Science
AAAS

Supplementary Materials for

A machine-learning tool to predict substrate-adaptive conditions for Pd-catalyzed C–N couplings

N. Ian Rinehart *et al*.

Corresponding authors: Raphael Bigler, raphael.bigler@roche.com; Serena Fantasia, serena_maria.fantasia@roche.com; Scott E. Denmark, sdenmark@illinois.edu

Science **381**, 965 (2023)
DOI: 10.1126/science.adg2114

The PDF file includes:

Materials and Methods
Supplementary Text
Figs. S1 to S22
Tables S1 to S4
Scheme S1
Charts S1 and S2
NMR Spectra
References

General Information

All reactions were performed in glassware that had been flame-dried under vacuum or oven-dried (140 °C) overnight. All reactions were conducted under an atmosphere of dry nitrogen or argon using a drying tube equipped with phosphorus pentoxide and calcium sulfate. Solvents used for extraction were reagent grade, and chromatography solvents were technical grade. Column chromatography was performed using Ultrapure Silica gel from Silicycle (40- 69µm) with a column mixed as a slurry, packed, and rinsed at 6-8 psi.

Solvents

Reaction solvents tetrahydrofuran (Fischer, HPLC grade), hexanes (Fischer, HPLC grade), diethyl ether (Fischer, BHT stabilized ACS grade), methylene chloride (Fischer, unstabilized HPLC grade), and DMF (Fischer, HPLC grade) were dried by percolation through two columns packed with neutral alumina under positive pressure of argon. Reaction solvent toluene (Fischer, ACS grade) was dried by percolation through a column packed with neutral alumina and a column packed with Q5 reactant, a supported copper catalyst for scavenging oxygen, under a positive pressure of argon.

Chromatography

Analytical thin-layer chromatography was performed on Merck silica gel 60 F254 plates. TLC plates were visualized by exposure to ultraviolet light or treatment with either vanillin, ceric ammonium nitrate, iodine, or $KMnO_4$ stains. Retention factor (Rf) values reported were measured using a 10 × 2 cm TLC plate in a developing chamber containing the solvent system described. Flash column chromatography was performed using Silicycle SiliaFlash®P60 (40-63 µm particle size, 230-400 mesh) (SiO2). Unless otherwise specified, “silica” refers to P60 grade silica gel. Analytical high pressure liquid chromatography (HPLC) was performed with a UV detector (220 or 207 nm) using an Agilent InfinityLab Poroshell 120 Reverse Phase EC-C18 column (4.6 x 50 mm, 2.7 µm particle size).

Instrumentation

NMR Spectroscopy. ^{1}H, ^{13}C, ^{19}F, and ^{31}P NMR spectra were recorded on a Varian Unity Inova 400 spectrometer (^{19}F and ^{31}P), a Varian Unity 500 spectrometer (^{1}H and ^{13}C), a Bruker Avance 500 spectrometer (^{1}H, ^{13}C, ^{19}F, ^{29}Si, and ^{31}P), a Varian VXR 500 spectrometer (^{1}H), a

Varian Unity Inova 600 spectrometer (600 MHz, ^{1}H; 150 MHz, ^{13}C; 119 MHz, ^{19}F; 565 MHz) equipped with a 5mm Varian AutoTuneX 1H/X PFG Z probe, or a Unity 500 NB spectrometer (^{1}H). Spectra are referenced to chloroform (δ = 7.26 ppm, ^{1}H; 77.0 ppm, ^{13}C), benzene (δ = 7.15 ppm, ^{1}H; 128.62 ppm, ^{13}C), methanol (δ = 3.31 ppm ^{1}H, 49.00 ppm ^{13}C), acetonitrile (δ = 1.94 ppm ^{1}H, 1.32, 118 ppm ^{13}C), or DMSO (δ = 2.50 ppm ^{1}H, 39.52 ppm ^{13}C). Chemical shifts are reported in ppm, and multiplicities are indicated by s (singlet), d (doublet), t (triplet), q (quartet), p (pentet), h (hextet), m (multiplet) and br (broad). Coupling constants, *J*, are reported in Hertz, and integration is provided, and assignments are indicated.

Mass Spectrometry. Mass spectrometry was performed by the University of Illinois Mass Spectrometry Laboratory. Mass spectrometric data was collected on a Waters Q-TOF Ultima (ESI) spectrometer, a Waters Synapt G2-Si spectrometer (ESI), a Waters Quattro Ultima spectrometer (ESI), or a Waters 70- VSE spectrometer (EI). Low resolution spectral data are reported as (mass, intensity), and high-resolution data are reported as calculated and measured masses to 10^{-4} mass accuracy.

Infrared Spectroscopy. Infrared spectra were recorded on a Perkin-Elmer UATR-2 FT-IR spectrophotometer. Peaks are reported in cm-1 with relative intensities indicated: s (strong, 67-100%); m (medium, 34-66%), w (weak, 0-33%).

Melting Points. Melting points (mp) were determined on a Thomas-Hoover capillary melting point apparatus in vacuum-sealed capillary tubes and are corrected.

Quantitative ^{1}H NMR. qNMR spectra were collected on 500 or 600 MHz spectrometers using 1,3,5-trimethoxybenzene as internal standard, a solvent volume of 750 μL in an appropriate solvent (varied from $CDCl_3$ for solubility considerations), using four transients with a relaxation delay of at least 45 seconds. T1 relaxation times were not measured. Samples were prepared using a stock solution of the internal standard in the desired solvent, and manually weighed quantities of purified dataset products. Peaks were chosen on a by-compound basis after verifying consistent integration of the desired analysis peak with the other resonances from the analyte. Multiple resonances were analyzed when possible, and if a resonance showed a lower integration than others, that was not used for the analysis or the spectra were re-taken with a 60 second relaxation delay. Molar ratios were calculated by using the ratio of integrals corrected for the number of protons contributing to that resonance for both the product and internal standard.

Reagents and Reactants

Amines were sublimed, distilled, or recrystallized prior to use and stored under a dry nitrogen or argon atmosphere. 1,3,5-Trimethoxybenzene was sublimed before use and stored under an inert atmosphere (autooxidation observed). Inorganic bases were purchased and opened in a glovebox to prevent contamination by moisture. DBU was stored in an inert atmosphere inside of a glovebox.

Commercial Chemical Sources:

Potassium carbonate was obtained from VWR Chemicals. Ad-BrettPhos, AlPhos, CPhos-Hybrid were obtained from Sinocompound. Pd-PEPPSI-IHeptCl was obtained from Total Synthesis. *trans*-4-Methylcyclohexan-1-amine (98%, 2523-55-9) was obtained from ABCR. Thiomorpholine , 2-Aminopyridine, 3-Bromopyridine, 1-Bromo-2-methoxybenzene, 5-Bromo-2-methylpyridine and 1-bromo-2-isopropylbenzene, 3,5-trifluromethylbromobenzene, 1-bromonaphthalene, 1-bromo-4-(trifluoromethyl)benzene and 4-methoxyaniline, 1-bromo-3,5-bis(trifluoromethyl)benzene and aniline were purchased from Oakwood Chemical. 3-Bromoquinoline, iodomethane and 5-bromo-1,2,3-trimethoxybenzene and 1-bromo-2-(trifluoromethyl)benzene were purchased from Alfa-Aesar. Dibutylamine, 1-methylpiperazine, 6-bromoquinoline, 4-bromo-3-methylanisole, 1,3,5-trimethoxybenzene, 2-(3-bromophenyl)-1,3-dioxolane, 4-bromo-1,3,5-trimethylpyrazole, 5-bromo-2-methylpyrimidine, *trans*-4-methylcyclohexylamine, 4-methylcyclohexylamine, dibutylamine, *cis*-decahydroisoquinoline, 2-bromopyridine and butyramide were purchased from TCI. Ad-BippyPhos, *t*-Bu-BrettPhos Pd G3, cataCXium PCy_3, copper(I) iodide, dicyclohexyl(3-isopropoxy-2’,4’,6’-triisopropyl-[1,1’-biphenyl]-2-yl)phosphine (EPhos), JohnPhos, Me_4-*t*-Bu-Xphos, RockPhos, (±)-*trans*-*N*,*N*’-dimethylcyclohexane-1,2-diamine, RuPhos Pd G3, silver trifluoromethanesulfonate, SPhos Pd G3, tris(dibenzylideneacetone)dipalladium(0), XPhos, cesium carbonate, lithium bis(trimethylsilyl)amide, potassium phosphate, sodium *tert*-butoxide, acetic acid, benzamide, butyraldehyde, sodium triacetoxyborohydride, hexamethyleneimine, Pyrrolidine, α-methylbenzylamine, N-benzylmethylamine, pyrrolidine, cyclohexanemethylamine, 6-bromoquinoxaline, 4-bromo-7-azaindole, 2-bromonaphthalene, 3-iodoimidazo[1,2-a]pyridine, 4-bromo-2-phenoxythiazole, *N*-methylacetamide, 4-bromo-1,3,5-trimethyl-1H-pyrazole, dibenzylamine, 2-bromoanisole, (*S*)-(−)-α-methylbenzylamine, 3-aminopyridine, pyrazole, 2,6-

dimethylaniline, cyclohexylmethanamine, 4-bromothiazole, 1-bromo-3-nitrobenzene, benzaldehyde, 4-bromo-7-azaindole, 4-bromo-1,3,5-trimethylpyrazole, CataCXium PCy, 2-bromothiazole, indole, N-methylaniline, piperidine, 4-bromodiphenyl ether, and pyrazole were purchased from Sigma-Aldrich. 4-Bromoisoquinoline and 5-fluoroindole were purchased from AK Scientific. 2-methylpropan-2-amine was obtained from Merck. 6-Bromo-2-methylbenzo[d]thiazole, 1-methyl-1H-pyrazol-5-amine, 4-bromo-1-methyl-1H-indazole, 3-bromoimidazo[1,2-a]pyridine, 1-(2-bromophenyl)-1H-pyrazole, 5-bromo-1-methylpyridin-2(1*H*)-one, 4-bromo-1-tritylpyrazole, 4-methoxy-2,6-dimethylaniline, pyrazin-2-amine, 2,6-dimethoxyaniline, 1-methyl-1*H*-pyrazol-4-amine, 2-(1-pyrazolyl)aniline, 2-aminooxazole, Sphos, 1-(2-bromophenyl)-pyrazole and 1-bromo-4-methoxy-2-methylbenzene were purchased from Ambeed. Bis(3,5-bis(trifluoromethyl)phenyl)(2’,6’-bis(isopropoxy)-3,6-dimethoxybiphenyl-2-yl)phosphine RuPhos-Hybrid, BrettPhos Pd G3, BrettPhos Pd G4, cataCXium PInCy, cataCXium POMeCy, EtCPhos · $(HBF_4)_2$, Me_4-^{t}Bu-XPhos Pd G3, Alphos, Cphos hybrid, Jackiephos, CataCXium POMecy, CataCXium PIncy, allyl palladium chloride dimer were purchased from Strem. 4-Bromo-1-phenyl-1h-pyrazole, 3-bromo-4-methylthiophene, 4-iodo-1-methyl-1h-imidazole, 1-methyl-1h-pyrazol-3-amine were purchased from Synthonix. Allylpalladium(II) chloride dimer, 1,3-bis(2,6-diisopropylphenyl)imidazolium chloride, 5-Bromopyrimidine, (2*R*,6*S*)-2,6-dimethylpiperidine (95% *cis*-isomer, 766-17-6) *N*-methyl-*tert*-butylamine, 1*H*-pyrazole, pyridin-2-amine, 1*H*-pyrrole, pyrrolidine, 1-Iodo-2-(trifluoromethyl)benzene was purchased from Acros Organics. Sodium phenoxide, 2-Bromo-1,3-diethylbenzene, 2-bromo-6-methoxypyridine, 2-bromo-1,3,5-triisopropylbenzene, and diphenylmethanimine were obtained from Alfa Aesar. (1-Methylpiperidin-4-yl)methanamine (7149-42-0) was obtained from Apollo Scientific. 5-Bromo-2-methylpyrimidine (98%, 7752-78-5) was obtained from Ark Pharm. 8-Azabicyclo[3.2.1]octane hydrochloride, 2-bromo-1,3-diethylbenzene, 4-bromo-1-methyl-1*H*-indazole, 1-bromo-3-nitrobenzene, 4-bromo-2-phenoxythiazole, 5-bromo-2-(piperidin-1-yl)pyrimidine, 4-bromoquinoline, 4-bromo-1-methylimidazole and 3-bromoimidazo[1,2-a]pyridine, 2-bromo-5-phenyl-1,3-thiazole, 4-bromo-1-methyl-1h-imidazole, 4-bromothiazole and 2-bromo-5-phenyl-1,3-thiazole were purchased from Enamine. 5-bromooxindole and 2-bromo-1,3-dimethoxybenzene, butan-1-amine and 1-methyl-1*H*-pyrazol-4-amine were obtained from Combi-Blocks. *N*-Methylaniline, 1-bromo-2-methoxybenzene and dibenzylamine were obtained from Fluka. Ph-DavePhos, Ph-SPhos, RuPhos, 3-bromo-9-ethyl-9*H*-carbazole (57102-

97-3), 5-bromo-2-methylpyridine (3430-13-5), 4-bromoquinoline (3964-04-3), 6-bromoquinoline (5332-25-2), 4-bromothiazole (34259-99-9), 1-bromo-3,4,5-trimethoxybenzene (2675-79-8), 4-bromo-1,3,5-trimethyl-1*H*-pyrazole (15801-19-1), 1-methyl-1*H*-pyrazol-3-amine (1904-31-0), 1-methyl-1*H*-pyrazol-5-amine (1192-21-8) and oazol-2-ylamine (4570-45-0) were obtained from Fluorochem. (1-Methylpiperidin-4-yl)methanamine was purchased from A2B. *N*,*N*'-(6-Bromopyrido[2,3-*d*]pyrimidine-2,4-diyl)bis(2,2-dimethylpropanamide),(*34*) (3-bromophenoxy)triisopropylsilane,(*35*) 5-fluoro-3-methyl-1H-indole(*36*),(*37*) 2-((2-bromobenzyl)oxy)tetrahydro-2H-pyran,(*38*),(*39*) *tert*-butyl (S)-5-oxopyrrolidine-2-carboxylate(*40*) were synthesized according to literature precedent and matched reported spectral data.

Computational and Informatics Methods

Computational Methods

A code package containing all necessary components of the computational workflow used in this manuscript was developed. The code depends on an internally developed package named molli (version 0.3), to handle 2D structure drawing input structures all the way through 3D conformer ensemble calculation and alignment. The molli package was developed by Alexander S. Shved with contributions by N. Ian Rinehart for this project. Then, a separate package specific to this work was developed by N. Ian Rinehart and is used for descriptor calculation and serialization, dynamic dataset/feature partitioning, modeling, inferencing, and generating data/prediction visualizations(*41*) using key dependencies.(*42*)-(*46*) That package is called Lucid_Somnambulist and is available as a command-line python package here.

Modeling and descriptor calculation were developed and performed on a Microway Dual EPYC WhisperStation (2 x AMD EPYC 7643 'Milan' 48-core CPU, 1 TB Memory @ 3200 MHz, NVIDIA 'Ampere' RTX A6000 GPUs with NVLink, Ubuntu 20.04 LTS).

Descriptors

For Reactants

A radial distribution function descriptor class was developed. Software was created that takes input structures as an ensemble of conformers for each reactant that have been minimized. The following workflow was applied to each reactant to calculate Radial Distribution Function (RDF) descriptors:

(1) Using an input structure and a defined reactive atom (Br or NH), a series of concentric spheres were created at designated radii from that reactive atom. These spheres defined spherical "slices" of space around the reactive atom which facilitated sorting of atoms from the rest of the structures into their respective regions.

(2) Layers, defined as the space between two concentric spheres (like layers of an onion), are treated as "bins" in which every atom in each conformer of each reactant are sorted. The distance increment for these spheres changed throughout the project from 0.5 Å to 0.85 Å.

(3) Various properties which describe each atom are used to capture a distance-weighted representation of the reactants. Some of these properties were scraped from calculations

(charge, Fukui indices, Wiberg bond orders, etc.), van der Waals radius to represent size, and in the case of heteroatoms, a binary indicator for the presence of a particular heteroatom was also used. For each atom within each spherical region of space, an atomic property is summed across all atoms in that radial slice. In the case of heteroatom indicators, this constituted counting the number of a particular heteroatom in each spherical slice of the space around a minimized reactant conformer.

(4) All properties were concatenated in the same order to create a reactant feature array. These features were then concatenated with catalyst, solvent, and base descriptors to generate a 1D vector for each reaction.

This workflow produces a vector representation of the spatial distribution of steric bulk around the reactive atom in each reactant. When *all* reactants had descriptors calculated, then pre-processing was used to eliminate any all-zero descriptors (individual spherical layers that always had zeros), as well as descriptors which had no variance across all structures, or which were correlated with one another (>0.95 R^2). An important development in this work was the observation that (hetero)aryl bromides proved particularly challenging for out-of-sample predictions with a spherical RDF. A simple change was made:

(1) For each structure, there is a planar (hetero)aryl fragment and a reactive C-Br bond. A plane was calculated for the aromatic system, and a perpendicular plane containing the C-Br bond vector was calculated.

(2) This plane bisects the molecule into halves. The spherical RDF workflow was applied to each half separately (generating a feature array 2x the length of amines, which were treated with a single, spherical RDF), generating a *hemi*spherical RDF.

(3) The order of concatenating each hemispherical RDF array for these reactants was determined based on (i) ortho, then meta, atomic numbers or (ii) substitution ortho, then meta. This effectively prioritizes the presence and identity of a heteroatom, then steric bulk by distance to the reactive *ipso* carbon. This simple algorithm is arbitrary but produces consistent results that can be mapped onto any (hetero)aryl bromide reactant.

In an illustrative example, this two-sided RDF better captures the difference between a symmetrically substituted arene (2,6-disubstituted) with a moderately bulky substituent and a mono-substituted (ortho) arene with a very large substituent. Two such reactants may be expected to behave differently as the mono-substituted reactant may accommodate greater steric effects by rotating a substituent "out of the way," while the disubstituted variant could not. Without representing each "half" of the molecule independently using an RDF, then empirically the descriptors between two such reactants are too similar for models to learn an effective quantitative structure reactivity relationship with a reasonable amount of data. An example of this is pictured in Figure S1, where the orange line represents the hemisphere division, and the colored concentric circles represent spherical "slices" used to bin atoms for conformer geometries.

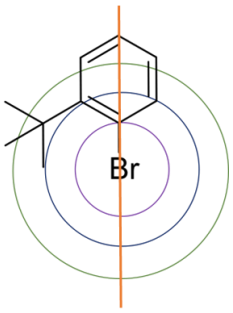


Figure S1. Reactant radial distance function descriptors.

For Catalysts

Catalysts were represented with a combination of grid-based and electronic descriptors. The grid-based descriptors include average steric occupancy (ASO) and average electronic indicator field (AEIF) descriptors described in prior work,(*47*),(*48*) and the electronic descriptors are derived from interactions between the ligand and a nickel tricarbonyl complex (Figure S2 shows a representative example with the Jackiephos ligand). An ensemble of conformers are used to represent each ligand, and these are identified using a molecular dynamics approach with Grimme's xTB/CREST.(*49*),(*50*) To ensure that conformers represent catalytically relevant geometries, the nickel tricarbonyl complex was used for this step. This prevents parts of the ligand from ending up where any metal complex would bind the ligand. The specific choice of a nickel tricarbonyl complex was made to enable calculated Tolman electronic parameter values (TEP). To obtain a meaningful ensemble of conformers, a search was initiated from two different geometries pictured in Figure S2. These differ primarily in the orientation of the distal arene of the biaryl backbone (or heteroaryl backbone for Beller-type ligands). The MD parameters used did not

consistently "flip" this orientation during a conformer search but performing two searches and combining the sets of conformer geometries obtained from both provided a representative conformer ensemble.

All ensembles for a particular ligand were aligned to the common substructure of the Ni-P-*ipso*-C substructure. It is important to recognize that (i) some ligands are *P*-stereogenic, and (ii) enantiomers have identical energies, and conformer search algorithms have no requirement to identify *both* enantiomers of each conformer. As a result, after embedding an aligned conformer ensemble in a 3D voxel grid, the ensembles had C_1 symmetry (and were thus chiral). To prevent a featurization based on an arbitrary *P* atom configuration or arbitrary (and stochastic) distribution of chiral conformer geometries, every conformer ensemble was enforced to a C_S symmetry by simply copying every geometry and inverting all atom coordinates through the plane defined by the three alignment substructure atom positions. The resulting aligned conformer ensembles thus depicted identical information on either side of this mirror plane. As a result, the 3D voxel grids were "pruned" (with a small buffer) to only capture roughly half of the grid. A representative example of both an aligned conformer overlay, and the resulting voxel grid are depicted in Figure S3. In that depiction, either the green or red "pixels" of the grid contain sufficient information for modeling.

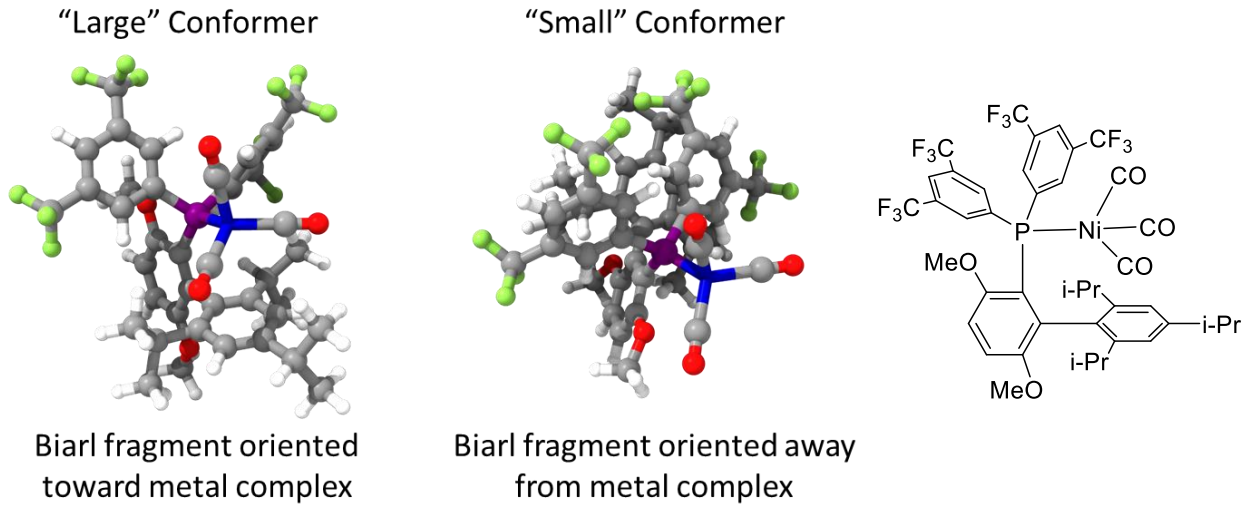


Figure S2: Bi(hetero)aryl ligand-nickel tricarbonyl complex used for *in silico* ligand representation (example shown with Jackiephos).

For each voxel grid point, the descriptor (ASO or AEIF) was calculated and then averaged across conformers for that ligand. This process was done *while ignoring the nickel tricarbonyl fragment* either by deletion of those atoms from the structure files, or by ignoring them with a mask (see code for explicit details). After the ligand descriptors were calculated, the voxel grids were flattened into 1D feature arrays that could be concatenated with appropriate reactant, solvent, and base descriptors.

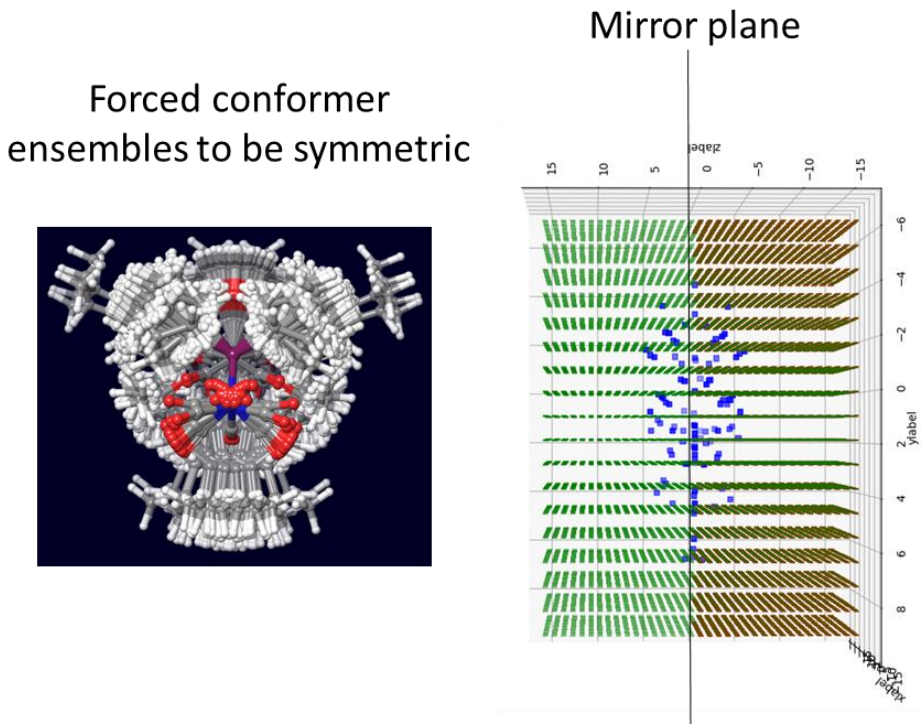


Figure S3: Enforced catalyst conformer ensemble symmetry and voxel grid with mirror plane

For Solvent/Base

Descriptors were identified for solvent and base which would likely provide generalizability in the future when more data exploring new combinations of solvent/base are incorporated. The current iteration of this workflow uses many descriptors as a catch-all, but these likely provide little more differentiation than one-hot encoding because so few solvents and bases were explored in this dataset. This decision to limit the reaction space was necessary, but limits generalizability in the solvent/base dimensions. Descriptors for solvents included density, refractive index, viscosity, dipole moment, dielectric constant, Dimroth ET(30), Catalan Sa, Sb, and Spp parameters, and Kamlet-Taft solvent parameters. Base descriptors were a collection of 1-D, 2-D, and 3-D descriptors contained in the following list: pKa, binary indicator of base solubility

(in given solvent), polarity, topological diameter, topological radius, unipolarity, global topological charge, Kier Hall electronegativity, maximal electrotopological negative variation, maximal electrotopological positive variation, mean topological charge index of order 1, mean topological charge index of order 2, molecular electrotopological variation, solvation connectivity index chi 0, solvation connectivity index chi 1, topological charge index of order 1, Van der Waals surface area, Randic shape index (2, 3, 4, 5 walk/path), Randic type index, reciprocal distance square Randic type index, HOMO energy, HOMO occupancy, lowest Rydberg, LUMO energy & occupancy.

Scope of Precatalysts, Reactants, and Reagents

The ligands used in this study are shown in Figure S4 with both the common name of their respective free ligands and their numerical designation throughout this work. These are depicted as their (allyl)triflate precatalyst structures.

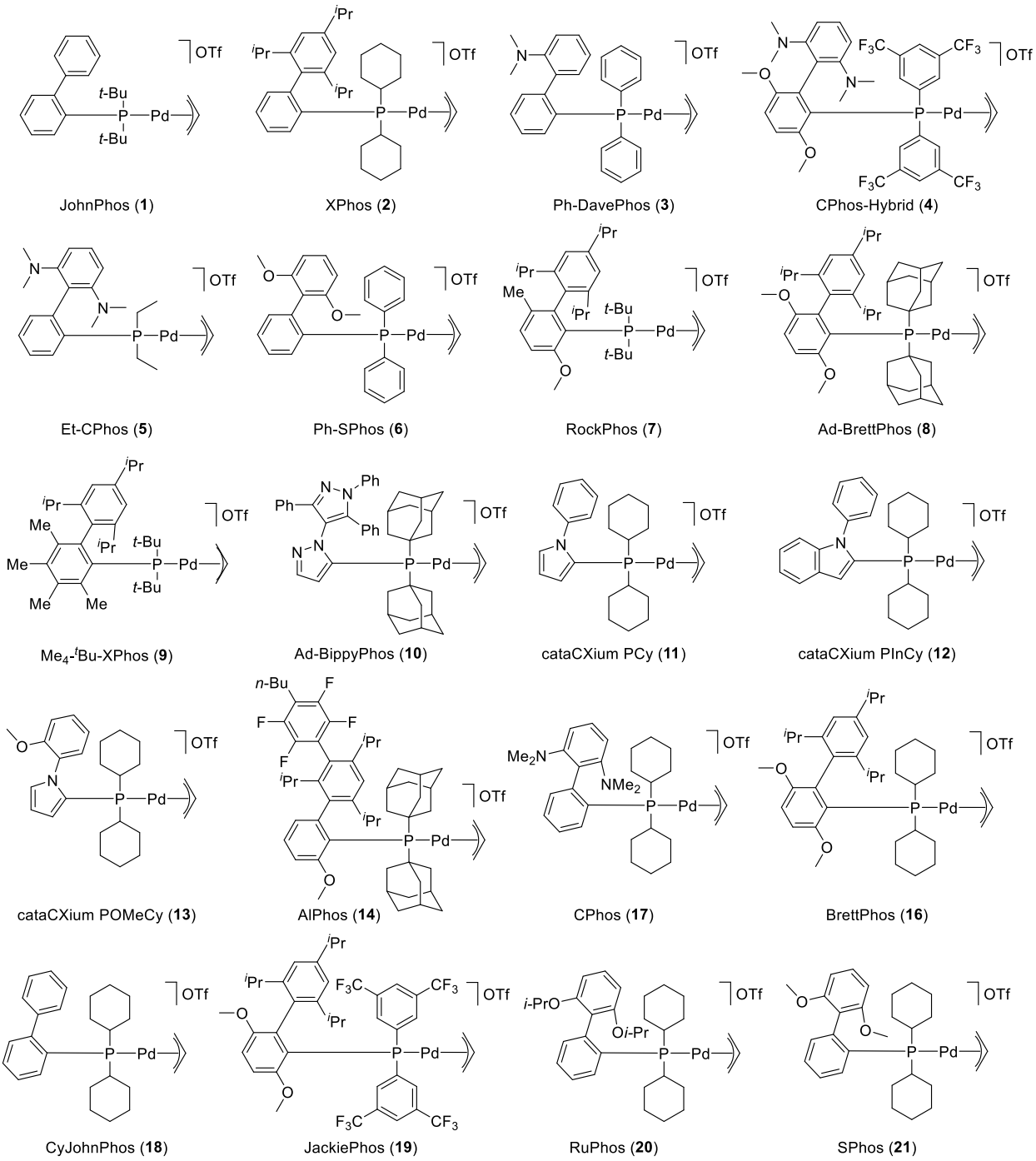


Figure S4: 20 Commercially available Buchwald- and Beller-type monophosphine ligands.

Fourteen of these 20 ligands were algorithmically selected using ASO/AEIF descriptors for all 50 commercially available Buchwald and Beller-type ligands and *k*-means clustering (*k*=15). One ligand was removed from consideration, then six were added to this list using expert knowledge (ligands 16-21). This strategy was intended as a balance between systematic, algorithmic selection and human expertise.

The scope of nucleophiles was intended to broadly cover the range of azoles, amides, cyclic aliphatic amines of varying steric bulk, acyclic aliphatic amines of varying order (primary and secondary), as well as amino-heterocycles and anilines of varying order (primary and secondary). Challenging nucleophiles like indole (which undergoes competitive C3-arylation), imidazole, and bulky piperidines were intentionally included. This ensured that trained models are not missing data from entire regions of reaction space.

Using a similar logic, (hetero)aryl bromides were selected to broadly represent proximal and distal steric effects, (hetero)arene electronic properties (electron rich and poor), as well as various important heterocycles and (where applicable) their isomers. Several challenging reactants were included to ensure that models could learn the limitations of this chemistry.

Reagents

For solvents, toluene, *t*-AmOH, and 1,4-dioxane were selected to broadly represent less polar aromatic, alcohol, and cyclic ether solvents commonly used in BH couplings. A temperature of 90 °C was identified as a good temperature for consistent experimentation. As a result, the more common solvents tetrahydrofuran and *t*-BuOH, which both boil below 90 °C, are replaced with solvents of similar properties and higher boilingpoints. For bases, the homogeneous base DBU was selected to represent a homogeneous organic base, though others are more common now. The two inorganic bases broadly represent a weak heterogeneous base (K_2CO_3) and a stronger homogeneous inorganic base (NaO*t*-Bu).

Reactant Clustering and Reactant Space

Amines

After several iterations of development, amines are clustered using a preprocessing sequence of variance threshold (0.05 variance), min/max scaling, removal of highly correlated features (>0.95 R^2, first feature kept), followed by an embedding step, then a clustering step. Amines were embedded with 6-component/5-neighbor Spectral Embedding or using Feature Agglomeration (20 "clusters"/features). Amines were clustered with either Agglomerative Clustering (8 clusters), or GaussianMixture. All combinations of these embedding/clustering methods were qualitatively valid, while other methods produced qualitatively poor-quality fits (as judged by the inappropriate groupings of "like" structures). Spectral embedding with Agglomerative Clustering was arbitrarily selected. The clustering is shown in Figure S6.

Bromides

Bromide clustering was independently optimized and showed similar behavior despite the doubled number of features compared to amines. Affinity propagation (a suboptimal result for amines) was particularly poor for bromides. The same preprocessing, embedding, and clustering procedure was applied to bromides (Figure S7).

Reaction Space

A network for the reaction space was constructed by creating a 2D matrix with the reactant dimensions represented by columns (bromides) and rows (amines). A graphical illustration of this is depicted in Figure S5. Since each reactant is organized along the reactant dimension, any position in this 2D matrix corresponds to a specific coupling of an amine and a bromide. When each reactant dimension is organized into clusters, then specific reactants, this encodes hierarchical information about clustering into the regions of the matrix. Thus, each region, or subspace, groups together couplings which are related by their class of bromide and class of amine. This visualization of the reaction space therefore maps the *types* of each reactant and *types* of couplings possible with them. Thus, new data can be identified as desirable (on the basis of its uniqueness from existing data) with this heuristic on inspection or using model error metrics (*vide infra*).

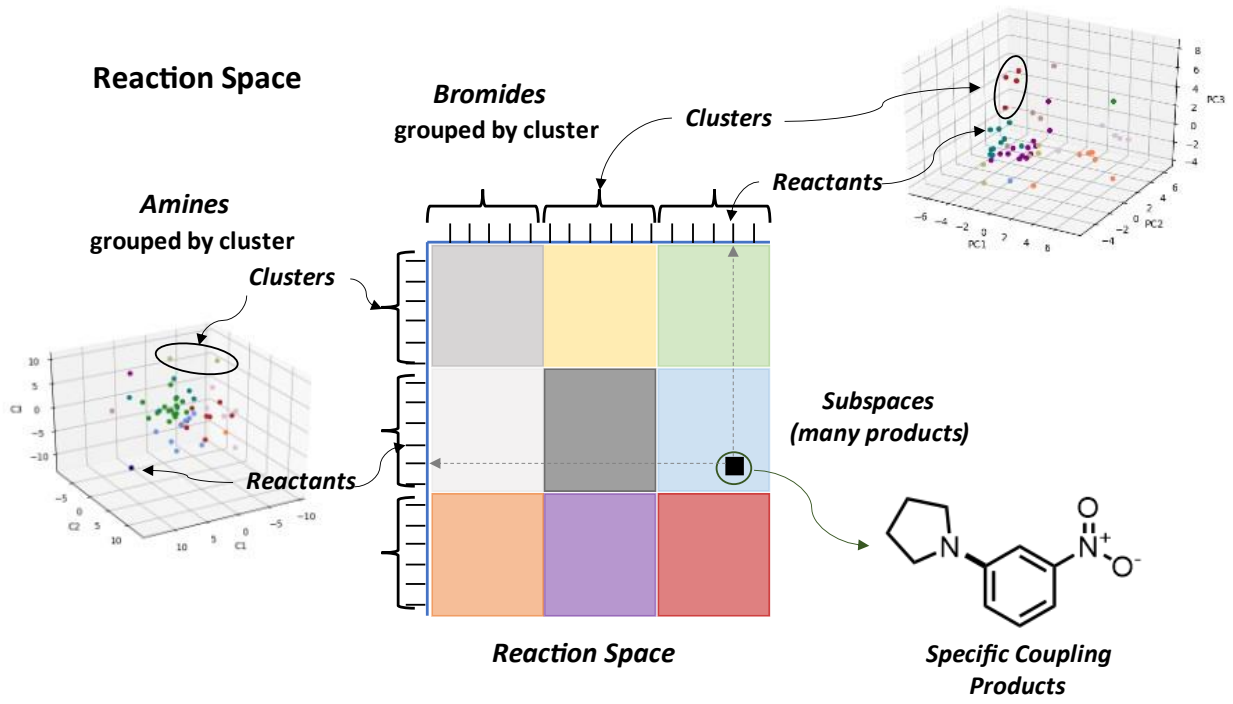


Figure S5. Graphical representation of 2D reaction space pictured in Figure 5.

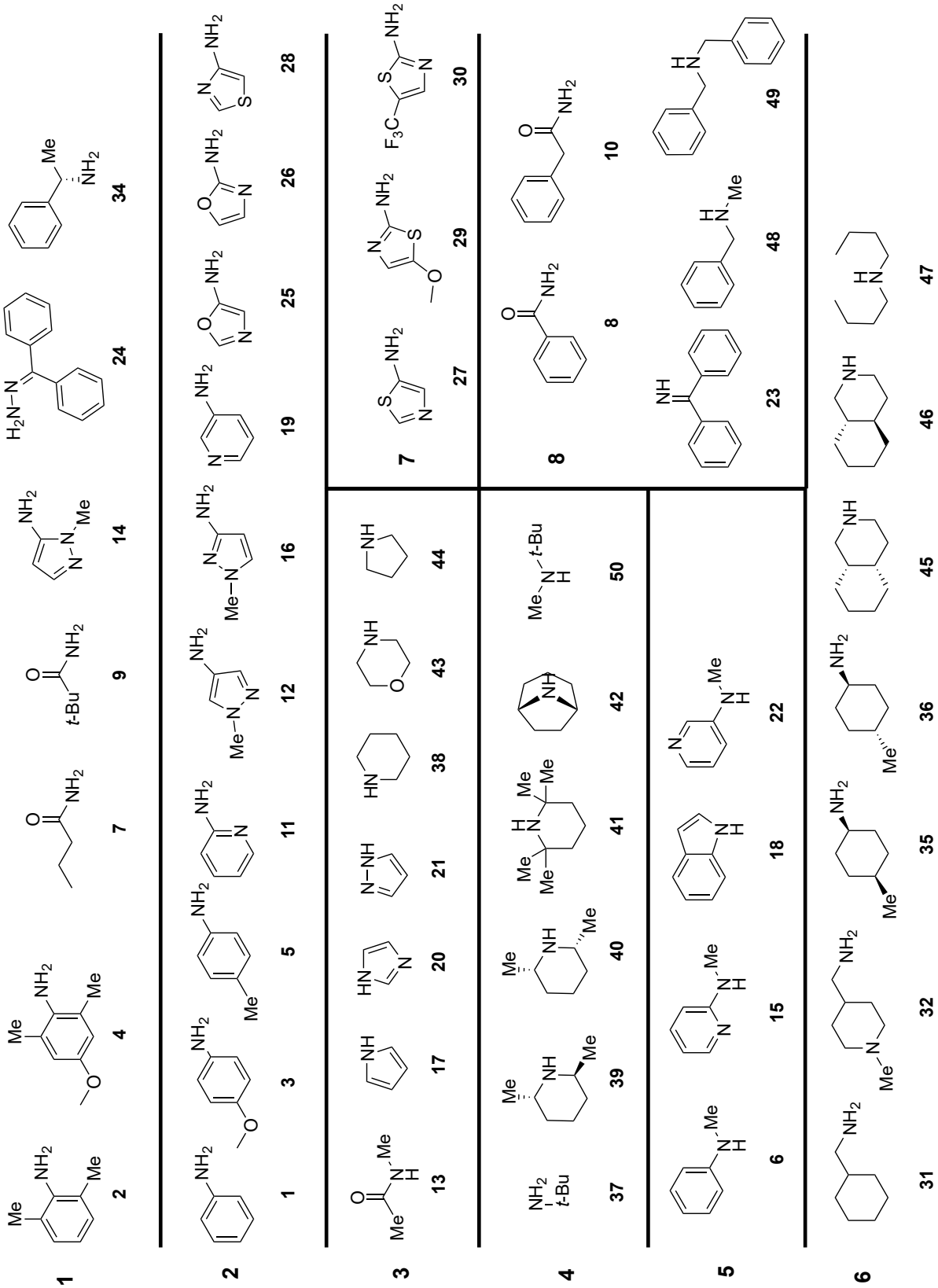


Figure S6. Amine reactant clustering into clusters 1-8 (large bold numbers).

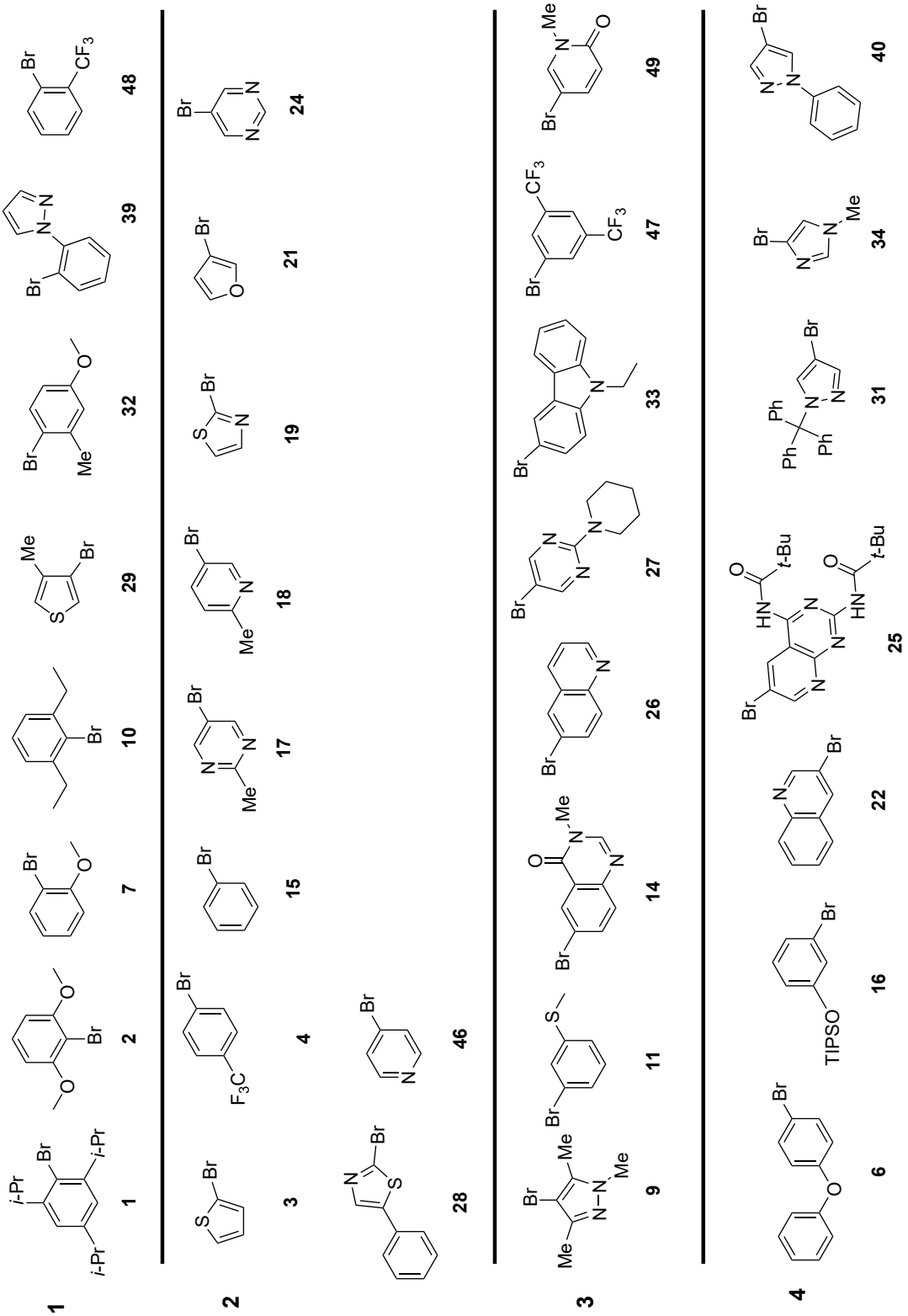


Figure S7.1. Bromide reactant clustering into clusters 1-4 (large bold numbers).

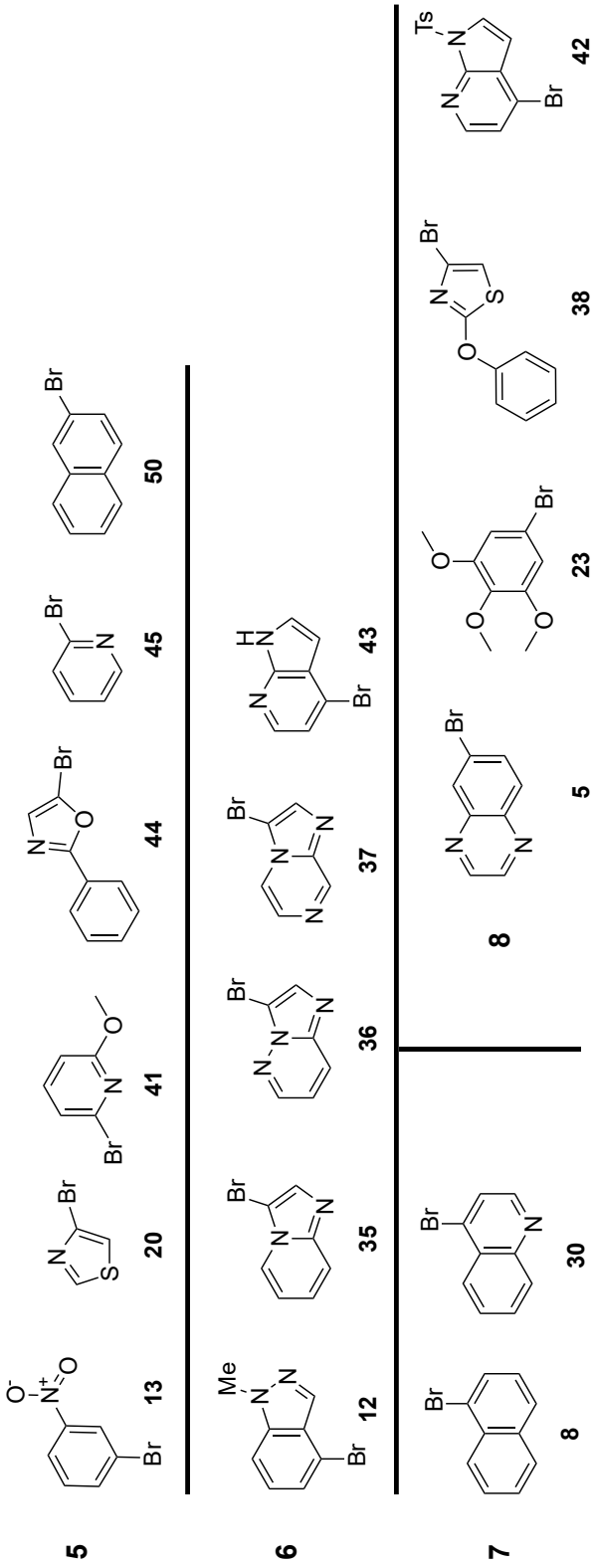


Figure S7.2. Bromide reactant clustering into clusters 5-8 (large bold numbers).

Modeling

All artificial neural network (ANN) modeling was performed using the Keras API/Tensorflow on a workstation equipped with GPUs (*vide supra*), with custom code from the Lucid_Somnambulist package (also available in the Zenodo deposit). Model architectures and hyperparameter configurations were identified simultaneously through a search routine. This search routine constructs ANN architectures with: (i) a dual input/regularization layer (Gaussian Noise) with tunable Gaussian noise (0.005 to 0.08 standard deviation), (ii) a fully-connected layer with variable nodes (256 to 3000) and ReLU activation, (iii) a dropout layer with tunable fraction of dropouts (0 to 0.65), (iv) a fully-connected layer with variable nodes (128 to 1280) and ReLU activation, (v) a dropout layer with tunable fraction of dropouts (0 to 0.65), (vi) a penultimate fully-connected layer with variable nodes (8 to 256) and ReLU activation, and finally (vii) a fully-connected layer with either (a) a single node and linear activation (for regression models) or (b) several nodes and categorical cross-entropy activation (for multiclass classification models). Models were compiled with a Stochastic Gradient Descent (SGD), Adam, or Agadelta optimizer with a tuned learning rate and mean-squared error as loss. Hyperband tuning was performed on many randomly partitioned instances of the dataset to provide partition-specific models.

Models were trained using a training set, hyperparameters were tuned using a validation set, and then models were evaluated using a test set partition to separate model tuning (using the validation set performance) from statistical tests of models (using the test set performance). The Hyperband search was efficient at identifying model configurations. Ten top hyperparameter configurations from the Hyperband tuner search were serialized (referred to as hypermodels here). These hypermodels were then used to generate inferences on future reactions after being trained on all available data to both (i) save time at inferencing, and (ii) enable consistent updating of models.

Models used for predictions were reconstructed hypermodel *graphs* with specific configurations but untrained, initial weights. These were retrained with features which underwent a fresh, unsupervised preprocessing step in parallel with the features for reactions being predicted. This ensured consistent preprocessing, thus consistent input order of features into the new hypermodels. The output from this inference routine is an ensemble of predictions made by many retrained models. Averaging them provided more robust out-of-sample predictions.

Randomized Feature Control

It is important to test if models learn chemical information. Using random feature vectors on a component-basis and of the same length as chemically meaningful descriptors rigorously tests whether models using chemical features are learning generalizable trends (i.e. "reactants like this are high yielding with catalysts like that") versus patterns inherent in the dataset (i.e. "this reactant is high yielding," or "this catalyst is good"). ANN models are complex and can effectively memorize a combinatorial dataset such that predictions on new combinations of components the models have memorized will not represent the models' prediction performance for new components.

To conduct this control experiment, randomized feature vectors for each reaction component (each amine, bromide, solvent, base, catalyst) were created. Then, those randomized vectors were used to assemble a feature array for the dataset. Models are trained on those features with otherwise identical preprocessing (scaling, feature selection, etc.). After training models on these random descriptors and separate models on chemically meaningful descriptors, the models were tested using out-of-sample reactant data. This control is *not* a standard in this field, but it is the opinion of these authors that it should be.

To effectively test out-of-sample predictions, pairs of an amine and a bromide for which a plate in the dataset were identified, and all plates with *either* the amine *or* the bromide *and* the plate with *both* were partitioned into an external test set. Then, random pairs of amine and bromide (5 pairs, not necessarily with a plate including both) were partitioned into the internal validation set used to tune hyperparameters (*vide supra*). This partitioning prevented any data leakage of test set reactants and enabled hyperparameters to be tuned by the validation set to reward generalizability. It did, unfortunately, remove a significant number of specific reactants, many of which serve as exemplars for key reactant domains.

Using chemically meaningful descriptors and random descriptors, 4 hypermodels were identified for each of the 120 partitions described above. The external test sets frequently include exemplars from the dataset which are important to network connectivity. In these cases, the test set performance is testing extrapolation performance for those exemplar reactants. If it is predicted poorly (but still shows some predictive power), then it suggests that exemplar is important for the dataset and confirms that models are learning chemical reactivity. If the performance is terrible for

a specific test set, then this suggests that the reactant is a crucial exemplar to the dataset. In the aggregate, the various test sets demonstrate an average performance across these cases (i.e. when test sets are closer to generalization or closer to extrapolation).

Notably, when data leakage of reactants was permitted (i.e. by not removing any plate with *either* the amine *or* the bromide, only the plate with *both*), the models trained with random features showed nonzero generalization performance. That is a consequence of the data leakage described above. This demonstrates that such a dataset partitioning scheme cannot distinguish models which are learning chemically generalizable patterns from those merely learning component identities. This is a key part of the modeling workflow here and is described in detail by Keiser and Chuang(*51*) in response to the 2018 *Science* paper by Doyle and coworkers.(*15*) The results obtained here support the conclusions of that discussion: such controls are important to continued development of machine learning in the domain of experimental chemistry.(*52*) They should be necessary in new publications.

Each reactant has a complex and varied role in the nework of the dataset, so this experiment must be evaluated in the aggregate: some indvidiaul test sets will fail, even with chemically meaningful descriptors, because the reactant is too unique. Therefore, the results of this control experiment are summarized by the distribution of slope and R^2 correlation coefficients of linear fits between predicted and observed yields (across 480 models trained on every possible partition of the 120 out-of-sample couplings using the top four hypermodels each). Figure S8 shows a histogram of the R^2 values and slope values for the test sets of all models. These belong to two categories: those trained using either chemically meaningful descriptors or random, component-wise features. Comparing these distributions evaluates the combined effort of the models and descriptors presented in this work toward learning and encoding general trends. The distributions of slope for chemically meaningful descriptors (mean 0.33, median 0.33) and random descriptors (mean 0.09, median 0.09) show a meaningful difference. The R^2 distributions for each are: (i) extremely skewed toward zero, leptokurtic (sharp), and *not* normal for the random descriptors (mean 0.08, median 0.05, one outlier at 0.48 *vide infra*, and ~90% lower than 0.2) and (ii) symmetric and platykurtic (flat) for chemically meaningful descriptors (mean 0.23, median 0.23, from ~0 to ~0.6). The distribution for random descriptors deviates too far from normality to rely on any ANOVA test, but these observations clearly differentiate the two distributions. The low

slope for random descriptors is consistent with underfit models predicting the average of training data (because no other meaningful model is *possible* with random descriptors). The distribution of slopes for chemically meaningful descriptors illustrates that the various out of sample reactant pairings have different importance to the network, and in most cases shows a clear positive correlation between predicted and observed yields. The sharp, skewed distribution of R^2 values towards zero for random descriptors confirms a failure to generalize predictions to the test sets used. The non-zero R^2 values generally describe systems where all predictions are identical, and a linear regression is able to fit a reasonable horizontal line to the values.

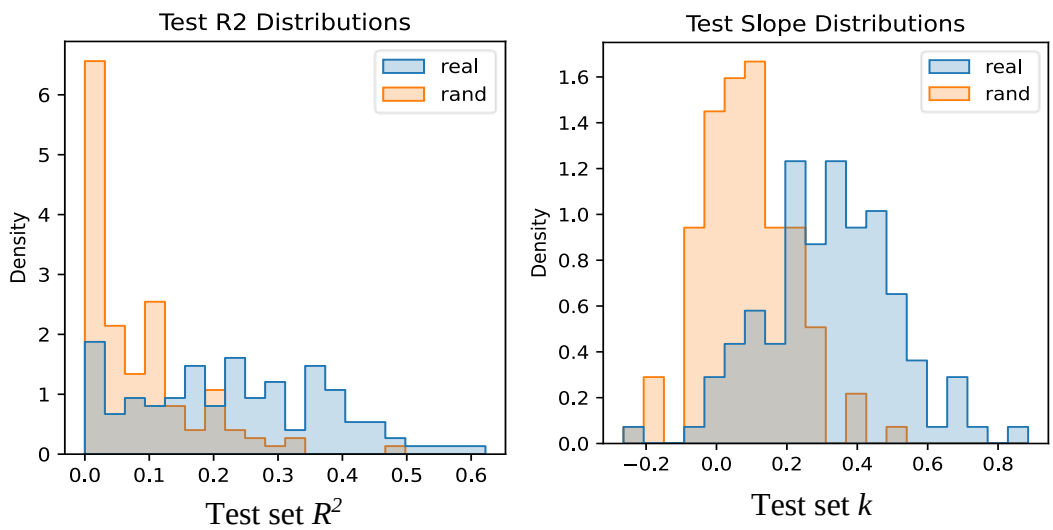


Figure S8. R^2 and slope distributions of out-of-sample partitions of dataset couplings. Both plots show the density (arbitrary units) vs the test set R^2 (left) or test set slope (right).

From the perspective of the models, these test sets are more challenging than the experimental validation but require a similar task. In this case, core dataset couplings that were necessary to train models for the experimental validation are removed in each partition. When some couplings are held out-of-sample, this significantly impacts the applicability domain of the models because no redundant or similar couplings are present in the dataset. For other couplings, the models are capable of generalization in line with the performance observed during experimental validation. In the case of random, component-wise descriptors, generalization/extrapolation was unsurprisingly not possible. By chance some out of sample

couplings had low yields close to the average training set yield, producing outliers which look performant. However, on inspection, these clearly did not demonstrate meaningful generalization.

To evaluate the results on a more granular level, the aggregate predictions of these models' test sets are shown in Figure S9 (the combined set of the many fits depicted in S8) for both chemically meaningful descriptors (left) and random descriptors (right). A visualization with points is not interpretable. Instead, Figure S9 displays these data using a kernel density estimate (KDE), which color codes the chart area based on the density of the data. Like a topography map, lines delineate changes in the projected *z* direction, which encodes density. Bright green indicates points of highest density, and purple is moderate density. This presentation significantly improves interpretability over a scatter plot representation because too many points make it impossible to interpret these distributions. To further aid this visualization, univariate distributions are plotted for each axis. *Note:* for both, the observed yield (y) distributions are necessarily identical.

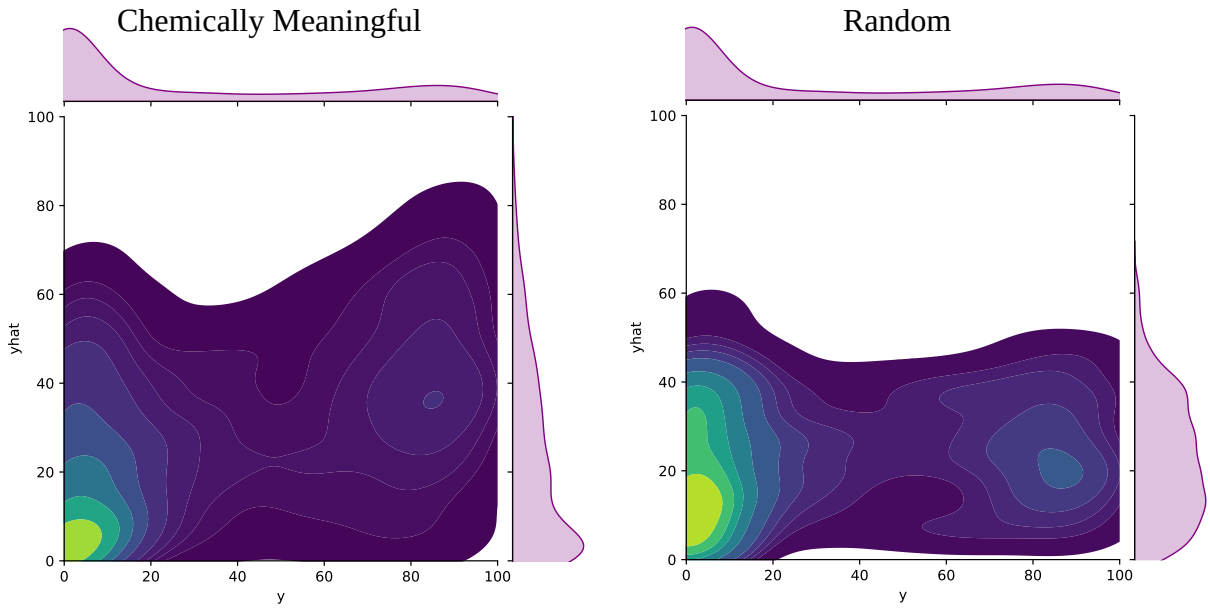


Figure S9. Predicted vs observed KDE joint plots of chemically meaningful features (left) and random features (right). Y axis is predictions (yhat), x axis is observations (y). Density of points increases from purple to yellow-green.

The results show the sparsity of high-yielding reactions in the dataset and that the chemically meaningful descriptors enable models to predict most of those accurately. However, the random descriptors do not enable models to make predictions with any sensitivity to the

structural features of the reactants as evidenced by the effectively horizontal slope. That those models predict the average of their training data (effectively a constant) is evidenced by the wider green distribution of low-yielding data in the y direction: each training set partition has a different average, so the low-yielding range shows a distribution of predictions. Contrasting that with chemically meaningful models demonstrates that those quite accurately predict the many zero-yielding reactions and have a diagonal, positive slope.

It is important to consider the couplings which were held out-of-sample in both test and validation sets. By removing them, models trained without that data face a significant disadvantage compared to the models used to make new predictions in this work. These models are for the purpose of a control experiment, and not the final models used in the tool. We interpret the results of this control experiment as a demonstration that (i) models learn generalizable information from the designed features and data, and (ii) that the couplings selected in this work are important to the growing applicability domain of models. Further, the fact that the performance diminishes in so many cases when the exemplar couplings are removed further supports the hypothesis presented in this work about domain expansion and dataset design.

Experimental Methods

Greenhouse Parallel Synthesizer

Reactor Description: The "Greenhouse" refers to a Radley's Greenhouse parallel synthesizer™ which allows 24 reactions to be run in parallel in glass tubes. Figure S10 shows a diagram with all of the parts of the Greenhouse. ™ The reactor itself consists of two metal plates which sandwich a thick glass cylinder. Figure S10.E shows the assembled reactor, including a thermocouple for the accompanying Heidolph stir plate (these are designed to work together). This plate was not exchanged for others for the sake of consistency. In Figure S10.E, the reactor is held together by the two large nuts with trigonal symmetry. The thermocouple reaches all the way to the tube rack (Figure S10.C), which has good thermal conductivity and thus the temperature of the reaction tubes is accurately reflected by the Heidolph thermocouple readout. The reactor is designed to be heated, and when in operation all tubes share the same inert atmosphere. To manage this, reflux pins are present in the lower face of the lid (Figure S10.B) which efficiently capture and return volatiles to the reaction mixtures. These pins are part of a single piece of nickel-plated, corrosion-resistant alloy comprising the lid, which is hollow. The hollow lid cavity has a network

of tunnels which plumb cooling water—the inlet/outlet for cooling water are visible in Figure 10.A as white Teflon quick-release adapters—throughout, and during operation the entire lid becomes cool to the touch. In the same image (Figure S10.A), the black nylon hose barb adapter for connecting the apparatus to an inert gas manifold (Schlenk line) is most visible.

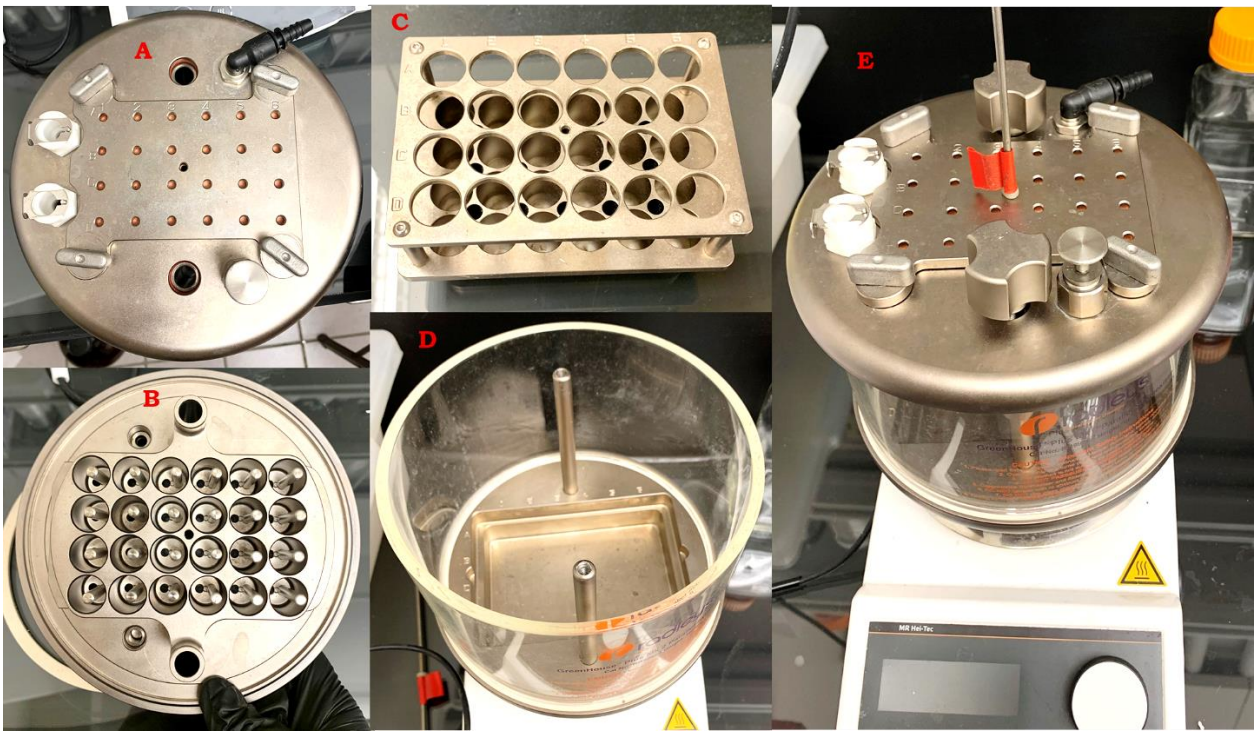


Figure S10. Radley's Greenhouse Parallel Synthesizer

Experimental Procedure for Dataset Reactions

The broad range of physical and chemical properties of reactants used in this work required a systematic workflow for experimental setup of Greenhouse™ tube rack reactions. Reaction tubes were cleaned using detergent and physical abrasion to remove bulk residues of Pd-black and other organics. Then, strong acid (aqua regia) or an acid bath (6 M sulfuric acid) treatment, followed by bicarbonate quench, rinse, then a base bath soak, followed by rinsing and thorough drying. After oven-drying overnight (or flame drying), the reaction tubes were loaded into the 24-position rack and charged with oven-dried stir bars (soaked with aqua regia, quenched/rinsed, and dried between each use). The tube rack was allowed to cool until it was not hot to the touch (ca. < 35 °C), then precatalysts were charged into each tube. Next, solid, non-hygroscopic reactants were charged. Then, the tube rack was transferred to the Greenhouse™ and the entire apparatus was pumped

down into the glovebox with all remaining materials, including hygroscopic or low melting solid reactants. In the glovebox, after removing the tube rack from the Greenhouse™ reactor body, solid bases were charged (potassium carbonate and sodium tert-butoxide), followed by any hygroscopic, solid reactants brought into the glovebox. Then, solvent was added to each tube (or an aliquot of a stock solution if using a reactant stock solution) until the total volume was 2 mL. Finally, liquid reactants and the liquid base (DBU) were charged into relevant tubes. All liquid additions (including solvent) were made with volumetric pipets, and stock solutions of reactants were mixed by charging a desired reactant gravimetrically into a volumetric flask inside of the glovebox, diluting, then dosing an aliquot using volumetric pipets. The tube rack was then transferred back into the reactor body, and the system was sealed shut (gas port sealed with a rubber pipet bulb), and the apparatus was removed from the glovebox and hooked up to a Schlenk line.

The reactor was placed onto a stir plate at 900 rpm. Heating on a Heidolf stir plate using the "fast" heating mode reliably heated the reactor body to >85 °C within 15 minutes. Then, the heating mode was switched to "precise" to gradually reach the desired 90 °C temperature and prevent overshooting it. After 16 h ± 15 min (data was rejected if reaction time was outside of this window), the heating was shut off while maintaining stirring until the reactor was at or below 30 °C. Then, the reactor body was opened to atmosphere, and a 1-mL aliquot of standard stock solution (1.402 ± 0.005 g of 1,3,5-trimethoxybenzene in 100 mL of spectroscopic grade acetonitrile) was added using a volumetric pipet. This delivers 1/6th equivalent of standard vs the 0.5 mmol of limiting reagent. The reactions were stirred continuously after this addition during which time a 30-µL aliquot of the resulting slurry was removed (1.0% volume of the total reaction mixture), which was diluted into 1.0 mL of spectroscopic grade acetonitrile and polish-filtered with a 0.2 µm filter. The samples were then analyzed using RP-HPLC while reaction tubes (with 99% of each reaction volume remaining) were retained for product isolation after analysis (*vide infra*).

Analytical Workflow for Determining Reaction Conversions

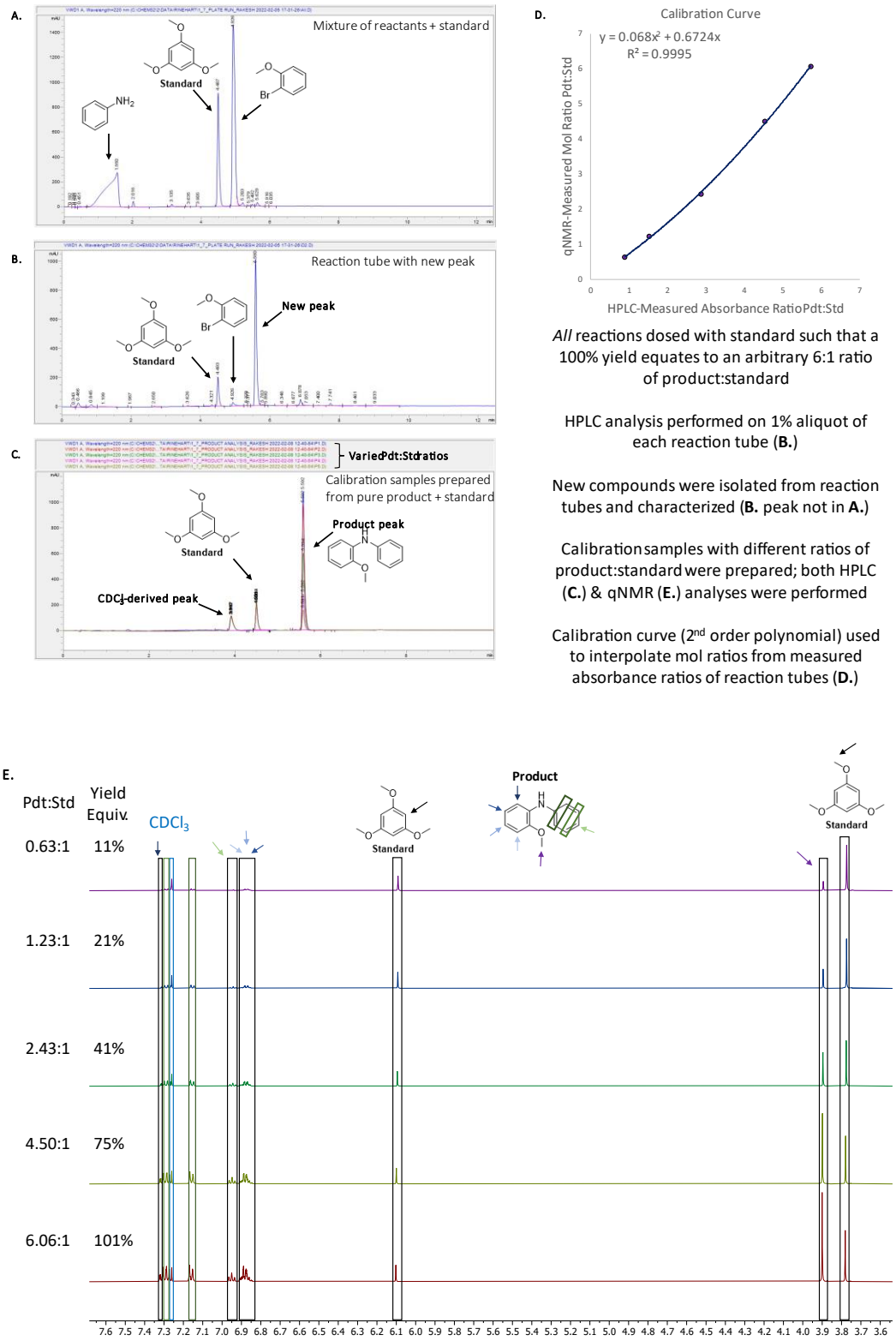
Reverse Phase HPLC (RP-HPLC) analysis was conducted using a single wavelength tunable UV detector set to 220 nm for most products. In several cases—when either: (i) a more linear relationship between absorbance and mol ratio was observed at another wavelength(*53*) or (ii) the extinction coefficient for product was so much higher than standard that product absorbance fell outside of the effective range of the detector (e.g. 50% yield and higher showed an absorbance plateau)—a new wavelength was used after inspecting the data collected at 220 nm. For all separations, an Agilent Poroshell 120 EC-C18 2.7 μm column (4.6 x 50 mm) was used. The typical method for analysis used acetonitrile, water, and 1% aqueous (w/w) tetrabutylammonium hydrogen sulfate (TBAHS) for gradient elution (starting ratio of 0:90:10 eluted for 30 s, then gradient to 90:0:10 over 6 min, then isocratic elution for 6 min) at a flow rate of 1.5 to 2.0 mL/min.

For new products, the RP-HPLC traces were inspected and compared to traces of pure starting materials to identify peaks corresponding to new components in any reaction mixtures. Figure S11.A-B illustrate this process for the coupling of aniline with 2-bromoanisole. In Figure S11.A, the RP-HPLC trace shows the retention times for each starting material and the standard. In S11.B, the RP-HPLC trace for a specific reaction tube from the 24-tube rack shows the near absence of both starting material peaks and the formation of a new peak. Since this instrument is not an LC-MS, there is no structural information, and this result is only a qualitative indicator that something new formed. For each new peak (often multiple products from protodebromination or constitutional isomers formed), the reaction tubes enriched in those species were noted.

After determining which tubes contained new species, the reaction tubes showing that new peak in RP-HPLC analysis (which still contained the remaining 99% volume of the reaction mixture + internal standard) were worked up under basic aqueous conditions: 3x CH_2Cl_2 and 1:1 brine/1M NaOH extractions, drying with sodium sulfate, then filtration and concentration on a rotary evaporator to a crude residue. Crude NMR analysis and purification by silica gel column chromatography then either led to identification of product or ruled out product formation. If no product formed in the 24 reaction tubes, then authentic product was synthesized by other means if possible.

Pure samples of products were isolated and characterized for all except six products which appear to not be amenable to C-N coupling or facile synthesis by other means. The pure samples

of products obtained from silica gel chromatography and/or crystallization were used to create a calibration curve relating absorbance ratios of product and standard on the HPLC to mol fractions. Note that the standard stock solution delivers 0.083 mmol of standard, one sixth of the 0.5 mmol limiting reagent. Thus, a 6:1 product/standard mol ratio represents a 100% yield. To calibrate the RP-HPLC data, several vials were prepared with varying product/standard ratios which represented yields from ca. 5%-10% to ca. 100%-105%. These samples were prepared using a stock solution of standard in deuterated solvent and manually weighed quantities of >98% pure product. Both RP-HPLC data (Figure S11.C.) and qNMR data (Figure S11.E.) were collected for each vial, enabling a second-order fit function relating qNMR-measured mol ratios to RP-HPLC-measured absorbance ratios (Figure S11.D.). This fit function was then used to interpolate yields for the RP-HPLC traces of the 24 reaction tubes. All qNMR measurements were done carefully with non-overlapping peaks which varied by structure. In all cases, 1,3,5-trimethoxybenzene was the standard because it had at least one peak which did not overlap with a product resonance.



All reactions dosed with standard such that a 100% yield equates to an arbitrary 6:1 ratio of product:standard

HPLC analysis performed on 1% aliquot of each reaction tube (**B.**)

New compounds were isolated from reaction tubes and characterized (**B.** peak not in **A.**)

Calibration samples with different ratios of product:standard were prepared; both HPLC (**C.**) & qNMR (**E.**) analyses were performed

Calibration curve (2nd order polynomial) used to interpolate mol ratios from measured absorbance ratios of reaction tubes (**D.**)

Figure S11. Procedure for calibrating measured HPLC absorbance ratios to yields.

After interpreting the RP-HPLC traces from all 24 reaction tubes, the yield data was tabulated and added to the database. Figure S12 shows the data for the example coupling described above. These data accurately reflect the sparsity of data for each reactant pair (only 24 out of 180 possible conditions are evaluated for most reactant pairs explored in the dataset), as well as the prioritized sampling of precatalysts (19/20 were evaluated, and only 3 catalysts were evaluated with more than one solvent/base combination). This strategy ensured that models learned trends in reactant reactivity related to catalyst structures while limited to running only 24 reactions per reactant pair.

		1 (JohnPhos)	**2** (XPhos)	**3** (Ph-DavePhos)	**4** (CPhos-Hybrid)	**5** (Et-CPhos)	**6** (Ph-SPhos)	**7** (RockPhos)	**8** (Ad-BrettPhos)	**9** (Me_4-^{t}Bu-XPhos)	**10** (Ad-BippyPhos)	**11** (CX PCy)	**12** (CX PInCy)	**13** (CX POMeCy)	**14** (AlPhos)	**16** (BrettPhos)	**17** (CPhos)	**18** (CyJohnPhos)	**19** (JackiePhos)	**20** (RuPhos)	**21** (SPhos)
	a) K_2CO_3												87%								
1,4 dioxane (1)	b) NaO^tBu	84%		30%								84%		74%			78%				42%
	c) DBU																				4%
	a) K_2CO_3					1%		82%	79%	82%											
tAmOH (2)	b) NaO^tBu		75%								79%				90%		84%			79%	
	c) DBU																				
	a) K_2CO_3				78%		14%									78%			13%		
PhMe (3)	b) NaO^tBu													82%			69%				72%
	c) DBU																				

Figure S12. Measured reaction yields by qNMR-calibrated HPLC traces.

Experimental Reproducibility of Testing/Setup

Reproducible yields were crucial to this work, and the primary challenge to this was reproducible dosing of reaction components. The precatalysts used in this work were dosed manually as solids to enable the use of multiple solvents without using multiple stock solutions, thus the need for accurate dosing of precatalysts using analytical balances (± 0.05 mg) determined the scale of the reactions. Reproducible data was obtained at the 0.5 mmol scale, where precatalyst quantities were between ~6.5 and ~12.0 mg. Reactions were run at 0.25 molar (2 mL volume). Working with 2 mL reaction volumes ensured reproducible heating and agitation of heterogeneous reactions. This scale also minimized changes in reagent quality based on sampling. For example, hygroscopic bases tend to clump and form a solid mixture with inhomogeneous hydration. Reaction yields were systematically lower when dosing clumped solid versus dry powder from the

same (old) bottle of NaO*t*-Bu into otherwise identical reaction conditions. After this observation, NaO*t*-Bu was used from fresh commercial bottles or after sublimation and was stored exclusively in a glovebox. In addition to ensuring the veracity and reproducibility of the data generated in this work, the other advantage of working on this scale was the ability to isolate preparative quantities of product standards from reaction tubes, instead of independently synthesizing them beforehand.

After determining the scale of reactions, several control variables were tested to establish their effect on reproducibility. The experimental variables tested for reproducibility were: (1) temperature homogeneity across positions of the tube rack under heating, (2) stirring consistency across positions in the reactor body and stir bar size, (3) the order of addition of reagents, and (4) repeat experiments of the same reactions with different experimentalists to test consistency and robustness of the experimental procedure.

The consistency of heating was measured using water and heating the apparatus to 70 °C. This test showed that the temperature in every tube position was identical (±1 °C) and consistent. To test if the position in the reactor body could affect the relative stirring of different tubes, four conditions were evaluated with the same chemical reaction using heterogeneous bases and different stir bar sizes. Each condition (base/solvent/stir bar size) was evaluated three times at randomized positions across the tube rack, and the resulting yields were compared for consistency. The reactions using the homogeneous base DBU showed zero yields, which were less informative. The reactions using the heterogeneous base K_2CO_3 showed reproducible yields for each size stir bar and across both sizes of stir bar. This was true in both 1,4-dioxane and toluene (the two solvents evaluated with this base). This suggests that the *size* of the stir bar had little effect on the reaction yields. Unsurprisingly, lack of stirring negatively impacted yield with heterogeneous bases.

The order of addition of reagents was tested using a model reaction (Figure S13). In this reaction, various sequences of reagent addition were tested, and notably both reactants were solids. The variability in yield was narrow (48-56%, mean 51% ± 2.5%). This suggested that reactions with two solid reactants are robust to changing order of addition. Solvent and base were always added after moving the apparatus to the glovebox in this test, and thus this was always followed. To ensure that solid bases charged into reaction tubes were not stuck on the inside walls of the reaction tubes, solvent was added last for reactions with solid bases. In other reactions using oils as reactants, if the precatalyst and that reactant were mixed before adding solvent, then often a

color change (we suspected catalyst activation) was observed, so this was avoided (*vide infra*). As a result, liquid reactants were added only after the bulk solvent was added (or low-melting/hygroscopic reactants were added with solvent as a stock solution) so that the precatalyst did not encounter neat liquid reactants. This decision was based on reasoning that catalyst death or early activation may be problematic for some of these reactions, and that would negatively impact the dataset. Reproducing a plate for the coupling of 1-bromonaphthalene and 4-methoxyaniline where 1-bromonaphthalene was added to precatalyst (neat), then base, then solvent showed a noticeable difference in yields (18% vs 36% average yield for 24 conditions). The same observation was made with the reaction of indole and 2-bromothiophene, where the average yield for the 24 conditions went from 5.8% to 12.5% by adding the oily electrophile to the reactions after solvent.

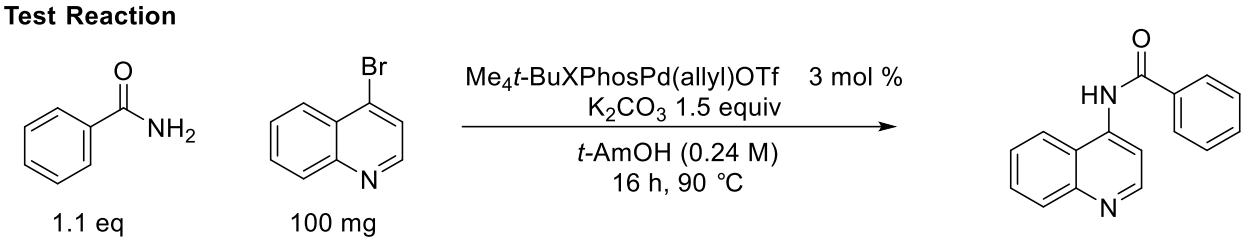


Figure S13. Order of addition test.

Multiple experimentalists contributed to this dataset. Before a new experimentalist's results were added to the dataset, they had to repeat 1-2 separate plates until their results matched the results obtained by the prior experimentalist. This ensured that a continuity of experimental practice was maintained over the lifetime of this project. The mean absolute deviation between two sets of experiments scales with the number of non-zero yielding tubes. Empirically, zero-yielding reactions are easy to reproduce compared to measured yields between 1-100%.

When one experimentalist reproduced their work across several couplings, the average experimental variation (AEV) between multiple iterations of the same 24 conditions showed small variations (Figure S14). These AEVs were generally lower than those between experimentalists.

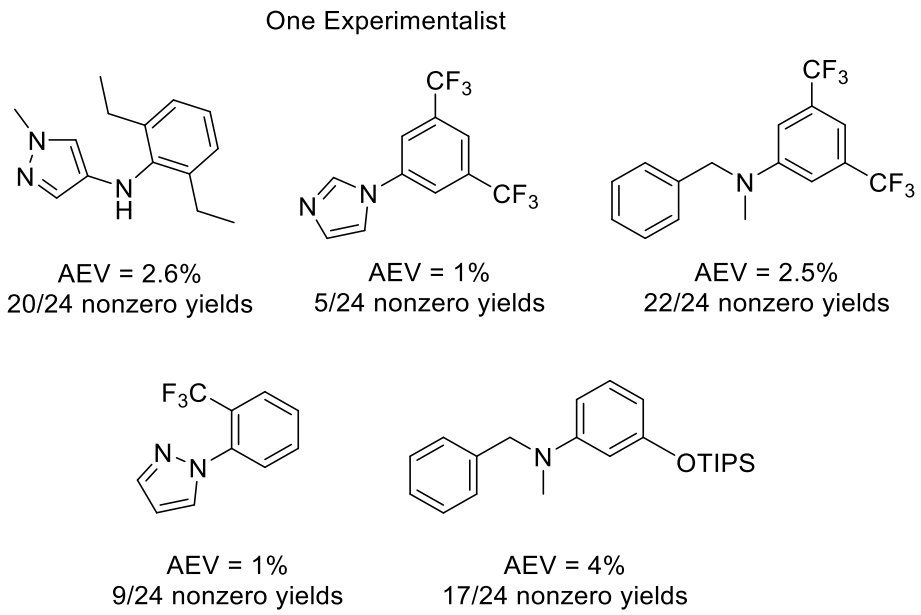


Figure S14. Average experimental variations (AEVs) when a single experimentalist repeated their work.

When new experimentalists repeated the work of other experimentalists to establish consistency of technique, AEVs were obtained. These were related to the number of nonzero conditions in a set of experiments as well as: (1) different analytical equipment (between facilities in Basel and Urbana), (2) different reagent suppliers and bottles (both from regional supply chain differences and temporal changes to reagents). These results are summarized in Figure S15, which shows five examples which were repeated by two (in one case three) separate experimentalists. The deviations varied from ca. 2.5% to 9%. The example showing 9% deviation may have been exacerbated by an instrument repair between runs (new lamp for detector) and is considered an extreme case.

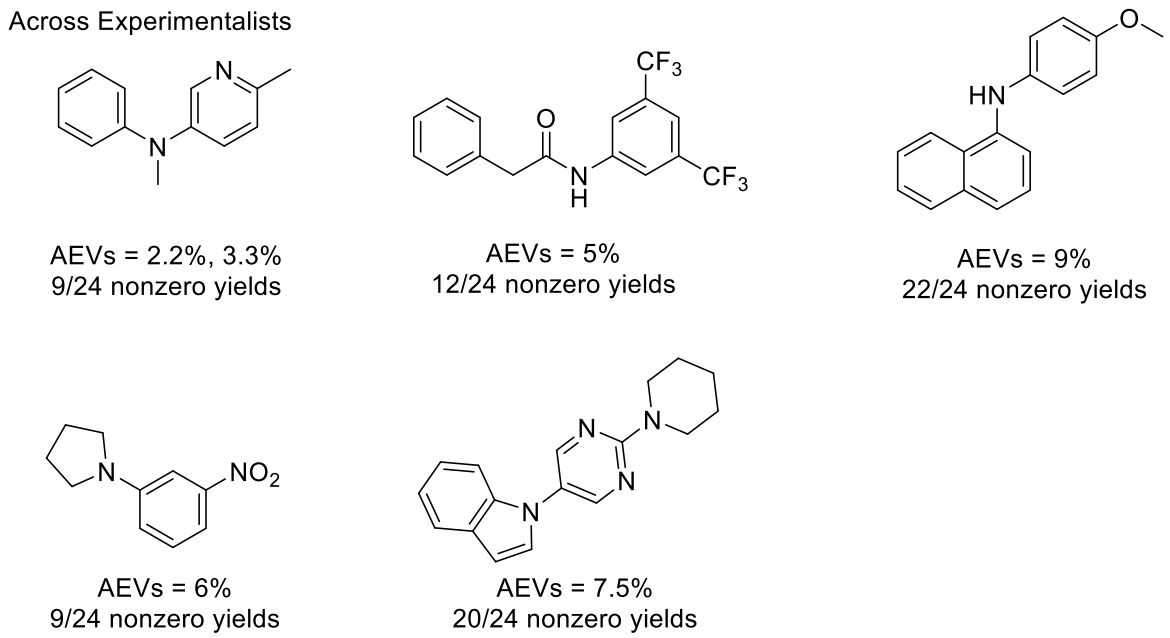


Figure S15. Average experimental variation when experimentalists repeated another's work.

The conclusions from these experiments were that: (1) order of addition for solid reactants is not critical but liquid reactants should be added last, (2) experimental variability for one experimentalist is generally <5%, but variation among experimentalists (owing to uncontrolled factors) is ca. 5-6%. Reactants were purified before use and stored under a dry, inert atmosphere between uses to minimize differences between reagent sources.

Transferability to Culture Tubes

To remove any reliance on the Greenhouse™ reactor setup, we evaluated various experimental setups for reproducibility compared to results obtained in the Greenhouse. ™ Running reactions in flat-bottomed 20 mL scintillation vials affected the reaction yields significantly. The best consistency was observed using screw-top glass culture tubes (16 mm x 125 mm) using Teflon stir bars (15 mm x 4.5 mm, with pivot ring), Teflon-taped threads, and screw caps from Chemglass used for 2-dram vials (green polypropylene cap with TFE septum). See Figure S16 for an image. The vessel shape closely mimicked the reaction tubes, and the Teflon tape improved the longevity of the static anaerobic atmosphere when these reaction vials were prepared in an inert atmosphere glovebox. The culture tubes can be heated in an oil bath or a metal heating block maintained at 90 °C to provide comparable yields to those obtained in the Greenhouse. ™

Figure S16. Reaction setup using common threaded glass culture tube.

To demonstrate this, the coupling of piperidine with 3-bromo-5-methylpyridine (Figure S17) was experimentally evaluated in the culture tube setup using four separate conditions which furnished yields ranging from ca. 30% to 90% in the Greenhouse™ reactor by one experimentalist. For this experiment, Table S1 lists the conditions, predicted/observed yields, and layout of the 12 tubes used by a different experimentalist. These data indicate that across these conditions, the average yield discrepancy was 6% between the two different experimental apparatus. This value is within the range of experimental error demonstrated by our reproducibility experiments across experimentalists (*vide supra*), thus demonstrating consistent experimental conditions between the two systems.

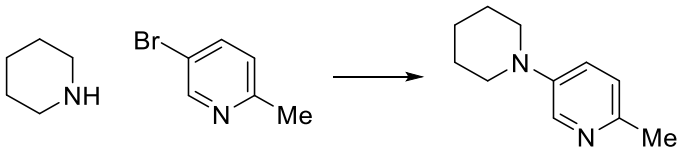


Figure S17. Coupling used to compare yields from culture tube setup and Greenhouse™ reactor.

Evaluated Conditions

Catalyst, Solvent, Base	Predicted Yield (%)	Observed Yield (%)	Label
20, 1, b	87	91	1
5, 1, b	80	71	2
2, 1, b	77	60	3
6, 1, b	59	33	4

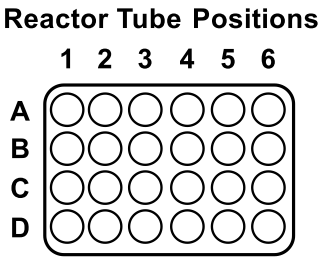


Plate Layout

	1	2	3	4	5	6
A	-	-	-	-	-	-
B	4	2	2	2	3	1
C	1	4	3	4	*	1
D	-	-	-	-	-	-

Yields (%)

	1	2	3	4	5	6
B	26	78	78	78	62	100
C	100	26	59	25	0	96

AEVs (%)

	1	2	3	4	5	6
B	7	7	6	6	2	9
C	9	7	1	8	0	4

Table S1. Reaction conditions, plate layout, yields, and AEVs for the test reactions evaluating Greenhouse™ and culture tube yield consistencies. *No catalyst used as an S_NAr control.

Experimental Validation Procedure

The validation experiments described in this work include data which was obtained using the standard Greenhouse™ procedure (couplings **d, g, i, j**, and **k** from Figure 6), and data which was obtained using culture tubes (couplings **a, b, c, e, f, h, l,** and **m** from Figure 6). A new analytical procedure was developed to ensure that the yields obtained using culture tubes were accurate without using an HPLC and calibration curve.

Experimental setup using culture tubes was similar to the setup using the Greenhouse: ™ order of addition for reagents, transfer to the glovebox with loose caps, then charging of remaining materials inside the glovebox. For culture tube reactions, Teflon tape was applied to their threads before sealing them inside the glovebox. Then, the tubes were brought out and stirred/heated for the same amount of time as a Greenhouse. ™ At the end of the reaction, standard was added as a stock solution, and the mixtures were then filtered through a pad of celite to remove heterogeneous material. Subsequently, a 1-mL aliquot of the solid-free filtrate was filtered through a Silacycle Si-Thiol (MetS) cartridge (1 mL tube pre-packed with 50 mg of functionalized silica and conditioned with 0.5 mL of acetonitrile) using gravity elution. This cartridge was used to remove homogeneous Pd species before the next step. After mechanical filtration and Pd scavenging as described above, the treated filtrate was then transferred to a parallel evaporation setup and evaporated under vacuum (1-5 Torr) with heating (35 then 50 °C). This procedure removed bulk solvent, but detectable quantities of reaction solvent did remain in samples. These quantities were small enough, however, to minimize solvent signals and enable effective ^{1}H qNMR on the concentrated residues after they were dissolved in an appropriate deuterated solvent. The procedure for acquiring ^{1}H qNMR was identical to the procedure for calibration curves (*vide supra*). Yields were calculated from measured standard and product peak integrations *for each reaction tube*, and the chemical shifts used for analysis were confirmed by ^{1}H NMR of products purified by silica gel chromatography and/or crystallization.

Workflow Development

Reactant combinations were selected by using the chemical space defined by only reactant descriptors. These comprised of the first incarnation of the RDF descriptor, which included steric, Highest Occupied Molecular Orbital, or HOMO, (coefficients for each atom), and Lowest Unoccupied Molecular Orbital, or LUMO, (coefficients for each atom) spherical RDFs for each reactant. Amine and bromide RDFs were concatenated for each of the 2,500 combinations (50 amines X 50 bromides) to make a 1-D vector representation of each of the 2,500 reactant combinations. This high-dimensional vector was reduced using Principal Component Analysis (PCA) to a lower-dimensional representation maintaining 86% explained variance (this was arbitrary), which was the first 14 principal components. Then, using unsupervised *k*-means clustering, all reactant pairs were partitioned into 23 clusters, which correspond to a number of desired initial coupling products and the clusters were qualitatively validated using the elbow method. Each cluster's centroid (a 1-D vector representing the position of its center) was used to select the closest reactant combination to that centroid (based on Euclidean distance), which served as a representative of that region of reactant pair space. The resulting 23 reactant combinations from this procedure are shown in Table S2. These reactant combinations represented a maximally diverse subset of combinations from the 2,500 possible combinations of reactants. Note: later, after further development of the new chemical descriptors, the reaction space changed because the descriptors changed. Qualitatively, the selection presented here is still diverse, the procedure used here was simply aimed at a reproducible selection.

Table S2. Diverse reactant pairs and their products selected to begin experimental efforts.

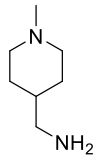
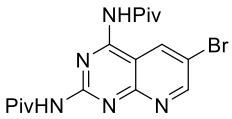
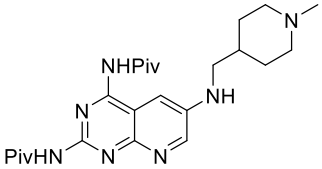
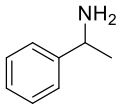
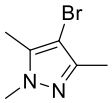
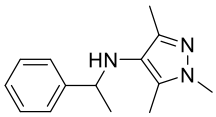
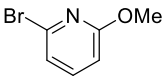
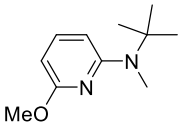
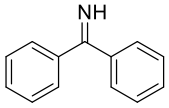
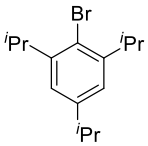
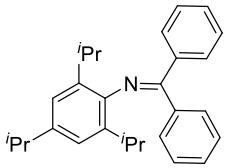
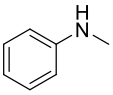
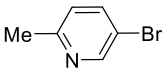
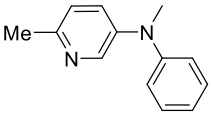
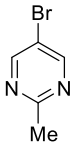
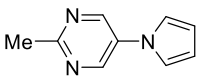
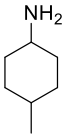
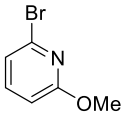
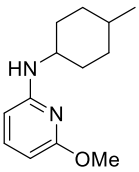
Amine	Bromide	Product
 **32**	 **25**	 **32_25**
 **34**	 **9**	 **34_9**
50	 **41**	 **50_41**
 **23**	 **1**	 **23_1**
 **6**	 **18**	 **6_18**
17	 **17**	 **17_17**
 **36**	 **41**	 **36_41**

Table S2. Diverse reactant pairs and their products selected to begin experimental efforts (continued).

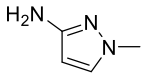
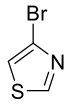
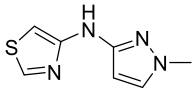
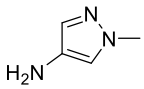
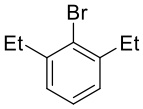
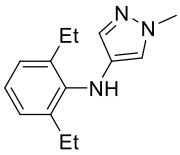
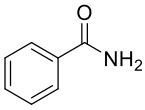
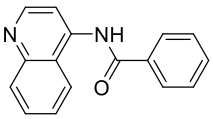
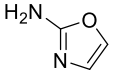
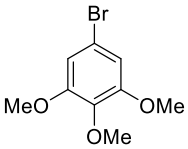
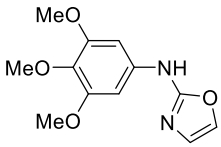
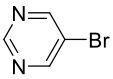
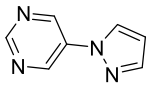
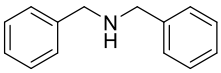
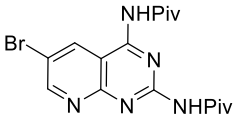
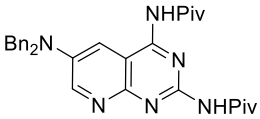
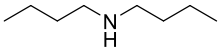
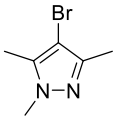
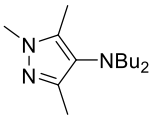
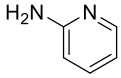
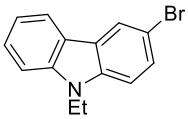
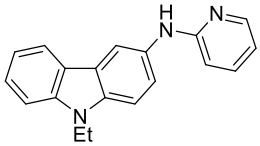
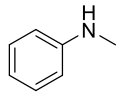
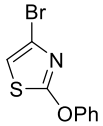
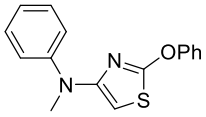
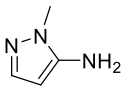
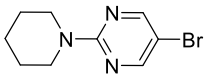
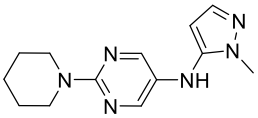
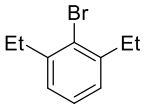
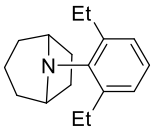
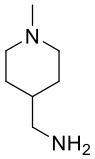
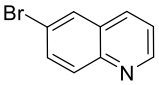
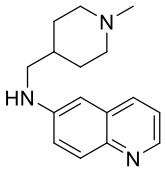
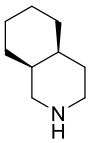
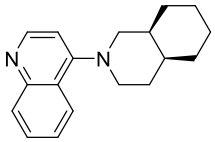
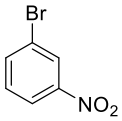
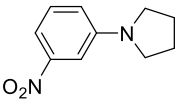
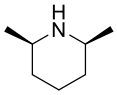
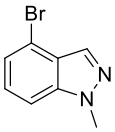
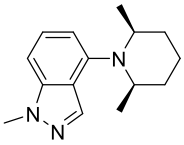
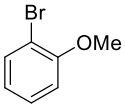
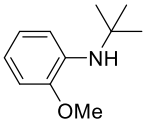
 **16**	 **20**	 **16_20**
 **12**	 **10**	 **12_10**
 **8**	**30**	 **8_30**
 **26**	 **23**	 **26_23**
21	 **24**	 **21_24**
 **49**	 **25**	 **49_25**
 **47**	 **9**	 **47_9**
 **11**	 **33**	 **11_33**

Table S2. Diverse reactant pairs and their products selected to begin experimental efforts (continued).

 **6**	 **38**	 **6_38**
 **14**	 **27**	 **14_27**
42	 **10**	 **42_10**
 **32**	 **26**	 **32_26**
 **45**	**30**	 **45_30**
44	 **13**	 **44_13**
 **40**	 **12**	 **40_12**
37	 **7**	 **37_7**

Initial Dataset from First 23 Plates

The first 552 experiments had 63% zero-yield reactions. 74% of the data was less than 5% yield, and 82% was less than 20% yield. The identity and combination of substrate, catalyst, bromide, solvent, and base were all important in determining yield on a case-by-case basis. From an extensive statistical metanalysis it became clear that on/off reactivity as a result of changing any of these variables was common, though catalyst identity was particularly important. More than one substrate combination gave zero yields under *all* conditions attempted. Chart S1 shows a histogram of these data organized into 5% yield bins.

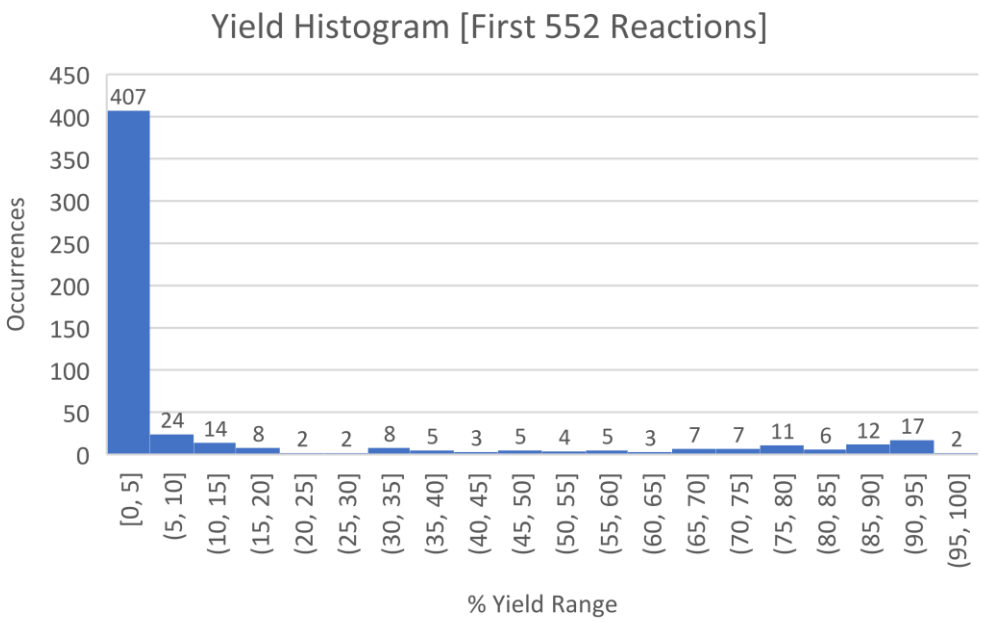


Chart S1. Yield histogram for first stage of data acquisition.

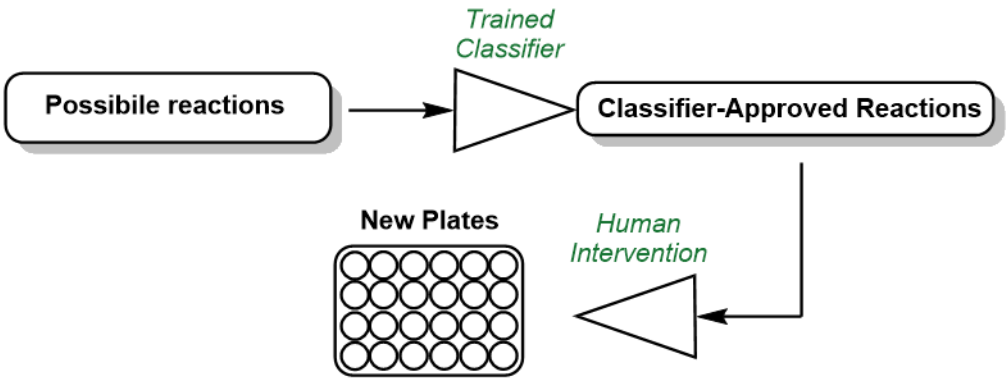
Limitations of the Initial dataset

First, the reactions with all zero-yield instances presents a problem: no model can learn if either amine or bromide structural features caused a zero yield when the reactants are not used again in another reactant pair. This observation led to the realization that predicting reaction yields for a coupling with the goal of generalization with respect to both reactants is a network problem. Second, the bias towards zero-yielding reactions is the most significant limitation to this dataset. Regression modeling failed, and we hypothesized that this arose from the lack of higher-yielding reactions.

Dataset Expansion using Models

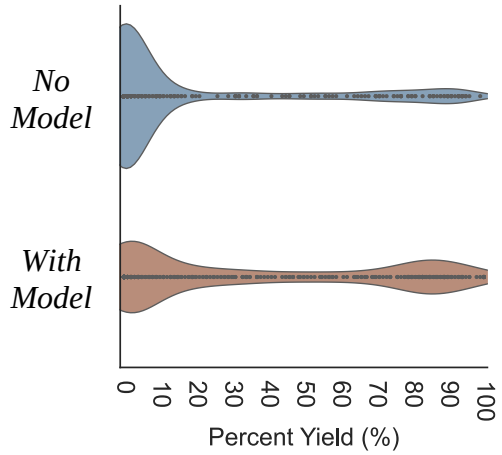
With the intention of covering as broad a scope of reaction space as possible, it became clear that regression modeling would require fewer zero-yield reactions for any meaningful trends between the reaction space and yield could be identified. New experiments were selected to expand the initial dataset with fewer zero-yielding experiments. By collecting more non-zero data, we hypothesized that the dataset could be augmented to enable regression modeling.

Scheme S1 depicts the generalized strategy for selecting subsequent reactions. To test this strategy, 18 reactant pairs from the 23 initially selected were experimentally evaluated with 24 *new conditions* which ought to provide non-zero yields. Those 18 reactant pairs were selected because five couplings were not judged possible: that data is still important for teaching models what is not possible, but not valuable for further experiments designed to gather more nonzero data. Using the initial dataset, binary classification models were trained to classify zero and non-zero yielding reactions (87% validation set accuracy). Then, one such classifier was used to predict the outcome of all conditions not previously evaluated for the 18 reactant pairs (156 conditions out of the 180 possible). From those predictions, 24 new conditions were selected which were predicted to provide non-zero yields by the classifier.



Scheme S1. Strategy for selecting fewer zero-yielding reactions.

The results of this intervention are summarized in Figure S18, which depicts a violin plot for the initial subset of 432 experiments (the original data for just the 18 reactant pairs which were re-evaluated using the classifier) and the new data (designed with the help of a binary classifier) gathered for the same 18 reactant pairs with different conditions. The result is a distribution of data far less skewed towards zero yield. However, the fundamental limitation of reactant generalization was only solved by the workflow and enriching the network connectivity of the dataset.



Before/After ML	***% of Data with 0% Yield***	***% of Data with >80% Yield***
No Model	**56**	**12**
With Classifier	**22**	**29**

Figure S18. Violin plots of initial yields for 18 reactant pairs using systematically varied conditions and new conditions selected with a binary classifier model.

Selecting New Reactant Pairs using the Reaction Space

After tabulating the data acquired thus far in the context of combinations of amine and bromide clusters, all possible combinations of amine and bromide clusters (see representation of subspaces in Figure S5) were first filtered to exclude single-member clusters, then sorted on the basis of their percent coverage, then the overall size of that subspace. This analysis effectively identified the largest and least-occupied subspaces, which made the selection and prioritization of new reactions to run facile.

To simplify this process, initially, these new products consisted of combinations of the exemplar for each cluster and one “backup” structure. From the dyad of possible products (two amines and two bromides), two were selected. This strategy was selected to balance the benefits of increasing the number of new products and the exploration of underrepresented regions of space with the necessity to acquire more non-zero-yield data and to use available, already-sampled

reactants. For some reactant clusters, differences in reactivity were more pronounced within the cluster. In those cases, on an as-needed basis, extra reactions were evaluated. One example of this is the cluster including indole and N-methyl aniline: from the descriptors, it is clear why those are clustered together. However, their reactivity are quite different, and we used expert knowledge to make the judgment that more couplings of each type should be evaluated.

We were able to train and validate multiclass classification models with top-1 errors near 60% and top-2 errors near 75% accuracy. These were predicting reactions to fall into six classes: zero yield, and quintiles of non-zero yield results (1-20%, 21-40% … see Figure S19). This modeling strategy was highly dependent on the dataset partitioning (*vida supra*), but a baseline model which showed good performance was eventually trained and used to predict all proposed new reactions. As multiclass classification modeling improved, error metrics were used to guide the selection of subspaces to explore. Eventually, smaller clusters, including single-member clusters, were explored, in addition to the inclusion of non-exemplar/backup reactants in larger clusters. Regression modeling was eventually integrated into the workflow after enough data had been gathered.

Design of Plates for New Reactant Pairs

Plates were designed to primarily explore catalyst/reactant pair combinations, then solvent/base combinations based on the early observation of the importance of ligand on the reaction outcome on a reactant-by-reactant basis. Figure S19 illustrates this process using a multiclass classification model, which ranks conditions into yield quintiles (as well as zero yield). The most important selection criterion was to explore most catalysts (at least 16/20, but often all 20). Less important (but still a consideration) was the predicted yield distribution of the plate. The goal was to provide a distribution of yields across the yield range when possible, and not bias towards all high-yielding or all low-yielding conditions.

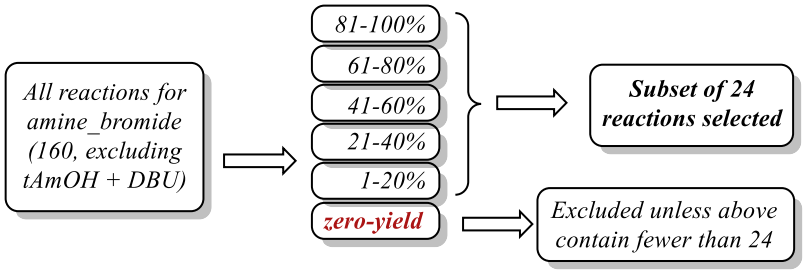


Figure S19. Procedure for mapping 24-tube plates.

Solvent/base combinations for each catalyst were varied systematically to provide yields spanning the range of 1-100%. For particularly difficult couplings where most conditions were predicted to give zero yield, every catalyst was evaluated, and solvent/base combinations were systematically varied across the inorganic bases for each catalyst. It is significant that a model bias against predicting high yields with DBU was observed, and the inorganic bases ended up getting used more. That observation, combined with the interest in obtaining more non-zero yielding data, resulted in the dataset being heavily biased towards the inorganic bases. This bias qualitatively reflects the chemical literature (and expert knowledge of Buchwald-Hartwig couplings), and Figure S20 shows the distribution of experiments across each solvent/base combination. The first three columns describe the three solvents (1,4-dioxane, *t*-AmOH, and toluene) with potassium carbonate. The second set of three columns describes the same solvents with sodium *tert*-butoxide. The final set of columns describes those same solvents with DBU. A complementary visualization of this data is depicted in Figure S21, which uses radar plots to show the relative fraction of the dataset that each catalyst (different angles) represents for a given base (different plots) or solvent (line colors). Note that the ordering of catalysts is based on their numerical designation and does not hold any chemical significance.

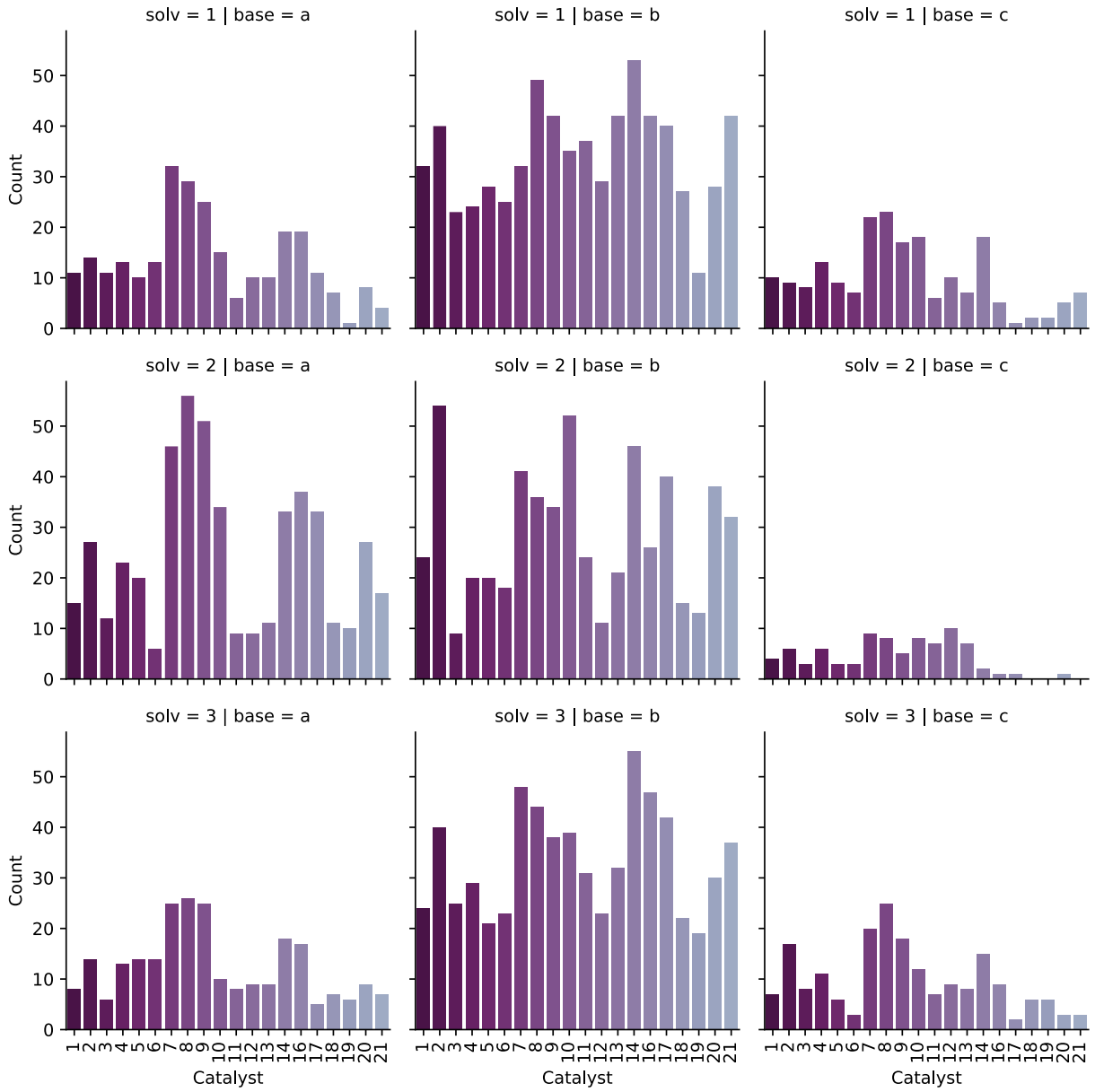


Figure S20. Experiments per catalyst for each solvent/base combination.

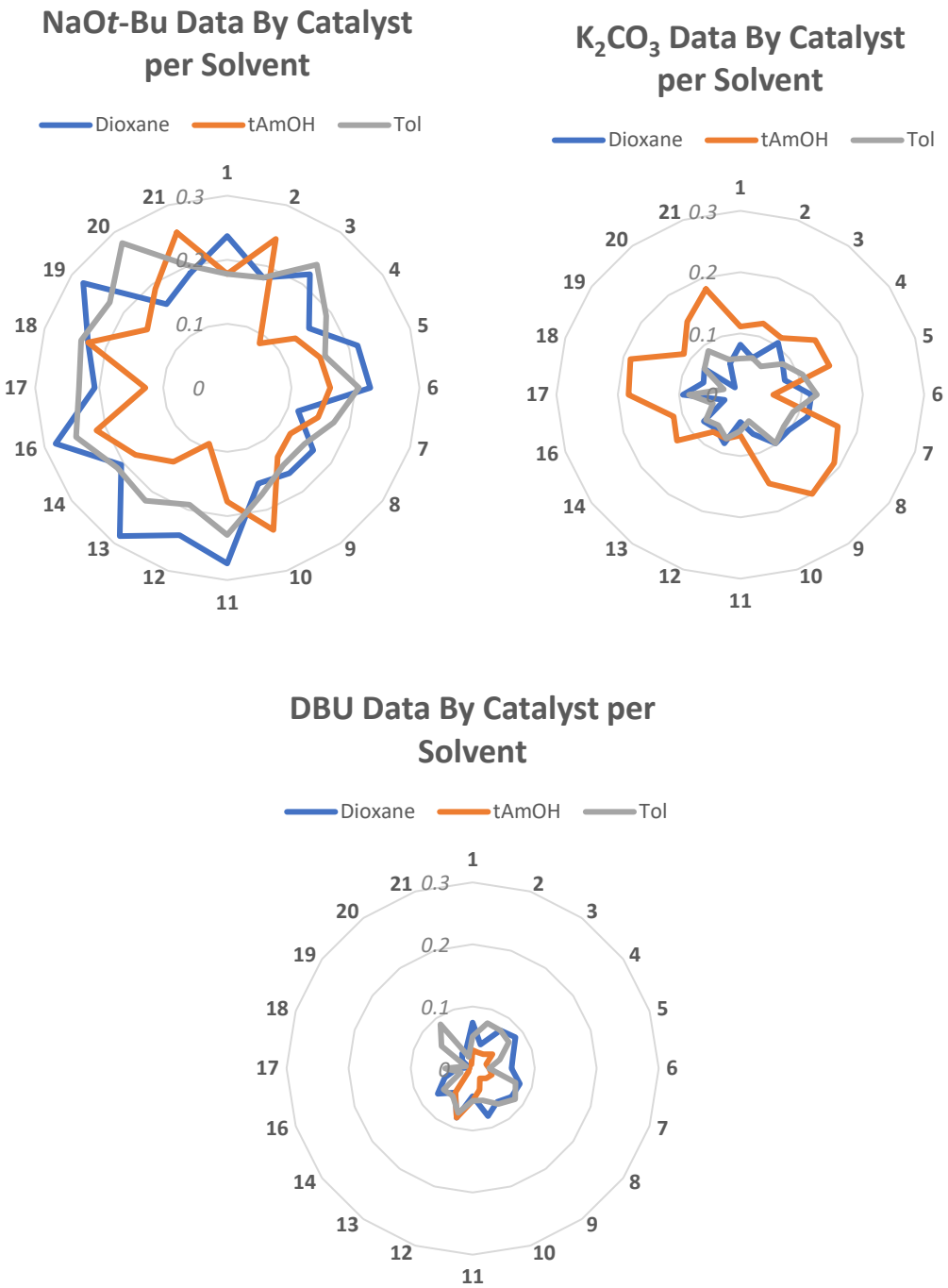


Figure S21. Fraction of experiments with each base and solvent. Radii represent the fraction (e.g. 0.1 = 10%) of data and the radial position represents each precatalyst.

Progression of Modeling

Figure S22 describes the relationship between model performance and dataset expansion guided by the workflow in Figure 4 of the manuscript. In panel A, three small representations of the dataset (otherwise identical to that in Figure 5A) show the progress of data acquisition at three distinct timepoints and should be used as a visual pattern. These timepoints are arbitrary and were selected for illustration purposes. New data for each step are shown in dark green, and the data from the previous iterations are shown in light green. Panel C contains regression models from the same chronological datasets in A. Finally, in the center, panel B describes theree phases of model performance in terms of the observable behavior. This is equivalent to the experimentalist's interpretation (step 8) in the workflow from Figure 4 in the manuscript.

In the first horizontal row, panel B describes on/off reactivity patterns as difficult for the models. This is emphasized by the red boxed region of the regression plot in panel C: many high-predicted conditions were zero yielding and *vice versa*. The dataset for this model includes the first set of 23 reactant pairs, including the augmented set enriched with nonzero data. Few additional combinations of reactants were tested, so reactant level trends were not learned. We distinguish that pathological stochastic error from errors associated with models predicting yield trends (e.g. a slope of ~0.5 instead of ~1). Many of those stochastic errors were investigated, and the hypothesis about insufficient network connectivity of the dataset (shown in Figure 5B in the manuscript) was formulated.

In the second horizontal row, more reactant pairs were selected in concentrated regions of the reaction space using exemplars. That generally improved predictive power, and when enough combinations were explored with each type of reactant, the reactivity trends were more effectively learned. A reduced stochastic error rate and an improved overall R^2 and slope exemplified this. However, at this stage, dataset partitions played a significant role in model performance. That was interpreted as an indiciation of insufficient network connectivity between clusters of reactants. When particular reactant pairs, which did not have enough similar couplings present in the dataset, were partitioned into the test set, then models were not performant. In other partitions, "easier" couplings with multiple similar types of couplings were partitioned into the test sets, and models showed significantly higher performance. This instability to dataset partitioning pointed to an imbalance in representation of the BH reaction space domain.

Finally, in the last row, modeling had improved its stochastic error rate significantly, and in many cases made accurate predictions of yield. In some difficult cases (i.e. those described above), the models were predicting yield trends instead of failing as they were in the prior stage. The stability of dataset partitioning improved, suggesting that the interconnectivity of the dataset network was robust enough that the reaction space was well represented. Note that several subspaces are not represented at all: in a few cases, this was due to either the impossibility of such a coupling, the difficulty of accessing reactants synthetically (particularly in cases where they were similar to reactants already used in the dataset), or the perceived value of the couplings that those subspaces represent.

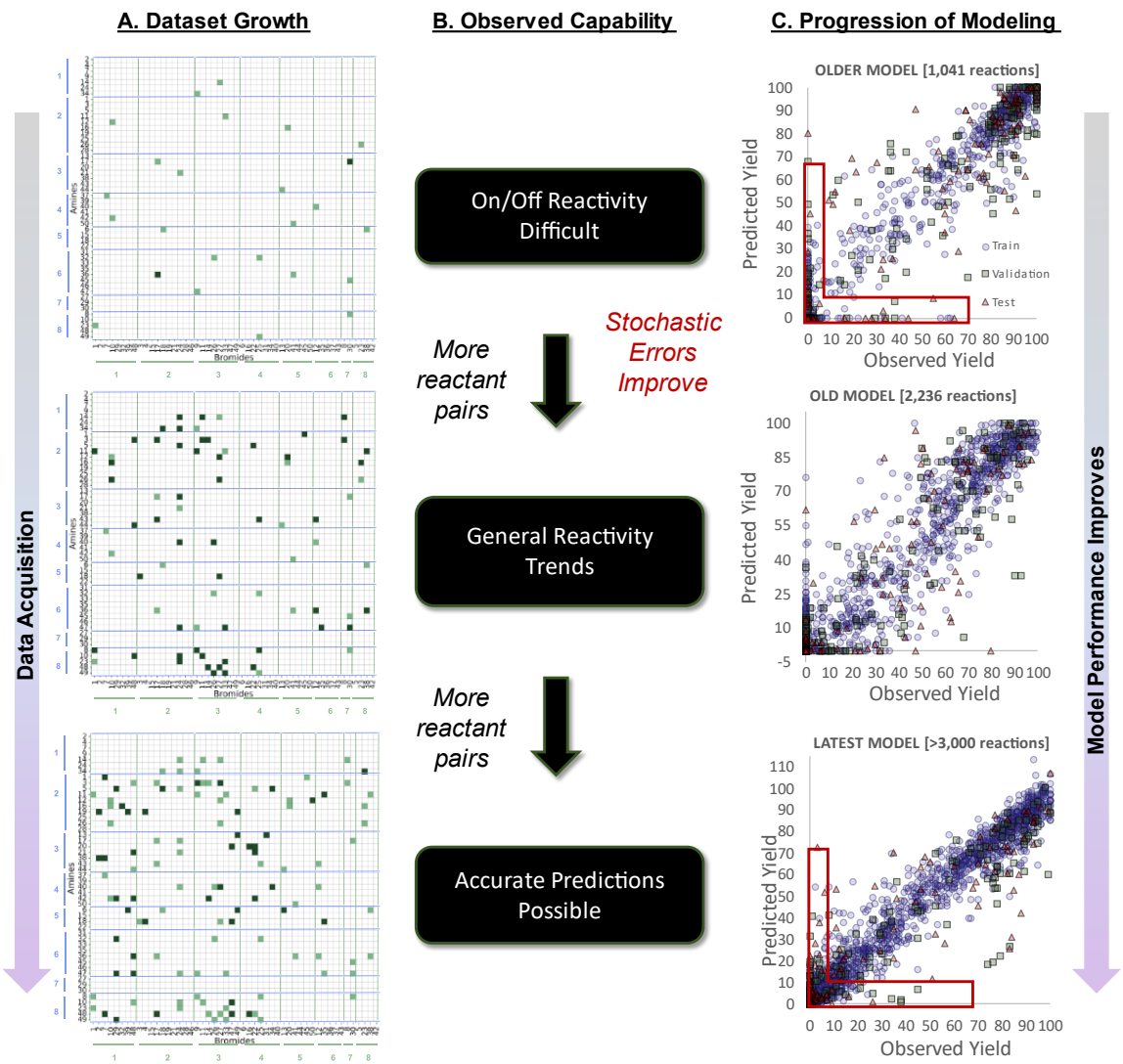


Figure S22. Prediction visualization shows relative sparsity of middle-yielding conditions. Progression of modeling during the experimental campaign showed reactivity cliff prediction improving.

Experimental Validation

The predictions used for experimental validation were generated using pre-tuned hypermodels trained on the 120 dataset coupling products while leaving these 13 experimental validation couplings out-of-sample. Using an ensemble of such models, predictions were averaged across these couplings. Conditions were selected as described in the manuscript. The experimental validation results in Figure 6 do not display linear regression fit statistics. Those statistics are instead displayed in Table S3. Consistent with the interpretation described in the manuscript, the statistics indicate a poor fit for both j and m, and generally better fits for **a-g**. Chart S2 displays all predicted vs observed plots *except* for products **h** and **l**, whose yields were expected and observed to be clustered around zero—making a linear fit an unreasonable method to interpret the results. Table S4 contains the data in the plots from Chart S2, including reaction handle (amine_bromide_catalyst_solvent_base), product number, predicted yield, and observed yield for each reaction. The data for **h** and **l** can be found there. In the case of **h**, all observed yields were close to the predicted yields. By contrast, **l** showed moderate yield predictions and low observed yields. Out of the rest of the couplings, a-c, e-f, h, and l-m, were tested with a small set of high and low-yielding predictions. For couplings d, g, i-k, a 24-tube plate was run.

Product	**Slope**	R^2	**Intercept**	***p*-value**	**MAE**	**RMSE**	**# exp.**	**Avg R^2**
a	0.32	0.930	1	7.E-06	26.7	38.5	10	
b	0.58	0.893	12	1.E-05	14.4	18.1	11	
c	0.43	0.912	3	5.E-06	25.2	34.5	11	
d	0.43	0.774	3	1.E-08	9.1	17.8	24	
e	0.48	0.745	-2	3.E-03	30.9	40.4	9	
f	0.95	0.805	1	1.E-03	4.2	7.1	9	
g	0.81	0.858	-1	8.E-11	12.5	16.2	24	0.845
i	0.34	0.699	3	4.E-07	31.0	38.4	24	
j	0.17	0.052	52	3.E-01	19.9	28.8	24	
k	0.43	0.401	38	9.E-04	20.4	27.5	24	
m	0.19	0.104	21	4.E-01	30.6	35.5	8	0.314
h	-	-	-	-	14.0	15.2	5	
l	-	-	-	-	56.5	56.9	4	

Table S3. Regression fit statistics for predicted vs observed yields of experimental validation experiments **a-m** (Figure 5). Note **h** and **l** were not fit to a line because the yields were all clustered and nearly zero—making a linear regression not meaningful.

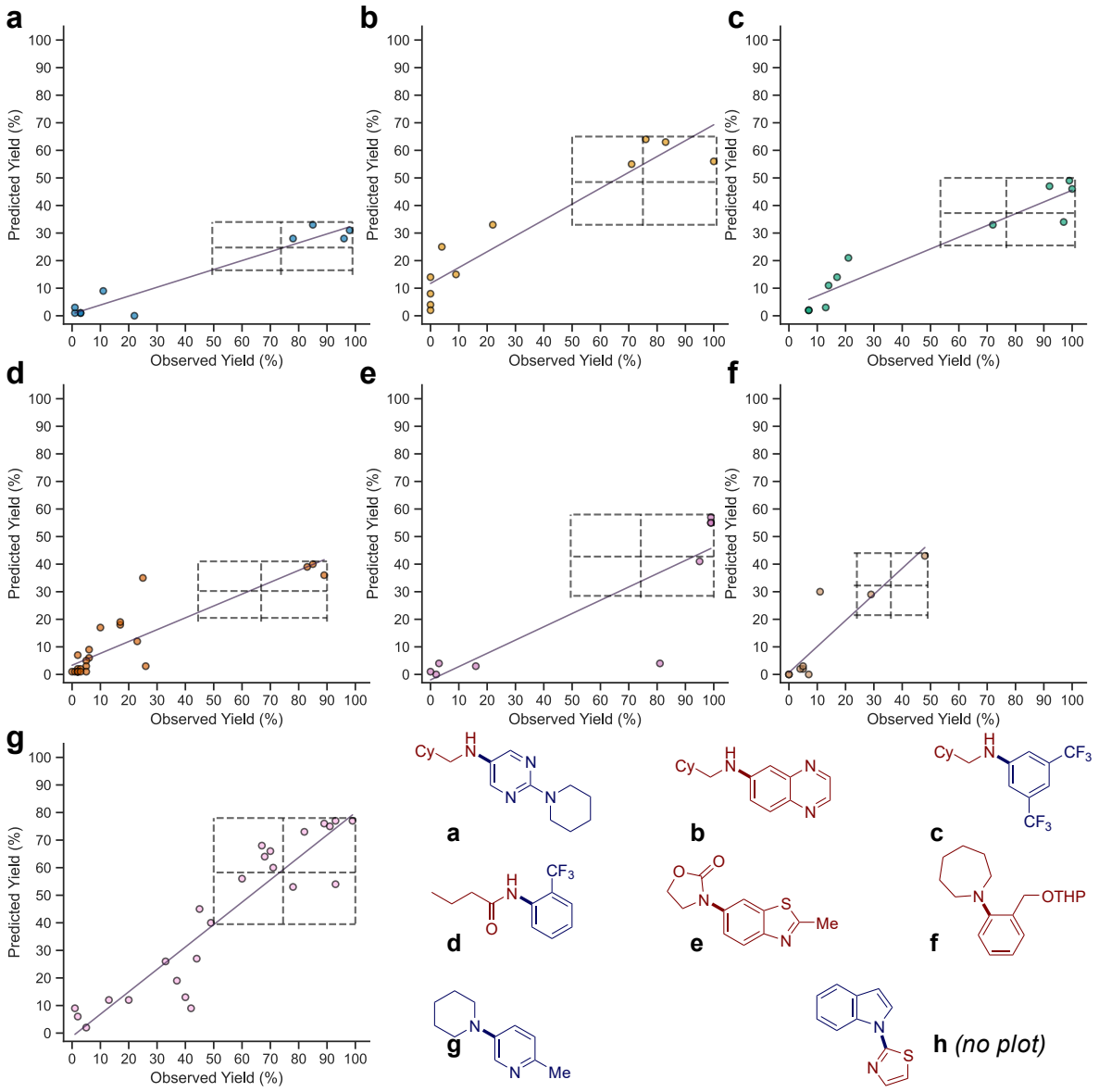


Chart S2.1 Array of predicted vs observed plots for experimental validation compounds which represent generalization and their corresponding structures.

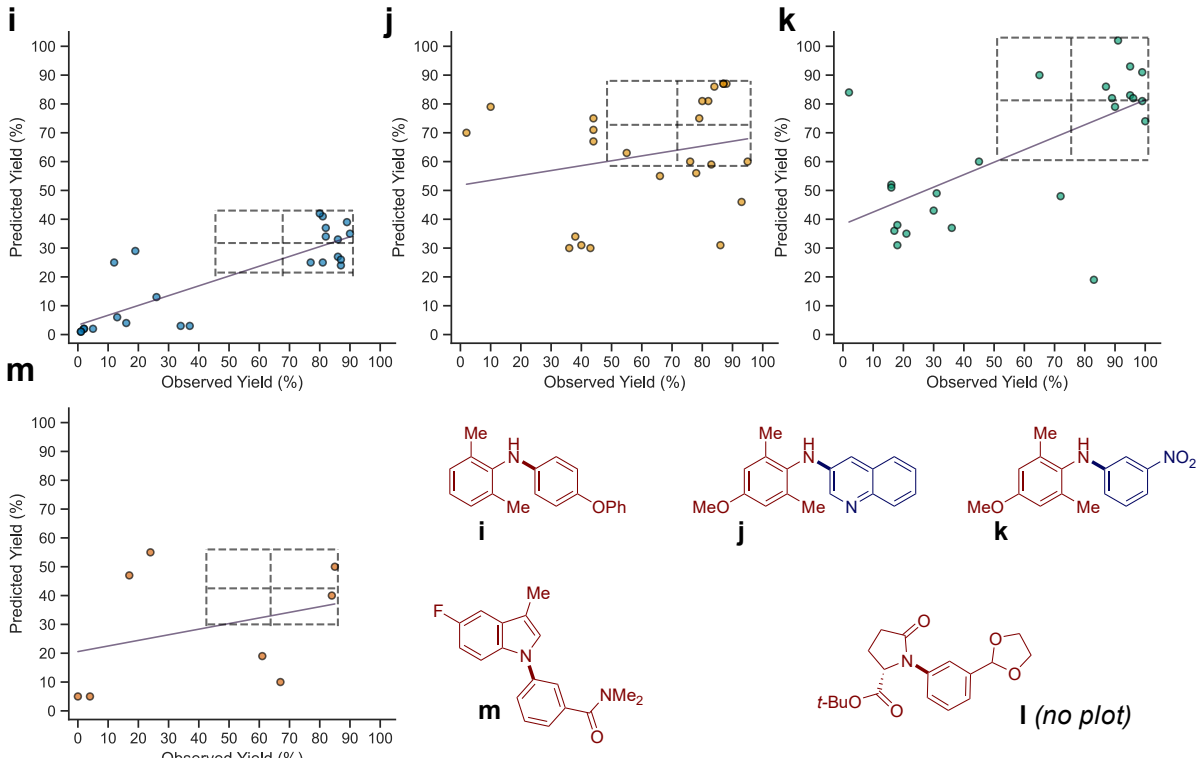


Chart S2.2 Array of predicted vs observed plots for experimental validation compounds which represent extrapolation and their corresponding structures.

Handle	Product	Observed	Predicted
1001_2003_18_3_c	**e**	2	0
1001_2003_19_1_a	**e**	81	4
1001_2003_3_2_a	**e**	0	1
1001_2003_4_3_a	**e**	16	3
1001_2003_6_2_a	**e**	3	4
1001_2003_7_2_a	**e**	99	55
1001_2003_8_1_c	**e**	95	41
1001_2003_8_2_a	**e**	99	57
1001_2003_9_2_a	**e**	99	55
1002_2002_19_2_b	**f**	29	29
1002_2002_20_2_b	**f**	11	30
1002_2002_4_2_b	**f**	48	43
1002_2002_7_2_a	**f**	7	0
1002_2002_7_2_b	**f**	5	3
1002_2002_8_2_a	**f**	0	0
1002_2002_8_2_b	**f**	5	2
1002_2002_9_2_a	**f**	0	0
1002_2002_9_2_b	**f**	4	2
1007_2004_17_1_a	**l**	8	59
1007_2004_17_2_a	**l**	17	67
1007_2004_20_1_a	**l**	1	59
1007_2004_20_2_a	**l**	1	68
1010_2001_17_2_a	**m**	85	50
1010_2001_17_2_b	**m**	84	40
1010_2001_20_2_a	**m**	24	55
1010_2001_21_2_b	**m**	17	47
1010_2001_4_2_b	**m**	4	5
1010_2001_6_2_b	**m**	0	5
1010_2001_7_1_b	**m**	67	10
1010_2001_7_2_b	**m**	61	19
18_19_14_2_a	**h**	0	11
18_19_14_2_b	**h**	25	17
18_19_14_3_a	**h**	0	9
18_19_7_2_a	**h**	0	23
18_19_9_2_a	**h**	0	19

Table S4.1. Experimental validation data.

Handle	Product	Observed	Predicted
2_6_1_1_b	**i**	86	27
2_6_10_1_a	**i**	34	3
2_6_11_1_a	**i**	5	2
2_6_12_1_b	**i**	81	25
2_6_13_1_b	**i**	90	35
2_6_14_2_b	**i**	12	25
2_6_16_3_b	**i**	77	25
2_6_17_1_a	**i**	26	13
2_6_17_1_b	**i**	81	41
2_6_18_2_a	**i**	2	2
2_6_19_3_a	**i**	13	6
2_6_2_1_b	**i**	82	34
2_6_20_1_b	**i**	82	37
2_6_20_2_b	**i**	87	24
2_6_21_1_a	**i**	16	4
2_6_21_1_b	**i**	80	42
2_6_21_1_c	**i**	1	1
2_6_21_2_b	**i**	87	26
2_6_21_3_b	**i**	89	39
2_6_3_3_a	**i**	1	1
2_6_4_1_a	**i**	37	3
2_6_6_3_a	**i**	2	2
2_6_7_2_a	**i**	86	33
2_6_9_3_b	**i**	19	29
31_47_11_3_a	**c**	7	2
31_47_12_2_a	**c**	13	3
31_47_12_2_b	**c**	72	33
31_47_18_3_a	**c**	7	2
31_47_3_2_b	**c**	21	21
31_47_4_2_b	**c**	14	11
31_47_6_3_b	**c**	17	14
31_47_7_3_b	**c**	97	34
31_47_8_1_b	**c**	100	46
31_47_8_3_b	**c**	92	47
31_47_9_1_b	**c**	99	49

Table S4.2. Experimental validation data.

Handle	Product	Observed	Predicted
38_18_1_1_b	**g**	93	54
38_18_10_2_b	**g**	49	40
38_18_11_1_b	**g**	70	66
38_18_12_3_b	**g**	67	68
38_18_13_1_b	**g**	82	73
38_18_14_2_a	**g**	42	9
38_18_16_3_b	**g**	44	27
38_18_17_1_a	**g**	20	12
38_18_18_1_b	**g**	68	64
38_18_19_2_a	**g**	2	6
38_18_2_1_b	**g**	60	56
38_18_20_1_b	**g**	91	75
38_18_20_2_b	**g**	93	77
38_18_20_3_a	**g**	13	12
38_18_20_3_b	**g**	89	76
38_18_20_3_c	**g**	5	2
38_18_21_1_b	**g**	99	77
38_18_3_3_b	**g**	45	45
38_18_4_1_b	**g**	78	53
38_18_5_1_b	**g**	71	60
38_18_6_1_b	**g**	33	26
38_18_7_2_b	**g**	37	19
38_18_8_2_a	**g**	1	9
38_18_9_2_b	**g**	40	13
31_5_1_1_a	**b**	0	4
31_5_13_3_b	**b**	71	55
31_5_17_1_b	**b**	76	64
31_5_19_1_b	**b**	4	25
31_5_20_3_a	**b**	0	14
31_5_3_1_b	**b**	22	33
31_5_4_1_b	**b**	9	15
31_5_6_2_a	**b**	0	8
31_5_8_1_b	**b**	100	56
31_5_9_1_c	**b**	0	2
31_5_9_2_b	**b**	83	63

Table S4.3. Experimental validation data.

Handle	Product	Observed	Predicted
4_13_1_3_b	**k**	72	48
4_13_10_1_b	**k**	21	35
4_13_11_1_b	**k**	16	52
4_13_12_1_b	**k**	18	38
4_13_13_1_a	**k**	30	43
4_13_14_1_a	**k**	45	60
4_13_16_1_a	**k**	100	74
4_13_17_1_a	**k**	95	83
4_13_17_2_a	**k**	91	102
4_13_17_2_b	**k**	65	90
4_13_17_2_c	**k**	2	84
4_13_17_3_a	**k**	89	82
4_13_18_1_b	**k**	16	51
4_13_19_3_a	**k**	36	37
4_13_2_2_a	**k**	95	93
4_13_2_2_b	**k**	87	86
4_13_20_2_a	**k**	99	91
4_13_21_2_a	**k**	90	79
4_13_3_3_b	**k**	18	31
4_13_4_3_a	**k**	83	19
4_13_6_3_a	**k**	31	49
4_13_7_2_a	**k**	96	82
4_13_8_2_a	**k**	99	81
4_13_9_3_b	**k**	17	36
31_27_12_2_b	**a**	22	0
31_27_2_2_b	**a**	11	9
31_27_20_2_b	**a**	3	1
31_27_21_2_b	**a**	3	1
31_27_3_2_b	**a**	1	1
31_27_4_2_b	**a**	1	3
31_27_7_2_b	**a**	85	33
31_27_8_1_b	**a**	96	28
31_27_9_2_b	**a**	78	28
31_27_9_3_b	**a**	98	31

Table S4.4. Experimental validation data.

Handle	Product	Observed	Predicted
4_22_7_1_a	**j**	79	75
4_22_9_1_c	**j**	2	70
4_22_12_1_b	**j**	55	63
4_22_21_1_b	**j**	95	60
4_22_13_1_b	**j**	76	60
4_22_20_1_b	**j**	83	59
4_22_11_1_b	**j**	78	56
4_22_7_2_a	**j**	87	87
4_22_2_2_a	**j**	87	87
4_22_16_2_a	**j**	88	87
4_22_8_2_a	**j**	84	86
4_22_7_2_b	**j**	66	55
4_22_14_2_a	**j**	82	81
4_22_9_2_a	**j**	80	81
4_22_7_2_c	**j**	10	79
4_22_18_3_a	**j**	36	30
4_22_10_3_b	**j**	86	31
4_22_6_3_a	**j**	40	31
4_22_4_3_a	**j**	38	34
4_22_3_3_b	**j**	43	30
4_22_1_3_b	**j**	93	46
4_22_19_3_a	**j**	44	67
4_22_9_3_c	**j**	44	71
4_22_7_3_a	**j**	44	75

Table S4.5. Experimental validation data.

Handle	Product	Observed	Predicted
7_48_1_1_b	**d**	3	1
7_48_10_1_a	**d**	17	19
7_48_10_2_a	**d**	25	35
7_48_11_2_b	**d**	2	1
7_48_12_3_a	**d**	3	2
7_48_13_1_b	**d**	2	1
7_48_14_2_a	**d**	6	9
7_48_16_1_a	**d**	85	40
7_48_16_1_b	**d**	26	3
7_48_16_1_c	**d**	2	2
7_48_16_2_a	**d**	83	39
7_48_16_3_a	**d**	89	36
7_48_17_2_a	**d**	23	12
7_48_18_1_b	**d**	1	1
7_48_19_3_b	**d**	5	1
7_48_2_1_b	**d**	2	1
7_48_2_2_a	**d**	6	6
7_48_20_2_a	**d**	5	5
7_48_3_3_b	**d**	0	1
7_48_4_3_b	**d**	5	3
7_48_6_1_b	**d**	2	1
7_48_7_2_a	**d**	17	18
7_48_8_2_a	**d**	10	17
7_48_9_2_a	**d**	2	7

Table S4.6. Experimental Validation Data

Master List of Dataset Products

Figure 22 is a list of products for dataset couplings (non-validation experiments used to train models). The numerical naming of each product uses the format "{amine}_{bromide}." Every product rendered in the multi-page Figure S22 is accompanied by its numerical identifier.

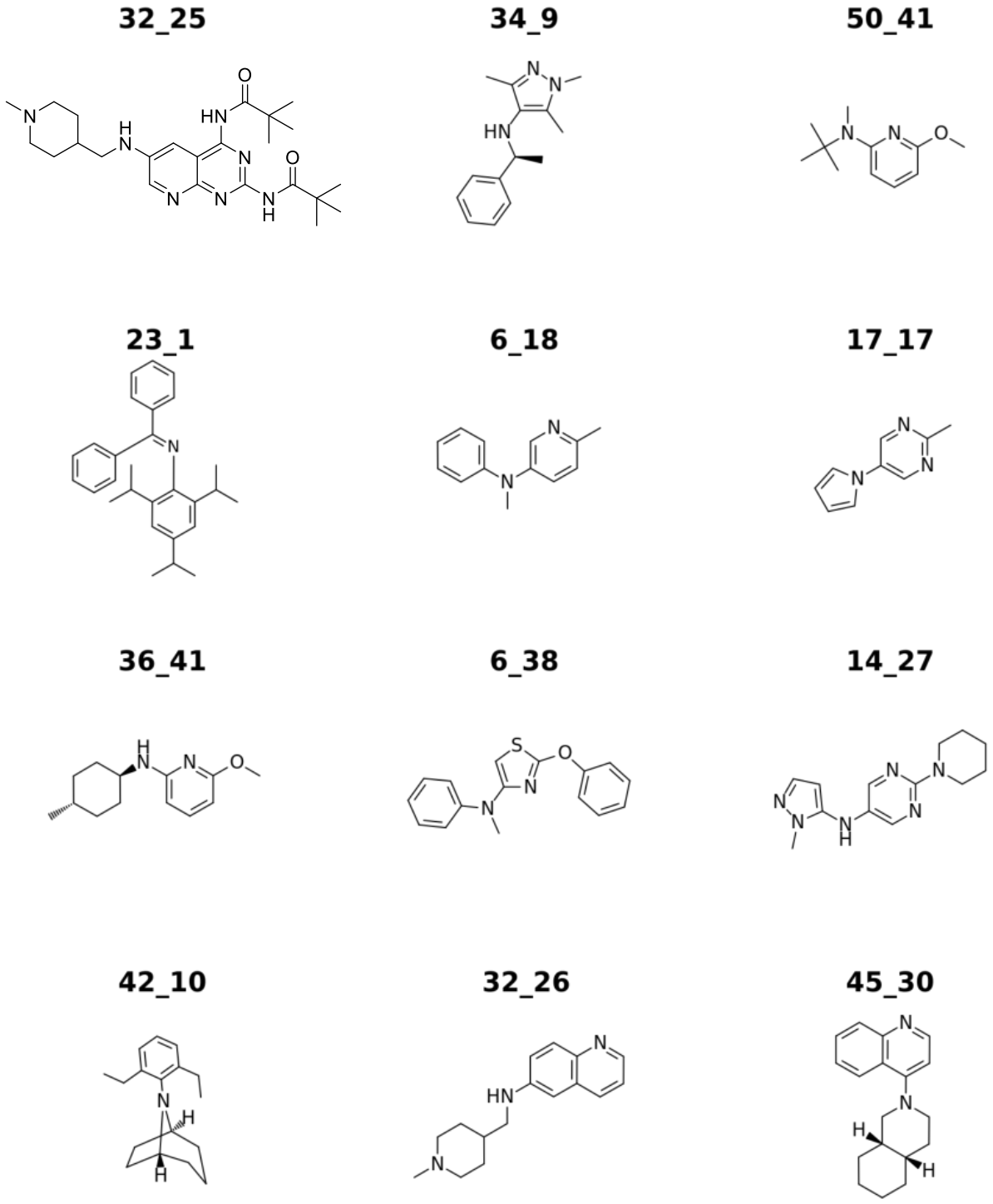
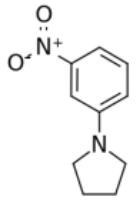
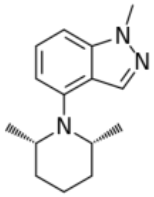


Figure S22. Dataset Products.

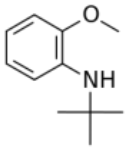
44_13



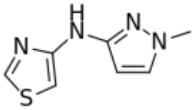
40_12



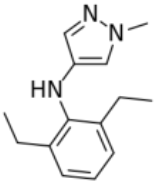
37_7



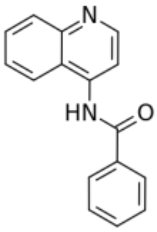
16_20



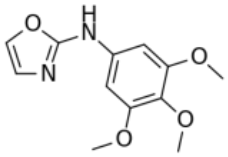
12_10



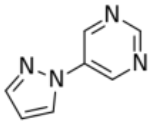
8_30



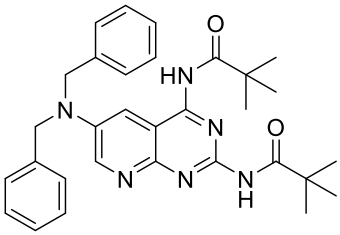
26_23



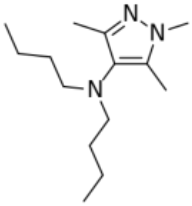
21_24



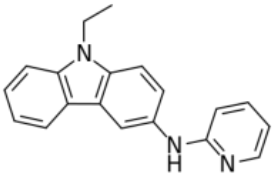
49_25



47_9



11_33



17_30

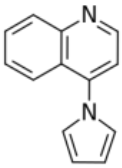


Figure S22. Dataset Products (continued).

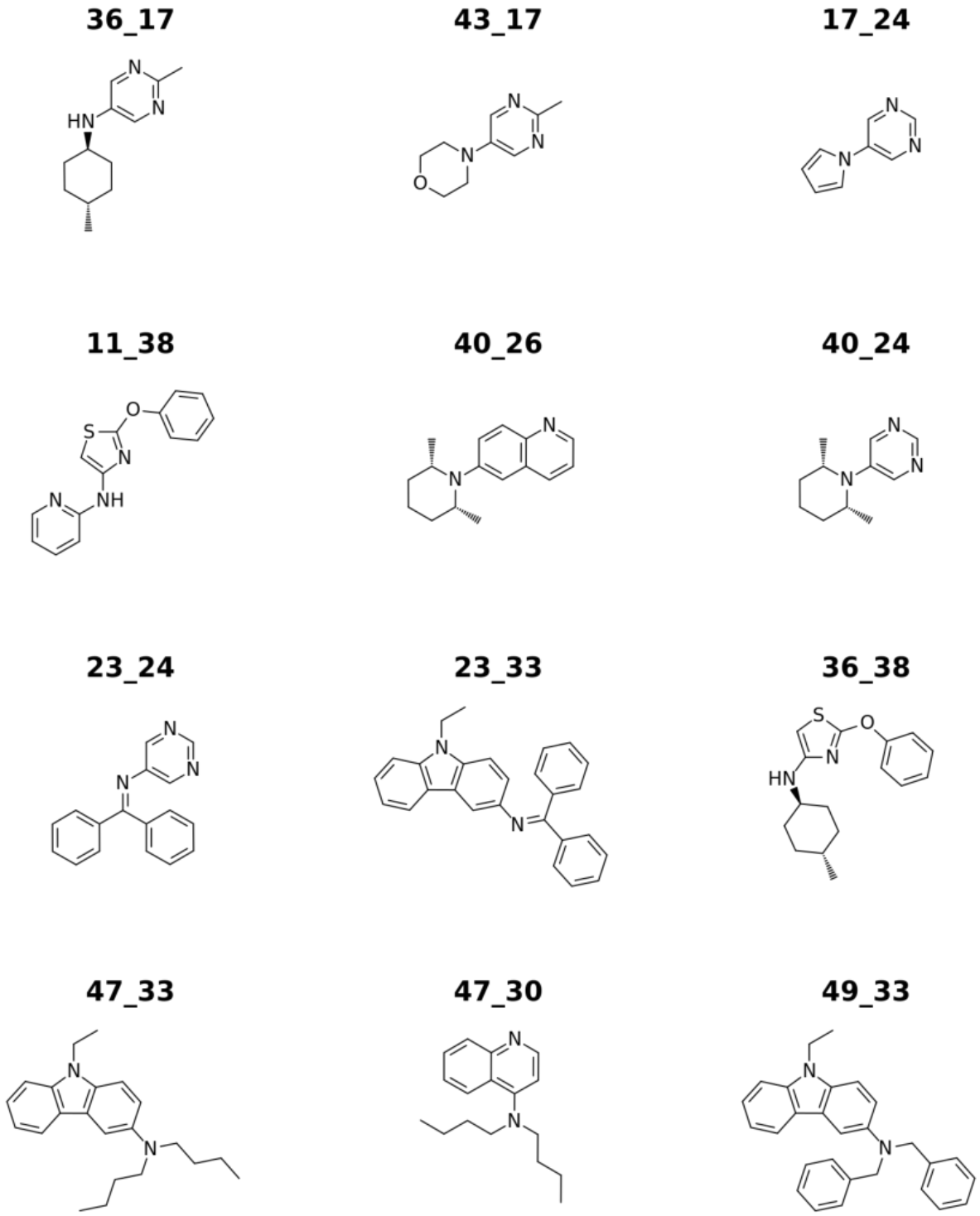
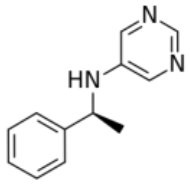
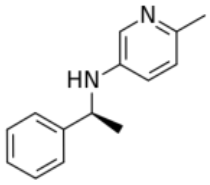


Figure S22. Dataset Products (continued).

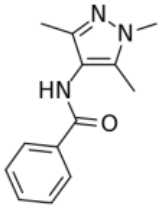
34_24



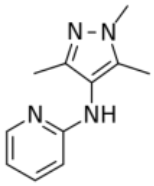
34_18



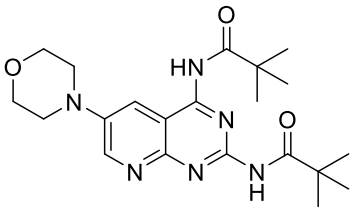
8_9



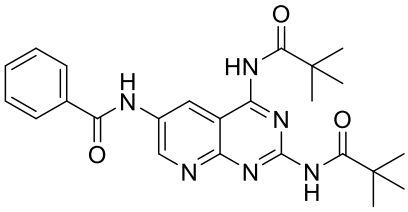
11_9



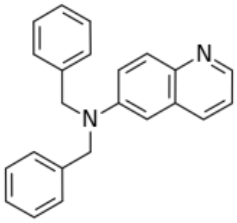
43_25



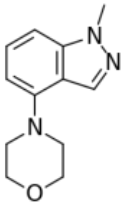
8_25



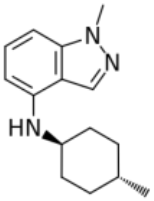
49_26



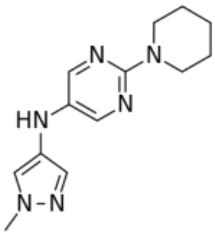
43_12



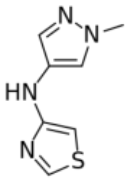
36_12



12_27



12_20



10_11

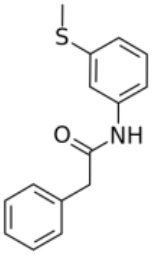
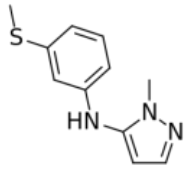
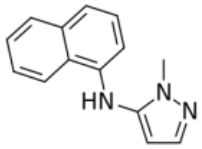


Figure S22. Dataset Products (continued).

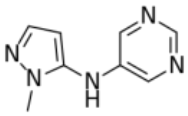
14_11



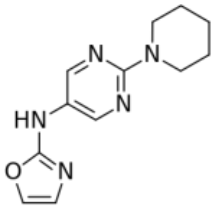
14_8



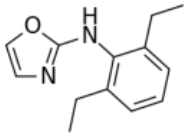
14_24



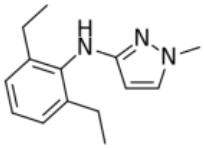
26_27



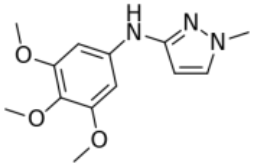
26_10



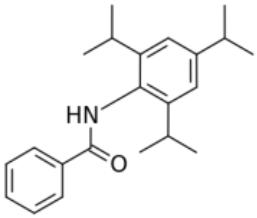
16_10



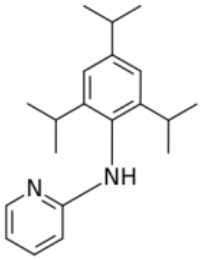
16_23



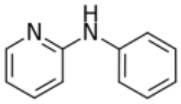
8_1



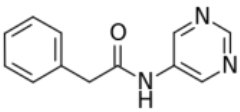
11_1



1_45



10_24



48_22

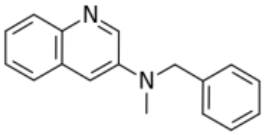
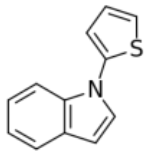
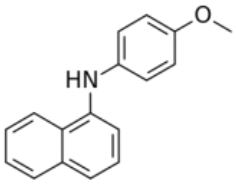


Figure S22. Dataset Products (continued).

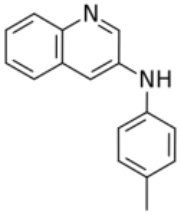
18_3



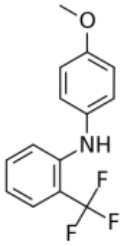
3_8



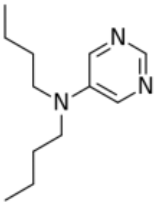
5_22



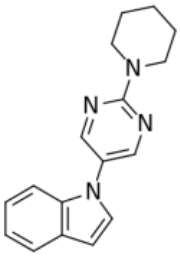
3_48



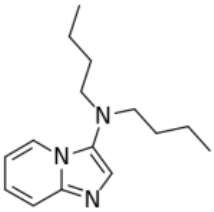
47_24



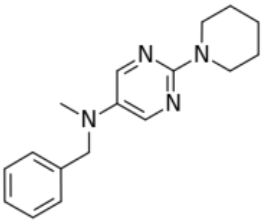
18_27



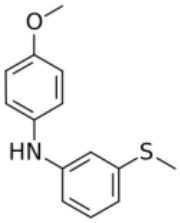
47_35



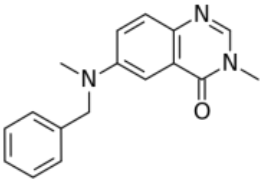
48_27



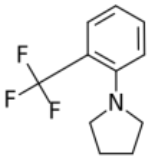
3_11



48_14



44_48



10_48

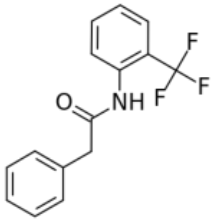


Figure S22. Dataset Products (continued).

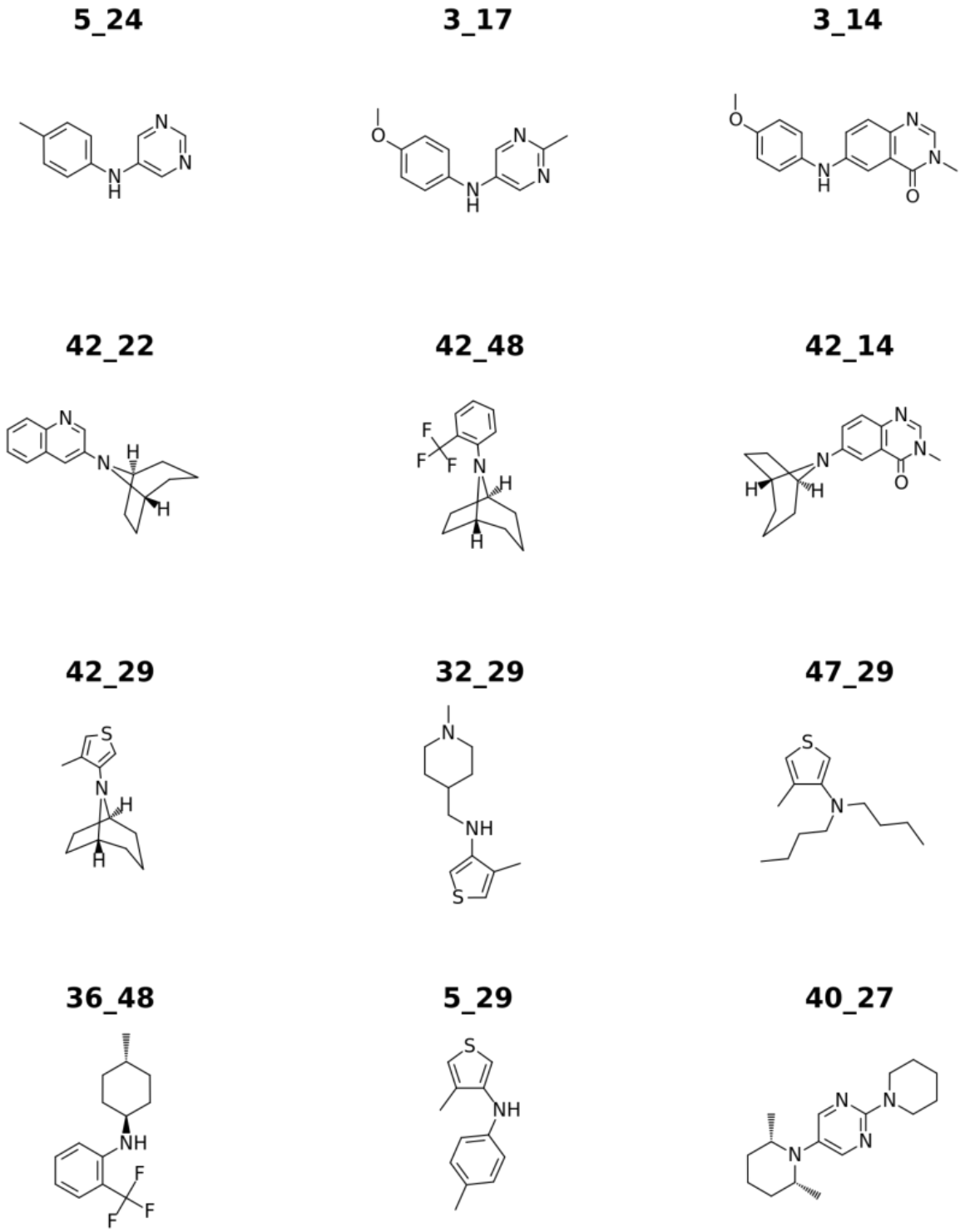
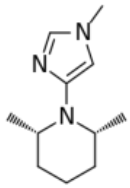
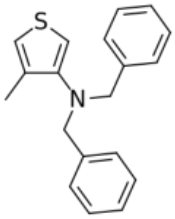


Figure S22. Dataset Products (continued).

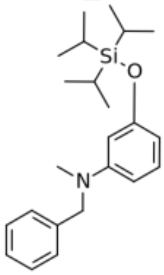
40_34



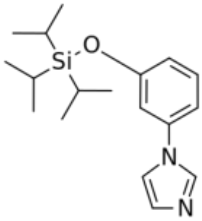
49_29



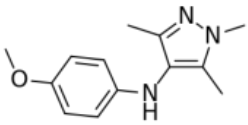
48_16



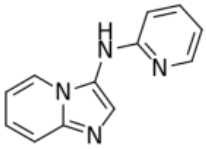
20_16



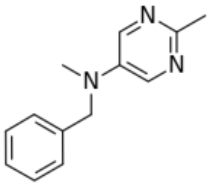
3_9



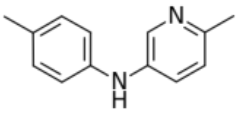
11_35



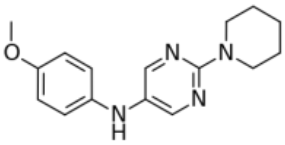
48_17



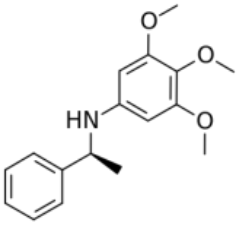
5_18



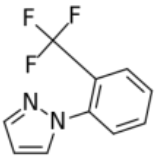
3_27



34_23



21_48



21_22

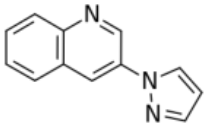
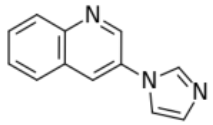
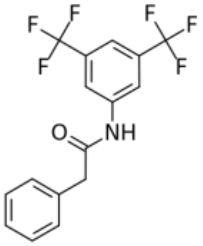


Figure S22. Dataset Products (continued).

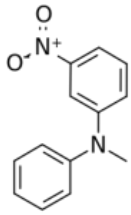
20_22



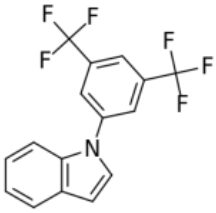
10_47



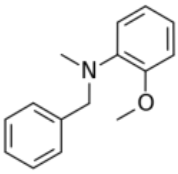
6_13



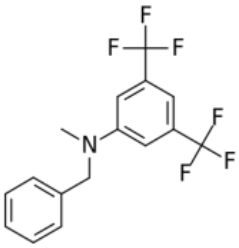
18_47



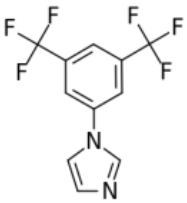
48_7



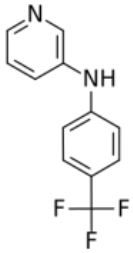
48_47



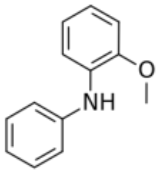
20_47



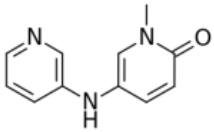
19_4



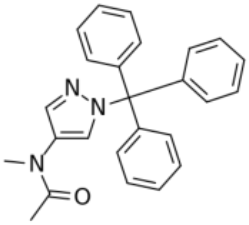
1_7



19_49



13_31



19_2

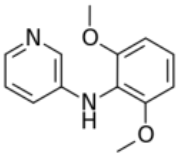
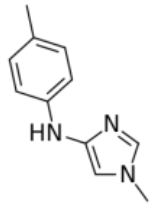
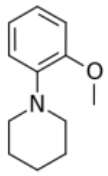


Figure S22. Dataset Products (continued).

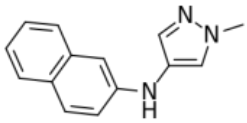
5_34



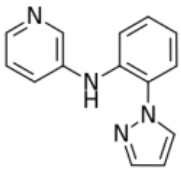
38_7



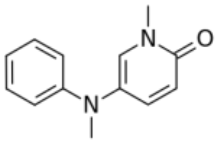
12_50



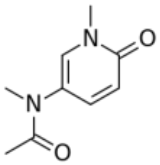
19_39



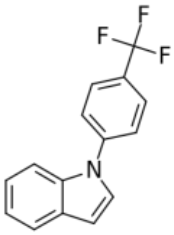
6_49



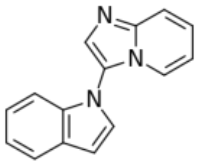
13_49



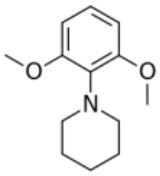
18_4



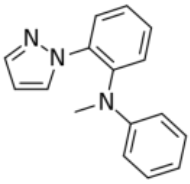
18_35



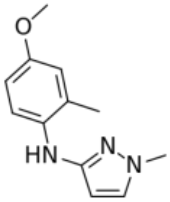
38_2



6_39



16_32



47_48

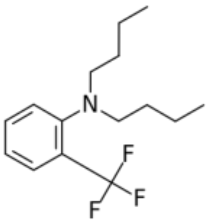
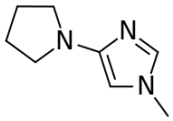
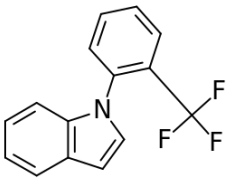


Figure S22. Dataset Products (continued).

44_34



18_48



34_7

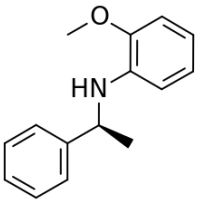


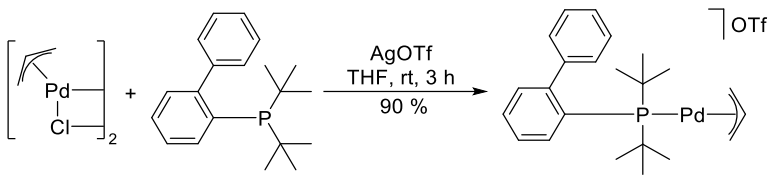
Figure S22. Dataset Products (continued).

Characterization Data

The following section contains: (1) syntheses of new compounds, (2) characterization data in tabular format, and (3) reactant pair summaries for dataset products. *Note*: the references in this section are for characterization data, and these are numbered independently from the references above. Precatalysts and experimental validation product entries contain only (1) and (2). For products which were synthesized using multiple synthetic steps, characterization data for new intermediates are provided in sequence to the dataset product.

Preparation of Precatalysts and Characterization Data

[Pd(allyl)(JohnPhos)]OTf (Catalyst 1)



Prepared in analogy to a literature procedure.(*54*) Silver trifluoromethanesulfonate (1.29 g, 5.00 mmol, 1.00 equiv) was added to allylpalladium(II) chloride dimer (915 mg, 2.50 mmol, 0.50 equiv) in THF (10 mL) and stirred at rt for 1 h under the exclusion of light. The solution was filtered with THF (10 mL) through Celite in a fritted glass filter. JohnPhos (1.49 g, 5.00 mmol) was added and the solution was stirred at rt for 2 h. Pentane (40 mL) was added and the mixture was stirred at rt for 0.5 h. The resulting precipitate was filtered through fritted glass filter and washed with pentane (2 × 10 mL) and dried under Schlenk line vacuum to afford the product as a beige solid. Yield: 2.67 g (90%).

<u>m.p.</u> 200 °C (d).

<u>^{1}H NMR</u> (400 MHz, $CDCl_3$)

δ 8.00 (br *s*, 2H, Ar-*H*), 7.91 – 7.85 (*m*, 1H, Ar-*H*), 7.56 – 7.33 (*m*, 4H, Ar-*H*), 7.06 (br *s*, 1H, Ar-*H*), 6.89 – 6.79 (*m*, 1H, Ar-*H*), 5.72 (*tt*, $^3J_{H,H'}$ = 13.2, 7.2 Hz, 1H, C*H* (allyl)), 4.42 (br *s*, 1H, C*H*H (allyl)), 3.83 (br *s*, 1H, C*H*H (allyl)), 3.25 – 2.78 (*m*, 2H, C*H*H (allyl)), 1.38 (br *s*, 18H, CH_3).

<u>^{13}C{^{1}H} NMR</u> (101 MHz, $CDCl_3$)

147.8 (*d*, $^2J_{P,C}$ = 20.9 Hz, arom.), 135.0 (br *s*, 2C, arom.), 134.2 (arom.), 133.2 (*d*, $^2J_{P,C}$ = 10.3 Hz, arom.), 131.7 (arom.), 131.1 (*d*, $^3J_{H,H}$ = 4.4 Hz, arom.), 130.0 (*d*, $^1J_{P,C}$ = 32.3 Hz, arom.), 128.14 (arom.), 128.11 (*d*, $^3J_{P,C}$ = 7.4 Hz, arom.), 122.5 (br *s*, arom.), 119.9 (*d*, $^2J_{P,C}$ = 5.9 Hz, *C*H (allyl)), 119.4 (br *s*,

arom.), 103.1 (br *s*, *C*H_2 (allyl)), 57.3 (br *s*, *C*H_2 (allyl)), 37.2 (*d*, $^1J_{P,C}$ = 14.7 Hz, 2C, P*C*), 30.5 (6C, *C*H_3).

$^{31}P\{^1H\}$ NMR (162 MHz, $CDCl_3$)

δ 71.9 (*s*).

IR (cm^{-1}) ATR (neat)

3014, 3052, 3006, 2970, 2943, 1582, 1565, 1550, 1477, 1462, 1434, 1401, 1391, 1369, 1359, 1320, 1271, 1258, 1252, 1223, 1180, 1157, 1083, 1071, 1027, 1004, 967, 936, 888, 812.

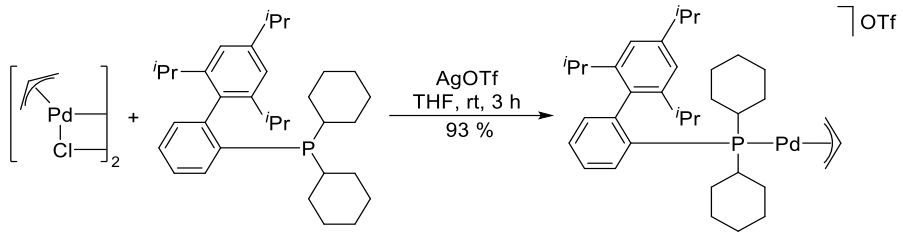
HRMS (ESI) Calcd. for $C_{23}H_{32}PPd$ *m*/*z* 445.1271, Found: 445.1274 $[M\text{-}OTf]^+$.

Analysis $C_{44}H_{32}F_3O_3PPdS$:

Calcd: C, 48.45; H, 5.42; P, 5.21

Found: C, 48.80; H, 5.37; P, 5.22.

[Pd(allyl)(XPhos)]OTf (Catalyst 2)



Prepared in analogy to a literature procedure.(*54*) Silver trifluoromethanesulfonate (1.29 g, 5.00 mmol, 1.00 equiv) was added to allylpalladium(II) chloride dimer (915 mg, 2.50 mmol, 0.50 equiv) in THF (10 mL) and stirred at rt for 1 h under the exclusion of light. The solution was filtered with THF (10 mL) through Celite in a fritted glass filter. XPhos (2.38 g, 5.00 mmol) was added and stirred at rt for 2 h. Pentane (40 mL) was added and stirred at rt for 0.5 h. The resulting precipitate was filtered through fritted glass filterand washed with pentane (2 × 10 mL) and dried under Schlenk line vacuum to afford the product as an off-white solid, which contains 0.84 equiv of THF. Yield: 3.89 g (93%).

<u>m.p.</u> 200 °C (d).

<u>^{1}H NMR</u> (400 MHz, $CDCl_3$)

δ 7.79 – 7.71 (*m*, 1H, Ar-*H*), 7.62 – 7.56 (*m*, 1H, Ar-*H*), 7.55 – 7.48 (*m*, 2H, Ar-*H*), 7.40 (*d*, $^4J_{H,H'}$ = 1.3 Hz, 1H, Ar-*H*), 6.83 – 6.78 (*m*, 1H, Ar-*H*), 5.71 – 5.57 (*m*, 1H, C*H* (allyl)), 4.24 – 4.20 (*m*, 1H, C*H*H (allyl)), 3.71 – 3.63 (*m*, 1H, C*H*H (allyl)), 3.03 (*qq*, $^3J_{H,H'}$ = 6.9, 6.9 Hz, 1H, C*H*), 2.78 (br *d*, $^3J_{H,H'}$ = 12.4 Hz, 1H, C*H*H (allyl)), 2.71 – 2.64 (*m*, 1H, C*H*H (allyl)), 2.50 – 2.02 (*m*, 6H, PC*H* (2H) + C*H* (2H) + C*H*H (2H)), 1.93 – 1.65 (*m*, 8H, C*H*H), 1.43 – 1.16 (*m*, 22H, C*H*H (10H) + C*H*$_3$ (12H)), 0.95 (*d*, $^3J_{H,H'}$ = 6.7 Hz, 3H), 0.91 (*d*, $^3J_{H,H'}$ = 6.7 Hz, 3H).

<u>^{13}C{^{1}H} NMR</u> (101 MHz, $CDCl_3$)

δ 152.8 (arom.), 149.0 (arom.), 148.3 (arom.), 145.1 (*d*, $^2J_{P,C}$ = 23.5 Hz, arom.), 134.3 (*d*, $^1J_{P,C}$ = 37.4 Hz, arom.), 132.5 (*d*, $^2J_{P,C}$ = 10.3 Hz, arom.), 132.4 (arom.), 131.8 (*d*, $^4J_{P,C}$ = 2.2 Hz, arom.), 128.9 (*d*, $^3J_{P,C}$ = 5.1 Hz, arom.), 125.8 (arom.), 125.7 (arom.), 120.9 (*d*, $^3J_{P,C}$ = 4.0 Hz, arom.), 120.3 (*d*, $^2J_{P,C}$ = 6.2 Hz, *C*H (allyl)), 101.3 (*d*, $^2J_{P,C}$ = 27.1 Hz, *C*H$_2$ (allyl)), 51.8 (*C*H$_2$ (allyl)), 37.9 (*d*, $^1J_{P,C}$ = 22.7 Hz, P*C*H), 36.6 (*d*, $^1J_{P,C}$ = 23.1 Hz, P*C*H), 33.9 (*C*H), 32.1

(*C*H), 32.0 (*C*H), 30.3 (CH_2), 29.9 (CH_2), 29.6 (CH_2), 29.4 (CH_2), 27.1 (*d*, $^2J_{P,C}$ = 12.1 Hz, CH_2), 26.9 (*d*, $^2J_{P,C}$ = 7.3 Hz, CH_2), 26.8 (*d*, $^2J_{P,C}$ = 7.0 Hz, CH_2), 26.7 (*d*, $^2J_{P,C}$ = 12.2 Hz, CH_2), 25.7 (CH_2), 25.6 (CH_2), 25.2 (CH_3), 25.1 (CH_3), 24.8 (CH_3), 24.7 (CH_3), 24.4 (CH_3), 24.1 (CH_3).

$^{31}P\{^1H\}$ NMR (162 MHz, $CDCl_3$)

δ 46.1 (*s*).

IR (cm^{-1}) ATR (neat)

3080, 3051, 2963, 2932, 2861, 1598, 1562, 1533, 1462, 1454, 1427, 1416, 1385, 1364, 1351, 1328, 1318, 1299, 1267, 1259, 1222, 1184, 1173, 1151, 1120, 1102, 1067, 1029, 1010, 954, 939, 908, 896, 885, 854, 825.

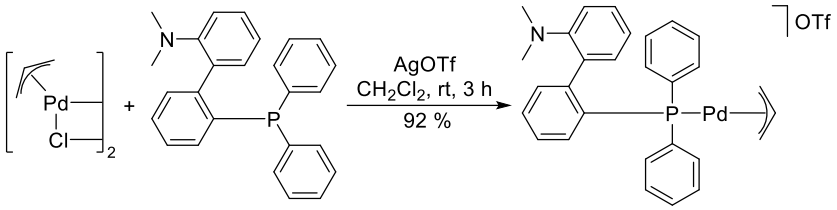
HRMS (ESI) Calcd. for $C_{36}H_{54}PPd$ *m/z* 623.2992, Found: 623.3022 $[M\text{-}OTf]^+$.

Analysis: $C_{37}H_{54}F_3O_3PPdS$

Calcd. 0.84 THF: C, 58.13; H, 7.35; P, 3.71

Found: C, 58.25; H, 7.32; P, 3.66.

[Pd(allyl)(Ph-DavePhos)]OTf (Catalyst 3)



Prepared in analogy to a literature procedure.(*54*) Ph-DavePhos (1.91 g, 5.00 mmol) was added to allylpalladium(II) chloride dimer (915 mg, 2.50 mmol, 0.50 equiv) in CH_2Cl_2 (10 mL) and stirred at rt for 1.5 h. Silver trifluoromethanesulfonate (1.29 g, 5.00 mmol, 1.00 equiv) was added and stirred at rt for 1.5 h under the exclusion of light. The solution was filtered with CH_2Cl_2 (10 mL) through Celite. Heptane (20 mL) was added and CH_2Cl_2 was removed under reduced pressure. The resulting precipitate was filtered through fritted glass filter and washed with pentane (2 × 10 mL) and dried under Schlenk line vacuum to afford the product as yellow solid. 3.10 g (92%).

<u>m.p.</u> 185 °C (d).

<u>^{1}H NMR</u> (400 MHz, $CDCl_3$)

δ 7.65 – 6.94 (*m*, 16H, Ar-*H*), 6.65 (br *s*, 1H, Ar-*H*), 6.28 (br *s*, 1H, Ar-*H*), 6.00 (br *s*, 1H, C*H* (allyl)), 4.72 (br *s*, 1H + 1H (major), C*H*H (allyl)), 4.12 (br *s*, 1H, C*H*H (allyl), minor), 3.32 (br *s*, 6H, NCH_3), 3.16 (br *s*, 1H, C*H*H (allyl)), 2.75 (br *s*, 1H, C*H*H (allyl), minor), 2.38 (br *s*, 1H, C*H*H (allyl), major).

<u>^{13}C{^{1}H} NMR</u> (101 MHz, $CDCl_3$)

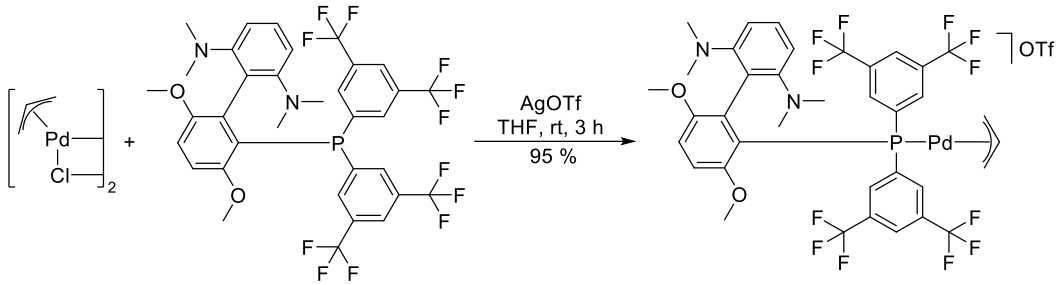
δ 150.4 (br *s*, arom.), 148.3 (br *d*, $^3J_{P,C}$ = 16.9 Hz, arom.), 134.9 – 134.6 (*m*, 2C, arom.), 133.0 – 132.5 (*m*, 4C, arom.), 132.3 (br *s*, 2C, arom.), 131.1 (br *s*, 2C, arom.), 130.6 (*d*, $^1J_{P,C}$ = 153.5 Hz, 2C, arom.), 129.4 – 128.8 (*m*, 4C, arom.), 128.19 (*d*, $^3J_{P,C}$ = 7.0 Hz, arom.), 128.15 (br *d*, $^2J_{P,C}$ = 42.2 Hz, arom.), 125.8 – 124.4 (*m*, 2C, arom.), 122.3 (br *d*, $^2J_{P,C}$ = 15.4 Hz, *C*H (allyl)), 121.0 (*d*, $^1J_{P,C}$ = 322.2 Hz, arom.), 118.8 – 118.3 (*m*, arom.), 90.9 (br *d*, $^2J_{P,C}$ = 22.4 Hz, *C*H_2 (allyl)), 59.5 (br *d*, $^2J_{P,C}$ = 6.2 Hz, *C*H_2 (allyl)), 54.82 (br *s*, 2C, N*C*H_3, minor), 53.6 (br *s*, 2C, N*C*H_3, major).

<u>^{31}P{^{1}H} NMR</u> (162 MHz, $CDCl_3$)

δ 23.2 (*s*, major), 21.9 (*s*, minor).

IR (cm^{-1})	ATR (neat)
	3083, 3055, 2941, 2857, 1600, 1584, 1561, 1490, 1478, 1465, 1436, 1408, 1388, 1309, 1281, 1263, 1221, 1186, 1176, 1163, 1142, 1107, 1099, 1075, 1062, 1032, 1007, 967, 946, 934, 920, 906, 860, 848.
HRMS (ESI)	Calcd. for $C_{29}H_{29}NPPd$ *m/z* 528.1067, Found: 528.1089 $[M\text{-}OTf]^+$.
Analysis	$C_{30}H_{29}F_3NO_3PPdS$:
	Calcd. C, 53.14; H, 4.31; N, 2.07; P, 4.57
	Found: C, 51.03; H, 4.29; N, 2.03; P, 4.26.

[Pd(allyl)(CPhos-Hybrid)]OTf (Catalyst 4)



Prepared in analogy to a literature procedure.(*54*) Silver trifluoromethanesulfonate (1.03 g, 4.00 mmol, 1.00 equiv) was added to allylpalladium(II) chloride dimer (732 mg, 2.00 mmol, 0.50 equiv) in THF (10 mL) and stirred at rt for 1 h under the exclusion of light. The solution was filtered with THF (10 mL) through Celite in a fritted glass filter. CPhos-Hybrid (3.03 g, 4.00 mmol) in THF (10 mL) was added and stirred at rt for 2 h. Heptane (20 mL) was added and THF was removed under reduced pressure. The resulting precipitate was filtered through fritted glass filter and washed with pentane (2 × 10 mL) and dried under Schlenk line vacuum to afford the product as an orange solid, which contains 0.52 equiv of heptane. Yield: 4.19 g (95%).

<u>m.p.</u> 110 °C (d)

<u>^{1}H NMR</u> (400 MHz, $CDCl_3$)

δ 8.03 (*s*, 2H, Ar-*H*), 7.86 (*s*, 2H, Ar-*H*), 7.83 (*s*, 2H, Ar-*H*), 7.41 (*t*, $^3J_{H,H'}$ = 8.2 Hz, 1H, Ar-*H*), 7.28 (*d*, $^3J_{H,H'}$ = 9.1 Hz, 1H, Ar-*H*), 7.10 (*dd*, $^3J_{H,H'}$ = 9.1 Hz, $^4J_{P,H}$ = 4.0 Hz, 1H, Ar-*H*), 7.03 (br *s*, 1H, Ar-*H*), 6.92 (br *s*, 1H, Ar-*H*), 5.84 – 5.65 (*m*, 1H, C*H* (allyl)), 4.03 – 3.93 (*m*, 2H, C*H*H (allyl)), 3.65 (*s*, 3H, OCH_3), 3.61 (*s*, 3H, OCH_3), 3.32 – 3.26 (*m*, 1H, C*H*H (allyl)), 3.04 – 2.86 (*m*, 1H, C*H*H (allyl)), 2.47 (br *s*, 6H, NCH_3), 2.23 (br *s*, 6H, NCH_3).

<u>^{13}C{^{1}H} NMR</u> (151 MHz, $CDCl_3$)

δ 157.9 (br *s*, arom.), 157.2 (br *s*, arom.), 155.0 (*d*, $^2J_{P,C}$ = 2.6 Hz, arom.), 152.2 (*d*, $^2J_{P,C}$ = 20.0 Hz, arom.), 136.7 (*d*, $^2J_{P,C}$ = 30.1 Hz, arom.), 135.1 (arom.), 133.6 – 133.3 (*m*, 2C, arom.), 133.3 – 132.9 (*m*, 4C, arom.), 132.3 (*qd*, $^2J_{F,C}$ = 34.2 Hz, $^3J_{P,C}$ = 10.6 Hz, 4C, arom.), 125.1 – 124.9 (*m*, 2C, arom.), 122.6 (*q*, $^1J_{F,C}$ = 273.5 Hz, 4C, CF_3), 121.3 (*d*, $^2J_{P,C}$ = 6.0 Hz, *C*H (allyl)), 120.3 (*d*, $^1J_{P,C}$ = 50.8 Hz, arom.), 119.0 (*d*, $^4J_{P,C}$ = 1.9 Hz, arom.), 113.3 (*d*, $^3J_{P,C}$ = 4.7 Hz,

arom.), 112.4 (br *s*, 2C, arom.), 99.0 (br *d*, $^{2}J_{P,C}$ = 29.5 Hz, *C*H$_2$ (allyl)), 95.8 (*d*, $^{3}J_{P,C}$ = 3.4 Hz, arom.), 60.6 (br *d*, $^{2}J_{P,C}$ = 3.7 Hz, *C*H$_2$ (allyl)), 56.7 (O*C*H$_3$), 55.2 (O*C*H$_3$), 44.2 (br *s*, 2C, N*C*H$_3$), 44.1 (br *s*, 2C, N*C*H$_3$).

^{19}F{^{1}H} NMR (376 MHz, CDCl$_3$)

δ -63.0 (*s*, 12F, C*F*$_3$), -78.3 (*s*, 3F, C*F*$_3$).

^{31}P{^{1}H} NMR (162 MHz, CDCl$_3$)

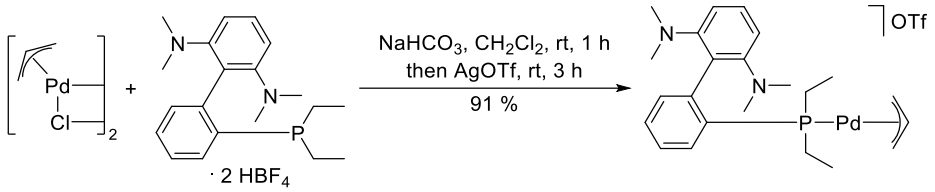
δ 38.0 (*s*).

IR (cm^{-1}) ATR (neat)

3088, 2938, 2841, 2790, 1618, 1581, 1544, 1501, 1471, 1435, 1425, 1412, 1355, 1275, 1261, 1224, 1176, 1121, 1109, 1096, 1044, 1030, 1013, 933, 918, 894, 844, 822, 803.

HRMS (ESI) Calcd. for $C_{37}H_{34}F_{12}N_2O_2PPd$ *m*/*z* 903.1196, Found: 903.1220 [M-OTf]$^{+}$.

[Pd(allyl)(Et-CPhos)]OTf (Catalyst 5)



Prepared in analogy to a literature procedure.(*54*) Saturated aqueous $NaHCO_3$ solution (20 mL) was added to Et-CPhos•2 HBF_4 (1.50 g, 2.98 mmol, 2.02 equiv) in CH_2Cl_2 (10 mL) and the solution was stirred at rt for 1 h. The organic phase was separated, dried over $MgSO_4$ (XX g) and filtered. Allylpalladium(II) chloride dimer (540 mg, 1.48 mmol, 0.50 equiv) was added and the solution was stirred at rt for 1.5 h. Silver trifluoromethanesulfonate (758 mg, 2.95 mmol) was added and the suspension stirred at rt for 1.5 h under the exclusion of light. The solution was filtered with CH_2Cl_2 (10 mL) through Celite in a fritted glass filter. Heptane (10 mL) was added and CH_2Cl_2 was removed under reduced pressure. The resulting precipitate was filtered through fritted glass filter and washed with pentane (2 × 10 mL) and dried under Schlenk line vacuum to afford the product as an off-white solid. Yield: 1.77 g (91%).

<u>m.p.</u> 170 °C (d)

<u>^{1}H NMR</u> (400 MHz, $CDCl_3$)

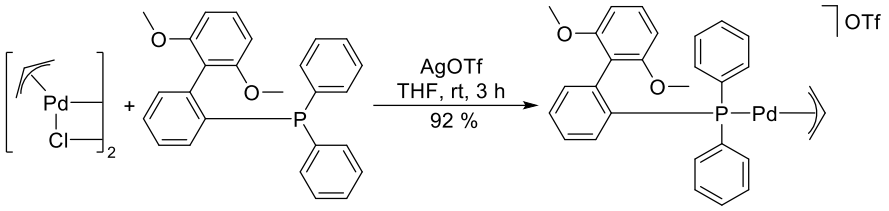
δ 7.71 – 7.65 (*m*, 1H, Ar-*H*), 7.52 – 7.43 (*m*, 2H, Ar-*H*), 7.33 – 7.27 (*m*, 1H, Ar-*H*), 7.08 – 7.00 (*m*, 2H, Ar-*H*), 6.98 – 6.92 (*m*, 1H, Ar-*H*), 5.70 – 5.49 (*m*, 1H, C*H* (allyl)), 4.00 (br *s*, 1H, C*H*H (allyl)), 3.88 – 3.79 (*m*, 1H, C*H*H (allyl)), 2.88 – 2.76 (*m*, 2H, C*H*H (allyl)), 2.64 (br *s*, 6H, NCH_3), 2.35 (br *s*, 6H, NCH_3), 2.26 – 2.03 (*m*, 4H, PC*H*H), 1.21 – 1.08 (*m*, 6H, CH_3).

<u>^{13}C{^{1}H} NMR</u> (101 MHz, $CDCl_3$)

δ 156.0 (br *s*, arom.), 154.0 (br *s*, arom.), 145.6 (*d*, $^3J_{P,C}$ = 23.8 Hz, arom.), 136.1 (*d*, $^2J_{P,C}$ = 44.4 Hz, arom.), 133.1 (arom.), 132.3 (*d*, $^3J_{P,C}$ = 2.2 Hz, arom.), 131.9 (*d*, $^2J_{P,C}$ = 12.5 Hz, arom.), 131.6 (arom.), 128.3 (*d*, $^3J_{P,C}$ = 5.9 Hz, arom.), 121.0 (*d*, $^1J_{P,C}$ = 322.2 Hz, arom.), 119.7 (*d*, $^2J_{P,C}$ = 5.9 Hz, *C*H (allyl)), 112.8 (br *s*, arom.), 112.4 (br *s*, arom.), 97.5 (*d*, $^2J_{P,C}$ = 29.0 Hz, *C*H_2 (allyl)), 51.7 (*d*, $^2J_{P,C}$ = 2.6 Hz, *C*H_2 (allyl)), 44.6 (br *s*, 2C, N*C*H_3) 44.5 (br *s*, 2C, N*C*H_3), 21.5 – 20.3 (m, 2C, P*C*H_2), 9.8 (br *d*, $^2J_{P,C}$ = 22.7 Hz, 2C, *C*H_3).

$^{31}P\{^{1}H\}$ NMR	(162 MHz, $CDCl_3$):
	δ 37.4 (*s*).
IR (cm^{-1})	ATR (neat)
	3083, 3054, 2968, 2875, 2801, 1571, 1553, 1483, 1455, 1440, 1419, 1413, 1391, 1378, 1351, 1261, 1220, 1201, 1184, 1154, 1092, 1050, 1043, 1027, 1009, 976, 961, 937, 916, 857, 822.
HRMS (ESI)	Calcd. for $C_{23}H_{34}N_2PPd$ *m/z* 475.1489, Found: 475.1512 $[M\text{-}OTf]^+$.
Analysis:	$C_{24}H_{34}F_3N_2O_3PPdS$:
	Calcd. C, 46.12; H, 5.48; N, 4.48; P, 4.96
	Found: C, 46.00; H, 5.55; N, 4.46; P, 4.56.

[Pd(allyl)(Ph-SPhos)]OTf (Catalyst 6)



Prepared in analogy to a literature procedure.(*54*) Silver trifluoromethanesulfonate (1.29 g, 5.00 mmol, 1.00 equiv) was added to allylpalladium(II) chloride dimer (915 mg, 2.50 mmol, 0.50 equiv) in THF (10 mL) and stirred at rt for 1 h under the exclusion of light. The solution was filtered with THF (10 mL) through Celite in a fritted glass filter. Ph-SPhos (1.99 g, 5.00 mmol) was added and stirred at rt for 2 h. Pentane (40 mL) was added and stirred at rt for 0.5 h. The resulting precipitate was filtered through fritted glass filter and washed with pentane (2 × 10 mL) and dried under Schlenk line vacuum to afford the product as a light orange solid. Yield: 3.18 g (92%).

<u>m.p.</u> 165 °C (d)

<u>^{1}H NMR</u> (400 MHz, $CDCl_3$)

δ 7.56 – 7.38 (*m*, 14H, Ar-*H*), 7.05 (*dd*, $^3J_{H,H'}$ = 7.7 Hz, $^4J_{P,H}$ = 4.2 Hz, 1H, Ar-*H*), 6.97 (*d*, $^3J_{H,H'}$ = 8.6 Hz, 2H, Ar-*H*), 5.85 – 5.73 (*m*, 1H, C*H* (allyl)), 4.05 – 3.95 (*m*, 1H, C*H*H (allyl)), 3.63 (br *s*, 7H, OCH_3 (6H) + C*H*H (1H, allyl)), 3.48 – 3.43 (*m*, 1H, C*H*H (allyl)), 2.77 (br *s*, 1H, C*H*H (allyl)).

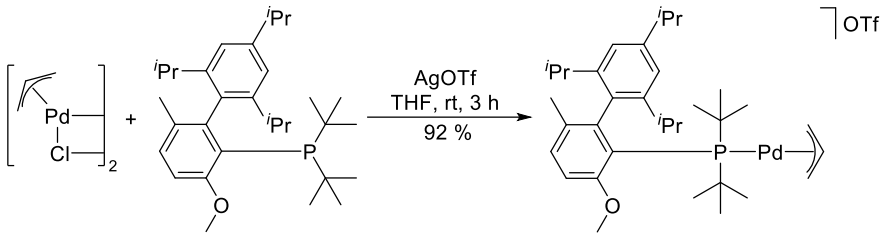
<u>^{13}C{^{1}H} NMR</u> (101 MHz, $CDCl_3$)

δ 159.1 (br *s*, 2C, arom.), 142.4 (*d*, $^3J_{P,C}$ = 26.8 Hz, arom.), 135.6 (*d*, $^2J_{P,C}$ = 48.1 Hz, arom.), 133.9 (*d*, $^4J_{P,C}$ = 8.8 Hz, 2C, arom.), 133.0 (br *d*, $^2J_{P,C}$ = 12.8 Hz, 4C, arom.), 132.11 (arom.), 132.06 (*d*, $^2J_{P,C}$ = 16.2 Hz, arom.), 131.1 (*d*, $^5J_{P,C}$ = 2.6 Hz, 2C, arom.), 130.8 (*d*, $^1J_{P,C}$ = 47.5 Hz, 2C, arom.),129.1 (*d*, $^3J_{P,C}$ = 10.6 Hz, 4C, arom.), 128.3 (*d*, $^3J_{P,C}$ = 6.2 Hz, arom.), 121.4 (*d*, $^2J_{P,C}$ = 5.5 Hz, *C*H (allyl)), 120.7 (*d*, $^1J_{P,C}$ = 322.2 Hz, arom.), 105.8 (br *s*, arom.), 104.7 (br *d*, $^3J_{P,C}$ = 5.5 Hz, arom.), 99.0 (br *d*, $^2J_{P,C}$ = 27.9 Hz, *C*H_2 (allyl)), 56.30 (2C, O*C*H_3), 56.0 (br *d*, $^2J_{P,C}$ = 2.9 Hz, *C*H_2 (allyl)).

<u>^{31}P{^{1}H} NMR</u> (162 MHz, $CDCl_3$)

	δ 30.4 (*s*).
IR (cm^{-1})	ATR (neat)
	3097, 3028, 3011, 2977, 2943, 2841, 1583, 1566, 1480, 1467, 1458, 1436, 1428, 1393, 1386, 1330, 1295, 1275, 1260, 1253, 1223, 1189, 1141, 1098, 1028, 1017, 998, 992, 974, 936, 921, 896, 880, 863, 848.
HRMS (ESI)	Calcd. for $C_{29}H_{28}O_2PPd$ *m/z* 545.0856, Found: 545.0873 $[M\text{-}OTf]^+$.
Analysis	$C_{30}H_{28}F_3O_5PPdS$:
	Calcd. C, 51.85; H, 4.06; P, 4.46
	Found: C, 51.80; H, 4.03; P, 4.22.

[Pd(allyl)(RockPhos)]OTf (Catalyst 7)



Prepared in analogy to a literature procedure.(*54*) Silver trifluoromethanesulfonate (771 mg, 3.00 mmol, 1.00 equiv) was added to allylpalladium(II) chloride dimer (549 mg, 1.50 mmol, 0.50 equiv) in THF (10 mL) and stirred at rt for 1 h under the exclusion of light. The solution was filtered with THF (10 mL) through Celite in a fritted glass filter. RockPhos (1.41 g, 3.00 mmol) was added and stirred at rt for 2 h. Heptane (15 mL) was added and THF was removed under reduced pressure. The resulting precipitate was filtered through fritted glass filterand washed with pentane (2 × 10 mL) and dried under Schlenk line vacuum to afford the product as a light brown solid. Yield: 2.10 g (92%).

<u>m.p.</u> 175 °C (d)

<u>^{1}H NMR</u> (400 MHz, $CDCl_3$)

δ 7.48 (*d*, $^4J_{H,H'}$ = 1.7 Hz, 1H, Ar-*H*), 7.41 (*d*, $^4J_{H,H'}$ = 1.7 Hz, 1H, Ar-*H*), 7.36 (*d*, $^3J_{H,H'}$ = 8.3 Hz, 1H, Ar-*H*), 7.03 (*dd*, $^3J_{H,H'}$ = 8.3 Hz, $^4J_{P,H}$ = 2.3 Hz, 1H, Ar-*H*), 5.72 – 5.54 (*m*, 1H, C*H* (allyl)), 4.53 – 4.47 (*m*, 1H, C*H*H (allyl)), 3.92 (*s*, 3H, OCH_3 (3H)), 3.47 – 3.39 (*m*, 1H, C*H*H (allyl)), 3.04 (*dd*, $^3J_{H,H'}$ = 7.0, 7.0 Hz, 1H, C*H*), 2.94 – 2.87 (*m*, 1H, C*H*H (allyl)), 2.67 (*dd*, $^3J_{H,H'}$ = 6.7, 6.7 Hz, 1H, C*H*), 2.43 – 2.24 (*m*, 2H, C*H* + C*H*H (allyl)), 1.45 (*d*, $^3J_{P,H}$ = 15.6 Hz, 9H, CH_3), 1.41 – 1.34 (*m*, 15H, CH_3), 1.32 (*d*, $^3J_{H,H'}$ = 7.0 Hz, 3H, CH_3), 1.30 (*d*, $^3J_{H,H'}$ = 6.7 Hz, 3H, CH_3), 1.13 (*s*, 3H, CH_3), 1.01 (*d*, $^3J_{H,H'}$ = 6.7 Hz, 3H, CH_3), 0.88 (*d*, $^3J_{H,H'}$ = 6.7 Hz, 3H, CH_3).

<u>^{13}C{^{1}H} NMR</u> (101 MHz, $CDCl_3$)

δ159.9 (*d*, $^2J_{P,C}$ = 1.5 Hz, arom.), 154.8 (arom.), 154.6 (arom.), 151.4 (arom.), 146.7 (*d*, $^2J_{P,C}$ = 22.4 Hz, arom.), 137.1 (*d*, $^5J_{P,C}$ = 1.8 Hz, arom.), 132.2 (*d*, $^3J_{P,C}$ = 11.7 Hz, arom.), 125.8 (*d*, $^3J_{P,C}$ = 24.2 Hz, arom.), 124.1 (*d*, $^4J_{P,C}$ = 22.4 Hz, arom.), 121.0 (*d*, $^1J_{P,C}$ = 322.2 Hz, arom.), 120.0 (*d*, $^2J_{P,C}$ = 5.5 Hz, *C*H (allyl)),

116.1 (*d*, $^{3}J_{P,C}$ = 3.7 Hz, arom.), 111.9 (*d*, $^{5}J_{P,C}$ = 3.7 Hz, arom.), 98.9 (*d*, $^{2}J_{P,C}$ = 26.8 Hz, *C*H_2 (allyl)), 59.3 (*d*, $^{2}J_{P,C}$ = 2.9 Hz, *C*H_2 (allyl)), 54.5 (O*C*H_3), 40.2 (*d*, $^{1}J_{P,C}$ = 14.7 Hz, *C*(CH_3)), 39.5 (*d*, $^{1}J_{P,C}$ = 14.3 Hz, *C*(CH_3)),34.1 (*C*H), 32.3 (*d*, $^{2}J_{P,C}$ = 6.2 Hz, 3C, C(*C*H_3)), 32.02 (*C*H), 31.98 (*d*, $^{2}J_{P,C}$ = 6.2 Hz, 3C, C(*C*H_3)), 31.8 (*C*H), 27.0 (*C*H_3), 26.6 (*C*H_3), 24.7 (*C*H_3), 24.5 (*C*H_3), 24.25 (*C*H_3), 24.22 (*C*H_3), 19.0 (*C*H_3).

<u>$^{31}P\{^{1}H\}$ NMR</u> (162 MHz, $CDCl_3$)

δ 85.2 (*s*).

<u>IR (cm^{-1})</u> ATR (neat)

3085, 3028, 2970, 2930, 2868, 1773, 1598, 1586, 1566, 1533, 1482, 1457, 1432, 1418, 1399, 1390, 1365, 1351, 1307, 1274, 1261, 1222, 1171, 1141, 1086, 1065, 1055, 1028, 1007, 973, 961, 937, 888, 882, 842, 814.

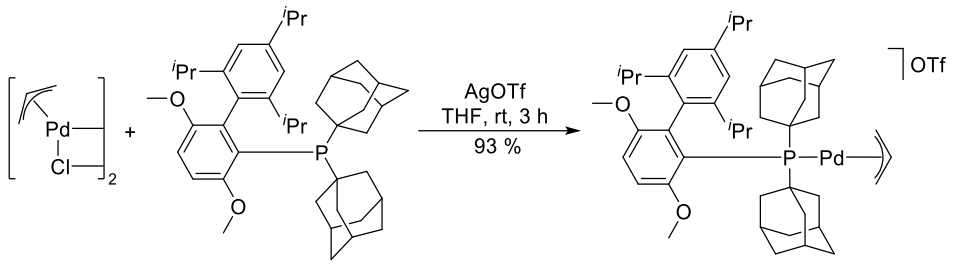
<u>HRMS (ESI)</u> Calcd. for $C_{34}H_{54}OPPd$ *m*/*z* 615.2942, Found: 615.2959 $[M\text{-}OTf]^{+}$.

<u>Analysis</u> $C_{35}H_{54}F_3O_4PPdS$:

Calcd. C, 54.93; H, 7.11; P, 4.05

Found: C, 55.20; H, 7.15; P, 4.00.

[Pd(allyl)(Ad-BrettPhos)]OTf (Catalyst 8)



Prepared in analogy to a literature procedure.(*54*) Silver trifluoromethanesulfonate (983 mg, 3.83 mmol, 1.00 equiv) was added to allylpalladium(II) chloride dimer (700 mg, 1.91 mmol, 0.50 equiv) in THF (10 mL) and stirred at rt for 1 h under the exclusion of light. The solution was filtered with THF (10 mL) through Celite in a fritted glass filter. Ad-BrettPhos (2.45 g, 3.83 mmol) in THF (15 mL) was added and stirred at rt for 2 h. Heptane (40 mL) was added and THF was removed under reduced pressure. The resulting precipitate was filtered through fritted glass filter and washed with pentane (2 × 10 mL) and dried under Schlenk line vacuum to afford the product as a brown solid, which contains 0.36 equiv of THF. Yield: 3.43 g (93%).

<u>m.p.</u> 180 °C (d).

<u>^{1}H NMR</u> (400 MHz, $CDCl_3$)

δ 7.39 (*d*, $^4J_{H,H'}$ = 1.6 Hz, 1H, Ar-*H*), 7.34 (*d*, $^4J_{H,H'}$ = 1.6 Hz, 1H, Ar-*H*), 7.17 (*dd*, $^3J_{H,H'}$ = 8.7 Hz, $^4J_{P,H}$ = 2.7 Hz, 1H, Ar-*H*), 7.03 (*d*, $^3J_{H,H'}$ = 8.7 Hz, 1H, Ar-*H*), 5.66 – 5.51 (*m*, 1H, C*H* (allyl)), 4.56 – 4.50 (*m*, 1H, C*H*H (allyl)), 3.94 (*s*, 3H, OCH_3 (3H)), 3.43 – 3.35 (*m*, 1H, C*H*H (allyl)), 3.38 (*s*, 3H, OCH_3 (3H)), 3.03 (*dd*, $^3J_{H,H'}$ = 6.9, 6.9 Hz, 1H, C*H*), 2.88 – 2.81 (*m*, 1H, C*H*H (allyl)), 2.62 (*dd*, $^3J_{H,H'}$ = 6.7, 6.7 Hz, 1H, C*H*), 2.34 – 1.92 (*m*, 20H, C*H* (7H) + C*H*H (12H) + C*H*H (1H, allyl)), 1.77 – 1.64 (*m*, 12H, C*H*H).

<u>^{13}C{^{1}H} NMR</u> (101 MHz, $CDCl_3$)

δ 157.1 (arom.), 154.7 (*d*, $^3J_{P,C}$ = 1.8 Hz, arom), 154.5 (arom.), 152.5 (arom.), 151.5 (*d*, $^2J_{P,C}$ = 15.8 Hz, arom), 136.9 (*d*, $^1J_{P,C}$ = 23.5 Hz, arom), 125.8 (arom.), 125.3 (arom.), 124.5 (*d*, $^2J_{P,C}$ = 20.5 Hz, arom), 119.2 (*d*, $^2J_{P,C}$ = 5.5 Hz, *C*H (allyl)), 115.3 (*d*, $^4J_{P,C}$ = 1.8 Hz, arom), 112.7 (*d*, $^3J_{P,C}$ = 4.0 Hz, arom), 100.0 (*d*, $^2J_{P,C}$ = 27.1 Hz, *C*H_2 (allyl)), 111.9 (*d*, $^3J_{P,C}$ = 4.8 Hz, arom), 58.0 (*d*, $^2J_{P,C}$

= 2.9 Hz, *C*H_2 (allyl)), 54.68 (O*C*H_3), 54.66 (O*C*H_3), 45.4 (*d*, $^1J_{P,C}$ = 11.4 Hz, P*C*), 44.6 (*d*, $^1J_{P,C}$ = 10.6 Hz, P*C*), 42.2 (*d*, $^2J_{P,C}$ = 1.8 Hz, 3C, *C*H_2), 41.9 (*d*, $^2J_{P,C}$ = 1.8 Hz, 3C, *C*H_2), 36.20 (3C, *C*H_2), 36.16 (3C, *C*H_2), 34.0 (*C*H), 32.0 (*C*H), 31.6 (*C*H), 29.2 (*d*, $^3J_{P,C}$ = 9.5 Hz, 3C, *C*H), 29.0 (*d*, $^3J_{P,C}$ = 9.5 Hz, 3C, *C*H), 26.0 (*C*H_3), 25.4 (*C*H_3), 24.8 (*C*H_3), 24.6 (*C*H_3), 24.3 (*C*H_3), 24.2 (*C*H_3).

$^{31}P\{^1H\}$ NMR (162 MHz, $CDCl_3$)

δ 88.9 (*s*).

IR (cm^{-1}) ATR (neat)

2905, 2854, 1600, 1578, 1534, 1463, 1423, 1384, 1362, 1346, 1297, 1261, 1222, 1176, 1151, 1090, 1065, 1047, 1028, 1013, 975, 936, 882, 843, 822.

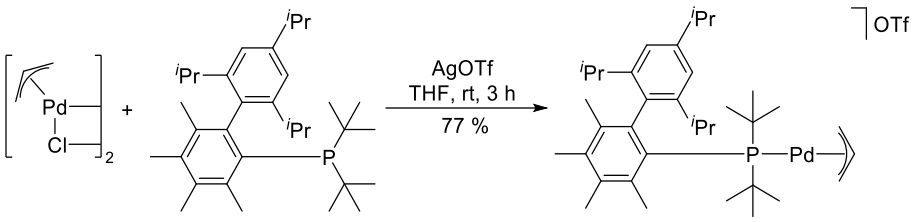
HRMS (ESI) Calcd. for $C_{46}H_{66}O_2PPd$ *m/z* 787.3830, Found: 787.3845 $[M\text{-}OTf]^+$.

Analysis $C_{47}H_{66}F_3O_2PPdS$

Calcd. 0.36 THF: C, 60.38; H, 7.33; P, 3.21

Found: C, 60.20; H, 7.28; P, 2.93.

[Pd(allyl)(Me$_4$-^{t}Bu-XPhos)]OTf (Catalyst 9)



Prepared in analogy to a literature procedure.(*54*) Silver trifluoromethanesulfonate (771 mg, 3.00 mmol, 1.00 equiv) was added to allylpalladium(II) chloride dimer (549 mg, 1.50 mmol, 0.50 equiv) in THF (10 mL) and stirred at rt for 1 h under the exclusion of light. The solution was filtered with THF (10 mL) through Celite in a fritted glass filter. Me$_4$-^{t}Bu-XPhos (1.44 g, 3.00 mmol) in THF (5 mL) was added and stirred at rt for 2 h. Heptane (15 mL) was added and THF was removed under reduced pressure. The resulting precipitate was filtered through fritted glass filter and washed with pentane (2 × 10 mL) and hot TBME (2 × 10 mL) and dried under Schlenk line vacuum to afford the product as a yellow solid. Yield: 1.79 g (77%).

<u>m.p.</u> 180 °C (d)

<u>^{1}H NMR</u> (400 MHz, $CDCl_3$)

δ 7.46 (*d*, $^4J_{H,H'}$ = 1.9 Hz, 1H, Ar-*H*), 7.39 (*d*, $^4J_{H,H'}$ = 1.9 Hz, 1H, Ar-*H*), 5.72 – 5.60 (*m*, 1H, C*H* (allyl)), 4.63 – 4.59 (*m*, 1H, C*H*H (allyl)), 3.41 – 3.33 (*m*, 1H, C*H*H (allyl)), 3.06 (*dd*, $^3J_{H,H'}$ = 6.9, 6.9 Hz, 1H, C*H*), 3.02 – 2.95 (*m*, 1H, C*H*H (allyl)), 2.66 (*dd*, $^3J_{H,H'}$ = 7.1, 7.1 Hz, 1H, C*H*), 2.61 (*s*, 3H, C*H*$_3$), 2.36 (*dd*, $^3J_{H,H'}$ = 6.9, 6.9 Hz, 1H, C*H*), 2.30 (*s*, 3H, C*H*$_3$), 2.20 – 2.14 (*m*, 1H, C*H*H (allyl)), 2.18 (*s*, 3H, C*H*$_3$), 1.51 (*d*, $^3J_{P,H}$ = 15.3 Hz, 9H, C*H*$_3$), 1.46 (*d*, $^3J_{P,H}$ = 15.3 Hz, 9H, C*H*$_3$), 1.37 (*d*, $^3J_{H,H'}$ = 6.9 Hz, 3H, C*H*$_3$), 1.37 (*d*, $^3J_{H,H'}$ = 6.9 Hz, 3H, C*H*$_3$), 1.29 (*d*, $^3J_{H,H'}$ = 7.1 Hz, 3H, C*H*$_3$), 0.93 (*d*, $^3J_{H,H'}$ = 6.7 Hz, 3H, C*H*$_3$), 0.88 (*s*, 3H, C*H*$_3$), 0.79 (*d*, $^3J_{H,H'}$ = 6.7 Hz, 3H, C*H*$_3$).

<u>^{13}C{^{1}H} NMR</u> (101 MHz, $CDCl_3$)

δ 155.0 (arom.), 154.6 (arom.), 151.4 (arom.), 143.2 (*d*, $^2J_{P,C}$ = 27.9 Hz, arom), 141.4 (*d*, $^4J_{P,C}$ = 2.2 Hz, arom), 139.2 (arom.), 138.4 (*d*, $^3J_{P,C}$ = 5.9 Hz, arom), 137.1 (*d*, $^3J_{P,C}$ = 13.6 Hz, arom), 133.6 (*d*, $^2J_{P,C}$ = 21.3 Hz, arom), 125.6 (arom.), 125.5 (arom.), 121.0 (*d*, $^1J_{P,C}$ = 322.5 Hz, arom), 120.1 (*d*, $^2J_{P,C}$ = 6.2 Hz, *C*H

(allyl)), 116.2 (*d*, $^{3}J_{P,C}$ = 3.7 Hz, arom.), 98.2 (*d*, $^{2}J_{P,C}$ = 27.9 Hz, *C*H_2 (allyl)), 62.9 ((*d*, $^{2}J_{P,C}$ = 4.0 Hz, *C*H_2 (allyl)), 40.9 (*d*, $^{1}J_{P,C}$ = 10.3 Hz, P*C*), 40.1 (*d*, $^{1}J_{P,C}$ = 10.3 Hz, P*C*), 34.1 (*C*H), 33.4 (*d*, $^{2}J_{P,C}$ = 7.0 Hz, 3C, *C*H_3), 32.9 (*d*, $^{2}J_{P,C}$ = 7.0 Hz, 3C, *C*H_3), 32.2 (*C*H), 32.1 (*C*H), 26.9 (*C*H_3), 26.4 (*C*H_3), 26.2 (*C*H_3), 24.8 (*C*H_3), 24.6 (*C*H_3), 24.4 (*C*H_3), 24.3 (*C*H_3), 18.7 (*C*H_3), 17.5 (*C*H_3), 17.3 (*C*H_3).

<u>$^{31}P\{^{1}H\}$ NMR</u> (162 MHz, $CDCl_3$):

δ 93.8 (*s*).

<u>IR (cm^{-1})</u> ATR (neat)

3096, 3017, 2974, 2959, 2928, 2869, 1597, 1540, 1457, 1421, 1403, 1387, 1369, 1361, 1318, 1308, 1264, 1221, 1150, 1109, 1082, 1070, 1054, 1030, 970, 950, 939, 904, 882, 803.

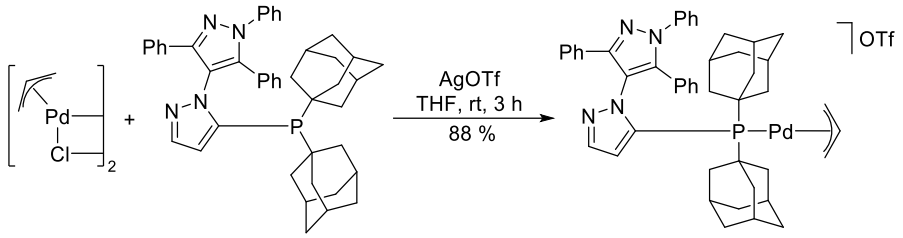
<u>HRMS (ESI)</u> Calcd. for $C_{36}H_{58}PPd$ *m*/*z* 627.3305, Found: 627.3336 $[M\text{-}OTf]^{+}$.

<u>Analysis</u> $C_{37}H_{58}F_3O_3PPdS$:

Calcd. C, 57.17; H, 7.52; P, 3.98

Found: C, 57.40; H, 7.54; P, 3.90.

[Pd(allyl)(Ad-BippyPhos)]OTf (Catalyst 10)



Prepared in analogy to a literature procedure.(*54*) Silver trifluoromethanesulfonate (1.29 g, 5.00 mmol, 1.00 equiv) was added to allylpalladium(II) chloride dimer (915 mg, 2.50 mmol, 0.50 equiv) in THF (10 mL) and stirred at rt for 1 h under the exclusion of light. The solution was filtered with THF (10 mL) through Celite in a fritted glass filter. Ad-BippyPhos (3.31 g, 5.00 mmol) was added and stirred at rt for 2 h. Pentane (40 mL) was added and stirred at rt for 0.5 h. The resulting precipitate was filtered through fritted glass filter and washed with pentane (2 × 10 mL) and dried under Schlenk line vacuum to afford the product as an off-white solid, which contains 0.52 equiv of THF. Yield: 4.42 g (88%).

<u>m.p.</u> 210 °C (d)

<u>^{1}H NMR</u> (400 MHz, $CDCl_3$)

δ 8.26 – 8.17 (*m*, 1H, Ar-*H*), 7.53 – 7.27 (*m*, 15H, Ar-*H*), 6.68 – 6.76 (*m*, 1H, Ar-*H*), 6.34 – 6.19 (*m*, 1H, C*H* (allyl), major), 6.04 – 5.89 (*m*, 1H, C*H* (allyl), minor), 4.74 – 4.61 (*m*, 1H, C*H*H (allyl)), 4.58 – 4.48 (*m*, 1H, C*H*H (allyl)), 4.12 – 4.05 (*m*, 1H, C*H*H (allyl), minor), 3.92 – 3.82 (*m*, 1H, C*H*H (allyl), major), 3.60 (br *d*, $^3J_{H,H'}$ = 12.4 Hz, 1H, C*H*H (allyl), minor), 3.09 (br *d*, $^3J_{H,H'}$ = 12.6 Hz, 1H, C*H*H (allyl), major), 1.72 – 1.14 (*m*, 30H, C*H* (6H) + C*H*H (24H)).

<u>^{13}C{^{1}H} NMR</u> (101 MHz, $CDCl_3$)

δ 156.4 (arom., major), 154.6 (arom., minor), 150.6 (arom., minor), 147.6 (arom., major), 146.2 (arom., major), 146.1 (arom., major), 145.9 (arom., minor), 145.8 (arom., minor), 140.0 (*d*, $^1J_{P,C}$ = 39.0 Hz, arom., major), 139.9 (*d*, $^1J_{P,C}$ = 38.3 Hz, arom., minor), 137.8 (arom., minor), 137.7 (arom., major), 131.2 (arom., major), 131.1 (arom., minor), 130.5 (arom., major), 130.2 (arom., 2C (major) + 1C (minor)) 130.1 (2C, arom., minor), 129.68 (arom., minor),

129.61 (2C, arom., major), 129.55 (2C, arom., minor), 129.5 (arom., minor), 129.4 (2C, arom., major), 129.34 (arom., minor), 129.32 (arom., major), 129.1 (2C, arom., major), 128.8 (2C, arom., minor), 128.2 (2C, arom., minor), 127.9 (2C, arom., major), 125.9 (arom., major), 125.7 (arom., minor), 125.4 (2C, arom., minor), 124.7 (2C, arom., major), 122.3 (*d*, $^{2}J_{P,C}$ = 5.8 Hz, *C*H (allyl), minor), 122.0 (*d*, $^{1}J_{P,C}$ = 5.8 Hz, *C*H (allyl), major), 121.0 (*q*, $^{1}J_{F,C}$ = 321.2 Hz, *C*F_3), 115.5 – 115.4 (*m*, arom.), 104.4 (arom., major), 104.3 (arom., minor), 94.0 (*d*, $^{2}J_{P,C}$ = 25.4 Hz, *C*H_2 (allyl), minor), 90.3 (*d*, $^{2}J_{P,C}$ = 24.7 Hz, *C*H_2 (allyl), major), 57.6 (*C*H_2 (allyl), minor), 56.5 (*C*H_2 (allyl), minor), 40.9 (*d*, $^{1}J_{P,C}$ = 15.0 Hz, P*C*, major), 40.6 (*d*, $^{1}J_{P,C}$ = 15.4 Hz, P*C*, major), 40.42 (3C, *C*H_2, minor), 40.39 (*d*, $^{1}J_{P,C}$ = 16.0 Hz, P*C*), 40.1 (3C, *C*H_2, major), 40.0 (3C, *C*H_2, major), 39.9 (3C, *C*H_2, minor), 35.65 (3C, *C*H_2, major), 35.62 (3C, *C*H_2, minor), 35.48 (3C, *C*H_2, minor), 35.4 (3C, *C*H_2, major), 28.13 (3C, *C*H), 28.07 (3C, *C*H).

<u>$^{31}P\{^{1}H\}$ NMR</u> (162 MHz, $CDCl_3$)

δ 48.4 (*s*, major), 47.5 (*s*, minor).

<u>IR (cm^{-1})</u> ATR (neat)

3074, 2903, 2850, 1593, 1579, 1517, 1494, 1462, 1445, 1404, 1385, 1353, 1342, 1317, 1258, 1223, 1181, 1151, 1104, 1075, 1061, 1048, 1027, 1000, 972, 954, 940, 921, 845, 830, 806.

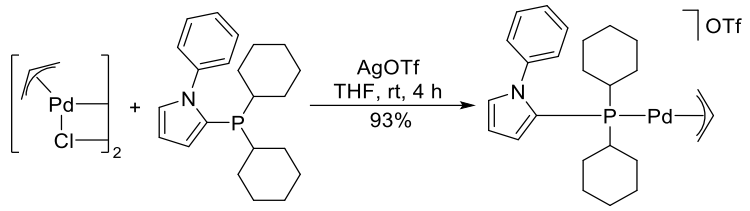
<u>HRMS (ESI)</u> Calcd. for $C_{47}H_{52}N_4PPd$ *m/z* 809.2959, Found: 808.2978 $[M\text{-}OTf]^+$.

<u>Analysis</u> $C_{48}H_{52}F_3N_4O_3PPdS$ ·

Calcd. 0.52 THF: C, 60.34; H, 5.69; N, 5.62; P, 3.10

Found: C, 60.42; H, 5.67; N, 5.66; P, 3.11.

[Pd(allyl)(cataCXium PCy)]OTf (Catalyst 11)



Prepared in analogy to a literature procedure.(*54*) cataCXium PCy (1.10 g, 3.23 mmol) was added to allylpalladium(II) chloride dimer (591 mg, 1.62 mmol, 0.50 equiv) in THF (20 mL) and stirred at rt for 2 h. Silver trifluoromethanesulfonate (830 mg, 3.23 mmol, 1.00 equiv) was added and stirred at rt for 2 h under the exclusion of light. The solution was filtered with THF (10 mL) through Celite in a fritted glass filter and concentrated to ca. 15 mL under reduced pressure. Pentane (60 mL) was added and stirred at rt for 0.5 h. The resulting precipitate was filtered through fritted glass filter and washed with pentane (2 × 10 mL) and dried under Schlenk line vacuum to afford the product as a light-yellow solid. Yield: 1.92 g (93%).

m.p.	185 °C (d)
^{1}H NMR	(400 MHz, $CDCl_3$)
	δ 7.75 – 7.66 (*m*, 2H, Ar-*H*), 7.49 – 7.43 (*m*, 1H, Ar-*H*), 7.42 – 7.36 (*m*, 2H, Ar-*H*), 7.08 – 7.04 (*m*, 2H, Ar-*H*), 6.70 – 6.66 (*m*, 1H, Ar-*H*), 6.49 – 6.46 (*m*, 2H, Ar-*H*), 5.12 – 5.02 (*m*, 1H, C*H* (allyl)), 4.87 (br *s*, 1H, C*H*H (allyl)), 3.60 (br *s*, 1H, C*H*H (allyl)), 2.24 (br *s*, 1H, C*H*H (allyl)), 2.19 – 2.05 (*m*, 2H, PC*H*), 1.87 – 1.84 (*m*, 10H, C*H*H), 1.47 – 1.03 (*m*, 10H, C*H*H).
^{13}C{^{1}H} NMR	(101 MHz, $CDCl_3$)
	δ 141.4 (*d*, $^3J_{P,C}$ = 1.5 Hz, arom.), 131.4 (2C, arom.), 128.6 (*d*, $^3J_{P,C}$ = 3.3 Hz, arom.), 127.1 (arom.), 120.8 (2C, arom.), 120.1 (*d*, $^4J_{P,C}$ = 2.2 Hz, arom.), 119.7 (*d*, $^1J_{P,C}$ = 50.6 Hz, arom.), 116.5 (*d*, $^2J_{P,C}$ = 5.1 Hz, *C*H (allyl)), 110.9 (*d*, $^2J_{P,C}$ = 6.2 Hz, arom.), 88.3 (br *s*, *C*H_2 (allyl)), 52.7 (br *s*, *C*H_2 (allyl)), 36.2 (br *d*, $^1J_{P,C}$ = 26.0 Hz, 2C, PC*H*), 29.6 – 29.4 (*m*, 2C, *C*H_2), 27.6 (br *s*, 2C, *C*H_2), 26.8 (*d*, $^3J_{P,C}$ = 7.0 Hz, *C*H_2), 26.7 (*d*, $^3J_{P,C}$ = 10.3 Hz, *C*H_2), 25.8 (*C*H_2), 25.7 (*C*H_2).
^{31}P{^{1}H} NMR	(162 MHz, $CDCl_3$)
	δ 11.6 (*s*).
IR (cm^{-1})	ATR (neat)

3100, 2926, 2849, 1586, 1577, 1511, 1484, 1447, 1419, 1389, 1330, 1318, 1297, 1264, 1223, 1212, 1183, 1172, 1147, 1135, 1090, 1069, 1052, 1029, 1009, 964, 937, 918, 904, 889, 880, 857, 848, 825, 818.

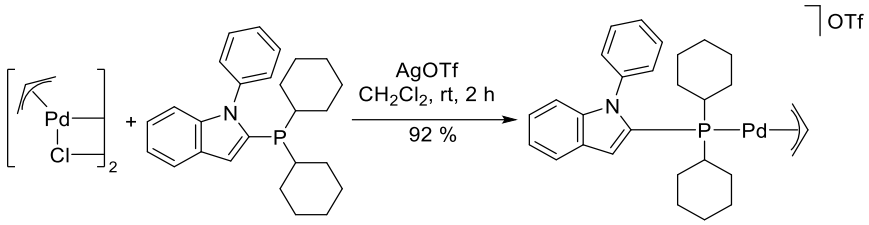
HRMS (ESI) Calcd. for $C_{25}H_{35}NPPd$ *m/z* 486.1536, Found: 486.1548 $[M\text{-}OTf]^+$.

Analysis $C_{26}H_{35}F_3NO_3PPdS$:

Calcd. C, 49.10; H, 5.55; N, 2.20; P, 4.87

Found: C, 49.10; H, 5.54; N, 2.17; P, 4.70

[Pd(allyl)(cataCXium PInCy)]OTf (Catalyst 12)



Prepared in analogy to a literature procedure.(*54*) cataCXium PInCy (974 g, 2.50 mmol) was added to allylpalladium(II) chloride dimer (457 mg, 1.25 mmol, 0.50 equiv) in CH_2Cl_2 (15 mL) and stirred at rt for 1 h. Silver trifluoromethanesulfonate (642 mg, 2.50 mmol, 1.00 equiv) was added and stirred at rt for 1 h under the exclusion of light. The solution was filtered with CH_2Cl_2 (10 mL) through Celite in a fritted glass filter. Heptane (25 mL) was added and CH_2Cl_2 was removed under reduced pressure. The resulting precipitate was filtered through fritted glass filter and washed with pentane (2 × 10 mL) and dried under Schlenk line vacuum to afford the product as a yellow solid. Yield: 1.58 g (92%).

<u>m.p.</u> 170 °C (d)

<u>^{1}H NMR</u> (400 MHz, $CDCl_3$)

δ 7.81 – 7.69 (*m*, 3H, Ar-*H*), 7.57 – 7.50 (*m*, 1H, Ar-*H*), 7.44 (br *s*, 2H, Ar-*H*), 7.28 – 7.21 (*m*, 2H, Ar-*H*), 7.14 – 7.08 (*m*, 1H, Ar-*H*), 7.02 (*d*, $^4J_{H,H'}$ = 1.1 Hz, 1H, Ar-*H*), 5.30 – 5.19 (*m*, 1H, C*H* (allyl)), 4.97 (br *s*, 1H, C*H*H (allyl)), 3.61 (br *s*, 1H, C*H*H (allyl)), 3.50 (br *s*, 1H, C*H*H (allyl)), 2.35 (br *s*, 1H, C*H*H (allyl)), 2.18 (br *s*, 2H, PC*H*), 1.88 – 1.76 (*m*, 8H, C*H*H), 1.73 – 1.64 (*m*, 2H, C*H*H), 1.57 – 1.43 (*m*, 2H, C*H*H), 1.36 – 1.06 (*m*, 8H, C*H*H).

<u>^{13}C{^{1}H} NMR</u> (101 MHz, $CDCl_3$)

δ 140.4 (*d*, $^3J_{P,C}$ = 4.0 Hz, arom.), 138.90 (arom.), 138.88 (arom.), 131.5 – 130.7 (*m*, 2C, arom.), 127.9 (*d*, $^2J_{P,C}$ = 40.9 Hz, arom.), 127.7 (arom.), 127.6 (*d*, $^4J_{P,C}$ = 4.0 Hz, arom.), 124.4 (arom.), 121.5 (arom.), 121.3 (arom.), 121.1 (*d*, $^1J_{P,C}$ = 321.8 Hz, arom.), 116.7 (*d*, $^2J_{P,C}$ = 4.8 Hz, *C*H (allyl)), 113.2 (*d*, $^5J_{P,C}$ = 2.2 Hz, arom.), 111.1 (*d*, $^5J_{P,C}$ = 1.5 Hz, arom.), 88.8 (br *s*, *C*H_2 (allyl)), 52.8 (br *s*, *C*H_2 (allyl)), 36.3 – 35.9 (*m*, 2C, P*C*H) 29.6 (br *d*, $^3J_{P,C}$ = 3.7 Hz, 2C, *C*H_2), 27.7

(2C, *C*H_2) 26.9 – 26.8 (*m*, 2C, *C*H_2) 26.7 (*d*, $^3J_{P,C}$ = 4.8 Hz, 2C, *C*H_2), 25.7 (br *s*, 2C, *C*H_2).

$^{31}P\{^1H\}$ NMR (162 MHz, $CDCl_3$)

δ 13.8 (*s*).

IR (cm^{-1}) ATR (neat)

3111, 3083, 2924, 2853, 1610, 1584, 1564, 1503, 1486, 1472, 1447, 1432, 1389, 1367, 1347, 1309, 1260, 1222, 1205, 1180, 1147, 1114, 1081, 1072, 1047, 1027, 1001, 969, 941, 917, 887, 857, 852, 836, 825.

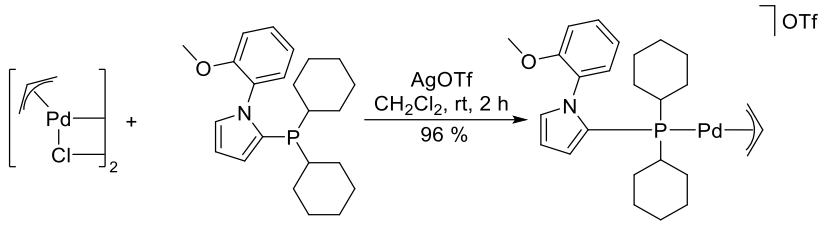
HRMS (ESI) Calcd. for $C_{29}H_{37}NPPd$ *m*/*z* 536.1693, Found: 536.1709 $[M\text{-}OTf]^+$.

Analysis $C_{30}H_{37}F_3NO_3PPdS$:

Calcd. C, 52.52; H, 5.44; N, 2.04; P, 4.51

Found: C, 52.57; H, 5.34; N, 2.04; P, 4.44.

[Pd(allyl)(cataCXium POMeCy)]OTf (Catalyst 13)



Prepared in analogy to a literature procedure.(*54*) cataCXium POMeCy (1.31 g, 3.55 mmol) was added to allylpalladium(II) chloride dimer (650 mg, 1.78 mmol, 0.50 equiv) in CH_2Cl_2 (10 mL) and stirred at rt for 1 h. Silver trifluoromethanesulfonate (913 mg, 3.55 mmol, 1.00 equiv) was added and stirred at rt for 1 h under the exclusion of light. The solution was filtered with CH_2Cl_2 (10 mL) through Celite in a fritted glass filter. Heptane (20 mL) was added and CH_2Cl_2 was removed under reduced pressure. The resulting precipitate was filtered through fritted glass filter and washed with pentane (2 × 10 mL) and dried under Schlenk line vacuum to afford the product as a light yellow solid. Yield: 2.27 g (96%).

<u>m.p.</u> 185 °C (d)

<u>^{1}H NMR</u> (400 MHz, $CDCl_3$)

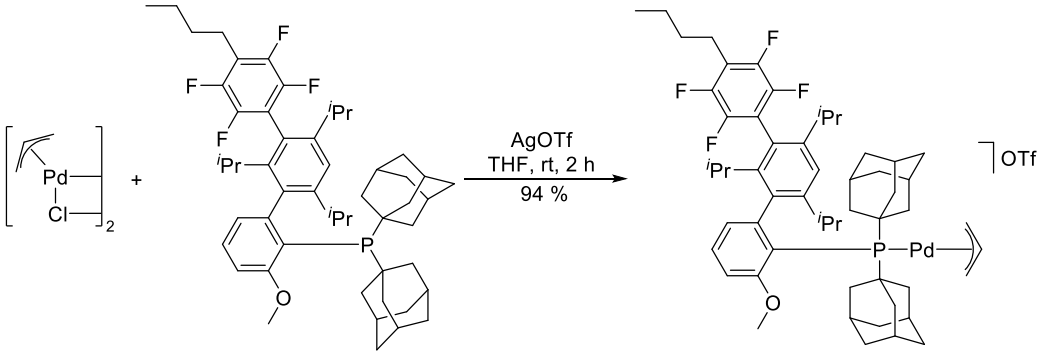
δ 7.50 – 7.44 (*m*, 1H, Ar-*H*), 7.41 – 7.35 (*m*, 1H, Ar-*H*), 7.29 (*d*, $^3J_{H,H'}$ = 6.7 Hz, 1H, Ar-*H*), 7.19 (*d*, $^3J_{H,H'}$ = 8.1 Hz, 1H, Ar-*H*), 6.92 (br *s*, 1H, Ar-*H*), 6.65 – 6.61 (*m*, 1H, Ar-*H*), 6.47 – 6.44 (*m*, 1H, Ar-*H*), 5.25 (br *s*, 1H, C*H* (allyl)), 4.66 (br *s*, 1H, C*H*H (allyl)), 3.83 (*s*, 3H, OCH_3), 3.50 (br *s*, 1H, C*H*H (allyl)), 2.74 (br *s*, 1H, C*H*H (allyl)), 2.17 (br *s*, 3H, PC*H* (2H) + C*H*H (1H, allyl)), 1.95 – 1.58 (*m*, 10H, C*H*H), 1.49 – 0.97 (*m*, 10H, C*H*H).

<u>^{13}C{^{1}H} NMR</u> (101 MHz, $CDCl_3$)

δ 155.2 (arom.), 129.8 (arom.), 129.6 (*d*, $^3J_{P,C}$ = 3.7 Hz, arom.), 127.1 (arom.), 122.3 (arom.), 120.7 (*d*, $^2J_{P,C}$ = 53.2 Hz, arom.), 120.3 (*d*, $^1J_{P,C}$ = 321.2 Hz, arom.), 119.2 (*d*, $^4J_{P,C}$ = 3.3 Hz, arom.), 117.2 (br *s*, *C*H (allyl)), 114.2 (br *s*, arom.), 110.8 (br *d*, $^3J_{P,C}$ = 4.8 Hz, arom.), 91.7 (br *s*, *C*H_2 (allyl)), 56.0 (O*C*H_3), 51.5 (br *s*, *C*H_2 (allyl)), 36.2 (2C, P*C*H), 29.9 – 28.8 (*m*, 2C, *C*H_2), 27.9 (br *s*, 2C, *C*H_2), 26.9 – 26.7 (*m*, 4C, *C*H_2), 25.8 (2C, *C*H_2).

$^{31}P\{^{1}H\}$ NMR	(162 MHz, $CDCl_3$)
	δ 15.3 (*s*, major), 13.0 (*s*, minor).
IR (cm^{-1})	ATR (neat)
	3133, 3078, 2925, 2850, 1575, 1514, 1491, 1463, 1451, 1446, 1436, 1418, 1392, 1347, 1328, 1297, 1271, 1257, 1221, 1195, 1181, 1152, 1137, 1117, 1091, 1054, 1028, 1015, 1004, 960, 936, 920, 889, 882, 854, 824, 810.
HRMS (ESI)	Calcd. for $C_{26}H_{37}NOPPd$ *m/z* 516.1642, Found: 516.1664 $[M\text{-}OTf]^+$.
Analysis	$C_{27}H_{37}F_3NO_4PPdS$:
	Calcd. C, 48.69; H, 5.60; N, 2.10; P, 4.65;
	Calcd. C, 48.60; H, 5.56; N, 2.07; P, 4.60.

[Pd(allyl)(AlPhos)]OTf (Catalyst 14)



Prepared in analogy to a literature procedure.(*54*) Silver trifluoromethanesulfonate (709 mg, 2.76 mmol, 1.00 equiv) was added to allylpalladium(II) chloride dimer (505 mg, 1.38 mmol, 0.50 equiv) in THF (10 mL) and stirred at rt for 1 h under the exclusion of light. The solution was filtered with THF (10 mL) through Celite in a fritted glass filter. AlPhos (2.25 g, 2.76 mmol) was added and stirred at rt for 2 h. Heptane (20 mL) was added and THF was removed under reduced pressure. The resulting precipitate was filtered through fritted glass filter and washed with pentane (2 × 10 mL) and dried under Schlenk line vacuum to afford the product as a light orange solid. Yield: 2.89 g (94%).

<u>m.p.</u> 155 °C (d)

<u>^{1}H NMR</u> (400 MHz, $CDCl_3$)

δ 7.73 (*s*, 1H, Ar-*H*, major), 7.70 (*s*, 1H, Ar-*H*, minor), 7.71 (*dd*, $^3J_{H,H'}$ = 8.1, 7.0 Hz, 1H, Ar-*H*), 7.16 (*d*, $^3J_{H,H'}$ = 8.1 Hz, 1H, Ar-*H*), 6.28 (*d*, $^3J_{H,H'}$ = 7.0 Hz, 1H, Ar-*H*), 5.94 – 5.81 (*m*, 1H, C*H* (allyl), minor), 5.68 – 5.54 (*m*, 1H, C*H* (allyl), major), 4.78 – 4.74 (*m*, 1H, C*H*H (allyl), minor), 4.64 – 4.58 (*m*, 1H, C*H*H (allyl), major), 4.01 (*s*, 3H, OCH_3), 3.87 – 3.80 (*m*, 1H, C*H*H (allyl), major), 3.50 – 3.42 (*m*, 1H, C*H*H (allyl), minor), 3.05 – 2.93 (*m*, 2H, C*H* (major) + C*H*H (1H, allyl) + C*H*H (1H, allyl, minor)), 2.86 – 2.78 (*m*, 2H, C*H*H), 2.73 – 2.61 (*m*, 1H, C*H*), 2.48 – 2.36 (*m*, 1H + 1H (major), C*H* (1H) + C*H*H (1H, allyl, major)), 2.36 – 2.28 (*m*, 1H (minor), C*H*), 2.26 – 1.86 (*m*, 18H, C*H* (6H) + C*H*H (12H)), 1.77 – 1.60 (*m*, 14H, C*H*H), 1.48 – 1.37 (*m*, 2H + 6H (minor), C*H*H (2H) + CH_3 (6H, minor)), 1.27 – 1.17 (*m*, 6H, CH_3), 1.03 – 0.83

(*m*, 6H + 6H (major), C*H*$_3$), 0.78 (*d*, $^3J_{H,H'}$ = 6.5 Hz, 3H, C*H*$_3$, minor), 0.67 (*d*, $^3J_{H,H'}$ = 5.9 Hz, 3H, C*H*$_3$, major).

<u>^{13}C{^{1}H} NMR</u> (151 MHz, dmso-d$_6$)

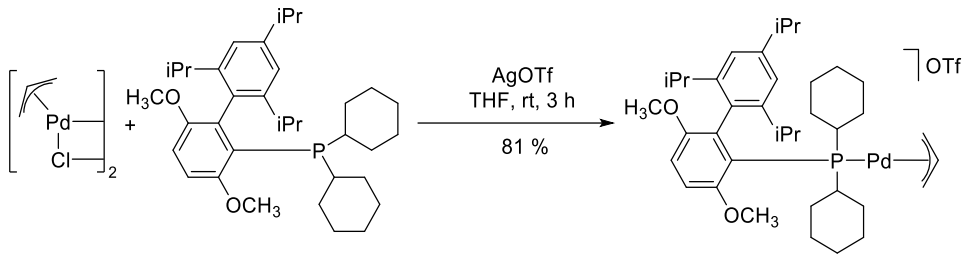
δ 161.6 (arom.), 154. 0 (arom., minor), 153.5 (arom., major), 152.8 (arom., minor), 152.6 (arom., major), 150.7 (arom., minor), 148.1 (arom., major), 147.1 (arom., major), 145.7 – 142.3 (*m*, 4C, arom.), 144.8 (arom., minor), 133.90 (arom., major), 133.86 (arom., minor), 127.7 (arom., major), 127.0 (arom.), 126.5 (arom., major), 125.4 (arom., minor), 124.4 (arom., minor), 122.3 (*C*H (allyl), major), 121.7 – 121.4 (*m*, 2C, arom.), 121.2 (arom., minor), 120.0 (*C*H (allyl), minor), 119.9 (arom., major), 115.8 – 115.1 (*m*, arom.), 111.57 (arom., major), 111.54 (arom., minor), 101.0 (*d*, *J* = 6.2 Hz, *C*H$_2$ (allyl), minor), 97.7 (*d*, *J* = 9.2 Hz, *C*H$_2$ (allyl), minor), 62.4 (*C*H$_2$ (allyl), minor), 59.5 (*C*H$_2$ (allyl), major), 55.75 (O*C*H$_3$, major), 55.74 (O*C*H$_3$, minor), 44.9 (P*C*, major), 44.6 (P*C*, minor), 43.8 (P*C*), 41.1 (*C*H$_2$, 3C, minor), 41.2 (*C*H$_2$, 3C, major), 41.1 (*C*H$_2$, 3C, minor), 40.9 (*C*H$_2$, 3C, major), 35.73 (*C*H$_2$, 6C, minor), 35.65 (*C*H$_2$, 6C, major), 32.8 (*C*H, major), 32.5 (*C*H, minor), 32.3 (*C*H, minor), 32.0 (*C*H$_2$), 30.7 (*C*H), 28.8 (3C, *C*H, major), 28.64 (3C, *C*H, minor), 28.61 (3C, *C*H, minor), 28.5 (3C, *C*H, minor), 25.4 (*C*H$_3$, minor), 25.0 (*C*H$_3$, minor), 24.9 (*C*H$_3$, major), 24.8 (*C*H$_3$, major), 23.5 (*C*H$_3$, minor), 23.39 (*C*H$_3$, major), 23.36 (*C*H$_3$, major), 23.2 (*C*H$_3$, minor), 23.1 (*C*H$_3$, minor), 22.6 (*C*H$_3$, major), 22.3 (*C*H$_2$), 22.0 (*d*, *J* = 2.3 Hz, 1H, *C*H$_3$, major), 21.6 (*d*, *J* = 2.5 Hz, 1H, *C*H$_2$), 21.1 (*d*, J_F = 2.5 Hz, 1H, *C*H$_3$, minor), 13.5 (*C*H$_3$).

<u>^{19}F{^{1}H} NMR</u> (376 MHz, CDCl$_3$)

δ -78.0 (*s*, 3F, C*F*$_3$), -135.8 (*dd*, $^3J_{F,F'}$ = 23.4 Hz, $^3J_{F,F'}$ = 13.0 Hz, 1F, Ar-*F*, major), -136.0 (*dd*, $^3J_{F,F'}$ = 23.4 Hz, $^3J_{F,F'}$ = 13.0 Hz, 1F, Ar-*F*, major), -137.0 (*dd*, $^3J_{F,F'}$ = 24.3 Hz, $^3J_{F,F'}$ = 12.1 Hz, 1F, Ar-*F*, minor), -138.7 (*dd*, $^3J_{F,F'}$ = 24.3 Hz, $^3J_{F,F'}$ = 12.1 Hz, 1F, Ar-*F*, minor), -142.9 (*dd*, $^3J_{F,F'}$ = 23.4 Hz, $^3J_{F,F'}$ = 13.0 Hz, 1F, Ar-*F*, major), -143.1 (*dd*, $^3J_{F,F'}$ = 24.3 Hz, $^3J_{F,F'}$ = 12.1 Hz, 1F, Ar-*F*, minor), -143.8 (*dd*, $^3J_{F,F'}$ = 24.3 Hz, $^3J_{F,F'}$ = 12.1 Hz, 1F, Ar-*F*, minor), -144.0 (*dd*, $^3J_{F,F'}$ = 23.4 Hz, $^3J_{F,F'}$ = 13.0 Hz, 1F, Ar-*F*, major).

$^{31}P\{^{1}H\}$ NMR	(162 MHz, $CDCl_3$)
	δ 88.0 (*s*, minor), 87.4 (*s*, major).
IR (cm^{-1})	ATR (neat)
	2906, 2850, 1582, 1567, 1476, 1419, 1389, 1365, 1344, 1323, 1298, 1263, 1222, 1147, 1104, 1087, 1030, 1014, 971, 938, 917, 893, 805.
HRMS (ESI)	Calcd. for $C_{55}H_{72}F_4OPPd$ *m/z* 961.4286, Found: 961.4312 $[M\text{-}OTf]^+$.
Analysis	$C_{56}H_{72}F_7O_4PPdS$:
	Calcd. C, 60.51; H, 6.53; P, 2.79;
	Found: C, 60.61; H, 6.62; P, 2.70.

[Pd(allyl)(BrettPhos)]OTf (Catalyst 16)



Prepared in analogy to a literature procedure.(*54*) Silver triflurometh anesulfonate (196.6 mg, 0.766 mmol, 1.00 equiv) was added to Allylpalladium(II) chloride dimer (140 mg, 0.382 mmol, 0.50 equiv) in THF (2 mL) and stirred rt for 1h under the exclusion of light. The solution was filtered with THF (1.5 ml) through Celite in a fritted glass filter. Brettphos (490 mg, 0.766 mmol) was added and stirred at rt for 2 h. Heptane (4 mL) was added and THF was removed under reduced pressure. The resulting precipitate was filtered through fritted glass filter and washed with pentane (1 X 3 mL) and dried under Schlenk line vacuum to afford the product as a yellow solid (620 mg, 81%).

<u>m.p</u> 168 °C (d)

<u>^{1}H NMR</u> ^{1}H NMR (600 MHz, $CDCl_3$)

δ 7.46 (s, 1H), 7.35 (s, 1H), 7.11 – 7.06 (m, 1H), 7.00 (d, *J* = 8.9 Hz, 1H), 5.56 (tt, *J* = 14.0, 7.2 Hz, 1H), 4.27 (d, *J* = 6.6 Hz, 1H), 3.95 (s, 3H), 3.54 (dd, *J* = 14.1, 9.4 Hz, 1H), 3.42 (s, 3H), 3.02 (p, *J* = 6.9 Hz, 1H), 2.83 (q, *J* = 12.3 Hz, 1H), 2.71 (d, *J* = 12.5 Hz, 1H), 2.60 (q, *J* = 12.7 Hz, 1H), 2.49 – 2.39 (m, 2H), 2.26 (p, *J* = 6.9 Hz, 1H), 2.01 (d, *J* = 16.3 Hz, 2H), 1.88 (t, *J* = 10.1 Hz, 3H), 1.76 (q, *J* = 15.0 Hz, 5H), 1.64 (d, *J* = 10.1 Hz, 3H), 1.55 – 1.50 (m, 1H), 1.35 (dd, *J* = 6.9, 3.4 Hz, 9H), 1.28 (d, *J* = 6.8 Hz, 5H), 1.22 (dd, *J* = 6.9, 4.0 Hz, 2H), 1.19 (t, *J* = 3.6 Hz, 1H), 1.17 – 1.14 (m, 2H), 0.91 (d, *J* = 6.8 Hz, 3H), 0.84 (d, *J* = 6.7 Hz, 3H).

<u>^{13}C{^{1}H} NMR</u> ^{13}C NMR (151 MHz, $CDCl_3$)

δ 155.00 (d, $J_{P,C,}$ = 3.02 Hz) 153.69, 152.44, 151.72 (d, $J_{P,C}$ = 15.1 Hz), 150.84, 135.40(d, $J_{P,C}$ = 22.65 Hz), 125.12(d, $J_{P,C}$ = 10.57 Hz),119.66(d, $J_{P,C}$ = 6.04 Hz), 115.23, 113.81(d, $J_{P,C}$ = 4.53 Hz), 112.78(d, $J_{P,C}$ = 4.53 Hz), 100.95(d, $J_{P,C}$ = 27.18 Hz),68.00, 56.06, 54.96, 52.30, 38.65(d, $J_{P,C}$ = 46.81 Hz), 34.07,

32.84(d, $J_{P,C}$ = 4.53 Hz), 32.84 (d, $J_{P,C}$ = 4.9 Hz), 31.94 (d, $J_{P,C}$ = 4.9 Hz), 31.82 (d, $J_{P,C}$ = 2.7 Hz), 30.31 (d, $J_{P,C}$ = 11.4 Hz), 27.42 (d, $J_{P,C}$ = 12.0 Hz), 27.30 (d, $J_{P,C}$ = 12.0 Hz), 27.00, 26.92 (d, $J_{P,C}$ = 3.3 Hz),25.97, 25.88, 25.76, 24.60, 24.29, 24.20, 24.05.

^{31}P NMR (243 MHz, $CDCl_3$)

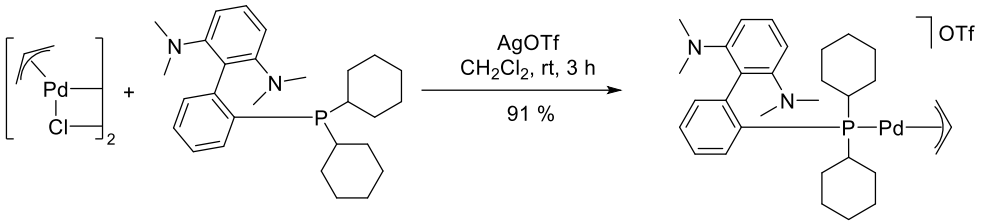
δ 51.97.

IR (cm^{-1}) ATR (neat)

2932 (m), 2855 (w), 1599 (w), 1578 (w), 1464 (m), 1427 (w), 1385 (w), 1363 (w), 1260 (s), 1223 (w), 1150 (m), 1089 (w), 1054 (w), 1031 (s), 1010 (w), 920 (w), 892 (w), 853 (w), 823 (w), 730 (w), 637 (m), 572 (w), 517 (w).

HRMS Calcd for $C_{38}H_{58}O_2PPd$ (M-OTf)+: 683.3209 Found: 683.3221

[Pd(allyl)(CPhos)]OTf (Catalyst 17)



Prepared in analogy to a literature procedure.(*54*) CPhos (130.98 mg 0.30 mmol) was added to allylpalladium(II) chloride dimer (54.8 mg, 0.15 mmol, 0.50 equiv) in 2mL CH_2Cl_2 and stirred at rt for 1h. Silver trifluromethanesulfonate (77.08 mg, 0.30 mmol 1.00 equiv) was added to reaction mixture and stirred at rt for 1h under the exclusion of light. The solution was filtered with CH_2Cl_2 (3 ml) through Celite in a fritted glass filter. Heptane (5 mL) was added and CH_2Cl_2 was removed under reduced pressure. The resulting precipitate was filtered through fritted glass filter and washed with pentane (1 X 3 mL) and dried under Schlenk line vacuum to afford the product as light-yellow solid (200 mg, 91%)

<u>m.p.</u> 177 °C (d)

<u>^{1}H NMR</u> (600 MHz, $CDCl_3$)

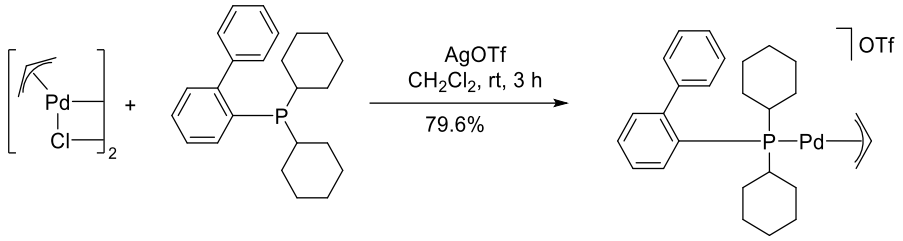
δ 7.71 (t, *J* = 7.3 Hz, 1H), 7.48 (t, *J* = 7.5 Hz, 1H), 7.43 (t, *J* = 7.4 Hz, 1H), 7.34 (t, *J* = 8.2 Hz, 1H), 7.01 (dd, *J* = 7.7, 3.2 Hz, 1H), 6.99 (d, *J* = 8.4 Hz, 1H), 6.88 (d, *J* = 8.1 Hz, 1H), 5.56 – 5.47 (m, 1H), 4.19 (d, *J* = 6.6 Hz, 1H), 4.04 (dd, *J* = 13.9, 8.8 Hz, 1H), 2.88 (d, *J* = 12.2 Hz, 1H), 2.76 – 2.72 (m, 1H), 2.71 (s, 6H), 2.57 (q, *J* = 12.4 Hz, 1H), 2.27 (s, 8H), 2.15 (s, 1H), 1.98 – 1.84 (m, 3H), 1.72 (d, *J* = 25.7 Hz, 4H), 1.60 – 1.44 (m, 2H), 1.42 – 1.33 (m, 3H), 1.29 – 1.15 (m, 6H).

<u>^{13}C{^{1}H} NMR</u> (151 MHz, $CDCl_3$)

δ 159.34, 155.76, 146.82 (d, $J_{P,C}$ = 22.9 Hz), 137.27 (d, $J_{P,C}$ = 39.2 Hz), 133.99, 133.20 (d, $J_{P,C}$ = 12.0 Hz), 132.59, 132.22, 128.08 (d, $J_{P,C}$ = 5.4 Hz), 120.05, 118.60 (d, $J_{P,C}$ = 4.9 Hz), 112.03 (d, $J_{P,C}$ = 10.9 Hz), 102.63, 100.43 (d, $J_{P,C}$ = 27.2 Hz), 53.58, 50.94, 45.04, 44.65, 37.79 (d, $J_{P,C}$ = 21.3 Hz), 35.93 (d, $J_{P,C}$ = 21.8 Hz), 33.15 (d, $J_{P,C}$ = 7.1 Hz), 30.35, 29.57, 28.06 (d, $J_{P,C}$ = 15.3 Hz), 27.77, 27.54 (d, $J_{P,C}$ = 8.7 Hz), 27.17 (d, $J_{P,C}$ = 13.1 Hz), 26.86 (d, $J_{P,C}$ = 12.0 Hz), 25.79 (d, $J_{P,C}$ = 16.3 Hz).

^{31}P NMR	(243 MHz, $CDCl_3$)
	δ 49.11.
IR (cm^{-1})	ATR (neat)
	2932 (m), 2855 (w), 2244 (w), 1576 (w), 1551 (w), 1493 (w), 1448 (w), 1422 (w), 1269 (s), 1223 (w), 1202 (w), 1148 (m), 1031 (s), 919 (w), 855 (w), 824 (w), 781 (w), 728 (w), 636 (m), 571 (w), 518 (w).
HRMS	Calcd for $C_{31}H_{46}N_2PPd$ (M-OTf)+: 583.2433 Found: 583.2444

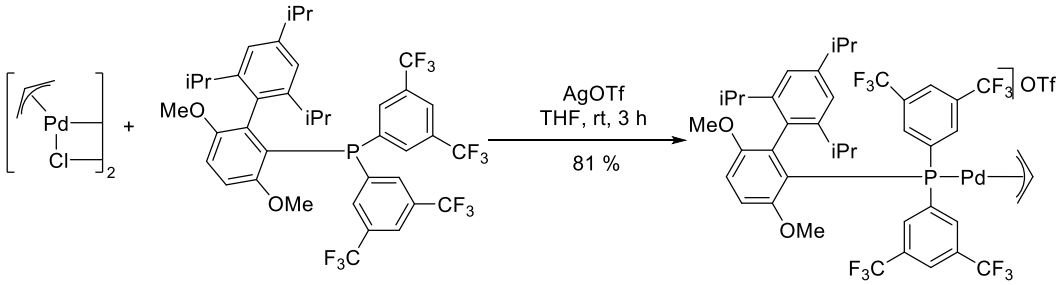
[Pd(allyl)(CyJohnPhos)]OTf (Catalyst 18)



Prepared in analogy to a literature procedure.(*54*) CyJohnPhos (108.64 mg, 0.31 mmol) was added to allylpalladium(II) chloride dimer (56.71 mg, 0.155 mmol, 0.50 equiv) in 1mL CH_2Cl_2 and stirred at rt for 2h. Silver trifluromethanesulfonate (79.65 mg, 0.31 mmol 1.00 equiv) was added to reaction mixture and stirred at rt for 1h under the exclusion of light. The solution was filtered with CH_2Cl_2 (2 ml) through celite in a fritted glass filter. Heptane (5 mL) was added and CH_2Cl_2 was removed under reduced pressure. The resulting precipitate was filtered through fritted glass filter and washed with pentane (1 X 3 mL) and dried under Schlenk line vacuum to afford the product as light-yellow solid (160 mg, 79.6%).

m.p.	189 °C (d).
^{1}H NMR	(600 MHz, $CDCl_3$)
	δ 8.01 (d, *J* = 121.0 Hz, 2H), 7.69 – 7.42 (m, 4H), 7.17 (s, 3H), 5.48 (d, *J* = 7.0 Hz, 1H), 4.06 – 3.65 (m, 3H), 3.01 (s, 1H), 2.23 (d, *J* = 104.5 Hz, 2H), 1.74 (d, *J* = 54.9 Hz, 11H), 1.22 (d, *J* = 78.9 Hz, 8H), 0.88 (s, 1H).
^{13}C{^{1}H} NMR	(151 MHz, $CDCl_3$)
	δ 148.22 (d, $J_{P,C}$ = 18.5 Hz), 140.52, 140.49, 135.74, 134.45, 132.50, 132.10, 132.04, 129.06 (d, $J_{P,C}$ = 5.3 Hz), 127.09 (d, $J_{P,C}$ = 36.0 Hz), 126.74, 122.13, 120.01, 118.84 (d, $J_{P,C}$ = 6.0 Hz), 99.15, 55.85, 36.43, 35.28, 29.49, 29.10, 28.37, 26.93, 26.83, 26.77, 26.70, 25.67.
^{31}P NMR	(243 MHz, $CDCl_3$)
	δ 40.71.
IR (cm^{-1})	ATR (neat)
	2931 (m), 2855 (w), 1450 (w), 1223 (w), 1150 (m), 1031 (s), 1005 (w), 919 (w), 853 (w), 755 (w), 732 (w), 636 (s), 572 (w), 517 (w).
HRMS	Calcd for $C_{27}H_{36}PPd$ (M-OTf)+: 497.1589 Found: 497.1600

[Pd(allyl)(JackiPhos)]OTf (Catalyst 19)



Prepared in analogy to a literature procedure.(*54*) Silver trifluromethanesulfonate (81.0 mg, 0.30 mmol 1.00 equiv) was added to allylpalladium(II) chloride dimer (60 mg, 0.14 mmol, 0.50 equiv) in THF (1 mL) and stirred ar rt for 1h under the exclusion of light. The solution was filtered with THF (1.5 ml) through Celite in a fritted glass filter. JackiePhos (247.0 mg, 0.30 mmol) was added and stirred at rt for 2 h. Heptane (3 mL) was added and THF was removed under reduced pressure. The resulting precipitate was filtered through fritted glass filter and washed with pentane (1 X 3 mL) and dried under Schlenk line vacuum to afford the product as light yellow solid (280 mg, 81%).

<u>m.p.</u> 193 °C (d).

<u>1H NMR</u> (600 MHz, $CDCl_3$)

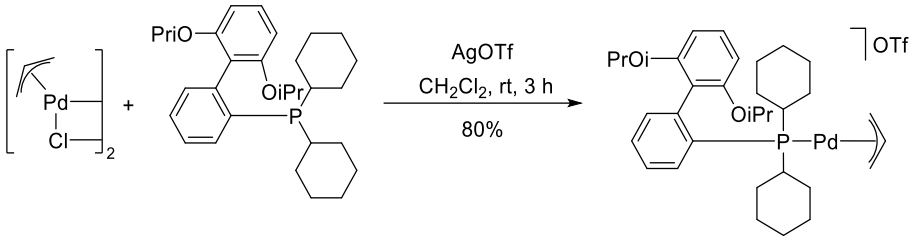
δ 8.09 (s, 2H), 7.88 (q, *J* = 12.8 Hz, 4H), 7.55 (d, *J* = 43.6 Hz, 2H), 7.36 (d, *J* = 9.1 Hz, 1H), 7.26 – 7.23 (m, 1H), 5.84 (ddd, *J* = 19.1, 14.0, 8.0 Hz, 1H), 3.91 (s, 1H), 3.83 (dd, *J* = 14.2, 10.0 Hz, 1H), 3.65 (s, 3H), 3.55 (s, 3H), 3.09 (hept, *J* = 6.8 Hz, 1H), 2.86 (t, *J* = 7.4 Hz, 1H), 2.72 (d, *J* = 12.1 Hz, 1H), 2.33 (d, *J* = 69.8 Hz, 2H), 1.37 (d, *J* = 6.9 Hz, 6H), 1.30 (s, 3H), 1.16 (s, 3H), 0.96 (d, *J* = 29.1 Hz, 6H).

<u>$^{13}C\{^1H\}$ NMR</u> (151 MHz, $CDCl_3$)

δ 154.65 (d, $J_{P,C}$ = 2.7 Hz), 152.39 (d, $J_{P,C}$ = 20.2 Hz), 150.21 (d, $J_{P,C}$ = 184.2 Hz), 149.60, 135.56 (d, $J_{P,C}$ = 31.6 Hz), 133.12, 132.12, 125.98, 125.56, 125.19, 123.38, 122.82 (d, $J_{P,C}$ = 6.5 Hz), 121.92, 121.57, 119.75, 119.69, 119.42, 114.57, 114.17, 102.51 (d, $J_{P,C}$ = 29.4 Hz), 67.99, 60.42, 55.62 (d, $J_{P,C}$ = 6.0 Hz), 34.11, 32.73 (d, $J_{P,C}$ = 21.3 Hz), 31.89, 25.62, 25.55, 24.34 (d, $J_{P,C}$ = 45.8 Hz), 23.90, 22.70.

^{31}P NMR	(243 MHz, $CDCl_3$)
	δ 32.91.
IR (cm^{-1})	ATR (neat)
	2965 (w), 1577 (w), 1471 (w), 1432 (w), 1357 (m), 1279 (s), 1224 (w), 1187 (w), 1138 (m), 1054 (w), 1031 (w), 1008 (w), 895 (w), 844 (w), 708 (w), 638 (w), 573 (w), 517 (w).
HRMS	Calcd for $C_{42}H_{42}O_2PPdF_{12}$ (M-OTf)+: 943.1766 Found: 943.1760

[Pd(allyl)(RuPhos)]OTf (Catalyst 20)



Prepared in analogy to a literature procedure.(*54*) RuPhos (144.65 mg, 0.31 mmol) was added to allylpalladium(II) chloride dimer (56.71 mg, 0.155 mmol, 0.50 equiv) in 1 mL CH_2Cl_2 and stirred at rt for 2h. Silver trifluromethanesulfonate (79.65 mg, 0.31 mmol 1.00 equiv) was added to reaction mixture and stirred at rt for 1h under the exclusion of light. The solution was filtered with CH_2Cl_2 (2 ml) through celite in a fritted glass filter. Heptane (5 mL) was added and CH_2Cl_2 was removed under reduced pressure. The resulting precipitate was filtered through fritted glass filter and washed with pentane (1 X 3 mL) and dried under Schlenk line vacuum to afford the product as light-yellow solid (200 mg, 80%).

<u>m.p</u> 177 °C (d).

<u>^{1}H NMR</u> (600 MHz, $CDCl_3$)

δ 7.60 (d, *J* = 7.4 Hz, 1H), 7.54 (t, *J* = 8.5 Hz, 1H), 7.46 (t, *J* = 4.3 Hz, 2H), 6.90 (dd, *J* = 34.5, 8.5 Hz, 2H), 6.76 – 6.67 (m, 1H), 5.67 (tt, *J* = 13.8, 7.8 Hz, 1H), 4.68 (ddt, *J* = 33.9, 12.4, 6.2 Hz, 2H), 4.05 – 3.92 (m, 2H), 2.79 – 2.63 (m, 2H), 2.23 (dq, *J* = 52.0, 11.1 Hz, 2H), 1.96 (t, *J* = 8.2 Hz, 4H), 1.74 (tt, *J* = 24.9, 10.0 Hz, 6H), 1.40 – 1.11 (m, 16H), 1.00 (dd, *J* = 25.1, 6.0 Hz, 6H).

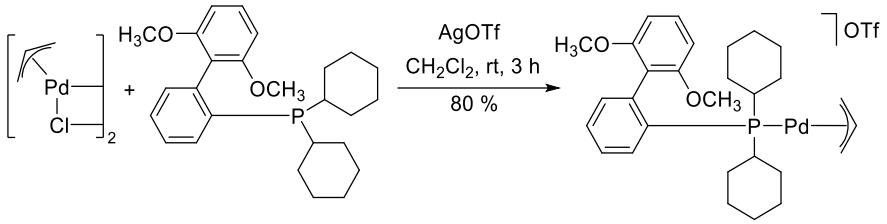
<u>^{13}C{^{1}H} NMR</u> (151 MHz, $CDCl_3$)

δ 160.74, 159.51, 145.48 (d, $J_{P,C}$ = 23.6 Hz), 135.82, 135.42 (d, $J_{P,C}$ = 41.1 Hz), 132.25 (d, $J_{P,C}$ = 2.3 Hz), 131.50 (d, $J_{P,C}$ = 12.6 Hz), 131.45, 128.02 (d, $J_{P,C}$ = 5.4 Hz), 120.19 (d, $J_{P,C}$ = 5.4 Hz), 106.95, 106.35, 104.52, 104.43 (d, $J_{P,C}$ = 27.2 Hz), 71.77 (d, $J_{P,C}$ = 25.2 Hz), 49.41, 36.22 (d, $J_{P,C}$ = 24.5 Hz), 35.95 (d, $J_{P,C}$ = 24.1 Hz), 30.28, 29.99, 29.46, 26.78 (d, $J_{P,C}$ = 2.3 Hz), 26.65 (d, $J_{P,C}$ = 10.4 Hz), 26.54, 26.00 (d, $J_{P,C}$ = 10.6 Hz), 21.95, 21.86, 21.73 (d, $J_{P,C}$ = 8.9 Hz).

21.48.

^{31}P	^{31}P NMR (243 MHz, $CDCl_3$
	δ 52.01.
IR (cm^{-1})	ATR (neat)
	2980 (w), 2932 (m), 2855 (w), 1739 (w), 1578 (w), 1443 (m), 1386 (w), 1267 (s), 1223 (w), 1149 (m), 1107 (m), 1063 (m), 1031 (s), 920 (w), 900 (w), 852 (w), 772 (w), 734 (w), 637 (s), 572 (w), 517 (w).
HRMS	Calcd for $C_{33}H_{48}O_2PPd$ (M-OTf)+: 613.2427 Found: 613.2443

[Pd(allyl)(Sphos)]OTf (Catalyst 21)

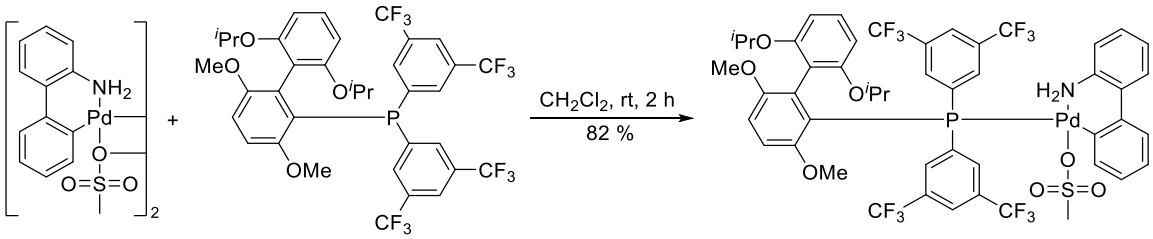


Prepared in analogy to a literature procedure.(*54*) Sphos (254.52 mg, 0.62mmol) was added to allylpalladium(II) chloride dimer (113.4 mg, 0.31 mmol, 0.50 equiv) in 2mL CH_2Cl_2 and stirred at rt for 2h. Silver trifluromethanesulfonate (159.30 mg, 0.62 mmol 1.00 equiv) was added to reaction mixture and stirred at rt for 1h under the exclusion of light. The solution was filtered with CH_2Cl_2 (3 ml) through celite in a fritted glass filter. Heptane (5 mL) was added and CH_2Cl_2 was removed under reduced pressure. The resulting precipitate was filtered through fritted glass filter and washed with pentane (1 X 3 mL) and dried under Schlenk line vacuum to afford the product as light-yellow solid. Yield: 400 mg (80%)

m.p.	190 °C (d)
^{1}H NMR	(600 MHz, $CDCl_3$)
	δ 7.64 (t, *J* = 6.1 Hz, 1H), 7.54 – 7.46 (m, 3H), 7.05 (dd, *J* = 36.9, 7.6 Hz, 2H), 6.80 (d, *J* = 6.0 Hz, 1H), 5.80 (ddd, *J* = 18.8, 14.1, 8.0 Hz, 1H), 4.23 (dd, *J* = 14.2, 8.9 Hz, 1H), 3.89 (d, *J* = 6.2 Hz, 1H), 3.84 (s, 3H), 3.75 (s, 3H), 2.79 (d, *J* = 12.8 Hz, 1H), 2.72 (t, *J* = 7.0 Hz, 1H), 2.30 – 2.10 (m, 2H), 1.96 – 1.69 (m, 11H), 1.41 – 1.08 (m, 10H).
^{13}C{^{1}H} NMR	(151 MHz, $CDCl_3$)
	δ 160.31, 159.53, 144.20 (d, *Jp,c* = 24.16 Hz,), 135.15 (d, *Jp,c*, = 39.26 Hz) 135.12, 132.48 (d, *Jp,c* = 3.02 Hz), 132.08, 131.62 (d, *Jp,c* = 12.08 Hz),128.25 (d, *Jp,c* = 6.04 Hz), 122.18, 120.74 (d, *Jp,c* = 6.04 Hz), 106.50 (d, *J,p-C* = 72.48 Hz), 105.58 (d, *Jp,c* = 25.67 Hz), 101.18, 56.69, 56.61, 53.58, 49.49, 36.40 (d, *Jp,c* = 24.16 Hz), 35.98 (d, *Jpc* = 19.63 Hz), 29.75, 29.44, 28.86 (d, *Jp,c* = 9.06 Hz), 27.09, 27.00, 26.91, 25.88.
^{31}P NMR	(243 MHz, $CDCl_3$)
	δ 51.52.

IR (cm^{-1})	ATR (neat)
	2930 (w), 2853 (w), 2246 (w), 1581 (w), 1561 (w), 1466 (m), 1425 (m), 1254 (s), 1223 (m), 1149 (m), 1102 (s), 1030 (s), 916 (w), 852 (w), 821 (w), 767 (m), 728 (m), 671 (w), 636 (s), 597 (w), 572 (w), 518 (m).
HRMS(ES+)	Calcd for $C_{29}H_{40}O_2PPd$ (M-OTf)+: 557.1801 Found: 557.1813

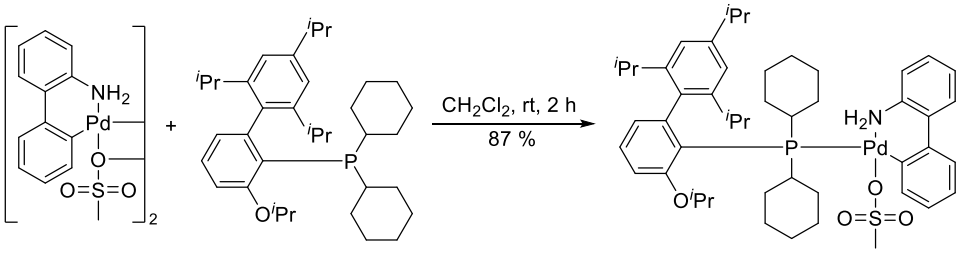
RuPhos-Hybrid Pd G3



Prepared in analogy to literature procedure. (*55*) RuPhos-Hybrid (125 mg, 159 μmol, 1.00 equiv) was added to [2-(2'-amino-1,1'-biphenyl)]palladium(II) methanesulfonate dimer (58.8 mg, 79.5 μmol) in CH_2Cl_2 (1.0 mL) and stirred at rt for 2 h. Heptane (6.0 mL) was added dropwise and CH_2Cl_2 was removed under reduced pressure. The resulting precipitate was filtered and washed with pentane (2 × 5.0 mL) to afford the product as an off-white solid. Yield: 151 mg (82%).

^{1}H NMR	(400 MHz, $CDCl_3$): A suitable spectrum could not be obtained.
^{13}C{^{1}H} NMR	(101 MHz, $CDCl_3$): A suitable spectrum could not be obtained.
^{31}P{^{1}H} NMR	(162 MHz, $CDCl_3$) δ 30.6 (*s*).
IR (cm^{-1})	3270, 3090, 2980, 2939, 2839, 1618, 1582, 1494, 1459, 1428, 1385, 1354, 1319 1279, 1247, 1182, 1122, 1106, 1095, 1058, 1018, 1001, 944, 898, 889, 845, 816.
HRMS (ESI)	Calcd. for $C_{48}H_{41}F_{12}NO_4PPd$ *m/z* 1060.1628, Found: 1060.1637 [M-OMs]$^+$.

EPhos Pd G3



Prepared in analogy to literature procedure. (*55*) EPhos (163 mg, 305 μmol, 1.00 equiv) was added to [2-(2'-amino-1,1'-biphenyl)]palladium(II) methanesulfonate dimer (112.7 mg, 152 μmol) in CH_2Cl_2 (1.5 mL) and stirred at rt for 2 h. Heptane (6.0 mL) was added dropwise and CH_2Cl_2 was removed under reduced pressure. The resulting precipitate was filtered and washed with pentane (2 × 5.0 mL) to afford the product as an off-white solid. Yield: 240 mg (87%).

<u>^{1}H NMR</u> (400 MHz, $CDCl_3$): δ 7.52 (*d*, $^4J_{H,H'}$ = 1.7 Hz, 1H, Ar-*H*), 7.41 – 7.36 (*m*, 2H, Ar-*H*), 7.27 (*d*, $^4J_{H,H'}$ = 1.7 Hz, 1H, Ar-*H*), 7.14 – 7.09 (*m*, 6H, Ar-*H*), 6.90 – 6.87 (*m*, 1H, Ar-*H*), 6.83 – 6.79 (*m*, 1H, Ar-*H*), 6.34 – 6.30 (*m*, 2H, Ar-*H* (1H) + N*H*H), 4.76 (*qq*, $^3J_{H,H'}$ = 6.1, 6.1 Hz, 1H, OC*H*), 3.39 (*qq*, $^3J_{H,H'}$ = 6.9, 6.9 Hz, 1H, C*H*), 2.94 – 2.74 (*m*, 3H, C*H* (1H) + PC*H* (2H)), 2.41 (*s*, 3H, SCH_3), 2.12 – 2.07 (*m*, 1H, C*H*H), 1.95 – 1.77 (*m*, 8H, C*H* (1H) + C*H*H (6H) + N*H*H (1H)), 1.86 (*d*, $^3J_{H,H'}$ = 6.8 Hz, 3H, CH_3), 1.56 (*d*, $^3J_{H,H'}$ = 6.9 Hz, 3H, CH_3), 1.53 – 1.18 (*m*, 8H, C*H*H), 1.50 (*d*, $^3J_{H,H'}$ = 6.1 Hz, 3H, CH_3), 1.49 (*d*, $^3J_{H,H'}$ = 6.9 Hz, 3H, CH_3), 1.38 (*d*, $^3J_{H,H'}$ = 6.1 Hz, 3H, CH_3), 1.10 (*d*, $^3J_{H,H'}$ = 6.8 Hz, 3H, CH_3), 1.08 – 0.78 (*m*, 5H, C*H*H), 0.76 (*d*, $^3J_{H,H'}$ = 6.7 Hz, 3H, CH_3), 0.75 (*d*, $^3J_{H,H'}$ = 7.0 Hz, 3H, CH_3), 0.37 – 0.30 (*m*, 1H, C*H*H).

<u>^{13}C{^{1}H} NMR</u> (101 MHz, $CDCl_3$): A suitable spectrum could not be obtained.

<u>^{31}P{^{1}H} NMR</u> (162 MHz, $CDCl_3$)

δ 37.4 (*s*).

<u>IR (cm^{-1})</u> ATR (neat)

3420, 3307, 3056, 2965, 2927, 2850, 1639, 1594, 1566, 1494, 1460, 1443, 1420, 1385, 1363, 1323, 1288, 1261, 1211, 1182, 1132, 1122, 1104, 1037, 1020, 1002, 955, 885, 851, 820.

<u>HRMS (ESI)</u> Calcd. for $C_{48}H_{65}NOPPd$ *m/z* 808.3833, Found: 808.3847 $[M\text{-}OMs]^+$.

Product Summaries and Product Characterization

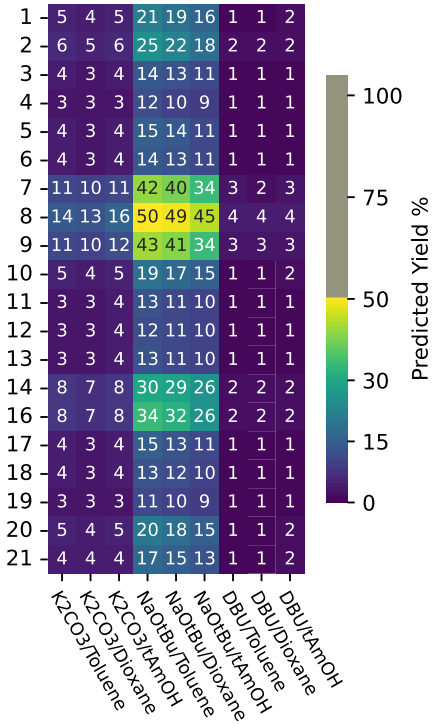
The following section contains (1) a table of observed and predicted yields for conditions which were tested, (2) a heatmap of predicted yields for all 180 conditions, (3) a drawing of the product, (4) predicted vs observed yields and summary statistics, and (5) the characterization summary table. The NMR spectra can be Found: in the same order in the *NMR Spectra* section.

The tabular reaction data uses reaction handles to specify the conditions (handle format = amine, bromide, catalyst, solvent, and base used in each experiment separated by "_"). All reaction handles use numerical designations for precatalyst (see Figure S4), solvent (1 = 1,4-dioxane, 2 = *t*-AmOH, 3 = toluene), and base (a = K_2CO_3, b = NaO*t*-Bu, c = DBU). These sections provide an accessible summary of the dataset couplings so that an experimentalist interested in seeing specific results can find them. All experimental data is also provided separate from this document in an easily parsed format using reaction handles.

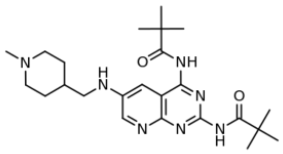
Characterization data for products used in experimental validation can be found at the end of this section.

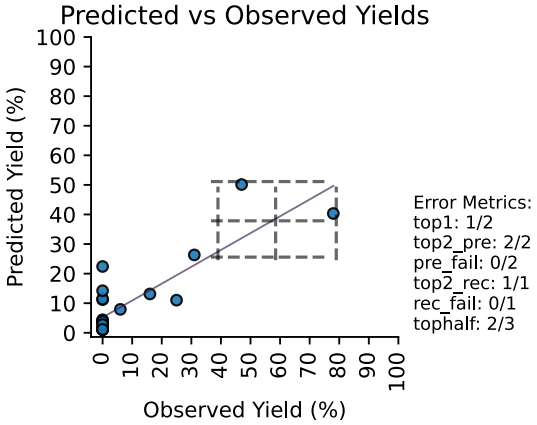
Data for **32_25**

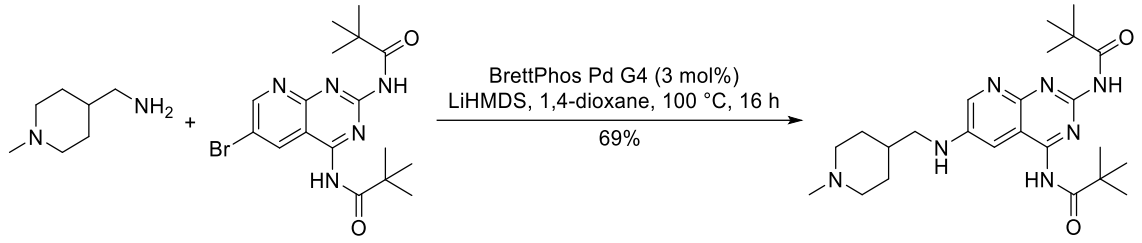
	Predicted Yield %	Observed Yield %
32_25_1_1_a	4.0	0.0
32_25_8_1_a	13.0	16.0
32_25_10_1_a	4.0	0.0
32_25_2_1_b	22.0	0.0
32_25_7_1_b	40.0	78.0
32_25_11_1_b	11.0	0.0
32_25_3_1_c	1.0	0.0
32_25_12_1_c	1.0	0.0
32_25_4_2_a	3.0	0.0
32_25_13_2_a	4.0	0.0
32_25_5_2_b	11.0	0.0
32_25_14_2_b	26.0	31.0
32_25_2_2_c	2.0	0.0
32_25_6_2_c	1.0	0.0
32_25_10_2_c	2.0	0.0
32_25_12_2_c	1.0	0.0
32_25_5_3_a	4.0	0.0
32_25_7_3_a	11.0	25.0
32_25_14_3_a	8.0	6.0
32_25_6_3_b	14.0	0.0
32_25_8_3_b	50.0	47.0
32_25_4_3_c	1.0	0.0
32_25_9_3_c	3.0	0.0
32_25_13_3_c	1.0	0.0



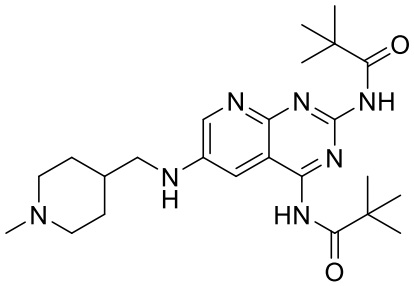
32_25







Prepared in analogy to a literature procedure.(*10*) (1-Methylpiperidin-4-yl)methanamine (154 mg, 1.20 mmol, 1.20 equiv), lithium bis(trimethylsilyl)amide (535 mg, 3.20 mmol, 3.20 equiv) and BrettPhos Pd G4 (27.6 mg, 30.0 µmol, 3.00 mol%) were added to *N*,*N*'-(6-bromopyrido[2,3-*d*]pyrimidine-2,4-diyl)bis(2,2-dimethylpropanamide) (408 mg, 1.00 mmol) in 1,4-dioxane (3.3 mL) and the solution was heated to 100 °C for 16 h. The reaction was cooled to rt, diluted with water (10 mL) and extracted three times with CH_2Cl_2 (3 × 10 mL). The combined organic phases were dried over $MgSO_4$, filtered, and the solvent was removed under reduced pressure. Purification by reverse phase HPLC afforded the product as a yellow solid. Yield: 312 mg (69%).



N,*N*'-(6-(((1-Methylpiperidin-4-yl)methyl)amino)pyrido[2,3-*d*]pyrimidine-2,4-diyl)bis(2,2-dimethylpropanamide) **(32_25)**

m.p. 122 °C.

^{1}H NMR ^{1}H NMR (400 MHz, $CDCl_3$)
δ 8.51 – 8.49 (*m*, 2H, Ar*H*), 7.67 (br *s*, 2H, N*H*), 4.97 (br *s*, 1H, N*H*), 3.53 – 3.44 (*m*, 2H, NC*H*H), 3.24 – 3.15 (*m*, 2H, NCH_2), 2.67 (*s*, 3H, NCH_3), 2.62 – 2.53 (*m*, 2H, NC*H*H), 1.99 – 1.82 (*m*, 5H, C*H*H (4H) + C*H* (1H)), 1.34 (*s*, 9H, C(CH_3)$_3$), 1.34 (*s*, 9H, C(CH_3)$_3$).

^{13}C{^{1}H} NMR ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$):

δ 181.7 (*C*=O), 180.8 (*C*=O), 168.6 (2C, arom.), 144.5 (arom.), 142.6 (arom.), 142.3 (arom.), 115.5 (arom.), 112.4 (arom.), 54.0 (2C, N*C*H_2), 48.3 (N*C*H_2), 43.6 (N*C*H_3), 40.3 (2C, *C*(CH_3)$_3$), 31.8 (*C*H_2), 27.7 (3C, C(*C*H_3)$_3$), 27.3 (2C, *C*H_2), 27.0 (3C, C(*C*H_3)$_3$).

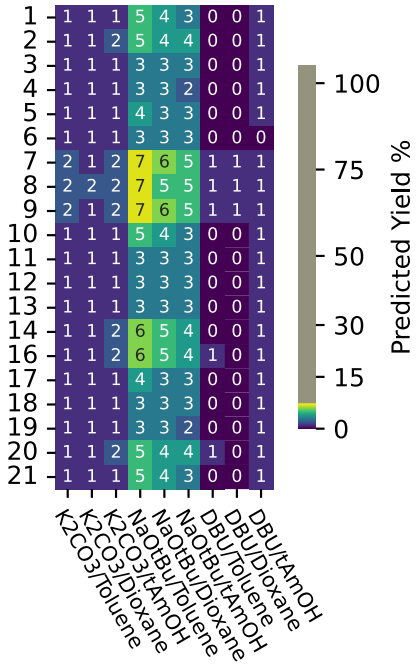
IR (cm^{-1}) ATR (neat)

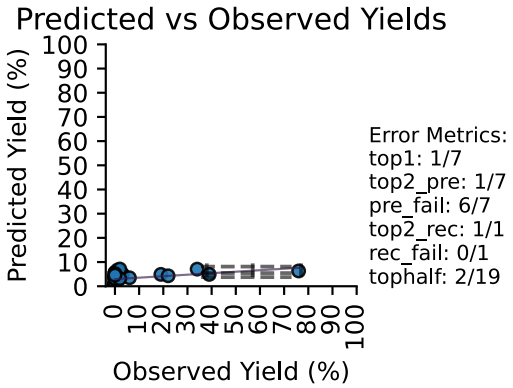
3373, 3272, 3045, 2959, 2929, 2871, 2785, 2696, 2493, 1655, 1607, 1546, 1510, 1478, 1455, 1433, 1397, 1368, 1339, 1398, 1208, 1152, 1067, 1044, 1023, 958, 886, 839, 816, 800.

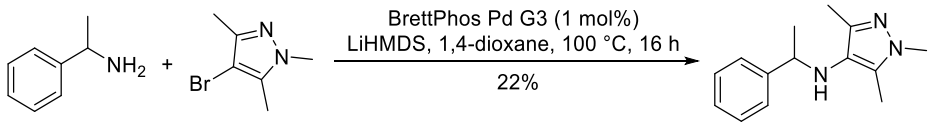
HRMS (ESI) Calcd. for $C_{24}H_{38}N_7O_2$ *m*/*z* 456.3081, Found: 456.3064 $[M+H]^+$.

Data for **34_9**

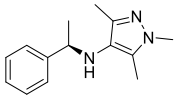
	Predicted Yield %	Observed Yield %
34_9_6_1_a	1.0	0.0
34_9_9_1_a	1.0	0.0
34_9_1_1_b	4.0	0.0
34_9_3_1_b	3.0	0.0
34_9_4_1_b	3.0	1.0
34_9_10_1_b	4.0	1.0
34_9_2_1_c	0.0	0.0
34_9_11_1_c	0.0	0.0
34_9_12_1_c	0.0	0.0
34_9_3_2_a	1.0	0.0
34_9_12_2_a	1.0	0.0
34_9_4_2_b	2.0	1.0
34_9_13_2_b	3.0	0.0
34_9_5_2_c	1.0	0.0
34_9_9_2_c	1.0	0.0
34_9_11_2_c	1.0	0.0
34_9_14_2_c	1.0	0.0
34_9_4_3_a	1.0	0.0
34_9_6_3_a	1.0	0.0
34_9_5_3_b	4.0	0.0
34_9_7_3_b	7.0	34.0
34_9_14_3_b	6.0	1.0
34_9_8_3_c	1.0	0.0
34_9_10_3_c	0.0	0.0
34_9_7_1_b	6.0	1.0
34_9_8_1_b	5.0	0.0
34_9_9_1_b	6.0	0.0
34_9_14_1_b	5.0	1.0
34_9_16_1_b	5.0	39.0
34_9_19_1_b	3.0	1.0
34_9_20_1_b	4.0	0.0
34_9_21_1_b	4.0	0.0
34_9_14_2_a	2.0	0.0
34_9_7_2_b	5.0	19.0
34_9_8_2_b	5.0	3.0
34_9_9_2_b	5.0	3.0
34_9_10_2_b	3.0	6.0
34_9_14_2_b	4.0	0.0
34_9_16_2_b	4.0	22.0
34_9_19_2_b	2.0	1.0
34_9_20_2_b	4.0	0.0
34_9_21_2_b	3.0	0.0
34_9_8_3_b	7.0	1.0
34_9_9_3_b	7.0	2.0
34_9_16_3_b	6.0	76.0
34_9_19_3_b	3.0	2.0
34_9_20_3_b	5.0	0.0
34_9_21_3_b	5.0	0.0







Prepared in analogy to a literature procedure.(*10*) 1-Phenylethylamine (284 µL, 2.20 mmol, 1.10 equiv), lithium bis(trimethylsilyl)amide (402 mg, 2.40 mmol, 1.20 equiv) and BrettPhos Pd G3 (18.1 mg, 20.0 µmol, 1.00 mol%) were added to 4-bromo-1,3,5-trimethyl-1*H*-pyrazole (378 mg, 2.00 mmol) in 1,4-dioxane (4.0 mL) and the solution was heated to 100 °C for 16 h. The reaction was cooled to rt, diluted with water (25 mL) and extracted twice with CH_2Cl_2 (2 × 25 mL). The combined organic phases were washed with saturated aqueous NaCl solution (25 mL), dried over $MgSO_4$, filtered, and the solvent was removed under reduced pressure. ^{1}H NMR analysis of the crude product with 1,3,5-trimethoxybenzene (112 mg, 667 µmol, 0.33 equiv) as the internal standard showed the formation of the product in 33%. Flash column chromatography on silica gel (EtOAc/heptane, 0:100 to 100:0, then CH_2Cl_2/MeOH, 0:100 to 10:90) afforded the product as a light brown oil. Yield: 99.7 mg (22%).



1,3,5-Trimethyl-*N*-(1-phenylethyl)-1H-pyrazol-4-amine **(34_9)**

<u>^{1}H NMR</u> (400 MHz, $CDCl_3$)
δ 7.33 – 7.20 (*m*, 5H, Ar-*H*), 3.97 (*q*, $^3J_{H,H'}$ = 6.7 Hz, 1H, NC*H*), 3.62 (*s*, 3H, NCH_3), 2.46 (br *s*, 1H, N*H*), 2.07 (*s*, 3H, CH_3), 1.95 (*s*, 3H, CH_3), 1.41 (*d*, $^3J_{H,H'}$ = 6.7 Hz, 3H, CH_3).

<u>^{13}C{^{1}H}</u> (101 MHz, $CDCl_3$)
<u>NMR</u> δ 145.4 (arom.), 142.8 (arom.), 133.3 (arom.), 128.3 (2C, arom.), 127.0 (arom.), 126.7 (2C, arom.), 124.6 (arom.), 59.4 (N*C*H), 36.1 (N*C*H_3), 22.7 (*C*H_3), 11.1 (*C*H_3), 8.9 (*C*H_3).

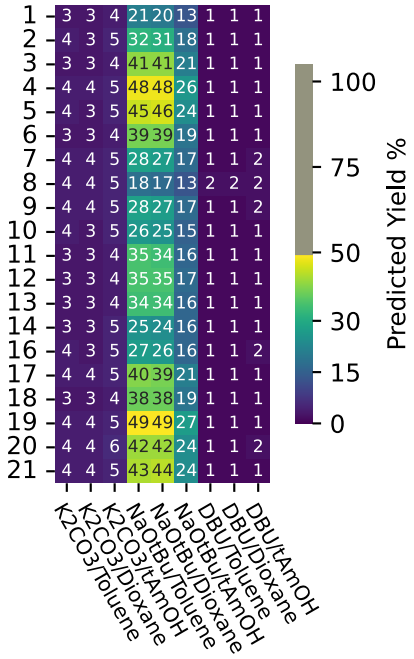
<u>IR (cm^{-1})</u> ATR (neat)
3279, 3026, 2966, 2921, 2866, 1603, 1581, 1480, 1451, 1382, 1297, 1234, 1206, 1154, 1090, 1064, 1019, 987, 911, 811.

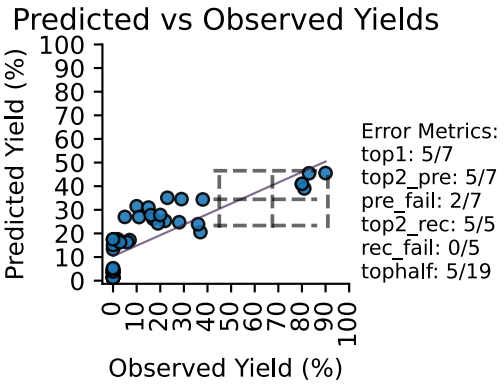
<u>HRMS (ESI)</u> Calcd. for $C_{14}H_{20}N_3$ *m/z* 230.1652, Found: 230.1644 $[M+H]^+$.

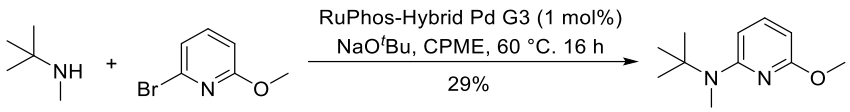
<u>TLC</u> R_f 0.25 (EtOAc)

Data for **50_41**

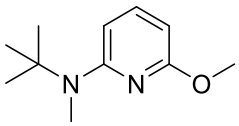
	Predicted Yield %	Observed Yield %
50_41_1_1_a	3.0	0.0
50_41_2_1_a	3.0	0.0
50_41_8_1_a	4.0	0.0
50_41_3_1_b	41.0	80.0
50_41_9_1_b	27.0	5.0
50_41_1_1_c	1.0	0.0
50_41_4_1_c	1.0	0.0
50_41_10_1_c	1.0	0.0
50_41_2_2_a	5.0	0.0
50_41_11_2_a	4.0	0.0
50_41_14_2_a	5.0	0.0
50_41_3_2_b	21.0	37.0
50_41_5_2_b	24.0	36.0
50_41_12_2_b	17.0	7.0
50_41_4_2_c	1.0	0.0
50_41_13_2_c	1.0	0.0
50_41_5_3_a	4.0	0.0
50_41_14_3_a	3.0	0.0
50_41_2_3_b	32.0	10.0
50_41_6_3_b	39.0	81.0
50_41_10_3_b	26.0	17.0
50_41_7_3_c	1.0	0.0
50_41_8_3_c	2.0	0.0
50_41_12_3_c	1.0	0.0
50_41_2_1_b	31.0	15.0
50_41_5_1_b	46.0	90.0
50_41_7_1_b	27.0	11.0
50_41_10_1_b	25.0	22.0
50_41_11_1_b	34.0	38.0
50_41_14_1_b	24.0	19.0
50_41_3_2_a	4.0	0.0
50_41_7_2_a	5.0	0.0
50_41_10_2_a	5.0	0.0
50_41_2_2_b	18.0	2.0
50_41_7_2_b	17.0	1.0
50_41_8_2_b	13.0	0.0
50_41_9_2_b	17.0	0.0
50_41_10_2_b	15.0	0.0
50_41_11_2_b	16.0	6.0
50_41_14_2_b	16.0	3.0
50_41_3_3_b	41.0	80.0
50_41_5_3_b	45.0	83.0
50_41_7_3_b	28.0	16.0
50_41_8_3_b	18.0	0.0
50_41_9_3_b	28.0	20.0
50_41_11_3_b	35.0	29.0
50_41_12_3_b	35.0	23.0
50_41_14_3_b	25.0	28.0







Prepared in analogy to a literature procedure.(*56*) *N*-Methyl-*tert*-butylamine (576 µL, 4.80 mmol, 2.40 equiv), sodium *tert*-butoxide (538 mg, 5.60 mmol, 2.80 equiv) and RuPhos-Hybrid Pd G3 (23.1 mg, 20.0 µmol, 1.00 mol%) were added to 2-bromo-6-methoxypyridine (246 µL, 2.00 mmol) in CPME (4.0 mL) and the solution was heated to 60 °C for 16 h. The reaction was cooled to rt, diluted with water (25 mL) and extracted twice with CH_2Cl_2 (2 × 25 mL). The combined organic phases were washed with saturated aqueous NaCl solution (25 mL), dried over $MgSO_4$, filtered, and the solvent was removed under reduced pressure. ^{1}H NMR analysis of the crude product with 1,3,5-trimethoxybenzene (112 mg, 667 µmol, 0.33 equiv) as the internal standard showed the formation of the product in 38%. Flash column chromatography on silica gel (CH_2Cl_2/heptane, 0:100 to 100:0, then EtOAc/heptane, 0:100 to 20:80) afforded the product as a light yellowish liquid. Yield: 113 mg (29%).



N-(*tert*-Butyl)-6-methoxy-*N*-methylpyridin-2-amine **(50_41)**

<u>^{1}H NMR</u> (400 MHz, $CDCl_3$)
δ 7.39 – 7.31 (*dd*, $^3J_{H,H'}$ = 8.1, 8.1 Hz, 1H, Ar-*H*), 6.20 (*d*, $^3J_{H,H'}$ = 8.1 Hz, 1H, Ar-*H*), 6.09 (*d*, $^3J_{H,H'}$ = 8.1 Hz, 1H, Ar-*H*), 3.87 (*s*, 3H, OC*H*$_3$), 2.96 (*s*, 3H, NC*H*$_3$), 1.49 (*s*, 9H, C*H*$_3$).

<u>^{13}C{^{1}H} NMR</u> (101 MHz, $CDCl_3$)
δ 161.8 (arom.), 160.0 (arom.), 139.0 (arom.), 103.6 (arom.), 98.3 (arom.), 55.9 (N*C*(CH$_3$)$_3$), 53.3 (O*C*H$_3$), 34.9 (N*C*H$_3$), 28.9 (3C, *C*H$_3$).

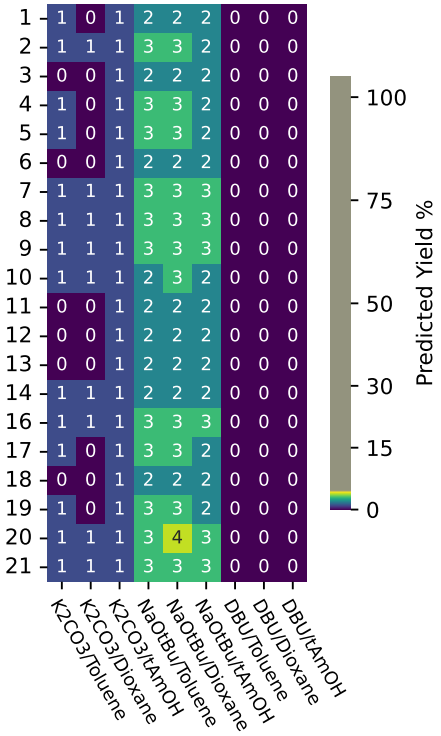
<u>IR (cm^{-1})</u> (neat)
2972, 1648, 1590, 1574, 1456, 1425, 1407, 1388, 1354, 1257, 1213, 1151, 1080, 1036, 982, 962, 915, 858.

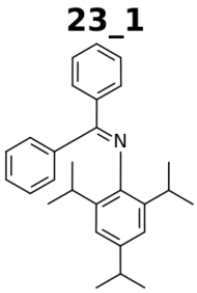
<u>HRMS (ESI)</u> Calcd. for $C_{11}H_{19}N_2O$ *m/z* 195.1492, Found: 195.1488 $[M+H]^+$.

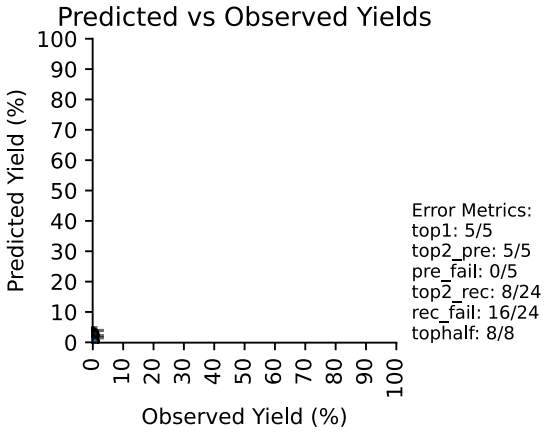
<u>TLC</u> R_f 0.60 (EtOAc/heptane, 10:90)

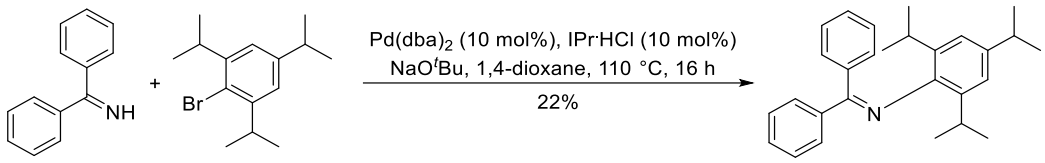
Data for **23_1**

	Predicted Yield %	Observed Yield %
23_1_4_1_a	0.0	0.0
23_1_7_1_a	1.0	0.0
23_1_5_1_b	3.0	0.0
23_1_8_1_b	3.0	0.0
23_1_14_1_b	2.0	0.0
23_1_1_1_c	0.0	0.0
23_1_9_1_c	0.0	0.0
23_1_1_2_a	1.0	0.0
23_1_10_2_a	1.0	0.0
23_1_2_2_b	2.0	0.0
23_1_11_2_b	2.0	0.0
23_1_3_2_c	0.0	0.0
23_1_4_2_c	0.0	0.0
23_1_7_2_c	0.0	0.0
23_1_8_2_c	0.0	0.0
23_1_12_2_c	0.0	0.0
23_1_4_3_a	1.0	0.0
23_1_12_3_a	0.0	0.0
23_1_13_3_a	0.0	0.0
23_1_5_3_b	3.0	0.0
23_1_10_3_b	2.0	0.0
23_1_14_3_b	2.0	0.0
23_1_2_3_c	0.0	0.0
23_1_6_3_c	0.0	0.0

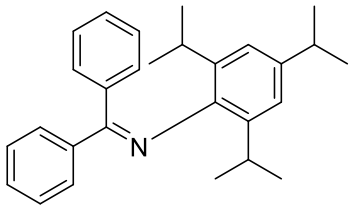








Prepared in analogy to a literature procedure.(*57*) Diphenylmethanimine (352 µL, 2.10 mmol, 1.05 equiv), sodium *tert*-butoxide (288 mg, 3.00 mmol, 1.50 equiv), 1,3-bis(2,6-diisopropylphenyl)imidazolium chloride (85.0 mg, 200 µmol, 10.0 mol%) and tris(dibenzylideneacetone)dipalladium(0) (91.6 mg, 100 µmol, 5.00 mol%) were added to 2-bromo-1,3,5-triisopropylbenzene (507 µL, 2.00 mmol) in 1,4-dioxane (4.0 mL) and the solution was heated to 110 °C for 16 h. The reaction was cooled to rt, diluted with water (25 mL) and extracted twice with CH_2Cl_2 (2 × 25 mL). The combined organic phases were washed with saturated aqueous NaCl solution (25 mL), dried over $MgSO_4$, filtered, and the solvent was removed under reduced pressure. ^{1}H NMR analysis of the crude product with 1,3,5-trimethoxybenzene (112 mg, 667 µmol, 0.33 equiv) as the internal standard showed the formation of the product in 54%. Flash column chromatography on silica gel (EtOAc/heptane, 0:100 to 10:90) afforded the product as a yellow solid. Yield: 171 mg (22%).



1,1-Diphenyl-*N*-(2,4,6-triisopropylphenyl)methanimine **(23_1)**

m.p. 99 °C.

^{1}H NMR (600 MHz, $CDCl_3$)

δ 7.79 (*d*, 2H, $^3J_{H,H'}$ = 7.0 Hz, 2H, Ar-*H*), 7.52 – 7.37 (*m*, 3H, Ar-*H*), 7.26 – 7.15 (*m*, 3H, Ar-*H*), 7.12 – 7.06 (*m*, 2H, Ar-*H*), 6.82 (*s*, 2H, Ar-*H*), 2.92 – 2.75 (*m*, 3H, C*H*), 1.21 (*d*, $^3J_{H,H'}$ = 7.0 Hz, 6H, CH_3), 1.13 (*d*, $^3J_{H,H'}$ = 6.5 Hz, 6H, CH_3), 0.91 (*d*, $^3J_{H,H'}$ = 6.7 Hz, 6H, CH_3).

^{13}C{^{1}H} NMR (151 MHz, $CDCl_3$)

δ 165.6 (*C*=N), 144.2 (arom.), 143.3 (arom.), 140.2 (arom.), 136.1 (aorm.), 135.2 (2C. arom.), 130.0 (arom.), 129.3 (2C, arom.), 129.23 (2C, arom.), 128.7

(arom.), 128.0 (2C, arom.), 127.5 (2C. arom.), 120.5 (2C, arom.), 33.9 (*C*H), 28.4 (2C, *C*H), 24.2 (2C, *C*H_3), 24.0 (2C, *C*H_3), 22.0 (2C, *C*H_3).

IR (cm^{-1}) (neat)

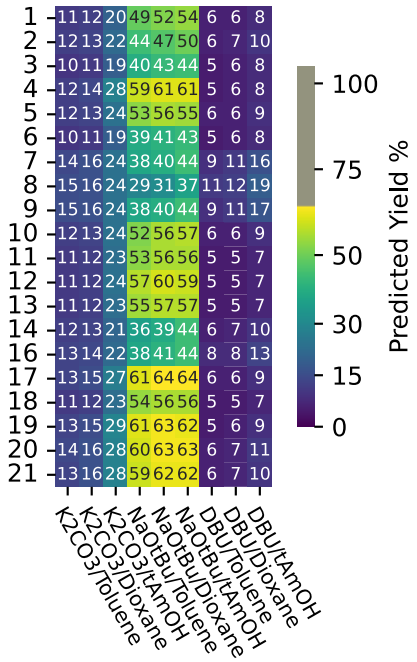
3057, 2959, 2863, 1620, 1577, 1458, 1445, 1380, 1361, 1316, 1292, 1267, 1215, 1116, 1074, 1026, 1000, 956, 943, 912, 874.

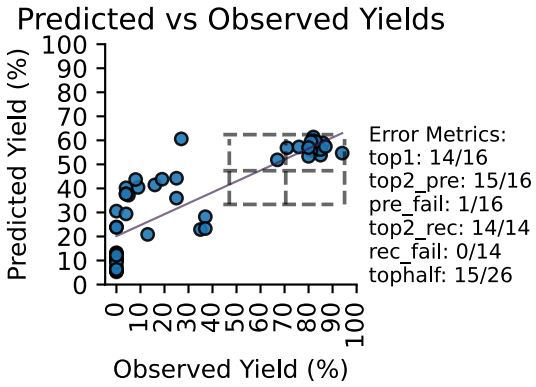
HRMS (ESI) Calcd. for $C_{28}H_{34}N$ *m/z* 384.2686, Found: 384.2684 $[M+H]^+$.

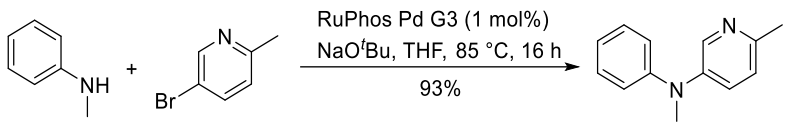
TLC R_f 0.83 (EtOAc/heptane, 10:90)

Data for **6_18**

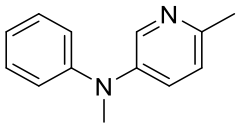
	Predicted Yield %	Observed Yield %
6_18_2_1_a	13.0	0.0
6_18_6_1_a	11.0	0.0
6_18_10_1_a	13.0	0.0
6_18_1_1_b	52.0	67.0
6_18_6_1_b	41.0	16.0
6_18_7_1_b	40.0	9.0
6_18_8_1_b	31.0	0.0
6_18_3_1_c	6.0	0.0
6_18_8_1_c	12.0	0.0
6_18_12_1_c	5.0	0.0
6_18_4_2_a	28.0	37.0
6_18_9_2_a	24.0	0.0
6_18_14_2_a	21.0	13.0
6_18_1_2_b	54.0	85.0
6_18_10_2_b	57.0	71.0
6_18_2_2_c	10.0	0.0
6_18_11_2_c	7.0	0.0
6_18_3_3_a	10.0	0.0
6_18_12_3_a	11.0	0.0
6_18_4_3_b	59.0	86.0
6_18_13_3_b	55.0	94.0
6_18_5_3_c	6.0	0.0
6_18_9_3_c	9.0	0.0
6_18_14_3_c	6.0	0.0
6_18_4_1_b	61.0	82.0
6_18_9_1_b	40.0	4.0
6_18_10_1_b	56.0	82.0
6_18_11_1_b	56.0	85.0
6_18_12_1_b	60.0	83.0
6_18_13_1_b	57.0	87.0
6_18_10_2_a	24.0	0.0
6_18_11_2_a	23.0	35.0
6_18_13_2_a	23.0	37.0
6_18_4_2_b	61.0	27.0
6_18_7_2_b	44.0	19.0
6_18_8_2_b	37.0	5.0
6_18_9_2_b	44.0	8.0
6_18_11_2_b	56.0	81.0
6_18_12_2_b	59.0	81.0
6_18_13_2_b	57.0	76.0
6_18_14_2_b	44.0	25.0
6_18_4_3_a	12.0	0.0
6_18_7_3_b	38.0	4.0
6_18_8_3_b	29.0	4.0
6_18_9_3_b	38.0	4.0
6_18_11_3_b	53.0	80.0
6_18_12_3_b	57.0	80.0
6_18_14_3_b	36.0	25.0







Prepared in analogy to a literature procedure.(*10*) *N*-Methylaniline (260 µL, 2.40 mmol, 1.20 equiv), sodium *tert*-butoxide (231 mg, 2.40 mmol, 1.20 equiv) and RuPhos Pd G3 (16.7 mg, 20.0 µmol, 1.00 mol%) were added to 5-bromo-2-methylpyridine (344 mg, 2.00 mmol) in THF (4.0 mL) and the solution was heated to 85 °C for 16 h. The reaction was cooled to rt, diluted with water (25 mL) and extracted twice with CH_2Cl_2 (2 × 25 mL). The combined organic phases were washed with saturated aqueous NaCl solution (25 mL), dried over $MgSO_4$, filtered, and the solvent was removed under reduced pressure. ^{1}H NMR analysis of the crude product with 1,3,5-trimethoxybenzene (112 mg, 667 µmol, 0.33 equiv) as the internal standard showed the formation of the product in 94%. Flash column chromatography on silica gel (EtOAc/heptane, 0:100 to 100:0) afforded the product as a light yellowish liquid. Yield: 369 mg (93%).



N,6-Dimethyl-*N*-phenylpyridin-3-amine **(6_18)**

<u>^{1}H NMR</u> (600 MHz, $CDCl_3$)

δ 8.26 (*d*, $^4J_{H,H'}$ = 2.8 Hz, 1H, Ar-*H*), 7.28 – 7.25 (*m*, 2H, Ar-*H*), 7.23 (*dd*, $^3J_{H,H'}$ = 8.4 Hz, $^4J_{H,H'}$ = 2.8 Hz, 1H, Ar-*H*), 7.04 (*d*, $^3J_{H,H'}$ = 8.4 Hz, 1H, Ar-*H*), 6.99 – 6.94 (*m*, 3H, Ar-*H*), 3.30 (*s*, 3H, NC*H*$_3$), 2.50 (*s*, 3H, C*H*$_3$).

<u>^{13}C{^{1}H} NMR</u> (151 MHz, $CDCl_3$)

δ 151.1 (arom.), 148.4 (arom.), 142.8 (arom.), 142.2 (arom.), 129.3 (2C, arom.), 128.5 (arom.), 123.2 (arom.), 121.5 (arom.), 119.7 (2C, arom.), 40.2 (N*C*H$_3$), 23.5 (*C*H$_3$).

<u>IR (cm^{-1})</u> ATR (neat)

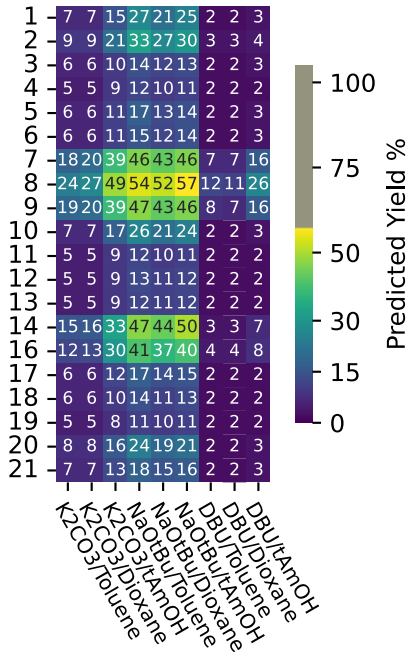
3270, 3090, 2980, 2939, 2839, 1618, 1582, 1494, 1459, 1428, 1385, 1354, 1319, 1279, 1247, 1182, 1122, 1106, 1095, 1058, 1018, 1011, 944, 898, 889, 845, 816.

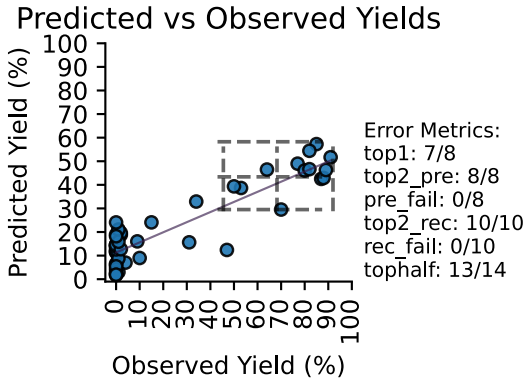
<u>HRMS (ESI)</u> Calcd. for $C_{13}H_{15}N_2$ *m/z* 199.1230, Found: 199.1219 $[M+H]^+$.

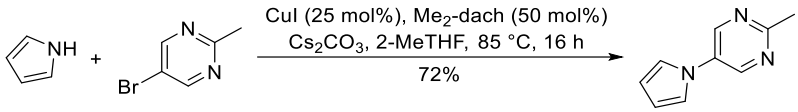
<u>TLC</u> R_f 0.38 (EtOAc/heptane, 50:50)

Data for **17_17**

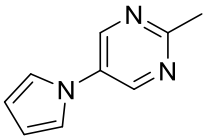
	Predicted Yield %	Observed Yield %
17_17_1_1_a	7.0	4.0
17_17_5_1_a	6.0	0.0
17_17_14_1_a	16.0	31.0
17_17_3_1_b	12.0	0.0
17_17_6_1_b	12.0	0.0
17_17_10_1_b	21.0	1.0
17_17_7_1_c	7.0	0.0
17_17_8_1_c	11.0	0.0
17_17_4_2_a	9.0	1.0
17_17_8_2_a	49.0	77.0
17_17_5_2_b	14.0	0.0
17_17_9_2_b	46.0	64.0
17_17_1_2_c	3.0	1.0
17_17_2_2_c	4.0	0.0
17_17_10_2_c	3.0	0.0
17_17_12_2_c	2.0	0.0
17_17_2_3_a	9.0	10.0
17_17_9_3_a	19.0	2.0
17_17_11_3_a	5.0	0.0
17_17_3_3_b	14.0	0.0
17_17_6_3_b	15.0	0.0
17_17_12_3_b	13.0	0.0
17_17_4_3_c	2.0	0.0
17_17_13_3_c	2.0	0.0
17_17_7_1_a	20.0	2.0
17_17_7_1_b	43.0	87.0
17_17_8_1_b	52.0	91.0
17_17_9_1_b	43.0	88.0
17_17_17_1_b	14.0	0.0
17_17_20_1_b	19.0	0.0
17_17_21_1_b	15.0	0.0
17_17_7_2_a	39.0	53.0
17_17_9_2_a	39.0	50.0
17_17_14_2_a	33.0	34.0
17_17_16_2_a	30.0	70.0
17_17_17_2_a	12.0	47.0
17_17_20_2_a	16.0	9.0
17_17_21_2_a	13.0	2.0
17_17_7_2_b	46.0	80.0
17_17_8_2_b	57.0	85.0
17_17_20_2_b	21.0	1.0
17_17_21_2_b	16.0	1.0
17_17_8_3_a	24.0	15.0
17_17_7_3_b	46.0	89.0
17_17_8_3_b	54.0	82.0
17_17_9_3_b	47.0	82.0
17_17_20_3_b	24.0	0.0
17_17_21_3_b	18.0	0.0







1*H*-Pyrrole (208 µL, 3.00 mmol, 1.50 equiv), cesium carbonate (1.30 g, 4.00 mmol, 2.00 equiv), copper(I) iodide (95.2 mg, 500 µmol, 25.0 mol%) and (±)-*trans*-*N*,*N*'-dimethylcyclohexane-1,2-diamine (158 µL, 1.00 mmol, 50.0 mol%) were added to 5-bromo-2-methylpyrimidine (346 mg, 2.00 mmol) in 2-MeTHF (4.0 mL) and the solution was heated to 85 °C for 16 h. The reaction was cooled to rt, diluted with 5% aqueous NH_3 solution (25 mL) and extracted twice with CH_2Cl_2 (2 × 25 mL). The combined organic phases were washed with saturated aqueous NaCl solution (25 mL), dried over $MgSO_4$, filtered, and the solvent was removed under reduced pressure. ^{1}H NMR analysis of the crude product with 1,3,5-trimethoxybenzene (112 mg, 667 µmol, 0.33 equiv) as the internal standard showed the formation of the product in 72%. Flash column chromatography on silica gel (EtOAc/heptane, 0:100 to 80:20) afforded the product as a white solid. Yield: 228 mg (72%).



5-Methyl-5-(1*H*-pyrrol-1-yl)pyrimidine **(17_17)**

m.p. 122 °C.

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

δ 8.65 (*s*, 2H, Ar-*H*), 7.02 – 6.96 (*m*, 2H, Ar-*H*), 6.38 – 6.32 (*m*, 2H, Ar-*H*), 2.70 (*s*, 3H, C*H*$_3$).

^{13}C{^{1}H} (101 MHz, $CDCl_3$)

NMR δ 165.0 (arom.), 148.2 (2C, arom.), 132.6 (arom.), 118.6 (2C, arom.), 111.6 (2C, arom.), 25.1 (*C*H$_3$).

IR (cm^{-1}) ATR (neat)

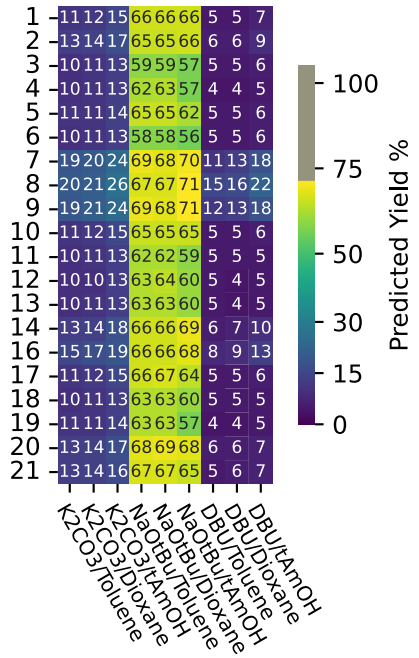
3133, 3117, 3094, 3040, 3015, 2978, 2928, 1901 1780, 1736, 1691, 1592, 1572, 1557, 1521, 1489, 1464, 1443, 1409, 1391, 1344, 1307, 1279, 1252, 1225, 1179, 1129, 1086, 1073, 1041, 1018, 934, 923, 891, 869, 853, 844, 818.

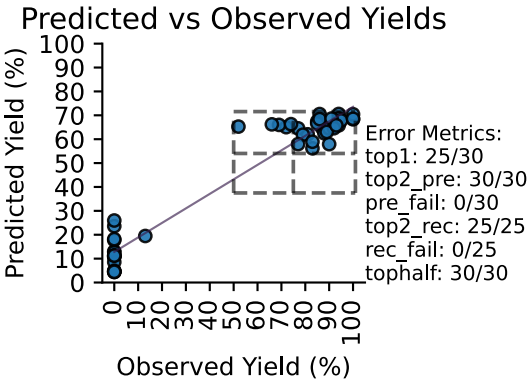
HRMS (ESI) Calcd. for $C_9H_{10}N_3$ *m*/*z* 180.0869, Found: 160.0862 $[M+H]^+$.

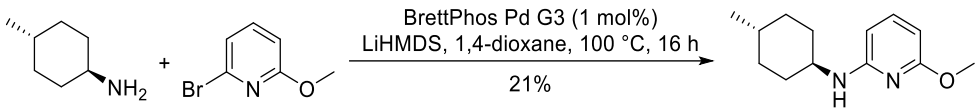
TLC R_f 0.37 (EtOAc/heptane, 50:50)

Data for **36_41**

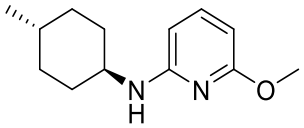
	Predicted Yield %	Observed Yield %
36_41_3_1_a	11.0	0.0
36_41_4_1_a	11.0	0.0
36_41_13_1_a	11.0	0.0
36_41_5_1_b	65.0	87.0
36_41_14_1_b	66.0	94.0
36_41_6_1_c	5.0	0.0
36_41_7_1_c	13.0	0.0
36_41_12_1_c	4.0	0.0
36_41_6_2_a	13.0	0.0
36_41_7_2_a	24.0	0.0
36_41_14_2_a	18.0	0.0
36_41_5_2_b	62.0	81.0
36_41_8_2_b	71.0	86.0
36_41_10_2_b	65.0	77.0
36_41_2_2_c	9.0	0.0
36_41_9_2_c	18.0	0.0
36_41_1_3_a	11.0	0.0
36_41_10_3_a	11.0	0.0
36_41_2_3_b	65.0	52.0
36_41_8_3_b	67.0	85.0
36_41_11_3_b	62.0	79.0
36_41_3_3_c	5.0	0.0
36_41_4_3_c	4.0	0.0
36_41_12_3_c	5.0	0.0
36_41_6_1_b	58.0	77.0
36_41_7_1_b	68.0	100.0
36_41_8_1_b	67.0	85.0
36_41_9_1_b	68.0	86.0
36_41_10_1_b	65.0	72.0
36_41_11_1_b	62.0	88.0
36_41_16_1_b	66.0	69.0
36_41_8_2_a	26.0	0.0
36_41_16_2_a	19.0	13.0
36_41_6_2_b	56.0	83.0
36_41_7_2_b	70.0	100.0
36_41_9_2_b	71.0	94.0
36_41_11_2_b	59.0	83.0
36_41_14_2_b	69.0	94.0
36_41_16_2_b	68.0	95.0
36_41_5_3_b	65.0	90.0
36_41_6_3_b	58.0	90.0
36_41_7_3_b	69.0	100.0
36_41_9_3_b	69.0	91.0
36_41_10_3_b	65.0	92.0
36_41_12_3_b	63.0	89.0
36_41_14_3_b	66.0	93.0
36_41_16_3_b	66.0	66.0
36_41_17_3_b	66.0	74.0







Prepared in analogy to a literature procedure.(*10*) *trans*-4-Methylcyclohexan-1-amine (290 µL, 2.20 mmol, 1.10 equiv), lithium bis(trimethylsilyl)amide (402 mg, 2.40 mmol, 2.20 equiv) and BrettPhos Pd G3 (18.1 mg, 20.0 µmol, 1.00 mol%) were added to 2-bromo-6-methoxypyridine (246 µL, 2.00 mmol) in 1,4-dioxane (4.0 mL) and the solution was heated to 100 °C for 16 h. The reaction was cooled to rt, diluted with 5% aqueous NH_3 solution (25 mL) and extracted twice with CH_2Cl_2 (2 × 25 mL). The combined organic phases were washed with saturated aqueous NaCl solution (25 mL), dried over $MgSO_4$, filtered, and the solvent was removed under reduced pressure. ^{1}H NMR analysis of the crude product with 1,3,5-trimethoxybenzene (112 mg, 667 µmol, 0.33 equiv) as the internal standard showed the formation of the product in 23%. Flash column chromatography on silica gel (EtOAc/heptane, 0:100 to 20:80, then CH_2Cl_2/heptane, 0:100 to 100:0)) afforded the product as a clear oil. Yield: 93.4 mg (21%).



6-Methoxy-*N*-(*trans*-4-methylcyclohexyl)pyridin-2-amine **(36_41)**

<u>^{1}H NMR</u> (400 MHz, $CDCl_3$)

δ 7.30 (*dd*, $^3J_{H,H'}$ = 7.8 Hz, 1H, Ar-*H*), 5.97 (*d*, $^3J_{H,H'}$ = 7.8 Hz, 1H, Ar-*H*), 5.90 (*d*, $^3J_{H,H'}$ = 7.8 Hz, 1H, Ar-*H*), 4.26 (br *d*, $^3J_{H,H'}$ = 5.4 Hz, 1H, N*H*), 3.83 (*s*, 3H, OCH_3), 3.48 – 3.35 (*m*, 1H, NC*H*), 2.14 – 2.08 (*m*, 2H, C*H*H), 1.78 – 1.71 (*m*, 2H, C*H*H), 1.44 – 1.31 (*m*, 1H, C*H*), 1.20 – 1.00 (*m*, 4H, C*H*H), 0.91 (*d*, $^3J_{H,H'}$ = 6.5 Hz, 3H, CH_3).

<u>^{13}C{^{1}H} NMR</u> (101 MHz, $CDCl_3$)

δ 163.6 (arom.), 157.1 (arom.), 139.8 (arom.), 97.6 (arom.), 96.7 (arom.), 52.9 (OCH_3), 50.7 (N*C*H), 34.0 (2C, CH_2), 33.4 (2C, CH_2), 32.2 (*C*H), 22.2 (CH_3).

<u>IR (cm^{-1})</u> (neat)

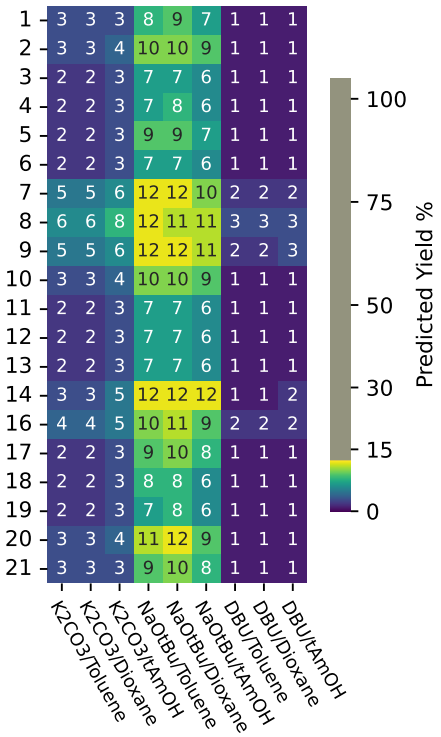
3397, 2946, 2923, 2846, 1604, 1582, 1493, 1454, 1423, 1404, 1369, 1330, 1259, 1250, 1225, 1144, 1128, 1117, 1078, 1039, 1017, 991, 937, 888.

<u>HRMS (ESI)</u> Calcd. for $C_{13}H_{21}N_2O$ *m*/*z* 221.1648, Found: 221.1641 $[M+H]^+$.

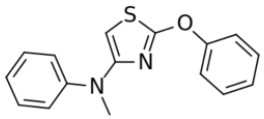
<u>TLC</u> R_f 0.42. (EtOAc/heptane, 10:90)

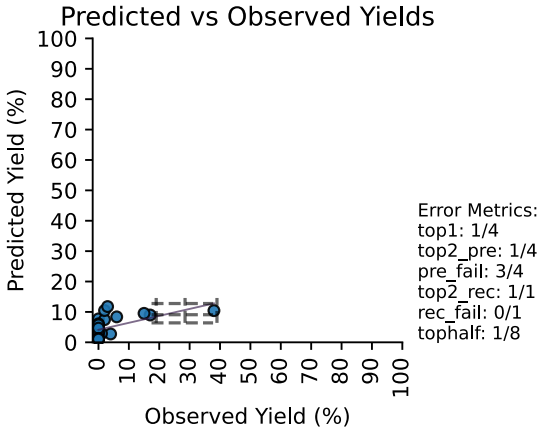
Data for **6_38**

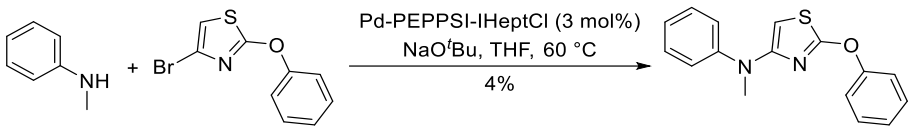
	Predicted Yield %	Observed Yield %
6_38_3_1_a	2.0	0.0
6_38_7_1_a	5.0	0.0
6_38_12_1_a	2.0	0.0
6_38_2_1_b	10.0	38.0
6_38_4_1_b	8.0	0.0
6_38_13_1_b	7.0	2.0
6_38_5_1_c	1.0	0.0
6_38_6_1_c	1.0	0.0
6_38_14_1_c	1.0	0.0
6_38_4_2_a	3.0	4.0
6_38_6_2_a	3.0	1.0
6_38_13_2_a	3.0	0.0
6_38_3_2_b	6.0	0.0
6_38_7_2_b	10.0	2.0
6_38_10_2_b	9.0	17.0
6_38_5_2_c	1.0	0.0
6_38_8_2_c	3.0	0.0
6_38_8_3_a	6.0	0.0
6_38_9_3_a	5.0	0.0
6_38_1_3_b	8.0	6.0
6_38_10_3_b	10.0	15.0
6_38_14_3_b	12.0	3.0
6_38_2_3_c	1.0	0.0
6_38_11_3_c	1.0	0.0



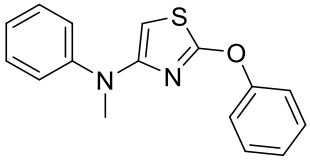
6_38







Prepared in analogy to a literature procedure.(*12*) *N*-Methylaniline (108 µL, 1.00 mmol), sodium *tert*-butoxide (144 mg, 1.50 mmol, 1.50 equiv) and Pd-PEPPSI-IHeptCl (29.2 mg, 30.0 µmol, 3.00 mol%) were added to 4-bromo-2-phenoxythiazole (307 mg, 1.20 mmol) in THF (2.0 mL) and the solution was heated to 60 °C for 16 h. The reaction was cooled to rt, diluted with water (25 mL) and extracted twice with CH_2Cl_2 (2 × 25 mL). The combined organic phases were washed with saturated aqueous NaCl solution (25 mL), dried over $MgSO_4$, filtered, and the solvent was removed under reduced pressure. ^{1}H NMR analysis of the crude product with 1,3,5-trimethoxybenzene (112 mg, 667 µmol, 0.33 equiv) as the internal standard showed the formation of the product in 66%. Reverse phase HPLC (MeCN/H_2O, 20:80 to 90:10) afforded the product as an brown oil. Yield: 11.6 mg (4%).



N-Methyl-2-phenoxy-*N*-phenylthiazol-4-amine **(6_38)**

m.p: Yellow oil

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

δ 7.40 – 7.34 (*m*, 2H, Ar-*H*), 7.31 – 7.18 (*m*, 7H, Ar-*H*), 6.98 (*tt*, $^3J_{H,H'}$ = 7.3, 1.2 Hz, 1H, Ar-*H*), 5.64 (*s*, 1H, Ar-*H*), 3.32 (*s*, 3H, NC*H*$_3$).

^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$)

δ 171.4 (arom.), 155.3 (arom.), 153.0 (arom.), 147.4 (arom.), 129.9 (2C, arom.), 129.0 (2C, arom.), 125.9 (arom.), 122.4 (arom.), 121.2 (2C, arom.), 120.3 (2C, arom.), 88.0 (arom.), 39.3 (N*C*H$_3$).

IR ATR (neat)

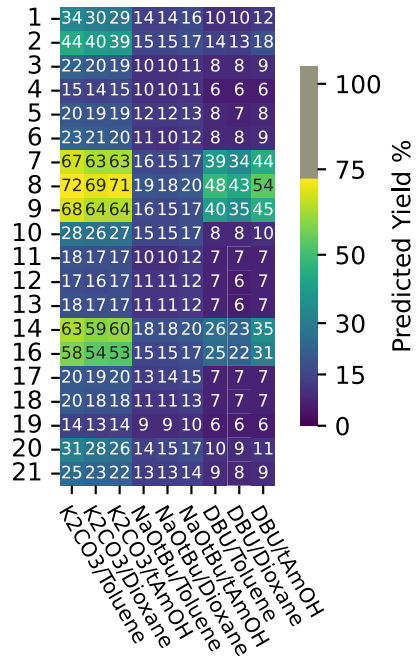
2963 (w br), 1746 (s), 1597 (w), 1535 (s), 1487 (m), 1455 (w), 1369 (m), 1211 (s), 1158 (w), 1119 (m), 1070 (w), 1026 (m), 975 (w), 853 (w), 749 (w), 691 (m), 638 (w), 600 (w), 558 (w).

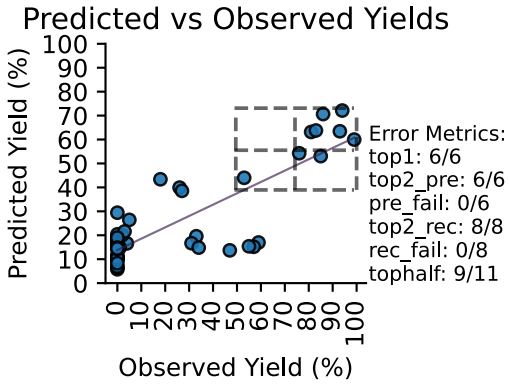
HRMS (ESI) Calcd for $C_{16}H_{15}N_2OS$ $(M+H)^+$: 283.0905 Found: 283.0901

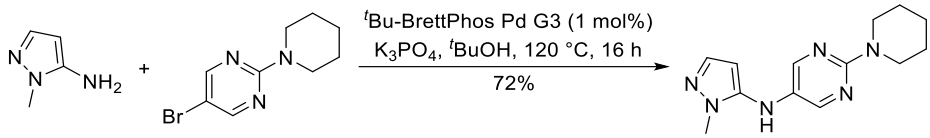
TLC R_f 0.56 (EtOAc/hexane, 10:90)

Data for **14_27**

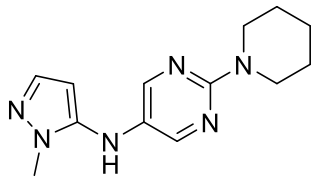
	Predicted Yield %	Observed Yield %
14_27_2_1_a	40.0	26.0
14_27_7_1_a	63.0	93.0
14_27_11_1_a	17.0	4.0
14_27_3_1_b	10.0	0.0
14_27_12_1_b	11.0	0.0
14_27_4_1_c	6.0	0.0
14_27_13_1_c	6.0	0.0
14_27_1_2_a	29.0	0.0
14_27_5_2_a	19.0	0.0
14_27_14_2_a	60.0	99.0
14_27_2_2_b	17.0	59.0
14_27_4_2_b	11.0	0.0
14_27_6_2_b	12.0	0.0
14_27_8_2_b	20.0	2.0
14_27_7_2_c	44.0	53.0
14_27_12_2_c	7.0	0.0
14_27_5_3_a	20.0	0.0
14_27_8_3_a	72.0	94.0
14_27_4_3_b	10.0	0.0
14_27_6_3_b	11.0	0.0
14_27_9_3_b	16.0	0.0
14_27_1_3_c	10.0	0.0
14_27_2_3_c	14.0	0.0
14_27_10_3_c	8.0	0.0
14_27_2_1_b	15.0	57.0
14_27_7_1_b	15.0	0.0
14_27_8_1_b	18.0	0.0
14_27_16_1_b	15.0	1.0
14_27_17_1_b	14.0	47.0
14_27_8_1_c	43.0	18.0
14_27_2_2_a	39.0	27.0
14_27_7_2_a	63.0	81.0
14_27_8_2_a	71.0	86.0
14_27_9_2_a	64.0	83.0
14_27_16_2_a	53.0	85.0
14_27_17_2_a	20.0	33.0
14_27_20_2_a	26.0	5.0
14_27_21_2_a	22.0	3.0
14_27_7_2_b	17.0	0.0
14_27_16_2_b	17.0	31.0
14_27_17_2_b	15.0	55.0
14_27_20_2_b	17.0	0.0
14_27_8_2_c	54.0	76.0
14_27_2_3_b	15.0	34.0
14_27_7_3_b	16.0	0.0
14_27_8_3_b	19.0	0.0
14_27_16_3_b	15.0	0.0
14_27_20_3_b	14.0	0.0







Prepared in analogy to a literature procedure.(*58*) 1-Methyl-1*H*-pyrazol-5-amine (214 mg, 2.20 mmol, 1.10 equiv), potassium phosphate (637 mg, 3.00 mmol, 1.50 equiv) and ^{t}Bu-BrettPhos Pd G3 (17.1 mg, 20.0 µmol, 1.00 mol%) were added to 5-bromo-2-(piperidin-1-yl)pyrimidine (484 mg, 2.00 mmol) in ^{t}BuOH (3.0 mL) and the solution was heated to 120 °C for 16 h. The reaction was cooled to rt, diluted with water (25 mL) and extracted twice with CH_2Cl_2 (2 × 25 mL). The combined organic phases were washed with saturated aqueous NaCl solution (25 mL), dried over $MgSO_4$, filtered, and the solvent was removed under reduced pressure. ^{1}H NMR analysis of the crude product with 1,3,5-trimethoxybenzene (112 mg, 667 µmol, 0.33 equiv) as the internal standard showed the formation of the product in 92%. Flash column chromatography on silica gel (EtOAc) afforded the product as an off-white solid. Yield: 370 mg (72%).



N-(1-Methyl-1*H*-pyrazol-5-yl)-2-(piperidin-1-yl)pyrimidin-5-amine **(14_27)**

m.p. 132 °C.

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

δ 8.05 (*s*, 2H, Ar-*H*), 7.29 (*d*, $^3J_{H,H'}$ = 1.7 Hz, 1H, Ar-*H*), 5.64 (*d*, $^3J_{H,H'}$ = 1.7 Hz, 1H, Ar-*H*), 5.54 (*s*, 1H, N*H*), 3.71 – 3.67 (*m*, 4H, NCH_2), 3.66 (*s*, 3H, NCH_3), 1.66 – 1.53 (*m*, 6H, CH_2).

^{13}C{^{1}H} (101 MHz, $CDCl_3$)

NMR δ 158.8 (arom.), 149.7 (2C, arom.), 143.6 (arom.), 138.4 (arom.), 127.7 (arom.), 93.6 (arom.), 45.2 (2C, NCH_2), 34.7 (NCH_3), 25.5 (2C, CH_2), 24.7 (CH_2).

IR (cm^{-1}) ATR (neat)

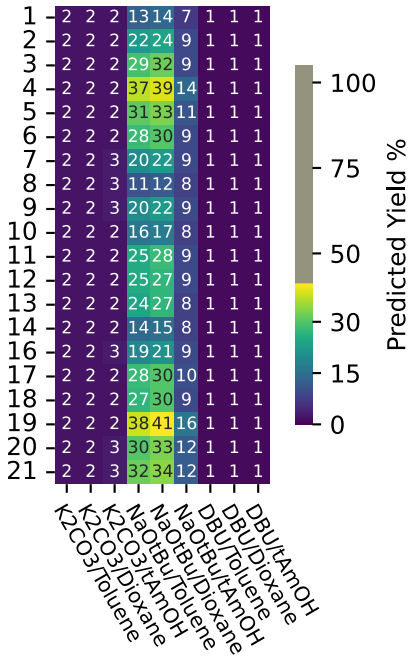
3237, 2991, 2927, 2850, 1612, 1586, 1551, 1530, 1485, 1452, 1427, 1404, 1362, 1342, 1288, 1258 1203, 1177, 1149, 1115, 1025, 1014, 999, 939, 887, 869, 849, 809.

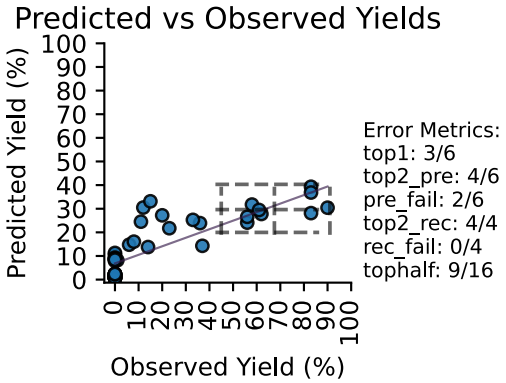
HRMS (ESI) Calcd. for $C_{13}H_{19}N_6$ *m/z* 259.1666, Found: 259.1661 $[M+H]^+$.

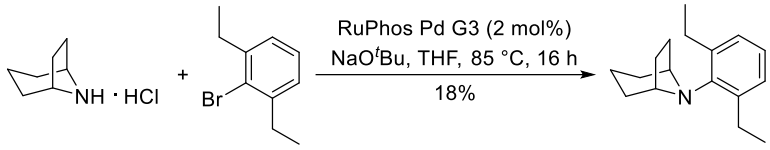
TLC R_f 0.43 (EtOAc)

Data for **42_10**

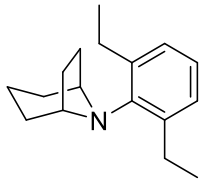
	Predicted Yield %	Observed Yield %
42_10_1_1_a	2.0	0.0
42_10_10_1_a	2.0	0.0
42_10_2_1_b	24.0	36.0
42_10_6_1_b	30.0	90.0
42_10_11_1_b	28.0	62.0
42_10_3_1_c	1.0	0.0
42_10_4_1_c	1.0	0.0
42_10_12_1_c	1.0	0.0
42_10_2_2_a	2.0	0.0
42_10_4_2_a	2.0	0.0
42_10_13_2_a	2.0	0.0
42_10_5_2_b	11.0	0.0
42_10_14_2_b	8.0	0.0
42_10_6_2_c	1.0	0.0
42_10_9_2_c	1.0	0.0
42_10_10_2_c	1.0	0.0
42_10_1_3_a	2.0	0.0
42_10_7_3_a	2.0	0.0
42_10_14_3_a	2.0	0.0
42_10_5_3_b	31.0	12.0
42_10_8_3_b	11.0	0.0
42_10_13_3_b	24.0	56.0
42_10_9_3_c	1.0	0.0
42_10_11_3_c	1.0	0.0
42_10_3_1_b	32.0	58.0
42_10_4_1_b	39.0	83.0
42_10_5_1_b	33.0	15.0
42_10_12_1_b	27.0	20.0
42_10_13_1_b	27.0	56.0
42_10_14_1_b	15.0	6.0
42_10_5_2_a	2.0	0.0
42_10_14_2_a	2.0	0.0
42_10_2_2_b	9.0	0.0
42_10_3_2_b	9.0	0.0
42_10_4_2_b	14.0	37.0
42_10_6_2_b	9.0	0.0
42_10_10_2_b	8.0	1.0
42_10_11_2_b	9.0	0.0
42_10_13_2_b	8.0	0.0
42_10_2_3_b	22.0	23.0
42_10_3_3_b	29.0	61.0
42_10_4_3_b	37.0	83.0
42_10_6_3_b	28.0	83.0
42_10_10_3_b	16.0	8.0
42_10_11_3_b	25.0	33.0
42_10_12_3_b	25.0	11.0
42_10_14_3_b	14.0	14.0







Prepared in analogy to a literature procedure.(*10*) 8-Azabicyclo[3.2.1]octane hydrochloride (148 mg, 1.00 mmol), sodium *tert*-butoxide (240 mg, 2.50 mmol, 2.50 equiv) and RuPhos Pd G3 (16.7 mg, 20.0 µmol, 2.00 mol%) were added to 2-bromo-1,3-diethylbenzene (253 µL, 1.50 mmol, 1.50 equiv) in THF (3.0 mL) and the solution was heated to 85 °C for 16 h. The reaction was cooled to rt, diluted with water (10 mL) and extracted three times with CH_2Cl_2 (3 × 10 mL). The combined organic phases were dried over $MgSO_4$, filtered, and the solvent was removed under reduced pressure. Flash column chromatography on silica gel (EtOAc/heptane, 0:100 to 20:80) afforded the product as a colorless oil. Yield: 42.8 mg (18%).



8-(2,6-Diethylphenyl)-8-azabicyclo[3.2.1]octane **(42_10)**

<u>^{1}H NMR</u> (400 MHz, $CDCl_3$): δ 7.10 (*d*, $^3J_{H,H'}$ = 7.6 Hz, 2H, Ar-*H*), 7.03 – 6.98 (*m*, 1H, Ar-*H*), 3.74 – 3.68 (*m*, 2H, NC*H*), 2.79 (*q*, $^3J_{H,H'}$ = 7.5 Hz, 4H, CH_2), 2.16 – 2.06 (*m*, 4H, C*H*H), 1.97 – 1.88 (*m*, 3H, C*H*H), 1.75 – 1.69 (*m*, 1H, C*H*H), 1.53 – 1.48 (*m*, 2H, C*H*H), 1.31 (*t*, $^3J_{H,H'}$ = 7.5 Hz, 6H, CH_3).

<u>^{13}C{^{1}H} NMR</u> (101 MHz, $CDCl_3$): δ 147.2 (arom.), 140.7 (2C, arom.), 127.0 (2C, arom.), 122.8 (arom.), 60.8 (2C, N*C*H), 32.8 (2C, *C*H_2), 30.9 (2C, *C*H_2), 25.7 (2C, *C*H_2), 17.5 (*C*H_2), 15.5 (2C, *C*H_3).

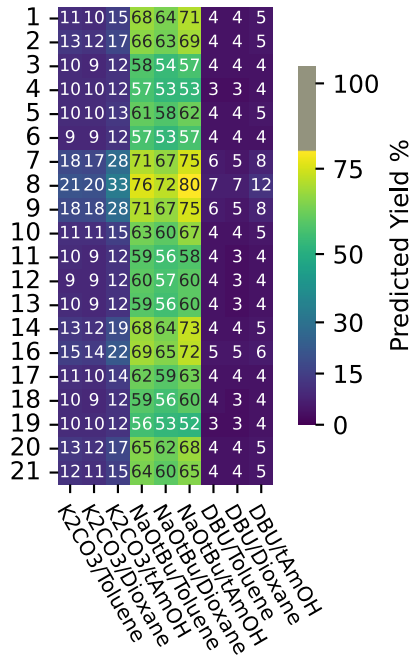
<u>IR (cm^{-1})</u> ATR (neat)
3057, 2959, 2930, 2868, 2846, 2652, 2555, 1911, 1849, 1787, 1694, 1649, 1591, 1575, 1484, 1450, 1438, 1364, 1342, 1302, 1277, 1244, 1226, 1191, 1164, 1151, 1122, 1094, 1068, 1031, 1008, 995, 958, 944, 929, 896, 869, 842, 824, 808.

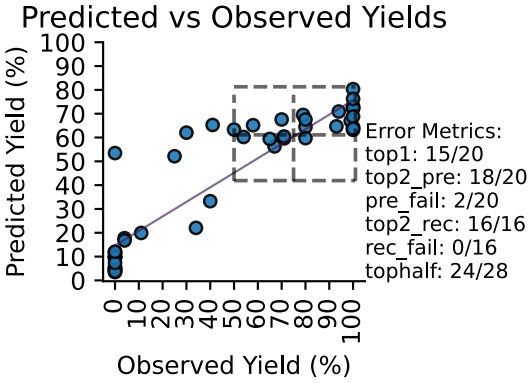
<u>HRMS (ESI)</u> Calcd. for $C_{17}H_{26}N$ *m/z* 244.2060, Found: 244.2057 $[M+H]^+$.

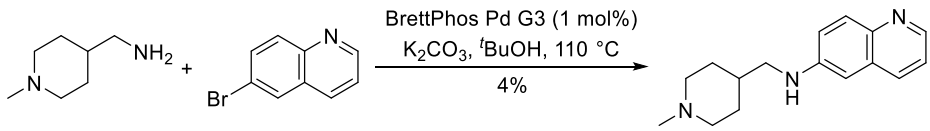
<u>TLC</u> R_f 0.69. (EtOAc/heptane, 10:90)

Data for **32_26**

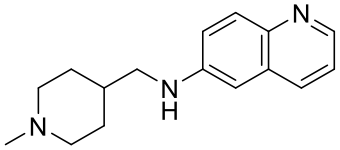
	Predicted Yield %	Observed Yield %
32_26_4_1_a	10.0	0.0
32_26_5_1_a	10.0	0.0
32_26_8_1_a	20.0	11.0
32_26_9_1_a	18.0	4.0
32_26_1_1_b	64.0	80.0
32_26_10_1_b	60.0	54.0
32_26_2_1_c	4.0	0.0
32_26_9_1_c	5.0	0.0
32_26_11_1_c	3.0	0.0
32_26_3_2_a	12.0	0.0
32_26_12_2_a	12.0	0.0
32_26_2_2_b	69.0	79.0
32_26_4_2_b	53.0	0.0
32_26_13_2_b	60.0	71.0
32_26_1_2_c	5.0	0.0
32_26_5_2_c	5.0	0.0
32_26_14_2_c	5.0	0.0
32_26_5_3_a	10.0	0.0
32_26_6_3_a	9.0	0.0
32_26_7_3_b	71.0	94.0
32_26_10_3_b	63.0	50.0
32_26_14_3_b	68.0	70.0
32_26_3_3_c	4.0	0.0
32_26_8_3_c	7.0	0.0
32_26_8_1_b	72.0	100.0
32_26_14_1_b	64.0	100.0
32_26_16_1_b	65.0	58.0
32_26_18_1_b	56.0	67.0
32_26_20_1_b	62.0	30.0
32_26_21_1_b	60.0	71.0
32_26_8_2_a	33.0	40.0
32_26_16_2_a	22.0	34.0
32_26_19_2_a	12.0	0.0
32_26_20_2_a	17.0	4.0
32_26_8_2_b	80.0	100.0
32_26_10_2_b	67.0	99.0
32_26_14_2_b	73.0	100.0
32_26_16_2_b	72.0	100.0
32_26_17_2_b	63.0	100.0
32_26_18_2_b	60.0	80.0
32_26_19_2_b	52.0	25.0
32_26_20_2_b	68.0	80.0
32_26_21_2_b	65.0	93.0
32_26_8_3_b	76.0	100.0
32_26_16_3_b	69.0	100.0
32_26_18_3_b	59.0	65.0
32_26_20_3_b	65.0	41.0
32_26_21_3_b	64.0	100.0







Prepared in analogy to a literature procedure.(*10*) (1-Methylpiperidin-4-yl)methanamine (308 mg, 2.40 mmol, 1.20 equiv), potassium carbonate (663 mg, 4.80 mmol, 2.40 equiv) and BrettPhos Pd G3 (18.1 mg, 20.0 µmol, 1.00 mol%) were added to 6-bromoquinoline (416 mg, 2.00 mmol) in ^{t}BuOH (4.0 mL) and the solution was heated to 110 °C for 16 h. The reaction was cooled to rt, diluted with water (25 mL) and extracted twice with CH_2Cl_2 (2 × 25 mL). The combined organic phases were washed with saturated aqueous NaCl solution (25 mL), dried over $MgSO_4$, filtered, and the solvent was removed under reduced pressure. ^{1}H NMR analysis of the crude product with 1,3,5-trimethoxybenzene (112 mg, 667 µmol, 0.33 equiv) as the internal standard showed the formation of the product in 93%. Flash column chromatography on silica gel (EtOAc) afforded the product as an off-white solid. Yield: 18.0 mg (4%).



N-((1-Methylpiperidin-4-yl)methyl)quinolin-6-amine **(32_26)**

m.p. 116 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ 8.59 (*dd*, $^3J_{H,H'}$ = 4.3 Hz, $^4J_{H,H'}$ = 1.6 Hz, 1H, Ar-*H*), 7.92 – 7.88 (*m*, 1H, Ar-*H*), 7.85 (*d*, $^3J_{H,H'}$ = 9.1 Hz, 1H, Ar-*H*), 7.26 – 7.21 (*m*, 1H, Ar-*H*), 7.06 (*dd*, $^3J_{H,H'}$ = 9.1 Hz, $^4J_{H,H'}$ = 2.7 Hz, 1H, Ar-*H*), 6.66 (*d*, $^4J_{H,H'}$ = 2.7 Hz, 1H, Ar-*H*), 4.05 (br *t*, $^3J_{H,H'}$ = 5.1 Hz, 1H, N*H*), 3.13 (*t*, $^3J_{H,H'}$ = 7.5, 5.1 Hz, 2H, NCH_2), 2.94 – 2.88 (*m*, 2H, NC*H*H), 2.30 (*s*, 3H, NCH_3), 2.02 – 1.94 (*m*, 2H, NC*H*H), 1.89 – 1.78 (*m*, 2H, CH_2), 1.72 – 1.60 (*m*, 1H, C*H*), 1.50 – 1.38 (*m*, 2H, CH_2).

^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$): δ 146.2 (arom.), 146.0 (arom.), 143.1 (arom.), 133.7 (arom.), 130.2 (arom.), 130.1 (arom.), 121.4 (arom.), 121.3 (arom.), 102.7 (arom.), 55.5 (2C, N*C*H_2), 49.7 (N*C*H_2), 46.2 (N*C*H_3), 34.8 (*C*H), 30.3 (2C, *C*H_2).

IR (cm^{-1}) (neat)

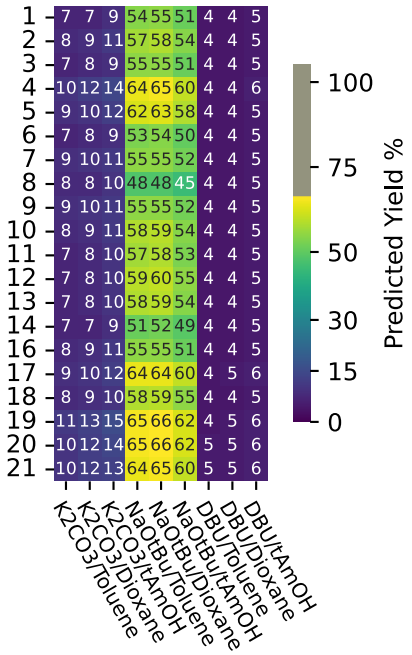
3268, 3073, 3023, 2935, 2881, 2828, 2847, 2794, 2737, 1682, 1704, 1677, 1622, 15593, 1577, 1549, 1536, 1465, 1448, 1433, 1376, 1367, 1332, 1299, 1276, 1264, 1259, 1223, 1198, 1184, 1156, 1141, 1123, 1193, 1077, 1062, 1040, 1019, 982, 955, 932, 912, 824.

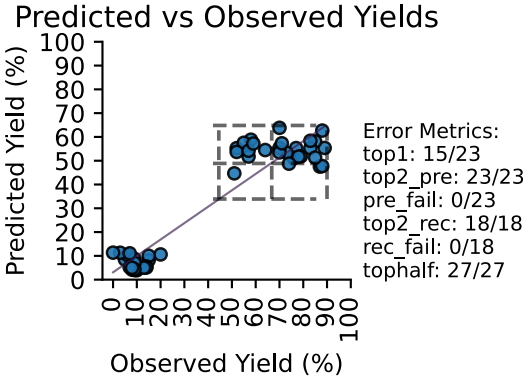
HRMS (ESI) Calcd. for $C_{16}H_{22}N_3$ *m/z* 256.1808, Found: 256.1818 $[M+H]^+$.

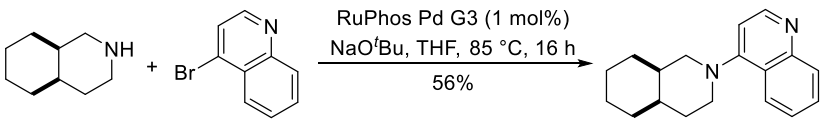
TLC R_f 0.05 (EtOAc)

Data for **45_30**

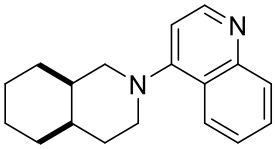
	Predicted Yield %	Observed Yield %
45_30_3_1_a	8.0	15.0
45_30_8_1_a	8.0	5.0
45_30_14_1_a	7.0	9.0
45_30_5_1_b	63.0	88.0
45_30_9_1_b	55.0	77.0
45_30_10_1_b	59.0	58.0
45_30_1_1_c	4.0	10.0
45_30_10_1_c	4.0	10.0
45_30_11_1_c	4.0	9.0
45_30_2_2_a	11.0	20.0
45_30_8_2_a	10.0	6.0
45_30_11_2_a	10.0	15.0
45_30_3_2_b	51.0	76.0
45_30_12_2_b	55.0	52.0
45_30_4_2_c	6.0	14.0
45_30_12_2_c	5.0	14.0
45_30_13_2_c	5.0	13.0
45_30_5_3_a	9.0	9.0
45_30_14_3_a	7.0	9.0
45_30_4_3_b	64.0	70.0
45_30_6_3_b	53.0	73.0
45_30_7_3_b	55.0	70.0
45_30_2_3_c	4.0	8.0
45_30_7_3_c	4.0	9.0
45_30_2_1_b	58.0	55.0
45_30_7_1_b	55.0	89.0
45_30_8_1_b	48.0	87.0
45_30_11_1_b	58.0	85.0
45_30_14_1_b	52.0	79.0
45_30_7_2_a	11.0	3.0
45_30_9_2_a	11.0	0.0
45_30_10_2_a	11.0	7.0
45_30_2_2_b	54.0	52.0
45_30_7_2_b	52.0	57.0
45_30_8_2_b	45.0	51.0
45_30_9_2_b	52.0	78.0
45_30_10_2_b	54.0	57.0
45_30_11_2_b	53.0	70.0
45_30_14_2_b	49.0	74.0
45_30_10_2_c	5.0	7.0
45_30_11_2_c	5.0	8.0
45_30_1_3_b	54.0	64.0
45_30_2_3_b	57.0	59.0
45_30_8_3_b	48.0	88.0
45_30_9_3_b	55.0	83.0
45_30_10_3_b	58.0	83.0
45_30_11_3_b	57.0	71.0
45_30_14_3_b	51.0	85.0







Prepared in analogy to a literature procedure.(*10*) *cis*-Decahydroisoquinoline (167 mg, 1.20 mmol, 1.20 equiv), sodium *tert*-butoxide (115 mg, 1.20 mmol, 1.20 equiv) and RuPhos Pd G3 (8.4 mg, 10.0 µmol, 1.00 mol%) were added to 4-bromoquinoline (208 mg, 1.00 mmol) in THF (2.0 mL) and the solution was heated to 85 °C for 16 h. The reaction was cooled to rt, diluted with water (25 mL) and extracted twice with CH_2Cl_2 (2 × 25 mL). The combined organic phases were washed with saturated aqueous NaCl solution (25 mL), dried over $MgSO_4$, filtered, and the solvent was removed under reduced pressure. ^{1}H NMR analysis of the crude product with 1,3,5-trimethoxybenzene (56.1 mg, 333 µmol, 0.33 equiv) as the internal standard showed the formation of the product in 60%. Flash column chromatography on silica gel (EtOAc/heptane, 0:100 to 100:0) afforded the product as a clear oil. Yield: 148 mg (56%).



rac-4-((4a*R*,8ai)-Octahydroisoquinolin-2(1*H*)-yl)quinoline (**45_30**)

<u>^{1}H NMR</u> (400 MHz, $CDCl_3$)

δ 8.70 (*d*, $^3J_{H,H'}$ = 5.0 Hz, 1H, Ar-*H*), 8.08 (*dd*, $^3J_{H,H'}$ = 8.4 Hz, $^4J_{H,H'}$ = 0.9 Hz, 1H, Ar-*H*), 8.05 – 8.01 (*m*, 1H, Ar-*H*), 7.63 (*ddd*, $^3J_{H,H'}$ = 8.4, 6.9 Hz, $^4J_{H,H'}$ = 1.5 Hz, 1H, Ar-*H*), 6.83 (*d*, $^3J_{H,H'}$ = 5.0 Hz, 1H, Ar-*H*), 3.55 – 3.23 (*m*, 2H, NC*H*H), 3.10 – 2.79 (*m*, 2H, NC*H*H), 2.26 – 1.88 (*m*, 4H, C*H* (2H) + C*H*H (2H)),1.81 – 1.33 (*m*, 8H, C*H*H).

<u>^{13}C{^{1}H}</u> (101 MHz, $CDCl_3$)

<u>NMR</u> δ 158.2 (arom.), 150.8 (arom.), 149.6 (arom.), 129.9 (arom.), 128.8 (arom.), 124.9 (arom.), 123.9 (2C, arom.), 108.8 (arom.). Aliphatic carbons observed as broad signals.

<u>^{13}C{^{1}H}</u> (101 MHz, DMSO-d_6, 120 °C)

<u>NMR</u> δ 55.8 (br *s*, N*C*H$_2$), 50.9 (br *s*, N*C*H$_2$), 35.5 (*C*H), 33.2 (br *s*, *C*H), 28.6 (br *s*, *C*H$_2$), 26.6 (*C*H$_2$), 26.1 (br *s*, *C*H$_2$), 23.9 (br *s*, *C*H$_2$), 21.5 (*C*H$_2$). Aromatic

carbons observed as broad signals.

IR (cm^{-1}) (neat)

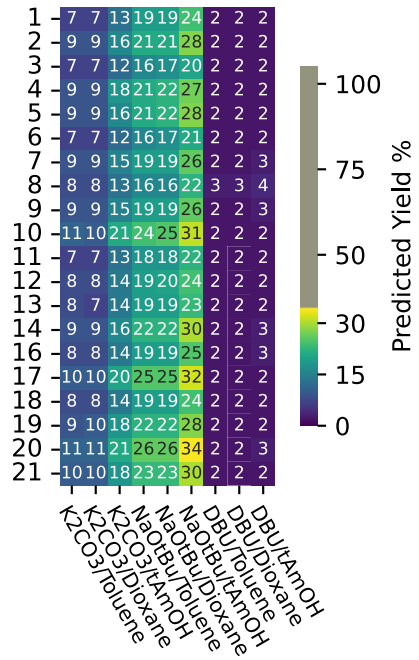
3059, 2919, 2855, 2804, 1907, 1735, 1613, 1576, 1505, 1461, 1422, 1395, 1382, 1335, 1299, 1262, 1238, 1201, 1180, 1153, 1123, 1106, 1064, 1043, 1014, 986, 952, 912, 891, 841, 828, 811.

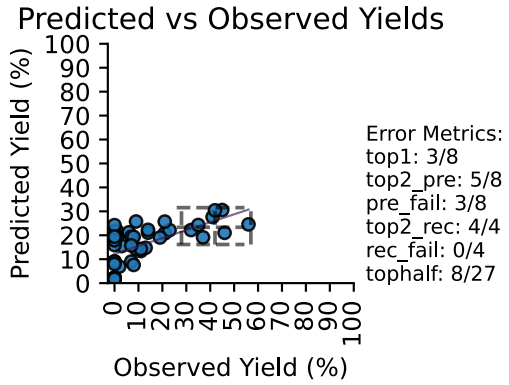
HRMS (ESI) Calcd. for $C_{18}H_{23}N_2$ *m/z* 267.1856, Found: 267.1853 $[M+H]^+$.

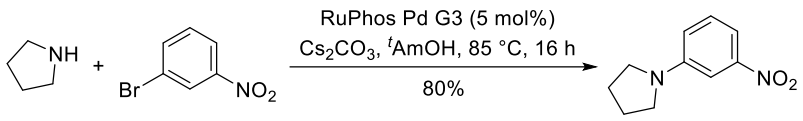
TLC R_f 0.28 (EtOAc/heptane, 50:50)

Data for **44_13**

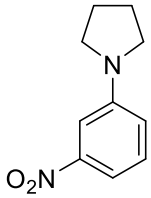
	Predicted Yield %	Observed Yield %
44_13_6_1_a	7.0	2.0
44_13_7_1_a	9.0	7.0
44_13_5_1_b	22.0	1.0
44_13_8_1_b	16.0	3.0
44_13_10_1_b	25.0	56.0
44_13_9_1_c	2.0	0.0
44_13_11_1_c	2.0	0.0
44_13_1_2_a	13.0	11.0
44_13_7_2_a	15.0	13.0
44_13_10_2_a	21.0	46.0
44_13_2_2_b	28.0	41.0
44_13_11_2_b	22.0	0.0
44_13_3_2_c	2.0	0.0
44_13_12_2_c	2.0	0.0
44_13_13_2_c	2.0	0.0
44_13_4_3_a	9.0	0.0
44_13_9_3_a	9.0	0.0
44_13_13_3_a	8.0	8.0
44_13_2_3_b	21.0	21.0
44_13_5_3_b	21.0	6.0
44_13_14_3_b	22.0	32.0
44_13_1_3_c	2.0	0.0
44_13_3_3_c	2.0	0.0
44_13_6_3_c	2.0	0.0
44_13_2_1_b	21.0	14.0
44_13_7_1_b	19.0	7.0
44_13_9_1_b	19.0	1.0
44_13_11_1_b	18.0	0.0
44_13_12_1_b	20.0	0.0
44_13_14_1_b	22.0	23.0
44_13_16_1_b	19.0	37.0
44_13_12_2_a	14.0	9.0
44_13_14_2_a	16.0	0.0
44_13_16_2_a	14.0	11.0
44_13_7_2_b	26.0	21.0
44_13_8_2_b	22.0	14.0
44_13_9_2_b	26.0	9.0
44_13_10_2_b	31.0	45.0
44_13_12_2_b	24.0	0.0
44_13_14_2_b	30.0	42.0
44_13_8_3_a	8.0	0.0
44_13_1_3_b	19.0	19.0
44_13_7_3_b	19.0	8.0
44_13_8_3_b	16.0	7.0
44_13_9_3_b	19.0	0.0
44_13_10_3_b	24.0	35.0
44_13_11_3_b	18.0	0.0
44_13_12_3_b	19.0	0.0







Prepared in analogy to a literature procedure.(*10*) Pyrrolidine (246 µL, 3.00 mmol, 1.50 equiv), cesium carbonate (978 mg, 3.00 mmol, 1.50 equiv) and RuPhos Pd G3 (83.6 mg, 100 µmol, 5.00 mol%) were added to 1-bromo-3-nitrobenzene (404 mg, 2.00 mmol) in ^{t}BuOH (4.0 mL) and the solution was heated to 85 °C for 16 h. The reaction was cooled to rt, diluted with water (25 mL) and extracted twice with CH_2Cl_2 (2 × 25 mL). The combined organic phases were washed with saturated aqueous NaCl solution (25 mL), dried over $MgSO_4$, filtered, and the solvent was removed under reduced pressure. ^{1}H NMR analysis of the crude product with 1,3,5-trimethoxybenzene (112 mg, 667 µmol, 0.33 equiv) as the internal standard showed the formation of the product in 91%. Flash column chromatography on silica gel (CH_2Cl_2/heptane, 0:100 to 50:50) afforded the product as an orange solid. Yield: 307 mg (80%).

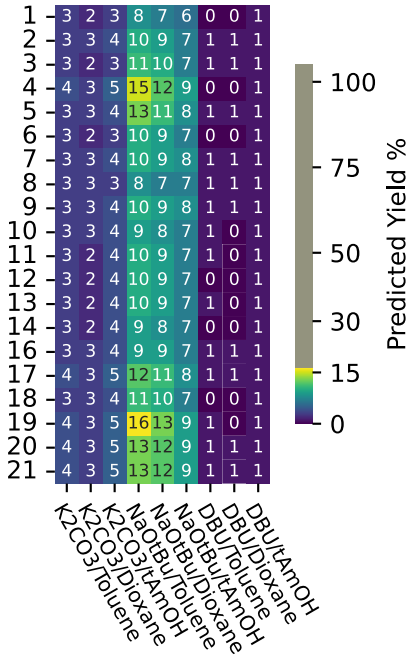


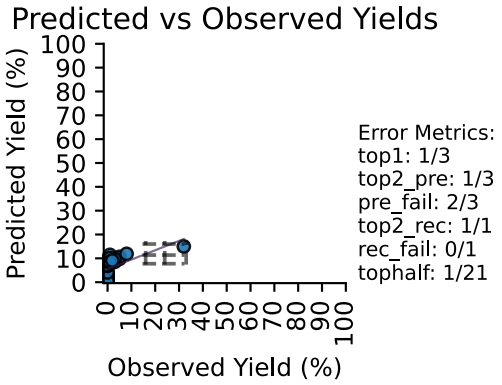
1-(3-Nitrophenyl)pyrrolidine **(44_13)**

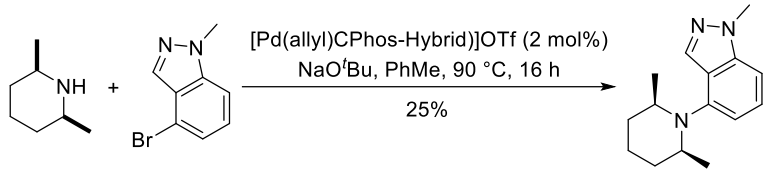
m.p.	96 °C.
^{1}H NMR	(400 MHz, $CDCl_3$)
	δ 7.49 – 7.43 (*m*, 1H, Ar-*H*), 7.34 – 7.27 (*m*, 2H, Ar-*H*), 6.82 – 6.77 (*m*, 1H, Ar-*H*), 3.38 – 3.30 (*m*, 2H, NC*H*$_2$), 2.09 – 2.02 (*m*, 2H, C*H*$_2$).
^{13}C{^{1}H}	(101 MHz, $CDCl_3$)
NMR	δ 149.3 (arom.), 148.2 (arom.), 129.5 (arom.), 117.2 (arom.), 109.8 (arom.), 105.6 (arom.), 47.8 (2C, N*C*H$_2$), 25.5 (2C, *C*H$_2$).
IR (cm^{-1})	ATR (neat)
	3095, 2976, 2851, 1625, 1613, 1566, 1518, 1481, 1462, 1451, 1379, 1342, 1313, 1287, 1249, 1230, 1181, 1161, 1100, 1075, 1006, 982, 918, 881, 837.
HRMS (ESI)	Calcd. for $C_{10}H_{13}N_2O_2$ *m*/*z* 193.0972, Found: 193.0963 $[M+H]^+$.
TLC	R_f 0.74 (EtOAc/heptane, 50:50)

Data for **40_12**

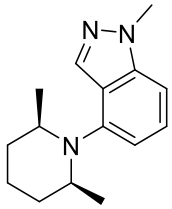
	Predicted Yield %	Observed Yield %
40_12_2_1_a	3.0	0.0
40_12_6_1_a	2.0	0.0
40_12_8_1_a	3.0	0.0
40_12_5_1_b	11.0	1.0
40_12_7_1_b	9.0	0.0
40_12_8_1_c	1.0	0.0
40_12_12_1_c	0.0	0.0
40_12_9_2_a	4.0	0.0
40_12_14_2_a	4.0	0.0
40_12_1_2_b	6.0	0.0
40_12_10_2_b	7.0	0.0
40_12_2_2_c	1.0	0.0
40_12_3_2_c	1.0	0.0
40_12_4_2_c	1.0	0.0
40_12_7_2_c	1.0	0.0
40_12_11_2_c	1.0	0.0
40_12_1_3_a	3.0	0.0
40_12_3_3_a	3.0	0.0
40_12_12_3_a	3.0	0.0
40_12_4_3_b	15.0	32.0
40_12_13_3_b	10.0	5.0
40_12_5_3_c	1.0	0.0
40_12_10_3_c	1.0	0.0
40_12_14_3_c	0.0	0.0
40_12_2_1_b	9.0	1.0
40_12_9_1_b	9.0	0.0
40_12_10_1_b	8.0	0.0
40_12_11_1_b	9.0	0.0
40_12_13_1_b	9.0	2.0
40_12_14_1_b	8.0	0.0
40_12_16_1_b	9.0	3.0
40_12_17_1_b	11.0	5.0
40_12_10_2_a	4.0	0.0
40_12_2_2_b	7.0	0.0
40_12_9_2_b	8.0	0.0
40_12_11_2_b	7.0	0.0
40_12_13_2_b	7.0	0.0
40_12_14_2_b	7.0	0.0
40_12_16_2_b	7.0	0.0
40_12_17_2_b	8.0	1.0
40_12_2_3_b	10.0	3.0
40_12_9_3_b	10.0	0.0
40_12_10_3_b	9.0	0.0
40_12_11_3_b	10.0	1.0
40_12_12_3_b	10.0	1.0
40_12_14_3_b	9.0	1.0
40_12_16_3_b	9.0	2.0
40_12_17_3_b	12.0	8.0







(2**S*,6*R**)-2,6-Dimethylpiperidine (80.9 µL, 600 µmol, 1.20 equiv), sodium *tert*-butoxide (104 mg, 750 µmol, 1.50 equiv) and [Pd(allyl)(CPhos-Hybrid)]OTf (11.1 mg. 10.0 µmol, 2.00 mol%) were added to 4-bromo-1-methyl-1*H*-indazole (106 mg, 500 µmol) in PhMe (2 mL) and the solution was heated to 90 °C for 16 h. HPLC analysis of the crude product with 1,3,5-trimethoxybenzene (14.0 mg, 83.3 µmol, 0.167 equiv) as the internal standard showed the formation of the product in 32%. The reaction was cooled to rt, diluted with saturated aqueous NaCl solution (15 mL) and extracted four times with EtOAc (4 × 15 mL). The combined organic phases were dried over $MgSO_4$, filtered, and the solvent was removed under reduced pressure. Flash column chromatography on silica gel (EtOAc/heptane, 0:100 to 50:50) afforded the product as a light red oil. Yield: 30.8 mg (25%). 4(2**S*,6*R**)-2,6-Dimethylpiperidin-1-yl)-1-methyl-1H-indazole



4-(*cis*-2,6-Dimethylpiperidin-1-yl)-1-methyl-1*H*-indazole (**40_12**)

<u>^{1}H NMR</u> (400 MHz, $CDCl_3$)

δ 8.13 (*s*, 1H, Ar-*H*), 7.34 – 7.27 (*m*, 1H, Ar-*H*), 7.18 (*d*, $^3J_{H,H'}$ = 8.3 Hz, 1H, Ar-*H*), 6.98 (*d*, $^3J_{H,H'}$ = 7.3 Hz, 1H, Ar-*H*), 4.05 (*s*, 3H, NC*H*$_3$), 3.17 – 3.03 (*m*, 2H, NC*H*), 1.86 – 1.71 (*m*, 3H, C*H*H), 1.64 – 1.51 (*m*, 1H, C*H*H), 1.48 – 1.36 (*m*, 2H, C*H*H), 0.68 (*d*, $^3J_{H,H'}$ = 6.2 Hz, 6H, C*H*$_3$).

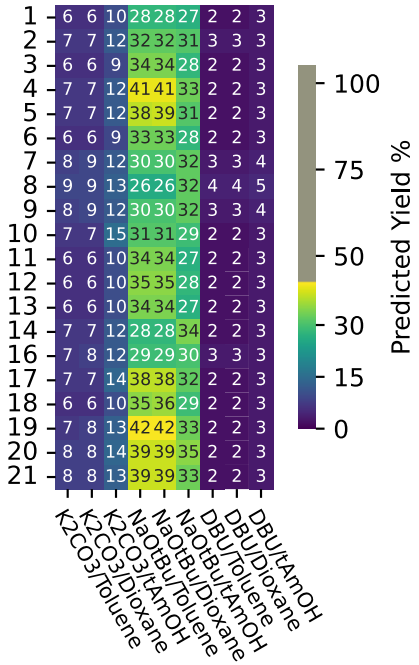
<u>^{13}C{^{1}H}</u> (101 MHz, $CDCl_3$)

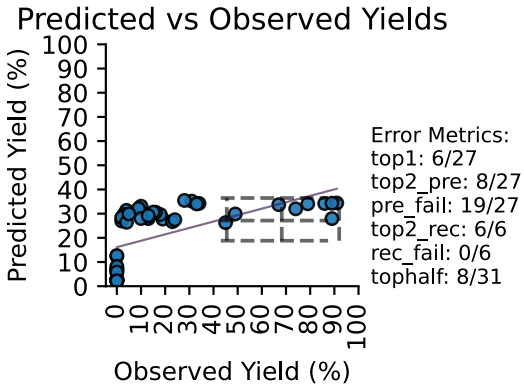
<u>NMR</u> δ 145.7 (arom.), 140.8 (arom.), 132.2 (arom.), 126.6 (arom.), 124.7 (arom.), 117.7 (arom.), 105.9 (arom.), 57.7 (2C, N*C*H), 35.5 (N*C*H$_3$), 35.4 (2C, *C*H$_2$), 24.5 (*C*H$_2$), 22.0 (2C, *C*H$_3$).

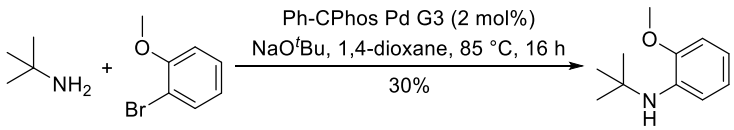
IR (cm^{-1})	ATR (neat)
	3055, 2961, 2927, 2855, 2790, 2694, 2649, 2590, 1610, 1580, 1504, 1450, 1433, 1407, 1385, 1370, 1358, 1310, 1262, 1246, 1223, 1196, 1175, 1149, 1118, 1090, 1055, 1030, 1023, 982, 977, 960, 913, 894, 838.
HRMS (ESI)	Calcd. for $C_{15}H_{22}N_3$ *m/z* 244.1808, Found: 244.1805 $[M+H]^+$
TLC	R_f 0.28. (EtOAc/heptane, 30:70)

Data for **37_7**

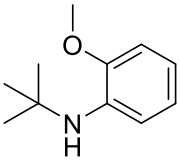
	Predicted Yield %	Observed Yield %
37_7_5_1_a	7.0	0.0
37_7_14_1_a	7.0	0.0
37_7_6_1_b	33.0	10.0
37_7_8_1_b	26.0	45.0
37_7_2_1_c	3.0	0.0
37_7_7_1_c	3.0	0.0
37_7_10_1_c	2.0	0.0
37_7_14_1_c	2.0	0.0
37_7_4_2_a	12.0	0.0
37_7_8_2_a	13.0	0.0
37_7_3_2_b	28.0	89.0
37_7_5_2_b	31.0	4.0
37_7_9_2_b	32.0	9.0
37_7_1_2_c	3.0	0.0
37_7_10_2_c	3.0	0.0
37_7_11_2_c	3.0	0.0
37_7_1_3_a	6.0	0.0
37_7_2_3_a	7.0	0.0
37_7_9_3_a	8.0	0.0
37_7_11_3_a	6.0	0.0
37_7_3_3_b	34.0	91.0
37_7_12_3_b	35.0	31.0
37_7_4_3_c	2.0	0.0
37_7_13_3_c	2.0	0.0
37_7_1_1_b	28.0	19.0
37_7_3_1_b	34.0	86.0
37_7_7_1_b	30.0	18.0
37_7_9_1_b	30.0	3.0
37_7_10_1_b	31.0	16.0
37_7_11_1_b	34.0	34.0
37_7_12_1_b	35.0	28.0
37_7_13_1_b	34.0	89.0
37_7_14_1_b	28.0	13.0
37_7_16_1_b	29.0	13.0
37_7_1_2_b	27.0	23.0
37_7_7_2_b	32.0	74.0
37_7_11_2_b	27.0	2.0
37_7_12_2_b	28.0	2.0
37_7_13_2_b	27.0	24.0
37_7_14_2_b	34.0	67.0
37_7_7_3_b	30.0	49.0
37_7_8_3_b	26.0	4.0
37_7_9_3_b	30.0	5.0
37_7_10_3_b	31.0	15.0
37_7_11_3_b	34.0	33.0
37_7_13_3_b	34.0	79.0
37_7_14_3_b	28.0	10.0
37_7_16_3_b	29.0	13.0







Prepared in analogy to a literature procedure.(*59*) 2-Methylpropan-2-amine (211 µL, 2.00 mmol, 2.00 equiv) sodium *tert*-butoxide (192 mg, 2.00 mmol, 2.00 equiv) and PhCPhos Pd G3[7] (17.1 mg, 21.5 µmol, 2.15 mol%) were added to 1-bromo-2-methoxybenzene (125 □L, 1.00 mmol) in 1,4-dioxane (3.0 mL) and the solution was heated to 85 °C for 16 h. The reaction was cooled to rt, diluted with water (10 mL) and extracted three times with CH_2Cl_2 (3 × 10 mL). The combined organic phases were dried over $MgSO_4$, filtered, and the solvent was removed under reduced pressure. Flash column chromatography on silica gel (EtOAc/heptane, 0:100 to 40:60) afforded the product as a colorless oil. Yield: 54.1 mg (30%).



N-(*tert*-Butyl)-2-methoxyaniline **(37_7)**

<u>^{1}H NMR</u> (400 MHz, $CDCl_3$)
δ 6.93 (*dd*, $^3J_{H,H'}$ = 7.9 Hz, $^4J_{H,H'}$ = 1.6 Hz, 1H, Ar-*H*), 6.85 (*ddd*, $^3J_{H,H'}$ = 7.9, 7.5 Hz, $^4J_{H,H'}$ = 1.5 Hz, 1H, Ar-*H*), 6.80 (*dd*, $^3J_{H,H'}$ = 7.9 Hz, $^4J_{H,H'}$ = 1.5 Hz, 1H, Ar-*H*), 6.70 (*ddd*, $^3J_{H,H'}$ = 7.9, 7.5 Hz, $^4J_{H,H'}$ = 1.6 Hz, 1H, Ar-*H*), 4.26 (br *s*, 1H, N*H*), 3.85 (*s*, 3H, OCH_3), 1.40 (*s*, 9H, CH_3).

<u>^{13}C{^{1}H} NMR</u> (101 MHz, $CDCl_3$)
δ 148.0 (arom.), 136.6 (arom.), 120.7 (arom.), 116.8 (arom.), 114.4 (arom.), 109.7 (arom.), 55.4 (O*C*H_3), 50.9 (*C*(CH_3)$_3$), 29.9 (3C, *C*H_3).

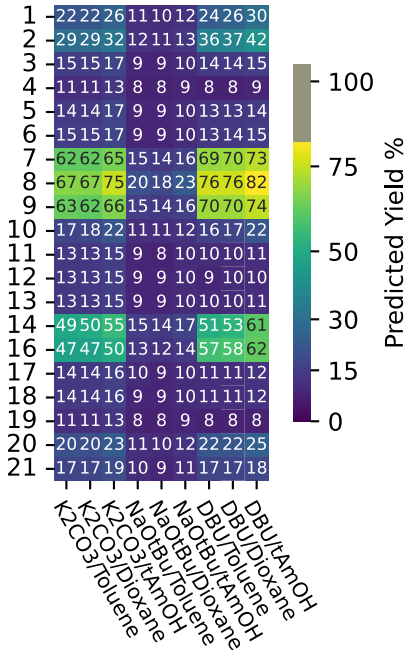
<u>IR (cm^{-1})</u> ATR (neat)
3422, 3060, 2963, 2869, 2833, 1728, 1601, 1511, 1483, 1462, 1453, 1430, 1390, 1364, 1345, 1303, 1257, 1222, 1175, 1118, 1053, 1028, 966, 922, 899, 833, 809, 766, 729, 698.

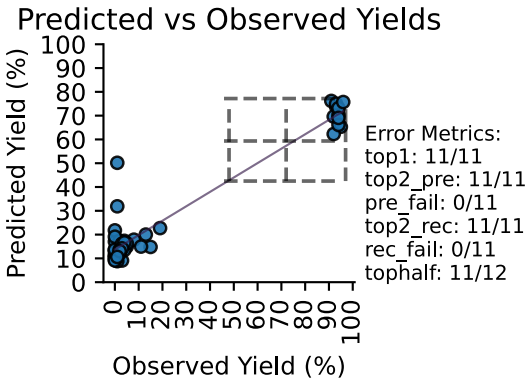
<u>HRMS (ESI)</u> Calcd. for $C_{11}H_{18}NO$ *m/z* 180.1383, Found: 180.1377 $[M+H]^+$.

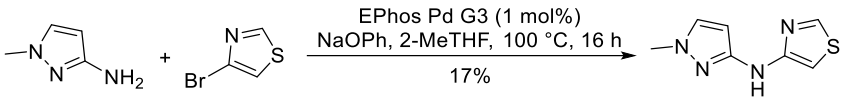
<u>TLC</u> R_f 0.55 (EtOAc/heptane, 20:80)

Data for **16_20**

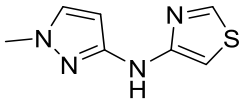
	Predicted Yield %	Observed Yield %
16_20_4_1_a	11.0	0.0
16_20_13_1_a	13.0	0.0
16_20_1_1_b	10.0	1.0
16_20_5_1_b	9.0	1.0
16_20_14_1_b	14.0	3.0
16_20_6_1_c	14.0	0.0
16_20_8_1_c	76.0	91.0
16_20_10_1_c	17.0	4.0
16_20_2_2_a	32.0	1.0
16_20_3_2_a	17.0	0.0
16_20_7_2_a	65.0	95.0
16_20_4_2_b	9.0	3.0
16_20_8_2_b	23.0	19.0
16_20_9_2_c	74.0	93.0
16_20_12_2_c	10.0	0.0
16_20_13_2_c	11.0	0.0
16_20_1_3_a	22.0	0.0
16_20_7_3_a	62.0	92.0
16_20_10_3_a	17.0	2.0
16_20_2_3_b	12.0	1.0
16_20_9_3_b	15.0	5.0
16_20_11_3_b	9.0	1.0
16_20_3_3_c	14.0	0.0
16_20_12_3_c	9.0	0.0
16_20_7_1_b	14.0	4.0
16_20_8_1_b	18.0	8.0
16_20_9_1_b	14.0	2.0
16_20_16_1_b	12.0	2.0
16_20_17_1_b	9.0	0.0
16_20_7_1_c	70.0	92.0
16_20_9_1_c	70.0	94.0
16_20_8_2_a	75.0	93.0
16_20_9_2_a	66.0	94.0
16_20_16_2_a	50.0	1.0
16_20_21_2_a	19.0	0.0
16_20_7_2_b	16.0	3.0
16_20_9_2_b	16.0	5.0
16_20_14_2_b	17.0	4.0
16_20_16_2_b	14.0	3.0
16_20_7_2_c	73.0	94.0
16_20_7_3_b	15.0	15.0
16_20_8_3_b	20.0	13.0
16_20_14_3_b	15.0	11.0
16_20_16_3_b	13.0	2.0
16_20_20_3_b	11.0	1.0
16_20_7_3_c	69.0	94.0
16_20_8_3_c	76.0	96.0







Prepared in analogy to a literature procedure.(*11*),(*60*) 1-Methyl-1*H*-pyrazol-3-amine (208 µL, 2.40 mmol, 1.20 equiv), sodium phenoxide (279 mg, 2.40 mmol, 1.20 equiv) and EPhos Pd G3 (18.1 mg, 100 µmol, 1.00 mol%) were added to 4-bromothiazole (328 mg, 2.00 mmol) in 2-MeTHF (4.0 mL) and the solution was heated to 100 °C for 16 h. The reaction was cooled to rt, diluted with water (25 mL) and extracted twice with CH_2Cl_2 (2 × 25 mL). The combined organic phases were washed with saturated aqueous NaCl solution (25 mL), dried over $MgSO_4$, filtered, and the solvent was removed under reduced pressure. ^{1}H NMR analysis of the crude product with 1,3,5-trimethoxybenzene (112 mg, 667 µmol, 0.33 equiv) as the internal standard showed the formation of the product in 17%. Flash column chromatography on silica gel (EtOAc/heptane, 0:100 to 100:0) afforded the product as a white solid. Yield: 60.6 mg (17%).



N-(1-Methyl-1*H*-pyrazol-3-yl)thiazol-4-amine **(16_20)**

m.p. 149 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ 8.57 (*d*, $^3J_{H,H'}$ = 2.4 Hz, 1H, Ar-*H*), 7.37 (br *s*, 1H, N*H*), 7.21 (*d*, $^4J_{H,H'}$ = 2.2 Hz, 1H, Ar-*H*), 6.96 (*d*, $^3J_{H,H'}$ = 2.4 Hz, 1H, Ar-*H*), 5.84 (*d*, $^4J_{H,H'}$ = 2.2 Hz, 1H, Ar-*H*), 3.82 (*s*, 3H, NC*H*$_3$).

^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$):
δ 153.3 (arom.), 150.6 (arom.), 150.5 (arom.), 130.7 (arom.), 92.9 (arom.), 91.2 (arom.), 38.8 (N*C*H$_3$).

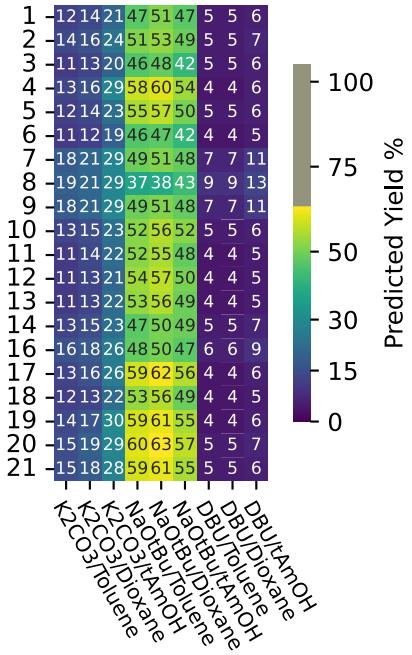
IR (cm^{-1}) ATR (neat)
3250, 3105, 3077, 2990, 2933, 1589, 1532, 1489, 1419, 1401, 1374, 1292, 1232, 1218, 1146, 1075, 1052, 1010, 995, 965, 872, 829, 820, 808.

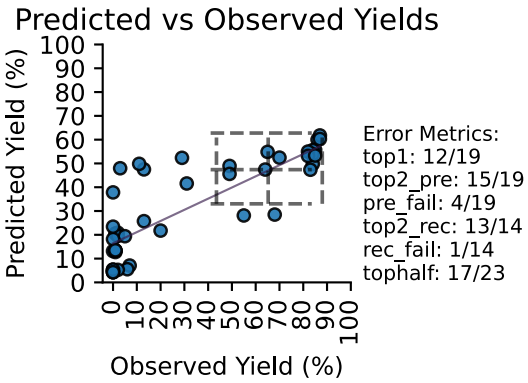
HRMS (ESI) Calcd. for $C_7H_9N_4S$ *m/z* 181.0542, Found: 181.0534 $[M+H]^+$.

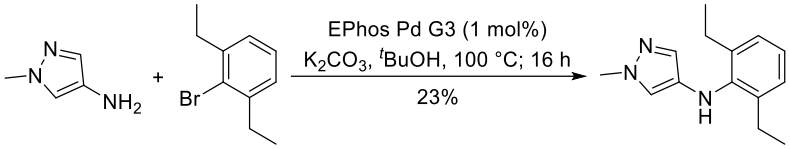
TLC R_f 0.39 (EtOAc/heptane, 70:30)

Data for **12_10**

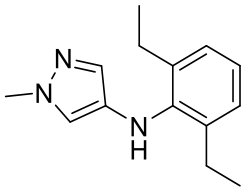
	Predicted Yield %	Observed Yield %
12_10_3_1_a	13.0	1.0
12_10_7_1_a	21.0	2.0
12_10_12_1_a	13.0	0.0
12_10_4_1_b	60.0	86.0
12_10_8_1_b	38.0	0.0
12_10_13_1_b	56.0	85.0
12_10_5_1_c	5.0	0.0
12_10_14_1_c	5.0	0.0
12_10_1_2_a	21.0	1.0
12_10_3_2_a	20.0	2.0
12_10_6_2_a	19.0	5.0
12_10_7_2_b	48.0	3.0
12_10_13_2_b	49.0	49.0
12_10_2_2_c	7.0	7.0
12_10_4_2_c	6.0	6.0
12_10_8_2_c	13.0	1.0
12_10_12_2_c	5.0	0.0
12_10_9_3_a	18.0	0.0
12_10_14_3_a	13.0	1.0
12_10_1_3_b	47.0	13.0
12_10_5_3_b	55.0	83.0
12_10_10_3_b	52.0	29.0
12_10_2_3_c	5.0	2.0
12_10_11_3_c	4.0	0.0
12_10_13_1_a	13.0	1.0
12_10_6_1_b	47.0	64.0
12_10_11_1_b	55.0	65.0
12_10_14_1_b	50.0	84.0
12_10_17_1_b	62.0	87.0
12_10_18_1_b	56.0	84.0
12_10_13_1_c	4.0	0.0
12_10_4_2_a	29.0	68.0
12_10_10_2_a	23.0	0.0
12_10_13_2_a	22.0	20.0
12_10_16_2_a	26.0	13.0
12_10_21_2_a	28.0	55.0
12_10_4_2_b	54.0	84.0
12_10_6_2_b	42.0	31.0
12_10_10_2_b	52.0	70.0
12_10_12_2_b	50.0	11.0
12_10_21_2_b	55.0	82.0
12_10_13_2_c	5.0	0.0
12_10_6_3_b	46.0	49.0
12_10_13_3_b	53.0	82.0
12_10_14_3_b	47.0	83.0
12_10_18_3_b	53.0	85.0
12_10_20_3_b	60.0	87.0
12_10_13_3_c	4.0	0.0







Prepared in analogy to a literature procedure.(*11*),(*60*) 1-Methyl-1*H*-pyrazol-4-amine (233 mg, 2.40 mmol, 1.20 equiv), potassium carbonate (415 mg, 3.00 mmol, 1.20 equiv) and EPhos Pd G3 (18.1 mg, 100 µmol, 1.00 mol%) were added 2-bromo-1,3-diethybenzene (337 µL, 2.00 mmol) in ^{t}BuOH (4.0 mL) and the solution was heated to 100 °C for 16 h. The reaction was cooled to rt, diluted with water (25 mL) and extracted twice with CH_2Cl_2 (2 × 25 mL). The combined organic phases were washed with saturated aqueous NaCl solution (25 mL), dried over $MgSO_4$, filtered, and the solvent was removed under reduced pressure. ^{1}H NMR analysis of the crude product with 1,3,5-trimethoxybenzene (112 mg, 667 µmol, 0.33 equiv) as the internal standard showed the formation of the product in 46%. Flash column chromatography on silica gel (EtOAc/heptane, 0:100 to 100:0) afforded the product as a light orange oil. Yield: 107 mg (23%).



N-(2,6-Diethylphenyl)-1-methyl-1*H*-pyrazol-4-amine **(12_10)**

<u>^{1}H NMR</u> (400 MHz, $CDCl_3$)
δ 7.13 – 7.05 (*m*, 4H, Ar-*H*), 6.71 (*d*, $^4J_{H,H'}$ = 0.8 Hz, 1H, Ar-*H*), 4.64 (br *s*, 1H, N*H*), 3.76 (*s*, 3H, NCH_3), 2.59 (*q*, $^3J_{H,H'}$ = 7.6 Hz, 4H, CH_2), 1.17 (*t*, $^3J_{H,H'}$ = 7.6 Hz, 6H, CH_3).

<u>^{13}C{^{1}H} NMR</u> (101 MHz, $CDCl_3$)
δ 140.7 (arom.), 138.7 (2C, arom.), 132.6 (arom.), 130.0 (arom.), 126.8 (2C, arom.), 124.6 (arom.), 118.5 (arom.), 39.2 (NCH_3), 24.6 (2C, CH_2), 14.7 (2C, CH_3).

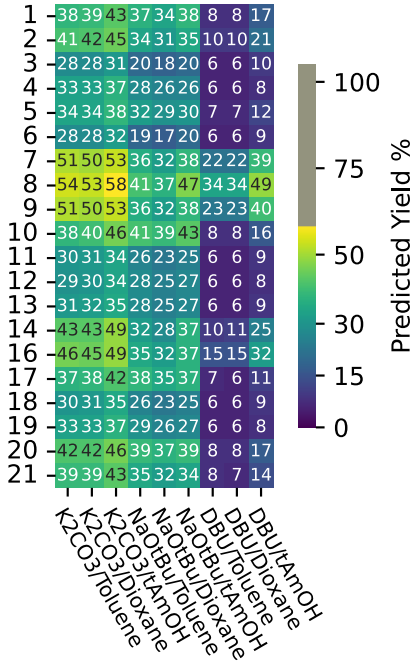
<u>IR (cm^{-1})</u> ATR (neat)
3303, 2963, 2932, 2871, 1577, 1455, 1404, 1371, 1342, 1269, 1204, 1183, 1166, 1106, 1058, 1018, 985, 877, 817, 741.

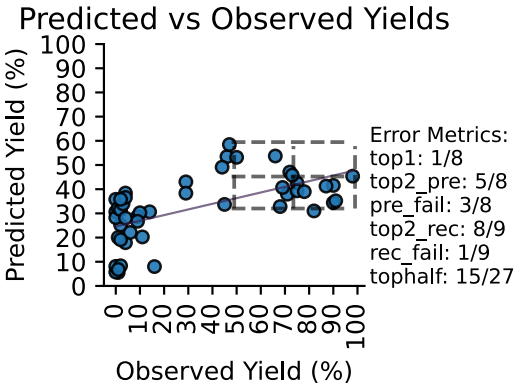
<u>HRMS (ESI)</u> Calcd. for $C_{14}H_{20}N_3$ *m/z* 230.1652, Found: 230.1651 $[M+H]^+$.

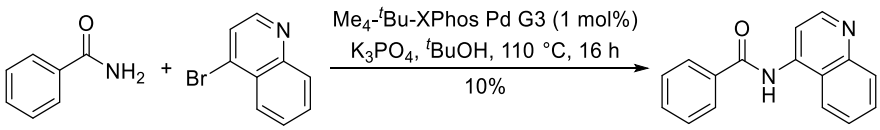
TLC R_f 0.55 (EtOAc/heptane, 70:30)

Data for **8_30**

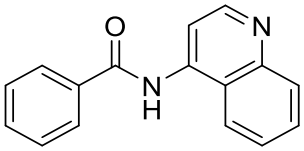
	Predicted Yield %	Observed Yield %
8_30_2_1_a	42.0	90.0
8_30_11_1_a	31.0	0.0
8_30_3_1_b	18.0	4.0
8_30_12_1_b	25.0	2.0
8_30_14_1_b	28.0	0.0
8_30_4_1_c	6.0	1.0
8_30_7_1_c	22.0	6.0
8_30_13_1_c	6.0	0.0
8_30_5_2_a	38.0	71.0
8_30_9_2_a	53.0	46.0
8_30_14_2_a	49.0	44.0
8_30_6_2_b	20.0	1.0
8_30_8_2_b	47.0	72.0
8_30_10_2_b	43.0	75.0
8_30_7_2_c	39.0	75.0
8_30_12_2_c	8.0	0.0
8_30_4_3_a	33.0	68.0
8_30_8_3_a	54.0	66.0
8_30_13_3_a	31.0	14.0
8_30_2_3_b	34.0	90.0
8_30_9_3_b	36.0	0.0
8_30_1_3_c	8.0	2.0
8_30_5_3_c	7.0	1.0
8_30_10_3_c	8.0	16.0
8_30_2_1_b	31.0	82.0
8_30_5_1_b	29.0	9.0
8_30_9_1_b	32.0	1.0
8_30_10_1_b	39.0	78.0
8_30_1_2_a	43.0	29.0
8_30_2_2_a	45.0	98.0
8_30_3_2_a	31.0	2.0
8_30_7_2_a	53.0	50.0
8_30_8_2_a	58.0	47.0
8_30_10_2_a	46.0	73.0
8_30_12_2_a	34.0	3.0
8_30_2_2_b	35.0	91.0
8_30_3_2_b	20.0	11.0
8_30_5_2_b	30.0	10.0
8_30_7_2_b	38.0	29.0
8_30_9_2_b	38.0	4.0
8_30_12_2_b	27.0	9.0
8_30_14_2_b	37.0	4.0
8_30_6_3_a	28.0	4.0
8_30_6_3_b	19.0	2.0
8_30_7_3_b	36.0	2.0
8_30_8_3_b	41.0	87.0
8_30_10_3_b	41.0	69.0
8_30_8_3_c	34.0	45.0







Prepared in analogy to a literature procedure.(*61*) Benzamide (291 mg, 2.40 mmol, 1.20 equiv), potassium phosphate (594 mg, 2.80 mmol, 1.40 equiv) and $Me_4{}^tBuXPhos$ Pd G3 (17.0 mg, 20 µmol, 1.00 mol%) were added to 4-bromoquinoline (416 mg, 2.00 mmol) in ^tBuOH (4.0 mL) and the solution was heated to 110 °C for 16 h. The reaction was cooled to rt, diluted with water (25 mL) and extracted twice with CH_2Cl_2 (2 × 25 mL). The combined organic phases were washed with saturated aqueous NaCl solution (25 mL), dried over $MgSO_4$, filtered, and the solvent was removed under reduced pressure. ^{1}H NMR analysis of the crude product with 1,3,5-trimethoxybenzene (112 mg, 667 µmol, 0.33 equiv) as the internal standard showed the formation of the product in 16%. Flash column chromatography on silica gel (MeOH/CH_2Cl_2, 0:100 to 10:90) afforded the product as an off-white solid. Yield: 47.2 mg (10%).



N-(Quinolin-4-yl)benzamide **(8_30)**

m.p. 149 °C.

^{1}H NMR (400 MHz, CD_2Cl_2)

δ 8.86 (*d*, $^3J_{H,H'}$ = 5.0 Hz, 1H, Ar-*H*), 8.69 (br *s*, 1H, N*H*), 8.35 (*d*, $^3J_{H,H'}$ = 5.0 Hz, 1H, Ar-*H*), 8.12 (*d*, $^3J_{H,H'}$ = 7.8 Hz, 1H, Ar-*H*), 8.02 – 7.93 (*m*, 3H, Ar-*H*), 7.78 – 7.72 (*m*, 1H, Ar-*H*), 7.68 – 7.55 (*m*, 4H, Ar-*H*).

^{13}C{^{1}H} NMR (101 MHz, CD_2Cl_2)

δ 166.6 (*C*=O), 151.5 (arom.), 149.5 (arom.), 141.2 (arom.), 134.9 (arom.), 132.9 (arom.), 130.9 (arom.), 129.8 (arom.), 129.4 (2C, arom.), 127.8 (2C, arom.), 126.9 (arom.), 121.2 (arom.), 120.3 (arom.), 112.3 (arom.).

IR (cm^{-1}) ATR (neat)

3284, 3065, 3028, 3003, 2920, 2850, 1654, 1617, 1596, 1581, 1566, 1547, 1513, 1500, 1486, 1459, 1445 1421, 1389, 1364, 1310, 1276, 1249, 1216,

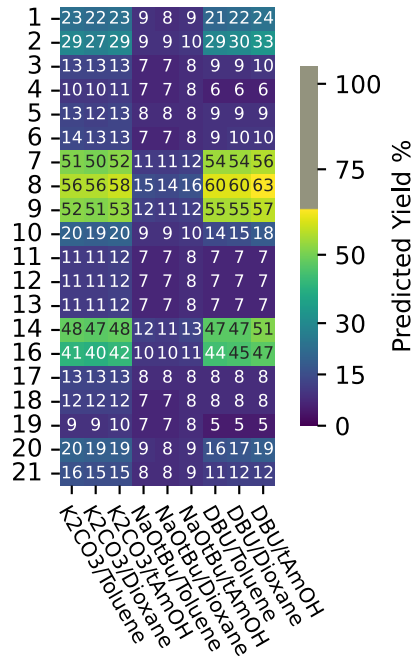
1183, 1159, 1152, 1123, 1103, 1074, 1049, 1039, 1027, 1014, 1001, 978, 961, 952, 925, 911, 859, 872, 848, 834, 811, 800.

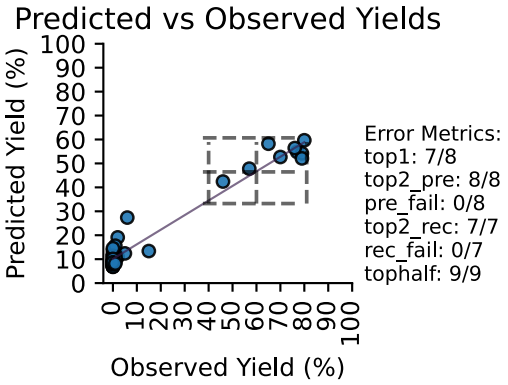
HRMS (ESI) Calcd. for $C_{16}H_{13}N_2O$ *m/z* 249.1022, Found: 249.1026 $[M+H]^+$.

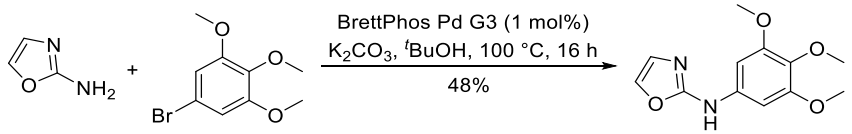
TLC R_f 0.21. ($MeOH/CH_2Cl_2$, 5:95)

Data for **26_23**

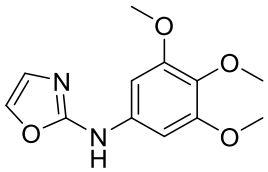
	Predicted Yield %	Observed Yield %
26_23_2_1_a	27.0	6.0
26_23_5_1_a	12.0	0.0
26_23_4_1_b	7.0	0.0
26_23_7_1_b	11.0	2.0
26_23_10_1_b	9.0	1.0
26_23_6_1_c	10.0	0.0
26_23_8_1_c	60.0	80.0
26_23_9_1_c	55.0	77.0
26_23_3_2_a	13.0	1.0
26_23_4_2_a	11.0	0.0
26_23_8_2_a	58.0	65.0
26_23_9_2_a	53.0	70.0
26_23_11_2_a	12.0	0.0
26_23_6_2_b	8.0	0.0
26_23_10_2_b	10.0	0.0
26_23_12_2_c	7.0	0.0
26_23_13_2_c	7.0	0.0
26_23_11_3_a	11.0	0.0
26_23_14_3_a	48.0	57.0
26_23_1_3_b	9.0	0.0
26_23_13_3_b	7.0	0.0
26_23_3_3_c	9.0	0.0
26_23_5_3_c	9.0	0.0
26_23_11_3_c	7.0	0.0
26_23_8_1_b	14.0	0.0
26_23_16_1_b	10.0	0.0
26_23_17_1_b	8.0	0.0
26_23_19_1_b	7.0	0.0
26_23_21_1_b	8.0	0.0
26_23_7_1_c	54.0	79.0
26_23_7_2_a	52.0	79.0
26_23_16_2_a	42.0	46.0
26_23_17_2_a	13.0	15.0
26_23_18_2_a	12.0	5.0
26_23_19_2_a	10.0	1.0
26_23_20_2_a	19.0	2.0
26_23_7_2_b	12.0	1.0
26_23_8_2_b	16.0	1.0
26_23_16_2_b	11.0	1.0
26_23_17_2_b	8.0	0.0
26_23_20_2_b	9.0	0.0
26_23_7_2_c	56.0	76.0
26_23_7_3_b	11.0	0.0
26_23_8_3_b	15.0	0.0
26_23_16_3_b	10.0	0.0
26_23_17_3_b	8.0	0.0
26_23_20_3_b	9.0	0.0
26_23_21_3_b	8.0	1.0







Prepared in analogy to a literature procedure.(*11*),(*60*) Oxazol-2-ylamine (202 mg, 2.40 mmol, 1.20 equiv), potassium carbonate (387 mg, 2.80 mmol, 1.40 equiv) and BrettPhos Pd G3 (18.1 mg, 20.0 µmol, 1.00 mol%) were added to 5-bromo-1,2,3-trimethoxybenzene (494 mg, 2.00 mmol) in *t*-BuOH (4.0 mL) and the solution was heated to 100 °C for 16 h. The reaction was cooled to rt, diluted with water (25 mL) and extracted twice with CH_2Cl_2 (2 × 25 mL). The combined organic phases were washed with saturated aqueous NaCl solution (25 mL), dried over $MgSO_4$, filtered, and the solvent was removed under reduced pressure. ^{1}H NMR analysis of the crude product with 1,3,5-trimethoxybenzene (112 mg, 667 µmol, 0.33 equiv) as the internal standard showed the formation of the product in 51%. Flash column chromatography on silica gel (CH_2Cl_2/heptane, 0:100 to 100:0) afforded the product as an off-white solid. Yield: 240 mg (48%).



N-(3,4,5-Trimethoxyphenyl)oxazol-2-amine **(26_23)**

m.p. 152 °C.

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

δ 7.27 (*d*, $^3J_{H,H'}$ = 0.9 Hz, 1H, Ar-*H*), 7.07 (br *s*, 1H, N*H*), 6.92 (*d*, $^3J_{H,H'}$ = 0.9 Hz, 1H, Ar-*H*), 6.76 (*s*, 1H, Ar-*H*), 3.88 (*s*, 6H, OCH_3), 3.81 (*s*, 3H, OCH_3).

^{13}C{^{1}H} (101 MHz, $CDCl_3$)

NMR δ 157.0 (arom.), 153.7 (2C, arom.), 134.8 (arom.), 133.4 (arom.), 132.3 (arom.), 126.7 (arom.), 95.1 (2C, arom.), 61.0 (OCH_3), 56.1 (2C, OCH_3).

IR (cm^{-1}) ATR (neat)

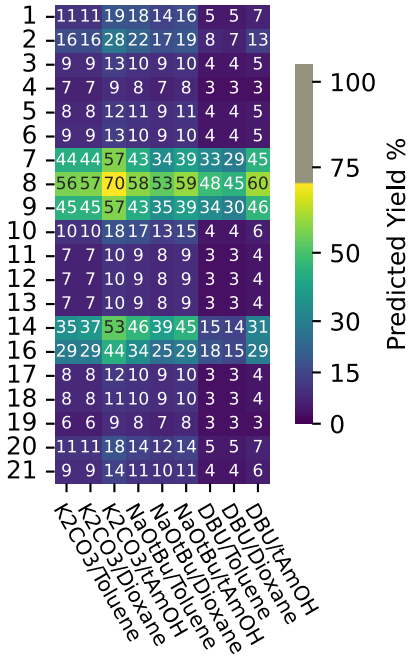
3327, 3168, 3129, 3068, 3003, 2931, 2833, 1667, 1607, 1592, 1502, 1465, 1453, 1433, 1393, 1355, 1293, 1275, 1233, 1196, 1184, 1168, 1150, 1118, 1050, 1010, 997, 946, 915, 834, 818.

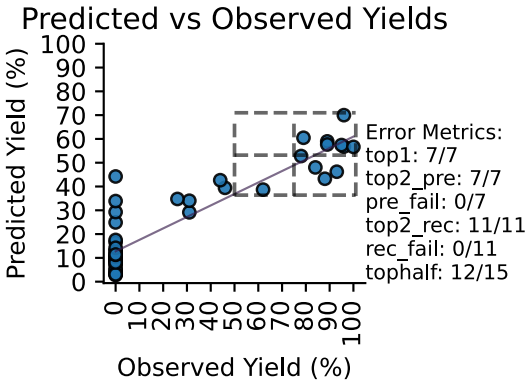
HRMS (ESI) Calcd. for $C_{12}H_{15}N_2O_4$ *m/z* 251.1026, Found: 251.1026 $[M+H]^+$.

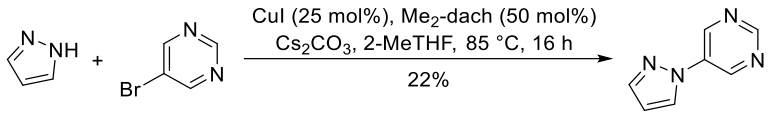
TLC R_f 0.42 (EtOAc/heptane, 50:50)

Data for **21_24**

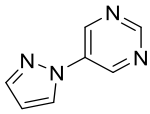
	Predicted Yield %	Observed Yield %
21_24_1_1_a	11.0	0.0
21_24_3_1_a	9.0	0.0
21_24_8_1_a	57.0	96.0
21_24_2_1_b	17.0	0.0
21_24_5_1_b	9.0	0.0
21_24_10_1_b	13.0	0.0
21_24_4_1_c	3.0	0.0
21_24_6_1_c	4.0	0.0
21_24_7_1_c	29.0	31.0
21_24_6_2_a	13.0	0.0
21_24_9_2_a	57.0	95.0
21_24_11_2_a	10.0	0.0
21_24_3_2_b	10.0	0.0
21_24_8_2_b	59.0	89.0
21_24_11_2_b	9.0	0.0
21_24_10_2_c	6.0	0.0
21_24_13_2_c	4.0	0.0
21_24_12_3_a	7.0	0.0
21_24_13_3_a	7.0	0.0
21_24_9_3_b	43.0	88.0
21_24_14_3_b	46.0	93.0
21_24_1_3_c	5.0	0.0
21_24_11_3_c	3.0	0.0
21_24_12_3_c	3.0	0.0
21_24_7_1_b	34.0	31.0
21_24_8_1_b	53.0	78.0
21_24_9_1_b	35.0	26.0
21_24_16_1_b	25.0	0.0
21_24_17_1_b	9.0	0.0
21_24_21_1_b	10.0	0.0
21_24_7_2_a	57.0	100.0
21_24_8_2_a	70.0	96.0
21_24_16_2_a	44.0	0.0
21_24_19_2_a	9.0	0.0
21_24_20_2_a	18.0	0.0
21_24_7_2_b	39.0	62.0
21_24_9_2_b	39.0	46.0
21_24_16_2_b	29.0	0.0
21_24_17_2_b	10.0	0.0
21_24_19_2_b	8.0	0.0
21_24_21_2_b	11.0	0.0
21_24_8_2_c	60.0	79.0
21_24_7_3_b	43.0	44.0
21_24_8_3_b	58.0	89.0
21_24_16_3_b	34.0	0.0
21_24_20_3_b	14.0	0.0
21_24_21_3_b	11.0	0.0
21_24_8_3_c	48.0	84.0







1*H*-Pyrazole (204 mg, 3.00 mmol, 1.50 equiv), cesium carbonate (1.30 g, 4.00 mmol, 2.00 equiv), copper(I) iodide (95.2 mg, 500 µmol, 25.0 mol%) and (±)-*trans*-*N*,*N*'-dimethylcyclohexane-1,2-diamine (158 µL, 1.00 mmol, 50.0 mol%) were added to 5-bromopyrimidine (318 mg, 2.00 mmol) in 2-MeTHF (4.0 mL) and the solution was heated to 85 °C for 16 h. The reaction was cooled to rt, diluted with 5% aqueous NH_3 solution (25 mL) and extracted twice with CH_2Cl_2 (2 × 25 mL). The combined organic phases were washed with saturated aqueous NaCl solution (25 mL), dried over $MgSO_4$, filtered, and the solvent was removed under reduced pressure. ^{1}H NMR analysis of the crude product with 1,3,5-trimethoxybenzene (112 mg, 667 µmol, 0.33 equiv) as the internal standard showed the formation of the product in 22%. Flash column chromatography on silica gel (EtOAc/heptane, 20:80 to 80:20) afforded the product as a white solid. Yield: 65.6 mg (22%).



5-(1*H*-Pyrazol-1-yl)pyrimidine **(21_24)**

m.p. 100 °C.

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

δ 9.10 – 9.06 (*m*, 3H, Ar-*H*), 7.95 (*d*, $^3J_{H,H'}$ = 2.4 Hz, 1H, Ar-*H*), 7.76 (*d*, $^3J_{H,H'}$ = 1.9 Hz, 1H, Ar-*H*), 6.58 – 6.47 (*m*, 1H, Ar-*H*).

^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$)

δ 156.0 (2C, arom.), 146.9 (arom.), 142.7 (arom.), 134.6 (arom.), 126.6 (arom.), 109.1 (arom.).

IR (cm^{-1}): ATR (neat)

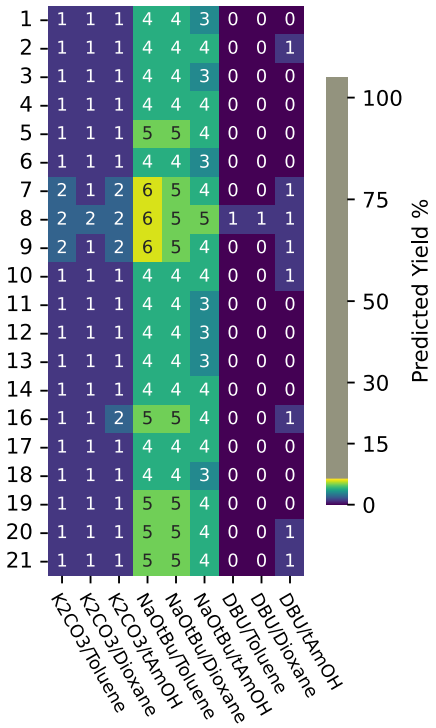
3124, 3105, 3096, 3068, 3048, 3031, 2926, 1980, 1953, 1573, 1515, 1467, 1433, 1399, 1386, 1360, 1336, 1259, 1214, 1178, 1168, 1149, 1142, 1126, 1098, 1051, 1045, 1017, 992, 966, 935, 909, 872, 819.

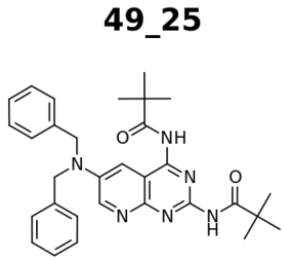
HRMS (ESI) Calcd. for $C_7H_7N_4$ *m*/*z* 147.0665, Found: 147.0662[M+H]$^+$.

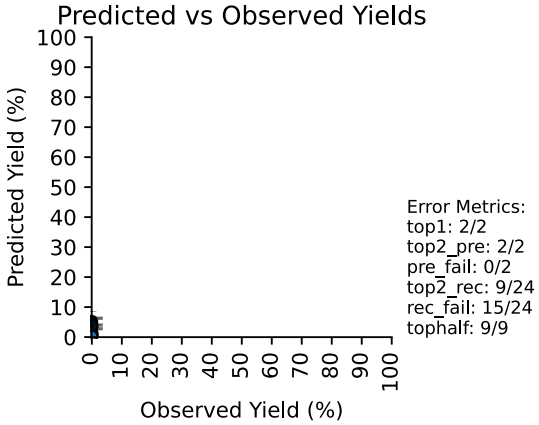
TLC R_f 0.25. (EtOAc/heptane, 50:50)

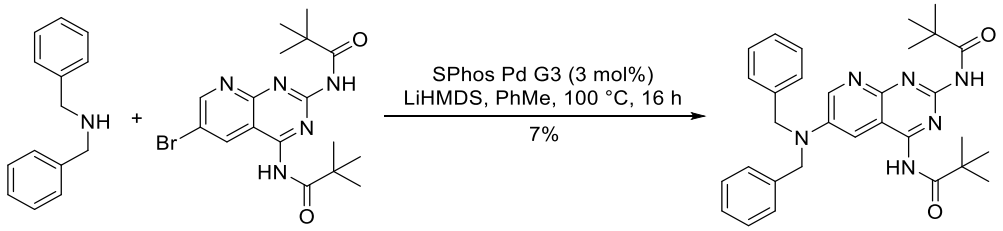
Data for **49_25**

	Predicted Yield %	Observed Yield %
49_25_1_1_a	1.0	0.0
49_25_7_1_a	1.0	0.0
49_25_3_1_b	4.0	0.0
49_25_6_1_b	4.0	0.0
49_25_8_1_b	5.0	0.0
49_25_11_1_b	4.0	0.0
49_25_2_1_c	0.0	0.0
49_25_5_1_c	0.0	0.0
49_25_9_1_c	0.0	0.0
49_25_4_2_a	1.0	0.0
49_25_7_2_a	2.0	0.0
49_25_6_2_b	3.0	0.0
49_25_9_2_b	4.0	0.0
49_25_14_2_b	4.0	0.0
49_25_8_2_c	1.0	0.0
49_25_10_2_c	1.0	0.0
49_25_11_2_c	0.0	0.0
49_25_5_3_a	1.0	0.0
49_25_10_3_a	1.0	0.0
49_25_13_3_a	1.0	0.0
49_25_12_3_b	4.0	0.0
49_25_13_3_b	4.0	0.0
49_25_4_3_c	0.0	0.0
49_25_14_3_c	0.0	0.0

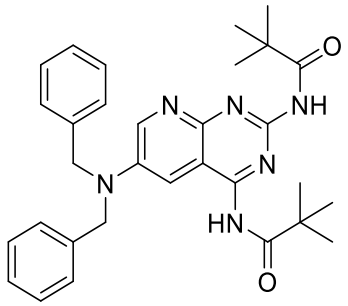








Prepared in analogy to a literature procedure.(*62*) Dibenzylamine (231 µL, 1.20 mmol, 1.20 equiv), lithium bis(trimethylsilyl)amide (535 mg, 3.20 mmol, 3.20 equiv) and SPhos Pd G3 (23.4 mg, 30.0 µmol, 3.00 mol%) were added to *N*,*N'*-(6-bromopyrido[2,3-*d*]pyrimidine-2,4-diyl)bis(2,2-dimethylpropanamide)[2] (408 mg, 1.00 mmol) in PhMe (3.0 mL) and the solution was heated to 100 °C for 16 h. The reaction was cooled to rt, diluted with water (10 mL) and extracted three times with CH_2Cl_2 (3 × 10 mL). The combined organic phases were dried over $MgSO_4$, filtered, and the solvent was removed under reduced pressure. Purification by reverse phase HPLC afforded the product as a yellow solid. Yield: 35.4 mg (7%).



N,*N'*-(6-(Dibenzylamino)pyrido[2,3-*d*]pyrimidine-2,4-diyl)bis(2,2-dimethylpropanamide) **(49_25)**

m.p. 124 °C.

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

δ 15.57 (br *s*, 1H, N*H*), 8.56 (*d*, $^4J_{H,H'}$ = 3.5 Hz, 1H, Ar-*H*), 8.13 (br *s*, 1H, N*H*), 7.96 (*d*, $^4J_{H,H'}$ = 3.5 Hz, 1H, Ar-*H*), 7.39 – 7.27 (*m*, 10H, Ar-*H*), 4.81 (*s*, 4H, NCH_2), 1.32 (*s*, 9H, CH_3), 1.23 (*s*, 9H, CH_3).

^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$)

δ 194.1 (arom.), 179.0 (arom.), 155.7 (*C*O), 149.4 (*C*O), 144.4 (arom.), 144.0 (arom.), 142.9 (arom.), 137.1 (2C, arom.), 129.0 (4C, arom.), 127.5 (2C,

arom.), 126.8 (4C, arom.), 115.0 (2C, arom.), 55.6 (2C, N*C*H_2), 42.4 (*C*(CH_3)$_3$), 40.3 (*C*(CH_3)$_3$), 27.6 (3C, *C*H_3), 27.1 (3C, *C*H_3).

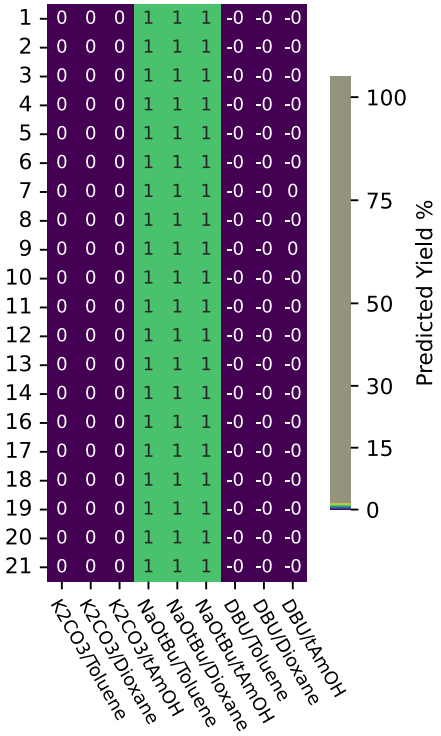
IR (cm^{-1}) ATR (neat)

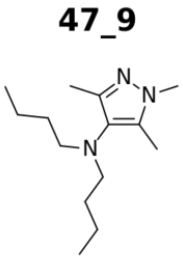
3436, 3085, 3062, 3028, 2962, 2926, 2867, 2631, 1689, 1601, 1568, 1533, 1494, 1477, 1434, 1390, 1352, 1326, 1297, 1271, 1252, 1242, 1221, 1203, 1162, 1146, 1075, 1026, 1002, 963, 941, 909, 876, 844, 810, 796, 780, 738, 697, 629, 618, 603.

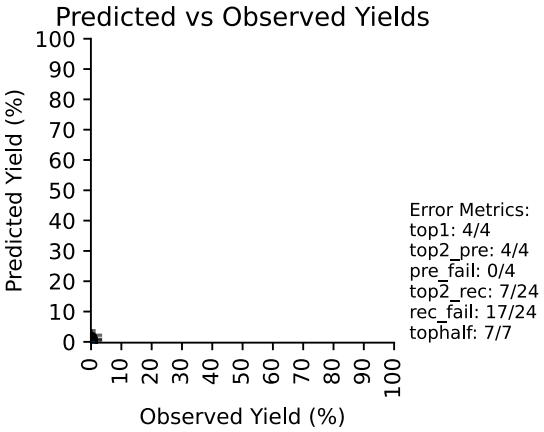
HRMS (ESI) Calcd. for $C_{31}H_{37}N_6O_2$ *m/z* 525.2973, Found: 525.2967 $[M+H]^+$.

Data for **47_9**

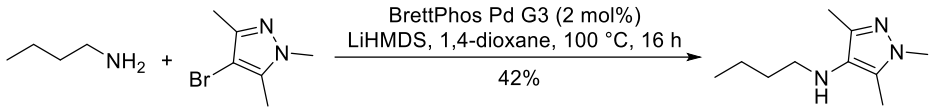
	Predicted Yield %	Observed Yield %
47_9_11_1_a	0.0	0.0
47_9_14_1_a	0.0	0.0
47_9_1_1_b	1.0	0.0
47_9_5_1_b	1.0	0.0
47_9_3_1_c	-0.0	0.0
47_9_13_1_c	-0.0	0.0
47_9_2_2_a	0.0	0.0
47_9_5_2_a	0.0	0.0
47_9_10_2_a	0.0	0.0
47_9_4_2_b	1.0	0.0
47_9_7_2_b	1.0	0.0
47_9_6_2_c	-0.0	0.0
47_9_8_2_c	-0.0	0.0
47_9_9_2_c	0.0	0.0
47_9_1_3_a	0.0	0.0
47_9_2_3_a	0.0	0.0
47_9_3_3_a	0.0	0.0
47_9_8_3_a	0.0	0.0
47_9_11_3_a	0.0	0.0
47_9_7_3_b	1.0	0.0
47_9_10_3_b	1.0	0.0
47_9_13_3_b	1.0	0.0
47_9_4_3_c	-0.0	0.0
47_9_12_3_c	-0.0	0.0



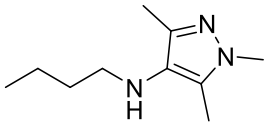




Data for intermediate-**47_9**



Prepared in analogy to a literature procedure.(*10*) Butan-1-amine (1.09 mL, 11.0 mmol, 2.20 equiv), lithium bis(trimethylsilyl)amide (1.67 g, 10.0 mmol, 2.00 equiv) and BrettPhos Pd G3 (90.7 mg, 100 µmol, 2.00 mol%) were added to 4-bromo-1,3,5-trimethyl-1*H*-amine (945 mg, 5.00 mmol) in 1,4-dioxane (5.0 mL) and the solution was heated to 100 °C for 16 h. The reaction was cooled to rt, diluted with saturated aqueous NaCl (50 mL) and extracted three times with CH_2Cl_2 (3 × 50 mL). The combined organic phases were dried over $MgSO_4$, filtered, and the solvent was removed under reduced pressure. ^{1}H NMR analysis of the crude product with 1,3,5-trimethoxybenzene (561 mg, 3.33 mmol, 0.33 equiv) as the internal standard showed the formation of the product in 58%. Flash column chromatography on silica gel (EtOAc) afforded the product as a light yellow liquid. Yield: 378 mg (42%).



N-Butyl-1,3,5-trimethyl-1*H*-pyrazol-4-amine **(intermediate 47_9)**

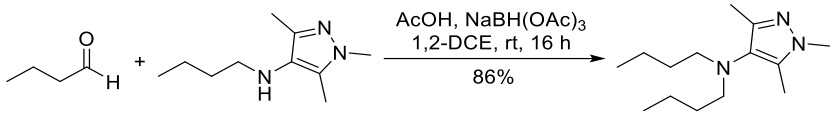
<u>^{1}H NMR</u> (400 MHz, $CDCl_3$)
δ 3.65 (*s*, 3H, NC*H*$_3$), 2.85 – 2.77 (*m*, 2H, NC*H*$_2$), 2.21 (br *s*, 1H, N*H*), 2.15 (*s*, 3H, C*H*$_3$), 2.12 (*s*, 3H, C*H*$_3$), 1.49 – 1.30 (*m*, 4H, C*H*$_2$), 0.90 (*t*, $^3J_{H,H'}$ = 7.3 Hz, 3H, C*H*$_3$).

<u>^{13}C{^{1}H} NMR</u> (101 MHz, $CDCl_3$)
δ 141.3 (arom.), 131.3 (arom.), 126.5 (arom.), 50.7 (N*C*H$_2$), 36.1 (N*C*H$_3$), 32.6 (*C*H$_2$), 20.2 (*C*H$_2$), 13.9 (*C*H$_3$), 11.1 (*C*H$_3$), 9.0 (*C*H$_3$).

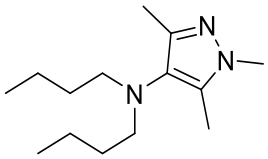
<u>IR (cm^{-1})</u> ATR (neat)
3303, 2955, 2927, 2871, 2860, 1647, 1582, 1517, 1481, 1466, 1456, 1442, 1382, 1298, 1257, 1236, 1219, 1153, 1115, 1076, 1041, 1012, 987, 903.

<u>GCMS</u> Calcd. for $C_{10}H_{20}N_3$ *m/z* 181.2, Found: 181.2 $[M]^+$.

<u>TLC</u> R_f 0.12 (EtOAc)



Butyraldehyde (316 µL, 3.51 mmol, 3.00 equiv) was added to *N*-butyl-1,3,5-trimethyl-1*H*-pyrazol-4-amine (212 mg, 1.17 mmol) in 1,2-dichloroethane (4.0 mL) and the solution was stirred at rt for 0.5 h. Acetic acid (33.5 µL, 585 µmol, 50.0 mol%) was added and the solution was stirred at rt for 0.5 h. Sodium triacetoxyborohydride (867 mg, 4.09 mmol, 3.50 equiv) was added and the solution was stirred at rt for 16 h. The reaction was diluted with saturated aqueous NaCl (25 mL) and saturated aqueous $NaHCO_3$ solution (25 mL) and extracted three times with CH_2Cl_2 (3 × 25 mL). The combined organic phases were dried over $MgSO_4$, filtered, and the solvent was removed under reduced pressure. Flash column chromatography on silica gel (EtOAc/heptane, 0:100 to 100:0) afforded the product as a colorless liquid. Yield: 238 mg (86%).



N,*N*-Dibutyl-1,3,5-trimethyl-1*H*-pyrazol-4-amine **(47_9)**

State: Oil

^{1}H NMR: (400 MHz, $CDCl_3$)
δ 3.65 (*s*, 3H, NC*H*$_3$), 2.84 (*t*, $^3J_{H,H'}$ = 6.7 Hz, 4H, NC*H*$_2$), 2.16 (*s*, 3H, C*H*$_3$), 2.10 (*s*, 3H, C*H*$_3$), 1.33 – 1.22 (*m*, 8H, C*H*$_2$), 0.88 – 0.82 (*m*, 6HH, C*H*$_3$).

^{13}C{^{1}H} NMR: (101 MHz, $CDCl_3$):
δ 144.4 (arom.), 136.1 (arom.), 127.8 (arom.), 55.5 (2C, N*C*H$_2$), 36.1 (N*C*H$_3$), 31.0 (2C, *C*H$_2$), 20.3 (2C, *C*H$_2$), 14.0 (2C, *C*H$_3$), 12.9 (*C*H$_3$), 9.3 (*C*H$_3$).

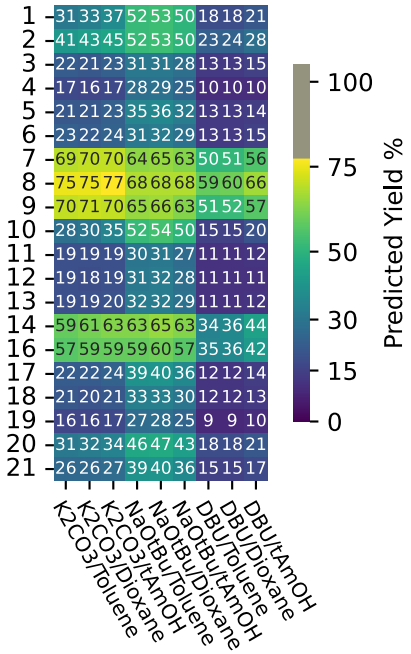
IR (cm^{-1}): ATR (neat)
2955, 2929, 2871, 2861, 2818, 1571, 1477, 1465, 1458, 1377, 1295, 1243, 1215, 1168, 1131, 1094, 1039, 989, 929, 899, 879, 841, 809.

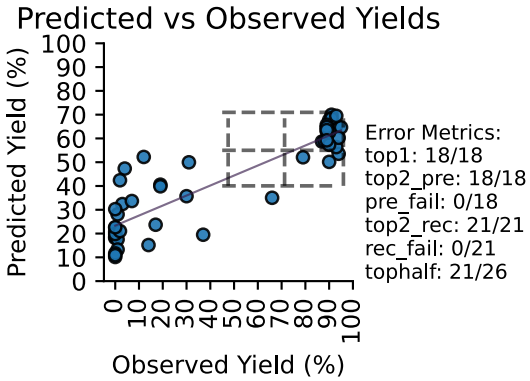
GCMS: Calcd. for $C_{14}H_{28}N_3$ *m*/*z* 237.2, Found: 237.2 $[M]^+$.

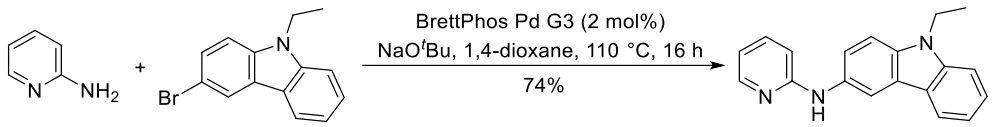
TLC: R_f 0.40 (EtOAc/heptane, 50:50)

Data for **11_33**

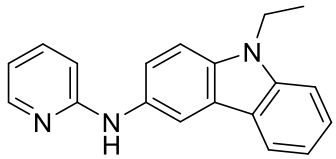
	Predicted Yield %	Observed Yield %
11_33_5_1_a	21.0	0.0
11_33_12_1_a	18.0	0.0
11_33_13_1_a	19.0	0.0
11_33_7_1_b	65.0	93.0
11_33_10_1_b	54.0	94.0
11_33_14_1_b	65.0	95.0
11_33_1_1_c	18.0	1.0
11_33_3_1_c	13.0	1.0
11_33_3_2_a	23.0	0.0
11_33_13_2_a	20.0	0.0
11_33_2_2_b	50.0	31.0
11_33_5_2_b	32.0	3.0
11_33_1_2_c	21.0	2.0
11_33_4_2_c	10.0	0.0
11_33_7_2_c	56.0	93.0
11_33_11_2_c	12.0	0.0
11_33_2_3_a	41.0	19.0
11_33_6_3_a	23.0	0.0
11_33_9_3_a	70.0	91.0
11_33_4_3_b	28.0	1.0
11_33_8_3_b	68.0	90.0
11_33_11_3_b	30.0	0.0
11_33_10_3_c	15.0	14.0
11_33_13_3_c	11.0	0.0
11_33_16_1_a	59.0	87.0
11_33_8_1_b	68.0	91.0
11_33_9_1_b	66.0	89.0
11_33_16_1_b	60.0	94.0
11_33_17_1_b	40.0	19.0
11_33_20_1_b	47.0	4.0
11_33_7_2_a	70.0	93.0
11_33_10_2_a	35.0	66.0
11_33_16_2_a	59.0	88.0
11_33_17_2_a	24.0	17.0
11_33_20_2_a	34.0	7.0
11_33_7_2_b	63.0	90.0
11_33_10_2_b	50.0	90.0
11_33_14_2_b	63.0	89.0
11_33_16_2_b	57.0	90.0
11_33_17_2_b	36.0	30.0
11_33_10_2_c	20.0	37.0
11_33_16_2_c	42.0	2.0
11_33_2_3_b	52.0	12.0
11_33_7_3_b	64.0	89.0
11_33_9_3_b	65.0	89.0
11_33_10_3_b	52.0	79.0
11_33_14_3_b	63.0	89.0
11_33_16_3_b	59.0	89.0







Prepared in analogy to a literature procedure.(*10*) Pyridin-2-amine (113 mg, 1.20 mmol, 1.20 equiv), sodium *tert*-butoxide (143 mg, 1.50 mmol, 1.50 equiv) and BrettPhos Pd G3 (18.3 mg, 20.2 µmol, 2.02 mol%) were added to 3-bromo-9-ethyl-9*H*-carbazole (273 mg, 1.00 mmol) in 1,4-dioxane (2.0 mL) and the solution was heated to 110 °C for 16 h. The reaction was cooled to rt, diluted with water (5 mL) and extracted three times with CH_2Cl_2 (2 × 5 mL). The combined organic phases were dried over $MgSO_4$, filtered, and the solvent was removed under reduced pressure. Flash column chromatography on silica gel (EtOAc/heptane, 0:100 to 50:50) afforded the product as an off-white solid. Yield: 211 mg (74%).



9-Ethyl-*N*-(pyridin-2-yl)-9*H*-carbazol-3-amine (**11_33**)

m.p. 176 °C.

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

δ 8.20 – 8.18 (*m*, 1H, Ar-*H*), 8.08 – 8.05 (*m*, 1H, Ar-*H*), 8.04 – 8.02 (*m*, 1H, Ar-*H*), 7.50 – 7.46 (*m*, 1H, Ar-*H*), 7.44 – 7.39 (*m*, 4H, Ar-*H*), 7.24 – 7.19 (*m*, 1H, Ar-*H*), 6.74 – 6.71 (*m*, 1H, Ar-*H*), 6.69 – 6.66 (*m*, 1H, Ar-*H*), 6.60 (br *s*, 1H, N*H*), 4.38 (*q*, $^3J_{H,H'}$ = 7.3 Hz, 2H, NCH_2), 1.45 (*t*, $^3J_{H,H'}$ = 7.3 Hz, 3H, CH_3).

^{13}C{^{1}H} (101 MHz, $CDCl_3$)

NMR δ 158.2 (arom.), 148.4 (arom.), 140.4 (arom.), 137.6 (arom.), 137.4 (arom.), 131.6 (arom.), 125.9 (arom.), 123.6 (arom.), 122.8 (arom.), 122.6 (arom.), 120.5 (arom.), 118.7 (arom.), 115.9 (arom.), 114.1 (arom.), 109.0 (arom.), 108.6 (arom.), 106.9 (arom.), 37.7 (NCH_2), 13.8 (CH_3).

IR (cm^{-1}) ATR (neat)

3177, 3135, 3086, 3067, 2968, 2946, 2869, 2051, 1979, 1934, 1896, 1876, 1861, 1811, 1789, 1775, 1747, 1716, 1599, 1581, 1526, 1490, 1482, 1469,

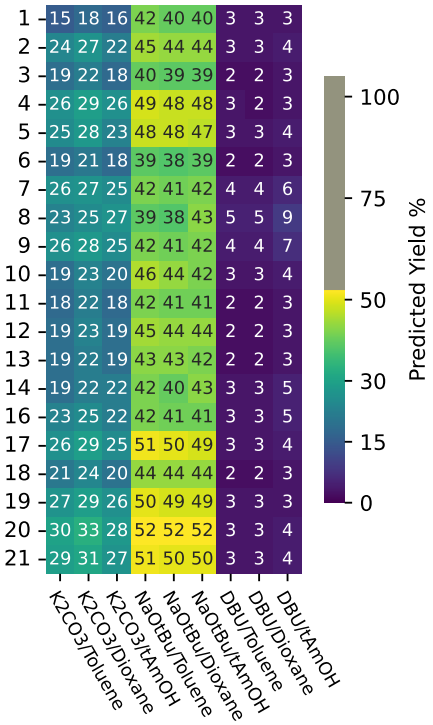
1446, 1438, 1432, 1382, 1375, 1360, 1350, 1330, 1316, 1291, 1284, 1275, 1239, 1227, 1212, 1201, 1194, 1151, 1140, 1121, 1098, 1085, 1057, 1044, 1022, 992, 988, 950, 932, 916, 896, 886, 858, 848, 808, 768, 750, 730, 717, 676, 650, 632, 628.

HRMS (ESI) Calcd. for $C_{19}H_{18}N_3$ *m/z* 288.1495, Found: 288.2499 $[M+H]^+$.

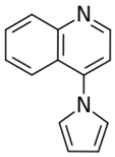
TLC R_f 0.08 (EtOAc/heptane, 20:80)

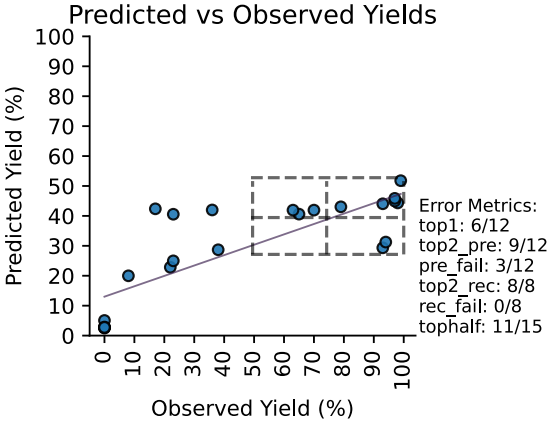
Data for **17_30**

	Predicted Yield %	Observed Yield %
17_30_4_1_a	29.0	38.0
17_30_12_1_a	23.0	22.0
17_30_17_1_a	29.0	93.0
17_30_21_1_a	31.0	94.0
17_30_7_1_b	41.0	65.0
17_30_9_1_b	41.0	23.0
17_30_4_1_c	2.0	0.0
17_30_5_1_c	3.0	0.0
17_30_10_1_c	3.0	0.0
17_30_7_2_a	25.0	23.0
17_30_10_2_a	20.0	8.0
17_30_2_2_b	44.0	98.0
17_30_7_2_b	42.0	63.0
17_30_8_2_b	43.0	79.0
17_30_9_2_b	42.0	36.0
17_30_10_2_b	42.0	17.0
17_30_12_2_b	44.0	93.0
17_30_20_2_b	52.0	99.0
17_30_2_3_b	45.0	97.0
17_30_7_3_b	42.0	70.0
17_30_10_3_b	46.0	97.0
17_30_8_3_c	5.0	0.0
17_30_10_3_c	3.0	0.0
17_30_17_3_c	3.0	0.0

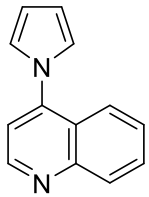


17_30





A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*



4-(1H-Pyrrol-1-yl)quinoline **(17_30)**

State Solid

m.p. 58 ºC

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

δ 8.95 (d, *J* = 4.6 Hz, 1H), 8.20 (d, *J* = 8.6 Hz, 1H), 8.06 (dd, *J* = 8.6, 1.6 Hz, 1H), 7.78 (ddd, *J* = 8.3, 6.7, 1.3 Hz, 1H), 7.58 (ddd, *J* = 8.3, 6.9, 1.3 Hz, 1H), 7.33 (d, *J* = 4.8 Hz, 1H), 7.09 (t, *J* = 2.1 Hz, 2H), 6.47 (t, *J* = 2.1 Hz, 2H).

^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$)

δ 150.66, 149.99, 145.74, 130.18, 130.07, 127.46, 123.87, 123.62, 122.66, 116.38, 110.87.

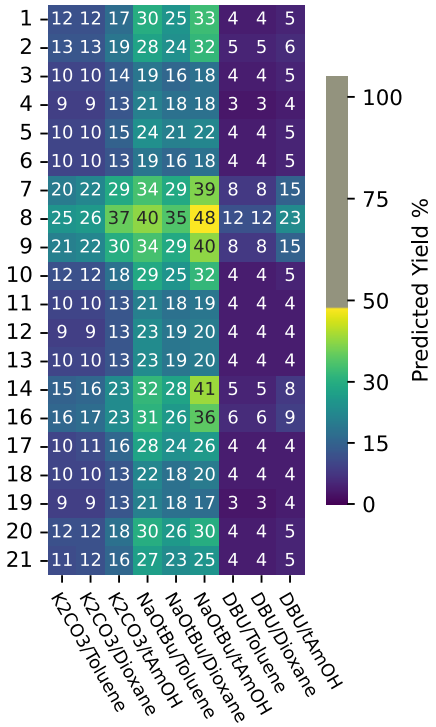
IR (cm^{-1}) ATR (neat)

611, 624, 652, 660, 784, 767, 731, 719, 813, 838, 801, 867 851, 877, 921, 967, 992 984, 1052, 1062, 1017, 1076, 1087, 1093, 1131, 1149, 1178, 1216, 1262, 1251, 1303 1339, 1362, 1386, 1400, 1423, 1460, 1482, 1506, 1521, 1565, 1592,1616, 1704, 1732, 1834, 1859, 1926, 2644, 2924, 3006, 3058, 3099, 3107, 3117

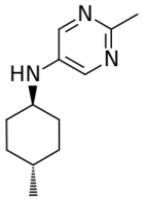
HRMS (ES+) Calcd for $C_{13}H_{11}N_2$ (M+H)+: 195.0918 Found: 195.0916

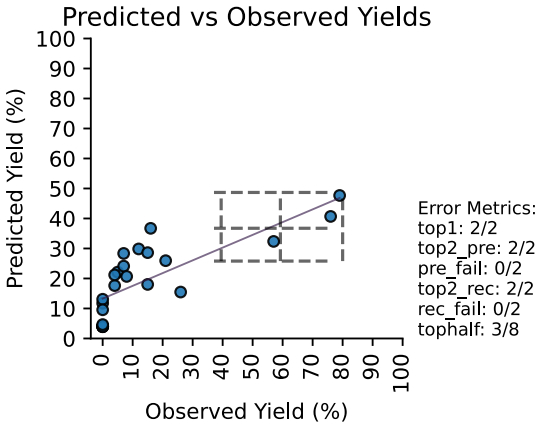
Data for **36_1**

	Predicted Yield %	Observed Yield %
36_17_8_1_a	26.0	21.0
36_17_9_1_a	22.0	5.0
36_17_10_1_a	12.0	0.0
36_17_2_1_b	24.0	7.0
36_17_5_1_b	21.0	8.0
36_17_1_1_c	4.0	0.0
36_17_10_1_c	4.0	0.0
36_17_8_2_a	37.0	16.0
36_17_9_2_a	30.0	12.0
36_17_10_2_a	18.0	15.0
36_17_12_2_a	13.0	0.0
36_17_3_2_b	18.0	4.0
36_17_8_2_b	48.0	79.0
36_17_10_2_b	32.0	57.0
36_17_14_2_b	41.0	76.0
36_17_11_3_a	10.0	0.0
36_17_14_3_a	15.0	26.0
36_17_2_3_b	28.0	7.0
36_17_10_3_b	29.0	15.0
36_17_11_3_b	21.0	4.0
36_17_3_3_c	4.0	0.0
36_17_5_3_c	4.0	0.0
36_17_10_3_c	4.0	0.0
36_17_14_3_c	5.0	0.0

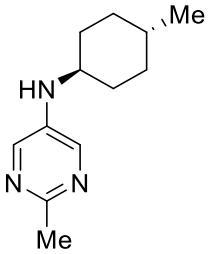


36_17





A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*

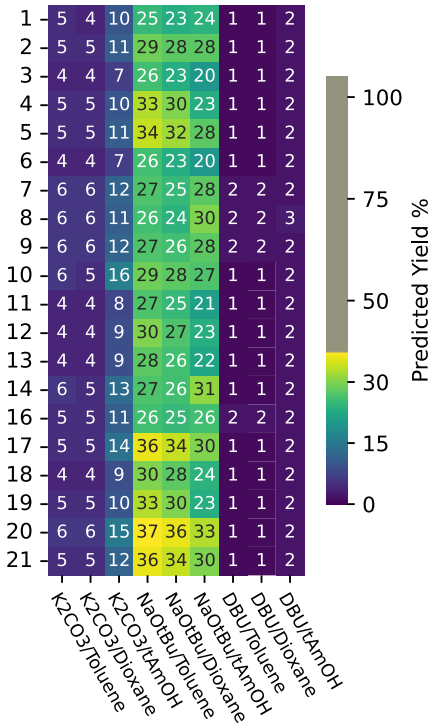


2-Methyl-N-(*trans*-4-methylcyclohexyl)pyrimidin-5-amine **(36_17)**

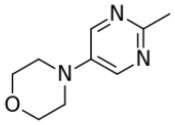
State	Solid
m.p.	124 ^{o}C
^{1}H NMR	(400 MHz, $CDCl_3$)
	δ 8.01 (s, 2H), 3.34 (d, *J* = 7.8 Hz, 1H), 3.22 – 3.10 (m, 1H), 2.59 (fs, 3H), 2.09 (m, 2H), 1.77 (m, 2H), 1.46 – 1.33 (m, 1H), 1.19 – 1.01 (m, 4H), 0.92 (d, *J* = 6.7 Hz, 3H).
^{13}C{^{1}H}	(101 MHz, $CDCl_3$)
NMR	δ 156.75, 141.85, 138.72, 52.05, 33.96, 33.39, 32.34, 24.78, 22.27.
IR (cm^{-1})	ATR (neat)
	654, 742, 782, 774, 839, 867, 886, 903, 921, 954, 966, 1007, 1039, 1071, 1115, 1151, 1170, 1189, 1221 1245 1269, 1284, 1312, 1323, 1341, 1378, 1390, 1448, 1503, 1568, 1589, 1839, 2383, 2635, 2849, 2921, 2949, 3028, 3068, 3127, 3292
HRMS (ES+)	Calcd for $C_{12}H_{20}N_3$ (M+H)+: 206.1651 Found: 206.1654

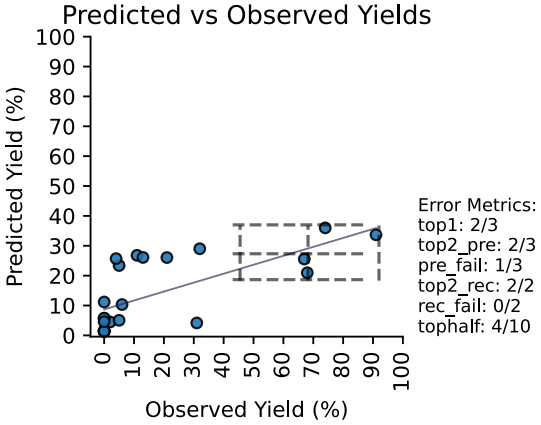
Data for **43_17**

	Predicted Yield %	Observed Yield %
43_17_4_1_a	5.0	2.0
43_17_7_1_a	6.0	0.0
43_17_9_1_a	6.0	0.0
43_17_11_1_a	4.0	31.0
43_17_20_1_a	6.0	0.0
43_17_17_1_b	34.0	91.0
43_17_3_1_c	1.0	0.0
43_17_12_1_c	1.0	0.0
43_17_16_1_c	2.0	0.0
43_17_20_1_c	1.0	0.0
43_17_21_1_c	1.0	0.0
43_17_4_2_a	10.0	6.0
43_17_8_2_a	11.0	0.0
43_17_4_2_b	23.0	5.0
43_17_11_2_b	21.0	68.0
43_17_16_2_b	26.0	21.0
43_17_2_3_a	5.0	5.0
43_17_4_3_a	5.0	0.0
43_17_6_3_b	26.0	67.0
43_17_7_3_b	27.0	11.0
43_17_8_3_b	26.0	4.0
43_17_10_3_b	29.0	32.0
43_17_16_3_b	26.0	13.0
43_17_21_3_b	36.0	74.0

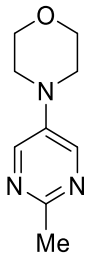


43_17





A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*

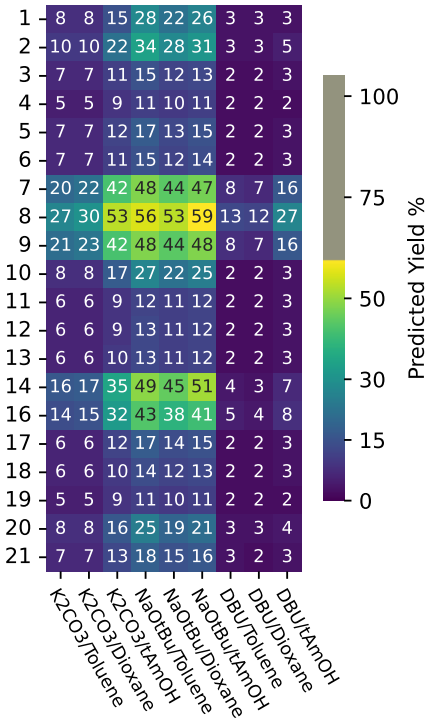


4-(2-Methylpyrimidin-5-yl)morpholine **(43_17)**

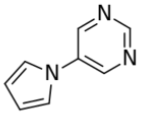
^{1}H NMR	(400 MHz, $CDCl_3$)
	δ 8.28 (s, 2H), 3.90 – 3.85 (m, 4H), 3.19 – 3.14 (m, 4H), 2.65 (s, 3H).
^{13}C{^{1}H}	(101 MHz, $CDCl_3$)
NMR	δ 159.36, 144.37, 142.14, 66.61, 48.31, 24.96.
IR (cm^{-1})	ATR (neat)
	626, 646, 716, 741, 763, 818, 835, 853, 860, 889, 924, 936, 1025, 1038, 1056, 1074, 1117, 1189, 1172, 1217, 1238, 1260,1282, 1296, 1311, 1342, 1355, 1368, 1388, 1401, 1444, 1456, 1465, 1484, 1538, 1582, 1644, 1779, 1827, 1880, 2380, 2597, 2710, 2751, 2845, 2870, 2924, 2904, 2959, 2971.
HRMS (ES+)	Calcd for $C_9H_{14}N_3O$ $(M+H)^+$: 180.1133 Found: 180.1130

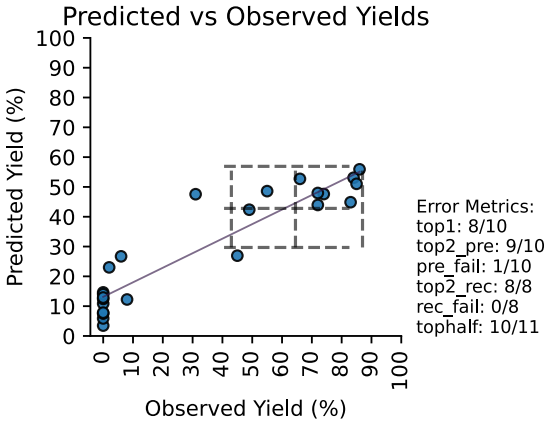
Data for **17_24**

	Predicted Yield %	Observed Yield %
17_24_9_1_a	23.0	2.0
17_24_8_1_b	53.0	84.0
17_24_9_1_b	44.0	72.0
17_24_13_1_b	11.0	0.0
17_24_14_1_b	45.0	83.0
17_24_21_1_b	15.0	0.0
17_24_8_1_c	12.0	0.0
17_24_14_1_c	3.0	0.0
17_24_8_2_a	53.0	66.0
17_24_9_2_a	42.0	49.0
17_24_17_2_a	12.0	8.0
17_24_6_2_b	14.0	0.0
17_24_9_2_b	48.0	31.0
17_24_14_2_b	51.0	85.0
17_24_8_3_a	27.0	6.0
17_24_13_3_a	6.0	0.0
17_24_7_3_b	48.0	74.0
17_24_8_3_b	56.0	86.0
17_24_9_3_b	48.0	72.0
17_24_10_3_b	27.0	45.0
17_24_14_3_b	49.0	55.0
17_24_7_3_c	8.0	0.0
17_24_8_3_c	13.0	0.0
17_24_9_3_c	8.0	0.0

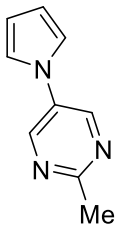


17_24





A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*

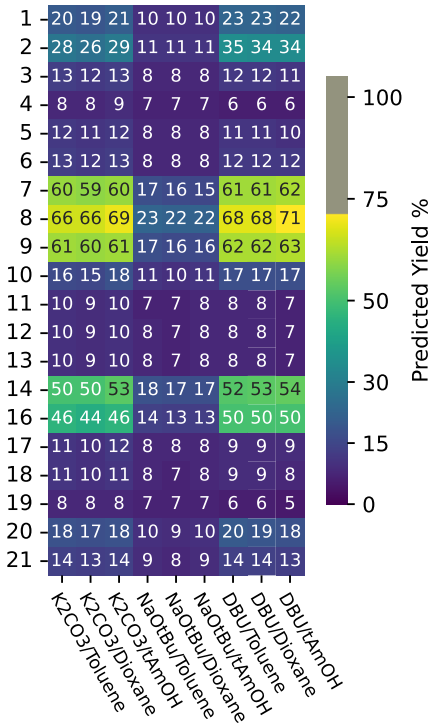


2-Methyl-5-(1H-pyrrol-1-yl)pyrimidine **(17_24)**

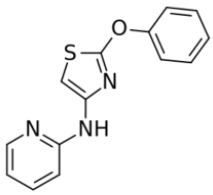
State	Solid
m.p.	138 ^{o}C
^{1}H NMR	(400 MHz, $CDCl_3$)
	δ 8.65 (s, 2H), 7.01 – 6.96 (m, 2H), 6.35 (t, *J* = 2.1 Hz, 2H), 2.70 (s, 3H).
^{13}C{^{1}H}	(101 MHz, $CDCl_3$)
NMR	δ 165.12, 148.36, 132.74, 118.74, 111.91, 25.27.
IR (cm^{-1})	610, 647,708, 738, 844, 818, 869, 853, 891, 934, 923, 1041, 1018, 1086, 1073, 1129, 1179, 1252, 1225, 1307, 1279, 1344, 1409, 1391,1464, 1443,1489,1521, 1572, 1557, 1592, 1691, 1736, 1780, 1901, 1941, 2928, 2978, 3040, 3015.
HRMS (ES+)	Calcd for $C_9H_{10}N_3$ (M+H)+: 160.0862 Found: 160.0866

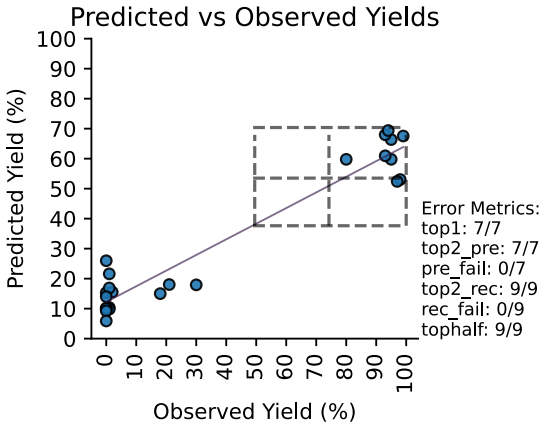
Data for **11_38**

	Predicted Yield %	Observed Yield %
11_38_2_1_a	26.0	0.0
11_38_8_1_a	66.0	95.0
11_38_10_1_a	15.0	18.0
11_38_17_1_a	10.0	1.0
11_38_1_1_b	10.0	1.0
11_38_10_1_b	10.0	0.0
11_38_8_1_c	68.0	93.0
11_38_14_1_c	53.0	98.0
11_38_7_2_a	60.0	80.0
11_38_8_2_a	69.0	94.0
11_38_10_2_a	18.0	21.0
11_38_12_2_a	10.0	0.0
11_38_7_2_b	15.0	0.0
11_38_8_2_b	22.0	1.0
11_38_7_3_a	60.0	95.0
11_38_10_3_a	16.0	2.0
11_38_7_3_b	17.0	1.0
11_38_14_3_b	18.0	30.0
11_38_7_3_c	61.0	93.0
11_38_8_3_c	68.0	99.0
11_38_14_3_c	52.0	97.0
11_38_18_3_c	9.0	0.0
11_38_19_3_c	6.0	0.0
11_38_21_3_c	14.0	0.0

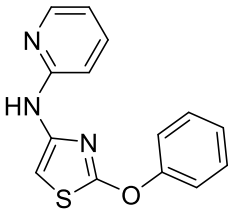


11_38





A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*



2-Phenoxy-*N*-(pyridin-2-yl)thiazol-4-amine **(11_38)**

State: Oil

^{1}H NMR: (400 MHz, $CDCl_3$)
δ 8.27 – 8.22 (m, 1H), 7.49 (ddd, *J* = 8.6, 7.1, 1.9 Hz, 1H), 7.45 – 7.39 (m, 2H), 7.35 – 7.23 (m, 4H), 6.99 (s, 1H), 6.79 – 6.69 (m, 2H).

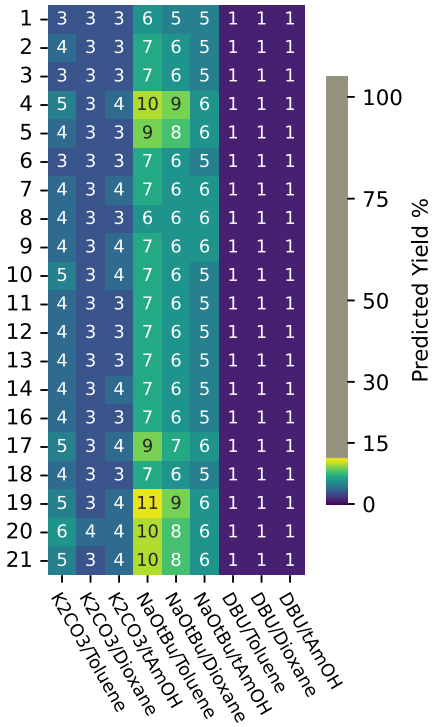
^{13}C{^{1}H} NMR: (101 MHz, $CDCl_3$)
δ 171.65, 155.43, 154.15, 147.86, 144.11, 137.41, 130.06, 126.11, 120.41, 115.34, 110.15, 89.10.

IR (cm^{-1}): ATR (neat)
625, 611, 687, 664, 698, 766, 748, 729, 852, 828, 859, 887, 908, 954, 988, 978, 967, 1023, 1010, 1003, 1069, 1050, 1086, 1157, 1147, 1133, 1194, 1239, 1261, 1276, 1306, 1336, 1384, 1422, 1473, 1453, 1497, 1525, 1562, 1605, 3055, 3028, 3073, 3140, 3108, 3168, 3195, 3266.

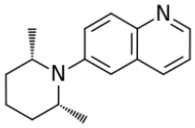
HRMS (ES+): Calcd for $C_{14}H_{12}N_3OS$ (M+H)+: 270.0698 Found: 270.0701

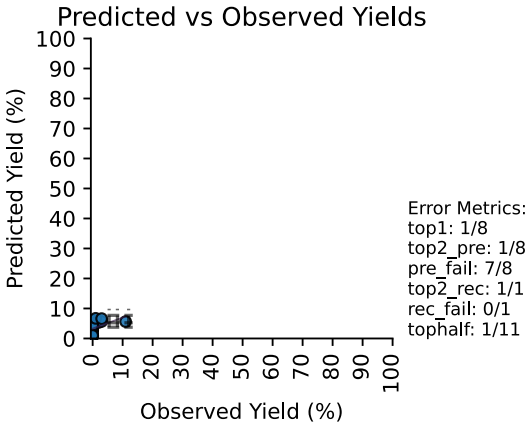
Data for **40_26**

	Predicted Yield %	Observed Yield %
40_26_1_1_a	3.0	0.0
40_26_6_1_a	3.0	0.0
40_26_7_1_a	3.0	0.0
40_26_12_1_a	3.0	0.0
40_26_10_1_b	6.0	1.0
40_26_14_1_b	6.0	0.0
40_26_16_1_b	6.0	0.0
40_26_1_1_c	1.0	0.0
40_26_2_1_c	1.0	0.0
40_26_13_1_c	1.0	0.0
40_26_14_1_c	1.0	0.0
40_26_4_2_a	4.0	0.0
40_26_14_2_a	4.0	0.0
40_26_21_2_a	4.0	0.0
40_26_2_2_b	5.0	2.0
40_26_10_2_b	5.0	0.0
40_26_17_2_b	6.0	11.0
40_26_19_2_b	6.0	3.0
40_26_14_3_a	4.0	0.0
40_26_10_3_b	7.0	1.0
40_26_13_3_b	7.0	3.0
40_26_1_3_c	1.0	0.0
40_26_2_3_c	1.0	0.0
40_26_7_3_c	1.0	0.0

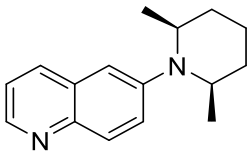


40_26





A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*



6-(*cis*-2,6-Dimethylpiperidin-1-yl)quinoline **(40_26)**

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

δ 8.78 (dd, *J* = 4.2, 1.7 Hz, 1H), 8.02 (td, *J* = 5.8, 3.0 Hz, 2H), 7.56 (dd, *J* = 9.1, 2.4 Hz, 1H), 7.39 (d, *J* = 2.4 Hz, 1H), 7.31 (dd, *J* = 8.3, 4.3 Hz, 1H), 3.28 – 3.16 (m, 2H), 1.88 – 1.71 (m, 3H), 1.62 – 1.40 (m, 3H), 0.84 (d, *J* = 6.4 Hz, 6H).

^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$)

δ 148.95, 148.64, 145.82, 135.48, 130.04, 128.97, 127.02, 121.12, 55.54, 34.37, 22.19, 21.37.

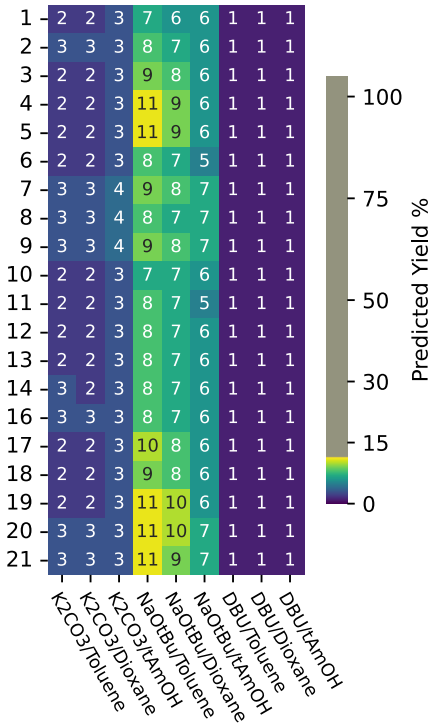
IR (cm^{-1}) ATR (neat)

604, 613, 618, 622,,647, 697, 670, 731, 773, 795, 787, 819, 826, 850, 888, 894, 901, 932, 949, 959, 980, 1023, 1030, 1061, 1087, 1121, 1142, 1154, 1163, 1183, 1222, 1231, 1260, 1290, 1313, 1320, 1358, 1371, 1438, 1451, 1468, 1493, 1568, 1588, 1615, 1713, 1749, 1787, 1852, 1887, 1925, 2589, 2650, 2673, 2694, 2725, 2790, 2868, 2855, 2927, 2963

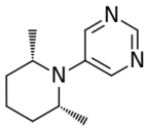
HRMS (ES+) Calcd for $C_{16}H_{21}N_2(M+H)^+$: 241.1702 Found: 241.1702

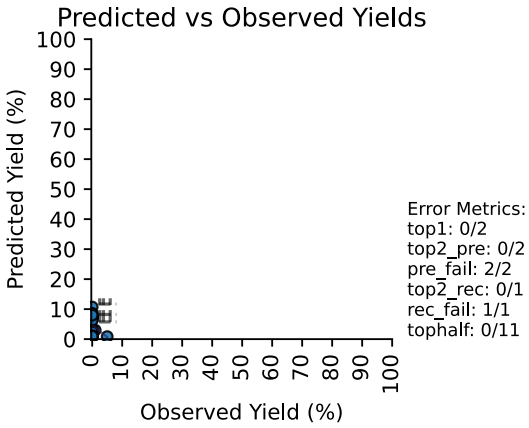
Data for **40_24**

	Predicted Yield %	Observed Yield %
40_24_9_1_a	3.0	0.0
40_24_17_1_a	2.0	0.0
40_24_2_1_b	7.0	0.0
40_24_7_1_b	8.0	0.0
40_24_8_1_b	7.0	0.0
40_24_14_1_b	7.0	0.0
40_24_16_1_b	7.0	0.0
40_24_5_1_c	1.0	5.0
40_24_18_1_c	1.0	0.0
40_24_1_2_a	3.0	1.0
40_24_10_2_a	3.0	0.0
40_24_14_2_a	3.0	0.0
40_24_7_2_b	7.0	0.0
40_24_9_2_b	7.0	0.0
40_24_17_2_b	6.0	0.0
40_24_7_3_a	3.0	0.0
40_24_18_3_a	2.0	0.0
40_24_4_3_b	11.0	0.0
40_24_7_3_b	9.0	0.0
40_24_16_3_b	8.0	0.0
40_24_6_3_c	1.0	0.0
40_24_7_3_c	1.0	0.0
40_24_8_3_c	1.0	0.0
40_24_9_3_c	1.0	0.0

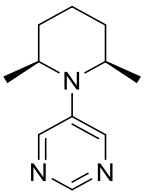


40_24





A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*



5-(*cis*-2,6-Dimethylpiperidin-1-yl)pyrimidine **(40_24)**

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

δ 8.76 (s, 1H), 8.39 (s, 2H), 3.60 – 3.49 (m, 2H), 1.92 – 1.73 (m, 3H), 1.61 – 1.54 (m, 3H), 0.99 (d, *J* = 6.6 Hz, 6H).

^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$)

δ 151.01, 148.35, 143.13, 51.65, 32.86, 19.90, 18.90.

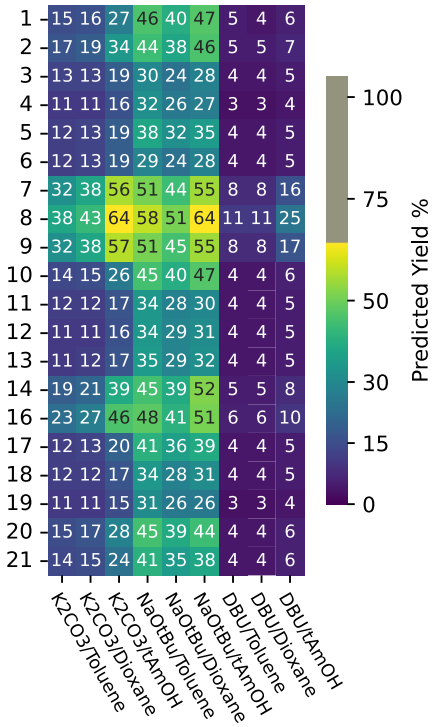
IR (cm^{-1}) ATR (neat)

621, 676, 700, 721, 731, 751, 769, 816, 863, 895, 913, 959, 980, 1013, 1024, 1040, 1066, 1088, 1116, 1149, 1223, 1200, 1246, 1256, 1275, 1321, 1363, 1378, 1407, 1447, 1539, 1560, 1673, 1717, 2853, 2869, 2927.

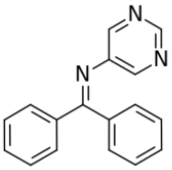
HRMS (ES+) Calcd for $C_{11}H_{18}N_3$ $(M+H)^+$: 192.1497 Found: 192.1494

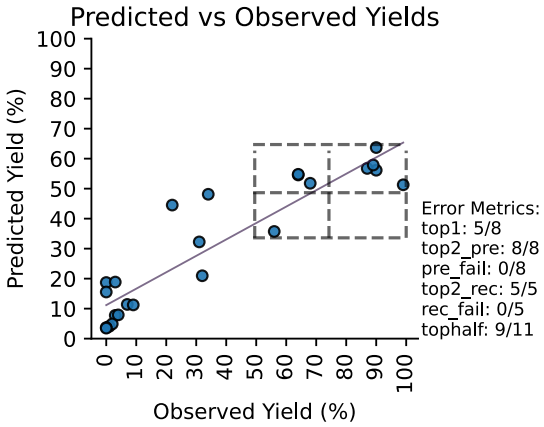
Data for 23_24

	Predicted Yield %	Observed Yield %
23_24_14_1_a	21.0	32.0
23_24_9_1_b	45.0	22.0
23_24_17_1_b	36.0	56.0
23_24_7_1_c	8.0	3.0
23_24_8_1_c	11.0	7.0
23_24_10_1_c	4.0	1.0
23_24_14_1_c	5.0	2.0
23_24_17_1_c	4.0	0.0
23_24_3_2_a	19.0	0.0
23_24_4_2_a	16.0	0.0
23_24_7_2_a	56.0	90.0
23_24_8_2_a	64.0	90.0
23_24_9_2_a	57.0	87.0
23_24_7_2_b	55.0	64.0
23_24_9_2_b	55.0	64.0
23_24_14_2_b	52.0	68.0
23_24_9_3_a	32.0	31.0
23_24_14_3_a	19.0	3.0
23_24_7_3_b	51.0	99.0
23_24_8_3_b	58.0	89.0
23_24_16_3_b	48.0	34.0
23_24_4_3_c	3.0	0.0
23_24_8_3_c	11.0	9.0
23_24_9_3_c	8.0	4.0

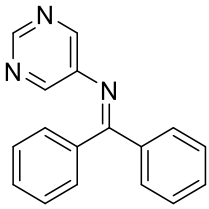


23_24





A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*



1,1-Diphenyl-*N*-(pyrimidin-5-yl)methanimine **(23_24)**

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

δ 8.76 (s, 1H), 8.14 (s, 2H), 7.79 – 7.73 (m, 2H), 7.52 – 7.45 (m, 1H), 7.40 (t, *J* = 7.5 Hz, 2H), 7.32 – 7.25 (m, 3H), 7.11 – 7.05 (m, 2H).

^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$)

δ 171.95, 153.51, 148.76, 145.07, 138.27, 134.77, 131.69, 129.57, 129.40, 129.16, 128.50, 128.36.

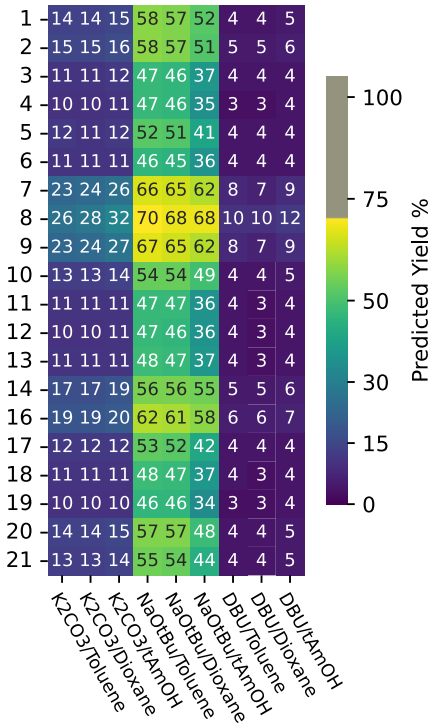
IR (cm^{-1}) ATR (neat)

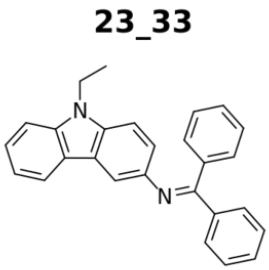
615, 603, 646, 673, 692, 722, 726, 767, 785, 847, 914, 897, 955, 971, 1000, 1029, 1037,1073, 1104, 1150, 1167, 1184, 1241, 1276, 1295, 1317, 1336, 1402, 1424, 1447, 1489, 1544, 1576, 1594 ,1612, 1813, 1916, 1961, 2082, 2235, 2340, 3025, 3081

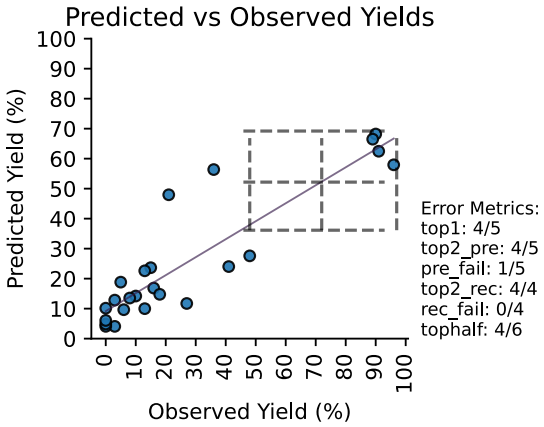
HRMS (ES+) Calcd for $C_{17}H_{14}N_3$ (M+H)+: 260.1187 Found: 260.1185

Data for **23_33**

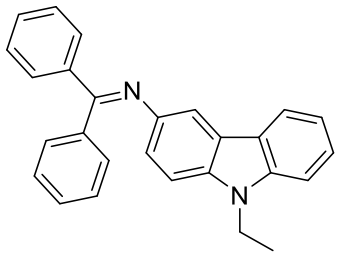
	Predicted Yield %	Observed Yield %
23_33_7_1_a	24.0	15.0
23_33_8_1_a	28.0	48.0
23_33_9_1_a	24.0	41.0
23_33_12_1_a	10.0	0.0
23_33_14_1_a	17.0	16.0
23_33_16_1_a	19.0	5.0
23_33_8_1_b	68.0	90.0
23_33_8_1_c	10.0	6.0
23_33_10_1_c	4.0	3.0
23_33_21_1_c	4.0	0.0
23_33_10_2_a	14.0	10.0
23_33_20_2_a	15.0	18.0
23_33_21_2_a	14.0	8.0
23_33_9_2_b	62.0	91.0
23_33_20_2_b	48.0	21.0
23_33_7_3_a	23.0	13.0
23_33_10_3_a	13.0	3.0
23_33_17_3_a	12.0	27.0
23_33_2_3_b	58.0	96.0
23_33_7_3_b	66.0	89.0
23_33_14_3_b	56.0	36.0
23_33_2_3_c	5.0	0.0
23_33_8_3_c	10.0	13.0
23_33_16_3_c	6.0	0.0







A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*



N-(9-Ethyl-9H-carbazol-3-yl)-1,1-diphenylmethanimine **(23_33)**

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

δ 7.90 (d, *J* = 7.8 Hz, 1H), 7.82 – 7.75 (m, 2H), 7.53 (d, *J* = 1.9 Hz, 1H), 7.46 – 7.34 (m, 4H), 7.29 (d, *J* = 8.1 Hz, 1H), 7.23 – 7.14 (m, 5H), 7.14 – 7.06 (m, 2H), 6.87 (dd, *J* = 8.6, 2.1 Hz, 1H), 4.20 (q, *J* = 7.3 Hz, 2H), 1.33 (t, *J* = 7.3 Hz, 3H).

^{13}C{^{1}H} (101 MHz, $CDCl_3$)

NMR δ 167.43, 143.30, 140.49, 140.37, 137.01, 130.47, 129.87, 129.31, 128.47, 128.26, 128.12, 125.60, 123.10, 123.06, 120.67, 120.45, 118.57, 113.44, 108.55, 108.20, 37.61, 13.89.

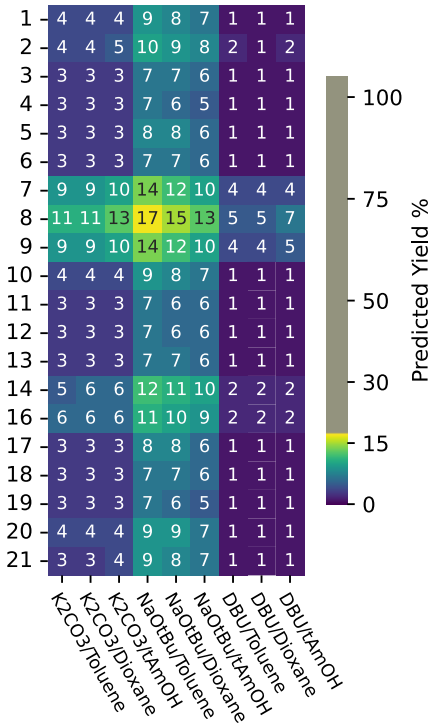
IR (cm^{-1}) ATR (neat)

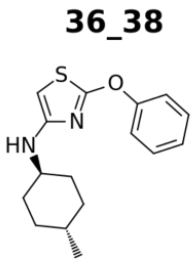
613, 617, 631, 653, 678, 693, 706, 730, 745, 766, 781, 805, 846, 874, 909, 958, 1000, 1022, 1058, 1073, 1086, 1122, 1136, 1153, 1191, 1227, 1269, 1283, 1315, 1332,1344, 1379, 1444, 1468, 1458, 1477, 1489 1569 1597, 1606, 2609, 2883, 2930, 2973, 3022, 3053

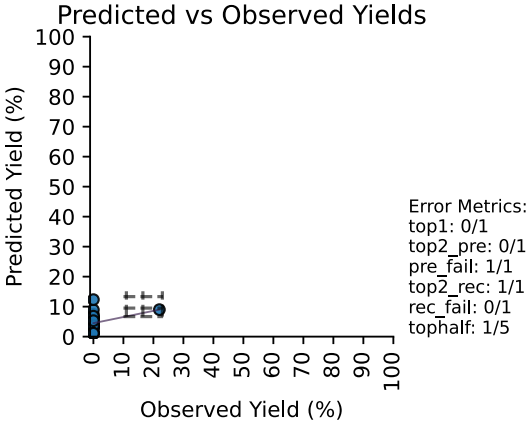
HRMS (ES+) Calcd for $C_{27}H_{23}N_2$ (M+H)+: 375.1861 Found: 375.1858

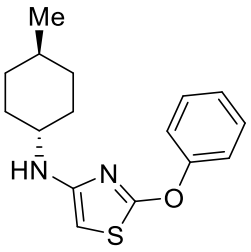
Data for **36_38**

	Predicted Yield %	Observed Yield %
36_38_7_1_a	9.0	22.0
36_38_11_1_b	6.0	0.0
36_38_2_1_c	1.0	0.0
36_38_4_1_c	1.0	0.0
36_38_8_1_c	5.0	0.0
36_38_11_1_c	1.0	0.0
36_38_2_2_a	5.0	0.0
36_38_10_2_a	4.0	0.0
36_38_11_2_a	3.0	0.0
36_38_14_2_a	6.0	0.0
36_38_17_2_a	3.0	0.0
36_38_5_2_b	6.0	0.0
36_38_10_2_b	7.0	0.0
36_38_2_3_a	4.0	0.0
36_38_4_3_a	3.0	0.0
36_38_10_3_a	4.0	0.0
36_38_11_3_a	3.0	0.0
36_38_10_3_b	9.0	0.0
36_38_11_3_b	7.0	0.0
36_38_14_3_b	12.0	0.0
36_38_7_3_c	4.0	0.0
36_38_8_3_c	5.0	0.0
36_38_11_3_c	1.0	0.0
36_38_18_3_c	1.0	0.0





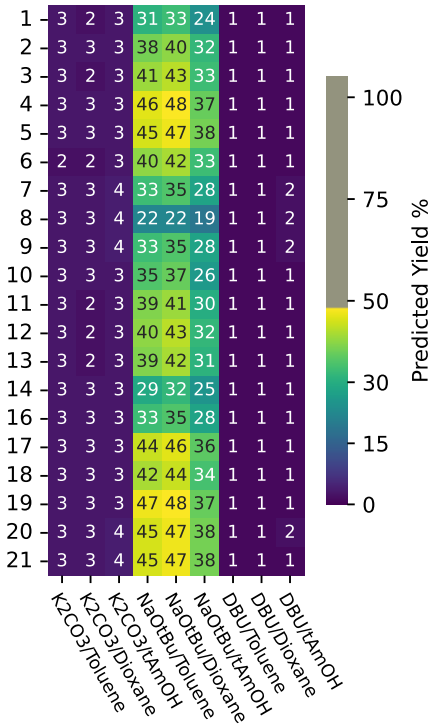


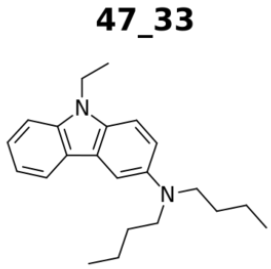


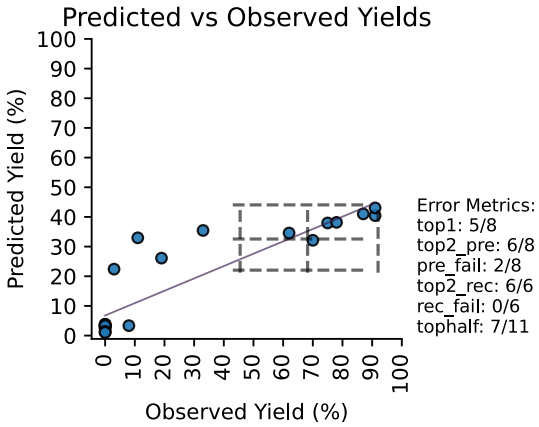
N-(*trans*-4-Methylcyclohexyl)-2-phenoxythiazol-4-amine **(36_38):** This product was not isolated in pure form from the reaction mixtures, and could not be independently synthesized. One reaction is reported at 22% product formation based on ^{1}H NMR.

Data for **47_33**

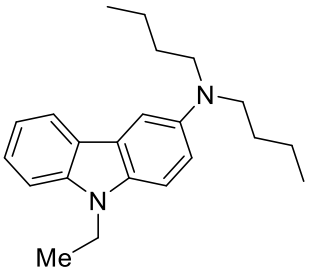
	Predicted Yield %	Observed Yield %
47_33_8_1_a	3.0	0.0
47_33_10_1_a	3.0	0.0
47_33_18_1_a	3.0	0.0
47_33_2_1_b	40.0	91.0
47_33_3_1_b	43.0	91.0
47_33_8_1_b	22.0	3.0
47_33_16_1_b	35.0	33.0
47_33_21_1_c	1.0	0.0
47_33_8_2_a	4.0	0.0
47_33_9_2_a	4.0	0.0
47_33_10_2_a	3.0	8.0
47_33_14_2_a	3.0	0.0
47_33_16_2_a	3.0	0.0
47_33_2_2_b	32.0	70.0
47_33_10_2_b	26.0	19.0
47_33_20_2_b	38.0	75.0
47_33_2_2_a	3.0	0.0
47_33_2_3_b	38.0	78.0
47_33_3_3_b	41.0	87.0
47_33_9_3_b	33.0	11.0
47_33_10_3_b	35.0	62.0
47_33_8_3_c	1.0	0.0
47_33_14_3_c	1.0	0.0







A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*



N,*N*-Dibutyl-9-ethyl-9H-carbazol-3-amine **(47_33)**

State Oil

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

δ 8.09 (dt, *J* = 7.8, 0.9 Hz, 1H), 7.52 (d, *J* = 2.4 Hz, 1H), 7.45 (ddd, *J* = 8.3, 7.0, 1.3 Hz, 1H), 7.37 (d, *J* = 8.3 Hz, 1H), 7.31 (d, *J* = 8.9 Hz, 1H), 7.19 (ddd, *J* = 8.1, 7.0, 1.2 Hz, 1H), 7.09 (dd, *J* = 8.9, 2.4 Hz, 1H), 4.33 (q, *J* = 7.3 Hz, 2H), 3.36 – 3.29 (m, 4H), 1.62 (tt, *J* = 7.8, 6.4 Hz, 4H), 1.44 (t, *J* = 7.1 Hz, 7H), 0.99 (t, *J* = 7.3 Hz, 6H).

^{13}C{^{1}H} (101 MHz, $CDCl_3$)

NMR δ 143.18, 140.50, 133.94, 125.32, 123.69, 123.01, 120.37, 117.99, 116.24, 108.93, 108.39, 106.53, 53.00, 37.61, 29.73, 20.69, 14.03.

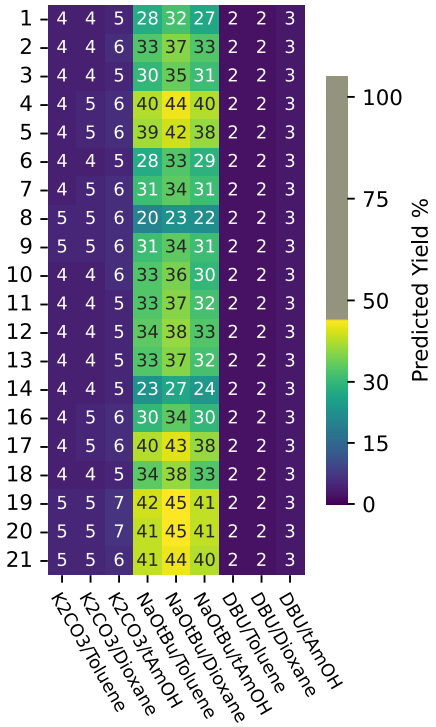
IR (cm^{-1}) ATR (neat)

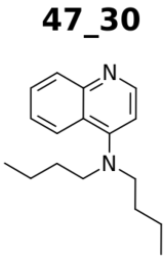
2954 (w), 2868 (w), 2318 (w), 1601 (w), 1491 (w), 1462 (w), 1375 (w), 1329 (w), 1230 (w), 1149 (w), 1086 (w), 1057 (w), 1022 (w), 924 (w), 808 (w), 727 (m), 640 (w).

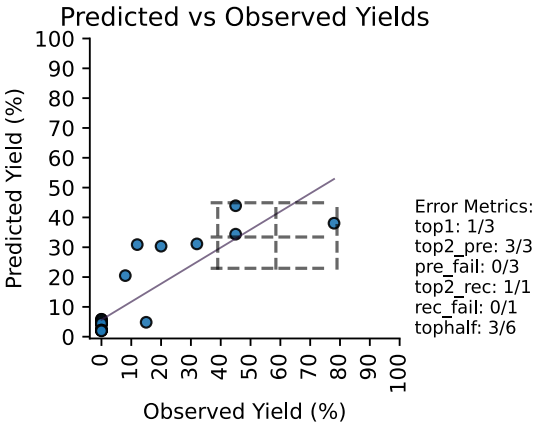
HRMS (ES+) Calcd for $C_{22}H_{31}N_2$ $(M+H)^+$: 323.2489 Found: 323.2489

Data for **47_30**

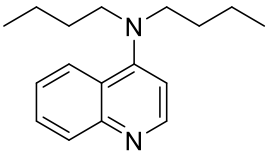
	Predicted Yield %	Observed Yield %
47_30_2_1_a	4.0	0.0
47_30_9_1_a	5.0	0.0
47_30_18_1_a	4.0	0.0
47_30_4_1_b	44.0	45.0
47_30_9_1_b	34.0	45.0
47_30_8_1_c	2.0	0.0
47_30_10_1_c	2.0	0.0
47_30_12_1_c	2.0	0.0
47_30_16_1_c	2.0	0.0
47_30_5_2_a	6.0	0.0
47_30_6_2_a	5.0	15.0
47_30_10_2_a	6.0	0.0
47_30_11_2_a	5.0	0.0
47_30_5_2_b	38.0	78.0
47_30_9_2_b	31.0	32.0
47_30_10_2_b	30.0	20.0
47_30_2_3_a	4.0	0.0
47_30_9_3_a	5.0	0.0
47_30_7_3_b	31.0	12.0
47_30_8_3_b	20.0	8.0
47_30_2_3_c	2.0	0.0
47_30_7_3_c	2.0	0.0
47_30_8_3_c	2.0	0.0
47_30_14_3_c	2.0	0.0







A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*

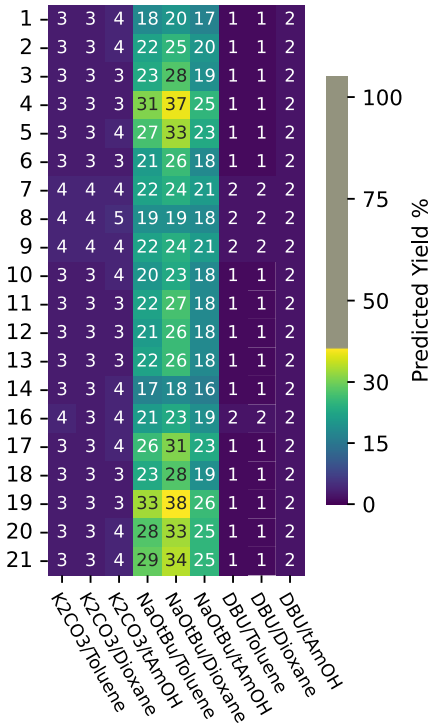


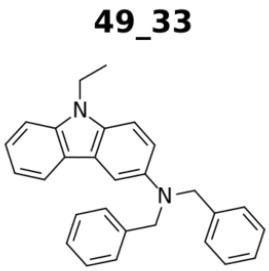
N,*N*-Dibutylquinolin-4-amine **(47_30)**

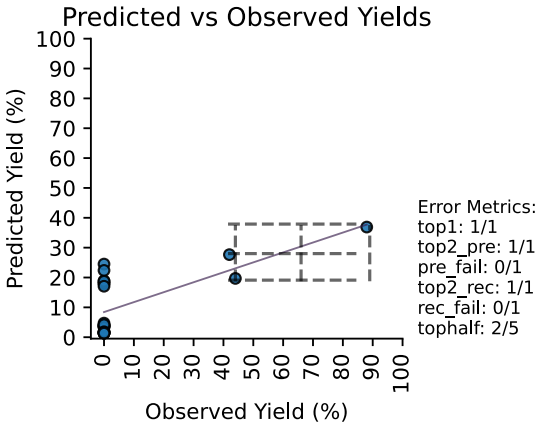
Color and state	Oil
^{1}H NMR	(400 MHz, $CDCl_3$) δ 8.66 (d, *J* = 5.1 Hz, 1H), 8.03 (ddd, *J* = 8.6, 7.1, 1.6 Hz, 2H), 7.65 – 7.60 (m, 1H), 7.44 (ddd, *J* = 8.3, 6.7, 1.3 Hz, 1H), 6.83 (d, *J* = 5.1 Hz, 1H), 3.35 – 3.25 (m, 4H), 1.62 – 1.52 (m, 4H), 1.29 (dq, *J* = 14.8, 7.4 Hz, 4H), 0.88 (t, *J* = 7.4 Hz, 6H).
^{13}C{^{1}H} NMR	(101 MHz, $CDCl_3$) δ 156.36, 150.41, 150.19, 130.01, 128.91, 124.77, 124.39, 110.37, 52.72, 29.27, 20.50, 14.04.
HRMS (ES+)	Calcd for $C_{17}H_{25}N_2$ $(M+H)^+$: 257.2010 Found: 257.2009

Data for **49_33**

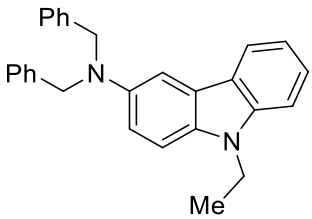
	Predicted Yield %	Observed Yield %
49_33_7_1_a	4.0	0.0
49_33_8_1_a	4.0	0.0
49_33_9_1_a	4.0	0.0
49_33_4_1_b	37.0	88.0
49_33_8_1_b	19.0	0.0
49_33_9_1_b	24.0	0.0
49_33_18_1_b	28.0	42.0
49_33_2_1_c	1.0	0.0
49_33_8_1_c	2.0	0.0
49_33_10_1_c	1.0	0.0
49_33_20_1_c	1.0	0.0
49_33_2_2_a	4.0	0.0
49_33_8_2_a	5.0	0.0
49_33_2_2_b	20.0	44.0
49_33_8_2_b	18.0	0.0
49_33_12_2_b	18.0	0.0
49_33_2_3_a	3.0	0.0
49_33_8_3_a	4.0	0.0
49_33_7_3_b	22.0	0.0
49_33_8_3_b	19.0	0.0
49_33_14_3_b	17.0	0.0
49_33_7_3_c	2.0	0.0
49_33_8_3_c	2.0	0.0
49_33_14_3_c	1.0	0.0







A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*



N,*N*-Dibenzyl-9-ethyl-9H-carbazol-3-amine **(49_33)**

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

δ 7.95 – 7.91 (m, 1H), 7.49 (d, *J* = 2.4 Hz, 1H), 7.42 – 7.36 (m, 1H), 7.36 – 7.28 (m, 9H), 7.27 – 7.20 (m, 3H), 7.13 – 7.08 (m, 1H), 7.05 (dd, *J* = 8.9, 2.7 Hz, 1H), 4.66 (s, 4H), 4.28 (q, *J* = 7.3 Hz, 2H), 1.39 (t, *J* = 7.1 Hz, 3H).

^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$)

δ 143.61, 140.53, 139.41, 133.99, 128.64, 127.41, 126.92, 125.45, 123.69, 122.86, 120.51, 118.01, 114.97, 109.01, 108.39, 105.43, 55.89, 37.64, 14.05.

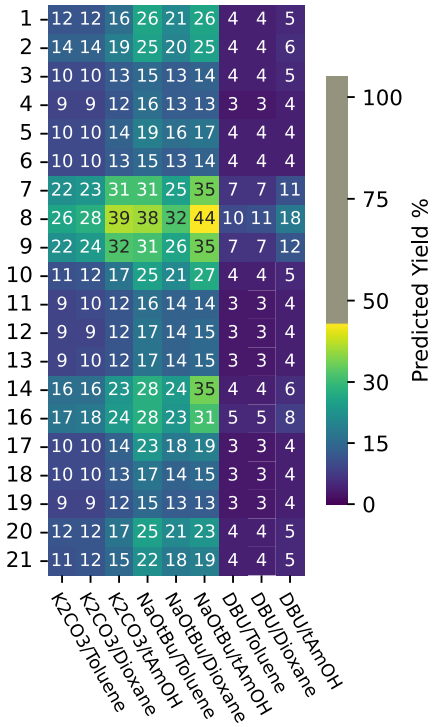
IR (cm^{-1}) ATR (neat)

613, 627, 653, 696, 732, 740, 762, 786, 803, 828, 843, 890, 927, 951, 959, 1007, 1029, 1066, 1042, 1088, 1124, 1150, 1172, 1201, 1233, 1256, 1277, 1296, 1327, 1362, 1379, 1449, 1474, 1492, 1570, 1602, 1632, 1737, 1814, 1860, 2851, 2921

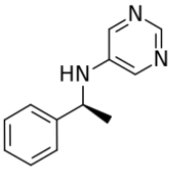
HRMS (ES+) Calcd for $C_{28}H_{27}N_2$ $(M+H)^+$: 391.2171 Found: 391.2165

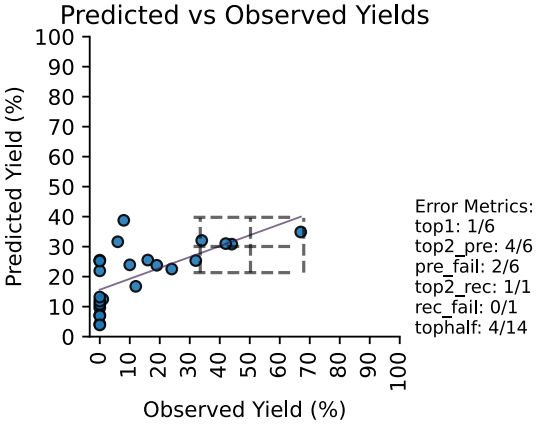
Data for **34_24**

	Predicted Yield %	Observed Yield %
34_24_9_1_a	24.0	10.0
34_24_13_1_a	10.0	0.0
34_24_20_1_a	12.0	1.0
34_24_7_1_b	25.0	32.0
34_24_8_1_b	32.0	34.0
34_24_9_1_b	26.0	16.0
34_24_14_1_b	24.0	19.0
34_24_8_1_c	11.0	0.0
34_24_9_1_c	7.0	0.0
34_24_14_1_c	4.0	0.0
34_24_4_2_a	12.0	0.0
34_24_8_2_a	39.0	8.0
34_24_9_2_a	32.0	6.0
34_24_20_2_a	17.0	12.0
34_24_2_2_b	25.0	0.0
34_24_9_2_b	35.0	67.0
34_24_19_2_b	13.0	0.0
34_24_9_3_a	22.0	0.0
34_24_7_3_b	31.0	44.0
34_24_9_3_b	31.0	42.0
34_24_10_3_b	25.0	0.0
34_24_17_3_b	23.0	24.0
34_24_9_3_c	7.0	0.0
34_24_20_3_c	4.0	0.0

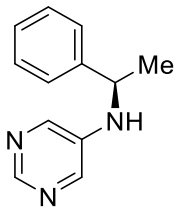


34_24





A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*

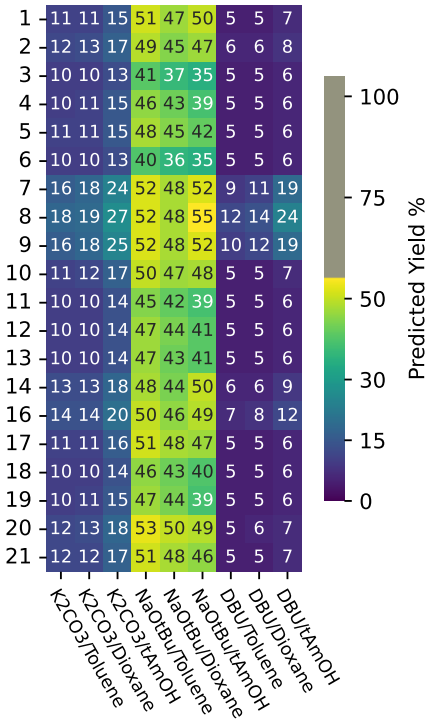


N-Phenylethyl)pyrimidin-5-amine **(34_24)** (*63*)

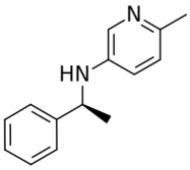
State	Oil
^{1}H NMR	(500 MHz, $CDCl_3$) δ 8.47 (s, 1H), 7.94 (s, 2H), 7.32 – 7.24 (m, 4H), 7.23 – 7.15 (m, 1H), 4.42 (p, *J* = 6.7 Hz, 1H), 4.21 (s, 1H), 1.50 (d, *J* = 6.7 Hz, 3H).
^{13}C{^{1}H} NMR	(126 MHz, $CDCl_3$) δ 148.56, 143.24, 141.45, 140.89, 129.12, 127.67, 125.77, 53.30, 24.96.
IR (cm^{-1})	ATR (neat) 3282 (w), 3025 (w), 2971 (w), 1738 (s), 1575 (m), 1519 (w), 1493 (w), 1451 (w), 1429 (m), 1367 (s), 1324 (w), 1300 (m), 1217 (s), 1133 (w), 1089 (w), 1028 (w), 915 (w), 874 (m), 758 (w), 725 (m), 702 (m), 633 (m), 528 (m).
HRMS (ESI+)	Calcd for $C_{12}H_{14}N_3$ (M+H)+: 200.1188 Found: 200.1183
TLC	R_f 0.45 (EtOAc/CH_2Cl_2, 20:80)

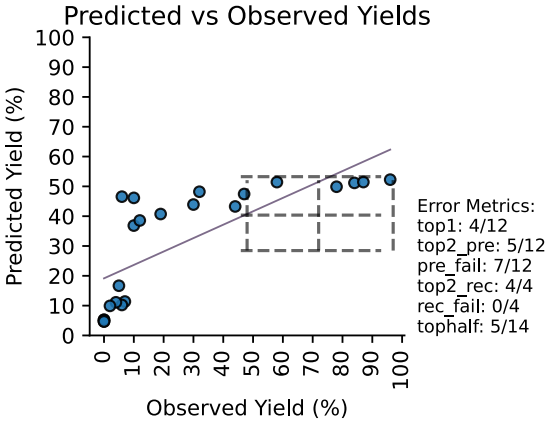
Data for **34_18**

	Predicted Yield %	Observed Yield %
34_18_1_1_a	11.0	7.0
34_18_13_1_a	10.0	6.0
34_18_1_1_b	47.0	47.0
34_18_3_1_b	37.0	10.0
34_18_10_1_b	47.0	6.0
34_18_12_1_b	44.0	30.0
34_18_13_1_b	43.0	44.0
34_18_1_1_c	5.0	0.0
34_18_13_1_c	5.0	0.0
34_18_21_2_a	17.0	5.0
34_18_1_2_b	50.0	78.0
34_18_4_2_b	39.0	12.0
34_18_10_2_b	48.0	32.0
34_18_13_2_b	41.0	19.0
34_18_1_3_a	11.0	4.0
34_18_13_3_a	10.0	2.0
34_18_1_3_b	51.0	84.0
34_18_4_3_b	46.0	10.0
34_18_9_3_b	52.0	96.0
34_18_17_3_b	51.0	87.0
34_18_21_3_b	51.0	58.0
34_18_10_3_c	5.0	0.0
34_18_18_3_c	5.0	0.0

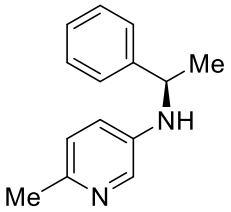


34_18





A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*

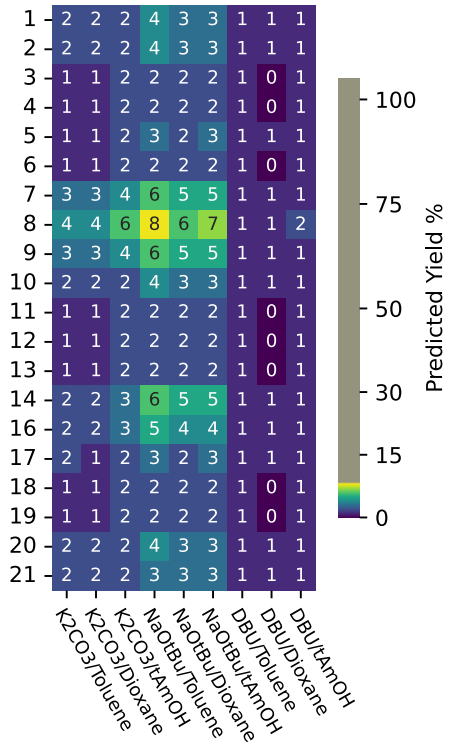


6-Methyl-*N*-(1-phenylethyl)pyridin-3-amine **(34_18)**

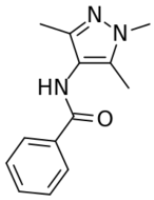
State	Solid
m.p.	107 °C
^{1}H NMR	(400 MHz, $CDCl_3$)
	δ 7.89 (d, *J* = 3.0 Hz, 1H), 7.36 – 7.27 (m, 4H), 7.24 – 7.18 (m, 1H), 6.81 (d, *J* = 8.3 Hz, 1H), 6.65 (dd, *J* = 8.5, 2.8 Hz, 1H), 4.43 (q, *J* = 6.7 Hz, 1H), 4.08 (s, 1H), 2.37 (s, 3H), 1.51 (d, *J* = 6.7 Hz, 3H).
^{13}C{^{1}H} NMR	(101 MHz, $CDCl_3$)
	δ 146.64, 144.55, 140.99, 135.69, 128.76, 127.10, 125.81, 122.98, 120.31, 53.55, 24.98, 23.15.
IR (cm^{-1})	ATR (neat)
	621, 646, 702, 722, 764, 828, 855, 867, 911, 947, 966, 999, 1017, 1028, 1068, 1096, 1128, 1146, 1172, 1203, 1233, 1276, 1302, 1331 1355, 1375, 1388, 1449, 1496, 1511, 1578, 1604, 2985, 3022, 3070, 3146, 3259
HRMS (ES+)	Calcd for $C_{14}H_{17}N_2$ (M+H)+: 213.1390 Found: 213.1392

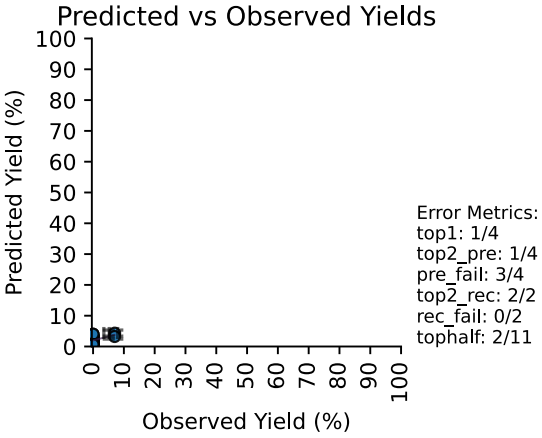
Data for **8_9**

	Predicted Yield %	Observed Yield %
8_9_4_1_a	1.0	0.0
8_9_7_1_a	3.0	0.0
8_9_10_1_a	2.0	0.0
8_9_2_1_b	3.0	0.0
8_9_4_1_b	2.0	0.0
8_9_10_1_b	3.0	0.0
8_9_21_1_b	3.0	0.0
8_9_2_1_c	1.0	0.0
8_9_3_1_c	0.0	0.0
8_9_10_1_c	1.0	0.0
8_9_21_1_c	1.0	0.0
8_9_2_2_a	2.0	0.0
8_9_4_2_a	2.0	0.0
8_9_9_2_a	4.0	7.0
8_9_10_2_a	2.0	0.0
8_9_19_2_a	2.0	0.0
8_9_2_2_b	3.0	0.0
8_9_17_2_b	3.0	0.0
8_9_7_3_a	3.0	7.0
8_9_20_3_a	2.0	0.0
8_9_2_3_b	4.0	0.0
8_9_10_3_b	4.0	0.0
8_9_1_3_c	1.0	0.0
8_9_2_3_c	1.0	0.0

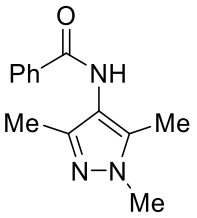


8_9





A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*



N-(1,3,5-Trimethyl-1H-pyrazol-4-yl)benzamide **(8_9)**

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

δ 7.90 (dd, *J* = 7.0, 1.6 Hz, 2H), 7.60 – 7.54 (m, 1H), 7.53 – 7.46 (m, 2H), 7.15 (s, 1H), 3.74 (s, 3H), 2.19 (s, 3H), 2.18 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$)

δ 157.46, 143.56, 135.54, 134.40, 132.04, 128.92, 127.35, 29.86, 11.41, 9.87.

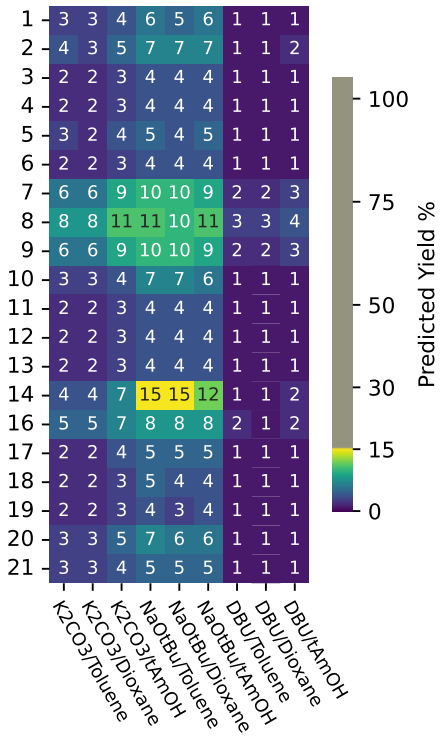
IR (cm^{-1}) (neat)

3268, 3061, 2924, 1644, 1601, 1579, 1548, 1506, 1491, 1466, 1436, 1385, 1306, 1284, 1225, 1154, 1117, 1074, 1030, 1002, 989, 927, 914, 851, 803, 767, 694, 665, 638, 618

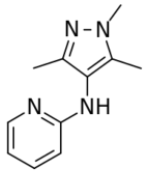
HRMS (ES+) Calcd for $C_{13}H_{16}N_3O$ (M+H)+: 230.1292 Found: 230.1292

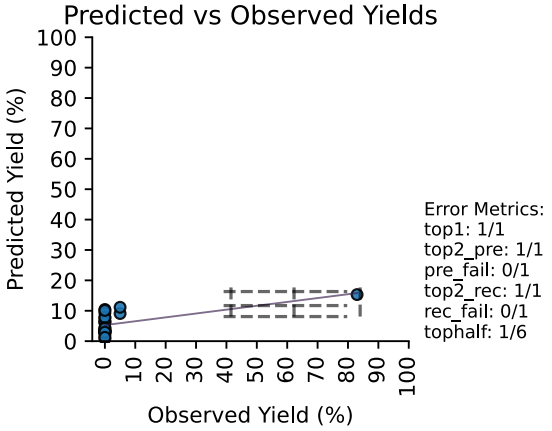
Data for **11_9**

	Predicted Yield %	Observed Yield %
11_9_7_1_a	6.0	0.0
11_9_8_1_a	8.0	0.0
11_9_4_1_b	4.0	0.0
11_9_8_1_b	10.0	0.0
11_9_10_1_b	7.0	0.0
11_9_14_1_b	15.0	83.0
11_9_8_1_c	3.0	0.0
11_9_9_1_c	2.0	0.0
11_9_10_1_c	1.0	0.0
11_9_9_2_a	9.0	5.0
11_9_11_2_a	3.0	0.0
11_9_17_2_a	4.0	0.0
11_9_18_2_a	3.0	0.0
11_9_8_2_b	11.0	5.0
11_9_9_2_b	9.0	0.0
11_9_10_2_b	6.0	0.0
11_9_2_3_a	4.0	0.0
11_9_8_3_a	8.0	0.0
11_9_10_3_a	3.0	0.0
11_9_14_3_a	4.0	0.0
11_9_3_3_b	4.0	0.0
11_9_7_3_b	10.0	0.0
11_9_8_3_c	3.0	0.0
11_9_14_3_c	1.0	0.0

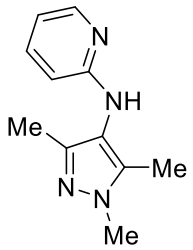


11_9





A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*

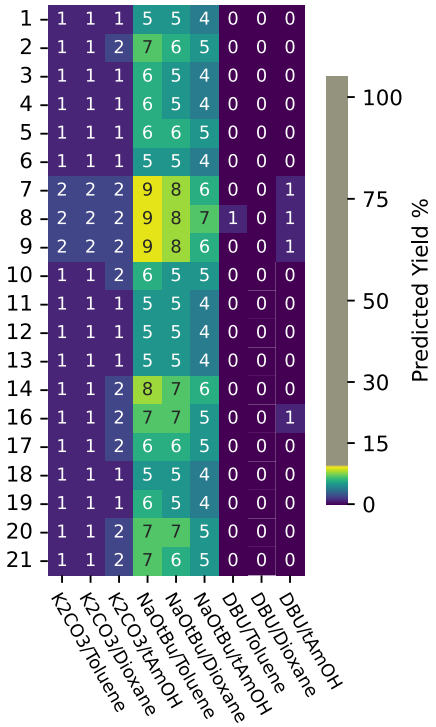


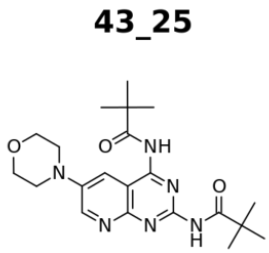
N-(1,3,5-Trimethyl-1H-pyrazol-4-yl)pyridin-2-amine **(11_9)**

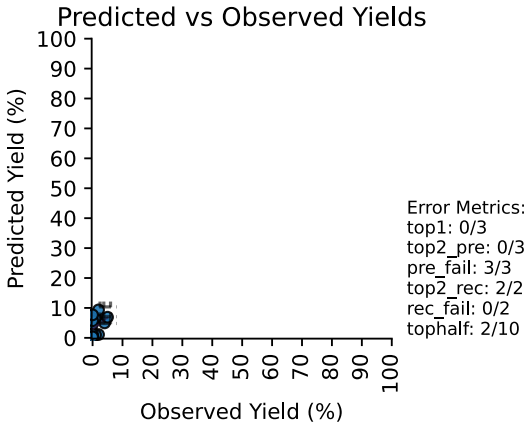
Color and state	Solid
m.p.	120 ^{o}C
^{1}H NMR	(400 MHz, $CDCl_3$)
	δ 8.05 (ddd, *J* = 5.1, 2.1, 0.8 Hz, 1H), 7.35 (ddd, *J* = 8.9, 7.3, 2.1 Hz, 1H), 6.58 (ddd, *J* = 7.3, 4.8, 1.1 Hz, 1H), 6.15 (dt, *J* = 8.3, 1.2 Hz, 2H), 3.71 (s, 3H), 2.09 (s, 3H), 2.06 (s, 3H).
^{13}C{^{1}H} NMR	(101 MHz, $CDCl_3$)
	δ 159.11, 148.23, 145.14, 137.90, 136.42, 117.14, 113.64, 105.78, 36.51, 11.16, 9.14.
IR (cm^{-1})	ATR (neat)
	3185 (w), 2923 (w), 1598 (m), 1588(s), 1522 (w), 1440(s), 1381(m), 1327 (s), 1300 (m), 1253 (w), 1153 (w), 992 (w), 774 (s), 701(m), 660(w), 628 (w).
HRMS (ES+)	Calcd for $C_{11}H_{15}N_4$ (M+H)+: 203.1297 Found: 203.1298

Data for **43_25**

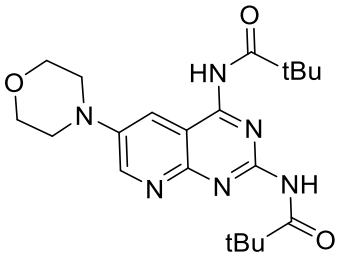
	Predicted Yield %	Observed Yield %
43_25_2_1_a	1.0	0.0
43_25_8_1_a	2.0	0.0
43_25_9_1_a	2.0	0.0
43_25_5_1_b	6.0	0.0
43_25_7_1_b	8.0	0.0
43_25_12_1_b	5.0	0.0
43_25_18_1_b	5.0	0.0
43_25_5_1_c	0.0	0.0
43_25_9_1_c	0.0	0.0
43_25_10_1_c	0.0	0.0
43_25_11_1_c	0.0	0.0
43_25_2_2_a	2.0	0.0
43_25_2_2_b	5.0	4.0
43_25_5_2_b	5.0	0.0
43_25_8_2_b	7.0	5.0
43_25_1_3_a	1.0	2.0
43_25_3_3_a	1.0	1.0
43_25_21_3_a	1.0	0.0
43_25_2_3_b	7.0	1.0
43_25_4_3_b	6.0	0.0
43_25_8_3_b	9.0	2.0
43_25_14_3_b	8.0	0.0
43_25_1_3_c	0.0	0.0
43_25_2_3_c	0.0	0.0







A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*

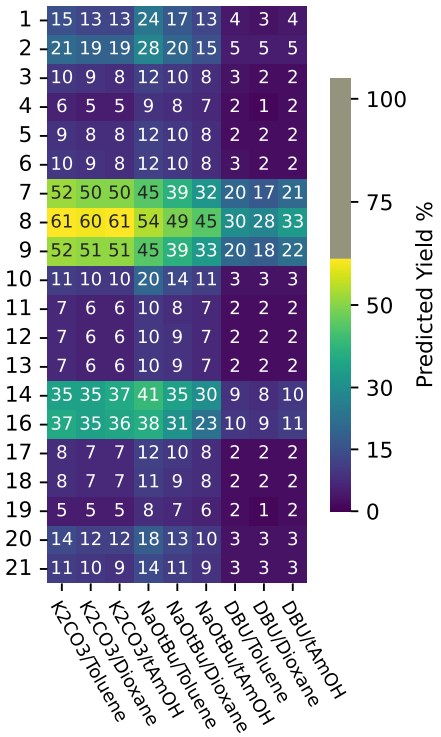


N,*N'*-(6-Morpholinopyrido[2,3-d]pyrimidine-2,4-diyl)bis(2,2-dimethylpropanamide) **(43_25)**

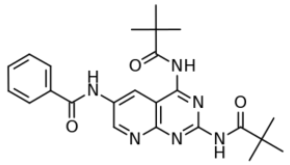
^{1}H NMR	(400 MHz, $CDCl_3$)
	δ 15.71 (s, 1H), 8.72 (d, *J* = 3.5 Hz, 1H), 8.26 (s, 1H), 8.10 (d, *J* = 3.2 Hz, 1H), 3.95 – 3.91 (m, 4H), 3.33 – 3.27 (m, 4H), 1.34 (s, 9H), 1.33 (s, 9H).
^{13}C{^{1}H} NMR	(101 MHz, $CDCl_3$)
	δ 189.73, 182.99, 165.71, 119.80, 96.85, 66.72, 48.76, 40.49, 27.89, 27.26.
IR (cm^{-1})	ATR (neat)
	630, 646, 728, 799, 830, 884, 906, 941, 974, 1025, 1049, 1078, 1117, 1163, 1204, 1244, 1274, 1298, 1339, 1437, 1478, 1535, 1570, 1612, 1693, 2250, 2853, 2923, 2960
HRMS (ES+)	Calcd for $C_{21}H_{31}N_6O_3$ $(M+H)^+$: 415.2453 Found: 415.2452

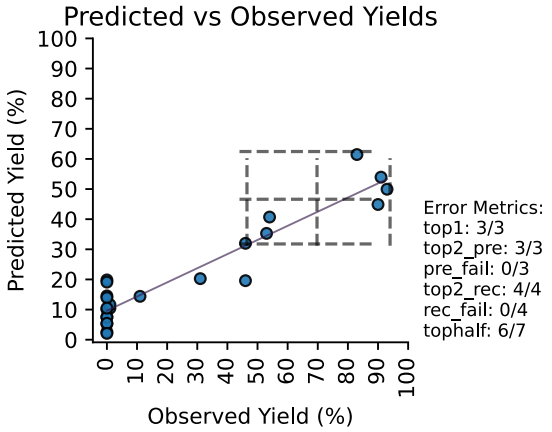
Data for **8_25**

	Predicted Yield %	Observed Yield %
8_25_10_1_a	10.0	0.0
8_25_2_1_b	20.0	0.0
8_25_4_1_b	8.0	0.0
8_25_10_1_b	14.0	11.0
8_25_14_1_b	35.0	53.0
8_25_10_1_c	3.0	0.0
8_25_2_2_a	19.0	0.0
8_25_4_2_a	5.0	0.0
8_25_7_2_a	50.0	93.0
8_25_10_2_a	10.0	1.0
8_25_20_2_a	12.0	1.0
8_25_2_2_b	15.0	0.0
8_25_7_2_b	32.0	46.0
8_25_13_2_b	7.0	0.0
8_25_8_3_a	61.0	83.0
8_25_7_3_b	45.0	90.0
8_25_8_3_b	54.0	91.0
8_25_10_3_b	20.0	31.0
8_25_14_3_b	41.0	54.0
8_25_21_3_b	14.0	0.0
8_25_2_3_c	5.0	0.0
8_25_7_3_c	20.0	46.0
8_25_16_3_c	10.0	0.0
8_25_17_3_c	2.0	0.0

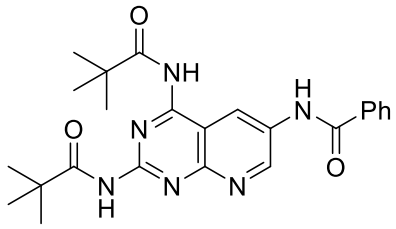


8_25





A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*

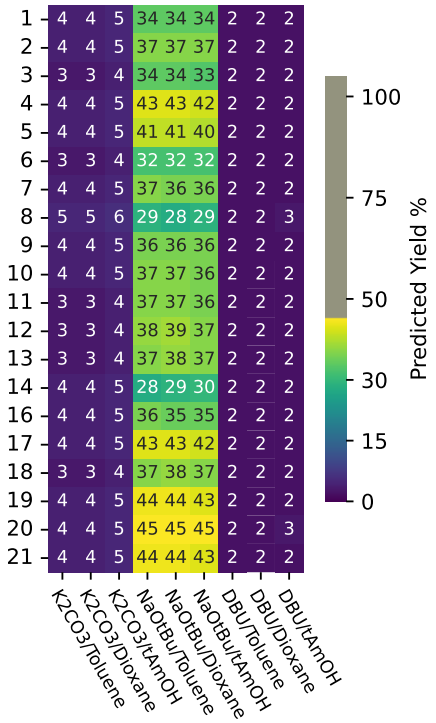


N,*N'*-(6-Benzamidopyrido[2,3-d]pyrimidine-2,4-diyl)bis(2,2-dimethylpropanamide) **(8_25)**

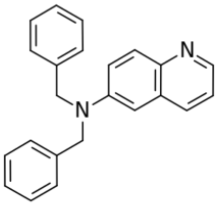
Color and state	Oil
^{1}H NMR	(400 MHz, $CDCl_3$) δ 15.64 (s, 1H), 9.24 (d, *J* = 3.0 Hz, 1H), 9.05 (s, 1H), 8.51 (s, 1H), 7.94 (d, *J* = 7.0 Hz, 2H), 7.56 (t, *J* = 7.4 Hz, 1H), 7.48 (t, *J* = 7.5 Hz, 2H), 1.32 (d, *J* = 4.3 Hz, 18H).
^{13}C{^{1}H} NMR	(101 MHz, $CDCl_3$) δ 179.41, 166.21, 150.12, 133.91, 132.79, 132.38, 128.87, 127.33, 125.36, 40.42, 27.58, 27.07.
IR (cm^{-1})	ATR (neat) 2966 (w), 1676 (w), 1601 (w), 1549 (w), 1473 (w), 1433 (m), 1387 (w), 1271 (w), 1207 (w), 1144 (w), 1068 (w), 1022 (w), 964 (w), 924 (w), 802 (w), 704 (w).
HRMS (ES+)	Calcd for $C_{24}H_{29}N_6O$ (M+H)+: 449.2307 Found: 449.2306

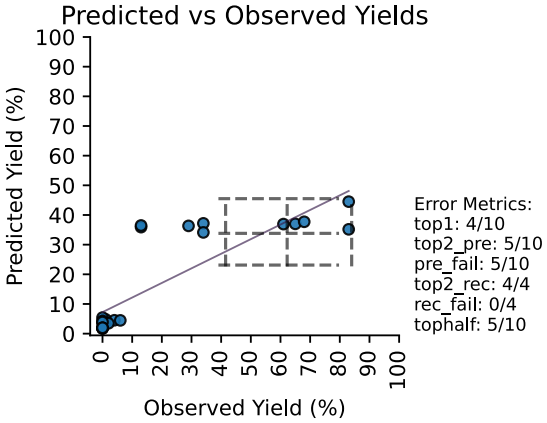
Data for **49_26**

	Predicted Yield %	Observed Yield %
49_26_6_1_a	3.0	1.0
49_26_13_1_a	3.0	0.0
49_26_2_1_b	37.0	65.0
49_26_7_1_b	36.0	13.0
49_26_11_1_b	37.0	34.0
49_26_13_1_b	38.0	68.0
49_26_16_1_b	35.0	83.0
49_26_13_1_c	2.0	0.0
49_26_14_1_c	2.0	0.0
49_26_1_2_a	5.0	4.0
49_26_2_2_a	5.0	1.0
49_26_7_2_a	5.0	0.0
49_26_13_2_a	4.0	6.0
49_26_10_2_b	36.0	29.0
49_26_20_2_b	45.0	83.0
49_26_7_3_a	4.0	0.0
49_26_13_3_a	3.0	2.0
49_26_21_3_a	4.0	0.0
49_26_1_3_b	34.0	34.0
49_26_2_3_b	37.0	61.0
49_26_9_3_b	36.0	13.0
49_26_2_3_c	2.0	0.0
49_26_7_3_c	2.0	0.0
49_26_9_3_c	2.0	0.0

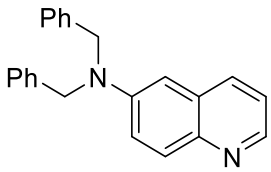


49_26





A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*

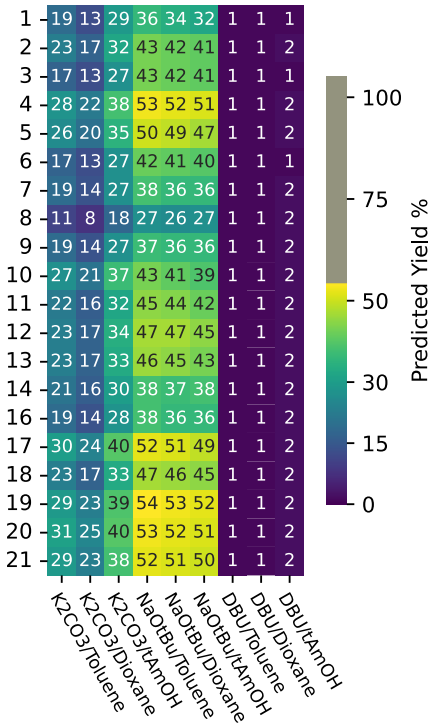


N,*N*-Dibenzylquinolin-6-amine **(49_26)**

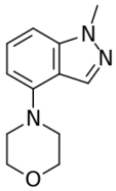
State	Oil
^{1}H NMR	(400 MHz, $CDCl_3$) δ 8.61 (dd, *J* = 4.3, 1.6 Hz, 1H), 7.92 (d, *J* = 9.7 Hz, 1H), 7.82 (dd, *J* = 8.3, 2.1 Hz, 1H), 7.38 – 7.31 (m, 5H), 7.28 (d, *J* = 6.2 Hz, 6H), 7.20 (dd, *J* = 8.3, 4.0 Hz, 1H), 6.87 (d, *J* = 3.0 Hz, 1H), 4.77 (s, 4H).
^{13}C{^{1}H} NMR	(101 MHz, $CDCl_3$) δ 147.32, 146.53, 142.63, 138.04, 134.15, 130.43, 129.93, 128.89, 127.24, 126.73, 121.40, 119.26, 105.30, 54.43.
IR (cm^{-1})	ATR (neat) 613, 618, 620, 643, 651, 667, 690, 701, 726, 738, 763, 770, 782, 789, 819, 833, 851, 883, 890, 898, 939, 956, 966, 986, 1001, 1027, 1036, 1054, 1070, 1076, 1123, 1148, 1154, 1162 1174, 1187, 1203, 1233, 1246, 1268 1283 1295, 1301 1326, 1331, 1353, 1367, 1393, 1434, 1444, 1449, 1476, 1492, 1506, 1553, 1565, 1583, 1604, 1619, 1641
HRMS (ES+)	Calcd for $C_{23}H_{20}N_2$ $(M+H)^+$: 235.1704 Found: 325.1706

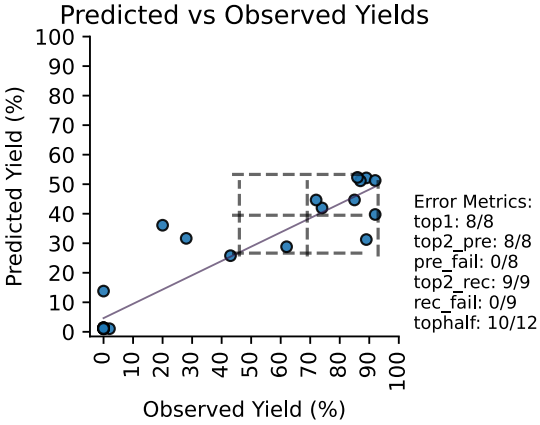
Data for **43_12**

	Predicted Yield %	Observed Yield %
43_12_9_1_a	14.0	0.0
43_12_3_1_b	42.0	74.0
43_12_4_1_b	52.0	89.0
43_12_8_1_b	26.0	43.0
43_12_9_1_b	36.0	20.0
43_12_13_1_b	45.0	85.0
43_12_1_1_c	1.0	2.0
43_12_6_1_c	1.0	0.0
43_12_8_1_c	1.0	0.0
43_12_18_1_c	1.0	0.0
43_12_1_2_a	29.0	62.0
43_12_20_2_a	40.0	92.0
43_12_1_2_b	32.0	28.0
43_12_4_2_b	51.0	87.0
43_12_12_2_b	45.0	72.0
43_12_20_2_b	51.0	92.0
43_12_20_3_a	31.0	89.0
43_12_17_3_b	52.0	86.0
43_12_3_3_c	1.0	0.0
43_12_7_3_c	1.0	0.0
43_12_9_3_c	1.0	0.0
43_12_13_3_c	1.0	0.0
43_12_16_3_c	1.0	0.0
43_12_18_3_c	1.0	0.0

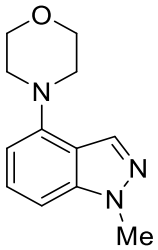


43_12





A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*

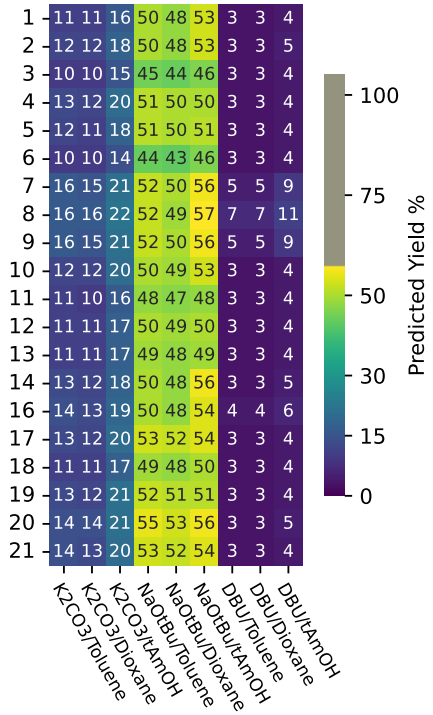


4-(1-Methyl-1H-indazol-4-yl)morpholine **(43_12)**

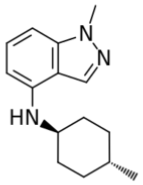
State	Solid
m.p.	138 °C
^{1}H NMR	(400 MHz, $CDCl_3$) δ 7.95 (s, 1H), 7.31 – 7.24 (m, 1H), 6.99 (d, *J* = 8.3 Hz, 1H), 6.49 (d, *J* = 7.5 Hz, 1H), 4.04 (s, 3H), 3.95 (t, *J* = 4.7 Hz, 4H), 3.33 – 3.26 (m, 4H).
^{13}C{^{1}H} NMR	(101 MHz, $CDCl_3$) δ 146.24, 141.64, 131.39, 127.35, 117.46, 105.82, 102.73, 67.13, 51.70, 35.78.
IR (cm^{-1})	ATR (neat) 620, 630, 638, 695, 732, 743, 783, 790, 820, 856, 905, 925, 988, 1010, 1028, 1064, 1070, 1079, 1112, 1155, 1163, 1212, 1231, 1255, 1266, 1280, 1298, 1330, 1368, 1377, 1394, 1413, 1435, 1448, 1462, 1508, 1580, 1603, 1706, 2562, 2652, 2683, 2730, 2755, 2825, 2851, 2875, 2918, 2895, 2936 2947, 2959, 2967, 2986.
HRMS (ES+)	Calcd for $C_{12}H_{16}N_3O$ $(M+H)^+$: 218.1290 Found: 218.1290

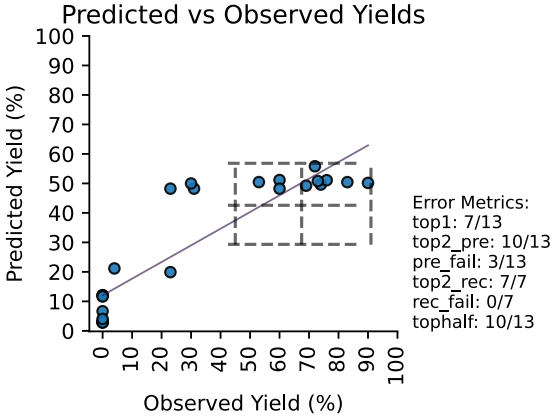
Data for **36_12**

	Predicted Yield %	Observed Yield %
36_12_2_1_a	12.0	0.0
36_12_14_1_a	12.0	0.0
36_12_2_1_b	48.0	23.0
36_12_5_1_b	50.0	74.0
36_12_8_1_b	49.0	69.0
36_12_9_1_b	50.0	90.0
36_12_14_1_b	48.0	31.0
36_12_14_1_c	3.0	0.0
36_12_7_2_a	21.0	4.0
36_12_10_2_a	20.0	23.0
36_12_5_2_b	51.0	60.0
36_12_14_2_b	56.0	72.0
36_12_5_3_a	12.0	0.0
36_12_2_3_b	50.0	30.0
36_12_4_3_b	51.0	76.0
36_12_5_3_b	51.0	73.0
36_12_10_3_b	50.0	53.0
36_12_11_3_b	48.0	60.0
36_12_14_3_b	50.0	83.0
36_12_5_3_c	3.0	0.0
36_12_8_3_c	7.0	0.0
36_12_11_3_c	3.0	0.0
36_12_12_3_c	3.0	0.0
36_12_16_3_c	4.0	0.0

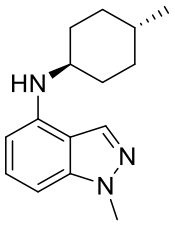


36_12





A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*

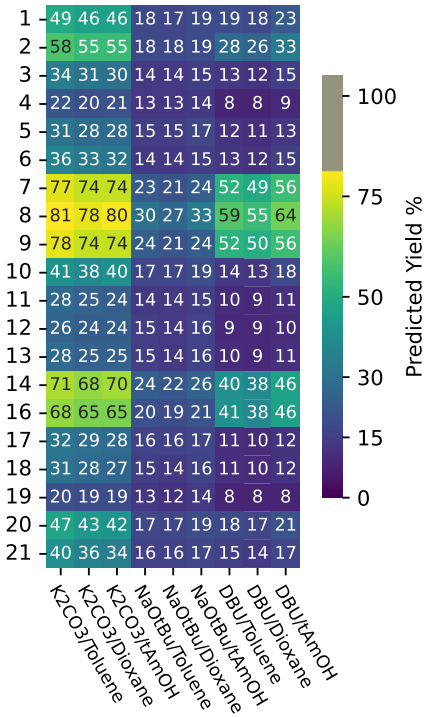


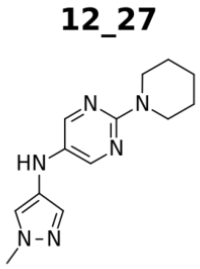
1-Methyl-*N*-(*trans*-4-methylcyclohexyl)-1H-indazol-4-amine **(36_12)**

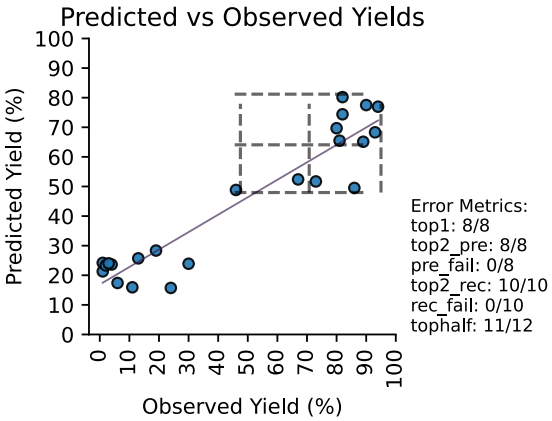
^{1}H NMR	(300 MHz, $CDCl_3$)
	δ 7.87 (d, *J* = 1.0 Hz, 1H), 7.21 (t, *J* = 8.0 Hz, 1H), 6.67 (d, *J* = 8.5 Hz, 1H), 6.21 (d, *J* = 7.7 Hz, 1H), 4.02–4.00 (m, 4H), 3.40 (tt, *J* = 10.9, 3.9 Hz, 1H), 2.20 (d, *J* = 14.7 Hz, 2H), 1.79 (d, *J* = 12.7 Hz, 2H), 1.51 – 1.33 (m, 1H), 1.29 – 1.04 (m, 4H), 0.95 (d, *J* = 6.4 Hz, 3H).
^{13}C{^{1}H} NMR	(75 MHz, $CDCl_3$)
	δ 141.53, 141.24, 129.56, 128.17, 114.38, 99.20, 97.28, 52.16, 35.71, 34.19, 33.58, 32.45, 22.38.
IR (cm^{-1})	ATR (neat)
	633, 650, 713, 744, 782, 768,,819, 849, 858, 880, 889, 921, 948, 964, 985, 1003, 1025, 1053, 1068 1116, 1146 1157 1179 1205 1212, 1221, 1239 1267, 1289, 1300, 1306 , 1314, 1342, 1361, 1381, 1396, 1409, 1429, 1447, 1469, 1508, 1524, 1530, 1582, 1592, 1613, 1703, 1874, 2636, 2717, 2842, 2856, 2914, 2949, 3047, 3067, 3116, 3325
HRMS (ES+)	Calcd for $C_{15}H_{22}N_3$ (M+H)+: 244.1809 Found: 244.1812

Data for **12_27**

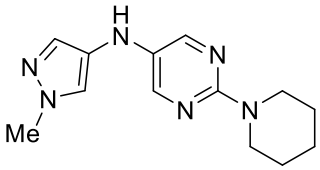
	Predicted Yield %	Observed Yield %
12_27_16_1_a	65.0	89.0
12_27_9_1_b	21.0	1.0
12_27_17_1_b	16.0	24.0
12_27_7_1_c	49.0	46.0
12_27_9_1_c	50.0	86.0
12_27_8_2_a	80.0	82.0
12_27_9_2_a	74.0	82.0
12_27_14_2_a	70.0	80.0
12_27_16_2_a	65.0	81.0
12_27_17_2_a	28.0	19.0
12_27_7_2_b	24.0	30.0
12_27_9_2_b	24.0	1.0
12_27_14_2_b	26.0	13.0
12_27_17_2_b	17.0	6.0
12_27_7_3_a	77.0	94.0
12_27_9_3_a	78.0	90.0
12_27_16_3_a	68.0	93.0
12_27_7_3_b	23.0	2.0
12_27_9_3_b	24.0	4.0
12_27_14_3_b	24.0	3.0
12_27_17_3_b	16.0	11.0
12_27_7_3_c	52.0	73.0
12_27_9_3_c	52.0	67.0







A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*

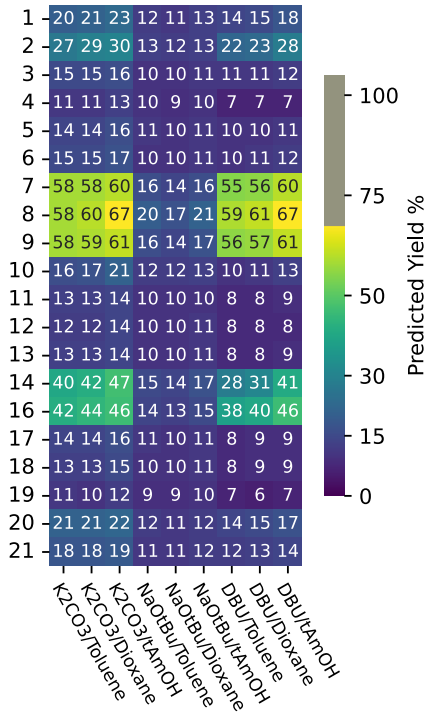


N-(1-Methyl-1H-pyrazol-4-yl)-2-(piperidin-1-yl)pyrimidin-5-amine **(12_27)**

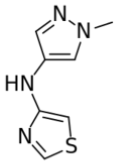
State	Oil
^{1}H NMR	(400 MHz, $CDCl_3$) δ 7.41 (s, 2H), 6.64 (s, 1H), 6.51 (s, 1H), 3.92 (s, 1H), 3.18 (s, 3H), 3.03 (t, *J* = 5.0 Hz, 4H), 1.04 – 0.90 (m, 6H).
^{13}C{^{1}H} NMR	(101 MHz, $CDCl_3$) δ 158.20, 147.20, 132.82, 123.59, 121.91, 113.34, 45.45, 39.34, 25.66, 24.84.
IR (cm^{-1})	ATR (neat) 3261 (w), 2925 (w), 2850 (w), 1589 (w), 1554 (w), 1485 (m), 1439 (m), 1398 (m), 1358 (m), 1254 (m), 1196 (w), 1167 (w), 1138 (w), 1011 (m), 982 (w), 941 (m), 906 (w), 849 (w), 779 (m), 727 (w), 687 (w), 646 (w), 611 (w).
HRMS (ES+)	Calcd for $C_{13}H_{19}N_6$ (M+H)+: 259.1671 Found: 259.1673

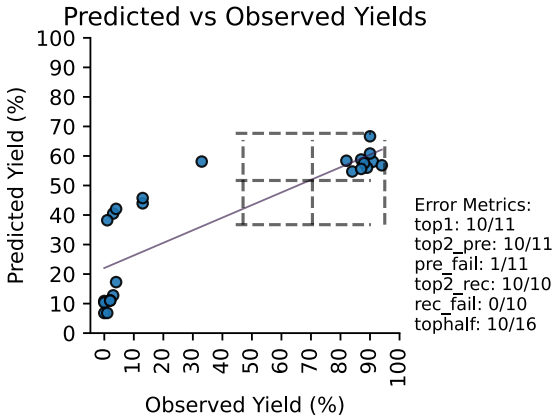
Data for **12_20**

	Predicted Yield %	Observed Yield %
12_20_4_1_a	11.0	0.0
12_20_7_1_a	58.0	91.0
12_20_8_1_b	17.0	4.0
12_20_9_1_a	59.0	87.0
12_20_16_1_a	44.0	13.0
12_20_17_1_b	10.0	0.0
12_20_4_1_c	7.0	0.0
12_20_7_1_c	56.0	89.0
12_20_9_1_c	57.0	94.0
12_20_16_1_c	40.0	3.0
12_20_4_2_a	13.0	3.0
12_20_8_2_a	67.0	90.0
12_20_9_2_a	61.0	90.0
12_20_16_2_a	46.0	13.0
12_20_4_3_a	11.0	2.0
12_20_7_3_a	58.0	88.0
12_20_8_3_a	58.0	33.0
12_20_9_3_a	58.0	82.0
12_20_16_3_a	42.0	4.0
12_20_17_3_b	11.0	2.0
12_20_4_3_c	7.0	1.0
12_20_7_3_c	55.0	84.0
12_20_9_3_c	56.0	87.0
12_20_16_3_c	38.0	1.0

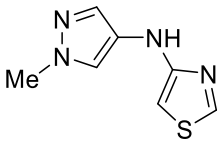


12_20





A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*

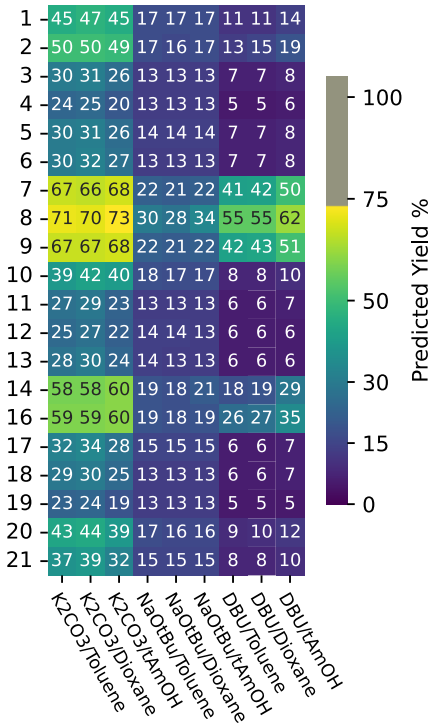


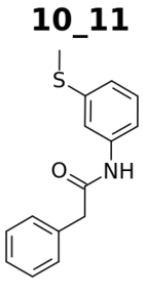
N-(1-Methyl-1H-pyrazol-4-yl)thiazol-4-amine **(12_20)**

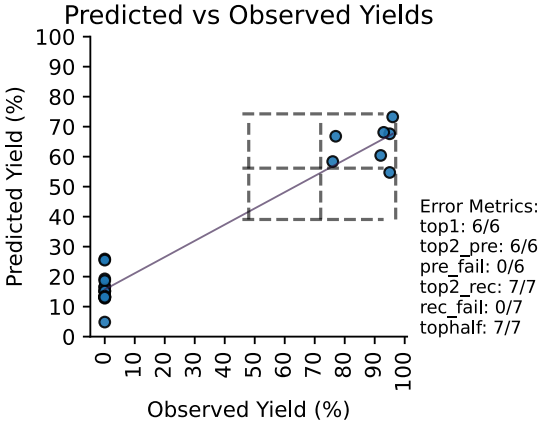
Color and state	Colorless solid
m.p.	125.3-126.3 °C (sealed tube)
^{1}H NMR	(500 MHz, $CDCl_3$) δ 8.53 (s, 1H), 7.42 (s, 1H), 7.36 (s, 1H), 6.42 (s, 1H), 5.95 (s, 1H), 3.86 (s, 3H).
^{13}C{^{1}H} NMR	(126 MHz, $CDCl_3$) δ 157.74, 151.46, 132.93, 125.81, 122.25, 87.61, 39.41.
IR (cm^{-1})	ATR (neat) 3239 (m), 3145 (w), 3057 (m), 1701 (w), 1599 (m), 1565 (m), 1537 (s), 1421 (m), 1381 (m), 1352 (m), 1285 (m), 1198 (m), 1157 (m), 1057 (m), 1019 (m), 990 (m), 962 (m), 877 (s), 832 (s), 805 (m), 735 (s), 690 (s), 645 (s), 606 (s).
HRMS (ES+)	Calcd for $C_7H_9N_4S$ $(M+H)^+$: 181.0548 Found: 181.0544
TLC	R_f 0.34 (EtOAc/CH_2Cl_2, 30:70)

Data for **10_11**

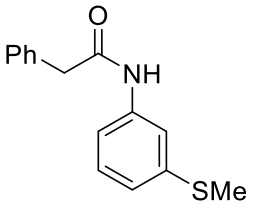
	Predicted Yield %	Observed Yield %
10_11_9_1_a	67.0	77.0
10_11_14_1_a	58.0	76.0
10_11_4_1_b	13.0	0.0
10_11_17_1_b	15.0	0.0
10_11_18_1_b	13.0	0.0
10_11_19_1_b	13.0	0.0
10_11_20_1_b	16.0	0.0
10_11_21_1_b	15.0	0.0
10_11_5_2_a	26.0	0.0
10_11_7_2_a	68.0	95.0
10_11_8_2_a	73.0	96.0
10_11_9_2_a	68.0	93.0
10_11_14_2_a	60.0	92.0
10_11_2_2_b	17.0	0.0
10_11_19_2_b	13.0	0.0
10_11_4_3_b	13.0	0.0
10_11_14_3_b	19.0	0.0
10_11_16_3_b	19.0	0.0
10_11_17_3_b	15.0	0.0
10_11_18_3_b	13.0	0.0
10_11_19_3_b	13.0	0.0
10_11_8_3_c	55.0	95.0
10_11_16_3_c	26.0	0.0
10_11_19_3_c	5.0	0.0







A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*

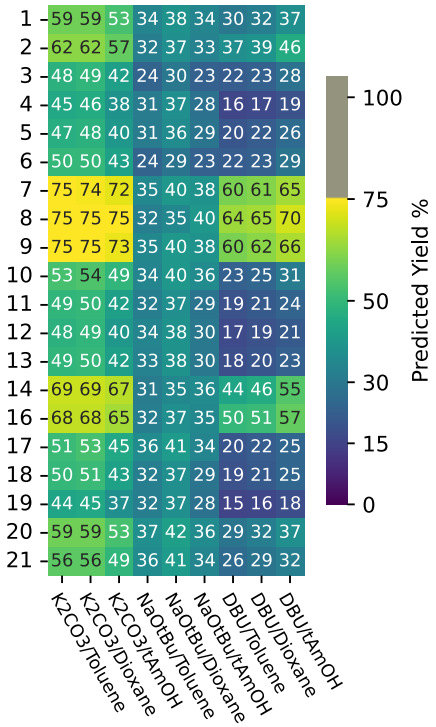


N-(3-(Methylthio)phenyl)-2-phenylacetamide **(10_11)**

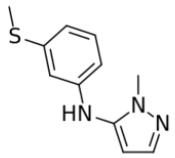
State	Solid
m.p.	82 ^{o}C
^{1}H NMR	(400 MHz, $CDCl_3$) δ 7.84 (s, 1H), 7.48 (s, 1H), 7.38 – 7.26 (m, 5H), 7.16 (dd, *J* = 3.5, 1.6 Hz, 2H), 6.99 – 6.93 (m, 1H), 3.66 (s, 2H), 2.40 (s, 3H).
^{13}C{^{1}H} NMR	(101 MHz, $CDCl_3$) δ 169.71, 139.50, 138.37, 134.51, 129.45, 129.17, 129.08, 127.53, 122.37, 117.72, 116.63, 44.59, 15.60.
IR (cm^{-1})	ATR (neat) 3272 (m), 3029 (w), 2920 (w), 1647 (m), 1583 (m), 1514 (m), 1473 (m), 1398 (m), 1340 (m), 1282 (m), 1236 (w), 1213 (w), 1190 (w), 1167 (m), 1097 (w), 1074 (w), 1028 (w), 993 (w), 976 (w), 935 (w), 895 (w), 849 (m), 791 (w), 768 (m), 715 (m), 692 (s), 675 (m), 634 (m).
HRMS (ES+)	Calcd for $C_{15}H_{16}NOS$ (M+H)+: 258.0953 Found: 258.0953

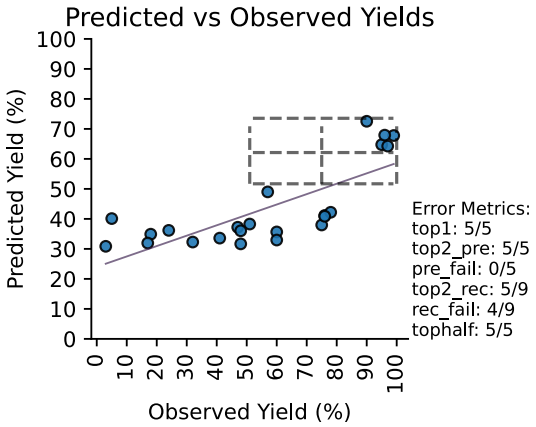
Data for **14_11**

	Predicted Yield %	Observed Yield %
14_11_16_1_a	68.0	99.0
14_11_1_1_b	38.0	51.0
14_11_8_1_b	35.0	18.0
14_11_13_1_b	38.0	75.0
14_11_16_1_b	37.0	47.0
14_11_17_1_b	41.0	76.0
14_11_20_1_b	42.0	78.0
14_11_21_1_b	41.0	76.0
14_11_5_2_a	40.0	5.0
14_11_9_2_a	73.0	90.0
14_11_10_2_a	49.0	57.0
14_11_16_2_a	65.0	95.0
14_11_10_2_b	36.0	60.0
14_11_14_2_b	36.0	24.0
14_11_16_3_a	68.0	96.0
14_11_1_3_b	34.0	41.0
14_11_8_3_b	32.0	17.0
14_11_13_3_b	33.0	60.0
14_11_14_3_b	31.0	3.0
14_11_16_3_b	32.0	32.0
14_11_17_3_b	36.0	48.0
14_11_19_3_b	32.0	48.0
14_11_8_3_c	64.0	97.0

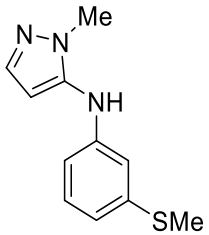


14_11





A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*

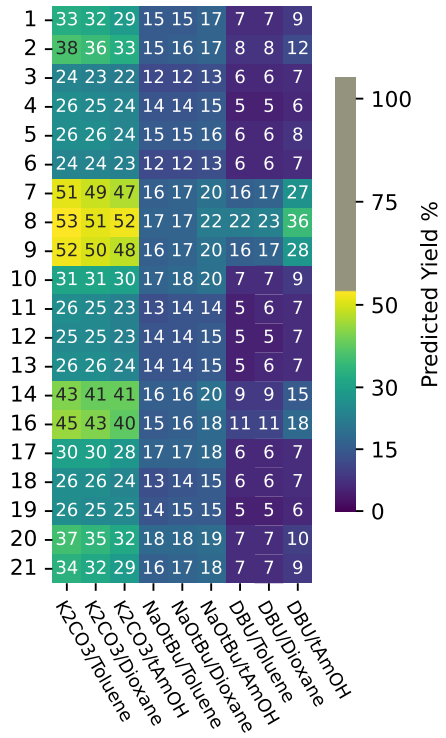


1-Methyl-*N*-(3-(methylthio)phenyl)-1H-pyrazol-5-amine **(14_11)**

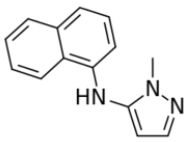
State	Oil
^{1}H NMR	(400 MHz, $CDCl_3$)
	δ 7.47 (d, *J* = 1.9 Hz, 1H), 7.13 (t, *J* = 7.9 Hz, 1H), 6.75 (m, 1H), 6.60 (t, *J* = 2.0 Hz, 1H), 6.46 (ddd, *J* = 8.1, 2.3, 0.9 Hz, 1H), 6.04 (d, *J* = 2.1 Hz, 1H), 5.40 (s, 1H), 3.70 (s, 3H), 2.43 (s, 3H).
^{13}C{^{1}H} NMR	(101 MHz, $CDCl_3$)
	δ 145.33, 140.10, 138.76, 129.92, 118.15, 112.37, 111.52, 99.72, 35.16, 15.69.
IR (cm^{-1})	ATR (neat)
	3232 (w), 2914 (w), 1583 (m), 1543 (m), 1473 (m), 1421 (m), 1381 (w), 1340 (w), 1271 (w), 1236 (w), 1207 (w), 1161 (w), 1097 (w), 1080 (w), 1005 (w), 964 (w), 930 (w), 901 (m), 854 (w), 762 (m), 727 (m), 681 (m), 634 (m).
HRMS (ES+)	Calcd for $C_{11}H_{14}N_3S$ (M+H)+: 220.0904 Found: 220.0910

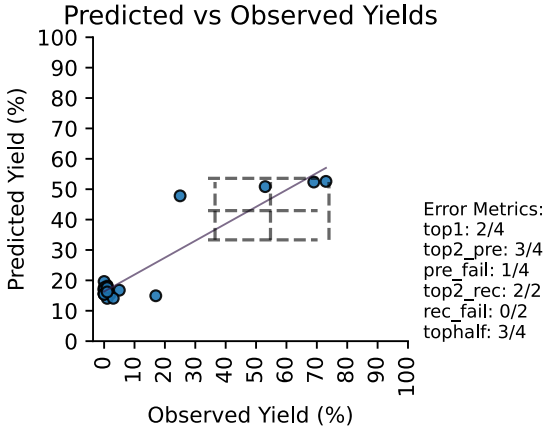
Data for **14_8**

	Predicted Yield %	Observed Yield %
14_8_8_1_a	51.0	53.0
14_8_1_1_b	15.0	2.0
14_8_8_1_b	17.0	0.0
14_8_13_1_b	14.0	1.0
14_8_14_1_b	16.0	0.0
14_8_16_1_b	16.0	0.0
14_8_17_1_b	17.0	1.0
14_8_20_1_b	18.0	1.0
14_8_21_1_b	17.0	5.0
14_8_8_2_a	52.0	69.0
14_8_9_2_a	48.0	25.0
14_8_1_2_b	17.0	0.0
14_8_10_2_b	20.0	0.0
14_8_13_2_b	15.0	17.0
14_8_17_2_b	18.0	1.0
14_8_21_2_b	18.0	0.0
14_8_8_3_a	53.0	73.0
14_8_8_3_b	17.0	0.0
14_8_14_3_b	16.0	0.0
14_8_16_3_b	15.0	0.0
14_8_17_3_b	17.0	1.0
14_8_19_3_b	14.0	3.0
14_8_20_3_b	18.0	1.0
14_8_21_3_b	16.0	1.0

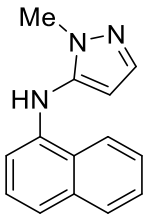


14_8





A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*

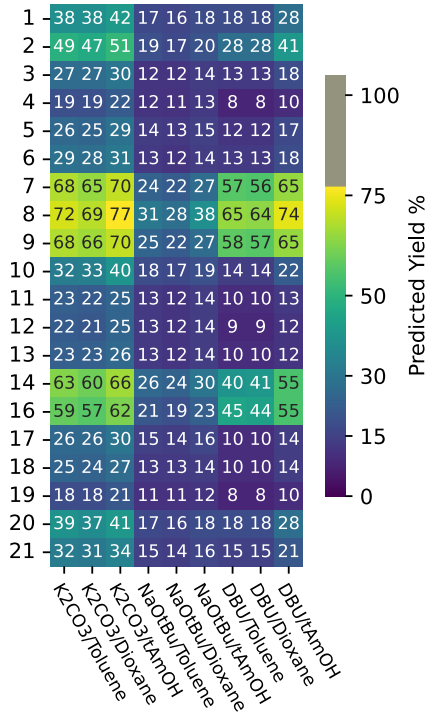


1-Methyl-*N*-(naphthalen-1-yl)-1H-pyrazol-5-amine **(14_8)**

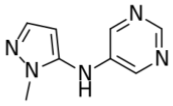
^{1}H NMR	(400 MHz, $CDCl_3$)
	δ 7.99 – 7.94 (m, 1H), 7.90 – 7.85 (m, 1H), 7.57 – 7.50 (m, 3H), 7.45 (d, *J* = 8.3 Hz, 1H), 7.31 (t, *J* = 7.8 Hz, 1H), 6.55 (d, *J* = 7.5 Hz, 1H), 6.06 (d, *J* = 2.1 Hz, 1H), 5.81 (s, 1H), 3.71 (s, 3H).
^{13}C{^{1}H} NMR	(101 MHz, $CDCl_3$)
	δ 140.95, 140.27, 138.81, 134.54, 128.94, 126.34, 126.32, 125.80, 124.30, 121.15, 120.28, 109.86, 99.90, 35.24.
IR (cm^{-1})	ATR (neat)
	3255 (w), 3047 (w), 2914 (w), 1537 (m), 1496 (w), 1427 (w), 1404 (w), 1334 (w), 1277 (w), 1207 (w), 1155 (w), 1086 (w), 1016 (w), 924 (w), 877 (w), 768 (m), 692 (w), 652 (w).
HRMS (ES+)	Calcd for $C_{14}H_{14}N_3$ (M+H)+: 224.1188 Found: 224.1188

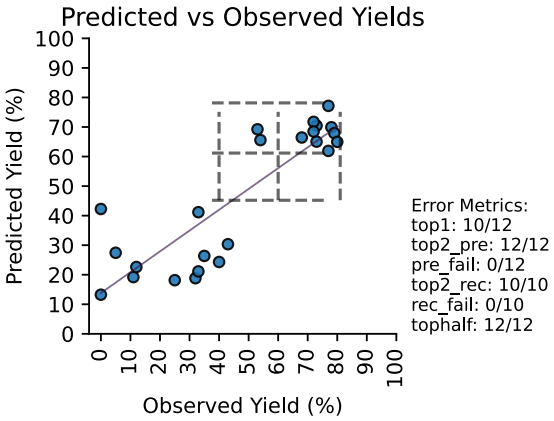
Data for **14_24**

	Predicted Yield %	Observed Yield %
14_24_7_1_a	65.0	73.0
14_24_8_1_a	69.0	53.0
14_24_9_1_a	66.0	54.0
14_24_5_1_b	13.0	0.0
14_24_14_1_b	24.0	40.0
14_24_16_1_b	19.0	11.0
14_24_1_2_a	42.0	0.0
14_24_7_2_a	70.0	78.0
14_24_8_2_a	77.0	77.0
14_24_9_2_a	70.0	73.0
14_24_14_2_a	66.0	68.0
14_24_16_2_a	62.0	77.0
14_24_17_2_a	30.0	43.0
14_24_18_2_a	27.0	5.0
14_24_20_2_a	41.0	33.0
14_24_16_2_b	23.0	12.0
14_24_7_3_a	68.0	79.0
14_24_8_3_a	72.0	72.0
14_24_9_3_a	68.0	72.0
14_24_2_3_b	19.0	32.0
14_24_10_3_b	18.0	25.0
14_24_14_3_b	26.0	35.0
14_24_16_3_b	21.0	33.0
14_24_8_3_c	65.0	80.0

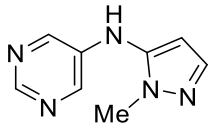


14_24





A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*

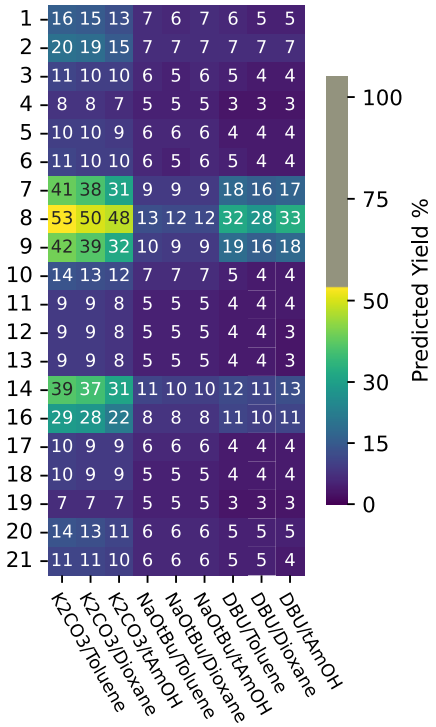


N-(1-Methyl-1H-pyrazol-5-yl)pyrimidin-5-amine **(14_24)**

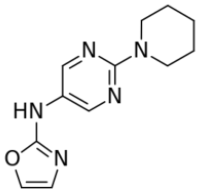
Color and state	Yellow solid
m.p.	148.9-149.9 °C (sealed tube)
^{1}H NMR	(500 MHz, $CDCl_3$) δ 8.74 (s, 1H), 8.24 (s, 2H), 7.49 (s, 1H), 6.11 (d, *J* = 30.1 Hz, 2H), 3.73 (s, 3H).
^{13}C{^{1}H} NMR	(126 MHz, $CDCl_3$) δ 150.95, 142.89, 139.54, 139.12, 138.20, 99.71, 35.23.
IR (cm^{-1})	ATR (neat) 3194 (w), 3123 (w), 3037 (w), 2948 (m), 2878 (m br), 1577 (m), 1551 (s), 1514 (m), 1476 (m), 1454 (w), 1420 (s), 1396 (m), 1348 (m), 1282 (m), 1212 (w), 1189 (m), 1114 (w), 1021 (m), 962 (w), 934 (s), 885 (m), 839 (w), 755 (s), 723 (s), 622 (s), 588 (m), 511 (m).
HRMS (ES+)	Calcd for $C_8H_{10}N_5$ (M+H)+: 176.0936 Found: 176.0931
TLC	R_f 0.3 (EtOAc/CH_2Cl_2, 20:80)

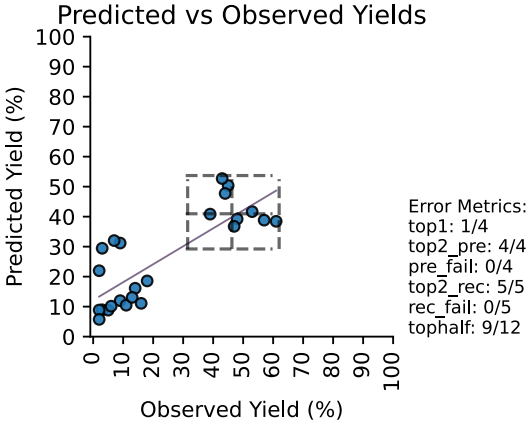
Data for **26_27**

	Predicted Yield %	Observed Yield %
26_27_7_1_a	38.0	61.0
26_27_8_1_a	50.0	45.0
26_27_9_1_a	39.0	48.0
26_27_14_1_a	37.0	47.0
26_27_8_1_b	12.0	9.0
26_27_9_1_b	9.0	3.0
26_27_14_1_b	10.0	11.0
26_27_9_1_c	16.0	14.0
26_27_7_2_a	31.0	9.0
26_27_8_2_a	48.0	44.0
26_27_9_2_a	32.0	7.0
26_27_16_2_a	22.0	2.0
26_27_17_2_a	9.0	5.0
26_27_9_2_b	9.0	2.0
26_27_14_2_b	10.0	6.0
26_27_17_2_b	6.0	2.0
26_27_7_3_a	41.0	39.0
26_27_8_3_a	53.0	43.0
26_27_9_3_a	42.0	53.0
26_27_14_3_a	39.0	57.0
26_27_16_3_a	29.0	3.0
26_27_8_3_b	13.0	13.0
26_27_14_3_b	11.0	16.0
26_27_9_3_c	19.0	18.0

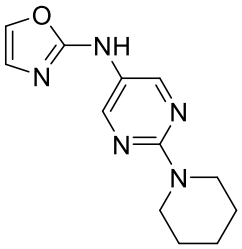


26_27





A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*

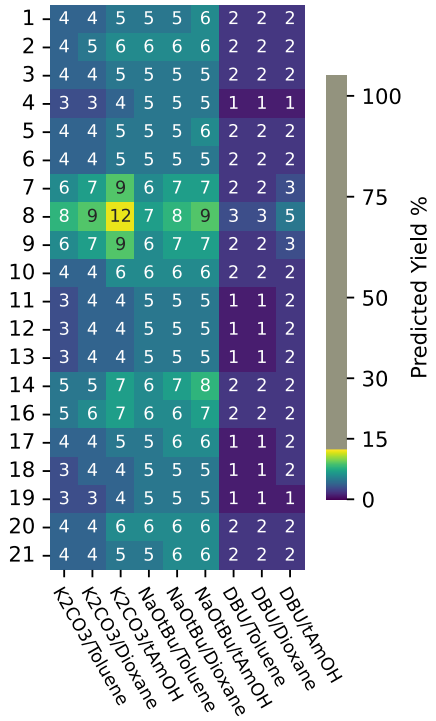


N-(2-(Piperidin-1-yl)pyrimidin-5-yl)oxazol-2-amine **(26_27)**

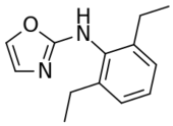
State	Oil
^{1}H NMR	(400 MHz, $CDCl_3$) δ 8.40 (s, 2H), 7.22 (d, *J* = 1.1 Hz, 1H), 6.84 (d, *J* = 1.3 Hz, 1H), 3.81 – 3.69 (m, 4H), 1.70 – 1.63 (m, 2H), 1.60 (m, 4H).
^{13}C{^{1}H} NMR	(101 MHz, $CDCl_3$) δ 159.30, 159.01, 150.89, 132.58, 126.36, 123.42, 45.34, 25.80, 24.95.
IR (cm^{-1})	ATR (neat) 2925 (w), 1705 (w), 1606 (w), 1502 (w), 1439 (w), 1358 (w), 1254 (w), 1022 (w), 941 (w), 849 (w), 791 (w).
HRMS (ES+)	Calcd for $C_{12}H_{16}N_5O$ (M+H)+: 246.1353 Found: 246.1352

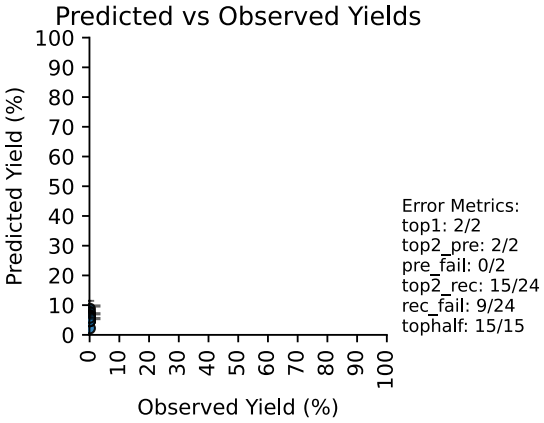
Data for **26_10**

	Predicted Yield %	Observed Yield %
26_10_7_1_a	7.0	0.0
26_10_9_1_a	7.0	0.0
26_10_2_1_b	6.0	0.0
26_10_4_1_b	5.0	0.0
26_10_9_1_b	7.0	0.0
26_10_13_1_b	5.0	0.0
26_10_18_1_b	5.0	0.0
26_10_19_1_b	5.0	0.0
26_10_20_1_b	6.0	0.0
26_10_7_1_c	2.0	0.0
26_10_9_2_a	9.0	0.0
26_10_2_2_b	6.0	0.0
26_10_14_2_b	8.0	0.0
26_10_20_2_b	6.0	0.0
26_10_7_3_a	6.0	0.0
26_10_9_3_a	6.0	0.0
26_10_2_3_b	6.0	0.0
26_10_4_3_b	5.0	0.0
26_10_9_3_b	6.0	0.0
26_10_14_3_b	6.0	0.0
26_10_17_3_b	5.0	0.0
26_10_18_3_b	5.0	0.0
26_10_19_3_b	5.0	0.0
26_10_20_3_b	6.0	0.0

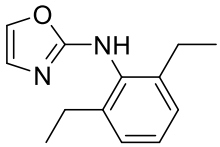


26_10





A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*

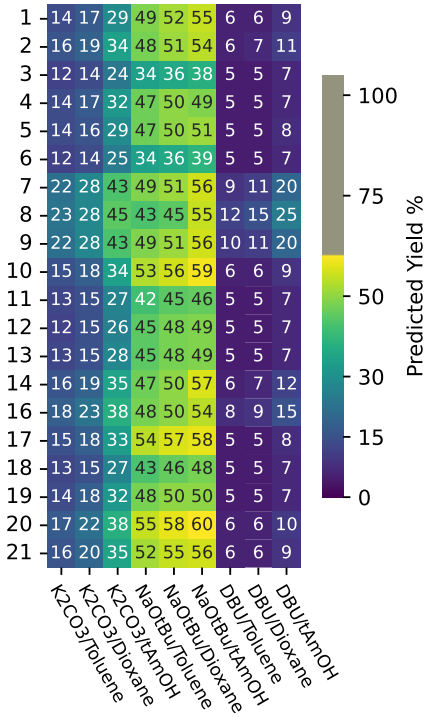


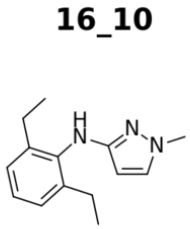
N-(2,6-Diethylphenyl)oxazol-2-amine **(26_10)**

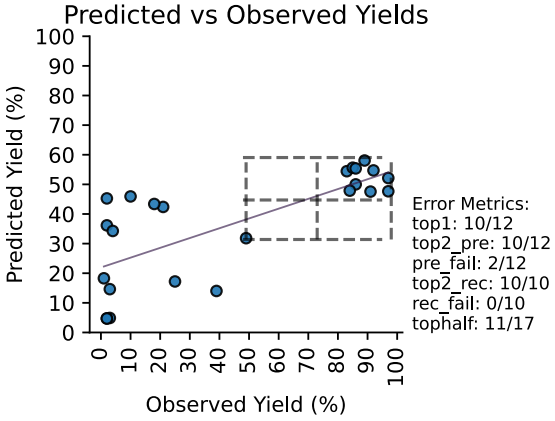
^{1}H NMR	(400 MHz, $CDCl_3$)
	δ 7.27 – 7.22 (m, 1H), 7.17 (s, 1H), 7.15 (s, 1H), 7.11 (d, *J* = 1.1 Hz, 1H), 6.76 (d, *J* = 1.3 Hz, 1H), 2.65 (q, *J* = 7.5 Hz, 4H), 1.17 (t, *J* = 7.5 Hz, 6H).
^{13}C{^{1}H} NMR	(101 MHz, $CDCl_3$)
	δ 160.47, 142.30, 133.97, 132.40, 127.92, 126.81, 126.75, 24.86, 14.67.
IR (cm^{-1})	ATR (neat)
	3261 (w), 2966 (w), 2931 (w), 2873 (w), 1687 (m), 1618 (m), 1577 (m), 1531 (w), 1456 (m), 1369 (w), 1230 (w), 1138 (m), 1103 (w), 964 (w), 912 (w), 866 (w), 756 (m), 727 (m), 687 (m).
HRMS (ES+)	Calcd for $C_{13}H_{17}N_2O$ (M+H)+: 217.1341 Found: 217.1338

Data for **16_10**

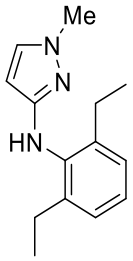
	Predicted Yield %	Observed Yield %
16_10_4_1_a	17.0	25.0
16_10_17_1_a	18.0	1.0
16_10_3_1_b	36.0	2.0
16_10_11_1_b	45.0	2.0
16_10_13_1_b	48.0	97.0
16_10_16_1_b	50.0	86.0
16_10_18_1_b	46.0	10.0
16_10_20_1_b	58.0	89.0
16_10_21_1_b	55.0	92.0
16_10_4_1_c	5.0	3.0
16_10_4_2_a	32.0	49.0
16_10_2_2_b	54.0	83.0
16_10_21_2_b	56.0	85.0
16_10_4_3_a	14.0	39.0
16_10_17_3_a	15.0	3.0
16_10_3_3_b	34.0	4.0
16_10_11_3_b	42.0	21.0
16_10_16_3_b	48.0	91.0
16_10_18_3_b	43.0	18.0
16_10_19_3_b	48.0	84.0
16_10_20_3_b	55.0	86.0
16_10_21_3_b	52.0	97.0
16_10_4_3_c	5.0	2.0
16_10_19_3_c	5.0	2.0







A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*

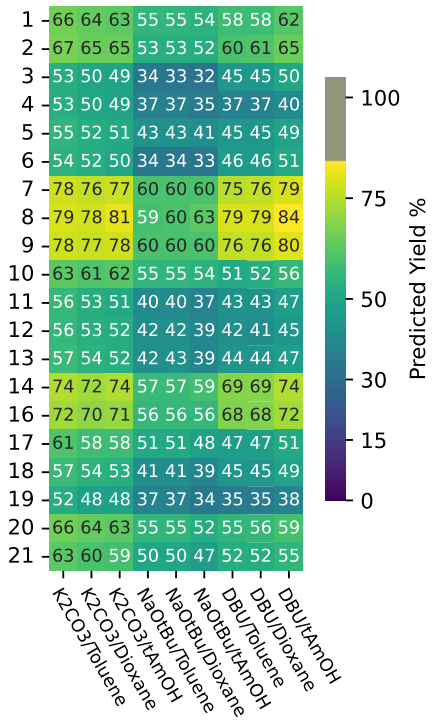


N-(2,6-Diethylphenyl)-1-methyl-1H-pyrazol-3-amine **(16_10)**

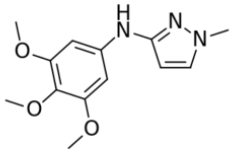
State	Oil
^{1}H NMR	(400 MHz, $CDCl_3$) δ 7.13 (d, *J* = 3.0 Hz, 3H), 7.01 (d, *J* = 2.1 Hz, 1H), 5.64 (s, 1H), 5.15 (d, *J* = 2.4 Hz, 1H), 3.70 (s, 3H), 2.66 (q, *J* = 7.7 Hz, 4H), 1.17 (t, *J* = 7.7 Hz, 6H).
^{13}C{^{1}H} NMR	(101 MHz, $CDCl_3$) δ 156.40, 141.12, 138.09, 130.61, 126.49, 125.76, 91.22, 38.41, 24.63, 14.73.
IR (cm^{-1})	ATR (neat) 3244 (w), 2960 (w), 2931 (w), 2873 (w), 1682 (w), 1595 (w), 1554 (m), 1491 (m), 1444 (m), 1410 (w), 1334 (w), 1294 (w), 1271 (w), 1225 (w), 1201 (w), 1109 (w), 1063 (w), 1039 (w), 987 (w), 872 (w), 843 (w), 820 (w), 791 (w), 739 (m), 623 (m).
HRMS (ES+)	Calcd for $C_{14}H_{20}N_3$ (M+H)+: 230.1656 Found: 230.1660

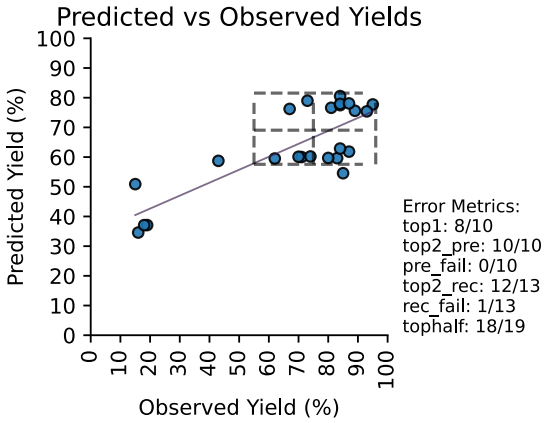
Data for **16_23**

	Predicted Yield %	Observed Yield %
16_23_7_1_a	76.0	67.0
16_23_8_1_a	78.0	95.0
16_23_9_1_a	77.0	81.0
16_23_4_1_b	37.0	19.0
16_23_7_1_b	60.0	71.0
16_23_8_1_b	60.0	83.0
16_23_9_1_b	60.0	74.0
16_23_7_1_c	76.0	89.0
16_23_5_2_a	51.0	15.0
16_23_7_2_a	77.0	84.0
16_23_8_2_a	81.0	84.0
16_23_9_2_a	78.0	84.0
16_23_10_2_a	62.0	87.0
16_23_4_2_b	35.0	16.0
16_23_7_2_b	60.0	70.0
16_23_7_3_a	78.0	87.0
16_23_8_3_a	79.0	73.0
16_23_10_3_a	63.0	84.0
16_23_4_3_b	37.0	18.0
16_23_7_3_b	60.0	62.0
16_23_8_3_b	59.0	43.0
16_23_9_3_b	60.0	80.0
16_23_10_3_b	55.0	85.0
16_23_7_3_c	75.0	93.0

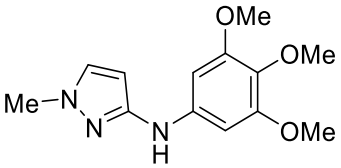


16_23





A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*

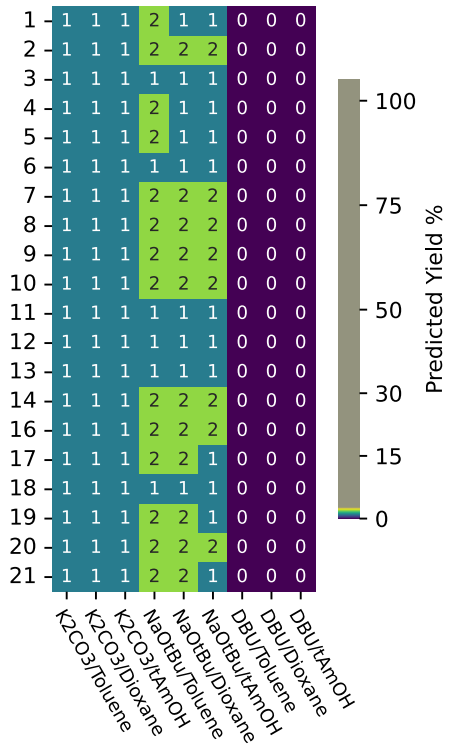


1-Methyl-*N*-(3,4,5-trimethoxyphenyl)-1H-pyrazol-3-amine **(16_23)**

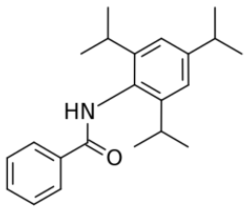
State	Oil
^{1}H NMR	(400 MHz, $CDCl_3$
	δ 7.21 (d, *J* = 2.4 Hz, 1H), 6.43 (s, 2H), 6.39 (br s, 1H), 5.90 (d, *J* = 2.1 Hz, 1H), 3.81 – 3.76 (m, 12H).
^{13}C{^{1}H} NMR	(101 MHz, $CDCl_3$)
	δ 153.57, 151.51, 140.05, 131.25, 130.74, 94.52, 93.31, 60.89, 55.81, 38.64.
IR (cm^{-1})	ATR (neat)
	3319 (w), 3215 (w), 3163 (w), 3128 (w), 2931 (w), 2833 (w), 1606 (w), 1566 (w), 1543 (m), 1502 (m), 1485 (w), 1450 (w), 1433 (w), 1358 (w), 1294 (w), 1225 (m), 1184 (w), 1120 (m), 1080 (w), 1051 (w), 993 (w), 918 (w), 814 (w), 779 (w), 733 (m), 692 (w), 658 (w).
HRMS (ES+)	Calcd for $C_{13}H_{18}N_3O_3$ (M+H)+: 264.1349 Found: 264.1350

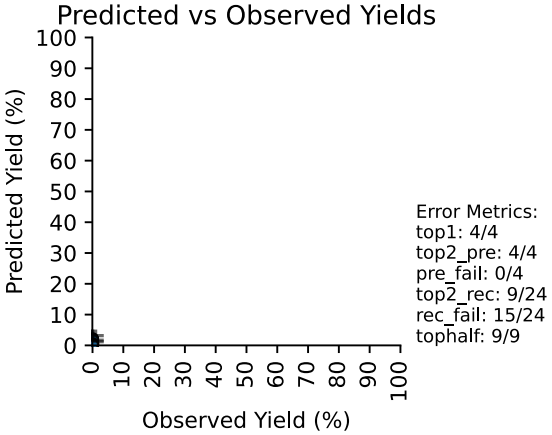
Data for **8_1**

	Predicted Yield %	Observed Yield %
8_1_4_1_a	1.0	0.0
8_1_10_1_a	1.0	0.0
8_1_12_1_a	1.0	0.0
8_1_2_1_b	2.0	0.0
8_1_8_1_b	2.0	0.0
8_1_4_1_c	0.0	0.0
8_1_10_1_c	0.0	0.0
8_1_2_2_a	1.0	0.0
8_1_5_2_a	1.0	0.0
8_1_6_2_a	1.0	0.0
8_1_7_2_a	1.0	0.0
8_1_2_2_b	2.0	0.0
8_1_4_2_b	1.0	0.0
8_1_10_2_b	2.0	0.0
8_1_2_3_a	1.0	0.0
8_1_4_3_a	1.0	0.0
8_1_10_3_b	2.0	0.0
8_1_20_3_b	2.0	0.0
8_1_21_3_b	2.0	0.0
8_1_2_3_c	0.0	0.0
8_1_4_3_c	0.0	0.0
8_1_7_3_c	0.0	0.0
8_1_10_3_c	0.0	0.0
8_1_12_3_c	0.0	0.0

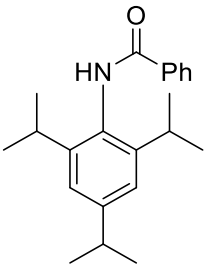


8_1





A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*

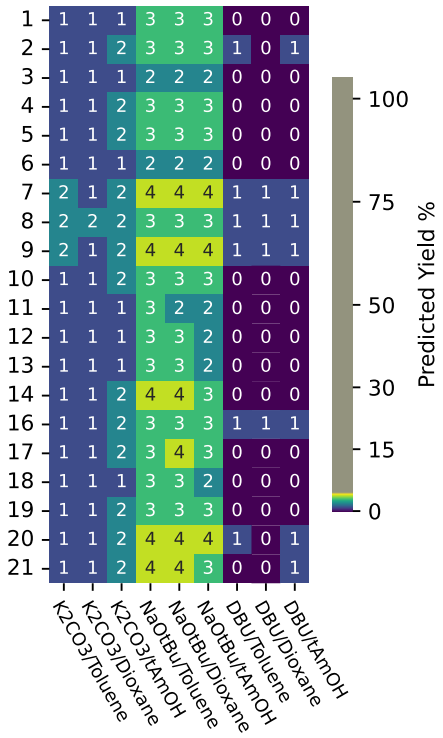


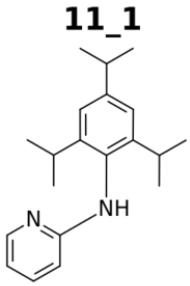
N-(2,4,6-Triisopropylphenyl)benzamide **(8_1)**

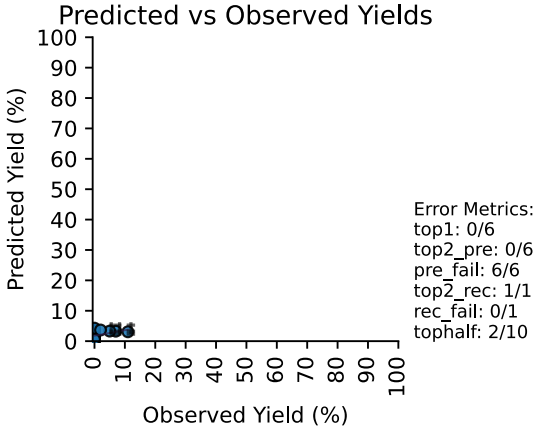
^{1}H NMR	(400 MHz, $CDCl_3$)
	δ 7.95 – 7.89 (m, 2H), 7.61 – 7.55 (m, 1H), 7.54 – 7.48 (m, 2H), 7.23 (s, 1H), 7.07 (s, 2H), 3.12 (hept, *J* = 7.0 Hz, 2H), 2.92 (p, *J* = 6.9 Hz, 1H), 1.27 (d, *J* = 7.0 Hz, 6H), 1.23 (d, *J* = 6.7 Hz, 12H).
^{13}C{^{1}H} NMR	(101 MHz, $CDCl_3$)
	δ 167.21, 148.90, 146.09, 134.98, 131.86, 128.97, 128.90, 127.30, 121.76, 34.48, 29.15, 24.23, 23.85.
IR (cm^{-1})	ATR (neat)
	3278 (m), 2757 (s), 2931 (w), 2867 (m), 1642 (s), 1620 (w), 1522 (s), 1489 (s), 1459 (m), 1361 (m), 1324 (w), 1303(w), 1292 (m), 1247 (w), 1182(w), 1106 (w), 1072 (w), 921 (w), 878 (m), 803(m), 710(s), 696 (s), 671(m), 649 (w).
HRMS (ES+)	Calcd for $C_{22}H_{30}NO$ (M+H)+: 324.2328 Found: 324.2324

Data for **11_1**

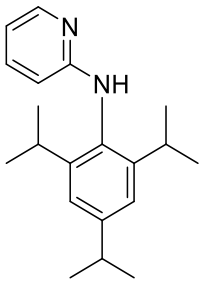
	Predicted Yield %	Observed Yield %
11_1_8_1_a	2.0	0.0
11_1_9_1_a	1.0	0.0
11_1_18_1_a	1.0	0.0
11_1_2_1_b	3.0	0.0
11_1_7_1_b	4.0	0.0
11_1_10_1_b	3.0	7.0
11_1_7_1_c	1.0	0.0
11_1_9_1_c	1.0	0.0
11_1_10_1_c	0.0	0.0
11_1_14_1_c	0.0	0.0
11_1_19_1_c	0.0	0.0
11_1_20_1_c	0.0	0.0
11_1_9_2_a	2.0	0.0
11_1_14_2_a	2.0	0.0
11_1_8_2_b	3.0	0.0
11_1_14_2_b	3.0	0.0
11_1_17_2_b	3.0	0.0
11_1_14_3_a	1.0	0.0
11_1_10_3_b	3.0	5.0
11_1_19_3_b	3.0	11.0
11_1_20_3_b	4.0	0.0
11_1_21_3_b	4.0	2.0
11_1_10_3_c	0.0	0.0
11_1_16_3_c	1.0	0.0







A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*

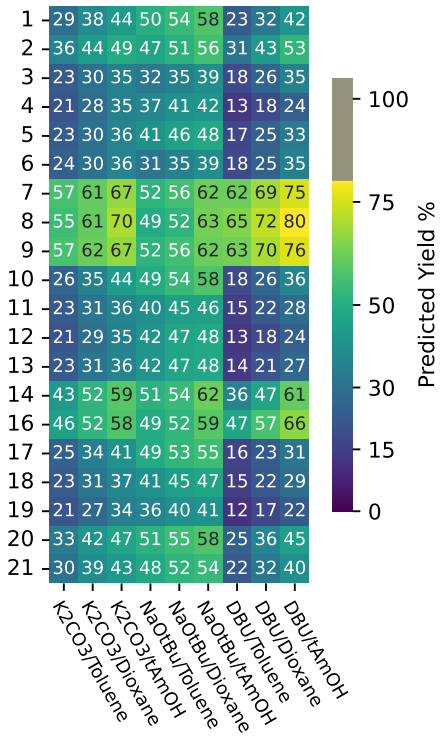


N-(2,4,6-Triisopropylphenyl)pyridin-2-amine **(11_1)**

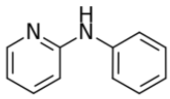
State	Solid
m.p.	123 °C
^{1}H NMR	(400 MHz, $CDCl_3$) δ 8.12 (ddd, *J* = 5.1, 2.1, 0.8 Hz, 1H), 7.33 (ddd, *J* = 8.6, 7.1, 2.0 Hz, 1H), 7.07 (s, 2H), 6.59 (ddd, *J* = 7.3, 5.1, 1.2 Hz, 1H), 6.09 (s, 1H), 6.00 (d, *J* = 8.6 Hz, 1H), 3.18 (hept, *J* = 6.7 Hz, 2H), 2.92 (hept, *J* = 7.0 Hz, 1H), 1.28 (d, *J* = 7.0 Hz, 6H), 1.14 (d, *J* = 6.7 Hz, 12H).
^{13}C{^{1}H} NMR	(101 MHz, $CDCl_3$) δ 159.56, 148.41, 147.60, 137.78, 131.17, 122.02, 113.36, 105.85, 34.41, 28.56, 24.24
IR (cm^{-1})	ATR (neat) 3182 (m), 2955 (s), 2925 (m), 2865 (m), 1605 (s), 1596(s), 1579(m), 1521(m), 1441(s), 1359 (m), 1327 (m), 1317(m), 1290 (w), 1279(w), 1249 (w), 1171(w), 1150(w), 1134 (w), 1093(w), 991 (m), 876 (m), 767 (s), 752 (w), 654 (m).
HRMS (ES+)	Calcd for $C_{20}H_{29}N_2$ (M+H)+: 297.2330 Found: 297.2330

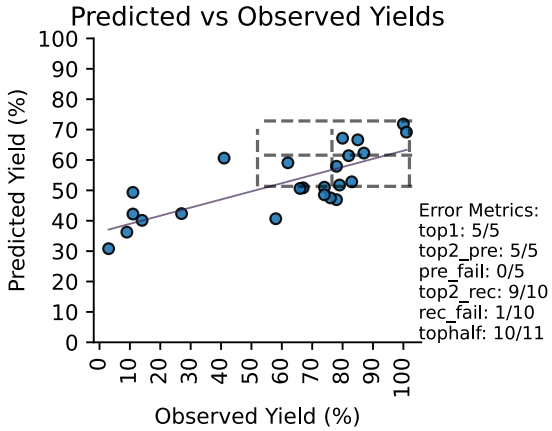
Data for **1_45**

	Predicted Yield %	Observed Yield %
1_45_8_1_a	61.0	41.0
1_45_8_1_c	72.0	100.0
1_45_21_1_b	52.0	79.0
1_45_7_1_a	61.0	82.0
1_45_7_1_c	69.0	101.0
1_45_19_1_b	40.0	14.0
1_45_17_1_b	53.0	83.0
1_45_2_1_b	51.0	67.0
1_45_13_1_b	47.0	78.0
1_45_9_2_a	67.0	80.0
1_45_20_2_b	58.0	78.0
1_45_7_2_a	67.0	85.0
1_45_17_2_a	41.0	58.0
1_45_2_2_a	49.0	11.0
1_45_14_2_a	59.0	62.0
1_45_7_3_c	62.0	87.0
1_45_20_3_b	51.0	74.0
1_45_21_3_b	48.0	76.0
1_45_19_3_b	36.0	9.0
1_45_17_3_b	49.0	74.0
1_45_2_3_c	31.0	3.0
1_45_12_3_b	42.0	11.0
1_45_13_3_b	42.0	27.0
1_45_14_3_b	51.0	66.0

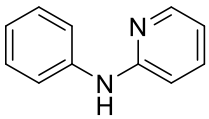


1_45





A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*



The structure and purity of the known compound **1_45** was confirmed by the comparison of their physical and spectral data (^{1}H NMR) with reported in the literature.(*64*)

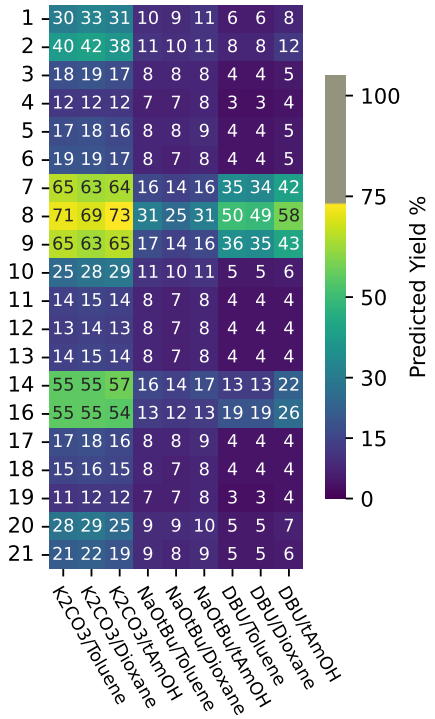
N-Phenylpyridin-2-amine (**1_45**)

<u>^{1}H NMR</u> (600 MHz, $CDCl_3$)

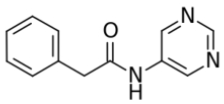
δ 8.21 (ddd, *J* = 5.0, 2.0, 0.9 Hz, 1H), 7.49 (ddd, *J* = 8.9, 7.3, 1.9 Hz, 1H), 7.34 (d, *J* = 1.0 Hz, 2H), 7.33 (s, 2H), 7.08 – 7.02 (m, 1H), 6.89 (dt, *J* = 8.4, 0.9 Hz, 1H), 6.83 – 6.79 (m, 1H), 6.73 (ddd, *J* = 7.2, 5.0, 0.9 Hz, 1H).

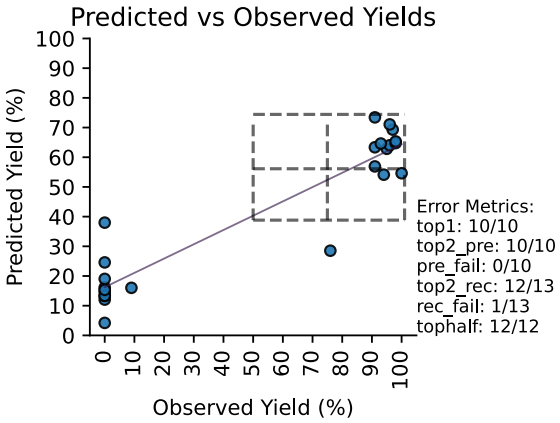
Data for **10_24**

	Predicted Yield %	Observed Yield %
10_24_5_1_c	4.0	0.0
10_24_7_1_a	63.0	95.0
10_24_8_1_a	69.0	97.0
10_24_9_1_a	63.0	91.0
10_24_16_1_a	55.0	100.0
10_24_2_2_a	38.0	0.0
10_24_4_2_a	12.0	0.0
10_24_5_2_a	16.0	0.0
10_24_7_2_a	64.0	96.0
10_24_8_2_a	73.0	91.0
10_24_9_2_a	65.0	93.0
10_24_10_2_a	29.0	76.0
10_24_14_2_a	57.0	91.0
10_24_16_2_a	54.0	94.0
10_24_16_2_b	13.0	0.0
10_24_17_2_a	16.0	9.0
10_24_18_2_a	15.0	0.0
10_24_20_2_a	25.0	0.0
10_24_21_2_a	19.0	0.0
10_24_7_3_a	65.0	98.0
10_24_8_3_a	71.0	96.0
10_24_9_3_a	65.0	98.0
10_24_16_3_b	13.0	0.0
10_24_18_3_a	15.0	0.0

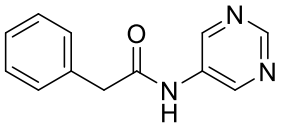


10_24





A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*



The structure and purity of the known compound **10_24** was confirmed by the comparison of their physical and spectral data (^{1}H NMR) with reported in the literature.(*65*)

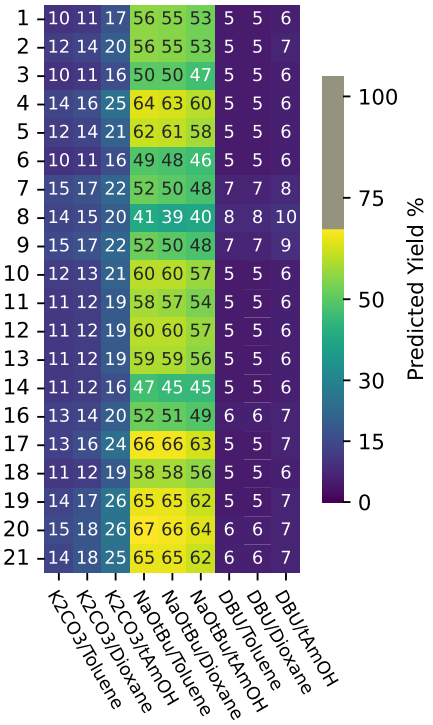
2-Phenyl-*N*-(pyrimidin-5-yl)acetamide (**10_24**)

<u>^{1}H NMR</u> (600 MHz, $CDCl_3$)

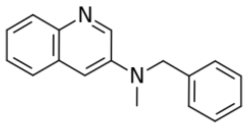
δ 8.95 – 8.88 (m, 3H), 7.45 – 7.24 (m, 6H), 3.78 (s, 2H).

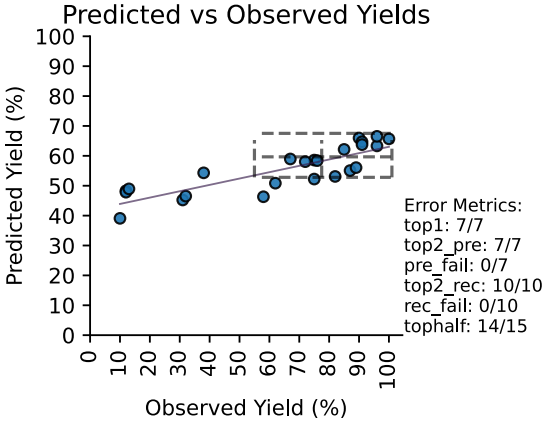
Data for **48_22**

	Predicted Yield %	Observed Yield %
48_22_2_1_b	55.0	87.0
48_22_6_1_b	48.0	12.0
48_22_8_1_b	39.0	10.0
48_22_13_1_b	59.0	75.0
48_22_14_1_b	45.0	31.0
48_22_16_1_b	51.0	62.0
48_22_17_1_b	66.0	100.0
48_22_18_1_b	58.0	72.0
48_22_20_1_b	66.0	90.0
48_22_21_1_b	65.0	91.0
48_22_2_2_b	53.0	82.0
48_22_5_2_b	58.0	76.0
48_22_6_2_b	46.0	58.0
48_22_7_2_b	48.0	12.0
48_22_11_2_b	54.0	38.0
48_22_17_2_b	63.0	96.0
48_22_20_2_b	64.0	91.0
48_22_21_2_b	62.0	85.0
48_22_2_3_b	56.0	89.0
48_22_6_3_b	49.0	13.0
48_22_13_3_b	59.0	67.0
48_22_14_3_b	47.0	32.0
48_22_16_3_b	52.0	75.0
48_22_20_3_b	67.0	96.0

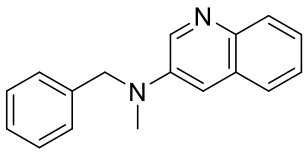


48_22





A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*

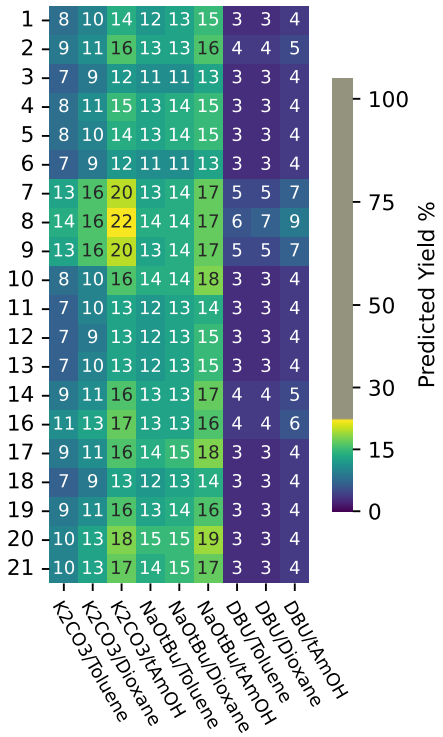


N-Benzyl-*N*-methylquinolin-3-amine (**48_22**)

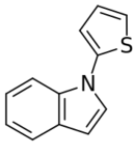
Color and state:	Solid
m.p.:	75.6-76.3 °C (sealed tube)
^{1}H NMR	(600 MHz, $CDCl_3$)
	δ 8.77 (d, *J* = 3.0 Hz, 1H), 7.97 (dt, *J* = 9.5, 3.4 Hz, 1H), 7.63 (dt, *J* = 9.7, 3.4 Hz, 1H), 7.44 (dt, *J* = 9.6, 3.5 Hz, 2H), 7.35 (td, *J* = 7.2, 1.8 Hz, 2H), 7.29 (dd, *J* = 8.3, 5.6 Hz, 3H), 7.19 (d, *J* = 3.0 Hz, 1H), 4.70 (s, 2H), 3.16 (s, 3H).
^{13}C{^{1}H} NMR	(151 MHz, $CDCl_3$)
	δ 143.24, 141.70, 141.56, 137.96, 129.34, 129.03, 128.89, 127.43, 126.97, 126.96, 126.21, 125.19, 112.72, 56.71, 38.77.
IR (cm^{-1})	ATR (neat)
	3062 (m), 3027 (m), 2917 (m), 1948 (w), 1591 (s), 1492 (s), 1435 (s), 1386 (s), 1350 (s), 1320 (s), 1278 (m), 1243 (m), 1195 (s), 1143 (s), 1111 (m), 1072 (m), 1008 (m), 942 (s), 871 (m), 836 (s), 782 (s), 749 (s), 722 (s), 692 (s), 610 (s), 538 (m).
HRMS(ES+):	Calcd for $C_{17}H_{17}N_2$ (M+H)+: 249.1392 Found: 249.1385
TLC	R_f 0.20 (EtOAc/hexane, 30:70) [UV, $KMnO_4$]

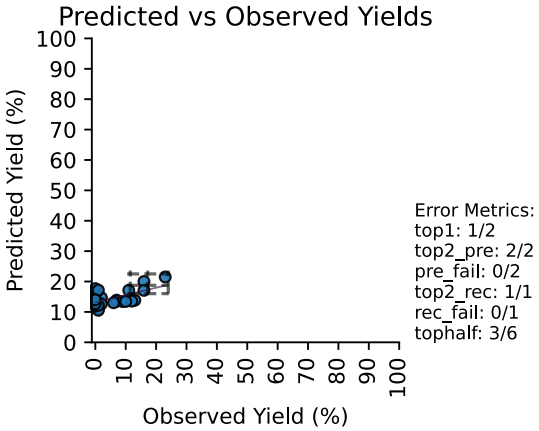
Data for **18_3**

	Predicted Yield %	Observed Yield %
18_3_6_1_b	11.0	1.0
18_3_7_1_b	14.0	7.0
18_3_8_1_b	14.0	13.0
18_3_14_1_b	13.0	7.0
18_3_16_1_b	13.0	0.0
18_3_17_1_b	15.0	0.0
18_3_21_1_b	15.0	2.0
18_3_6_2_b	13.0	2.0
18_3_7_2_a	20.0	16.0
18_3_8_2_a	22.0	23.0
18_3_9_2_b	17.0	16.0
18_3_14_2_b	17.0	11.0
18_3_16_2_b	16.0	0.0
18_3_17_2_b	18.0	0.0
18_3_21_2_b	17.0	1.0
18_3_6_3_b	11.0	1.0
18_3_7_3_b	13.0	9.0
18_3_8_3_b	14.0	12.0
18_3_9_3_b	13.0	10.0
18_3_11_3_b	12.0	0.0
18_3_13_3_b	12.0	1.0
18_3_14_3_b	13.0	6.0
18_3_16_3_b	13.0	0.0
18_3_17_3_b	14.0	0.0

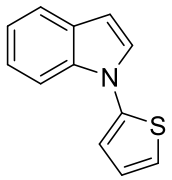


18_3





A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*



The structure and purity of the known compound **18_3** was confirmed by the comparison of their physical and spectral data (^{1}H NMR) with reported in the literature.(*66*)

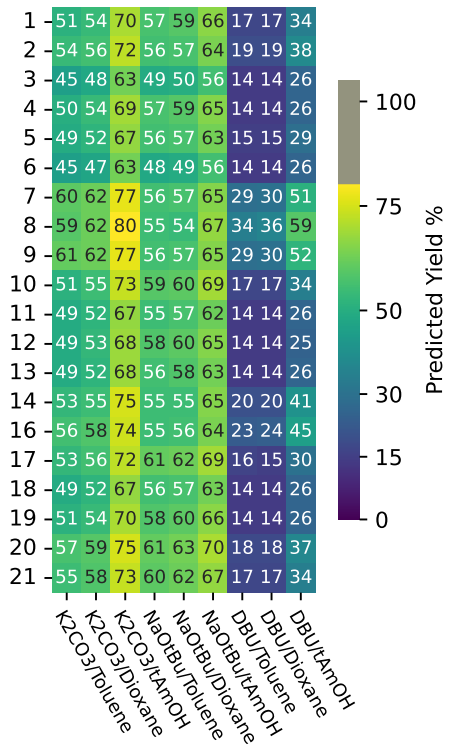
1-(Thiophen-2-yl)-1H-indole (**18_3**)

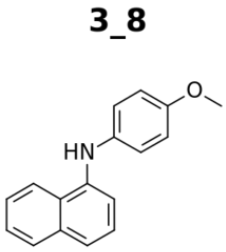
^{1}H NMR (499 MHz, $CDCl_3$)

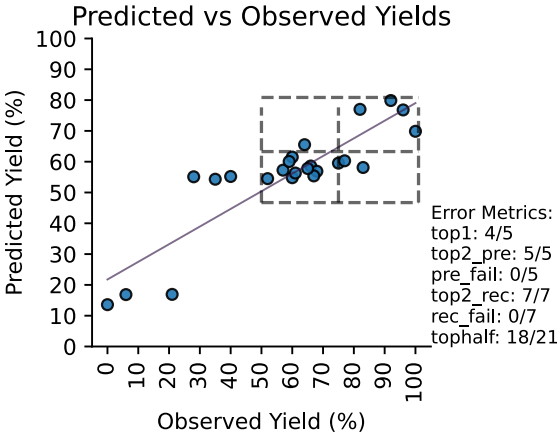
δ 7.69 (d, *J* = 7.8 Hz, 1H), 7.62 (d, *J* = 8.3 Hz, 1H), 7.35 – 7.25 (m, 2H), 7.22 (t, *J* = 6.4 Hz, 2H), 7.14 – 7.05 (m, 2H), 6.70 (d, *J* = 3.3 Hz, 1H).

Data for **3_8**

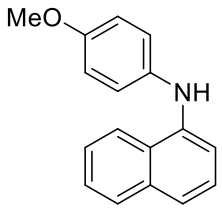
	Predicted Yield %	Observed Yield %
3_8_1_1_b	59.0	66.0
3_8_7_1_b	57.0	68.0
3_8_8_1_b	54.0	35.0
3_8_10_1_c	17.0	6.0
3_8_12_1_b	60.0	75.0
3_8_13_1_b	58.0	83.0
3_8_14_1_a	55.0	40.0
3_8_14_1_b	55.0	60.0
3_8_19_1_c	14.0	0.0
3_8_1_2_b	66.0	64.0
3_8_7_2_a	77.0	96.0
3_8_8_2_a	80.0	92.0
3_8_9_2_a	77.0	82.0
3_8_19_2_a	70.0	100.0
3_8_1_3_b	57.0	57.0
3_8_7_3_a	60.0	77.0
3_8_8_3_b	55.0	52.0
3_8_10_3_c	17.0	21.0
3_8_11_3_b	55.0	67.0
3_8_12_3_b	58.0	65.0
3_8_13_3_b	56.0	61.0
3_8_16_3_b	55.0	28.0
3_8_20_3_b	61.0	60.0
3_8_21_3_b	60.0	59.0







A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*

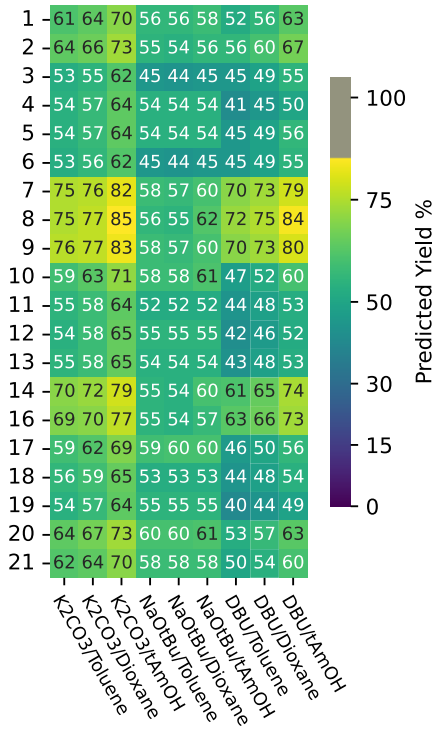


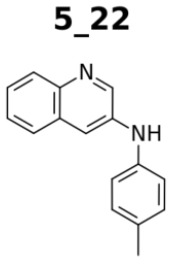
N-(4-Methoxyphenyl)naphthalen-1-amine **(3_8)** (*67*)-(*69*)

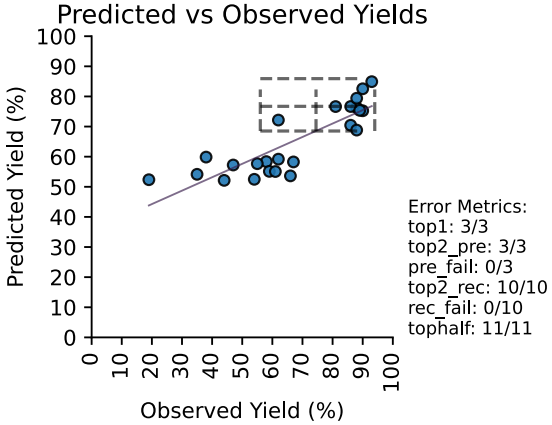
^{1}H NMR:	(500 MHz, $CDCl_3$)
	δ 8.03 – 7.98 (m, 1H), 7.85 (dd, *J* = 7.6, 2.1 Hz, 1H), 7.52 – 7.46 (m, 2H), 7.46 – 7.41 (m, 1H), 7.33 (t, *J* = 7.8 Hz, 1H), 7.11 (d, *J* = 8.7 Hz, 1H), 7.06 (d, *J* = 9.0 Hz, 2H), 6.88 (d, *J* = 6.6 Hz, 2H), 5.86 (s, 1H), 3.82 (s, 3H).
^{13}C{^{1}H} NMR	(126 MHz, $CDCl_3$)
	δ 155.50, 141.28, 137.29, 135.02, 129.00, 126.57, 126.41, 126.35, 125.75, 122.24, 121.45, 121.32, 115.18, 112.11, 56.02.
HRMS (ESI+)	Calcd for $C_{17}H_{15}NO$ (M+H)+: 250.1232 Found: 250.1221

Data for **5_22**

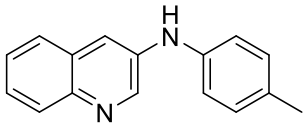
	Predicted Yield %	Observed Yield %
5_22_7_1_a	76.0	88.0
5_22_8_1_a	77.0	81.0
5_22_8_1_c	75.0	90.0
5_22_9_1_a	77.0	86.0
5_22_11_1_b	52.0	54.0
5_22_14_1_b	54.0	35.0
5_22_16_1_a	70.0	86.0
5_22_21_1_b	58.0	58.0
5_22_7_2_b	60.0	38.0
5_22_8_2_a	85.0	93.0
5_22_9_2_a	83.0	90.0
5_22_11_2_b	52.0	44.0
5_22_14_2_a	79.0	88.0
5_22_16_2_b	57.0	47.0
5_22_7_3_a	75.0	89.0
5_22_8_3_c	72.0	62.0
5_22_9_3_b	58.0	55.0
5_22_11_3_b	52.0	19.0
5_22_13_3_b	54.0	66.0
5_22_14_3_b	55.0	59.0
5_22_16_3_a	69.0	88.0
5_22_16_3_b	55.0	61.0
5_22_17_3_b	59.0	62.0
5_22_21_3_b	58.0	67.0







A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*



The structure and purity of the known compound **5_22** was confirmed by the comparison of their physical and spectral data (^{1}H NMR, ^{13}C NMR) with reported in the literature.(*70*)

N-(4-Tolyl)quinolin-3-amine (**5_22**)

<u>^{1}H NMR</u> (600 MHz, $CDCl_3$)

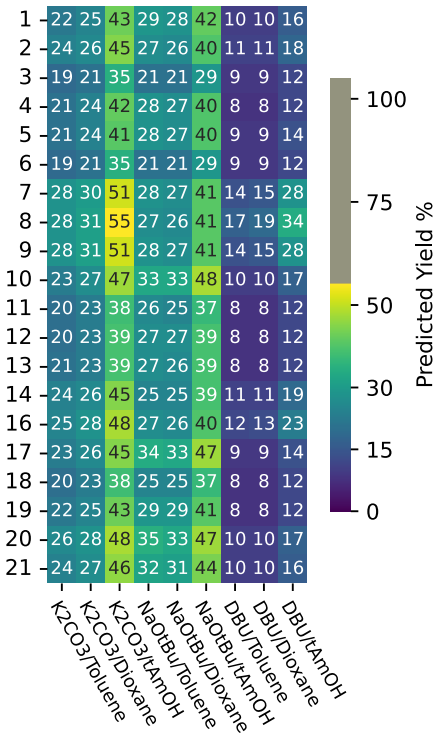
δ 8.65 (d, *J* = 2.8 Hz, 1H), 7.95 (d, *J* = 8.1 Hz, 1H), 7.59 (d, *J* = 2.7 Hz, 1H), 7.54 (dd, *J* = 8.0, 1.6 Hz, 1H), 7.41 (dddd, *J* = 20.8, 8.1, 6.9, 1.4 Hz, 2H), 7.11 (d, *J* = 8.1 Hz, 2H), 7.05 (d, *J* = 8.4 Hz, 2H), 5.96 (s, 1H), 2.28 (s, 3H).

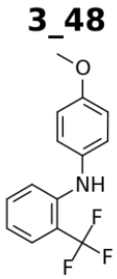
<u>^{13}C{^{1}H} NMR</u> (151 MHz, $CDCl_3$)

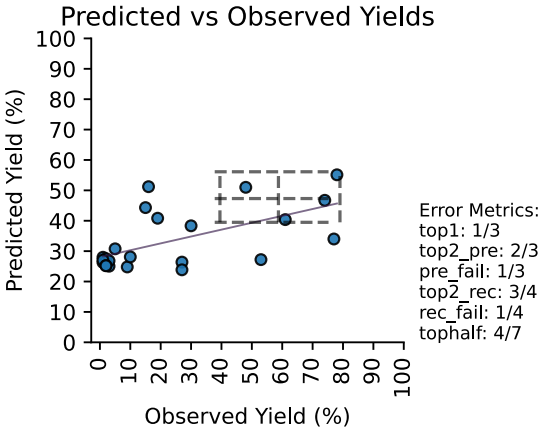
δ 144.10, 138.83, 138.05, 132.60, 130.20(broad, two carbons), 129.04, 128.56, 127.27, 126.41, 126.33, 119.79, 116.02, 20.80.

Data for **3_48**

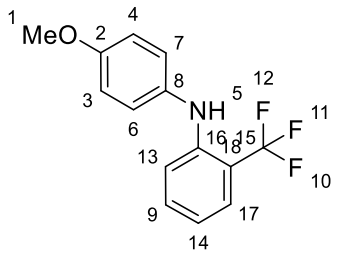
	Predicted Yield %	Observed Yield %
3_48_1_1_b	28.0	1.0
3_48_8_1_a	31.0	5.0
3_48_8_1_b	26.0	27.0
3_48_12_1_b	27.0	2.0
3_48_14_1_b	25.0	3.0
3_48_16_1_b	26.0	1.0
3_48_18_1_b	25.0	9.0
3_48_2_2_b	40.0	61.0
3_48_7_2_a	51.0	48.0
3_48_8_2_a	55.0	78.0
3_48_8_2_b	41.0	19.0
3_48_9_2_a	51.0	16.0
3_48_17_2_b	47.0	74.0
3_48_18_2_a	38.0	30.0
3_48_21_2_b	44.0	15.0
3_48_2_3_a	24.0	27.0
3_48_5_3_b	28.0	2.0
3_48_8_3_a	28.0	10.0
3_48_8_3_b	27.0	3.0
3_48_12_3_b	27.0	1.0
3_48_14_3_b	25.0	2.0
3_48_16_3_b	27.0	53.0
3_48_17_3_b	34.0	77.0
3_48_18_3_b	25.0	2.0







A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*

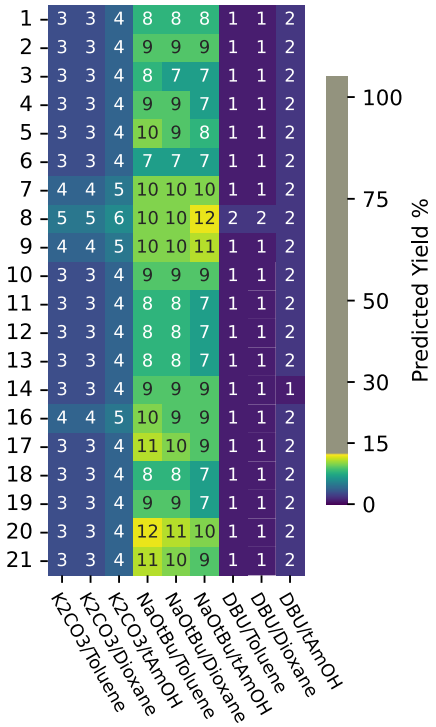


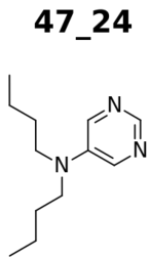
N-(4-Methoxyphenyl)-2-(trifluoromethyl)aniline **(3_48)**

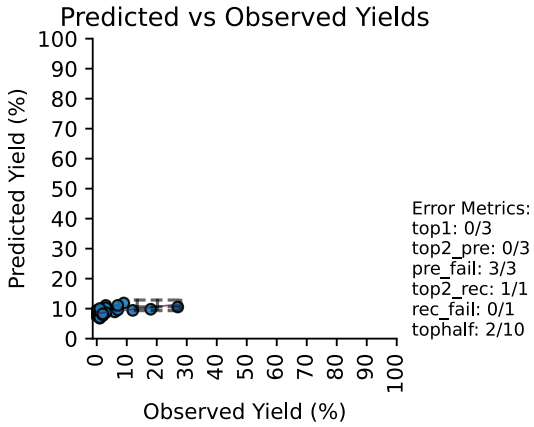
Color and state	Colorless oil
^{1}H NMR	(500 MHz, $CDCl_3$)
	δ 7.51 (d, *J* = 6.0 Hz, 1H, CH (17)), 7.29 (t, *J* = 7.4 Hz, 1H, CH (9)), 7.12 (d, *J* = 9.0 Hz, 2H, 2xCH (6 and 7)), 7.01 (d, *J* = 8.4 Hz, 1H, CH (13)), 6.91 (d, *J* = 9.0 Hz, 2H, 2xCH (3 and 4)), 6.82 (t, *J* = 7.6 Hz, 1H, 2xCH (14)), 5.95 (s, 1H, NH (5)), 3.82 (s, 3H, OCH_3 (1)).
^{13}C{^{1}H} NMR	(126 MHz, $CDCl_3$)
	δ 156.76 (s, C (2)), 144.30 (s, C(16)), 133.98 (s, C (8)), 132.84 (s, C (9)), 126.88 (q J_{CF} = 6.3 Hz, C (17)), 125.15 (q, J_{CF} = 273.42Hz, C (15)), 125.17 (s, C(6 and 7)), 118.19 (s, C (14)), 115.55 (s, C (13)), 115.32 (q, J_{CF} = 28.98 Hz, s, (18)), 114.96 (s, C (3 and 4), 55.68 (s, C (1).
^{19}F NMR	(471 MHz, $CDCl_3$)
	δ -61.95.
IR (cm^{-1})	ATR (neat)
	3456 (w), 2936 (w), 2837 (w), 1611 (m), 1583 (m), 1510 (s), 1465 (s), 1325 (s), 1282 (s), 1237 (s), 1166 (s), 1095 (s), 1058 (m), 1031 (s), 945 (w), 883 (w), 818 (m), 779 (w), 753 (s), 643 (m), 620 (m), 597 (w), 548 (w), 516 (m).
HRMS (ES+)	Calcd for $C_{14}H_{13}NOF_3$ (M+H)+: 268.0949 Found: 268.0940
TLC	R_f 0.4 (EtOAc/hexane, 2:98)

Data for **47_24**

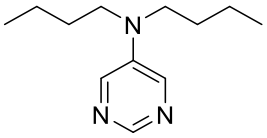
	Predicted Yield %	Observed Yield %
47_24_1_1_b	8.0	0.0
47_24_2_1_b	9.0	6.0
47_24_4_1_b	9.0	1.0
47_24_5_1_b	9.0	0.0
47_24_11_1_b	8.0	1.0
47_24_17_1_b	10.0	18.0
47_24_18_1_b	8.0	1.0
47_24_20_1_b	11.0	3.0
47_24_21_1_b	10.0	3.0
47_24_1_2_b	8.0	2.0
47_24_2_2_b	9.0	3.0
47_24_4_2_b	7.0	1.0
47_24_11_2_b	7.0	1.0
47_24_18_2_b	7.0	1.0
47_24_1_3_b	8.0	2.0
47_24_2_3_b	9.0	12.0
47_24_4_3_b	9.0	1.0
47_24_5_3_b	10.0	1.0
47_24_11_3_b	8.0	2.0
47_24_16_3_b	10.0	7.0
47_24_17_3_b	11.0	27.0
47_24_18_3_b	8.0	2.0
47_24_20_3_b	12.0	9.0
47_24_21_3_b	11.0	7.0







A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*

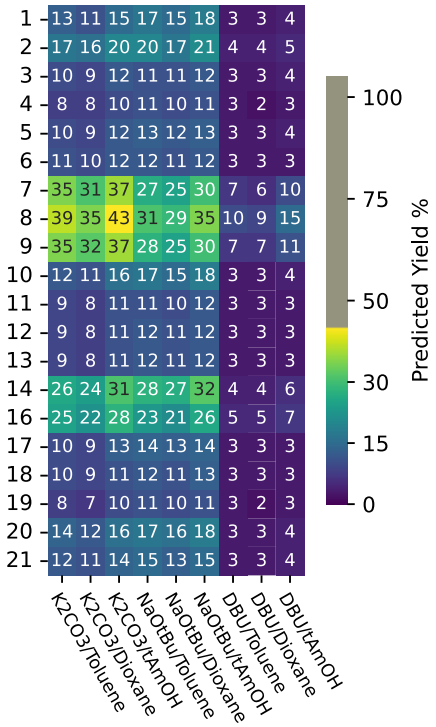


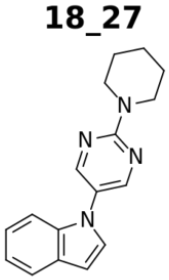
N-Dibutylpyrimidin-5-amine **(47_24)**

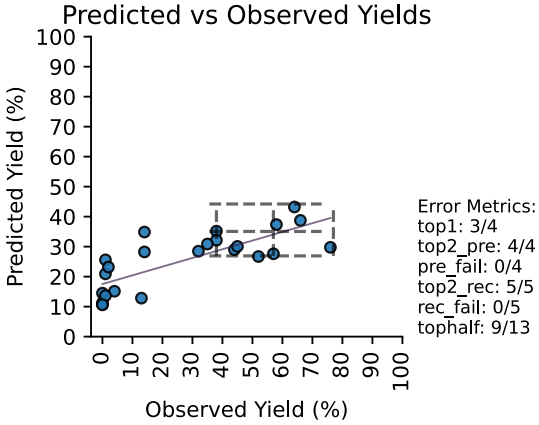
Color and state	Yellow oil
^{1}H NMR	(500 MHz, $CDCl_3$)
	δ 8.49 (s, 1H), 8.11 (s, 2H), 3.31 – 3.22 (m, 4H), 1.56 (p, *J* = 7.6 Hz, 4H), 1.35 (h, *J* = 7.4 Hz, 4H), 0.95 (t, *J* = 7.3 Hz, 6H).
^{13}C{^{1}H} NMR	(126 MHz, $CDCl_3$)
	δ 146.38, 141.51, 139.59, 50.16, 29.10, 20.29, 14.03.
IR (cm^{-1})	ATR (neat)
	3456 (w), 3040 (w), 2957 (m), 2931 (m), 2872 (m), 1742 (s), 1714 (w), 1567 (s), 1537 (m), 1444 (s), 1367 (s), 1291 (m), 1260 (w), 1229 (s), 1202 (s), 1172 (m), 1111 (m), 1052 (w), 1013 (w), 927 (w), 901 (w), 862 (m), 785 (w), 723 (s), 622 (m), 528 (w).
HRMS (ES+)	Calcd for $C_{12}H_{22}N_3$ (M+H)+: 208.1814 Found: 208.1814
TLC	R_f 0.3 (EtOAc/hexane, 10:90)

Data for **18_27**

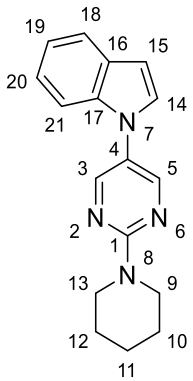
	Predicted Yield %	Observed Yield %
18_27_8_1_a	35.0	14.0
18_27_8_1_b	29.0	44.0
18_27_10_1_b	15.0	4.0
18_27_13_1_b	11.0	0.0
18_27_14_1_b	27.0	52.0
18_27_16_1_b	21.0	1.0
18_27_7_2_b	30.0	76.0
18_27_8_2_a	43.0	64.0
18_27_8_2_b	35.0	38.0
18_27_9_2_a	37.0	58.0
18_27_9_2_b	30.0	45.0
18_27_14_2_b	32.0	38.0
18_27_16_2_a	28.0	14.0
18_27_16_2_b	26.0	1.0
18_27_17_2_a	13.0	13.0
18_27_17_2_b	14.0	0.0
18_27_18_2_a	11.0	0.0
18_27_21_2_a	14.0	1.0
18_27_8_3_a	39.0	66.0
18_27_8_3_b	31.0	35.0
18_27_9_3_b	28.0	57.0
18_27_14_3_b	28.0	32.0
18_27_16_3_b	23.0	2.0
18_27_19_3_b	11.0	0.0







A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*

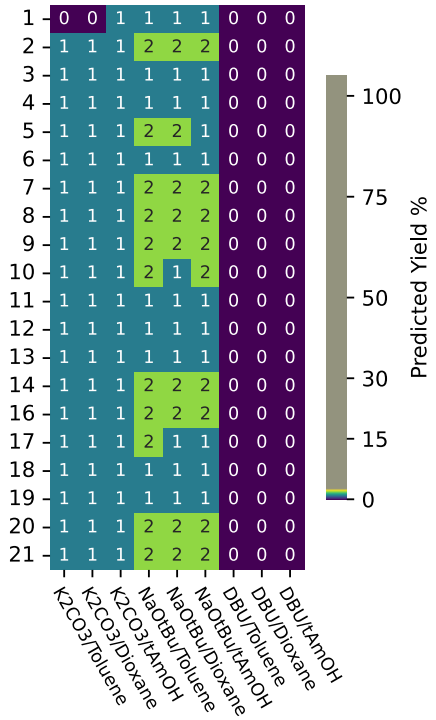


1-(2-(Piperidin-1-yl)pyrimidin-5-yl)-1H-indole **(18_27**)

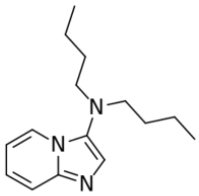
Color and state:	Colorless solid
m.p.	99.2-100.2 °C (sealed tube)
^{1}H NMR	(500 MHz, $CDCl_3$)
	δ 8.34 (s, 2H, 2xHC (3 and 5)), 7.61 (d, *J* = 7.8 Hz, 1H, HC (18)), 7.27 – 7.23 (m, 1H, HC (19)), 7.17 – 7.12 (m, 1H, HC, (21)), 7.12 – 7.07 (m, 2H, 2xHC (20 and 15)), 6.61 (d, *J* = 2.3 Hz, 1H, HC (14)), 3.83 – 3.76 (m, 4H, 2xCH_2 (9 and 13), 1.66 (p, *J* = 5.2 Hz, 2H, CH_2 (11)), 1.59 (p, *J* = 5.3 Hz, 4H, 2xCH_2 (10 and 12).
^{13}C{^{1}H} NMR	(126 MHz, $CDCl_3$)
	δ 160.27 (s, C(1)), 154.66 (s, 2xC(3 and 5), 136.85 (s, C(17)), 128.68 (s, C(4)), 128.07 (s, C(14)), 123.55 (s, C(16)), 122.36 (s, C(18)), 121.00 (s, C(19)), 120.23 (s, C(21)), 109.77(s, C(15)), 103.40 (s, C(20)), 45.04 (s, 2xC (9 and 13), 25.67 (s, 2xC (10 and 12), 24.68 (s, C(11).
IR (cm^{-1})	ATR (neat)
	3007 (w), 2954 (w), 2932 (m), 2850 (m), 1738 (w), 1611 (m), 1507 (s), 1412 (m), 1365 (s), 1331 (m), 1296 (m), 1255 (s), 1211 (m), 1178 (m), 1132 (s), 1110 (m), 1067 (w), 1024 (m), 938 (m), 911 (m), 881 (m), 854 (m).
HRMS (ESI+)	Calcd for $C_{17}H_{18}N_4$ (M+H)+: 279.1616 Found: 279.1616
TLC	R_f 0.35 (EtOAc/hexane, 30:70)

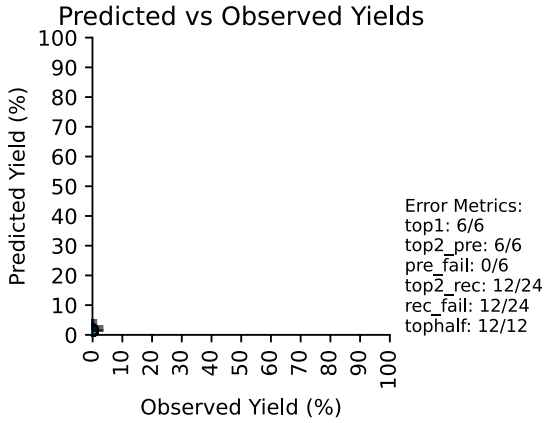
Data for **47_35**

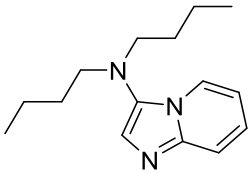
	Predicted Yield %	Observed Yield %
47_35_2_1_b	2.0	0.0
47_35_3_1_b	1.0	0.0
47_35_5_1_b	2.0	0.0
47_35_6_1_b	1.0	0.0
47_35_11_1_b	1.0	0.0
47_35_16_1_b	2.0	0.0
47_35_17_1_b	1.0	0.0
47_35_18_1_b	1.0	0.0
47_35_20_1_b	2.0	0.0
47_35_21_1_b	2.0	0.0
47_35_5_2_b	1.0	0.0
47_35_16_2_b	2.0	0.0
47_35_17_2_b	1.0	0.0
47_35_18_2_b	1.0	0.0
47_35_21_2_b	2.0	0.0
47_35_2_3_b	2.0	0.0
47_35_3_3_b	1.0	0.0
47_35_5_3_b	2.0	0.0
47_35_11_3_b	1.0	0.0
47_35_16_3_b	2.0	0.0
47_35_17_3_b	2.0	0.0
47_35_18_3_b	1.0	0.0
47_35_20_3_b	2.0	0.0
47_35_21_3_b	2.0	0.0



47_35



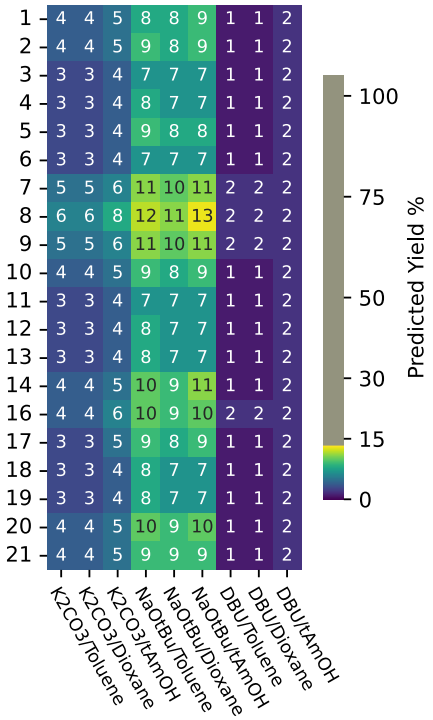


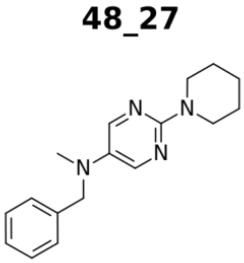


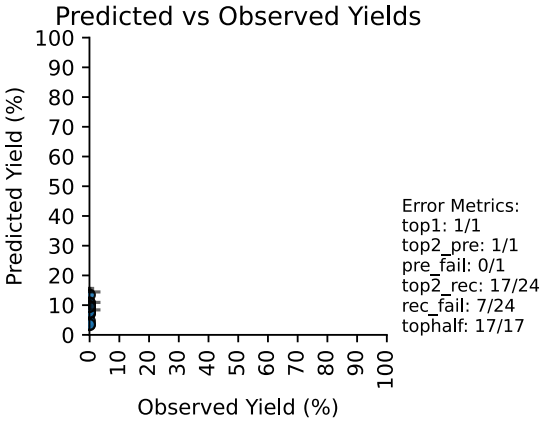
N,*N*-Dibutylimidazo[1,2-a]pyridin-3-amine (**47_35**): This product could not be independently synthesized in pure form. The quantity of unreacted starting material in the HPLC reaction data indicated that the reactions were all zero yielding.

Data for **48_27**

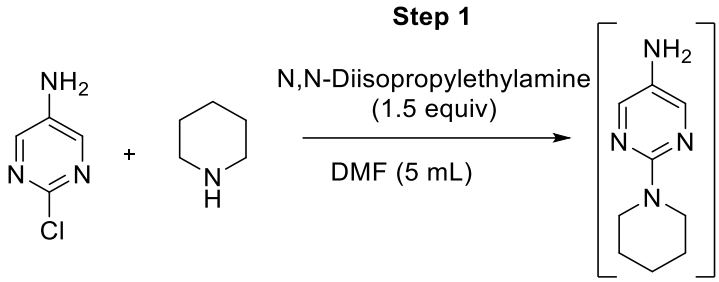
	Predicted Yield %	Observed Yield %
48_27_1_1_b	8.0	0.0
48_27_2_1_b	8.0	0.0
48_27_7_1_b	10.0	0.0
48_27_10_1_b	8.0	0.0
48_27_13_1_b	7.0	0.0
48_27_14_1_b	9.0	0.0
48_27_16_1_b	9.0	0.0
48_27_17_1_a	3.0	0.0
48_27_1_2_a	5.0	0.0
48_27_2_2_b	9.0	0.0
48_27_8_2_b	13.0	0.0
48_27_10_2_b	9.0	0.0
48_27_13_2_b	7.0	0.0
48_27_14_2_b	11.0	0.0
48_27_16_2_b	10.0	0.0
48_27_17_2_b	9.0	0.0
48_27_1_3_b	8.0	0.0
48_27_2_3_b	9.0	0.0
48_27_7_3_b	11.0	0.0
48_27_10_3_b	9.0	0.0
48_27_13_3_b	8.0	0.0
48_27_14_3_b	10.0	0.0
48_27_16_3_b	10.0	0.0
48_27_17_3_a	3.0	0.0



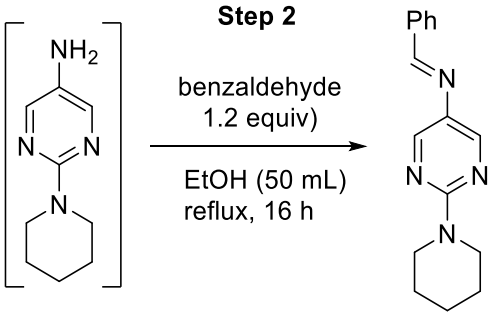




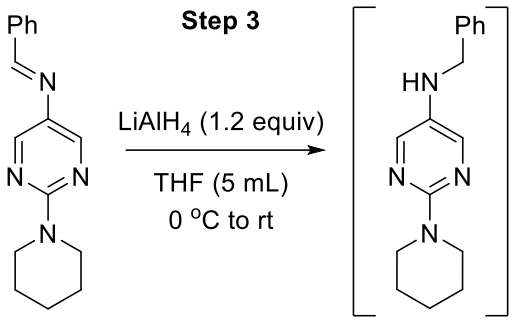
48_27 (method**)**



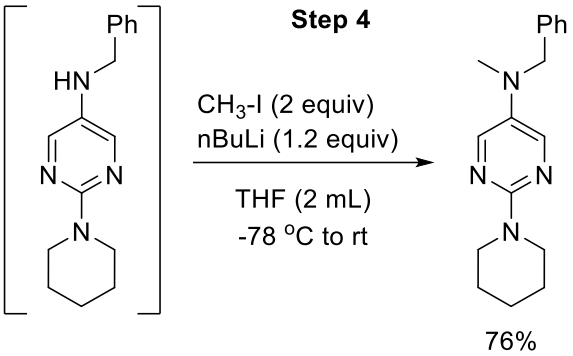
Step1: 2-chloropyrimidin-5-amine (500 mg, 3.86 mmol), piperidine (677 mg 7.95 mmol), and *N*-ethyl-*N*-isopropylpropan-2-amine (748mg, 1.5 equiv) were combined in DMF (5 mL) and stirred for 24 h at 120 °C. The reaction was mixture was then cooled to room temperature, diluted with water (15 mL), and extracted three times with CH_2Cl_2 (3 × 15 mL). The combined organic extracts were dried over $MgSO_4$, filtered through a paper filter, and the solvent was removed under reduced pressure. The crude product was used in the next step without further purification.



Step 2: Crude product from step 1 and benzaldehyde (1.2 equiv) were combined in 50 mL of ethanol and stirred at reflux for 16 h. The reaction mixture was then cooled to room temperature, concentrated under reduced pressure to remove the ethanol, diluted with brine solution (15 mL), and extracted three times with CH_2Cl_2 (3 × 15 mL). The combined organic phases were dried over $MgSO_4$, filtered through a paper filter, and concentrated under reduced pressure. The crude residue was purified by silica gel flash column chromatography (EtOAc/CH_2Cl_2 10:80 to 30:70) to give 1-phenyl-*N*-(2-(piperidin-1-yl)pyrimidin-5-yl)methanimine as a yellow solid.

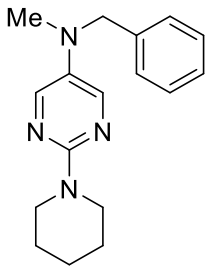


Step 3: $LiAlH_4$ (14.2 mg 1.0 equiv) was added to a 25 ml oven dry round bottom flask under a nitrogen atmosphere followed by 5 mL THF. The mixture was cooled to 0 °C. After 5 mins 1-phenyl-*N*-(2-(piperidin-1-yl)pyrimidin-5-yl)methanimine (100 mg) in a 1-ml aliquot of THF was added dropwise. The reaction mixture was warmed to room temperature and stirred for 2 h. The reaction was then quenched by addition of several drops of $NaSO_4$(*aq.*) and diluted with brine solution (15 mL) and extracted three times with CH_2Cl_2 (3 × 15 mL). The combined organic extracts were dried over $MgSO_4$, filtered through a paper filter, and concentrated under reduced pressure. The crude product was used in the next step without further purification.



Step 4: Crude product from step 3 was added to a 10 ml Schlenk tube under nitrogen followed by 2 ml THF. The reaction mixture was cooled to ca. -78 °C using a dry ice/acetone bath. After 5 minutes, 1.2 equiv. of *n*-BuLi (280 μL, 1.6 M in THF) were added dropwise. After 30 minutes, 2.0 equiv. of iodomethane (46.5 μL) were added dropwise. The reaction mixture was stirred for 5 minutes at -78 °C, then warmed to ambient temperature and stirred for 45 minutes longer. The reaction was quenched by saturated ammonium chloride solution, diluted with CH_2Cl_2 (10 mL), and extracted three times with CH_2Cl_2 (3 × 10 mL). The combined organic extracts were dried over $MgSO_4$, filtered through a paper filter, and concentrated under reduced pressure. The

crude residue was purified by flash chromatography (EtOAc/CH_2Cl_2 20:80 to 40:60) to give *N*-benzyl-N-methyl-2-(piperidin-1-yl)pyrimidin-5-amine as yellow oil (80 mg, 76%).

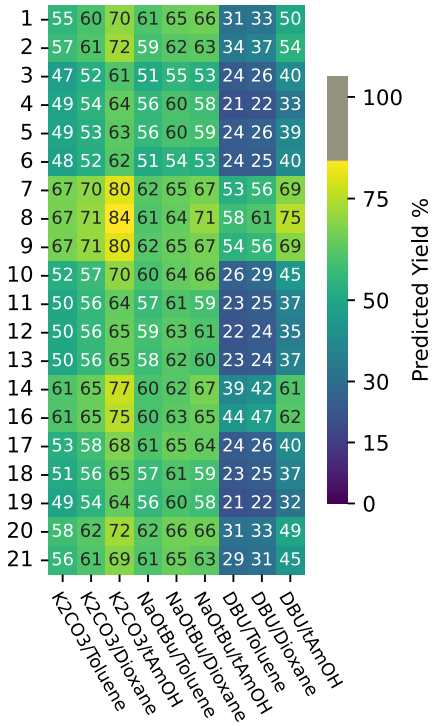


N-Benzyl-N-methyl-2-(piperidin-1-yl)pyrimidin-5-amine **(48_27)**

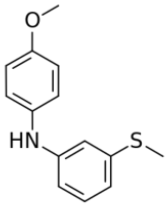
Color and sate	Yellow oil
^{1}H NMR	(500 MHz, $CDCl_3$)
	δ 8.04 (s, 2H), 7.31 (dd, *J* = 7.9, 6.7 Hz, 2H), 7.27 – 7.22 (m, 3H), 4.28 (s, 2H), 3.69 – 3.62 (m, 4H), 2.84 (s, 3H), 1.66 – 1.56 (m, 6H).
^{13}C{^{1}H} NMR	(126 MHz, $CDCl_3$)
	δ 157.29, 145.81, 138.23, 136.02, 128.71, 127.68, 127.36, 58.67, 45.62, 39.55, 25.80, 25.00.
IR (cm^{-1})	ATR (neat)
	3020 (w), 2929 (m), 2851 (m), 2796 (w), 1600 (m), 1527 (m), 1488 (s), 1436 (s), 1407 (s), 1362 (s), 1301 (m), 1263 (s), 1225 (m), 1205 (m), 1164 (m), 1107 (m), 1076 (m), 1029 (m), 978 (m), 943 (s), 907 (m), 850 (m), 826 (w), 788 (m), 745 (s), 705 (s), 650 (m), 609 (w), 578 (m), 528 (m).
HRMS (ES+)	Calcd for $C_{17}H_{23}N_4$ (M+H)+: 283.1918 Found: 283.1923
TLC	R_f 0.35 (EtOAc/hexane, 20:80)

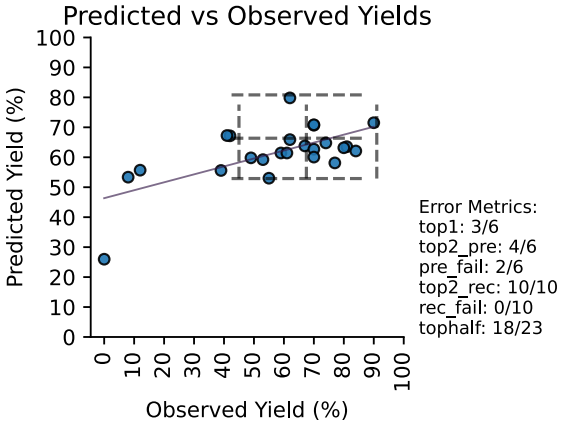
Data for **3_11**

	Predicted Yield %	Observed Yield %
3_11_9_1_a	71.0	70.0
3_11_1_1_b	65.0	74.0
3_11_8_1_b	64.0	81.0
3_11_10_1_b	64.0	67.0
3_11_12_1_b	63.0	80.0
3_11_13_1_b	62.0	84.0
3_11_16_1_b	63.0	70.0
3_11_5_1_c	26.0	0.0
3_11_7_1_c	56.0	39.0
3_11_2_2_a	72.0	90.0
3_11_7_2_a	80.0	62.0
3_11_1_2_b	66.0	62.0
3_11_6_2_b	53.0	8.0
3_11_8_2_b	71.0	70.0
3_11_8_3_a	67.0	42.0
3_11_9_3_a	67.0	41.0
3_11_1_3_b	61.0	59.0
3_11_4_3_b	56.0	12.0
3_11_8_3_b	61.0	61.0
3_11_12_3_b	59.0	53.0
3_11_13_3_b	58.0	77.0
3_11_14_3_b	60.0	70.0
3_11_16_3_b	60.0	49.0
3_11_7_3_c	53.0	55.0

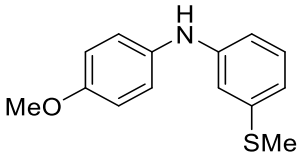


3_11





A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*

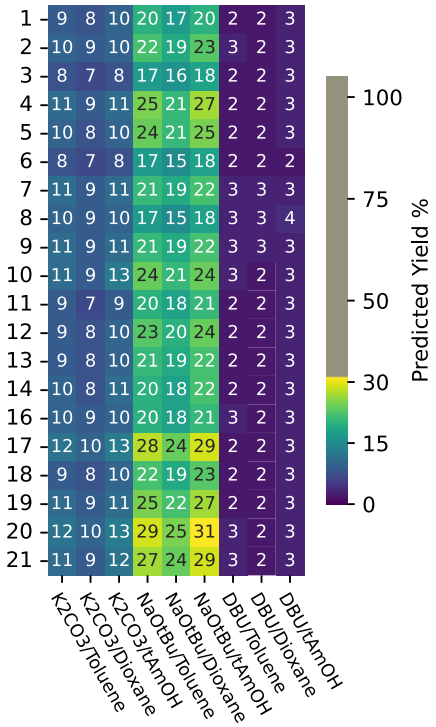


N-(4-Methoxyphenyl)-3-(methylthio)aniline **(3_11)**

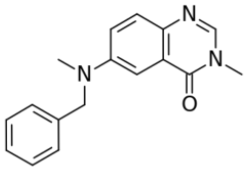
State	Solid
m.p.	75 °C
^{1}H NMR	(400 MHz, $CDCl_3$) δ 7.13 (t, *J* = 7.9 Hz, 1H), 7.08 (d, *J* = 8.9 Hz, 2H), 6.88 (d, *J* = 8.9 Hz, 2H), 6.80 (t, *J* = 2.1 Hz, 1H), 6.73 (ddd, *J* = 7.8, 1.9, 0.9 Hz, 1H), 6.67 (ddd, *J* = 8.1, 2.3, 0.9 Hz, 1H), 5.51 (s, 1H), 3.81 (s, 3H), 2.45 (s, 3H).
^{13}C{^{1}H} NMR	(101 MHz, $CDCl_3$) δ 155.63, 145.87, 139.56, 135.27, 129.73, 122.83, 117.51, 114.78, 113.24, 112.47, 55.65, 15.79.
IR (cm^{-1})	ATR (neat) 3382 (w), 2914 (w), 2827 (w), 1583 (m), 1502 (s), 1473 (m), 1433 (m), 1387 (w), 1311 (w), 1288 (m), 1230 (s), 1173 (m), 1097 (w), 1080 (w), 1028 (m), 987 (w), 964 (w), 912 (m), 820 (m), 762 (m), 727 (w), 681 (m), 646 (w), 617 (w).
HRMS (ES+)	Calcd for $C_{14}H_{15}NOS$ (M+H)+: 246.0953 Found: 246.0953

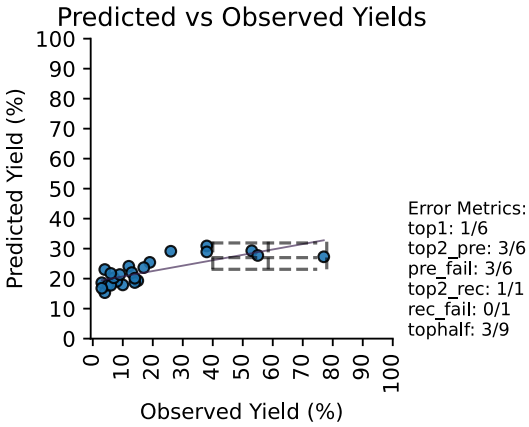
Data for **48_14**

	Predicted Yield %	Observed Yield %
48_14_2_1_b	19.0	15.0
48_14_6_1_b	15.0	4.0
48_14_9_1_b	19.0	3.0
48_14_11_1_b	18.0	10.0
48_14_13_1_b	19.0	14.0
48_14_16_1_b	18.0	5.0
48_14_17_1_b	24.0	12.0
48_14_18_1_b	19.0	8.0
48_14_20_1_b	25.0	19.0
48_14_21_1_b	24.0	17.0
48_14_2_2_b	23.0	4.0
48_14_6_2_b	18.0	6.0
48_14_17_2_b	29.0	53.0
48_14_20_2_b	31.0	38.0
48_14_21_2_b	29.0	38.0
48_14_2_3_b	22.0	13.0
48_14_6_3_b	17.0	3.0
48_14_11_3_b	20.0	7.0
48_14_13_3_b	21.0	9.0
48_14_16_3_b	20.0	14.0
48_14_17_3_b	28.0	55.0
48_14_18_3_b	22.0	6.0
48_14_20_3_b	29.0	26.0
48_14_21_3_b	27.0	77.0

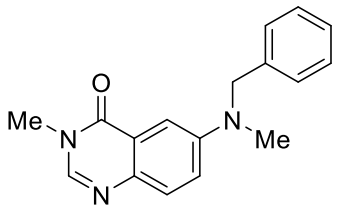


48_14





A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*

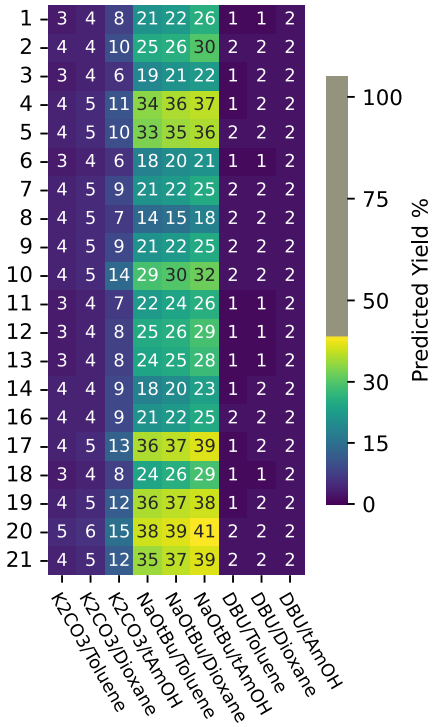


6-(Benzyl(methyl)amino)-3-methylquinazolin-4(3H)-one **(48_14)**

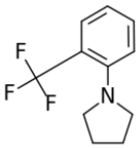
^{1}H NMR	(400 MHz, $CDCl_3$)
	δ 7.83 (s, 1H), 7.55 (d, *J* = 9.1 Hz, 1H), 7.48 (d, *J* = 3.0 Hz, 1H), 7.33 – 7.28 (m, 2H), 7.27 – 7.23 (m, 1H), 7.23 – 7.17 (m, 3H), 4.65 (s, 2H), 3.56 (s, 3H), 3.14 (s, 3H).
^{13}C{^{1}H} NMR	(101 MHz, $CDCl_3$)
	δ 161.86, 148.90, 143.02, 139.65, 138.11, 128.84, 128.61, 127.28, 126.75, 123.08, 120.25, 105.65, 56.53, 39.09, 34.11.
IR (cm^{-1})	ATR
	3058 (w), 2920 (w), 1873 (w), 1653 (m), 1612 (m), 1549 (w), 1508 (m), 1444 (m), 1398 (w), 1375 (m), 1340 (m), 1300 (m), 1265 (w), 1213 (w), 1167 (w), 1126 (w), 1103 (w), 1057 (w), 1016 (w), 947 (m), 889 (w), 849 (w), 814 (m), 779 (m), 727 (m), 692 (m).
HRMS (ES+)	Calcd for $C_{17}H_{18}N_3O$ $(M+H)^+$: 280.1450 Found: 280.1450

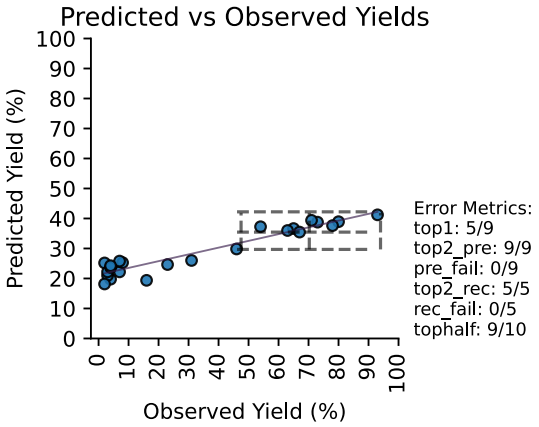
Data for **44_48**

	Predicted Yield %	Observed Yield %
44_48_2_1_b	26.0	31.0
44_48_6_1_b	20.0	4.0
44_48_9_1_b	22.0	7.0
44_48_11_1_b	24.0	4.0
44_48_13_1_b	25.0	8.0
44_48_17_1_b	37.0	54.0
44_48_18_1_b	26.0	7.0
44_48_20_1_b	39.0	73.0
44_48_21_1_b	37.0	65.0
44_48_2_2_b	30.0	46.0
44_48_6_2_b	21.0	3.0
44_48_7_2_b	25.0	2.0
44_48_17_2_b	39.0	71.0
44_48_20_2_b	41.0	93.0
44_48_21_2_b	39.0	80.0
44_48_2_3_b	25.0	23.0
44_48_3_3_b	19.0	16.0
44_48_6_3_b	18.0	2.0
44_48_11_3_b	22.0	3.0
44_48_13_3_b	24.0	4.0
44_48_17_3_b	36.0	63.0
44_48_18_3_b	24.0	4.0
44_48_20_3_b	38.0	78.0
44_48_21_3_b	35.0	67.0

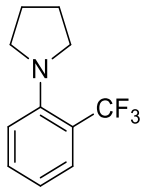


44_48





A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*

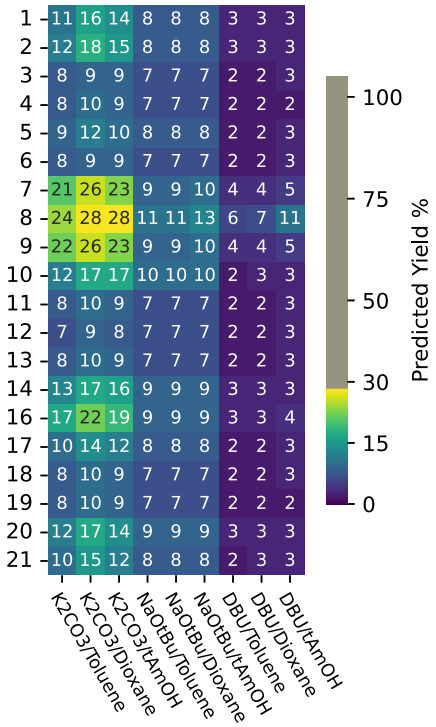


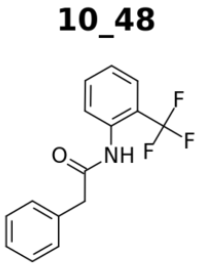
1-(2-(Trifluoromethyl)phenyl)pyrrolidine **(44_48)** (*71*)

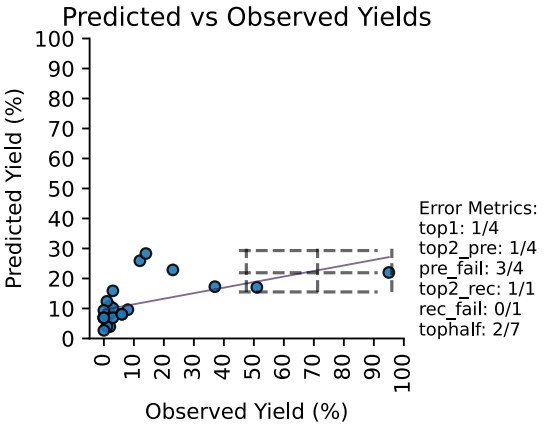
Color and sate	Brown oil
^{1}H NMR	(400 MHz, $CDCl_3$) δ 7.57 (dd, *J* = 7.9, 1.7 Hz, 1H), 7.36 (ddd, *J* = 8.9, 7.3, 2.0 Hz, 1H), 6.97 (d, *J* = 8.3 Hz, 1H), 6.87 – 6.81 (m, 1H), 3.36 – 3.29 (m, 4H), 1.97 – 1.92 (m, 4H).
^{13}C{^{1}H} NMR	(126 MHz, $CDCl_3$) δ 148.28, 132.31, 128.35 (q, J_{CF} = 5.04 Hz, 1C), 124.04(q, J_{CF} = 272.16 Hz, 1C), , 117.98, 117.64, 51.72(q, J_{CF} = 3.78 Hz, 1C), 25.75.
IR (cm^{-1})	ATR (neat) 2970 (w), 2834 (w), 1745 (w), 1711 (w), 1605 (m), 1565 (w), 1488 (m), 1451 (m), 1401 (w), 1348 (m), 1316 (s), 1263 (m), 1235 (m), 1173 (m), 1134 (s), 1095 (s), 1063 (s), 1030 (s), 953 (m), 879 (w), 849 (w), 748 (s), 661 (m), 633 (w), 599 (w), 538 (m).
HRMS (ES+)	Calcd for $C_{11}H_{13}F_3N$ $(M+H)^+$: 216.0999 Found: 216.0997

Data for **10_48**

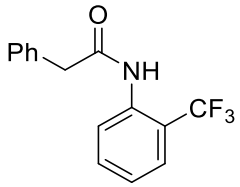
	Predicted Yield %	Observed Yield %
10_48_7_1_a	26.0	12.0
10_48_10_1_a	17.0	37.0
10_48_16_1_a	22.0	95.0
10_48_1_1_b	8.0	1.0
10_48_8_1_b	11.0	2.0
10_48_12_1_b	7.0	0.0
10_48_17_1_b	8.0	2.0
10_48_19_1_b	7.0	0.0
10_48_7_1_c	4.0	2.0
10_48_9_1_c	4.0	1.0
10_48_14_1_c	3.0	0.0
10_48_5_2_a	10.0	3.0
10_48_7_2_a	23.0	23.0
10_48_8_2_a	28.0	14.0
10_48_10_2_a	17.0	51.0
10_48_14_2_a	16.0	3.0
10_48_21_2_b	8.0	6.0
10_48_2_3_a	12.0	1.0
10_48_9_3_b	9.0	0.0
10_48_10_3_b	10.0	8.0
10_48_12_3_b	7.0	0.0
10_48_13_3_b	7.0	3.0
10_48_17_3_b	8.0	6.0
10_48_18_3_b	7.0	0.0







A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*

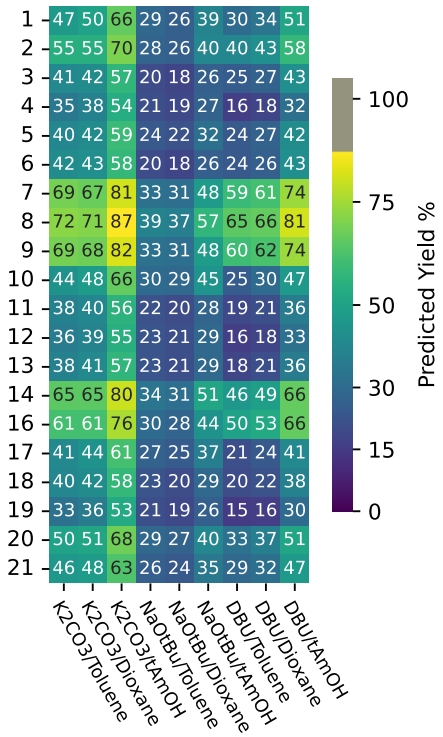


2-Phenyl-*N*-(2-(trifluoromethyl)phenyl)acetamide **(10_48)**

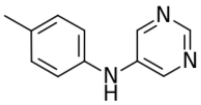
State	Solid
m.p.	183 ^{o}C
^{1}H NMR	(400 MHz, $CDCl_3$)
	δ 8.24 (d, *J* = 8.6 Hz, 1H), 7.56 – 7.49 (m, 2H), 7.46 – 7.39 (m, 3H), 7.39 – 7.31 (m, 3H), 7.18 (t, *J* = 7.7 Hz, 1H), 3.79 (s, 2H).
^{13}C{^{1}H} NMR	(101 MHz, $CDCl_3$)
	δ 169.45, 135.28, 133.61, 132.96, 129.85, 129.54, 128.14, 126.06 (q, J_{CF} = 6.3 Hz, IC), 124.50, 123.98, 123.83 (q, J_{CF} = 274.66 Hz, IC), 45.13.
IR (cm^{-1})	ATR (neat)
	3267 (w), 3029 (w), 1664 (m), 1606 (w), 1589 (w), 1525 (m), 1496 (w), 1450 (m), 1410 (w), 1317 (m), 1277 (m), 1248 (w), 1167 (m), 1115 (m), 1057 (w), 1034 (w), 970 (w), 953 (w), 768 (m), 698 (w), 652 (w).
HRMS (ES+)	Calcd for $C_{15}H_{13}F_3NO$ (M+H)+: 280.0950 Found: 280.0950

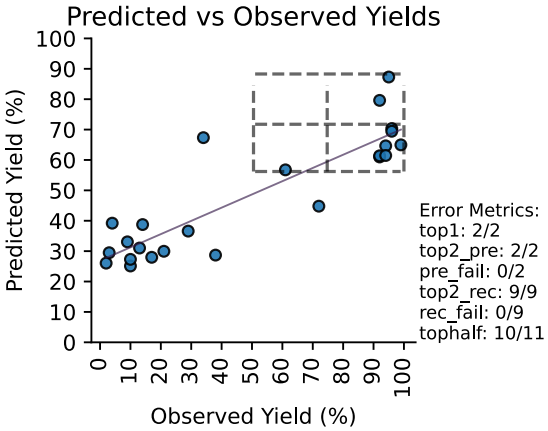
Data for **5_24**

	Predicted Yield %	Observed Yield %
5_24_7_1_a	67.0	34.0
5_24_14_1_a	65.0	94.0
5_24_1_1_b	26.0	2.0
5_24_8_1_b	37.0	29.0
5_24_9_1_b	31.0	13.0
5_24_10_1_b	29.0	38.0
5_24_16_1_b	28.0	17.0
5_24_17_1_b	25.0	10.0
5_24_7_1_c	61.0	92.0
5_24_2_2_a	70.0	96.0
5_24_8_2_a	87.0	95.0
5_24_13_2_a	57.0	61.0
5_24_14_2_a	80.0	92.0
5_24_17_2_a	61.0	92.0
5_24_1_2_b	39.0	4.0
5_24_10_2_b	45.0	72.0
5_24_13_2_b	29.0	3.0
5_24_9_3_a	69.0	96.0
5_24_14_3_a	65.0	99.0
5_24_16_3_a	61.0	94.0
5_24_7_3_b	33.0	9.0
5_24_8_3_b	39.0	14.0
5_24_10_3_b	30.0	21.0
5_24_17_3_b	27.0	10.0

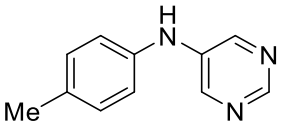


5_24





A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*

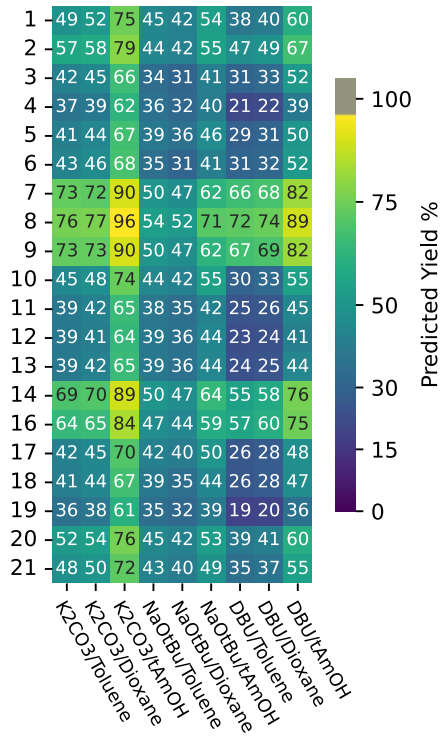


N-(4-Tolyl)pyrimidin-5-amine **(5_24)**

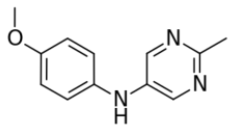
^{1}H NMR	(400 MHz, $CDCl_3$)
	δ 8.72 (s, 1H), 8.45 (s, 2H), 7.16 (d, *J* = 8.6 Hz, 2H), 7.03 (d, *J* = 8.6 Hz, 2H), 5.59 (br s, 1H), 2.34 (s, 3H).
^{13}C{^{1}H} NMR	(101 MHz, $CDCl_3$)
	δ 150.61, 144.16, 139.13, 137.67, 133.58, 130.48, 120.24, 20.94.
IR (cm^{-1})	ATR (neat)
	3238 (w), 3024 (w), 2914 (w), 2850 (w), 1734 (w), 1601 (w), 1572 (w), 1531 (w), 1508 (w), 1415 (w), 1375 (w), 1323 (w), 1236 (w), 1201 (w), 1178 (w), 1109 (w), 883 (w), 814 (w), 715 (w), 629 (w).
HRMS (ES+)	Calcd for $C_{11}H_{12}N_3$ (M+H)+: 186.1030 Found: 186.1020

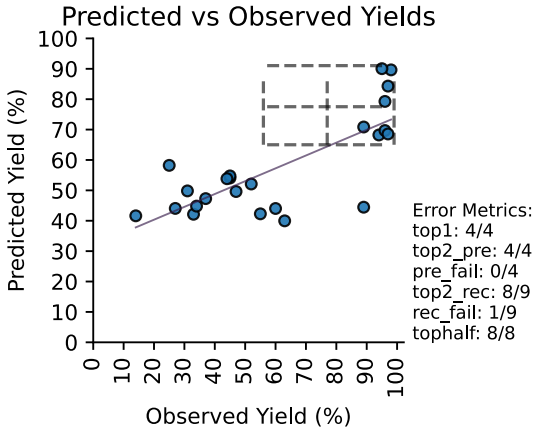
Data for **3_17**

	Predicted Yield %	Observed Yield %
3_17_2_1_a	58.0	25.0
3_17_1_1_b	42.0	33.0
3_17_8_1_b	52.0	52.0
3_17_9_1_b	47.0	37.0
3_17_10_1_b	42.0	14.0
3_17_16_1_b	44.0	60.0
3_17_17_1_b	40.0	63.0
3_17_7_1_c	68.0	94.0
3_17_2_2_a	79.0	96.0
3_17_7_2_a	90.0	98.0
3_17_9_2_a	90.0	95.0
3_17_16_2_a	84.0	97.0
3_17_17_2_a	70.0	96.0
3_17_1_2_b	54.0	45.0
3_17_8_2_b	71.0	89.0
3_17_10_2_b	55.0	45.0
3_17_13_2_b	44.0	27.0
3_17_14_3_a	69.0	97.0
3_17_1_3_b	45.0	34.0
3_17_2_3_b	44.0	89.0
3_17_7_3_b	50.0	47.0
3_17_8_3_b	54.0	44.0
3_17_9_3_b	50.0	31.0
3_17_17_3_b	42.0	55.0

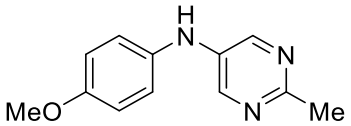


3_17





A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*

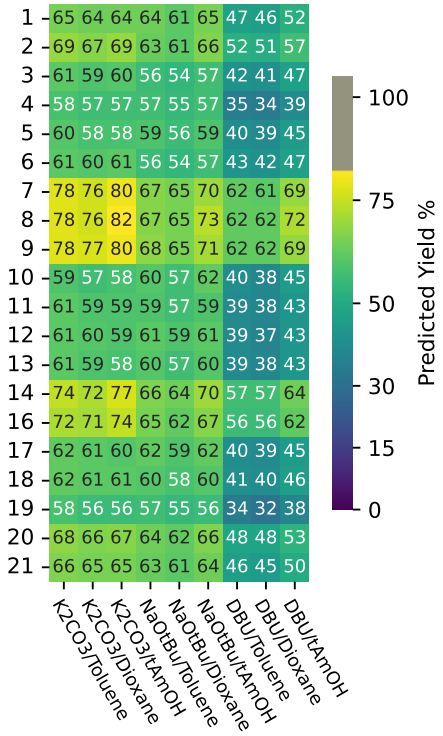


N-(4-Methoxyphenyl)-2-methylpyrimidin-5-amine **(3_17)**

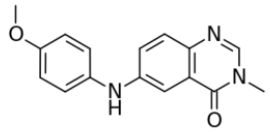
^{1}H NMR	(400 MHz, $CDCl_3$)
	δ 8.29 (s, 2H), 7.06 – 7.01 (m, 2H), 6.89 – 6.85 (m, 2H), 5.54 (br s, 1H), 3.79 (s, 3H), 2.63 (s, 3H).
^{13}C{^{1}H} NMR	(101 MHz, $CDCl_3$)
	δ 159.11, 156.19, 144.33, 137.17, 133.97, 122.25, 115.12, 55.69, 24.99.
IR (cm^{-1})	ATR (neat)
	3284 (w), 3035 (w), 2914 (w), 2833 (w), 1583 (w), 1560 (w), 1508 (m), 1444 (m), 1375 (w), 1323 (w), 1300 (w), 1277 (w), 1242 (m), 1173 (w), 1109 (w), 1022 (m), 901 (w), 820 (m), 779 (w), 762 (w), 739 (w), 646 (w).
HRMS (ES+)	Calcd for $C_{12}H_{14}N_3O$ (M+H)+: 216.1136 Found: 216.1136

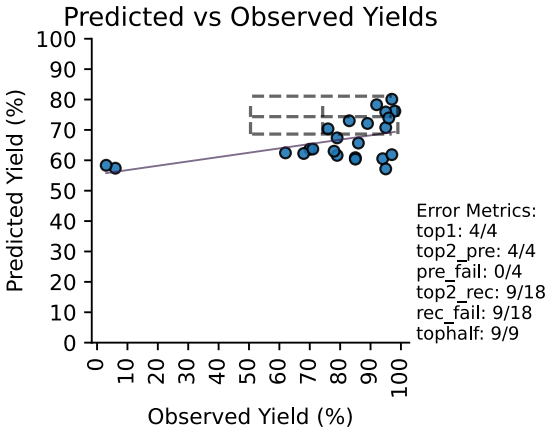
Data for **3_14**

	Predicted Yield %	Observed Yield %
3_14_7_1_a	76.0	98.0
3_14_8_1_a	76.0	95.0
3_14_14_1_a	72.0	89.0
3_14_16_1_a	71.0	95.0
3_14_17_1_a	61.0	94.0
3_14_10_1_b	57.0	6.0
3_14_14_1_b	64.0	70.0
3_14_20_1_b	62.0	68.0
3_14_21_1_b	61.0	85.0
3_14_9_1_c	62.0	97.0
3_14_9_2_a	80.0	97.0
3_14_10_2_a	58.0	3.0
3_14_16_2_a	74.0	96.0
3_14_7_2_b	70.0	76.0
3_14_8_2_b	73.0	83.0
3_14_20_2_b	66.0	86.0
3_14_21_2_b	64.0	71.0
3_14_9_3_a	78.0	92.0
3_14_7_3_b	67.0	79.0
3_14_10_3_b	60.0	85.0
3_14_17_3_b	62.0	79.0
3_14_21_3_b	63.0	78.0
3_14_8_3_c	62.0	62.0
3_14_14_3_c	57.0	95.0

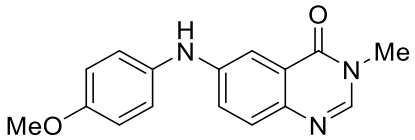


3_14





A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*

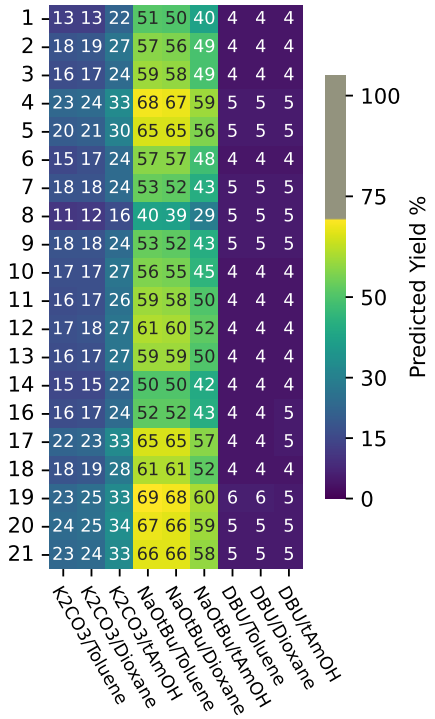


6-((4-Methoxyphenyl)amino)-3-methylquinazolin-4(3H)-one **(3_14)**

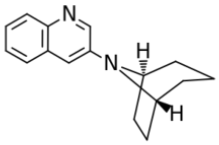
State	Solid
m.p.	99 °C
^{1}H NMR	(400 MHz, $CDCl_3$)
	δ 7.86 (s, 1H), 7.67 (d, *J* = 3.0 Hz, 1H), 7.56 (d, *J* = 8.9 Hz, 1H), 7.28 (dd, *J* = 8.9, 2.7 Hz, 1H), 7.14 (d, *J* = 9.1 Hz, 2H), 6.90 (d, *J* = 8.9 Hz, 2H), 5.83 (s, 1H), 3.82 (s, 3H), 3.56 (s, 3H).
^{13}C{^{1}H} NMR	(101 MHz, $CDCl_3$)
	δ 161.57, 156.36, 145.18, 143.80, 141.64, 134.41, 128.84, 123.58, 123.27, 122.89, 115.06, 108.50, 55.73, 34.13.
IR (cm^{-1})	ATR (neat)
	3313 (w), 2949 (w), 1647 (m), 1606 (m), 1525 (m), 1485 (m), 1433 (w), 1404 (w), 1329 (m), 1294 (w), 1271 (w), 1236 (m), 1173 (w), 1115 (w), 1063 (w), 1028 (m), 1011 (w), 924 (w), 889 (w), 866 (w), 820 (m), 785 (m), 762 (m), 704 (w).
HRMS (ES+)	Calcd for $C_{16}H_{16}N_3O_2$ (M+H)+: 282.1241 Found: 282.1241

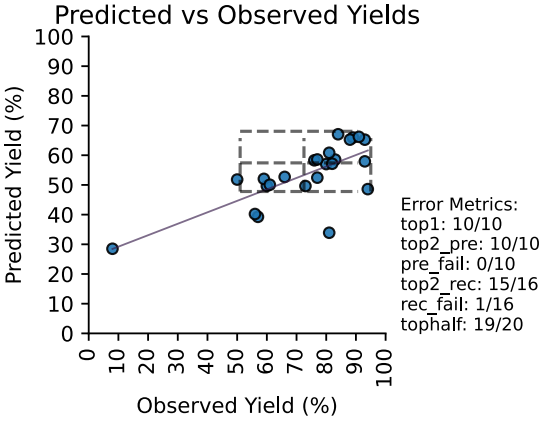
Data for **42_22**

	Predicted Yield %	Observed Yield %
42_22_1_1_b	50.0	60.0
42_22_4_1_b	67.0	84.0
42_22_6_1_b	57.0	80.0
42_22_8_1_b	39.0	57.0
42_22_9_1_b	52.0	59.0
42_22_11_1_b	58.0	76.0
42_22_13_1_b	59.0	77.0
42_22_14_1_b	50.0	73.0
42_22_16_1_b	52.0	50.0
42_22_20_1_b	66.0	89.0
42_22_20_2_a	34.0	81.0
42_22_2_2_b	49.0	94.0
42_22_8_2_b	29.0	8.0
42_22_21_2_b	58.0	93.0
42_22_3_3_b	59.0	83.0
42_22_5_3_b	65.0	93.0
42_22_6_3_b	57.0	82.0
42_22_8_3_b	40.0	56.0
42_22_9_3_b	53.0	66.0
42_22_14_3_b	50.0	61.0
42_22_16_3_b	52.0	77.0
42_22_17_3_b	65.0	88.0
42_22_18_3_b	61.0	81.0
42_22_21_3_b	66.0	91.0

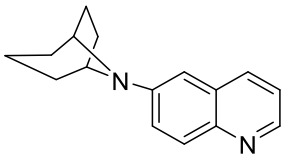


42_22





A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*

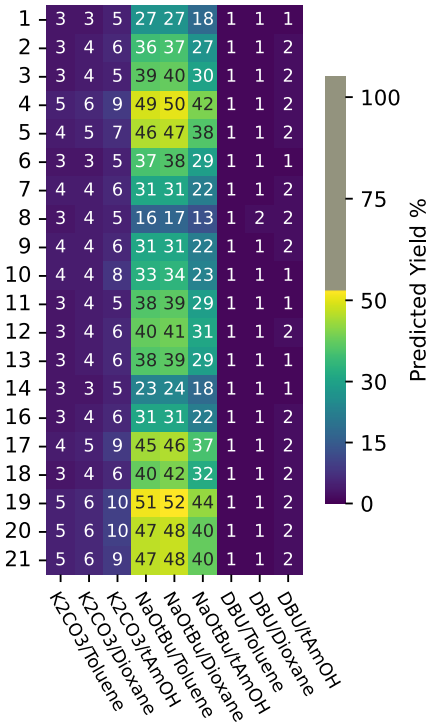


6-(8-Azabicyclo[3.2.1]octan-8-yl)quinoline **(42_22)**

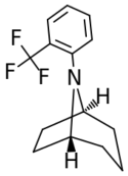
State	Solid
m.p.	71 ^{o}C
^{1}H NMR	(400 MHz, $CDCl_3$)
	δ 8.68 (d, *J* = 2.7 Hz, 1H), 7.98 – 7.92 (m, 1H), 7.59 (dt, *J* = 7.5, 2.6 Hz, 1H), 7.43 – 7.35 (m, 2H), 7.20 – 7.15 (m, 1H), 4.34 (q, *J* = 3.9 Hz, 2H), 2.17 – 2.04 (m, 2H), 1.99 – 1.77 (m, 5H), 1.51 – 1.42 (m, 1H), 1.39 – 1.29 (m, 2H).
^{13}C{^{1}H} NMR	(101 MHz, $CDCl_3$)
	δ 143.41, 141.46, 140.56, 129.76, 129.04, 126.83, 125.93, 124.96, 115.28, 54.76, 28.18, 27.00, 17.56.
IR (cm^{-1})	ATR (neat)
	606, 633, 646, 681, 729, 745, 778, 807, 816, 843, 855, 867, 893, 909, 930, 951, 970, 998, 1016, 1035, 1066, 1094, 1121, 1142, 1165, 1185, 1195, 1218, 1241, 1255, 1293, 1320, 1337, 1374, 1389, 1430, 1449, 1471, 1489, 1592, 1613, 1637, 1700, 1735, 1819, 1850, 1926, 2020, 2202, 2517, 2593, 2672, 2850, 2870, 2931
HRMS (ES+)	Calcd for $C_{16}H_{19}N_2(M+H)^+$: 239.1547 Found: 239.1547

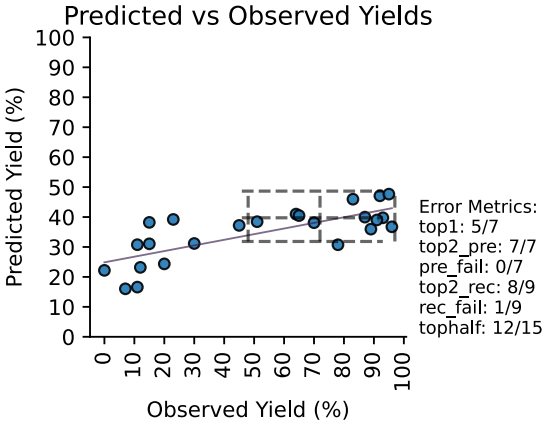
Data for **42_48**

	Predicted Yield %	Observed Yield %
42_48_2_1_b	37.0	96.0
42_48_3_1_b	40.0	87.0
42_48_5_1_b	47.0	92.0
42_48_6_1_b	38.0	70.0
42_48_8_1_b	17.0	11.0
42_48_9_1_b	31.0	15.0
42_48_11_1_b	39.0	23.0
42_48_12_1_b	41.0	64.0
42_48_14_1_b	24.0	20.0
42_48_16_1_b	31.0	30.0
42_48_21_1_b	48.0	95.0
42_48_9_2_b	22.0	0.0
42_48_20_2_b	40.0	93.0
42_48_2_3_b	36.0	89.0
42_48_3_3_b	39.0	91.0
42_48_5_3_b	46.0	83.0
42_48_6_3_b	37.0	45.0
42_48_8_3_b	16.0	7.0
42_48_9_3_b	31.0	11.0
42_48_11_3_b	38.0	15.0
42_48_13_3_b	38.0	51.0
42_48_14_3_b	23.0	12.0
42_48_16_3_b	31.0	78.0
42_48_18_3_b	40.0	65.0

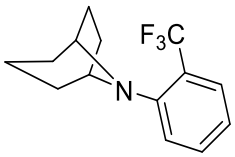


42_48





A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*

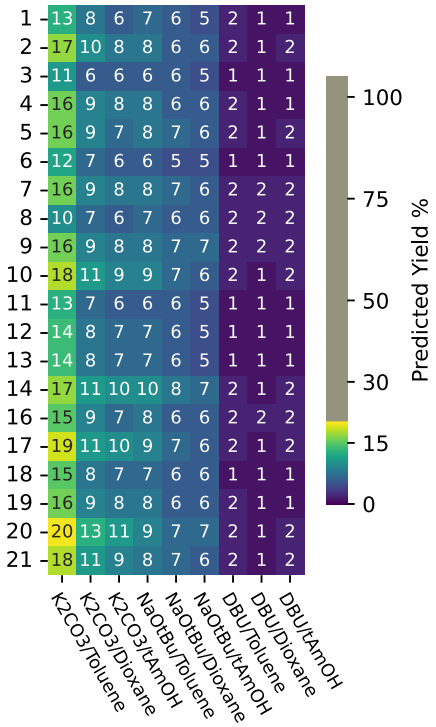


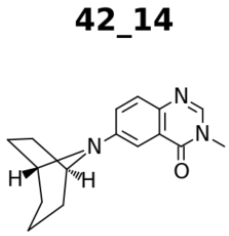
8-(2-(Trifluoromethyl)phenyl)-8-azabicyclo[3.2.1]octane **(42_48)**

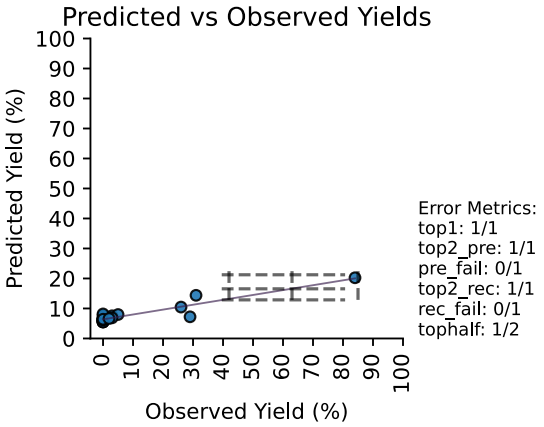
State	Oil
^{1}H NMR	(400 MHz, $CDCl_3$) δ 7.63 – 7.57 (m, 1H), 7.37 (td, *J* = 8.5, 1.9 Hz, 1H), 7.05 – 6.95 (m, 2H), 3.85 (p, *J* = 3.2 Hz, 2H), 2.04 – 1.91 (m, 4H), 1.80 – 1.72 (m, 2H), 1.72 – 1.55 (m, 2H), 1.50 (dtd, *J* = 13.2, 3.8, 1.9 Hz, 2H).
^{13}C{^{1}H} NMR	(101 MHz, $CDCl_3$) δ 150.76, 132.46, 128.28 (q, J_{CF} = 6.06 Hz, 1C), 127.605 (q, J_{CF} = 273.71 Hz, 1C), 122.95 (q, J_{CF} = 29.29 Hz, 1C), 121.03, 120.41, 61.71, 32.31, 28.02, 17.10.
IR (cm^{-1})	ATR (neat) 622, 643, 680, 689, 756, 776, 827, 845, 877, 923, 950, 979, 1003, 1031, 1049, 1060, 1081, 1105, 1122, 1160, 1204, 1228, 1259, 1275, 1311, 1336, 1349, 1359, 1452, 1478, 1489, 1576, 1602 1703,1810, 1921, 1954, 2134, 2564, 2664, 2852, 2871, 2947
HRMS (ES+)	Calcd for $C_{14}H_{17}F_3N$ $(M+H)^+$: 256.1341 Found: 256.1315

Data for **42_14**

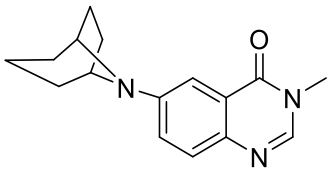
	Predicted Yield %	Observed Yield %
42_14_3_1_b	6.0	0.0
42_14_5_1_b	7.0	0.0
42_14_6_1_b	5.0	0.0
42_14_9_1_b	7.0	0.0
42_14_11_1_b	6.0	0.0
42_14_13_1_b	6.0	0.0
42_14_14_1_b	8.0	3.0
42_14_18_1_b	6.0	0.0
42_14_21_1_b	7.0	0.0
42_14_8_2_b	6.0	0.0
42_14_16_2_b	6.0	0.0
42_14_18_2_b	6.0	0.0
42_14_12_3_a	14.0	31.0
42_14_20_3_a	20.0	84.0
42_14_1_3_b	7.0	29.0
42_14_2_3_b	8.0	5.0
42_14_3_3_b	6.0	0.0
42_14_5_3_b	8.0	0.0
42_14_6_3_b	6.0	0.0
42_14_9_3_b	8.0	0.0
42_14_11_3_b	6.0	0.0
42_14_12_3_b	7.0	3.0
42_14_13_3_b	7.0	2.0
42_14_14_3_b	10.0	26.0







A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*

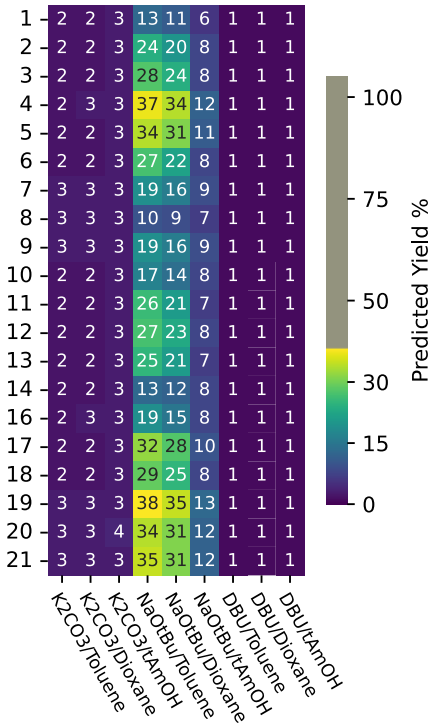


6-(8-Azabicyclo[3.2.1]octan-8-yl)-3-methylquinazolin-4(3H)-one **(42_14)**

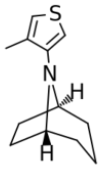
Color and state	Colorless solid
m.p.	139.5-140.5 °C (sealed tube)
^{1}H NMR	(600 MHz, $CDCl_3$)
	δ 7.83 (s, 1H), 7.58 (d, *J* = 8.9 Hz, 1H), 7.48 (d, *J* = 2.9 Hz, 1H), 7.24 (dd, *J* = 8.9, 3.0 Hz, 1H), 4.37 – 4.28 (m, 2H), 3.57 (s, 3H), 2.16 – 2.09 (m, 2H), 1.95 – 1.84 (m, 5H), 1.51 – 1.45 (m, 1H), 1.38 – 1.30 (m, 2H).
^{13}C{^{1}H} NMR	(151 MHz, $CDCl_3$)
	δ 161.82, 146.14, 142.93, 139.36, 128.84, 123.45, 122.65, 108.53, 54.91, 34.14, 28.31, 27.08, 17.61.
IR (cm^{-1})	ATR (neat)
	3064 (w), 2912 (m), 2863 (m), 1794 (w), 1665 (s), 1611 (s), 1491 (s), 1430 (m), 1390 (m), 1366 (s), 1346 (s), 1297 (m), 1259 (m), 1237 (m), 1185 (m), 1159 (m), 1121 (m), 1097 (m), 1056 (m), 1034 (m), 983 (w), 950 (m), 898 (m), 876 (m), 821 (s), 787 (m), 756 (m), 714 (m), 633 (m), 612 (m), 577 (w), 536 (m).
HRMS (ES+)	Calcd for $C_{16}H_{20}N_3O$ $(M+H)^+$: 270.1606 Found: 270.1597
TLC	R_f 0.3 (EtOAc/CH_2Cl_2, 30:70)

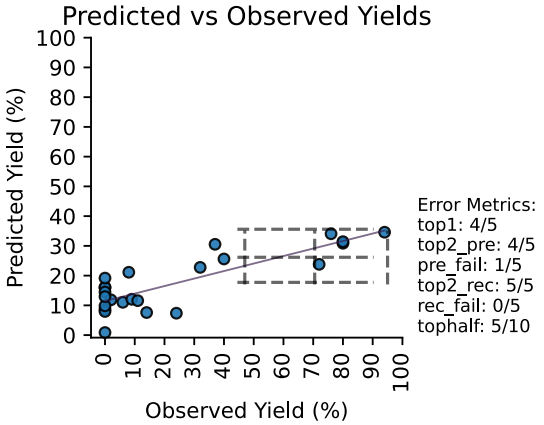
Data for **42_29**

	Predicted Yield %	Observed Yield %
42_29_1_1_b	11.0	6.0
42_29_5_1_b	31.0	37.0
42_29_7_1_b	16.0	0.0
42_29_9_1_b	16.0	0.0
42_29_10_1_b	14.0	0.0
42_29_11_1_b	21.0	8.0
42_29_12_1_b	23.0	32.0
42_29_14_1_b	12.0	2.0
42_29_20_1_b	31.0	80.0
42_29_21_1_b	31.0	80.0
42_29_1_1_c	1.0	0.0
42_29_8_2_b	7.0	24.0
42_29_9_2_b	9.0	0.0
42_29_14_2_b	8.0	14.0
42_29_16_2_b	8.0	0.0
42_29_20_2_b	12.0	9.0
42_29_21_2_b	12.0	11.0
42_29_2_3_b	24.0	72.0
42_29_8_3_b	10.0	0.0
42_29_9_3_b	19.0	0.0
42_29_11_3_b	26.0	40.0
42_29_14_3_b	13.0	0.0
42_29_20_3_b	34.0	76.0
42_29_21_3_b	35.0	94.0

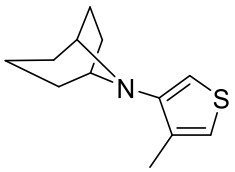


42_29





A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*

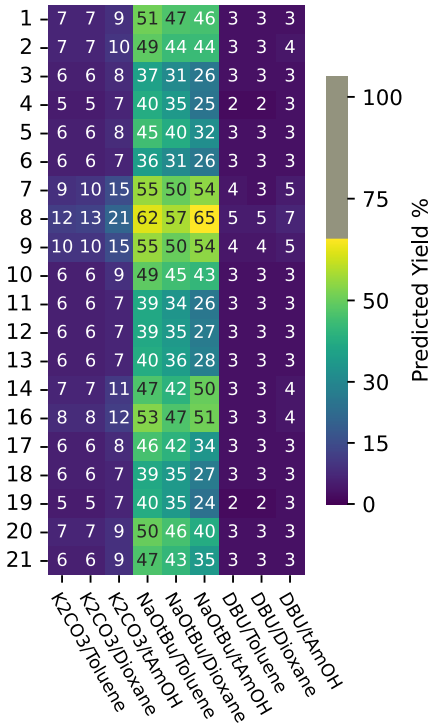


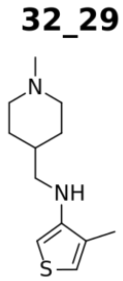
8-(4-Methylthiophen-3-yl)-8-azabicyclo[3.2.1]octane **(42_29)**

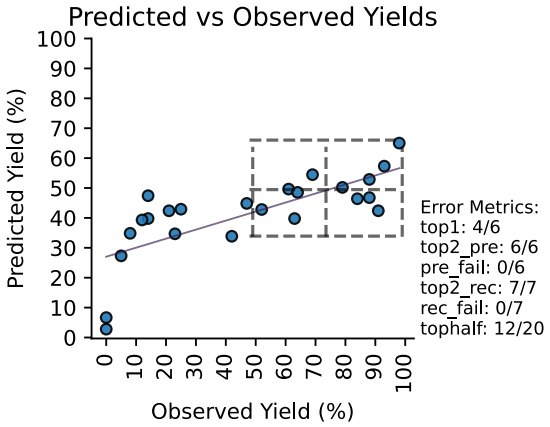
State	Oil
^{1}H NMR	(400 MHz, $CDCl_3$) δ 6.84 (dq, *J* = 3.5, 1.3 Hz, 1H), 6.26 (d, *J* = 3.5 Hz, 1H), 3.77 (dt, *J* = 5.9, 3.2 Hz, 2H), 2.21 (d, *J* = 1.1 Hz, 3H), 2.03 (ddd, *J* = 7.3, 5.1, 2.8 Hz, 2H), 1.91 (tdd, *J* = 12.9, 5.8, 3.1 Hz, 2H), 1.74 – 1.64 (m, 3H), 1.59 – 1.51 (m, 1H), 1.50 – 1.42 (m, 2H).
^{13}C{^{1}H} NMR	(101 MHz, $CDCl_3$) δ 150.33, 132.89, 120.98, 103.57, 59.84, 31.76, 27.42, 16.99, 15.21.
IR (cm^{-1})	ATR (neat) 2937 (w), 2862 (w), 2844 (w), 1543 (w), 1444 (m), 1352 (w), 1311 (w), 1254 (w), 1230 (w), 1201 (w), 1184 (w), 1155 (w), 1132 (w), 1074 (w), 1034 (w), 993 (w), 947 (w), 906 (m), 860 (w), 837 (w), 768 (m), 721 (w), 698 (w), 652 (w), 611 (w).
HRMS (ES+)	Calcd for $C_{12}H_{17}NS$ $(M+H)^+$: 208.1158 Found: 208.1150

Data for **32_29**

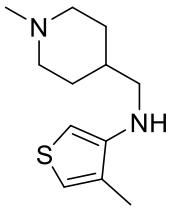
	Predicted Yield %	Observed Yield %
32_29_20_1_a	7.0	0.0
32_29_1_1_b	47.0	88.0
32_29_8_1_b	57.0	93.0
32_29_9_1_b	50.0	61.0
32_29_10_1_b	45.0	47.0
32_29_14_1_b	42.0	21.0
32_29_16_1_b	47.0	14.0
32_29_17_1_b	42.0	91.0
32_29_18_1_b	35.0	23.0
32_29_21_1_b	43.0	52.0
32_29_8_2_b	65.0	98.0
32_29_9_2_b	54.0	69.0
32_29_10_2_b	43.0	25.0
32_29_14_2_b	50.0	79.0
32_29_17_2_b	34.0	42.0
32_29_18_2_b	27.0	5.0
32_29_20_2_b	40.0	14.0
32_29_21_2_b	35.0	8.0
32_29_10_3_b	49.0	64.0
32_29_16_3_b	53.0	88.0
32_29_17_3_b	46.0	84.0
32_29_18_3_b	39.0	12.0
32_29_19_3_b	40.0	63.0
32_29_20_3_c	3.0	0.0







A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*

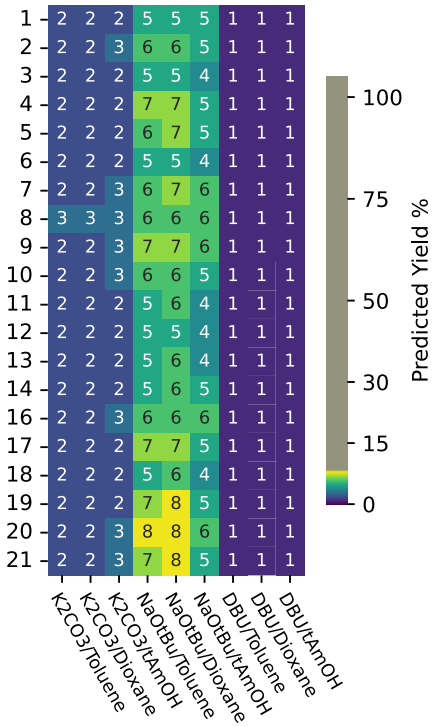


4-Methyl-N-((1-methylpiperidin-4-yl)methyl)thiophen-3-amine **(32_29)**

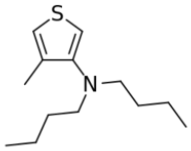
Color and state:	Red oil
^{1}H NMR	(500 MHz, $CDCl_3$)
	δ 6.82 (dt, *J* = 2.4, 1.1 Hz, 1H), 5.89 – 5.82 (m, 1H), 3.39 (s, 1H), 3.00 (d, *J* = 6.6 Hz, 2H), 2.94 (d, *J* = 8.5 Hz, 2H), 2.32 (s, 3H), 2.05 (s, 3H), 2.04 – 1.97 (m, 2H), 1.81 (dt, *J* = 12.5, 2.7 Hz, 2H), 1.70 – 1.60 (m, 1H), 1.44 (qd, *J* = 12.3, 4.0 Hz, 2H).
^{13}C{^{1}H} NMR	(126 MHz, $CDCl_3$)
	δ 147.06, 128.20, 120.69, 94.58, 55.60, 51.93, 46.22, 34.80, 30.25, 13.42.
IR (cm^{-1})	ATR (neat)
	3345 (w br), 2931 (m), 2843 (w), 2780 (m), 2734 (w), 2681 (w), 1678 (w), 1572 (m), 1490 (m), 1446 (m), 1378 (m), 1277 (m), 1209 (m), 1143 (s), 1101 (m), 1071 (m), 980 (m), 909 (m), 885 (w), 857 (m), 764 (s), 729 (s), 691 (m), 639 (m), 557 (m).
HRMS (ES+)	Calcd for $C_{12}H_{21}N_2S$ (M+H)+: 225.1425 Found: 225.1417
TLC	R_f 0.56 (EtOAc/hexane, 5:95)

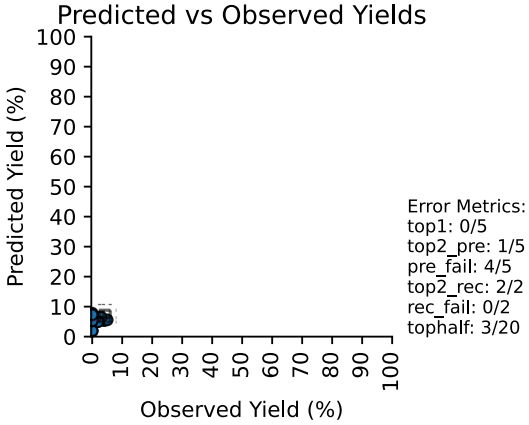
Data for **47_29**

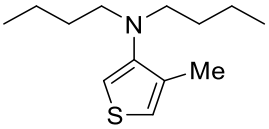
	Predicted Yield %	Observed Yield %
47_29_2_1_b	6.0	2.0
47_29_3_1_b	5.0	4.0
47_29_6_1_b	5.0	2.0
47_29_13_1_b	6.0	0.0
47_29_14_1_b	6.0	5.0
47_29_16_1_b	6.0	3.0
47_29_17_1_b	7.0	0.0
47_29_18_1_b	6.0	0.0
47_29_21_1_b	8.0	0.0
47_29_2_2_b	5.0	0.0
47_29_6_2_b	4.0	0.0
47_29_14_2_b	5.0	0.0
47_29_16_2_b	6.0	0.0
47_29_17_2_b	5.0	0.0
47_29_18_2_b	4.0	0.0
47_29_14_3_a	2.0	0.0
47_29_20_3_a	2.0	0.0
47_29_2_3_b	6.0	0.0
47_29_3_3_b	5.0	2.0
47_29_13_3_b	5.0	0.0
47_29_16_3_b	6.0	0.0
47_29_17_3_b	7.0	0.0
47_29_18_3_b	5.0	0.0
47_29_21_3_b	7.0	0.0



47_29



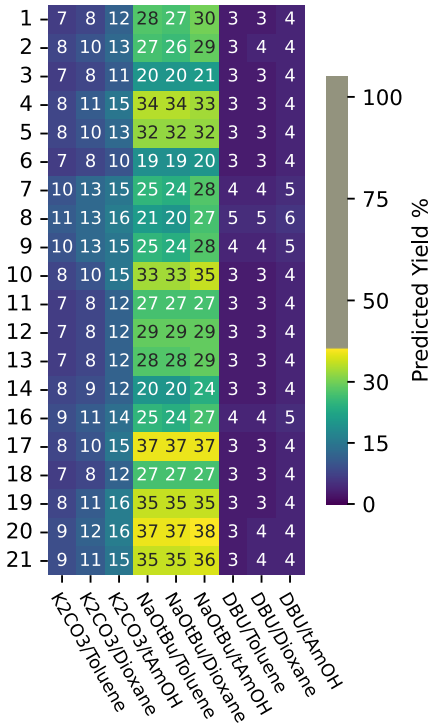




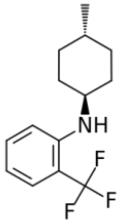
N,*N*-Dibutyl-4-methylthiophen-3-amine **(47_29):** This product was not isolated in pure form, and only formed trace product. Stability of intermediates hindered its independent synthesis.

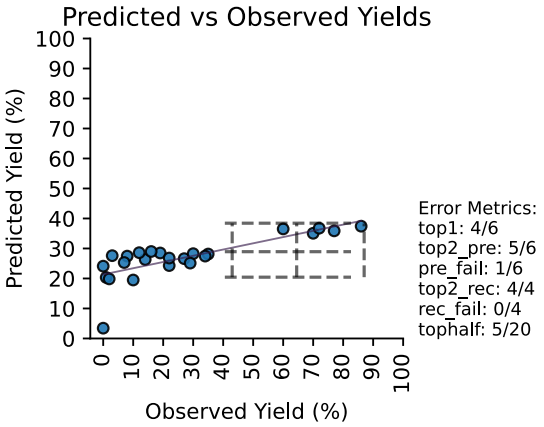
Data for **36_48**

	Predicted Yield %	Observed Yield %
36_48_2_1_b	26.0	14.0
36_48_6_1_b	19.0	10.0
36_48_12_1_b	29.0	19.0
36_48_13_1_b	28.0	35.0
36_48_14_1_b	20.0	1.0
36_48_16_1_b	24.0	22.0
36_48_17_1_b	37.0	60.0
36_48_18_1_b	27.0	27.0
36_48_21_1_b	35.0	70.0
36_48_10_1_c	3.0	0.0
36_48_2_2_b	29.0	16.0
36_48_6_2_b	20.0	2.0
36_48_7_2_b	28.0	3.0
36_48_14_2_b	24.0	0.0
36_48_16_2_b	27.0	34.0
36_48_17_2_b	37.0	86.0
36_48_18_2_b	27.0	8.0
36_48_21_2_b	36.0	77.0
36_48_7_3_b	25.0	7.0
36_48_12_3_b	29.0	12.0
36_48_13_3_b	28.0	30.0
36_48_16_3_b	25.0	29.0
36_48_17_3_b	37.0	72.0
36_48_18_3_b	27.0	22.0

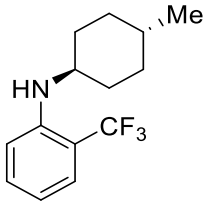


36_48





A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*

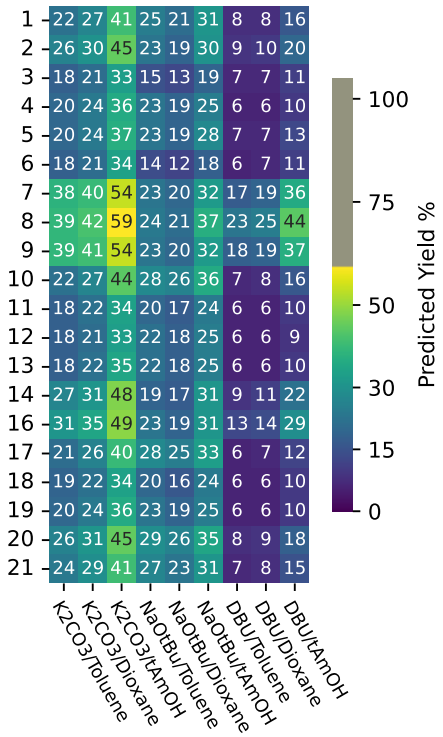


N-(4-Methylcyclohexyl)-2-(trifluoromethyl)aniline **(36_48)**

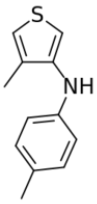
State	Oil
^{1}H NMR	(400 MHz, $CDCl_3$)
	δ 7.41 (d, *J* = 7.8 Hz, 1H), 7.33 (t, *J* = 8.7 Hz, 1H), 6.75 (d, *J* = 8.6 Hz, 1H), 6.66 (t, *J* = 7.0 Hz, 1H), 4.15 (d, *J* = 7.3 Hz, 1H), 3.27 (dtd, *J* = 11.0, 7.3, 3.8 Hz, 1H), 2.16 – 2.07 (m, 2H), 1.82 – 1.73 (m, 2H), 1.42 (dddq, *J* = 16.4, 9.9, 6.4, 3.2 Hz, 1H), 1.29 – 1.00 (m, 4H), 0.93 (d, *J* = 6.4 Hz, 3H).
^{13}C{^{1}H} NMR	(101 MHz, $CDCl_3$)
	δ 145.24, 133.07, 126.86 (q, J_{CF} = 5.05 Hz, 1C), , 125.52 (q, J_{CF} = 274.72 Hz, 1C), 115.41, 113.30 (q, J_{CF} = 29.29 Hz, 1C), 112.58, 52.09, 34.08, 33.30, 32.33, 22.34.
IR (cm^{-1})	ATR (neat)
	3377 (w), 2914 (w), 2856 (w), 1676 (w), 1612 (w), 1583 (w), 1566 (w), 1508 (m), 1444 (w), 1375 (w), 1352 (w), 1288 (w), 1242 (m), 1173 (w), 1120 (w), 1034 (w), 993 (w), 854 (w), 802 (m), 768 (m), 687 (w), 640 (w).
HRMS (ES+)	Calcd for $C_{14}H_{19}F_3N$ (M+H)+: 258.1457 Found: 258.1457

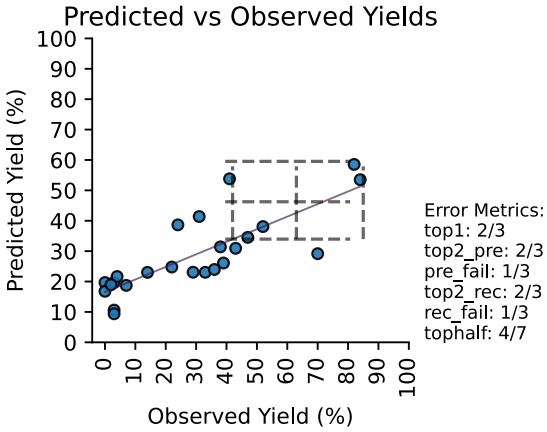
Data for **5_29**

	Predicted Yield %	Observed Yield %
5_29_7_1_b	20.0	3.0
5_29_9_1_b	20.0	0.0
5_29_10_1_b	26.0	39.0
5_29_14_1_b	17.0	0.0
5_29_7_1_c	19.0	7.0
5_29_8_1_c	25.0	22.0
5_29_14_1_c	11.0	3.0
5_29_7_2_a	54.0	84.0
5_29_8_2_a	59.0	82.0
5_29_9_2_a	54.0	41.0
5_29_21_2_a	41.0	31.0
5_29_14_2_b	31.0	38.0
5_29_20_2_b	35.0	47.0
5_29_21_2_b	31.0	43.0
5_29_7_3_a	38.0	52.0
5_29_8_3_a	39.0	24.0
5_29_10_3_a	22.0	4.0
5_29_7_3_b	23.0	33.0
5_29_8_3_b	24.0	36.0
5_29_9_3_b	23.0	14.0
5_29_14_3_b	19.0	2.0
5_29_20_3_b	29.0	70.0
5_29_8_3_c	23.0	29.0
5_29_14_3_c	9.0	3.0

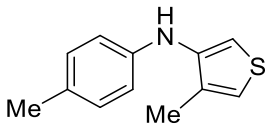


5_29





A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*

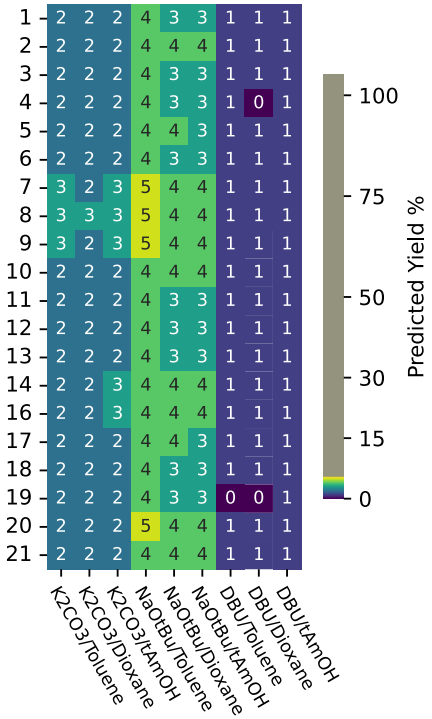


4-Methyl-N-(p-tolyl)thiophen-3-amine **(5_29)**

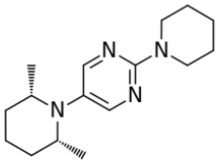
State	Oil
^{1}H NMR	(400 MHz, $CDCl_3$)
	δ 7.06 (d, *J* = 8.6 Hz, 2H), 6.93 (dd, *J* = 3.4, 1.2 Hz, 1H), 6.88 (d, *J* = 8.3 Hz, 2H), 6.74 (d, *J* = 3.2 Hz, 1H), 5.29 (br s, 1H), 2.29 (s, 3H), 2.14 (s, 3H).
^{13}C{^{1}H} NMR	(101 MHz, $CDCl_3$)
	δ 142.48, 141.13, 131.70, 129.96, 129.55, 120.82, 116.42, 106.46, 20.71, 13.76.
IR (cm^{-1})	ATR (neat)
	3460 (w), 2921 (w), 2846 (w), 1612 (m), 1585 (m), 1518 (m), 1470 (m), 1450 (w), 1369 (w), 1329 (m), 1281 (m), 1261 (m), 1146 (m), 1119 (m), 1092 (s), 1025 (m), 937 (w), 890 (w), 843 (w), 741 (m), 647 (w).
HRMS (ES+)	Calcd for $C_{12}H_{14}NS$ (M+H)+: 204.0836 Found: 204.0835

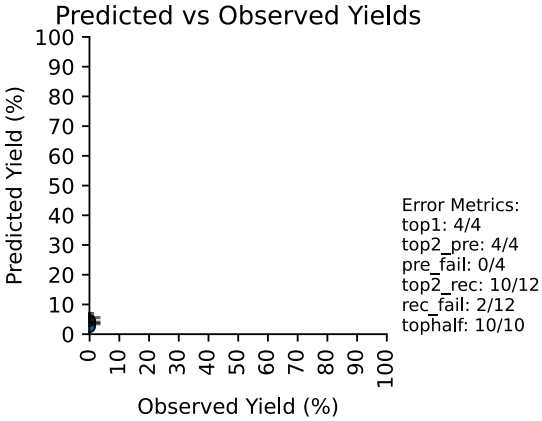
Data for **40_27**

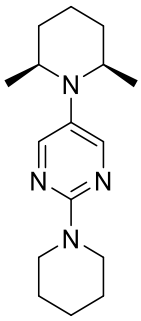
	Predicted Yield %	Observed Yield %
40_27_2_1_b	4.0	0.0
40_27_2_2_b	4.0	0.0
40_27_2_3_b	4.0	0.0
40_27_5_1_b	4.0	0.0
40_27_5_2_b	3.0	0.0
40_27_5_3_b	4.0	0.0
40_27_14_1_b	4.0	0.0
40_27_14_2_b	4.0	0.0
40_27_14_3_b	4.0	0.0
40_27_20_1_b	4.0	0.0
40_27_20_2_a	2.0	0.0
40_27_20_3_b	5.0	0.0



40_27



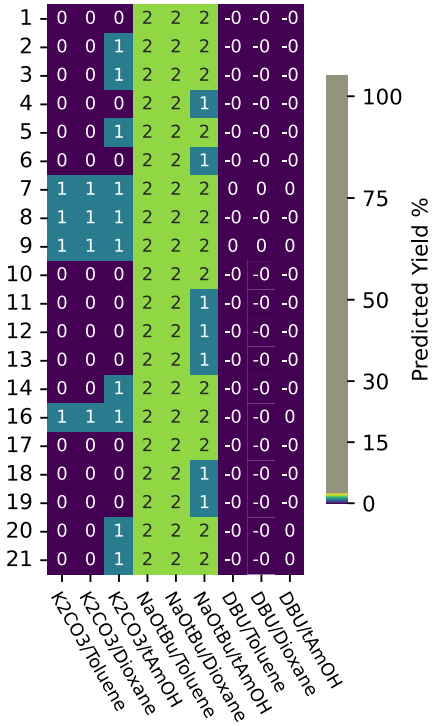




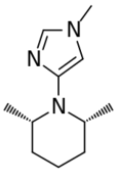
5-(*cis*-2,6-Dimethylpiperidin-1-yl)-2-(piperidin-1-yl)pyrimidine **(40_27):** This product was not formed in the reactions based on unreacted heteroaryl bromide, and was not independently synthesized.

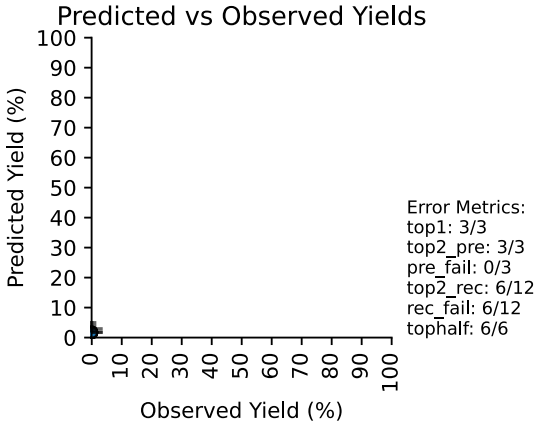
Data for **40_34**

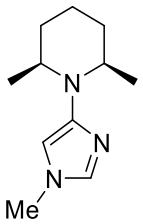
	Predicted Yield %	Observed Yield %
40_34_2_1_b	2.0	0.0
40_34_2_2_b	2.0	0.0
40_34_2_3_b	2.0	0.0
40_34_4_1_b	2.0	0.0
40_34_4_3_b	2.0	0.0
40_34_5_1_b	2.0	0.0
40_34_11_1_b	2.0	0.0
40_34_11_3_b	2.0	0.0
40_34_13_2_b	1.0	0.0
40_34_13_3_b	2.0	0.0
40_34_14_1_b	2.0	0.0
40_34_14_2_b	2.0	0.0



40_34



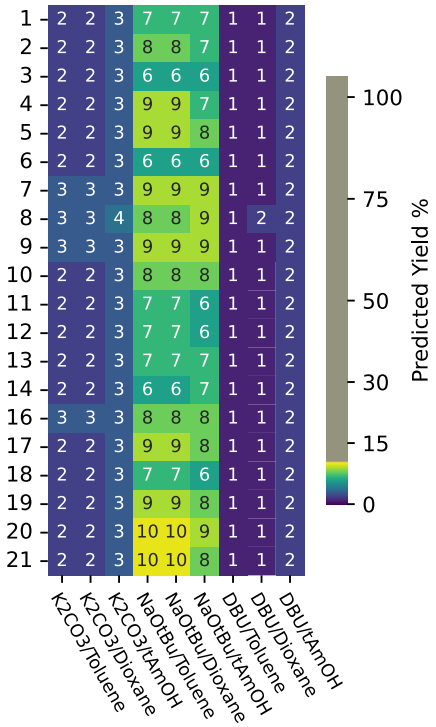




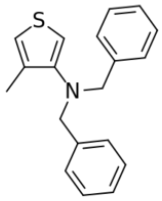
cis-2,6-Dimethyl-1-(1-methyl-1H-imidazol-4-yl)piperidine **(40_34):** This product was not formed in the reactions based on unreacted heteroaryl bromide, and was not independently synthesized.

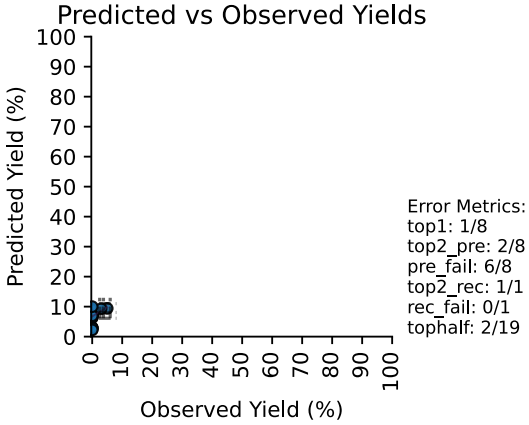
Data for **49_29**

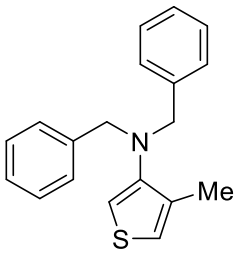
	Predicted Yield %	Observed Yield %
49_29_20_1_a	2.0	0.0
49_29_1_1_b	7.0	0.0
49_29_2_1_b	8.0	0.0
49_29_14_1_b	6.0	0.0
49_29_16_1_b	8.0	0.0
49_29_17_1_b	9.0	0.0
49_29_18_1_b	7.0	0.0
49_29_19_1_b	9.0	5.0
49_29_1_2_a	3.0	0.0
49_29_14_2_a	3.0	0.0
49_29_21_2_a	3.0	0.0
49_29_2_2_b	7.0	0.0
49_29_16_2_b	8.0	0.0
49_29_17_2_b	8.0	0.0
49_29_18_2_b	6.0	0.0
49_29_20_2_b	9.0	0.0
49_29_14_3_a	2.0	0.0
49_29_1_3_b	7.0	0.0
49_29_2_3_b	8.0	0.0
49_29_16_3_b	8.0	0.0
49_29_17_3_b	9.0	0.0
49_29_18_3_b	7.0	0.0
49_29_19_3_b	9.0	3.0
49_29_20_3_b	10.0	0.0



49_29



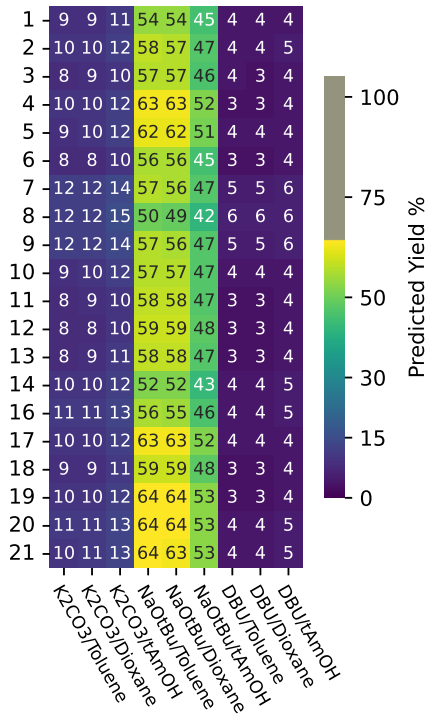


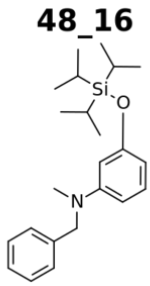


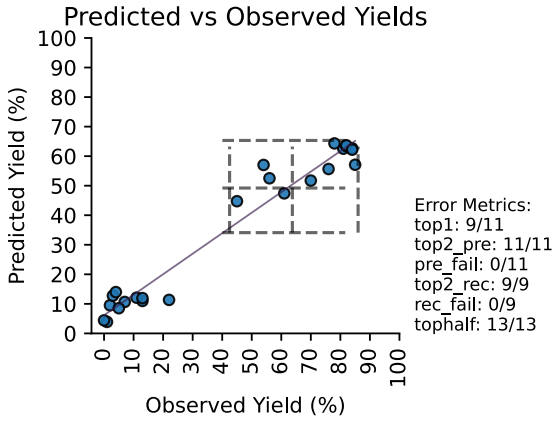
N,*N*-Dibenzyl-4-methylthiophen-3-amine **(49_29):** This product was not isolated in pure form, and only formed trace product. Stability of intermediates hindered its independent synthesis.

Data for **48_16**

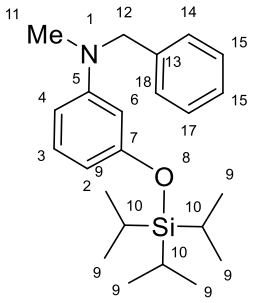
	Predicted Yield %	Observed Yield %
48_16_14_1_a	10.0	2.0
48_16_17_1_b	63.0	81.0
48_16_20_1_a	11.0	22.0
48_16_21_1_b	63.0	82.0
48_16_6_1_b	56.0	76.0
48_16_1_2_a	11.0	13.0
48_16_1_2_b	45.0	45.0
48_16_16_2_a	13.0	3.0
48_16_17_2_b	52.0	70.0
48_16_18_2_a	11.0	7.0
48_16_2_2_a	12.0	11.0
48_16_2_2_b	47.0	61.0
48_16_21_2_b	53.0	56.0
48_16_4_2_a	12.0	13.0
48_16_7_2_a	14.0	4.0
48_16_14_3_c	4.0	1.0
48_16_16_3_c	4.0	0.0
48_16_17_3_b	63.0	84.0
48_16_18_3_a	9.0	5.0
48_16_19_3_b	64.0	78.0
48_16_21_3_b	64.0	82.0
48_16_3_3_b	57.0	85.0
48_16_5_3_b	62.0	84.0
48_16_7_3_b	57.0	54.0







A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*

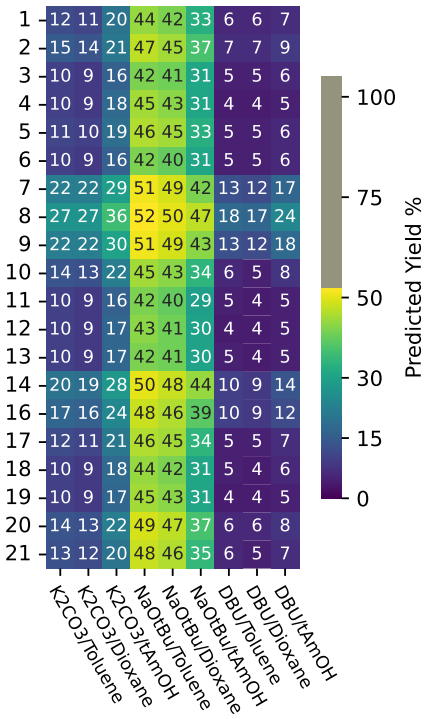


N-Benzyl-*N*-methyl-3-((triisopropylsilyl)oxy)aniline **(48_16**)

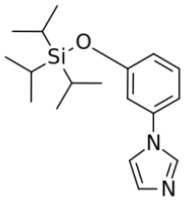
Color and state:	Colorless oil
^{1}H NMR	(500 MHz, $CDCl_3$)
	δ 7.30 (t, *J* = 7.3 Hz, 2H, 2xCH (14 and 18)), 7.25 – 7.18 (m, 3H, 3xCH (15-17)), 7.04 (t, *J* = 8.1 Hz, 1H, CH (3)), 6.36 (dd, *J* = 8.3, 2.7 Hz, 1H, CH (6)), 6.28 – 6.22 (m, 2H, 2xCH (4 and 9), 4.50 (s, 2H, CH2 (12)), 3.01 (s, 3H, CH_3 (11)), 1.19 – 1.11 (m, 3H, 3xCH (10)), 1.05 (d, *J* = 7.0 Hz, 18H, 6xCH_3 (9)).
^{13}C{^{1}H} NMR	(126 MHz, $CDCl_3$)
	δ 157.42 (s, C (7), 151.34 (s, C (5)), 139.43 (s, C(13)), 129.97 (s, C(3)), 128.89 (s, 2xC (14 and 18), 127.16 (s, C (16)), 127.05 (s, 2xC (16 and 17), 108.80 (s, C(2)), 105.89 (s, C (6)), 104.89 (s, C (2), 57.12 (s, C (12)), 39.23 (s, C(11)), 18.28 (s, 6xC (9)), 13.05 (s, 3xC (10)).
IR (cm^{-1})	ATR (neat)
	3028 (w), 2943 (m), 2891 (w), 2865 (m), 1598 (s), 1574 (s), 1497 (s), 1452 (s), 1353 (m), 1266 (s), 1197 (s), 1169 (s), 1117 (m), 1074 (w), 1013 (s), 969 (s), 932 (m), 882 (s), 826 (m).
HRMS (ESI+)	Calcd for $C_{23}H_{35}NOSi$ (M+H)+: 370.2553 Found: 370.2559
TLC	R_f 0.3 (EtOAc/hexane, 5:95)

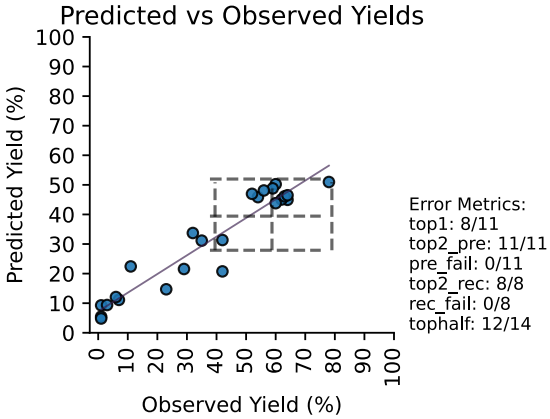
Data for **20_16**

	Predicted Yield %	Observed Yield %
20_16_16_1_b	46.0	54.0
20_16_17_1_b	45.0	64.0
20_16_1_1_a	11.0	7.0
20_16_2_1_b	45.0	62.0
20_16_3_1_a	9.0	1.0
20_16_7_1_c	12.0	6.0
20_16_8_1_b	50.0	60.0
20_16_9_1_b	49.0	59.0
20_16_21_1_b	46.0	63.0
20_16_21_1_c	5.0	1.0
20_16_18_1_a	9.0	3.0
20_16_6_1_c	5.0	1.0
20_16_10_2_b	34.0	32.0
20_16_18_2_b	31.0	42.0
20_16_20_2_a	22.0	29.0
20_16_17_2_a	21.0	42.0
20_16_8_2_b	47.0	52.0
20_16_4_2_b	31.0	35.0
20_16_16_3_b	48.0	56.0
20_16_17_3_b	46.0	64.0
20_16_1_3_b	44.0	60.0
20_16_2_3_a	15.0	23.0
20_16_7_3_b	51.0	78.0
20_16_9_3_a	22.0	11.0

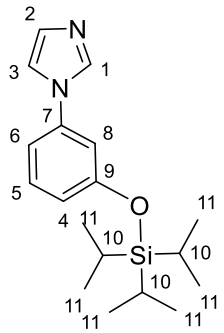


20_16





A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*



1-(3-((Triisopropylsilyl)oxy)phenyl)-1H-imidazole (**20_16**)

Color and state Yellow oil

^{1}H NMR (500 MHz, $CDCl_3$)

δ 7.83 (t, *J* = 1.2 Hz, 1H, HC (1)), 7.30 (t, *J* = 8.1 Hz, 1H, HC (2), 7.25 (t, *J* = 1.3 Hz, 1H, HC (6)), 7.19 (t, *J* = 1.1 Hz, 1H, HC (3)), 6.96 (ddd, *J* = 7.9, 2.1, 1.1 Hz, 1H, HC (4)), 6.90 (t, *J* = 2.2 Hz, 1H, HC (5)), 6.87 (ddd, *J* = 8.2, 2.4, 1.0 Hz, 1H, HC (6)), 1.28 (dt, *J* = 15.0, 7.4 Hz, 3H, HC (11), 1.12 (d, *J* = 7.2 Hz, 18H, CH_3 (10).

^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$)

δ 157.45 (s, C (9)), 138.51 (s, C(7)), 135.70 (s, C(1), 130.70 (s, C(2), 130.47 (s, C(8)), 118.97 (s, C(6)), 118.35 (s, C(3)), 114.09 (s, C(5)), 113.36 (s, C(4)), 18.02 (s, C (11)) 12.46 (s, C(10)).

IR (cm^{-1}) ATR (neat)

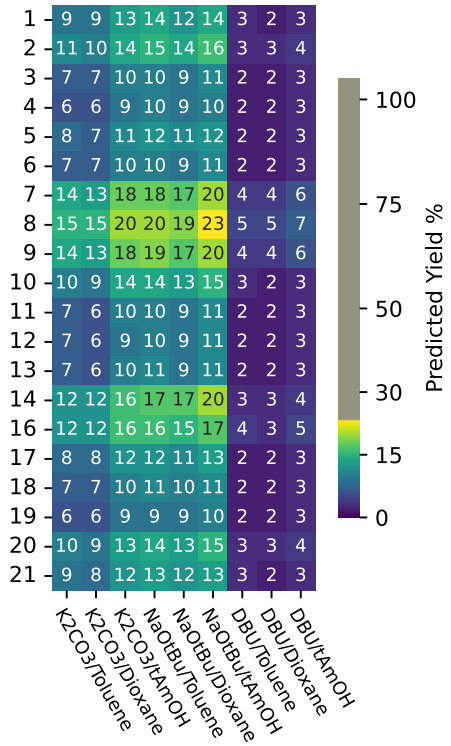
3113 (w), 2944 (m), 2892 (w), 2867 (m), 1602 (s), 1500 (s), 1463 (m), 1368 (w), 1312 (m), 1260 (m), 1219 (s), 1162 (w), 1111 (w), 1055 (m), 1008 (m), 916 (s), 882 (s), 862 (m), 810 (m).

HRMS(ES+) Calcd for $C_{18}H_{28}N_2OSi$ (M+H)+: 317.2049 Found: 317.2041

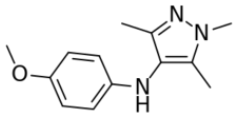
TLC R_f 0.44 (EtOAc/hexane, 20:80)

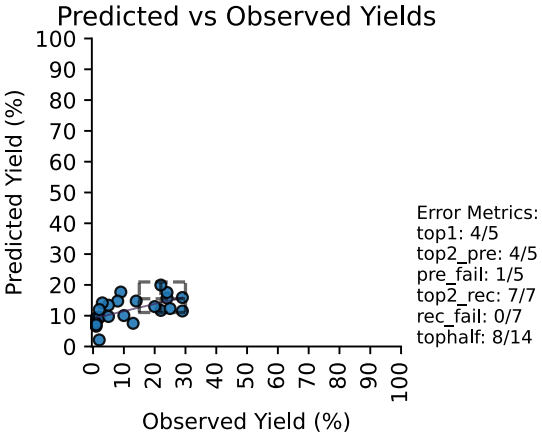
Data for **3_9**

	Predicted Yield %	Observed Yield %
3_9_16_1_a	12.0	22.0
3_9_12_1_b	9.0	2.0
3_9_18_1_a	7.0	1.0
3_9_11_1_b	9.0	1.0
3_9_13_1_b	9.0	2.0
3_9_17_1_a	8.0	13.0
3_9_16_2_a	16.0	29.0
3_9_17_2_a	12.0	29.0
3_9_2_2_b	16.0	24.0
3_9_7_2_a	18.0	24.0
3_9_8_2_a	20.0	22.0
3_9_17_2_b	13.0	20.0
3_9_19_2_b	10.0	10.0
3_9_9_2_a	18.0	9.0
3_9_10_2_b	15.0	8.0
3_9_20_2_a	13.0	5.0
3_9_1_2_b	14.0	3.0
3_9_21_2_a	12.0	2.0
3_9_5_3_a	8.0	1.0
3_9_16_3_a	12.0	25.0
3_9_2_3_b	15.0	14.0
3_9_6_3_a	7.0	1.0
3_9_4_3_b	10.0	5.0
3_9_19_3_c	2.0	2.0

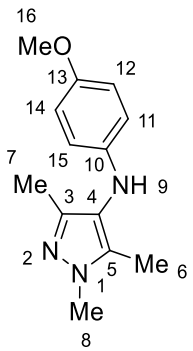


3_9





A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*

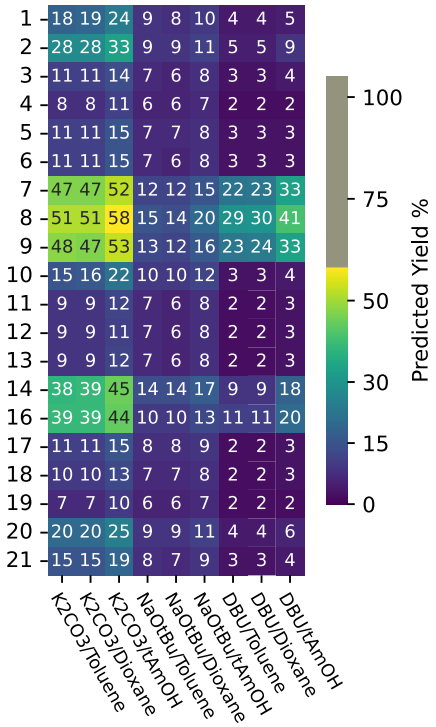


N-(4-Methoxyphenyl)-1,3,5-trimethyl-1H-pyrazol-4-amine **(3_9)**

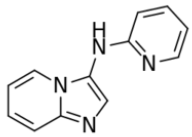
Color and state	Brown solid
m.p.	77.4-78.4 °C (sealed tube)
^{1}H NMR	(500 MHz, $CDCl_3$) δ 6.74 (d, *J* = 8.9 Hz, 2H, 2xCH (11 and 15)), 6.48 (d, *J* = 8.9 Hz, 2H, 2xCH (12 and 14)), 4.60 (br s, 1H, NH (9)), 3.73 (s, 6H 2xCH_3 (8 and 16)), 2.09 (s, 3H, CH_3 (7)), 2.07 (s, 3H, CH_3 (6)).
^{13}C{^{1}H} NMR	(126 MHz, $CDCl_3$) δ 152.55 (s, C (13)), 145.54 (s, C (3)), 142.32 (s, C (10)), 136.56 (s, C (4)), 119.81 (s, C (5)), 115.21 (s, 2xC (11 and 15)), 114.09 (s, 2xC (12 and 14)), 56.19 (s, C (16)), 36.78 (s, C (8)), 11.50 (s, C (7)), 9.44 (s, C (6)).
IR (cm^{-1})	ATR (neat) 3327 (w), 2933 (w br), 1688 (w), 1572 (w), 1508 (s), 1480 (m), 1451 (m), 1380 (m), 1298 (m), 1271 (m), 1235 (s), 1176 (m), 1103 (m), 1035 (s), 815 (s).
HRMS (ESI+)	Calcd for $C_{13}H_{17}N_3O$ (M+H)+: 232.1450 Found: 232.1445
TLC	R_f 0.4 (EtOAc/CH_2Cl_2, 30:70)

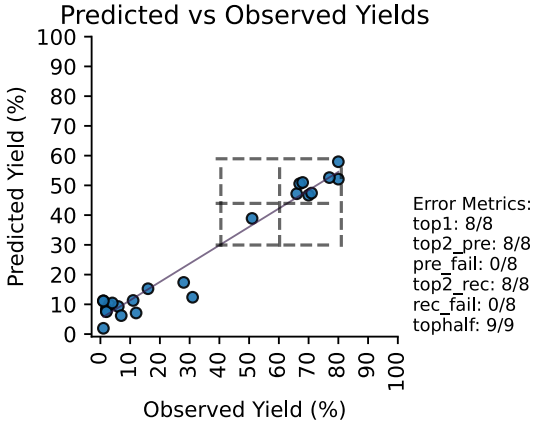
Data for **11_35**

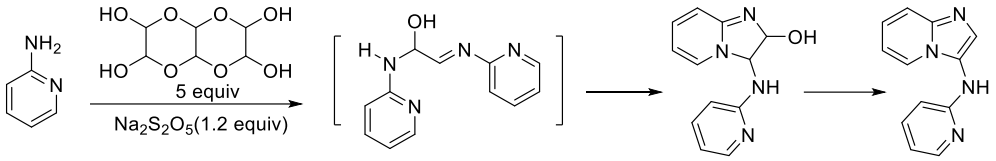
	Predicted Yield %	Observed Yield %
11_35_9_1_a	47.0	66.0
11_35_7_1_a	47.0	70.0
11_35_8_1_a	51.0	67.0
11_35_4_1_c	2.0	1.0
11_35_6_1_a	11.0	1.0
11_35_1_2_b	10.0	3.0
11_35_5_2_b	8.0	2.0
11_35_17_2_b	9.0	6.0
11_35_8_2_a	58.0	80.0
11_35_7_2_a	52.0	80.0
11_35_9_2_a	53.0	77.0
11_35_10_2_b	12.0	31.0
11_35_14_2_b	17.0	28.0
11_35_17_2_a	15.0	16.0
11_35_19_2_b	7.0	12.0
11_35_2_2_b	11.0	11.0
11_35_13_2_b	8.0	2.0
11_35_11_2_b	8.0	2.0
11_35_7_3_a	47.0	71.0
11_35_8_3_a	51.0	68.0
11_35_16_3_a	39.0	51.0
11_35_4_3_b	6.0	7.0
11_35_16_3_b	10.0	4.0
11_35_3_3_a	11.0	1.0



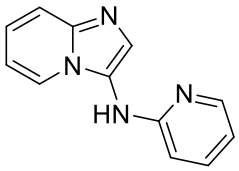
11_35







Prepared in analogy to a literature procedure.(*72*) A mixture of glyoxal trimer dihydrate (1.3 g) and $Na_2S_2O_5$ (4.25 g) in 15 mL of N_2-degassed water was heated on an oil bath at 90 ºC until homogeneous (15 min), then treated with 2-aminopyridine (3.5 g), and heated for an additional 12 h. The reaction mixture was allowed to cool to room temperature with vigorous stirring, diluted with water (30 mL) and extracted three times with CH_2Cl_2 (2 × 15 mL). The combined organic phases were dried over $MgSO_4$, filtered, and the solvent was removed under reduced pressure. Flash column chromatography on silica gel (EtOAc/ hexane, 0:100 to 50:50) afforded the product as white solid. Yield: 580 mg (20%).



N-(Pyridin-2-yl)imidazo[1,2-a]pyridin-3-amine **(11_35)**

Color and state: White needles

m.p. 175-177 °C (seal tube)

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.12 (dd, *J* = 5.0, 0.9 Hz, 1H), 7.92 (dt, *J* = 6.9, 1.2 Hz, 1H), 7.63 (dt, *J* = 9.2, 1.2 Hz, 1H), 7.60 (s, 1H), 7.41 (ddd, *J* = 8.4, 7.2, 1.9 Hz, 1H), 7.25 – 7.15 (m, 2H), 6.81 (td, *J* = 6.8, 1.2 Hz, 1H), 6.76 – 6.71 (m, 1H), 6.17 (d, *J* = 8.4 Hz, 1H).

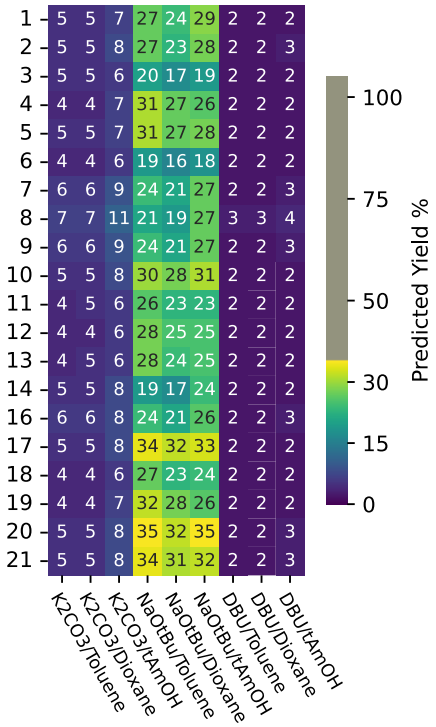
^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$)
δ 157.95, 148.76, 144.22, 138.81, 130.18, 124.87, 122.98, 121.85, 118.70, 115.88, 112.73, 106.92.

HRMS (ESI+) Calcd for $C_{12}H_{10}N_4$ (M+H)+: 211.0970 Found: 211.0976

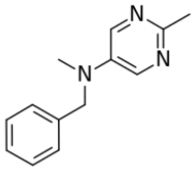
TLC R_f 0.35 (EtOAc/hexane, 50:50)

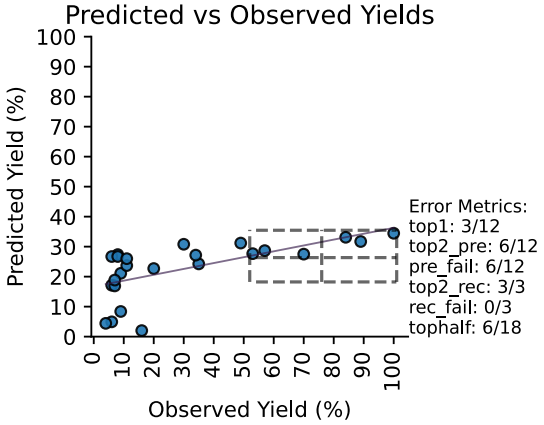
Data for **48_17**

	Predicted Yield %	Observed Yield %
48_17_14_1_b	17.0	6.0
48_17_17_1_b	32.0	89.0
48_17_16_1_b	21.0	9.0
48_17_13_1_b	24.0	35.0
48_17_5_1_b	27.0	34.0
48_17_11_1_b	23.0	20.0
48_17_3_1_b	17.0	7.0
48_17_14_2_b	24.0	11.0
48_17_8_2_b	27.0	8.0
48_17_9_2_b	27.0	6.0
48_17_17_2_b	33.0	84.0
48_17_7_2_b	27.0	8.0
48_17_10_2_b	31.0	49.0
48_17_1_2_b	29.0	57.0
48_17_19_2_b	26.0	11.0
48_17_2_2_b	28.0	53.0
48_17_20_2_a	8.0	9.0
48_17_21_3_a	5.0	6.0
48_17_12_3_c	2.0	16.0
48_17_6_3_a	4.0	4.0
48_17_1_3_b	27.0	70.0
48_17_4_3_b	31.0	30.0
48_17_14_3_b	19.0	7.0
48_17_17_3_b	34.0	100.0

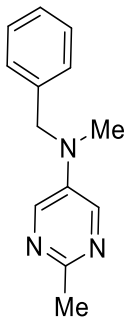


48_17





A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*

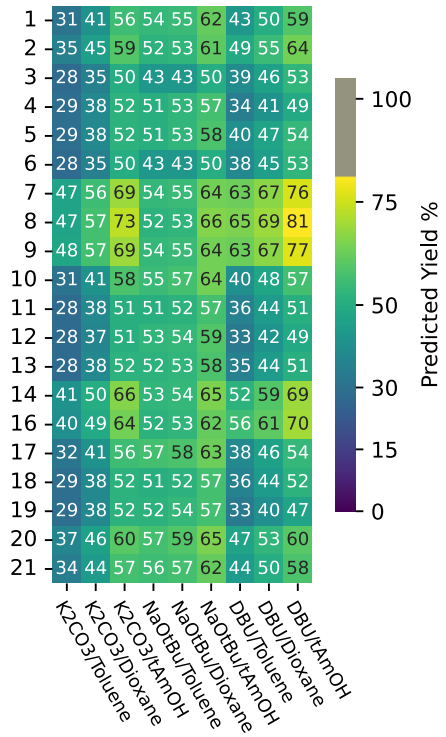


N-Benzyl-N,2-dimethylpyrimidin-5-amine **(48_17)**

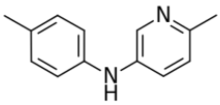
Color and state	Off white solid
m.p.	64.2-65.2 °C (sealed tube)
^{1}H NMR	(500 MHz, $CDCl_3$)
	δ 8.15 (s, 2H, 2xHC (3 and 5), 7.32 (t, *J* = 7.3 Hz, 2H, 2xHC(10 and 14), 7.27 (d, *J* = 6.4 Hz, 1H, HC (12)), 7.19 (d, *J* = 7.2 Hz, 2H, 2xHC (11 and 13), 4.51 (s, 2H, H_2C (8)), 3.03 (s, 3H, H_3CN (16)), 2.60 (s, 3H, H_3CC (15)).
^{13}C{^{1}H} NMR	(126 MHz, $CDCl_3$)
	δ 156.16 (s, C(1)) 140.97 (s, 2xC(3 and 5) 140.58 (s, C(4)), 137.36 (s, C(9)), 128.96 (s, 2xC(10 and 14)), 127.59(s, C(12)) 126.86 (s, 2XC(11 and 13), 56.14 (s, C(16), 38.35 (s, C(8)) 24.71 (s, C(15).
IR (cm^{-1})	ATR (neat)
	3024 (w), 2925 (m br), 1579 (m), 1538 (m), 1450 (s), 1376 (s), 1353 (s), 1293 (s), 1263 (m), 1216 (m), 1186 (s), 1123 (m), 1073 (m), 1028 (m), 1002 (m), 946 (m), 899 (m), 828 (m).
HRMS (ES+)	Calcd for $C_{13}H_{16}N_3$ (M+H)+: 214.1344 Found: 214.1338
TLC	R_f 0.3 (EtOAc/hexane, 30:70)

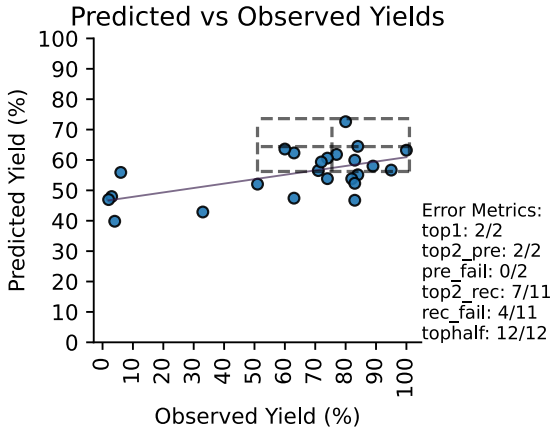
Data for **5_18**

	Predicted Yield %	Observed Yield %
5_18_8_1_a	57.0	95.0
5_18_14_1_b	54.0	74.0
5_18_2_1_c	55.0	84.0
5_18_19_1_b	54.0	82.0
5_18_5_1_c	47.0	83.0
5_18_6_1_b	43.0	33.0
5_18_10_2_b	64.0	84.0
5_18_5_2_a	52.0	83.0
5_18_20_2_a	60.0	83.0
5_18_13_2_b	58.0	89.0
5_18_21_2_b	62.0	77.0
5_18_1_2_b	62.0	63.0
5_18_11_2_b	57.0	71.0
5_18_2_2_b	61.0	74.0
5_18_2_2_a	59.0	72.0
5_18_8_2_a	73.0	80.0
5_18_17_2_a	56.0	6.0
5_18_16_2_a	64.0	60.0
5_18_9_3_a	48.0	3.0
5_18_16_3_a	40.0	4.0
5_18_7_3_a	47.0	63.0
5_18_8_3_a	47.0	2.0
5_18_2_3_b	52.0	51.0
5_18_9_3_c	63.0	100.0

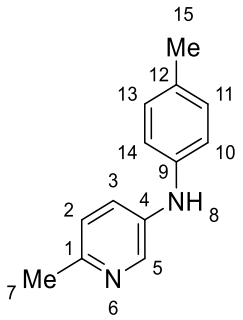


5_18





A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*

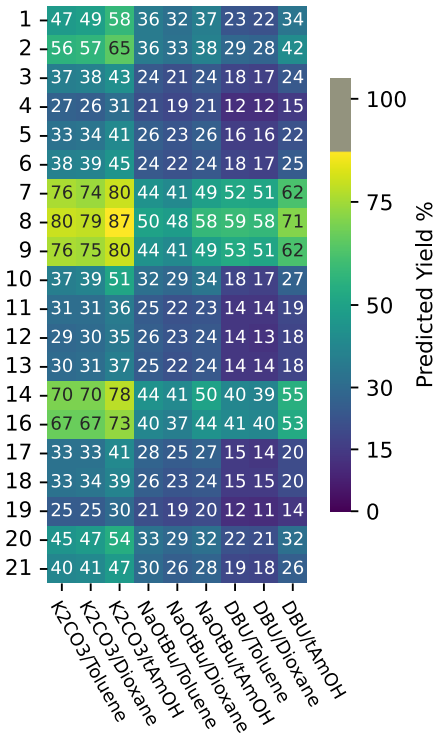


6-Methyl-*N*-(p-tolyl)pyridin-3-amine **(5_18)**

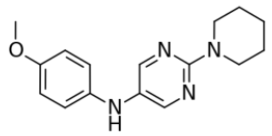
Color and state	Brown solid
m.p.	92.4-93.4 °C (sealed tube)
^{1}H NMR	(500 MHz, $CDCl_3$) δ 8.25 (d, *J* = 2.7 Hz, 1H, CH (5)), 7.29 (dd, *J* = 8.4, 2.9 Hz, 1H, CH (2)), 7.08 (d, *J* = 8.1 Hz, 2H, 2xCH (10 and 14)), 7.02 (d, *J* = 8.2 Hz, 1H, CH (3)), 6.94 (d, *J* = 8.5 Hz, 2H, 2xCH (11 and 13)), 5.56 (br s, 1H, NH (8)), 2.48 (s, 3H, CH_3 (7)), 2.30 (s, 3H, CH_3 (15)).
^{13}C{^{1}H} NMR	(126 MHz, $CDCl_3$) δ 150.64 (s, C(1)), 140.50 (s, C(9)), 139.95 (s, C(5)), 138.04 (s, C(4)), 131.51 (s, C(12), 130.38 (s, 2xC (10 and 14)), 125.09 (s, C(2)), 123.54 (s, C(3)), 118.54 (s, 2xC(11 and 13), 23.89 (s, C(7)), 21.05 (s, C(15).
IR (cm^{-1})	ATR (neat) 3255 (w), 3010 (w br), 2917 (w), 1606 (m), 1572 (w), 1520 (s), 1486 (m), 1415 (m), 1326 (s), 1248 (m), 1216 (m), 1177 (m), 1135 (m), 1110 (m), 1021 (m), 902 (m), 831 (m), 811 (s).
HRMS (ESI+)	Calcd for $C_{13}H_{14}N_2$ (M+H)+: 199.1235 Found: 199.1236
TLC	R_f 0.3 (EtOAc/hexane, 30:70)

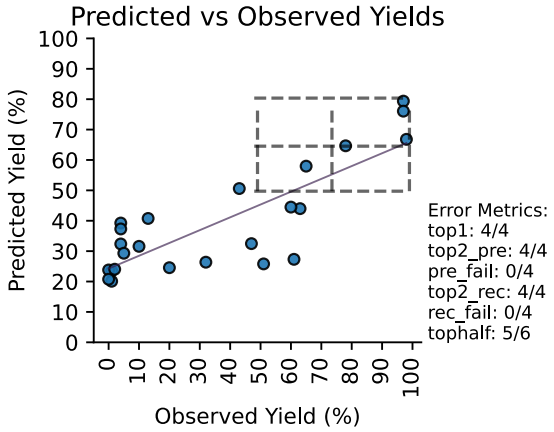
Data for **3_27**

	Predicted Yield %	Observed Yield %
3_27_1_1_b	32.0	47.0
3_27_5_1_b	23.0	1.0
3_27_7_1_b	41.0	13.0
3_27_8_1_a	79.0	97.0
3_27_16_1_a	67.0	98.0
3_27_21_1_b	26.0	32.0
3_27_7_1_c	51.0	43.0
3_27_16_2_b	44.0	63.0
3_27_20_2_b	32.0	4.0
3_27_19_2_b	20.0	1.0
3_27_18_2_a	39.0	4.0
3_27_17_2_b	27.0	61.0
3_27_13_2_b	24.0	0.0
3_27_8_2_b	58.0	65.0
3_27_2_2_a	65.0	78.0
3_27_4_2_b	21.0	0.0
3_27_3_3_b	24.0	2.0
3_27_9_3_b	44.0	60.0
3_27_9_3_a	76.0	97.0
3_27_10_3_a	37.0	4.0
3_27_10_3_b	32.0	10.0
3_27_11_3_b	25.0	20.0
3_27_12_3_a	29.0	5.0
3_27_12_3_b	26.0	51.0

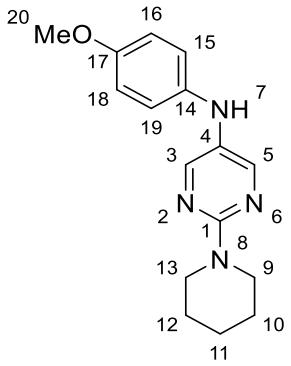


3_27





A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*

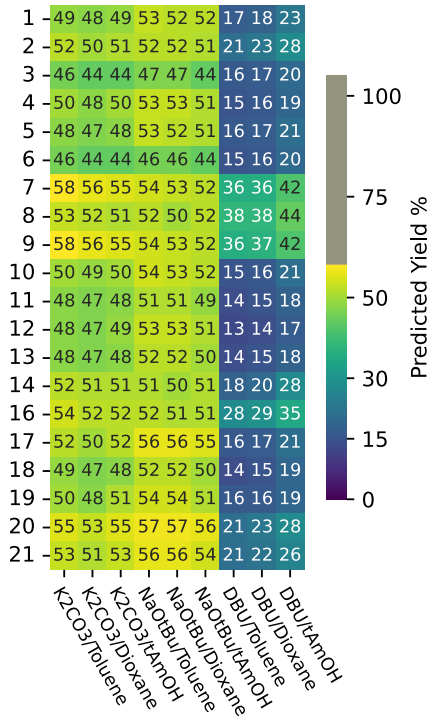


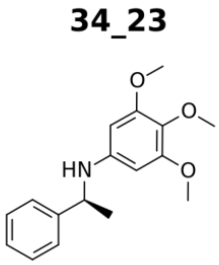
N-(4-Methoxyphenyl)-2-(piperidin-1-yl)pyrimidin-5-amine **(3_27)**

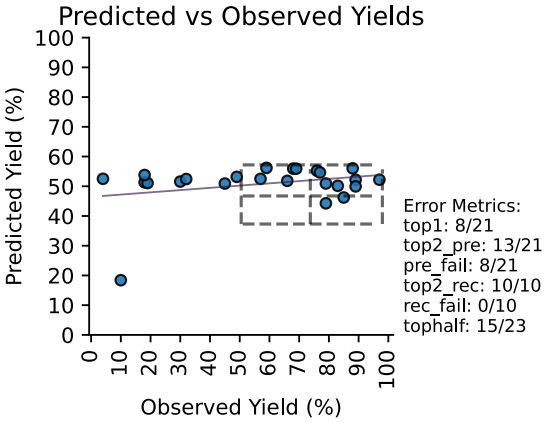
Color and state	Brown solid
m.p.	93.2-94.2 °C (sealed tube)
^{1}H NMR	(500 MHz, $CDCl_3$) δ 8.19 (s, 2H, 2xCH (3 and 5)), 6.78 (d, *J* = 9.0 Hz, 2H, 2xCH (15 and 19)), 6.74 (d, *J* = 9.0 Hz, 2H, 2xCH (16 and 18)), 4.94 (br s, 1H, NH (7)), 3.76-3.74 (m, 7H, 2xCH_2, OCH_3 (20, 9 and 13)), 1.67 (dp, *J* = 6.7, 3.3 Hz, 2H, CH_2 (11)), 1.65 – 1.59 (m, 4H, 2xCH2 (10 and 12)).
^{13}C{^{1}H} NMR	(126 MHz, $CDCl_3$) δ 159.52 (s, C (17), 154.03 (s, C(1), 153.65 (s, 2xC (3 and 5), 139.88 (s, C(14)), 127.57 (s, C (4)), 116.95 (s, 2xC (15 and 19)), 115.32 (s, 2xC (16 and 18), 56.13 (s, C (20)), 45.63 (s, 2xC (9 and 13)), 26.10 (s, 2xC (10 and 12)), 25.22 (s, C (11)).
IR (cm^{-1})	ATR (neat) 3339 (w), 2989 (w), 2917 (w), 2853 (w), 1603 (w), 1500 (s), 1432 (m), 1394 (m), 1362 (s), 1319 (w), 1294 (m), 1265 (m), 1239 (s), 1173 (m), 1108 (m), 1037 (m), 1016 (m), 942 (m), 891 (w), 870 (w), 849 (m), 812 (s).
HRMS (ESI+)	Calcd for $C_{16}H_{20}N_4O$ (M+H)+: 285.1702 Found: 285.1706
TLC	R_f 0.3 (EtOAc/hexane, 20:80)

Data for **34_2**

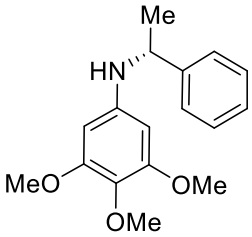
	Predicted Yield %	Observed Yield %
34_23_17_1_b	56.0	68.0
34_23_13_1_b	52.0	66.0
34_23_14_1_a	51.0	79.0
34_23_6_1_b	46.0	85.0
34_23_3_1_a	44.0	79.0
34_23_21_1_a	51.0	18.0
34_23_18_1_b	52.0	30.0
34_23_9_2_a	55.0	76.0
34_23_17_2_b	55.0	77.0
34_23_20_2_b	56.0	69.0
34_23_17_2_a	52.0	97.0
34_23_14_2_b	51.0	45.0
34_23_10_2_b	52.0	32.0
34_23_8_2_a	51.0	19.0
34_23_4_2_a	50.0	83.0
34_23_21_3_b	56.0	88.0
34_23_1_3_b	53.0	49.0
34_23_2_3_b	52.0	57.0
34_23_5_3_b	53.0	4.0
34_23_17_3_b	56.0	59.0
34_23_7_3_b	54.0	18.0
34_23_16_3_b	52.0	89.0
34_23_14_3_c	18.0	10.0
34_23_19_3_a	50.0	89.0







A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*



3,4,5-Trimethoxy-*N*-(1-phenylethyl)aniline **(34_23)** (*73*),(*74*)

<u>^{1}H NMR</u> (500 MHz, $CDCl_3$)

δ 7.38 (d, *J* = 6.7 Hz, 2H), 7.33 (t, *J* = 7.7 Hz, 2H), 7.23 (t, *J* = 7.2 Hz, 1H), 5.75 (s, 2H), 4.43 (q, *J* = 6.7 Hz, 1H), 3.95 (s, 1H), 3.72 (s, 3H), 3.69 (s, 6H), 1.52 (d, *J* = 6.7 Hz, 3H).

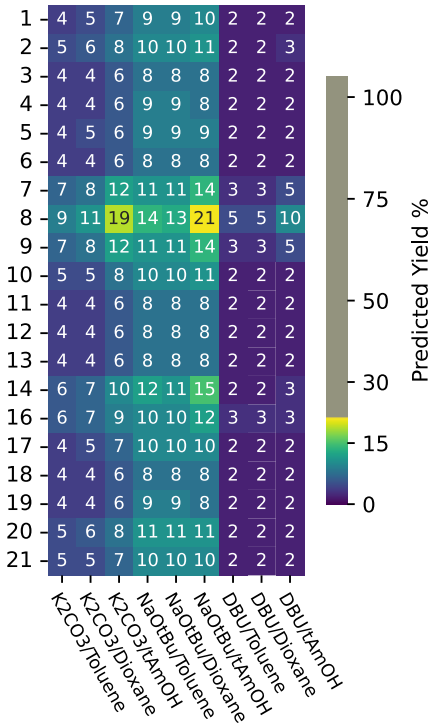
<u>^{13}C{^{1}H} NMR</u> (126 MHz, $CDCl_3$)

δ 154.11, 145.78, 144.46, 130.25, 129.09, 127.36, 126.16, 91.32, 61.42, 56.13, 54.55, 25.39.

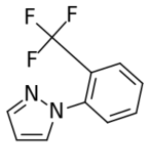
<u>HRMS</u> (ES+) Calcd for $C_{17}H_{21}NO_3$ (M)+: 287.1521 Found: 287.1511

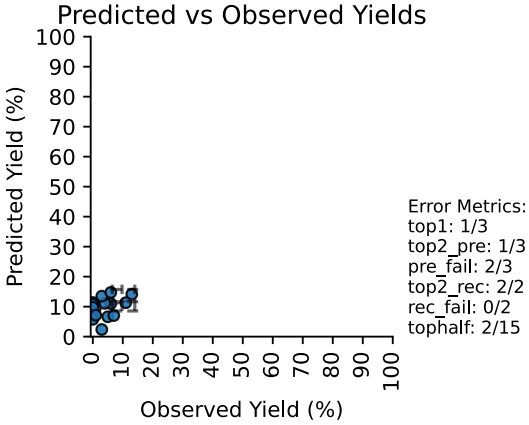
Data for **21_48**

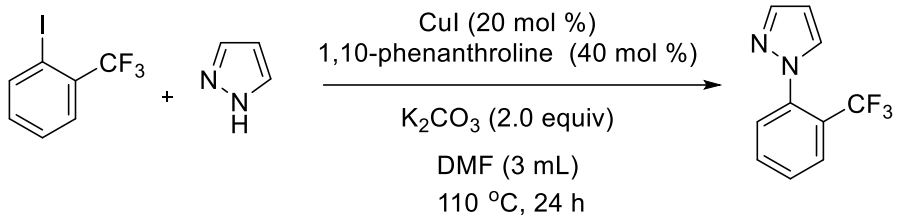
	Predicted Yield %	Observed Yield %
21_48_7_1_b	11.0	6.0
21_48_21_1_b	10.0	1.0
21_48_14_1_a	7.0	5.0
21_48_14_1_c	2.0	3.0
21_48_10_1_b	10.0	0.0
21_48_4_1_b	9.0	0.0
21_48_9_1_b	11.0	4.0
21_48_8_1_b	13.0	3.0
21_48_16_2_a	9.0	0.0
21_48_14_2_b	15.0	6.0
21_48_2_2_b	11.0	0.0
21_48_10_2_b	11.0	0.0
21_48_17_2_a	7.0	0.0
21_48_4_2_b	8.0	0.0
21_48_20_2_a	8.0	0.0
21_48_10_2_a	8.0	0.0
21_48_17_3_b	10.0	0.0
21_48_16_3_a	6.0	0.0
21_48_20_3_b	11.0	0.0
21_48_2_3_b	10.0	0.0
21_48_8_3_b	14.0	13.0
21_48_7_3_b	11.0	11.0
21_48_9_3_a	7.0	1.0
21_48_7_3_a	7.0	7.0



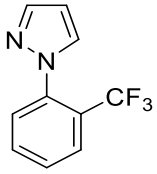
21_48







CuI (38 mg, 20 mol%), 1,10-phenanthroline (72 mg, 40 mol %) and K_2CO_3 (305 mg, 2.0 mmol) were added to DMF (3 mL) followed by 1-iodo-2-(trifluoromethyl)benzene (300 mg, 1.1 mmol) and 1H-pyrazole (89.9mg 1.32 mmol) under nitrogen. The reaction mixture was stirred at 110 °C for 24 h, cooled to ambient temperature, diluted with CH_2Cl_2 (10 mL), filtered through a celite pad on a fritted glass funnel which was washed with CH_2Cl_2 (10 mL). The combined filtrate was concentrated under reduced pressure, and the crude residue was purified by silica gel flash column chromatography (isocratic CH_2Cl_2) to give the product as colorless oil. Yield 150 mg (53.6 mg).



1-(2-(Trifluoromethyl)phenyl)-1H-pyrazole **(21_48)** (*75*),(*76*)

<u>^{1}H NMR</u> (500 MHz, $CDCl_3$)

δ 7.80 (dd, *J* = 7.9, 1.8 Hz, 1H), 7.75 (d, *J* = 1.8 Hz, 1H), 7.69 (d, *J* = 2.6 Hz, 1H), 7.66 (dd, *J* = 7.6, 1.8 Hz, 1H), 7.59 – 7.51 (m, 2H), 6.49 – 6.44 (m, 1H).

<u>^{13}C{^{1}H} NMR</u> (126 MHz, $CDCl_3$)

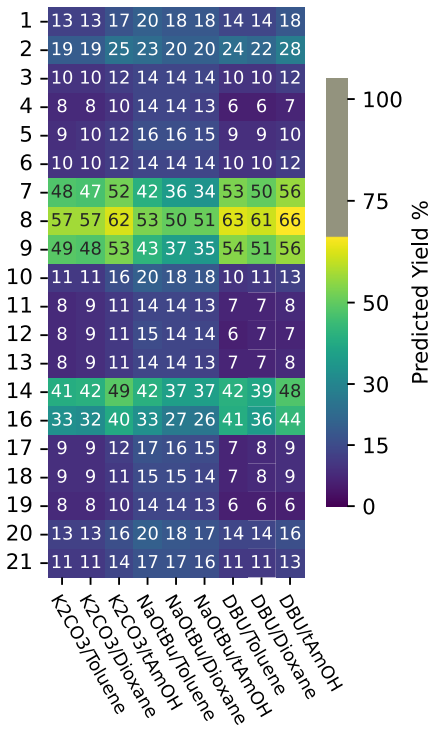
δ 141.53, 139.19, 133.13, 132.10 (q, J_{C3F} = 2.40Hz), 129.49, 129.16, 127.54 (q, J_{C3F} = 5.29 Hz), 126.34 (q, J_{C2F} = 31.25 Hz), 123.43 (q, J_{C1F} = 273.12 Hz), 107.28.

<u>HRMS</u> (ES+) Calcd for $C_{10}H_7F_3N_2$ (M+H)+: 213.0640 Found: 213.0636

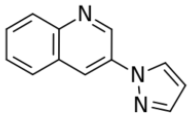
TLC R_f 0.6 (CH_2Cl_2)

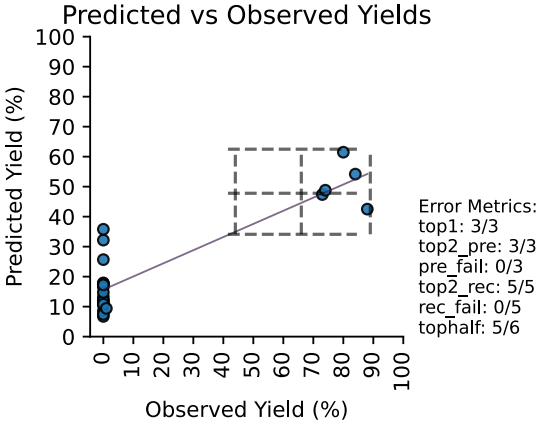
Data for **21_22**

	Predicted Yield %	Observed Yield %
21_22_1_1_a	13.0	0.0
21_22_1_1_b	18.0	0.0
21_22_10_1_a	11.0	0.0
21_22_12_1_c	7.0	0.0
21_22_13_1_a	9.0	0.0
21_22_16_1_a	32.0	0.0
21_22_16_1_c	36.0	0.0
21_22_7_1_a	47.0	73.0
21_22_8_1_c	61.0	80.0
21_22_10_2_b	18.0	0.0
21_22_12_2_a	11.0	0.0
21_22_3_2_a	12.0	0.0
21_22_14_2_a	49.0	74.0
21_22_16_2_b	26.0	0.0
21_22_20_2_b	17.0	0.0
21_22_5_2_a	12.0	0.0
21_22_17_3_b	17.0	0.0
21_22_18_3_b	15.0	0.0
21_22_18_3_c	7.0	0.0
21_22_21_3_b	17.0	0.0
21_22_21_3_a	11.0	0.0
21_22_5_3_a	9.0	1.0
21_22_9_3_c	54.0	84.0
21_22_9_3_b	43.0	88.0

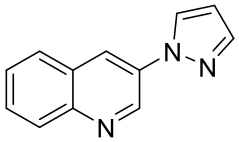


21_22





A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*



3-(1H-Pyrazol-1-yl)quinoline **(21_22)** (*77*)

^{1}H NMR (500 MHz, $CDCl_3$)

δ 9.37 (d, *J* = 2.6 Hz, 1H), 8.41 (d, *J* = 1.7 Hz, 1H), 8.15 (d, *J* = 8.5 Hz, 1H), 8.10 (d, *J* = 2.4 Hz, 1H), 7.89 (d, *J* = 6.4 Hz, 1H), 7.83 (d, *J* = 1.8 Hz, 1H), 7.73 (ddd, *J* = 8.5, 6.9, 1.5 Hz, 1H), 7.61 (ddd, *J* = 8.2, 6.9, 1.3 Hz, 1H), 6.58 (dd, *J* = 2.6, 1.7 Hz, 1H).

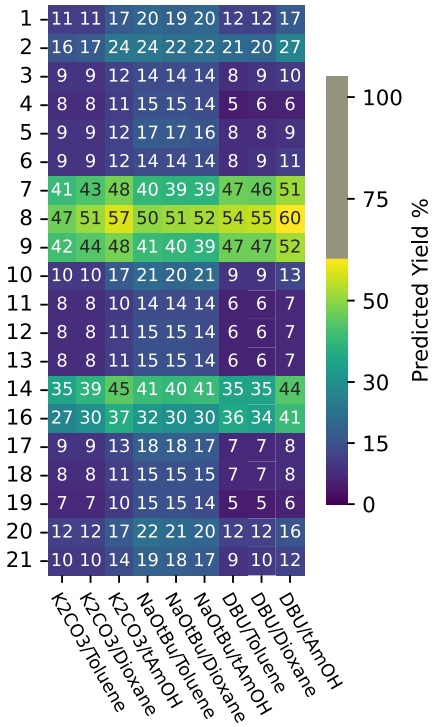
^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$)

δ 147.05, 143.42, 142.47, 133.89, 129.86, 129.69, 128.23, 128.18, 127.48, 124.18, 108.91.

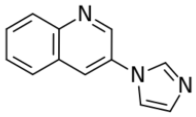
HRMS (ESI+) Calcd for $C_{12}H_9N_3$ (M+H)+: 196.0875 Found: 196.0875

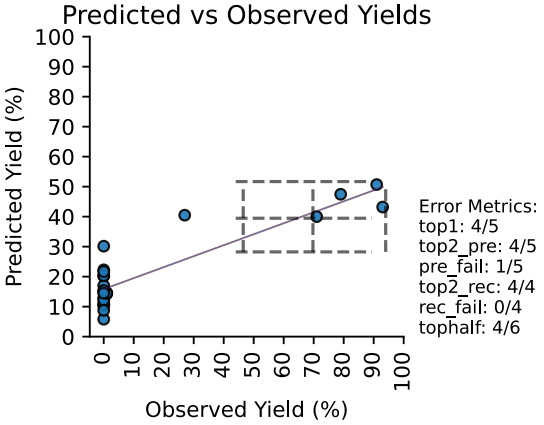
Data for **20_22**

	Predicted Yield %	Observed Yield %
20_22_10_1_a	10.0	0.0
20_22_10_1_b	20.0	0.0
20_22_16_1_b	30.0	0.0
20_22_18_1_b	15.0	0.0
20_22_2_1_a	17.0	0.0
20_22_2_1_b	22.0	0.0
20_22_7_1_a	43.0	93.0
20_22_8_1_b	51.0	91.0
20_22_9_1_b	40.0	71.0
20_22_12_2_a	11.0	0.0
20_22_13_2_a	11.0	0.0
20_22_13_2_b	14.0	1.0
20_22_17_2_a	13.0	0.0
20_22_18_2_b	15.0	1.0
20_22_5_2_a	12.0	0.0
20_22_1_3_b	20.0	0.0
20_22_11_3_b	14.0	1.0
20_22_12_3_c	6.0	0.0
20_22_19_3_b	15.0	0.0
20_22_20_3_b	22.0	0.0
20_22_5_3_a	9.0	0.0
20_22_6_3_b	14.0	0.0
20_22_7_3_b	40.0	27.0
20_22_9_3_c	47.0	79.0

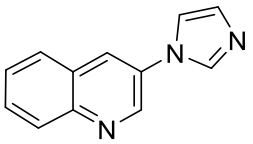


20_22





A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*



3-(1H-Imidazol-1-yl)quinoline **(20_22)** (*71*)

^{1}H NMR (500 MHz, $CDCl_3$)

δ 9.03 (d, *J* = 2.6 Hz, 1H), 8.17 (d, *J* = 8.5 Hz, 1H), 8.13 (d, *J* = 2.7 Hz, 1H), 7.98 (s, 1H), 7.89 (d, *J* = 7.3 Hz, 1H), 7.78 (ddd, *J* = 8.5, 6.9, 1.5 Hz, 1H), 7.65 (t, *J* = 6.9 Hz, 1H), 7.41 (t, *J* = 1.4 Hz, 1H), 7.31 (s, 1H).

^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$)

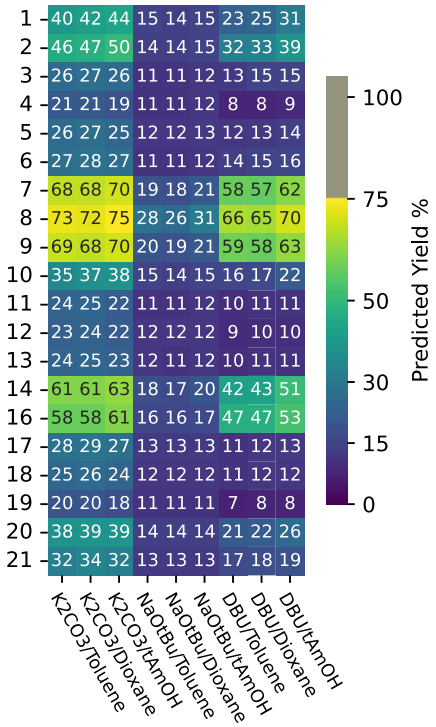
δ 147.33, 144.70, 135.97, 131.36, 130.90, 130.18, 129.73, 128.31, 127.85, 127.73, 126.94, 118.52.

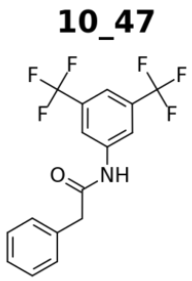
HRMS (ES+) Calcd for $C_{12}H_9N_3$ (M+H)+: 196.0875 Found: 196.0876

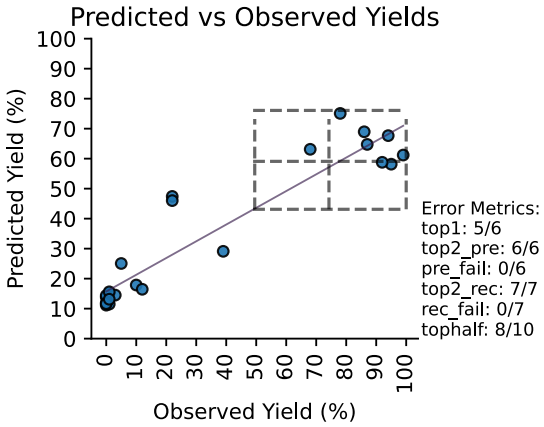
TLC R_f 0.3 (MeOH/CH_2Cl_2, 10:90)

Data for **10_47**

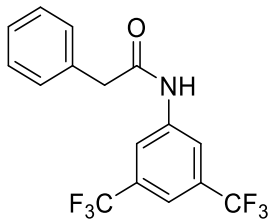
	Predicted Yield %	Observed Yield %
10_47_2_1_a	47.0	22.0
10_47_4_1_b	11.0	0.0
10_47_7_1_a	68.0	94.0
10_47_8_1_c	65.0	87.0
10_47_17_1_a	29.0	39.0
10_47_18_1_b	12.0	1.0
10_47_20_1_b	14.0	0.0
10_47_5_2_a	25.0	5.0
10_47_8_2_a	75.0	78.0
10_47_10_2_b	15.0	1.0
10_47_11_2_b	12.0	0.0
10_47_14_2_a	63.0	68.0
10_47_16_2_a	61.0	99.0
10_47_20_2_b	14.0	0.0
10_47_1_3_b	15.0	3.0
10_47_2_3_a	46.0	22.0
10_47_7_3_c	58.0	95.0
10_47_9_3_a	69.0	86.0
10_47_9_3_c	59.0	92.0
10_47_10_3_c	16.0	1.0
10_47_13_3_b	12.0	0.0
10_47_14_3_b	18.0	10.0
10_47_16_3_b	16.0	12.0
10_47_21_3_b	13.0	1.0







A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*



The structure and purity of the known compound **10_47** was confirmed by the comparison of their physical and spectral data (^{1}H NMR, ^{13}C NMR) with reported in the literature. (*78*)

N-(3,5-Bis(trifluoromethyl)phenyl)-2-phenylacetamide (**10_47**)

<u>^{1}H NMR</u> (600 MHz, $CDCl_3$)

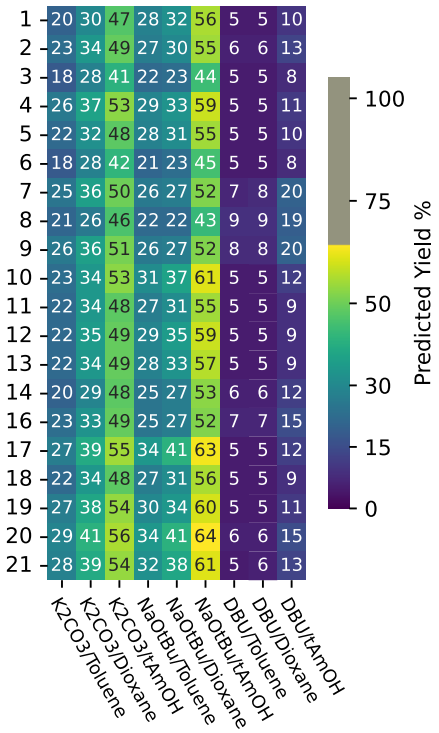
δ 7.93 (s, 2H), 7.58 (s, 1H), 7.44 (t, *J* = 7.4 Hz, 2H), 7.39 (t, *J* = 7.3 Hz, 1H), 7.34 (d, *J* = 7.2 Hz, 3H), 3.79 (s, 2H).

<u>^{13}C{^{1}H} NMR</u> (151 MHz, $CDCl_3$)

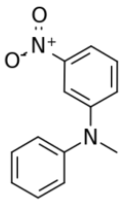
δ 169.58, 139.10, 133.59, 132.48 (q, *J* = 33.8 Hz), 129.68, 129.65, 128.30, 123.14 (q, *J* = 272.5 Hz), 119.56 (d, *J* = 3.8 Hz), 117.96 – 117.77 (m), 44.90.

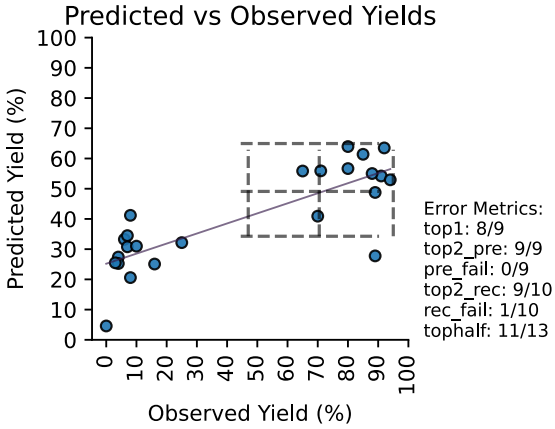
Data for **6_13**

	Predicted Yield %	Observed Yield %
6_13_4_1_b	33.0	6.0
6_13_19_1_b	34.0	7.0
6_13_11_1_b	31.0	7.0
6_13_9_1_b	27.0	4.0
6_13_5_1_a	32.0	25.0
6_13_6_1_a	28.0	89.0
6_13_17_1_b	41.0	70.0
6_13_1_2_b	56.0	71.0
6_13_21_2_a	54.0	91.0
6_13_16_2_a	49.0	89.0
6_13_10_2_a	53.0	94.0
6_13_2_2_b	55.0	88.0
6_13_13_2_b	57.0	80.0
6_13_20_2_b	64.0	80.0
6_13_17_2_b	63.0	92.0
6_13_21_2_b	61.0	85.0
6_13_3_2_a	41.0	8.0
6_13_18_2_b	56.0	65.0
6_13_10_3_b	31.0	10.0
6_13_14_3_b	25.0	4.0
6_13_16_3_b	25.0	16.0
6_13_7_3_a	25.0	3.0
6_13_4_3_c	5.0	0.0
6_13_8_3_a	21.0	8.0

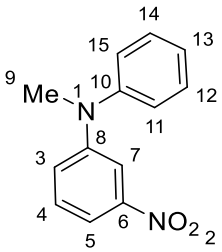


6_13





A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*



N-Methyl-3-nitro-*N*-phenylaniline **(6_13)**

Color and state: Orange solid

m.p.: 26.5-27.5 °C (sealed tube)

^{1}H NMR: (500 MHz, $CDCl_3$)
δ 7.65 (t, *J* = 2.4 Hz, 1H, CH(7)), 7.62 (ddd, *J* = 8.1, 2.1, 0.9 Hz, 1H, CH (5)), 7.44 – 7.37 (m, 2H, 2xCH (12 and 14)), 7.29 (t, *J* = 8.2 Hz, 1H, CH (4)), 7.23 – 7.16 (m, 3H, 3xCH (11, 15 and 13)), 7.09 (ddd, *J* = 8.2, 2.4, 0.9 Hz, 1H, CH (3)), 3.38 (s, 3H, NCH_3 (9)).

^{13}C{^{1}H} NMR: (126 MHz, $CDCl_3$)
δ 150.27 (s, C(6)), 149.63 (s, C(8)), 147.87 (s, C (10)), 130.33 (s, 2xC(11 and 15)), 129.77 (s, C(4)), 125.53 (s, C(13), 125.38 (s, 2xC (12 and 14)), 121.82 (s, C(3)), 113.45 (s, C(7)), 109.93 (s, C(5), 40.77 (s, C(9)).

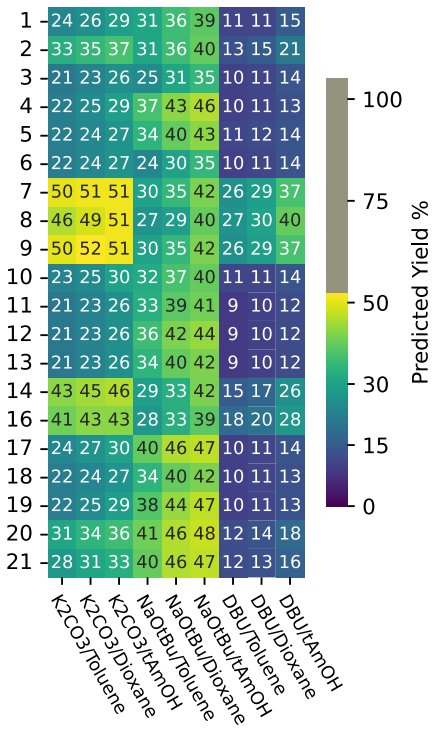
IR (cm^{-1}): ATR (neat)
3061 (w), 2883 (w br), 2819 (w), 1618 (m), 1592 (m), 1568 (m), 1520 (s), 1493 (s), 1452 (m), 1346 (s), 1303 (m), 1275 (m), 1250 (s), 1176 (m), 1134 (m), 1110 (m), 1089 (m), 1025 (m), 990 (m), 921 (w), 893 (w), 838 (s).

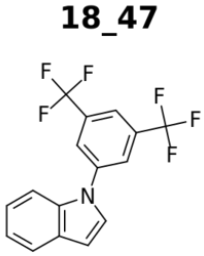
HRMS (ESI+): Calcd for $C_{13}H_{12}N_2O_2$ (M+H)+: 229.0977 Found: 229.0973

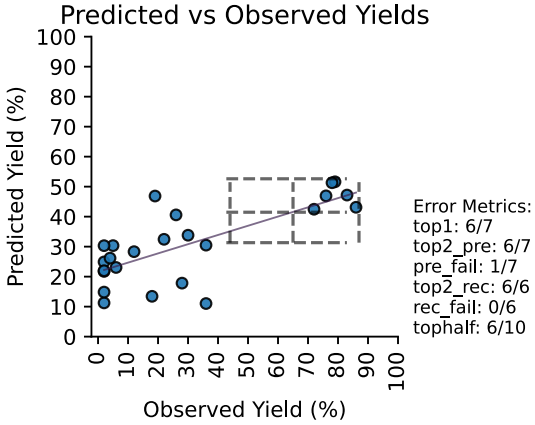
TLC: R_f 0.4 (EtOAc/hexane, 15:85)

Data for **18_47**

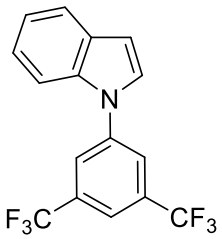
	Predicted Yield %	Observed Yield %
18_47_12_1_b	42.0	72.0
18_47_4_1_c	11.0	36.0
18_47_9_1_a	52.0	79.0
18_47_10_1_a	25.0	2.0
18_47_1_1_c	11.0	2.0
18_47_12_1_a	23.0	6.0
18_47_11_2_b	41.0	26.0
18_47_17_2_b	47.0	19.0
18_47_10_2_a	30.0	36.0
18_47_21_2_b	47.0	83.0
18_47_9_2_a	51.0	78.0
18_47_19_2_b	47.0	76.0
18_47_13_2_a	26.0	4.0
18_47_17_2_a	30.0	5.0
18_47_16_3_b	28.0	12.0
18_47_18_3_b	34.0	30.0
18_47_7_3_b	30.0	2.0
18_47_10_3_b	32.0	22.0
18_47_14_3_a	43.0	86.0
18_47_14_3_c	15.0	2.0
18_47_2_3_c	13.0	18.0
18_47_6_3_a	22.0	2.0
18_47_5_3_a	22.0	2.0
18_47_16_3_c	18.0	28.0







A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*



1-(3,5-Bis(trifluoromethyl)phenyl)-1H-indole **(18_47)** (*66*),(*79*)

^{1}H NMR (500 MHz, $CDCl_3$)

δ 7.99 (s, 2H), 7.85 (s, 1H), 7.72 (d, *J* = 7.9 Hz, 1H), 7.54 (dd, *J* = 8.2, 0.9 Hz, 1H), 7.37 (d, *J* = 3.4 Hz, 1H), 7.34 – 7.28 (m, 1H), 7.27 – 7.23 (m, 1H), 6.78 (d, *J* = 3.4 Hz, 1H).

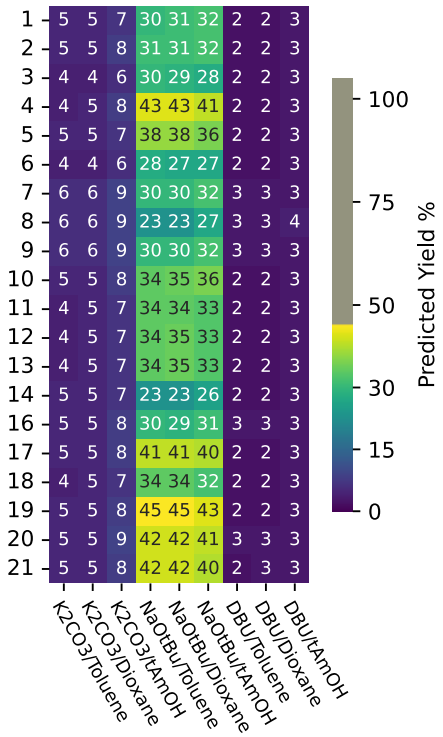
^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$)

δ 141.68, 135.79, 133.75 (q, J_{C2F} = 33.66 Hz) 130.19, 127.50, 124.24 (q, J_{C3F} = 3.78 Hz), 123.88, 123.02 (q, J_{C1F} = 272.64 Hz), 122.11, 121.90, 119.99 ((q, J_{C3F} = 3.78 Hz), 110.15, 106.30.

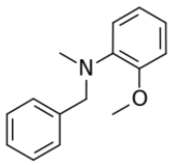
^{19}F NMR (471 MHz, $CDCl_3$) δ -62.95.

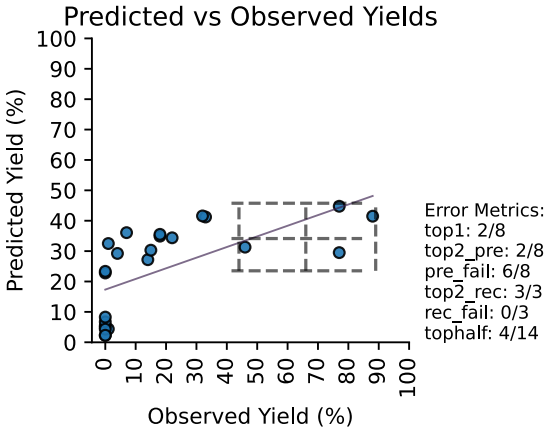
Data for **48_7**

	Predicted Yield %	Observed Yield %
48_7_1_1_b	31.0	46.0
48_7_5_1_a	5.0	0.0
48_7_6_1_a	4.0	1.0
48_7_6_1_b	27.0	14.0
48_7_8_1_b	23.0	0.0
48_7_12_1_b	35.0	18.0
48_7_12_1_c	2.0	0.0
48_7_14_1_b	23.0	0.0
48_7_16_1_a	5.0	0.0
48_7_16_1_b	29.0	4.0
48_7_4_2_b	41.0	88.0
48_7_5_2_b	36.0	7.0
48_7_10_2_b	36.0	18.0
48_7_18_2_a	7.0	0.0
48_7_18_2_b	32.0	1.0
48_7_20_2_b	41.0	33.0
48_7_21_2_a	8.0	0.0
48_7_3_3_b	30.0	77.0
48_7_7_3_b	30.0	15.0
48_7_13_3_a	4.0	0.0
48_7_13_3_b	34.0	22.0
48_7_19_3_b	45.0	77.0
48_7_19_3_c	2.0	0.0
48_7_21_3_b	42.0	32.0

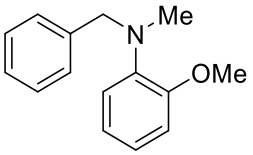


48_7





A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*



N-Benzyl-2-methoxy-*N*-methylaniline **(48_7)** (*80*),(*81*)

^{1}H NMR (500 MHz, $CDCl_3$)

δ 7.34 – 7.28 (m, 4H), 7.27 – 7.23 (m, 1H), 7.02 – 6.96 (m, 1H), 6.93 – 6.87 (m, 3H), 4.21 (s, 2H), 3.92 (s, 3H), 2.68 (s, 3H).

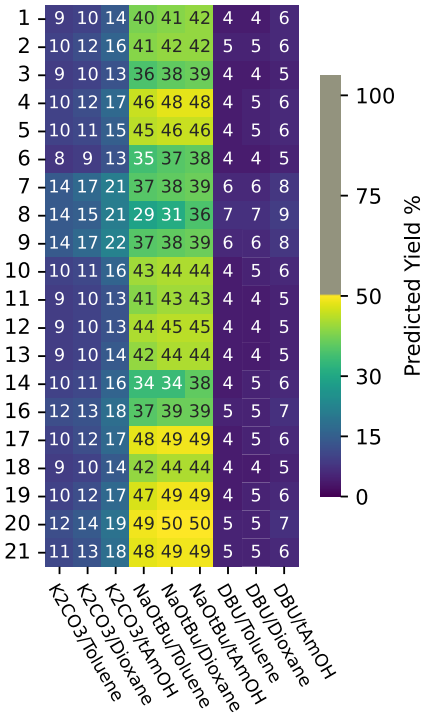
^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$)

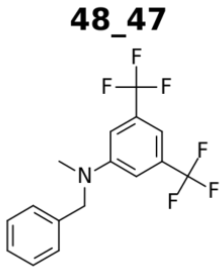
δ 152.25, 141.44, 138.71, 128.75, 127.97, 126.81, 122.15, 120.69, 119.17, 111.12, 59.49, 55.31, 38.93.

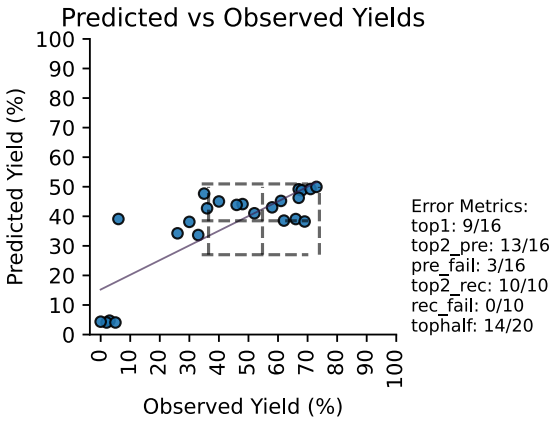
HRMS (ESI+) Calcd for $C_{15}H_{17}NO$ (M+H)+: 228.1388 Found: 228.1381

Data for **48_47**

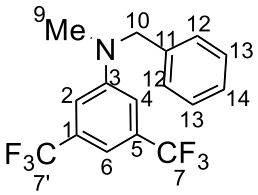
	Predicted Yield %	Observed Yield %
48_47_1_1_b	41.0	52.0
48_47_7_1_b	38.0	30.0
48_47_10_1_b	44.0	48.0
48_47_11_1_b	43.0	58.0
48_47_12_1_b	45.0	61.0
48_47_14_1_b	34.0	26.0
48_47_16_1_b	39.0	62.0
48_47_17_1_b	49.0	67.0
48_47_21_1_b	49.0	68.0
48_47_3_2_b	39.0	66.0
48_47_4_2_b	48.0	35.0
48_47_5_2_b	46.0	67.0
48_47_6_2_b	38.0	69.0
48_47_9_2_b	39.0	6.0
48_47_11_2_b	43.0	36.0
48_47_12_2_b	45.0	40.0
48_47_17_2_b	49.0	71.0
48_47_18_2_b	44.0	46.0
48_47_20_2_b	50.0	73.0
48_47_2_3_c	5.0	3.0
48_47_13_3_c	4.0	2.0
48_47_14_3_b	34.0	33.0
48_47_18_3_c	4.0	5.0
48_47_19_3_c	4.0	0.0







A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*



N-Benzyl-*N*-methyl-3,5-bis(trifluoromethyl)aniline **(48_47)**

Color and state: Colorless solid

m.p.: 27.5-28.5 °C (sealed tube)

^{1}H NMR: (500 MHz, $CDCl_3$)

δ 7.35 (t, *J* = 7.2 Hz, 2H, 2xCH (12)), 7.29 (t, *J* = 7.3 Hz, 1H, CH (14)), 7.20 (d, *J* = 6.7 Hz, 2H, 2xCH (13)), 7.16 (s, 1H, CH (6)), 7.06 (s, 2H, 2xCH (2 and 4), 4.62 (s, 2H, CH_2 (10)), 3.12 (s, 3H, CH_3 (9)).

^{13}C{^{1}H} NMR: (126 MHz, $CDCl_3$)

δ 150.05 (s, C (3)), 137.22(s, C(11)), 132.44 (q, J_{C2F} = 32.70 Hz, C (1 and 5)), 129.05 (s, C(12), 128.96 (q, J_{C1F} = 272.64 Hz C(7')), 127.64 (s, C(14)), 126.66 (s, C(13), 124.11 (q, J_{C1F} = 272.64 Hz, s, C (7)) 111.34 (q, J_{C3F} = 3.85 Hz, s, C(2 and 4)), 109.44 (sep, *J* = 3.85 Hz, s, C(6)), 56.38 (s, C (10)), 38.89 (s, C (9)).

^{19}F NMR: (471 MHz, $CDCl_3$)

δ -63.07.

IR (cm^{-1}): ATR (neat)

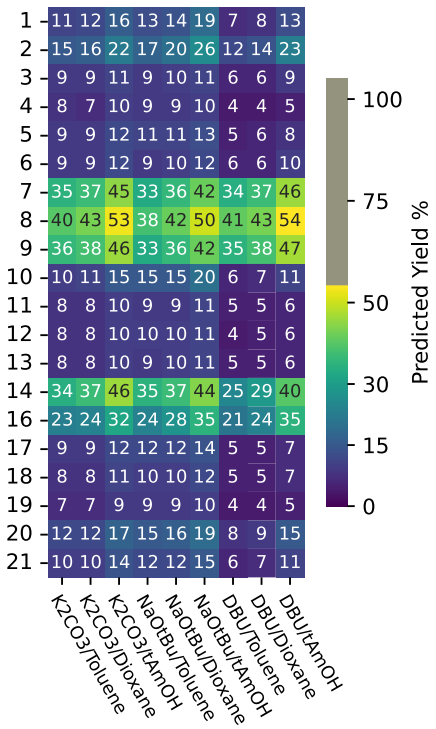
2928 (w br), 1725 (w), 1621 (m), 1497 (m), 1454 (w), 1434 (w), 1402 (m), 1354 (w), 1330 (w), 1273 (s), 1217 (w), 1169 (s), 1014 (m), 958 (m), 855 (m).

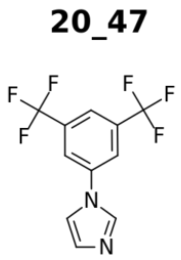
HRMS(ESI+): Calcd for $C_{16}H_{13}F_6N$ (M+H)+: 334.1030 Found: 334.1019

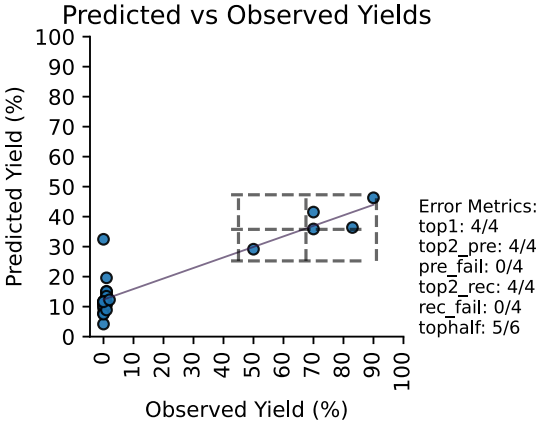
TLC: R_f 0.3 (EtOAc/hexane, 5:95)

Data for **20_47**

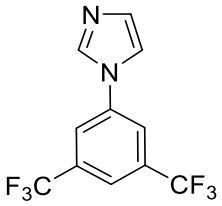
	Predicted Yield %	Observed Yield %
20_47_1_1_b	14.0	1.0
20_47_2_1_b	20.0	1.0
20_47_4_1_c	4.0	0.0
20_47_5_1_b	11.0	0.0
20_47_7_1_b	36.0	70.0
20_47_9_1_b	36.0	83.0
20_47_10_1_b	15.0	1.0
20_47_12_1_a	8.0	0.0
20_47_13_1_b	10.0	0.0
20_47_14_1_c	29.0	50.0
20_47_21_1_a	10.0	0.0
20_47_3_2_a	11.0	1.0
20_47_5_2_a	12.0	0.0
20_47_7_2_b	42.0	70.0
20_47_10_2_a	15.0	1.0
20_47_11_2_b	11.0	1.0
20_47_14_2_a	46.0	90.0
20_47_16_2_a	32.0	0.0
20_47_1_3_b	13.0	1.0
20_47_2_3_c	12.0	0.0
20_47_4_3_a	8.0	0.0
20_47_6_3_a	9.0	1.0
20_47_17_3_b	12.0	0.0
20_47_20_3_a	12.0	2.0







A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*



1-(3,5-Bis(trifluoromethyl)phenyl)-1H-imidazole (**20_47**) (*82*)-(*84*)

^{1}H NMR (500 MHz, $CDCl_3$)

δ 7.94 (s, 1H), 7.89 (s, 1H), 7.85 (s, 2H), 7.36 (t, J = 1.4 Hz, 1H), 7.31 – 7.28 (m, 1H).

^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$)

δ 138.75, 135.58, 133.90 (q, J_{C2F} = 34.1Hz), 131.97, 122.71(q, J_{C1F} = 273.60 Hz), 121.59 (q, J_{C3F} = 3.78 Hz), 121.1 (q, J_{C1F} = 273.60 Hz), 119.48, 118.07.

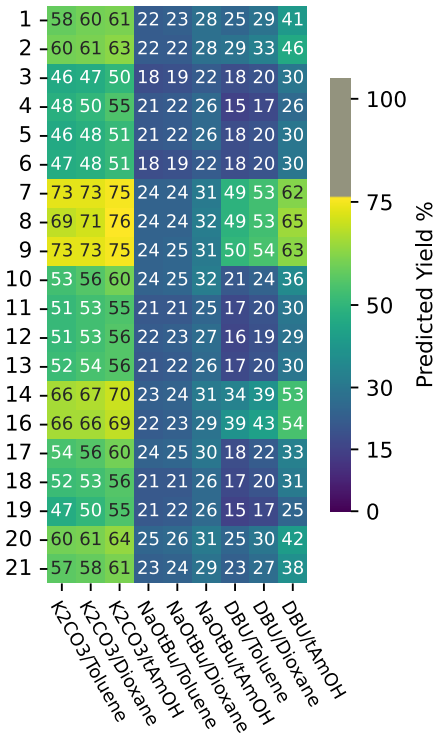
^{19}F NMR (471 MHz, $CDCl_3$)

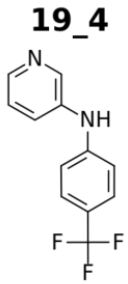
δ -63.03.

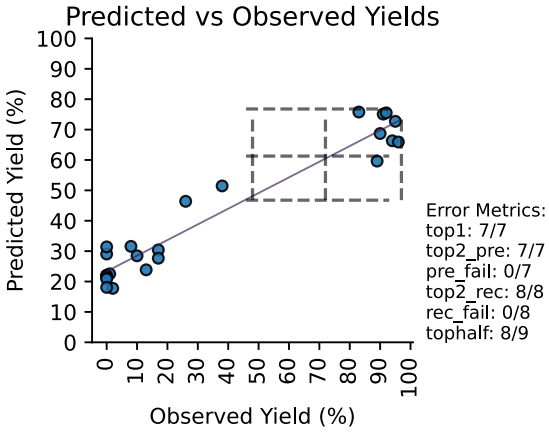
HRMS(ESI+) Calcd for $C_{11}H_6F_6N_2$ (M+H)+: 281.0513 Found: 281.0513

Data for Plate **19_4**

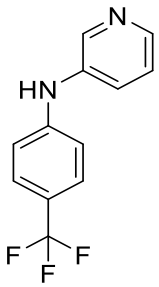
	Predicted Yield %	Observed Yield %
19_4_19_1_b	22.0	0.0
19_4_12_1_b	23.0	1.0
19_4_16_1_a	66.0	94.0
19_4_13_1_b	22.0	0.0
19_4_14_1_b	24.0	13.0
19_4_11_1_b	21.0	0.0
19_4_7_2_a	75.0	91.0
19_4_16_2_a	69.0	90.0
19_4_17_2_a	60.0	89.0
19_4_8_2_a	76.0	83.0
19_4_17_2_b	30.0	17.0
19_4_9_2_a	75.0	92.0
19_4_2_2_b	28.0	17.0
19_4_21_2_b	29.0	0.0
19_4_20_2_b	31.0	0.0
19_4_1_2_b	28.0	10.0
19_4_10_2_b	32.0	8.0
19_4_5_2_a	51.0	38.0
19_4_16_3_a	66.0	96.0
19_4_7_3_a	73.0	95.0
19_4_3_3_c	18.0	2.0
19_4_4_3_b	21.0	0.0
19_4_5_3_a	46.0	26.0
19_4_6_3_b	18.0	0.0







A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*



N-(4-Ttrifluoromethyl)phenyl)pyridin-3-amine (**19_4**) (*85*)

^{1}H NMR (500 MHz, DMSO)

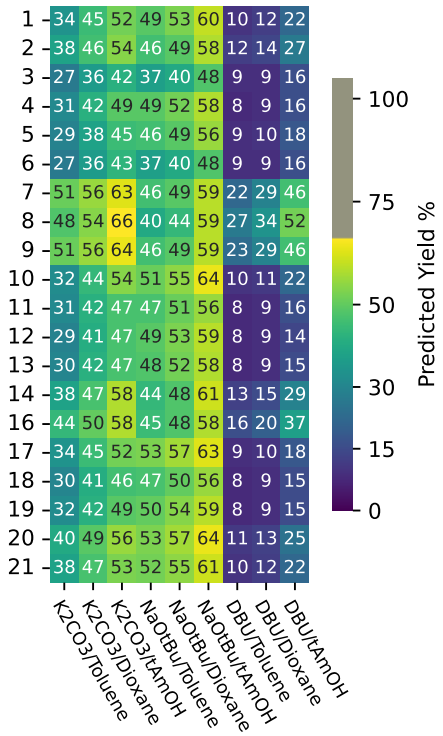
δ 8.86 (s, 1H), 8.44 (d, *J* = 2.7 Hz, 1H), 8.17 (dd, *J* = 4.6, 1.5 Hz, 1H), 7.60 (ddd, *J* = 8.2, 2.8, 1.4 Hz, 1H), 7.55 (d, *J* = 8.9 Hz, 2H), 7.32 (dd, *J* = 8.2, 4.6 Hz, 1H), 7.17 (d, *J* = 8.7 Hz, 2H).

^{13}C{^{1}H} NMR (126 MHz, DMSO)

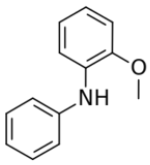
δ 146.78, 142.45, 141.06, 138.24, 126.64 (q, J_{C3F} = 5.04 Hz), 125.88, 124.78 (q, J_{C1F} = 270.9 Hz), 123.95, 119.50 (q, J_{C2F} = 32.76 Hz), 115.07.

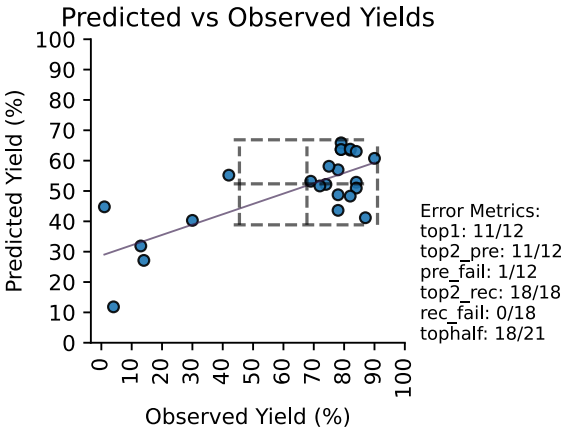
Data for **1_7**

	Predicted Yield %	Observed Yield %
1_7_21_1_b	55.0	42.0
1_7_17_1_b	57.0	78.0
1_7_13_1_b	52.0	74.0
1_7_1_1_b	53.0	84.0
1_7_11_1_b	51.0	84.0
1_7_12_1_a	41.0	87.0
1_7_3_1_b	40.0	30.0
1_7_21_1_c	12.0	4.0
1_7_20_2_b	64.0	79.0
1_7_7_2_a	63.0	82.0
1_7_8_2_a	66.0	79.0
1_7_2_2_b	58.0	75.0
1_7_10_2_b	64.0	79.0
1_7_14_2_b	61.0	90.0
1_7_9_2_a	64.0	82.0
1_7_17_2_b	63.0	84.0
1_7_5_2_a	45.0	1.0
1_7_6_3_a	27.0	14.0
1_7_19_3_a	32.0	13.0
1_7_4_3_b	49.0	78.0
1_7_16_3_a	44.0	78.0
1_7_17_3_b	53.0	69.0
1_7_21_3_b	52.0	72.0
1_7_13_3_b	48.0	82.0

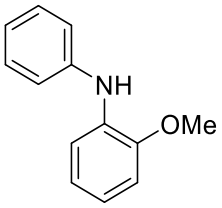


1_7





A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*



2-Methoxy-N-phenylaniline **(1_7)** (*86*)

^{1}H NMR (500 MHz, $CDCl_3$)

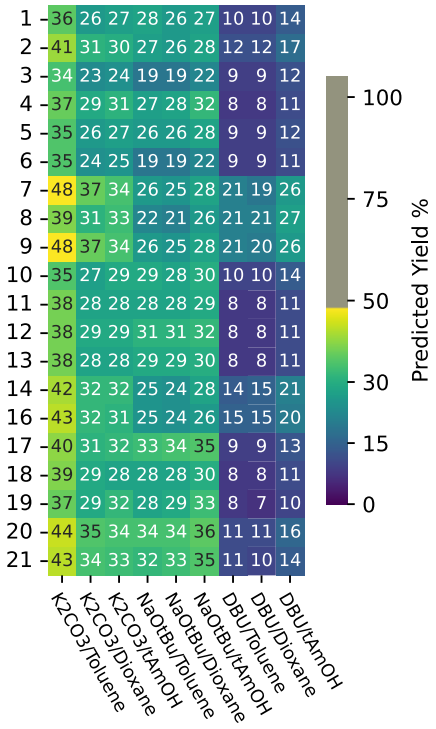
δ 7.38 – 7.28 (m, 3H), 7.19 (dd, *J* = 8.6, 1.1 Hz, 2H), 6.98 (t, *J* = 7.3 Hz, 1H), 6.95 – 6.87 (m, 3H), 6.20 (br s, 1H), 3.92 (s, 3H).

^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$)

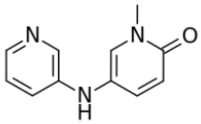
δ 148.38, 142.83, 133.07, 129.38, 121.25, 120.91, 120.01, 118.68, 114.78, 110.64, 55.70.

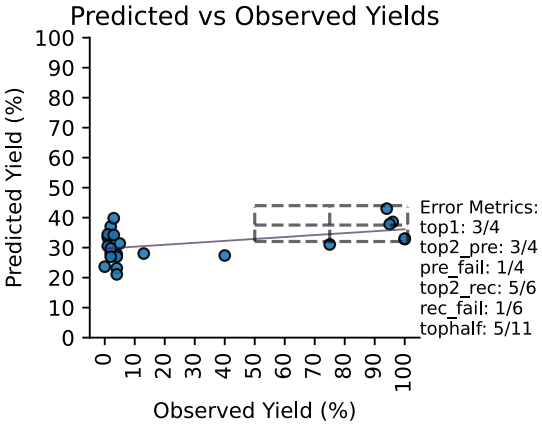
Data for **19_49**

	Predicted Yield %	Observed Yield %
19_49_8_1_a	31.0	5.0
19_49_6_1_a	24.0	0.0
19_49_3_1_a	23.0	4.0
19_49_8_1_c	21.0	4.0
19_49_9_1_a	37.0	2.0
19_49_8_2_a	33.0	1.0
19_49_7_2_a	34.0	2.0
19_49_9_2_a	34.0	1.0
19_49_16_2_a	31.0	1.0
19_49_14_2_b	28.0	2.0
19_49_2_2_b	28.0	4.0
19_49_10_2_b	30.0	2.0
19_49_20_2_a	34.0	3.0
19_49_1_2_b	27.0	4.0
19_49_13_2_a	28.0	13.0
19_49_5_2_a	27.0	40.0
19_49_21_2_a	33.0	100.0
19_49_19_2_b	33.0	100.0
19_49_18_3_a	39.0	96.0
19_49_11_3_a	38.0	95.0
19_49_12_3_b	31.0	75.0
19_49_4_3_b	27.0	2.0
19_49_17_3_a	40.0	3.0
19_49_16_3_a	43.0	94.0

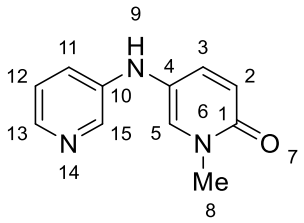


19_49





A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*



1-Methyl-5-(pyridin-3-ylamino)pyridin-2(1H)-one (**19_49)**

Color and state: Green solid

m.p. 178.2-179.2 °C (sealed tube)

^{1}H NMR (500 MHz, $CDCl_3$)

δ 8.07 (s, 1H, CH (15)), 7.99 (d, *J* = 4.6 Hz, 1H, CH (13)), 7.33 – 7.10 (m, 2H, 2xCH (12 and 5), 7.05 (d, *J* = 8.1 Hz, 1H, CH (11)), 6.93 (d, *J* = 9.0 Hz, 1H, CH (3)), 6.53 (d, *J* = 9.6 Hz, 1H, CH (2)), 5.73 (br s, 1H, NH (9)).

^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$)

δ 161.81 (s, C (1), 142.51 (s, C (10)), 140.72 (s, C(13)), 139.83 (s, C(5)), 137.46 (s, C(15)), 133.96 (s, C (12)), 123.94 (s, C (11)), 121.54 (s, C(3)), 120.45 (s, C (2)), 37.91 (s, C (8)).

IR (cm^{-1}) ATR (neat)

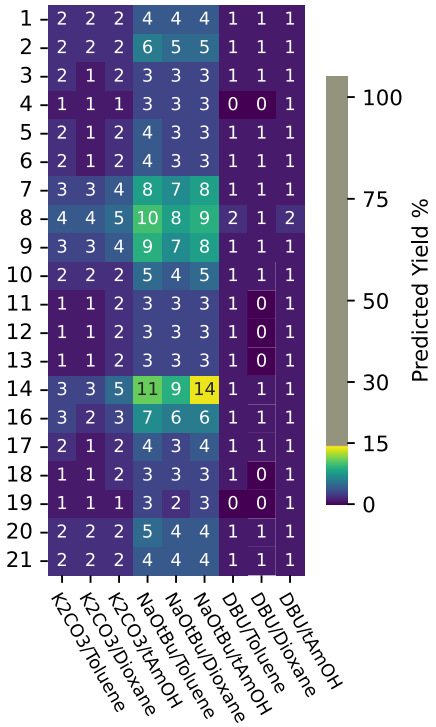
3225 (w), 3025 (m br), 1672 (m), 1573 (s), 1521 (s), 1483 (m), 1418 (s), 1367 (m), 1327 (m), 1303 (m), 1245 (m), 1186 (m), 1132 (m), 1109 (m), 1049 (m), 1009 (m), 900 (m), 812 (s).

HRMS (ES+) Calcd for $C_{11}H_{12}N_3O$ (M+H)+: 202.0980 Found: 202.0980

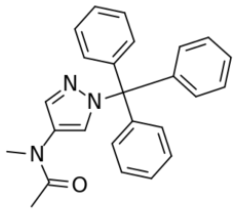
TLC R_f 0.4 ($MeOH/CH_2Cl_2$, 20:80)

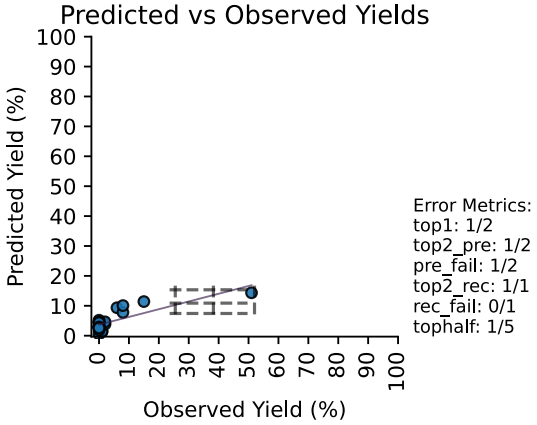
Data for **13_31**

	Predicted Yield %	Observed Yield %
13_31_14_1_b	9.0	6.0
13_31_13_1_b	3.0	0.0
13_31_11_1_b	3.0	0.0
13_31_18_1_a	1.0	1.0
13_31_3_1_c	1.0	0.0
13_31_5_1_a	1.0	1.0
13_31_17_2_a	2.0	0.0
13_31_9_2_a	4.0	2.0
13_31_16_2_a	3.0	0.0
13_31_7_2_b	8.0	8.0
13_31_14_2_b	14.0	51.0
13_31_8_2_a	5.0	2.0
13_31_10_2_b	5.0	0.0
13_31_2_2_b	5.0	0.0
13_31_20_2_b	4.0	0.0
13_31_6_2_b	3.0	0.0
13_31_12_3_b	3.0	0.0
13_31_21_3_b	4.0	0.0
13_31_19_3_b	3.0	0.0
13_31_1_3_b	4.0	0.0
13_31_4_3_b	3.0	0.0
13_31_8_3_b	10.0	8.0
13_31_16_3_a	3.0	0.0
13_31_14_3_b	11.0	15.0

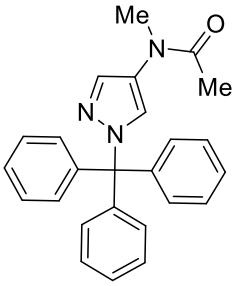


13_31





A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*

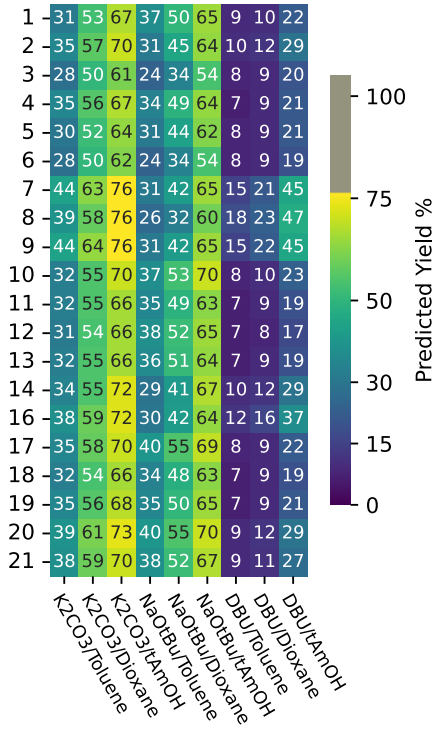


N-Methyl-*N*-(1-trityl-1H-pyrazol-4-yl)acetamide **(13_31)**

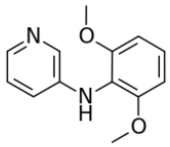
Color and state	Colorless solid
m.p.:	143.9-144.9 °C (sealed tube)
^{1}H NMR	(500 MHz, C_6D_6)
	δ 7.24 – 7.21 (m, 5H), 7.06 – 7.01 (m, 12H), 2.97 (s, 3H), 1.73 (s, 3H).
^{13}C{^{1}H} NMR	(126 MHz, $CDCl_3$)
	δ 169.74, 143.61, 136.73, 130.81, 130.64, 128.98, 128.35, 127.99, 127.34, 125.36, 79.55, 37.35, 22.12.
IR (cm^{-1})	ATR (neat)
	3136 (w), 2928 (w br), 1656 (s), 1595 (w), 1568 (m), 1491 (m), 1446 (s), 1417 (m), 1397 (s), 1372 (s), 1334 (m), 1261 (m), 1214 (m), 1165 (m), 1125 (m), 1081 (m), 1016 (m), 981 (m), 922 (m), 894 (m), 866 (m), 807 (m).
HRMS (ES+)	Calcd for $C_{25}H_{24}N_3O$ (M+H)+: 382.1919 Found: 382.1916
TLC	R_f 0.4 (EtOAc/CH_2Cl_2, 30:70)

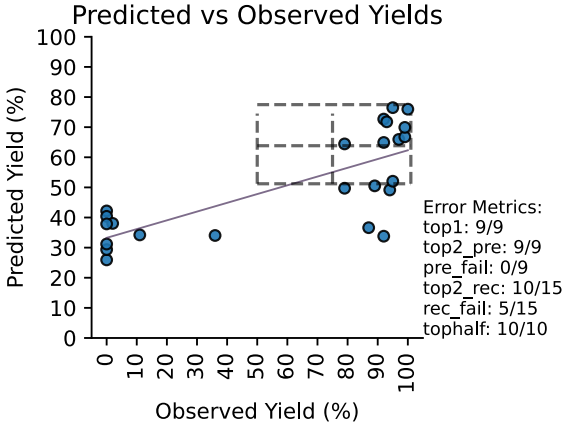
Data for **19_2**

	Predicted Yield %	Observed Yield %
19_2_7_1_b	42.0	0.0
19_2_13_1_b	51.0	89.0
19_2_11_1_b	49.0	94.0
19_2_3_1_a	50.0	79.0
19_2_5_1_a	52.0	95.0
19_2_6_1_b	34.0	36.0
19_2_12_2_a	66.0	97.0
19_2_20_2_a	73.0	92.0
19_2_14_2_a	72.0	93.0
19_2_9_2_a	76.0	95.0
19_2_2_2_b	64.0	79.0
19_2_14_2_b	67.0	99.0
19_2_7_2_b	65.0	92.0
19_2_10_2_b	70.0	99.0
19_2_8_2_a	76.0	100.0
19_2_1_3_b	37.0	87.0
19_2_4_3_b	34.0	11.0
19_2_17_3_b	40.0	0.0
19_2_21_3_b	38.0	2.0
19_2_8_3_b	26.0	0.0
19_2_16_3_a	38.0	0.0
19_2_14_3_b	29.0	0.0
19_2_7_3_b	31.0	0.0
19_2_18_3_b	34.0	92.0

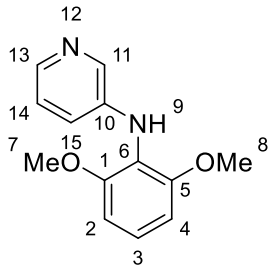


19_2





A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*



N-(2,6-Dimethoxyphenyl)pyridin-3-amine (**19_2)**

Color and state: Brown solid

m.p.: 103-5-104.5 °C (sealed tube)

^{1}H NMR: (500 MHz, $CDCl_3$)
δ 8.12 (d, *J* = 2.7 Hz, 1H, CH (11)), 8.06 (dd, *J* = 4.6, 1.5 Hz, 1H, CH (13)), 7.12 (t, *J* = 8.4 Hz, 1H, CH (3)), 7.07 (dd, *J* = 8.3, 4.7 Hz, 1H, CH (14)), 6.90 (ddd, *J* = 8.2, 2.9, 1.4 Hz, 1H, CH (15)), 6.65 (d, *J* = 8.4 Hz, 2H, 2xCH (2 and 4)), 5.65 (br s, 1H, NH (9)), 3.83 (s, 6H, OCH_3 (8 and 15)).

^{13}C{^{1}H} NMR: (126 MHz, $CDCl_3$)
δ 154.16 (s, 2xC (1 and 5), 141.83 (s, C (10)), 140.84 (s, C (13)), 138.93 (s, C (11)), 125.19 (s, C (3)), 123.49 (s, C (14), 122.19 (s, C (15)), 118.93 (s, C (6)), 104.80 (s, 2xC (2 and 4), 56.24 (s, C (8 and 15)).

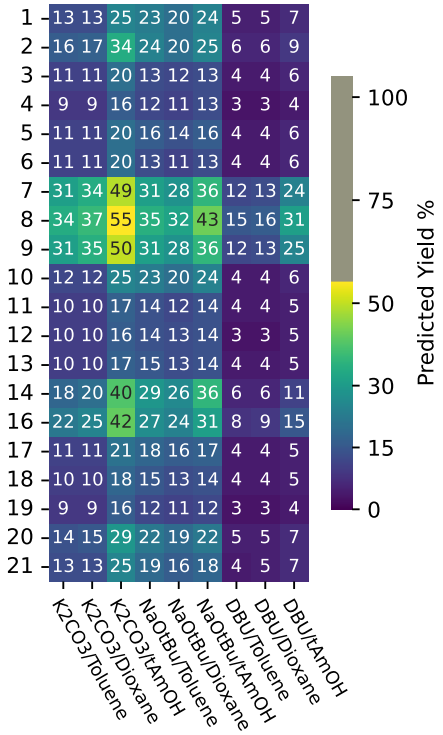
IR (cm^{-1}): ATR (neat)
3171 (w), 2971 (w br), 2935 (w), 2837 (w), 1738 (w), 1577 (m), 1532 (w), 1493 (m), 1472 (s), 1414 (m), 1313 (m), 1282 (w), 1256 (m), 1191 (w), 1111 (s), 1039 (m), 1012 (m), 909 (w), 879 (w), 845 (w).

HRMS (ES+): Calcd for $C_{13}H_{15}N_2O_2$ (M+H)+: 231.1134 Found: 231.1135

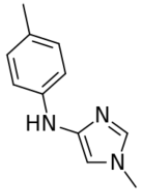
TLC: R_f 0.4 (CH_2Cl_2/hexane, 40:60)

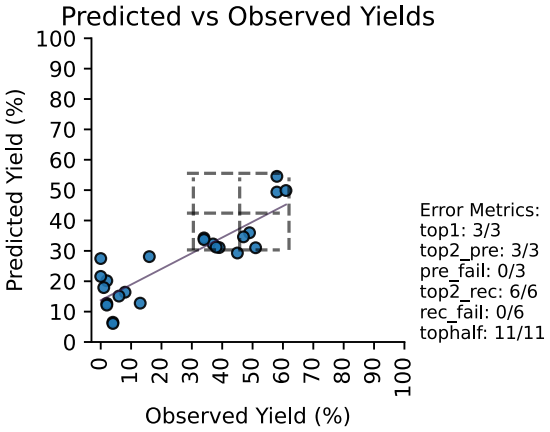
Data for **5_34**

	Predicted Yield %	Observed Yield %
5_34_7_1_a	34.0	34.0
5_34_7_1_c	13.0	13.0
5_34_8_1_b	32.0	37.0
5_34_8_1_c	16.0	8.0
5_34_9_1_b	28.0	16.0
5_34_14_1_a	20.0	2.0
5_34_14_1_c	6.0	4.0
5_34_18_1_b	13.0	2.0
5_34_7_2_a	49.0	58.0
5_34_8_2_a	55.0	58.0
5_34_9_2_a	50.0	61.0
5_34_9_2_b	36.0	49.0
5_34_16_2_b	31.0	39.0
5_34_20_2_b	22.0	0.0
5_34_21_2_b	18.0	1.0
5_34_7_3_b	31.0	51.0
5_34_8_3_a	34.0	34.0
5_34_8_3_b	35.0	47.0
5_34_8_3_c	15.0	6.0
5_34_9_3_b	31.0	38.0
5_34_14_3_b	29.0	45.0
5_34_14_3_c	6.0	4.0
5_34_16_3_b	27.0	0.0
5_34_19_3_b	12.0	2.0

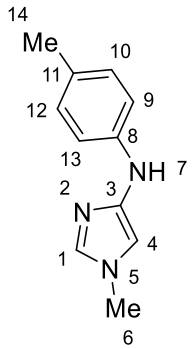


5_34





A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*



1-Methyl-*N*-(4-tolyl)-1H-imidazol-4-amine **(5_34)**

Color and state: Off white solid

m.p.: 151.9-152.9 °C (sealed tube)

^{1}H NMR: (499 MHz, $CDCl_3$)
δ 7.18 (s, 1H, CH (1)), 7.03 (d, *J* = 8.3 Hz, 2H, 2xCH (9 and 13)), 6.83 (d, *J* = 8.4 Hz, 2H, 2xCH (10 and 12)), 6.57 (s, 1H, CH (4)), 5.86 (s, 1H, NH (7)), 3.63 (s, 3H, CH_3 (6)), 2.26 (s, 3H, CH_3 (14)).

^{13}C{^{1}H} NMR: (126 MHz, $CDCl_3$)
δ 143.44 (s, C (3)), 141.83 (s, C (8)), 134.22 (s, C (1)), 129.83 (s, 2xC (9 and 13)), 128.53 (s, C (11), 115.06 (s, 2xC (10 and 12)), 104.13 (s, C (4)) , 33.83 (s, C (6)), 20.65 (s, C (14)).

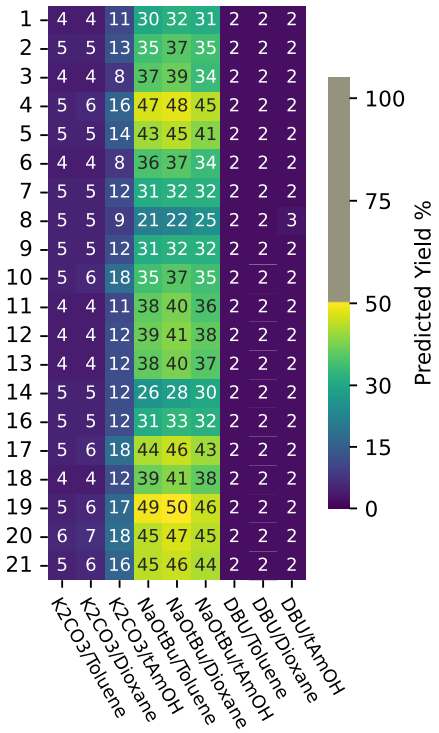
IR (cm^{-1}): ATR (neat)
3239 (w), 3028 (w br), 2920 (w), 1722 (w), 1643 (m), 1615 (m), 1567 (s), 1545 (s), 1509 (s), 1416 (m), 1386 (m), 1353 (m), 1318 (m), 1251 (s), 1214 (m), 1179 (m), 1124 (m), 1039 (m), 1002 (m), 944 (m), 868 (w), 808 (s).

HRMS (ES+): Calcd for $C_{11}H_{14}N_3O$ (M+H)+: 188.1188 Found: 188.1187

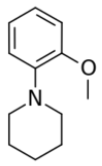
TLC: R_f 0.3 (EtOAc/hexane, 40:60)

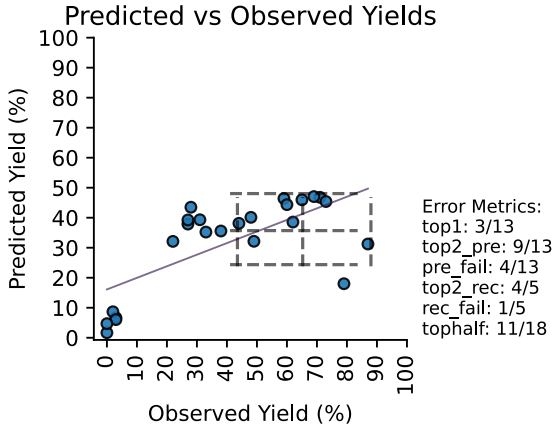
Data for **38_7**

	Predicted Yield %	Observed Yield %
38_7_3_1_b	39.0	62.0
38_7_20_1_b	47.0	71.0
38_7_17_1_b	46.0	65.0
38_7_13_1_b	40.0	48.0
38_7_20_1_a	7.0	3.0
38_7_14_1_c	2.0	0.0
38_7_21_1_b	46.0	59.0
38_7_1_2_b	31.0	87.0
38_7_10_2_a	18.0	79.0
38_7_7_2_b	32.0	49.0
38_7_8_2_a	9.0	2.0
38_7_9_2_b	32.0	22.0
38_7_5_3_b	43.0	28.0
38_7_2_3_b	35.0	33.0
38_7_6_3_b	36.0	38.0
38_7_11_3_b	38.0	27.0
38_7_12_3_b	39.0	27.0
38_7_4_3_b	47.0	69.0
38_7_13_3_b	38.0	44.0
38_7_20_3_a	6.0	3.0
38_7_18_3_b	39.0	31.0
38_7_17_3_b	44.0	60.0
38_7_16_3_a	5.0	0.0
38_7_20_3_b	45.0	73.0

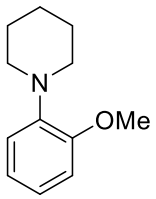


38_7





A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*



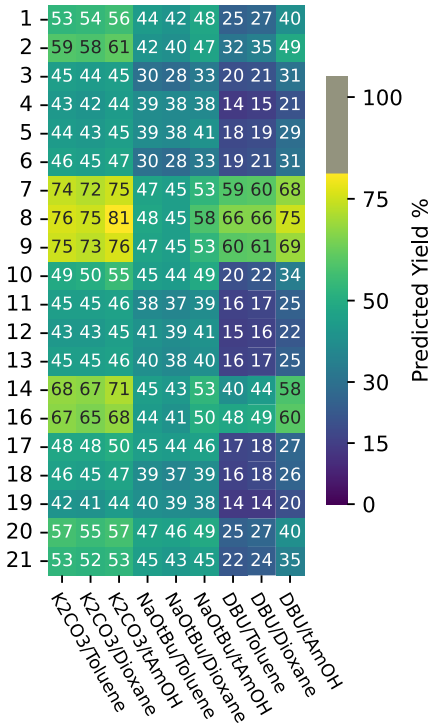
1-(2-Methoxyphenyl)piperidine **(38_7)** (*87*),(*88*)

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.00 – 6.94 (m, 2H), 6.93 – 6.88 (m, 1H), 6.85 (d, *J* = 9.5 Hz, 1H), 3.87 (s, 3H), 3.03 – 2.93 (m, 4H), 1.76 (p, *J* = 5.6 Hz, 4H), 1.57 (q, *J* = 6.1 Hz, 2H).

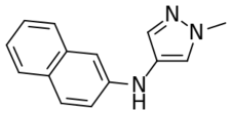
^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$) δ 152.78, 143.15, 122.89, 121.25, 118.78, 111.44, 55.73, 52.70, 26.73, 24.83.

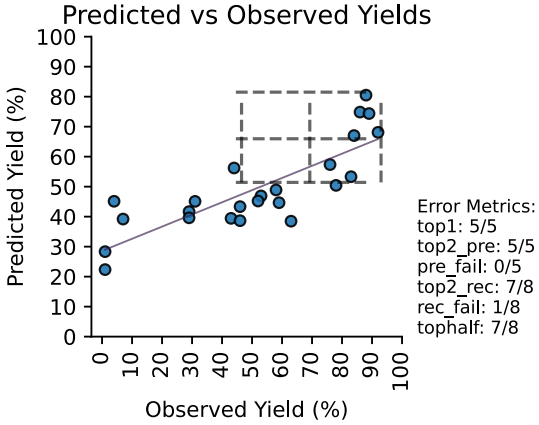
Data for **12_5**

	Predicted Yield %	Observed Yield %
12_50_21_1_b	43.0	46.0
12_50_13_1_b	38.0	63.0
12_50_12_1_b	39.0	7.0
12_50_4_1_a	42.0	29.0
12_50_3_1_b	28.0	1.0
12_50_14_1_a	67.0	84.0
12_50_6_1_a	45.0	31.0
12_50_2_2_b	47.0	53.0
12_50_20_2_a	57.0	76.0
12_50_10_2_b	49.0	58.0
12_50_17_2_a	50.0	78.0
12_50_21_2_b	45.0	52.0
12_50_18_2_b	39.0	43.0
12_50_11_2_b	39.0	46.0
12_50_1_2_a	56.0	44.0
12_50_5_2_a	45.0	4.0
12_50_16_2_a	68.0	92.0
12_50_8_2_a	81.0	88.0
12_50_21_3_c	22.0	1.0
12_50_19_3_b	40.0	29.0
12_50_21_3_a	53.0	83.0
12_50_9_3_a	75.0	86.0
12_50_7_3_a	74.0	89.0
12_50_21_3_b	45.0	59.0

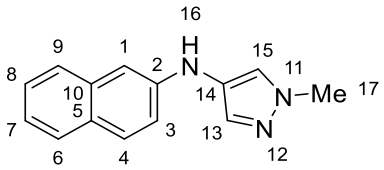


12_50





A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*



1-Methyl-N-(naphthalen-2-yl)-1H-pyrazol-4-amine (**12_50)**

Color and state: Brown solid

m.p.: 111.5-112.5 °C (sealed tube)

^{1}H NMR: (500 MHz, $CDCl_3$)
δ 7.68 – 6.99 (m, 7H, 7, CH (3, 4, 6, 7, 8, 9 and 13), 6.90 (s, 2H, 2xCH (1 and 15)), 5.19 (br s, 1H, NH (16)), 3.78 (s, 3H, CH_3 (17)).

^{13}C{^{1}H} NMR: (126 MHz, $CDCl_3$)
δ 144.59 (s, C (2)), 135.51 (s, C (13)), 134.96 (s, C(14)), 129.20 (s, C(1)), 128.09 (s, C(10)), 127.71 (s, C (4)), 126.52 (s, C(6)), 126.10 (s, C(8)), 124.88 (s, C (9)), 124.71 (s, C(5)), 122.56 (s, S (7)), 117.51 (s, C (1)), 106.39 (s, C(15), 39.45 (s, C (17)).

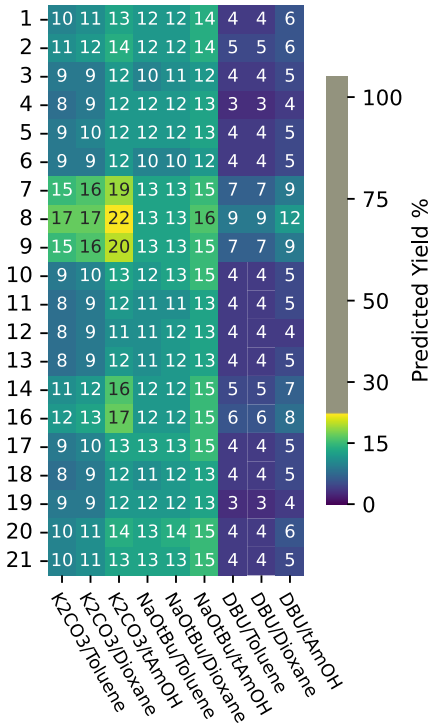
IR (cm^{-1}): ATR (neat)
3300 (m), 3106 (w), 3054 (w), 2933 (w), 1737 (w), 1626 (m), 1601 (m), 1568 (m), 1526 (m), 1471 (m), 1444 (m), 1393 (m), 1364 (s), 1306 (w), 1259 (m), 1221 (m), 1185 (m), 1161 (m), 1124 (w), 1022 (m), 977 (s), 952 (m), 870 (m), 813 (s).

HRMS (ES+): Calcd for $C_{14}H_{14}N_3$ (M+H)+: 224.1188 Found: 224.1187

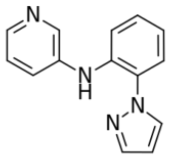
TLC: R_f 0.3 (EtOAc/hexane, 40:60)

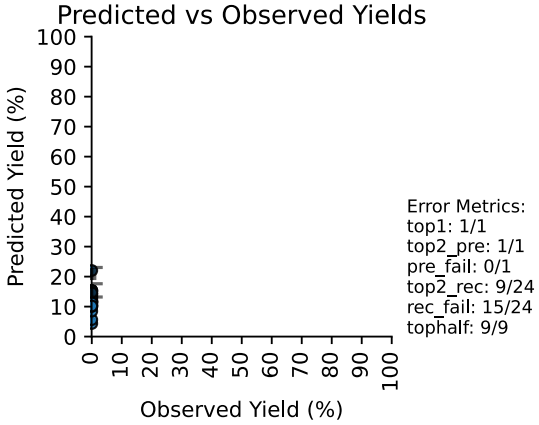
Data for **19_39**

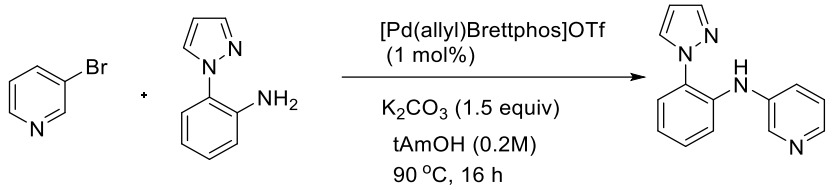
	Predicted Yield %	Observed Yield %
19_39_20_1_a	11.0	0.0
19_39_16_1_a	13.0	0.0
19_39_20_1_c	4.0	0.0
19_39_1_1_a	11.0	0.0
19_39_11_1_b	11.0	0.0
19_39_12_1_b	12.0	0.0
19_39_17_2_a	13.0	0.0
19_39_20_2_a	14.0	0.0
19_39_19_2_a	12.0	0.0
19_39_4_2_a	12.0	0.0
19_39_2_2_b	14.0	0.0
19_39_10_2_a	13.0	0.0
19_39_7_2_b	15.0	0.0
19_39_8_2_a	22.0	0.0
19_39_20_2_b	15.0	0.0
19_39_9_2_b	15.0	0.0
19_39_14_2_b	15.0	0.0
19_39_20_2_c	6.0	0.0
19_39_20_3_a	10.0	0.0
19_39_21_3_a	10.0	0.0
19_39_18_3_a	8.0	0.0
19_39_13_3_b	11.0	0.0
19_39_6_3_b	10.0	0.0
19_39_3_3_b	10.0	0.0



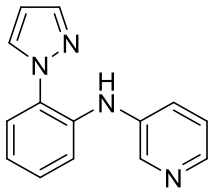
19_39







[Pd(allyl)BrettPhos]OTf (16.6 mg, 2 mol %) and K_2CO_3(207 mg, 1.5 mmol) under nitrogen was added ^{t}AmOH (3 mL) followed by 3-bromopyridine (158 mg, 1.0 mmol) and 2-(1H-pyrazol-1-yl)aniline (175 mg, 1.1 mmol). The reaction mixture was stirred at 90 ^{o}C for 16 h under nitrogen atmosphere, cooled to room temperature, diluted with water (10 mL), extracted with CH_2Cl_2 (3x10 mL), and concentrated under reduced pressure. The crude residue was purified by flash chromatography (EtOAc/hexane, 10:90 to 20:80) to give the product as light green oil. Yield 210 mg (89%)

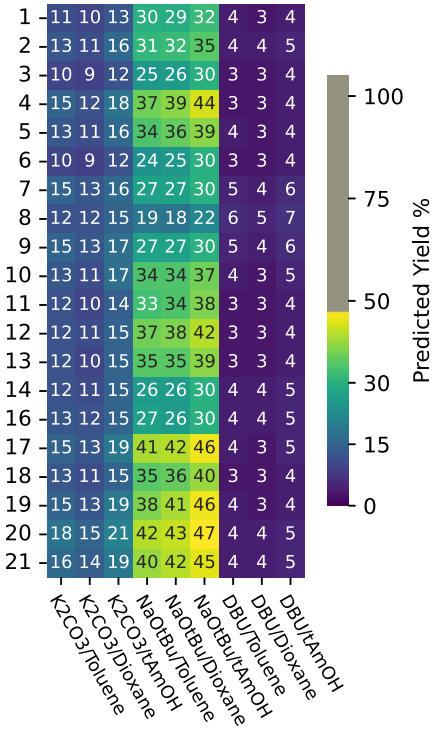


N-(2-(1H-Pyrazol-1-yl)phenyl)pyridin-3-amine **(19_39)**

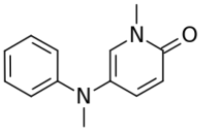
Color and State	Light green oil
^{1}H NMR	(500 MHz, $CDCl_3$)
	δ 8.44 (d, *J* = 2.7 Hz, 1H), 8.40 (s, 1H), 8.17 (dd, *J* = 4.7, 1.5 Hz, 1H), 7.78 (d, *J* = 2.5 Hz, 2H), 7.47 – 7.38 (m, 2H), 7.31 (dd, *J* = 7.9, 1.5 Hz, 1H), 7.23 (td, *J* = 7.8, 1.6 Hz, 1H), 7.15 (dd, *J* = 8.3, 4.7 Hz, 1H), 6.96 (td, *J* = 7.7, 1.3 Hz, 1H), 6.46 (t, *J* = 2.2 Hz, 1H).
^{13}C{^{1}H} NMR	(126 MHz, $CDCl_3$)
	δ 142.68, 141.74, 140.86, 138.80, 136.67, 130.00, 129.02, 128.20, 125.26, 124.16, 123.70, 120.83, 117.37, 106.88.
IR (cm^{-1})	ATR (neat)
	3297 (w br), 3038 (w), 1723 (w), 1579 (s), 1509 (s), 1480 (s), 1455 (s), 1422 (m), 1391 (m), 1314 (s), 1234 (w), 1185 (w), 1161 (w), 1127 (w), 1101 (m), 1047 (m), 1020 (m), 939 (m), 915 (m), 880 (w), 792 (m), 748 (s), 707 (s), 684 (m), 657 (m), 618 (s), 579 (m).
HRMS (ES+)	Calcd for $C_{14}H_{13}N_4$ (M+H)+: 237.1140 Found: 237.1136
TLC	R_f 0.3 (EtOAc/hexane, 20:80)

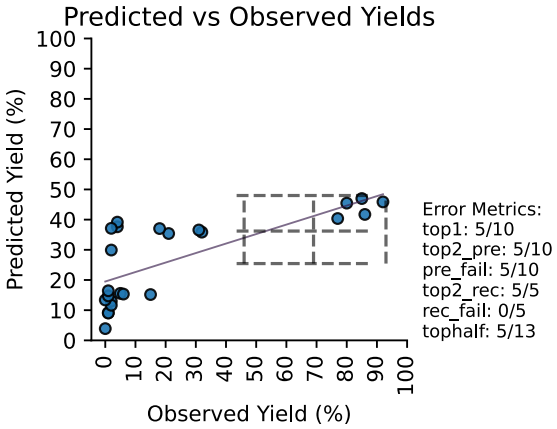
Data for **6_49**

	Predicted Yield %	Observed Yield %
6_49_21_1_b	42.0	86.0
6_49_13_1_b	35.0	21.0
6_49_19_1_a	13.0	2.0
6_49_18_1_b	36.0	32.0
6_49_3_1_a	9.0	1.0
6_49_6_1_a	9.0	1.0
6_49_8_1_a	12.0	2.0
6_49_21_2_b	45.0	80.0
6_49_20_2_b	47.0	85.0
6_49_1_2_a	13.0	0.0
6_49_2_2_a	16.0	5.0
6_49_17_2_b	46.0	92.0
6_49_10_2_b	37.0	31.0
6_49_11_2_b	38.0	4.0
6_49_5_2_b	39.0	4.0
6_49_14_2_a	15.0	6.0
6_49_16_2_a	15.0	15.0
6_49_7_2_b	30.0	2.0
6_49_9_3_a	15.0	1.0
6_49_4_3_b	37.0	2.0
6_49_12_3_b	37.0	18.0
6_49_21_3_a	16.0	1.0
6_49_21_3_c	4.0	0.0
6_49_21_3_b	40.0	77.0

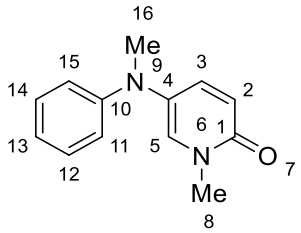


6_49





A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*



1-Methyl-5-(methyl(phenyl)amino)pyridin-2(1H)-one **(6_49)**

Color and state Green solid

mp: 131.5-132.5 °C (sealed tube)

^{1}H NMR 500 MHz, $CDCl_3$)

δ 7.25 – 7.18 (m, 3H, 3xCH (12, 14, and 3), 7.17 (d, *J* = 2.9 Hz, 1H, CH (5)), 6.81 (t, *J* = 7.3 Hz, 1H, CH (13)), 6.72 (d, *J* = 7.8 Hz, 2H, 2xCH (11 and 15), 6.57 (d, *J* = 9.6 Hz, 1H, CH (2)), 3.52 (s, 3H, NCH_3 (8)), 3.17 (s, 3H, NCH_3 (16)).

^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$)

δ 161.76 (s, C (1), 149.10 (s, C (4)), 140.68 (s, C (3)), 135.15 (s, C (5)), 129.39 (s, (10)), 129.23 (s, 2xC (11 and 15)), 121.53 (s, C (2)), 118.94 (s, C (13)), 115.06 (s, 2xC (12 and 14), 40.66 (s, C (8)), 37.81 (s, C (16)).

IR (cm^{-1}) ATR (neat)

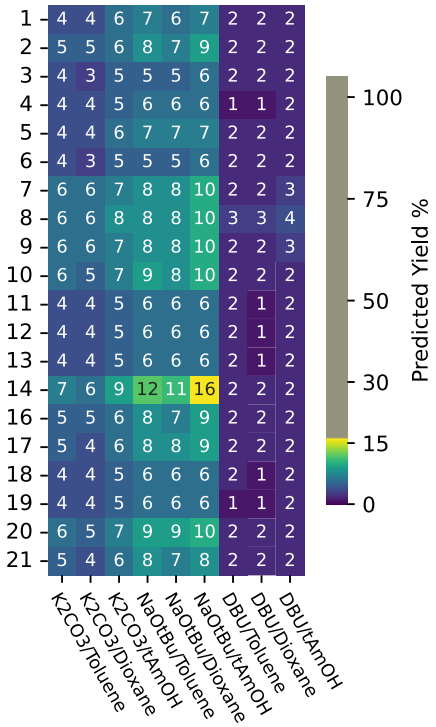
3048 (w), 2863 (w), 2803 (w), 1663 (s), 1585 (s), 1531 (m), 1495 (m), 1421 (m), 1373 (m), 1316 (m), 1287 (m), 1230 (w), 1188 (w), 1157 (m), 1123 (m), 1094 (m), 1074 (m), 1043 (m), 991 (m), 938 (w), 914 (w), 886 (w), 835 (m).

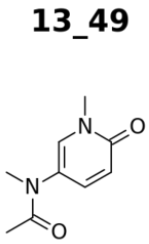
HRMS (ES+) Calcd for $C_{13}H_{15}N_2O$ (M+H)+: 215.1184 Found: 215.1189

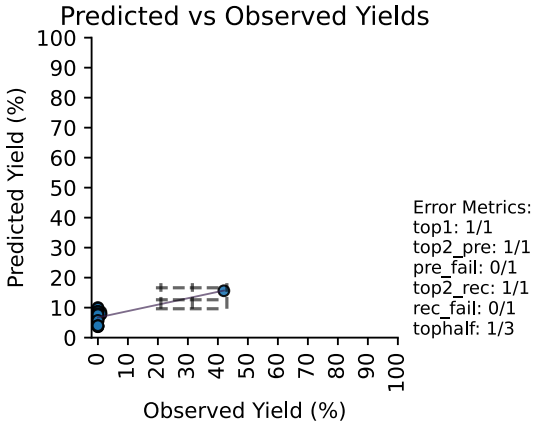
TLC R_f 0.3 (EtOAc/CH_2Cl_2, 50:50)

Data for **13_49**

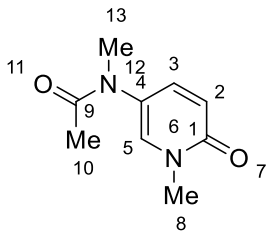
	Predicted Yield %	Observed Yield %
13_49_8_1_b	8.0	1.0
13_49_3_1_b	5.0	0.0
13_49_4_1_a	4.0	0.0
13_49_20_1_b	9.0	1.0
13_49_9_1_b	8.0	0.0
13_49_18_1_a	4.0	0.0
13_49_16_2_a	6.0	0.0
13_49_7_2_b	10.0	0.0
13_49_17_2_a	6.0	0.0
13_49_20_2_a	7.0	0.0
13_49_14_2_b	16.0	42.0
13_49_8_2_a	8.0	1.0
13_49_13_2_b	6.0	0.0
13_49_8_2_b	10.0	0.0
13_49_2_2_b	9.0	0.0
13_49_1_2_b	7.0	0.0
13_49_8_2_c	4.0	0.0
13_49_6_2_b	6.0	0.0
13_49_10_3_b	9.0	0.0
13_49_8_3_b	8.0	0.0
13_49_21_3_b	8.0	0.0
13_49_11_3_b	6.0	0.0
13_49_12_3_a	4.0	0.0
13_49_19_3_a	4.0	0.0







A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*



N-Methyl-N-(1-methyl-6-oxo-1,6-dihydropyridin-3-yl)acetamide (**13_49)**

Color and state: Green solid

mp: 123.7-124.7 °C (sealed tube)

^{1}H NMR: (500 MHz, $CDCl_3$)
δ 7.27 (s, 1H, CH (5)), 7.21 (dd, *J* = 9.6, 2.9 Hz, 1H, CH (3)), 6.61 (d, *J* = 9.6 Hz, 1H, CH (2)), 3.55 (s, 3H, NCH_3 (8)), 3.16 (s, 3H, NCH_3 (13)), 1.93 (s, 3H, CH_3 (10)).

^{13}C{^{1}H} NMR: (126 MHz, $CDCl_3$) δ 171.08 (s, C(9)), 161.85 (s, C(1)), 139.75 (s, C(3)), 136.96 (s, C (5)), 124.87 (s, C (4)), 121.90 (s, C (2)), 38.10 (s, C (8)), 37.41 (s, C (13)), 22.35 (s, C (10)).

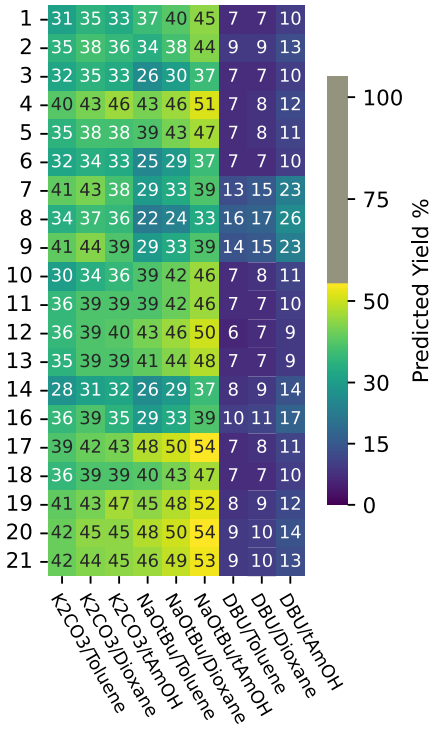
IR (cm^{-1}): ATR (neat)
3285 (w br), 3049 (w), 2927 (w br), 1674 (s), 1653 (s), 1599 (s), 1531 (m), 1419 (s), 1387 (s), 1307 (m), 1234 (m), 1159 (m), 1132 (m), 1096 (m), 1043 (m), 976 (m), 952 (w), 919 (w), 880 (w), 836 (s).

HRMS (ES+): Calcd for $C_9H_{13}N_2O_2$ (M+H)+: 181.0976 Found: 181.0977

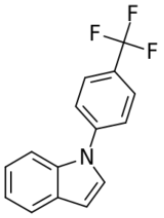
TLC: R_f 0.3 (EtOAc/CH_2Cl_2, 40:60)

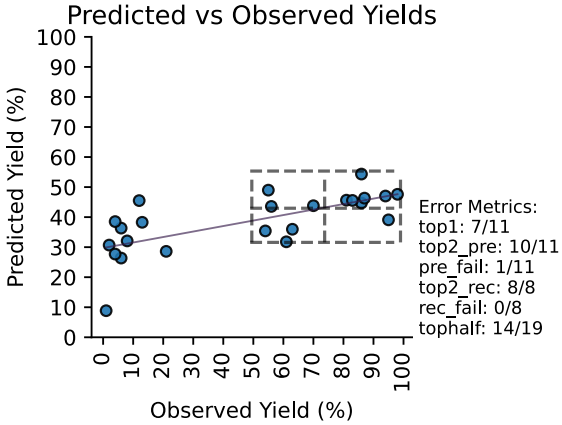
Data for **18_4**

	Predicted Yield %	Observed Yield %
18_4_12_1_b	46.0	81.0
18_4_21_1_b	49.0	55.0
18_4_14_1_a	31.0	2.0
18_4_14_1_b	29.0	21.0
18_4_13_1_b	44.0	56.0
18_4_16_1_a	39.0	95.0
18_4_14_1_c	9.0	1.0
18_4_20_2_b	54.0	86.0
18_4_8_2_a	36.0	6.0
18_4_9_2_a	39.0	4.0
18_4_14_2_a	32.0	8.0
18_4_7_2_a	38.0	13.0
18_4_19_2_a	47.0	94.0
18_4_10_2_b	46.0	12.0
18_4_2_2_b	44.0	70.0
18_4_1_2_b	45.0	86.0
18_4_4_2_a	46.0	83.0
18_4_11_2_b	46.0	87.0
18_4_18_3_a	36.0	63.0
18_4_17_3_b	48.0	98.0
18_4_6_3_a	32.0	61.0
18_4_5_3_a	35.0	54.0
18_4_3_3_b	26.0	6.0
18_4_14_3_a	28.0	4.0

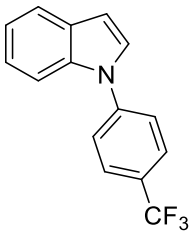


18_4





A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*



1-(4-(Trifluoromethyl)phenyl)-1H-indole **(18_4)** (*89*),(*90*)

^{1}H NMR (500 MHz, $CDCl_3$)

δ 7.79 (d, *J* = 8.4 Hz, 2H), 7.71 (d, *J* = 7.8 Hz, 1H), 7.65 (d, *J* = 8.1 Hz, 2H), 7.61 (dd, *J* = 8.2, 0.9 Hz, 1H), 7.36 (d, *J* = 3.4 Hz, 1H), 7.28 (dd, *J* = 7.1, 1.3 Hz, 1H), 7.22 (td, *J* = 7.6, 1.1 Hz, 1H), 6.74 (dd, *J* = 3.4, 0.9 Hz, 1H).

^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$)

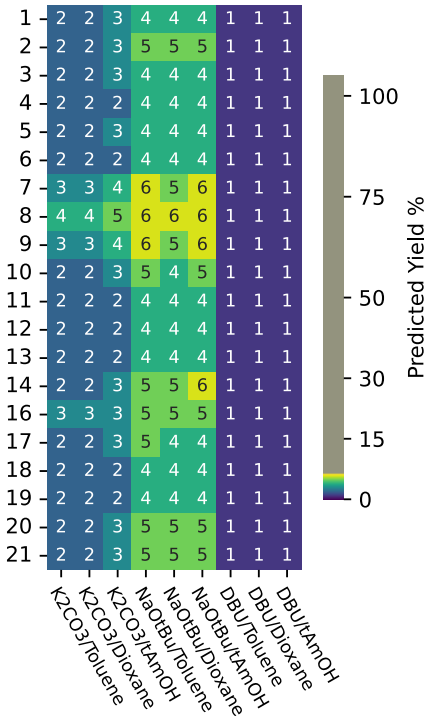
δ 142.96, 135.63, 129.84, 128.31 (q, J_{C2F} = 32.76 Hz), 127.55, 127.07 (q, J_{C3F} = 3.78 Hz), 124.07, 124.05 (q, J_{C1F} = 272.16 Hz), 123.07, 121.58, 121.14, 110.48, 105.06.

^{19}F NMR (471 MHz, $CDCl_3$)

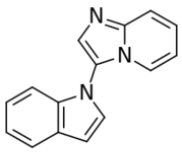
δ -62.25.

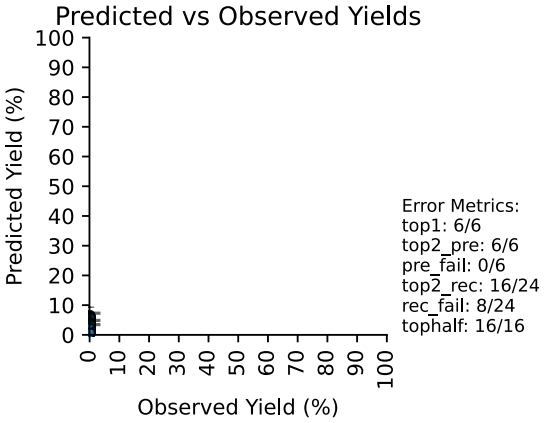
Data for **18_35**

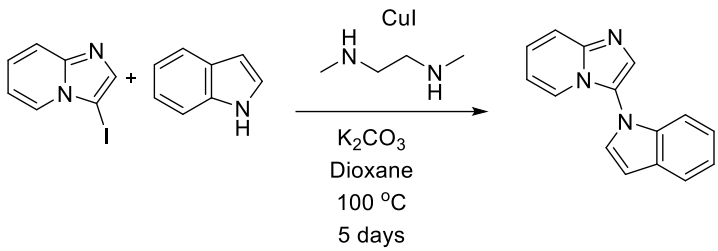
	Predicted Yield %	Observed Yield %
18_35_20_1_b	5.0	0.0
18_35_2_1_a	2.0	0.0
18_35_1_1_b	4.0	0.0
18_35_19_1_b	4.0	0.0
18_35_7_1_a	3.0	0.0
18_35_14_1_b	5.0	0.0
18_35_13_1_a	2.0	0.0
18_35_8_2_a	5.0	0.0
18_35_8_2_b	6.0	0.0
18_35_7_2_b	6.0	0.0
18_35_9_2_a	4.0	0.0
18_35_10_2_b	5.0	0.0
18_35_16_2_a	3.0	0.0
18_35_17_2_a	3.0	0.0
18_35_4_2_b	4.0	0.0
18_35_2_2_b	5.0	0.0
18_35_11_2_a	2.0	0.0
18_35_19_3_b	4.0	0.0
18_35_9_3_c	1.0	0.0
18_35_5_3_b	4.0	0.0
18_35_5_3_a	2.0	0.0
18_35_13_3_c	1.0	0.0
18_35_7_3_b	6.0	0.0
18_35_8_3_a	4.0	0.0



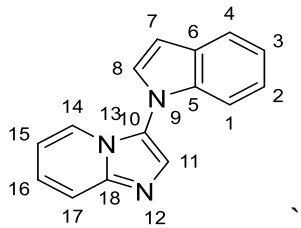
18_35







CuI (7.8 mg, 10 mol%) and K_2CO_3 (210 mg, 3.0 mmol) under nitrogen was added dioxane (2 mL) followed by N1,N2-dimethylethane-1,2-diamine (6.7 mg, 15 mol%), 3-iodoimidazo[1,2-a]pyridine (100 mg) and indole (57.6 mg, 1.2 equiv). The reaction mixture was stirred at 90 °C for 5 days, the reaction was cooled to rt, diluted with water (5 mL), and extracted three times with CH_2Cl_2 (2 × 15 mL). The combined organic phases were dried over $MgSO_4$, filtered, and the solvent was removed under reduced pressure. Flash column chromatography on silica gel (EtOAc/CH_2Cl_2, 10:90 to 30:70) afforded the product as a brown solid. Yield: 7 mg (7%).



3-(1H-Indol-1-yl)imidazo[1,2-a]pyridine **(18_35)**

Color and state: Brown solid

m.p.: 100-102 °C (sealed tube)

^{1}H NMR (500 MHz, $CDCl_3$)

δ 7.78 (s, 1H, CH (11)), 7.76 – 7.70 (m, 2H, 2xCH (1 and 4)), 7.52 (d, *J* = 6.9 Hz, 1H, CH (17)), 7.31 – 7.26 (m, 1H, CH (16)), 7.25 – 7.18 (m, 3H, 3xCH (2, 8, 14)), 6.99 (d, *J* = 7.8 Hz, 1H, CH (7)), 6.82 – 6.77 (m, 2H, 2xCH (3 and 15)).

^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$)

δ 144.17 (s, C (18), 137.70 (s, C (11)), 130.02, 129.27, 128.94, 125.30, 123.29, 122.74, 121.50, 121.36, 118.64, 113.08, 110.43, 105.22.

IR (cm^{-1}) ATR (neat)

3028 (w br), 2970 (w), 2854 (w), 2217 (w), 1742 (s), 1713 (w), 1577 (m), 1498 (m), 1454 (m), 1430 (w), 1402 (w), 1364 (s), 1309 (m), 1247 (w), 1210

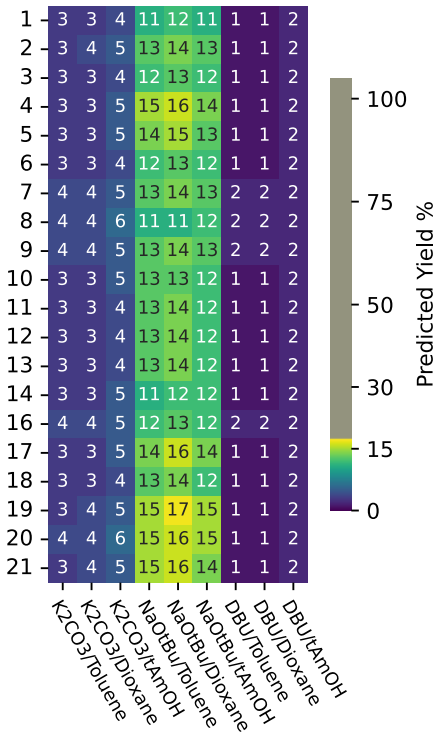
(s), 1144 (m), 1092 (w), 1049 (w), 1010 (w), 965 (w), 922 (w), 891 (w), 739 (s), 654 (w), 528 (w).

HRMS (ES+) Calcd for $C_{15}H_{12}N_3$ (M+H)+: 234.1031 Found: 234.1032

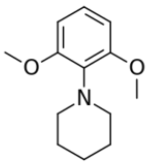
TLC R_f 0.37 (MeOH/CH_2Cl_2, 10:90)

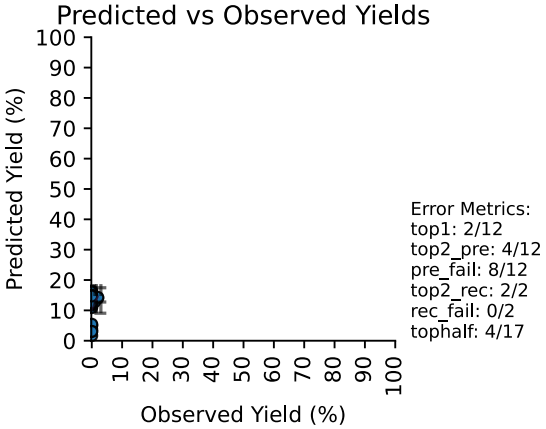
Data for **38_2**

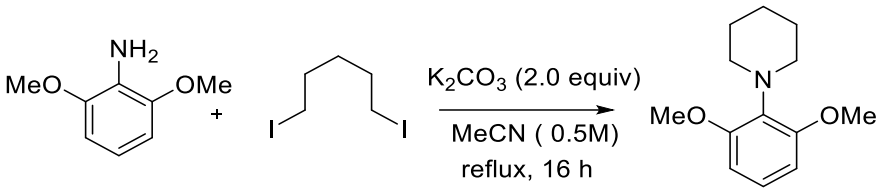
	Predicted Yield %	Observed Yield %
38_2_20_1_b	16.0	0.0
38_2_21_1_b	16.0	0.0
38_2_3_1_b	13.0	1.0
38_2_18_1_b	14.0	0.0
38_2_16_1_a	4.0	0.0
38_2_9_1_c	2.0	0.0
38_2_10_2_a	5.0	0.0
38_2_8_2_b	12.0	0.0
38_2_1_2_b	11.0	0.0
38_2_19_2_a	5.0	0.0
38_2_7_2_a	5.0	0.0
38_2_14_2_b	12.0	0.0
38_2_21_2_b	14.0	0.0
38_2_6_3_b	12.0	0.0
38_2_4_3_b	15.0	0.0
38_2_12_3_a	3.0	0.0
38_2_11_3_a	3.0	0.0
38_2_5_3_b	14.0	2.0
38_2_2_3_b	13.0	1.0
38_2_13_3_b	13.0	0.0
38_2_17_3_b	14.0	2.0
38_2_3_3_b	12.0	0.0
38_2_20_3_b	15.0	0.0
38_2_21_3_b	15.0	0.0



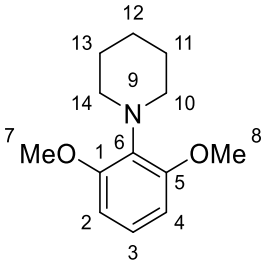
38_2







Prepared in analogy to a literature procedure.(*91*) 2,6 dimethoxy aniline (300 mg, 1.96 mol), 1,5-dibromopentane (634 mg 1.96 mol), K_2CO_3 (541 mg, 2.0 equiv), in CH_3CN (5 mL) were stirred for 16 h at reflux temperature, the reaction was cooled to room temperature, diluted with water (15 mL), and extracted three times with CH_2Cl_2 (3 × 15 mL). The combined organic phases were dried over $MgSO_4$, filtered, and the solvent was removed under reduced pressure. Flash column chromatography on silica gel (EtOAc/hexane, 00:90 to 20:80) afforded the product as brown solid. Yield: 274 mg (63%).



1-(2,6-Dimethoxyphenyl)piperidine (**38_2**)

<u>^{1}H NMR</u> (500 MHz, $CDCl_3$)

δ 6.96 (t, *J* = 8.3 Hz, 1H, CH (3)), 6.55 (d, *J* = 8.2 Hz, 2H, 2xCH (2 and 4)), 3.81 (s, 6H, 2xOMe (7 and 8)), 3.10 – 3.05 (m, 4H, 2xCH_2 (10 and 14)), 1.68 – 1.61 (m, 4H, 2xCH_2 (11 and 13)), 1.59 – 1.52 (m, 2H, CH_2 (12)).

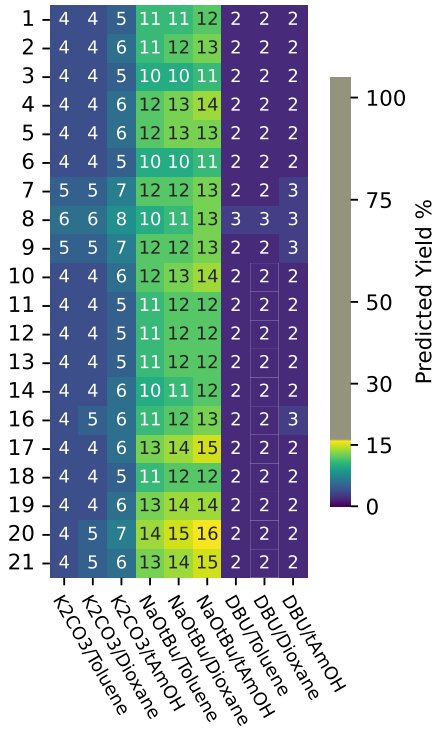
<u>^{13}C{^{1}H} NMR</u> (126 MHz, $CDCl_3$)

δ 157.23(s, 2xC (1 and 5), 131.35 (s, C (6)), 124.01 (s, C(3)), 106.16 (s, 2xC (2 and 4), 56.41(s, 2xC (7 and 8), 52.13 (s, 2xC (10 and 14), 27.28 (s, 2xC (11 and 13), 24.82 (s, C (12)).

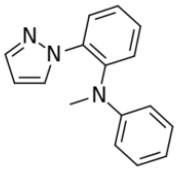
<u>HRMS</u> (ES+) Calcd for $C_{13}H_{20}NO_2$ (M+H)+: 222.1494 Found: 222.1496

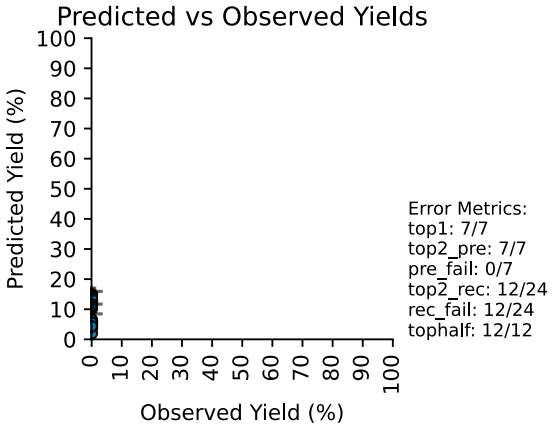
Data for **6_39**

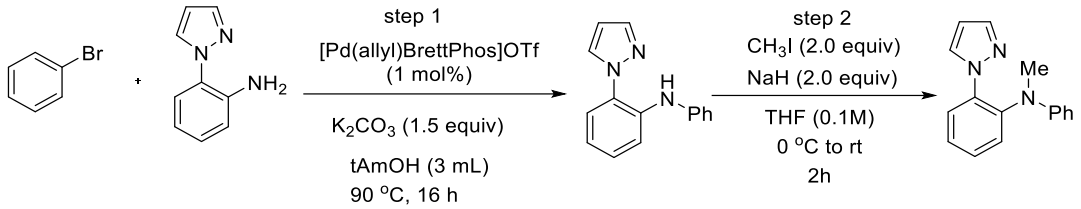
	Predicted Yield %	Observed Yield %
6_39_20_1_b	15.0	0.0
6_39_20_1_a	5.0	0.0
6_39_13_1_b	12.0	0.0
6_39_5_1_b	13.0	0.0
6_39_6_1_a	4.0	0.0
6_39_12_1_b	12.0	0.0
6_39_11_1_a	4.0	0.0
6_39_3_1_b	10.0	0.0
6_39_20_1_c	2.0	0.0
6_39_21_2_b	15.0	0.0
6_39_17_2_a	6.0	0.0
6_39_19_2_a	6.0	0.0
6_39_4_2_a	6.0	0.0
6_39_2_2_b	13.0	0.0
6_39_20_2_a	7.0	0.0
6_39_10_2_b	14.0	0.0
6_39_1_2_a	5.0	0.0
6_39_18_2_a	5.0	0.0
6_39_14_3_b	10.0	0.0
6_39_9_3_b	12.0	0.0
6_39_8_3_a	6.0	0.0
6_39_7_3_b	12.0	0.0
6_39_16_3_b	11.0	0.0
6_39_20_3_a	4.0	0.0



6_39

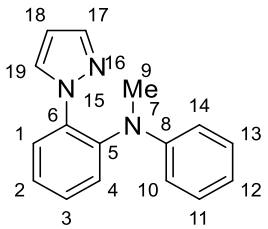






Step 1: [Pd(allyl)BrettPhos]OTf (16.6 mg 1 mol%) and K_2CO_3 (208 mg1.5 mmol) under nitrogen was added ^{t}AmOH (3 mL) followed by 3-bromobenzene (158 mg, 1.0 mmol) and 2-(1H-pyrazol-1-yl)aniline (177.82, 1.1 mmol). The reaction mixture was stirred at 90 ^{o}C for 16 h, The reaction was cooled to room temperature, diluted with water (5 mL) and extracted three times with CH_2Cl_2 (3 × 15 mL). The combined organic phases were dried over $MgSO_4$, filtered, and the solvent was removed under reduced pressure. Flash column chromatography on silica gel (EtOAc/heptane, 0:100 to 50:50) afforded the N-phenyl-2-(1H-pyrazol-1-yl)aniline as oil. Yield: 200 mg (84.7%).

Step: 2: A solution of N-phenyl-2-(1H-pyrazol-1-yl)aniline (100 mg 1.0 equiv) in anhydrous THF (0.1 M) was cooled to 0 °C and sodium hydride (20 mg, 2.0 equiv) was added. The resulting mixture was stirred for fifteen minutes, before adding methyl iodide (121 mg, 2.0 equiv). The reaction was then stirred for one hour at rt for 2h. The resulting mixture was diluted with ethyl acetate, and quenched by the addition of ice and 1.0 M NaOH. The organic layer was separated and the aqueous layer was extracted with ethyl acetate. The combined organic layers were washed with brine, dried over MgSO4, filtered, and concentrated in vacuo. The crude product was purified by flash column chromatography on silica gel (EtOAc/heptane, 0:100 to 20:80) afforded the product as yellow oil. Yield: 80 mg (75%).



N-Methyl-N-phenyl-2-(1H-pyrazol-1-yl)aniline **(6_39)**

<u>Color and state</u>: Yellow oil

<u>^{1}H NMR</u> (500 MHz, $CDCl_3$)

δ 7.80 – 7.75 (m, 1H), 7.66 (dd, *J* = 10.9, 2.2 Hz, 2H), 7.38 – 7.29 (m, 3H), 7.20 (dd, *J* = 8.8, 7.2 Hz, 2H), 6.79 (tt, *J* = 7.4, 1.1 Hz, 1H), 6.74 – 6.68 (m,

2H), 6.29 (dd, J = 2.4, 1.8 Hz, 1H), 2.90 (s, 3H).

$^{13}C\{^{1}H\}$ NMR (126 MHz, $CDCl_3$)

δ 148.58, 140.85, 140.80, 137.95, 130.30, 129.55, 129.29, 128.68, 127.08, 126.60, 118.33, 113.89, 107.20, 38.64.

IR (cm^{-1}) ATR (neat)

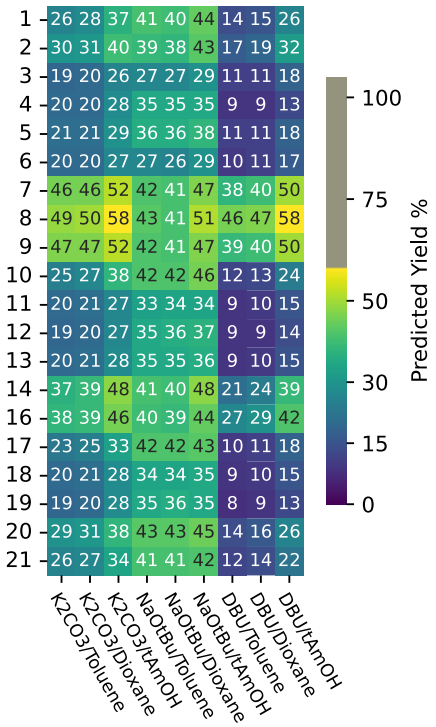
3359 (w), 3027 (w), 1738 (m), 1592 (s), 1496 (s), 1460 (m), 1435 (m), 1392 (m), 1313 (s), 1264 (m), 1216 (m), 1174 (m), 1126 (w), 1100 (m), 1077 (m), 1046 (m), 1021 (m), 938 (m), 915 (m), 886 (m), 747 (s), 694 (s), 661 (m), 622 (m), 576 (m).

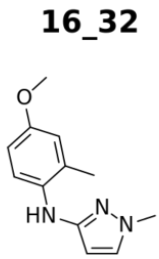
HRMS (ES+) Calcd for $C_{16}H_{16}N_3$ (M+H)+: 250.1344 Found: 250.1337

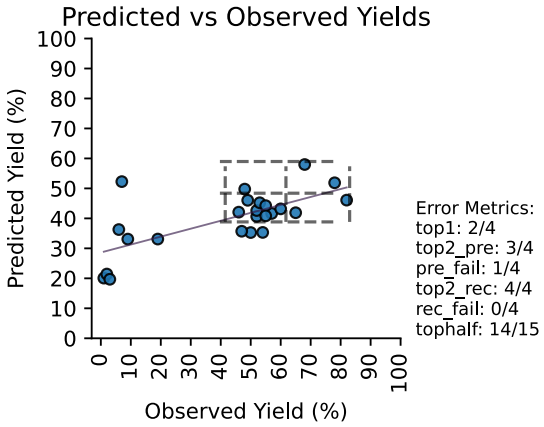
TLC R_f 0.3 (EtOAc/hexane, 15:85)

Data for **16_32**

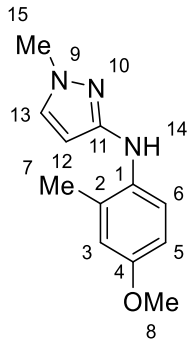
	Predicted Yield %	Observed Yield %
16_32_17_1_b	42.0	46.0
16_32_21_1_b	41.0	52.0
16_32_4_1_b	35.0	50.0
16_32_3_1_a	20.0	1.0
16_32_5_1_a	21.0	2.0
16_32_12_1_b	36.0	47.0
16_32_7_2_c	50.0	48.0
16_32_9_2_a	52.0	7.0
16_32_7_2_a	52.0	78.0
16_32_21_2_b	42.0	57.0
16_32_17_2_a	33.0	19.0
16_32_17_2_b	43.0	60.0
16_32_8_2_a	58.0	68.0
16_32_16_2_a	46.0	82.0
16_32_2_2_b	43.0	52.0
16_32_13_2_b	36.0	6.0
16_32_20_2_b	45.0	53.0
16_32_10_2_b	46.0	49.0
16_32_1_2_b	44.0	55.0
16_32_19_2_b	35.0	54.0
16_32_11_3_b	33.0	9.0
16_32_6_3_a	20.0	3.0
16_32_14_3_b	41.0	55.0
16_32_17_3_b	42.0	65.0







A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*



N-(4-Methoxy-2-methylphenyl)-1-methyl-1H-pyrazol-3-amine **(16_32)**

Color and state Yellow oil

^{1}H NMR (500 MHz, $CDCl_3$)

δ 7.18 (d, *J* = 8.5 Hz, 1H CH, (5)), 7.07 (d, *J* = 2.4 Hz, 1H, CH (13)), 6.65 (d, *J* = 3.2 Hz, 1H, CH (3)), 6.61 (dd, *J* = 8.7, 3.1 Hz, 1H, CH (6)), 5.68 (d, *J* = 2.4 Hz, 1H, CH (12)), 5.49 (br s, 1H, NH (14)), 3.66 (s, 6H, OCH_3 (8)), 2.15 (s, 3H, CH3 (7)).

^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$)

δ 154.11 (s, C (4)), 153.17 (s, C (11)), 135.23 (s, C (1)), 130.89 (s, C (13)), 128.07 (s, C (2)), 118.39 (s, C (3)), 116.45 (s, C (5)), 111.67 (s, C (6)), 93.68 (s, C (12)), 55.56 (s, C (8)), 38.72 (s, C (15)), 18.04 (s, C (7)).

IR (cm^{-1}) ATR (neat)

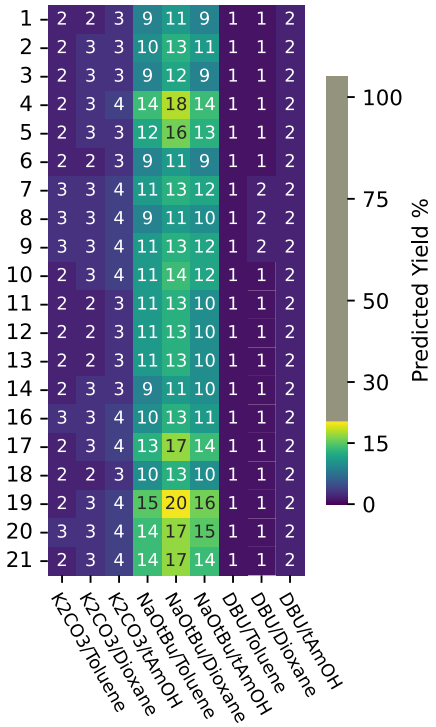
3220 (w), 2997 (w), 2933 (m br), 1724 (w), 1589 (m), 1552 (s), 1491 (s), 1461 (m), 1441 (m), 1415 (m), 1377 (m), 1288 (m), 1223 (s), 1154 (m), 1120 (m), 1076 (m), 1046 (s), 995 (m), 927 (w), 869 (m).

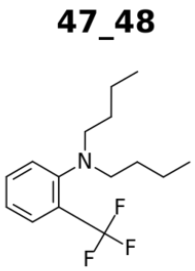
HRMS (ES+) Calcd for $C_{12}H_{16}N_3O$ (M+H)+: 218.1293 Found: 218.1293

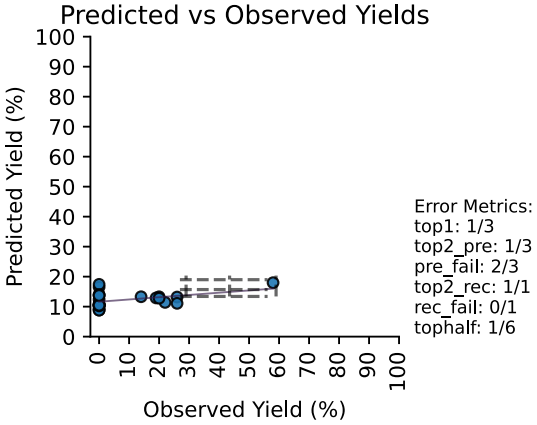
TLC R_f 0.3 (EtOAc/CH_2Cl_2, 15:85)

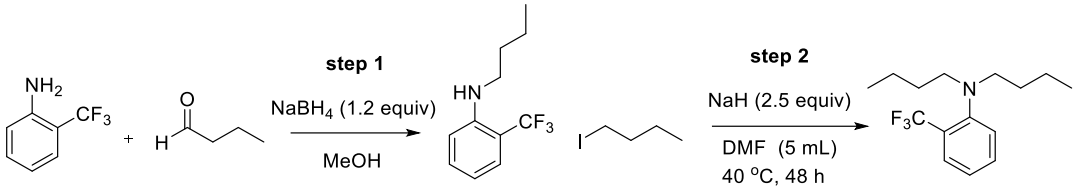
Data for **47_48**

	Predicted Yield %	Observed Yield %
47_48_2_1_b	13.0	26.0
47_48_4_1_b	18.0	58.0
47_48_6_1_b	11.0	22.0
47_48_11_1_b	13.0	14.0
47_48_12_1_b	13.0	20.0
47_48_14_1_b	11.0	26.0
47_48_16_1_b	13.0	19.0
47_48_17_1_b	17.0	0.0
47_48_20_1_b	17.0	0.0
47_48_5_2_b	13.0	20.0
47_48_16_2_b	11.0	0.0
47_48_17_2_b	14.0	0.0
47_48_18_2_b	10.0	0.0
47_48_3_3_b	9.0	0.0
47_48_5_3_b	12.0	0.0
47_48_6_3_b	9.0	0.0
47_48_11_3_b	11.0	0.0
47_48_12_3_b	11.0	0.0
47_48_13_3_b	11.0	0.0
47_48_14_3_b	9.0	0.0
47_48_16_3_b	10.0	0.0
47_48_18_3_b	10.0	0.0
47_48_20_3_b	14.0	0.0
47_48_21_3_b	14.0	0.0



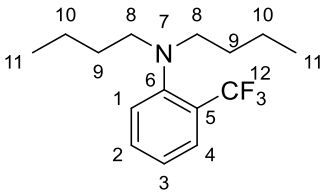






Step 1: 2-(trifluoromethyl)aniline (12.4 mmol, 1.0 equiv.) and butyraldehyde (12.6 mmol, 1.0 equiv) were dissolved in MeOH (30 mL), the resulting mixture was stirred for 4 h at RT, and then $NaBH_4$ (1.2 equiv) was added portion wise at 0 °C and warm to room temperature. After 2 h, water (30 mL) was added to the solution and then extracted with CH_2Cl_2. The combined organic layer was dried over Na_2SO_4 and then evaporated under reduced pressure to give the secondary amine. The product was used in the next step without further purification (NMR purity of crude is 97% product).

Step 2: A solution of N-butyl-2-(trifluoromethyl)aniline (100 mg) in DMF (2 mL) was added to oil-free sodium hydride (2.5 equiv) and stirred for 15 min at ambient temperature.1-iodobutane (2.5 equiv) was slowly added dropwise to the suspension, and the reaction mixture was maintained at 40 °C for 8 h. After careful addition of saturated aqueous NH_4Cl solution (4 mL) and extraction of the organic layer with tert-butyl methyl ether (2 × 20 mL), the combined organic phases were washed with water (4 × 20 mL) and dried over anhydrous Na_2SO_4. Flash column chromatography on silica gel (hexane) afforded the product as colorless oil 120 mg (95%).



N,*N*-Dibutyl-2-(trifluoromethyl)aniline **(47_48)**

Color and state Colorless oil

^{1}H NMR (500 MHz, $CDCl_3$)

δ 7.62 (d, *J* = 7.8 Hz, 1H (4)), 7.51 – 7.45 (m, 1H (2)), 7.37 (d, *J* = 8.1 Hz, 1H (1)), 7.18 (t, *J* = 7.6 Hz, 1H (3)), 2.94 – 2.86 (m, 4H (8)), 1.46 – 1.36 (m, 4H (9)), 1.26 (h, *J* = 7.3 Hz, 4H (10)), 0.86 (t, *J* = 7.4 Hz, 6H (11)).

^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$)

δ 152.49 (s, C (6)), 132.36 (s, C (2)), 128.30 (q, J_{CF} = 28.98 Hz, 1C (5)),

127.40 (q, J_{CF} = 6.3 Hz, 1C (4)), 125.53 (s, C (1)), 124.26 (s, C (3)), 124.22(q, J_{CF} = 274.68 Hz, 1C (12)), 55.58 (s, C (8)), 29.80 (s, C (9)), 20.58 (s, C (10)), 14.14 (s, C (11)).

^{19}F NMR (471 MHz, $CDCl_3$)

δ -59.72.

IR (cm^{-1}) ATR (neat)

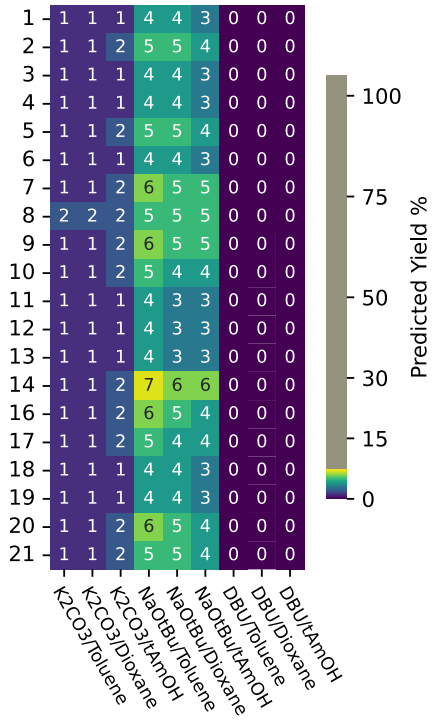
2959 (w), 2934 (w), 2873 (w), 2812 (w), 1738 (w), 1602 (w), 1494 (m), 1454 (m), 1378 (w), 1313 (s), 1256 (w), 1206 (w), 1135 (s), 1109 (s), 1037 (s), 952 (w), 928 (w), 899 (w), 762 (s), 648 (m), 600 (w), 574 (w).

HRMS (ES+) Calcd for $C_{15}H_{23}NF_3$ (M+H)+: 274.1783 Found: 274.1769

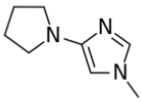
TLC R_f 0.5 (Et_2O/hexane, 2:98)

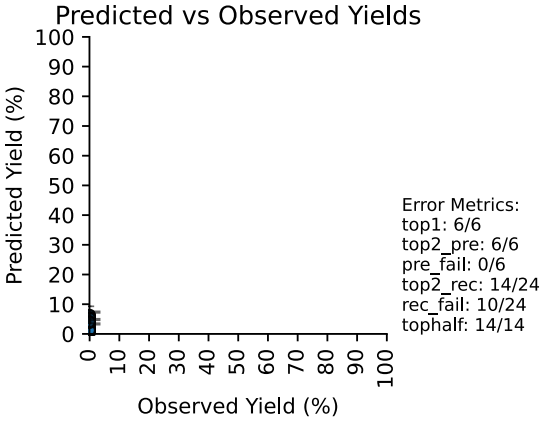
Data for **44_34**

	Predicted Yield %	Observed Yield %
44_34_21_1_b	5.0	0.0
44_34_17_1_b	4.0	0.0
44_34_2_1_b	5.0	0.0
44_34_7_1_c	0.0	0.0
44_34_18_1_a	1.0	0.0
44_34_13_1_a	1.0	0.0
44_34_14_2_b	6.0	0.0
44_34_8_2_a	2.0	0.0
44_34_19_2_b	3.0	0.0
44_34_17_2_a	2.0	0.0
44_34_10_2_a	2.0	0.0
44_34_21_2_b	4.0	0.0
44_34_6_2_a	1.0	0.0
44_34_20_2_a	2.0	0.0
44_34_21_3_b	5.0	0.0
44_34_17_3_b	5.0	0.0
44_34_20_3_b	6.0	0.0
44_34_13_3_b	4.0	0.0
44_34_4_3_b	4.0	0.0
44_34_2_3_b	5.0	0.0
44_34_3_3_a	1.0	0.0
44_34_5_3_b	5.0	0.0
44_34_12_3_b	4.0	0.0
44_34_1_3_b	4.0	0.0

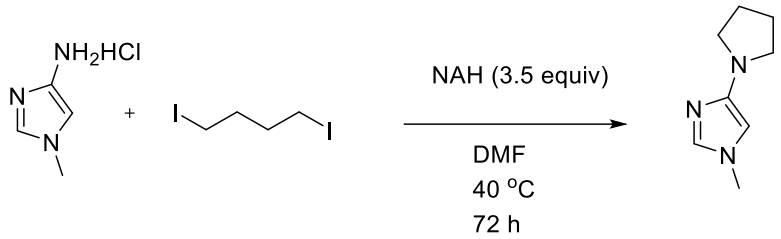


44_34

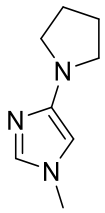




1-Methyl-4-(pyrrolidin-1-yl)-1H-imidazole **(44_34)**



1-Methyl-1H-imidazol-4-amine hydrochloride (100 mg, 0.74 mol), 1,4-diiodobutane (464 mg 1.5 mmol), NaH (62.9 mg, 3.5 equiv), in DMF (2 mL) were stirred for 72 h at 40 °C, the reaction was cooled to room temperature . The resulting mixture was quenched by the addition of ice and 1.0 M NaOH and diluted with ethyl acetate. The organic layer was separated, and the aqueous layer was extracted with ethyl acetate. The combined organic layers were washed with brine, dried over MgSO4, filtered, and concentrated in vacuo. The crude product was purified by flash column chromatography on silica gel (MeOH/CH_2Cl_2, 0:100 to 05:95) afforded the product as brown solid 5 mg (yield 4%).

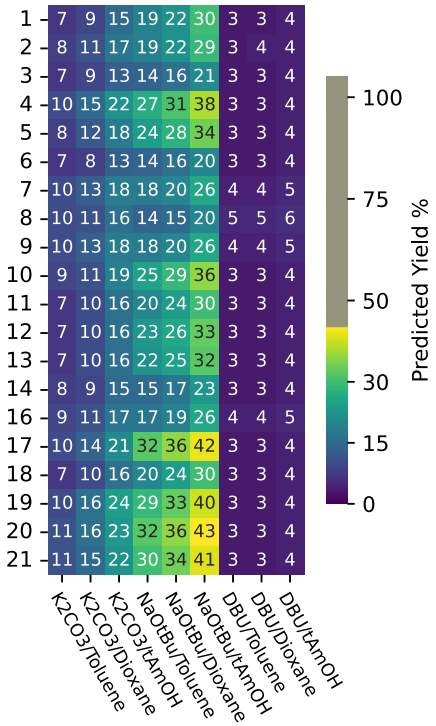


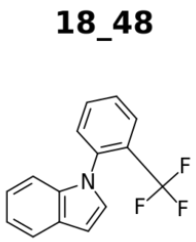
1-Methyl-4-(pyrrolidin-1-yl)-1H-imidazole **(44_34)**

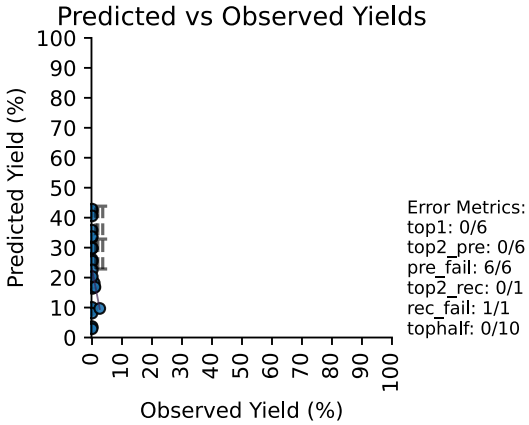
Color and sate	Brown solid
^{1}H NMR	(500 MHz, $CDCl_3$)
	δ 7.26 (s, 2H), 4.02 (t, *J* = 6.9 Hz, 2H), 3.76 (t, *J* = 7.0 Hz, 2H), 3.08 (s, 3H), 2.09 (p, *J* = 6.7 Hz, 2H), 2.05 – 1.98 (m, 2H).
^{13}C{^{1}H} NMR	(126 MHz, $CDCl_3$)
	δ 164.93, 162.26, 161.35, 50.25, 49.04, 26.30, 25.18, 23.91.
IR (cm^{-1})	ATR (neat)
	2925 (w), 2854 (w), 1718 (s), 1654 (s), 1601 (w), 1443 (m), 1412 (m), 1385 (m), 1345 (m), 1240 (w), 1199 (m), 1168 (w), 1114 (w), 1078 (w), 972 (w), 858 (w), 773 (m), 729 (w), 690 (w), 614 (w), 512 (w).
HRMS (ES+)	Calcd for $C_8H_{14}N_3$ (M+H)+: 152.1188 Found: 152.1186
TLC	R_f 0.35 (MeOH/ CH_2Cl_2, 2:98)

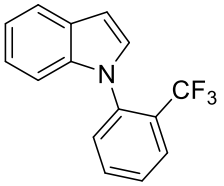
Data for **18_48**

	Predicted Yield %	Observed Yield %
18_48_14_1_a	9.0	0.0
18_48_18_1_a	10.0	0.0
18_48_12_1_b	26.0	0.0
18_48_16_1_b	19.0	0.0
18_48_19_1_b	33.0	0.0
18_48_20_1_b	36.0	0.0
18_48_21_1_b	34.0	0.0
18_48_10_1_c	3.0	0.0
18_48_2_2_a	17.0	1.0
18_48_8_2_a	16.0	0.0
18_48_9_2_a	18.0	1.0
18_48_16_2_a	17.0	1.0
18_48_17_2_b	42.0	0.0
18_48_20_2_b	43.0	0.0
18_48_21_2_b	41.0	0.0
18_48_1_2_b	30.0	0.0
18_48_14_3_a	8.0	0.0
18_48_17_3_a	10.0	3.0
18_48_10_3_b	25.0	0.0
18_48_12_3_b	23.0	0.0
18_48_18_3_b	20.0	0.0
18_48_21_3_b	30.0	0.0
18_48_16_3_c	4.0	0.0
18_48_19_3_c	3.0	0.0









The structure and purity of the known compound **18_48** was confirmed by the comparison of the physical and spectral data (^{1}H NMR, ^{13}C NMR) with a sample prepared by a procedure reported in the literature.(*92*),(*93*)

1-(2-Ttrifluoromethyl)phenyl)-1H-indole (**18_48**)

^{1}H NMR (500 MHz, $CDCl_3$)

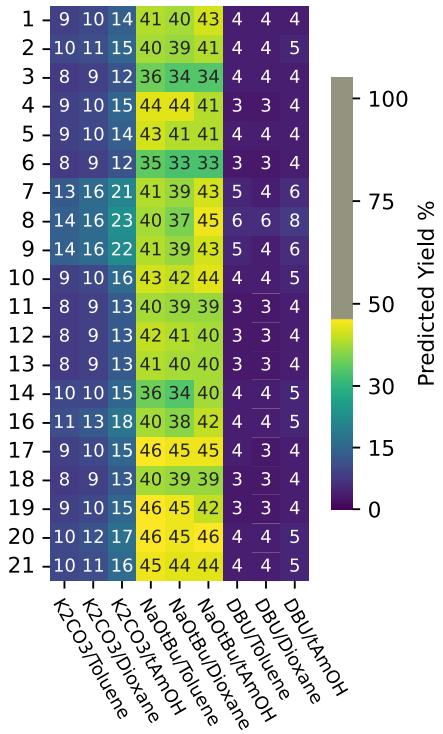
δ 7.81 (dd, *J* = 7.8, 1.6 Hz, 1H), 7.60 (td, *J* = 4.1, 2.8 Hz, 2H), 7.53 (tt, *J* = 7.7, 1.2 Hz, 1H), 7.38 (d, *J* = 7.8 Hz, 1H), 7.13 (dq, *J* = 2.3, 1.2 Hz, 1H), 7.12 – 7.06 (m, 2H), 6.96 – 6.92 (m, 1H), 6.62 (dd, *J* = 3.2, 0.9 Hz, 1H).

^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$)

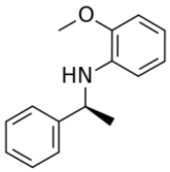
δ 142.15, 138.61, 137.71, 132.99, 131.16, 129.85, 128.78 (q, $J_{C\text{-}F}$ = 31.5 Hz), 128.78, 128.49, 128.08, 127.60 (q, $J_{C\text{-}F}$ = 5.04 Hz) = , 127.58, 127.53, 124.30, 122.46, 122.13, 120.99, 120.43, 110.44, 103.35.

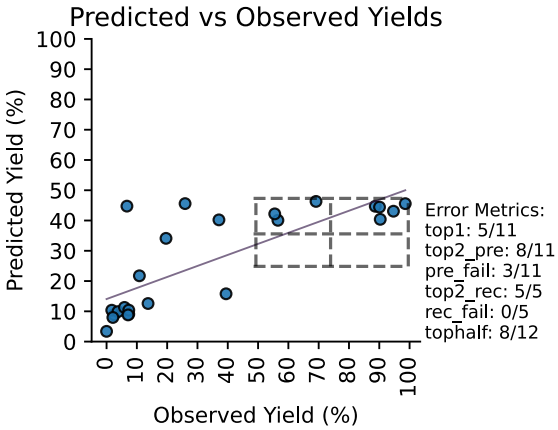
Data for **34_7**

	Predicted Yield %	Observed Yield %
34_7_19_1_b	45.0	7.0
34_7_3_1_b	34.0	20.0
34_7_13_1_b	40.0	37.0
34_7_1_1_b	40.0	57.0
34_7_18_1_a	9.0	2.0
34_7_11_1_a	9.0	7.0
34_7_19_1_a	10.0	2.0
34_7_19_1_c	3.0	0.0
34_7_9_2_a	22.0	11.0
34_7_10_2_a	16.0	39.0
34_7_19_2_b	42.0	55.0
34_7_7_2_b	43.0	95.0
34_7_14_2_b	40.0	90.0
34_7_8_2_b	45.0	89.0
34_7_12_2_a	13.0	14.0
34_7_2_3_a	10.0	4.0
34_7_6_3_a	8.0	2.0
34_7_16_3_a	11.0	6.0
34_7_17_3_b	46.0	99.0
34_7_20_3_b	46.0	69.0
34_7_20_3_a	10.0	7.0
34_7_4_3_a	9.0	7.0
34_7_4_3_b	44.0	90.0
34_7_19_3_b	46.0	26.0

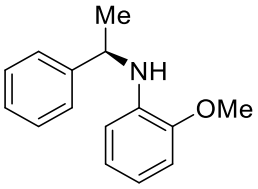


34_7





A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions.*



2-Methoxy-*N*-(1-phenylethyl)aniline **(34_7)** (*94*),(*95*)

^{1}H NMR (500 MHz, $CDCl_3$)

δ 7.38 (d, *J* = 7.0 Hz, 2H), 7.33 (t, *J* = 7.7 Hz, 2H), 7.23 (t, *J* = 7.2 Hz, 1H), 6.78 (dd, *J* = 7.9, 1.4 Hz, 1H), 6.71 (td, *J* = 7.6, 1.4 Hz, 1H), 6.62 (td, *J* = 7.6, 1.5 Hz, 1H), 6.36 (dd, *J* = 7.9, 1.6 Hz, 1H), 4.65 (br s, 1H), 4.49 (q, *J* = 6.7 Hz, 1H), 3.90 (s, 3H), 1.57 (d, *J* = 6.7 Hz, 3H).

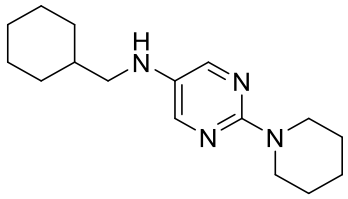
^{13}C{^{1}H} (126 MHz, $CDCl_3$)

NMR δ 146.67, 145.57, 137.34, 128.71, 126.89, 125.96, 121.27, 116.41, 111.14, 109.38, 55.55, 53.43, 25.30.

Experimental Validation Products

Data for **31_27 (validation a)**

A sample of the authentic product was isolated from culture tubes per the procedure described in section *Experimental Validation Procedure*.

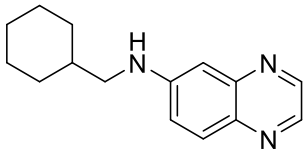


N-(Cyclohexylmethyl)-2-(piperidin-1-yl)pyrimidin-5-amine (**31_27**)

Color and state:	Pink crystalline plates
m.p.:	93.1-94.1 °C (sealed tube)
^{1}H NMR	(600 MHz, $CDCl_3$)
	δ 7.89 (s, 2H), 3.64 (t, *J* = 5.1 Hz, 4H), 3.11 (s, 1H), 2.88 (d, *J* = 6.7 Hz, 2H), 1.80 – 1.71 (m, 4H), 1.70 – 1.66 (m, 1H), 1.64 – 1.58 (m, 6H), 1.54 (ttd, *J* = 13.9, 6.9, 3.4 Hz, 1H), 1.28 – 1.11 (m, 3H), 0.96 (qd, *J* = 12.1, 3.2 Hz, 2H).
^{13}C{^{1}H} NMR	(151 MHz, $CDCl_3$)
	δ 157.57, 144.40, 133.92, 52.06, 45.80, 37.58, 31.30, 26.67, 26.07, 25.78, 25.01.
IR (cm^{-1})	ATR (neat)
	3265 (w), 2923 (m), 2852 (m), 2804 (w), 1554 (w), 1494 (m), 1435 (s), 1367 (m), 1301 (m), 1249 (s), 1221 (m), 1171 (m), 1140 (m), 1096 (m), 1056 (w), 1029 (m), 939 (s), 919 (m), 854 (m), 787 (m), 739 (w), 653 (m), 614 (m), 563 (m), 534 (m).
HRMS(ES+):	Calcd for $C_{16}H_{27}N_4$ (M+H)+: 275.2236 Found: 275.2225
TLC	R_f 0.15 (EtOAc/hexane, 15:85) [UV/$KMnO_4$]

Data for **31_5 (validation b)**

A sample of the authentic product was isolated from culture tubes per the procedure described in section *Experimental Validation Procedure*.



N-(Cyclohexylmethyl)quinoxalin-6-amine (**31_5**)

Color and state: Amber crystalline needles

m.p.: 92.2-92.7 °C (sealed tube)

^{1}H NMR (600 MHz, $CDCl_3$)

δ 8.62 (d, *J* = 1.9 Hz, 1H), 8.48 (d, *J* = 2.0 Hz, 1H), 7.80 (d, *J* = 9.0 Hz, 1H), 7.10 (dd, *J* = 9.1, 2.6 Hz, 1H), 6.93 (d, *J* = 2.6 Hz, 1H), 3.11 (t, *J* = 6.3 Hz, 2H), 1.85 (ddd, *J* = 12.0, 3.6, 1.6 Hz, 2H), 1.76 (dt, *J* = 12.3, 3.1 Hz, 2H), 1.73 – 1.66 (m, 2H), 1.31 – 1.12 (m, 3H), 1.03 (qd, *J* = 12.4, 3.4 Hz, 2H).

^{13}C{^{1}H} NMR (151 MHz, $CDCl_3$)

δ 149.60, 145.76, 145.04, 140.22, 138.03, 130.16, 122.41, 103.36, 50.41, 37.23, 31.38, 26.61, 26.02.

IR (cm^{-1}) ATR (neat)

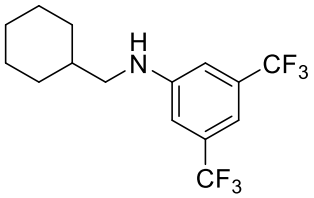
3313 (m), 3062 (w), 2927 (m), 2849 (m), 1915 (w), 1618 (s), 1582 (w), 1527 (s), 1466 (m), 1435 (s), 1353 (s), 1257 (m), 1231 (s), 1171 (m), 1133 (m), 1103 (m), 1044 (s), 947 (s), 893 (m), 861 (s), 824 (s), 769 (m), 749 (m), 665 (m), 592 (m), 552 (s), 510 (m).

HRMS(ES+): Calcd for $C_{15}H_{20}N_3$ (M+H)+: 242.1657 Found: 242.1651

TLC R_f = 0.14 (EtOAc/hexane, 40:60) [UV/$KMnO_4$]

Data for **31_47 (validation c)**

A sample of the authentic product was isolated from culture tubes per the procedure described in section *Experimental Validation Procedure*.

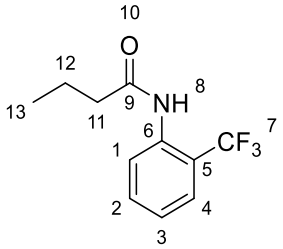


N-(Cyclohexylmethyl)-3,5-bis(trifluoromethyl)aniline (**31_47**)

Color and state:	White microcrystalline solid
m.p.:	38.6-39.0 °C (sealed tube)
^{1}H NMR	(600 MHz, $CDCl_3$)
	δ 7.11 (s, 1H), 6.90 (s, 2H), 4.12 (t, *J* = 5.7 Hz, 1H), 3.00 (dd, *J* = 6.7, 5.6 Hz, 2H), 1.82 (dd, *J* = 13.7, 2.0 Hz, 2H), 1.77 (dt, *J* = 12.5, 3.2 Hz, 2H), 1.71 (d, *J* = 12.4 Hz, 1H), 1.63 – 1.52 (m, 1H), 1.28 (qt, *J* = 12.4, 3.1 Hz, 2H), 1.20 (qt, *J* = 12.6, 3.0 Hz, 1H), 1.02 (qd, *J* = 11.8, 3.2 Hz, 2H).
^{13}C{^{1}H} NMR	(151 MHz, $CDCl_3$)
	δ 149.10, 132.34 (q, *J* = 32.5 Hz), 123.64 (q, *J* = 272.6 Hz), 111.58 (d, *J* = 3.8 Hz), 109.65 (p, *J* = 4.0 Hz), 50.16, 37.52, 31.18, 26.41, 25.85.
IR (cm^{-1})	ATR (neat)
	3445 (w), 2928 (m), 2858 (w), 1739 (w), 1621 (m), 1514 (m), 1470 (m), 1450 (w), 1430 (m), 1397 (m), 1364 (m), 1324 (w), 1271 (s), 1161 (s), 1131 (s), 1100 (s br), 1053 (m), 993 (m), 949 (m), 891 (w), 856 (m), 730 (m), 681 (s), 607 (w), 527 (w).
HRMS(ES+):	Calcd for $C_{15}H_{18}NF_6$ (M+H)+: 326.1343 Found: 326.1338
TLC	R_f = 0.27 (EtOAc/hexane, 1:99) [UV/$KMnO_4$]

Data for **7_48 (validation d)**

A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions*.

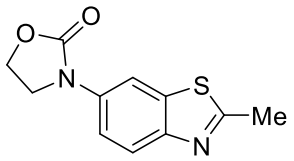


N-(2-(Trifluoromethyl)phenyl)butyramide (**7_48**)

Color and state	Colorless solid
m.p.	81.8-82.8 °C (sealed tube)
^{1}H NMR	(500 MHz, $CDCl_3$) δ 8.22 (d, *J* = 8.1 Hz, 1H, CH (4))), 7.60 (d, *J* = 6.4 Hz, 1H, CH (1)), 7.55 (t, *J* = 7.2 Hz, 1H, CH (2)), 7.41 (br s, 1H, NH (8)), 7.22 (t, *J* = 7.7 Hz, 1H, CH (3))), 2.39 (t, *J* = 7.4 Hz, 2H, CH_2 (11)), 1.77 (h, *J* = 7.4 Hz, 2H, CH_2 (12)), 1.03 (t, *J* = 7.3 Hz, 3H, CH_3 (13)).
^{13}C{^{1}H} NMR	(126 MHz, $CDCl_3$) δ 171.46 (s, C (9)), 135.44 (s, C (6)), 132.98 (s, C (2)), 126.14 (q, J_{CF}= 5.3 Hz, C (1)), 124.63 (q, J_{CF} =22. 1, s, C (4)), 124.22(*q*, J_{CF} =272.6. 1, s, C (7)), 39.78 (s, C (11)), 18.93 (s, C (12)), 13.60 (s, C (13)).
IR (cm^{-1})	ATR (neat) 3268 (w), 2962 (w), 2936 (w), 2873 (w), 1658 (m), 1612 (w), 1589 (w), 1530 (m), 1489 (w), 1454 (m), 1364 (w), 1316 (s), 1283 (m), 1263 (m), 1197 (w), 1166 (m), 1110 (s), 1056 (m), 948 (w), 904 (w), 874 (w), 808 (w).
HRMS (ES+)	Calcd for $C_{11}H_{13}F_3NO$ (M+H)+: 232.0949 Found: 232.0953
TLC	R_f 0.5 (Et_2O/hexane, 5:95)

Data for **1001_2003 (validation e)**

A sample of the authentic product was isolated from culture tubes per the procedure described in section *Experimental Validation Procedure*.

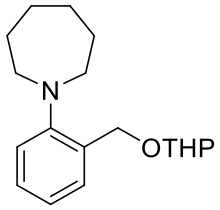


3-(2-Methylbenzo[d]thiazol-6-yl)oxazolidin-2-one (**1001_2003**)

Color and state:	Mustard microcrystalline solid
m.p.:	144.1-145.3 °C (sealed tube)
^{1}H NMR	(600 MHz, $CDCl_3$)
	δ 8.18 (d, *J* = 2.3 Hz, 1H), 7.90 (d, *J* = 8.8 Hz, 1H), 7.48 (dd, *J* = 8.9, 2.3 Hz, 1H), 4.51 (dd, *J* = 8.8, 7.2 Hz, 2H), 4.12 (dd, *J* = 8.8, 7.2 Hz, 2H), 2.81 (s, 3H).
^{13}C{^{1}H} NMR	(151 MHz, $CDCl_3$)
	δ 166.90, 155.44, 150.10, 136.86, 135.42, 122.50, 116.94, 111.29, 61.42, 45.72, 20.24.
IR (cm^{-1})	ATR (neat)
	2968 (w br), 1731 (s), 1606 (s), 1555 (m), 1524 (m), 1492 (m), 1467 (s), 1431 (m), 1403 (s), 1319 (s), 1288 (m), 1255 (s), 1223 (s), 1174 (m), 1125 (s), 1051 (s), 1007 (m), 973 (m), 872 (s), 840 (s), 780 (m), 749 (s), 710 (m), 669 (s), 613 (m), 586 (m), 532 (s).
HRMS(ES+):	Calcd for $C_{11}H_{11}N_2O_2S$ (M+H)+: 235.0541 Found: 235.0536
TLC	R_f = 0.19 (EtOAc/CH_2Cl_2, 30:70) [UV/I_2]

Data for **1002_2002 (validation f)**

A sample of the authentic product was isolated from culture tubes per the procedure described in section *Experimental Validation Procedure*.



1-(2-(((Tetrahydro-2H-pyran-2-yl)oxy)methyl)phenyl)azepane (**1002_2002**)

Color and state: Colorless oil

^{1}H NMR (500 MHz, $CDCl_3$)

δ 7.48 (dd, *J* = 7.7, 1.7 Hz, 1H), 7.23 (td, *J* = 7.6, 1.7 Hz, 1H), 7.12 (dd, *J* = 8.1, 1.3 Hz, 1H), 7.05 (td, *J* = 7.4, 1.3 Hz, 1H), 4.84 (d, *J* = 12.2 Hz, 1H), 4.78 (t, *J* = 3.6 Hz, 1H), 4.70 (d, *J* = 12.2 Hz, 1H), 3.98 (ddd, *J* = 11.5, 8.5, 2.9 Hz, 1H), 3.62 – 3.54 (m, 1H), 3.09 (td, *J* = 5.8, 3.0 Hz, 4H), 1.90 (ddq, *J* = 12.6, 7.8, 4.0 Hz, 1H), 1.82 – 1.51 (m, 13H).

^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$)

δ 154.44, 133.23, 128.95, 127.97, 122.77, 121.39, 98.28, 65.48, 62.09, 56.66, 30.78, 29.54, 27.15, 25.61, 19.49.

IR (cm^{-1}) ATR (neat)

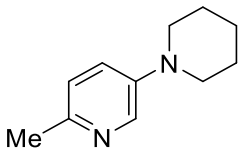
2923 (m), 2851 (w), 1598 (w), 1490 (m), 1449 (m), 1386 (w), 1348 (w), 1322 (w), 1284 (w), 1249 (w), 1200 (m), 1180 (m), 1155 (m), 1117 (m), 1077 (m), 1056 (m), 1022 (s), 977 (m), 905 (m), 869 (m), 816 (m), 759 (s), 727 (m), 609 (w), 558 (w), 531 (w).

HRMS(ES+): Calcd for $C_{18}H_{28}NO_2$ (M+H)+: 290.2120 Found: 290.2121

TLC R_f = 0.10 (EtOAc/hexane, 2:98) [UV/$KMnO_4$]

Data for **38_18 (validation-g)**

A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions*.



2-Methyl-5-(piperidin-1-yl)pyridine **(38_18):** The spectral and physical data matched those reported in the literature. (*96*)

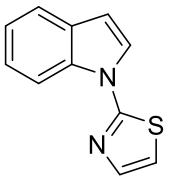
^{1}H NMR (500 MHz, $CDCl_3$)

δ 8.18 (d, *J* = 3.1 Hz, 1H), 7.13 (dd, *J* = 8.5, 3.0 Hz, 1H), 7.00 (d, *J* = 8.4 Hz, 1H), 3.14 – 3.08 (m, 4H), 2.45 (s, 3H), 1.71 (p, *J* = 5.6 Hz, 4H), 1.60 – 1.54 (m, 2H).

^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$) δ 148.67, 145.95, 138.41, 124.40, 123.09, 50.70, 25.79, 24.19, 23.35.

Data for **18_19** (**validation-h)**

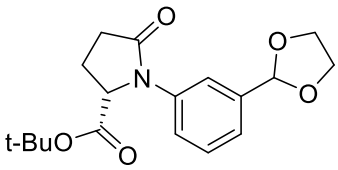
A sample of the authentic product was isolated from culture tubes per the procedure described in section *Experimental Validation Procedure*.



2-(1H-Indol-1-yl)thiazole (**18_19**): The structure and purity of the known compound **18_19** was confirmed by the comparison of their physical and spectral data (^{1}H NMR, ^{13}C NMR) with reported in the literature. (*29*)

Data for **1007_2004** (**validation-l)**

A sample of the authentic product was isolated from culture tubes per the procedure described in section *Experimental Validation Procedure*.



tert-Butyl (*S*)-1-(3-(1,3-Dioxolan-2-yl)phenyl)-5-oxopyrrolidine-2-carboxylate **(1007_2004)**

Color and state: White crystalline needles

m.p.: 111.0-112.8 (d) °C (sealed tube)

^{1}H NMR (600 MHz, $CDCl_3$)

δ 7.59 (ddd, *J* = 8.1, 2.3, 1.1 Hz, 1H), 7.52 (t, *J* = 1.9 Hz, 1H), 7.38 (t, *J* = 7.9 Hz, 1H), 7.28 (dt, *J* = 7.6, 1.4 Hz, 1H), 5.81 (s, 1H), 4.60 (dd, *J* = 9.0, 3.1 Hz, 1H), 4.14 – 4.06 (m, 2H), 4.06 – 3.98 (m, 2H), 2.74 (dt, *J* = 16.9, 9.4 Hz, 1H), 2.56 (ddd, *J* = 16.9, 9.6, 3.8 Hz, 1H), 2.45 (dq, *J* = 13.1, 9.3 Hz, 1H), 2.15 (ddt, *J* = 13.0, 9.5, 3.5 Hz, 1H), 1.38 (s, 9H).

^{13}C{^{1}H} NMR (151 MHz, $CDCl_3$)

δ 174.39, 171.01, 139.11, 138.60, 129.11, 123.46, 122.55, 119.24, 103.45, 82.71, 65.38, 65.35, 62.70, 31.15, 27.92, 23.25.

IR (cm^{-1}) ATR (neat)

2987 (w br), 2929 (w), 2870 (w), 1729 (s), 1703 (s), 1609 (m), 1588 (w), 1494 (m), 1457 (s), 1397 (s), 1369 (s), 1306 (s), 1286 (m), 1262 (w), 1226 (s), 1198 (m), 1152 (s), 1080 (s), 1032 (m), 984 (m), 939 (m), 916 (m), 872 (m), 851 (m), 793 (s), 723 (m), 690 (m), 644 (w), 563 (w).

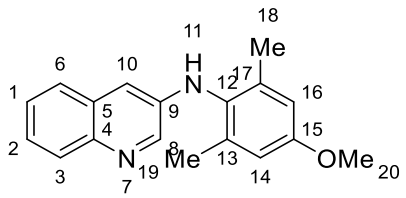
HRMS(ES+): Calcd for $C_{18}H_{24}NO_5$ (M+H)+: 334.1654 Found: 334.1644

TLC R_f = 0.23 (EtOAc/hexane, 20:80) [UV/I_2]

Opt. Rot.: $[\alpha]_D^{20} - 39.62$ ($c = 0.26$, EtOH)

Data for **4_22 (validation j)**

A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions*.



N-(4-Methoxy-2,6-dimethylphenyl)quinolin-3-amine **(4_22)**

Color and State: Off white solid

m.p. 128.4-129.4 °C (sealed tube)

^{1}H NMR (500 MHz, $CDCl_3$)

δ 8.59 (s, 1H, CH (8)), 7.96 (d, *J* = 7.8 Hz, 1H, CH (10)), 7.47 (d, *J* = 5.8 Hz, 1H, CH (3)), 7.43 – 7.34 (m, 2H, 2xCH (1 and 2)), 6.74 (s, 2H, 2xCH (14 and 16)), 6.66 (s, 1H, CH (10)), 5.45 (br s, 1H, NH (11)), 3.83 (s, 3H, OCH_3 (20)), 2.21 (s, 6H, 2xCH_3 (18 and 19)).

^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$)

δ 158.00 (s, C(15)), 142.87 (s, C (8)), 142.57 (s, C(9)), 140.65 (s, C (12)), 138.08 (s, C(5)), 129.72 (s, C (10)), 129.59 (s, C (4)), 129.11 (s, C(1)), 126.99 (s, C(6)), 126.06 (s, C(2)), 125.16 (s, C (3)), 113.93 (s, 2xC(14 and 16), 111.15 (s, 2xC (13 and 17), 55.44 (s, C (20)) 18.63 (s, 2xC (18 and 19).

IR (cm^{-1}) ATR (neat)

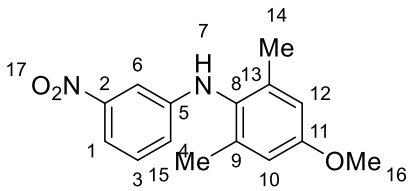
3310 (w br), 3008 (w), 2917 (w), 1607 (m), 1568 (w), 1488 (s), 1435 (m), 1362 (m), 1326 (s), 1281 (m), 1247 (m), 1224 (m), 1204 (m), 1153 (s), 1065 (s), 1019 (m), 988 (m), 957 (m), 927 (w), 892 (m), 841 (m), 820 (m), 777 (m), 752 (s), 701 (m), 627 (m), 600 (s), 558 (m), 533 (m).

HRMS (ES+) Calcd for $C_{18}H_{19}N_2O$ (M+H)+: 279.1497 Found: 279.1497

TLC R_f 0.35 (EtOAc/hexane, 10:90)

Data for **4_13 (validation k)**

A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions*.



4-Methoxy-2,6-dimethyl-*N*-(3-nitrophenyl)aniline **(4_13)**

Color and state: Brown solid

m.p.: 141.3-142.3 °C (sealed tube)

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.44 (d, *J* = 6.1 Hz, 1H, CH (4)), 7.20 – 7.12 (m, 2H, 2xCH (6 and 3), 6.65 (d, *J* = 8.4 Hz, 1H, CH (1)), 6.61 (s, 2H, 2xCH (10 and 12)), 5.29 (s, 1H, NH (7)), 3.73 (s, 3H, OCH_3 (16)), 2.09 (s, 6H, 2xCH_3 (14 and 15)).

^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$)
δ 158.20 (s, C (11)), 149.72 (s, C (2)), 148.34 (s, C (6)), 138.29 (s, C (8)), 130.02 (s, C (3)), 129.46 (s, C (13)), 118.41 (s, C (5)), 113.98 (s, 2xC (10 and 12), 112.41 (s, C (1)), 106.86 (s, C (9)), 55.43 (s, C (16)), 18.44 (s, 2xC (14 and 15).

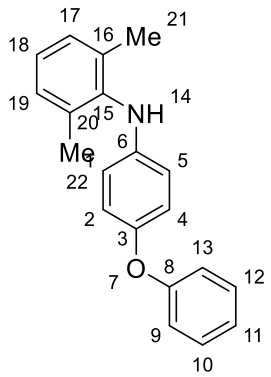
IR (cm^{-1}) ATR (neat)
3370 (m), 2921 (w), 1619 (m), 1592 (w), 1527 (s), 1478 (m), 1429 (w), 1378 (w), 1349 (s), 1329 (s), 1269 (s), 1212 (m), 1190 (m), 1152 (s), 1083 (m), 1063 (m), 992 (m), 951 (w), 886 (w), 860 (m), 832 (m), 786 (m), 731 (s), 672 (s), 633 (m), 593 (m), 553 (m), 533 (m).

HRMS (ES+): Calcd for $C_{15}H_{17}N_2O_3$ (M+H)+: 273.1239 Found: 273.1239

TLC R_f 0.45 (EtOAc/hexane, 30:70)

Data for **2_6 (validation i)**

A sample of the authentic product was isolated from reaction tubes per the general Greenhouse™ procedure described in section *Experimental Procedure for Dataset Reactions*.



2,6-Dimethyl-*N*-(4-phenoxyphenyl)aniline **(2_6)**

Color and state: Colorless solid

m.p.: 70.2-71.2 °C (sealed tube)

^{1}H NMR (500 MHz, $CDCl_3$)

δ 7.32 – 7.27 (m, 2H, 2xCH (9 and 13)), 7.13 (d, *J* = 6.6 Hz, 2H), 7.08 (dd, *J* = 8.5, 6.3 Hz, 1H), 7.02 (t, *J* = 7.4 Hz, 1H), 6.96 (dd, *J* = 8.9, 1.1 Hz, 2H), 6.88 (d, *J* = 8.9 Hz, 2H, 2xCH (2 and 4)), 6.51 (d, *J* = 8.9 Hz, 2H, 2xCH (1 and 5)), 5.14 (s, 1H), 2.24 (s, 6H).

^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$)

δ 159.00, 148.52, 142.83, 138.75, 135.62, 129.64, 128.76, 125.71, 122.18, 121.09, 117.42, 114.87, 18.53.

IR (cm^{-1}) ATR (neat)

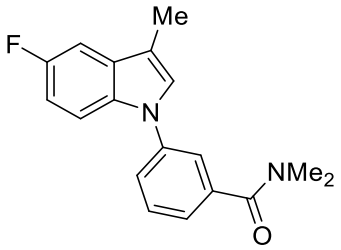
3380 (m), 3046 (w), 2916 (w), 1938 (w), 1607 (m), 1587 (m), 1503 (s), 1477 (s), 1393 (w), 1311 (m), 1290 (m), 1224 (s), 1165 (m), 1100 (m), 1074 (m), 1024 (m), 984 (w), 929 (w), 865 (m), 838 (s), 756 (s), 713 (m), 691 (s), 605 (m), 585 (m), 532 (m).

HRMS(ES+): Calcd for $C_{20}H_{20}NO$ (M+H)+: 290.1545 Found: 290.1544

TLC R_f 0.3 (Et_2O/hexane, 3:97)

Data for **1010_2001 (validation-m)**

A sample of the authentic product was isolated from culture tubes per the procedure described in section *Experimental Validation Procedure*.



3-(5-Fluoro-3-methyl-1H-indol-1-yl)-*N*,*N*-dimethylbenzamide (**1010_2001**)

Color and state: Gold oil

^{1}H NMR (500 MHz, $CDCl_3$)

δ 7.56 – 7.49 (m, 2H), 7.45 (dd, *J* = 9.0, 4.2 Hz, 1H), 7.36 (s, 2H), 7.26 – 7.23 (m, 1H), 7.17 (d, *J* = 1.2 Hz, 1H), 6.96 (td, *J* = 9.0, 2.5 Hz, 1H), 3.14 (s, 3H), 3.04 (s, 3H), 2.34 (d, *J* = 1.2 Hz, 3H).

^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$)

δ 170.71, 158.21 (d, *J* = 235.4 Hz), 140.06, 138.21, 132.51, 130.59 (d, *J* = 9.3 Hz), 129.96, 128.48, 126.92, 124.73 (d, *J* = 15.8 Hz), 122.43, 113.40 (d, *J* = 4.4 Hz), 111.18 (d, *J* = 9.8 Hz), 110.90 (d, *J* = 26.2 Hz), 104.43 (d, *J* = 23.4 Hz), 39.73, 35.55, 9.69.

^{19}F NMR δ -123.94 (td, *J* = 9.4, 4.3 Hz).

IR (cm^{-1}) ATR (neat)

2924 (w), 1636 (s), 1605 (m), 1583 (m), 1486 (s), 1455 (s), 1394 (m), 1269 (w), 1225 (w), 1202 (w), 1182 (w), 1137 (m), 1076 (w), 1002 (w), 976 (w), 931 (w), 884 (w), 851 (w), 789 (w), 755 (w), 704 (w), 663 (w), 640 (w), 620 (w), 569 (w).

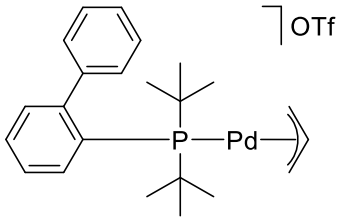
HRMS(ES+): Calcd for $C_{18}H_{18}N_2OF$ (M+H)+: 297.1403 Found: 297.1400

TLC R_f = 0.31 (EtOAc/hexane, 15:85) [UV/$KMnO_4$]

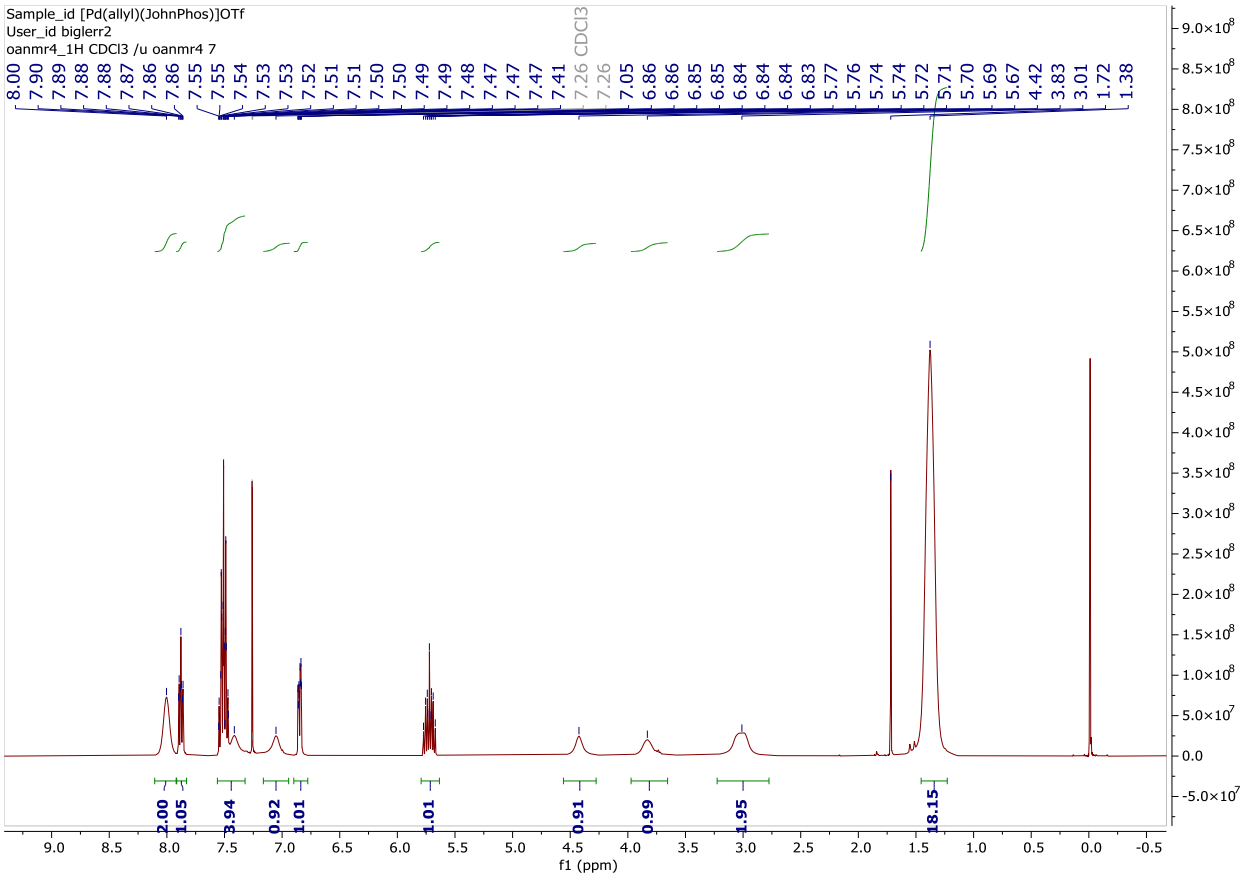
NMR Spectra

Precatalysts

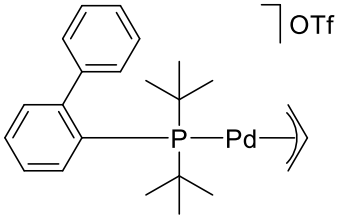
^{1}H NMR



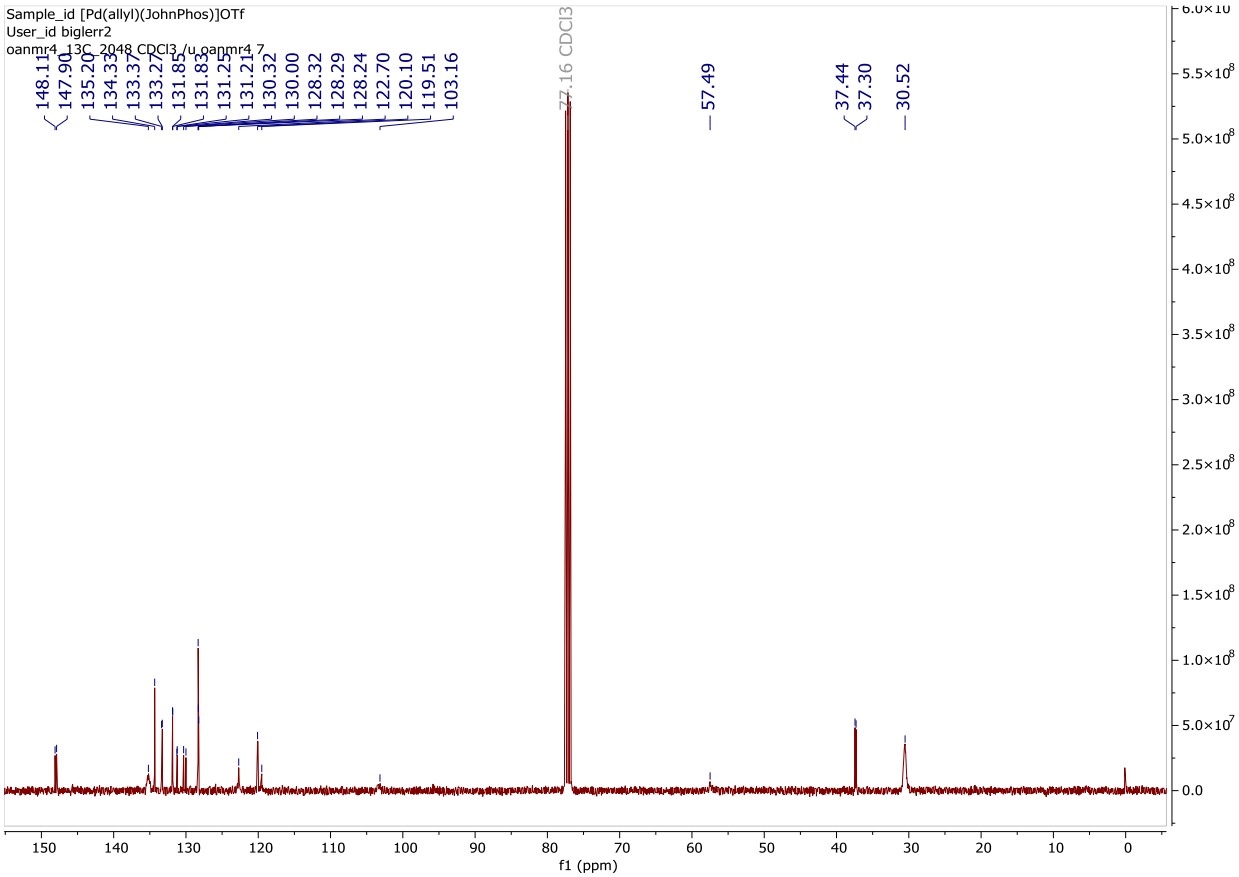
[Pd(allyl)(JohnPhos)]OTf (cat 1)



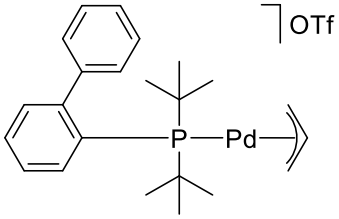
^{13}C NMR



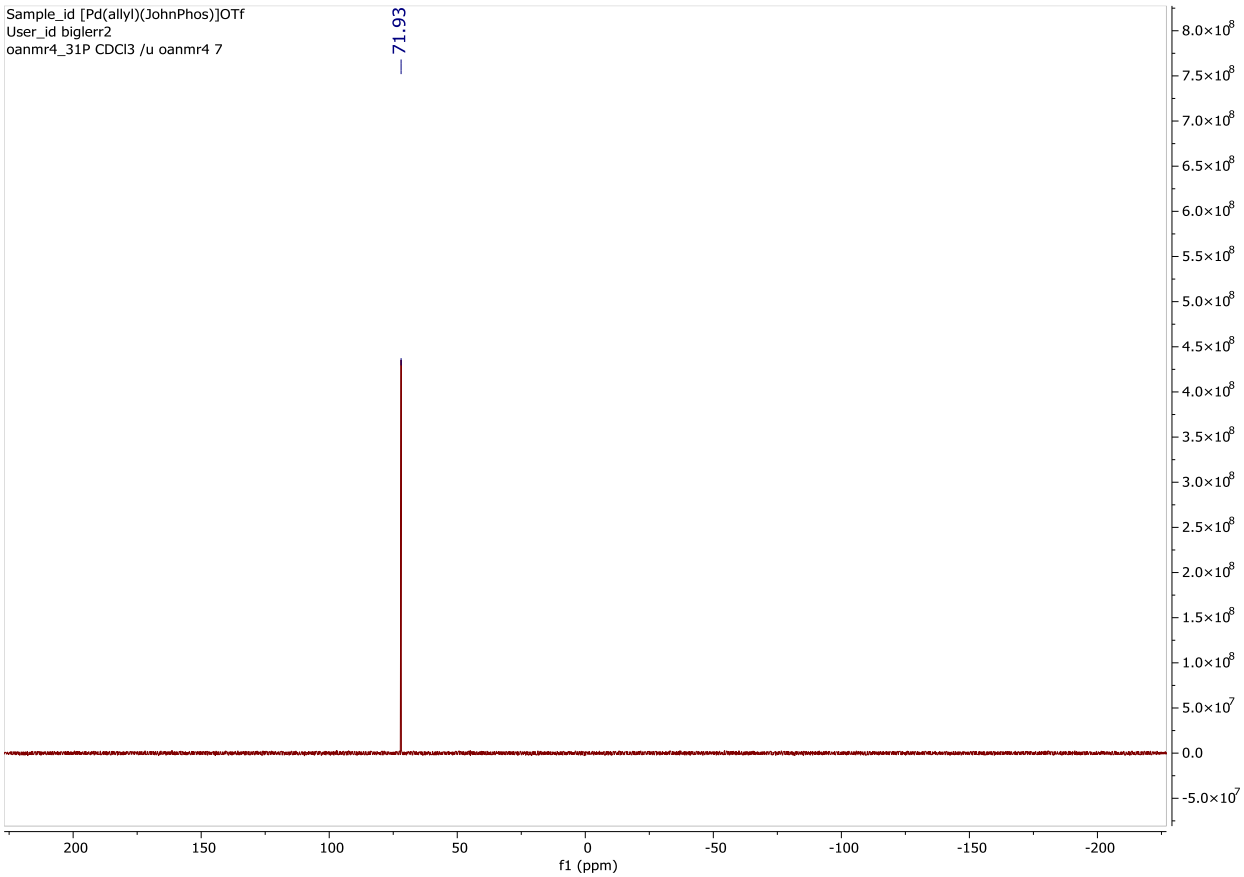
[Pd(allyl)(JohnPhos)]OTf (cat 1)



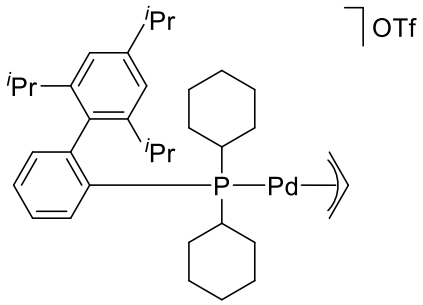
^{31}P NMR



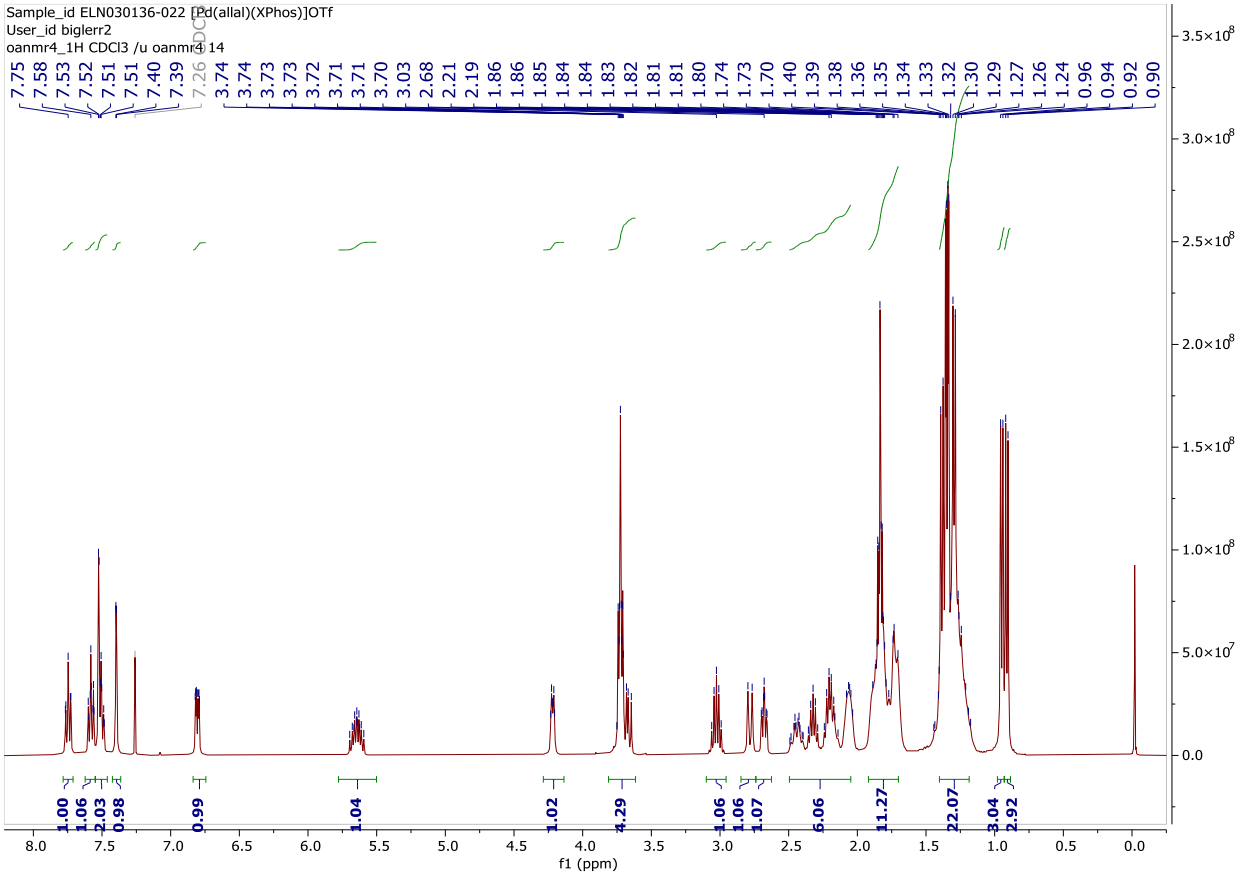
[Pd(allyl)(JohnPhos)]OTf (cat 1)



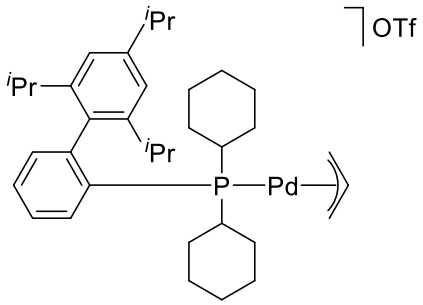
^{1}H NMR



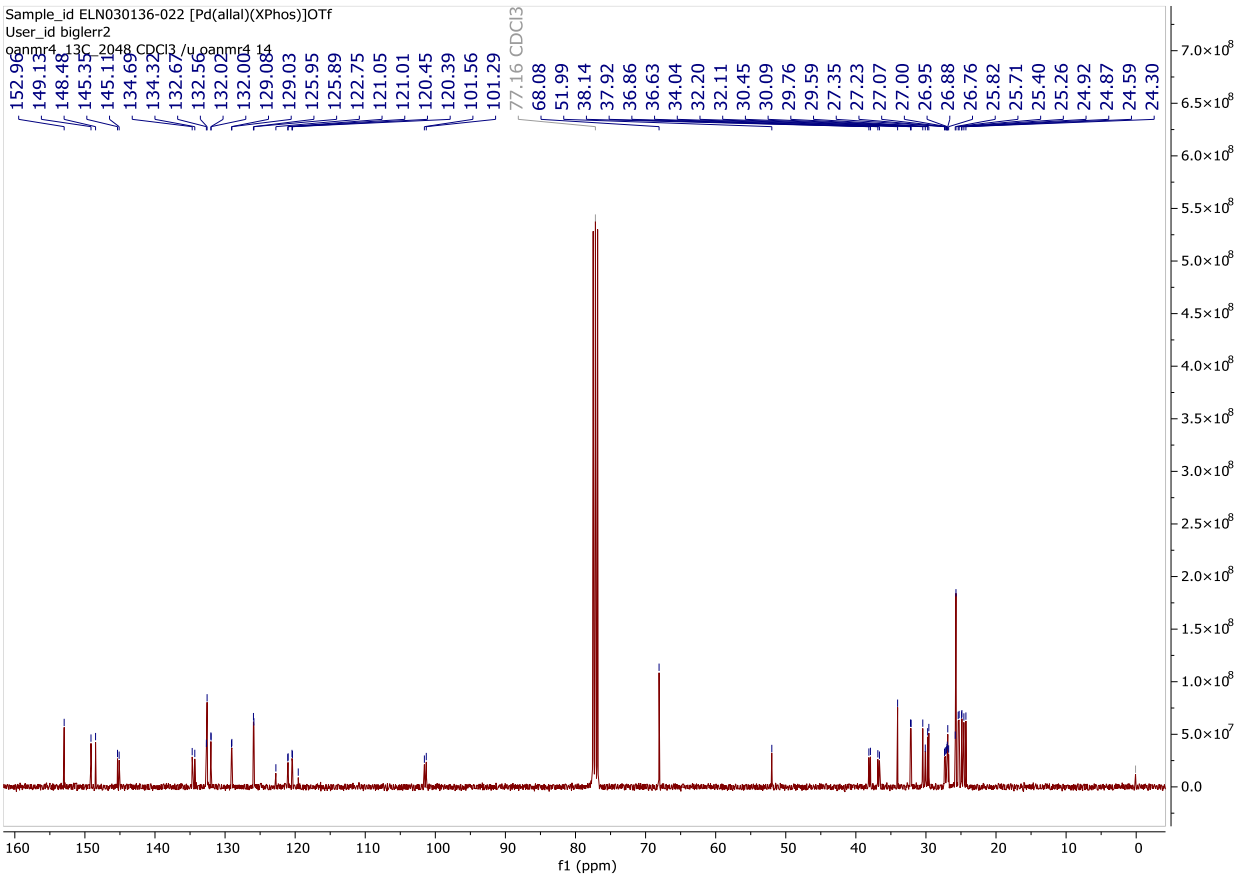
[Pd(allyl)(XPhos)]OTf (Cat 2)



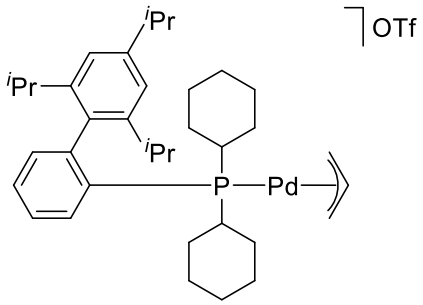
^{13}C NMR



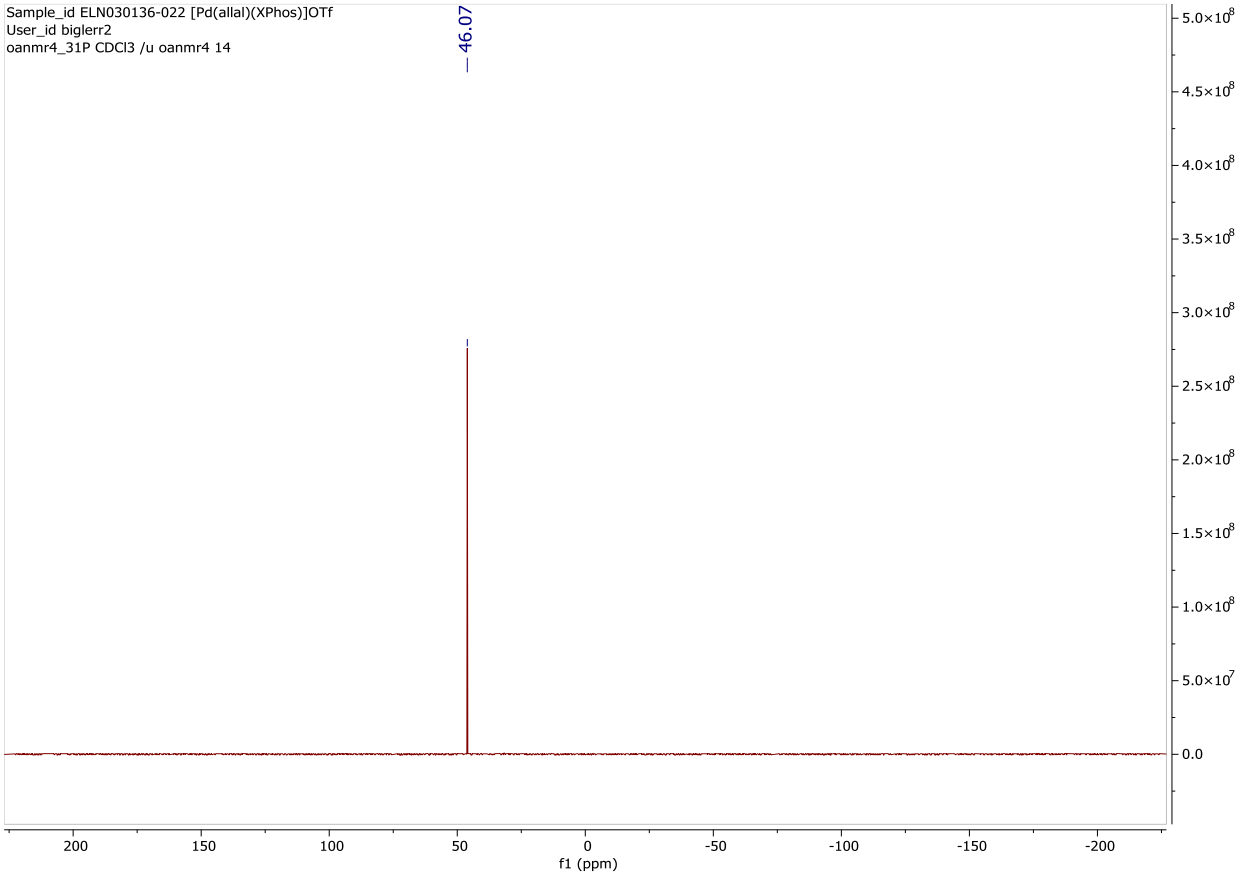
[Pd(allyl)(XPhos)]OTf (Cat 2)



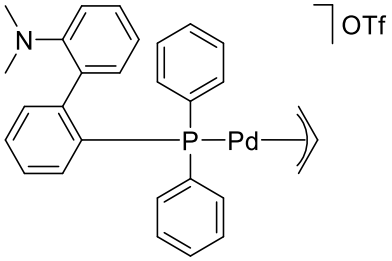
^{31}P NMR



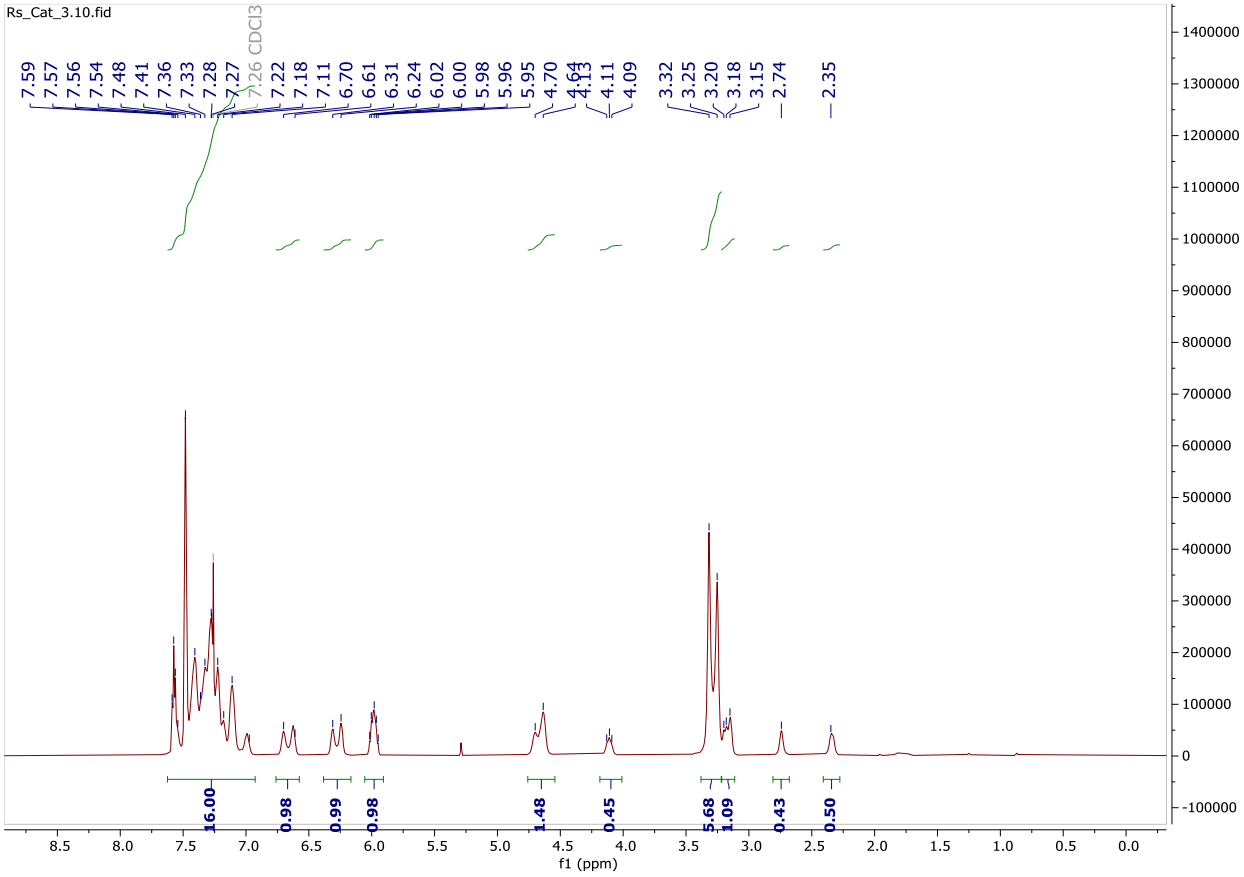
[Pd(allyl)(XPhos)]OTf (Cat 2)



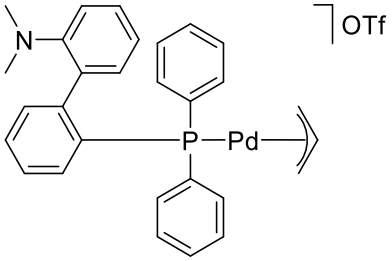
^{1}H NMR



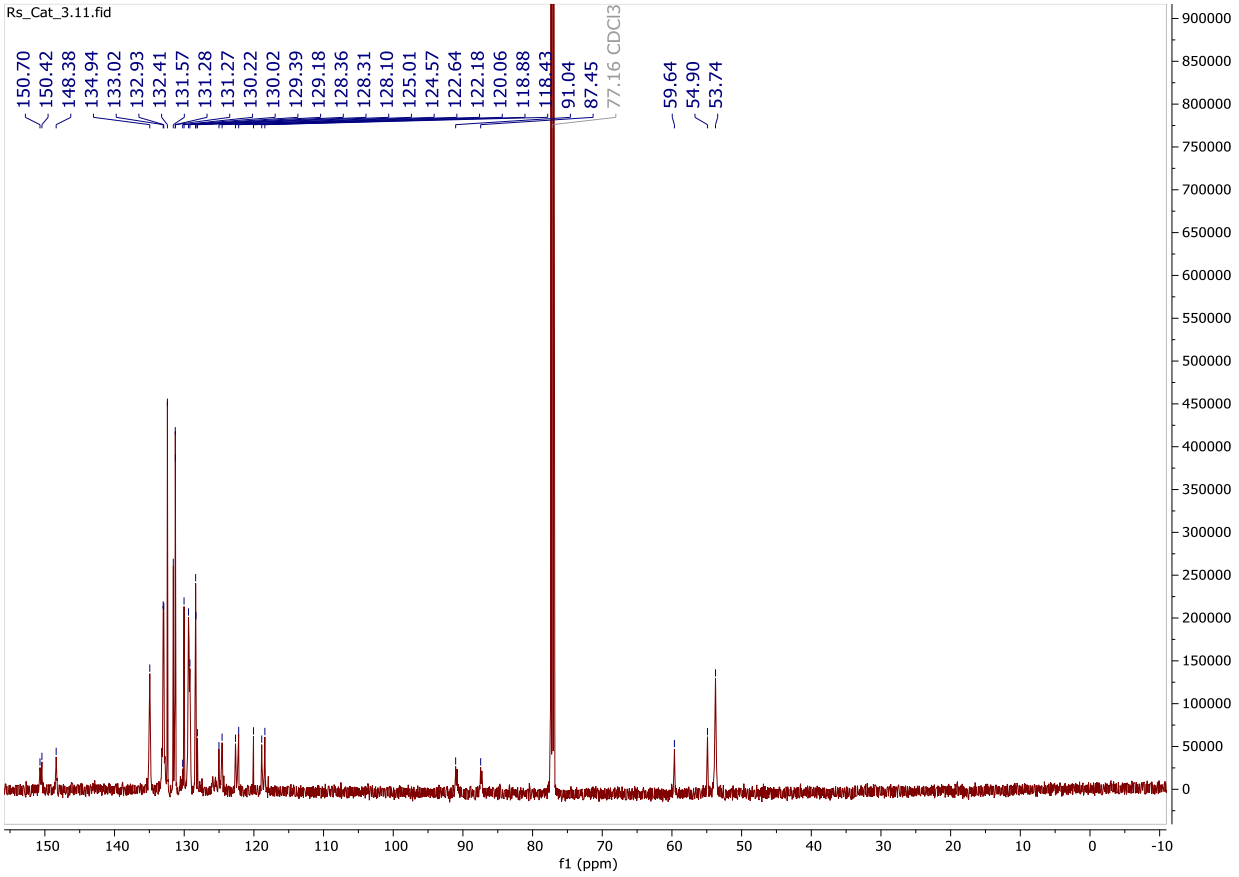
[Pd(allyl)(Ph-DavePhos)]OTf (cat 3)



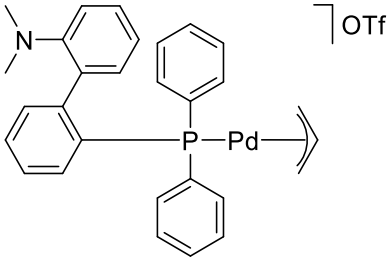
^{13}C NMR



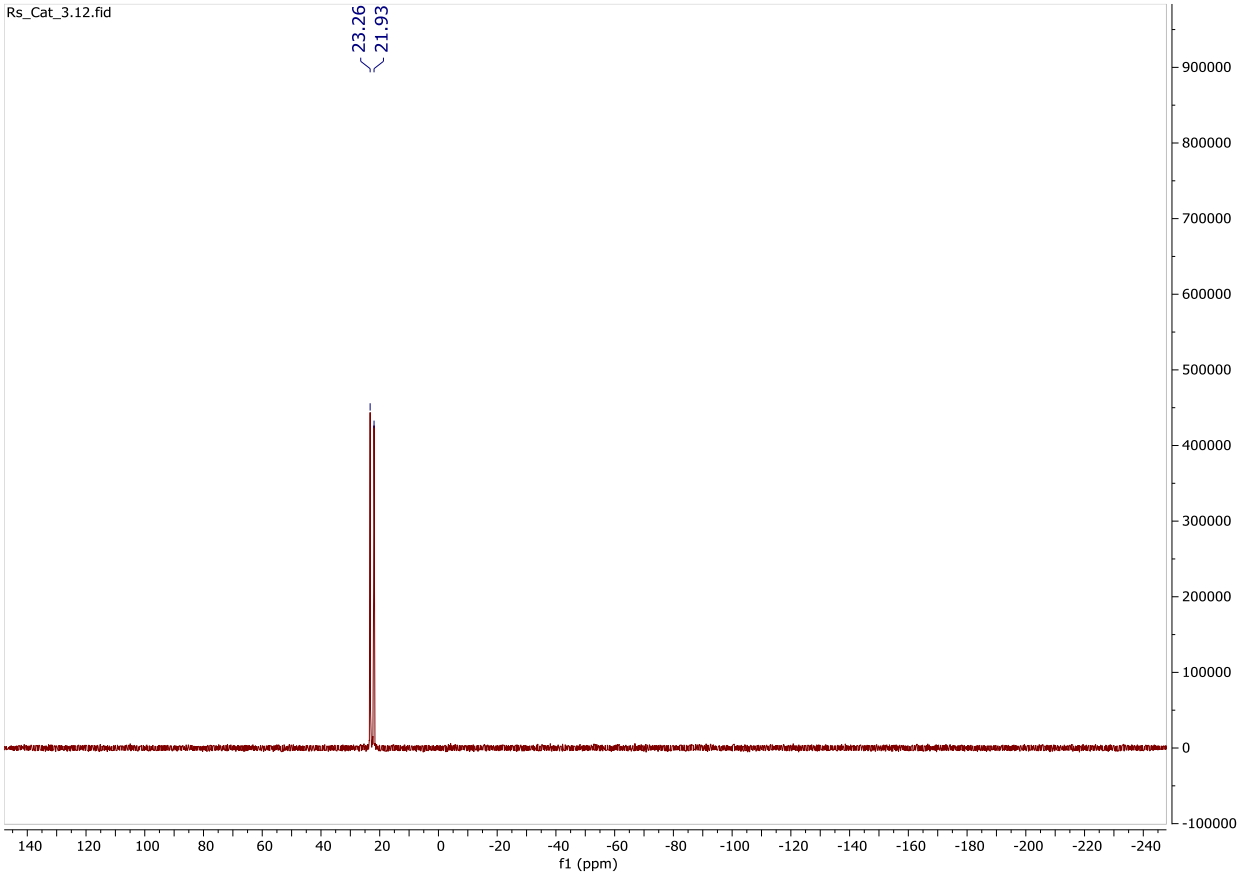
[Pd(allyl)(Ph-DavePhos)]OTf (cat 3)



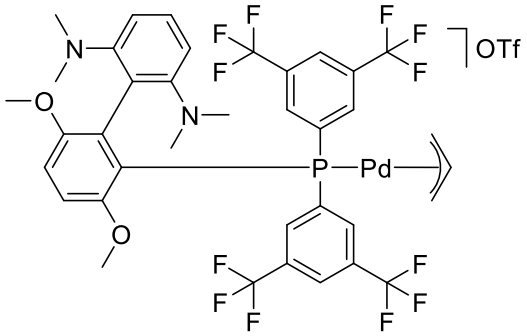
^{31}P NMR



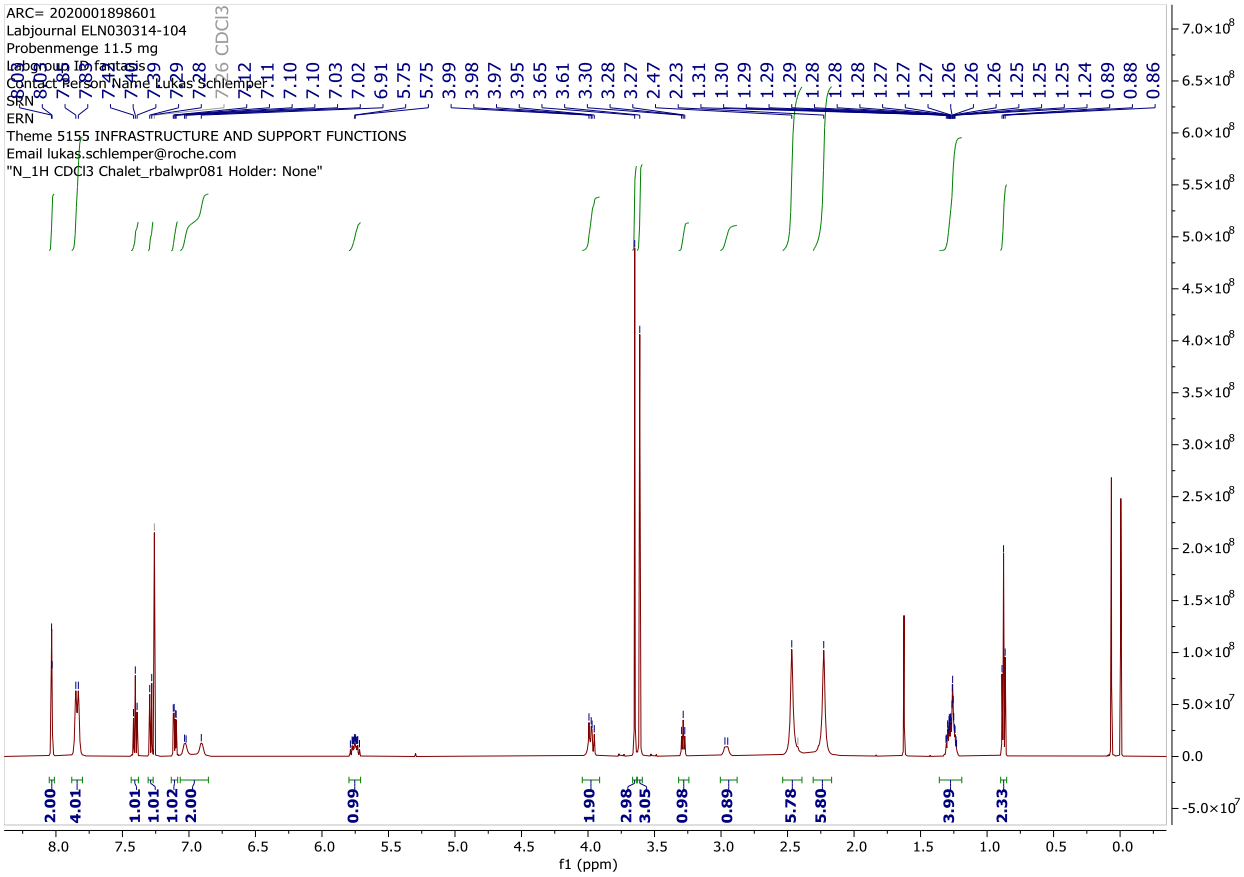
[Pd(allyl)(Ph-DavePhos)]OTf (cat 3)



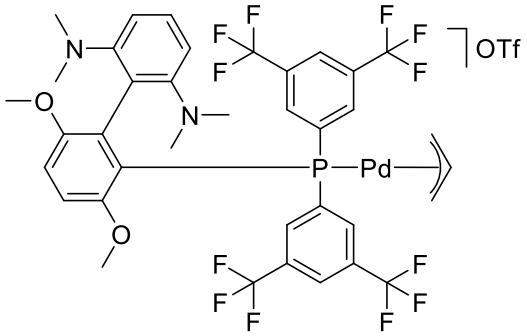
^{1}H NMR



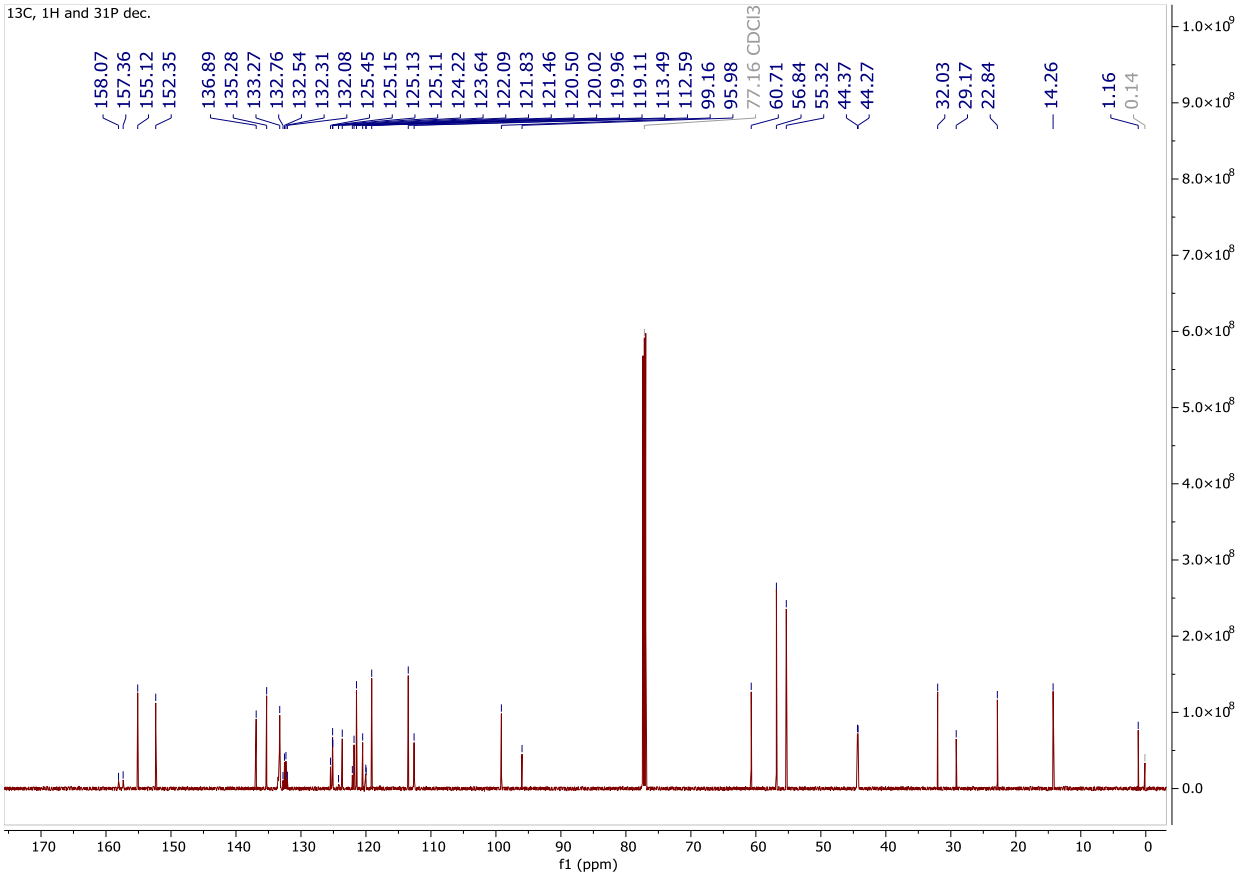
[Pd(allyl)(CPhos-Hybrid)]OTf (Cat 4)



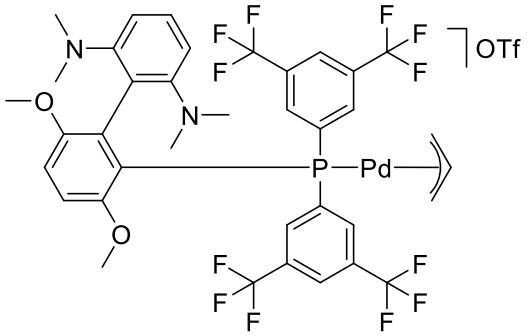
^{13}C NMR



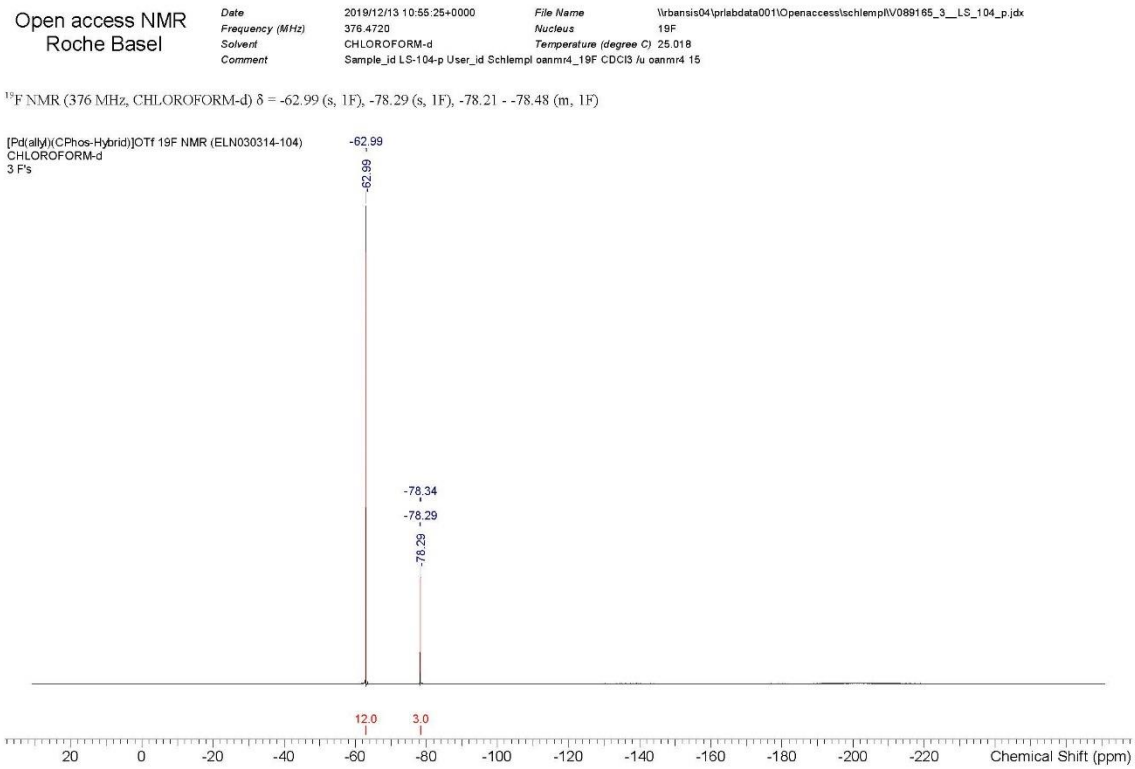
[Pd(allyl)(CPhos-Hybrid)]OTf (Cat 4)



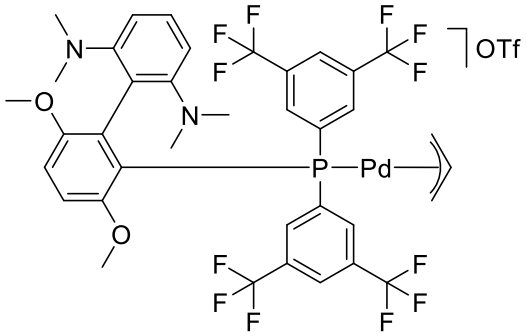
^{19}F NMR



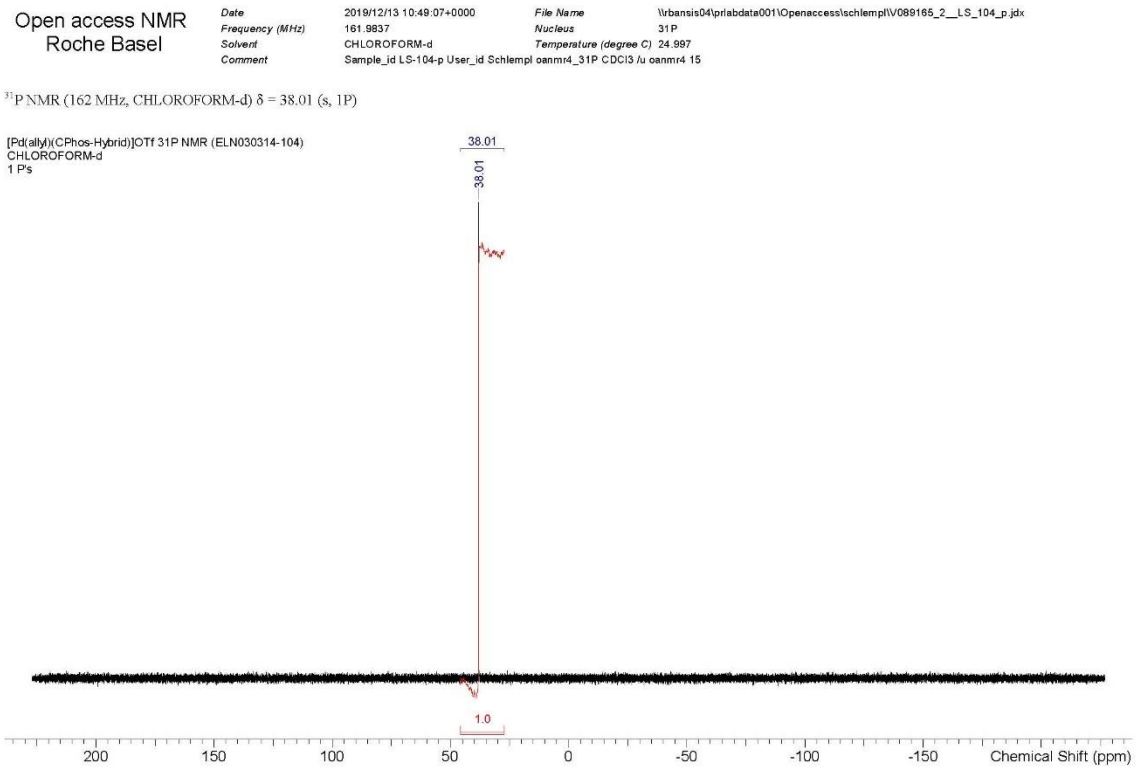
[Pd(allyl)(CPhos-Hybrid)]OTf (Cat 4)



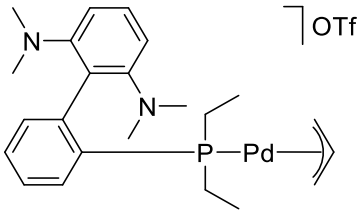
^{31}P NMR



[Pd(allyl)(CPhos-Hybrid)]OTf (Cat 4)



^{1}H NMR

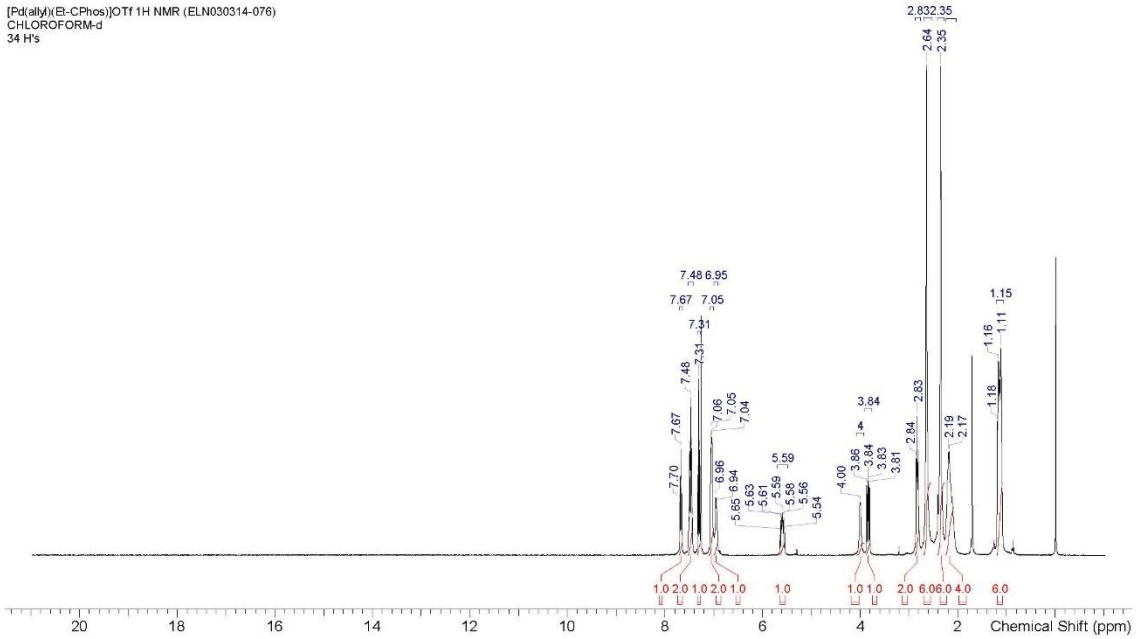


[Pd(allyl)(Et-CPhos)]OTf (Cat 5)

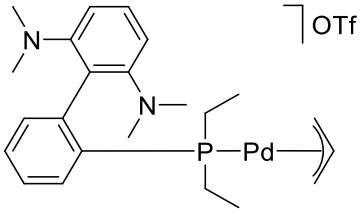
Open access NMR
Roche Basel

Date	2019/12/19 17:50:37+0000	*File Name*	\\rbansis04\prlabdata001\Openaccess\schlempl\V089292_1__LS_SI_EtCPhos.jdx
Frequency (MHz)	400.1540	*Nucleus*	1H
Solvent	CHLOROFORM-d	*Temperature (degree C)*	25.002
Comment	Sample_id LS-SI-EtCPhos User_id Schlempl oanmr4_1H CDCl3 /u oanmr4 30		

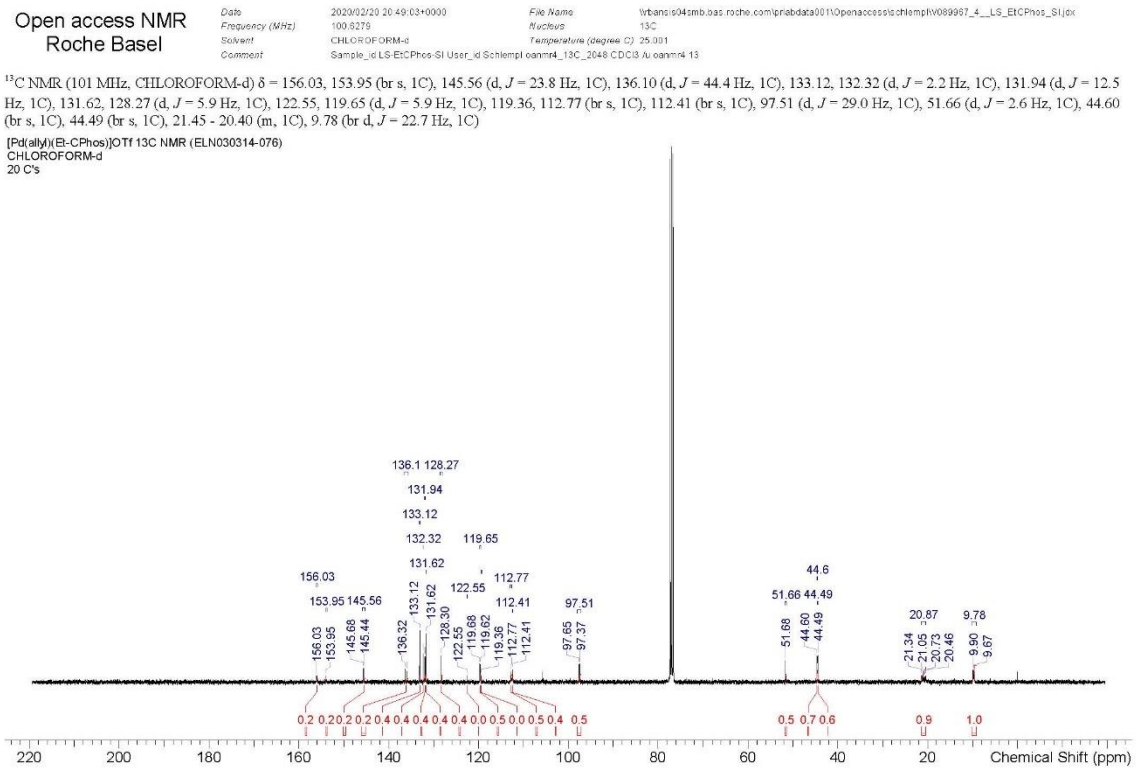
^{1}H NMR (400 MHz, CHLOROFORM-d) δ = 7.71 - 7.65 (m, 1H), 7.52 - 7.43 (m, 2H), 7.33 - 7.27 (m, 1H), 7.08 - 7.00 (m, 2H), 6.95 (br d, *J* = 7.5 Hz, 1H), 5.70 - 5.49 (m, 1H), 4.00 (br d, *J* = 1.6 Hz, 1H), 3.84 (dd, *J* = 9.4, 14.0 Hz, 1H), 2.88 - 2.76 (m, 2H), 2.64 (br s, 6H), 2.35 (br s, 6H), 2.18 (br d, *J* = 7.3 Hz, 4H), 1.15 (br dd, *J* = 8.5, 18.4 Hz, 6H)



^{13}C NMR

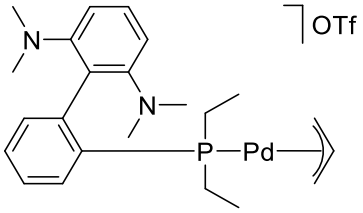


[Pd(allyl)(Et-CPhos)]OTf (Cat 5)

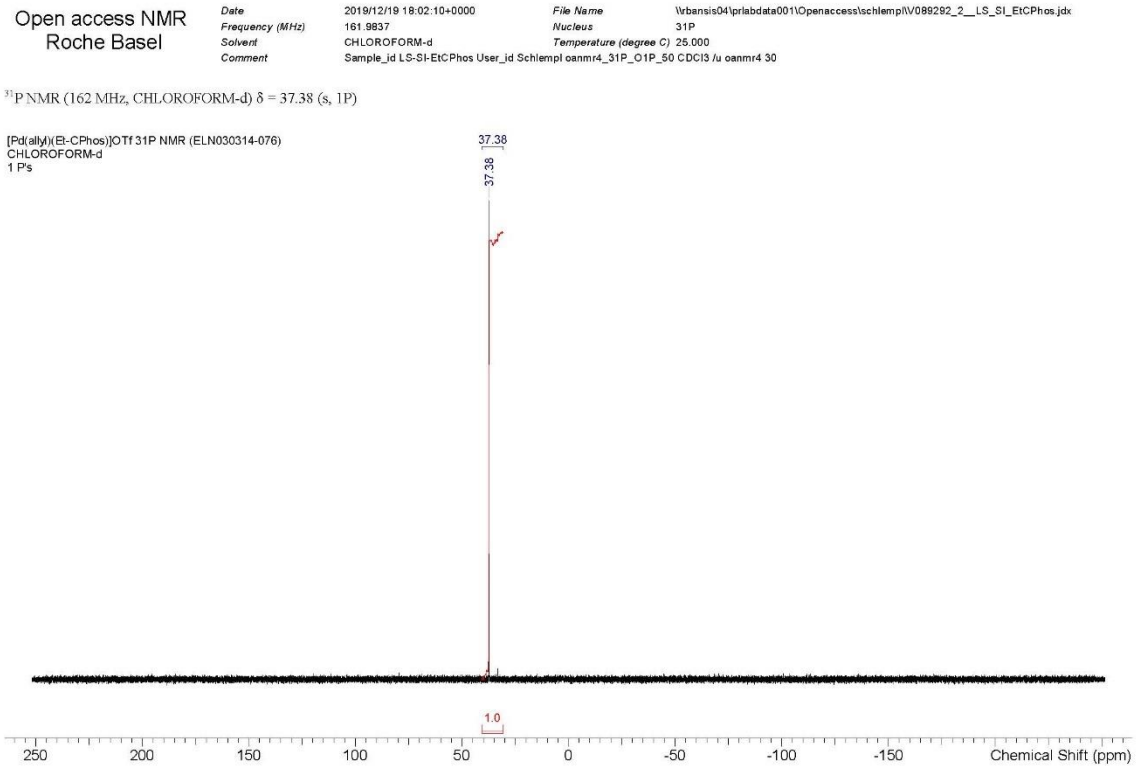


^{13}C NMR (101 MHz, CHLOROFORM-d) δ = 156.03, 153.95 (br s, 1C), 145.56 (d, *J* = 23.8 Hz, 1C), 136.10 (d, *J* = 44.4 Hz, 1C), 133.12, 132.32 (d, *J* = 2.2 Hz, 1C), 131.94 (d, *J* = 12.5 Hz, 1C), 131.62, 128.27 (d, *J* = 5.9 Hz, 1C), 122.55, 119.65 (d, *J* = 5.9 Hz, 1C), 119.36, 112.77 (br s, 1C), 112.41 (br s, 1C), 97.51 (d, *J* = 29.0 Hz, 1C), 51.66 (d, *J* = 2.6 Hz, 1C), 44.60 (br s, 1C), 44.49 (br s, 1C), 21.45 - 20.40 (m, 1C), 9.78 (br d, *J* = 22.7 Hz, 1C)

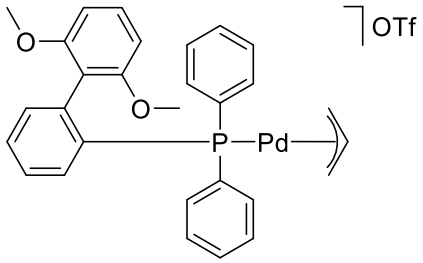
^{31}P NMR



[Pd(allyl)(Et-CPhos)]OTf (Cat 5)



^{1}H NMR

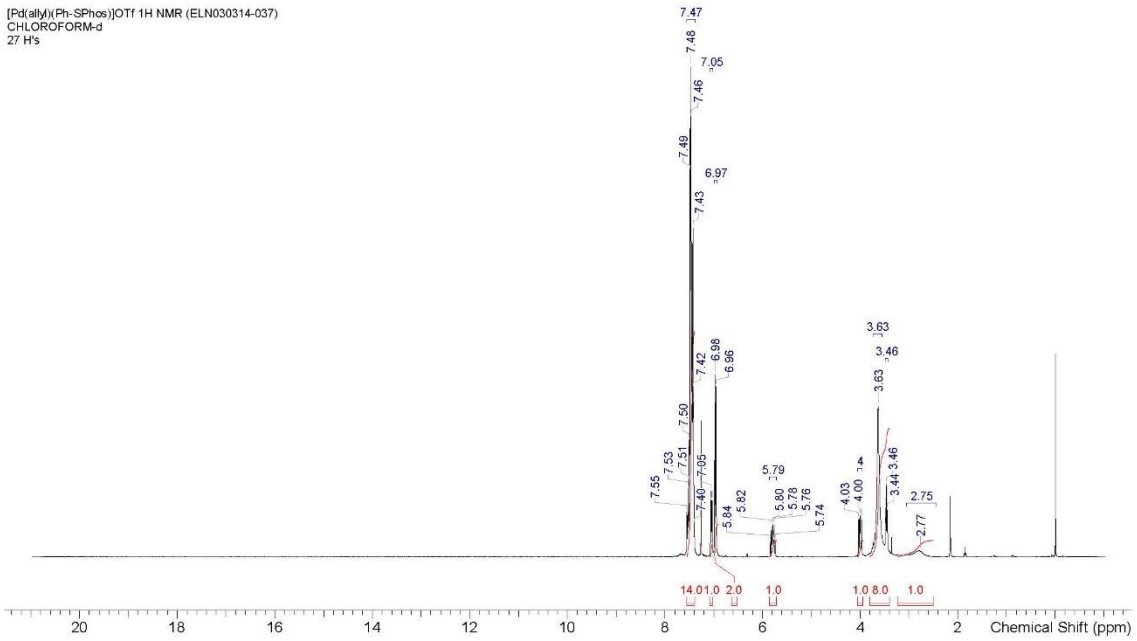


[Pd(allyl)(Ph-SPhos)]OTf (Cat 6)

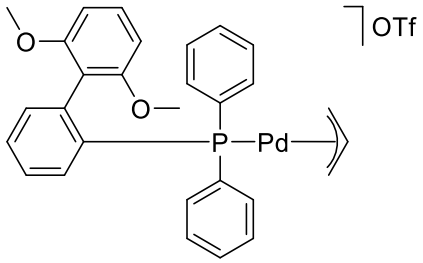
Open access NMR
Roche Basel

Date	2019/10/31 08:02:04+0000	*File Name*	\\rbansis04\prlabdata001\Openaccess\schlempl\\V088390_1__LS_037_P_RePrecip.jdx
Frequency (MHz)	400.1540	*Nucleus*	1H
Solvent	CHLOROFORM-d	*Temperature (degree C)*	25.002
Comment	Sample_id LS-037-P-RePrecip User_id Schlempl oanmr4_1H CDCl3 /u oanmr4 6		

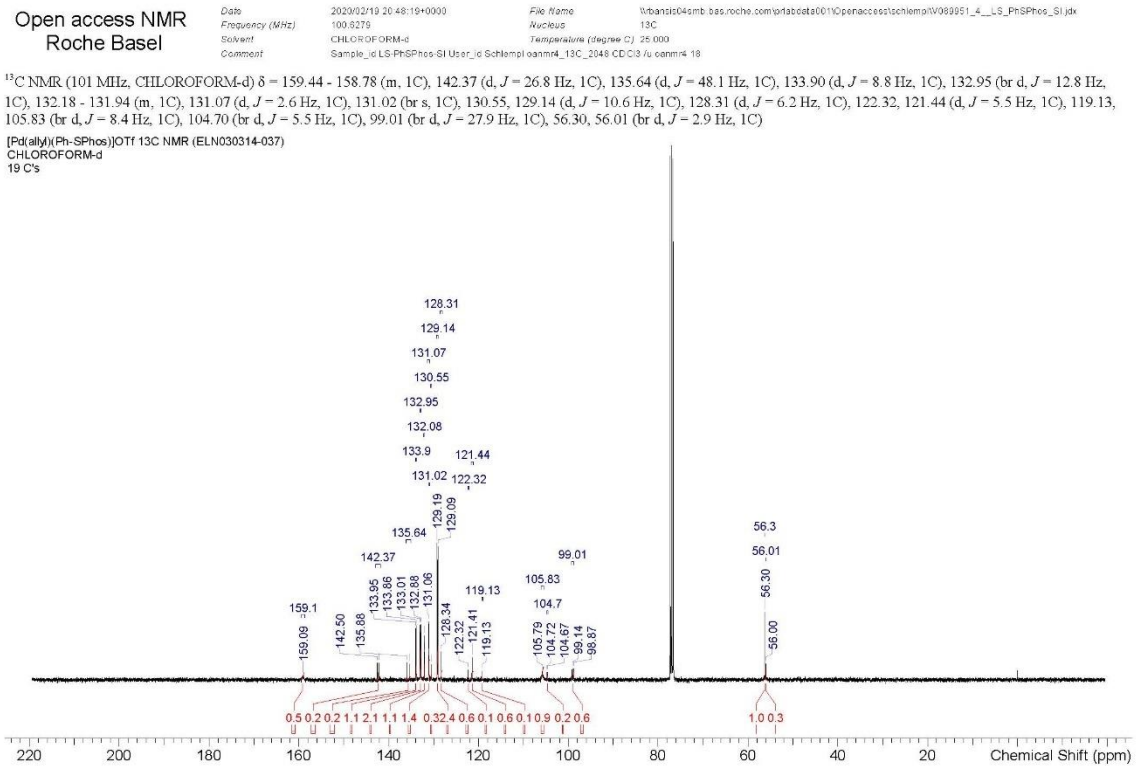
^{1}H NMR (400 MHz, CHLOROFORM-d) δ = 7.56 - 7.38 (m, 14H), 7.05 (dd, *J* = 4.2, 7.7 Hz, 1H), 6.97 (d, *J* = 8.6 Hz, 2H), 5.79 (qd, *J* = 8.9, 14.3 Hz, 1H), 4.00 (dd, *J* = 9.3, 14.1 Hz, 1H), 3.63 (br s, 6H), 3.46 (br t, *J* = 7.1 Hz, 1H), 3.05 - 2.44 (m, 1H)



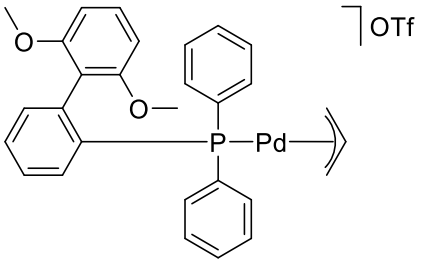
^{13}C NMR



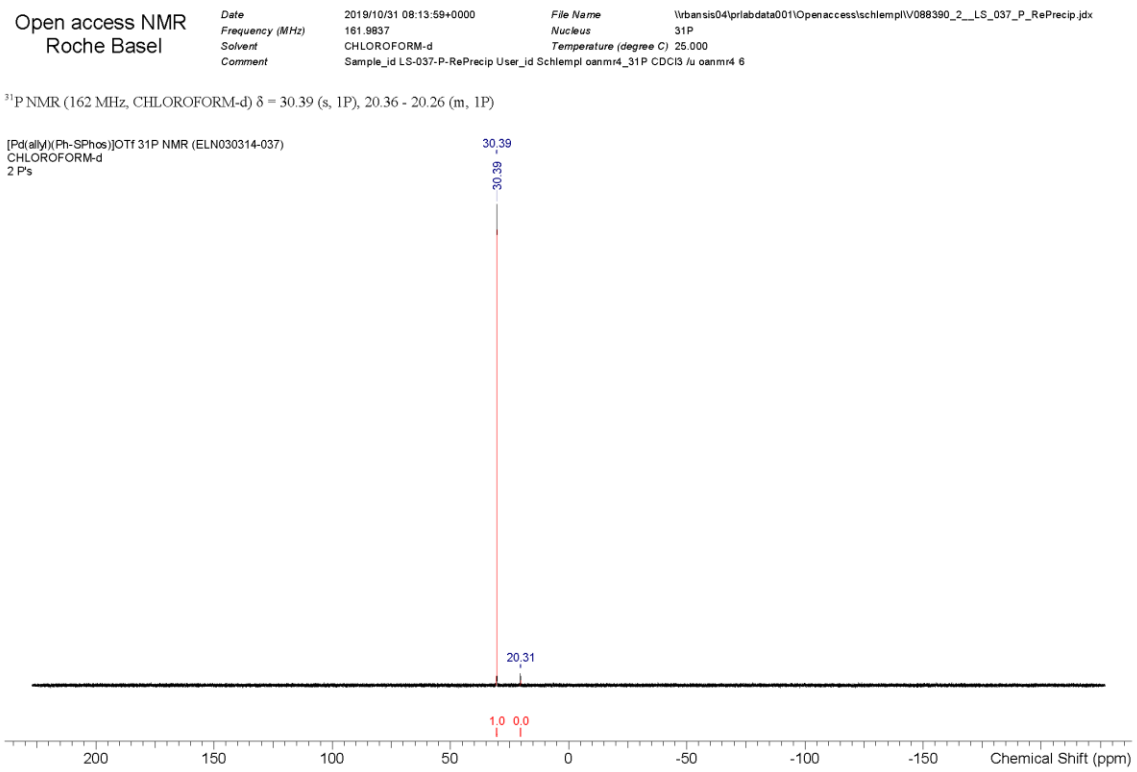
[Pd(allyl)(Ph-SPhos)]OTf (Cat 6)



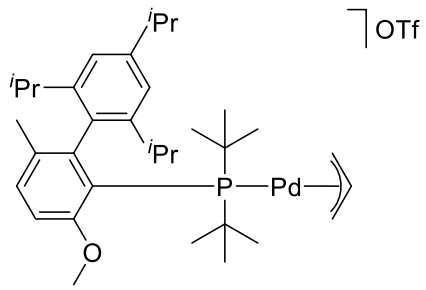
^{31}P NMR



[Pd(allyl)(Ph-SPhos)]OTf (Cat 6)



^{1}H NMR

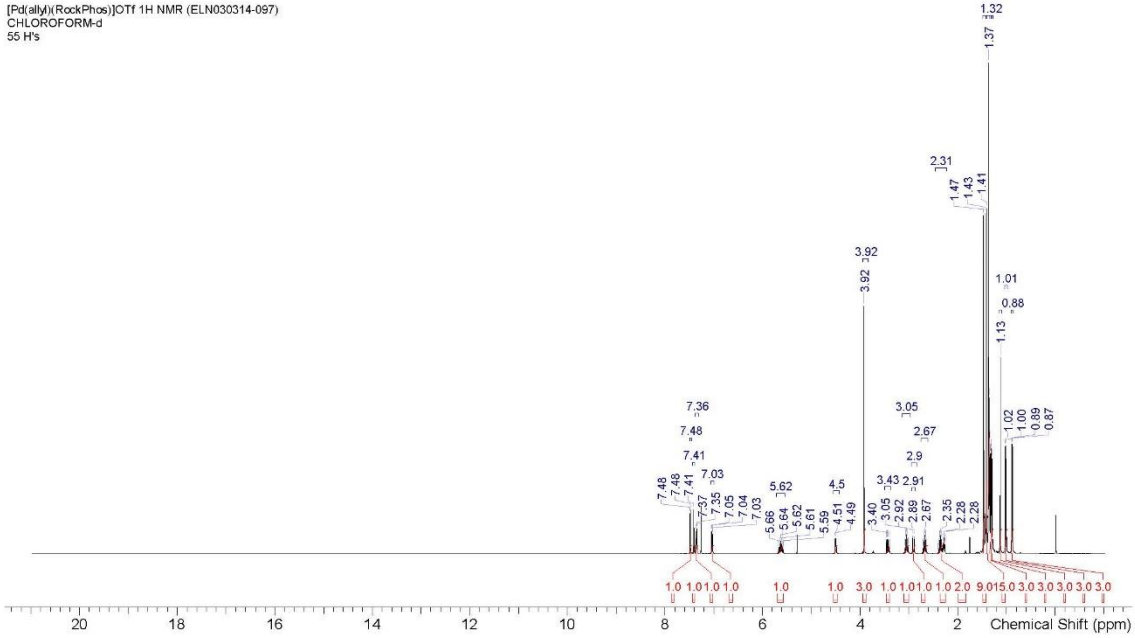


[Pd(allyl)(RockPhos)]OTf (Cat 7)

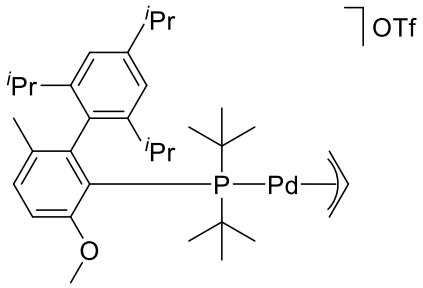
Open access NMR
Roche Basel

Date	2019/12/10 10:16:35+0000	*File Name*	\\rbansis04\prlabdata001\Openaccess\schlempl\V089079_1__LS_097.jdx
Frequency (MHz)	400.1540	*Nucleus*	1H
Solvent	CHLOROFORM-d	*Temperature (degree C)*	25.004
Comment	Sample_id LS-097 User_id Schlempl oanmr4_1H CDCl3 /u oanmr4 9		

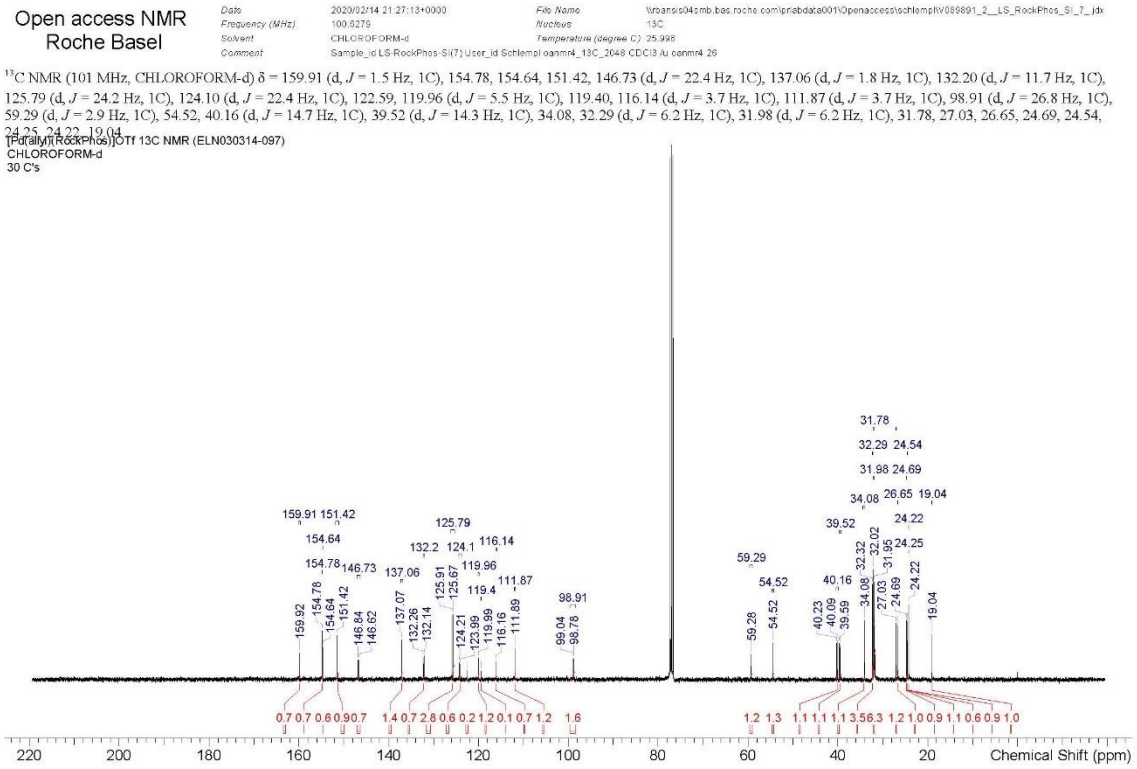
^{1}H NMR (400 MHz, CHLOROFORM-d) δ = 7.48 (d, *J* = 1.6 Hz, 1H), 7.41 (d, *J* = 1.9 Hz, 1H), 7.36 (d, *J* = 8.3 Hz, 1H), 7.03 (dd, *J* = 2.3, 8.5 Hz, 1H), 5.72 - 5.54 (m, 1H), 4.50 (dd, *J* = 1.2, 6.6 Hz, 1H), 3.92 (s, 3H), 3.43 (dd, *J* = 9.4, 13.7 Hz, 1H), 3.05 (td, *J* = 7.0, 13.8 Hz, 1H), 2.91 (d, *J* = 12.6 Hz, 1H), 2.95 - 2.84 (m, 1H), 2.67 (quin, *J* = 6.7 Hz, 1H), 2.46 - 2.22 (m, 2H), 1.45 (d, *J* = 15.6 Hz, 9H), 1.41 - 1.34 (m, 15H), 1.32 (d, *J* = 7.0 Hz, 3H), 1.30 (d, *J* = 6.7 Hz, 3H), 1.13 (s, 3H), 1.01 (d, *J* = 6.7 Hz, 3H), 0.88 (d, *J* = 6.7 Hz, 3H)



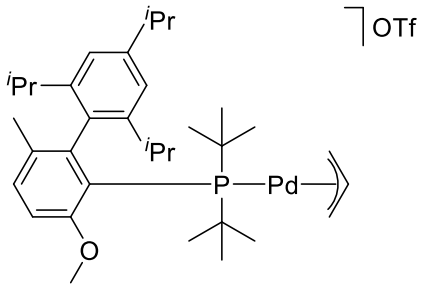
^{13}C NMR



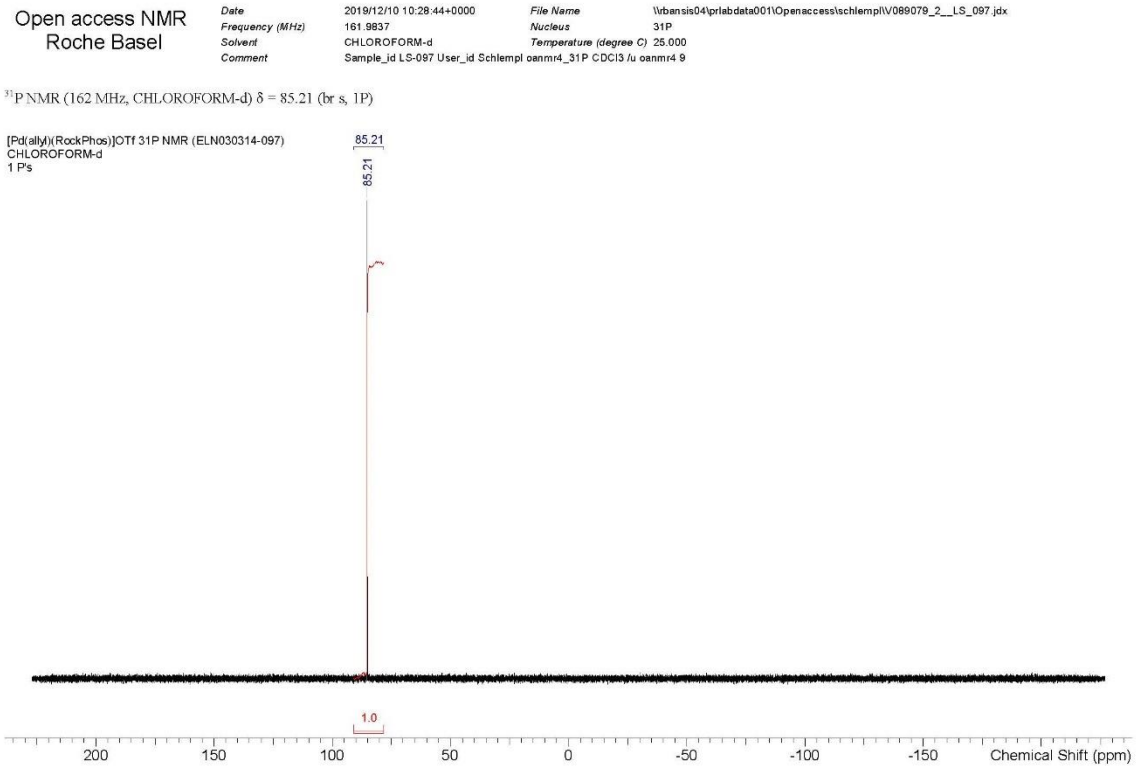
[Pd(allyl)(RockPhos)]OTf (Cat 7)



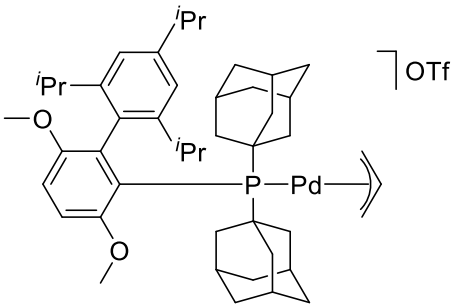
^{31}P NMR



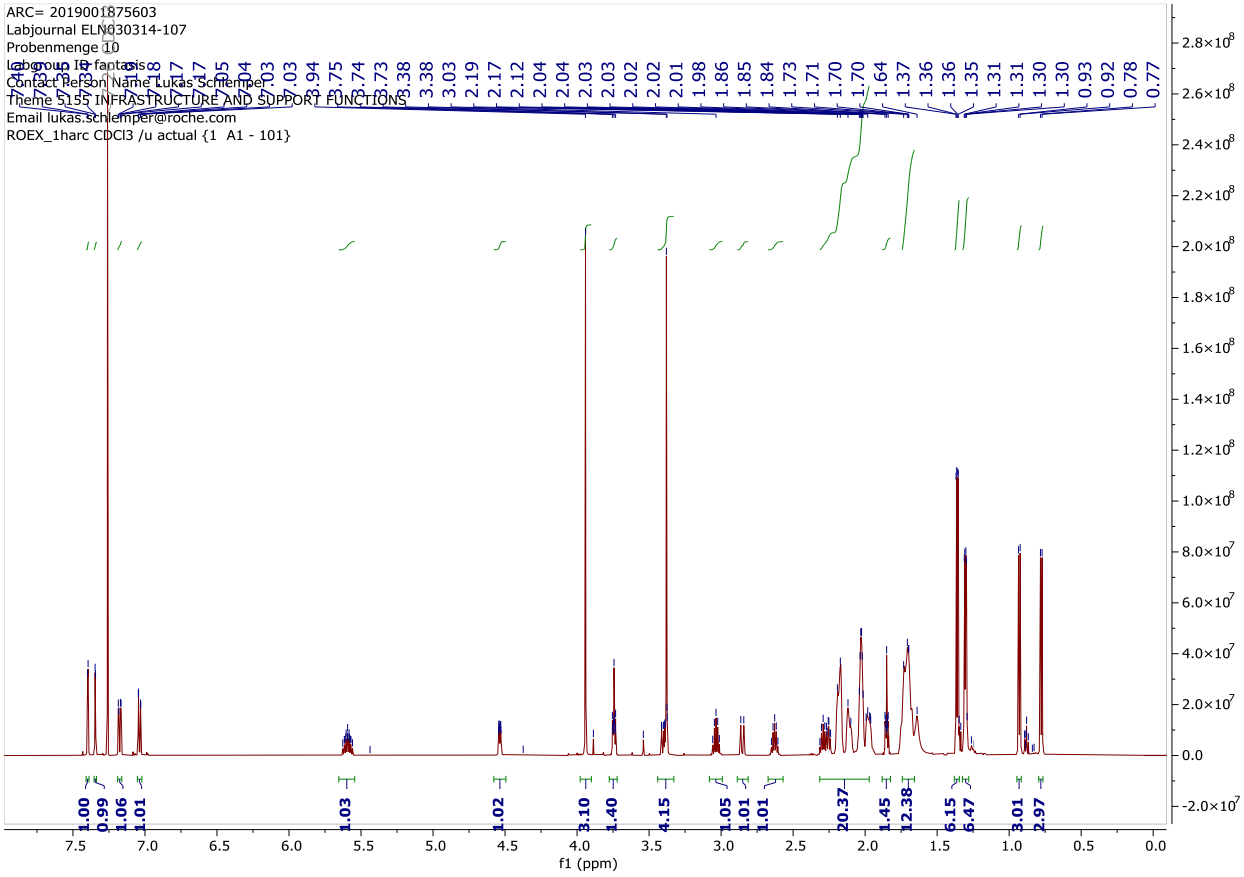
[Pd(allyl)(RockPhos)]OTf (Cat 7)



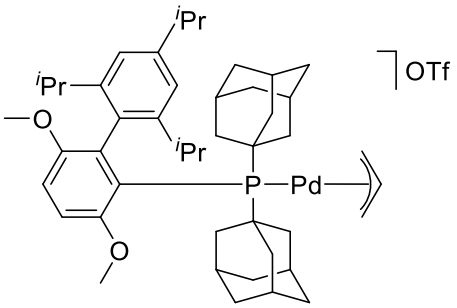
^{1}H NMR



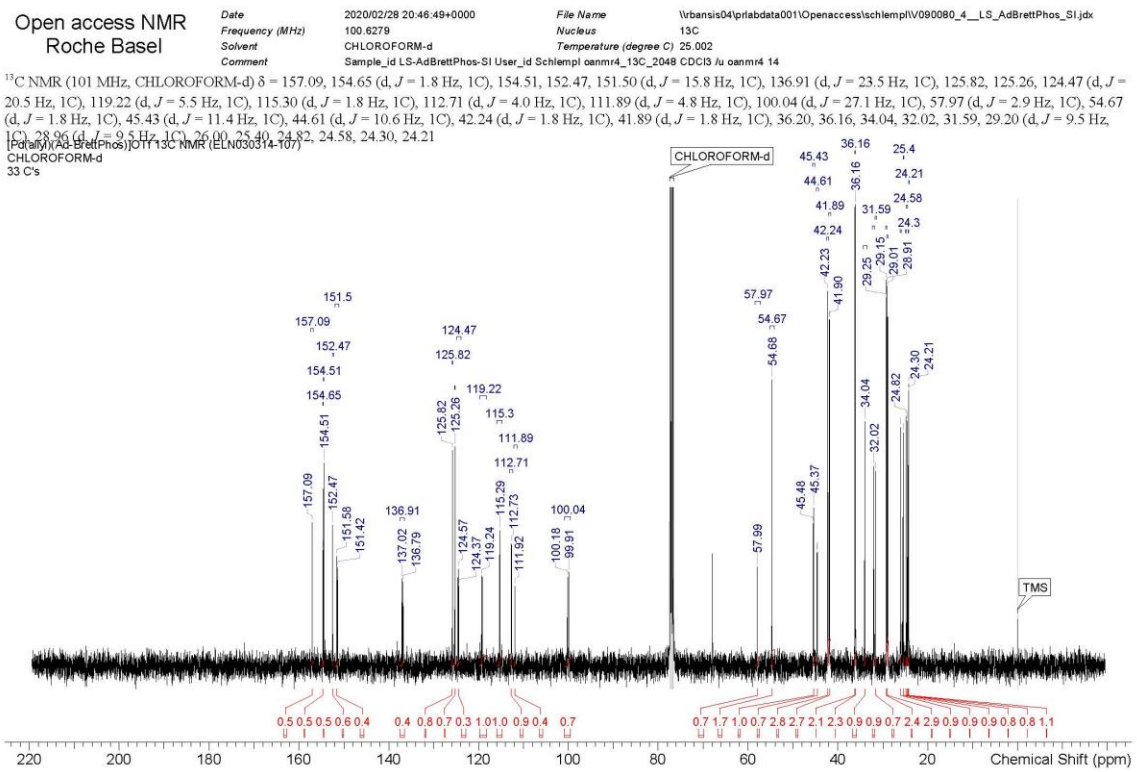
[Pd(allyl)(Ad-BrettPhos)]OTf (Cat 8)



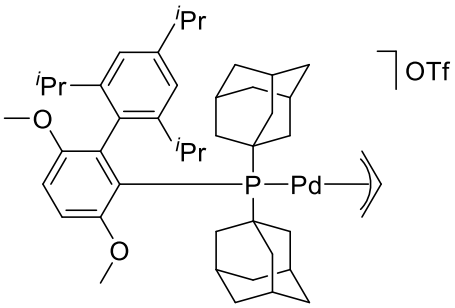
^{13}C NMR



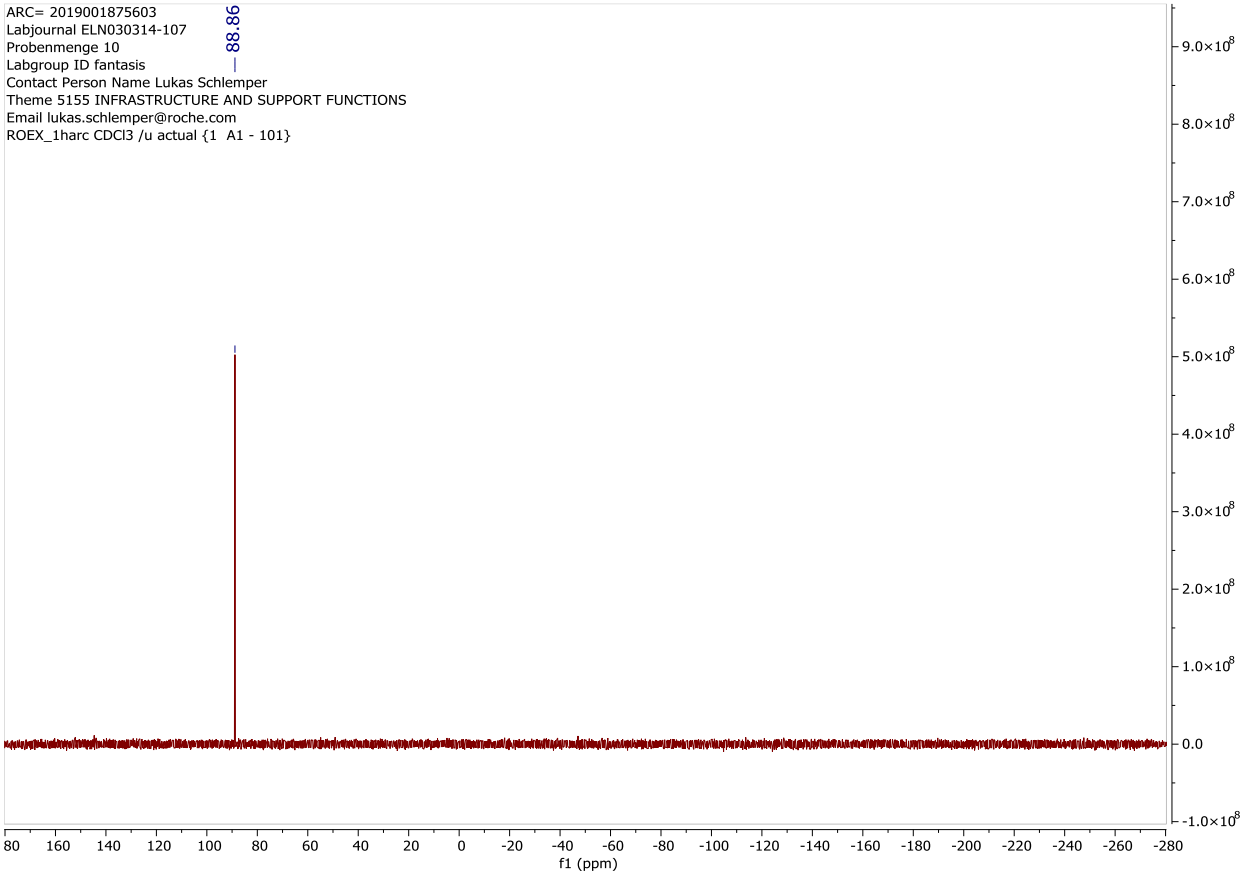
[Pd(allyl)(Ad-BrettPhos)]OTf (Cat 8)



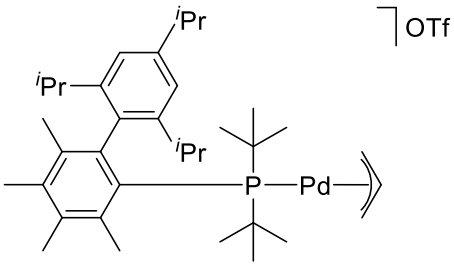
^{31}P NMR



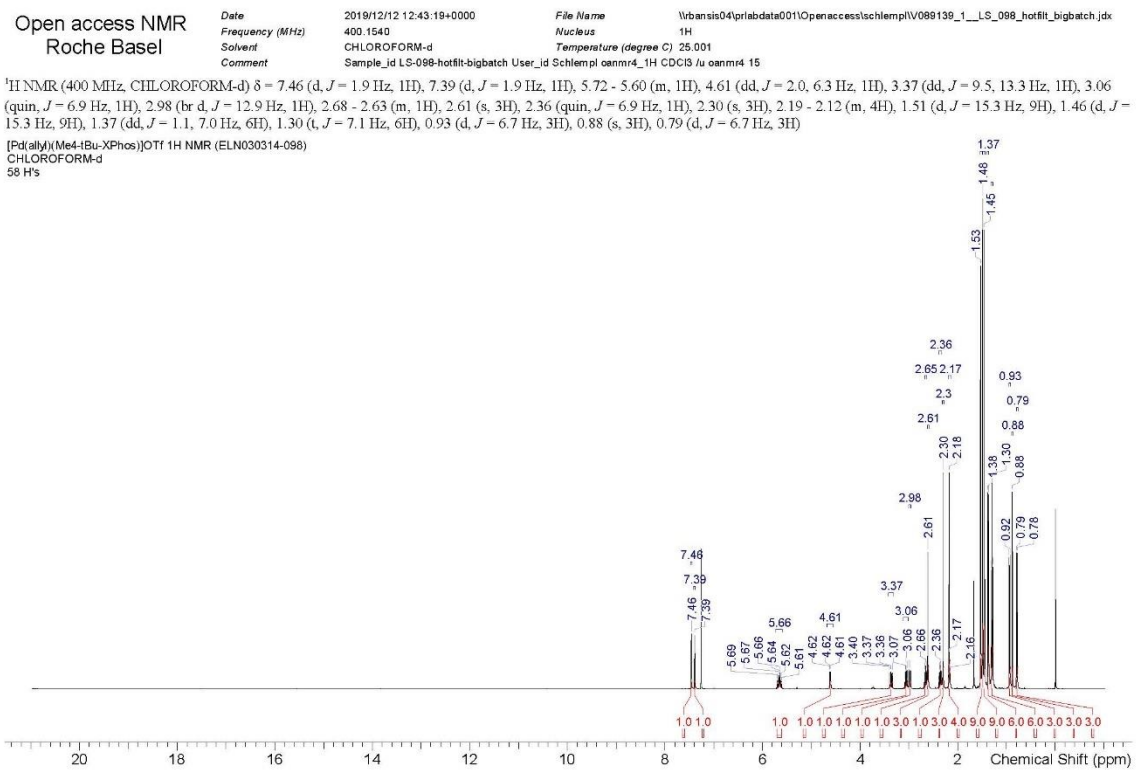
[Pd(allyl)(Ad-BrettPhos)]OTf (Cat 8)



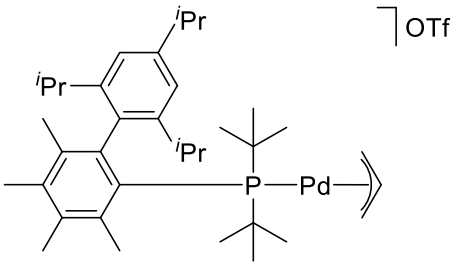
^{1}H NMR



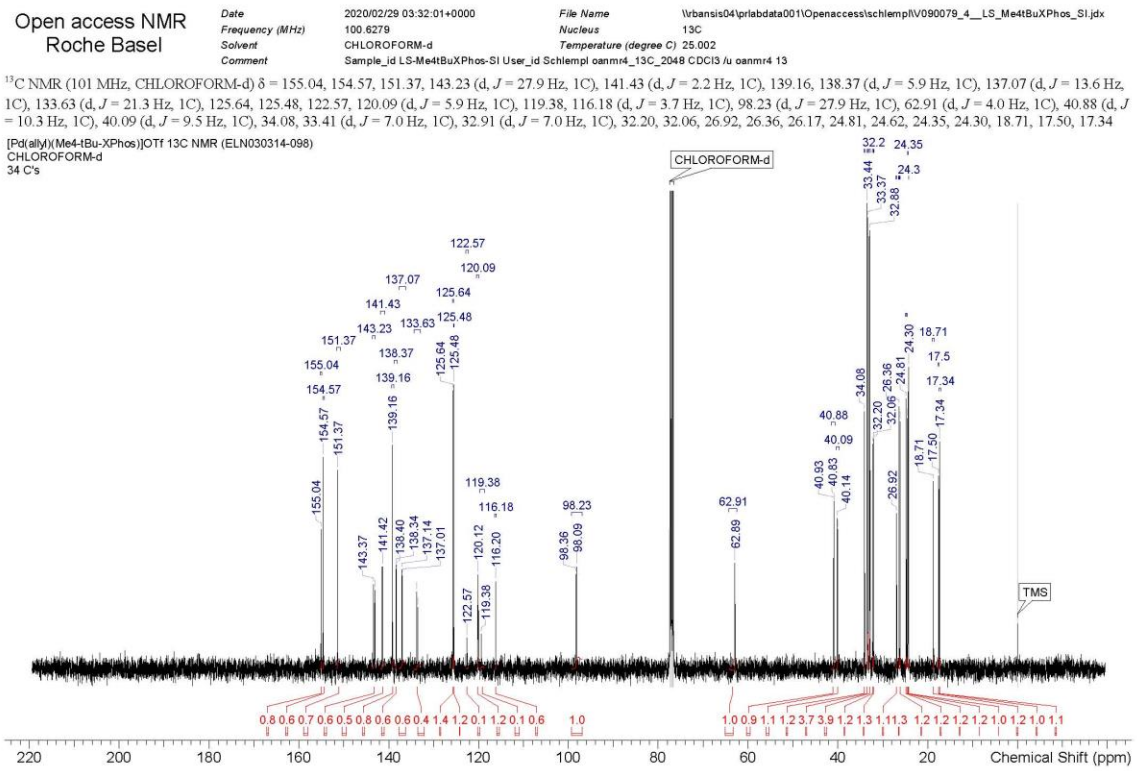
[Pd(allyl)(Me$_4$-^{t}Bu-XPhos)]OTf (Cat 9)



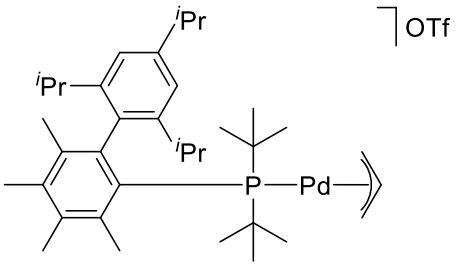
^{13}C NMR



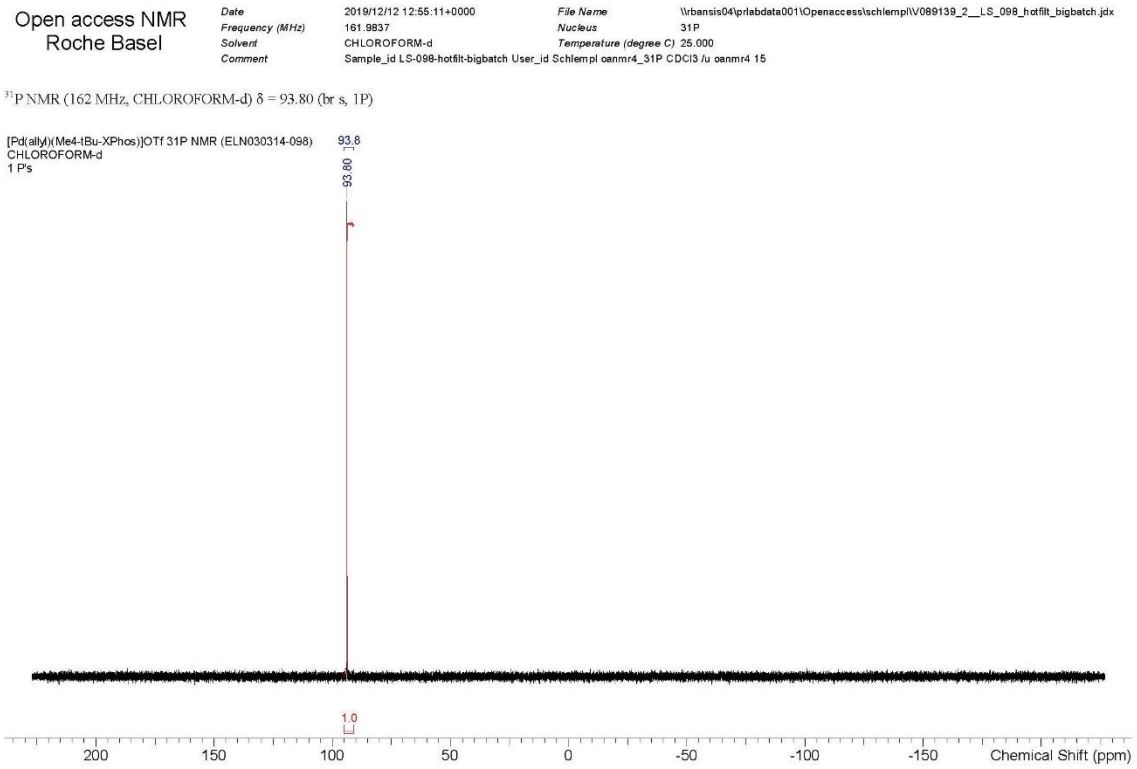
[Pd(allyl)(Me$_4$-^{t}Bu-XPhos)]OTf (Cat 9)



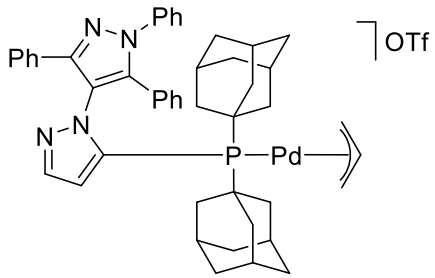
^{31}P NMR



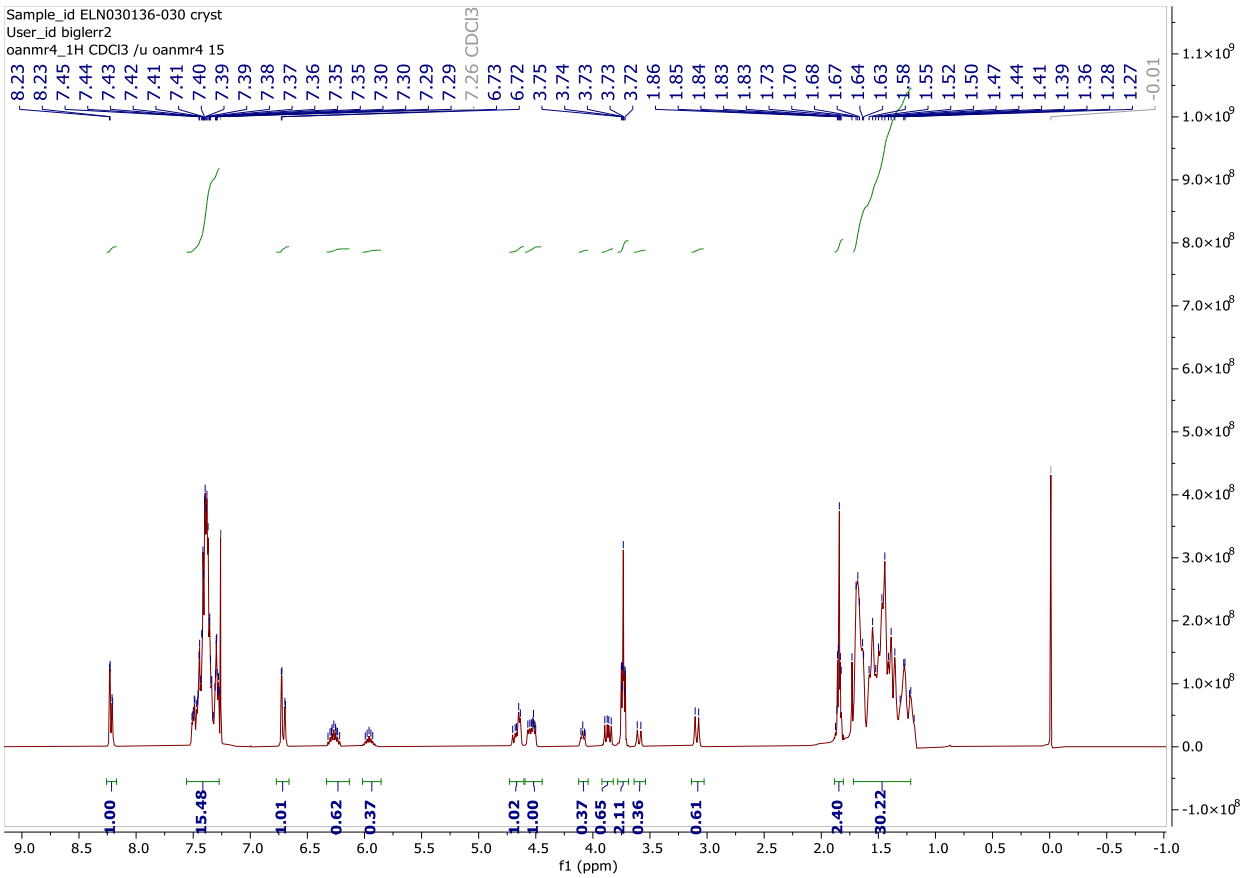
[Pd(allyl)(Me$_4$-^{t}Bu-XPhos)]OTf (Cat 9)



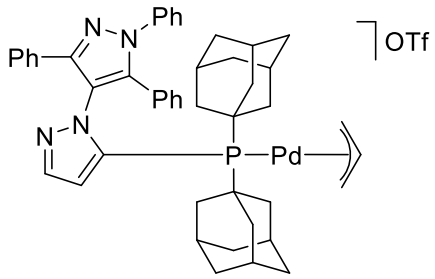
^{1}H NMR



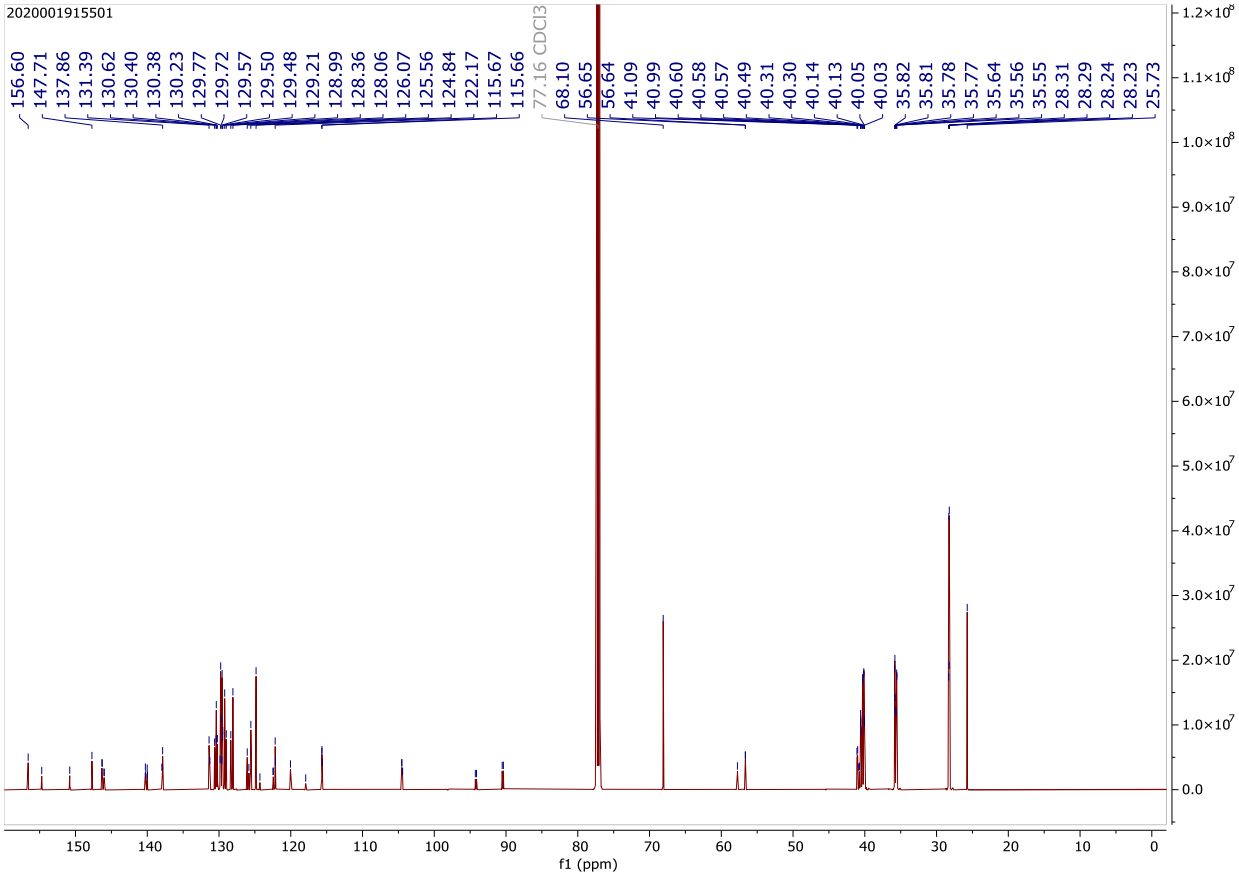
[Pd(allyl)(Ad-BippyPhos)]OTf (cat 10)



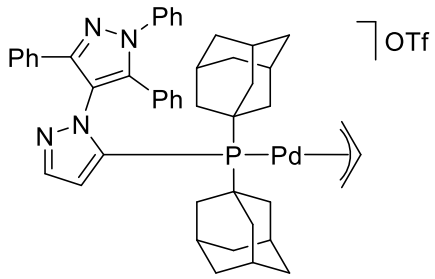
^{13}C NMR



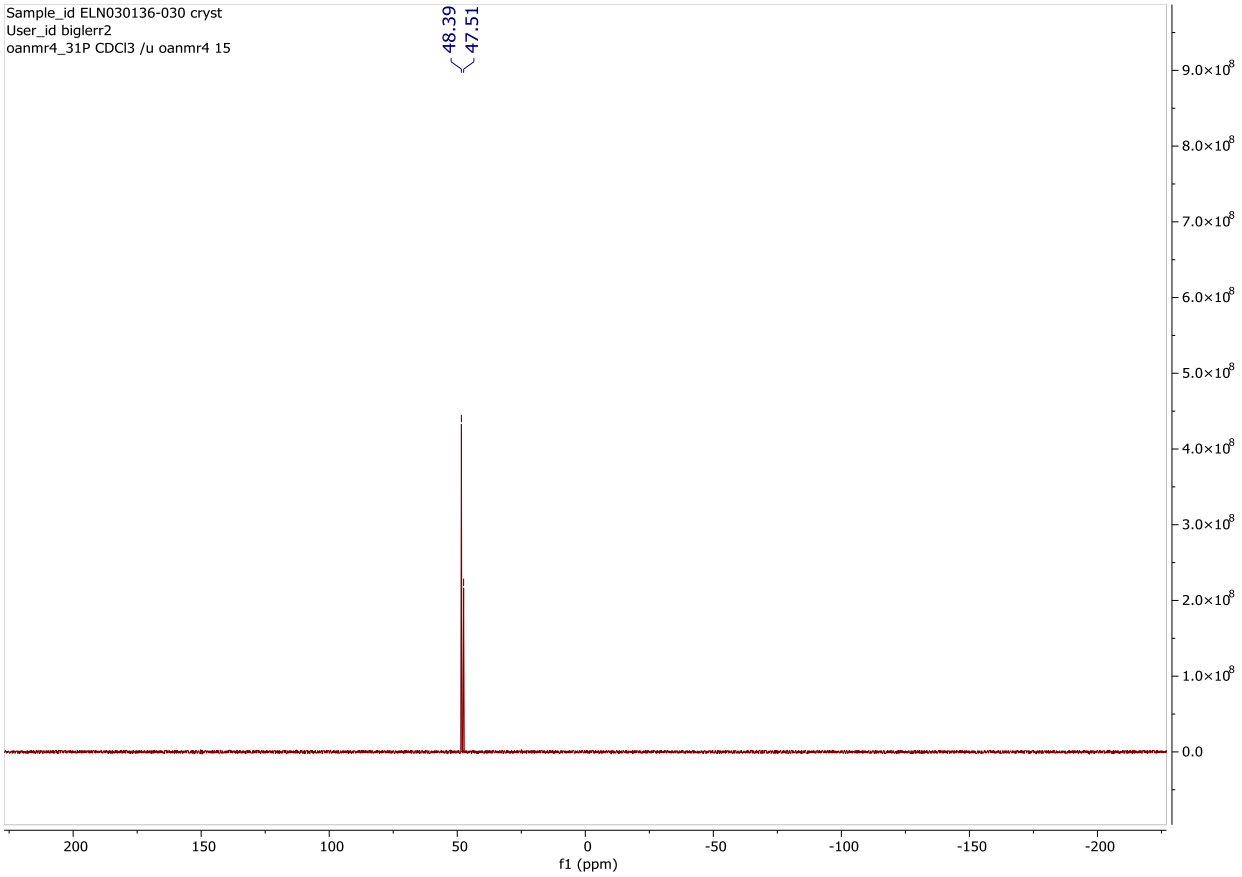
[Pd(allyl)(Ad-BippyPhos)]OTf (cat 10)



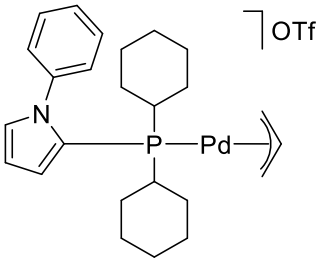
^{31}P NMR



[Pd(allyl)(Ad-BippyPhos)]OTf (cat 10)



^{1}H NMR



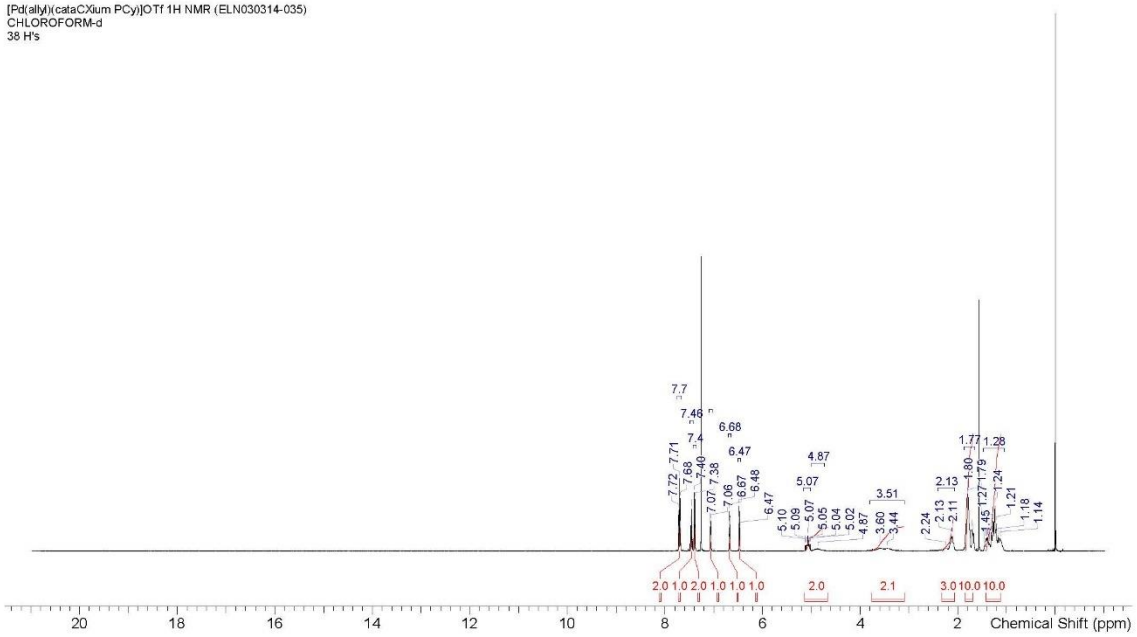
[Pd(allyl)(cataCXium PCy)]OTf (Cat 11)

Open access NMR
Roche Basel

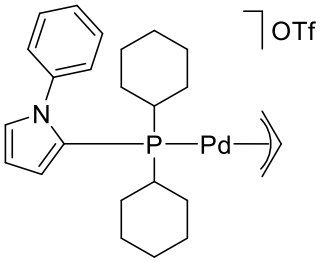
Date	2019/10/29 11:12:02+0000	*File Name*	\\rbansis04\prlabdata001\Openaccess\schlempl\V088336_1__LS_035_P_Dry.jdx
Frequency (MHz)	400.1540	*Nucleus*	1H
Solvent	CHLOROFORM-d	*Temperature (degree C)*	24.996
Comment	Sample_id LS-035-P-Dry User_id Schlempl oanmr4_1H CDCl3 /u oanmr4 3		

^{1}H NMR (400 MHz, CHLOROFORM-d) δ = 7.75 - 7.66 (m, 2H), 7.49 - 7.43 (m, 1H), 7.42 - 7.36 (m, 2H), 7.06 (ddd, *J* = 1.5, 2.6, 3.7 Hz, 1H), 6.68 (td, *J* = 1.3, 3.8 Hz, 1H), 6.47 (ddd, *J* = 1.1, 2.7, 3.8 Hz, 1H), 5.16 - 5.02 (m, 1H), 4.99 - 4.73 (m, 1H), 3.80 - 3.10 (m, 2H), 2.40 - 2.06 (m, 3H), 1.87 - 1.65 (m, 11H), 1.48 - 1.04 (m, 12H)

[Pd(allyl)(cataCXium PCy)]OTf 1H NMR (ELN030314-035)
CHLOROFORM-d
38 H's



^{13}C NMR

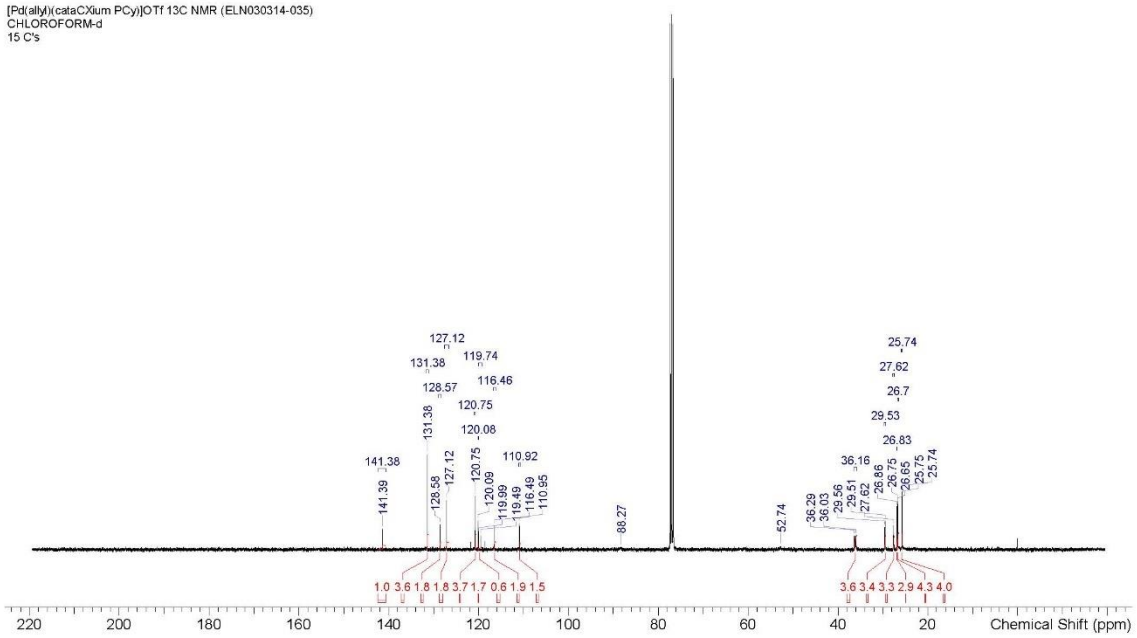


[Pd(allyl)(cataCXium PCy)]OTf (Cat 11)

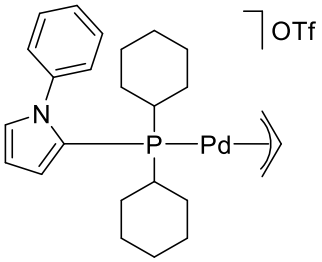
Open access NMR
Roche Basel

Date	2020/01/03 20:03:39+0000	*File Name*	\\rbansis04\prlabdata001\Openaccess\biglerr2\V089328_6__ELN030016_035_cryst.jdx
Frequency (MHz)	100.6279	*Nucleus*	13C
Solvent	CHLOROFORM-d	*Temperature (degree C)*	24.997
Comment	Sample_id ELN030016-035 cryst User_id biglerr2 oanmr4_13C_2048 CDCl3 /u oanmr4 35		

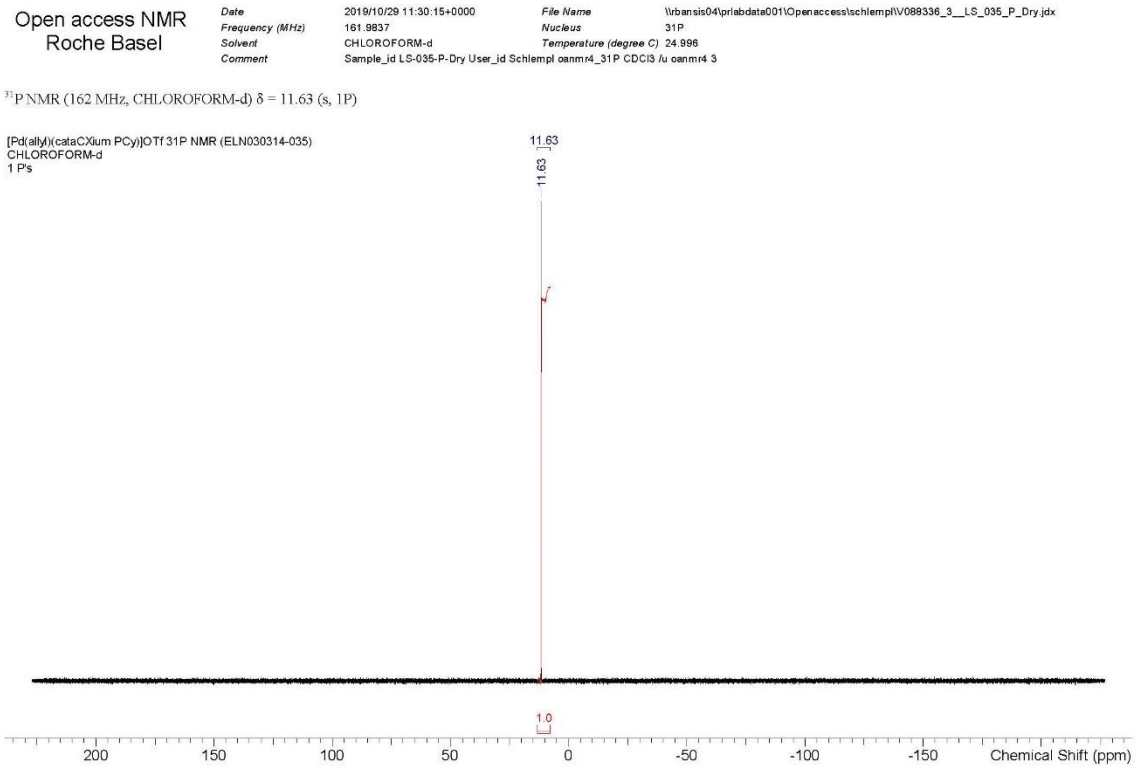
^{13}C NMR (101 MHz, CHLOROFORM-d) δ = 141.38 (d, *J* = 1.5 Hz, 1C), 131.38, 128.57 (d, *J* = 3.3 Hz, 1C), 127.12, 120.75, 120.08 (d, *J* = 2.2 Hz, 1C), 119.74 (d, *J* = 50.6 Hz, 1C), 116.46 (d, *J* = 5.1 Hz, 1C), 110.92 (d, *J* = 6.2 Hz, 1C), 36.16 (br d, *J* = 26.0 Hz, 1C), 29.53 (br d, *J* = 4.4 Hz, 1C), 27.62 (br s, 1C), 26.83 (d, *J* = 7.0 Hz, 1C), 26.70 (d, *J* = 10.3 Hz, 1C), 25.74 (d, *J* = 1.5 Hz, 1C)



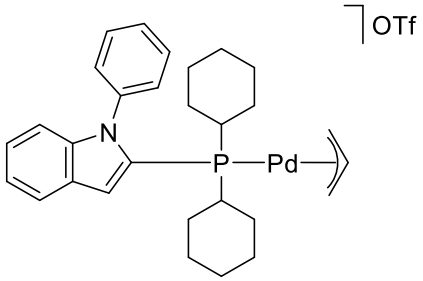
^{31}P NMR



[Pd(allyl)(cataCXium PCy)]OTf (Cat 11)



^{1}H NMR

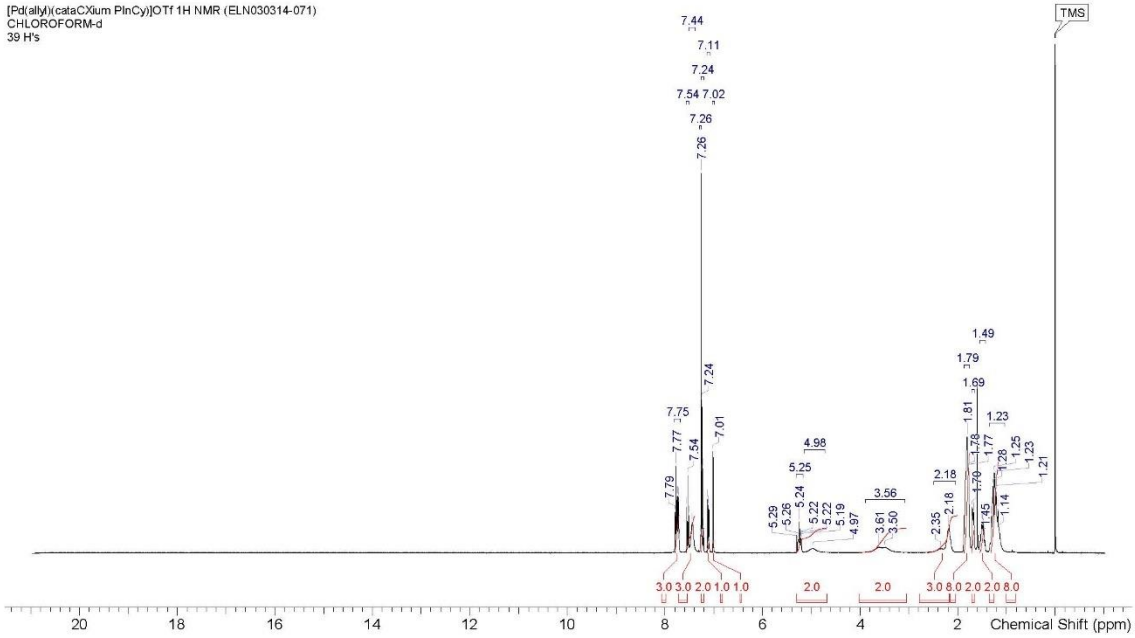


[Pd(allyl)(cataCXium PInCy)]OTf (Cat 12)

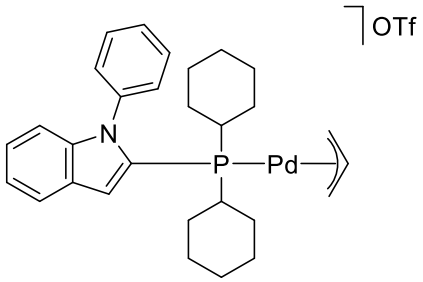
Open access NMR
Roche Basel

Date	2019/11/22 07:34:36+0000	*File Name*	\\rbansis04\prlabdata001\Openaccess\schlempl\V088785_1__LS_071_Prod.jdx
Frequency (MHz)	400.1540	*Nucleus*	1H
Solvent	CHLOROFORM-d	*Temperature (degree C)*	25.006
Comment	Sample_id LS-071-Prod User_id Schlempl oanmr4_1H CDCl3 /u oanmr4 3		

^{1}H NMR (400 MHz, CHLOROFORM-d) δ = 7.81 - 7.69 (m, 3H), 7.57 - 7.50 (m, 1H), 7.44 (br s, 2H), 7.29 - 7.26 (m, 1H), 7.26 - 7.20 (m, 2H), 7.14 - 7.08 (m, 1H), 7.02 (d, *J* = 1.1 Hz, 1H), 5.31 - 5.17 (m, 1H), 5.15 - 4.72 (m, 1H), 3.89 - 3.08 (m, 2H), 2.49 - 2.05 (m, 3H), 1.87 - 1.75 (m, 8H), 1.69 (br d, *J* = 10.2 Hz, 2H), 1.55 - 1.43 (m, 2H), 1.35 - 1.03 (m, 9H)



^{13}C NMR

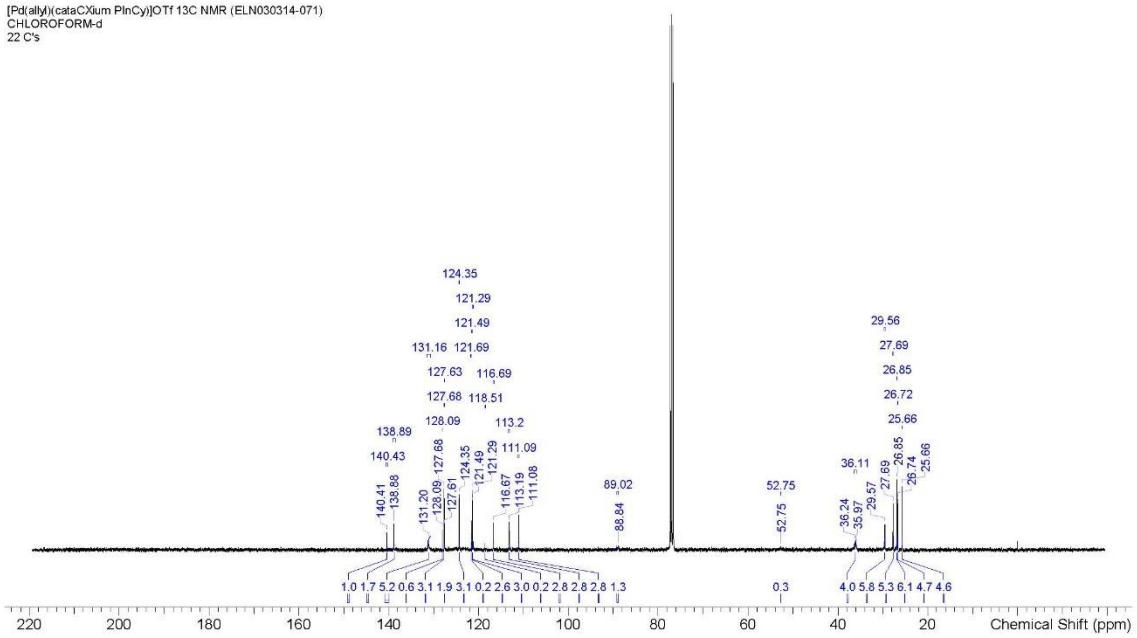


[Pd(allyl)(cataCXium PInCy)]OTf (Cat 12)

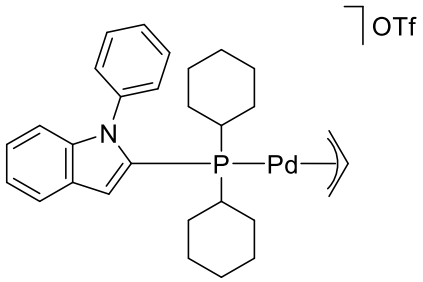
Open access NMR
Roche Basel

Date	2020/02/12 20:37:22+0000	*File Name*	\\rbansis04smb.bas.roche.com\prlabdata001\Openaccess\schlempl\V089852_5__LS_PInCy_SI.jdx
Frequency (MHz)	100.6279	*Nucleus*	13C
Solvent	CHLOROFORM-d	*Temperature (degree C)*	24.998
Comment	Sample_id LS-PInCy-SI User_id Schlempl oanmr4_13C_2048 CDCl3 /u oanmr4 35		

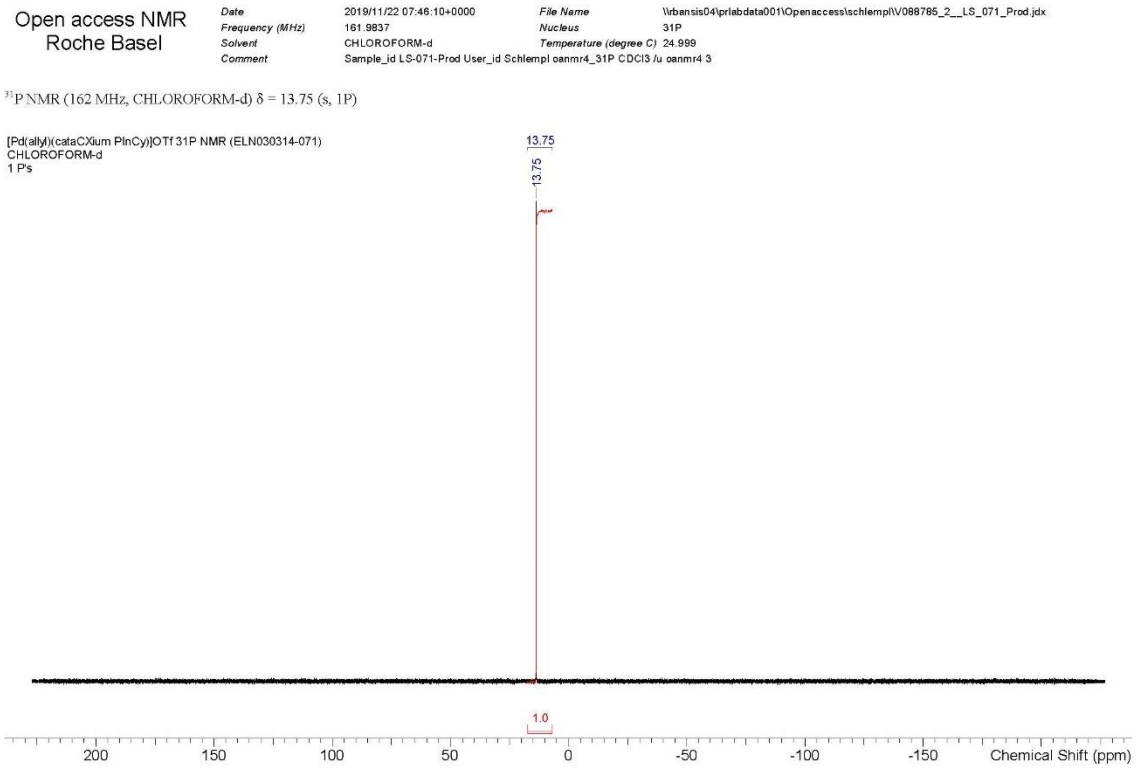
^{13}C NMR (101 MHz, CHLOROFORM-d) δ = 140.43 (d, *J* = 4.0 Hz, 1C), 138.89 (d, *J* = 1.5 Hz, 1C), 131.54 - 130.66 (m, 1C), 128.09, 127.68, 127.63 (d, *J* = 4.0 Hz, 1C), 124.35, 121.69, 121.49, 121.29, 118.51, 116.69 (d, *J* = 4.8 Hz, 1C), 113.20 (d, *J* = 2.2 Hz, 1C), 111.09 (d, *J* = 1.5 Hz, 1C), 89.02 (br d, *J* = 34.8 Hz, 1C), 52.75, 36.11 (br d, *J* = 26.8 Hz, 1C), 29.56 (br d, *J* = 3.7 Hz, 1C), 27.69, 26.91 - 26.79 (m, 1C), 26.72 (d, *J* = 4.8 Hz, 1C), 25.66



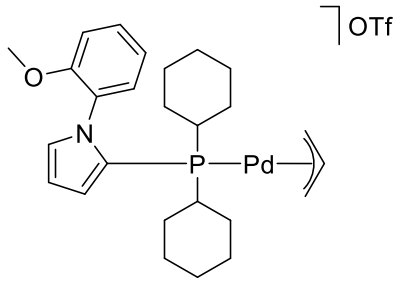
^{31}P NMR



[Pd(allyl)(cataCXium PInCy)]OTf (Cat 12)



^{1}H NMR

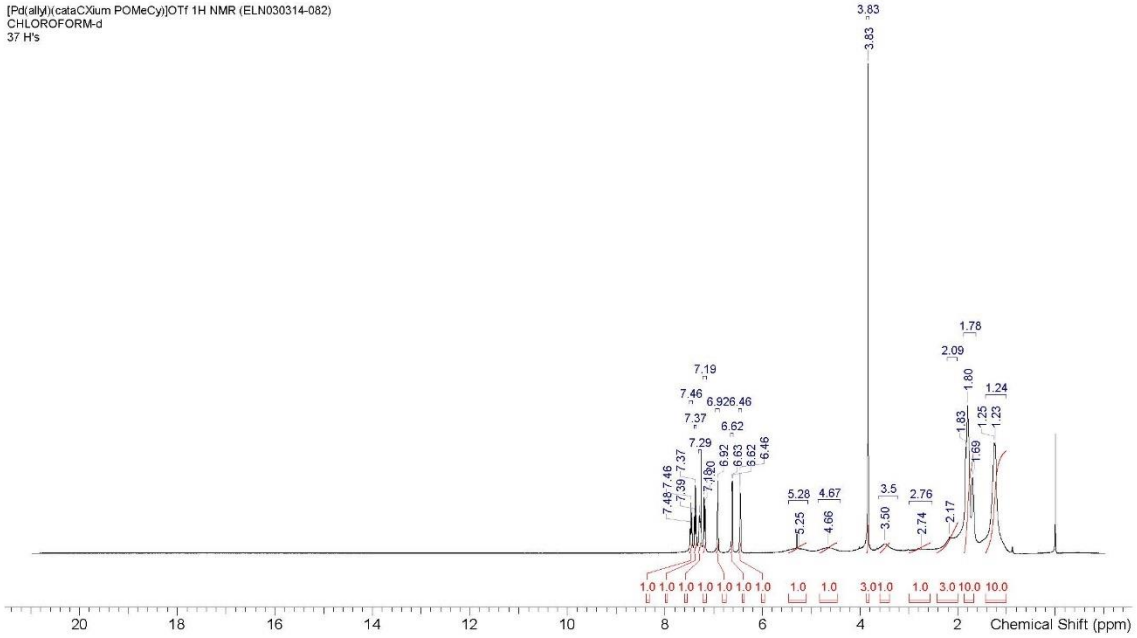


[Pd(allyl)(cataCXium POMeCy)]OTf (Cat 13)

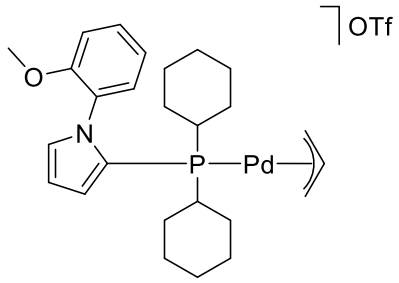
Open access NMR
Roche Basel

Date	2019/12/03 18:07:11+0000	*File Name*	\\rbansis04\prlabdata001\Openaccess\schlempl\V088980_1__LS_082_Prod.jdx
Frequency (MHz)	400.1540	*Nucleus*	1H
Solvent	CHLOROFORM-d	*Temperature (degree C)*	25.005
Comment	Sample_id LS-082-Prod User_id Schlempl oanmr4_1H CDCl3 /u oanmr4 8		

^{1}H NMR (400 MHz, CHLOROFORM-d) δ = 7.50 - 7.44 (m, 1H), 7.37 (br t, *J* = 7.1 Hz, 1H), 7.29 (br d, *J* = 6.7 Hz, 1H), 7.19 (br d, *J* = 8.1 Hz, 1H), 6.92 (br s, 1H), 6.66 - 6.60 (m, 1H), 6.46 (t, *J* = 2.7 Hz, 1H), 5.47 - 5.07 (m, 1H), 4.86 - 4.41 (m, 1H), 3.83 (s, 3H), 3.62 - 3.24 (m, 1H), 2.99 - 2.52 (m, 1H), 2.22 - 2.01 (m, 2H), 1.87 - 1.62 (m, 11H), 1.24 (br d, *J* = 7.8 Hz, 10H)



^{13}C NMR



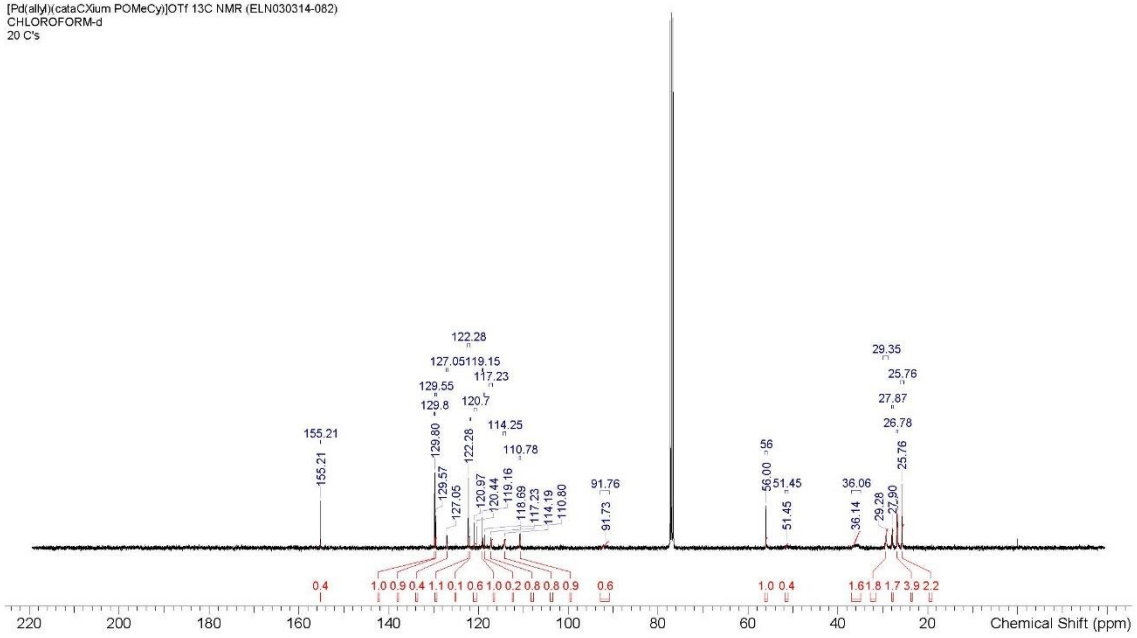
[Pd(allyl)(cataCXium POMeCy)]OTf (Cat 13)

Open access NMR
Roche Basel

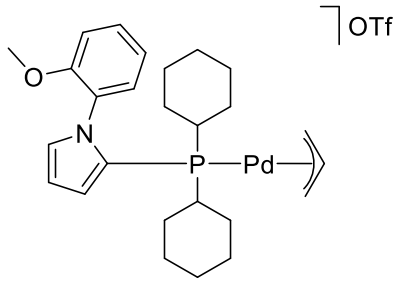
Date	2020/02/13 20:48:00+0000	*File Name*	\\rbansis04smb.bas.roche.com\prlabdata001\Openaccess\schlempl\V089861_4__LS_POMeCy_SI.jdx
Frequency (MHz)	100.6279	*Nucleus*	13C
Solvent	CHLOROFORM-d	*Temperature (degree C)*	25.000
Comment	Sample_id LS-POMeCy-SI User_id Schlempl oanmr4_13C_2048 CDCl3 /u oanmr4 8		

^{13}C NMR (101 MHz, CHLOROFORM-d) δ = 155.21, 129.80, 129.55 (d, *J* = 3.7 Hz, 1C), 127.05, 122.28, 121.87, 120.70 (d, *J* = 53.2 Hz, 1C), 119.15 (d, *J* = 3.3 Hz, 1C), 118.69, 117.23 (br s, 1C), 114.48 - 113.91 (m, 1C), 110.78 (br d, *J* = 4.8 Hz, 1C), 92.87 - 90.88 (m, 1C), 56.00, 51.45, 36.98 - 35.00 (m, 1C), 29.86 - 28.80 (m, 1C), 28.11 - 27.71 (m, 1C), 26.97 - 26.60 (m, 1C), 25.76

[Pd(allyl)(cataCXium POMeCy)]OTf 13C NMR (ELN030314-082)
CHLOROFORM-d
20 C's



^{31}P NMR

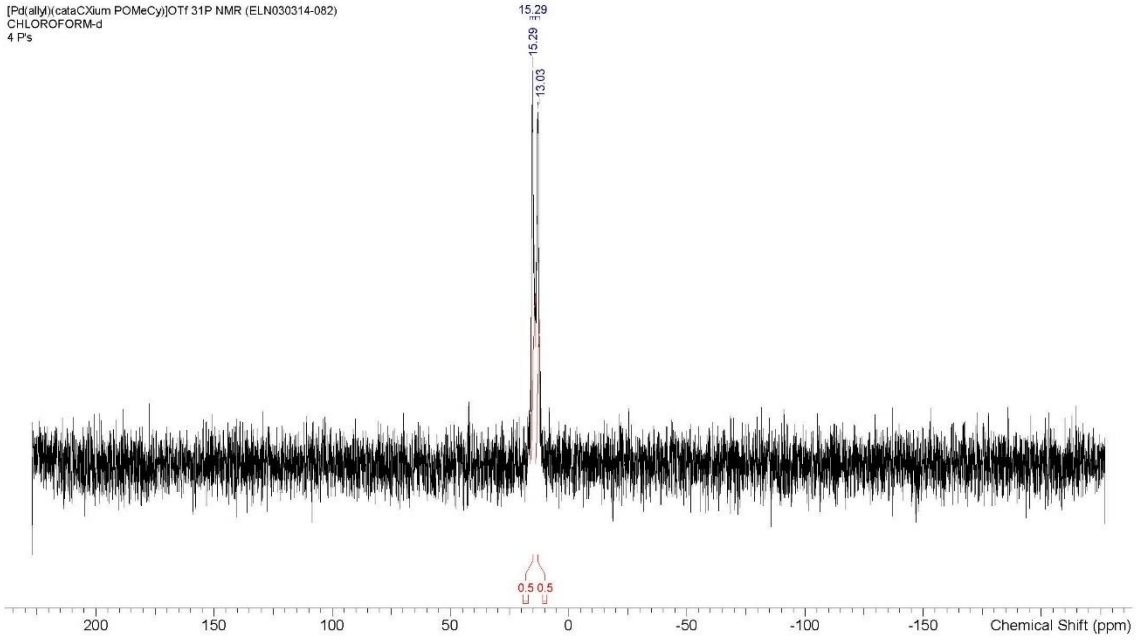


[Pd(allyl)(cataCXium POMeCy)]OTf (Cat 13)

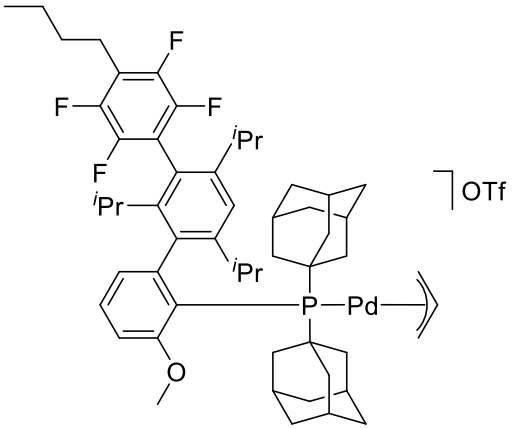
Open access NMR
Roche Basel

Date	2019/12/03 18:19:00+0000	*File Name*	\\rbansis04\prlabdata001\Openaccess\schlempl\V088980_2__LS_082_Prod.jdx
Frequency (MHz)	161.9837	*Nucleus*	31P
Solvent	CHLOROFORM-d	*Temperature (degree C)*	24.999
Comment	Sample_id LS-082-Prod User_id Schlempl oanmr4_31P CDCl3 /u oanmr4 8		

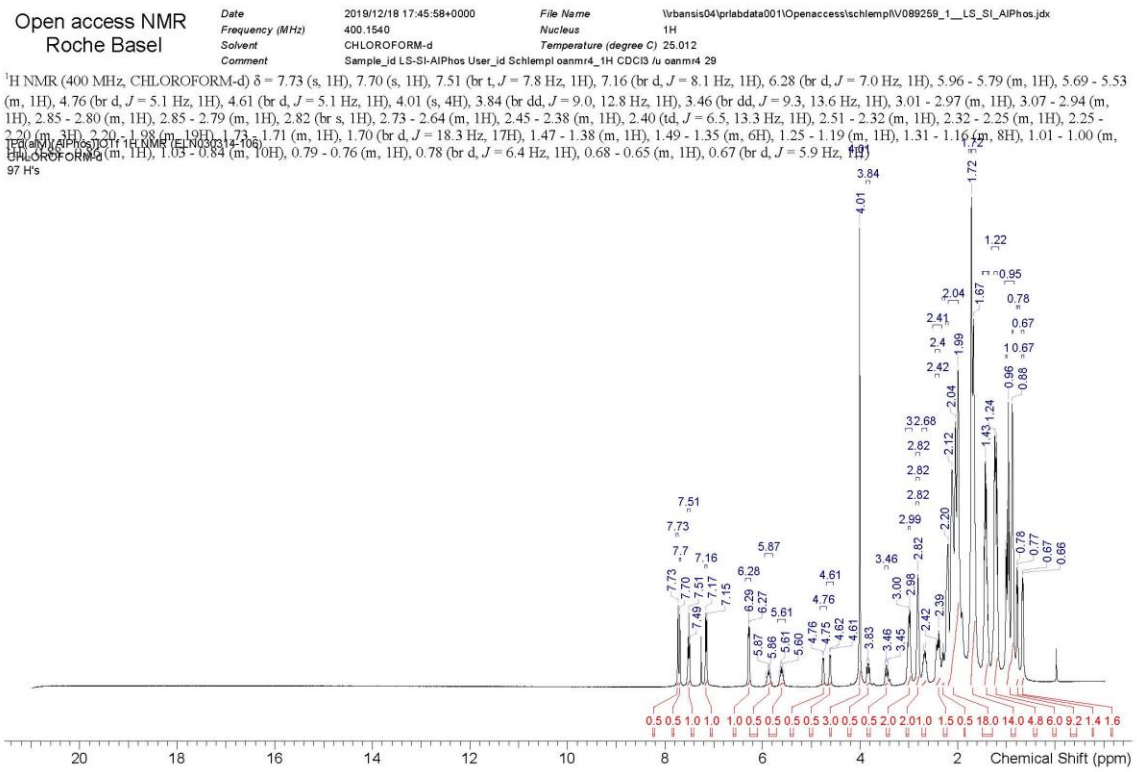
^{31}P NMR (162 MHz, CHLOROFORM-d) δ = 15.29 (s, 1P), 16.28 - 14.06 (m, 1P), 13.03 (s, 1P), 13.91 - 12.10 (m, 1P)



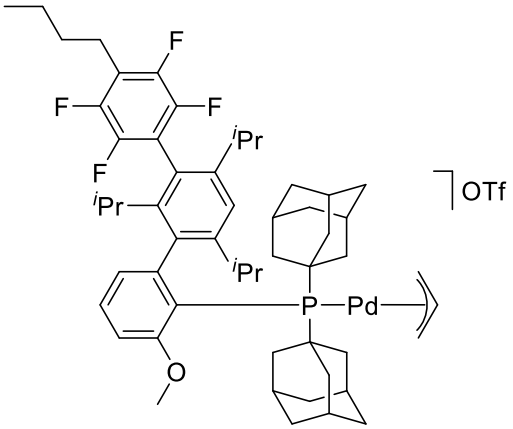
^{1}H NMR



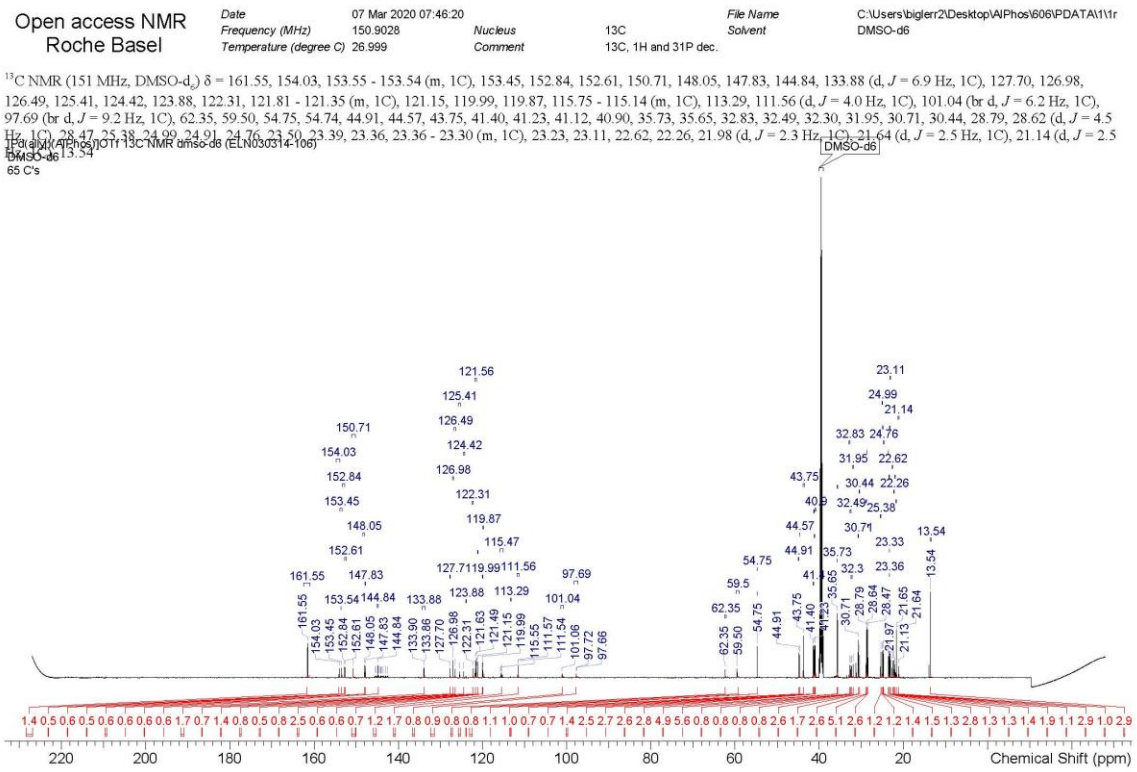
[Pd(allyl)(AlPhos)]OTf (Cat 14)



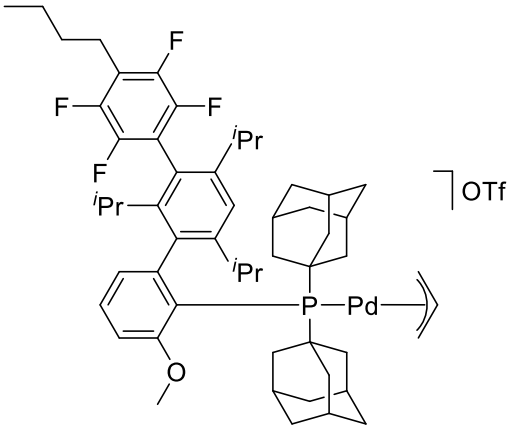
^{13}C NMR



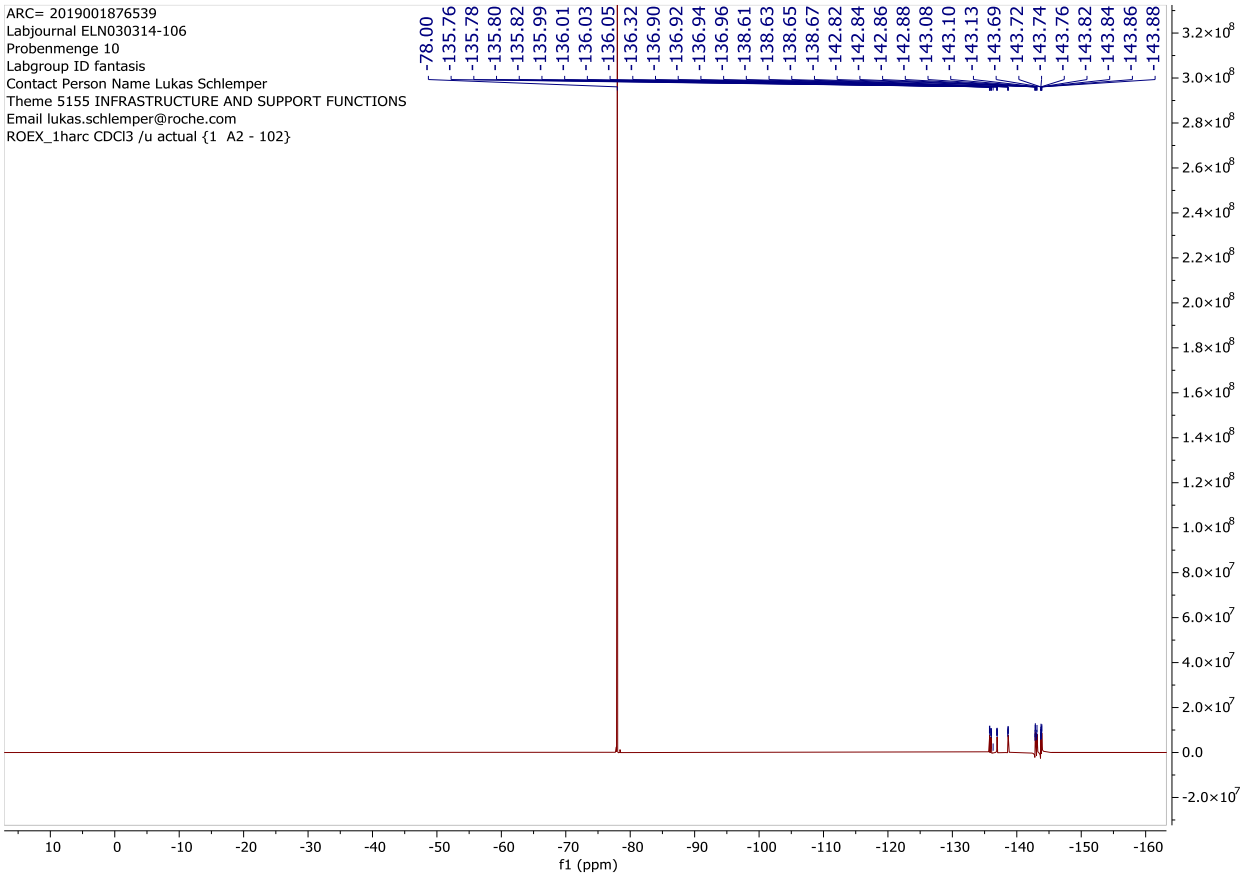
[Pd(allyl)(AlPhos)]OTf (Cat 14)



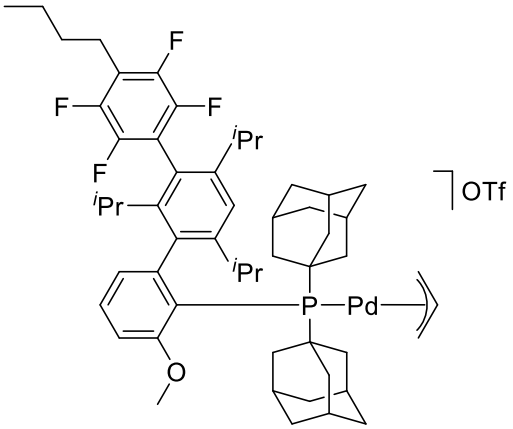
^{19}F NMR



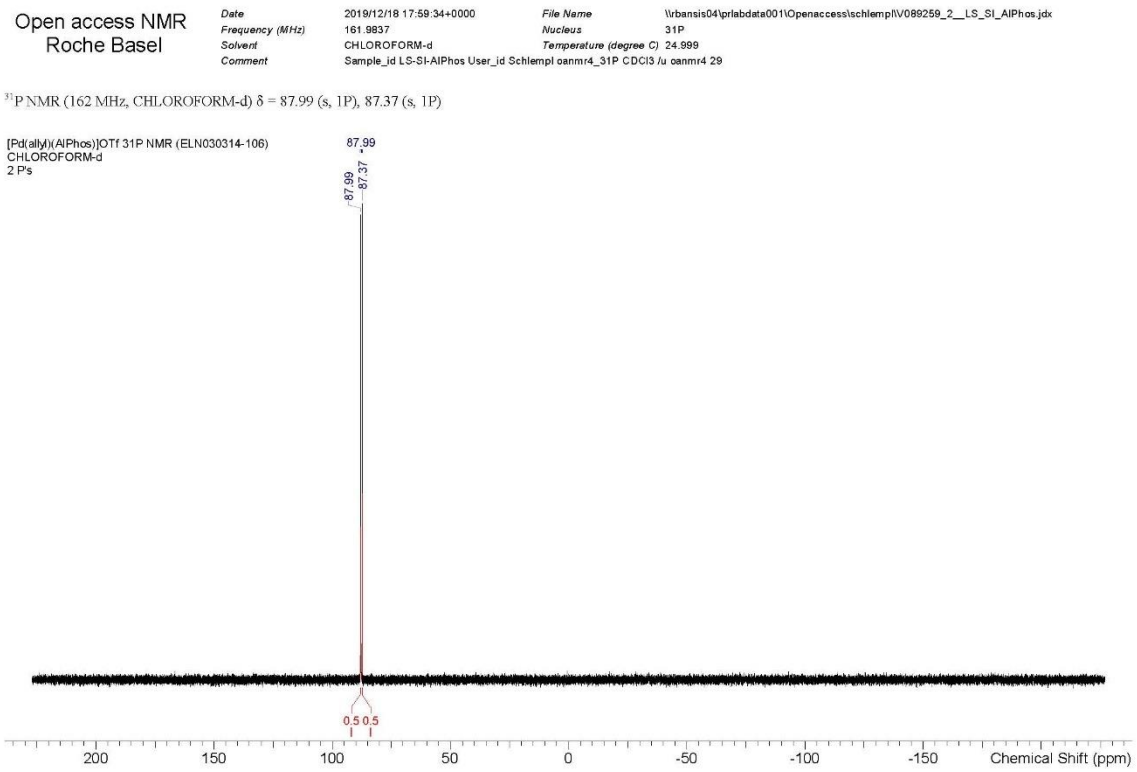
[Pd(allyl)(AlPhos)]OTf (Cat 14)



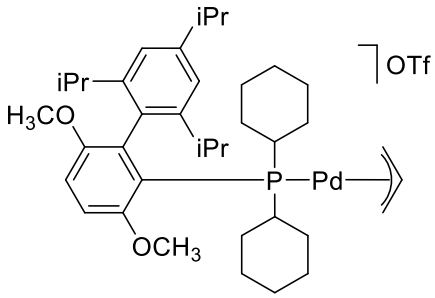
^{31}P NMR



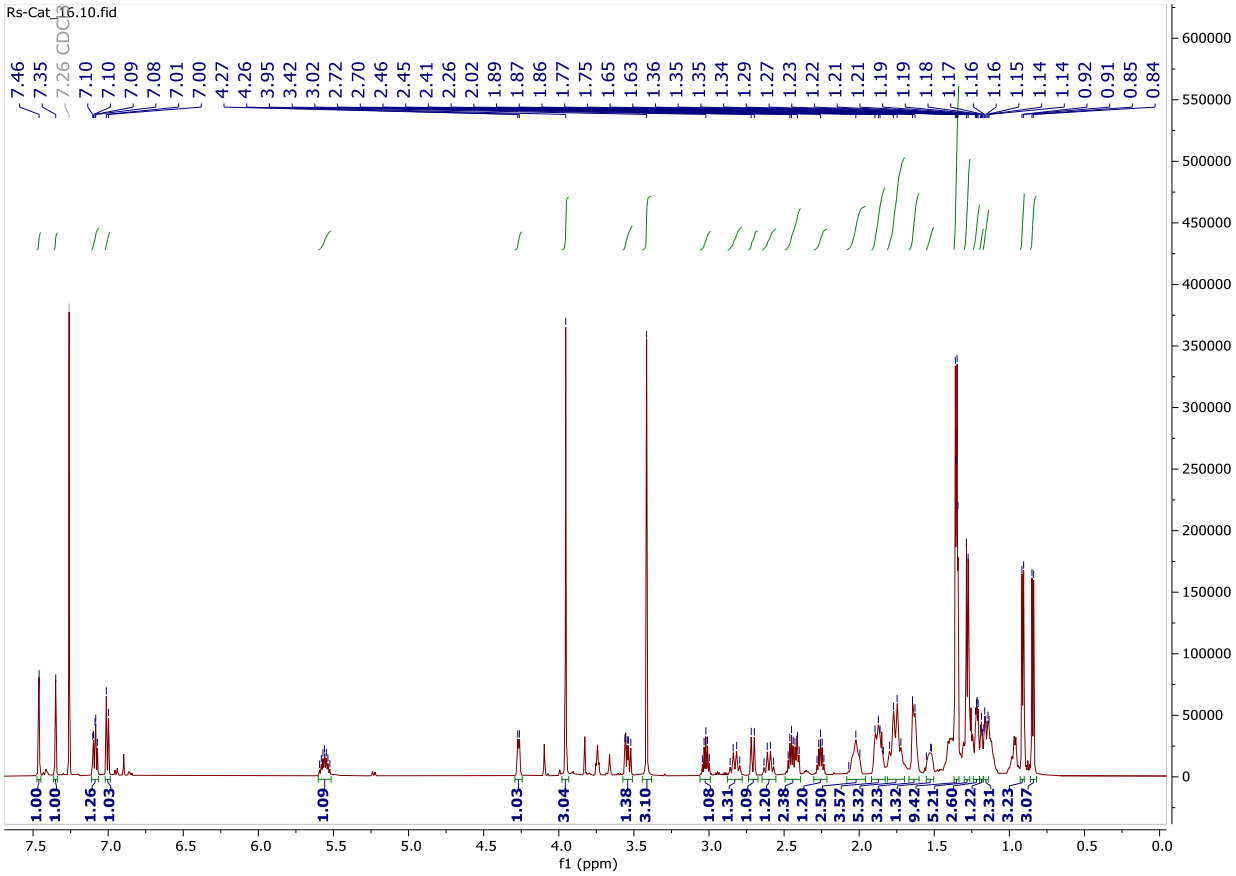
[Pd(allyl)(AlPhos)]OTf (Cat 14)



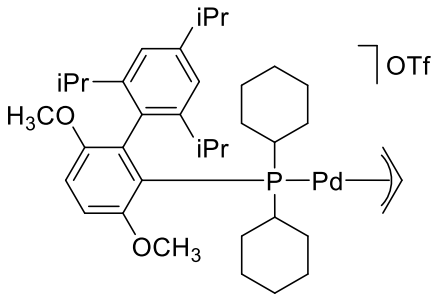
^{1}H NMR



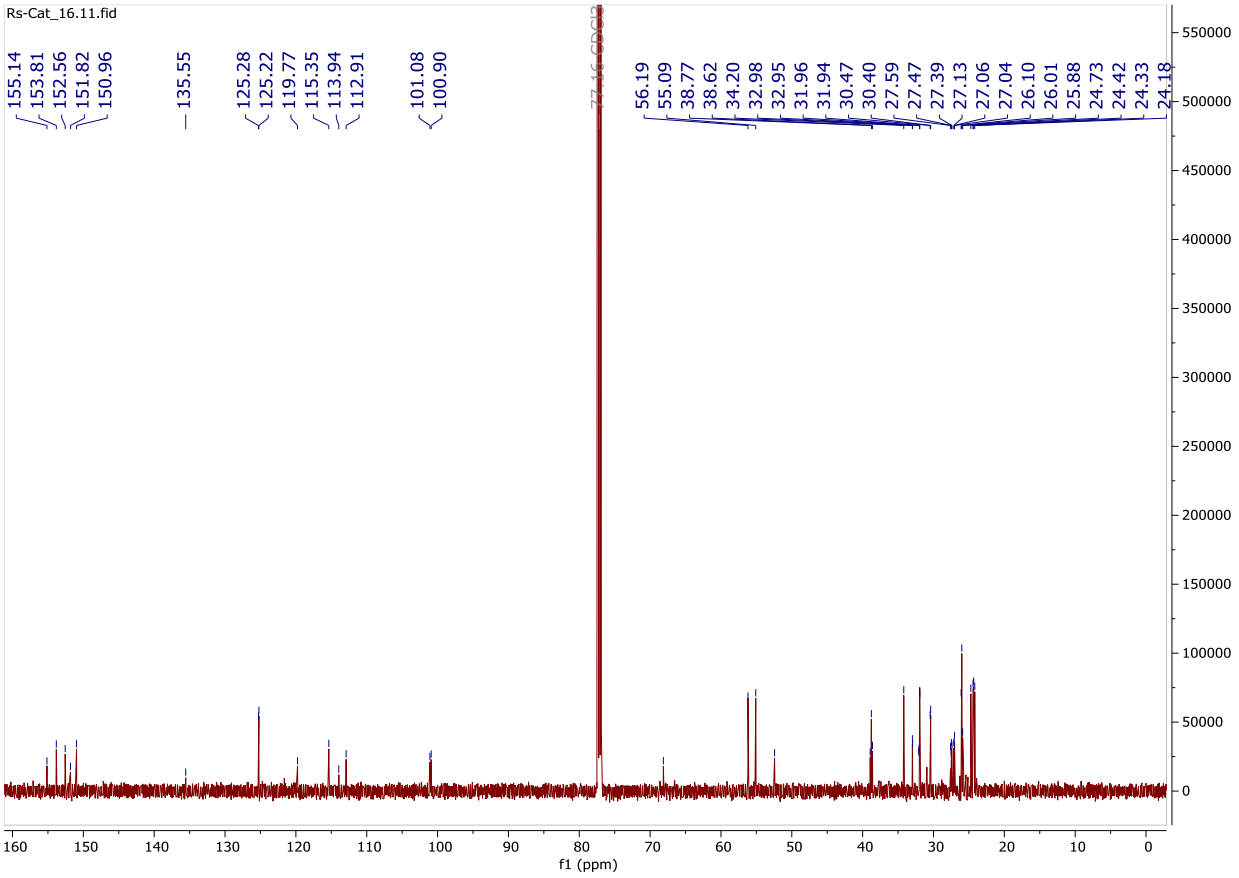
[Pd(allyl)(BrettPhos)]OTf **(Cat 16)**



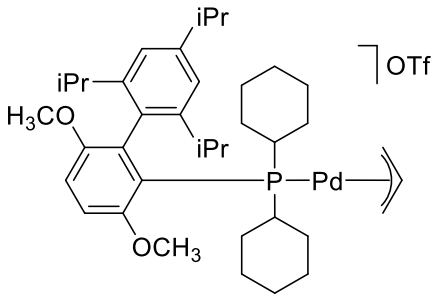
^{13}C NMR



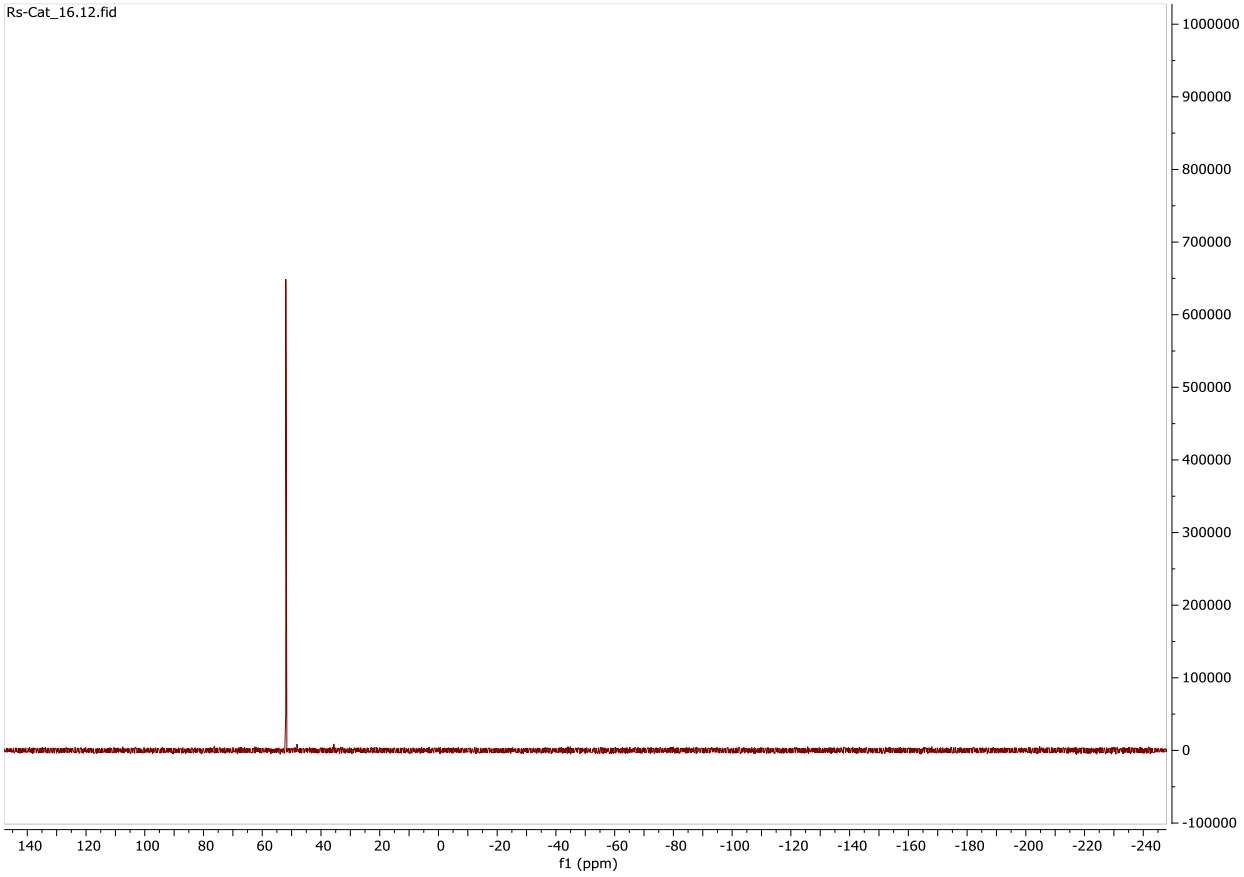
[Pd(allyl)(BrettPhos)]OTf **(Cat 16)**



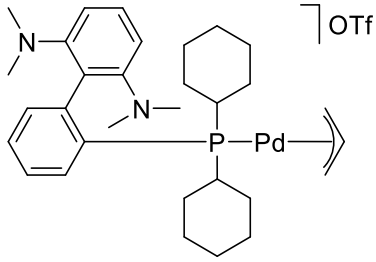
^{31}P NMR



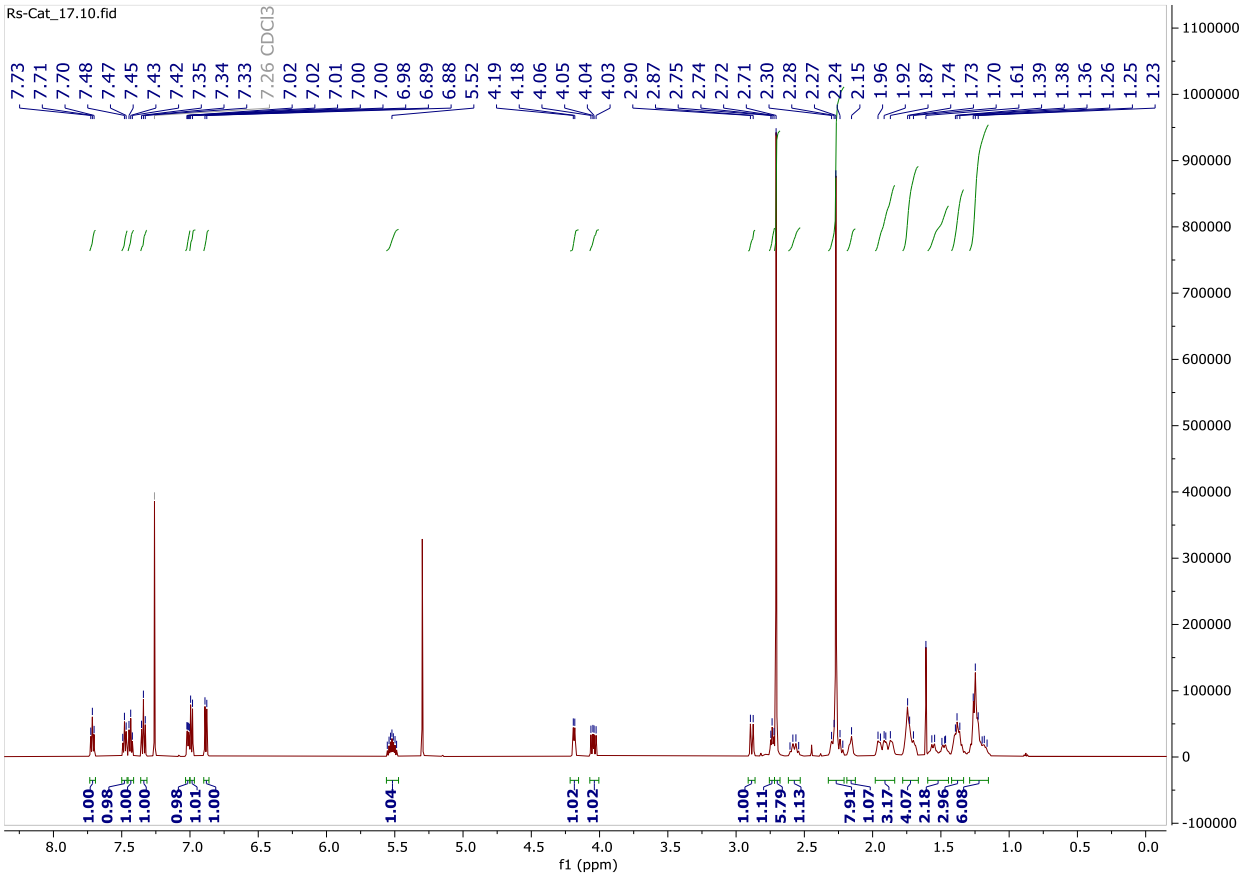
[Pd(allyl)(BrettPhos)]OTf **(Cat 16)**



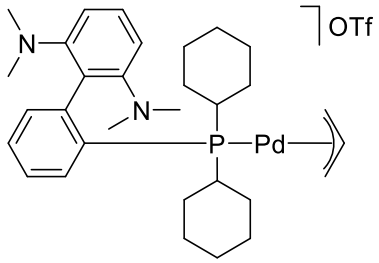
^{1}H NMR



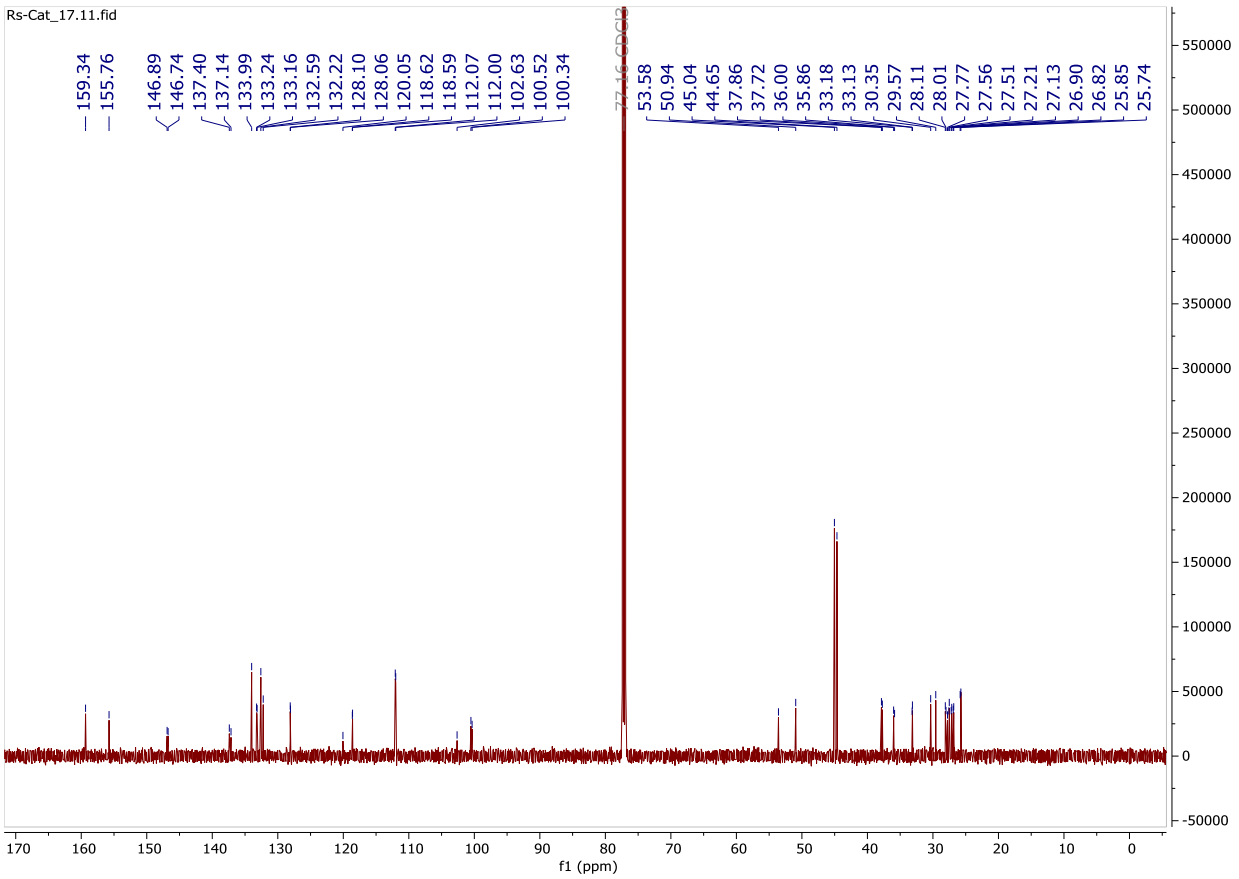
[Pd(allyl)(CPhos)]OTf (Cat-17)



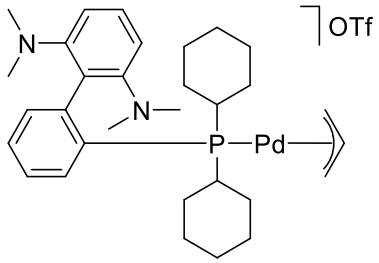
^{13}C NMR



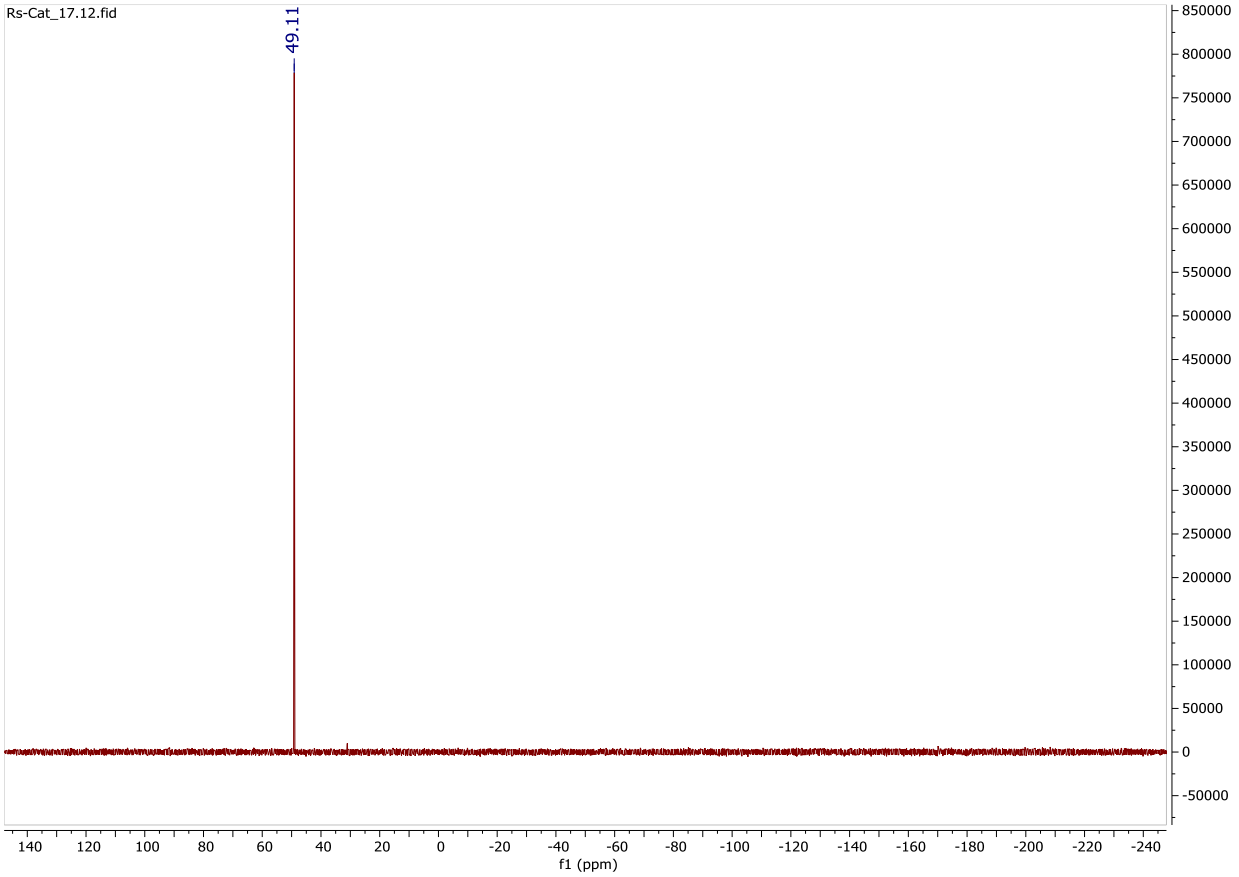
[Pd(allyl)(CPhos)]OTf (Cat-17)



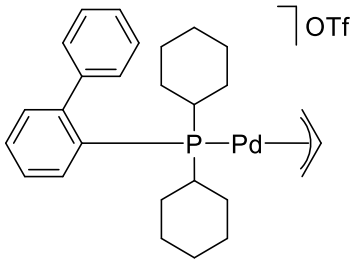
^{31}P NMR



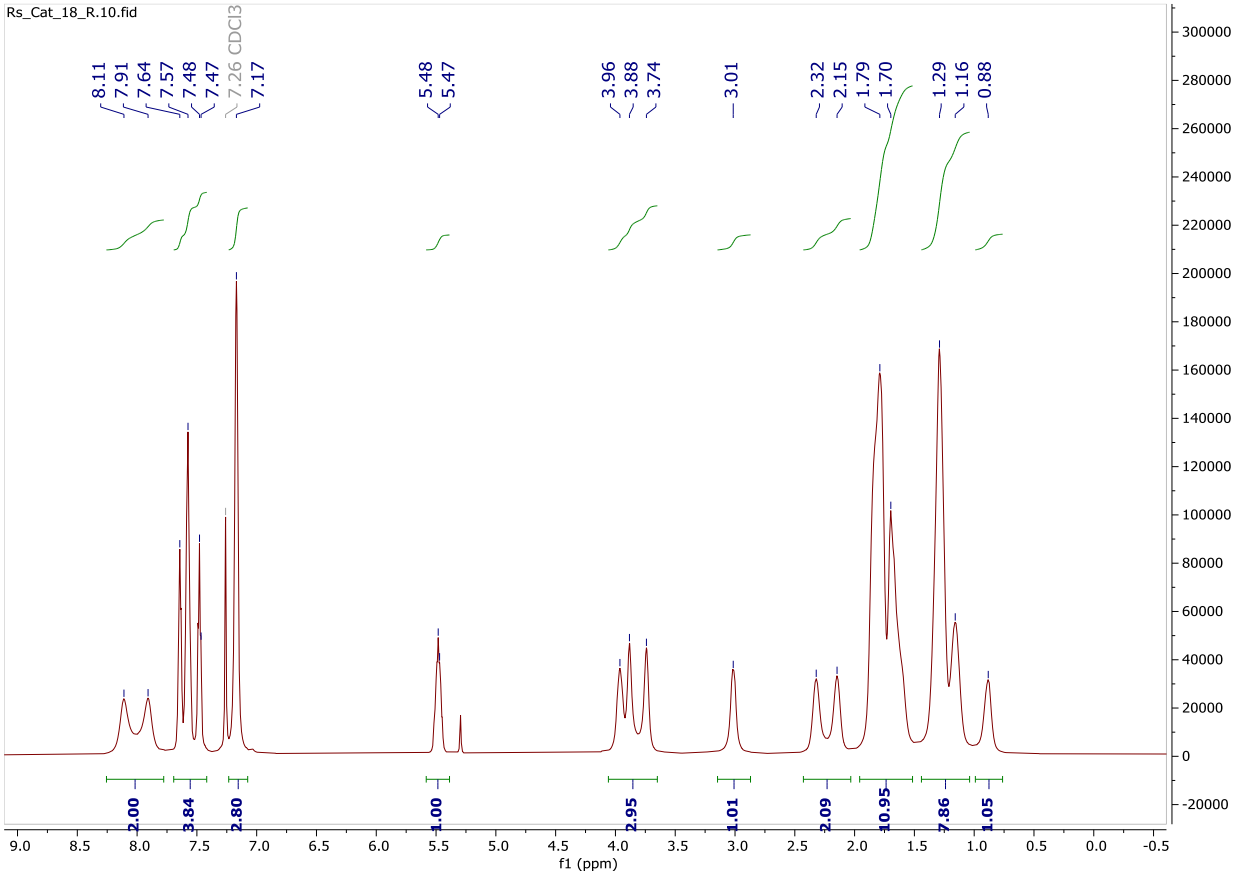
[Pd(allyl)(CPhos)]OTf (Cat-17)



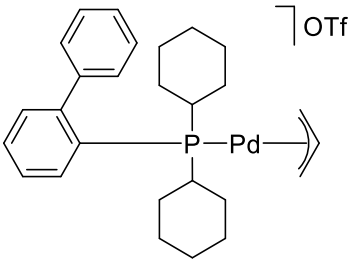
^{1}H NMR



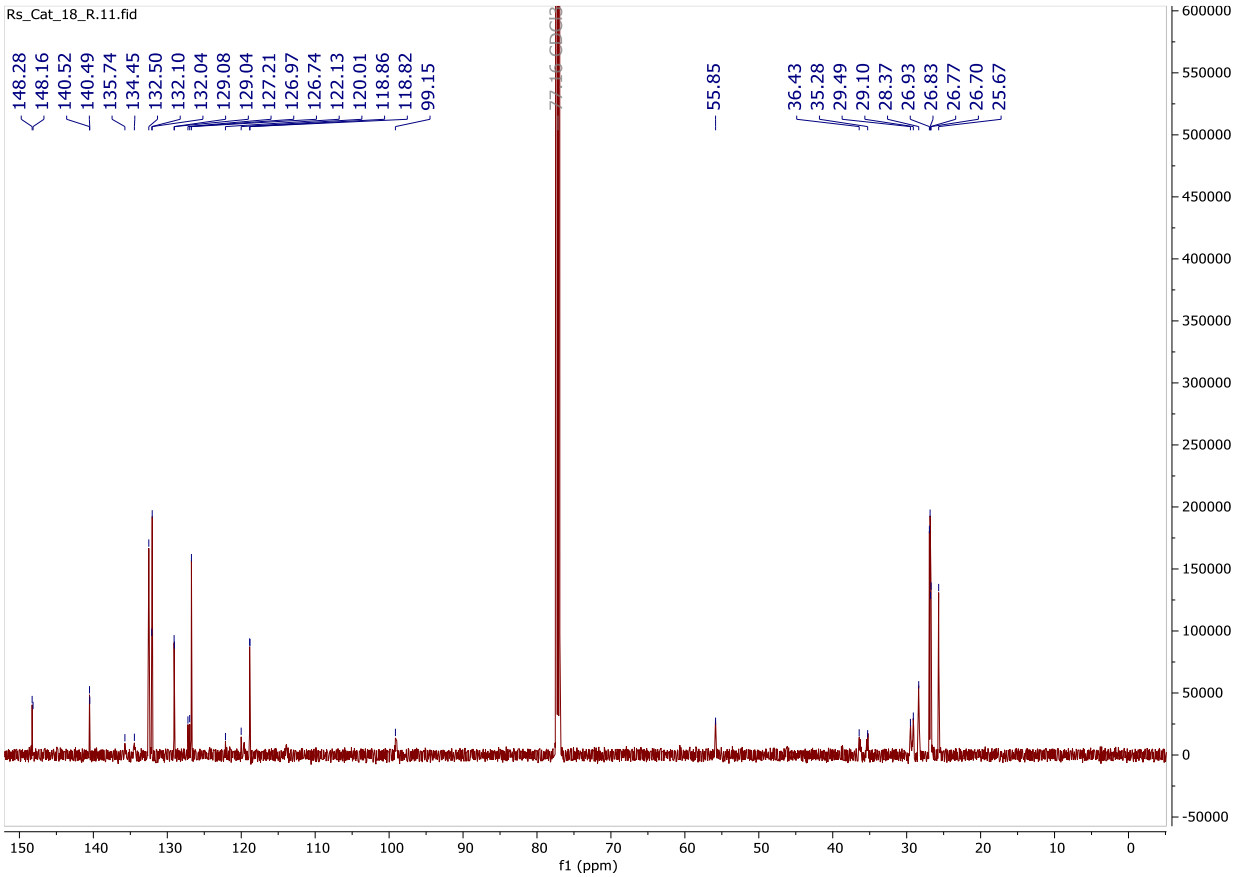
[Pd(allyl)(CyJohnPhos)]OTf (Cat-18)



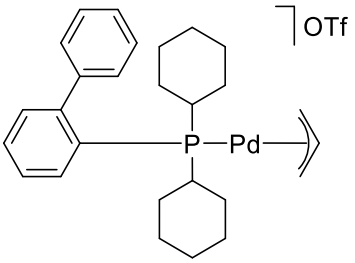
^{3}CNMR



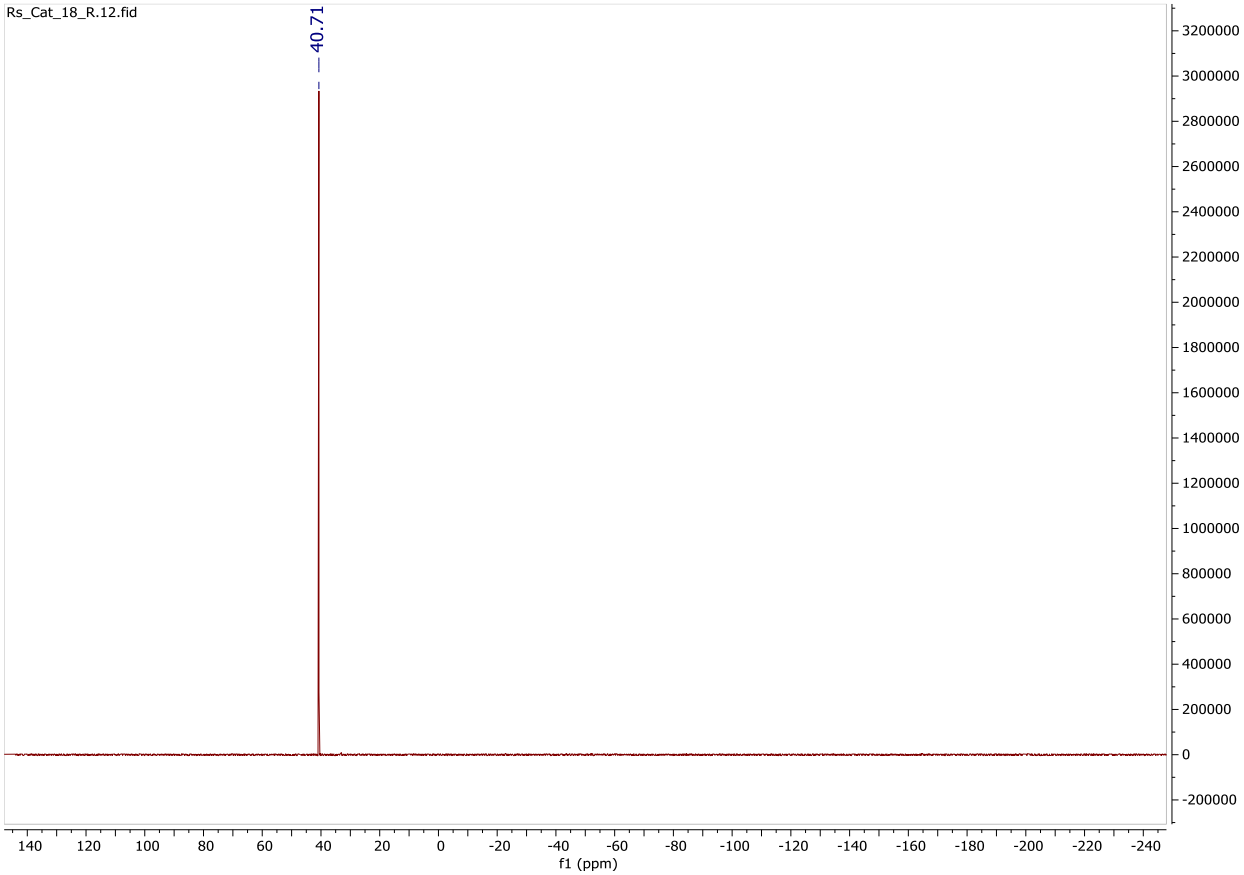
[Pd(allyl)(CyJohnPhos)]OTf (Cat-18)



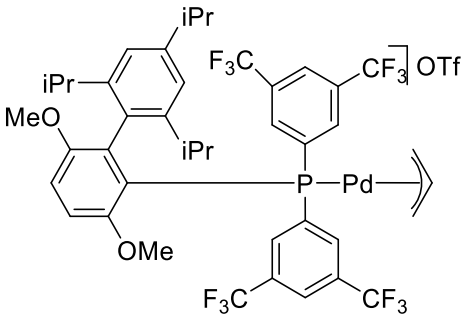
^{31}P NMR



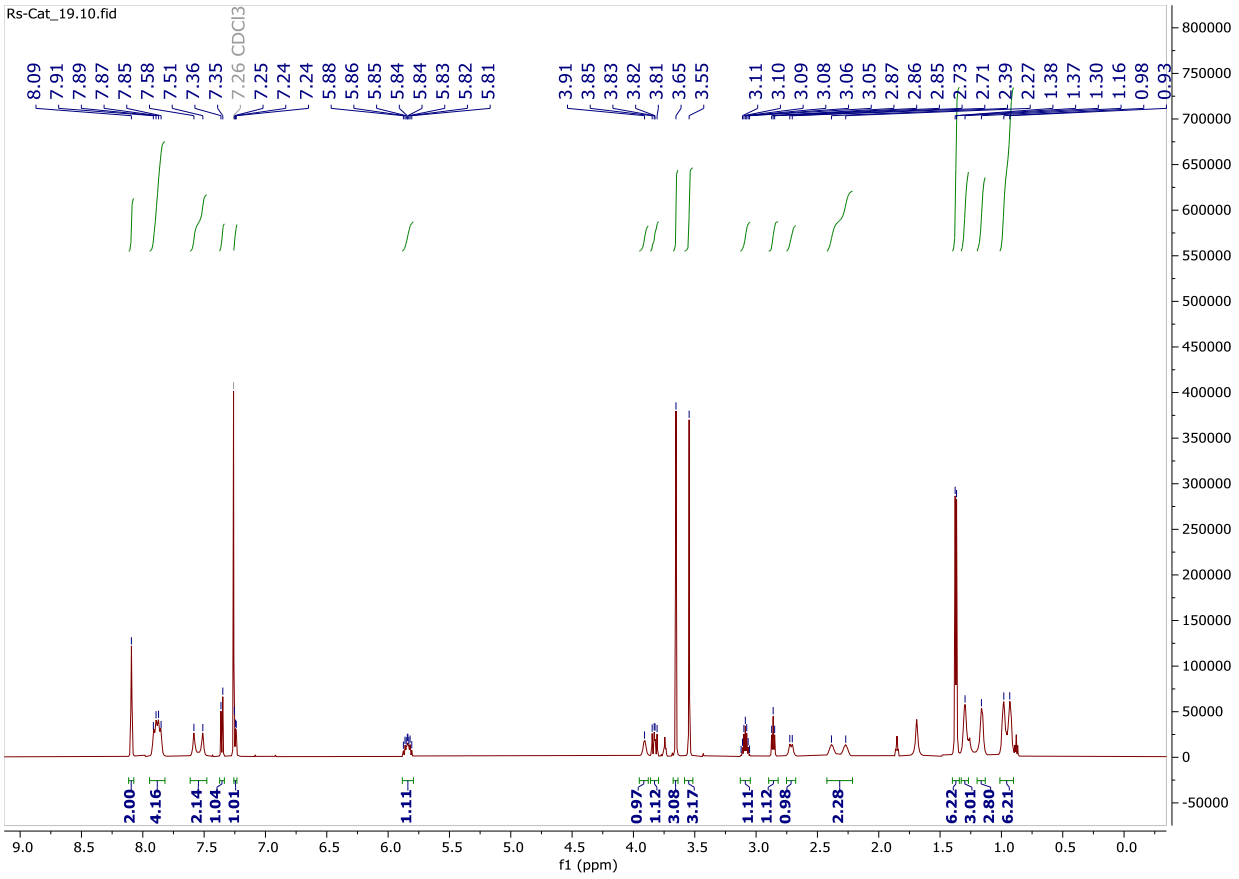
[Pd(allyl)(CyJohnPhos)]OTf (Cat-18)



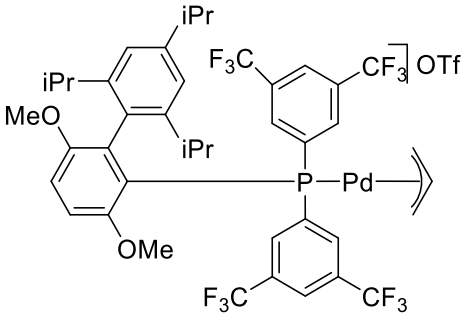
^{1}H NMR



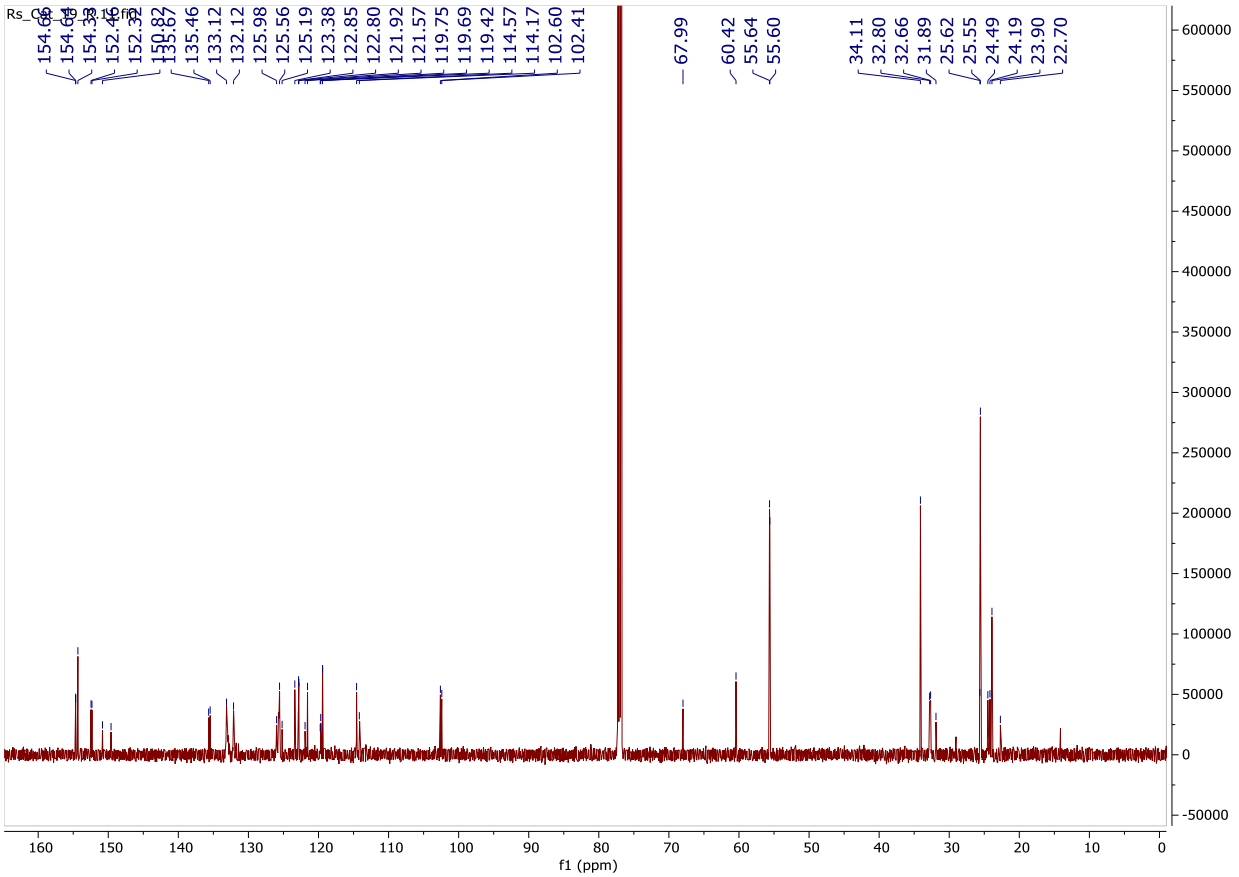
[Pd(allyl)(JackiPhos)]OTf (Cat 19)



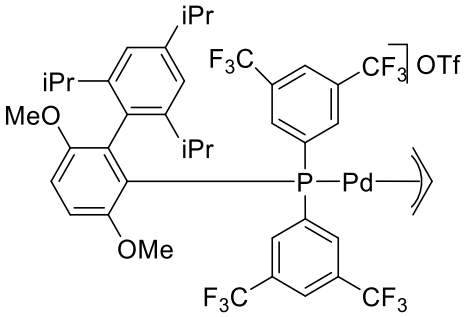
^{13}C NMR



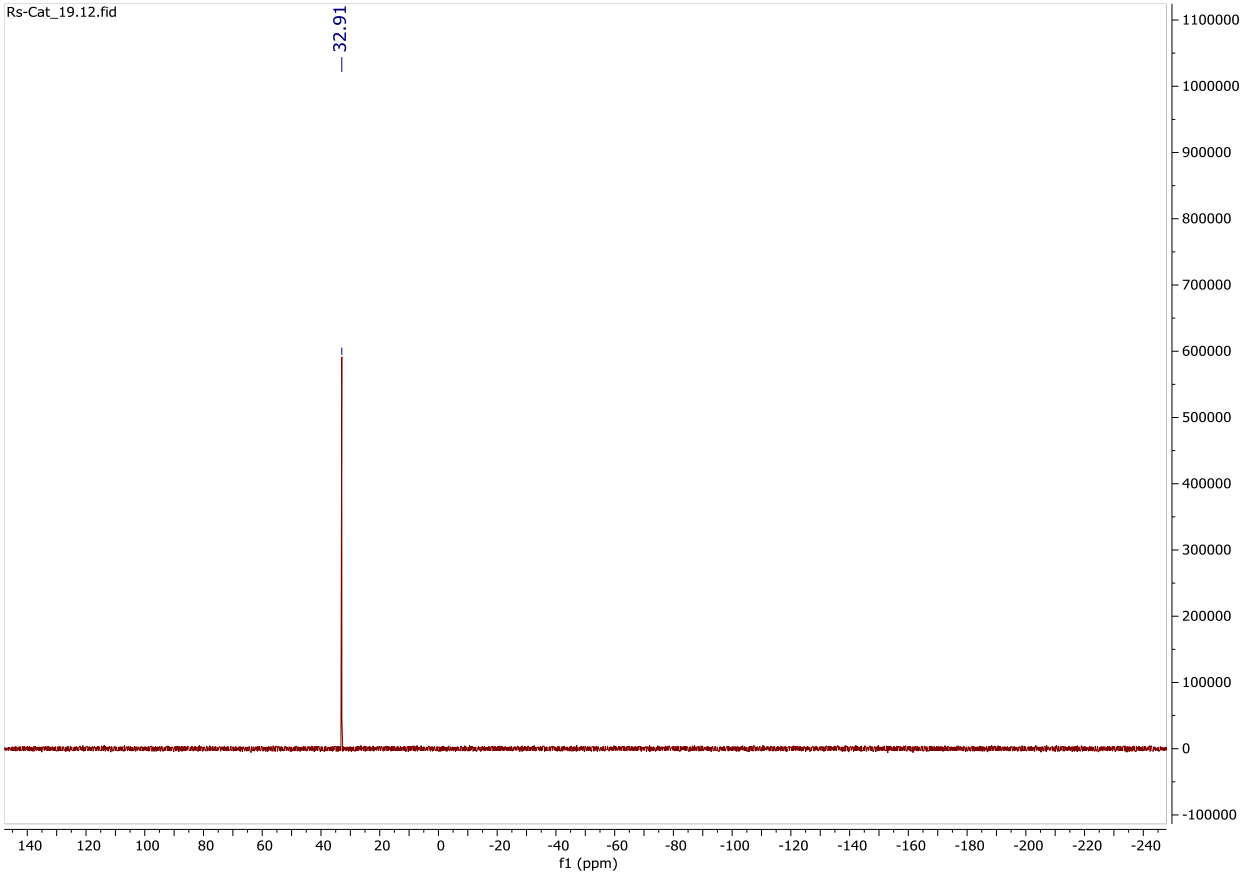
[Pd(allyl)(JackiPhos)]OTf (Cat 19)



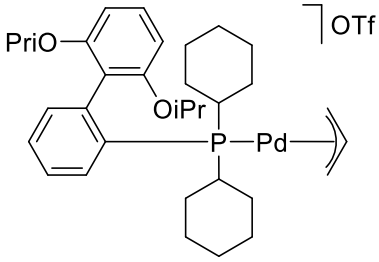
^{31}P NMR



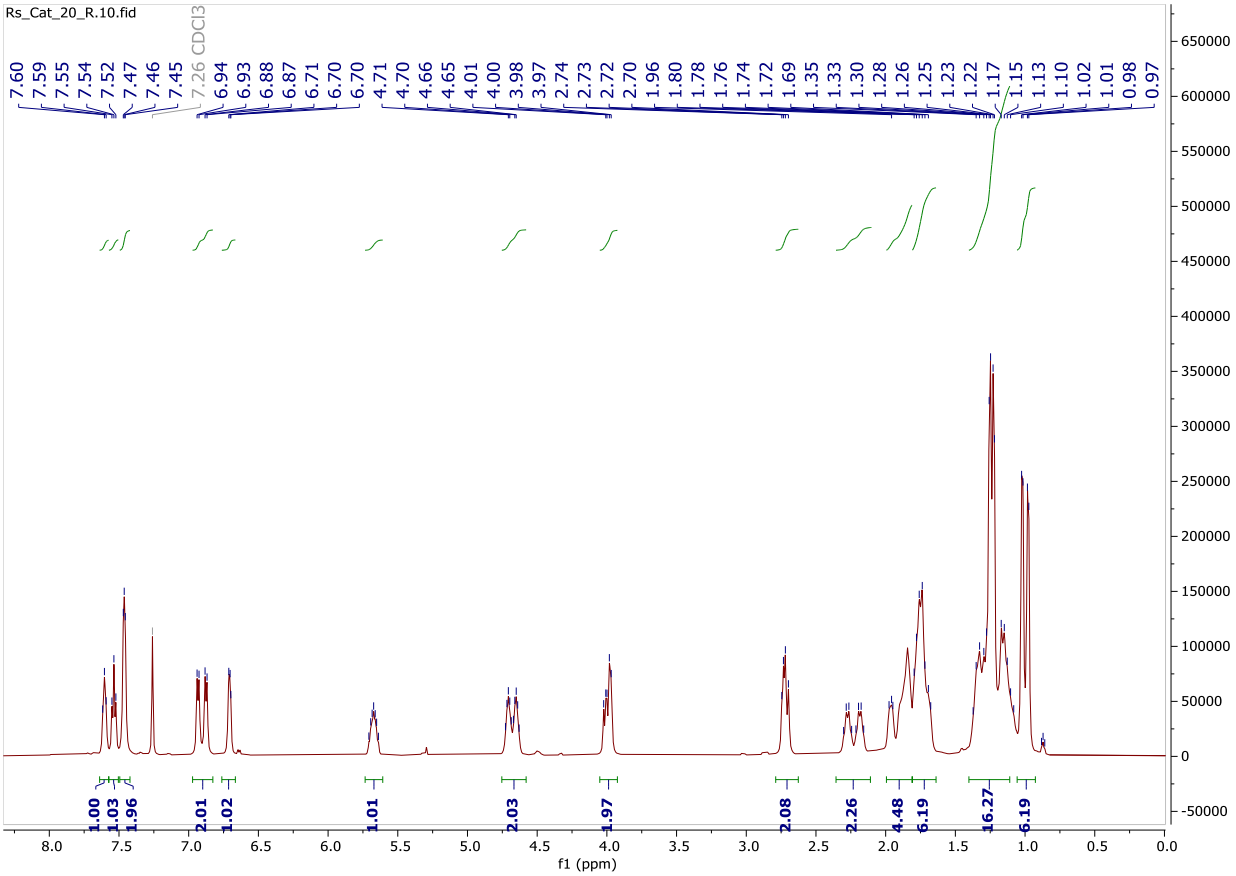
[Pd(allyl)(JackiPhos)]OTf (Cat 19)



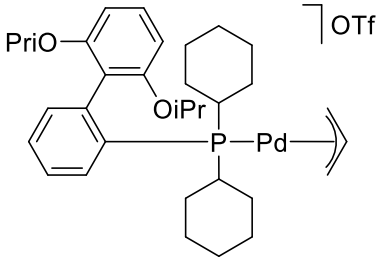
^{1}H NMR



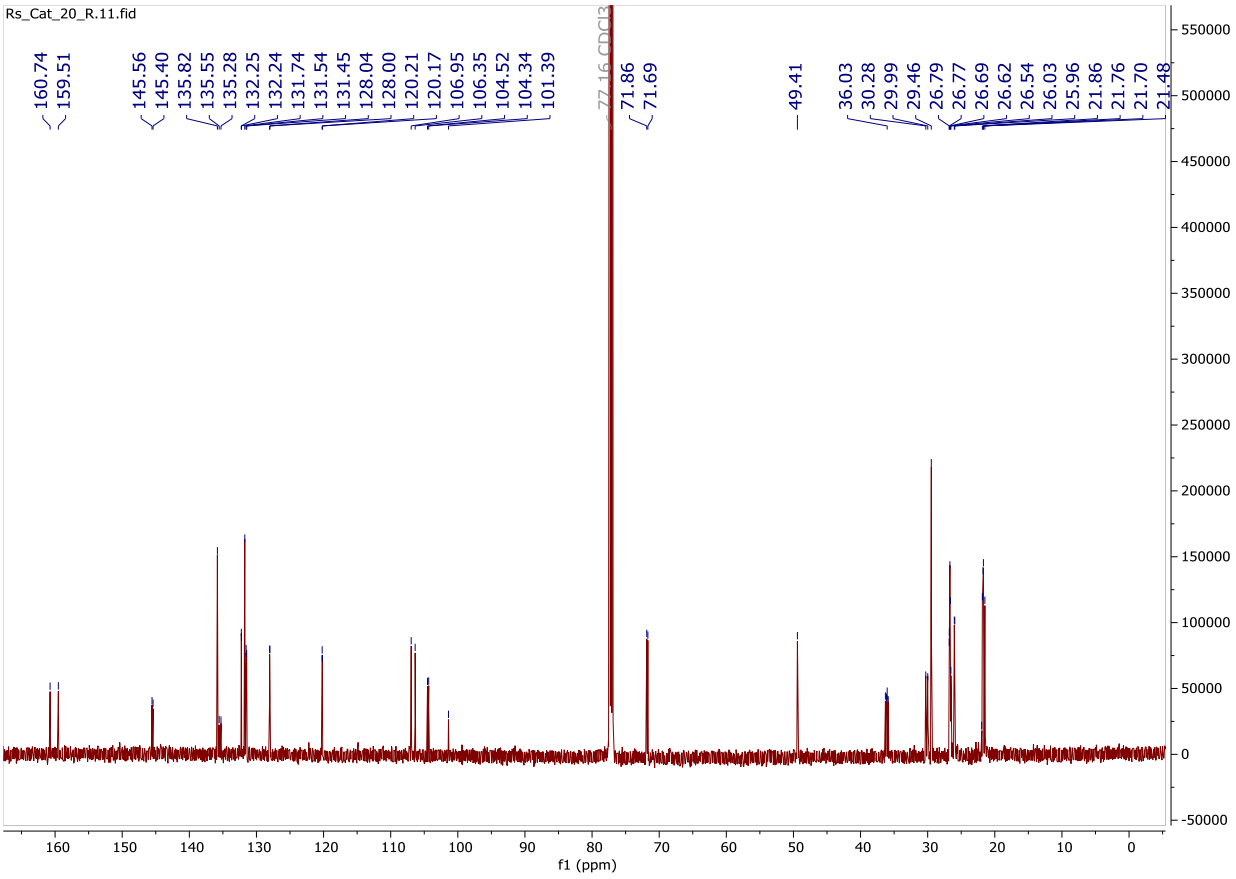
[Pd(allyl)(RuPhos)]OTf (Cat-20)



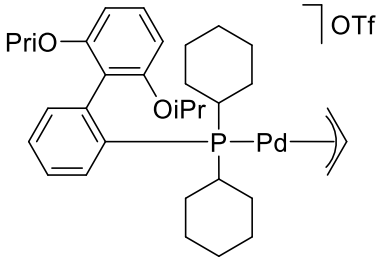
^{13}C NMR



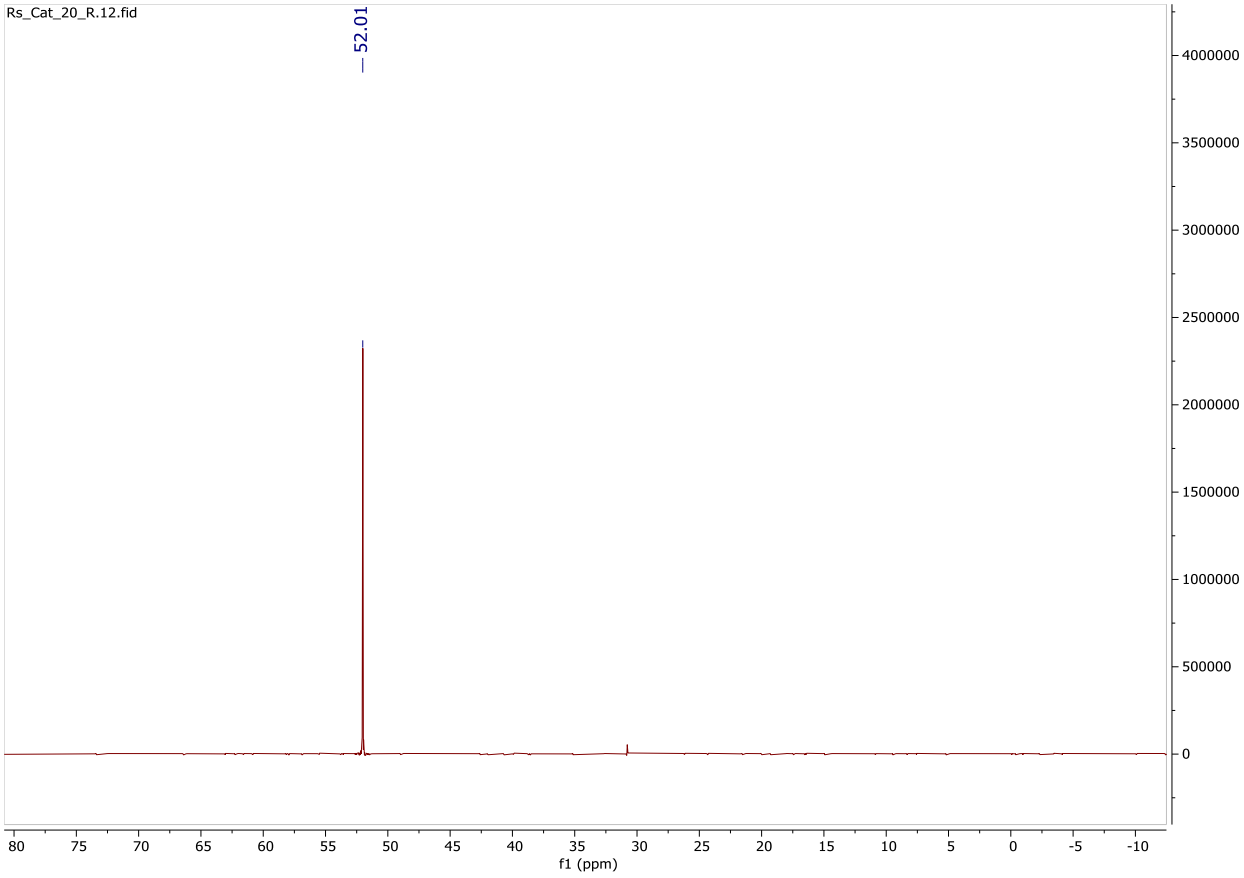
[Pd(allyl)(RuPhos)]OTf (Cat-20)



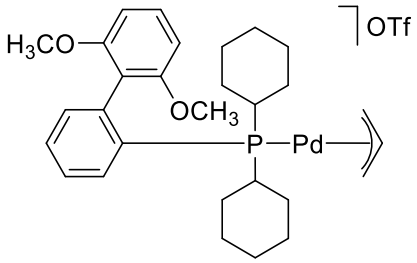
^{31}P NMR



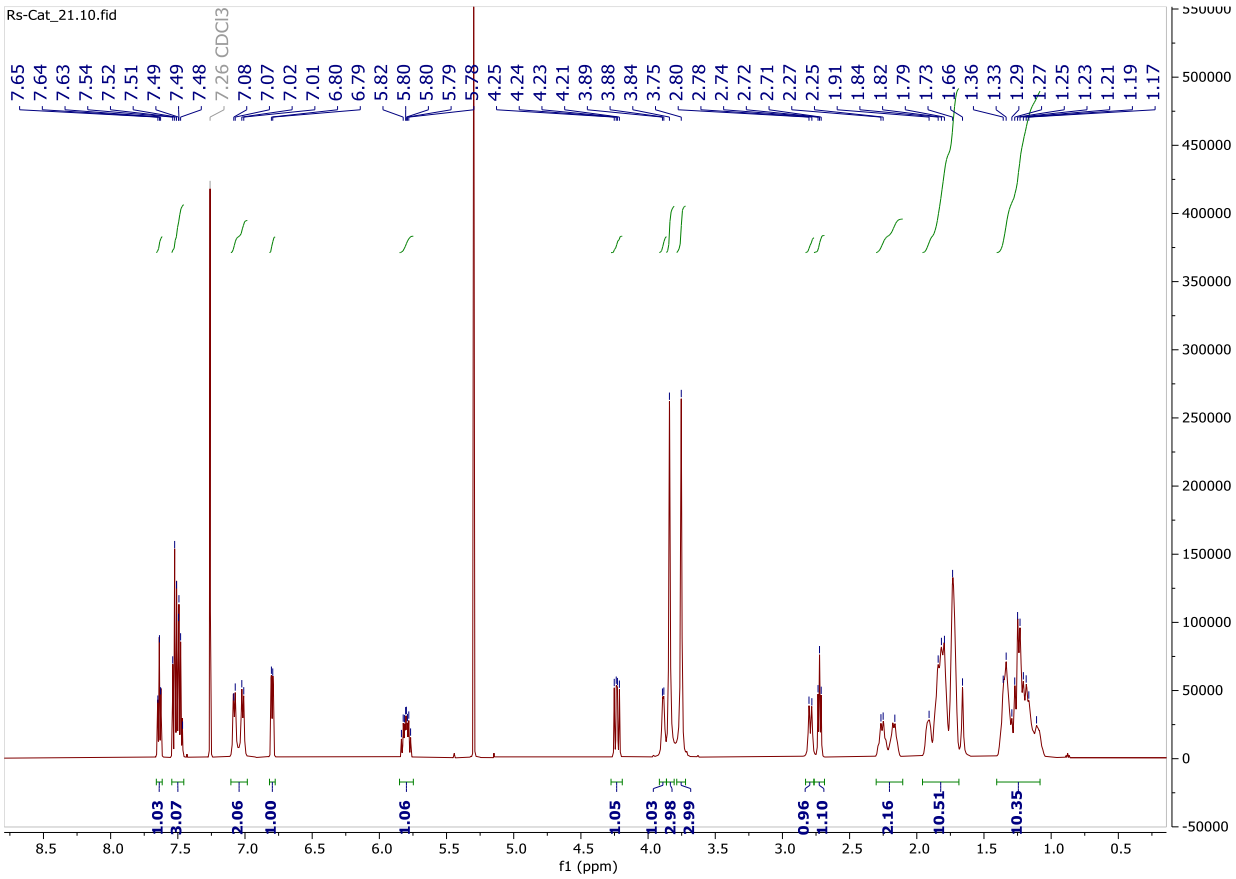
[Pd(allyl)(RuPhos)]OTf (Cat-20)



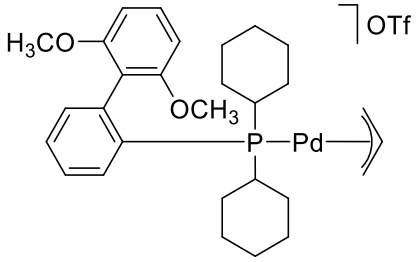
^{1}H NMR



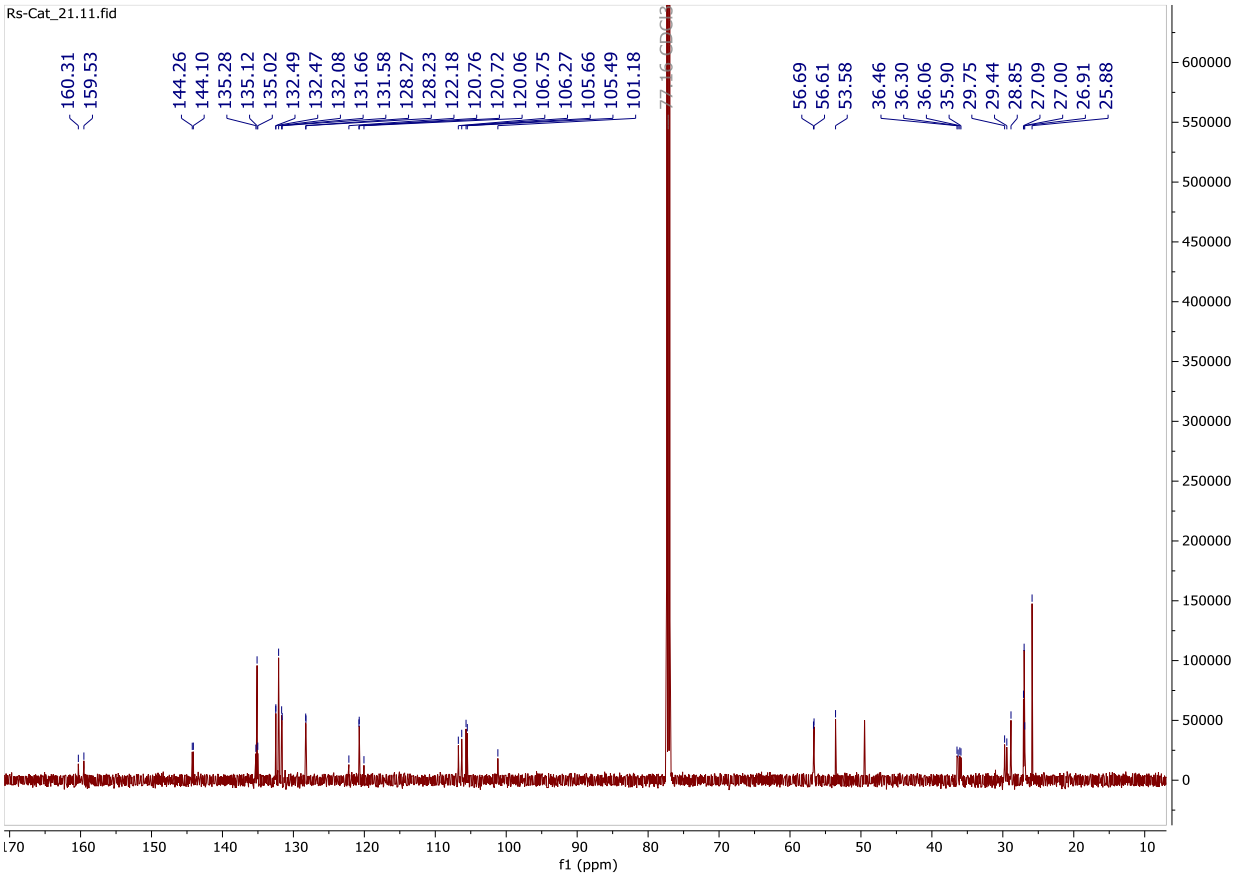
[Pd(allyl)(Sphos)]OTf (Cat 21)



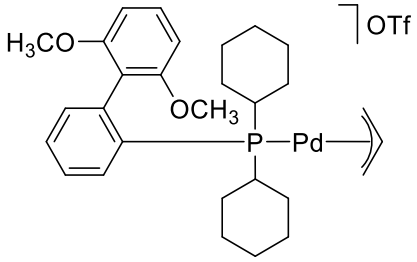
^{13}H NMR



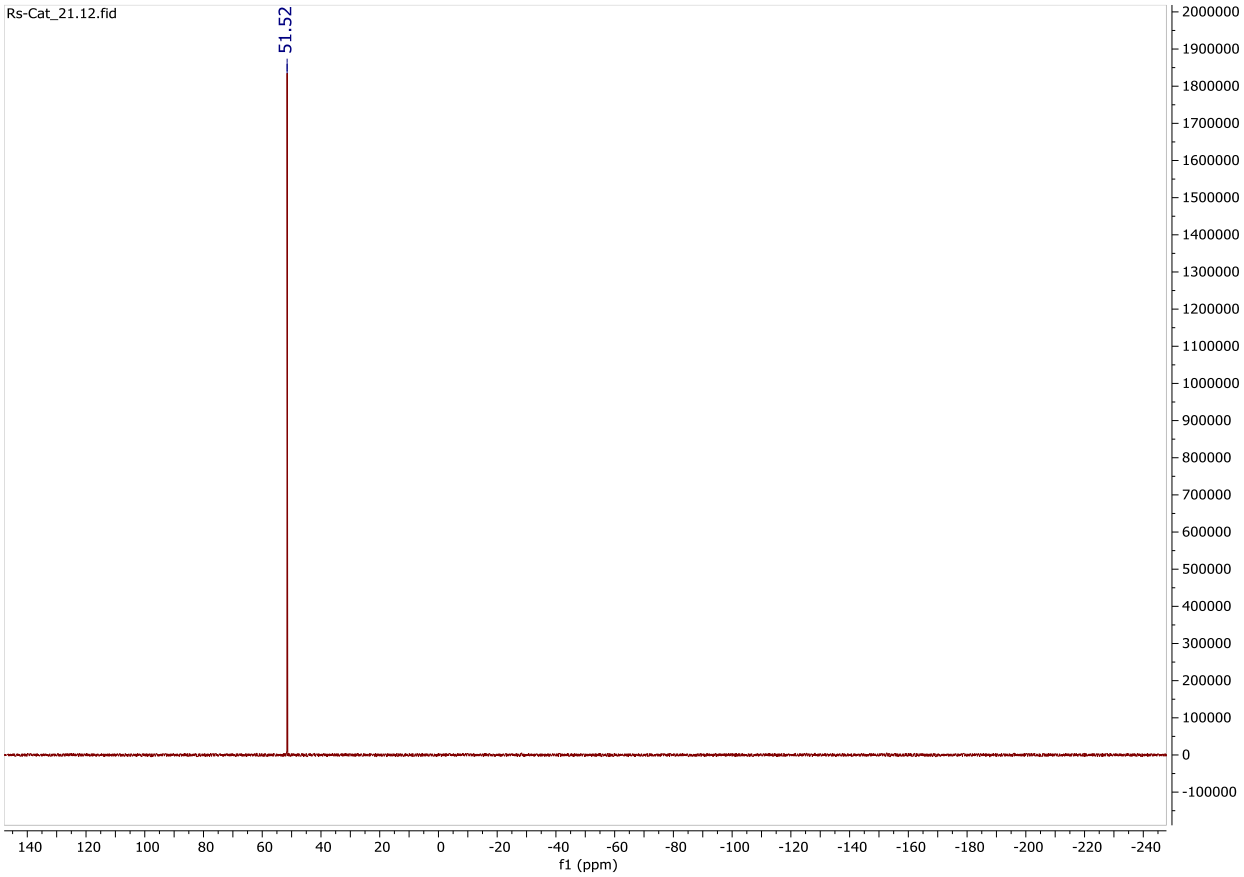
[Pd(allyl)(Sphos)]OTf (Cat 21)



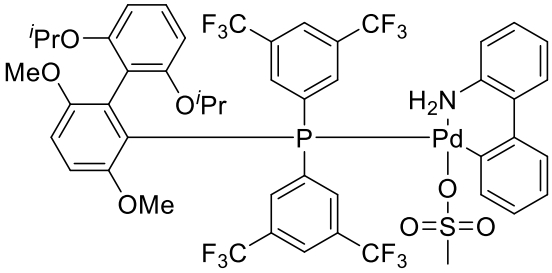
^{31}P NMR



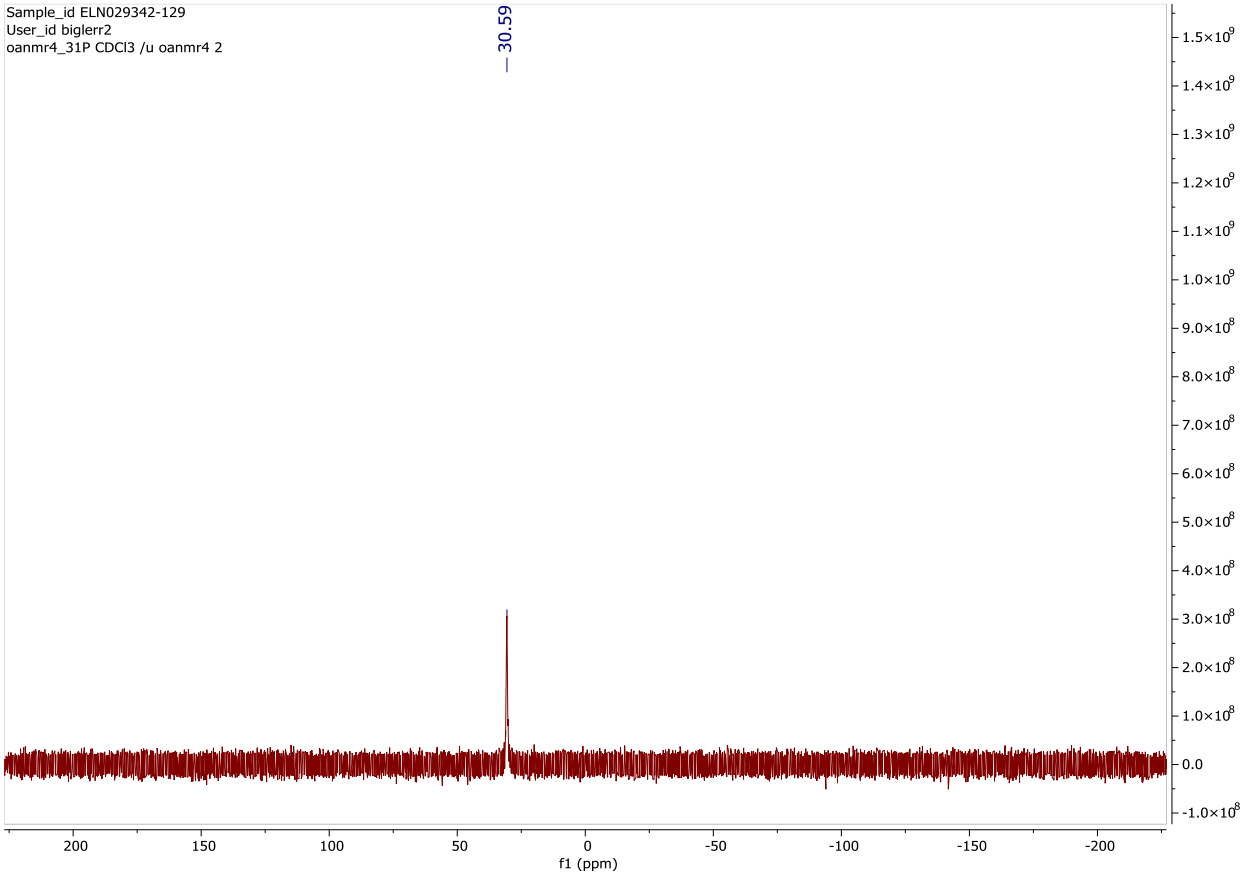
[Pd(allyl)(Sphos)]OTf (Cat 21)



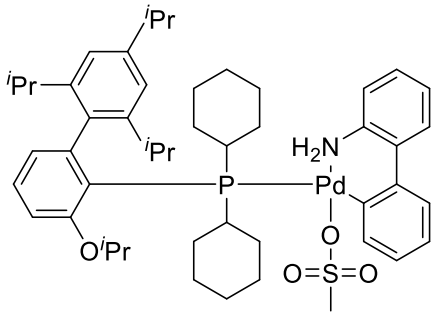
^{31}P NMR



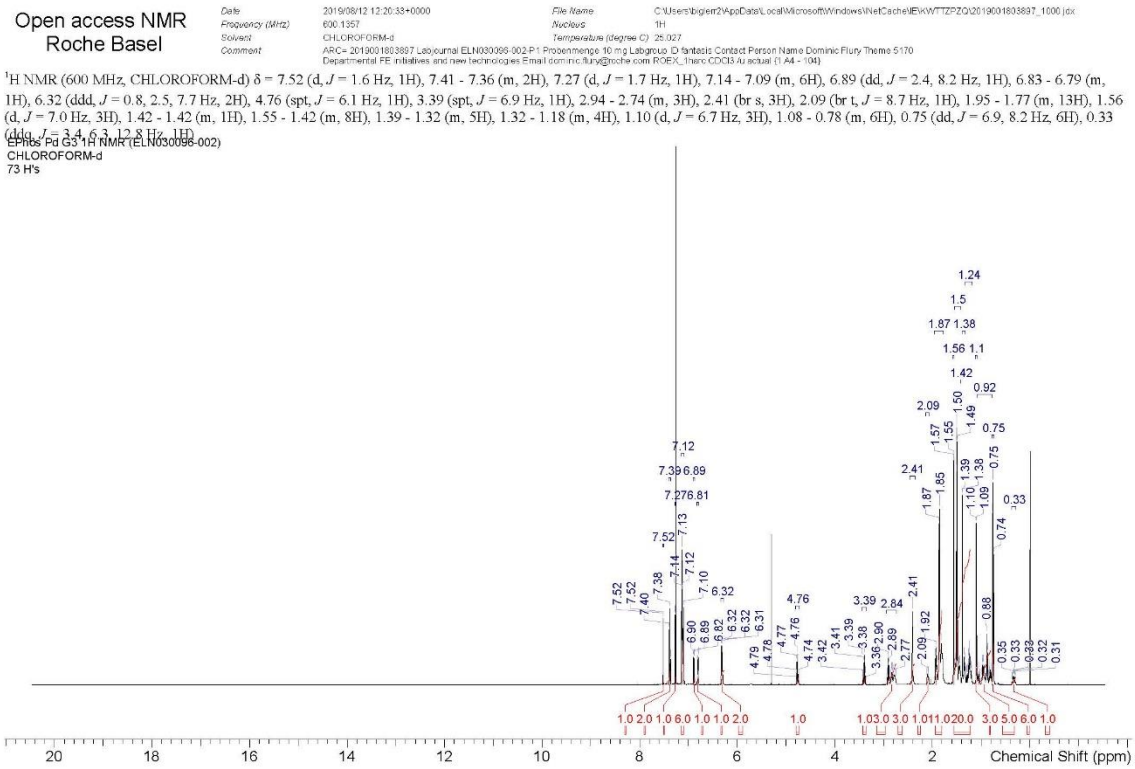
RuPhos-Hybrid Pd G3



^{1}H NMR

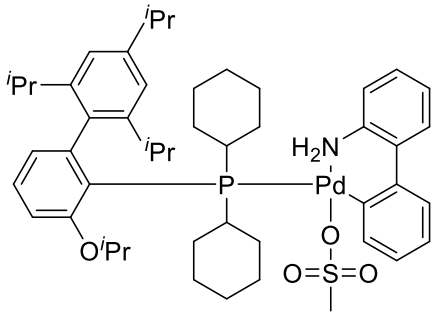


EPhos Pd G3

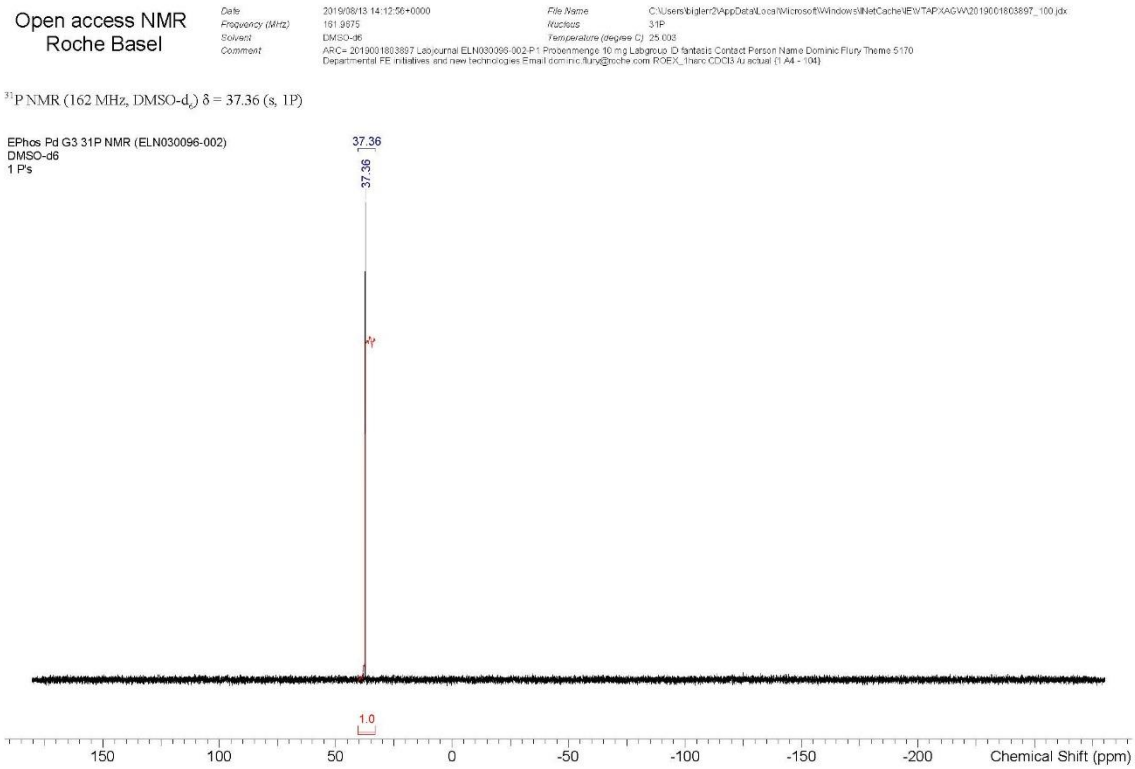


^{1}H NMR (600 MHz, CHLOROFORM-d) δ = 7.52 (d, *J* = 1.6 Hz, 1H), 7.41 - 7.36 (m, 2H), 7.27 (d, *J* = 1.7 Hz, 1H), 7.14 - 7.09 (m, 6H), 6.89 (dd, *J* = 2.4, 8.2 Hz, 1H), 6.83 - 6.79 (m, 1H), 6.32 (ddd, *J* = 0.8, 2.5, 7.7 Hz, 2H), 4.76 (spt, *J* = 6.1 Hz, 1H), 3.39 (spt, *J* = 6.9 Hz, 1H), 2.94 - 2.74 (m, 3H), 2.41 (br s, 3H), 2.09 (br t, *J* = 8.7 Hz, 1H), 1.95 - 1.77 (m, 13H), 1.56 (d, *J* = 7.0 Hz, 3H), 1.42 - 1.42 (m, 1H), 1.55 - 1.42 (m, 8H), 1.39 - 1.32 (m, 5H), 1.32 - 1.18 (m, 4H), 1.10 (d, *J* = 6.7 Hz, 3H), 1.08 - 0.78 (m, 6H), 0.75 (dd, *J* = 6.9, 8.2 Hz, 6H), 0.33 (ddq, *J* = 3.4, 6.3, 12.8 Hz, 1H).

^{31}P NMR

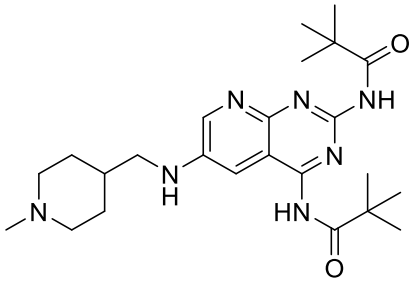


EPhos Pd G3

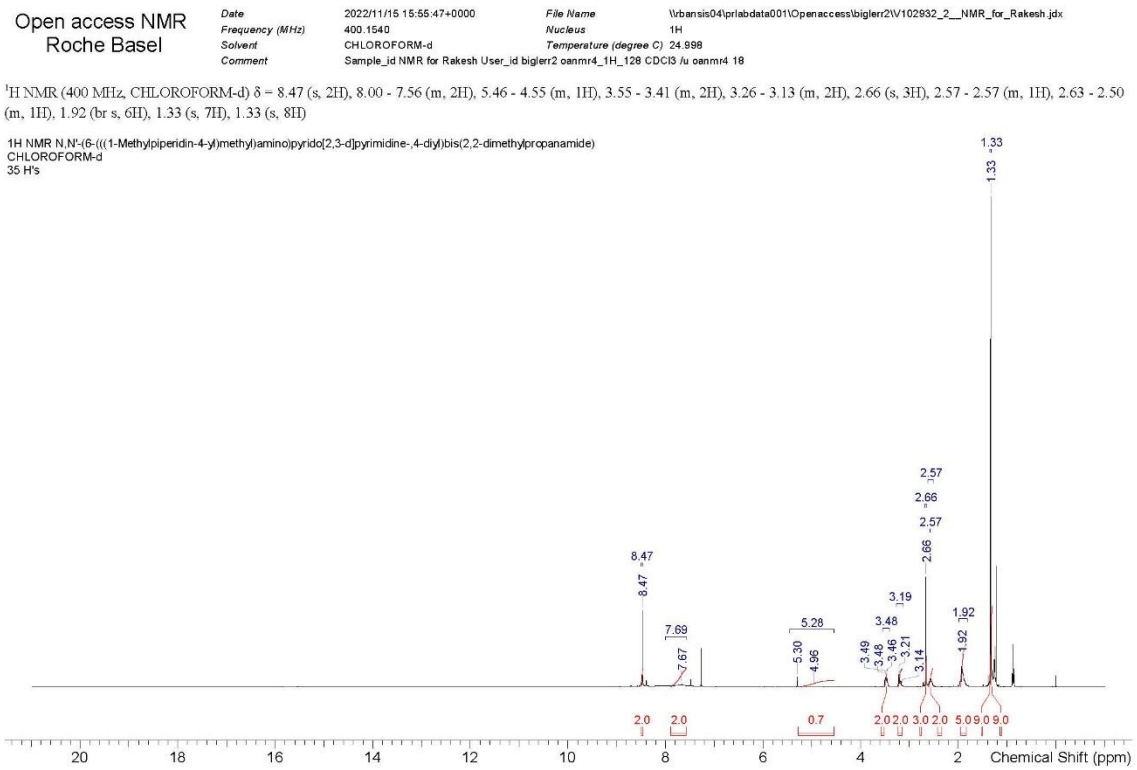


NMR Spectra for data set compounds

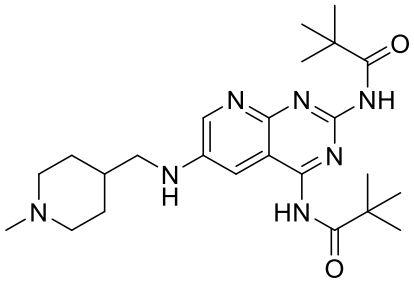
^{1}H NMR



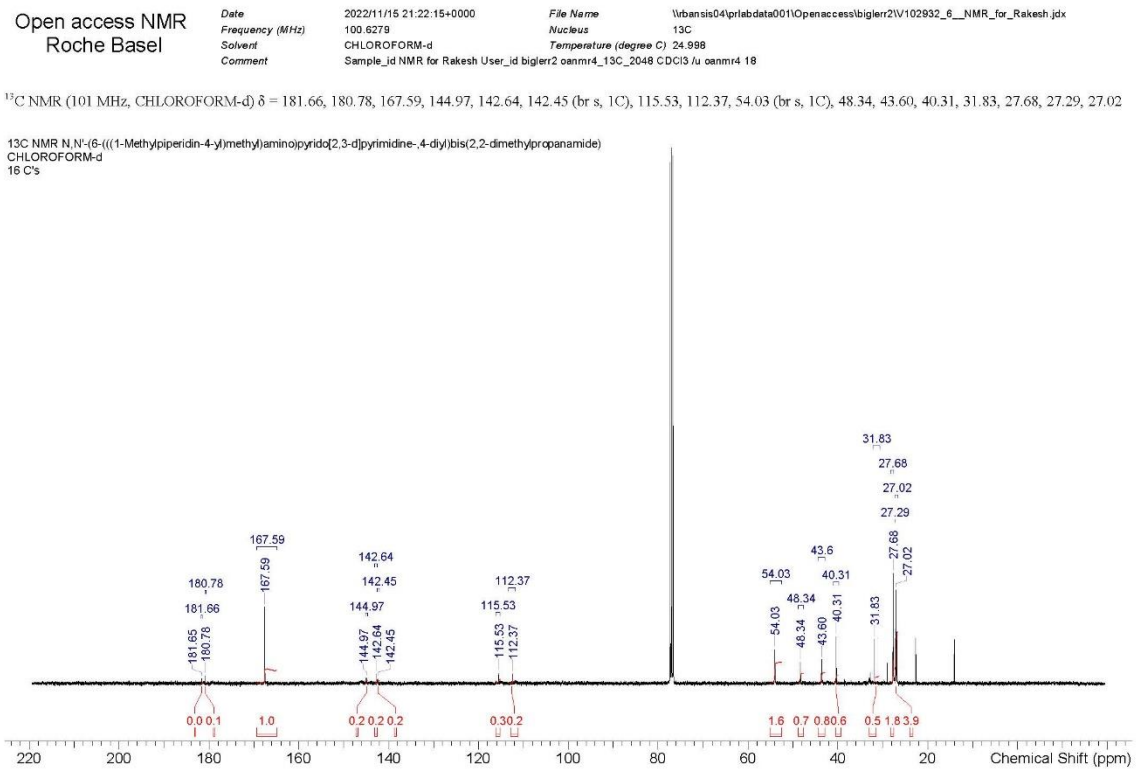
N,*N'*-(6-(((1-Methylpiperidin-4-yl)methyl)amino)pyrido[2,3-*d*]pyrimidine-2,4-diyl)bis(2,2-dimethylpro-panamide) **(32_25)**



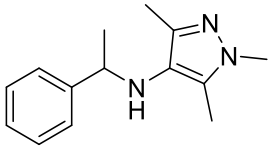
$^{13}C\{^{1}H\}$ NMR



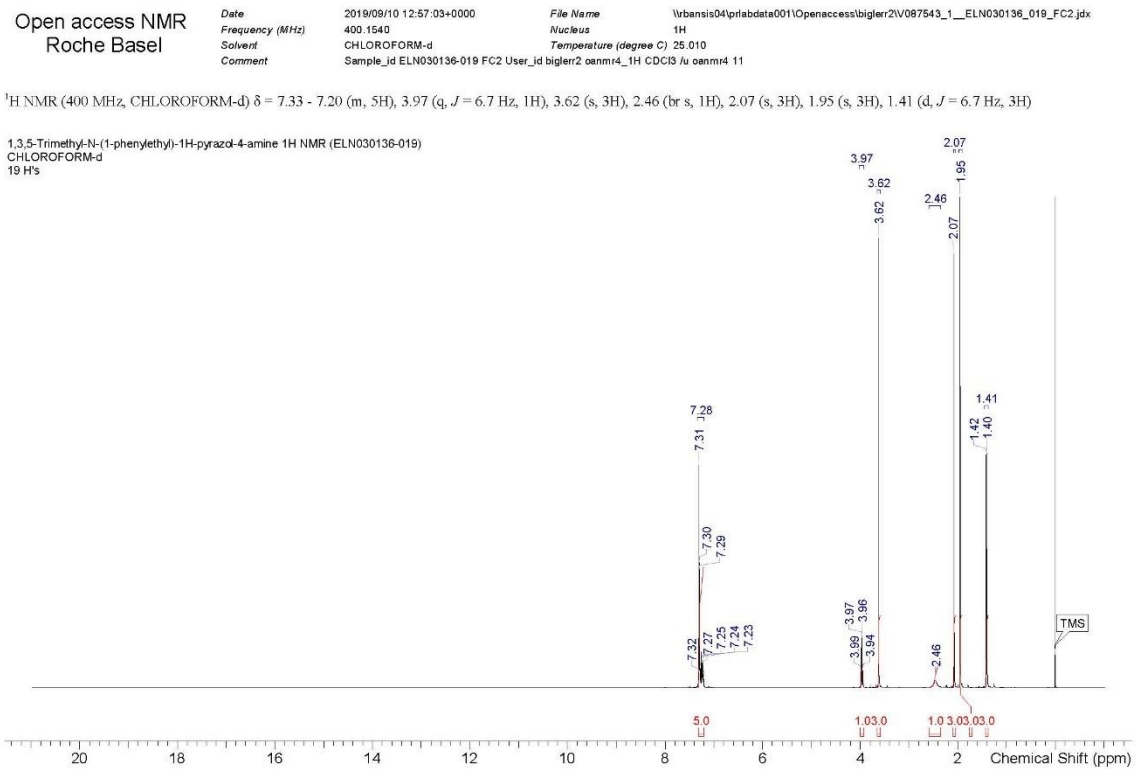
N,*N*'-(6-(((1-Methylpiperidin-4-yl)methyl)amino)pyrido[2,3-*d*]pyrimidine-2,4-diyl)bis(2,2-dimethylpro-panamide) **(32_25)**



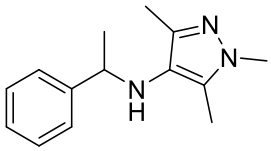
^{1}H NMR



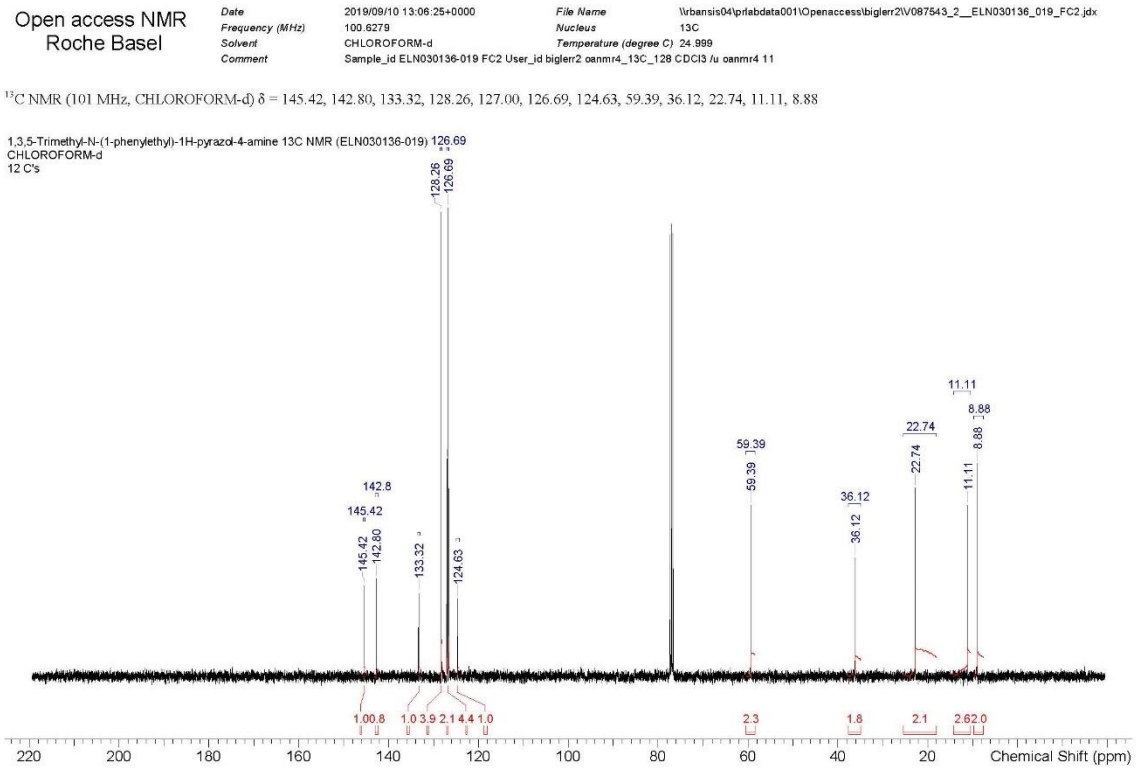
1,3,5-Trimethyl-*N*-(1-phenylethyl)-1H-pyrazol-4-amine (34_9)



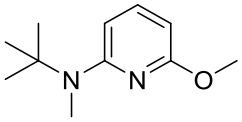
$^{13}C\{^{1}H\}$ NMR



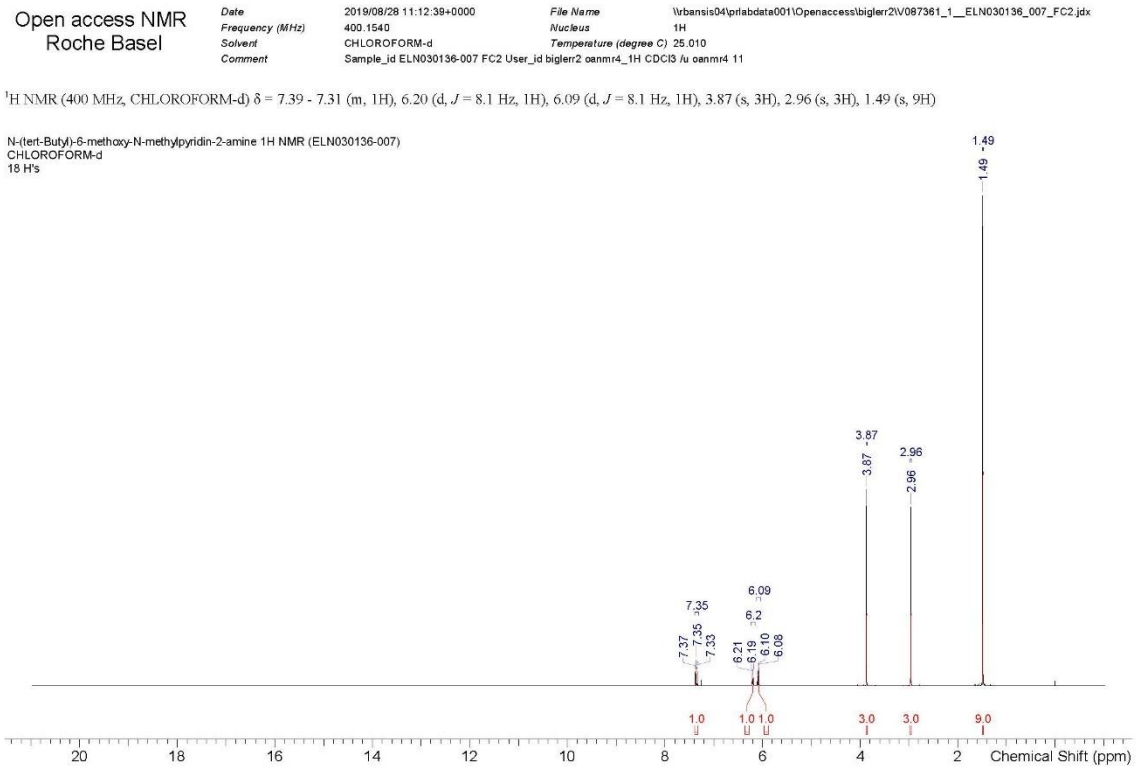
1,3,5-Trimethyl-*N*-(1-phenylethyl)-1H-pyrazol-4-amine (34_9)



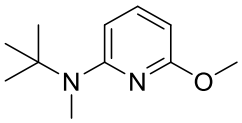
^{1}H NMR



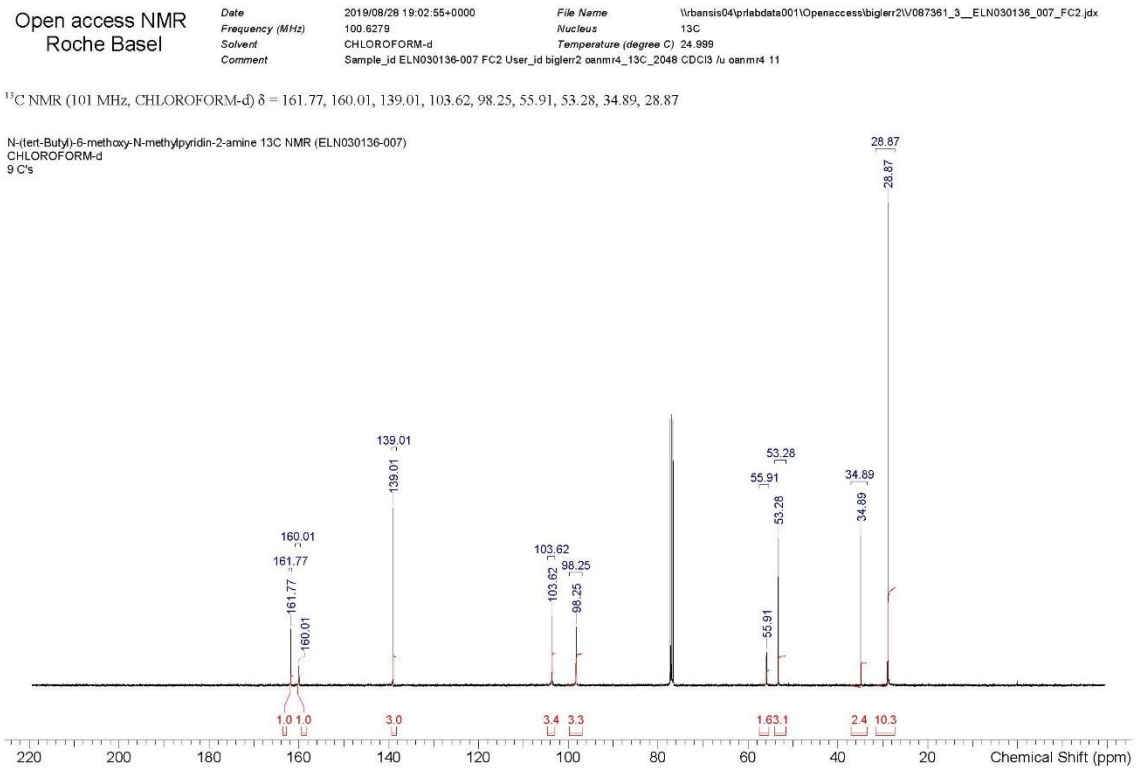
N-(*tert*-Butyl)-6-methoxy-*N*-methylpyridin-2-amine **(50_41)**



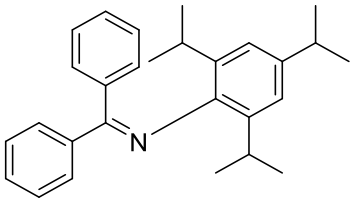
$^{13}C\{^{1}H\}$ NMR



N-(*tert*-Butyl)-6-methoxy-*N*-methylpyridin-2-amine **(50_41)**



^{1}H NMR

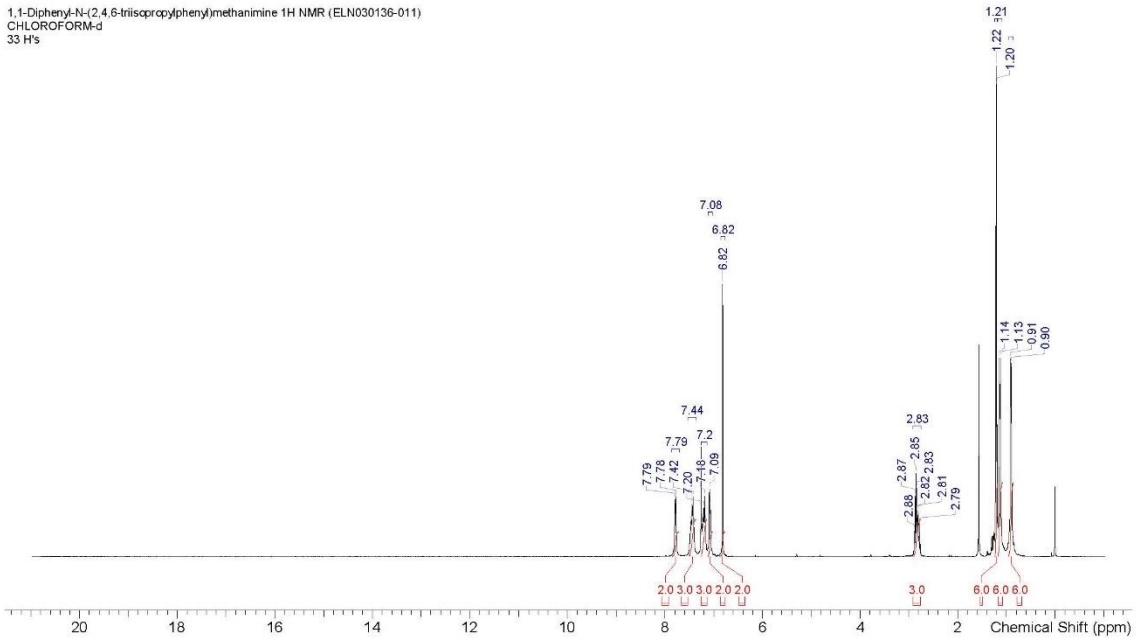


1,1-Diphenyl-*N*-(2,4,6-triisopropylphenyl)methanimine **(23_1)**

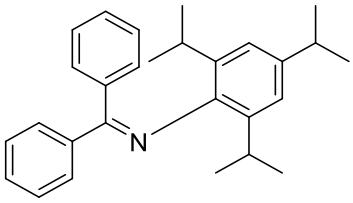
Open access NMR
Roche Basel

Date	2019/09/02 15:45:27+0000	*File Name*	\\rbansis04\prlabdata001\Openaccess\biglerr2\V087428_1__ELN030136_011_FC.jdx
Frequency (MHz)	400.1540	*Nucleus*	1H
Solvent	CHLOROFORM-d	*Temperature (degree C)*	25.000
Comment	Sample_id ELN030136-011 FC User_id biglerr2 oanmr4_1H CDCl3 /u oanmr4 11		

^{1}H NMR (400 MHz, CHLOROFORM-d) δ = 7.79 (br d, *J* = 7.0 Hz, 2H), 7.44 (td, *J* = 7.0, 14.3 Hz, 3H), 7.20 (td, *J* = 6.9, 13.9 Hz, 3H), 7.08 (br d, *J* = 7.0 Hz, 2H), 6.82 (s, 2H), 2.92 - 2.75 (m, 3H), 1.21 (d, *J* = 7.0 Hz, 6H), 1.13 (br d, *J* = 6.4 Hz, 6H), 0.91 (br d, *J* = 6.7 Hz, 6H)



$^{13}C\{^{1}H\}$ NMR



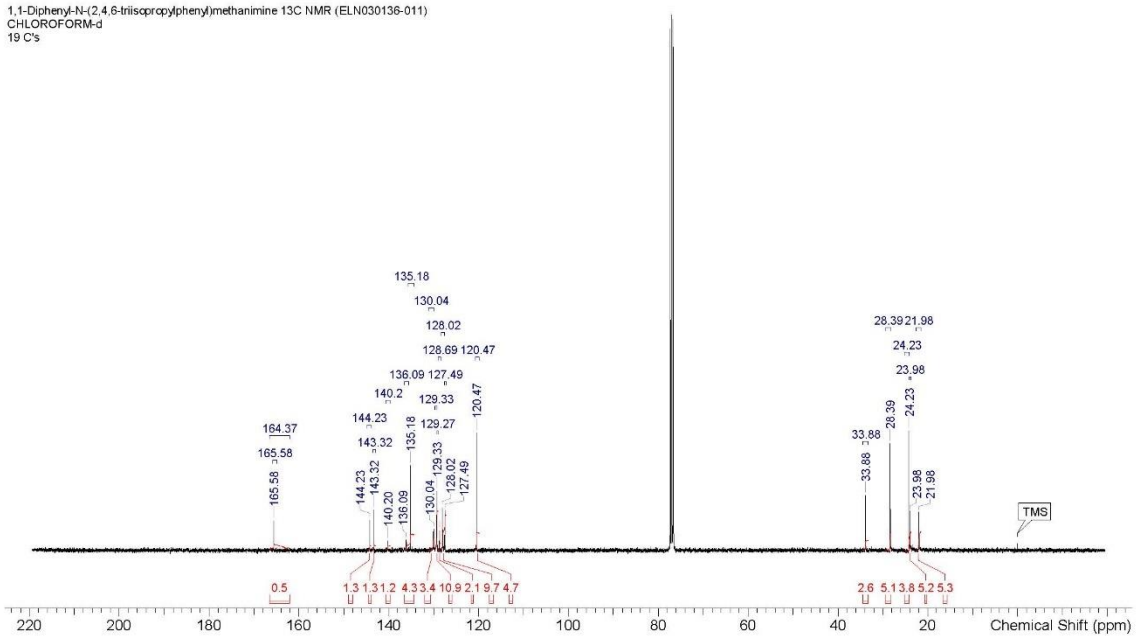
1,1-Diphenyl-*N*-(2,4,6-triisopropylphenyl)methanimine **(23_1)**

Open access NMR
Roche Basel

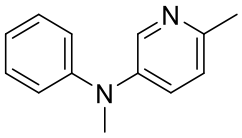
Date	2019/09/02 19:02:10+0000	*File Name*	\\rbansis04\prlabdata001\Openaccess\biglerr2\V087428_3__ELN030136_011_FC.jdx
Frequency (MHz)	100.6279	*Nucleus*	13C
Solvent	CHLOROFORM-d	*Temperature (degree C)*	25.001
Comment	Sample_id ELN030136-011 FC User_id biglerr2 oanmr4_13C_2048 CDCl3 /u oanmr4 11		

^{13}C NMR (101 MHz, CHLOROFORM-d) δ = 165.58, 166.64 - 162.10 (m, 1C), 144.23, 143.32, 140.20, 136.09, 135.18, 130.04, 129.33 (br s, 1C), 129.27 (br s, 1C), 128.69, 128.02, 127.49, 120.47, 33.88, 28.39, 24.23, 23.98 (br s, 1C), 21.98 (br s, 1C)

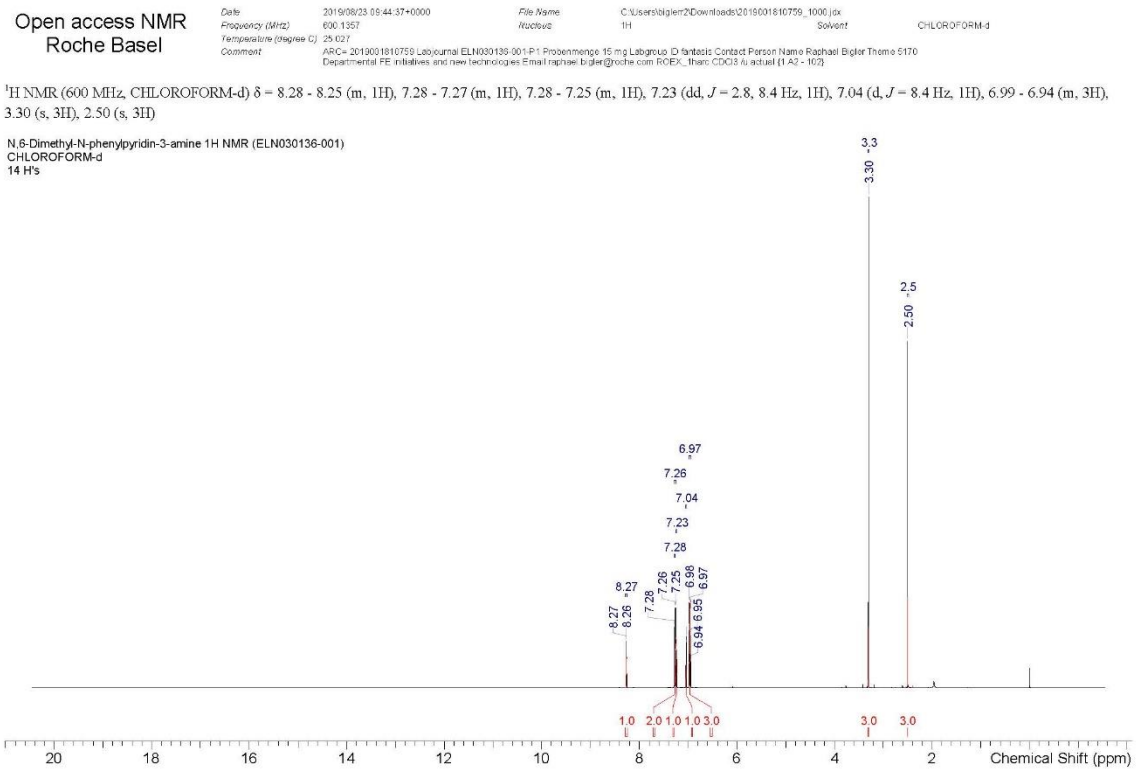
1,1-Diphenyl-N-(2,4,6-triisopropylphenyl)methanimine 13C NMR (ELN030136-011)
CHLOROFORM-d
19 C's



^{1}H NMR

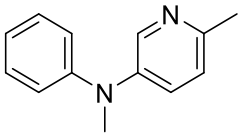


N,6-Dimethyl-*N*-phenylpyridin-3-amine **(6_18)**

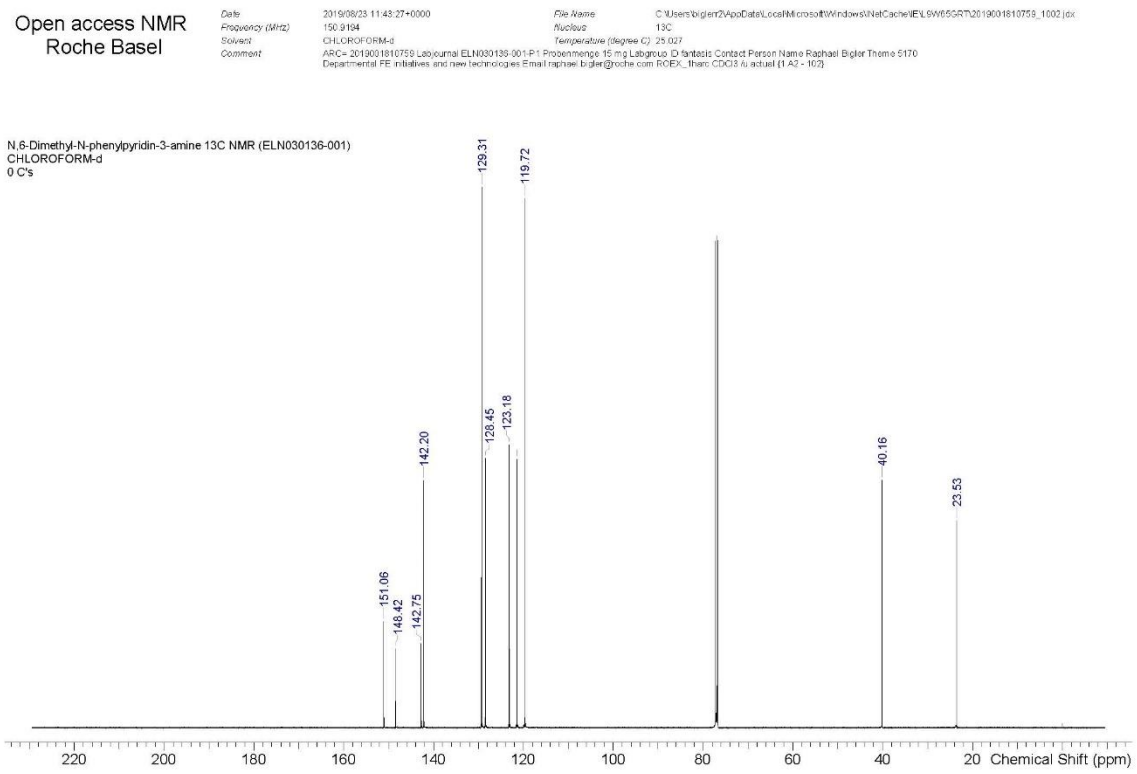


^{1}H NMR (600 MHz, CHLOROFORM-d) δ = 8.28 - 8.25 (m, 1H), 7.28 - 7.27 (m, 1H), 7.28 - 7.25 (m, 1H), 7.23 (dd, *J* = 2.8, 8.4 Hz, 1H), 7.04 (d, *J* = 8.4 Hz, 1H), 6.99 - 6.94 (m, 3H), 3.30 (s, 3H), 2.50 (s, 3H)

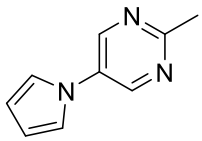
$^{13}C\{^{1}H\}$ NMR



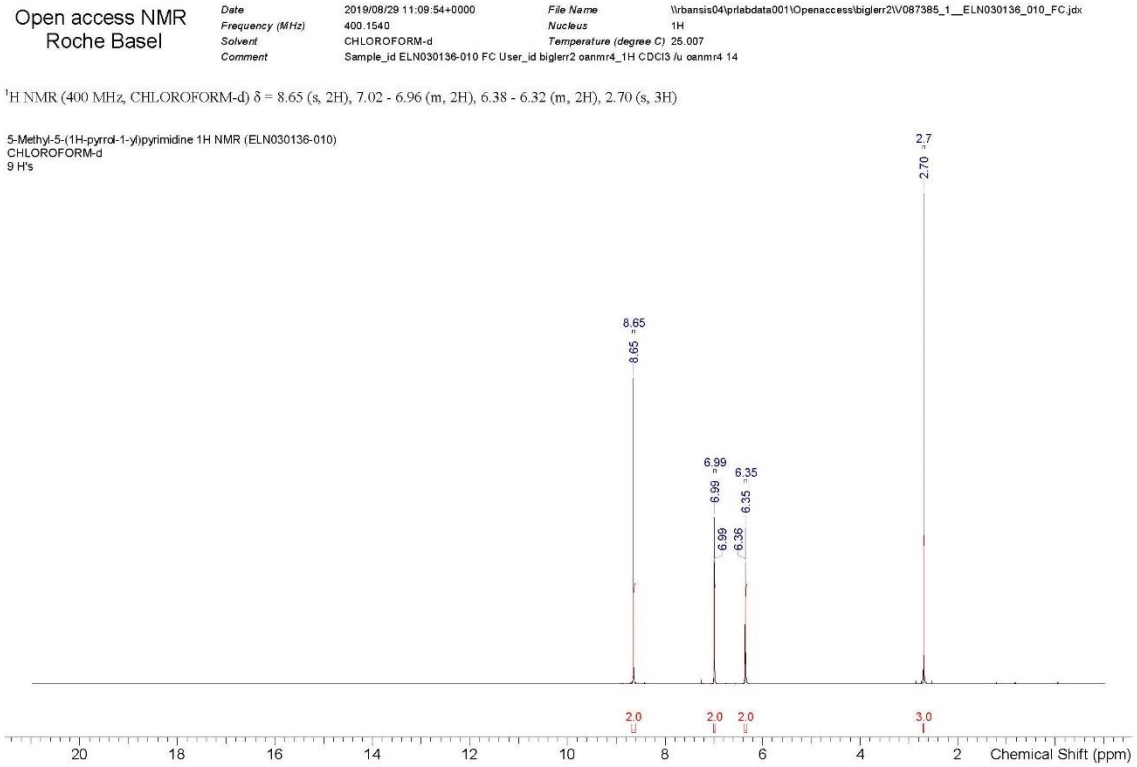
N,6-Dimethyl-*N*-phenylpyridin-3-amine **(6_18)**



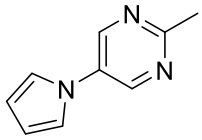
^{1}H NMR



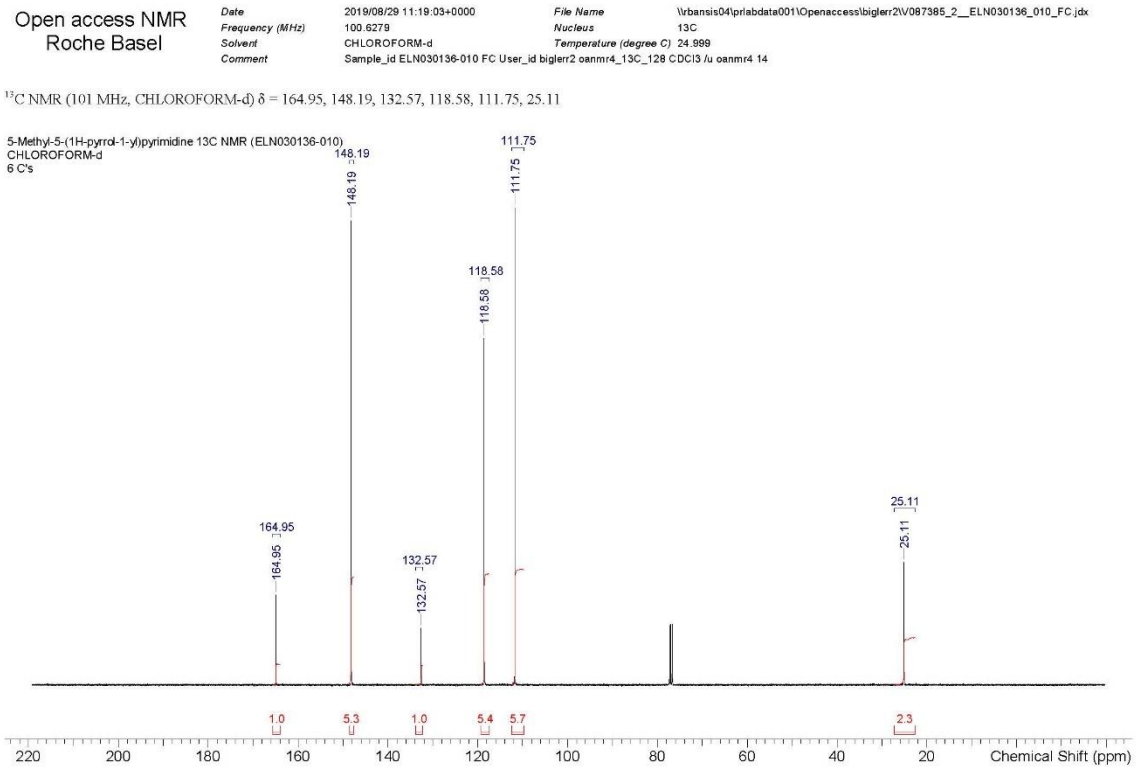
5-Methyl-5-(1*H*-pyrrol-1-yl)pyrimidine **(17_17)**



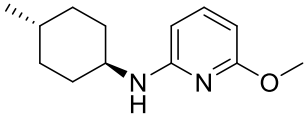
$^{13}C\{^{1}H\}$ NMR



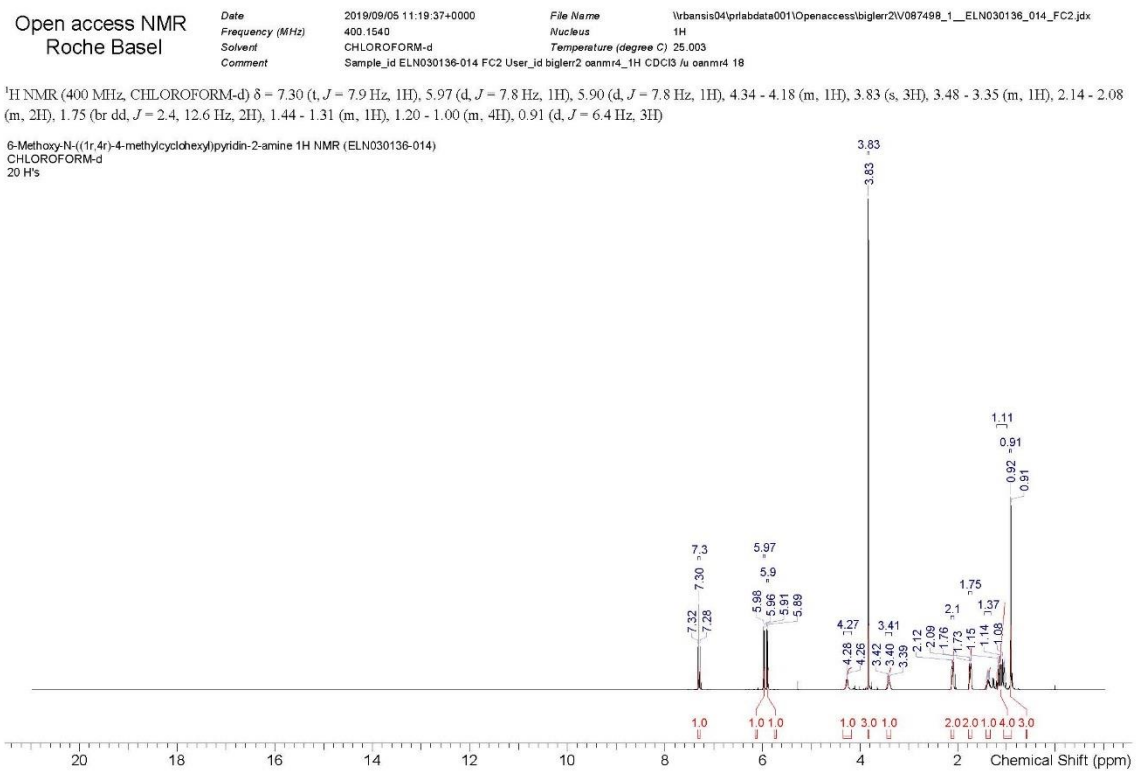
5-Methyl-5-(1*H*-pyrrol-1-yl)pyrimidine **(17_17)**



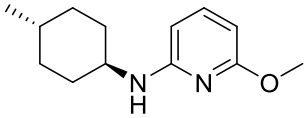
^{1}H NMR



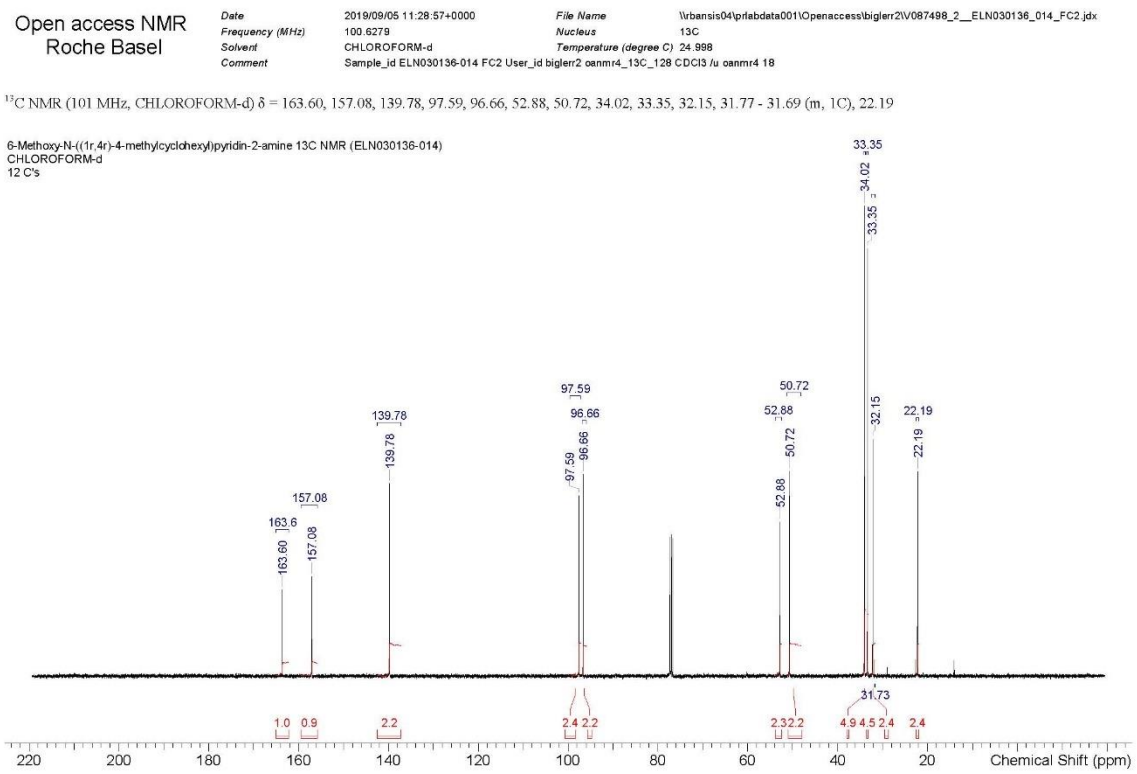
6-Methoxy-*N*-((1*r*,4*r*)-4-methylcyclohexyl)pyridin-2-amine (36_41)



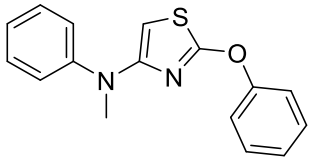
$^{13}C\{^{1}H\}$ NMR



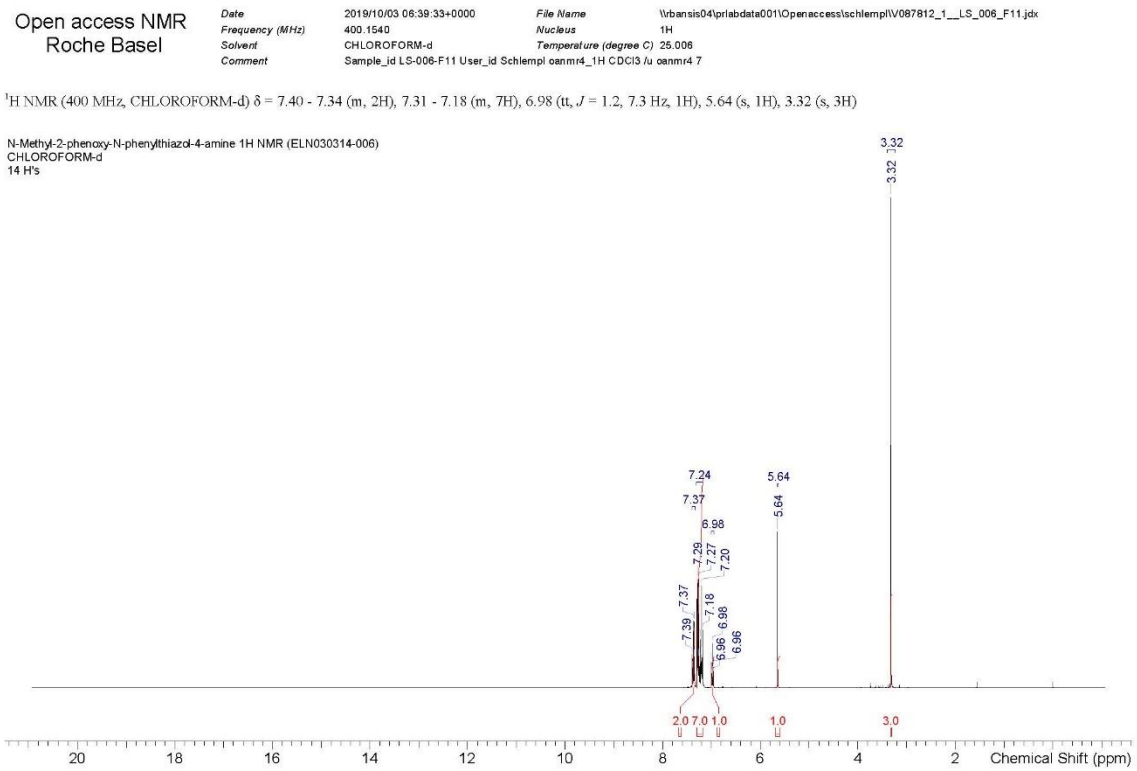
6-Methoxy-*N*-((1*r*,4*r*)-4-methylcyclohexyl)pyridin-2-amine (36_41)



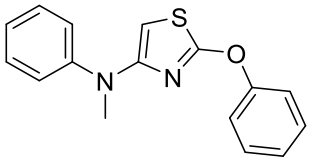
^{1}H NMR



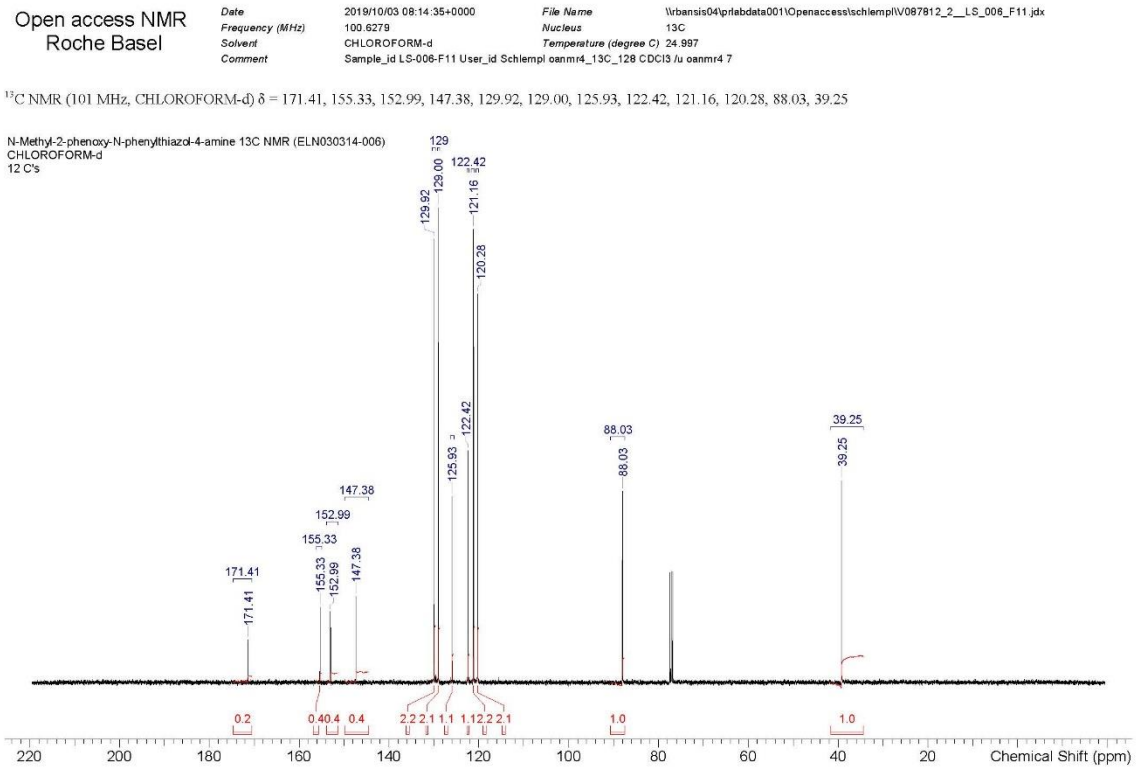
N-Methyl-2-phenoxy-*N*-phenylthiazol-4-amine **(6_38)**



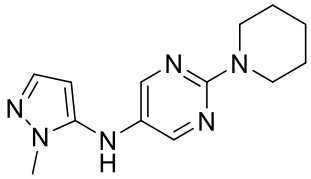
$^{13}C\{^{1}H\}$ NMR



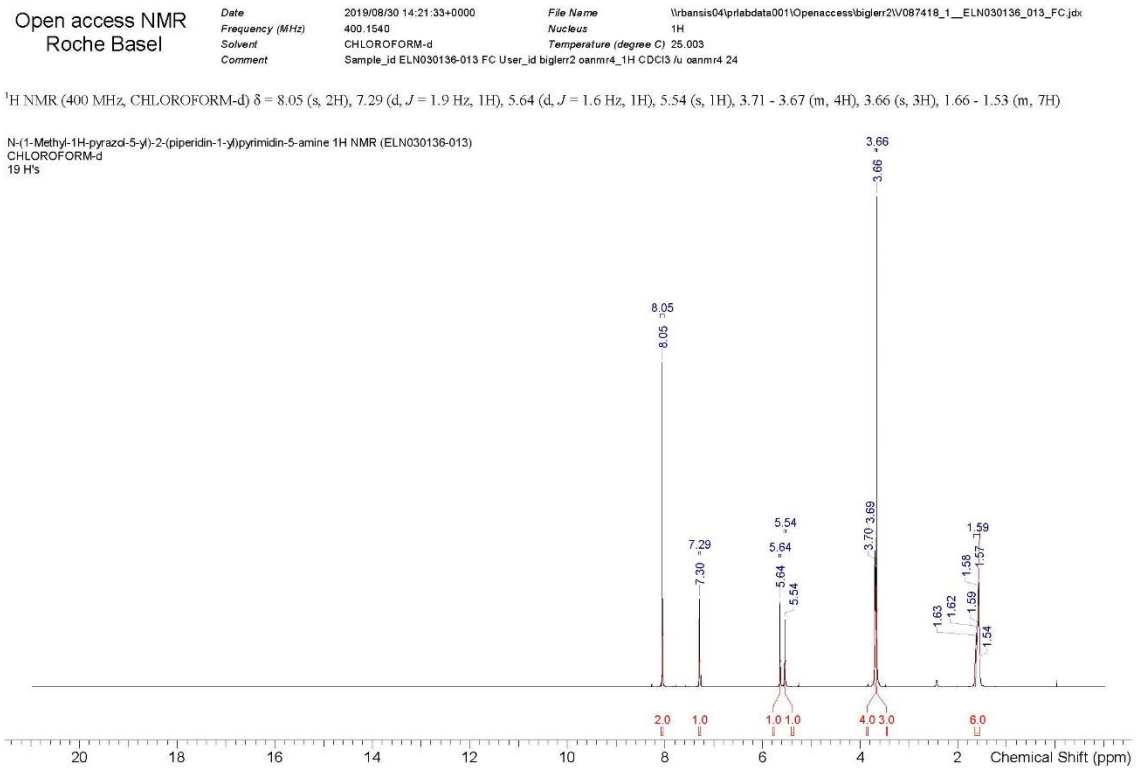
N-Methyl-2-phenoxy-*N*-phenylthiazol-4-amine **(6_38)**



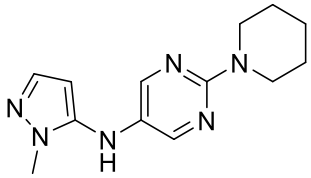
^{1}H NMR



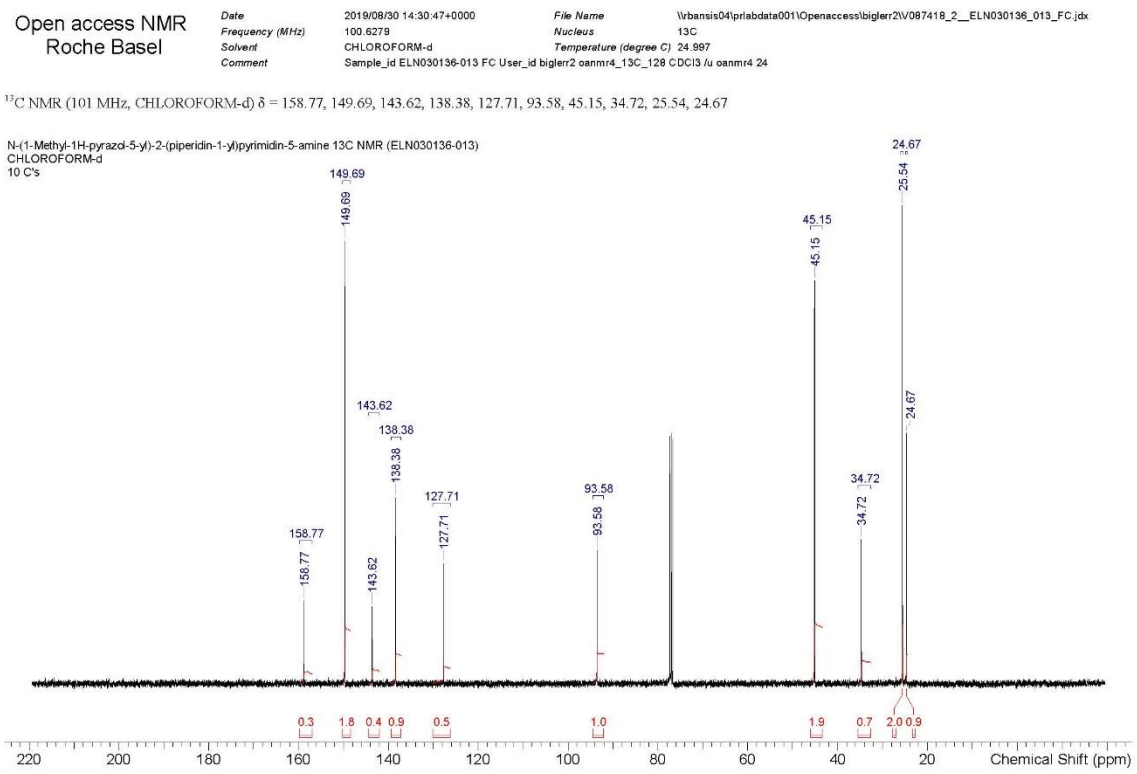
N-(1-Methyl-1*H*-pyrazol-5-yl)-2-(piperidin-1-yl)pyrimidin-5-amine **(14_27)**



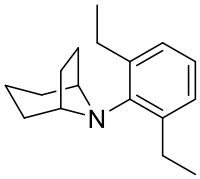
$^{13}C\{^{1}H\}$ NMR



N-(1-Methyl-1*H*-pyrazol-5-yl)-2-(piperidin-1-yl)pyrimidin-5-amine **(14_27)**



^{1}H NMR

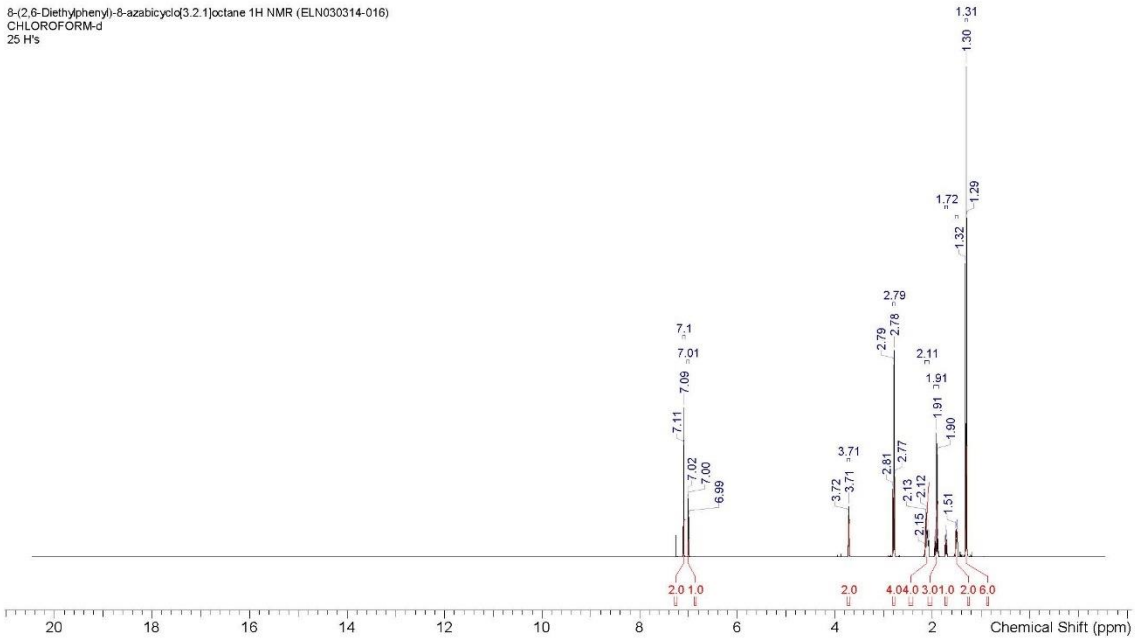


8-(2,6-Diethylphenyl)-8-azabicyclo[3.2.1]octane **(42_10)**

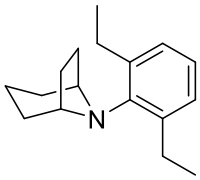
Open access NMR
Roche Basel

Date	2019/11/08 13:28:45+0000	File Name	C:\Users\bigler2\AppData\Local\Microsoft\Windows\INetCache\IE\X5BV0GVE\20190018470 47_1000.jdx
Frequency (MHz)	600.1357	Nucleus	1H
Solvent	CHLOROFORM-d	Temperature (degree C)	25.027
Comment	ARC= 20190018470 47 Lab/journal ELN030314-016 Probenmenge 42 Labgroup ID fantasia Contact Person Name Lukas Schlemper Theme 5155 INFRASTRUCTURE AND SUPPORT FUNCTIONS Email lukas.schlemper@roche.com ROEX_1hsrc CDCl3 Au actual (1 B3 - 115)		

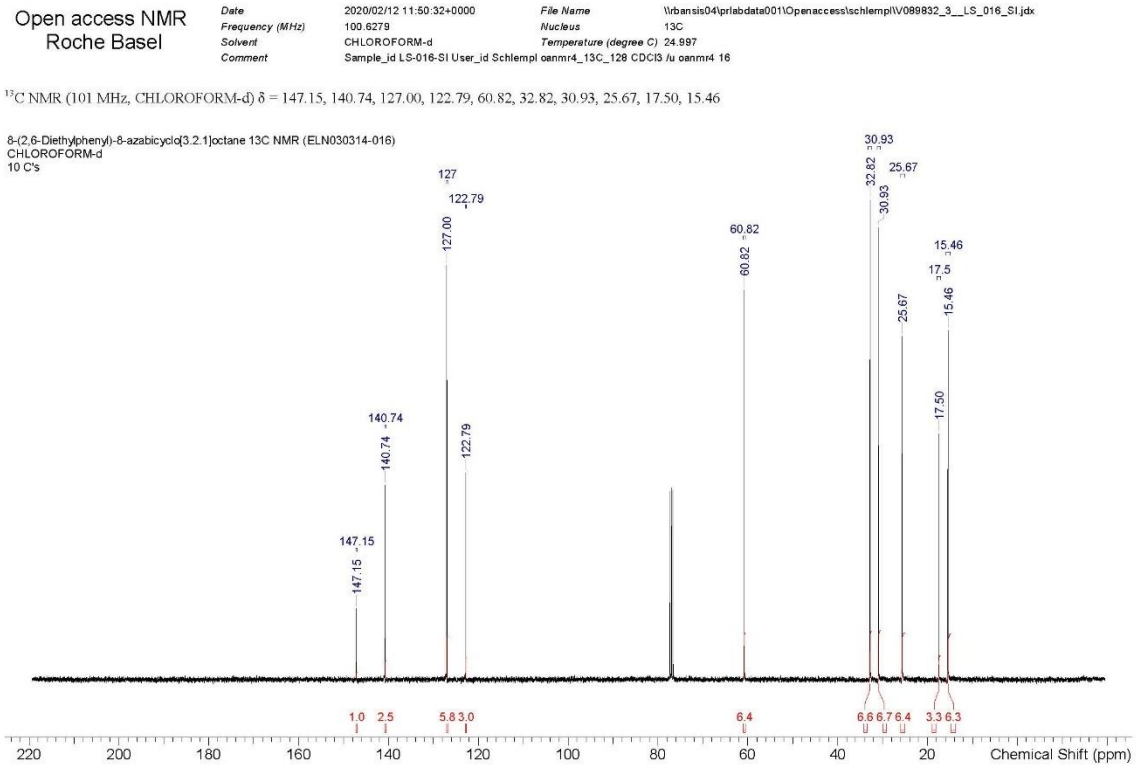
^{1}H NMR (600 MHz, CHLOROFORM-d) δ = 7.10 (d, *J* = 7.6 Hz, 2H), 7.03 - 6.98 (m, 1H), 3.74 - 3.68 (m, 2H), 2.79 (q, *J* = 7.5 Hz, 4H), 2.16 - 2.06 (m, 4H), 1.97 - 1.88 (m, 3H), 1.75 - 1.69 (m, 1H), 1.53 - 1.48 (m, 2H), 1.31 (t, *J* = 7.5 Hz, 6H)



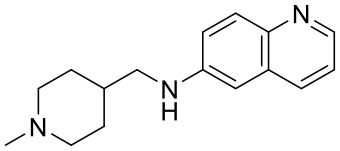
$^{13}C\{^{1}H\}$ NMR



8-(2,6-Diethylphenyl)-8-azabicyclo[3.2.1]octane **(42_10)**



^{1}H NMR



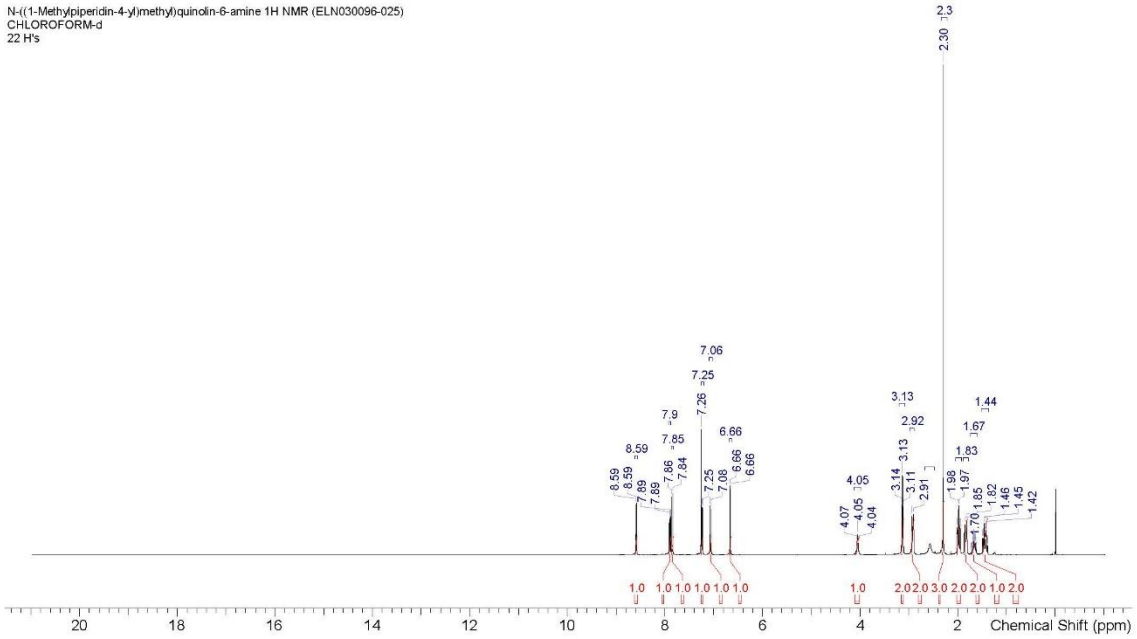
N-((1-Methylpiperidin-4-yl)methyl)quinolin-6-amine (32_26)

Open access NMR
Roche Basel

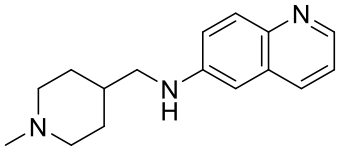
Date	2019/09/27 13:09:20+0000	*File Name*	C:\Users\biglerr2\Desktop\201900183058 4_V087754_1__DF3.jdx		
Frequency (MHz)	400.1540	*Nucleus*	1H	*Solvent*	CHLOROFORM-d
Temperature (degree C)	25.002	*Comment*	Sample_id DF3 User_id biglerr2 oanmr4_1H CDCl3 /u oanmr4 14		

^{1}H NMR (400 MHz, CHLOROFORM-d) δ = 8.59 (dd, *J* = 1.6, 4.3 Hz, 1H), 7.90 (dd, *J* = 0.8, 8.3 Hz, 1H), 7.85 (d, *J* = 9.1 Hz, 1H), 7.26 - 7.21 (m, 1H), 7.06 (dd, *J* = 2.6, 9.0 Hz, 1H), 6.66 (d, *J* = 2.7 Hz, 1H), 4.05 (br t, *J* = 5.1 Hz, 1H), 3.13 (t, *J* = 6.3 Hz, 2H), 2.92 (br d, *J* = 11.6 Hz, 2H), 2.57 (br s, 1H), 2.30 (s, 3H), 1.98 (dt, *J* = 2.4, 11.8 Hz, 2H), 1.89 - 1.78 (m, 2H), 1.67 (ddq, *J* = 3.9, 6.9, 11.1 Hz, 1H), 1.52 - 1.36 (m, 2H)

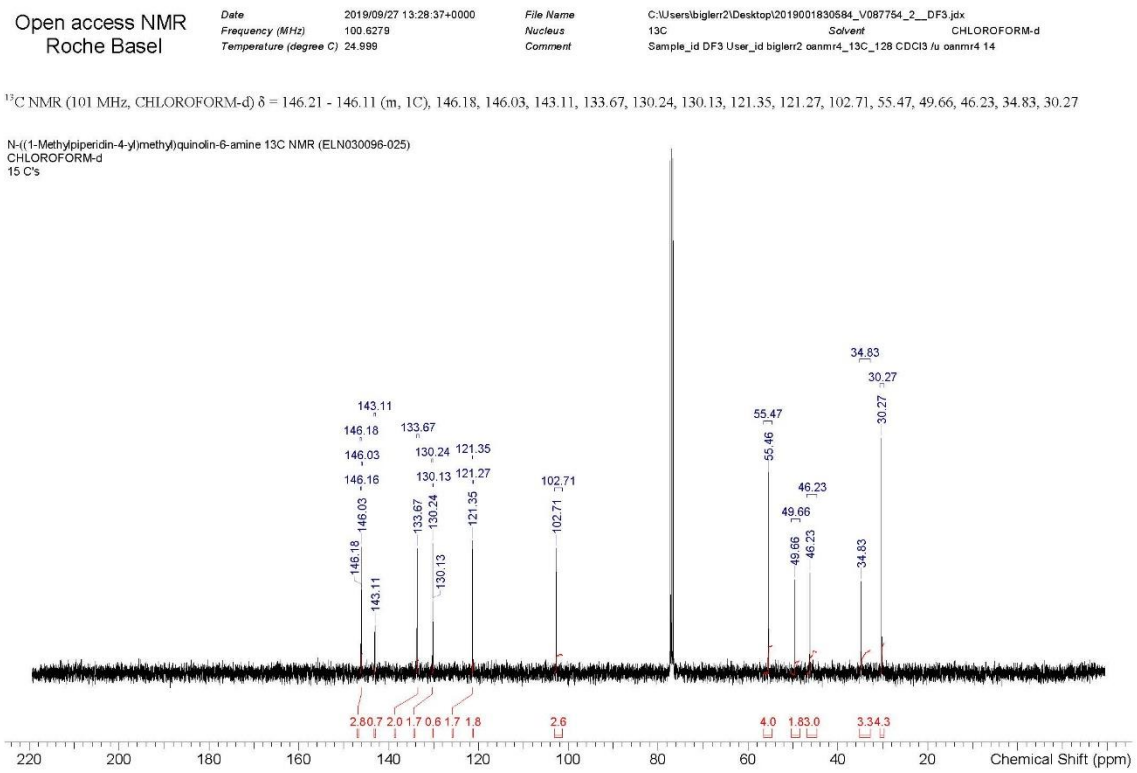
N-((1-Methylpiperidin-4-yl)methyl)quinolin-6-amine 1H NMR (ELN030096-025)
CHLOROFORM-d
22 H's



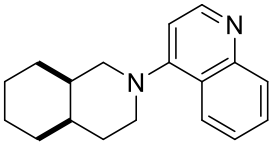
$^{13}C\{^{1}H\}$ NMR



N-((1-Methylpiperidin-4-yl)methyl)quinolin-6-amine (32_26)



^{1}H NMR



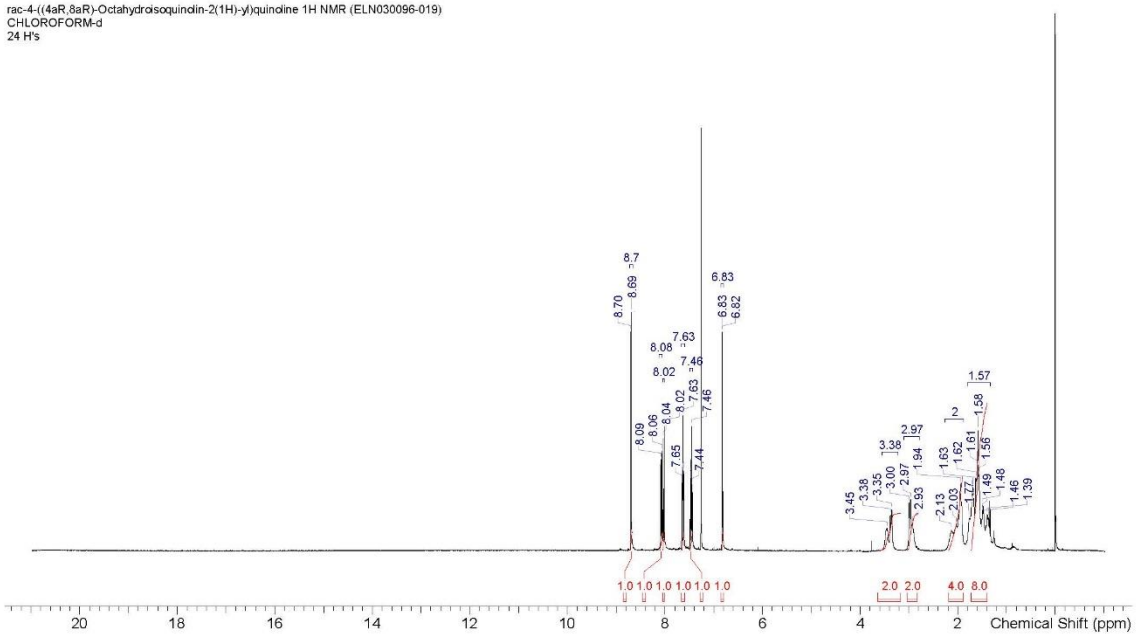
rac-4-((4aR,8aR)-Octahydroisoquinolin-2(1*H*)-yl)quinoline (**45_30**)

Open access NMR
Roche Basel

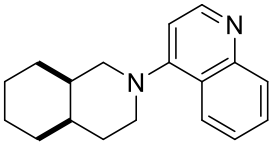
Date	2019/09/05 13:38:34+0000	*File Name*	\\rbansis04\prlabdata001\Openaccess\fluryd\V087504_1__ELN030096_019_P1.jdx
Frequency (MHz)	400.1540	*Nucleus*	1H
Solvent	CHLOROFORM-d	*Temperature (degree C)*	25.010
Comment	Sample_id ELN030096-019-P1 User_id fluryd oanmr4_1H CDCl3 /u oanmr4 24		

^{1}H NMR (400 MHz, CHLOROFORM-d) δ = 8.70 (d, *J* = 4.8 Hz, 1H), 8.08 (dd, *J* = 0.9, 8.5 Hz, 1H), 8.05 - 8.01 (m, 1H), 7.63 (ddd, *J* = 1.5, 6.9, 8.3 Hz, 1H), 7.46 (ddd, *J* = 1.2, 6.9, 8.3 Hz, 1H), 6.83 (d, *J* = 5.1 Hz, 1H), 3.55 - 3.23 (m, 2H), 3.10 - 2.79 (m, 2H), 2.26 - 1.88 (m, 4H), 1.81 - 1.33 (m, 10H)

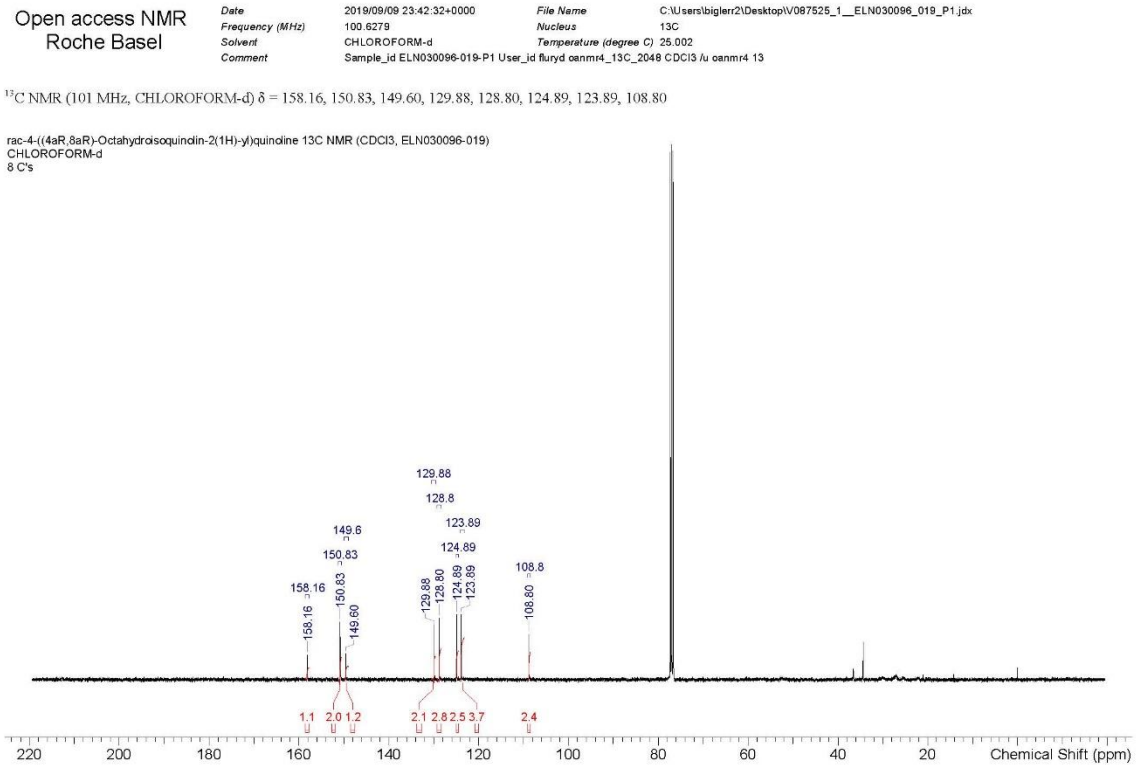
rac-4-((4aR,8aR)-Octahydroisoquinolin-2(1H)-yl)quinoline 1H NMR (ELN030096-019)
CHLOROFORM-d
24 H's



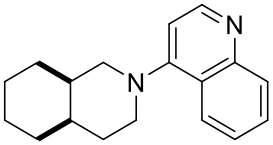
$^{13}C\{^{1}H\}$ NMR



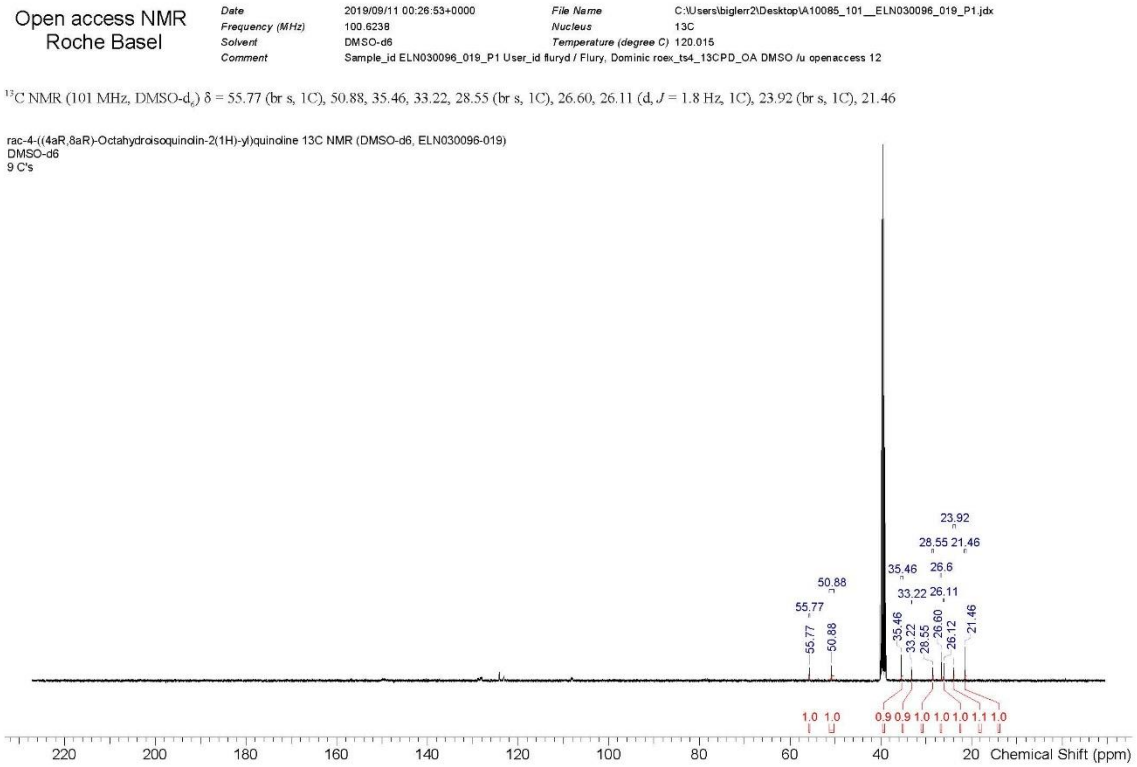
rac-4-((4aR,8aR)-Octahydroisoquinolin-2(1*H*)-yl)quinoline (**45_30**)



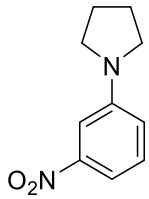
$^{13}C\{^{1}H\}$ NMR



rac-4-((4aR,8aR)-Octahydroisoquinolin-2(1*H*)-yl)quinoline (**45_30**)



^{1}H NMR

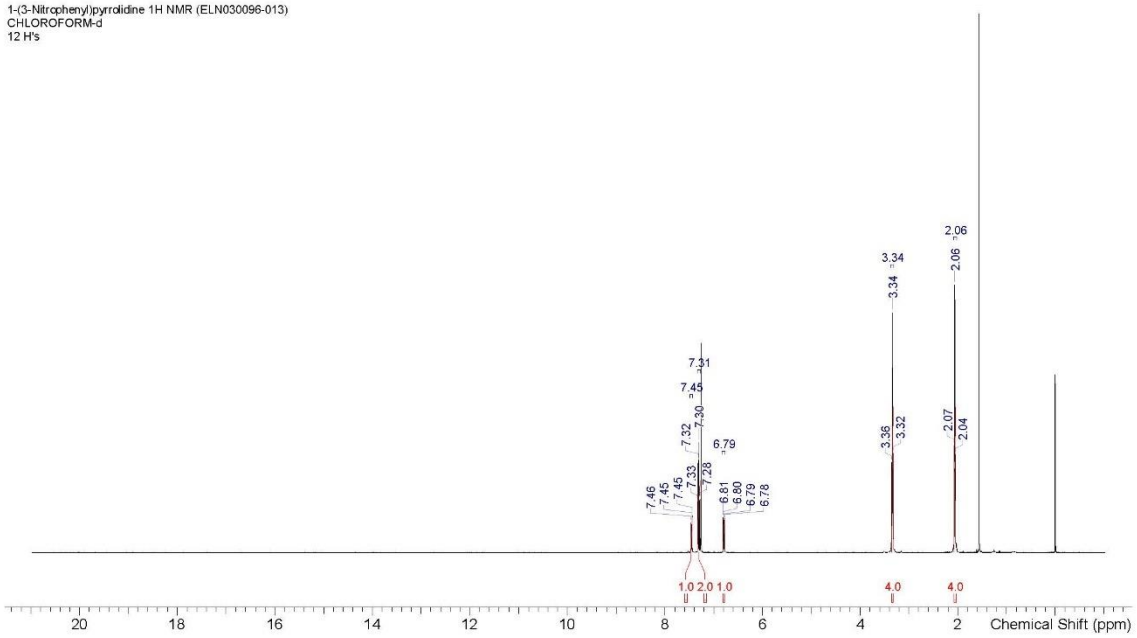


1-(3-Nitrophenyl)pyrrolidine (44_13)

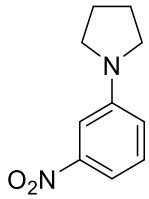
Open access NMR
Roche Basel

Date	2019/08/30 12:37:22+0000	*File Name*	\\rbansis04\prlabdata001\Openaccess\fluryd\V087416_1__ELN030096_013_P1.jdx
Frequency (MHz)	400.1540	*Nucleus*	1H
Solvent	CHLOROFORM-d	*Temperature (degree C)*	25.001
Comment	Sample_id ELN030096-013-P1 User_id fluryd oanmr4_1H CDCl3 /u oanmr4 22		

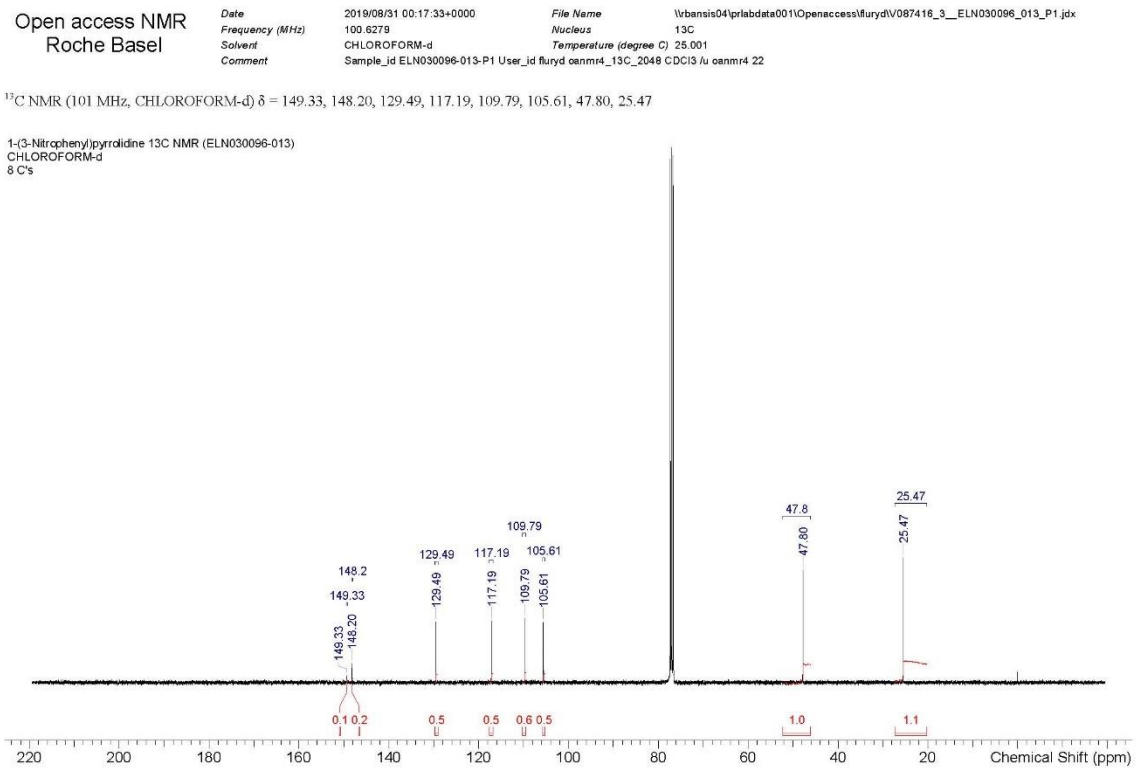
^{1}H NMR (400 MHz, CHLOROFORM-d) δ = 7.49 - 7.43 (m, 1H), 7.34 - 7.27 (m, 2H), 6.79 (dd, *J* = 2.6, 8.2 Hz, 1H), 3.38 - 3.30 (m, 4H), 2.09 - 2.02 (m, 4H)



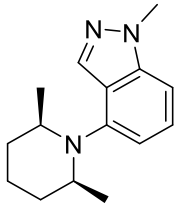
$^{13}C\{^{1}H\}$ NMR



1-(3-Nitrophenyl)pyrrolidine (44_13)



^{1}H NMR

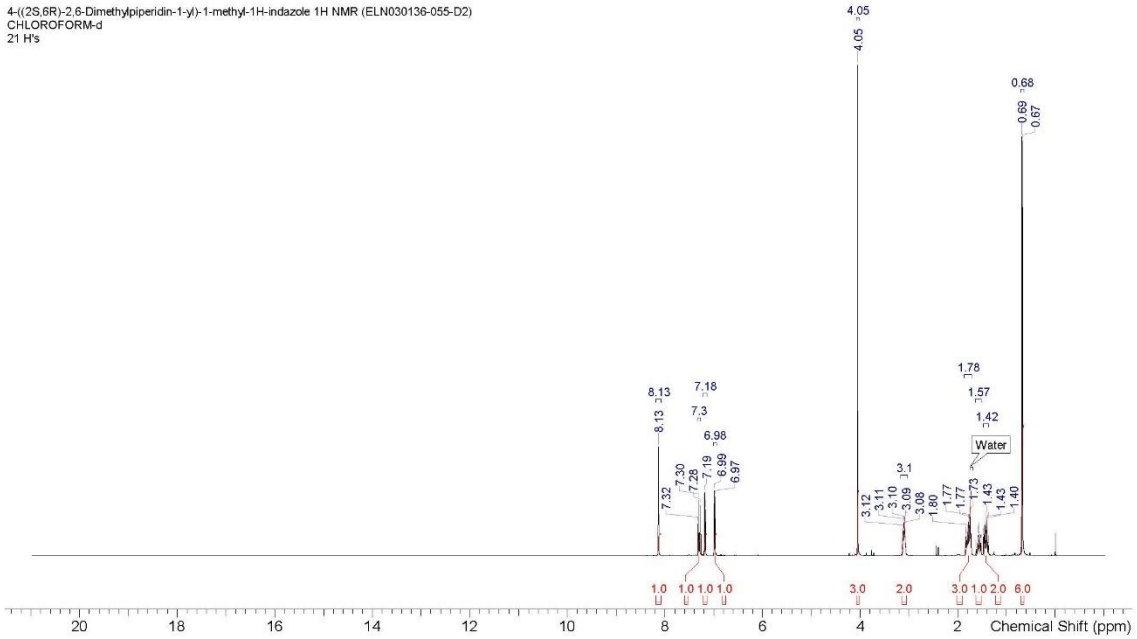


4-((2*S*,6*R*)-2,6-Dimethylpiperidin-1-yl)-1-methyl-1*H*-indazole (**40_12**)

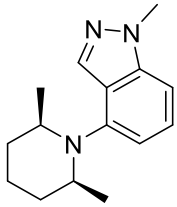
Open access NMR
Roche Basel

Date	2020/04/15 14:21:24+0000	*File Name*	\\rbansis04\prlabdata001\Openaccess\biglerr2\V090363_1__ELN030136_055_D2_FC.jdx
Frequency (MHz)	400.1540	*Nucleus*	1H
Solvent	CHLOROFORM-d	*Temperature (degree C)*	25.000
Comment	Sample_id ELN030136-055 D2 FC User_id biglerr2 oanmr4_1H_128 CDCl3 /u oanmr4 13		

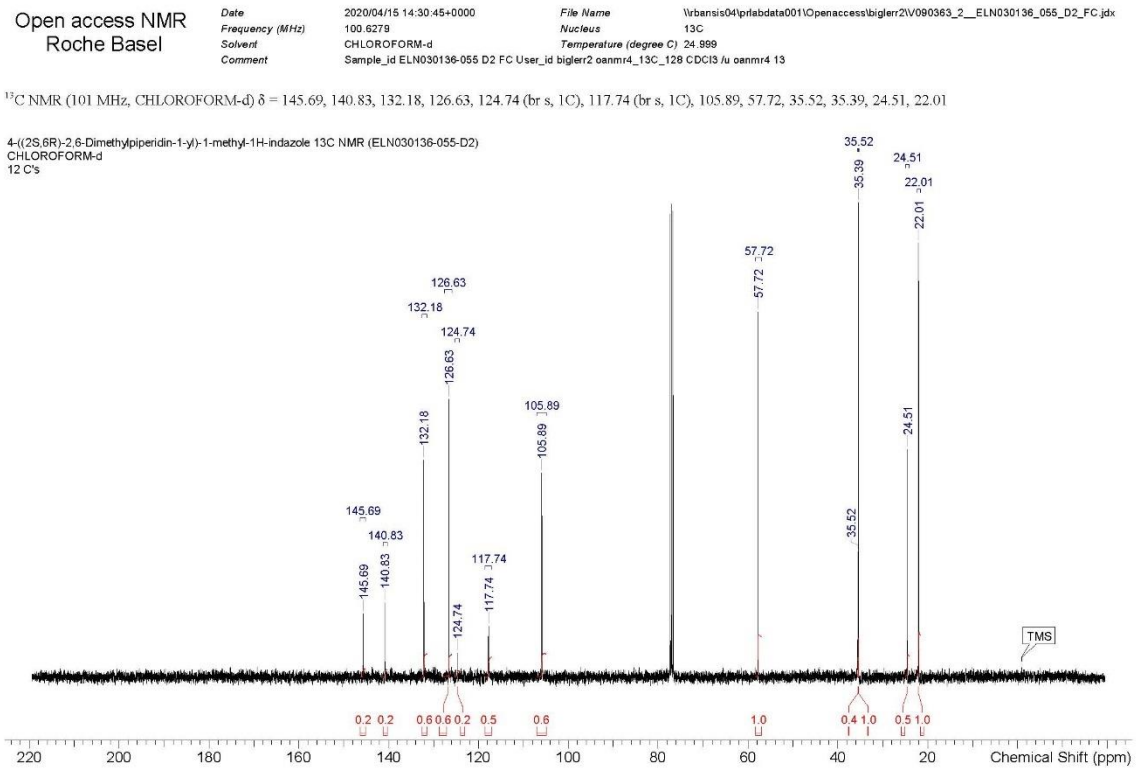
^{1}H NMR (400 MHz, CHLOROFORM-d) δ = 8.13 (s, 1H), 7.34 - 7.27 (m, 1H), 7.18 (d, *J* = 8.3 Hz, 1H), 6.98 (d, *J* = 7.3 Hz, 1H), 4.05 (s, 3H), 3.17 - 3.03 (m, 2H), 1.86 - 1.71 (m, 3H), 1.64 - 1.51 (m, 1H), 1.48 - 1.36 (m, 2H), 0.68 (d, *J* = 6.2 Hz, 6H)



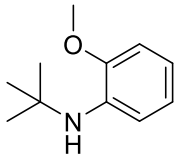
^{1}H NMR



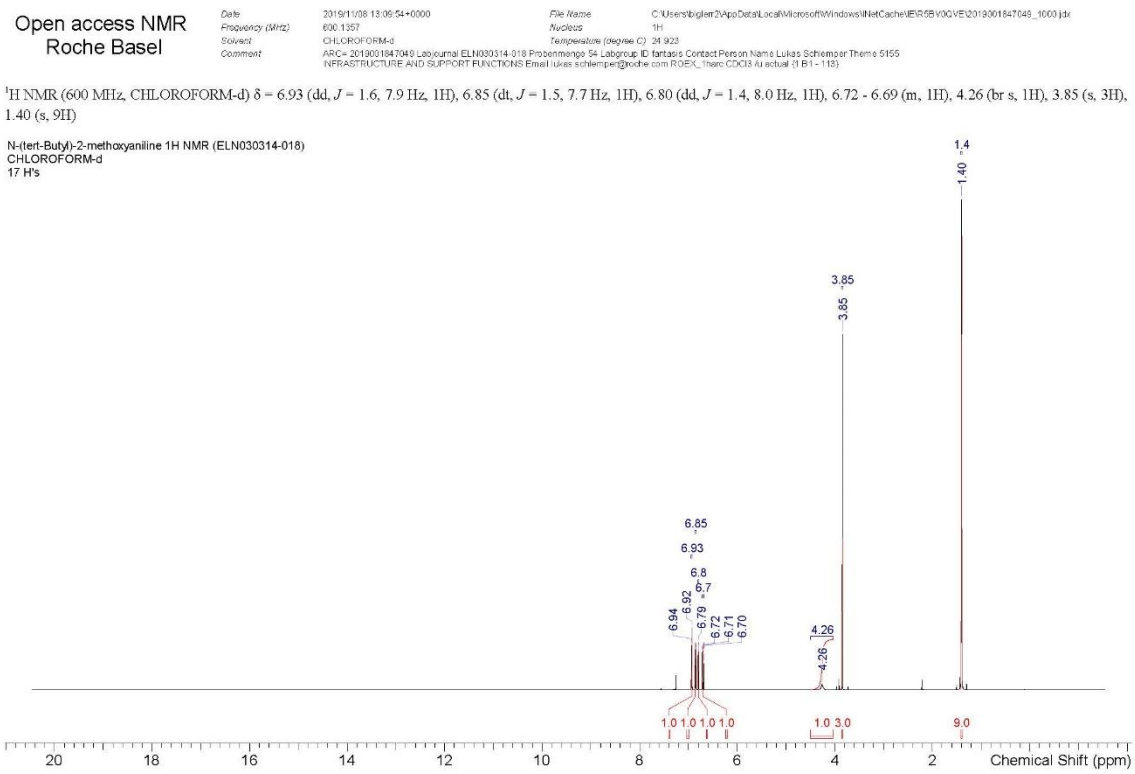
4-((2*S*,6*R*)-2,6-Dimethylpiperidin-1-yl)-1-methyl-1*H*-indazole (**40_12**)



^{1}H NMR

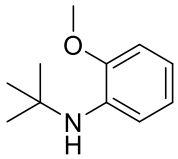


N-(*tert*-Butyl)-2-methoxyaniline **(37_7)**

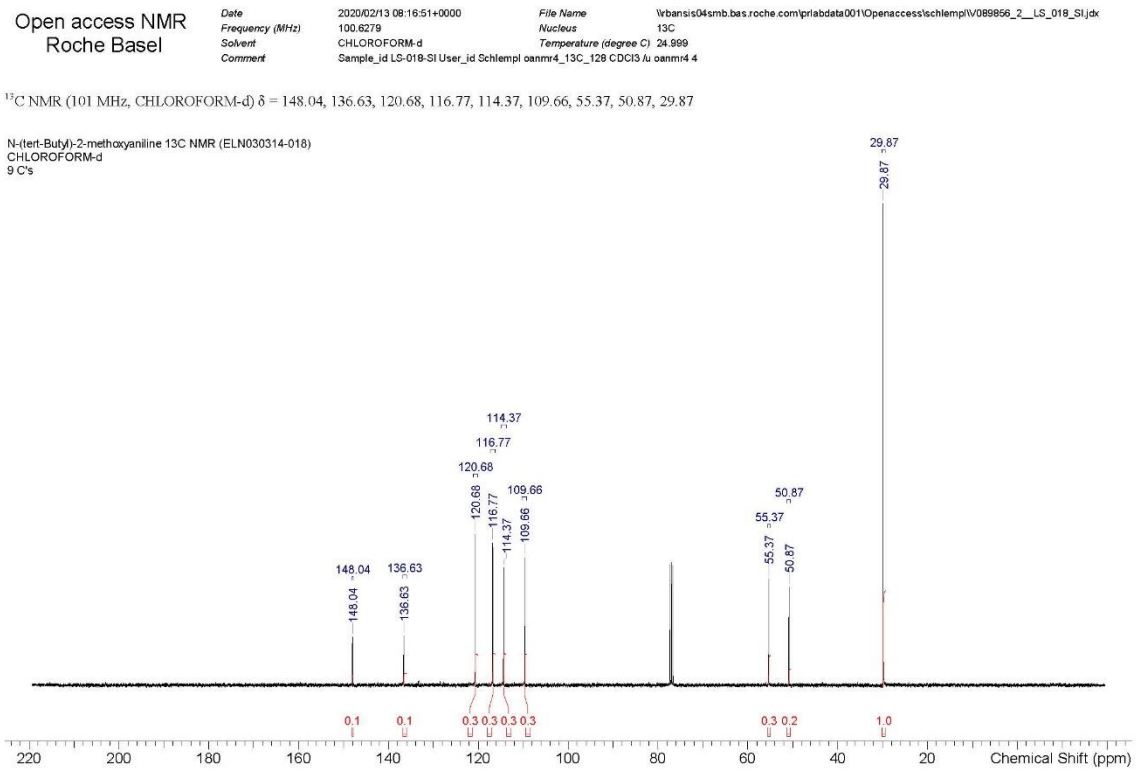


^{1}H NMR (600 MHz, CHLOROFORM-d) δ = 6.93 (dd, *J* = 1.6, 7.9 Hz, 1H), 6.85 (dt, *J* = 1.5, 7.7 Hz, 1H), 6.80 (dd, *J* = 1.4, 8.0 Hz, 1H), 6.72 - 6.69 (m, 1H), 4.26 (br s, 1H), 3.85 (s, 3H), 1.40 (s, 9H)

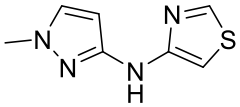
$^{13}C\{^{1}H\}$ NMR



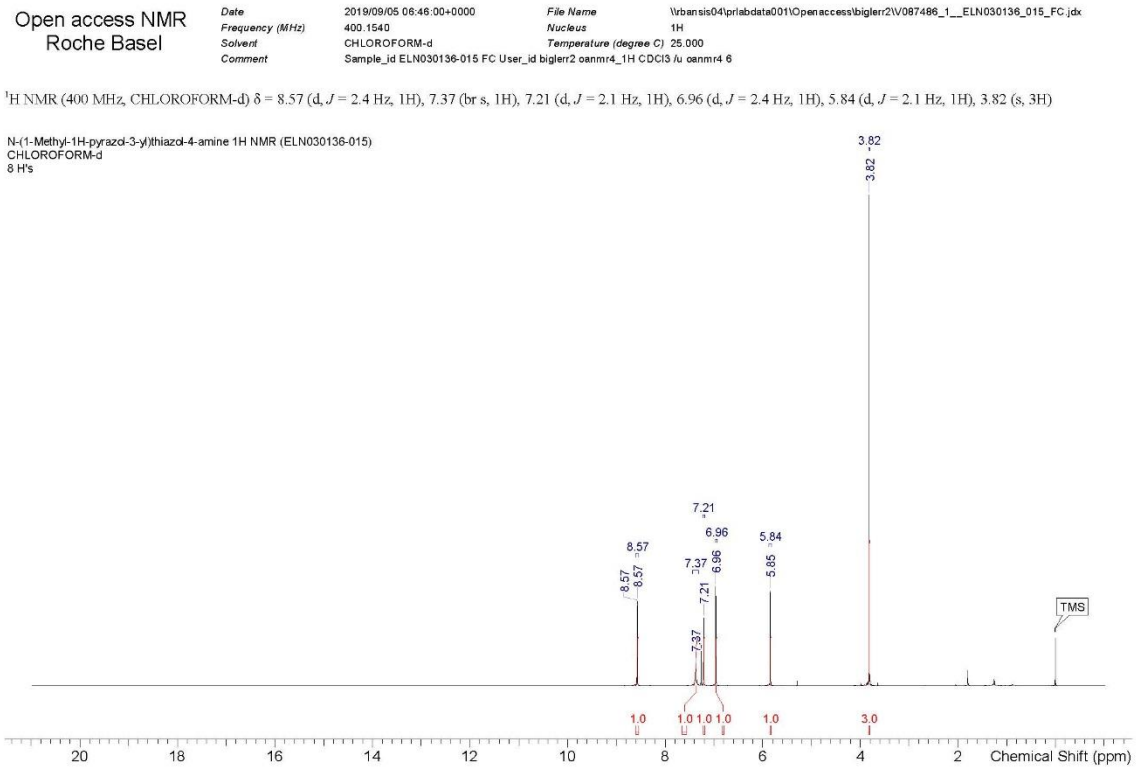
N-(*tert*-Butyl)-2-methoxyaniline **(37_7)**



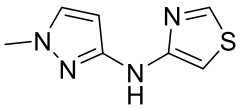
^{1}H NMR



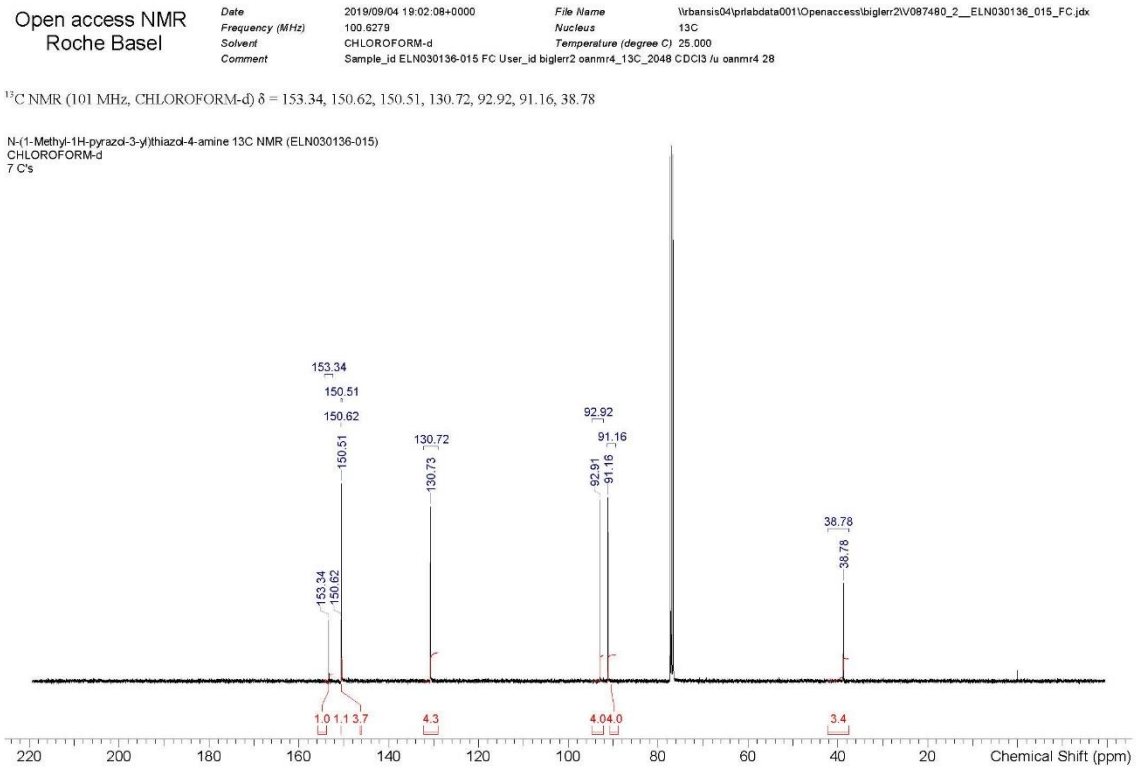
N-(1-Methyl-1*H*-pyrazol-3-yl)thiazol-4-amine (16_20)



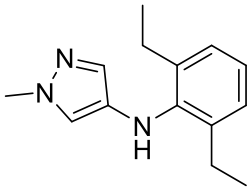
$^{13}C\{^{1}H\}$ NMR



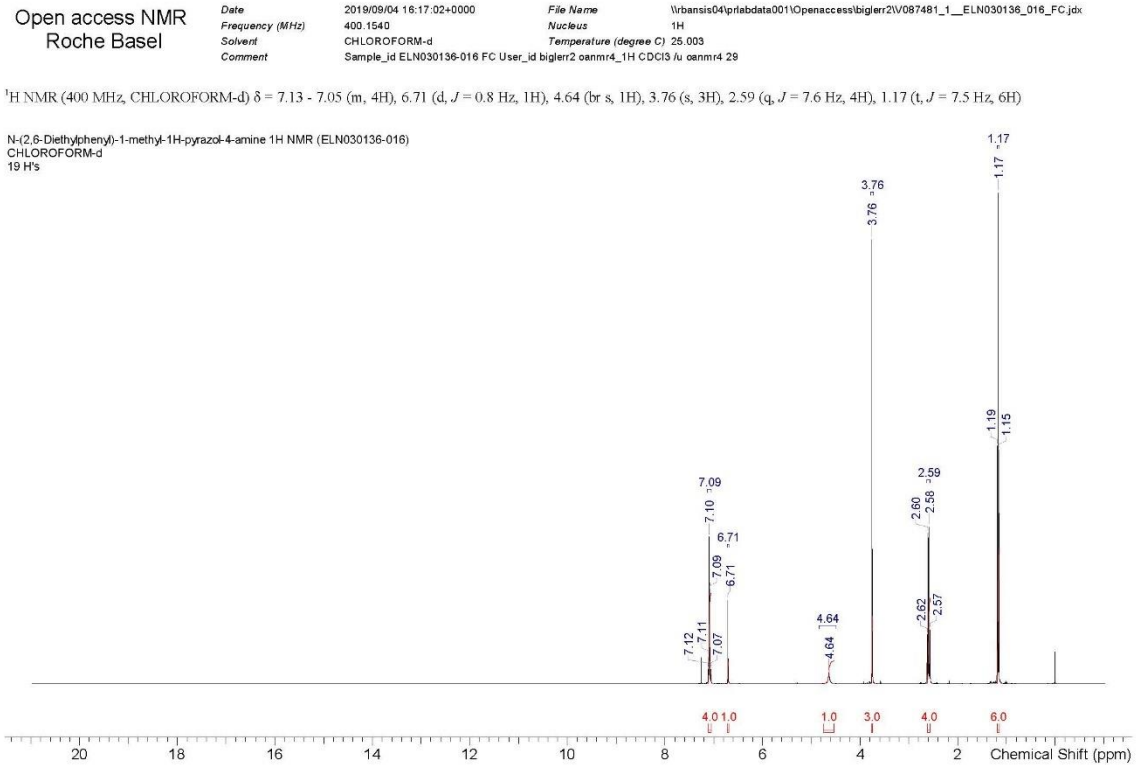
N-(1-Methyl-1*H*-pyrazol-3-yl)thiazol-4-amine (16_20)



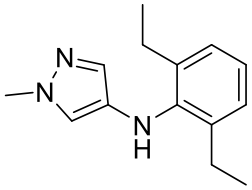
^{1}H NMR



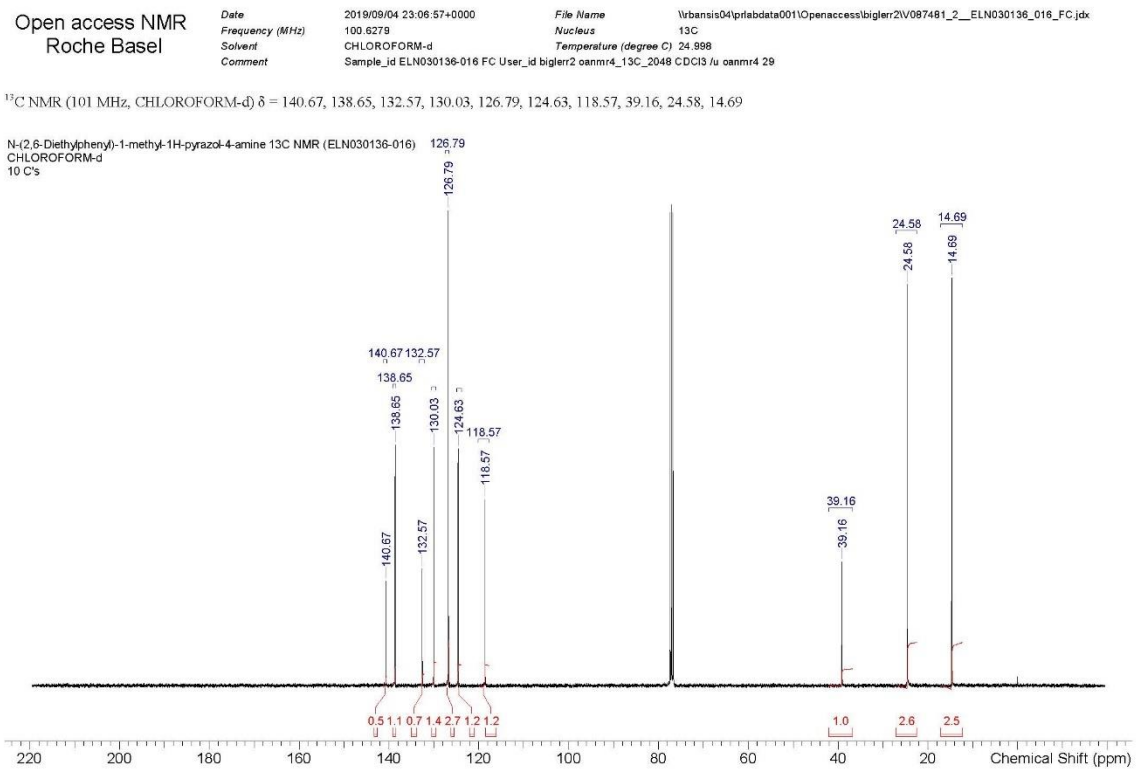
N-(2,6-Diethylphenyl)-1-methyl-1*H*-pyrazol-4-amine **(12_10)**



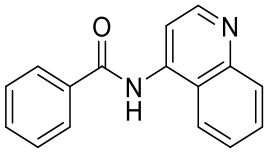
$^{13}C\{^{1}H\}$ NMR



N-(2,6-Diethylphenyl)-1-methyl-1*H*-pyrazol-4-amine **(12_10)**



^{1}H NMR

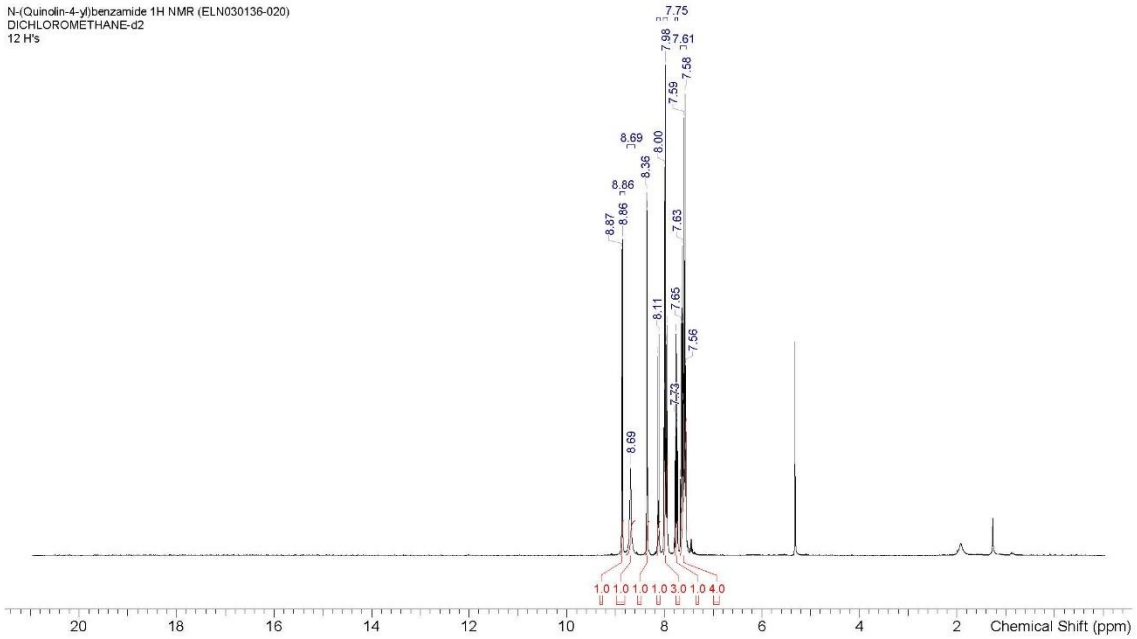


N-(Quinolin-4-yl)benzamide **(8_30)**

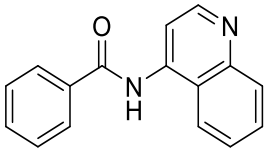
Open access NMR
Roche Basel

Date	2019/10/04 11:07:55+0000	*File Name*	\\rbansis04\prlabdata001\Openaccess\biglerr2\V087855_1__ELN030136_020.jdx
Frequency (MHz)	400.1540	*Nucleus*	1H
Solvent	DICHLOROMETHANE-d2	*Temperature (degree C)*	25.003
Comment	Sample_id ELN030136-020 User_id biglerr2 oanmr4_1H CD2Cl2 /u oanmr4 16		

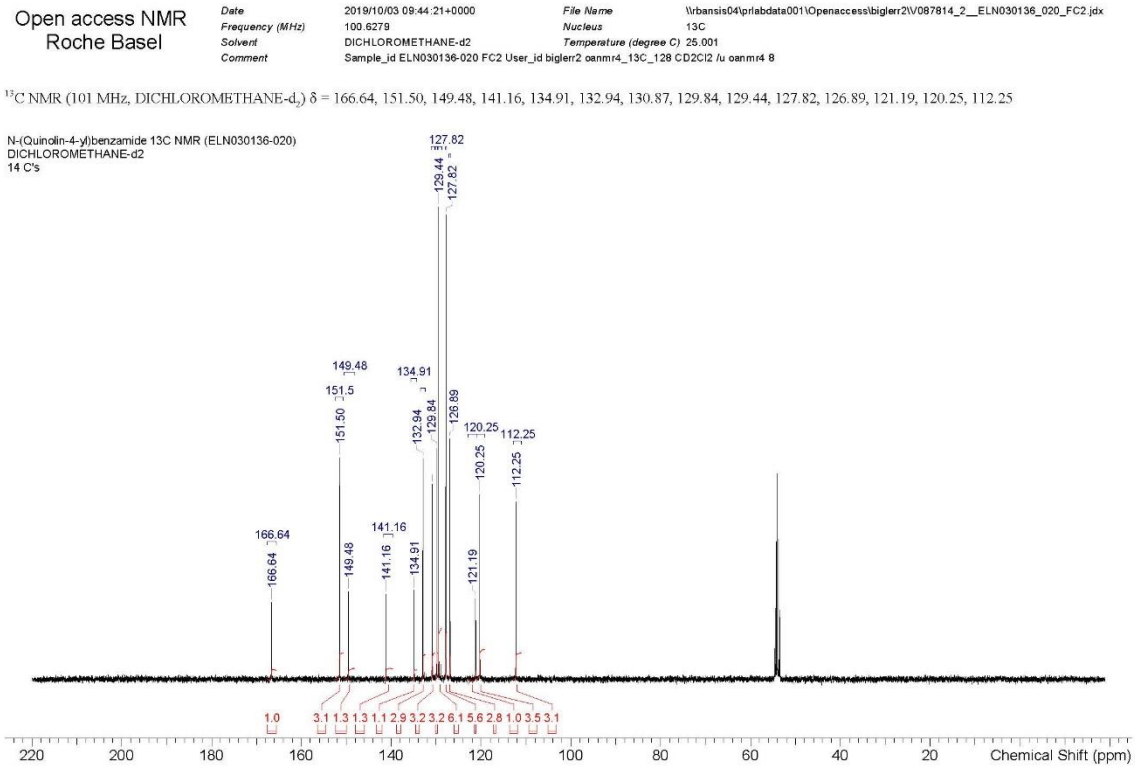
^{1}H NMR (400 MHz, DICHLOROMETHANE-d_2) δ = 8.86 (d, *J* = 4.8 Hz, 1H), 8.69 (br s, 1H), 8.35 (d, *J* = 5.1 Hz, 1H), 8.12 (d, *J* = 7.8 Hz, 1H), 8.02 - 7.93 (m, 3H), 7.75 (ddd, *J* = 1.1, 7.0, 8.3 Hz, 1H), 7.68 - 7.55 (m, 4H)



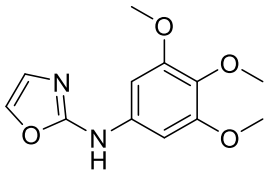
$^{13}C\{^{1}H\}$ NMR



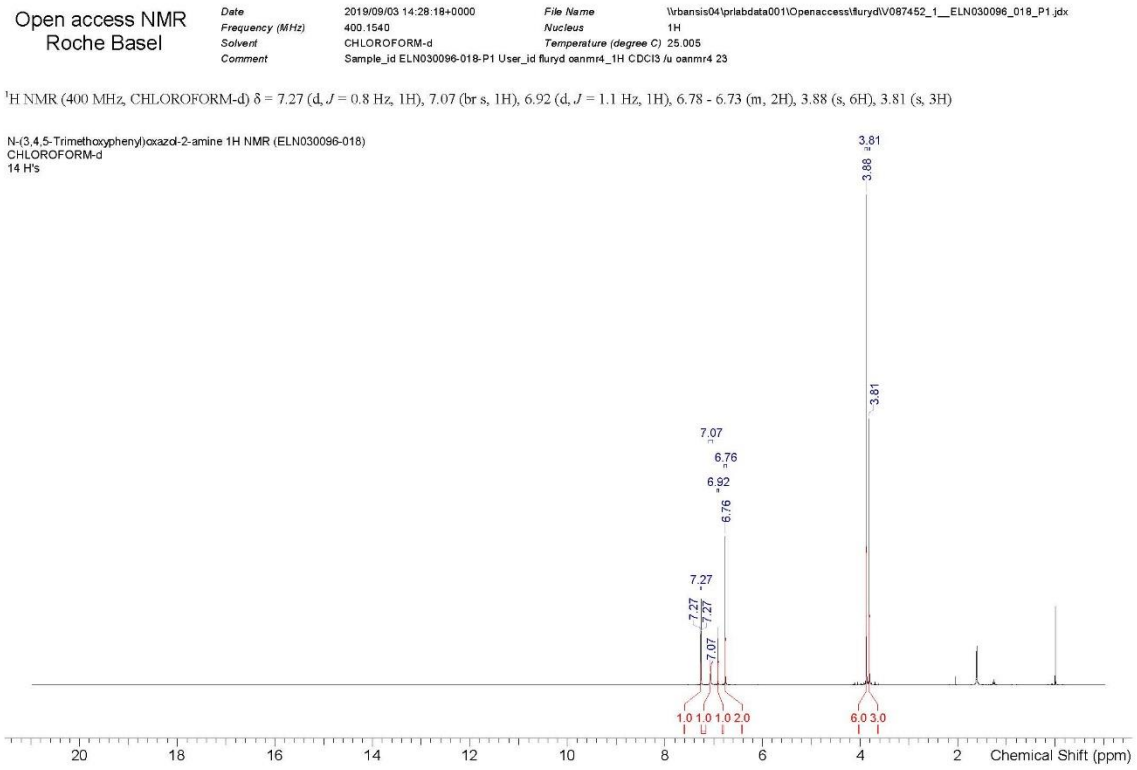
N-(Quinolin-4-yl)benzamide **(8_30)**



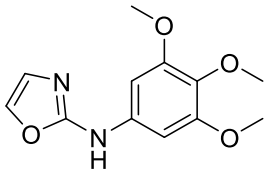
^{1}H NMR



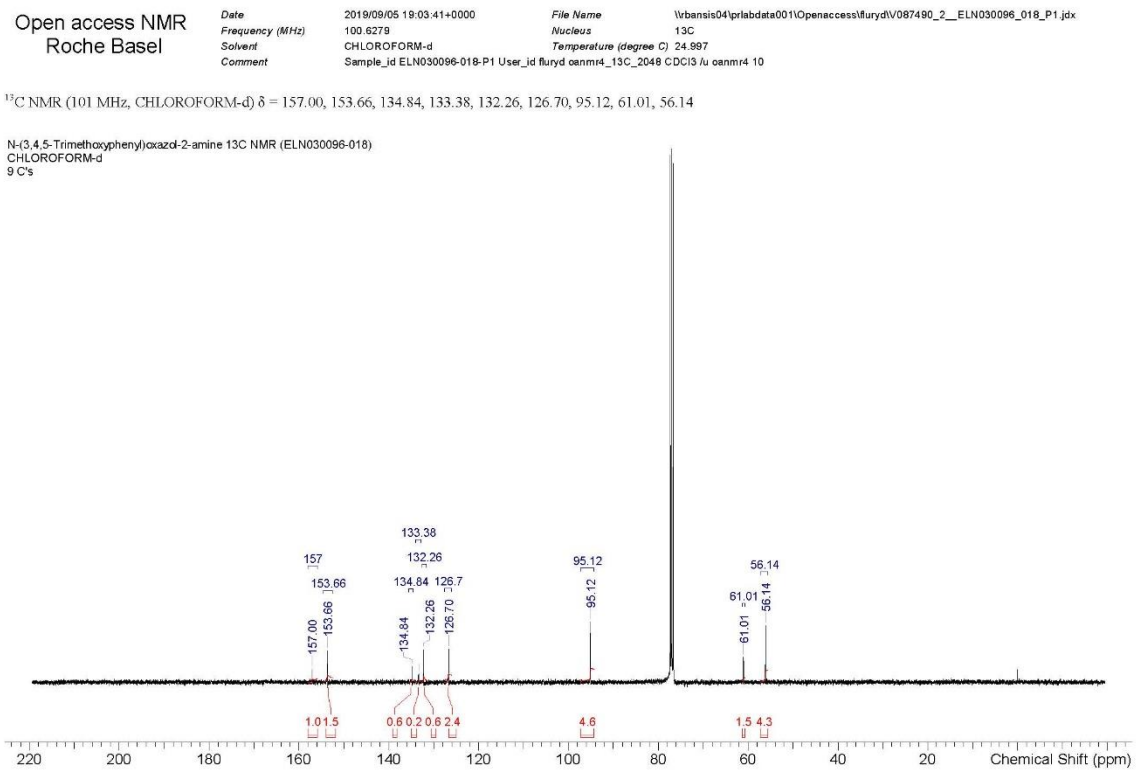
N-(3,4,5-Trimethoxyphenyl)oxazol-2-amine **(26_23)**



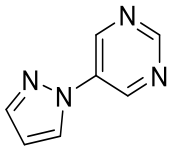
$^{13}C\{^{1}H\}$ NMR



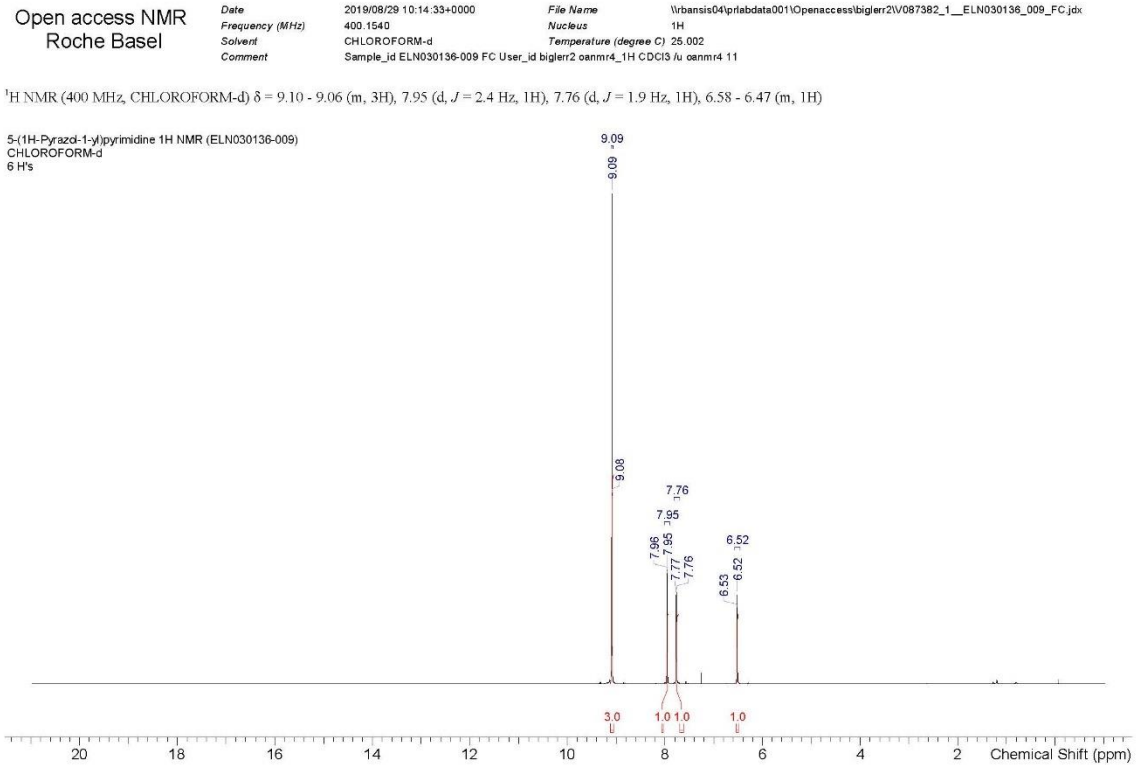
N-(3,4,5-Trimethoxyphenyl)oxazol-2-amine **(26_23)**



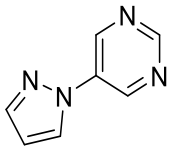
^{1}H NMR



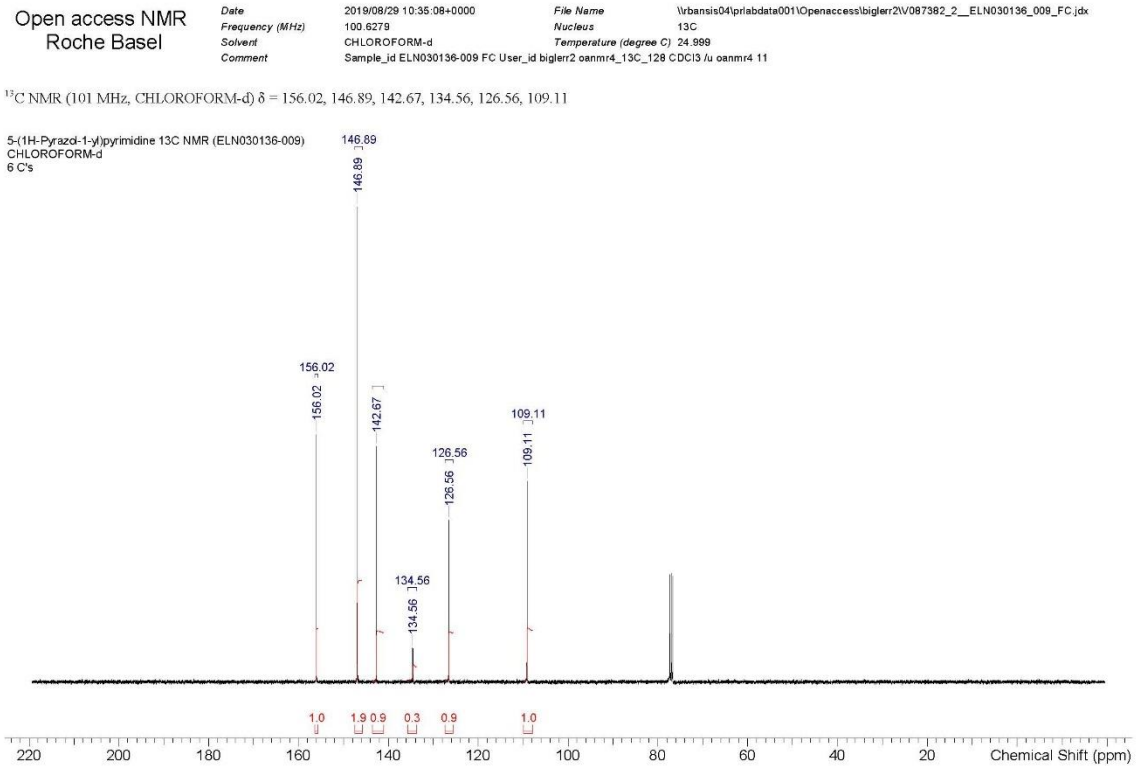
5-(1*H*-Pyrazol-1-yl)pyrimidine (21_24)



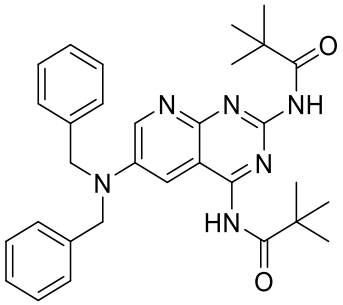
$^{13}C\{^{1}H\}$ NMR



5-(1*H*-Pyrazol-1-yl)pyrimidine (21_24)

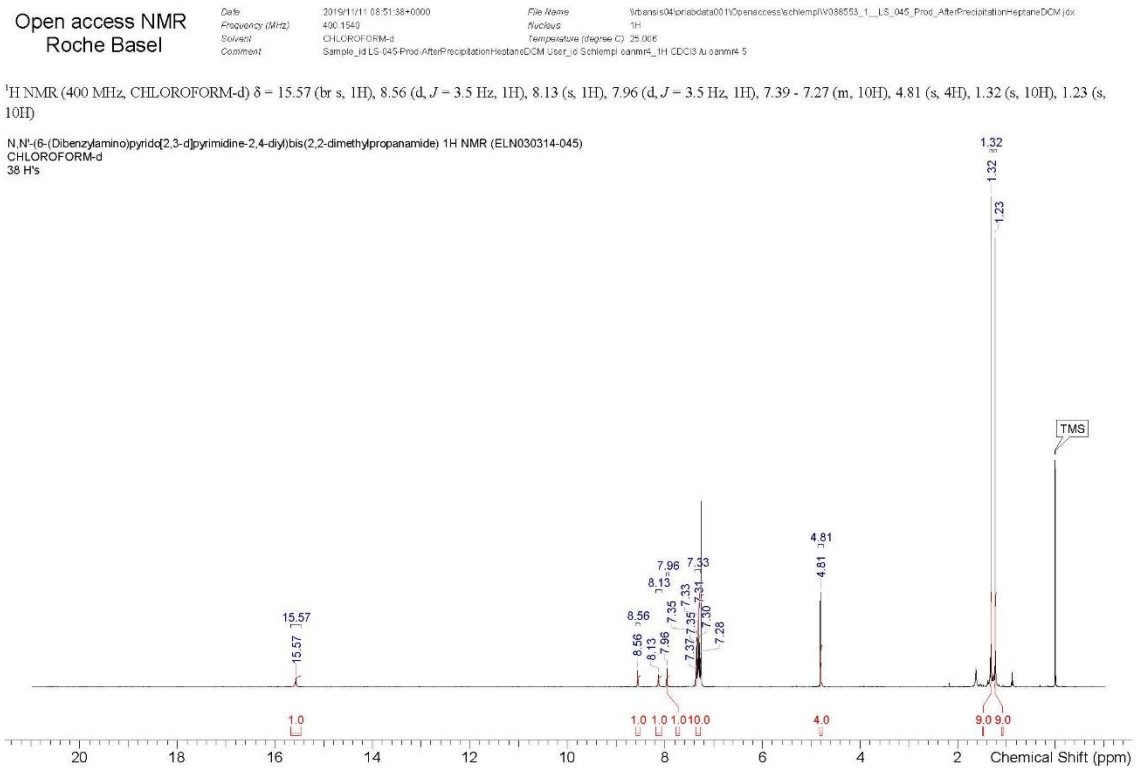


^{1}H NMR

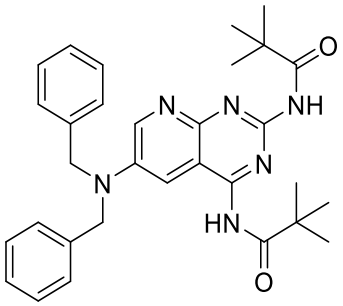


N,*N*'-(6-(Dibenzylamino)pyrido[2,3-*d*]pyrimidine-2,4-diyl)bis(2,2-dimethylpropanamide)

(49_25)

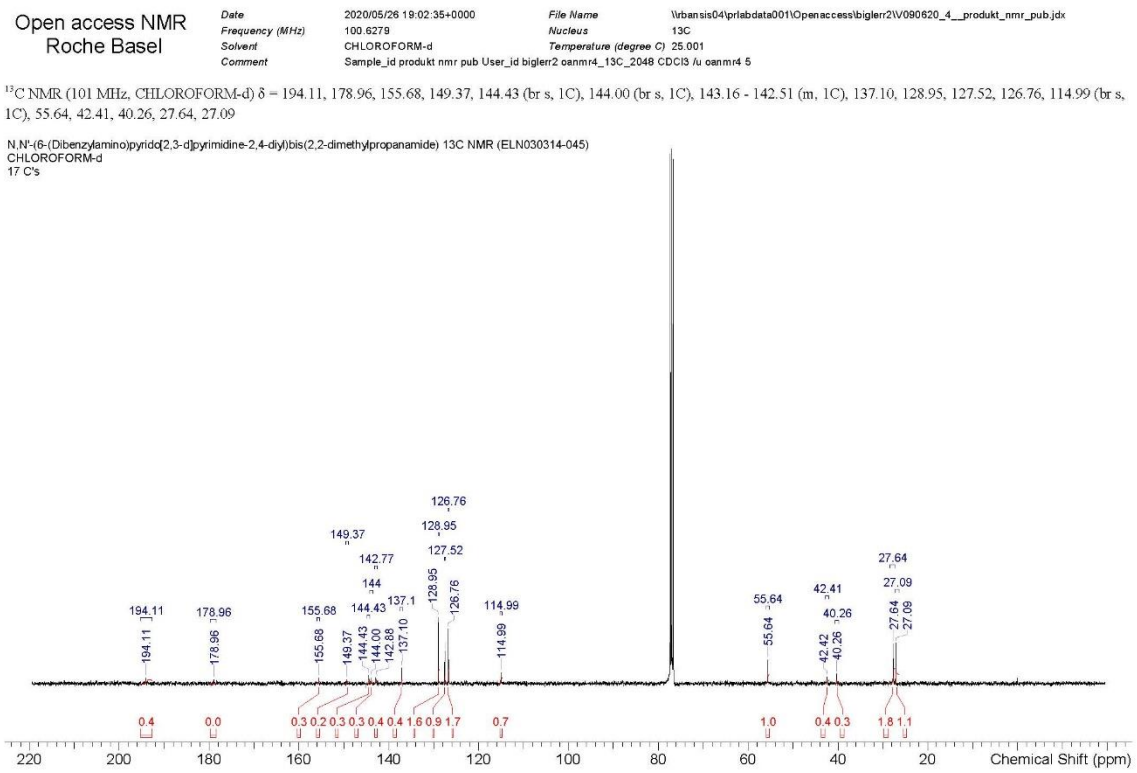


$^{13}C\{^{1}H\}$ NMR

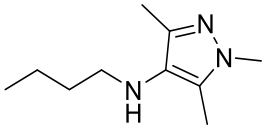


N,*N'*-(6-(Dibenzylamino)pyrido[2,3-*d*]pyrimidine-2,4-diyl)bis(2,2-dimethylpropanamide)

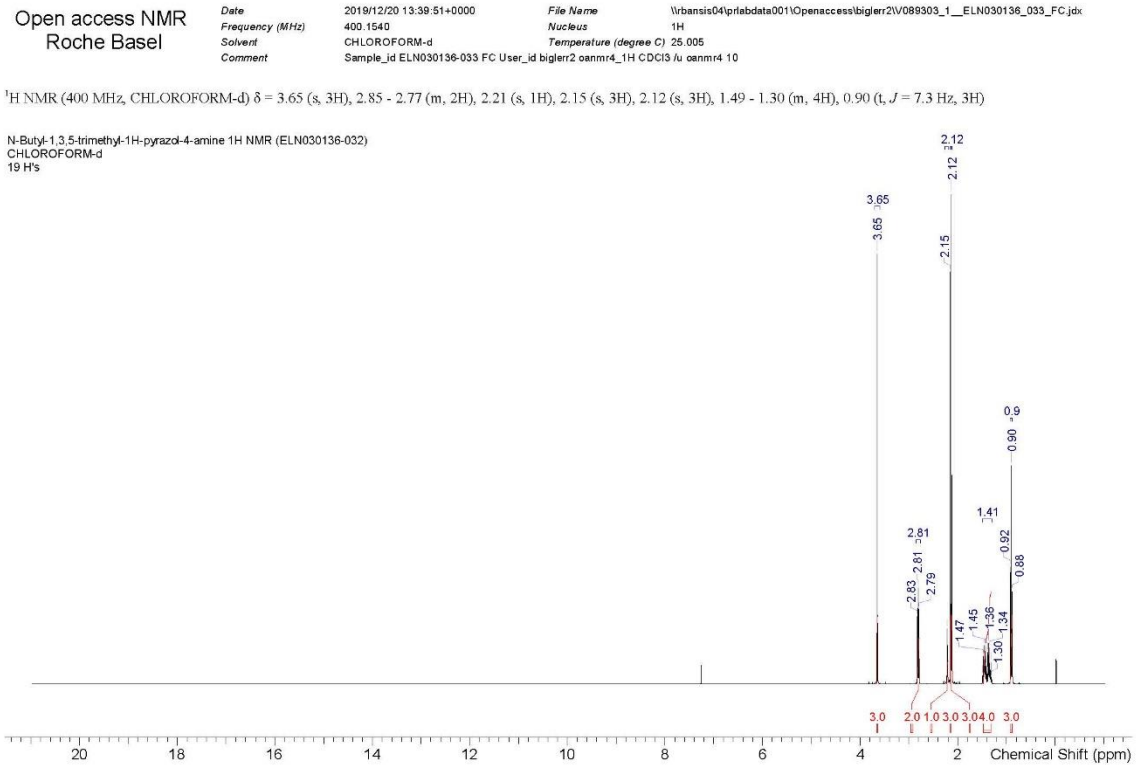
(49_25)



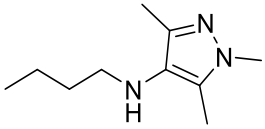
^{1}H NMR



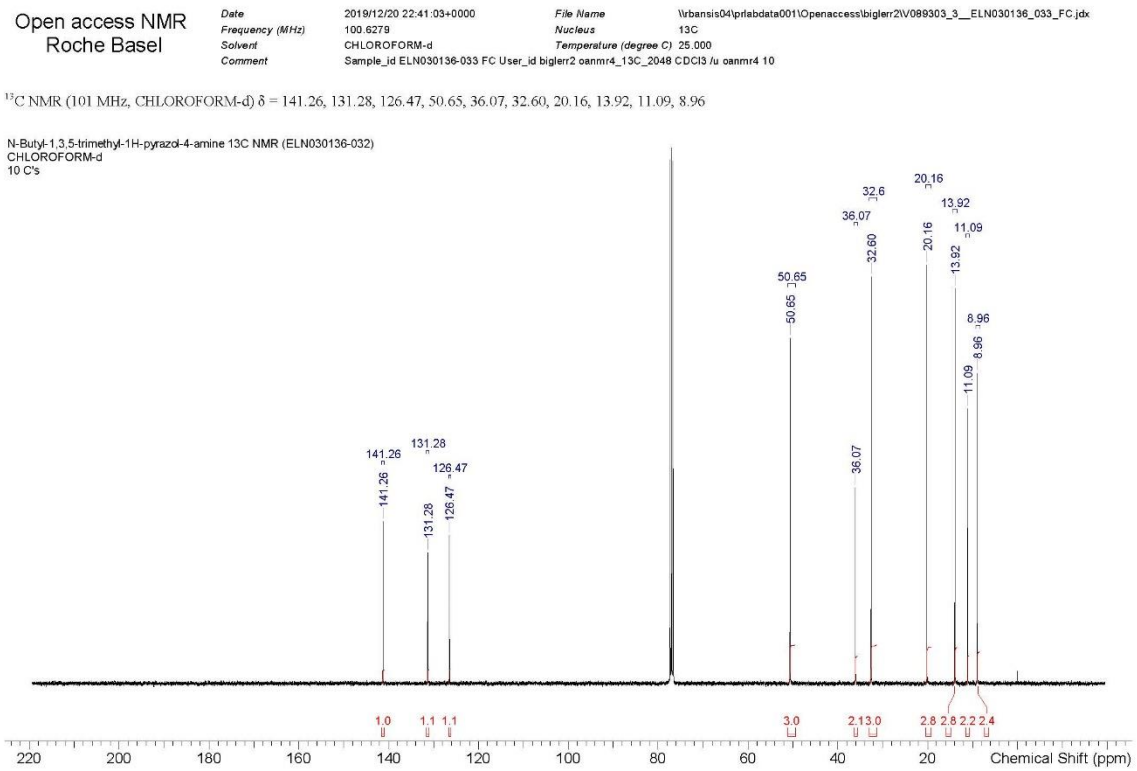
N-Butyl-1,3,5-trimethyl-1*H*-pyrazol-4-amine (intermediate 47_9)



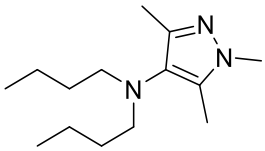
$^{13}C\{^{1}H\}$ NMR



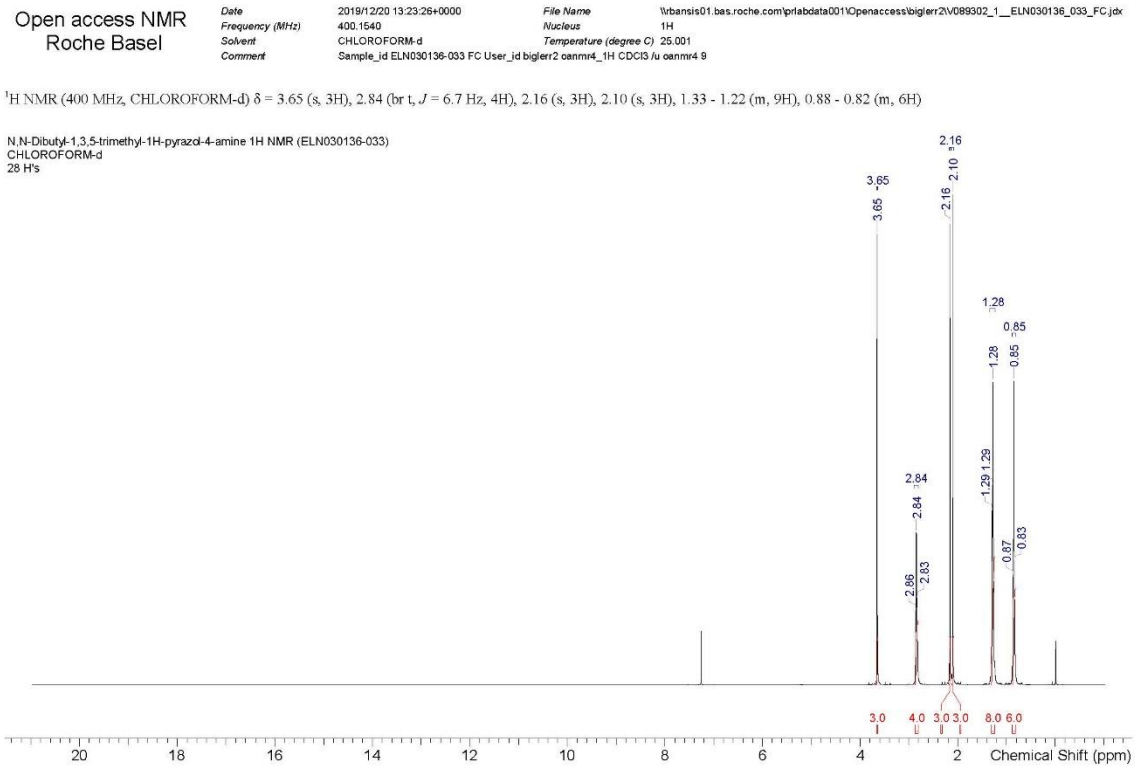
N-Butyl-1,3,5-trimethyl-1*H*-pyrazol-4-amine (intermediate 47_9)



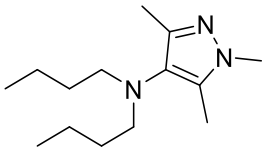
^{1}H NMR



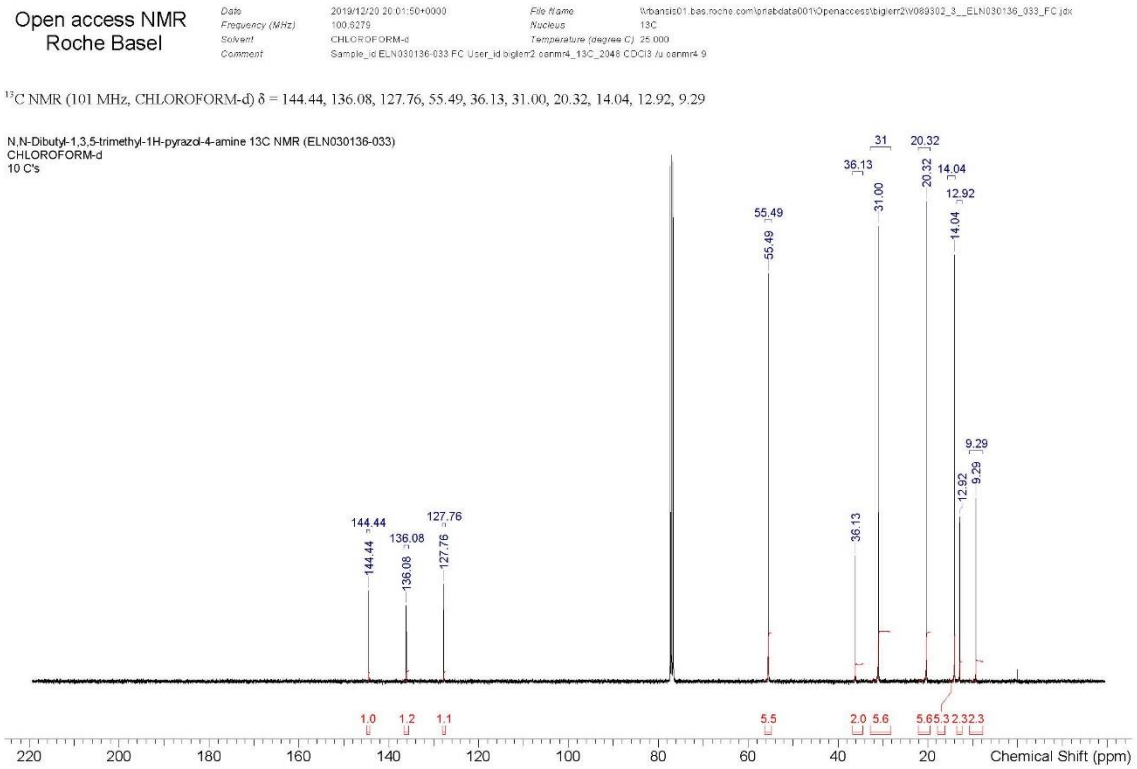
N,*N*-Dibutyl-1,3,5-trimethyl-1*H*-pyrazol-4-amine **(47_9)**



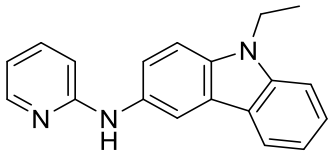
$^{13}C\{^{1}H\}$ NMR



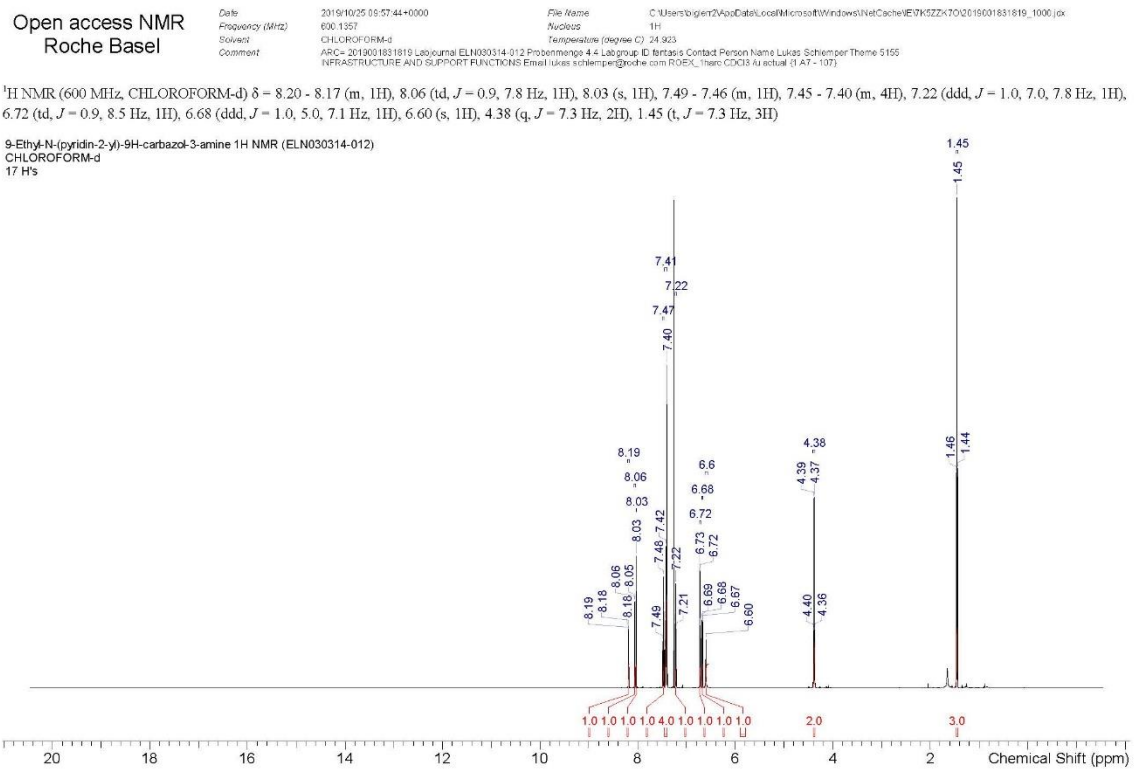
N,*N*-Dibutyl-1,3,5-trimethyl-1*H*-pyrazol-4-amine **(47_9)**



^{1}H NMR

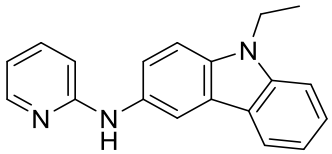


9-Ethyl-*N*-(pyridin-2-yl)-9*H*-carbazol-3-amine (**11_33**)

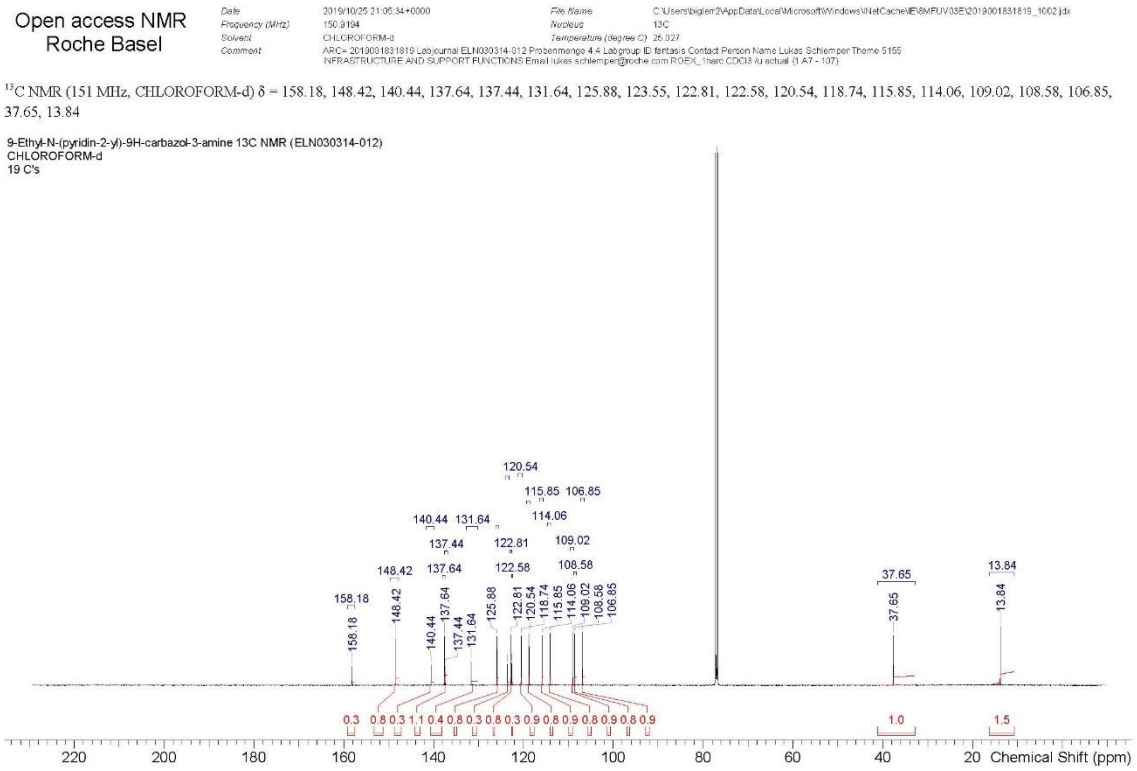


^{1}H NMR (600 MHz, CHLOROFORM-d) δ = 8.20 - 8.17 (m, 1H), 8.06 (td, *J* = 0.9, 7.8 Hz, 1H), 8.03 (s, 1H), 7.49 - 7.46 (m, 1H), 7.45 - 7.40 (m, 4H), 7.22 (ddd, *J* = 1.0, 7.0, 7.8 Hz, 1H), 6.72 (td, *J* = 0.9, 8.5 Hz, 1H), 6.68 (ddd, *J* = 1.0, 5.0, 7.1 Hz, 1H), 6.60 (s, 1H), 4.38 (q, *J* = 7.3 Hz, 2H), 1.45 (t, *J* = 7.3 Hz, 3H)

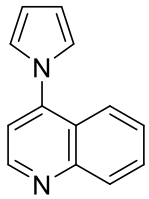
$^{13}C\{^{1}H\}$ NMR



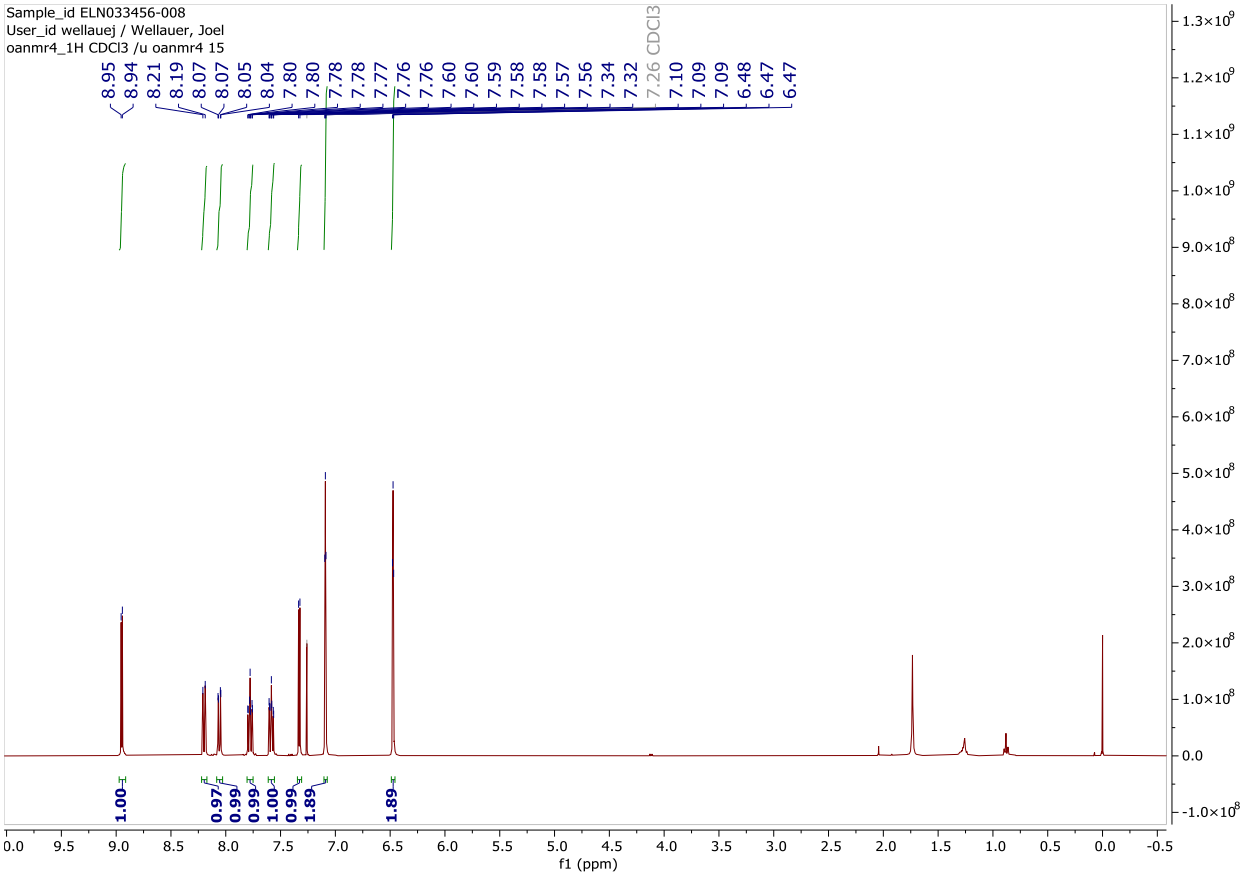
9-Ethyl-*N*-(pyridin-2-yl)-9*H*-carbazol-3-amine (**11_33**)



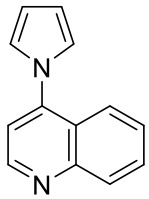
^{1}H NMR



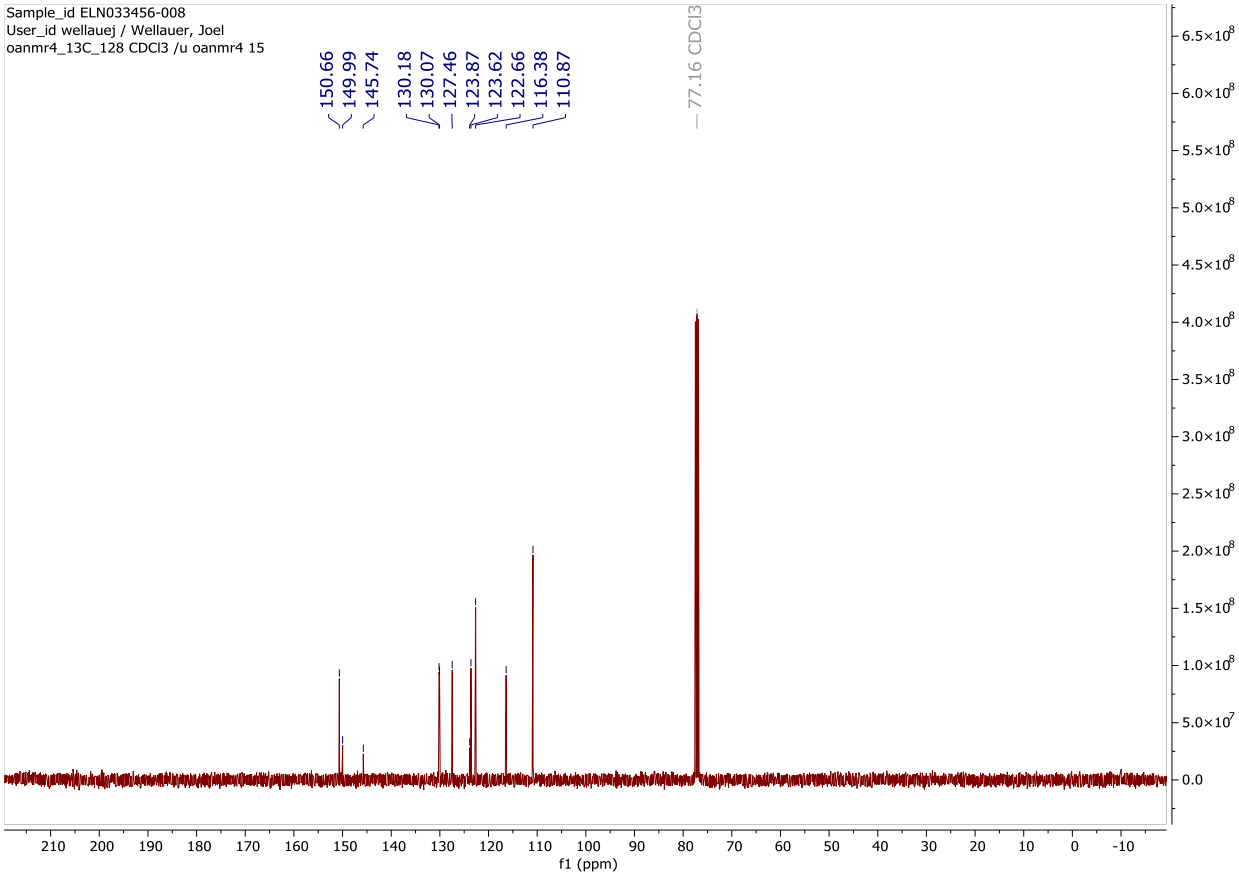
4-(1H-pyrrol-1-yl)quinoline (17_30)



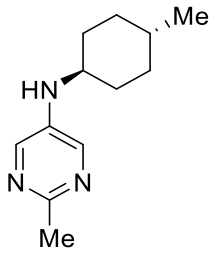
$^{13}C\{^{1}H\}$ NMR



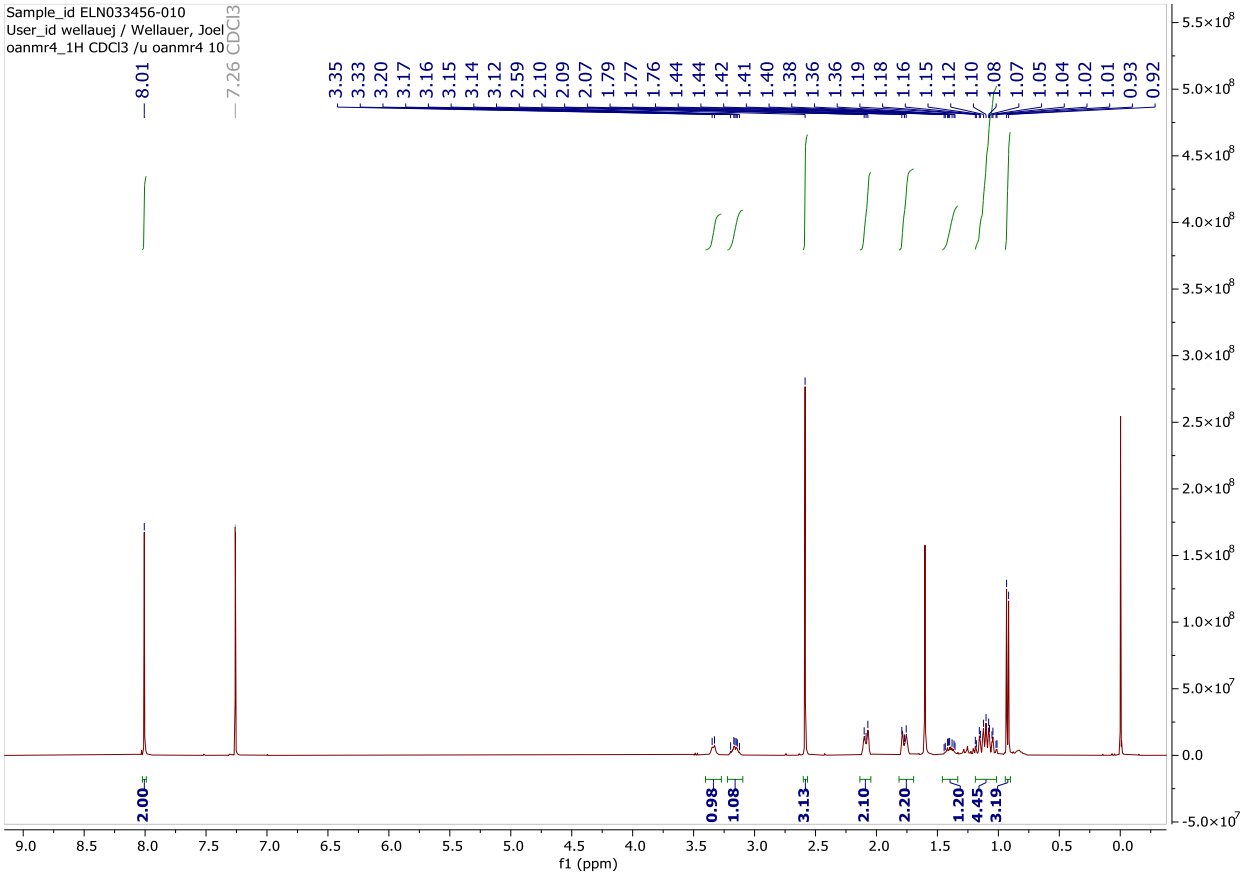
4-(1H-pyrrol-1-yl)quinoline (17_30)



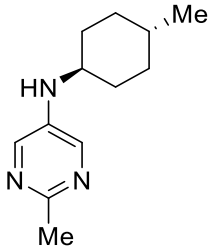
^{1}H NMR



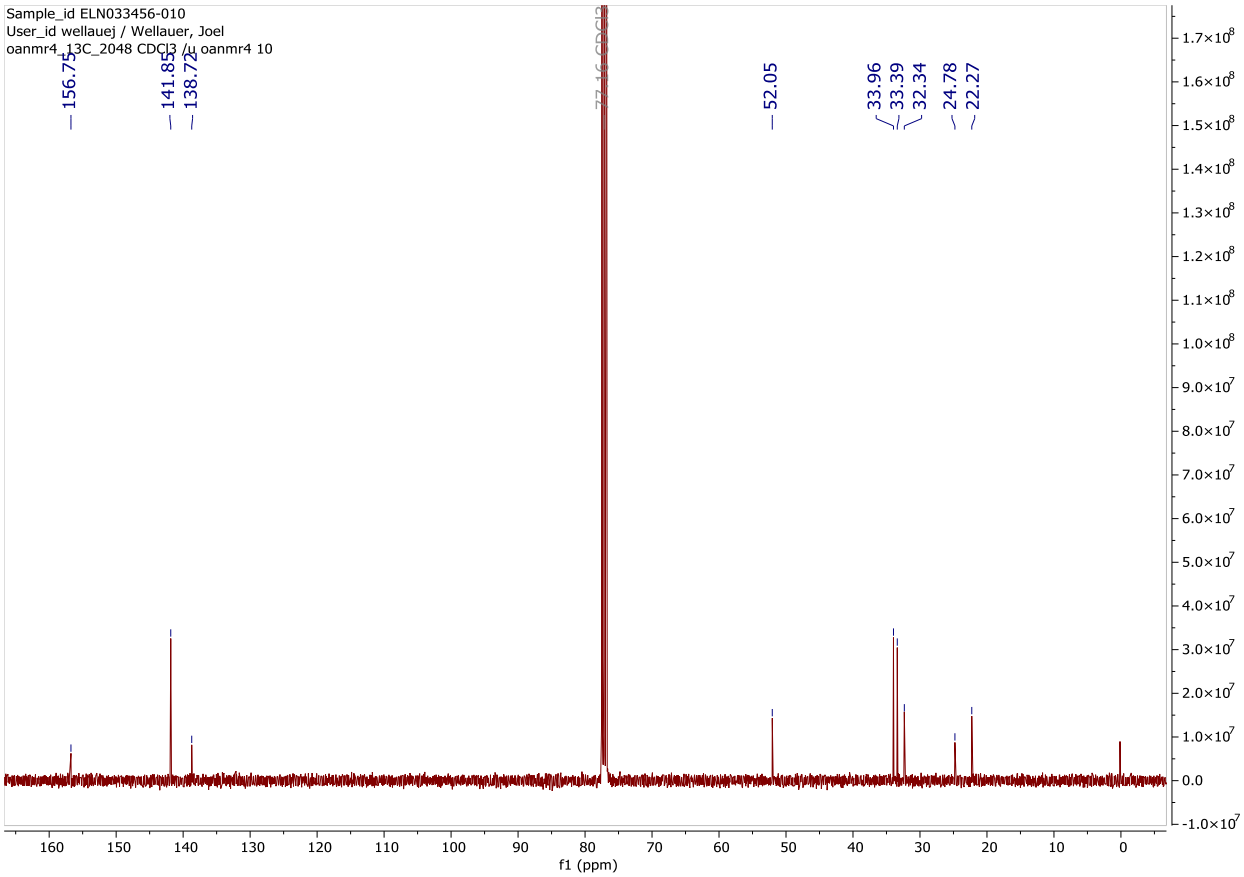
2-methyl-N-((1r,4r)-4-methylcyclohexyl)pyrimidin-5-amine (36_17)



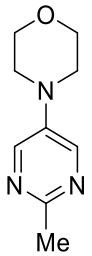
$^{13}C\{^{1}H\}$ NMR



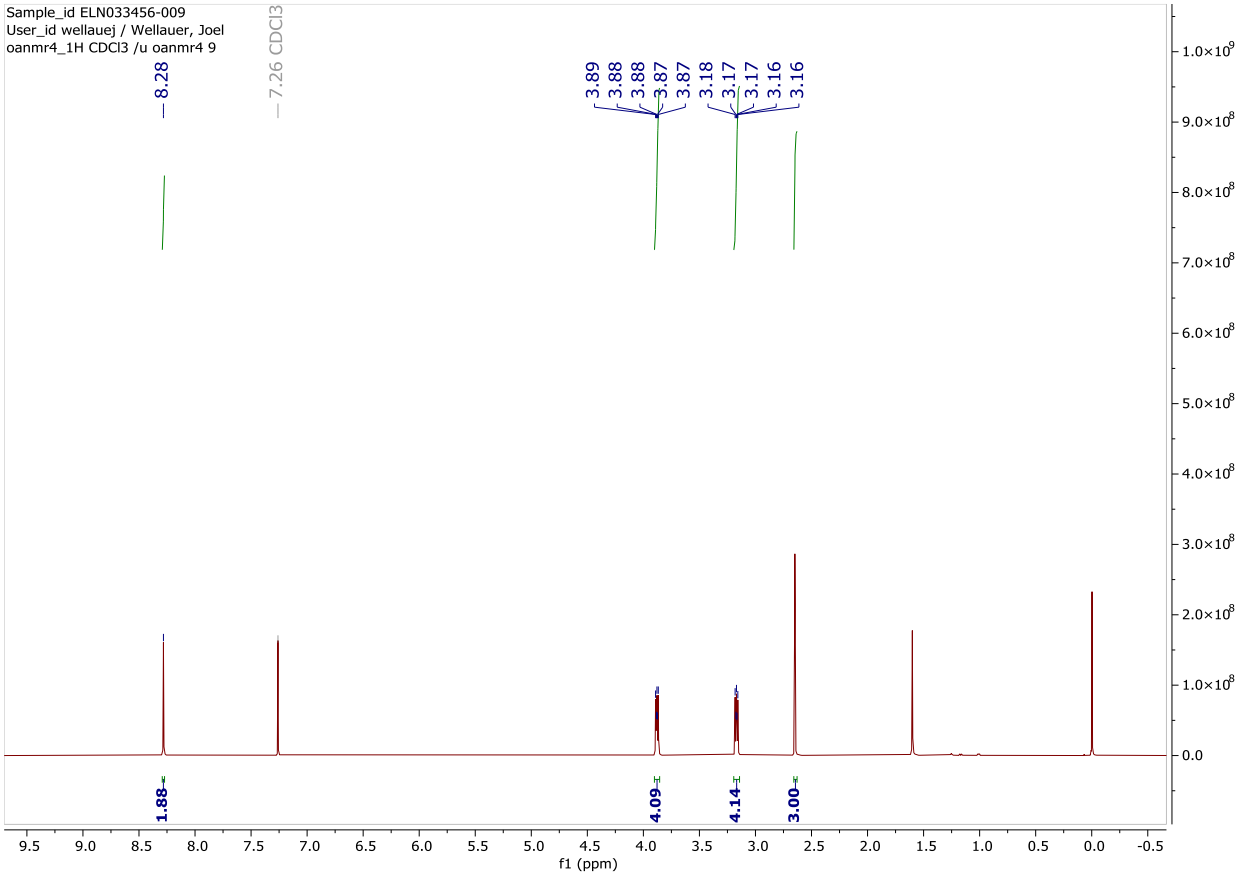
2-methyl-N-((1r,4r)-4-methylcyclohexyl)pyrimidin-5-amine (36_17)



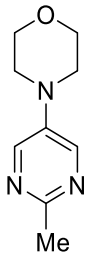
^{1}H NMR



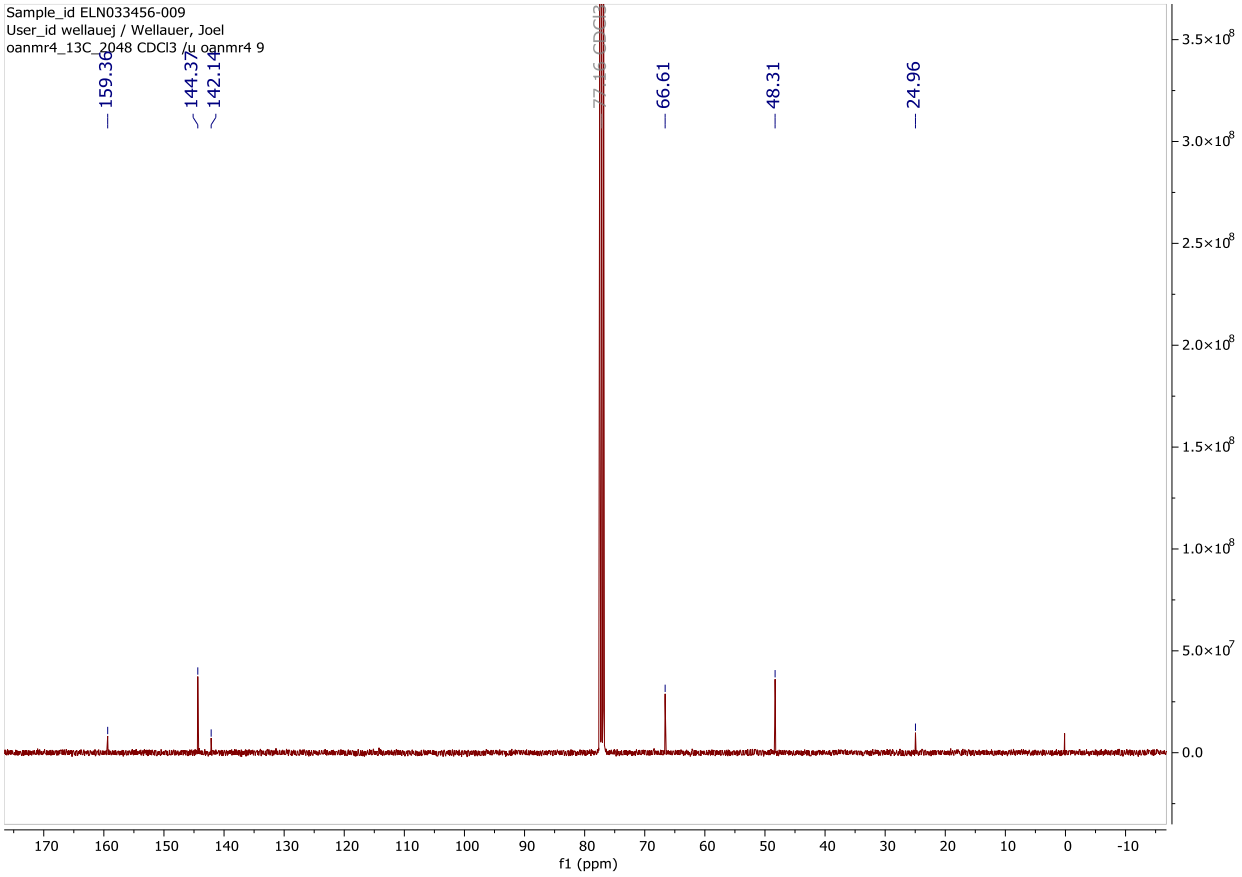
4-(2-methylpyrimidin-5-yl)morpholine (43_17)



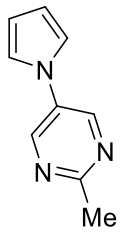
$^{13}C\{^{1}H\}$ NMR



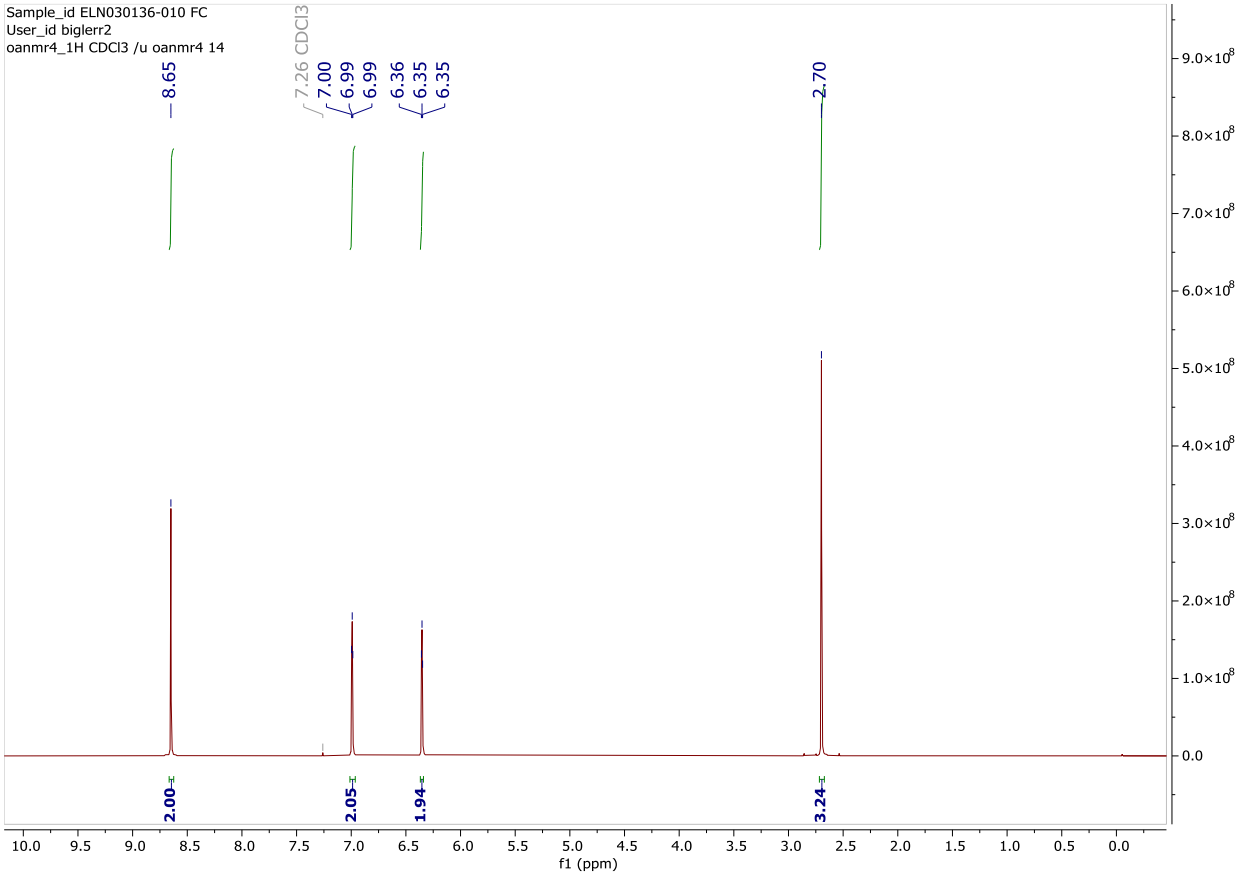
4-(2-methylpyrimidin-5-yl)morpholine (43_17)



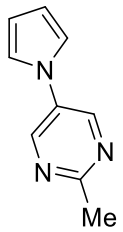
^{1}H NMR



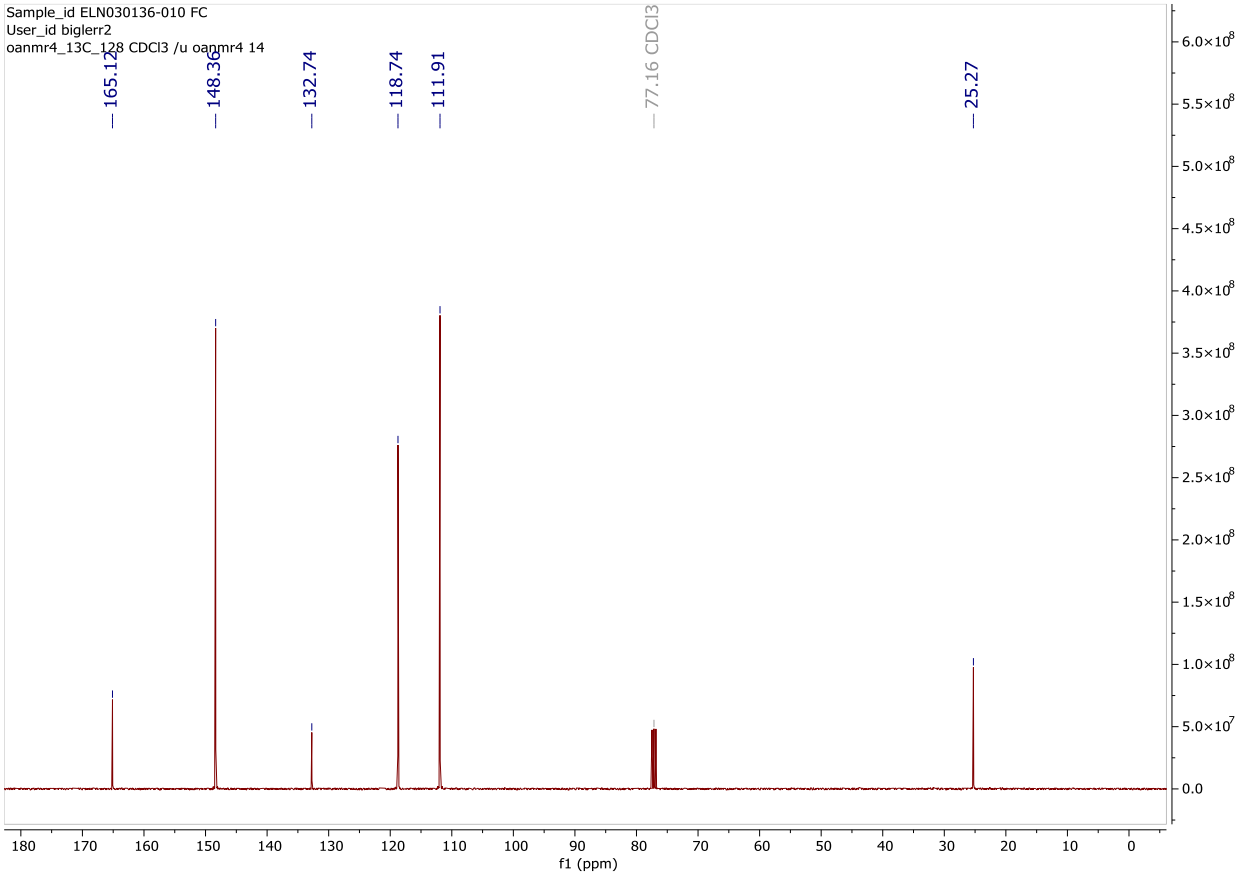
2-methyl-5-(1H-pyrrol-1-yl)pyrimidine (17_24)



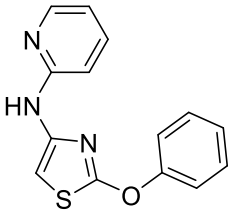
$^{13}C\{^{1}H\}$ NMR



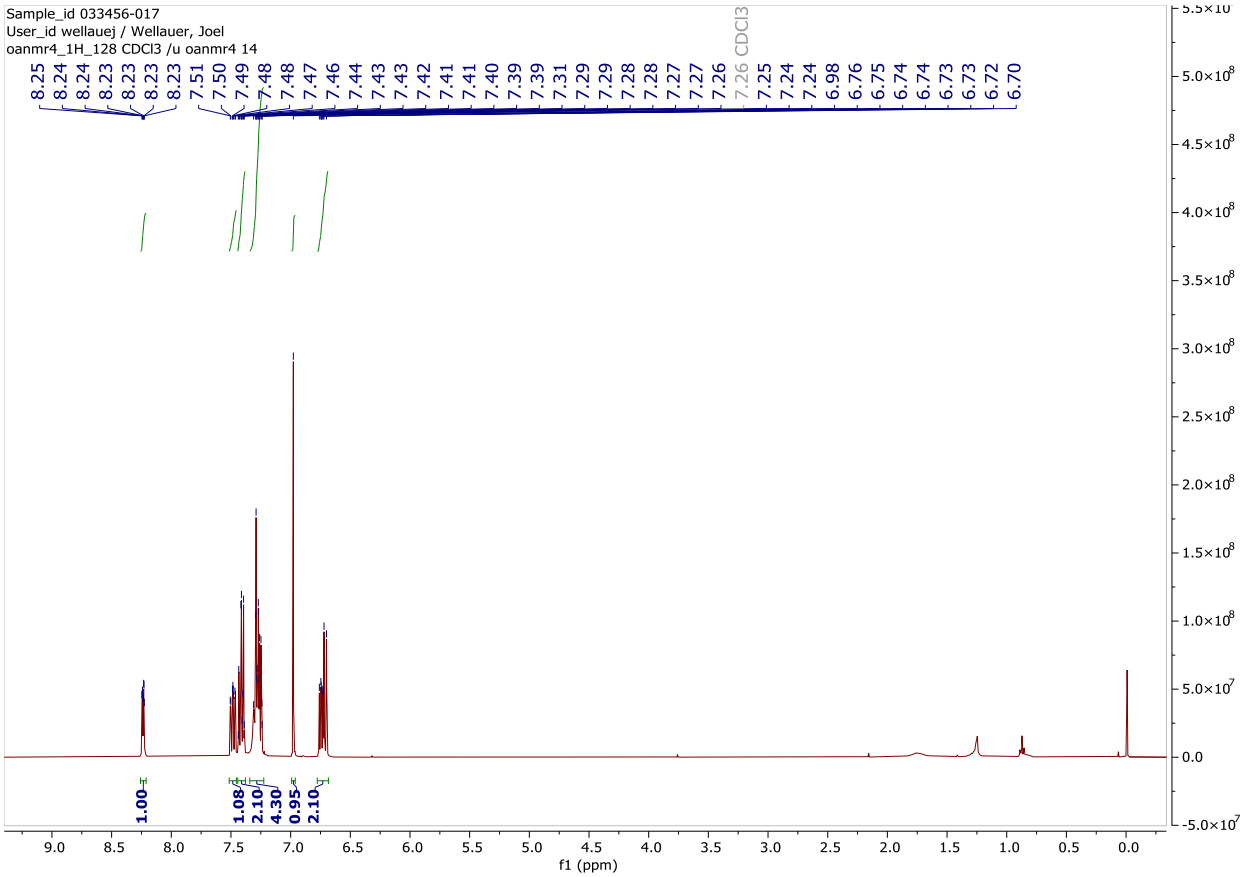
2-methyl-5-(1H-pyrrol-1-yl)pyrimidine (17_24)



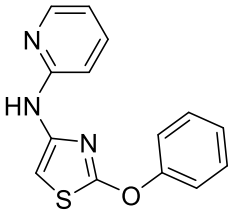
^{1}H NMR



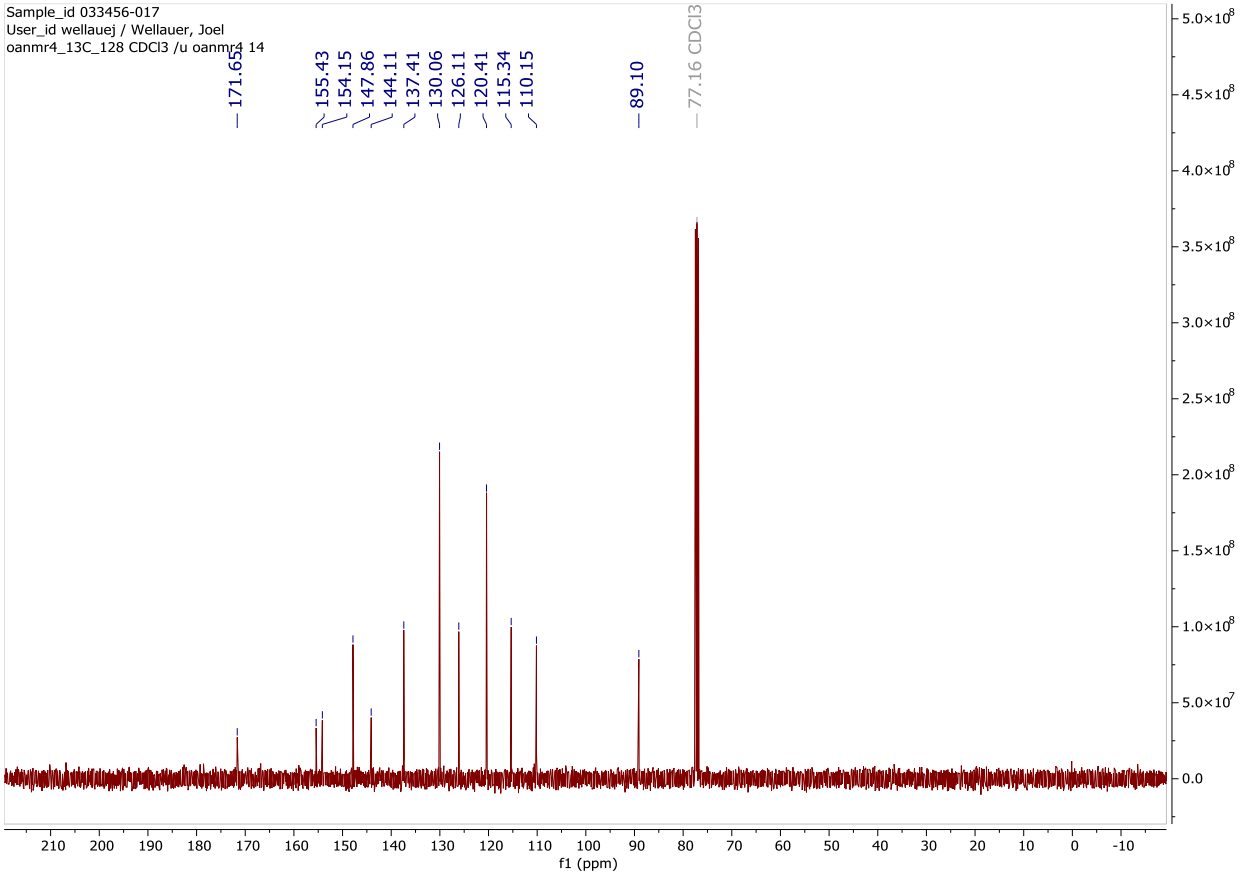
2-phenoxy-N-(pyridin-2-yl)thiazol-4-amine (11_38)



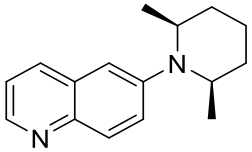
$^{13}C\{^{1}H\}$ NMR



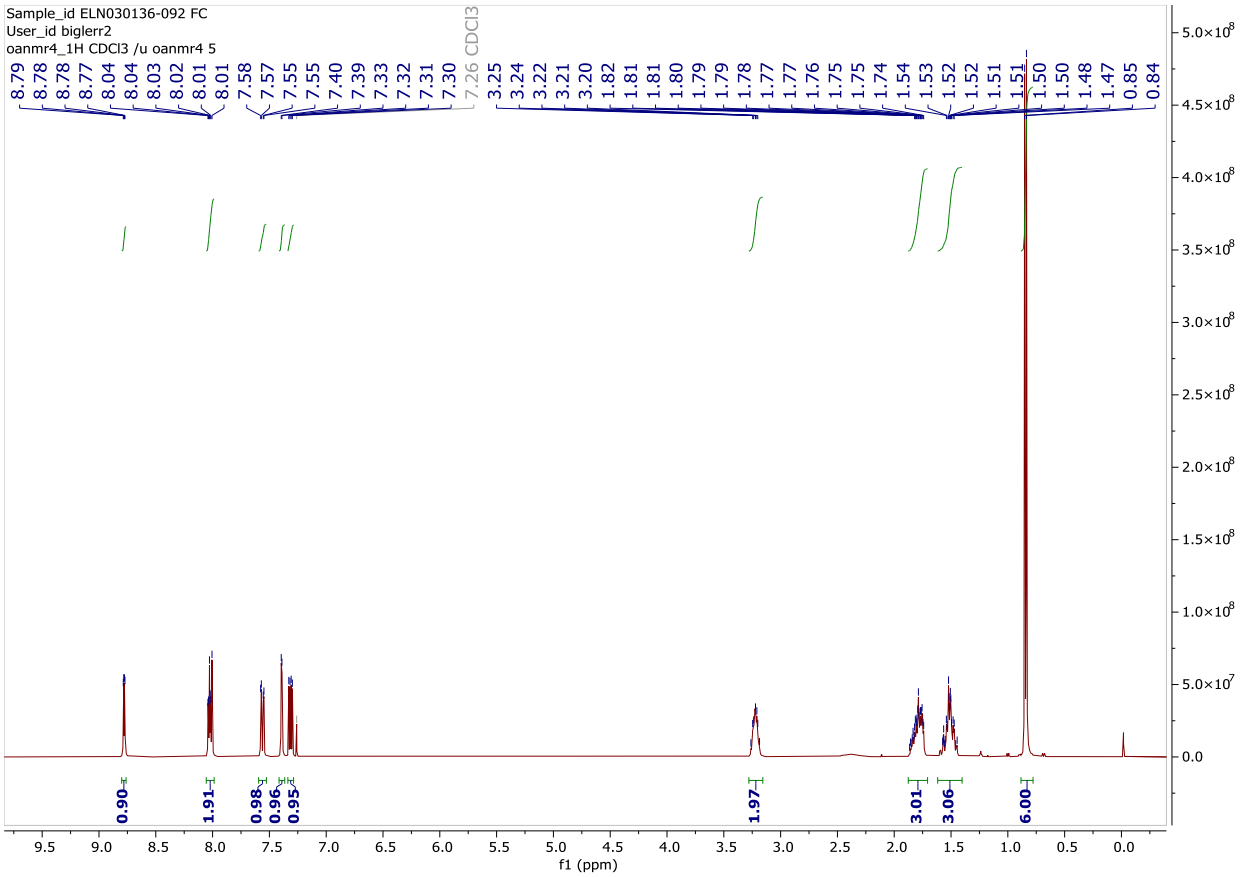
2-phenoxy-N-(pyridin-2-yl)thiazol-4-amine (11_38)



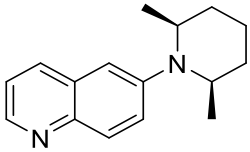
^{1}H NMR



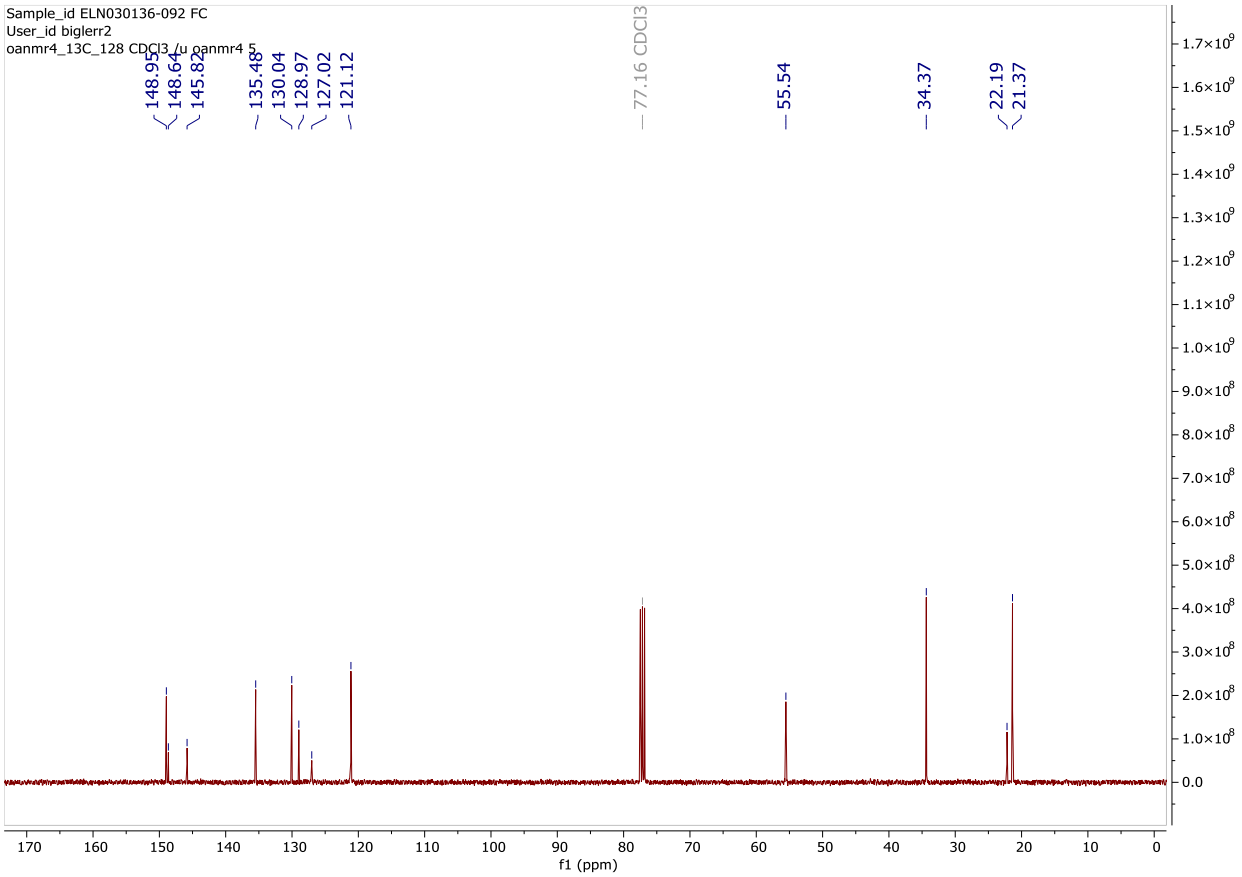
6-((2R,6S)-2,6-dimethylpiperidin-1-yl)quinoline (40_26)



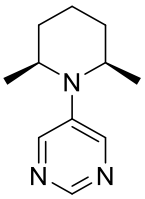
$^{13}C\{^{1}H\}$ NMR



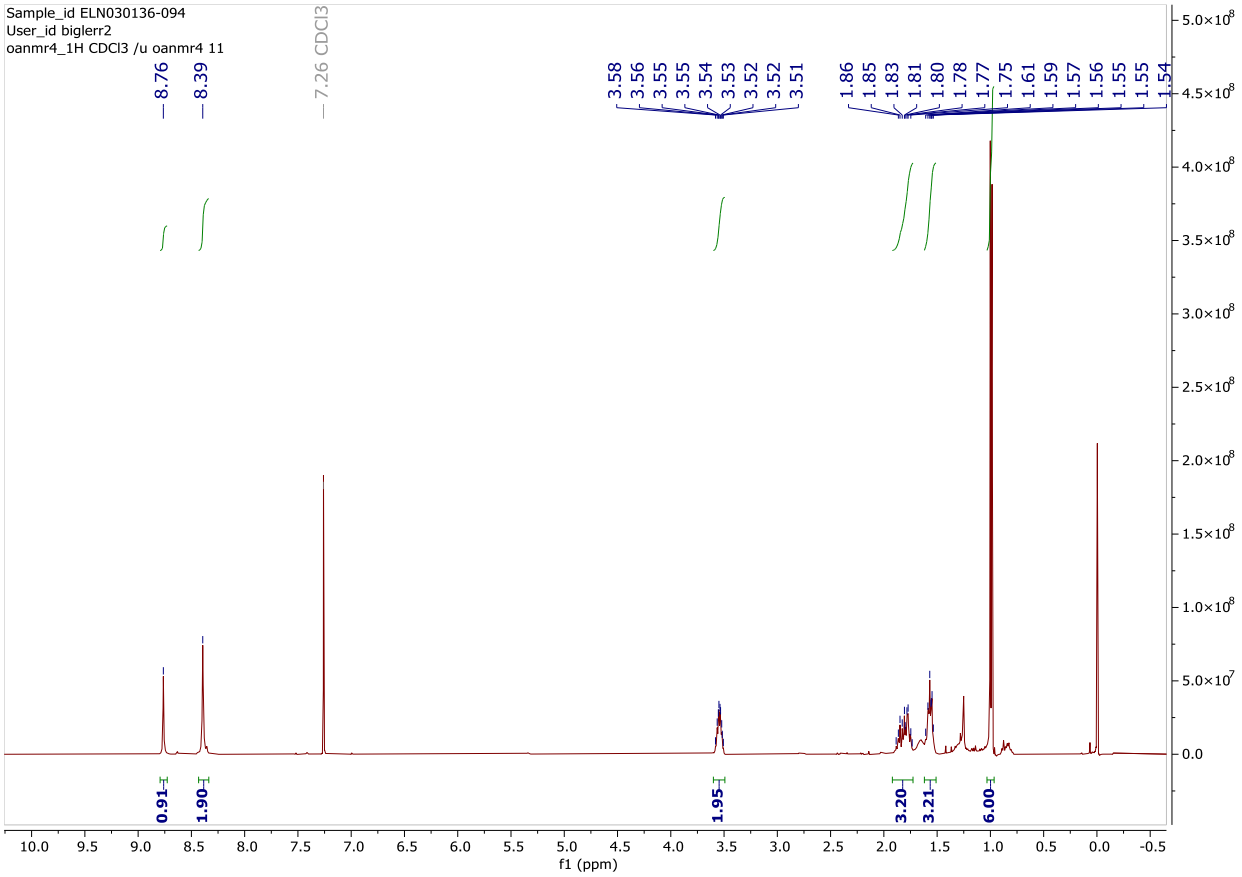
6-((2R,6S)-2,6-dimethylpiperidin-1-yl)quinoline (40_26)



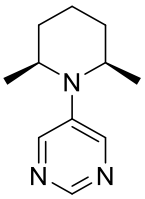
^{1}H NMR



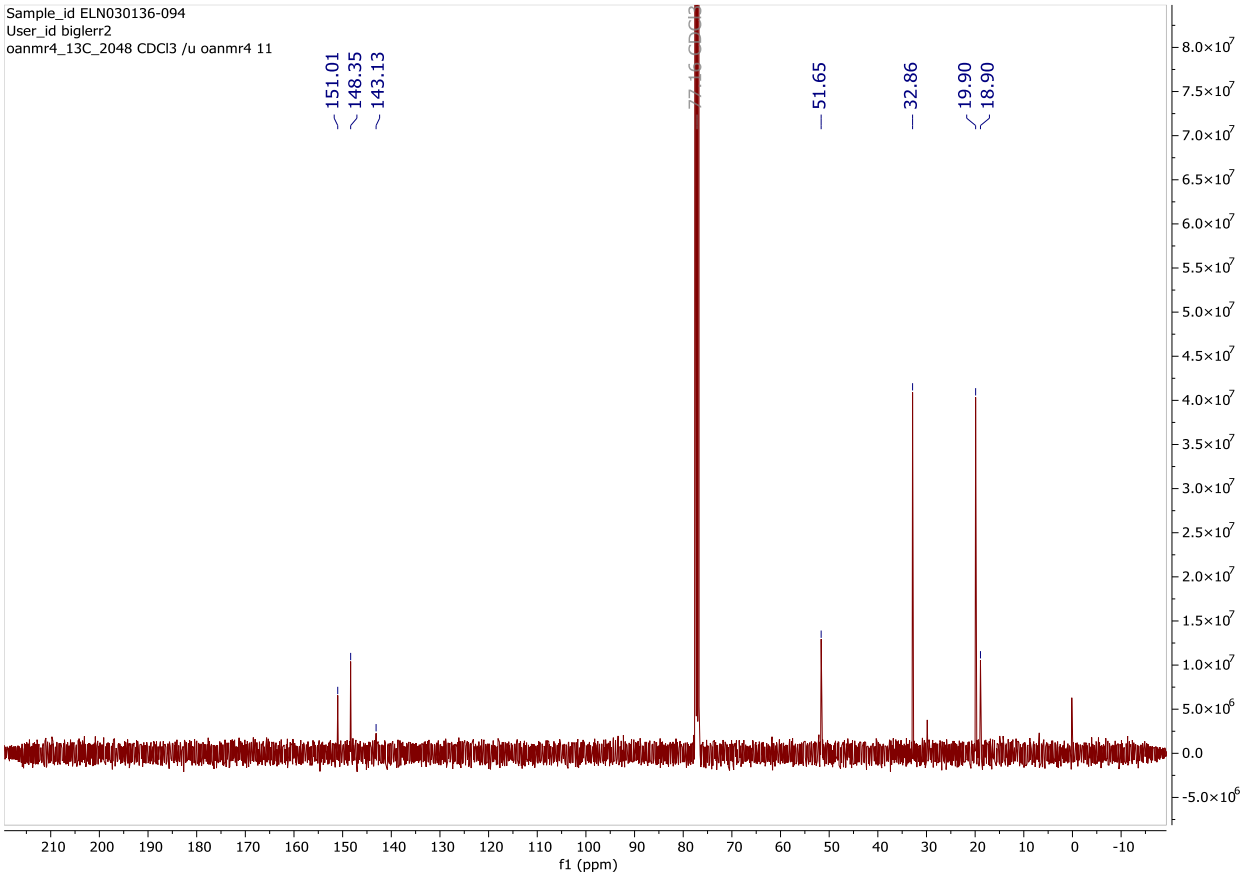
5-((2R,6S)-2,6-dimethylpiperidin-1-yl)pyrimidine (40_24)



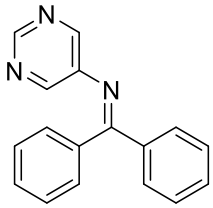
$^{13}C\{^{1}H\}$ NMR



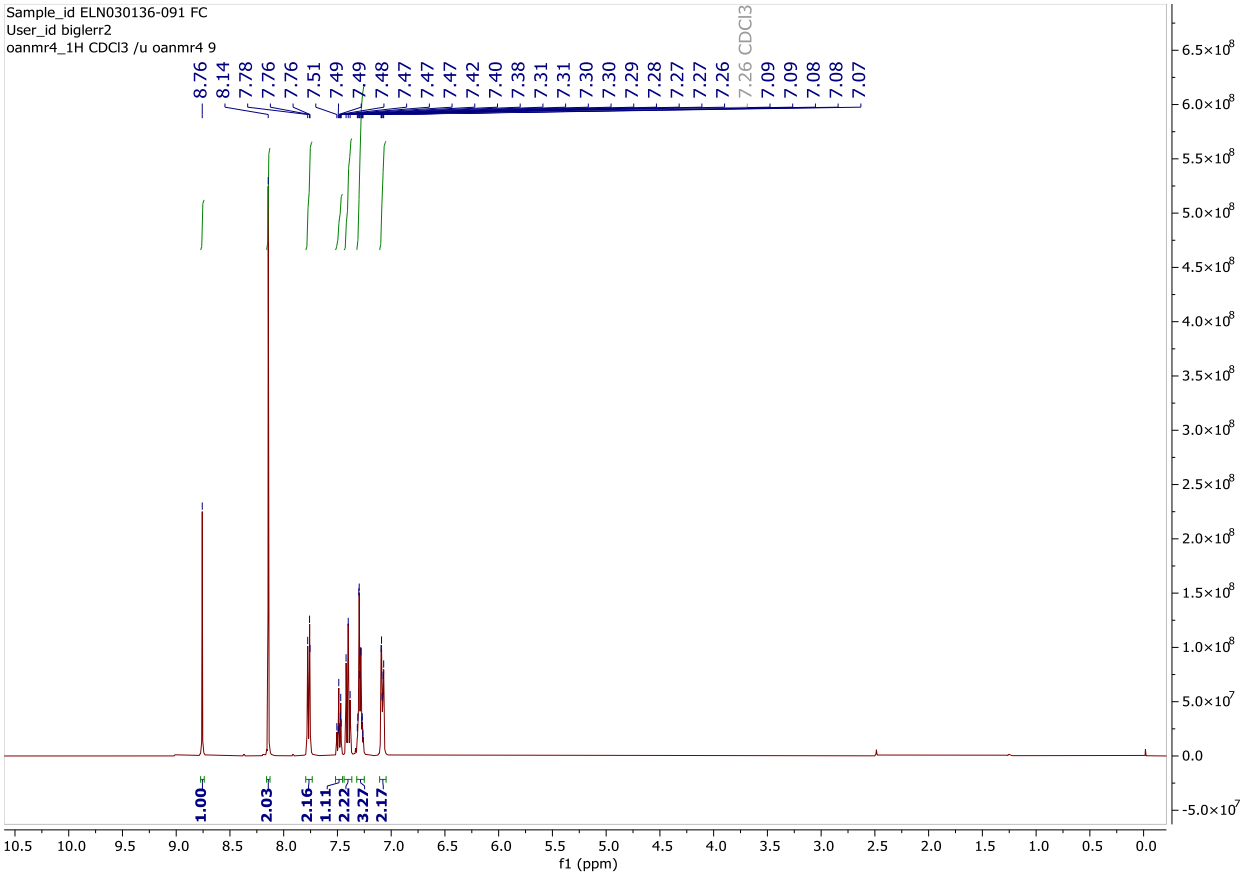
5-((2R,6S)-2,6-dimethylpiperidin-1-yl)pyrimidine (40_24)



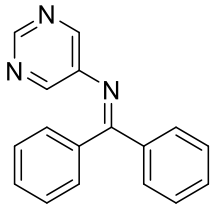
^{1}H NMR



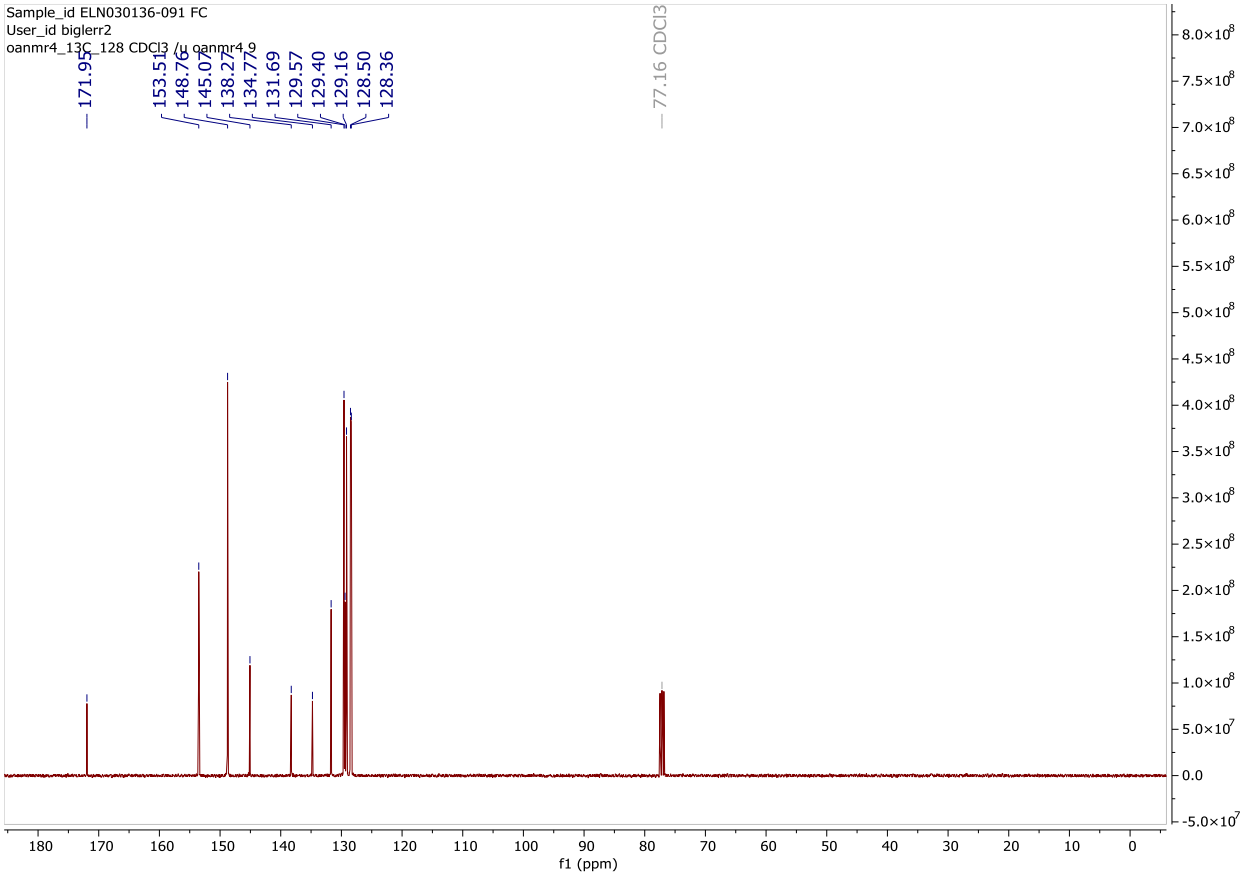
1,1-diphenyl-N-(pyrimidin-5-yl)methanimine (23_24)



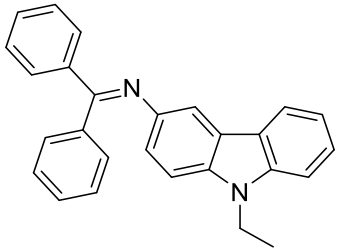
$^{13}C\{^{1}H\}$ NMR



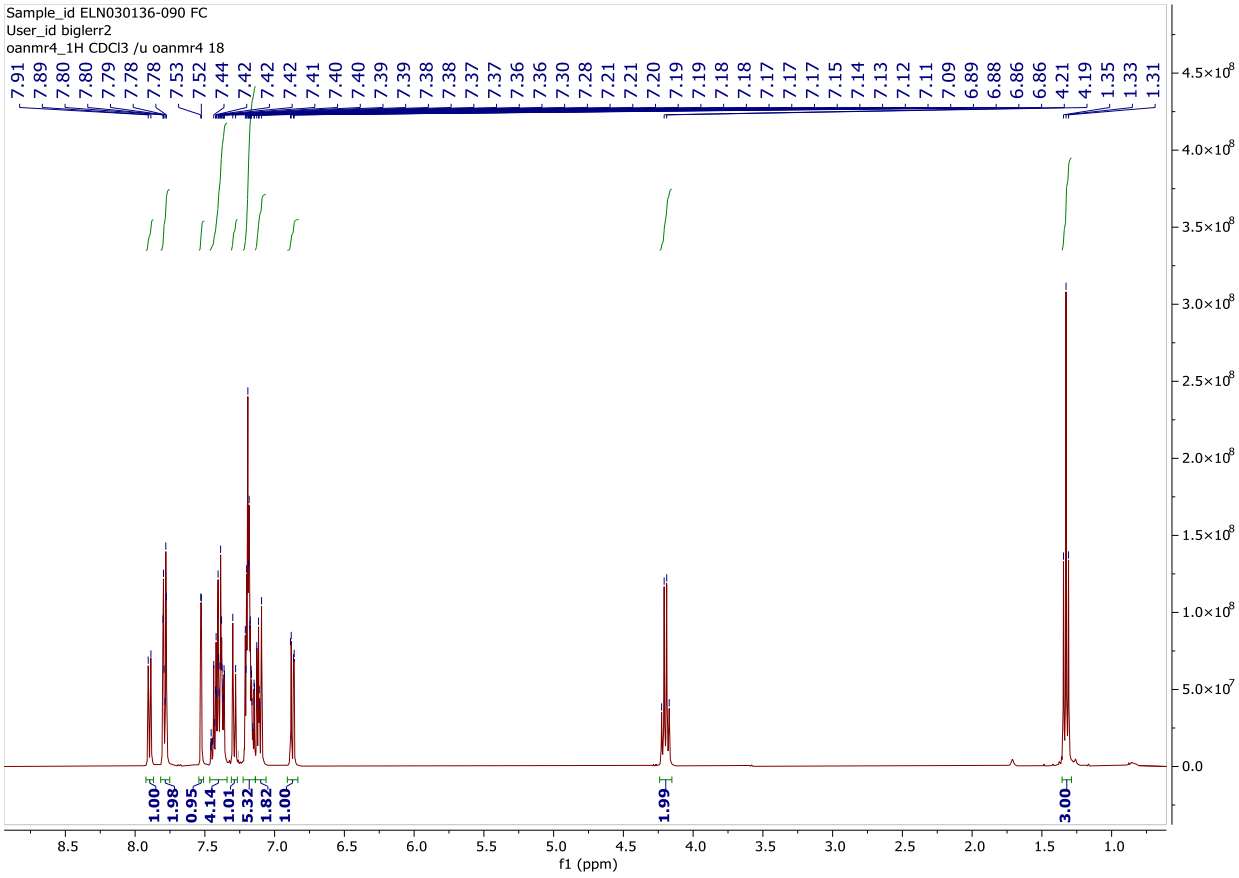
1,1-diphenyl-N-(pyrimidin-5-yl)methanimine (23_24)



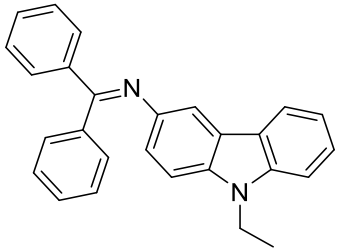
^{1}H NMR



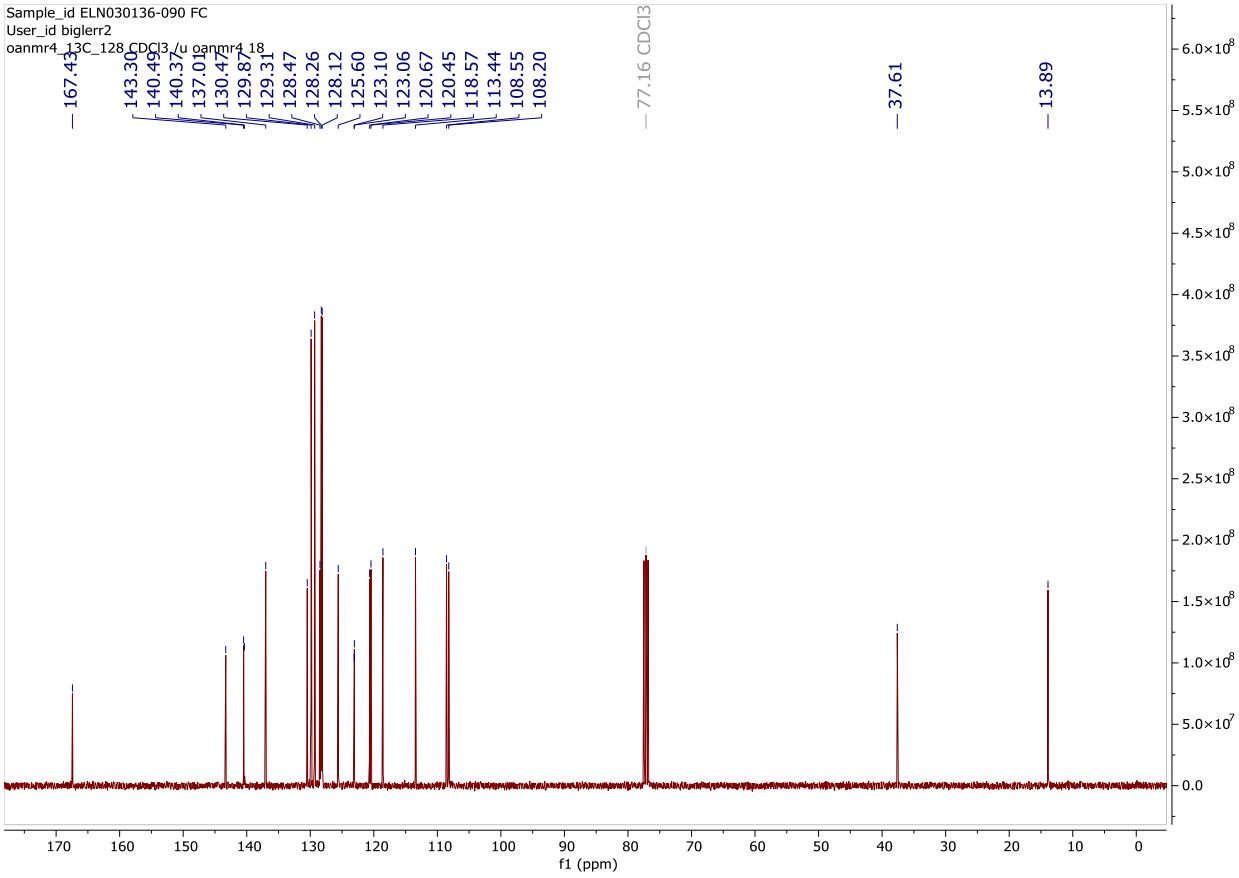
N-(9-ethyl-9H-carbazol-3-yl)-1,1-diphenylmethanimine (23_33)



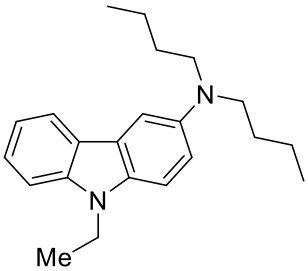
$^{13}C\{^{1}H\}$ NMR



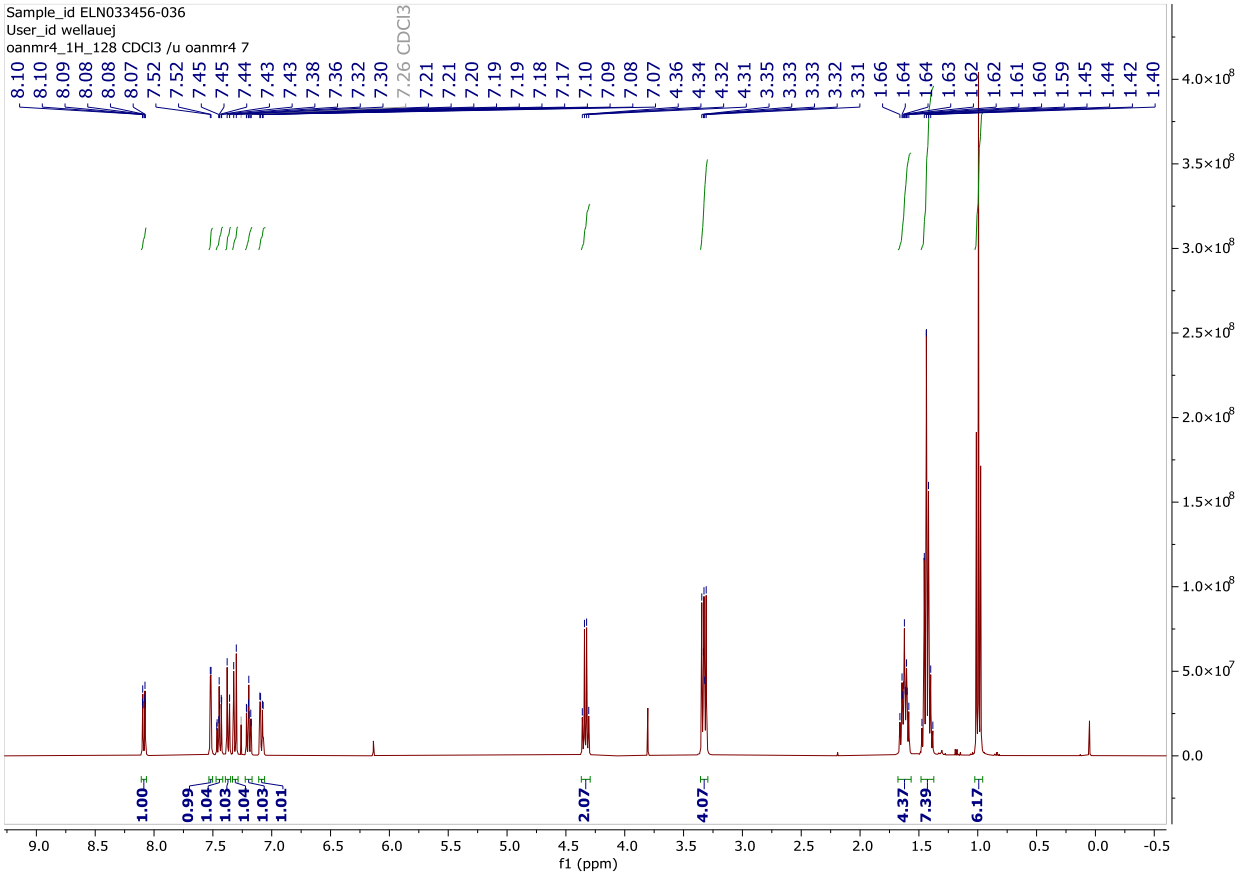
N-(9-ethyl-9H-carbazol-3-yl)-1,1-diphenylmethanimine (23_33)



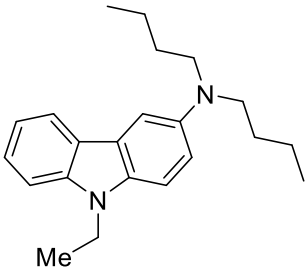
^{1}H NMR



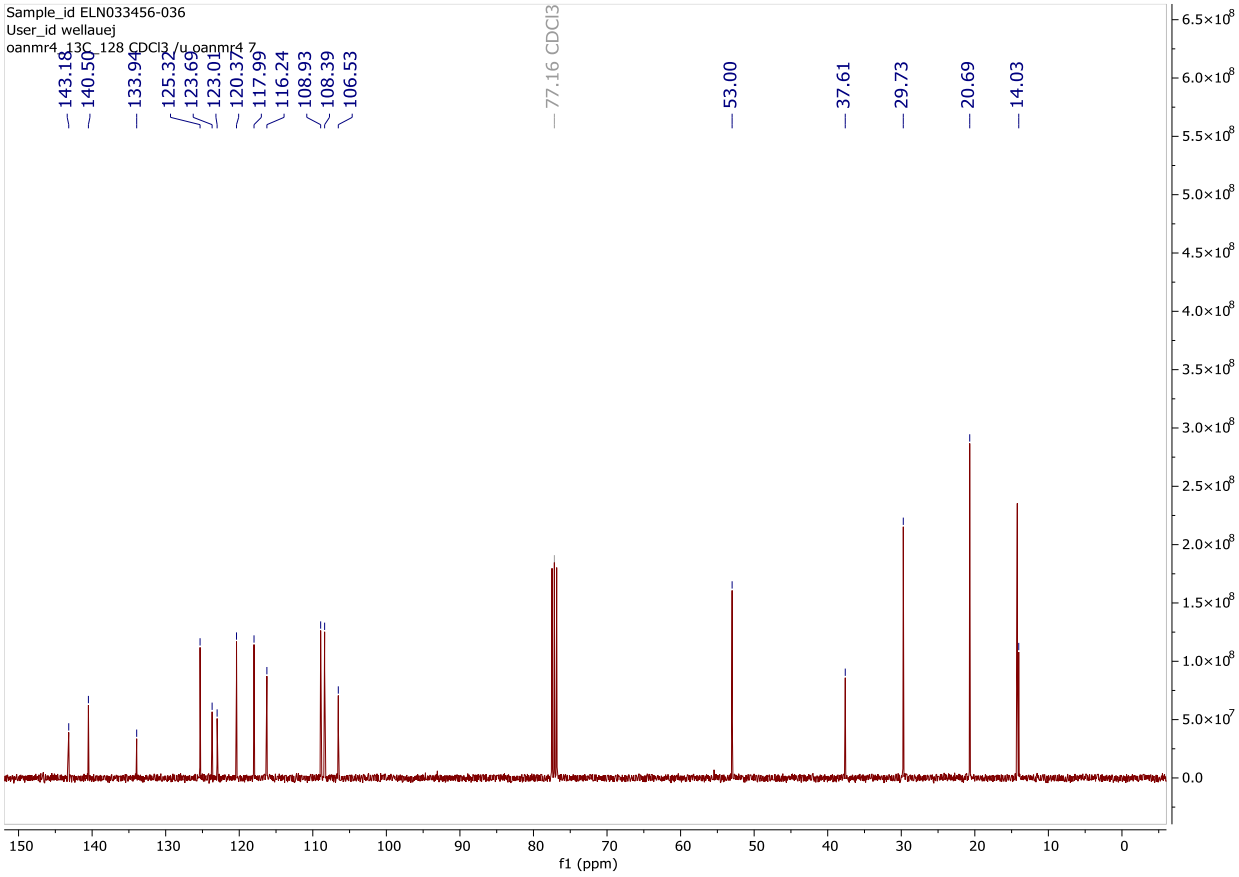
N,N-dibutyl-9-ethyl-9H-carbazol-3-amine (47_33)



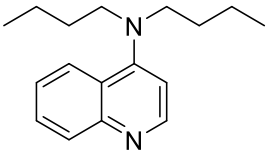
$^{13}C\{^{1}H\}$ NMR



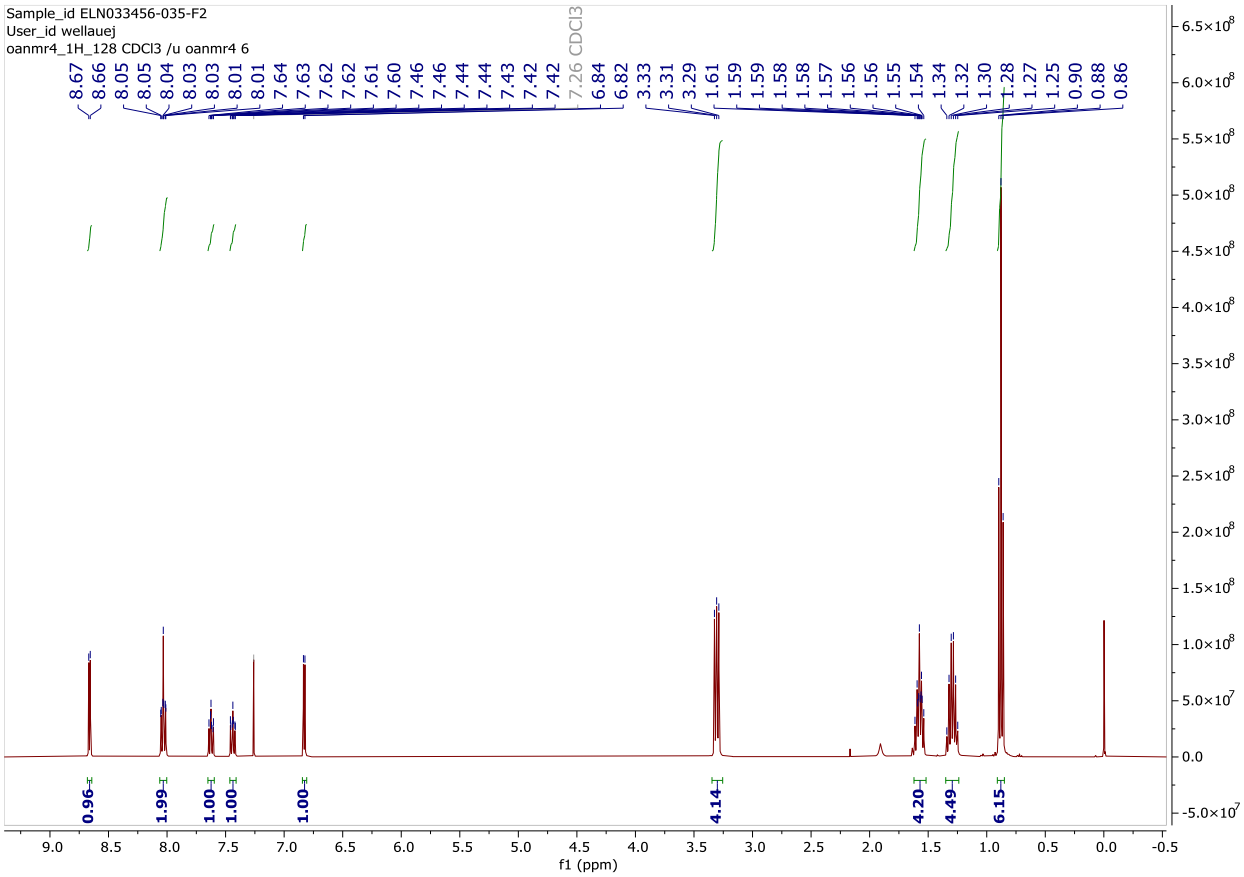
N,N-dibutyl-9-ethyl-9H-carbazol-3-amine (47_33)



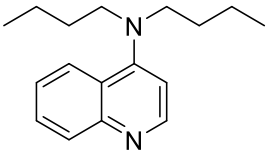
^{1}H NMR



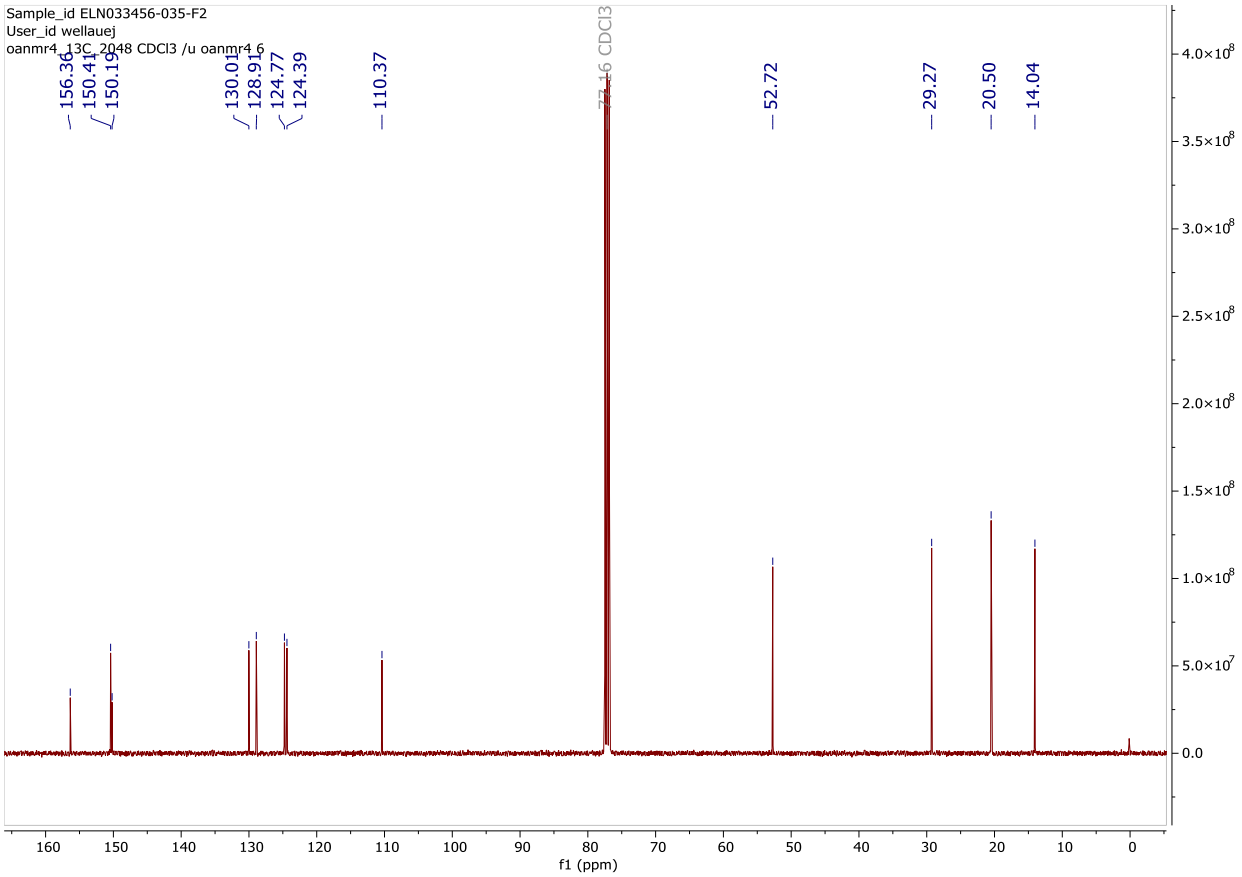
N,N-dibutylquinolin-4-amine (47_30)



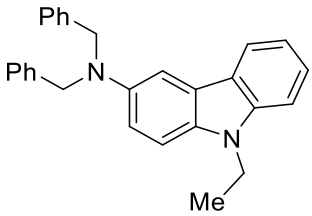
$^{13}C\{^{1}H\}$ NMR



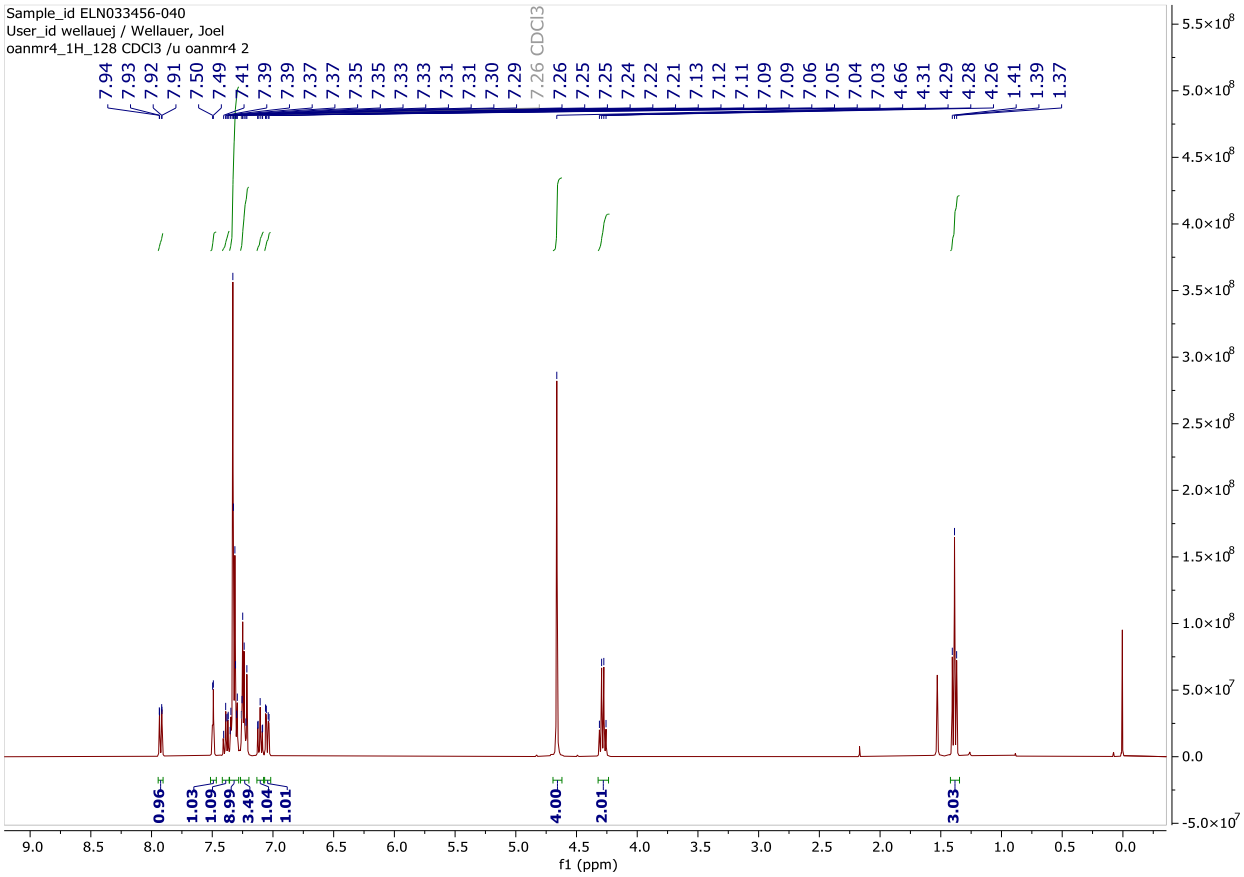
N,N-dibutylquinolin-4-amine (47_30)



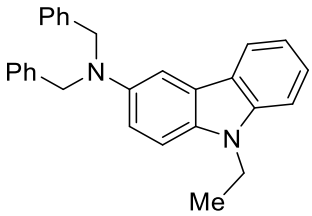
^{1}H NMR



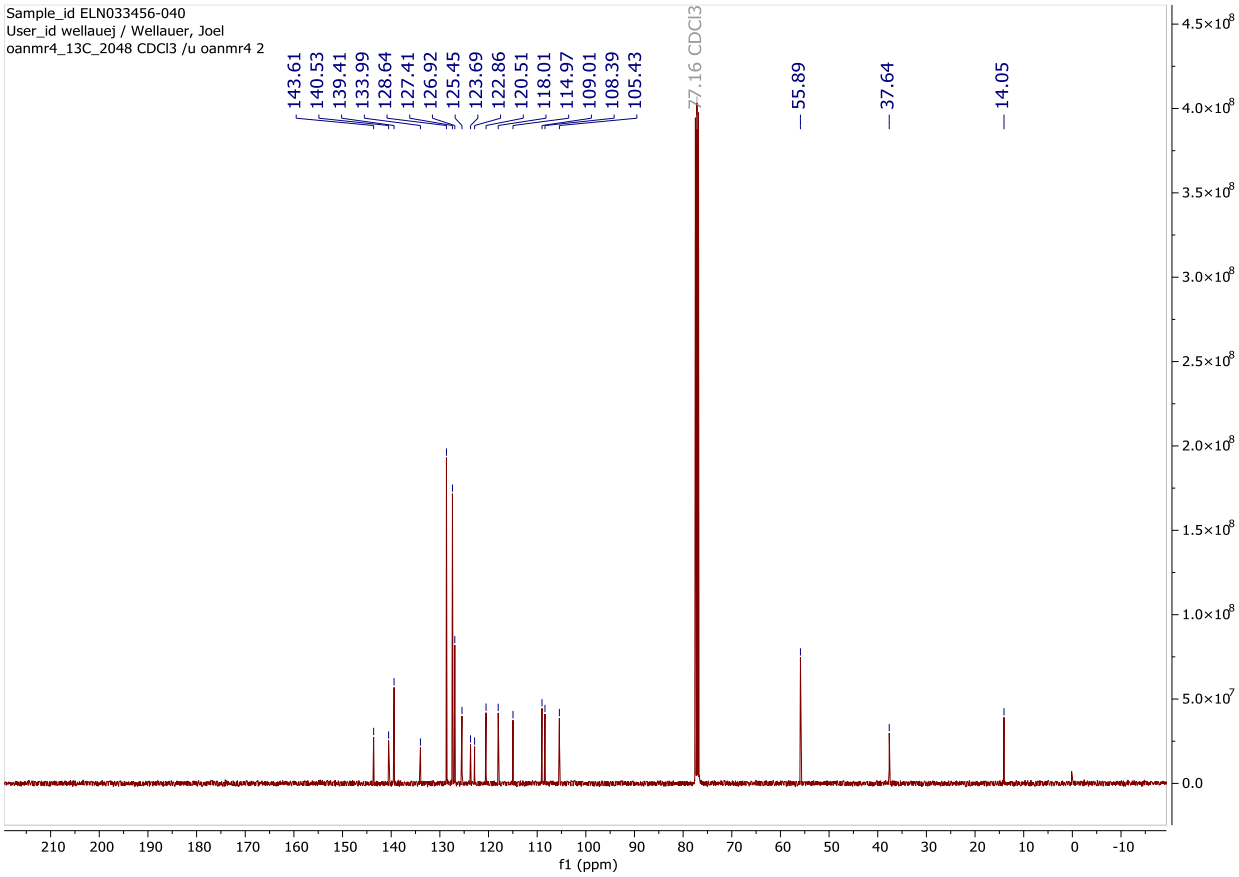
N,N-dibenzyl-9-ethyl-9H-carbazol-3-amine (49_33)



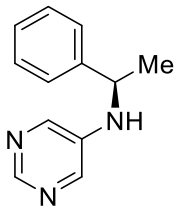
$^{13}C\{^{1}H\}$ NMR



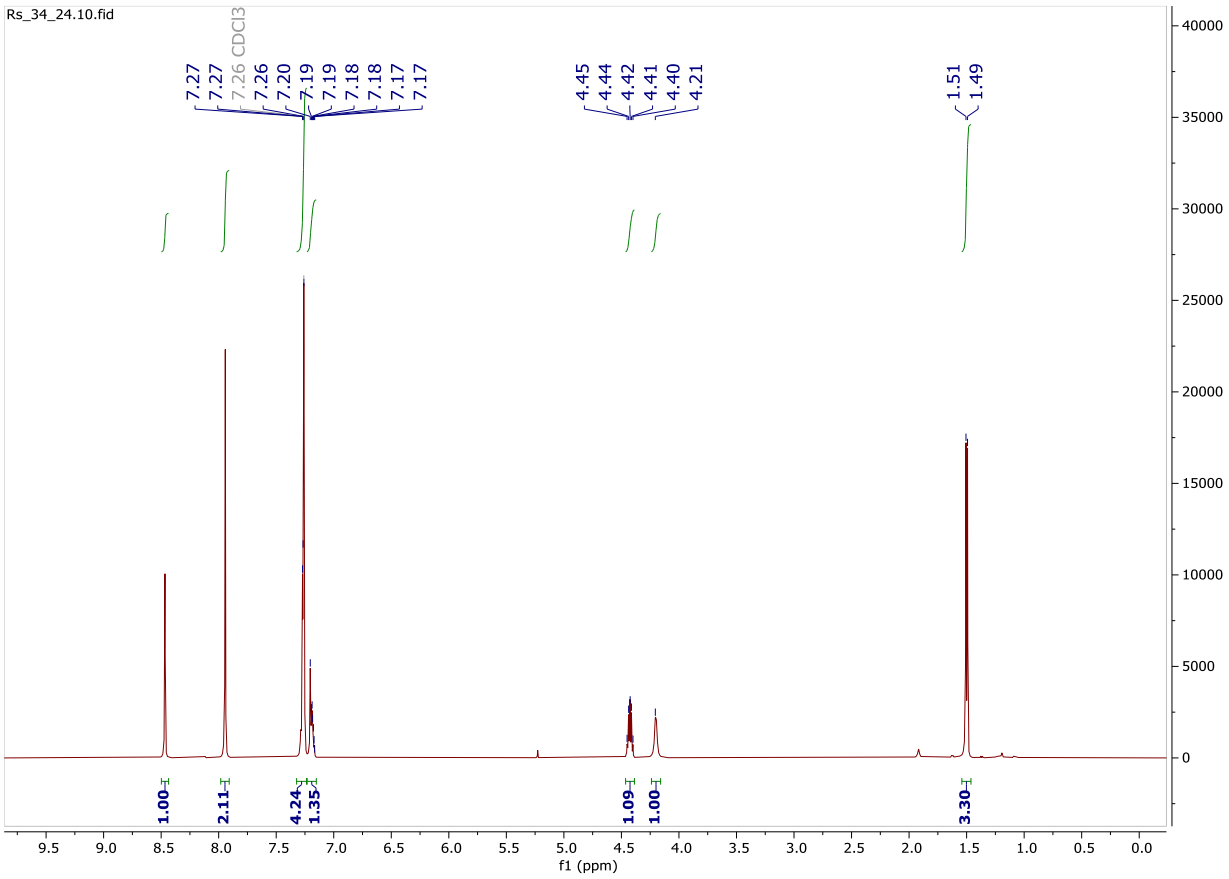
N,N-dibenzyl-9-ethyl-9H-carbazol-3-amine (49_33)



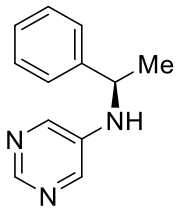
^{1}H NMR



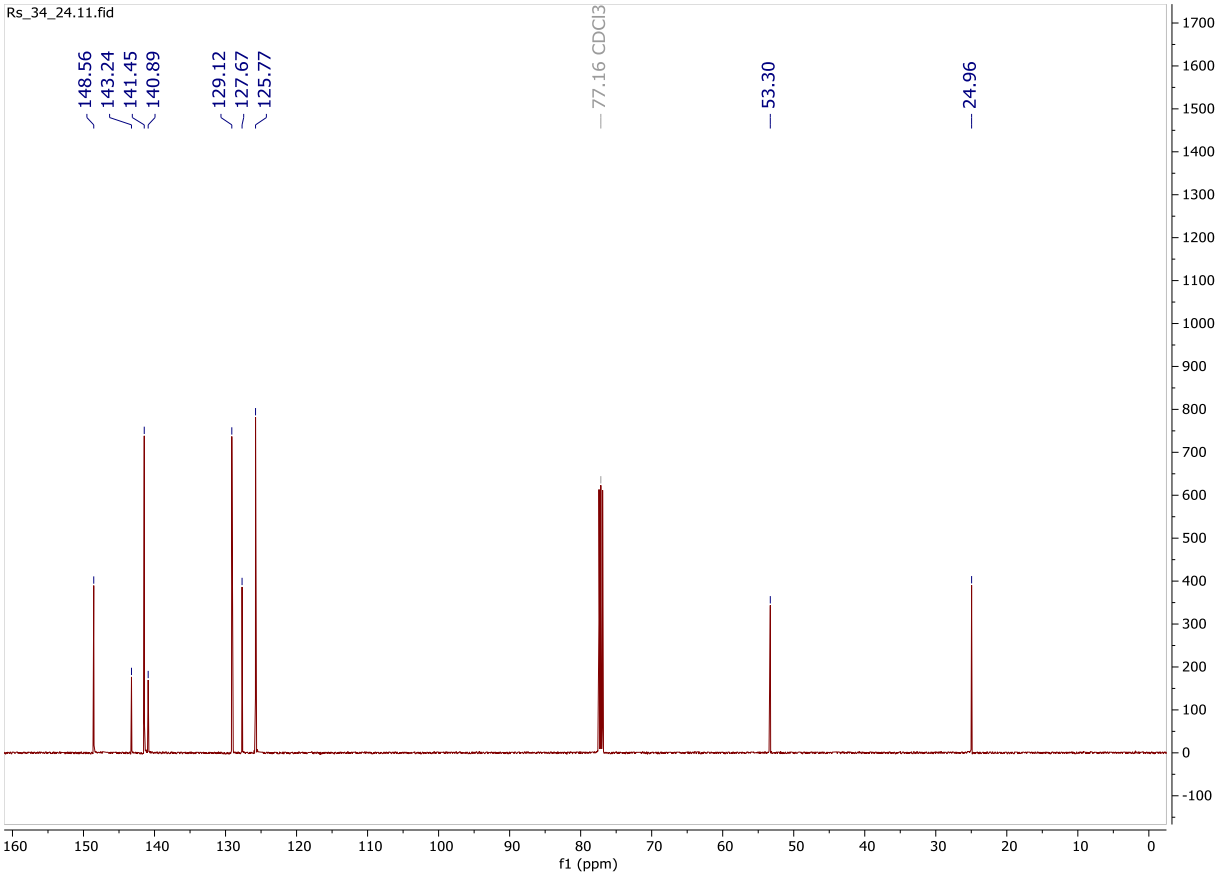
N-(1-phenylethyl)pyrimidin-5-amine (34_24)



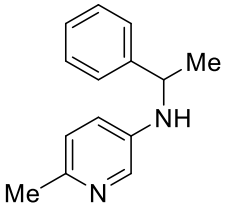
$^{13}C\{^{1}H\}$ NMR



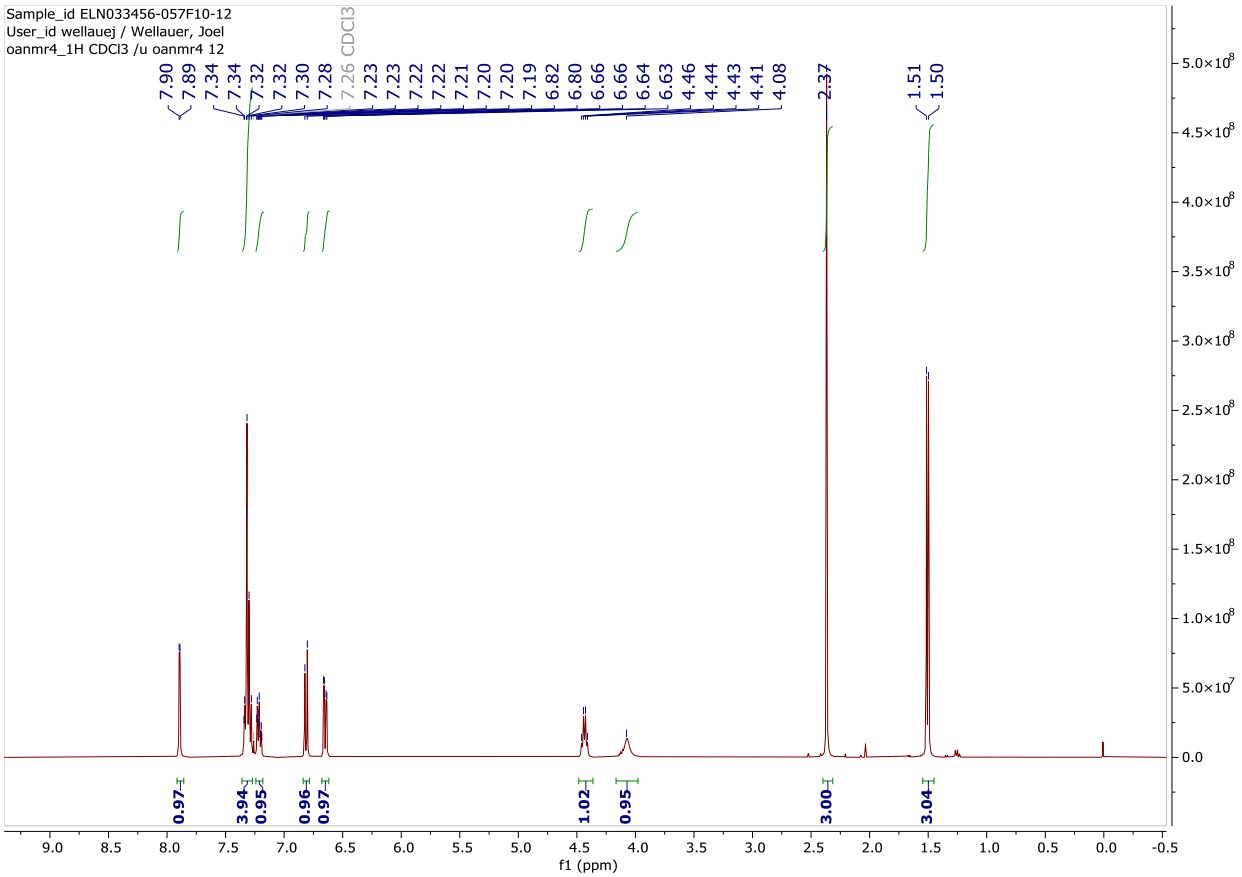
N-(1-phenylethyl)pyrimidin-5-amine (34_24)



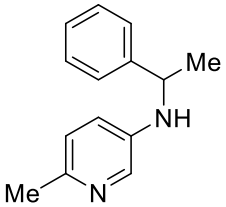
^{1}H NMR



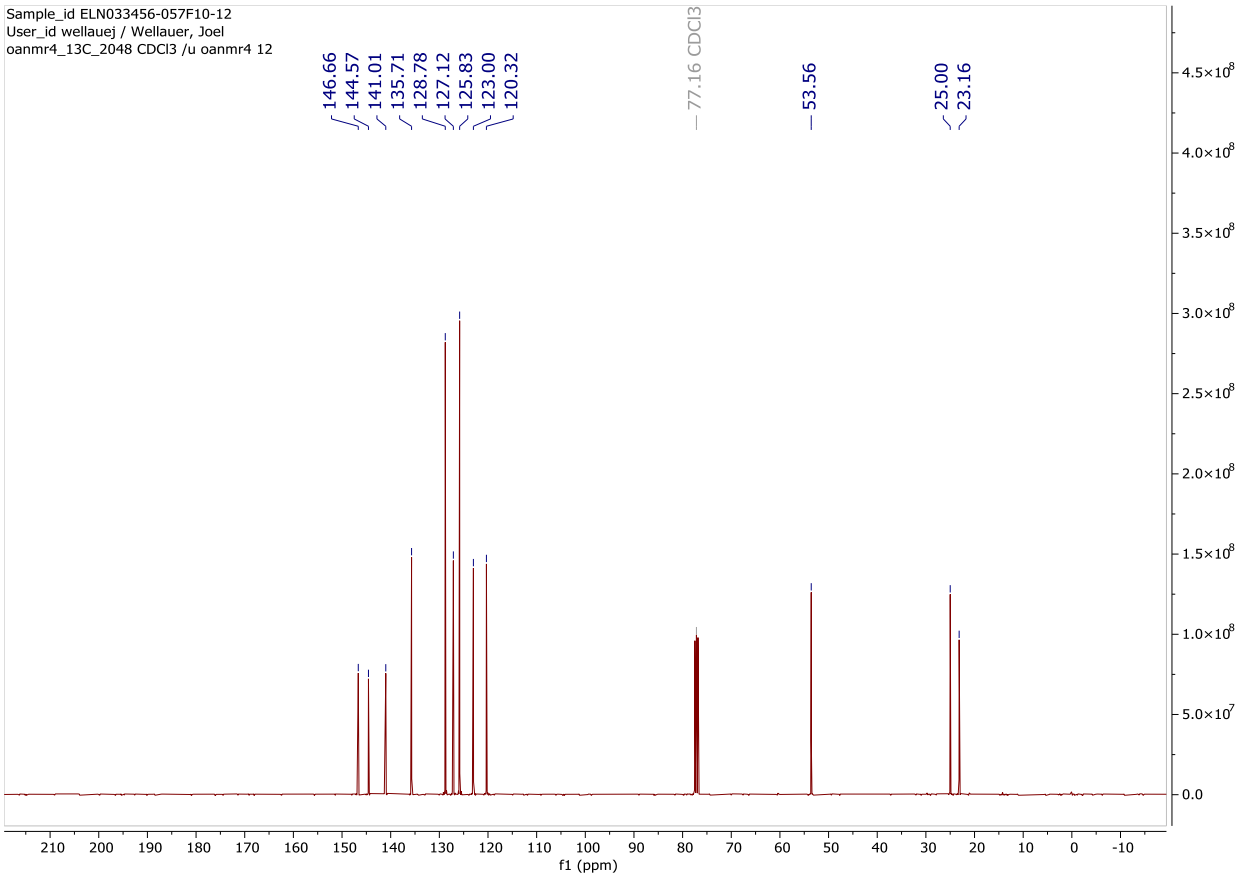
6-methyl-N-(1-phenylethyl)pyridin-3-amine (34_18)



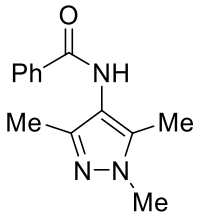
$^{13}C\{^{1}H\}$ NMR



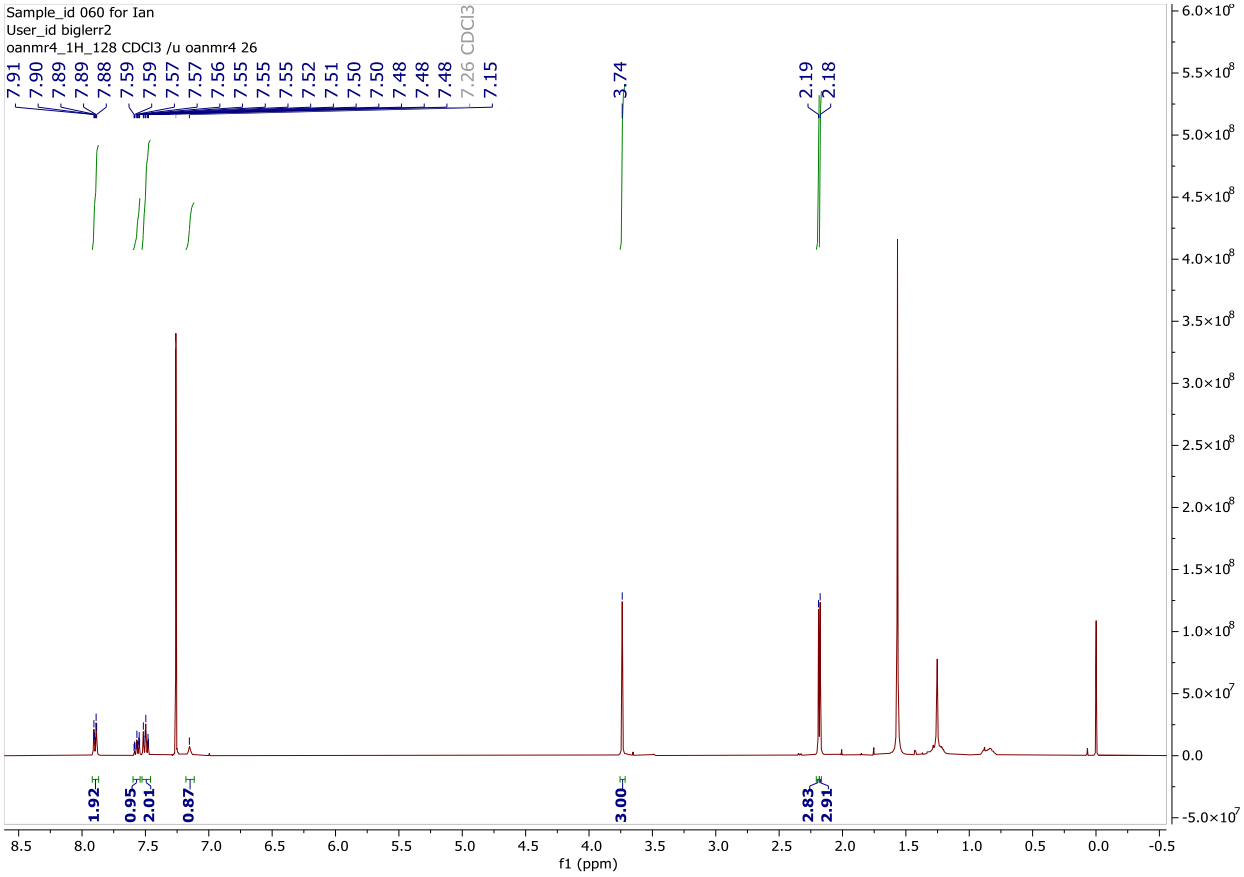
6-methyl-N-(1-phenylethyl)pyridin-3-amine (34_18)



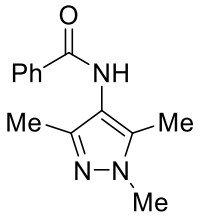
^{1}H NMR



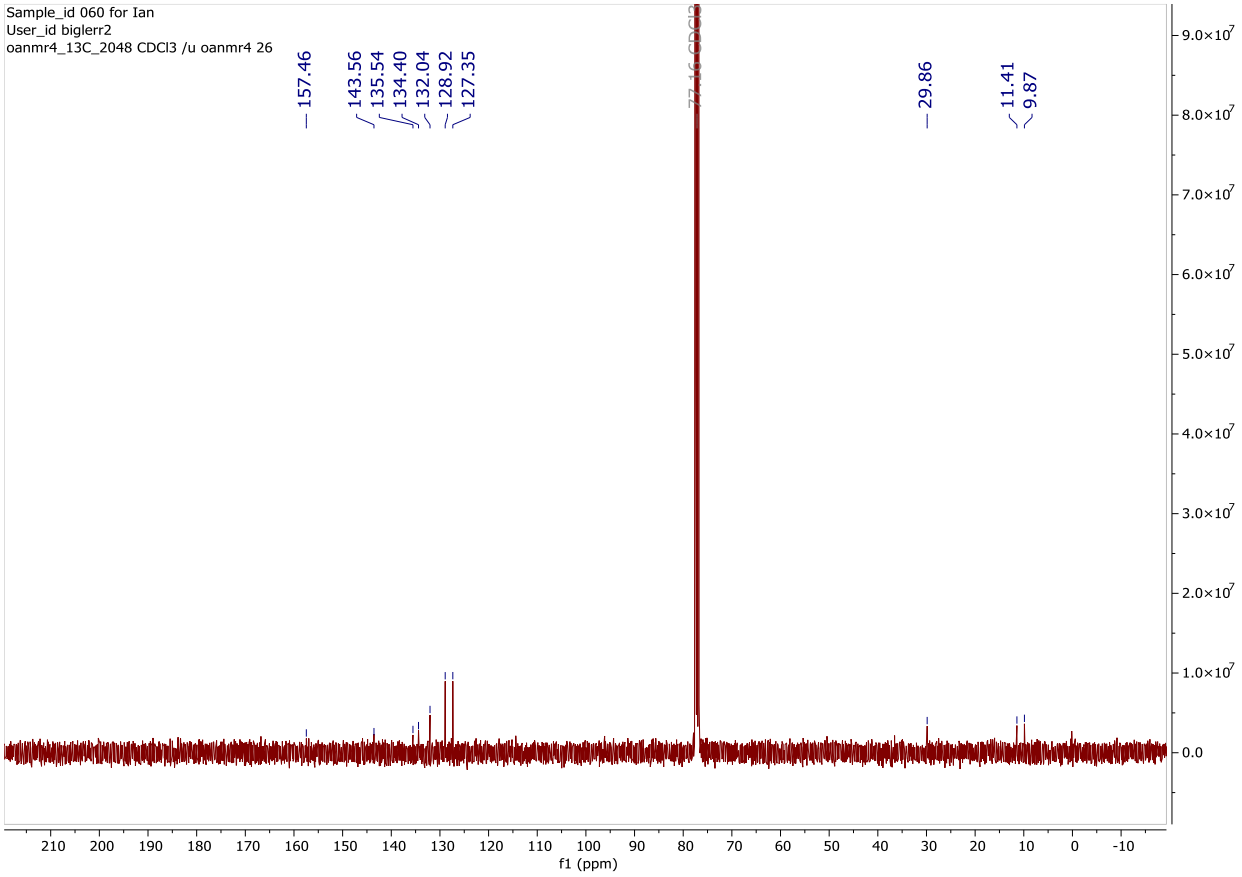
N-(1,3,5-trimethyl-1H-pyrazol-4-yl)benzamide (8_9)



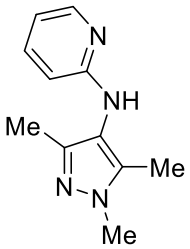
^{13}C NMR



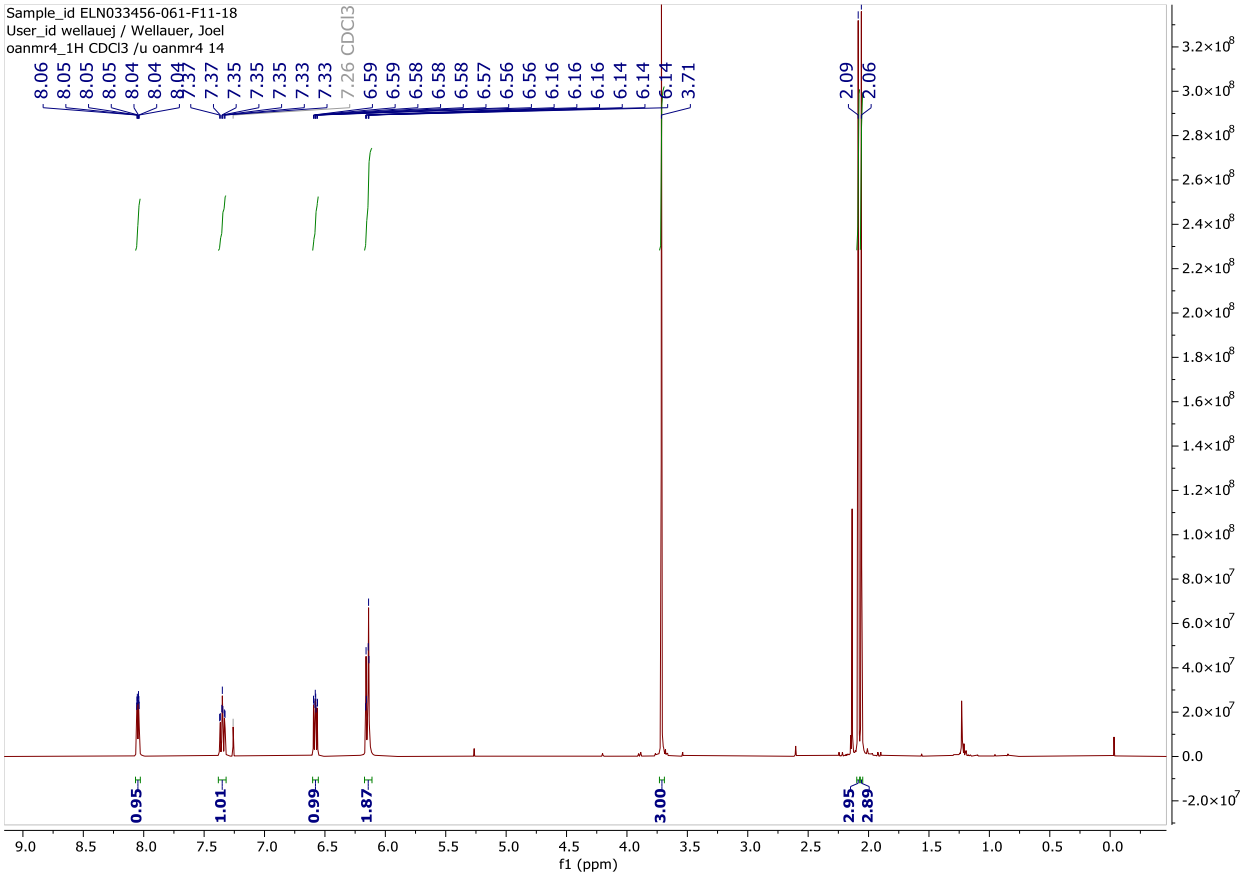
N-(1,3,5-trimethyl-1H-pyrazol-4-yl)benzamide (8_9)



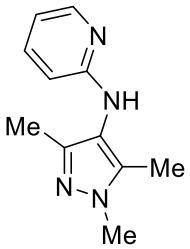
^{1}H NMR



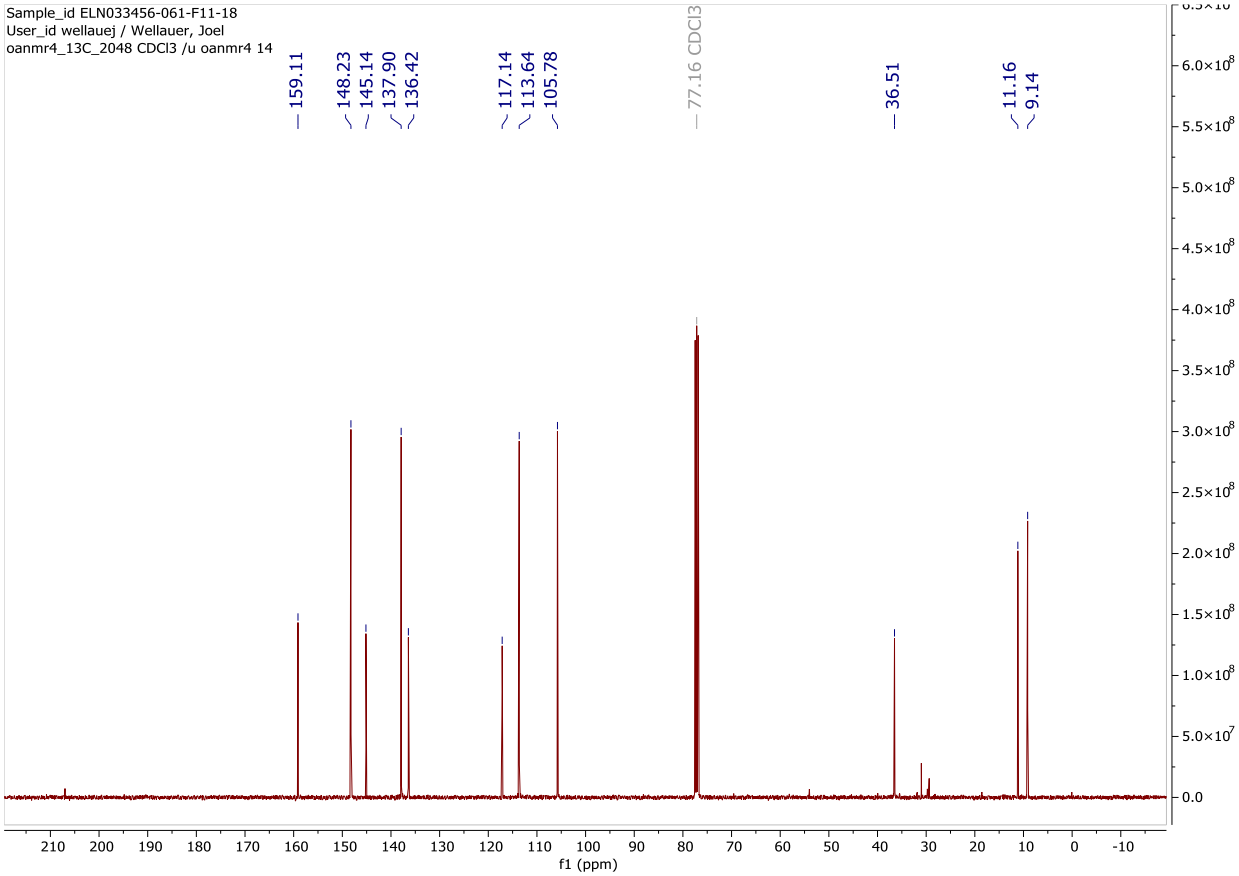
N-(1,3,5-trimethyl-1H-pyrazol-4-yl)pyridin-2-amine (11_9)



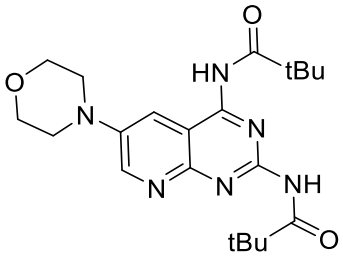
$^{13}C\{^{1}H\}$ NMR



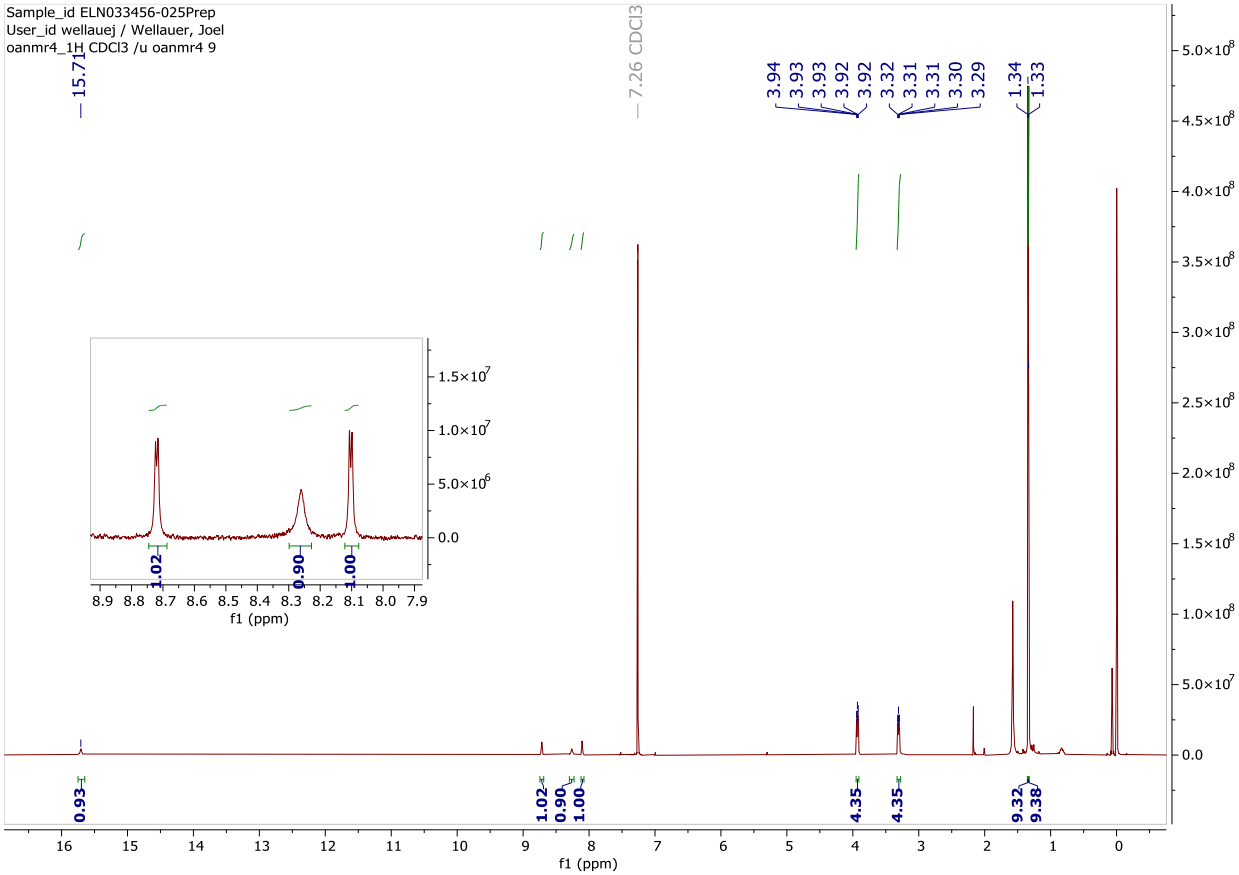
N-(1,3,5-trimethyl-1H-pyrazol-4-yl)pyridin-2-amine (11_9)



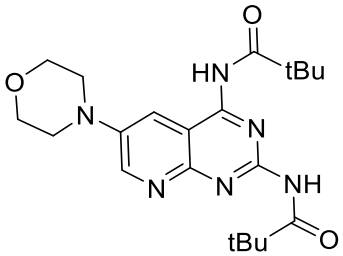
^{1}H NMR



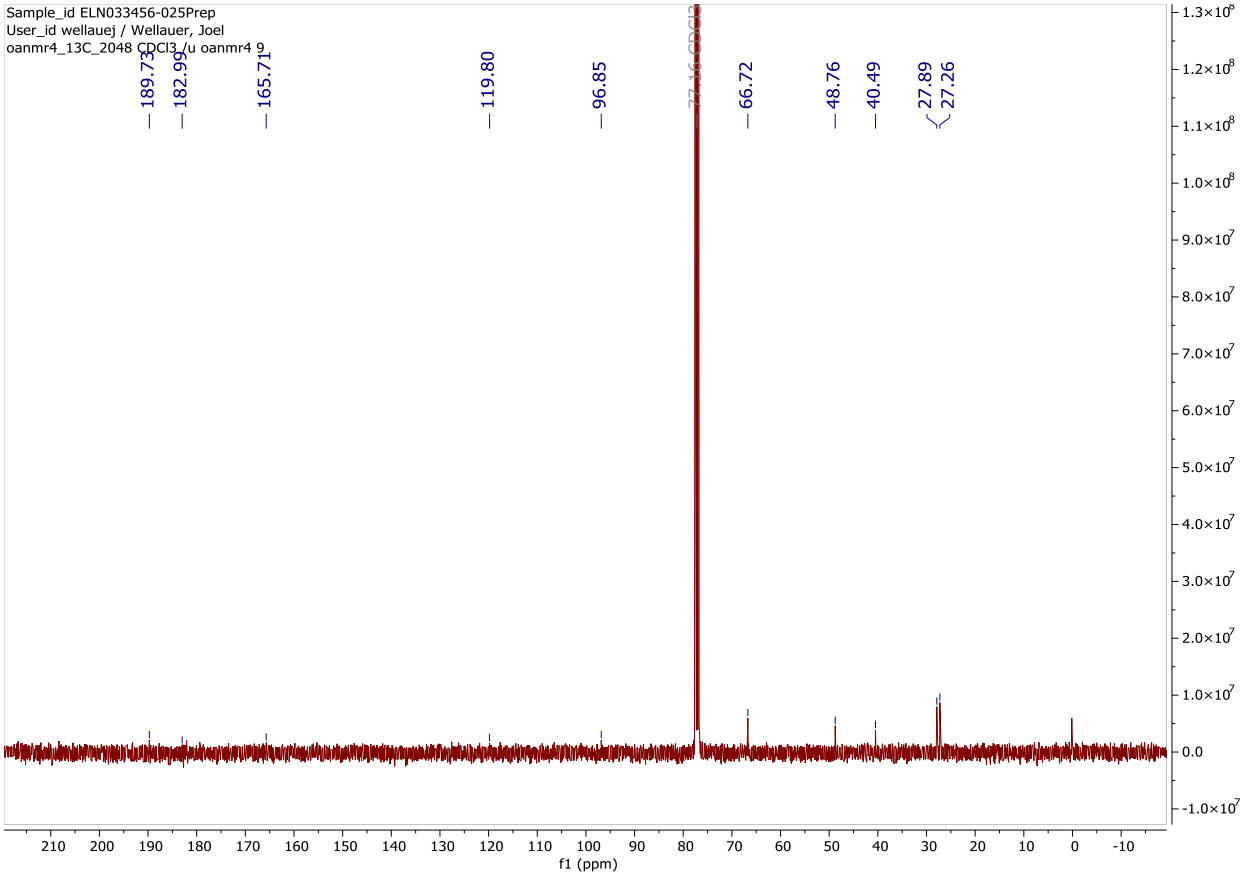
N,N'-(6-morpholinopyrido[2,3-d]pyrimidine-2,4-diyl)bis(2,2-dimethylpropanamide) (43_25)



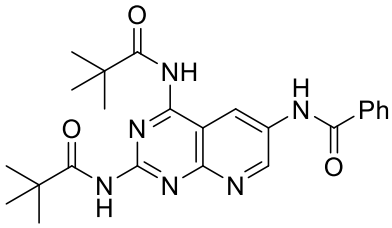
$^{13}C\{^{1}H\}$ NMR



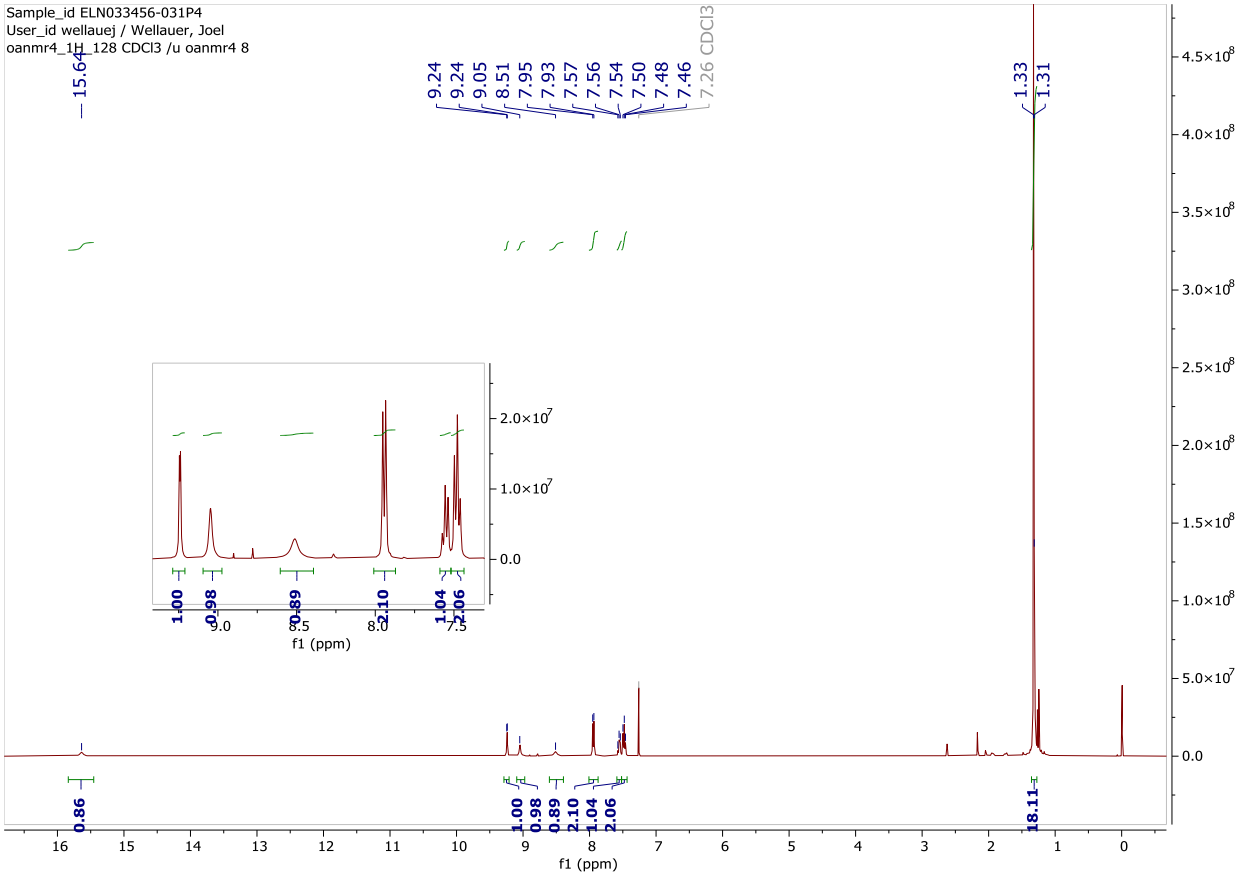
N,N'-(6-morpholinopyrido[2,3-d]pyrimidine-2,4-diyl)bis(2,2-dimethylpropanamide) (43_25)



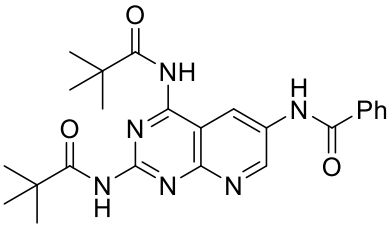
^{1}H NMR



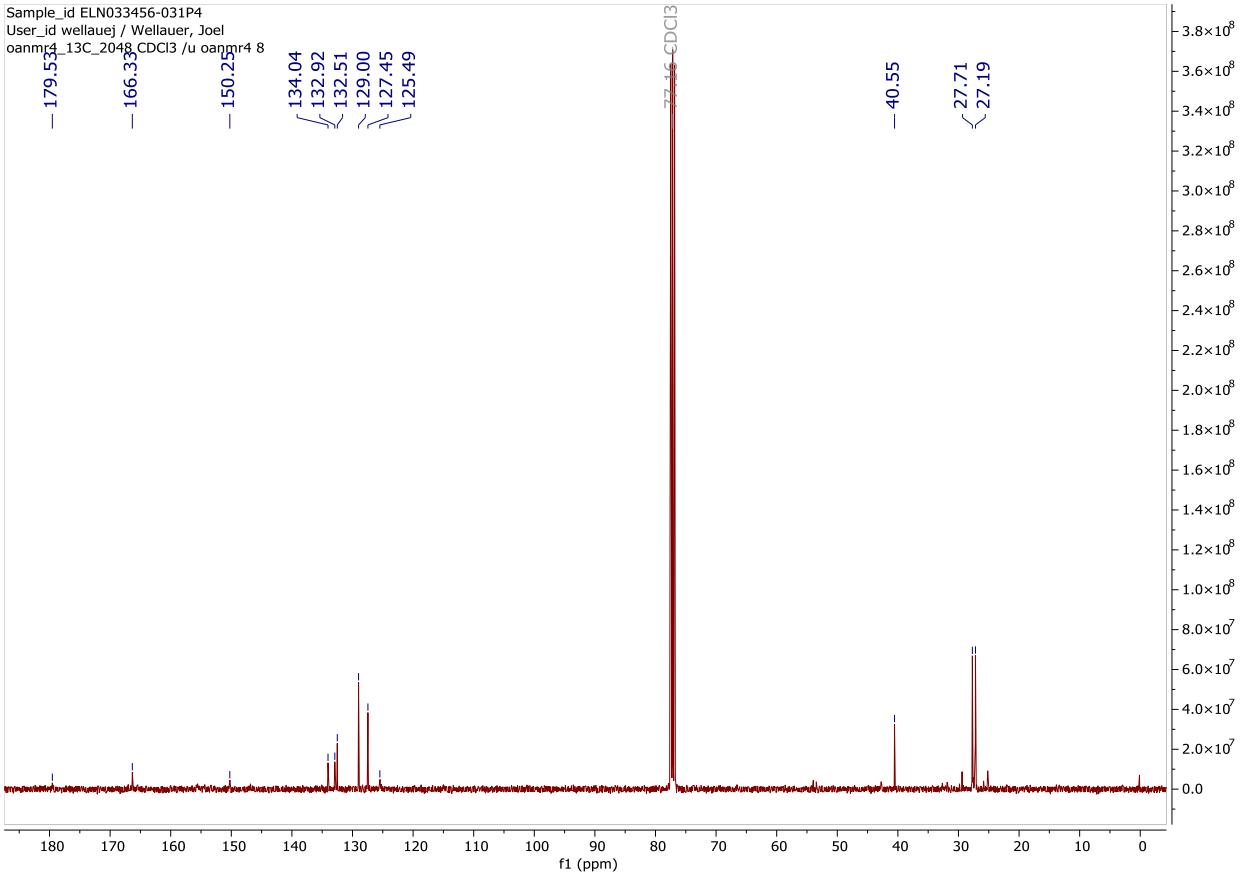
N,N'-(6-benzamidopyrido[2,3-d]pyrimidine-2,4-diyl)bis(2,2-dimethylpropanamide) (8_25)



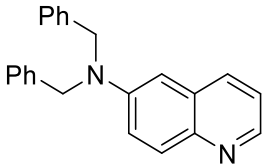
$^{13}C\{^{1}H\}$ NMR



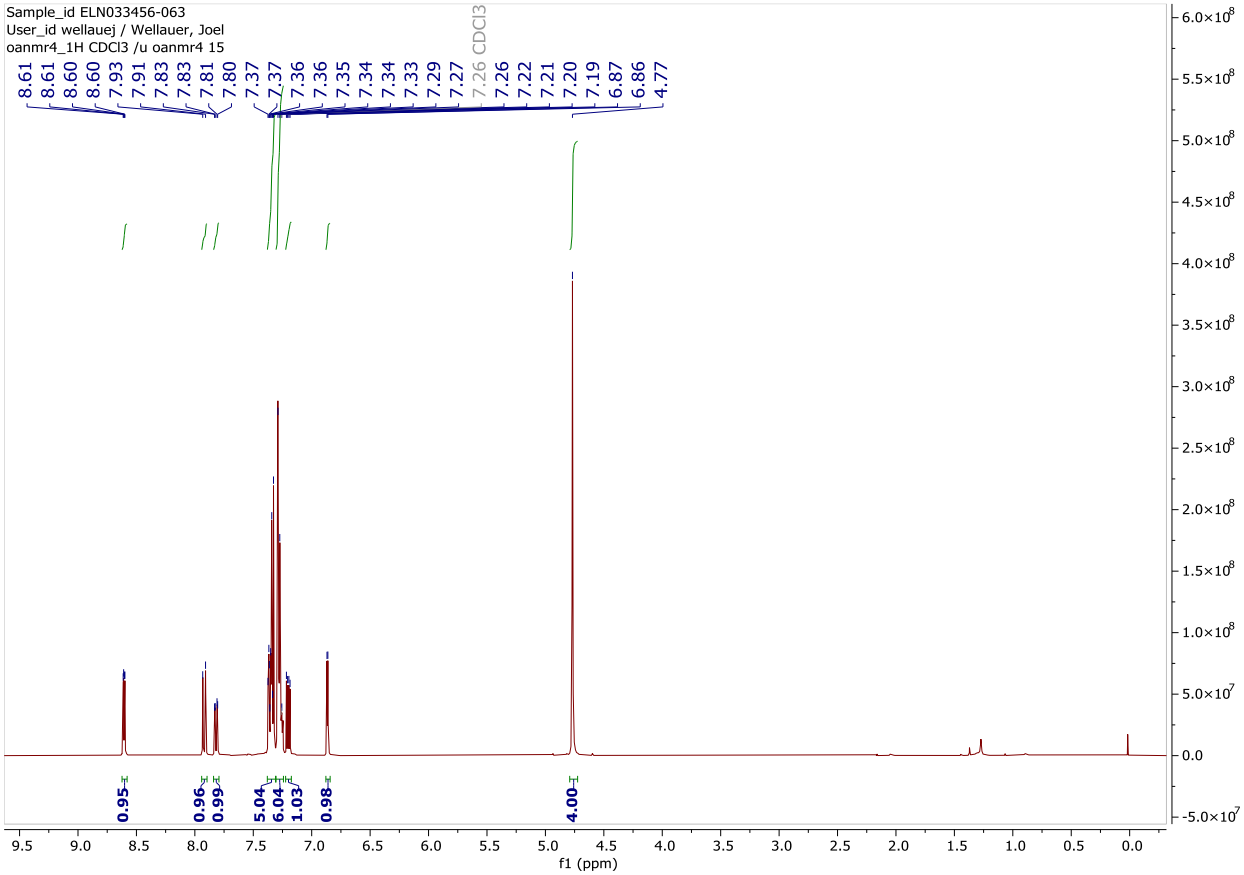
N,N'-(6-benzamidopyrido[2,3-d]pyrimidine-2,4-diyl)bis(2,2-dimethylpropanamide) (8_25)



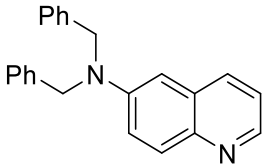
^{1}H NMR



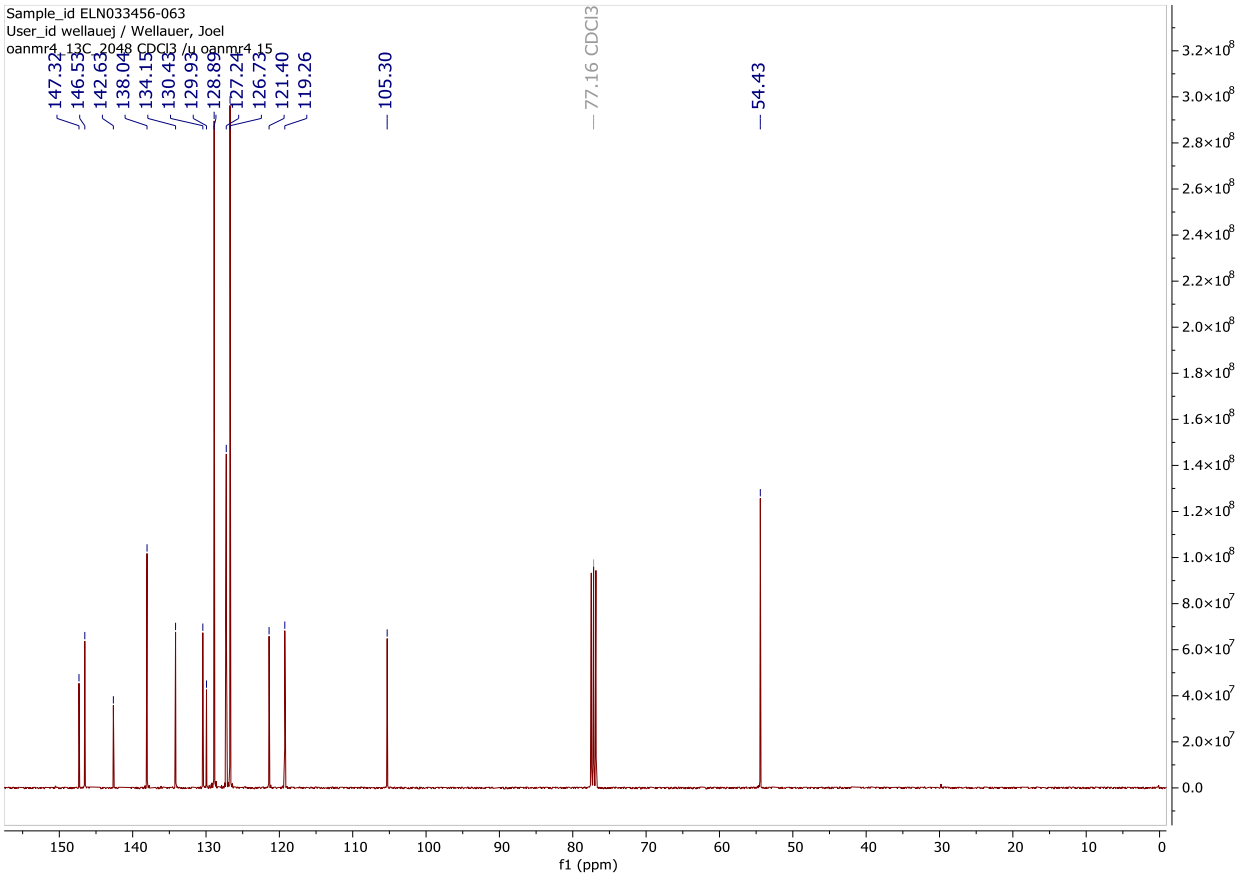
N,N-dibenzylquinolin-6-amine (49_26)



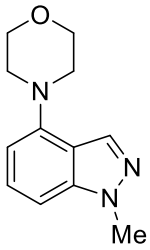
$^{13}C\{^{1}H\}$ NMR



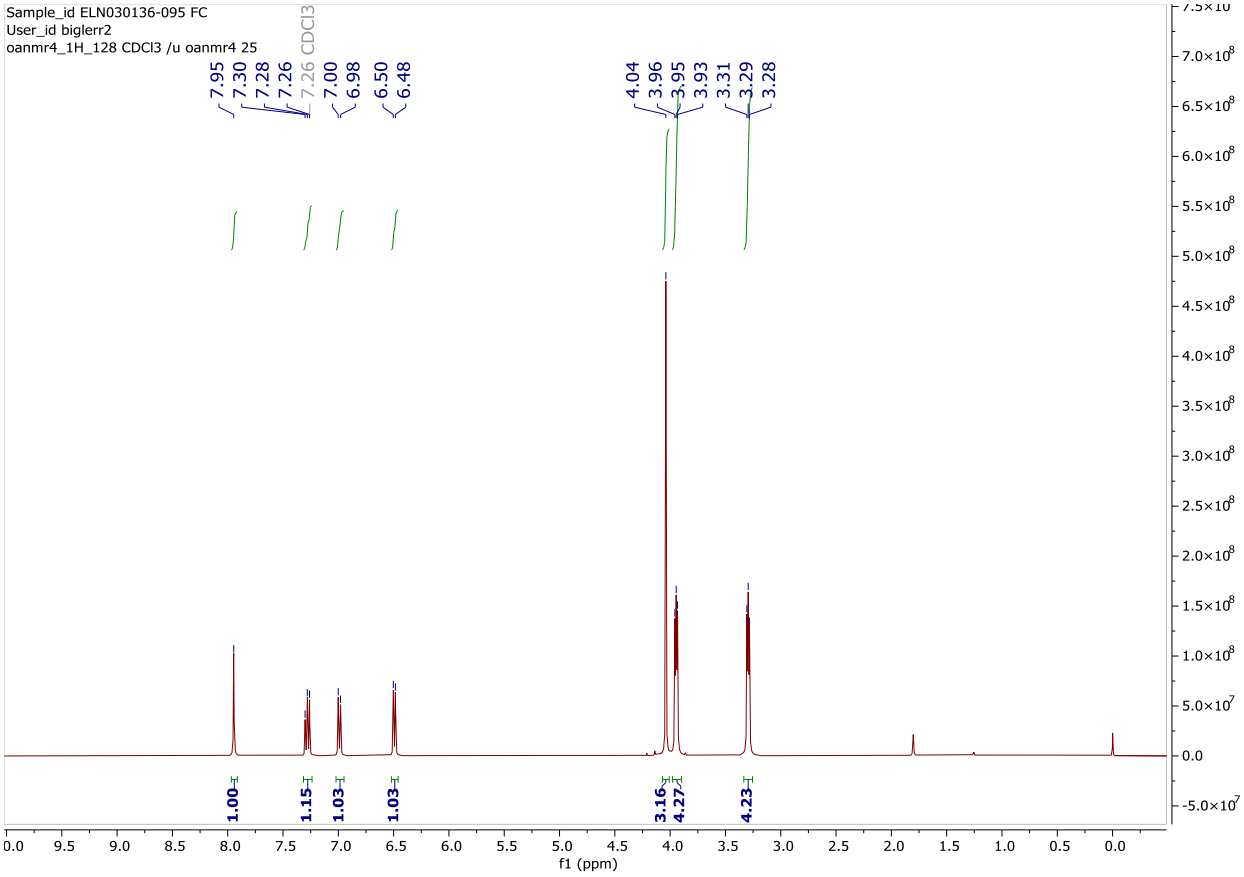
N,N-dibenzylquinolin-6-amine (49_26)



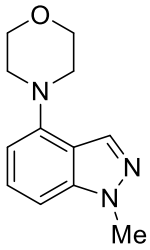
^{1}H NMR



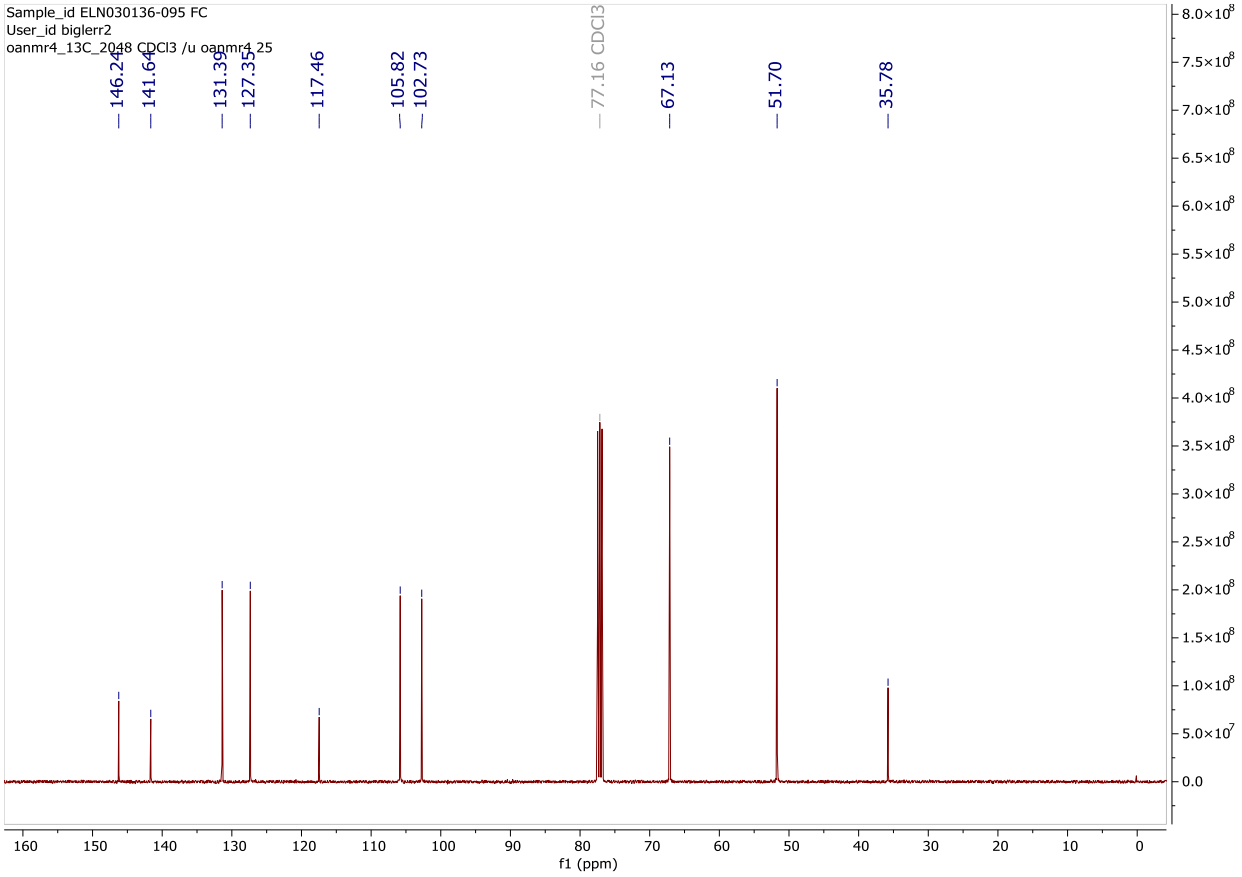
4-(1-methyl-1H-indazol-4-yl)morpholine (43_12)



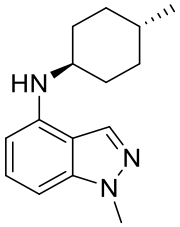
$^{13}C\{^{1}H\}$ NMR



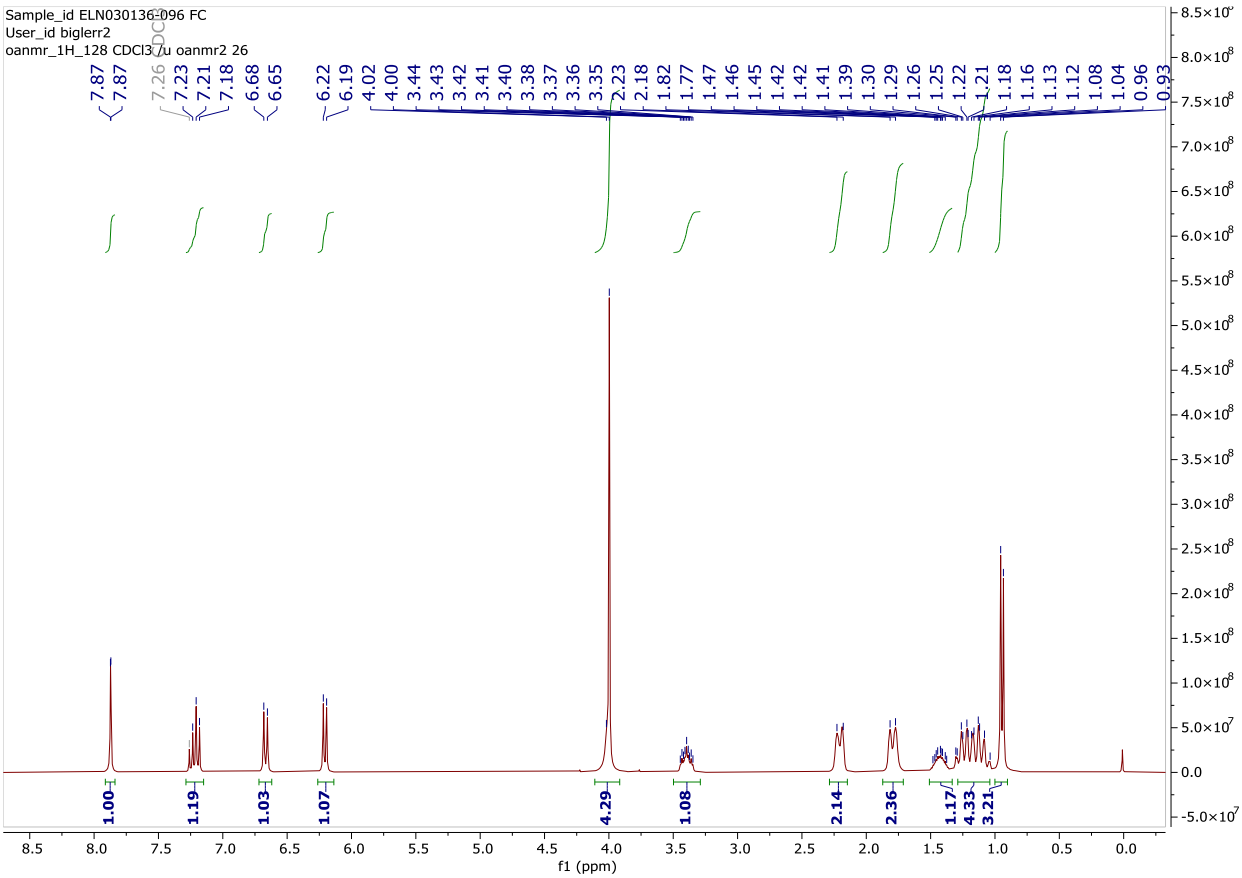
4-(1-methyl-1H-indazol-4-yl)morpholine (43_12)



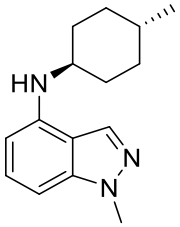
^{1}H NMR



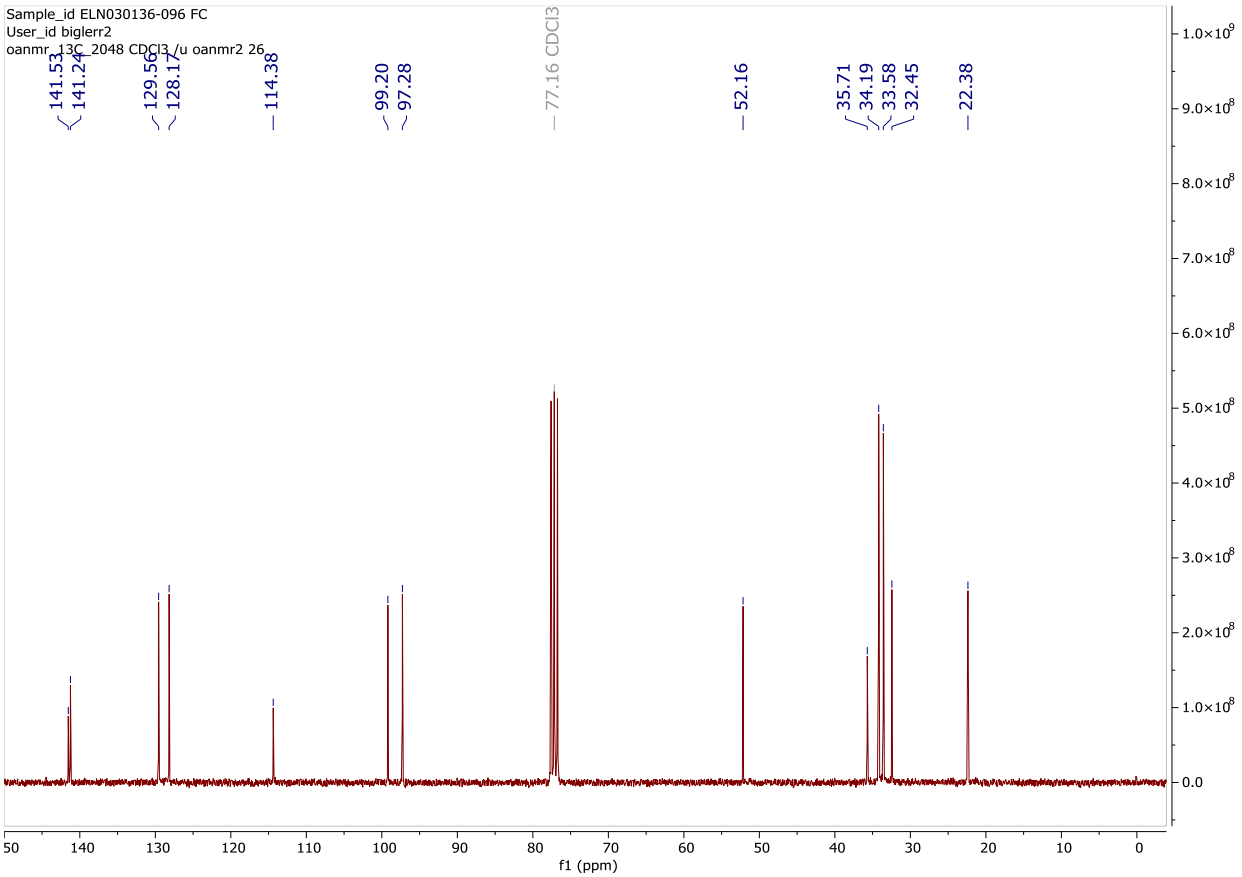
1-methyl-N-((1r,4r)-4-methylcyclohexyl)-1H-indazol-4-amine (36_12)



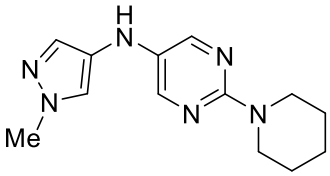
$^{13}C\{^{1}H\}$ NMR



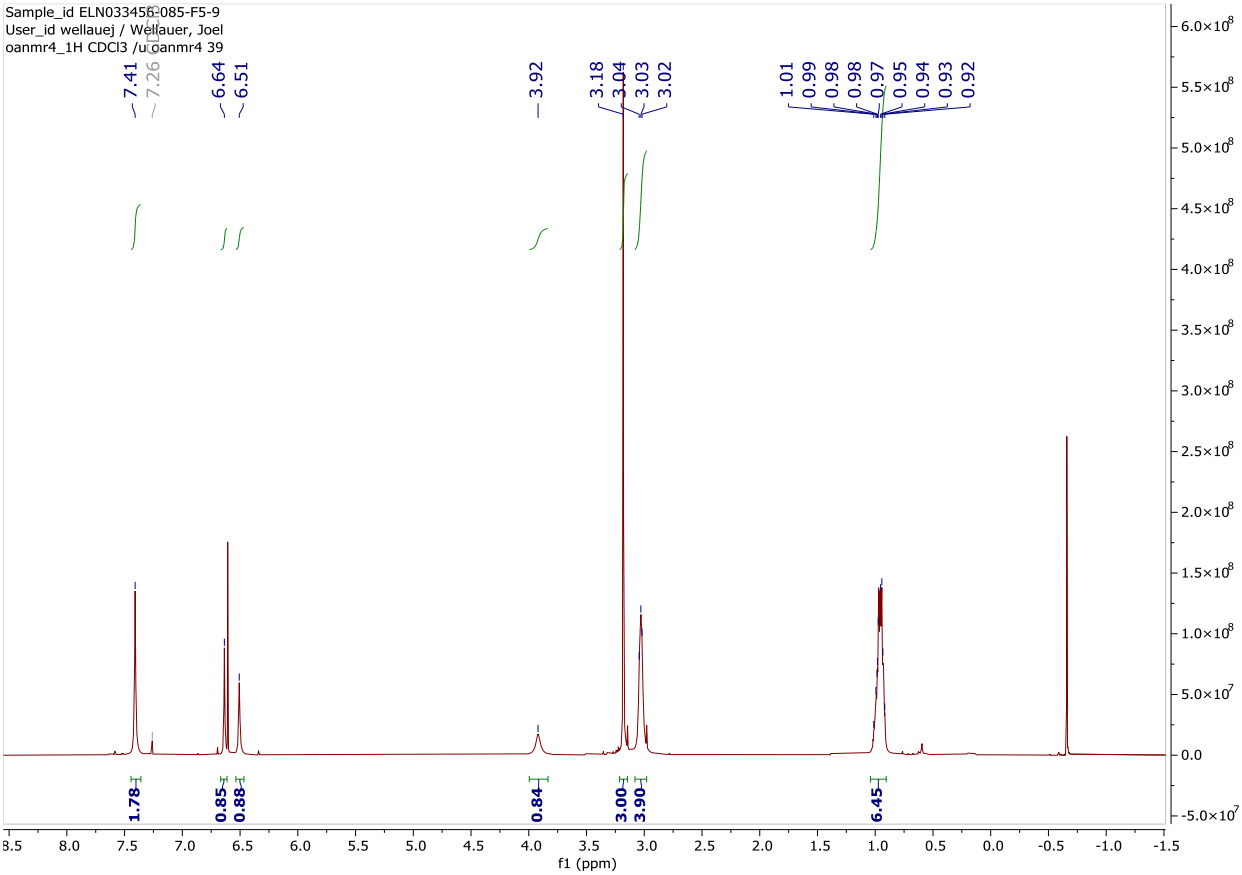
1-methyl-N-((1r,4r)-4-methylcyclohexyl)-1H-indazol-4-amine (36_12)



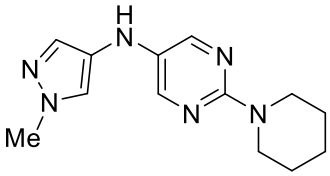
^{1}H NMR



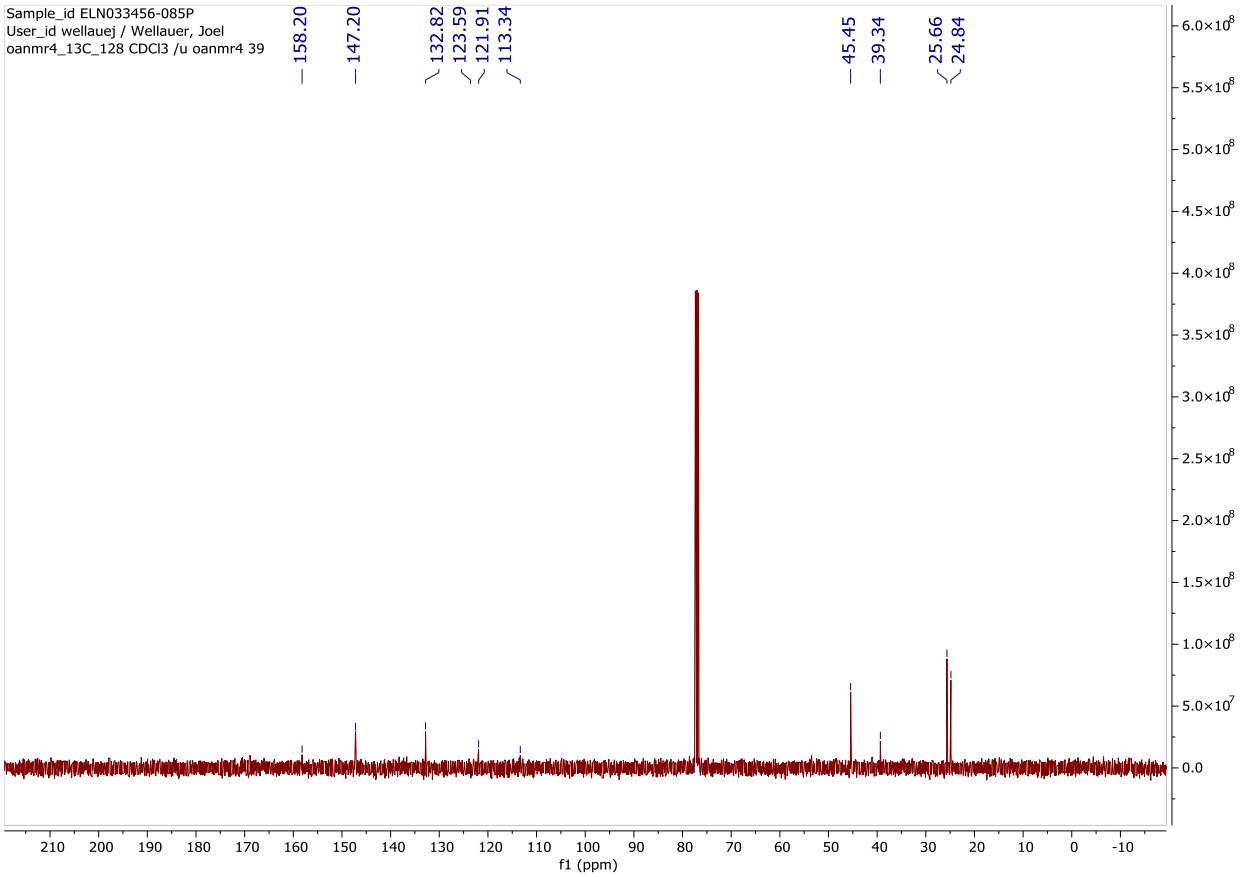
N-(1-methyl-1H-pyrazol-4-yl)-2-(piperidin-1-yl)pyrimidin-5-amine (12_27)



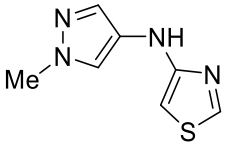
$^{13}C\{^{1}H\}$ NMR



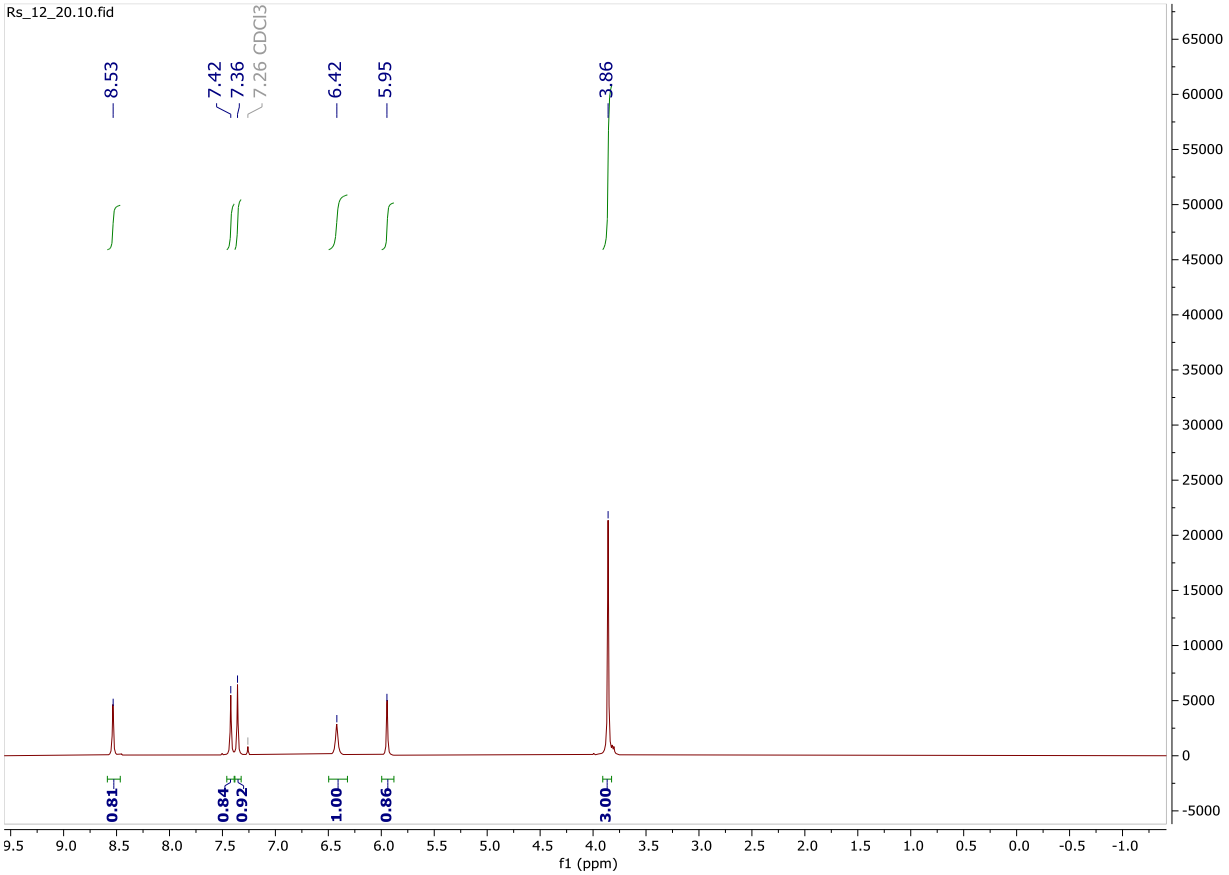
N-(1-methyl-1H-pyrazol-4-yl)-2-(piperidin-1-yl)pyrimidin-5-amine (12_27)



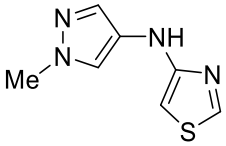
^{1}H NMR



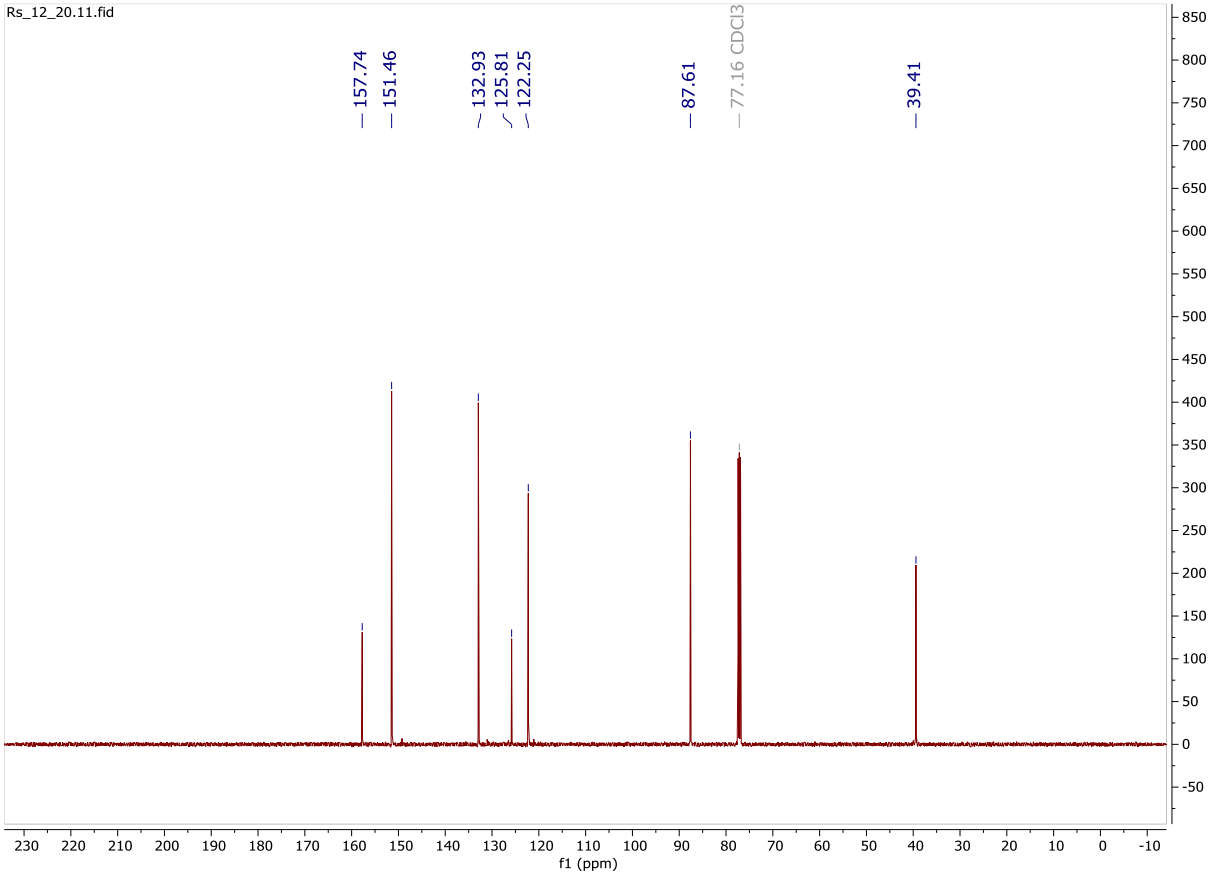
N-(1-methyl-1H-pyrazol-4-yl)thiazol-4-amine (12_20)



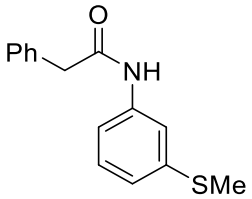
$^{13}C\{^{1}H\}$ NMR



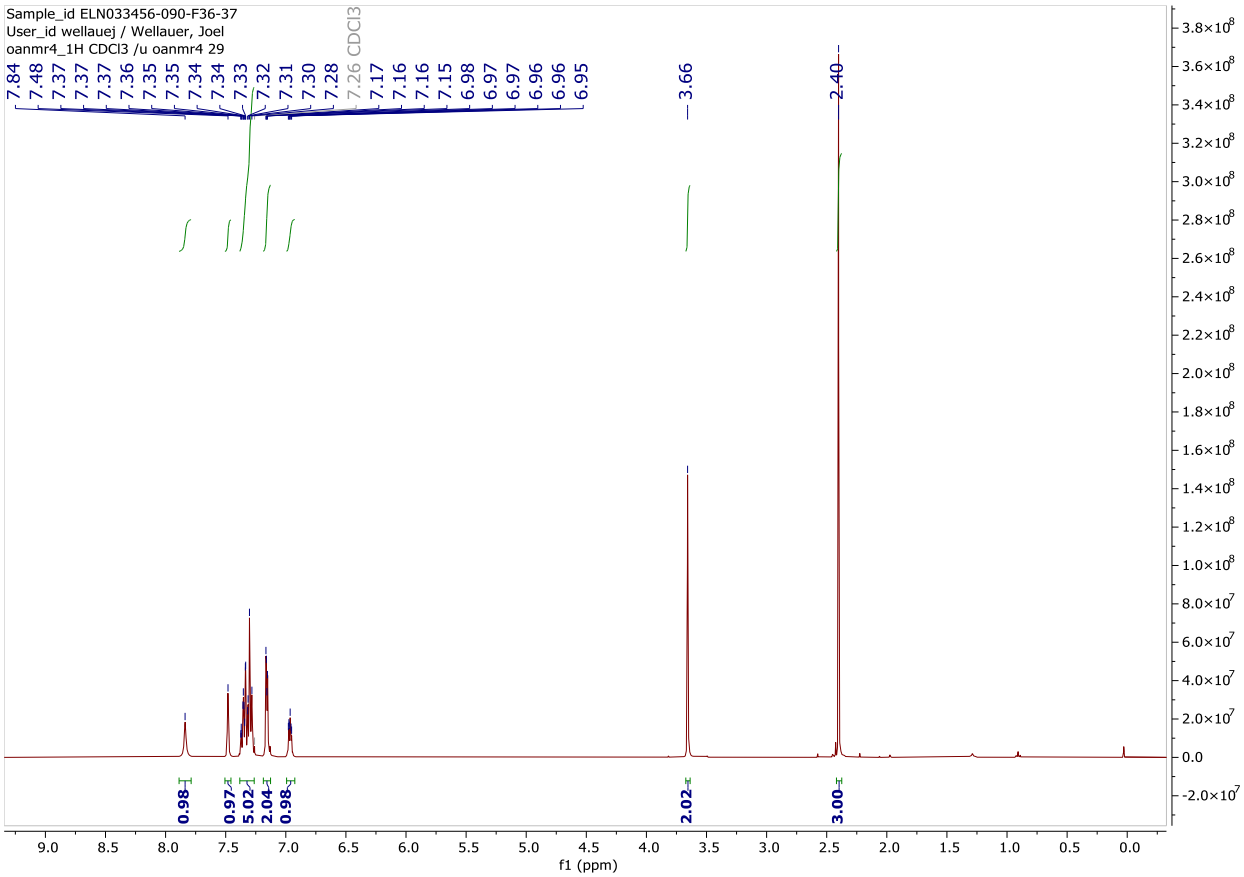
N-(1-methyl-1H-pyrazol-4-yl)thiazol-4-amine (12_20)



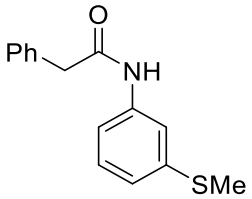
^{1}H NMR



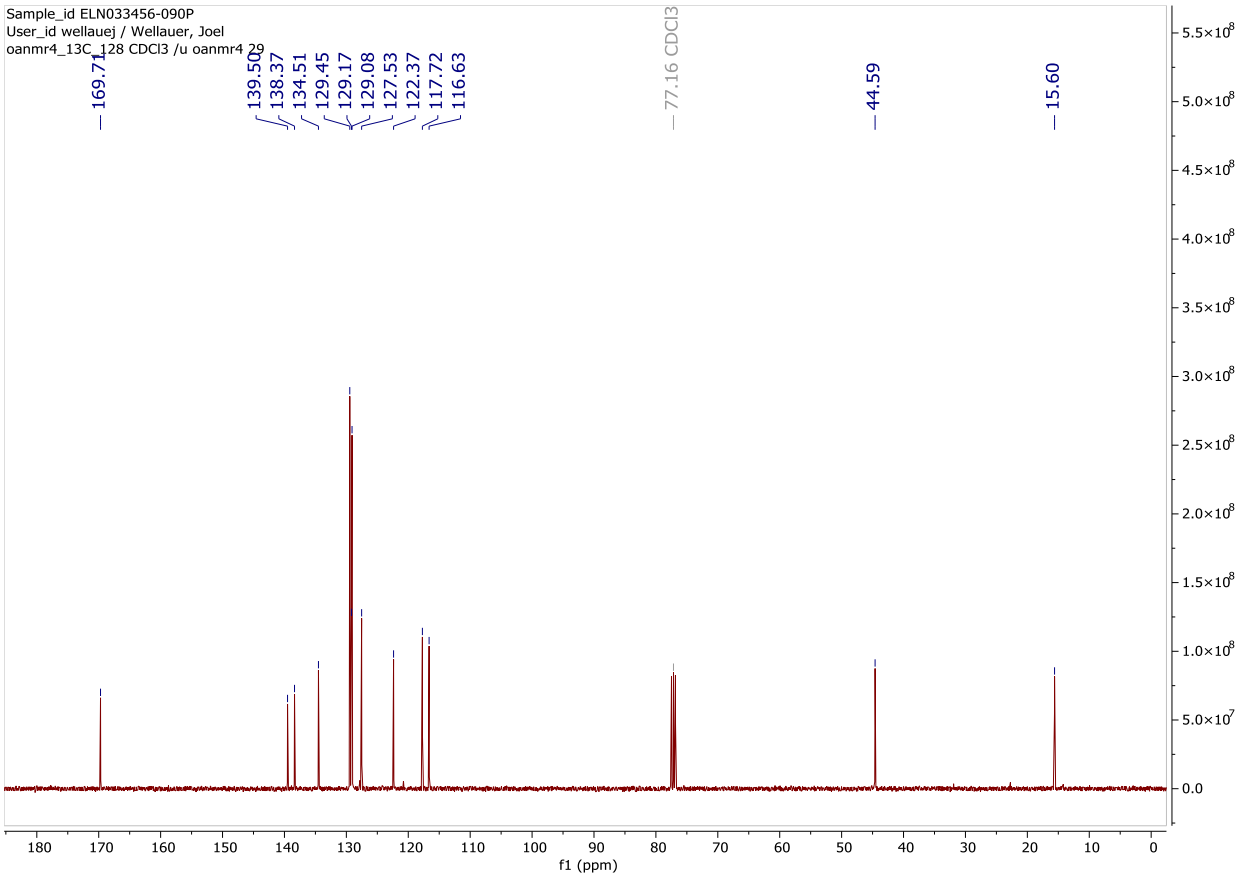
N-(3-(methylthio)phenyl)-2-phenylacetamide (10_11)



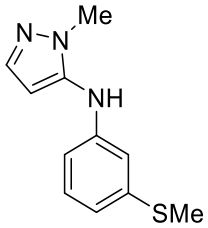
$^{13}C\{^{1}H\}$ NMR



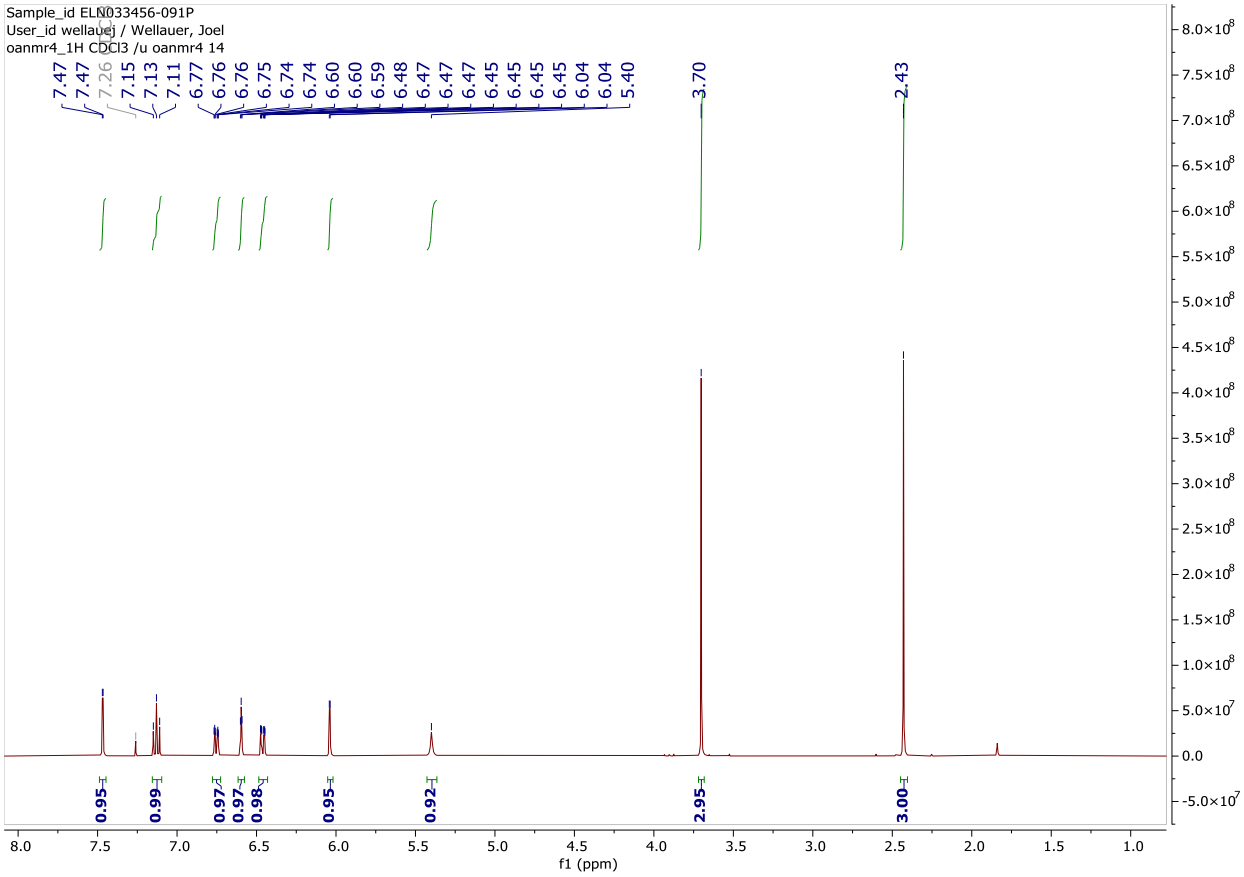
N-(3-(methylthio)phenyl)-2-phenylacetamide (10_11)



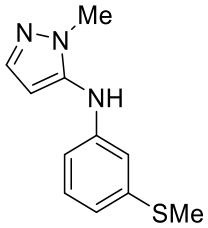
^{1}H NMR



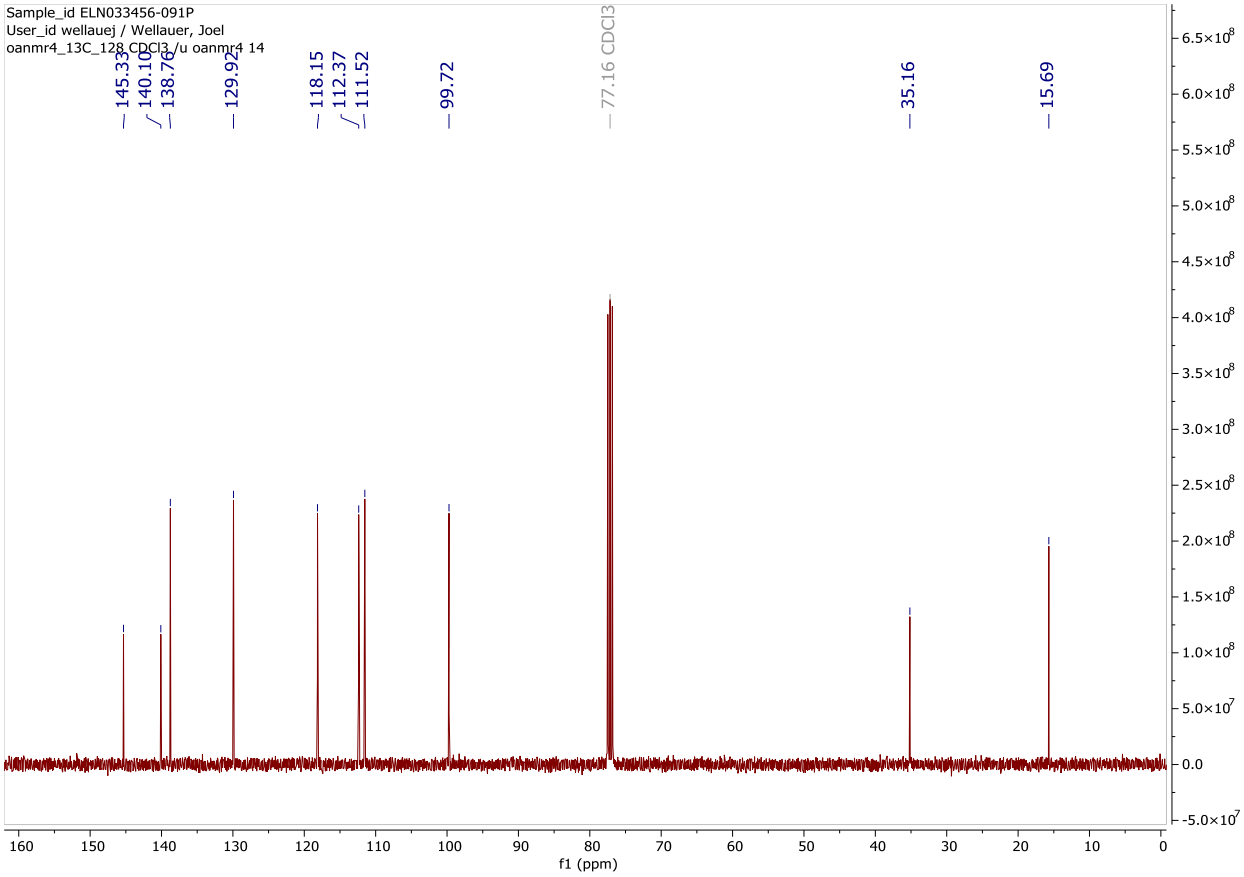
1-methyl-N-(3-(methylthio)phenyl)-1H-pyrazol-5-amine (14_11)



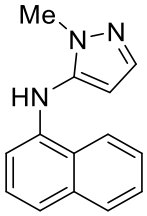
$^{13}C\{^{1}H\}$ NMR



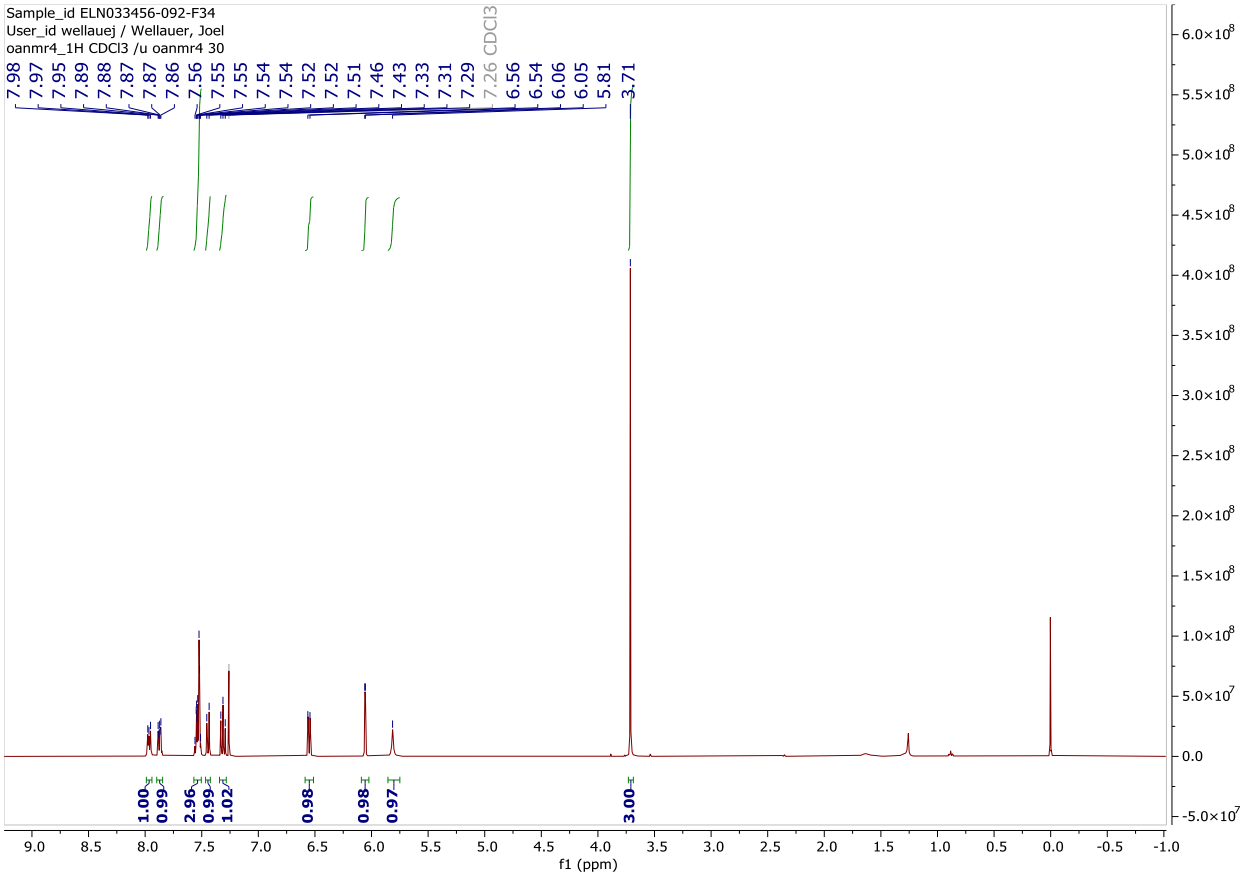
1-methyl-N-(3-(methylthio)phenyl)-1H-pyrazol-5-amine (14_11)



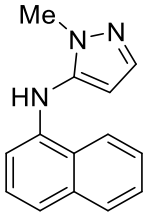
^{1}H NMR



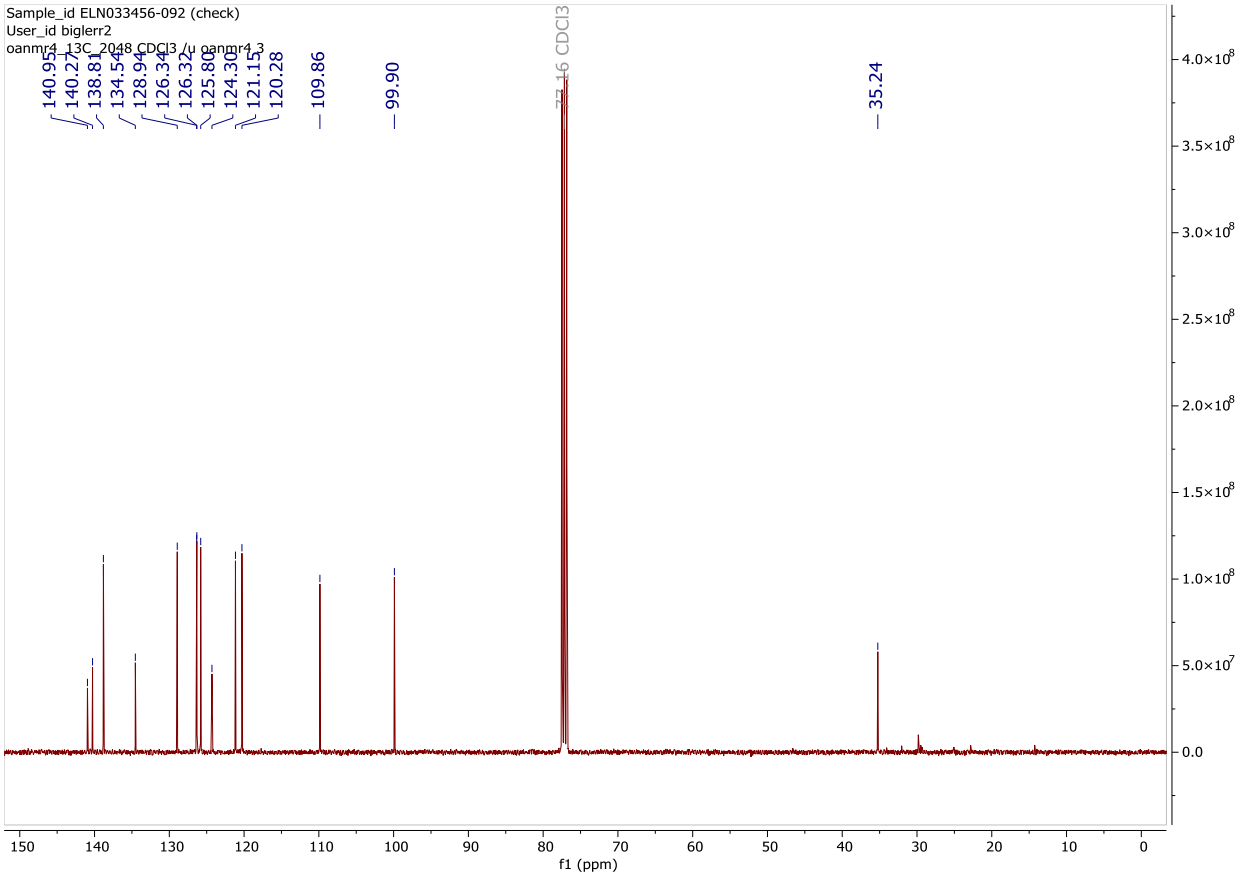
1-methyl-N-(naphthalen-1-yl)-1H-pyrazol-5-amine (14_8)



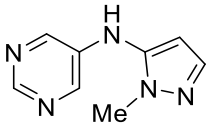
$^{13}C\{^{1}H\}$ NMR



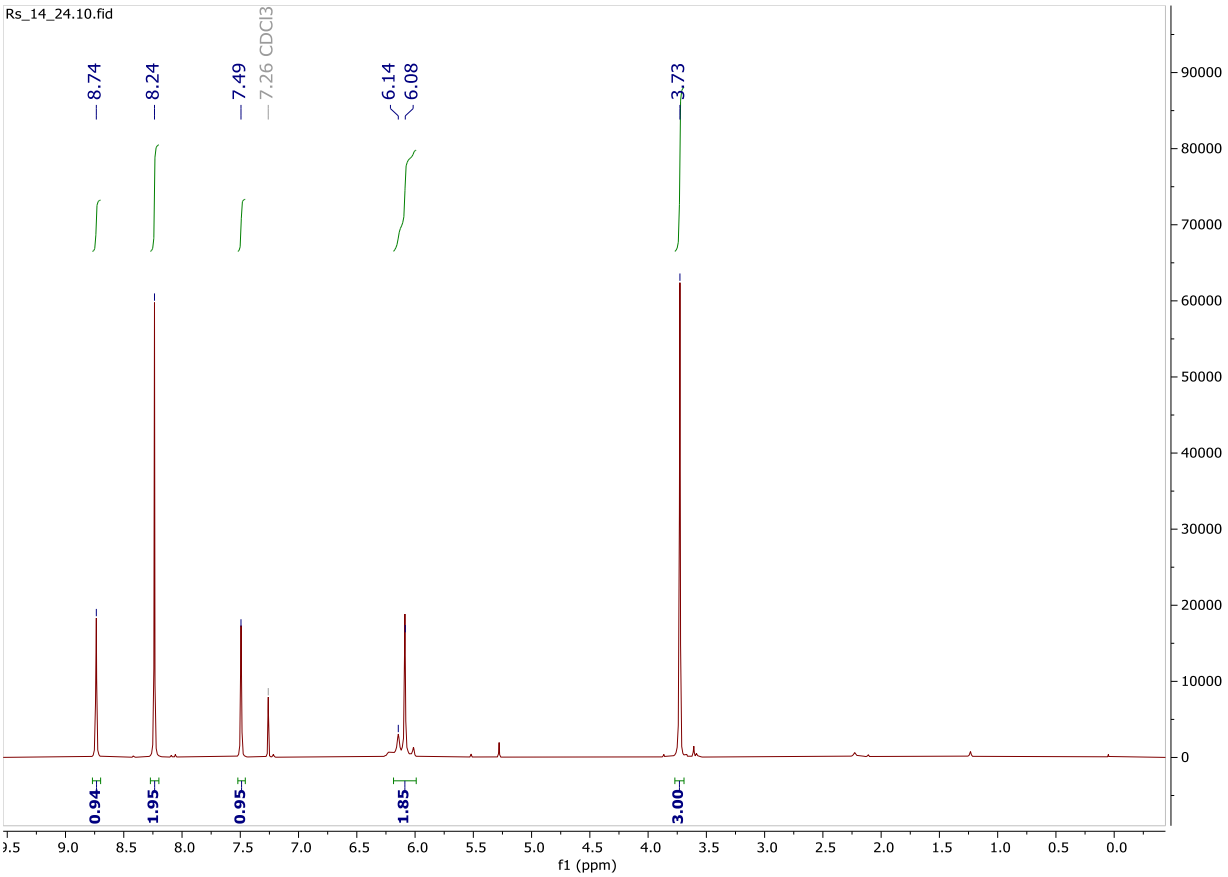
1-methyl-N-(naphthalen-1-yl)-1H-pyrazol-5-amine (14_8)



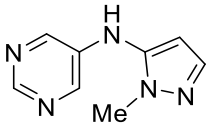
^{1}H NMR



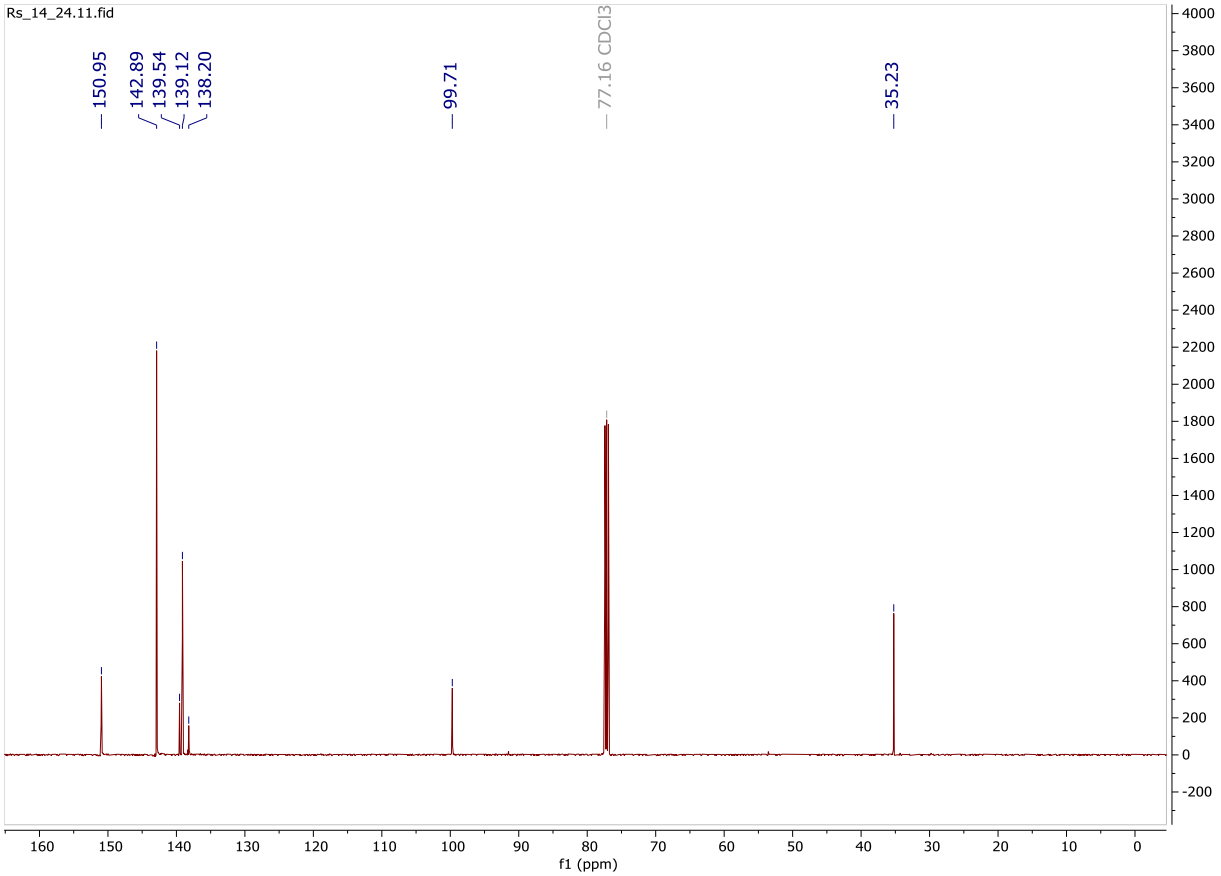
N-(1-methyl-1H-pyrazol-5-yl)pyrimidin-5-amine (14_24)



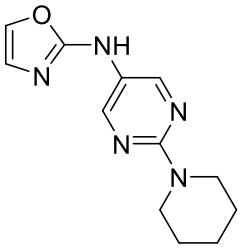
$^{13}C\{^{1}H\}$ NMR



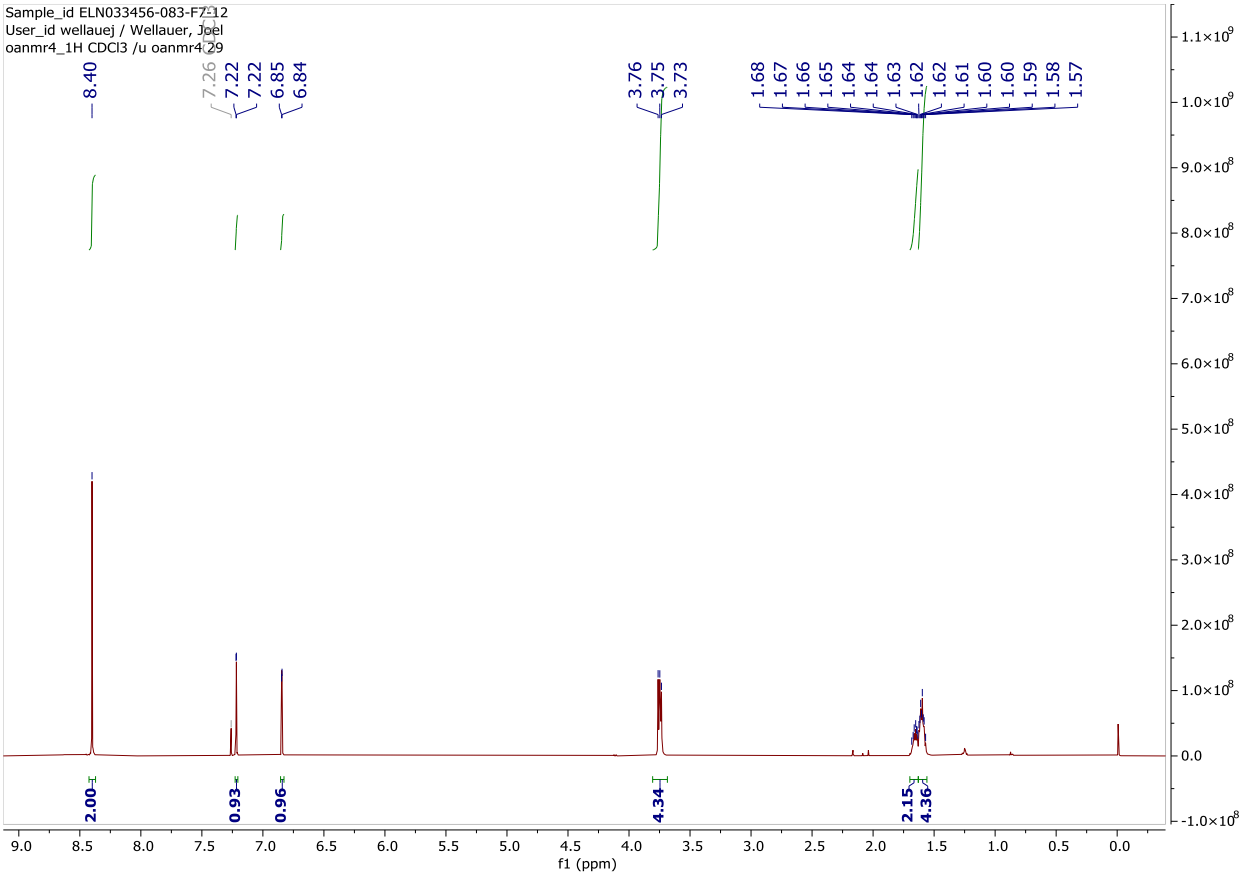
N-(1-methyl-1H-pyrazol-5-yl)pyrimidin-5-amine (14_24)



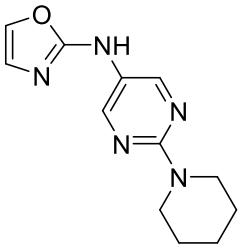
^{1}H NMR



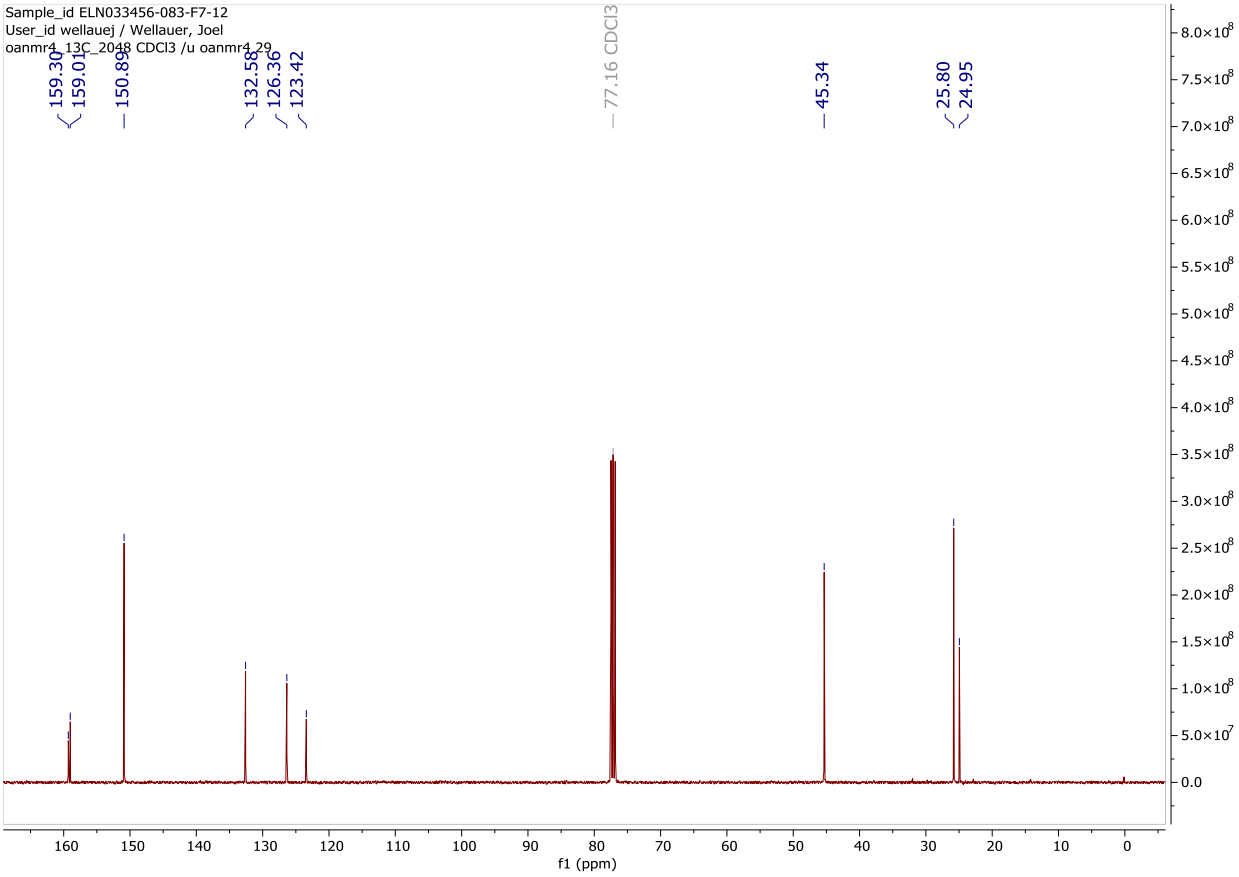
N-(2-(piperidin-1-yl)pyrimidin-5-yl)oxazol-2-amine (26_27)



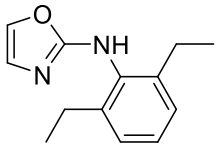
$^{13}C\{^{1}H\}$ NMR



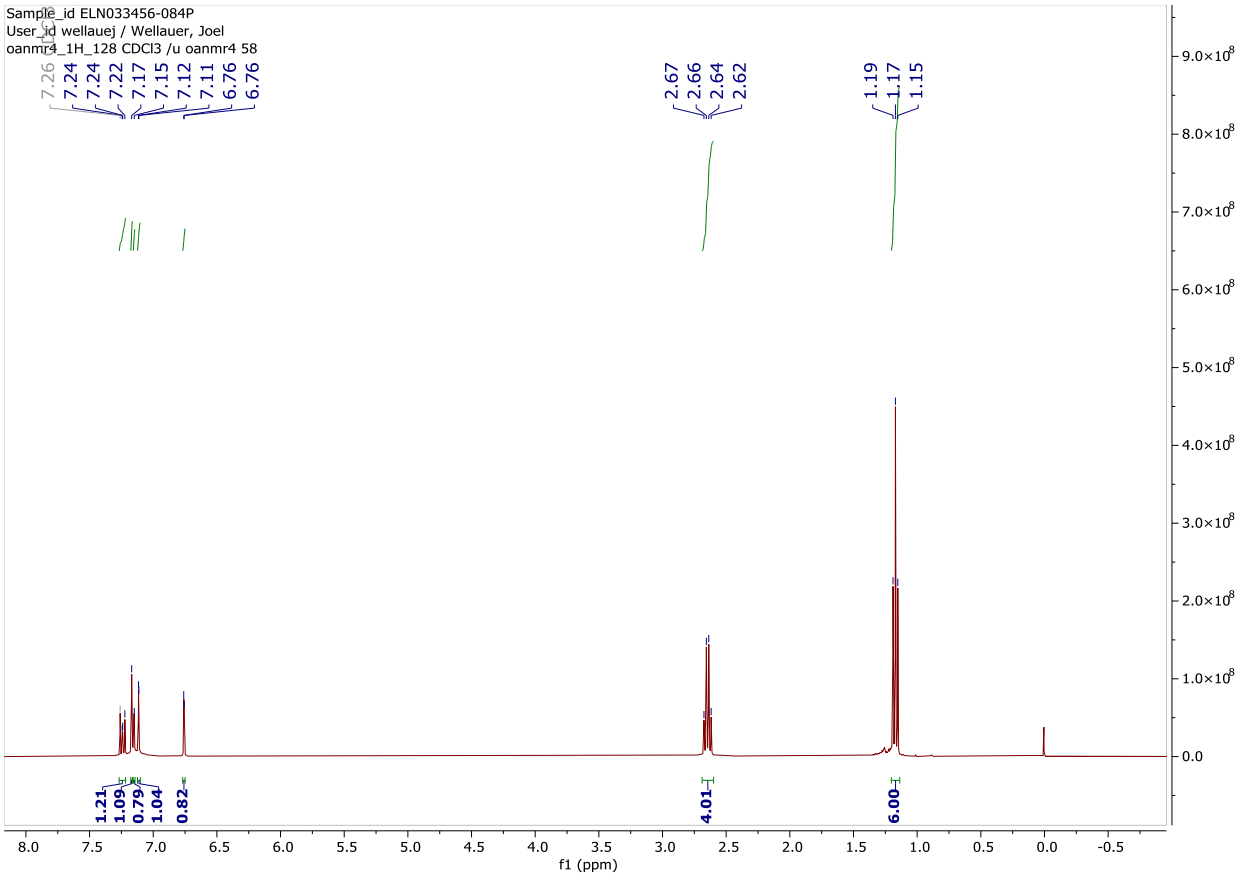
N-(2-(piperidin-1-yl)pyrimidin-5-yl)oxazol-2-amine (26_27)



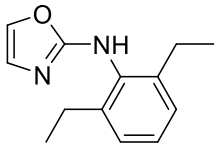
^{1}H NMR



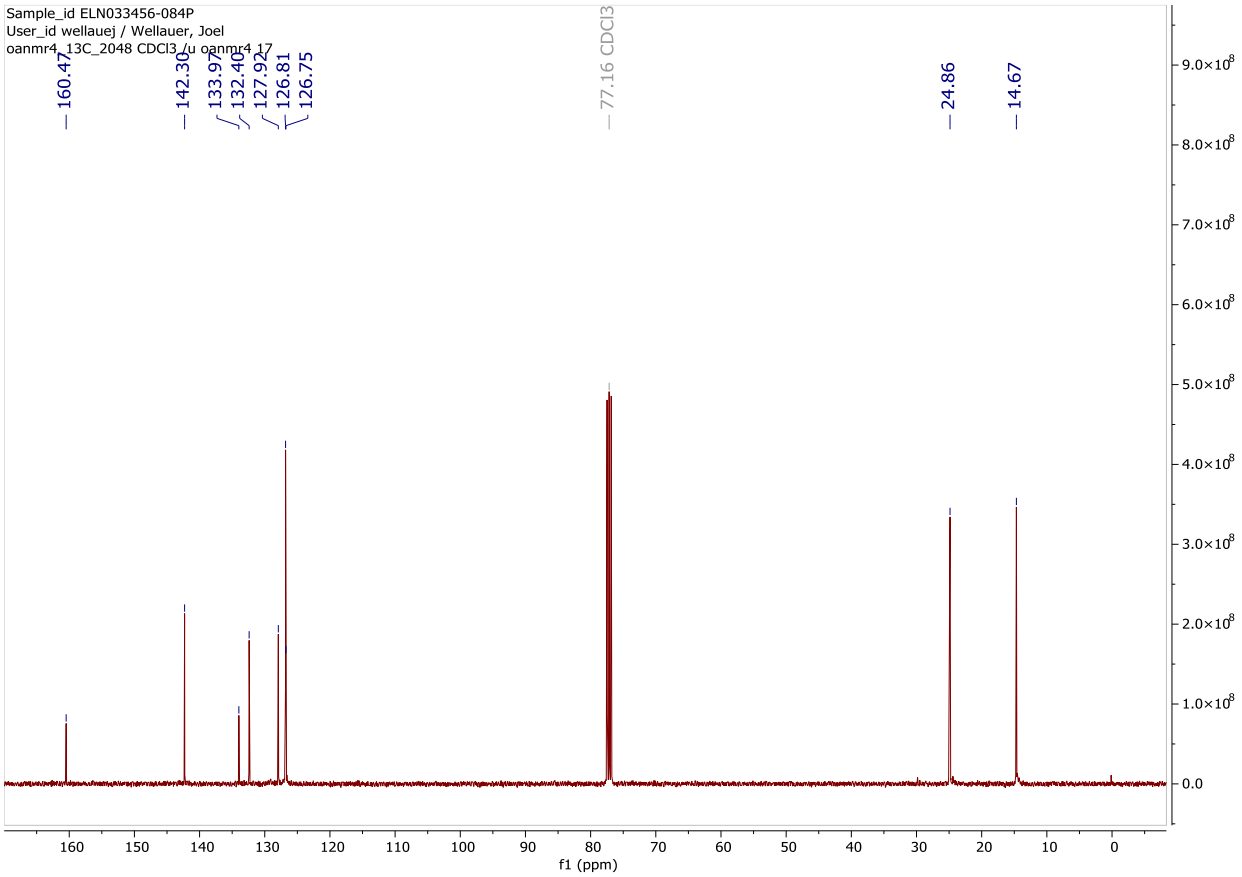
N-(2,6-diethylphenyl)oxazol-2-amine (26_10)



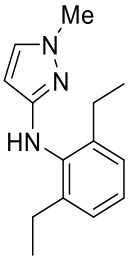
$^{13}C\{^{1}H\}$ NMR



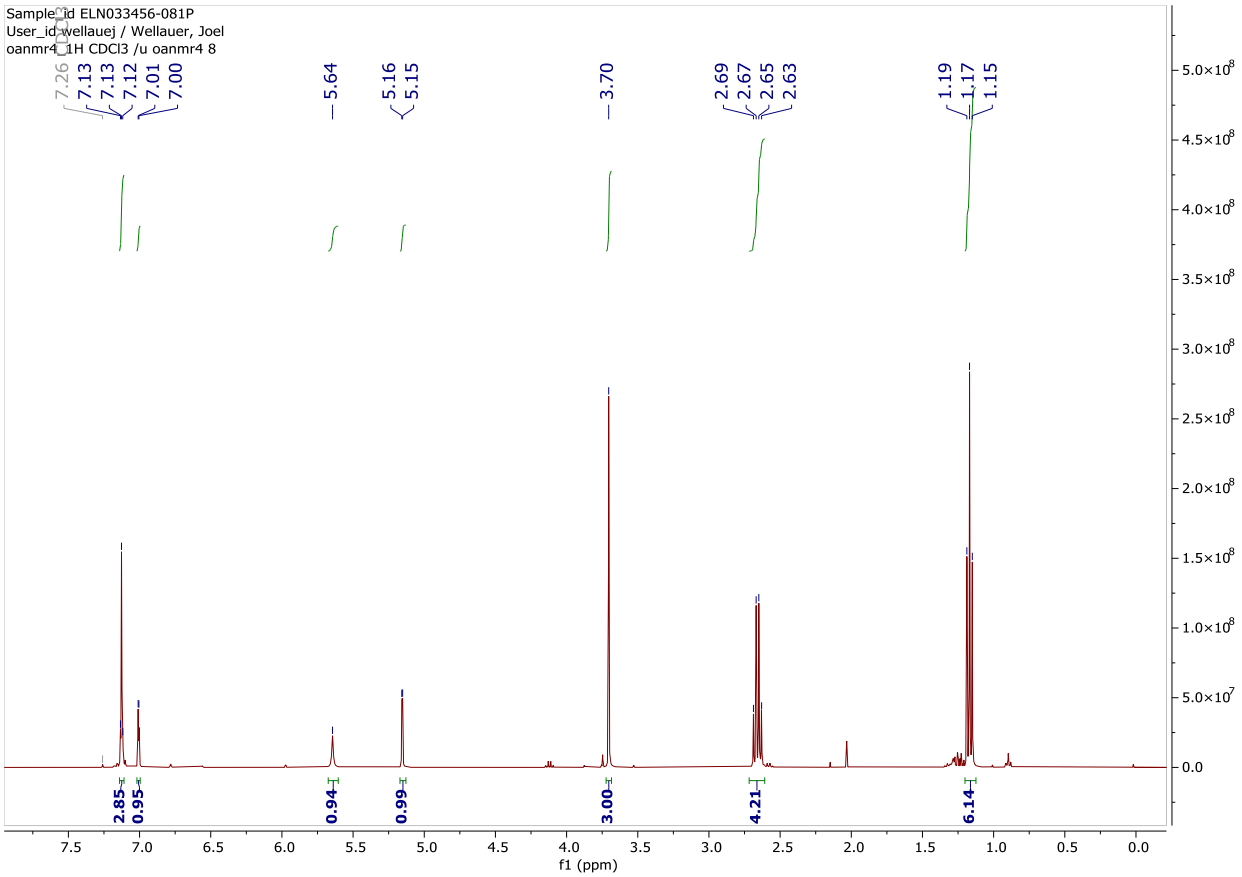
N-(2,6-diethylphenyl)oxazol-2-amine (26_10)



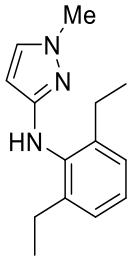
^{1}H NMR



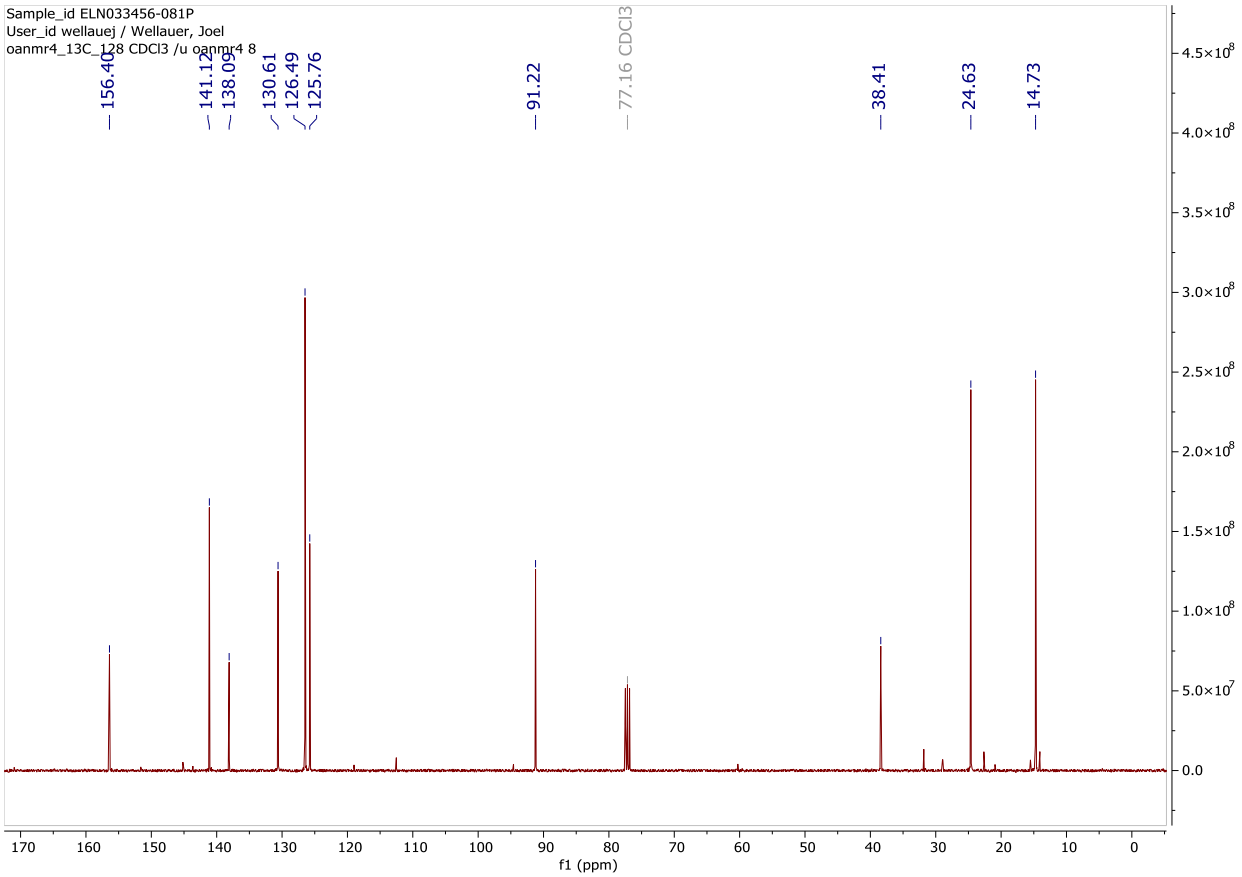
N-(2,6-diethylphenyl)-1-methyl-1H-pyrazol-3-amine (16_10)



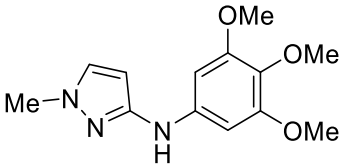
$^{13}C\{^{1}H\}$ NMR



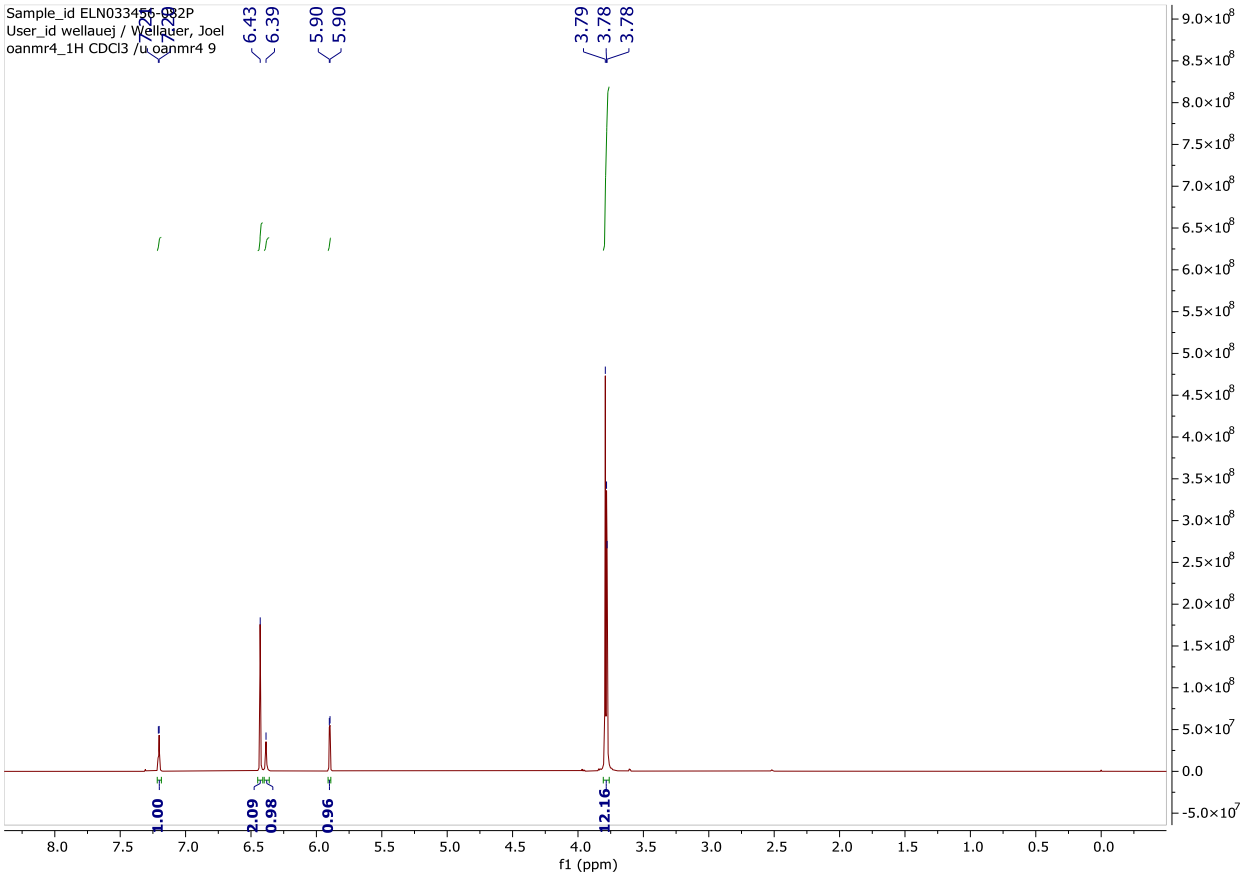
N-(2,6-diethylphenyl)-1-methyl-1H-pyrazol-3-amine (16_10)



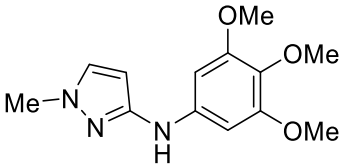
^{1}H NMR



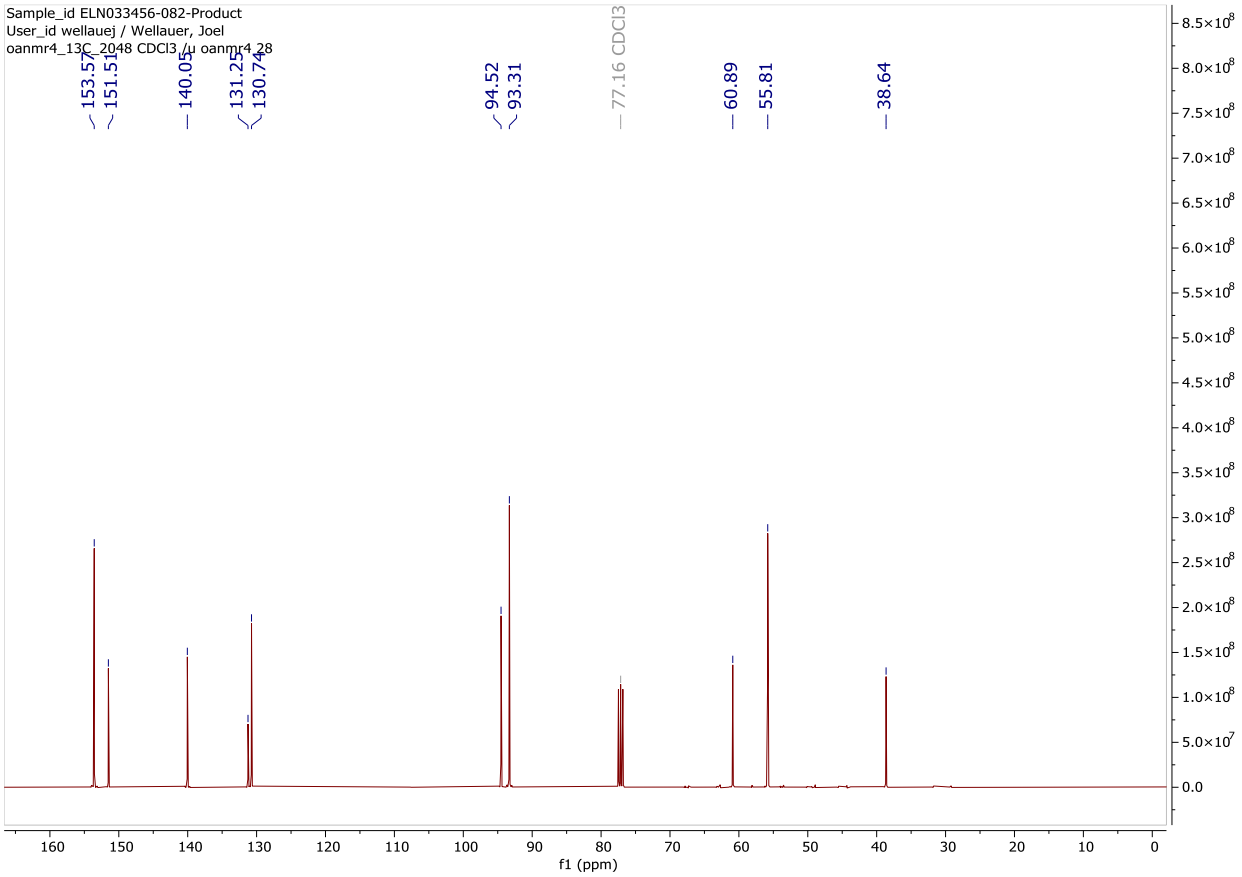
1-methyl-N-(3,4,5-trimethoxyphenyl)-1H-pyrazol-3-amine (16_23)



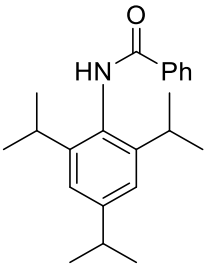
$^{13}C\{^{1}H\}$ NMR



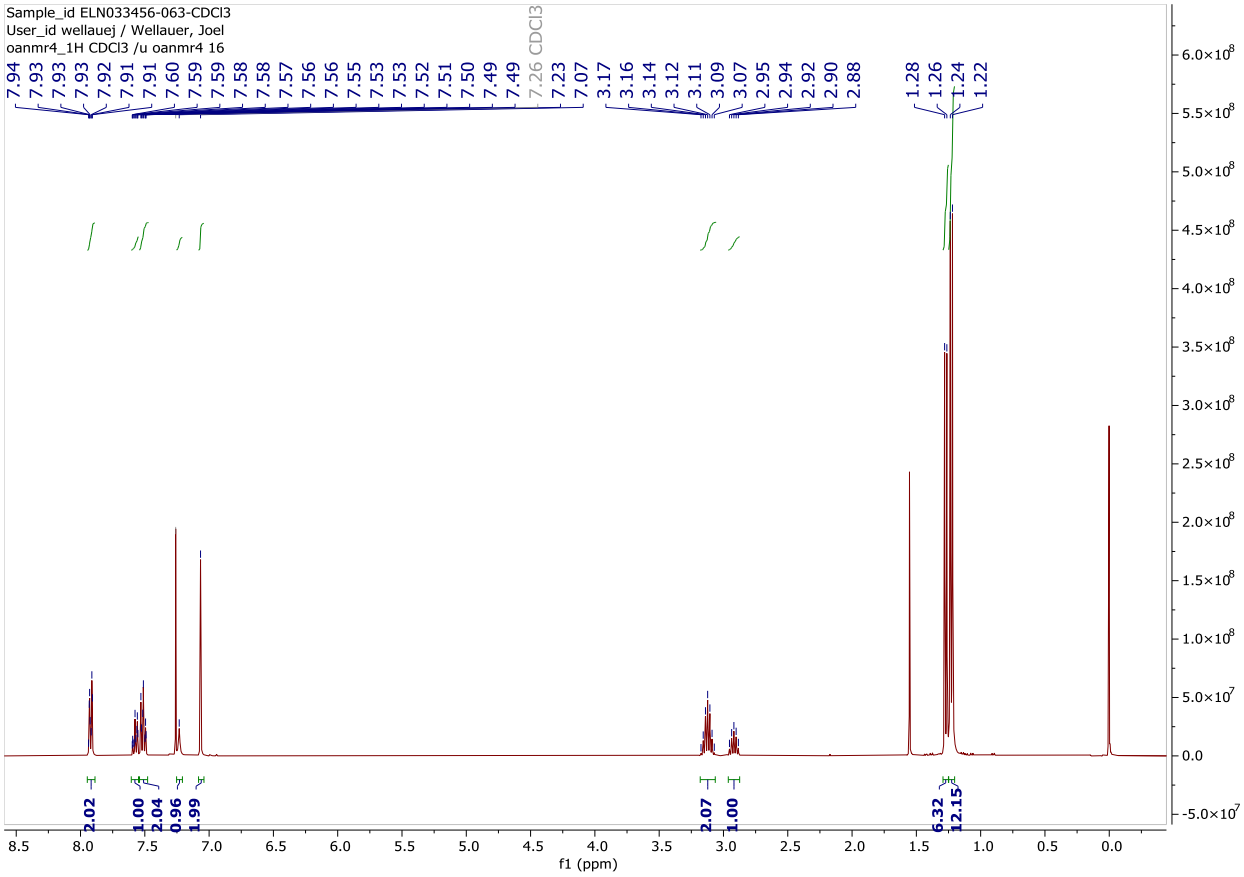
1-methyl-N-(3,4,5-trimethoxyphenyl)-1H-pyrazol-3-amine (16_23)



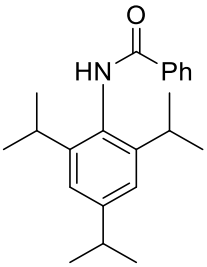
^{1}H NMR



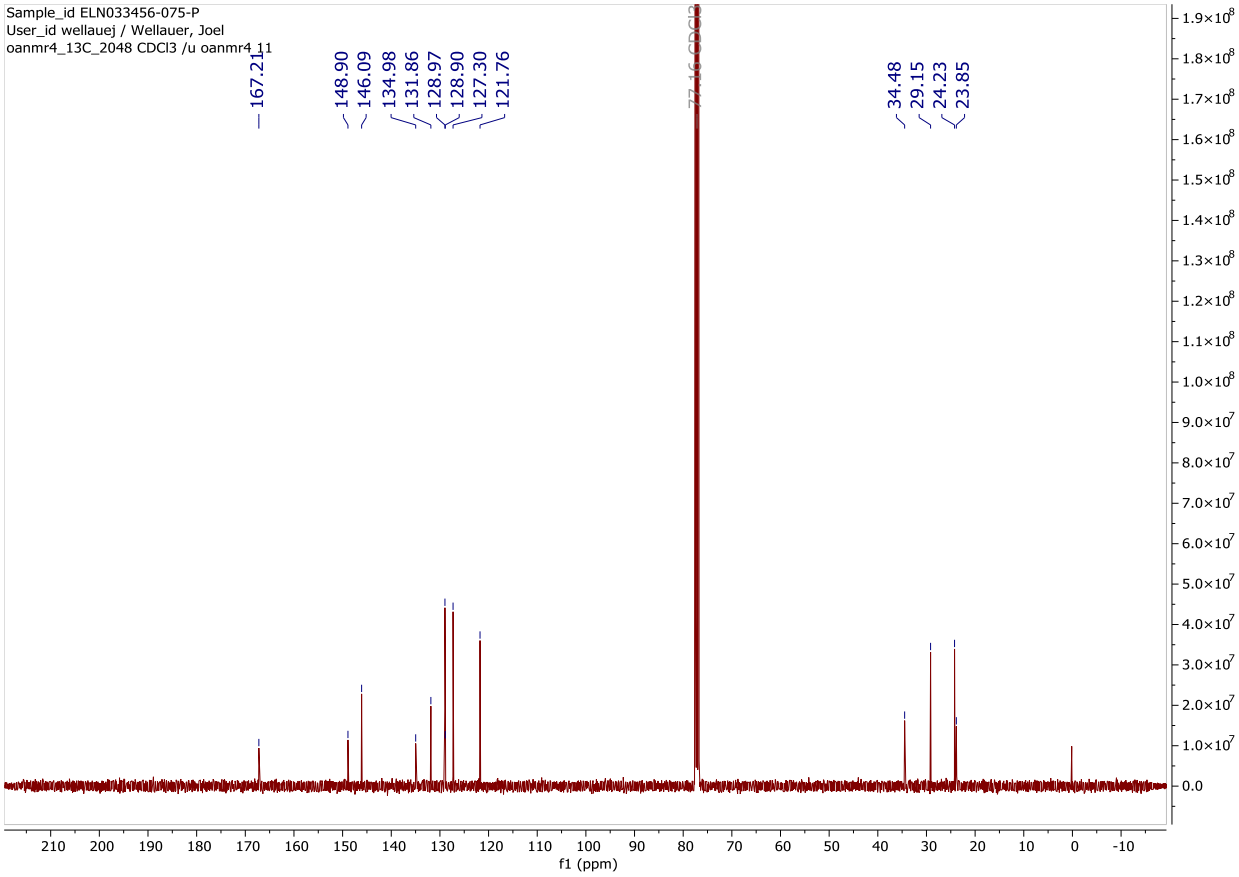
N-(2,4,6-triisopropylphenyl)benzamide (8_1)



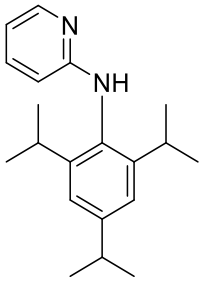
$^{13}C\{^{1}H\}$ NMR



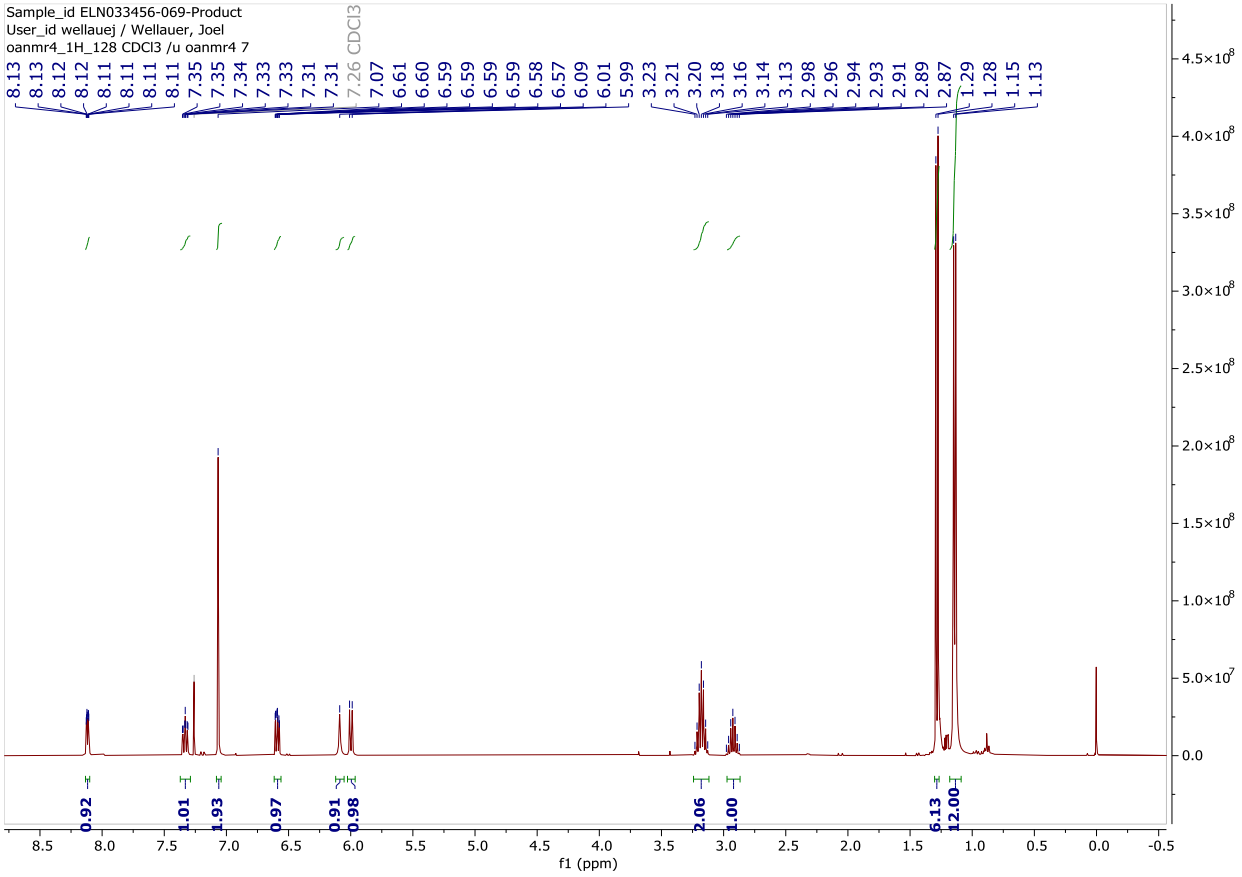
N-(2,4,6-triisopropylphenyl)benzamide (8_1)



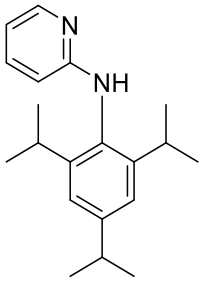
^{1}H NMR



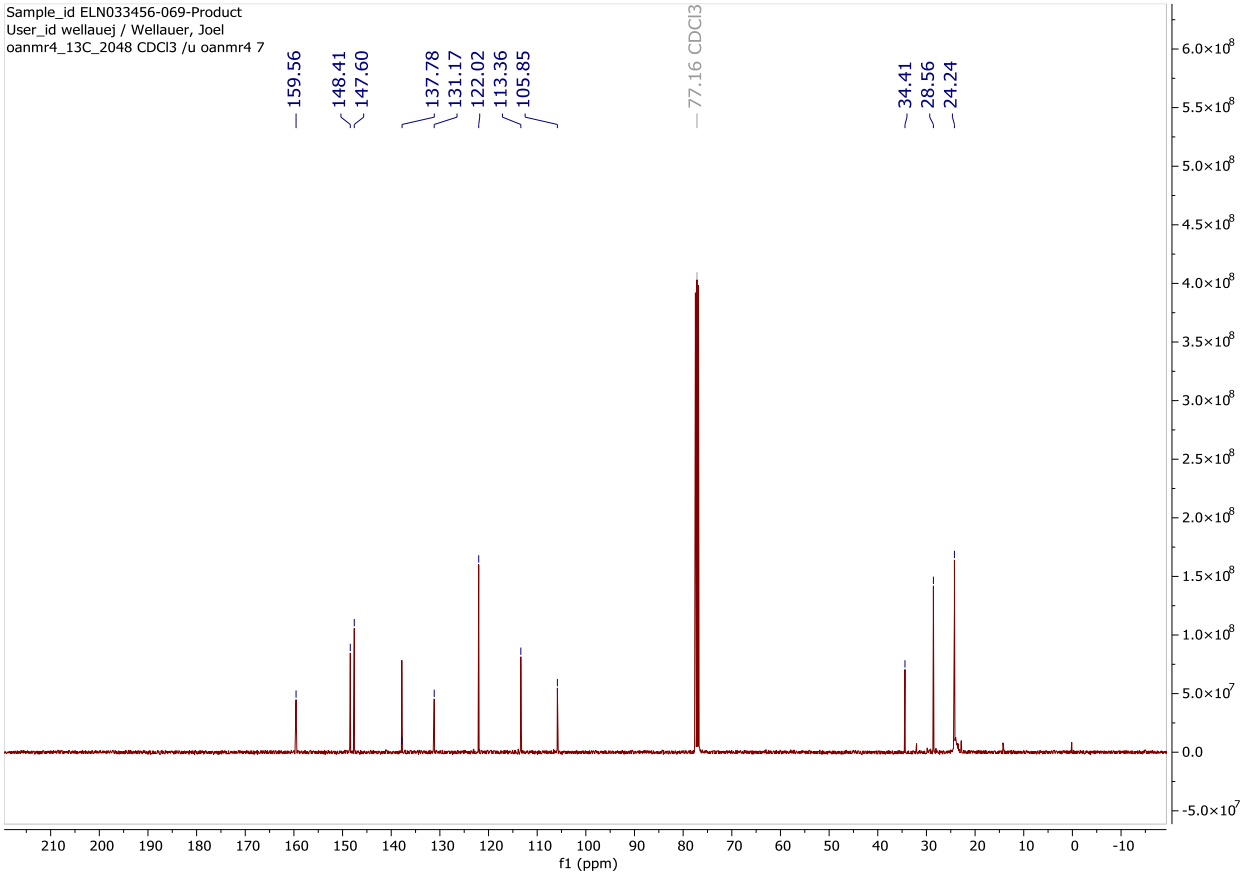
N-(2,4,6-triisopropylphenyl)pyridin-2-amine (11_1)



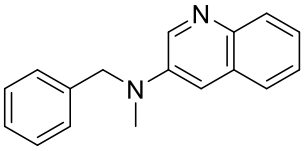
$^{13}C\{^{1}H\}$ NMR



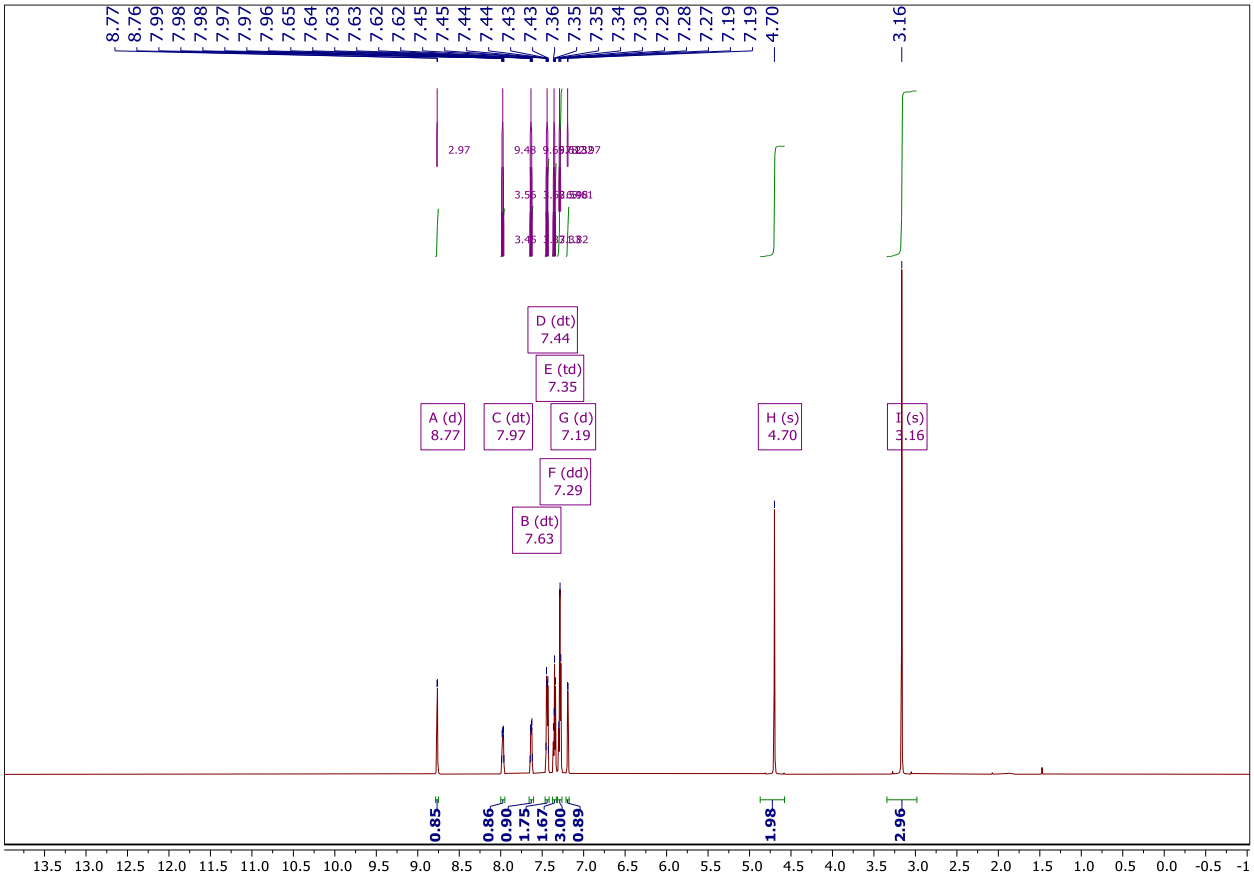
N-(2,4,6-triisopropylphenyl)pyridin-2-amine (11_1)



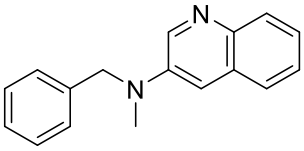
^{1}H NMR



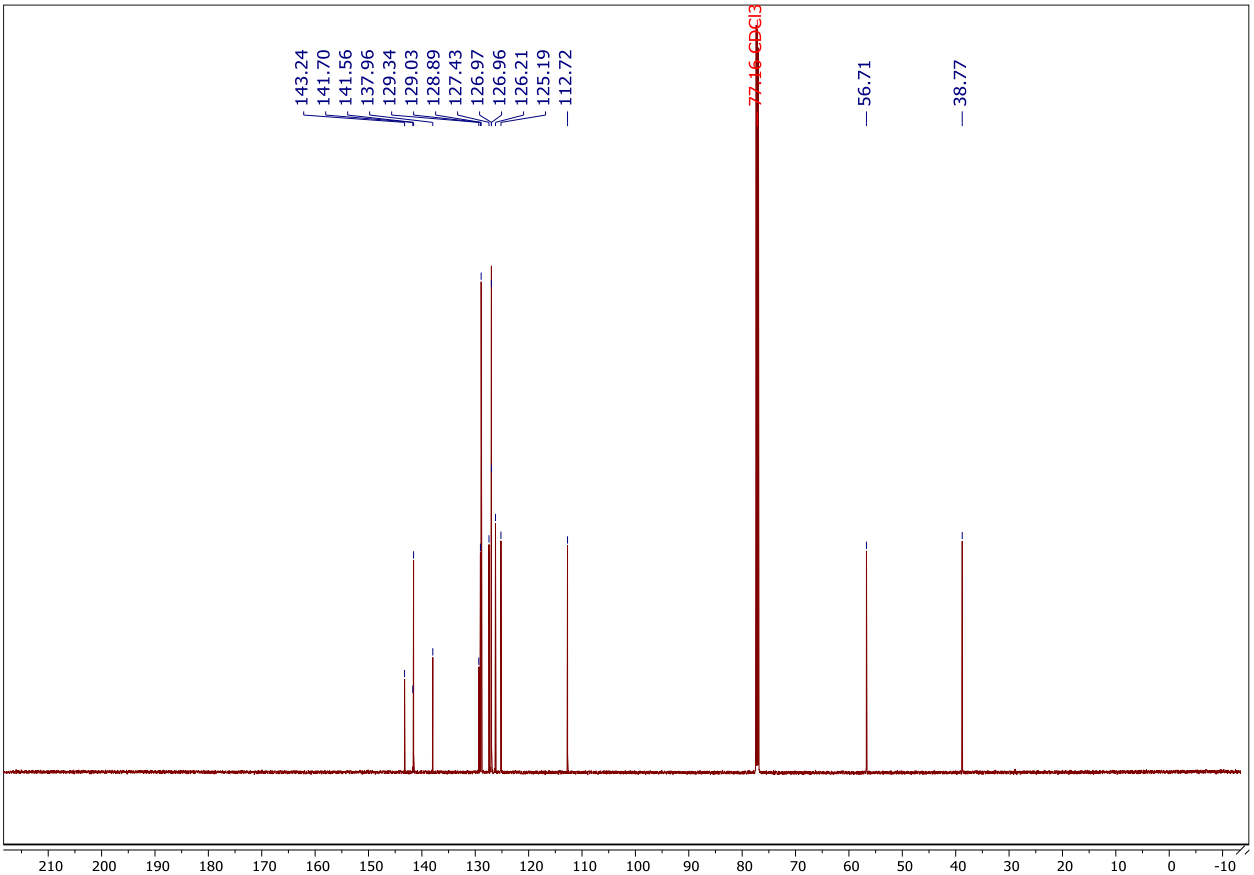
N-benzyl-N-methylquinolin-3-amine (48_22)



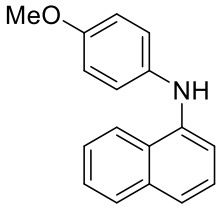
$^{13}C\{^{1}H\}$ NMR



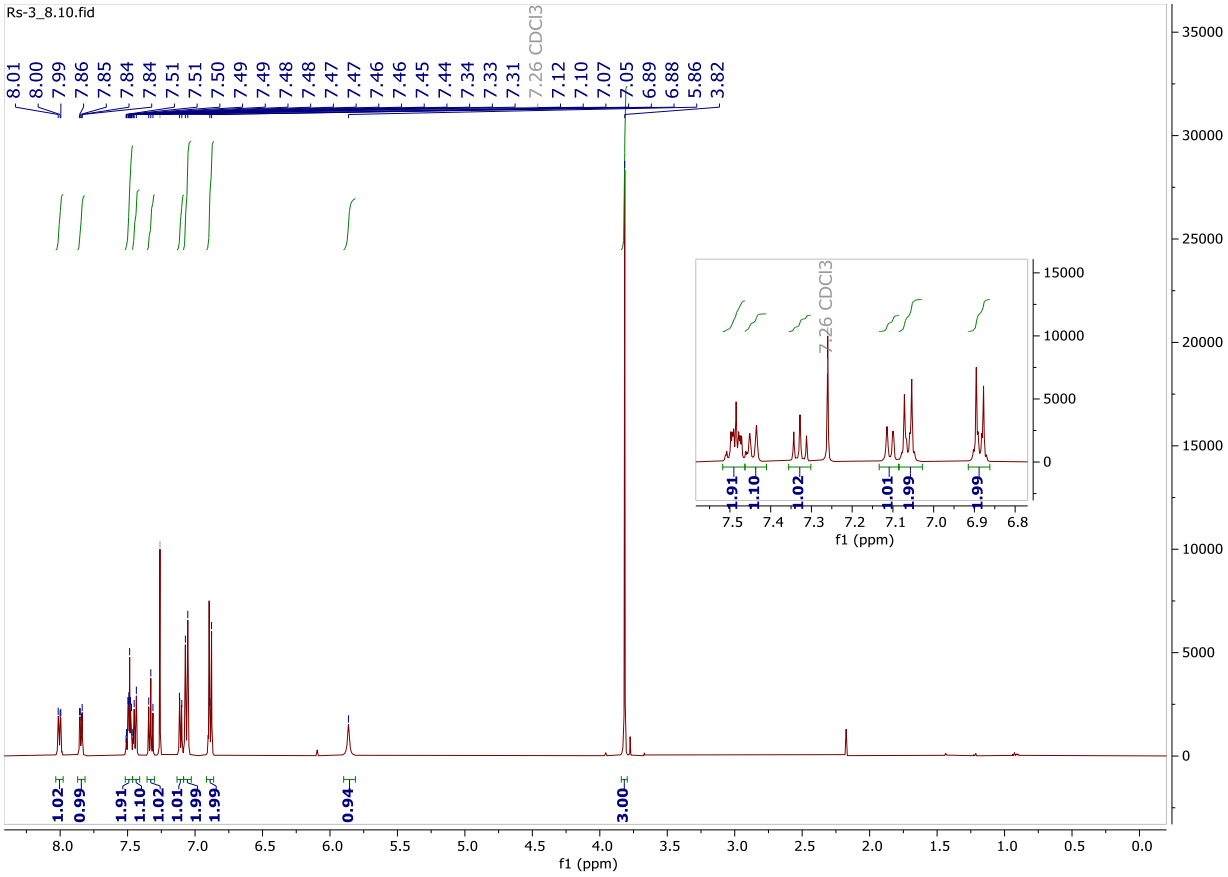
N-benzyl-N-methylquinolin-3-amine (48_22)



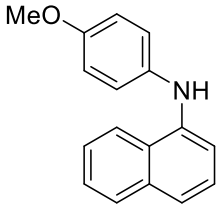
^{1}H NMR



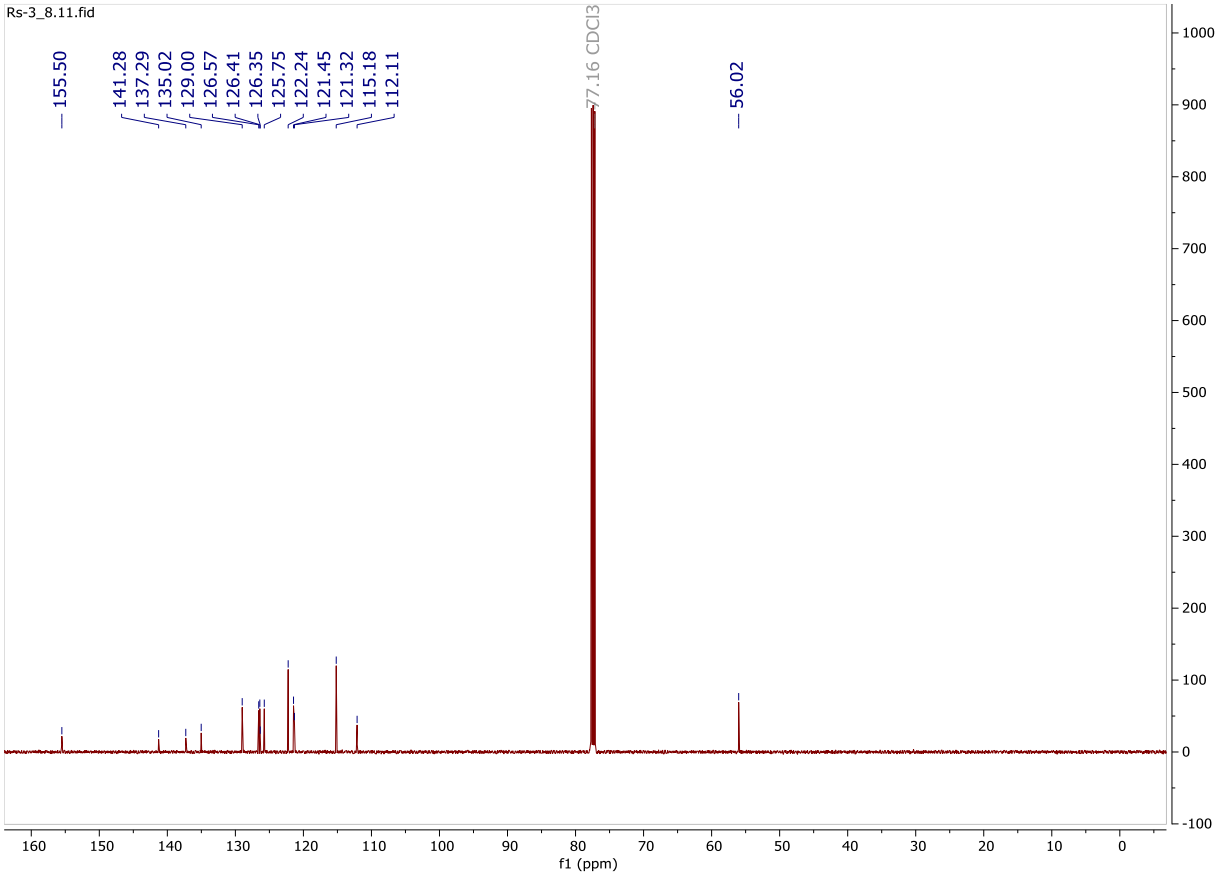
N-(4-methoxyphenyl)naphthalen-1-amine (3_8)



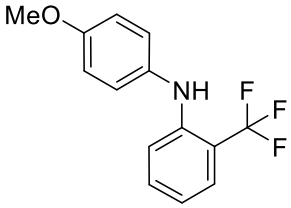
$^{13}C\{^{1}H\}$ NMR



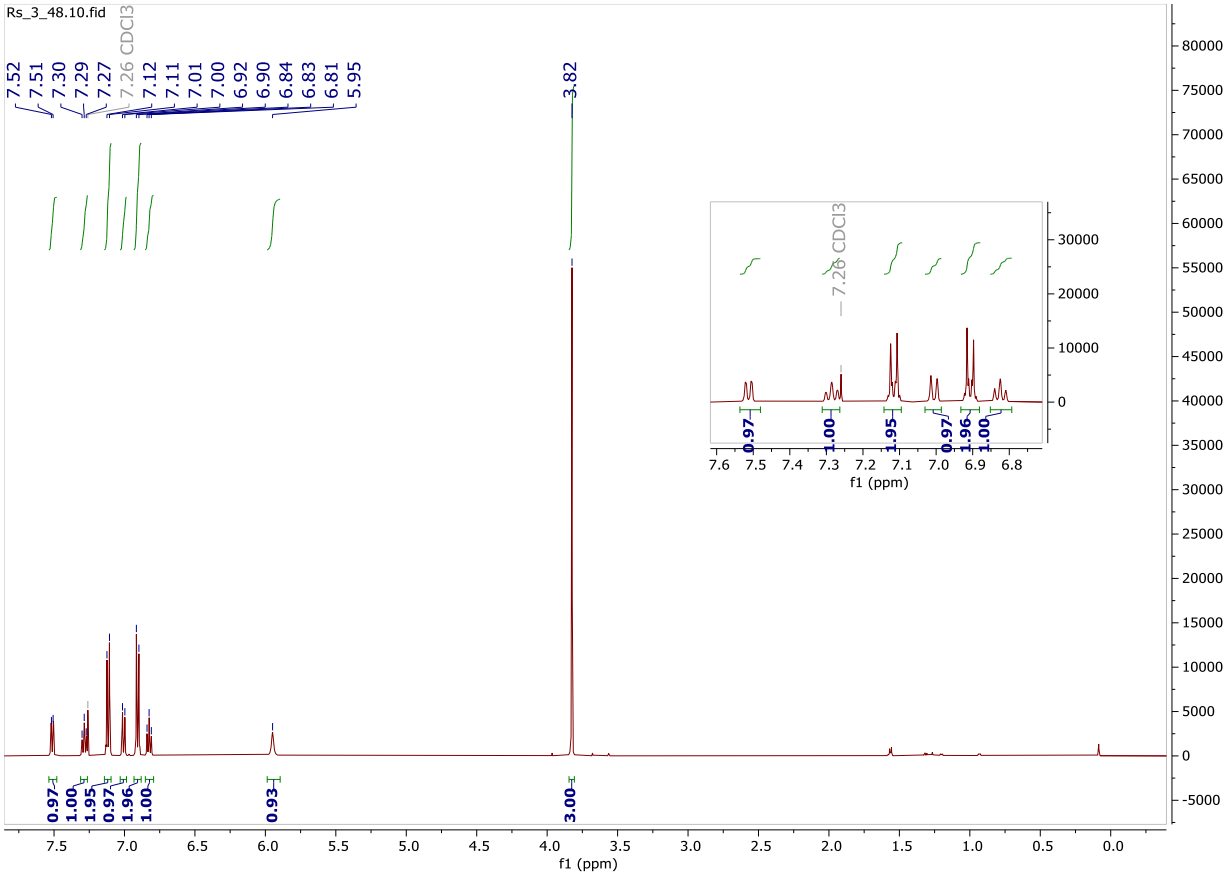
N-(4-methoxyphenyl)naphthalen-1-amine (3_8)



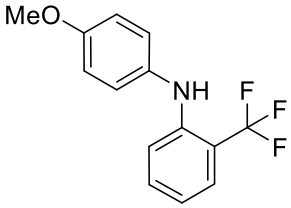
^{1}H NMR



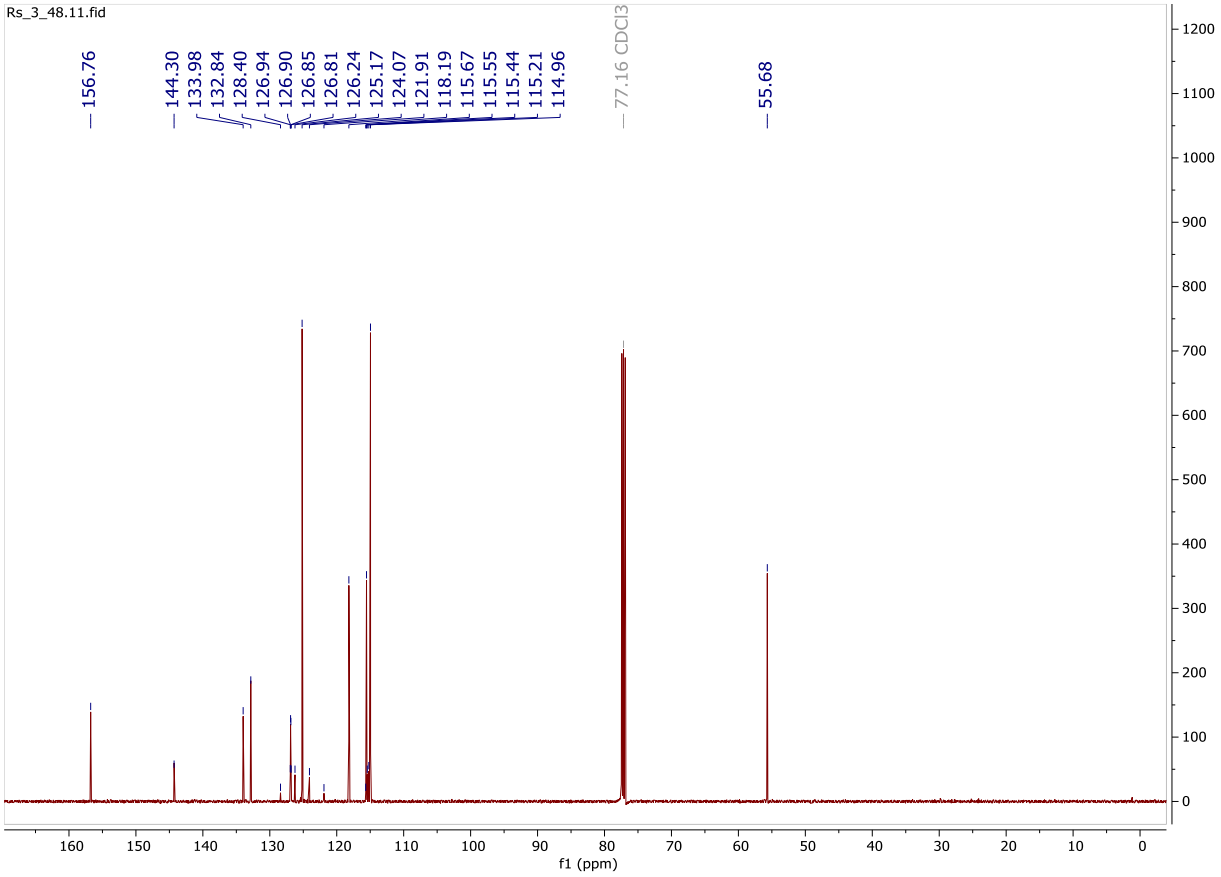
N-(4-methoxyphenyl)-2-(trifluoromethyl)aniline (3_48)



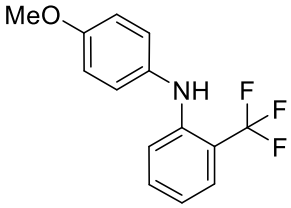
$^{13}C\{^{1}H\}$ NMR



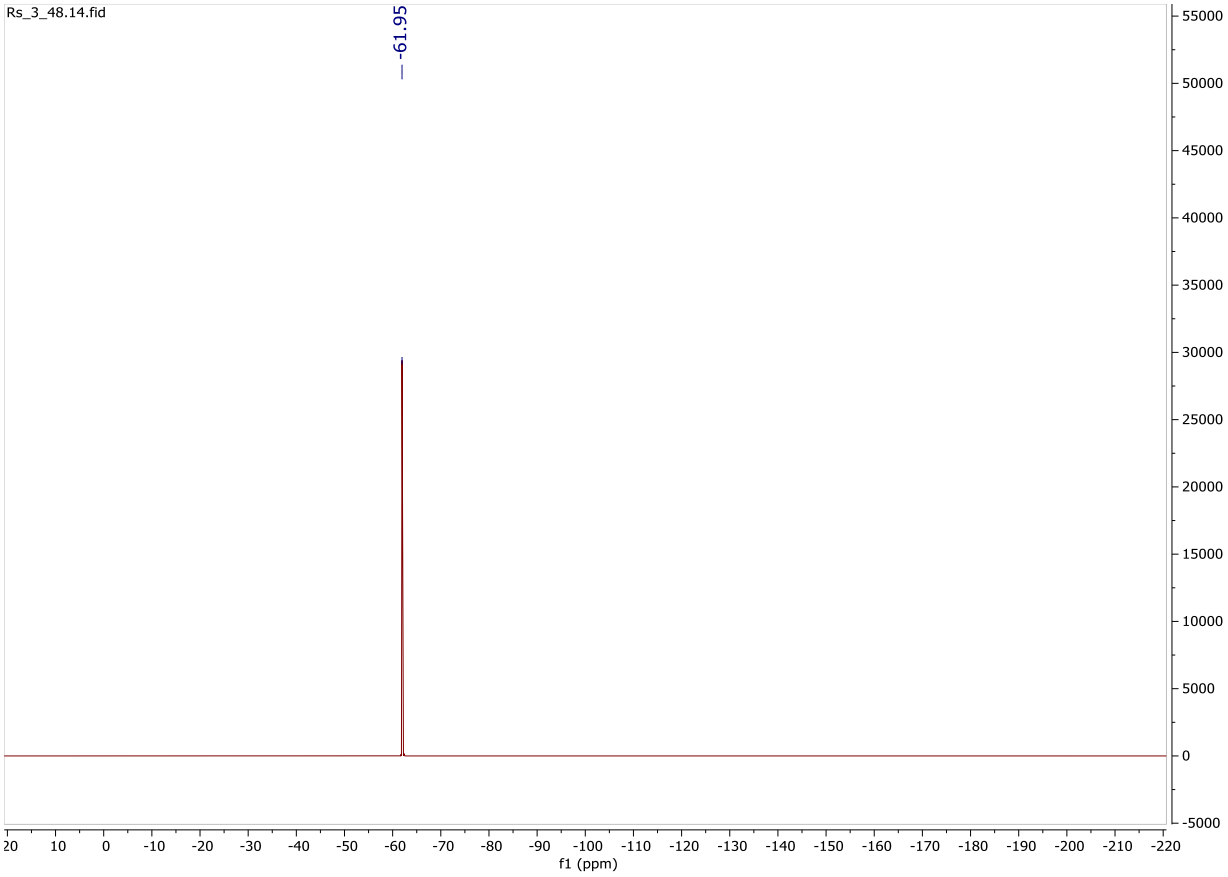
N-(4-methoxyphenyl)-2-(trifluoromethyl)aniline (3_48)



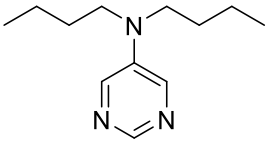
^{19}F NMR



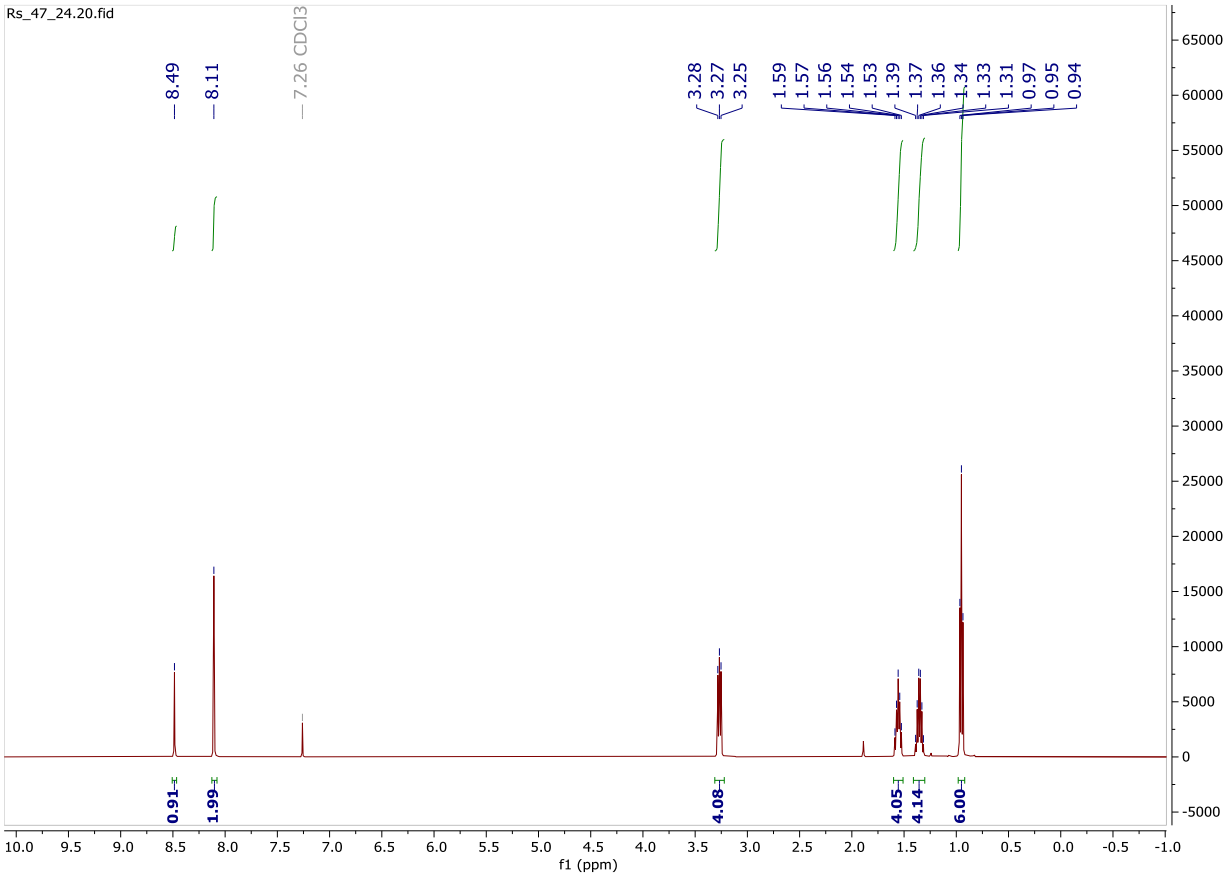
N-(4-methoxyphenyl)-2-(trifluoromethyl)aniline (3_48)



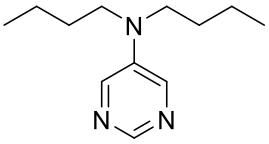
^{1}H NMR



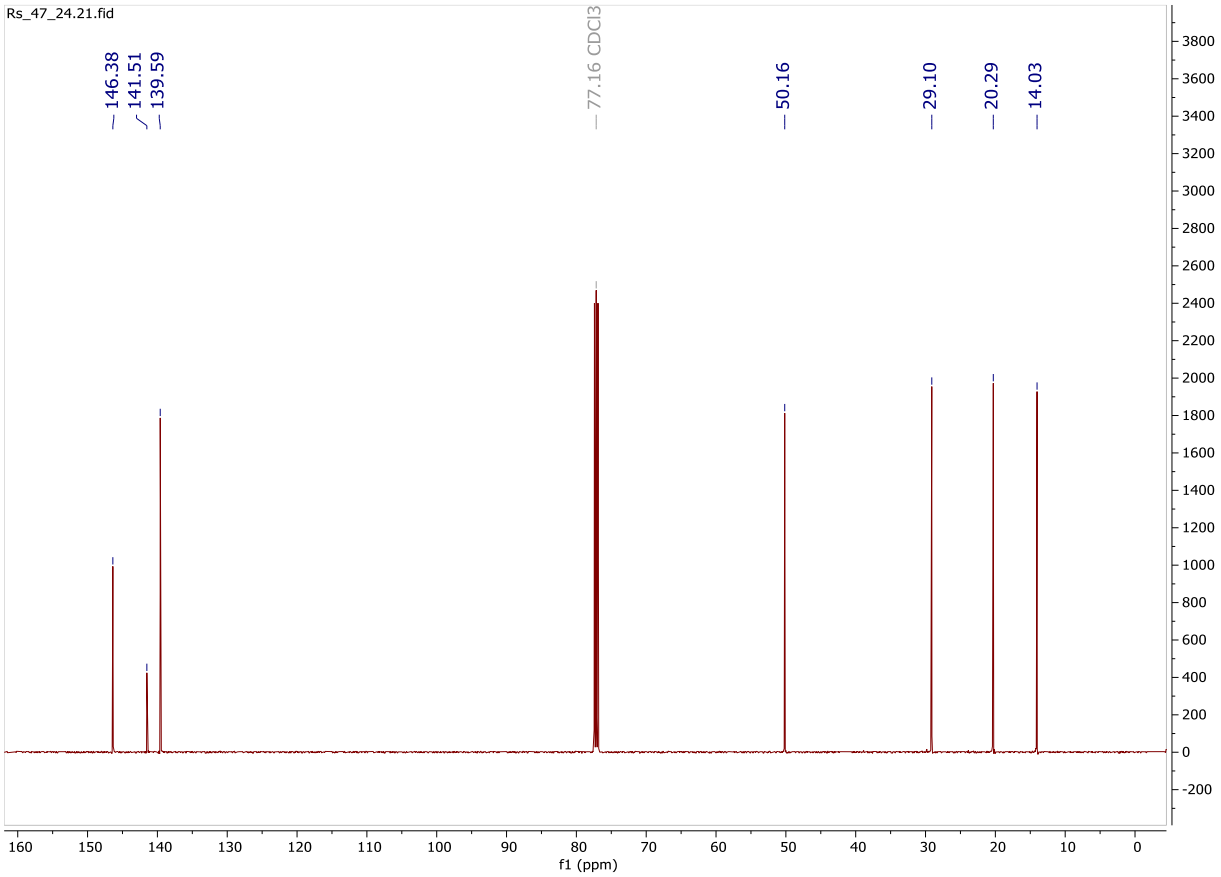
N,N-dibutylpyrimidin-5-amine (47_24)



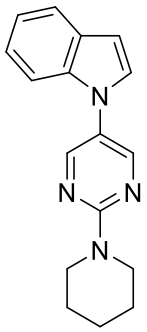
13 C NMR



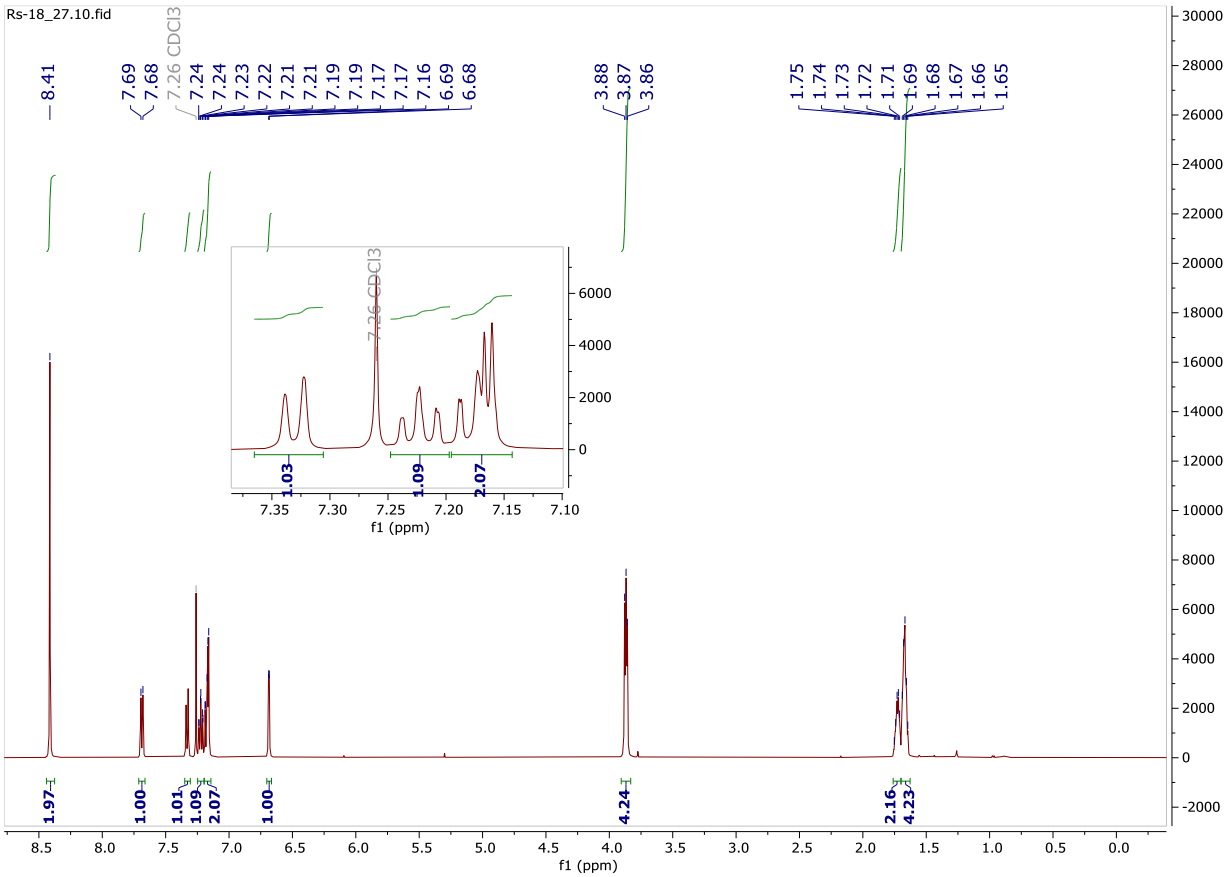
N,N-dibutylpyrimidin-5-amine (47_24)



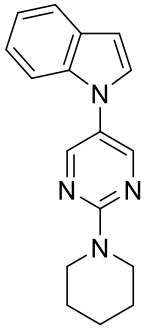
^{1}H NMR



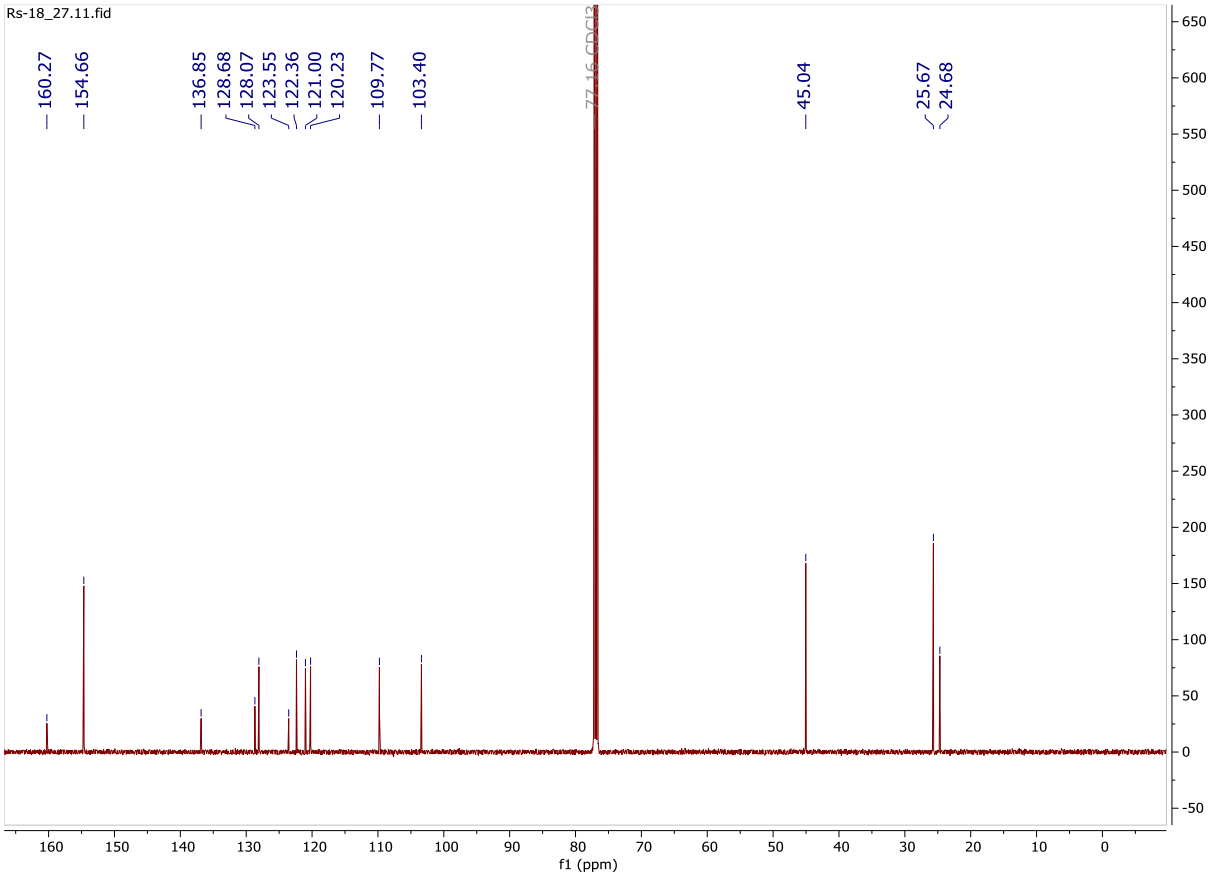
1-(2-(piperidin-1-yl)pyrimidin-5-yl)-1H-indole (18_27)



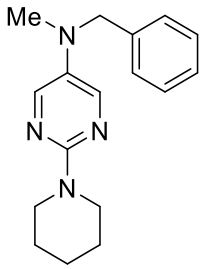
$^{13}C\{^{1}H\}$ NMR



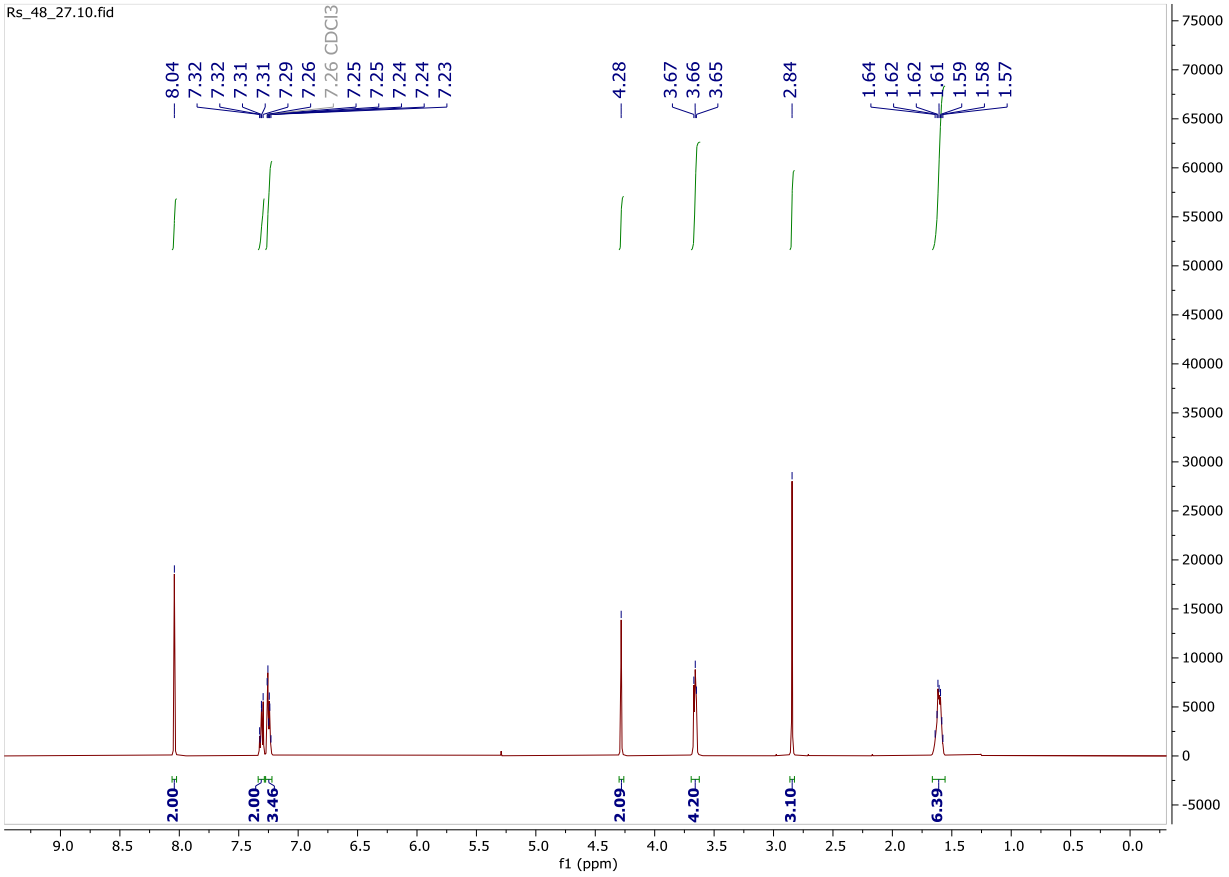
1-(2-(piperidin-1-yl)pyrimidin-5-yl)-1H-indole (18_27)



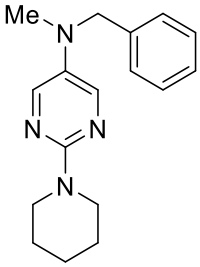
^{1}H NMR



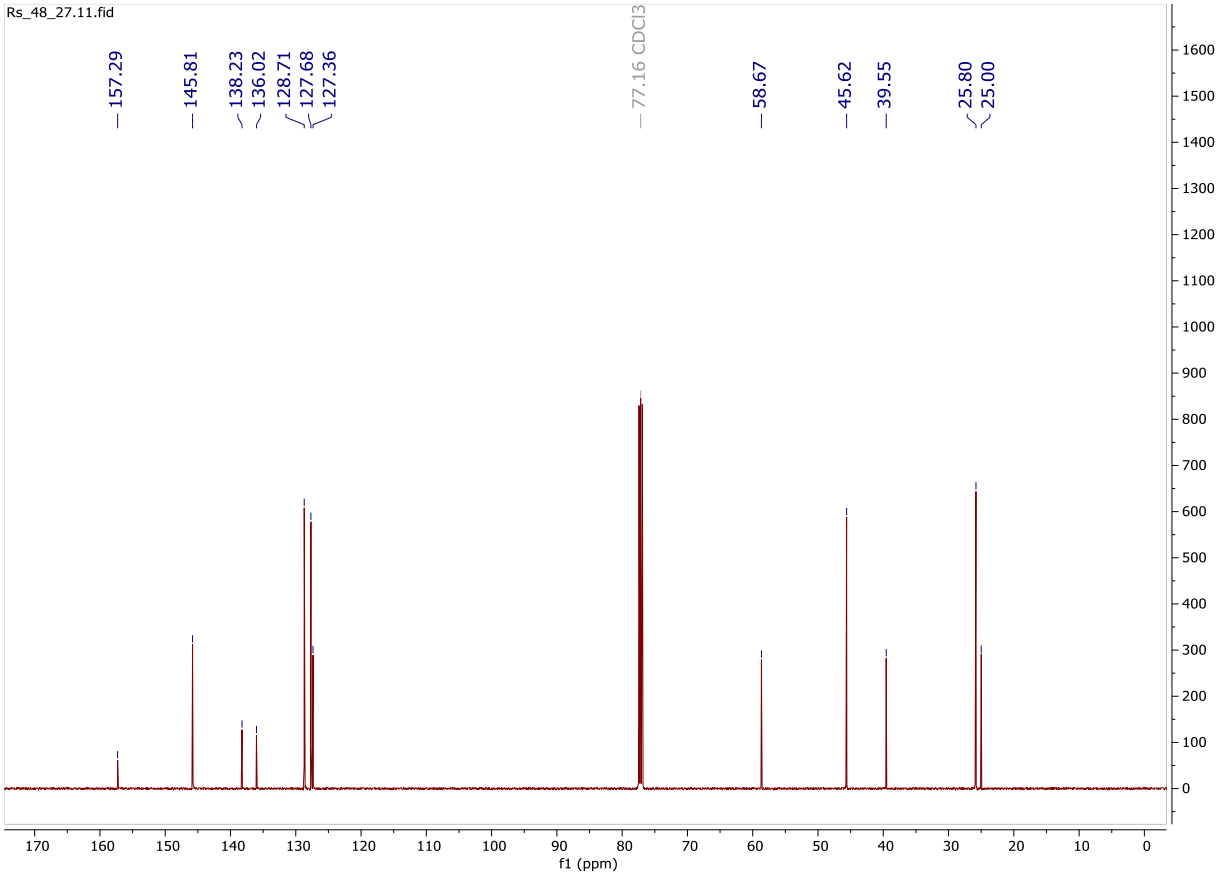
N-benzyl-N-methyl-2-(piperidin-1-yl)pyrimidin-5-amine (48_27)



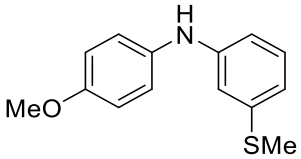
$^{13}C\{^{1}H\}$ NMR



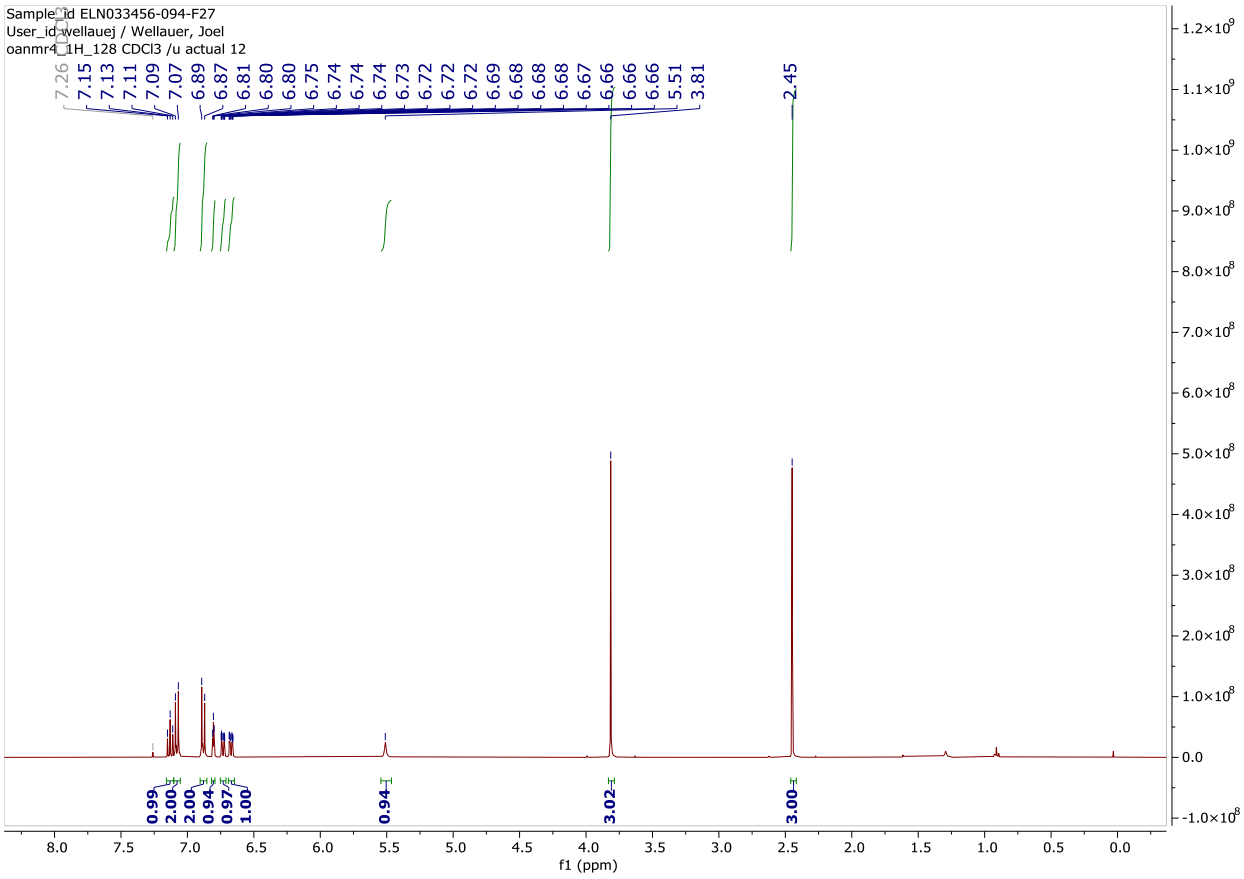
N-benzyl-N-methyl-2-(piperidin-1-yl)pyrimidin-5-amine (48_27)



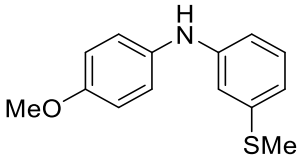
^{1}H NMR



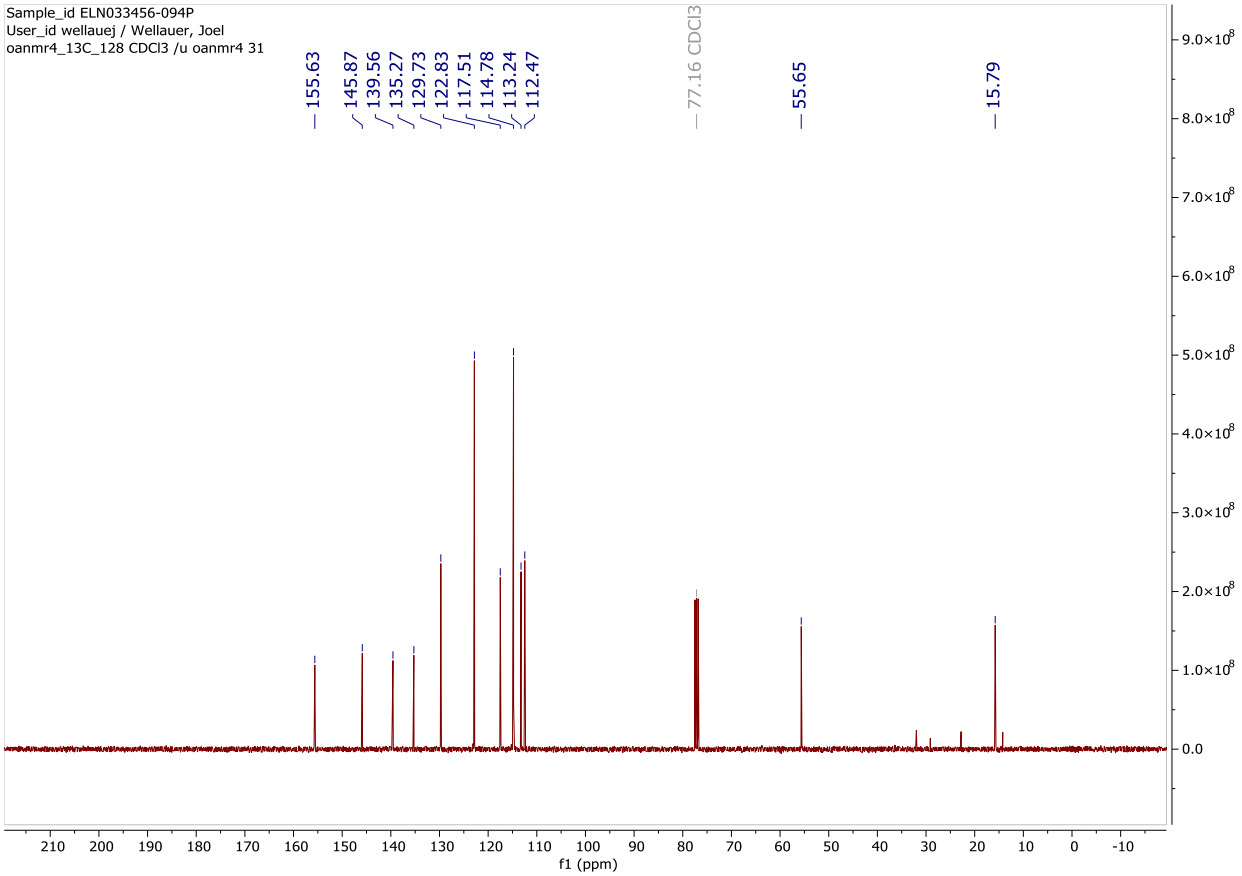
N-(4-methoxyphenyl)-3-(methylthio)aniline (3_11)



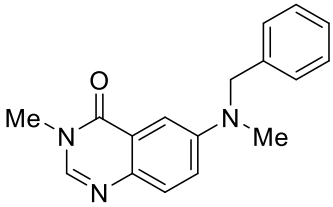
$^{13}C\{^{1}H\}$ NMR



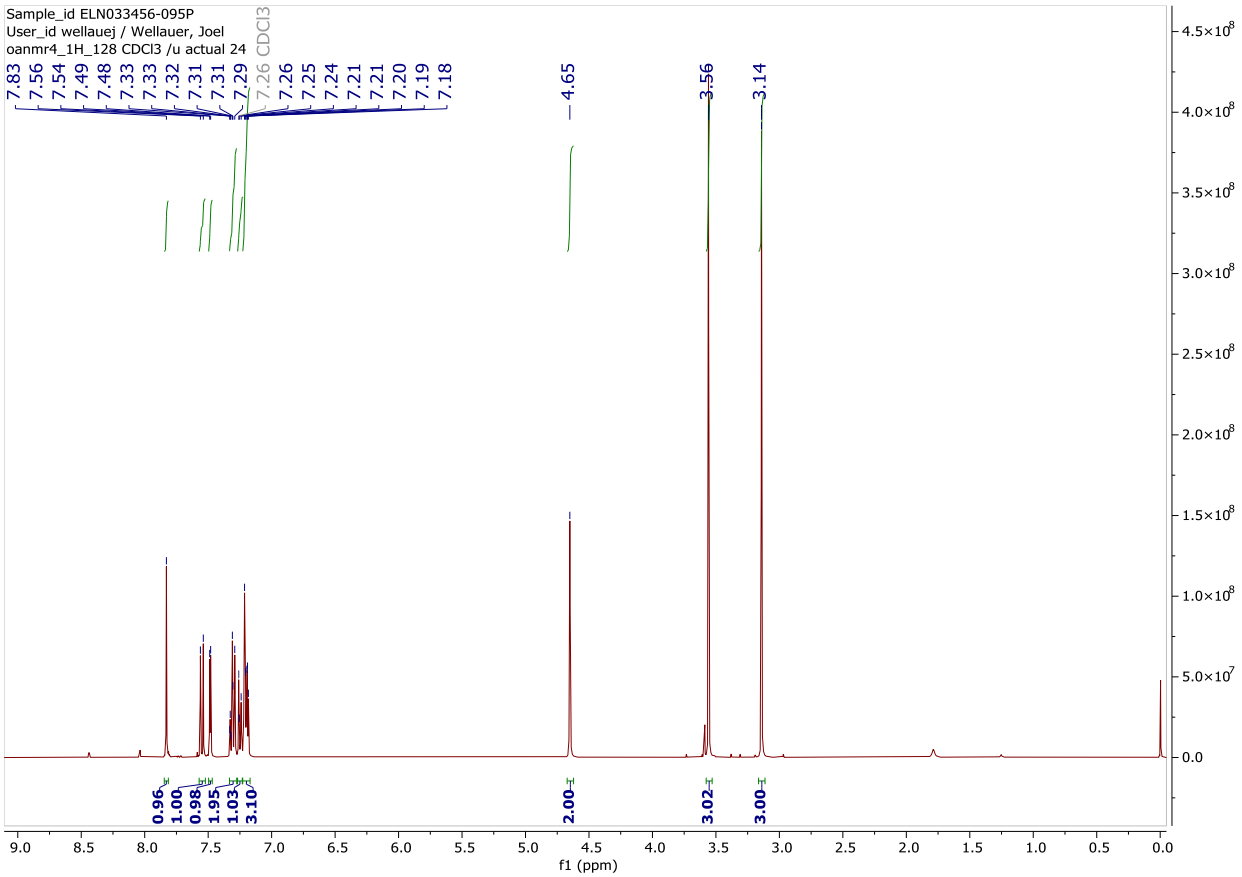
N-(4-methoxyphenyl)-3-(methylthio)aniline (3_11)



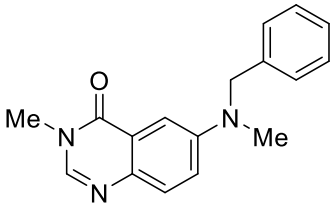
^{1}H NMR



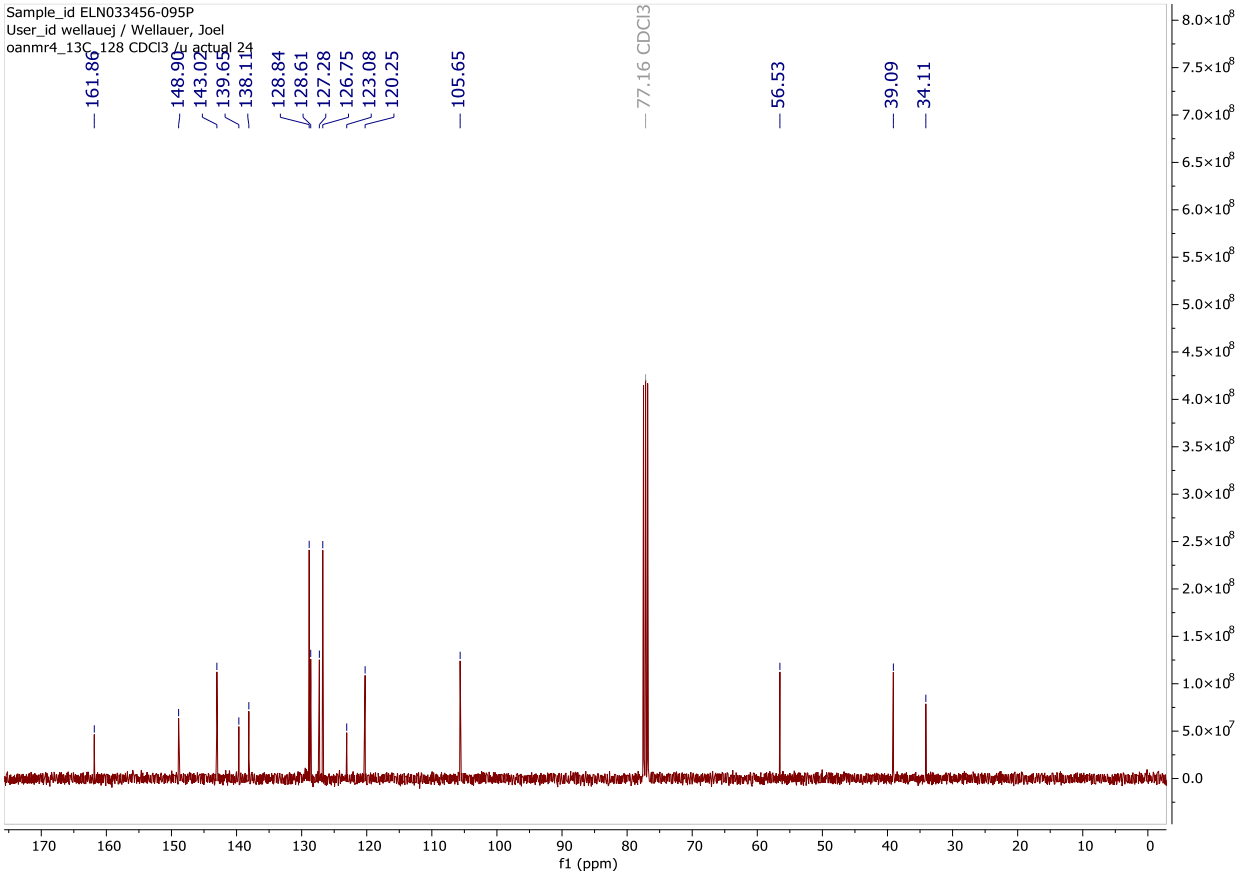
\6-(benzyl(methyl)amino)-3-methylquinazolin-4(3H)-one (48_14)



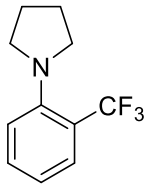
$^{13}C\{^{1}H\}$ NMR



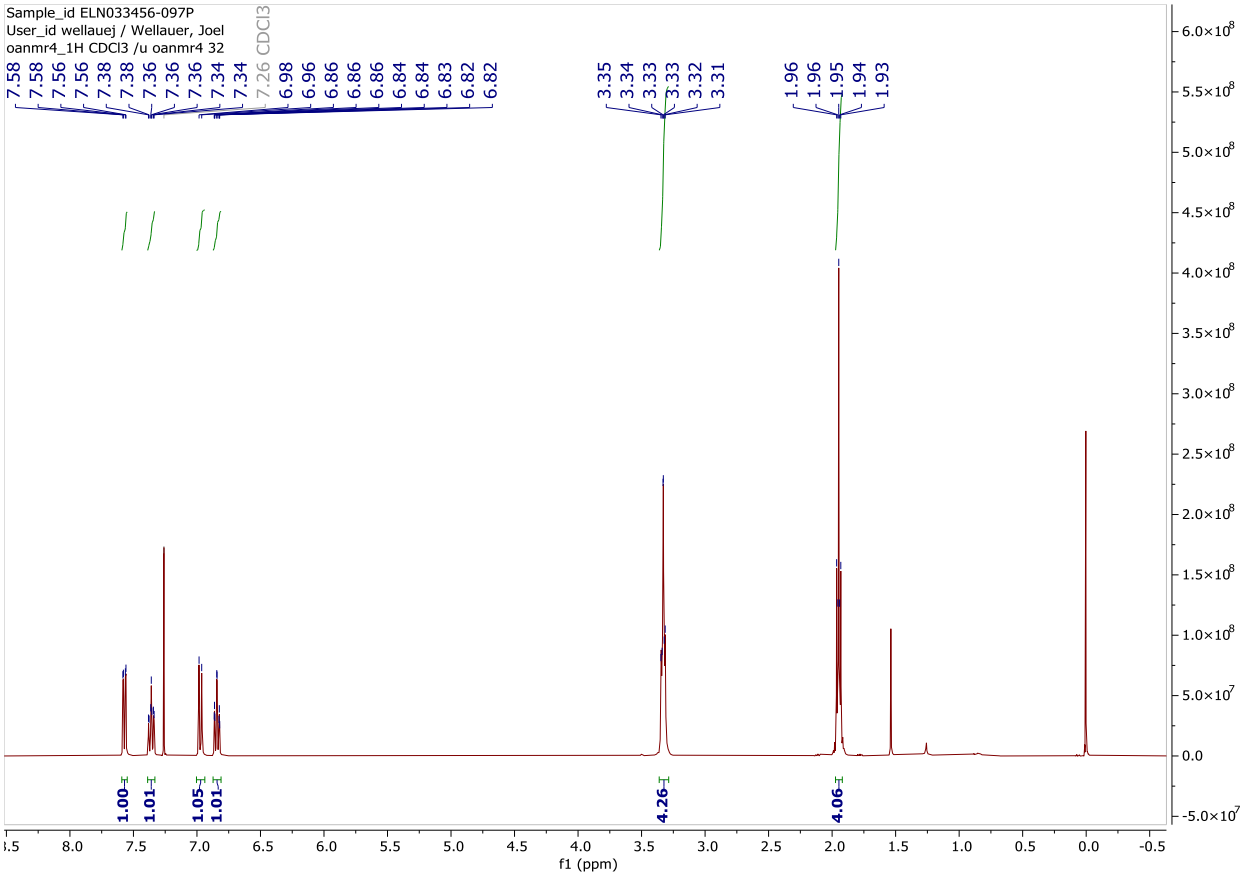
\6-(benzyl(methyl)amino)-3-methylquinazolin-4(3H)-one (48_14)



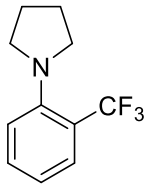
^{1}H NMR



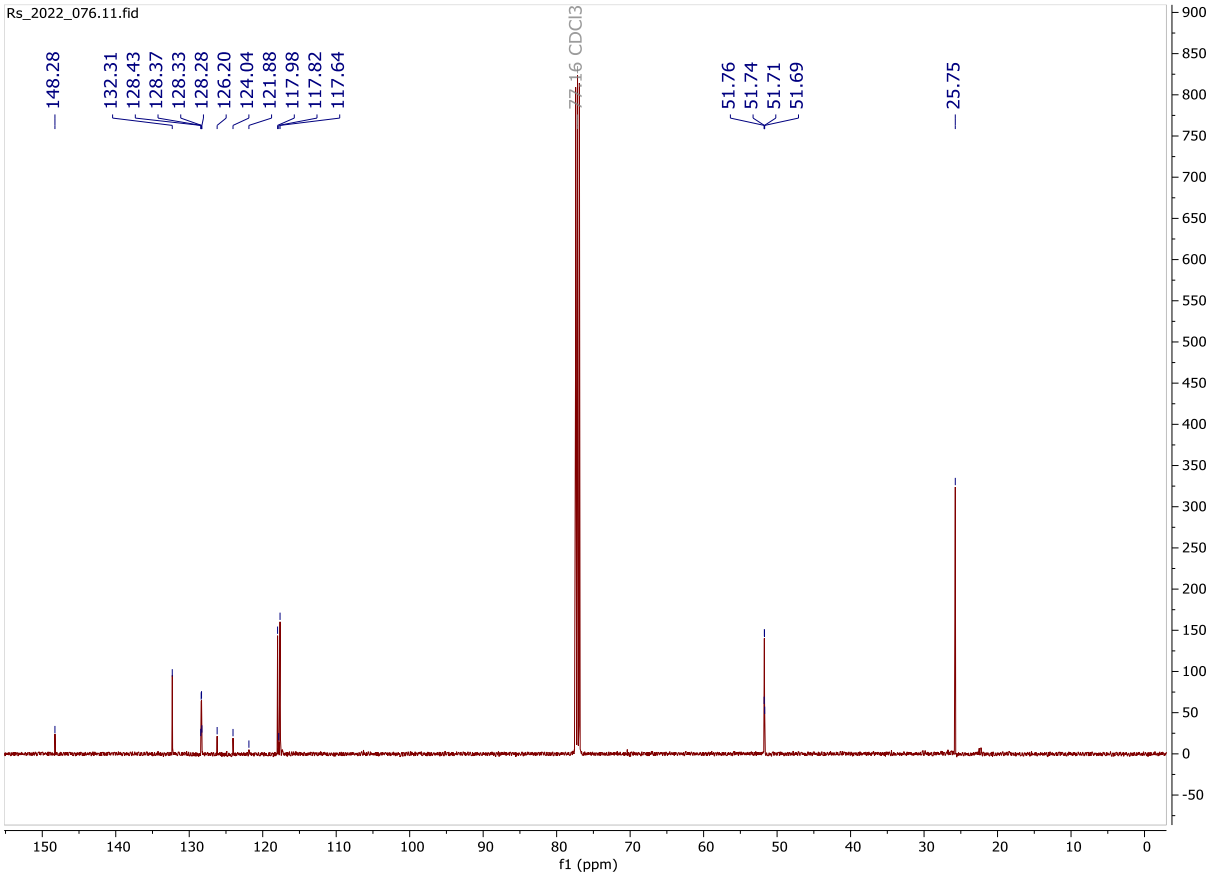
1-(2-(trifluoromethyl)phenyl)pyrrolidine (44_48)



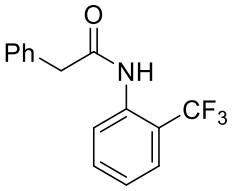
$^{13}C\{^{1}H\}$ NMR



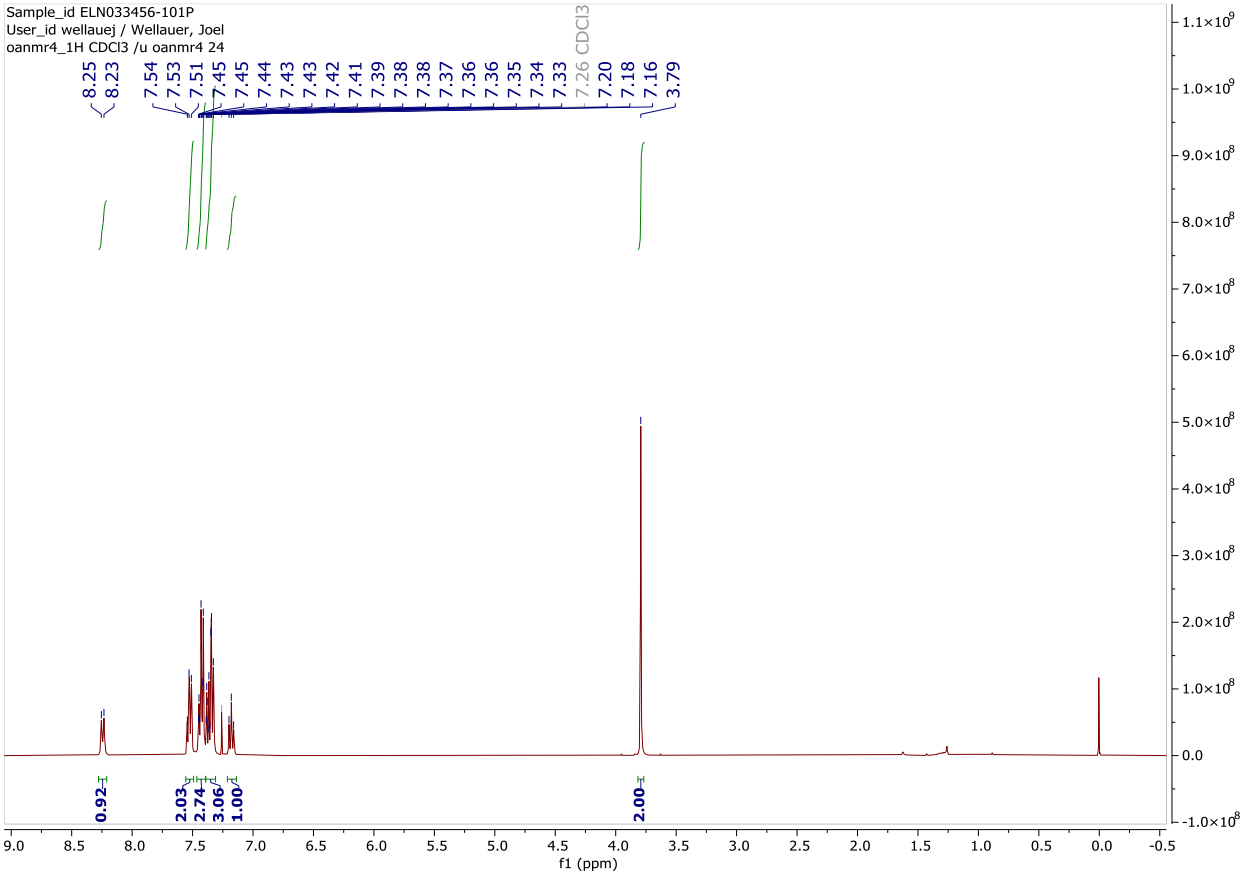
1-(2-(trifluoromethyl)phenyl)pyrrolidine (44_48)



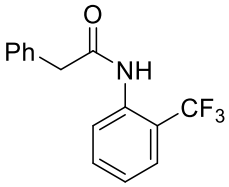
^{1}H NMR



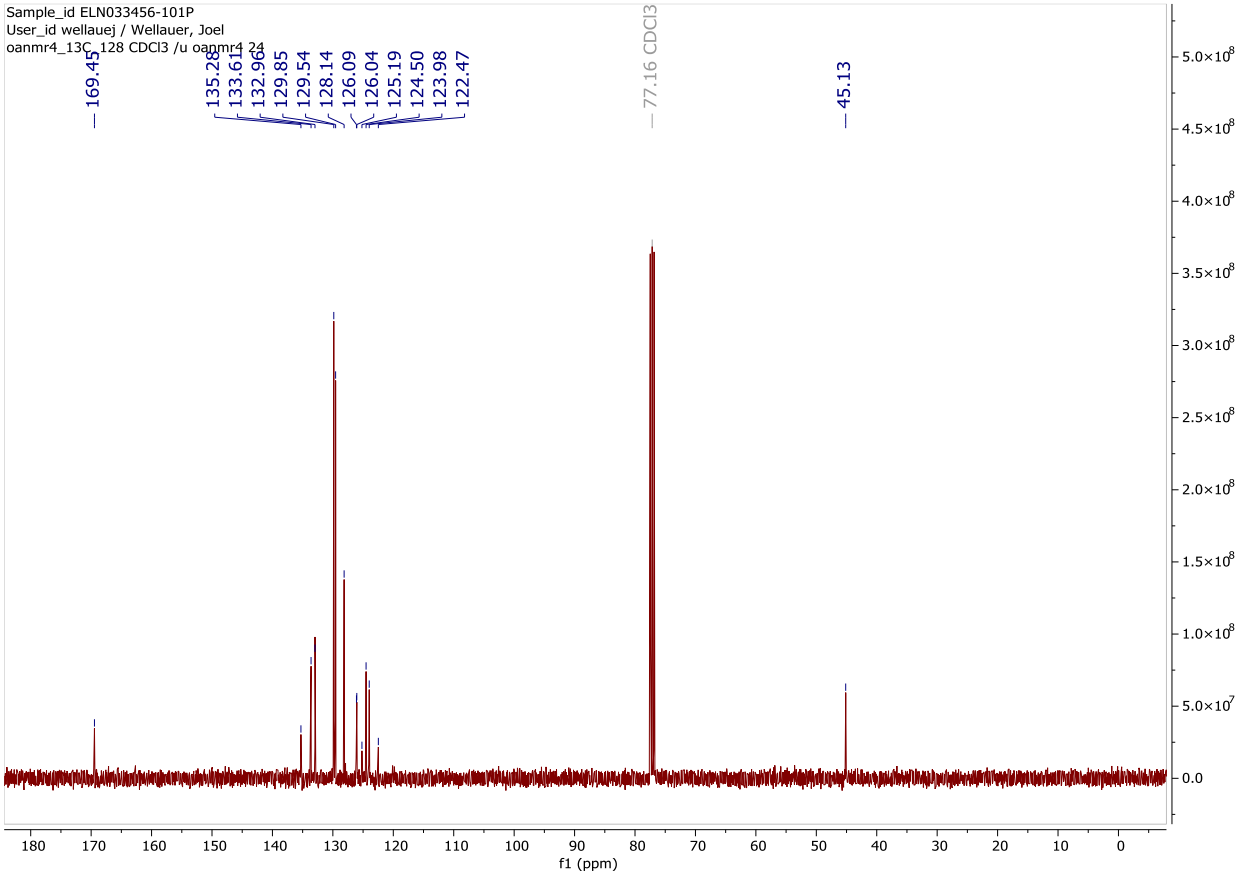
2-phenyl-N-(2-(trifluoromethyl)phenyl)acetamide (10_48)



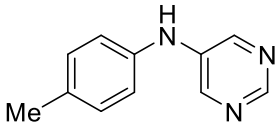
$^{13}C\{^{1}H\}$ NMR



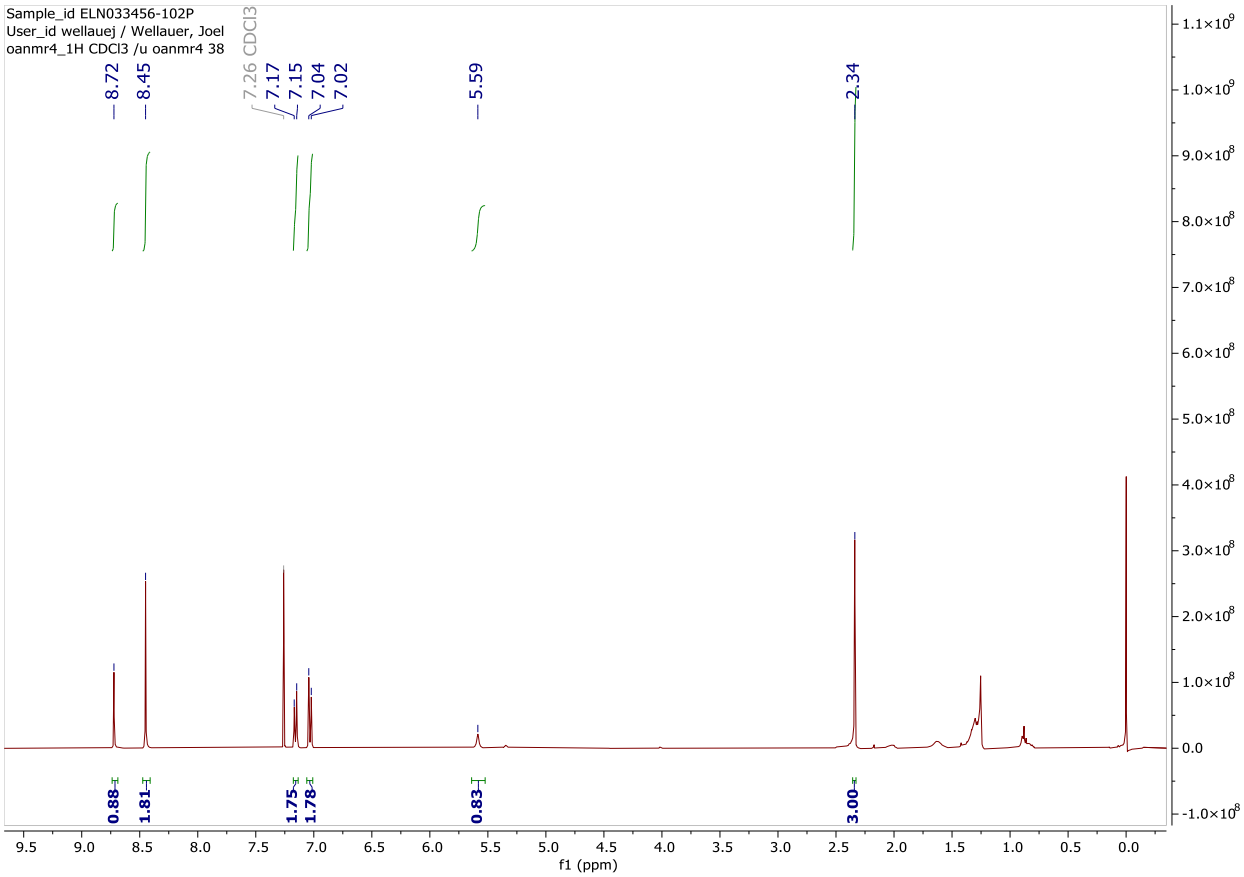
2-phenyl-N-(2-(trifluoromethyl)phenyl)acetamide (10_48)



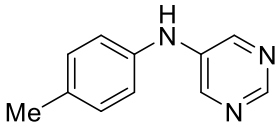
^{1}H NMR



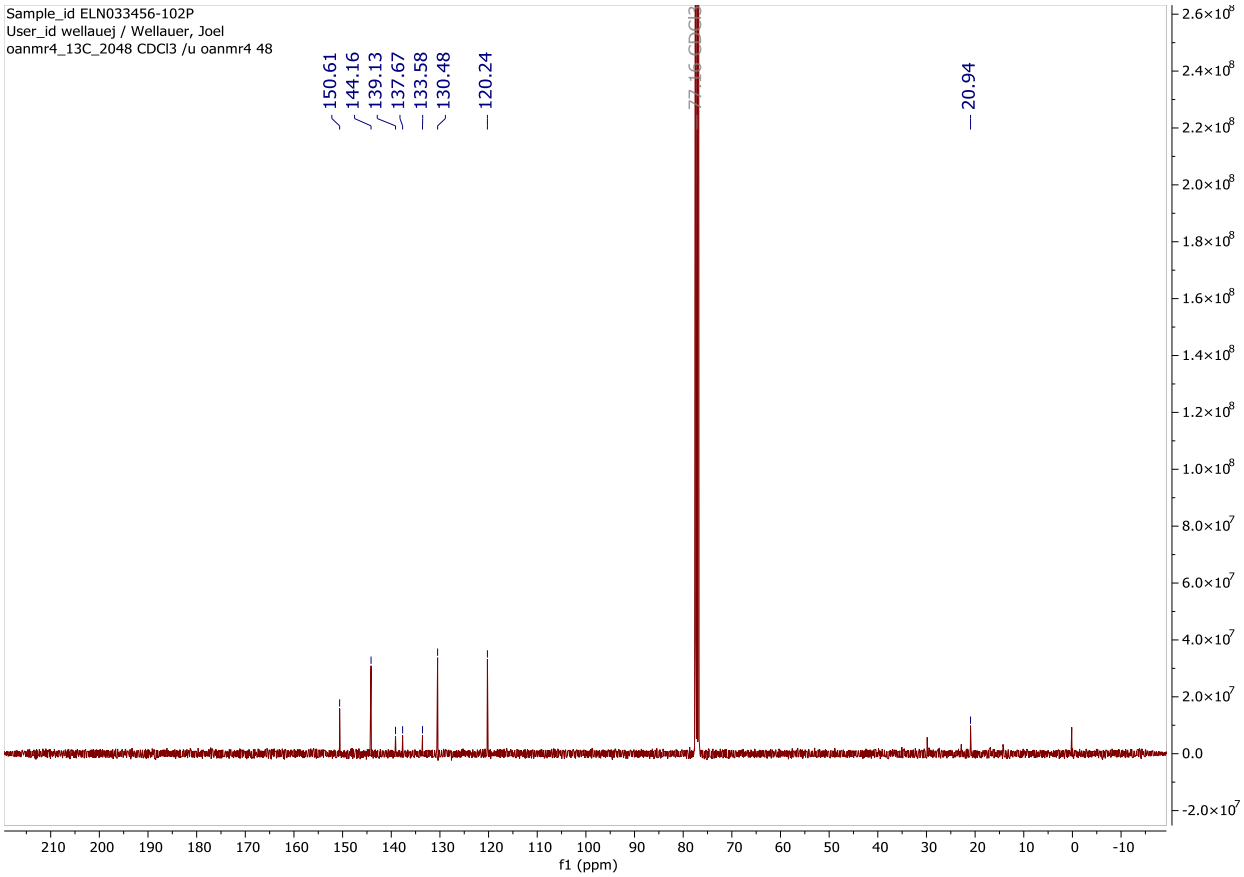
N-(p-tolyl)pyrimidin-5-amine (5_24)



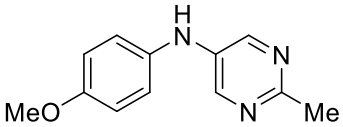
$^{13}C\{^{1}H\}$ NMR



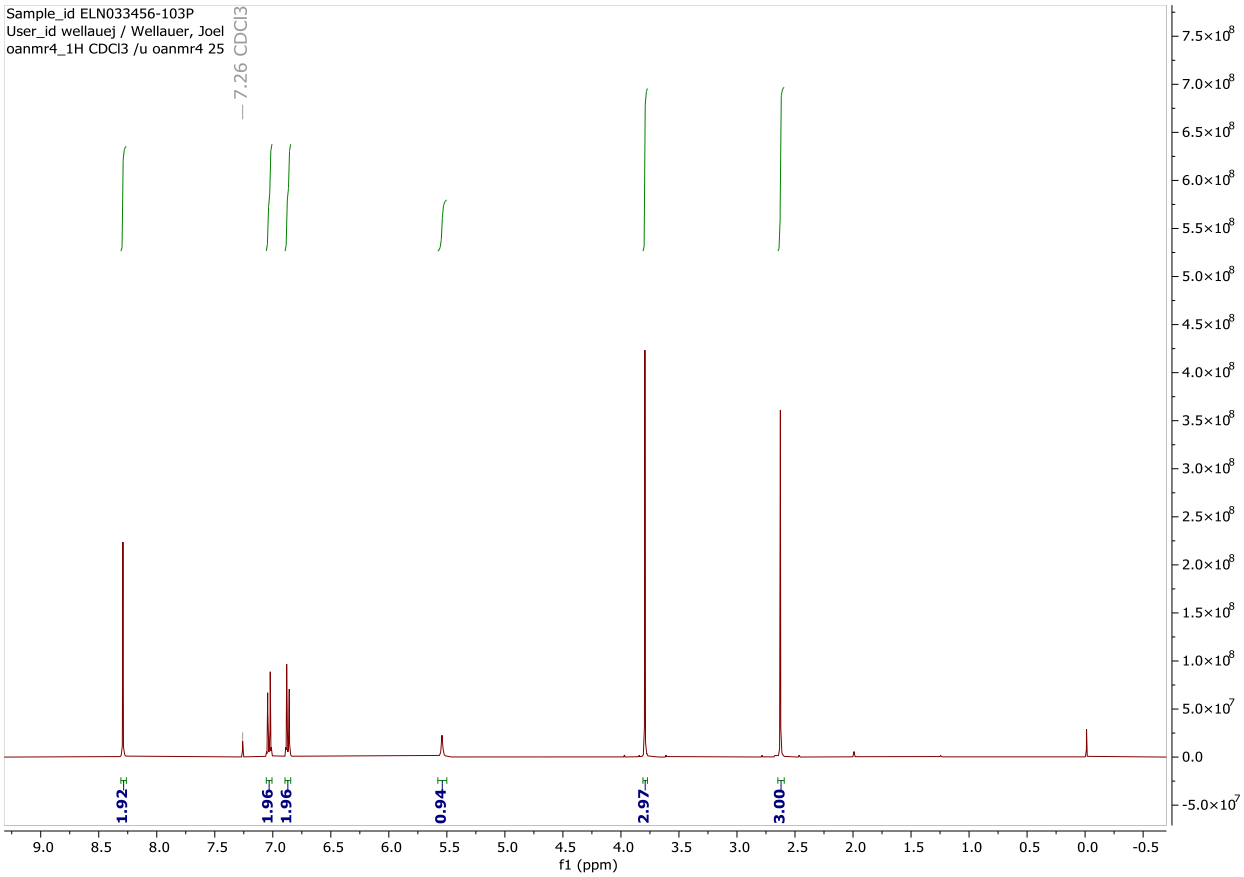
N-(p-tolyl)pyrimidin-5-amine (5_24)



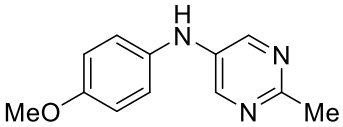
^{1}H NMR



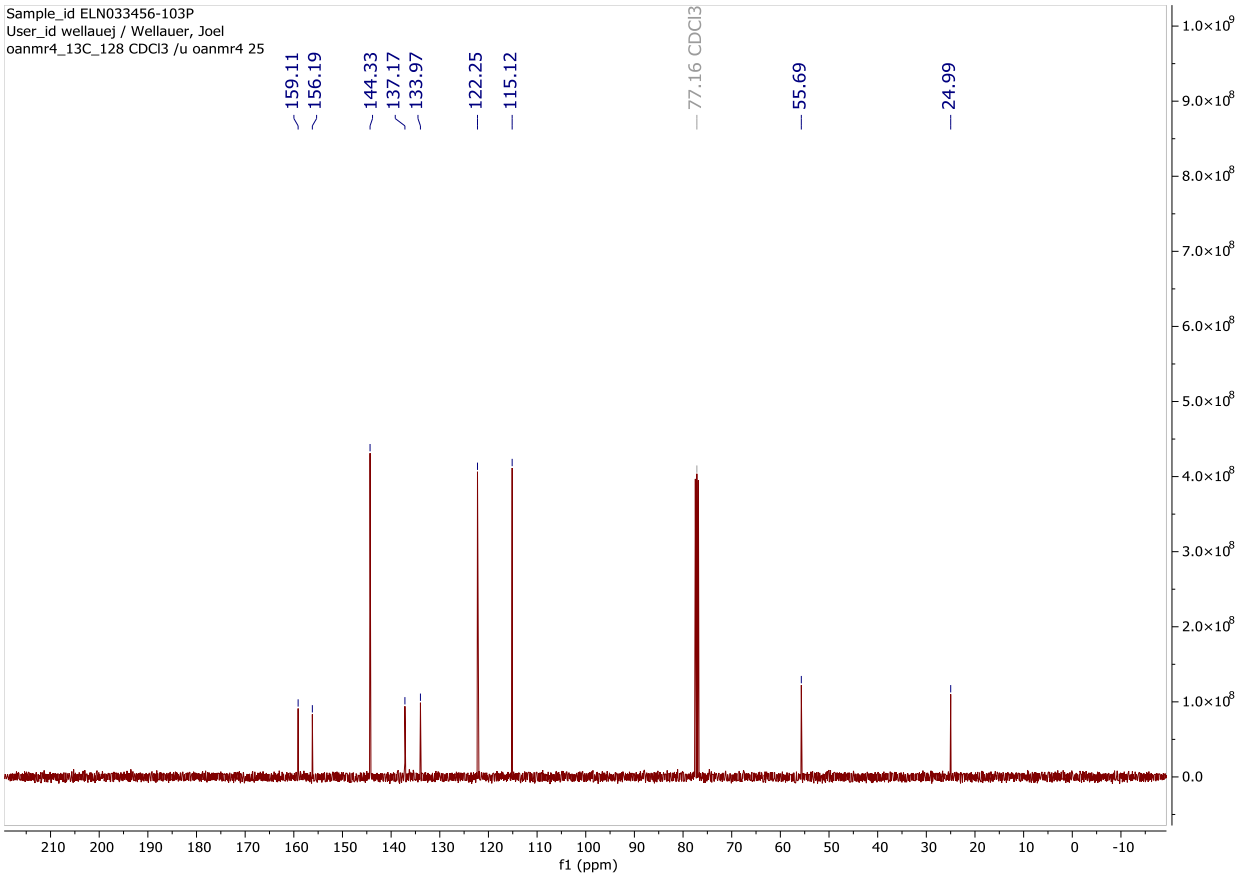
N-(4-methoxyphenyl)-2-methylpyrimidin-5-amine (3_17)



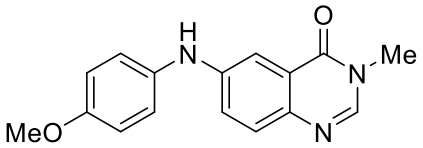
$^{13}C\{^{1}H\}$ NMR



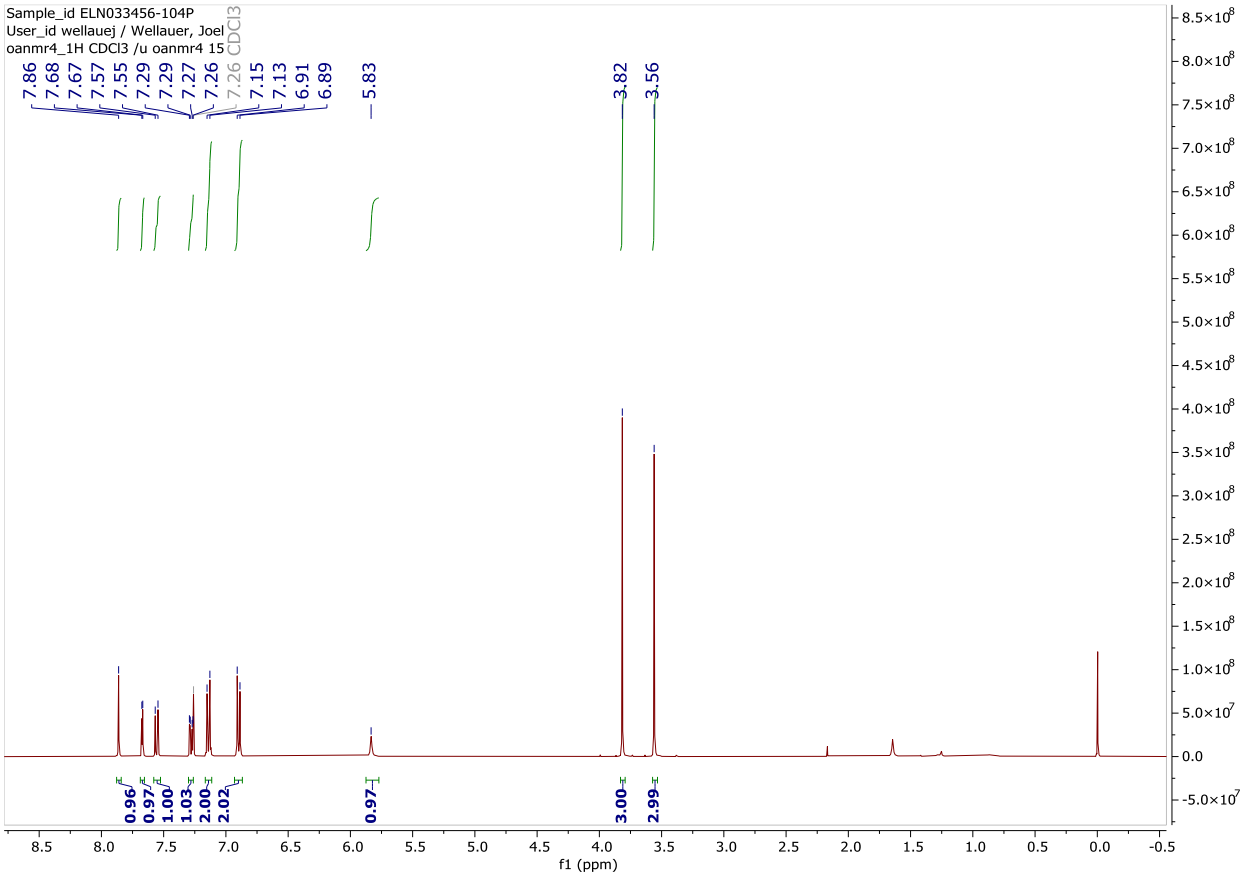
N-(4-methoxyphenyl)-2-methylpyrimidin-5-amine (3_17)



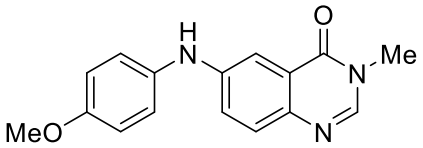
^{1}H NMR



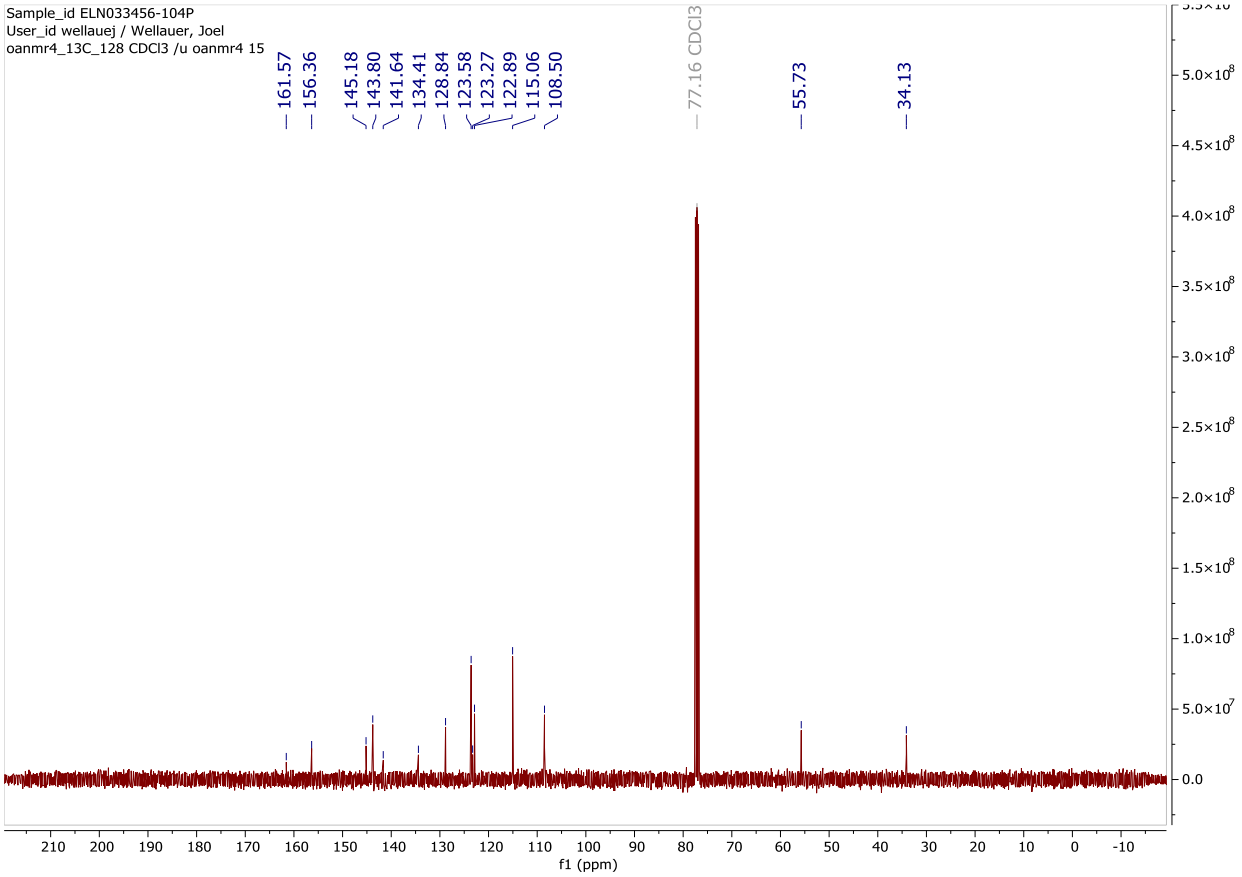
6-((4-methoxyphenyl)amino)-3-methylquinazolin-4(3H)-one (3_14)



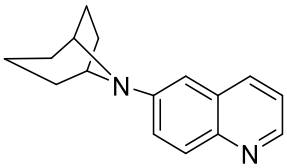
$^{13}C\{^{1}H\}$ NMR



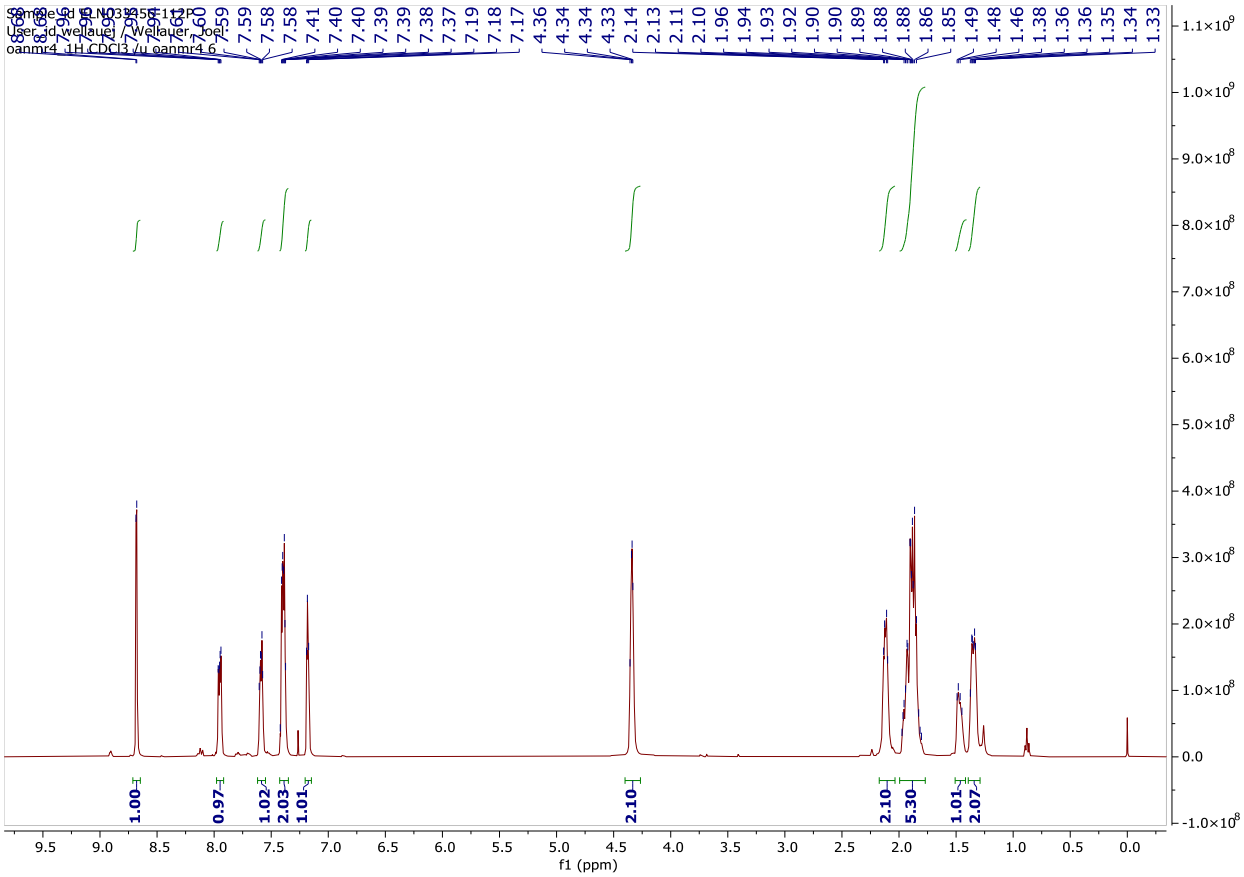
6-((4-methoxyphenyl)amino)-3-methylquinazolin-4(3H)-one (3_14)



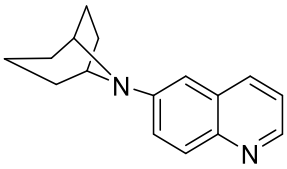
^{1}H NMR



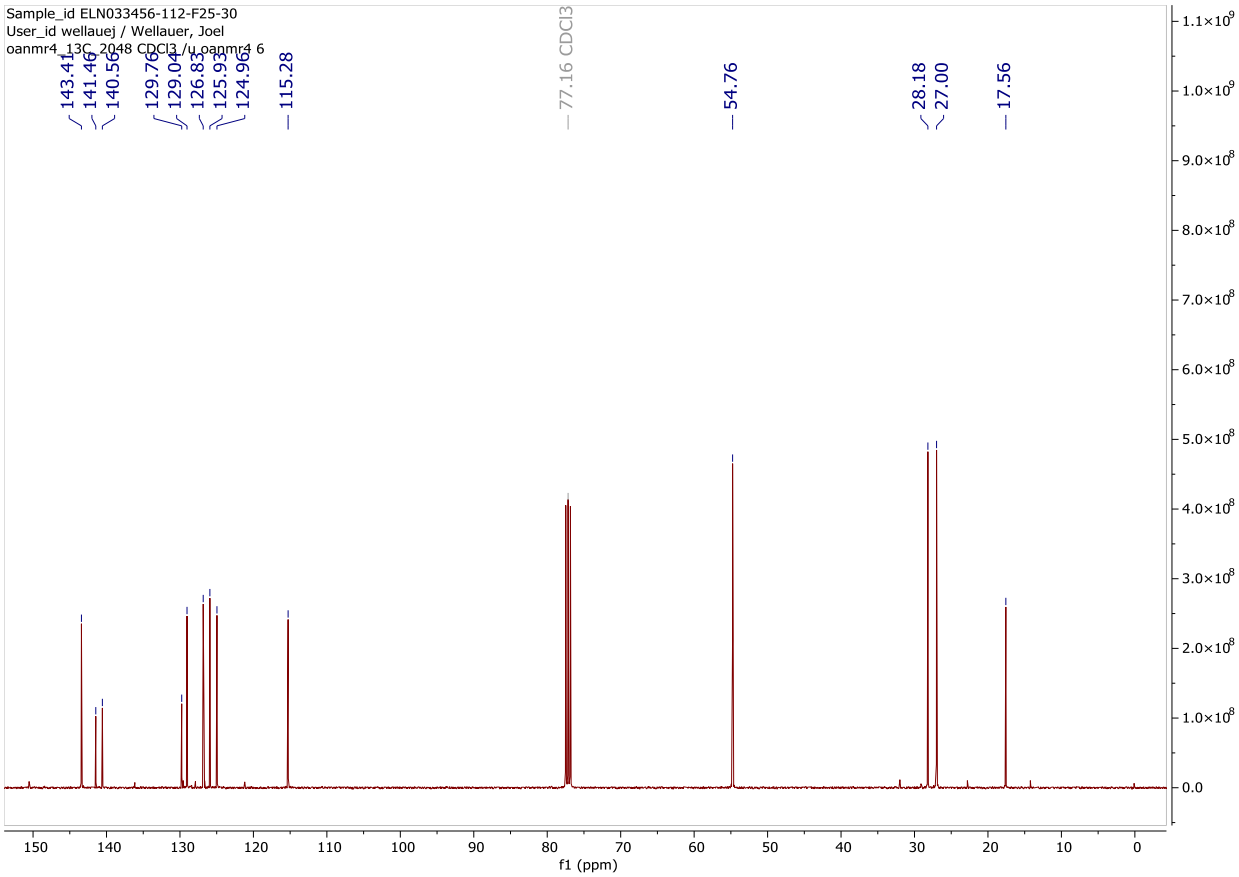
6-((1R,5S)-8-azabicyclo[3.2.1]octan-8-yl)quinoline (42_22)



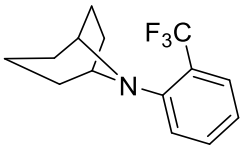
$^{13}C\{^{1}H\}$ NMR



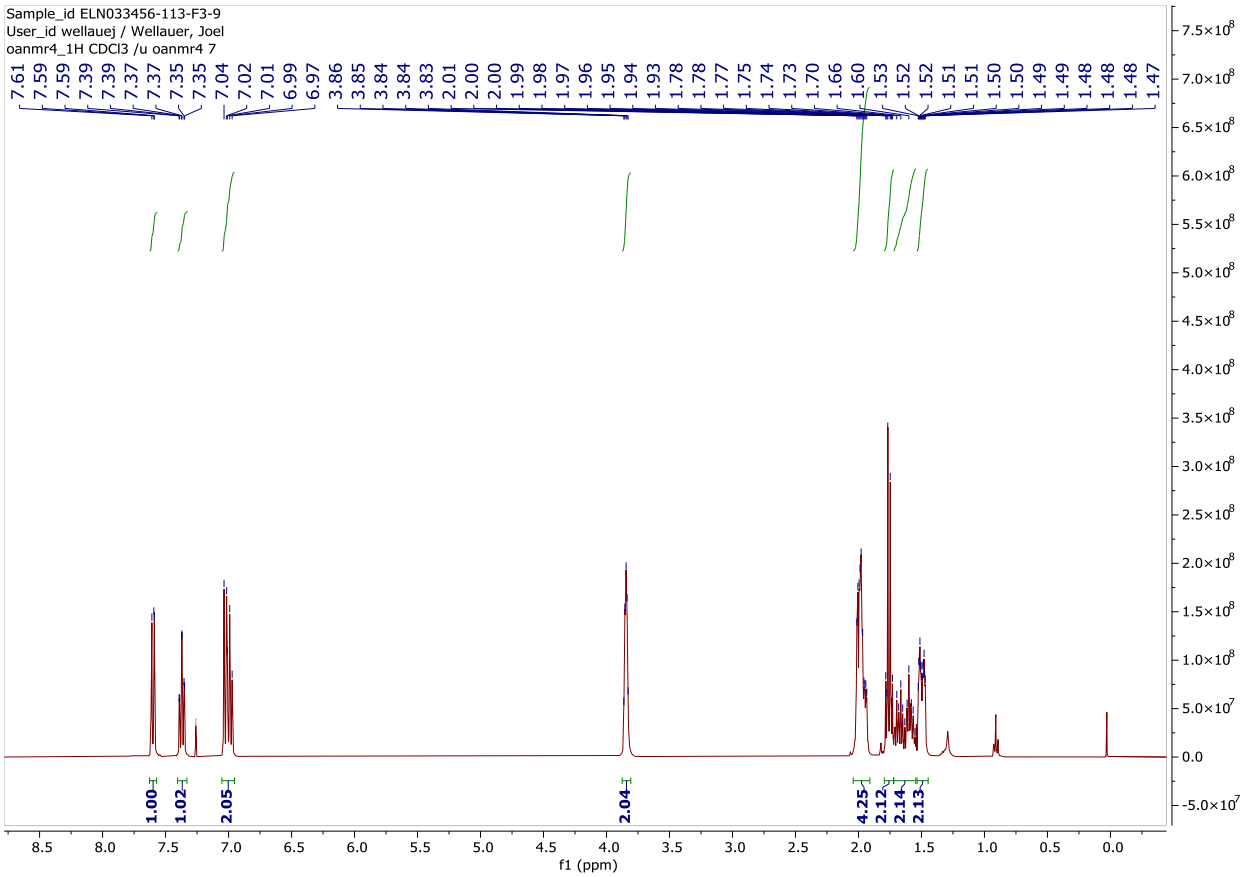
6-((1R,5S)-8-azabicyclo[3.2.1]octan-8-yl)quinoline (42_22)



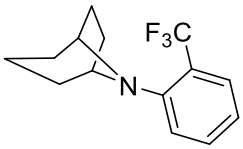
^{1}H NMR



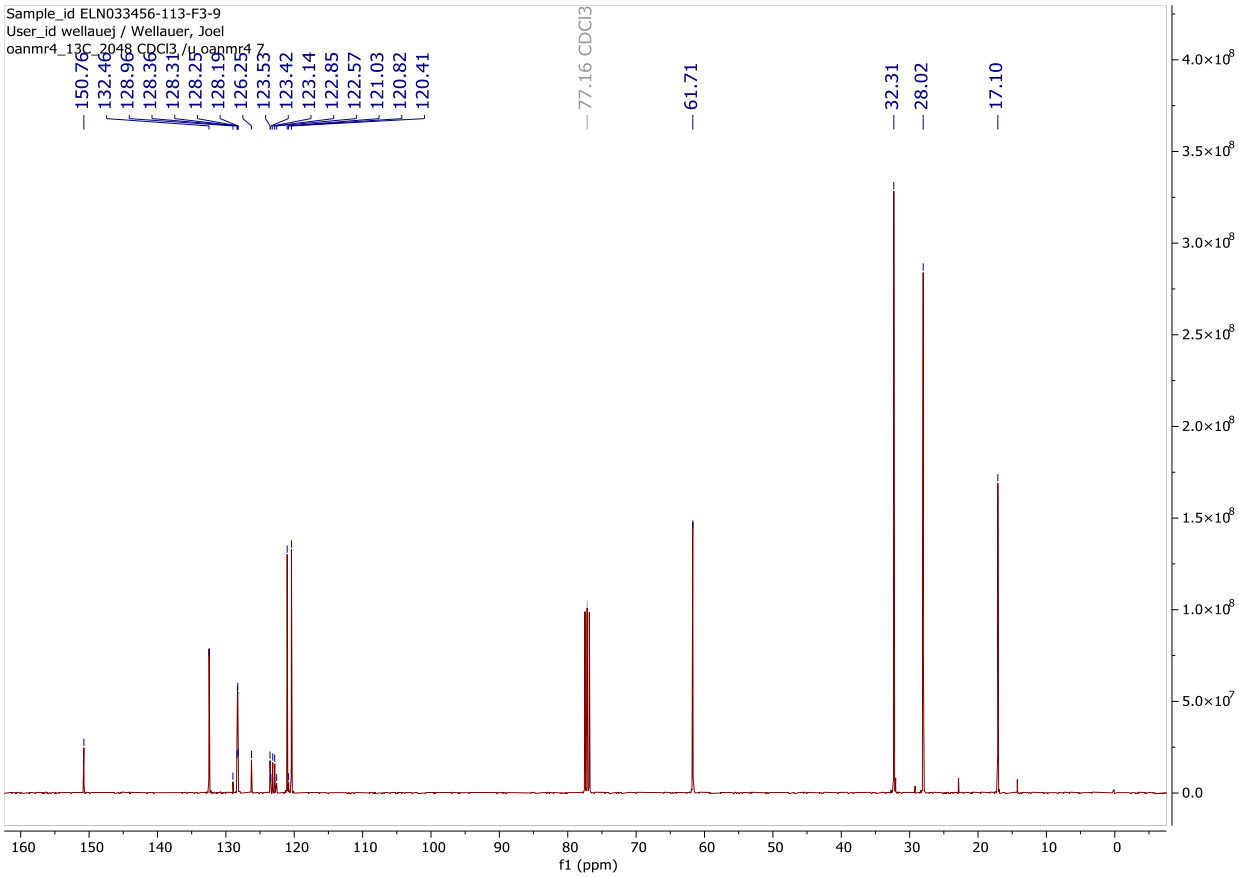
(1R,5S)-8-(2-(trifluoromethyl)phenyl)-8-azabicyclo[3.2.1]octane (42_48)



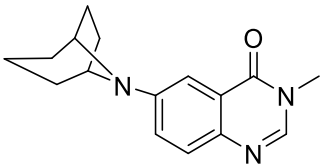
$^{13}C\{^{1}H\}$ NMR



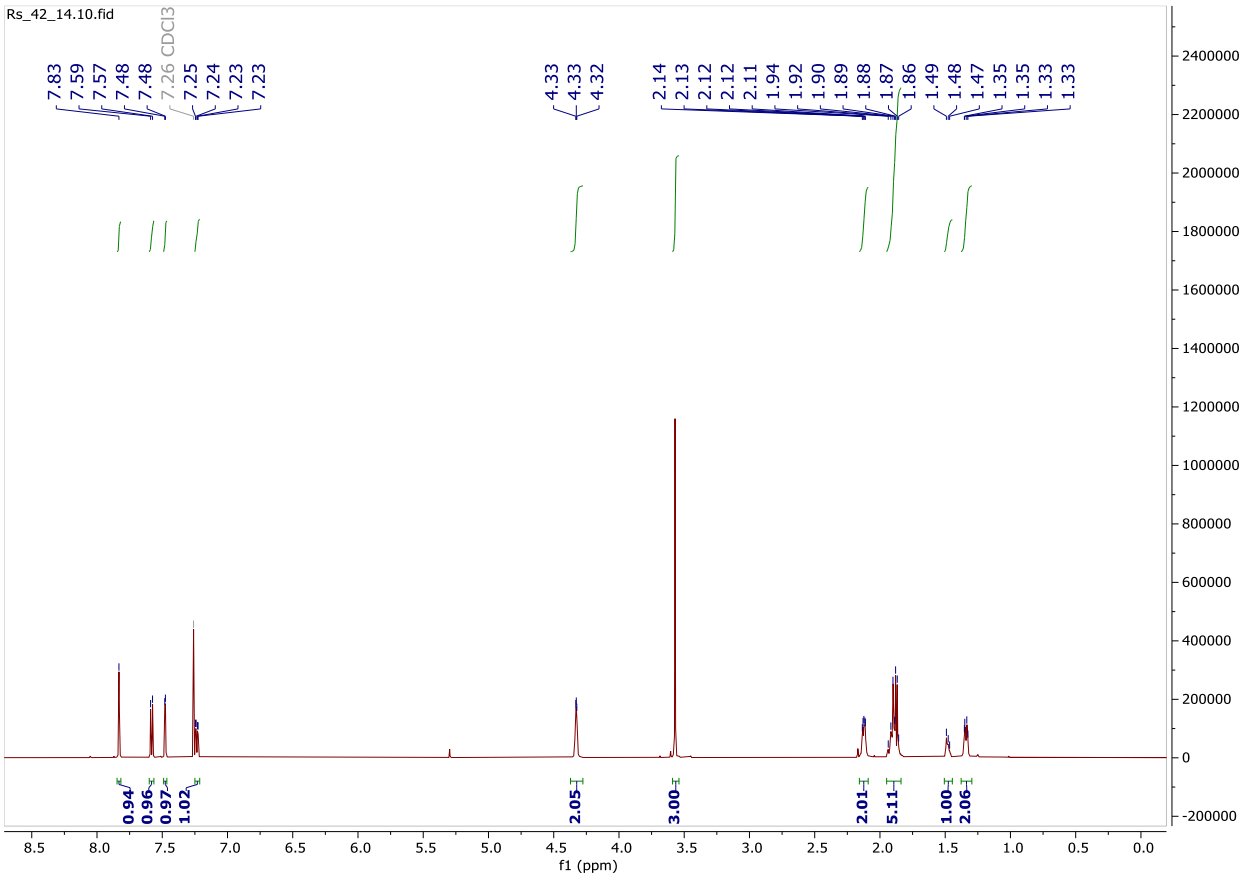
(1R,5S)-8-(2-(trifluoromethyl)phenyl)-8-azabicyclo[3.2.1]octane (42_48)



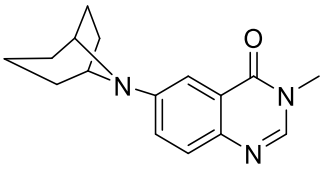
^{1}H NMR



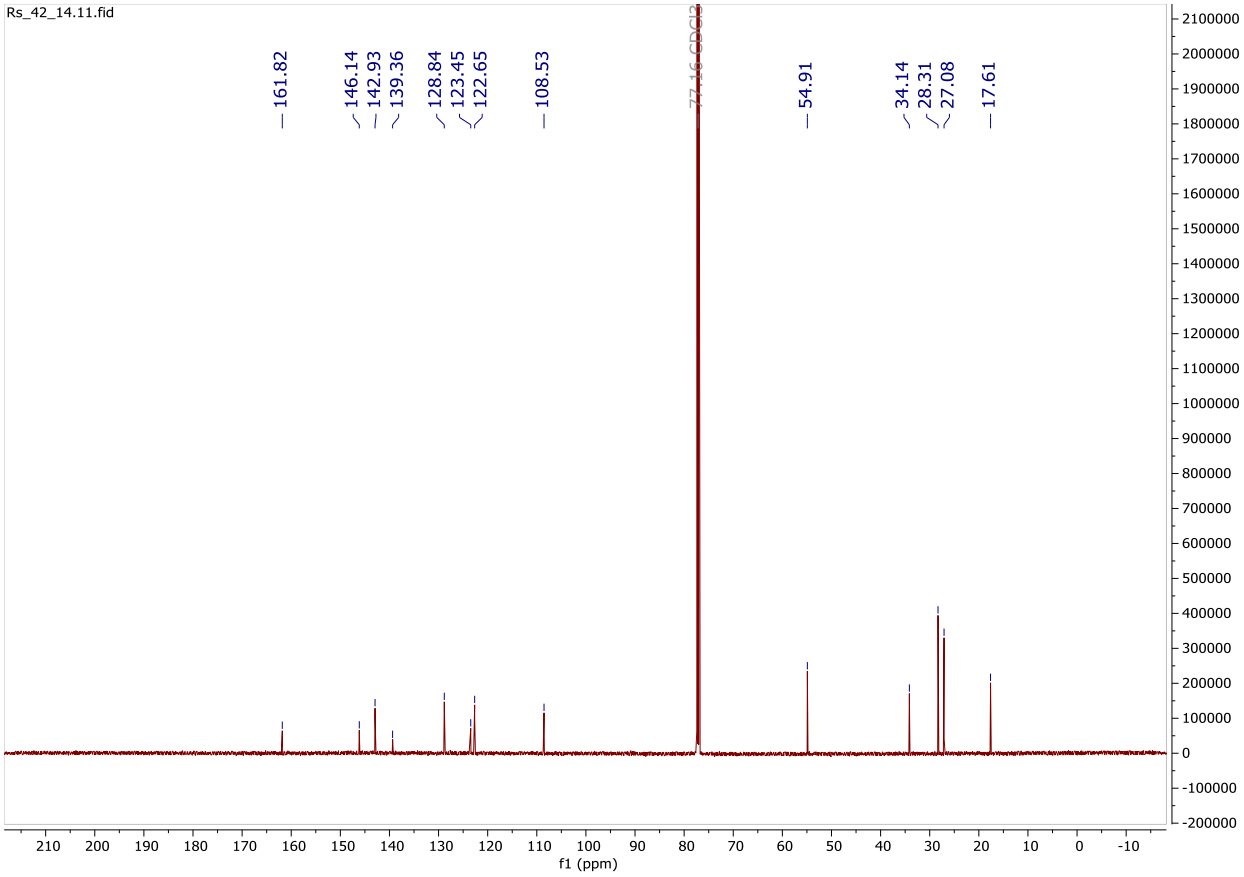
6-((1R,5S)-8-azabicyclo[3.2.1]octan-8-yl)-3-methylquinazolin-4(3H)-one (42_14)



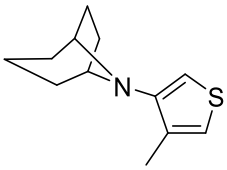
$^{13}C\{^{1}H\}$ NMR



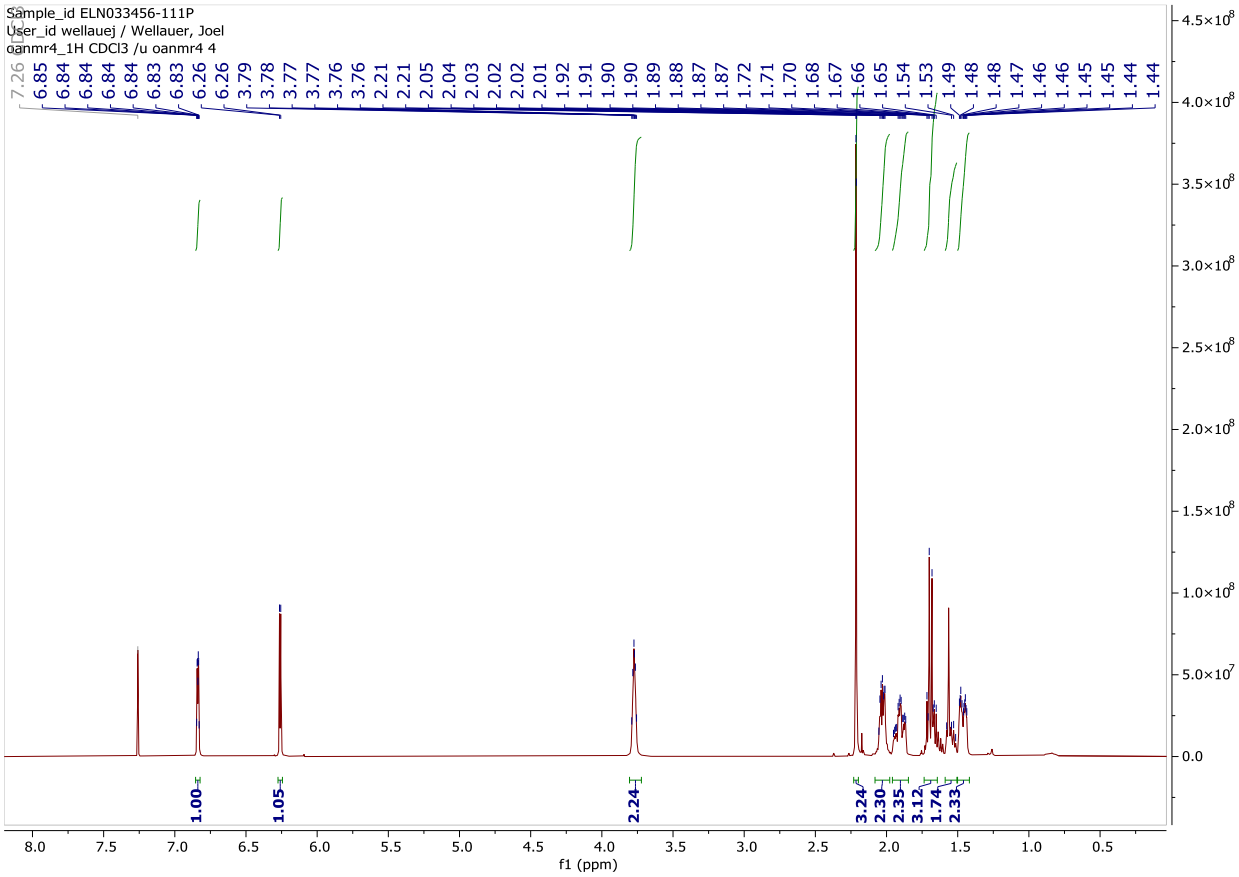
6-((1R,5S)-8-azabicyclo[3.2.1]octan-8-yl)-3-methylquinazolin-4(3H)-one (42_14)



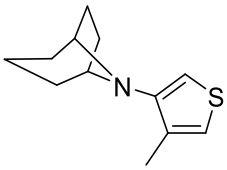
^{1}H NMR



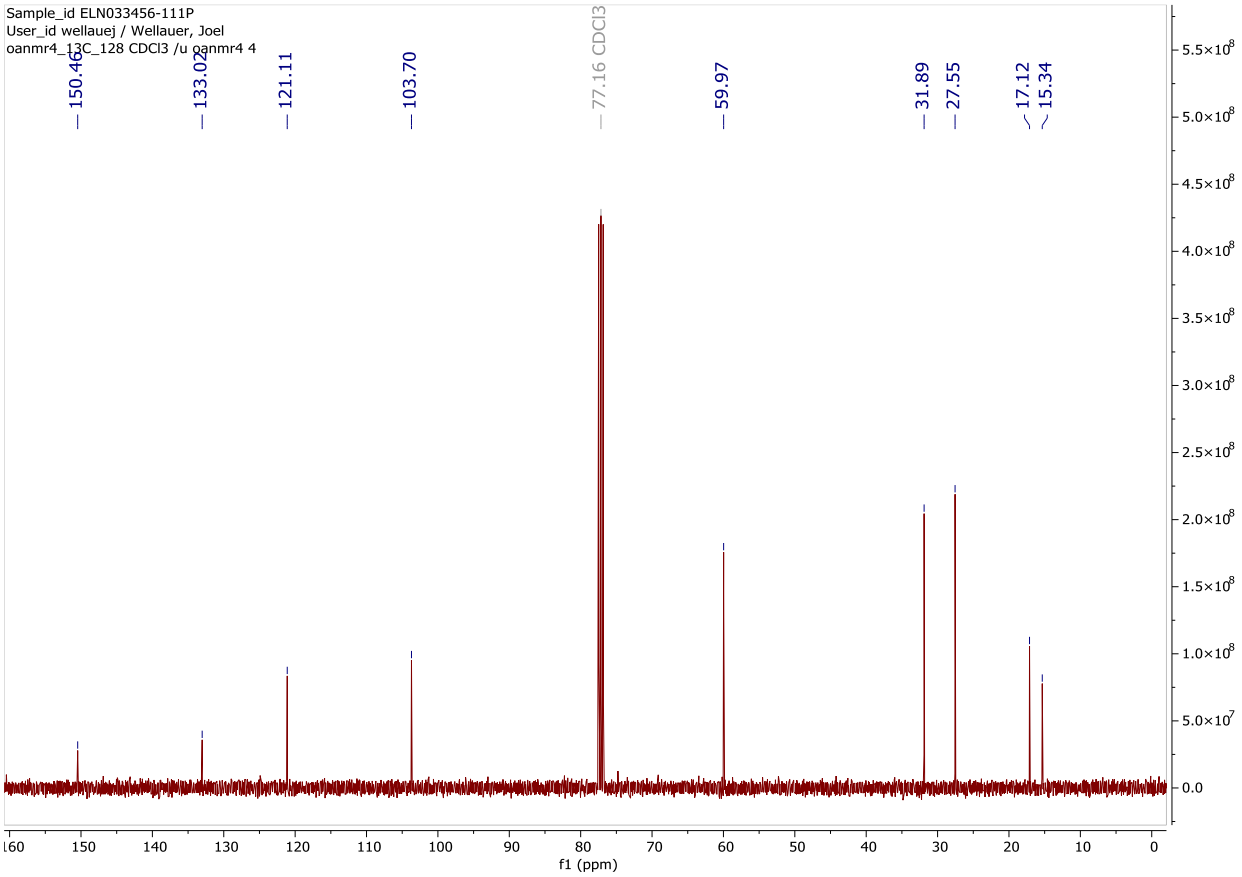
(1R,5S)-8-(4-methylthiophen-3-yl)-8-azabicyclo[3.2.1]octane (42_29)



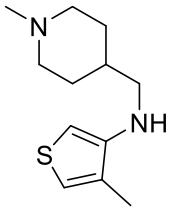
$^{13}C\{^{1}H\}$ NMR



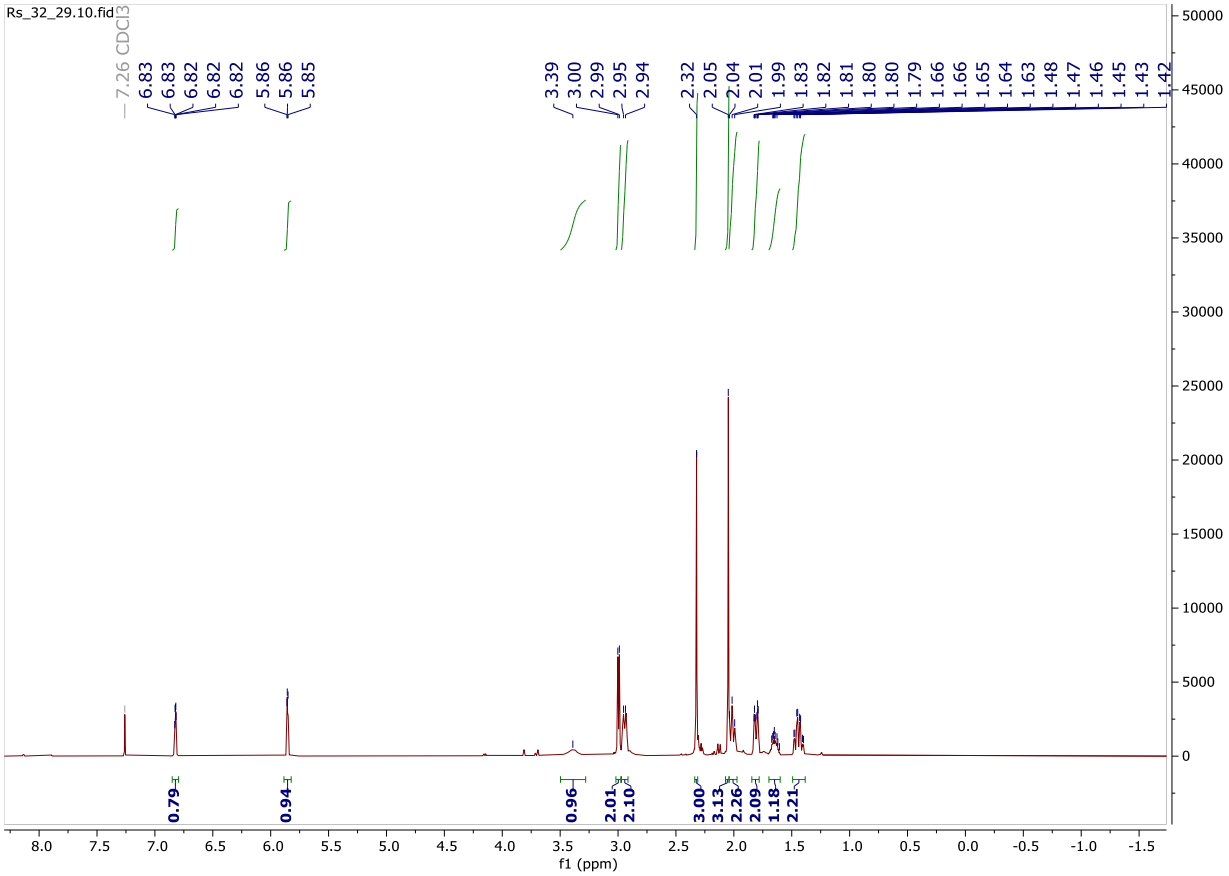
(1R,5S)-8-(4-methylthiophen-3-yl)-8-azabicyclo[3.2.1]octane (42_29)



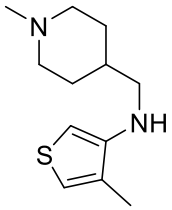
^{1}H NMR



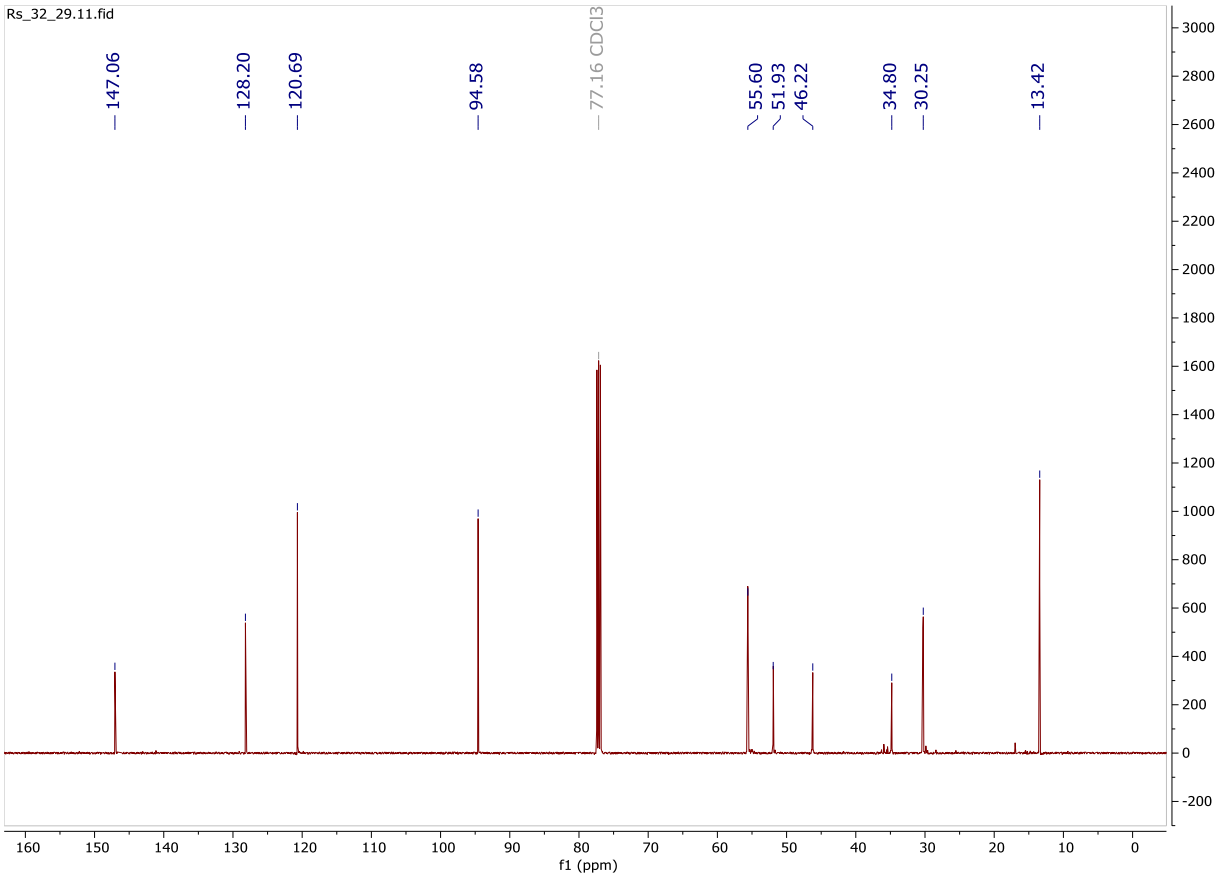
4-methyl-N-((1-methylpiperidin-4-yl)methyl)thiophen-3-amine (32_29)



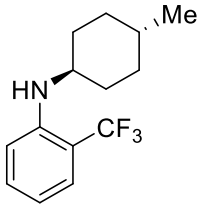
$^{13}C\{^{1}H\}$ NMR



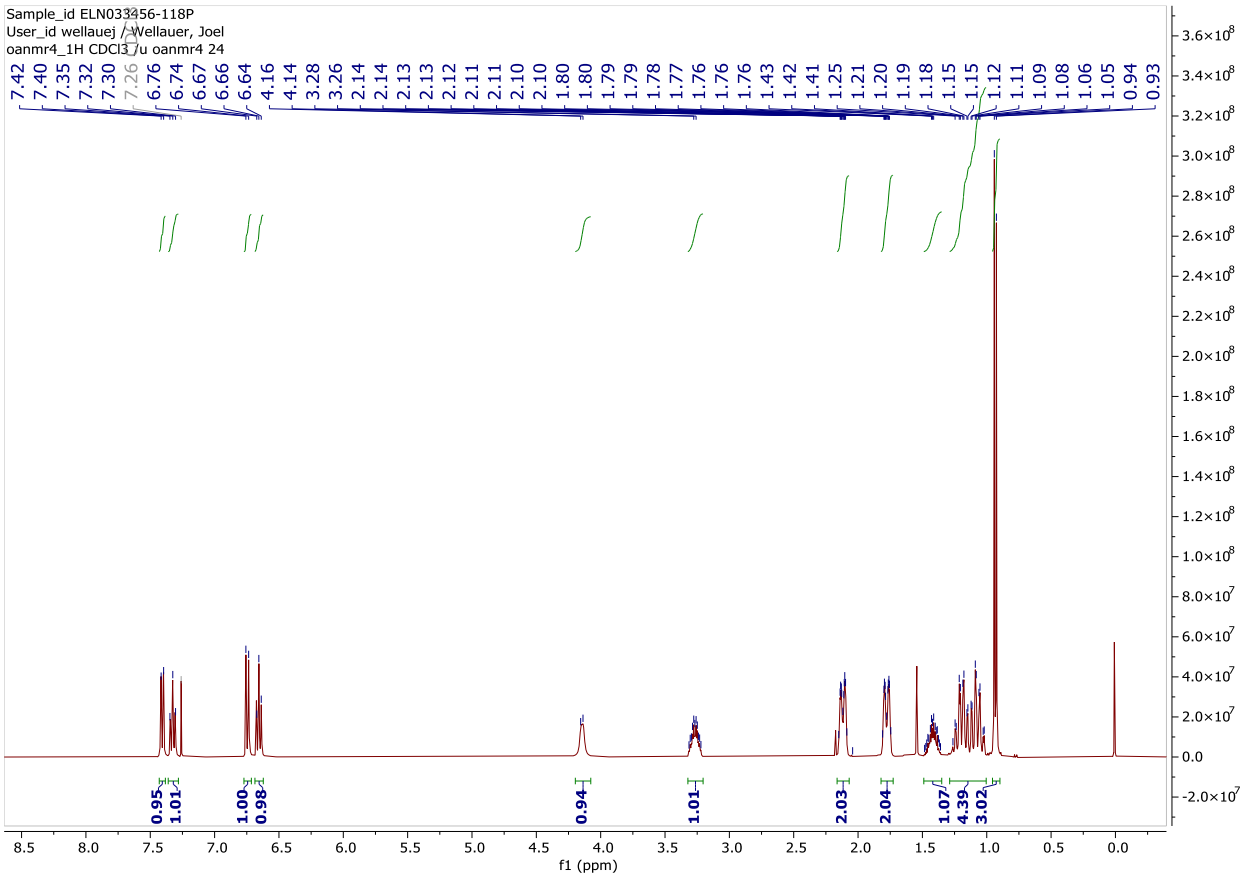
4-methyl-N-((1-methylpiperidin-4-yl)methyl)thiophen-3-amine (32_29)



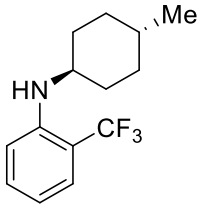
^{1}H NMR



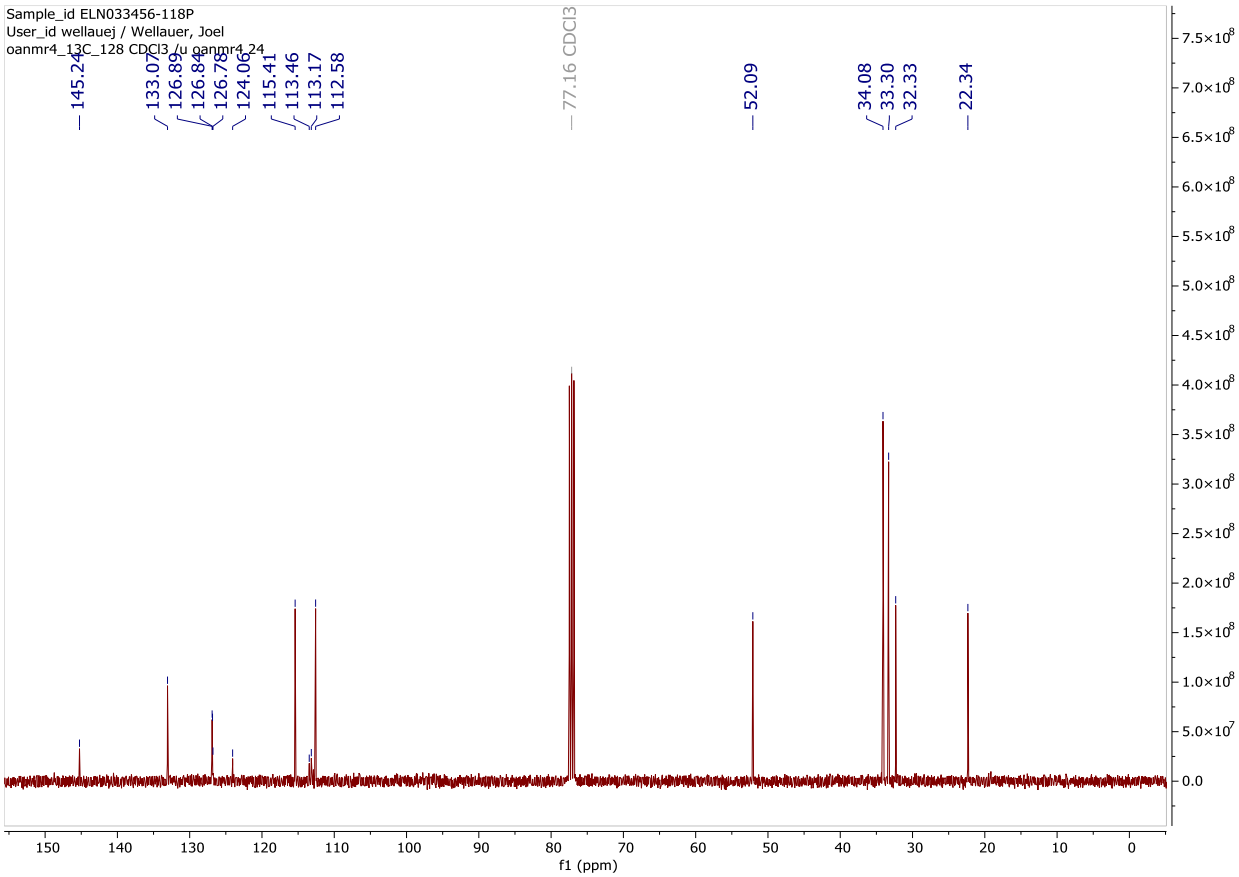
N-((1r,4r)-4-methylcyclohexyl)-2-(trifluoromethyl)aniline (36_48)



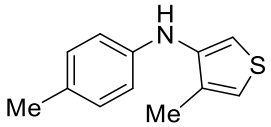
$^{13}C\{^{1}H\}$ NMR



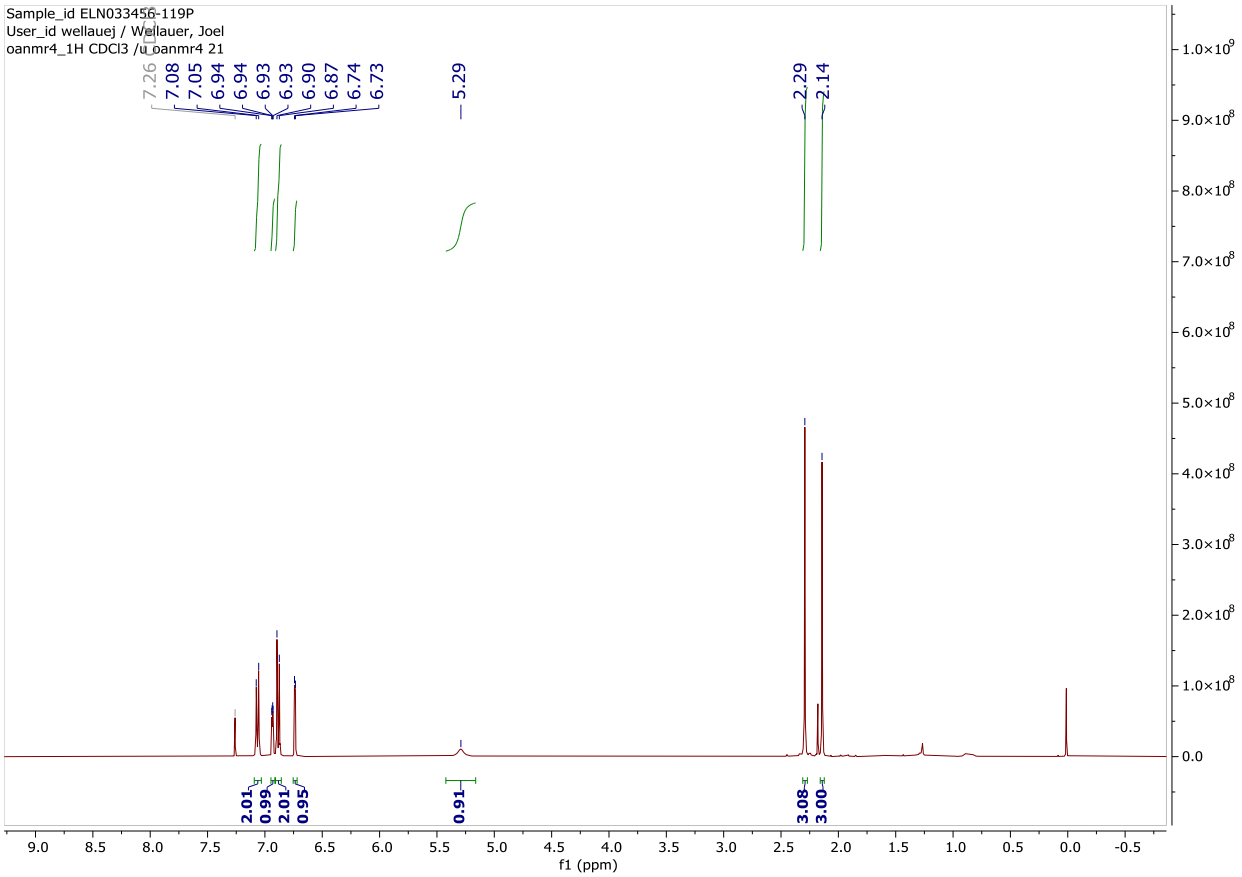
N-((1r,4r)-4-methylcyclohexyl)-2-(trifluoromethyl)aniline (36_48)



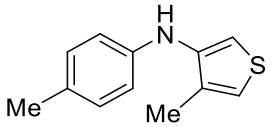
^{1}H NMR



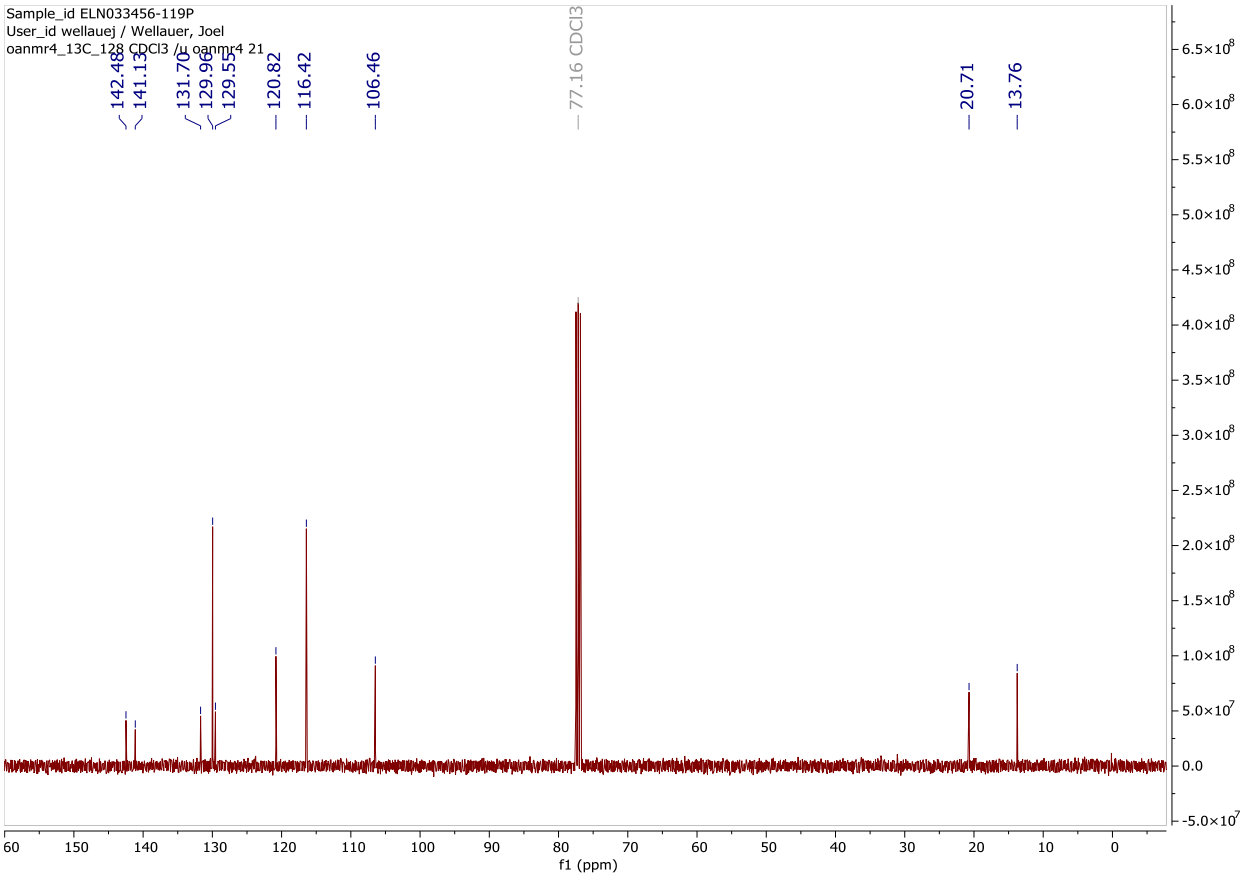
4-methyl-N-(p-tolyl)thiophen-3-amine (5_29)



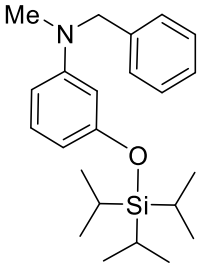
$^{13}C\{^{1}H\}$ NMR



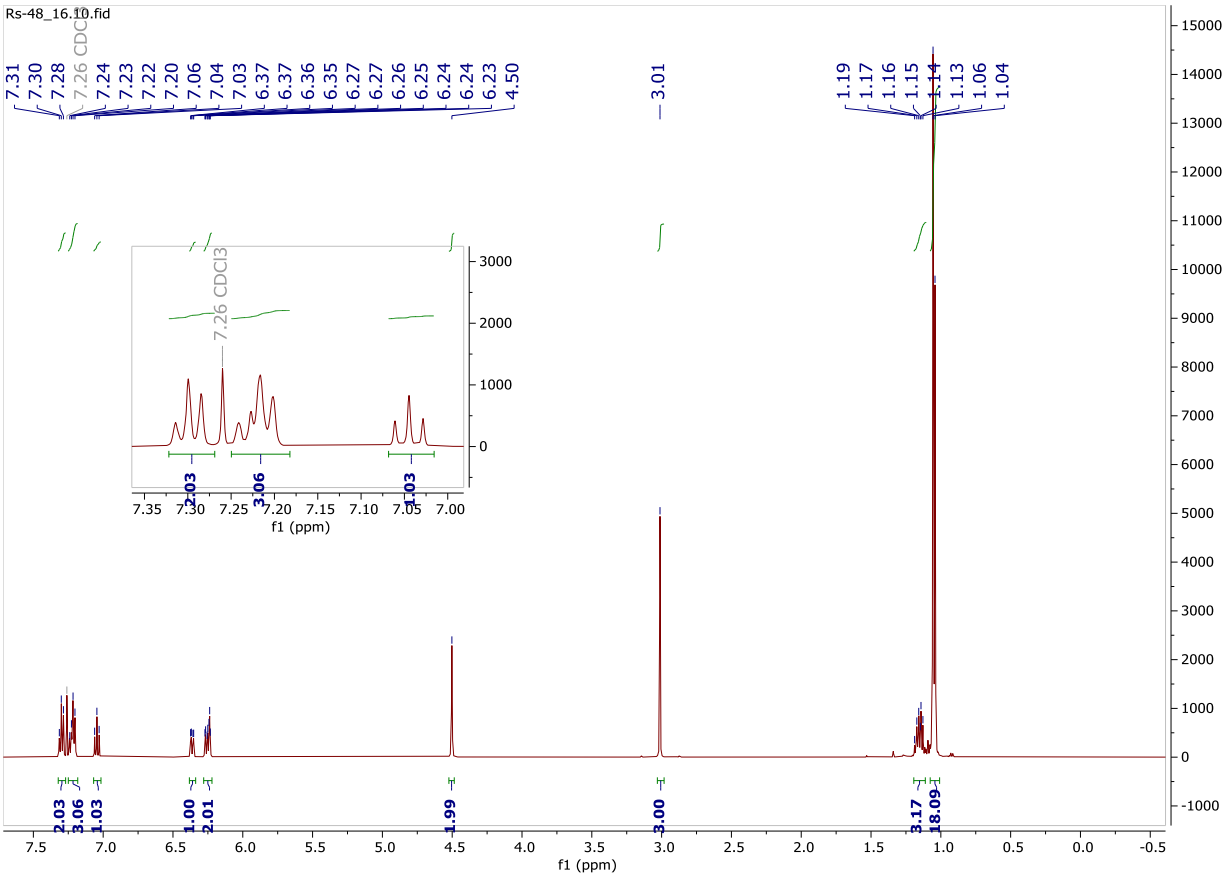
4-methyl-N-(p-tolyl)thiophen-3-amine (5_29)



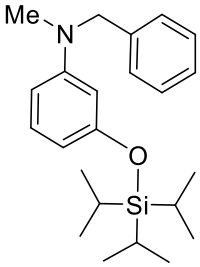
^{1}H NMR



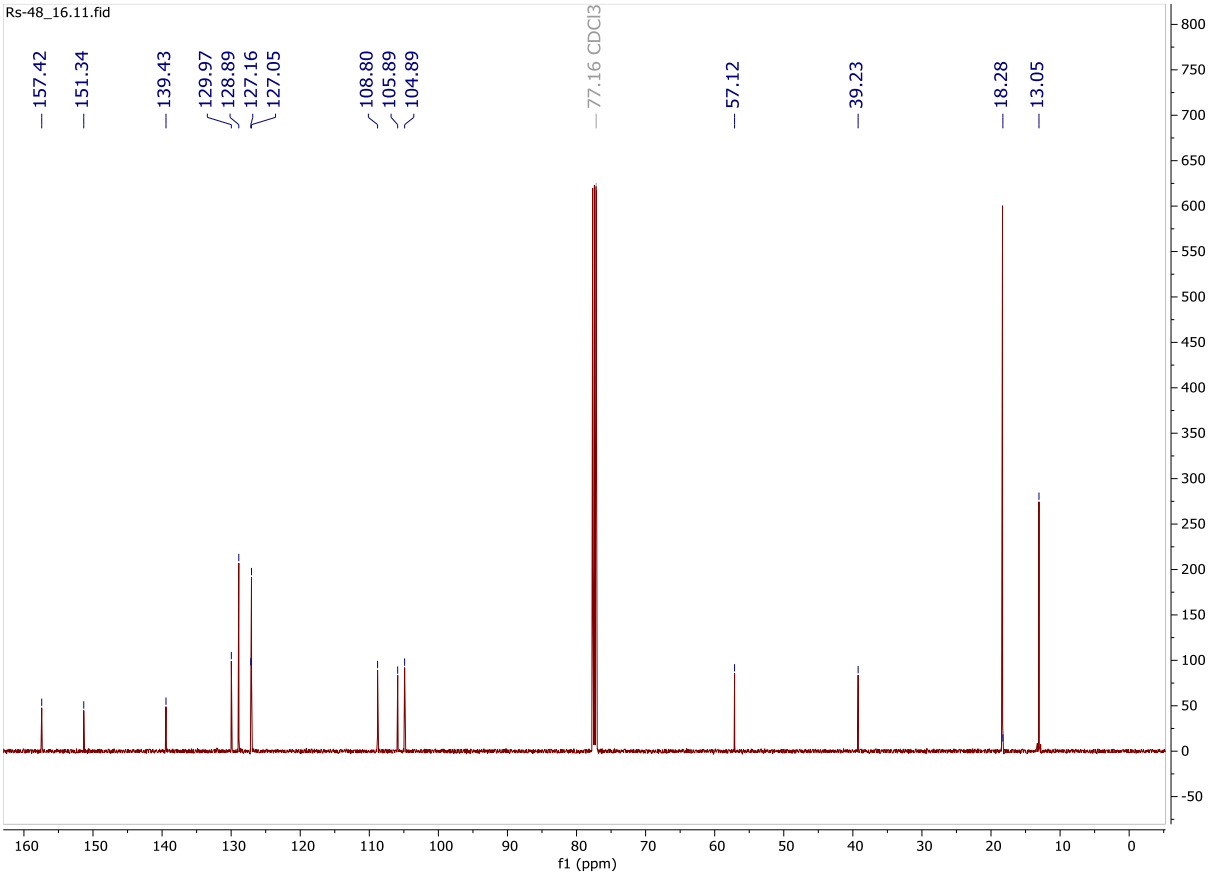
N-benzyl-N-methyl-3-((triisopropylsilyl)oxy)aniline (Roche Plate 48_16)



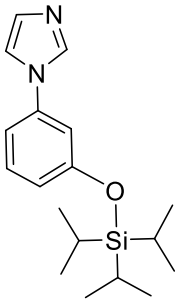
$^{13}C\{^{1}H\}$ NMR



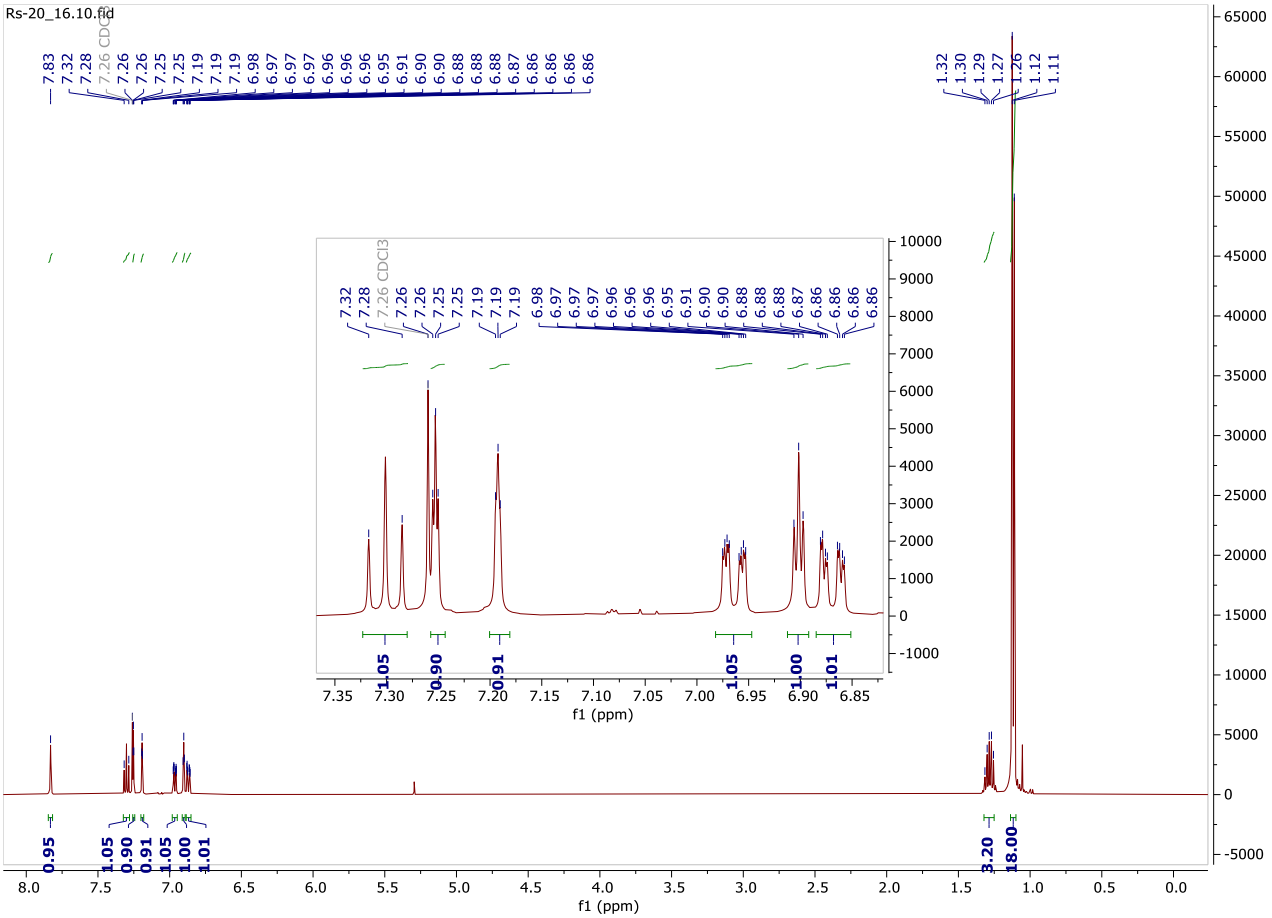
N-benzyl-N-methyl-3-((triisopropylsilyl)oxy)aniline (Roche Plate 48_16)



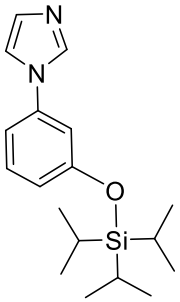
^{1}H NMR



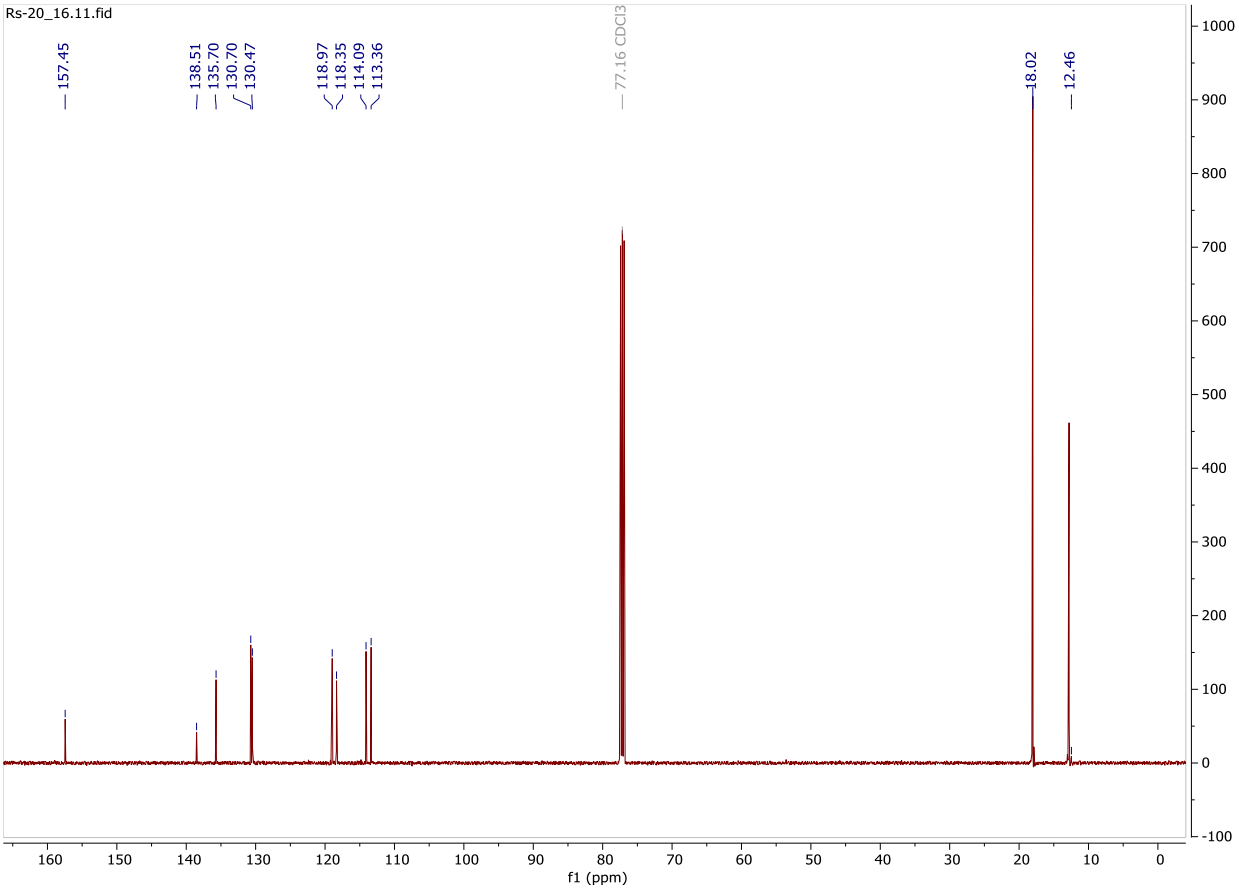
1-(3-((triisopropylsilyl)oxy)phenyl)-1H-imidazole (20_16)



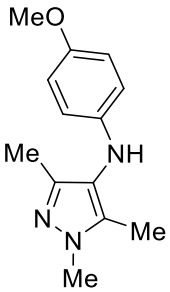
$^{13}C\{^{1}H\}$ NMR



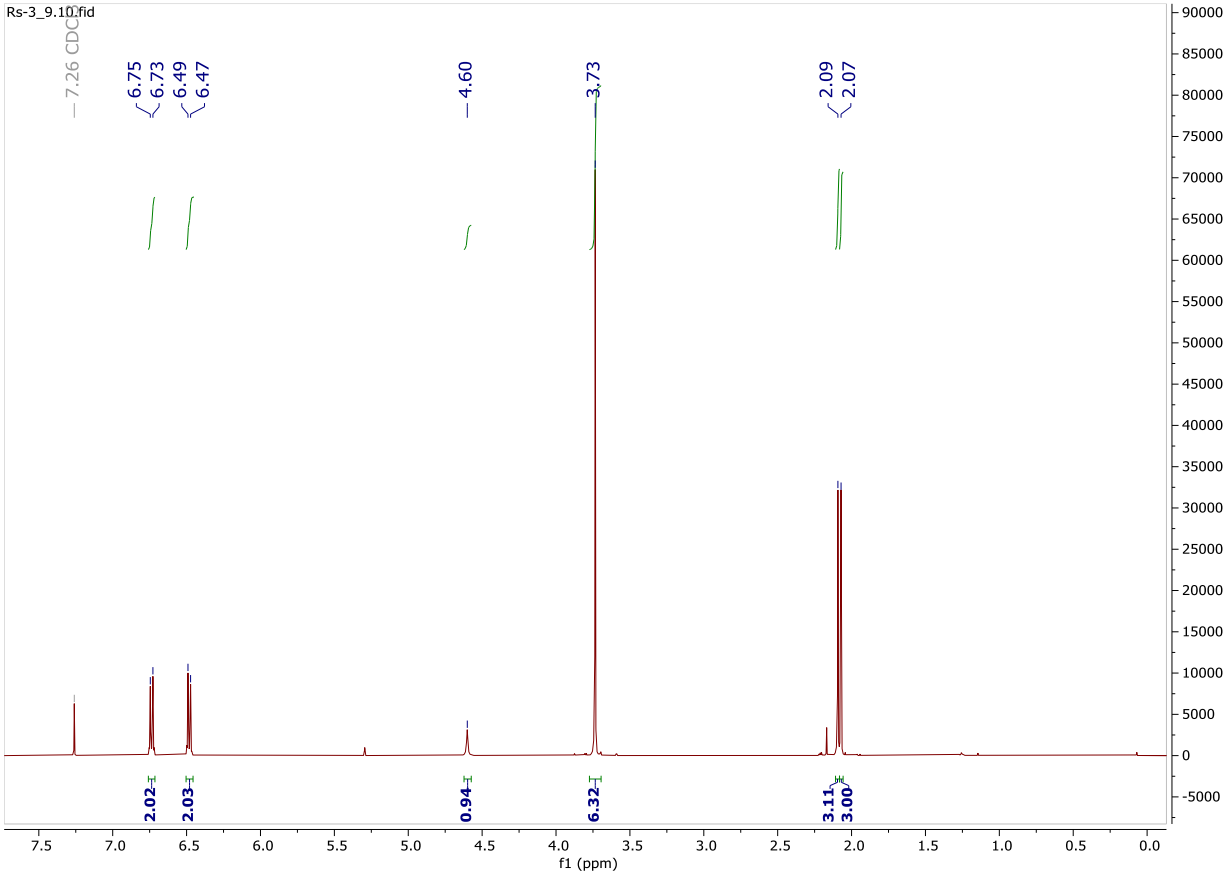
1-(3-((triisopropylsilyl)oxy)phenyl)-1H-imidazole **(20_16)**



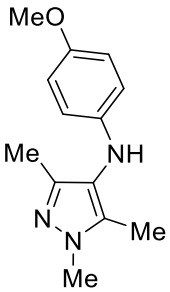
^{1}H NMR



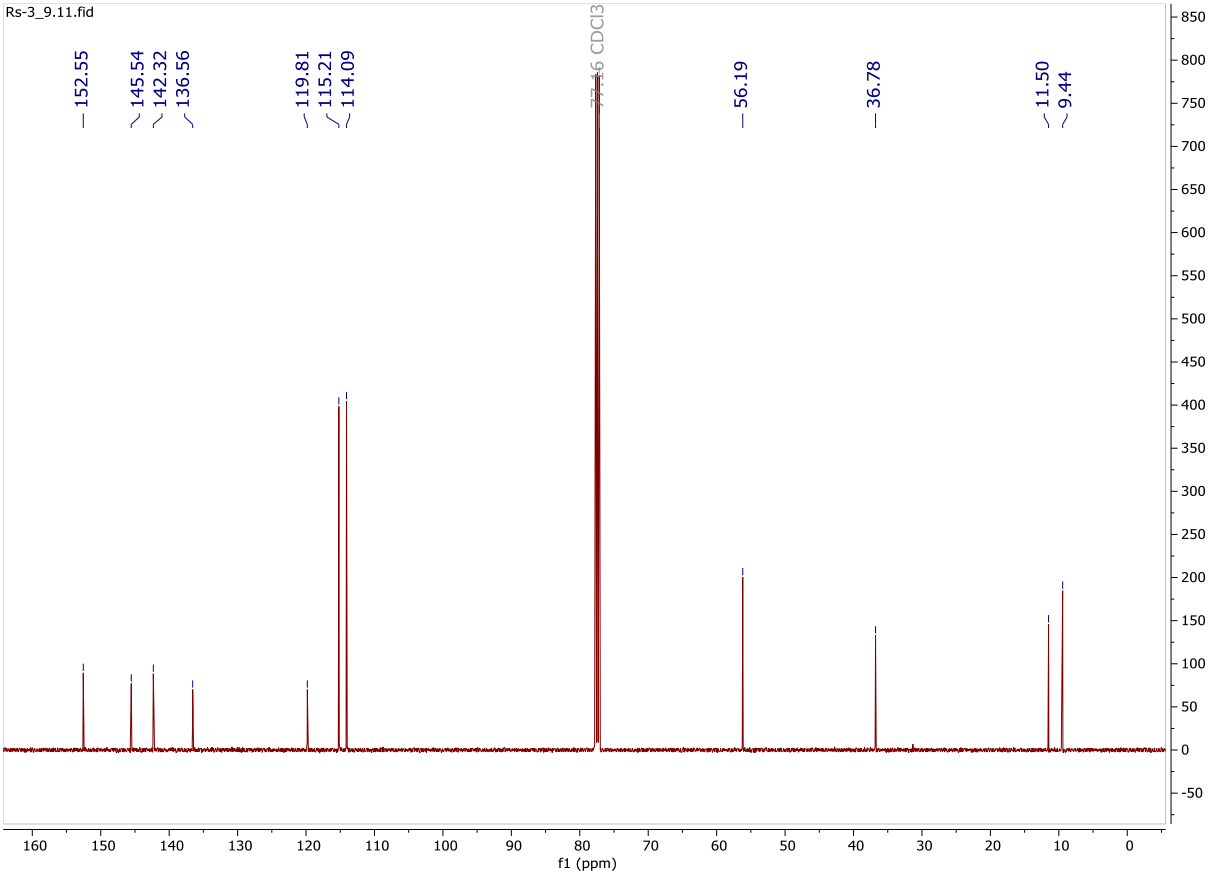
N-(4-methoxyphenyl)-1,3,5-trimethyl-1H-pyrazol-4-amine (3_9)



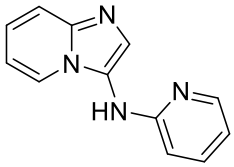
$^{13}C\{^{1}H\}$ NMR



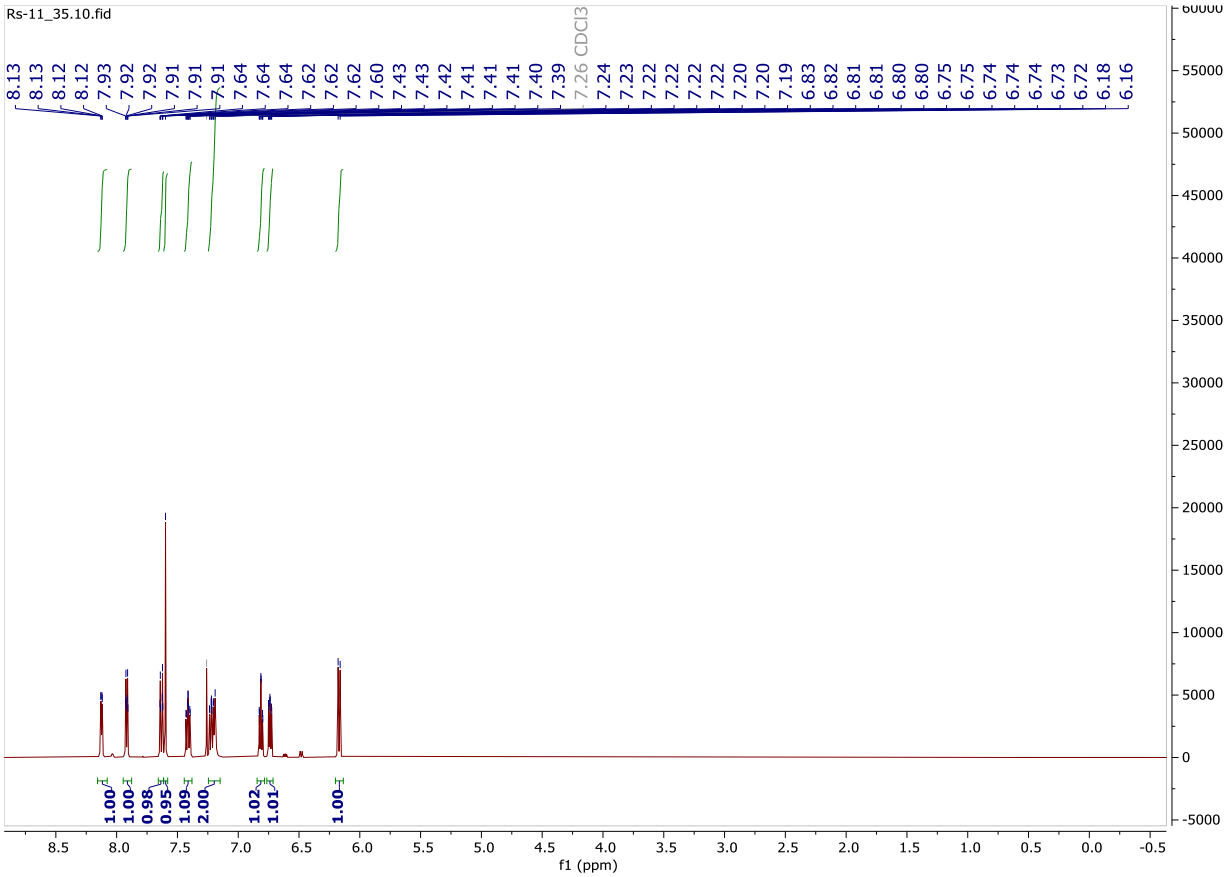
N-(4-methoxyphenyl)-1,3,5-trimethyl-1H-pyrazol-4-amine (3_9)



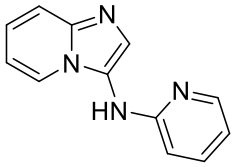
^{1}H NMR



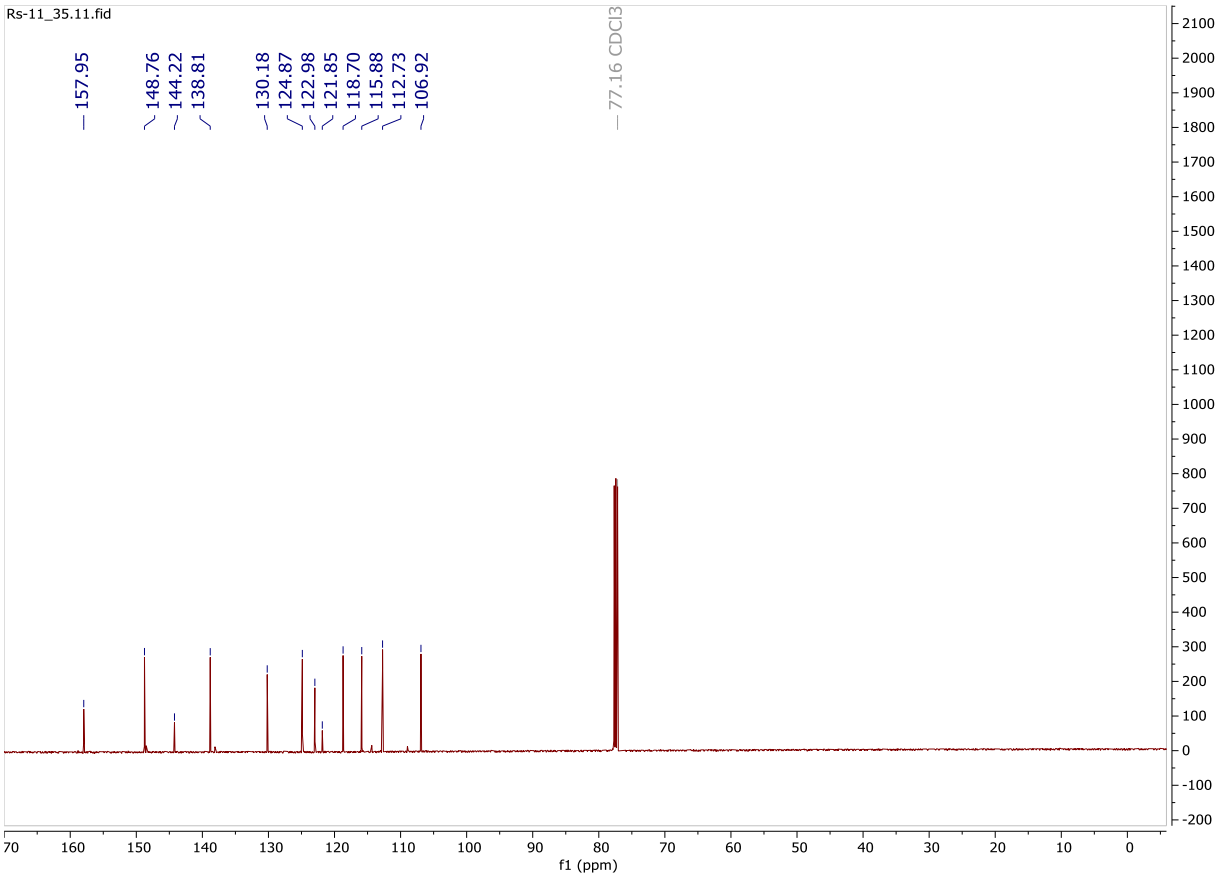
N-(pyridin-2-yl)imidazo[1,2-a]pyridin-3-amine (11_35)



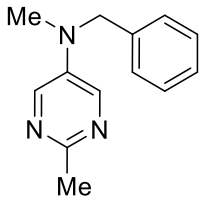
$^{13}C\{^{1}H\}$ NMR



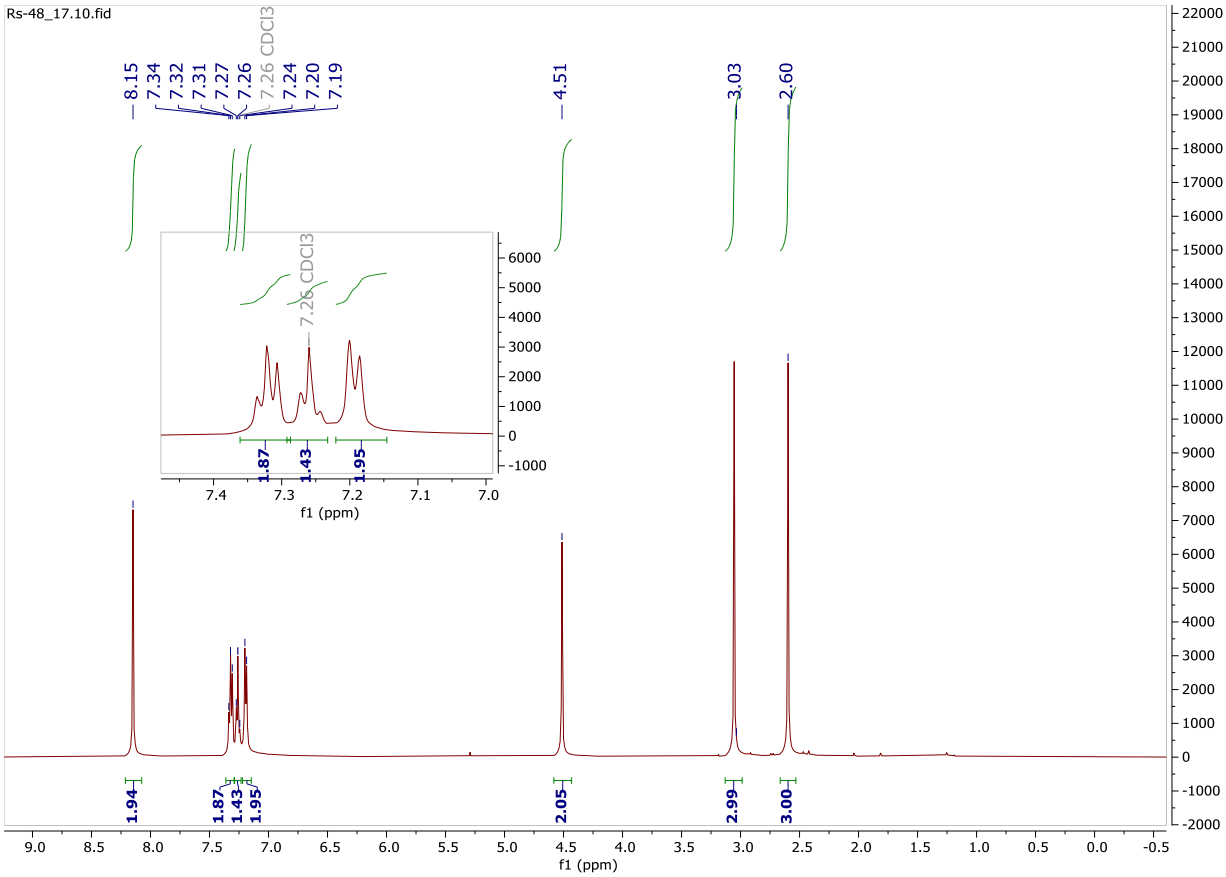
N-(pyridin-2-yl)imidazo[1,2-a]pyridin-3-amine (11_35)



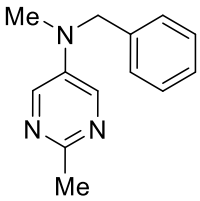
^{1}H NMR



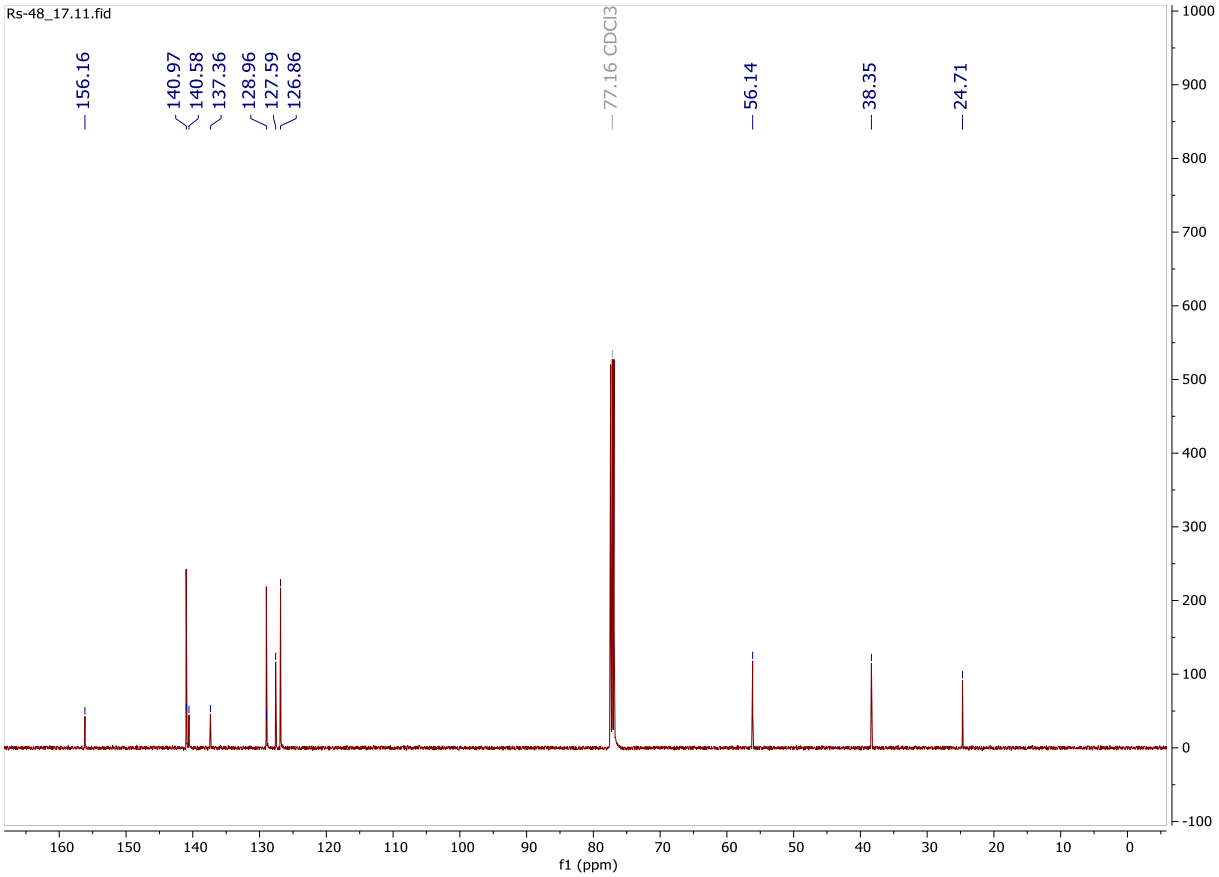
N-benzyl-N,2-dimethylpyrimidin-5-amine (48_17)



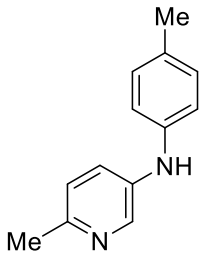
$^{13}C\{^{1}H\}$ NMR



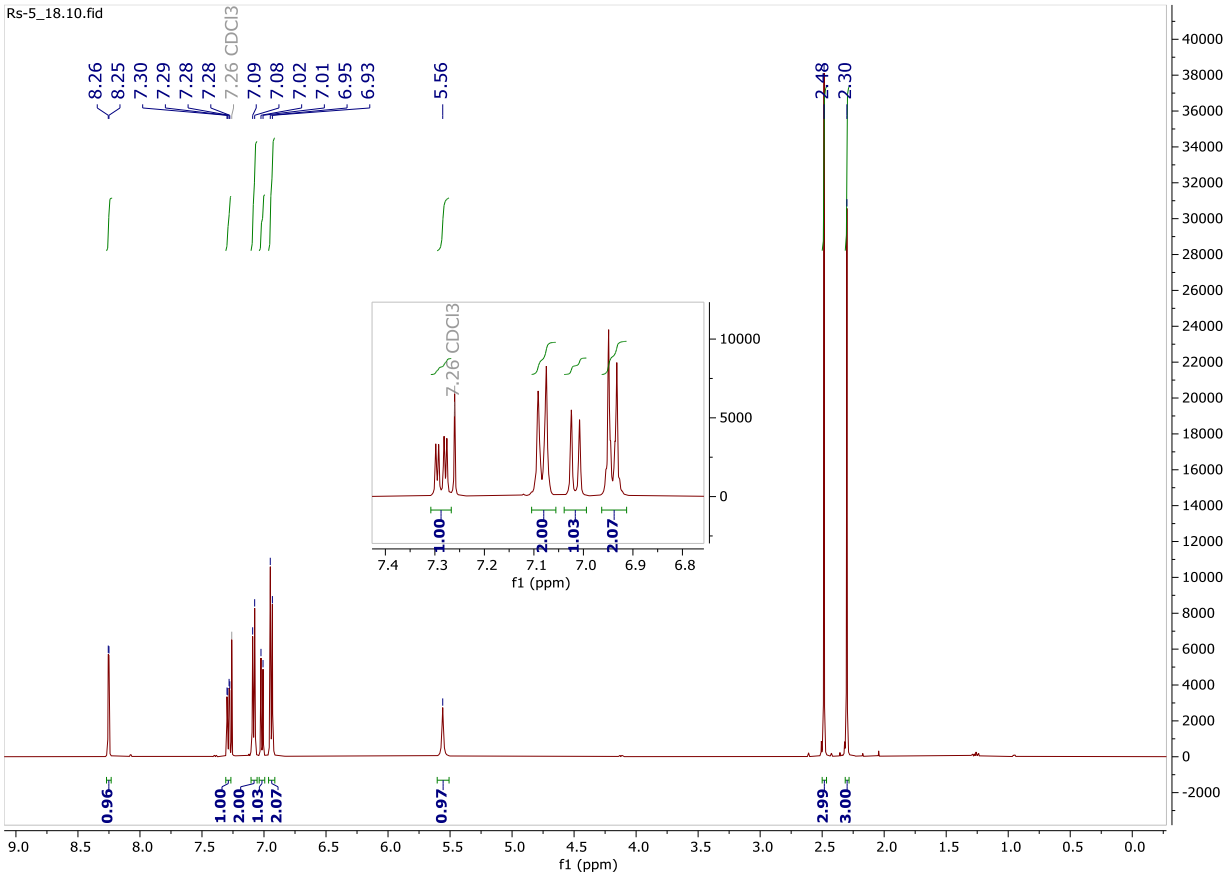
N-benzyl-N,2-dimethylpyrimidin-5-amine (48_17)



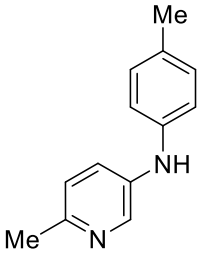
^{1}H NMR



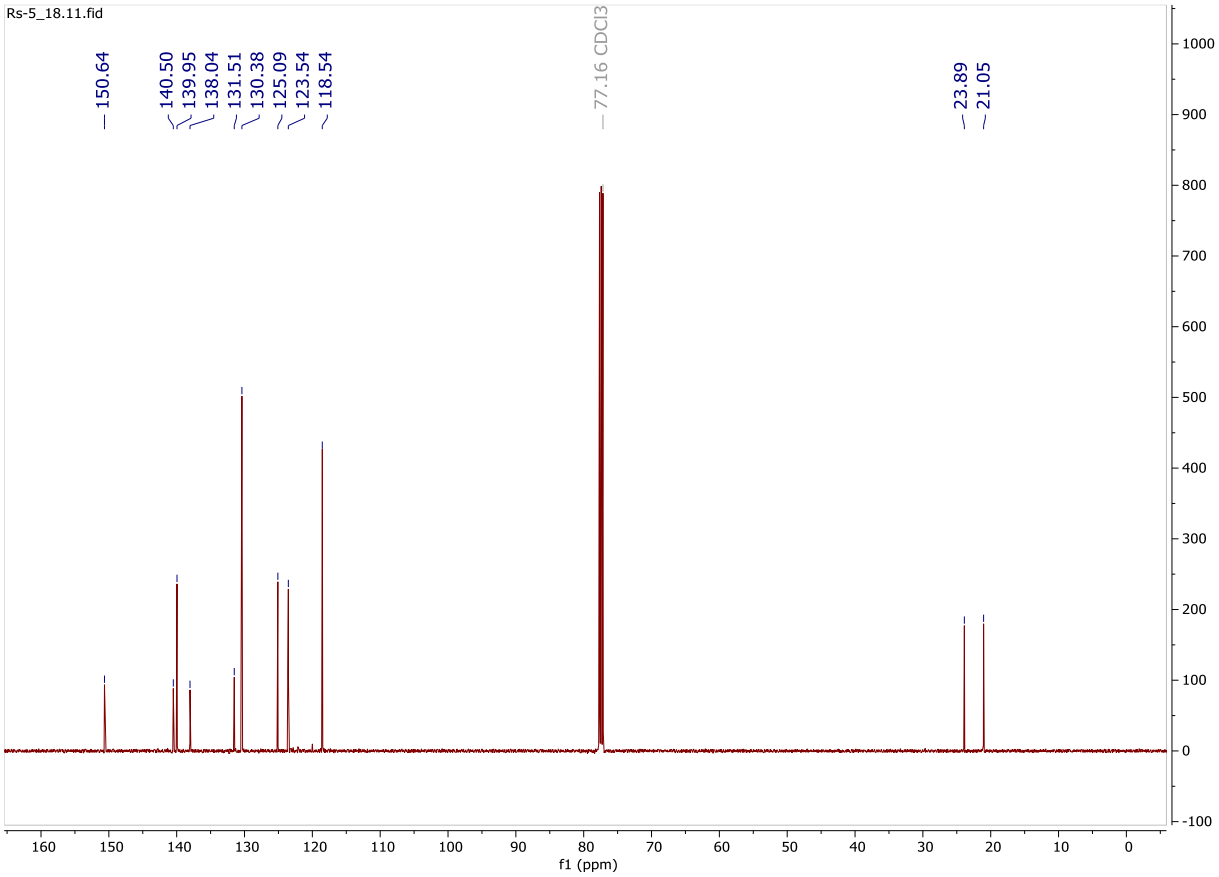
6-methyl-N-(p-tolyl)pyridin-3-amine (5_18)



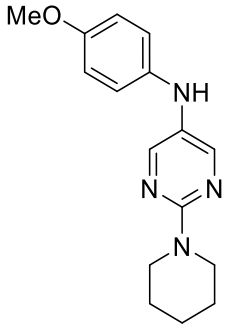
$^{13}C\{^{1}H\}$ NMR



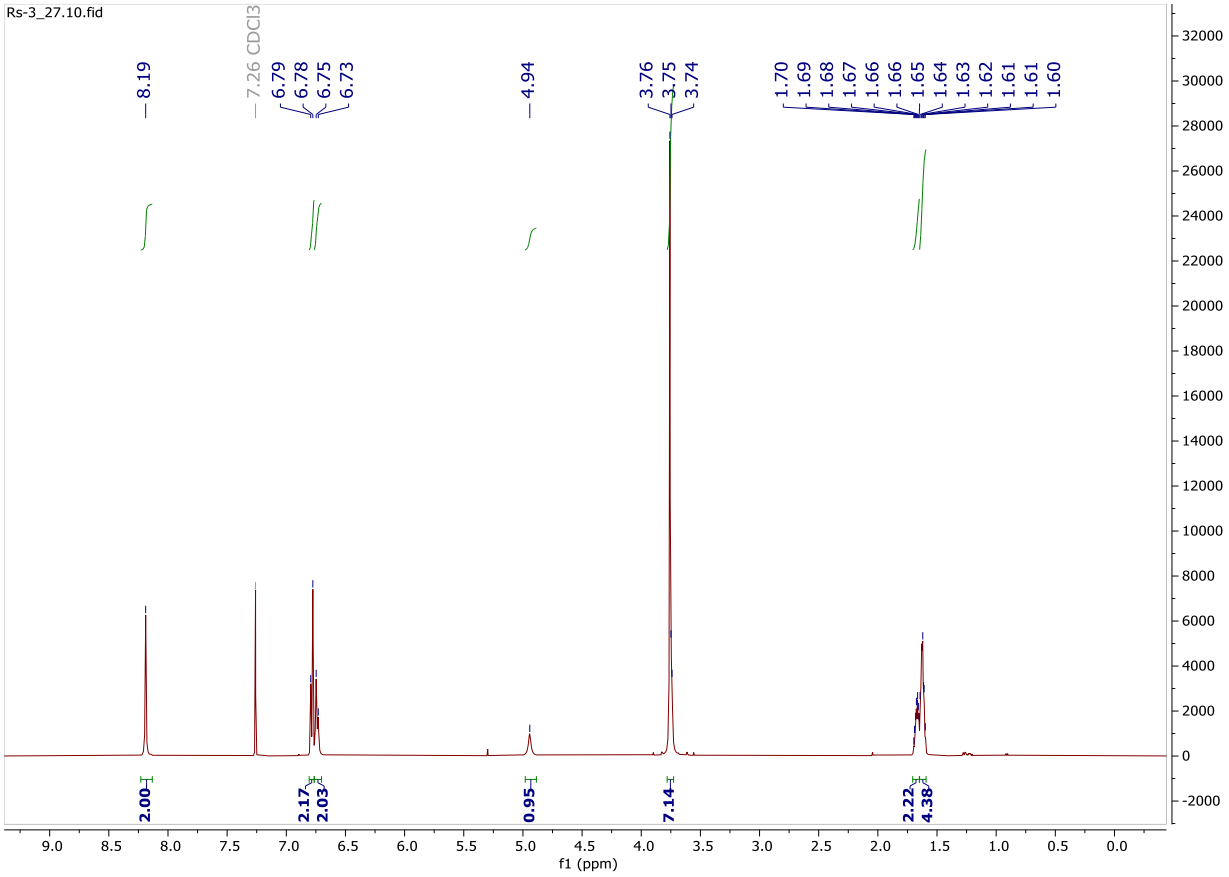
6-methyl-N-(p-tolyl)pyridin-3-amine (5_18)



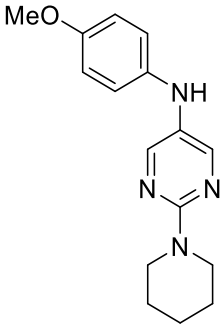
^{1}H NMR



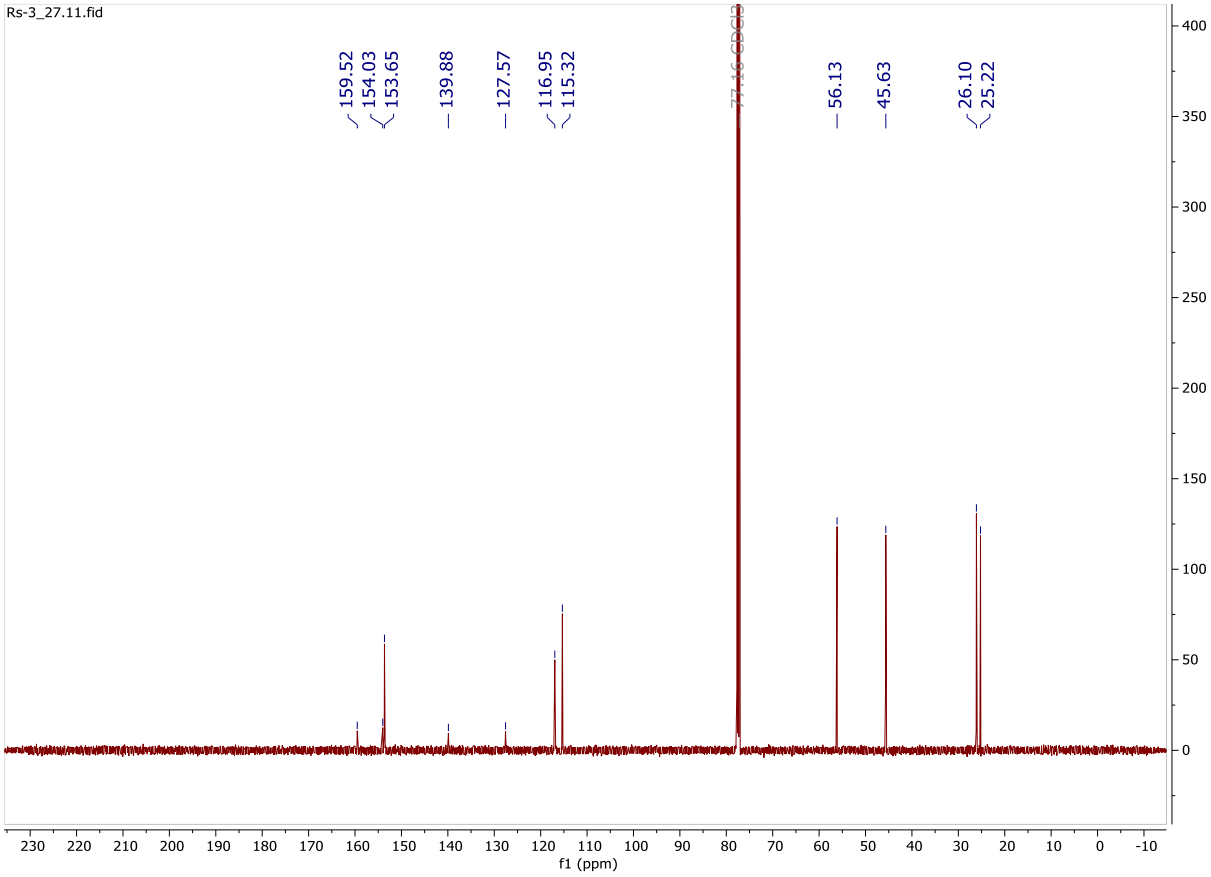
N-(4-methoxyphenyl)-2-(piperidin-1-yl)pyrimidin-5-amine (3_27)



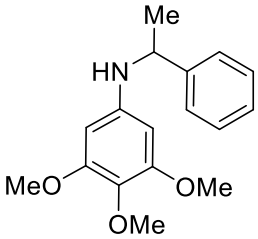
$^{13}C\{^{1}H\}$ NMR



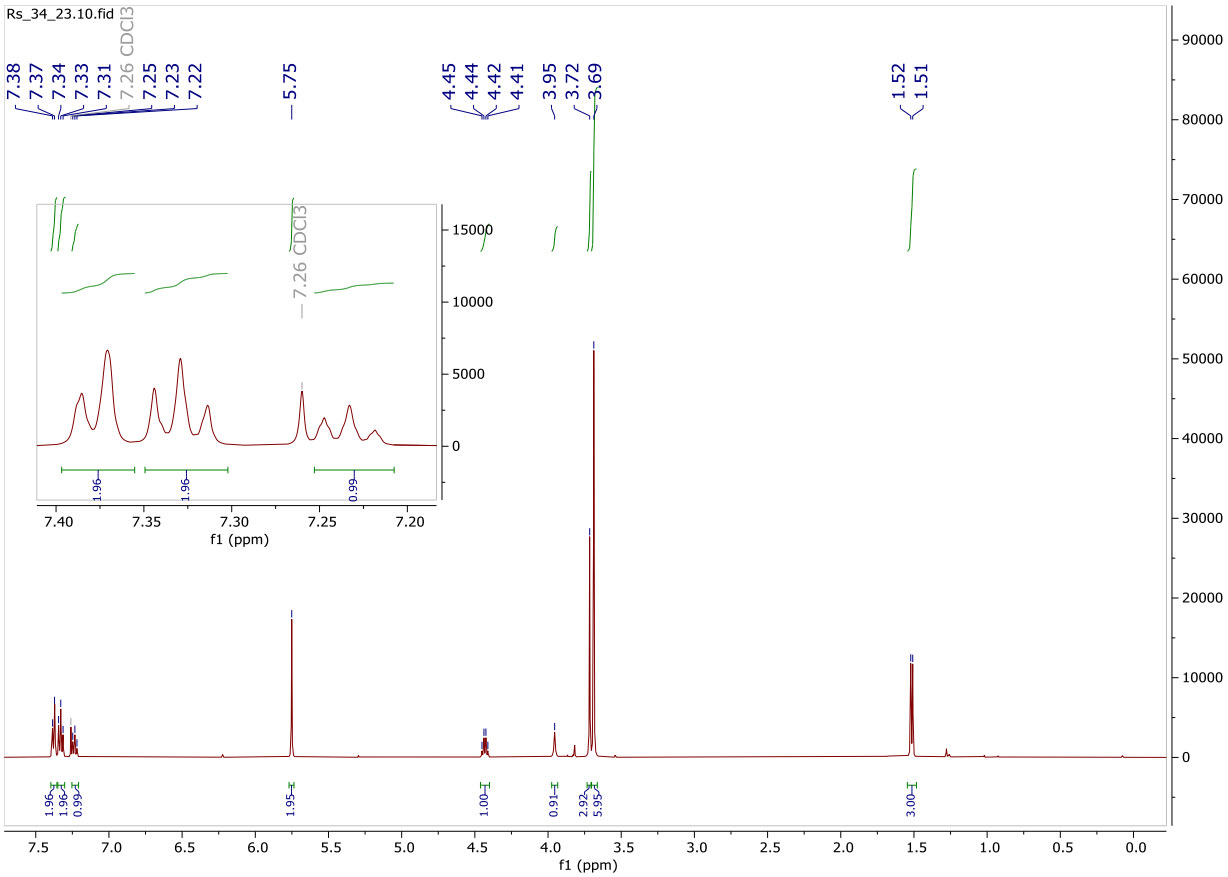
N-(4-methoxyphenyl)-2-(piperidin-1-yl)pyrimidin-5-amine (3_27)



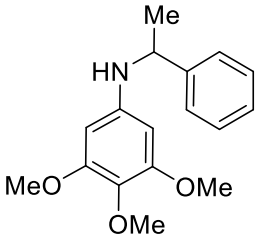
^{1}H NMR



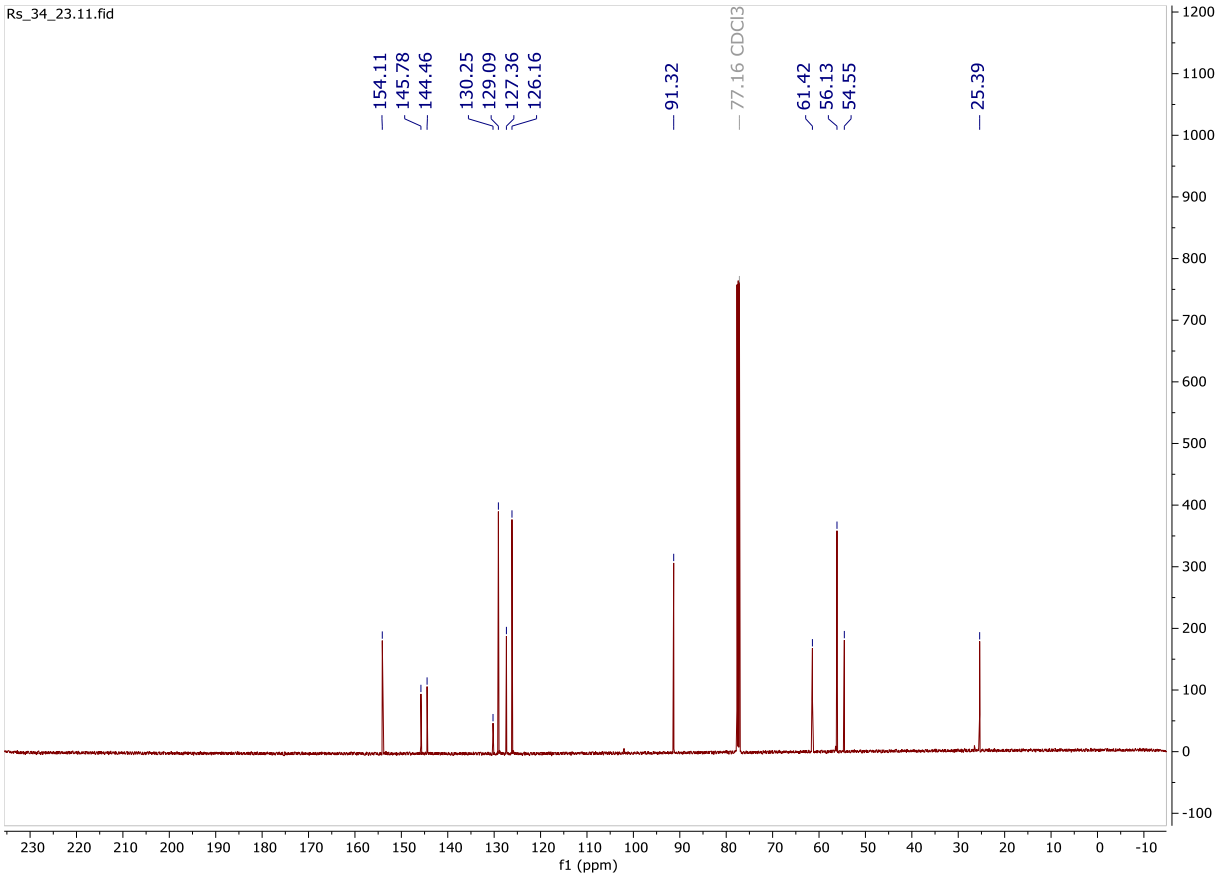
3,4,5-trimethoxy-N-(1-phenylethyl)aniline (34_23)



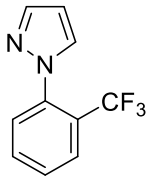
$^{13}C\{^{1}H\}$ NMR



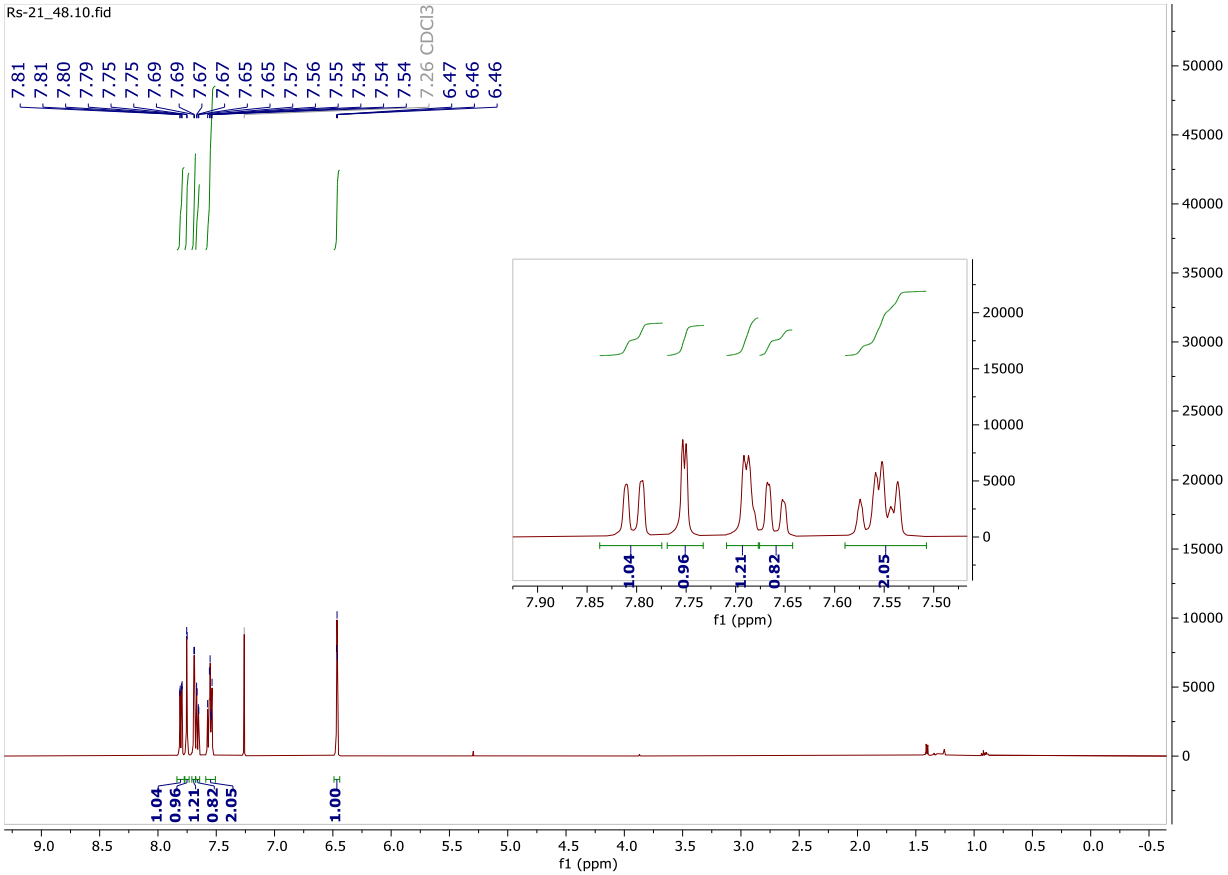
3,4,5-trimethoxy-N-(1-phenylethyl)aniline (34_23)



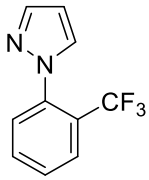
^{1}H NMR



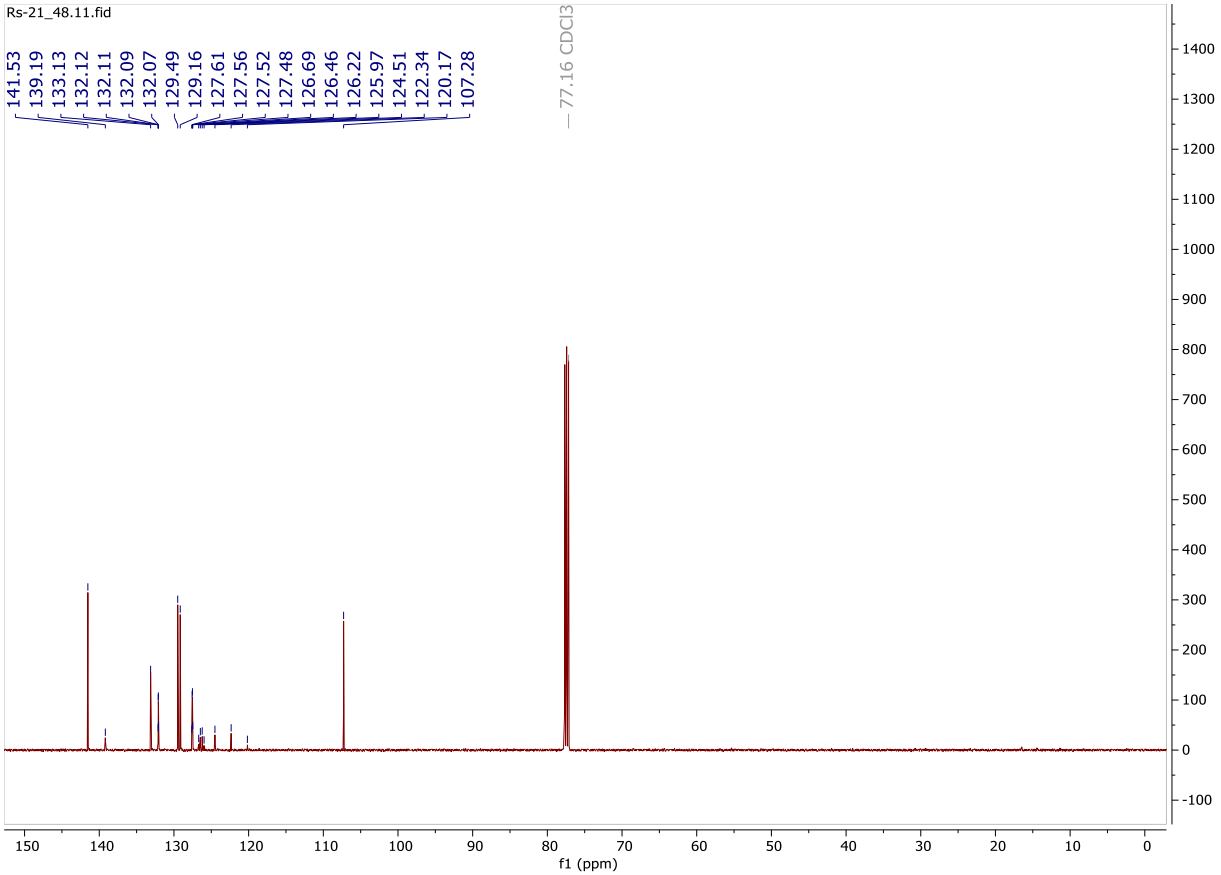
1-(2-(trifluoromethyl)phenyl)-1H-pyrazole (21_48)



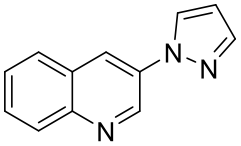
$^{13}C\{^{1}H\}$ NMR



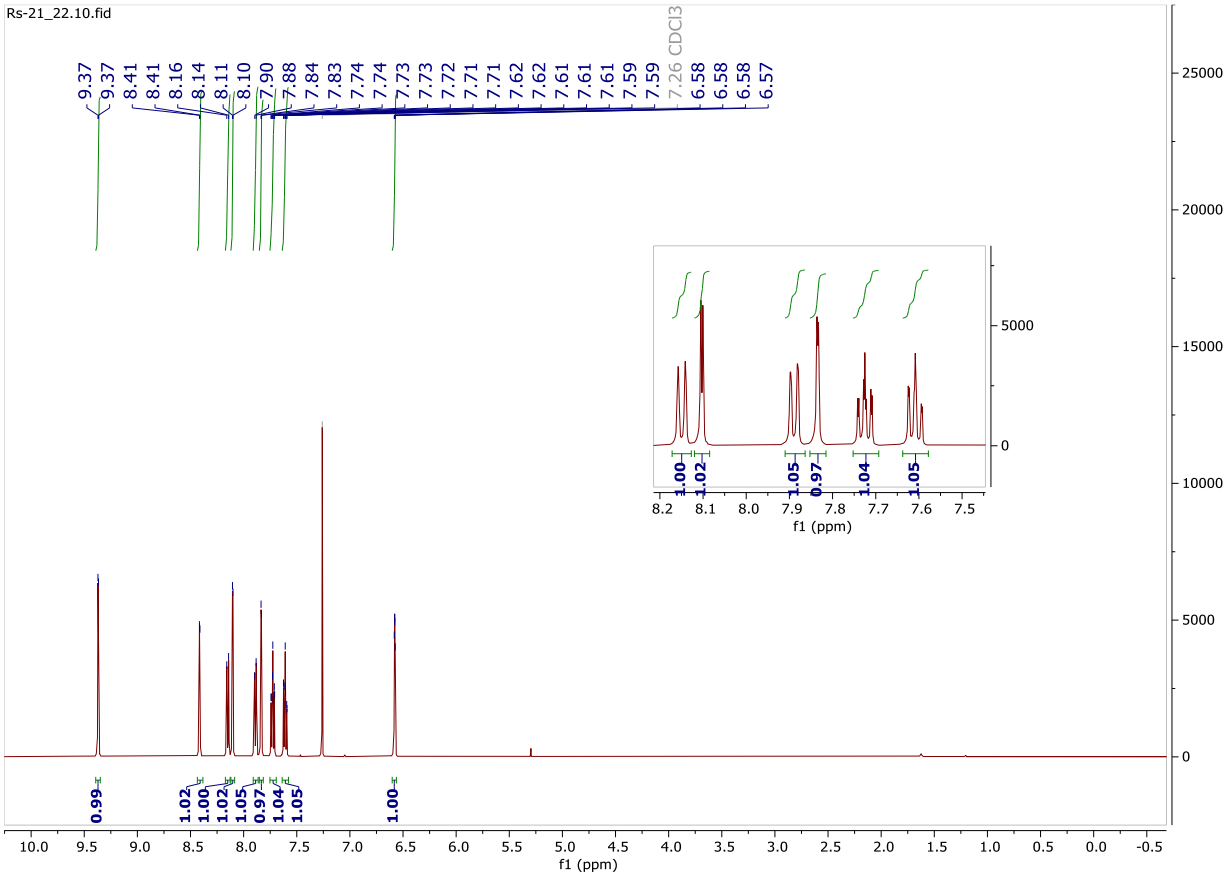
1-(2-(trifluoromethyl)phenyl)-1H-pyrazole (21_48)



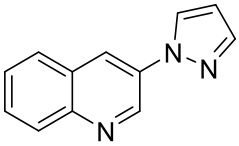
^{1}H NMR



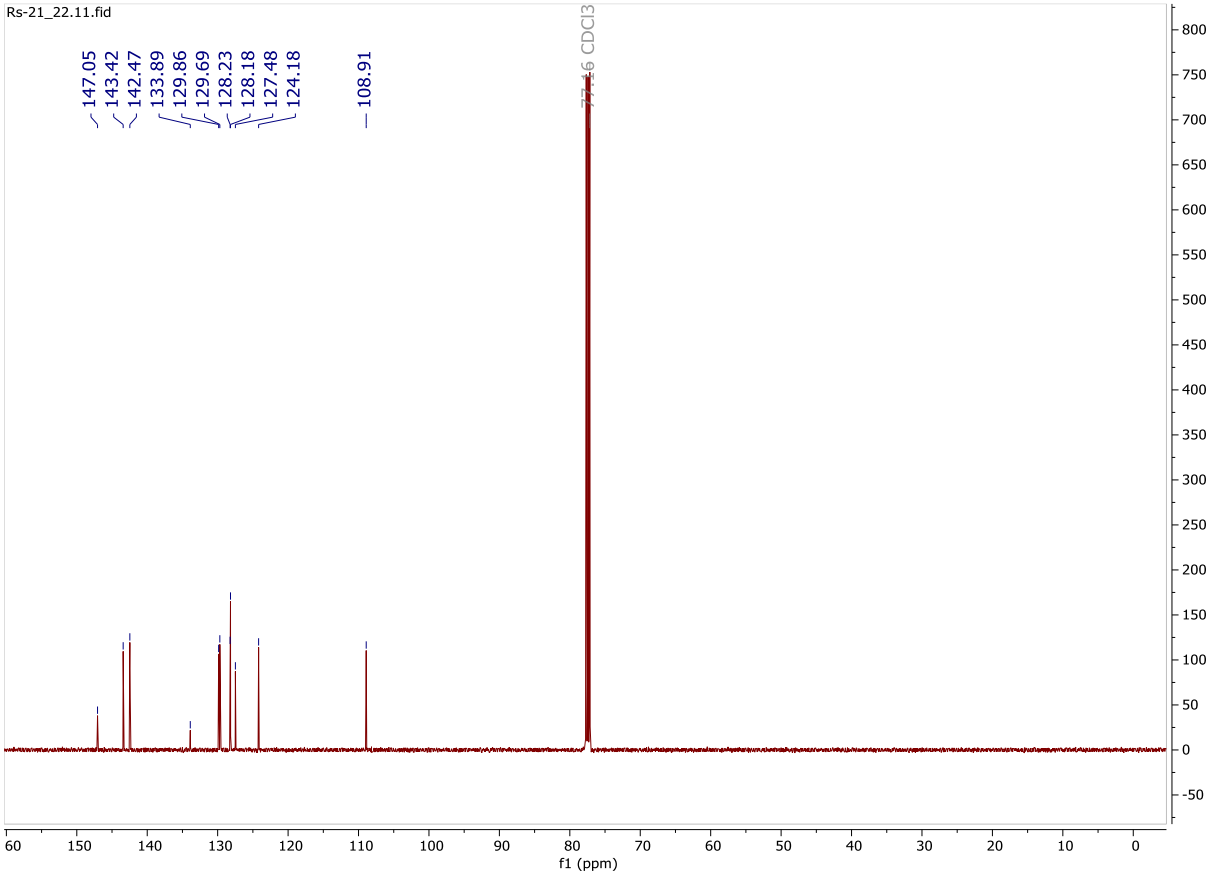
3-(1H-pyrazol-1-yl)quinoline (21_22)



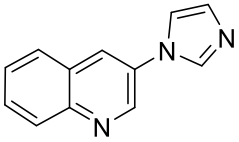
$^{13}C\{^{1}H\}$ NMR



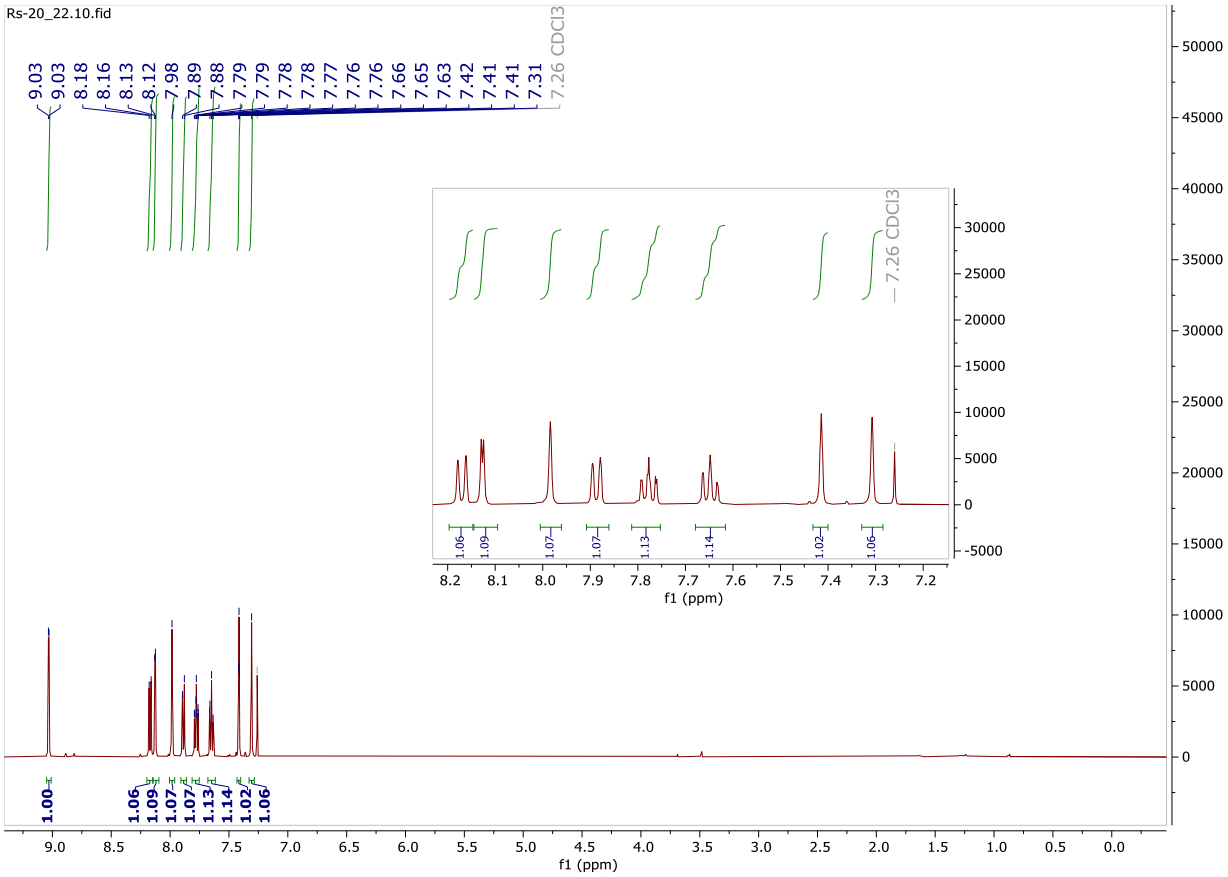
3-(1H-pyrazol-1-yl)quinoline (21_22)



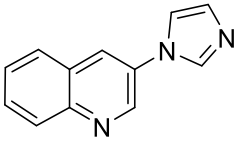
^{1}H NMR



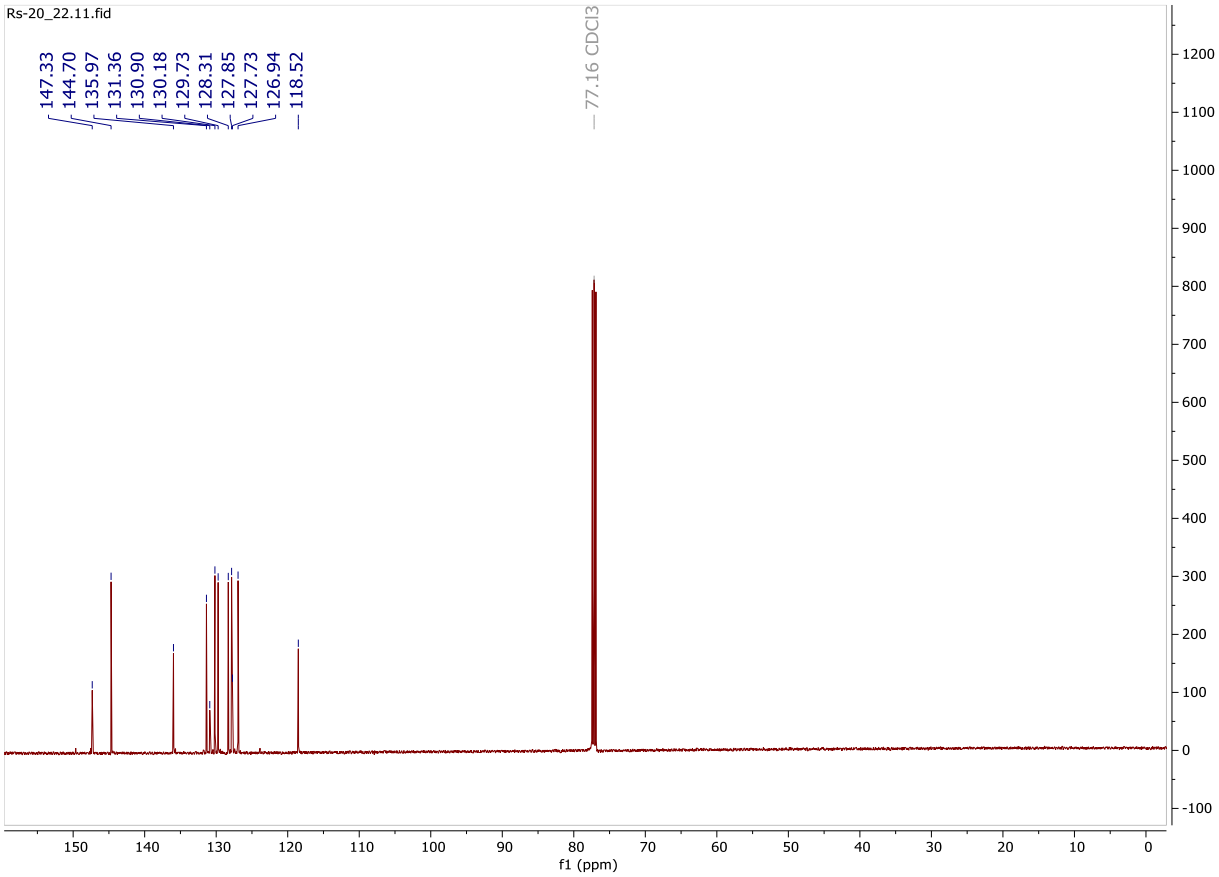
3-(1H-imidazol-1-yl)quinoline (20_22)



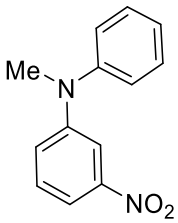
$^{13}C\{^{1}H\}$ NMR



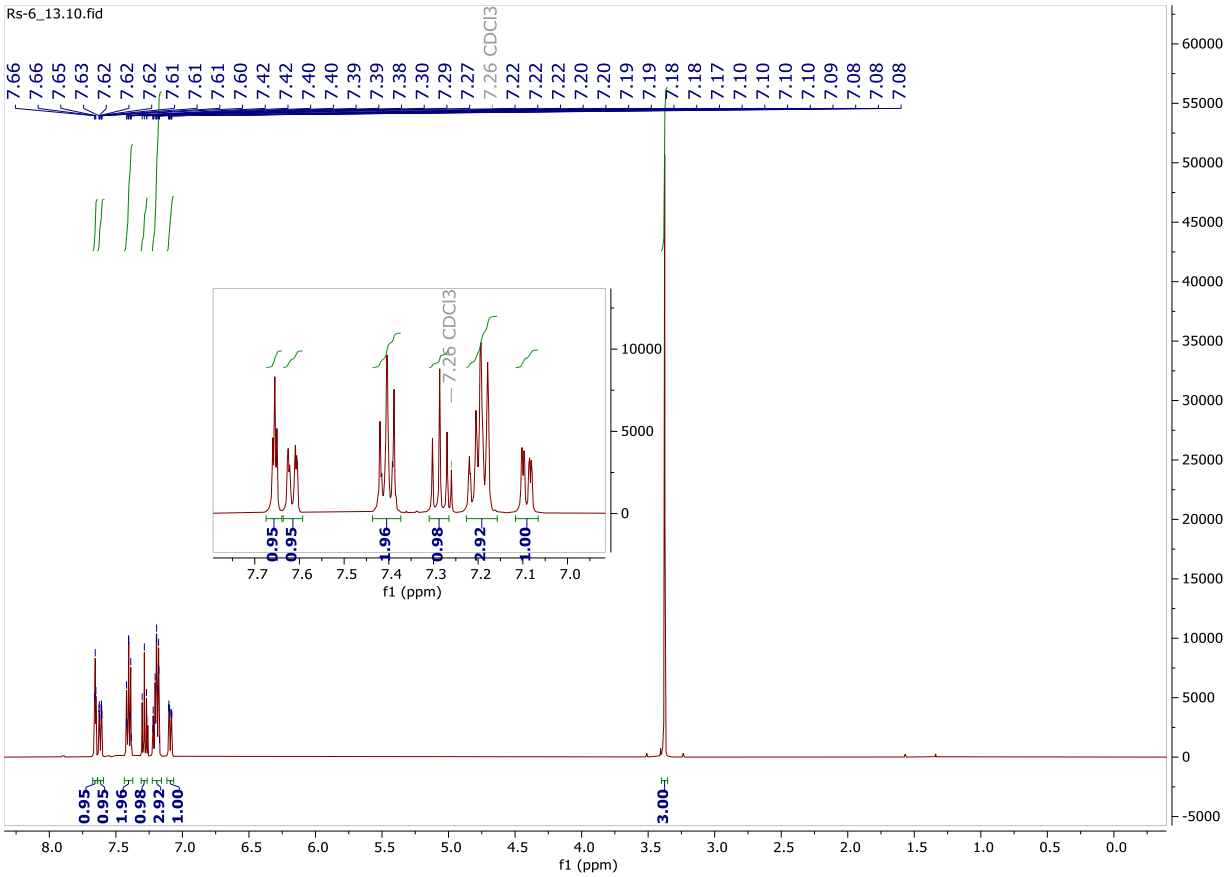
3-(1H-imidazol-1-yl)quinoline (20_22)



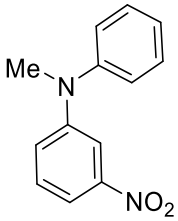
^{1}H NMR



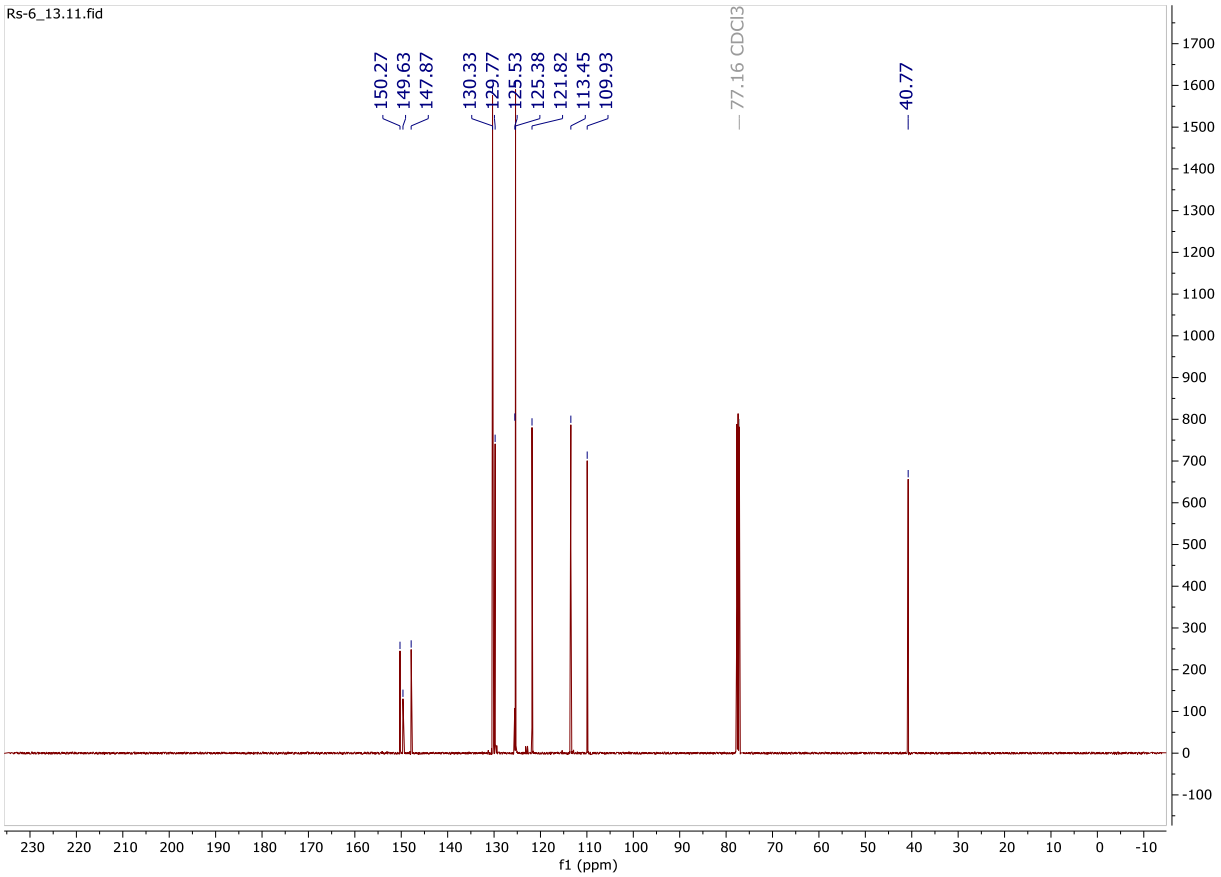
N-methyl-3-nitro-N-phenylaniline (6_13)



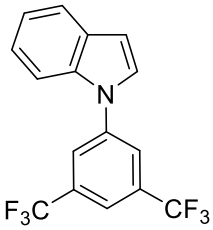
$^{13}C\{^{1}H\}$ NMR



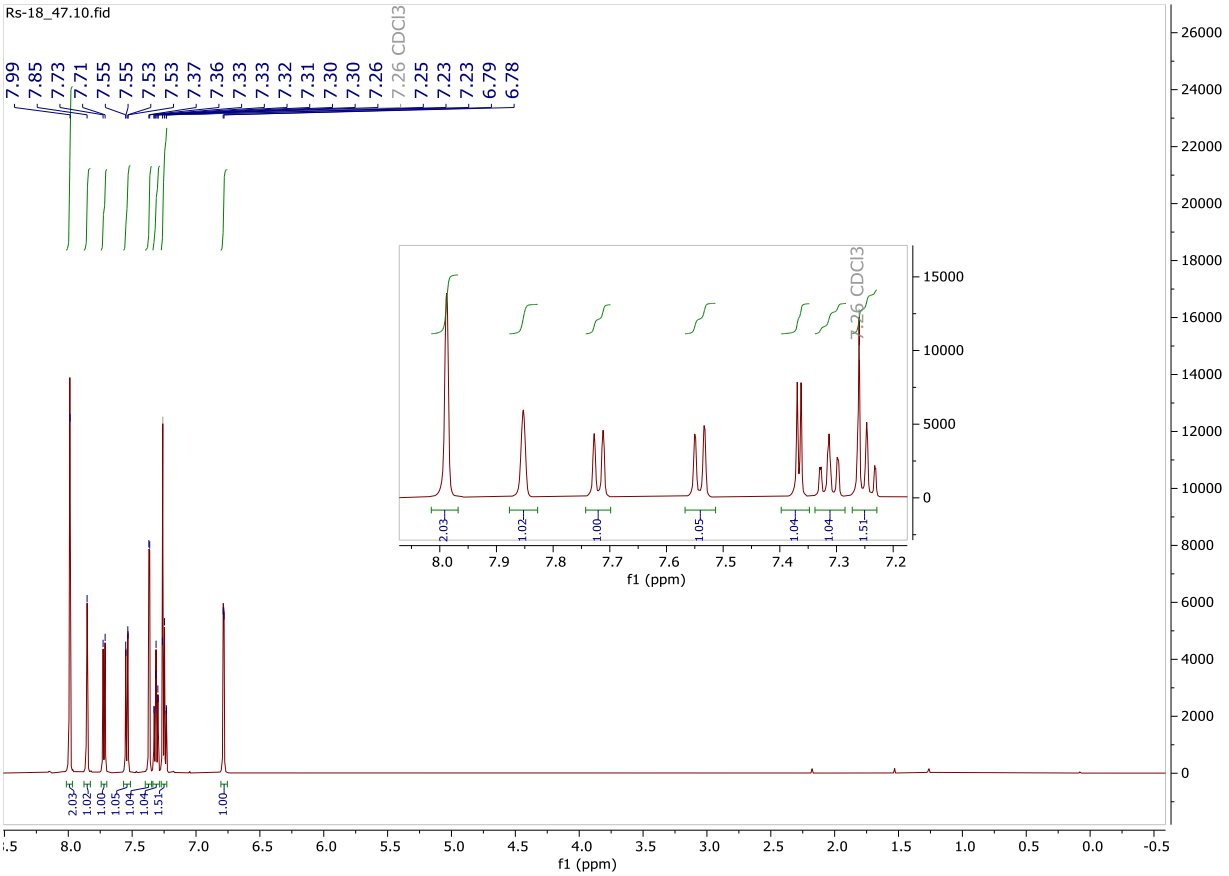
N-methyl-3-nitro-N-phenylaniline (6_13)



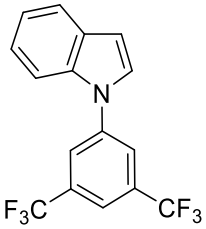
^{1}H NMR



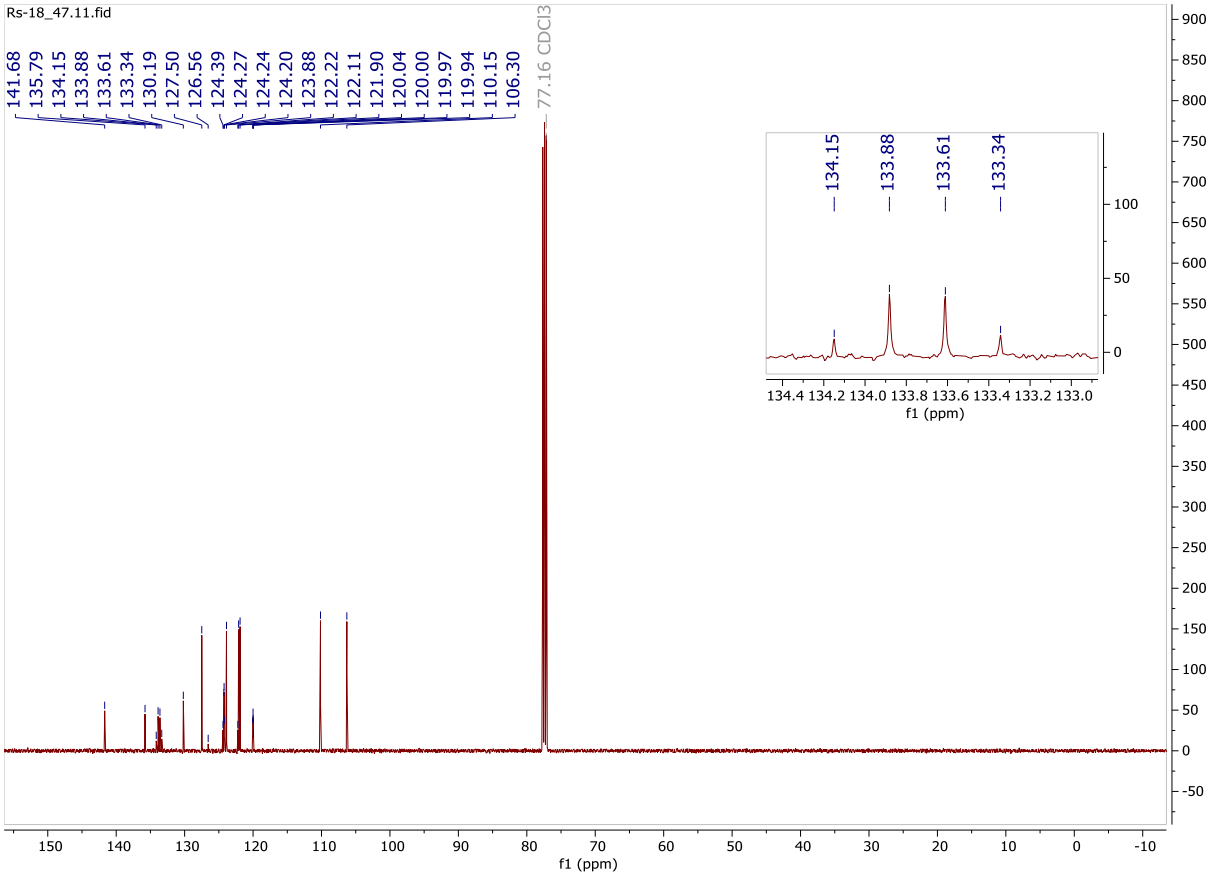
1-(3,5-bis(trifluoromethyl)phenyl)-1H-indole (18_47)



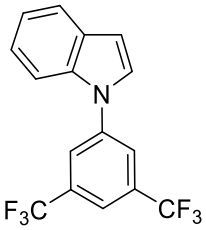
$^{13}C\{^{1}H\}$ NMR



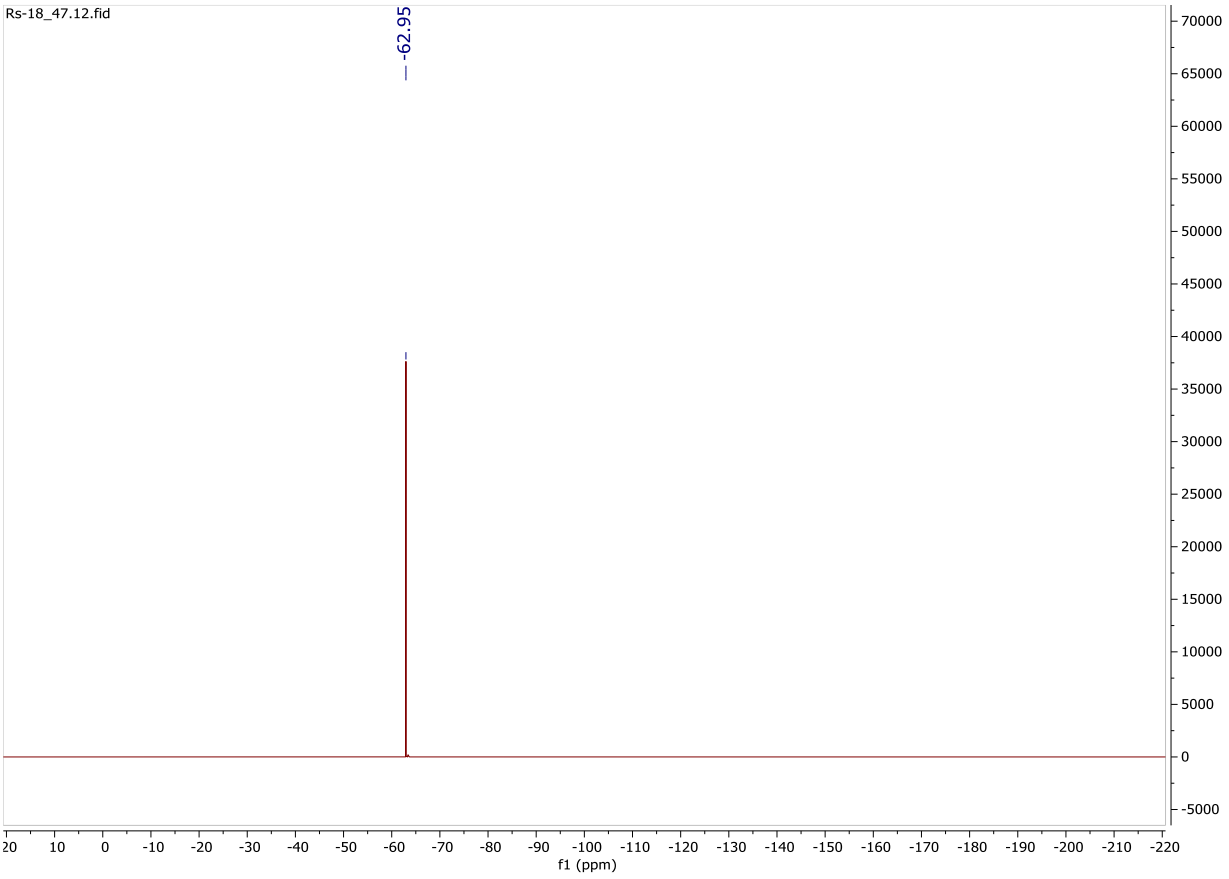
1-(3,5-bis(trifluoromethyl)phenyl)-1H-indole (18_47)



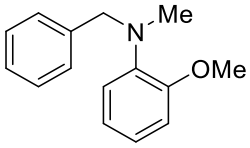
^{19}F NMR



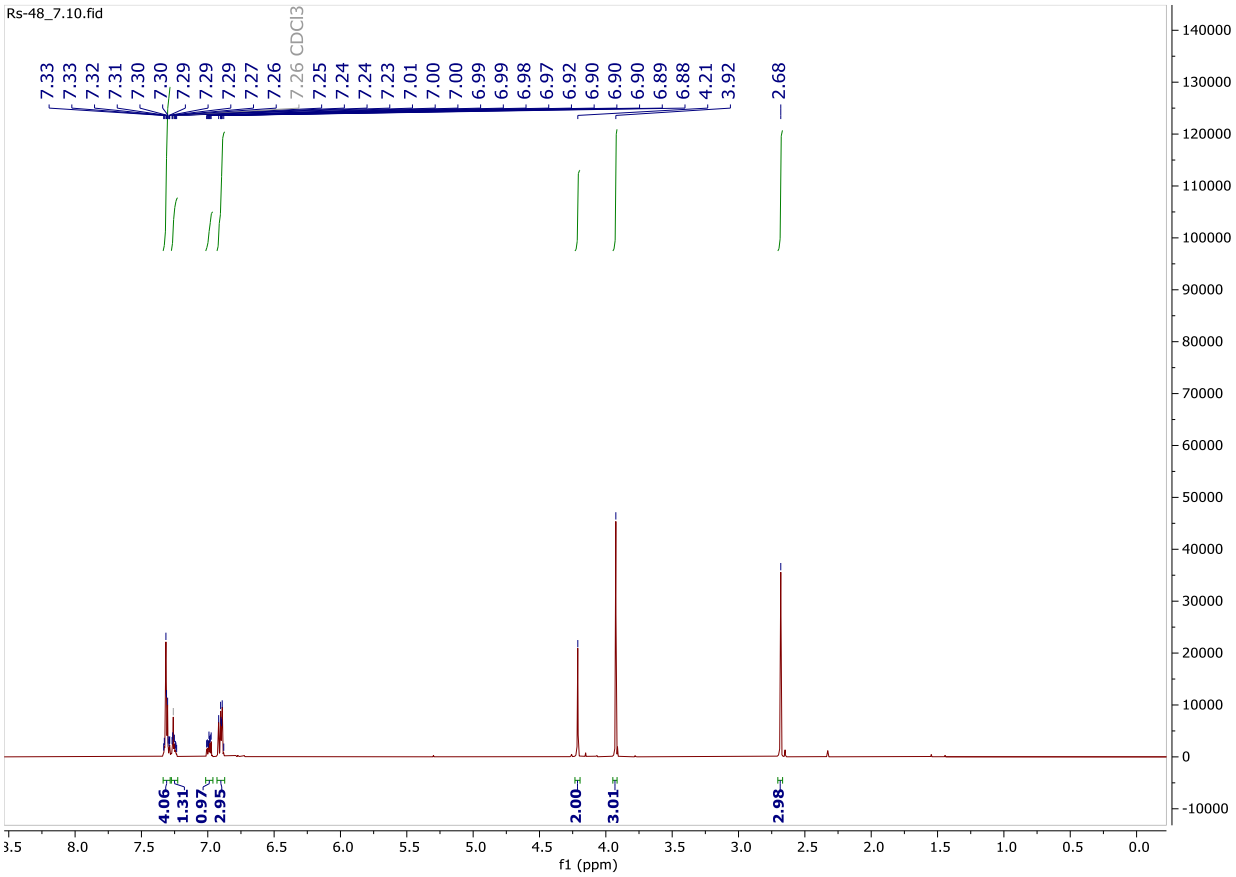
1-(3,5-bis(trifluoromethyl)phenyl)-1H-indole (18_47)



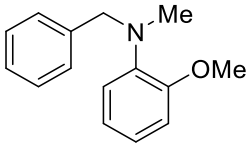
^{1}H NMR



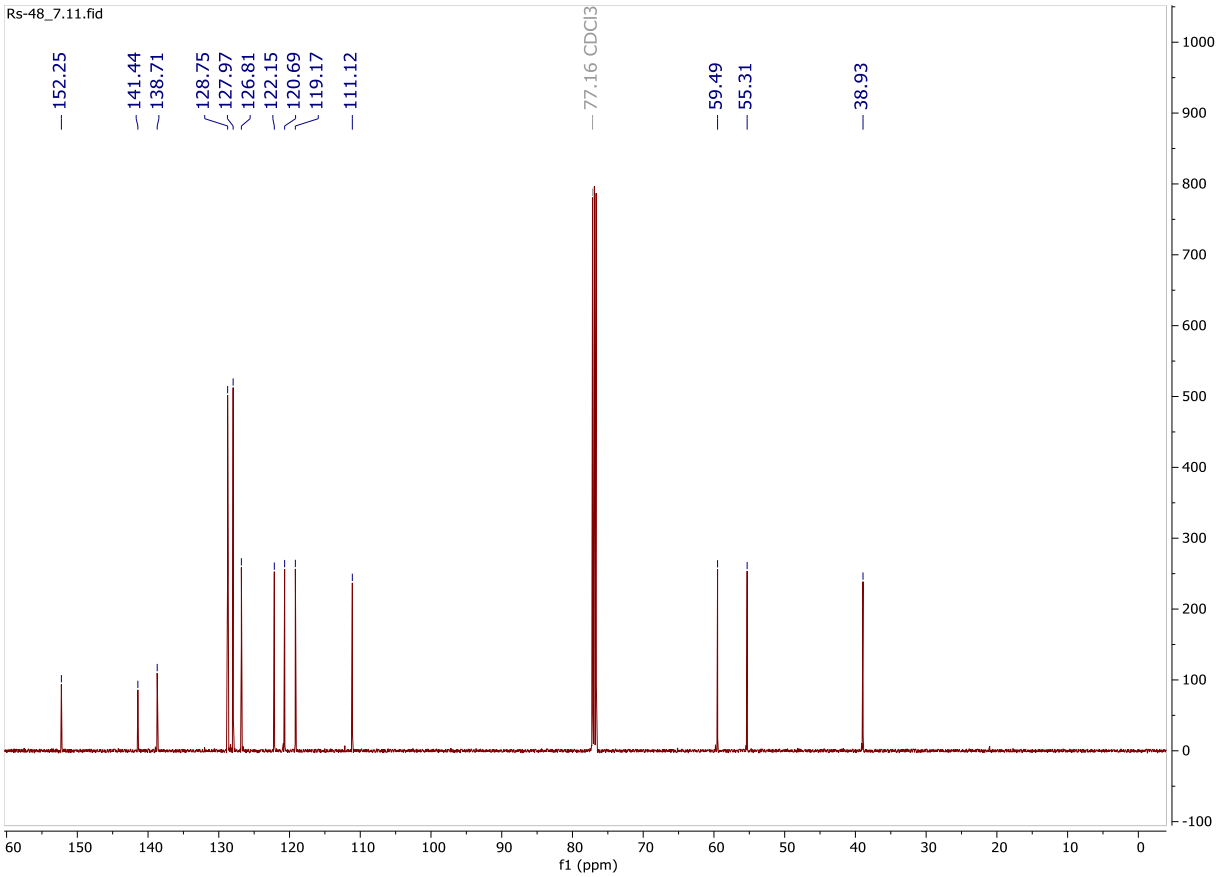
N-benzyl-2-methoxy-N-methylaniline (48_7)



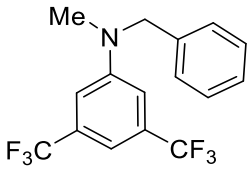
$^{13}C\{^{1}H\}$ NMR



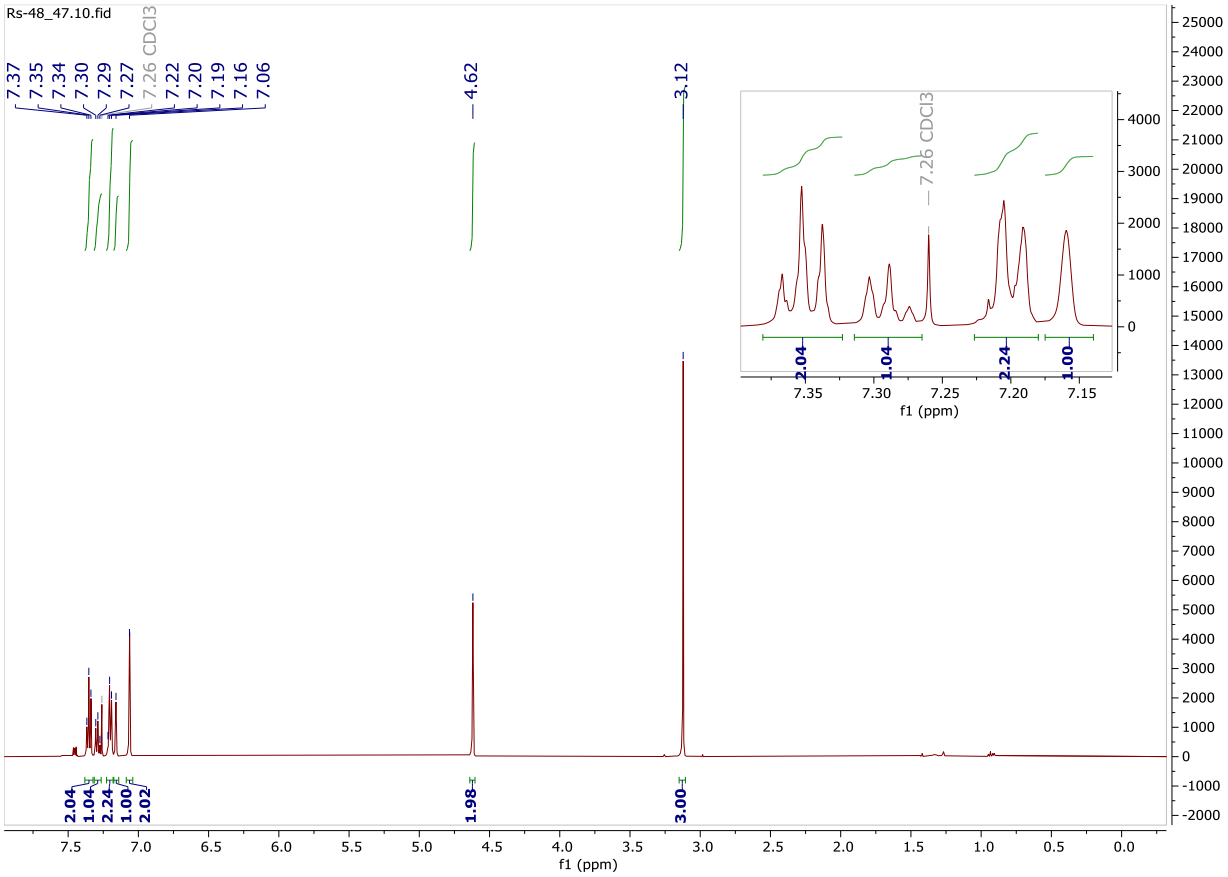
N-benzyl-2-methoxy-N-methylaniline (48_7)



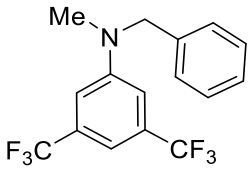
^{1}H NMR



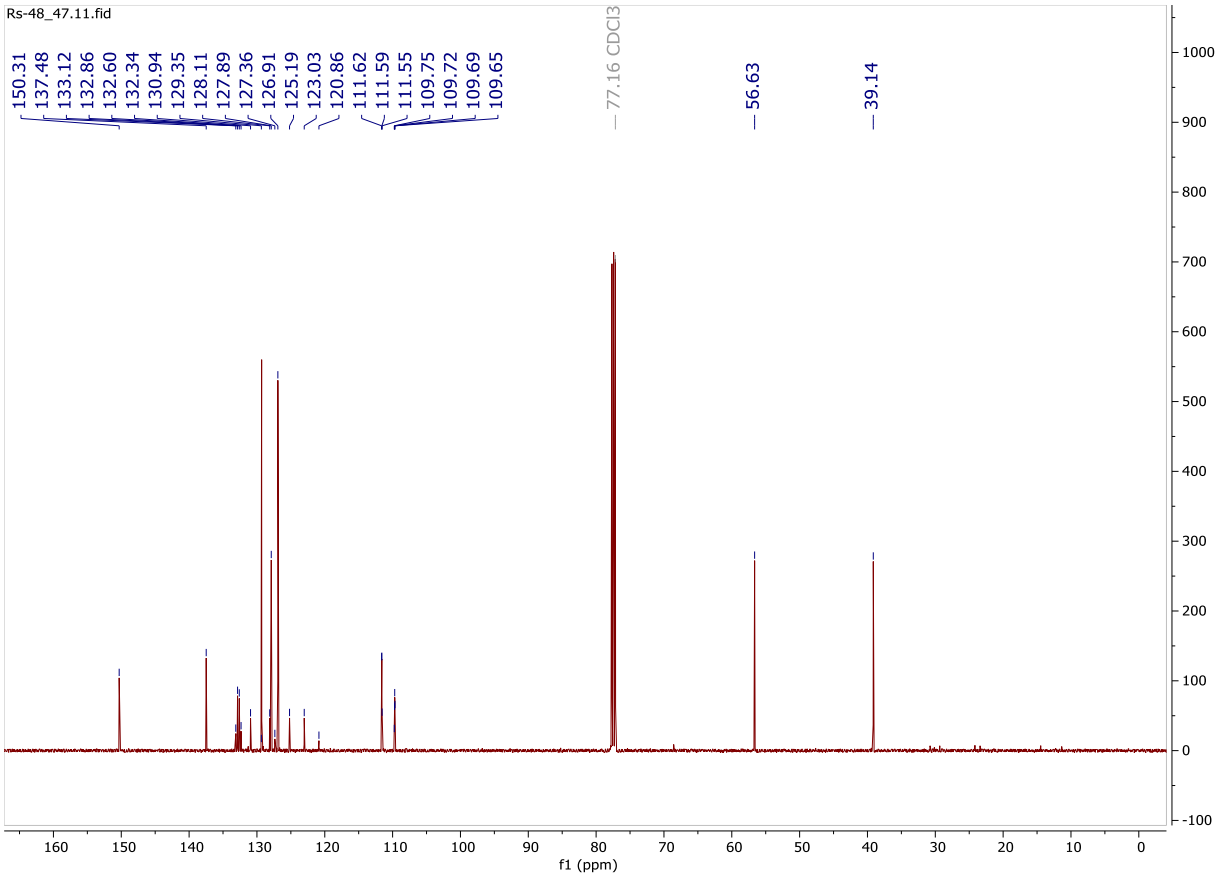
N-benzyl-N-methyl-3,5-bis(trifluoromethyl)aniline (Roche plate 48_47)



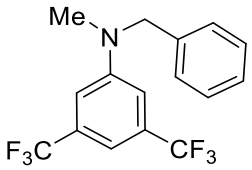
$^{13}C\{^{1}H\}$ NMR



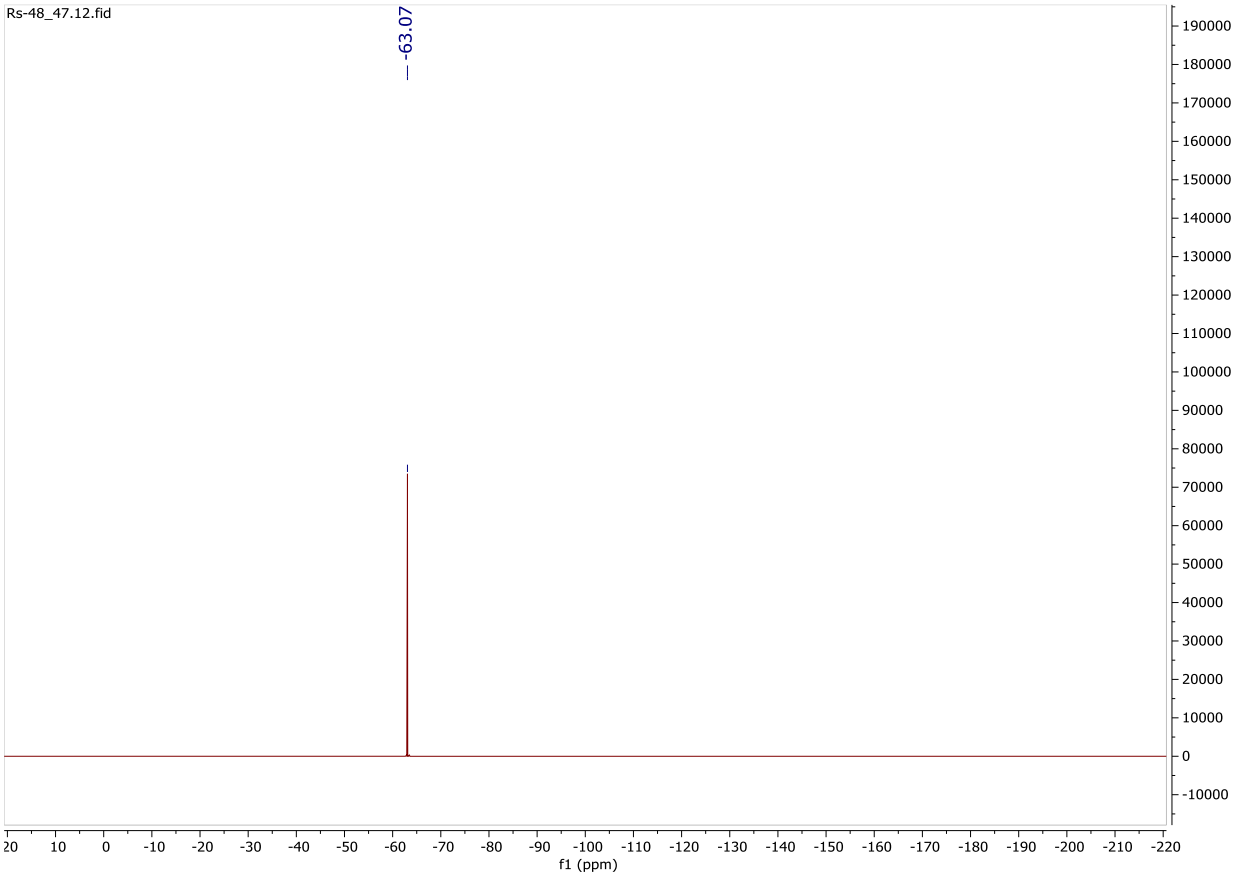
N-benzyl-N-methyl-3,5-bis(trifluoromethyl)aniline (Roche plate 48_47)



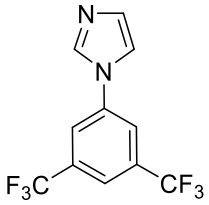
^{19}F NMR



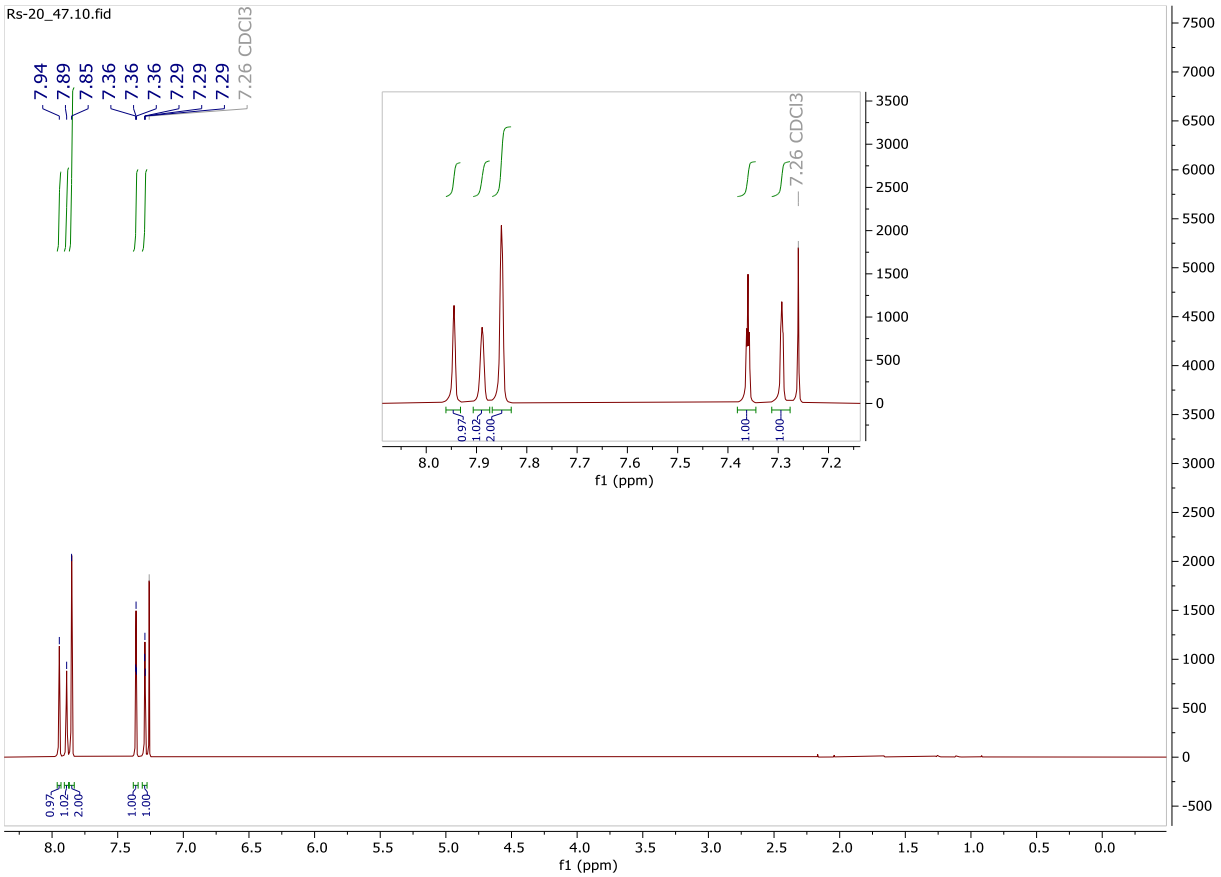
N-benzyl-N-methyl-3,5-bis(trifluoromethyl)aniline (Roche plate 48_47)



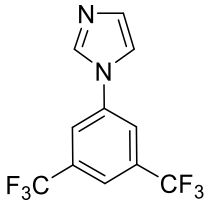
^{1}H NMR



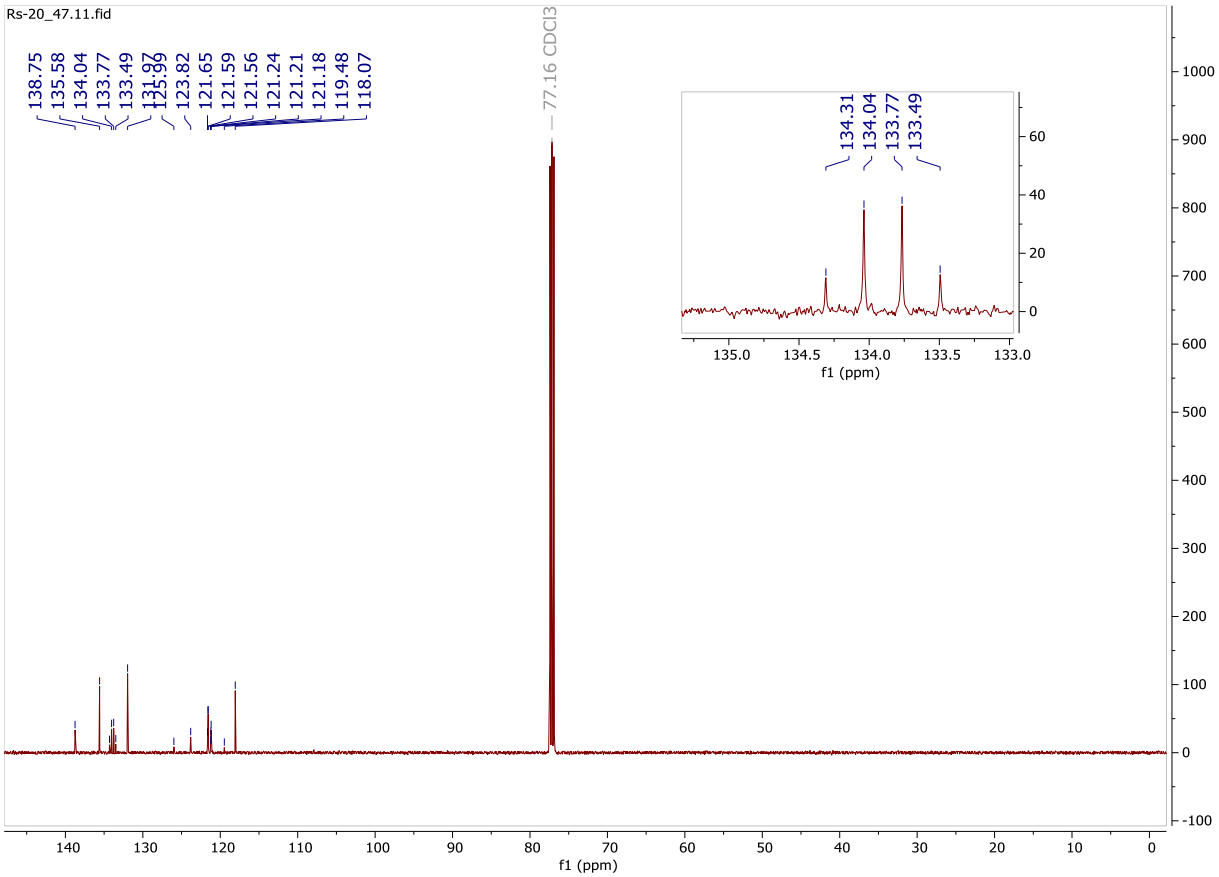
1-(3,5-bis(trifluoromethyl)phenyl)-1H-imidazole (20_47)



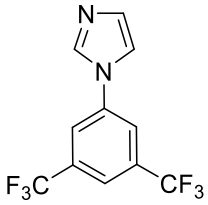
$^{13}C\{^{1}H\}$ NMR



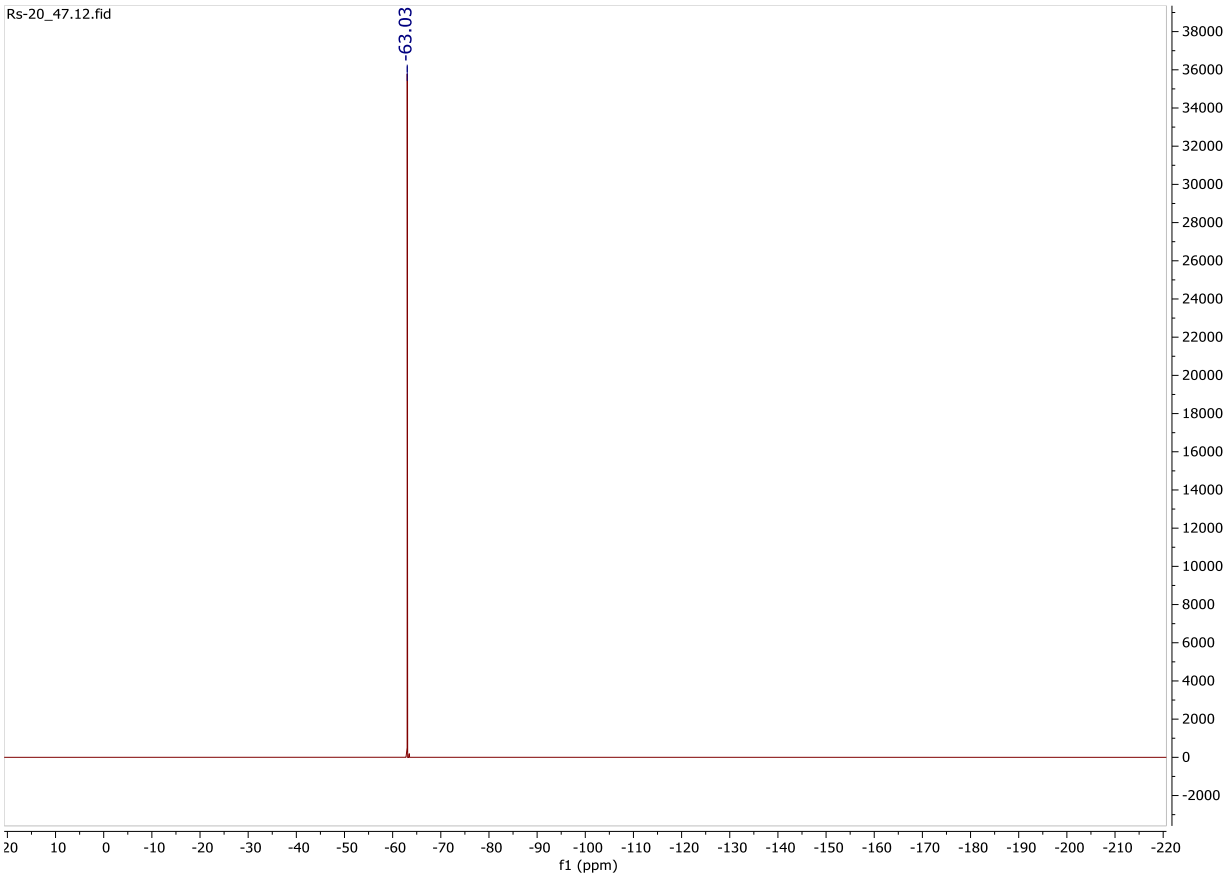
1-(3,5-bis(trifluoromethyl)phenyl)-1H-imidazole (Roche Plate **20_47**)



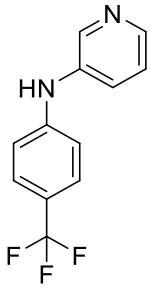
^{19}F NMR



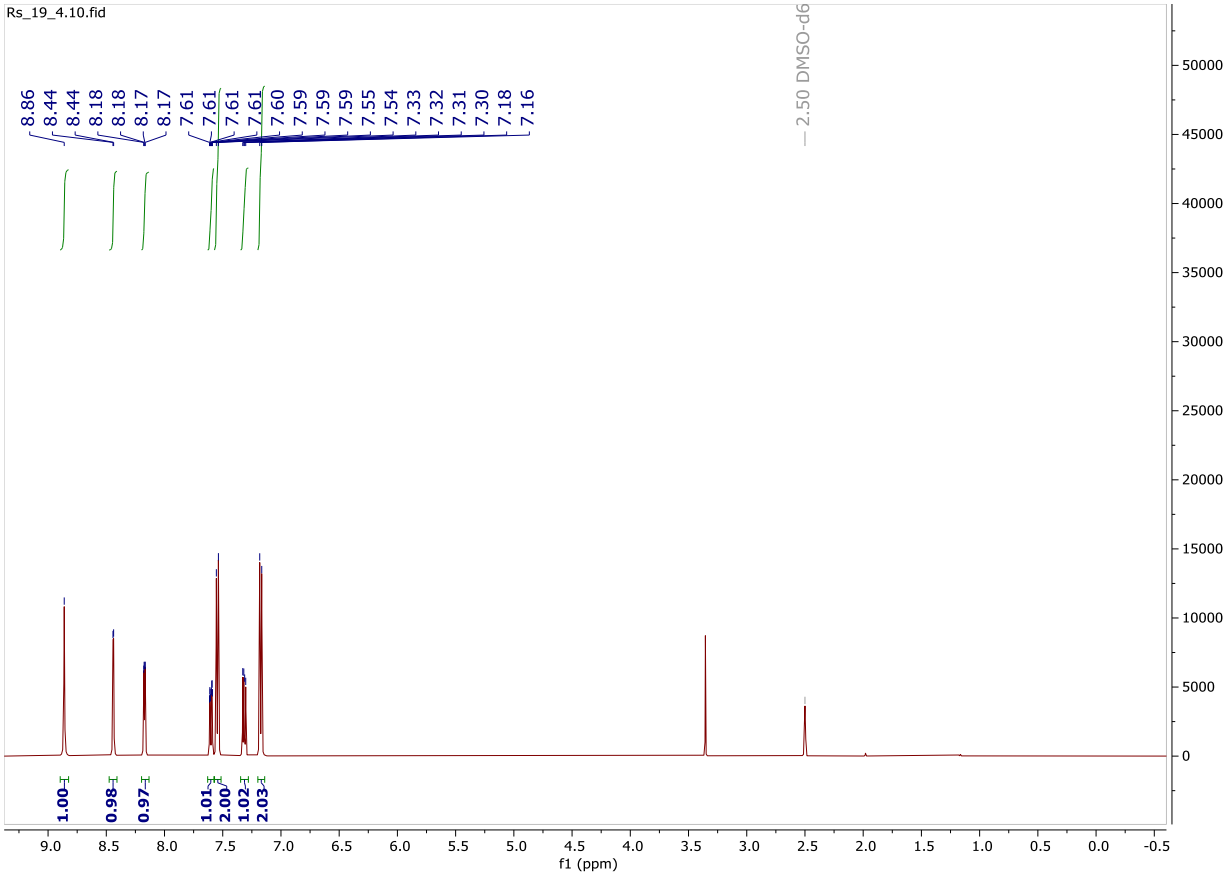
1-(3,5-bis(trifluoromethyl)phenyl)-1H-imidazole (Roche Plate **20_47**)



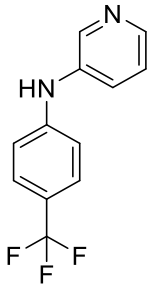
^{1}H NMR



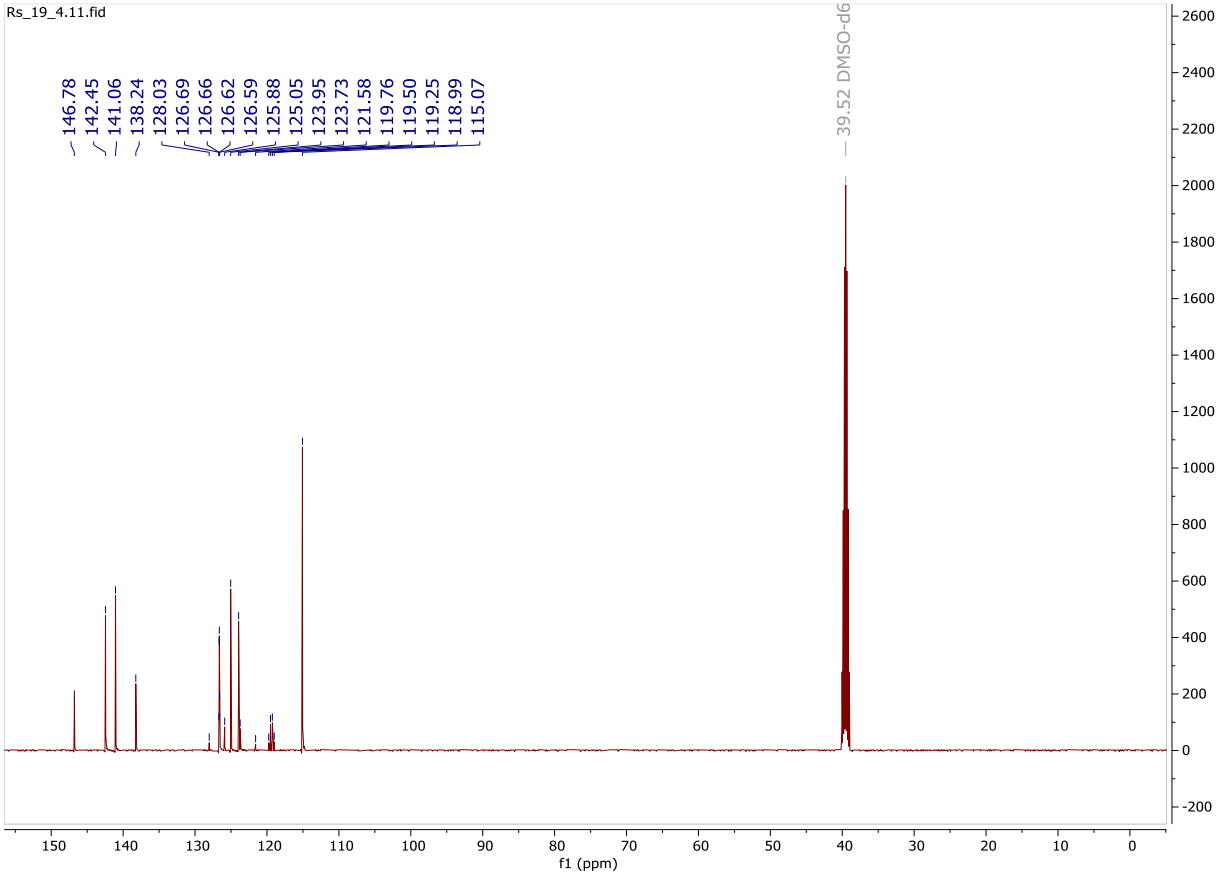
N-(4-(trifluoromethyl)phenyl)pyridin-3-amine (19_4)



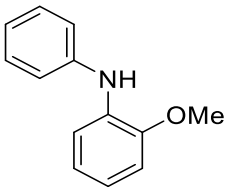
$^{13}C\{^{1}H\}$ NMR



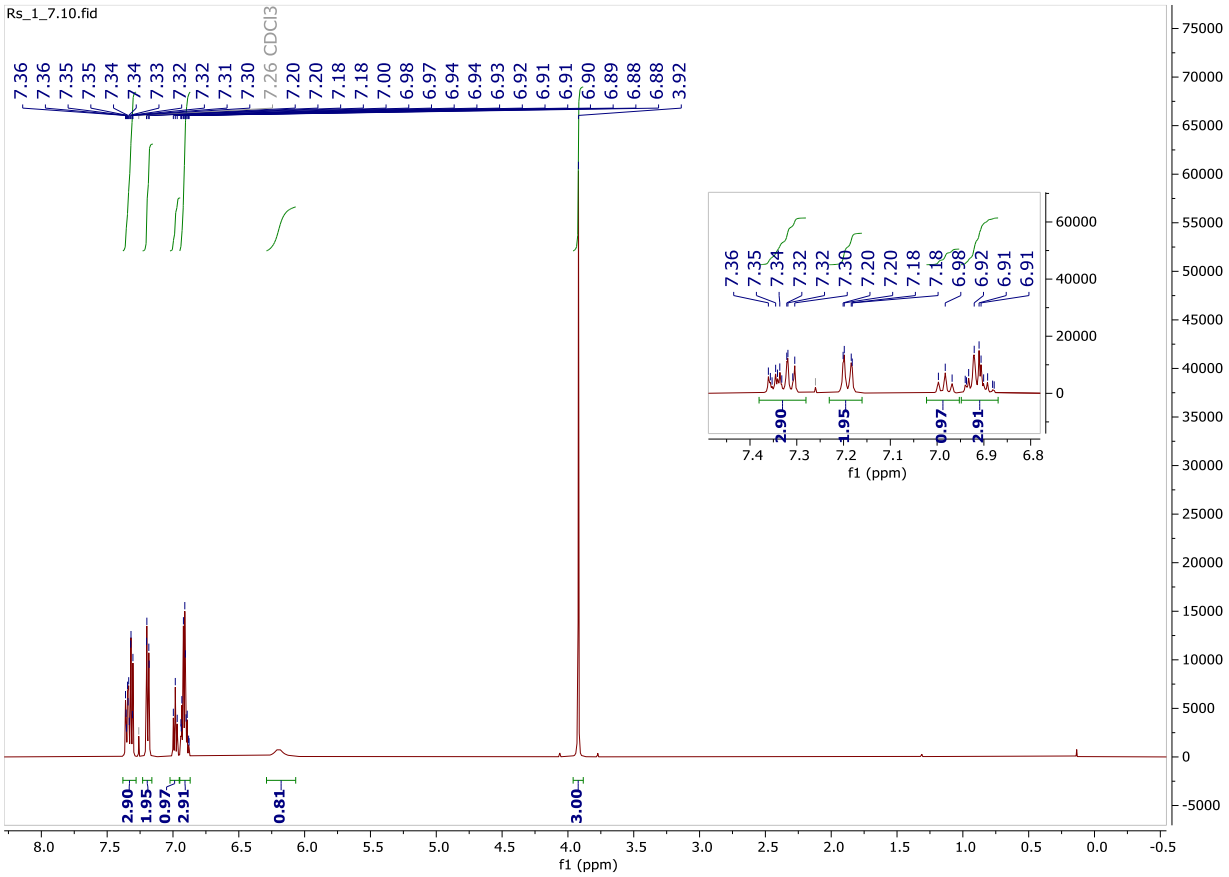
N-(4-(trifluoromethyl)phenyl)pyridin-3-amine (19_4)



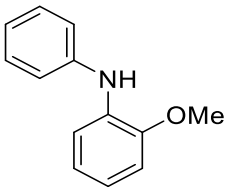
^{1}H NMR



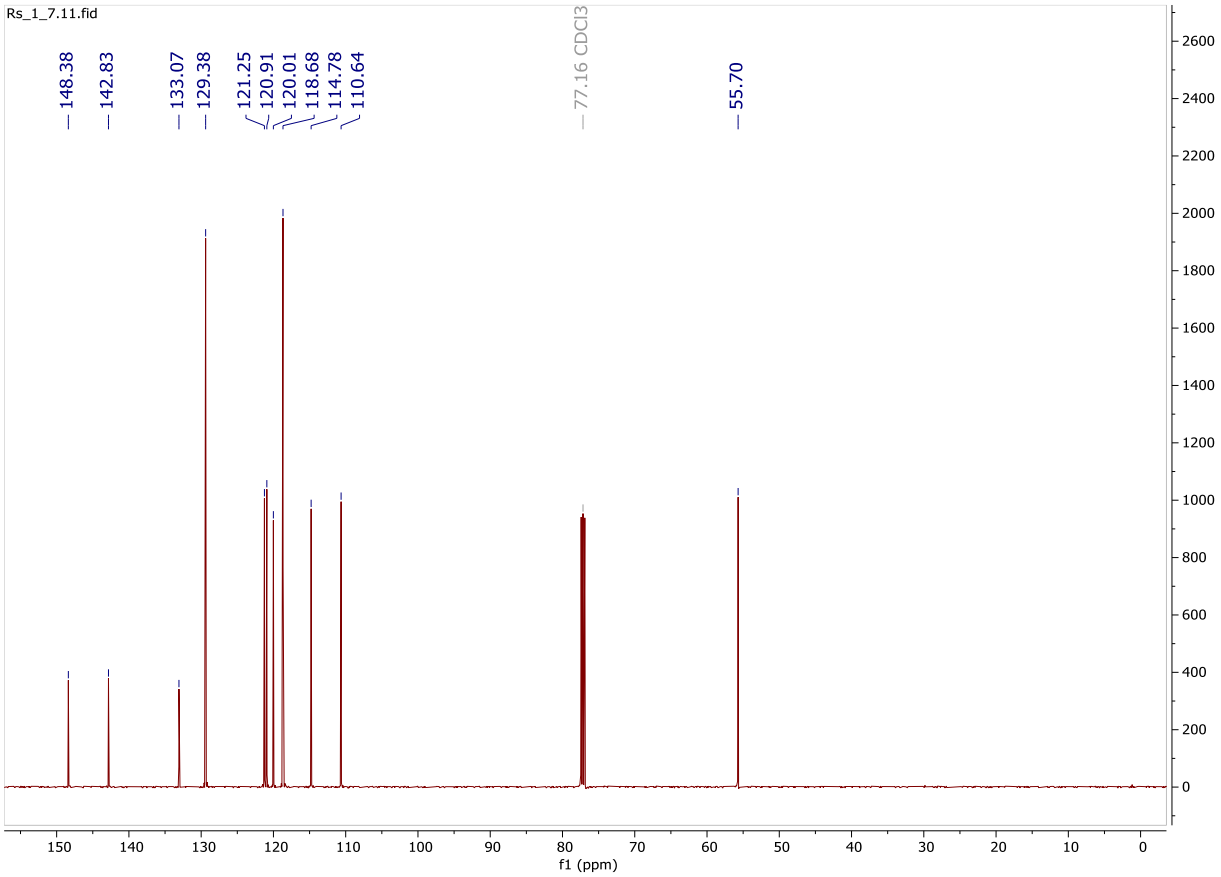
2-Methoxy-N-phenylaniline (1_7)



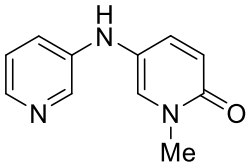
$^{13}C\{^{1}H\}$ NMR



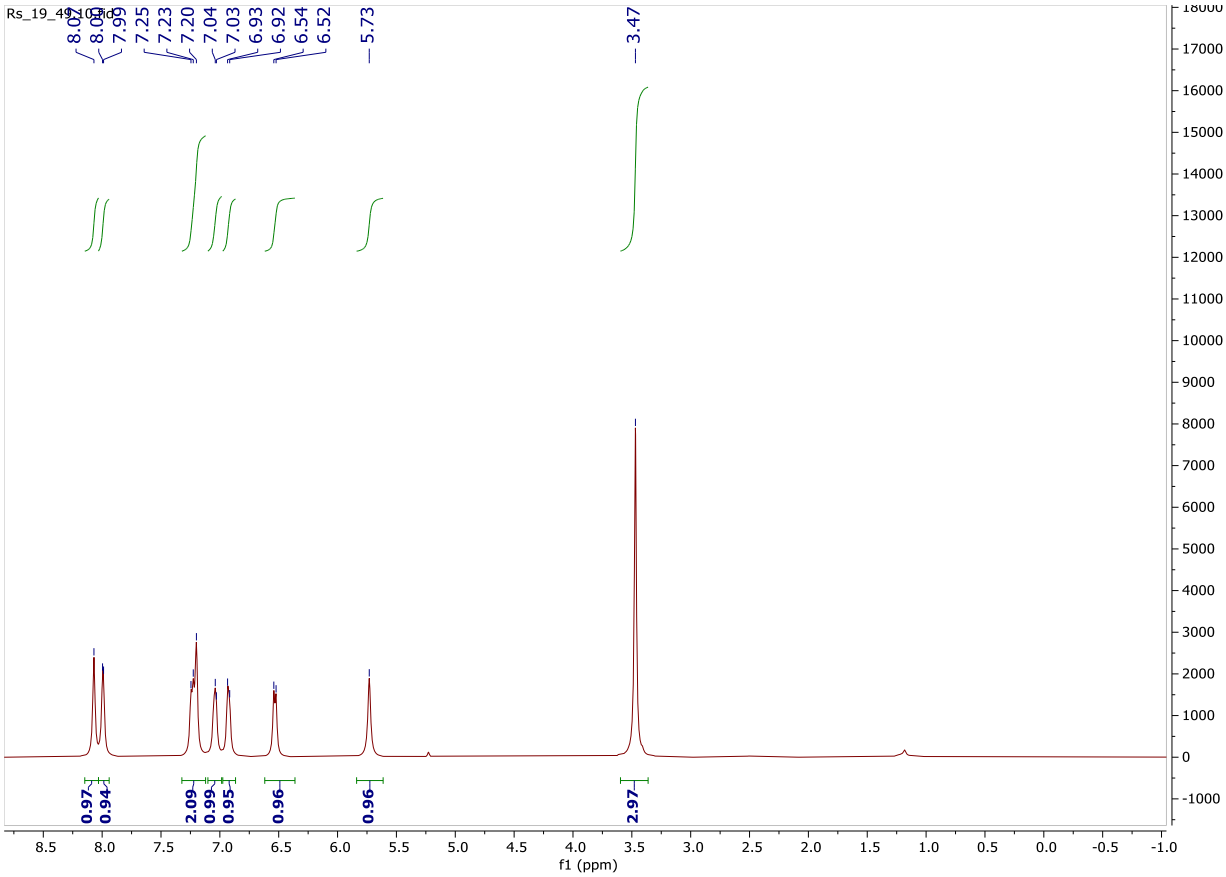
2-Methoxy-N-phenylaniline (1_7)



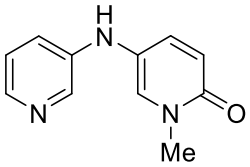
^{1}H NMR



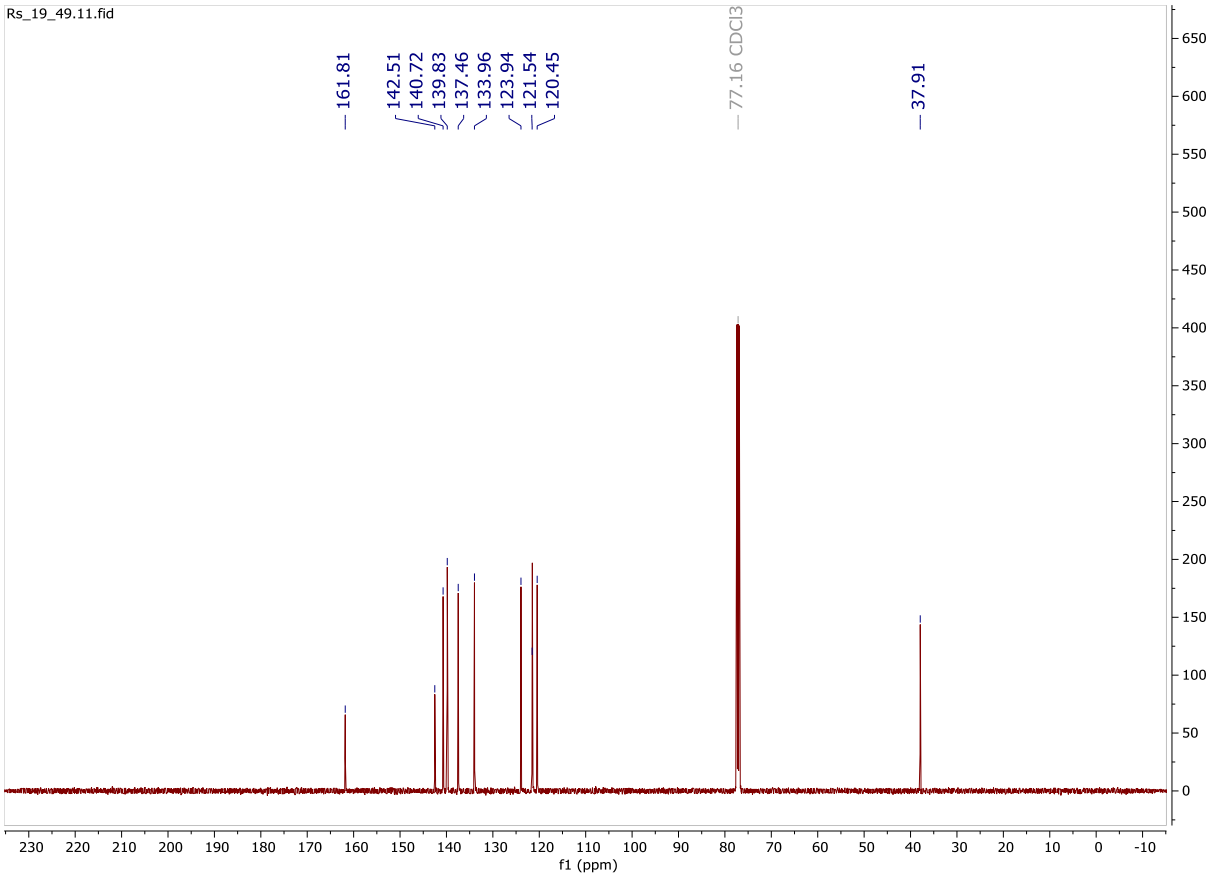
1-methyl-5-(pyridin-3-ylamino)pyridin-2(1H)-one (19_49)



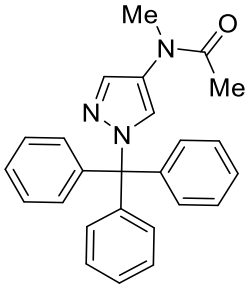
$^{13}C\{^{1}H\}$ NMR



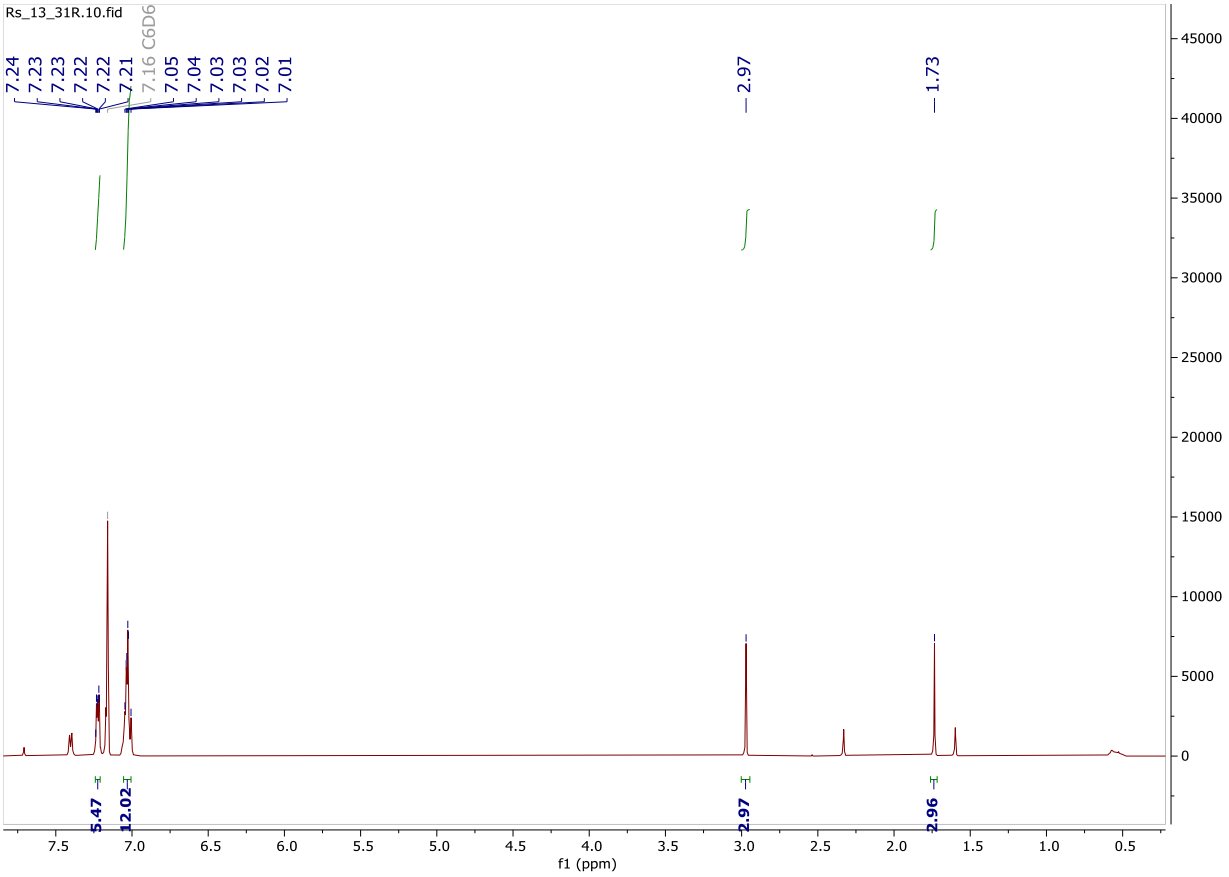
1-methyl-5-(pyridin-3-ylamino)pyridin-2(1H)-one (19_49)



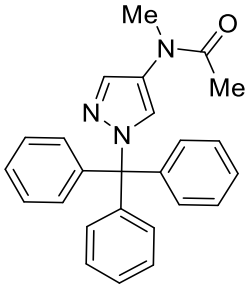
^{1}H NMR



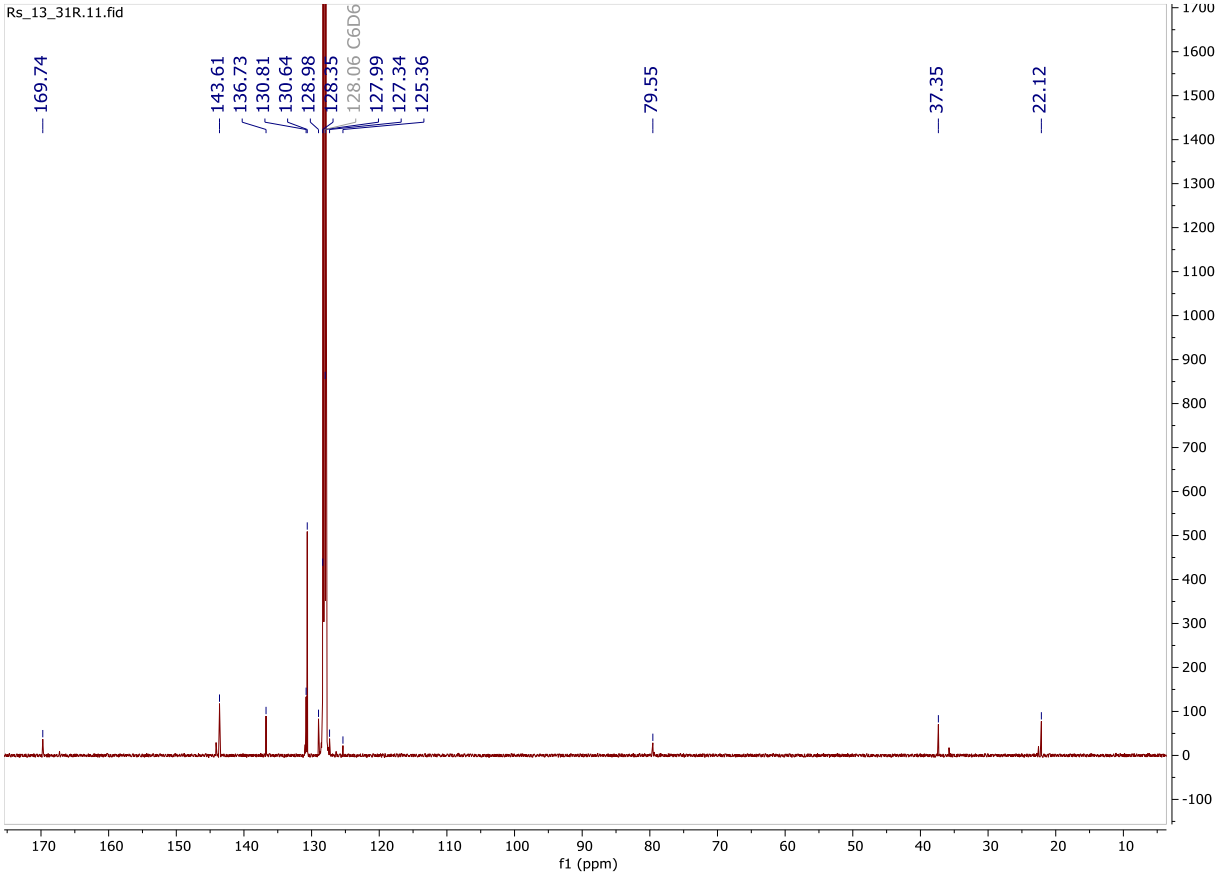
N-methyl-N-(1-trityl-1H-pyrazol-4-yl)acetamide (13_31)



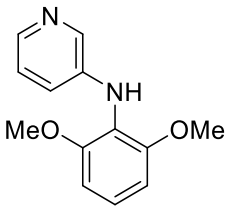
$^{13}C\{^{1}H\}$ NMR



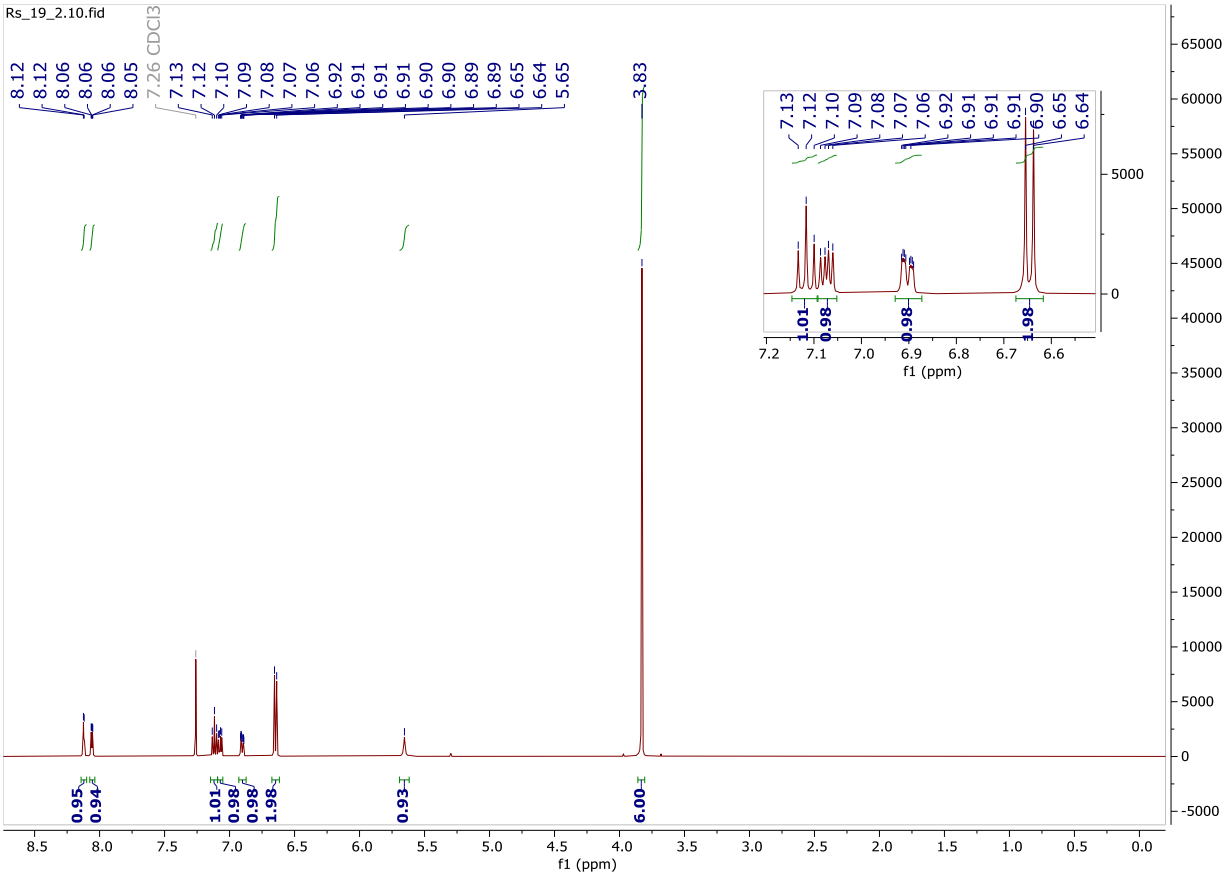
N-methyl-N-(1-trityl-1H-pyrazol-4-yl)acetamide (13_31)



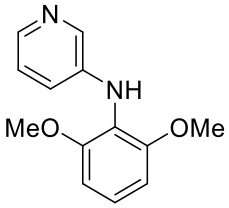
^{1}H NMR



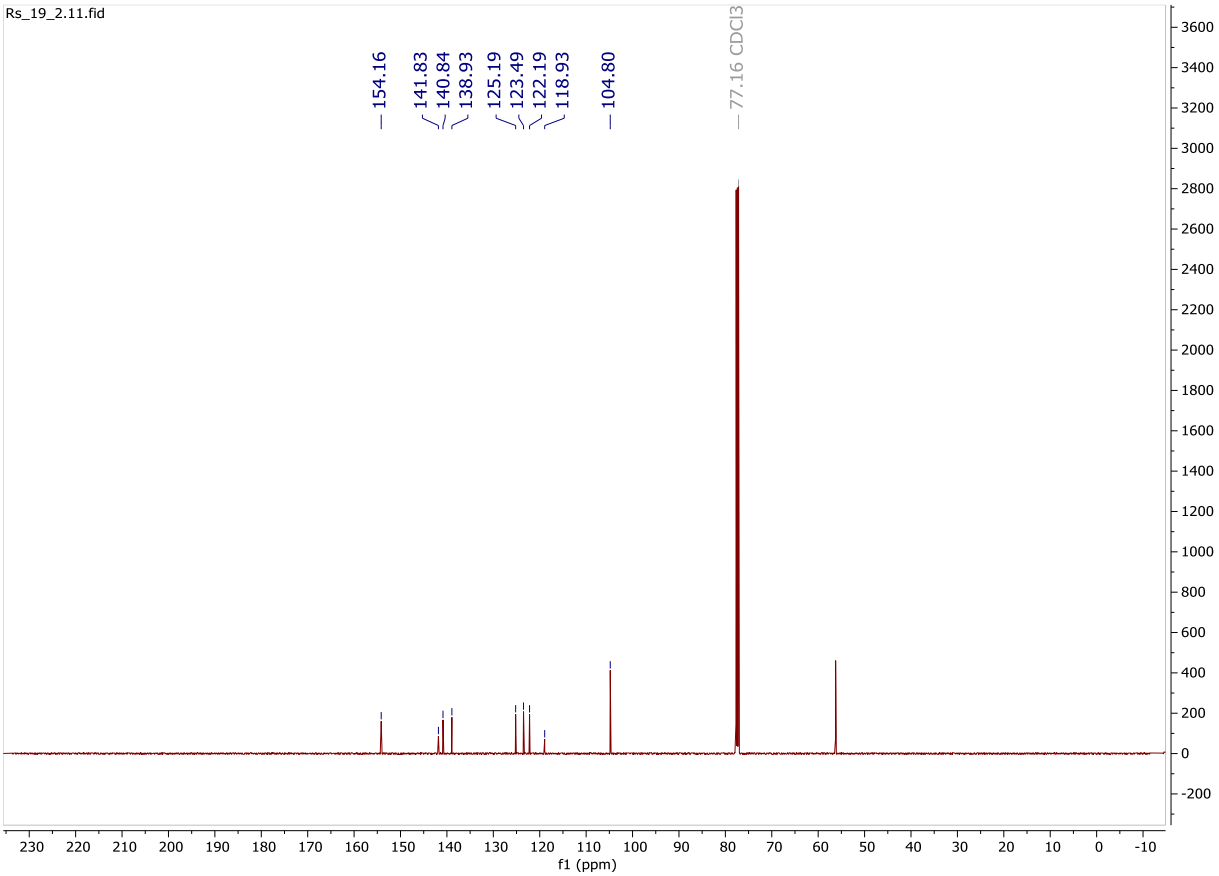
N-(2,6-dimethoxyphenyl)pyridin-3-amine (19_2)



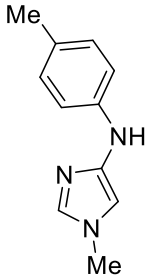
$^{13}C\{^{1}H\}$ NMR



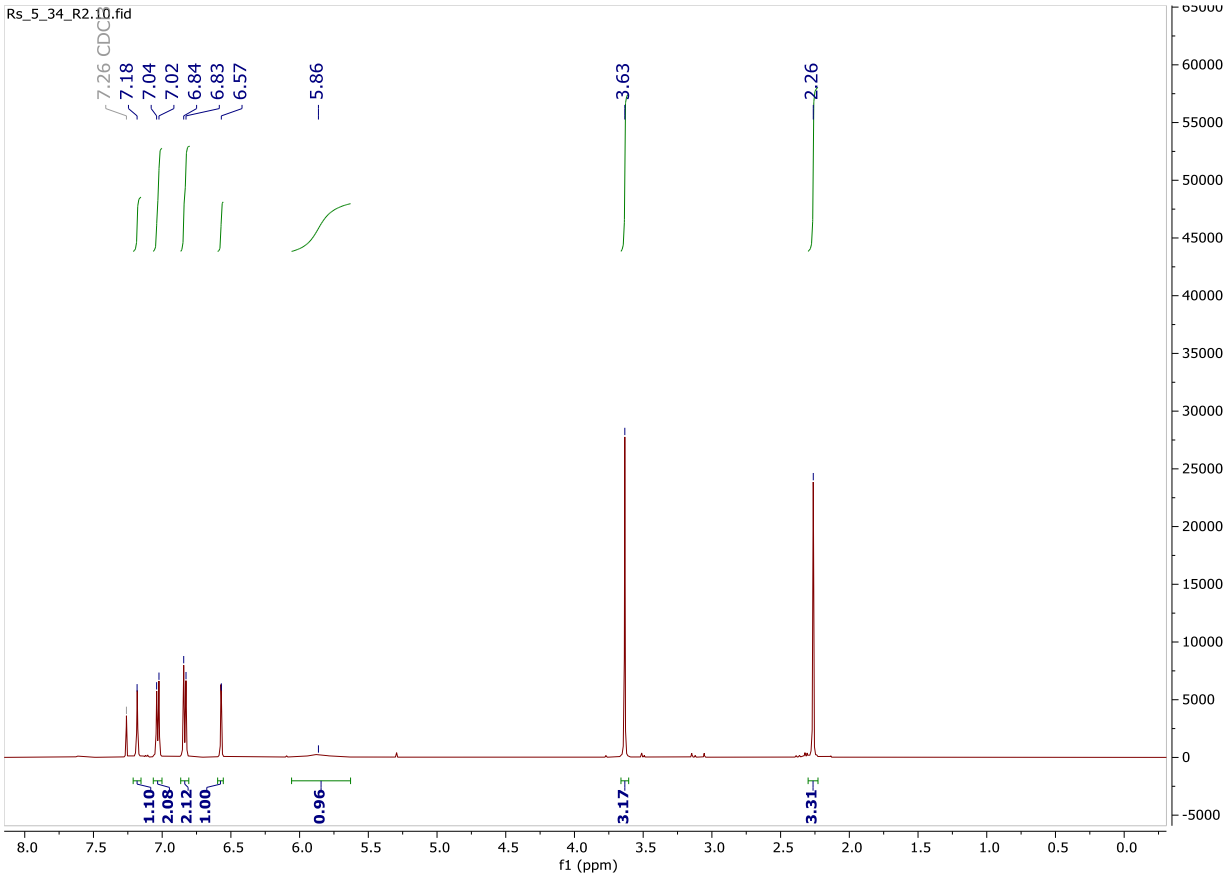
N-(2,6-dimethoxyphenyl)pyridin-3-amine (19_2)



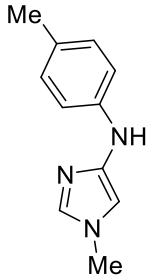
^{1}H NMR



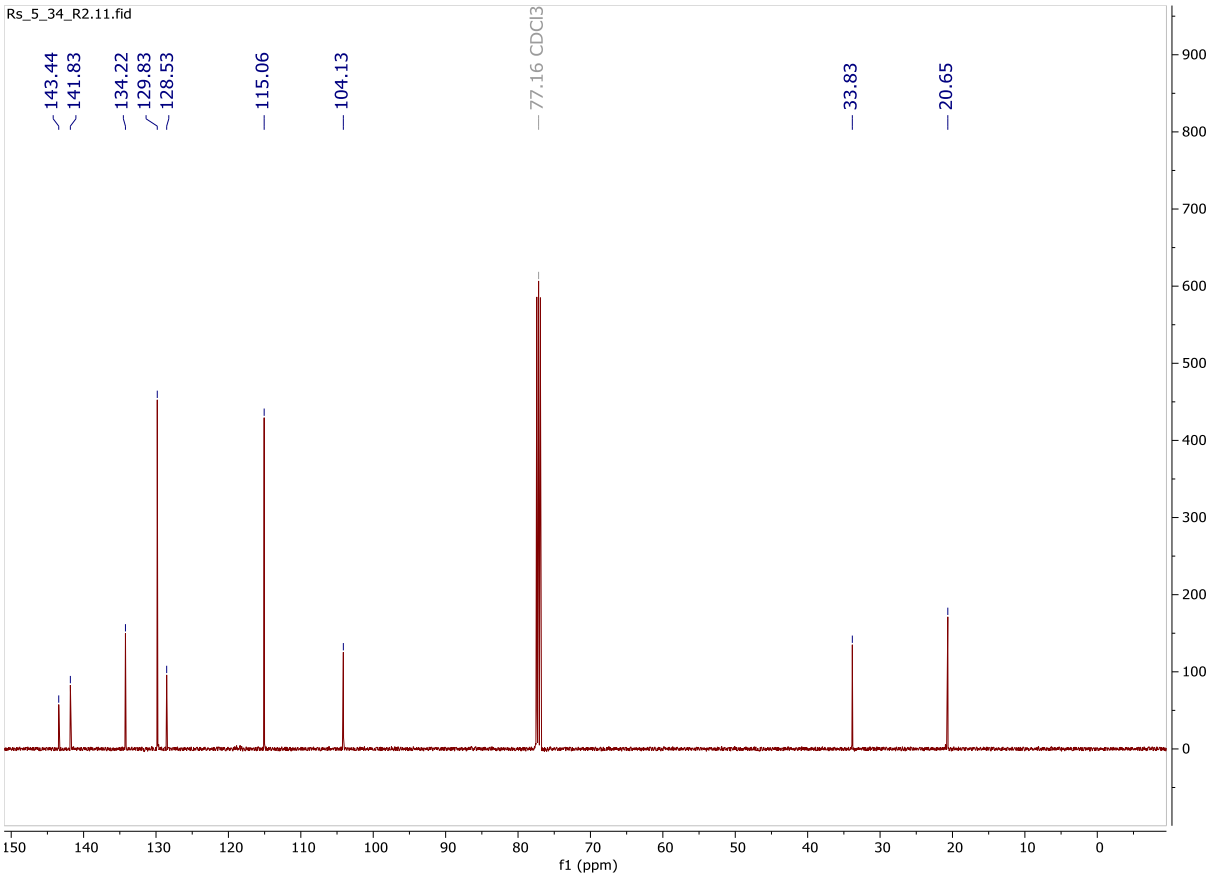
1-methyl-N-(p-tolyl)-1H-imidazol-4-amine (5_34)



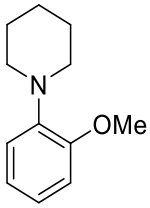
$^{13}C\{^{1}H\}$ NMR



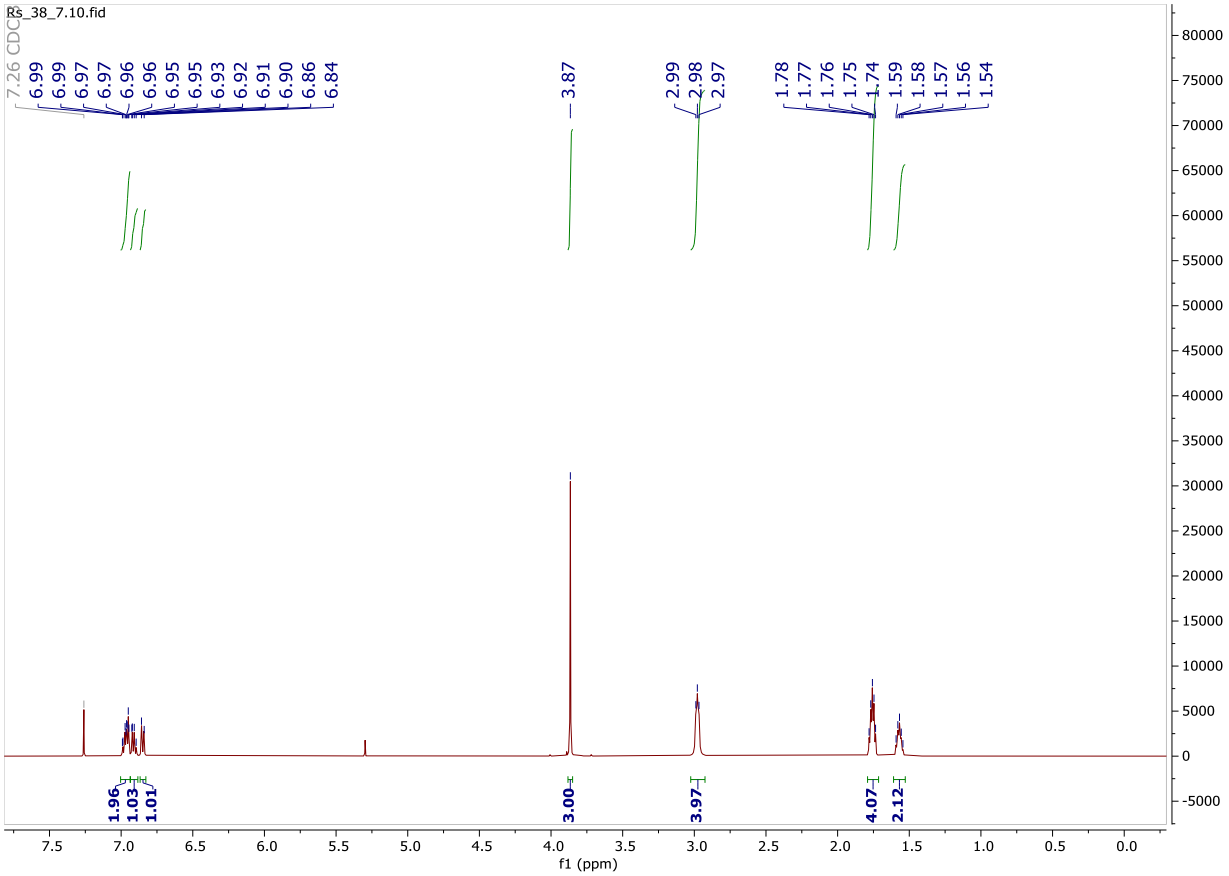
1-methyl-N-(p-tolyl)-1H-imidazol-4-amine (5_34)



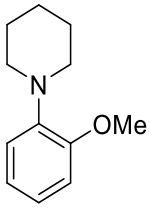
^{1}H NMR



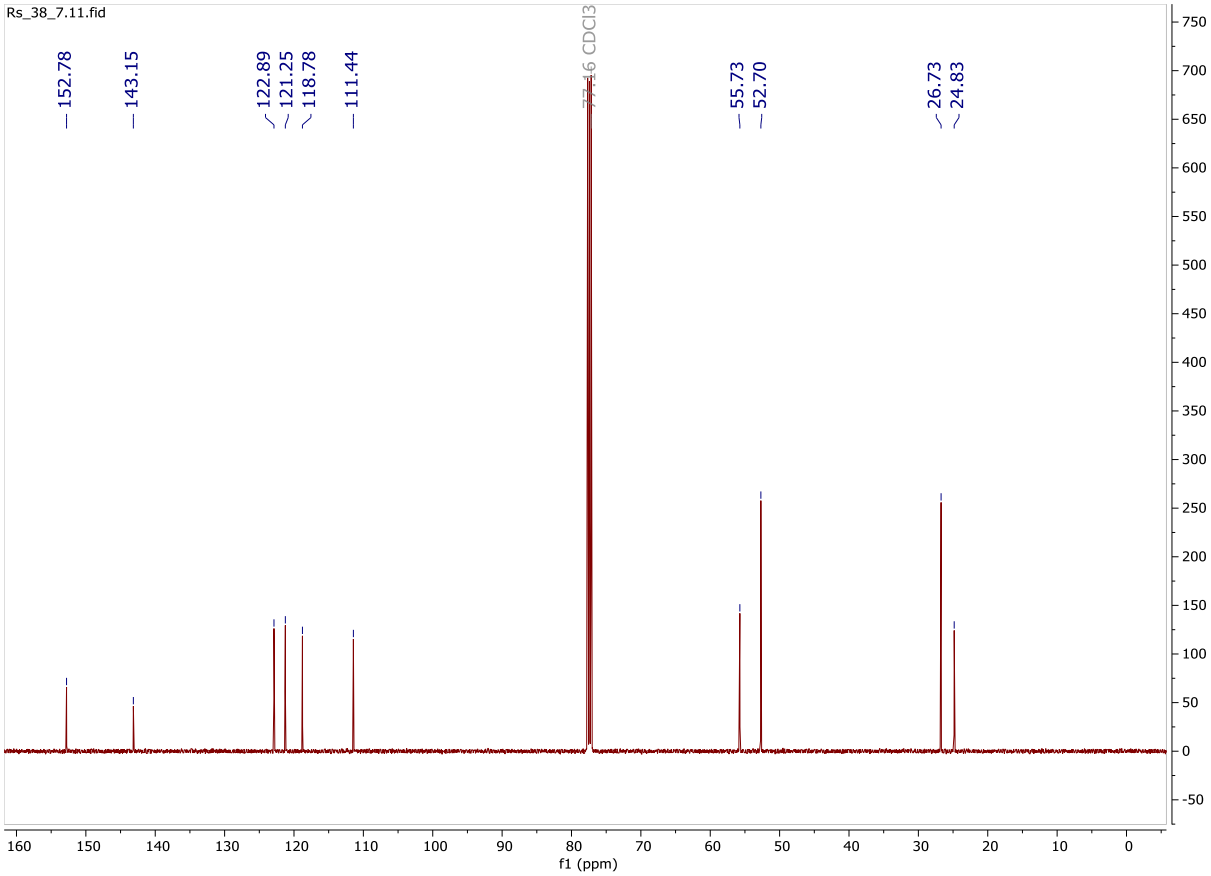
1-(2-methoxyphenyl)piperidine (38_7)



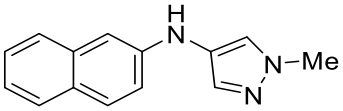
$^{13}C\{^{1}H\}$ NMR



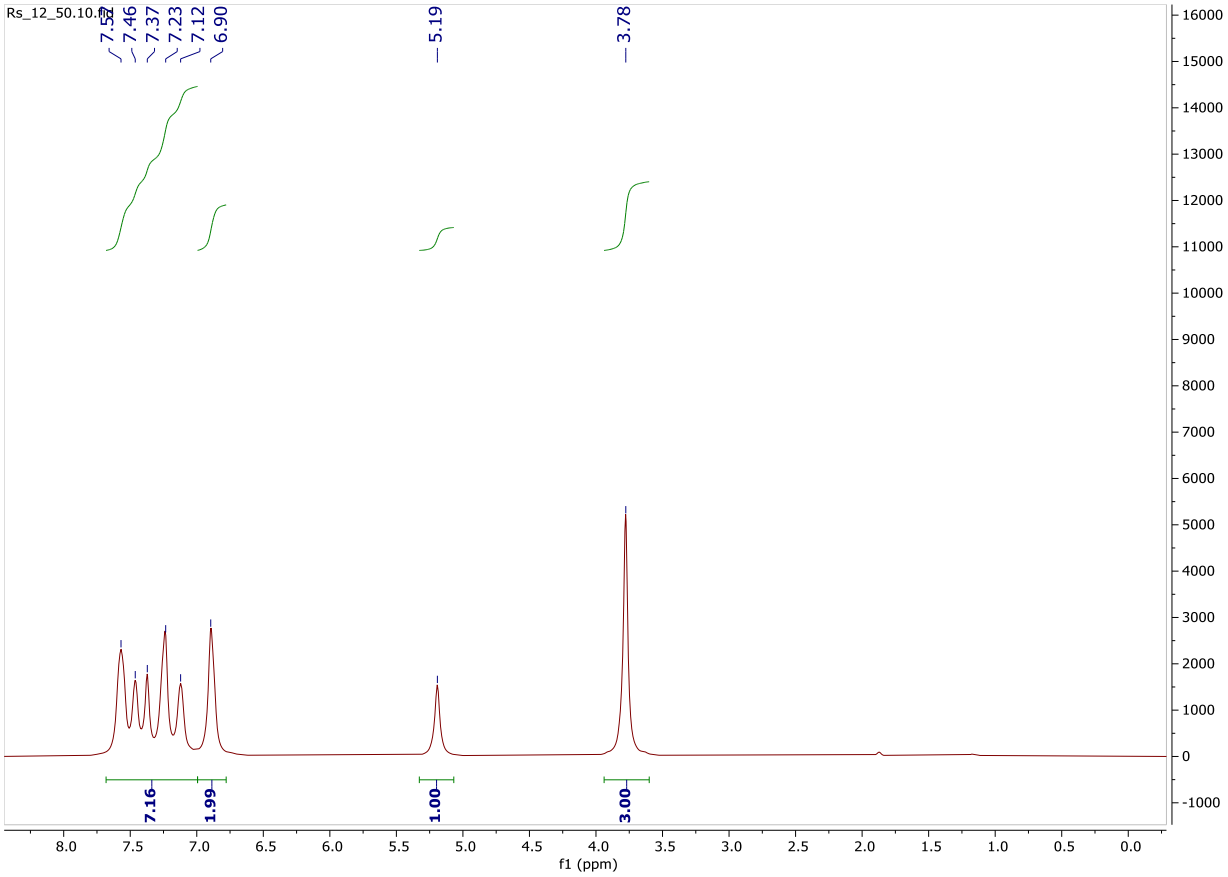
1-(2-methoxyphenyl)piperidine (38_7)



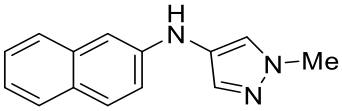
1H NMR



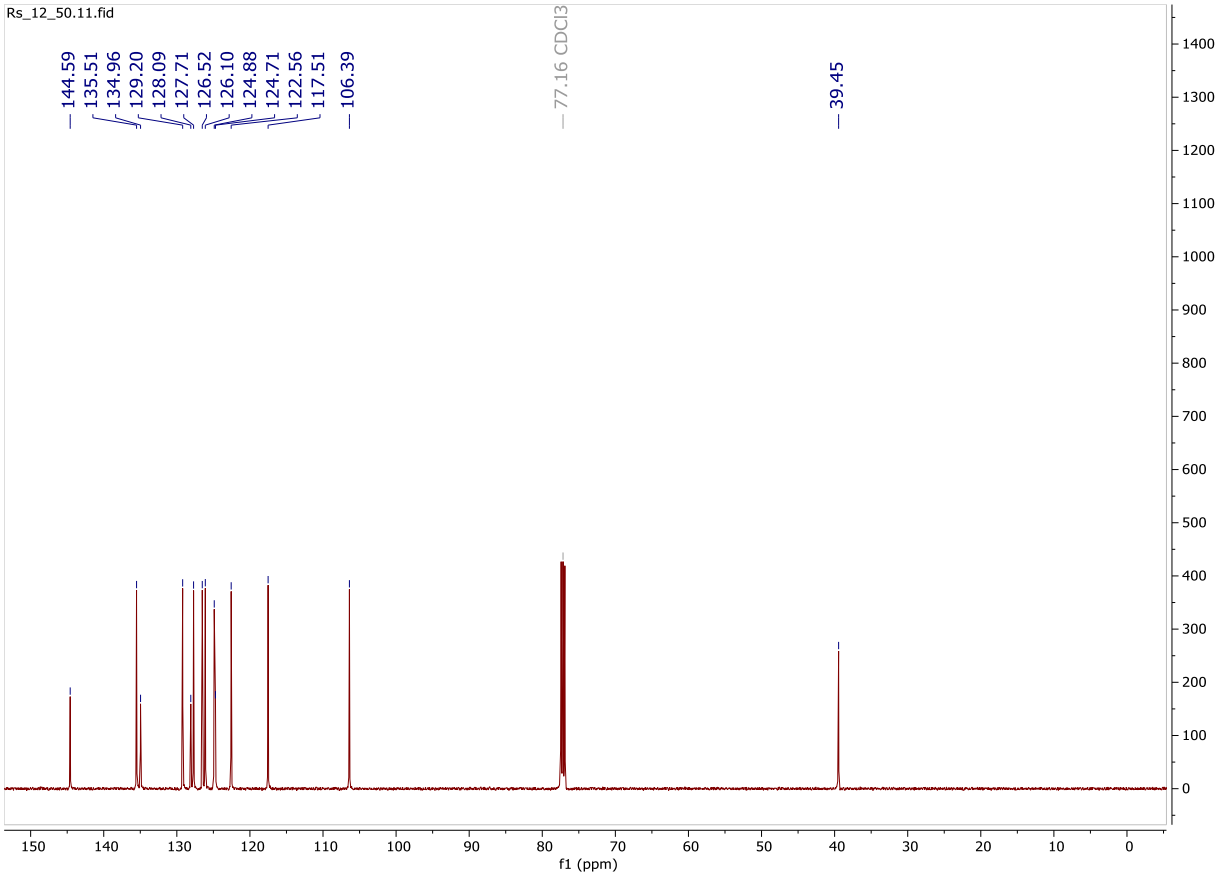
1-methyl-N-(naphthalen-2-yl)-1H-pyrazol-4-amine (12_50)



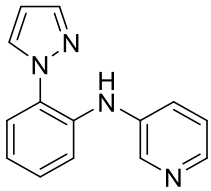
$^{13}C\{^{1}H\}$ NMR



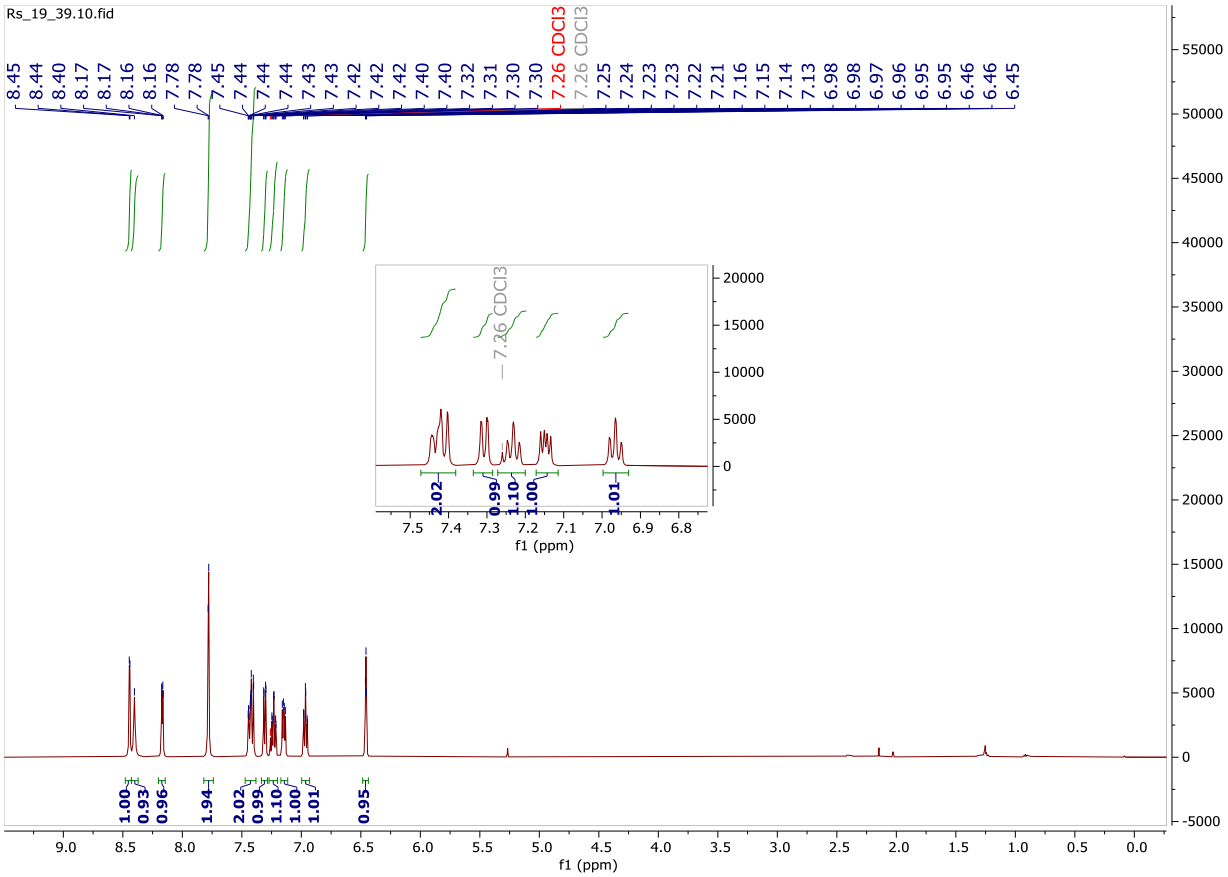
1-methyl-N-(naphthalen-2-yl)-1H-pyrazol-4-amine (12_50)



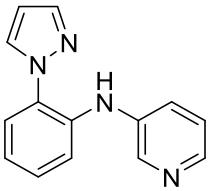
^{1}H NMR



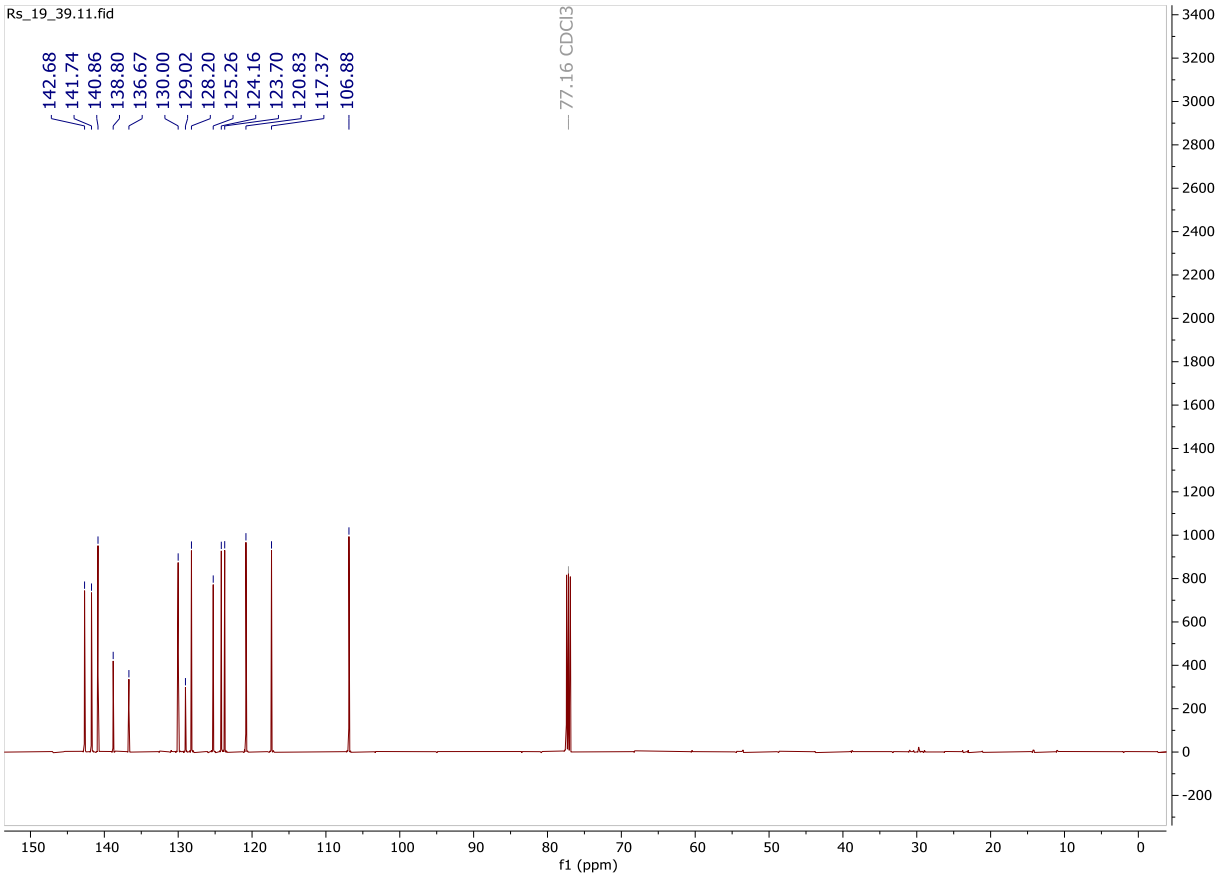
N-(2-(1H-pyrazol-1-yl)phenyl)pyridin-3-amine (19_39)



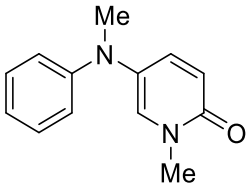
$^{13}C\{^{1}H\}$ NMR



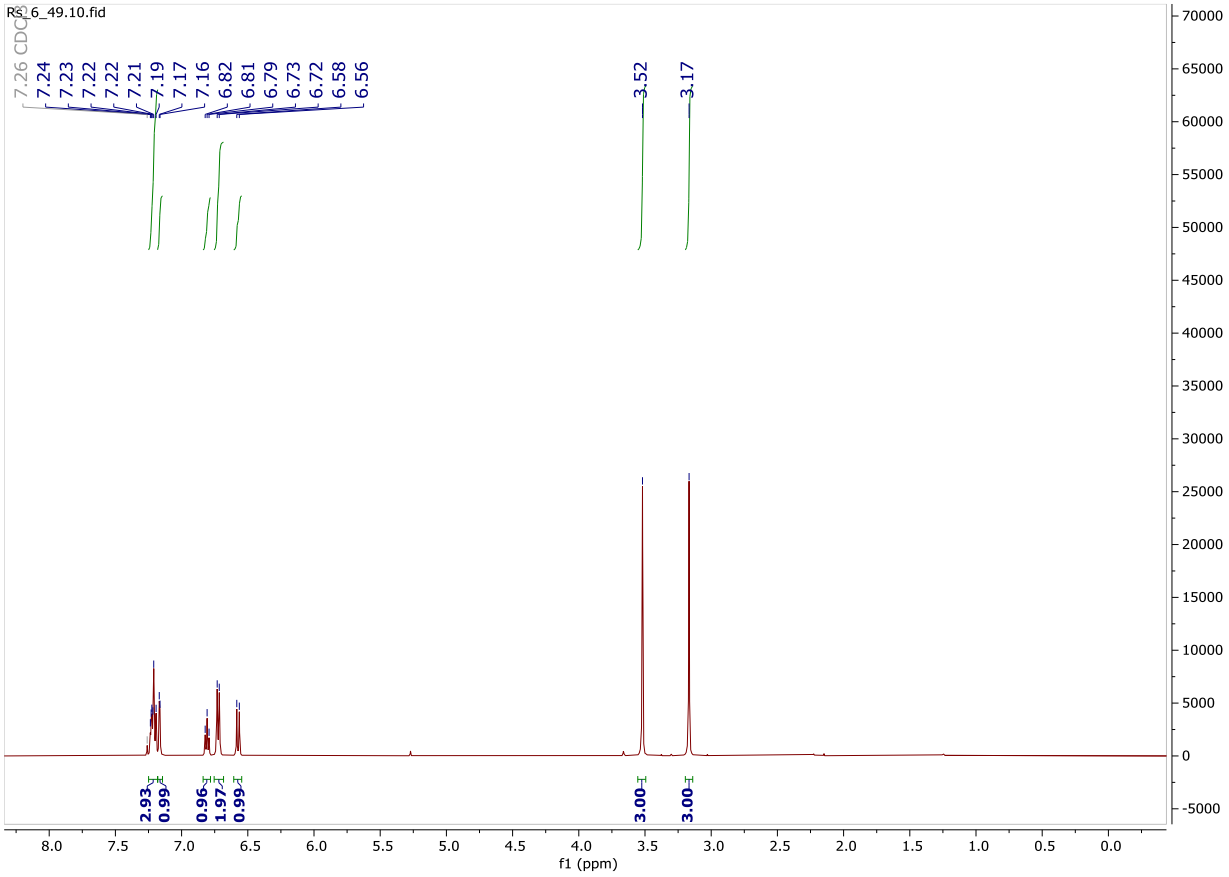
N-(2-(1H-pyrazol-1-yl)phenyl)pyridin-3-amine (19_39)



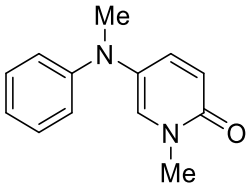
^{1}H NMR



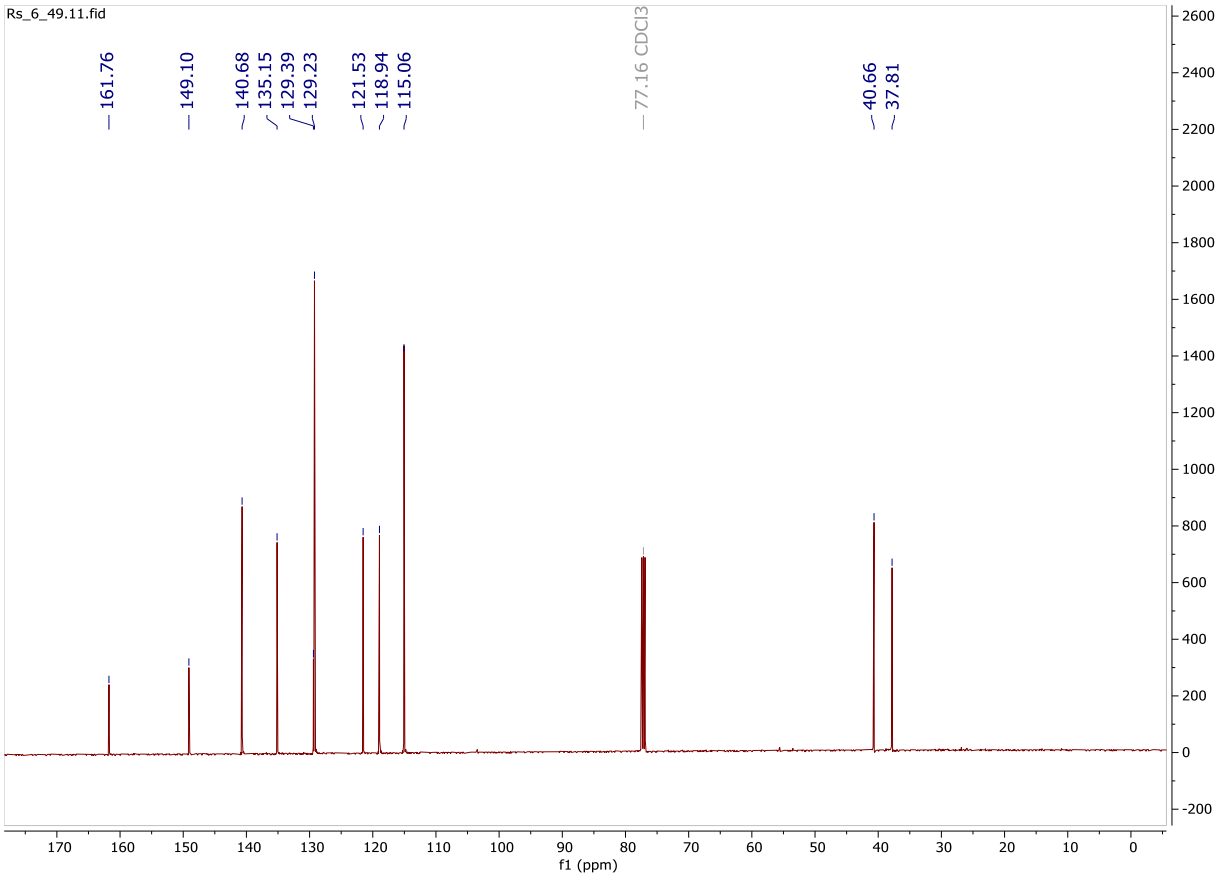
1-methyl-5-(methyl(phenyl)amino)pyridin-2(1H)-one (6_49)



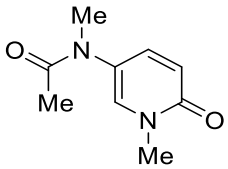
$^{13}C\{^{1}H\}$ NMR



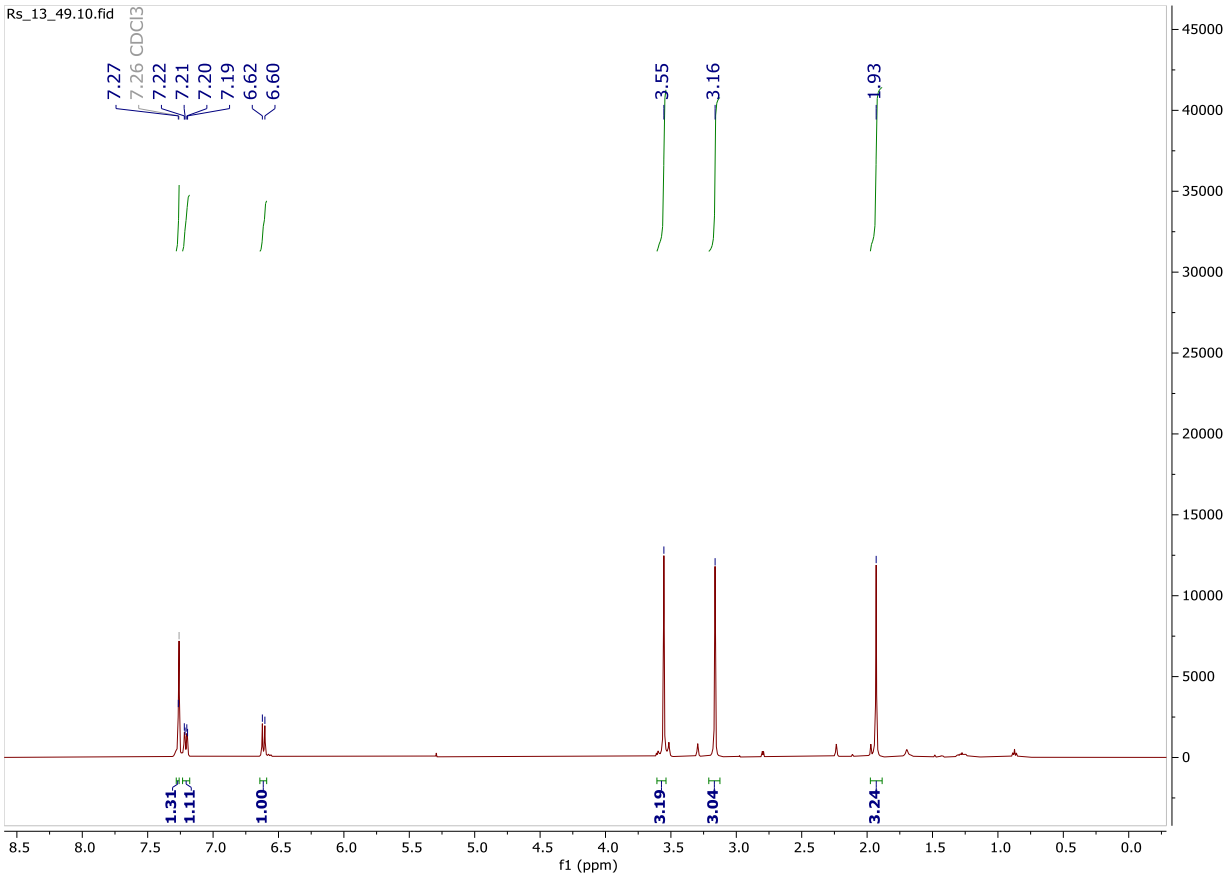
1-methyl-5-(methyl(phenyl)amino)pyridin-2(1H)-one (6_49)



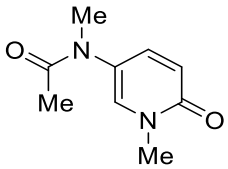
^{1}H NMR



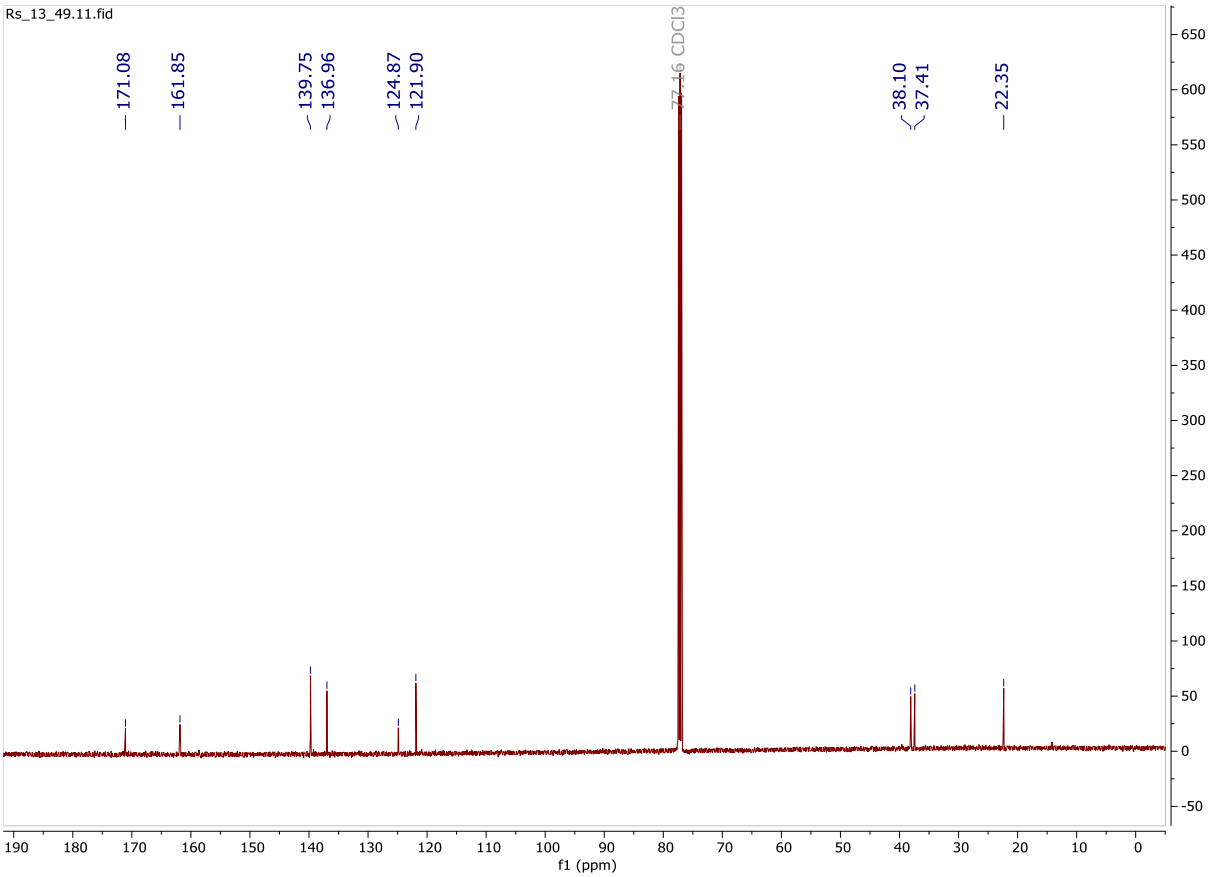
N-methyl-N-(1-methyl-6-oxo-1,6-dihydropyridin-3-yl)acetamide (13_49)



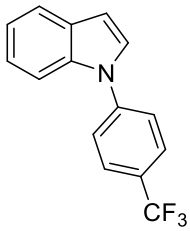
$^{13}C\{^{1}H\}$ NMR



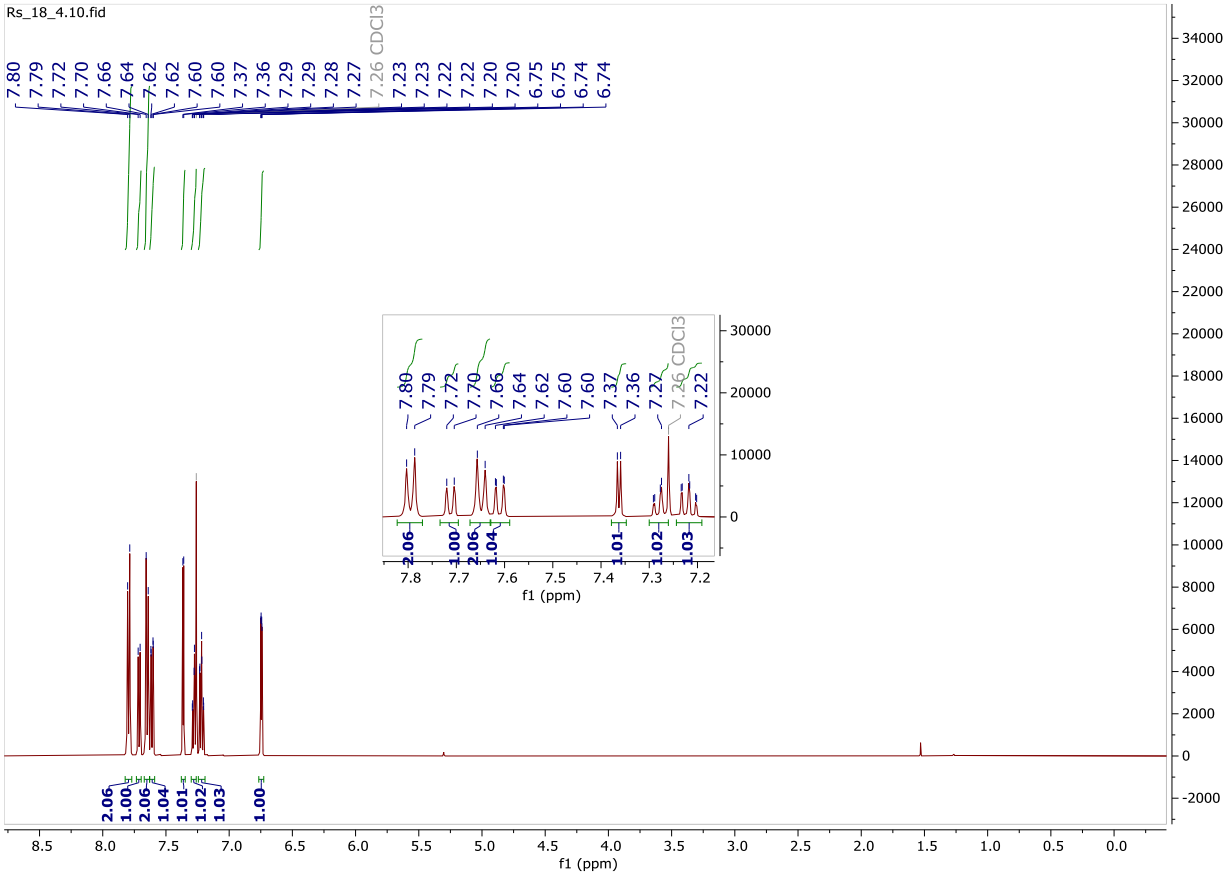
N-methyl-N-(1-methyl-6-oxo-1,6-dihydropyridin-3-yl)acetamide (13_49)



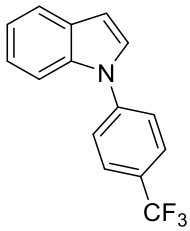
^{1}H NMR



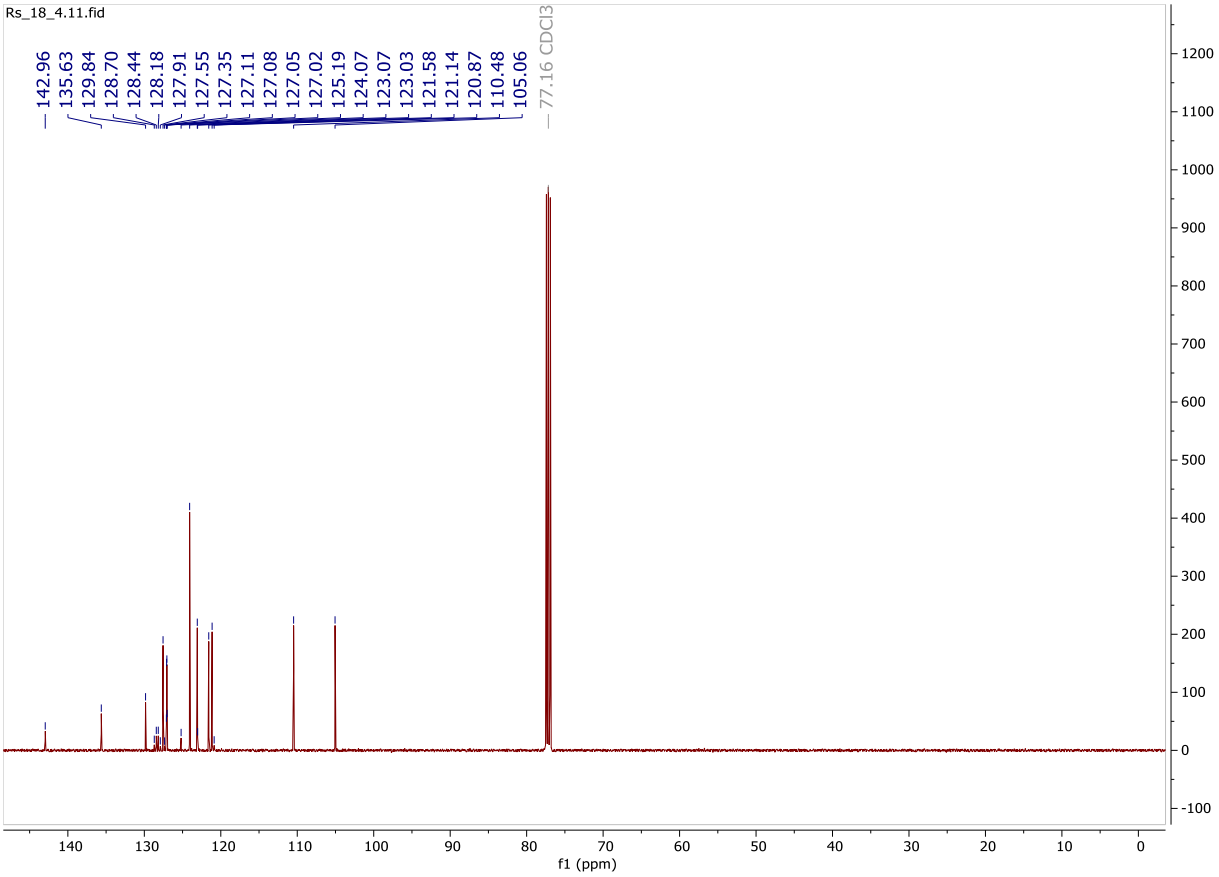
1-(4-(trifluoromethyl)phenyl)-1H-indole (18_4)



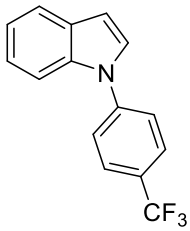
$^{13}C\{^{1}H\}$ NMR



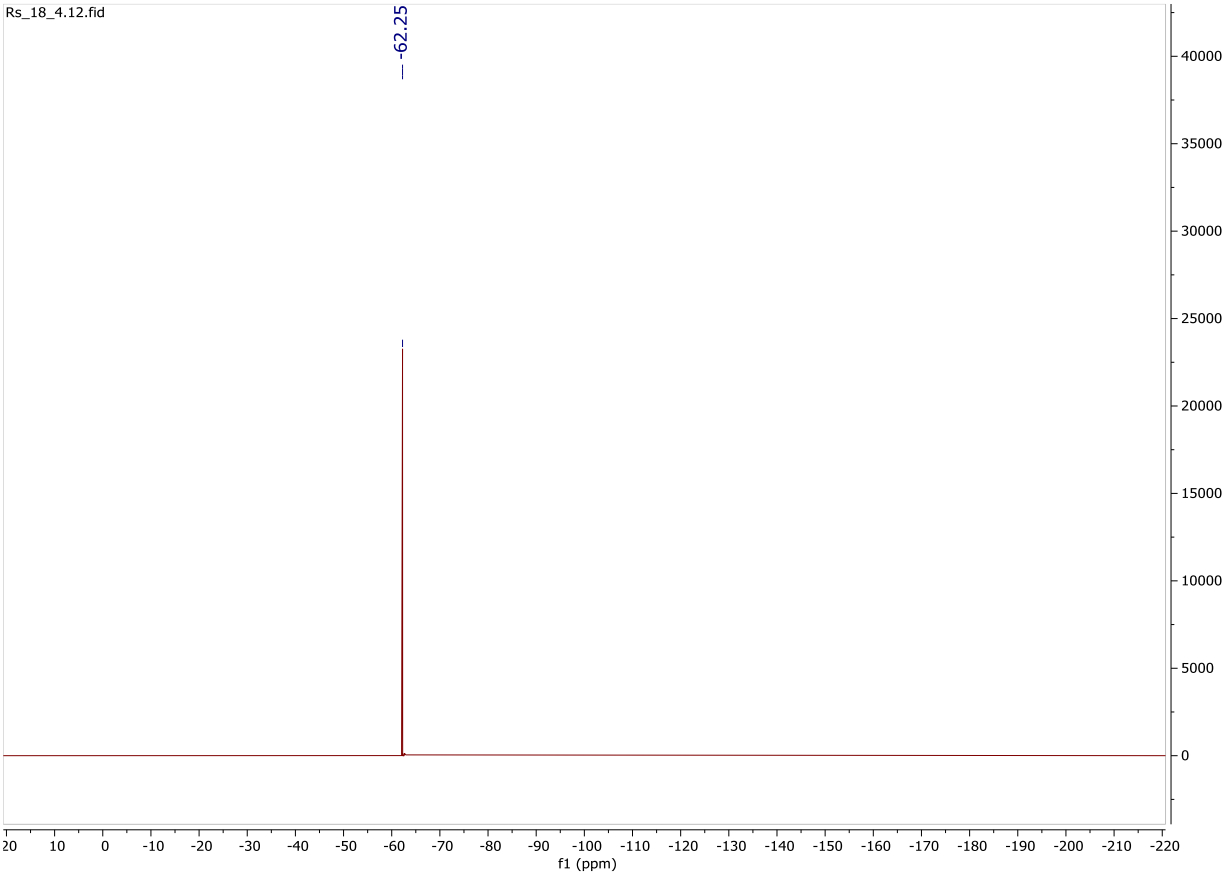
1-(4-(trifluoromethyl)phenyl)-1H-indole (18_4)



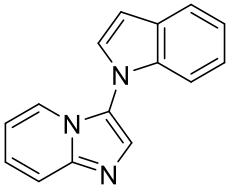
^{19}F NMR



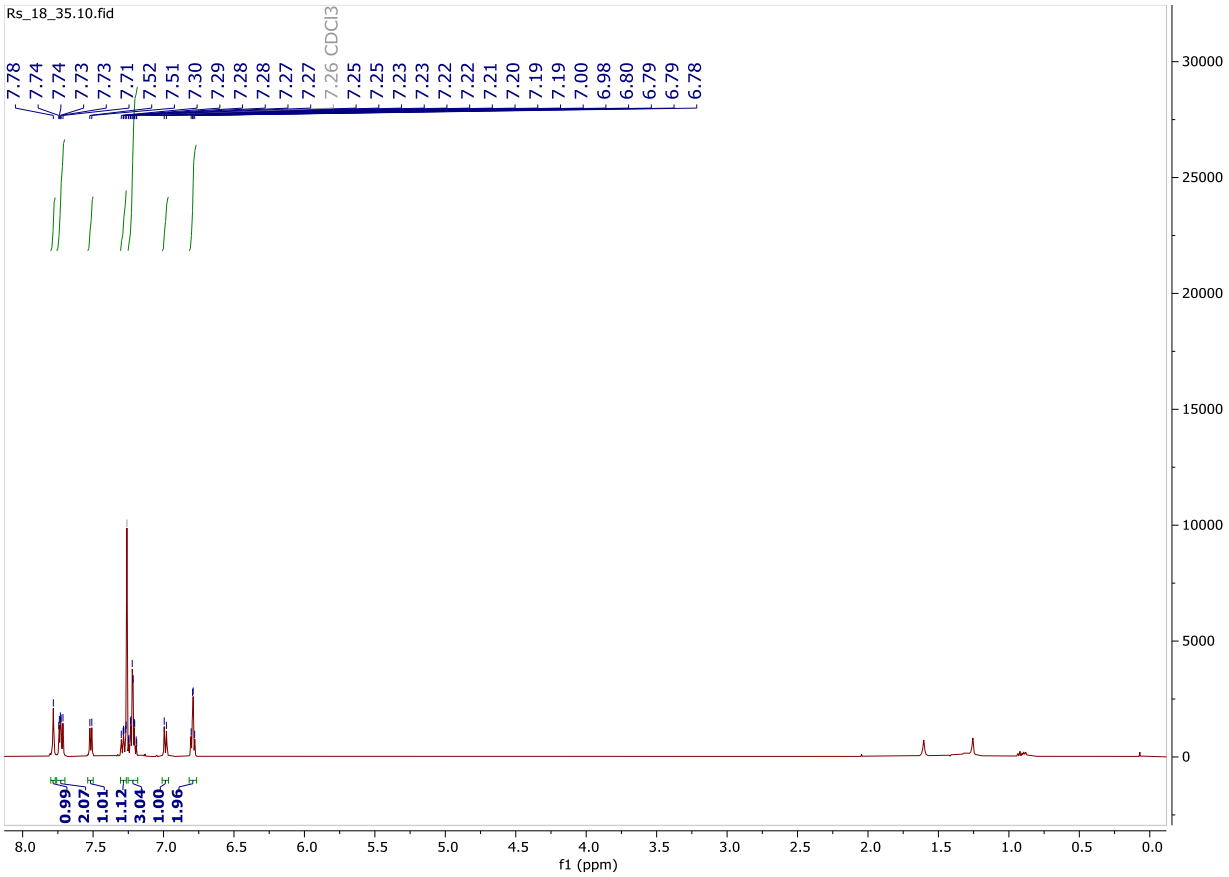
1-(4-(trifluoromethyl)phenyl)-1H-indole (18_4)



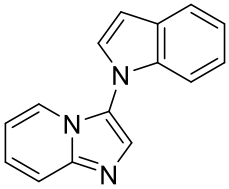
^{1}H NMR



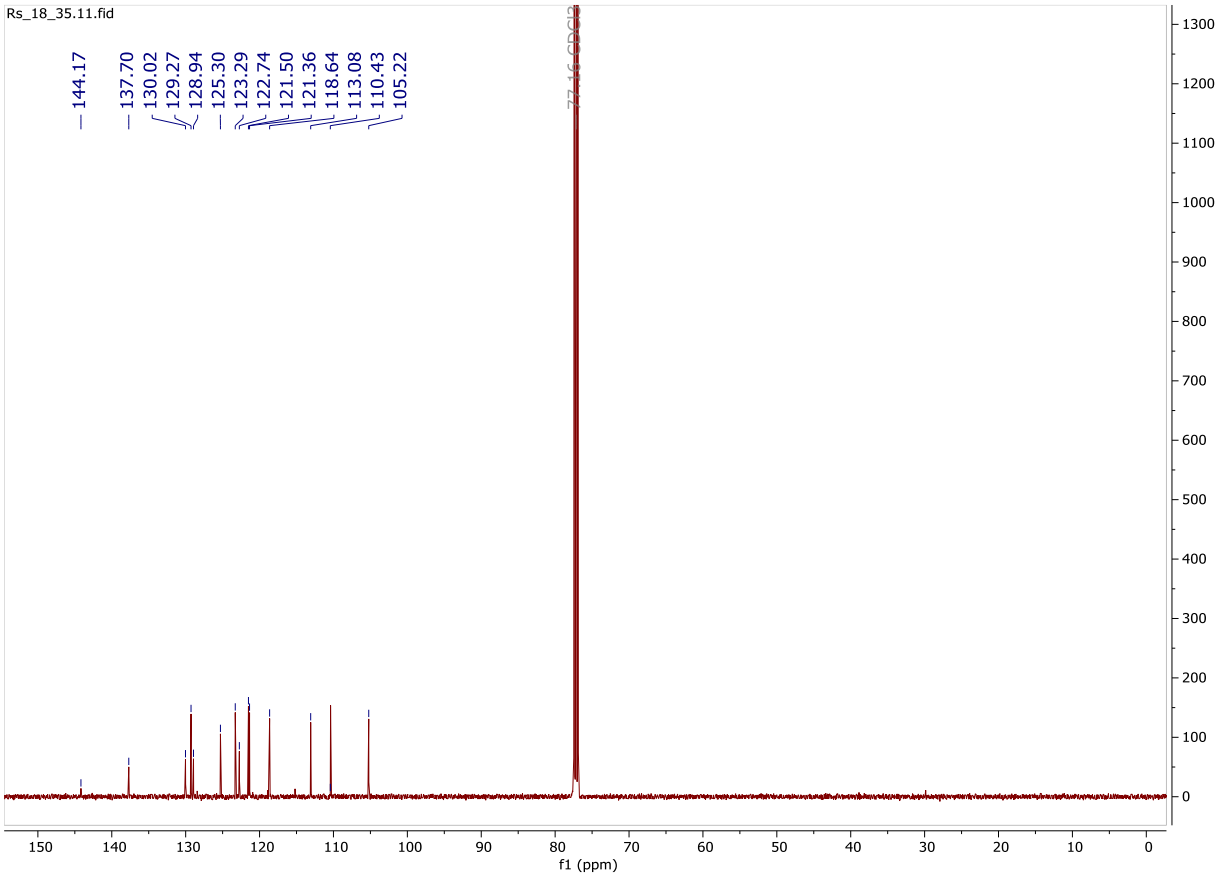
3-(1H-indol-1-yl)imidazo[1,2-a]pyridine (18_35)



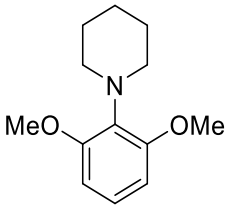
$^{13}C\{^{1}H\}$ NMR



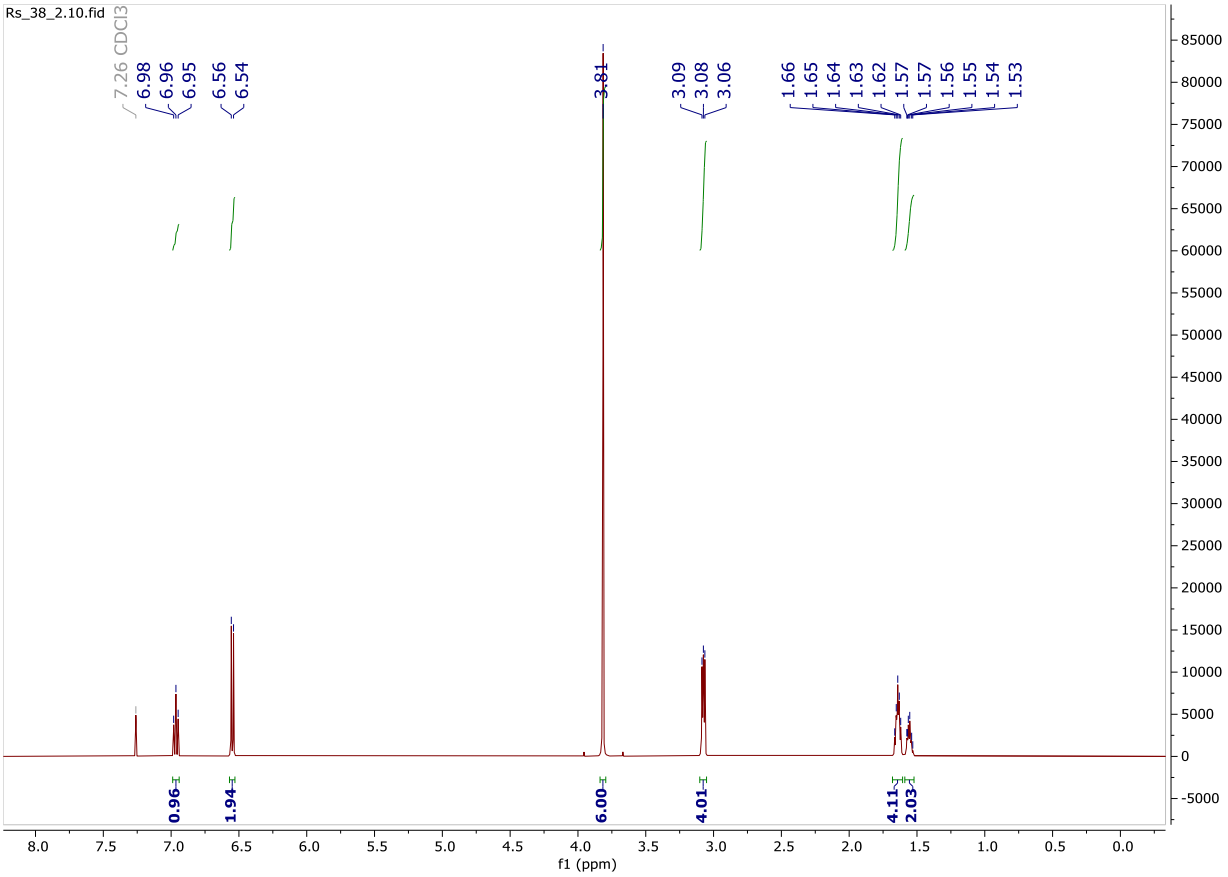
3-(1H-indol-1-yl)imidazo[1,2-a]pyridine (18_35)



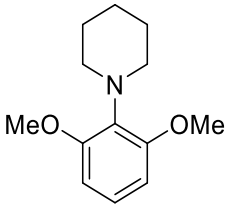
^{1}H NMR



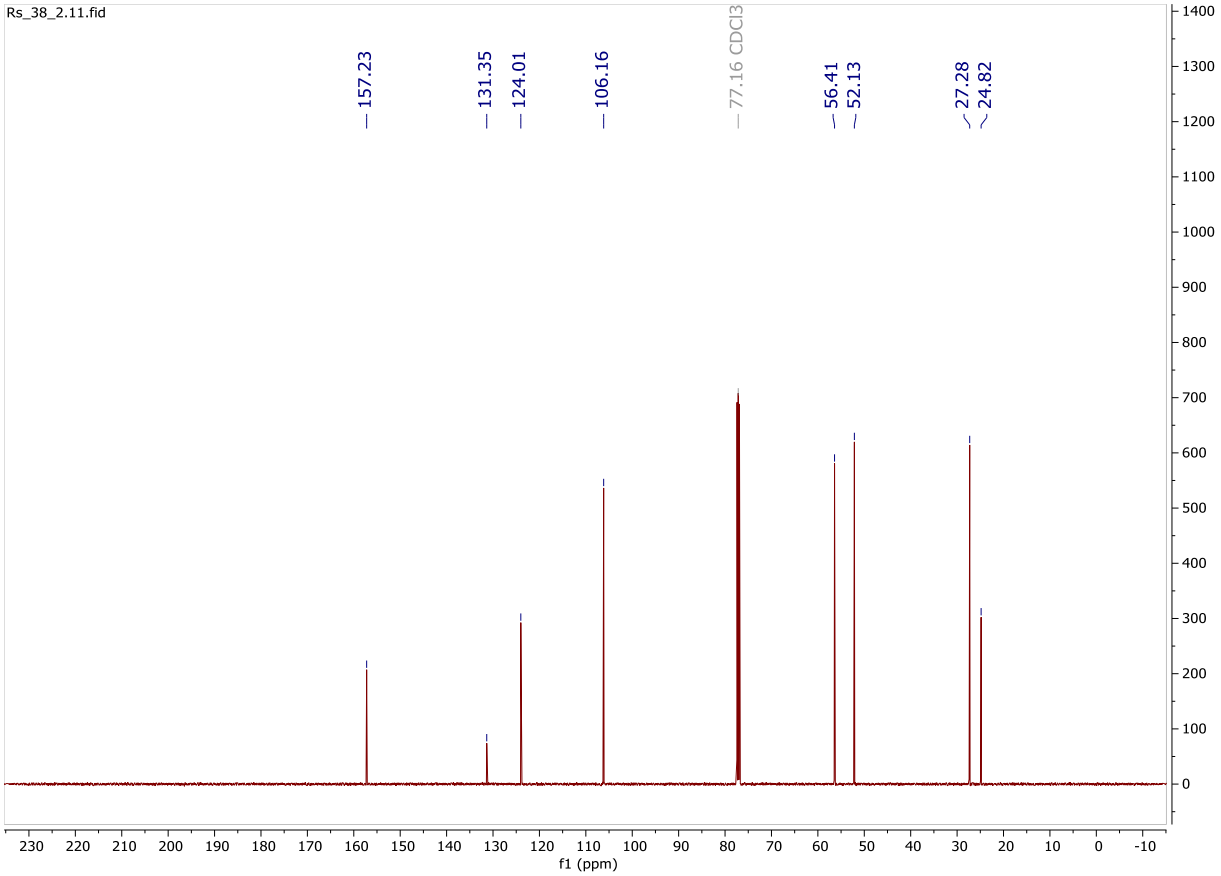
1-(2,6-dimethoxyphenyl)piperidine (38_2)



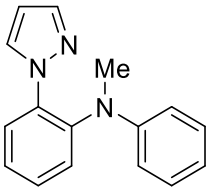
$^{13}C\{^{1}H\}$ NMR



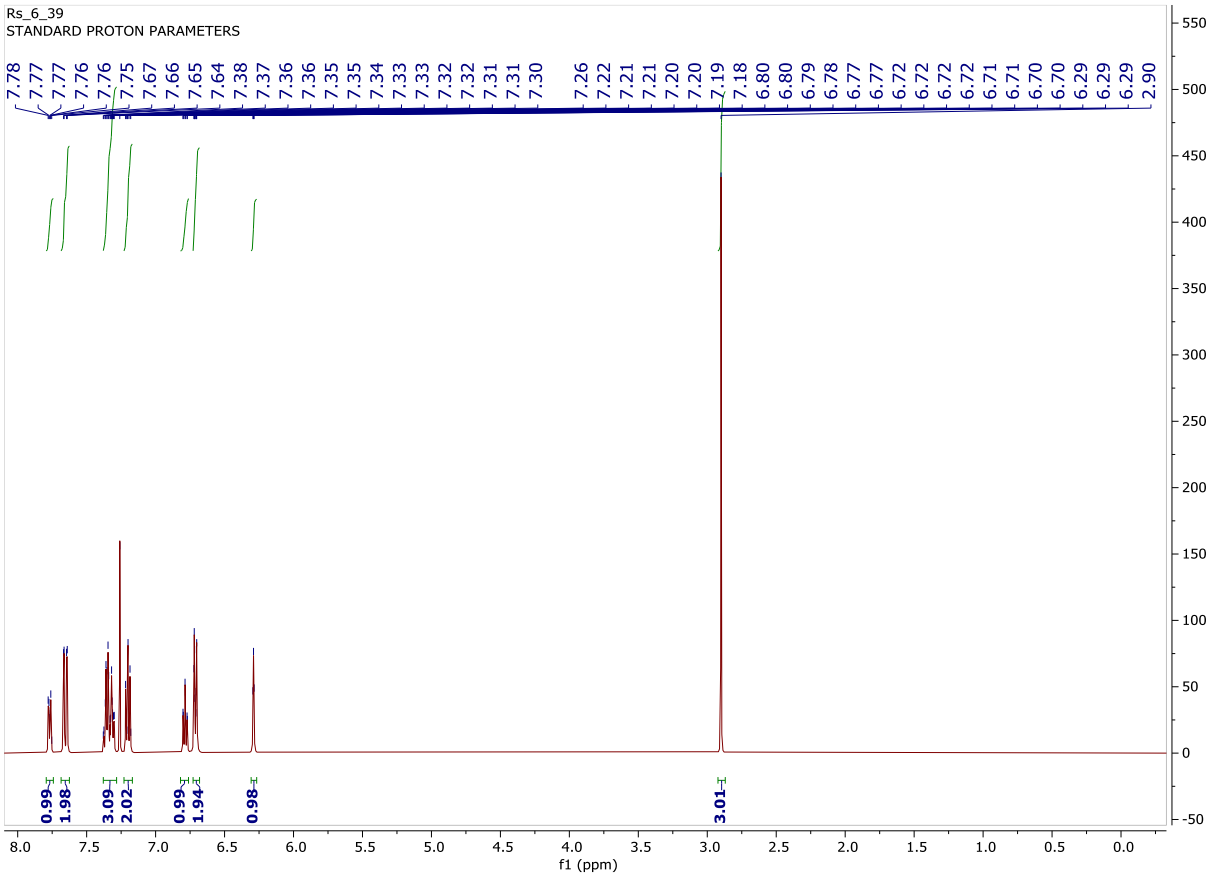
1-(2,6-dimethoxyphenyl)piperidine (38_2)



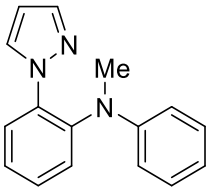
^{1}H NMR



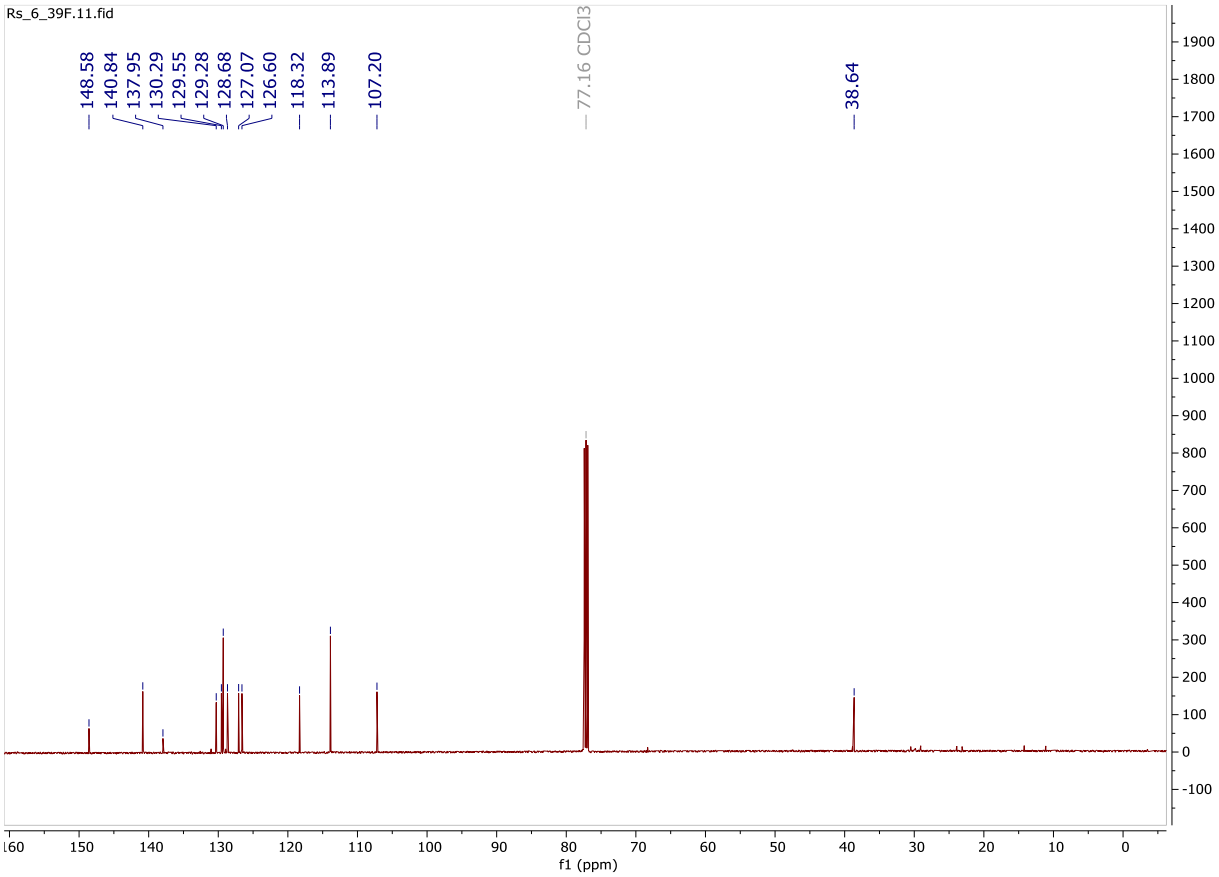
N-methyl-N-phenyl-2-(1H-pyrazol-1-yl)aniline (6_39)



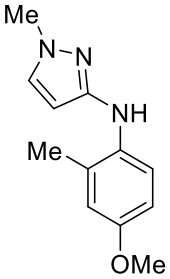
$^{13}C\{^{1}H\}$ NMR



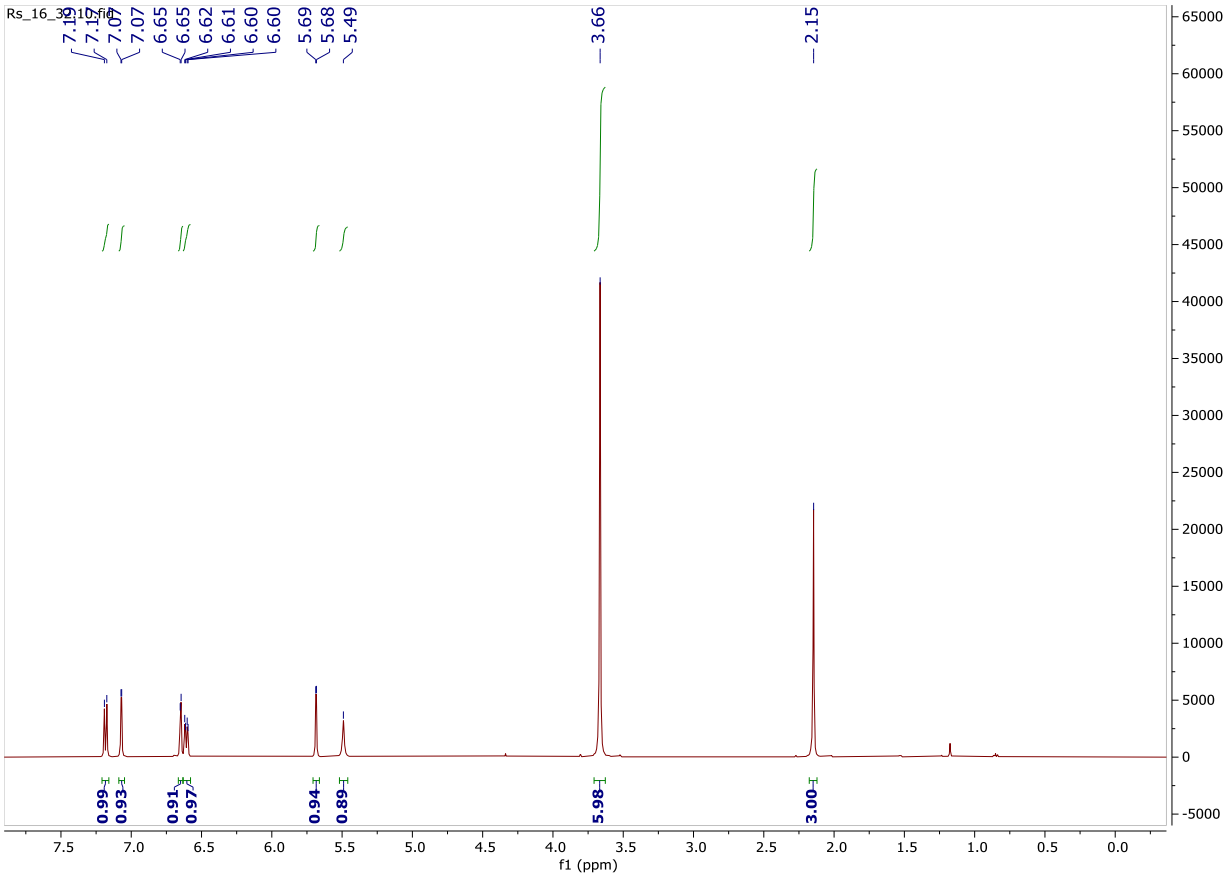
N-methyl-N-phenyl-2-(1H-pyrazol-1-yl)aniline (6_39)



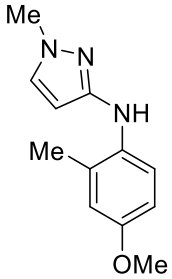
^{1}H NMR



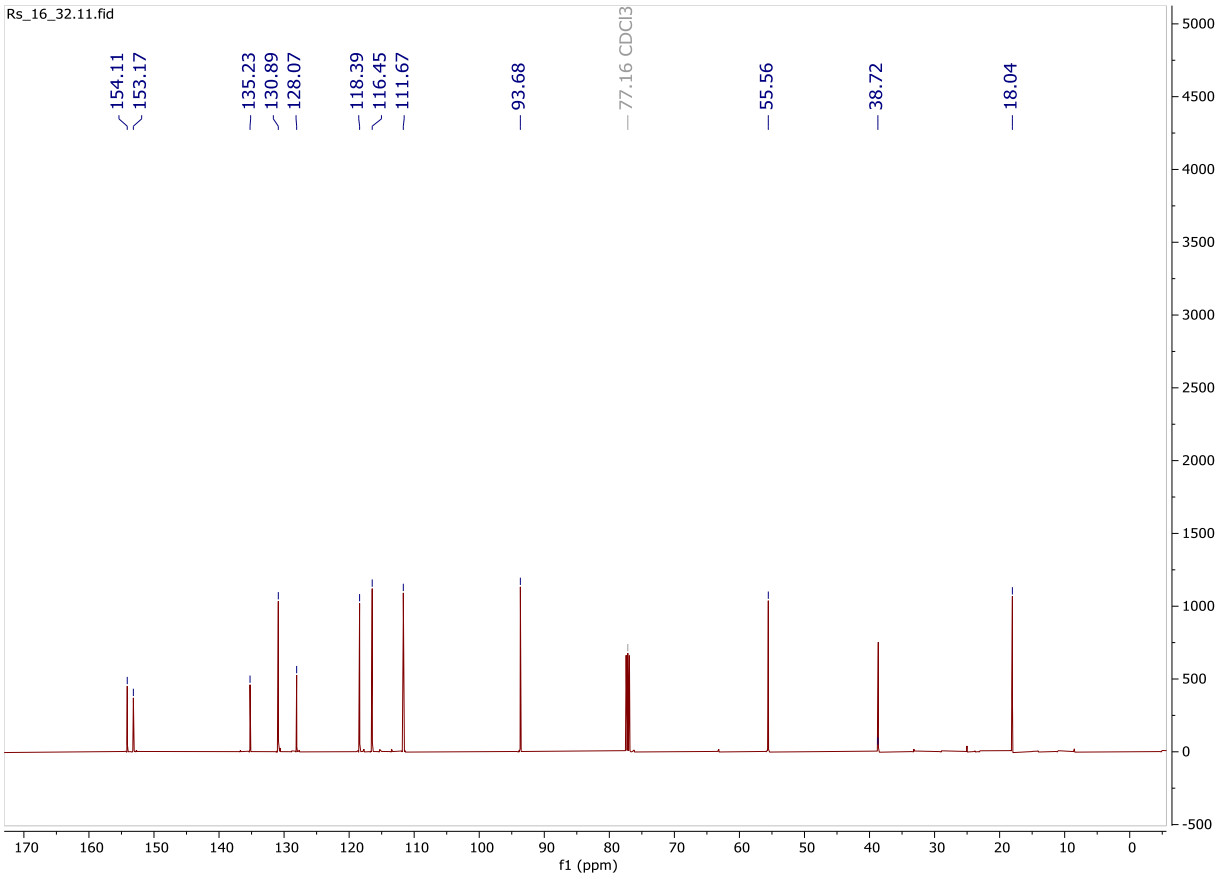
N-(4-methoxy-2-methylphenyl)-1-methyl-1H-pyrazol-3-amine (16_32)



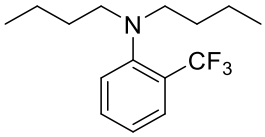
$^{13}C\{^{1}H\}$ NMR



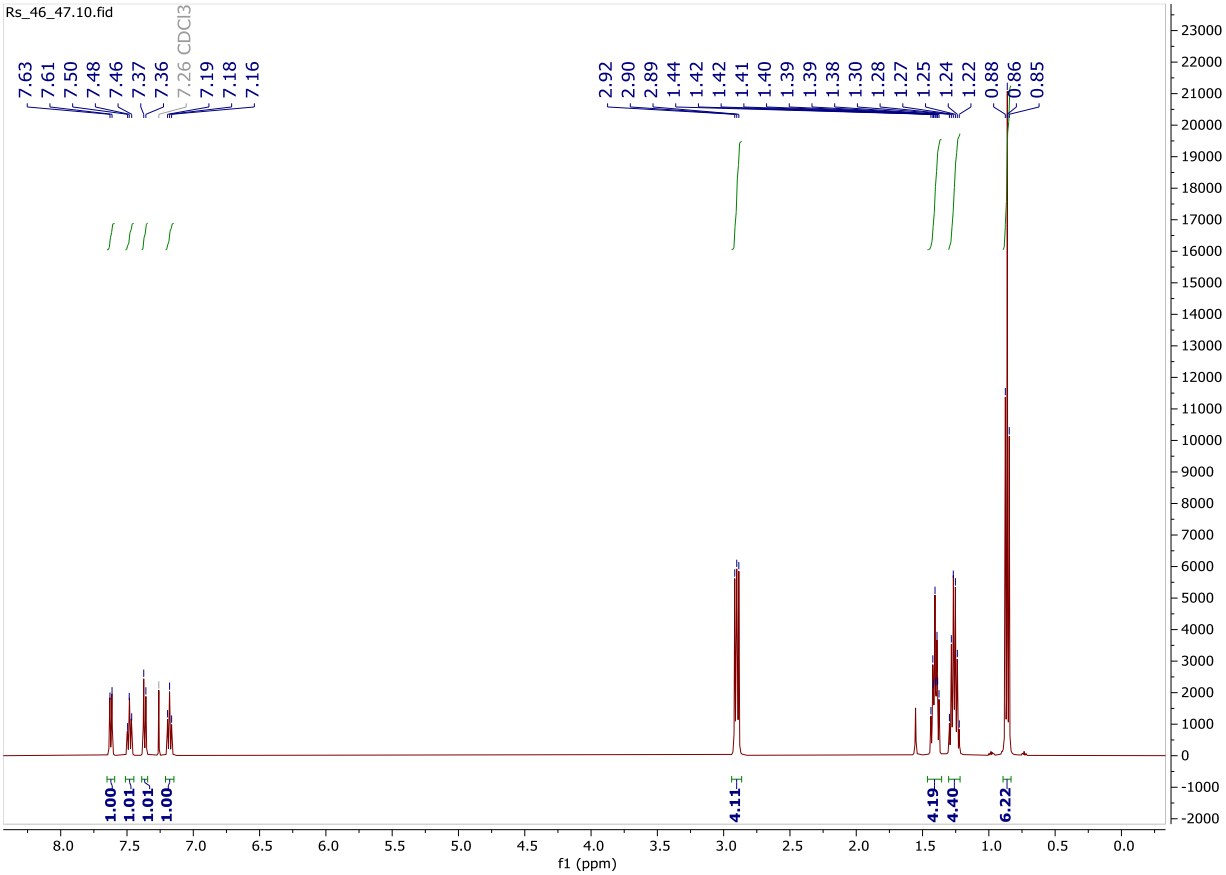
N-(4-methoxy-2-methylphenyl)-1-methyl-1H-pyrazol-3-amine (16_32)



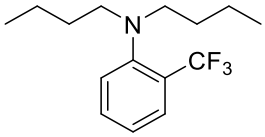
^{1}H NMR



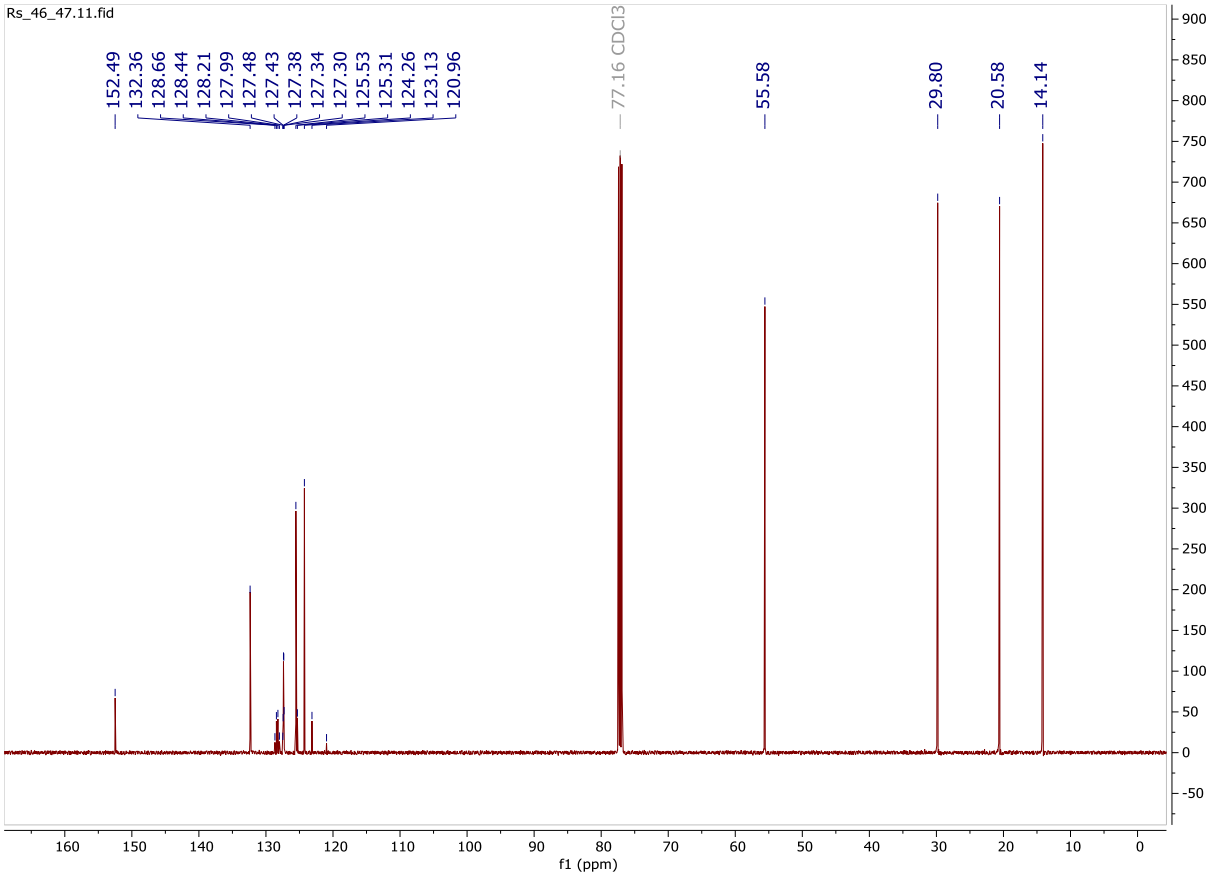
N,N-dibutyl-2-(trifluoromethyl)aniline (47_48)



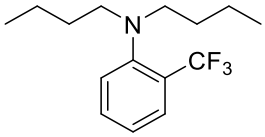
$^{13}C\{^{1}H\}$ NMR



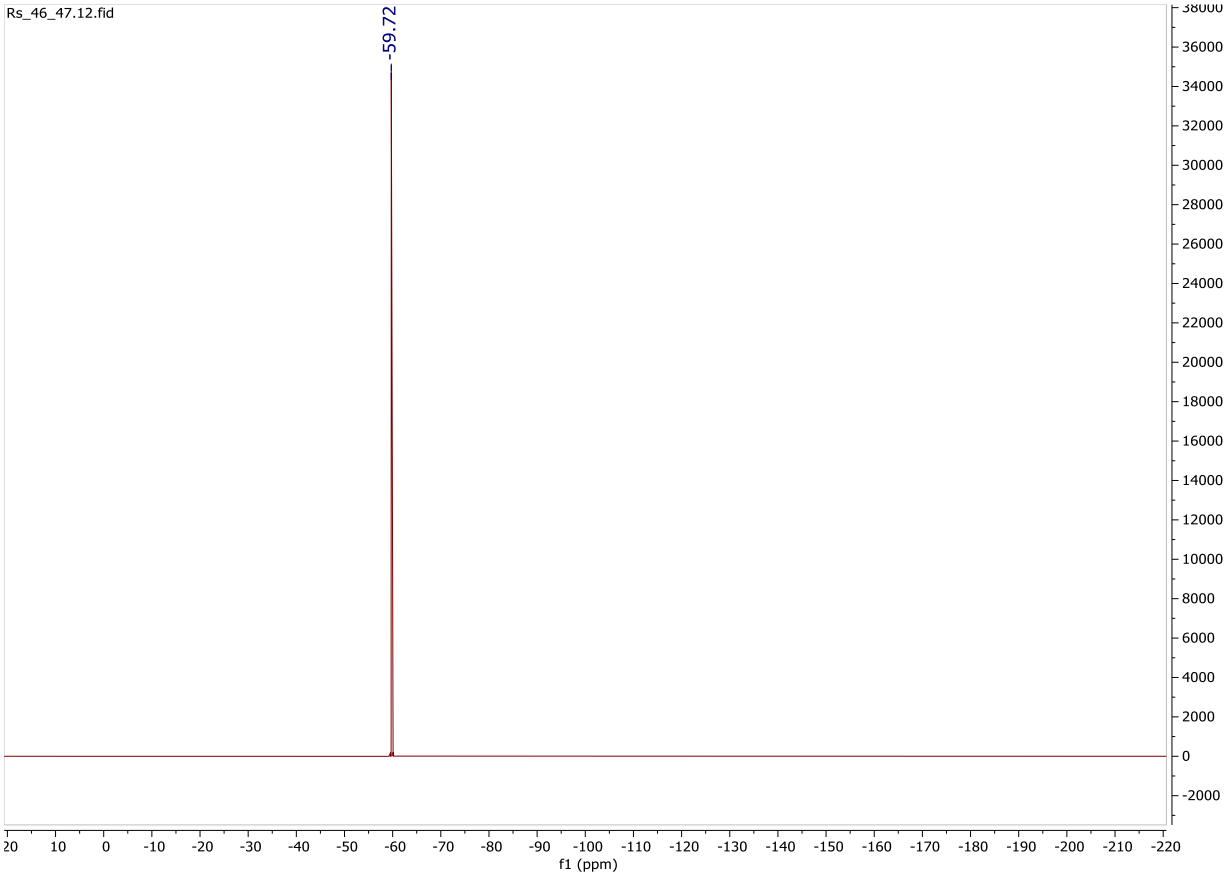
N,N-dibutyl-2-(trifluoromethyl)aniline (47_48)



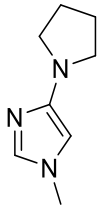
^{19}F NMR



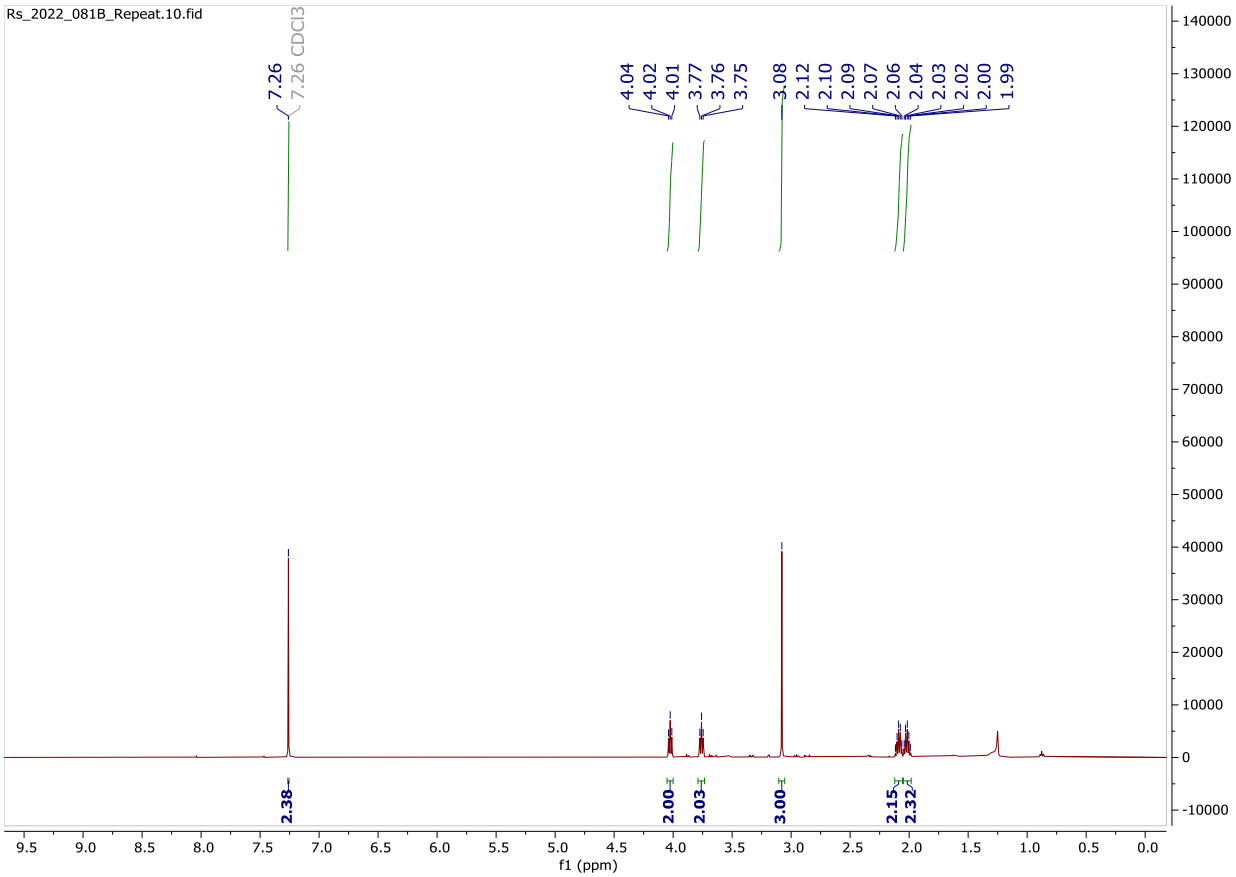
N,N-dibutyl-2-(trifluoromethyl)aniline (47_48)



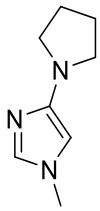
^{1}H NMR



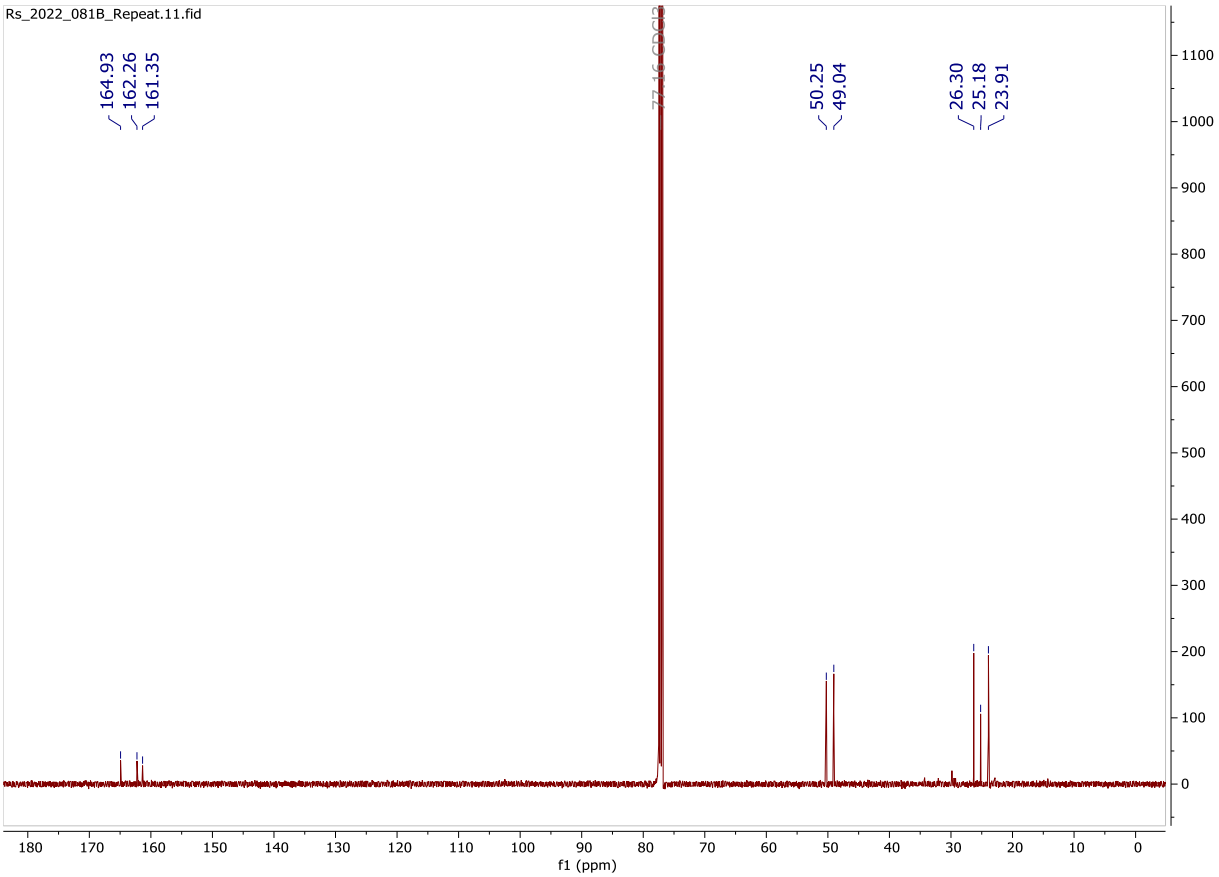
1-methyl-4-(pyrrolidin-1-yl)-1H-imidazole (44_34)



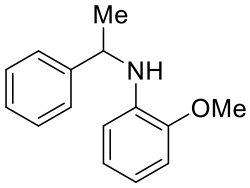
$^{13}C\{^{1}H\}$ NMR



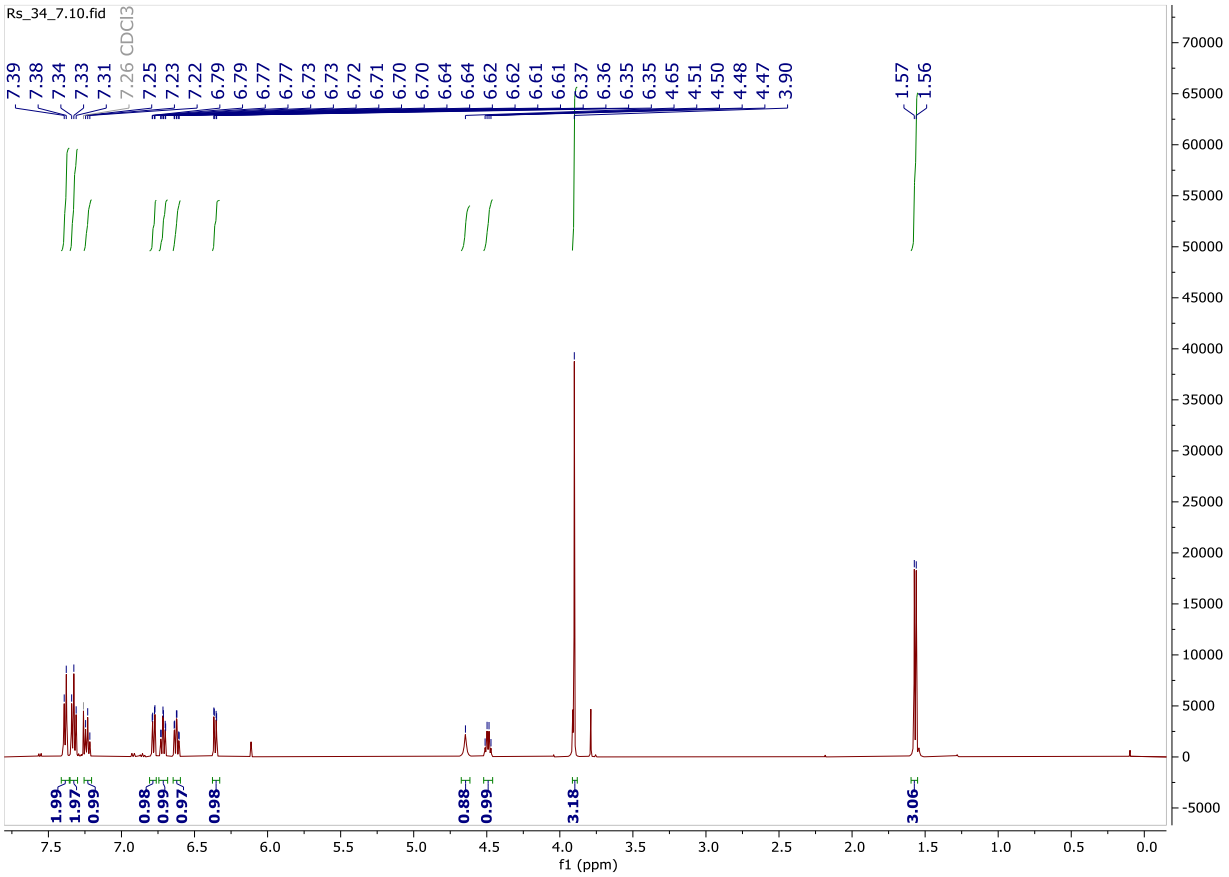
1-methyl-4-(pyrrolidin-1-yl)-1H-imidazole (44_34)



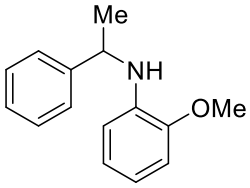
1H NMR



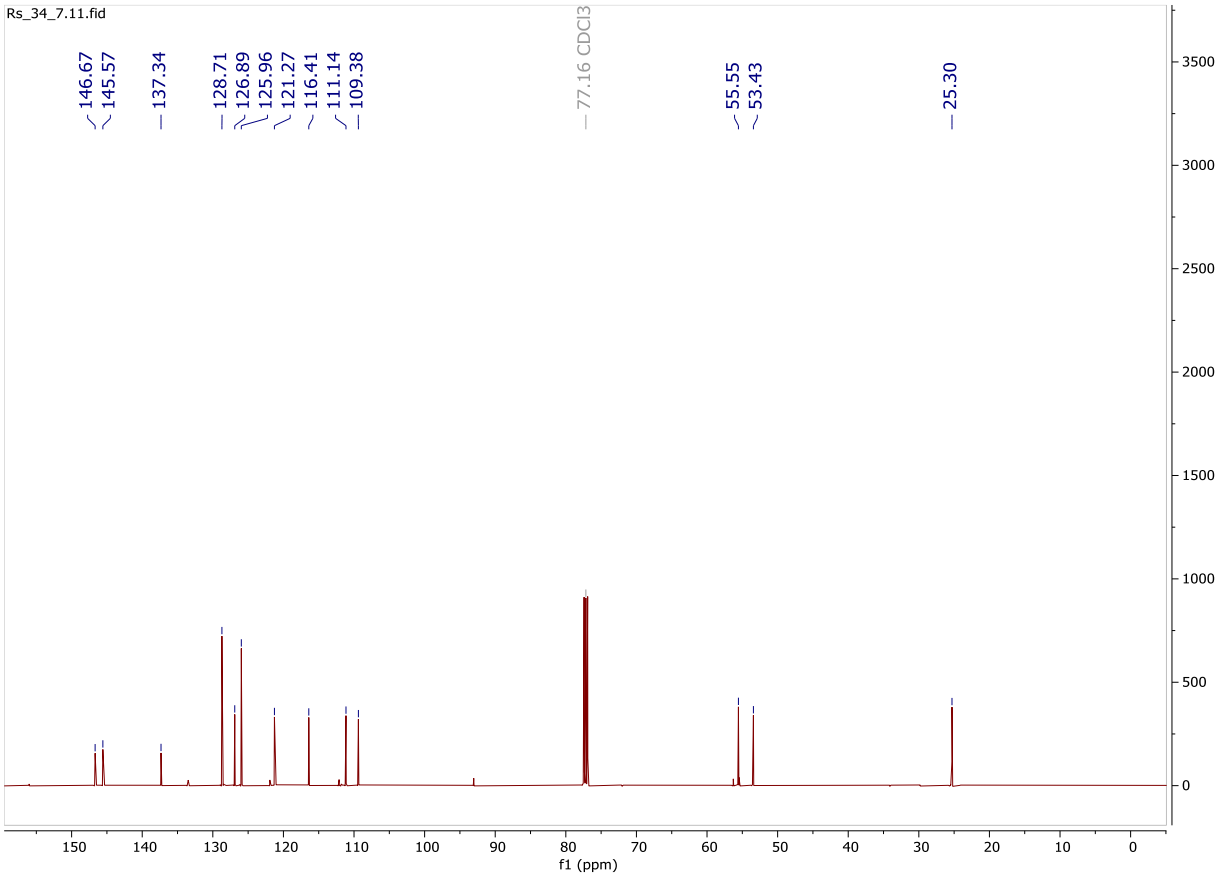
2-methoxy-N-(1-phenylethyl)aniline (34_7)



$^{13}C\{^{1}H\}$ NMR

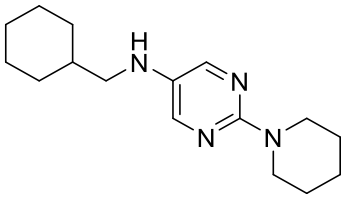


2-methoxy-N-(1-phenylethyl)aniline (34_7)

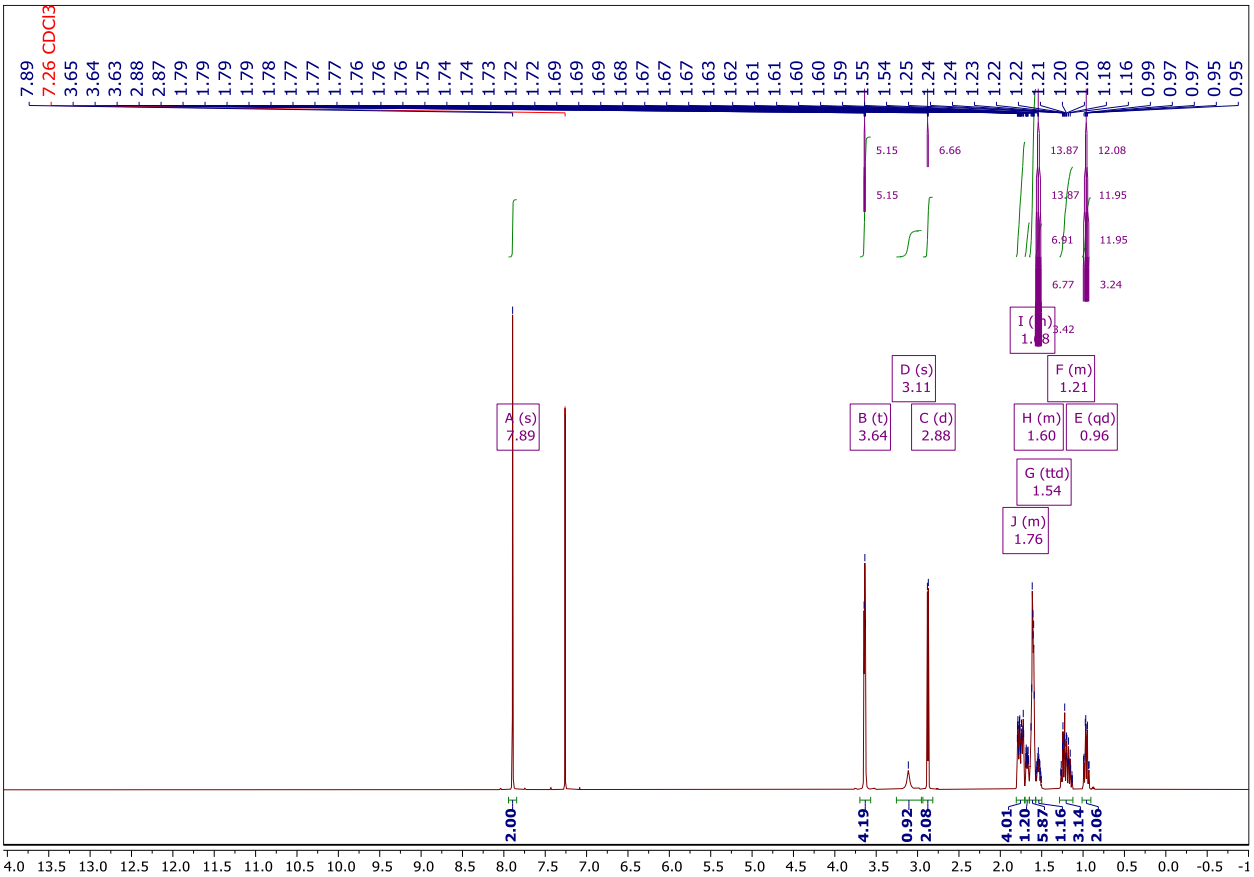


NMR Spectra for Experimental Validation Products

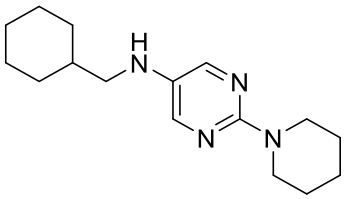
^{1}H NMR



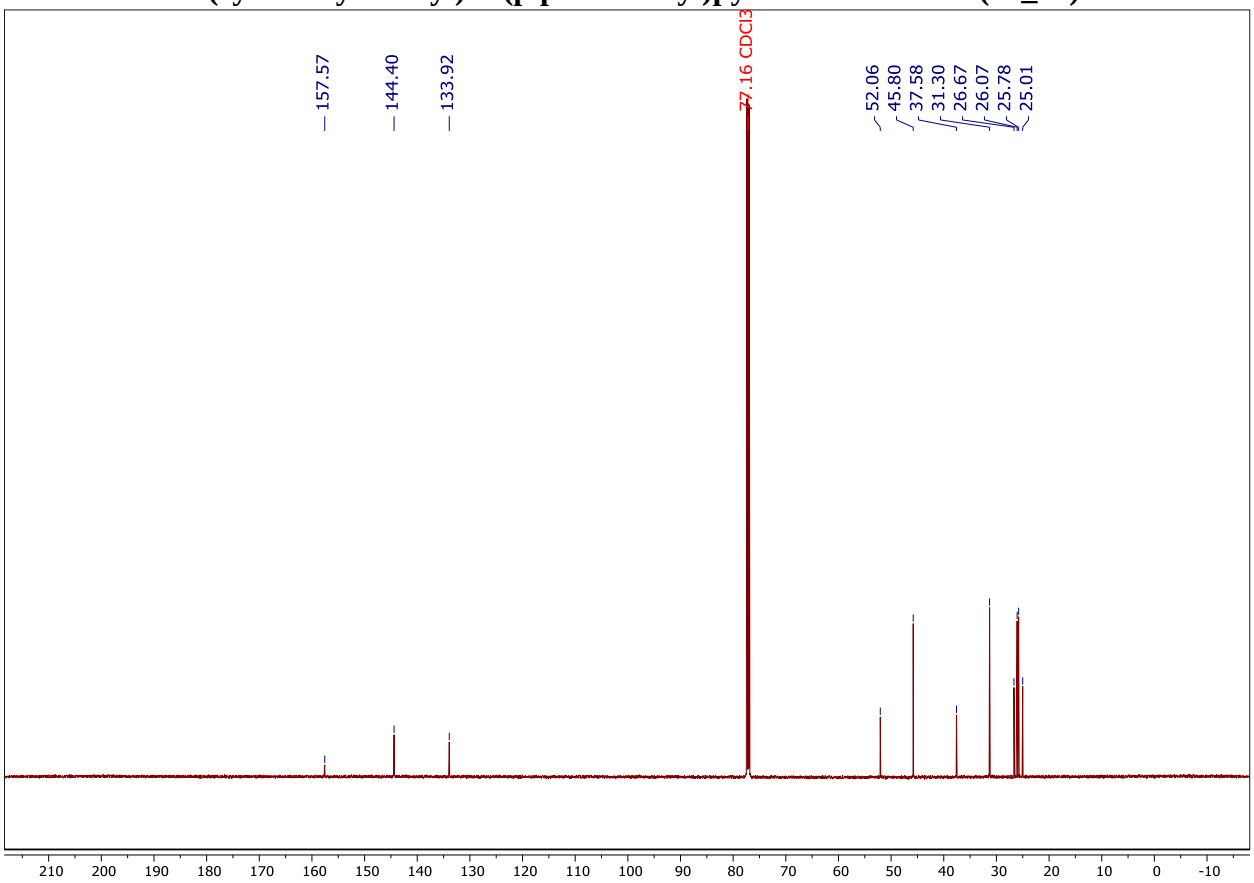
N-(cyclohexylmethyl)-2-(piperidin-1-yl)pyrimidin-5-amine (31_27)



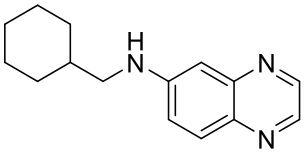
$^{13}C\{^{1}H\}$ NMR



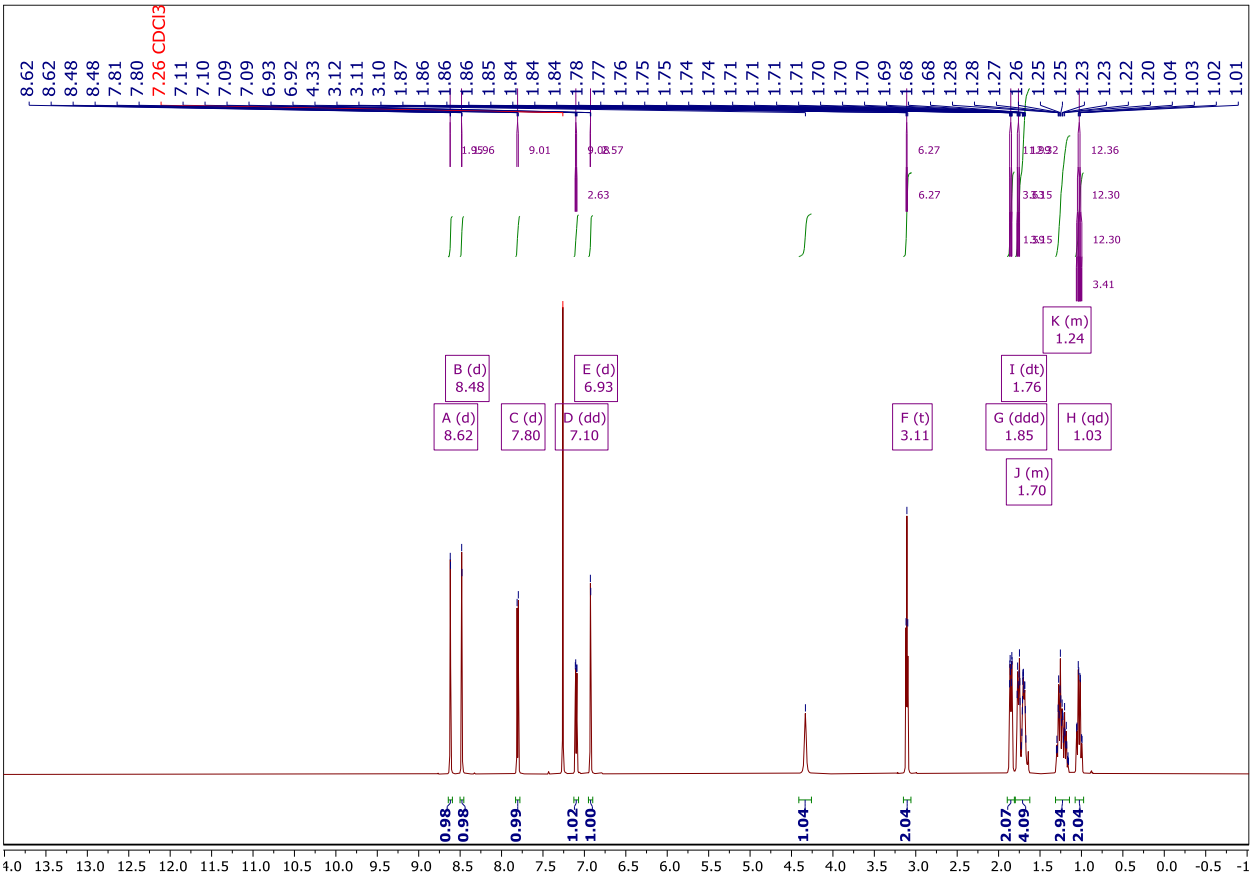
N-(cyclohexylmethyl)-2-(piperidin-1-yl)pyrimidin-5-amine (31_27)



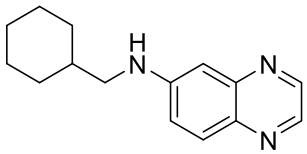
^{1}H NMR



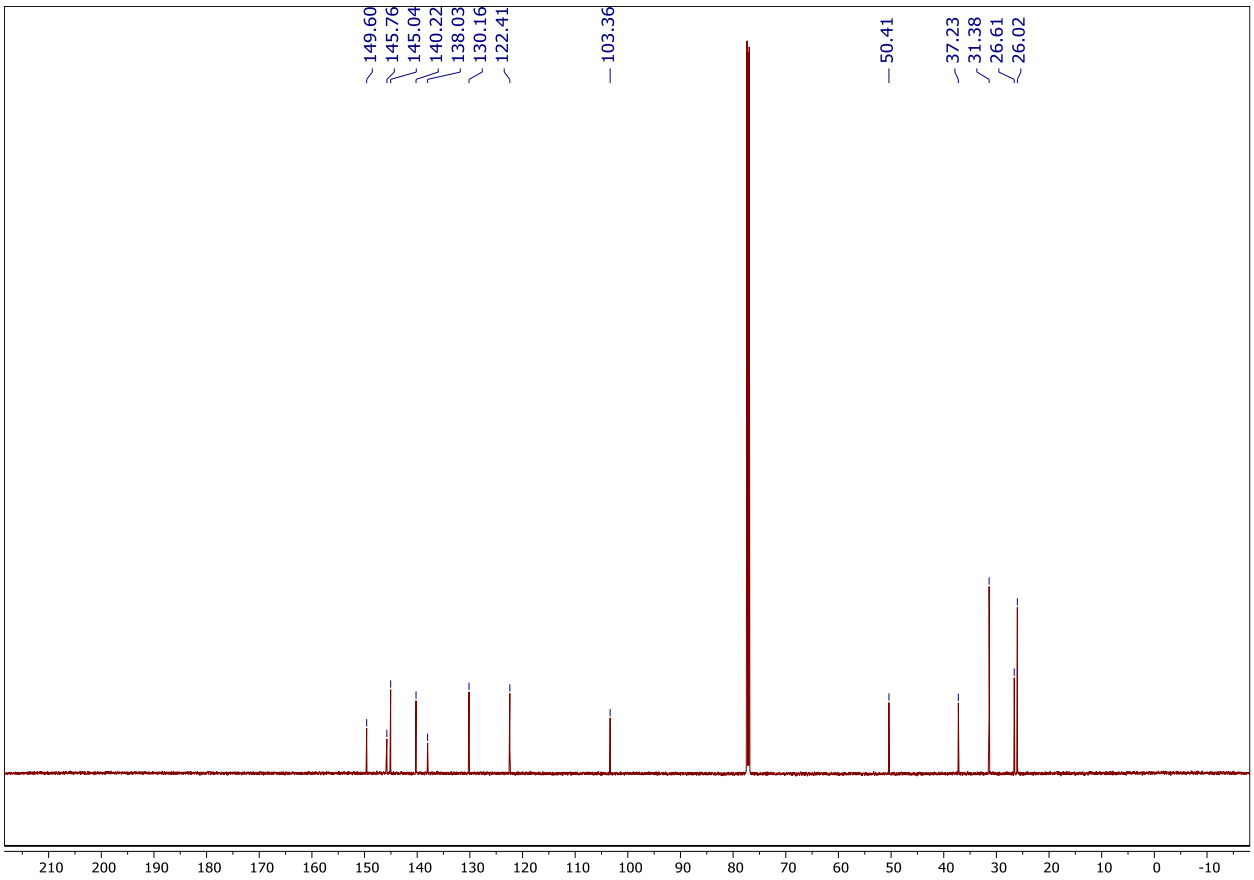
N-(cyclohexylmethyl)quinoxalin-6-amine (31_5)



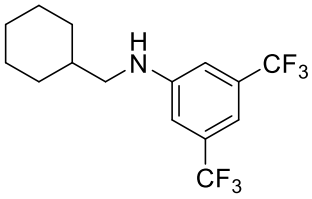
$^{13}C\{^{1}H\}$ NMR



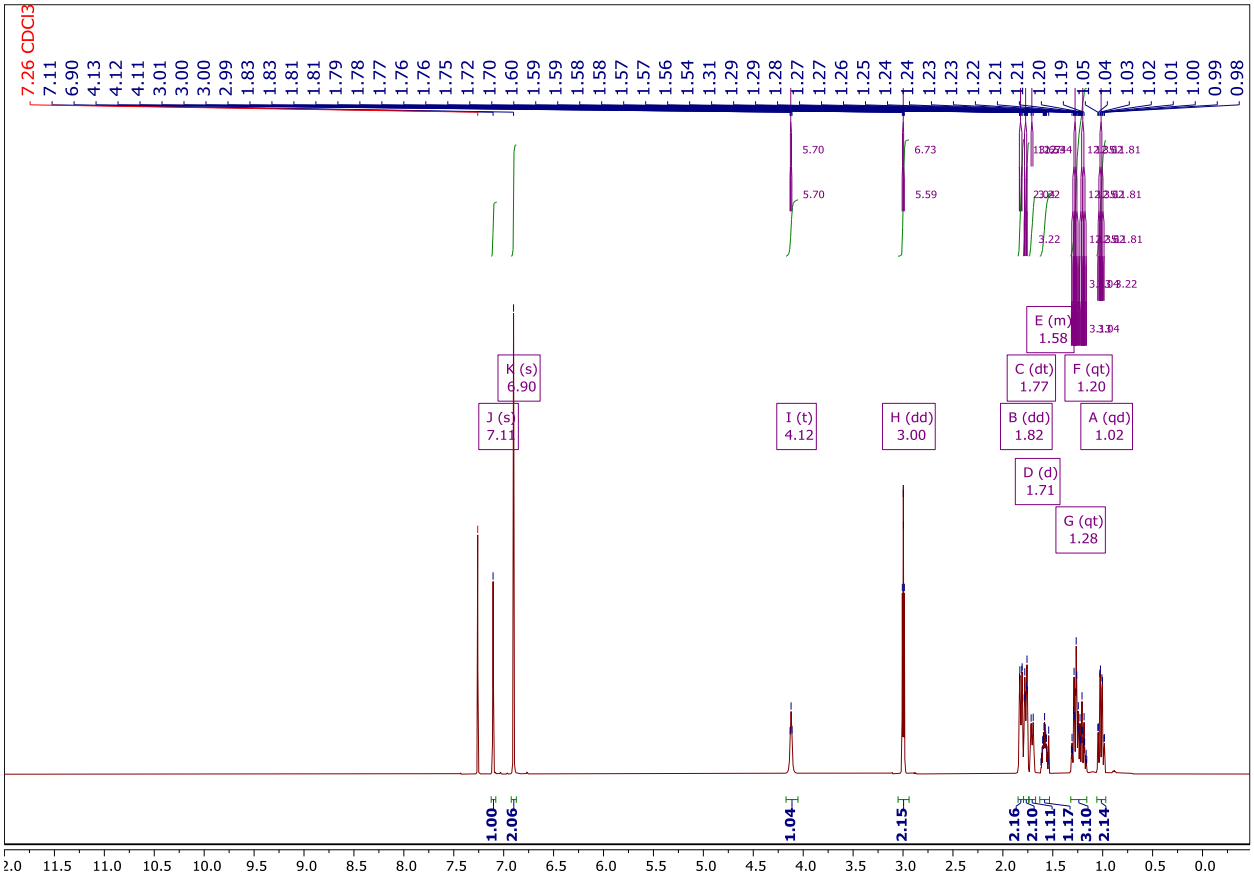
N-(cyclohexylmethyl)quinoxalin-6-amine (31_5)



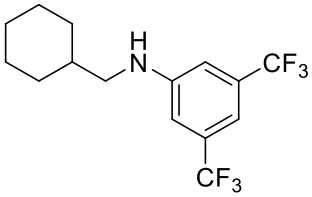
^{1}H NMR



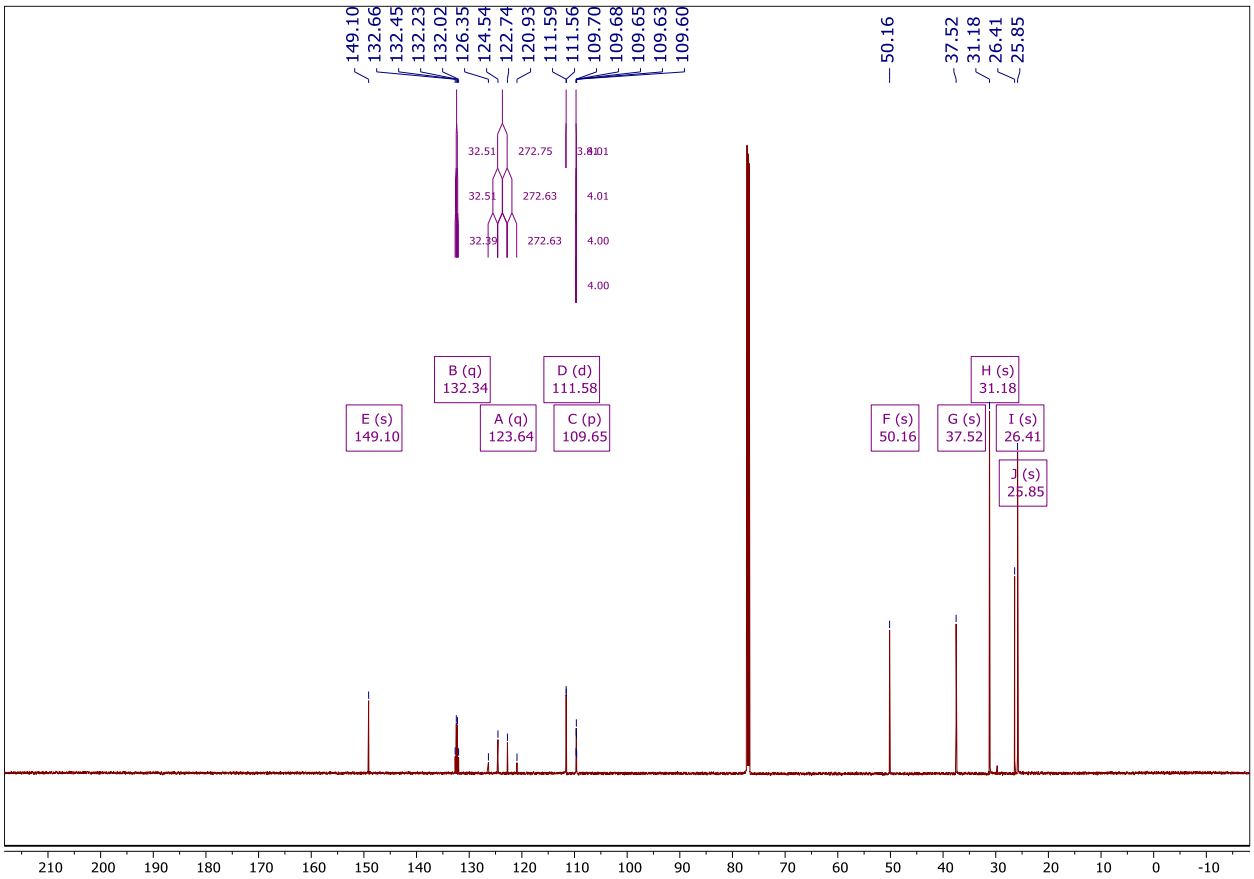
N-(cyclohexylmethyl)-3,5-bis(trifluoromethyl)aniline (31_47)



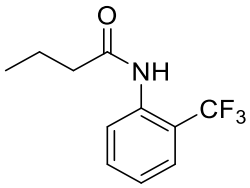
$^{13}C\{^{1}H\}$ NMR



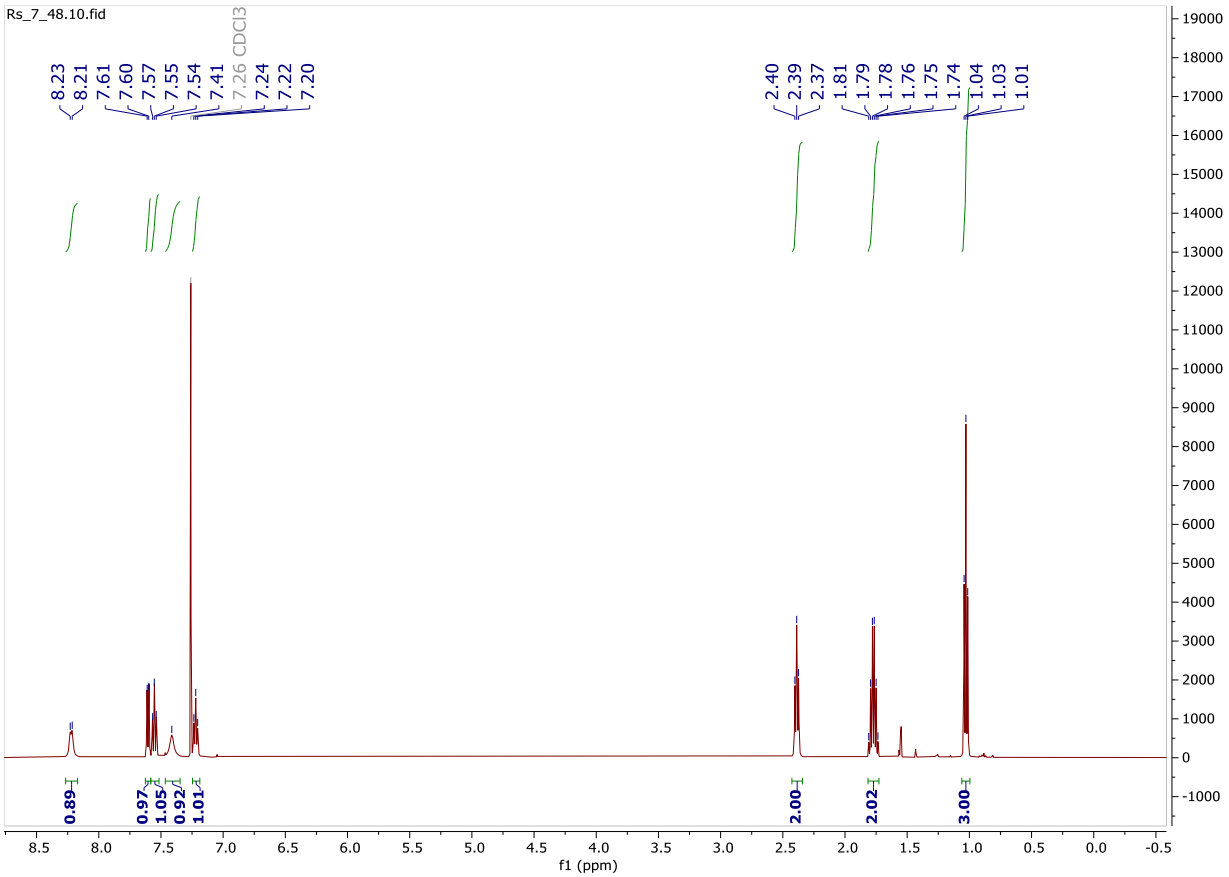
N-(cyclohexylmethyl)-3,5-bis(trifluoromethyl)aniline (31_47)



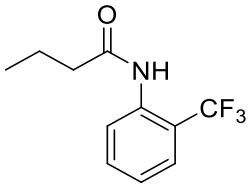
^{1}H NMR



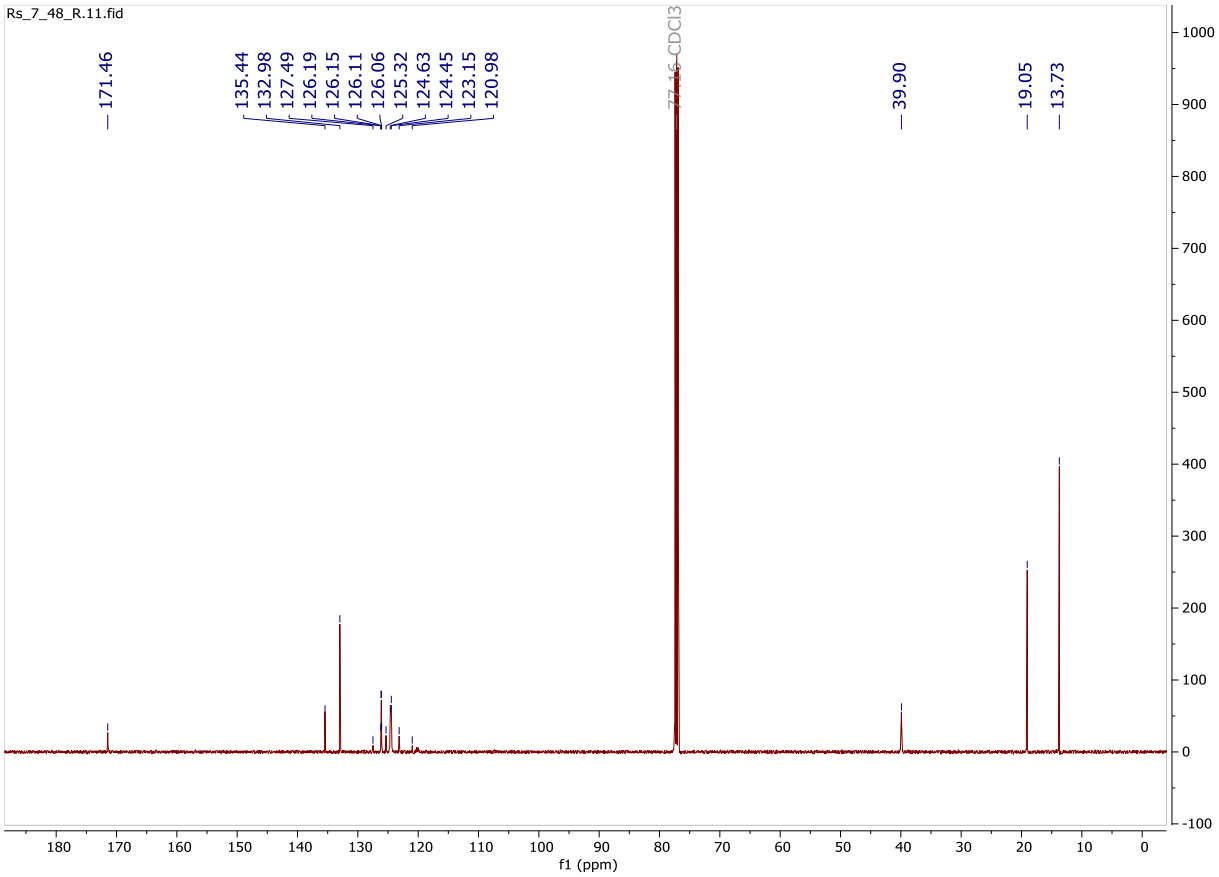
N-(2-(trifluoromethyl)phenyl)butyramide (7_48)



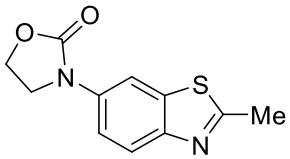
$^{13}C\{^{1}H\}$ NMR



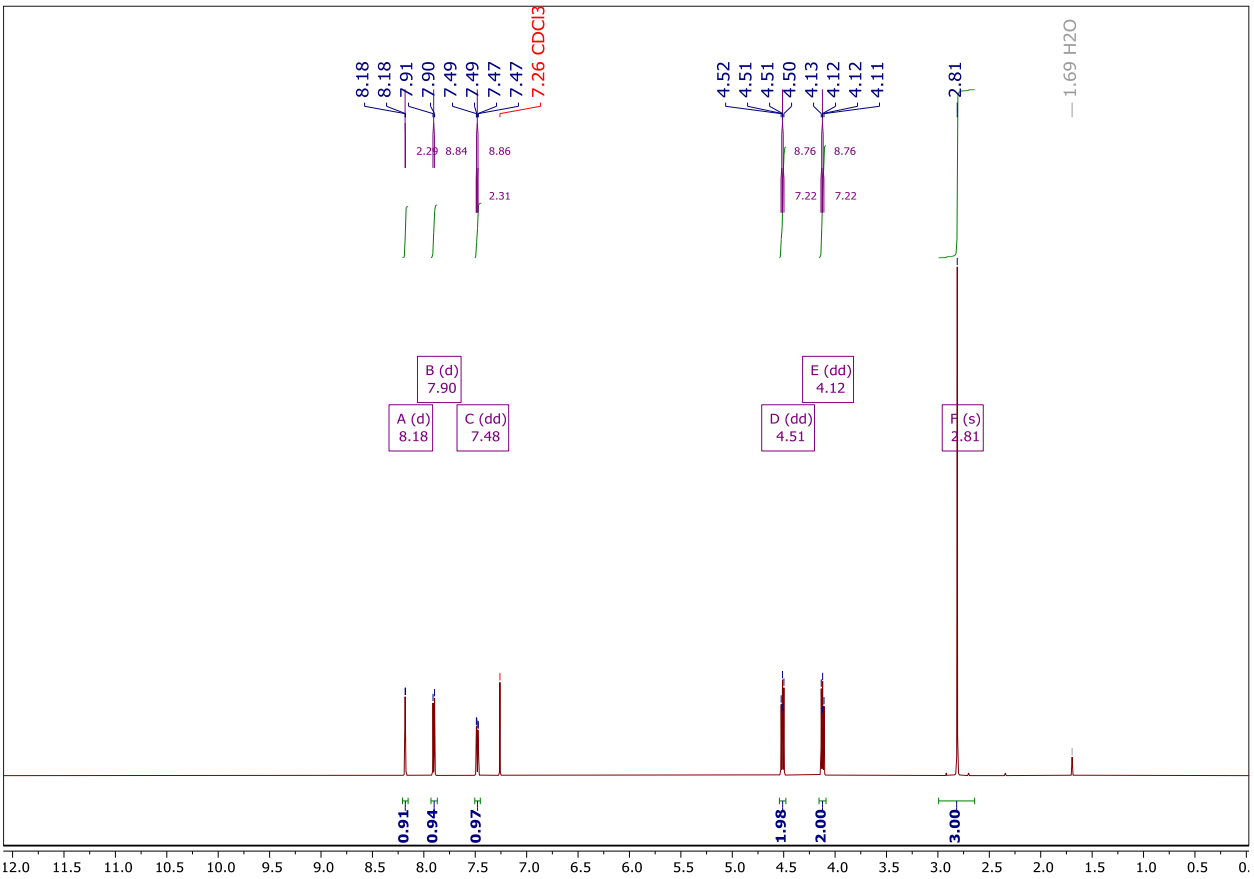
N-(2-(trifluoromethyl)phenyl)butyramide (7_48)



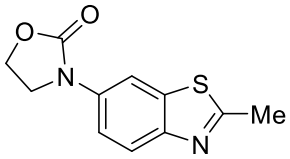
^{1}H NMR



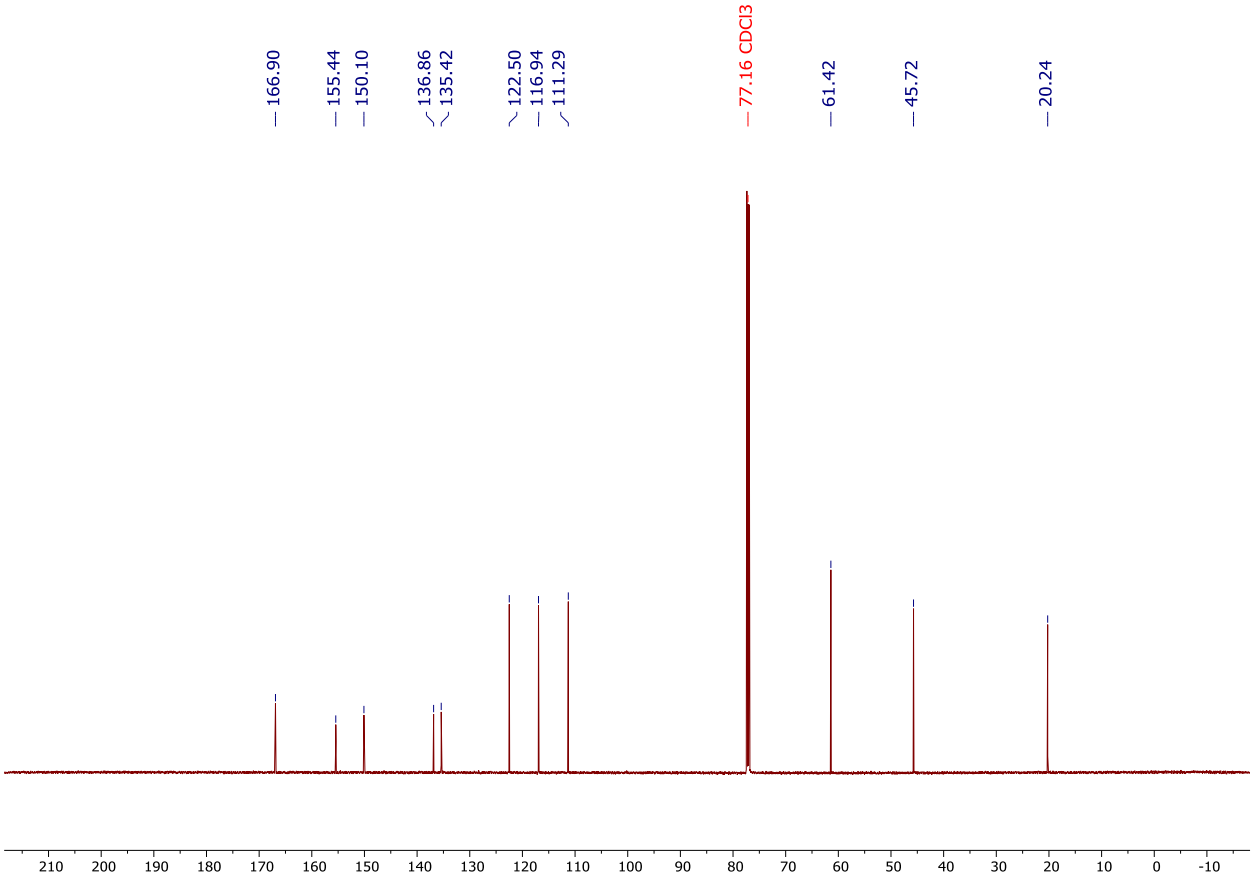
3-(2-methylbenzo[d]thiazol-6-yl)oxazolidin-2-one (1001_2003)



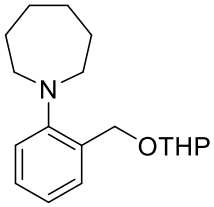
$^{13}C\{^{1}H\}$ NMR



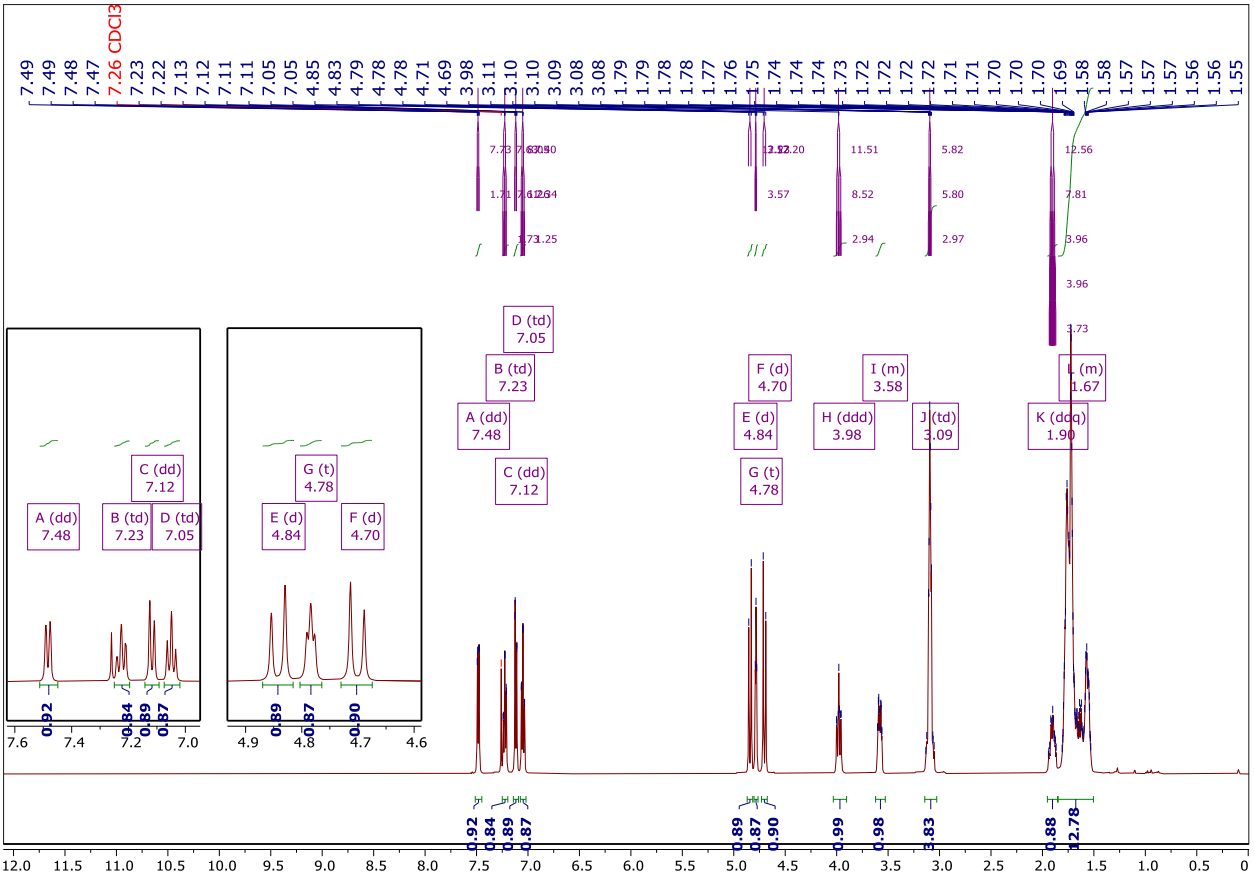
3-(2-methylbenzo[d]thiazol-6-yl)oxazolidin-2-one (1001_2003)



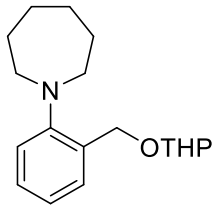
^{1}H NMR



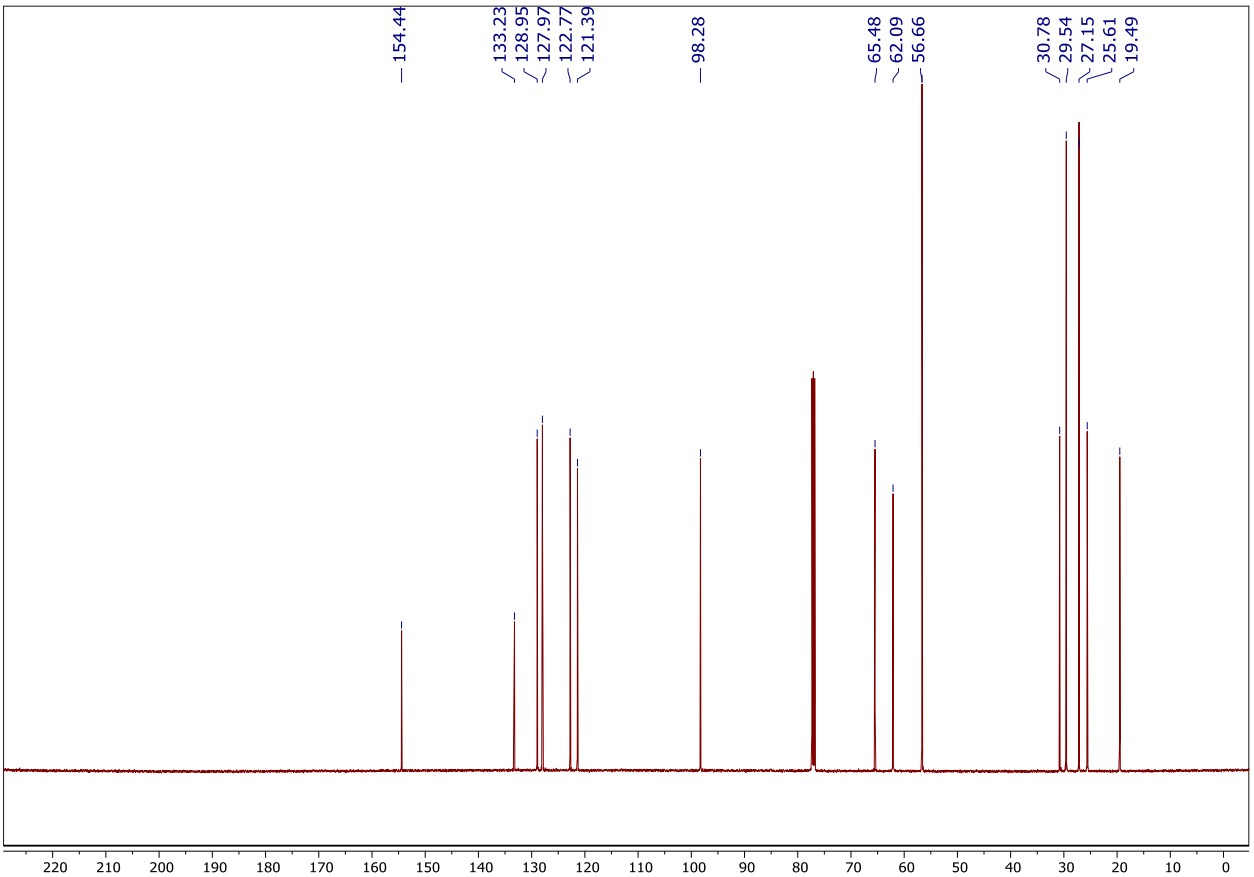
1-(2-(((tetrahydro-2H-pyran-2-yl)oxy)methyl)phenyl)azepane (1002_2002)



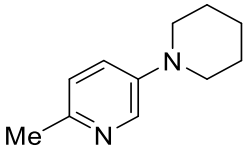
$^{13}C\{^{1}H\}$ NMR



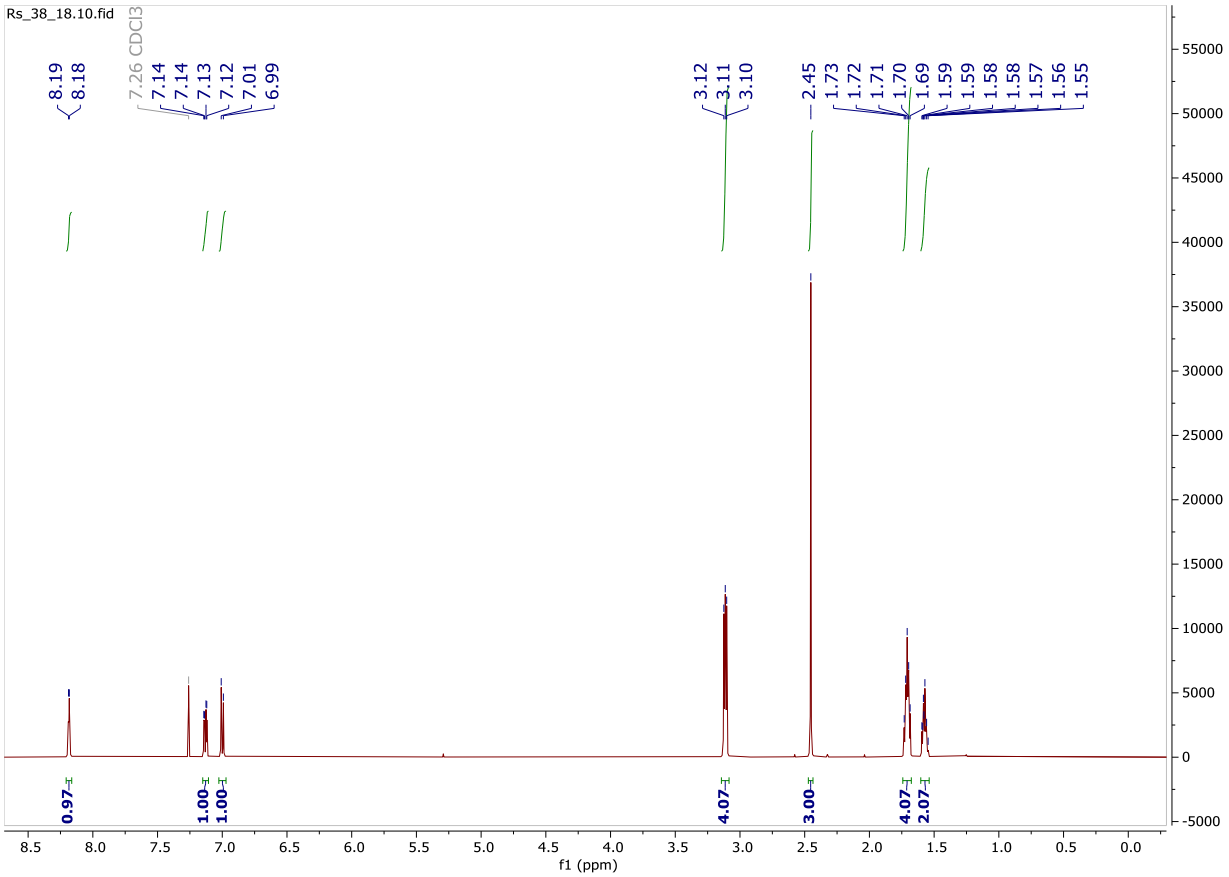
1-(2-(((tetrahydro-2H-pyran-2-yl)oxy)methyl)phenyl)azepane (1002_2002)



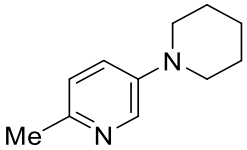
^{1}H NMR



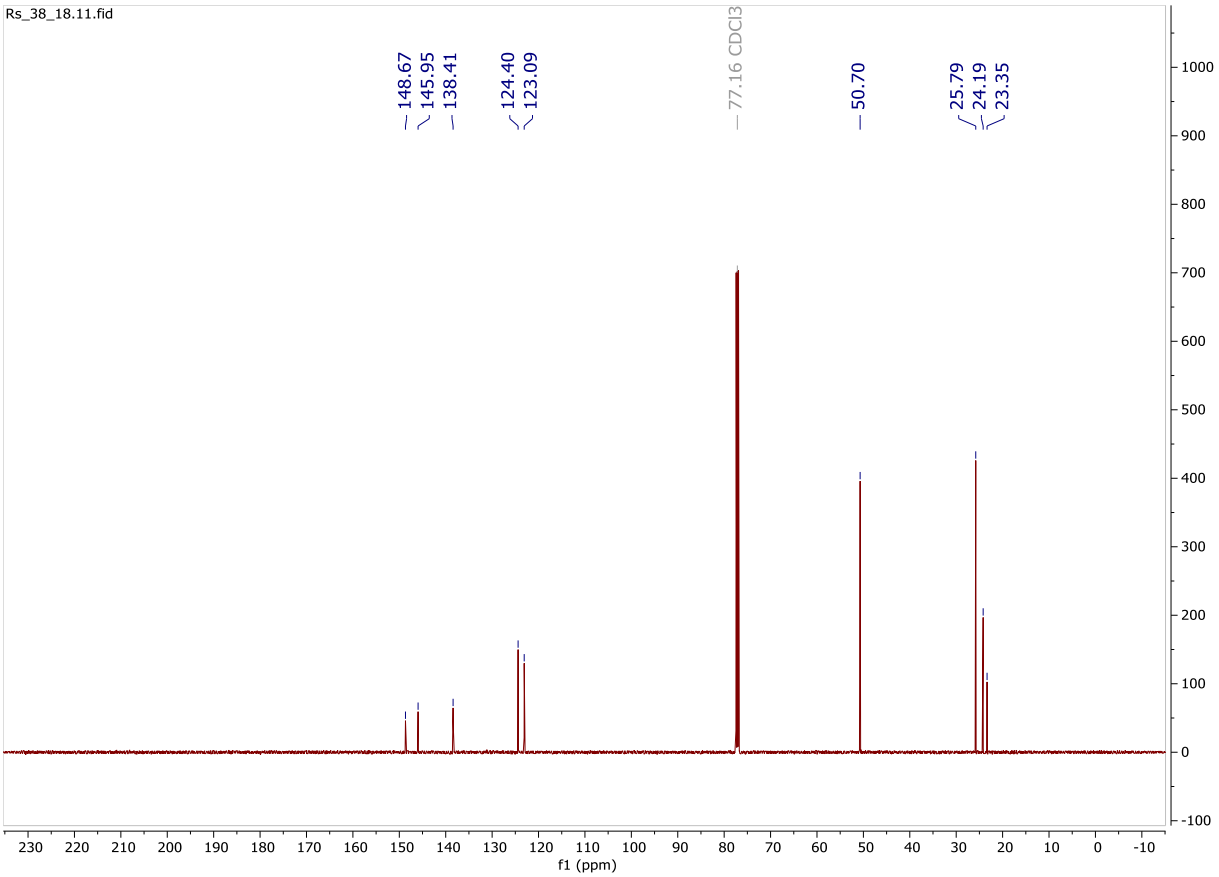
2-methyl-5-(piperidin-1-yl)pyridine (38_18)



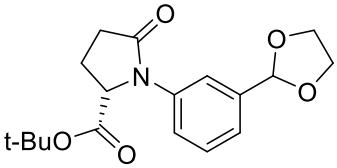
$^{13}C\{^{1}H\}$ NMR



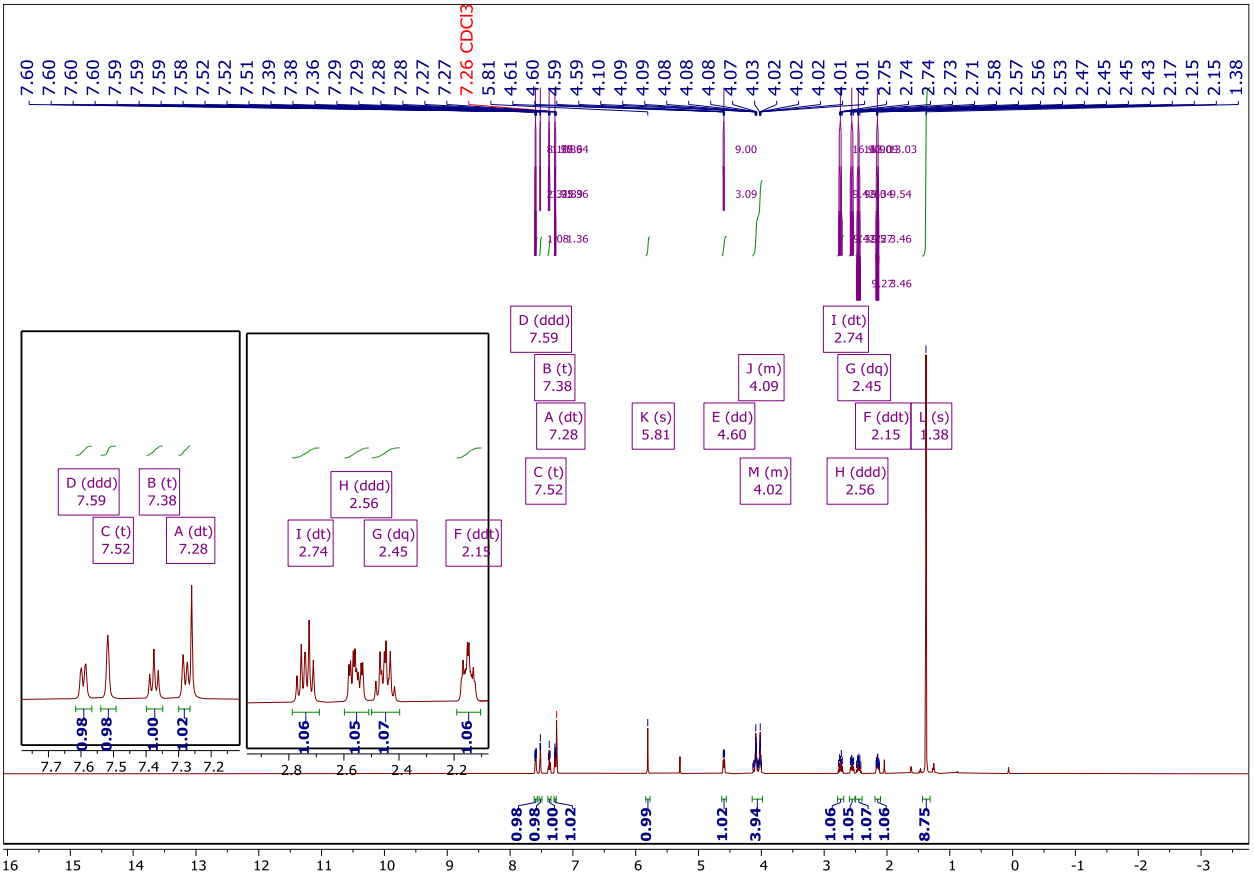
2-methyl-5-(piperidin-1-yl)pyridine (38_18)



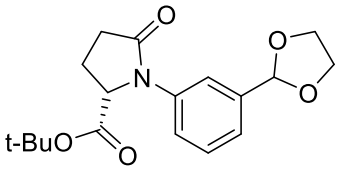
^{1}H NMR



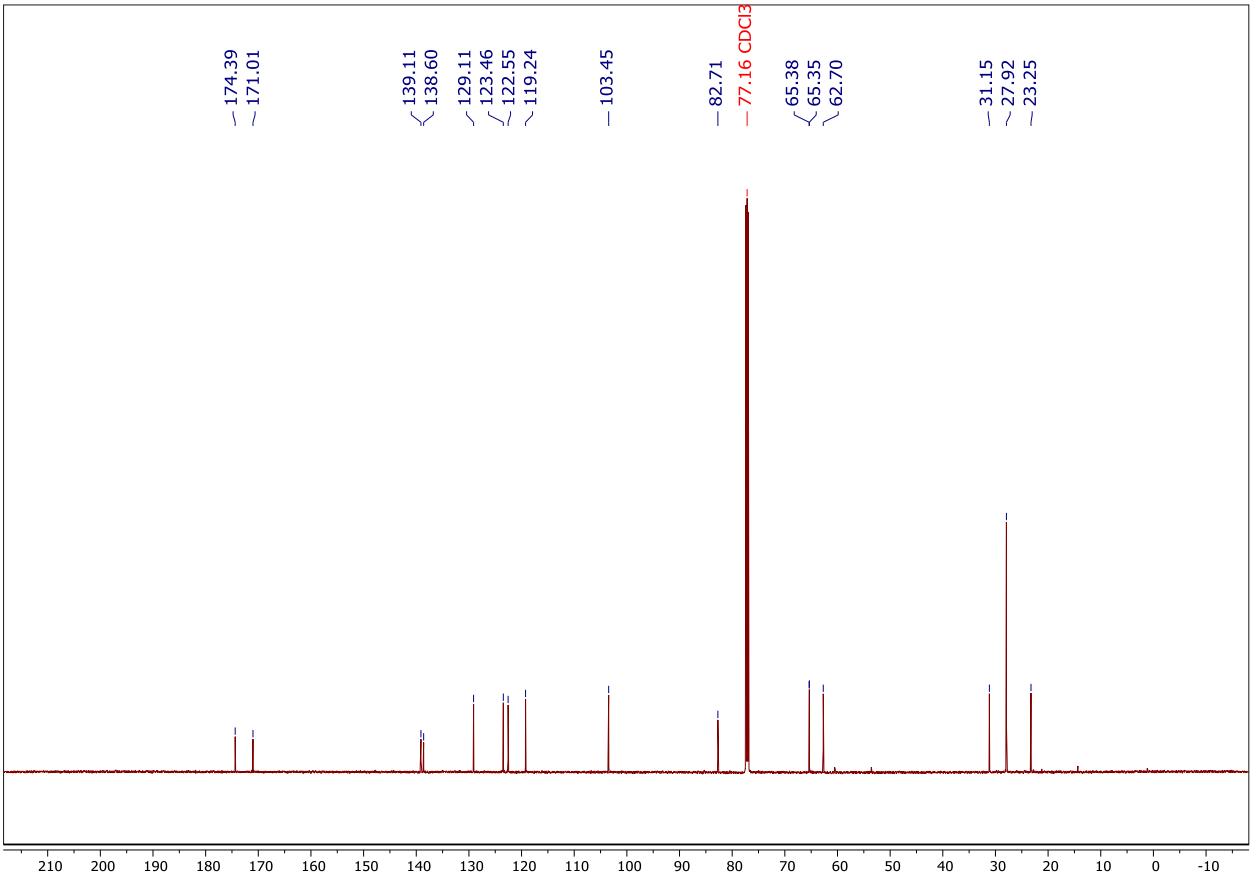
tert-butyl (S)-1-(3-(1,3-dioxolan-2-yl)phenyl)-5-oxopyrrolidine-2-carboxylate (1007_2004)



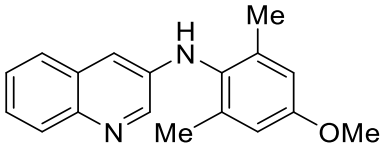
$^{13}C\{^{1}H\}$ NMR



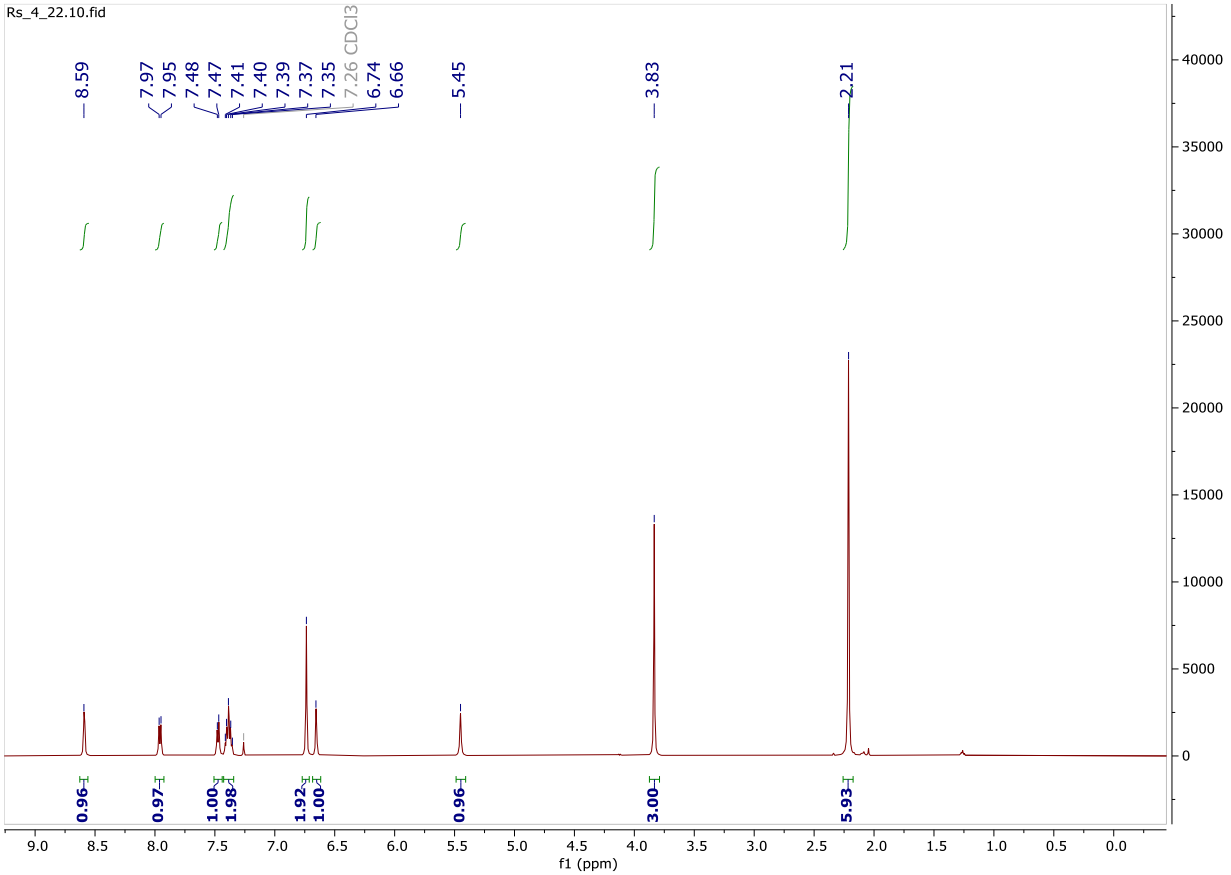
tert-butyl (S)-1-(3-(1,3-dioxolan-2-yl)phenyl)-5-oxopyrrolidine-2-carboxylate (1007_2004)



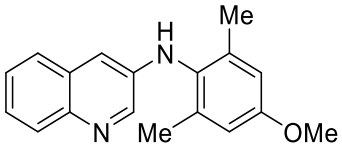
^{1}H NMR



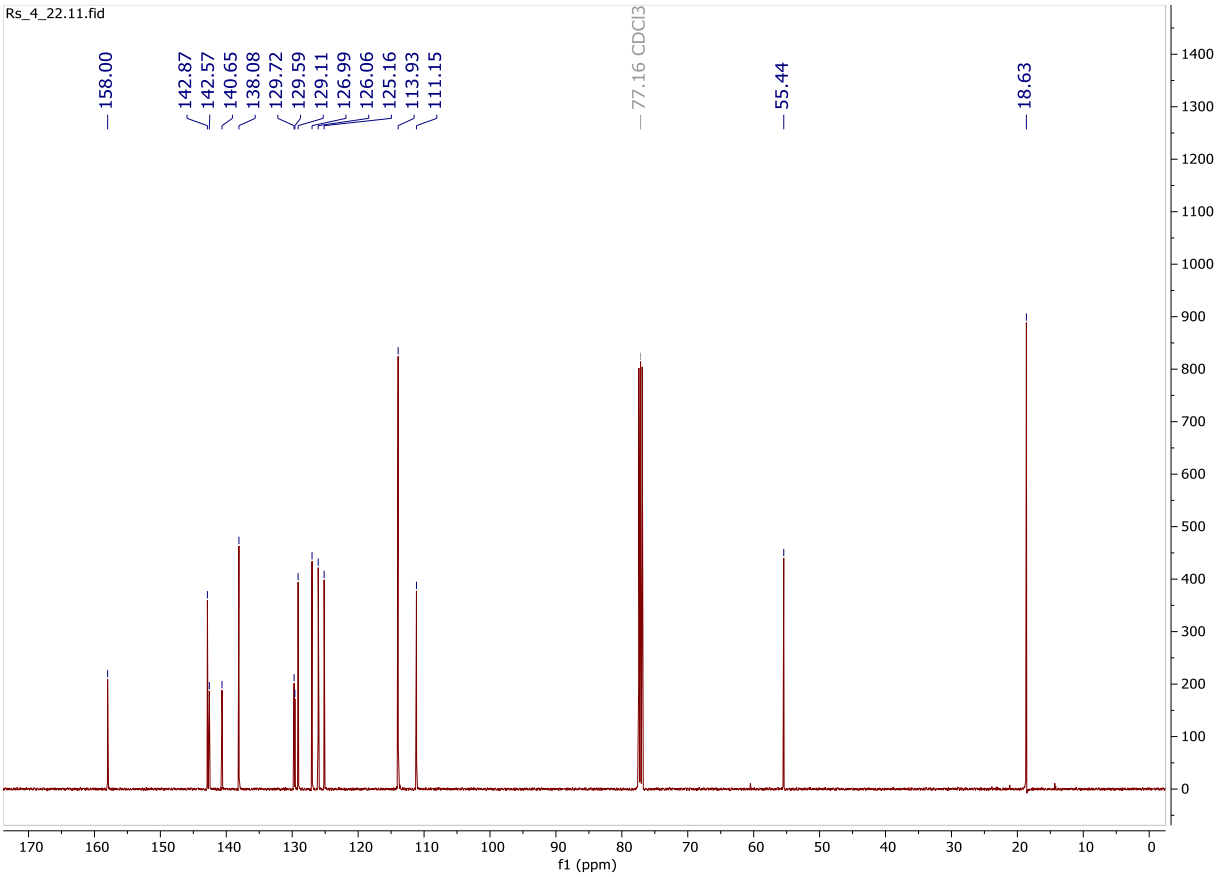
N-(4-methoxy-2,6-dimethylphenyl)quinolin-3-amine (4_22)



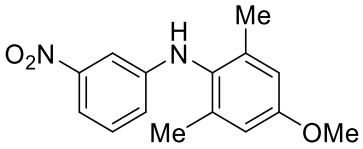
$^{13}C\{^{1}H\}$ NMR



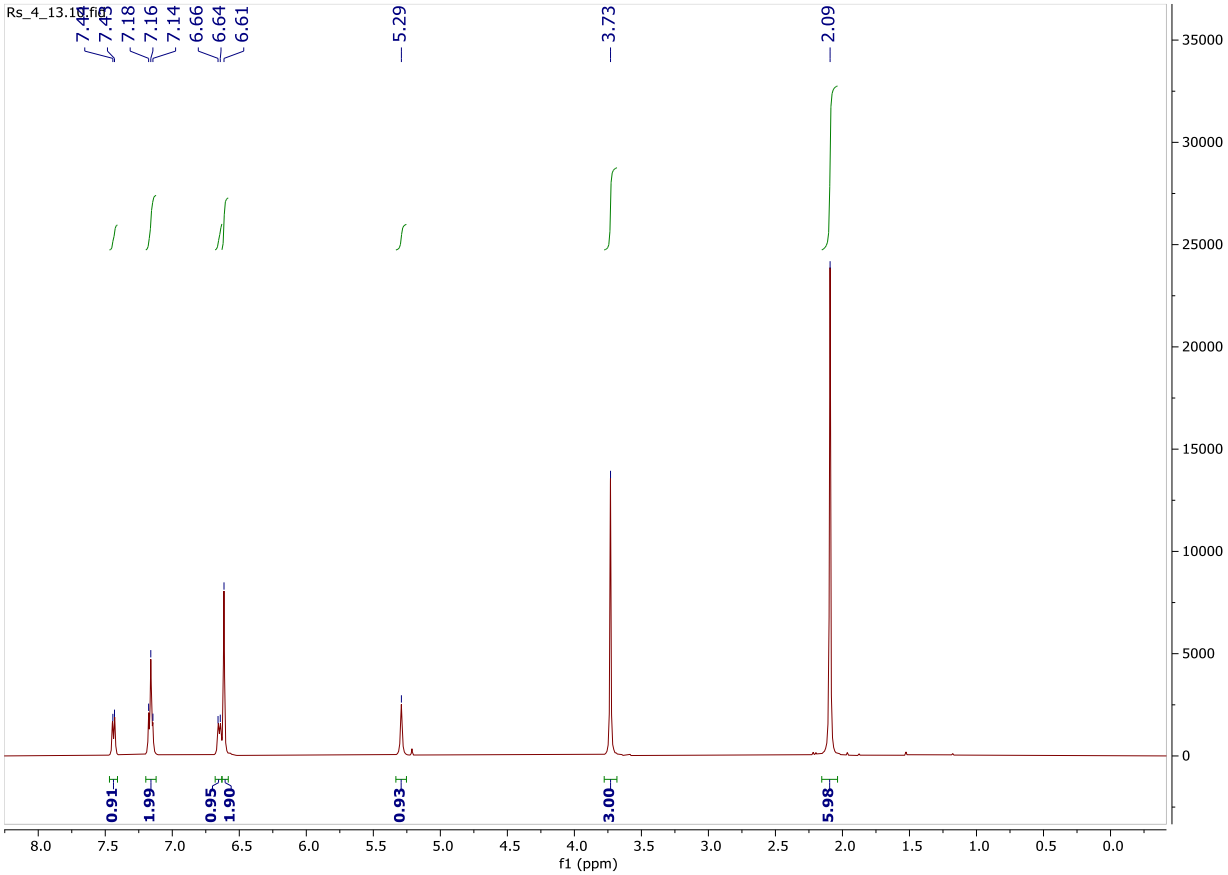
N-(4-methoxy-2,6-dimethylphenyl)quinolin-3-amine (4_22)



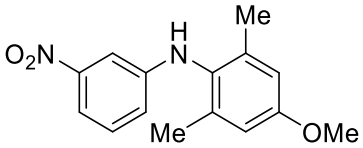
^{1}H NMR



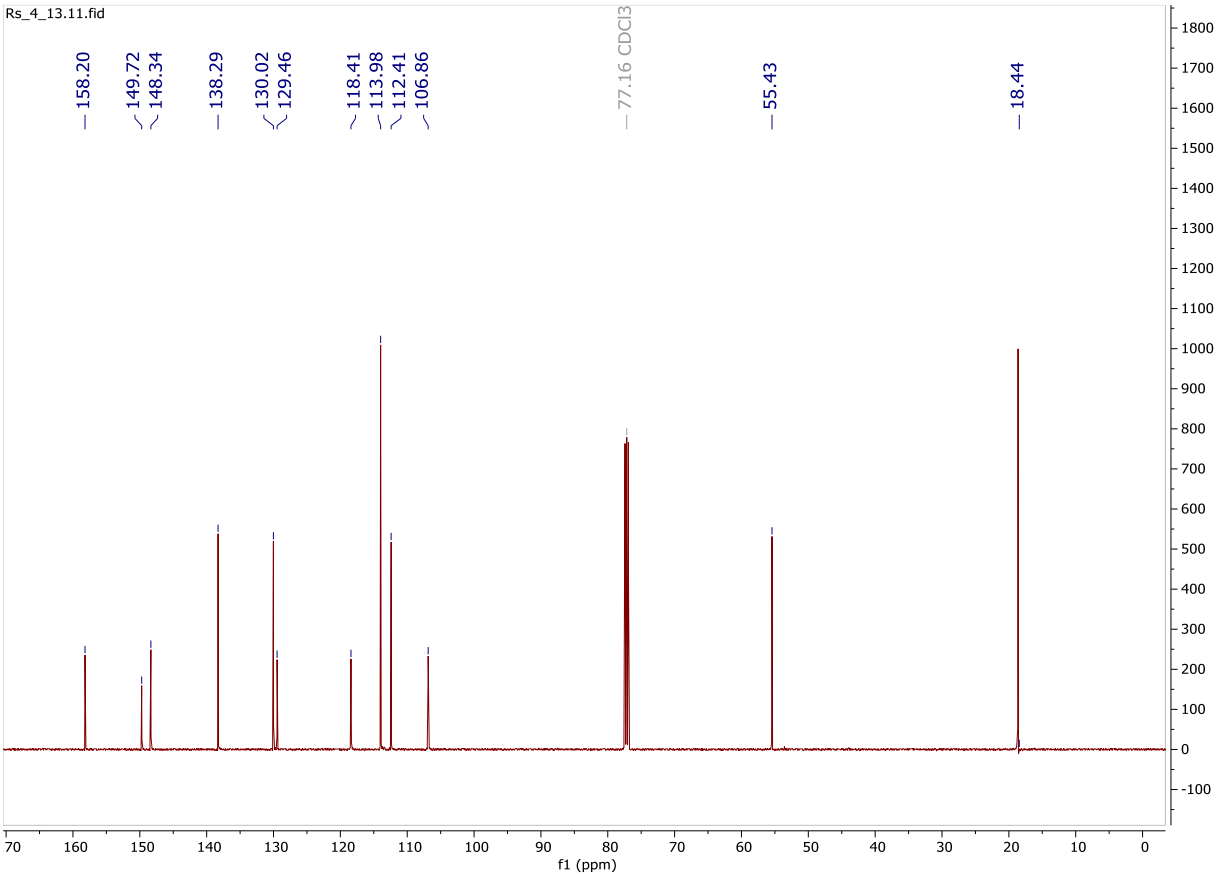
4-methoxy-2,6-dimethyl-N-(3-nitrophenyl)aniline (4_13)



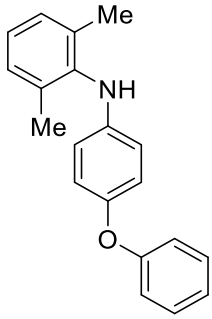
$^{13}C\{^{1}H\}$ NMR



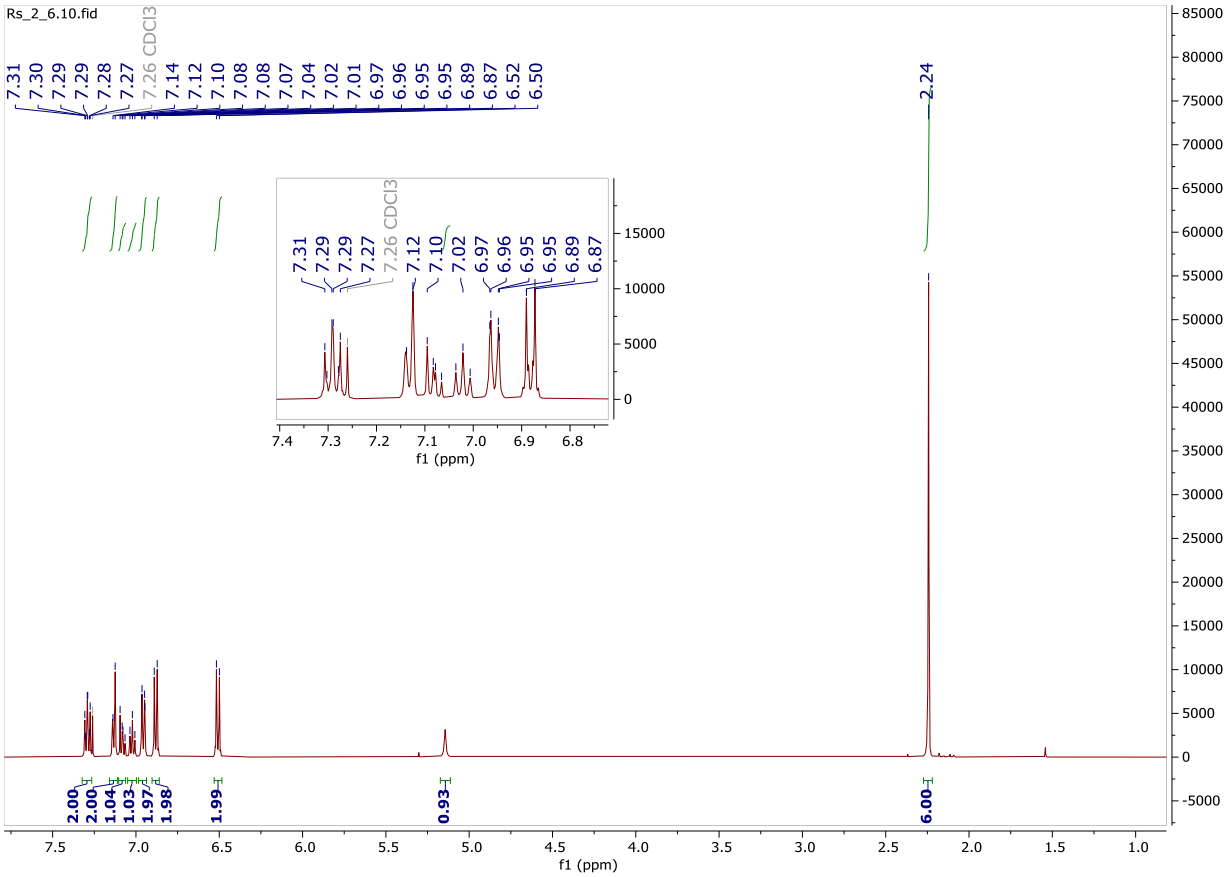
4-methoxy-2,6-dimethyl-N-(3-nitrophenyl)aniline (4_13)



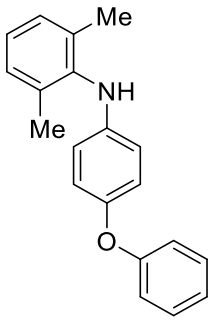
^{1}H NMR



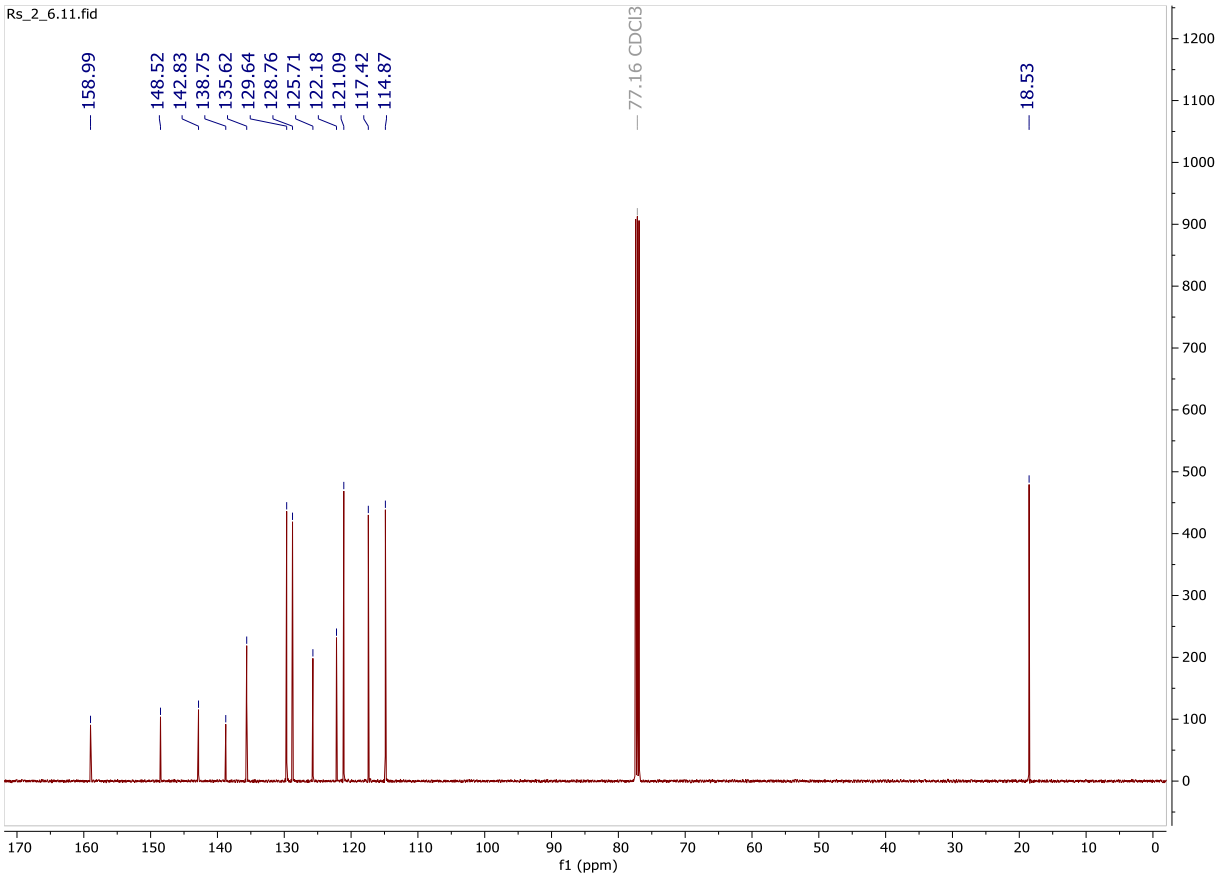
2,6-dimethyl-N-(4-phenoxyphenyl)aniline (2_6)



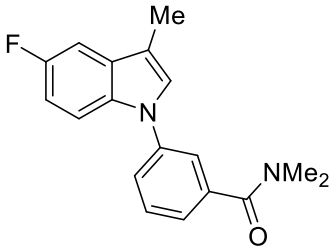
$^{13}C\{^{1}H\}$ NMR



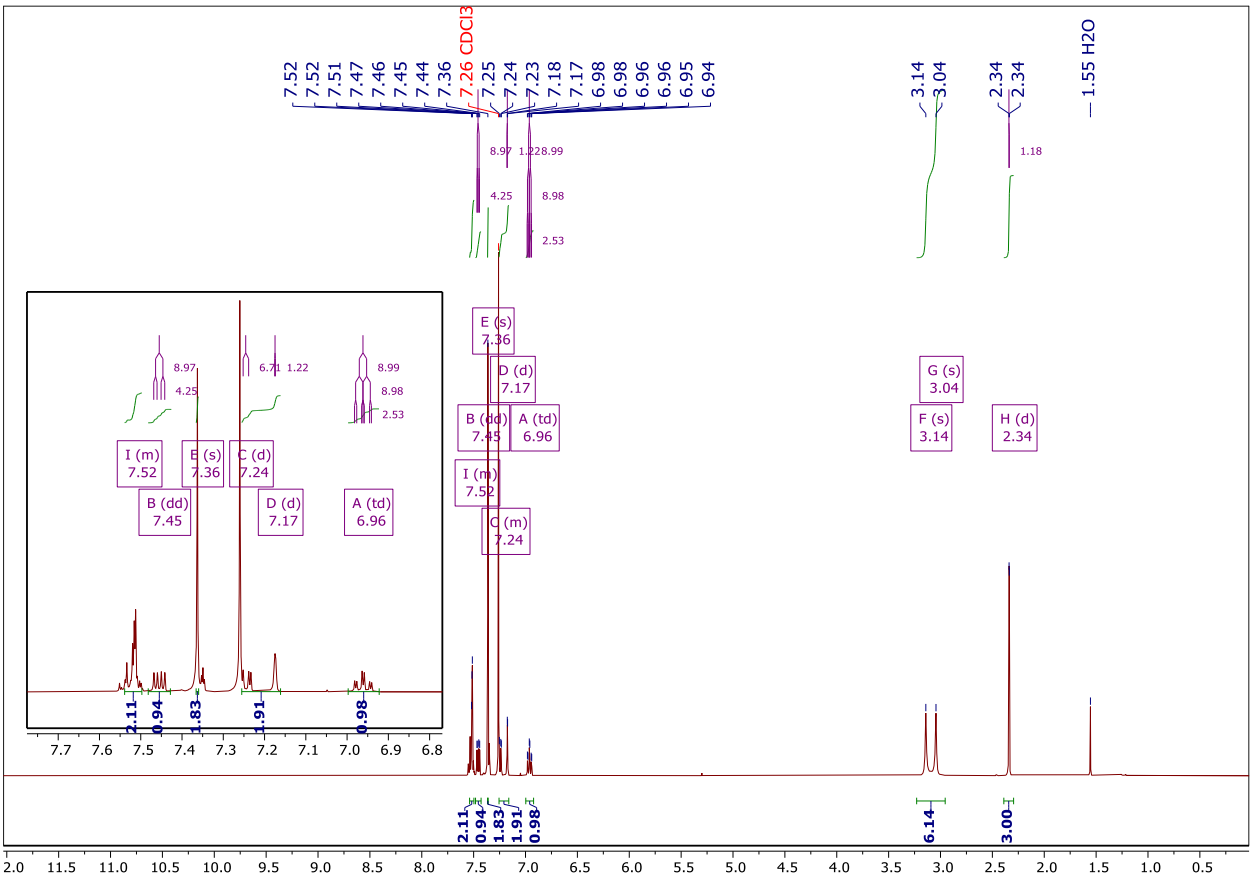
2,6-dimethyl-N-(4-phenoxyphenyl)aniline (2_6)



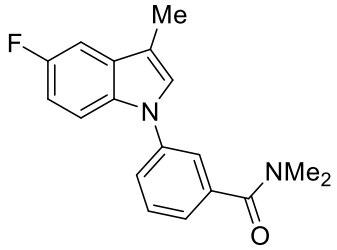
^{1}H NMR



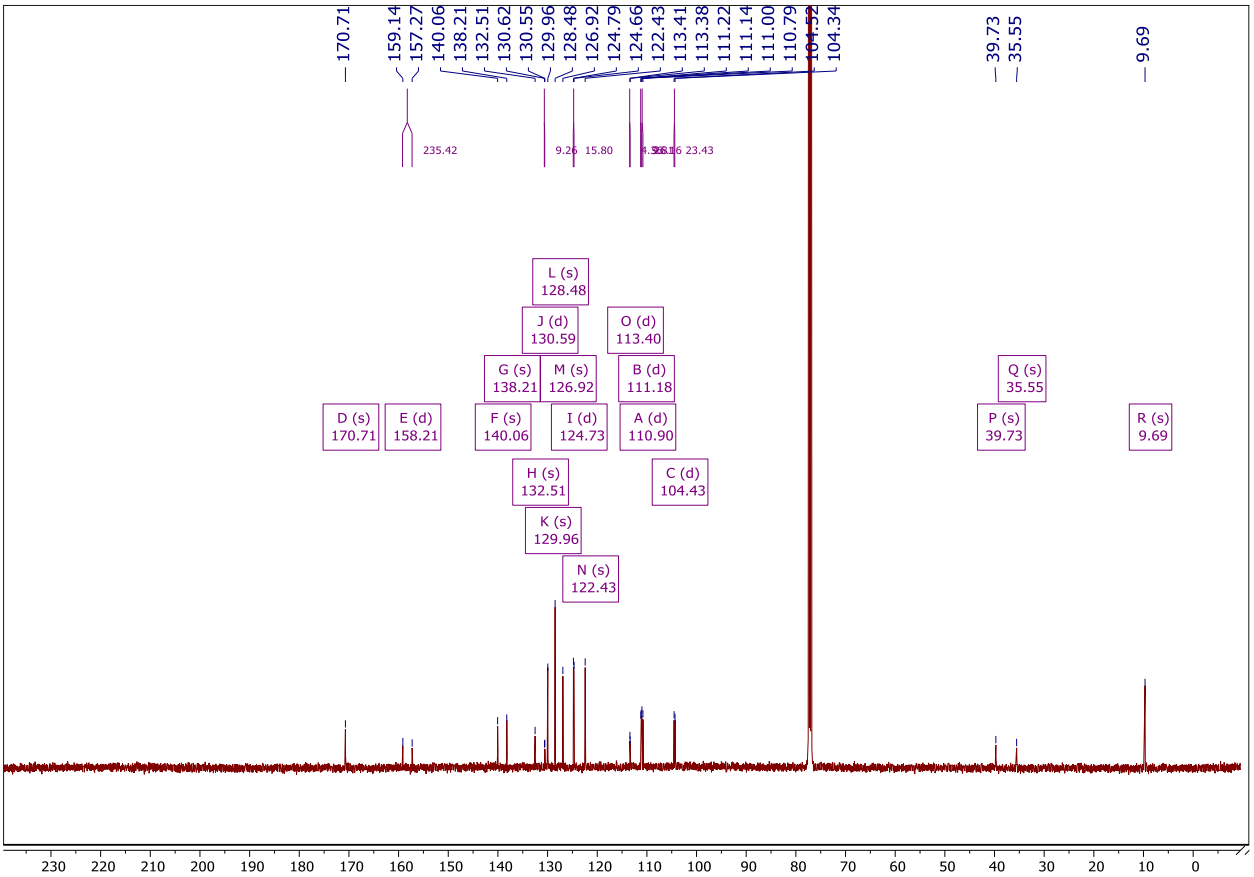
3-(5-fluoro-3-methyl-1H-indol-1-yl)-N,N-dimethylbenzamide (1010_2001)



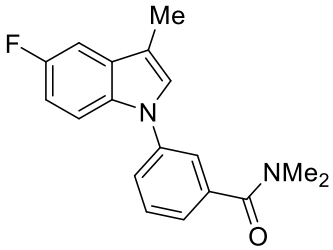
$^{13}C\{^{1}H\}$ NMR



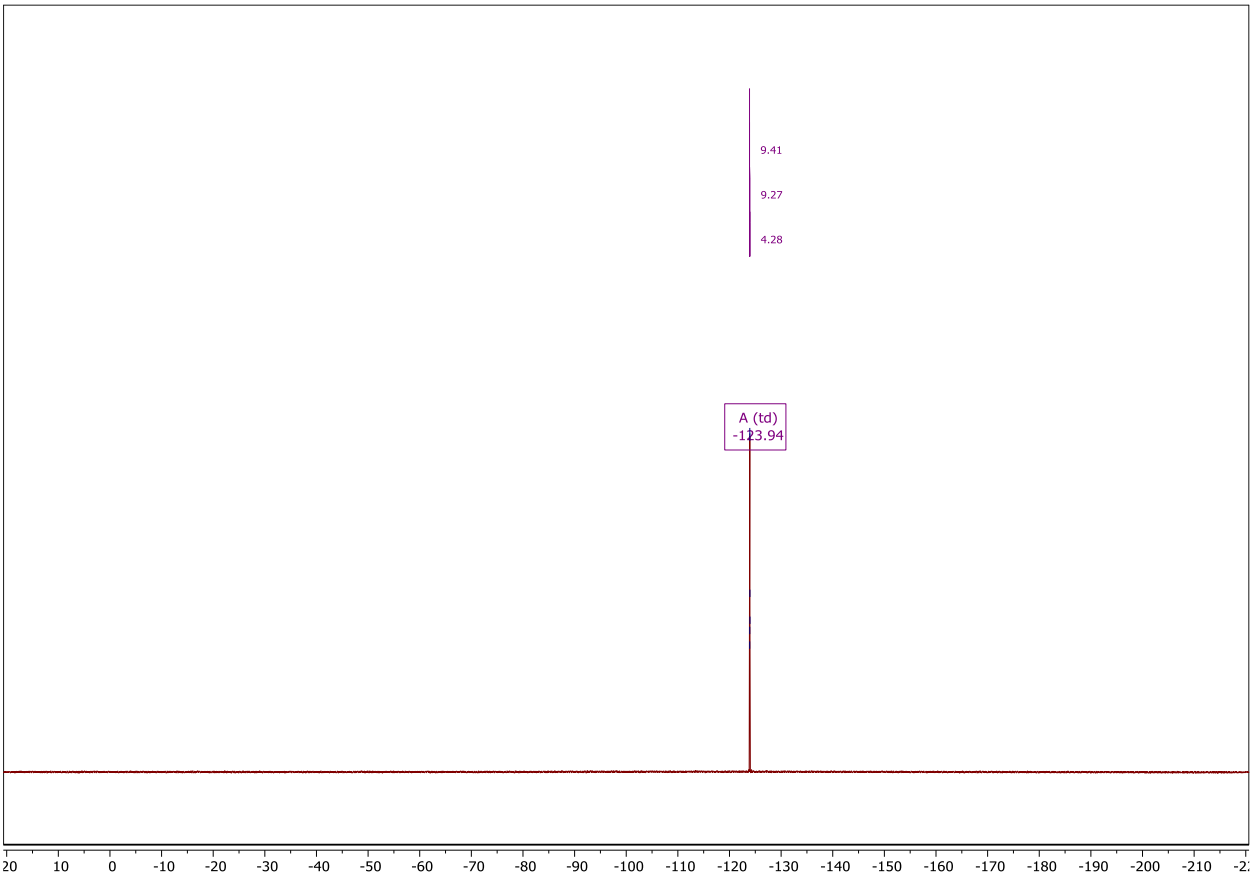
3-(5-fluoro-3-methyl-1H-indol-1-yl)-N,N-dimethylbenzamide (1010_2001)



^{19}F NMR



3-(5-fluoro-3-methyl-1H-indol-1-yl)-N,N-dimethylbenzamide (1010_2001)



References and Notes

1. A. S. Guram, R. A. Rennels, S. L. Buchwald, A Simple catalytic method for the conversion of aryl bromides to arylamines. *Angew. Chem. Int. Ed.* **34**, 1348–1350 (1995). doi:10.1002/anie.199513481

2. J. Louie, J. F. Hartwig, Palladium-catalyzed synthesis of arylamines from aryl halides. Mechanistic studies lead to coupling in the absence of tin reagents. *Tetrahedron Lett.* **36**, 3609–3612 (1995). doi:10.1016/0040-4039(95)00605-C

3. P. Ruiz-Castillo, S. L. Buchwald, Applications of palladium-catalyzed C–N cross-coupling reactions. *Chem. Rev.* **116**, 12564–12649 (2016). doi:10.1021/acs.chemrev.6b00512 Medline

4. J. F. Hartwig, K. H. Shaughnessy, S. Shekhar, R. A. Green, "Palladium-catalyzed amination of aryl halides" in vol. 100 of *Organic Reactions*, S. E. Denmark, Ed. (Wiley, 2019), pp. 853–958.

5. R. J. Lundgren, M. Stradiotto, Addressing challenges in palladium-catalyzed cross-coupling reactions through ligand design. *Chemistry* **18**, 9758–9769 (2012). doi:10.1002/chem.201201195 Medline

6. B. T. Ingoglia, C. C. Wagen, S. L. Buchwald, Biaryl monophosphine ligands in palladium-catalyzed C–N coupling: An updated user's guide. *Tetrahedron* **75**, 4199–4211 (2019). doi:10.1016/j.tet.2019.05.003 Medline

7. M. Fitzner, G. Wuitschik, R. J. Koller, J.-M. Adam, T. Schindler, J.-L. Reymond, What can reaction databases teach us about Buchwald-Hartwig cross-couplings? *Chem. Sci.* **11**, 13085–13093 (2020). doi:10.1039/D0SC04074F Medline

8. D. S. Surry, S. L. Buchwald, Dialkylbiaryl phosphines in Pd-catalyzed amination: A user's guide. *Chem. Sci.* **2**, 27–50 (2011). doi:10.1039/C0SC00331J Medline

9. M. D. Charles, P. Schultz, S. L. Buchwald, Efficient pd-catalyzed amination of heteroaryl halides. *Org. Lett.* **7**, 3965–3968 (2005). doi:10.1021/ol0514754 Medline

10. D. Maiti, B. P. Fors, J. L. Henderson, Y. Nakamura, S. L. Buchwald, Palladium-catalyzed coupling of functionalized primary and secondary amines with aryl and heteroaryl halides: Two ligands suffice in most cases. *Chem. Sci.* **2**, 57–68 (2011). doi:10.1039/C0SC00330A Medline

11. E. P. K. Olsen, P. L. Arrechea, S. L. Buchwald, Mechanistic insight leads to a ligand which facilitates the palladium-catalyzed formation of 2-(hetero)arylaminooxazoles and 4-(hetero)arylaminothiazoles. *Angew. Chem. Int. Ed.* **56**, 10569–10572 (2017). doi:10.1002/anie.201705525 Medline

12. A. C. Sather, T. A. Martinot, Data-rich experimentation enables palladium-catalyzed couplings of piperidines and five-membered (hetero)aromatic electrophiles. *Org. Process Res. Dev.* **23**, 1725–1739 (2019). doi:10.1021/acs.oprd.9b00233

13. B. J. Shields, J. Stevens, J. Li, M. Parasram, F. Damani, J. I. M. Alvarado, J. M. Janey, R. P. Adams, A. G. Doyle, Bayesian reaction optimization as a tool for chemical synthesis. *Nature* **590**, 89–96 (2021). doi:10.1038/s41586-021-03213-y Medline

14. F. Häse, L. M. Roch, C. Kreisbeck, A. Aspuru-Guzik, Phoenics: A Bayesian optimizer for chemistry. *ACS Cent. Sci.* **4**, 1134–1145 (2018). doi:10.1021/acscentsci.8b00307 Medline

15. D. T. Ahneman, J. G. Estrada, S. Lin, S. D. Dreher, A. G. Doyle, Predicting reaction performance in C–N cross-coupling using machine learning. *Science* **360**, 186–190 (2018). doi:10.1126/science.aar5169 Medline

16. K. D. Collins, F. Glorius, Intermolecular reaction screening as a tool for reaction evaluation. *Acc. Chem. Res.* **48**, 619–627 (2015). doi:10.1021/ar500434f Medline

17. P. Schwaller, A. C. Vaucher, T. Laino, J.-L. Reymond, Prediction of chemical reaction yields using deep learning. *Mach. Learn. Sci. Technol.* **2**, 015016 (2021). doi:10.1088/2632-2153/abc81d

18. T. R. Gimadiev, A. Lin, V. A. Afonina, D. Batyrshin, R. I. Nugmanov, T. Akhmetshin, P. Sidorov, N. Duybankova, J. Verhoeven, J. Wegner, H. Ceulemans, A. Gedich, T. I. Madzhidov, A. Varnek, Reaction data curation I: Chemical structures and transformations standardization. *Mol. Inform.* **40**, e2100119 (2021). doi:10.1002/minf.202100119 Medline

19. J. Li, M. D. Eastgate, Making better decisions during synthetic route design: Leveraging prediction to achieve greenness-by-design. *React. Chem. Eng.* **4**, 1595–1607 (2019). doi:10.1039/C9RE00019D

20. M. Fitzner, G. Wuitschik, R. Koller, J.-M. Adam, T. Schindler, Machine learning C–N couplings: Obstacles for a general-purpose reaction yield prediction. *ACS Omega* **8**, 3017–3025 (2023). doi:10.1021/acsomega.2c05546 Medline

21. N. I. Rinehart, R. K. Saunthwal, J. Wellauer, A. F. Zahrt, L. Schlemper, A. S. Shved, R. Bigler, S. Fantasia, S. E. Denmark, Development and validation of a chemoinformatic workflow for predicting reaction yield for Pd-catalyzed C–N couplings with substrate generalizability. chemRxiv chemrxiv-2022-hspvw-v2 [Preprint] (2023); https://doi.org/10.26434/chemrxiv-2022-hspwv-v2.

22. E. Shim, J. A. Kammeraad, Z. Xu, A. Tewari, T. Cernak, P. M. Zimmerman, Predicting reaction conditions from limited data through active transfer learning. *Chem. Sci.* **13**, 6655–6668 (2022). doi:10.1039/D1SC06932B Medline

23. N. H. Angello, V. Rathore, W. Beker, A. Wołos, E. R. Jira, R. Roszak, T. C. Wu, C. M. Schroeder, A. Aspuru-Guzik, B. A. Grzybowski, M. D. Burke, Closed-loop optimization of general reaction conditions for heteroaryl Suzuki-Miyaura coupling. *Science* **378**, 399–405 (2022). doi:10.1126/science.adc8743 Medline

24. A. Buitrago Santanilla, E. L. Regalado, T. Pereira, M. Shevlin, K. Bateman, L.-C. Campeau, J. Schneeweis, S. Berritt, Z.-C. Shi, P. Nantermet, Y. Liu, R. Helmy, C. J. Welch, P. Vachal, I. W. Davies, T. Cernak, S. D. Dreher, Organic chemistry. Nanomole-scale high-throughput chemistry for the synthesis of complex molecules. *Science* **347**, 49–53 (2015). doi:10.1126/science.1259203 Medline

25. M. K. Nielsen, D. T. Ahneman, O. Riera, A. G. Doyle, Deoxyfluorination with sulfonyl fluorides: Navigating reaction space with machine learning. *J. Am. Chem. Soc.* **140**, 5004–5008 (2018). doi:10.1021/jacs.8b01523 Medline

26. M. Yamaguchi, K. Suzuki, Y. Sato, K. Manabe, Palladium-catalyzed direct C3-selective arylation of N-unsubstituted indoles with aryl chlorides and triflates. *Org. Lett.* **19**, 5388–5391 (2017). doi:10.1021/acs.orglett.7b02669 Medline

27. S. Basak, S. Dutta, D. Maiti, Accessing C2-functionalized 1,3-(benz)azoles through transition metal-catalyzed C–H activation. *Chemistry* **27**, 10533–10557 (2021). doi:10.1002/chem.202100475 Medline

28. D. S. Surry, S. L. Buchwald, Biaryl phosphane ligands in palladium-catalyzed amination. *Angew. Chem. Int. Ed.* **47**, 6338–6361 (2008). doi:10.1002/anie.200800497 Medline

29. H. Chen, M. Lei, L. Hu, Synthesis of 1-aryl indoles via coupling reaction of indoles and aryl halides catalyzed by CuI/metformin. *Tetrahedron* **70**, 5626–5631 (2014). doi:10.1016/j.tet.2014.06.080

30. S. A. Iqbal, K. Yuan, J. Cid, J. Pahl, M. J. Ingleson, Controlling selectivity in N-heterocycle directed borylation of indoles. *Org. Biomol. Chem.* **19**, 2949–2958 (2021). doi:10.1039/D1OB00018G Medline

31. J.-K. Kwon, J.-H. Lee, T. S. Kim, E. K. Yum, H. J. Park, Diversification of indoles via microwave-assisted ligand-free copper-catalyzed N-arylation. *Bull. Korean Chem. Soc.* **37**, 1927–1933 (2016). doi:10.1002/bkcs.10995

32. A. Shoberu, C.-K. Li, H.-F. Qian, J.-P. Zou, Copper-catalyzed, N-auxiliary group-controlled switchable transannulation/nitration initiated by nitro radicals: Selective synthesis of pyridoquinazolones and 3-nitroindoles. *Org. Chem. Front.* **8**, 5821–5830 (2021). doi:10.1039/D1QO01141C

33. N. I. Rinehart, Substrate-adaptive C–N coupling yield prediction. Zenodo (2023); https://doi.org/10.5281/zenodo.8185014.

34. A. Gangjee, R. Devraj, F.-T. Lin, Synthesis of 2,4-diamino-5,10-dideaza nonclassical antifolates. *J. Heterocycl. Chem.* **28**, 1747–1751 (1991). doi:10.1002/jhet.5570280717

35. A. N. Butkevich, V. N. Belov, K. Kolmakov, V. V. Sokolov, H. Shojaei, S. C. Sidenstein, D. Kamin, J. Matthias, R. Vlijm, J. Engelhardt, S. W. Hell, Hydroxylated fluorescent dyes for live-cell labeling: Synthesis, spectra and super-resolution STED. *Chemistry* **23**, 12114–12119 (2017). doi:10.1002/chem.201701216 Medline

36. H.-G. Cheng, L.-Q. Lu, T. Wang, Q.-Q. Yang, X.-P. Liu, Y. Li, Q.-H. Deng, J.-R. Chen, W.-J. Xiao, Highly enantioselective Friedel-Crafts alkylation/N-hemiacetalization cascade reaction with indoles. *Angew. Chem. Int. Ed.* **52**, 3250–3254 (2013). doi:10.1002/anie.201209998 Medline

37. M. E. Muratore, C. A. Holloway, A. W. Pilling, R. I. Storer, G. Trevitt, D. J. Dixon, Enantioselective Brønsted acid-catalyzed N-acyliminium cyclization cascades. *J. Am. Chem. Soc.* **131**, 10796–10797 (2009). doi:10.1021/ja9024885 Medline

38. M. Miyashita, A. Yoshikoshi, P. A. Grieco, Pyridinium *p*-toluenesulfonate. A mild and efficient catalyst for the tetrahydropyranylation of alcohols. *J. Org. Chem.* **42**, 3772–3774 (1977). doi:10.1021/jo00443a038

39. S. J. Barraza, S. E. Denmark, Synthesis, reactivity, functionalization, and ADMET properties of silicon-containing nitrogen heterocycles. *J. Am. Chem. Soc.* **140**, 6668–6684 (2018). doi:10.1021/jacs.8b03187 Medline

40. A. L. Johnson, W. A. Price, P. C. Wong, R. F. Vavala, J. M. Stump, Synthesis and pharmacology of the potent angiotensin-converting enzyme inhibitor *N*-[1(*S*)-(ethoxycarbonyl)-3-phenylpropyl]-(*S*)-alanyl-(*S*)-pyroglutamic acid. *J. Med. Chem.* **28**, 1596–1602 (1985). doi:10.1021/jm00149a009 Medline

41. A. F. Zahrt, J. J. Henle, S. E. Denmark, Cautionary guidelines for machine learning studies with combinatorial datasets. *ACS Comb. Sci.* **22**, 586–591 (2020). doi:10.1021/acscombsci.0c00118 Medline

42. P. Virtanen, R. Gommers, T. E. Oliphant, M. Haberland, T. Reddy, D. Cournapeau, E. Burovski, P. Peterson, W. Weckesser, J. Bright, S. J. van der Walt, M. Brett, J. Wilson, K. J. Millman, N. Mayorov, A. R. J. Nelson, E. Jones, R. Kern, E. Larson, C. J. Carey, İ. Polat, Y. Feng, E. W. Moore, J. VanderPlas, D. Laxalde, J. Perktold, R. Cimrman, I. Henriksen, E. A. Quintero, C. R. Harris, A. M. Archibald, A. H. Ribeiro, F. Pedregosa, P. van Mulbregt; SciPy 1.0 Contributors, SciPy 1.0: Fundamental algorithms for scientific computing in Python. *Nat. Methods* **17**, 261–272 (2020). doi:10.1038/s41592-019-0686-2 Medline

43. C. R. Harris, K. J. Millman, S. J. van der Walt, R. Gommers, P. Virtanen, D. Cournapeau, E. Wieser, J. Taylor, S. Berg, N. J. Smith, R. Kern, M. Picus, S. Hoyer, M. H. van Kerkwijk, M. Brett, A. Haldane, J. F. Del Río, M. Wiebe, P. Peterson, P. Gérard-Marchant, K. Sheppard, T. Reddy, W. Weckesser, H. Abbasi, C. Gohlke, T. E. Oliphant, Array programming with NumPy. *Nature* **585**, 357–362 (2020). doi:10.1038/s41586-020-2649-2 Medline

44. TensorFlow (2022); https://www.tensorflow.org/.

45. keras-team, KerasTuner (2022); https://github.com/keras-team/keras-tuner [accessed 9 August 2022].

46. F. Pedregosa, G. Varoquaux, A. Gramfort, V. Michel, B. Thirion, O. Grisel, M. Blondel, P. Prettenhofer, R. Weiss, V. Dubourg, J. Vanderplas, A. Passos, D. Cournapeau, M. Brucher, M. Perrot, É. Duchesnay, Scikit-Learn: Machine learning in Python. *J. Mach. Learn. Res.* **12**, 2825–2830 (2011).

47. J. J. Henle, A. F. Zahrt, B. T. Rose, W. T. Darrow, Y. Wang, S. E. Denmark, Development of a computer-guided workflow for catalyst optimization. Descriptor validation, subset selection, and training set analysis. *J. Am. Chem. Soc.* **142**, 11578–11592 (2020). doi:10.1021/jacs.0c04715 Medline

48. A. F. Zahrt, J. J. Henle, B. T. Rose, Y. Wang, W. T. Darrow, S. E. Denmark, Prediction of higher-selectivity catalysts by computer-driven workflow and machine learning. *Science* **363**, eaau5631 (2019). doi:10.1126/science.aau5631 Medline

49. S. Grimme, Exploration of chemical compound, conformer, and reaction space with meta-dynamics simulations based on tight-binding quantum chemical calculations. *J. Chem. Theory Comput.* **15**, 2847–2862 (2019). doi:10.1021/acs.jctc.9b00143 Medline

50. C. Bannwarth, E. Caldeweyher, S. Ehlert, A. Hansen, P. Pracht, J. Seibert, S. Spicher, S. Grimme, Extended tight-binding quantum chemistry methods. *Wiley Interdiscip. Rev. Comput. Mol. Sci.* **11**, e1493 (2021). doi:10.1002/wcms.1493

51. K. V. Chuang, M. J. Keiser, Comment on "Predicting reaction performance in C–N cross-coupling using machine learning". *Science* **362**, eaat8603 (2018). doi:10.1126/science.aat8603 Medline

52. J. G. Estrada, D. T. Ahneman, R. P. Sheridan, S. D. Dreher, A. G. Doyle, Response to comment on "Predicting reaction performance in C–N cross-coupling using machine learning". *Science* **362**, eaat8763 (2018). doi:10.1126/science.aat8763 Medline

53. As a possible explanation, some products may form exciplexes at concentrations reached during high-performance liquid chromatography (HPLC) separation and ultraviolet (UV) detection. This effect should lead to nonlinearity between product-to-standard mol ratio and absorbance ratios with a lower measured absorbance than a linear function would predict at higher product concentrations. In practice, most products in this work showed some nonlinearity, and a second-order polynomial was used for calibration curves.

54. A. J. DeAngelis, P. G. Gildner, R. Chow, T. J. Colacot, Generating active "L-Pd(0)" via neutral or cationic π-allylpalladium complexes featuring biaryl/bipyrazolylphosphines: Synthetic, mechanistic, and structure-activity studies in challenging cross-coupling reactions. *J. Org. Chem.* **80**, 6794–6813 (2015). doi:10.1021/acs.joc.5b01005 Medline

55. N. C. Bruno, M. T. Tudge, S. L. Buchwald, Design and preparation of new palladium precatalysts for C–C and C–N cross-coupling reactions. *Chem. Sci.* **4**, 916–920 (2013). doi:10.1039/C2SC20903A Medline

56. N. H. Park, E. V. Vinogradova, D. S. Surry, S. L. Buchwald, Design of new ligands for the palladium-catalyzed arylation of α-branched secondary amines. *Angew. Chem. Int. Ed.* **54**, 8259–8262 (2015). doi:10.1002/anie.201502626 Medline

57. G. A. Grasa, M. S. Viciu, J. Huang, S. P. Nolan, Amination reactions of aryl halides with nitrogen-containing reagents mediated by palladium/imidazolium salt systems. *J. Org. Chem.* **66**, 7729–7737 (2001). doi:10.1021/jo010613+ Medline

58. S. Ueda, S. L. Buchwald, Catalyst-controlled chemoselective arylation of 2-aminobenzimidazoles. *Angew. Chem. Int. Ed.* **51**, 10364–10367 (2012). doi:10.1002/anie.201204710 Medline

59. P. Ruiz-Castillo, D. G. Blackmond, S. L. Buchwald, Rational ligand design for the arylation of hindered primary amines guided by reaction progress kinetic analysis. *J. Am. Chem. Soc.* **137**, 3085–3092 (2015). doi:10.1021/ja512903g Medline

60. C. Yuan, L. Zhang, Y. Zhao, Cu(II)-catalyzed C–N coupling of (hetero)aryl halides and *N*-nucleophiles promoted by α-benzoin oxime. *Molecules* **24**, 4177 (2019). doi:10.3390/molecules24224177 Medline

61. B. P. Fors, K. Dooleweerdt, Q. Zeng, S. L. Buchwald, An efficient system for the Pd-catalyzed cross-coupling of amides and aryl chlorides. *Tetrahedron* **65**, 6576–6583 (2009). doi:10.1016/j.tet.2009.04.096 Medline

62. A. Gangjee, O. A. Namjoshi, S. Raghavan, S. F. Queener, R. L. Kisliuk, V. Cody, Design, synthesis, and molecular modeling of novel pyrido[2,3-d]pyrimidine analogues as antifolates; Application of Buchwald-Hartwig aminations of heterocycles. *J. Med. Chem.* **56**, 4422–4441 (2013). doi:10.1021/jm400086g Medline

63. G. Song, L. Yang, J.-S. Li, W.-J. Tang, W. Zhang, R. Cao, C. Wang, J. Xiao, D. Xue, Chiral arylated amines via C–N coupling of chiral amines with aryl bromides promoted by light. *Angew. Chem. Int. Ed.* **60**, 21536–21542 (2021). doi:10.1002/anie.202108587 Medline

64. J. Duan, P. Y. Choy, K. B. Gan, F. Y. Kwong, *N*-Difluoromethylation of *N*-pyridyl-substituted anilines with ethyl bromodifluoroacetate. *Org. Biomol. Chem.* **20**, 1883–1887 (2022). doi:10.1039/D2OB00119E Medline

65. J. Shao, X. Huang, S. Wang, B. Liu, B. Xu, A straightforward synthesis of *N*-monosubstituted α-keto amides via aerobic benzylic oxidation of amides. *Tetrahedron* **68**, 573–579 (2012). doi:10.1016/j.tet.2011.11.005

66. V. Soni, U. N. Patel, B. Punji, Metal-free regioselective C-3 acetoxylation of *N*-substituted indoles: Crucial impact of nitrogensubstituent. *RSC Advances* **5**, 57472–57481 (2015). doi:10.1039/C5RA10428A

67. R. J. Key, A. K. Vannucci, Nickel dual photoredox catalysis for the synthesis of aryl amines. *Organometallics* **37**, 1468–1472 (2018). doi:10.1021/acs.organomet.8b00121

68. C. A. Malapit, N. Ichiishi, M. S. Sanford, Pd-Catalyzed decarbonylative cross-couplings of aroyl chlorides. *Org. Lett.* **19**, 4142–4145 (2017). doi:10.1021/acs.orglett.7b02024 Medline

69. Z. Chen, H. Zeng, S. A. Girard, F. Wang, N. Chen, C.-J. Li, Formal direct cross-coupling of phenols with amines. *Angew. Chem. Int. Ed.* **54**, 14487–14491 (2015). doi:10.1002/anie.201506751 Medline

70. M. O. Akram, A. Das, I. Chakrabarty, N. T. Patil, Ligand-enabled gold-catalyzed C(sp^2)-N cross-coupling reactions of aryl iodides with amines. *Org. Lett.* **21**, 8101–8105 (2019). doi:10.1021/acs.orglett.9b03082 Medline

71. G. Manolikakes, A. Gavryushin, P. Knochel, An efficient silane-promoted nickel-catalyzed amination of aryl and heteroaryl chlorides. *J. Org. Chem.* **73**, 1429–1434 (2008). doi:10.1021/jo702219f Medline

72. M. P. Groziak, S. R. Wilson, G. L. Clauson, N. J. Leonard, Fluorescent heterocyclic systems: Syntheses, structures, and physicochemical properties of dipyrido-substituted 1,3,4,6-tetraazapentalenes. *J. Am. Chem. Soc.* **108**, 8002–8006 (1986). doi:10.1021/ja00285a020

73. K. Saito, H. Miyashita, T. Akiyama, Asymmetric transfer hydrogenation of ketimines by indoline as recyclable hydrogen donor. *Org. Lett.* **16**, 5312–5315 (2014). doi:10.1021/ol502486f Medline

74. T. Akiyama, K. Saito, S. Janczak, Z. J. Lesnikowski, Phosphoric acid bridged cobalt bis(dicarbollide) ion as a highly efficient catalyst for the organocatalytic hydrogenation of ketimines. *Synlett* **25**, 795–798 (2014). doi:10.1055/s-0033-1340847

75. A. Mital, D. Murugesan, M. Kaiser, C. Yeates, I. H. Gilbert, Discovery and optimisation studies of antimalarial phenotypic hits. *Eur. J. Med. Chem.* **103**, 530–538 (2015). doi:10.1016/j.ejmech.2015.08.044 Medline

76. D. Murugesan, A. Mital, M. Kaiser, D. M. Shackleford, J. Morizzi, K. Katneni, M. Campbell, A. Hudson, S. A. Charman, C. Yeates, I. H. Gilbert, Discovery and structure-activity relationships of pyrrolone antimalarials. *J. Med. Chem.* **56**, 2975–2990 (2013). doi:10.1021/jm400009c Medline

77. N. V. Shevchuk, K. Liubchak, K. G. Nazarenko, A. A. Yurchenko, D. M. Volochnyuk, O. O. Grygorenko, A. A. Tolmachev, A convenient synthesis of (1*H*-azol-1-yl)piperidines. *Synthesis* **44**, 2041–2048 (2012). doi:10.1055/s-0031-1291126

78. C. E. Coomber, V. Laserna, L. T. Martin, P. D. Smith, H. C. Hailes, M. J. Porter, T. D. Sheppard, Catalytic direct amidations in *tert*-butyl acetate using $B(OCH_2CF_3)_3$. *Org. Biomol. Chem.* **17**, 6465–6469 (2019). doi:10.1039/C9OB01012B Medline

79. T. N. Ansari, A. Taussat, A. H. Clark, M. Nachtegaal, S. Plummer, F. Gallou, S. Handa, Insights on bimetallic micellar nanocatalysis for Buchwald–Hartwig aminations. *ACS Catal.* **9**, 10389–10397 (2019). doi:10.1021/acscatal.9b02622

80. Y. Zhao, S. Zhang, Y. Yamamoto, M. Bao, T. Jin, M. Terada, Heterogeneous catalytic reduction of tertiary amides with hydrosilanes using unsupported nanoporous gold catalyst. *Adv. Synth. Catal.* **361**, 4817–4824 (2019). doi:10.1002/adsc.201900838

81. K. P. Jayasundera, T. G. W. Engels, D. J. Lun, M. N. Mungalpara, P. G. Plieger, G. J. Rowlands, The synthesis of planar chiral *pseudo-gem* aminophosphine pre-ligands based on [2.2]paracyclophane. *Org. Biomol. Chem.* **15**, 8975–8984 (2017). doi:10.1039/C7OB02393F Medline

82. L. Alakonda, M. Periasamy, Simple and convenient methods for N-arylation of heterocycles and diphenylamine. *Synthesis* **44**, 1063–1068 (2012). doi:10.1055/s-0031-1290162

83. D. Cheng, F. Gan, W. Qian, W. Bao, D-Glucosamine—A natural ligand for the *N*-arylation of imidazoles with aryl and heteroaryl bromides catalyzed by CuI. *Green Chem.* **10**, 171–173 (2008). doi:10.1039/B713658G

84. B. Weng, J.-H. Li, Betti base-derived tetradentate ligand: Synthesis and application in copper-catalyzed *N*-arylation of imidazoles. *Appl. Organomet. Chem.* **23**, 375–378 (2009). doi:10.1002/aoc.1529

85. C.-H. Lim, M. Kudisch, B. Liu, G. M. Miyake, C–N cross-coupling via photoexcitation of nickel-amine complexes. *J. Am. Chem. Soc.* **140**, 7667–7673 (2018). doi:10.1021/jacs.8b03744 Medline

86. G. L. Beutner, J. R. Coombs, R. A. Green, B. Inankur, D. Lin, J. Qiu, F. Roberts, E. M. Simmons, S. R. Wisniewski, Palladium-catalyzed amidation and amination of (hetero)aryl hlorides under homogeneous conditions enabled by a soluble DBU/NaTFA dual-base system. *Org. Process Res. Dev.* **23**, 1529–1537 (2019). doi:10.1021/acs.oprd.9b00196

87. B. R. Trowse, F. P. Byrne, J. Sherwood, P. O'Brien, J. Murray, T. Farmer, 2,2,5,5-Tetramethyloxolane (TMO) as a solvent for Buchwald–Hartwig aminations. *ACS Sustain. Chem. Eng.* **9**, 17330–17337 (2021). doi:10.1021/acssuschemeng.1c06292

88. Y. Chen, F. Du, F. Chen, Q. Zhou, G. Chen, Methyl-α-D-glucopyranoside as green ligand for selective copper-catalyzed N-arylation. *Synthesis* **51**, 4590–4600 (2019). doi:10.1055/s-0039-1690702

89. X.-L. Zhang, R.-L. Guo, M.-Y. Wang, B.-Y. Zhao, Q. Jia, J.-H. Yang, Y.-Q. Wang, Palladium-catalyzed three-component regioselective dehydrogenative coupling of indoles, 2-methylbut-2-ene, and carboxylic acids. *Org. Lett.* **23**, 9574–9579 (2021). doi:10.1021/acs.orglett.1c03776 Medline

90. C. A. Malapit, M. Borrell, M. W. Milbauer, C. E. Brigham, M. S. Sanford, Nickel-catalyzed decarbonylative amination of carboxylic acid esters. *J. Am. Chem. Soc.* **142**, 5918–5923 (2020). doi:10.1021/jacs.9b13531 Medline

91. A. H. Sommers, S. E. Aaland, The reaction of 1,5-dibromopentane with *o*-substituted anilines. The synthesis of 1-arylpiperi dines. *J. Am. Chem. Soc.* **75**, 5280–5283 (1953). doi:10.1021/ja01117a041

92. T. Mino, Y. Harada, H. Shindo, M. Sakamoto, T. Fujita, Copper-catalyzed N-arylation of amides and azoles using phosphine-free hydrazone ligands. *Synlett* **2008**, 614–620 (2008). doi:10.1055/s-2008-1042763

93. X. Yang, H. Xing, Y. Zhang, Y. Lai, Y. Zhang, Y. Jiang, D. Ma, CuI/8-hydroxyquinalidine promoted N-arylation of indole and azoles. *Chin. J. Chem.* **30**, 875–880 (2012). doi:10.1002/cjoc.201100433

94. J. D. Grayson, F. M. Dennis, C. C. Robertson, B. M. Partridge, Chan-Lam amination of secondary and tertiary benzylic boronic esters. *J. Org. Chem.* **86**, 9883–9897 (2021). doi:10.1021/acs.joc.1c00976 Medline

95. V. Skrypai, S. E. Varjosaari, F. Azam, T. M. Gilbert, M. J. Adler, Chiral Brønsted acid-catalyzed metal-free asymmetric direct reductive amination using 1-hydrosilatrane. *J. Org. Chem.* **84**, 5021–5026 (2019). doi:10.1021/acs.joc.8b03073 Medline

96. J. H. Pang, A. Kaga, S. Chiba, Nucleophilic amination of methoxypyridines by a sodium hydride-iodide composite. *Chem. Commun.* **54**, 10324–10327 (2018). doi:10.1039/C8CC05979A Medline