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Supplementary Materials for

Native functionality in triple catalytic cross-coupling: sp^3 C–H bonds as latent nucleophiles

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This PDF file includes:

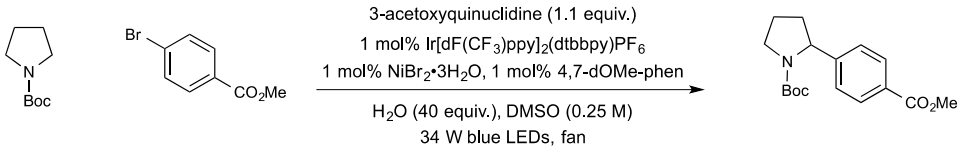
TABLE OF CONTENTS

I. General Information

Commercial reagents were purified prior to use following the guidelines of Perrin and Armarego.[38] $Ir[dF(CF_3)ppy]_2(dtbbpy)PF_6$ was prepared using literature procedures.[30] Anhydrous dimethyl sulfoxide was used as received from Sigma-Aldrich in Sure/Seal® bottles or from Acros in AcroSeal bottles. Organic solutions were concentrated under reduced pressure on a Büchi rotary evaporator using a water bath. Chromatographic purification of products was accomplished using forced-flow chromatography on silica gel (Fluka, 230–400 mesh) according to the method of Still.[39] Thin-layer chromatography (TLC) was performed on Silicycle 0.25 mm silica gel F-254 plates. Visualization of the developed chromatogram was performed by fluorescence quenching or $KMnO_4$ stain. ^1H NMR spectra were recorded on a Bruker UltraShield Plus Avance III 500 MHz unless otherwise noted and are internally referenced to residual $CHCl_3$ signals (7.26 ppm). Data for ^1H NMR are reported as follows: chemical shift (δ ppm), multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet, dd = doublet of doublets, dt = doublet of triplets, br = broad), coupling constant (Hz), and integration. ^{13}C NMR spectra were recorded on a Bruker UltraShield Plus Avance III 500 MHz (125 MHz) and data are reported in terms of chemical shift relative to $CDCl_3$ (77.16 ppm). ^{19}F NMR spectra were recorded on a Bruker NanoBay 300 MHz (282 MHz). IR spectra were recorded on a Perkin Elmer Spectrum 100 FTIR spectrometer and are reported in wavenumbers (cm^{-1}). High-resolution mass spectra were obtained from the Princeton University Mass Spectral Facility.

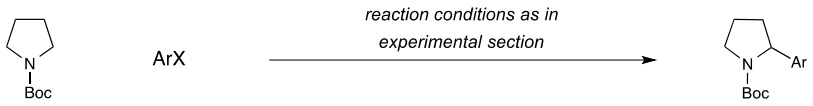
Degassing via freeze-pump-backfill-thaw cycles was carried out as follows:
The reaction mixture, in a vial equipped with a N_2 inlet line, was submerged in a dry ice/acetone bath for 2–5 minutes, until the mixture was frozen. The vial was evacuated for 5 minutes, then backfilled with N_2 and allowed to warm to ambient temperature. The mixture was then stirred for ~10 sec and the process was repeated.

II. Control Experiments



Control experiments	Product yield*
all components present	85%
no photocatalyst	0%
no light	0%
no nickel catalyst	0%
no ligand	36%
no 3-acetoxyquinuclidine	0%
no H_2O	42%

Table S1. Control experiments for photoredox-mediated HAT nickel cross-coupling
* Yields calculated by ^{1}H NMR using an internal standard



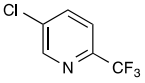
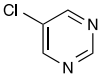
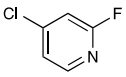
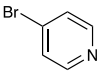
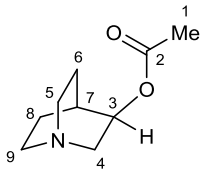
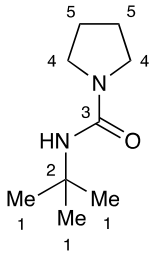
ArX	Control experiment	Product yield*
	with $NiBr_2$•4,7-dOMe-phen	81%
	without $NiBr_2$•4,7-dOMe-phen	0%
	with $NiBr_2$•4,7-dOMe-phen	61%
	without $NiBr_2$•4,7-dOMe-phen	0%
	with $NiBr_2$•4,7-dOMe-phen	86%
	without $NiBr_2$•4,7-dOMe-phen	0%
	with $NiBr_2$•4,7-dOMe-phen	66%
	without $NiBr_2$•4,7-dOMe-phen	0%

Table S2. Control experiments for heteroaromatic halides
* Yields calculated by ^{1}H NMR using an internal standard

III. Substrate Synthesis

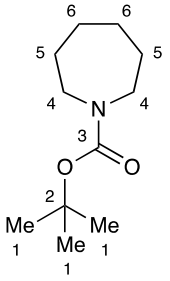


3-Acetoxyquinuclidine (3). A 250 mL round-bottomed flask equipped with a magnetic stirring bar was charged with quinuclidin-3-ol (15.0 g, 118 mmol) and acetic anhydride (75 mL) and the solution was heated to reflux for 4 hours. The reaction mixture was cooled to room temperature and concentrated *in vacuo*. Sat. aq. $NaHCO_3$ (75 mL) and chloroform (50 mL) were added and the solution was stirred vigorously for 20 minutes. The layers were separated and the aqueous portion was further extracted with 10% isopropanol/chloroform (5 × 100 mL). The organic extracts were combined, dried over Na_2SO_4 and concentrated *in vacuo*. The residue was diluted with chloroform (50 mL) and stirred vigorously again with sat. aq. $NaHCO_3$ for 20 minutes. The layers were separated and the aqueous portion was further extracted with 10% isopropanol/chloroform (5 × 100 mL). The organic extracts were combined, dried over Na_2SO_4 and concentrated *in vacuo*. The residue was purified by distillation under high vacuum (65-70 °C, 100 mTorr) to provide the title compound as a colorless oil (14.9 g, 88.0 mmol, 75% yield). ^{1}H NMR (500 MHz, $CDCl_3$): δ 4.76 (dddd, *J* = 8.5, 3.5, 3.5, 1.5 Hz, 1H, C(3)**H**), 3.21 (ddd, *J* = 14.6, 8.5, 2.3 Hz, 1H, C(4)$\mathbf{H}_a$), 2.92–2.61 (m, 5H, C(4)$\mathbf{H}_b$, C(5)$\mathbf{H_2}$ and C(9)$\mathbf{H_2}$), 2.05 (s, 3H, C(1)$\mathbf{H}_3$), 1.96 (m, 1H, C(7)**H**), 1.81 (ddddd, *J* = 13.2, 10.2, 5.2, 3.1, 3.1 Hz, 1H, C(6)$\mathbf{H}_a$), 1.66 (dddd, *J* = 13.8, 10.2, 5.1, 3.8 Hz, 1H, C(8)$\mathbf{H}_a$), 1.53 (ddddd, *J* = 13.2, 10.4, 5.7, 2.8, 2.8 Hz, 1H, C(8)$\mathbf{H}_b$), 1.36 (m, 1H, C(6)$\mathbf{H}_b$). ^{13}C NMR (125 MHz, $CDCl_3$): δ 171.04, 71.52, 55.65, 47.53, 46.66, 25.27, 24.77, 21.36, 19.65. IR (thin film): 2940, 2870, 1727, 1456, 1365, 1322, 1236, 1176, 1132, 1108, 1079, 1059, 1025 cm^{-1}. HRMS (ESI-TOF) calculated for $C_9H_{15}NO_2$ $[M+H]^+$ requires m/z 170.1176, found 170.1176. *Note: Stirring twice with $NaHCO_3$ is important as a small impurity was sometimes observed by ^{1}H NMR (singlet at 1.95 ppm and shifting of all the peaks) corresponding to the quinuclidinium acetate salt, the presence of small quantities of this impurity was detrimental to the yield of the reaction.*

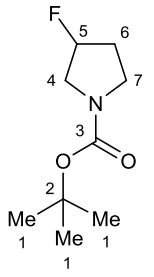


***N*-(*tert*-Butyl)pyrrolidine-1-carboxamide.** A 50 mL round-bottom flask was charged with *tert*-butyl isocyanate (2.1 mL, 18 mmol, 1.5 equiv.), triethylamine (2.5 mL, 18 mmol, 1.5 equiv.), and

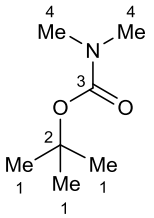
pyrrolidine (0.99 mL, 12 mmol, 1.0 equiv.). Dichloromethane (24 mL, 0.50 M) was added and the resulting colorless solution was stirred for 5 h. The reaction mixture was diluted with water (30 mL) and the aqueous layer was extracted with three portions of dichloromethane (20 mL). The combined organic layers were washed with brine (30 mL), dried over Na_2SO_4, filtered, and concentrated. The residue was purified by flash chromatography eluting with 25–50% EtOAc/hexanes to afford the title compound as a white solid (2.0 g, 11 mmol, 88% yield). ^{1}H NMR (500 MHz, $CDCl_3$): δ 4.21 (s, 1H, N**H**), 3.33–3.25 (m, 4H, 2 × C(4)**H$_2$**), 1.93–1.85 (m, 4H, 2 × C(5)**H$_2$**), 1.35 (s, 9H, 3 × C(1)**H$_3$**). ^{13}C NMR (125 MHz, $CDCl_3$): δ 156.21, 50.86, 45.88, 29.70, 25.73. IR (thin film): 3342, 2965, 2868, 1628, 1524, 1475, 1447, 1376, 1355, 1334, 1241, 1217, 1131, 1026 cm^{-1}. HRMS (ESI-TOF) calculated for $C_9H_{18}N_2O$ $[M+H]^+$ requires m/z 171.1492, found 171.1493.



***tert*-Butyl azepane-1-carboxylate.** A 500 mL round-bottom flask was charged with azepane (10.0 mL, 89 mmol, 1.05 equiv.) and dichloromethane (85 mL, 1.0 M). The resulting colorless solution was cooled to 0 ºC before di-*tert*-butyl dicarbonate (18.4 g, 85 mmol, 1.0 equiv.) was added in several portions. The reaction mixture was allowed to warm to ambient temperature and stir for 2 h. The reaction mixture was washed with 1 M HCl and brine, dried over Na_2SO_4, filtered, and concentrated. The residue was purified by distillation under high vacuum (~500 mTorr) at 75 ºC to afford the title compound as a colorless liquid (15.9 g, 80 mmol, 95% yield, mixture of rotamers 1:1 A:B). ^{1}H NMR (500 MHz, $CDCl_3$): δ 3.37 (t, *J*=6.2 Hz, 4H, 2 × C(4)**H$_2$**, A or B) , 3.30 (t, *J*=6.0 Hz, 4H, 2 × C(4)**H$_2$**, B or A), 1.71–1.58 (m, 8H, 2 × C(5)**H$_2$**, A+B), 1.55–1.47 (m, 8H, 2 × C(6)**H$_2$**, A+B), 1.44 (s, 18H, 3 × C(1)**H$_3$**, A+B). ^{13}C NMR (125 MHz, $CDCl_3$): δ 155.83 (A+B), 79.01 (A+B), 47.08 (A or B), 46.68 (B or A), 28.68 (A+B), 28.65 (A or B), 28.57 (B or A), 27.60 (A or B), 26.97 (B or A). IR (thin film): 2974, 2927, 2858, 1688, 1480, 1453, 1413, 1364, 1304, 1279, 1252, 1160, 1115, 1078, 1002 cm^{-1}. HRMS (ESI-TOF) calculated for $C_{11}H_{21}NO_2$ $[M+Na]^+$ requires m/z 222.1465, found 222.1466.



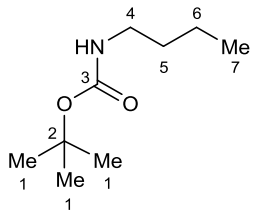
***tert*-Butyl 3-fluoropyrrolidine-1-carboxylate.** A 250 mL round-bottomed flask equipped with a magnetic stirring bar was charged with di-*tert*-butyl dicarbonate (4.74 g, 21.7 mmol, 1.0 equiv.), (*S*)-3-fluoropyrrolidine hydrochloride (3.00 g, 23.9 mmol, 1.1 equiv.) and CH_2Cl_2 (109 mL). Triethylamine (3.33 mL, 23.9 mmol, 1.1 equiv.) was added at 0 °C and then the solution was warmed to room temperature and stirred for 16 h. Water (50 mL) was added and the aqueous portion was extracted with CH_2Cl_2 (3 × 30 mL). The organic extracts were combined, dried over Na_2SO_4, filtered and concentrated *in vacuo*. The residue was purified by distillation under vacuum (120-125 °C, 25 Torr) to afford the title compound as a colorless oil (3.48 g, 18.4 mmol, 85% yield, 1:1 mixture of rotamers observable by ^{13}C NMR). ^1H NMR (500 MHz, $CDCl_3$): δ 5.20 (ddd, J = 52.8, 3.8, 3.8 Hz, 1H, C(5)**H**), 3.76–3.38 (m, 4H, C(4)$\mathbf{H_2}$ and C(7)$\mathbf{H_2}$), 2.20 (m, 1H, C(6)$\mathbf{H}_a$), 1.97 (m, 1H, C(6)$\mathbf{H}_b$), 1.46 (s, 9H, 3 × C(1)$\mathbf{H_3}$). ^{13}C NMR (125 MHz, $CDCl_3$): δ 154.59, 154.47, 93.2 (d, J = 175.9 Hz), 92.4 (d, J = 175.8 Hz), 79.69, 52.83 (d, J = 23.2 Hz), 52.48 (d, J = 23.1 Hz), 43.86, 43.49, 32.64 (d, J = 21.7 Hz), 31.90 (d, J = 21.7 Hz), 28.61. The spectroscopic properties of this compound are consistent with data reported in the literature.[40]



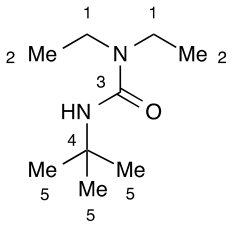
***tert*-Butyl dimethylcarbamate**. A 100 mL round-bottomed flask equipped with a magnetic stirring bar was charged with di-*tert*-butyl dicarbonate (10.0 g, 45.8 mmol, 1.0 equiv.), dimethylamine hydrochloride (4.11 g, 50.4 mmol, 1.1 equiv.) and CH_2Cl_2 (45 mL). Triethylamine (7.02 mL, 50.4 mmol, 1.1 equiv.) was added at 0 °C and then the solution was warmed to room temperature and stirred for 16 h. Water (100 mL) was added and the aqueous portion was extracted with CH_2Cl_2 (3 × 50 mL). The organic extracts were combined, dried over Na_2SO_4, filtered and concentrated *in vacuo*. The residue was purified by distillation under vacuum (65-70 °C, 20 Torr) to afford the title compound as a colorless oil (4.05 g, 27.9 mmol, 61% yield, mixture of rotamers 1:1 A:B). ^1H NMR (500 MHz, $CDCl_3$): δ 2.84 (s, 12H, 2 × C(4)$\mathbf{H_3}$, A+B), 1.44 (s, 18H, 3 × C(1)$\mathbf{H_3}$, A+B). ^{13}C NMR (125 MHz, $CDCl_3$): δ 156.17 (A+B), 79.30 (A+B), 36.27 (A), 36.03 (B),

28.57 (A+B). The spectroscopic properties of this compound are consistent with data reported in the literature.[41]

***N*-Methyl *tert*-butylamine**: Prepared according to a literature procedure.[42]

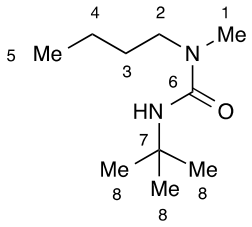


***tert*-Butyl butylcarbamate.** A 250 mL round-bottomed flask equipped with a magnetic stirring bar was charged with di-*tert*-butyl dicarbonate (19.6 g, 90.0 mmol, 1.0 equiv.) and MeCN (90 mL). Butylamine (9.74 mL, 99.0 mmol, 1.1 equiv.) was added at 0 °C and then the solution was warmed to room temperature and stirred for 16 h. The reaction mixture was concentrated *in vacuo* and the resulting oil was diluted with Et_2O (200 mL). The solution was washed with 1 M aq. HCl (100 mL) and brine (50 mL), dried over Na_2SO_4, filtered and concentrated *in vacuo*. The residue was purified by distillation under vacuum (8-9 Torr, 80 °C) to afford the title compound as a colorless oil (13.9 g, 80.0 mmol, 89% yield). ^{1}H NMR (500 MHz, $CDCl_3$): δ 4.50 (br. m, 1H, N**H**), 3.11 (dt, J = 6.8, 6.8 Hz, 2H, C(4)$\mathbf{H_2}$), 1.51–1.38 (m, 11H, C(5)$\mathbf{H_2}$ and 3 × C(1)$\mathbf{H_3}$), 1.33 (tq, J = 7.3, 7.3 Hz, 2H, C(6)$\mathbf{H_2}$), 0.91 (t, J = 7.3 Hz, 3H, C(7)$\mathbf{H_3}$). ^{13}C NMR (125 MHz, $CDCl_3$): δ 156.11, 79.12, 40.46, 32.27, 28.57, 20.10, 13.90. The spectroscopic properties of this compound are consistent with data reported in the literature.[43]

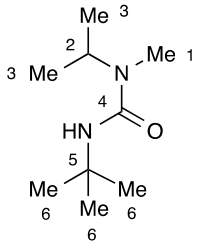


3-(*tert*-Butyl)-1,1-diethylurea. A 100 mL round-bottomed flask equipped with a magnetic stirring bar was charged with *tert*-butylisocyanate (3.0 mL, 26.3 mmol, 1.0 equiv.) diethylamine (3.3 mL, 31.5 mmol, 1.2 equiv.) and triethylamine (5.5 mL, 39.4 mmol, 1.5 equiv.). Anhydrous CH_2Cl_2 (52.5 mL, 0.50 M) was added and the reaction was stirred for 12 h. After 12 h, water (30 mL) was added and the aqueous layer was extracted with three portions of CH_2Cl_2. The combined organic layers were dried over Na_2SO_4, filtered, and concentrated. The residue was purified by recrystallization from EtOAc/hexanes to afford the title compound as a crystalline solid (3.65 g, 21.2 mmol, 81% yield). ^{1}H NMR (500 MHz, $CDCl_3$): 4.15 (br. s, 1H, N**H**), 3.20 (q, J = 7.2 Hz, 4H, 2 × C(1)$\mathbf{H_2}$), 1.33 (br. s, 9H, 3 × C(5)$\mathbf{H_3}$), 1.10 (t, J = 7.1 Hz, 6H, 2 × C(2)$\mathbf{H_3}$). ^{13}C NMR (125 MHz, $CDCl_3$): δ 156.68, 50.68, 41.12, 29.75, 13.97. IR (thin film): 3343, 2966, 2930, 1621, 1529,

1486, 1452, 1401, 1373, 1357, 1306, 1280, 1216, 1183, 1098, 1082 cm^{-1}. HRMS (ESI-TOF) calculated for $C_9H_{20}N_2O$ $[M+H]^+$ requires m/z 173.1648, found 173.1649.

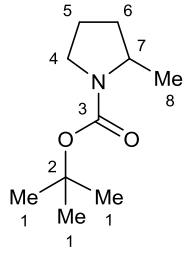


3-(*tert*-Butyl)-1-butyl-1-methylurea. A 100 mL round-bottomed flask equipped with a magnetic stirring bar was charged with *tert*-butylisocyanate (3.0 mL, 26.3 mmol, 1.0 equiv.), *N*-methylbutan-1-amine (3.7 mL, 31.5 mmol, 1.2 equiv.), and triethylamine (5.5 mL, 39.4 mmol, 1.5 equiv.). Anhydrous CH_2Cl_2 (52.5 mL, 0.50 M) was added and the reaction was stirred for 12 h. After 12 h, water (30 mL) was added and the aqueous layer was extracted with three portions of CH_2Cl_2. The combined organic layers were dried over Na_2SO_4, filtered, and concentrated. The residue was purified by recrystallization from EtOAc/hexanes to afford the title compound as a crystalline solid (4.44 g, 23.9 mmol, 91% yield). ^{1}H NMR (500 MHz, $CDCl_3$): 4.17 (br. s, 1H, N**H**), 3.16 (t, J = 7.5 Hz, 2H, C(2)$\mathbf{H_2}$), 2.79 (s, 3H, C(1)$\mathbf{H_3}$), 1.49–1.42 (m, 2H, C(3)$\mathbf{H_2}$), 1.32–1.23 (m, 2H, C(4)$\mathbf{H_2}$), 1.31 (s, 9H, 3 × C(8)$\mathbf{H_3}$), 0.90 (t, J = 7.4 Hz, 3H, C(5)$\mathbf{H_3}$). ^{13}C NMR (125 MHz, $CDCl_3$): δ 157.41, 50.67, 48.57, 34.37, 30.28, 29.64, 20.18, 13.99. IR (thin film): 3375, 2951, 2930, 2873, 1630, 1524, 1483, 1446, 1387, 1377, 1357, 1306, 1250, 1225, 1205, 1192, 1061 cm^{-1}. HRMS (ESI-TOF) calculated for $C_{10}H_{22}N_2O$ $[M+H]^+$ requires m/z 187.1805, found 187.1804.



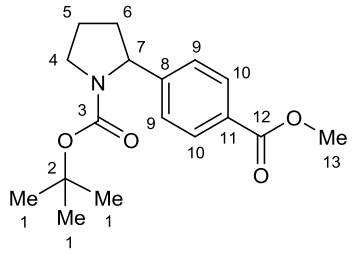
3-(*tert*-Butyl)-1-isopropyl-1-methylurea. A 50 mL round-bottomed flask equipped with a magnetic stirring bar was charged with *tert*-butylisocyanate (0.91 mL, 7.98 mmol, 1.0 equiv.), *N*-methylpropan-2-amine (1.0 mL, 9.57 mmol, 1.2 equiv.), and triethylamine (1.7 mL, 12.0 mmol, 1.5 equiv.). Anhydrous CH_2Cl_2 (16.0 mL, 0.50 M) was added and the reaction was stirred for 12 h. After 12 h, water (30 mL) was added and the aqueous layer was extracted with three portions of CH_2Cl_2. The combined organic layers were dried over Na_2SO_4, filtered, and concentrated. The residue was purified by recrystallization from EtOAc/hexanes to afford the title compound as a crystalline solid (1.26 g, 7.30 mmol, 92% yield). ^{1}H NMR (500 MHz, $CDCl_3$): 4.42 (hept, J = 6.8 Hz, 1H, C(2)**H**), 4.17 (br. s, 1H, N**H**), 2.61 (s, 3H, C(1)$\mathbf{H_3}$), 1.32 (br. s, 9H, 3 × C(6)$\mathbf{H_3}$), 1.04 (d, J = 6.8 Hz, 6H, 2 × C(3)$\mathbf{H_3}$). ^{13}C NMR (125 MHz, $CDCl_3$): δ 157.26, 50.69, 44.72, 29.68, 26.99,

20.14. IR (thin film): 3359, 2977, 2957, 2925, 1629, 1525, 1481, 1451, 1387, 1363, 1356, 1335, 1321, 1234, 1209, 1193, 1148, 1122, 1075 cm^{-1}. HRMS (ESI-TOF) calculated for $C_9H_{20}N_2O$ $[M+H]^+$ requires m/z 173.1648, found 173.1647.



***tert*-Butyl 2-methylpyrrolidine-1-carboxylate.** A 50 mL round-bottomed flask equipped with a magnetic stirring bar was charged with di-*tert*-butyl dicarbonate (2.44 g, 11.2 mmol, 1.0 equiv.) and MeCN (11 mL). 2-methylpyrrolidine (1.20 mL, 11.7 mmol, 1.05 equiv.) was added and the solution was stirred at room temperature for 16 h. The reaction mixture was concentrated *in vacuo* and the resulting oil was diluted with Et_2O (100 mL). The solution was washed with 1 M aq. HCl (50 mL) and brine (50 mL), dried over Na_2SO_4, filtered and concentrated *in vacuo*. The residue was purified by flash column chromatography eluting 5% EtOAc/hexanes to afford the title compound as a colorless oil (1.76 g, 9.51 mmol, 85% yield). ^{1}H NMR (500 MHz, $CDCl_3$): δ 3.86 (m, 1H, C(7)**H**), 3.37–3.28 (m, 2H, C(4)$\mathbf{H_2}$), 1.97 (dddd, J = 12.0, 9.5, 7.4, 7.4 Hz, 1H, C(6)$\mathbf{H}_a$), 1.86 (m, 1H, C(5)$\mathbf{H}_a$), 1.77 (m, 1H, C(5)$\mathbf{H}_b$), 1.53 (m, 1H, C(6)$\mathbf{H}_b$), 1.45 (s, 9H, 3 × C(1)$\mathbf{H_3}$), 1.14 (d, J = 6.3 Hz, 3H, C(8)$\mathbf{H_3}$). ^{13}C NMR (125 MHz, $CDCl_3$): δ 154.67, 78.91, 52.90, 46.39, 33.12, 28.71, 23.38, 20.65. The spectroscopic properties of this compound are consistent with data reported in the literature.[44]

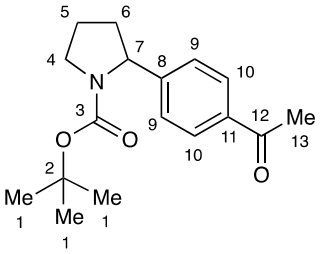
IV. Experimental Data



***tert*-Butyl 2-(4-(methoxycarbonyl)phenyl)pyrrolidine-1-carboxylate (14).** An 8 mL vial equipped with a magnetic stirring bar was charged with methyl 4-bromobenzoate (108 mg, 0.50 mmol, 1.0 equiv.) and $Ir[dF(CF_3)ppy]_2(dtbbpy)PF_6$ (5.6 mg, 5.0 μmol, 1.0 mol%). Anhydrous DMSO (1.0 mL) and 3-acetoxyquinuclidine (85 μL, 0.55 mmol, 1.1 equiv.) were added. 4,7-Dimethoxy-1,10-phenanthroline (1.2 mg, 5.0 μmol, 1.0 mol%) and nickel(II) bromide trihydrate (1.4 mg, 5.0 μmol, 1.0 mol%) were added as a 0.50 M stock solution in anhydrous DMSO (1 mL, sonicated for 10 minutes before addition). *N*-Boc pyrrolidine (175 μL, 1.0 mmol, 2.0 equiv.) and water (360 μL, 20 mmol, 40 equiv.) were added before the mixture was degassed via two cycles of freeze-pump-backfill-thaw. The reaction was sealed and placed ~6 cm away from a 34 W blue LED and stirred for 16 h with cooling by fan. The reaction mixture was removed from the light, diluted with aq. $NaHCO_3$ and EtOAc, and the aqueous layer was extracted with three portions of EtOAc. The combined organic layers were dried over Na_2SO_4, filtered, and concentrated. The residue was purified by flash chromatography eluting with 5% EtOAc/hexanes to afford the title compound as a waxy white solid (123 mg, 0.40 mmol, 81% yield, mixture of rotamers 2.1:1 A:B). ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.96 (d, J = 8.3 Hz, 4H, 2 × C(10)**H**, A+B), 7.22 (d, J = 8.3 Hz, 4H, 2 × C(9)**H**, A+B), 4.96 (br. m, 1H, C(7)**H**, B), 4.78 (br. m, 1H, C(7)**H**, A), 3.89 (s, 6H, C(13)$\mathbf{H_3}$, A+B), 3.67–3.46 (br. m, 4H, C(4)$\mathbf{H_2}$, A+B), 2.40–2.24 (br. m, 2H, C(6)$\mathbf{H}_a$, A+B), 1.94–1.73 (m, 6H, C(5)$\mathbf{H_2}$ and C(6)$\mathbf{H}_b$, A+B), 1.43 (br. s, 9H, 3 × C(1)$\mathbf{H}_3$, B), 1.15 (br. s, 9H, 3 × C(1)$\mathbf{H}_3$, A). ^{13}C NMR (125 MHz, $CDCl_3$): δ 167.11 (A+B), 154.51 (A+B), 150.70 (A), 149.66 (B), 129.90 (B), 129.71 (A), 128.59 (A+B), 125.56 (A+B), 79.59 (A+B), 61.30 (A), 60.75 (B), 52.13 (A+B), 47.48 (B), 47.25 (A), 36.04 (A), 34.87 (B), 28.56 (B), 28.23 (A), 23.68 (B), 23.38 (A). The spectroscopic properties of this compound are consistent with data reported in the literature.[45]

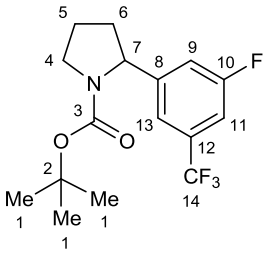
***tert*-Butyl 2-(4-(methoxycarbonyl)phenyl)pyrrolidine-1-carboxylate (14): large-scale reaction.** A 40 mL vial equipped with a cross-shaped magnetic stirring bar was charged with *tert*-butyl pyrrolidine-1-carboxylate (2.0 mL, 11 mmol, 2.0 equiv.) and methyl 4-bromobenzoate (1.2 g, 5.6 mmol, 1.0 equiv.). $Ir[dF(CF_3)ppy]_2(dtbbpy)PF_6$ (63 mg, 56 μmol, 1.0 mol%) was added as a 0.50 M solution in anhydrous DMSO (7.0 mL) and quinuclidin-3-yl acetate (0.96 mL, 6.2 mmol, 1.1 equiv.) was added. 4,7-Dimethoxy-1,10-phenanthroline (13 mg, 56.0 μmol, 1.0 mol%) and nickel(II) bromide trihydrate (15 mg, 56.0 μmol, 1.0 mol%) were added as a 0.50 M stock solution in anhydrous DMSO (7.0 mL, sonicated for 10 minutes before addition). Water (3.0 mL, 168

mmol, 30 equiv.) was added before the mixture was degassed via two cycles of freeze-pump-backfill-thaw. The reaction was sealed, placed between two 34 W blue LEDs (~6 cm), and stirred for 24 h with cooling by fan. The reaction mixture was removed from the light, diluted with aq. K_2CO_3 and EtOAc, and the aqueous layer was extracted with three portions of EtOAc. The combined organic layers were dried over Na_2SO_4, filtered, and concentrated. The residue was purified by flash chromatography eluting with 5–8% EtOAc/hexanes. A small amount of residual phenol was removed by washing the contaminated material, dissolved in EtOAc, with five portions of K_2CO_3. The resulting organic layer was dried over Na_2SO_4, filtered, and concentrated. Consolidation of the purified material afforded the title compound as a waxy white solid (1.34 g, 4.4 mmol, 78% yield).

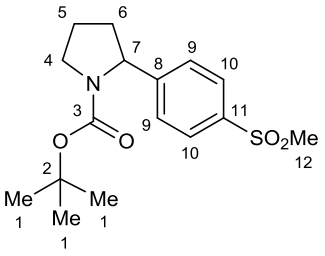


***tert*-Butyl-2-(4-acetylphenyl)pyrrolidine-1-carboxylate (15).** An 8 mL vial equipped with a magnetic stirring bar was charged with 4'-bromoacetophenone (100 mg, 0.50 mmol, 1.0 equiv.) and $Ir[dF(CF_3)ppy]_2(dtbbpy)PF_6$ (5.6 mg, 5.0 µmol, 1.0 mol%). Anhydrous DMSO (1.0 mL) and 3-acetoxyquinuclidine (85 µL, 0.55 mmol, 1.1 equiv.) were added. 4,7-Dimethoxy-1,10-phenanthroline (1.2 mg, 5.0 µmol, 1.0 mol%) and nickel(II) bromide trihydrate (1.4 mg, 5.0 µmol, 1.0 mol%) were added as a 0.50 M stock solution in anhydrous DMSO (1 mL, sonicated for 10 minutes before addition). *N*-Boc pyrrolidine (175 µL, 1.0 mmol, 2.0 equiv.) and water (360 µL, 20 mmol, 40 equiv.) were added before the mixture was degassed via two cycles of freeze-pump-backfill-thaw. The reaction was sealed and placed ~6 cm away from a 34 W blue LED and stirred for 12 h with cooling by fan. The reaction mixture was removed from the light, diluted with aq. $NaHCO_3$ and EtOAc, and the aqueous layer was extracted with three portions of EtOAc. The combined organic layers were dried over Na_2SO_4, filtered, and concentrated. The residue was purified by flash chromatography eluting with 15–25% EtOAc/hexanes to afford the title compound as a colorless oil (121 mg, 0.42 mmol, 84% yield, mixture of rotamers 3:1 A:B). ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.90 (d, J = 8.3 Hz, 4H, 2 × C(10)**H**, A+B), 7.26 (d, J = 8.1 Hz, 4H, 2 × C(9)**H**, A+B), 4.96 (br. m, 1H, C(7)**H**, B), 4.81 (br. m, 1H, C(7)**H**, A), 3.70–3.48 (br. m, 4H, C(4)$\mathbf{H_2}$, A+B), 2.59 (s, 6H, C(13)$\mathbf{H_3}$, A+B), 2.41–2.27 (br. m, 2H, C(6)$\mathbf{H}_a$, A+B), 1.94–1.84 (m, 4H, C(5)$\mathbf{H_2}$, A+B), 1.80 (dddd, J = 11.9, 6.0, 5.7, 5.7 Hz, 2H, C(6)$\mathbf{H}_b$, A+B), 1.47 (br. s, 9H, 3 × C(1)$\mathbf{H}_3$, B), 1.17 (br. s, 9H, 3 × C(1)$\mathbf{H}_3$, A). ^{13}C NMR (125 MHz, $CDCl_3$): δ 197.94 (A+B), 154.55 (A+B), 150.95 (A), 149.93 (B), 135.83 (A+B), 128.78 (B), 128.57 (A), 125.76 (A+B), 79.65 (A+B), 61.29 (A), 60.80 (B), 47.55 (B), 47.27 (A), 36.04 (A), 34.92 (B), 28.61 (B), 28.29 (A),

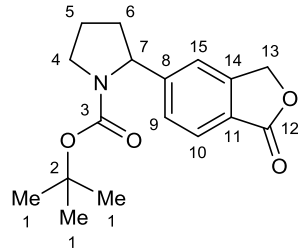
26.77 (A+B), 23.78 (B), 23.39 (A). The spectroscopic properties of this compound are consistent with data reported in the literature.[8]



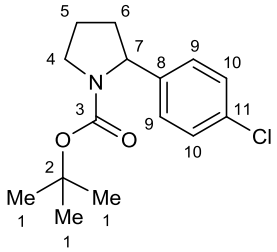
***tert*-Butyl-2-(3-fluoro-5-(trifluoromethyl)phenyl)pyrrolidine-1-carboxylate (16).** An 8 mL vial equipped with a magnetic stirring bar was charged with 1-bromo-3-fluoro-5-(trifluoromethyl)benzene (121 mg, 0.50 mmol, 1.0 equiv.) and Ir[dF(CF_3)ppy]$_2$(dtbbpy)PF_6 (5.6 mg, 5.0 µmol, 1.0 mol%). Anhydrous DMSO (1.0 mL) and 3-acetoxyquinuclidine (85 µL, 0.55 mmol, 1.1 equiv.) were added. 4,7-Dimethoxy-1,10-phenanthroline (1.2 mg, 5.0 µmol, 1.0 mol%) and nickel(II) bromide trihydrate (1.4 mg, 5.0 µmol, 1.0 mol%) were added as a 0.50 M stock solution in anhydrous DMSO (1 mL, sonicated for 10 minutes before addition). *N*-Boc pyrrolidine (175 µL, 1.0 mmol, 2.0 equiv.) and water (180 µL, 10 mmol, 20 equiv.) were added before the mixture was degassed via two cycles of freeze-pump-backfill-thaw. The reaction was sealed and placed ~6 cm away from a 34 W blue LED and stirred for 16 h with cooling by fan. The reaction mixture was removed from the light, diluted with aq. $NaHCO_3$ and EtOAc, and the aqueous layer was extracted with three portions of EtOAc. The combined organic layers were dried over Na_2SO_4, filtered, and concentrated. The residue was purified by flash chromatography eluting with 2% EtOAc/toluene to afford the title compound as a colorless oil (120 mg, 0.35 mmol, 71% yield, mixture of rotamers 1.75:1 A:B). ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.27–7.15 (br. m, 4H, C(13)**H** and C(11)**H**, A+B), 7.10 (d, J = 9.0 Hz, 2H, C(9)**H**, A+B), 4.98 (br. m, 1H, C(7)**H**, B), 4.80 (br. m, 1H, C(7)**H**, A), 3.72–3.50 (br. m, 4H, C(4)$\mathbf{H_2}$, A+B), 2.46–2.29 (br. m, 2H, C(6)$\mathbf{H}_a$, A+B), 1.99–1.76 (br. m, 6H, C(5)$\mathbf{H_2}$ and C(6)$\mathbf{H}_b$, A+B), 1.48 (br. s, 9H, 3 × C(1)$\mathbf{H_3}$, B), 1.22 (br. s, 9H, 3 × C(1)$\mathbf{H_3}$, A). ^{13}C NMR (125 MHz, $CDCl_3$): δ 162.68 (d, J = 249.1 Hz, A+B), 154.65 (B), 154.38 (A), 149.57 (A), 148.54 (B), 132.53 (q, J = 29.8 Hz, A+B), 123.45 (q, J = 272.7 Hz, A+B), 118.32 (A), 118.11 (B), 116.08 (d, J = 21.8 Hz, A+B), 111.10 (d, J = 24.8 Hz, A+B), 80.00 (A+B), 60.97 (A), 60.39 (B), 47.53 (B), 47.30 (A), 36.04 (A), 34.86 (B), 28.54 (B), 28.22 (A), 23.68 (B), 23.46 (A). ^{19}F NMR (282 MHz, $CDCl_3$): δ -62.77 (s, A+B), -111.12 (dd, J = 9.0, 9.0 Hz, A+B). IR (thin film): 3318, 2977, 1737, 1693, 1607, 1453, 1389, 1365,1348, 1251, 1229, 1162, 1125, 1091 cm^{-1}. HRMS (ESI-TOF) calculated for $C_{16}H_{19}F_4NO_2$ $[M+Na]^+$ requires m/z 356.1244, found 356.1244.



***tert*-Butyl-2-(4-(methylsulfonyl)phenyl)pyrrolidine-1-carboxylate (17).** An 8 mL vial equipped with a magnetic stirring bar was charged with 1-bromo-4-(methylsulfonyl)benzene (118 mg, 0.50 mmol, 1.0 equiv.) and $Ir[dF(CF_3)ppy]_2(dtbbpy)PF_6$ (5.6 mg, 5.0 μmol, 1.0 mol%). Anhydrous DMSO (1.0 mL) and 3-acetoxyquinuclidine (85 μL, 0.55 mmol, 1.1 equiv.) were added. 4,7-Dimethoxy-1,10-phenanthroline (1.2 mg, 5.0 μmol, 1.0 mol%) and nickel(II) bromide trihydrate (1.4 mg, 5.0 μmol, 1.0 mol%) were added as a 0.50 M stock solution in anhydrous DMSO (1 mL, sonicated for 10 minutes before addition). *N*-Boc pyrrolidine (175 μL, 1.0 mmol, 2.0 equiv.) and water (360 μL, 20 mmol, 40 equiv.) were added before the mixture was degassed via two cycles of freeze-pump-backfill-thaw. The reaction was sealed and placed ~6 cm away from a 34 W blue LED and stirred for 12 h with cooling by fan. The reaction mixture was removed from the light, diluted with aq. $NaHCO_3$ and EtOAc, and the aqueous layer was extracted with three portions of EtOAc. The combined organic layers were dried over Na_2SO_4, filtered, and concentrated. The residue was purified by flash chromatography eluting with 30% EtOAc/hexanes to afford the title compound as a white solid (127 mg, 0.39 mmol, 78% yield, mixture of rotamers 1.2:1 A:B). ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.88 (d, J = 8.1 Hz, 4H, 2 × C(10)**H**, A+B), 7.37 (d, J = 8.1 Hz, 4H, 2 × C(9)**H**, A+B), 4.99 (br. m, 1H, C(7)**H**, B), 4.84 (br. m, 1H, C(7)**H**, A), 3.70–3.51 (br. m, 4H, C(4)$\mathbf{H_2}$, A+B), 3.05 (s, 3H, C(12)$\mathbf{H_3}$, A), 3.03 (s, 3H, C(12)$\mathbf{H_3}$, B), 2.45–2.29 (br. m, 2H, C(6)$\mathbf{H}_a$, A+B), 1.95-1.73 (br. m, 6H, C(5)$\mathbf{H_2}$ and C(6)$\mathbf{H}_b$, A+B), 1.46 (br. s, 9H, 3 × C(1)$\mathbf{H_3}$, B), 1.18 (br. s, 9H, 3 × C(1)$\mathbf{H_3}$, A). ^{13}C NMR (125 MHz, $CDCl_3$): δ 154.70 (B), 154.40 (A), 151.88 (A), 150.86 (B), 138.89 (A+B), 127.84 (B), 127.57 (A), 126.54 (A), 126.43 (B), 80.00 (B), 79.90 (A), 61.18 (A), 60.71 (B), 47.63 (B), 47.31 (A), 44.74 (A+B), 36.08 (A), 34.97 (B), 28.60 (B), 28.29 (A), 23.75 (B), 23.38 (A). IR (thin film): 2997, 2973, 2921, 2874, 1685, 1597, 1478, 1451, 1393, 1363, 1303, 1284, 1244, 1212, 1145, 1116, 1088, 1077 cm^{-1}. HRMS (ESI-TOF) calculated for $C_{16}H_{23}NO_4S$ $[M+Na]^+$ requires m/z 348.1240, found 348.1244.

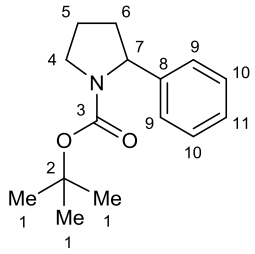


***tert*-Butyl-2-(1-oxo-1,3-dihydroisobenzofuran-5-yl)pyrrolidine-1-carboxylate (18).** An 8 mL vial equipped with a magnetic stirring bar was charged with 5-bromoisobenzofuran-1(3*H*)-one (107 mg, 0.50 mmol, 1.0 equiv.) and Ir[dF(CF_3)ppy]$_2$(dtbbpy)PF_6 (5.6 mg, 5.0 μmol, 1.0 mol%). Anhydrous DMSO (1.0 mL) and 3-acetoxyquinuclidine (85 μL, 0.55 mmol, 1.1 equiv.) were added. 4,7-Dimethoxy-1,10-phenanthroline (1.2 mg, 5.0 μmol, 1.0 mol%) and nickel(II) bromide trihydrate (1.4 mg, 5.0 μmol, 1.0 mol%) were added as a 0.50 M stock solution in anhydrous DMSO (1 mL, sonicated for 10 minutes before addition). *N*-Boc pyrrolidine (175 μL, 1.0 mmol, 2.0 equiv.) and water (360 μL, 20 mmol, 40 equiv.) were added before the mixture was degassed via two cycles of freeze-pump-backfill-thaw. The reaction was sealed and placed ~6 cm away from a 34 W blue LED and stirred for 18 h with cooling by fan. The reaction mixture was removed from the light, diluted with aq. $NaHCO_3$ and EtOAc, and the aqueous layer was extracted with three portions of EtOAc. The combined organic layers were dried over Na_2SO_4, filtered, and concentrated. The residue was purified by flash chromatography eluting with 15% EtOAc/toluene to afford the title compound as a white solid (115 mg, 0.38 mmol, 76% yield, mixture of rotamers 1.3:1 A:B). ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.85 (d, J = 7.9 Hz, 2H, C(10)**H**, A+B), 7.35 (br. d, J = 7.9 Hz, 2H, C(9)**H**, A+B), 7.29 (s, 2H, C(15)**H**, A+B), 5.28 (s, 4H, C(13)$\mathbf{H_2}$, A+B), 5.01 (br. m, 1H, C(7)**H**, B), 4.87 (br. m, 1H, C(7)**H**, A), 3.72–3.53 (br. m, 4H, C(4)$\mathbf{H_2}$, A+B), 2.46–2.31 (br. m, 2H, C(6)$\mathbf{H_a}$, A+B), 1.91 (dddd, J = 6.9, 6.9, 6.7, 6.7 Hz, 4H, C(5)$\mathbf{H_2}$, A+B), 1.86–1.76 (br. m, 2H, C(6)$\mathbf{H_b}$, A+B), 1.45 (br. s, 9H, 3 × C(1)$\mathbf{H_3}$, B), 1.16 (br. s, 9H, 3 × C(1)$\mathbf{H_3}$, A). ^{13}C NMR (125 MHz, $CDCl_3$): δ 171.07 (A+B), 154.69 (B), 154.38 (A), 152.78 (A), 151.77 (B), 147.29 (B), 147.11 (A), 126.95 (A), 126.67 (B), 126.05 (B), 125.85 (A), 124.45 (A+B), 119.06 (B), 118.90 (A), 80.00 (B), 79.85 (A), 69.72 (B), 69.65 (A), 61.51 (A), 61.13 (B), 47.70 (B), 47.36 (A), 36.22 (A), 35.15 (B), 28.60 (B), 28.29 (A), 23.88 (B), 23.44 (A). The spectroscopic properties of this compound are consistent with data reported in the literature.[45]



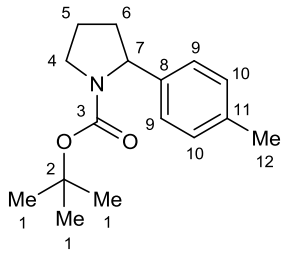
***tert*-Butyl-2-(4-chlorophenyl)pyrrolidine-1-carboxylate (19).** An 8 mL vial equipped with a magnetic stirring bar was charged with 1-bromo-4-chlorobenzene (96 mg, 0.50 mmol, 1.0 equiv.) and Ir[dF(CF_3)ppy]$_2$(dtbbpy)PF_6 (5.6 mg, 5.0 μmol, 1.0 mol%). Anhydrous DMSO (1.0 mL) and 3-acetoxyquinuclidine (85 μL, 0.55 mmol, 1.1 equiv.) were added. 4,7-Dimethoxy-1,10-phenanthroline (1.2 mg, 5.0 μmol, 1.0 mol%) and nickel(II) bromide trihydrate (1.4 mg, 5.0 μmol, 1.0 mol%) were added as a 0.50 M stock solution in anhydrous DMSO (1 mL, sonicated for 10 minutes before addition). *N*-Boc pyrrolidine (175 μL, 1.0 mmol, 2.0 equiv.) and water (360 μL, 20 mmol, 40 equiv.) were added before the mixture was degassed via two cycles of freeze-pump-

backfill-thaw. The reaction was sealed and placed ~6 cm away from a 34 W blue LED and stirred for 18 h with cooling by fan. The reaction mixture was removed from the light, diluted with aq. $NaHCO_3$ and EtOAc, and the aqueous layer was extracted with three portions of EtOAc. The combined organic layers were dried over Na_2SO_4, filtered, and concentrated. The residue was purified by flash chromatography eluting with 2% EtOAc/toluene to afford the title compound as a colorless oil (99 mg, 0.35 mmol, 70% yield, mixture of rotamers 1.9:1 A:B). ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.28–7.24 (m, 4H, 2 × C(10)**H**, A+B), 7.10 (br. d, J = 8.4 Hz, 4H, 2 × C(9)**H**, A+B), 4.89 (br. m, 1H, C(7)**H**, B), 4.73 (br. m, 1H, C(7)**H**, A), 3.67–3.44 (br. m, 4H, C(4)$\mathbf{H_2}$, A+B), 2.37–2.21 (br. m, 2H, C(6)$\mathbf{H}_a$, A+B), 1.94–1.81 (m, 4H, C(5)$\mathbf{H_2}$, A+B), 1.81–1.73 (dddd, J = 11.8, 5.9, 5.4, 5.4 Hz, 2H, C(6)$\mathbf{H}_b$, A+B), 1.44 (br. s, 9H, 3 × C(1)$\mathbf{H_3}$, B), 1.20 (br. s, 9H, 3 × C(1)$\mathbf{H_3}$, A). ^{13}C NMR (125 MHz, $CDCl_3$): δ 154.59 (A+B), 143.84 (A), 142.83 (B), 132.21 (A+B), 128.42 (A+B), 126.97 (A+B), 79.55 (A+B), 60.87 (A), 60.37 (B), 47.23 (A+B), 36.12 (A), 34.98 (B), 28.34 (A+B), 23.30 (A+B). The spectroscopic properties of this compound are consistent with data reported in the literature.[8]

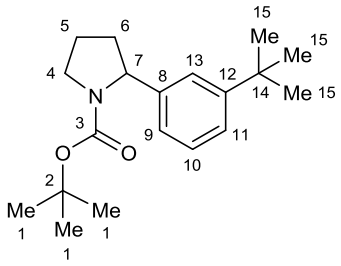


***tert*-Butyl-2-phenylpyrrolidine-1-carboxylate (20).** An 8 mL vial equipped with a magnetic stirring bar was charged with bromobenzene (79 mg, 0.50 mmol, 1.0 equiv.) and $Ir[dF(CF_3)ppy]_2(dtbbpy)PF_6$ (5.6 mg, 5.0 μmol, 1.0 mol%). Anhydrous DMSO (1.0 mL) and 3-acetoxyquinuclidine (85 μL, 0.55 mmol, 1.1 equiv.) were added. 4,7-Dimethoxy-1,10-phenanthroline (1.2 mg, 5.0 μmol, 1.0 mol%) and nickel(II) bromide trihydrate (1.4 mg, 5.0 μmol, 1.0 mol%) were added as a 0.50 M stock solution in anhydrous DMSO (1 mL, sonicated for 10 minutes before addition). *N*-Boc pyrrolidine (175 μL, 1.0 mmol, 2.0 equiv.) and water (360 μL, 20 mmol, 40 equiv.) were added before the mixture was degassed via two cycles of freeze-pump-backfill-thaw. The reaction was sealed and placed ~6 cm away from a 34 W blue LED and stirred for 18 h with cooling by fan. The reaction mixture was removed from the light, diluted with aq. $NaHCO_3$ and EtOAc, and the aqueous layer was extracted with three portions of EtOAc. The combined organic layers were dried over Na_2SO_4, filtered, and concentrated. The residue was purified by flash chromatography eluting with 2% EtOAc/toluene to afford the title compound as a waxy white solid (89 mg, 0.36 mmol, 72% yield, mixture of rotamers 2.2:1 A:B). ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.29 (dd, J = 7.6, 7.6 Hz, 4H, 2 × C(10)**H**, A+B), 7.23–7.13 (m, 6H, 2 × C(9)**H** and C(11)**H**, A+B), 4.96 (br. m, 1H, C(7)**H**, B), 4.75 (br. m, 1H, C(7)**H**, A), 3.70–3.45 (br. m, 4H, C(4)$\mathbf{H_2}$, A+B), 2.38–2.21 (br. m, 2H, C(6)$\mathbf{H}_a$, A+B), 1.97–1.75 (m, 6H, C(5)$\mathbf{H_2}$ and C(6)$\mathbf{H}_b$, A+B), 1.45 (br. s, 9H, 3 × C(1)$\mathbf{H_3}$, B), 1.17 (br. s, 9H, 3 × C(1)$\mathbf{H_3}$, A). ^{13}C NMR (125 MHz, $CDCl_3$): δ

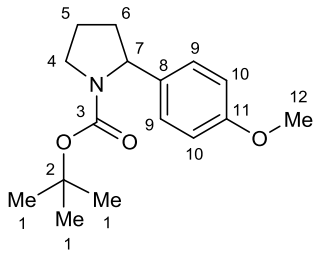
154.72 (A+B), 145.27 (A), 144.16 (B), 128.44 (B), 128.23 (A), 126.59 (A+B), 125.64 (A), 125.47 (B), 79.30 (A+B), 61.47 (A), 60.77 (B), 47.45 (B), 47.22 (A), 36.16 (A), 34.95 (B), 28.65 (B), 28.27 (A), 23.57 (B), 23.33 (A). The spectroscopic properties of this compound are consistent with data reported in the literature.[46]



***tert*-Butyl-2-(*p*-tolyl)pyrrolidine-1-carboxylate (21).** An 8 mL vial equipped with a magnetic stirring bar was charged with 1-bromo-4-methylbenzene (86 mg, 0.50 mmol, 1.0 equiv.) and $Ir[dF(CF_3)ppy]_2(dtbbpy)PF_6$ (5.6 mg, 5.0 μmol, 1.0 mol%). Anhydrous DMSO (1.0 mL) and 3-acetoxyquinuclidine (85 μL, 0.55 mmol, 1.1 equiv.) were added. 4,7-Dimethoxy-1,10-phenanthroline (1.2 mg, 5.0 μmol, 1.0 mol%) and nickel(II) bromide trihydrate (1.4 mg, 5.0 μmol, 1.0 mol%) were added as a 0.50 M stock solution in anhydrous DMSO (1 mL, sonicated for 10 minutes before addition). *N*-Boc pyrrolidine (175 μL, 1.0 mmol, 2.0 equiv.) and water (360 μL, 20 mmol, 40 equiv.) were added before the mixture was degassed via two cycles of freeze-pump-backfill-thaw. The reaction was sealed and placed ~6 cm away from a 34 W blue LED and stirred for 20 h with cooling by fan. The reaction mixture was removed from the light, diluted with aq. $NaHCO_3$ and EtOAc, and the aqueous layer was extracted with three portions of EtOAc. The combined organic layers were dried over Na_2SO_4, filtered, and concentrated. The residue was purified by flash chromatography eluting with 2% EtOAc/toluene to afford the title compound as a white solid (95 mg, 0.36 mmol, 73% yield, mixture of rotamers 2:1 A:B). ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.13–7.01 (m, 8H, 2 × C(9)**H** and 2 × C(10)**H**, A+B), 4.92 (br. m, 1H, C(7)**H**, B), 4.74 (br. m, 1H, C(7)**H**, A), 3.67–3.43 (br. m, 4H, C(4)$\mathbf{H_2}$, A+B), 2.37–2.20 (br. m, 8H, C(12)$\mathbf{H_3}$ and C(6)$\mathbf{H}_a$, A+B), 1.95–1.74 (m, 6H, C(5)$\mathbf{H_2}$ and C(6)$\mathbf{H}_b$, A+B), 1.45 (br. s, 9H, 3 × C(1)$\mathbf{H_3}$, B), 1.19 (br. s, 9H, 3 × C(1)$\mathbf{H_3}$, A). ^{13}C NMR (125 MHz, $CDCl_3$): δ 154.77 (A), 154.61 (B), 142.18 (A), 141.23 (B), 136.04 (A+B), 129.15 (B), 128.85 (A), 125.54 (A), 125.39 (B), 79.22 (A+B), 61.14 (A), 60.56 (B), 47.42 (B), 47.12 (A), 36.14 (A), 35.02 (B), 28.65 (B), 28.32 (A), 23.59 (B), 23.23 (A), 21.17 (A+B). The spectroscopic properties of this compound are consistent with data reported in the literature.[46]

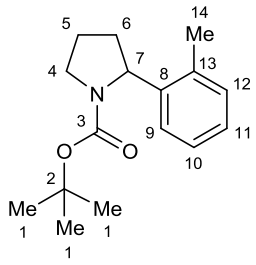


***tert*-Butyl-2-(3-(*tert*-butyl)phenyl)pyrrolidine-1-carboxylate (22).** An 8 mL vial equipped with a magnetic stirring bar was charged with 1-bromo-3-(*tert*-butyl)benzene (107 mg, 0.50 mmol, 1.0 equiv.) and $Ir[dF(CF_3)ppy]_2(dtbbpy)PF_6$ (5.6 mg, 5.0 μmol, 1.0 mol%). Anhydrous DMSO (1.0 mL) and 3-acetoxyquinuclidine (85 μL, 0.55 mmol, 1.1 equiv.) were added. 4,7-Dimethoxy-1,10-phenanthroline (1.2 mg, 5.0 μmol, 1.0 mol%) and nickel(II) bromide trihydrate (1.4 mg, 5.0 μmol, 1.0 mol%) were added as a 0.50 M stock solution in anhydrous DMSO (1 mL, sonicated for 10 minutes before addition). *N*-Boc pyrrolidine (175 μL, 1.0 mmol, 2.0 equiv.) and water (360 μL, 20 mmol, 40 equiv.) were added before the mixture was degassed via two cycles of freeze-pump-backfill-thaw. The reaction was sealed and placed ~6 cm away from a 34 W blue LED and stirred for 16 h with cooling by fan. The reaction mixture was removed from the light, diluted with aq. $NaHCO_3$ and EtOAc, and the aqueous layer was extracted with three portions of EtOAc. The combined organic layers were dried over Na_2SO_4, filtered, and concentrated. The residue was purified by flash chromatography eluting with 2% EtOAc/toluene to afford the title compound as a colorless oil (120 mg, 0.40 mmol, 79% yield, rotameric). ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.25–7.20 (m, 2H, C(10)**H** and C(11)**H**), 7.16 (br. m, 1H, C(13)**H**), 6.97 (m, 1H, C(9)**H**), 4.75 (br. m, 1H, C(7)**H**), 3.71–3.44 (br. m, 2H, C(4)$\mathbf{H_2}$), 2.30 (br. m, 1H, C(6)$\mathbf{H}_a$), 1.99–1.77 (br. m, 3H, C(5)$\mathbf{H_2}$ and C(6)$\mathbf{H}_b$), 1.59–0.98 (br. m, 18H, 3 × C(1)$\mathbf{H_3}$ and 3 × C(15)$\mathbf{H_3}$).^{13}C NMR (125 MHz, $CDCl_3$): δ 154.71, 151.03, 145.00, 127.97, 123.51, 122.68, 122.54, 79.19, 61.81, 47.31, 36.27, 34.73, 31.52, 28.37, 23.44. IR (thin film): 2965, 2817, 1692, 1605, 1478, 1454, 1389, 1364, 1250, 1159, 1111, 1079 cm^{-1}. HRMS (ESI-TOF) calculated for $C_{19}H_{29}NO_2$ $[M+H]^+$ requires m/z 304.2271, found 304.2266.



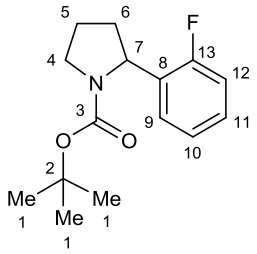
***tert*-Butyl-2-(4-methoxyphenyl)pyrrolidine-1-carboxylate (23).** An 8 mL vial equipped with a magnetic stirring bar was charged with 4-bromoanisole (94 mg, 0.50 mmol, 1.0 equiv.) and $Ir[dF(CF_3)ppy]_2(dtbbpy)PF_6$ (5.6 mg, 5.0 μmol, 1.0 mol%). Anhydrous DMSO (1.0 mL) and 3-acetoxyquinuclidine (85 μL, 0.55 mmol, 1.1 equiv.) were added. 4,7-Dimethoxy-1,10-phenanthroline (1.2 mg, 5.0 μmol, 1.0 mol%) and nickel(II) bromide trihydrate (1.4 mg, 5.0 μmol,

1.0 mol%) were added as a 0.50 M stock solution in anhydrous DMSO (1 mL, sonicated for 10 minutes before addition). *N*-Boc pyrrolidine (175 µL, 1.0 mmol, 2.0 equiv.) and water (360 µL, 20 mmol, 40 equiv.) were added before the mixture was degassed via two cycles of freeze-pump-backfill-thaw. The reaction was sealed and placed ~6 cm away from a 34 W blue LED and stirred for 24 h with cooling by fan. The reaction mixture was removed from the light, diluted with aq. $NaHCO_3$ and EtOAc, and the aqueous layer was extracted with three portions of EtOAc. The combined organic layers were dried over Na_2SO_4, filtered, and concentrated. The residue was purified by flash chromatography eluting with 5% EtOAc/hexanes to afford the title compound as a colorless oil (89 mg, 0.32 mmol, 64% yield, mixture of rotamers 2:1 A:B). ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.08 (d, *J* = 8.3 Hz, 4H, 2 × C(9)**H,** A+B), 6.83 (d, *J* = 8.3 Hz, 4H, 2 × C(10)**H,** A+B), 4.90 (br. m, 1H, C(7)**H**, B), 4.71 (br. m, 1H, C(7)**H**, A), 3.79 (s, 6H, C(12)$\mathbf{H_3}$, A+B), 3.66–3.42 (br. m, 4H, C(4)$\mathbf{H_2}$, A+B), 2.34–2.17 (br. m, 2H, C(6)$\mathbf{H}_a$, A+B), 1.95–1.74 (m, 6H, C(5)$\mathbf{H_2}$ and C(6)$\mathbf{H}_b$, A+B), 1.45 (br. s, 9H, 3 × C(1)$\mathbf{H_3}$, B), 1.20 (br. s, 9H, 3 × C(1)$\mathbf{H_3}$, A). ^{13}C NMR (125 MHz, $CDCl_3$): δ 158.34 (A+B), 154.78 (A+B), 137.43 (A), 136.40 (B), 126.72 (A+B), 113.88 (B), 113.56 (A), 79.25 (A+B), 60.86 (A), 60.25 (B), 55.40 (A+B), 47.39 (B), 47.12 (A), 36.19 (A), 35.01 (B), 28.65 (B), 28.35 (A), 23.59 (B), 23.27 (A). The spectroscopic properties of this compound are consistent with data reported in the literature.[46]

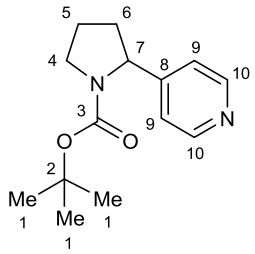


***tert*-Butyl-2-(*o*-tolyl)pyrrolidine-1-carboxylate (24).** An 8 mL vial equipped with a magnetic stirring bar was charged with 1-bromo-2-methylbenzene (86 mg, 0.50 mmol, 1.0 equiv.) and $Ir[dF(CF_3)ppy]_2(dtbbpy)PF_6$ (5.6 mg, 5.0 µmol, 1.0 mol%). Anhydrous DMSO (1.0 mL) and 3-acetoxyquinuclidine (85 µL, 0.55 mmol, 1.1 equiv.) were added. 4,7-Dimethoxy-1,10-phenanthroline (1.2 mg, 5.0 µmol, 1.0 mol%) and nickel(II) bromide trihydrate (1.4 mg, 5.0 µmol, 1.0 mol%) were added as a 0.50 M stock solution in anhydrous DMSO (1 mL, sonicated for 10 minutes before addition). *N*-Boc pyrrolidine (175 µL, 1.0 mmol, 2.0 equiv.) and water (360 µL, 20 mmol, 40 equiv.) were added before the mixture was degassed via two cycles of freeze-pump-backfill-thaw. The reaction was sealed and placed ~6 cm away from a 34 W blue LED and stirred for 32 h with cooling by fan. The reaction mixture was removed from the light, diluted with aq. $NaHCO_3$ and EtOAc, and the aqueous layer was extracted with three portions of EtOAc. The combined organic layers were dried over Na_2SO_4, filtered, and concentrated. The residue was purified by flash chromatography eluting with 2% EtOAc/toluene to afford the title compound as a colorless oil (91 mg, 0.35 mmol, 70% yield, mixture of rotamers 2.1:1 A:B). ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.17–6.98 (m, 8H, C(9)**H**, C(10)**H**, C(11)**H** and C(12)**H**, A+B), 5.13 (br. m, 1H, C(7)**H**,

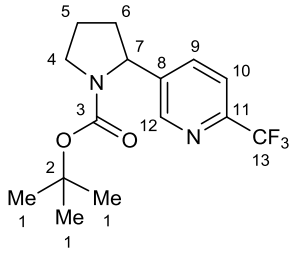
B), 4.96 (br. m, 1H, C(7)**H**, A), 3.73–3.45 (br. m, 4H, C(4)$\mathbf{H_2}$, A+B), 2.38–2.20 (br. m, 8H, C(14)$\mathbf{H_3}$ and C(6)$\mathbf{H}_a$, A+B), 2.00–1.79 (m, 4H, C(5)$\mathbf{H_2}$, A+B), 1.77–1.64 (m, 2H, C(6)$\mathbf{H}_b$, A+B), 1.46 (br. s, 9H, 3 × C(1)$\mathbf{H_3}$, B), 1.14 (br. s, 9H, 3 × C(1)$\mathbf{H_3}$, A). ^{13}C NMR (125 MHz, $CDCl_3$): δ 154.54 (A+B), 143.36 (A), 142.01 (B), 134.20 (B), 133.96 (A), 130.67 (B), 130.08 (A), 126.55 (B), 126.36 (A), 126.02 (A), 125.91 (B), 124.56 (A), 124.03 (B), 79.35 (B), 79.13 (A), 58.17 (A+B), 47.53 (B), 47.22 (A), 34.27 (A), 32.99 (B), 28.67 (B), 28.20 (A), 23.27 (A+B), 19.39 (A+B). The spectroscopic properties of this compound are consistent with data reported in the literature.[46]



***tert*-Butyl-2-(2-fluorophenyl)pyrrolidine-1-carboxylate (25).** An 8 mL vial equipped with a magnetic stirring bar was charged with 1-bromo-2-fluorobenzene (87 mg, 0.50 mmol, 1.0 equiv.) and Ir[dF(CF_3)ppy]$_2$(dtbbpy)PF_6 (5.6 mg, 5.0 μmol, 1.0 mol%). Anhydrous DMSO (1.0 mL) and 3-acetoxyquinuclidine (85 μL, 0.55 mmol, 1.1 equiv.) were added. 4,7-Dimethoxy-1,10-phenanthroline (1.2 mg, 5.0 μmol, 1.0 mol%) and nickel(II) bromide trihydrate (1.4 mg, 5.0 μmol, 1.0 mol%) were added as a 0.50 M stock solution in anhydrous DMSO (1 mL, sonicated for 10 minutes before addition). *N*-Boc pyrrolidine (175 μL, 1.0 mmol, 2.0 equiv.) and water (360 μL, 20 mmol, 40 equiv.) were added before the mixture was degassed via two cycles of freeze-pump-backfill-thaw. The reaction was sealed and placed ~6 cm away from a 34 W blue LED and stirred for 24 h with cooling by fan. The reaction mixture was removed from the light, diluted with aq. $NaHCO_3$ and EtOAc, and the aqueous layer was extracted with three portions of EtOAc. The combined organic layers were dried over Na_2SO_4, filtered, and concentrated. The residue was purified by flash chromatography eluting with 2% EtOAc/toluene to afford the title compound as a colorless oil (79 mg, 0.30 mmol, 60% yield, mixture of rotamers A(major):B(minor)). ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.22–7.03 (m, 6H, C(9)**H**, C(10)**H** and C(11)**H**, A+B), 6.99 (dd, *J* = 10.2, 8.5 Hz, 2H, C(12)**H**, A+B), 5.27–4.96 (br. m, 2H, C(7)**H**, A+B), 3.69–3.42 (br. m, 4H, C(4)$\mathbf{H_2}$, A+B), 2.41–2.24 (br. m, 2H, C(6)$\mathbf{H}_a$, A+B), 1.95–1.78 (br. m, 6H, C(5)$\mathbf{H_2}$ and C(6)$\mathbf{H}_b$, A+B), 1.45 (br. s, 9H, 3 × C(1)$\mathbf{H_3}$, B), 1.19 (br. s, 9H, 3 × C(1)$\mathbf{H_3}$, A). ^{13}C NMR (125 MHz, $CDCl_3$): δ 159.95 (d, *J* = 245.2 Hz, A+B), 154.47 (A+B), 131.89 (A), 130.91 (B), 128.13 (d, *J* = 8.1 Hz, A+B), 127.03 (A), 126.70 (B), 123.86 (d, *J* = 3.4 Hz, A+B), 115.21 (d, *J* = 22.2 Hz, A+B), 79.45 (A+B), 55.37 (A+B), 47.00 (A+B), 34.58 (A), 33.50 (B), 28.25 (A+B), 23.46 (A+B). ^{19}F NMR (282 MHz, $CDCl_3$): δ -118.66 (br. s, B), -119.96 (br. s, A). IR (thin film): 2975, 2878, 1692, 1588, 1486, 1457, 1388, 1364, 1274, 1245, 1223, 1158, 1115, 1096, 1080 cm^{-1}. HRMS (ESI-TOF) calculated for $C_{15}H_{20}FNO_2$ $[M+Na]^+$ requires m/z 288.1370, found 288.1371.

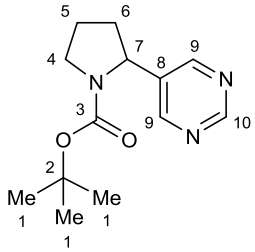


***tert*-Butyl-2-(pyridin-4-yl)pyrrolidine-1-carboxylate (26).** An 8 mL vial equipped with a magnetic stirring bar was charged with 4-bromopyridine.HCl (97 mg, 0.50 mmol, 1.0 equiv.) and Ir[dF(CF_3)ppy]$_2$(dtbbpy)PF_6 (5.6 mg, 5.0 μmol, 1.0 mol%). Anhydrous DMSO (3.0 mL) and 3-acetoxyquinuclidine (162 μL, 1.05 mmol, 2.1 equiv.) were added. 4,7-Dimethoxy-1,10-phenanthroline (1.2 mg, 5.0 μmol, 1.0 mol%) and nickel(II) bromide trihydrate (1.4 mg, 5.0 μmol, 1.0 mol%) were added as a 0.50 M stock solution in anhydrous DMSO (1 mL, sonicated for 10 minutes before addition). *N*-Boc pyrrolidine (175 μL, 1.0 mmol, 2.0 equiv.) and water (901 μL, 50 mmol, 100 equiv.) were added before the mixture was degassed via two cycles of freeze-pump-backfill-thaw. The reaction was sealed and placed ~6 cm away from a 34 W blue LED and stirred for 8 h with cooling by fan. The reaction mixture was removed from the light, diluted with aq. $NaHCO_3$ and EtOAc, and the aqueous layer was extracted with three portions of EtOAc. The combined organic layers were dried over Na_2SO_4, filtered, and concentrated. The residue was purified by flash chromatography eluting with 66% EtOAc/hexane to afford the title compound as a pale yellow oil (81 mg, 0.33 mmol, 65% yield, mixture of rotamers 1.8:1 A:B). ^{1}H NMR (500 MHz, $CDCl_3$): δ 8.58–8.44 (br. m, 4H, 2 × C(10)**H**, A+B), 7.10 (d, *J* = 5.8 Hz, 4H, 2 × C(9)**H**, A+B), 4.90 (br. m, 1H, C(7)**H**, B), 4.73 (dd, *J* = 8.1, 4.6 Hz, 1H, C(7)**H**, A), 3.69–3.45 (m, 4H, C(4)$\mathbf{H_2}$, A+B), 2.42–2.25 (m, 2H, C(6)$\mathbf{H}_a$, A+B), 1.92–1.83 (m, 4H, C(5)$\mathbf{H_2}$, A+B), 1.83–1.74 (m, 2H, C(6)$\mathbf{H}_b$, A+B), 1.45 (br. s, 9H, 3 × C(1)$\mathbf{H_3}$, B), 1.19 (br. s, 9H, 3 × C(1)$\mathbf{H_3}$, A). ^{13}C NMR (125 MHz, $CDCl_3$): δ 154.60 (A+B), 154.34 (A), 154.32 (B), 149.78 (A+B), 120.87 (A+B), 79.90 (A+B), 60.61 (A), 60.06 (B), 47.47 (B), 47.23 (A), 35.64 (A), 34.44 (B), 28.59 (B), 28.24 (A), 23.75 (B), 23.35 (A). The spectroscopic properties of this compound are consistent with data reported in the literature.[45]



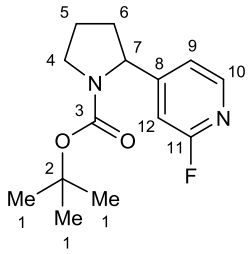
***tert*-Butyl-2-(6-(trifluoromethyl)pyridin-3-yl)pyrrolidine-1-carboxylate (27).** An 8 mL vial equipped with a magnetic stirring bar was charged with 5-chloro-2-(trifluoromethyl)pyridine (91

mg, 0.50 mmol, 1.0 equiv.) and $Ir[dF(CF_3)ppy]_2(dtbbpy)PF_6$ (5.6 mg, 5.0 μmol, 1.0 mol%). Anhydrous DMSO (1.0 mL) and 3-acetoxyquinuclidine (85 μL, 0.55 mmol, 1.1 equiv.) were added. 4,7-Dimethoxy-1,10-phenanthroline (1.2 mg, 5.0 μmol, 1.0 mol%) and nickel(II) bromide trihydrate (1.4 mg, 5.0 μmol, 1.0 mol%) were added as a 0.50 M stock solution in anhydrous DMSO (1 mL, sonicated for 10 minutes before addition). *N*-Boc pyrrolidine (175 μL, 1.0 mmol, 2.0 equiv.) and water (18 μL, 1.00 mmol, 2 equiv.) were added before the mixture was degassed via two cycles of freeze-pump-backfill-thaw. The reaction was sealed and placed ~6 cm away from a 34 W blue LED and stirred for 4 h with cooling by fan. The reaction mixture was removed from the light, diluted with aq. $NaHCO_3$ and EtOAc, and the aqueous layer was extracted with three portions of EtOAc. The combined organic layers were dried over Na_2SO_4, filtered, and concentrated. The residue was purified by flash chromatography eluting with 3% EtOAc/hexanes to afford the title compound as a white solid (128 mg, 0.41 mmol, 81% yield, mixture of rotamers 1.3:1 A:B). ^{1}H NMR (500 MHz, $CDCl_3$): δ 8.56 (br. s, 2H, C(12)**H**, A+B), 7.69–7.58 (m, 4H, C(9)**H** and C(10)**H**, A+B), 4.99 (br. m, 1H, C(7)**H**, B), 4.85 (br. m, 1H, C(7)**H**, A), 3.70–3.50 (m, 4H, C(4)$\mathbf{H_2}$, A+B), 2.46–2.31 (m, 2H, C(6)$\mathbf{H}_a$, A+B), 1.97–1.75 (m, 6H, C(5)$\mathbf{H_2}$ and C(6)$\mathbf{H}_b$, A+B), 1.44 (br. s, 9H, 3 × C(1)$\mathbf{H_3}$, B), 1.18 (br. s, 9H, 3 × C(1)$\mathbf{H_3}$, A). ^{13}C NMR (125 MHz, $CDCl_3$): δ 154.60 (B), 154.21 (A), 148.18 (A), 147.85 (B), 146.80 (q, J = 35.8 Hz, A), 146.69 (q, J = 35.1 Hz, B), 143.89 (A), 142.89 (B), 134.49 (B), 134.29 (A), 121.71 (q, J = 273.8 Hz, A+B), 120.30 (B), 120.15 (A), 80.15 (A+B), 59.05 (A), 58.72 (B), 47.49 (B), 47.27 (A), 35.97 (A), 34.70 (B), 28.53 (B), 28.26 (A), 23.80 (B), 23.44 (A). ^{19}F NMR (282 MHz, $CDCl_3$): δ -67.71 (br. s, A+B). The spectroscopic properties of this compound are consistent with data reported in the literature.[8]



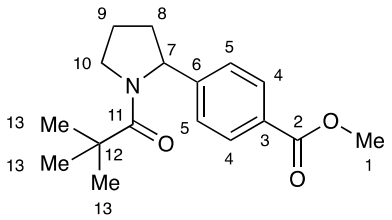
***tert*-Butyl-2-(pyrimidin-5-yl)pyrrolidine-1-carboxylate (28).** An 8 mL vial equipped with a magnetic stirring bar was charged with 5-chloropyrimidine (57 mg, 0.50 mmol, 1.0 equiv.) and $Ir[dF(CF_3)ppy]_2(dtbbpy)PF_6$ (5.6 mg, 5.0 μmol, 1.0 mol%). Anhydrous DMSO (1.0 mL) and 3-acetoxyquinuclidine (85 μL, 0.55 mmol, 1.1 equiv.) were added. 4,7-Dimethoxy-1,10-phenanthroline (1.2 mg, 5.0 μmol, 1.0 mol%) and nickel(II) bromide trihydrate (1.4 mg, 5.0 μmol, 1.0 mol%) were added as a 0.50 M stock solution in anhydrous DMSO (1 mL, sonicated for 10 minutes before addition). *N*-Boc pyrrolidine (175 μL, 1.0 mmol, 2.0 equiv.) was added before the mixture was degassed via two cycles of freeze-pump-backfill-thaw. The reaction was sealed and placed ~6 cm away from a 34 W blue LED and stirred for 4 h with cooling by fan. The reaction mixture was removed from the light, diluted with aq. $NaHCO_3$ and EtOAc, and the aqueous layer

was extracted with three portions of EtOAc. The combined organic layers were dried over Na_2SO_4, filtered, and concentrated. The residue was purified by flash chromatography eluting with 80-100% Et_2O/hexanes to afford the title compound as a pale yellow solid (76 mg, 0.31 mmol, 61% yield, mixture of rotamers 1.4:1 A:B). ^{1}H NMR (500 MHz, $CDCl_3$): δ 9.10 (br. s, 2H, C(10)**H**, A+B), 8.58 (br. s, 4H, 2 × C(9)**H**, A+B), 4.93 (br. m, 1H, C(7)**H**, B), 4.75 (br. m, 1H, C(7)**H**, A), 3.71–3.47 (br. m, 4H, C(4)$\mathbf{H_2}$, A+B), 2.47–2.30 (br. m, 2H, C(6)$\mathbf{H}_a$, A+B), 2.01–1.78 (br. m, 6H, C(5)$\mathbf{H_2}$ and C(6)$\mathbf{H}_b$, A+B), 1.44 (br. s, 9H, 3 × C(1)$\mathbf{H_3}$, B), 1.21 (br. s, 9H, 3 × C(1)$\mathbf{H_3}$, A). ^{13}C NMR (125 MHz, $CDCl_3$): δ 157.52 (A), 157.39 (B), 154.78 (A+B), 154.57 (B), 154.13 (A), 137.94, (A), 136.99 (B), 80.28 (A+B), 57.44 (A), 56.97 (B), 47.37 (B), 47.23 (A), 35.76 (A), 34.38 (B), 28.54 (B), 28.32 (A), 23.89 (B), 23.55 (A). IR (thin film): 2977, 1739, 1688, 1565, 1478, 1447, 1400, 1367, 1344, 1253, 1230, 1217, 1198, 1160, 1118, 1107 cm^{-1}. HRMS (ESI-TOF) calculated for $C_{13}H_{19}N_3O_2$ $[M+H]^+$ requires m/z 250.1550, found 250.1547.

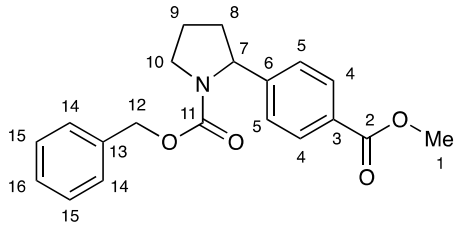


***tert*-Butyl-2-(2-fluoropyridin-4-yl)pyrrolidine-1-carboxylate (29).** An 8 mL vial equipped with a magnetic stirring bar was charged with 4-chloro-2-fluoropyridine (66 mg, 0.50 mmol, 1.0 equiv.) and $Ir[dF(CF_3)ppy]_2(dtbbpy)PF_6$ (5.6 mg, 5.0 μmol, 1.0 mol%). Anhydrous DMSO (1.0 mL) and 3-acetoxyquinuclidine (85 μL, 0.55 mmol, 1.1 equiv.) were added. 4,7-Dimethoxy-1,10-phenanthroline (1.2 mg, 5.0 μmol, 1.0 mol%) and nickel(II) bromide trihydrate (1.4 mg, 5.0 μmol, 1.0 mol%) were added as a 0.50 M stock solution in anhydrous DMSO (1 mL, sonicated for 10 minutes before addition). *N*-Boc pyrrolidine (175 μL, 1.0 mmol, 2.0 equiv.) was added before the mixture was degassed via two cycles of freeze-pump-backfill-thaw. The reaction was sealed and placed ~6 cm away from a 34 W blue LED and stirred for 5 h with cooling by fan. The reaction mixture was removed from the light, diluted with aq. $NaHCO_3$ and EtOAc, and the aqueous layer was extracted with three portions of EtOAc. The combined organic layers were dried over Na_2SO_4, filtered, and concentrated. The residue was purified by flash chromatography eluting with 10% EtOAc/hexanes to afford the title compound as a colorless oil (111 mg, 0.42 mmol, 83% yield, mixture of rotamers 1.5:1 A:B). ^{1}H NMR (500 MHz, $CDCl_3$): δ 8.17–8.09 (br. m, 2H, C(10)**H**, A+B), 7.00 (d, J = 4.9 Hz, 2H, C(9)**H**, A+B), 6.73 (s, 2H, C(12)**H**, A+B), 4.92 (br. m, 1H, C(7)**H**, B), 4.76 (br. m, 1H, C(7)**H**, A), 3.68–3.46 (br. m, 4H, C(4)$\mathbf{H_2}$, A+B), 2.43–2.27 (br. m, 2H, C(6)$\mathbf{H}_a$, A+B), 1.95–1.75 (br. m, 6H, C(5)$\mathbf{H_2}$ and C(6)$\mathbf{H}_b$, A+B), 1.45 (br. s, 9H, 3 × C(1)$\mathbf{H_3}$, B), 1.22 (br. s, 9H, 3 × C(1)$\mathbf{H_3}$, A). ^{13}C NMR (125 MHz, $CDCl_3$): δ 164.28 (d, J = 237.9 Hz, A+B), 160.60 (d, J = 7.5 Hz, A), 159.55 (d, J = 9.0 Hz, B), 154.62 (B), 154.22 (A), 147.69 (d, J = 14.8 Hz, A+B), 118.73 (B), 118.63 (A), 106.34 (d, J = 37.9 Hz, A+B), 80.17 (A+B), 60.43 (A), 59.96

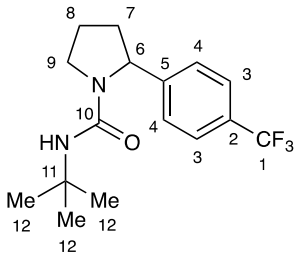
(B), 47.48 (B), 47.22 (A), 35.54 (A), 34.37 (B), 28.57 (B), 28.27 (A), 23.82 (B), 23.38 (A). ^{19}F NMR (282 MHz, $CDCl_3$): δ -68.48 (br. s, A+B). IR (thin film): 2976, 2880, 1691, 1610, 1572, 1479, 1454, 1387, 1365, 1279, 1256, 1160, 1143, 1109, 1080 cm^{-1}. HRMS (ESI-TOF) calculated for $C_{14}H_{19}FN_2O_2$ $[M+H]^+$ requires m/z 267.1503, found 267.1504.



Methyl 4-(1-pivaloylpyrrolidin-2-yl)benzoate (30). An 8 mL vial equipped with a magnetic stirring bar was charged with 2,2-dimethyl-1-(pyrrolidin-1-yl)propan-1-one (155 mg, 1.0 mmol, 2.0 equiv.), methyl 4-bromobenzoate (108 mg, 0.50 mmol, 1.0 equiv.), and $Ir[dF(CF_3)ppy]_2(dtbbpy)PF_6$ (5.6 mg, 5.0 μmol, 1.0 mol%). 3-acetoxyquinuclidine (85 μL, 0.55 mmol, 1.1 equiv.) and anhydrous DMSO (1.0 mL) were added. 4,7-Dimethoxy-1,10-phenanthroline (1.2 mg, 5.0 μmol, 1.0 mol%) and nickel(II) bromide trihydrate (1.4 mg, 5.0 μmol, 1.0 mol%) were added as a 0.50 M stock solution in anhydrous DMSO (1.0 mL, sonicated for 10 minutes before addition). Water (450 μL, 25 mmol, 50 equiv.) was added before the mixture was degassed via two cycles of freeze-pump-backfill-thaw. The reaction was sealed, placed ~6 cm away from a 34 W blue LED, and stirred for 12 h with cooling by fan. The reaction mixture was removed from the light, diluted with aq. $NaHCO_3$ and EtOAc, and the aqueous layer was extracted with three portions of EtOAc. The combined organic layers were dried over Na_2SO_4, filtered, and concentrated. The residue was purified by flash chromatography eluting with 10% EtOAc/hexanes to afford the title compound as a white solid (115 mg, 0.40 mmol, 79% yield, rotameric). ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.96 (d, *J*=8.1 Hz, 2H, 2 × C(4)**H**), 7.19 (d, *J*=8.1 Hz, 2H, 2 × C(5)**H**), 5.22 (br m, 1H, C(7)**H**), 3.88 (s, 3H, C(1)$\mathbf{H_3}$), 3.86 (br m, 2H, C(10)$\mathbf{H_2}$), 2.26 (dddd, *J*=12.5, 8.0, 8.0, 8.0 Hz, 1H, C(8)$\mathbf{H_a}$), 1.99 (br m, 1H, C(9)$\mathbf{H_a}$), 1.93 (br m, 1H, C(9)$\mathbf{H_b}$), 1.73 (br m, 1H, C(8)$\mathbf{H_b}$), 1.27 (br s, 9H, 3 × C(13)$\mathbf{H_3}$). ^{13}C NMR (125 MHz, $CDCl_3$): δ 176.57, 167.10, 150.00, 130.01, 128.57, 125.27, 62.76, 52.13, 49.01, 39.31, 33.34, 27.64, 25.49. IR (thin film): 2962, 2880, 1715, 1613, 1509, 1482, 1417, 1428, 1403, 1360, 1311, 1285, 1231, 1203, 1192, 1174, 1165, 1149, 1115, 1103, 1033, 1019 cm^{-1}. HRMS (ESI-TOF) calculated for $C_{17}H_{23}NO_3$ $[M+H]^+$ requires m/z 290.1751, found 290.1748.



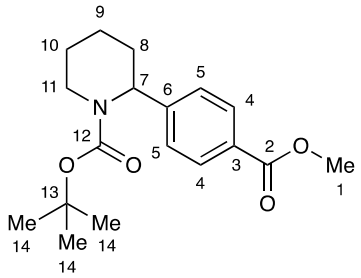
Benzyl 2-(4-(methoxycarbonyl)phenyl)pyrrolidine-1-carboxylate (31). An 8 mL vial equipped with a magnetic stirring bar was charged with benzyl pyrrolidine-1-carboxylate (205 mg, 1.0 mmol, 2.0 equiv.), and methyl 4-bromobenzoate (108 mg, 0.50 mmol, 1.0 equiv.). $Ir[dF(CF_3)ppy]_2(dtbbpy)PF_6$ (5.6 mg, 5.0 μmol, 1.0 mol%) was added as a 0.50 M stock solution in anhydrous DMSO (1.0 mL) and 3-acetoxyquinuclidine (85 μL, 0.55 mmol, 1.1 equiv.) was added. 4,7-Dimethoxy-1,10-phenanthroline (1.2 mg, 5.0 μmol, 1.0 mol%) and nickel(II) bromide trihydrate (1.4 mg, 5.0 μmol, 1.0 mol%) were added as a 0.50 M stock solution in anhydrous DMSO (1.0 mL, sonicated for 10 minutes before addition). Water (450 μL, 25 mmol, 50 equiv.) was added before the mixture was degassed via two cycles of freeze-pump-backfill-thaw. The reaction was sealed, placed ~6 cm away from a 34 W blue LED, and stirred for 24 h with cooling by fan. The reaction mixture was removed from the light, diluted with aq. $NaHCO_3$ and EtOAc, and the aqueous layer was extracted with three portions of EtOAc. The combined organic layers were dried over Na_2SO_4, filtered, and concentrated. The residue was purified by flash chromatography eluting with 15% EtOAc/hexanes to afford the title compound as a colorless oil (86 mg, 0.25 mmol, 51% yield, mixture of rotamers 1.4:1 A:B). ^1H NMR (500 MHz, $CDCl_3$): δ 8.02–7.93 (m, 4H, 2 × C(4)**H**, A+B), 7.42–7.30 (m, 4H, 2 × C(14)**H**, A+B), 7.30–7.10 (m, 8H, 2 × C(15)**H**, A+B and 2 × C(5)**H**, A+B), 6.88 (d, *J*=7.2 Hz, 2H, C(16)**H**, A+B), 5.16 (d, *J*=12.5 Hz, 1H, C(12)$\mathbf{H_a}$, B), 5.09 (d, *J*=12.5 Hz, 1H, C(12)$\mathbf{H_b}$, B), 5.06–4.88 (m, 4H, C(12)$\mathbf{H_2}$, A and C(7)**H**, A+B), 3.93 (s, 3H, C(1)$\mathbf{H_3}$, A), 3.90 (s, 3H, C(1)$\mathbf{H_3}$, B), 3.76–3.59 (m, 4H, C(10)$\mathbf{H_2}$, A+B), 2.43–2.27 (m, 2H, C(8)$\mathbf{H_a}$, A+B), 1.96–1.81 (m, 6H, C(9)$\mathbf{H_2}$, A+B and C(8)$\mathbf{H_b}$, A+B). ^{13}C NMR (125 MHz, $CDCl_3$): δ 167.07 (A+B), 155.03 (A+B), 149.80 (A), 149.01 (B), 136.98 (B), 136.57 (A), 129.99 (B), 129.94 (A), 128.87 (A+B), 128.61 (B), 128.31 (A), 128.12 (B), 128.10 (A), 127.78 (B), 127.51 (A), 125.64 (A+B), 67.02 (B), 66.86 (A), 61.37 (B), 61.10 (A), 52.23 (A), 52.18 (B), 47.84 (A), 47.36 (B), 35.94 (A), 34.84 (B), 23.81 (B), 23.16 (A). IR (thin film): 2951, 2880, 1698, 1610, 1498, 1435, 1406, 1349, 1310, 1274, 1211, 1175, 1102, 1077, 1018 cm^{-1}. HRMS (ESI-TOF) calculated for $C_{20}H_{21}NO_4$ $[M+H]^+$ requires m/z 340.1543, found 340.1542; $[M+Na]^+$ requires m/z 362.1363, found 362.1363; $[M+K]^+$ requires m/z 378.1102, found 378.1103.



***N*-(*tert*-Butyl)-2-(4-(trifluoromethyl)phenyl)pyrrolidine-1-carboxamide (32).** An 8 mL vial equipped with a magnetic stirring bar was charged with *N*-(*tert*-butyl)pyrrolidine-1-carboxamide (341 mg, 2.0 mmol, 2.0 equiv.), and 1-bromo-4-(trifluoromethyl)benzene (140 μL, 1.0 mmol, 1.0 equiv.). $Ir[dF(CF_3)ppy]_2(dtbbpy)PF_6$ (11.2 mg, 10 μmol, 1.0 mol%) was added as a 0.50 M stock

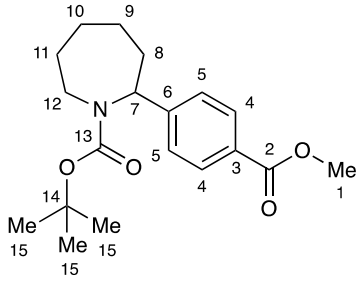
solution in anhydrous DMSO (2.0 mL) and 3-acetoxyquinuclidine (171 µL, 2.2 mmol, 1.1 equiv.) was added. 4,7-Dimethoxy-1,10-phenanthroline (2.4 mg, 10 µmol, 1.0 mol%) and nickel(II) bromide trihydrate (2.7 mg, 10 µmol, 1.0 mol%) were added as a 0.50 M stock solution in anhydrous DMSO (2.0 mL, sonicated for 10 minutes before addition). Water (540 µL, 30 mmol, 30 equiv.) was added before the mixture was degassed via two cycles of freeze-pump-backfill-thaw. The reaction was sealed, placed ~6 cm away from a 34 W blue LED, and stirred for 24 h with cooling by fan. The reaction mixture was removed from the light, diluted with aq. $NaHCO_3$ and EtOAc, and the aqueous layer was extracted with three portions of EtOAc. The combined organic layers were dried over Na_2SO_4, filtered, and concentrated. The residue was purified by flash chromatography eluting with 30% EtOAc/hexanes to afford the title compound as a white solid (250 mg, 0.80 mmol, 80% yield). ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.59 (d, *J*=8.1 Hz, 2H, 2 × C(3)**H**), 7.34 (d, *J*=8.1 Hz, 2H, 2 × C(4)**H**), 4.86 (dd, *J*=8.0, 3.7 Hz, 1H, C(6)**H**), 3.94 (br s, 1H, N**H**), 3.60 (dd, *J*=6.7, 6.7 Hz, 2H, C(9)$\mathbf{H_2}$), 2.38 (dddd, *J*=12.3, 8.0, 8.0, 8.0 Hz, 1H, C(7)$\mathbf{H_a}$), 1.95–1.87 (m, 2H C(8)$\mathbf{H_2}$), 1.86–1.79 (m, 1H, C(7)$\mathbf{H_b}$), 1.22 (s, 9H, 3 × C(12)$\mathbf{H_3}$). ^{13}C NMR (125 MHz, $CDCl_3$): δ 156.24, 148.22, 129.56 (q, *J*=32.3 Hz), 126.06, 125.81 (q, *J*=3.8 Hz), 124.27 (q, *J*=272.0 Hz), 60.67, 50.89, 47.17, 36.18, 29.54, 23.56. IR (thin film): 3324, 2970, 2871, 1633, 1531, 1479, 1452, 1419, 1391, 1357, 1324, 1271, 1241, 1214, 1160, 1119, 1105, 1066, 1016 cm^{-1}. HRMS (ESI-TOF) calculated for $C_{16}H_{21}F_3N_2O$ $[M+H]^+$ requires m/z 315.1679, found 315.1677.

Deprotection of a related substrate, N-Bac 2-phenylpyrroldine, was conducted according to a literature procedure.[47]



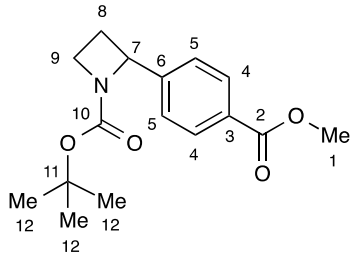
***tert*-Butyl 2-(4-(methoxycarbonyl)phenyl)piperidine-1-carboxylate (33).** An 8 mL vial equipped with a magnetic stirring bar was charged with *tert*-butyl piperidine-1-carboxylate (190 µL, 1.0 mmol, 2.0 equiv.), and methyl 4-bromobenzoate (108 mg, 0.50 mmol, 1.0 equiv.). $Ir[dF(CF_3)ppy]_2(dtbbpy)PF_6$ (5.6 mg, 5.0 µmol, 1.0 mol%) was added as a 0.50 M stock solution in anhydrous DMSO (1.0 mL) and 3-acetoxyquinuclidine (43 µL, 0.28 mmol, 0.55 equiv.) was added. 4,7-Dimethoxy-1,10-phenanthroline (1.2 mg, 5.0 µmol, 1.0 mol%) and nickel(II) bromide trihydrate (1.4 mg, 5.0 µmol, 1.0 mol%) were added as a 0.50 M stock solution in anhydrous DMSO (1.0 mL, sonicated for 10 minutes before addition). Water (360 µL, 20 mmol, 40 equiv.) was added before the mixture was degassed via two cycles of freeze-pump-backfill-thaw. The reaction was sealed, placed ~6 cm away from a 34 W blue LED, and stirred for 6 h with cooling by

fan. After 6 h, additional 3-acetoxyquinuclidine (43 µL, 0.28 mmol, 0.55 equiv.) was added and the mixture was resealed, replaced ~6 cm away from the 34 W blue LED, and stirred for an additional 18 h with cooling by fan. The reaction mixture was removed from the light, diluted with aq. $NaHCO_3$ and EtOAc, and the aqueous layer was extracted with three portions of EtOAc. The combined organic layers were dried over Na_2SO_4, filtered, and concentrated. The residue was purified by flash chromatography eluting with 10% Et_2O/hexanes to afford the title compound as a colorless oil (67 mg, 0.21 mmol, 42% yield). ^{1}H NMR (500 MHz, $CDCl_3$): δ 8.00 (d, *J*=8.2 Hz, 2H, 2 × C(4)**H**), 7.28 (d, *J*=8.2 Hz, 2H 2 × C(5)**H**), 5.47–5.36 (br m, 1H, C(7)**H**), 4.13–4.00 (br m, 1H, C(11)$\mathbf{H_a}$), 3.91 (s, 3H, C(1)$\mathbf{H_3}$), 2.76 (ddd, *J*=13.5, 12.2, 3.7 Hz, 1H C(11)$\mathbf{H_b}$), 2.34–2.25 (br m, 1H C(8)$\mathbf{H_a}$), 1.92 (dddd, *J*=13.7, 13.7, 5.6, 3.6 Hz, C(8)$\mathbf{H_b}$), 1.66–1.28 (m, 4H, C(9)$\mathbf{H_2}$ and C(10)$\mathbf{H_2}$), 1.45 (s, 9H, 3 × C(14)$\mathbf{H_3}$). ^{13}C NMR (125 MHz, $CDCl_3$): δ 167.10, 155.70, 146.38, 129.99, 128.49, 126.65, 79.97, 53.60, 52.21, 40.46, 28.55, 28.42, 25.41, 19.51. IR (thin film): 2937, 2863, 1722, 1687, 1611, 1574, 1436, 1410, 1365, 1336, 1316, 1273, 1252, 1176, 1154, 1106, 1031, 1018 cm^{-1}. HRMS (ESI-TOF) calculated for $C_{18}H_{25}NO_4$ $[M+Na]^+$ requires m/z 342.1676, found 342.1676.



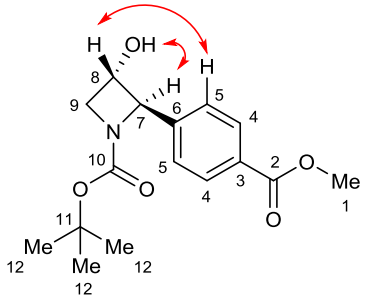
***tert*-Butyl 2-(4-(methoxycarbonyl)phenyl)azepane-1-carboxylate (34).** An 8 mL vial equipped with a magnetic stirring bar was charged with *tert*-butyl azepane-1-carboxylate (205 µL, 1.0 mmol, 2.0 equiv.), methyl 4-bromobenzoate (108 mg, 0.50 mmol, 1.0 equiv.), and $Ir[dF(CF_3)ppy]_2(dtbbpy)PF_6$ (5.6 mg, 5.0 µmol, 1.0 mol%). Anhydrous DMSO (2.0 mL) and 3-acetoxyquinuclidine (85 µL, 0.55 mmol, 1.1 equiv.) were added. 4,7-Dimethoxy-1,10-phenanthroline (1.2 mg, 5.0 µmol, 1.0 mol%) and nickel(II) bromide trihydrate (1.4 mg, 5.0 µmol, 1.0 mol%) were added as a 0.50 M stock solution in anhydrous DMSO (1.0 mL, sonicated for 10 minutes before addition). Water (405 µL, 23 mmol, 45 equiv.) was added before the mixture was degassed via two cycles of freeze-pump-backfill-thaw. The reaction was sealed, placed ~6 cm away from a 34 W blue LED, and stirred for 20 h with cooling by fan. The reaction mixture was removed from the light, diluted with aq. $NaHCO_3$ and EtOAc, and the aqueous layer was extracted with three portions of EtOAc. The combined organic layers were dried over Na_2SO_4, filtered, and concentrated. The residue was purified by flash chromatography eluting with 10% Et_2O/hexanes to afford the title compound as a colorless oil (115 mg, 0.35 mmol, 69% yield, mixture of rotamers 1.1:1 A:B). ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.96 (d, *J*=8.3 Hz, 4H, 2 × C(4)**H**, A+B), 7.27 (d, *J*=8.6 Hz, 2H, 2 × C(5)**H**, B), 7.23 (d, *J*=8.1 Hz, 2H, 2 × C(5)**H**, A), 5.21 (dd, *J*=12.1, 6.4 Hz, 1H,

C(7)**H**, B), 4.93 (dd, *J*=12.3, 5.7 Hz, 1H, C(7)**H**, A), 4.18 (ddd, *J*=14.4, 3.3, 3.3 Hz, 1H, C(12)$\mathbf{H_a}$, A), 3.96–3.87 (m, 1H, C(12)$\mathbf{H_a}$, B), 3.90 (s, 3H, C(1)$\mathbf{H_3}$, A), 3.89 (s, 3H, C(1)$\mathbf{H_3}$, B), 3.01 (dd, *J*=14.4, 11.5 Hz, 1H, C(12)$\mathbf{H_b}$, A), 2.89 (ddd, *J*=14.1, 11.9, 1.3 Hz, 1H, C(12)$\mathbf{H_b}$, B), 2.43–2.34 (m, 1H, C(8)$\mathbf{H_a}$, B), 2.24 (ddd, *J* = 14.5, 8.3, 5.7 Hz, 1H, C(8)$\mathbf{H_a}$, A), 2.01–1.19 (m, 14H, C(8)$\mathbf{H_b}$, A+B, C(9)$\mathbf{H_2}$, A+B, C(10)$\mathbf{H_2}$, A+B, and C(11)$\mathbf{H_2}$, A+B), 1.47 (s, 9H, 3 × C(15)$\mathbf{H_3}$, B), 1.27 (s, 9H, 3 × C(15)$\mathbf{H_3}$, A). ^{13}C NMR (125 MHz, $CDCl_3$): δ 167.15 (B), 167.14 (A), 156.18 (B), 155.85 (A), 150.56 (A), 149.40 (B), 129.97 (B), 129.84 (A), 128.57 (B), 128.54 (A), 125.83 (B), 125.61 (A), 79.82 (A), 79.73 (B), 60.85 (A), 58.70 (B), 52.18 (A), 52.14 (B), 43.66 (B), 43.39 (A), 36.43 (A), 35.64 (B), 30.12 (A), 29.73 (B), 29.68 (B), 29.62 (A), 28.65 (B), 28.42 (A), 26.78 (A), 25.86 (B). IR (thin film): 2972, 2928, 2855, 1722, 1687, 1611, 1436, 1401, 1365, 1341, 1310, 1274, 1214, 1155, 1103, 1018 cm^{-1}. HRMS (ESI-TOF) calculated for $C_{19}H_{27}NO_4$ $[M+Na]^+$ requires m/z 356.1832, found 356.1829.

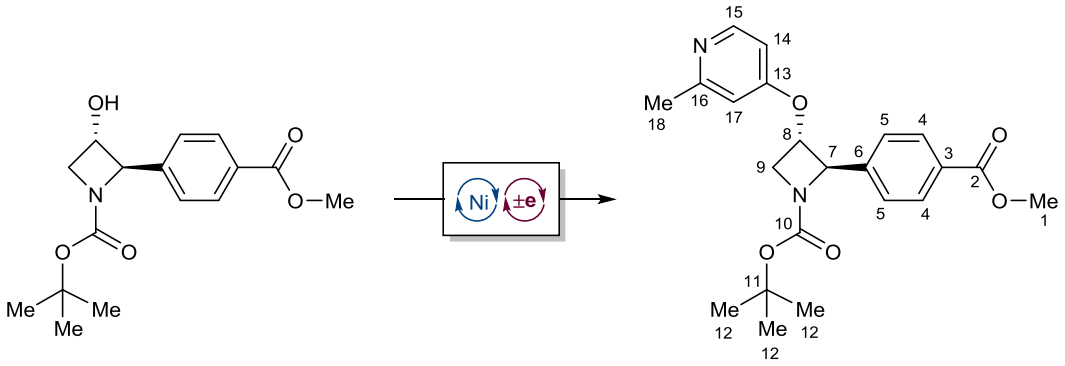


***tert*-Butyl-2-(4-(methoxycarbonyl)phenyl)azetidine-1-carboxylate (35).** An 8 mL vial equipped with a magnetic stirring bar was charged with *N*-Boc azetidine (236 mg, 1.5 mmol, 3.0 equiv.), methyl 4-bromobenzoate (108 mg, 0.50 mmol, 1.0 equiv.) and $Ir[dF(CF_3)ppy]_2(dtbbpy)PF_6$ (5.6 mg, 5.0 μmol, 1.0 mol%). Anhydrous DMSO (1.0 mL) and 3-acetoxyquinuclidine (43 μL, 0.28 mmol, 0.55 equiv.) were added. 4,7-Dimethoxy-1,10-phenanthroline (1.2 mg, 5.0 μmol, 1.0 mol%) and nickel(II) bromide trihydrate (1.4 mg, 5.0 μmol, 1.0 mol%) were added as a 0.50 M stock solution in anhydrous DMSO (1.0 mL, sonicated for 10 minutes before addition). Water (360 μL, 20 mmol, 40 equiv.) was added before the mixture was degassed via two cycles of freeze-pump-backfill-thaw. The reaction was sealed and placed ~6 cm away from a 34 W blue LED and stirred for 12 h with cooling by fan. After 12 h, an additional portion of 3-acetoxyquinuclidine (43 μL, 0.28 mmol, 0.55 equiv.) was added via syringe addition through the septum and stirring was continued for a further 18 h (30 h total). The reaction mixture was removed from the light, diluted with aq. $NaHCO_3$ and EtOAc, and the aqueous layer was extracted with three portions of EtOAc. The combined organic layers were dried over Na_2SO_4, filtered, and concentrated. The residue was purified by flash chromatography eluting with 10% EtOAc/hexanes to afford the title compound as a colorless oil (85 mg, 0.29 mmol, 58% yield). ^{1}H NMR (500 MHz, $CDCl_3$): δ 8.03 (d, *J* = 8.1 Hz, 2H, 2 × C(4)**H**), 7.41 (d, *J* = 8.1 Hz, 2H, 2 × C(5)**H**), 5.23 (dd, *J* = 7.3, 7.3 Hz, 1H, C(7)**H**), 4.07–3.96 (m, 2H, C(9)$\mathbf{H_2}$), 3.92 (s, 3H, C(1)$\mathbf{H_3}$), 2.65 (m, 1H, C(8)$\mathbf{H_a}$), 2.11 (m, 1H, C(8)$\mathbf{H_b}$), 1.33 (br. s, 9H, 3 × C(12)$\mathbf{H_3}$). ^{13}C NMR (125 MHz, $CDCl_3$): δ 167.05, 156.52, 147.81, 129.93, 129.24, 125.85, 79.85, 64.00, 52.18, 29.80, 28.37, 25.40. IR (thin film): 3002, 2975, 2954, 2889, 1721,

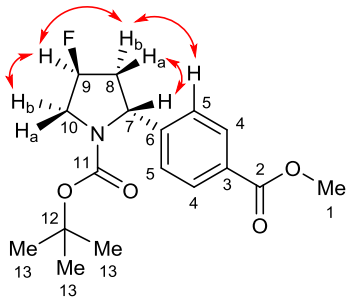
1683, 1610, 1462, 1439, 1381, 1366, 1348, 1311, 1273, 1255, 1192, 1177, 1152, 1133, 1113, 1101, 1058, 1017 cm^{-1}. HRMS (ESI-TOF) calculated for $C_{16}H_{21}NO_4$ $[M+Na]^+$ requires m/z 314.1363, found 314.1364.



***tert*-Butyl-3-hydroxy-2-(4-(methoxycarbonyl)phenyl)azetidine-1-carboxylate (36).** An 8 mL vial equipped with a magnetic stirring bar was charged with methyl 4-bromobenzoate (108 mg, 0.50 mmol, 1.0 equiv.), *tert*-butyl 3-hydroxyazetidine-1-carboxylate (260 mg, 1.5 mmol, 3.0 equiv.) and $Ir[dF(CF_3)ppy]_2(dtbbpy)PF_6$ (5.6 mg, 5.0 µmol, 1.0 mol%). Anhydrous DMSO (2.0 mL) and 3-acetoxyquinuclidine (43 µL, 0.28 mmol, 0.55 equiv.) were added. 4,7-Dimethoxy-1,10-phenanthroline (1.2 mg, 5.0 µmol, 1.0 mol%) and nickel(II) bromide trihydrate (1.4 mg, 5.0 µmol, 1.0 mol%) were added as a 0.50 M stock solution in anhydrous DMSO (1 mL, sonicated for 10 minutes before addition). Water (540 µL, 30.0 mmol, 60 equiv.) was added before the mixture was degassed via two cycles of freeze-pump-backfill-thaw. The reaction was sealed and placed ~6 cm away from a 34 W blue LED and stirred with cooling by fan. After 6 h, an additional portion of 3-acetoxyquinuclidine (43 µL, 0.28 mmol, 0.55 equiv.) was added via syringe addition through the septum and stirring was continued for a further 18 h (24 h total). The reaction mixture was removed from the light, diluted with aq. $NaHCO_3$ and EtOAc, and the aqueous layer was extracted with five portions of EtOAc. The combined organic layers were dried over Na_2SO_4, filtered, and concentrated. The residue was purified by flash chromatography eluting with 10-15% EtOAc/toluene to afford the title compound as a white solid (69 mg, 0.23 mmol, 45% yield, >20:1 d.r.). ^1H NMR (500 MHz, $CDCl_3$): δ 8.01 (d, J = 8.3 Hz, 2H, 2 × C(4)**H**), 7.38 (d, J = 8.3 Hz, 2H, 2 × C(5)**H**), 4.99 (d, J = 4.3 Hz, 1H, C(7)**H**), 4.26 (m, 1H, C(8)**H**), 4.18 (m, 1H, C(9)$\mathbf{H}_a$), 3.91 (s, 3H, C(1)$\mathbf{H_3}$), 3.85 (dd, J = 9.1, 5.0 Hz, 1H, C(9)$\mathbf{H}_b$), 2.77 (br. s, 1H, O**H**), 1.33 (s, 9H, 3 × C(12)$\mathbf{H_3}$). ^{13}C NMR (125 MHz, $CDCl_3$): δ 167.10, 157.09, 144.97, 130.01, 129.55, 125.88, 80.41, 74.24, 69.93, 56.40, 52.30, 28.34. IR (thin film): 3342, 2979, 1718, 1706, 1646, 1610, 1438, 1414, 1386, 1369, 1280, 1180, 1145, 1097, 1080, 1019 cm^{-1}. HRMS (ESI-TOF) calculated for $C_{16}H_{21}NO_5$ $[M+Na]^+$ requires m/z 330.1312, found 330.1312. *The relative stereochemistry of the title compound was corroborated by nOe experiments (as indicated on the compound structure). No significant nOe was observed between C(5)**H** and the O**H**.*

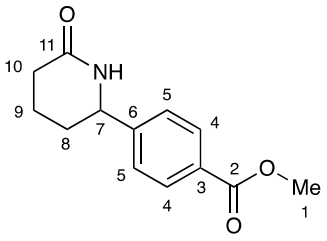


***tert*-Butyl 2-(4-(methoxycarbonyl)phenyl)-3-((2-methylpyridin-4-yl)oxy)azetidine-1-carboxylate.** An 8 mL vial equipped with a magnetic stirring bar was charged with quinuclidine (4.5 mg, 0.04 mmol, 0.1 equiv.), *tert*-butyl-3-hydroxy-2-(4-(methoxycarbonyl)phenyl)azetidine-1-carboxylate **36** (123 mg, 0.40 mmol, 1.0 equiv.), $Ir[dF(CF_3)ppy]_2(dtbbpy)PF_6$ (4.5 mg, 4.0 µmol, 1.0 mol%) and K_2CO_3 (55 mg, 0.40 mmol, 1.0 equiv.) and then anhydrous MeCN (1.1 mL) was added. 4,4'-di-*tert*-butyl-2,2'-dipyridyl (5.4 mg, 20.0 µmol, 5.0 mol%) and $NiCl_2$·DME (4.4 mg, 20.0 µmol, 5.0 mol%) were added as a stock solution in anhydrous MeCN (0.5 mL, sonicated for 10 minutes before addition). 4-Bromo-2-methylpyridine (71 µL, 0.60 mmol, 1.5 equiv.) was added before the mixture was degassed via three cycles of freeze-pump-backfill-thaw. The reaction was sealed, placed 1 cm away from three blue LED strips and stirred with cooling by fan. After 28 h, the reaction mixture was removed from the light, diluted with aq. $NaHCO_3$ (50 mL) and EtOAc (20 mL), and the aqueous layer was extracted with two further portions of EtOAc (2 × 20 mL). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated. The residue was purified by flash chromatography eluting with 60% EtOAc/hexane to afford the title compound as a pale yellow oil (123 mg, 0.31 mmol, 77% yield, >20:1 d.r.). ^{1}H NMR (500 MHz, $CDCl_3$): δ 8.27 (d, *J* = 5.7 Hz, 1H, C(15)**H**), 8.08 (d, *J* = 8.2 Hz, 2H, 2 × C(4)**H**), 7.46 (d, *J* = 8.2 Hz, 2H, 2 × C(5)**H**), 6.46-6.38 (m, 2H, C(14)**H** and C(17)**H**), 5.20 (br. m, 1H, C(7)**H**), 4.68 (ddd, *J* = 6.4, 4.3, 4.3 Hz, 1H, C(8)**H**), 4.41 (dd, *J* = 9.5, 6.6 Hz, 1H, C(9)$\mathbf{H}_a$), 4.05 (dd, *J* = 9.6, 4.5 Hz, 1H, C(9)$\mathbf{H}_b$), 3.94 (s, 3H, C(1)$\mathbf{H_3}$), 2.43 (s, 3H, C(18)$\mathbf{H_3}$), 1.33 (br. s, 9H, 3 × C(12)$\mathbf{H_3}$). ^{13}C NMR (125 MHz, $CDCl_3$): δ 166.83, 162.94, 160.59, 156.38, 150.76, 143.80, 130.29, 130.22, 126.49, 109.91, 108.06, 80.77, 73.17, 71.45, 54.07, 52.38, 28.31, 24.72. IR (thin film): 2972, 1703, 1596, 1570, 1480, 1435, 1389, 1366, 1307, 1276, 1178, 1140, 1107, 1077, 1049, 1019 cm^{-1}. HRMS (ESI-TOF) calculated for $C_{22}H_{26}N_2O_5$ $[M+H]^+$ requires m/z 399.1914, found 399.1914. *The relative stereochemistry of the title compound was assigned by analogy with azetidine **36**.*



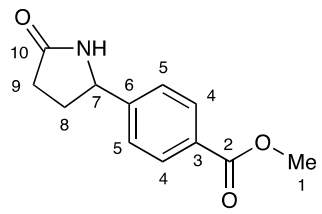
***tert*-Butyl-4-fluoro-2-(4-(methoxycarbonyl)phenyl)pyrrolidine-1-carboxylate (37).** An 8 mL vial equipped with a magnetic stirring bar was charged with methyl 4-bromobenzoate (108 mg, 0.50 mmol, 1.0 equiv.), *tert*-butyl 3-fluoropyrrolidine-1-carboxylate (189 mg, 1.0 mmol, 2.0 equiv.) and Ir[dF(CF_3)ppy]$_2$(dtbbpy)PF_6 (5.6 mg, 5.0 µmol, 1.0 mol%). Anhydrous DMSO (1.0 mL) and 3-acetoxyquinuclidine (43 µL, 0.28 mmol, 0.55 equiv.) were added. 4,7-Dimethoxy-1,10-phenanthroline (1.2 mg, 5.0 µmol, 1.0 mol%) and nickel(II) bromide trihydrate (1.4 mg, 5.0 µmol, 1.0 mol%) were added as a 0.50 M stock solution in anhydrous DMSO (1 mL, sonicated for 10 minutes before addition). Water (450 µL, 25.0 mmol, 50 equiv.) was added before the mixture was degassed via two cycles of freeze-pump-backfill-thaw. The reaction was sealed and placed ~6 cm away from a 34 W blue LED and stirred with cooling by fan. After 6 h, an additional portion of 3-acetoxyquinuclidine (43 µL, 0.28 mmol, 0.55 equiv.) was added via syringe addition through the septum and stirring was continued for a further 24 h (30 h total). The reaction mixture was removed from the light, diluted with aq. $NaHCO_3$ and EtOAc, and the aqueous layer was extracted with three portions of EtOAc. The combined organic layers were dried over Na_2SO_4, filtered, and concentrated. The residue was purified by flash chromatography eluting with 5% acetone/hexanes to afford the title compound as a white solid (110 mg, 0.34 mmol, 68% yield, 2.8:1 d.r. (A:B, 2.8:1), mixtures of rotamers A1(major):A2(minor) and B1(major):B2(minor) observable in ^{13}C spectrum). ^1H NMR (500 MHz, $CDCl_3$): δ 8.02–7.96 (m, 4H, 2 × C(4)**H**, A+B), 7.33–7.25 (m, 4H, 2 × C(5)**H**, A+B), 5.33–5.15 (br. m, 2H, C(9)**H**, A+B), 5.15–4.88 (br. m, 2H, C(7)**H**, A+B), 4.17–3.62 (m, 10H, C(10)$\mathbf{H}_2$ and C(1)$\mathbf{H}_3$, A+B), 2.76–2.47 (m, 2H, C(8)$\mathbf{H}_a$, A+B), 2.29 (m, 1H, C(8)$\mathbf{H}_b$, B), 1.95 (br. ddd, J = 42.0, 10.9, 10.9 Hz, C(8)$\mathbf{H}_b$, A), 1.54–1.04 (m, 18H, 3 × C(13)$\mathbf{H}_3$, A+B). ^{13}C NMR (125 MHz, $CDCl_3$): δ 167.09 (**2**B1+2), 166.95 (**2**A1+2), 154.49 (**11**A1+2), 154.23 (**11**B1+2), 149.65 (**6**A1), 149.36 (**6**B1), 148.71 (**6**A2), 148.50 (**6**B2), 130.23, 129.96, 129.68 (**4**A1+2 + **4**B1+2), 129.03 (**3**A1+2), 128.72 (**3**B1+2), 125.85, 125.67, 125.39 (**5**A1+2 + **5**B1+2), 93.15 (d, J = 174.3 Hz, **9**B2), 92.11 (d, J = 177.8 Hz, **9**B1), 91.82 (d, J = 178.2 Hz, **9**A2), 91.28 (d, J = 177.8 Hz, **9**A1), 80.29 (**12**B1+2), 80.24 (**12**A1+2), 60.04, 59.72 (**7**A1+2 and **7**B1+2), 54.48 (d, J = 22.3 Hz, **10**A/B), 54.12 (d, J = 22.4 Hz, **10**A/B), 52.19 (**1**A1+2), 52.12 (**1**B1+2), 43.57 (d, J = 21.5 Hz, **8**A1), 42.66 (d, J = 21.3 Hz, **8**A2), 41.28 (d, J = 20.4 Hz, **8**B1), 40.60 (d, J = 20.4 Hz, **8**B2), 28.45, 28.09 (**13**A1+2 and **13**B1+2). ^{19}F NMR (282 MHz, $CDCl_3$): δ -171.30 (br. m, B), -178.16 (br. m, A). IR (thin film): 2980, 1694, 1611, 1478, 1437, 1393, 1366, 1314, 1278, 1170, 1114, 1060, 1018 cm^{-1}. HRMS (ESI-TOF) calculated for $C_{17}H_{22}FNO_4$ $[M+Na]^+$ requires m/z 346.1425, found 346.1423.

An analytical sample of diastereomer A was obtained by flash chromatography eluting with 10% EtOAc/hexanes to allow assignment of the relative stereochemistry. ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.99 (d, *J* = 8.3 Hz, 2H, 2 × C(4)**H**), 7.28 (d, *J* = 8.3 Hz, 2H, 2 × C(5)**H**), 5.23 (br. m, 1H, C(9)**H**), 4.92 (br. m, 1H, C(7)**H**), 4.10 (br. m, 1H, C(10)$\mathbf{H}_a$), 3.91 (s, 3H, C(1)$\mathbf{H}_3$), 3.74 (br. m, 1H, C(10)$\mathbf{H}_b$), 2.69 (m, 1H, C(8)$\mathbf{H}_a$), 1.95 (br. ddd, *J* = 42.0, 10.9, 10.9 Hz, C(8)$\mathbf{H}_b$), 1.49–1.04 (m, 9H, 3 × C(13)$\mathbf{H}_3$). *The relative stereochemistry of the title compound was corroborated by nOe experiments (as indicated on the compound structure). A strong nOe was observed between C(5)**H** and C(10)$\boldsymbol{H}_b$. No significant nOe was observed between C(5)**H** and C(10)$\boldsymbol{H}_a$. A strong nOe was observed between C(9)**H** and C(10)$\boldsymbol{H}_b$. No significant nOe was observed between C(9)**H** and C(10)$\boldsymbol{H}_a$.*

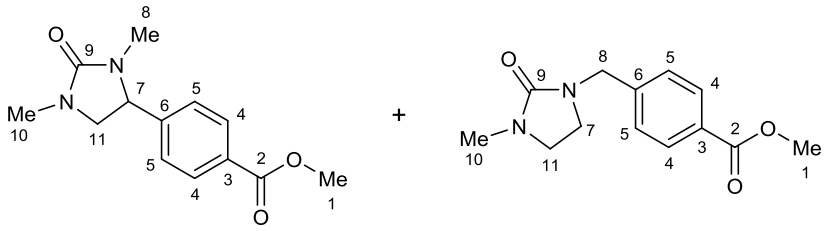


Methyl 4-(6-oxopiperidin-2-yl)benzoate (38). An 8 mL vial equipped with a magnetic stirring bar was charged with piperidin-2-one (99 mg, 1.0 mmol, 2.0 equiv.), and methyl 4-bromobenzoate (108 mg, 0.50 mmol, 1.0 equiv.). Ir[dF(CF_3)ppy]$_2$(dtbbpy)PF_6 (5.6 mg, 5.0 µmol, 1.0 mol%) was added as a 0.50 M stock solution in anhydrous DMSO (1.0 mL). An additional 2.0 mL anhydrous DMSO and 3-acetoxyquinuclidine (43 µL, 0.28 mmol, 0.55 equiv.) were added. 4,7-Dimethoxy-1,10-phenanthroline (1.2 mg, 5.0 µmol, 1.0 mol%) and nickel(II) bromide trihydrate (1.4 mg, 5.0 µmol, 1.0 mol%) were added as a 0.50 M stock solution in anhydrous DMSO (1.0 mL, sonicated for 10 minutes before addition). Water (1.1 mL, 60 mmol, 120 equiv.) was added before the mixture was degassed via two cycles of freeze-pump-backfill-thaw. The reaction was sealed, placed ~6 cm away from a 34 W blue LED, and stirred for 6 h with cooling by fan. After 6 h, additional 3-acetoxyquinuclidine (43 µL, 0.28 mmol, 0.55 equiv.) was added and the mixture was resealed, replaced ~6 cm away from the 34 W blue LED, and stirred for an additional 18 h with cooling by fan (24 h total). The reaction mixture was removed from the light, diluted with aq. $NaHCO_3$ and EtOAc, and the aqueous layer was extracted with five portions of EtOAc. The combined organic layers were dried over Na_2SO_4, filtered, and concentrated. The residue was purified by flash chromatography eluting with 100% EtOAc to afford the title compound as an off-white solid (72 mg, 0.31 mmol, 62% yield). ^{1}H NMR (500 MHz, $CDCl_3$): δ 8.04 (d, *J*=8.4 Hz, 2H, 2 × C(4)**H**), 7.37 (d, *J*=8.4 Hz, 2H, 2 × C(5)**H**), 5.97 (br s, 1H, N**H**), 4.63 (dd, *J*=8.9, 4.8 Hz, 1H, C(7)**H**), 3.92 (s, 3H, C(1)$\mathbf{H_3}$), 2.56–2.38 (m, 2H, C(10)$\mathbf{H_2}$), 2.20–2.07 (m, 1H, C(8)$\mathbf{H_a}$), 1.96–1.86 (m, 1H, C(9)$\mathbf{H_a}$), 1.86–1.75 (m, 1H, C(9)$\mathbf{H_b}$), 1.68 (dddd, *J*=13.8, 10.8, 8.9, 3.1 Hz, 1H, C(8)$\mathbf{H_b}$). ^{13}C NMR (125 MHz, $CDCl_3$): δ 172.45, 166.74, 147.65, 130.33, 130.01, 126.21, 57.65, 52.36, 32.09, 31.42, 19.64. IR (thin film): 3182, 3059, 2952, 2911, 1716, 1642, 1578, 1480, 1440, 1424,

1401, 1339, 1306, 1275, 1185, 1156, 1114, 1101, 1076, 1060, 1020 cm^{-1}. The spectroscopic properties of this compound are consistent with data reported in the literature.[48]

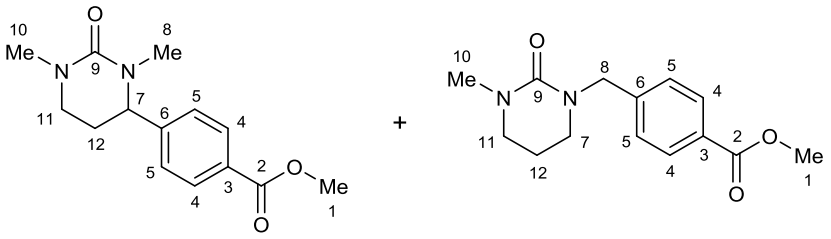


Methyl 4-(5-oxopyrrolidin-2-yl)benzoate (39). An 8 mL vial equipped with a magnetic stirring bar was charged with pyrrolidin-2-one (85 mg, 1.0 mmol, 2.0 equiv.), and methyl 4-bromobenzoate (108 mg, 0.50 mmol, 1.0 equiv.). $Ir[dF(CF_3)ppy]_2(dtbbpy)PF_6$ (5.6 mg, 5.0 μmol, 1.0 mol%) was added as a 0.50 M stock solution in anhydrous DMSO (1.0 mL). An additional 2.0 mL anhydrous DMSO and 3-acetoxyquinuclidine (43 μL, 0.28 mmol, 0.55 equiv.) were added. 4,7-Dimethoxy-1,10-phenanthroline (1.2 mg, 5.0 μmol, 1.0 mol%) and nickel(II) bromide trihydrate (1.4 mg, 5.0 μmol, 1.0 mol%) were added as a 0.50 M stock solution in anhydrous DMSO (1.0 mL, sonicated for 10 minutes before addition). Water (1.1 mL, 60 mmol, 120 equiv.) was added before the mixture was degassed via two cycles of freeze-pump-backfill-thaw. The reaction was sealed, placed ~6 cm away from a 34 W blue LED, and stirred for 6 h with cooling by fan. After 6 h, additional 3-acetoxyquinuclidine (43 μL, 0.28 mmol, 0.55 equiv.) was added and the mixture was resealed, replaced ~6 cm away from the 34 W blue LED, and stirred for an additional 18 h with cooling by fan. The reaction mixture was removed from the light, diluted with aq. $NaHCO_3$ and EtOAc, and the aqueous layer was extracted with three portions of EtOAc. The combined organic layers were dried over Na_2SO_4, filtered, and concentrated. The residue was purified by flash chromatography eluting with 100% EtOAc to afford the title compound as an off-white solid (76 mg, 0.35 mmol, 69% yield). ^1H NMR (500 MHz, $CDCl_3$): δ 8.03 (d, *J*=8.4 Hz, 2H, 2 × C(4)**H**), 7.37 (d, *J*=8.4 Hz, 2H, 2 × C(5)**H**), 6.41 (s, 1H, N**H**), 4.82 (dd, *J*=7.1, 7.1 Hz, 1H, C(7)**H**), 3.91 (s, 3H, C(1)$\mathbf{H_3}$), 2.61 (dddd, *J*=12.9, 9.3, 7.8, 5.2 Hz, 1H, C(8)$\mathbf{H_a}$), 2.53–2.36 (m, 2H, C(9)$\mathbf{H_2}$), 1.95 (dddd, *J*=12.9, 9.3, 8.1, 6.5 Hz, 1H, C(8)$\mathbf{H_b}$). ^{13}C NMR (125 MHz, $CDCl_3$): δ 178.65, 166.76, 147.73, 130.41, 129.96, 125.70, 57.90, 52.34, 31.30, 30.21. IR (thin film): 3175, 3075, 2950, 1717, 1685, 1610, 1465, 1425, 1368, 1349, 1318, 1278, 1263, 1188, 1158, 1105, 1038, 1018 cm^{-1}. HRMS (ESI-TOF) calculated for $C_{12}H_{13}NO_3$ $[M+H]^+$ requires m/z 220.0968, found 220.0964.



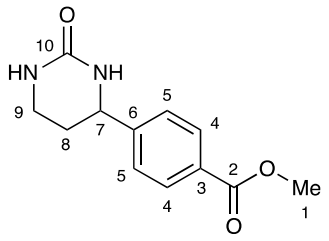
Methyl 4-(1,3-dimethyl-2-oxoimidazolidin-4-yl)benzoate (40A) and methyl 4-((3-methyl-2-oxoimidazolidin-1-yl)methyl)benzoate (40B). An 8 mL vial equipped with a magnetic stirring bar was charged with methyl 4-bromobenzoate (108 mg, 0.50 mmol, 1.0 equiv.) and $Ir[dF(CF_3)ppy]_2(dtbbpy)PF_6$ (5.6 mg, 5.0 µmol, 1.0 mol%). Anhydrous DMSO (1.0 mL) and 3-acetoxyquinuclidine (85 µL, 0.55 mmol, 1.1 equiv.) were added. 4,7-Dimethoxy-1,10-phenanthroline (1.2 mg, 5.0 µmol, 1.0 mol%) and nickel(II) bromide trihydrate (1.4 mg, 5.0 µmol, 1.0 mol%) were added as a 0.50 M stock solution in anhydrous DMSO (1 mL, sonicated for 10 minutes before addition). Water (360 µL, 20.0 mmol, 40 equiv.) and *N*,*N*'-dimethylethyleneurea (109 µL, 1.0 mmol, 2.0 equiv.) were added before the mixture was degassed via two cycles of freeze-pump-backfill-thaw. The reaction was sealed and placed ~6 cm away from a 34 W blue LED and stirred for 9 h with cooling by fan. The reaction mixture was removed from the light, diluted with aq. $NaHCO_3$ and EtOAc, and the aqueous layer was extracted with five portions of EtOAc. The combined organic layers were dried over Na_2SO_4, filtered, and concentrated. The residue was purified by flash chromatography eluting with 15% EtOAc/toluene to afford the title compound as a colorless oil (104 mg, 0.42 mmol, 84% yield, mixture of regioisomers 3:1 A:B). ^{1}H NMR (500 MHz, $CDCl_3$): δ 8.04 (d, *J* = 8.4 Hz, 2H, 2 × C(4)**H**, A), 7.98 (d, *J* = 8.3 Hz, 2H, 2 × C(4)**H**, B), 7.37 (d, *J* = 8.4 Hz, 2H, 2 × C(5)**H**, A), 7.33 (d, *J* = 8.3 Hz, 2H, 2 × C(5)**H**, B), 4.45–4.40 (m, 3H, C(7)**H** (A) and C(8)$\mathbf{H_2}$ (B)), 3.91 (s, 3H, C(1)$\mathbf{H_3}$, A), 3.89 (s, 3H, C(1)$\mathbf{H_3}$, B), 3.66 (t, *J* = 8.8 Hz, 1H, C(11)$\mathbf{H}_a$, A), 3.31–3.26 (m, 2H, C(11)$\mathbf{H_2}$, B), 3.19–3.13 (m, 2H, C(7)$\mathbf{H_2}$, B), 3.04 (t, *J* = 8.8 Hz, 1H, C(11)$\mathbf{H}_b$, A), 2.83 (s, 6H, C(10)$\mathbf{H_3}$, A+B), 2.63 (s, 3H, C(8)$\mathbf{H_3}$, A). ^{13}C NMR (125 MHz, $CDCl_3$): δ 166.98 (B), 166.72 (A), 161.78 (A), 161.52 (B), 144.87 (A), 142.86 (B), 130.40 (A), 130.38 (A), 130.00 (B), 129.38 (B), 128.04 (B), 127.02 (A), 60.34 (A), 53.99 (A), 52.34 (A), 52.22 (B), 48.42 (B), 45.10 (B), 42.37 (B), 31.56 (B), 31.41 (A), 29.96 (A). IR (thin film): 3468, 2951, 2866, 1693, 1611, 1497, 1436, 1415, 1397, 1355, 1309, 1274, 1190, 1176, 1103, 1079, 1052, 1018 cm^{-1}. HRMS (ESI-TOF) calculated for $C_{13}H_{16}N_2O_3$ $[M+H]^+$ requires m/z 249.1234, found 249.1229.

Solvent regioselectivity effects: *Under modified reaction conditions (MeCN (0.25 M), 12 eq. H_2O) the regioselectivity of the C-H arylation protocol was observed to be 1:1* ***40A:40B*** *(18% yield).*

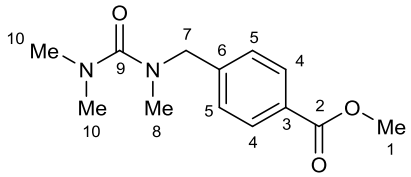


Methyl 4-(1,3-dimethyl-2-oxohexahydropyrimidin-4-yl)benzoate (41A) and methyl 4-((3-methyl-2-oxotetrahydropyrimidin-1(2*H*)-yl)methyl)benzoate (41B). An 8 mL vial equipped with a magnetic stirring bar was charged with methyl 4-bromobenzoate (108 mg, 0.50 mmol, 1.0 equiv.) and $Ir[dF(CF_3)ppy]_2(dtbbpy)PF_6$ (5.6 mg, 5.0 μmol, 1.0 mol%). Anhydrous DMSO (1.0 mL) and 3-acetoxyquinuclidine (85 μL, 0.55 mmol, 1.1 equiv.) were added. 4,7-Dimethoxy-1,10-phenanthroline (1.2 mg, 5.0 μmol, 1.0 mol%) and nickel(II) bromide trihydrate (1.4 mg, 5.0 μmol, 1.0 mol%) were added as a 0.50 M stock solution in anhydrous DMSO (1 mL, sonicated for 10 minutes before addition). Water (360 μL, 20.0 mmol, 40 equiv.) and *N*,*N*'-dimethylpropyleneurea (121 μL, 1.0 mmol, 2.0 equiv.) were added before the mixture was degassed via two cycles of freeze-pump-backfill-thaw. The reaction was sealed and placed ~6 cm away from a 34 W blue LED and stirred for 8 h with cooling by fan. The reaction mixture was removed from the light, diluted with aq. $NaHCO_3$ and EtOAc, and the aqueous layer was extracted with five portions of EtOAc. The combined organic layers were dried over Na_2SO_4, filtered, and concentrated. The residue was purified by flash chromatography eluting with 50% EtOAc/hexanes to afford the title compound as a pale yellow oil (93 mg, 0.36 mmol, 71% yield, mixture of regioisomers 1:1.2 A:B). ^{1}H NMR (500 MHz, $CDCl_3$): δ 8.00 (d, *J* = 8.3 Hz, 2H, 2 × C(4)**H**, A), 7.95 (d, *J* = 8.2 Hz, 2H, 2 × C(4)**H**, B), 7.31 (d, *J* = 8.2 Hz, 2H, 2 × C(5)**H**, B), 7.22 (d, *J* = 8.3 Hz, 2H, 2 × C(5)**H**, A), 4.57 (s, 2H, C(8)$\mathbf{H_2}$, B), 4.50 (m, 1H, C(7)**H**, A), 3.89 (s, 3H, C(1)$\mathbf{H_3}$, A), 3.87 (s, 3H, C(1)$\mathbf{H_3}$, B), 3.25 (t, *J* = 6.0 Hz, 2H, C(11)$\mathbf{H}_2$, B), 3.15 (t, *J* = 6.0 Hz, 2H, C(7)$\mathbf{H}_2$, B), 3.08–3.04 (m, 2H, C(11)$\mathbf{H_2}$, A), 2.96 (s, 6H, C(10)$\mathbf{H_3}$, A+B), 2.85 (s, 3H, C(8)$\mathbf{H_3}$, A), 2.37 (dddd, *J* = 13.4, 10.1, 5.9, 5.9 Hz, 1H, C(12)$\mathbf{H}_a$, A), 1.95-1.84 (m, 3H, C(12)$\mathbf{H}_b$ (A) and C(12)$\mathbf{H_2}$ (B)). ^{13}C NMR (125 MHz, $CDCl_3$): δ 167.04, 166.76 (A+B), 156.69, 156.51 (A+B), 146.87 (A), 144.17 (B), 130.15 (A), 129.86 (B), 129.56 (A), 128.99 (B), 127.68 (B), 126.31 (A), 61.23 (A), 52.24, 52.12 (A+B). 51.19 (B), 47.95 (B), 45.53 (B), 43.93 (A), 35.94 (A+B), 34.98 (A), 29.64 (A), 22.28 (B). IR (thin film): 2947, 2863, 2234, 1718, 1623, 1514, 1436, 1416, 1316, 1277, 1214, 1193, 1178, 1107, 1019 cm^{-1}. HRMS (ESI-TOF) calculated for $C_{14}H_{18}N_2O_3$ $[M+H]^+$ requires m/z 263.1390, found 263.1388.

Solvent regioselectivity effects: *Under modified reaction conditions (MeCN (0.25 M), 12 eq. H_2O) the regioselectivity of the C-H arylation protocol was observed to be 1:10* ***41A:41B*** *(50% yield).*

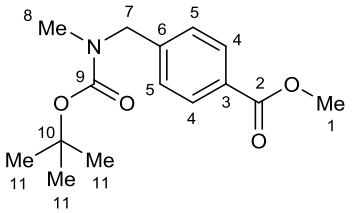


Methyl 4-(2-oxohexahydropyrimidin-4-yl)benzoate (42). An 8 mL vial equipped with a magnetic stirring bar was charged with tetrahydropyrimidin-2(1H)-one (85 mg, 1.0 mmol, 2.0 equiv.), and methyl 4-bromobenzoate (108 mg, 0.50 mmol, 1.0 equiv.). $Ir[dF(CF_3)ppy]_2(dtbbpy)PF_6$ (5.6 mg, 5.0 μmol, 1.0 mol%) was added as a 0.50 M stock solution in anhydrous DMSO (1.0 mL) and 3-acetoxyquinuclidine (85 μL, 0.55 mmol, 1.1 equiv.) was added. 4,7-Dimethoxy-1,10-phenanthroline (0.6 mg, 2.5 μmol, 0.50 mol%) and nickel(II) bromide trihydrate (0.7 mg, 2.5 μmol, 0.50 mol%) were added as a 0.50 M stock solution in anhydrous DMSO (1.0 mL, sonicated for 10 minutes before addition). Water (360 μL, 20 mmol, 40 equiv.) was added before the mixture was degassed via two cycles of freeze-pump-backfill-thaw. The reaction was sealed, placed ~6 cm away from a 34 W blue LED, and stirred for 24 h with cooling by fan. The reaction mixture was removed from the light, diluted with aq. $NaHCO_3$ and $CHCl_3$, and the aqueous layer was extracted with three portions of $CHCl_3$. The combined organic layers were washed with aq. LiCl, dried over Na_2SO_4, filtered, and concentrated. The residue was purified by flash chromatography eluting with 3% MeOH/dichloromethane to afford the title compound as an off-white solid (81 mg, 0.35 mmol, 70% yield). ^{1}H NMR (500 MHz, $CDCl_3$): δ 8.04 (d, *J*=8.3 Hz, 2H, 2 × C(4)**H**), 7.41 (d, *J* = 8.3 Hz, 2H, 2 × C(5)**H**), 5.01 (br s, 2H, 2 × N**H**), 4.66 (dd, *J* = 7.0, 4.3 Hz, 1H, C(7)**H**), 3.92 (s, 3H, C(1)$\mathbf{H_3}$), 3.41–3.32 (m, 1H, C(9)$\mathbf{H_a}$), 3.28–3.20 (m, 1H, C(9)$\mathbf{H_b}$), 2.25–2.12 (m, 1H, C(8)$\mathbf{H_a}$), 1.92 (dddd, *J* = 12.8, 7.9, 7.9, 4.3 Hz, 1H C(8)$\mathbf{H_b}$). ^{13}C NMR (125 MHz, $CDCl_3$): δ 166.78, 156.59, 147.46, 130.31, 130.01, 126.23, 54.92, 52.36, 38.33, 30.31. IR (thin film): 3224, 3081, 2921, 1730, 1716, 1677, 1610, 1578, 1516, 1439, 1417, 1355, 1338, 1312, 1278, 1215, 1198, 1170, 1135, 1116, 1105, 1071, 1020 cm^{-1}. HRMS (ESI-TOF) calculated for $C_{12}H_{14}N_2O_3$ $[M+H]^+$ requires m/z 235.1077, found 235.1076.



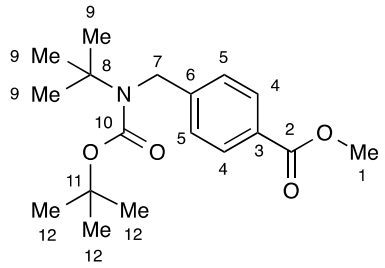
Methyl 4-((1,3,3-trimethylureido)methyl)benzoate (43). An 8 mL vial equipped with a magnetic stirring bar was charged with methyl 4-bromobenzoate (108 mg, 0.50 mmol, 1.0 equiv.) and $Ir[dF(CF_3)ppy]_2(dtbbpy)PF_6$ (5.6 mg, 5.0 μmol, 1.0 mol%). Anhydrous DMSO (1.0 mL) and 3-acetoxyquinuclidine (85 μL, 0.55 mmol, 1.1 equiv.) were added. 4,7-Dimethoxy-1,10-phenanthroline (1.2 mg, 5.0 μmol, 1.0 mol%) and nickel(II) bromide trihydrate (1.4 mg, 5.0 μmol,

1.0 mol%) were added as a 0.50 M stock solution in anhydrous DMSO (1 mL, sonicated for 10 minutes before addition). Water (360 µL, 20.0 mmol, 40 equiv.) and 1,1,3,3-tetramethylurea (120 µL, 1.0 mmol, 2.0 equiv.) were added before the mixture was degassed via two cycles of freeze-pump-backfill-thaw. The reaction was sealed and placed ~6 cm away from a 34 W blue LED and stirred for 32 h with cooling by fan. The reaction mixture was removed from the light, diluted with aq. $NaHCO_3$ and EtOAc, and the aqueous layer was extracted with five portions of EtOAc. The combined organic layers were dried over Na_2SO_4, filtered, and concentrated. The residue was purified by flash chromatography eluting with 15% EtOAc/toluene to afford the title compound as a pale yellow oil (93 mg, 0.37 mmol, 74% yield). ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.97 (d, J = 8.3 Hz, 2H, 2 × C(4)**H**), 7.31 (d, J = 8.3 Hz, 2H, 2 × C(5)**H**), 4.39 (s, 2H, C(7)$\mathbf{H_2}$), 3.87 (s, 3H, C(1)$\mathbf{H_3}$), 2.81 (s, 6H, 2 × C(10)$\mathbf{H_3}$), 2.71 (s, 3H, C(8)$\mathbf{H_3}$). ^{13}C NMR (125 MHz, $CDCl_3$): δ 166.95, 165.46, 143.63, 129.92, 129.09, 127.57, 53.95, 52.14, 38.76, 36.94. IR (thin film): 3476, 2948, 1718, 1639, 1612, 1495, 1435, 1416, 1379, 1274, 1176, 1106, 1062, 1018 cm^{-1}. HRMS (ESI-TOF) calculated for $C_{13}H_{18}N_2O_3$ $[M+H]^+$ requires m/z 251.1390, found 251.1389.

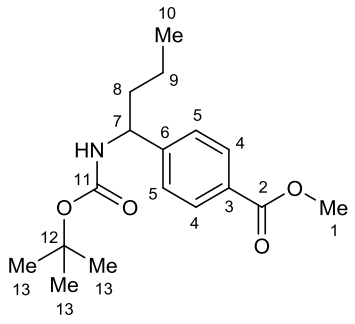


Methyl 4-(((*tert*-butoxycarbonyl)(methyl)amino)methyl)benzoate (44). An 8 mL vial equipped with a magnetic stirring bar was charged with methyl 4-bromobenzoate (108 mg, 0.50 mmol, 1.0 equiv.), *tert*-butyl dimethylcarbamate (218 mg, 1.5 mmol, 3.0 equiv.) and $Ir[dF(CF_3)ppy]_2(dtbbpy)PF_6$ (5.6 mg, 5.0 µmol, 1.0 mol%). Anhydrous DMSO (2.0 mL) and 3-acetoxyquinuclidine (85 µL, 0.55 mmol, 1.1 equiv.) were added. 4,7-Dimethoxy-1,10-phenanthroline (0.6 mg, 2.5 µmol, 0.5 mol%) and nickel(II) bromide trihydrate (0.7 mg, 2.5 µmol, 0.5 mol%) were added as a 0.50 M stock solution in anhydrous DMSO (1 mL, sonicated for 10 minutes before addition). Water (720 µL, 40.0 mmol, 80 equiv.) was added before the mixture was degassed via two cycles of freeze-pump-backfill-thaw. The reaction was sealed and placed ~6 cm away from a 34 W blue LED and stirred for 36 h with cooling by fan. The reaction mixture was removed from the light, diluted with aq. $NaHCO_3$ and EtOAc, and the aqueous layer was extracted with three portions of EtOAc. The combined organic layers were dried over Na_2SO_4, filtered, and concentrated. The residue was purified by flash chromatography eluting with 5% EtOAc/hexanes to afford the title compound as a colorless oil (91 mg, 0.33 mmol, 65% yield, mixture of rotamers A(major):B(minor)). ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.99 (d, J = 8.0 Hz, 4H, 2 × C(4)**H**, A+B), 7.31–7.22 (br. m, 4H, 2 × C(5)**H**, A+B), 4.52–4.40 (br. m, 4H, C(7)$\mathbf{H_2}$, A+B), 3.90 (s, 6H, C(1)$\mathbf{H_3}$, A+B), 2.86 (br. s, 3H, C(8)$\mathbf{H_3}$, A), 2.79 (br. s, 3H, C(8)$\mathbf{H_3}$, B) 1.49 (br. s, 9H, 3 × C(11)$\mathbf{H_3}$, B), 1.43 (br. s, 9H, 3 × C(11)$\mathbf{H_3}$, A). ^{13}C NMR (125 MHz, $CDCl_3$): δ 167.00 (A+B), 156.25 (B), 155.77 (A), 143.65 (A+B), 129.98 (A+B), 129.21 (A+B), 127.55 (B), 127.04 (A), 80.07 (A+B),

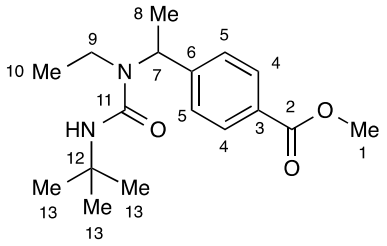
52.65 (A), 52.20 (A+B), 51.89 (B), 34.41 (A), 34.27 (B), 28.52 (A+B). IR (thin film): 2977, 1721, 1690, 1613, 1480, 1452, 1435, 1391, 1366, 1276, 1246, 1175, 1143, 1107, 1019 cm^{-1}. HRMS (ESI-TOF) calculated for $C_{15}H_{21}NO_4$ $[M+Na]^+$ requires m/z 302.1363, found 302.1360.



Methyl 4-(((*tert*-butoxycarbonyl)(*tert*-butyl)amino)methyl)benzoate (45). An 8 mL vial equipped with a magnetic stirring bar was charged with *N*-methyl *tert*-butylamine (187 mg, 1.0 mmol, 2.0 equiv.), methyl 4-bromobenzoate (108 mg, 0.50 mmol, 1.0 equiv.) and $Ir[dF(CF_3)ppy]_2(dtbbpy)PF_6$ (5.6 mg, 5.0 µmol, 1.0 mol%). Anhydrous DMSO (3.0 mL) and 3-acetoxyquinuclidine (85 µL, 0.55 mmol, 1.1 equiv.) were added. 4,7-Dimethoxy-1,10-phenanthroline (1.2 mg, 5.0 µmol, 1.0 mol%) and nickel(II) bromide trihydrate (1.4 mg, 5.0 µmol, 1.0 mol%) were added as a 0.50 M stock solution in anhydrous DMSO (1.0 mL, sonicated for 10 minutes before addition). Water (720 µL, 40 mmol, 80 equiv.) was added before the mixture was degassed via two cycles of freeze-pump-backfill-thaw. The reaction was sealed and placed ~6 cm away from a 34 W blue LED and stirred for 24 h with no fan cooling (at 50 ºC). The reaction mixture was removed from the light, diluted with aq. $NaHCO_3$ and EtOAc, and the aqueous layer was extracted with three portions of EtOAc. The combined organic layers were dried over Na_2SO_4, filtered, and concentrated. The residue was purified by flash chromatography eluting with 10% EtOAc/hexanes to afford the title compound as a colorless oil (75 mg, 0.23 mmol, 47% yield). ^1H NMR (500 MHz, $CDCl_3$): δ 7.98 (d, J = 8.2 Hz, 2H, 2 × C(4)**H**), 7.27 (d, J = 7.7 Hz, 2H, 2 × C(5)**H**), 4.61 (s, 2H, C(7)$\mathbf{H_2}$), 3.90 (s, 3H, C(1)$\mathbf{H_3}$), 1.43 (s, 9H, 3 × C(9)$\mathbf{H_3}$), 1.37 (s, 9H, 3 × C(12)$\mathbf{H_3}$). ^{13}C NMR (125 MHz, $CDCl_3$): δ 167.20, 156.05, 147.01, 129.86, 128.48, 126.20, 79.90, 56.32, 52.16, 48.70, 29.66, 28.60. IR (thin film): 2961, 2925, 1719, 1683, 1612, 1454, 1435, 1418, 1374, 1363, 1276, 1247, 1208, 1155, 1104, 1072, 1028, 1015 cm^{-1}. HRMS (ESI-TOF) calculated for $C_{18}H_{27}NO_4$ $[M+Na]^+$ requires m/z 344.1832, found 344.1833.

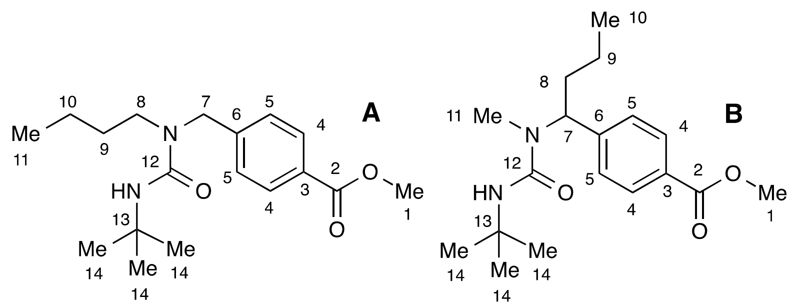


Methyl 4-(1-((*tert*-butoxycarbonyl)amino)butyl)benzoate (46). An 8 mL vial equipped with a magnetic stirring bar was charged with methyl 4-bromobenzoate (108 mg, 0.50 mmol, 1.0 equiv.), *tert*-butyl butylcarbamate (173 mg, 1.0 mmol, 2.0 equiv.) and $Ir[dF(CF_3)ppy]_2(dtbbpy)PF_6$ (5.6 mg, 5.0 μmol, 1.0 mol%). Anhydrous DMSO (3.0 mL) and 3-acetoxyquinuclidine (85 μL, 0.55 mmol, 1.1 equiv.) were added. 4,7-Dimethoxy-1,10-phenanthroline (1.2 mg, 5.0 μmol, 1.0 mol%) and nickel(II) bromide trihydrate (1.4 mg, 5.0 μmol, 1.0 mol%) were added as a 0.50 M stock solution in anhydrous DMSO (1 mL, sonicated for 10 minutes before addition). Water (990 μL, 55.0 mmol, 110 equiv.) was added before the mixture was degassed via two cycles of freeze-pump-backfill-thaw. The reaction was sealed and placed ~6 cm away from a 34 W blue LED and stirred for 32 h with cooling by fan. The reaction mixture was removed from the light, diluted with aq. $NaHCO_3$ and EtOAc, and the aqueous layer was extracted with five portions of EtOAc. The combined organic layers were dried over Na_2SO_4, filtered, and concentrated. The residue was purified by flash chromatography eluting with 5-8% EtOAc/hexanes to afford the title compound as a white solid (89 mg, 0.29 mmol, 58% yield). ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.99 (d, J = 8.1 Hz, 2H, 2 × C(4)**H**), 7.33 (d, J = 8.1 Hz, 2H, 2 × C(5)**H**), 4.85 (br. s, 1H, N**H**), 4.66 (br. m, 1H, C(7)**H**), 3.90 (s, 3H, C(1)$\mathbf{H_3}$), 1.76–1.59 (br. m, 2H, C(8)$\mathbf{H_2}$), 1.48–1.19 (m, 11H, C(9)$\mathbf{H_2}$ and 3 × C(13)$\mathbf{H_3}$), 0.91 (t, J = 7.4 Hz, 3H, C(10)$\mathbf{H}_3$). ^{13}C NMR (125 MHz, $CDCl_3$): δ 167.07, 155.31, 148.76, 130.02, 129.05, 126.38, 79.75, 54.69, 52.21, 39.13, 28.49, 19.46, 13.92. IR (thin film): 3360, 2985, 2939, 2877, 1714, 1678, 1612, 1525, 1447, 1434, 1389, 1367, 1358, 1341, 1307, 1280, 1267, 1249, 1168, 1113, 1101, 1085, 1063, 1002 cm^{-1}. HRMS (ESI-TOF) calculated for $C_{17}H_{25}NO_4$ $[M+Na]^+$ requires m/z 330.1676, found 330.1674.



Methyl 4-(1-(3-(*tert*-butyl)-1-ethylureido)ethyl)benzoate (47). An 8 mL vial equipped with a magnetic stirring bar was charged with *N*-Bac diethylamine (172 mg, 1.0 mmol, 2.0 equiv.), methyl 4-bromobenzoate (108 mg, 0.50 mmol, 1.0 equiv.) and $Ir[dF(CF_3)ppy]_2(dtbbpy)PF_6$ (5.6 mg, 5.0 μmol, 1.0 mol%). 4,7-Dimethoxy-1,10-phenanthroline (1.2 mg, 5.0 μmol, 1.0 mol%) and nickel(II) bromide trihydrate (1.4 mg, 5.0 μmol, 1.0 mol%) were added as a 0.50 M stock solution in anhydrous DMSO (1.0 mL, sonicated for 10 minutes before addition). 3-acetoxyquinuclidine (85 μL, 0.55 mmol, 1.1 equiv.) and water (270 μL, 15 mmol, 30 equiv.) were added before the mixture was degassed via two cycles of freeze-pump-backfill-thaw. The reaction was sealed and placed ~6 cm away from a 34 W blue LED and stirred for 24 h with cooling by fan. The reaction mixture was removed from the light, diluted with aq. $NaHCO_3$ and EtOAc, and the aqueous layer

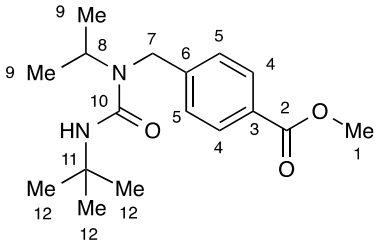
was extracted with five portions of EtOAc. The combined organic layers were dried over Na_2SO_4, filtered, and concentrated. The residue was purified by flash chromatography eluting with 10% EtOAc/toluene to afford the title compound as a crystalline solid (101 mg, 0.33 mmol, 66% yield). ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.98 (d, *J* = 8.1 Hz, 2H, 2 × C(4)**H**), 7.37 (d, *J* = 8.2 Hz, 2H, 2 × C(5)**H**), 5.63 (q, *J* = 7.2 Hz, 1H, C(7)**H**), 4.19 (br. s, 1H, N**H**), 3.90 (s, 3H, C(1)$\mathbf{H_3}$), 3.04 (dq, *J* = 14.4, 7.1 Hz, 1H, C(9)$\mathbf{H}_a$), 2.93 (dq, *J* = 14.6, 7.2 Hz, 1H, C(9)$\mathbf{H}_b$), 1.53 (d, *J* = 7.2 Hz, 3H, C(8)$\mathbf{H_3}$), 1.33 (br. s, 9H, 3 × C(13)$\mathbf{H_3}$), 1.01 (t, *J* = 7.2 Hz, 3H, C(10)$\mathbf{H_3}$). ^{13}C NMR (125 MHz, $CDCl_3$): δ 167.03, 156.90, 148.08, 129.78, 128.96, 127.23, 52.20, 51.74, 50.93, 37.88, 29.69, 17.50, 15.38. IR (thin film): 3363, 2955, 2928, 1716, 1617, 1524, 1502, 1450, 1433, 1393, 1377, 1358, 1315, 1274, 1215, 1189, 1110, 1082, 1066, 1018 cm^{-1}. HRMS (ESI-TOF) calculated for $C_{17}H_{26}N_2O_3$ $[M+H]^+$ requires m/z 307.2016, found 307.2014.



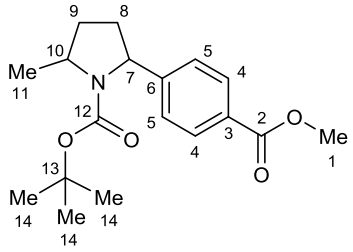
Methyl 4-((3-(*tert*-butyl)-1-butylureido)methyl)benzoate (48A) and methyl 4-(1-(3-(*tert*-butyl)-1-methylureido)butyl)benzoate (48B). An 8 mL vial equipped with a magnetic stirring bar was charged with *N*-Bac butylmethylamine (186 mg, 1.0 mmol, 2.0 equiv.), methyl 4-bromobenzoate (108 mg, 0.50 mmol, 1.0 equiv.) and $Ir[dF(CF_3)ppy]_2(dtbbpy)PF_6$ (5.6 mg, 5.0 µmol, 1.0 mol%). Anhydrous DMSO (3.0 mL) and 3-acetoxyquinuclidine (85 µL, 0.55 mmol, 1.1 equiv.) were added. 4,7-Dimethoxy-1,10-phenanthroline (1.2 mg, 5.0 µmol, 1.0 mol%) and nickel(II) bromide trihydrate (1.4 mg, 5.0 µmol, 1.0 mol%) were added as a 0.50 M stock solution in anhydrous DMSO (1.0 mL, sonicated for 10 minutes before addition). Water (720 µL, 40 mmol, 80 equiv.) was added before the mixture was degassed via two cycles of freeze-pump-backfill-thaw. The reaction was sealed and placed ~6 cm away from a 34 W blue LED and stirred for 24 h with cooling by fan. The reaction mixture was removed from the light, diluted with aq. $NaHCO_3$ and EtOAc, and the aqueous layer was extracted with five portions of EtOAc. The combined organic layers were dried over Na_2SO_4, filtered, and concentrated. The residue was purified twice by flash chromatography, first by eluting with 10% EtOAc/toluene, followed by eluting with 20% acetone/hexanes to afford the title compound as a colorless oil (124 mg, 0.39 mmol, 78% yield, mixture of regioisomers 4:1 A:B). Regioisomer **A**: ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.98 (d, *J* = 8.2 Hz, 2H, 2 × C(4)**H**), 7.28 (d, *J* = 8.1 Hz, 2H, 2 × C(5)**H**), 4.47 (s, 2H, C(7)$\mathbf{H_2}$), 4.19 (br. s, 1H, N**H**), 3.88 (s, 3H, C(1)$\mathbf{H_3}$), 3.16 (t, *J* = 7.5 Hz, 2H, C(8)$\mathbf{H_2}$), 1.53–1.45 (m, 2H, C(9)$\mathbf{H_2}$), 1.34–1.22 (m, 2H, C(10)$\mathbf{H_2}$), 1.28 (br. s, 9H, 3 × C(14)$\mathbf{H_3}$), 0.88 (t, *J* = 7.4 Hz, 3H, C(11)$\mathbf{H_3}$). ^{13}C NMR (125 MHz, $CDCl_3$): δ 166.96, 157.17, 144.18, 130.05, 129.21, 126.99, 52.17, 50.88, 50.29, 47.50,

30.56, 29.51, 20.27, 13.93. Regioisomer **B**: ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.96 (d, *J* = 8.6 Hz, 2H, 2 × C(4)**H**), 7.35 (d, *J* = 8.2 Hz, 2H, 2 × C(5)**H**), 5.55 (dd, *J* = 9.9, 5.8 Hz, 1H, C(7)**H**), 4.24 (br. s, 1H, N**H**), 3.88 (s, 3H, C(1)$\mathbf{H_3}$), 2.50 (s, 3H, C(11)$\mathbf{H_3}$), 1.94–1.73 (m, 2H, C(8)$\mathbf{H_2}$), 1.41–1.32 (m, 2H, C(9)$\mathbf{H_2}$), 1.34 (br. s, 9H, 3 × C(14)$\mathbf{H_3}$), 0.96 (t, *J* = 7.4 Hz, 3H, C(10)$\mathbf{H_3}$). ^{13}C NMR (125 MHz, $CDCl_3$): δ 167.03, 157.75, 146.97, 129.73, 128.89, 127.53, 55.37, 52.14, 50.91, 32.75, 29.59, 28.81, 19.71, 14.11. IR (thin film): 3384, 2958, 2930, 2873, 1720, 1639, 1613, 1515, 1481, 1454, 1435, 1392, 1362, 1276, 1208, 1176, 1108, 1019 cm^{-1}. HRMS (ESI-TOF) calculated for $C_{18}H_{28}N_2O_3$ $[M+H]^+$ requires m/z 321.2173, found 321.2171.

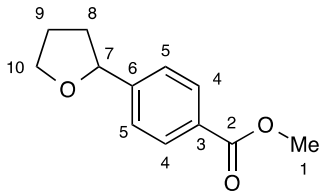
Solvent regioselectivity effects: *Under modified reaction conditions (MeCN (0.25 M), 20 eq. H_2O) the regioselectivity of the C-H arylation protocol was observed to be 10:1* ***48A:48B*** *(53% yield).*



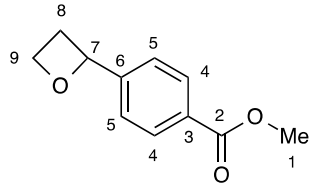
Methyl 4-((3-(*tert*-butyl)-1-isopropylureido)methyl)benzoate (49). An 8 mL vial equipped with a magnetic stirring bar was charged with *N*-Bac isopropylmethylamine (172 mg, 1.0 mmol, 2.0 equiv.), methyl 4-bromobenzoate (108 mg, 0.50 mmol, 1.0 equiv.) and $Ir[dF(CF_3)ppy]_2(dtbbpy)PF_6$ (5.6 mg, 5.0 μmol, 1.0 mol%). Anhydrous DMSO (1.0 mL) and 3-acetoxyquinuclidine (85 μL, 0.55 mmol, 1.1 equiv.) were added. 4,7-Dimethoxy-1,10-phenanthroline (1.2 mg, 5.0 μmol, 1.0 mol%) and nickel(II) bromide trihydrate (1.4 mg, 5.0 μmol, 1.0 mol%) were added as a 0.50 M stock solution in anhydrous DMSO (1.0 mL, sonicated for 10 minutes before addition). Water (360 μL, 20 mmol, 40 equiv.) was added before the mixture was degassed via two cycles of freeze-pump-backfill-thaw. The reaction was sealed and placed ~6 cm away from a 34 W blue LED and stirred for 24 h with cooling by fan. The reaction mixture was removed from the light, diluted with aq. $NaHCO_3$ and EtOAc, and the aqueous layer was extracted with five portions of EtOAc. The combined organic layers were dried over Na_2SO_4, filtered, and concentrated. The residue was purified by flash chromatography eluting with 10% EtOAc/toluene to afford the title compound as a crystalline solid (125 mg, 0.41 mmol, 82% yield). ^{1}H NMR (500 MHz, $CDCl_3$): δ 8.00 (d, *J* = 8.3 Hz, 2H, 2 × C(4)**H**), 7.34 (d, *J* = 8.1 Hz, 2H, 2 × C(5)**H**), 4.59 (hept, *J* = 6.8 Hz, 1H, C(8)**H**), 4.32 (s, 2H, C(7)$\mathbf{H_2}$), 4.01 (br. s, 1H, N**H**), 3.89 (s, 3H, C(1)$\mathbf{H_3}$), 1.18 (br. s, 9H, 3 × C(12)$\mathbf{H_3}$), 1.10 (d, *J* = 6.8 Hz, 6H, 2 × C(9)$\mathbf{H_3}$). ^{13}C NMR (125 MHz, $CDCl_3$): δ 166.84, 157.28, 144.82, 130.12, 129.24, 126.34, 52.17, 50.86, 45.71, 44.99, 29.39, 20.87. IR (thin film): 3444, 2965, 2925, 1703, 1655, 1610, 1517, 1454, 1422, 1391, 1363, 1328, 1278, 1211, 1175, 1108, 1064, 1015 cm^{-1}. HRMS (ESI-TOF) calculated for $C_{17}H_{26}N_2O_3$ $[M+H]^+$ requires m/z 307.2016, found 307.2019.



***tert*-Butyl-2-(4-(methoxycarbonyl)phenyl)-5-methylpyrrolidine-1-carboxylate (50).** An 8 mL vial equipped with a magnetic stirring bar was charged with methyl 4-bromobenzoate (108 mg, 0.50 mmol, 1.0 equiv.), *tert*-butyl 2-methylpyrrolidine-1-carboxylate (185 mg, 1.0 mmol, 2.0 equiv.) and $Ir[dF(CF_3)ppy]_2(dtbbpy)PF_6$ (5.6 mg, 5.0 μmol, 1.0 mol%). Anhydrous DMSO (3.0 mL) and 3-acetoxyquinuclidine (85 μL, 0.55 mmol, 1.1 equiv.) were added. 4,7-Dimethoxy-1,10-phenanthroline (1.2 mg, 5.0 μmol, 1.0 mol%) and nickel(II) bromide trihydrate (1.4 mg, 5.0 μmol, 1.0 mol%) were added as a 0.50 M stock solution in anhydrous DMSO (1 mL, sonicated for 10 minutes before addition). Water (540 μL, 30.0 mmol, 60 equiv.) was added before the mixture was degassed via two cycles of freeze-pump-backfill-thaw. The reaction was sealed and placed ~6 cm away from a 34 W blue LED and stirred for 24 h with cooling by fan. The reaction mixture was removed from the light, diluted with aq. $NaHCO_3$ and EtOAc, and the aqueous layer was extracted with five portions of EtOAc. The combined organic layers were dried over Na_2SO_4, filtered, and concentrated. The residue was purified by flash chromatography eluting with 5% EtOAc/hexanes to afford the title compound as a colorless oil (99 mg, 0.31 mmol, 62% yield, 1:1 d.r. (A:B, 1:1), mixtures of rotamers 2:1 A1:A2 and B1(major):B2(minor)). ^{1}H NMR (500 MHz, $CDCl_3$): δ 8.00–7.93 (m, 8H, 2 × C(4)**H**, A1+2 and B1+2), 7.29 (d, J = 8.1 Hz, 4H, 2 × C(5)**H**, B1+2), 7.18 (d, J = 8.1 Hz, 4H, 2 × C(5)**H**, A1+2), 5.01 (d, J = 8.6 Hz, 1H, C(7)**H**, A2), 4.97–4.67 (m, 3H, C(7)**H**, A1 and B1+2), 4.28 (m, 1H, C(10)**H**, A1), 4.21–3.97 (m, 3H, C(10)**H**, A2 and B1+2), 3.89–3.85 (m, 12H, C(1)$\mathbf{H}_3$, A1+2 and B1+2), 2.50–2.37 (m, 2H, C(8)$\mathbf{H}_a$, A1+2), 2.30–2.22 (m, 2H, C(8)$\mathbf{H}_a$, B1+2), 2.13–1.99 (m, 4H, C(9)$\mathbf{H}_a$, A1+2 and B1+2), 1.89–1.79 (m, 2H, C(8)$\mathbf{H}_b$, B1+2), 1.72–1.63 (m, 2H, C(8)$\mathbf{H}_b$, A1+2), 1.61–1.55 (m, 2H, C(9)$\mathbf{H}_b$, B1+2), 1.54–1.48 (m, 2H, C(9)$\mathbf{H}_b$, A1+2), 1.48–1.04 (br. m, 48H, C(11)$\mathbf{H_3}$ and 3 × C(14)$\mathbf{H_3}$, A1+2 and B1+2). ^{13}C NMR (125 MHz, $CDCl_3$): δ 167.17, 167.12 (**2**A1+2 + **2**B1+2), 154.64 (**12**B1+2), 154.06 (**12**A2), 153.88 (**12**A1), 151.01 (**6**A1), 150.76 (**6**B1+2), 149.73 (**6**A2), 129.90 (**4**A2), 129.78 (**4**B1+2), 129.67 (**4**A1), 128.56, 128.53, 128.49 (**3**A1+2 + **3**B1+2), 125.62 (**5**B1+2), 125.39 (**5**A1), 125.28 (**5**A2), 79.61 (**13**A2), 79.51 (**13**B1+2), 79.36 (**13**A1), 63.04 (**7**B1), 62.72 (**7**B2), 61.55 (**7**A1), 61.05 (**7**A2), 54.74, 54.02 (**10**A1+2 + **10**B1+2), 52.16, 52.13, 52.10 (**1**A1+2 + **1**B1+2), 34.74 (**8**B1), 33.85 (**8**B2), 32.52 (**8**A1), 32.26 (**9**B1+2), 31.77 (**8**A2), 29.95 (**9**A2), 29.25 (**9**A1), 28.61, 28.22 (**14**A1+2 + **14**B1+2), 21.46 (**11**B2), 21.14 (**11**B1), 20.72 (**11**A2), 19.90 (**11**A1). IR (thin film): 2973, 1721, 1683, 1611, 1436, 1386, 1366, 1276, 1167, 1109, 1085, 1018 cm^{-1}. HRMS (ESI-TOF) calculated for $C_{18}H_{25}NO_4$ $[M+Na]^+$ requires m/z 342.1676, found 342.1679.

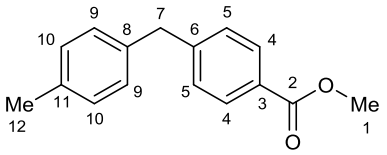


Methyl 4-(tetrahydrofuran-2-yl)benzoate (51). An 8 mL vial equipped with a magnetic stirring bar was charged with methyl 4-bromobenzoate (108 mg, 0.50 mmol, 1.0 equiv.) and $Ir[dF(CF_3)ppy]_2(dtbbpy)PF_6$ (5.6 mg, 5.0 μmol, 1.0 mol%). Anhydrous DMSO (1.0 mL) and 3-acetoxyquinuclidine (85 μL, 0.55 mmol, 1.1 equiv.) were added. 4,7-Dimethoxy-1,10-phenanthroline (1.2 mg, 5.0 μmol, 1.0 mol%) and nickel(II) bromide trihydrate (1.4 mg, 5.0 μmol, 1.0 mol%) were added as a 0.50 M stock solution in anhydrous DMSO (1.0 mL, sonicated for 10 minutes before addition). Tetrahydrofuran (203 μL, 2.5 mmol, 5.0 equiv.) and water (360 μL, 20 mmol, 40 equiv.) were added before the mixture was degassed via two cycles of freeze-pump-backfill-thaw. The reaction was sealed and placed ~6 cm away from two 34 W blue LEDs and stirred for 24 h with cooling by fan. The reaction mixture was removed from the light, diluted with aq. $NaHCO_3$ and EtOAc, and the aqueous layer was extracted with three portions of EtOAc. The combined organic layers were dried over Na_2SO_4, filtered, and concentrated. The residue was purified by flash chromatography eluting with 10% EtOAc/hexanes to afford the title compound as a colorless oil (78 mg, 0.38 mmol, 76% yield). ^{1}H NMR (500 MHz, $CDCl_3$): δ 8.00 (d, J = 8.4 Hz, 2H, 2 × C(4)**H**), 7.39 (d, J = 8.2 Hz, 2H, 2 × C(5)**H**), 4.94 (dd, J = 7.2, 7.2 Hz, 1H, C(7)**H**), 4.11 (dt, J = 8.4, 6.9 Hz, 1H, C(10)$\mathbf{H}_a$), 3.96 (dt, J = 8.0, 7.1 Hz, 1H, C(10)$\mathbf{H}_b$), 3.90 (s, 3H, C(1)$\mathbf{H_3}$), 2.36 (m, 1H, C(8)$\mathbf{H}_a$), 2.01–1.97 (m, 2H, C(9)$\mathbf{H_2}$), 1.77 (m, 1H, C(8)$\mathbf{H}_b$). ^{13}C NMR (125 MHz, $CDCl_3$): δ 167.16, 149.09, 129.80, 129.04, 125.56, 80.32, 69.00, 52.18, 34.85, 26.10. IR (thin film): 2952, 2876, 1718, 1612, 1435, 1409, 1308, 1274, 1190, 1176, 1109, 1057, 1018 cm^{-1}. HRMS (ESI-TOF) calculated for $C_{12}H_{14}O_3$ $[M+H]^+$ requires m/z 207.1016, found 207.1017. The spectroscopic properties of this compound are consistent with data reported in the literature.[49]



Methyl 4-(oxetan-2-yl)benzoate (52). An 8 mL vial equipped with a magnetic stirring bar was charged with methyl 4-bromobenzoate (108 mg, 0.50 mmol, 1.0 equiv.) and $Ir[dF(CF_3)ppy]_2(dtbbpy)PF_6$ (5.6 mg, 5.0 μmol, 1.0 mol%). Anhydrous DMSO (1.0 mL) and 3-acetoxyquinuclidine (85 μL, 0.55 mmol, 1.1 equiv.) were added. 4,7-Dimethoxy-1,10-phenanthroline (1.2 mg, 5.0 μmol, 1.0 mol%) and nickel(II) bromide trihydrate (1.4 mg, 5.0 μmol, 1.0 mol%) were added as a 0.50 M stock solution in anhydrous DMSO (1.0 mL, sonicated for 10 minutes before addition). Oxetane (228 μL, 3.5 mmol, 7.0 equiv.) and water (360 μL, 20 mmol, 40

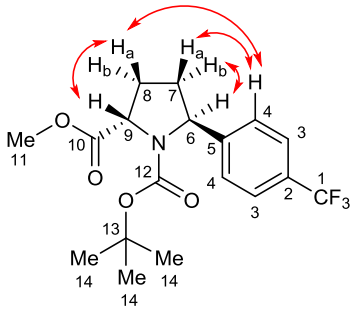
equiv.) were added before the mixture was degassed via two cycles of freeze-pump-backfill-thaw. The reaction was sealed and placed ~6 cm away from a 34 W blue LED and stirred for 36 h with cooling by fan. The reaction mixture was removed from the light, diluted with aq. $NaHCO_3$ and EtOAc, and the aqueous layer was extracted with three portions of EtOAc. The combined organic layers were dried over Na_2SO_4, filtered, and concentrated. The residue was purified by flash chromatography eluting with 10% EtOAc/hexanes to afford the title compound as a colorless oil (51 mg, 0.26 mmol, 53% yield). ^{1}H NMR (500 MHz, $CDCl_3$): δ 8.06 (d, J = 8.2 Hz, 2H, 2 × C(4)**H**), 7.49 (d, J = 8.1 Hz, 2H, 2 × C(5)**H**), 5.86 (dd, J = 7.6, 7.6 Hz, 1H, C(7)**H**), 4.85 (ddd, J = 7.9, 5.9, 5.9 Hz, 1H, C(9)$\mathbf{H}_a$), 4.68 (ddd, J = 9.2, 5.8, 5.8 Hz, 1H, C(9)$\mathbf{H}_b$), 3.92 (s, 3H, C(1)$\mathbf{H_3}$), 3.07 (m, 1H, C(8)$\mathbf{H}_a$), 2.62 (m, 1H, C(8)$\mathbf{H}_b$). ^{13}C NMR (125 MHz, $CDCl_3$): δ 167.04, 148.84, 130.01, 129.58, 125.02, 82.37, 68.58, 52.25, 30.75. IR (thin film): 2954, 2890, 1717, 1612, 1436, 1408, 1275, 1192, 1106, 1064, 1018 cm^{-1}. HRMS (EI) calculated for $C_{11}H_{12}O_3$ $[M]^+$ requires m/z 192.0781, found 192.0781.



Methyl 4-(4-methylbenzyl)benzoate (53). An 8 mL vial equipped with a magnetic stirring bar was charged with methyl 4-bromobenzoate (53.8 mg, 0.25 mmol, 1.0 equiv.) and $Ir[dF(CF_3)ppy]_2(dtbbpy)PF_6$ (2.8 mg, 2.5 μmol, 1.0 mol%). Anhydrous DMSO (0.5 mL) and 3-acetoxyquinuclidine (43 μL, 0.28 mmol, 1.1 equiv.) were added. 4,7-Dimethoxy-1,10-phenanthroline (0.6 mg, 2.5 μmol, 1.0 mol%) and nickel(II) bromide trihydrate (0.7 mg, 2.5 μmol, 1.0 mol%) were added as a 0.50 M stock solution in anhydrous DMSO (0.5 mL, sonicated for 10 minutes before addition). Xylene (154 μL, 1.25 mmol, 5.0 equiv.) and water (135 μL, 7.5 mmol, 30 equiv.) were added before the mixture was degassed via two cycles of freeze-pump-backfill-thaw. The reaction was sealed and placed ~6 cm away from a 34 W blue LED and stirred for 24 h with cooling by fan. The reaction mixture was removed from the light, diluted with aq. $NaHCO_3$ and EtOAc, and the aqueous layer was extracted with three portions of EtOAc. The combined organic layers were dried over Na_2SO_4, filtered, and concentrated. A 54% *in situ* yield was obtained by ^{1}H NMR spectroscopy against 1,3-benzodioxole as an internal standard. ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.95 (d, J = 8.4 Hz, 2H, 2 × C(4)**H**), 7.25 (d, J = 8.4 Hz, 2H, 2 × C(5)**H**), 7.11 (d, J = 7.8 Hz, 2H, 2 × C(10)**H**), 7.07 (d, J = 8.1 Hz, 2H, 2 × C(9)**H**), 3.99 (s, 2H, C(7)$\mathbf{H}_2$), 3.90 (s, 3H, C(1)$\mathbf{H}_3$), 2.33 (s, 3H, C(12)$\mathbf{H}_3$). ^{13}C NMR (125 MHz, $CDCl_3$): δ 167.21, 146.97, 137.20, 136.04, 129.92, 129.41, 129.00, 128.95, 128.11, 52.14, 41.63, 21.16. The spectroscopic properties of this compound are consistent with data reported in the literature.[50]

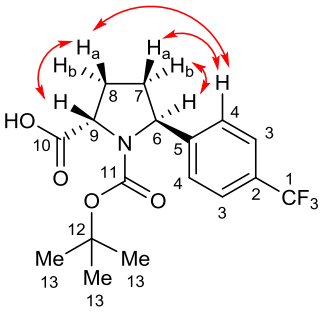
During the course of our studies, we were intrigued to find that using modified reaction conditions in the absence of 3-acetoxyquinuclidine (2 equiv. xylene, 1 equiv. methyl 4-bromobenzoate, 1

mol% nickel(II) bromide trihydrate, 1 mol% 4,7-dimethoxy-1,10-phenanthroline, 1 mol% $Ir[dF(CF_3)ppy]_2(dtbbpy)PF_6$, 2 equiv. Na_2CO_3, MeCN (0.25 M), fan cooling, 24 h) a 74% *in situ* yield was obtained by ^1H NMR spectroscopy against 1,3-benzodioxole as an internal standard. Under these conditions an alternative mechanism appears to be operative and we spectulate that bromine radical, generated from bromide, is responsible for the HAT event.



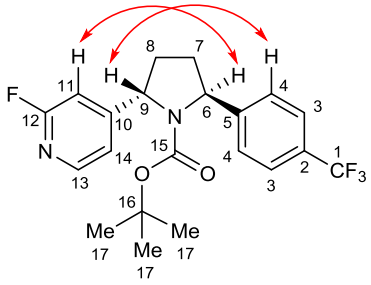
1-(*tert*-Butyl)-2-methyl-5-(4-(trifluoromethyl)phenyl)pyrrolidine-1,2-dicarboxylate. An 8 mL vial equipped with a magnetic stirring bar was charged with 1-bromo-4-(trifluoromethyl)benzene (113 mg, 0.50 mmol, 1.0 equiv.), N-Boc-*L*-proline methyl ester (229 mg, 1.0 mmol, 2.0 equiv.) and $Ir[dF(CF_3)ppy]_2(dtbbpy)PF_6$ (5.6 mg, 5.0 µmol, 1.0 mol%). Anhydrous DMSO (1.0 mL) and 3-acetoxyquinuclidine (85 µL, 0.55 mmol, 1.1 equiv.) were added. 4,7-Dimethoxy-1,10-phenanthroline (2.4 mg, 10.0 µmol, 2.0 mol%) and nickel(II) bromide trihydrate (2.7 mg, 10.0 µmol, 2.0 mol%) were added as a 0.50 M stock solution in anhydrous DMSO (1 mL, sonicated for 10 minutes before addition). Water (450 µL, 25.0 mmol, 50 equiv.) was added before the mixture was degassed via two cycles of freeze-pump-backfill-thaw. The reaction was sealed and placed ~6 cm away from a 34 W blue LED and stirred for 48 h with cooling by fan. The reaction mixture was removed from the light, diluted with aq. $NaHCO_3$ and EtOAc, and the aqueous layer was extracted with five portions of EtOAc. The combined organic layers were dried over Na_2SO_4, filtered, and concentrated. The residue was purified by flash chromatography eluting with 1% acetone/hexanes and then dried under high vacuum (100 mTorr) at 65 °C for 3 h to afford the title compound as a colorless oil (123 mg, 0.33 mmol, 66% yield, 4:1 d.r. (A:B, 4:1), mixtures of rotamers 1.1:1 A1:A2 and 1.2:1 B1:B2). ^1H NMR (500 MHz, $CDCl_3$): δ 7.71–7.66 (m, 4H, 2 × C(4)**H**, B1+2), 7.61–7.54 (m, 8H, 2 × C(3)**H**, A1+2 + B1+2), 7.32–7.24 (m, 4H, 2 × C(4)**H**, A1+2), 5.22 (d, J = 8.7 Hz, 1H, C(6)**H**, A1), 5.08 (dd, J = 8.7, 1.8 Hz, 1H, C(6)**H**, A2), 5.01 (dd, J = 8.1, 4.1 Hz, 1H, C(6)**H**, B2), 4.80 (dd, J = 7.3, 7.3 Hz, 1H, C(6)**H**, B1), 4.64 (dd, J = 9.0, 1.8 Hz, 1H, C(9)**H**, A2), 4.56–4.48 (m, 2H, C(9)**H**, A1 + B1), 4.38 (dd, J = 7.6, 7.6 Hz, 1H, C(9)**H**, B2), 3.81 (s, 6H, C(11)$\mathbf{H_3}$, B1+2), 3.77 (s, 3H, C(11)$\mathbf{H}_3$, A1/2), 3.77 (s, 3H, C(11)$\mathbf{H}_3$, A1/2), 2.57–2.45 (m, 2H, C(7)$\mathbf{H}_b$, A1+2), 2.40–2.31 (m, 2H, 1 × C(7)$\mathbf{H_2}$, B1+2), 2.30–2.19 (m, 4H, C(8)$\mathbf{H}_a$ (A1+2) and 1 × C(8)$\mathbf{H_2}$ (B1+2)), 2.10–1.86 (m, 6H, C(8)$\mathbf{H}_b$ (A1+2), 1 × C(8)$\mathbf{H_2}$ (B1+2) and 1 × C(7)$\mathbf{H_2}$ (B1+2)), 1.82–1.72 (m, 2H, C(7)$\mathbf{H}_a$, A1+2), 1.40 (s, 18H, 3 × C(14)$\mathbf{H}_3$, A1/2 + B1/2), 1.19 (s, 9H, 3 × C(14)$\mathbf{H}_3$, A1/2), 1.14 (s, 9H, 3 × C(14)$\mathbf{H}_3$, B1/2). ^{13}C NMR (125 MHz, $CDCl_3$): δ 173.77 (**10**B2), 173.68 (**10**B1), 173.44 (**10**A1), 173.13 (**10**A2), 154.28 (**12**B1), 154.20 (**12**A2), 153.84 (**12**B2), 153.69 (**12**A1), 148.68

(**5**A2), 148.33 (**5**B1), 147.67 (**5**A1), 147.32 (**5**B2), 129.28 (q, *J* = 32.3 Hz, **2**A1), 129.25 (q, *J* = 32.3 Hz, **2**A2), 129.12 (q, *J* = 32.3 Hz, **2**B1+2), 126.73 (**4**B1), 126.46 (**4**B2), 125.78 (**4**A2), 125.75 (**4**A1), 125.67 (q, *J* = 3.8 Hz, **3**A1/2), 125.52 (q, *J* = 4.0 Hz, **3**B1/2), 125.40 (q, *J* = 3.8 Hz, **3**A1/2), 125.25 (q, *J* = 3.9 Hz, **3**B1/2), 124.44 (q, *J* = 271.8 Hz, **1**B1+2), 124.32 (q, *J* = 272.0 Hz, **1**A1/2), 124.29 (q, *J* = 271.9 Hz, **1**A1/2), 80.85 (**13**B1/2), 80.75 (**13**A1), 80.56 (**13**A2 + **13**B1/2), 62.69 (**6**B1), 61.96 (**6**B2), 61.33 (**6**A2), 61.07 (**6**A1), 60.77 (**9**B2), 60.38 (**9**A1), 60.26 (**9**B1), 59.95 (**9**A2), 52.44, 52.27 (**11**A1+2 + **11**B1+2), 35.55 (**7**B1), 34.45 (**7**B2), 33.51 (**7**A2), 32.54 (**7**A1), 29.09 (**8**B2), 28.83 (**8**B1), 28.36 (**14**A1/2), 28.32 (**14**B1/2), 28.17 (**8**A1), 28.15 (**14**A1/2), 28.09 (**14**B1/2), 27.27 (**8**A2). ^{19}F NMR (282 MHz, $CDCl_3$): δ -62.32 (s, B1/2), -62.34 (s, A1/2), -62.40 (s, B1/2), -62.43 (s, A1/2). IR (thin film): 2975, 1746, 1698, 1620, 1420, 1382, 1366, 1323, 1257, 1216, 1199, 1158, 1114, 1066, 1016 cm^{-1}. HRMS (ESI-TOF) calculated for $C_{18}H_{22}F_3NO_4$ $[M+Na]^+$ requires m/z 396.1393, found 396.1395. *The relative stereochemistry of the major diastereomer A of the title compound was corroborated by nOe experiments (as indicated on the compound structure). No significant nOe was observed between C(4)**H** and C(7)**H**$_b$ or C(8)**H**$_b$. No significant nOe was observed between C(9)**H** and C(8)**H**$_b$.*



1-(*tert*-Butoxycarbonyl)-5-(4-(trifluoromethyl)phenyl)pyrrolidine-2-carboxylic acid (55). A 50 mL round-bottomed flask equipped with a magnetic stirring bar was charged with 1-(*tert*-butyl)-2-methyl-5-(4-(trifluoromethyl)phenyl)pyrrolidine-1,2-dicarboxylate (400 mg, 1.1 mmol, 1.0 equiv.), THF (7 mL) and H_2O (3.5 mL). LiOH (128 mg, 5.4 mmol, 5.0 equiv.) was added and the solution was stirred at room temperature for 10 h. The reaction mixture was concentrated *in vacuo* to remove the THF and was then diluted with H_2O (100 mL) and Et_2O (50 mL). The aqueous portion was further extracted with Et_2O (50 mL) and was then acidified to pH 4 by addition of 1 M aq. HCl. The acidified aqueous portion was extracted with Et_2O (3 × 75 mL) and these organic extracts were combined, washed with brine (50 mL), dried over Na_2SO_4 and concentrated *in vacuo* to afford the title compound as a white solid (347 mg, 0.97 mmol, 90% yield, 6:1 d.r. (A:B, 6:1), mixtures of rotamers 2:1 A1:A2 and B1(major):B2(minor)). ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.62–7.56 (m, 8H, 2 × C(3)**H**, A1+2 + B1+2), 7.37 (d, *J* = 7.9 Hz, 4H, 2 × C(4)**H**, B1+2), 7.30 (d, *J* = 8.0 Hz, 2H, 2 × C(4)**H**, A2), 7.24 (d, *J* = 8.1 Hz, 2H, 2 × C(4)**H**, A1), 5.23 (d, *J* = 8.7 Hz, 1H, C(6)**H**, A2), 5.02 (d, *J* = 8.5 Hz, 1H, C(6)**H**, A1), 4.76 (dd, *J* = 6.7, 6.7 Hz, 2H, C(6)**H**, B1+2), 4.72 (d, *J* = 8.6 Hz, 1H, C(9)**H**, A1), 4.61–4.53 (m, 3H, C(9)**H**, A2 + B1+2), 2.58–2.45 (m, 4H, C(7)**H**$_b$ (A1+2) and 1 × C(7)**H$_2$** (B1+2)), 2.42–2.26 (m, 4H, C(8)**H**$_a$ (A1+2) and 1 × C(8)**H$_2$**

(B1+2)), 2.23–2.04 (m, 4H, C(8)$\mathbf{H}_b$ (A1+2) and 1 × C(8)$\mathbf{H_2}$ (B1+2)), 2.00–1.89 (m, 2H, 1 × C(7)$\mathbf{H_2}$, B1+2), 1.87–1.77 (m, 2H, C(7)$\mathbf{H}_a$, A1+2), 1.43 (s, 18H, 3 × C(13)$\mathbf{H_3}$, A2 + B1/2), 1.21 (s, 9H, 3 × C(13)$\mathbf{H_3}$, A1), 1.15 (s, 9H, 3 × C(13)$\mathbf{H_3}$, B1/2). ^{13}C NMR (125 MHz, $CDCl_3$): δ 179.04 (**10**B2), 178.89 (**10**A2), 176.76 (**10**A1), 175.74 (**10**B1), 155.95 (**11**B1), 155.08 (**11**A1), 153.87 (**11**B2), 153.70 (**11**A2), 148.16 (**5**A1), 147.61 (**5**B1), 147.46 (**5**A2), 147.12 (**5**B2), 129.48 (q, J = 33.0 Hz, **2**B1+2), 129.42 (q, J = 32.4 Hz, **2**A1), 129.37 (q, J = 32.4 Hz, **2**A2), 126.52 (**4**B1), 126.44 (**4**B2), 125.75 (**4**A2), 125.70 (**4**A1), 125.49 (q, J = 3.8 Hz, **3**A1/2), 124.30 (q, J = 271.9 Hz, **1**A2), 124.25 (q, J = 271.9 Hz, **1**A1), 82.00 (**12**B1), 81.46 (**12**A1), 81.33 (**12**B2), 81.19 (**12**A2), 63.09 (**6**B1), 62.08 (**6**B2), 61.58 (**6**A1), 61.07 (**6**A2), 60.79 (**9**B1), 60.74 (**9**B2), 60.18 (**9**A2), 60.02 (**9**A1), 35.65 (**7**B1), 34.51 (**7**B2), 33.51 (**7**A1), 32.53 (**7**A2), 29.10 (**8**B2), 28.35 (**13**A2), 28.15 (**13**A1), 28.06 (**8**A2), 27.85 (**8**B1), 26.69 (**8**A1). ^{19}F NMR (282 MHz, $CDCl_3$): δ -62.37 (s), -62.42 (s), -62.43 (s). IR (thin film): 2984, 1753, 1636, 1419, 1373, 1325, 1243, 1159, 1141, 1113, 1067 cm^{-1}. HRMS (ESI-TOF) calculated for $C_{17}H_{20}F_3NO_4$ $[M+Na]^+$ requires m/z 382.1237, found 382.1236. *The carbon peaks for **3**A1/2, **3**B1+2, **1**B1+2 and **13**B1+2 could not be identified due to overlapping signals/the low quantity of the minor diastereomer. The relative stereochemistry of the major diastereomer A of the title compound was corroborated by nOe experiments (as indicated on the compound structure). No significant nOe was observed between C(4)**H** and C(7)$\mathbf{H}_b$ or C(8)$\mathbf{H}_b$. No significant nOe was observed between C(9)**H** and C(8)$\mathbf{H}_b$.*



***tert*-Butyl-2-(2-fluoropyridin-4-yl)-5-(4-(trifluoromethyl)phenyl)pyrrolidine-1-carboxylate (56).** A 40 mL vial equipped with a magnetic stirring bar was charged with 1-(*tert*-butoxycarbonyl)-5-(4-(trifluoromethyl)phenyl)pyrrolidine-2-carboxylic acid (108 mg, 0.30 mmol, 1.0 equiv.), $NiCl_2$.glyme (6.6 mg, 30.0 µmol, 10 mol%.), 4,4'-di-*tert*-butyl-2,2'dipyridyl (12.1 mg, 45.0 µmol, 15 mol%), Cs_2CO_3 (98 mg, 0.30 mmol, 1.0 equiv.) and Ir[dF(CF_3)ppy]$_2$(dtbbpy)PF_6 (3.4 mg, 3.0 µmol, 1.0 mol%). 4-Bromo-2-fluoropyridine (79 mg, 0.45 mmol, 1.5 equiv.) in anhydrous DMF (15 mL) was added and the reaction mixture was degassed by sparging the solution with N_2 for 20 minutes. The reaction was sealed, placed between two 34 W blue LEDs (approx. 6 cm from each) and stirred for 24 h with cooling by fan. The reaction mixture was removed from the light and diluted with aq. $NaHCO_3$ (30 mL) and EtOAc (30 mL). The layers were separated and the aqueous layer was further extracted with three portions of EtOAc (3 × 30 mL). The combined organic layers were washed with water (50 mL) and brine (50 mL), dried over Na_2SO_4, filtered, and concentrated. The residue was purified by flash chromatography eluting with

10-15% EtOAc/hexanes to afford the title compound as a colorless oil (90 mg, 0.22 mmol, 73% yield, 4:1 d.r. (A:B, 4:1), A: mixture of rotamers 1.1:1 A1:A2, B: rotameric but peaks unresolved). ^{1}H NMR (500 MHz, $CDCl_3$): δ 8.18 (dd, *J* = 9.8, 5.1 Hz, 3H, C(13)**H**, A1+2 + B), 7.65–7.56 (m, 6H, 2 × C(3)**H**, A1+2 + B), 7.50–7.38 (br. m, 2H, 2 × C(4)**H**, B), 7.34–7.28 (m, 4H, 2 × C(4)**H**, A1+2), 7.16 (br. m, 1H, C(14)**H**, B), 7.09–7.04 (m, 2H, C(14)**H**, A1+2), 6.90 (br. m, 1H, C(11)**H**, B), 6.82–6.75 (br. m, 2H, C(11)**H**, A1+2), 5.34 (d, *J* = 7.3 Hz, 1H, C(6)**H**, A2), 5.29 (d, *J* = 8.0 Hz, 1H, C(9)**H**, A1), 5.19 (d, *J* = 7.8 Hz, 1H, C(6)**H**, A1), 5.15 (d, *J* = 7.6 Hz, 1H, C(9)**H**, A2), 5.01 (br. m, 2H, C(6)**H** and C(9)**H**, B), 2.52–2.36 (m, 6H, C(7)$\mathbf{H}_a$ and C(8)$\mathbf{H}_a$, A1+2 + B), 2.11–1.91 (m, 2H, C(7)$\mathbf{H}_b$ and C(8)$\mathbf{H}_b$, B), 1.83–1.71 (m, 4H, C(7)$\mathbf{H}_b$ and C(8)$\mathbf{H}_b$, A1+2), 1.26–1.12 (m, 27H, 3 × C(17)$\mathbf{H_3}$, A1+2 + B). ^{13}C NMR (125 MHz, $CDCl_3$): δ 164.38 (d, *J* = 238.5 Hz, **12**A1), 164.32 (d, *J* = 238.9 Hz, **12**A2), 164.27 (d, *J* = 238.4 Hz, **12**B), 160.03 (d, *J* = 7.2 Hz, **10**A2), 158.88 (d, *J* = 7.2 Hz, **10**A1), 155.44 (**15**B), 153.72 (**15**A1), 153.41 (**15**A2), 148.46 (**5**A1), 147.95 (d, *J* = 15.4 Hz, **13**A1/2), 147.90 (d, *J* = 15.3 Hz, **13**A1/2), 147.25 (**5**A2), 129.45 (q, *J* = 32.4 Hz, **2**A1/2), 129.43 (q, *J* = 32.4 Hz, **2**A1/2), 126.60 (**4**B), 125.76 (q, *J* = 3.7 Hz, **3**A1/2), 125.63 (**4**A1), 125.57 (**4**A2), 125.51 (q, *J* = 3.8 Hz, **3**A1/2), 124.25 (q, *J* = 271.9 Hz, **1**A2), 124.21 (q, *J* = 271.9 Hz, **1**A1), 119.21 (**14**B), 118.64 (d, *J* = 3.8 Hz, **14**A1), 118.48 (d, *J* = 3.8 Hz, **14**A2), 107.13 (d, *J* = 38.2 Hz, **11**B), 106.25 (d, *J* = 38.1 Hz, **11**A1), 106.18 (d, *J* = 37.9 Hz, **11**A2), 81.09 (**16**B), 80.86 (**16**A2), 80.77 (**16**A1), 62.01 (**6**A1), 61.51 (**6**A2), 61.29 (d, *J* = 2.9 Hz, **9**A2), 60.83 (d, *J* = 3.0 Hz, **9**A1), 32.24 (**8**A1), 31.66 (**7**A2), 31.44 (**8**A2), 30.91 (**7**A1), 28.16 (**17**B), 28.14 (**17**A1/2), 28.08 (**17**A1/2). ^{19}F NMR (282 MHz, $CDCl_3$): δ -62.35 (s), -62.42 (s), -67.99 (s), -68.10 (s). IR (thin film): 2976, 1738, 1694, 1611, 1572, 1480, 1411, 1379, 1366, 1323, 1161, 1112, 1067, 1015 cm^{-1}. HRMS (ESI-TOF) calculated for $C_{21}H_{22}F_4N_2O_2$ $[M+H]^+$ requires m/z 411.1690, found 411.1689. *Due to the highly rotameric nature of diastereomer B of the title compound only characteristic ^{13}C signals are provided. The relative stereochemistry of the major diastereomer A of the title compound was corroborated by nOe experiments (as indicated on the compound structure). No significant nOe was observed between C(6)**H** and C(9)**H**.*

V. Cyclic Voltammetry Data

Cyclic voltammetry was performed on a CH Instruments Electrochemical Analyzer (CHI600E). A 0.005 M CH_3CN solution of 3-acetoxyquinuclidine **3** was prepared with 0.1 M tetrabutylammonium hexafluorophosphate as the supporting electrolyte and the solution was sparged with N_2 for 15 minutes. The cyclic voltammogram was obtained using a glassy carbon working electrode, a Pt counter electrode, and a saturated calomel reference electrode. Scan rate = 0.05 V/s.

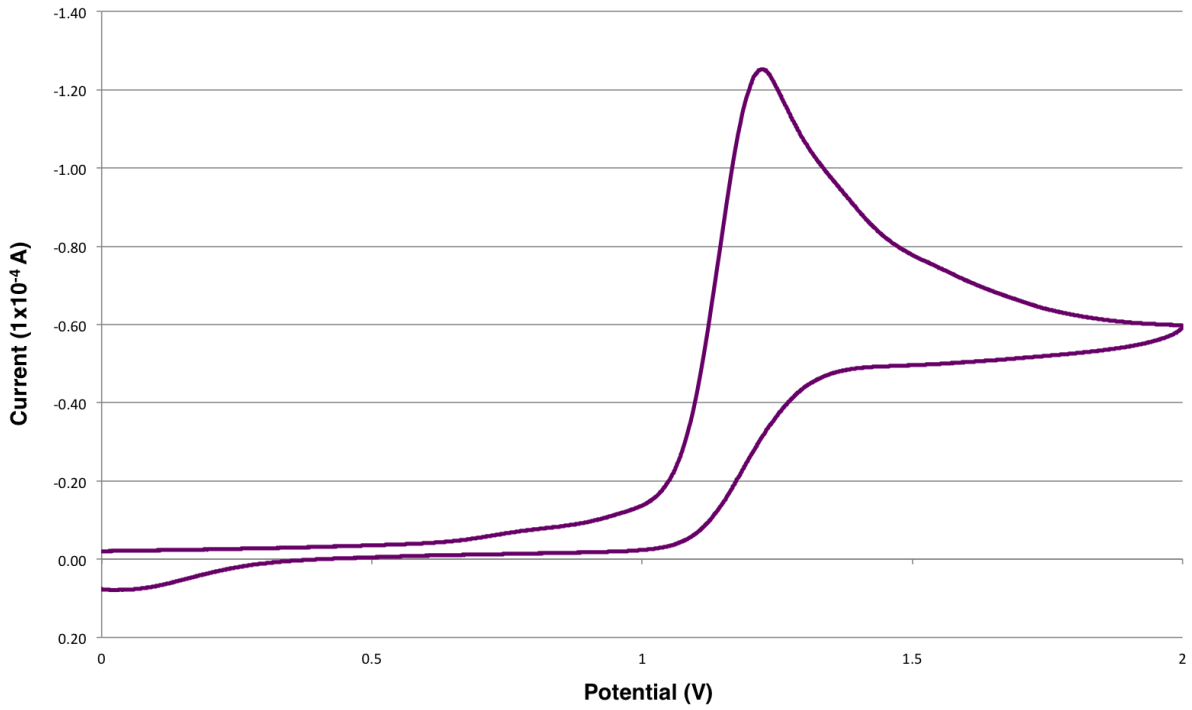
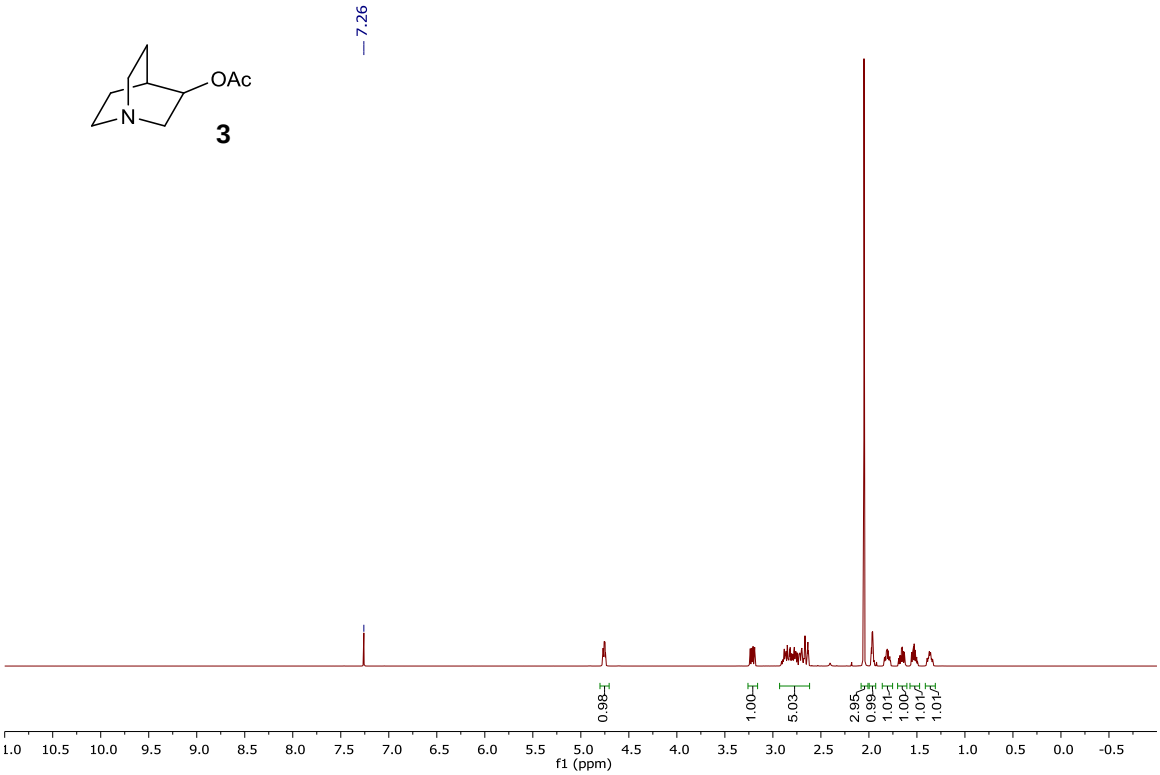
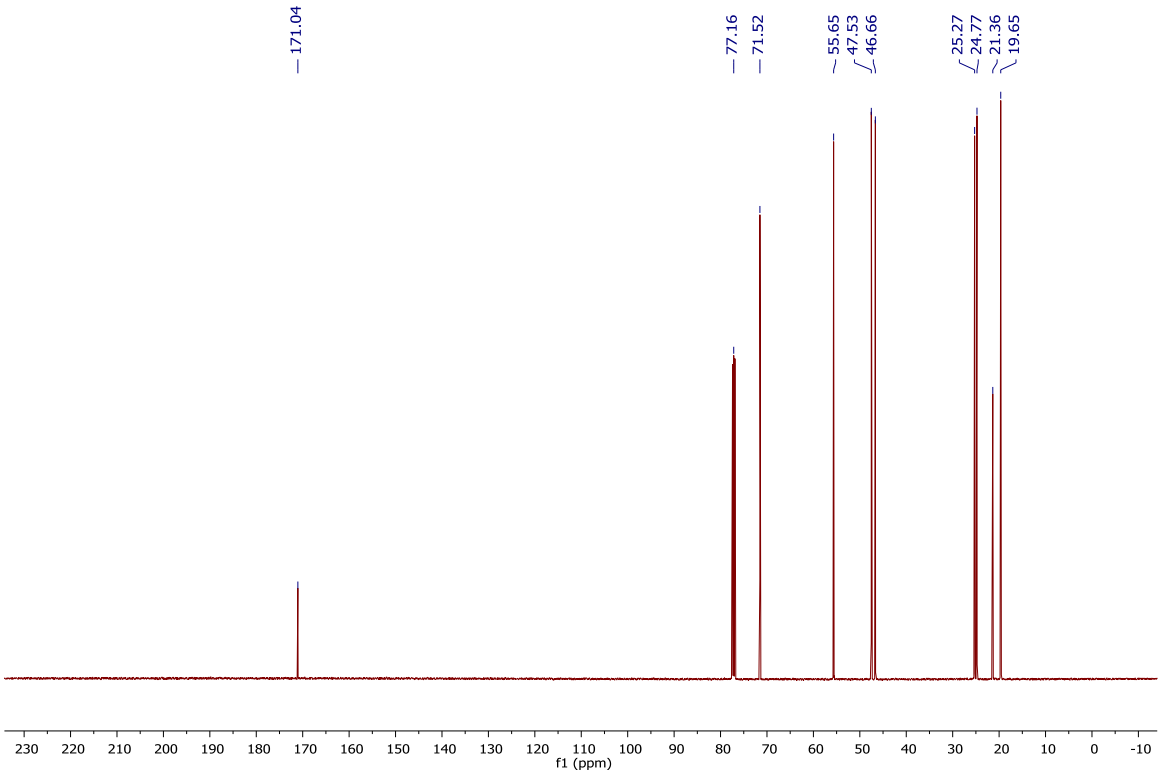
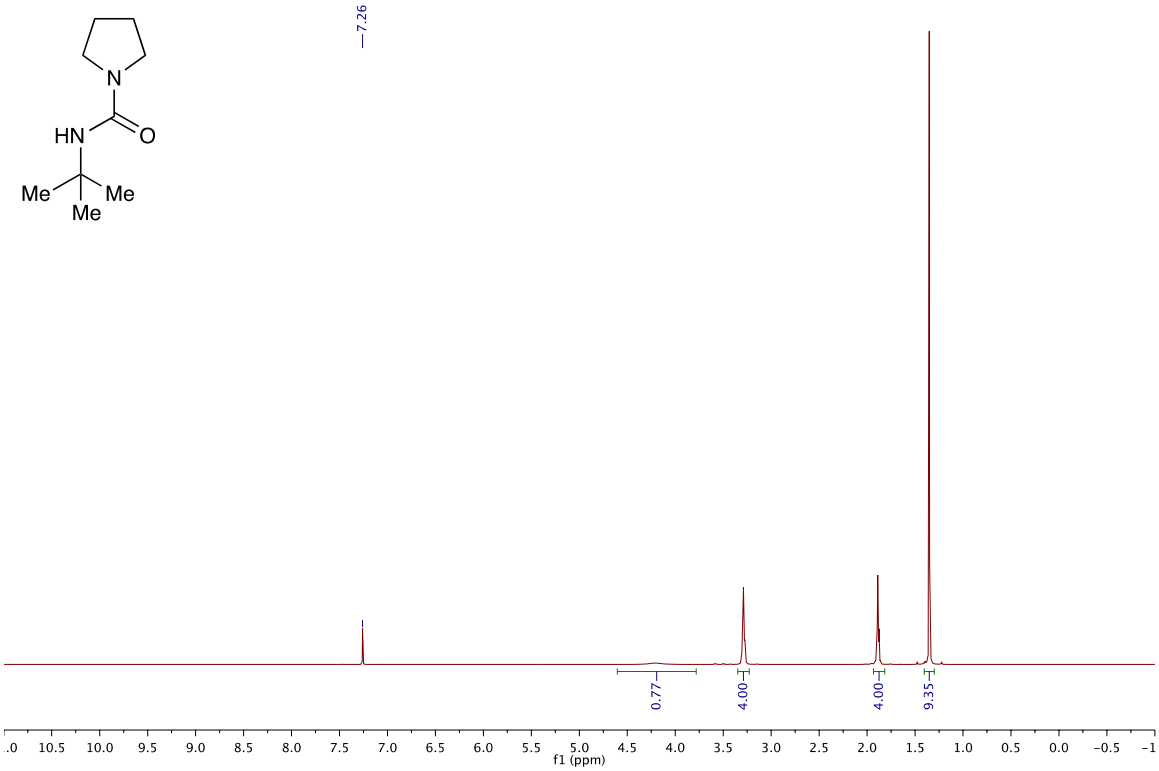


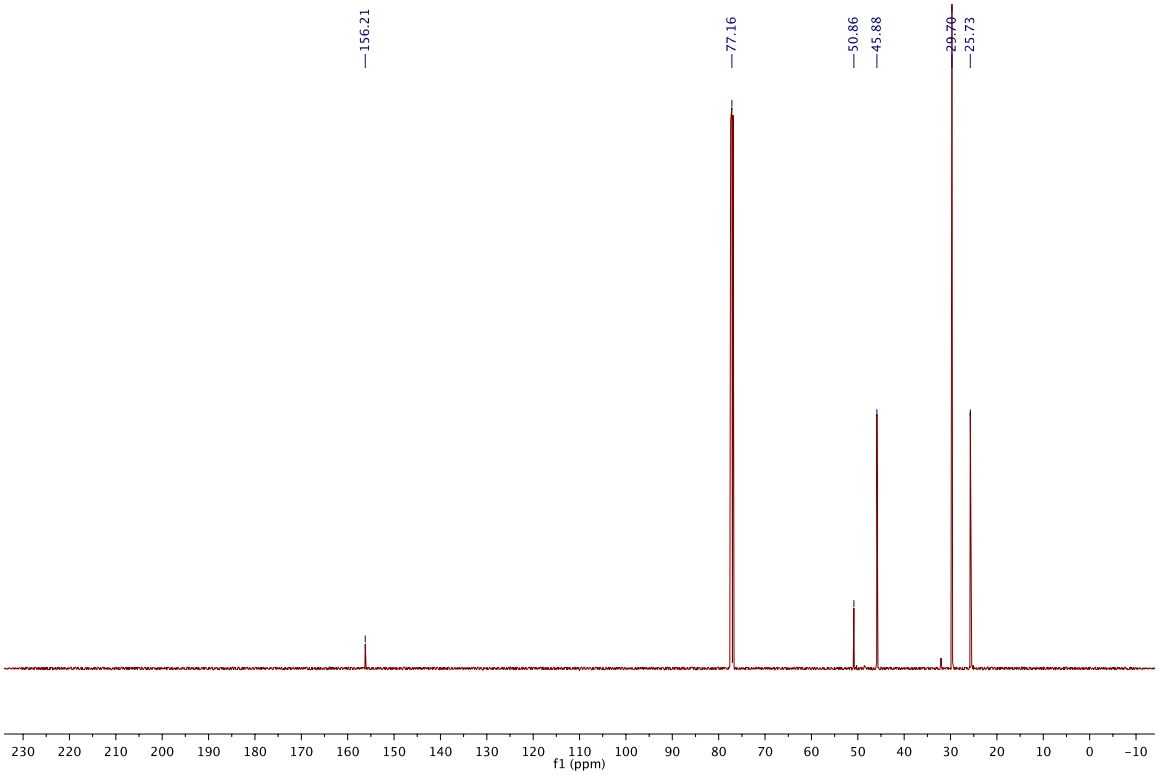
Figure S1. Cyclic voltammogram of HAT reagent **3** shows an irreversible oxidation event at +1.22 V vs. SCE in CH_3CN, which corresponds to the generation of amine radical cation **5**.

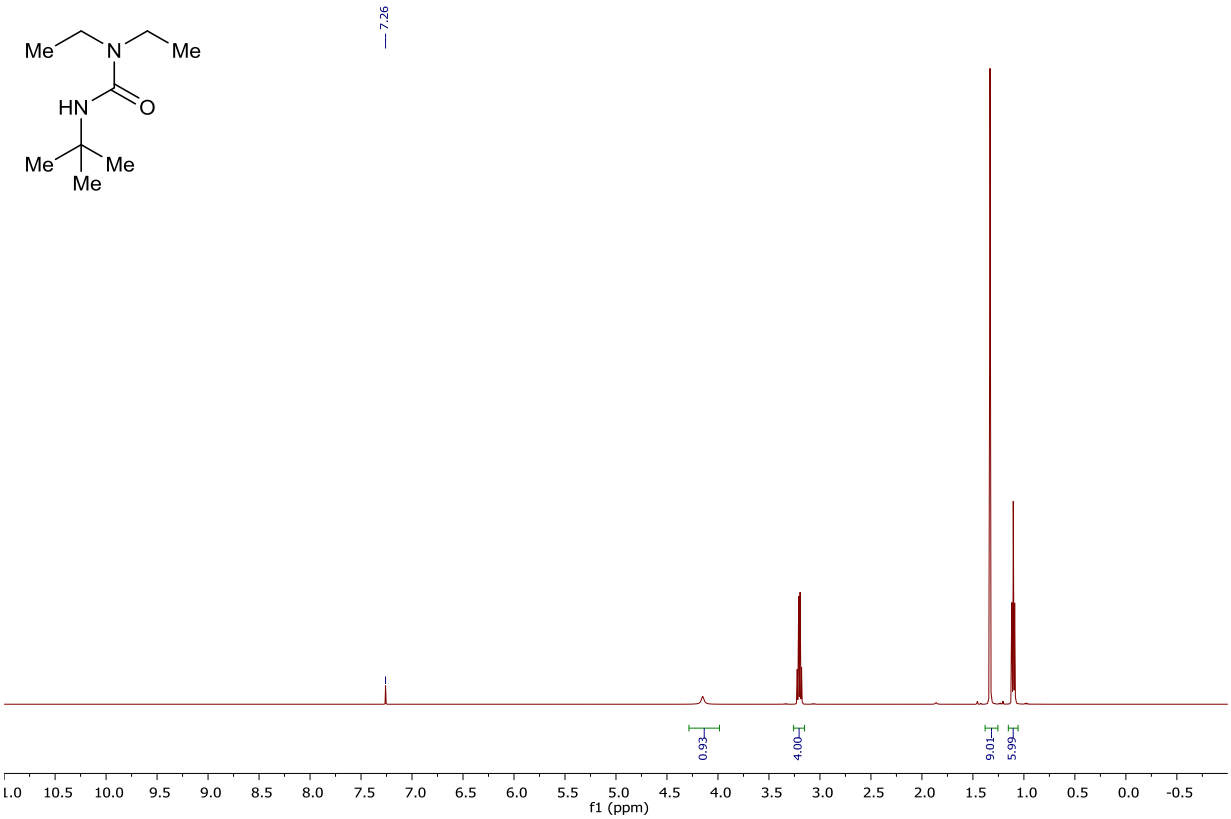
VI. NMR Spectral Data for Novel Compounds

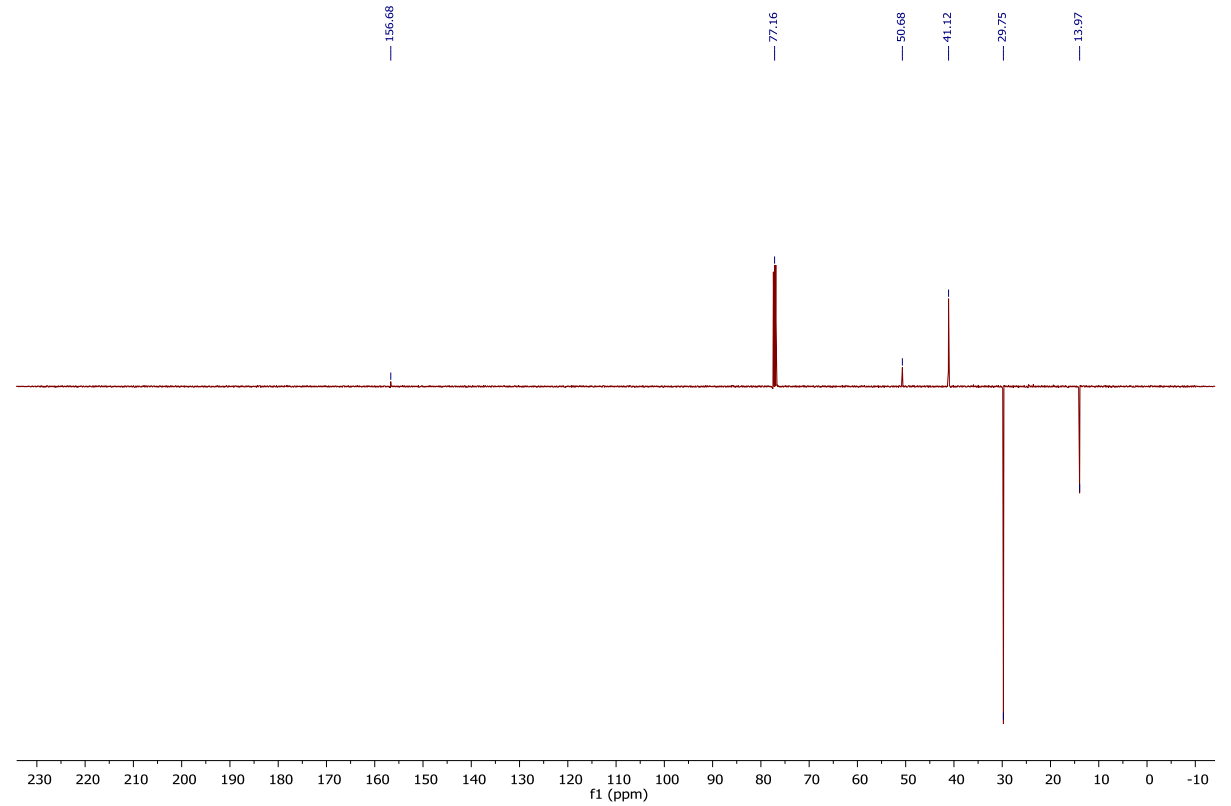


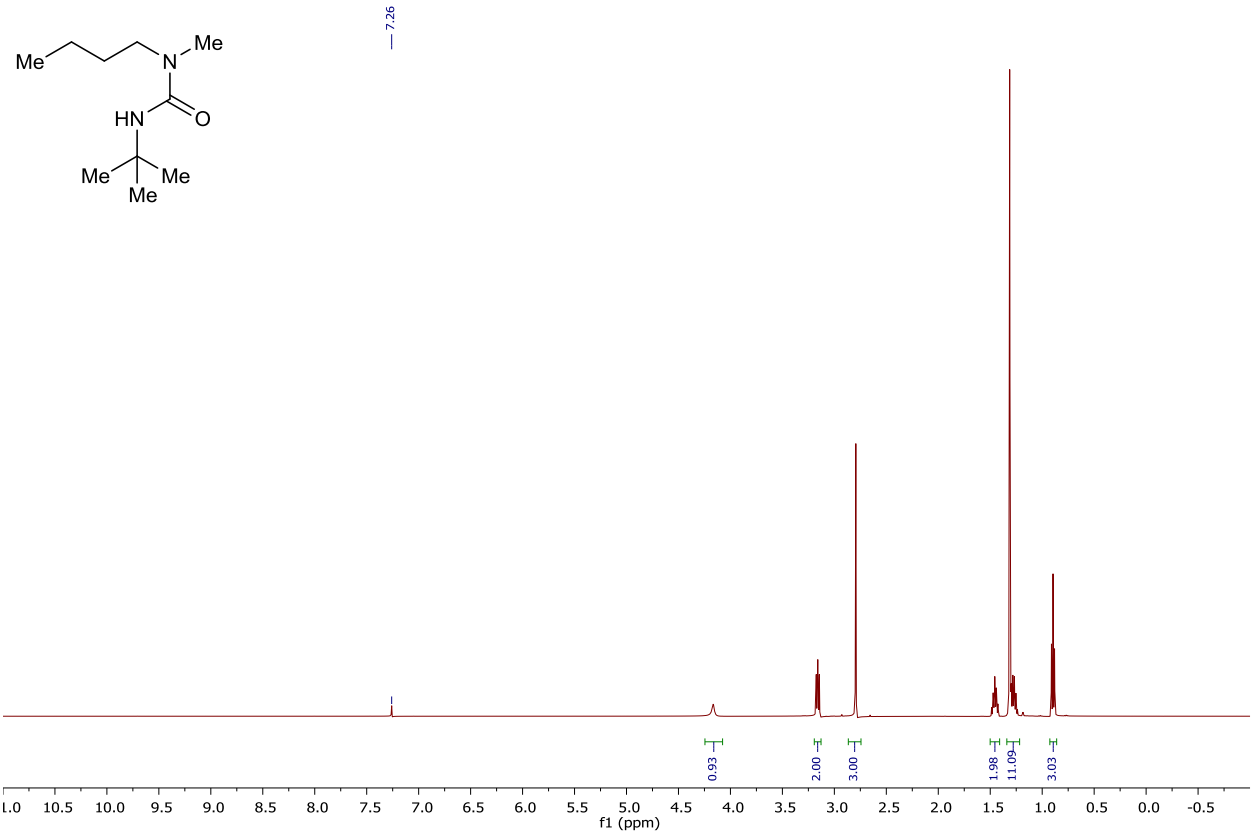


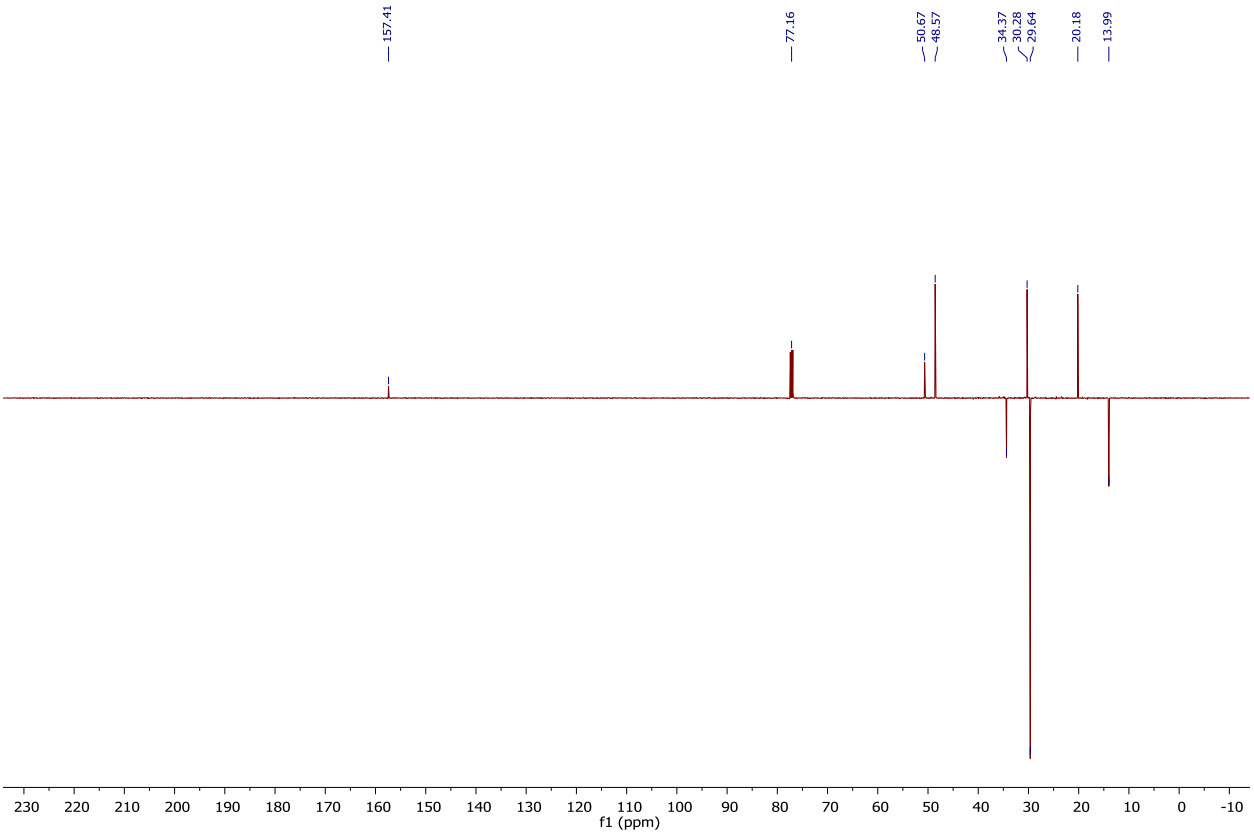

7.26
N
HN
O
Me
Me
Me
0.77
4.00
4.00
9.35
f1 (ppm)


156.21
77.16
50.86
45.88
29.70
25.73
f1 (ppm)


Me
N
Me
HN
O
Me
Me
Me
7.26
0.93
4.00
9.01
5.99
f1 (ppm)


156.68
77.16
50.68
41.12
29.75
13.97
f1 (ppm)


Me
N
Me
HN
O
Me
Me
Me
7.26
0.93
2.00
3.00
1.98
11.09
3.03
f1 (ppm)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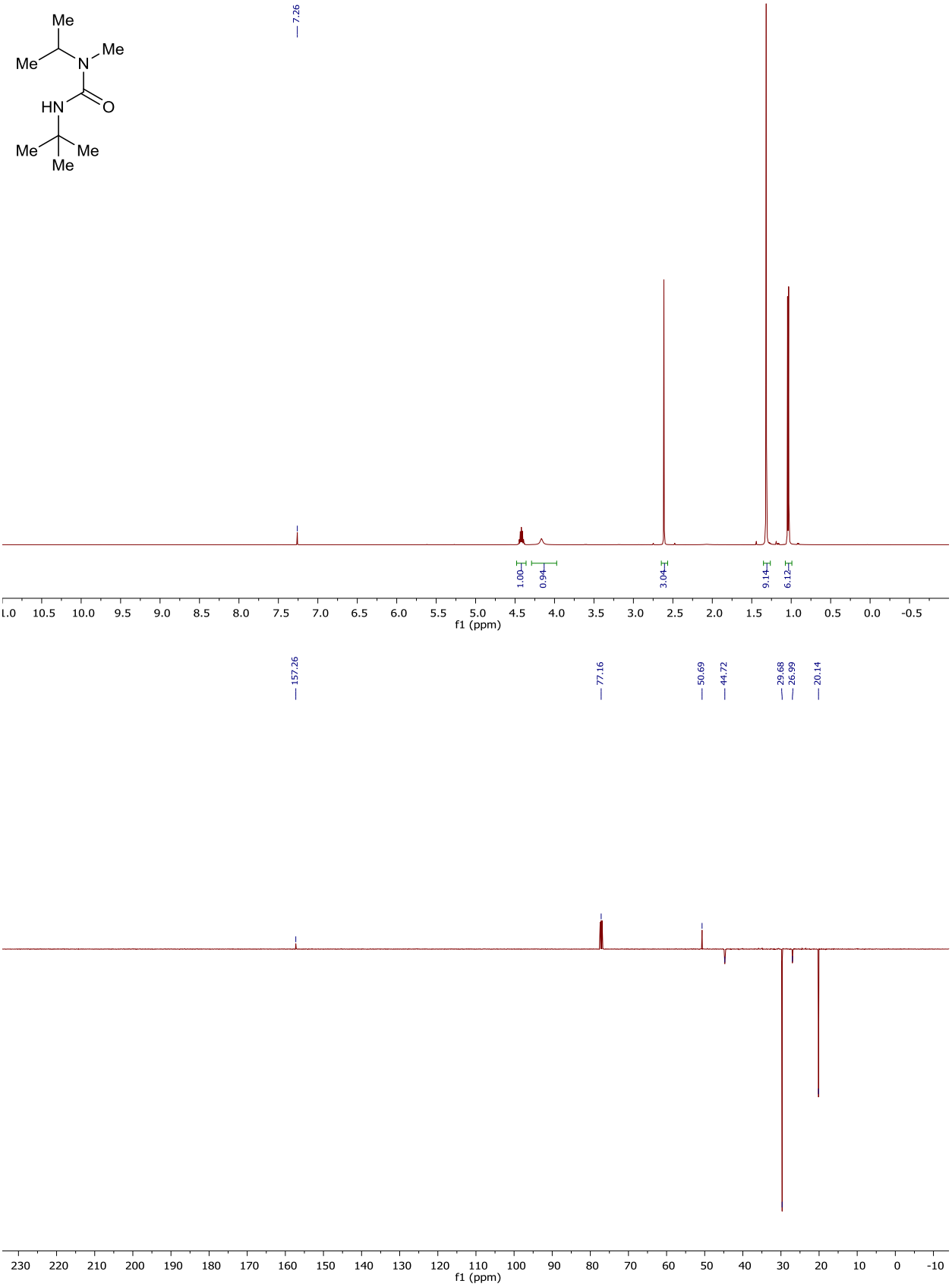
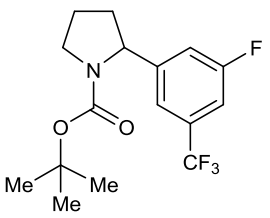
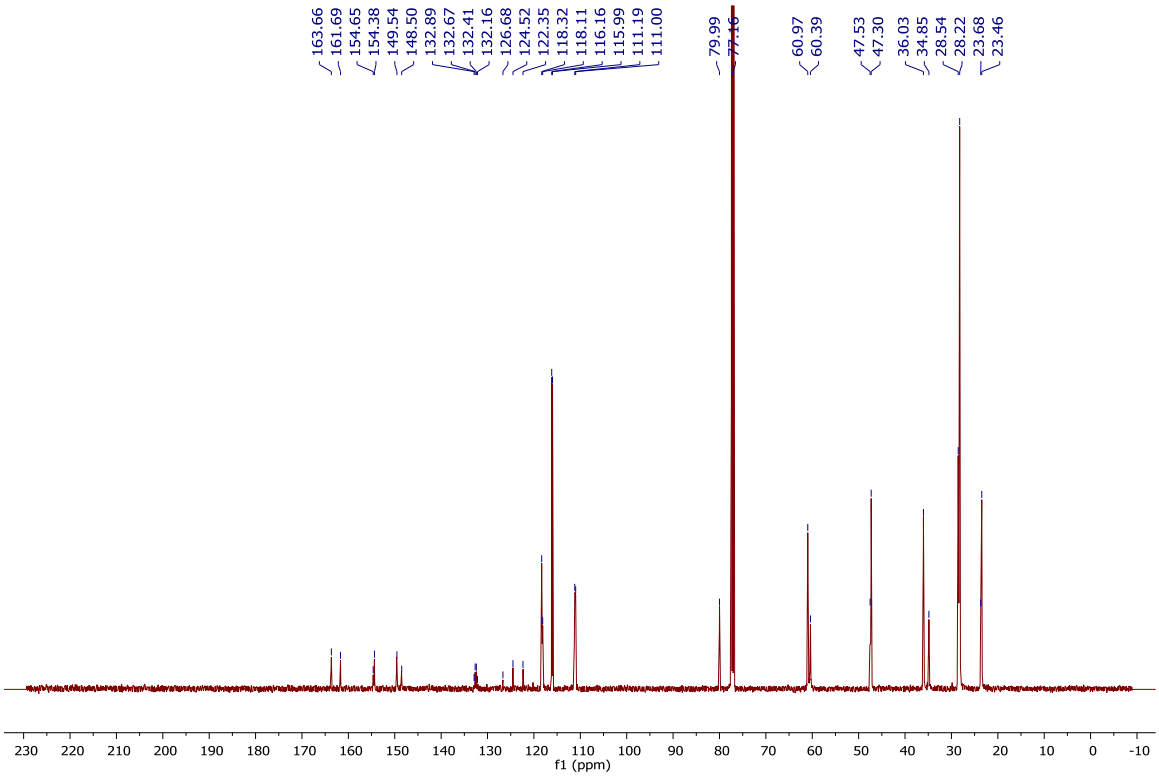
77.16
50.67
48.57
34.37
30.28
29.64
20.18
13.99
f1 (ppm)


Me
Me
N
Me
HN
O
Me
Me
Me
7.26
1.00
0.94
3.04
9.14
6.12
f1 (ppm)
157.26
77.16
50.69
44.72
29.68
26.99
20.14
f1 (ppm)


F
N
O
O
CF3
Me
Me
Me

16

7.26
2.00
1.00
1.00
2.05
1.02
3.07
3.36
5.55
f1 (ppm)


163.66
161.69
154.65
154.38
149.54
148.50
132.89
132.67
132.41
132.16
126.68
124.52
122.35
118.32
118.11
116.16
115.99
111.19
111.00
79.99
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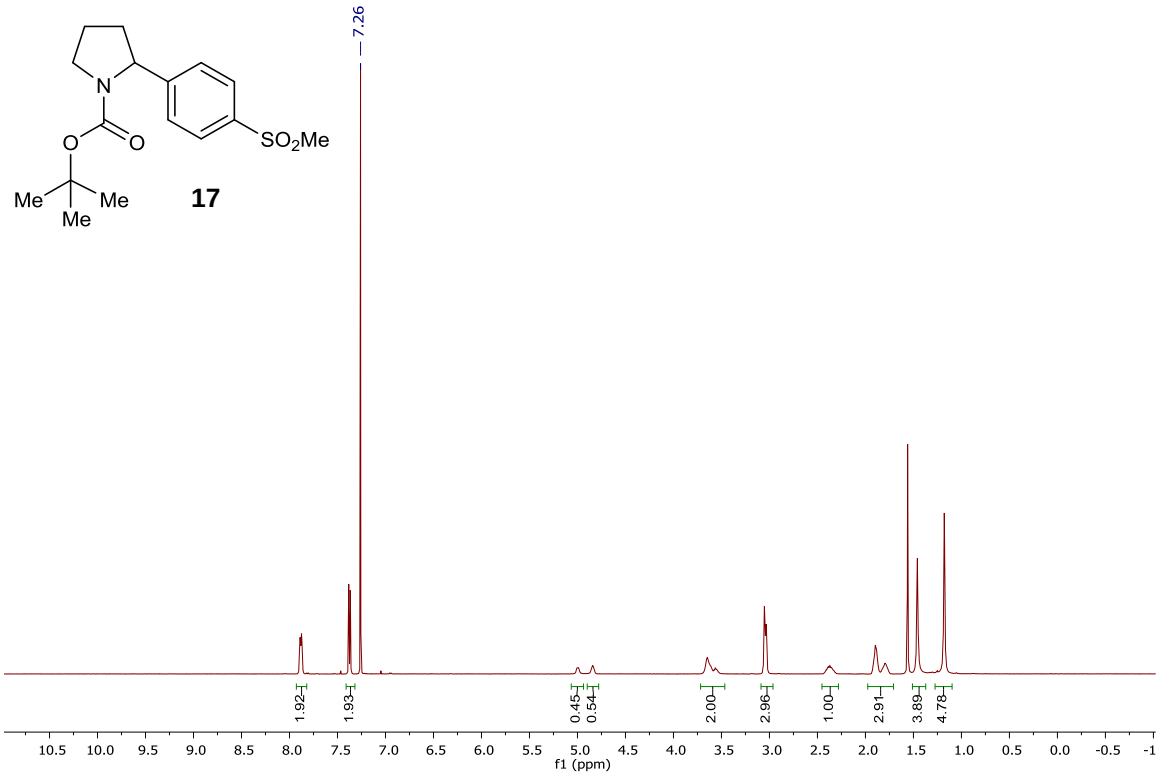
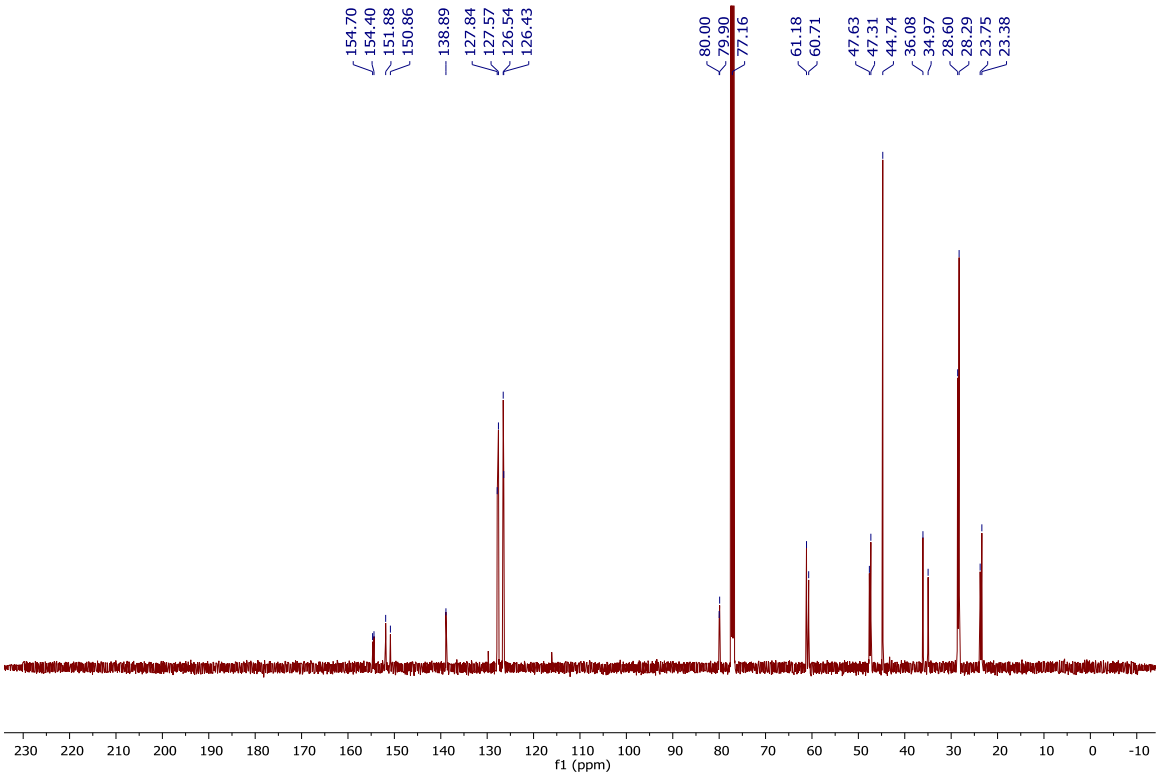
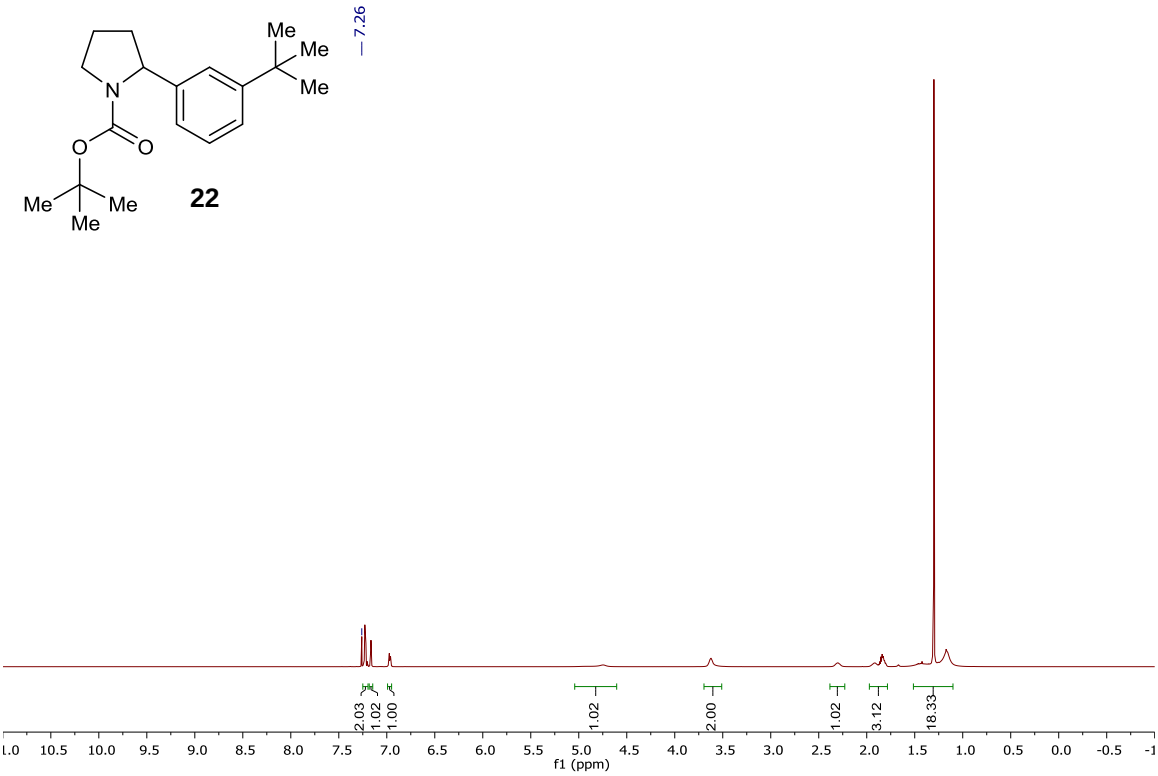
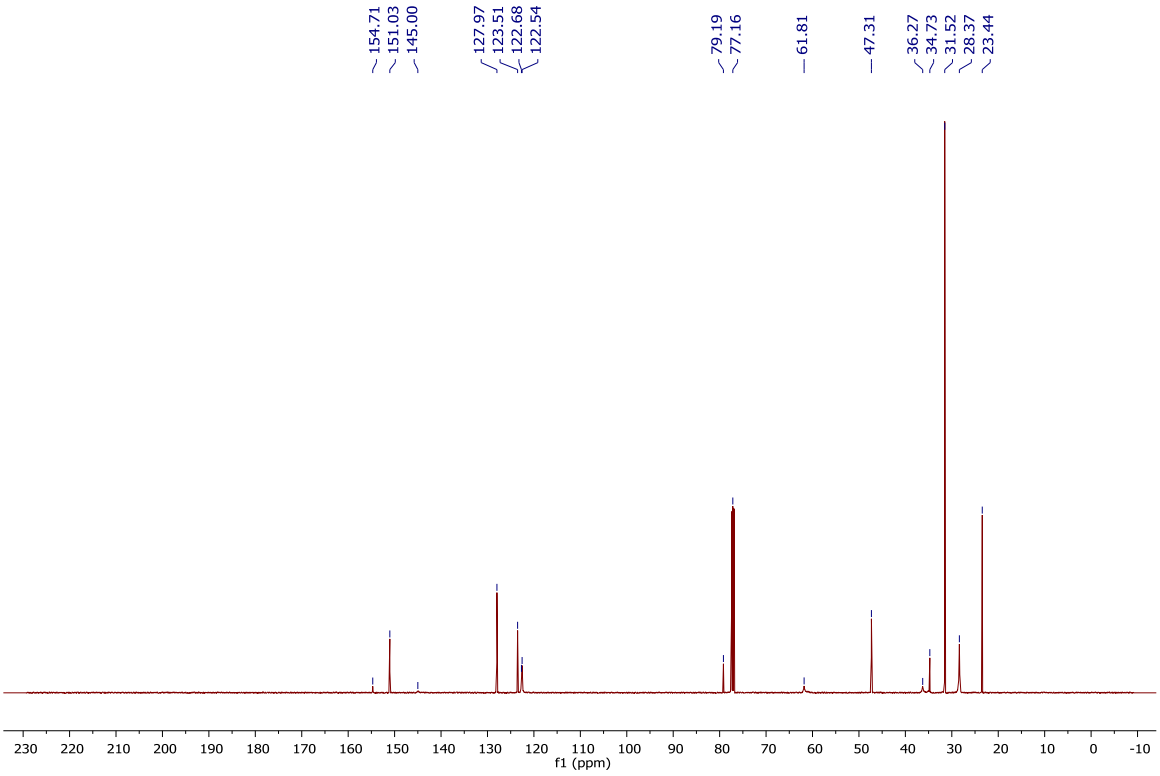
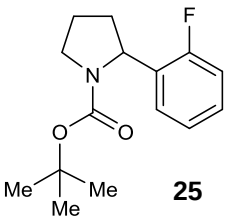
28.54
28.22
23.68
23.46
f1 (ppm)


7.26
1.92
1.93
0.45
0.54
2.00
2.96
1.00
2.91
3.89
4.78
f1 (ppm)


154.70
154.40
151.88
150.86
138.89
127.84
127.57
126.54
126.43
80.00
79.90
77.16
61.18
60.71
47.63
47.31
44.74
36.08
34.97
28.60
28.29
23.75
23.38
f1 (ppm)

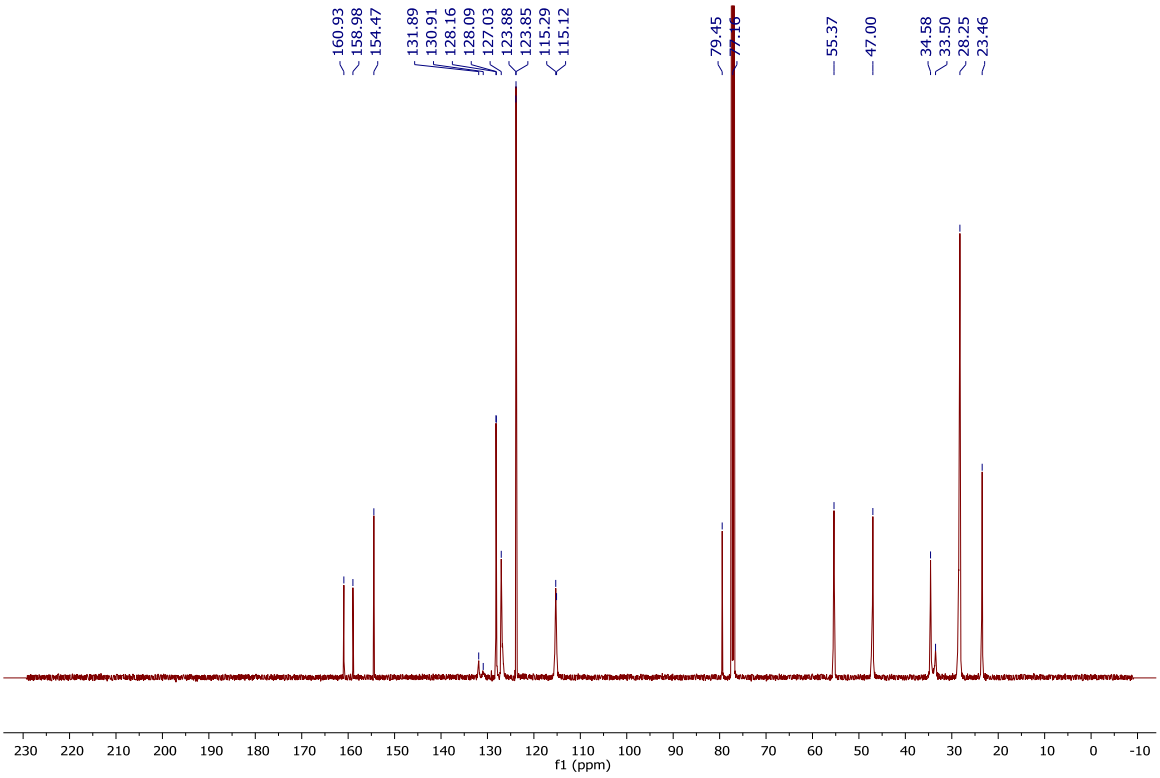

Me
Me
Me
7.26
N
O
O
Me
Me
Me
22
2.03
1.02
1.00
1.02
2.00
1.02
3.12
18.33
f1 (ppm)


154.71
151.03
145.00
127.97
123.51
122.68
122.54
79.19
77.16
61.81
47.31
36.27
34.73
31.52
28.37
23.44
f1 (ppm)


F
N
O
O
Me
Me
Me

25

7.26
1.00
1.97
0.99
1.00
2.05
1.03
3.04
9.20
f1 (ppm)


160.93
158.98
154.47
131.89
130.91
128.16
128.09
127.03
123.88
123.85
115.29
115.12
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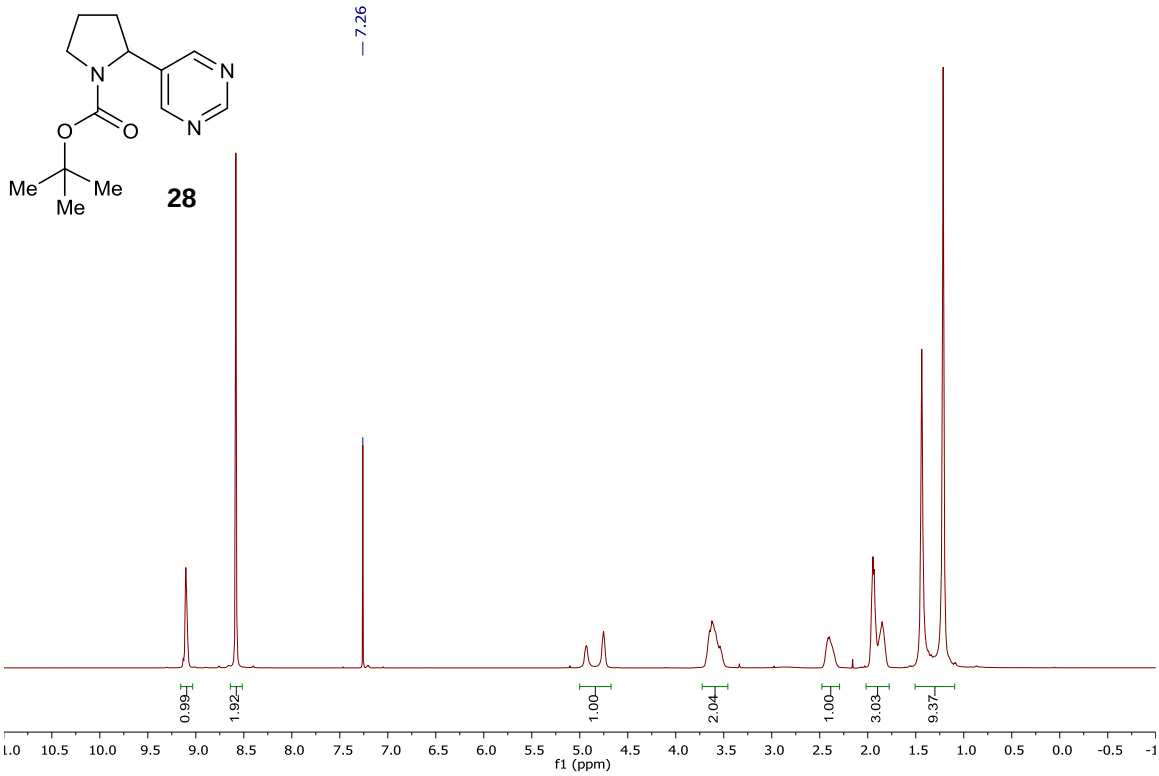
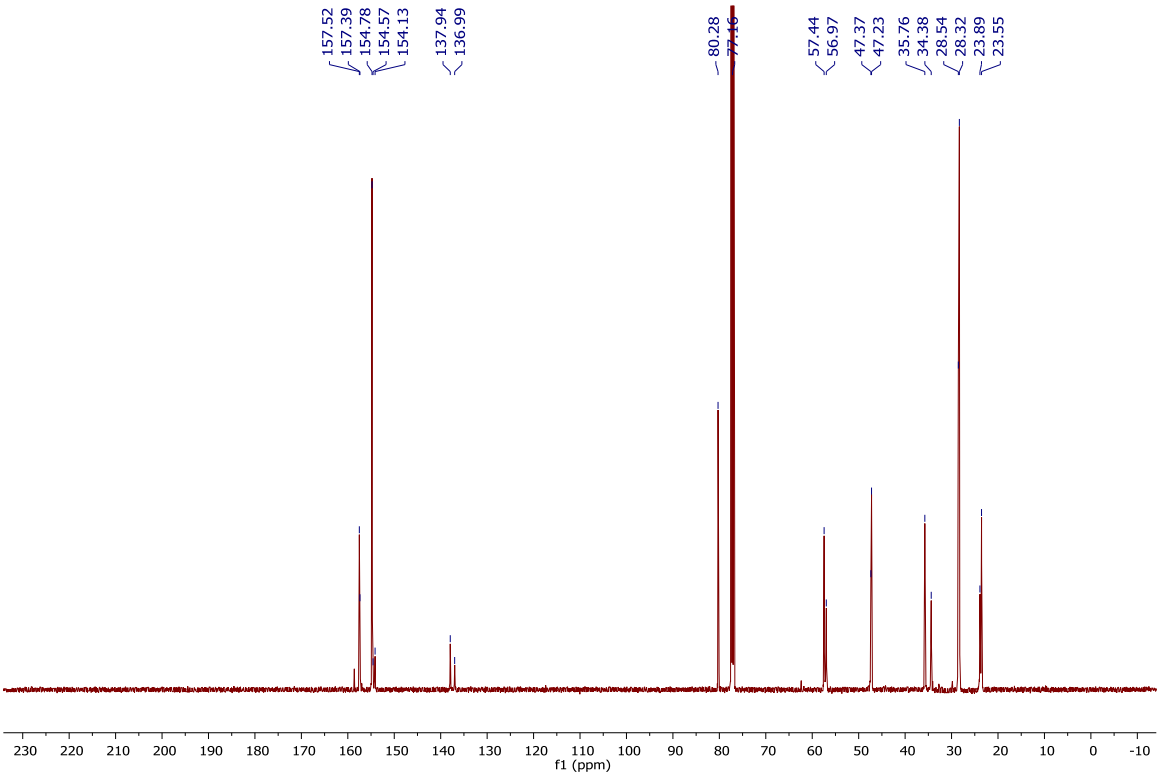
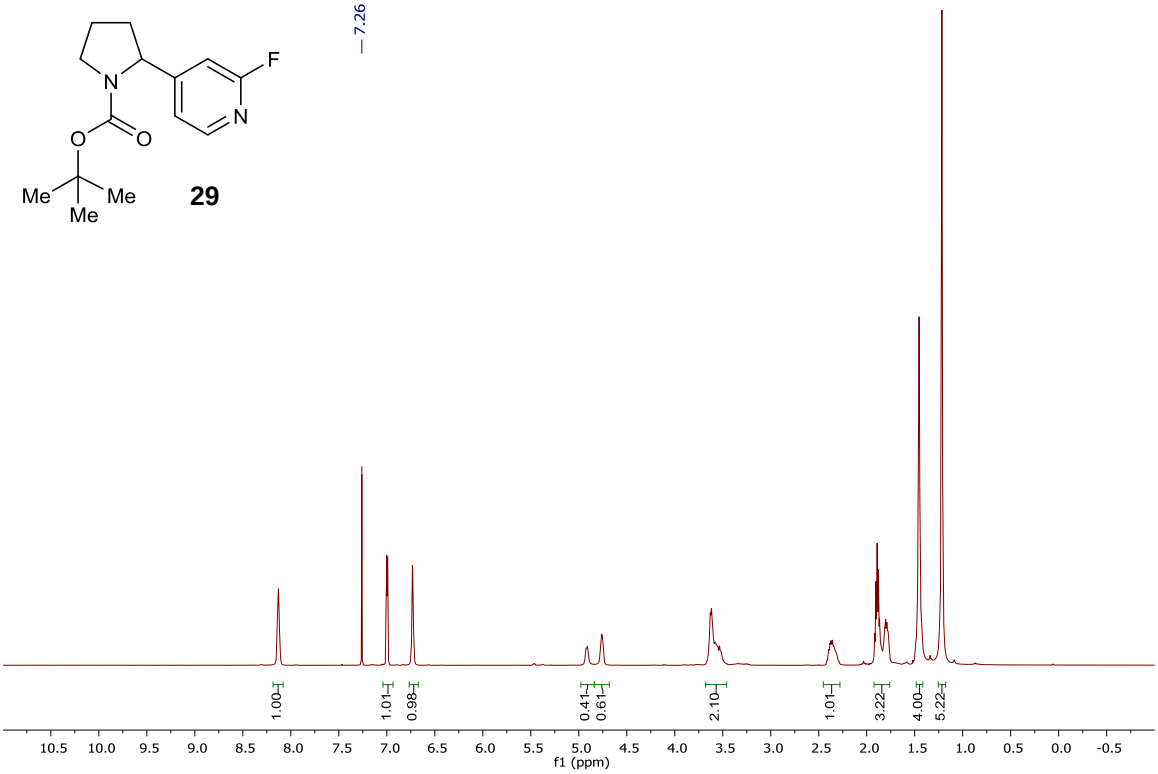
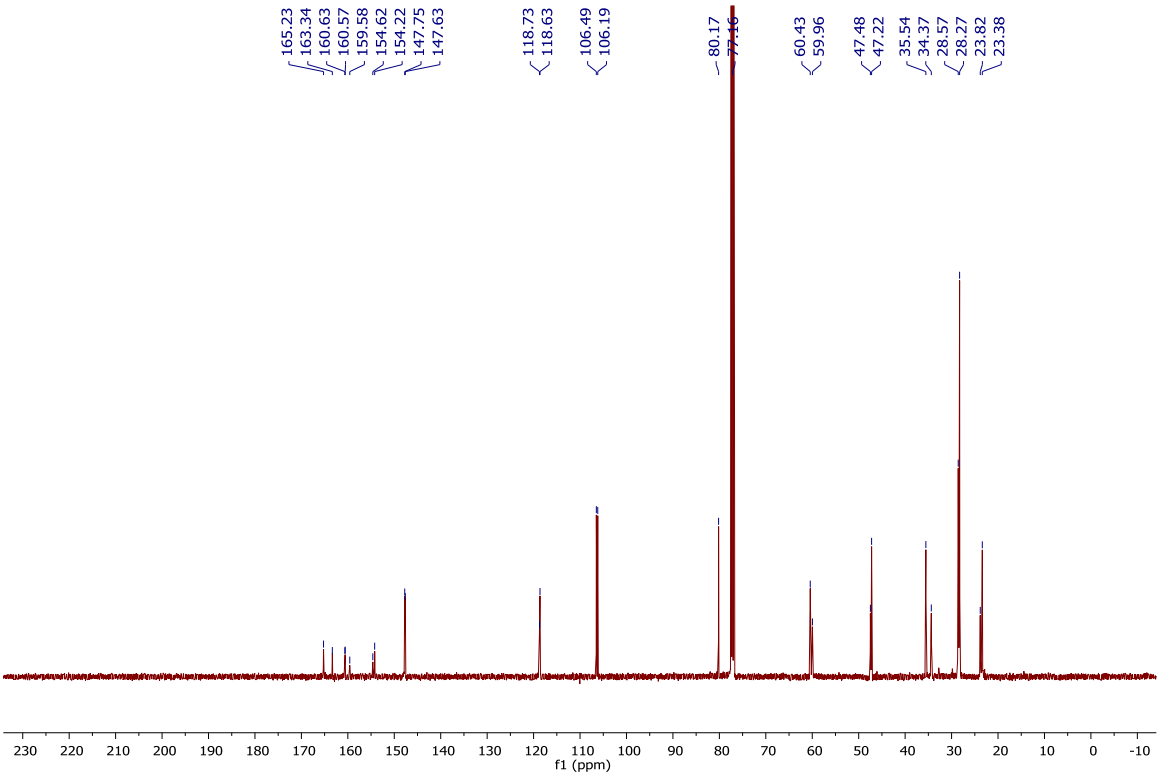
47.00
34.58
33.50
28.25
23.46
f1 (ppm)


7.26
N
N
O
O
Me
Me
Me
28
0.99
1.92
1.00
2.04
1.00
3.03
9.37
f1 (ppm)


157.52
157.39
154.78
154.57
154.13
137.94
136.99
80.28
77.16
57.44
56.97
47.37
47.23
35.76
34.38
28.54
28.32
23.89
23.55
f1 (ppm)


7.26
1.00
1.01
0.98
0.41
0.61
2.10
1.01
3.22
4.00
5.22
f1 (ppm)

29


165.23
163.34
160.63
160.57
159.58
154.62
154.22
147.75
147.63
118.73
118.63
106.49
106.19
80.17
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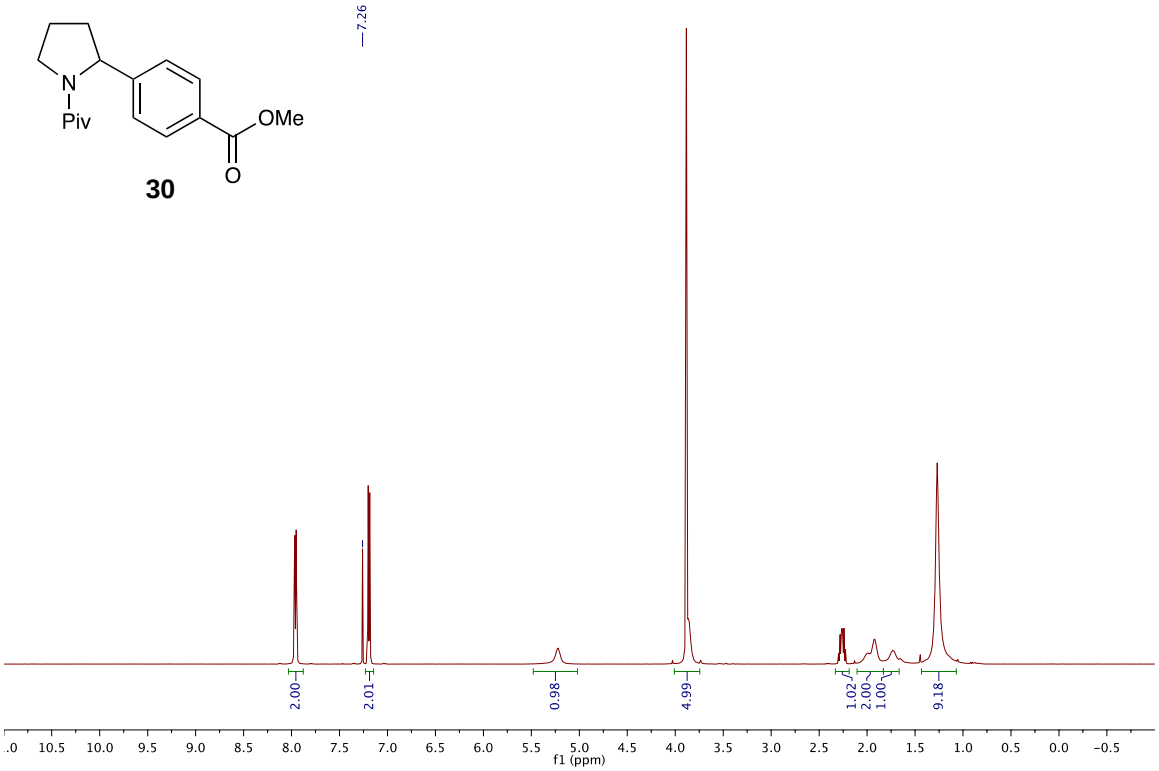
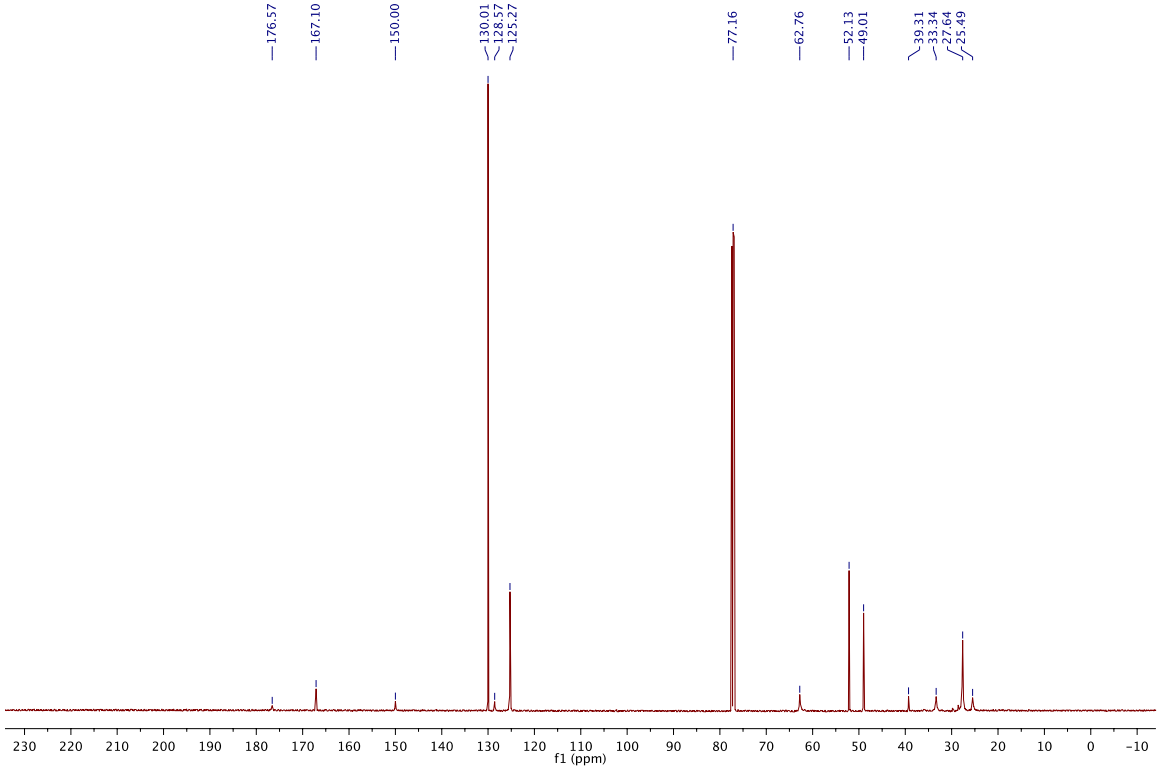
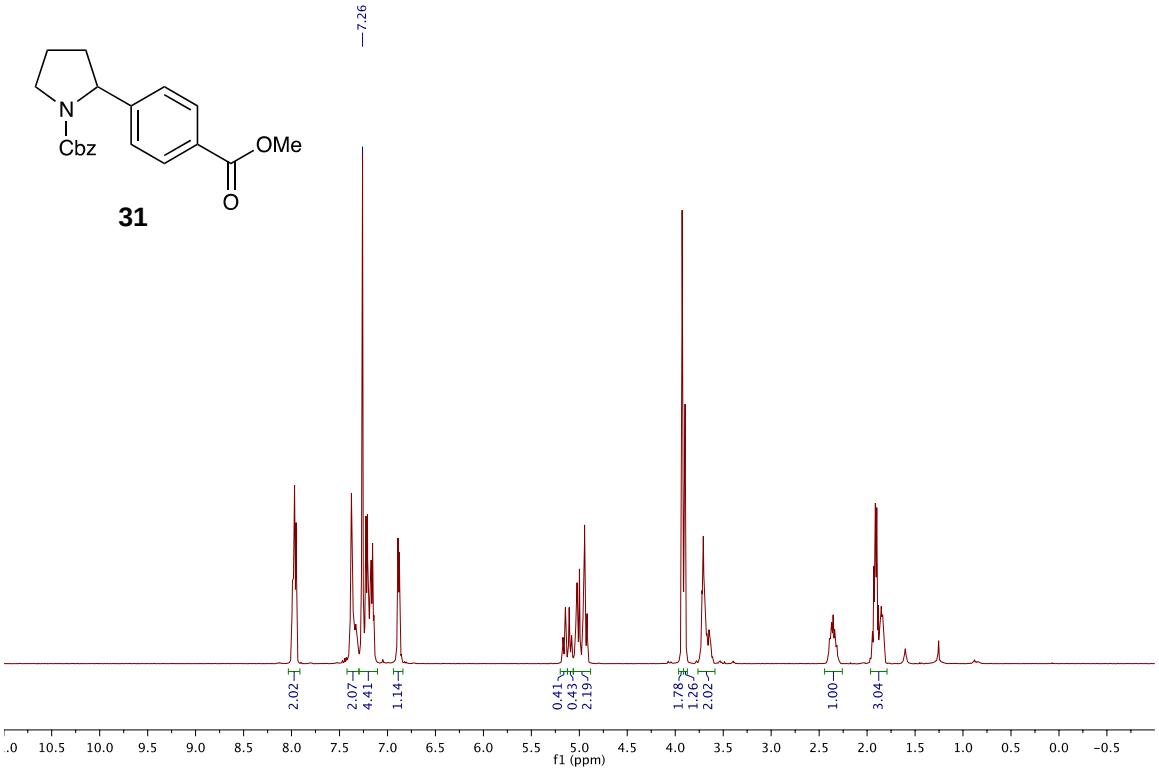
47.22
35.54
34.37
28.57
28.27
23.82
23.38
f1 (ppm)

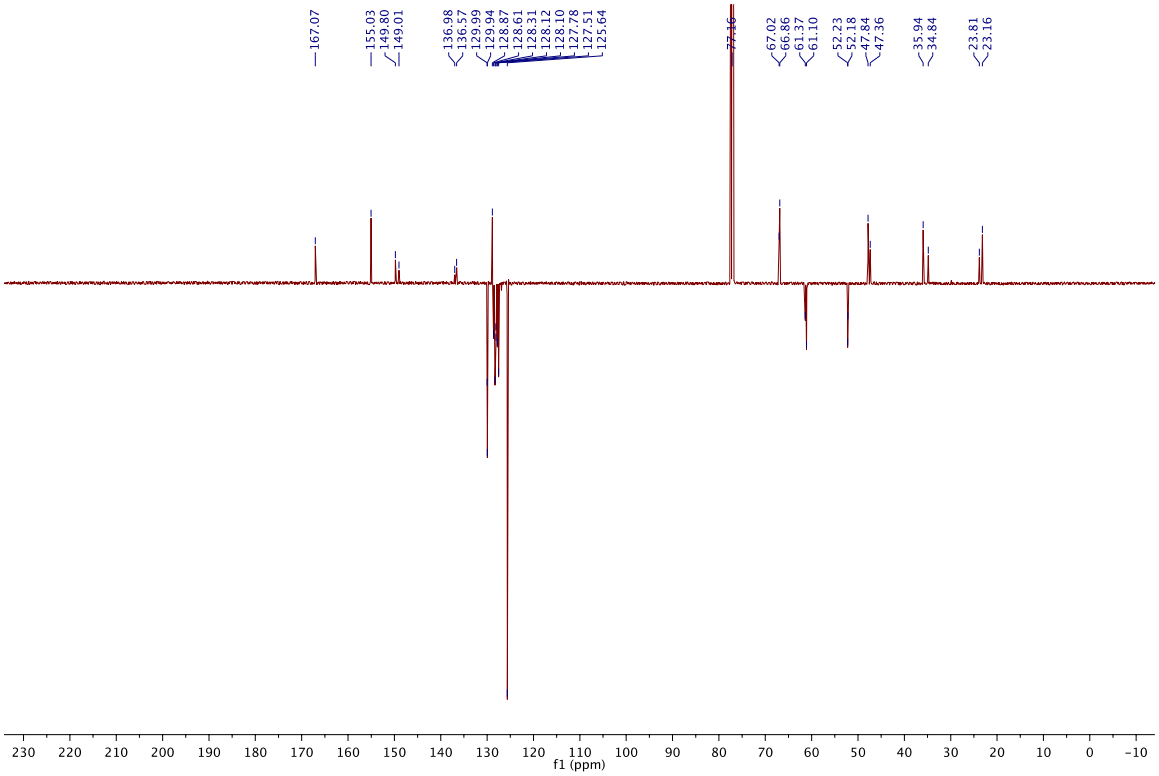

7.26
N
Piv
OMe
O
2.00
2.01
0.98
4.99
1.02
2.00
1.00
9.18
f1 (ppm)

30


176.57
167.10
150.00
130.01
128.57
125.27
77.16
62.76
52.13
49.01
39.31
33.34
27.64
25.49
f1 (ppm)


7.26
N
Cbz
OMe
O
2.02
2.07
4.41
1.14
0.41
0.43
2.19
1.78
1.26
2.02
1.00
3.04
f1 (ppm)

31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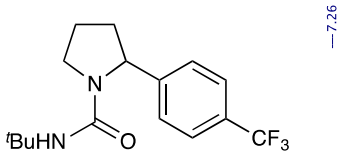
155.03
149.80
149.01
136.98
136.57
129.99
129.94
128.87
128.61
128.31
128.12
128.10
127.78
127.51
125.64
77.16
67.02
66.86
61.37
61.10
52.23
52.18
47.84
47.36
35.94
34.84
23.81
23.16
f1 (ppm)


N
tBuHN
O
CF3

32

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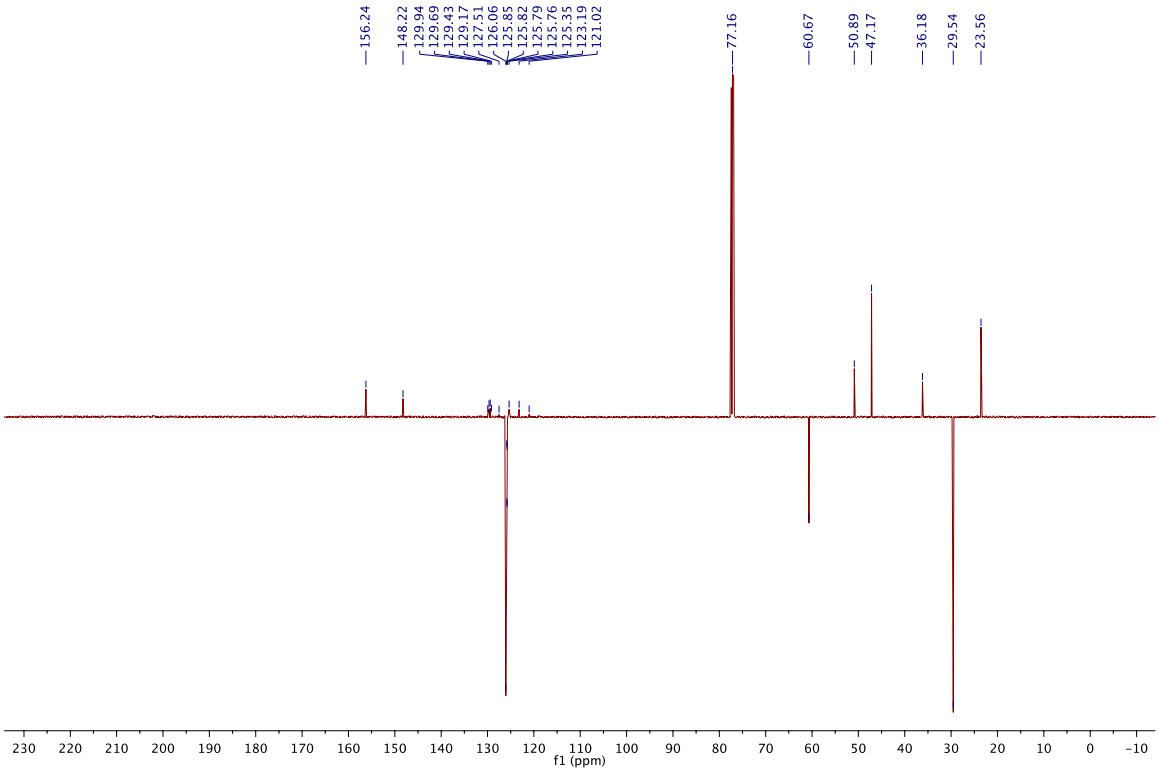
2.00
0.98
0.95
1.99
1.01
2.01
1.01
9.06
f1 (ppm)


156.24
148.22
129.94
129.69
129.43
129.17
127.51
126.06
125.85
125.82
125.79
125.76
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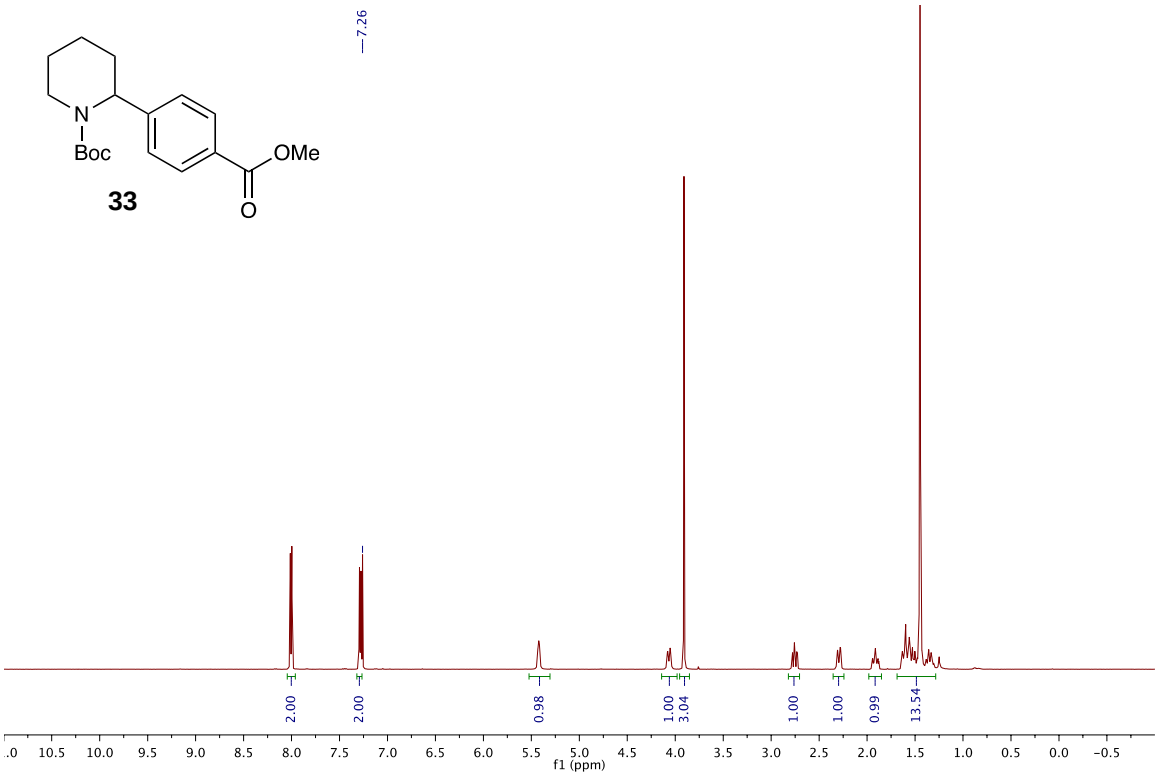
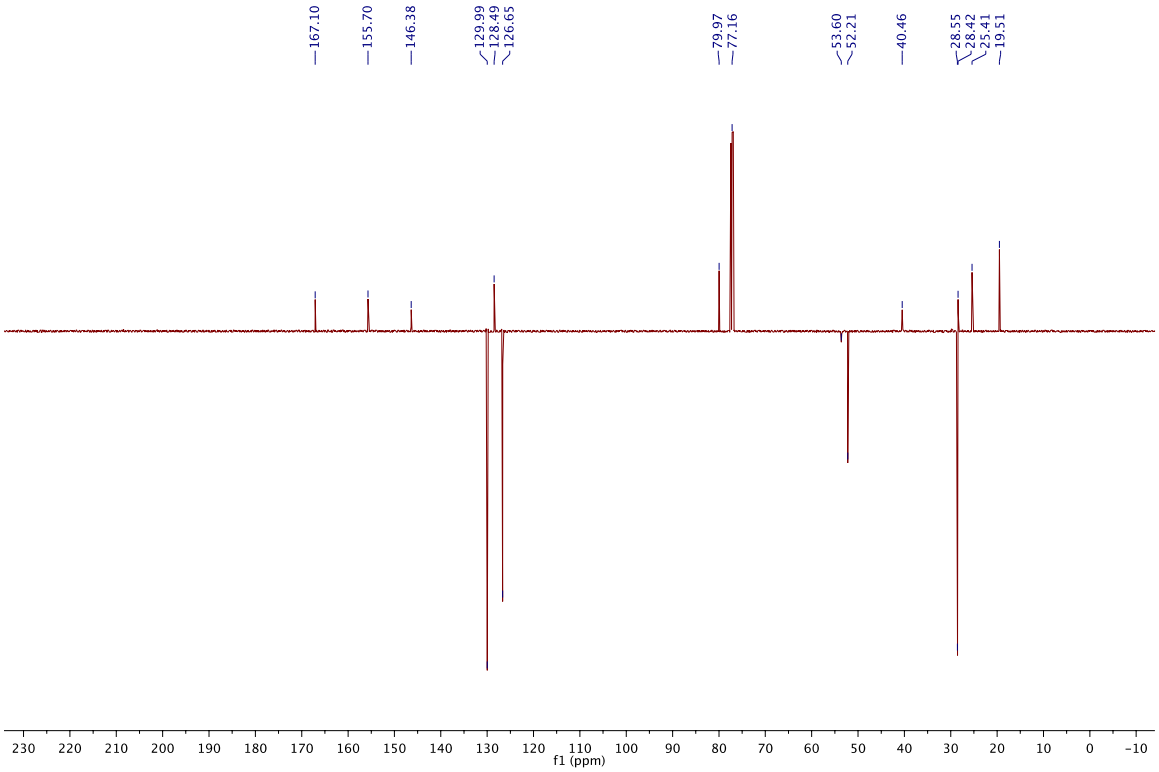
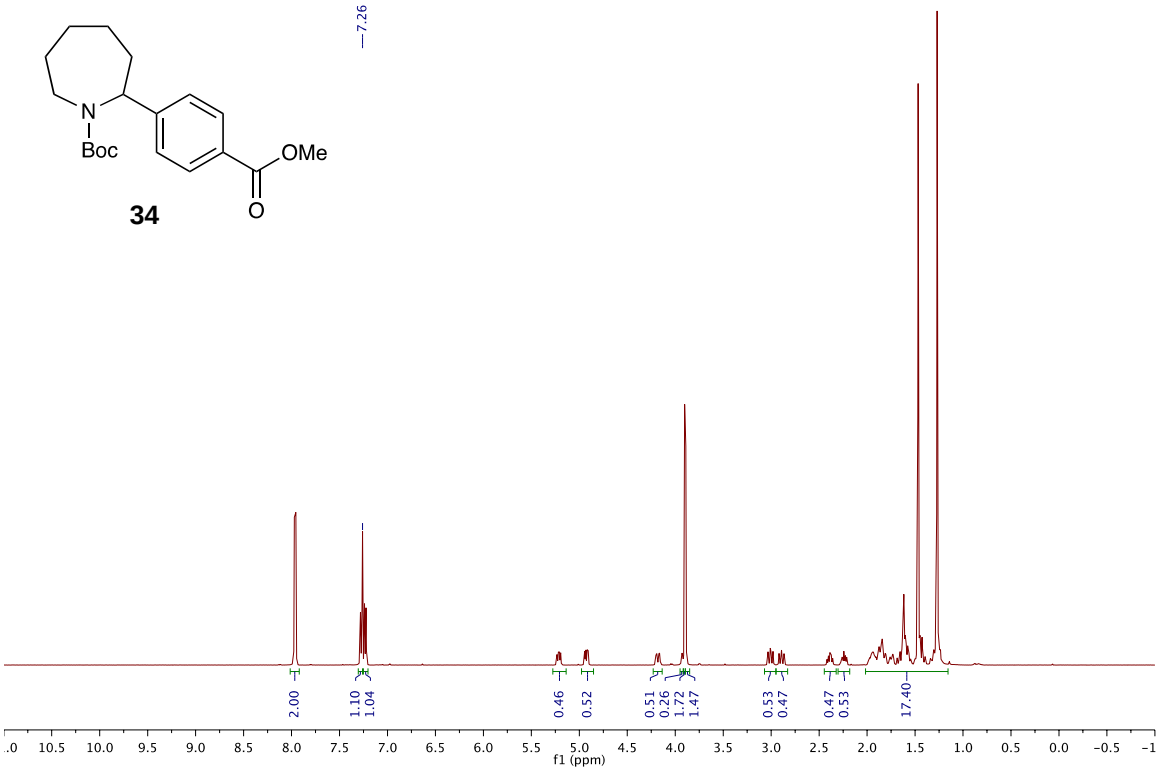
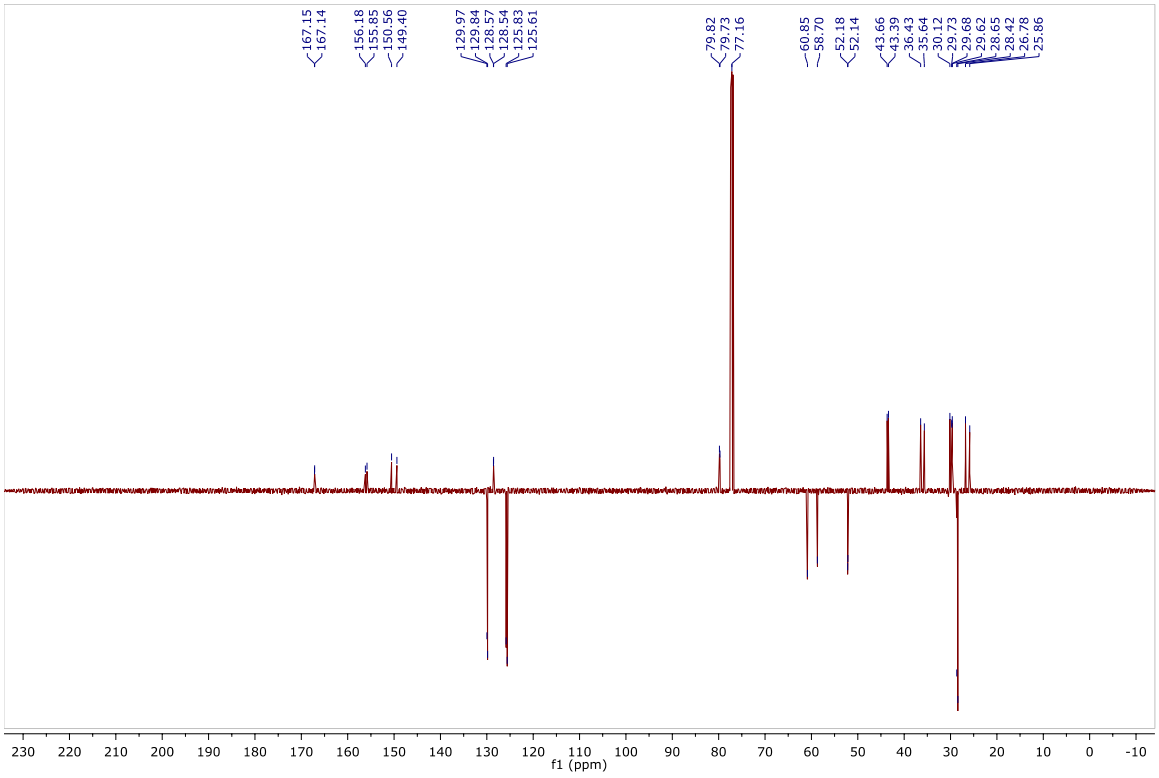
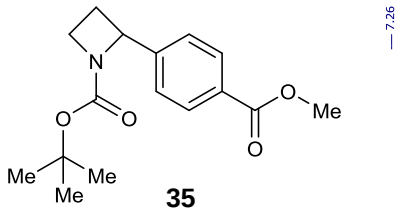
47.17
36.18
29.54
23.56
f1 (ppm)


N
Boc
OMe
O
33
7.26
2.00
2.00
0.98
1.00
3.04
1.00
1.00
0.99
13.54
f1 (ppm)


167.10
155.70
146.38
129.99
128.49
126.65
79.97
77.16
53.60
52.21
40.46
28.55
28.42
25.41
19.51
f1 (ppm)

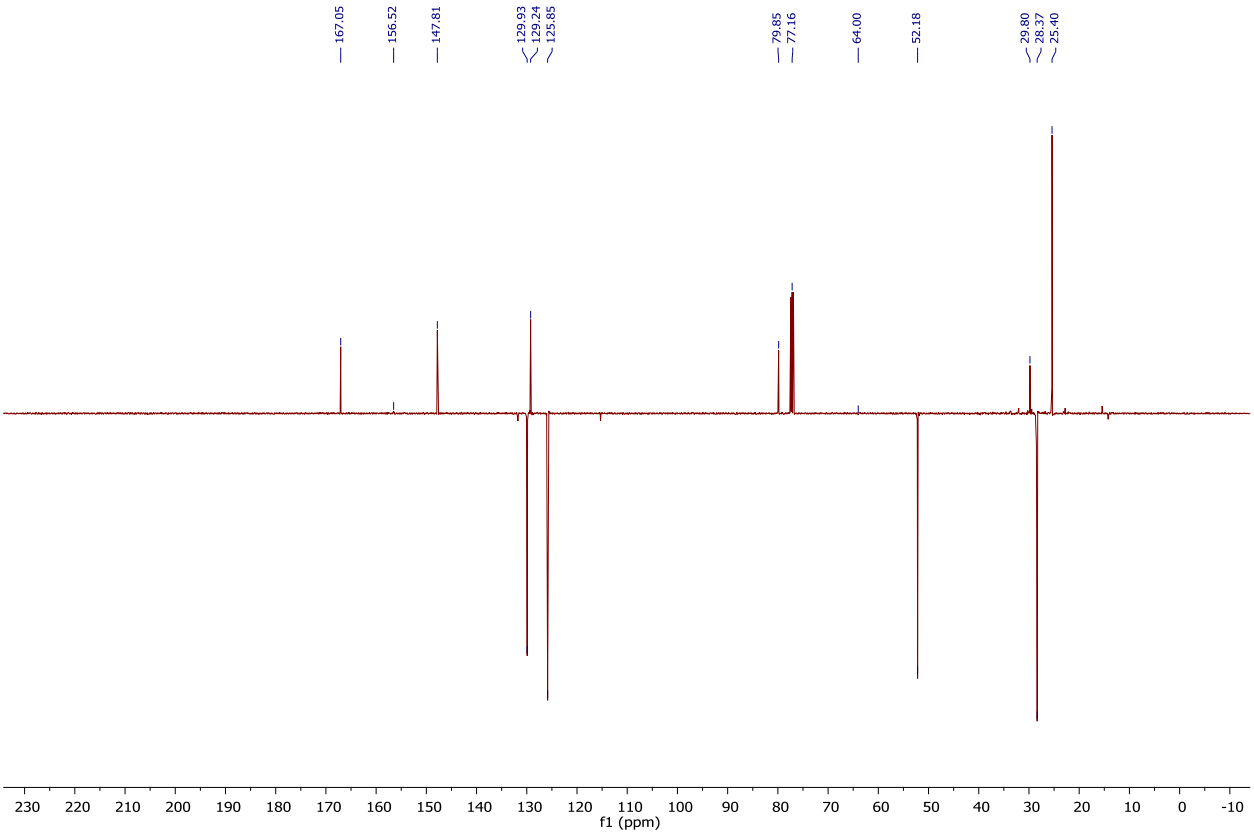

N
Boc
OMe
O
34
7.26
2.00
1.10
1.04
0.46
0.52
0.51
0.26
1.72
1.47
0.53
0.47
0.47
0.53
17.40
f1 (ppm)


167.15
167.14
156.18
155.85
150.56
149.40
129.97
129.84
128.57
128.54
125.83
125.61
79.82
79.73
77.16
60.85
58.70
52.18
52.14
43.66
43.39
36.43
35.64
30.12
29.73
29.68
29.62
28.65
28.42
26.78
25.86
f1 (ppm)


N
O
O
O
O
Me
Me
Me
Me

35

7.26
2.00
1.98
0.97
2.00
3.02
1.00
0.99
9.00
f1 (ppm)


167.05
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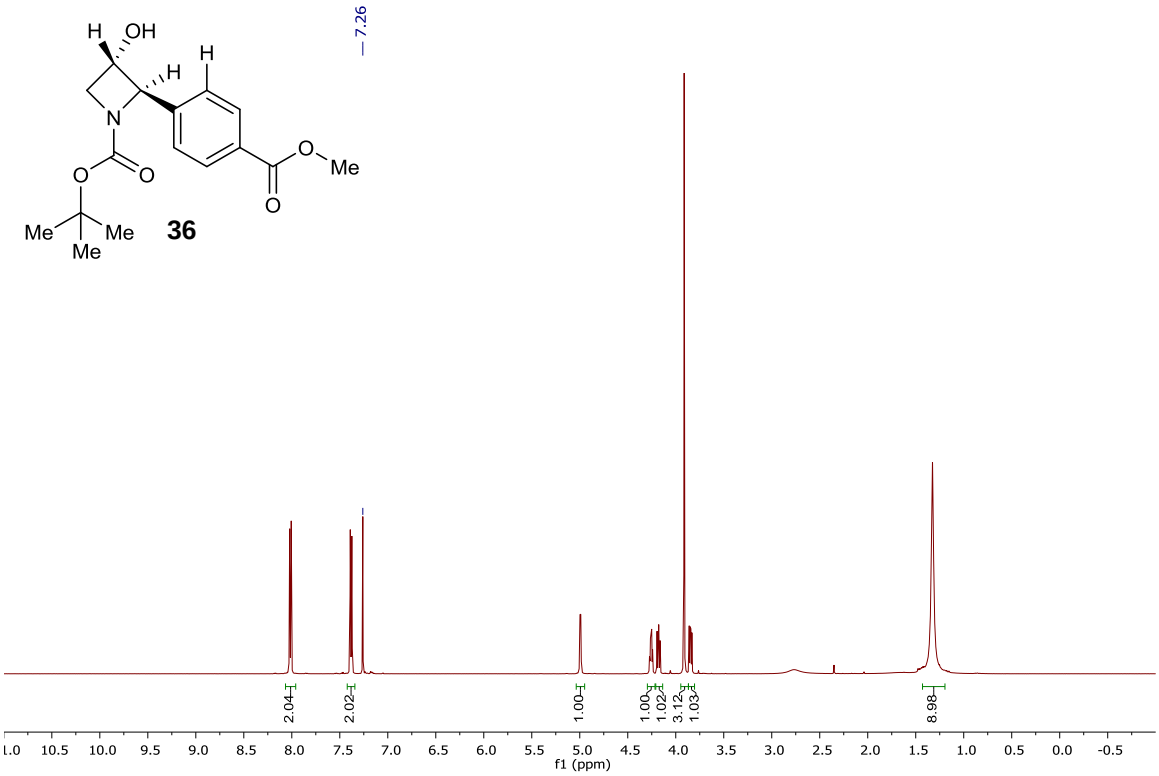
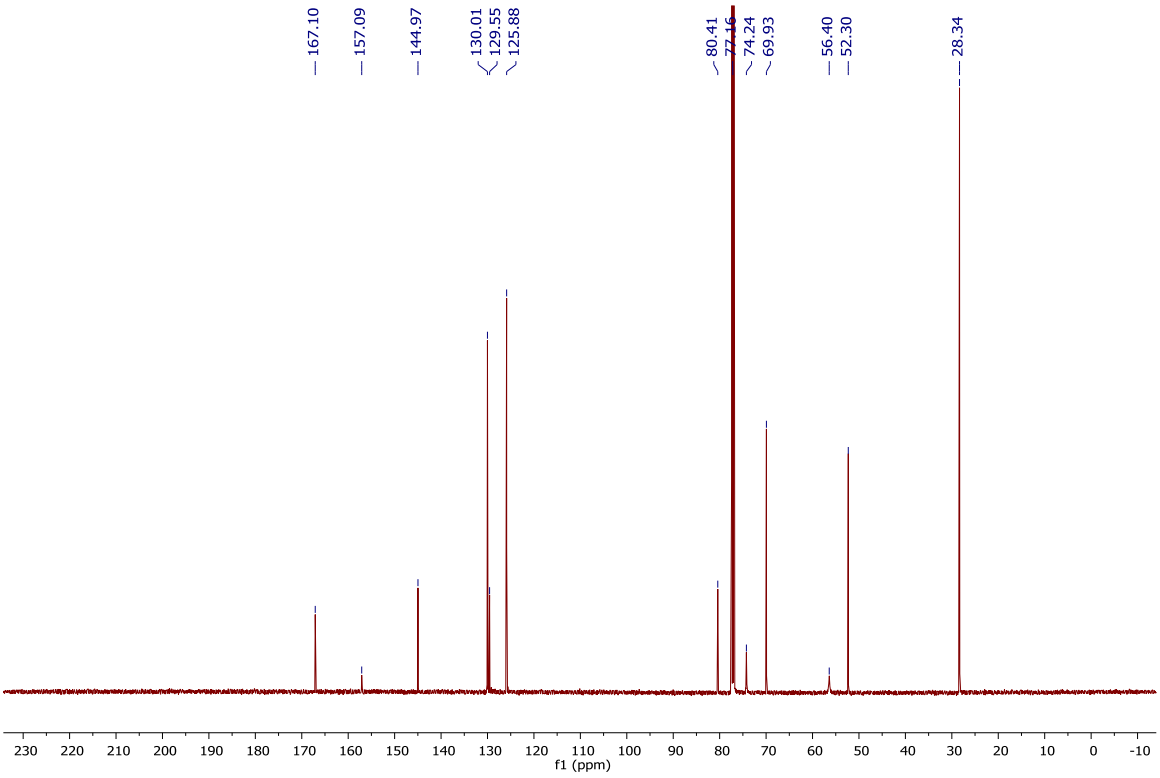
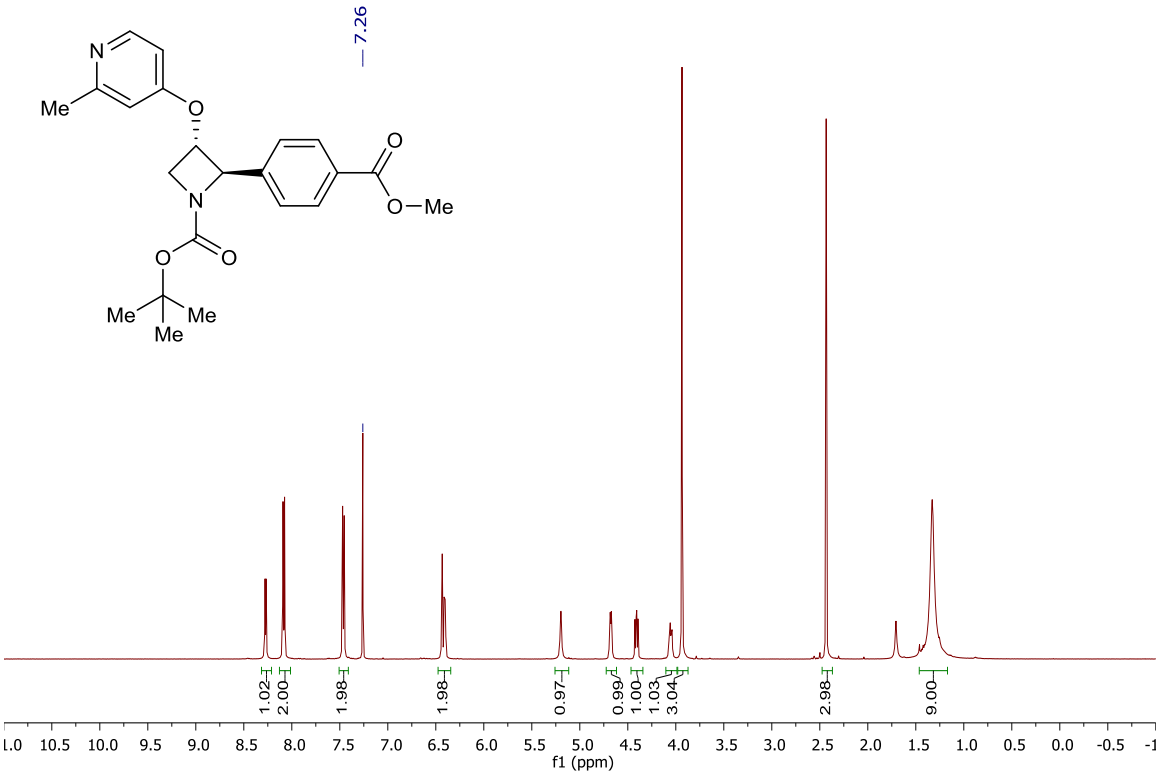
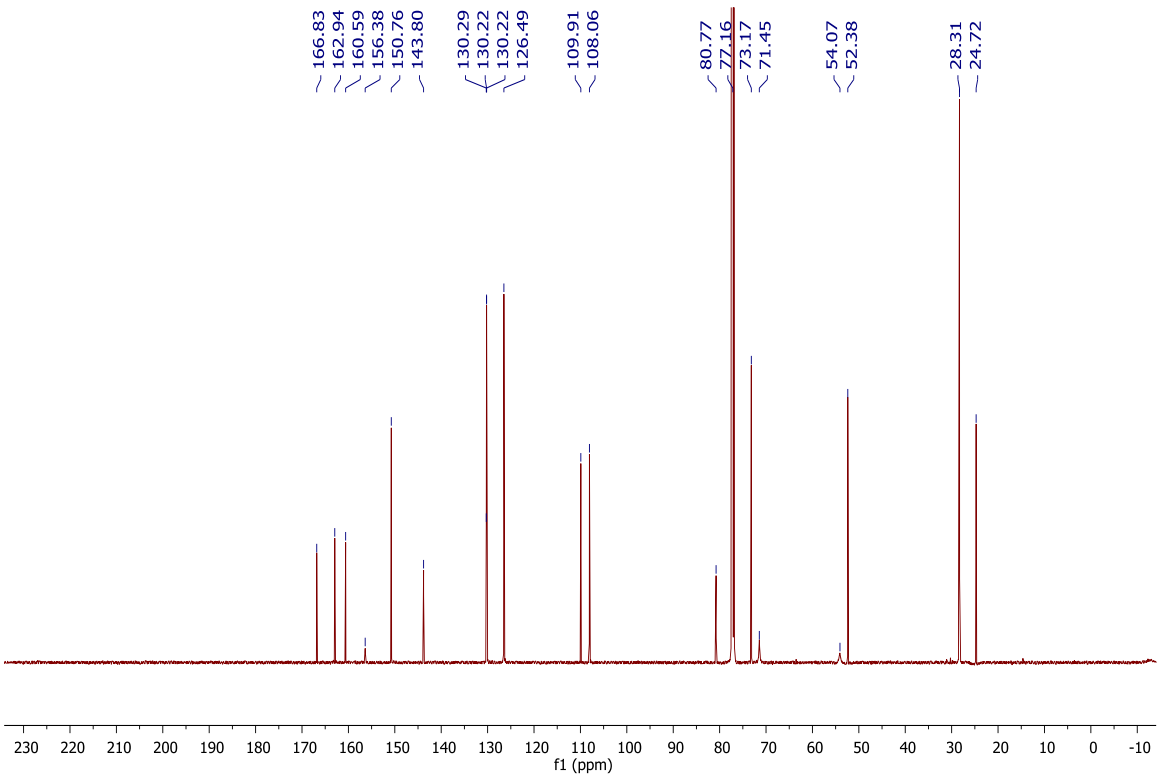
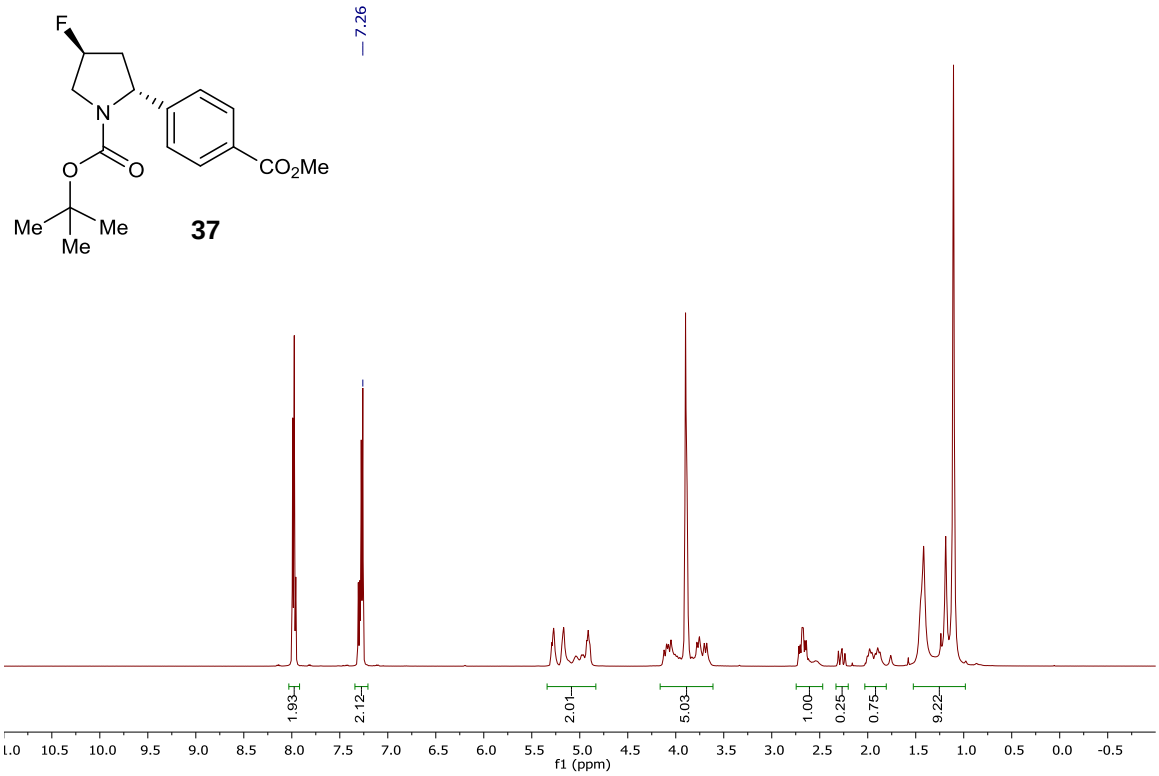
129.24
125.85
79.85
77.16
64.00
52.18
29.80
28.37
25.40
f1 (ppm)

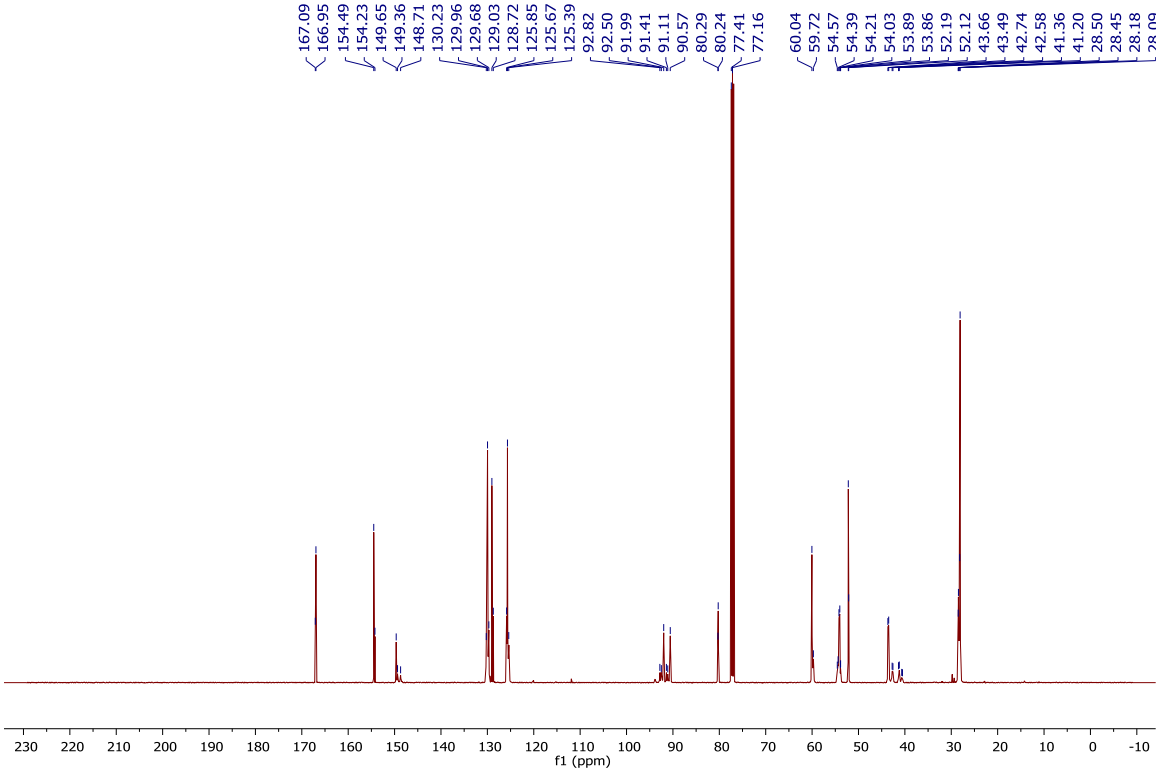

H
OH
H
H
N
O
O
O
Me
O
Me
Me
Me
36
7.26
2.04
2.02
1.00
1.00
1.02
3.12
1.03
8.98
f1 (ppm)

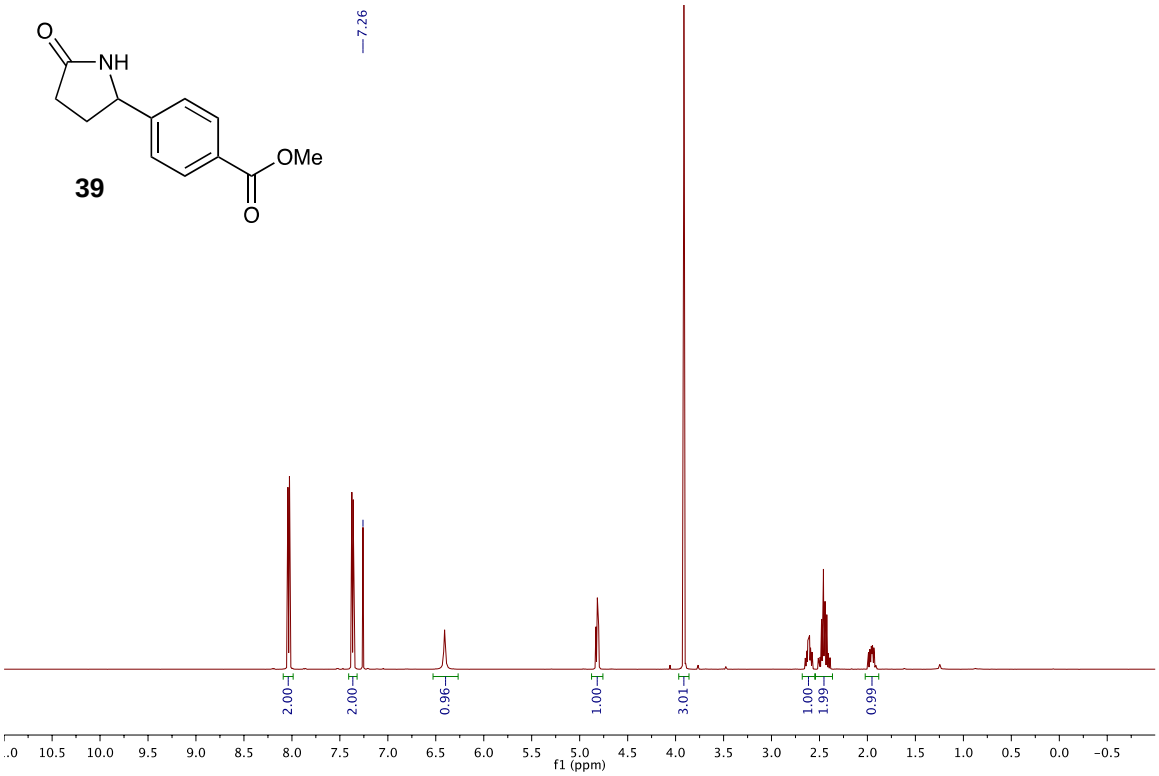

167.10
157.09
144.97
130.01
129.55
125.88
80.41
77.16
74.24
69.93
56.40
52.30
28.34
f1 (ppm)

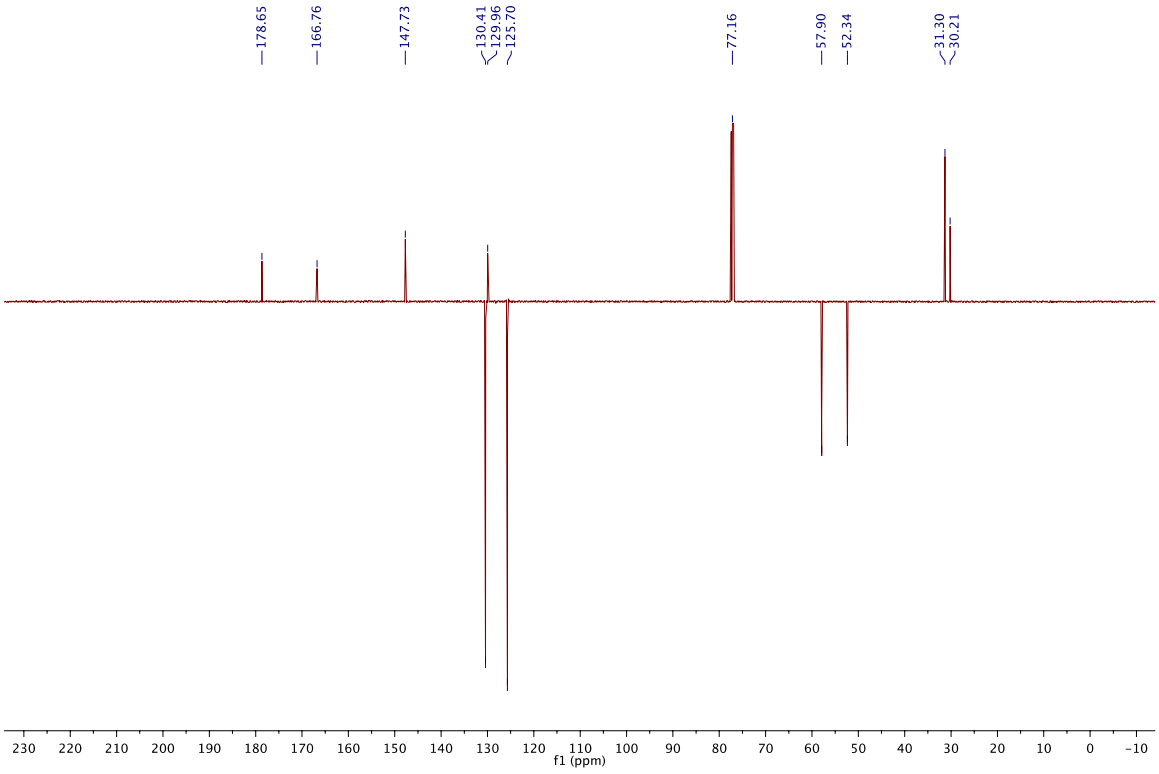

7.26
N
Me
O
N
O
O
O
O—Me
O
Me
Me
Me
1.02
2.00
1.98
1.98
0.97
0.99
1.00
1.03
3.04
2.98
9.00
f1 (ppm)

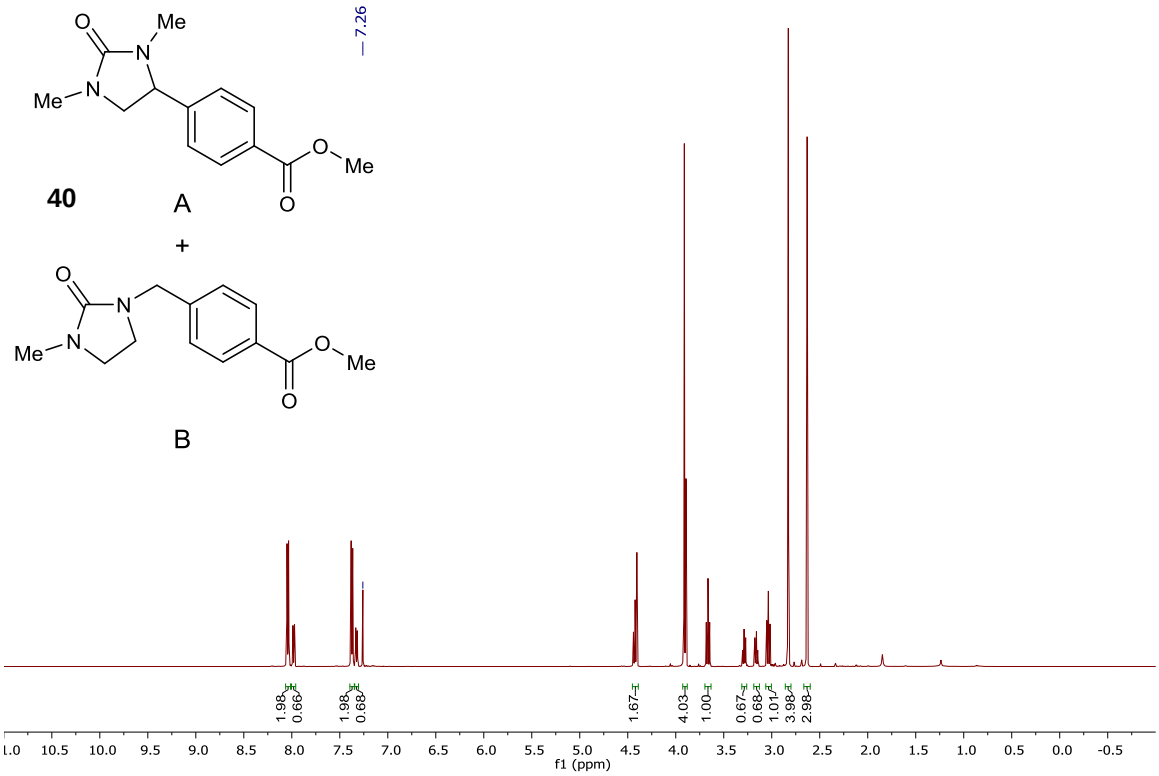

166.83
162.94
160.59
156.38
150.76
143.80
130.29
130.22
130.22
126.49
109.91
108.06
80.77
77.16
73.17
71.45
54.07
52.38
28.31
24.72
f1 (ppm)

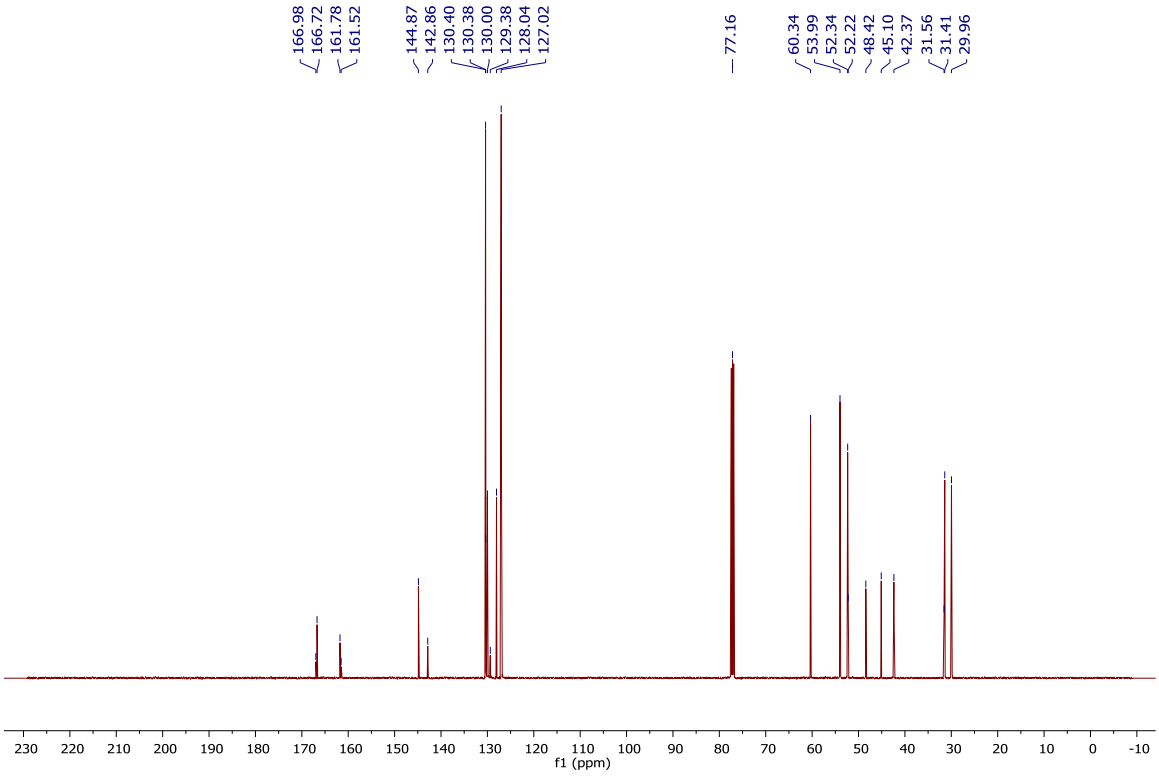

F
N
O
O
CO2Me
Me
Me
Me
37
7.26
1.93
2.12
2.01
5.03
1.00
0.25
0.75
9.22
f1 (ppm)

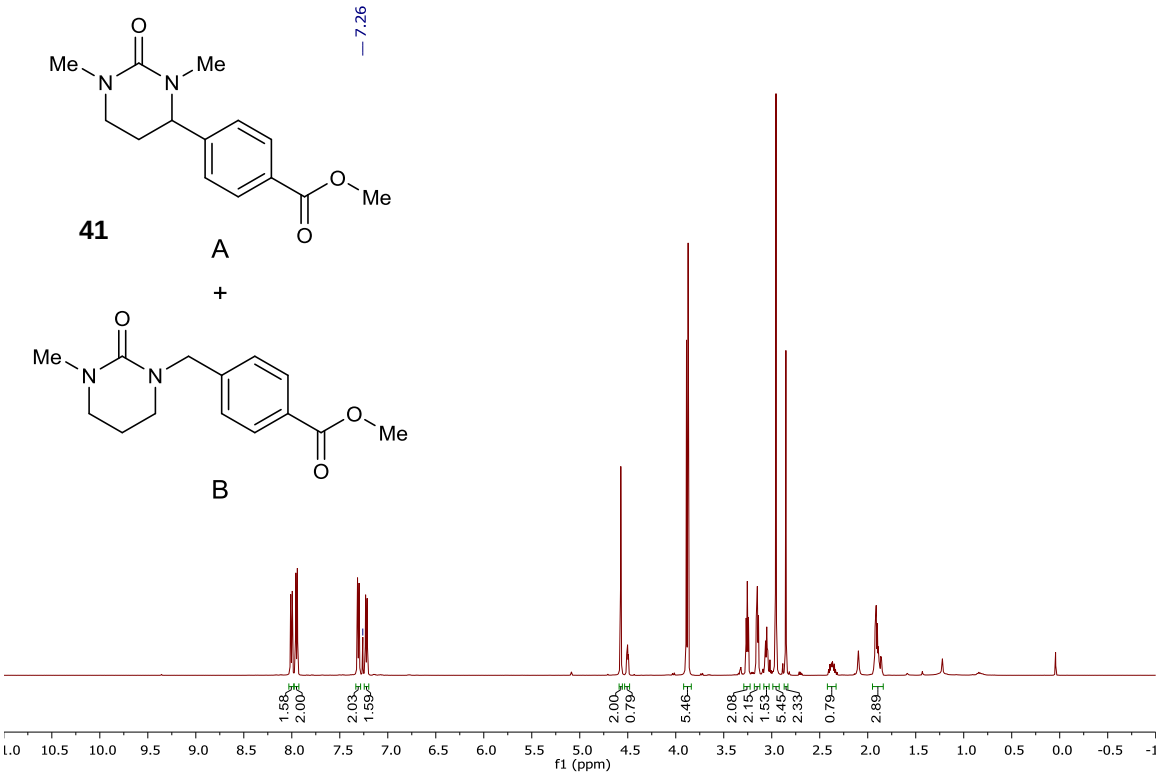

167.09
166.95
154.49
154.23
149.65
149.36
148.71
130.23
129.96
129.68
129.03
128.72
125.85
125.67
125.39
92.82
92.50
91.99
91.41
91.11
90.57
80.29
80.24
77.41
77.16
60.04
59.72
54.57
54.39
54.21
54.03
53.89
53.86
52.19
52.12
43.66
43.49
42.74
42.58
41.36
41.20
28.50
28.45
28.18
f1 (ppm)

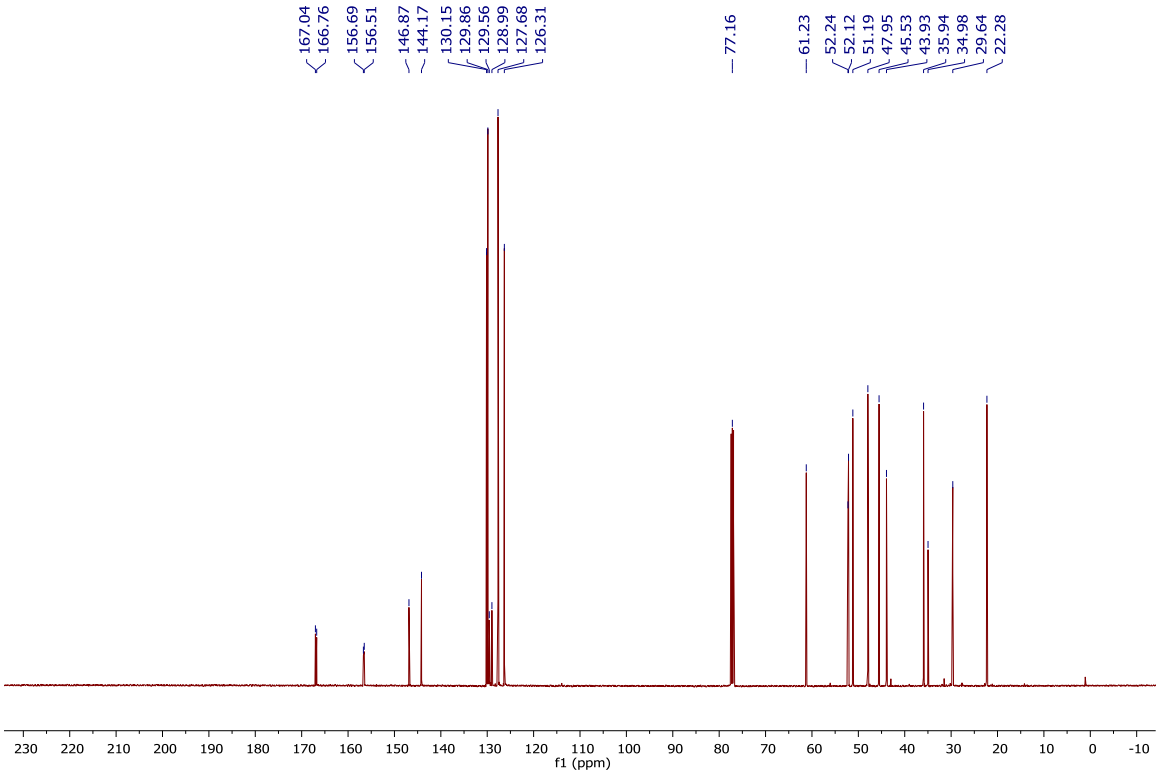

O
NH
OMe
O
39
7.26
2.00
2.00
0.96
1.00
3.01
1.00
1.99
0.99
f1 (ppm)

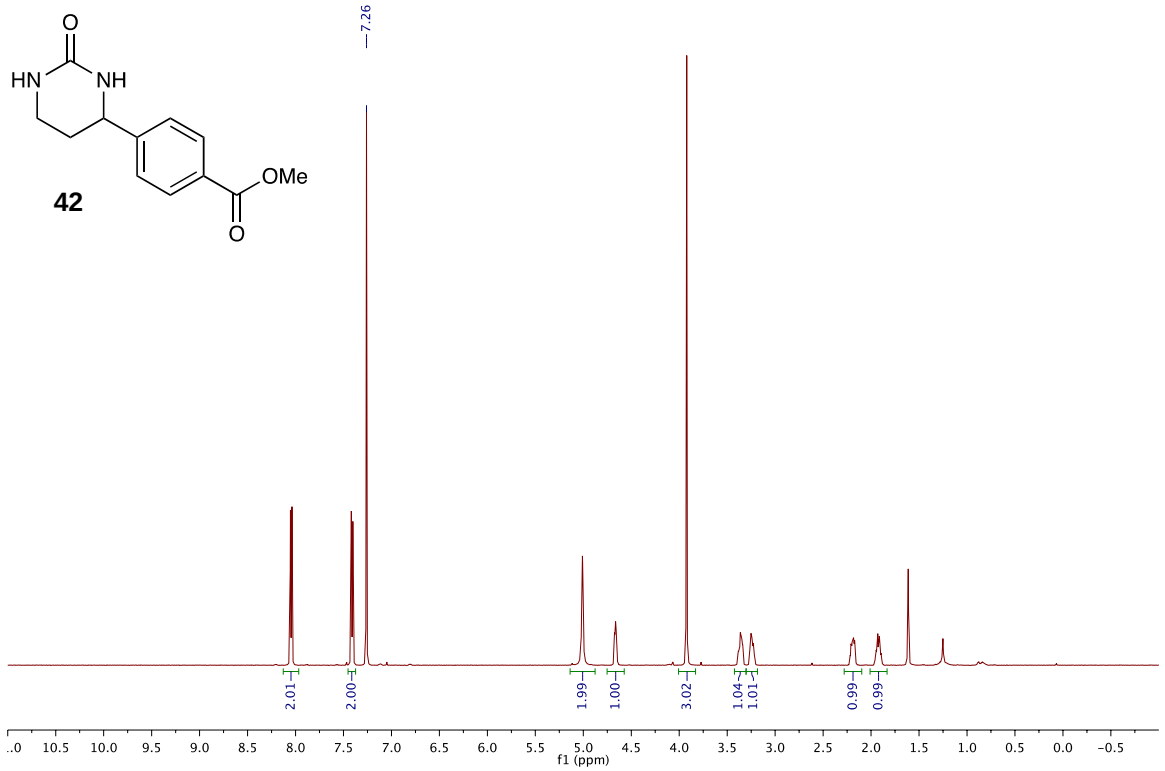

178.65
166.76
147.73
130.41
129.96
125.70
77.16
57.90
52.34
31.30
30.21
f1 (ppm)

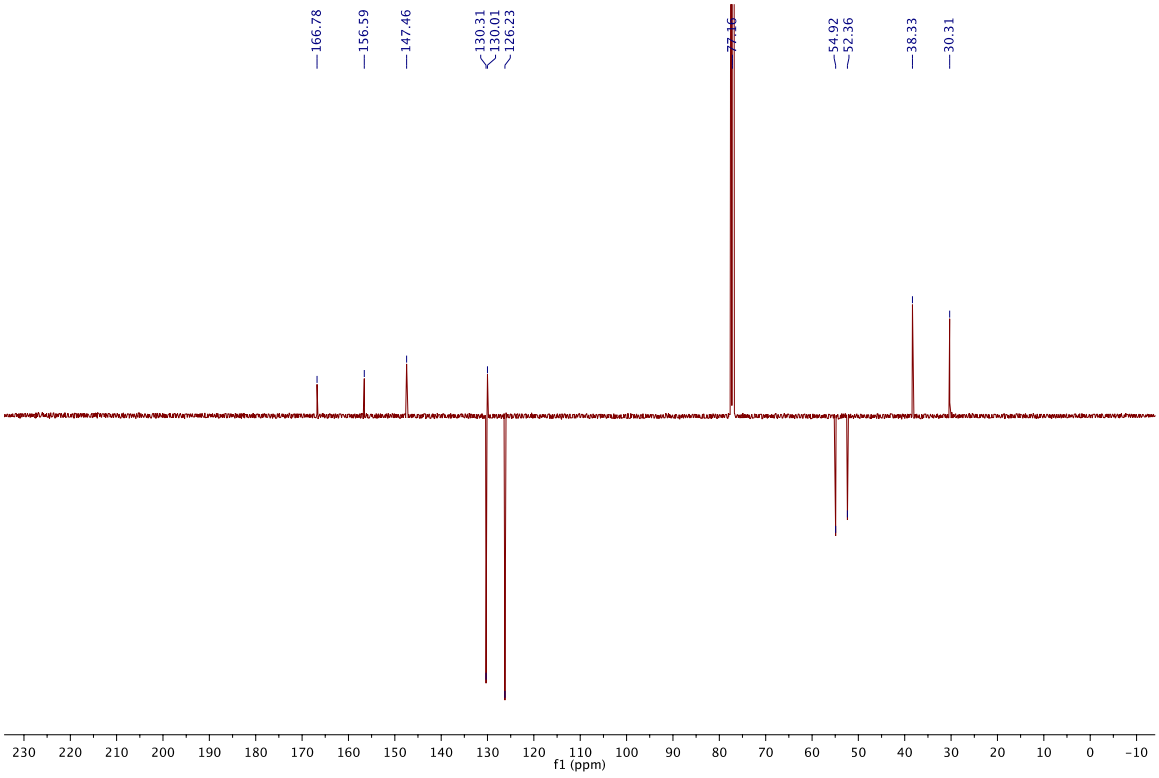

7.26
Me
O
N
Me
N
O
Me
O
40
A
+
O
N
Me
N
O
Me
O
B
1.98
0.68
1.98
0.68
1.67
4.03
1.00
0.67
0.68
1.01
3.98
2.98
f1 (ppm)

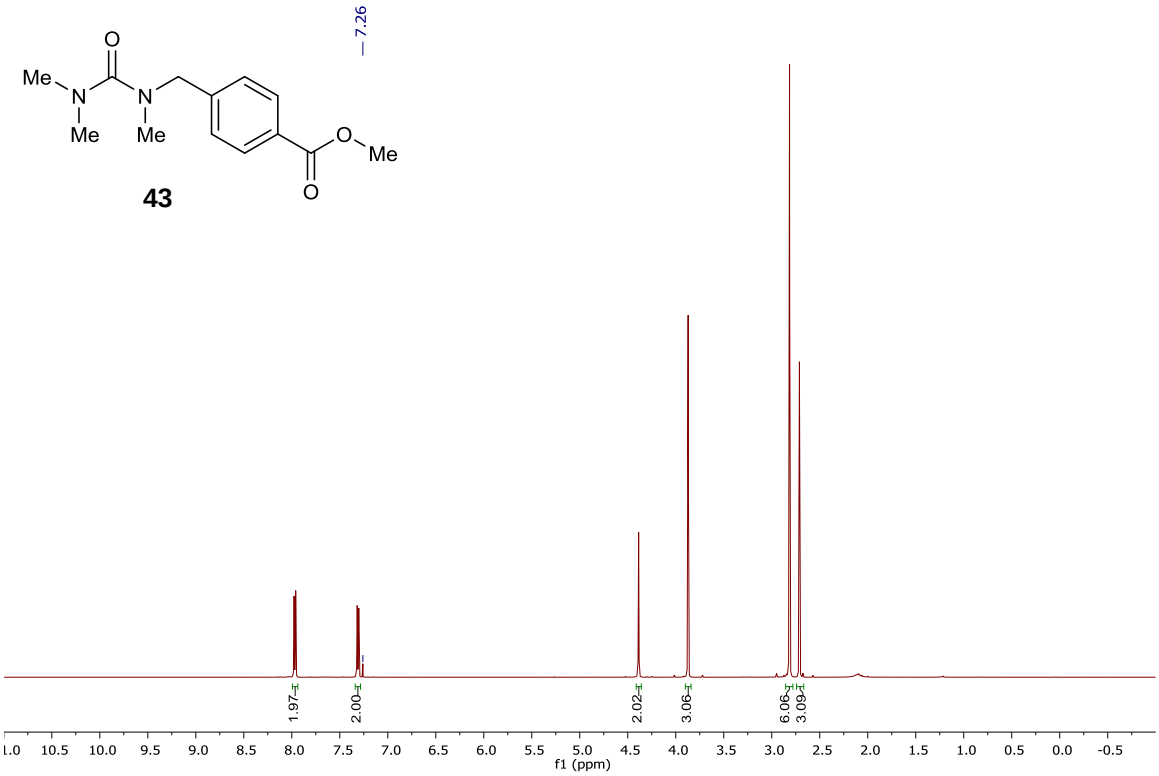

166.98
166.72
161.78
161.52
144.87
142.86
130.40
130.38
130.00
129.38
128.04
127.02
77.16
60.34
53.99
52.34
52.22
48.42
45.10
42.37
31.56
31.41
29.96
f1 (ppm)

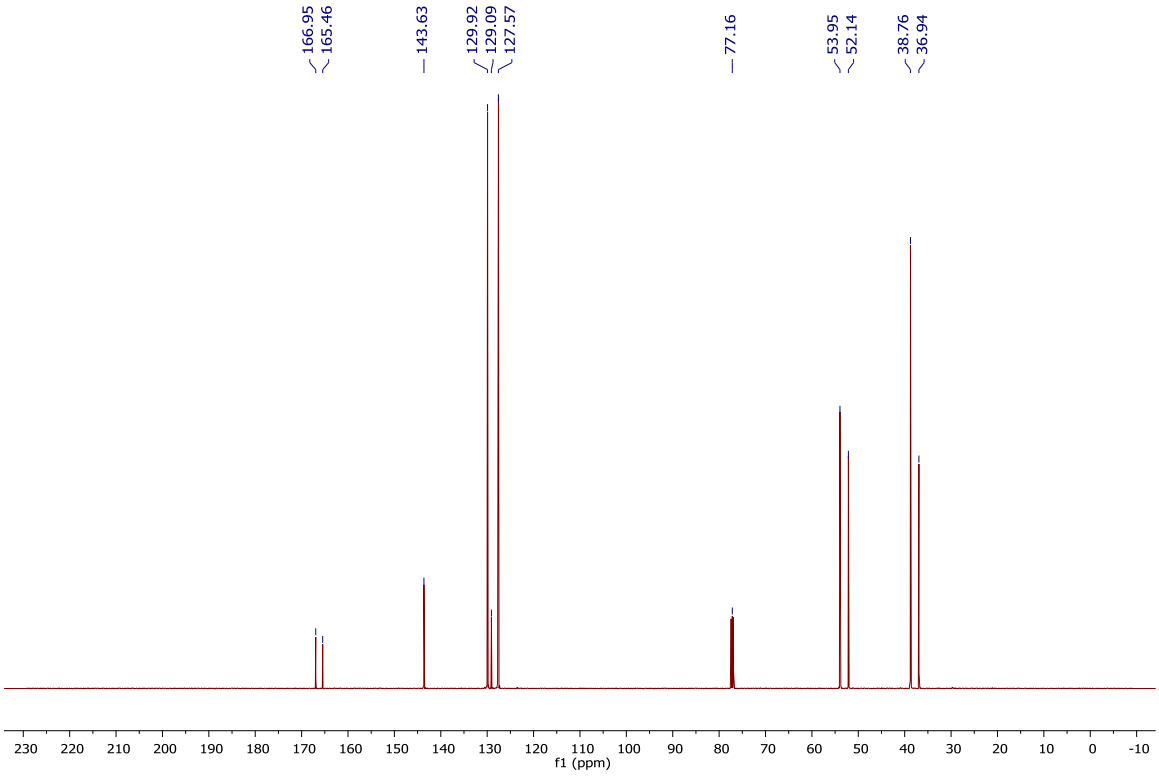

41
A
+
B
7.26
1.58
2.00
2.03
1.59
2.00
0.79
5.46
2.08
2.15
1.53
5.45
2.33
0.79
2.89
f1 (ppm)

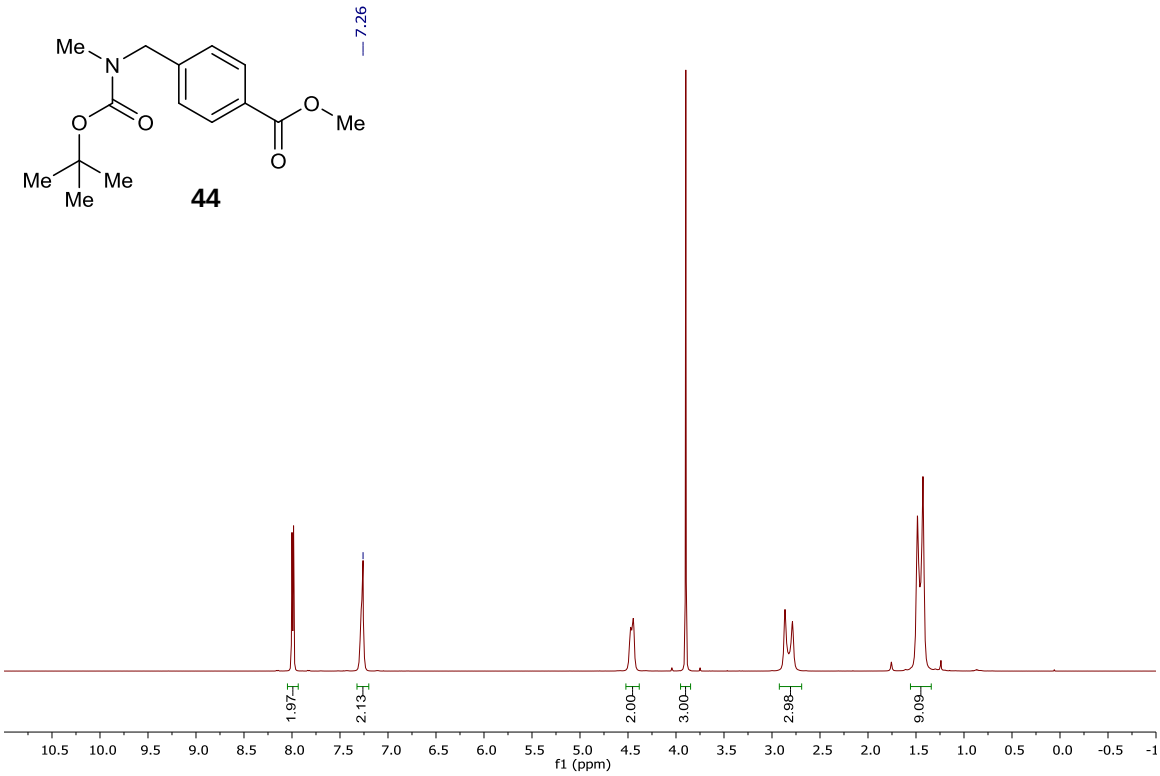

167.04
166.76
156.69
156.51
146.87
144.17
130.15
129.86
129.56
128.99
127.68
126.31
77.16
61.23
52.24
52.12
51.19
47.95
45.53
43.93
35.94
34.98
29.64
22.28
f1 (ppm)

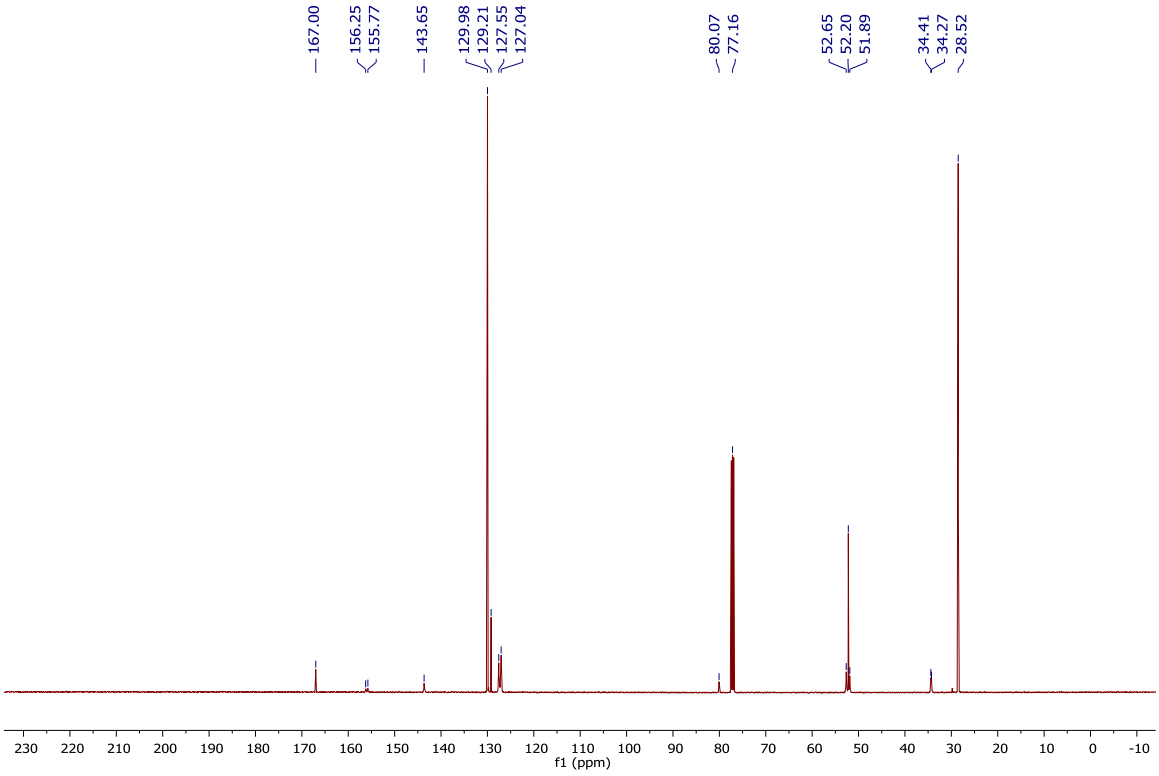

O
HN
NH
OMe
O
42
7.26
2.01
2.00
1.99
1.00
3.02
1.04
1.01
0.99
0.99
f1 (ppm)

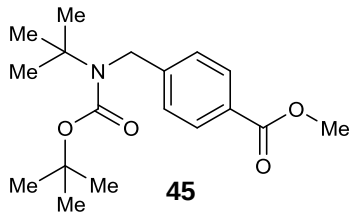

166.78
156.59
147.46
130.31
130.01
126.23
77.16
54.92
52.36
38.33
30.31
f1 (ppm)


7.26
Me
N
Me
O
N
Me
O
Me
O
43
1.97
2.00
2.02
3.06
6.06
3.09
f1 (ppm)


166.95
165.46
143.63
129.92
129.09
127.57
77.16
53.95
52.14
38.76
36.94
f1 (ppm)

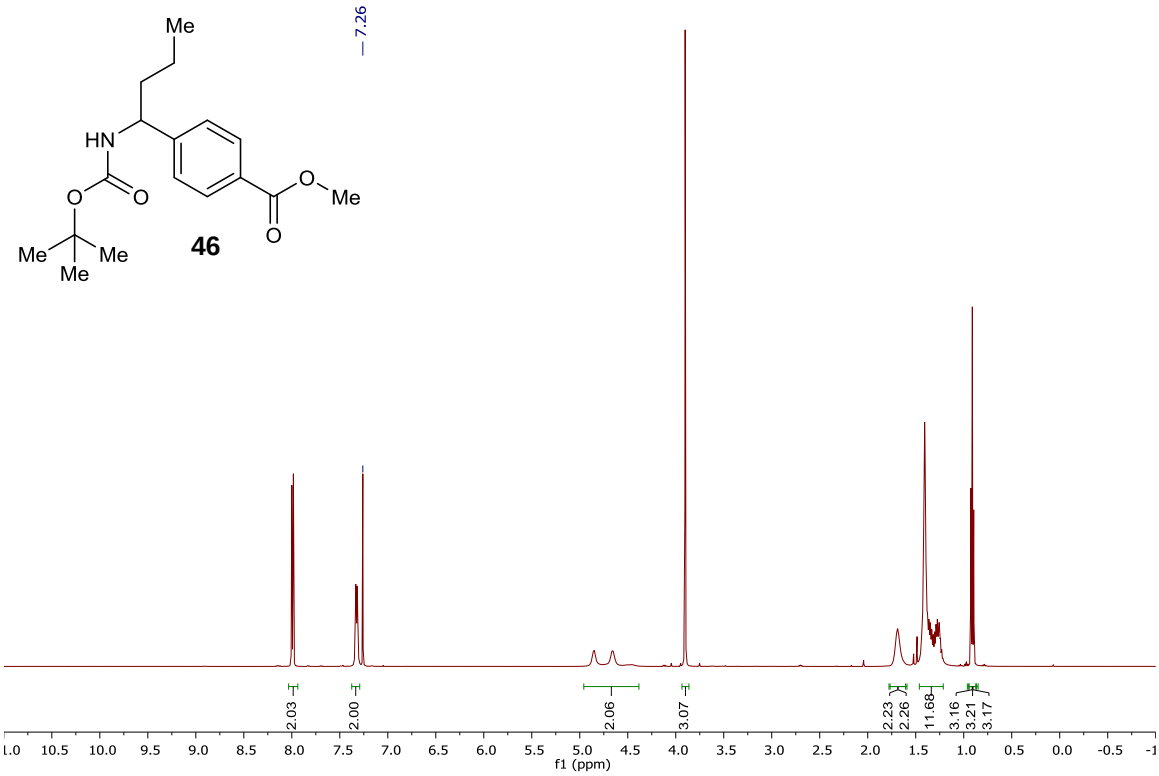

Me
N
O
O
Me
Me
Me
Me
O
O
Me
44
7.26
1.97
2.13
2.00
3.00
2.98
9.09
f1 (ppm)

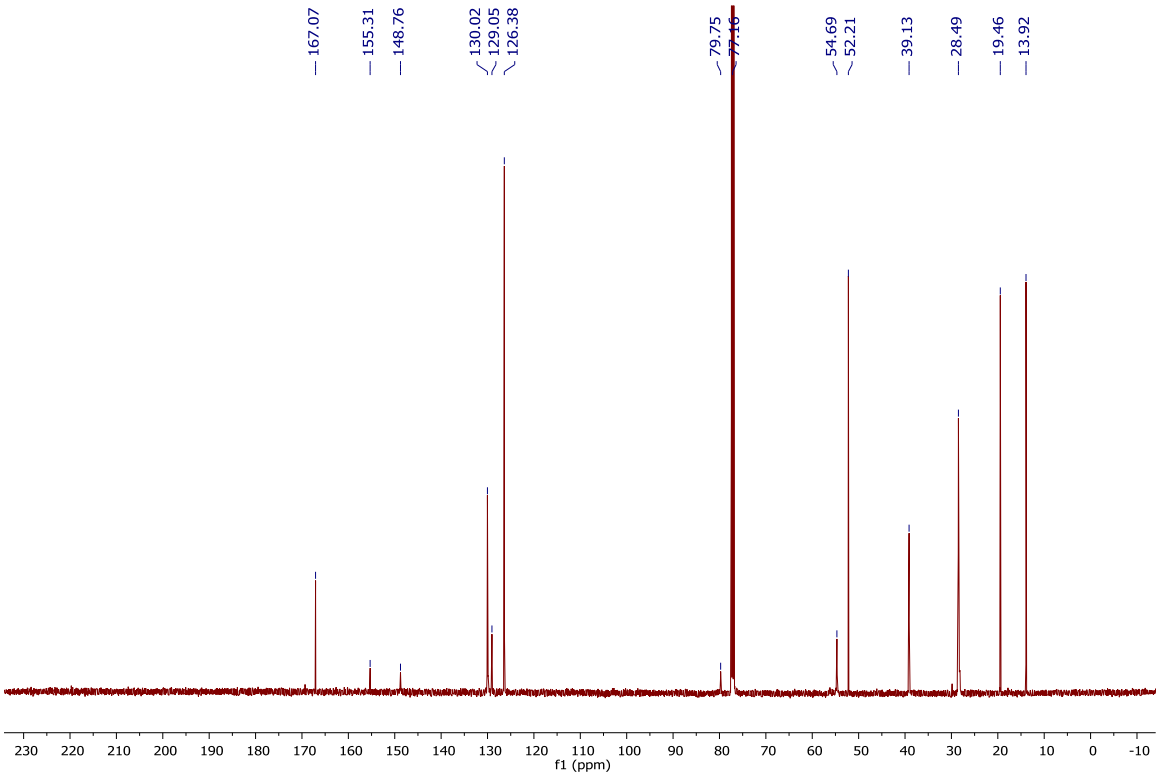

167.00
156.25
155.77
143.65
129.98
129.21
127.55
127.04
80.07
77.16
52.65
52.20
51.89
34.41
34.27
28.52
f1 (ppm)

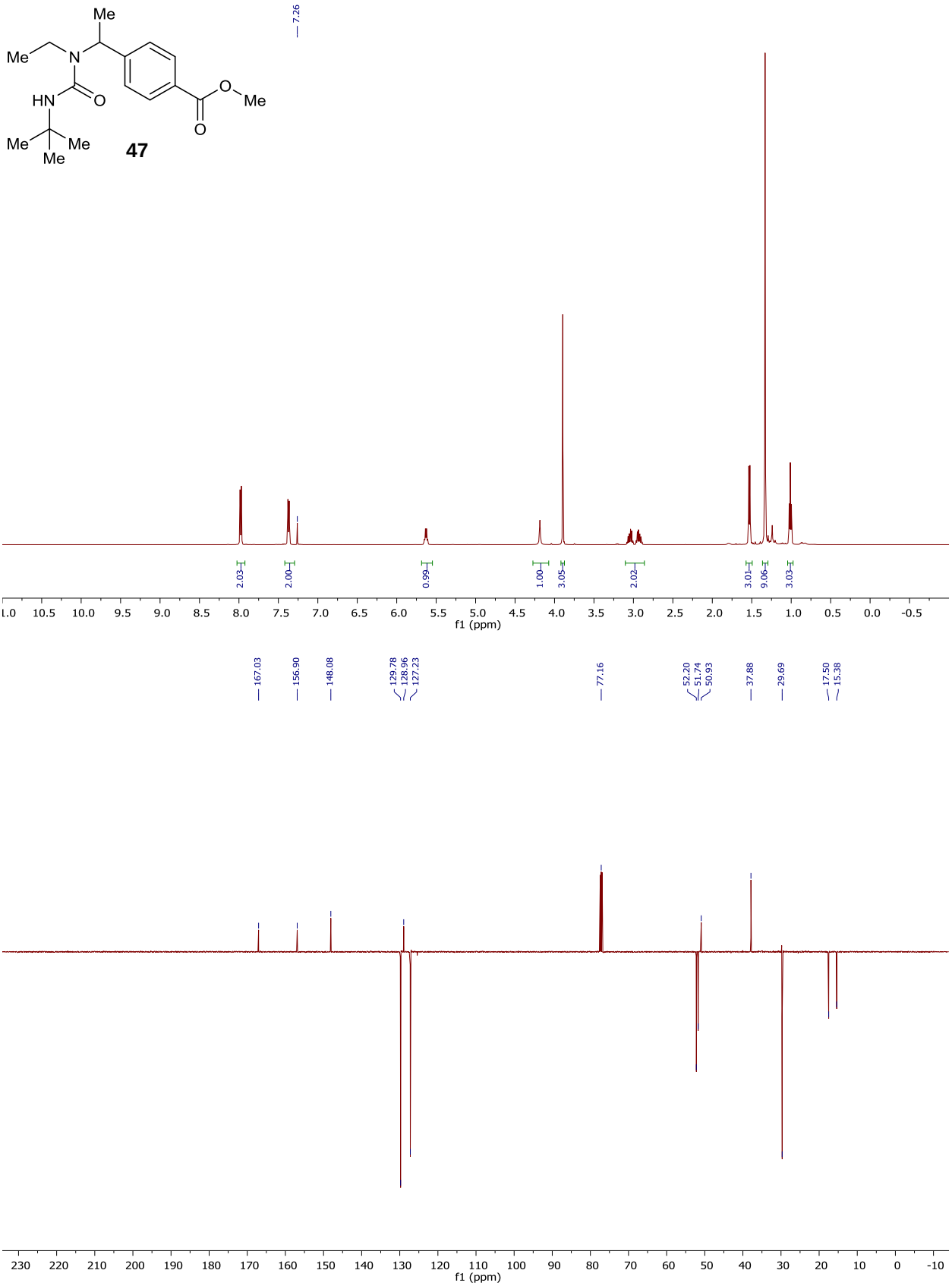

Me
Me
Me
N
O
O
O
Me
O
Me
Me
Me

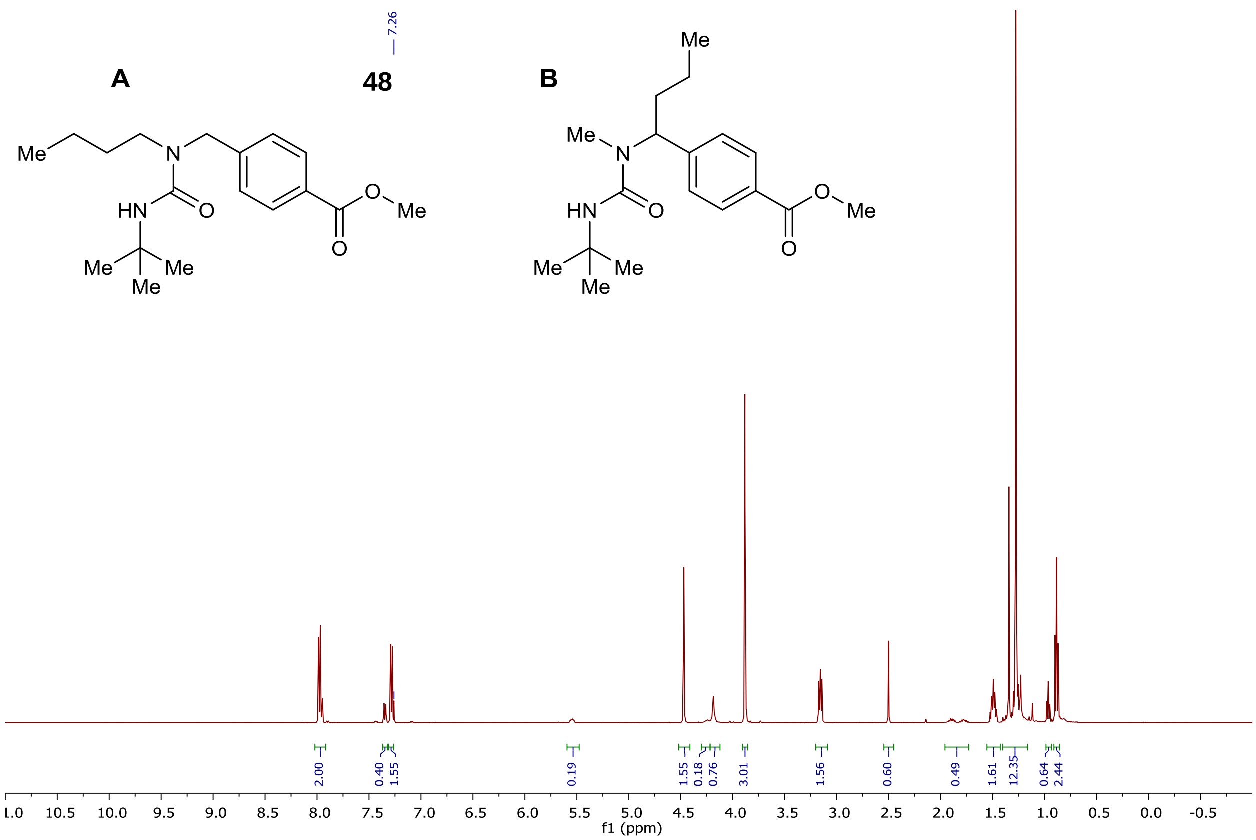
45

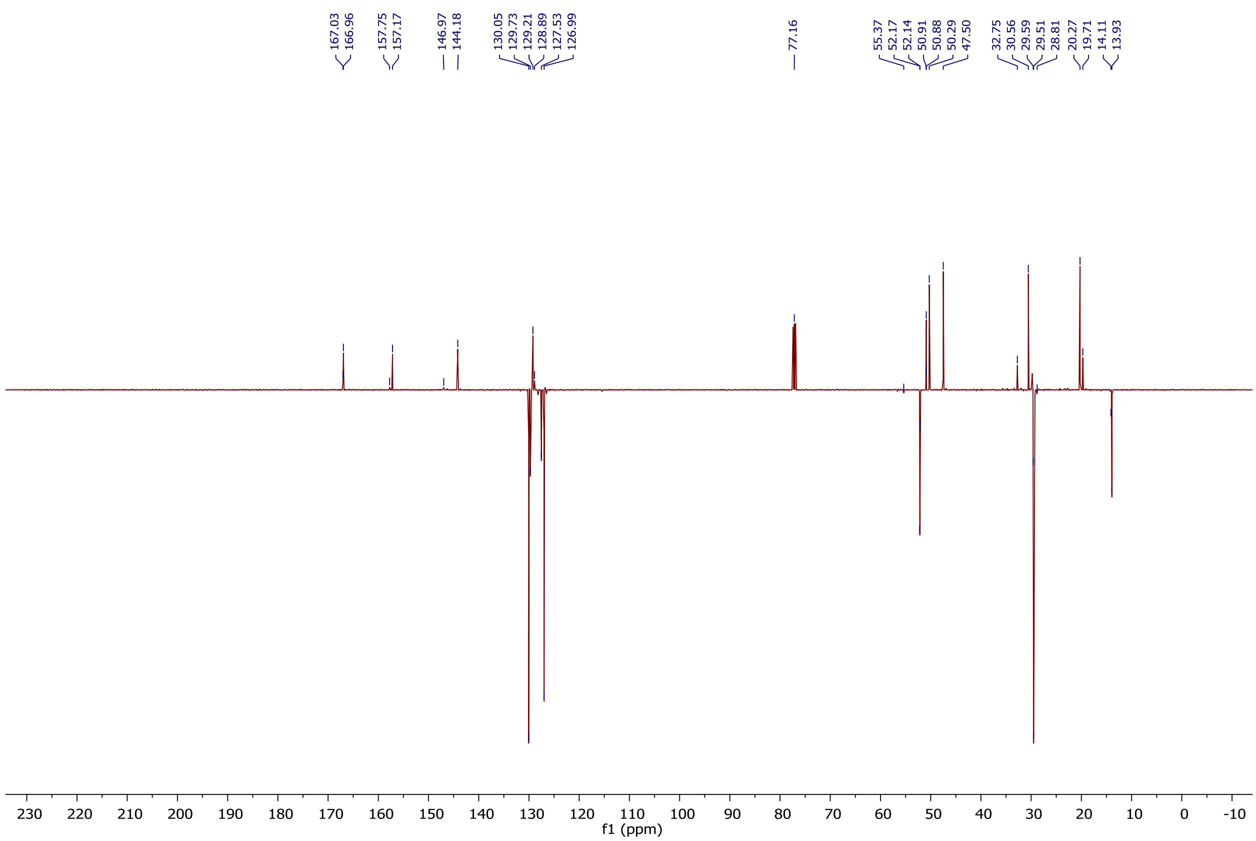
7.26
2.00
2.44
1.95
3.02
8.92
9.25
f1 (ppm)
167.20
156.05
147.01
129.86
128.48
126.20
79.90
77.16
56.32
52.16
48.70
29.66
28.60
f1 (ppm)

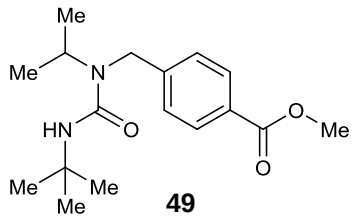

Me
HN
O
O
O
Me
Me
Me
Me
46
7.26
2.03
2.00
2.06
3.07
2.23
2.26
11.68
3.16
3.21
3.17
f1 (ppm)


167.07
155.31
148.76
130.02
129.05
126.38
79.75
77.16
54.69
52.21
39.13
28.49
19.46
13.92
f1 (ppm)


Me
Me
N
HN
O
O
Me
O
Me
Me
Me
47
7.26
2.03
2.00
0.99
1.00
3.05
2.02
3.01
9.06
3.03
f1 (ppm)
167.03
156.90
148.08
129.78
128.96
127.23
77.16
52.20
51.74
50.93
37.88
29.69
17.50
15.38
f1 (ppm)

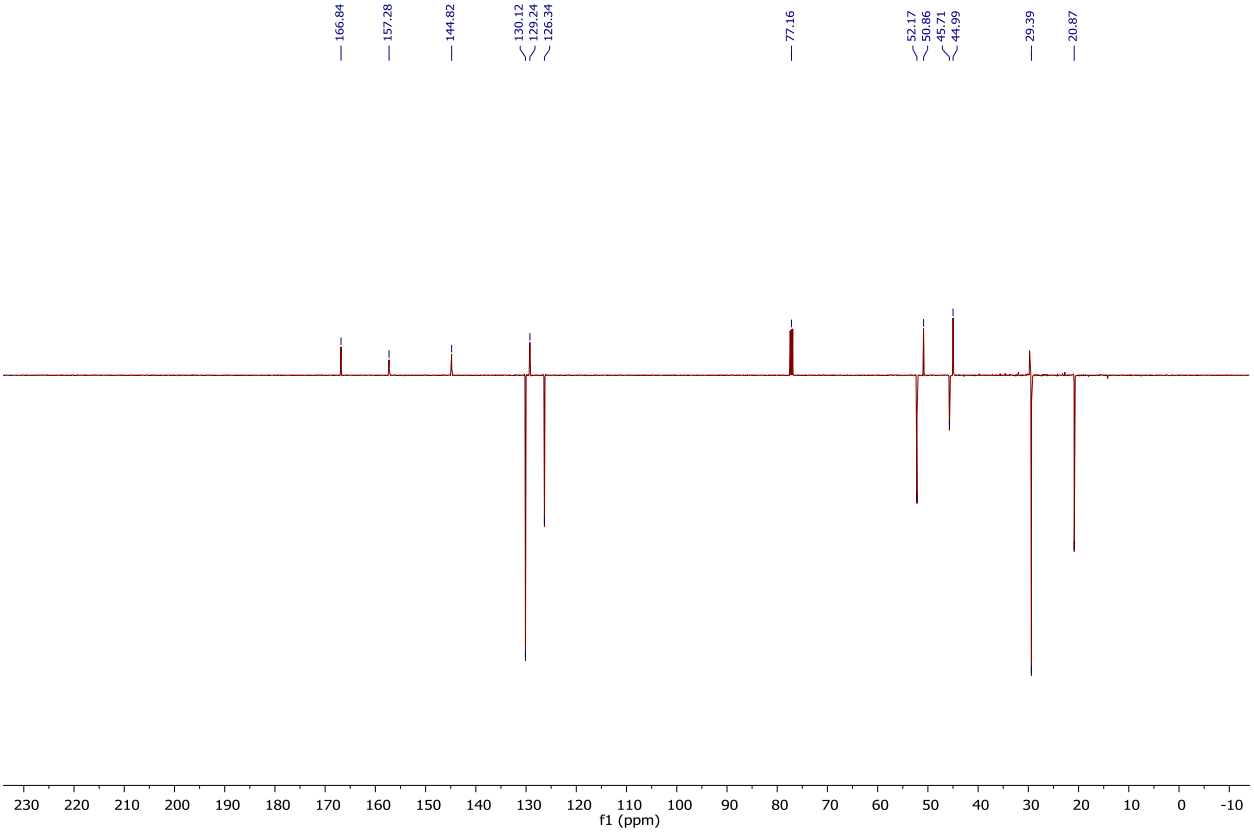

A
48
B
Me
HN
N
O
Me
7.26
2.00
0.40
1.55
0.19
1.55
0.18
0.76
3.01
1.56
0.60
0.49
1.61
12.35
0.64
2.44
f1 (ppm)

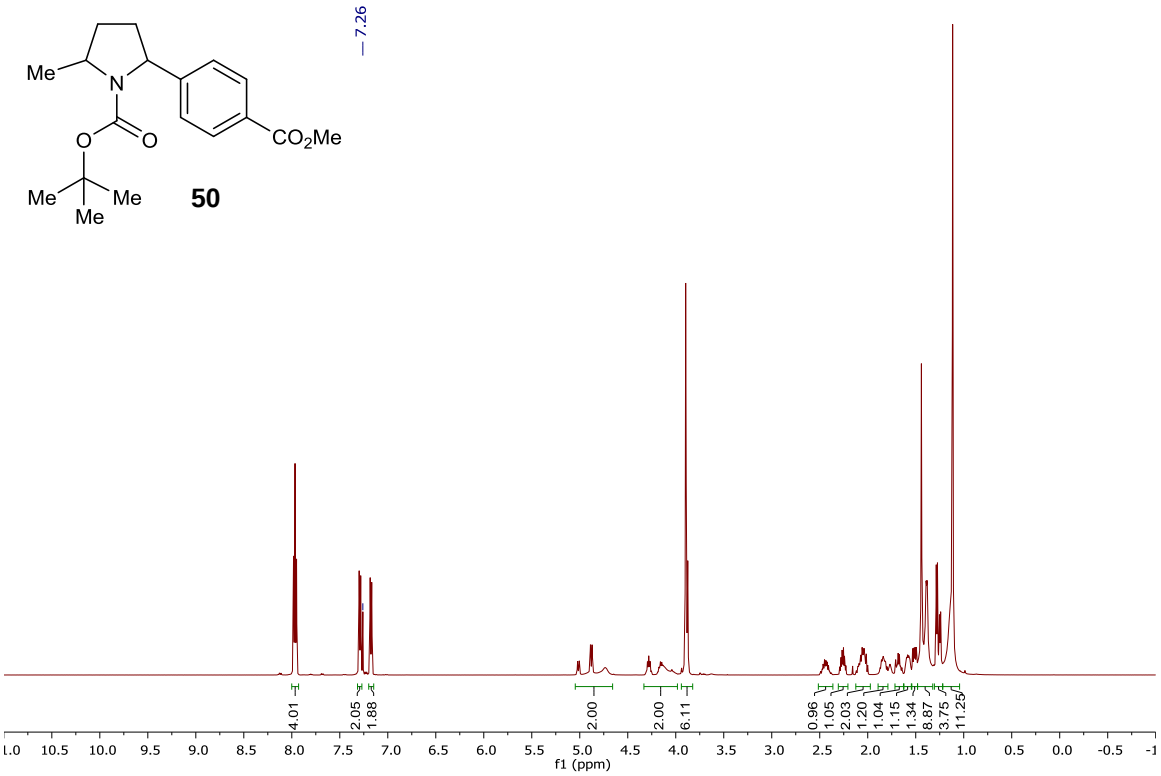

167.03
166.96
157.75
157.17
146.97
144.18
130.05
129.73
129.21
128.89
127.53
126.99
77.16
55.37
52.17
52.14
50.91
50.88
50.29
47.50
32.75
30.56
29.59
29.51
28.81
20.27
19.71
14.11
13.93
f1 (ppm)

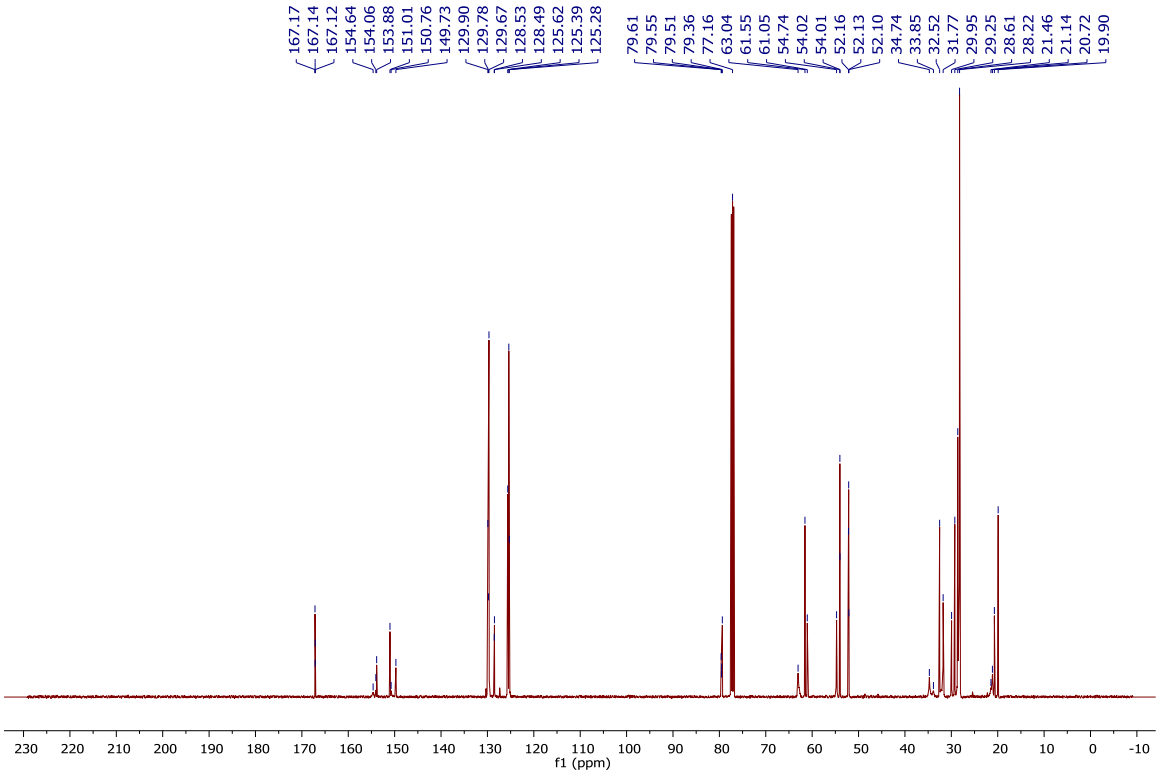

Me
Me
N
HN
O
Me
Me
Me
Me
O
O
Me

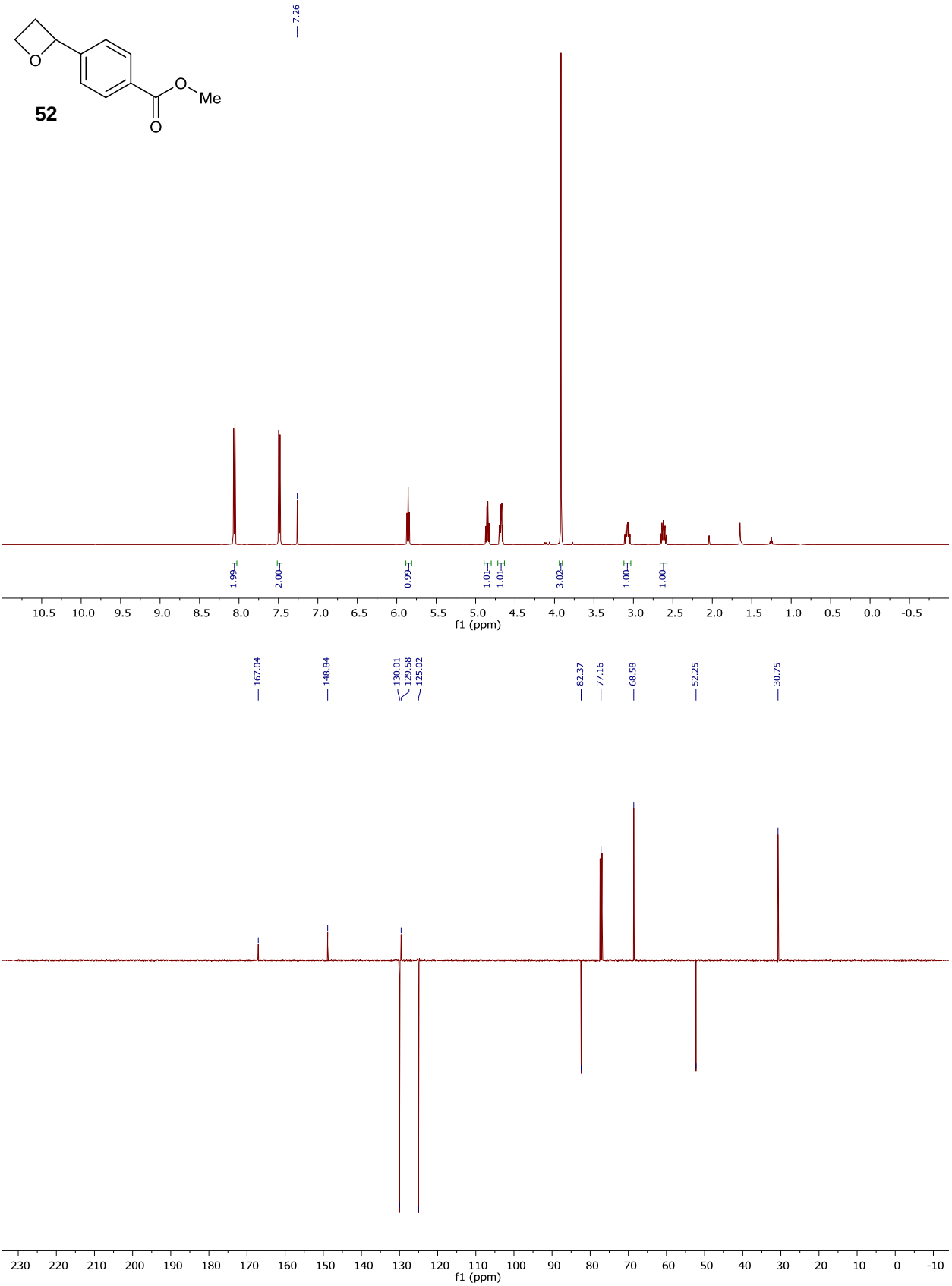
49

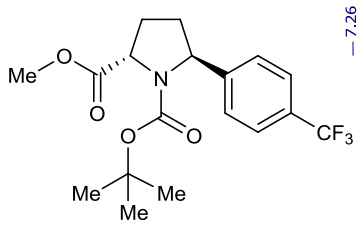
7.26
2.00
2.01
0.98
1.99
0.97
3.01
9.10
6.17
f1 (ppm)


166.84
157.28
144.82
130.12
129.24
126.34
77.16
52.17
50.86
45.71
44.99
29.39
20.87
f1 (ppm)


Me
N
O
O
CO2Me
Me
Me
Me
50
7.26
4.01
2.05
1.88
2.00
2.00
6.11
0.96
1.05
2.03
1.20
1.04
1.15
1.34
8.87
3.75
11.25
f1 (ppm)

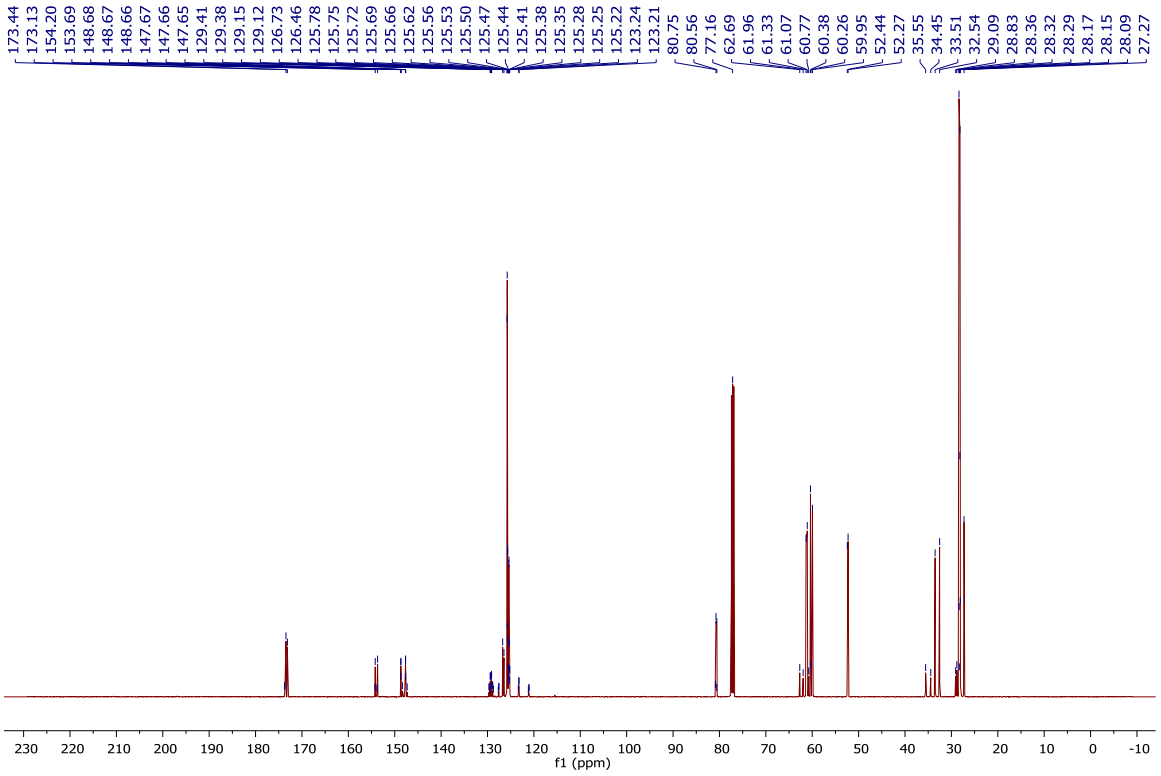

167.17
167.14
167.12
154.64
154.06
153.88
151.01
150.76
149.73
129.90
129.78
129.67
128.53
128.49
125.62
125.39
125.28
79.61
79.55
79.51
79.36
77.16
63.04
61.55
61.05
54.74
54.02
54.01
52.16
52.13
52.10
34.74
33.85
32.52
31.77
29.95
29.25
28.61
28.22
21.46
21.14
20.72
19.90
f1 (ppm)

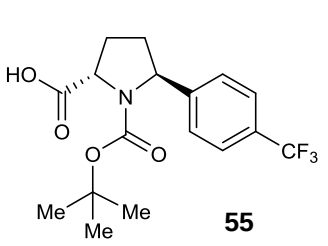

52
O
O
Me
O
7.26
1.99
2.00
0.99
1.01
1.01
3.02
1.00
1.00
f1 (ppm)
167.04
148.84
130.01
129.58
125.02
82.37
77.16
68.58
52.25
30.75
f1 (ppm)


Me
O
O
N
O
O
Me
Me
Me
CF3

4:1 d.r.

7.26
0.49
2.45
2.29
1.00
0.11
0.13
1.12
0.11
0.73
2.98
1.01
0.27
1.25
1.47
0.99
5.72
4.32
1.18
f1 (ppm)

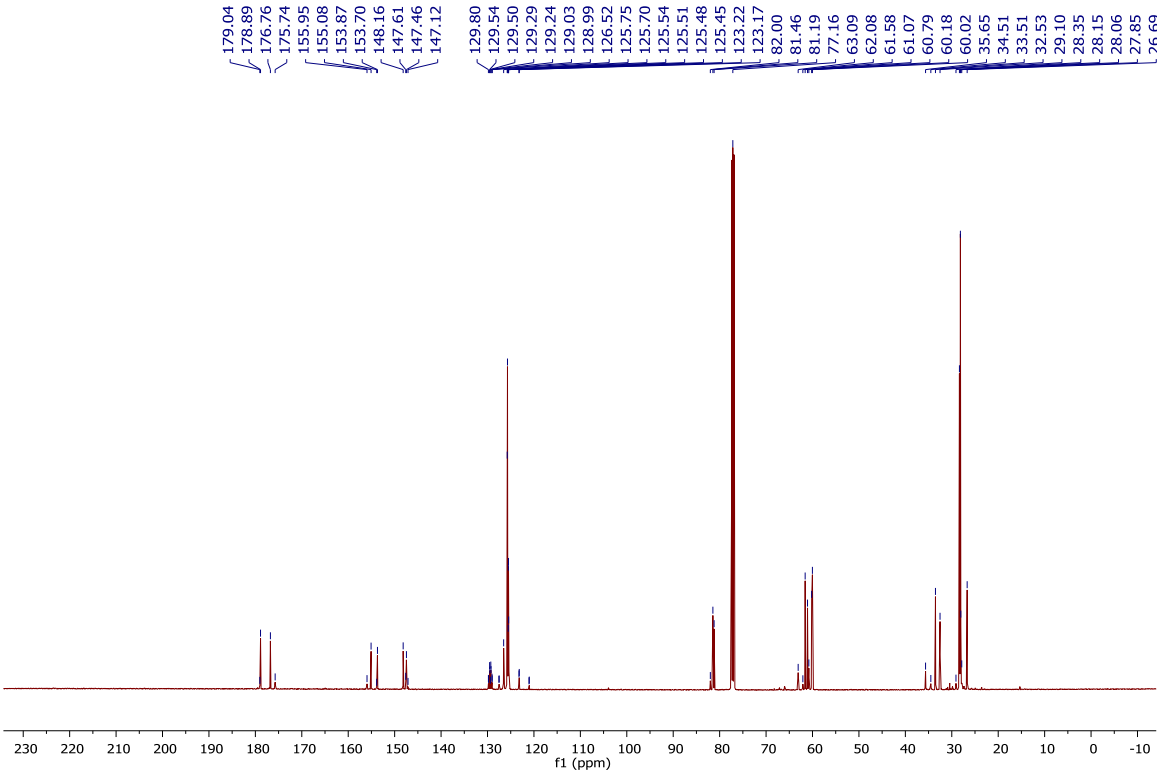

173.44
173.13
154.20
153.69
148.68
148.67
148.66
147.67
147.66
147.65
129.41
129.38
129.15
129.12
126.73
126.46
125.78
125.75
125.72
125.69
125.66
125.62
125.56
125.53
125.50
125.47
125.44
125.41
125.38
125.35
125.28
125.25
125.22
123.24
123.21
80.75
80.56
77.16
62.69
61.96
61.33
61.07
60.77
60.38
60.26
59.95
52.44
52.27
35.55
34.45
33.51
32.54
29.09
28.83
28.36
28.32
28.29
28.17
28.15
28.09
27.27
f1 (ppm)

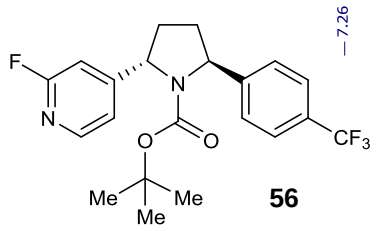

HO
O
N
O
O
CF3
Me
Me
Me

55

4:1 d.r.

7.26
2.55
0.47
7.14
1.00
1.39
1.19
1.27
1.20
0.34
0.97
3.45
7.99
7.81
f1 (ppm)

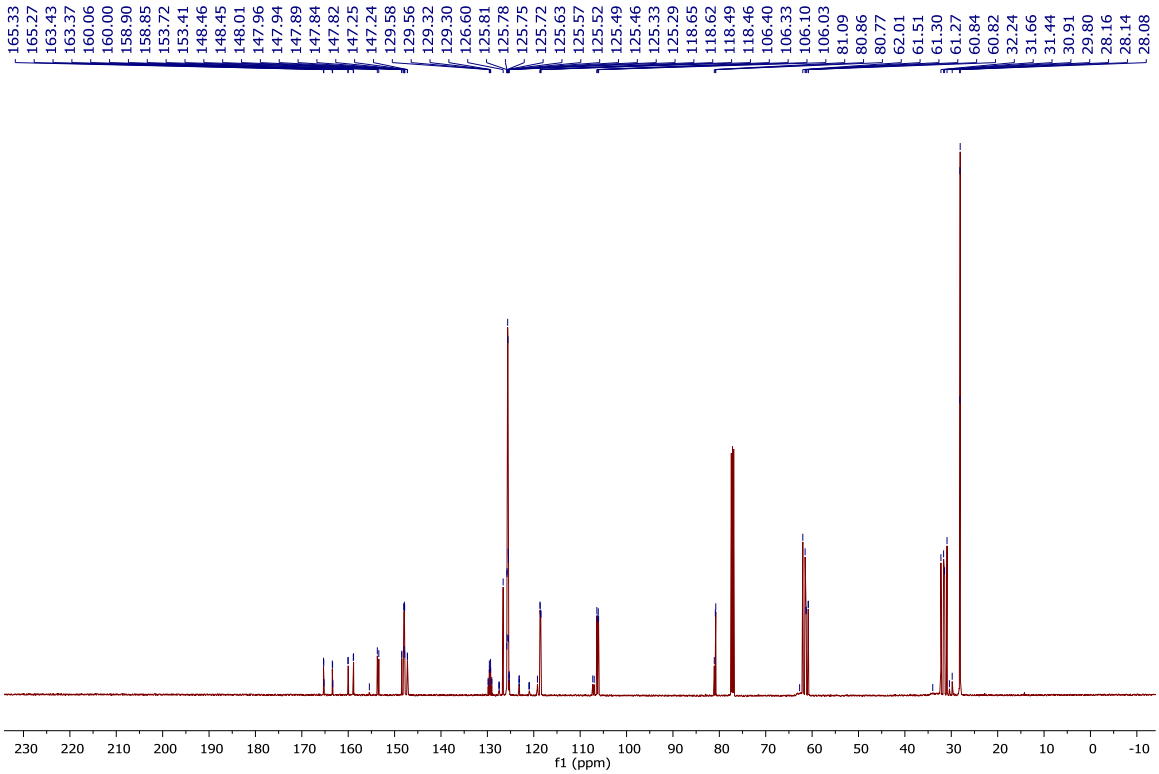

179.04
178.89
176.76
175.74
155.95
155.08
153.87
153.70
148.16
147.61
147.46
147.12
129.80
129.54
129.50
129.29
129.24
129.03
128.99
126.52
125.75
125.70
125.54
125.51
125.48
125.45
123.22
123.17
82.00
81.46
81.19
77.16
63.09
62.08
61.58
61.07
60.79
60.18
60.02
35.65
34.51
33.51
32.53
29.10
28.35
28.15
28.06
27.85
f1 (ppm)


F
N
N
O
O
Me
Me
Me
CF3

56

4:1 d.r.

7.26
1.22
2.54
0.48
0.22
1.01
0.21
1.00
1.03
1.07
0.47
2.51
0.45
2.18
12.03
f1 (ppm)


165.33
165.27
163.43
163.37
160.06
160.00
158.90
158.85
153.72
153.41
148.46
148.45
148.01
147.96
147.94
147.89
147.84
147.82
147.25
147.24
129.58
129.56
129.32
129.30
126.60
125.81
125.78
125.75
125.72
125.63
125.57
125.52
125.49
125.46
125.33
125.29
118.65
118.62
118.49
118.46
106.40
106.33
106.10
106.03
81.09
80.86
80.77
62.01
61.51
61.30
61.27
60.84
60.82
32.24
31.66
31.44
30.91
29.80
28.16
28.14
28.08
f1 (ppm)

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