Supplementary Information

A Strategy for the Controllable Generation of Organic Superbases from Benchtop-Stable Salts

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I. General Information

General Reagent Information: *tert*-Butylimino-tri(pyrrolidino)phosphorane (BTPP), 1-*tert*-butyl-2,2,4,4,4-pentakis(dimethylamino)-2λ^5,4λ^5-catenadi(phosphazene) (P_2-*t*-Bu) and 1-ethyl-2,2,4,4,4-pentakis(dimethylamino)-2λ^5,4λ^5-catenadi(phosphazene) (P_2-Et) were purchased from Millipore Sigma (products #79432, #79416 and #79417, respectively) and were stored in a -30 °C freezer inside a nitrogen-filled glovebox. Before use, the superbases were allowed to warm to room temperature (rt) and homogenize if any solid was evident. Tetrahydrofuran and toluene were deoxygenated and dried by passage over packed columns of neutral alumina and copper (II) oxide under positive pressure of nitrogen. The following solvents were purchased anhydrous from Millipore Sigma and used as received: dimethyl sulfoxide (#276855), *N*,*N*-dimethylformamide (#227056), 1,4-dioxane (#296309), and acetonitrile (#271004). *t*-BuXPhosPdG3 (#762229) and *t*-BuBrettPhosPdG3 (#745979) were purchased from Millipore Sigma and used as received. Deoxybenzoin was purchased from Combi-Blocks (#QE-4078) and recrystallized from ethanol before use. *N*-(Diphenylmethylene)glycine *tert*-butyl ester was purchased from Oakwood Chemical (#050237) and recrystallized from hexanes before use. 4-Nitrobenzaldehyde was purchased from Combi-Blocks (#AN-3207) and recrystallized from 1:1 EtOH/H_2O before use. 4-Ethoxycarbonylmethylphenylboronic acid, pinacol ester was purchased from Combi-Blocks (#PN-8932) and was purified by silica gel chromatography (5% EtOAc in hexanes) before use. 2-(4-Aminophenyl)acetonitrile was purchased from Ambeed (#A913458) and purified by silica gel chromatography (40% EtOAc in hexanes) before use. All other reagents were purchased from Millipore Sigma, Combi-Blocks, Ambeed, Oakwood Chemical, TCI, Acros Organics, Matrix, or Alfa Aesar and used as received. Flash Chromatography was performed on 40-63 μm silica gel (SiliaFlash® F60 from Silicycle).

General Analytical Information: All new compounds were characterized by ^{1}H, ^{13}C, ^{19}F and ^{31}P (as appropriate) NMR spectroscopy, FTIR spectroscopy, mass spectrometry, and melting point analysis (if solid). NMR spectra were obtained on a Bruker Advanced NEO or Varian Inova 400 MHz spectrometer. ^{1}H NMR data is reported as follows: chemical shift (δ ppm), multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, dd = doublet of doublets, td = triplet of doublets, ddd = doublet of doublet of doublets, m = multiplet), coupling constant (Hz), and integration. ^{13}C NMR data is reported as follows: chemical shift (δ ppm), multiplicity (if applicable, d = doublet, q = quartet). All ^{1}H and ^{13}C NMR signals are reported as chemical shifts (δ ppm) relative to residual solvent peaks of the deuterated NMR solvents. ^{31}P NMR data is reported in reference to 85% phosphoric acid as an external standard with delay time of 2 s. For comparison between multiple ^{31}P NMR experiments, triphenylphosphine oxide internal standard (set to δ 23.2 ppm) was used. All ^{31}P NMR data is reported as follows: chemical shift (δ ppm), multiplicity (if applicable, s = singlet, d = doublet). All ^{19}F NMR signals are reported as chemical shifts (δ ppm) in reference to an internal standard (fluorobenzene set to -112.96 ppm) and are not proton decoupled. High resolution mass spectra (HRMS) were recorded on an Agilent 6210 TOF interfaced to a DART

100 or APCI source provided by Colorado State University's Materials and Molecular Analysis Center. Infrared spectra were recorded using a Thermo Scientific Nicolet iS-50 FTIR Spectrometer and reported as frequency of absorption (cm^{-1}). Melting point analyses were conducted using a Mel-Temp capillary melting point apparatus. Thin-layer chromatography analysis was performed on silica gel 60Å F254 plates (250 µm, SiliaPlate from Silicycle, #TLGR10014B-323) and interpreted using UV light (254 nm) and/or potassium permanganate stain. Preparatory thin layer chromatography purification was performed on silica gel 60 Å F254 (1000 µm, SiliaPlate from Silicycle, #TLGR10011B-341) and interpreted using UV light (254 nm). Gel permeation chromatography (GPC) was used to analyze number (M_n) and weight (M_w) average molecular weights and dispersity index of polymers. GPC data was obtained using an Agilent 1260 II instrument equipped with an Agilent HPLC system one guard column and two PLgel 5 µm mixed-C gel permeation columns and coupled with a Wyatt DAWN HELEOS II multi (18)-angle light scattering detector, a Wyatt Optilab TrEX dRI detector, and a Wyatt Viscostar III viscometer.

Note on nomenclature: The names provided for the structures below were obtained from ChemDraw Professional 20.0.

Abbreviations: List of abbreviations used in this document.

BTPP salt **A** = 1-phenyl-1-cyclopropanecarboxylate *tert*-butylimino-tri(pyrrolidino)phosphorane
BTPP salt **B** = 2-cyclohexylphenylacetate *tert*-butylimino-tri(pyrrolidino)phosphorane
P_2-*t*-Bu salt **A** = 2-methyl-phenylpropionate 1-*tert*-butyl-2,2,4,4,4-pentakis(dimethylamino)-2λ^5,4λ^5-catenadi(phosphazene)
P_2-*t*-Bu salt **B** = 1-(4-fluorophenyl)cylohpentanecarboxylate 1-*tert*-butyl-2,2,4,4,4-pentakis(dimethylamino)-2λ^5,4λ^5-catenadi(phosphazene)
Me = methyl
Et = ethyl
t-Bu = *tert*-butyl
n-Bu = *n*-butyl
Ph = phenyl
Bn = benzyl
PMP = *para*-methoxyphenyl
Ar = aryl
Ts = *p*-toluenesulfonyl
h = hour
min = minute
s = second
rt = room temperature

II. Superbase Salt Synthesis

a. Identification of a crystalline carboxylate salt for BTPP

We investigated a series of carboxylic acids to identify one that forms a solid, shelf-stable salt with the BTPP superbase (representative examples shown in Figure S1). This led to identification of 1-phenyl-1-cyclopropanecarboxylic acid that forms a stable salt with BTPP, labeled as BTPP salt **A**.

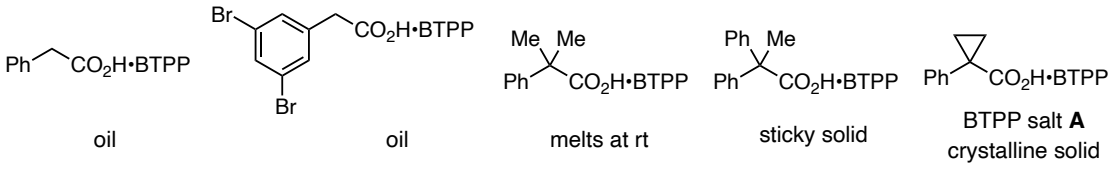
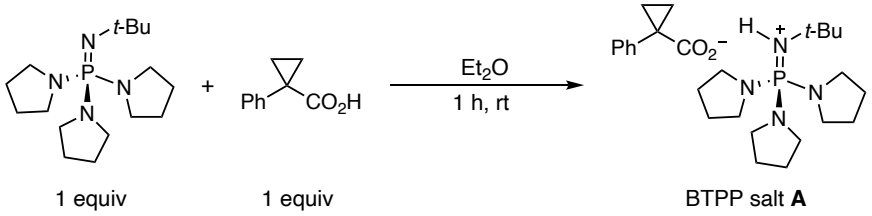


Figure S1: BTPP•carboxylic acid salts examined to identify a solid salt.

Carboxylate Salt Testing Procedure: An oven-dried 1-dram vial (ThermoFisher, C4015-1) was charged with a magnetic stir bar, carboxylic acid (0.25 mmol, 1.0 equiv) and brought into a nitrogen-filled glovebox. Diethyl ether (0.5 mL, 0.5 M) and BTPP (78.1 mg, 0.25 mmol, 1.0 equiv) were added to the vial. The vial was capped with a PTFE-lined cap (ThermoFisher, C4015-1A), removed from the glovebox, and stirred for 2 h at 25 °C. The solutions were concentrated *in vacuo*, then placed under high vacuum for drying. The physical state of each salt was then evaluated visually and with agitation using a spatula. Representative results are shown in Figure S1 above.

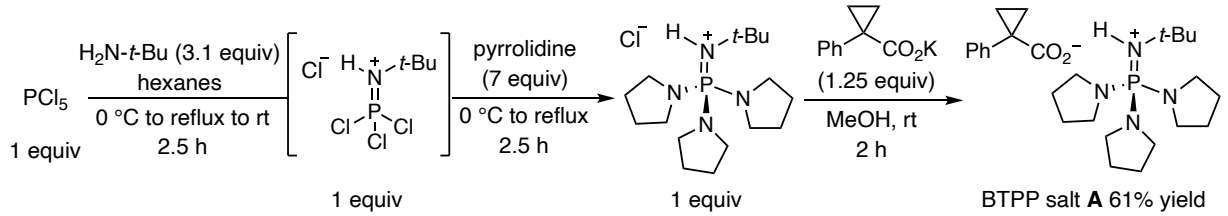
b. Synthesis of BTPP Salt A from commercial BTPP freebase



Procedure: An oven-dried 250 mL round bottom flask was charged with a magnetic stir bar, 1-phenyl-1-cyclopropanecarboxylic acid (811.0 mg, 5 mmol, 1.0 equiv) and diethyl ether (10 mL, 0.5 M). In a nitrogen-filled glovebox an oven-dried 20 mL scintillation vial (ThermoFisher, 03-341-25D) was charged with BTPP (1.56 g, 5 mmol, 1.0 equiv) and diluted with diethyl ether (10 mL). The vial was capped and removed from the glovebox. The vial containing BTPP was uncapped, and the solution was added *via* pipette to the stirring solution of 1-phenyl-1-cyclopropanecarboxylic acid. The reaction mixture was stirred for 1 hour at rt. The reaction solution was concentrated, and the resulting crystalline solid was washed with cold diethyl ether, dried *in vacuo*, and collected as a white powder (2.01 g, 4.24 mmol, 85% yield). **^{1}H NMR** (400

MHz, $CDCl_3$) δ 7.84 (d, *J* = 10.2 Hz, 1H), 7.33 (d, *J* = 7.5 Hz, 2H), 7.10 (t, *J* = 7.5 Hz, 2H), 6.99 (t, *J* = 7.5 Hz, 1H), 3.17 – 3.08 (m, 12H), 1.83 – 1.71 (m, 12H), 1.36 (q, *J* = 3.2 Hz, 2H), 1.23 (s, 9H), 0.74 (q, *J* = 3.2 Hz, 2H). **^{31}P NMR** (162 MHz, $CDCl_3$) δ 22.5 (s). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 177.2, 146.1, 130.4, 127.1, 124.6, 52.0 (d, *J* = 2.0 Hz), 47.4 (d, *J* = 5.1 Hz), 31.7, 31.3 (d, *J* = 4.9 Hz), 26.0 (d, *J* = 8.0 Hz), 14.1. **IR (neat)** 2963, 2862, 2812, 1585, 1443, 1343, 1199, 1065, 984, 740 cm^{-1}. **HRMS (DART)** $[M]^+$ calcd. for $[C_{16}H_{34}N_4P]^+$ (for protonated phosphazene) = 313.2521, found 313.2533. **MP** 100 – 103 °C.

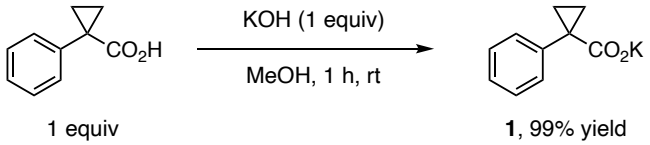
c. Synthesis of BTPP salt A from phosphorus pentachloride



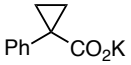
***tert*-Butyliminotri(pyrrolidino)phosphorane • hydrogen chloride**. Phosphorus pentachloride and *tert*-butylphosphorimidoyl trichloride are air and moisture sensitive; care was taken to exclude ambient air and moisture for the following procedure. In a nitrogen-filled glovebox, an oven-dried 1000 mL round bottom flask was charged with a magnetic stir bar and PCl_5 (15.6 g, 75 mmol, 1.0 equiv). The flask was capped with a rubber septum, removed from the glovebox, and connected to a nitrogen-flushed reflux condenser with a positive pressure of nitrogen. Hexanes (250 mL, 0.3 M) was added *via* nitrogen-flushed syringe. The solution was cooled to 0 °C in an ice bath with stirring and *tert*-butylamine (24.4 mL, 233 mmol, 3.1 equiv) was added dropwise *via* nitrogen-flushed syringe. The reaction solution was stirred for 30 min at 0 °C. The solution was warmed to rt, placed in an oil bath, and refluxed at 70 °C for 2 h. The reaction flask was removed from the oil bath, cooled to rt, and then cooled to 0 °C in an ice bath. Pyrrolidine (43.1 mL, 525 mmol, 7.0 equiv) was added *via* nitrogen-flushed syringe and stirred for 30 min at 0 °C. The solution was warmed to rt, placed in an oil bath, and refluxed at 70 °C for 2 h. The reaction flask was removed from the oil bath and cooled to rt. Water (400 mL) was added and the resulting mixture was transferred to a separatory funnel, then washed with ethyl acetate (2 x 200 mL). The aqueous layer was then extracted with dichloromethane (3 x 150 mL). The combined dichloromethane layers were washed with brine (150 mL), dried over Na_2SO_4, then concentrated *in vacuo* to yield mostly pure BTPP•HCl. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 6.51 (d, *J* = 9.5 Hz, 1H), 3.28 – 3.19 (m, 12H), 1.88 – 1.79 (m, 12H), 1.31 (s, 9H). **^{31}P NMR** (162 MHz, $CDCl_3$) δ 22.3 (s). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 47.7 (d, *J* = 5.1 Hz), 31.5 (d, *J* = 4.6 Hz), 26.1 (d, *J* = 8.1 Hz).

BTPP salt A. An oven-dried 250 mL round bottom flask was charged with a magnetic stir bar, the crude BTPP•HCl salt (assumed to be 75 mmol) from above and MeOH (100 mL). Potassium 1-phenyl-1-cyclopropanecarboxylate (18.78 g, 93.75 mmol, 1.25 equiv) was added. The solution

was stirred at rt for 2 h. The methanol was then removed *in vacuo*. The crude residue was placed in a filter and washed with EtOAc under vacuum to obtain a yellow solution. The filtrate was then concentrated and dried *in vacuo*. The yellow oil solidified under vacuum drying. The solid was then recrystallized from a minimal amount of hot ethyl acetate with hexanes layered over the solution to afford BTPP salt **A** as a colorless, crystalline solid (21.7 g, 45.6 mmol, 61% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.84 (d, *J* = 10.2 Hz, 1H), 7.33 (d, *J* = 7.5 Hz, 2H), 7.10 (t, *J* = 7.5 Hz, 2H), 6.99 (t, *J* = 7.5 Hz, 1H), 3.17 – 3.08 (m, 12H), 1.83 – 1.71 (m, 12H), 1.36 (q, *J* = 3.2 Hz, 2H), 1.23 (s, 9H), 0.74 (q, *J* = 3.2 Hz, 2H). **^{31}P NMR** (162 MHz, $CDCl_3$) δ 22.5 (s). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 177.2, 146.1, 130.4, 127.1, 124.6, 52.0 (d, *J* = 2.0 Hz), 47.4 (d, *J* = 5.1 Hz), 31.7, 31.3 (d, *J* = 4.9 Hz), 26.0 (d, *J* = 8.0 Hz), 14.1. Characterization data matches BTPP salt **A** synthesized in Section IIb.

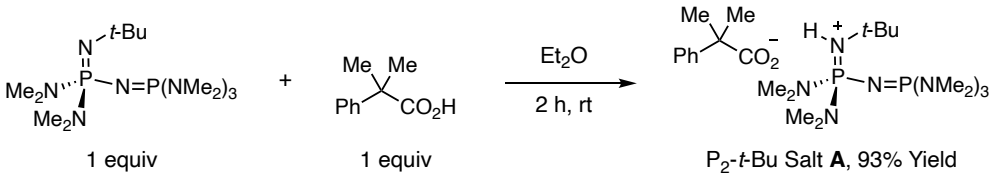


Potassium 1-phenyl-1-cyclopropanecarboxylate preparation (1). An oven-dried 500 mL round bottom flask was charged with a magnetic stir bar, 1-phenyl-1-cyclopropanecarboxylic acid (51.8 g, 319.3 mmol, 1.0 equiv) and MeOH (200 mL). An oven-dried 250 mL Erlenmeyer flask was charged with KOH (85%) (20.6 g, 319.3 mmol, 1.0 equiv) and solubilized with a minimal amount to MeOH (~50 mL). The KOH/MeOH solution was added dropwise to the stirring acid/MeOH solution. The round bottom flask was capped with a rubber septum and the combined solution was stirred for 1 h at rt. The MeOH was removed *in vacuo*, PhMe (150 mL) was added and removed *in vacuo* three times. The white solid was filtered and washed with ethyl acetate. The solid was collected and dried *in vacuo* to afford **1** as a white powder (63.2 g, 316.1 mmol, 99% yield). **^{1}H NMR** (400 MHz, DMSO-*d*$_6$) δ 7.21 (d, *J* = 8.1 Hz, 2H), 7.14 (t, *J* = 7.4 Hz, 2H), 7.03 (t, *J* = 7.1 Hz, 1H), 1.16 – 1.09 (m, 2H), 0.62 – 0.56 (m, 2H). **^{13}C NMR** (101 MHz, DMSO-*d*$_6$) δ 175.4, 146.6, 130.6, 127.4, 124.9, 31.7, 13.9. **IR (neat)** 3305, 3050, 1561, 1383, 700 cm^{-1}. **HRMS (DART)** $[RCO_2H+NH_4]^+$ calcd. for $[C_{10}H_{14}NO_2]^+$ = 180.1019, found 180.1027. **MP** 170 – 175 °C.



c. Identification of a crystalline carboxylate salt for P_2-*t*-Bu

We found that a solid salt does not form between 1-phenyl-1-cyclopropanecarboxylic acid and P_2-*t*-Bu, but with a slight modification to the carboxylate structure, 2-methyl-1-phenylpropanecarboxylic acid forms a solid salt with P_2-*t*-Bu to give P_2-*t*-Bu salt **A**.



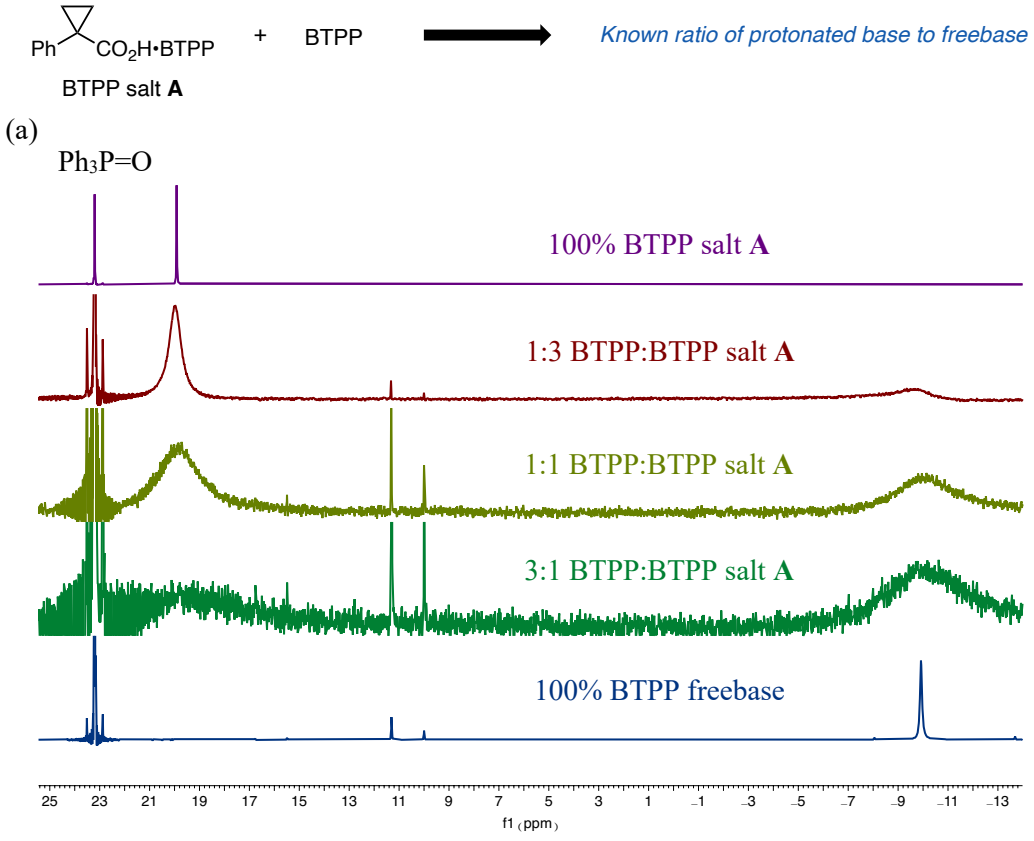
Procedure: An oven-dried 250 mL round bottom flask was charged with a magnetic stir bar, 2-methyl-2-phenylpropionic acid (1.6 g, 10 mmol, 1.0 equiv) and diethyl ether (50 mL, 0.2 M). In a nitrogen-filled glovebox, an oven-dried 20 mL scintillation vial (ThermoFisher, 03-341-25D) was charged with P_2-*t*-Bu (5 mL of a 2M THF solution, 10 mmol, 1.0 equiv) and diluted with diethyl ether (10 mL). The vial was capped and removed from the glovebox. The vial containing P_2-*t*-Bu dissolved in diethyl ether was uncapped and the solution was added slowly *via* pipette to the stirring solution of 2-methyl-2-phenylpropionic acid. The reaction solution was stirred for 2 h at rt. The reaction mixture was concentrated *in vacuo*, and the resulting crystalline solid was washed with 10 mL of cold diethyl ether, dried *in vacuo*, and collected as a white powder (4.9 g, 9.3 mmol, 93% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.56 (d, *J* = 7.7 Hz, 2H), 7.17 (t, *J* = 7.7 Hz, 2H), 7.02 (t, *J* = 7.7 Hz, 2H), 6.19 (d, *J* = 12.8 Hz, 1H)2.67 – 2.37 (m, 30H), 1.56 (s, 6H), 1.25 (s, 9H). **^{31}P NMR** (162 MHz, $CDCl_3$) δ 16.2 (d, *J* = 67.4 Hz, 1P), 12.2 (d, *J* = 67.4 Hz, 1P). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 180.0, 150.9, 127.2, 126.6, 124.2, 48.2, 37.2 (d, *J* = 5.7 Hz), 37.0 (d, *J* = 5.0 Hz), 31.2, 28.5. **IR (neat)** 2910, 2850, 2812, 1592, 1572, 1456, 1331, 1292, 1182, 979 cm^{-1}. **HRMS (DART)** $[M]^+$ calcd. for $[C_{14}H_{43}N_8P_2]^+$ (for protonated phosphazene) = 368.2854, found 368.2767. **MP** 95 – 100 °C.

d. Discussion of the storage of superbase salts

The superbase salts were stored in 20 mL scintillation vials both in a benchtop desiccator and a freezer at -30 °C. The salts were regularly used and handled open-to-air for the studies described in the Article and detailed below, for both activation experiments and reaction applications. Additionally, once per week the salts were removed from the benchtop desiccator, uncapped, and mixed around with a metal spatula to mimic usage. No difference in the performance of the superbase salts stored in each of these environments was observed. See Section VIII for a more detailed description of the long-term stability of these superbases salts in a variety of environments and for development of less hygroscopic BTPP and P_2-*t*-Bu salts.

III. BTPP Salt A Activation Studies

In this section, we discuss the investigation of epoxide additives that, when added to solution with BTPP salt **A**, facilitate the generation of BTPP with formation of an alcohol activation byproduct. For these activation studies, we tested a series of aryl-substituted epoxides under various conditions and assessed the formation of BTPP and the tertiary alcohol byproduct by ^{31}P and ^{1}H NMR spectroscopy (Figure S3 and S4, respectively), measured in DMSO-d_6. When analyzing the protonation state of BTPP in an activation study by ^{31}P NMR spectroscopy, the proton exchange rate between the free and protonated BTPP is slower than the NMR timescale. This leads to the observation of two peaks, one at 20 ppm that corresponds to protonated BTPP and one at -10 ppm that corresponds to neutral BTPP. By comparing the ratio of the integrals of the two signals, we are able to estimate the percentage of the freebase; we note that this amount typically correlates closely (± 5%) with the amount of the alcohol activation byproduct formed, determined by ^{1}H NMR spectroscopy. Figure S2 below shows titration experiments of different ratios of BTPP freebase to protonated base both with and without the alcohol activation byproduct present. For each sample, we measured the relative integration between protonated and neutral BTPP peaks. In each case, this ratio matches the ratio of BTPP:BTPP salt **A** that was premixed for the experiment. At the end of this section, Figures S3 and S4 show example ^{31}P and ^{1}H NMR spectra (measured in DMSO-d_6) respectively, to demonstrate how we assess the amount of freebase and byproduct formed in an activation study.



(b)

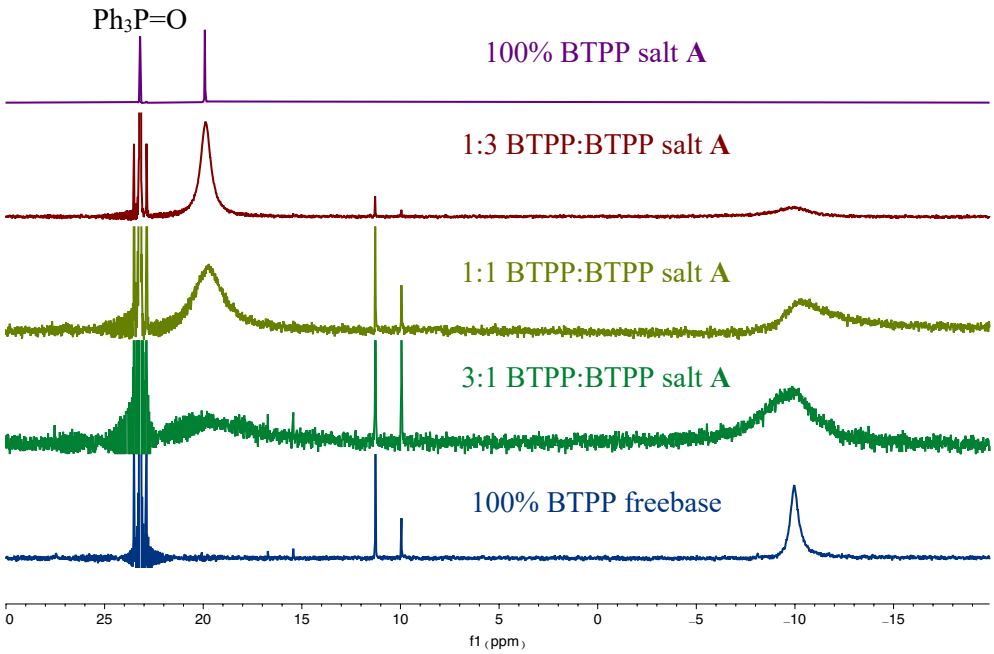
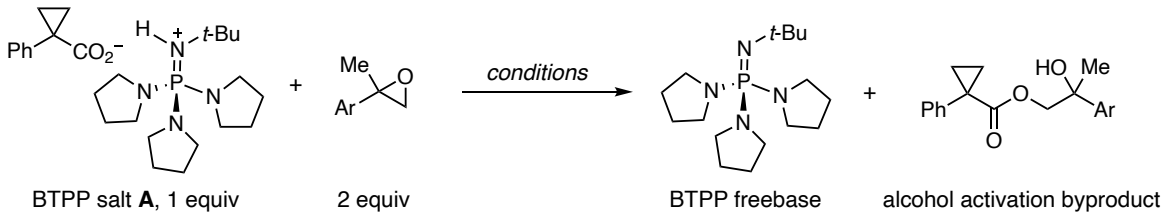


Figure S2: (a) ^{31}P NMR spectra of BTPP and BTPP salt **A** mixed in various ratios in DMSO-d_6. (b) ^{31}P NMR spectra of BTPP and BTPP salt **A** in various ratios with 1.0 equiv alcohol activation byproduct **62** present in DMSO-d_6. Signals at 10 to 12 ppm correspond to decomposed BTPP and the resulting phosphoramide. The peak at 23.2 ppm corresponds to triphenylphosphine oxide (Ph_3P=O) internal standard.

a. General activation procedure and analysis for BTPP salt A activation studies



General Procedure A: Activation studies for BTPP salt A. Note: these control activation studies were carried out under nitrogen atmosphere and in deuterated solvents. An oven-dried 1-dram vial (ThermoFisher, C4015-1) was charged with a magnetic stir bar and BTPP salt **A** (23.7 mg, 0.05 mmol, 1.0 equiv). The vial was brought into a nitrogen-filled glovebox where deuterated solvent (0.1 mL, 0.5 M) and epoxide additive (0.1 mmol, 2.0 equiv) were added. The reaction vial was capped with a PTFE-lined cap (ThermoFisher, C4015-1A), removed from the glovebox, and placed in a preheated aluminum reaction block with stirring for the indicated time. The vial was then taken into a nitrogen-filled glovebox where the solution was diluted with additional deuterated solvent (0.4 mL, total of 0.5 mL), transferred to an NMR tube, which was then capped and sealed

with parafilm wax. ^{31}P NMR and ^{1}H NMR spectroscopy were used to assess each reaction and determine the percentage of freebase and alcohol activation byproduct, respectively.

Example of percent freebase assessment. Below is a representative example of an activation study using BTPP salt **A** and epoxide **2** in DMSO-d_6. The reaction was set up using General Procedure A and Figure S3 shows a ^{31}P NMR spectrum of a time point taken at 45 min. Based on the ratio of the protonated superbase to the freebase, we assess this activation reaction to be 53% generation of BTPP. We also analyze the results of the activation studies by ^{1}H NMR spectroscopy where we can observe the presence of the alcohol activation byproduct, which shows characteristic peaks (two doublets) at 4.0 – 4.5 ppm. In all cases, the amount of the activation byproduct (analyzed by ^{1}H NMR spectroscopy) correlates with the amount of freebase formed (analyzed by ^{31}P NMR spectroscopy). Therefore, we can also use ^{1}H NMR spectroscopy to reliably assess the amount of freebase produced in an activation study. In this study, we assessed the amount of the activation byproduct in relation to the BTPP methylene peak at 3.12 ppm and determined a 52% yield, which correlates to the amount of freebase determined by ^{31}P NMR spectroscopy.

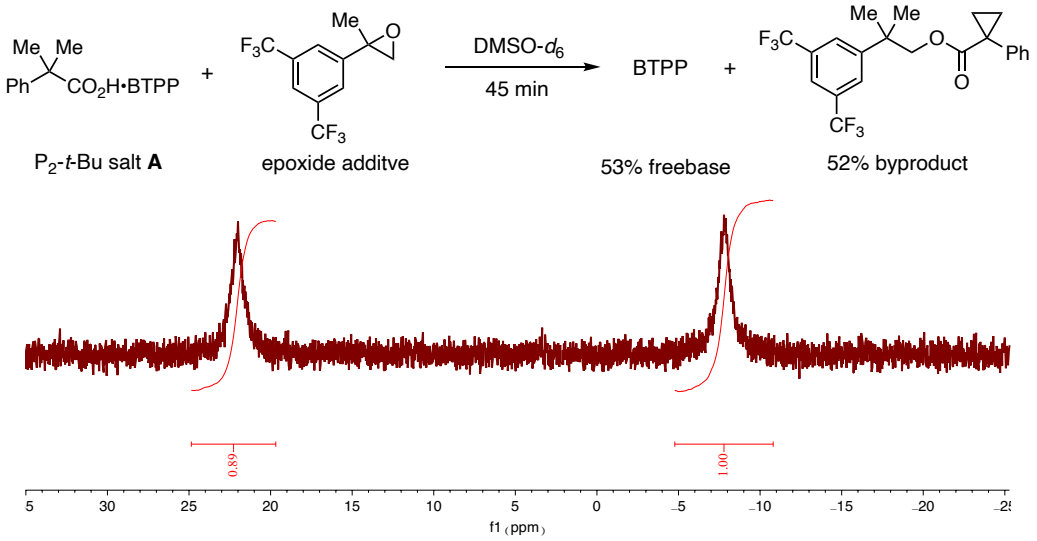


Figure S3: Example ^{31}P NMR spectrum from above activation reaction of BTPP salt A and epoxide **2** at 45 min in DMSO-d_6. The peak at 22 ppm corresponds to protonated BTPP and the peak at -7.8 ppm corresponds to BTPP freebase. Based on the integration values on the spectrum, we assess activation to be 53% generation of BTPP freebase.

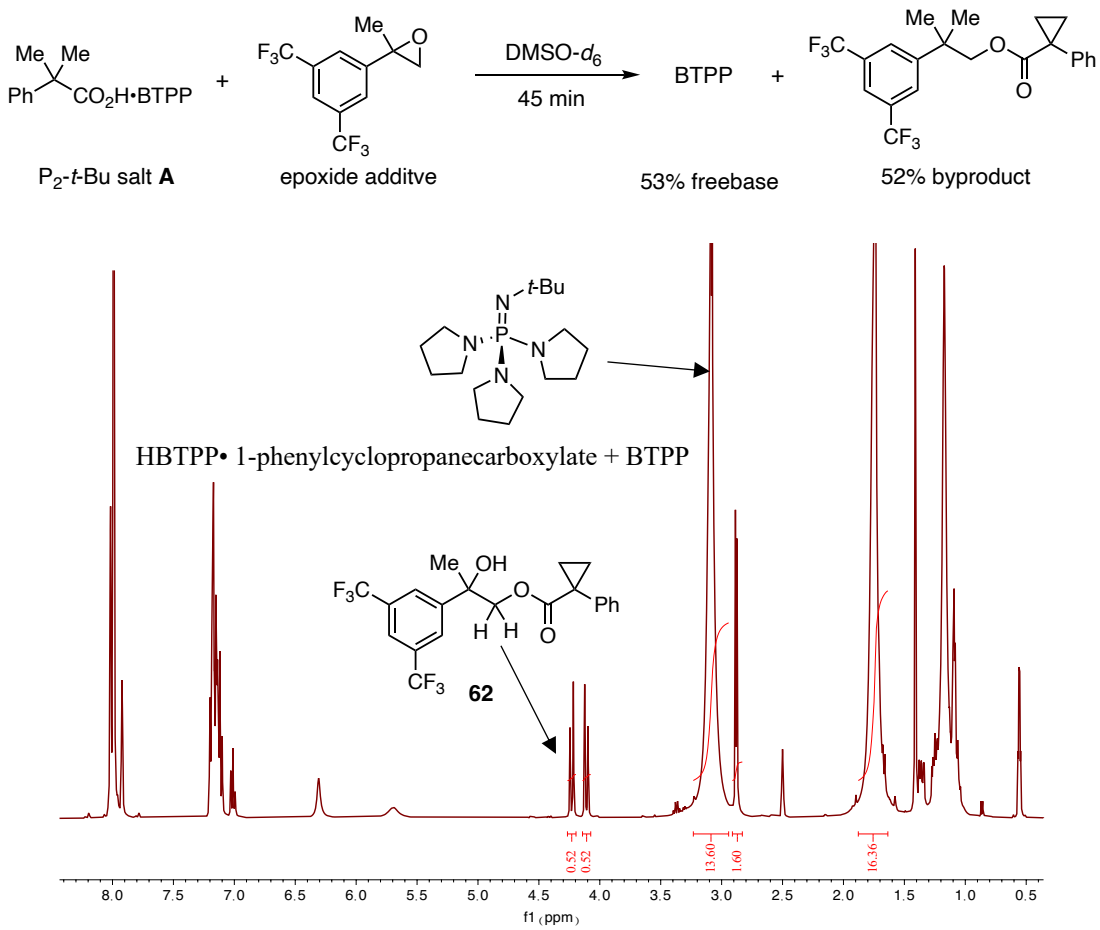
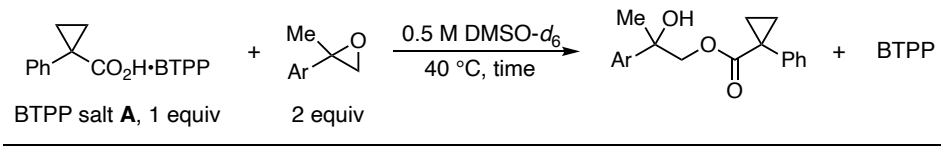
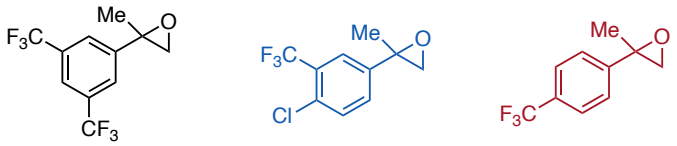


Figure S4: Example ^{1}H NMR spectrum from above activation reaction of BTPP salt A and epoxide **2** at 45 min in DMSO-d_6. The peaks at 4.1 and 4.25 ppm correspond to the methylene protons of alcohol activation byproduct **62**. Based on integration with respect to the BTPP signal at 3.12 ppm, we assess activation to be 52% generation of alcohol activation byproduct **62**.

b. Activation studies of BTPP salt A under various conditions

Epoxide effects on BTPP freebase generation. General Procedure A was followed using epoxides **2**-**4**. Each time point was obtained from an individual reaction set up and stopped at the indicated time *via* dilution with DMSO-d_6.





2 **3** **4**

Entry	Time (min)	Estimated % BTPP Freebase		
		Epoxide 2	Epoxide 3	Epoxide 4
1	0	0	0	0
2	5	17	7	0
3	15	31	13	2.5
4	45	53	28	5
5	90	70	40	10
6	240	93	69	30

Table S1: Amount of BTPP freebase generated over time by epoxides **2**, **3** and **4**.

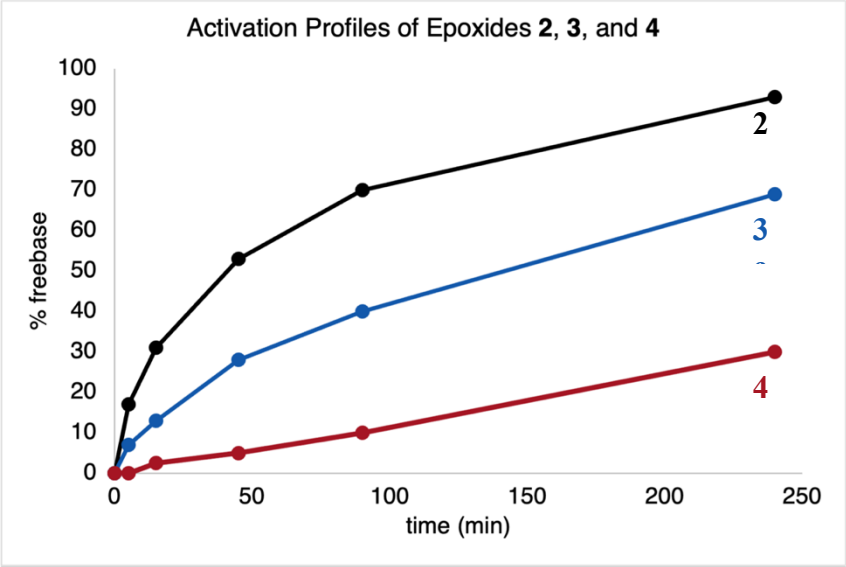
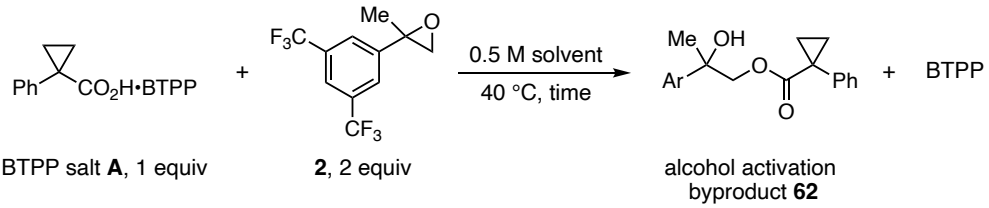


Figure S5: Activation curves for BTPP salt **A** using epoxides **2** (black curve), **3** (blue curve) and **4** (red curve).

Solvent-dependent BTPP freebase generation. General Procedure A was followed using BTPP salt **A** and epoxide **2**. Each time point was obtained from an individual reaction set up and stopped at the indicated time *via* dilution with deuterated solvent (DMSO-d_6, CD_3CN, THF-d_8 or PhMe-d_8). Note: for reactions run in CD_3CN, the ^{31}P NMR spectra have baselines with too much noise for reliable integration for percent freebase determination, likely due to low solubility of BTPP in

MeCN. Therefore, in these cases, ^{1}H NMR spectroscopy was used to determine the amount of freebase by analyzing the amount of activation byproduct **62** formed in the reaction.



Entry	Time (min)	Estimated % BTPP Freebase			
		DMSO-d_6	CD_3CN	THF-d_8	PhMe-d_8
1	0	0	0	0	0
2	5	17	10	24	24
3	15	31	15	39	32
4	45	53	25	60	44
5	90	70	50	76	54
6	240	93	55	93	73

Table S2: Amount of BTPP freebase generated over time in DMSO-d_6, CD_3CN, THF-d_8 and PhMe-d_8 using BTPP salt **A** and epoxide **2**.

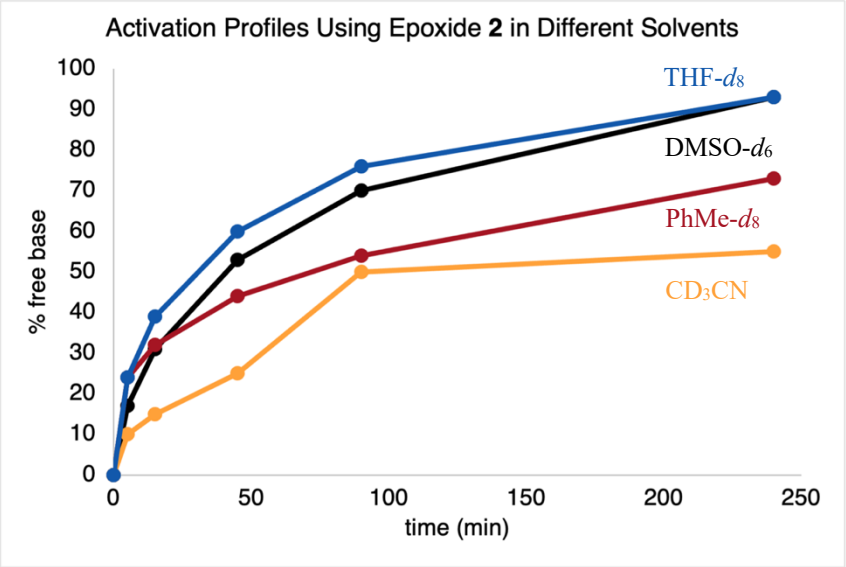
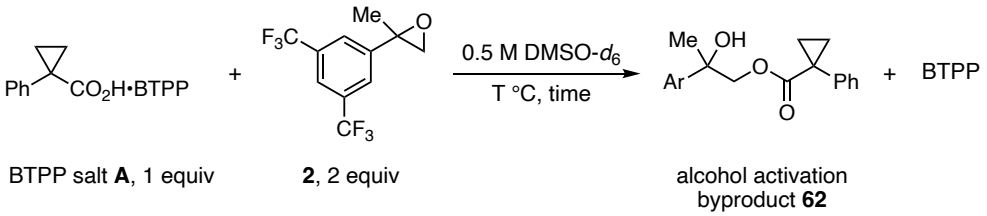


Figure S6: Activation curves in DMSO-d_6 (black curve), CD_3CN (orange curve), THF-d_8 (blue curve), and PhMe-d_8 (red curve) using BTPP salt **A** and epoxide **2**.

Temperature-dependent BTPP freebase generation. General Procedure A was followed using BTPP salt **A** and epoxide **2**. Each time point was obtained from an individual reaction set up and stopped at the indicated time *via* dilution with DMSO-d_6.



Entry	Time (min)	Estimated % BTPP Freebase			
		25 °C	40 °C	60 °C	80 °C
1	0	0	0	0	0
2	5	11	17	60	99
3	15	17	31	85	99
4	45	29	53	99	99
5	90	40	70	99	99
6	240	64	93	99	99

Table S3: Amount of BTPP freebase generated over time at 25, 40, 60, and 80 °C using BTPP salt **A** and epoxide **2**.

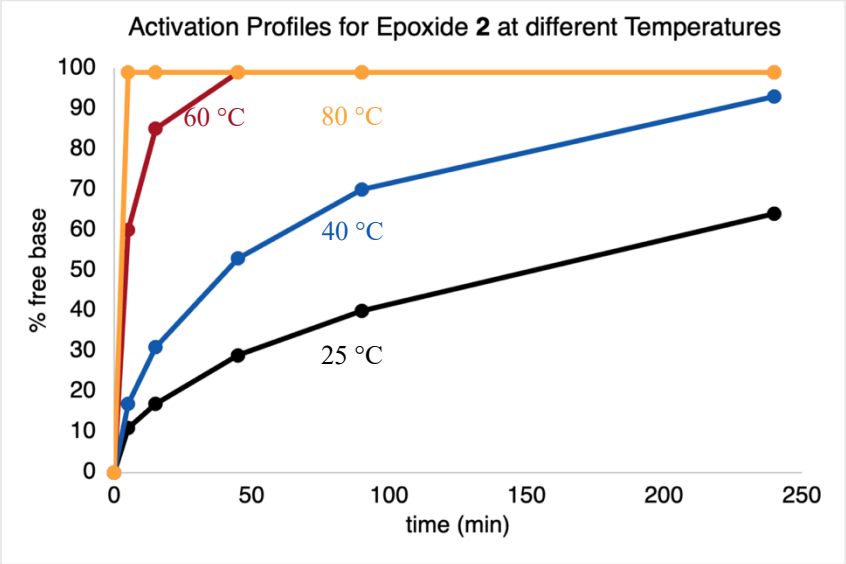


Figure S7: Activation curves at 25 (black curve), 40 (blue curve), 60 (red curve), and 80 °C (orange curve) using BTPP salt **A** and epoxide **2**.

IV. Applications of BTPP Salt A and Epoxides as Precatalyst Systems

a. Use of BTPP salt A as a precatalyst for Michael, aldol, and Mannich reactions

i. Reaction scheme and General Procedures

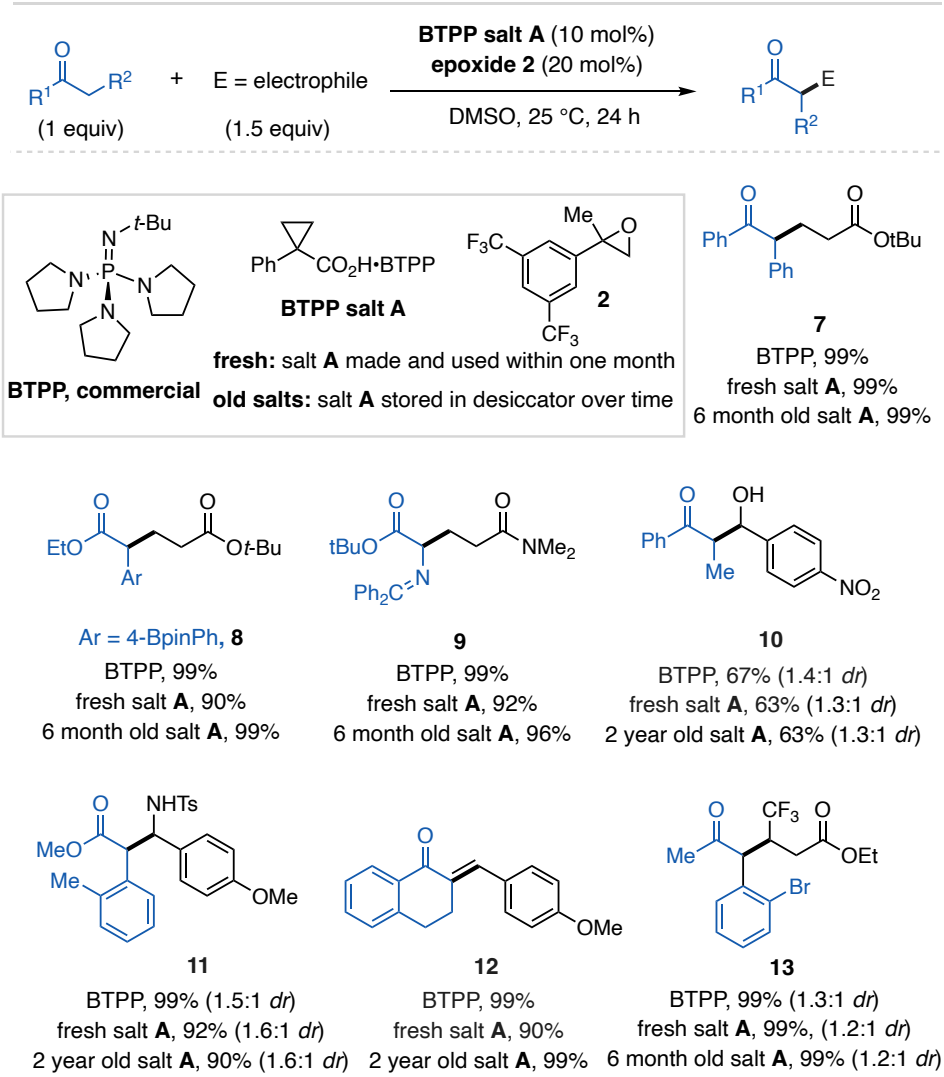


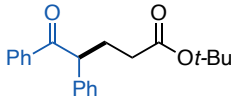
Table S4: Example substrates of addition reactions using BTPP salt **A** and epoxide **2**. General Procedure C was followed for BTPP freebase yields.

General Procedure B: BTPP salt A and epoxide 2 promoted reaction. An oven-dried 1-dram vial (ThermoFisher, C4015-1) was charged with a magnetic stir bar and BTPP salt **A** (47.5 mg, 0.1 mmol, 10 mol%). The vial was sealed with a PTFE lined screw cap (ThermoFisher, C4015-A) and evacuated then flushed with nitrogen three times *via* a nitrogen inlet tube on a Schlenk manifold line. DMSO (2 mL, 0.5M), pronucleophile (1 mmol, 1.0 equiv), electrophile (1.5 mmol,

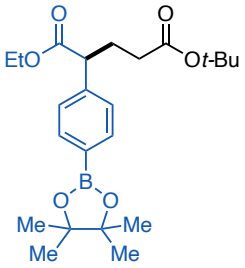
1.5 equiv), and epoxide **2** (ρ = 1.39 g/mL, 38.8 µL, 0.2 mmol, 20 mol%) were added to the vial *via* nitrogen-flushed microsyringe. **Note**: the pronucleophile and/or electrophile were charged to the vial prior to capping and nitrogen flushing if they are solids at rt. The reaction vial was left under a positive pressure of nitrogen and placed into an aluminum reaction block preheated to 25 °C with stirring for 24 h. Dibromomethane (35.1 mL, 0.5 mmol, 0.5 equiv) or 1,3,5-trimethoxybenzene (84.1 mg, 0.5 mmol, 0.5 equiv) internal standard was then added to the reaction solution, a 50 µL aliquot was taken and added to an NMR tube, then diluted with $CDCl_3$ (0.5 mL). ^{1}H NMR spectroscopy was used to determine the yield of the reaction.

ii. Reaction results and characterization data

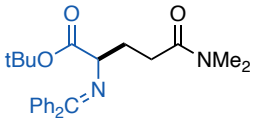
General description: For all of the substrates in this section, we use ^{1}H NMR yields to assess the efficacy of the precatalyst salt system. In each case, we benchmarked the success of the precatalyst against the use of commercial BTPP and BTPP salt **A** that has been handled regularly open to air and stored in a benchtop desiccator for six months to two years (see Section VIII for details). The reactions carried out with commercial BTPP were set up in a nitrogen-filled glovebox, described in General Procedure C, and the reactions carried out with aged BTPP salt **A** were set up using General Procedure B. The substrates were subsequently isolated from General Procedure B with fresh BTPP salt **A** for characterization. To do this, the crude reactions mixtures were directly subjected to flash column chromatography to yield purified products. The results of these experiments are summarized in Table S4 above. We note that these reactions are sensitive to water and therefore anhydrous DMSO must be used.



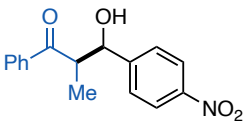
***tert*-butyl 5-oxo-4,5-diphenylpentanoate (7).** General Procedure B was followed using deoxybenzoin (196.2 mg, 1 mmol, 1.0 equiv), *tert*-butyl acrylate (219.7 µL, 1.5 mmol, 1.5 equiv), BTPP salt **A** (47.5 mg, 0.1 mmol, 10 mol%), and epoxide **2** (54.0 mg, 0.2 mmol, 20 mol%) in DMSO (2 mL) to provide 99% ^{1}H NMR yield. The reaction was repeated using commercial BTPP (99% ^{1}H NMR yield) and six-month-old BTPP salt **A** (99% ^{1}H NMR yield). Following General Procedure B, the product was purified *via* silica gel chromatography using 100% hexanes to 6% EtOAc/hexanes to afford **7** as a white solid (323.7 mg, 1 mmol, 100% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.95 (d, *J* = 8.3 Hz, 1H), 7.47 (t, *J* = 7.2 Hz, 1H), 7.38 (t, *J* = 7.6 Hz, 2H), 7.29 (d, *J* = 4.4 Hz, 4H), 7.24 – 7.18 (m, 2H), 4.68 (t, *J* = 7.2 Hz, 1H), 2.48 – 2.35 (m, 1H), 2.21 (t, *J* = 6.9 Hz, 2H), 2.18 – 2.07 (m, 1H), 1.43 (s, 9H). Characterization data matches literature reports.[1]



5-(*tert*-butyl) 1-ethyl 2-(4-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)phenyl)pentanedioate (8). General Procedure B was followed using ethyl 2-(4-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)phenyl)acetate (290.2 mg, 1 mmol, 1.0 equiv), *tert*-butyl acrylate (219.7 µL, 1.5 mmol, 1.5 equiv), BTPP salt **A** (47.5 mg, 0.1 mmol, 10 mol%), and epoxide **2** (54.0 mg, 0.2 mmol, 20 mol%) in DMSO (2 mL) to provide 90% ^{1}H NMR yield. The reaction was repeated using commercial BTPP (99% ^{1}H NMR yield) and six-month-old BTPP salt **A** (99% ^{1}H NMR yield). Following General Procedure B, the reaction was purified *via* silica gel chromatography using 5% MeOH/DCM to afford **8** as a colorless oil (420.0 mg, 1 mmol, 100% yield). The silica gel used for this purification was dried in an oven (120 °C) for 24 hours before use; approximately 10% protodeboronation occurred during purification and we note this side product is not observed in ^{1}H NMR analysis of the crude reaction mixture. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.76 (d, *J* = 7.5 Hz, 2H), 7.29 (d, *J* = 7.7 Hz, 2H), 4.20 – 4.01 (m, 2H), 3.66 – 3.54 (m, 1H), 2.38 – 2.23 (m, 1H), 2.15 (t, *J* = 7.6 Hz, 1H), 2.13 – 1.96 (m, 1H), 1.42 (s, 7H), 1.33 (s, 10H), 1.18 (t, *J* = 7.1 Hz, 2H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 173.4, 172.3, 135.3, 135.2, 128.8, 127.5, 83.9, 80.5, 61.0, 50.9, 33.2, 28.6, 28.2, 25.0, 14.2. **IR** (neat) 3061, 3026, 2971, 2932, 1926, 1677, 1367, 1158, 1142, 696 cm^{-1}. **HRMS (DART)** $[M+H]^+$ calcd. for $[C_{23}H_{36}BO_6]^+$ = 419.2599, found 419.2614. Note: peaks can be observed at 141.8 and 41.8 ppm in the ^{13}C NMR spectrum that correspond to protodeboronation of **8**.

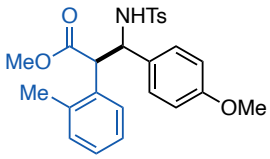


***tert*-butyl 5-(dimethylamino)-2-((diphenylmethylene)amino)-5-oxopentanoate (9).** General Procedure B was followed using *tert*-butyl 2-((diphenylmethylene)amino)acetate (295.4 mg, 1 mmol, 1.0 equiv), *N,N*-dimethylacrylamide (154.9 µL, 1.5 mmol, 1.5 equiv), BTPP salt **A** (47.5 mg, 0.1 mmol, 10 mol%), and epoxide **2** (54.0 mg, 0.2 mmol, 20 mol%) in DMSO (2 mL) to provide 92% ^{1}H NMR yield. The reaction was repeated using commercial BTPP (99% ^{1}H NMR yield) and six-month-old BTPP salt **A** (96% ^{1}H NMR yield). Following General Procedure B, the product was purified *via* silica gel chromatography using 50% EtOAc/hexanes to afford **9** as a white solid (318.0 mg, 0.81 mmol, 81% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.64 (d, *J* = 7.3 Hz, 2H), 7.47 – 7.40 (m, 3H), 7.37 (d, *J* = 7.1 Hz, 1H), 7.32 (t, *J* = 7.4 Hz, 3H), 7.16 (dd, *J* = 6.6, 2.9 Hz, 2H), 4.01 (t, *J* = 6.0 Hz, 1H), 3.00 (s, 3H), 2.90 (s, 3H), 2.50 – 2.27 (m, 2H), 2.21 (s, 2H), 1.43 (s, 9H). Characterization data matches literature reports.[2]

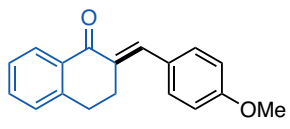


3-hydroxy-2-methyl-3-(4-nitrophenyl)-1-phenylpropan-1-one (10). General Procedure B was followed using propiophenone (132.9 µL, 1 mmol, 1.0 equiv), 4-nitrobenzaldehyde (227.0 mg, 1.5 mmol, 1.5 equiv), BTPP salt **A** (47.5 mg, 0.1 mmol, 10 mol%), and epoxide **2** (81.0 mg, 0.3 mmol, 30 mol%) in DMSO (2 mL) to provide 63% ^{1}H NMR yield and 1.3:1 dr (1,3,5-trimethoxybenzene internal standard used to avoid overlap with product peaks). The reaction was repeated using commercial BTPP (67% ^{1}H NMR yield, 1.4:1 dr) and two-year-old BTPP salt **A** (63% ^{1}H NMR

yield, 1.3:1 dr). Following General Procedure B, the product was purified *via* silica gel chromatography using 20% EtOAc in hexanes to afford **10** as a mixture of diastereomers as a yellow oil (173.4 mg, 0.61 mmol, 61% yield, 1.3:1 dr). ^{1}H NMR shifts are reported with signals corresponding to major and minor isomers labeled. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.27 – 8.17 (m, 2H, includes both isomers), 7.99-7.89 (m, 2H includes both isomers), 7.67-7.55 (m, 3H includes both isomers), 7.55-7.43 (m, 2H, includes both isomers), 5.36 (s, 1H, minor), 5.10 (t, *J* = 6.2 Hz, 1H, major), 4.01 (d, *J* = 1.9 Hz, 1H, minor), 3.82 (p, *J* = 7.2 Hz, 1H, major), 3.69 (qd, *J* = 7.3, 2.7 Hz, 1H, minor), 3.47 (d, *J* = 3.5 Hz, 1H, major), 1.19 (d, *J* = 7.3 Hz, 3H, major), 1.16 (d, *J* = 7.3 Hz, 3H, minor). Characterization data matches literature reports.[3]

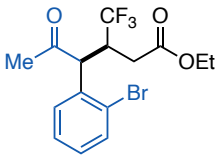


Methyl 3-((4-methylphenyl)sulfonamido)-3-(4-nitrophenyl)-2-(o-tolyl)propanoate (11). General Procedure B was followed using methyl 2-(*o*-tolyl)acetate (164.2 mg, 1 mmol, 1.0 equiv), *N*-(4-methoxybenzylidene)-4-methylbenzenesulfonamide[4] (434.0 mg, 1.5 mmol, 1.5 equiv), BTPP salt **A** (47.5 mg, 0.1 mmol, 10 mol%), and epoxide **2** (54.0 mg, 0.2 mmol, 20 mol%) in DMSO (2 mL) to provide 92% ^{1}H NMR yield and 1.6:1 dr (1,3,5-trimethoxybenzene internal standard used to avoid overlap with product peaks). The reaction was repeated using commercial BTPP (99% ^{1}H NMR yield, 1.5:1 dr) and six-month-old BTPP salt **A** (90% ^{1}H NMR yield, 1.6:1 dr). Following General Procedure B, the product was purified *via* silica gel chromatography using 20% EtOAc in hexanes to afford **11** as mixture of diastereomers as a white solid (363.5 mg, 0.80 mmol, 80% yield, 2.6:1 dr). ^{1}H NMR shifts are reported with signals corresponding to major and minor isomers labeled. **^{1}H NMR** (400 MHz, DMSO-*d*$_6$) δ 8.35 (d, *J* = 9.4 Hz, 1H, major), 8.02 (d, *J* = 10.4 Hz, 1H, minor), 7.70 (d, *J* = 9.1 Hz, 1H, minor), 7.43 (d, *J* = 8.0 Hz, 1H, major), 7.36 (d, *J* = 8.0 Hz, 1H, minor), 7.28 (d, *J* = 8.3 Hz, 2H, major), 7.22-7.12 (m, 3H, 1H from major, 2H from minor), 7.09-7.01 (m, 3H, 2H from major and 1H from minor), 7.03 (d, *J* = 8.1 Hz, 2H, major), 7.01-6.93 (m, 1H, both isomers), 6.90 (d, *J* = 7.5 Hz, 2H, minor), 6.82 (d, *J* = 9.0 Hz, 2H, major), 6.64 (d, *J* = 8.6 Hz, 2H, minor), 6.36 (d, *J* = 8.6 Hz, 2H, major), 4.97-4.87 (m, 1H, both isomers), 4.31 (d, *J* = 11.5 Hz, 1H, major), 4.19 (d, *J* = 11.5 Hz, 1H, minor), 3.67 (s, 3H, minor), 3.56 (s, 3H, major), 3.54 (s, 3H, major), 3.24 (s, 3H, minor), 2.41 (s, 3H, minor), 2.37 (s, 1H, both isomers), 2.25 (s, 3H, minor), 2.23 (s, 3H, major), 2.04 (s, 3H, major). **^{13}C NMR** (101 MHz, DMSO-*d*$_6$) δ 172.4, 171.4, 158.9, 158.4, 142.3, 142.0, 141.9, 139.1, 138.9, 137.5, 136.5, 134.3, 133.9, 131.7, 130.7, 130.5, 130.4, 139.8, 129.3, 129.2, 129.1, 129.0, 128.1, 127.8, 127.6, 126.7, 126.6, 126.6, 126.5, 126.1, 60.2, 58.5, 55.5, 55.3, 53.9, 52.6, 52.4, 52.2, 21.4, 21.3, 19.9, 19.7. **IR** (neat) 3389, 3241, 2959, 1746, 1516, 1157 cm^{-1}. **HRMS (DART)** $[M+H]^+$ calcd. for $[C_{25}H_{28}NO_5S]^+$ = 454.1683, found 454.1690. **MP** 125 – 130 °C.



2-(4-methoxybenzylidene)-3,4-dihydronaphthalen-1(2H)-one (12). General Procedure B was followed using 3,4-dihydronaphthalen-1(2*H*)-one (133.0 µL, 1 mmol, 1.0 equiv), *N*-(4-methoxybenzylidene)-4-methylbenzenesulfonamide[4] (434.0 mg, 1.5 mmol, 1.5 equiv), BTPP salt

A (47.5 mg, 0.1 mmol, 10 mol%), and epoxide **2** (54 mg, 0.2 mmol, 20 mol%) in DMSO (2 mL) to provide 90% ^{1}H NMR yield. The reaction was repeated using commercial BTPP (99% ^{1}H NMR yield) and two-year-old BTPP salt **A** (99% ^{1}H NMR yield). Following General Procedure B, the product was purified *via* silica gel chromatography using 10% EtOAc in hexanes to afford **12** as a yellow solid (248.5 mg, 0.94 mmol, 94% yield). **^{1}H NMR** (400 MHz, DMSO-d_6) δ 7.95 (d, J = 7.8 Hz, 1H), 7.69 (s, 1 H), 7.61-7.49 (m, 3H), 7.44-7.34 (m, 2H), 7.03 (d, J = 8.5 Hz, 2H), 3.81 (s, 3H), 3.10 (t, J = 5.5 Hz, 2 H), 2.94 (t, J = 5.5 Hz, 2 H). Characterization data matches literature reports.[5]



ethyl 4-(2-bromophenyl)-5-oxo-3-(trifluoromethyl)hexanoate (13). General Procedure B was followed using 1-(2-bromophenyl)propan-2-one (213.1 mg, 1 mmol, 1.0 equiv), ethyl (*E*)-4,4,4-trifluorobut-2-enoate (224.2 µL, 1.5 mmol, 1.5 equiv), BTPP salt **A** (47.5 mg, 0.1 mmol, 10 mol%), and epoxide **2** (54.0 mg, 0.2 mmol, 20 mol%) in DMSO (2 mL) to provide 99% ^{1}H NMR yield and 1.2:1 dr. The reaction was repeated using commercial BTPP (99% ^{1}H NMR yield, 1.3:1 dr) and six-month-old BTPP salt **A** (99% ^{1}H NMR yield, 1.2:1 dr). Following General Procedure B, the product was purified *via* silica gel chromatography using 5% EtOAc to 25% EtOAc/hexanes to afford **13** as a mixture of diastereomers as a pale-yellow oil (348.6 mg, 0.91 mmol, 91% yield, 1.3:1 dr). ^{1}H NMR shifts are reported with signals corresponding major and minor isomers labeled. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.64 (d, J = 8.0 Hz, 1H, both isomers), 7.33 – 7.12 (m, 3H, both isomers), 4.88 (d, J = 9.4 Hz, 1H, minor), 4.74 (d, J = 10.5 Hz, 1H, major), 4.15 (q, J = 7.1 Hz, 2H, major), 4.08 – 3.81 (m, 3H, 1 from major and 2 from minor), 3.61 – 3.45 (m, 1H, minor), 2.78 (dd, J = 16.6, 7.0 Hz, 1H, minor), 2.62 (dd, J = 16.6, 3.9 Hz, 1H, minor), 2.41 (dd, J = 16.7, 6.7 Hz, 1H, major), 2.14 (s, 3H, major), 2.11 (s, 3H, minor), 2.03 (dd, J = 16.7, 6.0 Hz, 1H, major), 1.26 (t, J = 7.1 Hz, 3H, minor), 1.13 (t, J = 7.1 Hz, 3H, major). **^{19}F NMR** (376 MHz, $CDCl_3$) δ -66.85 (d, J = 9.0 Hz), -69.97 (d, J = 8.3 Hz). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 204.5, 203.7, 170.7, 170.4, 134.5, 133.9, 133.8, 133.1, 130.3, 130.1, 129.8, 129.6, 129.4 (q, J = 205.7 Hz), 128.8 (q, J = 190.6 Hz), 128.3, 128.1, 125.9, 125.8, 61.2, 61.1, 55.0, 54.5, 42.2 (q, J = 26.3 Hz), 40.9 (q, J = 26.0 Hz), 32 (q, J = 2.9 Hz), 31.5 (q, J = 2.5 Hz), 30.2, 30.0, 14.2, 14.1. **IR** (neat) 3026, 2970, 2922, 1726, 1676, 1367, 1280, 1158, 1142, 696 cm^{-1}. **HRMS (DART)** $[M+H]^+$ calcd. for $[C_{15}H_{17}BrF_3O_3]^+$ = 381.0308, found 381.0308.

iii. Control reactions for Michael, aldol, and Mannich reactions

In this section we describe a series of control reactions that support that the BTPP generated from the precatalyst salt is responsible for reaction catalysis and not background reactivity from any components or intermediates of the activation process. General Procedure C below was followed for each control reaction. We also tested to see if the carboxylate anion is capable of catalyzing reactions by running reactions with only BTPP salt **A**, with a variety of 1-phenylcyclopropanecarboxylate salts. Here, we tested different countercations (e.g., potassium and

ammoniums) to survey salt solubility trends. Additionally, we tested if using only epoxide **2** could promote the reaction. We also considered the possibility that a carboxylate anion can attack the epoxide to generate an alkoxide intermediate that could serve as an active basic catalyst. We tested this by mixing non-superbase carboxylate salts with epoxide **2** under reaction conditions. For each indicated system other than the commercial freebase or full precatalyst system, we observed either 0% or reduced yield of the product. Overall, these results are consistent with the active catalyst being BTPP generated from the precatalyst system, as the individual components and intermediates of the activation process do not provide high yields. We also conducted time studies for the synthesis of **7** using epoxides **2** and **3** to test the effect of the precatalyst activation rate on the reaction rate. Figure S8 shows an extended induction period when epoxide **3** is employed, indicative of slower precatalyst activation, further supporting that BTPP generated from the precatalyst system is the active catalyst *in situ*. Data for these experiments is provided in Tables S5 and S6 for substrates **7** and **8**, respectively. We note that for all substrates in Table S4, reactions cannot be promoted by BTPP salt **A** without the use of an epoxide.

General Procedure C: Control reactions run in a nitrogen-filled glovebox. In a nitrogen-filled glovebox, an oven-dried 1-dram vial (ThermoFisher, C4015-1) was charged with a magnetic stir bar, pronucleophile (0.1 mmol, 1.0 equiv), DMSO (0.2 mL, 0.5 M), epoxide **2** (5.4 mg, 0.2 mmol, 20 mol%, unless excluded), Michael acceptor (0.15 mmol, 1.5 equiv), and the indicated catalyst mixture in Table S5 or S6 (0.01 mmol, 10 mol%, unless excluded) in successive order. The vial was capped with a PTFE-lined cap (ThermoFisher, C4015-1A), removed from the glovebox, and placed into an aluminum reaction block preheated to 25 °C with stirring for 24 h. Dibromomethane (0.1 mmol, 7 µL, 1.0 equiv) internal standard was added to the reaction solution, a 50 µL aliquot was taken and added to an NMR tube, then diluted with $CDCl_3$ (0.5 mL). Analysis of the ^{1}HNMR spectrum was used to determine the yield of product.

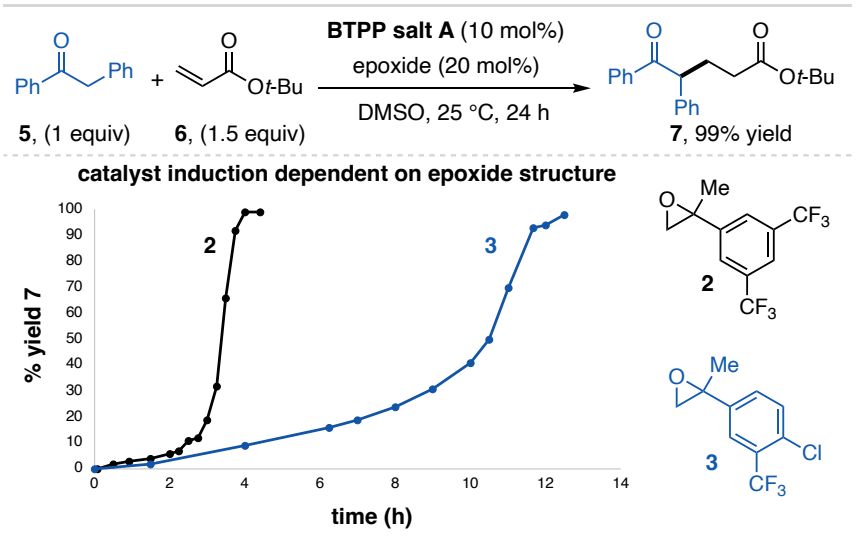
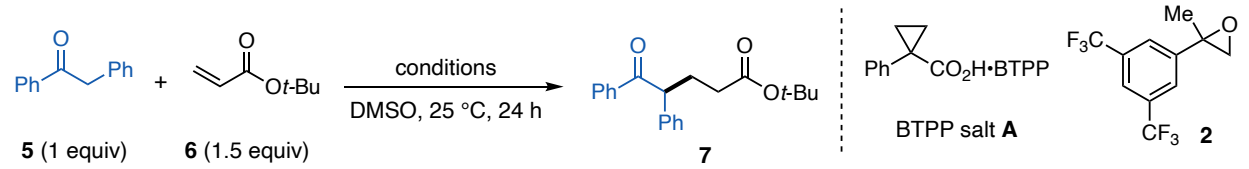


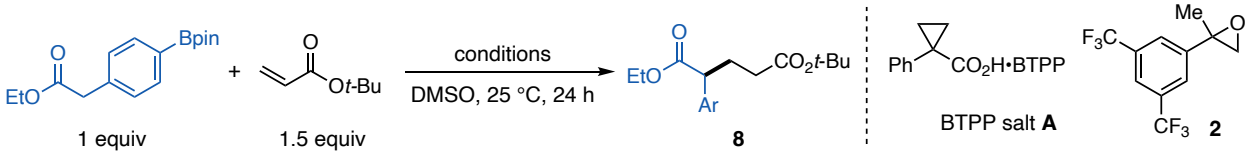
Figure S8. Michael addition reaction between deoxybenzoin (**5**) and *tert*-butylacrylate (**6**) using the BTPP precatalyst system with epoxides **2** and **3**.



5 (1 equiv) **6** (1.5 equiv) **7** BTPP salt **A** **2**

Entry	Conditions	Results
1	10% BTPP	99%
2	10% BTPP salt **A** + 20% epoxide **2**	99%
3	5% BTPP salt **A** + 10% epoxide **2**	6%
4	2.5% BTPP salt **A** + 5% epoxide **2**	2%
5	10% BTPP salt **B** + 20% epoxide **2**	99%
6	10% BTPP salt **B** (aged 2 h in 84% humidity) + 20% epoxide **2**	99%
7[a]	10% BTPP salt **A** (from moisture recovery) + 20% epoxide **2**	99%
8	10% BTPP salt **A**	5%
9	10% potassium 1-phenylcyclopropanecarboxylate	0%
10	10% triethylammonium 1-phenylcyclopropanecarboxylate	0%
11	10% NEt_3	0%
12	10% pyridinium 1-phenylcyclopropanecarboxylate + 20% epoxide **2**	0%
13	10% pyridine	0%
14	10% tetrabutylammonium acetate + 20% epoxide **2**	10%
15	20% epoxide **2**	0%
16	10% potassium 1-phenylcyclopropanecarboxylate + 20% epoxide **2**	0%
17	10% H^+NEt_3 1-phenylcyclopropanecarboxylate + epoxide **2**	0%

Table S5: Control reactions for the Michael addition between deoxybenzoin (**5**) and *tert*-butyl acrylate (**6**) with various potential catalyst systems. For the controls, all salts fully dissolve in the DMSO reaction solution. [a] Indicates the use of P_2-*t*-Bu salt **A** that has been recovered after water absorption *via* azeotrope with PhMe, see Section VIIIb for details.



1 equiv 1.5 equiv **8** BTPP salt **A** **2**

Entry	Conditions	Results
1	10% BTPP	86%
2	10% BTPP salt **A** + 20% epoxide **2**	90%
3	5% BTPP salt **A** + 10% epoxide **2**	46%
4	2.5% BTPP salt **A** + 5% epoxide **2**	0%
5	10% BTPP salt **B** + epoxide **2**	93%
6	10% BTPP salt **B** (aged 2h in 84% humidity) + epoxide **2**	93%
7	10% BTPP salt **A**	0%
8	10% triethylammonium 1-phenylcyclopropanecarboxylate	0%

9	10% NEt_3	0%
10	10% tetrabutylammonium acetate	0%
11	20% epoxide **2**	0%
12	10% potassium 1-phenylcyclopropanecarboxylate + 20% epoxide **2**	78%
13	10% H^+NEt_3 1-phenylcyclopropanecarboxylate + epoxide **2**	0%

Table S6: Control reactions for the Michael addition between ethyl 2-(4-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)phenyl)acetate and *tert*-butyl acrylate with various potential catalyst systems. For the controls, all salts fully dissolve in the DMSO reaction solution.

We note that for Table S6 Entry 12, the combination of potassium 1-phenylcyclopropanecarboxylate and epoxide **2** is capable of promoting the Michael addition reaction; here, we speculate a potassium alkoxide intermediate is generated that promotes the reaction. However, the corresponding alkoxide intermediate in the use of the precatalyst system likely neutralizes the BTPP immediately to generate the freebase as the active catalyst. We supported this by stirring BTPP salt **A** with epoxide **2** at 80 °C for 30 min to allow preformation of the base (100% freebase observed by ^{31}P NMR), followed by addition of starting materials. Here, the Michael addition rate using the precatalyst system is very similar to use of BTPP freebase (reaction complete in 1h). Direct use of BTPP salt **A** and epoxide **2** shows a slower reaction rate (reaction complete in 6 h), consistent with precatalyst activation. When potassium 1-phenylcyclopropanecarboxylate and epoxide **2** are used, we observe an even slower reaction rate (0% yield at 1h, 12% yield in 6 h). These results are consistent with the BTPP generated from the precatalyst system being the active catalyst for the reaction.

b. Use of BTPP salt A as a precatalyst for ester amidation reactions

i. Reaction scheme and General Procedures

This application is inspired by prior reports on the use of phosphazenes, especially BEMP, to catalyze ester amidation reactions.[6] The results presented in this section are therefore benchmarked against this work and as such we compared the utility of BTPP salt **A** with epoxide **2** against the use of BEMP, as described below.

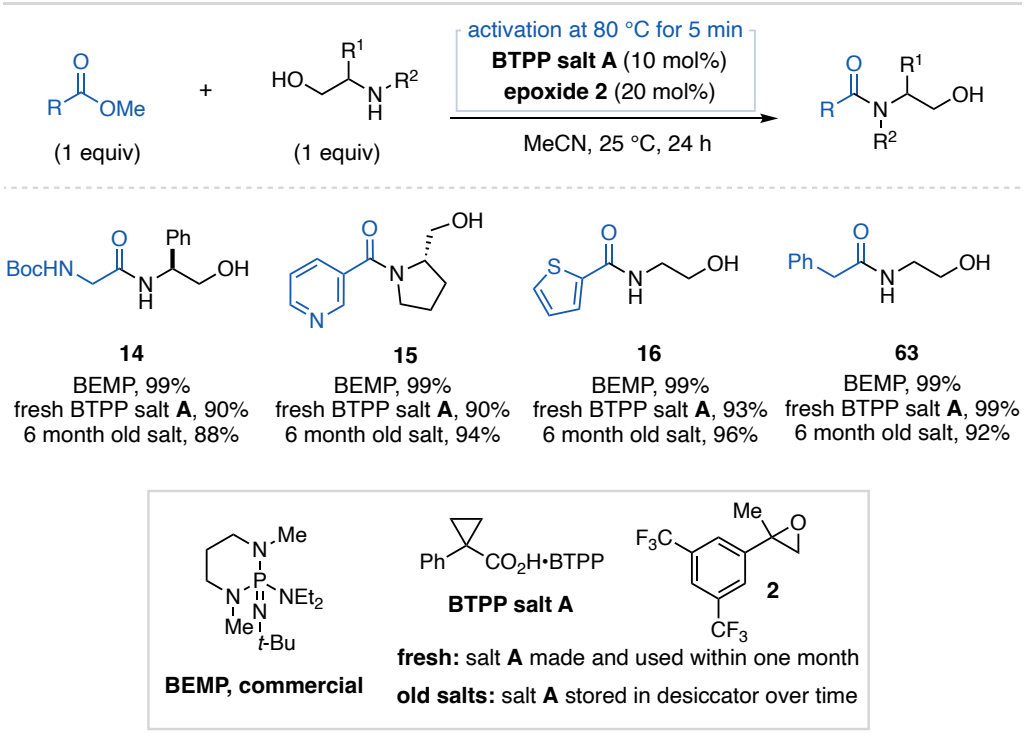


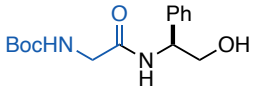
Table S7: Example substrates of ester amidation using BTPP salt **A** and epoxide **2**. General Procedure E followed for BEMP freebase yields.

General Procedure D: BTPP salt A and epoxide 2 promoted reaction. For these reactions, we found the aminoalcohol substrate reacts with epoxide **2**, preventing the BTPP activation process. To address this, we developed a preactivation procedure where an oven-dried 1-dram vial (ThermoFisher, C4015-1) was charged with a magnetic stir bar and BTPP salt **A** (47.5 mg, 0.1 mmol, 10 mol%). The vial was capped with a PTFE-lined cap (ThermoFisher, C4015-1A) and evacuated then back filled with nitrogen three times *via* a nitrogen inlet tube on a Schlenk manifold line. While attached to the inlet tube to maintain positive pressure of nitrogen, DMSO (0.2 mL, 0.5 M in BTPP salt A) and epoxide **2** (54.0 mg, 0.2 mmol, 20 mol%) were added *via* nitrogen-flushed syringe. The pre-activation solution vial was placed in a preheated aluminum reaction block at 80 °C for 5 minutes while attached to the nitrogen inlet tube.

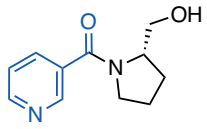
Reagent solution: a separate oven-dried 1-dram vial (ThermoFisher, C4015-1) was charged with a magnetic stir bar and capped (ThermoFisher, C4015-1A) and evacuated then back filled with nitrogen three times *via* a nitrogen inlet tube on a Schlenk manifold line. While attached to the nitrogen inlet tube, MeCN (0.8 mL, 1 M with respect to total reaction volume), ester (1 mmol, 1.0 equiv), and aminoalcohol (1 mmol, 1.0 equiv) were added *via* nitrogen-flushed syringe. The pre-activation solution was allowed to cool to rt, at which point the reagent solution was transferred to the pre-activation solution *via* nitrogen-flushed syringe. The combined reaction solution was stirred at rt for 24 h. Dibromomethane (35.0 µL, 0.5 mmol, 0.5 equiv) internal standard was added to the reaction solution, a 50 µL aliquot was taken and added to an NMR tube, then diluted with $CDCl_3$ (0.5 mL). ^1H NMR spectroscopy was used to determine the yield of the reaction.

ii. Reaction and characterization data

General description: For all of the substrates in this section, we use ^1H NMR yields to determine the efficacy of the precatalyst salt system. In each case, we benchmarked the success of the precatalyst against the use of commercial BEMP and BTPP salt **A** that has been aged in a benchtop desiccator for six months (see Section VIII for details). The reactions carried out with BEMP were set up with the use of a nitrogen-filled glovebox, described in General Procedure E, and the reactions carried out with BTPP salt **A** that has been aged for six months were set up using General Procedure D. The products were subsequently isolated using General Procedure D and BTPP salt **A** for characterization. To do this, the crude reactions mixtures were directly subjected to flash column chromatography to yield purified products. The purification conditions and characterization data are given below. The results are summarized in Table S7 above.

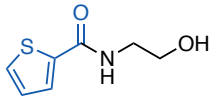


***tert*-butyl (*S*)-(2-((2-hydroxy-1-phenylethyl)amino)-2-oxoethyl)carbamate (14).** General Procedure D was followed using BTPP salt **A** (47.5 mg, 0.1 mmol, 10 mol%), epoxide **2** (54.0 mg, 0.2 mmol, 20 mol%), DMSO (0.2 mL), methyl (*tert*-butoxycarbonyl)glycinate (189.2 mg, 1.0 mmol, 1.0 equiv), (*S*)-2-amino-2-phenylethan-1-ol (137.2 mg, 1.0 mmol, 1.0 equiv), and MeCN (0.8 mL) to provide 90% ^1H NMR yield. The reaction was repeated using commercial BEMP (99% ^1H NMR yield) and six-month-old BTPP salt **A** (88% ^1H NMR yield). The product was isolated *via* silica gel chromatography using 100% DCM to 6% MeOH/DCM to afford **14** as a white solid (296.8 mg, 1 mmol, 100% yield). **^1H NMR** (400 MHz, $CDCl_3$) δ 7.37 – 7.25 (m, 5H), 7.11 (d, J = 7.8 Hz, 1H), 5.44 (s, 1H), 5.11 – 5.02 (m, 1H), 3.89 – 3.75 (m, 4H), 3.20 (s, 1H), 1.43 (s, 9H). Characterization data matches literature reports.[7]

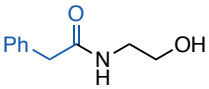


(*S*)-(2-(hydroxymethyl)pyrrolidin-1-yl)(pyridin-3-yl)methanone (15). General Procedure D was followed using BTPP salt **A** (47.5 mg, 0.1 mmol, 10 mol%), epoxide **2** (54.0 mg, 0.2 mmol, 20 mol%), DMSO (0.2 mL), methyl nicotinate (137.1 mg, 1.0 mmol, 1.0 equiv), (*S*)-pyrrolidin-2-ylmethanol (98.7 µL, 1.0 mmol, 1.0

equiv), and MeCN (0.8 mL) to provide 90% ^{1}H NMR yield. The reaction was repeated using commercial BEMP (99% ^{1}H NMR yield) and six-month-old BTPP salt **A** (94% ^{1}H NMR yield). The product was isolated *via* silica gel chromatography using 100% DCM to 6% MeOH/DCM to afford **15** as a colorless oil (197.6 mg, 0.96 mmol, 96% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.76 (s, 1H), 8.66 (d, *J* = 4.9 Hz, 1H), 7.84 (d, *J* = 7.9 Hz, 1H), 7.35 (dd, *J* = 7.9, 4.9 Hz, 1H), 4.56 (s, 1H), 4.46 – 4.34 (m, 1H), 3.86 – 3.78 (m, 1H), 3.78 – 3.69 (m, 1H), 3.56 – 3.46 (m, 2H), 2.22 – 2.11 (m, 1H), 1.98 – 1.87 (m, 1H), 1.89 – 1.64 (m, 2H). Characterization data matches literature reports.[6]



***N*-(2-hydroxyethyl)thiophene-2-carboxamide (16).** General Procedure D was followed using BTPP salt **A** (47.5 mg, 0.1 mmol, 10 mol%), epoxide **2** (54.0 mg, 0.2 mmol, 20 mol%), DMSO (0.2 mL), ethyl thiophene-2-carboxylate (134.4 µL, 1.0 mmol, 1.0 equiv), 2-aminoethan-1-ol (60.4 µL, 1.0 mmol, 1.0 equiv), and MeCN (0.8 mL) to provide 93% ^{1}H NMR yield. The reaction was repeated using commercial BEMP (99% ^{1}H NMR yield) and six-month-old BTPP salt **A** (96% ^{1}H NMR yield). The product was isolated *via* silica gel chromatography using 100% DCM to 5% MeOH/DCM to afford **16** as a white solid (167.2 mg, 0.98 mmol, 98% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.54 (d, *J* = 3.7 Hz, 1H), 7.42 (d, *J* = 4.9 Hz, 1H), 7.13 (t, *J* = 5.7 Hz, 1H), 7.00 (t, *J* = 4.4 Hz, 1H), 3.75 (t, *J* = 5.1 Hz, 2H), 3.63 (s, 1H), 3.54 (q, *J* = 5.3 Hz, 2H). Characterization data matches literature reports.[6]



***N*-(2-hydroxyethyl)-2-phenylacetamide (63).** General Procedure D was followed using BTPP salt **A** (47.5 mg, 0.1 mmol, 10 mol%), epoxide **2** (54.0 mg, 0.2 mmol, 20 mol%), DMSO (0.2 mL), methyl phenylacetate (140.9 µL, 1.0 mmol, 1.0 equiv), 2-aminoethan-1-ol (60.4 µL, 1.0 mmol, 1.0 equiv), and MeCN (0.8 mL) to provide 99% ^{1}H NMR yield. The reaction was repeated using commercial BEMP (99% ^{1}H NMR yield) and six-month-old BTPP salt **A** (92% ^{1}H NMR yield). The product was isolated *via* silica gel chromatography using 100% DCM to 6% MeOH/DCM to afford **63** as a white solid (169.2 mg, 0.94 mmol, 94% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.38 – 7.31 (m, 2H), 7.30 – 7.24 (m, 3H), 6.10 (s, 1H), 3.63 (t, *J* = 5.0 Hz, 2H), 3.56 (s, 2H), 3.34 (q, *J* = 5.3 Hz, 2H), 2.97 (s, 1H). Characterization data matches literature reports.[6]

iii. Control Reactions

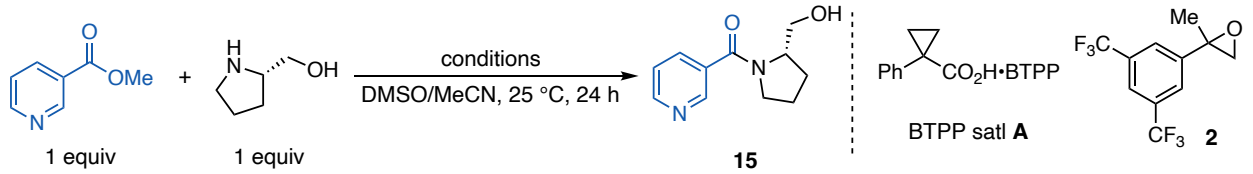
In this section we describe control reactions that support BTPP generated from the precatalyst salt is responsible for catalyzing the amidation reaction and not background reactivity from any components or intermediates of the activation process. General Procedure E was followed for each control reaction. We also tested to see if the carboxylate anion is capable of catalyzing reactions by running reactions with only BTPP salt **A**, with a variety of 1-phenylcyclopropanecarboxylate salts. Here, we tested different countercations (e.g., potassium and ammoniums) to survey salt solubility trends. Additionally, we tested if using only epoxide **2** could promote the reaction. We

also considered the possibility that a carboxylate anion can attack the epoxide to generate an alkoxide intermediate that could serve as an active basic promoter. We tested this by mixing non-superbase carboxylate salts with epoxide **2** under reaction conditions. For each indicated catalyst system other than the commercial freebase or precatalyst system, we observed either 0% or reduced yield of the product. In certain cases, a limited amount of reactivity is observed, but does not account for the significant product yield observed when the precatalyst system is used. Overall, these results are consistent with the active catalyst being BTPP generated from the precatalyst system. Data for these experiments is provided in Tables S8 and S9 for substrates **16** and **63**, respectively.

General Procedure E: Control reactions run in a nitrogen-filled glovebox. Since a pre-activation procedure was required for amidation reactions with the BTPP salt **A** precatalyst, a pre-activation procedure was used for control reactions that employ epoxide **2**. If epoxide was excluded from the control reaction, all reagents were added sequentially inside a nitrogen-filled glovebox.

Pre-activation procedure: in a nitrogen-filled glovebox an oven-dried 1-dram vial (ThermoFisher, C4015-1) was charged with a magnetic stir bar, indicated catalyst mixture in Table S8 or S9 (0.01 mmol, 10 mol%), DMSO (0.1 mL, 0.1 M in indicated catalyst mixture) and epoxide **2** (0.02 mmol, 20 mol%). The vial was capped with a PTFE-lined cap (ThermoFisher, C4015-1A), removed from the glovebox, and placed in a preheated aluminum reaction block at 80 °C for 5 minutes.

Reagent solution: in a nitrogen-filled glovebox, a separate oven-dried 1-dram vial (ThermoFisher, C4015-1) was charged with a magnetic stir bar. If epoxide was excluded, the indicated potential catalyst (0.01 mmol, 10 mol%) was added, followed by ester (0.1 mmol, 1.0 equiv), MeCN (0.1 mL, 1 M) and aminoalcohol (0.1 mmol, 1.0 equiv). The vial was capped (ThermoFisher, C4015-1A), removed from the glovebox, and connected to a Schlenk manifold line *via* an inlet tube and placed under positive pressure of nitrogen. The pre-activation solution was allowed to cool to rt. The pre-activated solution (20 µL, 0.01 mmol, 10 mol% indicated catalyst mixture) was transferred *via* nitrogen-flushed syringe to the reagent solution. The combined reaction solution was stirred for 24 h in a preheated aluminum reaction block at 25 °C. Dibromomethane (1.0 equiv, 0.1 mmol 7 µL) internal standard was added to the reaction solution, a 50 µL aliquot was taken and added to an NMR tube, then diluted with $CDCl_3$ (0.5 mL). ^1H NMR spectroscopy was used to determine the yield of product.

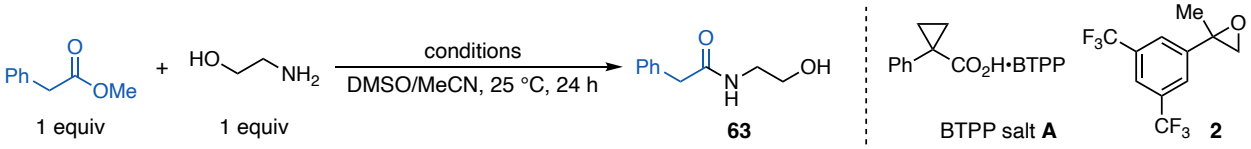


Entry	Conditions	Results
1[a]	10% BEMP	99%
2	10% BTPP salt **A** + 20% epoxide **2**	99%

3	5% BTPP salt **A** + 10% epoxide **2**	82%
4	2.5% BTPP salt **A** + 5% epoxide **2**	68%
5[a]	10% BTPP salt **A**	44%
6	10% BTPP salt **A** + 20% epoxide **2** (5 h reaction time)	99%
7	10% BTPP salt **A** (5 h reaction time)	0%
8[a]	10% triethylammonium 1-phenylcyclopropanecarboxylate salt	0%
9[a]	10% NEt_3	35%
10[a]	10% tetrabutylammonium acetate	0%
11[a]	20% epoxide **2**	0%
12	10% potassium 1-phenylcyclopropanecarboxylate + 20% epoxide **2**	30%
13	10% potassium 1-phenylcyclopropanecarboxylate + 20% epoxide **2** (5 h reaction time)	0%
14	10% H^+NEt_3 1-phenylcyclopropanecarboxylate + 20% epoxide **2**	35%

Table S8: Control reactions for the ester amidation reaction between methyl nicotinate and (*S*)-pyrrolidin-2-ylmethanol with various potential catalyst systems. [a] A preactivation procedure was not followed as noted in General Procedure E.

We note that for substrate **15** above, BTPP salt **A** on its own and potassium 1-phenylcyclopropanecarboxylate with epoxide **2** are capable of promoting the reaction. Here, we speculate that either the carboxylate or potassium alkoxide intermediate is promoting the reaction. However, the ester amidation rate utilizing the precatalyst system is very similar to use of BTPP freebase (reaction complete in 5 h). Conversely, when just BTPP salt A or potassium 1-phenylcyclopropanecarboxylate with epoxide **2** are used, we observe a much slower rate (0% yield in 5 h). These results are consistent with the BTPP generated from the precatalyst system being the active catalyst for the reaction. Additionally, we note that the ester amidation reaction for substrate **63** below is more challenging, which illustrates that only BTPP freebase works to catalyze the reaction in high yield.



Entry	Conditions	Results
1[a]	10% BEMP	99%
2	10% BTPP salt **A** + 20% epoxide **2**	94%
3	5% BTPP salt **A** + 10% epoxide **2**	8%
4	2.5% BTPP salt **A** + epoxide **2**	8%
5[a]	10% BTPP salt **A**	8%
6[a]	10% triethylammonium 1-phenylcyclopropanecarboxylate salt	0%
7[a]	10% NEt_3	4%
8[a]	10% tetrabutylammonium acetate	0%

9[a]	20% epoxide **2**	0%
10	10% potassium 1-phenylcyclopropanecarboxylate + 20% epoxide **2**	4%
11	10% H^+NEt_3 1-phenylcyclopropanecarboxylate + 20% epoxide **2**	8%

Table S9: Control reactions for the ester amidation reaction between methyl phenylacetate and 2-aminoethan-1-ol with various potential catalyst systems. [a] A preactivation procedure was not followed as noted in General Procedure E.

c. Use of BTPP salt A as a stoichiometric prereagent for alcohol deoxyfluorination

i. Reaction scheme and General Procedures

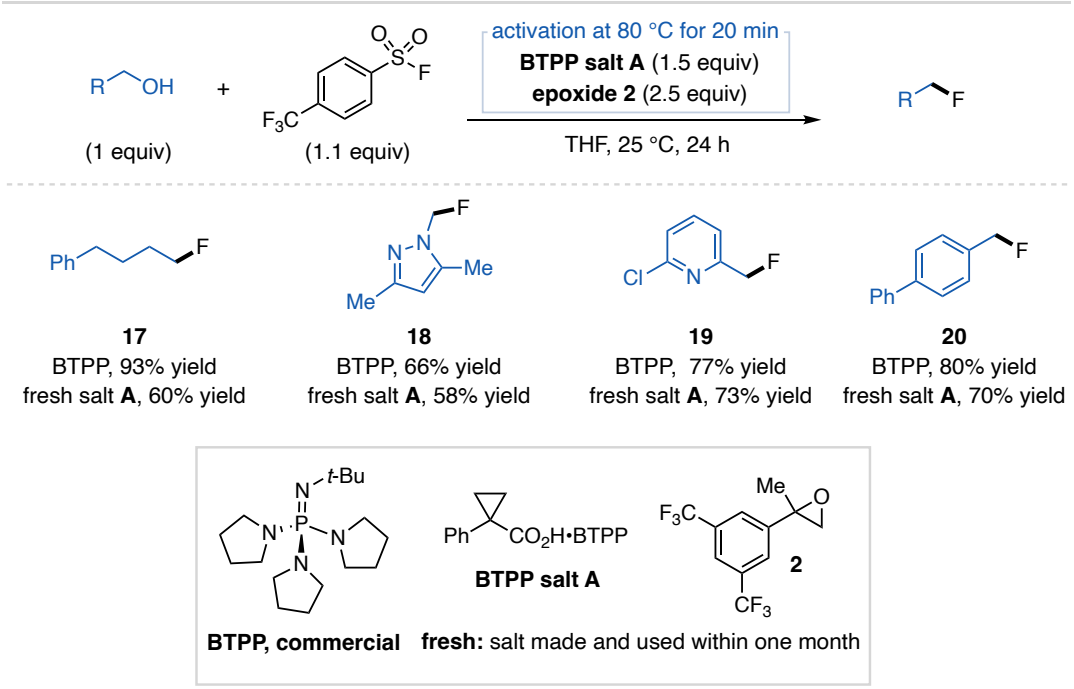


Table S10: Example substrates of deoxyfluorination using BTPP salt **A** and epoxide **2**. General Procedure G was followed for BTPP freebase yields.

General Procedure F: BTPP salt A and epoxide 2 promoted reaction. For these reactions, we found the alcohol substrate reacts with epoxide **2**, which interrupts the BTPP activation process. To address this, we developed a preactivation procedure where an oven-dried 1-dram vial (ThermoFisher, C4015-1) was charged with a magnetic stir bar and BTPP salt **A** (336.0 mg, 0.75 mmol, 1.5 equiv). The vial was capped with a PTFE-lined cap (ThermoFisher, C4015-1A) and evacuated then back filled with nitrogen three times *via* a nitrogen inlet tube on a Schlenk manifold line. While attached to the nitrogen inlet tube, THF (0.25 mL, 3 M in BTPP salt A) and epoxide **2** (337.7 mg, 1.25 mmol, 2.5 equiv) were then added *via* nitrogen-flushed syringe. The pre-activation

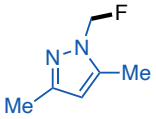
solution was placed in a preheated aluminum reaction block at 80 °C for 20 min with stirring while attached to the nitrogen inlet.

Reagent solution: a separate oven-dried 1-dram vial (ThermoFisher, C4015-1) was charged with 4-(trifluoromethyl)benzenesulfonyl fluoride[8] (125.5 mg, 0.55 mmol, 1.1 equiv). The vial was capped with a PTFE-lined cap (ThermoFisher, C4015-1A) and evacuated then back filled with nitrogen three times *via* a nitrogen inlet tube on a Schlenk manifold line. While attached to the nitrogen inlet tube, THF (0.5 mL, 1.0 M) and alcohol (1.0 equiv, 0.5 mmol) were added *via* nitrogen-flushed syringes. The pre-activation solution was allowed to cool to rt and the reagent solution was transferred to the pre-activation solution *via* nitrogen-flushed syringe. The combined reaction solution was stirred at 25 °C for 24 h. Dibromomethane (35.1 µL, 0.5 mmol, 1.0 equiv) internal standard was added to the reaction solution, a 50 µL aliquot was taken and added to an NMR tube, then diluted with $CDCl_3$ (0.5 mL). ^{1}H NMR spectroscopy was used to determine the yield of the crude reaction. The crude reaction material was directly subjected to flash chromatography to yield pure product for characterization.

ii. Reaction and characterization data

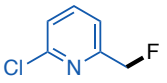
General description: For all of the substrates in this section, we use ^{1}H NMR yields to determine the efficacy of the precatalyst salt system. In each case, we benchmarked the success of the precatalyst against the use of commercial BTPP. The reactions carried out with BTPP were set up with the use of a nitrogen-filled glovebox, as described below. The substrates were subsequently isolated using General Procedure F and BTPP salt **A** for characterization. To do this, the crude reactions mixtures were directly subjected to flash column chromatography to yield purified products. The purification conditions and characterization data are given below.

(4-fluorobutyl)benzene (17). General Procedure F was followed using BTPP salt **A** (336.0 mg, 0.75 mmol, 1.5 equiv), epoxide **2** (337.7 mg mg, 1.25 mmol, 2.5 equiv), THF (0.25 mL for preactivation), 4-phenylbutan-1-ol (76.3 µL, 0.5 mmol, 1.0 equiv), 4-(trifluoromethyl)benzenesulfonyl fluoride[8] (125.5 mg, 0.55 mmol, 1.1 equiv), and THF (0.5 mL) to provide 60% ^{1}H NMR yield. The reaction was repeated using commercial BTPP (93% ^{1}H NMR yield). Following General Procedure F, the product was purified *via* preparatory thin layer chromatography using 1% EtOAc/hexanes to afford **17** as a colorless oil (12.2 mg, 0.08 mmol, 16% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.36 – 7.26 (m, 2H), 7.26 – 7.17 (m, 3H), 4.60 – 4.50 (m, 1H), 4.43 (t, J = 5.8 Hz, 1H), 2.69 (t, J = 7.2 Hz, 2H), 1.87 – 1.67 (m, 4H). Characterization data matches literature reports.[8]

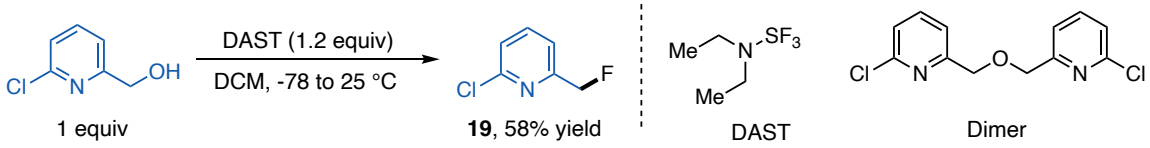


1-(fluoromethyl)-3,5-dimethyl-1H-pyrazole (18). General Procedure F was followed using BTPP salt **A** (336.0 mg, 0.75 mmol, 1.5 equiv), epoxide **2** (337.7 mg mg, 1.25 mmol, 2.5 equiv), THF (0.25 mL for preactivation), (3,5-dimethyl-1*H*-pyrazol-1-yl)methanol (63.1 mg, 0.5 mmol, 1.0 equiv), 4-(trifluoromethyl)benzenesulfonyl

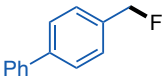
fluoride[8] (125.5 mg, 0.55 mmol, 1.1 equiv), and THF (0.5 mL) to provide 58% ^{1}H NMR yield. The reaction was repeated using commercial BTPP (66% ^{1}H NMR yield). Substrate **18** has been previously reported to be unstable to silica gel chromatography.[8] Therefore, for identification, the crude material was extracted with saturated aqueous sodium chloride (10 mL), dried over sodium sulfate, and concentrated *in vacuo* to afford crude **18** as a brown-yellow oil that also contains BTPP, byproduct **62**, epoxide **2**, 4-(trifluoromethyl)benzenesulfonate side products and other minor species. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 5.92 (d, *J* = 54.4 Hz, 2H), 5.92 (s, 1H), 2.32 (s, 3H), 2.25 – 2.21 (m, 3H). Characterization data matches literature reports.[8]



2-chloro-6-(fluoromethyl)pyridine (19). General Procedure F was followed using BTPP salt **A** (336.0 mg, 0.75 mmol, 1.5 equiv), epoxide **2** (337.7 mg mg, 1.25 mmol, 2.5 equiv), THF (0.25 mL for preactivation), (6-chloropyridin-2-yl)methanol (71.8 mg, 0.5 mmol, 1 equiv), 4-(trifluoromethyl)benzenesulfonyl fluoride[8] (125.5 mg, 0.55 mmol, 1.1 equiv), and THF (0.5 mL) to provide 73% ^{1}H NMR yield. The reaction was repeated using commercial BTPP (77% ^{1}H NMR yield). Under these deoxyfluorination conditions, substrate **19** could not be separated from ether dimer using normal phase chromatography. Therefore, for characterization purposes, the product was prepared *via* deoxyfluorination using DAST, described below.



Deoxyfluorination with DAST procedure. An oven-dried 50 mL round bottom flask was charged with a magnetic stir bar, (6-chloropyridin-2-yl)methanol (718.0 mg, 5.0 mmol, 1.0 equiv) and DCM (20 mL). The flask was sealed with a rubber septum, connected to a Schlenk manifold line under a positive pressure of nitrogen, and cooled to -78 °C in an acetone and dry ice bath. Diethylaminosulfur trifluoride (DAST) (967.1 mg, 6 mmol, 1.2 equiv) was solubilized in DCM (5 mL). The DAST solution was added dropwise to the reaction flask *via* syringe. The reaction solution was allowed to warm to rt then stirred for 12 h. The reaction solution was transferred to a separatory funnel with water (25 mL), followed by slow addition of a saturated $NaHCO_3$ solution (25 mL). The mixture was extracted with Et_2O (3 x 25 mL). The combined organic layers were washed with brine (25 mL), dried over sodium sulfate, filtered, and concentrated *in vacuo*. Silica gel column chromatography using 100% hexanes to 5% EtOAc/hexanes afforded **19** as a white solid (430.2 mg, 2.9 mmol, 58% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.71 (t, *J* = 7.8 Hz, 1H), 7.38 (d, *J* = 7.6 Hz, 1H), 7.27 (d, *J* = 8.1 Hz, 1H), 5.43 (d, *J* = 46.6 Hz, 2H). **^{19}F NMR** (376 MHz, $CDCl_3$) δ 18.99 (t, *J* = 46.6 Hz). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 157.4 (d, *J* = 22.5 Hz), 150.9 (d, *J* = 2.8 Hz), 139.5, 123.6, 118.7 (d, *J* = 6.2 Hz), 83.5 (d, *J* = 171.5 Hz). **IR** (neat) 3082, 2946, 1581.94, 1436, 1155, 1035, 987, 855, 788, 701, 608 cm^{-1}. **HRMS (DART)** $[M+H]^+$ calcd. for $[C_6H_6ClFN]^+$ = 146.0167, found 146.0173. **MP** 32 – 38 °C.



4-(fluoromethyl)-1,1'-biphenyl (20). General Procedure F was followed using BTPP salt **A** (336.0 mg, 0.75 mmol, 1.5 equiv), epoxide **2** (337.7 mg mg, 1.25 mmol, 2.5 equiv), THF (0.25 mL for preactivation), 4-(hydroxymethyl)biphenyl (92.1 mg, 0.5 mmol, 1.0 equiv), 4-(trifluoromethyl)benzenesulfonyl fluoride[8] (125.5 mg, 0.55 mmol, 1.1 equiv), and THF (0.5 mL) to provide 70% ^{1}H NMR yield. The reaction was repeated using commercial BTPP (80% ^{1}H NMR yield). Following General Procedure F, the product was purified *via* preparatory thin layer chromatography using 20% DCM/hexanes to afford **20** as a white solid (37.5 mg, 0.20 mmol, 40% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.62 (dd, *J* = 10.6, 7.8 Hz, 4H), 7.50 – 7.42 (m, 4H), 7.42 – 7.33 (m, 1H), 5.44 (d, *J* = 46.9 Hz, 2H). Characterization data matches literature reports.[8]

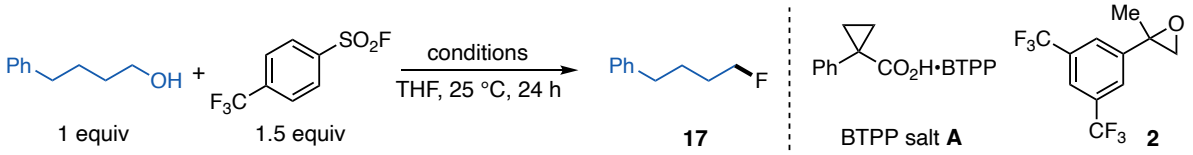
iii. Control Reactions

In this section we describe control reactions that support the BTPP generated from the prereagent salt is responsible for promoting deoxyfluorination and not background reactivity from any components or intermediates of the activation process. General Procedure G was followed for each of the controls. We also tested to see if the carboxylate anion is capable of catalyzing reactions by running reactions with only BTPP salt **A**, with a variety of 1-phenylcyclopropanecarboxylate salts. Here, we tested different countercations (e.g., potassium and ammoniums) to survey salt solubility trends. Additionally, we tested if using only epoxide **2** could promote the reaction. We also considered the possibility that a carboxylate anion could attack the epoxide to generate an alkoxide intermediate that could serve as an active basic promoter. We tested this by mixing non-superbase carboxylate salts with epoxide **2** under reaction conditions. For each indicated potential promotor other than the commercial freebase or precatalyst system, we observed either 0% or significantly reduced yield of the product. Overall, these results are consistent with the active promoter being BTPP generated from the prereagent system. Data for these experiments is provided in Tables S11 and S12 for substrates **17** and **20**, respectively.

General Procedure G: Control reactions run in a nitrogen-filled glovebox. Since a pre-activation procedure was required for deoxyfluorination reactions with BTPP salt A, a pre-activation procedure was used for control reactions that employed epoxide **2**. If epoxide was excluded from the reaction, all reagents were added sequentially inside a nitrogen-filled glovebox.

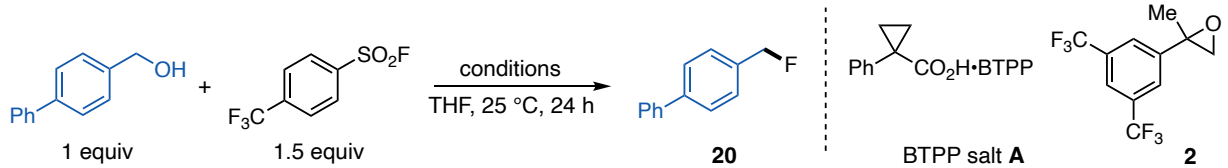
Pre-activation procedure: in a nitrogen-filled glovebox, an oven-dried 1-dram vial was charged with a magnetic stir bar, indicated basic additive (0.075 mmol, 1.5 equiv), THF (0.125 mL, 0.5 M) and epoxide **2** (0.125 mmol, 2.5 equiv relative to basic "reagent"). The vial was capped with a PTFE-lined cap (ThermoFisher, C4015-1A), removed from the glovebox, and placed in a preheated aluminum reaction block at 80 °C for 20 minutes. The pre-activation solution was then allowed to cool to rt and taken into a nitrogen-filled glovebox. Alcohol (0.05 mmol, 1.0 equiv) and sulfonyl fluoride (0.055 mmol, 1.1 equiv) were added, the vial was recapped, removed from the

glovebox and placed in an aluminum reaction block at 25 °C with stirring for 24 h. Dibromomethane (2.0 equiv, 0.1 mmol 7 μL) internal standard was added to the reaction solution, a 50 μL aliquot was taken and added to an NMR tube, then diluted with $CDCl_3$ (0.5 mL). ^1H NMR spectroscopy was used to determine product yield.



Entry	Conditions	Results
1[a]	1.5 equiv BTPP	93%
2	1.5 equiv BTPP salt **A** + 2.5 equiv epoxide **2**	60%
3[a]	1.5 equiv BTPP salt **A**	0%
4[a]	1.5 equiv triethylammonium 1-phenylcyclopropanecarboxylate salt	0%
5[a]	NEt_3	0%
6[a]	1.5 equiv tetrabutylammonium acetate	0%
7	1.5 equiv H^+NEt_3 1-phenylcyclopropanecarboxylate + 2.5 equiv epoxide **2**	0%
8	1.5 equiv tetrabutylammonium acetate + 2.5 equiv epoxide **2**	0%
9[a]	2.5 equiv epoxide **2**	0%

Table S11: Control reactions for the deoxyfluorination reaction of 4-phenylbutan-1-ol with various potential promoters. [a] A preactivation procedure was not followed as noted in General Procedure G.



Entry	Conditions	Results
1[a]	1.5 equiv BTPP	80%
2	1.5 equiv BTPP salt **A** + 2.5 equiv epoxide **2**	70%
3[a]	1.5 equiv BTPP salt **A**	0%
4	1.5 equiv triethylammonium 1-phenylcyclopropanecarboxylate[a]	0%
5[a]	NEt_3	0%
6[a]	1.5 equiv tetrabutylammonium acetate	0%
7	1.5 equiv H^+NEt_3 1-phenylcyclopropanecarboxylate + 2.5 equiv epoxide **2**	0%
8	1.5 equiv tetrabutylammonium acetate + 2.5 equiv epoxide **2**	0%
9[a]	2.5 equiv epoxide **2**	0%

Table S12: Control reactions for the deoxyfluorination reaction of [1,1'-biphenyl]-4-ylmethanol with various potential promoters. [a] A preactivation procedure was not followed as noted in General Procedure G.

V. P_2-*t*-Bu Salt A Activation Studies

i. Procedure for evaluating the generation of P_2-*t*-Bu from P_2-*t*-Bu salt A

In this section we discuss investigation of epoxide additives that, when added to solution with P_2-*t*-Bu salt **A**, facilitate the generation of P_2-*t*-Bu along with an alcohol activation byproduct. For these studies, we tested epoxides under various conditions and assessed the formation of P_2-*t*-Bu and the tertiary alcohol byproduct by ^{31}P and ^{1}H NMR spectroscopy, respectively. When analyzing the protonation state of P_2-*t*-Bu in an activation study by ^{31}P NMR spectroscopy, the proton exchange between free and protonated P_2-*t*-Bu is relatively fast, and as such, we do not observe distinct peaks for the protonated and freebase. Therefore, we developed a process for estimating the quantity of P_2-*t*-Bu based on known ratios of the protonated and freebase, described below. For reference, protonated P_2-*t*-Bu displays two doublets at 16.2 and 13.6 ppm and the freebase displays two doublets at 14.8 and -6.7 ppm.

The amount of freebase can be estimated using ^{31}P NMR spectroscopy by evaluating the chemical shift of the two phosphorus signals. To determine the characteristic spectra of various ratios of freebase to P_2-*t*-Bu carboxylate salt, we conducted titration experiments where we prepared a series of solutions by mixing commercial P_2-*t*-Bu with P_2-*t*-Bu salt **A** at various ratios on a 0.1 mmol scale. Figure S9 shows ratios ranging from 10:1 to 1:10 P_2-*t*-Bu salt **A**:P_2-*t*-Bu freebase. Here, we utilized a 2 s delay time as well as increased number of scans in order to improve baseline resolution for observation of broad spectral features. The ^{31}P NMR spectra of activation studies were compared to these spectra and an estimated range of percent freebase was assigned. The amount of the alcohol activation byproduct formed in the reaction was determined using ^{1}H NMR spectroscopy with 1,3,5-trimethoxybenzene as an internal standard. The amount of the alcohol byproduct matches well (± 10%) with the estimated amount of P_2-*t*-Bu generated from the activation reaction.

The ^{31}P NMR spectra for high ratios of the freebase to protonated base (Figure S9, 4:1 P_2-*t*-Bu:P_2-*t*-Bu salt **A** and 10:1 P_2-*t*-Bu:P_2-*t*-Bu salt **A**) are broader than commercial P_2-*t*-Bu. We reasoned that under the activation reaction conditions, this peak broadening could be due to interactions between the freebase and the activation byproduct (e.g., H-bonding). To support this, we subjected commercial P_2-*t*-Bu mixed with 1 equivalent of alcohol activation byproduct **64** and 1 equivalent of epoxide **22** to ^{31}P NMR spectroscopy (Figure S10) and found that the peaks broaden in its presence.

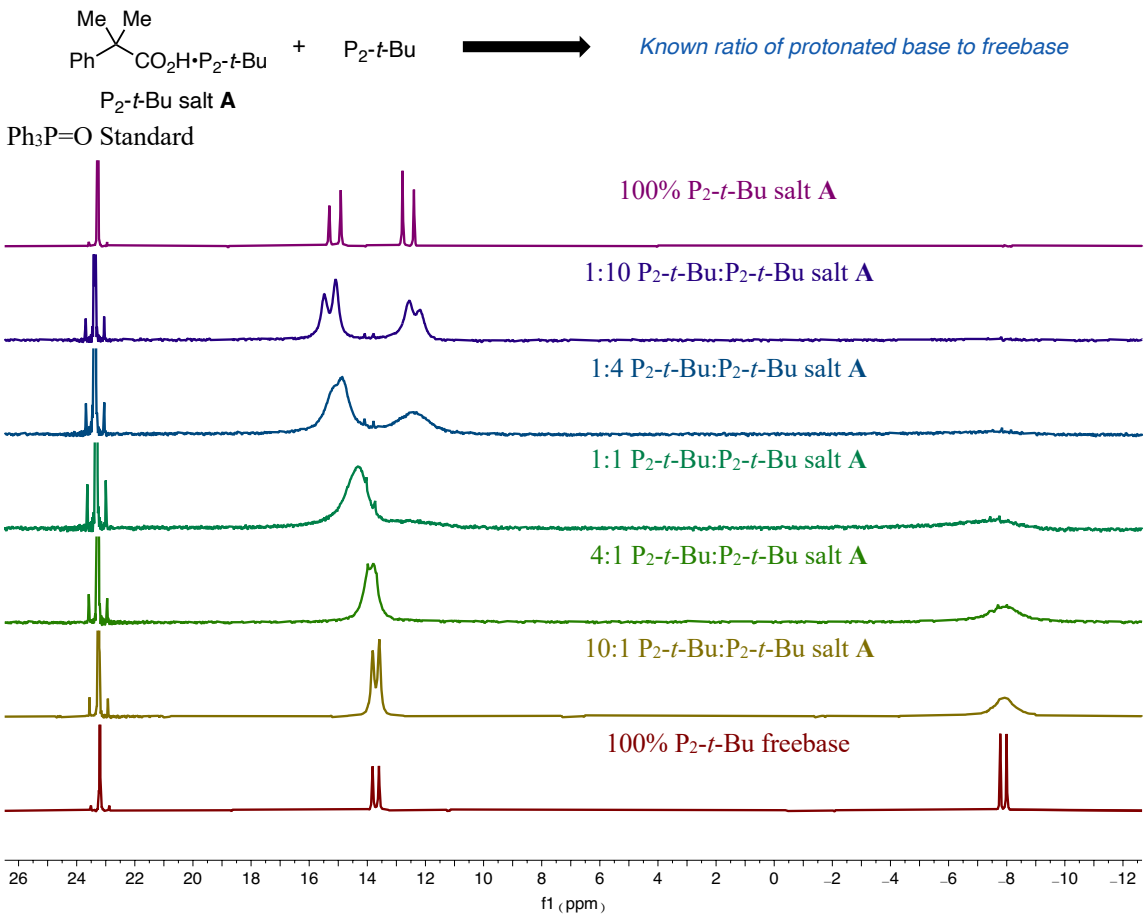


Figure S9: ^{31}P NMR spectra of various ratios of P_2-*t*-Bu freebase and salt **A** in PhMe-d_8.

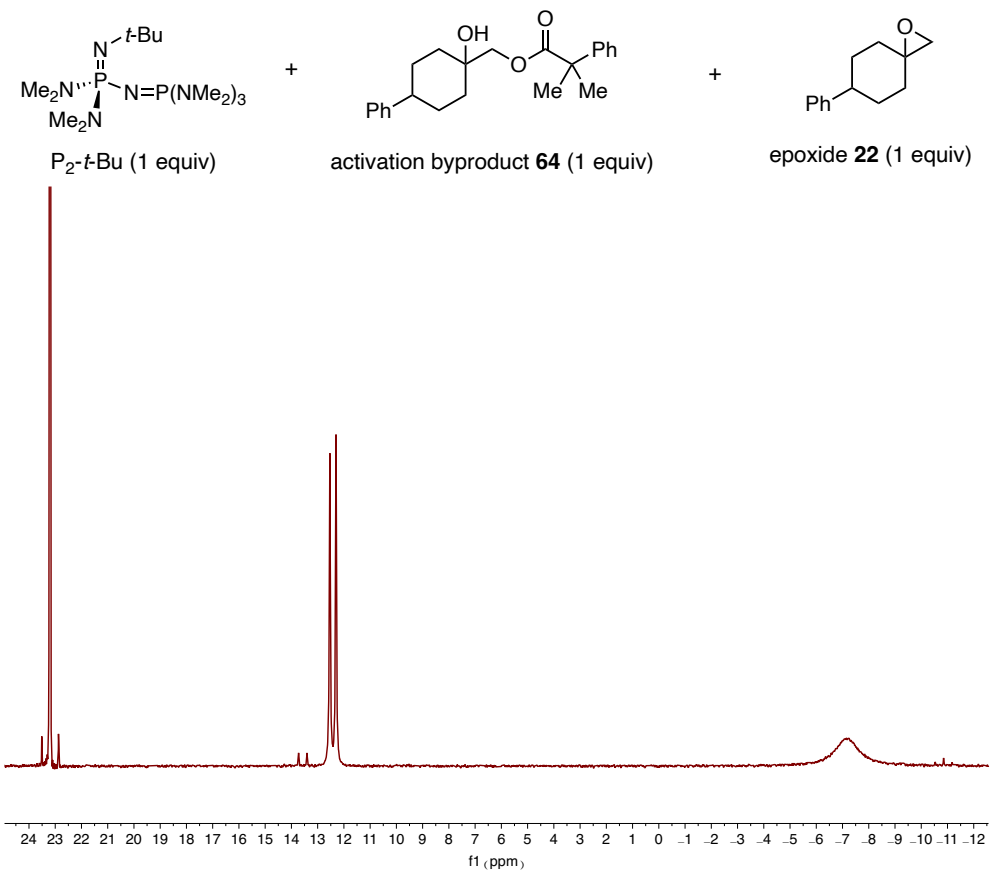


Figure S10. ^{31}P NMR spectrum of commercial P$_2$-*t*-Bu mixed with 1 equivalent of activation byproduct **64** and epoxide **22** that shows broadened spectral features in PhMe-d_8.

b. Examination of epoxide additives for the activation of P$_2$-*t*-Bu salt A

General Procedure H: Activation studies for P$_2$-*t*-Bu salt A. An oven-dried 1-dram vial (ThermoFisher, C4015-1) was charged with a magnetic stir bar and P$_2$-*t*-Bu salt **A** (26.6 mg, 0.05 mmol, 1.0 equiv). The vial was brought into a nitrogen-filled glovebox where solvent (0.1 mL, 0.5 M) and epoxide additive (0.1 mmol, 2.0 equiv) were added successively. The vial was sealed with a PTFE-lined cap (ThermoFisher, C4015-1A), removed from the glovebox, and placed in a preheated aluminum reaction block with stirring for the indicated time. The vial was then brought into a nitrogen-filled glovebox where the reaction solution was diluted with deuterated solvent (0.5 mL), transferred to an NMR tube that was capped and sealed with parafilm wax. ^{31}P and ^{1}H NMR

spectroscopy were used to assess each reaction to determine the amount of freebase produced and yield of the activation byproduct according to the process described above.

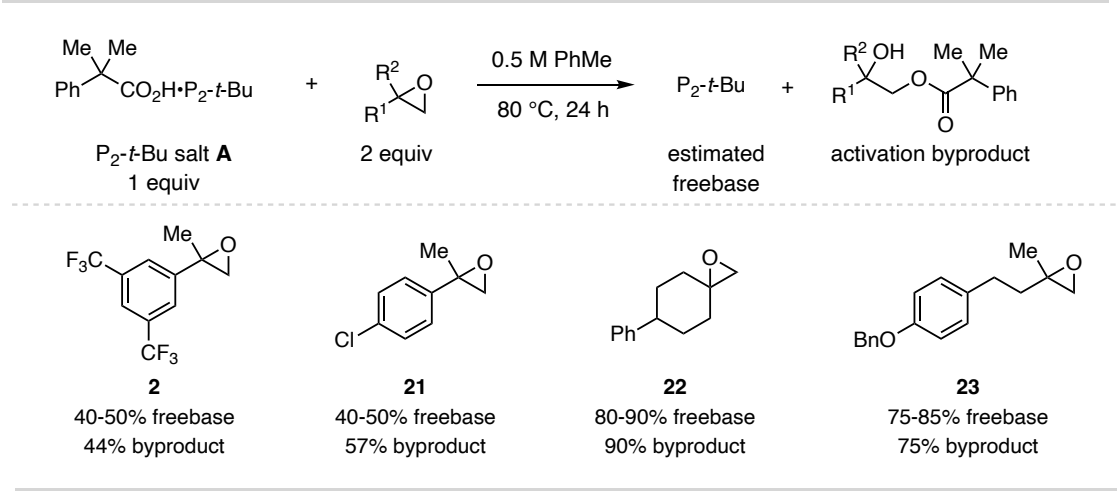


Table S13. Epoxide additives tested for the activation of P_2-*t*-Bu salt **A**. Shown are the estimated ranges for percent freebase generated and the yield of the alcohol activation byproduct.

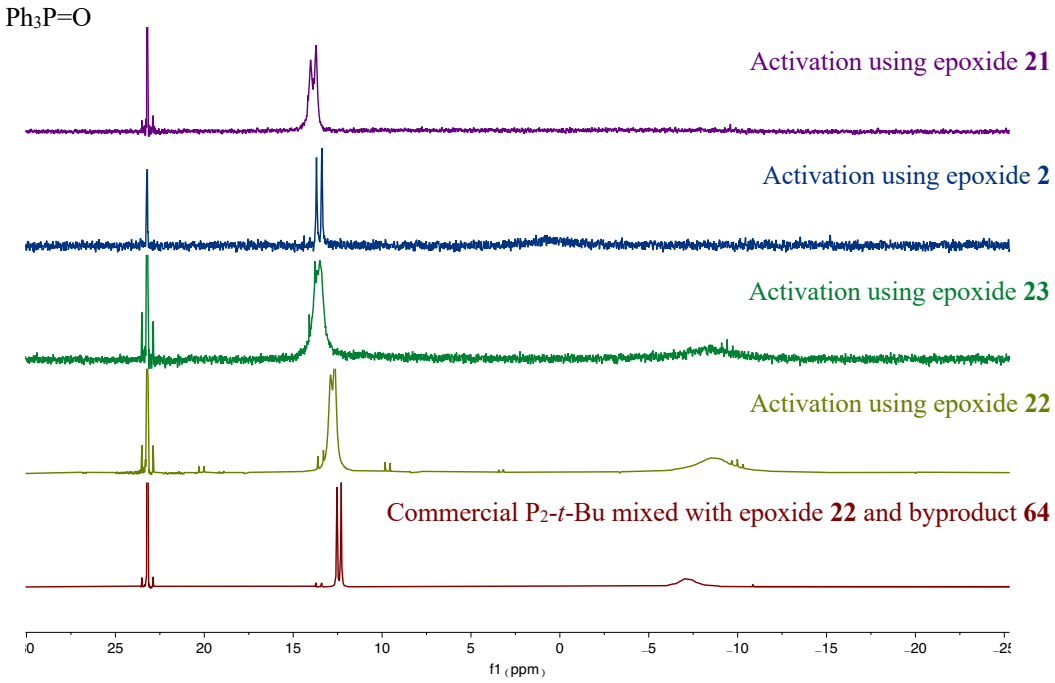


Figure S11. Stacked ^{31}P NMR spectra for the activation of P_2-*t*-Bu salt **A** using various epoxides in PhMe-d_8, with commercial P_2-*t*-Bu mixed with epoxide **22** and byproduct **64**, for comparison.

Description of initial findings: Using General Procedure H in PhMe at 80 °C we first tried aryl substituted epoxides (epoxides **2** and **21** in Table S13 as representative examples), as these epoxides allow rapid and facile activation of BTPP salt **A**. We observed that epoxides **2** and **21**

result in 40-50% freebase. Aliphatic epoxides lead to an increased amount of freebase generated, with epoxides **22** and **23** as representative examples leading to 80-90% and 75-85% freebase, respectively. Figure S11 above shows the ^{31}P NMR spectra for use of epoxides in Table S13 in the activation reaction of P$_2$-*t*-Bu salt **A**. With more freebase generated, a characteristic upfield shift of the peak at 14-16 ppm is observed as well as the appearance of the peak at approximately -6 ppm. Figure S12 below shows the ^{1}H NMR spectra for the activation with epoxides **2** and **22** showing the amount of activation byproduct formed in each case.

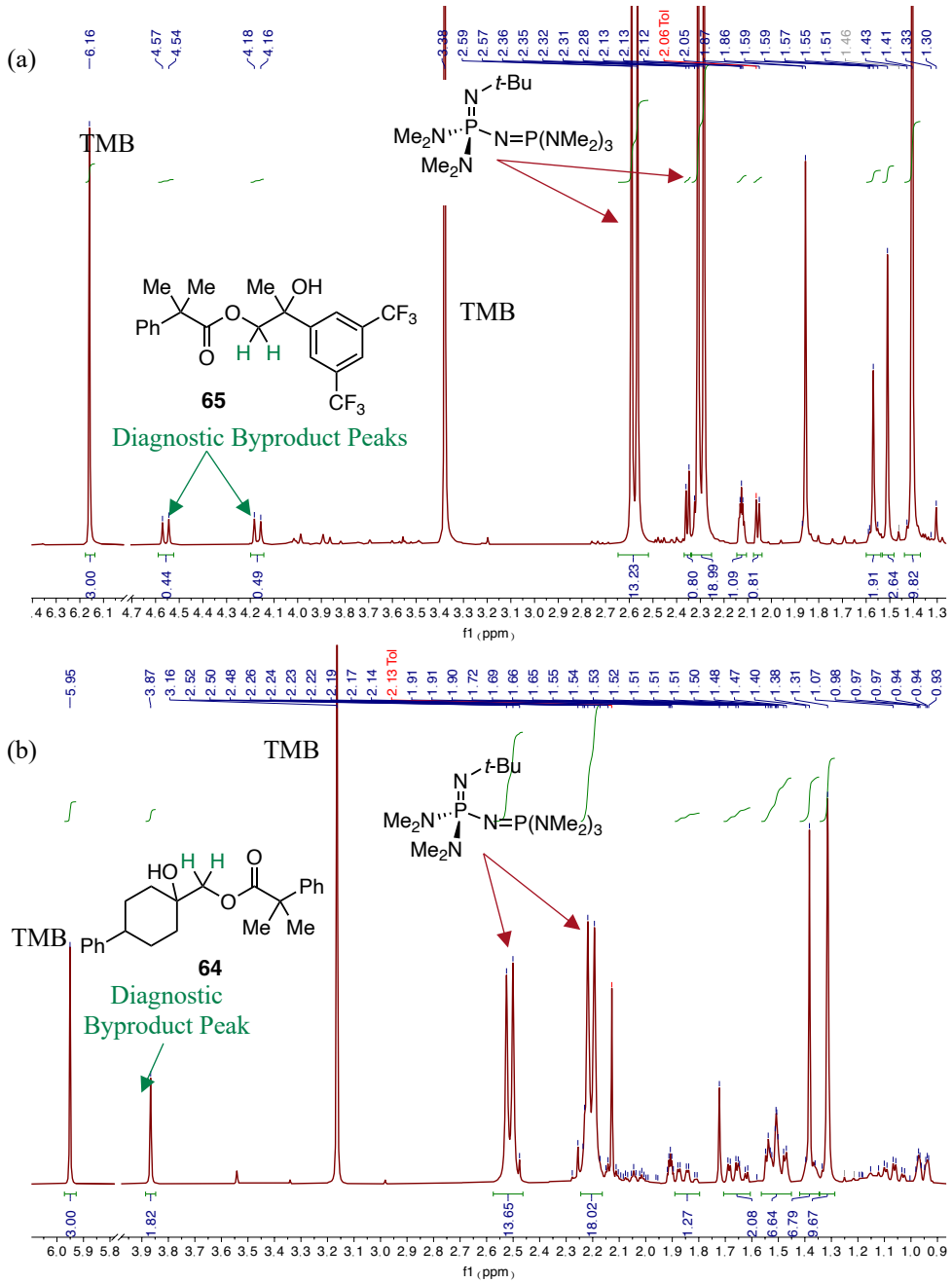
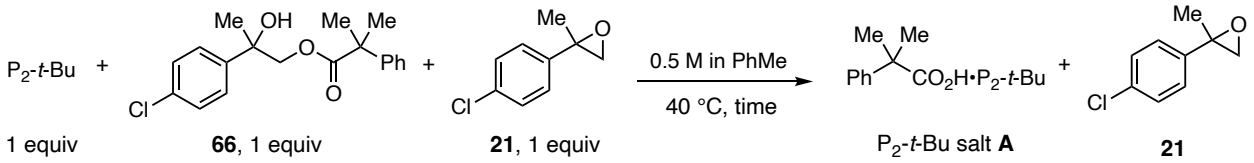


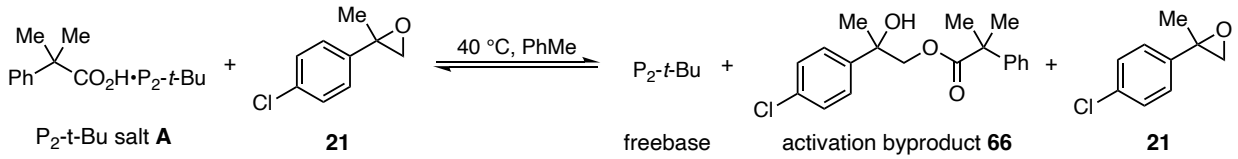
Figure S12: (a) ^{1}H NMR spectrum of epoxide **2** activation reaction with byproduct **65** peaks labeled and integrated compared to 1,3,5-trimethoxybenzene internal standard. (b) ^{1}H NMR

spectrum of epoxide **22** activation reaction with byproduct **64** peaks labeled and integrated compared to 1,3,5-trimethoxybenzene (TMB) internal standard.

While we were investigating epoxides for P_2-*t*-Bu salt **A** activation, we found that when aryl-substituted epoxides are used, activation never exceeds 50% generation of the freebase. Our hypothesis for this observation is that activation reaches an equilibrium point at approximately 50% freebase when aryl-substituted epoxides are used. To test this proposal, we studied both the forward and reverse reactions of P_2-*t*-Bu salt **A** activation, using epoxide **21** at 40 °C, as this temperature allowed us to monitor the reaction rate. The forward reaction was set up following General Procedure H and the reverse reaction was setup using General Procedure I (below). The amount of epoxide **21** and byproduct **66** in the crude reaction mixture were evaluated *via* ^{1}H NMR spectroscopy. The results show that the forward and reverse reactions converge at 50% conversion (Figure S13), indicating that the activation of P_2-*t*-Bu salt **A** using aryl-substituted epoxides is reversible and limited by the reaction equilibrium. This limitation was overcome by using aliphatic epoxides like **22** and **23**, which shift the equilibrium towards P_2-*t*-Bu freebase.



General Procedure I: Reverse activation process for P_2-*t*-Bu salt A. An oven-dried 1-dram vial (ThermoFisher, C4015-1) was charged with a magnetic stir bar and 2-(4-chlorophenyl)-2-hydroxypropyl 2-methyl-2-phenylpropanoate (**66**) (33.3 mg, 0.1 mmol, 1 equiv) open to air. The vial was brought into a nitrogen-filled glovebox where PhMe-d_8 (0.2 mL, 0.5M), epoxide **21** (16.9 mg, 0.1 mmol, 1 equiv), and P_2-*t*-Bu (50 µL of a 2 M THF solution, 0.1 mmol, 1 equiv) were added successively. The vial was sealed with a PTFE-lined cap (ThermoFisher, C4015-1A), removed from the glovebox, placed in a preheated aluminum reaction block at 40 °C with stirring for the indicated time. The vial was brought into a nitrogen-filled glovebox where the reaction solution was diluted with deuterated PhMe (0.4 mL, total of 0.5 mL), transferred to an NMR tube that was capped and sealed with parafilm wax. ^{31}P NMR and ^{1}H NMR spectroscopic analyses were used to assess each reaction to determine the amount of freebase and alcohol activation byproduct.



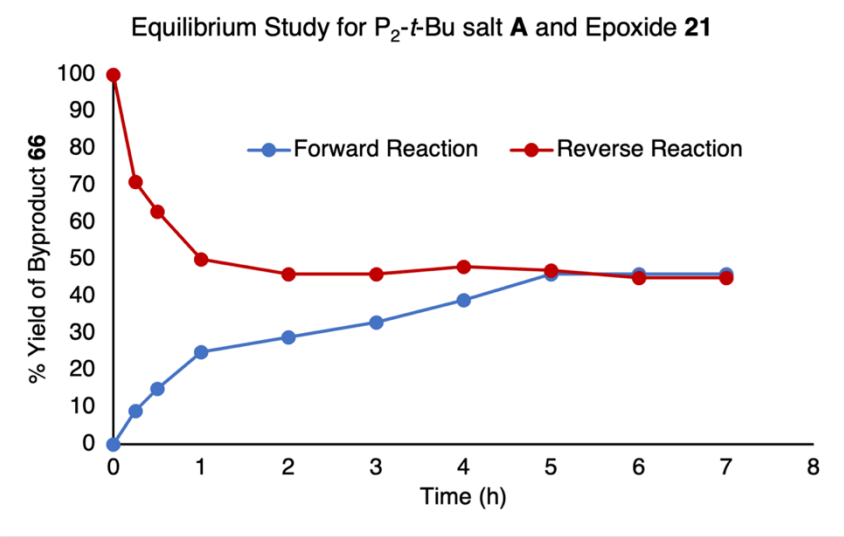
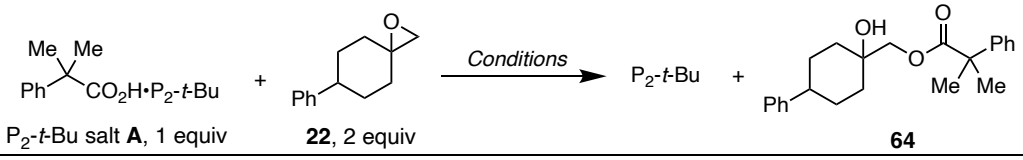


Figure S13: Equilibrium study showing forward and reverse activation reaction for P_2-*t*-Bu salt **A** and epoxide **21**.

b. P_2-*t*-Bu A activation with epoxide 22 under various conditions

This section describes condition variation using epoxide **22** to activate P_2-*t*-Bu salt **A** in a variety of solvents, temperatures, concentrations, and reaction times (Table S14). These experiments were setup using General Procedure H. Entry 1 shows the initial conditions that were used to evaluate the epoxide structure.



Entry	Conditions	Estimated Free Base Yield	Byproduct 64 Yield
1	80 °C, 24 h, 0.5 M in PhMe	80-90%	90%
2	80 °C, 3 h, 0.5 M in PhMe	60-70%	75%
3	80 °C, 3 h, 0.5 M in PhMe (open air)	25-35%	38%
4	80 °C, 3 h, 0.5 M in THF	65-75%	73%
5	40 °C, 24 h, 1.0 M in PhMe	50-60%	51%
6	40 °C, 24 h, 1.0 M in THF	50-60%	58%
7	60 °C, 3 h, 1.0 M in THF	65-75%	70%

8	60 °C, 3 h, 1.0 M in DME	65-75%	71%
9	40 °C, 24 h, 1.0 M in *n*-Bu_2O	50-60%	74%
10	80 °C, 24 h, 1.0 M in NMP	40-50%	53%
11	80 °C, 24 h, 0.5 M in DMSO	25-35%	40%
12	80 °C, 24 h, 0.5 M in DMF	65-75%	69%
13	100 °C, 0.5 h, 0.6 M in 1,4-Dioxane	75-85%	92%

Table S14: Data for the activation of P_2-*t*-Bu salt **A** with epoxide **22** under various conditions.

c. All-in-one activation system combining P_2-*t*-Bu salt A with epoxide 23

For the activation studies described thus far, the superbase salt and epoxide additive have been stored separately and combined *in situ* for base activation. We identified solid epoxide **23** that can be stored in the same vial as P_2-*t*-Bu salt **A** as a stable mixture. We made this by combining P_2-*t*-Bu salt **A** with epoxide **23** in a 1:2 ratio in a vial and mixing them together with a spatula for even distribution. This mixture was stored in a benchtop desiccator with no physical or spectral changes over 1 month of storage. Stored in a freezer, we observe no physical changes for 1 year of storage. We note that in ^{1}H NMR spectra in Figure S14, the ratio of P_2-*t*-Bu salt **A** to epoxide **23** changes depending on the sample taken, observable at 1–1.5 ppm. Due to manual mixing of the components, the ratio can vary by 1-10% based on the sample that is taken from the vial, resulting in relative peak intensity differences. See Table S16 for data on application of the all-in-one precatalyst in the oxa-Michael addition where it functions just as well as P_2-*t*-Bu salt **A** stored separate from the epoxide.

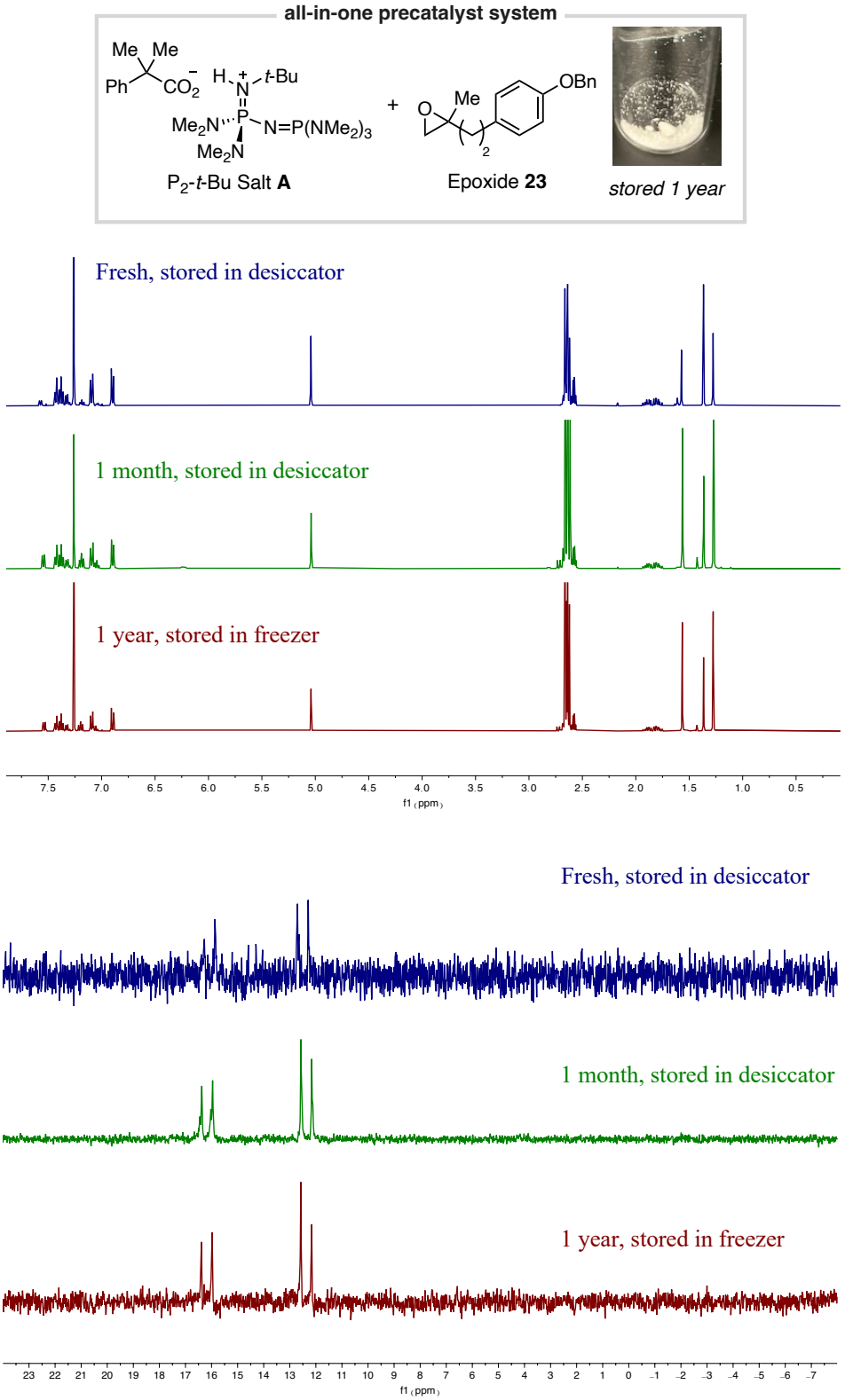


Figure S14. Top: ^{1}H NMR spectra for "all-in-one" precatalyst aged over time with only minor changes in spectral features. Bottom: ^{31}P NMR spectra for "all-in-one" precatalyst aged over time with minimal changes in spectral features.

VI. Applications of P_2-*t*-Bu Salt A and Epoxides as Precatalyst Systems

a. Use of P_2-*t*-Bu salt A as a precatalyst for oxa- and aza-Michael reactions

i. Reaction scheme and General Procedures

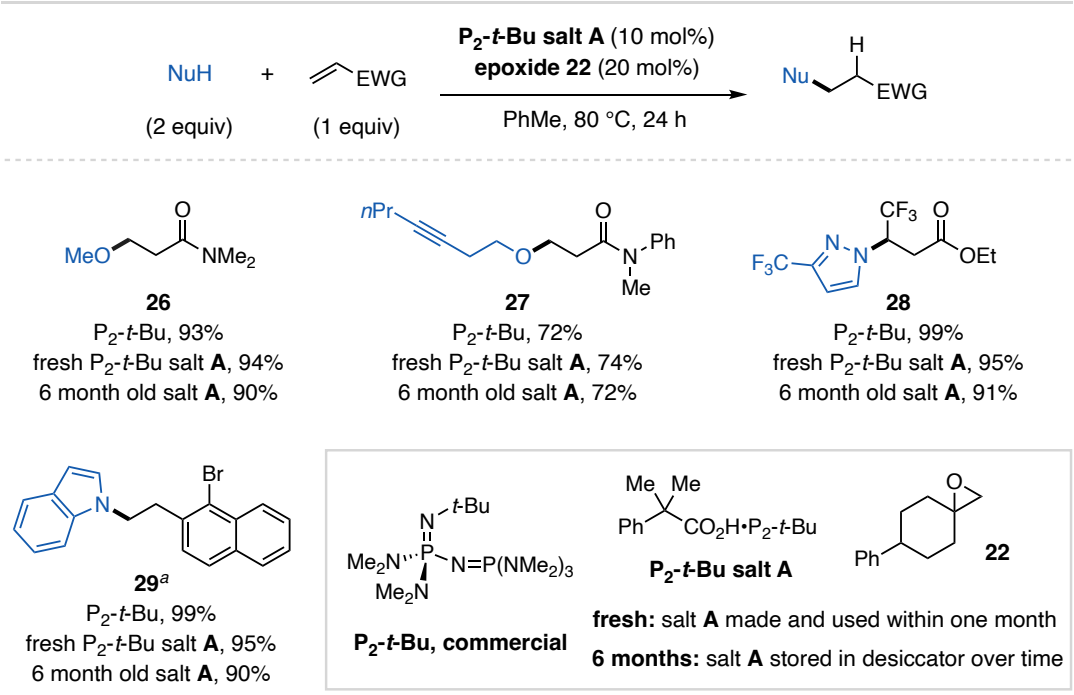
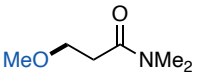


Table S15: Substrate table of oxa/aza-Michael addition reactions run using P_2-*t*-Bu catalyst systems stored in various environments. [a] Reaction run in DMSO.

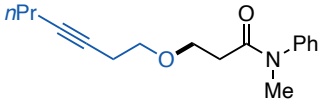
General Procedure J: P_2-*t*-Bu salt A and epoxide 22 promoted reaction. An oven-dried 1-dram vial (ThermoFisher, C4015-1) was charged with a magnetic stir bar, P_2-*t*-Bu salt **A** (53.2 mg, 0.10 mmol, 10 mol%), and epoxide **22** (37.6 mg, 0.20 mmol, 20 mol%). The vial was sealed with a PTFE lined screw cap (ThermoFisher, C4015-A) and evacuated then flushed with nitrogen three times *via* a nitrogen inlet tube on a Schlenk manifold line. PhMe (2.0 mL, 0.5 M), alkene (1.0 mmol, 1.0 equiv), and pronucleophile (2.0 mmol, 2.0 equiv) were added to the vial *via* nitrogen-flushed syringe. **Note**: alkene and/or pronucleophile were charged to the vial prior to capping and nitrogen flushing if they are solids at rt. The inlet tube was removed from the vial and the cap was wrapped in parafilm and PVC tape. The vial was placed into a preheated aluminum reaction block at 80 °C with stirring for 24 h. The reaction solution was cooled to rt and dibromomethane (70 µL, 1.0 mmol, 1.0 equiv) was added to the solution, a 50 µL aliquot was taken and added to an NMR tube, then diluted with $CDCl_3$ (0.5 mL). ^{1}H NMR spectroscopy was used to determine the yield of the reaction. The crude reaction material was directly subjected to flash chromatography to yield purified product for characterization.

ii. Reaction and characterization data

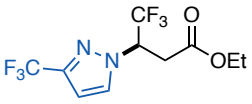
General description: For all of the substrates in this section, we use ^{1}H NMR yields to assess the efficacy of the precatalyst salt system. In each case, we benchmarked the success of the precatalyst against the use of commercial P$_2$-*t*-Bu and P$_2$-*t*-Bu salt **A** that has been handled regularly open to air and stored in a benchtop desiccator for six months (see Section VIII for details). The reactions carried out with P$_2$-*t*-Bu were set up using General Procedure K below, and the reactions carried out with aged P$_2$-*t*-Bu salt **A** were set up using General Procedure J. The substrates were subsequently isolated using General Procedure J and P$_2$-*t*-Bu salt **A** for characterization. The purification conditions and characterization data are given below.



3-Methoxy-*N*,*N*-dimethylpropanamide (26). General Procedure J was followed using *N*,*N*-dimethylacrylamide (99.1 mg, 1 mmol, 1.0 equiv), methanol (81 µL, 2.0 mmol, 2.0 equiv), P$_2$-*t*-Bu salt **A** (53.2 mg, 0.1 mmol, 10 mol%), epoxide **22** (37.6 mg, 0.2 mmol, 20 mol%) and PhMe (2 mL) to provide 94% ^{1}H NMR yield. The reaction was repeated using commercial P$_2$-*t*-Bu (93% ^{1}H NMR yield) and six-month-old P$_2$-*t*-Bu salt **A** (90% ^{1}H NMR yield). Following General Procedure J, the product was purified *via* silica gel chromatography (TLC visualized with PMA stain) using 10% EtOAc in hexanes to afford **26** as a colorless oil (98.1 mg, 0.75 mmol, 75% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 3.65 (t, *J* = 6.6 Hz, 2H), 3.31 (s, 3H), 2.97 (s, 3H), 2.90 (s, 3H), 2.55 (t, *J* = 6.6 Hz, 2H). Characterization data matches literature reports.[9]

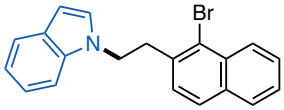


3-(Hept-3-yn-1-yloxy)-*N*-methyl-*N*-phenylpropanamide (27). General Procedure J was followed using *N*-methyl-*N*-phenylprop-2-enamide[10] (161.0 mg, 1.0 mmol, 1.0 equiv), 3-heptyn-1-ol (250.0 µL, 2.0 mmol, 2.0 equiv), P$_2$-*t*-Bu salt **A** (53.2 mg, 0.1 mmol, 10 mol%), epoxide **22** (37.6 mg, 0.2 mmol, 20 mol%) and PhMe (2 mL) to provide 74% ^{1}H NMR yield. The reaction was repeated using commercial P$_2$-*t*-Bu (72% ^{1}H NMR yield) and six-month-old P$_2$-*t*-Bu salt **A** (72% ^{1}H NMR yield). Following General Procedure J, the product was purified *via* silica gel chromatography using 20% EtOAc in hexanes to afford **27** as a colorless oil (167.6 mg, 0.61 mmol, 61% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.42-7.35 (m, 2H), 7.34-7.27 (m, 1H), 7.22-7.16 (m, 2H), 3.69 (t, *J* = 6.8 Hz, 2H), 3.45 (t, *J* = 7.1 Hz, 2H), 3.25 (s, 3H), 2.41-2.30 (m, 4H), 2.07 (tt, *J* = 7.0, 2.4 Hz, 2H), 1.45 (h, *J* = 7.3 Hz, 2H), 0.92 (t, *J* = 7.4 Hz, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 170.9, 144.0, 129.8, 127.9, 127.5, 81.3, 76.8, 69.9, 67.2, 37.3, 34.6, 22.4, 20.8, 20.1, 13.5. **IR** (neat) 2961, 2931, 2870, 1654, 1595, 1496, 1382, 1110, 773, 700 cm^{-1}. **HRMS (DART)** $[M+H]^+$ calcd. for $[C_{17}H_{24}NO_2]^+$ = 274.1807, found 274.1802.



Ethyl-4,4,4-trifluoro-3-(3-(trifluoromethyl)-1*H*-pyrazol-1-yl)-butanoate (28). General Procedure J was followed using ethyl (*E*)-4,4,4-trifluorobut-2-enoate (149.4 µL, 1.0 mmol, 1.0 equiv), 3-(trifluoromethyl)pyrazole (272.2 mg, 2.0 mmol, 2.0 equiv), P$_2$-*t*-Bu salt **A** (53.2 mg, 0.1 mmol, 10 mol%),

epoxide **22** (37.6 mg, 0.2 mmol, 20 mol%), and PhMe (2 mL) to provide 95% ^{1}H NMR yield. The reaction was repeated using commercial P$_2$-*t*-Bu (99% ^{1}H NMR yield) and six-month-old P$_2$-*t*-Bu salt **A** (91% ^{1}H NMR yield). Following General Procedure J, the product was purified *via* silica gel chromatography using 20% EtOAc in hexanes to afford **28** as a colorless oil (152.1 mg, 0.50 mmol, 50% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.60 (d, *J* = 2.5 Hz, 2H), 6.59 (d, *J* = 2.5 Hz, 2H), 5.25 (dqd, *J* = 10.6, 6.9, 3.6 Hz, 1H), 4.19 – 4.04 (m, 2H), 3.54 (dd *J* = 17.2, 10.5 Hz, 1H), 3.07 (dd, *J* = 17.2, 3.6 Hz, 1H), 1.18 (t, *J* = 7.1 Hz, 3H). **^{19}F NMR** (376 MHz, $CDCl_3$) δ -62.22 (s, 3F), -74.55 (d, *J* = 6.9 Hz, 3F). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 168.5, 144.1 (q, *J* = 38.8 Hz), 132.8, 123.0 (q, *J* = 286.9 Hz), 121.3 (q, *J* = 271.6 Hz), 105.5, 61.8, 60.0 (q, *J* = 32.4 Hz), 32.7, 14.0. **IR** (neat) 3134, 2989, 1738, 1487, 1388, 1315, 1241, 1167, 1126 cm^{-1}. **HRMS (ESI)** $[M+H]^+$ clacd. for $[C_{10}H_{11}F_6N_2O_2]^+$ = 305.0725, found 305.0720.



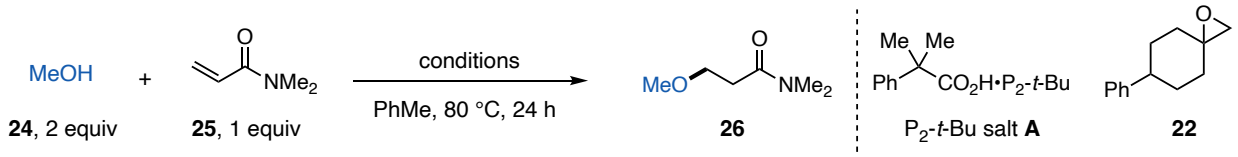
1-(2-(1-bromonaphthalen-2-yl)ethyl)-1*H*-indole (29). General Procedure J was followed using 1-bromo-2-vinylnaphthalene[11] (233.1 mg, 1.0 mmol, 1.0 equiv), 1*H*-indole (234.3 mg, 2.0 mmol, 2.0 equiv), P$_2$-*t*-Bu salt **A** (53.2 mg, 0.1 mmol, 10 mol%), epoxide **22** (37.6 mg, 0.2 mmol, 20 mol%), and DMSO (2 mL) to provide 95% ^{1}H NMR yield. The reaction was repeated using commercial P$_2$-*t*-Bu (99% ^{1}H NMR yield) and six-month-old P$_2$-*t*-Bu salt **A** (90% ^{1}H NMR yield). Following General Procedure J, the product was purified *via* silica gel chromatography using 5% EtOAc in hexanes with 2% NEt_3 to afford **29** as a white solid (295.0 mg, 0.84 mmol, 90% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.36 (dd, *J* = 8.5, 1.2 Hz, 1H), 7.80 (dd, *J* = 8.1, 1.3 Hz, 1H), 7.70 – 7.58 (m, 3H), 7.56 – 7.45 (m, 2H), 7.23 (t, *J* = 7.5 Hz, 1H), 7.13 (t, *J* = 7.4 Hz, 1H), 7.07 (d, *J* = 8.3 Hz, 1H), 6.97 (d, *J* = 3.1 Hz, 1H), 6.46 (dd, *J* = 3.1, 0.9 Hz, 1H), 4.47 (t, *J* = 7.7 Hz, 2H), 3.50 (t, *J* = 7.7 Hz, 2H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 136.1, 136.0, 133.7, 132.7, 128.9, 128.4, 128.3, 128.0, 128.0, 127.7, 127.4, 126.4, 124.2, 121.7, 121.2, 119.5, 109.5, 101.4, 46.3, 38.6. **IR** (neat) 3052, 2933, 1555, 1513, 1462, 1359, 1319, 1173, 1019, 732 cm^{-1}. **HRMS (DART)** $[M+H]^+$ calcd. for $[C_{20}H_{16}BrN]^+$ = 350.0539, found 350.0547. **MP** 72 – 76 °C.

iii. Control Reactions

In this section we describe control reactions to support that P$_2$-*t*-Bu generated from the precatalyst salt is responsible for catalyzing the reaction and not background reactivity from any components or intermediates of the activation process. General Procedure K below was followed for each of the controls. We also tested to see if the carboxylate anion is capable of catalyzing reactions by running reactions with only P$_2$-*t*-Bu salt **A**, with a variety of 1-phenylcyclopropanecarboxylate salts. Here, we tested different countercations (e.g., potassium and ammoniums) to survey salt solubility trends. Additionally, we tested if using only epoxide **22** could promote the reaction. We also considered the possibility that a carboxylate anion can attack the epoxide to generate an alkoxide intermediate that could serve as an active basic catalyst. We tested this by mixing non-superbase carboxylate salts with epoxide **22** under reaction conditions. For each indicated catalyst

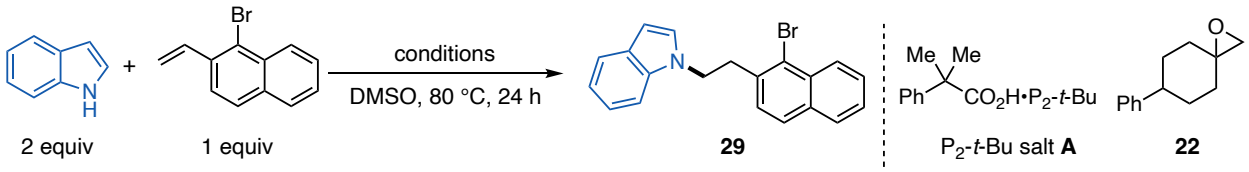
system other than the commercial freebase or precatalyst system, we observed either 0% or reduced yield of the product. Overall, these results are consistent with the active catalyst being P_2-*t*-Bu generated from the precatalyst system. Data for these experiments is provided in Tables S16 and S17 for substrates **26** and **29**, respectively.

General Procedure K: Control reactions run in a nitrogen-filled glovebox. In a nitrogen-filled glovebox, an oven-dried 1-dram vial (ThermoFisher, C4015-1) was charged with a magnetic stir bar, pronucleophile (0.2 mmol, 2.0 equiv), PhMe (0.2 mL, 0.5 M), epoxide **22** (0.02 mmol, 20 mol%, unless excluded), alkene (0.1 mmol, 1.0 equiv), and the indicated catalyst (0.01 mmol, 10 mol%) in successive order. The vial was sealed with a PTFE-lined cap (ThermoFisher, C4015-1A), removed from the glovebox, placed in a preheated aluminum reaction block at 80 °C with stirring for 24 h. The reaction solution was cooled to rt and dibromomethane (7 µL, 0.1 mmol, 1.0 equiv) internal standard was added to the reaction solution. A 50 µL aliquot was taken and added to an NMR tube, then diluted with 0.5 mL of $CDCl_3$. Analysis of the ^1H NMR spectrum was used to determine the yield of the product.



Entry	Conditions	Results
1	10% P_2-*t*-Bu	93%
2 [a]	10% P_2-*t*-Bu salt **A** + 20% epoxide **22**	94%
3	5% P_2-*t*-Bu salt **A** + 10% epoxide **22**	95%
4	2.5% P_2-*t*-Bu salt **A** + 5% epoxide **22**	33%
5	1% P_2-*t*-Bu salt **A** + 2% epoxide **22**	22%
6 [a]	10% P_2-*t*-Bu salt **A** + epoxide **23**	89%
7	10% P_2-*t*-Bu salt **B** + 20% epoxide **22**	87%
8	10% P_2-*t*-Bu salt **B** (aged 2h in 84% humidity) + 20% epoxide **22**	89%
9 [b]	10% P_2-*t*-Bu salt **A** + 20% epoxide **23** (all-in-one precatalyst)	96%
10 [a,c]	10% P_2-*t*-Bu salt **A** + 20% epoxide **23** (all-in-one precatalyst), 1-month old	91%
11 [d]	10% P_2-*t*-Bu salt **A** (from moisture recovery) + 20% epoxide **22**	90%
12	10% P_2-*t*-Bu salt **A**	0%
13	10% potassium 2-methyl-2-phenylpropionate	0%
14	10% triethylammonium 2-methyl-2-phenylpropionate	0%
15	10% NEt_3	0%
16	10% tetrabutylammonium acetate	0%
17	20% epoxide **22**	0%
18	10% potassium 2-methyl-2-phenylpropionate + 20% epoxide **22**	0%
19	10% $HNEt_3^+$ 2-methyl-2-phenylpropionate + 20% epoxide **22**	0%
20	10% tetrabutylammonium acetate + 20% epoxide **22**	0%

Table S16. Control reactions for methanol addition to *N,N*-dimethylacrylamide. [a] Indicates reaction was set up following General Procedure J . [b] Indicates use of the combined P_2-*t*-Bu salt **A** and epoxide **23** all-in-one system, see Section Vc for details. [c] Indicates the use of the all-in-one system after it had been aged for 1 month in a benchtop desiccator. [d] Indicates the use of P_2-*t*-Bu salt **A** that has been recovered after water absorption *via* azeotrope with PhMe, see Section VIIIb for details.



2 equiv 1 equiv **29** P_2-*t*-Bu salt **A** **22**

Entry	Conditions	Results
1	10% P_2-*t*-Bu	99%
2	10% P_2-*t*-Bu salt **A** + 20% epoxide **22**	93%
3 [a]	10% P_2-*t*-Bu salt **A** (from moisture recovery) + 20% epoxide **22**	94%
4	10% P_2-*t*-Bu salt **B** + 20% epoxide **22**	91%
5	10% P_2-*t*-Bu salt **A**	19%
6	10% potassium 2-methyl-2-phenylpropionate	0%
7	10% triethylammonium 2-methyl-2-phenylpropionate	0%
8	10% NEt_3	0%
9	10% tetrabutylammonium acetate	0%
10	20% epoxide **22**	0%
11	10% potassium 2-methyl-2-phenylpropionate + 20% epoxide **22**	66%
12	10% $HNEt_3^+$ 2-methyl-2-phenylpropionate + 20% epoxide **22**	0%
13	10% tetrabutylammonium acetate + 20% epoxide **22**	0%
14	No Base	0%

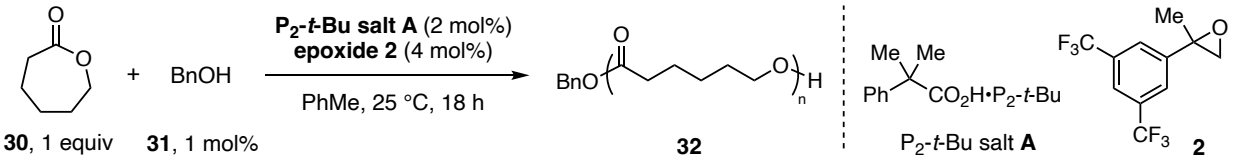
Table S17: Control reactions for addition of indole to 1-bromo-2-vinylnaphthalene. [a] Indicates the use of P_2-*t*-Bu salt **A** that has been recovered after water absorption *via* azeotrope with PhMe, see Section VIIIb for details.

We note that for Table S17 Entry 11, the combination of potassium 2-methyl-2-phenylpropionate and epoxide **22** is capable of promoting the hydroamination reaction; we speculate a potassium alkoxide intermediate is generated that promotes the reaction. However, the corresponding alkoxide intermediate of the precatalyst system likely neutralizes P_2-*t*-Bu immediately to generate the freebase as the active catalyst. We supported this by premixing P_2-*t*-Bu salt **A** with epoxide **22** for 1 h at 100 °C in PhMe that showed complete formation of the freebase (observed by ^{31}P and ^{1}H NMR spectroscopy), followed by addition of starting materials. Here, the hydroamination rate is very similar to the use of P_2-*t*-Bu freebase (reaction complete in 2 h). Direct use of the preacatlyst system shows a slower rate (60% yield in 6 h), consistent with precatalyst activation. When potassium 2-methyl-2-phenylpropionate with epoxide **22** is used, we observe a slower reaction

rate (40% yield at 6 h). Additionally, we repeated Entries 5 and 11 from Table S17 for substrates **27** and **28** to assess whether any background processes could be responsible for catalyzing these reactions and found that all gave 0% or very low yield as compared to the use of the precatalyst. Collectively, these results are consistent with the P_2-*t*-Bu generated from the precatalyst system being the active catalyst in these reactions.

b. Use of P_2-*t*-Bu salt A as a precatalyst for the polymerization of ε-caprolactone

i. Reaction scheme and General Procedures



General Procedure L: P_2-*t*-Bu salt A and epoxide 2 promoted reaction. Note: this reaction is run at 25 °C and as such epoxide **2**, which can activate P_2-*t*-Bu salt **A** to 50% conversion at low temperatures, was used in place of epoxide **22**, which requires high temperature for activation. An oven-dried 1-dram vial (ThermoFisher, C4015-1) was charged with a magnetic stir bar and P_2-*t*-Bu salt **A** (31.9 mg, 0.06 mmol, 2.0 mol%). The vial was sealed with a PTFE lined screw cap (ThermoFisher, C4015-A) and evacuated then flushed with nitrogen three times on a Schlenk manifold line. Toluene (1.2 mL, 2.5 M), ε-caprolactone (**30**, 332.2 µL, 3.0 mol, 1.0 equiv), benzyl alcohol (**31**, 3.1 µL, 0.03 mol, 1.0 mol%) were added to the vial *via* nitrogen-flushed syringe. Epoxide **2** (32.4 mg, 0.12 mmol, 4.0 mol%) was weighed into a 50 µL microsyringe and added to the vial. The vial was wrapped in parafilm and PVC tape and placed into a preheated aluminum reaction block at 25 °C with stirring for 24 h. Benzoic acid (100 µL) was used to quench the reaction and a 50 µL aliquot was taken and added to an NMR tube, then diluted with $CDCl_3$ (0.5 mL). ^{1}H NMR analysis showed 90% polymerization of the ε-caprolactone monomer initiated by BnOH, characterized by the diagnostic triplet at 4.15 ppm against the diagnostic multiplet of the monomer at 4.30 ppm. Representative spectra are shown below in Figure S15 for the analysis of the degree of polymerization for various time points. We note that when P_2-*t*-Bu salt **A** and epoxide **2** are used, 5-10% of an oligomer side product is also formed. The crude reaction mixture was added dropwise to 10 mL of MeOH in an ice bath at 0 °C and to precipitate the polymeric material. The solid material was isolated using vacuum filtration and redissolved in $CHCl_3$ and then precipitated again in cold MeOH. The white solid was collected by vacuum filtration (130.4 mg material collected) and GPC analysis showed approximate M_n = 14.9 kDa with Đ = 1.07. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 5.12 (s, 2H, end group), 4.06 (t, *J* = 6.7 Hz, 2 H, repeat unit), 2.31 (t, *J* = 7.5 Hz, 2 H, repeat unit), 1.66 (m, 4 H, repeat unit), 1.38 (m, 2 H, repeat unit). Characterization matches literature reports.[12]

For comparison to the use of the precatalyst system, we isolated material from a polymerization reaction using the P_2-*t*-Bu freebase using the same protocol as described in General Procedure L, set up in a N_2-filled glovebox (no oligomer side product is observed). The isolated material shows the same spectral features as the material isolated from the precatalyst procedure. This material was analyzed by GPC and showed approximate M_n = 12.0 kDa with Đ = 1.14.

ii. Polymerization of ε-Caprolactone Reaction Analysis

To assess polymerization, the total integration of diagnostic polymer **32** peak (triplet, 4.15 ppm) was divided by the total integration of both the polymer peak and monomer **30** peak (triplet, 4.30 ppm). We note that for reactions run with P_2-*t*-Bu salt **A** and epoxide **2**, a peak at 4.25 ppm appears, corresponding to an oligomer side product that is may be initiated by the alcohol activation byproduct. We do not observe the formation of the oligomer side product when P_2-*t*-Bu is used as the catalyst. In these cases, the percent conversion to polymer **32** was assessed by dividing the integration of diagnostic polymer **32** peak by the sum of polymer peak, monomer **30** peak, and oligomer side product peak. After undergoing the precipitation procedures to purify these materials (described in General Procedure L), the oligomer side product is not present in isolated materials. Ongoing work is being conducted to eliminate the formation of this side product in polymerization applications.

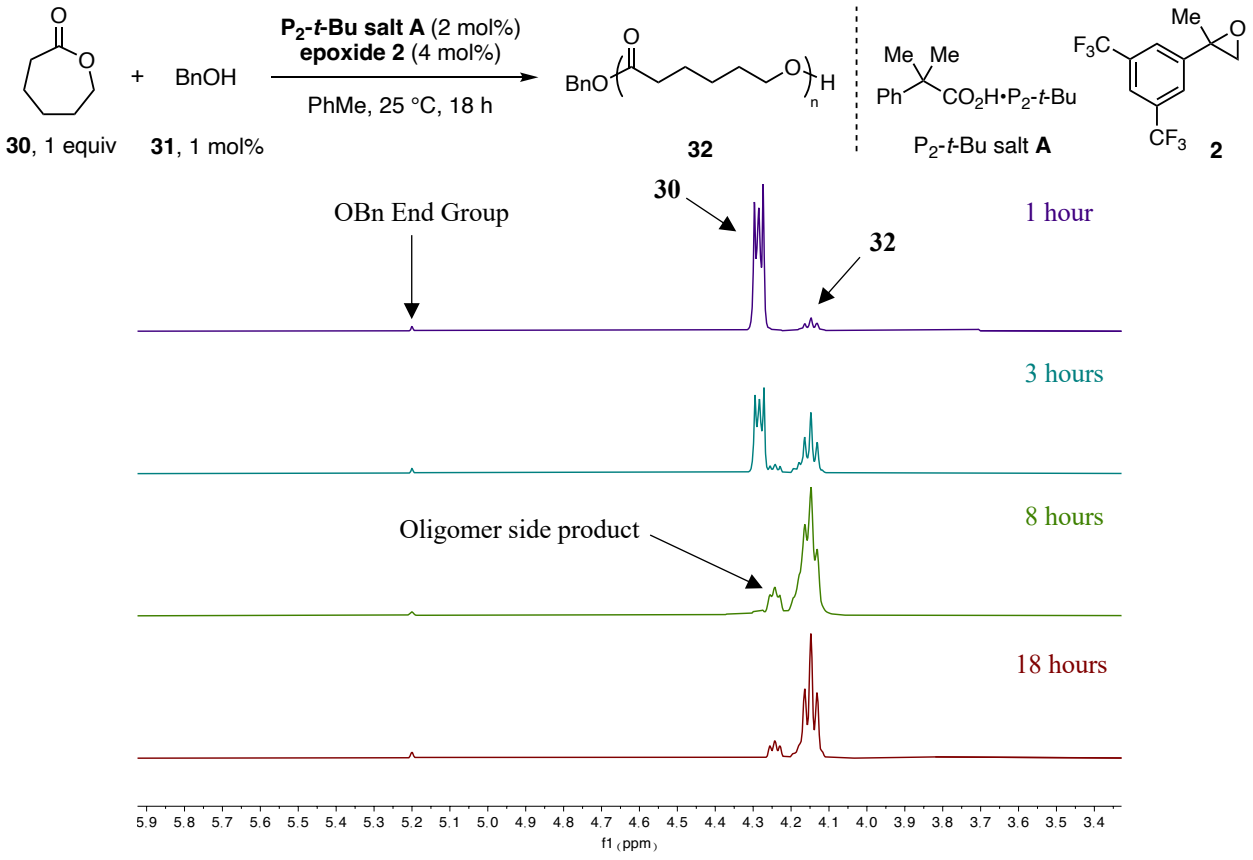
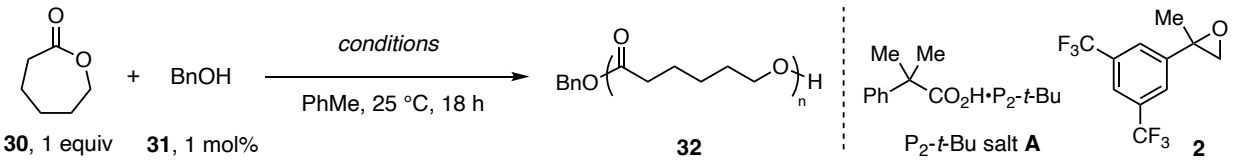


Figure S15. Overlayed ^{1}H NMR spectra of ε-caprolactone polymerization reaction demonstrating the growth of polymer **32** and consumption of monomer **30** over time. The signal at 4.25 ppm corresponds to an oligomer side product.

iii. Control Reactions

In this section we describe control reactions that support the P_2-*t*-Bu generated from the precatalyst salt is responsible for catalyzing polymerization and not background reactivity from any components or intermediates of the activation process. General Procedure M below was followed for each of the controls. We also considered the possibility that a carboxylate can attack the epoxide to generate an alkoxide intermediate that could serve as an active basic catalyst. We tested this by mixing non-superbase carboxylate salts with epoxide **2** under reaction conditions. We also tested if the presence of epoxide or activation byproduct with commercial P_2-*t*-Bu have any inhibitory effect on the polymerization. We investigated if a carboxylate-opened epoxide intermediate could catalyze polymerization by using tetrabutylammonium acetate with epoxide **2**. For each potential system other than the commercial freebase or precatalyst system, we observed 0% conversion to polymer. Overall, these results are consistent with the active catalyst as P_2-*t*-Bu generated from the precatalyst system. Data for these experiments is provided in Table S18.

General Procedure M: Control reactions run in a nitrogen-filled glovebox. In a nitrogen-filled glovebox, an oven-dried 1-dram vial (ThermoFisher, C4015-1) was charged with a magnetic stir bar, PhMe (1.2 mL, 2.5 M), ε-caprolactone (332.2 µL, 3.0 mol, 1.0 equiv), benzyl alcohol (3.1 µL, 0.03 mol, 1.0 mol%), and the potential control catalyst (0.06 mmol, 2.0 mol%). The vial was sealed with a PTFE-lined cap (ThermoFisher, C4015-1A), removed from the glovebox, placed in a preheated aluminum reaction block at 25 °C with stirring for 24 h. Benzoic acid (100 µL) was used to quench the reaction and a 50 µL aliquot was taken and added to an NMR tube, then diluted with $CDCl_3$ (0.5 mL). ^{1}H NMR analysis was utilized to determine the percent conversion.



30, 1 equiv **31**, 1 mol% **32** P_2-*t*-Bu salt **A** **2**

Entry	Conditions	% Conversion to 32	% Oligomer
1	2% P_2-*t*-Bu	97%	0%
2	2% P_2-*t*-Bu salt **A** + 4% epoxide **2**	90%	10%
3	1% P_2-*t*-Bu salt **A** + 2% epoxide **2**	92%	8%
4	2% P_2-*t*-Bu + 2% activation byproduct **62** + 2% epoxide **2**	90%	9%
5	2% P_2-*t*-Bu salt **A**	0%	0%
6	2% Bu_4NOAc	0%	0%

7	2% Bu_4NOAc + 4% Epoxide **2**	0%	0%
8 [a]	2% activation byproduct **62**	0%	0%

Table S18: Control reactions for the polymerization of ε-caprolactone. For all control reactions, all components are fully soluble in PhMe. [a]Activation byproduct **62** was used in this case as it was previously synthesized for BTPP salt **A** activation studies and is structurally similar to **65**.

c. Use of P_2-*t*-Bu salt A as a prereagent for nucleophilic aromatic substitution (S_NAr) reactions

i. Reaction scheme and General Procedures

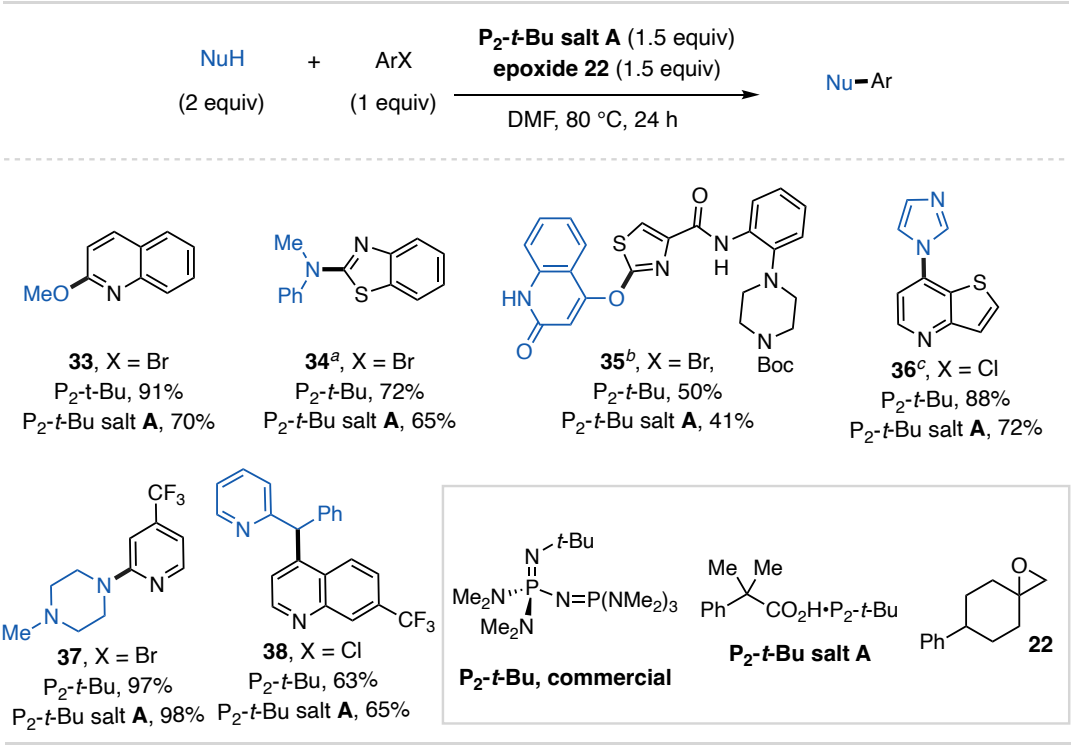


Table S19: Substrate table for S_NAr reactions run using the P_2-*t*-Bu prereagent system compared to P_2-*t*-Bu freebase. [a] Reaction using prereagent system run in THF. [b] Reaction run in DMSO. [c] Reaction requires preactivation for 1 h in PhMe at 100 °C.

General Procedure N: P_2-*t*-Bu salt A and epoxide 22 promoted reaction. An oven-dried 1-dram vial (ThermoFisher, C4015-1) was charged with a magnetic stir bar, P_2-*t*-Bu salt **A** (398.7 mg, 0.75 mmol, 1.5 equiv), and epoxide **22** (141.2 mg, 0.75 mmol, 1.5 equiv). The vial was sealed with a PTFE-lined cap (ThermoFisher, C4015-1A) and evacuated then backfilled with nitrogen three times *via* a nitrogen inlet tube on a Schlenk manifold line. To the vial, solvent (1 mL, 0.75M with respect to P_2-*t*-Bu salt **A**) was added *via* nitrogen-flushed syringe and the vial was evacuated then backfilled with nitrogen three times under vigorous stirring *via* a nitrogen inlet tube on a

Schlenk manifold line. To a separate oven-dried 1-dram vial (ThermoFisher, C4015-1), solid electrophile (0.5 mmol, 1.0 equiv) and solid pronucleophile (1.0 mmol, 2.0 equiv) were added. The vial was sealed with a PTFE-lined cap (ThermoFisher, C4015-1A) and evacuated then backfilled with nitrogen three times. To the vial, solvent (1 mL, 0.25M for total volume), and, if liquid, electrophile (0.5 mmol, 1.0 equiv) and pronucleophile (1.0 mmol, 2.0 equiv) were added to the vial *via* nitrogen-flushed syringe and the vial was evacuated then backfilled with nitrogen three times under vigorous stirring *via* a nitrogen inlet tube on a Schlenk manifold line. The prereagent solution was transferred to the reagent vial *via* nitrogen-flushed syringe. The inlet tube was removed from the vial and the cap was wrapped in parafilm and PVC tape. The vial was placed in a preheated aluminum reaction block at 80 °C for 24 h with stirring. The reaction solution was cooled to rt and dibenzyl ether (95.0 µL, 0.5 mmol, 1.0 equiv) was added to the reaction solution, a 50 µL aliquot was taken and added to an NMR tube, then diluted with $CDCl_3$ (0.5 mL). ^1H NMR spectroscopic analysis was used to determine the yield of the reaction.

General Procedure O: Preactivation for P_2-*t*-Bu salt A and epoxide 22 promoted reaction. Note: this procedure was used for substrate **36** because imidazole reacts with epoxide **22**, preventing the P_2-*t*-Bu activation process. An oven-dried 1-dram vial (ThermoFisher, C4015-1) was charged with a magnetic stir bar, P_2-*t*-Bu salt **A** (398.7 mg, 0.15 mmol, 1.5 equiv), and epoxide **22** (141.2 mg, 0.15 mmol, 1.5 equiv). The vial was sealed with a PTFE-lined cap (ThermoFisher, C4015-1A) and evacuated then back filled with nitrogen three times *via* a nitrogen inlet tube on a Schlenk manifold line. PhMe (1 mL, 0.75 M with respect to P_2-*t*-Bu salt **A**) was added as the activation solvent to the vial *via* nitrogen-flushed syringe and the vial was evacuated and backfilled with nitrogen three times under vigorous stirring *via* a nitrogen inlet tube on a Schlenk manifold line to degas the solution. The inlet tube was removed from the vial and the cap was wrapped in parafilm and PVC tape. The vial was placed in a preheated aluminum reaction block at 100 °C for 1 h with stirring.

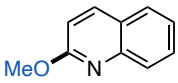
Reagent solution: a separate oven-dried 1-dram vial (ThermoFisher, C4015-1) was charged with a magnetic stir bar, solid pronucleophile (0.5 mmol, 1.0 equiv), and solid electrophile (1.0 mmol, 2.0 equiv). The vial was sealed with a PTFE-lined cap (ThermoFisher, C4014-1A) and evacuated and backfilled with nitrogen three times *via* a nitrogen inlet tube on a Schlenk manifold line. While attached to the inlet tube to maintain positive pressure of nitrogen, solvent (1 mL, 0.25 M total volume) was added to the vial *via* nitrogen-flushed syringe and the vial was evacuated and backfilled with nitrogen three times under vigorous stirring *via* a nitrogen inlet tube on a Schlenk manifold line. The preactivation solution was allowed to cool to rt, placed under a nitrogen atmosphere *via* a nitrogen inlet tube from the Schlenk manifold, and was transferred to the reagent solution *via* nitrogen-flushed syringe. The inlet tube was removed from the reagent solution and the cap was wrapped in parafilm and PVC tape. The vial was placed in a preheated aluminum reaction block at 80 °C for 24 h with stirring. The reaction solution was cooled to rt and dibenzyl ether (95.0 µL, 0.5 mmol, 1.0 equiv) was added to the reaction solution, a 50 µL aliquot was taken

and added to an NMR tube, then diluted with $CDCl_3$ (0.5 mL). ^1H NMR spectroscopy was used to determine the yield of the reaction.

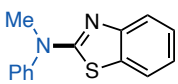
General Procedure P: P_2-*t*-Bu freebase promoted control reactions. An oven-dried 1-dram vial (ThermoFisher, C4015-1) was charged with a magnetic stir bar. For solid electrophiles and pronucleophiles, the electrophile (1.0 mmol, 2.0 equiv) and the pronucleophile (0.5 mmol, 1.0 equiv) were added to the vial. The vial was brought into a nitrogen-filled glovebox where solvent (2 mL, 0.25M) was added *via* syringe. For liquid electrophiles and pronucleophiles, the electrophile (1.0 mmol, 2.0 equiv) and the pronucleophile (0.5 mmol, 1.0 equiv) were added to the vial. P_2-*t*-Bu (2.0 M solution in THF, 0.375 mL, 0.75 mmol, 1.5 equiv) was added to the vial *via* syringe. The vial was sealed with a PTFE-lined cap (ThermoFisher, C4015-1A), removed from the glovebox and placed into a preheated aluminum reaction block at 80 °C with stirring for 24 h. The reaction solution was cooled to rt and dibenzyl ether (95.3 µL, 0.5 mmol, 1.0 equiv) was added to the reaction solution, a 50 µL aliquot was taken and added to an NMR tube, then diluted with $CDCl_3$ (0.5 mL). ^1H NMR spectroscopy was used to determine the yield of the reaction. The product was purified *via* silica gel chromatography for characterization.

ii. Reaction and characterization data

General description: For all of the substrates in this section, we use ^1H NMR yields to determine the efficacy of the prereagent salt system. In each case, we benchmarked the success of the prereagent against the use of commercial P_2-*t*-Bu setup using General Procedure P above. The substrates were subsequently isolated using General Procedure P to be characterized and confirm the product identity. The purification conditions and characterization data are given below.

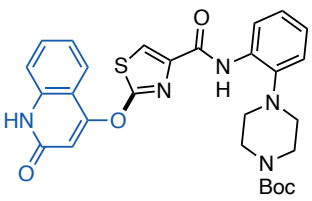


2-Methoxyquinoline (33). General Procedure N was followed using 2-bromoquinoline (104.1 mg, 0.5 mmol, 1.0 equiv), methanol (60.7 µL, 1.5 mmol, 3.0 equiv), P_2-*t*-Bu salt **A** (398.7 mg, 0.75 mmol, 1.5 equiv), epoxide **22** (141.2 mg, 0.75 mmol, 1.5 equiv) and DMF (2 mL) to provide 70% ^1H NMR yield. The reaction was repeated using commercial P_2-*t*-Bu (91% ^1H NMR yield). Following General Procedure P, for characterization purposes, the product was purified *via* silica gel chromatography using 10% EtOAc in hexanes to afford **33** as a yellow oil (68.4 mg, 0.40 mmol, 80% yield). **^1H NMR** (400 MHz, $CDCl_3$) δ 7.97 (d, *J* = 9.4 Hz, 1H), 7.87 (dd, *J* = 8.4, 1.5 Hz, 1H), 7.71 (dd, *J* = 8.0, 1.5 Hz, 1H), 7.63 (ddd, *J* = 8.5, 7.0, 1.5 Hz, 1H), 7.38 (ddd, *J* = 8.1, 7.0, 1.2 Hz, 1H), 6.91 (d, *J* = 8.8 Hz, 1H), 4.09 (s, 3H). Characterization data matches literature reports.[13]

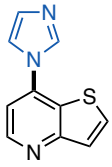


***N*-methyl-*N*-phenylbenzo[d]thiazol-2-amine (34).** General Procedure N was followed using 2-bromobenzothiazole (107.0 mg, 0.5 mmol, 1.0 equiv), *N*-methylaniline (108.3 µL, 1.0 mmol, 2.0 equiv), P_2-*t*-Bu salt **A** (398.7 mg, 0.75 mmol, 1.5 equiv), epoxide **22** (141.2 mg, 0.75 mmol, 1.5 equiv), and DMF (2 mL) to provide 65%

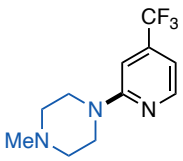
^{1}H NMR yield. The reaction was repeated using commercial P$_2$-*t*-Bu (72% ^{1}H NMR yield). Following General Procedure P, for characterization purposes, the product was purified *via* silica gel chromatography using 5% EtOAc in hexanes to afford **34** as a yellow oil (84.1 mg, 0.35 mmol, 70% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.62 (d, *J* = 7.5 Hz, 1H), 7.53 – 7.40 (m, 5H), 7.39 – 7.27 (m, 2H), 7.07 (t, *J* = 7.5 Hz, 1H), 3.65 (s, 3H). Characterization data matches literature reports.[14]



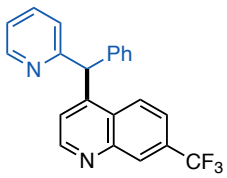
***tert*-Butyl 4-(2-(2-((2-oxo-1,2-dihydroquinolin-4-yl)oxy)thiazole-4-carboxamido)phenyl)piperazine-1-carboxyalte (35).** General Procedure N was followed on a 0.25 mmol scale using *tert*-butyl 4-(2-(2-bromothiazole-4-carboxamido)phenyl)piperazine-1-carboxylate[15] (116.8 mg, 0.25 mmol, 1.0 equiv), 4-hydroxyquinolin-2(1*H*)-one (80.6 mg, 0.5 mmol, 2.0 equiv), P$_2$-*t*-Bu salt **A** (199.4 mg, 0.375 mmol, 1.5 equiv), epoxide **22** (70.6 mg, 0.375 mmol, 1.5 equiv), and DMSO (1 mL) to provide 41% ^{1}H NMR yield. The reaction was repeated using commercial P$_2$-*t*-Bu (50% ^{1}H NMR yield). Following General Procedure P, for characterization purposes, the product was purified *via* silica gel chromatography using 100% EtOAc to afford **35** as a pale-yellow solid (72.9 mg, 0.13 mmol, 50% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 11.31 (s, 1H), 10.02 (s, 1H), 8.53 (d, *J* = 7.8 Hz, 1H), 8.00 (s, 1H), 7.94 (dd, *J* = 8.1, 1.4 Hz, 1H), 7.61 (ddd, *J* = 8.5, 7.3, 1.4 Hz, 1H), 7.41 (d, *J* = 8.2 Hz, 1H), 7.32 (ddd, *J* = 8.2, 7.2, 1.0 Hz, 1 H), 7.25 – 7.17 (m, 1H), 7.15 – 7.06 (m, 2H), 6.63 (s, 1H), 3.52 – 3.24 (m, 4H), 2.77 (t, 4.9 Hz, 4H), 1.44 (s, 9H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 168.7, 164.1, 161.3, 157.9, 154.5, 145.2, 141.5, 138.7, 132.8, 132.3, 125.6, 124.3, 123.1, 122.6, 120.4, 120.1, 119.8, 116.2, 114.5, 106.3, 79.8, 77.2, 52.1, 28.4. **IR** (neat) 3042, 1661, 1510, 1412, 1213, 756 cm^{-1}. **HRMS (DART)** $[M+H]^+$ calcd. for $[C_{28}H_{30}N_5O_5S]^+$ = 548.1968, found 548.1974. **MP** 239 – 244 °C.



7-(1*H*-Imidazol-1-yl)thieno[3,2-*b*]pyridine (36). General Procedure O was followed using P$_2$-*t*-Bu salt **A** (398.7 mg, 0.75 mmol, 1.5 equiv), epoxide **22** (141.2 mg, 0.75 mmol, 1.5 equiv), 7-chlorothieno[3,2-*b*]pyridine (84.8 mg, 0.5 mmol, 1.0 equiv), 1*H*-imidazole (68.1 mg, 1.0 mmol, 2.0 equiv), and DMF (2 mL) to provide 72% ^{1}H NMR yield. The reaction was repeated using commercial P$_2$-*t*-Bu (88% ^{1}H NMR yield). Following General Procedure P, for characterization purposes, the product was purified *via* silica gel chromatography using 5% MeOH in DCM to afford **36** as a pale-yellow solid (67.5 mg, 0.34 mmol, 68% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.80 (d, *J* = 5.1 Hz, 1H), 8.15 (s, 1H), 7.87 (d, *J* = 5.6 Hz, 1H), 7.69 (d, *J* = 5.5 Hz, 1H), 7.58 (s, 1H), 7.35 (s, 1H), 7.28 (d, *J* = 5.1 Hz, 2H). **^{13}C NMR** (101 Hz, $CDCl_3$) δ 159.1, 148.9, 139.6, 136.1, 131.5, 131.3, 126.2, 125.7, 118.2, 111.6. **IR** (neat) 3159, 3071, 1554, 1516, 1478, 1311, 1250, 1168, 1107, 1062, 1022, 812, 666 cm^{-1}. **HRMS (DART)** $[M+H]^+$ calcd. for $[C_{10}H_8N_3S]^+$ = 202.0467, found 202.0441. **MP** 153 – 159 °C.



1-Methyl-4-(4-(trifluoromethyl)pyridine-2-yl)piperazine (37). General Procedure N was followed using 2-chloro-4-(trifluoromethyl)pyridine (64.3 µL, 0.5 mmol, 1.0 equiv), *N*-methylpiperazine (110.9 µL, 1.0 mmol, 2.0 equiv), P_2-*t*-Bu salt **A** (398.7 mg, 0.75 mmol, 1.5 equiv), epoxide **22** (141.2 mg, 0.75 mmol, 1.5 equiv), and DMF (2 mL) to provide 98% ^{1}H NMR yield. The reaction was repeated using commercial P_2-*t*-Bu (97% ^{1}H NMR yield). Following General Procedure P, for characterization purposes, the product was purified *via* silica gel chromatography using 5% MeOH in DCM to afford **37** as a yellow solid (93.0 mg, 0.38 mmol, 76% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.32 (d, *J* = 5.1 Hz, 1H), 6.82 (s, 1H), 6.80 (d, *J* = 5.1 Hz, 1H), 3.65 (t, *J* = 5.1 Hz, 4H), 2.55 (t, *J* = 5.1 Hz, 4H), 2.38 (s, 3H). Characterization data matches literature reports.[16]



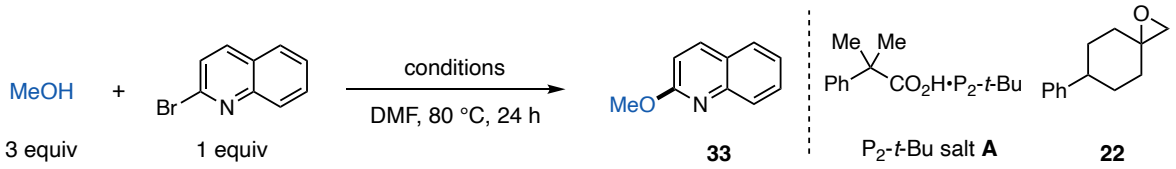
4-(Phenyl(pyridine-2-yl)methyl)-7-(trifluoromethyl)quinoline (38). General Procedure N was followed using 4-chloro-7-(trifluoromethyl)quinoline (115.8 mg, 0.5 mmol, 1.0 equiv), 2-benzylpyridine (169.2 mg, 1.0 mmol, 2.0 equiv), P_2-*t*-Bu salt **A** (398.7 mg, 0.75 mmol, 1.5 equiv), epoxide **22** (141.2 mg, 0.75 mmol, 1.5 equiv), and DMF (2 mL) to provide 65% ^{1}H NMR yield. The reaction was repeated using commercial P_2-*t*-Bu (63% ^{1}H NMR yield). Following General Procedure P, for characterization purposes, the product was purified *via* silica gel chromatography using 40% EtOAc in hexanes to afford **38** as a yellow solid (106.8 mg, 0.29 mmol, 58% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.91 (d, *J* = 4.5 Hz, 1H), 8.62 (d, *J* = 4.9 Hz, 1H), 8.42 (s, 1H), 8.08 (d, *J* = 8.8 Hz, 1H), 7.69 – 7.58 (m, 2H), 7.39-7.27 (m, 3H), 7.21 (ddd, *J* = 7.5, 4.9, 1.2 Hz, 1H), 7.18 – 7.13 (m, 2H), 7.08 – 6.99 (m, 2H), 6.39 (s, 1H). **^{19}F NMR** (376 MHz, $CDCl_3$) δ -62.64. **^{13}C NMR** (101 MHz, $CDCl_3$) δ 161.2, 151.6, 150.1, 148.8, 147.7, 140.3, 136.9, 130.8 (q, *J* = 32.9 Hz), 129.4, 129.0, 128.1 (q, *J* = 4.4 Hz), 127.4, 125.6, 124.0, 123.8 (q, *J* = 272.6 Hz), 123.5, 122.3 (q, *J* = 3.1 Hz), 122.1, 77.2, 55.5. **IR** (neat) 3052, 2925, 1598, 1433, 1335, 1123, 841, 738 cm^{-1}. **HRMS (DART)** $[M+H]^+$ calcd. for $[C_{22}H_{16}F_3N_2]^+$ = 365.1261, found 365.1280. **MP** 144 – 148 °C.

iii. Control Reactions

In this section we describe control reactions that support the P_2-*t*-Bu generated from the prereagent system is responsible for promoting the reaction and not background reactivity from any components or intermediates of the activation process. General Procedure Q below was followed for each of the controls. We also tested to see if the carboxylate anion is capable of catalyzing reactions by running reactions with only P_2-*t*-Bu salt **A**, with a variety of 1-phenylcyclopropanecarboxylate salts. Here, we tested different countercations (e.g., potassium and ammoniums) to survey salt solubility trends. Additionally, we tested if using only epoxide **22** could promote the reaction. We also considered the possibility that a carboxylate anion can attack the epoxide to generate an alkoxide intermediate that could serve as an active basic promoter. We tested this by mixing non-superbase carboxylate salts with epoxide **22** under reaction conditions.

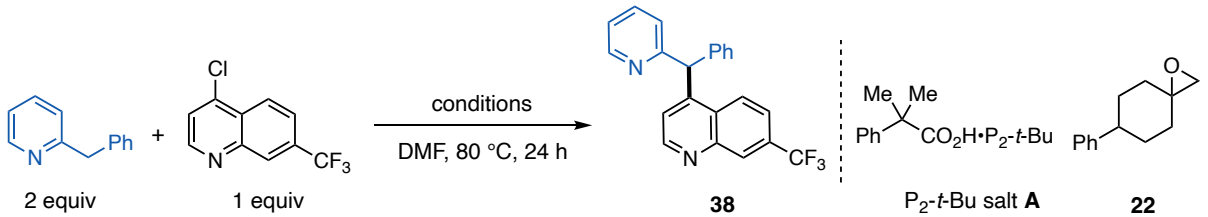
Overall, the results of the below control reactions are consistent with the active catalyst as P_2-*t*-Bu generated from the precatalyst system, as described below. Data for these experiments is provided in Tables S20 and S21 for substrates **33** and **34**, respectively.

General Procedure Q: Control reactions. In a nitrogen-filled glovebox, an oven-dried 1-dram vial (ThermoFisher, C4015-1) was charged with a magnetic stir bar, pronucleophile (0.10 mmol, 2.0 equiv), electrophile (0.05 mmol, 1.0 equiv), epoxide (0.075 mmol, 1.5 equiv), solvent (0.2 mL, 0.25 M), and the indicated basic additive (0.075 mmol, 1.5 equiv) in successive order. The vial was sealed with a PTFE-lined cap (ThermoFisher, C4015-1A), removed from the glovebox, and placed in a preheated aluminum reaction block at 80 °C with stirring for 24 h. The reaction solution was cooled to rt and dibenzyl ether (9.5 µL, 0.05 mmol, 1.0 equiv) internal standard was added to the reaction solution. A 50 µL aliquot was taken and added to an NMR tube, then diluted with 0.5 mL of $CDCl_3$. ^1H NMR spectroscopy was used to determine the yield of the product.



Entry	Conditions	Results
1	1.5 equiv P_2-*t*-Bu	91%
2	1.5 equiv P_2-*t*-Bu salt **A** + 1.5 equiv epoxide **22**	70%
3	1.5 equiv P_2-*t*-Bu salt **B** + 1.5 equiv epoxide **22**	65%
4[a]	1.5 equiv P_2-*t*-Bu salt **B** (aged 2h in 84% humidity) + 1.5 equiv epoxide **22**	62%
5	1.5 equiv P_2-*t*-Bu salt **A**	2%
6	1.5 equiv potassium 2-methyl-2-phenylpropionate	0%
7	1.5 equiv tetrabutylammonium acetate	5%
8	1.5 equiv epoxide **22**	0%
9	1.5 equiv potassium 2-methyl-2-phenylpropionate + 1.5 equiv epoxide **22**	52%
10	1.5 equiv tetrabutylammonium acetate + 1.5 eqiuv epoxide **22**	23%
11	No Base	0%

Table S20: Control reactions for the S_NAr reaction between 2-bromoquinoline and methanol. [a] Reaction utilizing P_2-*t*-Bu salt **B** that had been stored in a humidity chamber with set 84% humidity, see Section VIIIb for more details.

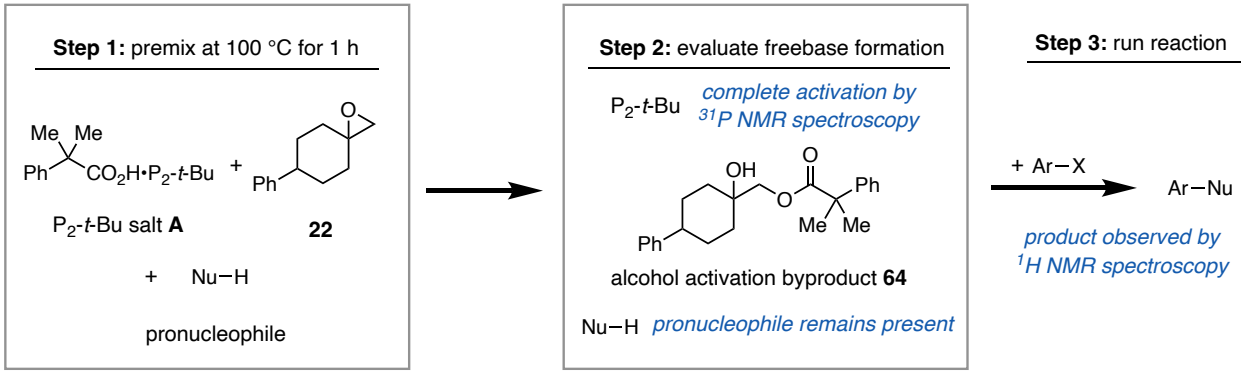


Entry	Conditions	Results
1	1.5 equiv P_2-*t*-Bu	63%

2	1.5 equiv P_2-*t*-Bu salt **A** + 1.5 equiv epoxide **22**	65%
3	1.5 equiv P_2-*t*-Bu salt **A**	0%
4	1.5 equiv potassium 2-methyl-2-phenylpropionate	0%
5	1.5 equiv tetrabutylammonium acetate	0%
6	1.5 equiv epoxide **22**	0%
7	1.5 equiv potassium 2-methyl-2-phenylpropionate + 1.5 equiv epoxide **22**	61%
8	1.5 equiv tetrabutylammonium acetate + 1.5 eqiuv epoxide **22**	0%
9	No Base	0%

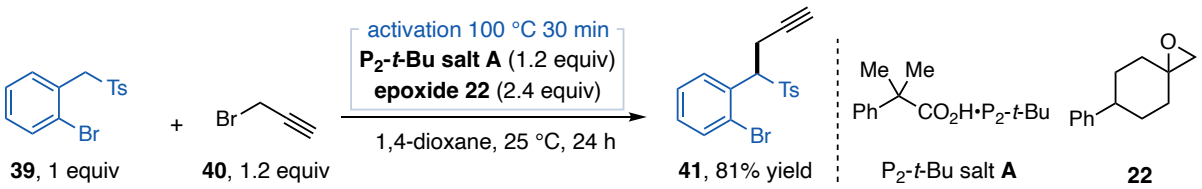
Table S21: Control reactions for the S_NAr reaction between 4-chloro-7-(trifluoromethyl)quinoline and 2-benzylpyridine.

We note that for Table S20, Entry 9 and Table S21, Entry 7 the combination of potassium 2-methyl-2-phenylpropionate and epoxide **22** is capable of promoting the respective S_NAr reaction; we speculate a potassium alkoxide intermediate is generated that promotes the reaction. However, the corresponding alkoxide intermediate of the prereagent system likely neutralizes the P_2-*t*-Bu to generate the freebase as the active catalyst. We supported this by conducting a control experiment where we preactivated P_2-*t*-Bu salt **A** with epoxide **22** in the presence of the pronucleophile (Step 1 in scheme below, MeOH for **33** and 2-benzylpyridine for **38**).



In each case, we observed complete generation of P_2-*t*-Bu from the prereagent system by ^{31}P NMR and ^{1}H NMR spectroscopy, indicating P_2-*t*-Bu is the base that forms in the mixture of these reagents. We then add the aryl electrophile to these activation solutions and observed 53% yield of **33** and 50% yield of **38**. These results are consistent with the P_2-*t*-Bu generated from prereagent activation being the active basic promoter in solution. Entries 5 and 9 from Table S20 were repeated for the rest of the substrates in Table S19 and we found that substrate **37** can be promoted by these conditions, albeit in reduced yield (65% and 53%, respectively).

c. Use of P_2-*t*-Bu salt A as a prereagent for enolate-type alkylation reaction



General Procedure R: Use of P_2-*t*-Bu salt A and epoxide 22. Note: A preactivation procedure is required as the alkylation reaction takes place at 25°C while P_2-*t*-Bu salt **A** with epoxide **22** does not activate quickly at 25°C. An oven-dried 1-dram vial (ThermoFisher, C4015-1) was charged with a magnetic stir bar, P_2-*t*-Bu salt **A** (63.8 mg, 0.12 mmol, 1.2 equiv), and epoxide **22** (45.2 mg, 0.24 mmol, 2.4 equiv). The vial was sealed with a PTFE-lined cap (ThermoFisher, C4015-1A) and evacuated then back filled with nitrogen three times *via* a nitrogen inlet tube on a Schlenk manifold line. 1,4-Dioxane (0.2 mL, 0.6 M with respect to P_2-*t*-Bu salt **A**) was added to the vial *via* nitrogen-flushed syringe. The manifold line was removed from the vial and the cap was wrapped in parafilm and PVC tape. The vial was placed in a preheated aluminum reaction block at 100 °C for 1 h with stirring.

Reaction Solution: a separate oven-dried 1-dram vial (ThermoFisher, C4015-1) was charged with a magnetic stir bar and 1-bromo-2-(tosylmethyl)benzene (32.5 mg, 0.1 mmol, 1.0 equiv). The vial was sealed with a PTFE-lined cap (ThermoFisher, C4015-1A) and evacuated then back filled with nitrogen three times *via* a nitrogen inlet tube on a Schlenk manifold line. 1,4-Dioxane (0.2 mL, 0.5 M with respect to limiting reagent) and propargyl bromide (80 wt. % in PhMe, contains 0.3% magnesium oxide as stabilizer, 21.2 µL, 0.12 mmol, 1.2 equiv) were added *via* nitrogen-flushed syringe. The vial containing the preactivation solution was removed from the reaction block, allowed to cool to rt and placed under a nitrogen atmosphere *via* a nitrogen inlet tube on a Schlenk manifold line. The preactivation solution was transferred to the starting material solution *via* nitrogen-flushed syringe. The preactivation vial was washed with an additional 0.1 mL (0.2 M total volume) of 1,4-dioxane and this was transferred to the reaction vial. The inlet tube was removed from the reaction vial and the cap was wrapped in parafilm and PVC tape. The vial was placed in a preheated aluminum reaction block at 25 °C with stirring for 24 h. The reaction solution was removed from the reaction block and 1,3,5-trimethoxybenzene (16.8 mg, 0.1 mmol, 1.0 equiv) was added to the reaction solution, a 50 µL aliquot was taken and added to an NMR tube, then diluted with $CDCl_3$ (0.5 mL). ^{1}H NMR spectroscopic analysis was used to determine the yield of the reaction (81% yield).

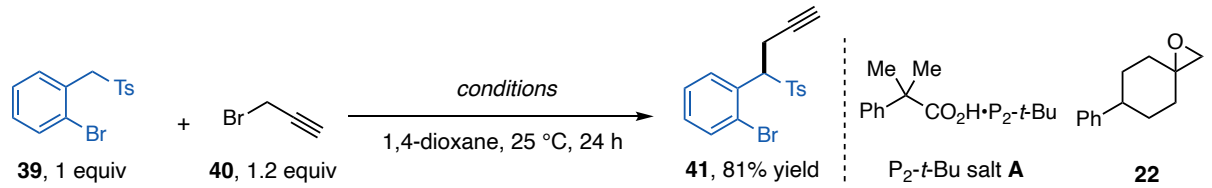
General Procedure S: Use of P_2-*t*-Bu freebase. Note: this procedure was adapted from a report using P_2-Et to promote this transformation and serves as a control for the prereagent method.[17] This procedure was also used to isolate the pure material for characterization purposes. An oven-dried 2-dram vial (ThermoFisher, C4015-2) was charged with a magnetic stir bar and 1-bromo-2-(tosylmethyl)benzene (162.6 mg, 0.5 mmol, 1.0 equiv). The vial was brought into a nitrogen-filled

glovebox where 1,4-dioxane (2.5 mL, 0.2 M), propargyl bromide (80 wt. % in PhMe, contains 0.3% magnesium oxide as stabilizer, 106.2 µL, 0.6 mmol, 1.2 equiv), and P_2-*t*-Bu (2.0 M solution in THF, 0.3 mL, 0.6 mmol, 1.2.0 equiv) were added to the solution. The vial was sealed with a PTFE-lined cap (ThermoFisher, C4015-1A), removed from the glovebox, and placed into a preheated aluminum reaction block at 25 °C with stirring for 24 h. The reaction vial was removed from the reaction block, 1,3,5-trimethoxybenzene (84.1 mg, 0.5 mmol, 1.0 equiv) was added to the solution and a 50 µL aliquot was taken and added to an NMR tube, then diluted with $CDCl_3$ (0.5 mL). For characterization purposes, the product was purified *via* silica gel chromatography using 10% EtOAc in hexanes to afford **41** as a yellow solid (157.1 mg, 0.43 mmol, 86% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.71 (d, *J* = 7.9 Hz, 1H), 7.56 – 7.37 (m, 4H), 7.26 – 7.16 (m, 3H), 5.13 (dd, *J* = 11.2 Hz, 4.2 Hz, 1H), 3.37 – 3.27 (m, 1H), 3.18 – 3.05 (m, 1H), 2.43 (s, 3H), 1.87 (t, *J* = 2.6 Hz, 1H). Characterization data matches literature reports.[17]

ii. Control Reactions

In this section we describe control reactions that support P_2-*t*-Bu generated from the prereagent salt is responsible for promoting the reaction and not background reactivity from any components or intermediates of the activation process. General Procedure T below was followed for each of the controls. We also tested to see if the carboxylate anion is capable of catalyzing reactions by running reactions with only P_2-*t*-Bu salt **A**, with a variety of 1-phenylcyclopropanecarboxylate salts. Here, we tested different countercations (e.g., potassium and ammoniums) to survey salt solubility trends. Additionally, we tested if using only epoxide **22** or byproduct **64** could promote the reaction. We also considered the possibility that a carboxylate anion can attack the epoxide to generate an alkoxide intermediate that could serve as an active base. We tested this by mixing non-superbase carboxylate salts with epoxide **22** under reaction conditions. For each indicated basic system other than the commercial freebase or precatalyst system, we observed 0% yield of the product. These results are consistent with the active basic promoter as P_2-*t*-Bu generated from the prereagent system. Data for these experiments is provided in Tables S20 for substrate **41**.

General Procedure T: Control reactions. In a nitrogen-filled glovebox, an oven-dried 1-dram vial (ThermoFisher, C4015-1) was charged with a magnetic stir bar, 1,4-dioxane (0.5 mL, 0.2 M), 1-bromo-2-(tosylmethyl)benzene (32.5 mg, 0.1 mmol, 1.0 equiv), propargyl bromide (80 wt. % in PhMe, contains 0.3% magnesium oxide as stabilizer, 21.2 µL, 0.12 mmol, 1.2.0 equiv), indicated basic additive (0.12 mmol, 1.2 equiv), and epoxide **22** (0.24 mmol, 2.4 equiv (unless excluded)) in successive order. The vial was sealed with a PTFE lined cap (ThermoFisher, C4015-1A), removed from the glovebox, and placed in a preheated aluminum reaction block at 25 °C with stirring for 24 h. 1,3,5-Trimethoxybenzene (16.8 mg, 0.1 mmol, 1.0 equiv) internal standard was added to the reaction solution and a 50 µL aliquot was taken and added to an NMR tube, then diluted with $CDCl_3$ (0.5 mL). ^{1}H NMR spectroscopy was used to determine the reaction yield.



Entry	Conditions	Results
1	1.2 equiv P_2-*t*-Bu	88%
2	1.2 equiv P_2-*t*-Bu salt **A** + 2.4 equiv epoxide **22** with preactivation	81%
3	1.2 equiv P_2-*t*-Bu salt **A**	0%
4	1.2 equiv potassium 2-methyl-2-phenylpropionate	0%
5	1.2 equiv tetrabutylammomnium acetate	0%
6	2.4 equiv epoxide **22**	0%
7	1.2 equiv byproduct **64**	0%
8	1.2 equiv potassium 2-methyl-2-phenylpropionate + 2.4 equiv epoxide **22**	0%
9[a]	1.2 equiv potassium 2-methyl-2-phenylpropionate + 2.4 equiv epoxide **22**	0%
10	1.2 equiv tetrabutylammonium acetate + 2.4 equiv epoxide **22**	0%

Table S22: Control reactions for the substitution reaction between 1-bromo-2-(tosylmethyl)benzene (**39**) and propargyl bromide (**40**). [a] A preactivation procedure was followed by stirring potassium 2-methyl-2-phenylpropionate and epoxide **22** for 1 h at 100 °C in 1,4-dioxane.

VII. Prereagent Application in Pd-Catalyzed Cross-Coupling Reactions

a) Reaction Scheme and General Procedures

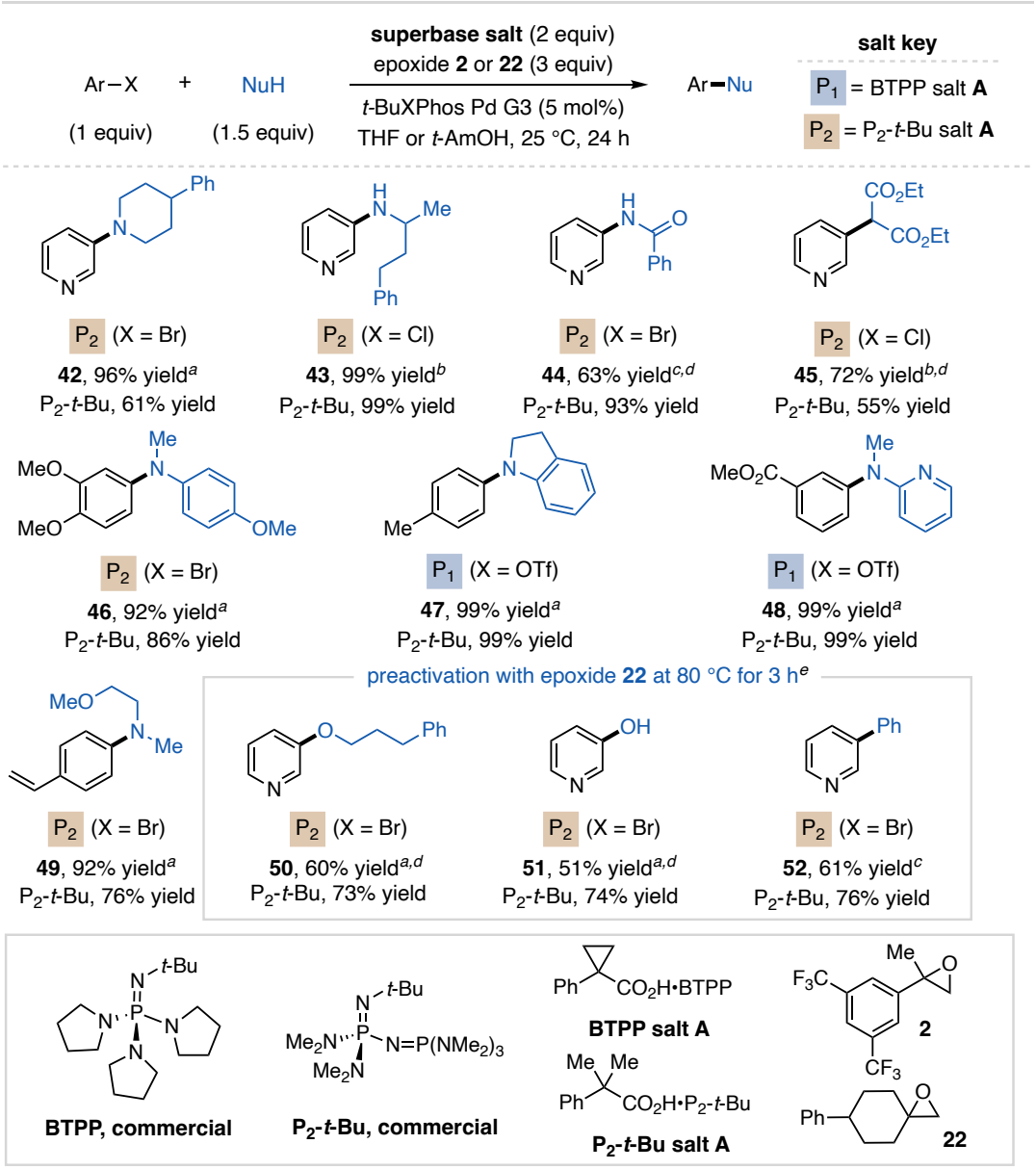


Table S23: Substrate table for Pd-catalyzed cross coupling using either BTPP salt **A** or P$_2$-*t*-Bu salt **A** with comparison to their corresponding freebases. All reactions that do not use a preactivation procedure use epoxide **2**. [a] THF used as solvent. [b] *tert*-Amyl alcohol used as solvent. [c] DMSO used as solvent. [d] *t*-BuBrettPhos Pd G3 (5 mol%) used as catalyst. [e] Pre-activation with equimolar P$_2$-*t*-Bu salt **A** and epoxide **22** at 100 °C for 3 h in PhMe.

General Procedure U: Prereagent salt and epoxide promoted reaction. An oven-dried 1-dram vial (ThermoFisher, C4015-1) was charged with a magnetic stir bar, prereagent salt (531.7 mg, 1.0

mmol, 2.0 equiv) and Pd precatalyst (0.025 mmol, 5 mol%). The vial was sealed with a PTFE-lined cap (ThermoFisher, C4015-1A), and evacuated then backfilled with nitrogen three times *via* a nitrogen inlet tube on a Schlenk manifold line. Solvent (2.5 mL, 0.2 M) was then added to the vial *via* nitrogen-flushed syringe. Aryl halide (0.5 mmol, 1.0 equiv), nucleophile (0.75 mmol, 1.5 equiv), then epoxide (1.5 mmol, 3 equiv) were added *via* nitrogen-flushed syringes. Note: aryl halide and/or nucleophile were charged to the vial prior to capping and nitrogen flushing if they are solids at rt. The reaction vial was then disconnected from the Schlenk line, sealed with parafilm wax, and placed in a preheated aluminum reaction block at 25 °C with stirring for 24 h. Dibromomethane (35 μL, 0.5 mmol, 1.0 equiv) was added to the reaction solution, a 50 μL aliquot was taken and added to an NMR tube, then diluted with $CDCl_3$ (0.5 mL). ^1H NMR spectroscopy was used to determine the yield of the reaction.

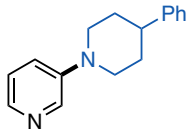
General Procedure V: Prereagent salt and epoxide promoted reaction with preactivation. An oven-dried 1-dram vial (ThermoFisher, C4015-1) was charged with a magnetic stir bar, prereagent salt (1.0 mmol, 2.0 equiv) and epoxide (1.5 mmol, 3 equiv). The vial was sealed with a PTFE-lined cap (ThermoFisher, C4015-1A) and evacuated then backfilled with nitrogen three times *via* a nitrogen inlet tube on a Schlenk manifold line. PhMe (2 mL, 0.5 M with respect to P_2-*t*-Bu salt **A**) was added *via* nitrogen-flushed syringe. The inlet tube was removed from the vial and the cap was wrapped in parafilm and PVC tape. The vial was placed in a preheated aluminum reaction block at 80 °C for 3 h with stirring.

Reagent solution. A separate oven-dried 1-dram vial (ThermoFisher, C4015-1) was charged with Pd precatalyst (0.025 mmol, 5 mol%). The vial was sealed with a PTFE-lined cap (ThermoFisher, C4015-1A), and evacuated then backfilled with nitrogen three times *via* a nitrogen inlet tube on a Schlenk manifold line. Solvent (0.5 mL, 0.2M total volume), aryl halide (0.5 mmol, 1.0 equiv), and nucleophile (0.75 mmol, 1.5 equiv) were added *via* nitrogen-flushed syringes and the solution was mixed thoroughly. Note: aryl halide and/or nucleophile were charged to the vial prior to capping and nitrogen flushing if they are solids at rt. The preactivation solution was allowed to cool to rt and was placed under a positive pressure of nitrogen *via* a nitrogen inlet tube from the Schlenk manifold. The reagent solution was transferred to the preactivation vial *via* nitrogen-flushed syringe. The inlet tube was removed from the reaction vial and the cap was wrapped in parafilm and PVC tape. The vial was placed into a preheated aluminum reaction block at 25 °C for 24 h with stirring. Dibromomethane (35 μL, 0.5 mmol, 1.0 equiv) was added to the reaction solution, a 50 μL aliquot was taken and added to an NMR tube, then diluted with $CDCl_3$ (0.5 mL). ^1H NMR spectroscopy was used to determine the yield of the reaction.

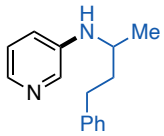
b) Reaction and characterization data

General description: For all of the substrates in this section, we use ^1H NMR yields to assess the efficacy of the precatalyst salt system. In each case, we benchmarked the success of the prereagent against the use of commercial BTPP or P_2-*t*-Bu using ^1H NMR yields. The reactions carried out

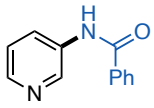
with BTPP or P_2-*t*-Bu were set up using General Procedure W below. The substrates were subsequently isolated using General Procedures U and V, depending on if preactivation was necessary, for characterization. To do this, the crude reactions mixtures were directly subjected to flash column chromatography to yield purified products. The purification conditions and characterization data are given below.



3-(4-phenylpiperidin-1-yl)pyridine (42). General Procedure U was followed using P_2-*t*-Bu salt **A** (531.6 mg, 1.0 mmol, 2.0 equiv), *t*-BuXPhos Pd G3 (19.9 mg, 0.025 mmol, 5 mol%), epoxide **2** (405.2 mg, 1.5 mmol, 3.0 equiv), 3-bromopyridine (48.2 µL, 0.5 mmol, 1.0 equiv), 4-phenylpiperidine (120.9 mg, 0.75 mmol, 1.5 equiv), and THF (2.5 mL, 0.2 M) to provide 96% ^{1}H NMR yield. The reaction was repeated using commercial P_2-*t*-Bu (61% ^{1}H NMR yield). Following General Procedure U, the product was purified *via* silica gel chromatography using 100% DCM to 5% MeOH/DCM to afford **42** as a pale-yellow solid (81.5 mg, 0.34 mmol, 68% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.42 (d, *J* = 2.9 Hz, 1H), 8.15 (d, *J* = 4.5 Hz, 1H), 7.38 (t, *J* = 7.5 Hz, 2H), 7.33 – 7.18 (m, 4H), 7.22 (dd, *J* = 8.5, 4.6 Hz, 1H), 3.88 (d, *J* = 11.9 Hz, 2H), 2.93 (td, *J* = 12.2, 2.9 Hz, 2H), 2.73 (tt, *J* = 11.9, 3.9 Hz, 1H), 2.08 – 1.87 (m, 4H). Characterization data matches literature reports.[18]

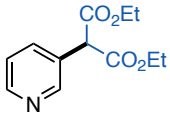


***N*-(4-phenylbutan-2-yl)pyridin-3-amine (43).** General Procedure U was followed using P_2-*t*-Bu salt **A** (531.6 mg, 1.0 mmol, 2.0 equiv), *t*-BuXPhos Pd G3 (19.9 mg, 0.025 mmol, 5 mol%), epoxide **2** (405.2 mg, 1.5 mmol, 3.0 equiv), 3-chloropyridine (47.5 µL, 0.5 mmol, 1.0 equiv), 4-phenylbutan-2-amine (121.6 µL, 0.75 mmol, 1.5 equiv), and *tert*-amyl alcohol (2.5 mL, 0.2 M) to provide 99% ^{1}H NMR yield. The reaction was repeated using commercial P_2-*t*-Bu (99% ^{1}H NMR yield). Following General Procedure U, the product was purified *via* silica gel chromatography using 1% NEt_3/DCM to 8% MeOH/1% NEt_3 in DCM to afford **43** as a brown oil (94.3 mg, 0.42 mmol, 84% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.00 (d, *J* = 2.9 Hz, 1H), 7.96 (d, *J* = 4.7 Hz, 1H), 7.33 (t, *J* = 7.4 Hz, 2H), 7.28 – 1.18 (m, 3H), 7.08 (dd, *J* = 8.3, 4.6 Hz, 1H), 6.83 – 6.76 (m, 1H), 3.57 – 3.44 (m, 2H), 2.77 (t, *J* = 7.8 Hz, 2H), 2.00 – 1.78 (m, 2H), 1.32 – 1.24 (m, 4H). Characterization data matches literature reports.[18]

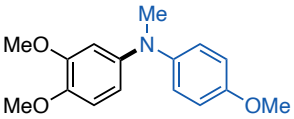


***N*-(pyridin-3-yl)benzamide (44).** General Procedure U was followed using P_2-*t*-Bu salt **A** (531.6 mg, 1.0 mmol, 2.0 equiv), *t*-BuBrettPhos Pd G3 (21.4 mg, 0.025 mmol, 5 mol%), epoxide **2** (405.2 mg, 1.5 mmol, 3.0 equiv), 3-bromopyridine (48.2 µL, 0.5 mmol, 1.0 equiv), benzamide (90.9 mg, 0.75 mmol, 1.5 equiv), and DMSO (2.5 mL, 0.2 M) to provide 63% ^{1}H NMR yield. The reaction was repeated using commercial P_2-*t*-Bu (93% ^{1}H NMR yield). Following General Procedure U, the product was purified *via* silica gel chromatography using 100% hexanes to 75% EtOAc in hexanes to afford **44** as a yellow solid (58.2 mg, 0.29 mmol, 58% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.48 (d, *J* = 2.6 Hz, 1H), 8.35 (s, 1H), 8.13 (d, *J* = 4.8

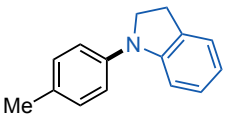
Hz, 1H), 8.09 (d, J = 8.5 Hz, 1H), 7.69 (d, J = 7.4 Hz, 2H), 7.39 – 7.31 (m, 1H), 7.26 (t, J = 7.6 Hz, 2H), 7.13 – 7.05 (m, 1H). Characterization data matches literature reports.[18]



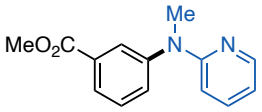
diethyl 2-(pyridin-3-yl)malonate (45). General Procedure U was followed using P_2-*t*-Bu salt **A** (531.6 mg, 1.0 mmol, 2.0 equiv), *t*-BuBrettPhos Pd G3 (21.4 mg, 0.025 mmol, 5 mol%), epoxide **2** (405.2 mg, 1.5 mmol, 3.0 equiv), 3-chloropyridine (47.5 µL, 0.5 mmol, 1.0 equiv), diethyl malonate (113.9 µL, 0.75 mmol, 1.5 equiv), and *tert*-amyl alcohol (2.5 mL, 0.2 M) to provide 72% ^{1}H NMR yield. The reaction was repeated using commercial P_2-*t*-Bu (55% ^{1}H NMR yield). Following General Procedure U, the product was purified *via* silica gel chromatography using 100% hexanes to 40% EtOAc in hexanes to afford **45** as a yellow oil (50.3 mg, 0.21 mmol, 42% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.60 – 8.53 (m, 2H), 7.83 (dd, J = 8.1, 2.2 Hz, 1H), 7.30 (dd, J = 8.0, 4.8 Hz, 1H), 4.61 (s, 1H), 4.26 – 4.15 (m, 4H), 1.25 (t, J = 7.1 Hz, 6H). Characterization data matches literature reports.[18]



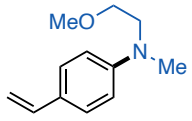
3,4-dimethoxy-*N*-(4-methoxyphenyl)-*N*-methylaniline (46). General Procedure U was followed using P_2-*t*-Bu salt **A** (531.6 mg, 1.0 mmol, 2.0 equiv), *t*-BuXPhos Pd G3 (19.9 mg, 0.025 mmol, 5 mol%), epoxide **2** (405.2 mg, 1.5 mmol, 3.0 equiv), 4-bromo-1,2-dimethoxybenzene (71.9 µL, 0.5 mmol, 1.0 equiv), 4-methoxy-*N*-methylaniline (102.9 mg, 0.75 mmol, 1.5 equiv), and THF (2.5 mL, 0.2 M) to provide 92% ^{1}H NMR yield. The reaction was repeated using commercial P_2-*t*-Bu (86% ^{1}H NMR yield). Following General Procedure U, the product was purified *via* silica gel chromatography using 40% EtOAc in hexanes to afford **46** as a brown solid (15.6 mg, 0.06 mmol, 12% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 6.95 (d, J = 8.9 Hz, 2H), 6.84 (d, J = 9.0 Hz, 2H), 6.79 (d, J = 8.5 Hz, 2H), 6.56 – 6.45 (m, 2H), 3.85 (s, 3H), 3.79 (s, 3H), 3.77 (s, 3H), 3.23 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 154.8, 149.6, 144.3, 143.9, 143.6, 122.3, 114.7, 112.3, 111.4, 105.1, 56.5, 55.9, 55.7, 41.2. **IR** (neat) 2922, 1598, 1505, 1460, 1231, 1131, 1024, 947, 839, 770 cm^{-1}. **HRMS (DART)** $[M+H]^+$ *m/z* calcd. for $[C_{16}H_{20}NO_3]^+$ = 274.1438, found 274.1451. **MP** 90 – 94 °C.



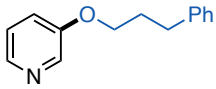
1-(*p*-tolyl)indoline (47). General Procedure U was followed using BTPP salt **A** (118.7 mg, 0.5 mmol, 2.0 equiv), *t*-BuXPhos Pd G3 (9.9 mg, 0.0125 mmol, 5 mol%), epoxide **2** (202.6 mg, 0.75 mmol, 3.0 equiv), *p*-tolyl trifluoromethanesulfonate (44.7 µL, 0.25 mmol, 1.0 equiv), indoline (42.0 µL, 0.375 mmol, 1.5 equiv), and THF (1.3 mL, 0.2 M) to provide 99% ^{1}H NMR yield. The reaction was repeated using commercial BTPP (99% ^{1}H NMR yield). Following General Procedure U, the product was purified *via* silica gel chromatography using 10% EtOAc in hexanes to afford **47** as a white solid (41.5 mg, 0.20 mmol, 80% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.21 – 7.13 (m, 5H), 7.08 (d, J = 4.2 Hz, 2H), 6.79 – 6.71 (m, 1H), 3.94 (t, J = 8.4 Hz, 2H), 3.14 (t, J = 8.4 Hz, 2H), 2.36 (s, 3H). Characterization data matches literature reports.[19]



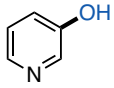
methyl 3-(methyl(pyridin-2-yl)amino)benzoate (48). General Procedure U was followed using BTPP salt **A** (118.7 mg, 0.5 mmol, 2.0 equiv), *t*-BuXPhos Pd G3 (9.9 mg, 0.0125 mmol, 5 mol%), epoxide **2** (202.6 mg, 0.75 mmol, 3.0 equiv), methyl 3-(((trifluoromethyl)sulfonyl)oxy)benzoate (71.1 mg, 0.25 mmol, 1.0 equiv), *N*-methylpyridin-2-amine (38.5 µL, 0.375 mmol, 1.5 equiv), and THF (1.3 mL, 0.2 M) to provide 99% ^{1}H NMR yield. The reaction was repeated using commercial BTPP (99% ^{1}H NMR yield). Following General Procedure U, the product was purified *via* silica gel chromatography using 50% EtOAc in hexanes to afford **48** as a yellow oil (51.1 mg, 0.21 mmol, 84% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.24 (d, *J* = 4.9 Hz, 1H), 7.94 (s, 1H), 7.89 – 7.80 (m, 1H), 7.49 – 7.42 (m, 2H), 7.38 – 7.32 (m, 1H), 6.66 (dd, *J* = 7.2, 5.0 Hz, 1H), 6.57 (d, *J* = 8.7, 1H), 3.91 (s, 3H), 3.49 (s, 3H). Characterization data matches literature reports.[19]



***N*-(2-methoxyethyl)-*N*-methyl-4-vinylaniline (49).** General Procedure U was followed using P_2-*t*-Bu salt **A** (531.6 mg, 1.0 mmol, 2.0 equiv), *t*-BuXPhos Pd G3 (19.9 mg mg, 0.025 mmol, 5 mol%), epoxide **2** (405.2 mg, 1.5 mmol, 3.0 equiv), 4-bromostyrene (65.4 µL, 0.5 mmol, 1.0 equiv), 2-methoxy-*N*-methylethan-1-amine (81.6 µL, 0.75 mmol, 1.5 equiv), and THF (2.5 mL, 0.2 M) to provide 92% ^{1}H NMR yield. The reaction was repeated using commercial P_2-*t*-Bu (76% ^{1}H NMR yield). Following General Procedure U, the product was purified *via* silica gel chromatography using 20% EtOAc in hexanes to afford **49** as a yellow oil (36.1 mg, 0.19 mmol, 38% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.31 (d, *J* = 8.6 Hz, 2H), 6.75 – 6.59 (m, 3H), 5.55 (d, *J* = 17.6 Hz, 1H), 5.03 (d, *J* = 11.0 Hz, 1H), 3.61 – 3.47 (m, 4H), 3.37 (s, 3H), 3.01 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 149.1, 136.7, 127.4, 126.1, 112.1, 109.3, 70.3, 59.2, 52.5, 39.1. **IR** (neat) 2883, 1616, 1518, 1367, 1192, 1115, 817 cm^{-1}. **HRMS (DART)** $[M+H]^+$ calcd. for $[C_{12}H_{18}NO]^+$ = 192.1383, found 192.1386.



3-(3-phenylpropoxy)pyridine (50). General Procedure V was followed using P_2-*t*-Bu salt **A** (531.6 mg, 1.0 mmol, 2.0 equiv), epoxide **22** (282.4 mg, 1.5 mmol, 3.0 equiv), THF (2 mL), *t*-BuBrettPhos Pd G3 (21.4 mg, 0.025 mmol, 5 mol%), 3-bromopyridine (48.2 µL, 0.5 mmol, 1.0 equiv), 3-phenylpropan-1-ol (102.0 µL, 0.75 mmol, 1.5 equiv), and THF (0.5 mL, 0.2 M total volume) to provide 60% ^{1}H NMR yield. The reaction was repeated without a preactivation protocol using commercial P_2-*t*-Bu (73% ^{1}H NMR yield). Following General Procedure V, the product was purified *via* silica gel chromatography using 100% hexanes to 40% EtOAc in hexanes to afford **50** as a yellow oil (30.0 mg, 0.14 mmol, 28% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.32 (d, *J* = 2.6 Hz, 1H), 8.21 (d, *J* = 4.4 Hz, 1H), 7.39 – 7.29 (m, 2H), 7.29 – 7.17 (m, 5H), 4.00 (t, *J* = 6.2 Hz, 2H), 2.82 (t, *J* = 7.6 Hz, 2H), 2.13 (p, *J* = 6.6 Hz, 3H). Characterization data matches literature reports.[18]



pyridin-3-ol (51). General Procedure V was followed using P_2-*t*-Bu salt **A** (531.6 mg, 1.0 mmol, 2.0 equiv), epoxide **22** (282.4 mg, 1.5 mmol, 3.0 equiv), THF (2 mL), *t*-BuBrettPhos Pd G3 (21.4 mg, 0.025 mmol, 5 mol%), 3-bromopyridine (48.2 µL, 0.5

mmol, 1.0 equiv), water (13.5 µL, 0.75 mmol, 1.5 equiv), and THF (0.5 mL, 0.2 M total volume) to provide 51% ^{1}H NMR yield. The reaction was repeated without a preactivation protocol using commercial P$_2$-*t*-Bu (74% ^{1}H NMR yield). The crude ^{1}H NMR spectrum matches with commercial pyridin-3-ol, and therefore this product was not isolated from reaction conditions. The characteristic peak at 8.29 ppm (d, 1H) was used to assess ^{1}H NMR yields of this product (see Figure S16 below).

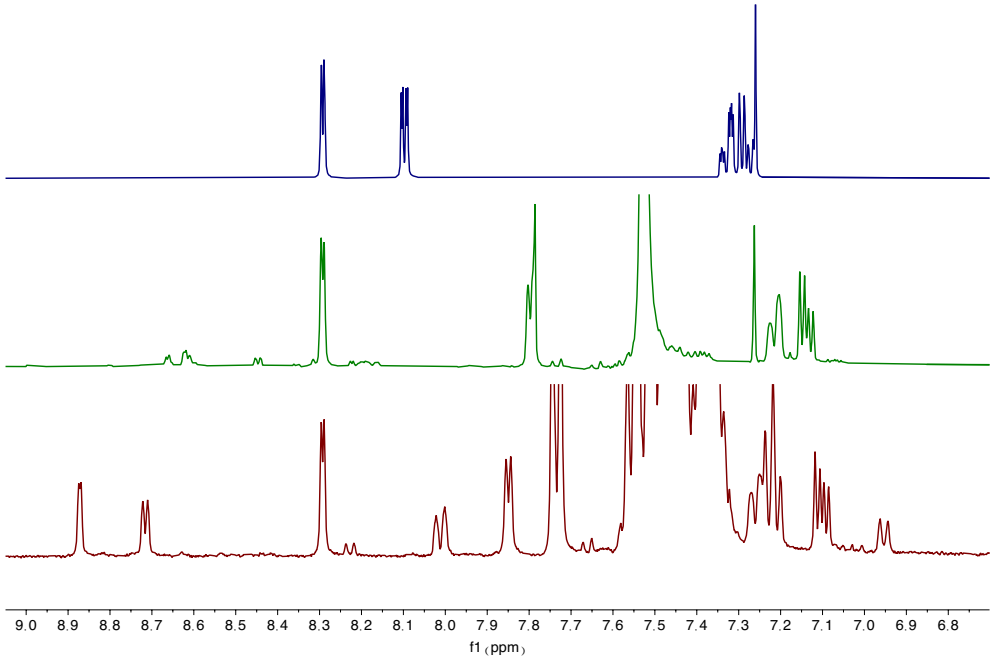
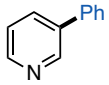


Figure S16. Stacked ^{1}H NMR spectrum of commercial 3-hydroxypyridine (top) compared to crude reaction mixtures using P$_2$-*t*-Bu freebase (middle) and prereagent system (bottom). The peak at 8.29 ppm was used to assess the yield of the reaction. For the freebase and prereagent system spectra, the peak at 8.10 ppm shifts due to a different protonation state of the product in the presence of differing amounts of base.



3-phenylpyridine (52). General Procedure V was followed using P$_2$-*t*-Bu salt **A** (531.6 mg, 1.0 mmol, 2.0 equiv), epoxide **22** (282.4 mg, 1.5 mmol, 3.0 equiv), THF (2 mL), *t*-BuXPhos Pd G3 (19.9 mg, 0.025 mmol, 5 mol%), 3-bromopyridine (48.2 µL, 0.5 mmol, 1.0 equiv), 4,4,5,5-tetramethyl-2-phenyl-1,3,2-dioxaborolane (153.1 mg, 0.75 mmol, 1.5 equiv), water (18.0 µL, 1.0 mmol, 2.0 equiv), and DMSO (0.5 mL, 0.2 M total volume) to provide 61% ^{1}H NMR yield. The reaction was repeated without a preactivation protocol using commercial P$_2$-*t*-Bu (76% ^{1}H NMR yield). The crude ^{1}H NMR spectrum matches with commercial 3-phenylpyridine, and therefore this product was not isolated from reaction conditions. The characteristic peak at 8.86 ppm (s, 1H) was used to assess ^{1}H NMR yields of this product (see Figure S17 below)

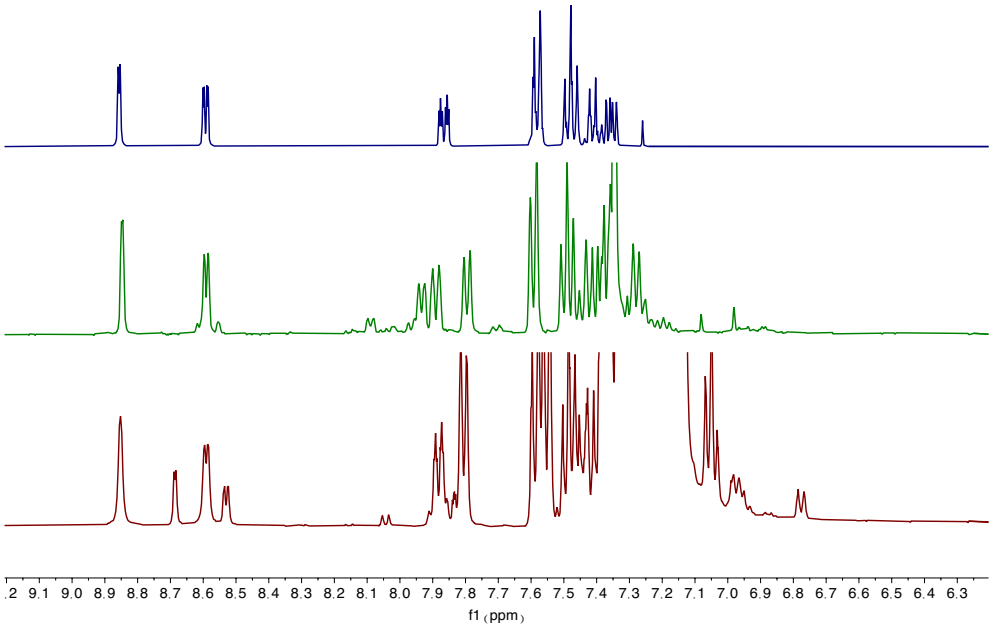


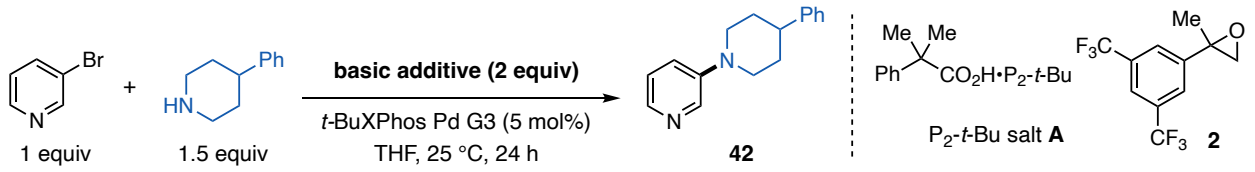
Figure S17. Stacked ^{1}H NMR spectrum of commercial 3-phenylpyridine (top) compared to crude reaction mixtures using P_2-*t*-Bu freebase (middle) and prereagent system (bottom). The peak at 8.86 ppm was used to assess the yield of the reaction.

c) Control Reactions

In this section we describe control reactions that support P_2-*t*-Bu generated from the prereagent salt is responsible for promoting the reactions and not background reactivity from any components or intermediates of the activation process. General Procedure W below was followed for each of the controls. We also tested to see if the carboxylate anion is capable of catalyzing reactions by running reactions with only P_2-*t*-Bu salt **A**, with a variety of 1-phenylcyclopropanecarboxylate salts. Here, we tested different countercations (e.g., potassium and ammoniums) to survey salt solubility trends. Additionally, we tested if using only epoxide **2** could promote the reaction. We also considered the possibility that a carboxylate anion can attack the epoxide to generate an alkoxide intermediate that could serve as an active basic catalyst. We tested this by mixing non-superbase carboxylate salts with epoxide **2** under reaction conditions. For each indicated basic system other than the commercial freebase or precatalyst system, we observed 0% yield of the product. These results are consistent with the active basic promoter being P_2-*t*-Bu generated from the prereagent system. Data for these experiments is provided in Table S24 for substrate **42**.

General Procedure W: Control reactions. In a nitrogen-filled glovebox, an oven-dried 1-dram vial (ThermoFisher, C4015-1) was charged with a magnetic stir bar, indicated basic additive (0.2 mmol, 2.0 equiv), epoxide **2** (if applicable) (0.3 mmol, 3 equiv), *t*-BuXPhos Pd G3 (4.0 mg, 0.005 mmol, 5 mol%), 3-bromopyridine (9.6 µL, 0.1 mmol, 1.0 equiv), 4-phenylpiperidine (24.2 mg,

0.15 mmol, 1.5 equiv), and THF (0.5 mL, 0.2 M). The vial was sealed with a PTFE-lined cap (ThermoFisher, C4015-1A) and removed from the glovebox. The reaction vial was then placed in a preheated aluminum reaction block at 25 °C for 24 h with stirring. Dibromomethane (7 µL, 0.1 mmol, 1.0 equiv) was added to the reaction solution, a 50 µL aliquot was taken and added to an NMR tube, then diluted with $CDCl_3$ (0.5 mL). ^1H NMR spectroscopy was used to determine the yield of the reaction.



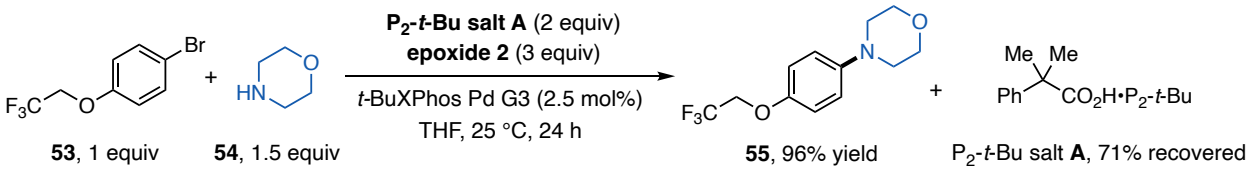
Entry	Conditions	Results
1	2 equiv P_2-*t*-Bu	61%
2	2 equiv P_2-*t*-Bu salt **A** + 3 equiv epoxide **2**	96%
3	2 equiv P_2-*t*-Bu salt **A** + 3 equiv epoxide **22**	2%
4[a]	2 equiv P_2-*t*-Bu salt **A** + 3 equiv epoxide **22** with preactivation	99%
5[b]	2 equiv P_2-Et	83%
6	2 equiv P_2-*t*-Bu salt **A**	0%
7	2 equiv potassium 2-methyl-2-phenylpropionate	0%
8	2 equiv tetrabutylammonium acetate	0%
9	3 equiv epoxide **2**	0%
10	2 equiv potassium 2-methyl-2-phenylpropionate + 3 equiv epoxide **2**	0%
11	2 equiv tetrabutylammonium acetate + 3 equiv epoxide **2**	0%
12	No Base	0%

Table S24: Control reactions for the Pd-catalyzed C–N coupling reaction of 3-bromopyridine and 4-phenylpiperidine with various basic promoters. [a] General Procedure V was followed for preactivation protocol. [b] This work is follows a previous literature report[18] where P_2-Et was used and this base is included here for comparison.

Next, conditions from Entries 6 and 10 were repeated for substrates **43**-**52** to assess whether or not background processes can promote other amination reactions. For Entry 6, only substrate **47** can be promoted by this condition to 41% yield, which is significantly lower than the yield with the prereagent system (99% yield). For entry 10, substrates **44** and **47** can be promoted by potassium 2-methyl-2-phenylpropionate plus epoxide **2** to 79% and 62%, respectively; we speculate a potassium alkoxide intermediate is generated that promotes the reaction. However, the corresponding alkoxide intermediate of the precatalyst system likely neutralizes the P_2-*t*-Bu immediately to generate the freebase as the active basic promoter as previously described and studied for P_2-*t*-Bu salt **A** promoted addition and S_NAr reactions. Overall, the results for substrates **42**-**52** are consistent with the P_2-*t*-Bu generated from the precatalyst system being the active basic promoter for these reactions.

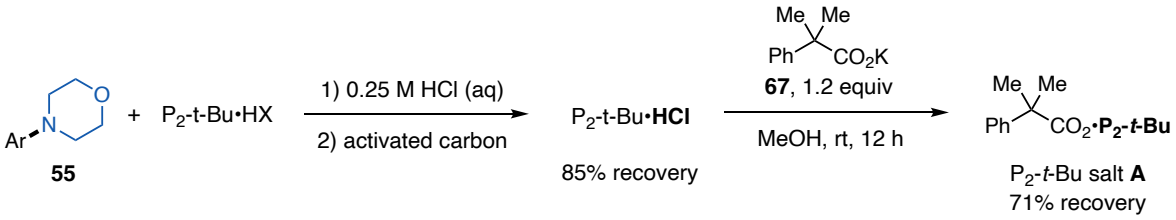
d) Scaled-up Pd-catalyzed cross-coupling for the recovery and regeneration P_2-*t*-Bu salt A

i. Isolation and recovery of P_2-*t*-Bu salt A from a reaction mixture



53, 1 equiv **54**, 1.5 equiv **55**, 96% yield P_2-*t*-Bu salt **A**, 71% recovered

Isolation of 4-(4-(2,2,2-trifluoroethoxy)phenyl)morpholine and P_2-*t*-Bu•HCl: An oven-dried 25 mL round bottom flask was charged with a magnetic stir bar, *t*-BuXPhos Pd G3 (19.9 mg, 0.025 mmol, 2.5 mol%), P_2-*t*-Bu salt **A** (1.063 g, 2.0 mmol, 2.0 equiv), and 1-bromo-4-(2,2,2-trifluoroethoxy)benzene (255.0 mg, 1.0 mmol, 1.0 equiv). The flask was sealed with a rubber septum (Chemglass, CG-3022-06) and evacuated then backfilled with nitrogen three times *via* a nitrogen inlet tube on a Schlenk manifold line. To the flask, THF (5.0 mL, 0.2 M), morpholine (131.2 µL, 1.5 mmol, 1.5 equiv), and epoxide **2** (810.4 mg, 3.0 mmol, 3.0 equiv) were added *via* nitrogen-flushed syringes. The inlet tube was removed, and the flask was placed in a 25 °C oil bath with stirring for 24 h. THF was then removed *in vacuo* and the crude material was transferred to a separatory funnel using 10 mL of diethyl ether. The solution was washed with 0.25M aqueous HCl (3 x 5 mL), water (5 mL) and brine (5 mL) and was dried over Na_2SO_4. The combined organic layer was then concentrated *in vacuo*. The crude organic material was purified by column chromatography (100% hexanes to 20% EtOAc/hexanes to yield pure 4-(4-(2,2,2-trifluoroethoxy)phenyl)morpholine (**55**) as a pale-orange solid (250.0 mg, 0.96 mmol, 96% isolated yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 6.94– 6.84 (m, 4H), 4.30 (q, *J* = 8.2 Hz, 2H), 3.89 – 3.83 (m, 4H), 3.11 – 3.04 (m, 4H). Characterization data matches literature reports.[20]



55 85% recovery P_2-*t*-Bu salt **A** 71% recovery

Recovery of P_2-*t*-Bu salt A through anion metathesis: The combined aqueous layers from the above workup were added to a round bottom flask containing a magnetic stir bar and activated carbon (~3 g) then stirred for 12 h at rt. The aqueous solution was filtered through a bed of celite then concentrated *in vacuo* (aq $NaHCO_3$ was added to the receiving flask to neutralize the condensed solution) to collect P_2-*t*-Bu•HCl (686.8 mg, 1.70 mmol, 85% recovery). The collected material was added to a 25 mL round bottom flask with MeOH (10 mL) and a magnetic stir bar. Potassium 2-methyl-2-phenylpropanoate (**68**, 404.4 mg, 2.0 mmol, 1.2 equiv) was added and the mixture was stirred for 12 h at rt. The MeOH was removed *in vacuo* and the crude salt mixture was suspended in ethyl acetate and filtered through a fine fritted funnel. The ethyl acetate solution

was concentrated *in vacuo* and dried under vacuum. The pale-yellow oil was placed in a -30 °C freezer overnight to crystallize. The resulting P_2-*t*-Bu salt **A** crystals were collected *via* vacuum filtration with a fine fritted funnel and cold diethyl ether. The crystallization and filtration process were repeated to yield white powdery crystals of P_2-*t*-Bu salt **A** (754.9 mg, 1.42 mmol, 71% regeneration). Characterization data matches P_2-*t*-Bu salt **A** synthesized in Section IId.

ii. Use of recovered P_2-*t*-Bu salt A in a Pd-catalyzed cross-coupling reaction

In this section, we use the recovered P_2-*t*-Bu salt **A** from above in the Pd-catalyzed cross-coupling of 1-bromo-4-(2,2,2-trifluoroethoxy)benzene (**53**) and morpholine (**54**) (Figure S18) following General Procedure U. The results demonstrate there is no difference in reactivity between P_2-*t*-Bu salt **A** synthesized from the commercial freebase and P_2-*t*-Bu salt **A** recovered using the anion metathesis procedure above.

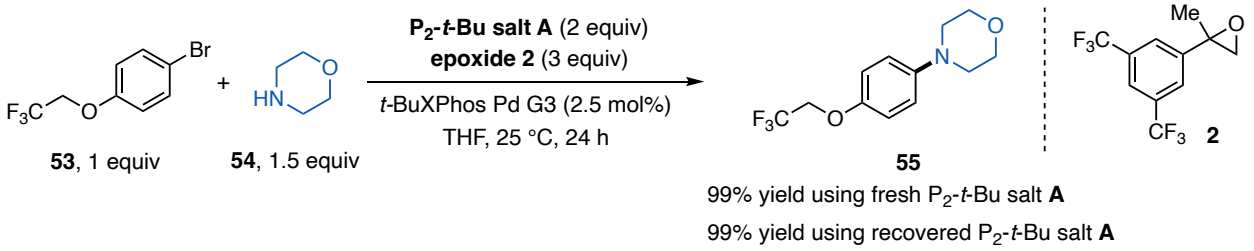
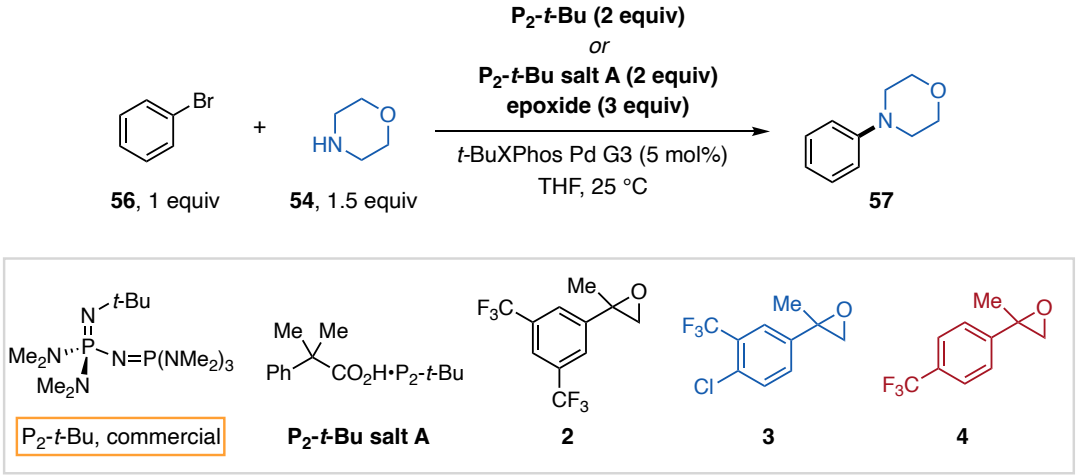


Figure S18. Use of fresh and recovered P_2-*t*-Bu salt **A** in the Pd-catalyzed cross-coupling of 1-bromo-4-(2,2,2-trifluoroethoxy)benzene (**53**) and morpholine (**54**).

e) Pd-Catalyzed Cross-Coupling of Bromobenzene and Morpholine Using Various Epoxides



General Procedure X: reaction profiles for the coupling of bromobenzene and morpholine. In a nitrogen-filled glovebox, an oven-dried 1-dram vial (ThermoFisher, C4015-1) was charged with a magnetic stir bar, *t*-BuXPhos Pd G3 (4.0 mg, 0.005 mmol, 5 mol%), 1,3,5-

trimethoxybenzene (16.8 mg, 0.1 mmol, 1.0 equiv, used as an internal NMR standard), THF (0.5 mL, 0.2 M), bromobenzene (16.8 mg, 0.1 mmol, 1.0 equiv), morpholine (13.1 µL, 0.15 mmol, 1.5 equiv), then P_2-*t*-Bu (2.0 M THF solution, 50 µL, 0.2 mmol, 2.0 equiv) or P_2-*t*-Bu salt **A** (106.3 mg, 0.2 mmol, 2.0 equiv) and epoxide (0.3 mmol, 3 equiv). The vial was capped with a PTFE-lined cap (ThermoFisher, C4015-1A) and homogenized. Immediately after, a 50 µL aliquot was taken and added to an NMR tube, then diluted with $CDCl_3$ (0.5 mL) and recorded as time point 0 min. The reaction vial was then removed from the glovebox and placed in a preheated reaction block at 25 °C with stirring. Aliquots (50 µL) were taken at various time points; each aliquot was added to an NMR tube, then diluted with $CDCl_3$ (0.5 mL). ^{1}H NMR spectroscopy was used to determine the amount of product at each time point. The amount of product versus time is graphed below. The ^{1}H NMR peaks for the product are consistent with commercial *N*-phenylmorpholine (**57**) and therefore the product was not isolated for these studies. To determine ^{1}H NMR yields for the below studies, the characteristic peak at 4.13 ppm (t, 4H) was used.

	Time	Base system (% yield of 57)			
Entry	**(min)**	**P_2-*t*-Bu**	**P_2-*t*-Bu salt A + 2**	**P_2-*t*-Bu salt A + 3**	**P_2-*t*-Bu salt A + 4[a]**
1	0	11	0	0	0
2	5	41	22	6	2
3	10	64	49	16	2
4	15	94	71	25	3
5	20	100	85	37	6
6	40	-	-	62	11
7	60	100	100	80	20
8	120	-	-	100	39

Table S25: ^{1}H NMR yields over time using P_2-*t*-Bu salt **A** with epoxides **2**, **3**, and **4** as compared to using commercial P_2-*t*-Bu. [a] This reaction reaches 86% yield after 7 h.

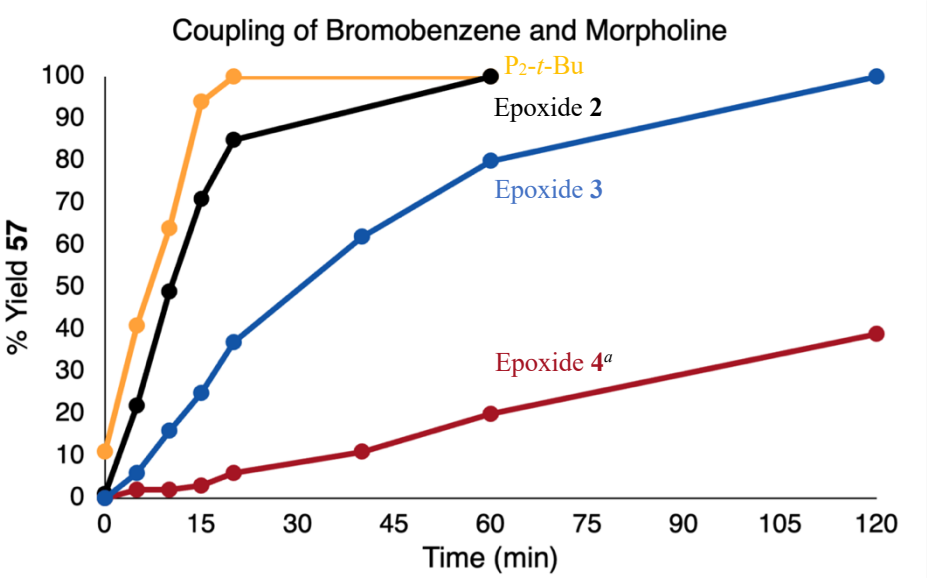


Figure S19. Reaction profiles for the coupling of bromobenzene and morpholine using P_2-*t*-Bu (yellow) and epoxides **2** (black curve), **3** (blue curve), and **4** (red curve) with P_2-*t*-Bu salt **A**. [a] This reaction reaches 86% yield after 24 h.

f) Base-sensitive amine coupling enabled by epoxide-controlled base release

During our studies on Pd-catalyzed cross-coupling reactions using the P_2-*t*-Bu prereagent system, we noticed numerous cases where use of the prereagent gives a higher yield than use of the commercial freebase. Table S26 shows examples of this trend with substrates **58-61**. For each substrate, epoxides **2-4** were examined and the best yield is shown in Table S26 below. The ^{1}H NMR yields for substrates in Table S24 are the average of two runs. Additionally, we lowered the Pd catalyst loading from 5 mol% to 2.5 mol% and observed a more pronounced effect. We hypothesize that as the concentration of Pd is lowered, the reaction becomes more sensitive to the amount of base present. To elucidate the nature of this effect, we selected substrate **61** to investigate further, discussed below. For each substrate shown in this section, Entries 6 and 10 from Table S24 were repeated to support that P_2-*t*-Bu generated from the prereagent is the active base promoter in solution.

i. Reaction scheme and General Procedures

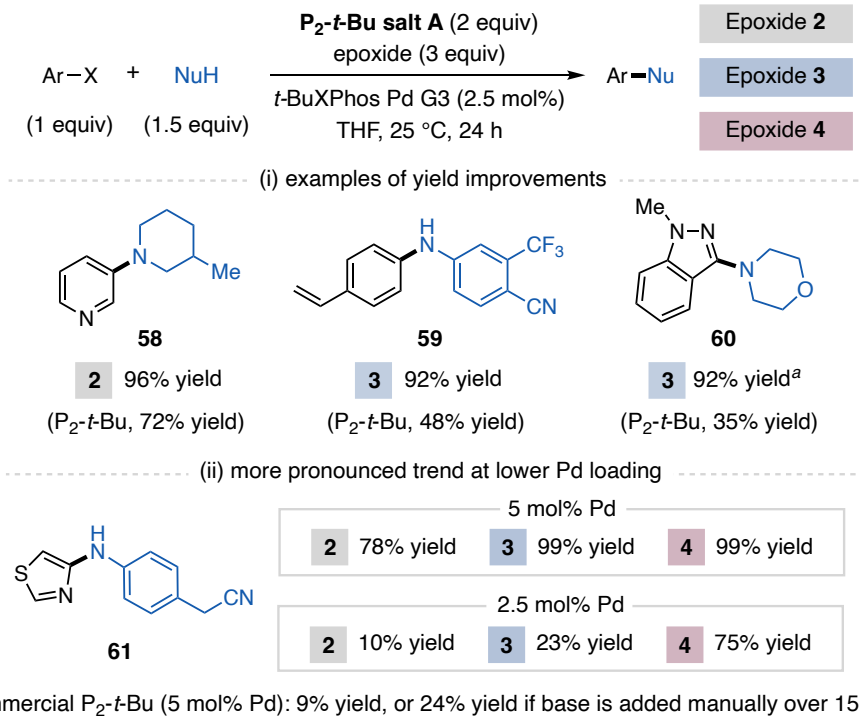
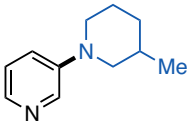


Table S26. Examples of yield improvements by using the P_2-*t*-Bu prereagent salt system over commercial P_2-*t*-Bu in Pd-catalyzed cross-coupling reactions. [a] Reaction uses 5 mol% Pd.

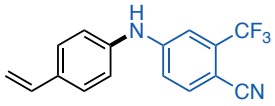
ii. Reaction and characterization data

General description: For all of the substrates in this section, we use ^{1}H NMR yields. In each case, we benchmarked the success of the prereagent against the use of commercial P_2-*t*-Bu. All reactions were carried out using General Procedure W in a nitrogen-filled glovebox and the crude reaction mixtures were subsequently directly subjected to flash column chromatography to yield purified products. Each substrate in Table S26 was reproduced on a 0.5 mmol scale using a Schlenk line procedure described in General Procedure U.

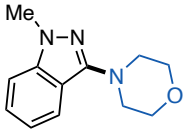


3-(3-methypiperidin-1-yl)pyridine (58). General Procedure W was followed using P_2-*t*-Bu salt **A** (531.7 mg, 1.0 mmol, 2.0 equiv), *t*-BuXPhos Pd G3 (9.9 mg, 0.0125 mmol, 2.5 mol%), epoxide **2** (405.3 mg, 1.5 mmol, 3.0 equiv), 3-

bromopyridine (48.2 µL, 0.5 mmol, 1.0 equiv), 3-methylpiperidine (88.0 µL, 0.75 mmol, 1.5 equiv), and THF (2 mL, 0.25 M) to provide 96% ^{1}H NMR yield. The reaction was repeated using commercial P$_2$-*t*-Bu (72% ^{1}H NMR yield) and on a 0.5 mmol scale using P$_2$-*t*-Bu Salt **A** with General Procedure U (99% ^{1}H NMR yield). Following General Procedure W, the product was purified *via* silica gel chromatography using 20% EtOAc in hexanes to afford **58** as a yellow oil (76.6 mg, 0.43 mmol, 86% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.30 (s, 1H), 8.03 (d, J = 4.4 Hz, 1H), 7.22 – 7.08 (m, 2H), 3.66 – 3.51 (m, 2H), 2.68 (t, J = 11.8 Hz, 1H), 2.37 (t, J = 10.3 Hz, 1H), 1.92 – 1.59 (m, 4H), 1.13 – 0.98 (m, 1H), 0.95 (d, J = 6.8 Hz, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 147.7, 140.0, 139.0, 123.5, 122.7, 57.0, 49.3, 32.8, 30.8, 25.2, 19.6. **IR** (neat) 2926, 2864, 1586, 1494, 1420, 1249, 1138 796, 712 cm^{-1}. **HRMS (ESI)** $[M+H]^+$ calcd. for $[C_{11}H_{17}N_2]^+$ = 177.1392, found 177.1386.

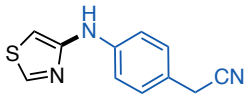


2-(trifluoromethyl)-4-((4-vinylphenyl)amino)benzonitrile (59). General Procedure W was followed using P$_2$-*t*-Bu salt **A** (531.7 mg, 1.0 mmol, 2.0 equiv), *t*-BuXPhos Pd G3 (9.9 mg, 0.0125 mmol, 2.5 mol%), epoxide **3** (354.9 mg, 1.5 mmol, 3.0 equiv), 4-bromostyrene (65.4 µL, 0.5 mmol, 1.0 equiv), 4-(methylamino)-2-(trifluoromethyl)benzonitrile (139.6 mg, 0.75 mmol, 1.5 equiv), and THF (2 mL, 0.25 M) to provide 93% ^{1}H NMR yield. The reaction was repeated using commercial P$_2$-*t*-Bu (48% ^{1}H NMR yield) and on a 0.5 mmol scale using P$_2$-*t*-Bu Salt **A** with General Procedure U (91% ^{1}H NMR yield). Following General Procedure W, the product was purified *via* silica gel chromatography using 20% EtOAc in hexanes to afford **59** as a yellow solid (60.5 mg, 0.21 mmol, 42% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.61 (d, J = 8.5 Hz, 1H), 7.44 (d, J = 8.1 Hz, 2H), 7.23 (d, J = 2.2 Hz, 1H), 7.14 (d, J = 8.1 Hz, 2H), 7.09 (dd, J = 8.5, 2.2 Hz), 6.71 (dd, J = 17.6, 10.8 Hz, 6.26 (bs, 1H), 5.73 (d, J = 17.6 Hz, 1H), 5.26 (d, J = 10.9 Hz, 1H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 148.0, 138.3, 136.3, 135.8, 134.7, 134.6, 127.7, 122.4 (q, J = 273.2 Hz), 121.9, 116.5, 116.4, 113.8, 112.6 (q, J = 4.9 Hz), 98.5. **^{19}F NMR** (376 MHz, $CDCl_3$) δ -62.37. **IR** (neat) 3319, 2926, 2226, 1591, 1529, 1350, 1176, 1130, 1040, 827 cm^{-1}. **HRMS (ESI)** $[M+H]^+$ calcd. for $[C_{16}H_{12}F_3N_2]^+$ = 289.0953, found 289.0947. MP 151 – 154 °C.



4-(1-methyl-1*H*-indazol-3-yl)morpholine (60). General Procedure W was followed using P$_2$-*t*-Bu salt **A** (531.7 mg, 1.0 mmol, 2.0 equiv), *t*-BuXPhos Pd G3 (19.9 mg, 0.025 mmol, 5 mol%), epoxide **3** (354.9 mg, 1.5 mmol, 3.0 equiv), 3-bromo-1-methyl-1*H*-indazole (105.5 mg, 0.5 mmol, 1.0 equiv), morpholine (65.3 µL, 0.75 mmol, 1.5 equiv), and THF (2 mL, 0.25 M) to provide 92% ^{1}H NMR yield. The reaction was repeated using commercial P$_2$-*t*-Bu (35% ^{1}H NMR yield) and on a 0.5 mmol scale using P$_2$-*t*-Bu Salt **A** with General Procedure U (99% ^{1}H NMR yield). Following General Procedure W, the product was purified *via* silica gel chromatography using 20% EtOAc in hexanes to afford **60** as a yellow oil (22.6 mg, 0.11 mmol, 22% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.71 (d, J = 8.2 Hz, 1H), 7.37 (t, J = 7.8 Hz, 1H), 7.30 – 7.25 (m, 1H), 7.05 (t, J = 8.5 Hz, 1H), 3.98 – 3.93 (m, 4H), 3.93 (s, 3H), 3.49 – 3.41 (m, 4H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 151.4, 142.1, 126.7, 121.2,

118.8, 115.2, 109.1, 66.9, 50.5, 35.1. **IR** (neat) 2964, 2915, 2855, 1740, 1616, 1523, 1447, 1249, 1122, 750 cm^{-1}. **HRMS (ESI)** $[M+H]^+$ calcd. for $[C_{12}H_{16}N_3O]^+$ = 218.1293, found 218.1288.



2-(4-(thiazol-4-ylamino)phenyl)acetonitrile (61). General Procedure U was followed using P_2-*t*-Bu salt **A** (265.8 mg, 0.5 mmol, 2.0 equiv), *t*-BuXPhos Pd G3 (9.9 mg, 0.0125 mmol, 5 mol%), epoxide **4** (151.6 mg, 0.75 mmol, 3.0 equiv), 4-bromothiazole (22.3 µL, 0.25 mmol, 1.0 equiv), 2-(4-aminophenyl)acetonitrile (49.6 mg, 0.375 mmol, 1.5 equiv), and THF (1.25 mL, 0.2 M) to provide **61** in 99% yield. The reaction was repeated using commercial P_2-*t*-Bu (9% ^{1}H NMR yield) and on a 0.5 mmol scale using P_2-*t*-Bu Salt **A** with General Procedure U (92% ^{1}H NMR yield). Following General Procedure U, the product was purified *via* preparatory thin layer chromatography using 5% EtOAc in DCM to afford **61** as a grey solid (21.4 mg, 0.1 mmol, 40% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.64 (s, 1H), 7.25 (d, *J* = 9.3 Hz, 2H), 7.14 (d, *J* = 8.4 Hz, 2H), 6.68 (bs, 1H), 6.51 (s, 1H), 3.70 (s, 2H). Characterization data matches literature reports.[21]

iii. Additional investigation with substrate 61

We selected substrate **61** to investigate further to elucidate the nature of the yield improvements using the prereagent system over commercial P_2-*t*-Bu. Direct use of commercial P_2-*t*-Bu results in 9% yield of **61** with observation of a black precipitate form inside of the vial, suggesting the Pd catalyst may not be stable towards excess base under these conditions. For comparison, we conducted the model reaction with manual slow addition of commercial P_2-*t*-Bu over 15 minutes, resulting in an increased yield of 24% **61**, suggesting the reaction is sensitive to the initial concentration of base. We next investigated use of P_2-*t*-Bu salt **A** with epoxides **2**-**4** at 5 mol% and 2.5 mol% Pd loading (Table S26ii). Here, we observe that slower activating epoxides result in higher yield of **61**, a trend that is amplified at lower catalyst loading. These results suggest that the ability to slowly generate base in solution, enabled by the prereagent system, is key to obtain high yield. To understand the effect of high concentration of base on the reaction, we conducted further control studies, described below.

iv. Control studies for the effect of base on the individual reaction components

Here, we tested to see if P_2-*t*-Bu engages in undesired background processes with any of the reaction components that could lead to reaction inhibition. We tested for this by subjecting 4-bromothiazole and 2-(4-aminophenyl)acetonitrile to P_2-*t*-Bu to observe their stability over time.

General Procedure Y: Mixing starting materials with excess P_2-*t*-Bu. In a nitrogen-filled glovebox, an oven-dried 1-dram vial (ThermoFisher, C4015-1) was charged with a magnetic stir bar, 4-bromothiazole (4.5 µL, 0.05 mmol, 1.0 equiv) and/or 2-(4-aminophenyl)acetonitrile (9.9 mg, 0.075 mmol, 1.5 equiv), P_2-*t*-Bu (2.0 M THF solution, 50 µL, 0.2 mmol, 2.0 equiv), and THF

(0.25 mL, 0.2 M). The vial was sealed with a PTFE-lined cap (ThermoFisher, C4015-1A) and removed from the glovebox. The reaction vial was then placed in a preheated aluminum reaction block at 25 °C with magnetic stirring for 24 h. A 1 M solution of aqueous HCl (100 µL, 1.0 mmol) and dibenzyl ether (9.5 µL, 0.05 mmol, 1.0 equiv) were added to the reaction solution, a 50 µL aliquot was taken and added to an NMR tube, then diluted with $CDCl_3$ (0.5 mL). ^1H NMR spectroscopy was used to determine the mass balance of the starting materials and yield of potential products.

Stability 4-bromothiazole in the presence of P_2-*t*-Bu:

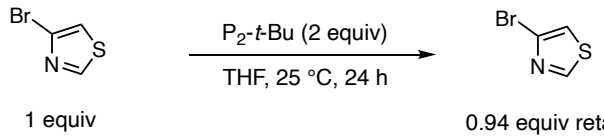


Figure S20. Treatment of 4-bromothiazole with P_2-*t*-Bu under pseudo-reaction conditions.

Results: Stirring 4-bromothiazole with P_2-*t*-Bu over the course of 24 h results in near complete retention of the starting material. This indicates this aryl halide is not sensitive to P_2-*t*-Bu alone.

Stability of 2-(4-aminophenyl)acetonitrile in the presence of P_2-*t*-Bu:

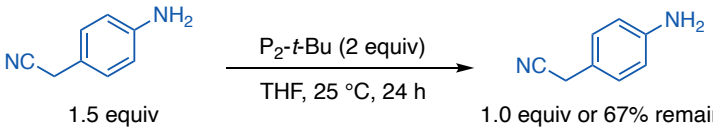


Figure S21. Treatment of 2-(4-aminophenyl)acetonitrile with P_2-*t*-Bu under pseudo-reaction conditions.

Results: Stirring 2-(4-aminophenyl)acetonitrile with P_2-*t*-Bu over the course of 24 h results in the loss of 33% of the aniline mass balance. This indicates this aniline is sensitive to the presence of P_2-*t*-Bu in solution.

Stability 4-bromothiazole + 2-(4-aminophenyl)acetonitrile in the presence of P_2-*t*-Bu:

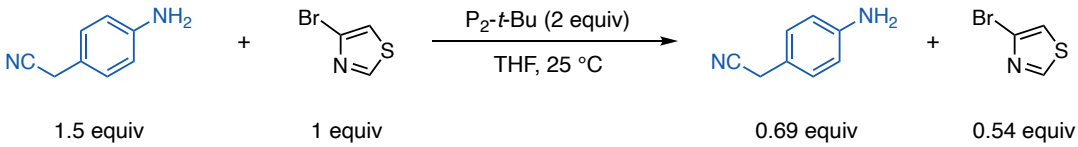


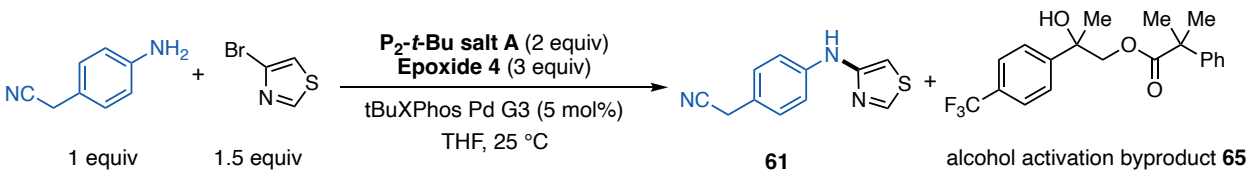
Figure S22. Treatment of 4-bromothiazole and 2-(4-aminophenyl)acetonitrile with P_2-*t*-Bu under pseudo-reaction conditions.

Results: Stirring both 4-bromothiazole and 2-(4-aminophenyl)acetonitrile together with P_2-*t*-Bu over the course of 24 h resulted in loss of mass balance of both substrates. This indicates the substrate combination of this reaction is sensitive to the presence of P_2-*t*-Bu in solution.

v. Reaction profile of the coupling reaction using P_2-*t*-Bu salt A and epoxide 4

Here, we provide a reaction profile for the formation of **61** using P_2-*t*-Bu salt **A** and epoxide **4**, also tracking the amount of activation byproduct **65** that is formed (Table S27, Figure S23). We observe similar rates of formation of **61** and the of alcohol activation byproduct **65**, aside from a short induction period in the beginning for the formation of **65**.

General Procedure Z: Reaction profile using P_2-*t*-Bu salt A and epoxide 4. In a nitrogen-filled glovebox, an oven-dried 1-dram vial (ThermoFisher, C4015-1) was charged with a magnetic stir bar, *t*-BuXPhos Pd G3 (4.0 mg, 0.005 mmol, 5 mol%), 1,3,5-trimethoxybenzene (16.8 mg, 0.1 mmol, 1.0 equiv, to serve as an internal NMR standard), THF (0.5 mL, 0.2 M), 4-bromothiazole (8.9 µL, 0.1 mmol, 1.0 equiv), 2-(4-aminophenyl)acetonitrile (19.8 mg, 0.15 mmol, 1.5 equiv), P_2-*t*-Bu salt **A** (106.3 mg, 0.2 mmol, 2.0 equiv) and epoxide **4** (60.7 mg, 0.3 mmol, 3 equiv) in successive order. The vial was capped with a PTFE-lined cap (ThermoFisher, C4015-1A) and homogenized. Immediately after, a 50 µL aliquot was taken and added to an NMR tube, then diluted with $CDCl_3$ (0.5 mL) as time point 0 min. The reaction vial was then placed in a preheated aluminum reaction block at 25 °C for 24 h with stirring. Aliquots (50 µL) were taken at various time points and each aliquot was added to an NMR tube, then diluted with $CDCl_3$ (0.5 mL). ^{1}H NMR spectroscopy was used to determine the amount of product and alcohol activation byproduct at each time point. The amount of these products versus time is graphed below.



Time (h)	% yield 61	% yield 65
0	0	0
0.15	2	3
0.5	3	13
1	11	26
2	29	46
3	44	64
4.5	60	81
6	75	97
7.5	88	109

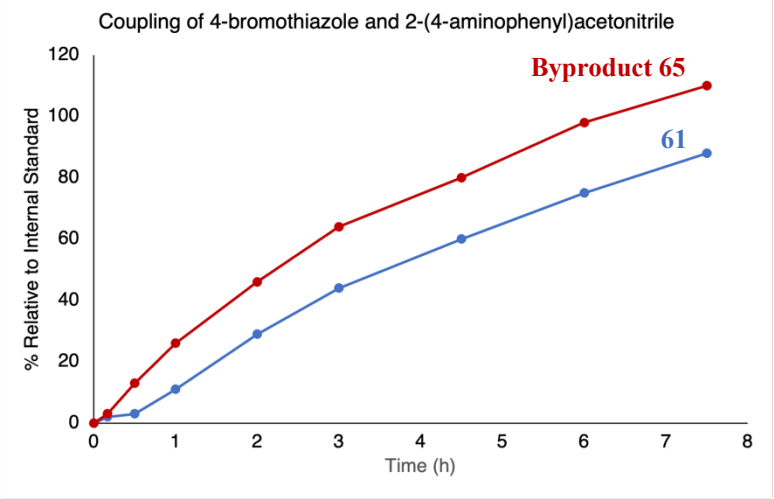


Table S27 and Figure S23: Reaction profile for the Pd-catalyzed coupling reaction of 4-bromothiazole and 2-(4-aminophenyl)acetonitrile with P_2-*t*-Bu salt **A** and epoxide **4**. Blue profile corresponds to the yield of **61** and red corresponds to the yield of byproduct **65**, relative to 1,3,5-trimethoxybenzene internal standard. The product yield was observed to be 95% at 23 h with 1.20 equiv byproduct generated.

Summary discussion: Based on the studies described here, we found that the amine, aryl halide and Pd catalyst all possess base sensitivity which may lead to low yield. The results of the above time study show a direct correlation between the rate of epoxide opening and the reaction yield. This suggests that with the prereagent system using epoxide **4**, P_2-*t*-Bu is consumed as it is generated. Collectively, the results described in Sections ii-v provide support for the hypothesis that the prereagent system can controllably introduce base into solution to facilitate coupling reactions that are sensitive to high concentration of base.

VIII. Long-Term Stability of Superbase Carboxylate Salts

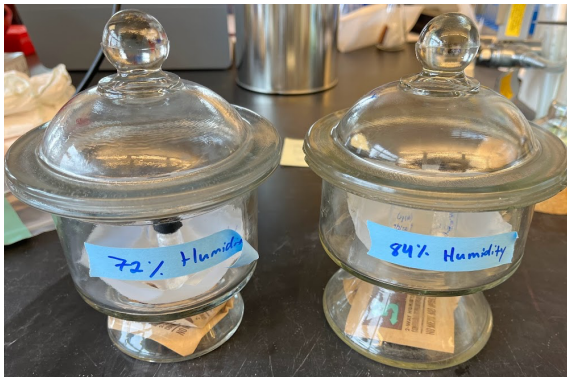
This section describes experiments and studies performed to test the long-term stability of the superbase carboxylate salts under various environments. In order to confirm that the salts do not lose their reactivity benchmark use of them are shown in Tables S5, S6, S16, S17, and S20.

a) Longevity studies with BTPP salt A and P_2-*t*-Bu salt A

In order to test the long-term stability of the phosphazene carboxylate salts, we prepared two 20 mL scintillation vials containing 2 g of either BTPP salt **A** or P_2-*t*-Bu salt **A**. These vials were stored in a benchtop desiccator for six months, and three times per week the vials were uncapped and the salts were mixed around open to air with a spatula to mimic heavy usage. After six months, no change was observed in the physical properties of these salts or their performance in reactions. Use of these aged salts in reaction applications are shown in throughout Sections IV and VI.

b) Observation of moisture sensitivity of superbase carboxylate salts

During our studies, the superbase carboxylate salts have been stable over long periods of time in a benchtop desiccator. However, upon exposure to high humidity (greater than 60%), we observe the formation of droplets when the salts are on weigh paper as the salts began absorbing water. When stored over long periods of time open-to-air in this environment, the salts became wet semi-solids. It is important to note that this work was conducted in Fort Collins, Colorado, where the atmosphere is typically under 50% humidity. We therefore investigated the salt sensitivity to greater humidity levels, detailed here. In order to accomplish this, we used humidity control packets that can maintain 72% (Boveda 72% RH size 8) and 84% (Boveda 84% RH size 8) humidity and placed them in a glass chamber sealed with high-vacuum grease and kept on the benchtop (see images below).



We placed a hygrometer inside each of these chambers to confirm the humidity levels. To test how long a salt can maintain its physical properties as a free-flowing powder in the humid environment, it was placed into the humidity chamber on a piece of weigh paper. Every five minutes, the chamber was opened, and the salt was mixed around with a metal spatula to mimic use in the humid environment. When BTPP salt **A** and P_2-*t*-Bu salt **A** were tested in this fashion, we found that they each lasted for fifteen minutes before they became sticky and clumped together and formed droplets on the weigh paper, becoming challenging to handle. We note that the absorption of water by the salts is exacerbated on weigh paper and as such we recommend storage in glass containers while not in use. These findings motivated us to develop solutions to overcome humidity sensitivity. For reference, we stored commercial P_2-*t*-Bu (in its crystalline form) in the 84% humidity chamber and after five minutes the base clumped together and formed droplets on

the weigh paper, indicative of moisture absorption. ^{31}P and ^{1}H NMR spectra of this material are shown in Figure S24. Additionally, we stored BTPP open-to-air for two weeks and observed significant formation of the phosphoramide through reaction with CO_2 in the air, the primary decomposition pathway of BTPP (Figure S25).

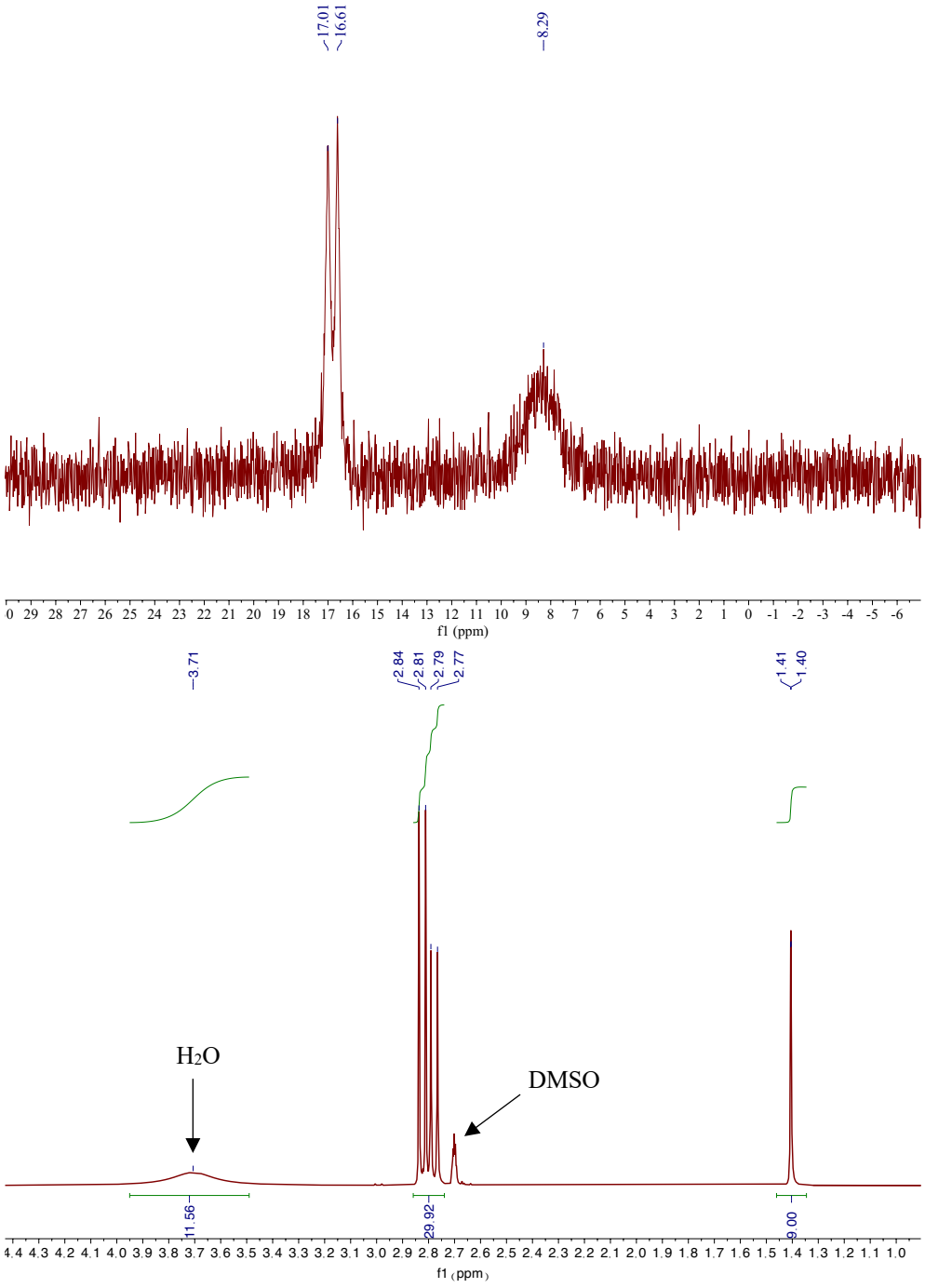


Figure S24. ^{31}P (top) and ^{1}H NMR (bottom) spectra for commercial P_2-*t*-Bu that has been in 84% humidity for 8 h. The ^{31}P NMR spectrum shows peaks at 16 and 7.5 ppm which are similar to

protonated P_2-*t*-Bu, indicating that it has absorbed water. The broad singlet at 3.71 ppm on the ^{1}H NMR spectrum corresponds to the absorbed water.

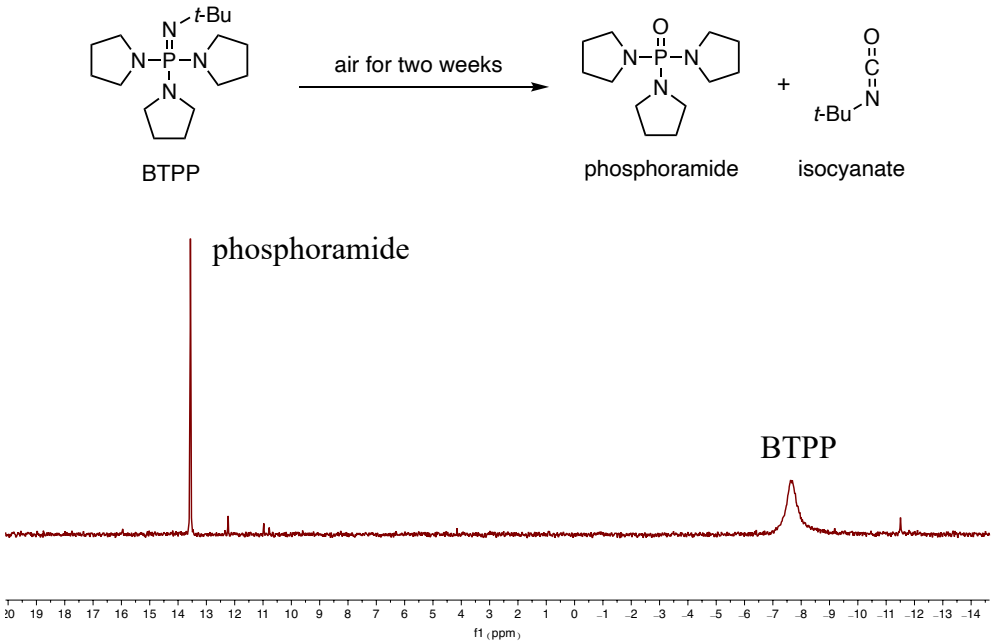


Figure S25. ^{31}P NMR spectrum of commercial BTPP left open-to-air for two weeks. Peak at -8 ppm corresponds to the freebase and the peak at 13.5 ppm corresponds to the phosphoramide resulting from reaction with CO_2

c) Solutions to moisture sensitivity of superbase carboxylate salts

To address this limitation, we developed two solutions to enable the use of superbase carboxylate salts in more humid environments. First, we developed a restoration process that allows for the facile removal of the absorbed water to re-obtain the crystalline solid *via* an azeotrope with PhMe where the water is removed by rotary evaporation (Figure S26). For the second solution, changes in the carboxylate structure led to superbase salts that are far less hygroscopic and last for longer periods of time in the humidity chambers (Figure S29). These salts are shown to be equally effective as the freshly synthesized salts, as seen in Sections IVaiii and VIaiii. Ultimately, we recommend storage of the superbase salts in a benchtop desiccator or freezer when not in use to ensure their long-term stability.

i. Regeneration of crystalline solid superbase salts *via* azeotrope with PhMe

General Procedure AA: Azeotrope with PhMe to remove water from carboxylate salts. We placed the superbase salts uncapped into an 84% humidity chamber after which we subjected them to the following procedure. To the vial containing the water-absorbed carboxylate salt, PhMe (~5

mL/g) was added, then the solution was concentrated using a rotary evaporator. This procedure was repeated three times, and the sample was dried on a Schlenk line under high vacuum for 12 h, providing dry, crystalline powder. The regenerated crystalline superbase salts were stored in a benchtop desiccator for further use (see Entry 6 in Table S7 for use of recovered BTPP salt **A** in the Michael addition reaction and Entry 11 in Table S16 for use of the recovered P_2-*t*-Bu salt **A** salts in the oxa-Michael addition reaction, where they perform similarly to freshly prepared salts). An illustration of this procedure is shown in Figure S26 below, where BTPP salt **A** and P_2-*t*-Bu salt **A** were placed into an 84% humidity chamber. Both salts absorbed enough water (41.4 mg and 32.4 mg of water, respectively) to turn from crystalline solids to oils in the vial. After the restoration process, the salts regained their crystallinity and showed removal of all of the added mass of water. Figures S27 and S28 show the ^{1}H NMR spectra of this process and the appearance and removal of water for both BTPP salt **A** and P_2-*t*-Bu salt **A**.

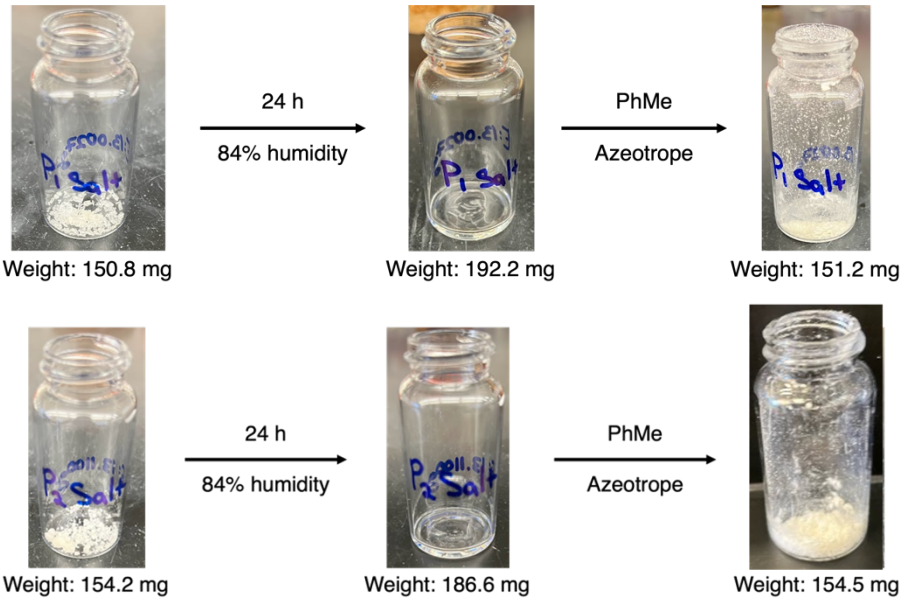


Figure S26. Images of BTPP Salt **A** (top) and P_2-*t*-Bu Salt **A** (bottom) stored for 24 h in 84% humidity and recovery using the regeneration procedure through azeotrope with toluene.

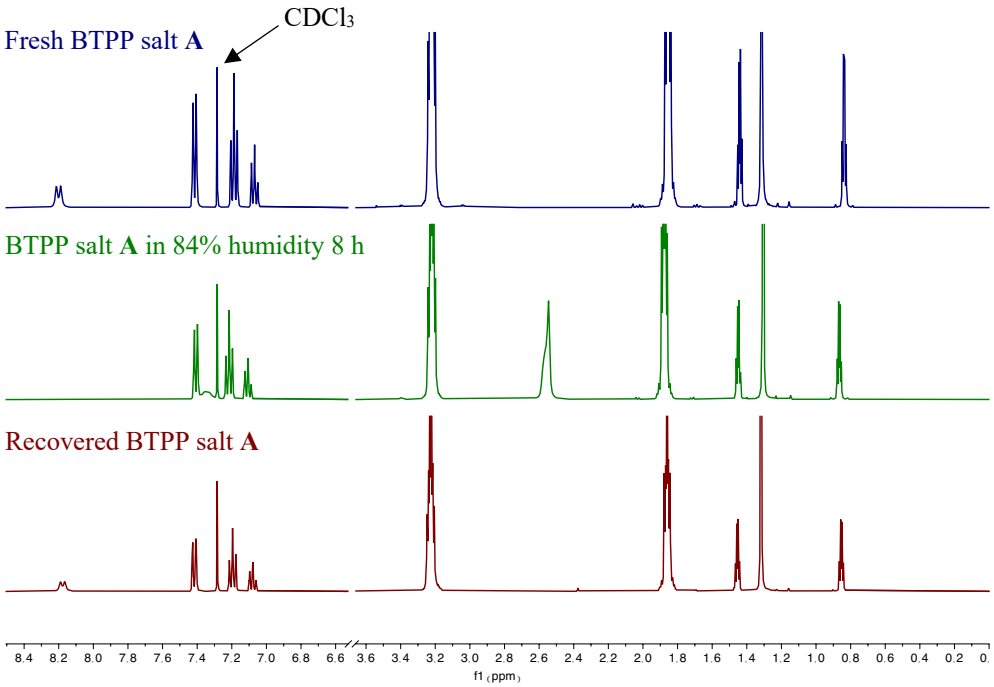


Figure S27. ^{1}H NMR spectra comparing fresh BTPP salt **A** (top), BTPP salt **A** exposed to 84% humidity (middle), and BTPP salt **A** recovered *via* the azeotrope procedure (bottom).

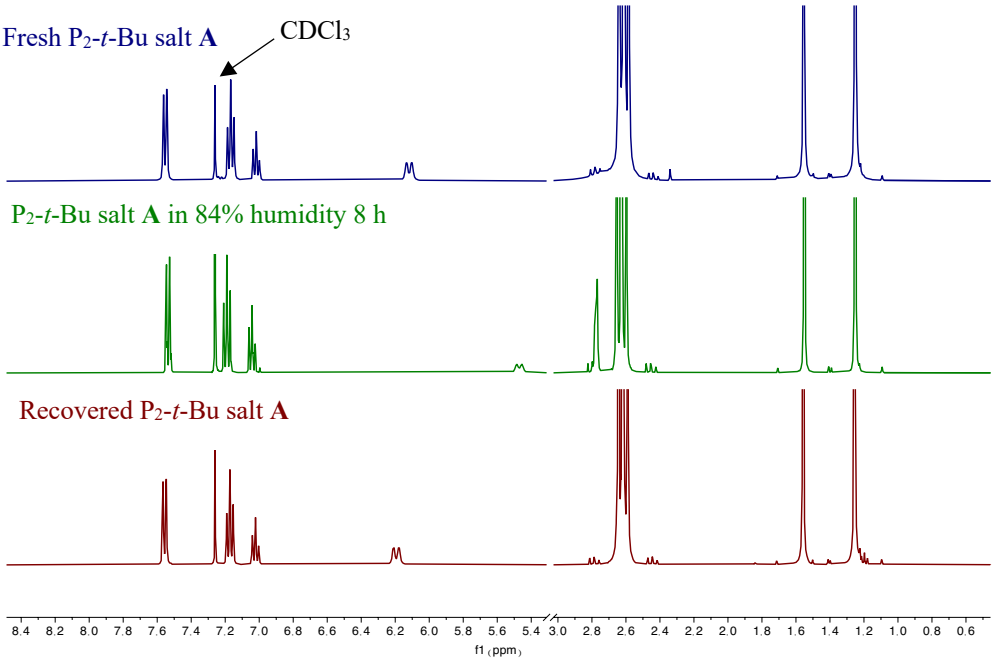


Figure S28. ^{1}H NMR spectra comparing fresh P_2-*t*-Bu salt **A** (top), P_2-*t*-Bu salt **A** exposed to 84% humidity (middle), and P_2-*t*-Bu salt **A** recovered *via* the azeotrope procedure (bottom).

ii. Preparation of less hygroscopic superbase carboxylate salts.

Superbase salts with alternate carboxylate anions were synthesized for both BTPP and P_2-*t*-Bu from the commercial superbase and a carboxylic acid using the procedures described below. From this investigation, we found BTPP salt **B** and P_2-*t*-Bu salt **B** form solid, crystalline salts. These salts retain their crystallinity and ease-of-use without any changes in physical appearance or formation of droplets on the weighing paper for 8 and 24 hours, respectively, when stored in an 84% humidity chamber. Additionally, these salts show no change in physical characteristics over 24 h in 84% humidity while stored in an open vial. The syntheses of these salts are shown below and their use in reaction applications are shown in Sections IV and VI where they work just as well as BTPP salt **A** and P_2-*t*-Bu salt **A**.

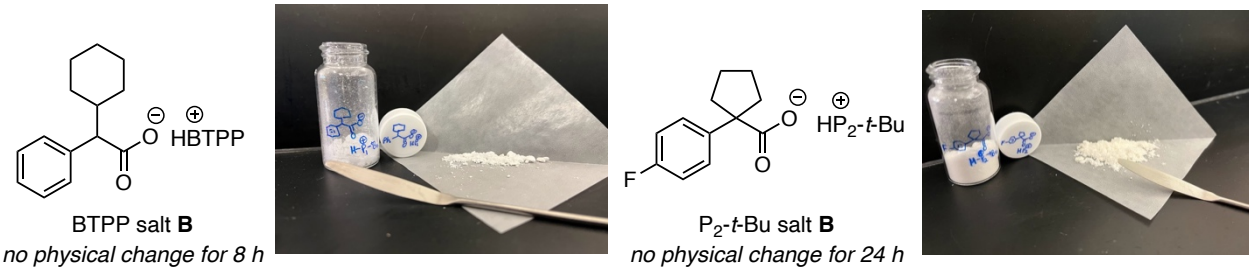
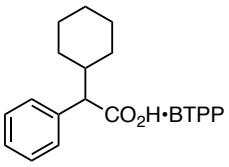
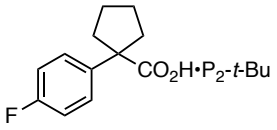


Figure S29. Structures and images of BTPP salt **B** and P_2-*t*-Bu salt **B** that show improved stability in highly humid environments. Shown with the salts is the length of time they remain crystalline in 84% humidity without any changes to their physical properties or droplets forming on the weigh paper.



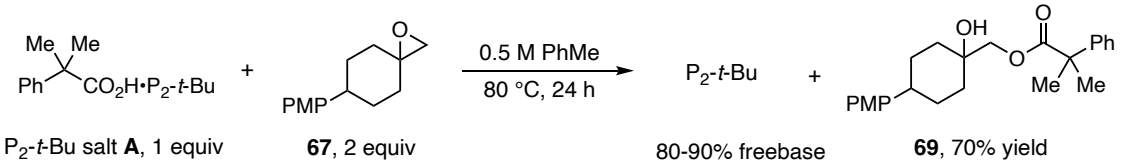
***tert*-butylimino-tri(pyrrolidino)phosphorane 2-cyclohexyl-2-phenylacetate (BTPP Salt B).** An oven-dried 20 mL scintillation vial (ThermoFisher, 03-341-25D) was charged with a magnetic stir bar, 2-cyclohexyl-2-phenylacetic acid (436.6 mg, 2.0 mmol, 1.0 equiv), and Et_2O (5 mL, 0.1 M). In a nitrogen-filled glovebox, an oven-dried 20 mL scintillation vial (ThermoFisher, 03-341-25D) was charged with BTPP (611.4 µL, 2.0 mmol, 1.0 equiv) and Et_2O (1 mL, 2 M). The vial was capped and removed from the glovebox. The vial containing BTPP dissolved in Et_2O was opened to air and added dropwise *via* glass pipette to the stirring solution of the acid. The reaction mixture was stirred at rt for 1 hr, during which time a white precipitate formed. The precipitated solid was filtered and washed with cold Et_2O, providing the product as a white solid (1.99 g, 3.8 mmol, 75% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.51 (d, *J* = 10.4 Hz, 1H), 7.46 (d, *J* = 7.3 Hz, 2 H), 7.16 (t, *J* = 7.5 Hz, 2 H), 7.10 – 7.01 (m, 1H), 3.20 (h, *J* = 3.6 Hz, 12H), 3.05 (d, *J* = 10.7 Hz, 1 H), 2.13 (d, *J* = 12.9 Hz, 1 H), 2.03 (dt, 11.1, 3.1 Hz, 1H), 1.83 – 1.72 (m, 12H), 1.69 (d, *J* = 12.8 Hz, 1H), 1.62 – 1.51 (m, 2 H), 1.40 – 1.30 (m, 1H), 1.28 (s, 9H), 1.17-1.04 (m, 3 H), 0.79-0.59 (m, 1H). **^{31}P NMR** (162 MHz, $CDCl_3$) δ 22.82 (s, 1P). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 177.4, 143.8, 129.0, 127.2, 124.8, 64.6, 51.9 (d, *J* = 2.2 Hz), 47.5 (d, *J* = 5.1 Hz), 41.4, 32.6, 31.3 (d, *J* = 4.8 Hz), 31.1, 26.9, 26.6, 26.5, 26.1 (d, *J* = 8.0 Hz). **IR** (neat) 3058, 2925, 2683, 1598, 1486,

1364, 1205, 1077, 1022, 709 cm^{-1}. **HRMS (DART)** $[M]^+$ calcd. for $[C_{16}H_{34}N_4P]^+$ (for protonated phosphazene) = 313.2516, found 313.2558. **MP** 110 – 115 °C.

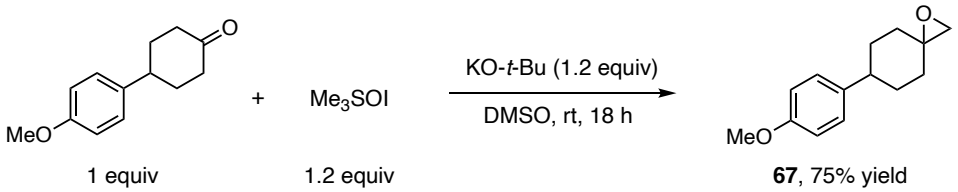


***tert*-butylimino-tri(pyrrolidino)phosphorane 1-(4-fluorophenyl)cyclopentane-1-carboxylate (P_2-*t*-Bu Salt B).** An oven-dried 20 mL scintillation vial (ThermoFisher, 03-341-25D) was charged with a magnetic stir bar, 1-(4-fluorophenyl)cyclopentanecarboxylic acid (1.11 g, 5.0 mmol, 1.0 equiv), and Et_2O (5 mL, 0.1 M). In a nitrogen-filled glovebox, an oven-dried 20 mL scintillation vial (ThermoFisher, 03-341-25D) was charged with P_2-*t*-Bu (0.2 M solution in THF, 2.5 mL, 5.0 mmol, 1.0 equiv) and Et_2O (1 mL, 2M). The vial was capped and removed from the glovebox. The vial containing P_2-*t*-Bu dissolved in Et_2O was opened to air and added dropwise *via* glass pipette to the stirring solution of the acid. The reaction mixture was stirred at rt open-to-air for 1 hr, during which time a white precipitate formed. The precipitated solid was filtered and washed with cold Et_2O, providing the product as a white solid (2.01 g, 3.4 mmol, 68% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.48 (dd, *J* = 8.5, 5.8 Hz, 2 H), 6.84 (t, *J* = 8.8 Hz, 2H), 6.09 (d, 12.4 Hz, 1H), 2.85 – 2.78 (m, 2H), 2.67 – 2.54 (m, 30 H), 1.84 – 1.76 (m, 2H), 1.75 – 1.64 (m, 2H), 1.64 – 1.55 (m, 2H), 1.25 (s, 9H). **^{31}P NMR** (162 MHz, $CDCl_3$) δ 16.23 (d, *J* = 67.8 Hz, 1P), 12.25 (d, *J* = 67.2 Hz, 1P). **^{19}F NMR** (376 MHz, $CDCl_3$) δ -121.03. **^{13}C NMR** (101 MHz, $CDCl_3$) δ 178.7, 161.8 (d, *J* = 242.6 Hz), 145.4 (d, *J* = 3.0 Hz), 128.7 (d, *J* = 7.5 Hz), 113.5 (d, *J* = 20.6 Hz), 61.1, 50.8 (d, *J* = 2.6 Hz), 37.4, 37.1 (d, *J* = 5.5 Hz), 37.0 (d *J* = 5.1 Hz), 31.1 (d, *J* = 4.7 Hz), 24.3. **IR** (neat) 3060, 2928, 2681, 1592, 1473, 1351, 1213, 1067, 1014, 703 cm^{-1}. **HRMS (DART)** $[M]^+$ calcd. for $[C_{14}H_{40}N_7P_2]^+$ (for protonated phosphazene)= 368.2815, found 368.2866. **MP** 95 – 100 °C.

iv. Identification of a crystalline solid spirocyclic epoxide



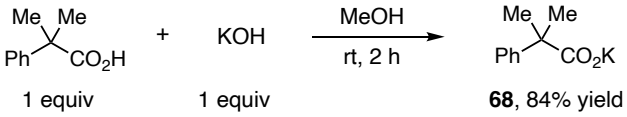
In our studies with superbase salt activation using epoxide additives, we found that epoxide **22** is a semisolid that melts near rt, so we identified a new epoxide that remains solid at rt. Epoxide **67** is a crystalline solid alternative to epoxide **22**, with the ability to generate 80-90% freebase along with 70% of the activation byproduct at equilibrium in an activation reaction setup according to General Procedure H. Provided below is the synthesis and characterization of this epoxide. See Table S16 for use of this epoxide in the oxa-Michael addition reaction.

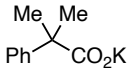


6-(4-methoxyphenyl)-1-oxaspiro[2.5]octane (67). An oven-dried 250 mL round bottom flask was charged with a magnetic stir bar, trimethylsulfoxonium iodide (6.61 g, 30.0 mmol, 1.2 equiv), and DMSO (125 mL, 0.2 M) open to air. To the stirring mixture, KO-*t*-Bu (3.37 g, 30.0 mmol, 1.2 equiv) was added slowly, in portions, and the solution was stirred for 1 h. To the stirring mixture, 4-(4-methoxyphenyl)cyclohexan-1-one[22] (5.11 g, 25.0 mmol, 1.0 equiv) was added and the reaction was allowed to stir at rt for a further 18 h. Water (150 mL) was added to the reaction flask and the mixture was extracted with EtOAc (3 x 100 mL). The combined organic layers were washed with brine (100 mL), dried over Na_2SO_4, and concentrated *in vacuo*. The crude material was purified *via* silica gel chromatography using 7% EtOAc in hexanes to afford **67** as a white solid (4.09 g, 18.8 mmol, 75% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.17 (d, *J* = 8.7 Hz, 2H), 6.86 (d, *J* = 8.8 Hz, 2H), 3.79 (s, 3H), 2.69 (s, 2H), 2.57 (tt, *J* = 11.5, 3.9 Hz, 2H), 2.12 – 1.99 (m, 1H), 1.95 – 1.76 (m, 4H), 1.37 (d, *J* = 14.2 Hz, 2H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 157.9, 138.9, 127.7, 113.8, 57.8, 55.3, 54.0, 42.4, 33.3, 31.8. **IR (neat)** 3018, 2944, 2856, 1611, 1516, 1441, 1178, 1038, 982, 918, 817. **HRMS (DART)** $[M+H]^+$ calcd. for $[C_{14}H_{19}O_2]^+$ = 219.1385, found 219.1377. **MP** 53 – 57 °C.

IX. Reagent Synthesis

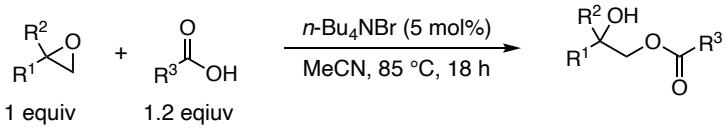
a. Synthesis of potassium carboxylate salts and epoxide activation byproducts



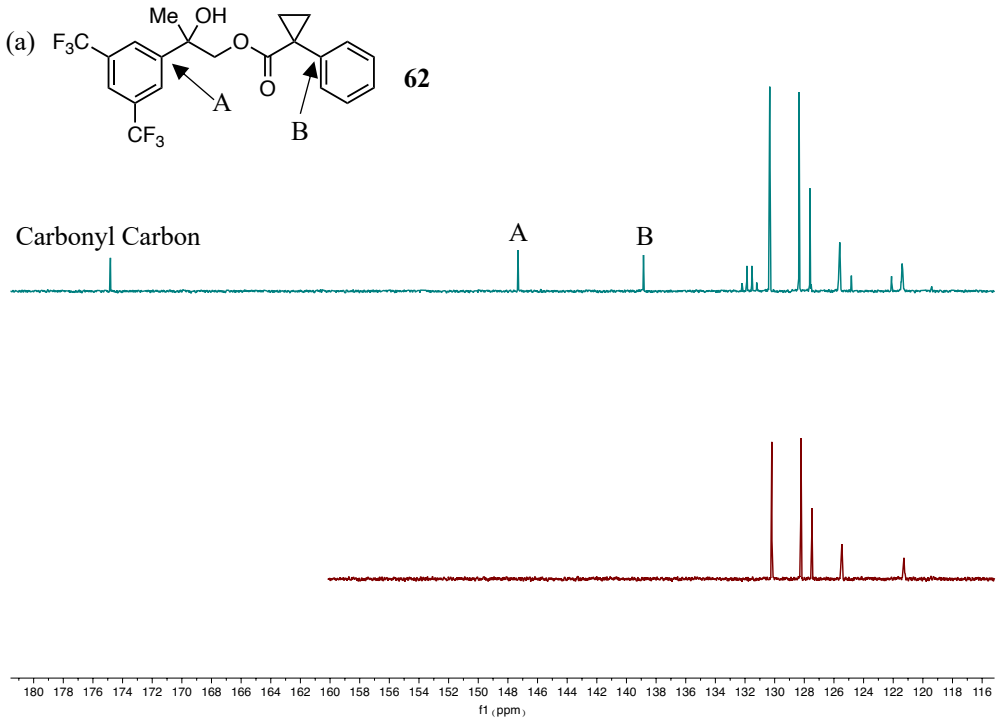


Potassium 2-methyl-2-phenylpropionate (68). An oven-dried 250 mL round bottom flask was charged with a magnetic stir bar, 2-methyl-2-phenylpropionic acid (20.0 g, 121.8 mmol, 1.0 equiv), and MeOH (75 mL, 1.6 M). A 125 mL Erlenmeyer flask was charged with KOH (85%) (7.859 g, 121.8 mmol, 1.0 equiv) and solubilized with a minimal amount to MeOH (50 mL). The KOH/MeOH solution was added dropwise to the stirring carboxylic acid/MeOH solution. The round bottom flask was capped with a rubber septum and the combined solution was stirred for 2 h at rt. The solution was concentrated *in vacuo*, PhMe (40 mL) was added and removed *in vacuo* three times. The white solid was filtered and washed with ethyl acetate (15 mL). The solid was collected and dried *in vacuo* to yield **68** (20.83 g, 102.9 mmol, 84% yield) as a white powder. **^{1}H NMR** (400 MHz, DMSO-d_6) δ 7.35 (d, *J* = 7.7 Hz, 2H), 7.17 (t, *J* = 7.5 Hz,

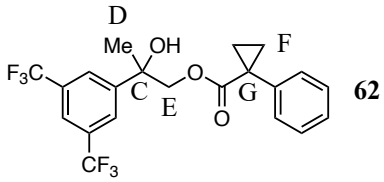
2H), 7.04 (t, J = 7.4 Hz, 1H), 1.31 (s, 6H). **^{13}C NMR** (101 MHz, DMSO-d_6) 178.0, 151.1, 127.5, 126.5, 124.7, 47.5, 28.9 δ . **IR (neat)** 3350, 3050, 2957, 1577, 1468, 1399, 1356, 703 cm^{-1}. **HRMS (DART)** $[RCO_2H+K]^+$ calcd. for $[C_{10}H_{12}O_2K]^+$ = 203.0474, found 203.0468. **MP** 205 – 210 °C.



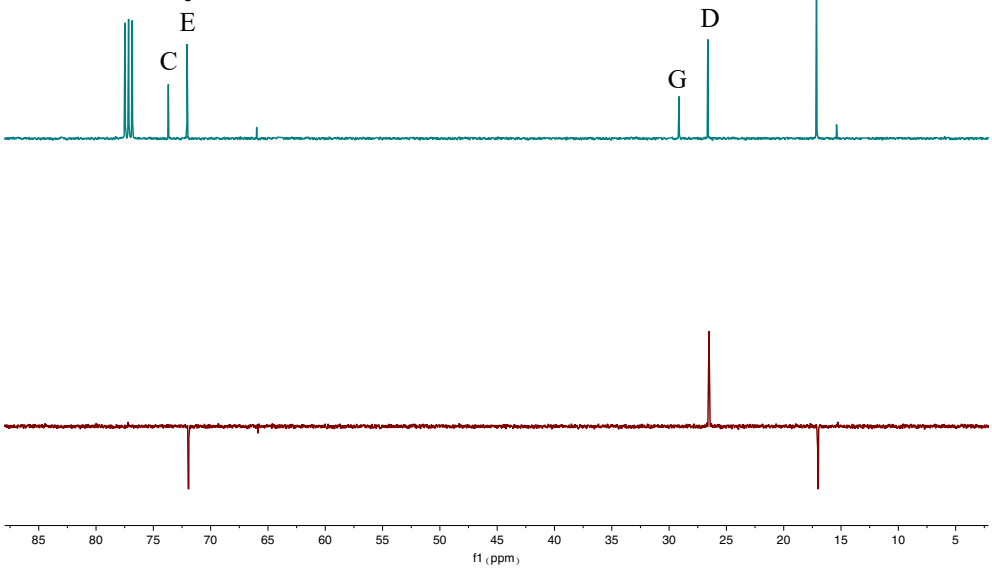
General Procedure AB: alcohol activation byproduct synthesis. An oven-dried 250 mL round bottom flask was charged with a magnetic stir bar, epoxide (10.0 mmol, 1.0 equiv) and MeCN (35 mL, 0.25 M). To the stirring solution, carboxylic acid (12.0 mmol, 1.2 equiv) and tetrabutylammonium bromide (161.2 mg, 0.5 mmol, 5.0 mol%) were added. The round bottom flask was fitted with a reflux condenser and the reaction solution was refluxed for 18 h in an oil bath with stirring. The reaction mixture was allowed to cool to rt, and water (35 mL) was added to the flask and the mixture was extracted with EtOAc (3 x 20 mL). The combined organic layers were washed with brine (25 mL), dried over Na_2SO_4, and concentrated *in vacuo*. The crude material was purified *via* silica gel chromatography. To confirm which isomer of the byproduct is present, we collected DEPT 135 ^{13}C NMR and HMBC spectra of **62** to determine the identities of key carbon atoms and to which hydrogen atoms they correlate. Figure S30 below shows this analysis where we support the structure to be as drawn for substrates **62**, **66**, and **64**. Highlighted on the HMBC spectrum is the O–H proton at 2.60 ppm, which correlates to carbons A, D, and E, leading to our structural assignment.



(b)


D
Me
OH
F
F3C
C
E
O
G
O
CF3

62


E
C
G
D
F
85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5
f1 (ppm)

(c)

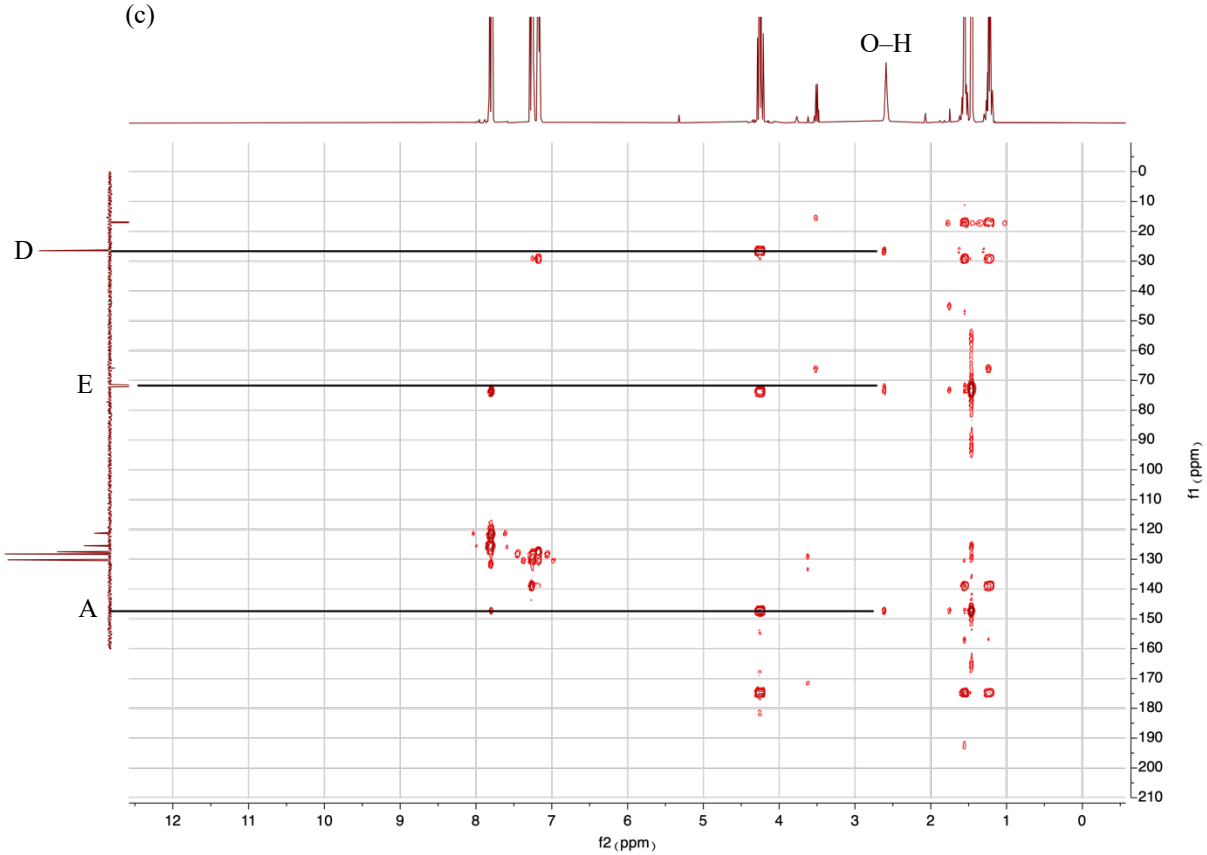
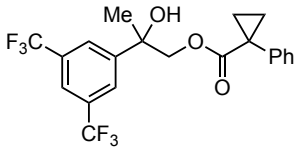
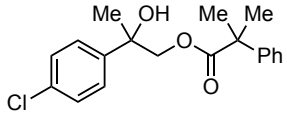

O–H
D
E
A
12 11 10 9 8 7 6 5 4 3 2 1 0
f2 (ppm)
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210
f1 (ppm)

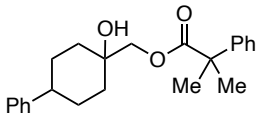
Figure S30. (a) Stacked ^{13}C NMR and DEPT spectra in the aromatic region. (b) Stacked ^{13}C NMR and DEPT spectra in the aliphatic region. (c) HMBC between ^{13}C and ^{1}H NMR spectra.



2-(3,5-bis(trifluoromethyl)phenyl)-2-hydroxypropyl 1-phenylcyclopropane-1-carboxylate (62). General Procedure AB was followed using 2-(3,5-bis(trifluoromethyl)phenyl)-2-methyloxirane (2.7 g, 10.0 mmol, 1.0 equiv), 1-phenylcyclopropanecarboxylic acid (1.6 g, 12.0 mmol, 1.2 equiv), tetrabutylammonium bromide (161.2 mg, 0.5 mmol, 5.0 mol%), and MeCN (35 mL, 0.25 M). The crude material was purified *via* silica gel chromatography using 30% EtOAc in hexanes to afford **62** as a pale-yellow oil (1.86 g, 4.3 mmol, 43% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.79 (d, *J* = 10.2 Hz, 3H), 7.27 – 7.19 (m, 3H), 7.15 (dd, *J* = 6.8, 3.0 Hz, 2H), 4.29 – 4.17 (m, 2H), 2.61 (bs, 1H), 1.59 – 1.47 (m, 2H), 1.44 (s, 3H), 1.29 – 1.14 (m, 2H). **^{19}F NMR** (376 MHz, $CDCl_3$) δ -62.59. **^{13}C NMR** (101 MHz, $CDCl_3$) δ 174.8, 147.3, 138.8, 131.7 (q, *J* = 33.2 Hz), 130.3, 128.5, 127.6, 125.6 (m), 123.3 (q, *J* = 272.7 Hz), 121.38 (m), 73.7, 72.0, 29.1, 26.6, 17.1. **IR** (neat) 3473.01, 2984, 1708, 1372, 1275, 1167, 1126, 899 cm^{-1}. **HRMS (DART)** $[M+H]^+$ calcd. for $[C_{21}H_{19}F_6O_3]^+$ = 432.1160, found 432.1145.



2-(4-chlorophenyl)-2-hydroxypropyl 2-methyl-2-phenylpropanoate (66). General Procedure AB was followed using 2-(4-chlorophenyl)-2-methyloxirane (1.7 g, 10.0 mmol, 1.0 equiv), 2-methyl-2-phenylpropionic acid (2.0 g, 12.0 mmol, 1.2.0 equiv), tetrabutylammonium bromide (161.2 mg, 0.5 mmol, 5.0 mol%), and MeCN (35 mL, 0.25 M). The crude material was purified *via* silica gel chromatography using 20% EtOAc in hexanes to afford **66** as a colorless oil (2.03 g, 5.4 mmol, 30% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.45 – 7.17 (m, 9H), 4.31 (d, *J* = 11.3 Hz, 1H), 4.15, (d, *J* = 11.3 Hz, 1H), 2.31 (bs, 1H), 1.54 (s, 3H), 1.51 (s, 3H), 1.41 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 176.6, 144.1, 142.7, 133.1, 128.5, 128.3, 126.9, 126.5, 125.7, 125.6, 71.9, 46.6, 26.5, 26.2. **IR** (neat) 3552, 2981, 1717, 1494, 1253, 1157, 1101, 1016, 820, 703 cm^{-1}. **HRMS (DART)** $[M+NH_4]^+$ calcd. for $[C_{19}H_{25}ClNO_3]^+$ = 350.1517, found 350.1534. **MP** 35 – 37 °C.

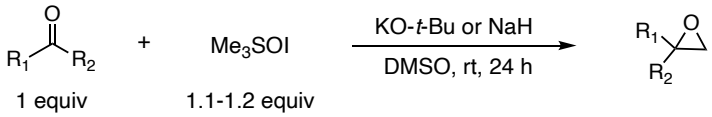


(1-hydroxy-4-phenylcyclohexyl)methyl 2-methyl-2-phenylpropanoate (64). General Procedure AB was followed using 6-phenyl-1-oxaspiro[2,5]octane (1.9 g, 10.0 mmol, 1.0 equiv), 2-methyl-2-phenylpropionic acid (2.0 g, 12.0 mmol, 1.2.0 equiv), tetrabutylammonium bromide (161.2 mg, 0.5 mmol, 5.0 mol%), and MeCN (35 mL, 0.25 M). The crude material was purified *via* silica gel chromatography using 20% EtOAc in hexanes to afford **64** as a colorless solid (1.8 g, 5.0 mmol, 50% yield).). **^{1}H NMR** (400 MHz, DMSO-d_6) δ 7.40 – 7.32 (m, 4H), 7.31 – 7.23 (m, 3H), 7.22 – 7.12 (m, 3H), 4.43 (s, 1H), 3.82 (s, 2H), 2.29 (tt, *J* = 12.4 Hz, 2.8 Hz, 1H), 1.82 – 1.67 (m, 2H), 1.54 – 1.46 (m, 4H), 1.30 (td, 13.4, 4.1 Hz, 2H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 176.7, 146.9, 144.5, 128.4, 128.3, 126.9, 126.8, 126.1, 125.7, 72.8, 69.8, 46.7, 44.0, 34.1, 28.6, 26.4. **IR** (neat)

3538, 2941, 1712, 1492, 1255, 1149, 1107, 977, 701 cm^{-1}. **HRMS (DART)** $[M+NH_4]^+$ calcd. for $[C_{23}H_{32}NO_3]^+$ = 370.2377, found 370.2386. **MP**: 46 – 51 °C.

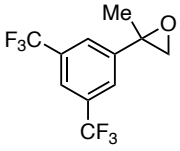
b. Epoxide Synthesis

i. General Procedures

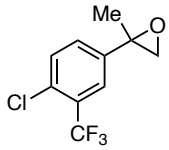


General Procedure AC: Epoxidation *via* the Corey-Chaykovsky reaction. An oven-dried 500 mL round bottom flask was charged with a magnetic stir bar, trimethylsulfoxonium iodide (1.1 – 1.2 equiv), and DMSO (0.2 M). To the stirring mixture, base (KO-*t*-Bu or NaH, 1.1 – 1.2 equiv) was added slowly, in portions, and the solution was stirred for 1 h. To the stirring mixture, the ketone (1.0 equiv) was added, and the reaction mixture was stirred for 18 h at rt. Water (150 mL) was added to the reaction flask and the mixture was extracted with EtOAc (3 x 100 mL). The combined organic layers were washed with brine (100 mL), dried over Na_2SO_4, and concentrated *in vacuo*. The crude material was purified *via* silica gel chromatography.

ii. Substrate Characterization

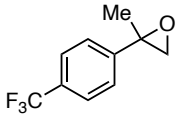


2-(3,5-bis(trifluoromethyl)phenyl)-2-methyloxirane (2). General Procedure AC was followed using 3',5'-bis(trifluoromethyl)acetophenone (15.0 g, 58.6 mmol, 1.0 equiv), trimethylsulfoxonium iodide (14.17 g, 64.4 mmol, 1.1 equiv), KO-*t*-Bu (7.23 g, 64.4 mmol, 1.1.0 equiv), and DMSO (250 mL, 0.2 M). The crude material was purified *via* silica gel chromatography using 100% hexanes to 5% EtOAc in hexanes to afford **2** as a colorless oil (10.01 g, 37.1 mmol, 63% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.84 (s, 2H), 7.82 (s, 1H), 3.08 (d, *J* = 5.2 Hz, 1H), 2.81 (d, *J* = 5.2 Hz, 1H), 1.81 (s, 3H). **^{19}F NMR** (376 MHz, $CDCl_3$) δ -62.76. **^{13}C NMR** (101 MHz, $CDCl_3$) δ 144.3, 132.0 (q, 33.3 Hz), 125.8 (m),123.2 (q, *J* = 272.8 Hz), 121.7 (dt, 7.8 Hz, 3.9 Hz), 57.2, 56.2, 21.4. **IR** (neat) 2973, 2876, 1574, 1384, 1277, 1131, 682 cm^{-1}. **HRMS (ESI)** $[M+H]^+$ calcd. for $[C_{11}H_9F_6O]^+$ = 271.0552, found 271.0552.

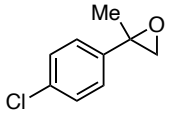


2-(4-chloro-3-(trifluoromethyl)phenyl)-2-methyloxirane (3). General Procedure AC was followed using 4'-chloro-3'-(trifluoromethyl)acetophenone (10.0 g, 44.9 mmol, 1.0 equiv), trimethylsulfoxonium iodide (11.86 g, 53.9 mmol, 1.2 equiv), KO-*t*-Bu (6.05 g, 53.9 mmol, 1.2.0 equiv), and DMSO (220 mL, 0.2 M). The crude material was purified *via* silica gel chromatography using 100% hexanes to 5% EtOAc in hexanes to afford **3** as a colorless oil (6.91 g, 29.2 mmol, 65% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.67 (s, 1H), 7.47 (s, 1H), 3.01 (d, *J* = 5.2 Hz, 1H), 2.75 (d, *J* = 5.3 Hz, 1H), 1.72 (s, 3H). **^{19}F NMR**

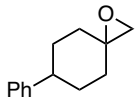
(376 MHz, $CDCl_3$) δ -62.51. **^{13}C NMR** (101 MHz, $CDCl_3$) δ 140.8, 131.6, 130.0, 128.7, 124.8 (q, *J* = 5.3 Hz), 122.8 (q, *J* = 173.2 Hz), 57.1, 56.0, 21.5. **IR** (neat) 3051, 2990, 1580, 1319, 1128, 1069, 682 cm^{-1}. **HRMS (ESI)** $[M+H]^+$ calcd. for $[C_{10}H_9ClF_3O]^+$ = 237.0289, found 237.0296.



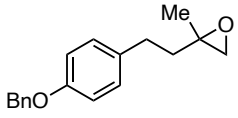
2-methyl-2-(4-(trifluoromethyl)phenyl)oxirane (4). General Procedure AC was followed using 4'-(trifluoromethyl)acetophenone (5.0 g, 26.6 mmol, 1.0 equiv) trimethylsulfoxonium iodide (7.02 g, 31.9 mmol, 1.2.0 equiv), KO-*t*-Bu (3.58 g, 31.9 mmol, 1.2.0 equiv), and DMSO (140 mL, 0.2 M). The crude material was purified *via* silica gel chromatography using 100% hexanes to 5% EtOAc in hexanes to afford **4** as a colorless oil (4.29 g, 21.2 mmol, 80% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.60 (d, *J* = 8.1 Hz, 2H), 7.48 (d, *J* = 8.1 Hz, 2H), 3.01 (d, *J* = 5.3 Hz, 1H), 2.77 (d, *J* = 5.4 Hz, 1H), 1.74 (s, 3H). Characterization data matches literature reports.[23]



2-(4-chlorophenyl)-2-methyloxirane (21). General Procedure AC was followed using 4'-chloroacetophenone (3.09 g, 20.0 mmol, 1.0 equiv), trimethylsulfoxonium iodide (5.29 g, 24.0 mmol, 1.2.0 equiv), KO-*t*-Bu (2.69 g, 24.0 mmol, 1.2.0 equiv), and DMSO (100 mL, 0.2 M). The crude material was purified *via* silica gel chromatography using 100% hexanes to 5% EtOAc in hexanes to afford **21** as a colorless oil (2.42 g, 14.3 mmol, 72% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.28 – 7.24 (m, 4H), 2.93 (d, *J* = 5.4 Hz, 1H), 2.71 (d, *J* = 5.4 Hz, 1H), 1.66 (s, 3H). Characterization data matches literature reports.[24]



6-phenyl-1-oxaspiro[2.5]octane (22). General Procedure AC was followed using 4-phenylcyclohexanone (6.97 g, 40.0 mmol, 1.0 equiv), trimethylsulfoxonium iodide (10.57 g, 48.0 mmol, 1.2.0 equiv), KO-*t*-Bu (5.39 g, 48.0 mmol, 1.2.0 equiv), and DMSO (200 mL, 0.2 M). The crude material was purified *via* silica gel chromatography using 5% EtOAc in hexanes to afford **22** as a colorless, low melting point solid (5.96 g, 31.6 mmol, 79%). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.38 – 7.28 (m, 4H), 7.24 (tt, *J* = 6.9, 1.6 Hz, 1H), 2.73 (s, 2H), 2.71 – 2.69 (m, 1 H), 2.10 (td, *J* = 13.2, 5.1 Hz, 2H), 2.00-1.85 (m, 4H) 1.46 – 1.38 (m, 2H). Characterization data matches literature reports.[25]



2-(4-(benzyloxy)phenethyl)-2-methyloxirane (23). General Procedure AC was followed using 4-(4-(benzyloxy)phenyl)butan-2-one[26] (3.81 g, 15.0 mmol, 1.0 equiv), trimethylsulfoxonium iodide (3.96 g, 18.0 mmol, 1.2.0 equiv), NaH (60 wt% dispersion in mineral oil, 0.75 g, 18.0 mmol, 1.2.0 equiv), and DMSO (75 mL, 0.2 M). The crude material was purified *via* silica gel chromatography using 5% EtOAc in hexanes to afford **23** as a white solid (3.31 g, 11.60 mmol, 77% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.48 – 7.32 (m, 5H), 7.12 (d, *J* = 8.4 Hz, 2H), 6.92 (d, *J* = 8.6 Hz, 2H), 5.07 (s, 2H), 2.72 – 2.65 (m, 2H), 2.61 (q, *J* = 4.9 Hz), 1.97 – 1.87 (m, 1H), 1.86 – 1.77 (m, 1H), 1.39 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 157.1, 137.2, 134.0, 129.2, 128.6, 127.9, 127.5, 114.8, 70.1, 56.7, 54.0, 38.8,

30.6, 21.1. **IR** (neat) 3042, 2930, 1600, 1518, 1383, 1237, 1181, 1016, 823, 748,– 59 °C. **HRMS (DART)** $[M+H]^+$ calcd. for $[C_{18}H_{21}O_2]^+$ = 269.1537, found 269.1544.

X. References

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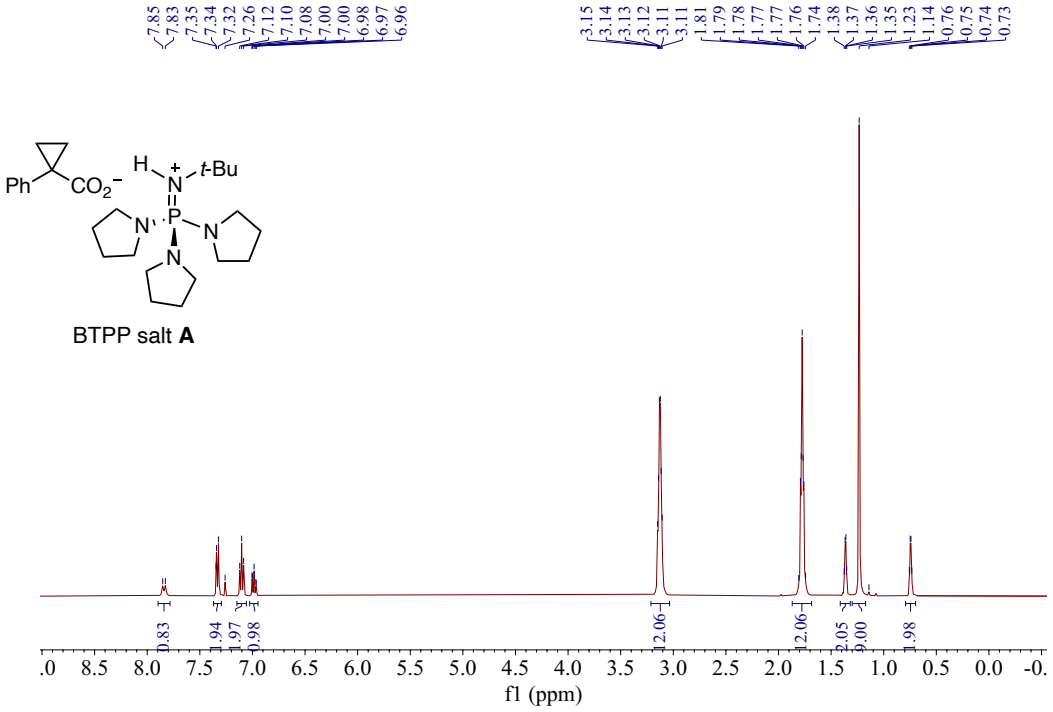
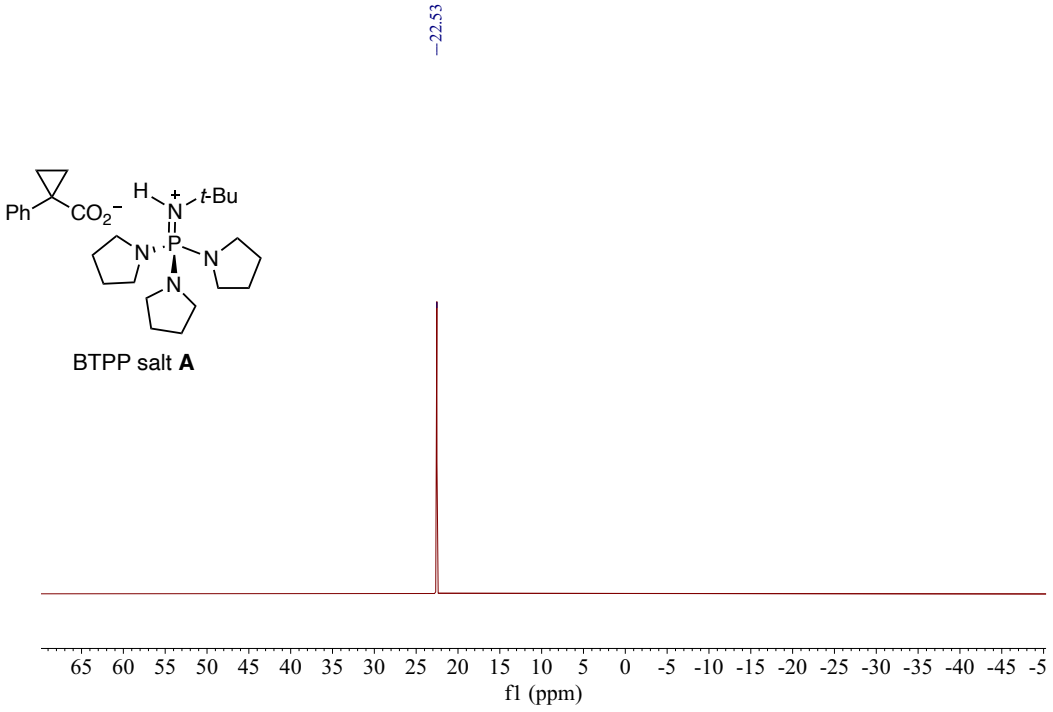
XI. NMR Spectra

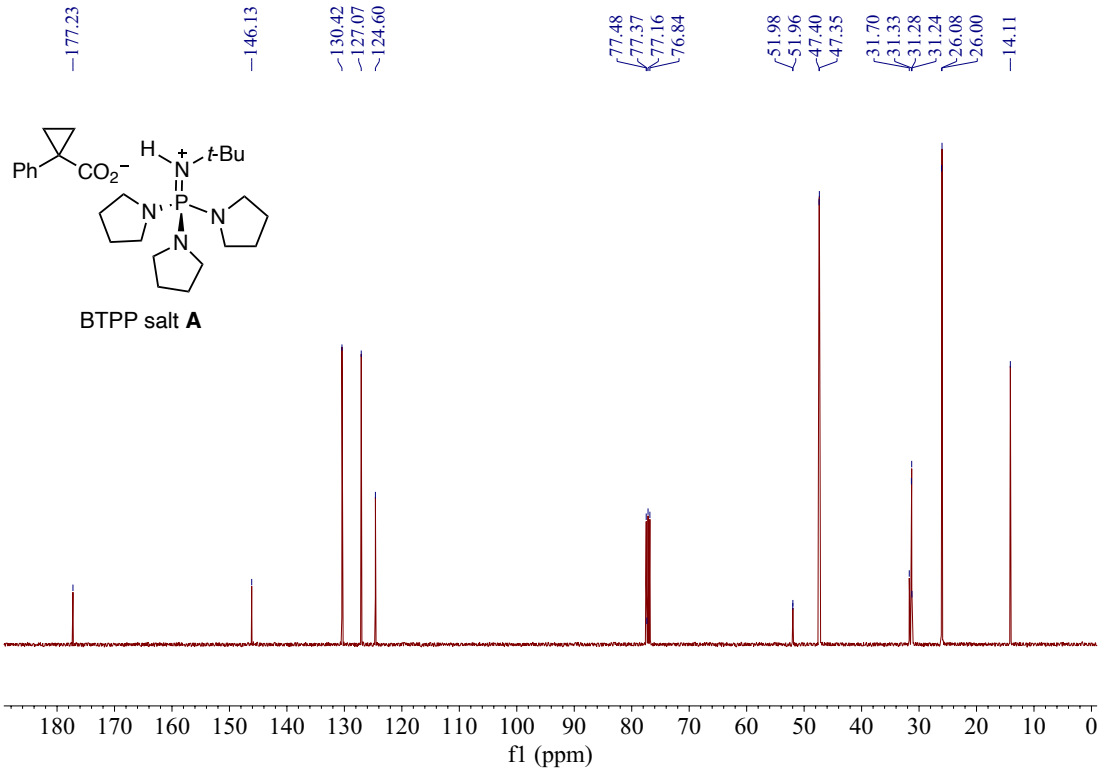
Note: NMR spectra are compiled in the order the compounds appear in the manuscript and subsequently the Supporting Information.



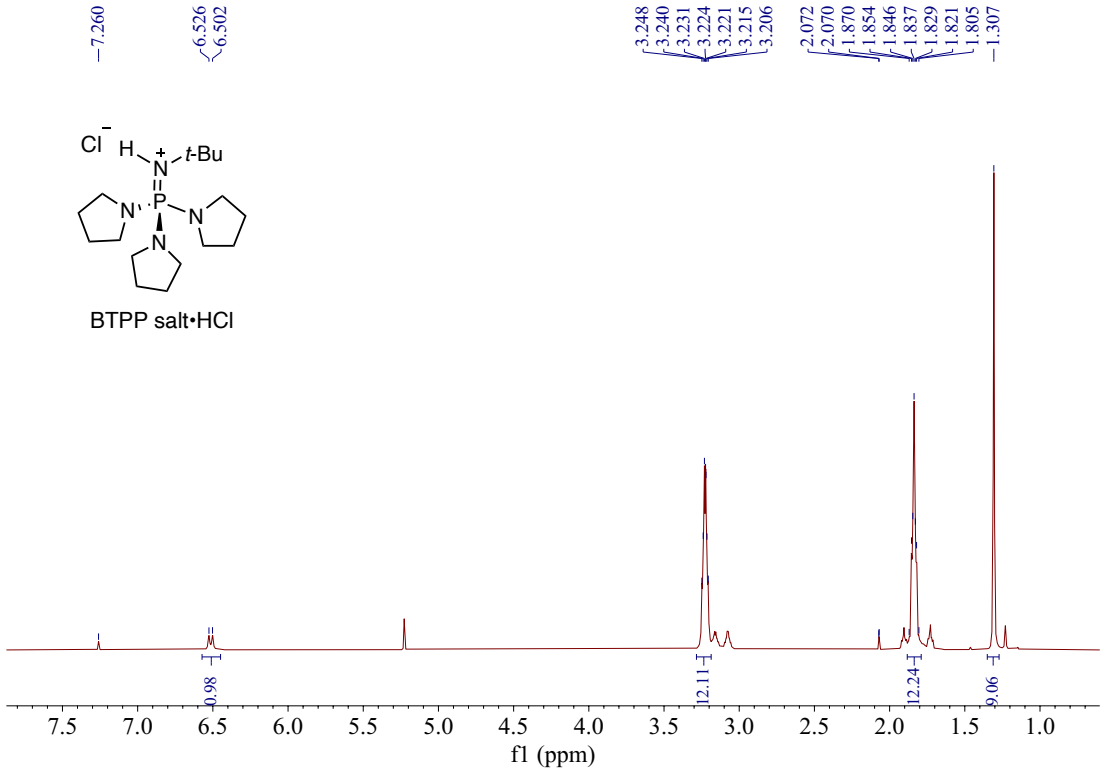
^{1}H NMR of BTPP salt **A** (400 MHz, $CDCl_3$)



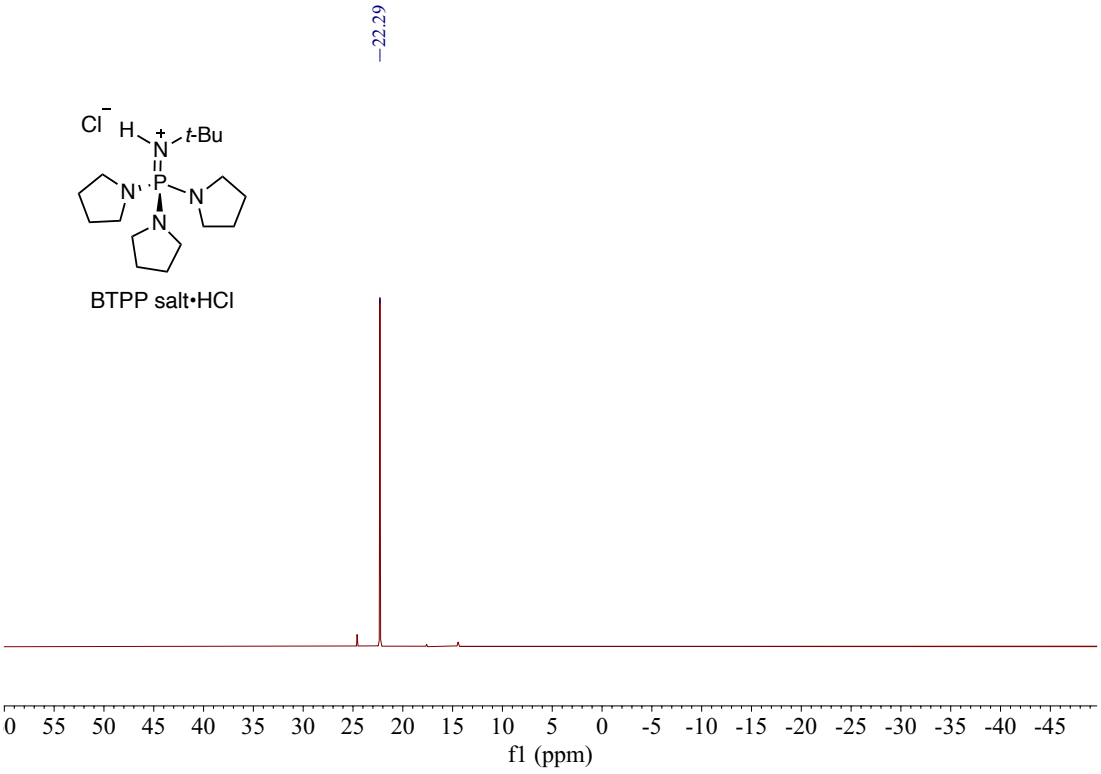
^{31}P NMR of BTPP Salt **A** (162 MHz, $CDCl_3$)



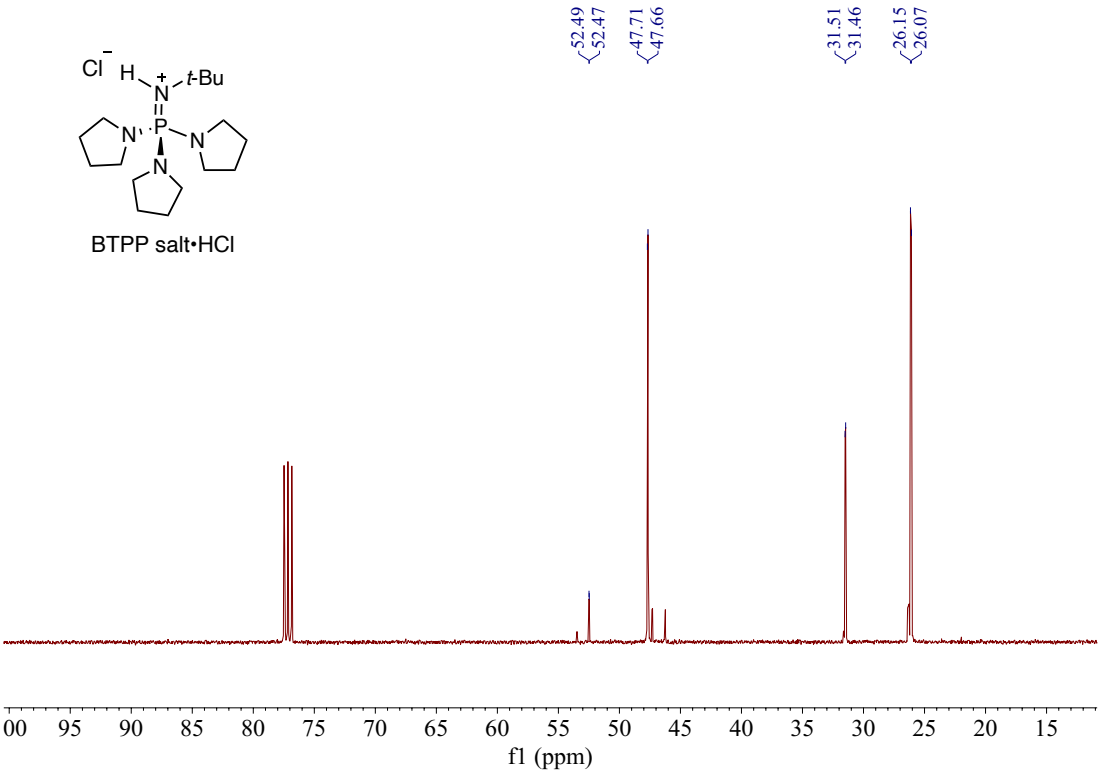
^{13}C NMR of BTPP Salt **A** (101 MHz, $CDCl_3$)



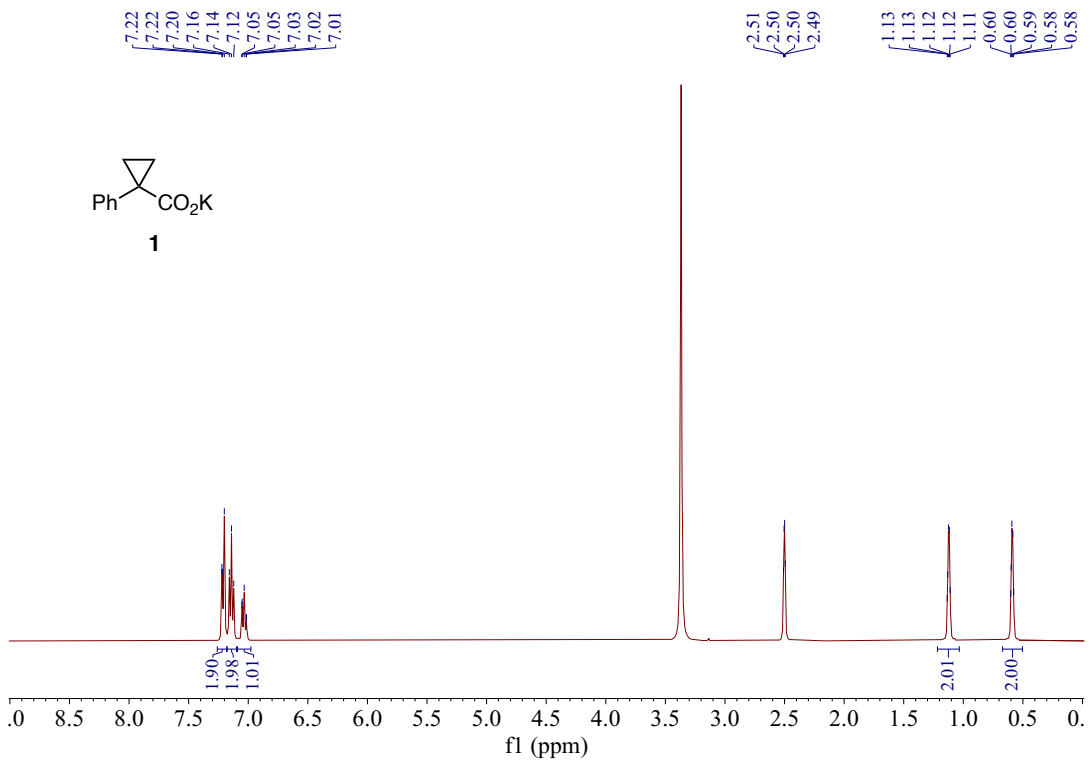
^{1}H NMR of BTPP•HCl (400 MHz, $CDCl_3$)



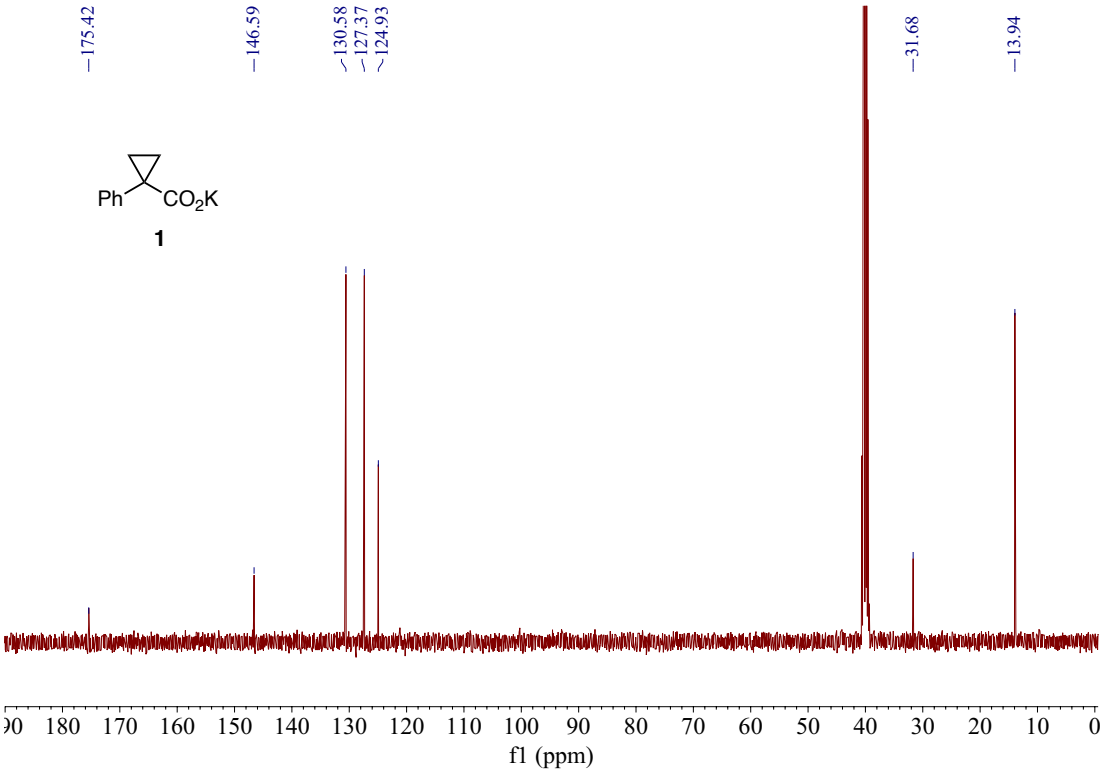
^{31}P NMR of BTPP•HCl (162 MHz, $CDCl_3$)



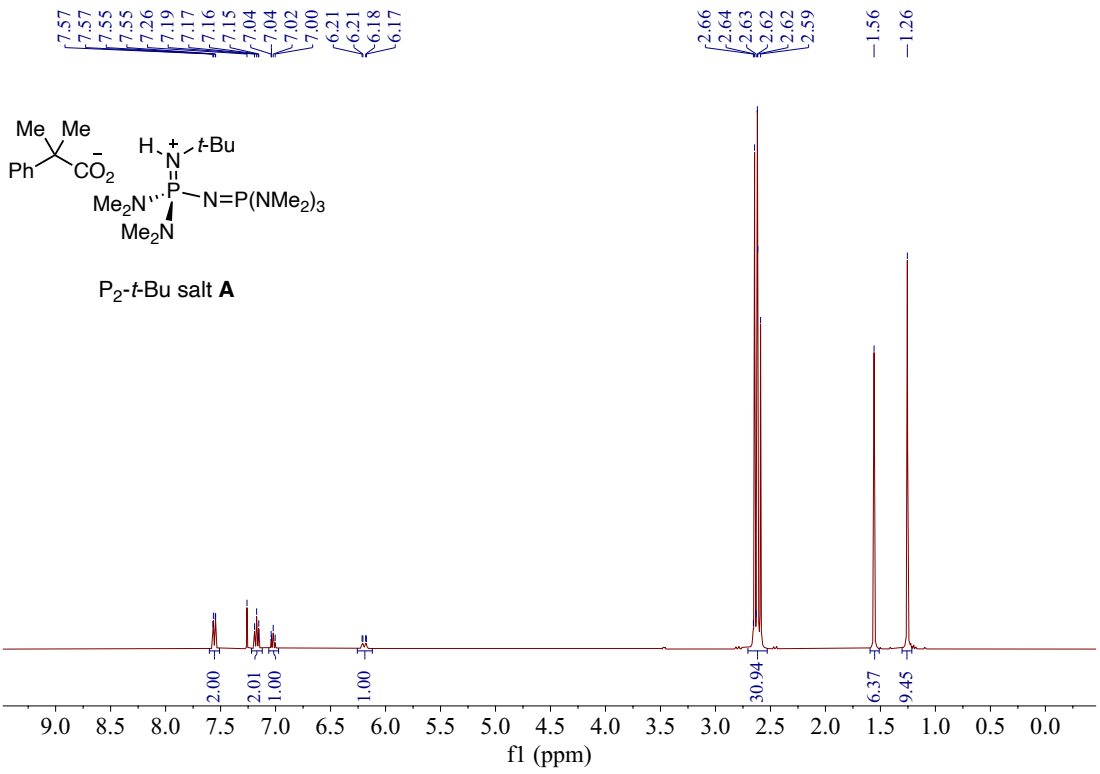
^{13}C NMR of BTPP•HCl (101 MHz, $CDCl_3$)



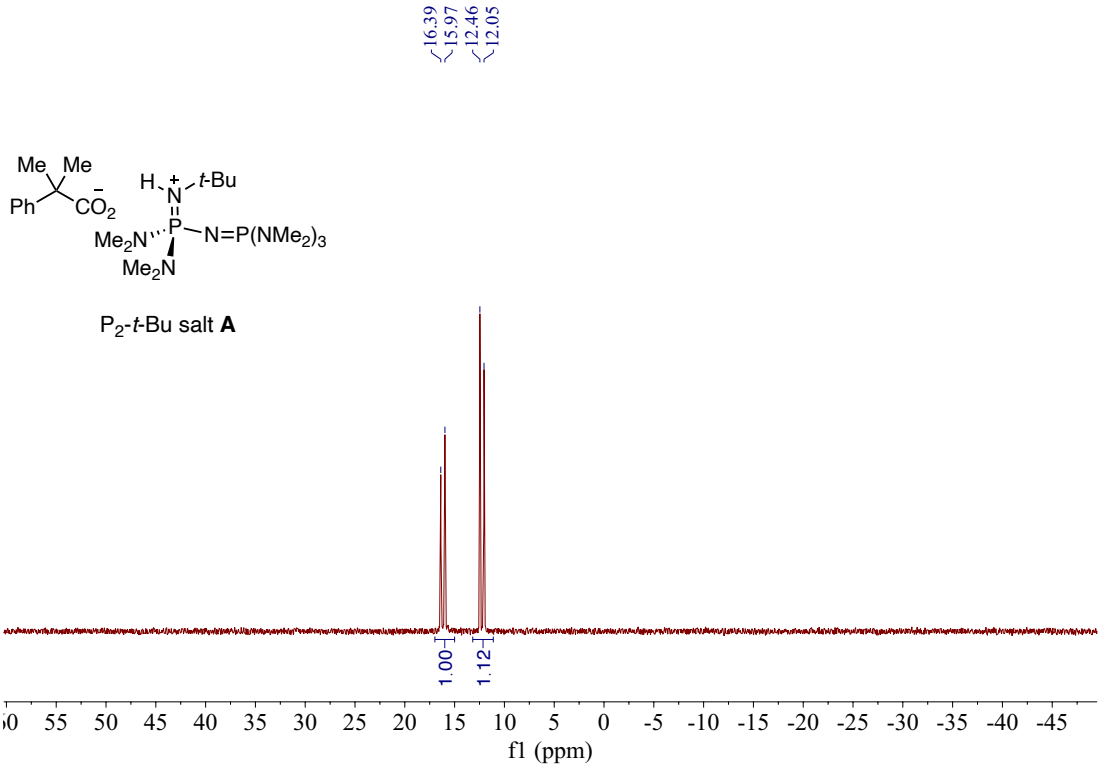
^{1}H NMR of Compound **1** (400 MHz, $CDCl_3$)



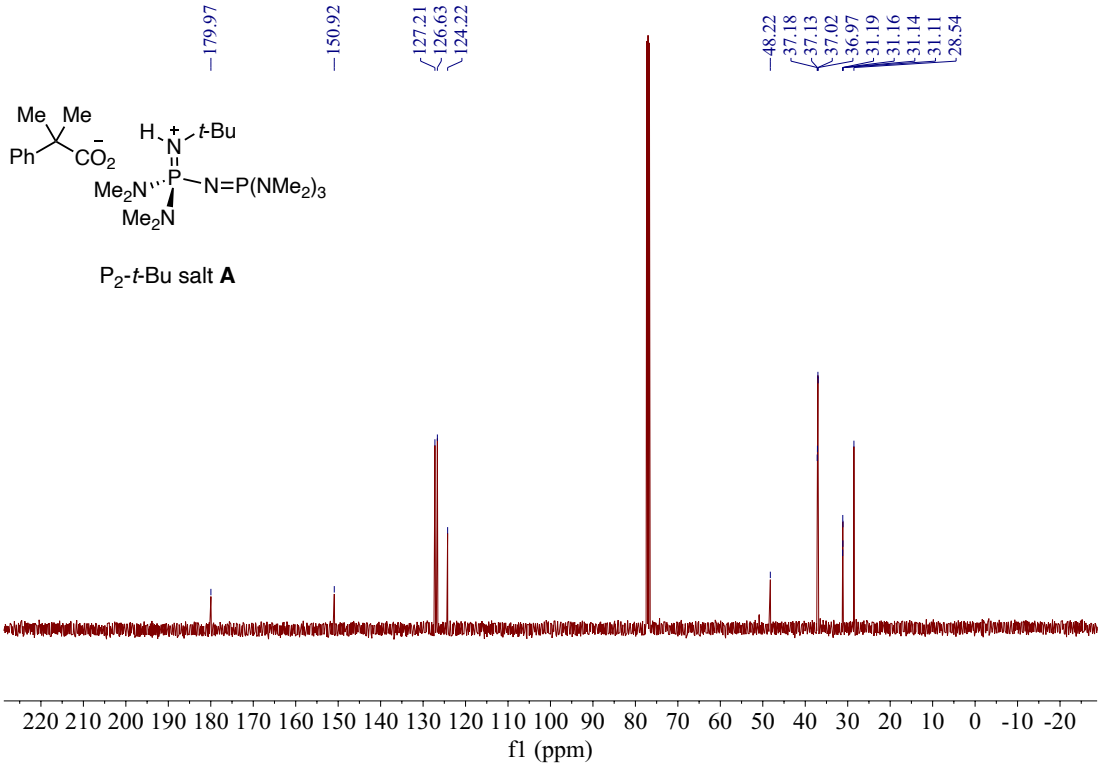
^{13}C NMR of Compound **1** (101 MHz, $CDCl_3$)



^{1}H NMR of P_2-*t*-Bu salt **A** (400 MHz, $CDCl_3$)



^{31}P NMR of P_2-*t*-Bu salt **A** (162 MHz, $CDCl_3$)



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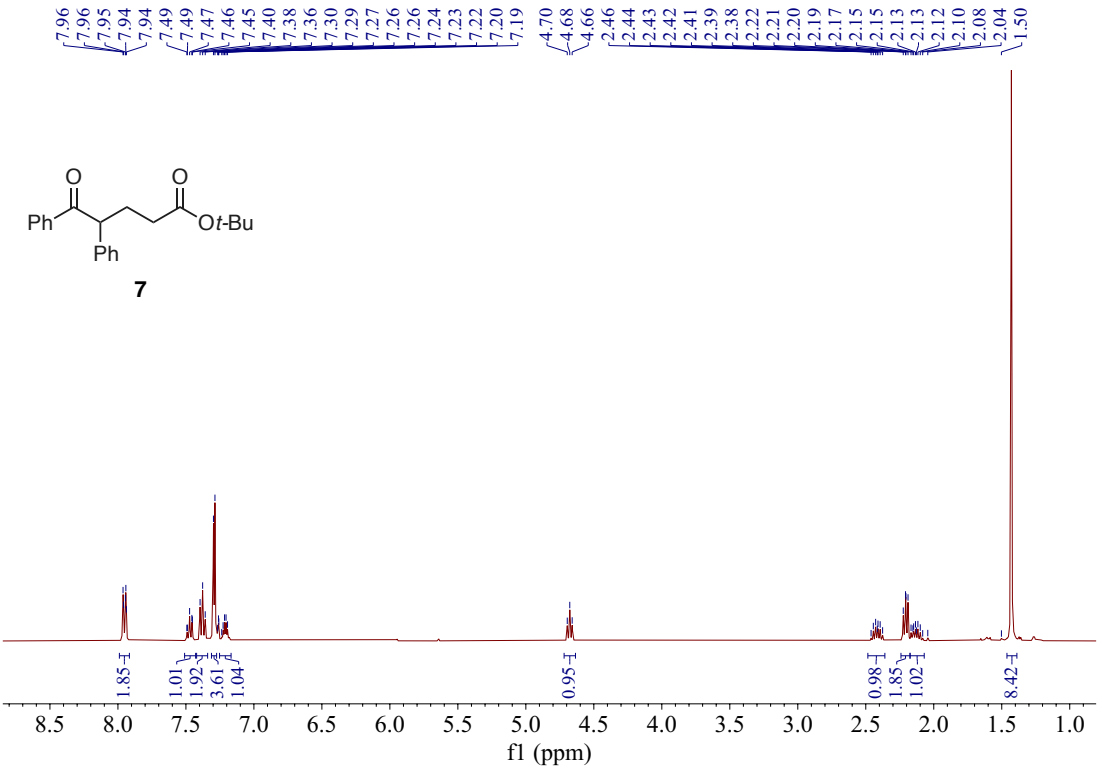
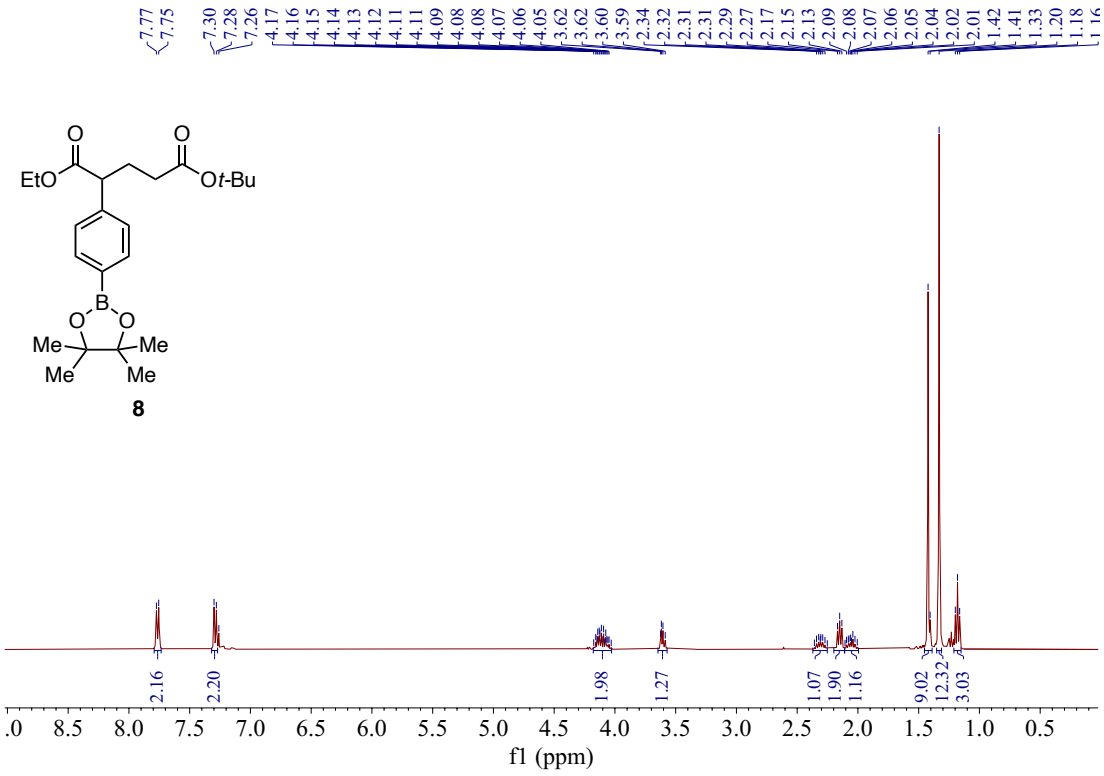
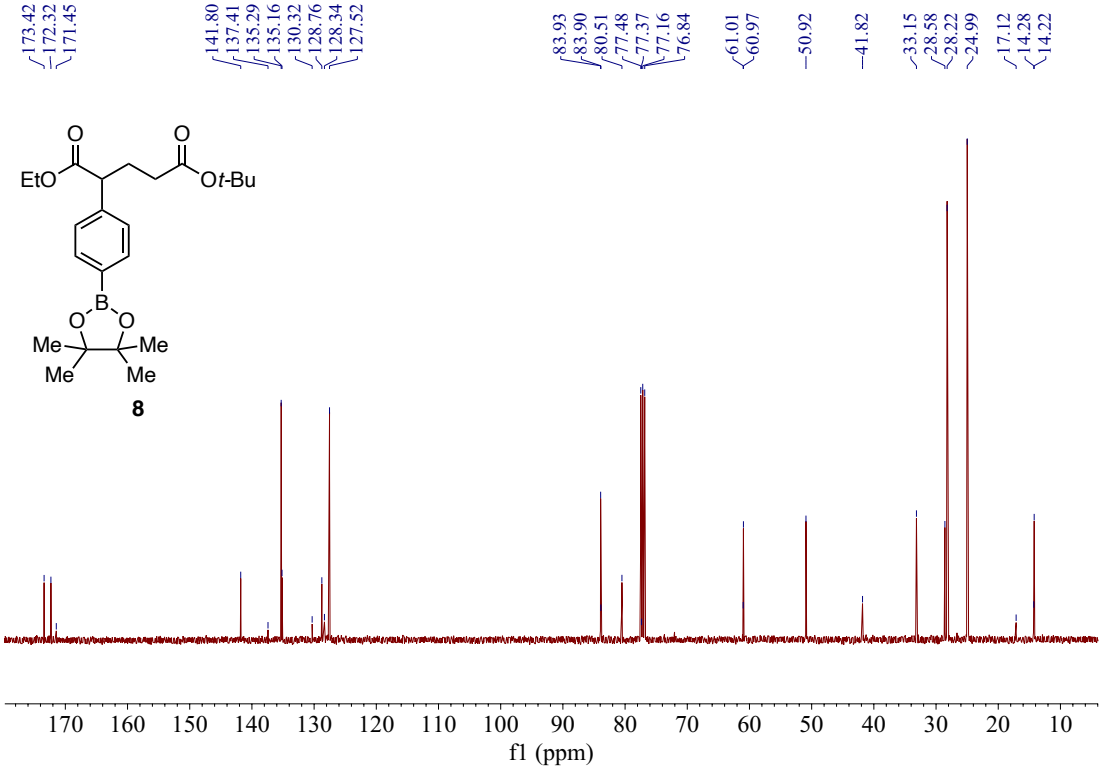


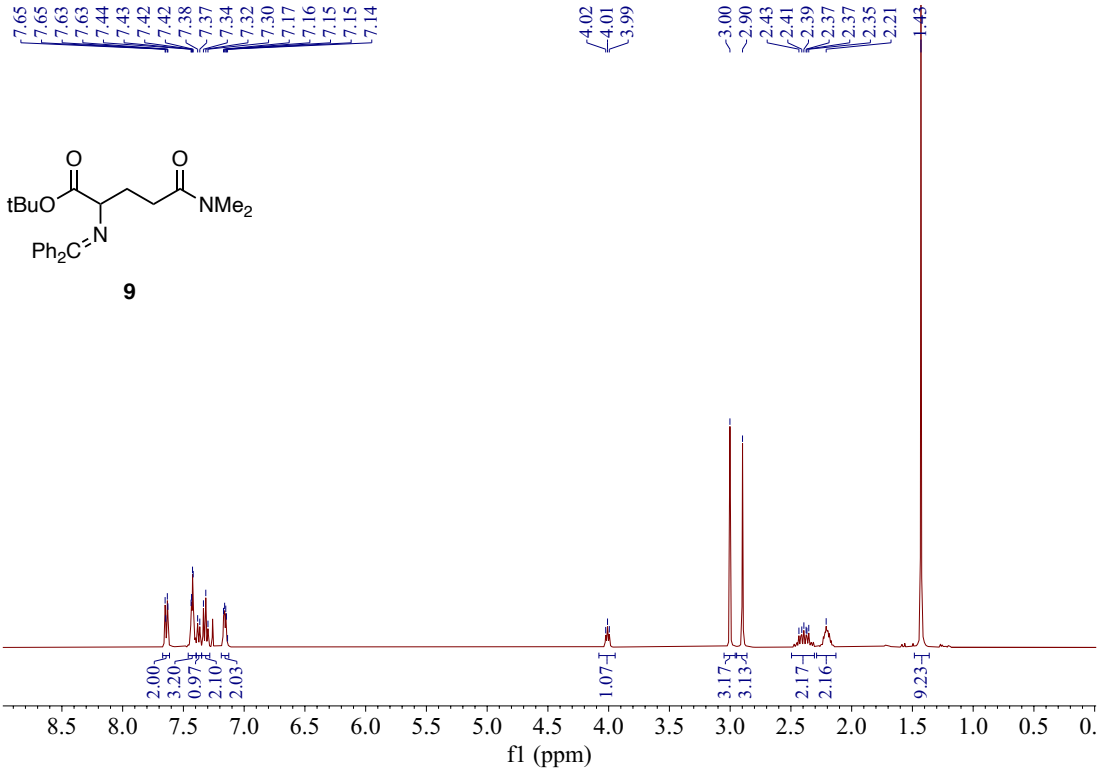
^{1}H NMR of Compound **7** (400 MHz, $CDCl_3$)



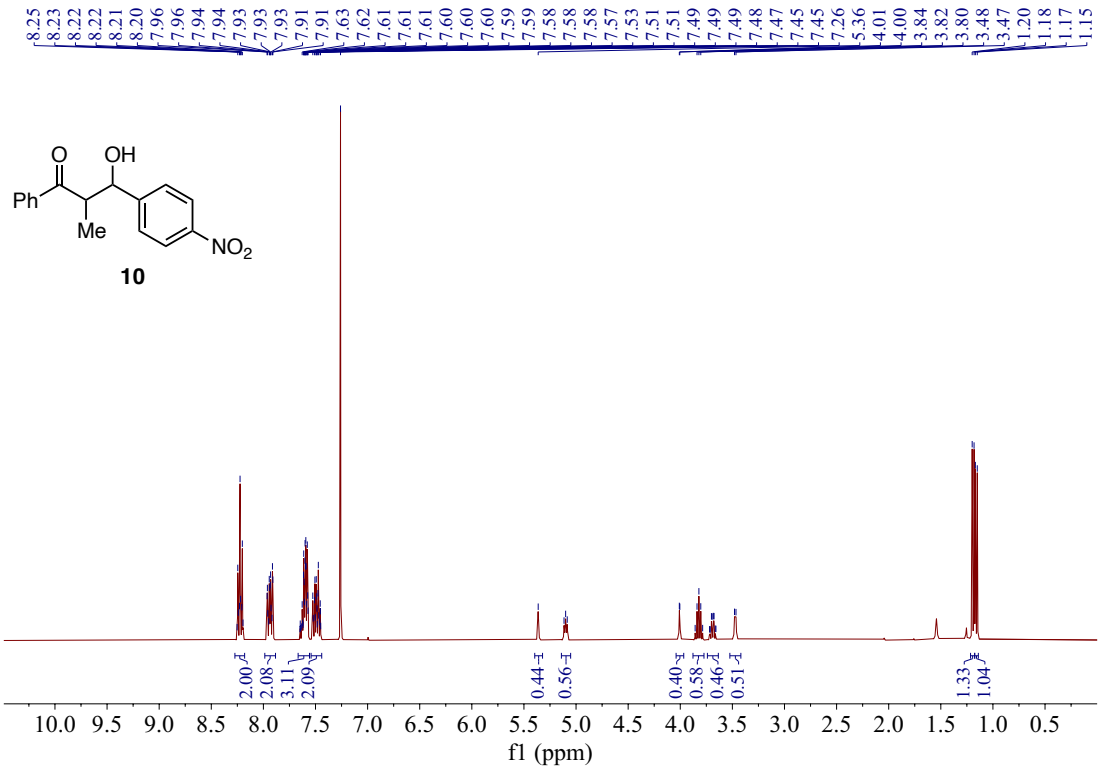
^{1}H NMR of Compound **8** (400 MHz, $CDCl_3$)



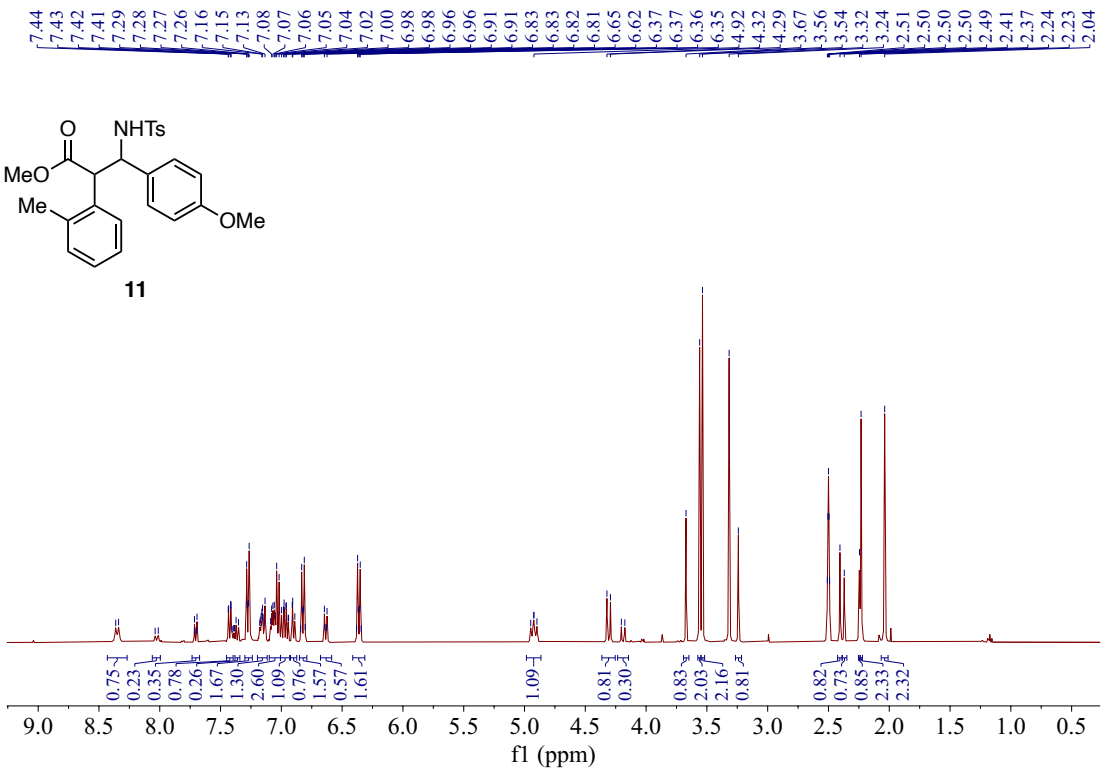
^{13}C NMR of Compound **8** (101 MHz, $CDCl_3$)



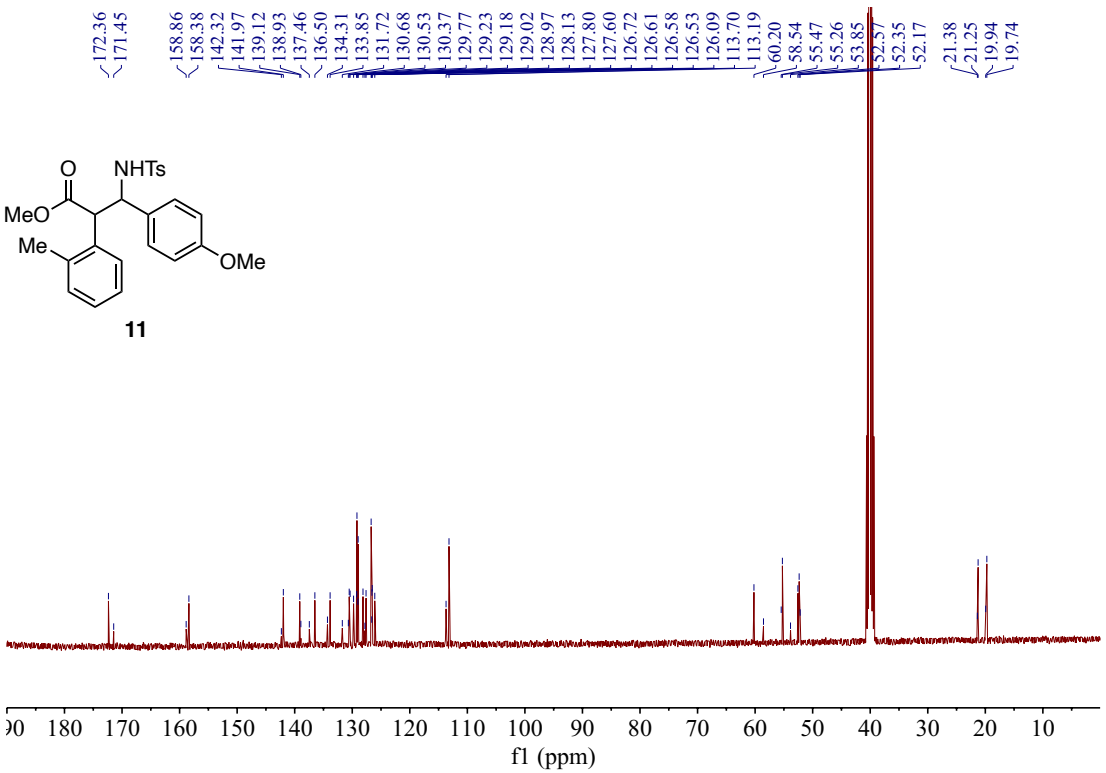
^{1}H NMR of Compound **9** (400 MHz, $CDCl_3$)



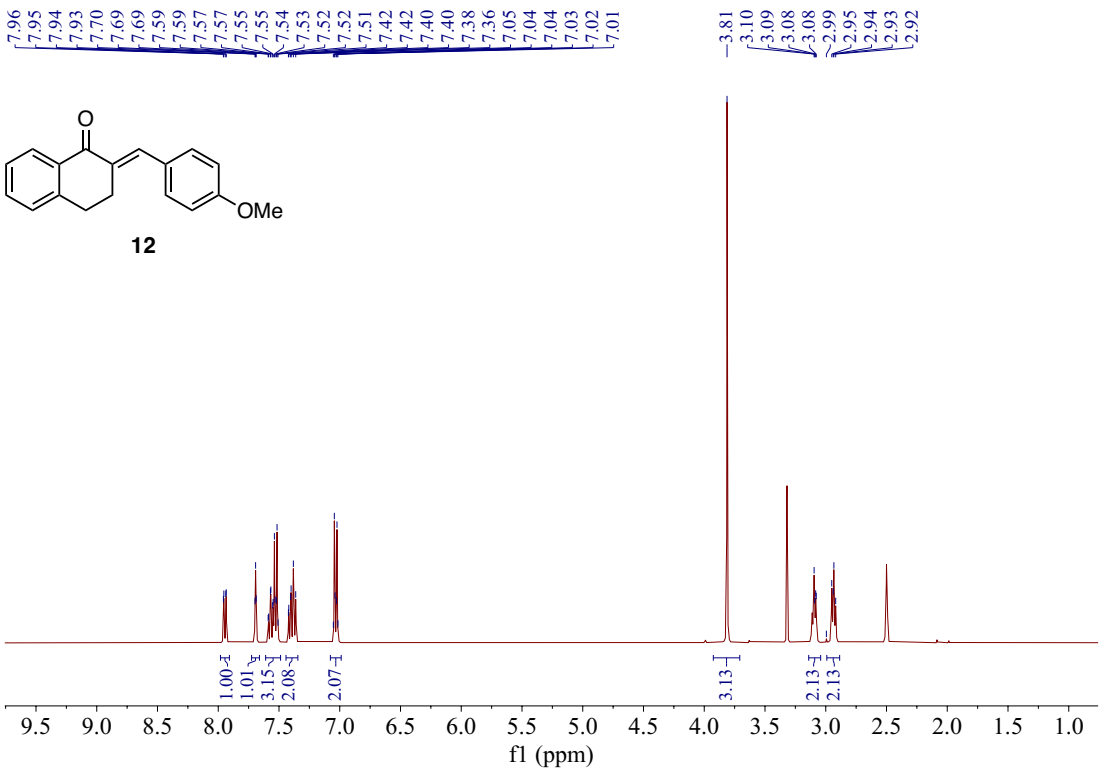
^{1}H NMR of Compound **10** as a mixture of diastereomers (400 MHz, $CDCl_3$)



^{1}H NMR of Compound **11** as a mixture of diastereomers (400 MHz, DMSO-d_6)



^{13}C NMR of Compound **11** as a mixture of diastereomers (101 MHz, DMSO-d_6)



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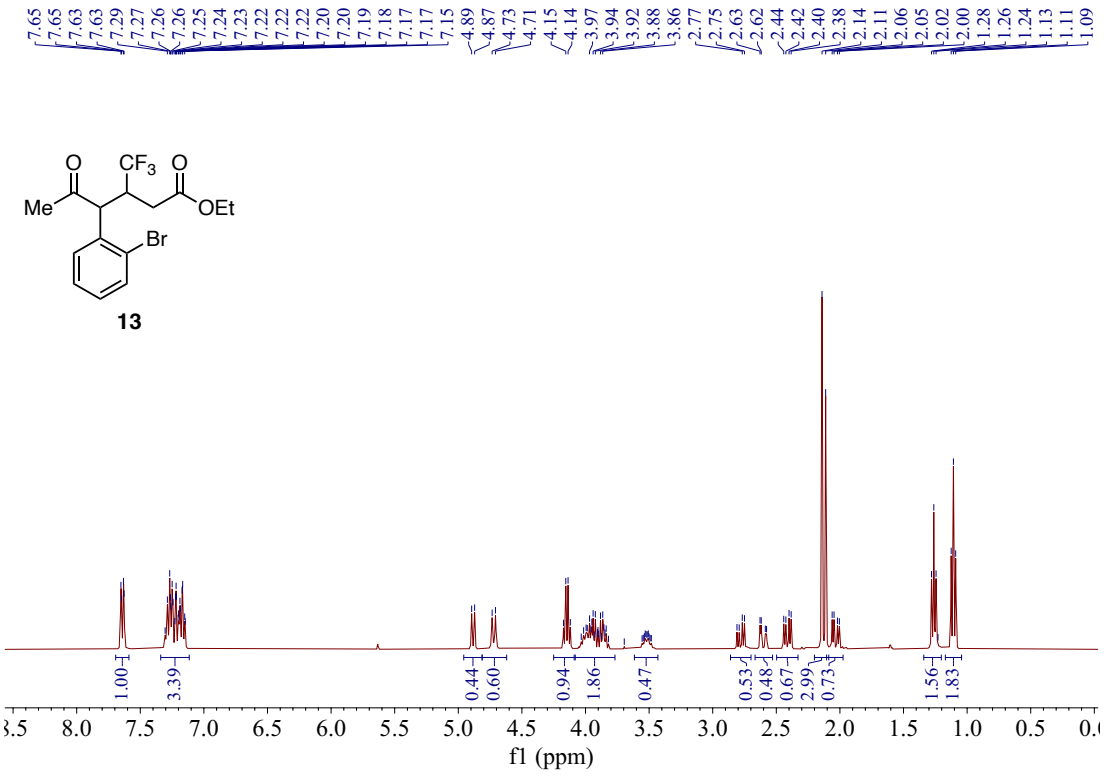
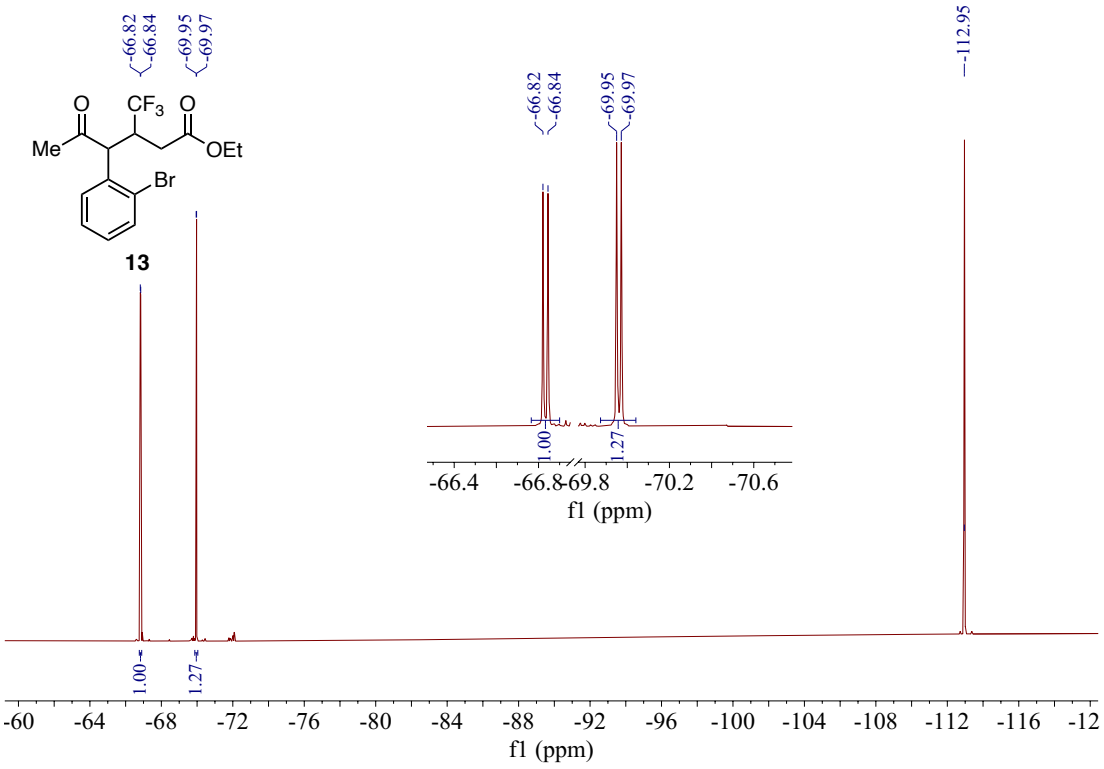
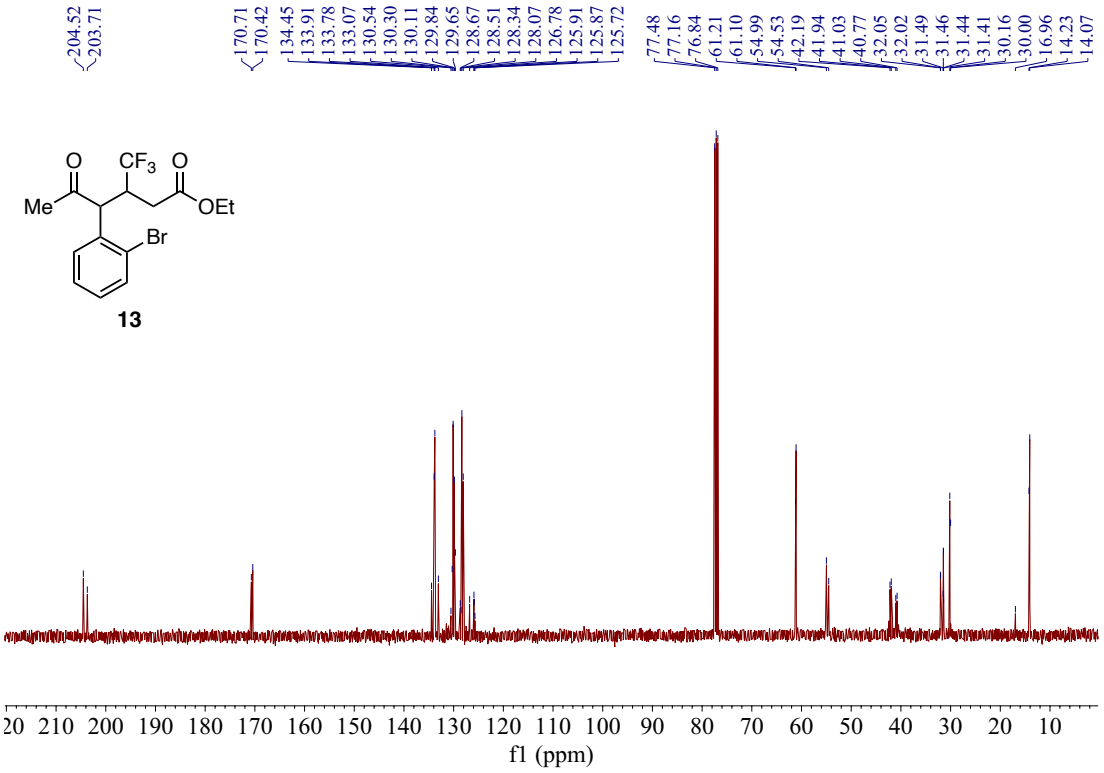


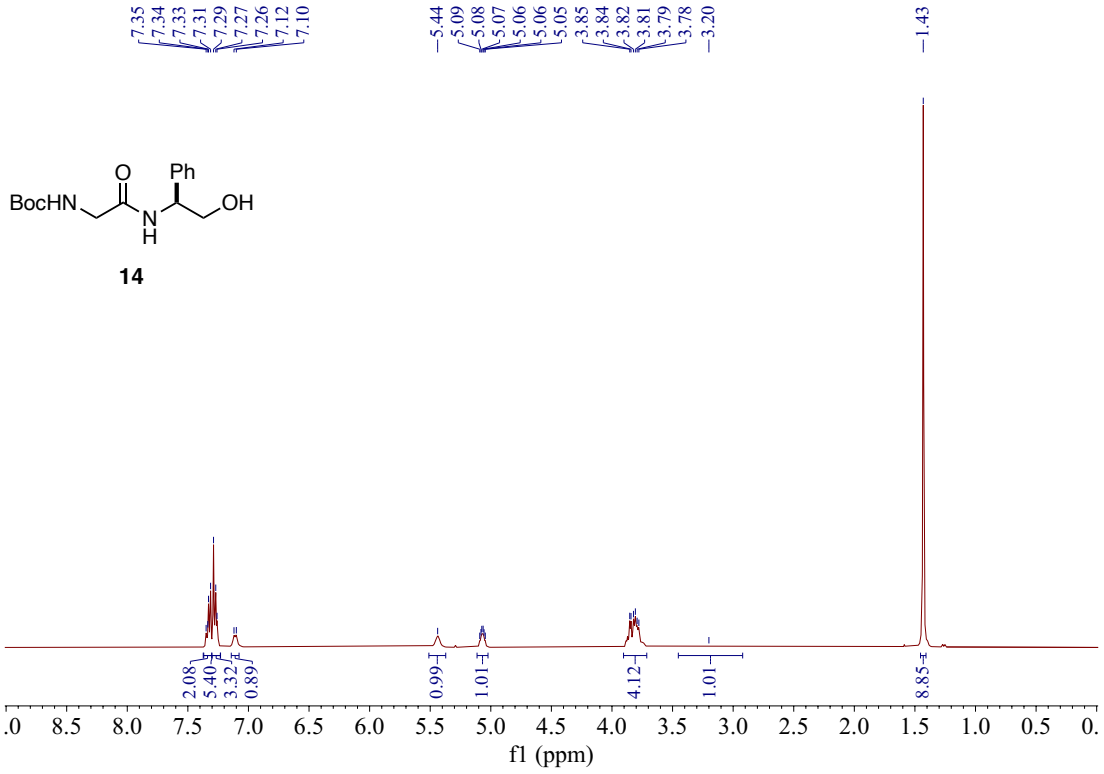
^{1}H NMR of Compound **13** as a mixture of diastereomers (400 MHz, $CDCl_3$)



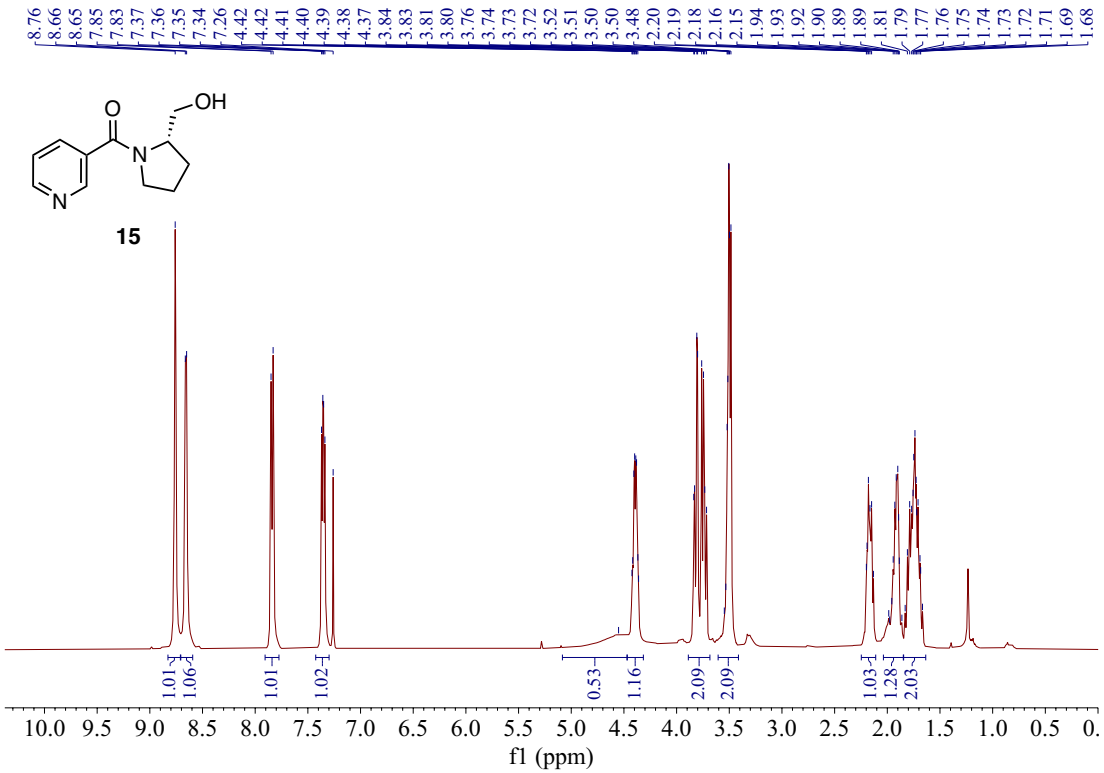
^{19}F NMR of Compound **13** as a mixture of diastereomers (376 MHz, $CDCl_3$)



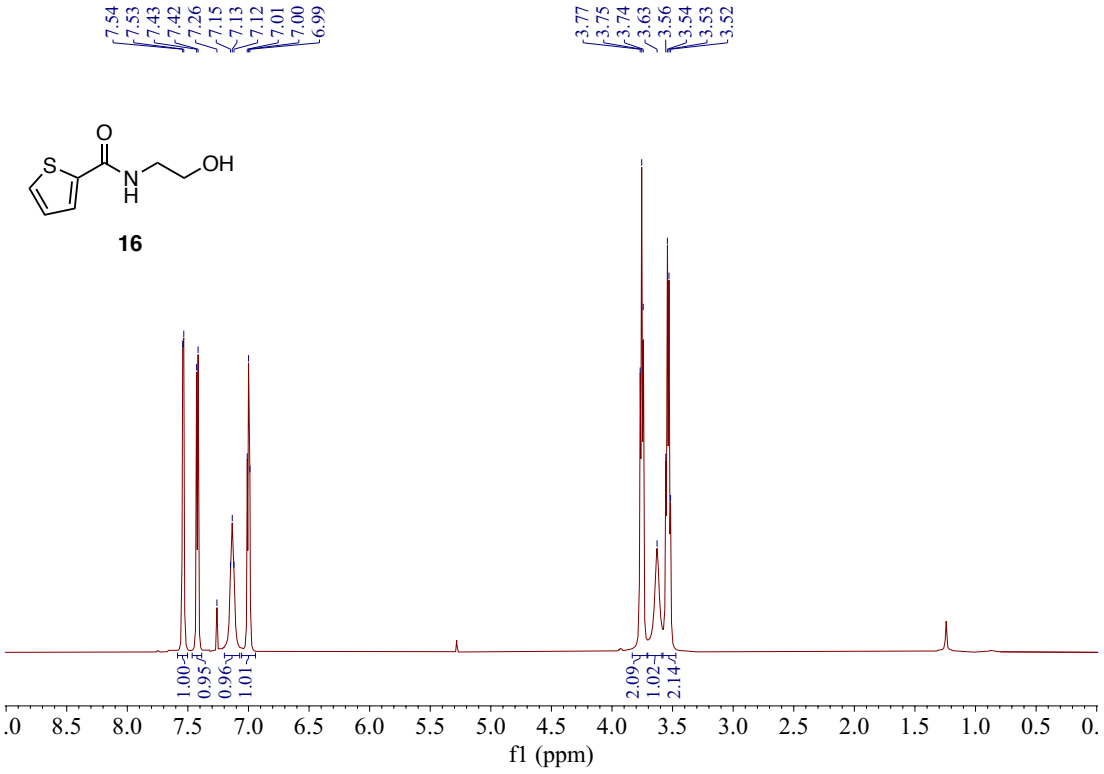
^{13}C NMR of Compound **13** as a mixture of diastereomers (101 MHz, $CDCl_3$)



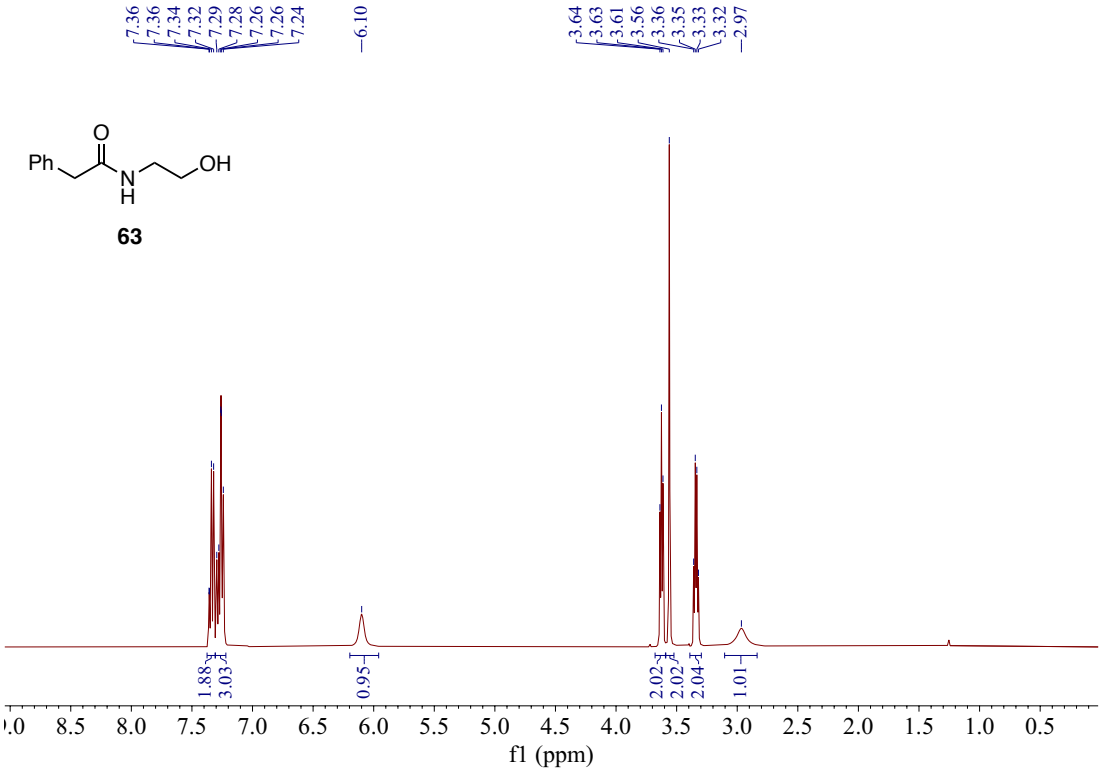
^{1}H NMR of Compound **14** (400 MHz, $CDCl_3$)



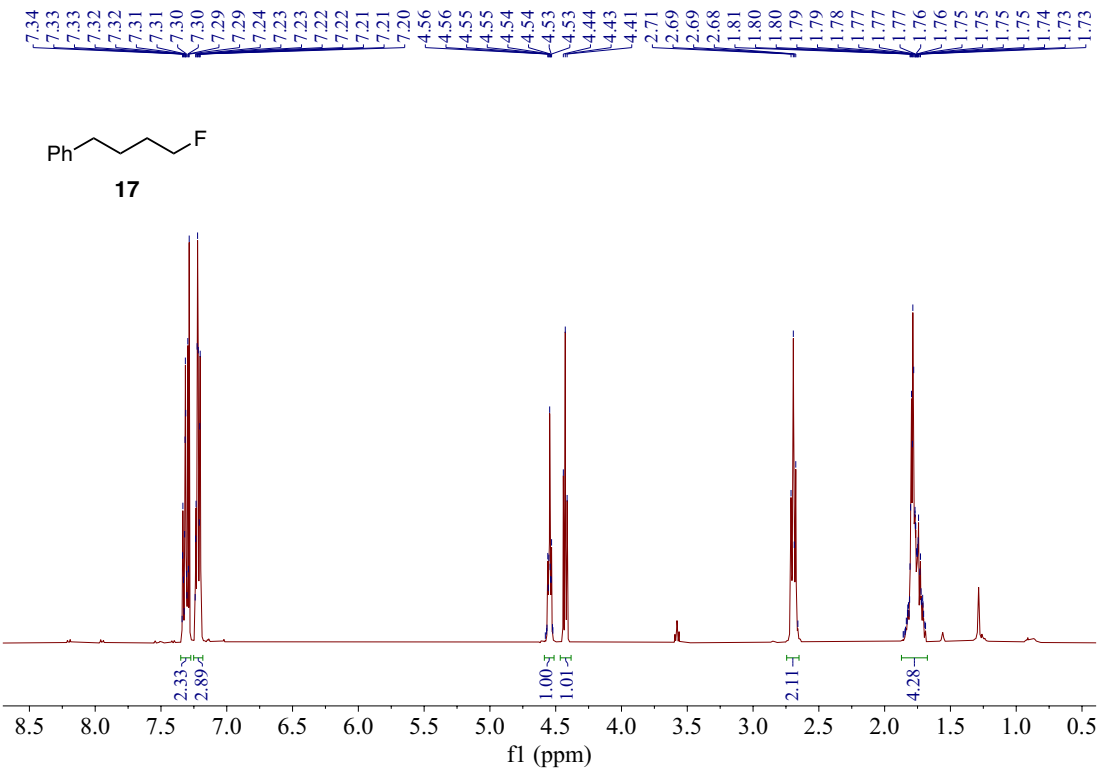
^{1}H NMR of Compound **15** (400 MHz, $CDCl_3$)



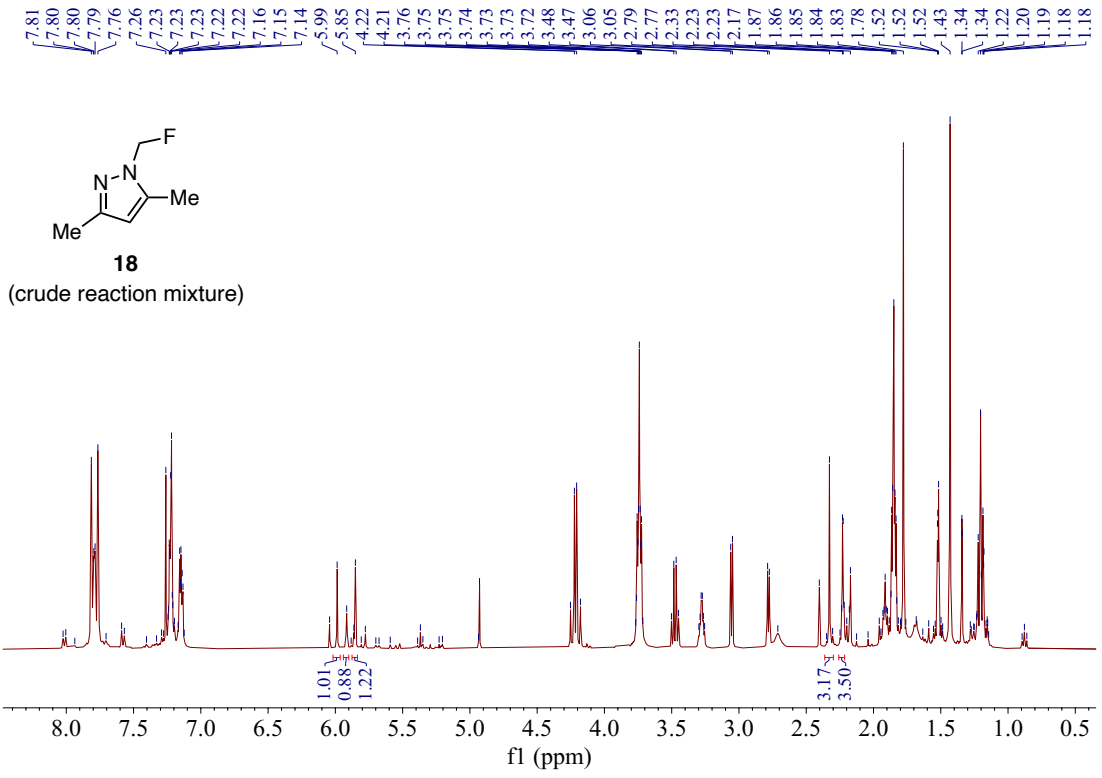
^{1}H NMR of Compound **16** (400 MHz, $CDCl_3$)



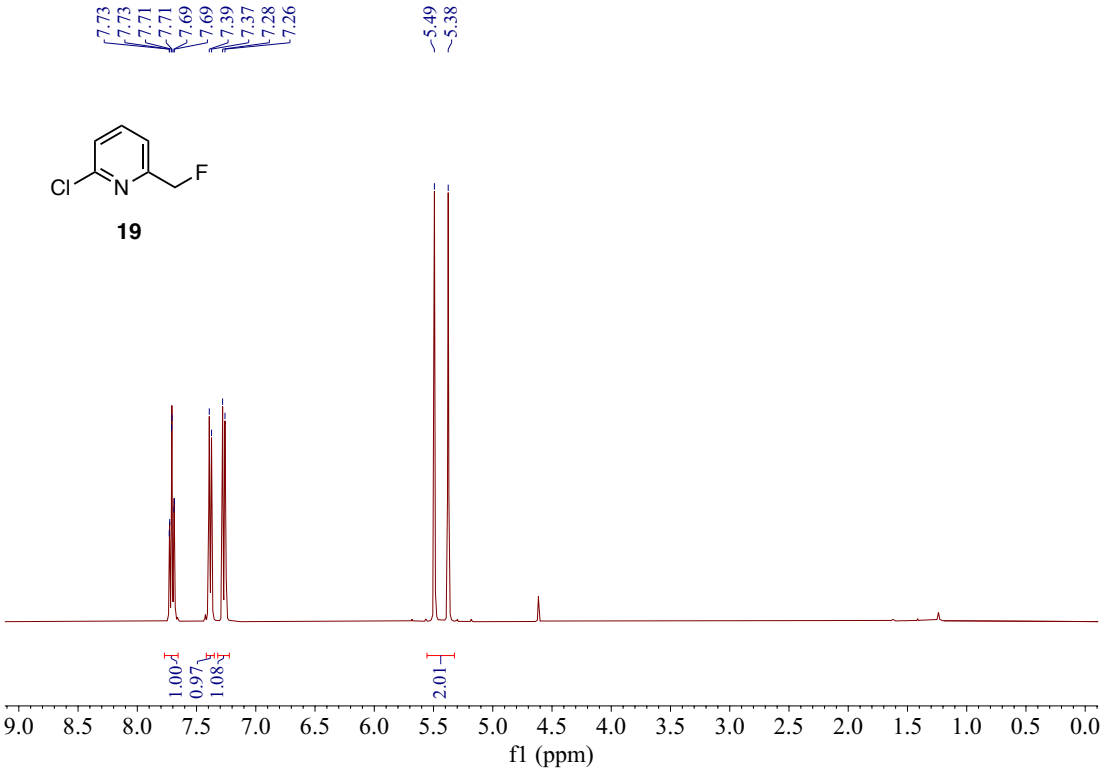
^{1}H NMR of Compound **63** (400 MHz, $CDCl_3$)



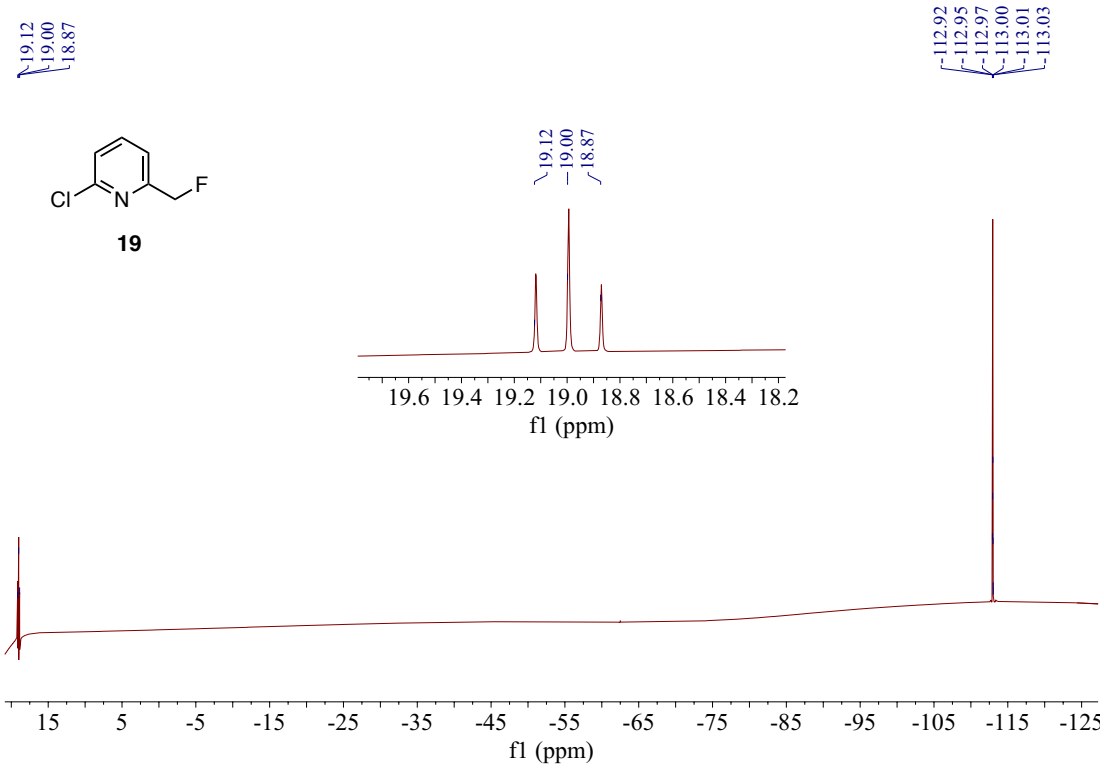
^{1}H NMR of Compound **17** (400 MHz, $CDCl_3$)



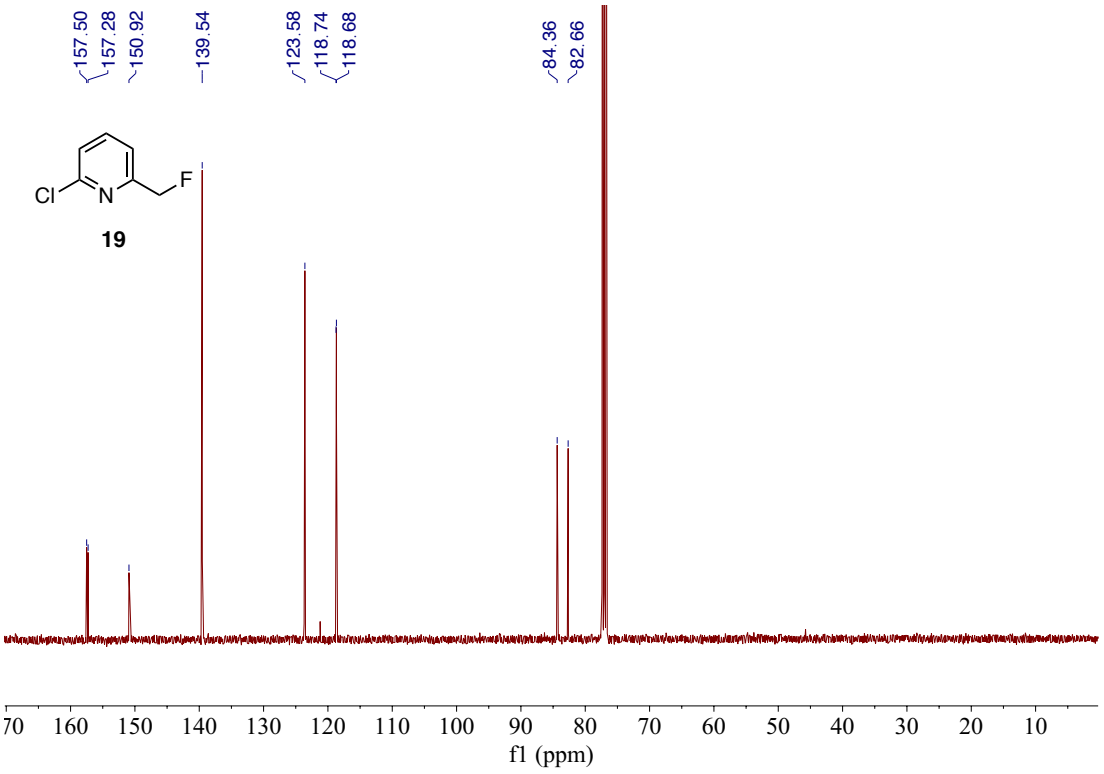
^{1}H NMR of Compound **18** crude reaction mixture (400 MHz, $CDCl_3$)



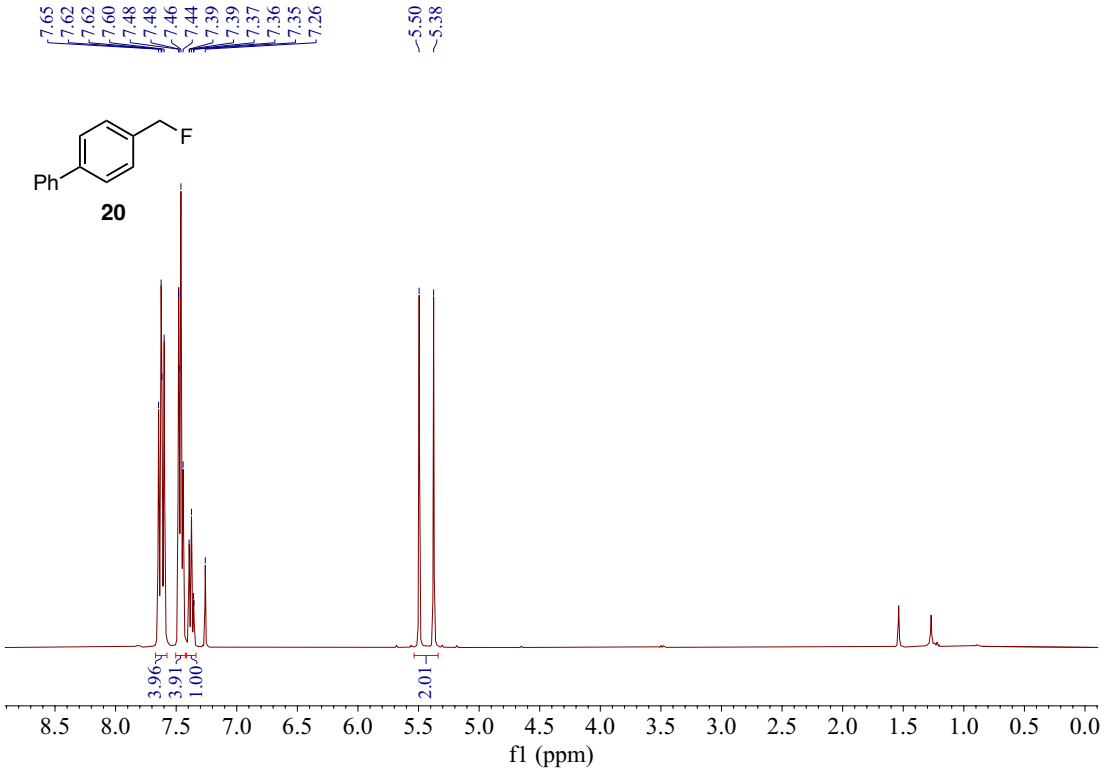
^{1}H NMR of Compound **19** (400 MHz, $CDCl_3$)



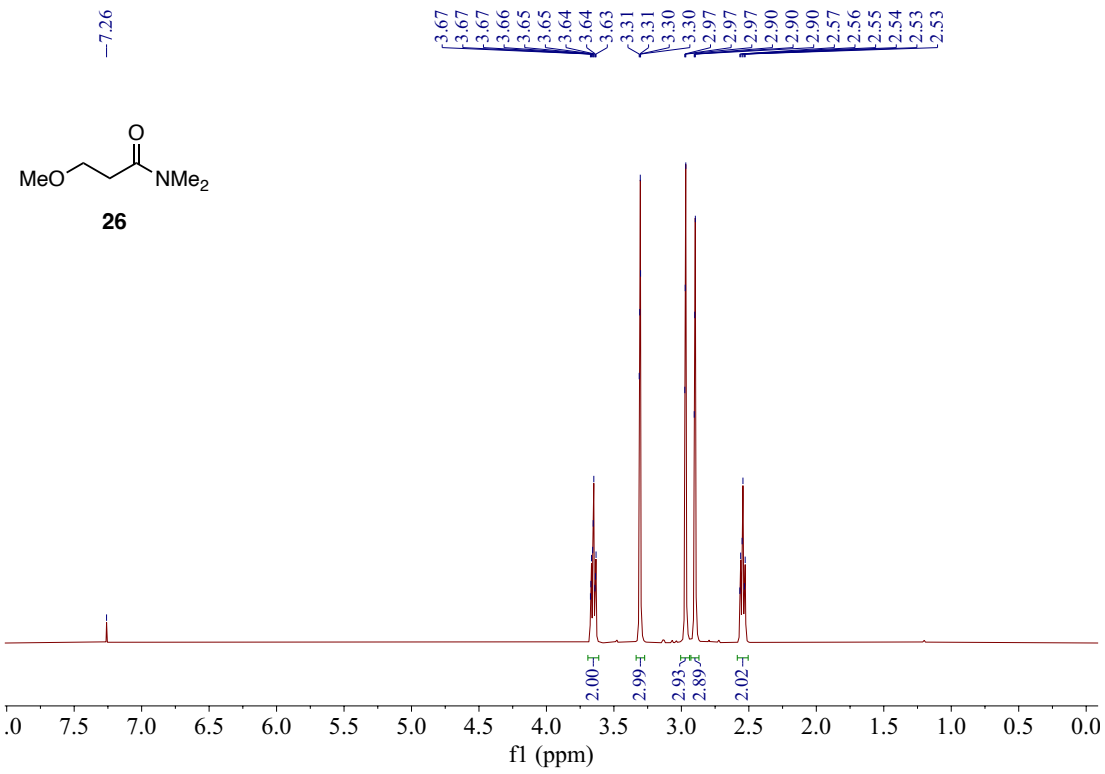
^{19}F NMR of Compound **19** (376 MHz, $CDCl_3$)



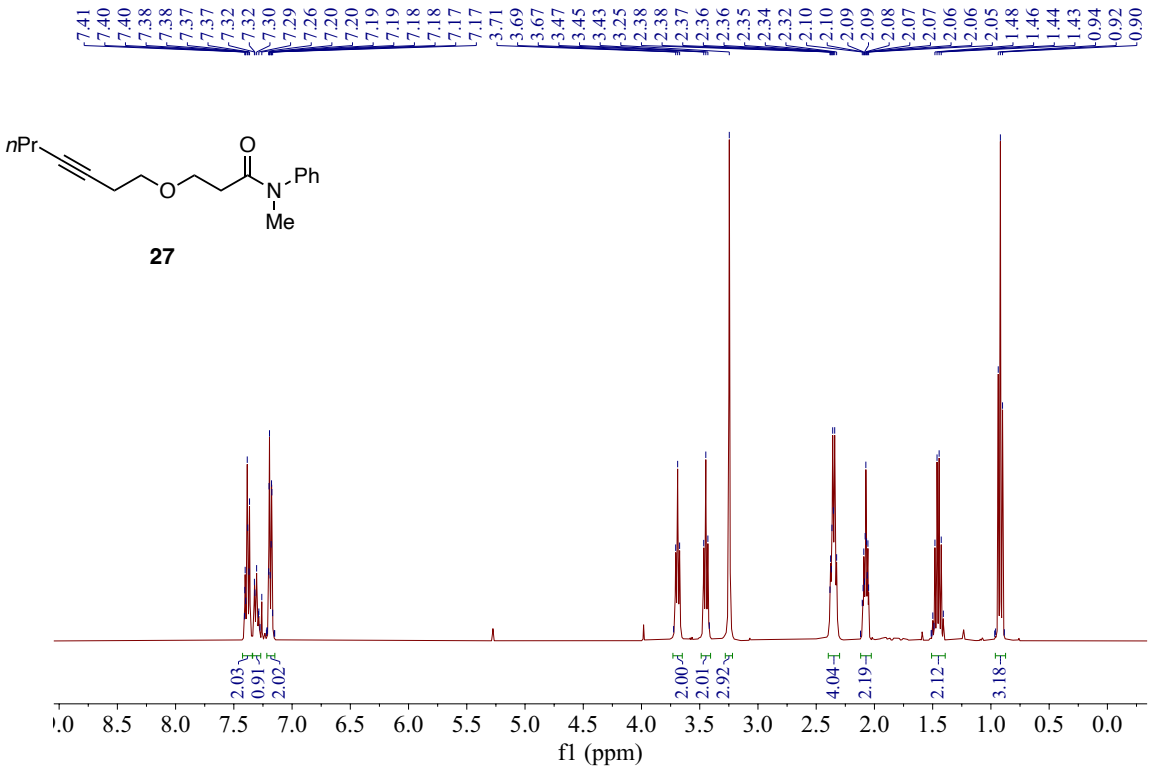
^{13}C NMR of Compound **19** ($CDCl_3$)



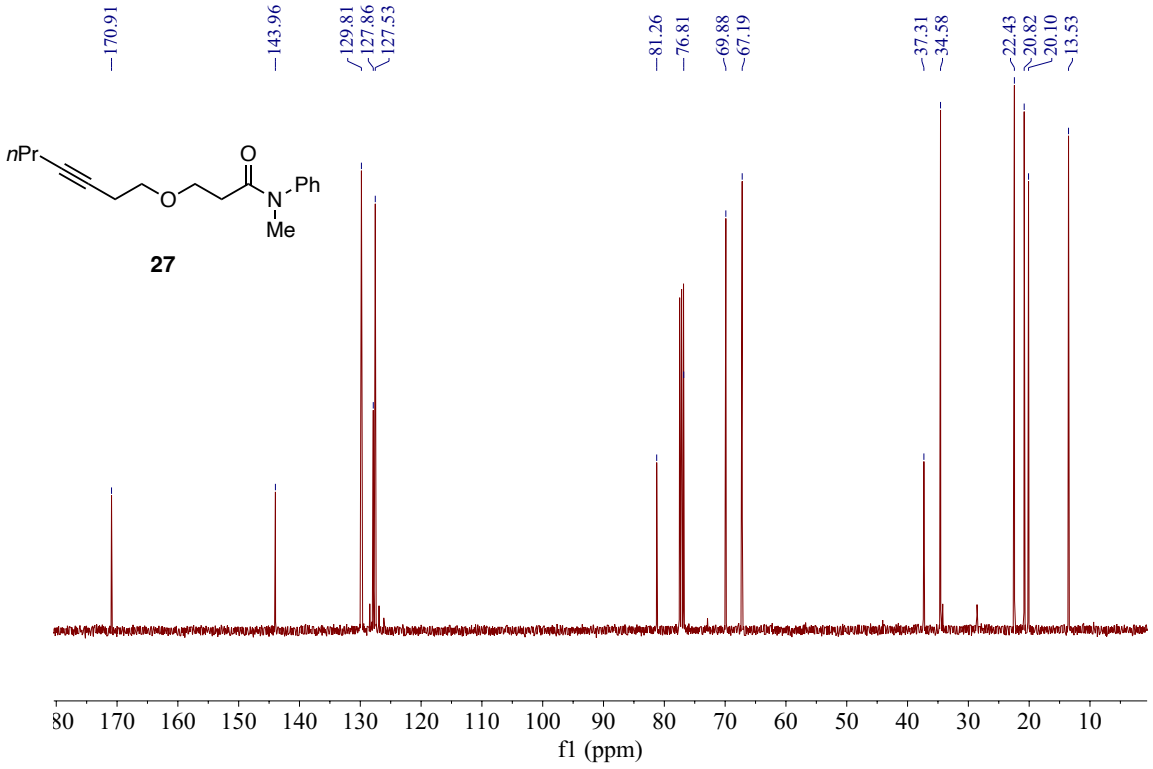
^{1}H NMR of Compound **20** (400 MHz, $CDCl_3$)



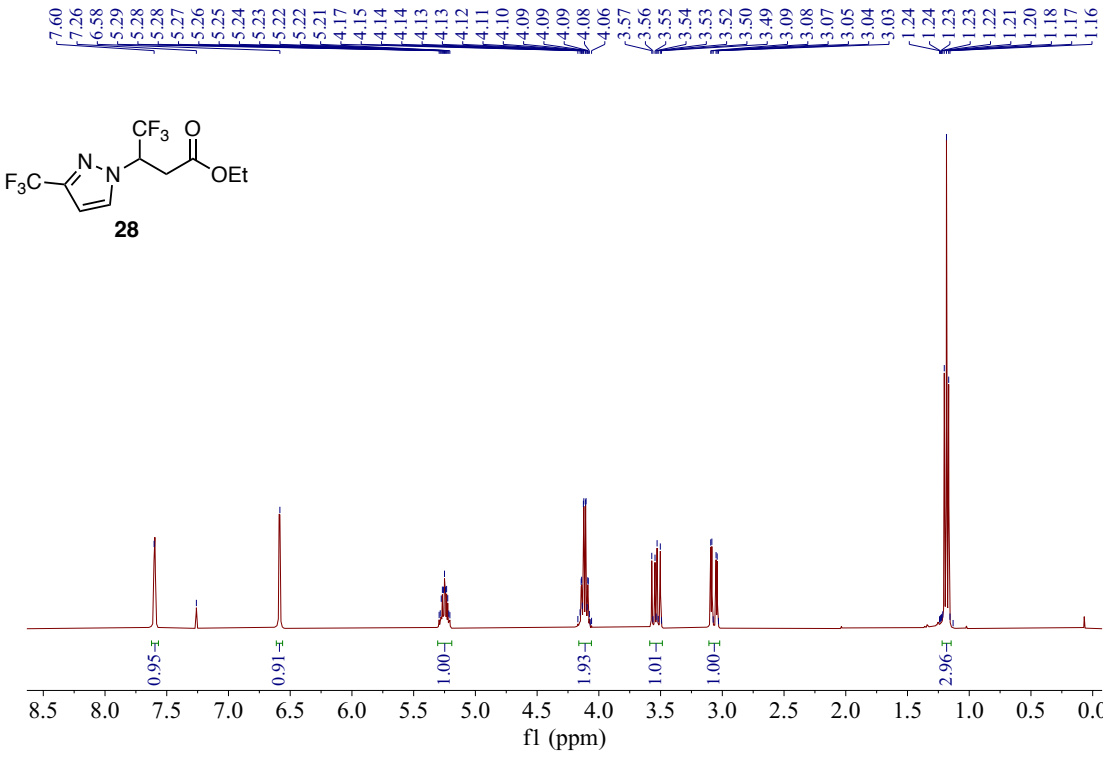
^{1}H NMR of Compound **26** (400 MHz, $CDCl_3$)



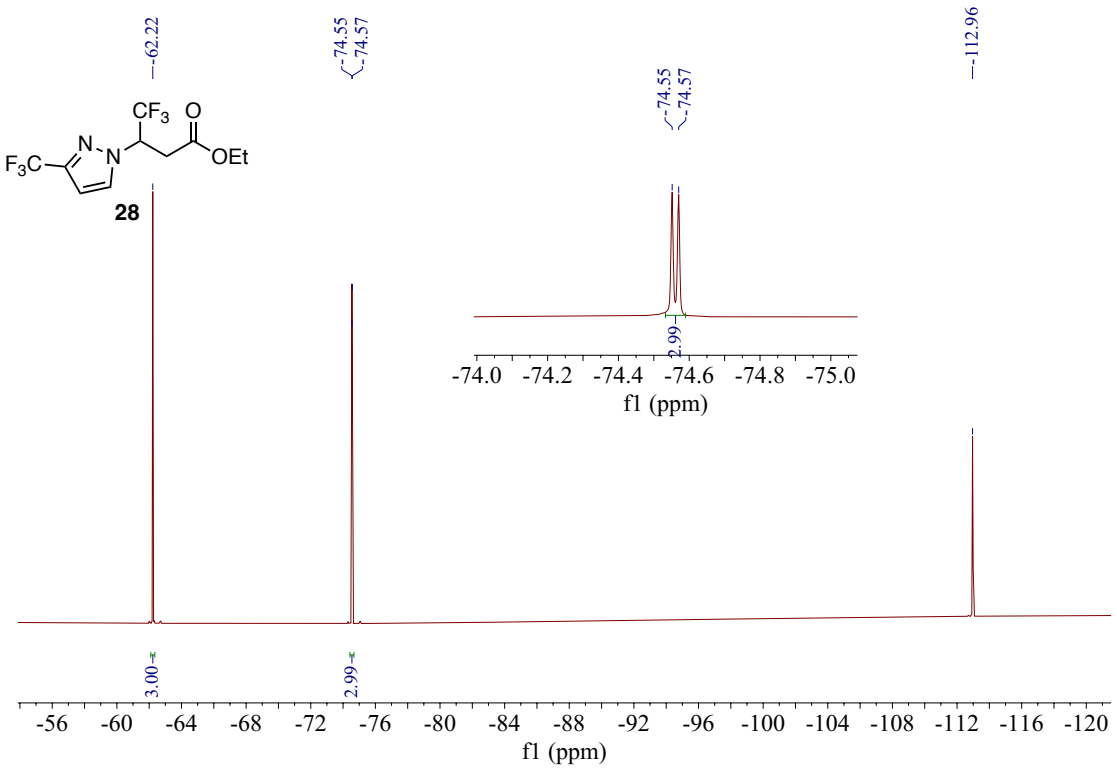
^{1}H NMR of Compound **27** (400 MHz, $CDCl_3$)



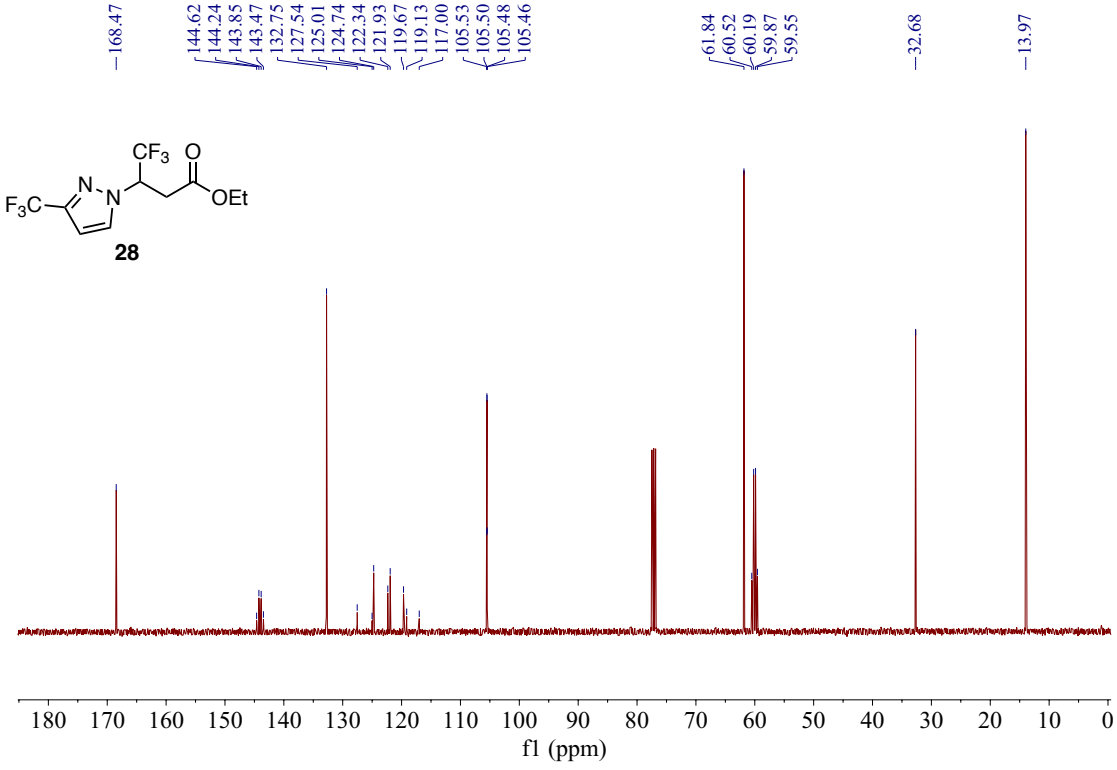
^{13}C NMR of Compound **27** (101 MHz, $CDCl_3$)



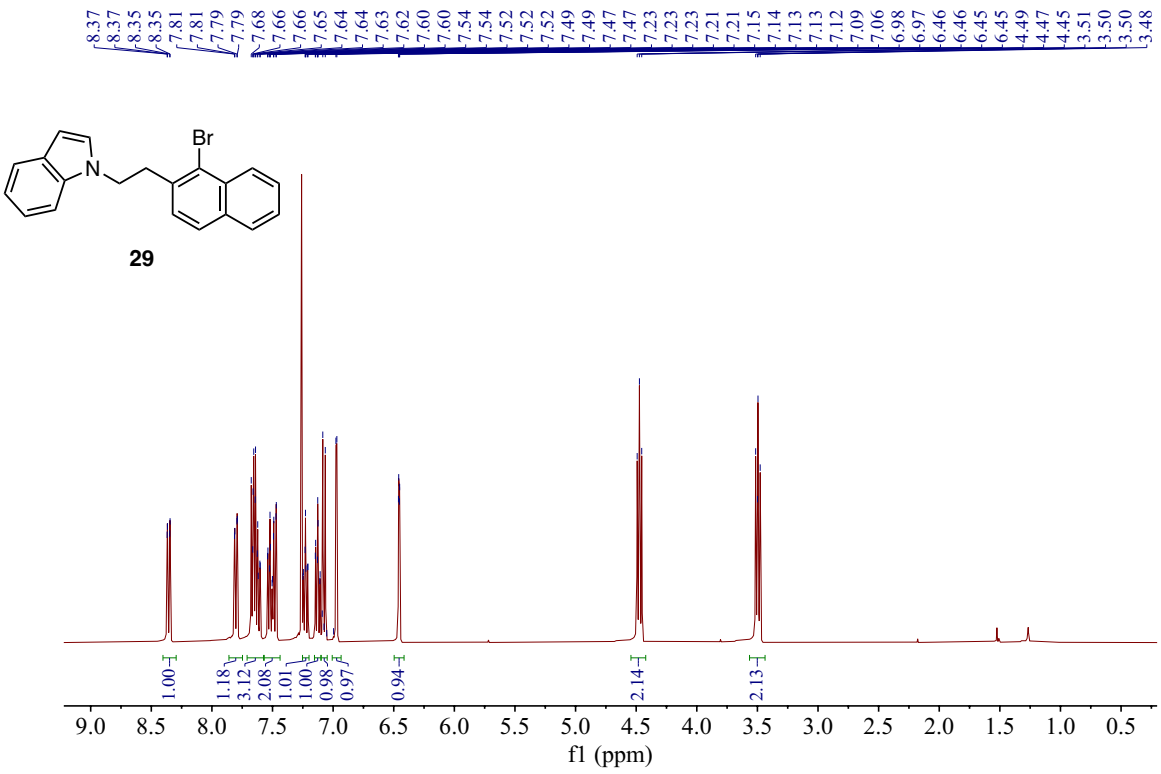
^{1}H NMR of Compound **28** (400 MHz, $CDCl_3$)



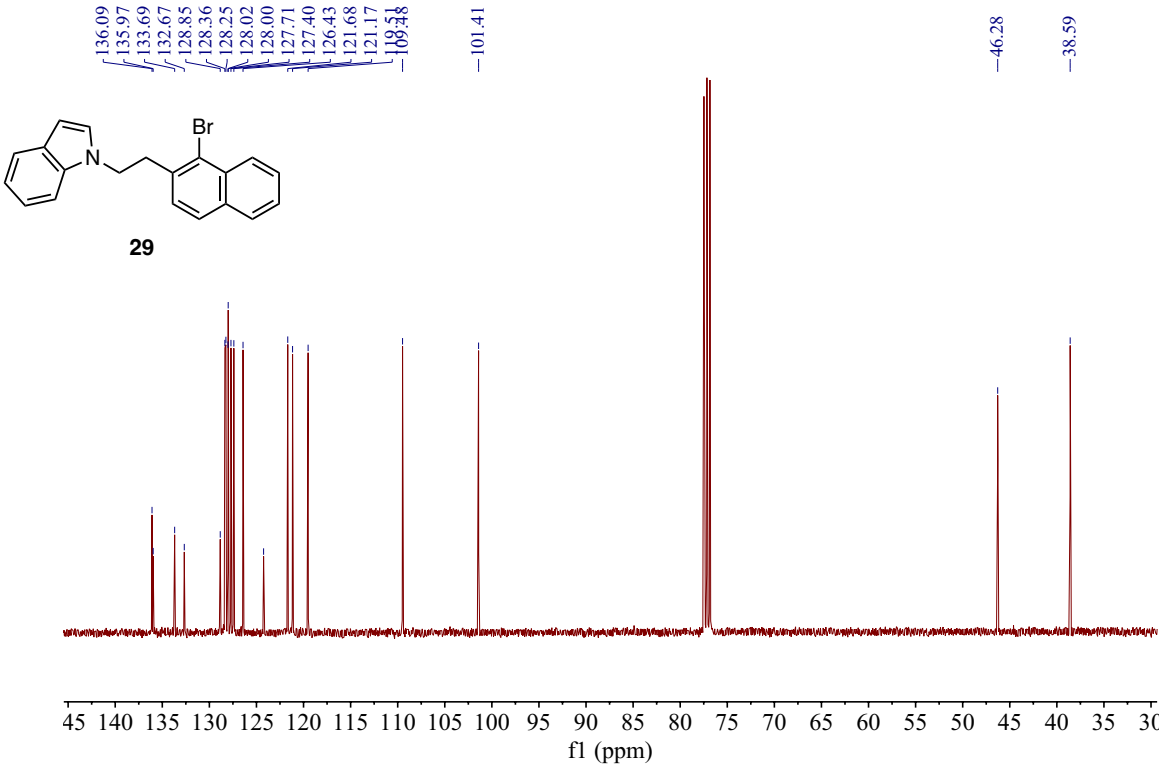
^{19}F NMR of Compound **28** (376 MHz, $CDCl_3$)



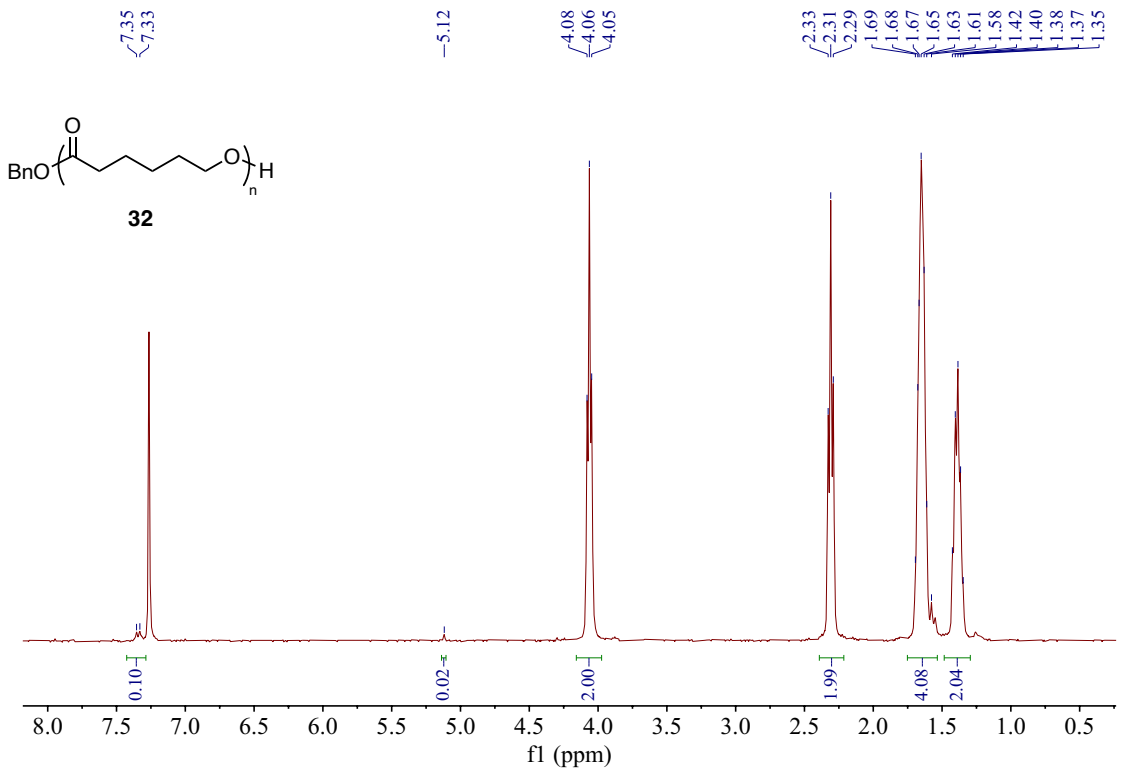
^{13}C NMR of Compound **28** (101 MHz, $CDCl_3$)



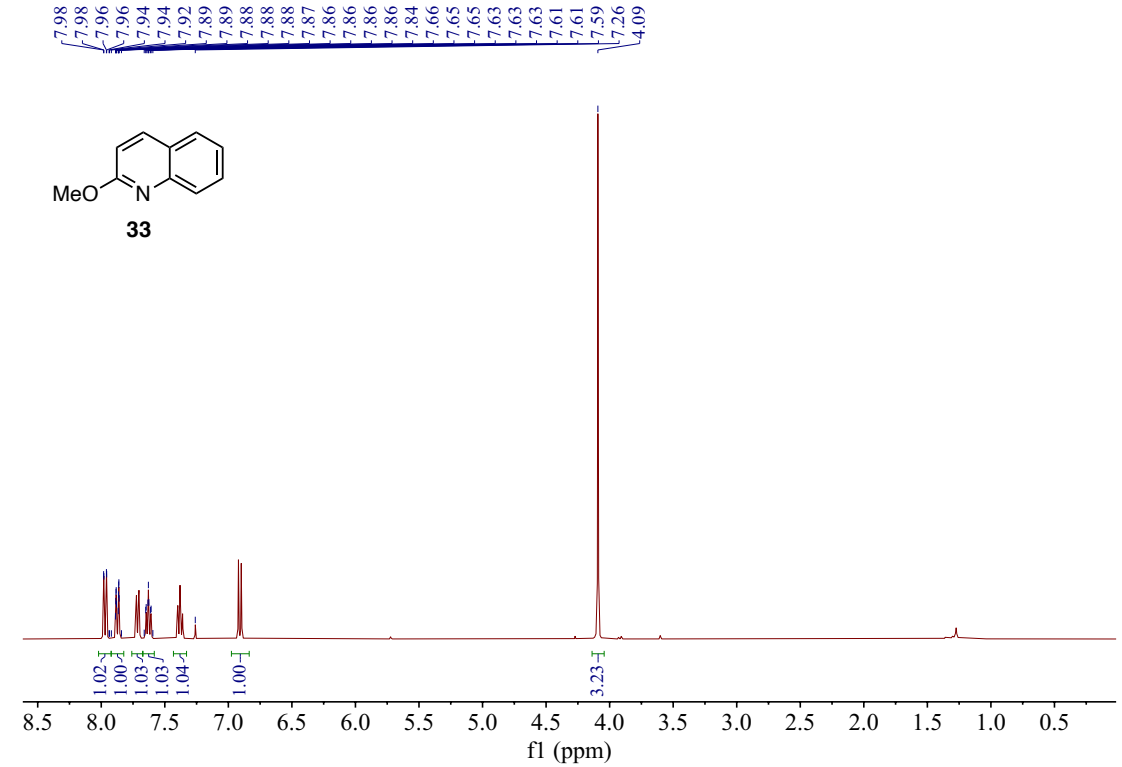
^{1}H NMR of Compound **29** (400 MHz, $CDCl_3$)



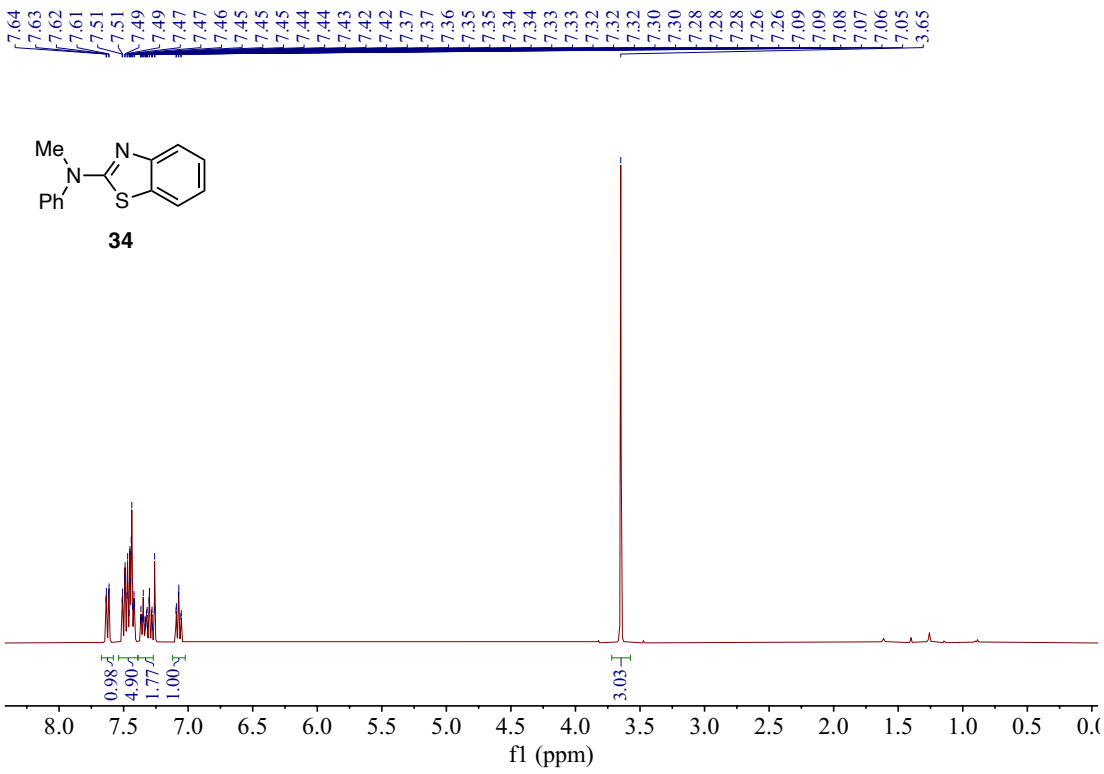
^{13}C NMR of Compound **29** (101 MHz, $CDCl_3$)



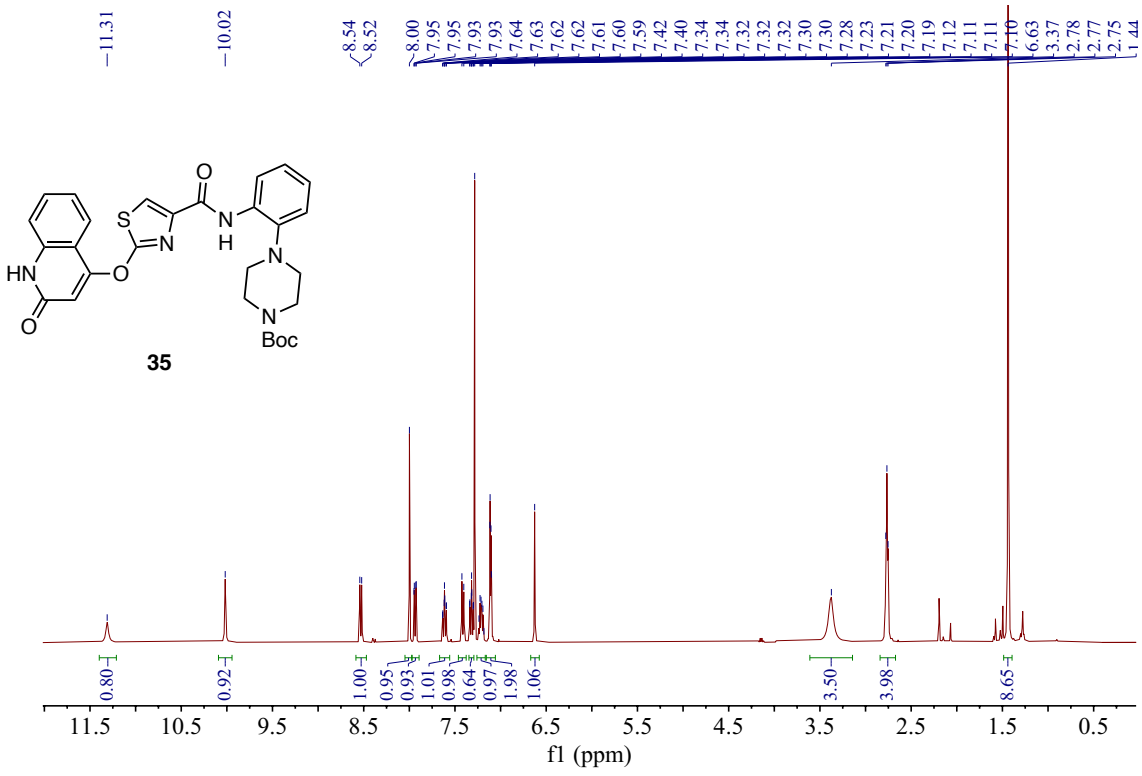
^{1}H NMR of Polymer **32** (400 MHz, $CDCl_3$)



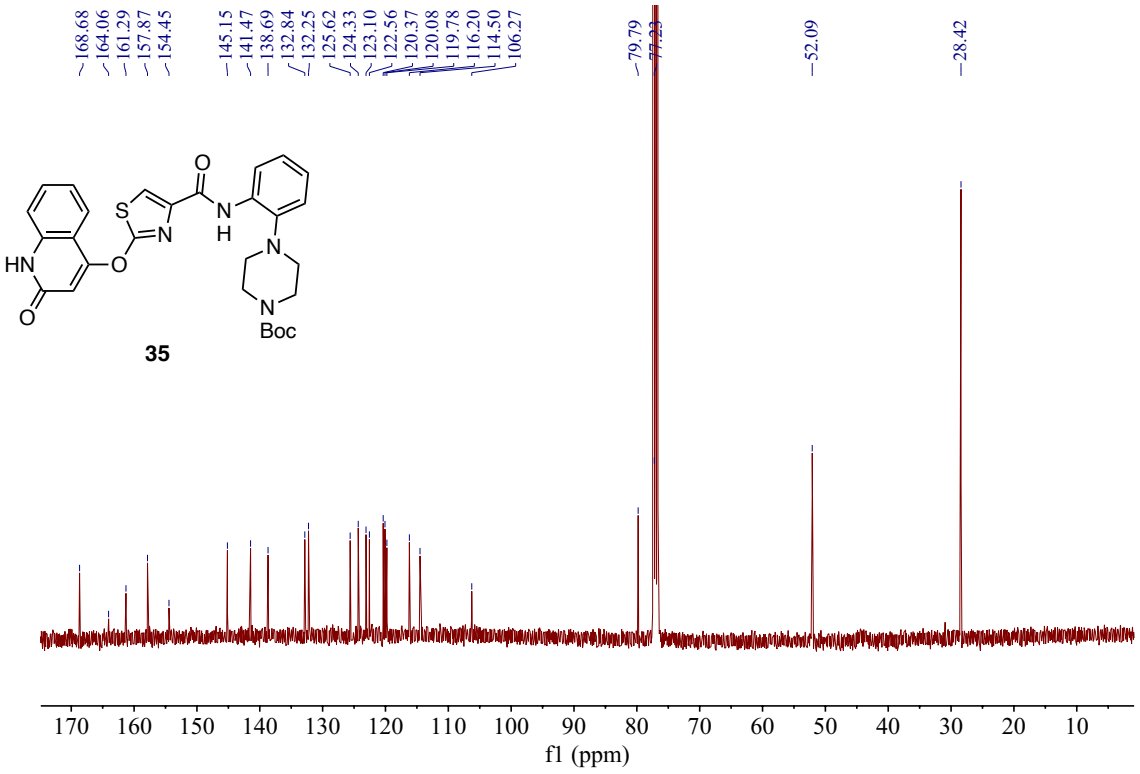
^{1}H NMR of Compound **33** (400 MHz, $CDCl_3$)



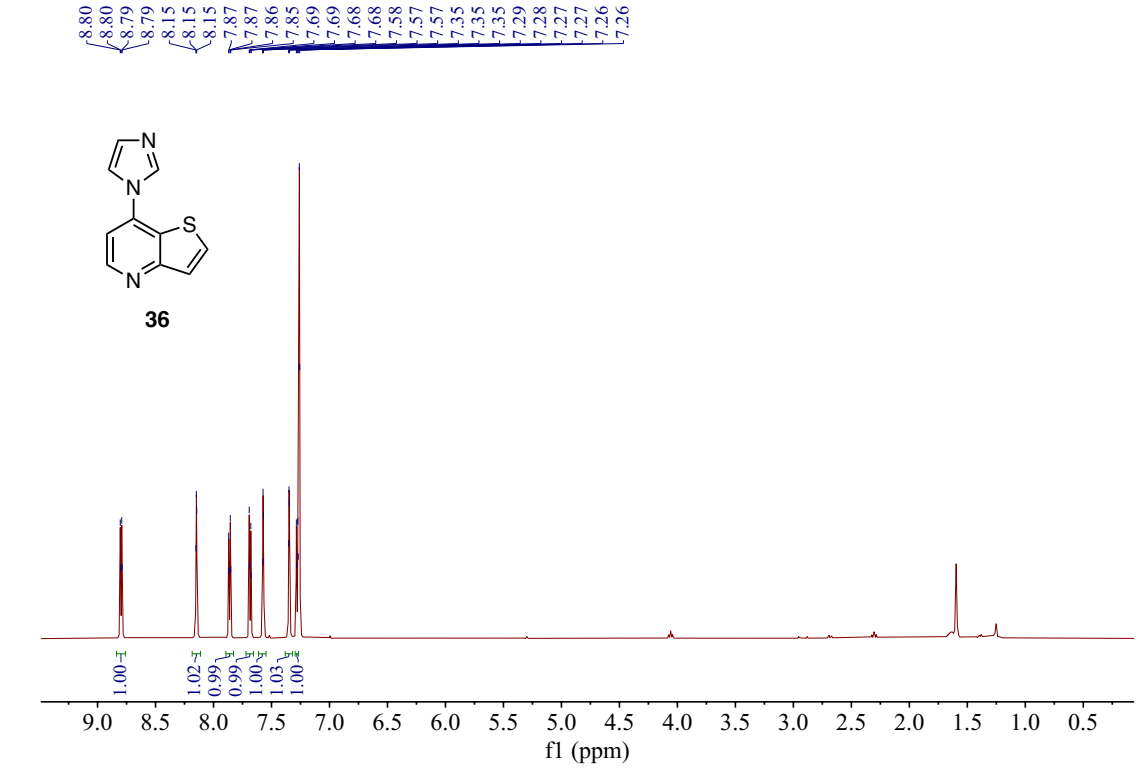
^{1}H NMR of Compound **34** (400 MHz, $CDCl_3$)



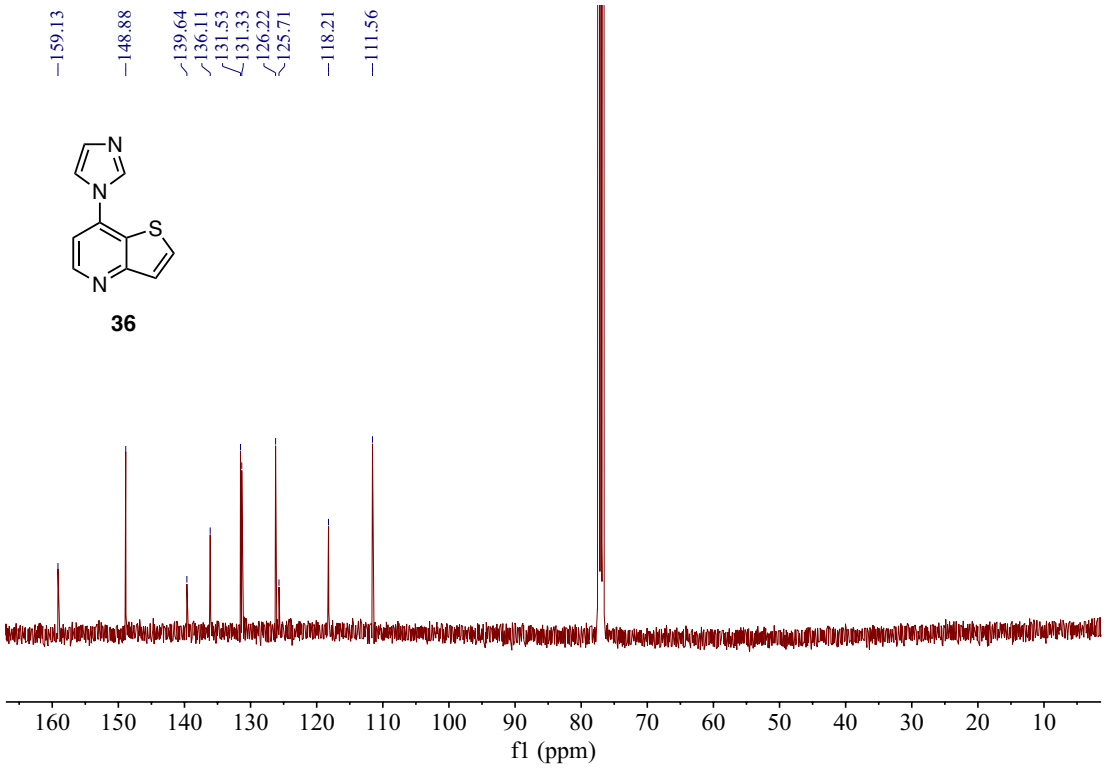
^{1}H NMR of Compound **35** (400 MHz, $CDCl_3$)



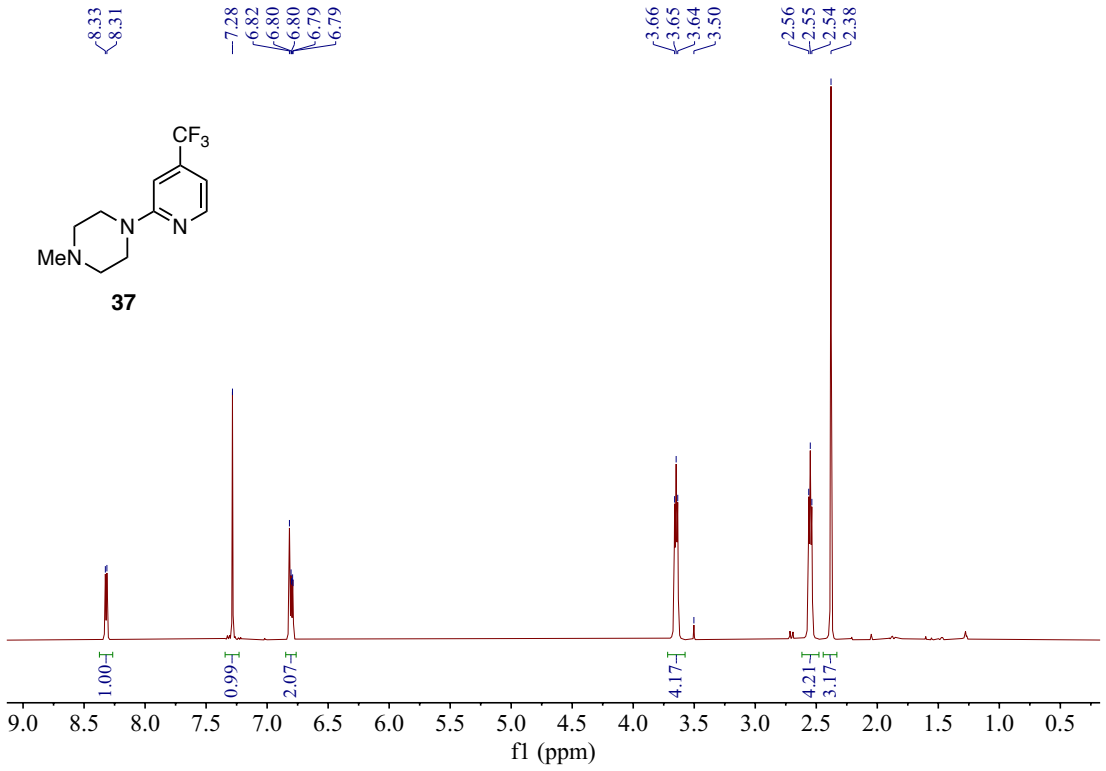
^{13}C NMR of Compound **35** (101 MHz, $CDCl_3$)



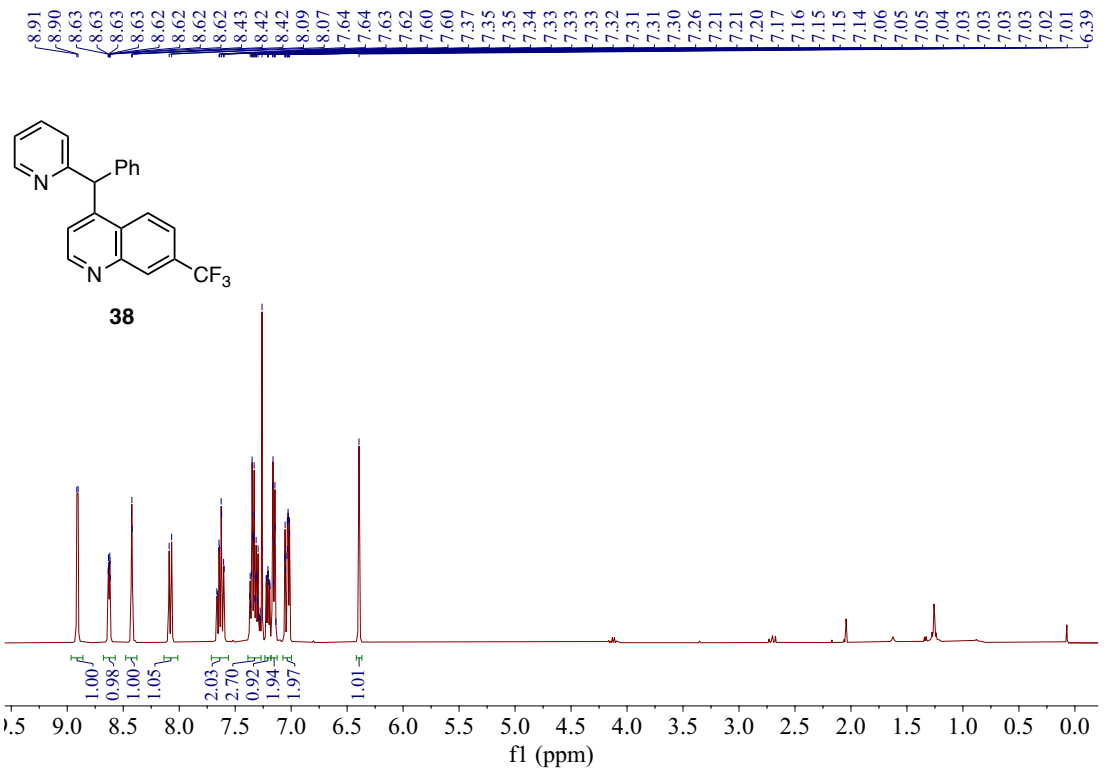
^{1}H NMR of Compound **36** (400 MHz, $CDCl_3$)



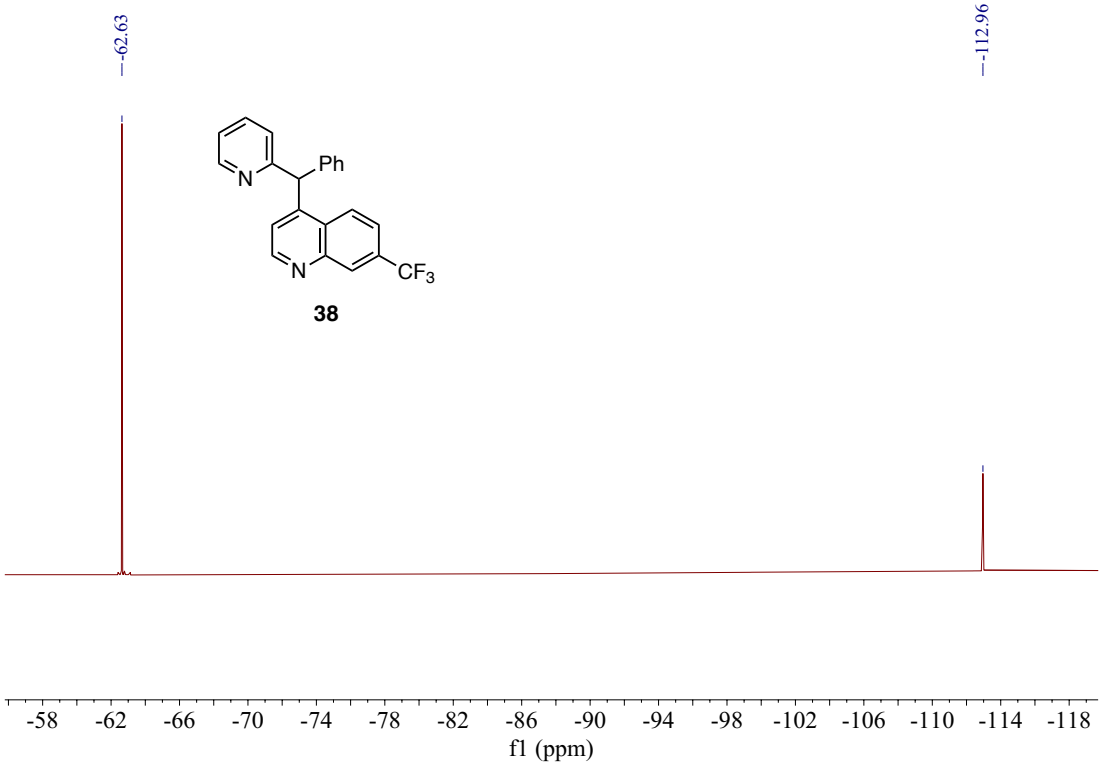
^{13}C NMR of Compound **36** (101 MHz, $CDCl_3$)



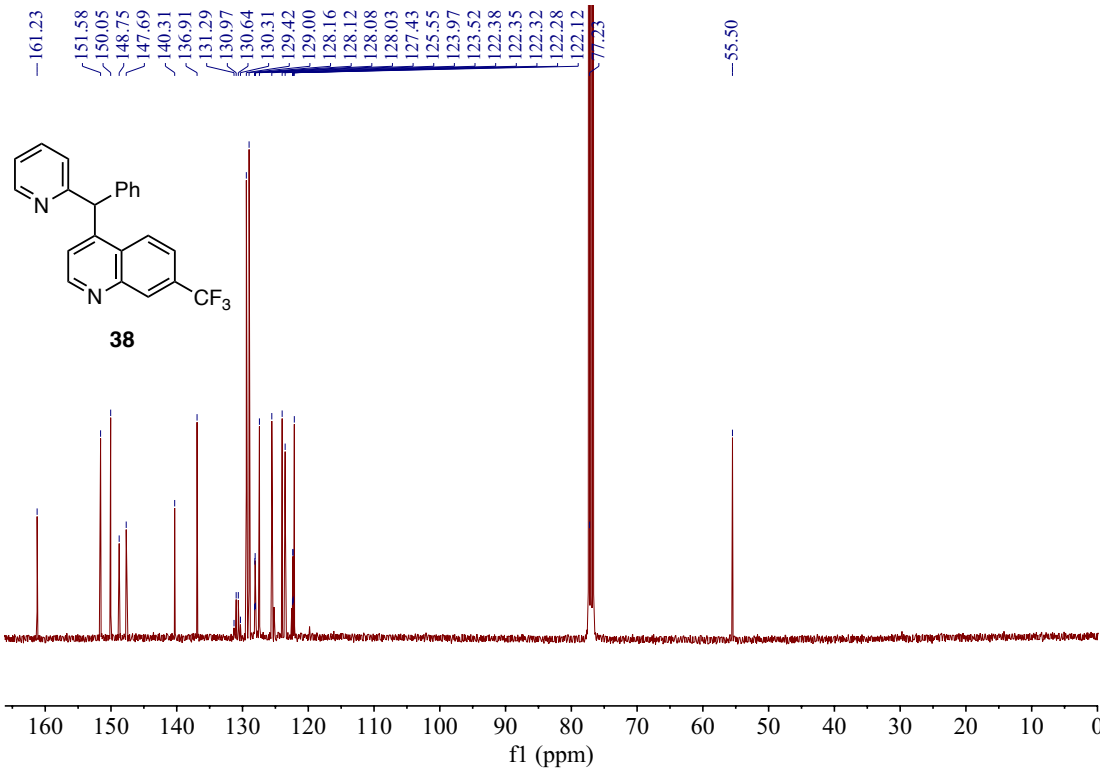
^{1}H NMR of Compound **37** (400 MHz, $CDCl_3$)



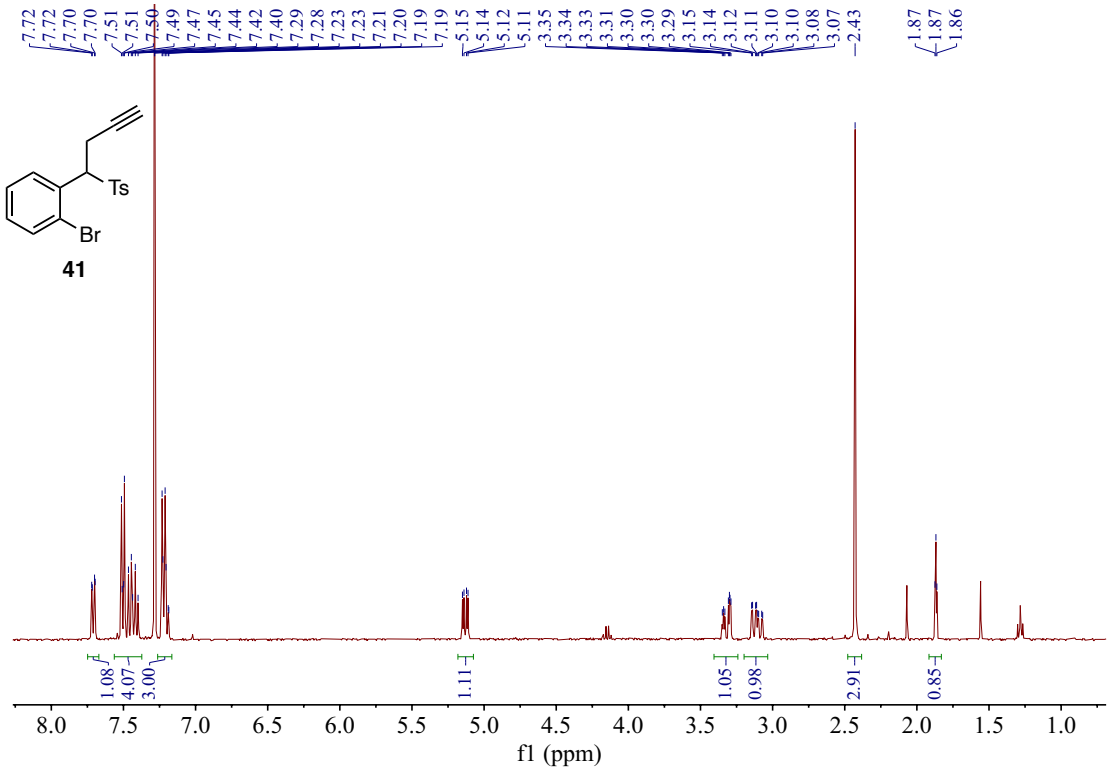
^{1}H NMR of Compound **38** (400 MHz, $CDCl_3$)



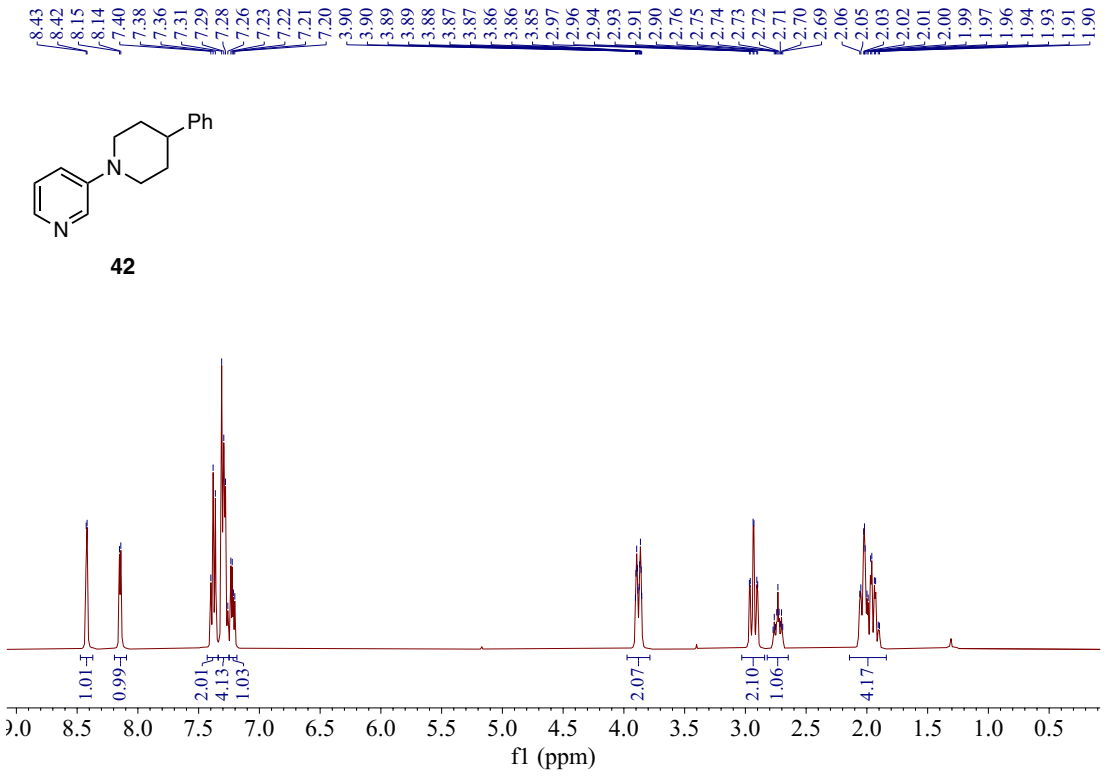
^{19}F NMR of Compound **38** (376 MHz, $CDCl_3$)



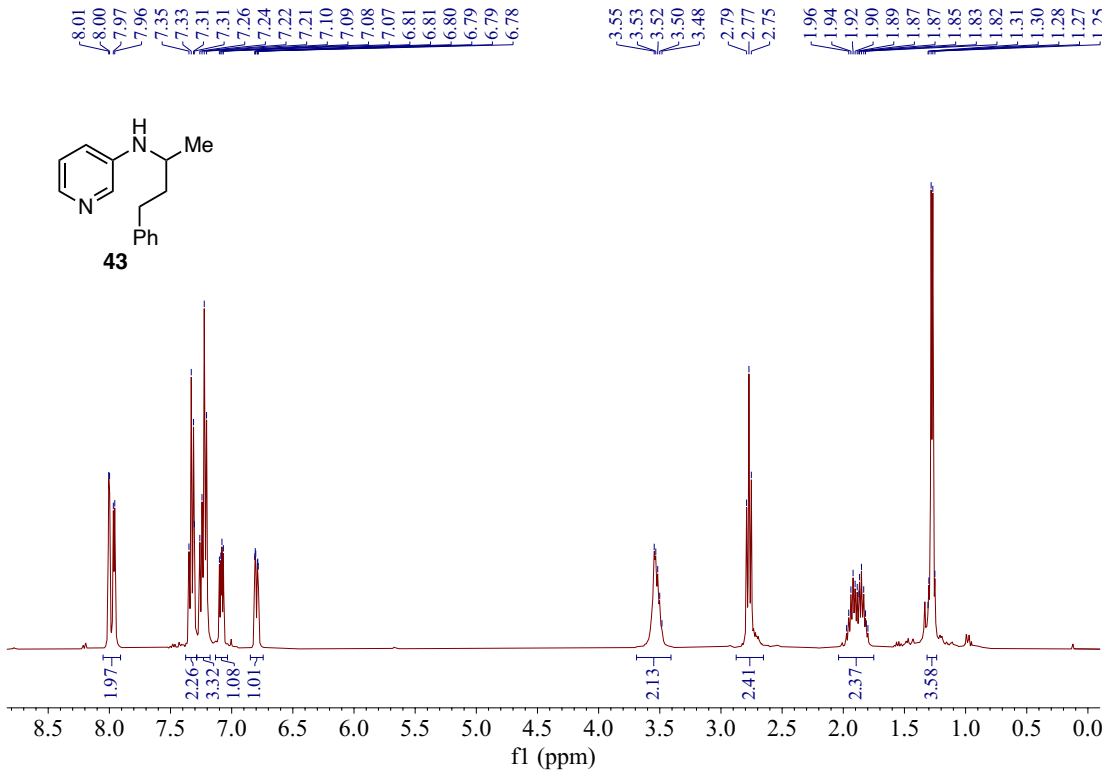
^{13}C NMR of Compound **38** (101 MHz, $CDCl_3$)



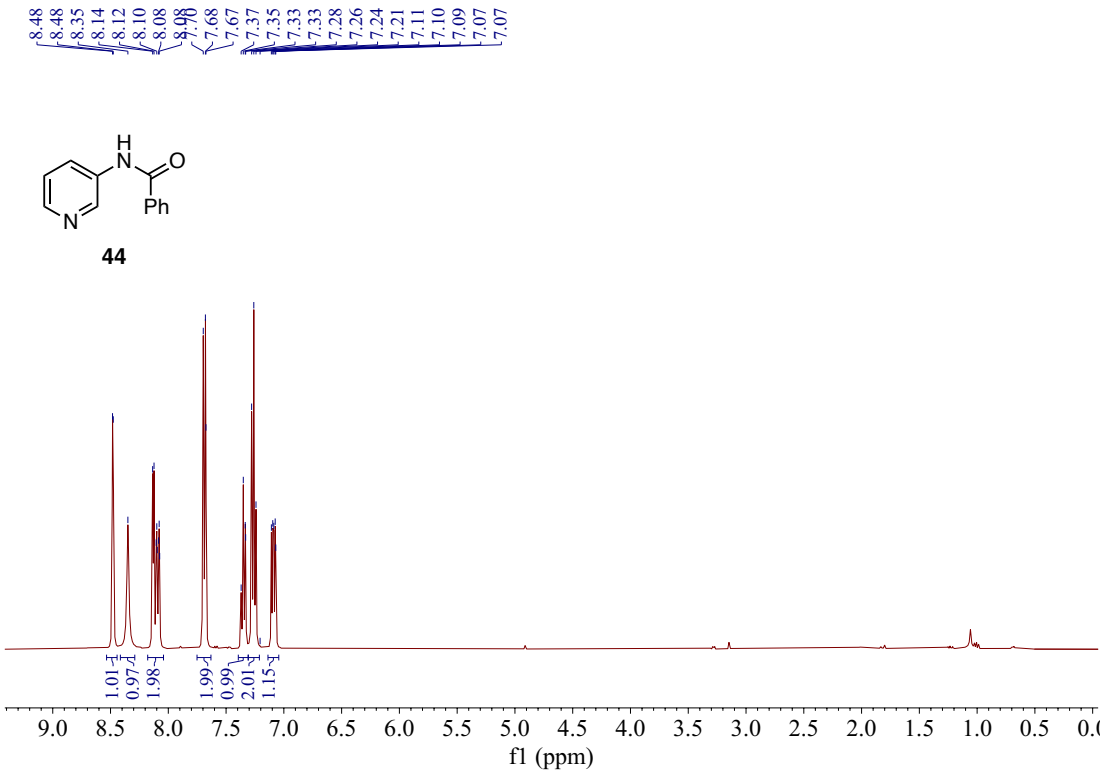
^{1}H NMR of Compound **41** (400 MHz, $CDCl_3$)



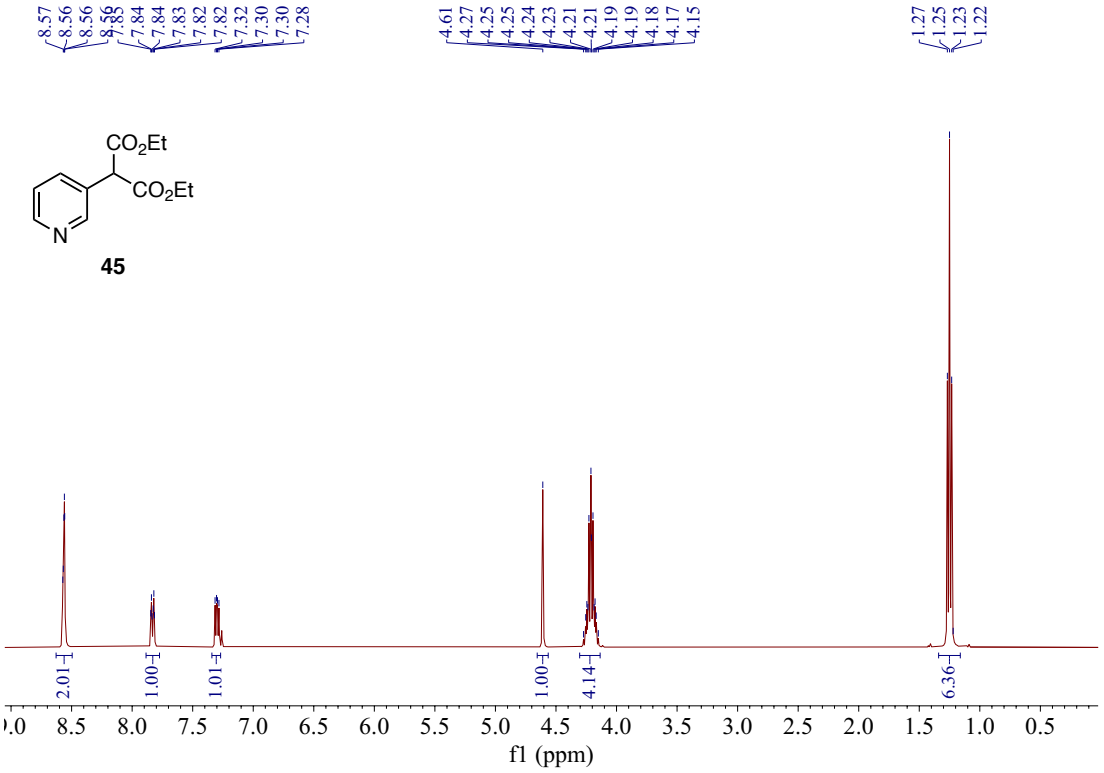
^{1}H NMR of Compound **42** (400 MHz, $CDCl_3$)



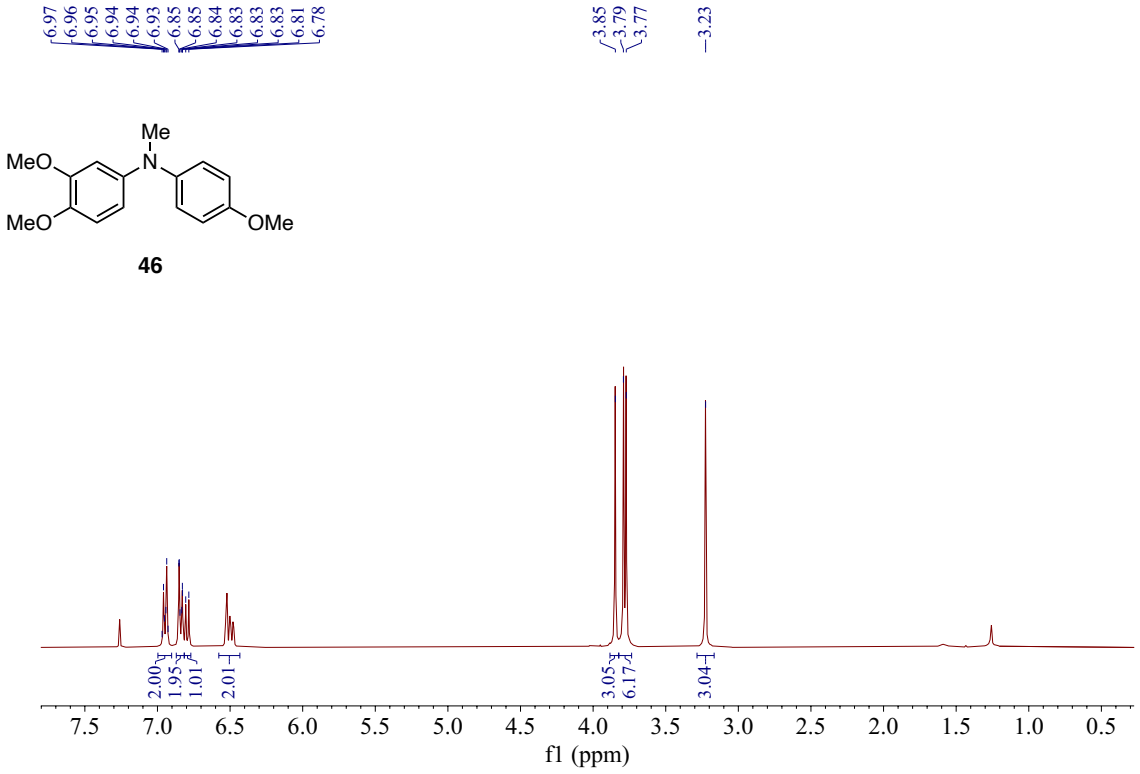
^{1}H NMR of Compound **43** (400 MHz, $CDCl_3$)



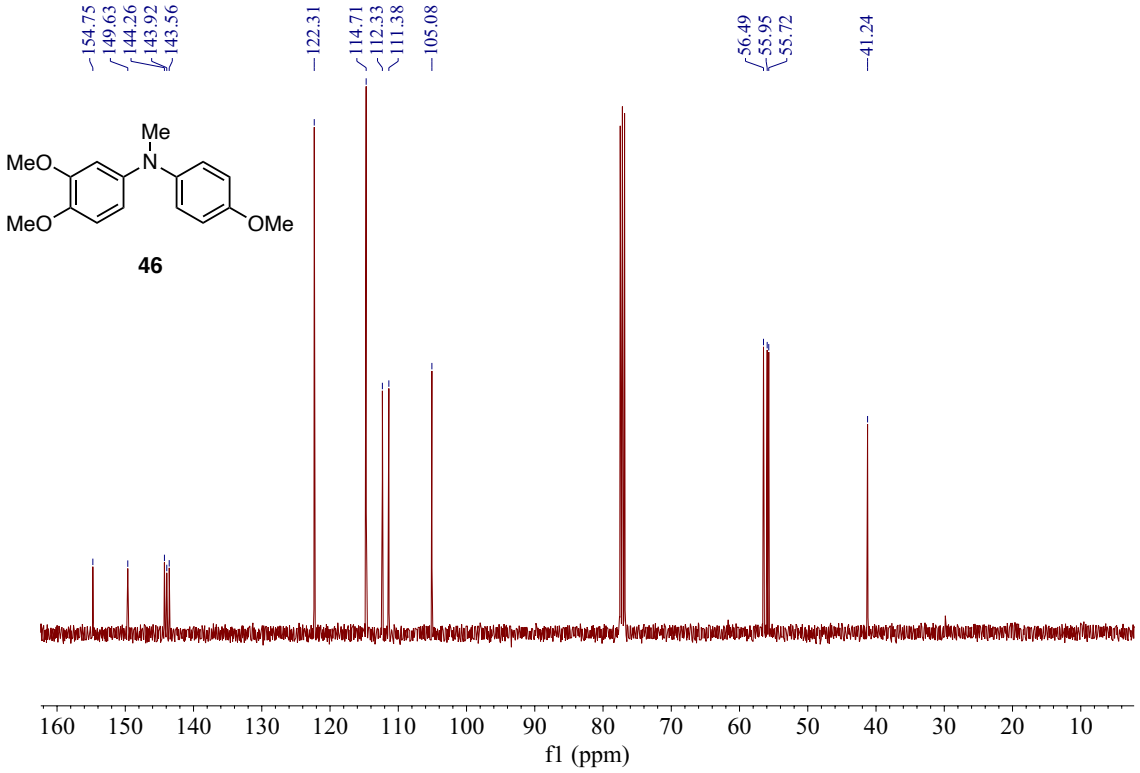
^{1}H NMR of Compound **44** (400 MHz, $CDCl_3$)



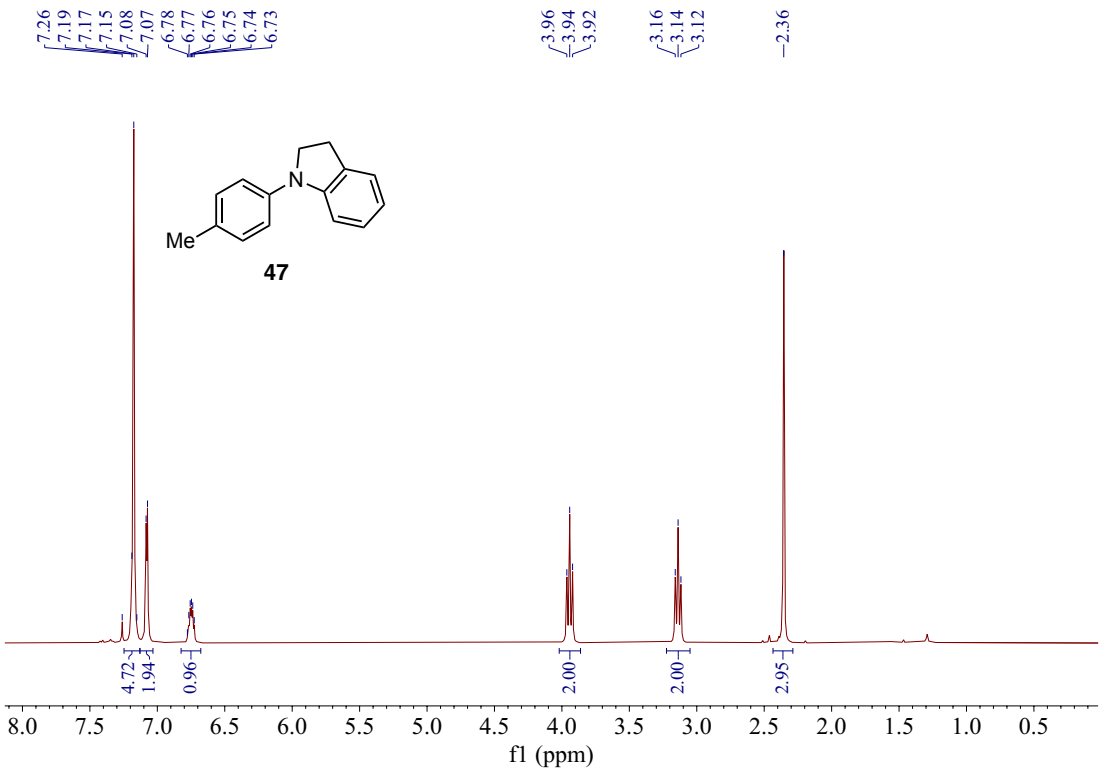
^{1}H NMR of Compound **45** (400 MHz, $CDCl_3$)



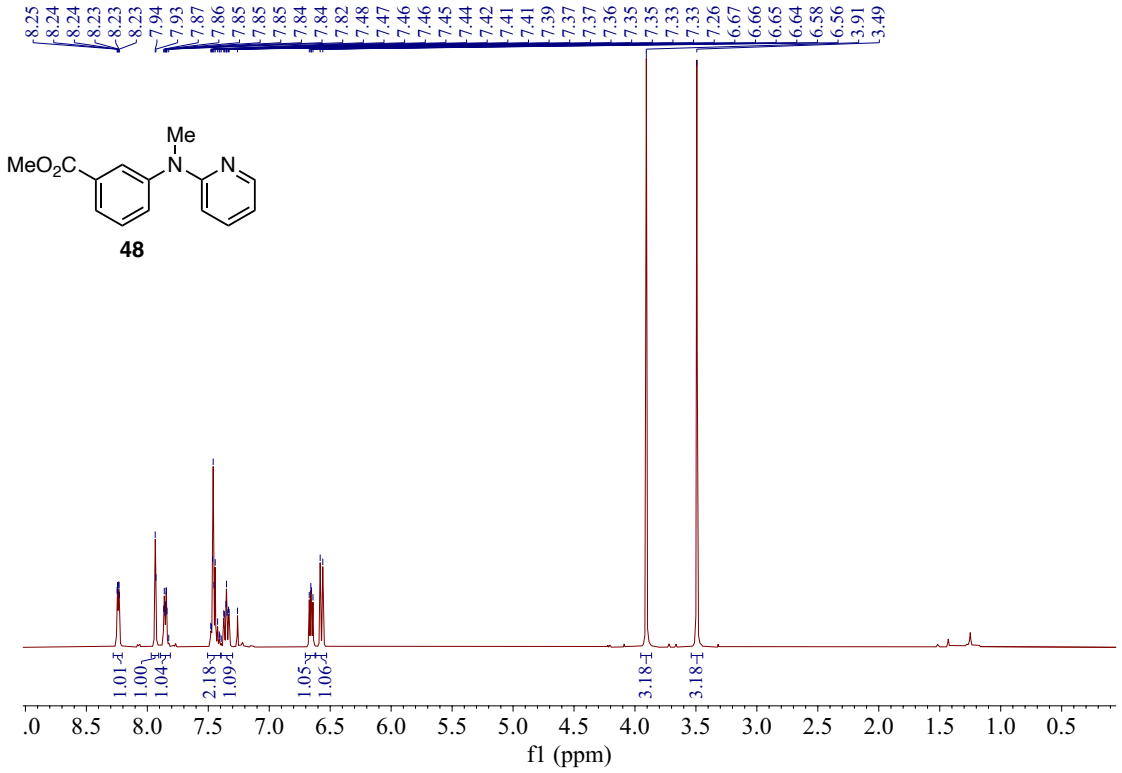
^{1}H NMR of Compound **46** (400 MHz, $CDCl_3$)



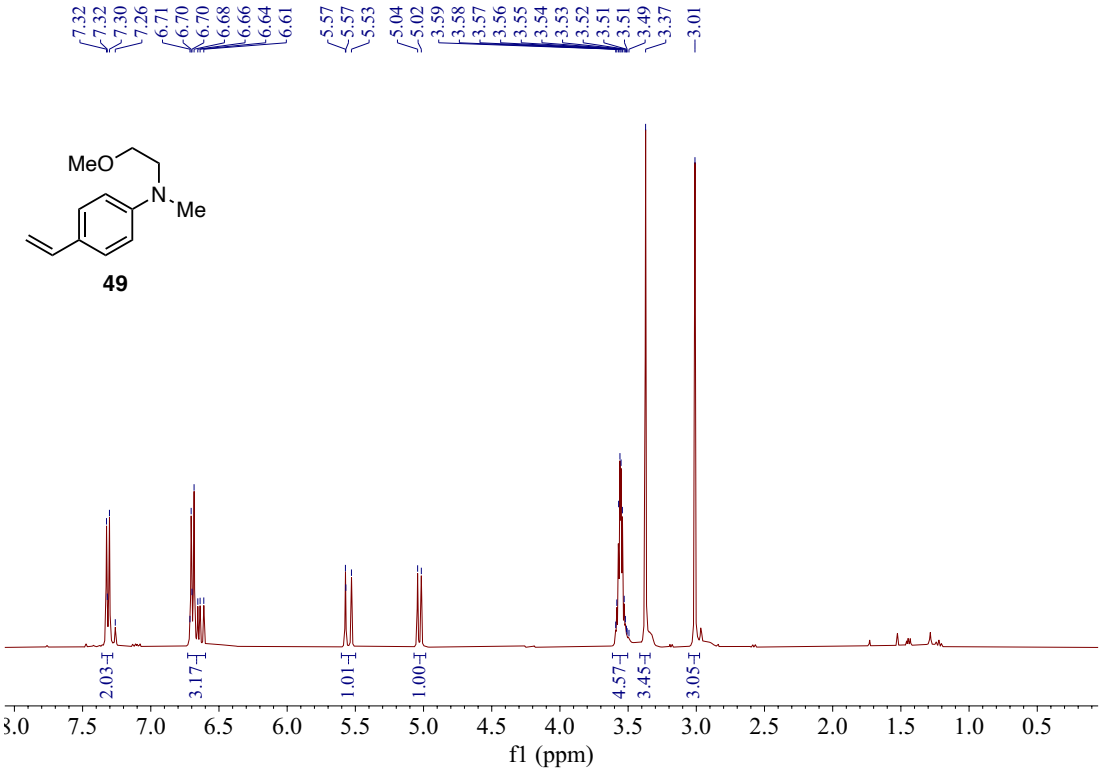
^{13}C NMR of Compound **46** (101 MHz, $CDCl_3$)



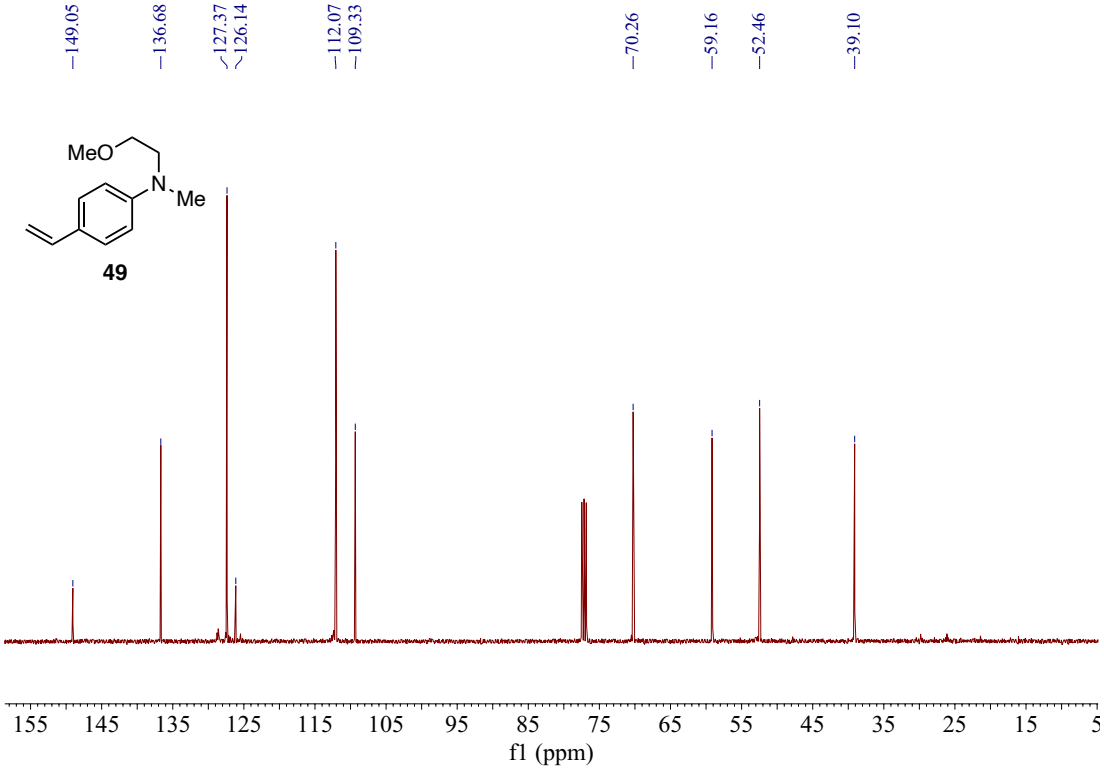
^{1}H NMR of Compound **47** (400 MHz, $CDCl_3$)



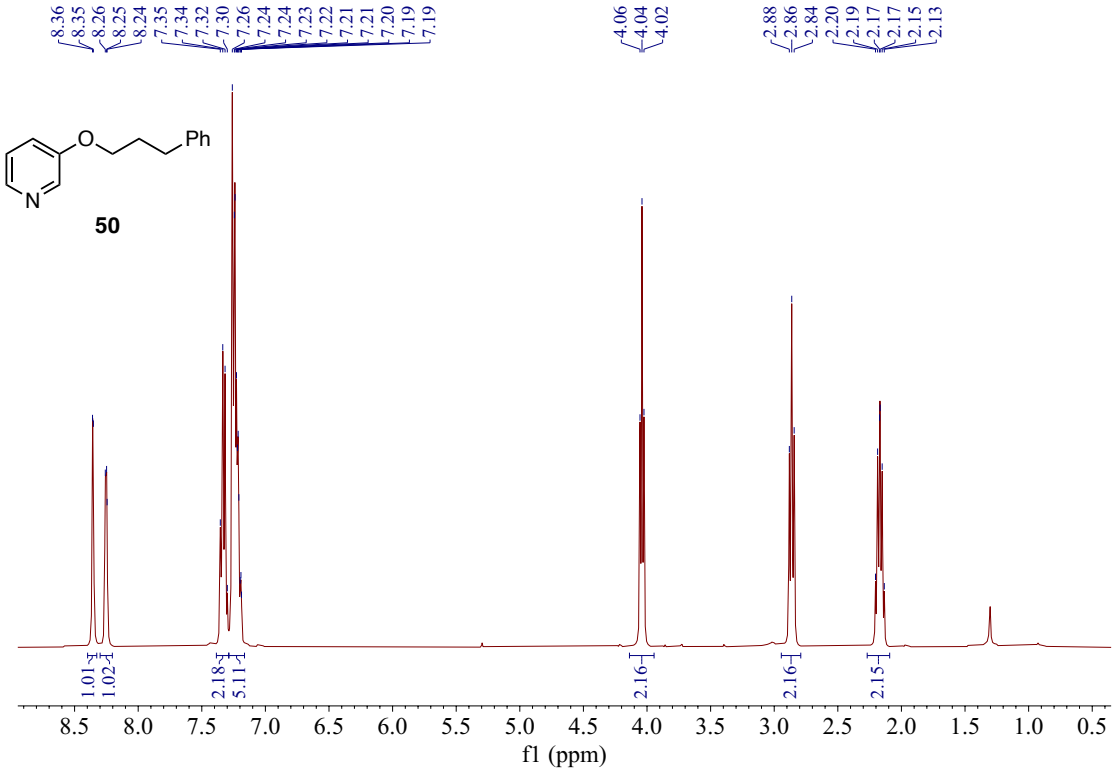
^{1}H NMR of Compound **48** (400 MHz, $CDCl_3$)



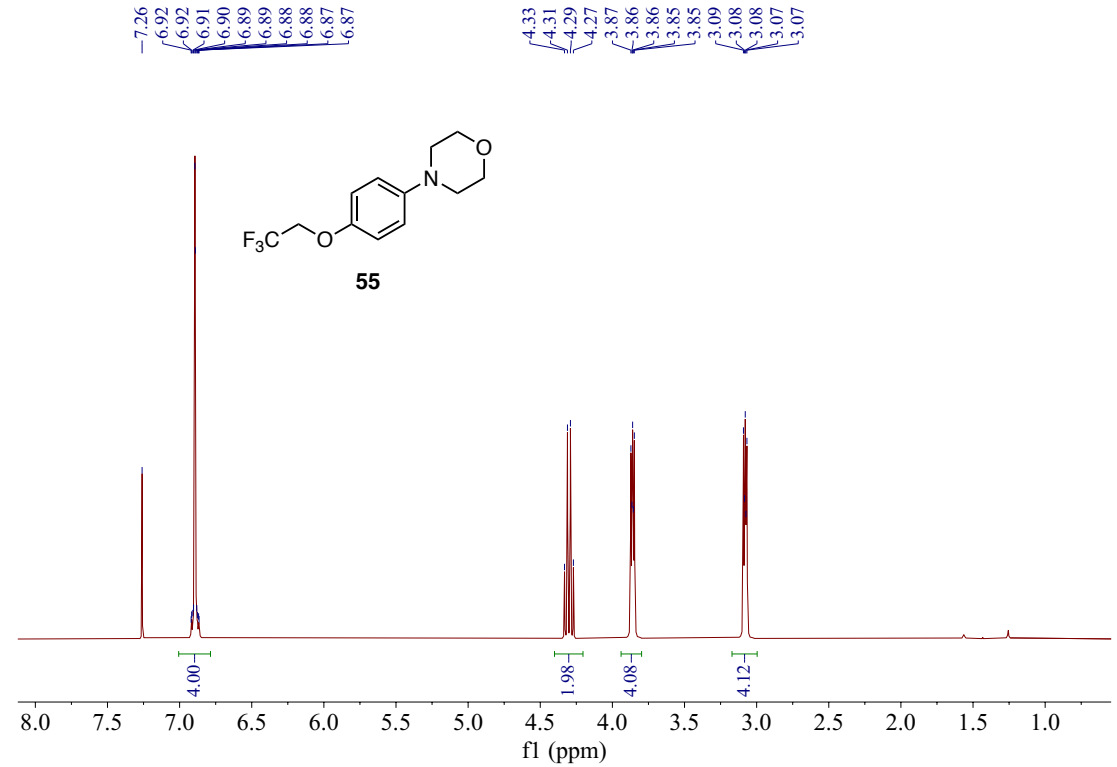
^{1}H NMR of Compound **49** (400 MHz, $CDCl_3$)



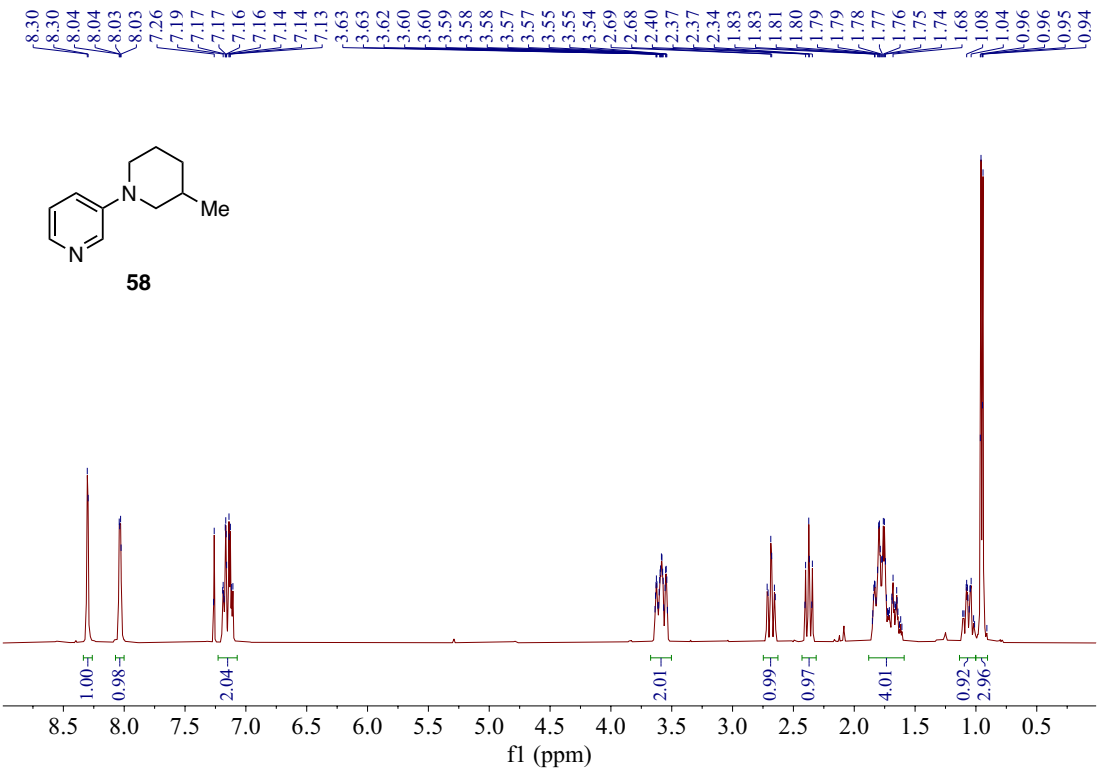
^{13}C NMR of Compound **49** (101 MHz, $CDCl_3$)



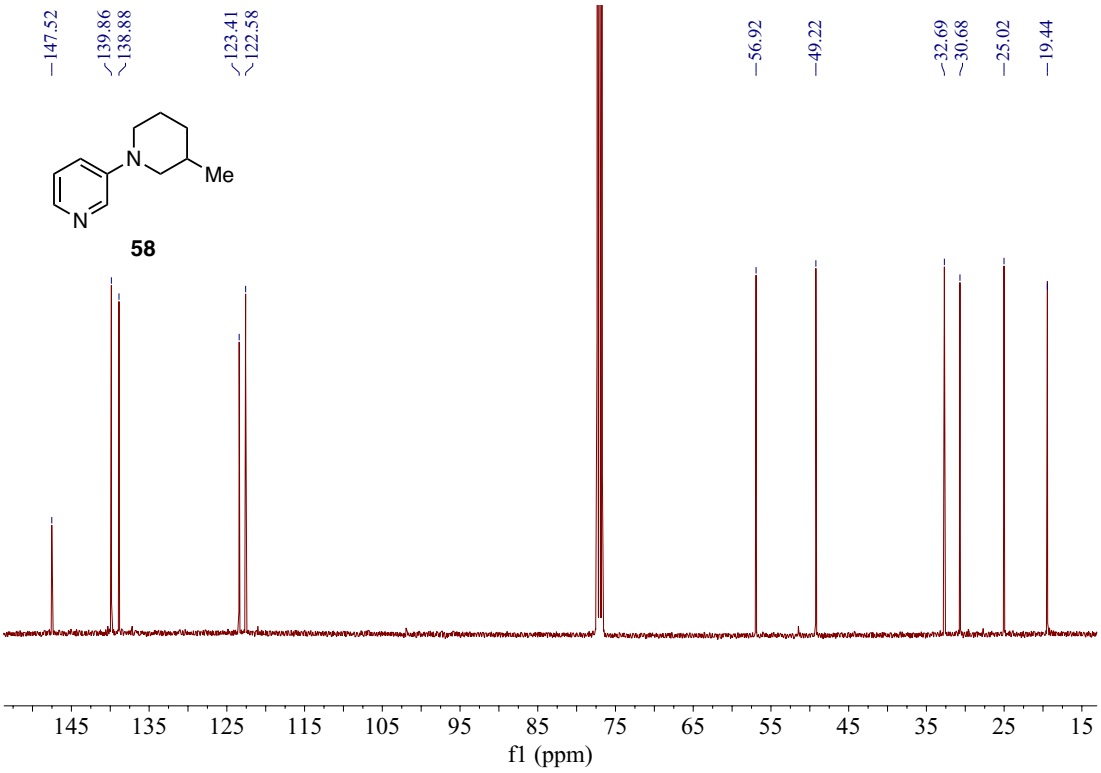
^{1}H NMR of Compound **50** (400 MHz, $CDCl_3$)



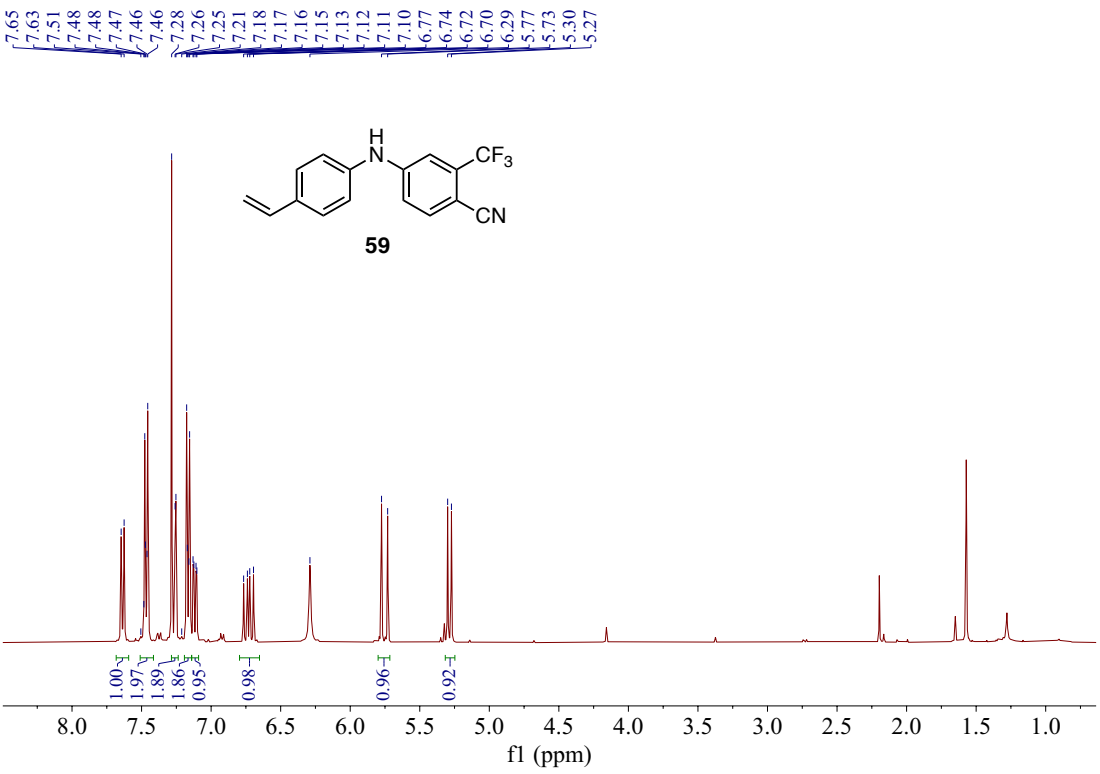
^{1}H NMR of Compound **55** (400 MHz, $CDCl_3$)



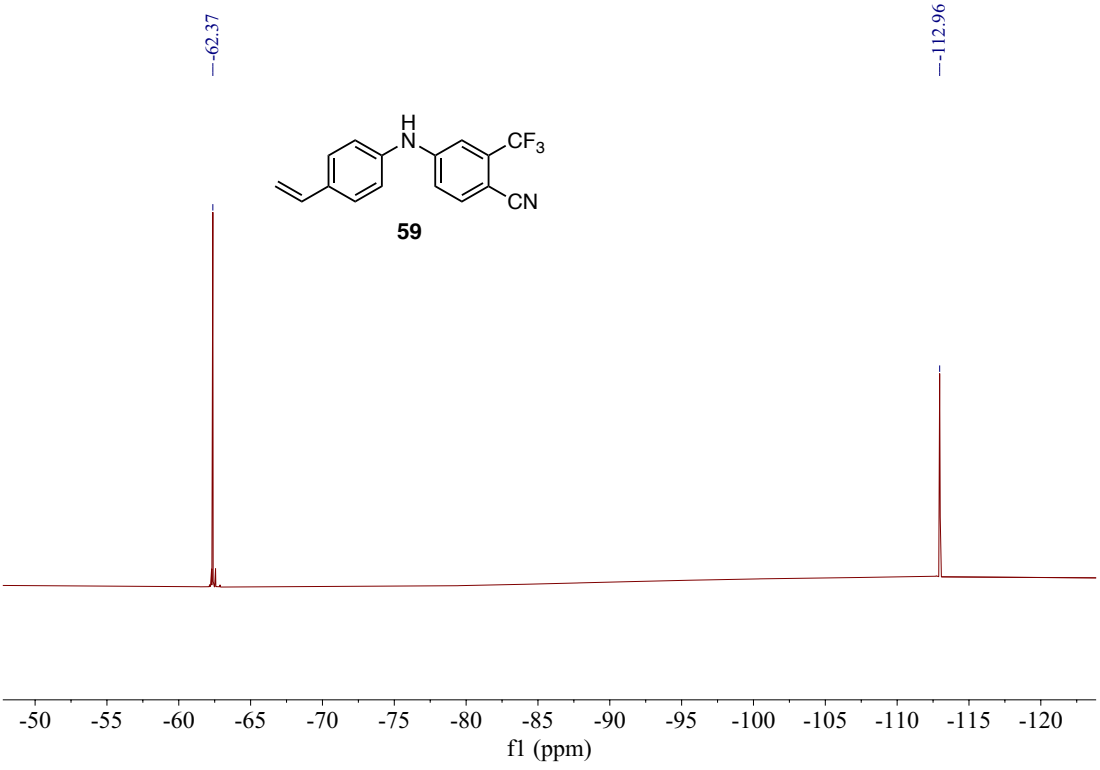
^{1}H NMR of Compound **58** (400 MHz, $CDCl_3$)



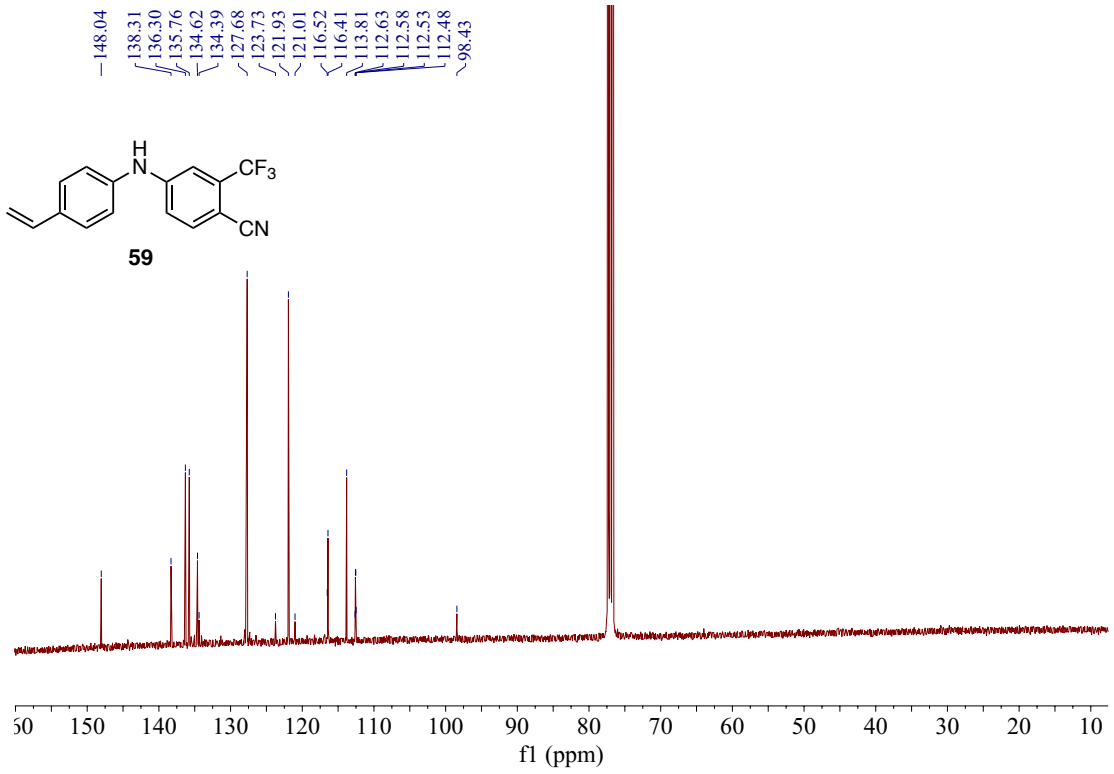
^{13}C NMR of Compound **58** (101 MHz, $CDCl_3$)



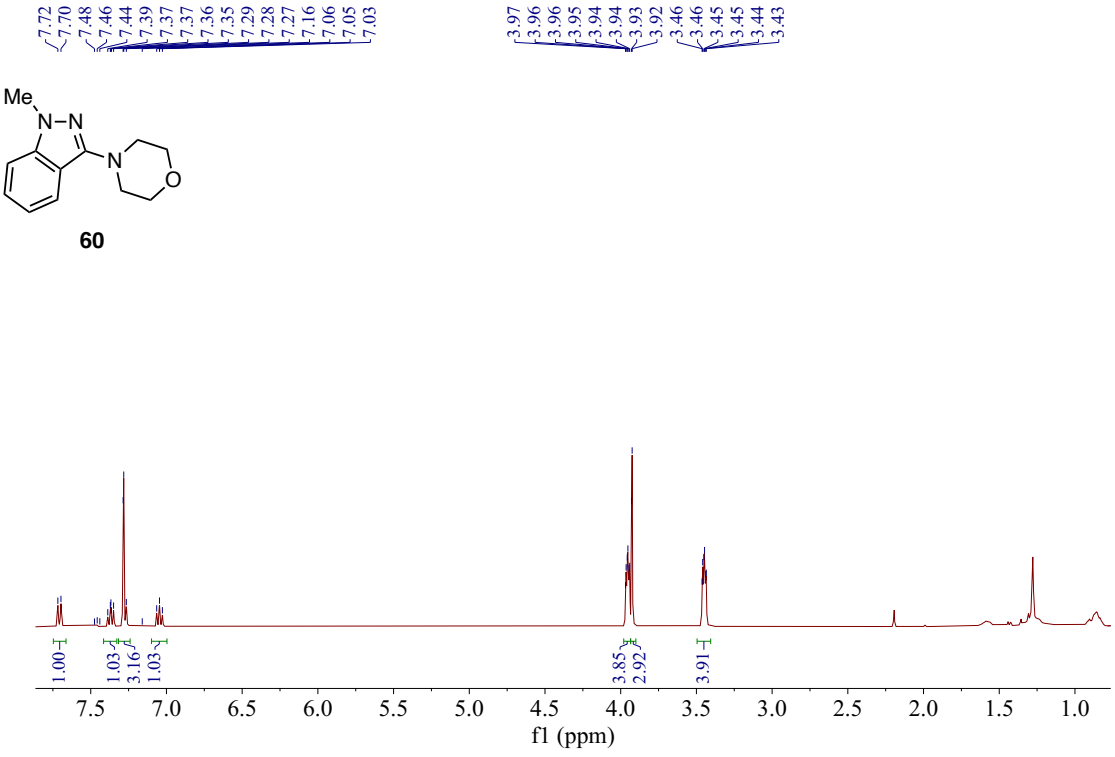
^{1}H NMR of Compound **59** (400 MHz, $CDCl_3$)



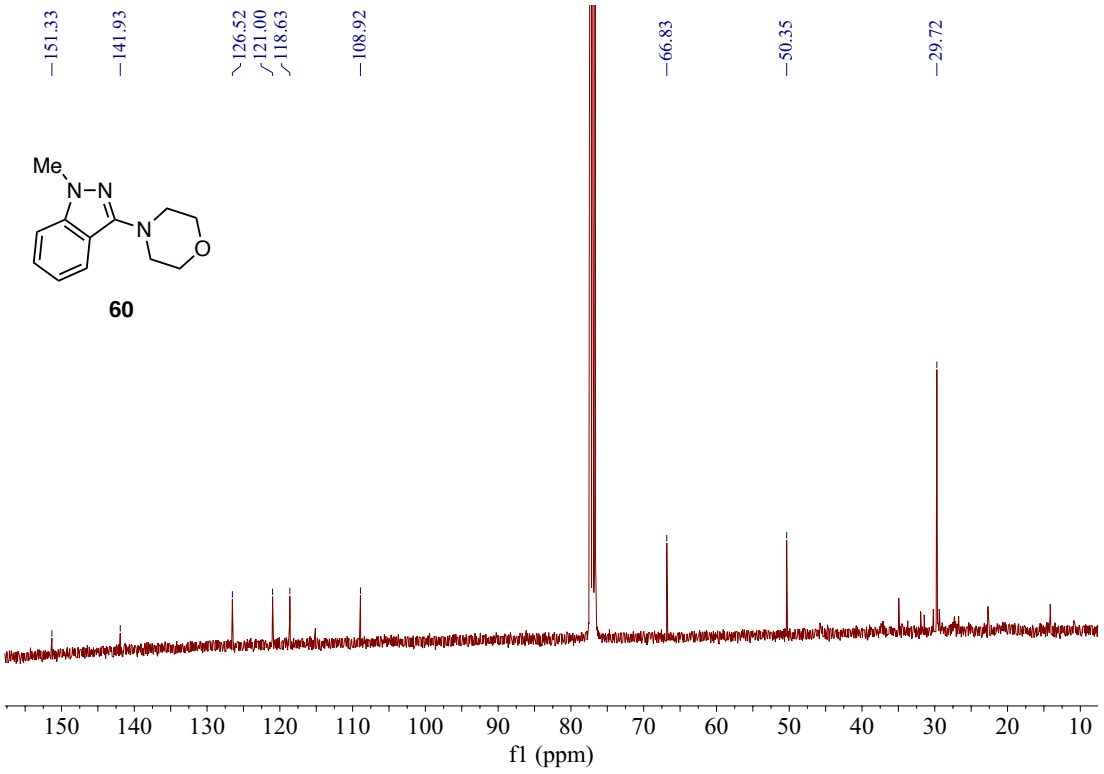
^{19}F NMR of Compound **59** (376 MHz, $CDCl_3$)



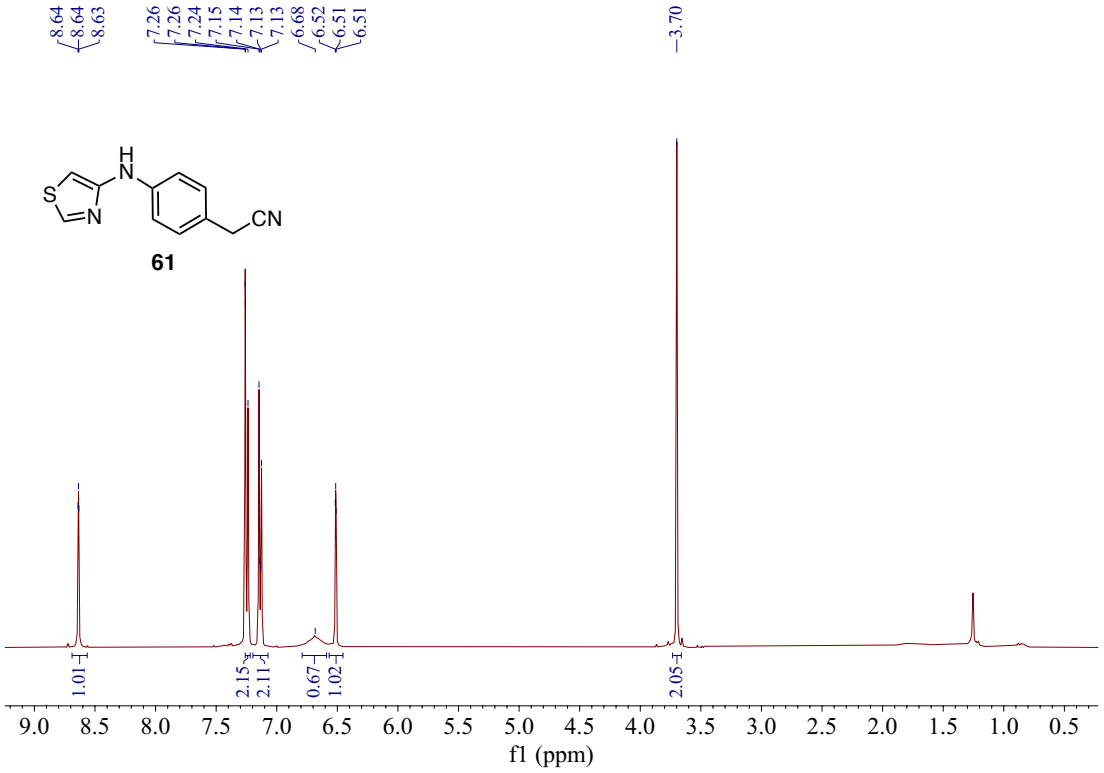
^{13}C NMR of Compound **59** (101 MHz, $CDCl_3$)



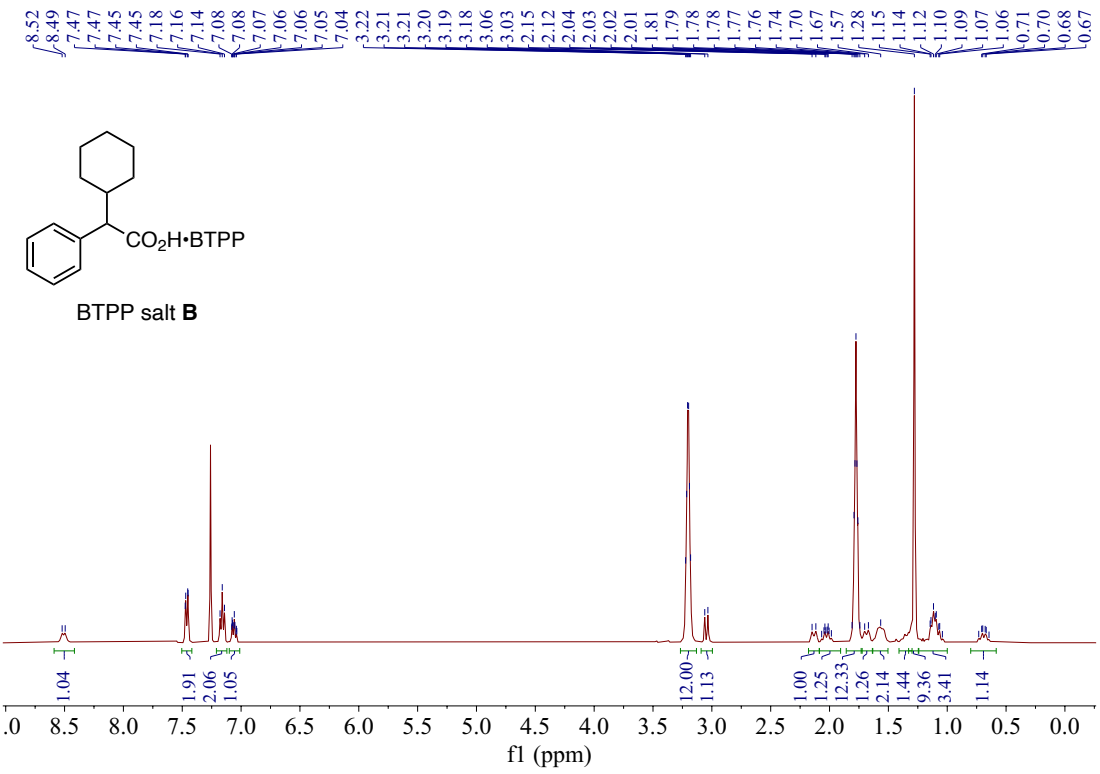
^{1}H NMR of Compound **60** (400 MHz, $CDCl_3$)



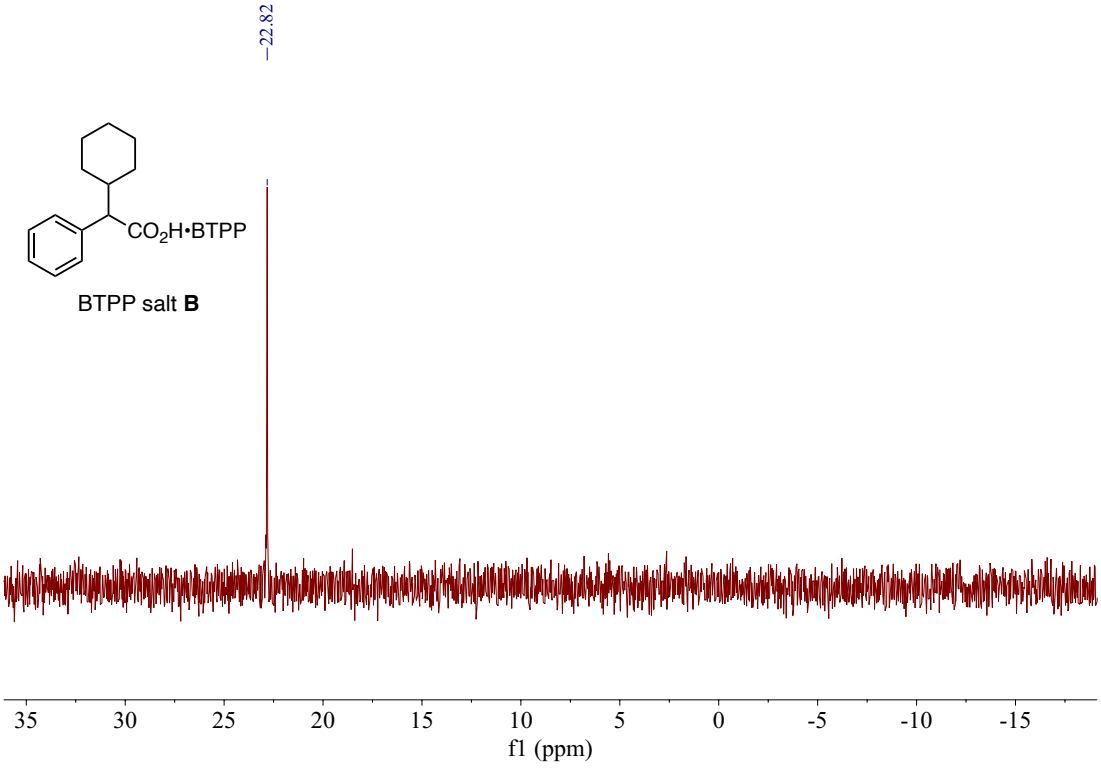
^{13}C NMR of Compound **60** (101 MHz, $CDCl_3$)



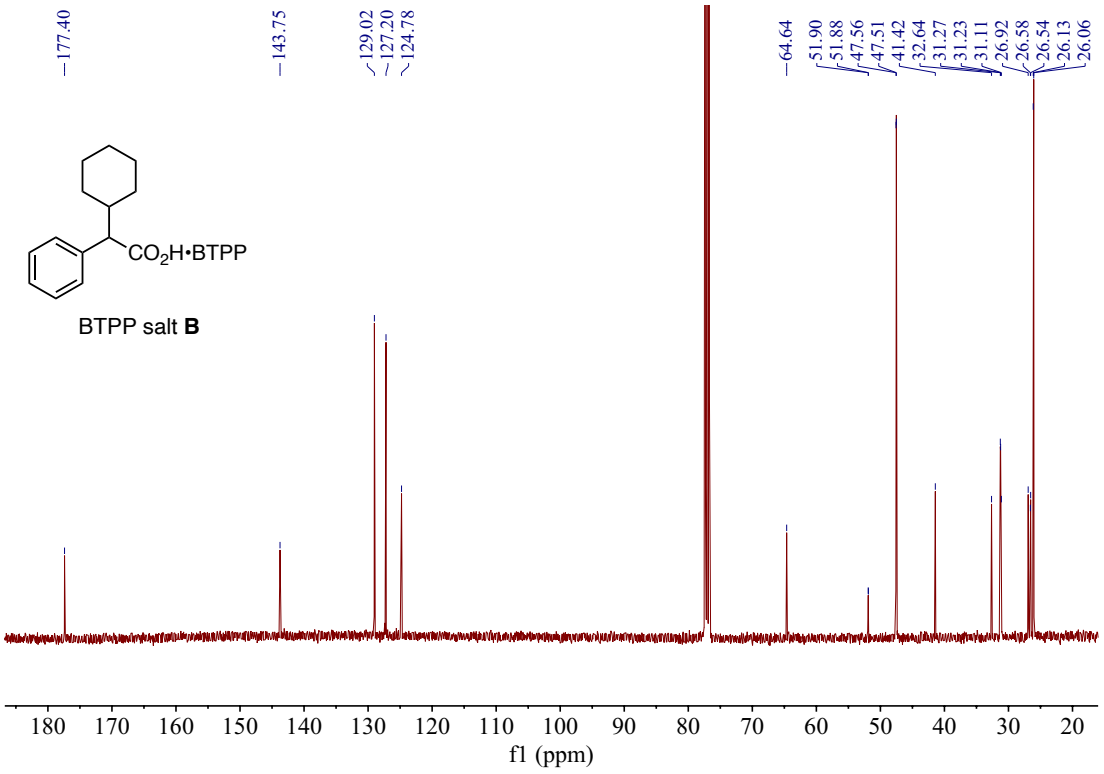
^{1}H NMR of Compound **61** (400 MHz, $CDCl_3$)



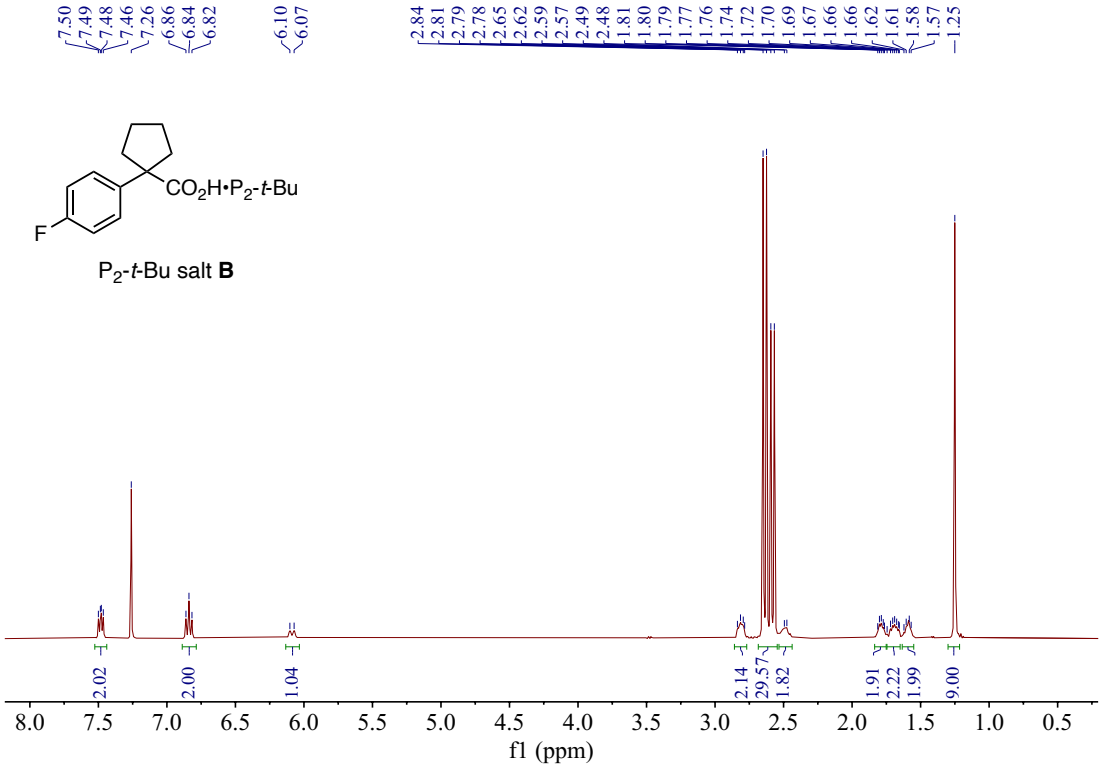
^{1}H NMR of BTPP salt **B** (400 MHz, $CDCl_3$)



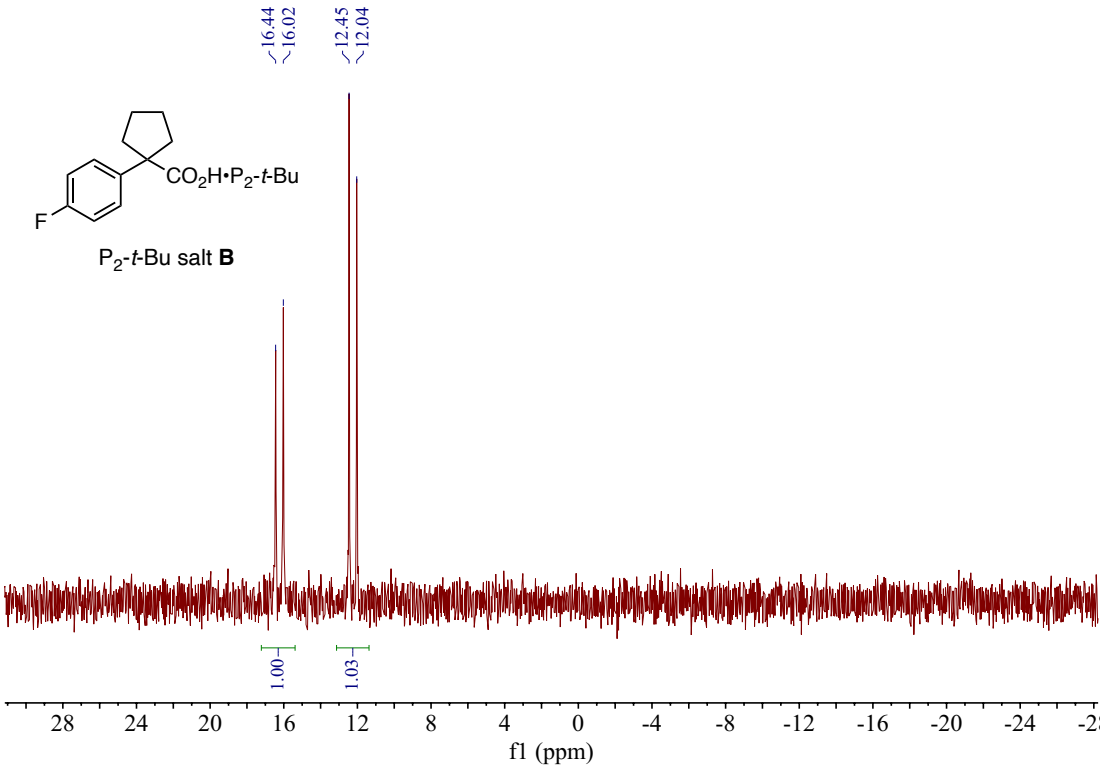
^{31}P NMR of BTPP Salt **B** (162 MHz, $CDCl_3$)



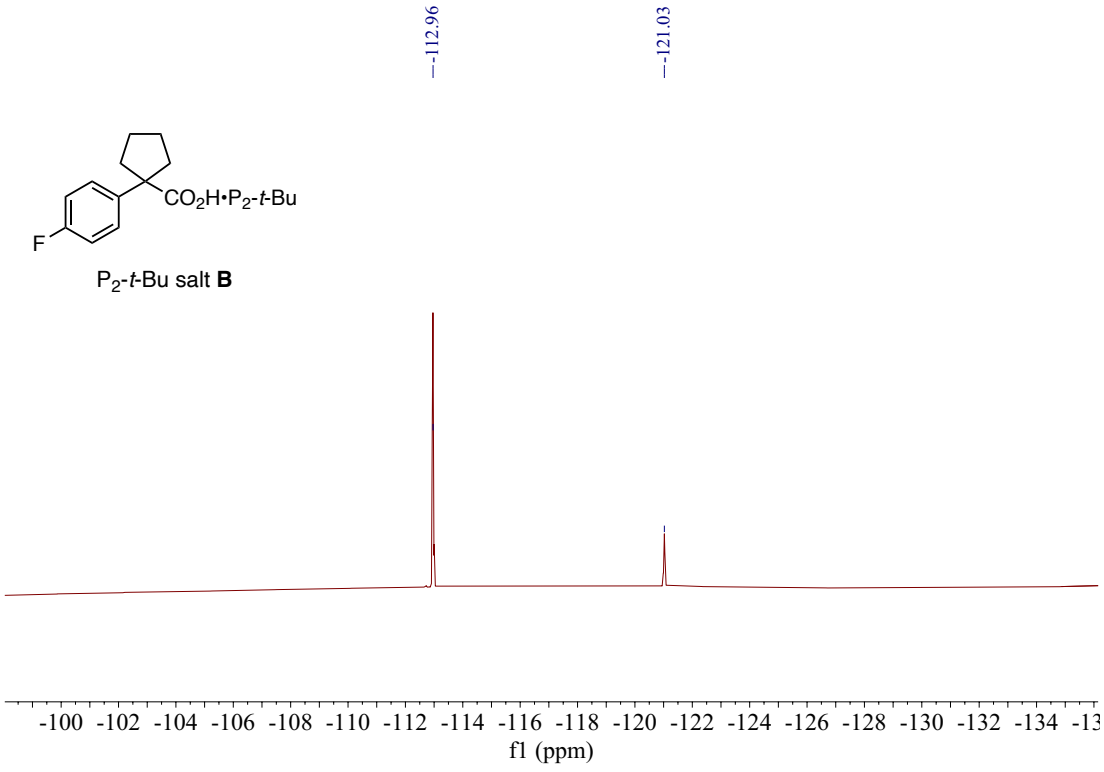
^{13}C NMR of BTPP salt **B** (101 MHz, $CDCl_3$)



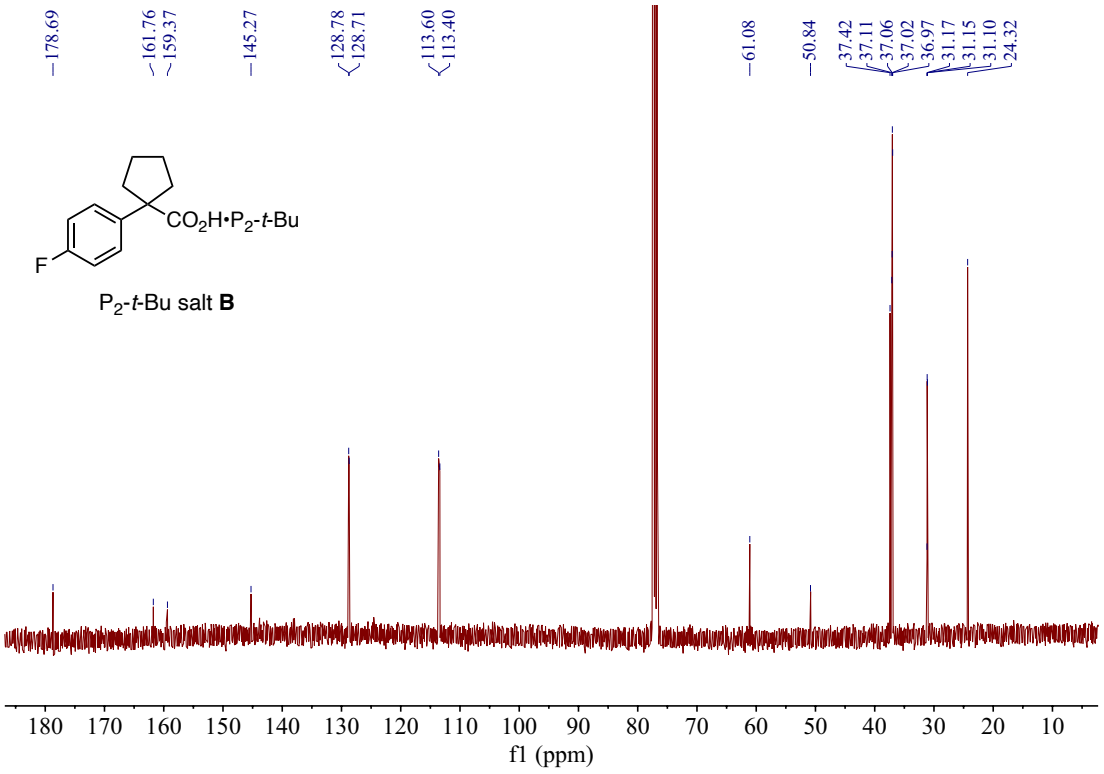
^{1}H NMR of P_2-*t*-Bu salt **B** (400 MHz, $CDCl_3$)



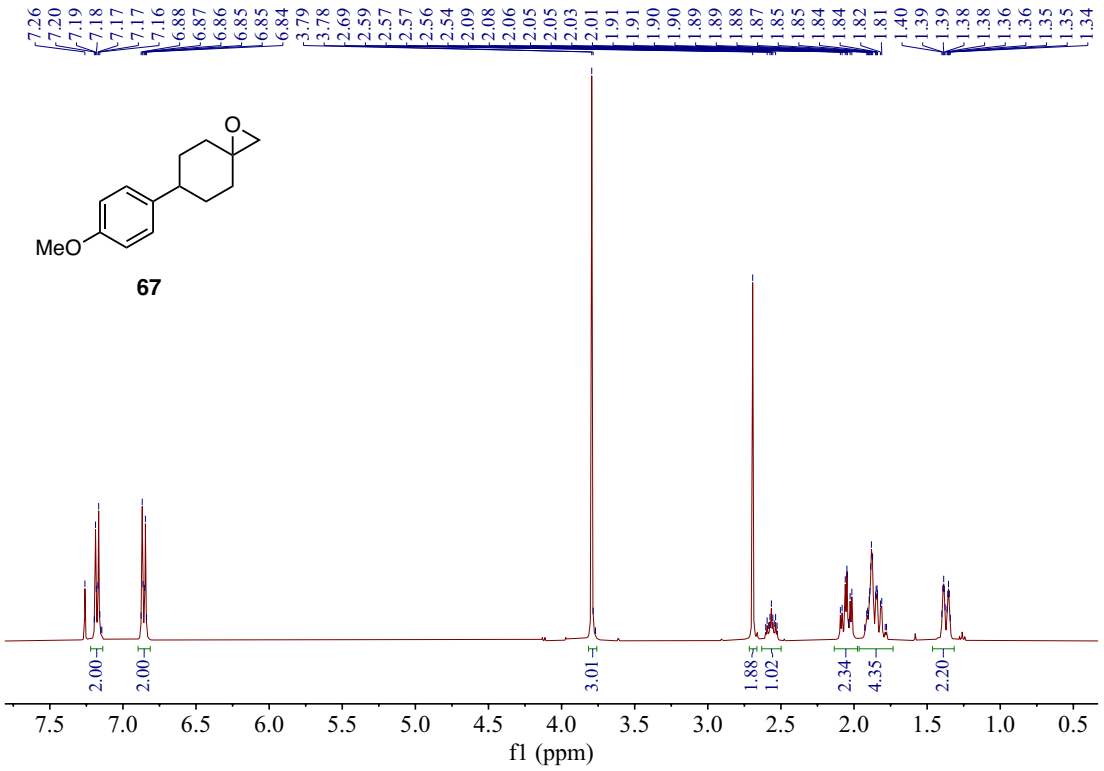
^{31}P NMR of P_2-*t*-Bu Salt **B** (162 MHz, $CDCl_3$)



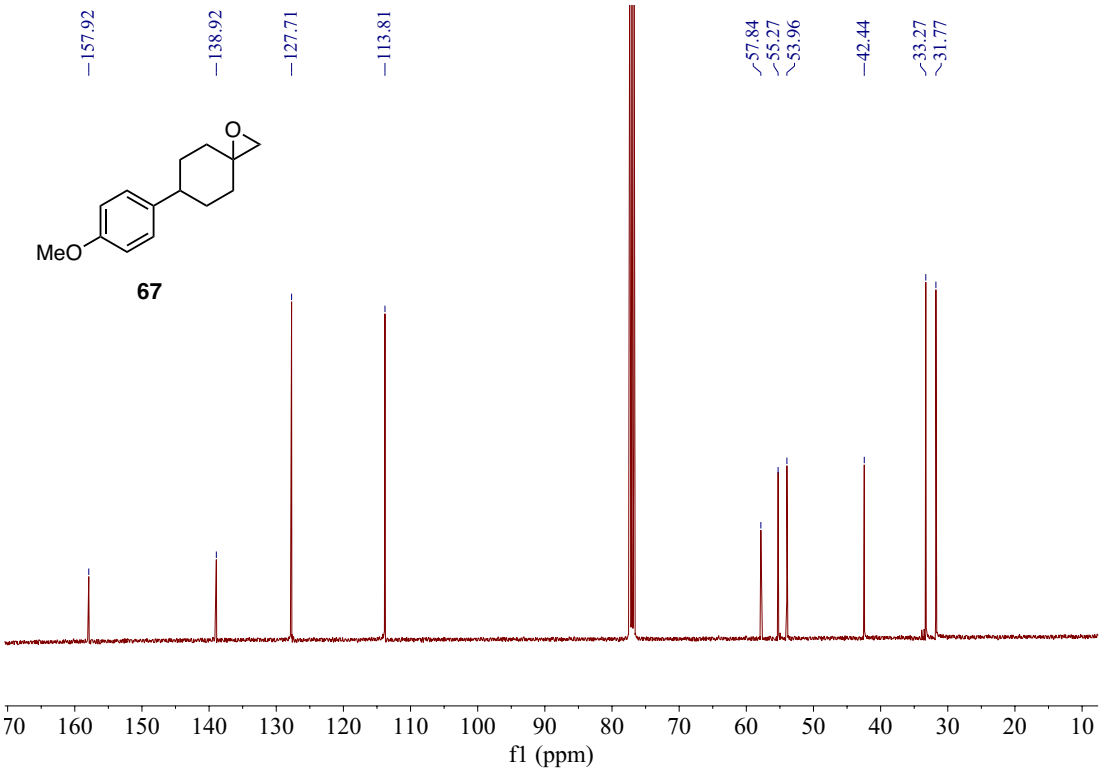
^{19}F NMR of P_2-*t*-Bu Salt **B** (376 MHz, $CDCl_3$)



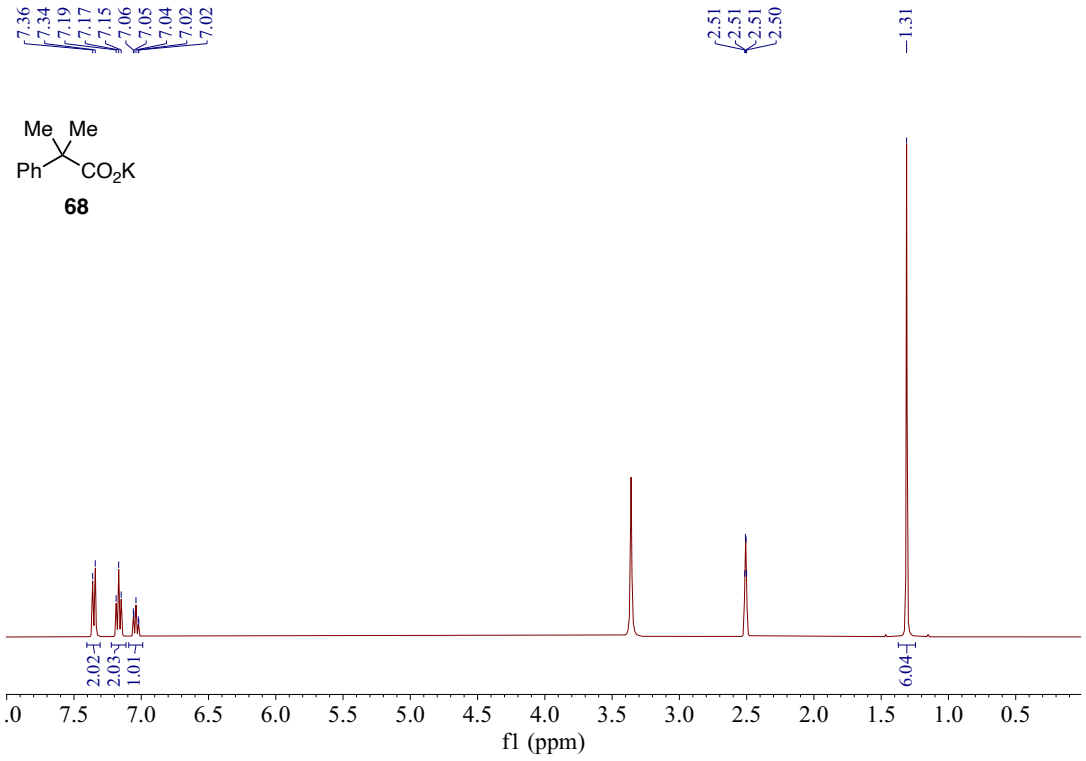
^{13}C NMR of P_2-*t*-Bu salt **B** (101 MHz, $CDCl_3$)



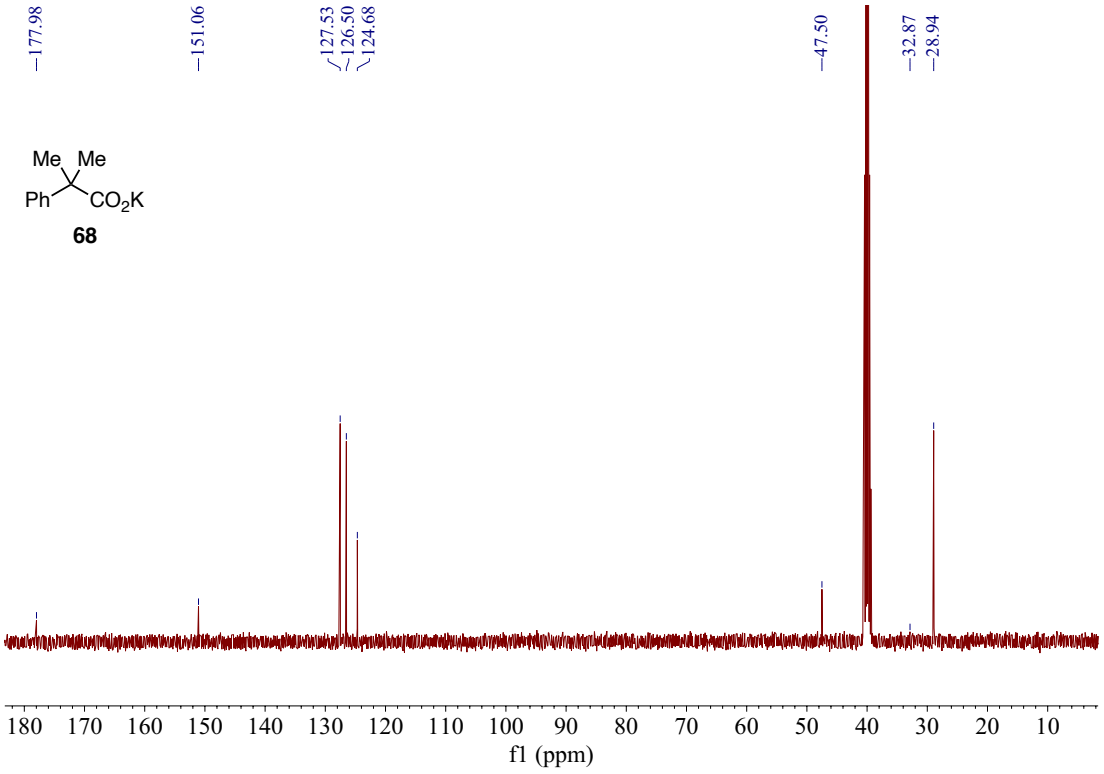
^{1}H NMR of Compound **67** (400 MHz, $CDCl_3$)



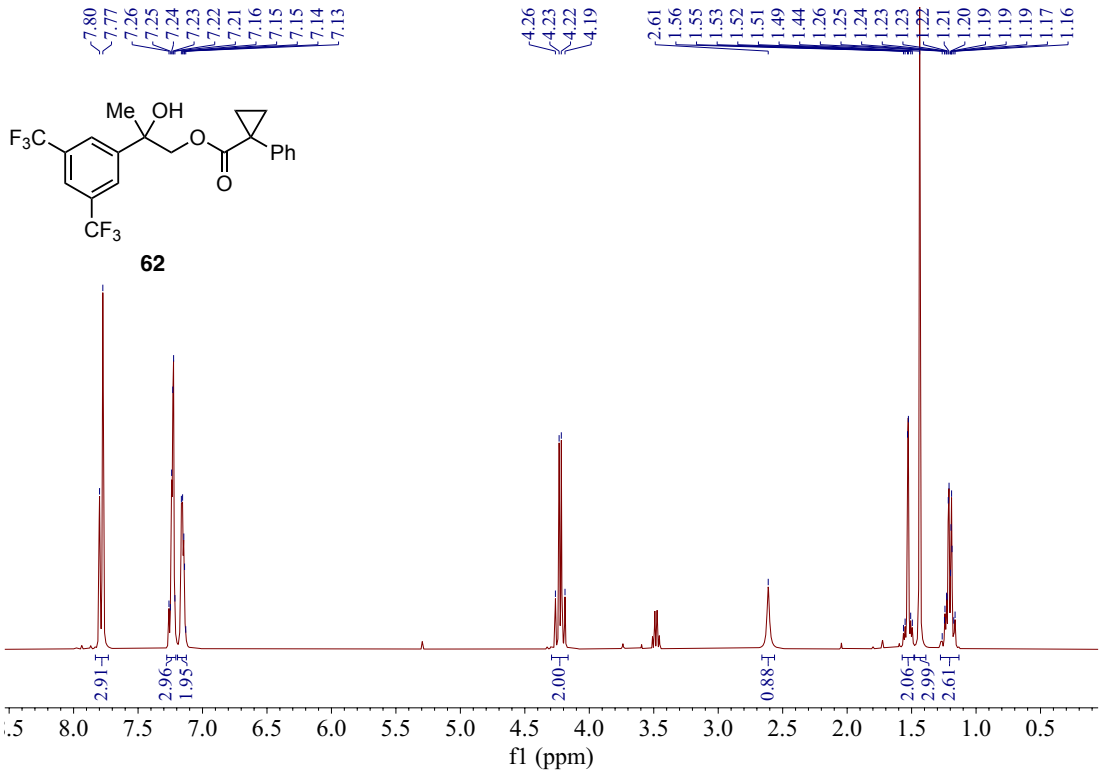
^{13}C NMR of Compound **67** (101 MHz, $CDCl_3$)



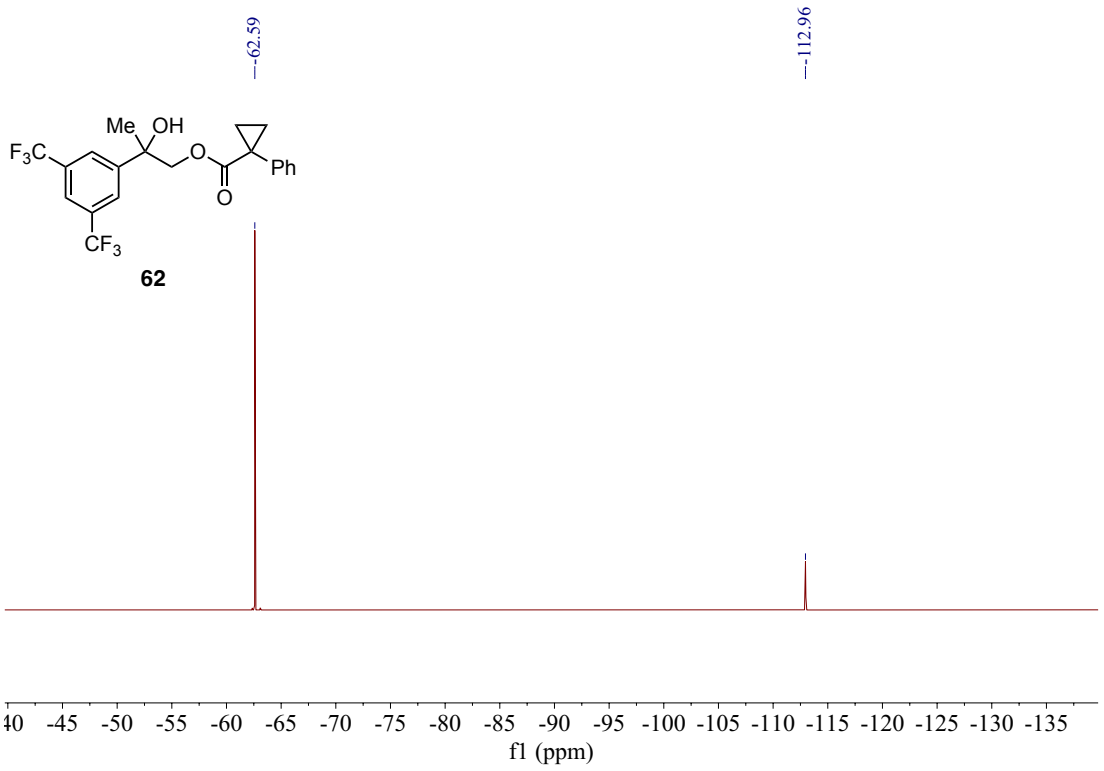
^{1}H NMR of Compound **68** (400 MHz, DMSO-d_6)



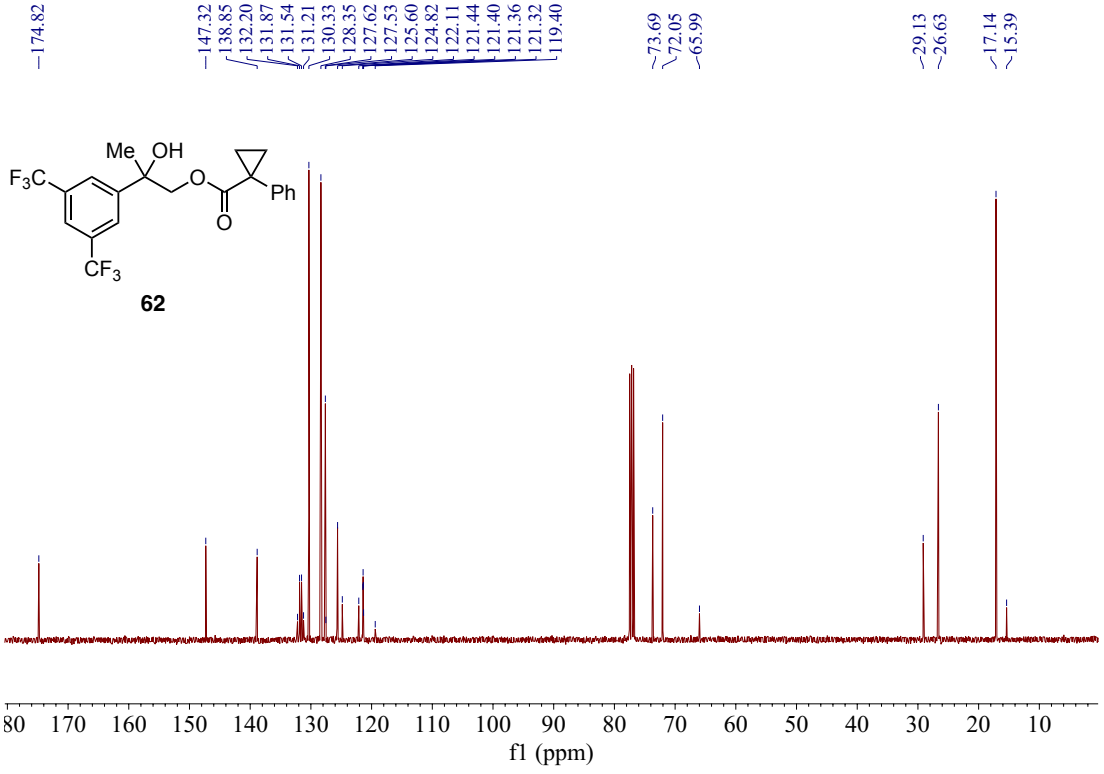
^{13}C NMR of Compound **68** (101 MHz, DMSO-d_6)



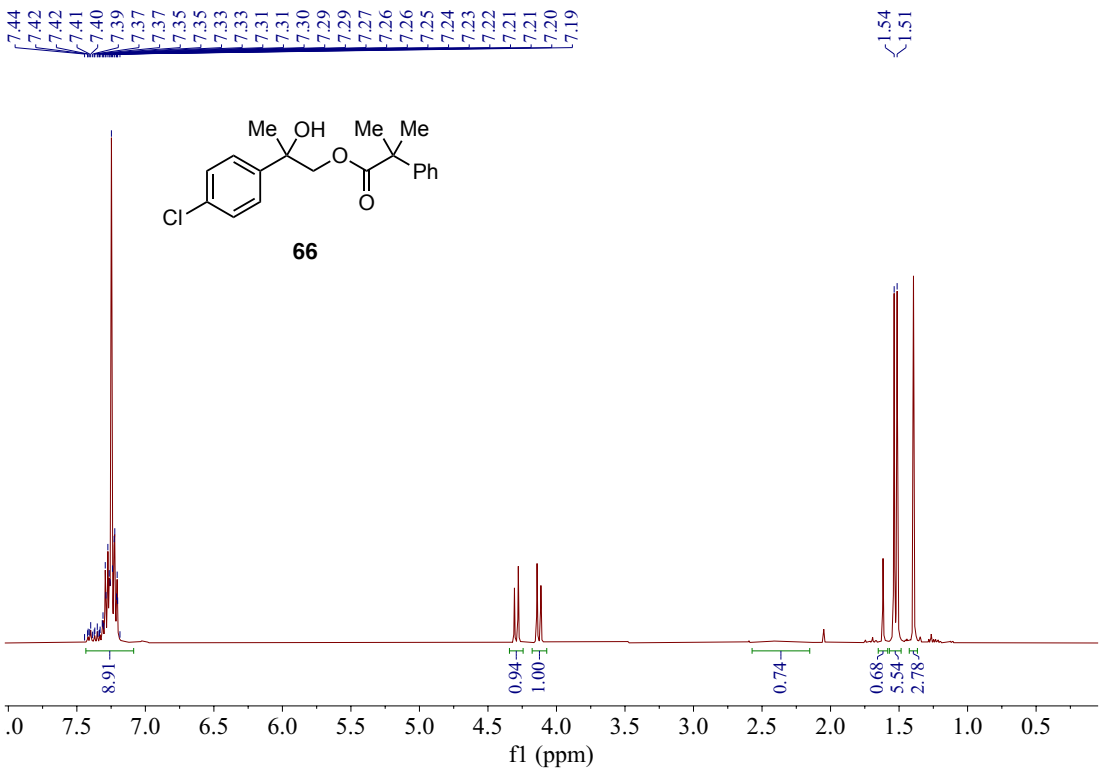
^{1}H NMR of Compound **62** (400 MHz, $CDCl_3$)



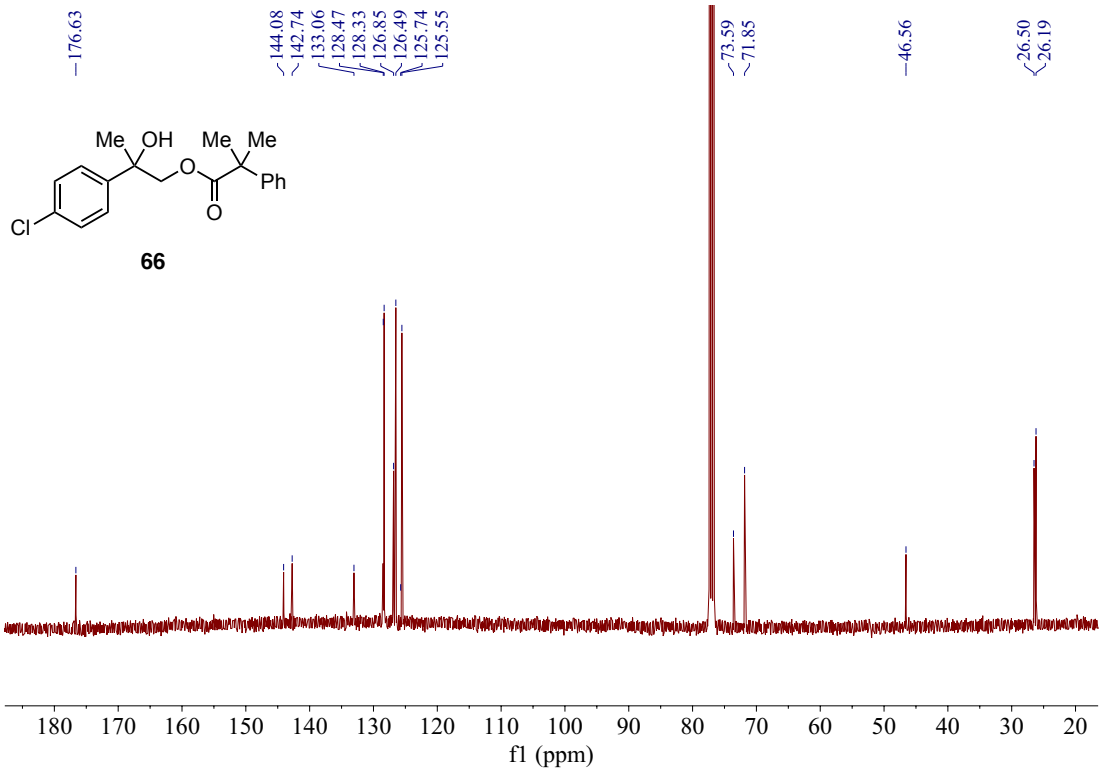
^{19}F NMR of Compound **62** (376 MHz, $CDCl_3$)



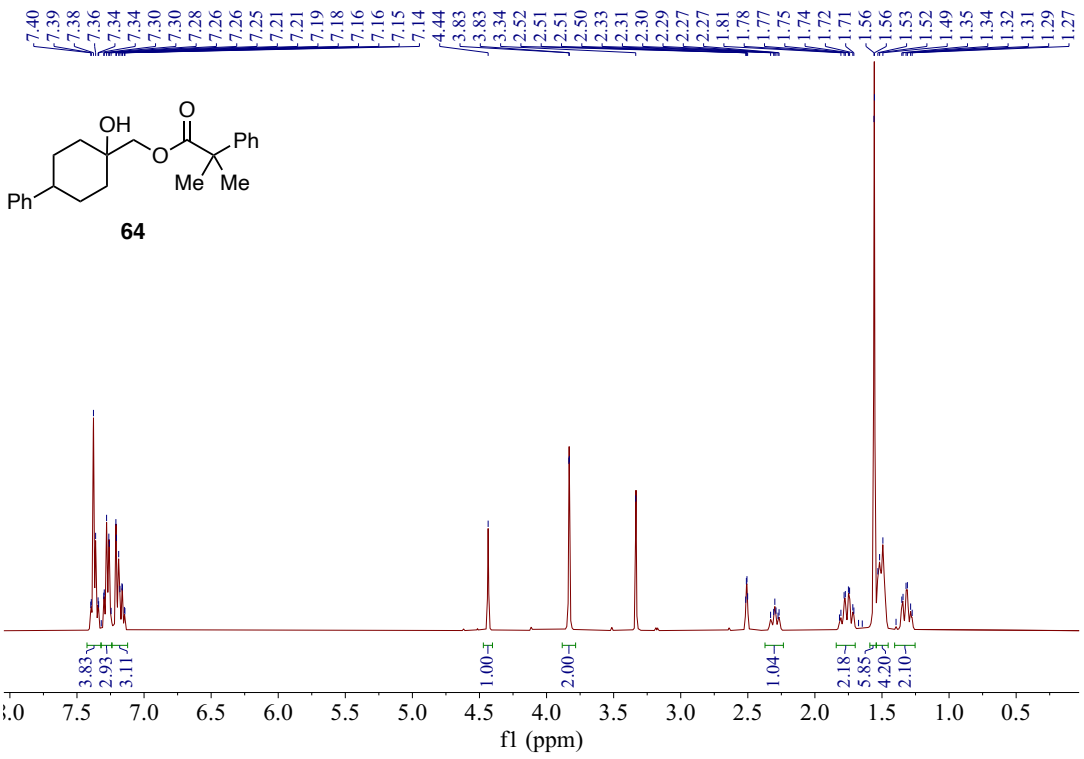
^{13}C NMR of Compound **62** (101 MHz, $CDCl_3$)



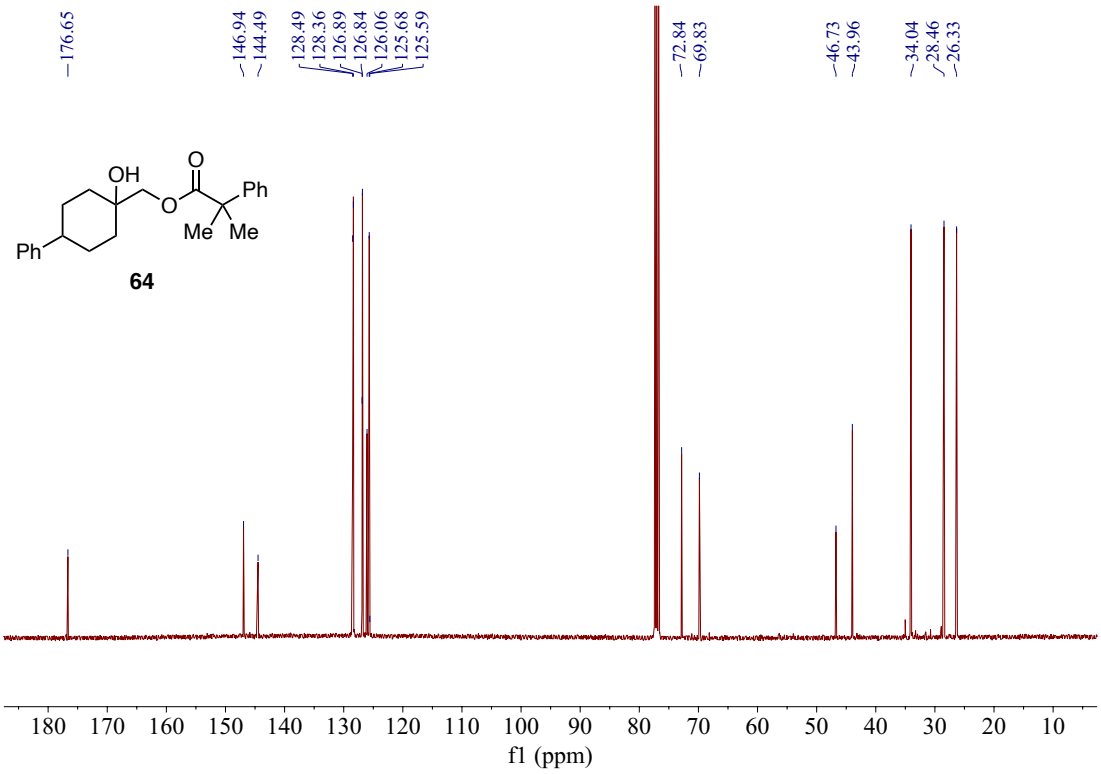
^{1}H NMR of Compound **66** (400 MHz, $CDCl_3$)



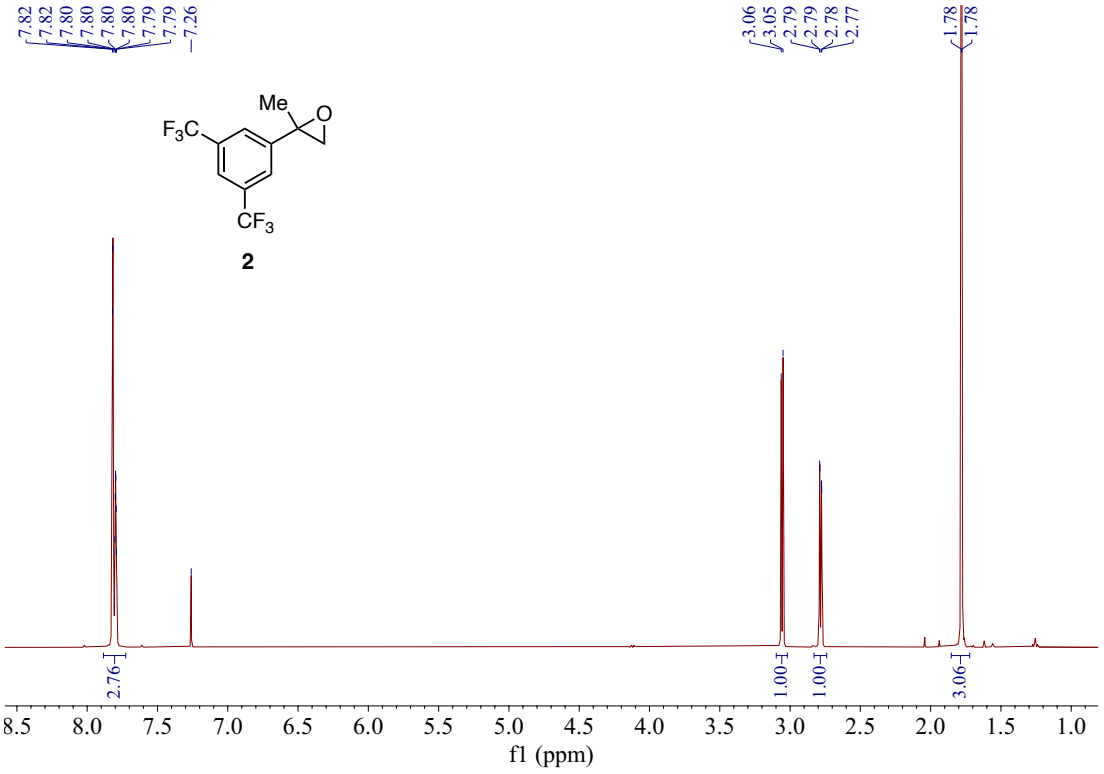
^{13}C NMR of Compound **66** (101 MHz, $CDCl_3$)



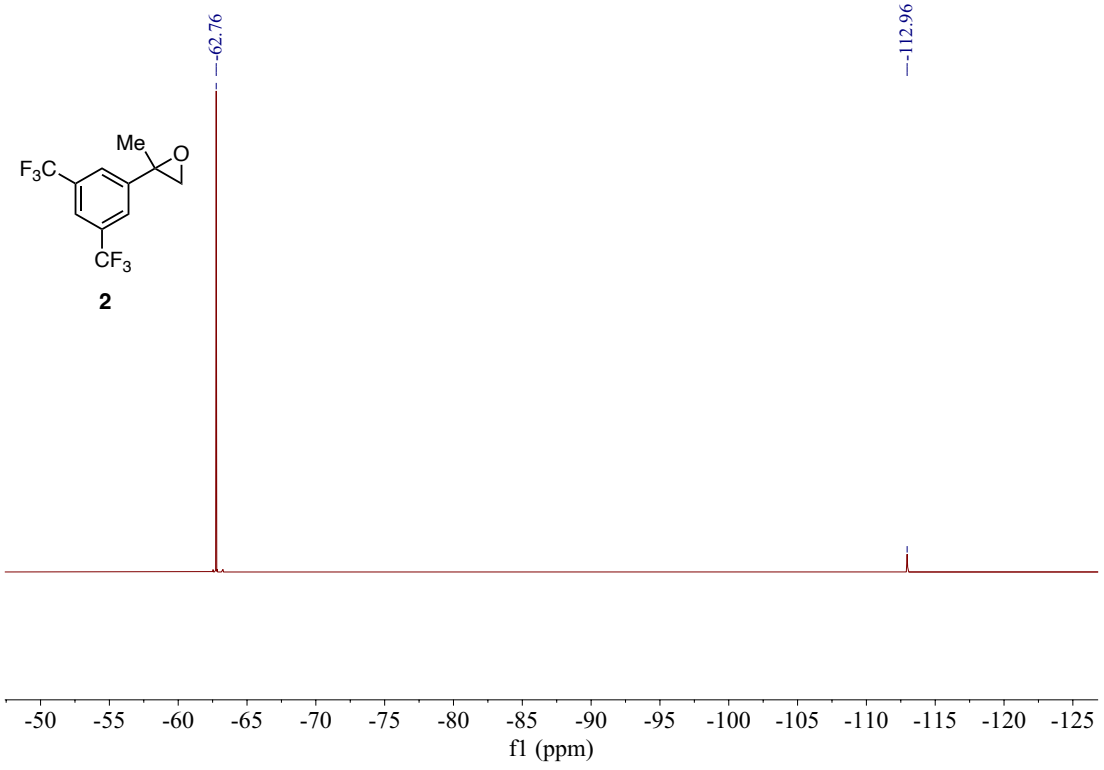
^{1}H NMR of Compound **64** (400 MHz, DMSO-d_6)



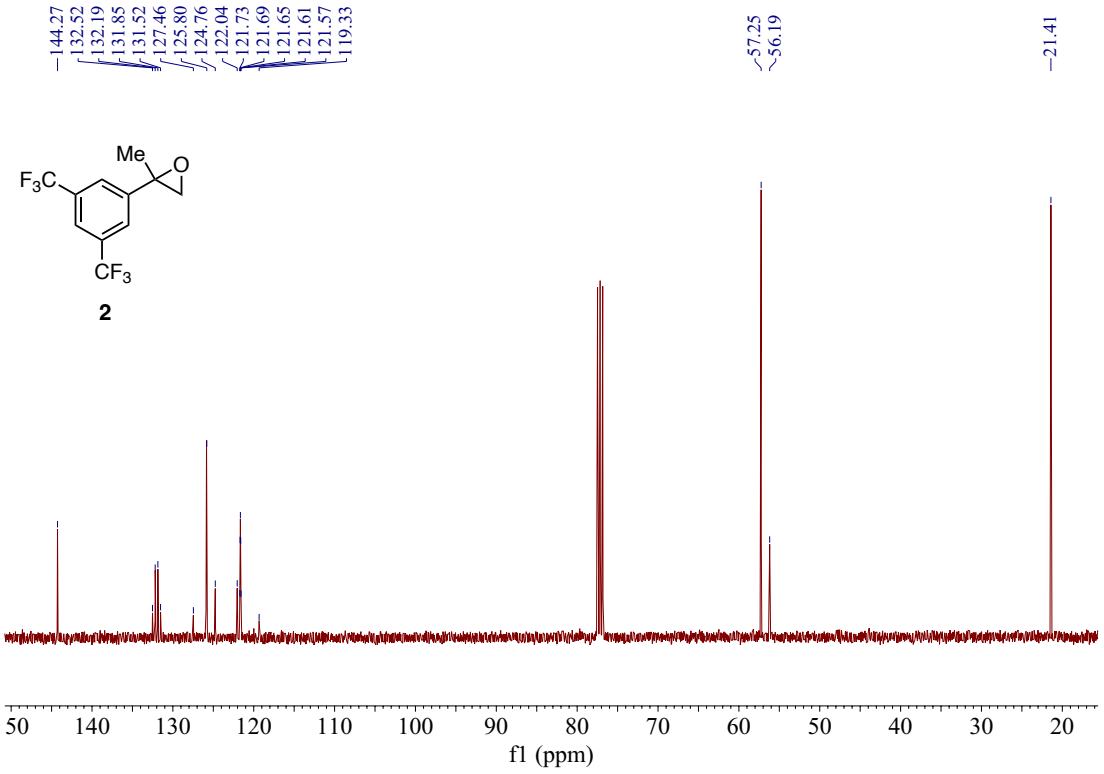
^{13}C NMR of Compound **64** (101 MHz, $CDCl_3$)



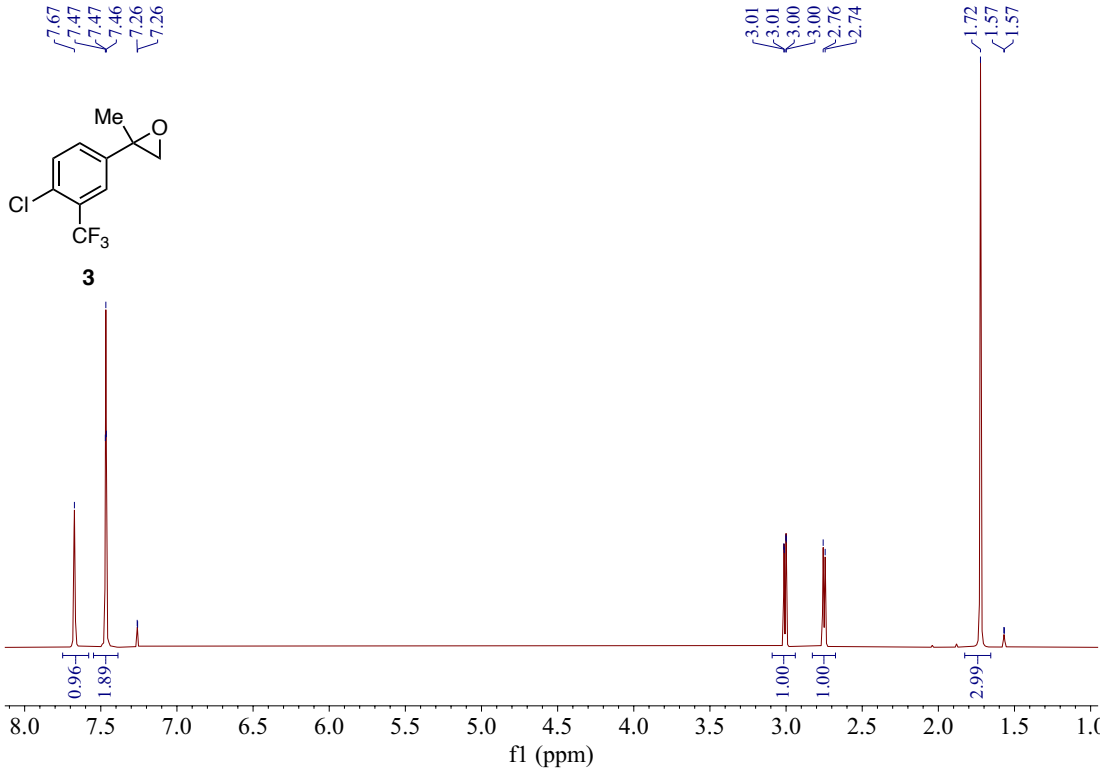
^{1}H NMR of Compound **2** (400 MHz, $CDCl_3$)



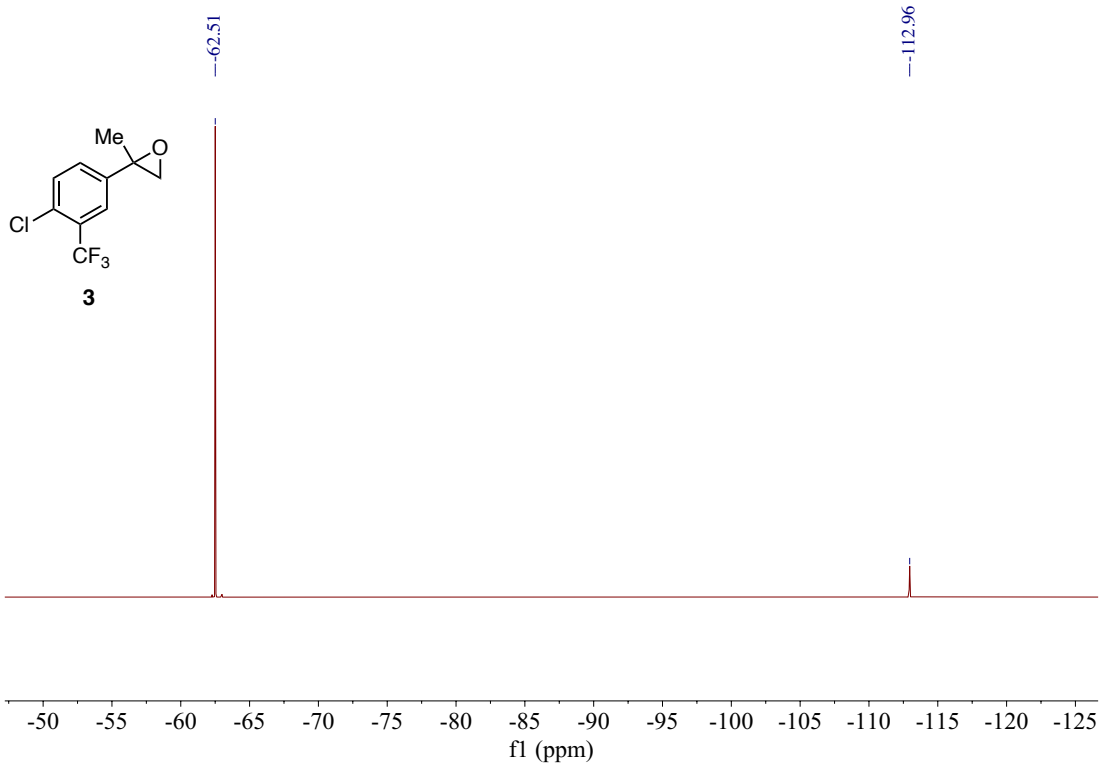
^{19}F NMR of Compound **2** (376 MHz, $CDCl_3$)



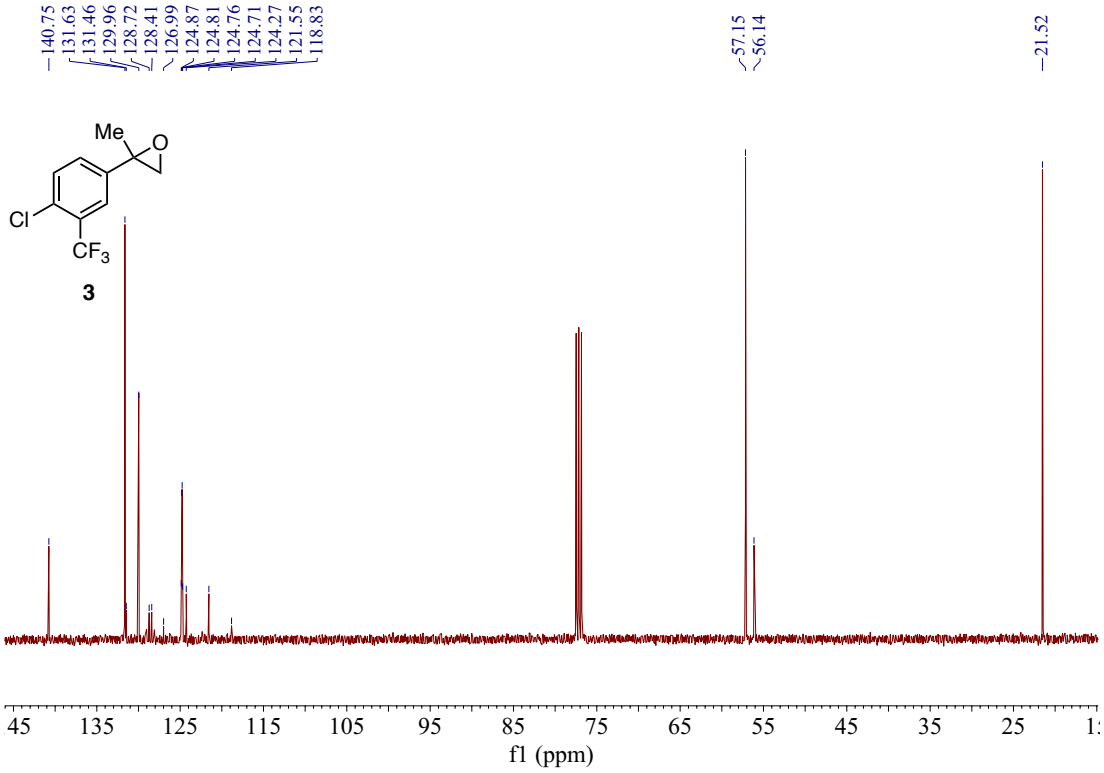
^{13}C NMR of Compound **2** (101 MHz, $CDCl_3$)



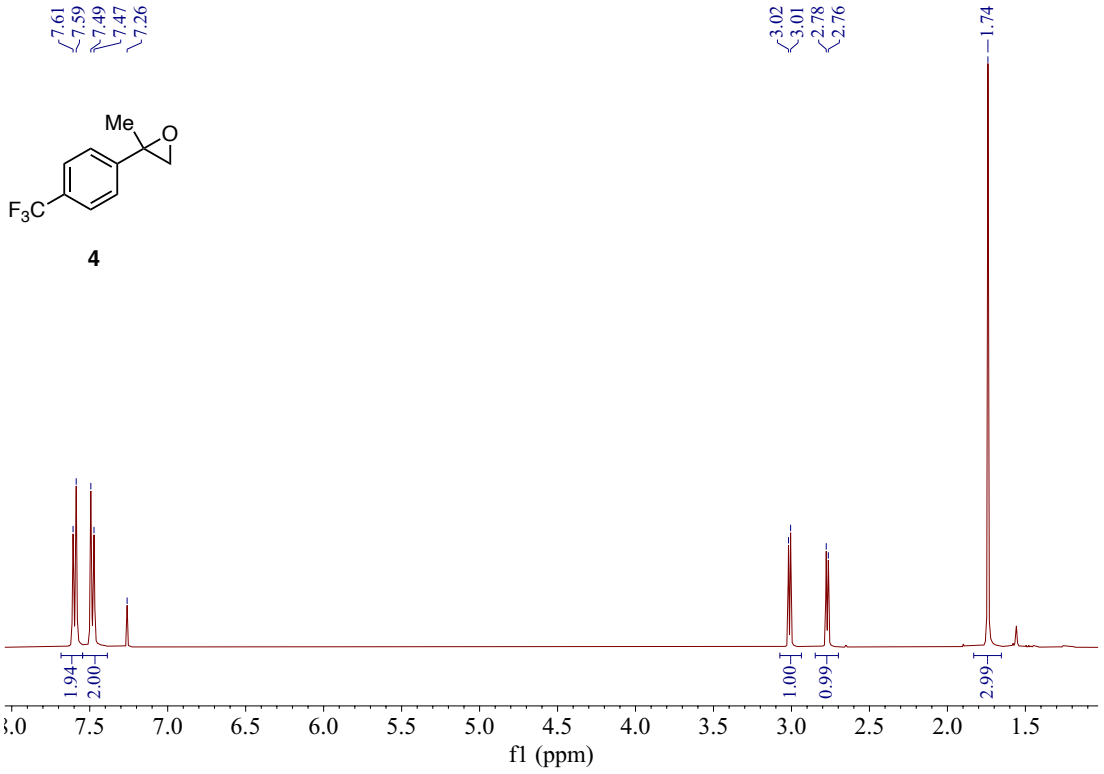
^{1}H NMR of Compound **3** (400 MHz, $CDCl_3$)



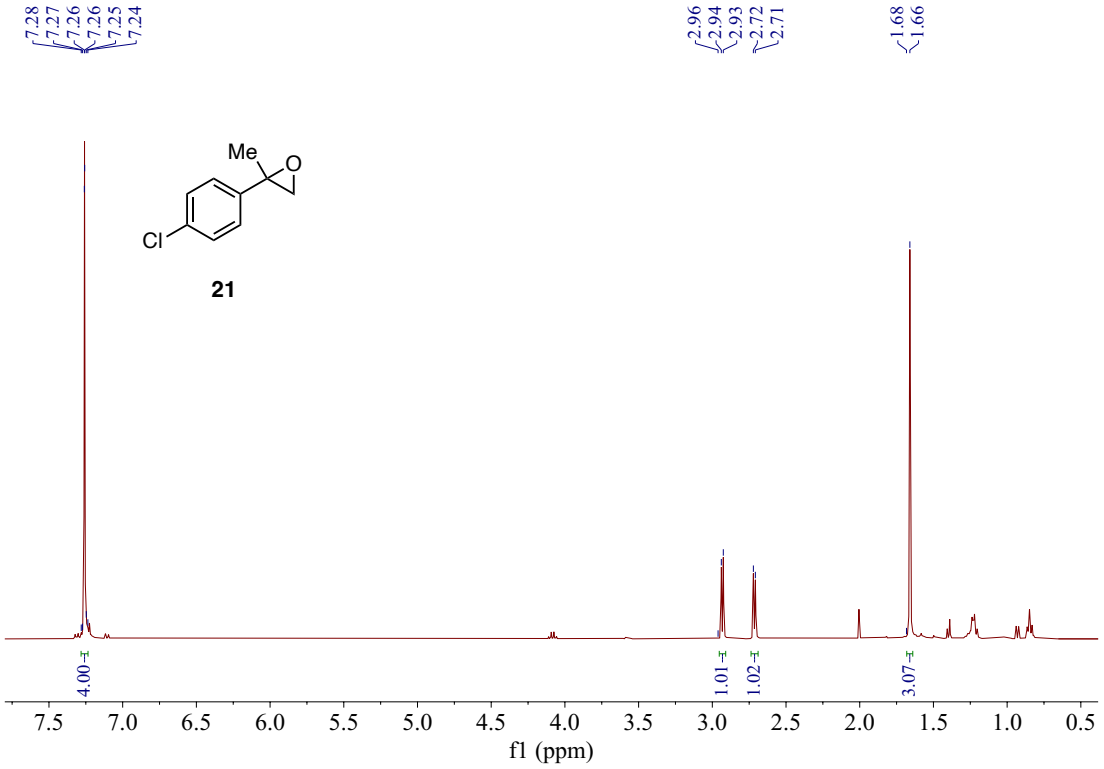
^{19}F NMR of Compound **3** (376 MHz, $CDCl_3$)



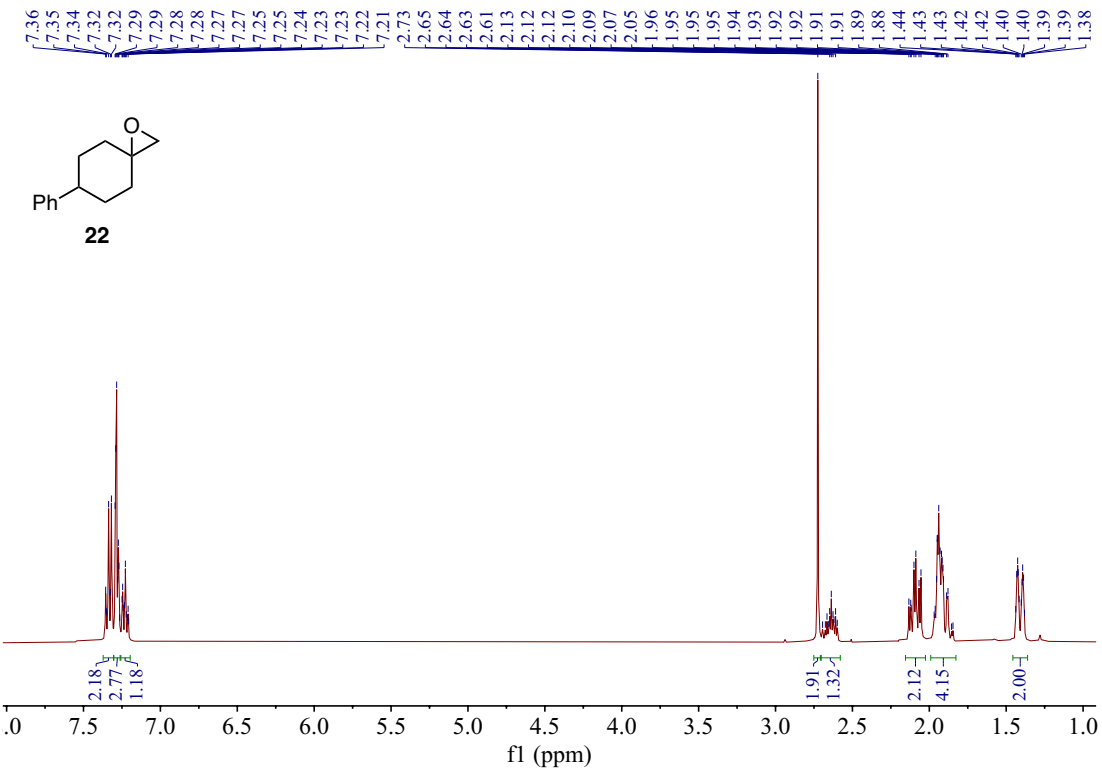
^{13}C NMR of Compound **3** (101 MHz, $CDCl_3$)



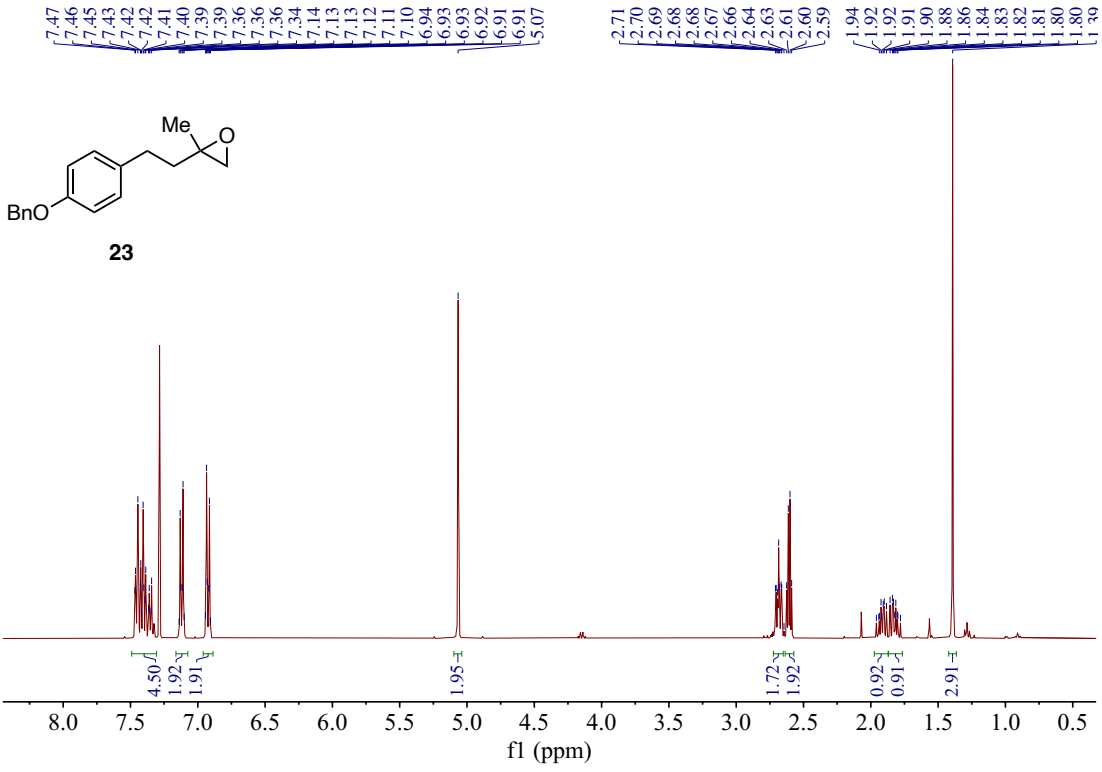
^{1}H NMR of Compound **4** (400 MHz, $CDCl_3$)



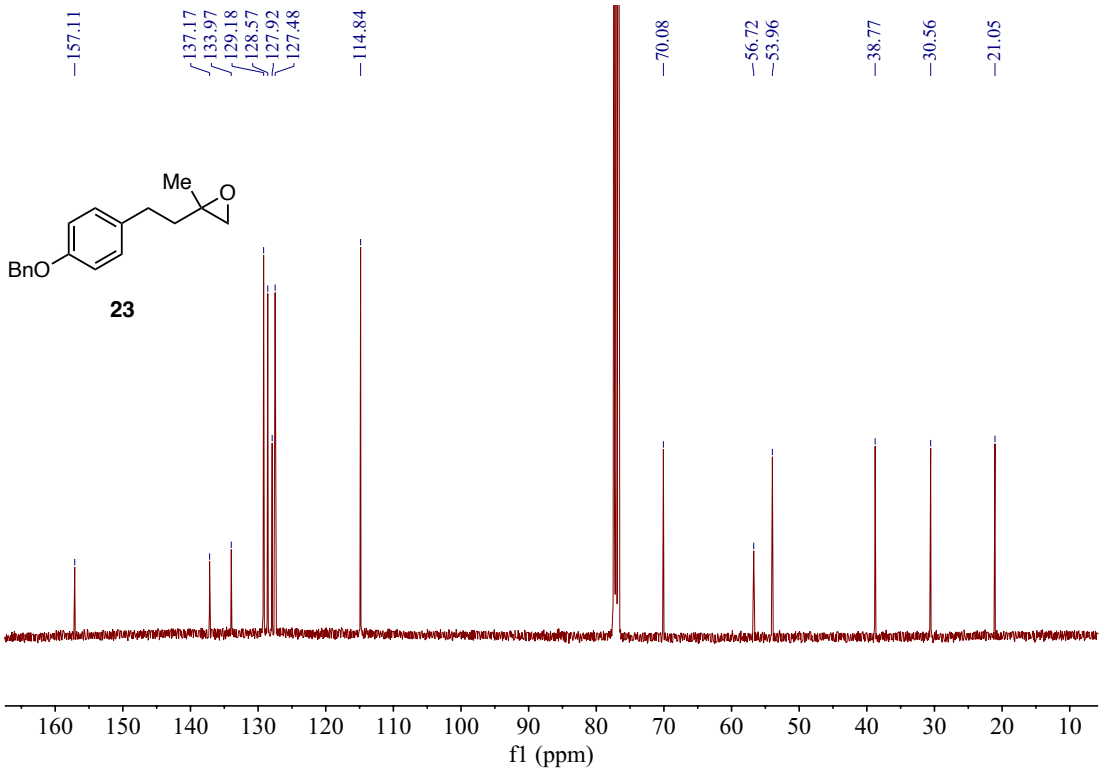
^{1}H NMR of Compound **21** (400 MHz, $CDCl_3$)



^{1}H NMR of Compound **22** (400 MHz, $CDCl_3$)



^{1}H NMR of Compound **23** (400 MHz, $CDCl_3$)



^{13}C NMR of Compound **23** (101 MHz, $CDCl_3$)