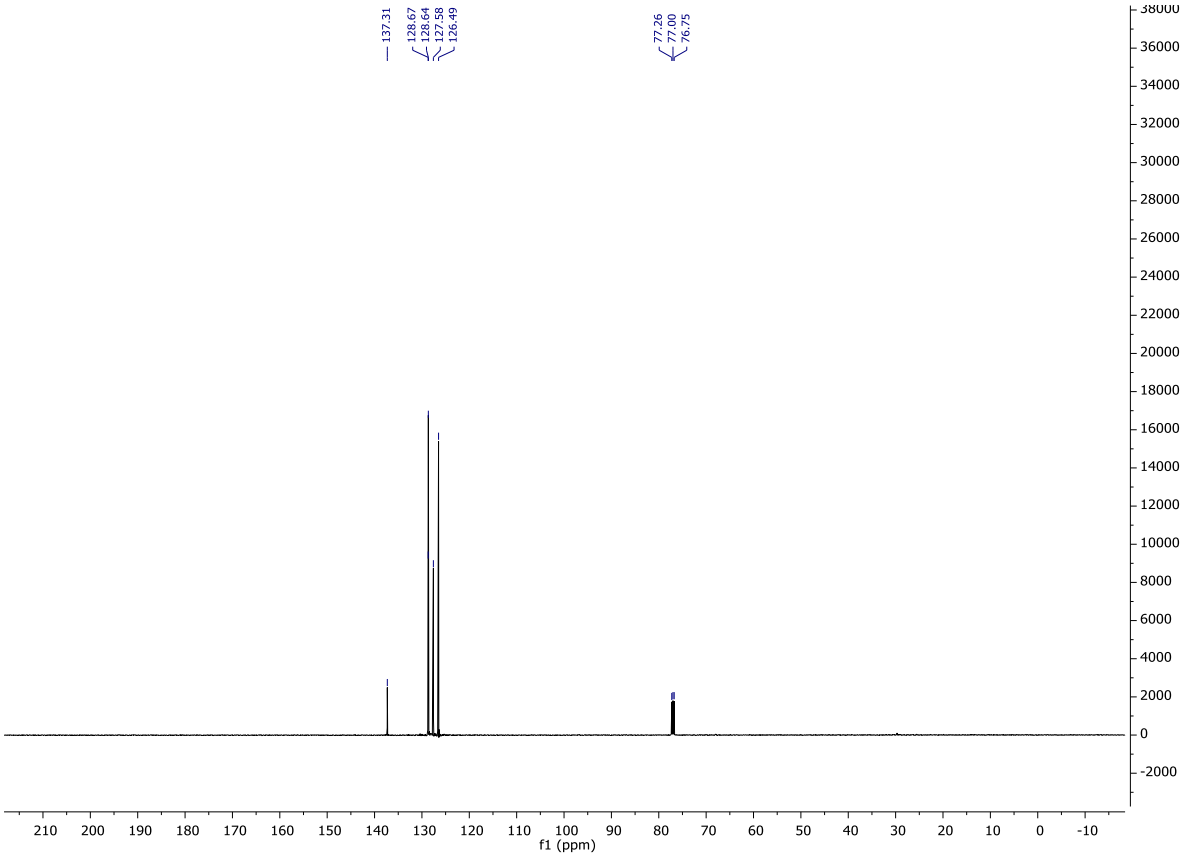


Compound 3ac

^{1}H NMR of 3ac, $CDCl_3$, 400 MHz

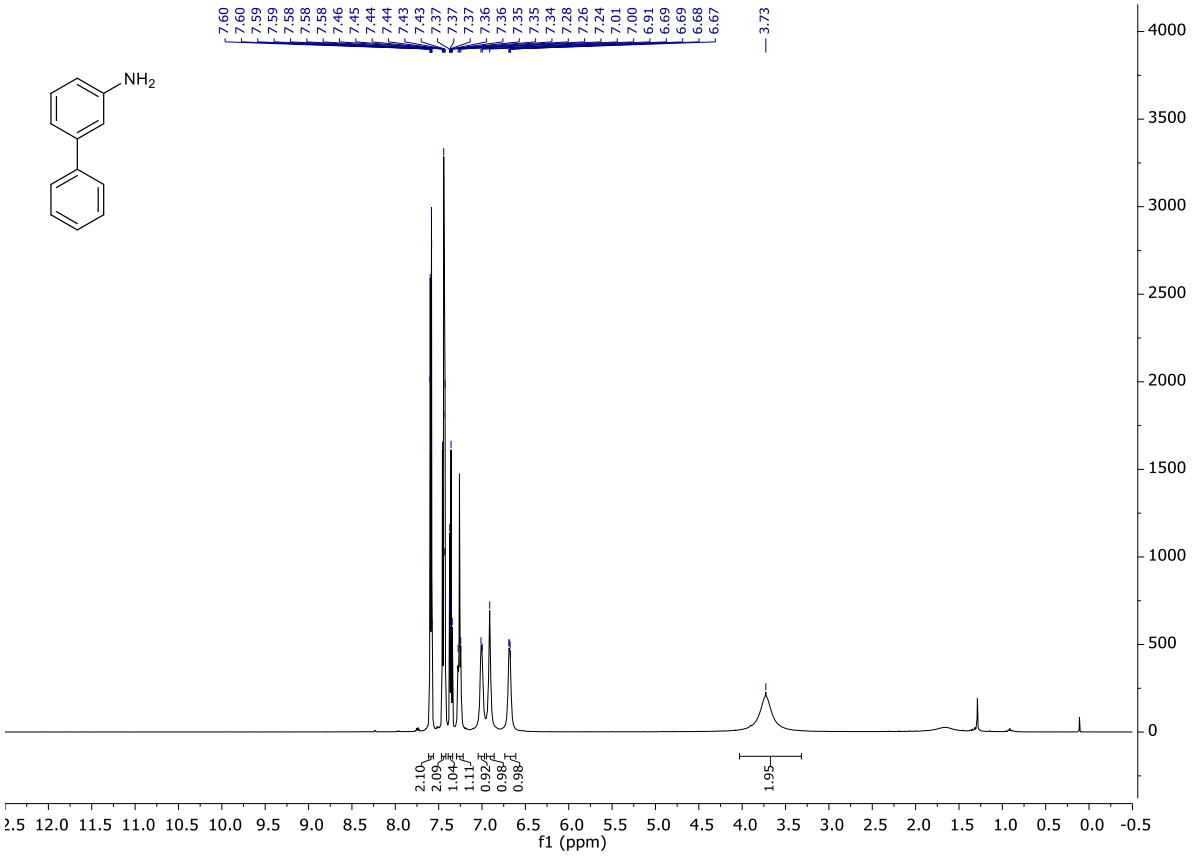


^{13}C NMR of 3ac, $CDCl_3$, 101 MHz

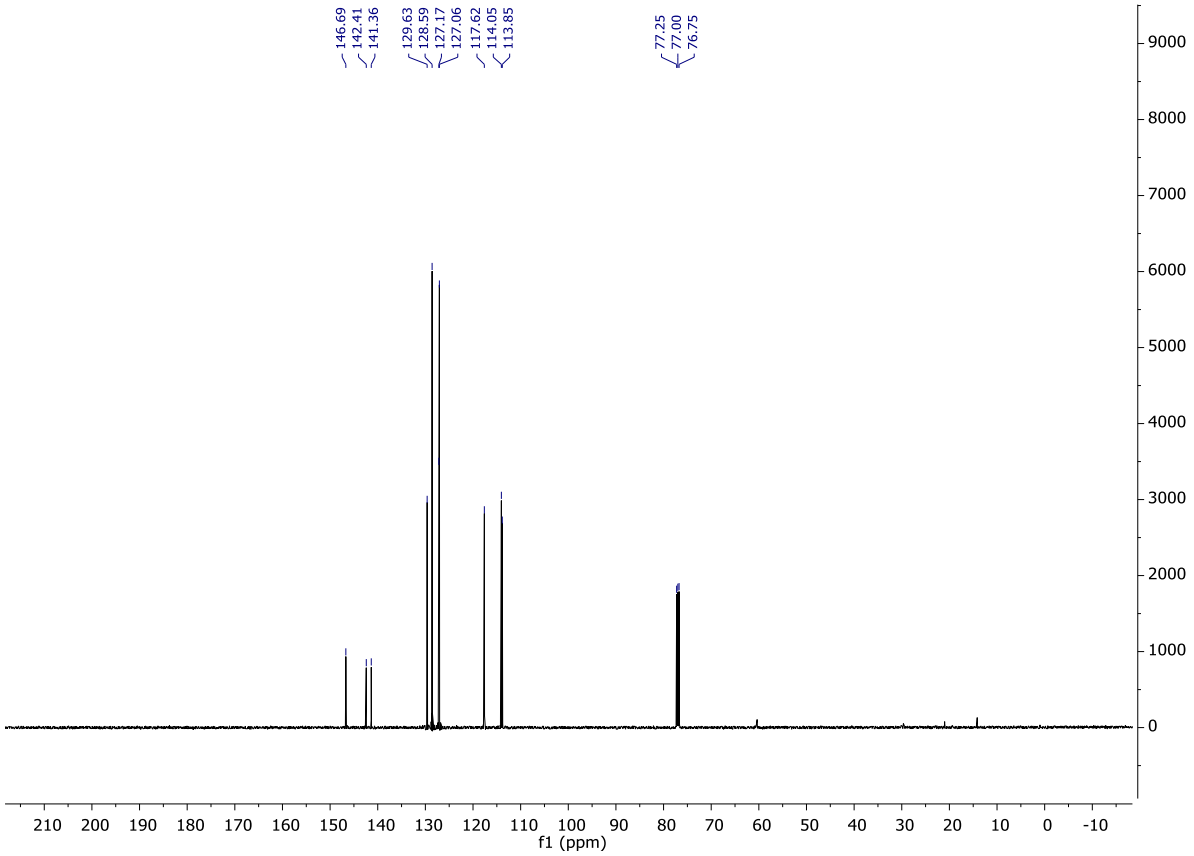


Compound 3ad

^{1}H NMR of 3ad, $CDCl_3$, 400 MHz

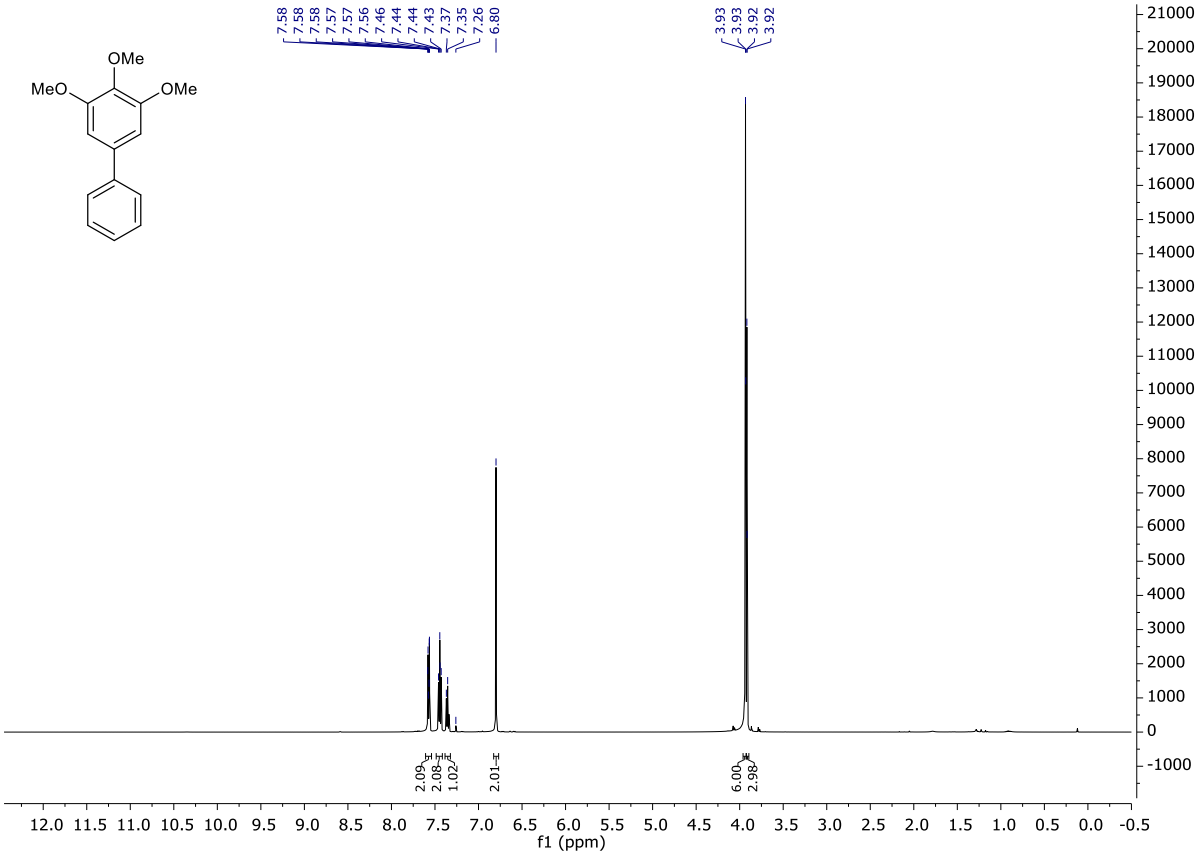


^{13}C NMR of 3ad, $CDCl_3$, 101 MHz

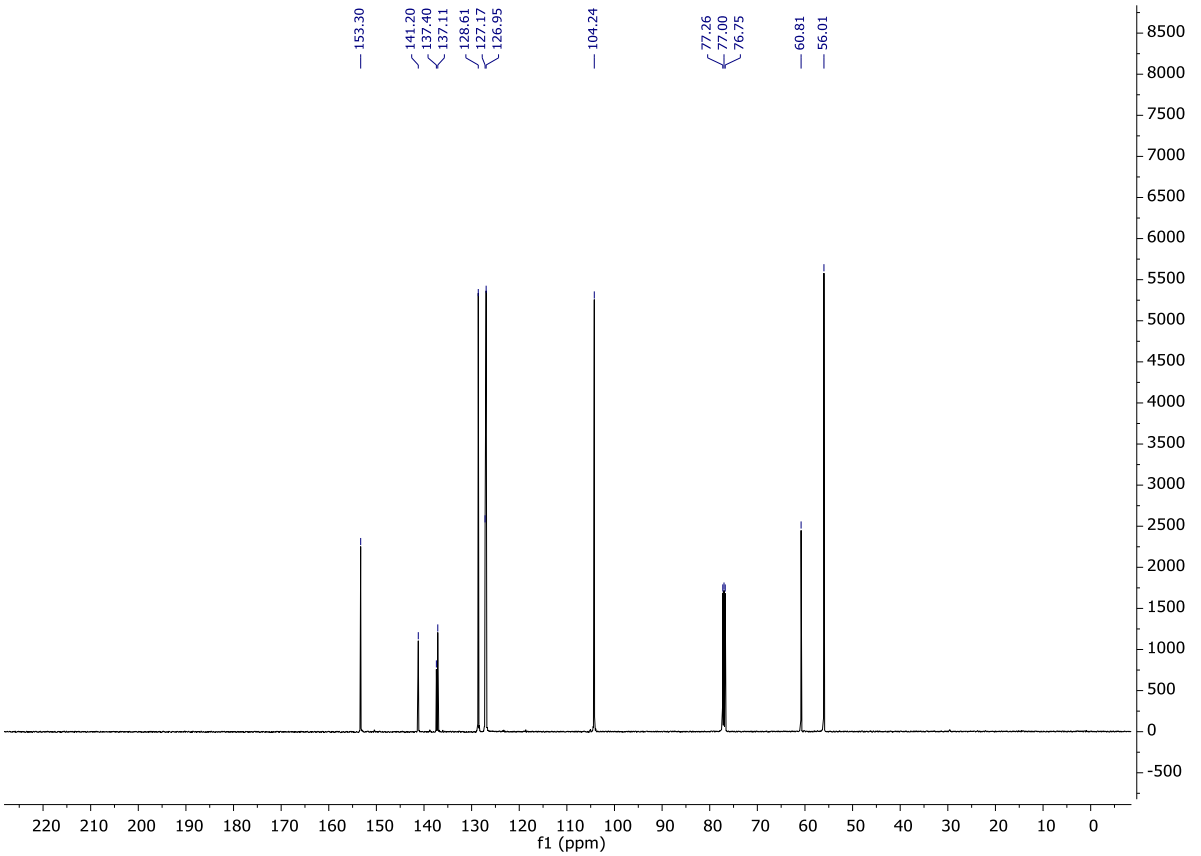


Compound 3ae

^{1}H NMR of 3ae, $CDCl_3$, 400 MHz

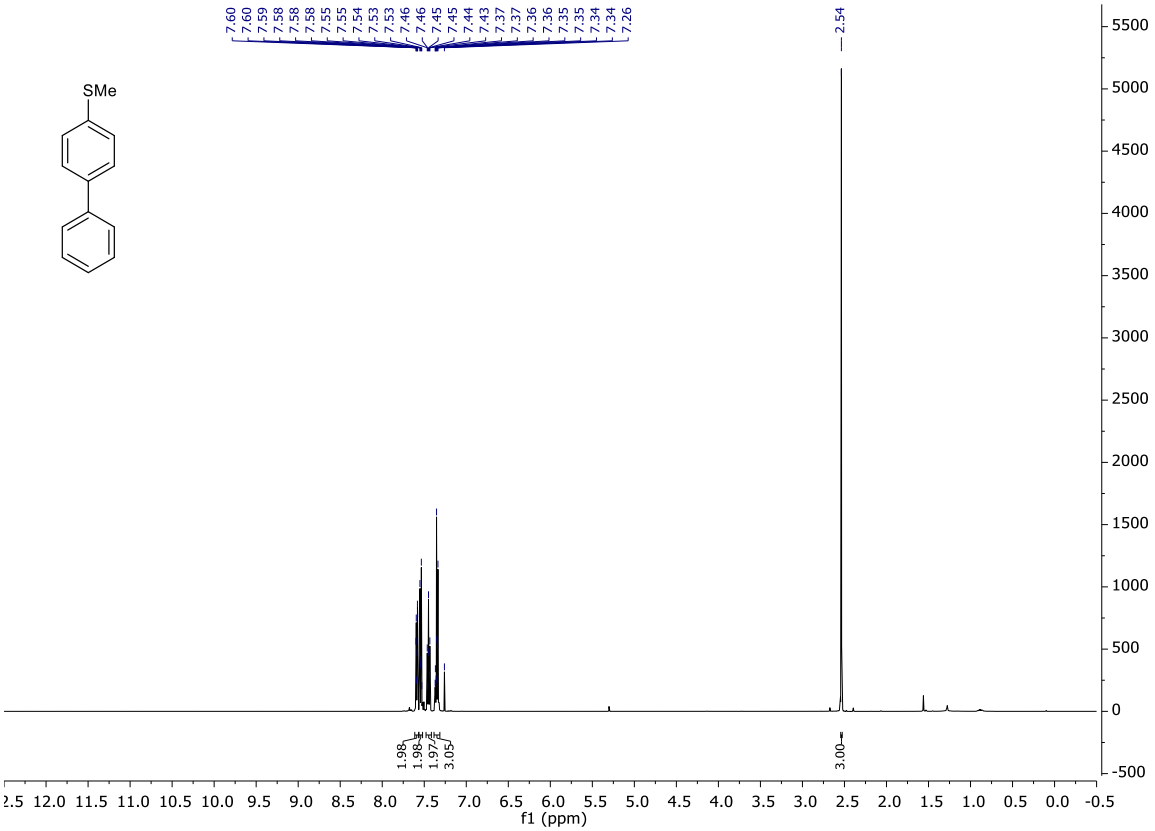


^{13}C NMR of 3ae, $CDCl_3$, 126 MHz

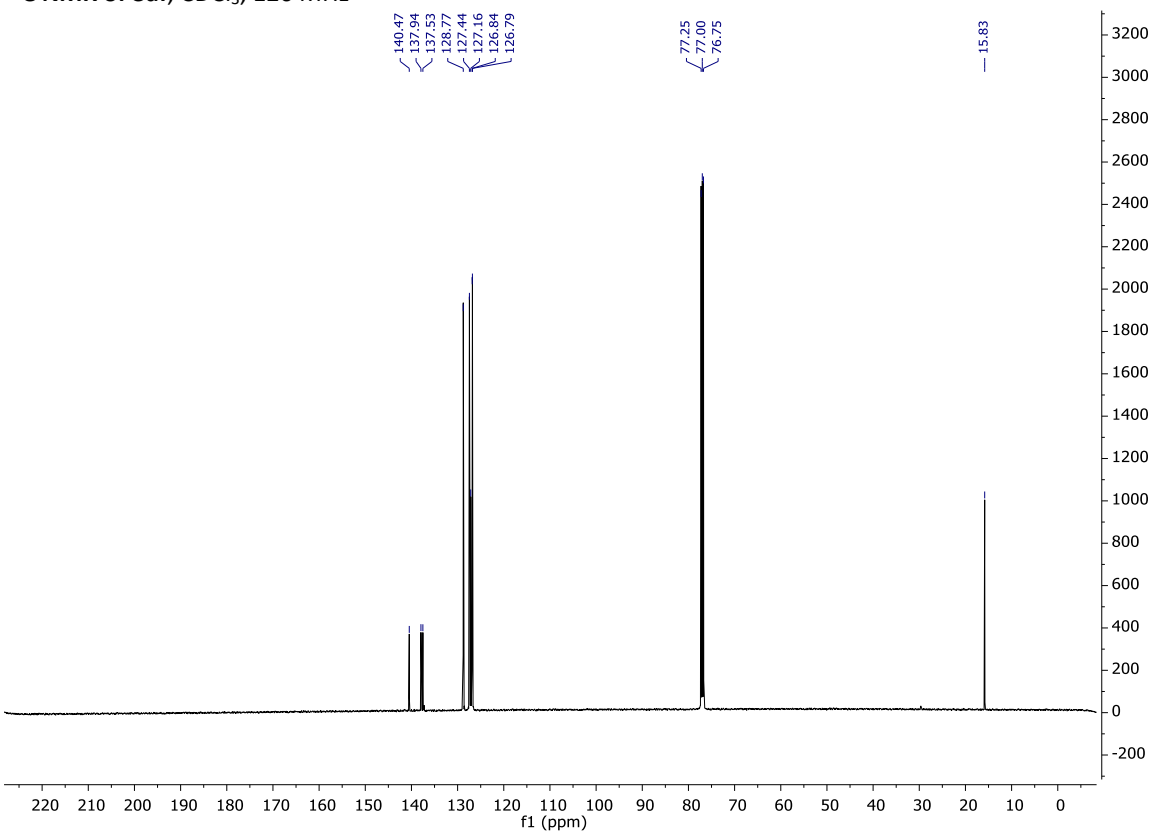


Compound 3af

^{1}H NMR of 3af, $CDCl_3$, 500 MHz

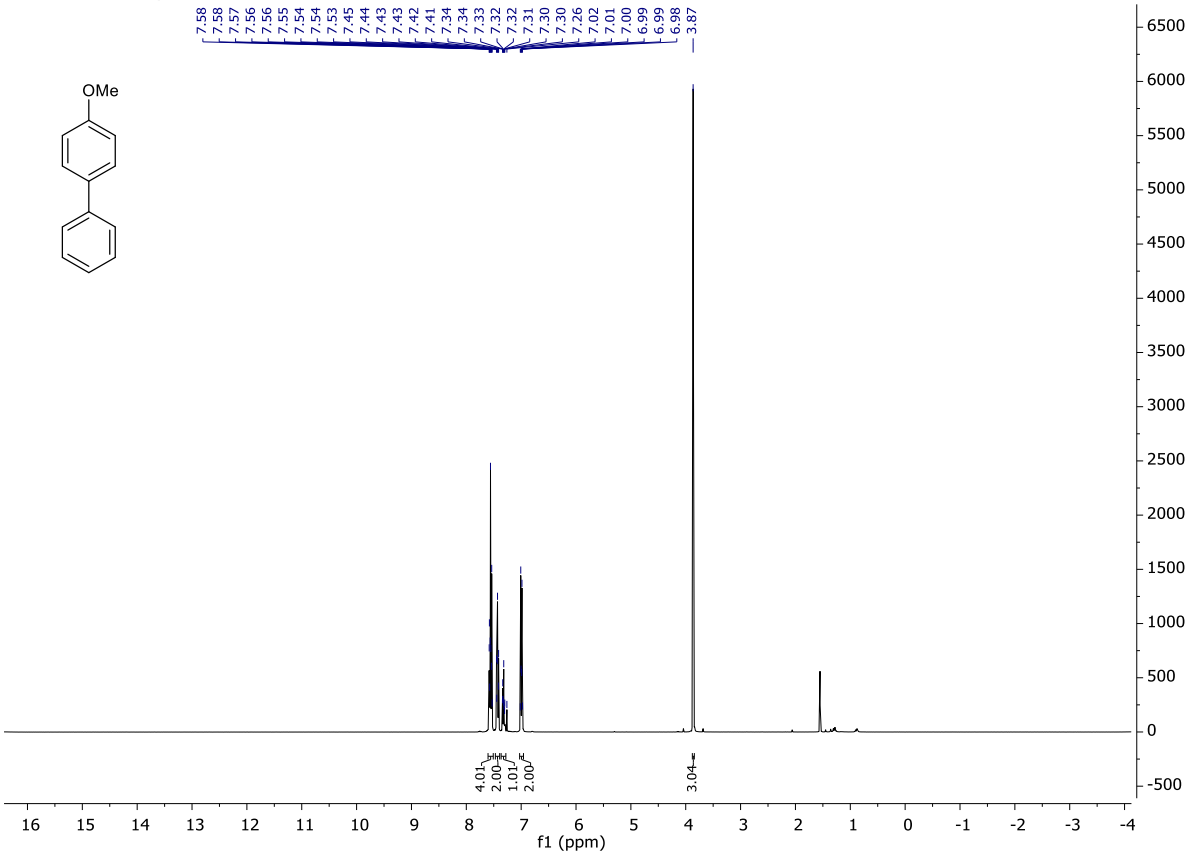


^{13}C NMR of 3af, $CDCl_3$, 126 MHz

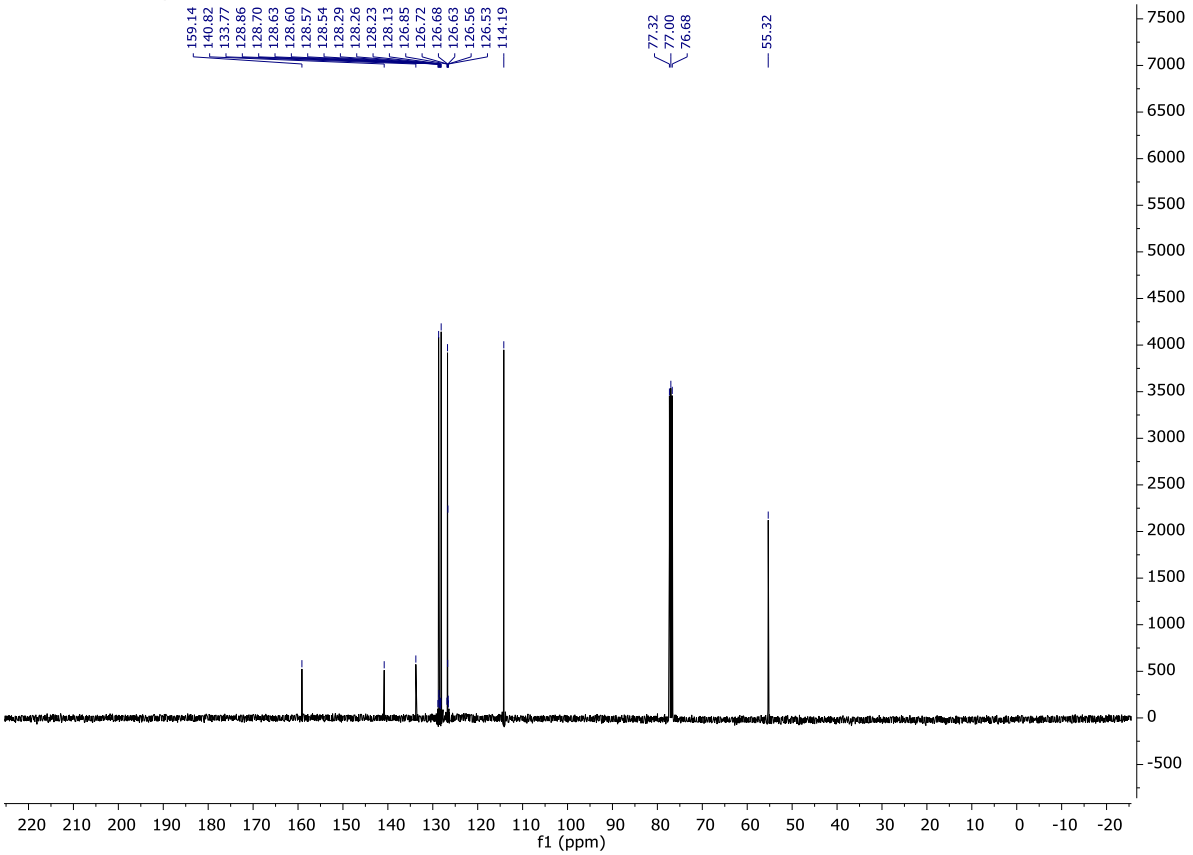


Compound 3ag

^{1}H NMR of 3ag, $CDCl_3$, 400 MHz

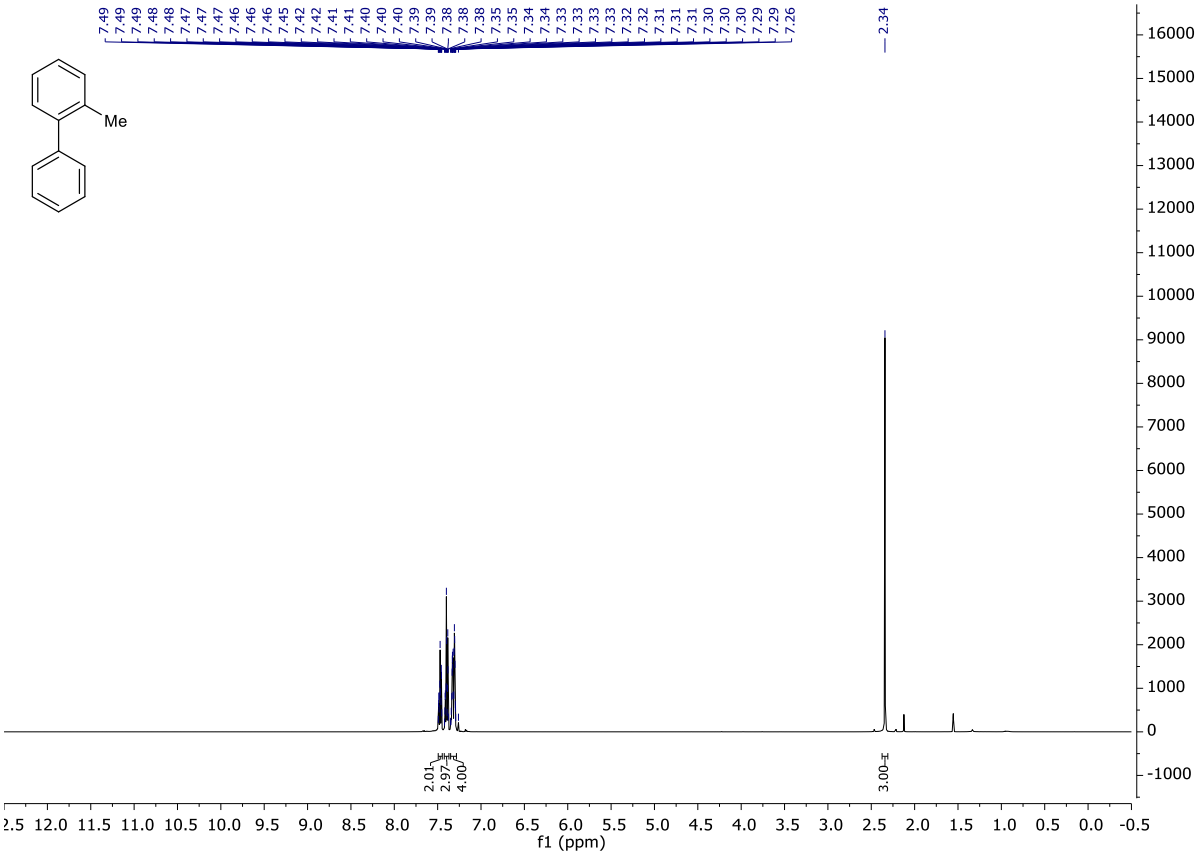


^{13}C NMR of 3ag, $CDCl_3$, 101 MHz

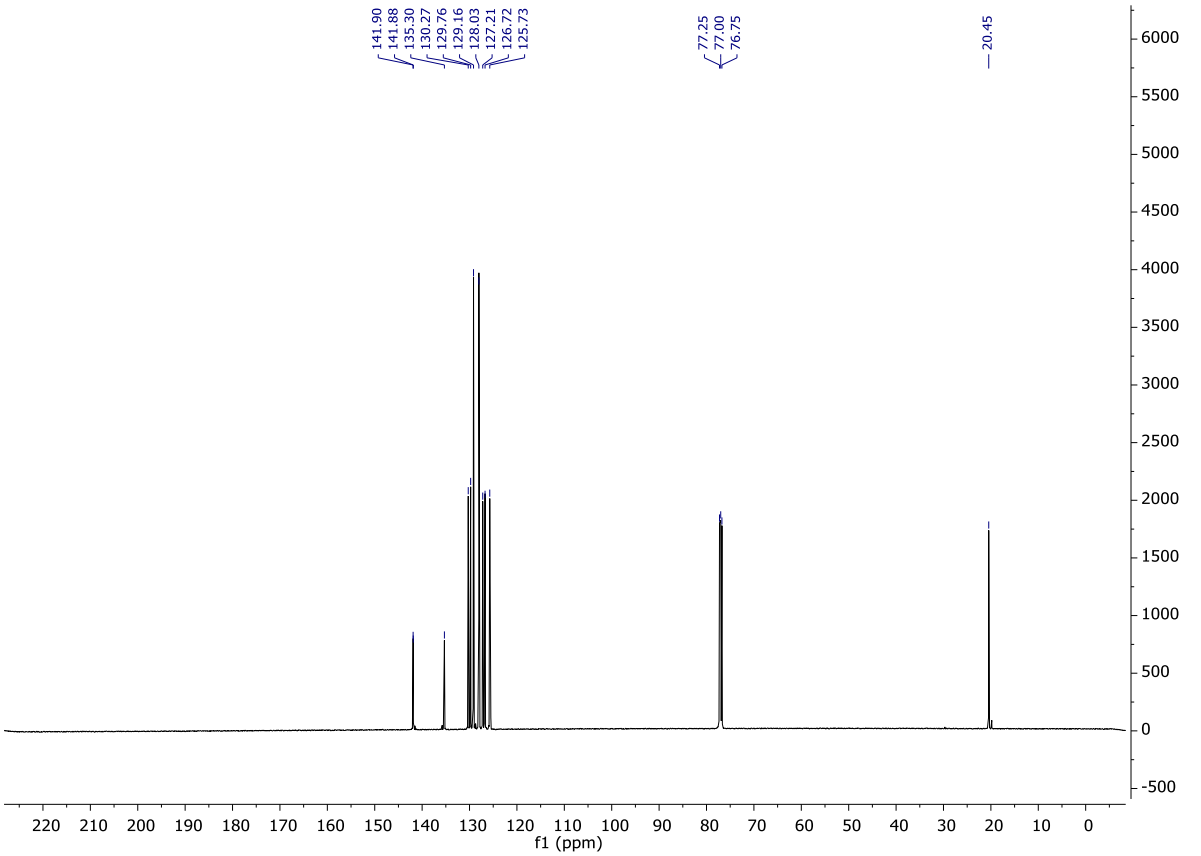


Compound 3ai

^{1}H NMR of 3ai, $CDCl_3$, 400 MHz

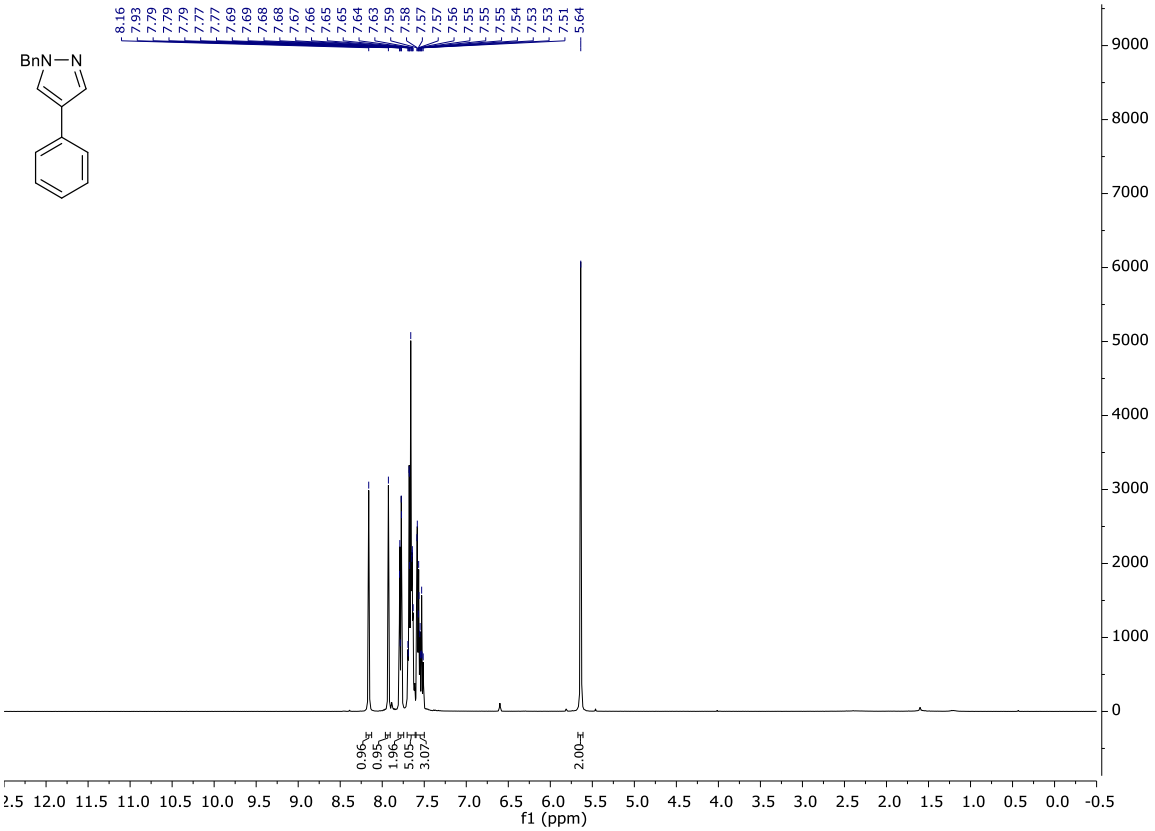


^{13}C NMR of 3ai, $CDCl_3$, 101 MHz

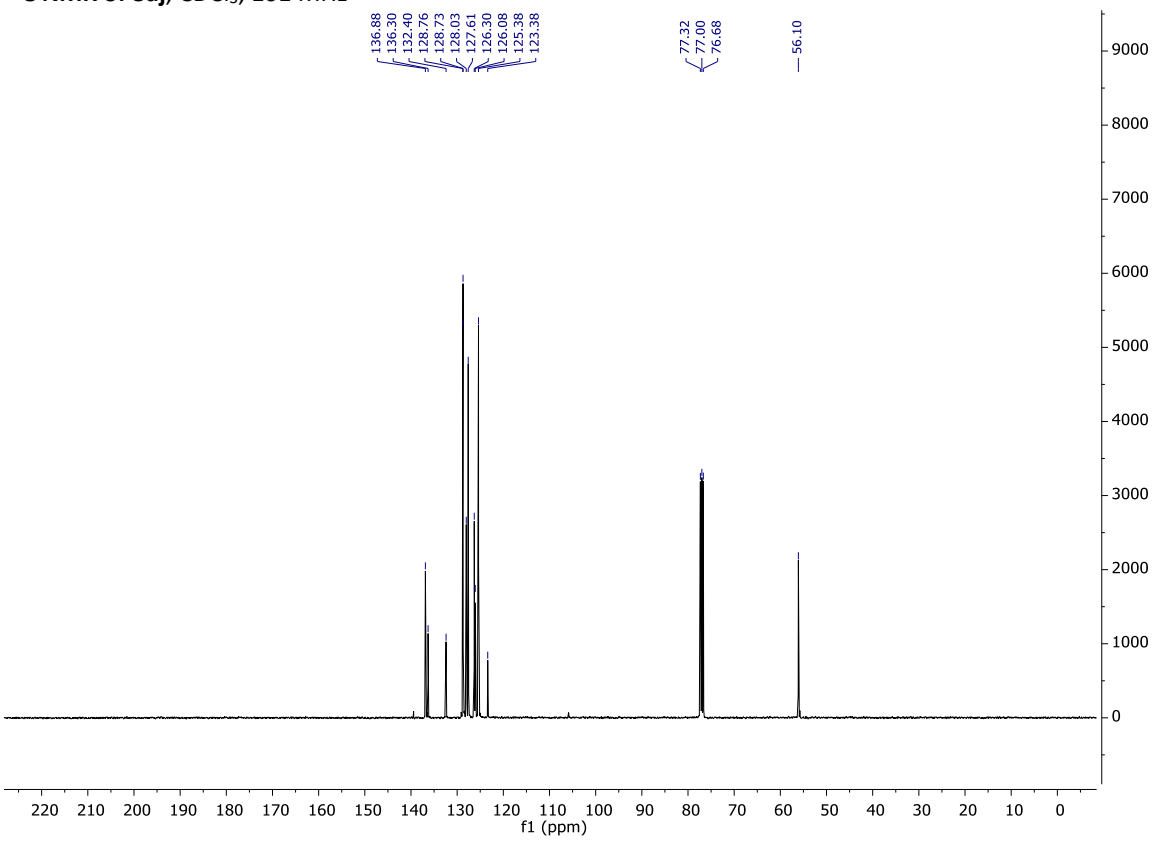


Compound 3aj

^{1}H NMR of 3aj, $CDCl_3$, 500 MHz

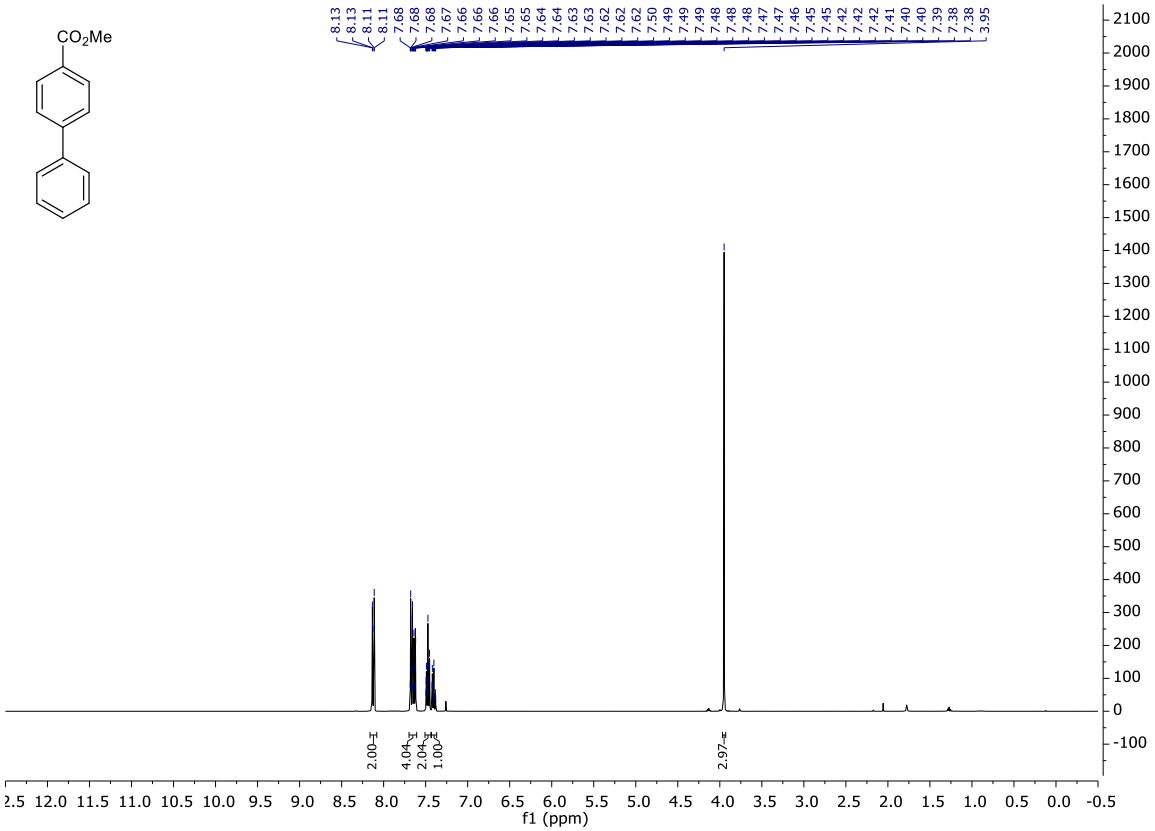


^{13}C NMR of 3aj, $CDCl_3$, 101 MHz



Compound 3ak

^{1}H NMR of 3ak, $CDCl_3$, 400 MHz



^{13}C NMR of 3ak, $CDCl_3$, 101 MHz