Supporting Information

Visible-Light Palladium Catalysis for Alkylated and Difluoroalkylated Pyrazolones

Anindya Das[a], Lennard Kloene,[b] Sneha Chandra,[a] Rene M. Koenigs*[b], and Sandip Murarka*[a]

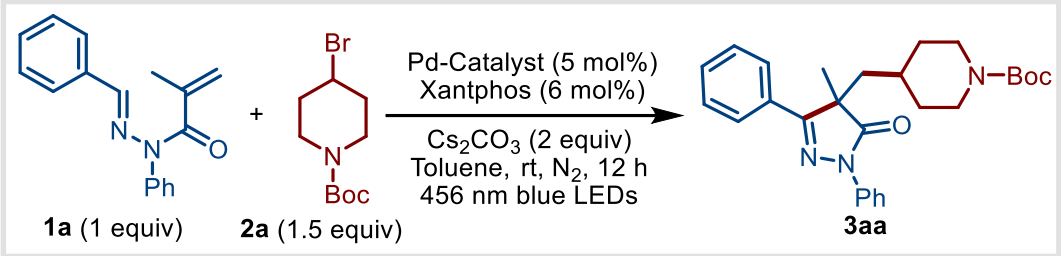
[a]Department of Chemistry, Indian Institute of Technology Jodhpur, Karwar-342037, Rajasthan, India. Email: sandipmurarka@iitj.ac.in.

[b]Chair of Organic Chemistry II, University of Bayreuth, 95447 Bayreuth, Germany. Email: rene.koenigs@uni-bayreuth.de

Table of Contents

1. Detailed Optimizations-

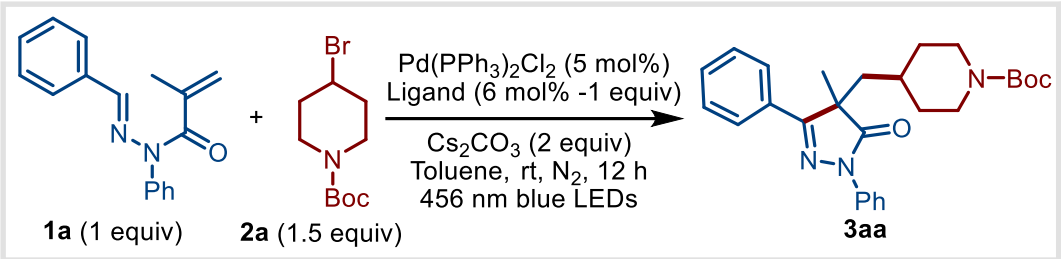
Table-S1 Investigation of catalysts[a]



Sl No.	Pd-Cat (equivalent)	Yield (%)[b]
1	$Pd(PPh_3)_4$ (5 mol%)	35
2	$Pd(OAc)_2$(5 mol%)	trace
3	$PdCl_2(PTol_3)_2$(5 mol%)	ND
4	**$(PPh_3)_2PdCl_2$(5 mol%)**	**36**

[a]Reaction Conditions: **1a** (0.1 mmol, 1 equiv), **2a** (1.5 equiv), Pd-Catalyst (5 mol%), PPh_3 (1 equiv), Cs_2CO_3(2 equiv), and toluene (1 mL) under nitrogen atmosphere using blue LEDs (456 nm) for 12 h. [b]Isolated yield

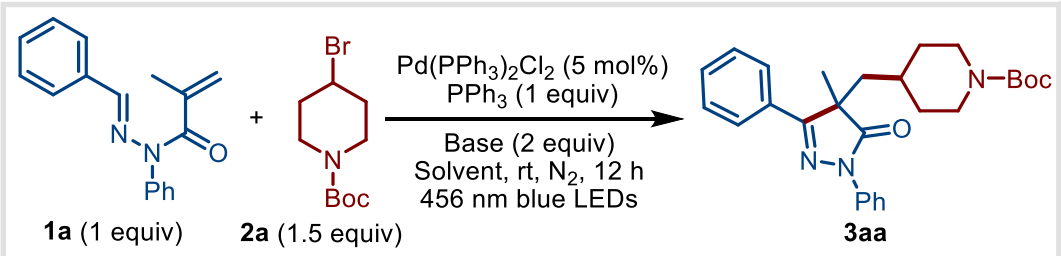
Table-S2 Investigation of ligand[a]



Sl No.	Ligand (equivalent)	Yield (%)[b]
1	Xantphos (6 mol%)	36
2	Ruphos (6 mol%)	ND
3	Rac BINAP (6 mol%)	trace
4	PPh_3 (6 mol%)	31
5	**PPh_3 (1 equiv)**	**78**

[a]Reaction Conditions: **1a** (0.1 mmol, 1 equiv), **2a** (1.5 equiv), $Pd(PPh_3)_2Cl_2$ (5 mol%), ligand (6 mol% -1 equiv), Cs_2CO_3 (2 equiv), and toluene (1 mL) under nitrogen atmosphere using blue LEDs (456 nm) for 12 h. [b]Isolated yield

Table-S3 Investigation of base[a]

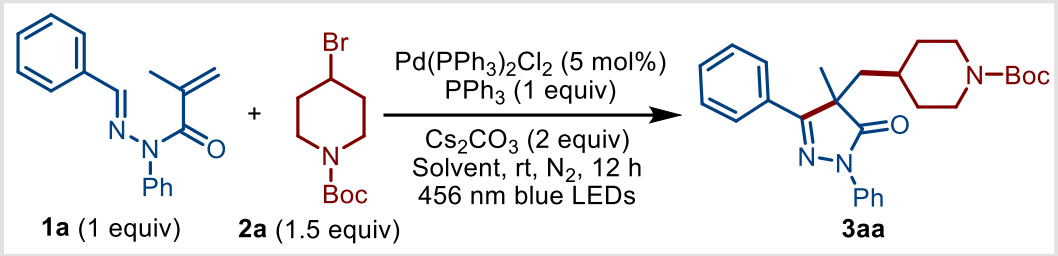


Sl. No.	Base (equivalent)	Yield (%)[b]
1	Na_2CO_3 (2 equiv)	21

2	**Cs_2CO_3 (2 equiv)**	**78**
3	K_3PO_4 (2 equiv)	34
4	Et_3N (2 equiv)	ND
5	DIPEA (2 equiv)	trace
6	2,6 Lutidine (2 equiv)	0

[a]Reaction Conditions: **1a** (0.1 mmol, 1 equiv), **2a** (1.5 equiv), $Pd(PPh_3)_2Cl_2$ (5 mol%), PPh_3 (1 equiv), Base (2 equiv) and toluene (1 mL) under nitrogen atmosphere using blue LEDs (456 nm) for 12 h. [b]Isolated yield

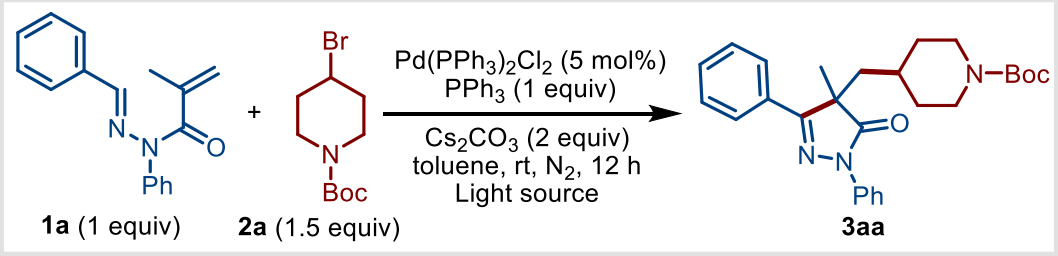
Table-S4 Investigation of solvent[a]



Sl. No.	Solvent	Yield (%)[b]
1	ACN	41
2	DMF	28
3	Benzene	71
4	**Toluene**	**78**
5	DMSO	23
6	DMF: Toluene (1:1)	25
7	ACN: Toluene (1:1)	27
8	DMSO: Toluene (1:1)	21

[a]Reaction Conditions: **1a** (0.1 mmol, 1 equiv), **2a** (1.5 equiv), $Pd(PPh_3)_2Cl_2$ (5 mol%), PPh_3 (1 equiv), Cs_2CO_3 (2 equiv), and solvent (1 mL) under nitrogen atmosphere using blue LEDs (456 nm) for 12 h. [b]Isolated yield

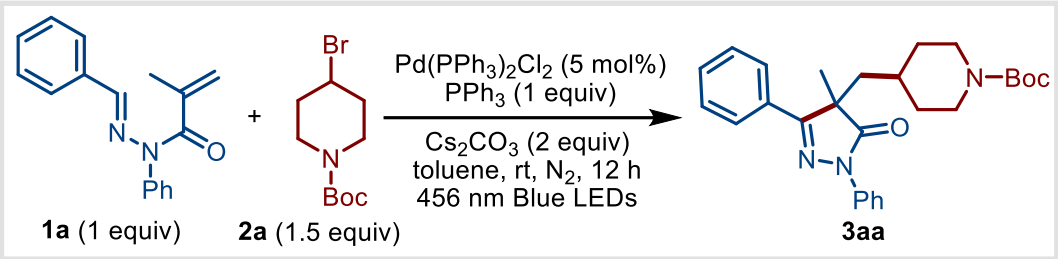
Table-S5 Investigation of light source[a]



Sl. No.	Light source	Yield (%)[b]
1	390 nm	65
2	427 nm	70
3	**456 nm**	**78**
4	467 nm	72
5	525 nm	ND

[a]Reaction Conditions: **1a** (0.1 mmol, 1 equiv), **2a** (1.5 equiv), $Pd(PPh_3)_2Cl_2$ (5 mol%), PPh_3 (1 equiv), Cs_2CO_3 (2 equiv), and toluene (1 mL) under nitrogen atmosphere using blue LEDs for 12 h. [b]Isolated yield

Table-S6 Investigation of stoichiometry[a]

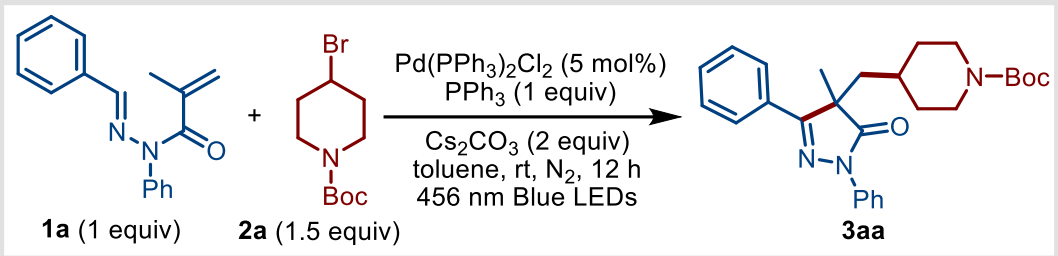


1a (1 equiv) **2a** (1.5 equiv) **3aa**

Sl. No.	Deviation from Standard	Yield (%)[b]
1	0.7 equiv of PPh_3	55
2	3 mol% of $(PPh_3)_2PdCl_2$	58
3	1 mol% of $(PPh_3)_2PdCl_2$	trace
4	1.2 equiv of alkyl bromide	68
5	1 equiv of Cs_2CO_3	19
6	Alkyl iodide instead of bromide	62

[a]Reaction Conditions: **1a** (0.1 mmol, 1 equiv), **2a** (1.5 equiv), $Pd(PPh_3)_2Cl_2$ (1 - 5 mol%), PPh_3 (0.7 - 1 equiv), Cs_2CO_3 (1 - 2 equiv), and toluene (1 mL) under nitrogen atmosphere using blue LEDs (456 nm) for 12 h. [b]Isolated yield

Table-S7 Control experiments[a]

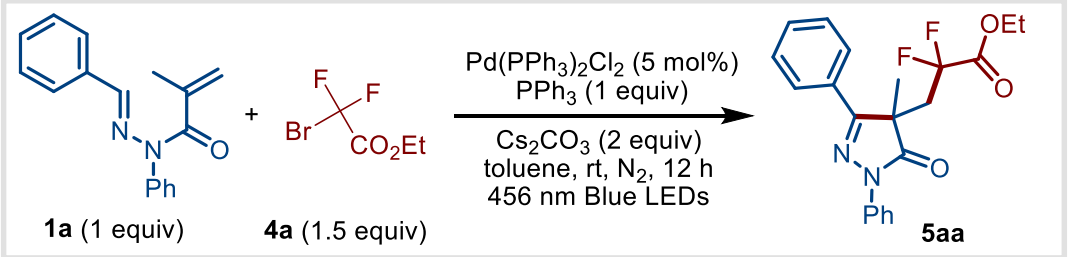


1a (1 equiv) **2a** (1.5 equiv) **3aa**

Sl. No.	Deviation from Standard	Yield (%)[b]
1	**None**	**78**
2	No Catalyst	ND
3	No Ligand	trace
4	Dark	ND
5	No Base	ND
6	In air	35

[a]Standard Reaction Conditions: **1a** (0.1 mmol, 1 equiv), **2a** (1.5 equiv), $Pd(PPh_3)_2Cl_2$ (5 mol%), PPh_3 (1 equiv), Cs_2CO_3 (2 equiv), and toluene (1 mL) under nitrogen atmosphere using blue LEDs (456 nm) for 12 h. [b]Isolated yield

Table-S8 Control experiments for difluoroalkylation reaction[a]



1a (1 equiv) **4a** (1.5 equiv) **5aa**

Sl. No.	Deviation from Standard	Yield (%)[b]
1	**None**	**62**
2	No Catalyst	ND
3	Dark	ND
4	At 0 °C instead of rt	58

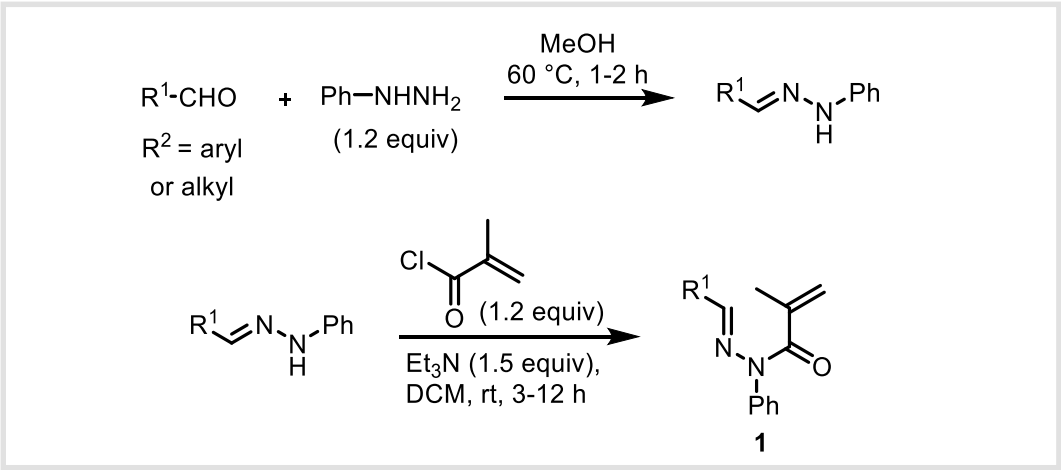
[a]Standard Reaction Conditions: **1a** (0.1 mmol, 1 equiv), **4a** (1.5 equiv), $Pd(PPh_3)_2Cl_2$ (5 mol%), PPh_3 (1 equiv), Cs_2CO_3 (2 equiv), and toluene (1 mL) under nitrogen atmosphere using blue LEDs (456 nm) for 12 h. [b]Isolated yield

2. General Information

Photochemical reactions were performed under a N_2 atmosphere for all the reaction sets using pre-dried glassware and the standard Schlenk technique. All the solvents were obtained from Merck (Emparta grade), dried with calcium hydride, and freshly distilled under Nitrogen. The following starting materials and the reaction components, such as substituted aldehyde, phenyl hydrazine, methacryloyl chloride, alkyl bromides, PPh_3, *N*,*N*'-Dicyclohexylcarbodiimide (DCC), 4-*N*,*N*-dimethylamino-pyridine (DMAP), Triethylamine (Et_3N), K_3PO_4, Cs_2CO_3, DPE, and TEMPO were obtained from commercial sources and used without further purification. *N*′-benzylidene-*N*-phenyl methacrylohydrazide, alkyl halide derivatives were synthesized by the synthetic procedures mentioned below. Yields refer to isolated compounds, estimated to be >95% pure as determined by ^1H NMR and ^{13}C NMR. All optimized reactions were conducted under the photo irradiation using 40W Kessil PR160L (Linear Reflector)- (440-467nm) lamp (Avg. Intensity in 2×4 cm area = 137 mW/cm^2) with 2 cm from the reaction tube made up of borosilicate glass without any filter. Thin layer chromatography (TLC) was performed on Merck pre-coated silica gel 60 F254 aluminum sheets with detection under UV light at 254 nm. Chromatographic separations were carried out on Avra silica gel (100-200 mesh or 230−400 mesh). Nuclear magnetic resonance (NMR) spectroscopy was performed using Bruker 500 MHz spectrometers. Chemical shifts (δ) are provided in ppm if not otherwise specified. HRMS spectra were recorded using Agilent 6500 Q-TOF spectrometer.

3. Preparation of Starting Materials:

3.1 Preparation of (*E*)-*N*'-benzylidene-*N*-phenyl methacrylohydrazide substrates[1]

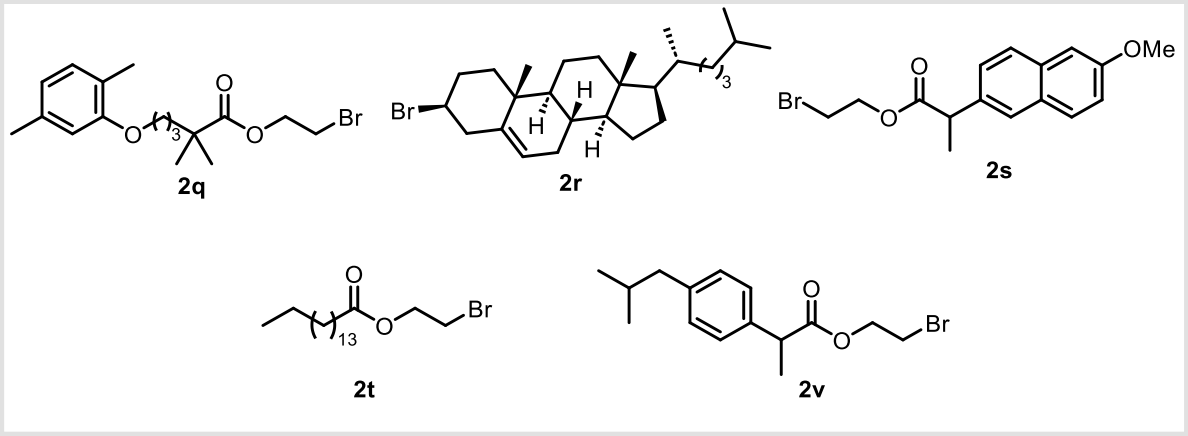


Step-1: A solution of phenyl hydrazine (1.2 equiv) in methanol (0.1 M) was heated to 60 °C using an oil bath until completely dissolved. Then, respective aldehydes (1 equiv) were slowly added to the mixture and heating was continued for another 1-2 h. Afterward, the precipitate crude product was washed with petroleum ether and dried *in vacuo* to afford corresponding *N*-phenyl substituted hydrazones, which were directly used in the next step without further purification.

Step-2: Next, crude mixture of *N*-substituted hydrazones (1 equiv) in DCM, and triethyl amine (1.5 equiv) was cooled to 0 °C followed by dropwise addition of methacryloyl chloride (1.2 equiv). The resulting solution was allowed to come to room temperature and stirring was continued for 3-12 h till the completion of the reaction (confirmed by TLC). Afterward, the solvent was evaporated and the crude mixture was purified via silica gel column chromatography using 20% EtOAc in hexane as eluent to afford the corresponding products **1**.

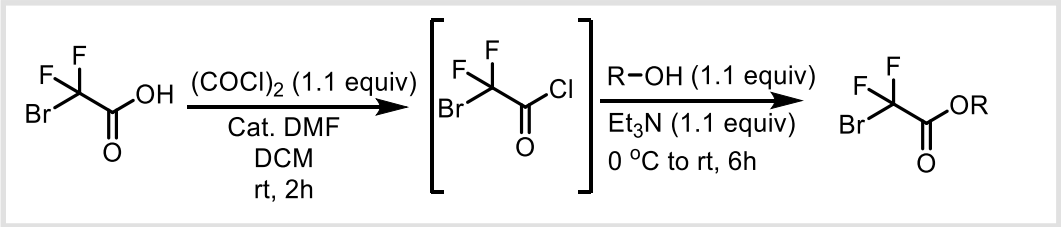
3.2 Preparation of Alkyl halides:

The alkyl halides **2q**,[2] **2r**,[3] **2s**,[4] **2t**,[5] and **2v**[2] were prepared following previous literature procedures, and the obtained characterization data were in alignment with the literature-reported data.



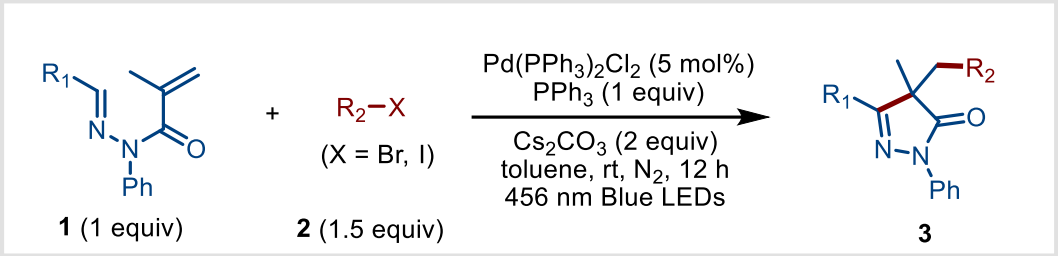
3.3 Preparation of Difluoro-alkyl halide:

The difluoro-alkyl halides were prepared following previous literature procedures, and the characterization data were in alignment with the literature-reported data.[6]



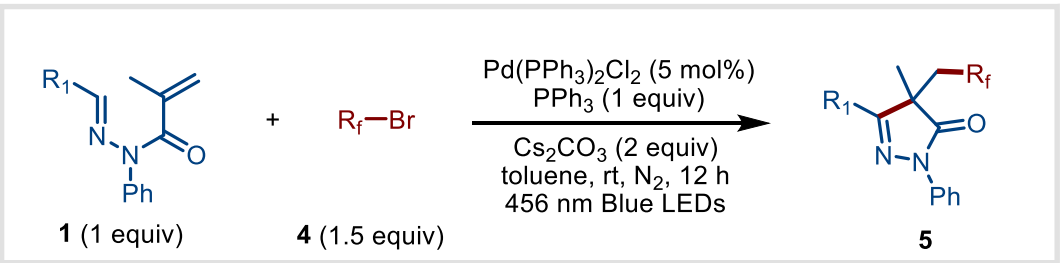
4. General Experimental Procedure:

4.1 General Procedure (GP1) for the Visible Light-Mediated Palladium-Catalyzed Cascade Cyclization of (*E*)-*N*'-benzylidene-*N*-methacryloylhydrazide 1 with Alkyl halide 2:



(*E*)-*N*'-benzylidene-*N*-methacryloyl-hydrazide derivative **1** (0.20 mmol, 1.0 equiv), alkyl halides **2** (0.30 mmol, 1.5 equiv), Cs_2CO_3 (0.40 mmol, 2 equiv), PPh_3 (0.20 mmol, 1.0 equiv), and $Pd(PPh_3)_2Cl_2$ (0.010 mmol, 5 mol%) were added in a pre-dried 10 mL Schlenk tube under N_2 atmosphere. The tube was degassed and purged with N_2 three times. Then, freshly distilled toluene (2 mL) was added under a N_2 atmosphere. The resulting reaction mixture was allowed to stir for 12 h at room temperature under the irradiation of a 40 W Kessil blue LEDs (456 nm) lamp. After completion, the reaction mixture was concentrated under vacuum and purified by silica gel column chromatography using 10-15% ethyl acetate in hexane to afford the desired product **3aa** to **3au**.

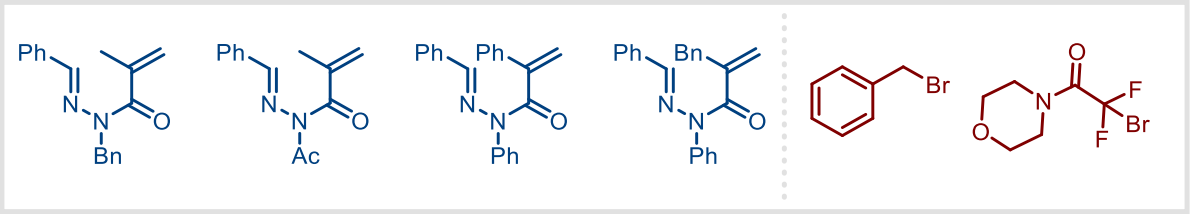
4.2 General Procedure (GP2) for the Visible Light-Mediated Palladium-Catalyzed Cascade Cyclization of (*E*)-*N*'-benzylidene-*N*-methacryloylhydrazide 1 with Difluoroalkyl halide 4:



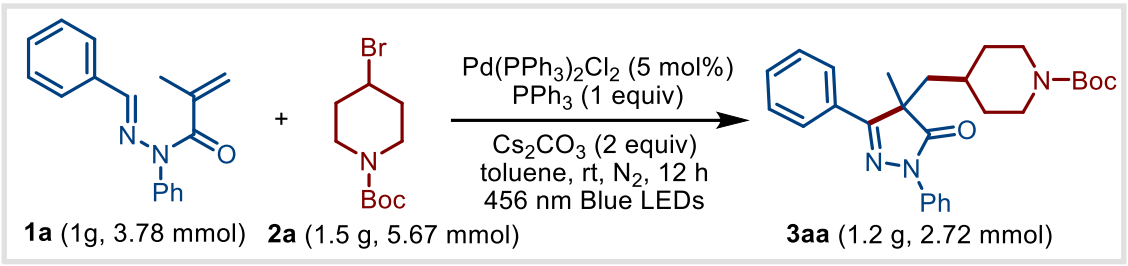
(*E*)-*N*'-benzylidene-*N*-methacryloyl-hydrazide derivative **1** (0.20 mmol, 1.0 equiv), difluoroalkyl halides **4** (0.30 mmol, 1.5 equiv), Cs_2CO_3 (0.40 mmol, 2 equiv), PPh_3 (0.20 mmol, 1.0 equiv), and $Pd(PPh_3)_2Cl_2$ (0.010 mmol, 5 mol%) were added in a pre-dried 10 mL Schlenk tube under N_2 atmosphere. The tube was degassed and purged with N_2 three times. Then, freshly distilled toluene (2 mL) was added under a N_2 atmosphere. The resulting reaction

mixture was allowed to stir for 12 h at room temperature under the irradiation of a 40 W Kessil blue LEDs (456 nm) lamp. After completion, the reaction mixture was concentrated under vacuum and purified by silica gel column chromatography using 10-15% ethyl acetate in hexane to afford the desired product **5aa** to **5ab**.

Unsuccessful Substrates:



5. Gram-Scale Synthesis of 3aa:



(E)-*N'*-benzylidene-*N*-phenylmethacrylohydrazide **1a** (1 g, 3.78 mmol, 1.0 equiv), *tert*-butyl 4-bromopiperidine-1-carboxylate **2a** (1.5 g, 5.67 mmol, 1.5 equiv), Cs_2CO_3 (2.4 g, 7.56 mmol, 2 equiv), PPh_3 (0.9 g, 3.78 mmol, 1.0 equiv), and $Pd(PPh_3)_2Cl_2$ (0.12 g, 0.18 mmol, 5 mol%) were added in a pre-dried 50 mL Schlenk flask under N_2 atmosphere. The flask was degassed and purged with N_2 three times. Then toluene (30 mL) was added under a N_2 atmosphere, and the resulting solution was allowed to stir for 12 h under irradiation of a 40 W Kessil blue LEDs (456 nm) lamp. After completion, the reaction mixture was concentrated under vacuum and purified by silica gel column chromatography using 10 to 15% ethyl acetate in hexane to afford *tert*-butyl-4-((4-methyl-5-oxo-1,3-diphenyl-4,5-dihydro-1H-pyrazol-4-yl)methyl)piperidine-1-carboxylate **3aa** (1.2 g, 72%).

6. Image of the photoinduced reaction setup

Front view: **Top view:**

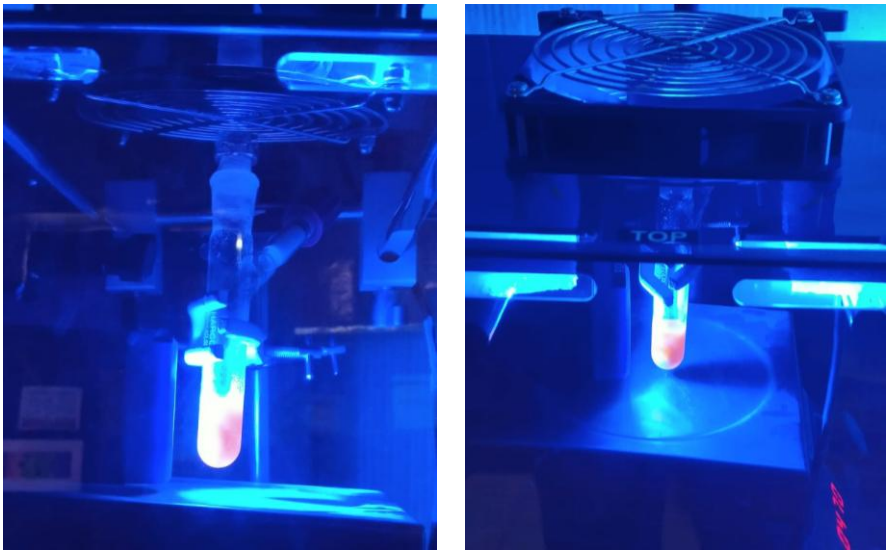
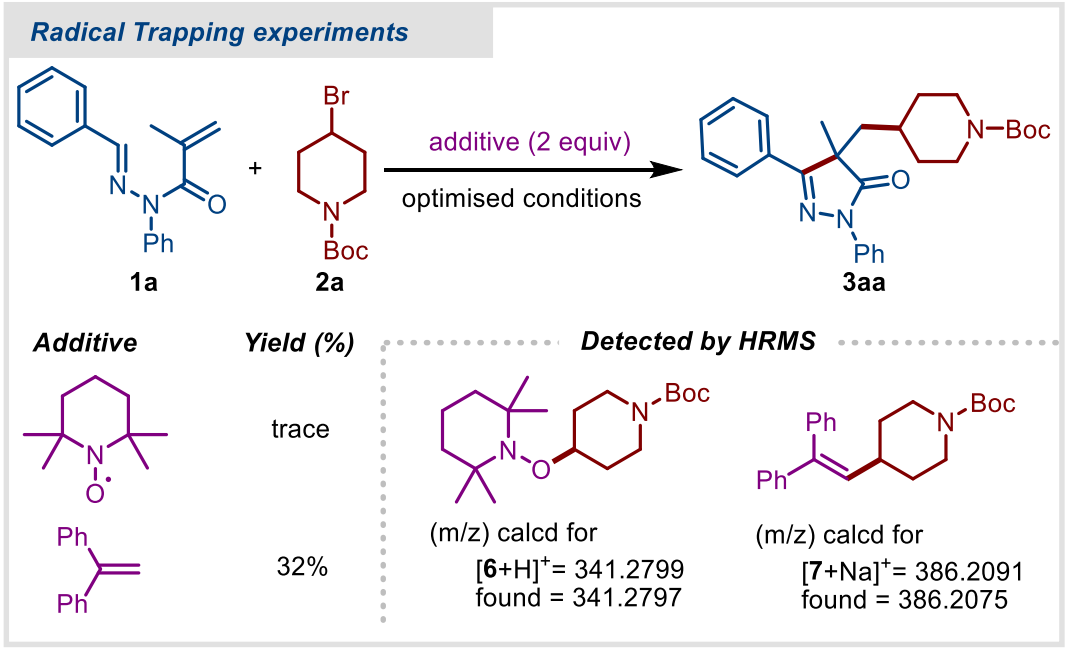


Figure S1: Representative pictures of the reaction setup.

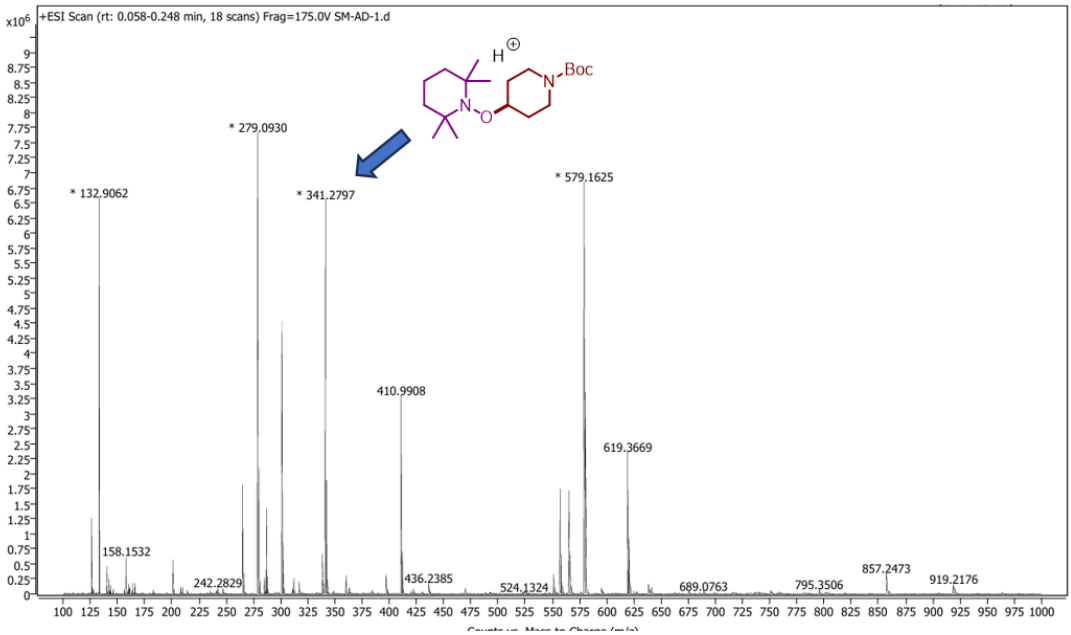
7. Procedure for the Radical Trapping Experiments:



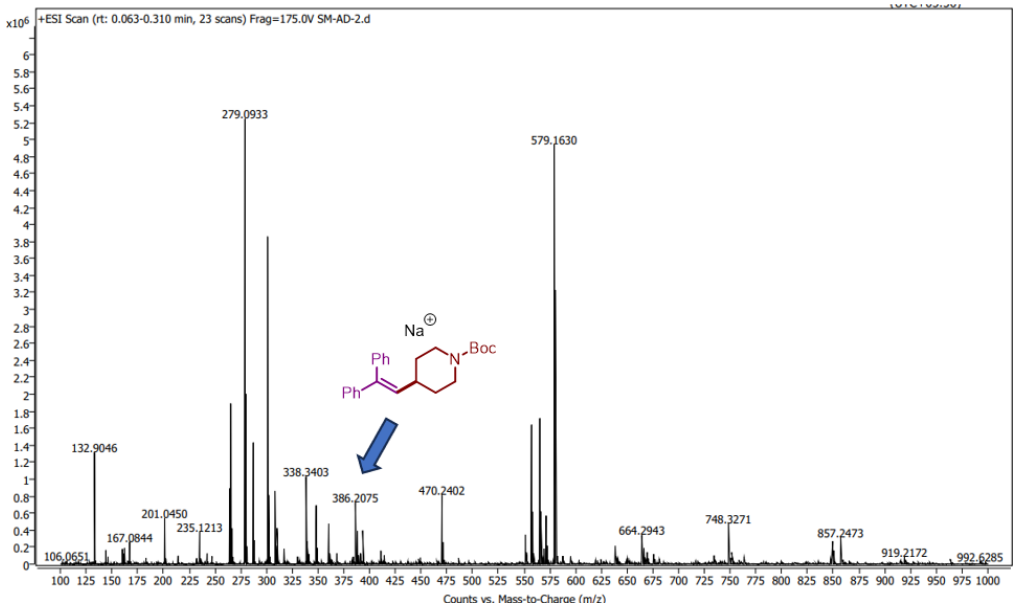
Scheme S2: Radical trapping experiments.

(a) (*E*)-*N*'-benzylidene-*N*-methacryloylhydrazide derivative **1a** (0.053 g, 0.20 mmol, 1.0 equiv), *tert*-butyl 4-bromopiperidine-1-carboxylate **2a** (0.079 g, 0.30 mmol, 1.5 equiv), Cs_2CO_3 (0.130 g, 0.40 mmol, 2 equiv), PPh_3 (0.052 g, 0.20 mmol, 1.0 equiv), $Pd(PPh_3)_2Cl_2$ (0.007 g, 0.010 mmol, 5 mol%), and 2,2,6,6-Tetramethylpiperidin-1- yloxyl

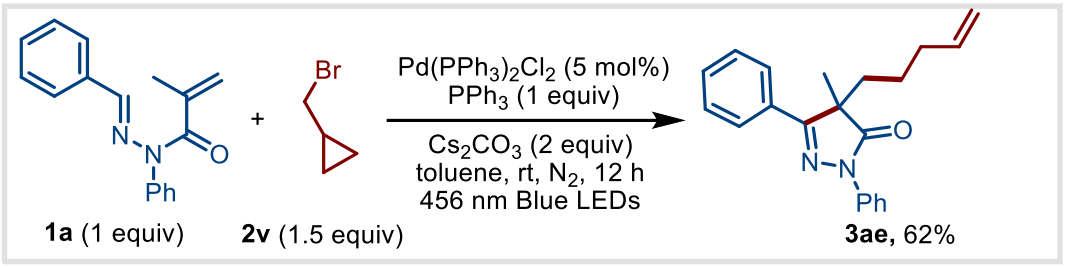
(TEMPO, 0.093g, 0.6 mmol, 3.0 equiv) were added in a pre-dried 10 mL Schlenk tube under N_2 atmosphere. The tube was degassed and purged with N_2 three times. Then, Toluene (2 mL) was added under a N_2 atmosphere. Then the mixture was allowed to stir for 5 h under irradiation of 40 W Kessil blue LED (456 nm) lamp. After completion, the reaction mixture was concentrated under vacuum and purified by silica gel column chromatography using 10-15% ethyl acetate in hexane to afford the adduct. Formation of adducts was confirmed by HRMS.



(b) (*E*)-*N*'-benzylidene-*N*-methacryloylhydrazide derivative **1a** (0.053 g, 0.20 mmol, 1.0 equiv), *tert*-butyl 4-bromopiperidine-1-carboxylate **2a** (0.079 g, 0.30 mmol, 1.5 equiv), Cs_2CO_3 (0.130 g, 0.40 mmol, 2 equiv), PPh_3 (0.052 g, 0.20 mmol, 1.0 equiv), $Pd(PPh_3)_2Cl_2$ (0.007 g, 0.010 mmol, 5 mol%), and ethene-1,1-diyldibenzene (0.108 g, 0.6 mmol, 3.0 equiv) were added in a pre-dried 10 mL Schlenk tube under N_2 atmosphere. The tube was degassed and purged with N_2 three times. Then Toluene (2 ml) was added under a N_2 atmosphere. Then the mixture was allowed to stir for 4 h under irradiation of 40 W Kessil blue LED (456 nm) lamp. After completion, the reaction mixture was concentrated under vacuum, and purified by silica gel column chromatography using 10-15% ethyl acetate in hexane to afford the adduct. Formation of adducts were confirmed by HRMS.

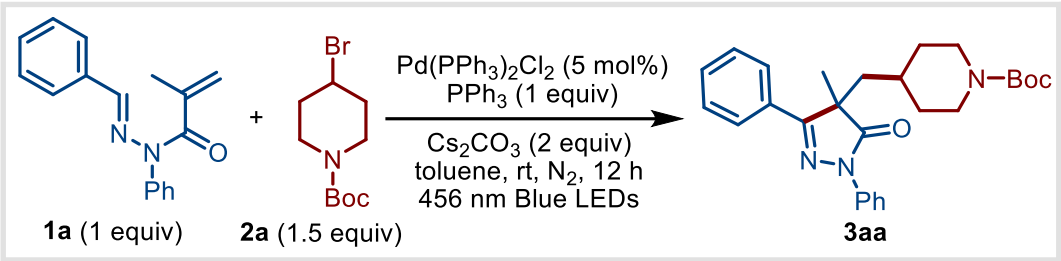


8. Procedure for Radical Clock Experiment:



(E)-*N'*-benzylidene-*N*-phenylmethacrylohydrazide **1a** (0.053 g, 0.20 mmol, 1.0 equiv), (bromomethyl)cyclopropane **2v** (0.040 g, 0.30 mmol, 1.5 equiv), Cs_2CO_3 (0.130 g, 0.40 mmol, 2 equiv), PPh_3 (0.052 g, 0.20 mmol, 1.0 equiv), and $Pd(PPh_3)_2Cl_2$ (0.007 g, 0.010 mmol, 5 mol%) were added in a pre-dried 50 mL Schlenk flask under N_2 atmosphere. The flask was degassed and purged with N_2 three times. Then toluene (30 mL) was added under a N_2 atmosphere, and the resulting solution was allowed to stir for 12 h under irradiation of a 40 W Kessil blue LEDs (456 nm) lamp. After completion, the reaction mixture was concentrated under vacuum and purified by silica gel column chromatography using 10 to 15% ethyl acetate in hexane to afford *tert*-butyl-4-((4-methyl-5-oxo-1,3-diphenyl-4,5-dihydro-1H-pyrazol-4-yl)methyl)piperidine-1-carboxylate **3ae** (0.039 g, 62%).

9. Light On-Off Experiment:



(*E*)-*N*'-benzylidene-*N*-methacryloylhydrazide derivative **1a** (0.053 g, 0.20 mmol, 1.0 equiv), *tert*-butyl 4-bromopiperidine-1-carboxylate **2a** (0.079 g, 0.30 mmol, 1.5 equiv), Cs_2CO_3 (0.130 g, 0.40 mmol, 2 equiv), PPh_3 (0.052 g, 0.20 mmol, 1.0 equiv), and $Pd(PPh_3)_2Cl_2$ (0.007 g, 0.010 mmol, 5 mol%) were added in a pre-dried 10 mL Schlenk tube under N_2 atmosphere. The tube was degassed and purged with N_2 three times. Then Toluene (3 mL) was added under a N_2 atmosphere. The reaction mixture was irradiated using a 40 W Kessil blue LED lamp (λ = 456 nm) and subjected to alternating light and dark conditions every 30 minutes. At each 30-minute interval, a 0.5 mL aliquot was withdrawn using a syringe and quenched with water. The organic layer was then extracted with ethyl acetate and analyzed by NMR spectroscopy. The reaction yield was determined by NMR using mesitylene as an internal standard.

Entry	Time (hr)	Light Source	Yield (%) of 3aa
1	2	On	26
2	4	Off	26
3	6	On	41
4	8	Off	41
5	10	On	53
6	12	Off	53

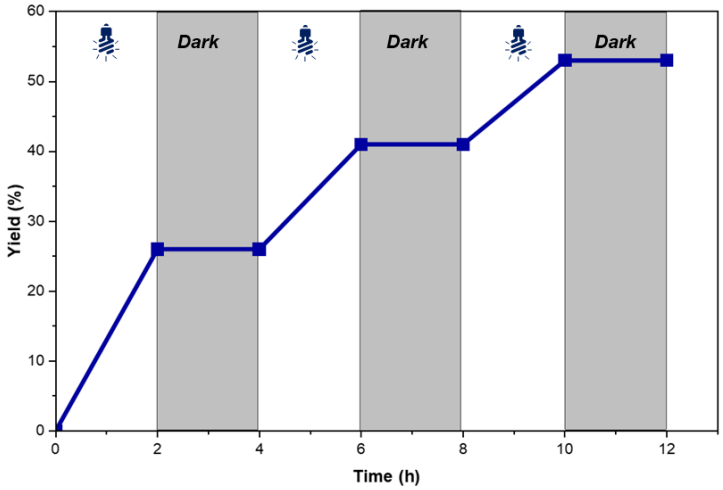


Figure S2: Light on-off Experiment.

10.Determination of Quantum Yield:

A. Determination of light intensity of the Blue LED:

0.737 g of potassium ferrioxalate trihydrate was dissolved in 10 mL H_2SO_4 (0.05 M) and stored in the dark. Then, a buffer solution was prepared by dissolving 2.5 g of sodium acetate and 0.5 mL of H_2SO_4 (95-98%) in 50 mL of distilled water.

General Protocol to assess the photon flux of the 456 nm blue LEDs: To a 10 mL Schlenk flask containing a stirring bar, 1 mL of the actinometer solution was added. Then, the solution was irradiated for 60 s. Immediately, a 100 µL aliquot was taken and added to a 10 mL volumetric flask containing 15 mg of 1, 10-phenanthroline in 3 mL of the buffer solution. The flask was filled with distilled water. The absorbance of this solution was then measured at 510 nm by UV/Vis spectrophotometry. In a similar manner, this procedure is repeated with the actinometer solution stored in the dark. Using then the Beer's Law, the number of moles of Fe^{2+} produced by light irradiation is obtained by:

$$Fe^{2+} = \frac{v_1 v_3 \Delta A(510\ \text{nm})}{10^3 v_2 l \varepsilon} \quad \text{.....1}$$

Where:

v_1 = Irradiated volume (1 mL)

v_2 = The aliquot of the irradiated solution taken for the estimation of Fe^{+} ions (0.100 mL)

v_3 = Final volume of the solution after complexation with 1, 10-phenanthroline (10 mL).

ε (510 nm) = Molar extinction coefficient of $[Fe(Phen)_3]^{2+}$ complex (11100 L mol^{-1} cm^{-1}).

l = Optical path-length of the cuvette (1 cm)

ΔA (510 nm) = absorbance difference between the irradiated solution and the solution stored in dark.

$$Fe^{2+} = \frac{1\text{ml} \times 10\text{ ml} \times 3.486\ (510\ \text{nm})}{10^3 \times 10^3 \times 0.1\ \text{mL} \times 1\text{cm} \times 11100\ \text{L mol}^{-1}\ \text{cm}^{-1}}$$

$$= 3.14 \times 10^{-8}\ \text{mol}$$

The photon flux (F) was obtained by using the following equation:

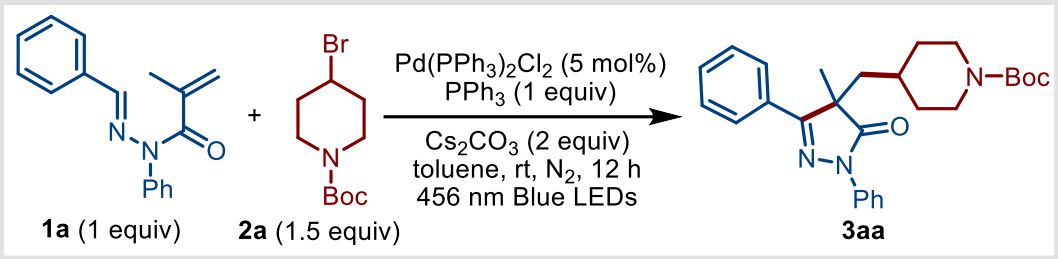
$$\phi(\lambda) = \frac{mol\ Fe^{2+}}{F(1\text{-}10^{-A\lambda})}$$

$$F = 3.14 \times 10^{-8}\ \text{einsteins/s}$$

Where: Φ (λ) = The quantum yield for Fe^{2+} formation at 456 nm is 1.

A (λ) = ferrioxalate actinometer absorbance at 456 nm, which was measured placing 1 mL of the solution in a cuvette of path length 1 cm by UV/Vis spectrophotometry. We obtained an absorbance value of 3.1200. The photon flux (F) is 3.14 x 10^{-8} einsteins/s.

B. Quantum Yield Calculation:



(*E*)-*N*'-benzylidene-*N*-methacryloyl-hydrazide derivative **1a** (0.053 g, 0.20 mmol, 1.0 equiv), *tert*-butyl 4-bromopiperidine-1-carboxylate **2a** (0.079 g, 0.30 mmol, 1.5 equiv), Cs_2CO_3 (0.130 g, 0.40 mmol, 2 equiv), PPh_3 (0.052 g, 0.20 mmol, 1.0 equiv), and $Pd(PPh_3)_2Cl_2$ (0.007 g, 0.010 mmol, 5 mol%) were added in a pre-dried 10 mL Schlenk tube under N_2 atmosphere. The tube was degassed and purged with N_2 three times. Then Toluene (3 mL) was added under a N_2 atmosphere. The mixture was irradiated using a 40 W Kessil blue LED (456 nm) lamp in the optimized condition for 7200 s and 5.20x10^{-5} moles of product were obtained. The Quantum yield was calculated using the following equations;

$$\phi\ (456\ \text{nm}) = \frac{mol\ of\ product}{F(1\text{-}10^{-A(456\ \text{nm})})t}$$

$$\phi\ (456\ \text{nm}) = \frac{5.2\times\ 10^{-5}\ \text{mol}}{3.4\times10^{-8}\times1\times\ 7200\text{s}}$$

$$= 0.212$$

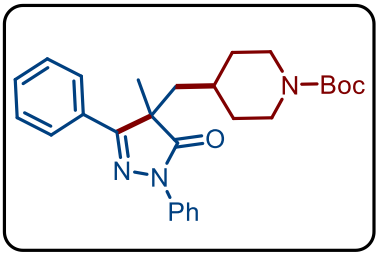
Where: A (456 nm) = is the absorbance at 456 nm of the photocatalytic reaction, which was measured by placing 1 mL of the solution in a cuvette of path length 1 cm by UV/Vis spectrophotometry.

t = is the reaction time, i.e., 7200 s.

The quantum yield (Φ) of the reaction is **0.212**

11. Report of NMR Spectra:

***Tert*-butyl-4-((4-methyl-5-oxo-1,3-diphenyl-4,5-dihydro-1H-pyrazol-4-yl)methyl) piperidine-1-carboxylate (3aa)**



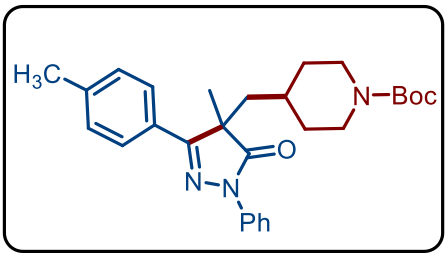
The compound was prepared according to **GP1** using *(E)-N′*-benzylidene-*N*-phenylmethacrylohydrazide **1a** (0.053 g, 0.20 mmol, 1.0 equiv), *tert*-butyl 4-bromopiperidine-1-carboxylate **2a** (0.079 g, 0.30 mmol, 1.5 equiv), Cs_2CO_3 (0.130 g, 0.40 mmol, 2 equiv), PPh_3 (0.052 g, 0.20 mmol, 1.0 equiv), and $Pd(PPh_3)_2Cl_2$ (0.007 g, 0.010 mmol, 5 mol%). Purification by column chromatography (10-15% ethyl acetate in hexane) gave **3aa** as a white solid (0.069 g, 78%).

^{1}H NMR (500 MHz, $CDCl_3$); δ 8.04 (d, *J* = 7.9 Hz, 2H), 7.92 (dd, *J* = 6.6, 3.0 Hz, 2H), 7.51 – 7.42 (m, 5H), 7.23 (d, *J* = 7.4 Hz, 1H), 3.88 (m, 2H), 2.46 (m, 2H), 2.18 – 2.06 (m, 2H), 1.55 (s, 3H), 1.43 (m, 1H), 1.39 (s, 9H), 1.36 – 1.21 (m, 2H), 1.06 (m, 2H).

^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$); δ 177.3, 161.8, 155.0, 138.6, 131.4, 130.9, 129.4 (2C), 126.8, 125.8, 119.4, 79.7, 54.0, 44.6, 34.1, 33.1, 32.4, 28.8, 25.2.

HRMS-ESI (*m/z*): calcd for $C_{27}H_{33}N_3O_3Na$ $[M+Na]^+$ 470.2420; found 470.2413.

***Tert*-butyl-4-((4-methyl-5-oxo-1-phenyl-3-(p-tolyl)-4,5-dihydro-1H-pyrazol-4-yl) methyl)piperidine-1-carboxylate (3ba)**



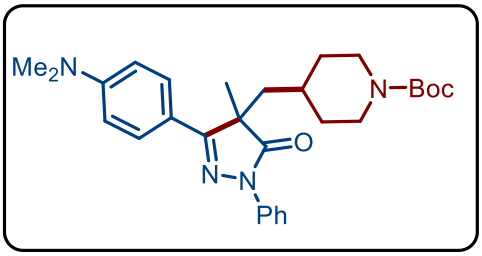
The compound was prepared according to **GP1** using *(E)-N′*-(4-methylbenzylidene)-*N*-phenylmethacrylohydrazide **1b** (0.056 g, 0.20 mmol, 1.0 equiv), *tert*-butyl 4-bromopiperidine-1-carboxylate **2a** (0.079 g, 0.30 mmol, 1.5 equiv), Cs_2CO_3 (0.130 g, 0.40 mmol, 2 equiv), PPh_3 (0.052 g, 0.20 mmol, 1.0 equiv), and $Pd(PPh_3)_2Cl_2$ (0.007 g, 0.010 mmol, 5 mol%). Purification by column chromatography (10-15% ethyl acetate in hexane) gave **3ba** as a white solid (0.066 g, 66%).

^{1}H NMR (500 MHz, $CDCl_3$); δ 8.01 (d, *J* = 8.1 Hz, 2H), 7.79 (d, *J* = 8.2 Hz, 2H), 7.42 (t, *J* = 7.9 Hz, 2H), 7.26 – 7.19 (m, 3H), 3.89 – 3.80 (m, 2H), 2.48 – 2.41 (m, 2H), 2.40 (s, 3H), 2.11 – 2.07 (m, 2H), 1.52 (s, 3H), 1.36 (s, 9H), 1.23 – 1.13 (m, 3H), 1.08 – 0.96 (m, 2H), 0.85 (m, 1H).

^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$); δ 176.9, 161.4, 154.6, 140.9, 138.2, 129.7, 129.0, 128.2, 126.3, 125.3, 119.0, 79.3, 53.6, 44.1, 33.7, 32.6, 31.9, 28.4, 24.8, 21.5.

HRMS-ESI (*m/z*): calcd for $C_{28}H_{35}N_3O_3$ $[M+H]^+$ 462.2757; found 462.2760.

***Tert*-butyl-4-((3-(4-(dimethylamino)phenyl)-4-methyl-5-oxo-1-phenyl-4,5-dihydro-1H-pyrazol-4-yl)methyl)piperidine-1-carboxylate (3ca)**



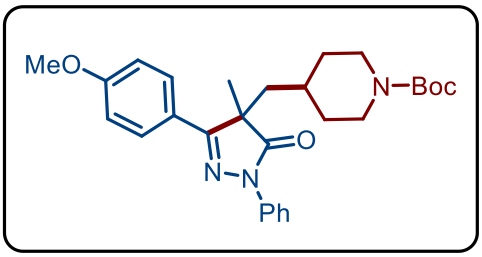
The compound was prepared according to **GP1** using *(E)-N'*-(4-(dimethylamino)benzylidene)-*N*-phenylmethacrylohydrazide **1c** (0.061 g, 0.20 mmol, 1.0 equiv), *tert*-butyl 4-bromopiperidine-1-carboxylate **2a** (0.079 g, 0.30 mmol, 1.5 equiv), Cs_2CO_3 (0.130 g, 0.40 mmol, 2 equiv), PPh_3 (0.052 g, 0.20 mmol, 1.0 equiv), and $Pd(PPh_3)_2Cl_2$ (0.007 g, 0.010 mmol, 5 mol%). Purification by column chromatography (10-15% ethyl acetate in hexane) gave **3ca** as a white solid (0.069 g, 71%).

^{1}H NMR (500 MHz, $CDCl_3$); δ 8.08 (d, *J* = 8.0 Hz, 2H), 7.83 (d, *J* = 8.9 Hz, 2H), 7.46 (t, *J* = 7.9 Hz, 2H), 7.23 (t, *J* = 7.4 Hz, 1H), 6.76 (d, *J* = 8.9 Hz, 2H), 4.00 – 3.77 (m, 2H), 3.08 (s, 6H), 2.49 (s, 2H), 2.12 (d, *J* = 6.5 Hz, 2H), 1.56 (s, 3H), 1.41 (s, 9H), 1.06 (s, 3H), 1.01 – 0.83 (m, 2H).

^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$); δ 176.8, 161.7, 154.6, 151.5, 138.4, 128.9, 127.7, 124.9, 119.0, 118.5, 111.7, 79.2, 53.6, 44.3, 40.1, 33.6, 32.7, 31.9, 28.4, 25.0.

HRMS-ESI (*m/z*): calcd for $C_{29}H_{38}KN_4O_3$ $[M+K]^+$ 529.2581; found 529.2588.

***Tert*-butyl-4-((3-(4-methoxyphenyl)-4-methyl-5-oxo-1-phenyl-4,5-dihydro-1H-pyrazol-4-yl)methyl)piperidine-1-carboxylate (3da)**



The compound was prepared according to **GP1** using *(E)-N'*-(4-methoxybenzylidene)-*N*-phenylmethacrylohydrazide **1d** (0.059 g, 0.20 mmol, 1.0 equiv), *tert*-butyl 4-bromopiperidine-1-carboxylate **2a** (0.079 g, 0.30 mmol, 1.5 equiv), Cs_2CO_3 (0.130 g, 0.40 mmol, 2 equiv), PPh_3 (0.052 g, 0.20 mmol, 1.0 equiv), and $Pd(PPh_3)_2Cl_2$ (0.007 g, 0.010 mmol, 5 mol%). Purification by column chromatography (10-15% ethyl acetate in hexane) gave **3da** as a white solid (0.075 g, 79%).

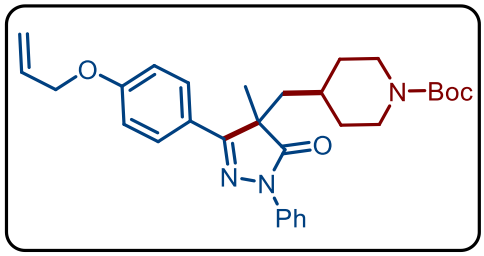
^{1}H NMR (500 MHz, $CDCl_3$); δ 8.03 (d, *J* = 8.0 Hz, 2H), 7.87 (d, *J* = 8.9 Hz, 2H), 7.45 (t, *J* = 8.0 Hz, 2H), 7.23 (t, *J* = 7.4 Hz, 1H), 6.99 (d, *J* = 8.9 Hz, 2H), 3.88 (s, 5H), 2.46 (m, 2H), 2.17

– 2.03 (m, 2H), 1.70 (s, 1H), 1.54 (s, 3H), 1.39 (s, 9H), 1.34 – 1.18 (m, 2H), 1.16 – 0.94 (m, 2H).

$^{13}C\{^{1}H\}$ NMR (126 MHz, $CDCl_3$); δ 176.8, 161.3, 161.2, 154.6, 138.2, 129.0, 128.0, 125.2, 123.7, 119.0, 114.4, 79.3, 55.4, 53.6, 44.2, 33.7, 32.7, 32.0, 28.4, 24.9.

HRMS-ESI (*m/z*): calcd for $C_{28}H_{36}N_3O_4$ $[M+H]^+$ 471.2701; found 471.2694.

***Tert*-butyl-4-((3-(4-(allyloxy)phenyl)-4-methyl-5-oxo-1-phenyl-4,5-dihydro-1H-pyrazol-4-yl)methyl)piperidine-1-carboxylate (3ea)**



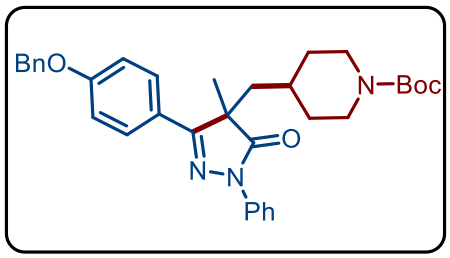
The compound was prepared according to **GP1** using *(E)-N'*-(4-(allyloxy)benzylidene)-*N*-phenylmethacrylohydrazide **1e** (0.064 g, 0.20 mmol, 1.0 equiv), *tert*-butyl 4-bromopiperidine-1-carboxylate **2a** (0.079 g, 0.30 mmol, 1.5 equiv), Cs_2CO_3 (0.130 g, 0.40 mmol, 2 equiv), PPh_3 (0.052 g, 0.20 mmol, 1.0 equiv), and $Pd(PPh_3)_2Cl_2$ (0.007 g, 0.010 mmol, 5 mol%). Purification by column chromatography (10-15% ethyl acetate in hexane) gave **3ea** as a white solid (0.068 g, 68%).

^{1}H NMR (500 MHz, $CDCl_3$); δ 8.06 (d, J = 7.9 Hz, 2H), 7.88 (d, J = 8.9 Hz, 2H), 7.47 (t, J = 7.9 Hz, 2H), 7.25 (t, J = 7.3 Hz, 1H), 7.02 (d, J = 8.9 Hz, 2H), 6.11 (m, 1H), 5.42 (m, 2H), 4.64 (d, J = 5.3 Hz, 2H), 4.02 – 3.79 (m, 2H), 2.48 (m, 2H), 2.26 – 1.98 (m, 2H), 1.57 (s, 3H), 1.41 (s, 9H), 1.21 – 0.99 (m, 3H), 0.97 – 0.83 (m, 2H).

$^{13}C\{^{1}H\}$ NMR (126 MHz, $CDCl_3$); δ 176.7, 161.1, 160.3, 154.6, 138.2, 132.7, 128.9, 127.9, 125.2, 123.7, 119.0, 118.2, 115.1, 79.3, 68.9, 53.6, 44.1, 33.7, 32.7, 31.9, 28.4, 24.8.

HRMS-ESI (*m/z*): calcd for $C_{30}H_{37}KN_3O_4$ $[M+K]^+$ 542.2421; found 542.2430.

***Tert*-butyl-4-((3-(4-(benzyloxy)phenyl)-4-methyl-5-oxo-1-phenyl-4,5-dihydro-1H-pyrazol-4-yl)methyl)piperidine-1-carboxylate (3fa)**



The compound was prepared according to **GP1** using *(E)-N'*-(4-(benzyloxy)benzylidene)-*N*-phenylmethacrylohydrazide **1f** (0.061 g, 0.20 mmol, 1.0 equiv), *tert*-butyl 4-bromopiperidine-1-carboxylate **2a** (0.079 g, 0.30 mmol, 1.5 equiv), Cs_2CO_3 (0.130 g, 0.40 mmol, 2 equiv), PPh_3 (0.052 g, 0.20 mmol, 1.0 equiv), and $Pd(PPh_3)_2Cl_2$ (0.007 g, 0.010 mmol,

5 mol%). Purification by column chromatography (10-15% ethyl acetate in hexane) gave **3fa** as a white solid (0.082 g, 74%).

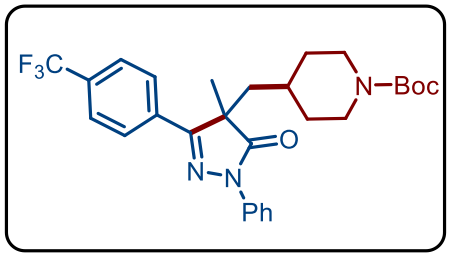
^{1}H NMR (500 MHz, $CDCl_3$); δ 8.04 (d, *J* = 7.9 Hz, 2H), 7.87 (d, *J* = 8.8 Hz, 2H), 7.46 (d, *J* = 6.9 Hz, 4H), 7.44 – 7.40 (m, 3H), 7.37 (d, *J* = 7.2 Hz, 1H), 7.23 (t, *J* = 7.4 Hz, 1H), 7.06 (d, *J* = 8.8 Hz, 2H), 5.14 (s, 2H), 4.00 – 3.70 (m, 2H), 2.47 (m, 2H), 2.17 – 2.02 (m, 2H), 1.54 (s, 3H), 1.39 (s, 9H), 1.22 – 0.99 (m, 3H), 0.95 – 0.78 (m, 2H).

^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$); δ 176.8, 161.1, 160.5, 154.6, 138.2, 136.4, 128.9, 128.7, 128.6, 128.2, 128.0, 127.5, 125.2, 123.9, 119.0, 115.3, 79.3, 53.6, 44.1, 33.7, 32.7, 32.0, 28.4, 24.8.

^{19}F NMR (471 MHz, $CDCl_3$); δ -113.11

HRMS-ESI (*m/z*): calcd for $C_{34}H_{39}KN_3O_4$ $[M+K]^+$ 592.2578; found 592.2586.

***Tert*-butyl-4-((4-methyl-5-oxo-1-phenyl-3-(4-(trifluoromethyl)phenyl)-4,5-dihydro-1H-pyrazol-4-yl)methyl)piperidine-1-carboxylate (3ga)**



The compound was prepared according to **GP1** using *(E)*-*N*-phenyl-*N'*-(4-(trifluoromethyl)benzylidene)methacrylohydrazide **1g** (0.066 g, 0.20 mmol, 1.0 equiv), *tert*-butyl 4-bromopiperidine-1-carboxylate **2a** (0.079 g, 0.30 mmol, 1.5 equiv), Cs_2CO_3 (0.130 g, 0.40 mmol, 2 equiv), PPh_3 (0.052 g, 0.20 mmol, 1.0 equiv), and $Pd(PPh_3)_2Cl_2$ (0.007 g, 0.010 mmol, 5 mol%). Purification by column chromatography (10-15% ethyl acetate in hexane) gave **3ga** as a white solid (0.058 g, 57%).

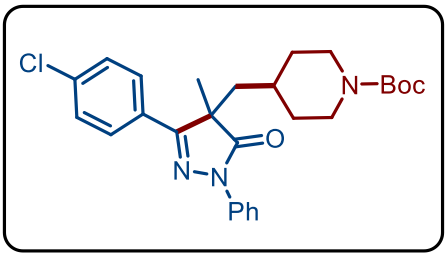
^{1}H NMR (500 MHz, $CDCl_3$); δ 8.02 (dd, *J* = 12.5, 8.2 Hz, 4H), 7.74 (d, *J* = 8.4 Hz, 2H), 7.47 (t, *J* = 7.9 Hz, 2H), 7.27 (d, *J* = 7.5 Hz, 1H), 3.89 (d, *J* = 10.1 Hz, 2H), 2.45 (m, 2H), 2.14 (m, 2H), 1.57 (s, 3H), 1.39 (s, 9H), 1.23 (m, 3H), 1.07 – 0.84 (m, 2H).

^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$); δ 176.6, 159.8, 154.6, 137.9, 132.0 (q, *J* = 32.9 Hz), 131.63, 129.09, 126.53, 126.04 (q, J = 3.7 Hz), 125.4 (q, *J* = 267.8 Hz), 125.71, 119.09, 79.4, 53.4, 44.1, 33.8, 32.7, 31.9, 28.4, 24.6.

^{19}F NMR (471 MHz, $CDCl_3$); -62.96

HRMS-ESI (*m/z*): calcd for $C_{28}H_{32}F_3KN_3O_3$ $[M+K]^+$ 554.2033; found 554.2041.

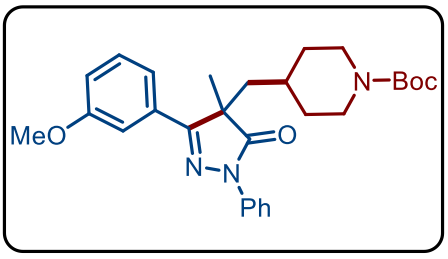
***Tert*-butyl-4-((3-(4-chlorophenyl)-4-methyl-5-oxo-1-phenyl-4,5-dihydro-1H-pyrazol-4-yl)methyl)piperidine-1-carboxylate (3ha)**



The compound was prepared according to **GP1** using *(E)-N′*-(4-chlorobenzylidene)-*N*-phenylmethacrylohydrazide **1h** (0.060 g, 0.20 mmol, 1.0 equiv), *tert*-butyl 4-bromopiperidine-1-carboxylate **2a** (0.079 g, 0.30 mmol, 1.5 equiv), Cs_2CO_3 (0.130 g, 0.40 mmol, 2 equiv), PPh_3 (0.052 g, 0.20 mmol, 1.0 equiv), and $Pd(PPh_3)_2Cl_2$ (0.007 g, 0.010 mmol, 5 mol%). Purification by column chromatography (10-15% ethyl acetate in hexane) gave **3ha** as a white solid (0.065 g, 68%).

^{1}H NMR (500 MHz, $CDCl_3$); δ 8.04 (d, *J* = 8.2 Hz, 2H), 7.88 (d, *J* = 8.5 Hz, 2H), 7.51 – 7.48 (m, 2H), 7.47 (m, 2H), 7.26 (d, *J* = 7.4 Hz, 1H), 3.91 (m, 2H), 2.47 (m, 2H), 2.22 – 2.06 (m, 2H), 1.57 (s, 3H), 1.41 (s, 9H), 1.37 – 1.14 (m, 3H), 1.09 – 0.89 (m, 2H).
^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$); δ 176.5, 160.1, 154.4, 137.8, 136.4, 129.2, 128.9, 127.4, 125.3, 125.2, 118.9, 79.3, 53.3, 43.9, 33.6, 32.5, 31.8, 28.3, 28.2, 24.6, 24.5.
HRMS-ESI (*m/z*): calcd for $C_{27}H_{33}NaN_3O_3$ $[M+H]^+$ 482.2250; found 482.2249.

***Tert*-butyl-4-((3-(3-methoxyphenyl)-4-methyl-5-oxo-1-phenyl-4,5-dihydro-1H-pyrazol-4-yl)methyl)piperidine-1-carboxylate (3ia)**

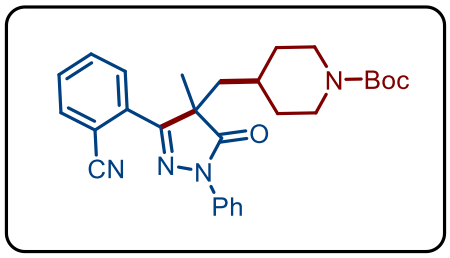


The compound was prepared according to **GP1** using *(E)-N′*-(3-methoxybenzylidene)-*N*-phenylmethacrylohydrazide **1i** (0.059 g, 0.20 mmol, 1.0 equiv), *tert*-butyl 4-bromopiperidine-1-carboxylate **2a** (0.079 g, 0.30 mmol, 1.5 equiv), Cs_2CO_3 (0.130 g, 0.40 mmol, 2 equiv), PPh_3 (0.052 g, 0.20 mmol, 1.0 equiv), and $Pd(PPh_3)_2Cl_2$ (0.007 g, 0.010 mmol, 5 mol%). Purification by column chromatography (10-15% ethyl acetate in hexane) gave **3ia** as a white solid (0.068 g, 72%).

^{1}H NMR (500 MHz, $CDCl_3$); δ 8.06 (d, *J* = 8.5 Hz, 2H), 7.48 (d, *J* = 7.5 Hz, 3H), 7.44 – 7.39 (m, 1H), 7.27 (d, *J* = 1.8 Hz, 1H), 7.21 (s, 2H), 7.08 – 7.03 (m, 1H), 3.92 (s, 5H), 2.49 (m, 2H), 2.38 (m, 2H), 2.15 (d, *J* = 6.1 Hz, 2H), 1.59 (s, 3H), 1.42 (s, 9H), 1.40 – 1.16 (m, 3H), 1.15 – 0.99 (m, 2H).
^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$); δ 177.0, 161.3, 160.1, 154.7, 138.2, 132.3, 130.1, 129.1, 125.5, 119.2, 118.9, 116.2, 111.9, 79.4, 55.5, 53.7, 44.1, 33.8, 32.8, 32.1, 28.5, 25.0.

HRMS-ESI (*m/z*): calcd for $C_{28}H_{35}N_3KO_4$ $[M+K]^+$ 516.2265; found 516.2265.

***Tert*-butyl-4-((3-(2-cyanophenyl)-4-methyl-5-oxo-1-phenyl-4,5-dihydro-1H-pyrazol-4-yl)methyl)piperidine-1-carboxylate (3ja)**



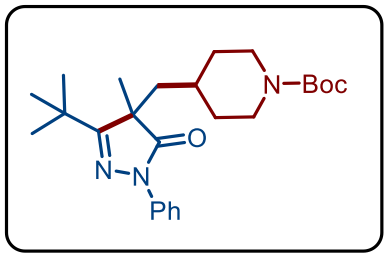
The compound was prepared according to **GP1** using *(E)-N′*-(2-cyanobenzylidene)-N-phenylmethacrylohydrazide **1j** (0.057 g, 0.20 mmol, 1.0 equiv), *tert*-butyl 4-bromopiperidine-1-carboxylate **2a** (0.079 g, 0.30 mmol, 1.5 equiv), Cs_2CO_3 (0.130 g, 0.40 mmol, 2 equiv), PPh_3 (0.052 g, 0.20 mmol, 1.0 equiv), and $Pd(PPh_3)_2Cl_2$ (0.007 g, 0.010 mmol, 5 mol%). Purification by column chromatography (10-15% ethyl acetate in hexane) gave **3ja** as a white solid (0.053 g, 56%).

^{1}H NMR (500 MHz, $CDCl_3$); δ 8.12 (d, *J* = 8.0 Hz, 2H), 7.94 (d, *J* = 7.8 Hz, 1H), 7.71 (t, *J* = 8.3 Hz, 2H), 7.64 – 7.58 (m, 1H), 7.49 (t, *J* = 7.9 Hz, 2H), 7.26 (d, *J* = 7.4 Hz, 1H), 3.92 (s, 2H), 2.52 (d, *J* = 7.6 Hz, 2H), 2.14 (m, 1H), 2.00 – 1.95 (m, 1H), 1.61 (s, 3H), 1.41 (s, 9H), 1.35 – 1.24 (m, 2H), 1.08 (m, 3H).

^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$); δ 176.0, 158.1, 154.6, 137.8, 136.3, 133.2, 132.7, 130.1, 129.1, 128.4, 127.3, 125.7, 119.0, 118.6, 111.1, 79.4, 53.9, 44.0, 33.7, 32.8, 31.9, 28.4, 24.5.

HRMS-ESI (*m/z*): calcd for $C_{28}H_{33}N_4O_3$ $[M+H]^+$ 473.2548; found 473.2551.

***Tert*-butyl-4-((3-(*tert*-butyl)-4-methyl-5-oxo-1-phenyl-4,5-dihydro-1H-pyrazol-4-yl)methyl)piperidine-1-carboxylate (3ka)**



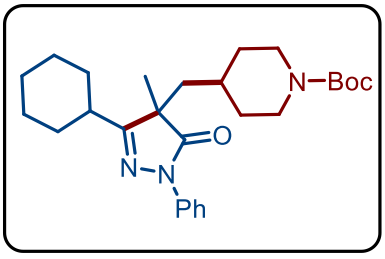
The compound was prepared according to **GP1** using *(E)-N′*-(2,2-dimethylpropylidene)-*N*-phenylmethacrylohydrazide **1k** (0.058 g, 0.20 mmol, 1.0 equiv), *tert*-butyl 4-bromopiperidine-1-carboxylate **2a** (0.079 g, 0.30 mmol, 1.5 equiv), Cs_2CO_3 (0.130 g, 0.40 mmol, 2 equiv), PPh_3 (0.052 g, 0.20 mmol, 1.0 equiv), and $Pd(PPh_3)_2Cl_2$ (0.007 g, 0.010 mmol, 5 mol%). Purification by column chromatography (10-15% ethyl acetate in hexane) gave **3ka** as a white solid (0.055 g, 65%).

^{1}H NMR (500 MHz, $CDCl_3$); δ 7.97 – 7.93 (m, 2H), 7.47 – 7.40 (m, 2H), 7.21 (t, *J* = 7.4 Hz, 1H), 3.97 (m, 2H), 2.72 – 2.42 (m, 2H), 1.96 – 1.86 (m, 2H), 1.45 (s, 3H), 1.43 (s, 9H), 1.39 (s, 9H), 1.33 – 1.24 (m, 2H), 1.12 (m, 3H).

$^{13}C\{^1H\}$ NMR (126 MHz, $CDCl_3$); δ 176.4, 171.9, 154.6, 138.2, 128.9, 124.9, 118.7, 79.3, 55.3, 44.1, 36.6, 34.1, 32.9, 32.0, 29.8, 29.7, 28.4, 23.5.

HRMS-ESI (*m/z*): calcd for $C_{25}H_{36}NaN_3O_3$ $[M+Na]^+$ 450.2783; found 428.2782.

***Tert*-butyl-4-((3-cyclohexyl-4-methyl-5-oxo-1-phenyl-4,5-dihydro-1H-pyrazol-4-yl)methyl)piperidine-1-carboxylate (3la)**



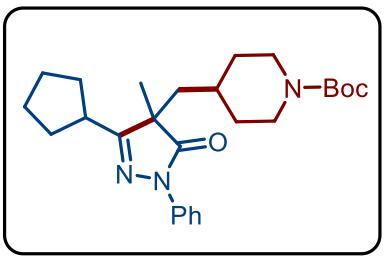
The compound was prepared according to **GP1** using *(E)-N′*-(cyclohexylmethylene)-*N*-phenylmethacrylohydrazide **1l** (0.054 g, 0.20 mmol, 1.0 equiv), *tert*-butyl 4-bromopiperidine-1-carboxylate **2a** (0.079 g, 0.30 mmol, 1.5 equiv), Cs_2CO_3 (0.130 g, 0.40 mmol, 2 equiv), PPh_3 (0.052 g, 0.20 mmol, 1.0 equiv), and $Pd(PPh_3)_2Cl_2$ (0.007 g, 0.010 mmol, 5 mol%). Purification by column chromatography (10-15% ethyl acetate in hexane) gave **3la** as a white solid (0.060 g, 66%).

^1H NMR (500 MHz, $CDCl_3$); δ 7.91 (d, *J* = 7.8 Hz, 2H), 7.40 (t, *J* = 8.0 Hz, 2H), 7.17 (t, *J* = 7.4 Hz, 1H), 4.10 – 3.89 (m, 2H), 2.62 – 2.46 (m, 2H), 2.31 (m, 1H), 2.00 – 1.64 (m, 10H), 1.47 (s, 2H), 1.41 (s, 9H), 1.32 (s, 3H), 1.24 (m, 3H), 1.07 (m, 2H).

$^{13}C\{^1H\}$ NMR (126 MHz, $CDCl_3$); δ 176.1, 170.8, 154.7, 138.3, 128.8, 124.9, 118.8, 79.3, 54.4, 42.7, 37.9, 33.5, 33.1, 32.2, 30.4, 28.4, 26.2, 25.7, 23.1.

HRMS-ESI (*m/z*): calcd for $C_{27}H_{40}N_3O_3$ $[M+H]^+$ 454.3080; found 454.2087.

***Tert*-butyl-4-((3-cyclopentyl-4-methyl-5-oxo-1-phenyl-4,5-dihydro-1H-pyrazol-4-yl)methyl)piperidine-1-carboxylate (3ma)**



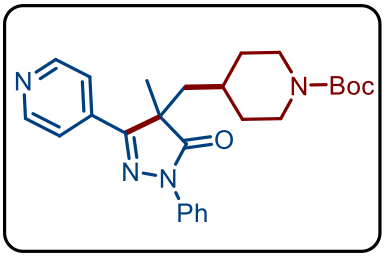
The compound was prepared according to **GP1** using *(E)-N′*-(cyclopentylmethylene)-*N*-phenylmethacrylohydrazide **1m** (0.052 g, 0.20 mmol, 1.0 equiv), *tert*-butyl 4-bromopiperidine-1-carboxylate **2a** (0.079 g, 0.30 mmol, 1.5 equiv), Cs_2CO_3 (0.130 g, 0.40 mmol, 2 equiv), PPh_3 (0.052 g, 0.20 mmol, 1.0 equiv), and $Pd(PPh_3)_2Cl_2$ (0.007 g, 0.010 mmol, 5 mol%). Purification by column chromatography (10-15% ethyl acetate in hexane) gave **3ma** as a white solid (0.060 g, 61%).

^1H NMR (500 MHz, $CDCl_3$); δ 7.95 – 7.90 (m, 2H), 7.40 (t, *J* = 8.0 Hz, 2H), 7.18 (t, *J* = 7.4 Hz, 1H), 4.07 – 3.81 (m, 2H), 2.67 (m, 1H), 2.62 – 2.44 (m, 2H), 1.86 (m, 1H), 1.69 (m, 1H), 1.47 (m, 2H), 1.41 (s, 9H), 1.35 (m, 6H), 1.30 (s, 3H), 1.28 – 1.14 (m, 3H), 1.13 – 1.01 (m, 2H).

$^{13}C\{^1H\}$ NMR (126 MHz, $CDCl_3$); δ 176.2, 171.4, 154.7, 138.3, 128.9, 124.9, 118.8, 79.4, 54.4, 42.8, 33.5, 32.9, 32.2, 28.4, 28.2, 23.3, 22.5, 20.5.

HRMS-ESI (*m/z*): calcd for $C_{26}H_{37}NaN_3O_3$ $[M+H]^+$ 462.2733; found 462.2724.

***Tert*-butyl-4-((4-methyl-5-oxo-1-phenyl-3-(pyridin-4-yl)-4,5-dihydro-1H-pyrazol-4-yl)methyl)piperidine-1-carboxylate (3na)**



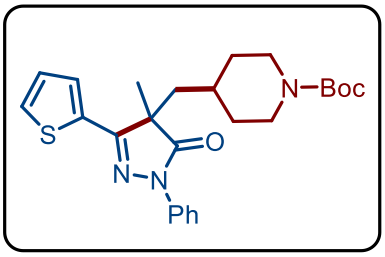
The compound was prepared according to **GP1** using *(E)-N*-phenyl-*N′*-(pyridin-4-ylmethylene)methacrylohydrazide **1a** (0.053 g, 0.20 mmol, 1.0 equiv), *tert*-butyl 4-bromopiperidine-1-carboxylate **2a** (0.079 g, 0.30 mmol, 1.5 equiv), Cs_2CO_3 (0.130 g, 0.40 mmol, 2 equiv), PPh_3 (0.052 g, 0.20 mmol, 1.0 equiv), and $Pd(PPh_3)_2Cl_2$ (0.007 g, 0.010 mmol, 5 mol%). Purification by column chromatography (10-15% ethyl acetate in hexane) gave **3na** as a white solid (0.062 g, 70%).

^1H NMR (500 MHz, $CDCl_3$); δ 8.72 (d, *J* = 6.1 Hz, 2H), 7.96 (d, *J* = 8.0 Hz, 2H), 7.72 (d, *J* = 6.1 Hz, 2H), 7.44 (t, *J* = 8.0 Hz, 2H), 7.25 – 7.14 (m, 1H), 3.86 (m, 2H), 2.42 (m, 2H), 2.22 – 2.02 (m, 2H), 1.83 (m, 1H), 1.54 (s, 3H), 1.35 (s, 9H), 1.22 (m, 2H), 1.03 (m, 2H).

$^{13}C\{^1H\}$ NMR (126 MHz, $CDCl_3$) δ 176.7, 159.1, 154.5, 150.8 , 137.7, 129.1 (2C), 125.9, 119.9, 119.1, 79.4, 53.2, 44.0, 33.8, 32.7, 31.9, 28.4, 24.5.

HRMS-ESI (*m/z*): calcd for $C_{26}H_{33}N_4O_3$ $[M+H]^+$ 449.2553; found 449.2559.

***Tert*-butyl-4-((4-methyl-5-oxo-1-phenyl-3-(thiophen-2-yl)-4,5-dihydro-1H-pyrazol-4-yl)methyl)piperidine-1-carboxylate (3oa)**



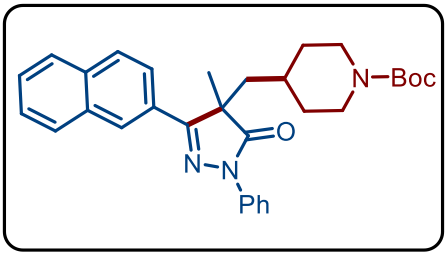
The compound was prepared according to **GP1** using *(E)-N*-phenyl-*N′*-(thiophen-2-ylmethylene)methacrylohydrazide **1o** (0.053 g, 0.20 mmol, 1.0 equiv), *tert*-butyl 4-bromopiperidine-1-carboxylate **2a** (0.079 g, 0.30 mmol, 1.5 equiv), Cs_2CO_3 (0.130 g, 0.40 mmol, 2 equiv), PPh_3 (0.052 g, 0.20 mmol, 1.0 equiv), and $Pd(PPh_3)_2Cl_2$ (0.007 g, 0.010 mmol, 5 mol%). Purification by column chromatography (10-15% ethyl acetate in hexane) gave **3oa** as a white solid (0.057 g, 64%).

^1H NMR (500 MHz, $CDCl_3$); δ 7.99 (d, *J* = 7.9 Hz, 2H), 7.53 – 7.41 (m, 4H), 7.23 (t, *J* = 7.4 Hz, 1H), 7.16 – 7.12 (m, 1H), 3.97 – 3.69 (m, 2H), 2.47 (m, 2H), 2.13 – 2.03 (m, 2H), 1.55 (s, 3H), 1.49 (m, 1H), 1.39 (s, 9H), 1.29 (m, 2H), 1.05 (m, 2H).

$^{13}C\{^1H\}$ NMR (126 MHz, $CDCl_3$); δ 176.1, 157.9, 154.6, 137.9, 134.3, 128.9, 128.4, 127.8, 127.2, 125.4, 119.0, 79.3, 53.7, 43.9, 33.6, 32.6, 32.1, 28.4, 24.9.

HRMS-ESI (*m/z*): calcd for $C_{25}H_{31}KN_3O_3S$ $[M+K]^+$ 492.1723; found 492.1714.

Tert-butyl-4-((4-methyl-3-(naphthalen-2-yl)-5-oxo-1-phenyl-4,5-dihydro-1H-pyrazol-4-yl)methyl)piperidine-1-carboxylate (3pa)



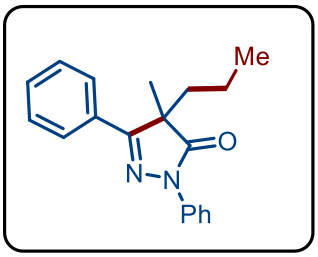
The compound was prepared according to **GP1** using *(E)-N′*-(naphthalen-2-ylmethylene)-*N*-phenylmethacrylohydrazide **1p** (0.063 g, 0.20 mmol, 1.0 equiv), *tert*-butyl 4-bromopiperidine-1-carboxylate **2a** (0.079 g, 0.30 mmol, 1.5 equiv), Cs_2CO_3 (0.130 g, 0.40 mmol, 2 equiv), PPh_3 (0.052 g, 0.20 mmol, 1.0 equiv), and $Pd(PPh_3)_2Cl_2$ (0.007 g, 0.010 mmol, 5 mol%). Purification by column chromatography (10-15% ethyl acetate in hexane) gave **3pa** as a white solid (0.065 g, 65%).

^1H NMR (500 MHz, $CDCl_3$); δ 8.20 (dd, J = 10.9, 2.1 Hz, 2H), 8.09 (d, J = 8.0 Hz, 2H), 7.97 – 7.86 (m, 3H), 7.57 (p, J = 5.3 Hz, 2H), 7.49 (t, J = 8.0 Hz, 2H), 7.26 (t, J = 3.7 Hz, 1H), 3.87 (m, 2H), 2.44 (m, 2H), 2.24 (m, 2H), 1.67 (s, 3H), 1.48 – 1.41 (m, 1H), 1.37 (s, 9H), 1.27 (m, 2H), 1.14 – 0.94 (m, 2H).

$^{13}C\{^1H\}$ NMR (126 MHz, $CDCl_3$); δ 176.9, 161.3, 154.6, 138.2, 134.2, 133.0, 129.0, 128.9, 128.8, 128.5, 127.9, 127.6, 126.9, 126.3, 125.4, 123.3, 119.1, 79.3, 53.7, 44.5, 33.8, 32.7, 32.0, 28.4, 25.1.

HRMS-ESI (*m/z*): calcd for $C_{31}H_{35}KN_3O_3$ $[M+K]^+$ 536.2315; found 536.2313.

4-Methyl-2,5-diphenyl-4-propyl-2,4-dihydro-3H-pyrazol-3-one (3ab)



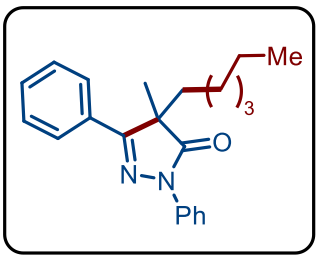
The compound was prepared according to **GP1** using *(E)-N′*-benzylidene-*N*-phenylmethacrylohydrazide **1a** (0.053 g, 0.20 mmol, 1.0 equiv), ethyl bromide **2b** (0.033 g, 0.30 mmol, 1.5 equiv), Cs_2CO_3 (0.130 g, 0.40 mmol, 2 equiv), PPh_3 (0.052 g, 0.20 mmol, 1.0 equiv), and $Pd(PPh_3)_2Cl_2$ (0.007 g, 0.010 mmol, 5 mol%). Purification by column chromatography (5-10 % ethyl acetate in hexane) gave **3ab** as a white gel (0.036 g, 61%).

^{1}H NMR (500 MHz, $CDCl_3$); δ 8.07 (d, *J* = 7.9 Hz, 2H), 7.93 (dd, *J* = 6.6, 3.1 Hz, 2H), 7.52 – 7.42 (m, 5H), 7.23 (t, *J* = 7.4 Hz, 1H), 2.15 – 1.98 (m, 2H), 1.59 (s, 3H), 1.22 – 1.05 (m, 2H), 0.82 (t, *J* = 7.3 Hz, 3H).

^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$); δ 176.9, 161.3, 138.2, 131.1, 130.3, 128.9, 126.4, 125.1, 118.9, 54.8, 39.9, 22.8, 18.3, 14.0.

HRMS-ESI (*m/z*): calcd for $C_{19}H_{21}N_2O$ $[M+H]^+$ 293.1654 found 293.1659.

4-Methyl-4-(2-methylpentan-2-yl)-2,5-diphenyl-2,4-dihydro-3H-pyrazol-3-one (3ac)



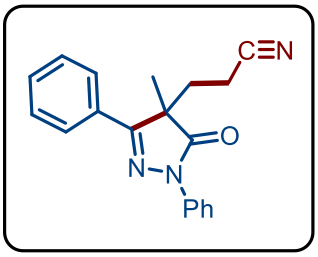
The compound was prepared according to **GP1** using *(E)-N'*-benzylidene-*N*-phenylmethacrylohydrazide **1a** (0.053 g, 0.20 mmol, 1.0 equiv), 1-bromopentane **2c** (0.045 g, 0.30 mmol, 1.5 equiv), Cs_2CO_3 (0.130 g, 0.40 mmol, 2 equiv), PPh_3 (0.052 g, 0.20 mmol, 1.0 equiv), and $Pd(PPh_3)_2Cl_2$ (0.007 g, 0.010 mmol, 5 mol%). Purification by column chromatography (5-10 % ethyl acetate in hexane) gave **3ac** as a white solid (0.046 g, 69%).

^{1}H NMR (500 MHz, $CDCl_3$); δ 8.11 – 8.04 (m, 2H), 7.97 – 7.89 (m, 2H), 7.52 – 7.41 (m, 5H), 7.25 – 7.20 (m, 1H), 2.15 – 1.99 (m, 2H), 1.58 (s, 3H), 1.24 – 1.06 (m, 6H), 0.78 (t, *J* = 7.0 Hz, 3H).

^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$); δ 176.9, 161.3, 138.2, 131.1, 130.3, 128.9, 128.8, 126.4, 125.1, 118.9, 54.8, 37.7, 31.2, 29.1, 24.8, 22.8, 22.4, 13.9**.**

HRMS-ESI (*m/z*): calcd for $C_{20}H_{23}N_2O$ $[M+H]^+$ 307.1810; found 307.1806.

3-(4-Methyl-5-oxo-1,3-diphenyl-4,5-dihydro-1H-pyrazol-4-yl)propanenitrile (3ad)



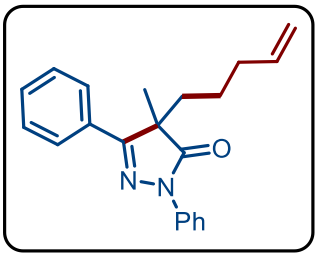
The compound was prepared according to **GP1** using *(E)-N'*-benzylidene-*N*-phenylmethacrylohydrazide **1a** (0.053 g, 0.20 mmol, 1.0 equiv), bromoacetonitrile **2d** (0.036 g, 0.30 mmol, 1.5 equiv), Cs_2CO_3 (0.130 g, 0.40 mmol, 2 equiv), PPh_3 (0.052 g, 0.20 mmol, 1.0 equiv), and $Pd(PPh_3)_2Cl_2$ (0.007 g, 0.010 mmol, 5 mol%). Purification by column chromatography (10-15% ethyl acetate in hexane) gave **3ad** as a white solid (0.030 g, 48 %).

^{1}H NMR (500 MHz, $CDCl_3$); δ 8.02 (d, *J* = 7.8 Hz, 2H), 7.90 (dd, *J* = 6.5, 3.1 Hz, 2H), 7.53 – 7.43 (m, 5H), 7.25 (m, 1H), 2.56 – 2.33 (m, 2H), 2.29 – 2.12 (m, 2H), 1.68 (s, 3H).

^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$); δ 174.9, 159.5, 137.7, 131.04, 130.05, 129.3, 129.0, 126.2, 125.7, 119.0, 118.0, 53.2, 32.4, 22.4, 13.0.

HRMS-ESI (*m/z*): calcd for $C_{19}H_{18}N_3O$ $[M+H]^+$ 304.1850; found 304.1859.

4-Methyl-4-(pent-4-en-2-yl)-2,5-diphenyl-2,4-dihydro-3H-pyrazol-3-one (3ae)



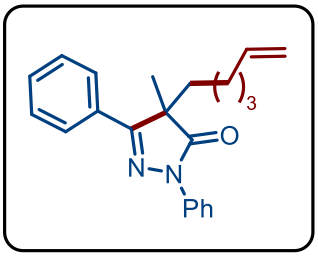
The compound was prepared according to **GP1** using *(E)-N'*-benzylidene-*N*-phenylmethacrylohydrazide **1a** (0.053 g, 0.20 mmol, 1.0 equiv), 4-bromobut-1-ene **2e** (0.036 g, 0.30 mmol, 1.5 equiv), Cs_2CO_3 (0.130 g, 0.40 mmol, 2 equiv), PPh_3 (0.052 g, 0.20 mmol, 1.0 equiv), and $Pd(PPh_3)_2Cl_2$ (0.007 g, 0.010 mmol, 5 mol%). Purification by column chromatography (5% ethyl acetate in hexane) gave **3ae** as a white solid (0.040 g, 64 %).

^{1}H NMR (500 MHz, $CDCl_3$); δ 8.06 (d, *J* = 7.9 Hz, 2H), 7.91 (dd, *J* = 6.7, 3.0 Hz, 2H), 7.51 – 7.40 (m, 5H), 7.22 (m, 1H), 5.66 – 5.56 (m, 1H), 4.95 – 4.86 (m, 2H), 2.03 (m, 4H), 1.58 (s, 3H), 1.17 (d, *J* = 7.1 Hz, 2H).

^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$); δ 176.8, 161.1, 138.1, 137.5, 131.0, 130.4, 128.9, 128.9, 126.4, 125.2, 118.9, 115.2, 54.6, 37.1, 33.4, 24.0, 22.7.

HRMS-ESI (*m/z*): calcd for $C_{21}H_{22}N_2O$ $[M+H]^+$ 318.1732; found 318.1727.

4-Methyl-4-(2-methylpent-4-en-2-yl)-2,5-diphenyl-2,4-dihydro-3H-pyrazol-3-one (3af)



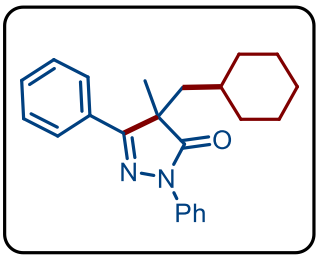
The compound was prepared according to **GP1** using *(E)-N'*-benzylidene-*N*-phenylmethacrylohydrazide **1a** (0.053 g, 0.20 mmol, 1.0 equiv), 5-bromopent-1-ene **2f** (0.045 g, 0.30 mmol, 1.5 equiv), Cs_2CO_3 (0.130 g, 0.40 mmol, 2 equiv), PPh_3 (0.052 g, 0.20 mmol, 1.0 equiv), and $Pd(PPh_3)_2Cl_2$ (0.007 g, 0.010 mmol, 5 mol%). Purification by column chromatography (5% ethyl acetate in hexane) gave **3af** as a white solid (0.043 g, 65 %).

^{1}H NMR (500 MHz, $CDCl_3$);δ 8.06 (d, *J* = 7.9 Hz, 2H), 7.92 (dd, *J* = 6.7, 2.9 Hz, 2H), 7.58 – 7.38 (m, 5H), 7.23 (t, *J* = 7.4 Hz, 1H), 5.65 (m, 1H), 4.92 – 4.80 (m, 2H), 2.15 – 2.00 (m, 2H), 1.91 (q, *J* = 7.2 Hz, 2H), 1.59 (s, 3H), 1.33 – 1.26 (m, 2H), 1.17 – 1.05 (m, 2H).

^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$); δ 176.9, 161.2, 138.3, 138.2, 131.0, 130.4, 128.9, 128.9, 126.4, 125.2, 118.9, 114.6, 54.7, 37.5, 33.1, 28.6, 24.3, 22.8.

HRMS-ESI (*m/z*): calcd for $C_{22}H_{23}N_2O$ $[M+H]^+$ 331.1810; found 316.1814.

4-(Cyclohexylmethyl)-4-methyl-2,5-diphenyl-2,4-dihydro-3H-pyrazol-3-one (3ag)



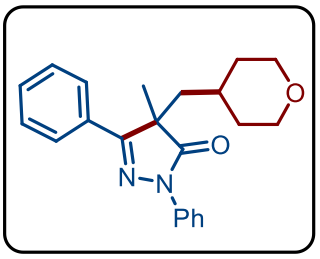
The compound was prepared according to **GP1** using *(E)-N'*-benzylidene-*N*-phenylmethacrylohydrazide **1a** (0.053 g, 0.20 mmol, 1.0 equiv), bromocyclohexane **2g** (0.049 g, 0.30 mmol, 1.5 equiv), Cs_2CO_3 (0.130 g, 0.40 mmol, 2 equiv), PPh_3 (0.052 g, 0.20 mmol, 1.0 equiv), and $Pd(PPh_3)_2Cl_2$ (0.007 g, 0.010 mmol, 5 mol%). Purification by column chromatography (5% ethyl acetate in hexane) gave **3ag** as a white solid (0.050 g, 72 %).

^{1}H NMR (500 MHz, $CDCl_3$); δ 8.03 (d, *J* = 7.7 Hz, 2H), 7.92 (dd, *J* = 6.6, 3.2 Hz, 2H), 7.46 (m, 5H), 7.23 (t, *J* = 7.4 Hz, 1H), 2.15 – 2.01 (m, 2H), 1.53 (s, 3H), 1.50 – 1.34 (m, 4H), 1.28 – 1.10 (m, 2H), 1.08 – 0.94 (m, 3H), 0.92 – 0.76 (m, 2H).

^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$); δ 177.3, 161.7, 138.3, 131.3, 130.3, 128.9, 128.9, 126.5, 125.2, 119.1, 53.8, 45.2, 35.3, 34.1, 32.9, 26.0, 25.9, 25.9, 24.9.

HRMS-ESI (*m/z*): calcd for $C_{23}H_{27}N_2O$ $[M+H]^+$ 347.2123; found 347.2127.

4-Methyl-2,5-diphenyl-4-((tetrahydro-2H-pyran-4-yl)methyl)-2,4-dihydro-3H-pyrazol-3-one (3ah)



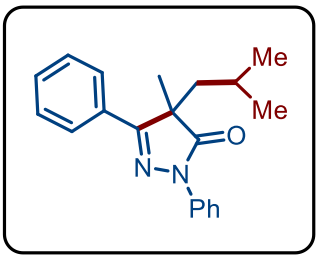
The compound was prepared according to **GP1** using *(E)-N'*-benzylidene-*N*-phenylmethacrylohydrazide **1a** (0.053 g, 0.20 mmol, 1.0 equiv), 4-bromotetrahydro-2H-pyran **2j** (0.049 g, 0.30 mmol, 1.5 equiv), Cs_2CO_3 (0.130 g, 0.40 mmol, 2 equiv), PPh_3 (0.052 g, 0.20 mmol, 1.0 equiv), and $Pd(PPh_3)_2Cl_2$ (0.007 g, 0.010 mmol, 5 mol%). Purification by column chromatography (15% ethyl acetate in hexane) gave **3af** as a white solid (0.056 g, 81 %).

^{1}H NMR (500 MHz, $CDCl_3$); δ 8.04 (d, *J* = 7.8 Hz, 2H), 7.93 (dd, *J* = 6.7, 3.0 Hz, 2H), 7.51 – 7.42 (m, 5H), 7.24 (m, 1H), 3.81 – 3.69 (m, 2H), 3.14 (dd, *J* = 12.8, 10.1 Hz, 2H), 2.14 (dd, *J* = 6.1, 4.2 Hz, 2H), 1.57 (s, 3H), 1.31 (m, 5H).

^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$);δ 176.9, 161.4, 138.2, 131.1, 130.5, 129.01, 129.00, 126.4, 125.3, 119.0, 67.5 (2C), 53.5, 44.5, 33.5, 32.8, 32.7, 24.7.

HRMS-ESI (*m/z*): calcd for $C_{22}H_{25}N_2O_2$ $[M+H]^+$ 349.1916; found 349.1922.

4-Isobutyl-4-methyl-2,5-diphenyl-2,4-dihydro-3H-pyrazol-3-one (3ai)



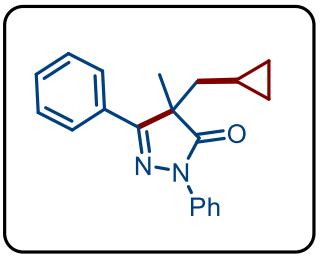
The compound was prepared according to **GP1** using *(E)-N'*-benzylidene-*N*-phenylmethacrylohydrazide **1a** (0.053 g, 0.20 mmol, 1.0 equiv), 2-bromopropane **2i** (0.037 g, 0.30 mmol, 1.5 equiv), Cs_2CO_3 (0.130 g, 0.40 mmol, 2 equiv), PPh_3 (0.052 g, 0.20 mmol, 1.0 equiv), and $Pd(PPh_3)_2Cl_2$ (0.007 g, 0.010 mmol, 5 mol%). Purification by column chromatography (5% ethyl acetate in hexane) gave **3ai** as a white solid (0.048 g, 78 %).

^{1}H NMR (500 MHz, $CDCl_3$); δ 8.11 – 8.07 (m, 2H), 7.99 – 7.95 (m, 2H), 7.53 – 7.45 (m, 5H), 7.26 (t, *J* = 7.4 Hz, 1H), 2.13 (m, 2H), 1.59 (s, 3H), 1.52 (dt, *J* = 13.6, 6.6 Hz, 1H), 0.80 (d, *J* = 6.7 Hz, 3H), 0.76 (d, *J* = 6.6 Hz, 3H).

^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$); δ 183.1, 169.9, 140.1, 134.7, 133.1, 133.0, 131.3, 128.2, 127.8, 127.4, 126.4, 125.3, 124.9, 120.6, 51.6, 50.4, 31.8, 30.7, 27.6, 26.3.

HRMS-ESI (*m/z*): calcd for $C_{20}H_{23}N_2O$ $[M+H]^+$ 307.1810; found 307.1806.

4-(Cyclopropylmethyl)-4-methyl-2,5-diphenyl-2,4-dihydro-3H-pyrazol-3-one (3aj)



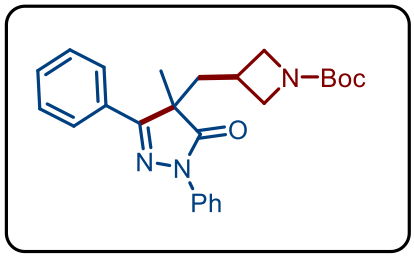
The compound was prepared according to **GP1** using *(E)-N'*-benzylidene-*N*-phenylmethacrylohydrazide **1a** (0.053 g, 0.20 mmol, 1.0 equiv), bromocyclopropane **2h** (0.036 g, 0.30 mmol, 1.5 equiv), Cs_2CO_3 (0.130 g, 0.40 mmol, 2 equiv), PPh_3 (0.052 g, 0.20 mmol, 1.0 equiv), and $Pd(PPh_3)_2Cl_2$ (0.007 g, 0.010 mmol, 5 mol%). Purification by column chromatography (5% ethyl acetate in hexane) gave **3ah** as a white solid (0.043 g, 71 %).

^{1}H NMR (500 MHz, $CDCl_3$); δ 8.16 (d, *J* = 7.8 Hz, 2H), 8.10 – 8.01 (m, 2H), 7.64 – 7.51 (m, 5H), 7.33 (t, *J* = 7.4 Hz, 1H), 2.42 (dd, *J* = 14.1, 5.3 Hz, 1H), 1.87 (dd, *J* = 14.1, 8.9 Hz, 1H), 1.67 (s, 3H), 0.61 – 0.50 (m, 1H), 0.33 (m, 2H), 0.26 – 0.19 (m, 1H), 0.08 – 0.02 (m, 1H).

^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$); δ 177.3, 161.5, 138.3, 131.3, 130.3, 128.9, 128.9, 126.4, 125.2, 119.0, 54.0, 46.5, 26.2, 24.8, 23.9, 22.2.

HRMS-ESI (*m/z*): calcd for $C_{20}H_{21}N_2O$ $[M+H]^+$ 305.1654; found 305.1655.

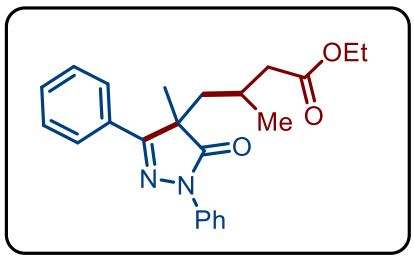
***Tert*-buty-3-((4-methyl-5-oxo-1,3-diphenyl-4,5-dihydro-1H-pyrazol-4-yl)methyl)azetidine -1-carboxylate (3ak)**



The compound was prepared according to **GP1** using *(E)*-*N*′-benzylidene-*N*-phenylmethacrylohydrazide **1a** (0.053 g, 0.20 mmol, 1.0 equiv), *tert*-butyl 3-bromoazetidine-1-carboxylate **2k** (0.070 g, 0.30 mmol, 1.5 equiv), Cs_2CO_3 (0.130 g, 0.40 mmol, 2 equiv), PPh_3 (0.052 g, 0.20 mmol, 1.0 equiv), and $Pd(PPh_3)_2Cl_2$ (0.007 g, 0.010 mmol, 5 mol%). Purification by column chromatography (15% ethyl acetate in hexane) gave **3ak** as a white solid (0.067 g, 80 %).

^{1}H NMR (500 MHz, $CDCl_3$); δ 8.03 (d, *J* = 7.8 Hz, 2H), 7.93 (dd, *J* = 6.6, 3.0 Hz, 2H), 7.53 – 7.44 (m, 5H), 7.26 (t, *J* = 7.4 Hz, 1H), 3.79 (m, 2H), 3.61 (dd, *J* = 8.4, 5.2 Hz, 1H), 3.36 (dd, *J* = 8.5, 5.3 Hz, 1H), 2.40 (t, *J* = 8.6 Hz, 2H), 2.01 (m, 1H), 1.65 (s, 3H), 1.37 (s, 9H).
^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$); δ 176.1, 160.6, 156.0, 137.8, 130.7, 130.6, 129.1, 129.0, 126.3, 125.5, 119.0, 79.3, 54.4, 53.6, 41.8, 28.3, 25.7, 22.5.
HRMS-ESI (*m/z*): calcd for $C_{25}H_{29}KN_3O_3$ $[M+K]^+$ 458.1846; found 458.1842.

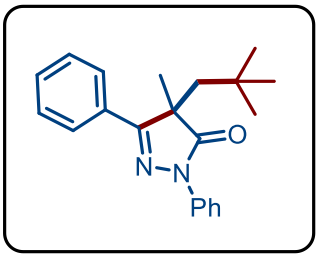
Ethyl-3-methyl-4-(4-methyl-5-oxo-1,3-diphenyl-4,5-dihydro-1H-pyrazol-4-yl)butanoate (3al)



The compound was prepared according to **GP1** using *(E)*-*N*′-benzylidene-*N*-phenylmethacrylohydrazide **1a** (0.053 g, 0.20 mmol, 1.0 equiv), ethyl 3-bromobutanoate **2l** (0.058 g, 0.30 mmol, 1.5 equiv), Cs_2CO_3 (0.130 g, 0.40 mmol, 2 equiv), PPh_3 (0.052 g, 0.20 mmol, 1.0 equiv), and $Pd(PPh_3)_2Cl_2$ (0.007 g, 0.010 mmol, 5 mol%). Purification by column chromatography (15% ethyl acetate in hexane) gave **3ak** as a white solid (0.054 g, 71 %).

^{1}H NMR (500 MHz, $CDCl_3$); δ 8.07 (d, *J* = 7.8 Hz, 2H), 7.95 (dd, *J* = 6.6, 3.1 Hz, 2H), 7.52 – 7.45 (m, 5H), 7.26 (t, *J* = 7.4 Hz, 1H), 3.76 (dq, *J* = 10.5, 3.5 Hz, 2H), 2.70 (dd, *J* = 14.2, 7.1 Hz, 1H), 2.35 – 2.15 (m, 2H), 1.62 (s, 3H), 1.08 (d, *J* = 6.9 Hz, 3H), 1.04 (t, *J* = 7.1 Hz, 3H).
^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$); δ 176.4, 175.1, 160.4, 138.1, 130.7, 130.4, 128.9, 128.8, 126.5, 125.4, 119.1, 60.4, 53.6, 40.6, 36.9, 24.0, 18.2, 13.8.
HRMS-ESI (*m/z*): calcd for $C_{23}H_{27}N_2O_3$ $[M+H]^+$ 379.2022; found 379.2025.

4-Methyl-4-neopentyl-2,5-diphenyl-2,4-dihydro-3H-pyrazol-3-one (3am)



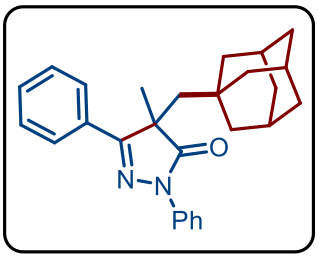
The compound was prepared according to **GP1** using *(E)-N'*-benzylidene-*N*-phenylmethacrylohydrazide **1a** (0.053 g, 0.20 mmol, 1.0 equiv), 2-bromo-2-methylpropane **2m** (0.041 g, 0.30 mmol, 1.5 equiv), Cs_2CO_3 (0.130 g, 0.40 mmol, 2 equiv), PPh_3 (0.052 g, 0.20 mmol, 1.0 equiv), and $Pd(PPh_3)_2Cl_2$ (0.007 g, 0.010 mmol, 5 mol%). Purification by column chromatography (5% ethyl acetate in hexane) gave **3ak** as a white solid (0.046 g, 72 %).

^{1}H NMR (500 MHz, $CDCl_3$); δ 8.08 – 8.03 (m, 2H), 7.98 (dd, *J* = 7.7, 1.9 Hz, 2H), 7.48 – 7.39 (m, 5H), 7.22 (t, *J* = 7.4 Hz, 1H), 2.24 (q, *J* = 14.6 Hz, 2H), 1.56 (s, 3H), 0.77 (s, 9H).

^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$); δ 177.1, 161.7, 138.4, 131.9, 130.1, 128.9, 128.7, 126.6, 125.2, 119.0, 53.2, 51.3, 32.0, 30.7, 26.6.

HRMS-ESI (*m/z*): calcd for $C_{21}H_{25}N_2O$ $[M+H]^+$ 321.1967; found 321.1969.

4-((Adamantan-1-yl)methyl)-4-methyl-2,5-diphenyl-2,4-dihydro-3H-pyrazol-3-one (3an)



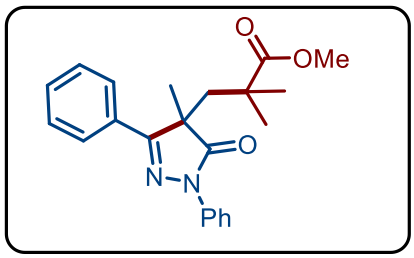
The compound was prepared according to **GP1** using *(E)-N'*-benzylidene-*N*-phenylmethacrylohydrazide **1a** (0.053 g, 0.20 mmol, 1.0 equiv), 1-bromoadamantane **2n** (0.064 g, 0.30 mmol, 1.5 equiv), Cs_2CO_3 (0.130 g, 0.40 mmol, 2 equiv), PPh_3 (0.052 g, 0.20 mmol, 1.0 equiv), and $Pd(PPh_3)_2Cl_2$ (0.007 g, 0.010 mmol, 5 mol%). Purification by column chromatography (5% ethyl acetate in hexane) gave **3an** as a white solid (0.064 g, 80 %).

^{1}H NMR (500 MHz, $CDCl_3$); δ 8.06 (d, *J* = 7.9 Hz, 2H), 8.02 – 7.97 (m, 2H), 7.46 (m, 5H), 7.24 (t, *J* = 7.4 Hz, 1H), 2.12 (q, *J* = 14.8 Hz, 2H), 1.77 (s, 3H), 1.54 (m, 6H), 1.50 – 1.40 (m, 6H), 1.33 – 1.23 (m, 3H).

^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$); δ 177.13, 161.9, 138.4, 131.8, 130.1, 128.9, 128.6, 126.7, 125.2, 119.2, 52.4, 52.3, 43.2, 36.5, 34.1, 28.5, 26.8.

HRMS-ESI (*m/z*): calcd for $C_{27}H_{31}N_2O$ $[M+H]^+$ 399.2436; found 399.2433.

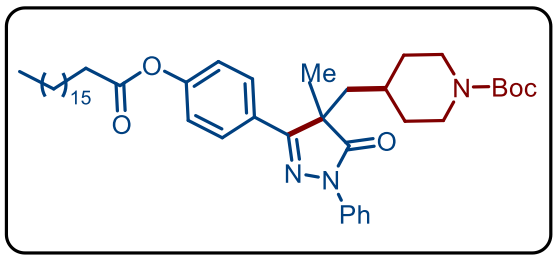
Methyl-2,2-dimethyl-3-(4-methyl-5-oxo-1,3-diphenyl-4,5-dihydro-1H-pyrazol-4-yl)propanoate (3ao)



The compound was prepared according to **GP1** using *(E)-N′*-benzylidene-*N*-phenylmethacrylohydrazide **1a** (0.053 g, 0.20 mmol, 1.0 equiv), methyl 2-bromo-2-methylpropanoate **2o** (0.054 g, 0.30 mmol, 1.5 equiv), Cs_2CO_3 (0.130 g, 0.40 mmol, 2 equiv), PPh_3 (0.052 g, 0.20 mmol, 1.0 equiv), and $Pd(PPh_3)_2Cl_2$ (0.007 g, 0.010 mmol, 5 mol%). Purification by column chromatography (5% ethyl acetate in hexane) gave **3ao** as a white solid (0.032 g, 45 %).

^{1}H NMR (500 MHz, $CDCl_3$); δ 8.06 (d, *J* = 8.4 Hz, 2H), 7.97 (dd, *J* = 7.7, 1.6 Hz, 2H), 7.48 (dt, *J* = 7.1, 4.2 Hz, 5H), 7.26 (t, *J* = 7.4 Hz, 1H), 3.68 (m, 1H), 3.12 (s, 3H), 2.68 (d, *J* = 14.9 Hz, 1H), 2.46 (d, *J* = 14.9 Hz, 1H), 1.64 (s, 3H), 1.12 (s, 3H), 1.05 (s, 3H).
^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$); ^{13}C NMR (126 MHz, $CDCl_3$) δ 176.6, 176.3, 160.4, 138.2, 131.2, 130.2, 128.9, 128.6, 126.6, 125.3, 119.1, 52.8, 51.4, 46.7, 41.9, 27.8, 26.5, 24.1.
HRMS-ESI (*m/z*): calcd for $C_{22}H_{24}KN_2O_3$ $[M+K]^+$ 403.1424; found 403.1418.

***Tert*-butyl-4-((4-methyl-5-oxo-1-phenyl-3-(4-(stearoyloxy)phenyl)-4,5-dihydro-1H-pyrazol-4-yl)methyl)piperidine-1-carboxylate-λ^3-methane (3qa)**

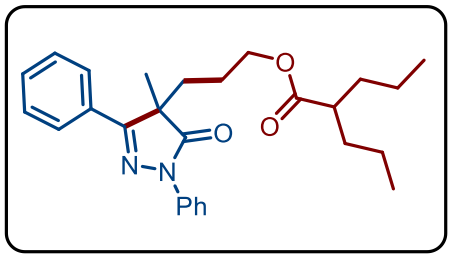


The compound was prepared according to **GP1** using *(E)-N′*-benzylidene-*N*-phenylmethacrylo-hydrazide **1a** (0.053 g, 0.20 mmol, 1.0 equiv), methyl 2-bromo-2-methylpropanoate **2o** (0.054 g, 0.30 mmol, 1.5 equiv), Cs_2CO_3 (0.130 g, 0.40 mmol, 2 equiv), PPh_3 (0.052 g, 0.20 mmol, 1.0 equiv), and $Pd(PPh_3)_2Cl_2$ (0.007 g, 0.010 mmol, 5 mol%). Purification by column chromatography (5% ethyl acetate in hexane) gave **3ao** as a white solid (0.032 g, 45 %).

^{1}H NMR (500 MHz, $CDCl_3$); δ 8.01 (d, *J* = 8.0 Hz, 2H), 7.93 (d, *J* = 8.7 Hz, 2H), 7.45 (t, *J* = 7.9 Hz, 2H), 7.22 (m, 2H), 3.89 (m, 2H), 2.59 (m, 2H), 2.46 (m, 2H), 2.11 (m, 2H), 1.85 – 1.71 (m, 2H), 1.65 (m, 2H), 1.54 (s, 3H), 1.48 – 1.44 (m, 1H), 1.39 (s, 9H), 1.26 (, 28H), 1.11 – 0.98 (m, 2H), 0.88 (t, *J* = 6.9 Hz, 3H).
^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$); δ 176.8, 172.1, 160.6, 154.7, 152.5, 138.2, 129.1, 128.6, 127.6, 125.5, 122.4, 119.2, 79.4, 53.6, 44.3, 43.9, 43.7, 34.5, 33.8, 32.9, 32.8, 32.1, 32.0, 31.9, 29.8, 29.7, 29.6, 29.5, 29.2, 28.6, 28.5, 25.0, 24.9, 24.8, 22.9, 22.8, 14.3.

HRMS-ESI (*m/z*): calcd for $C_{46}H_{71}N_3O_5$ $[M+H]^+$ 746.5466; found 746.5466.

3-(4-Methyl-5-oxo-1,3-diphenyl-4,5-dihydro-1H-pyrazol-4-yl)propyl 2-propylpentanoate (3ap)



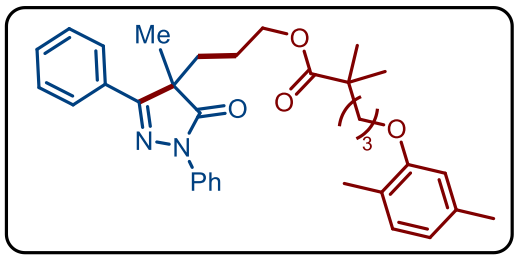
The compound was prepared according to **GP1** using *(E)-N′*-benzylidene-*N*-phenylmethacrylohydrazide **1a** (0.053 g, 0.20 mmol, 1.0 equiv), 2-bromoethyl 2-propylpentanoate **2p** (0.075 g, 0.30 mmol, 1.5 equiv), Cs_2CO_3 (0.130 g, 0.40 mmol, 2 equiv), PPh_3 (0.052 g, 0.20 mmol, 1.0 equiv), and $Pd(PPh_3)_2Cl_2$ (0.007 g, 0.010 mmol, 5 mol%). Purification by column chromatography (5% ethyl acetate in hexane) gave **3ap** as a white solid (0.061 g, 71%).

^{1}H NMR (500 MHz, $CDCl_3$); δ 8.06 (dd, *J* = 8.7, 1.0 Hz, 2H), 7.94 – 7.88 (m, 2H), 7.50 – 7.41 (m, 5H), 7.25 – 7.20 (m, 1H), 4.03 – 3.88 (m, 2H), 2.28 (tt, *J* = 8.9, 5.4 Hz, 1H), 2.22 – 2.06 (m, 2H), 1.61 (s, 3H), 1.57 – 1.47 (m, 2H), 1.46 – 1.31 (m, 4H), 1.23 (dq, *J* = 15.2, 7.5 Hz, 4H), 0.86 (td, *J* = 7.3, 4.6 Hz, 6H).

^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$); δ 176.4, 160.8, 138.0, 130.8, 130.5, 129.1, 128.9, 128.9, 126.3, 125.3, 118.9, 63.2, 54.2, 45.2, 34.5, 34.4, 34.1, 24.3, 22.7, 20.6, 20.6, 14.0.

HRMS-ESI (*m/z*): calcd for $C_{27}H_{34}N_2NaO_3$ $[M+Na]^+$ 457.2467; found 457.2477.

3-(4-Methyl-5-oxo-1,3-diphenyl-4,5-dihydro-1H-pyrazol-4-yl)propyl 5-(2,5-dimethylphenoxy) -2,2-dimethylpentanoate-λ^3-methane (3aq)



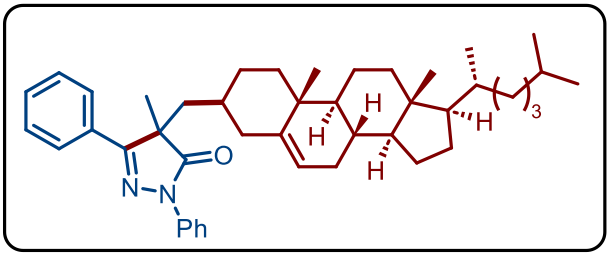
The compound was prepared according to **GP1** using *(E)-N′*-benzylidene-*N*-phenylmethacrylohydrazide **1a** (0.053 g, 0.20 mmol, 1.0 equiv), 2-bromoethyl 5-(2,5-dimethylphenoxy)-2,2-dimethylpentanoate **2q** (0.107 g, 0.30 mmol, 1.5 equiv), Cs_2CO_3 (0.130 g, 0.40 mmol, 2 equiv), PPh_3 (0.052 g, 0.20 mmol, 1.0 equiv), and $Pd(PPh_3)_2Cl_2$ (0.007 g, 0.010 mmol, 5 mol%). Purification by column chromatography (5% ethyl acetate in hexane) gave **3ap** as a white solid (0.072 g, 65%).

^{1}H NMR (500 MHz, $CDCl_3$); δ 8.07 (dd, *J* = 7.8, 0.9 Hz, 2H), 7.96 – 7.89 (m, 2H), 7.50 – 7.42 (m, 5H), 7.24 (t, *J* = 7.4 Hz, 1H), 7.00 (d, *J* = 7.4 Hz, 1H), 6.67 (d, *J* = 7.4 Hz, 1H), 6.60 (s, 1H), 4.05 – 3.77 (m, 4H), 2.32 (s, 3H), 2.15 (m, 5H), 1.66 (s, 3H), 1.62 (s, 3H), 1.42 (m, 2H), 1.16 (s, 6H).

$^{13}C\{^1H\}$ NMR (126 MHz, $CDCl_3$); δ 177.9, 176.7, 161.2, 157.3, 138.4, 136.8, 131.1, 130.9, 130.6, 129.4, 129.3, 126.7, 125.6, 123.9, 121.0, 119.3, 112.3, 68.2, 63.9, 54.6, 42.4, 37.4, 34.4, 25.5, 25.48, 25.45, 24.7, 23.1, 21.8, 16.1.

HRMS-ESI (*m/z*): calcd for $C_{35}H_{43}N_2NaO_4$ $[M+Na]^+$ 578.3121; found 578.3126.

4-(((3S,8S,9S,10R,13R,14S,17R)-10,13-Dimethyl-17-((R)-6-methylheptan-2-yl)-2,3,4,7,8,9,10,11,12,13,14,15,16,17-tetradecahydro-1H-cyclopenta[a]phenanthren-3-yl)methyl)-4-methyl-2,5-diphenyl-2,4-dihydro-3H-pyrazol-3-one-λ^3-methane(3ar)



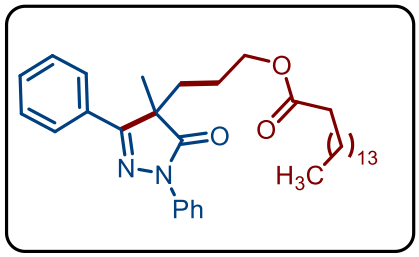
The compound was prepared according to **GP1** using *(E)-N′*-benzylidene-*N*-phenylmethacrylohydrazide **1a** (0.053 g, 0.20 mmol, 1.0 equiv), (3S,8S,9S,10R,13R,14S,17R)-3-bromo-10,13-dimethyl-17-((R)-6-methylheptan-2-yl)-2,3,4,7,8,9,10,11,12,13,14,15,16,17-tetradecahydro-1H-cyclopenta[a]phenanthrene **2r** (0.075 g, 0.30 mmol, 1.5 equiv), Cs_2CO_3 (0.130 g, 0.40 mmol, 2 equiv), PPh_3 (0.134 g, 0.20 mmol, 1.0 equiv), and $Pd(PPh_3)_2Cl_2$ (0.007 g, 0.010 mmol, 5 mol%). Purification by column chromatography (2-5% ethyl acetate in hexane) gave **3ar** as a white solid (0.088 g, 70%, dr 1.9:1).

^1H NMR (500 MHz, $CDCl_3$); ^1H NMR (500 MHz, $CDCl_3$) δ 8.09 (m, 2H), 8.01 – 7.93 (m, 2H), 7.48 (m, 5H), 7.25 (m, 1H), 5.09 (m, 1H), 2.27 (m, 1H), 2.03 (m, 3H), 1.94 – 1.75 (m, 3H), 1.72 – 1.50 (m, 9H), 1.47 – 1.27 (m, 9H), 1.12 (m, 11H), 0.90 (m, 11H), 0.67 (s, 3H).

$^{13}C\{^1H\}$ NMR (126 MHz, $CDCl_3$); δ 176.9, 176.7, 161.3, 161.1, 141.7, 139.6, 139.0, 131.1, 130.2, 128.7, 126.3, 125.0, 124.9, 122.5, 120.0, 118.9, 118.7, 56.7, 56.66, 56.60, 56.0, 54.16, 54.12, 53.57, 53.54, 50.3, 50.0, 45.0, 42.1, 42.1, 39.4, 39.3, 36.9, 36.0, 33.9, 31.6, 29.8, 28.1, 27.9, 27.8, 26.3, 24.2, 24.1, 23.78, 23.74, 22.72, 22.4, 20.5, 19.1, 19.0, 18.6, 18.6, 18.5, 11.7, 11.6.

HRMS-ESI (*m/z*): calcd for $C_{45}H_{63}KN_2O$ $[M+K]^+$ 686.4577; found 686.4587.

3-(4-Methyl-5-oxo-1,3-diphenyl-4,5-dihydro-1H-pyrazol-4-yl)propyl 4,4,4,4,4,4,4,4,4,4,4-undecamethyl-4 λ^{16}-pentanoate-formaldehyde (3as)



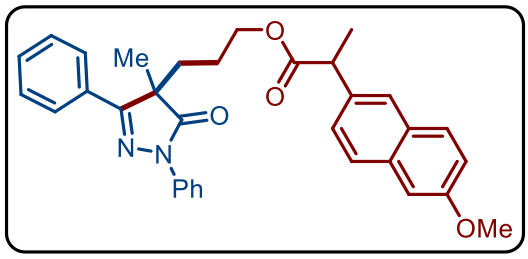
The compound was prepared according to **GP1** using *(E)-N′*-benzylidene-*N*-phenylmethacrylohydrazide **1a** (0.053 g, 0.20 mmol, 1.0 equiv), 2-bromoethyl palmitate **2t** (0.101 g, 0.30 mmol, 1.5 equiv), Cs_2CO_3 (0.130 g, 0.40 mmol, 2 equiv), PPh_3 (0.052 g, 0.20 mmol, 1.0 equiv), and $Pd(PPh_3)_2Cl_2$ (0.007 g, 0.010 mmol, 5 mol%). Purification by column chromatography (2% ethyl acetate in hexane) gave **3at** as a white solid (0.116 g, 66%).

^{1}H NMR (500 MHz, $CDCl_3$); δ 8.09 – 8.02 (m, 2H), 7.95 – 7.88 (m, 2H), 7.51 – 7.41 (m, 5H), 7.23 (t, *J* = 7.4 Hz, 1H), 4.04 – 3.86 (m, 2H), 2.25 – 2.00 (m, 4H), 1.61 (s, 3H), 1.57 – 1.50 (m, 2H), 1.47 – 1.35 (m, 2H), 1.25 (m, 24H), 0.88 (t, *J* = 6.9 Hz, 3H).

^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$); δ 176.4, 173.6, 160.8, 138.0, 130.8, 130.5, 129.0, 128.9, 126.3, 125.3, 118.9, 63.3, 54.2, 34.2, 33.9, 31.9, 29.7 (4C), 29.64, 29.60, 29.5, 29.3, 29.2, 29.1, 24.8, 24.2, 22.7, 22.7, 14.1.

HRMS-ESI (*m/z*): calcd for $C_{35}H_{48}N_2O_3$ $[M+H]^+$ 544.3665; found 544.3674.

3-(4-Methyl-5-oxo-1,3-diphenyl-4,5-dihydro-1H-pyrazol-4-yl)propyl 2-(6-methoxynaphthalen-2-yl)propanoate (3at)



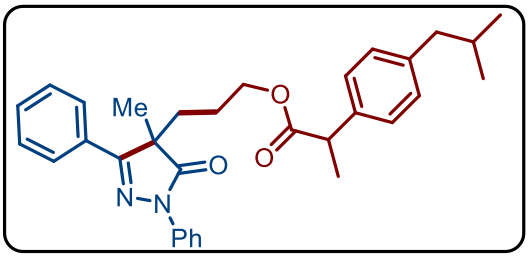
The compound was prepared according to **GP1** using *(E)-N′*-benzylidene-*N*-phenylmethacrylohydrazide **1a** (0.053 g, 0.20 mmol, 1.0 equiv), 2-bromoethyl 2-(6-methoxynaphthalen-2-yl)propanoate **2s** (0.101 g, 0.30 mmol, 1.5 equiv), Cs_2CO_3 (0.130 g, 0.40 mmol, 2 equiv), PPh_3 (0.052 g, 0.20 mmol, 1.0 equiv), and $Pd(PPh_3)_2Cl_2$ (0.007 g, 0.010 mmol, 5 mol%). Purification by column chromatography (5% ethyl acetate in hexane) gave **3as** as a white solid (0.064 g, 61%).

^{1}H NMR (500 MHz, $CDCl_3$); δ 8.03 (dd, *J* = 7.6, 5.4 Hz, 2H), 7.86 – 7.81 (m, 1H), 7.79 – 7.76 (m, 1H), 7.74 – 7.65 (m, 2H), 7.62 (d, *J* = 2.9 Hz, 1H), 7.47 – 7.33 (m, 6H), 7.23 (t, *J* = 7.8 Hz, 1H), 7.14 (dt, *J* = 8.8, 3.0 Hz, 1H), 7.10 (t, *J* = 2.8 Hz, 1H), 4.02 – 3.92 (m, 2H), 3.91 (s, 3H), 3.76 (m, 1H), 2.11 – 1.88 (m, 2H), 1.50 (m, 6H), 1.41 – 1.32 (m, 2H).

^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$); δ 176.4, 174.4, 160.8, 157.7, 138.0, 135.7, 135.5, 133.7, 130.7, 130.5, 128.9, 127.1, 127.0, 126.3, 126.2, 125.9, 125.8, 125.3, 119.0, 118.9, 105.6, 63.8, 55.3, 54.1, 45.3,33.8, 24.2, 22.5, 18.5, 18.1.

HRMS-ESI (*m/z*): calcd for : $C_{33}H_{33}N_2O_4$ $[M+H]^+$ 521.2440; found 521.2454.

3-(4-Methyl-5-oxo-1,3-diphenyl-4,5-dihydro-1H-pyrazol-4-yl)propyl 2-(4-isobutylphenyl)propanoate (3au)



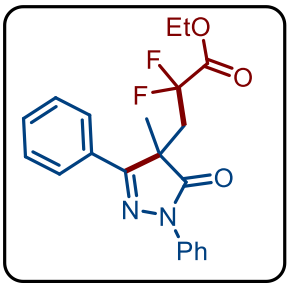
The compound was prepared according to **GP1** using *(E)-N'*-benzylidene-*N*-phenylmethacrylo-hydrazide **1a** (0.053 g, 0.20 mmol, 1.0 equiv), 2-bromoethyl 2-(4-isobutylphenyl)propanoate **2u** (0.094 g, 0.30 mmol, 1.5 equiv), Cs_2CO_3 (0.130 g, 0.40 mmol, 2 equiv), PPh_3 (0.052 g, 0.20 mmol, 1.0 equiv), and $Pd(PPh_3)_2Cl_2$ (0.007 g, 0.010 mmol, 5 mol%). Purification by column chromatography (2% ethyl acetate in hexane) gave **3at** as a white solid (0.64 g, 64%).

^{1}H NMR (500 MHz, $CDCl_3$); δ 8.08 – 8.02 (m, 2H), 7.90 – 7.84 (m, 2H), 7.50 – 7.42 (m, 5H), 7.23 (t, *J* = 7.2 Hz, 1H), 7.18 – 7.13 (m, 2H), 7.12 – 7.04 (m, 2H), 4.03 – 3.86 (m, 2H), 3.69 – 3.54 (m, 1H), 2.44 (dd, *J* = 7.2, 1.8 Hz, 2H), 2.03 (m, 2H), 1.84 (dt, *J* = 13.5, 6.6 Hz, 1H), 1.56 (d, *J* = 12.6 Hz, 3H), 1.43 (dd, *J* = 5.9, 3.0 Hz, 3H), 1.38 (dd, *J* = 11.5, 5.7 Hz, 2H), 0.89 (d, *J* = 6.6 Hz, 6H).

^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$); δ 182.8, 169.7, 142.0, 133.4, 130.1, 129.9, 128.3, 128.0, 126.8, 119.1, 50.9, 38.3, 32.0, 30.0, 29.9, 29.8, 29.7, 29.6, 29.5, 29.45 (2C), 29.37, 27.34, 27.32, 26.3, 24.9, 23.2, 22.8, 14.3.

HRMS-ESI (*m/z*): calcd for $C_{32}H_{36}N_2NaO_3$ $[M+Na]^+$ 519.2624; found 519.2624.

Ethyl-2,2-difluoro-3-(4-methyl-5-oxo-1,3-diphenyl-4,5-dihydro-1H-pyrazol-4-yl)propanoate (5aa)



The compound was prepared according to **GP2** using *(E)-N'*-benzylidene-*N*-phenylmethacrylohydrazide **1a** (0.053 g, 0.20 mmol, 1.0 equiv), ethyl 2-bromo-2,2-difluoroacetate **4a** (0.094 g, 0.30 mmol, 1.5 equiv), Cs_2CO_3 (0.130 g, 0.40 mmol, 2 equiv), PPh_3 (0.052 g, 0.20 mmol, 1.0 equiv), and $Pd(PPh_3)_2Cl_2$ (0.007 g, 0.010 mmol, 5 mol%). Purification by column chromatography (10% ethyl acetate in hexane) gave **5aa** as a white solid (0.048 g, 62%).

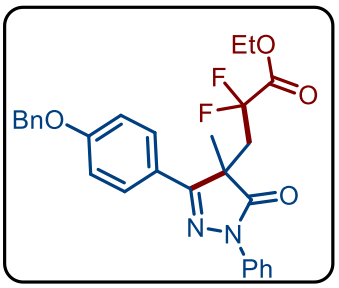
^{1}H NMR (500 MHz, $CDCl_3$); δ 8.01 (d, *J* = 7.7 Hz, 2H), 7.89 (dd, *J* = 6.6, 3.1 Hz, 2H), 7.50 – 7.41 (m, 5H), 7.23 (d, *J* = 7.4 Hz, 1H), 4.08 (m, 2H), 3.13 – 2.84 (m, 2H), 1.65 (s, 3H), 1.22 (t, *J* = 7.2 Hz, 3H).

$^{13}C\{^1H\}$ NMR (126 MHz, $CDCl_3$); δ 174.9, δ 163.0 (t, *J* = 31.8 Hz), 159.3, 138.0, 130.8, 130.4, 128.9, 128.8,126.4, 125.5, 119.3, 113.9 (t, *J* = 253.3 Hz), 63.2, 49.6, 40.9 (t, *J* = 23.1 Hz), 40.7, 24.4, 13.7.

$^{19}F\{^1H\}$ NMR (471 MHz, $CDCl_3$); δ -101.89 (m), -105.32 (m).

HRMS-ESI (*m/z*): calcd for $C_{21}H_{21}F_2N_2O_3$ $[M+H]^+$ 387.1520; found 387.1538.

Ethyl-3-(3-(4-(benzyloxy)phenyl)-4-methyl-5-oxo-1-phenyl-4,5-dihydro-1H-pyrazol-4-yl)-2,2-difluoropropanoate (5ba)



The compound was prepared according to **GP2** using *(E)-N'*-(4-(benzyloxy)benzylidene)-*N*-phenylmethacrylohydrazide **1f** (0.061 g, 0.20 mmol, 1.0 equiv), ethyl 2-bromo-2,2-difluoroacetate **4a** (0.094 g, 0.30 mmol, 1.5 equiv), Cs_2CO_3 (0.130 g, 0.40 mmol, 2 equiv), PPh_3 (0.052 g, 0.20 mmol, 1.0 equiv), and $Pd(PPh_3)_2Cl_2$ (0.007 g, 0.010 mmol, 5 mol%). Purification by column chromatography (10% ethyl acetate in hexane) gave **5ba** as a white solid (0.069 g, 70%).

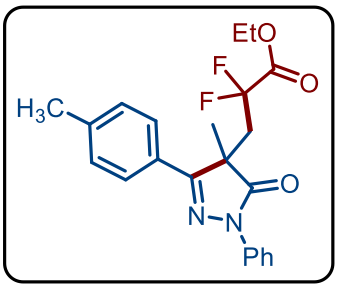
^1H NMR (500 MHz, $CDCl_3$); δ 8.01 (d, *J* = 7.7 Hz, 2H), 7.84 (d, *J* = 8.9 Hz, 2H), 7.43 (m, 6H), 7.35 (t, *J* = 7.1 Hz, 1H), 7.22 (t, *J* = 7.4 Hz, 1H), 7.05 (d, *J* = 8.9 Hz, 2H), 5.13 (s, 2H), 4.20 – 3.99 (m, 2H), 3.10 – 2.85 (m, 2H), 1.62 (s, 3H), 1.21 (t, *J* = 7.1 Hz, 3H).

$^{13}C\{^1H\}$ NMR (126 MHz, $CDCl_3$); δ 174.7, 163.0 (t, *J* = 31.8 Hz), 160.4, 159.0, 138.1, 136.4, 128.8, 128.7, 128.2, 128.1, 127.5, 125.3, 123.7, 119.2, 115.1, 114.9 (t, *J* = 126.2 Hz), 70.1, 63.2, 49.6, 41.0 (t, *J* = 23.2 Hz), 24.4, 13.7.

^{19}F NMR (471 MHz, $CDCl_3$); δ -101.61 (m), -103.83 (d, *J* = 266.4 Hz).

HRMS-ESI (*m/z*): calcd for $C_{28}H_{27}F_2N_2O$ $[M+H]^+$ 493.1939; found 493.1928.

Ethyl-2,2-difluoro-3-(4-methyl-5-oxo-1-phenyl-3-(p-tolyl)-4,5-dihydro-1H-pyrazol-4-yl)propanoate (5ca)



The compound was prepared according to **GP2** using *(E)-N'*-(4-methylbenzylidene)-*N*-phenylmethacrylohydrazide **1b** (0.056 g, 0.20 mmol, 1.0 equiv), ethyl 2-bromo-2,2-difluoroacetate **4a** (0.094 g, 0.30 mmol, 1.5 equiv), Cs_2CO_3 (0.130 g, 0.40 mmol, 2 equiv), PPh_3 (0.052 g, 0.20 mmol, 1.0 equiv), and $Pd(PPh_3)_2Cl_2$ (0.007 g, 0.010 mmol, 5 mol%). Purification by column chromatography (10% ethyl acetate in hexane) gave **5ca** as a white solid (0.059 g, 70%).

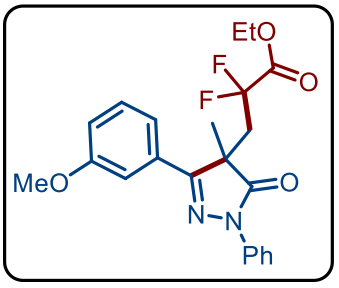
^{1}H NMR (500 MHz, $CDCl_3$); δ 8.07 – 7.96 (m, 2H), 7.78 (d, *J* = 8.2 Hz, 2H), 7.44 (t, *J* = 8.0 Hz, 2H), 7.23 (t, *J* = 7.4 Hz, 3H), 4.17 – 4.02 (m, 2H), 3.09 – 2.89 (m, 2H), 2.41 (s, 3H), 1.63 (s, 3H), 1.22 (t, *J* = 7.2 Hz, 3H).

^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$); δ 174.8, 163.0 (t, *J* = 29.3 Hz), 159.3, 140.7, 138.1, 129.5, 129.0, 128.8, 128.0, 126.4, 125.4, 119.3, 63.2, 49.6, 40.9 (t, *J* = 23.3 Hz), 24.4, 21.5, 13.7.

^{19}F NMR (471 MHz, $CDCl_3$); δ -101.74 (d, *J* = 266.0 Hz), -104.03 (d, *J* = 266.0 Hz).

HRMS-ESI (*m/z*): calcd for $C_{22}H_{23}F_2N_2O_3$ $[M+H]^+$ 401.1677; found 401.1684.

Ethyl-2,2-difluoro-3-(3-(3-methoxyphenyl)-4-methyl-5-oxo-1-phenyl-4,5-dihydro-1H-pyrazol-4-yl)propanoate (5da)



The compound was prepared according to **GP2** using *(E)-N'*-(3-methoxybenzylidene)-*N*-phenylmethacrylohydrazide **1i** (0.059 g, 0.20 mmol, 1.0 equiv), ethyl 2-bromo-2,2-difluoroacetate **4a** (0.094 g, 0.30 mmol, 1.5 equiv), Cs_2CO_3 (0.130 g, 0.40 mmol, 2 equiv), PPh_3 (0.052 g, 0.20 mmol, 1.0 equiv), and $Pd(PPh_3)_2Cl_2$ (0.007 g, 0.010 mmol, 5 mol%). Purification by column chromatography (10% ethyl acetate in hexane) gave **5ca** as a white solid (0.063 g, 76%).

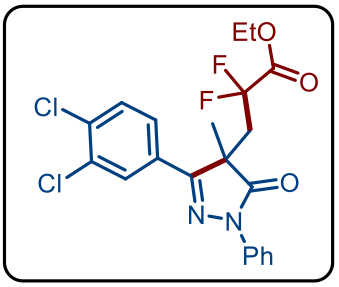
^{1}H NMR (500 MHz, $CDCl_3$); δ 8.04 (d, *J* = 7.9 Hz, 2H), 7.45 (m, 5H), 7.29 – 7.25 (m, 1H), 7.03 (dd, *J* = 7.9, 1.5 Hz, 1H), 4.21 – 4.04 (m, 2H), 3.91 (s, 3H), 3.12 – 2.91 (m, 2H), 1.67 (s, 3H), 1.25 (t, *J* = 7.2 Hz, 3H).

^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$); δ 174.8, 162.9 (t, *J* = 31.9 Hz), 159.8, 159.1, 137.9, 132.0, 129.8, 128.9, 125.5, 119.3, 118.9, 117.2– 109.2 (m), 63.2, 55.3, 49.6, 40.9 (t, *J* = 23.1 Hz), 24.4, 13.7.

^{19}F NMR (471 MHz, $CDCl_3$); δ -101.72 (d, *J* = 265.9 Hz), -103.88 (d, *J* = 265.9 Hz)

HRMS-ESI (*m/z*): calcd for $C_{22}H_{23}F_2N_2O_4$ $[M+H]^+$ 417.1620; found 417.1621.

Ethyl-3-(3-(3,4-dichlorophenyl)-4-methyl-5-oxo-1-phenyl-4,5-dihydro-1H-pyrazol-4-yl)-2,2-difluoropropanoate (5ea)



The compound was prepared according to **GP2** using *(E)-N'-(*3,4-dichlorobenzylidene)-*N*-methylmethacrylohydrazide **1r** (0.054 g, 0.20 mmol, 1.0 equiv), ethyl 2-bromo-2,2-difluoroacetate **4a** (0.094 g, 0.30 mmol, 1.5 equiv), Cs_2CO_3 (0.130 g, 0.40 mmol, 2 equiv), PPh_3 (0.052 g, 0.20 mmol, 1.0 equiv), and $Pd(PPh_3)_2Cl_2$ (0.007 g, 0.010 mmol, 5 mol%). Purification by column chromatography (10% ethyl acetate in hexane) gave **5ca** as a white solid (0.063 g, 68%).

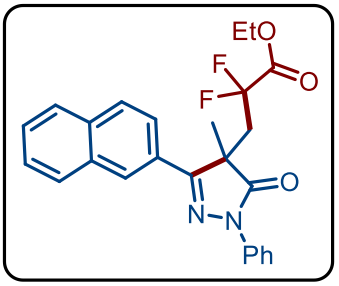
^{1}H NMR (500 MHz, $CDCl_3$); δ 7.95 (d, *J* = 8.1 Hz, 2H), 7.63 (d, *J* = 8.0 Hz, 1H), 7.48 (dd, *J* = 15.1, 7.7 Hz, 3H), 7.36 (t, *J* = 7.9 Hz, 1H), 7.26 (t, *J* = 7.4 Hz, 1H), 4.31 (m, 2H), 2.85 – 2.67 (m, 2H), 1.56 (s, 3H), 1.32 (t, *J* = 7.1 Hz, 3H).

^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$); 173.4, 163.0 (m), 158.6, 137.7, 134.9, 132.8, 131.9, 131.8, 128.9, 128.2, 127.3, 125.7, 119.3, 116.2- 112.1 (m), 63.5, 51.6, 39.2, 39.0 (t, *J* = 23.3 Hz), 22.4, 13.7.

^{19}F NMR (471 MHz, $CDCl_3$); δ -99.81 (d, *J* = 266.0 Hz), -103.93 (d, *J* = 266.0 Hz).

HRMS-ESI (*m/z*): calcd for $C_{21}H_{19}Cl_2F_2N_2O_3$ $[M+H]^+$ 455.0735; found 455.0732.

Ethyl-2,2-difluoro-3-(4-methyl-3-(naphthalen-2-yl)-5-oxo-1-phenyl-4,5-dihydro-1H-pyrazol-4-yl)propanoate (5fa)



The compound was prepared according to **GP2** using *(E)-N'*-(naphthalen-2-ylmethylene)-*N*-phenylmethacrylohydrazide **1p** (0.063 g, 0.20 mmol, 1.0 equiv), ethyl 2-bromo-2,2-difluoroacetate **4a** (0.094 g, 0.30 mmol, 1.5 equiv), Cs_2CO_3 (0.130 g, 0.40 mmol, 2 equiv), PPh_3 (0.052 g, 0.20 mmol, 1.0 equiv), and $Pd(PPh_3)_2Cl_2$ (0.007 g, 0.010 mmol, 5 mol%). Purification by column chromatography (10% ethyl acetate in hexane) gave **5ca** as a white solid (0.69 g, 66%).

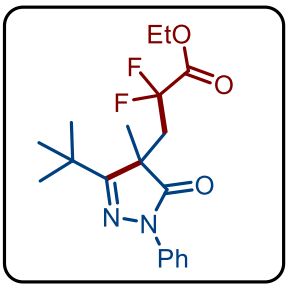
^{1}H NMR (500 MHz, $CDCl_3$); δ 8.22 – 8.17 (m, 2H), 8.11 – 8.06 (m, 2H), 7.98 – 7.87 (m, 3H), 7.60 – 7.57 (m, 2H), 7.49 (dd, *J* = 11.3, 4.6 Hz, 2H), 7.29 – 7.25 (m, 1H), 4.16 – 3.95 (m, 2H), 3.20 – 3.06 (m, 2H), 1.78 (s, 3H), 1.19 (t, *J* = 7.2 Hz, 3H).

^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$); δ 174.9, 163.1 (m), 159.1, 138.0, 134.0, 132.9, 128.9, 128.7, 128.6, 127.8, 127.5, 126.8, 126.3, 125.5, 123.5, 119.4, 115.9, 114.1 (m), 63.2, 49.6, 41.1 (t, *J* = 23.1 Hz), 24.6, 13.6.

^{19}F NMR (471 MHz, $CDCl_3$); δ -101.86 (d, *J* = 266.5 Hz), -103.57 (d, *J* = 266.5 Hz).

HRMS-ESI (*m/z*): calcd for $C_{25}H_{23}F_2N_2O_3$ $[M+H]^+$ 437.1671; found 437.1680.

Ethyl-3-(3-(tert-butyl)-4-methyl-5-oxo-1-phenyl-4,5-dihydro-1H-pyrazol-4-yl)-2,2-difluoropropanoate (5ga)



The compound was prepared according to **GP2** using *(E)-N′*-(2,2-dimethylpropylidene)-*N*-phenylmethacrylohydrazide **1k** (0.058 g, 0.20 mmol, 1.0 equiv), ethyl 2-bromo-2,2-difluoroacetate **4a** (0.094 g, 0.30 mmol, 1.5 equiv), Cs_2CO_3 (0.130 g, 0.40 mmol, 2 equiv), PPh_3 (0.052 g, 0.20 mmol, 1.0 equiv), and $Pd(PPh_3)_2Cl_2$ (0.007 g, 0.010 mmol, 5 mol%). Purification by column chromatography (10% ethyl acetate in hexane) gave **5da** as a white solid (0.043 g, 59%).

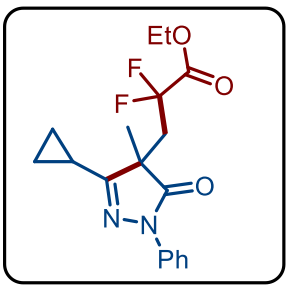
^{1}H NMR (500 MHz, $CDCl_3$); δ 7.95 (d, *J* = 7.7 Hz, 2H), 7.42 (t, *J* = 8.0 Hz, 2H), 7.20 (t, *J* = 7.4 Hz, 1H), 4.27 (m, 2H), 2.92 – 2.71 (m, 2H), 1.53 (s, 3H), 1.43 (s, 9H), 1.30 (t, *J* = 7.1 Hz, 3H).

^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$); δ 174.1, 170.3, 163.1 (t, *J* = 31.9 Hz),138.1, 128.7, 125.0, 119.0, 114.0 (t, *J* = 250.7 Hz), 63.3, 51.0, 42.35 – 39.28 (m), 36.7, 29.8, 28.1, 23.1, 13.7, 13.7.

^{19}F NMR (471 MHz, $CDCl_3$); δ -101.23 (m), -106.31 (d, *J* = 263.9 Hz).

HRMS-ESI (*m/z*): calcd for $C_{19}H_{25}F_2N_2O_3$ $[M+H]^+$ 367.1833; found 367.1848.

Ethyl-3-(3-cyclopropyl-4-methyl-5-oxo-1-phenyl-4,5-dihydro-1H-pyrazol-4-yl)-2,2-difluoropropanoate (5ha)



The compound was prepared according to **GP2** using (E)-*N′*-(cyclopropylmethylene)-*N*-methylmethacrylohydrazide (0.045 g, 0.20 mmol, 1.0 equiv), ethyl 2-bromo-2,2-difluoroacetate **4a** (0.094 g, 0.30 mmol, 1.5 equiv), Cs_2CO_3 (0.130 g, 0.40 mmol, 2 equiv), PPh_3 (0.052 g, 0.20 mmol, 1.0 equiv), and $Pd(PPh_3)_2Cl_2$ (0.007 g, 0.010 mmol, 5 mol%). Purification by column chromatography (10% ethyl acetate in hexane) gave **5da** as a white solid (0.046 g, 66%).

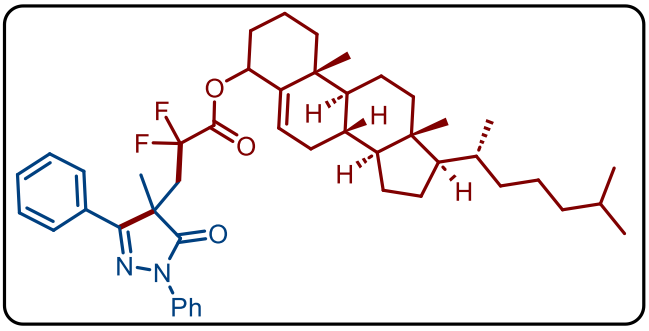
^{1}H NMR (500 MHz, $CDCl_3$); 7.90 (d, *J* = 7.8 Hz, 2H), 7.40 (t, *J* = 7.9 Hz, 2H), 7.22 – 7.16 (m, 1H), 4.32 – 4.23 (m, 2H), 2.88 – 2.61 (m, 2H), 1.62 (m, 1H), 1.46 (s, 3H), 1.38 (dd, *J* = 6.5, 4.0 Hz, 1H), 1.30 (t, *J* = 7.1 Hz, 3H), 1.08 – 0.95 (m, 3H).

$^{13}C\{^1H\}$ NMR (126 MHz, $CDCl_3$); δ 174.2, 167.1, 163.1, 138.1, 128.7, 124.9, 118.8, 63.3, 50.7, 39.4 (t, *J* = 23.2 Hz), 23.2, 13.7, 10.6, 8.8, 7.2.

^{19}F NMR (471 MHz, $CDCl_3$); δ -100.72 (d, *J* = 265.9 Hz), -102.88 (d, *J* = 265.9 Hz).

HRMS-ESI (*m/z*): calcd for $C_{18}H_{21}F_2N_2O_3$ $[M+H]^+$ 351.1515; found 351.1508.

(8S,9S,10R,13R,14S,17R)-10,13-Dimethyl-17-((R)-6-methylheptan-2-yl)-2,3,4,7,8,9,10,11,12,13,14,15,16,17-tetradecahydro-1H-cyclopenta[a]phenanthren-4-yl 2,2-difluoro-3-((R)-4-methyl-5-oxo-1,3-diphenyl-4,5-dihydro-1H-pyrazol-4-yl)propanoate (5ab)



The compound was prepared according to **GP2** using *(E)-N'*-benzylidene-*N*-phenylmethacrylohydrazide **1a** (0.053 g, 0.20 mmol, 1.0 equiv), (3S,8S,9S,10R,13R,14S,17R)-10,13-dimethyl-17-((R)-6-methylheptan-2-yl)-2,3,4,7,8,9,10,11,12,13,14,15,16,17-tetradecahydro-1H-cyclopenta[a]phenanthren-3-yl 2-bromo-2,2-difluoroacetate **4b** (0.162 g, 0.30 mmol, 1.5 equiv), Cs_2CO_3 (0.130 g, 0.40 mmol, 2 equiv), PPh_3 (0.052 g, 0.20 mmol, 1.0 equiv), and $Pd(PPh_3)_2Cl_2$ (0.007 g, 0.010 mmol, 5 mol%). Purification by column chromatography (2% ethyl acetate in hexane) gave **5ab** as a white solid (0.081 g, 56%, dr 1:1.1).

^1H NMR (500 MHz, $CDCl_3$); δ 8.04 (d, *J* = 8.4 Hz, 2H), 7.95 – 7.89 (m, 2H), 7.51 – 7.44 (m, 5H), 7.30 – 7.27 (m, 1H), 5.37 (s, 1H), 4.68 – 4.51 (m, 1H), 3.17 – 2.90 (m, 2H), 2.42 – 2.24 (m, 2H), 2.06 – 1.98 (m, 2H), 1.90 – 1.82 (m, 3H), 1.69 (s, 3H), 1.64 – 1.45 (m, 8H), 1.39 (m, 3H), 1.33 – 1.26 (m, 2H), 1.23 – 1.06 (m, 9H), 1.02 (s, 3H), 0.95 (d, *J* = 6.4 Hz, 3H), 0.91 (m, 6H), 0.71 (s, 3H)

$^{13}C\{^1H\}$ NMR (126 MHz, $CDCl_3$); δ 175.3, 162.5 (t, *J* = 31.6 Hz), 159.8, 138.8, 137.9, 130.8, 130.4, 128.9, 128.8, 126.5, 125.7, 123.5, 119.6, 113.9 (t, *J* =253.9 Hz), 56.8, 56.2, 50.0, 49.9, 42.4, 41.0 (t, *J* = 23.4 Hz), 39.8, 39.6, 37.5, 37.5, 36.8, 36.6, 36.3, 35.9, 32.0, 31.9, 28.3, 28.1, 27.3, 27.3, 24.4, 24.3, 23.9, 22.9, 22.7, 21.1, 19.3, 18.8, 12.0.

^{19}F NMR (471 MHz, $CDCl_3$); δ -101.35 (dd, *J* = 266.7, 90.4 Hz), -104.45 (dd, *J* = 266.7, 128.1 Hz).

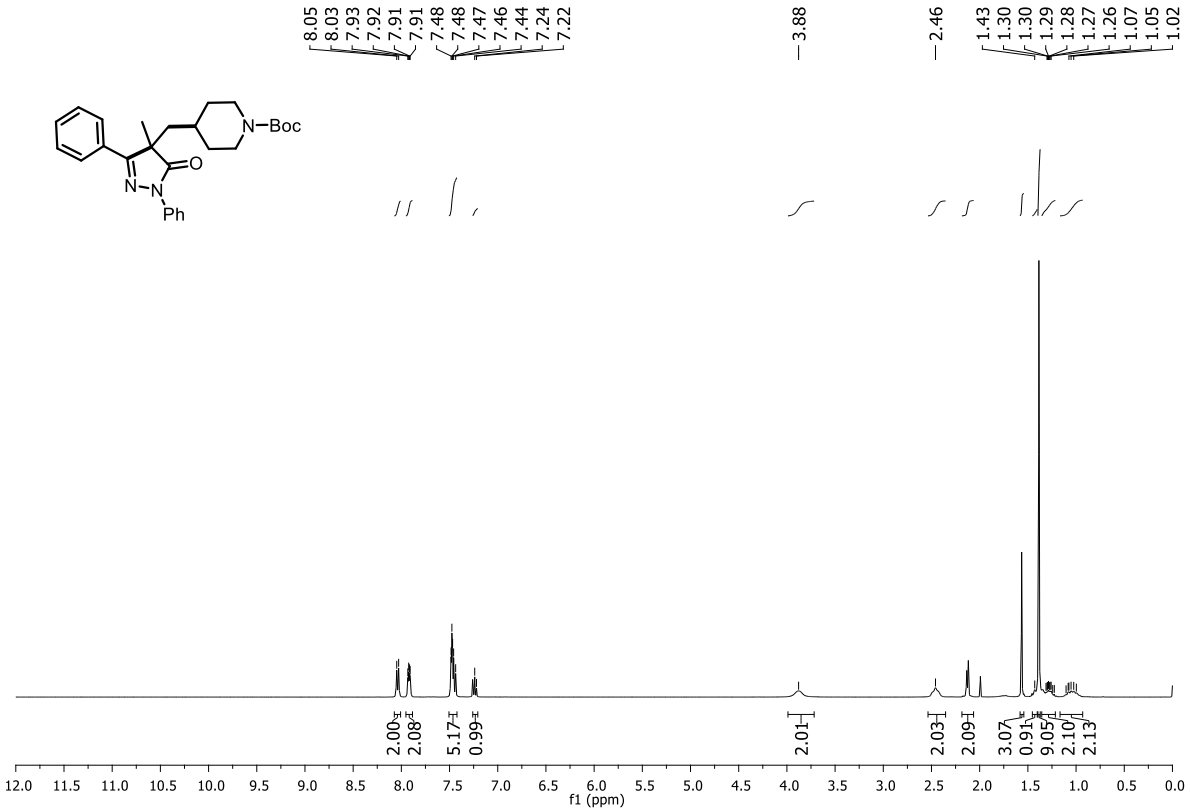
HRMS-ESI (*m/z*): calcd for $C_{46}H_{61}F_2N_2O_3$ $[M+H]^+$ 727.4650; found 727.4671.

12. Reference:

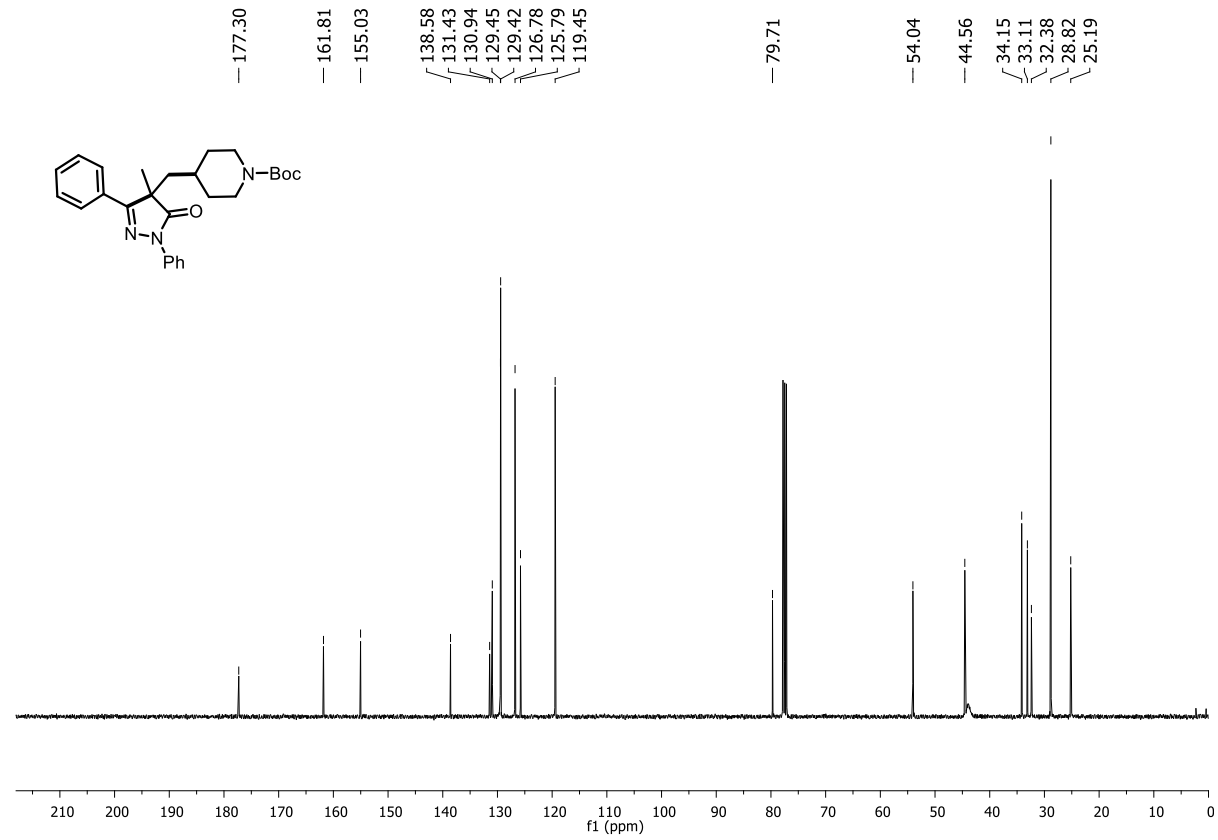
1. Panda, S. P.; Dash, R.; Hota, S. K.; Murarka, S. *Org. Lett.* **2024**, *26*, 3667-3672.
2. Falk, E.; Franchino, A.; Horak, T.; Gürtler, L.; Morandi, B. *Org. Lett.* **2023**, *25*, 1695-1700.
3. Van Kalkeren, H. A.; Leenders, S. H. A. M.; Hommersom, C. R. A.; Rutjes, F. P. J. T.; van Delft, F. L. *Chem. Eur. J.* **2011**, *17*, 11290-11295.
4. Lin, Z.; Lan, Y.; Wang, C. *Org. Lett.* **2019**, *21*, 8316-8322.
5. Vandevoorde, S.; Tsuboi, K.; Ueda, N.; Jonsson, K.O.; Fowler, C. J.; Lambert, D. M. *J. Med. Chem.* **2003**, *46*, 4373-4376.
6. Jana, S.; Cramer, N. *J. Am. Chem. Soc.* **2024**, *146*, 35199-35207.

13. NMR Spectra of Compounds;

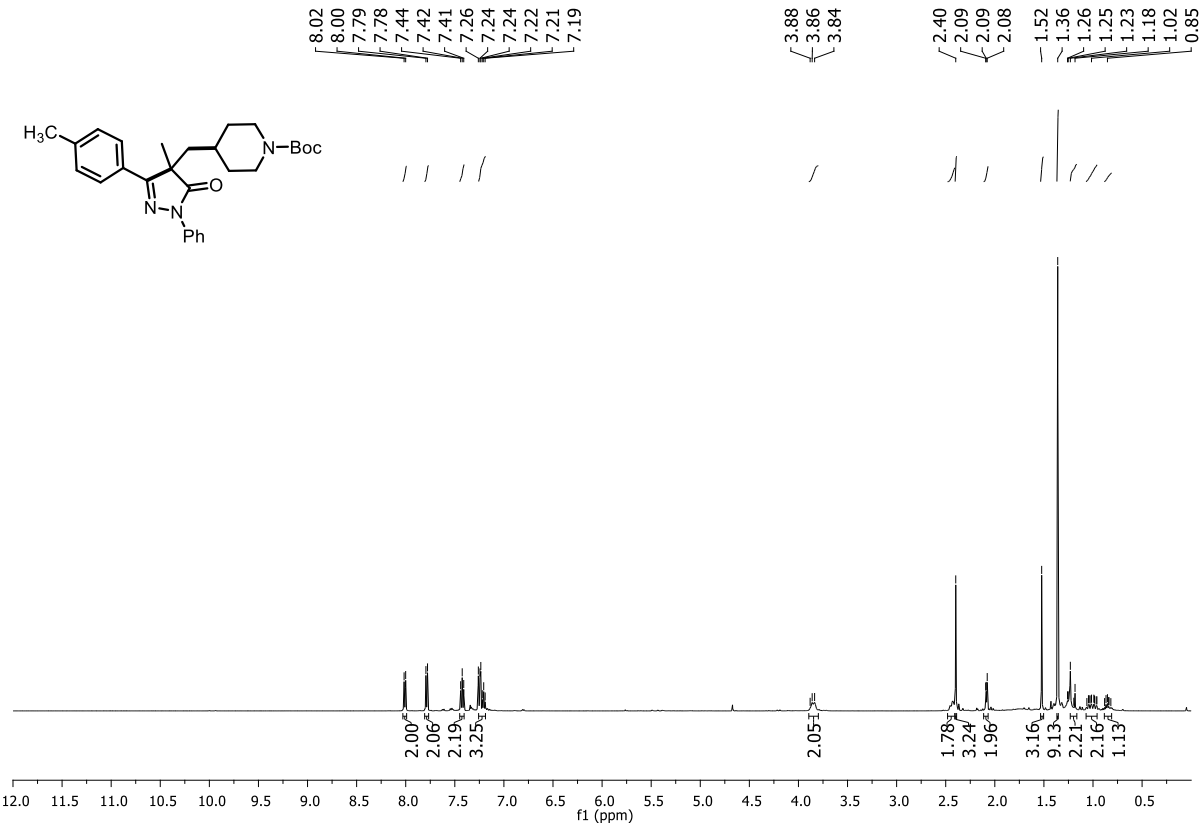
^{1}H NMR spectrum of 3aa ($CDCl_3$, 500 MHz)



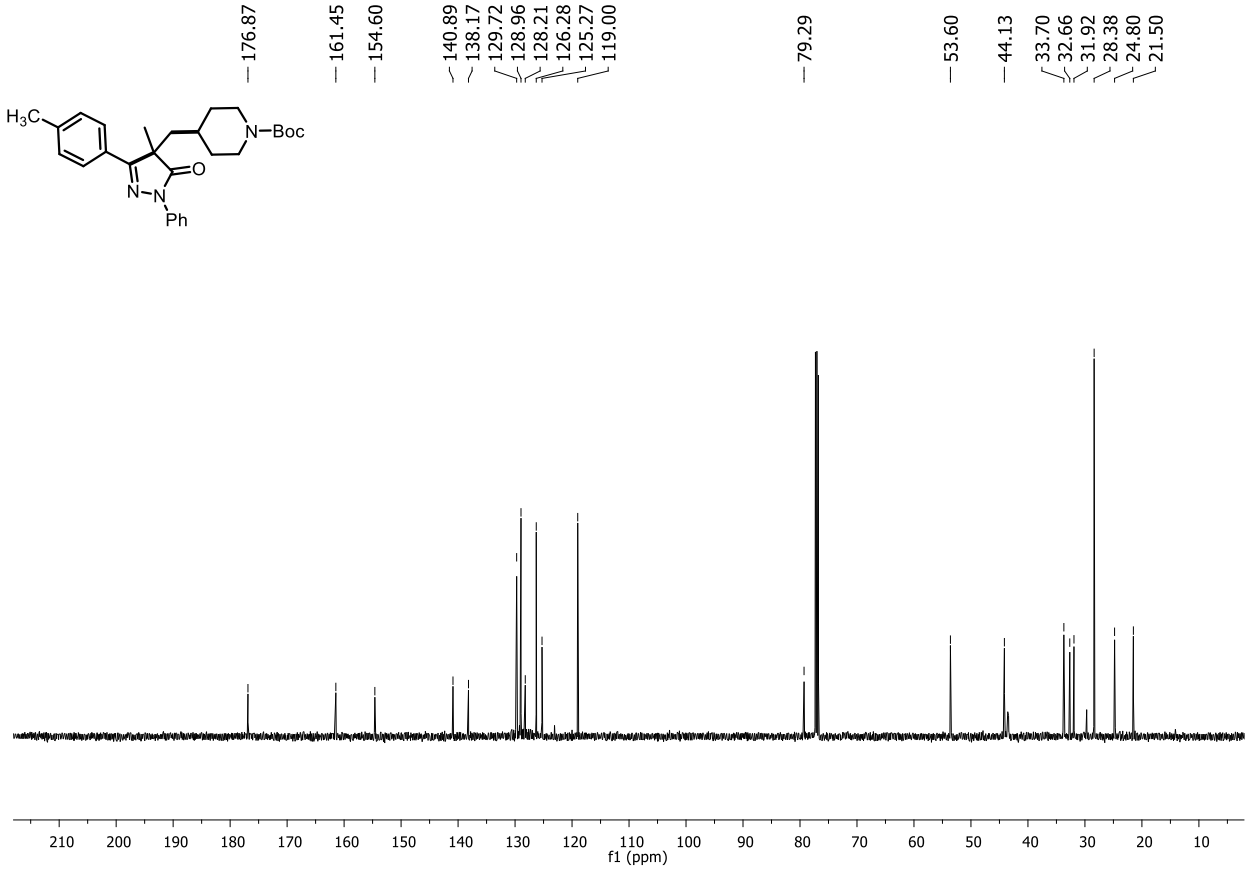
^{13}C{^{1}H} NMR spectrum of 3aa ($CDCl_3$, 126 MHz)



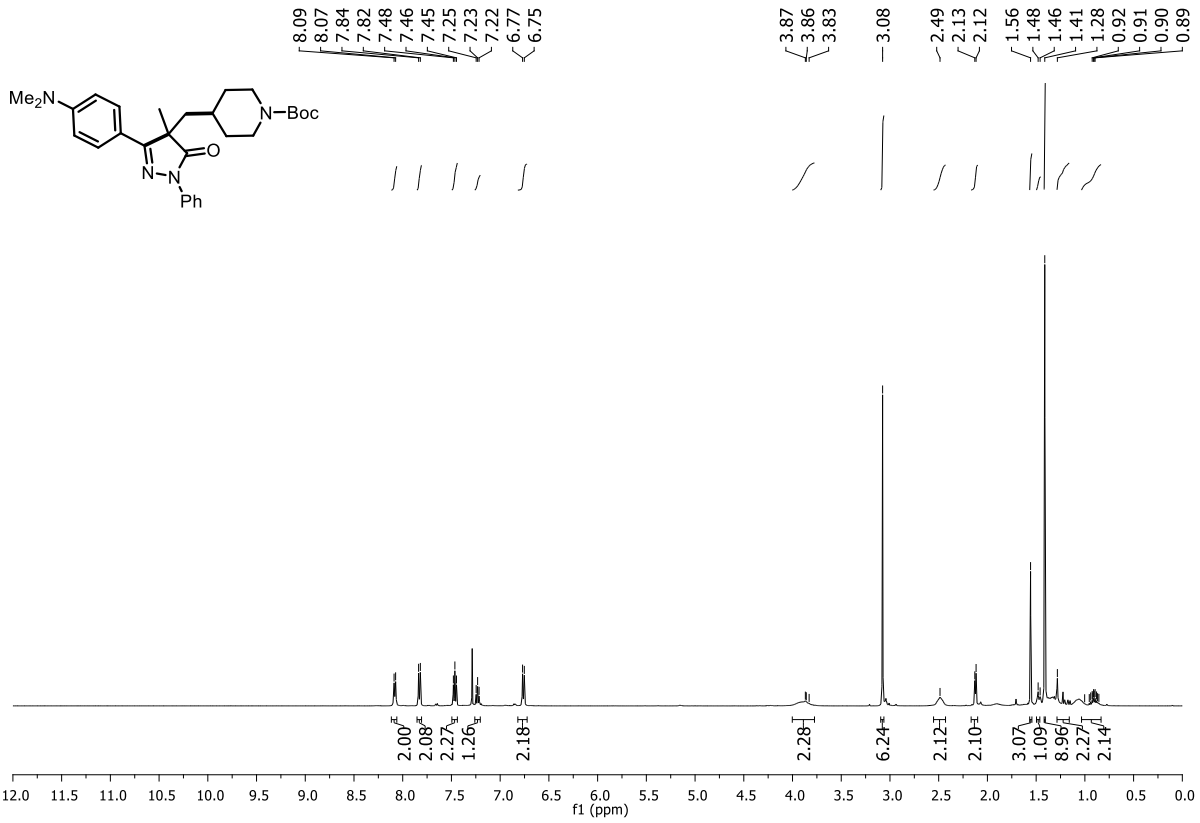
^{1}H NMR spectrum of 3ba ($CDCl_3$, 500 MHz)



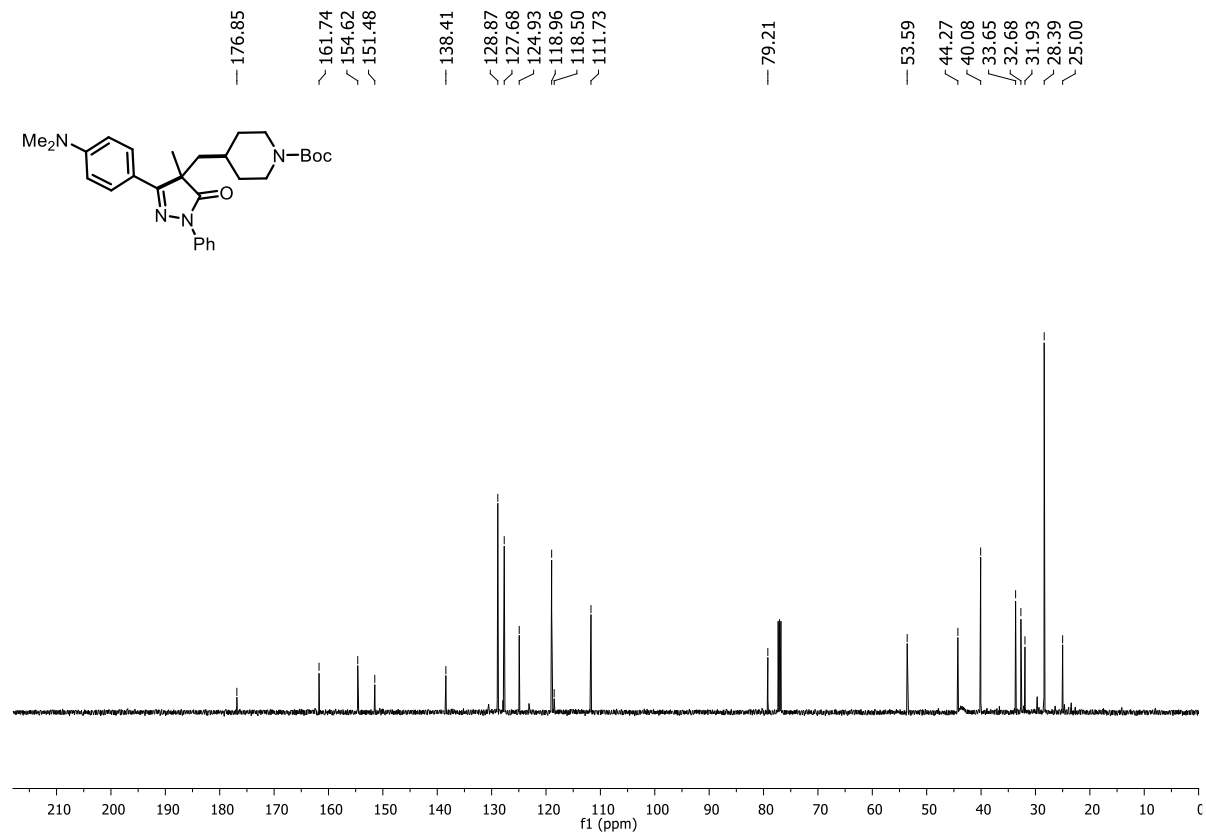
^{13}C{^{1}H} NMR spectrum of 3ba ($CDCl_3$, 126 MHz)



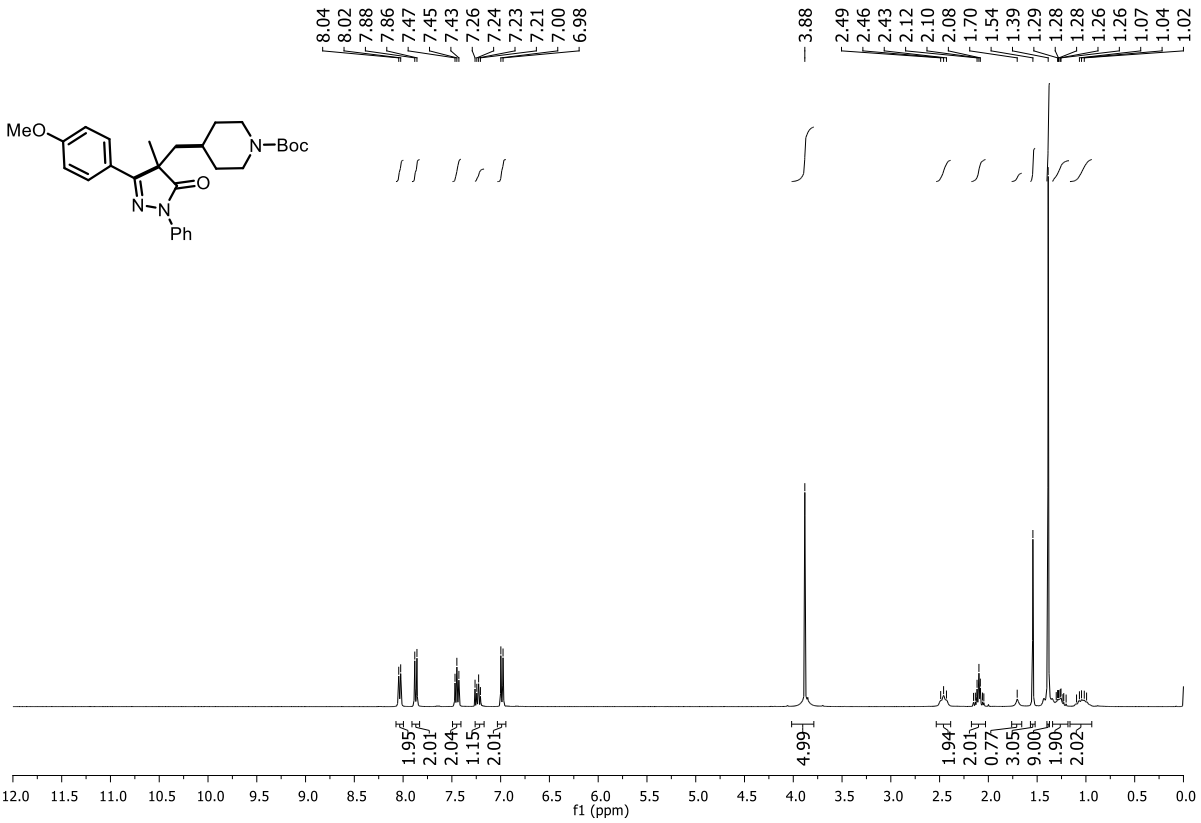
^{1}H NMR spectrum of 3ca ($CDCl_3$, 500 MHz)



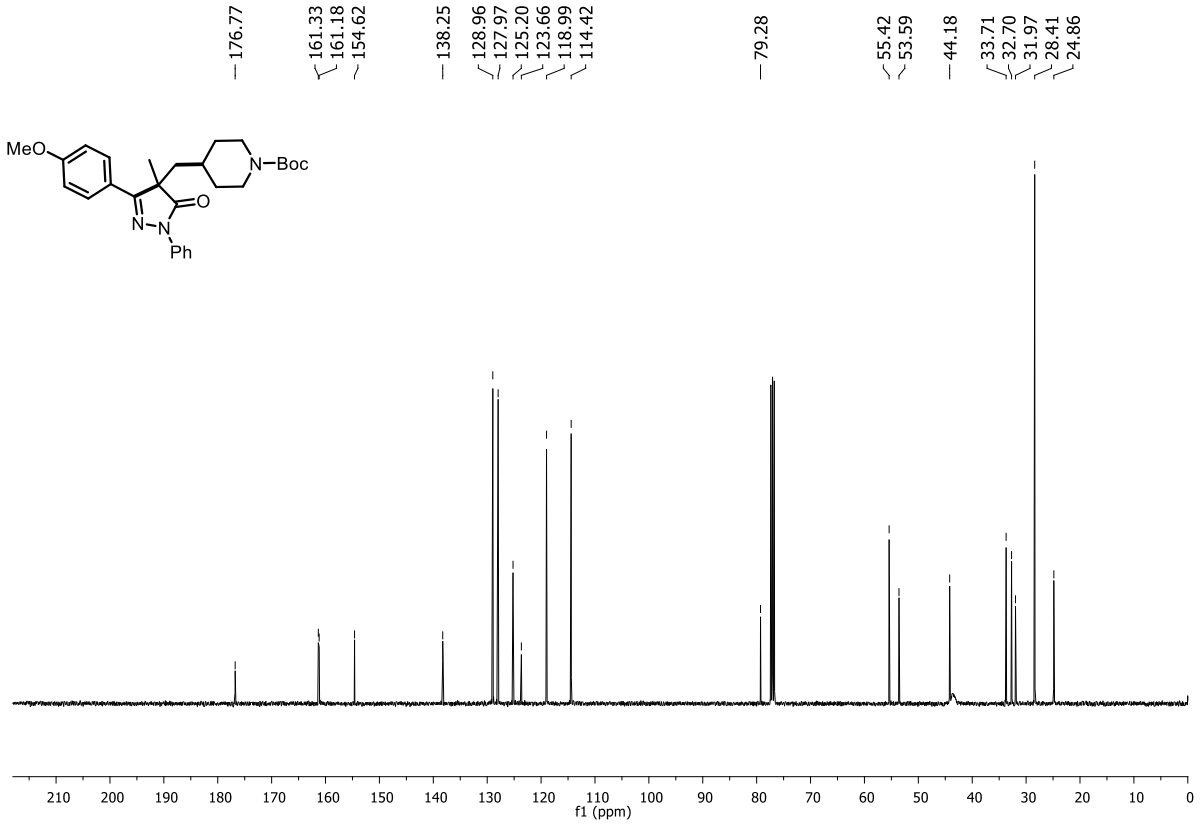
^{13}C{^{1}H} NMR spectrum of 3ca ($CDCl_3$, 126 MHz)



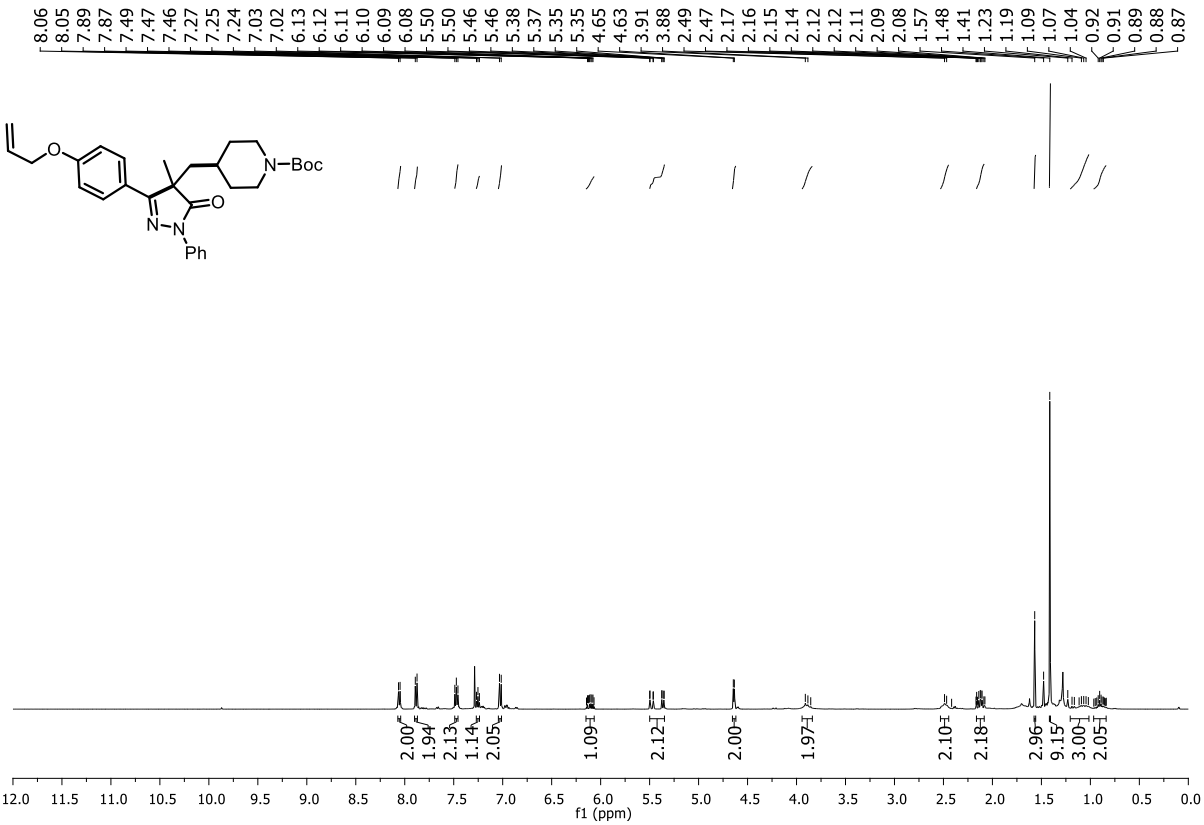
^{1}H NMR spectrum of 3da ($CDCl_3$, 500 MHz)



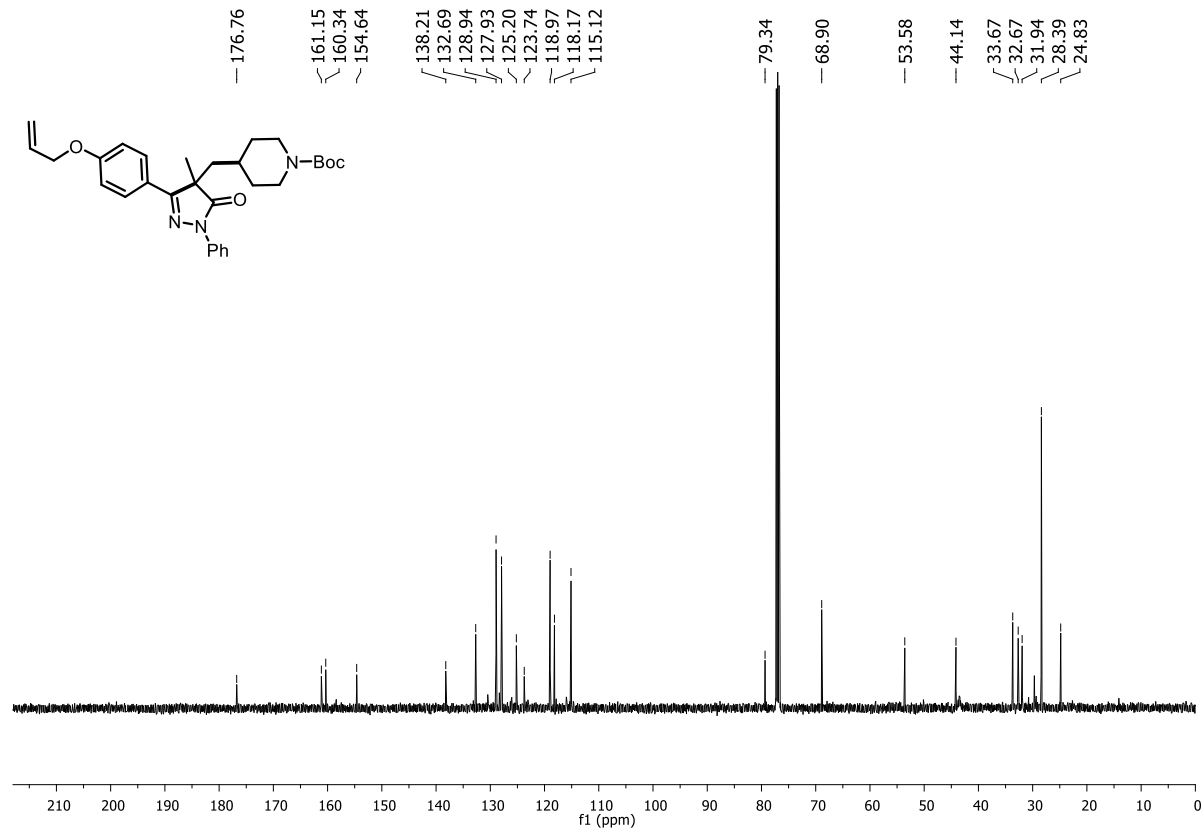
^{13}C{^{1}H} NMR spectrum of 3da ($CDCl_3$, 126 MHz)



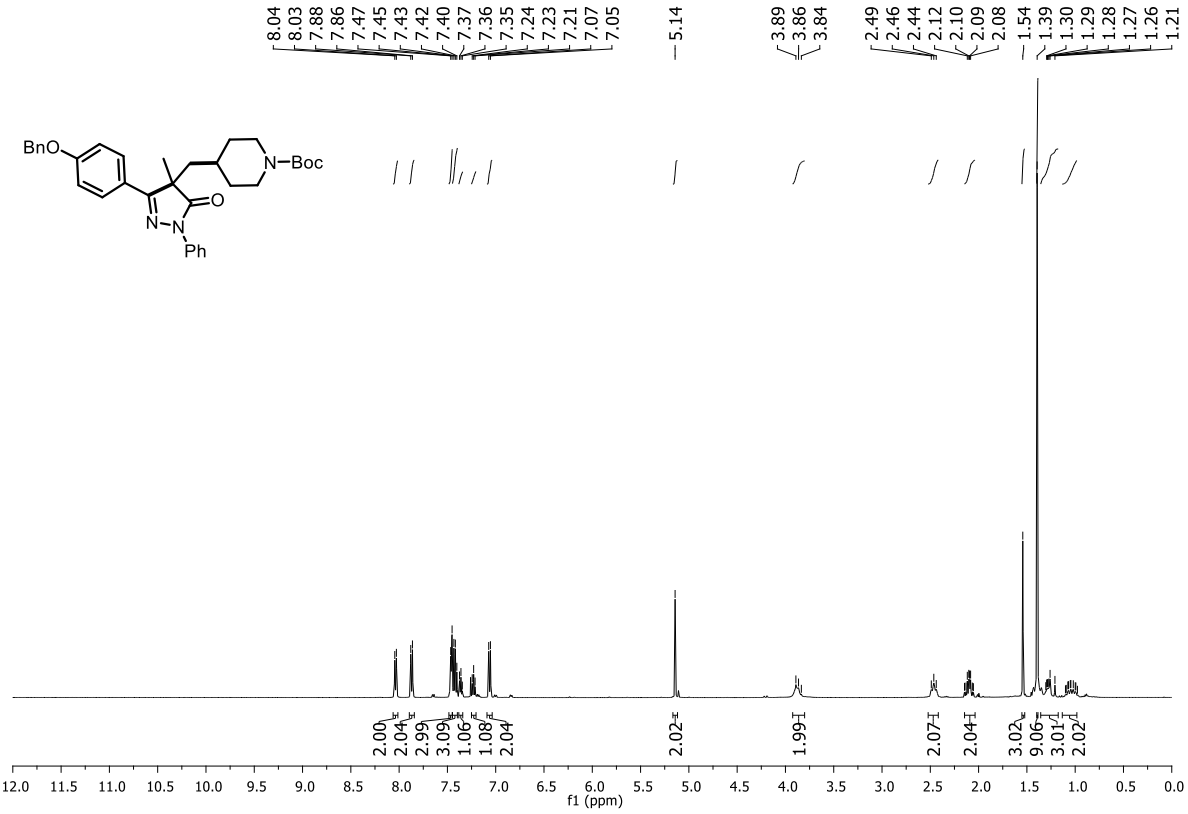
^{1}H NMR spectrum of 3ea ($CDCl_3$, 500 MHz)



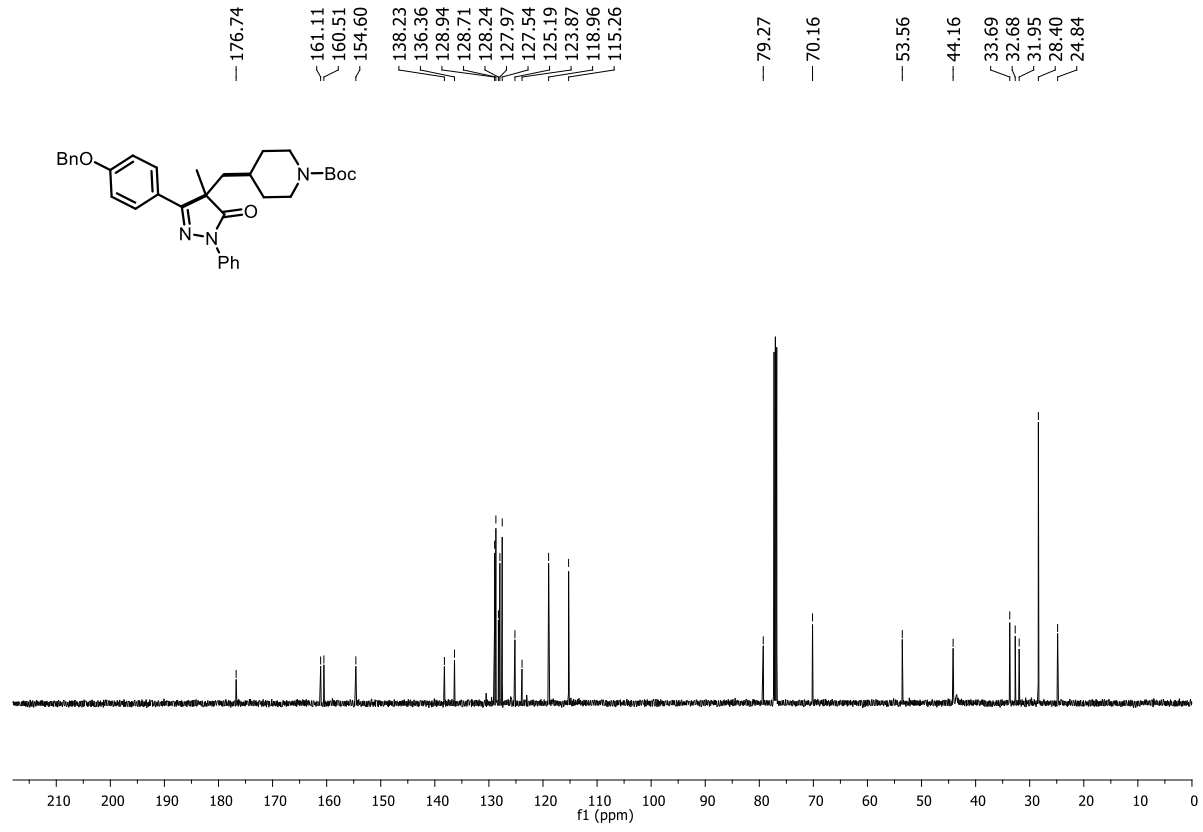
^{13}C{^{1}H} NMR spectrum of 3ea ($CDCl_3$, 126 MHz)



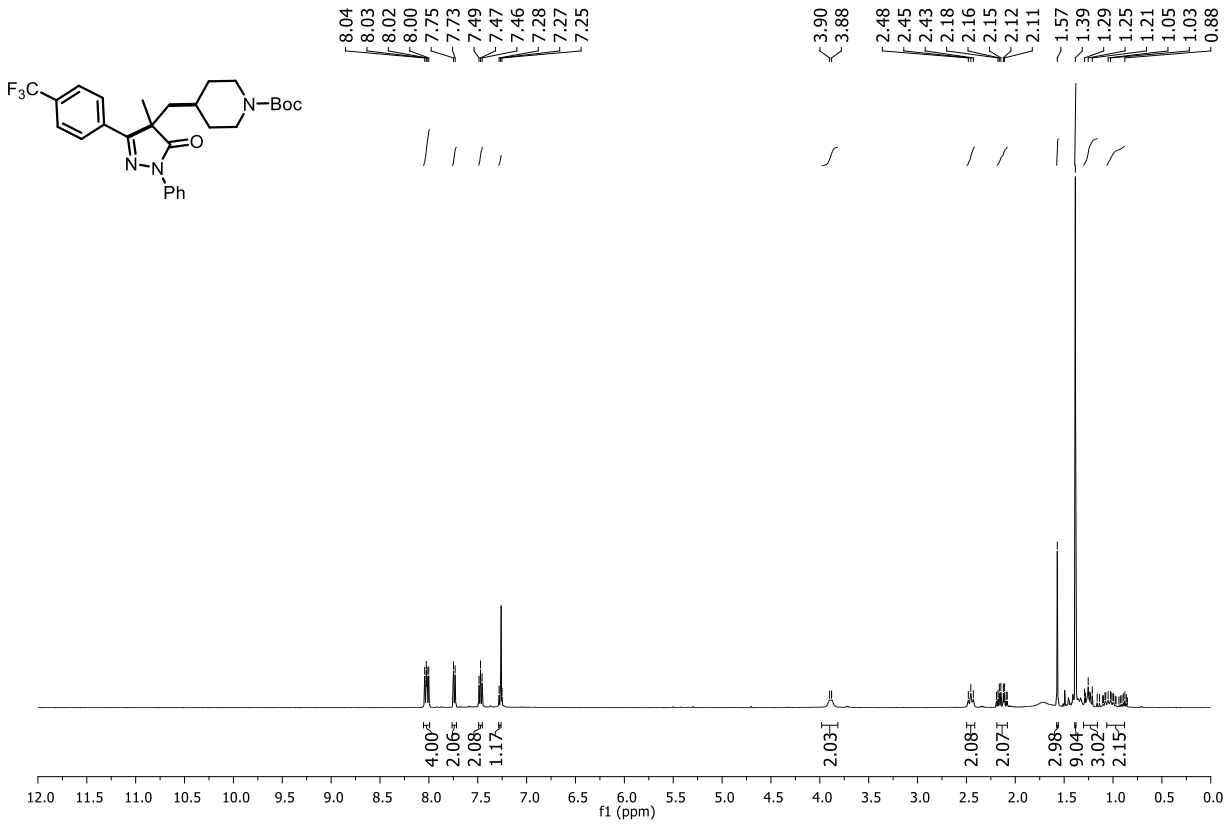
^{1}H NMR spectrum of 3fa ($CDCl_3$, 500 MHz)



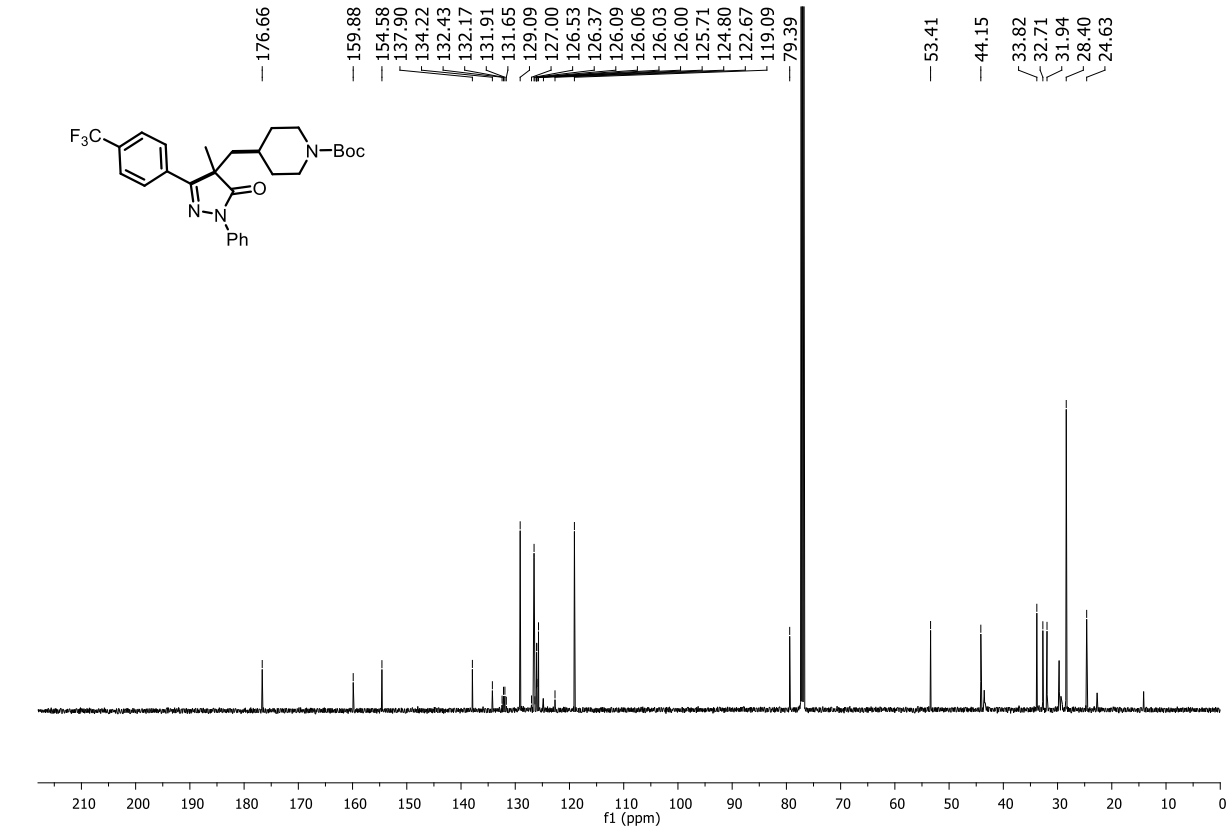
^{13}C{^{1}H} NMR spectrum of 3fa ($CDCl_3$, 126 MHz)



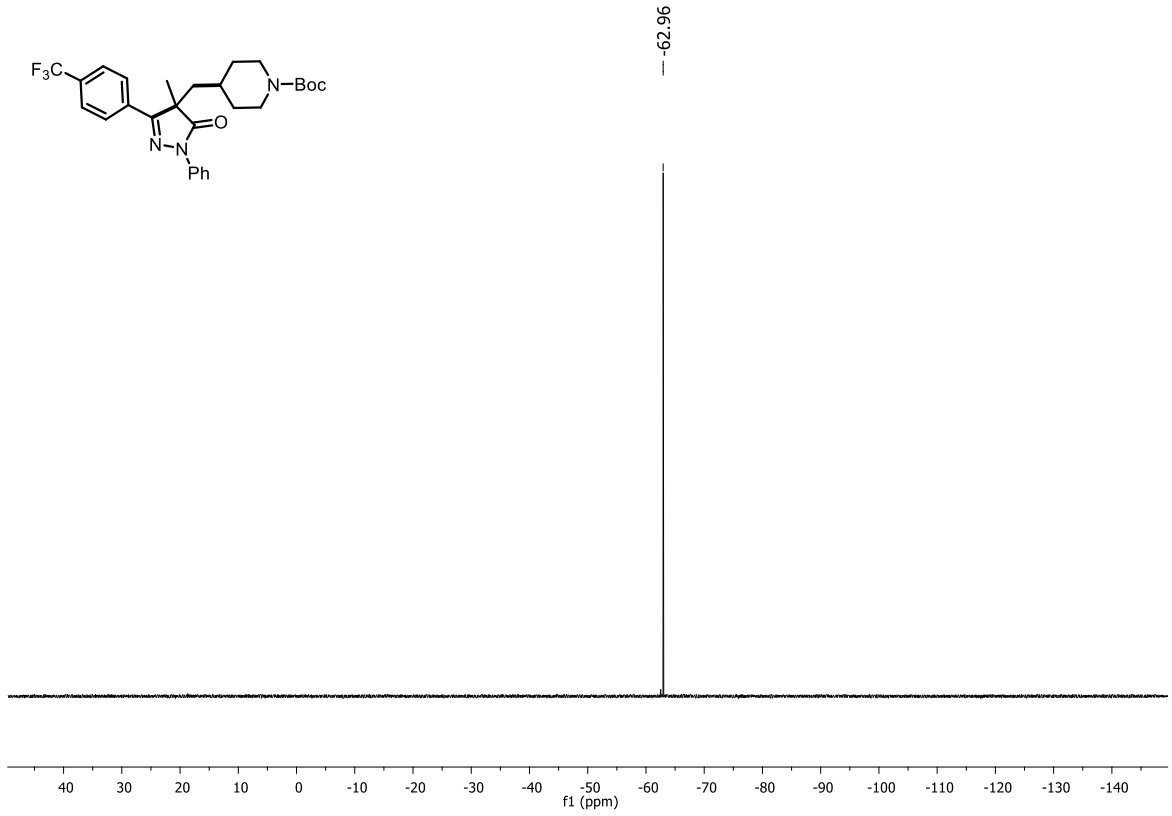
^{1}H NMR spectrum of 3ga ($CDCl_3$, 500 MHz)



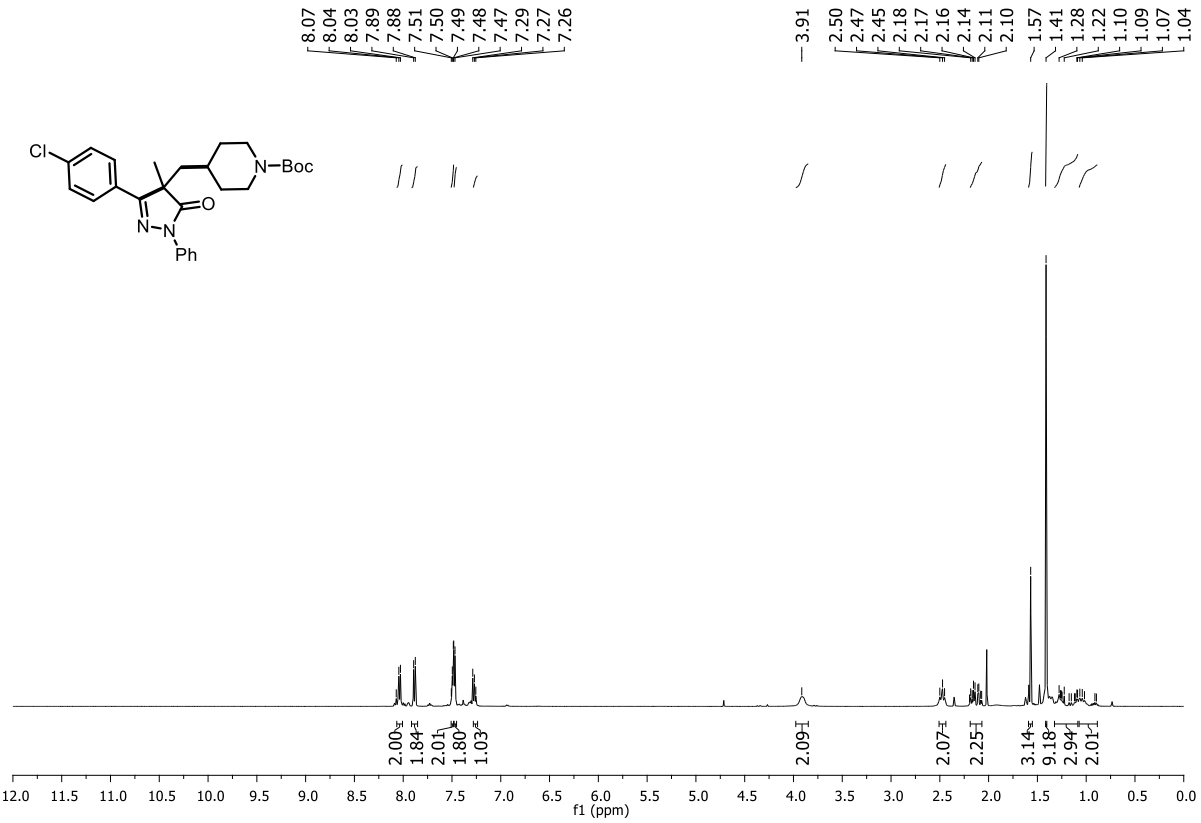
^{13}C{^{1}H} NMR spectrum of 3ga ($CDCl_3$, 126 MHz)



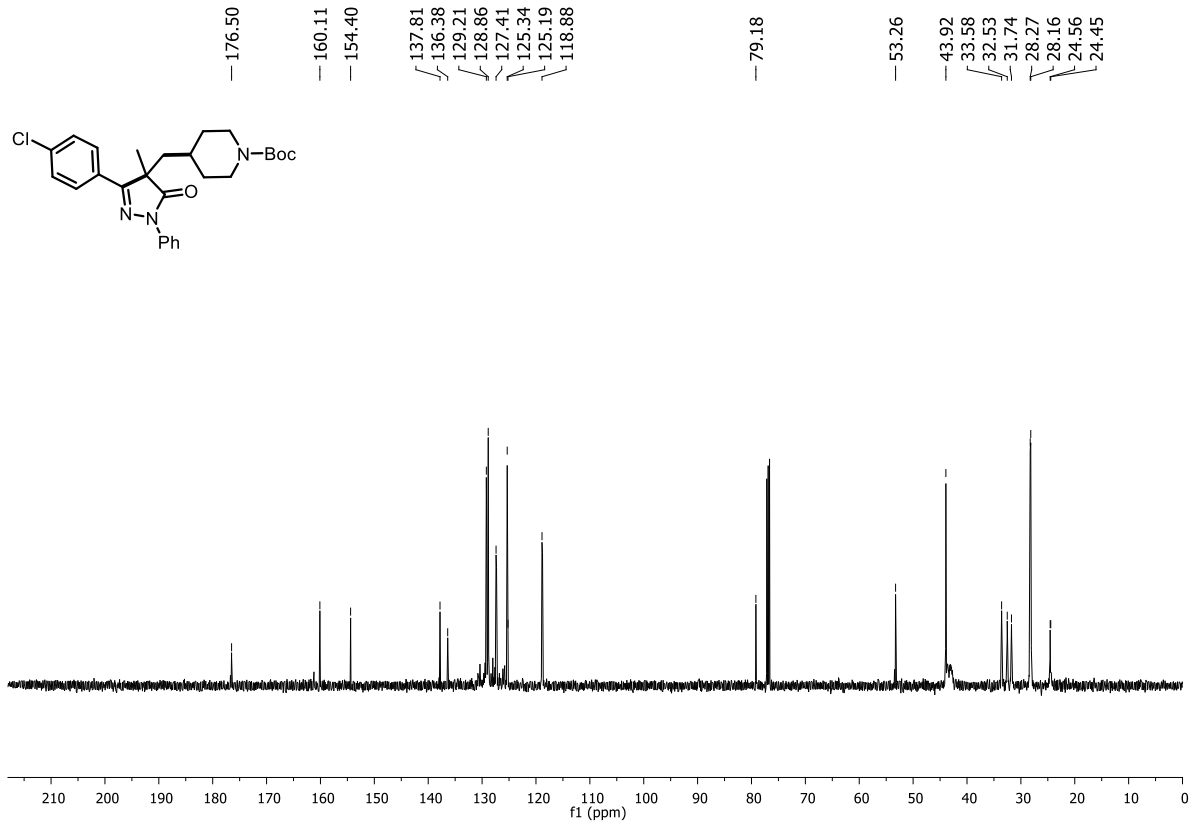
$^{19}F\{^{1}H\}$ NMR spectrum of 3ga ($CDCl_3$, 471 MHz)



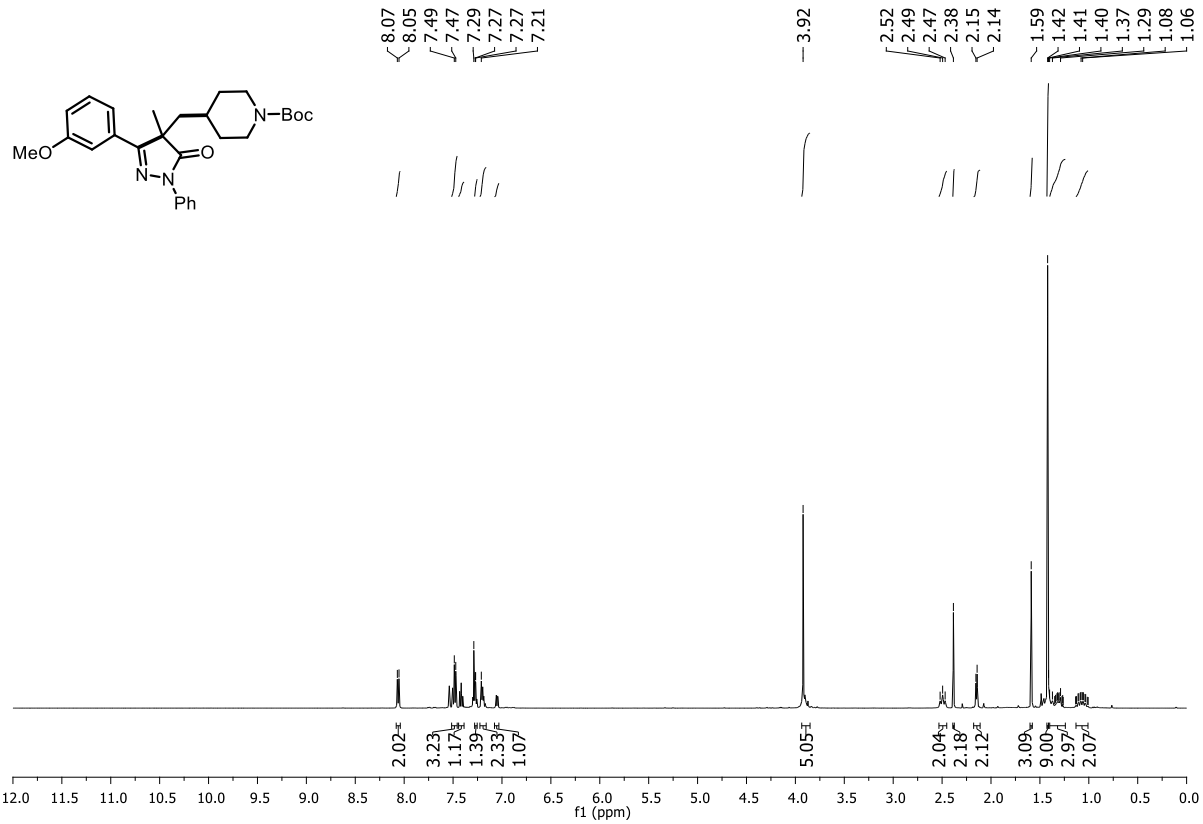
^{1}H NMR spectrum of 3ha ($CDCl_3$, 500 MHz)



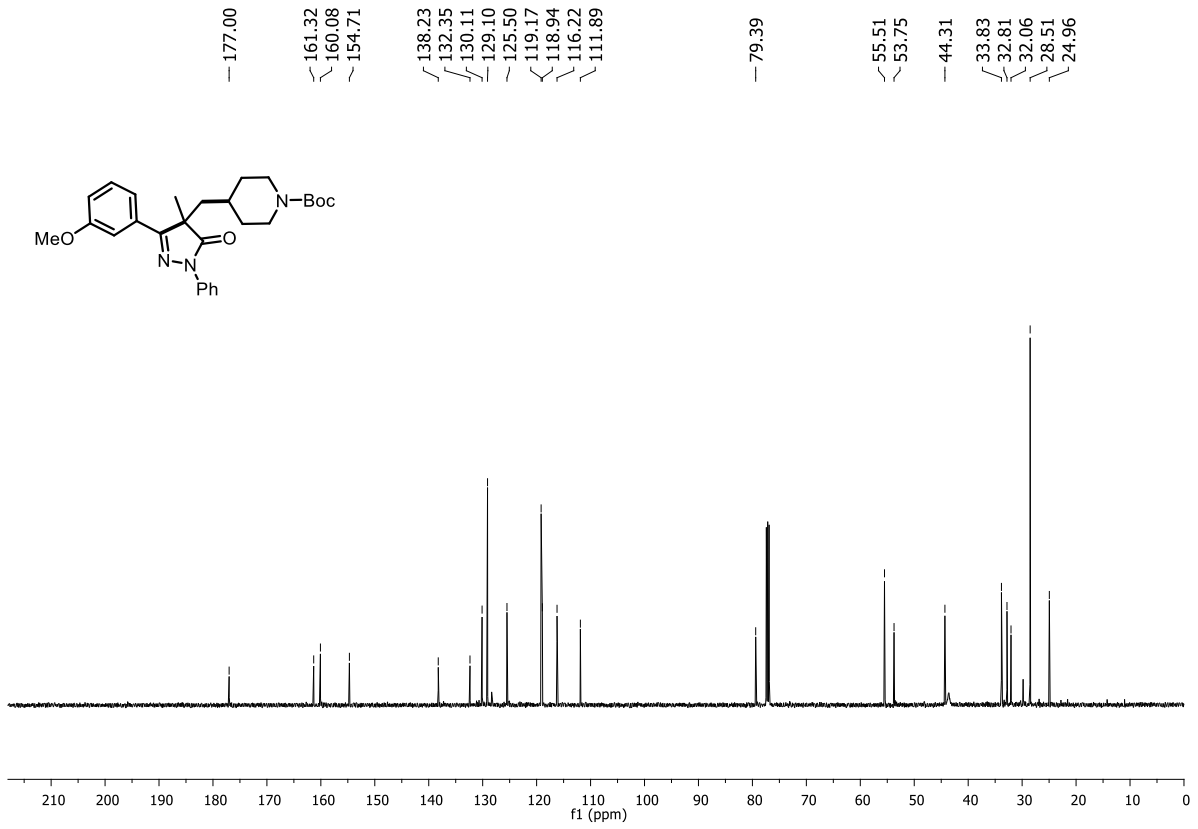
^{13}C{^{1}H} NMR spectrum of 3ha ($CDCl_3$, 126 MHz)



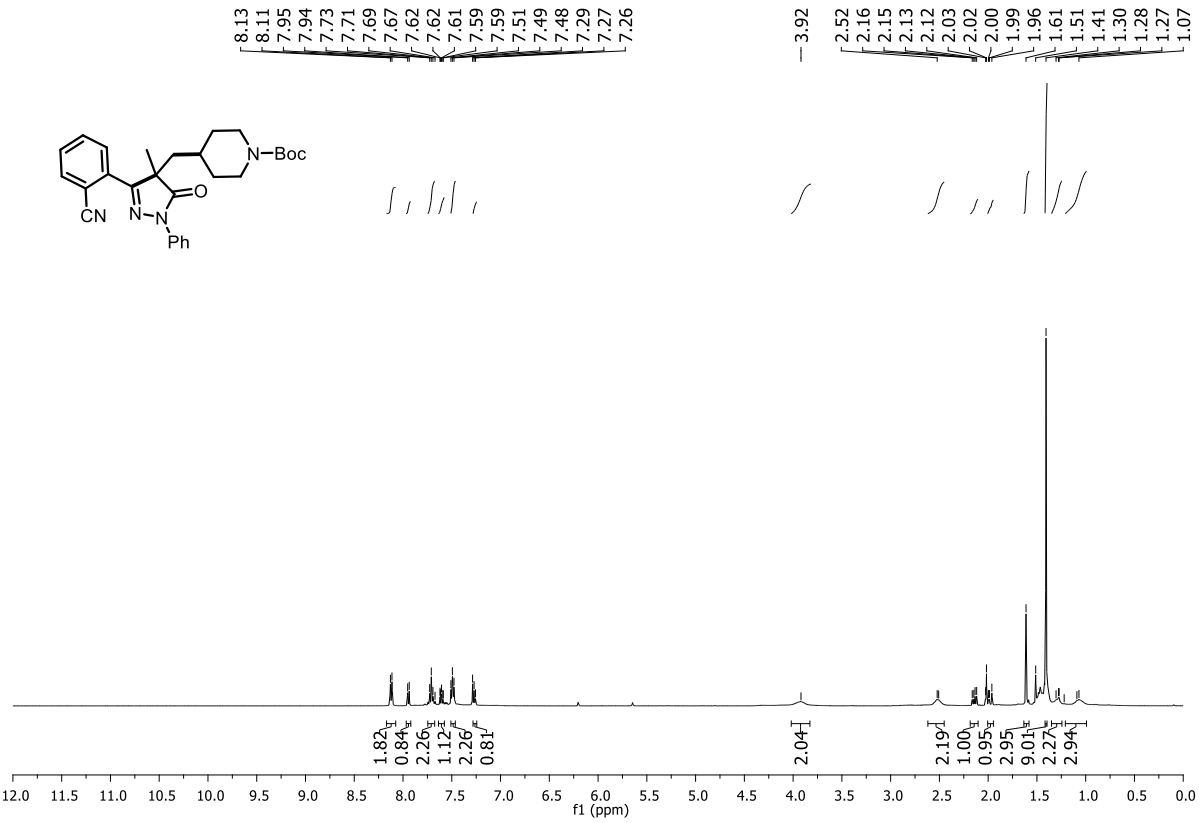
^{1}H NMR spectrum of 3ia ($CDCl_3$, 500 MHz)



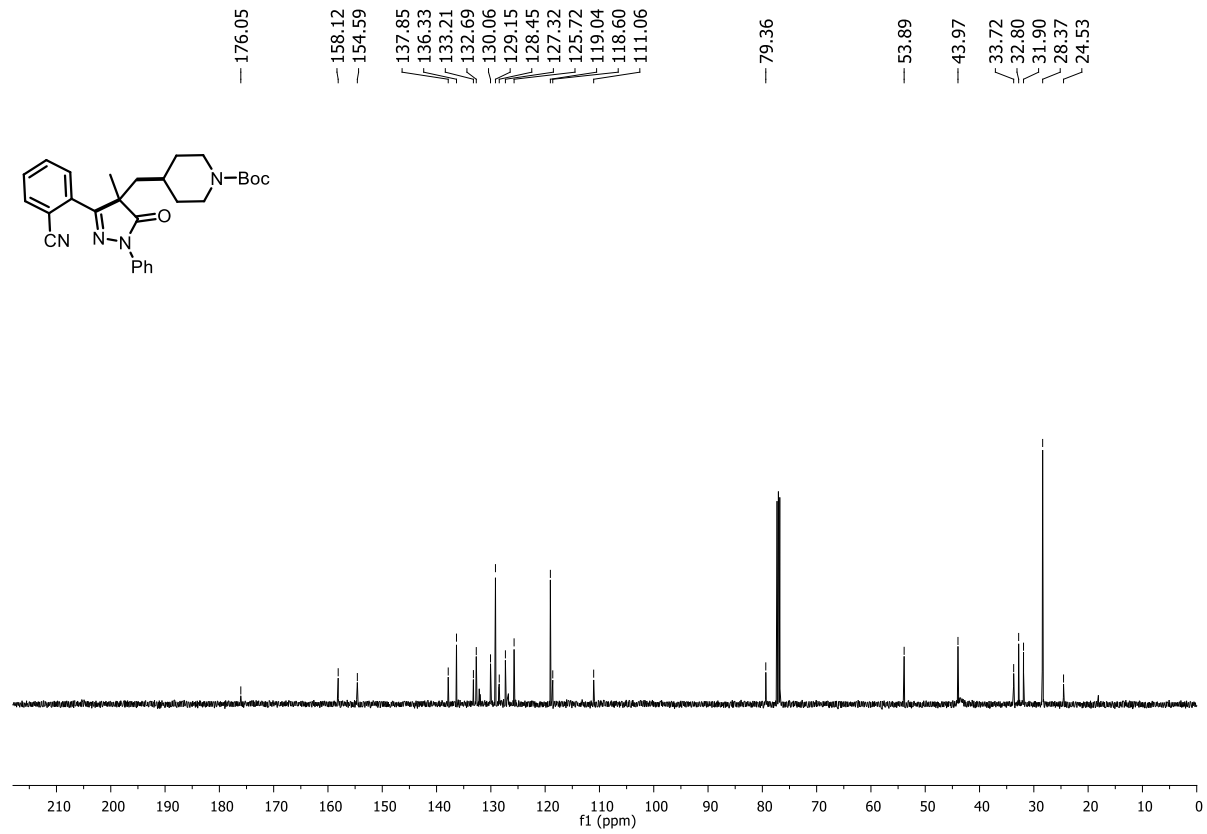
^{13}C{^{1}H} NMR spectrum of 3ia ($CDCl_3$, 126 MHz)



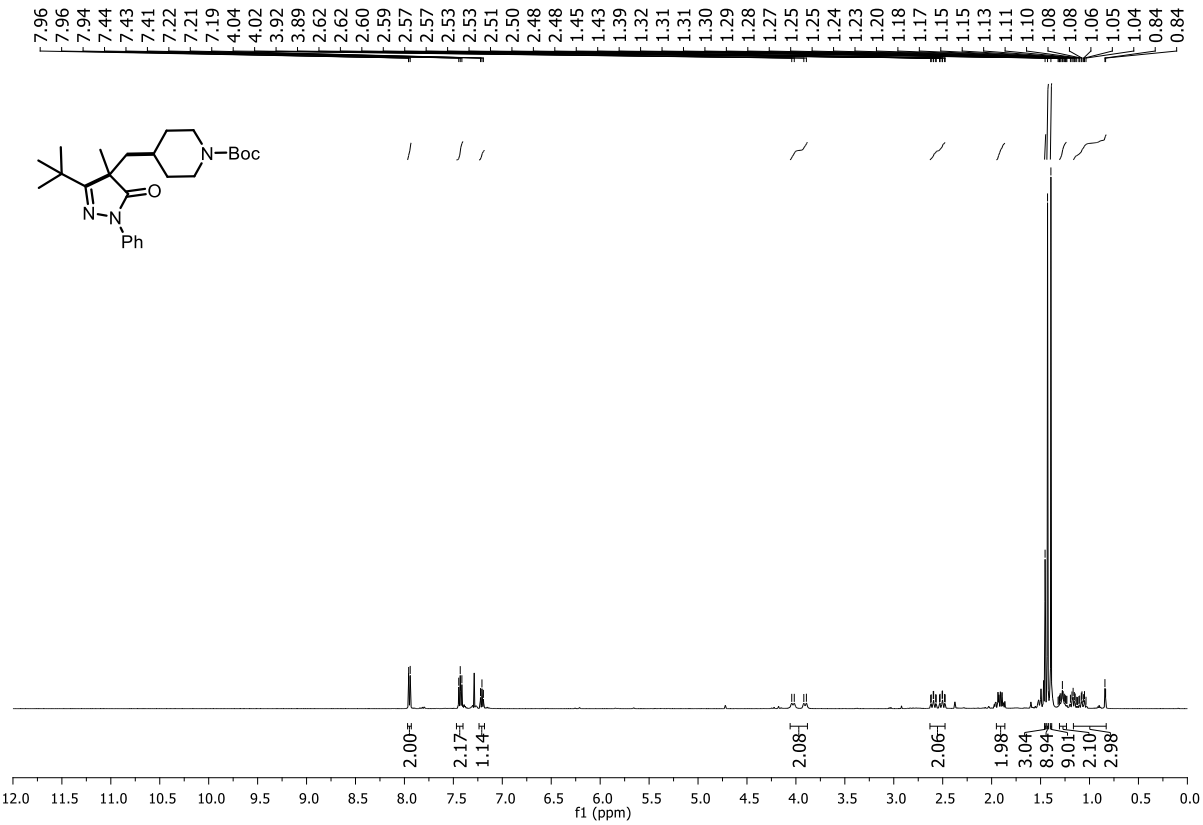
^{1}H NMR spectrum of 3ja ($CDCl_3$, 500 MHz)



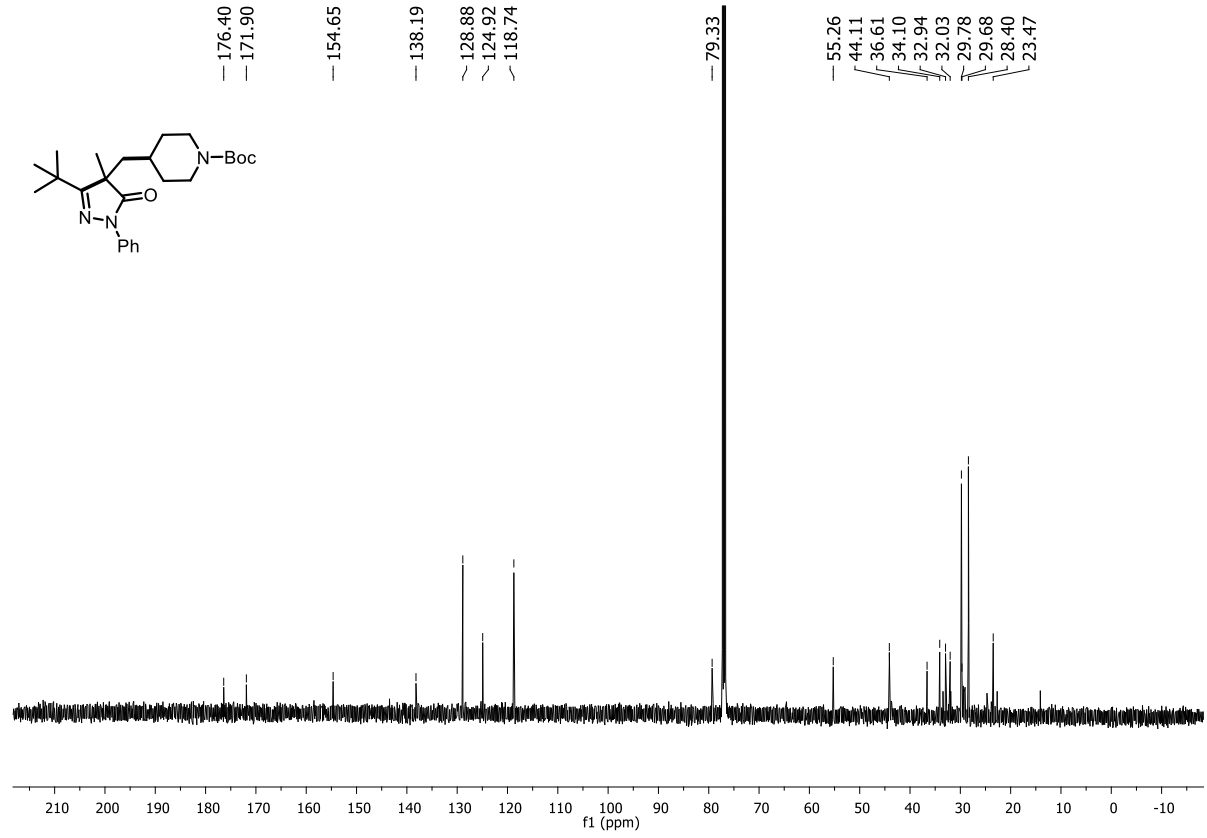
^{13}C{^{1}H} NMR spectrum of 3ja ($CDCl_3$, 126 MHz)



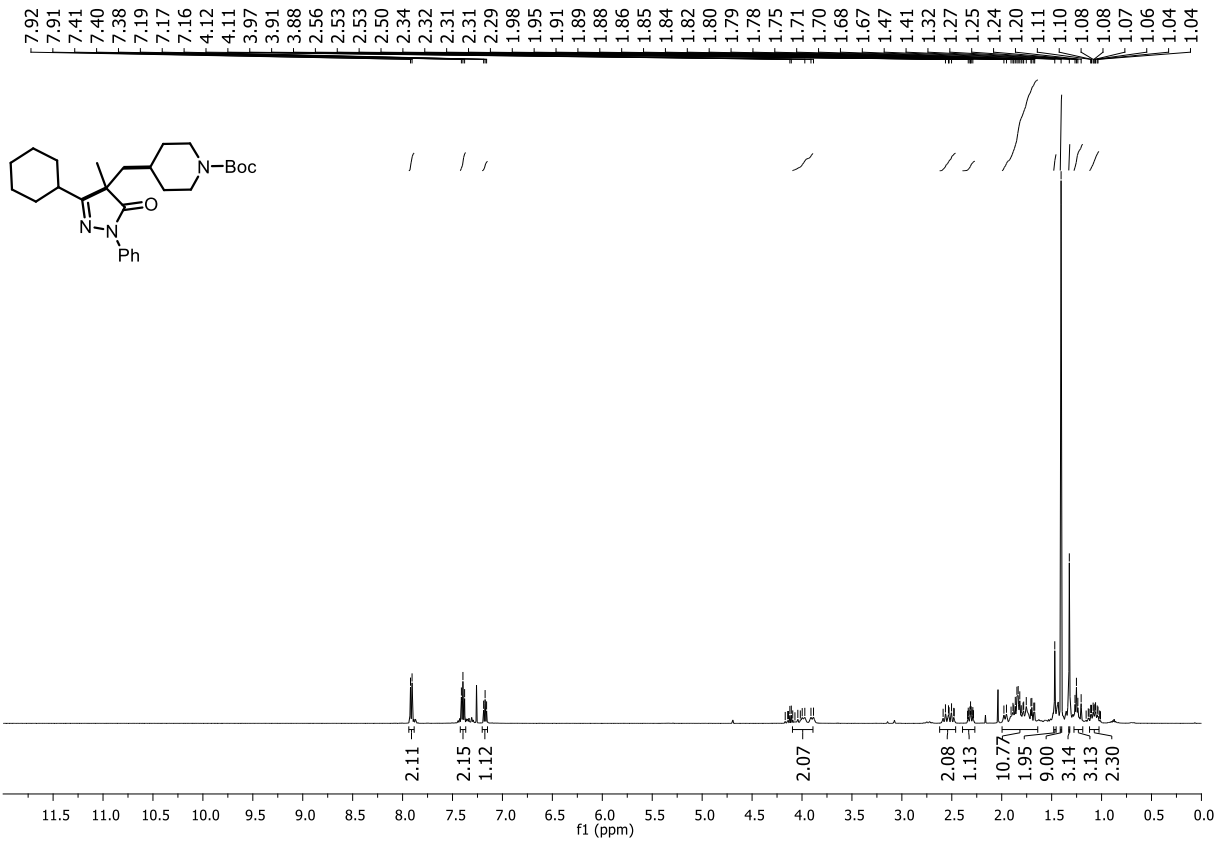
^{1}H NMR spectrum of 3ka ($CDCl_3$, 126 MHz)



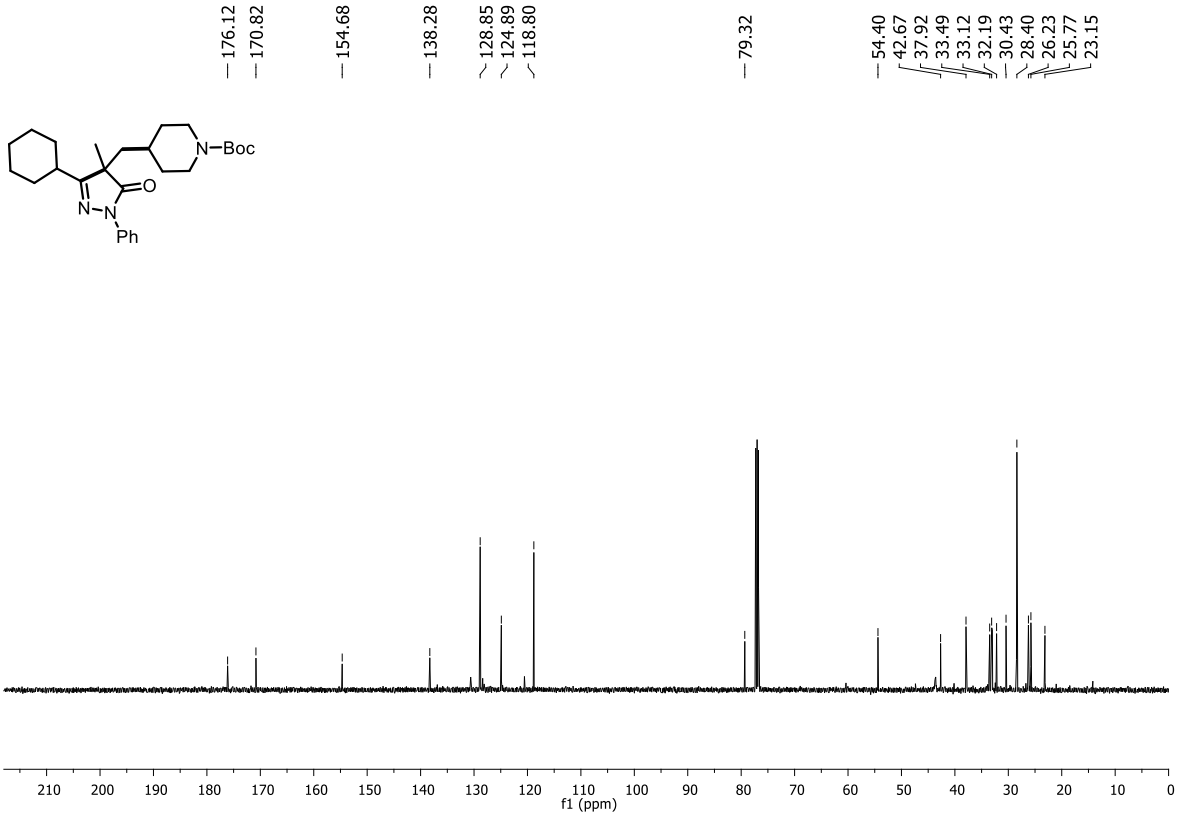
^{13}C{^{1}H} NMR spectrum of 3ka ($CDCl_3$, 126 MHz)



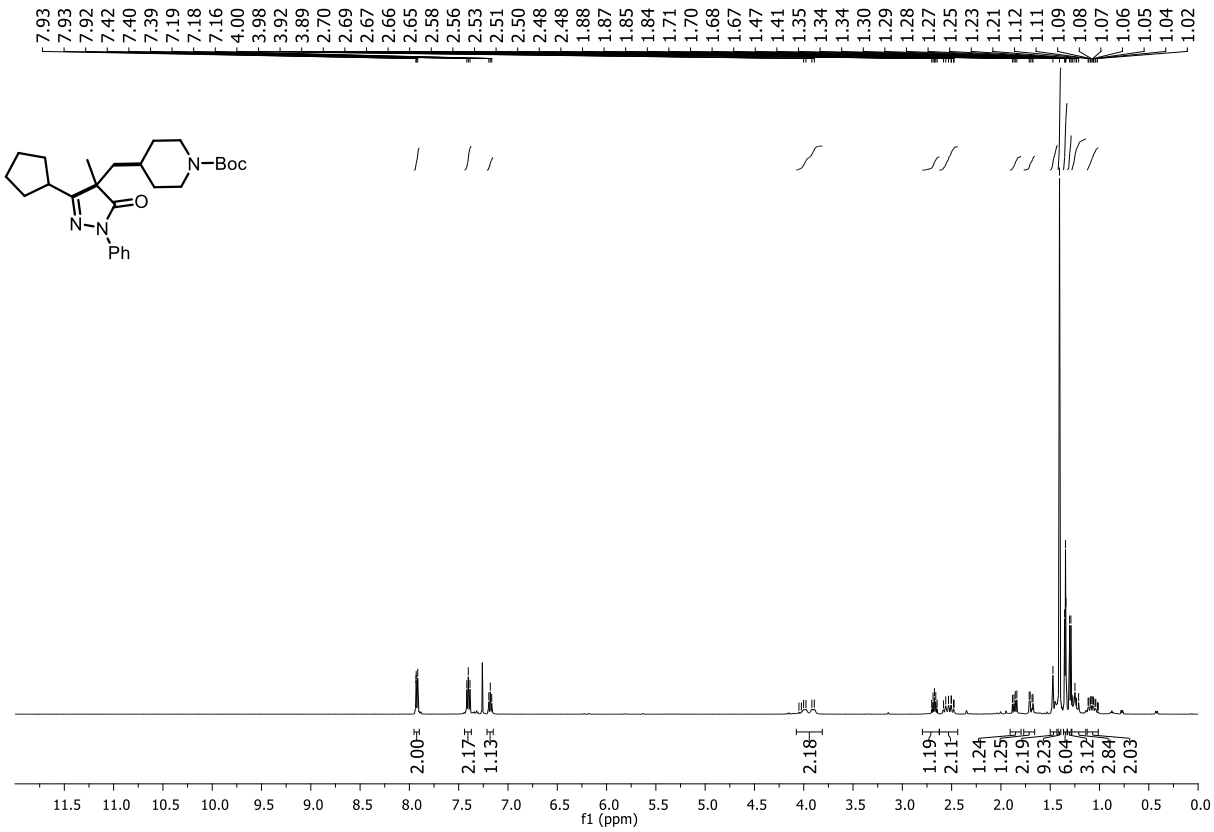
^{1}H NMR spectrum of 3la ($CDCl_3$, 126 MHz)



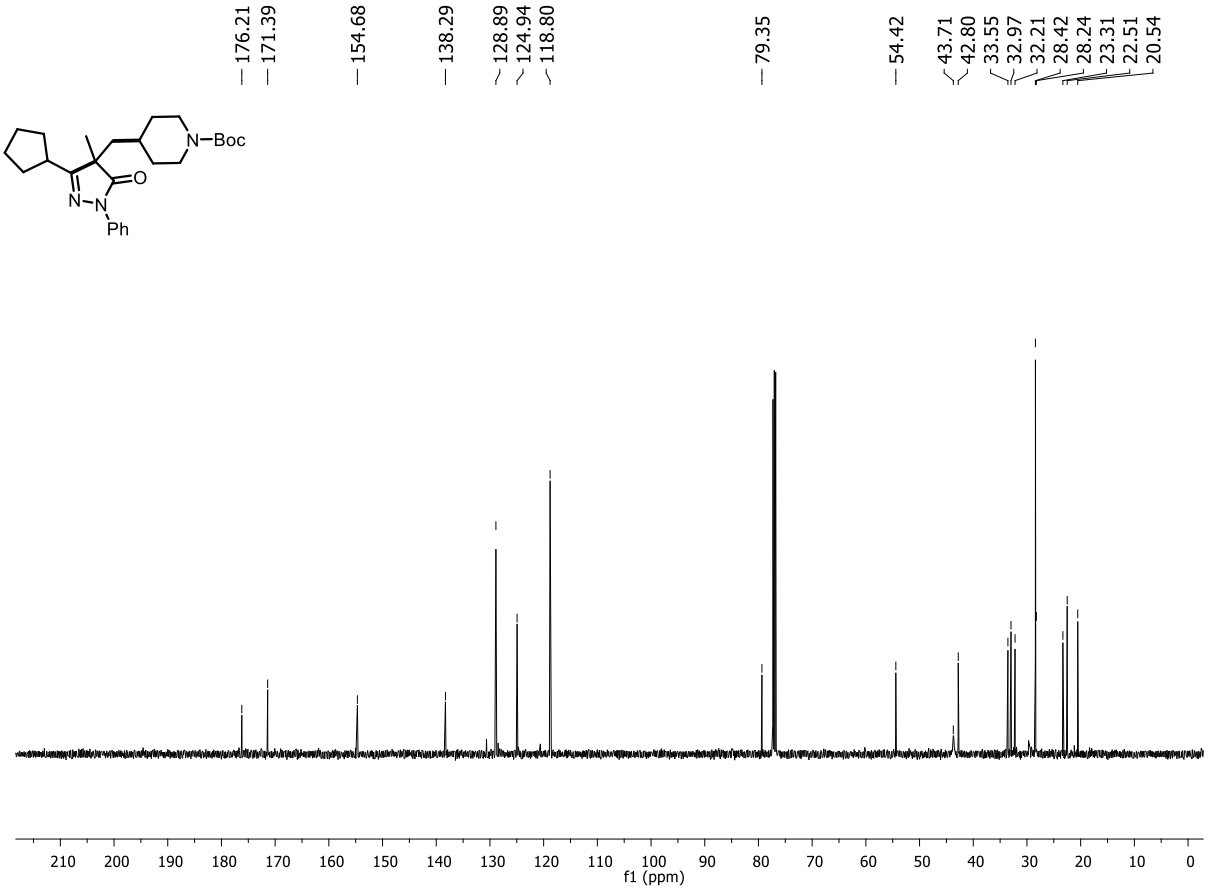
^{13}C{^{1}H} NMR spectrum of 3la ($CDCl_3$, 126 MHz)



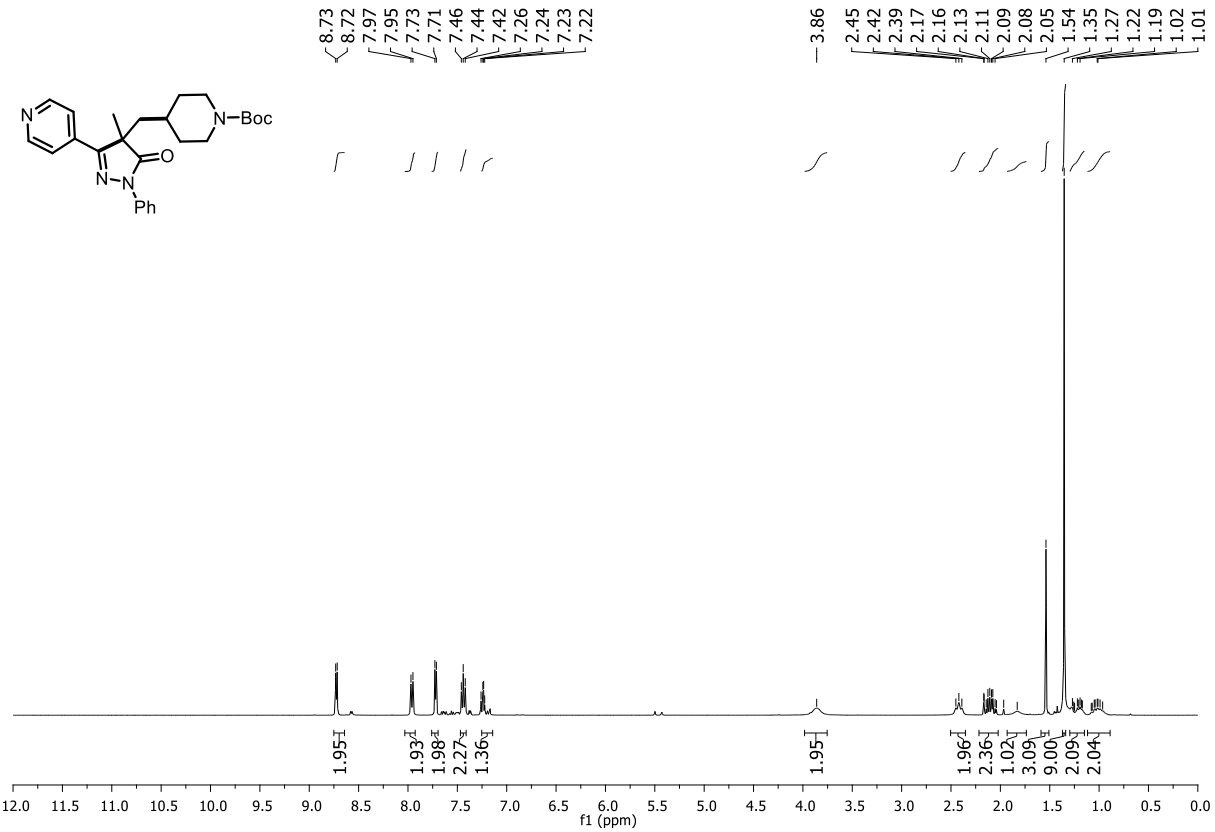
^{1}H NMR spectrum of 3ma ($CDCl_3$, 500 MHz)



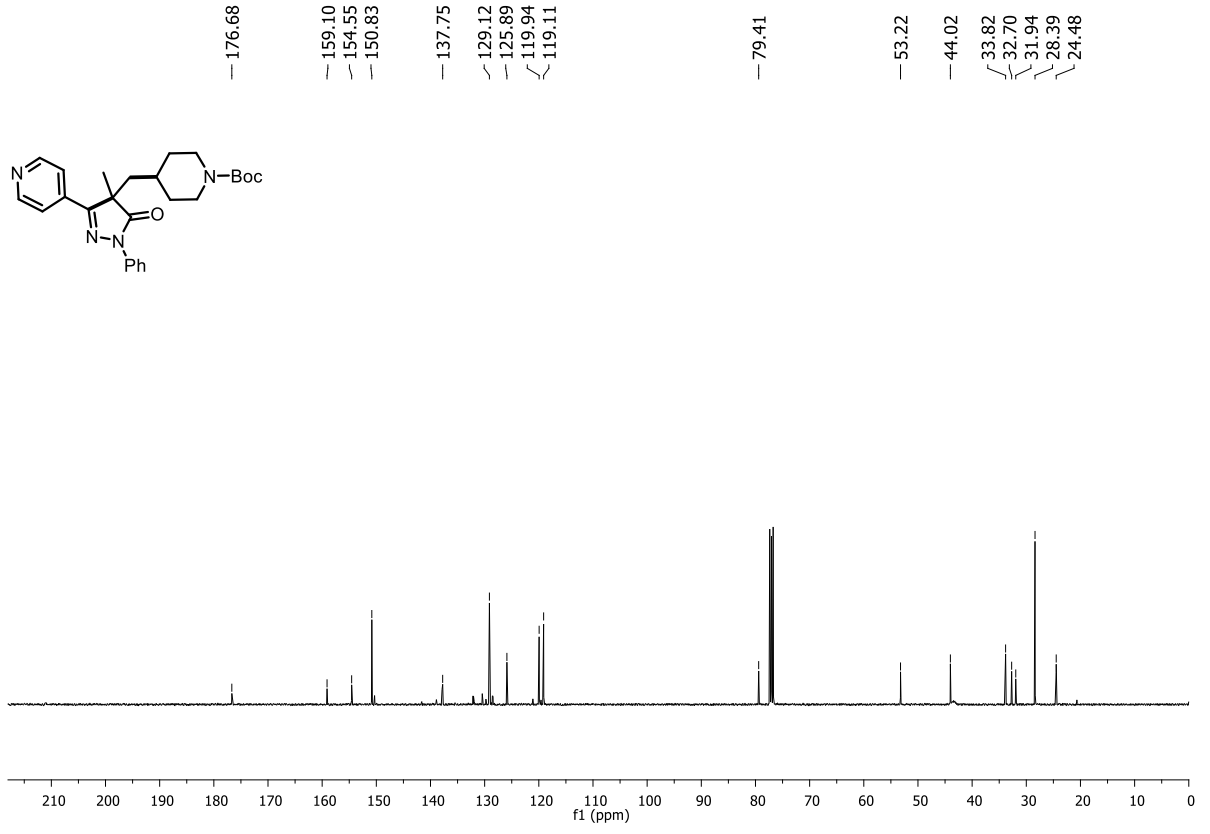
^{13}C{^{1}H} NMR spectrum of 3ma ($CDCl_3$, 126 MHz)



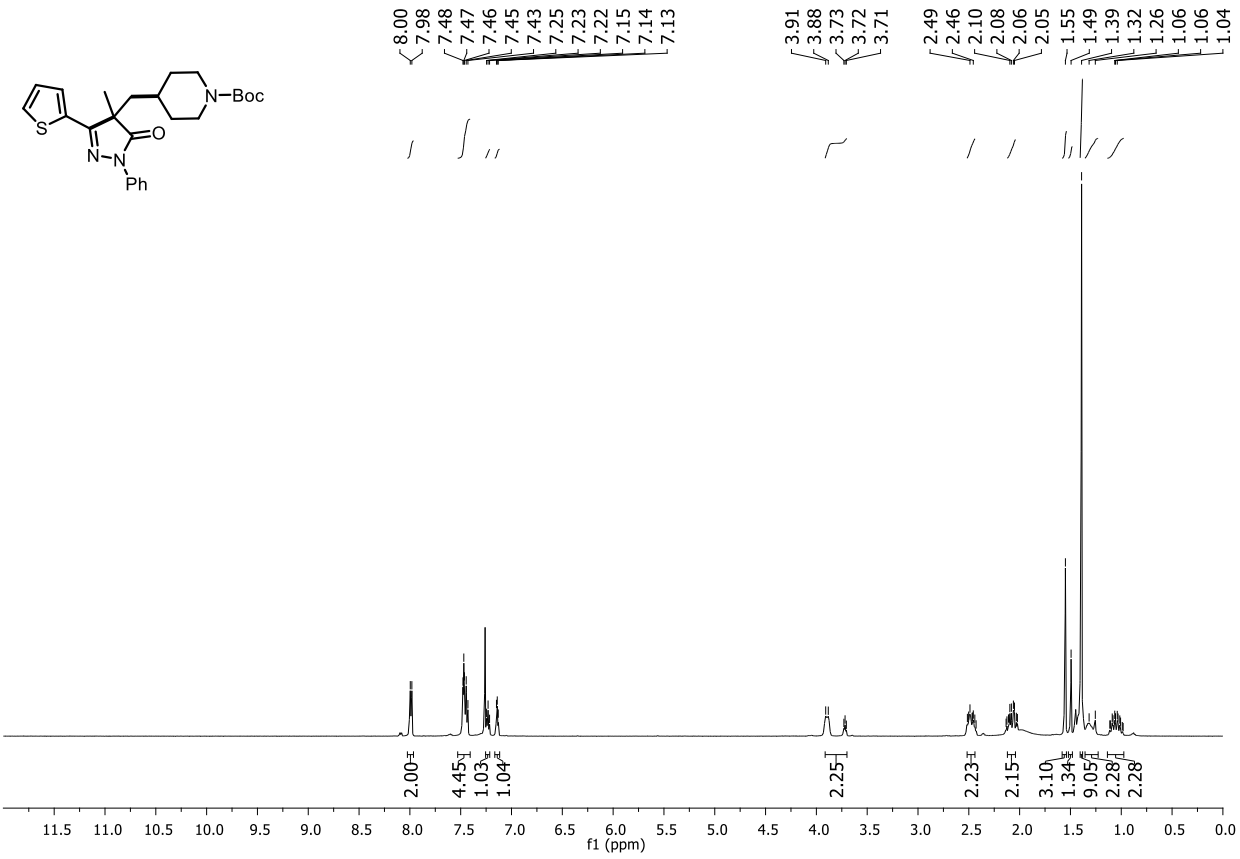
^{1}H NMR spectrum of 3na ($CDCl_3$, 500 MHz)



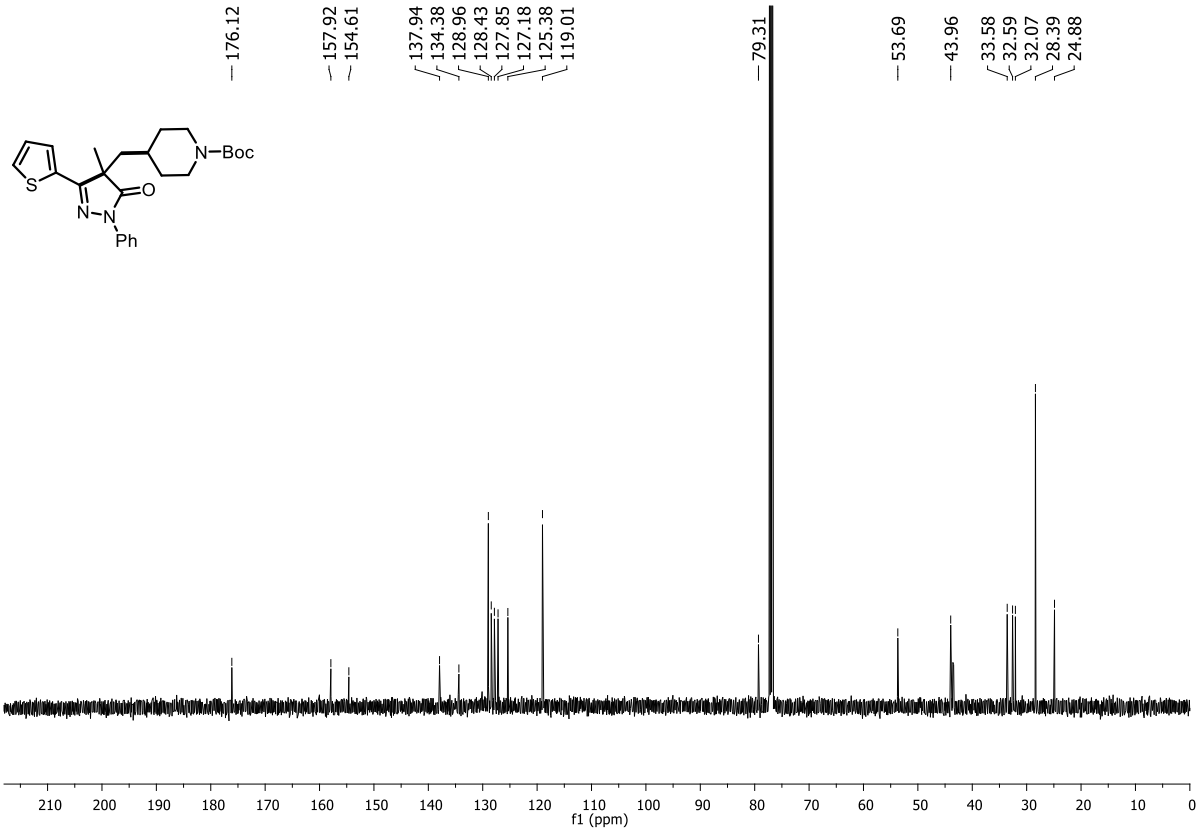
^{13}C{^{1}H} NMR spectrum of 3na ($CDCl_3$, 126 MHz)



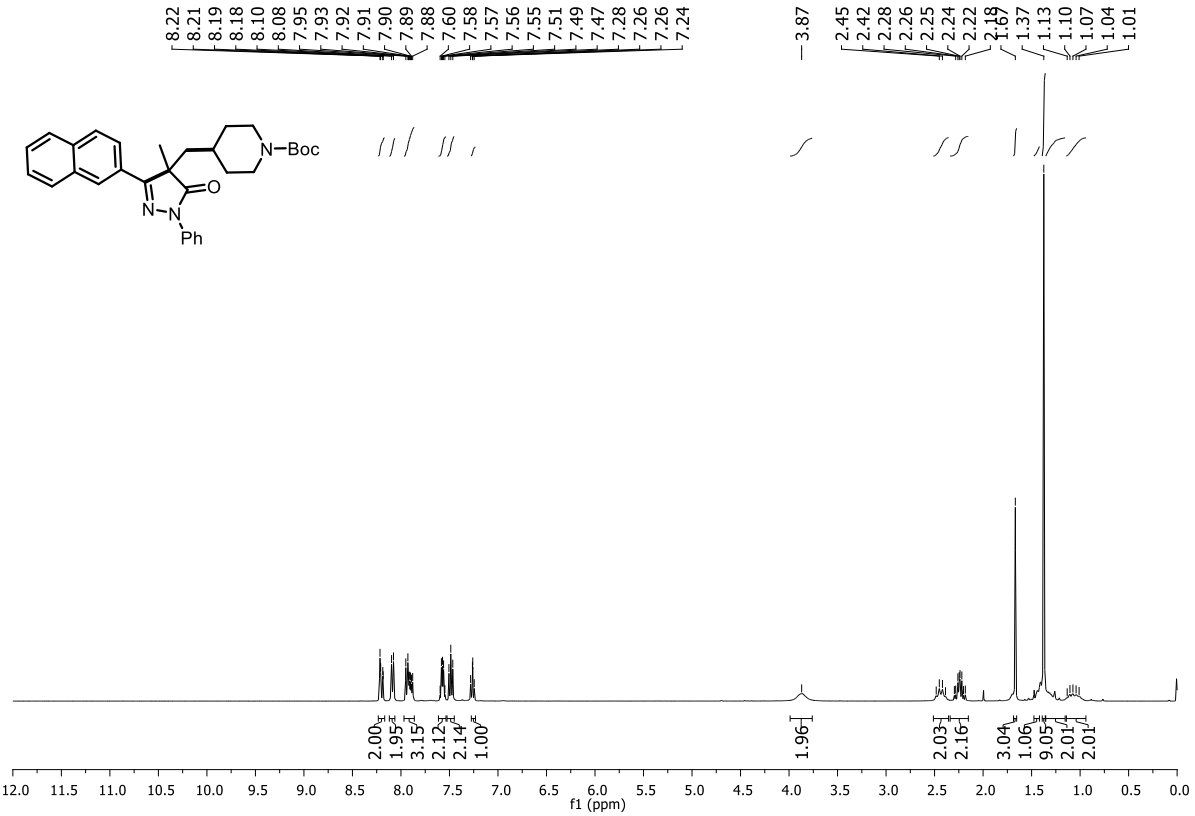
^{1}H NMR spectrum of 3oa ($CDCl_3$, 500 MHz)



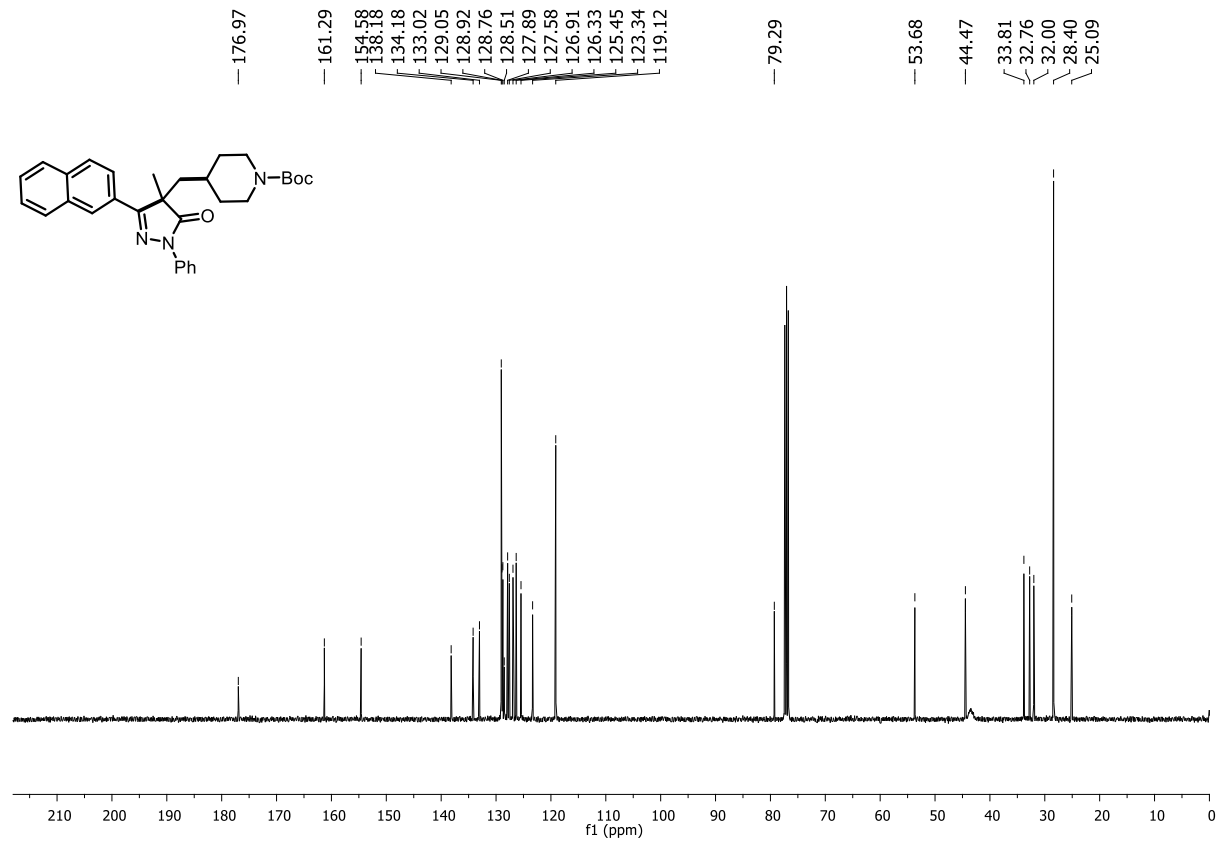
^{13}C{^{1}H} NMR spectrum of 3oa ($CDCl_3$, 126 MHz)



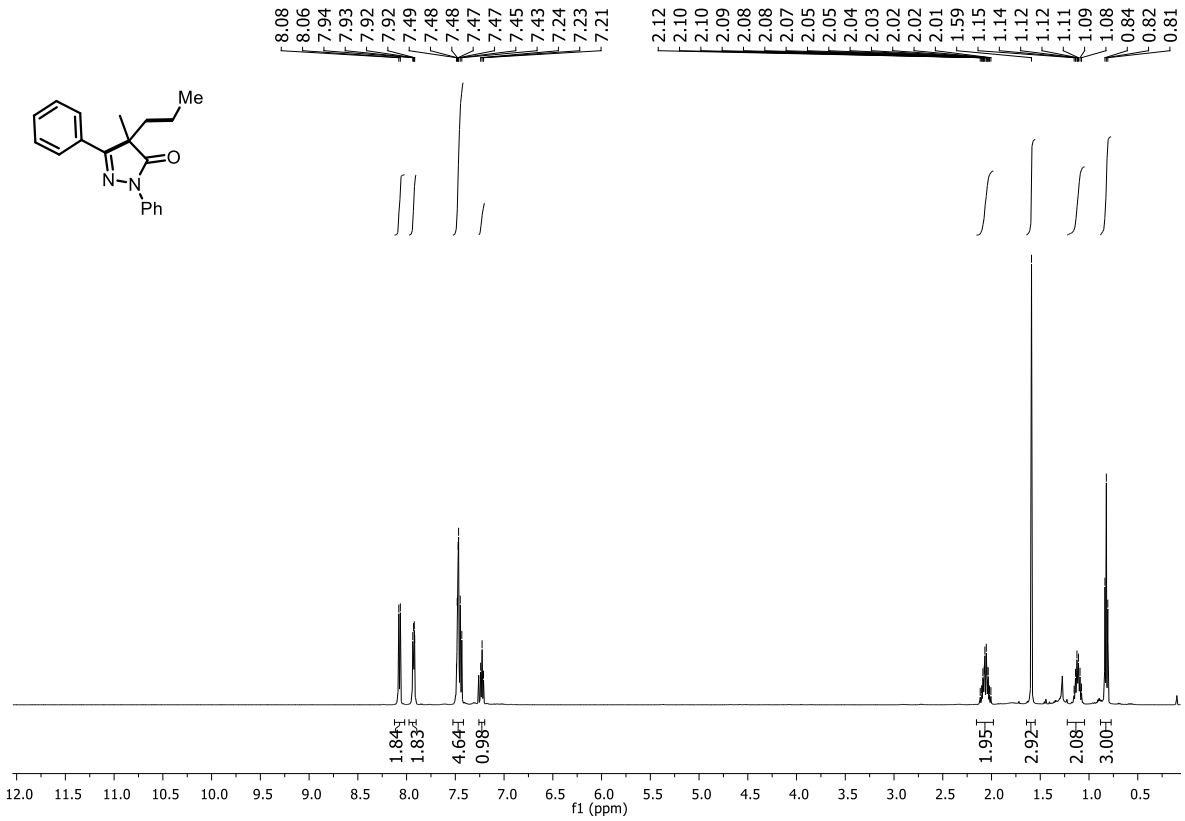
^{1}H NMR spectrum of 3pa ($CDCl_3$, 500 M)



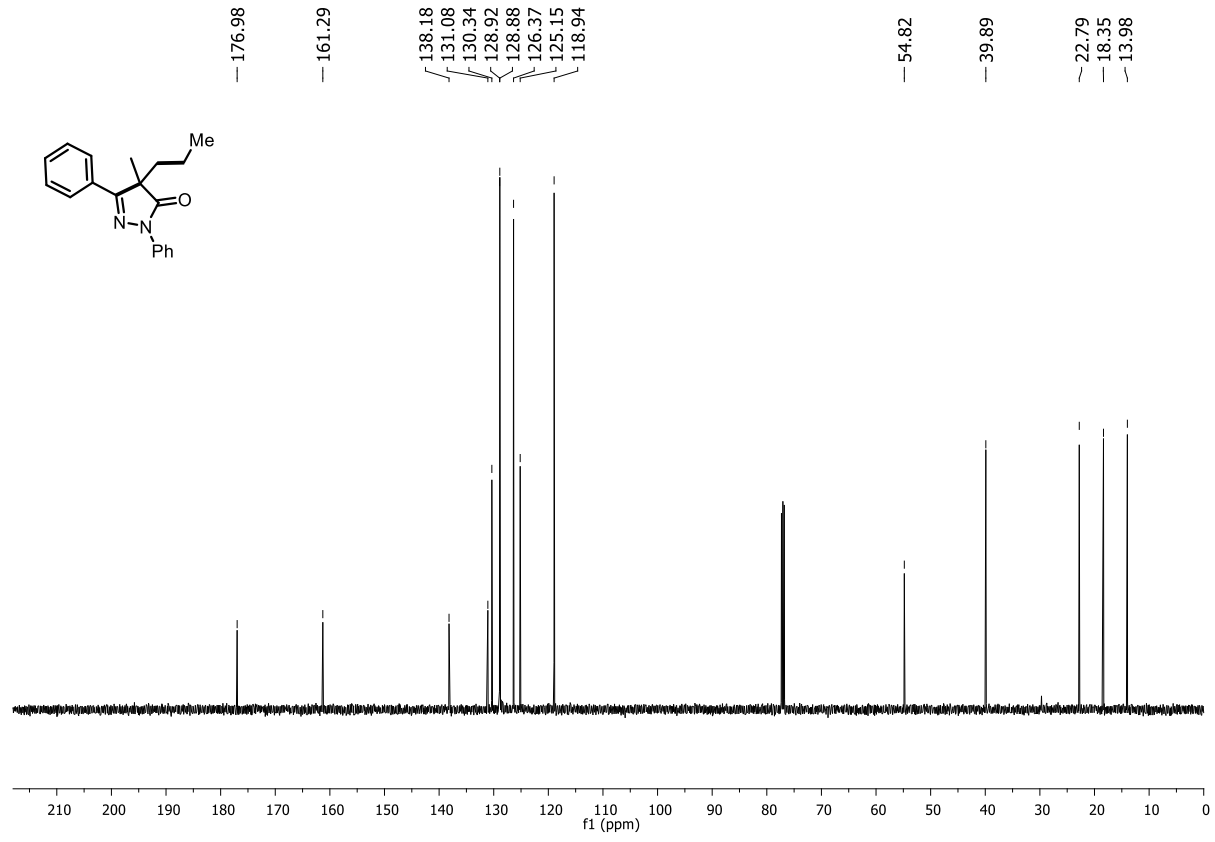
^{13}C{^{1}H} NMR spectrum of 3oa ($CDCl_3$, 126 MHz)



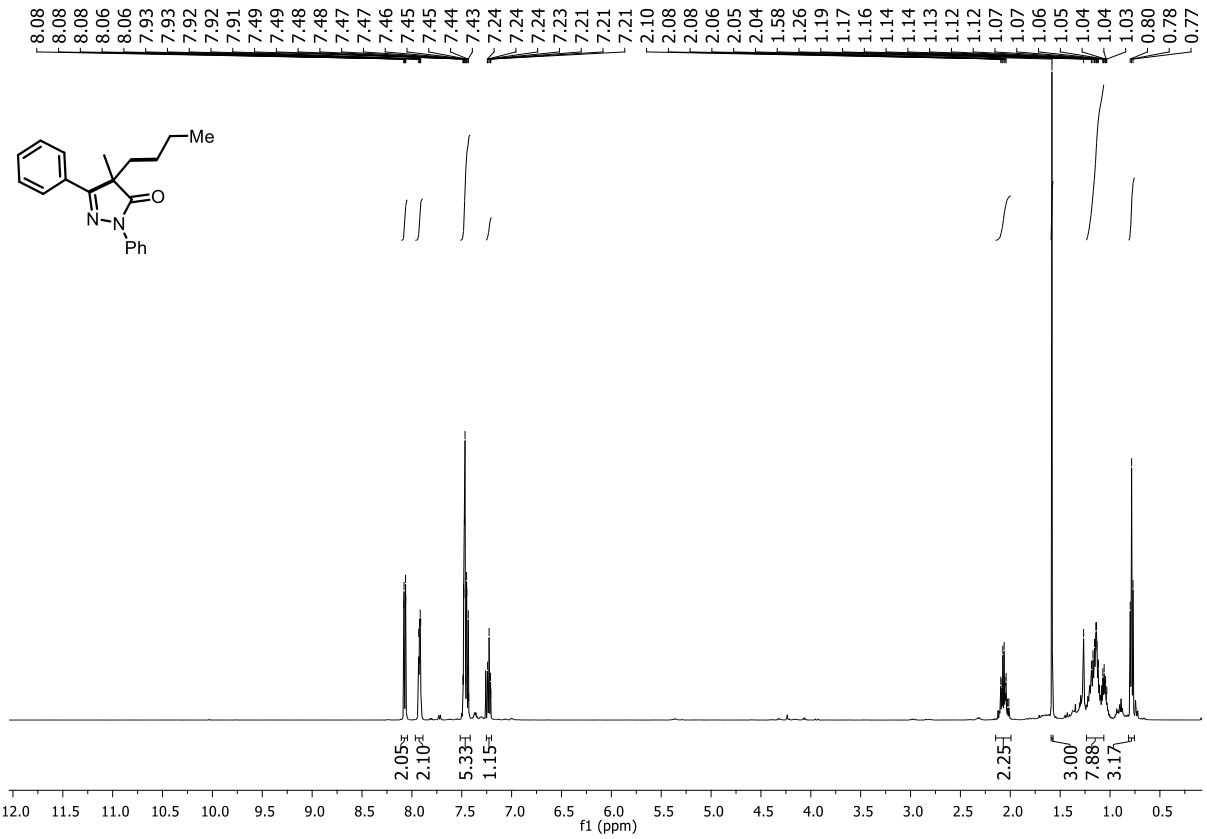
^{1}H NMR spectrum of 3ab ($CDCl_3$, 500 MHz)



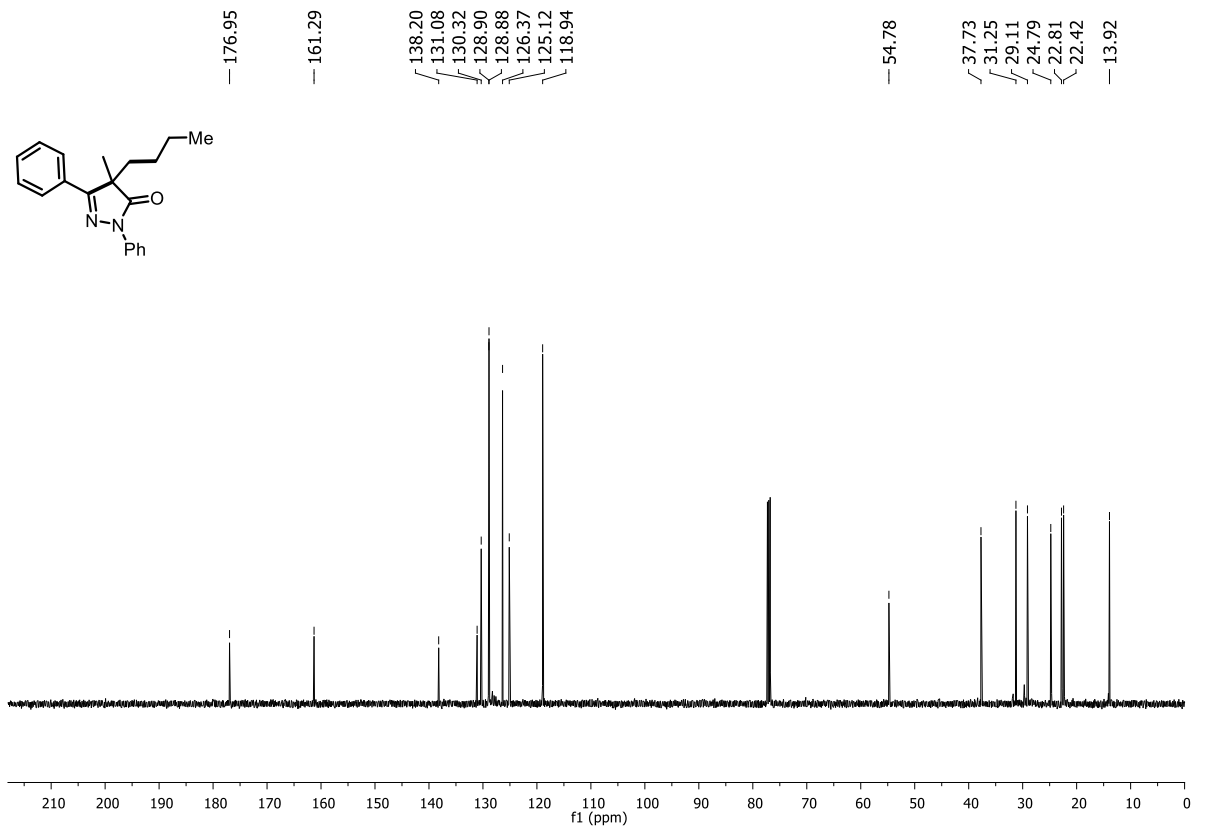
^{13}C{^{1}H} NMR spectrum of 3ab ($CDCl_3$, 126 MHz)



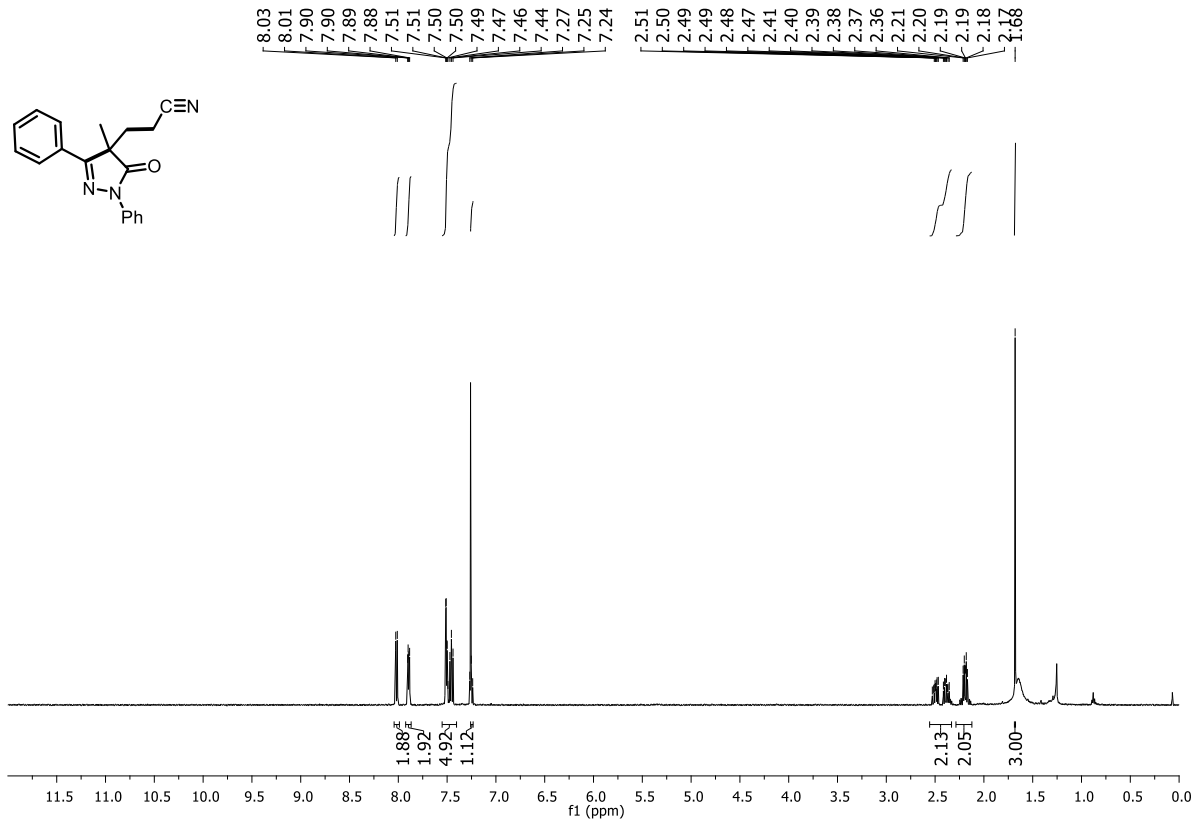
^{1}H NMR spectrum of 3ac ($CDCl_3$, 500 MHz)



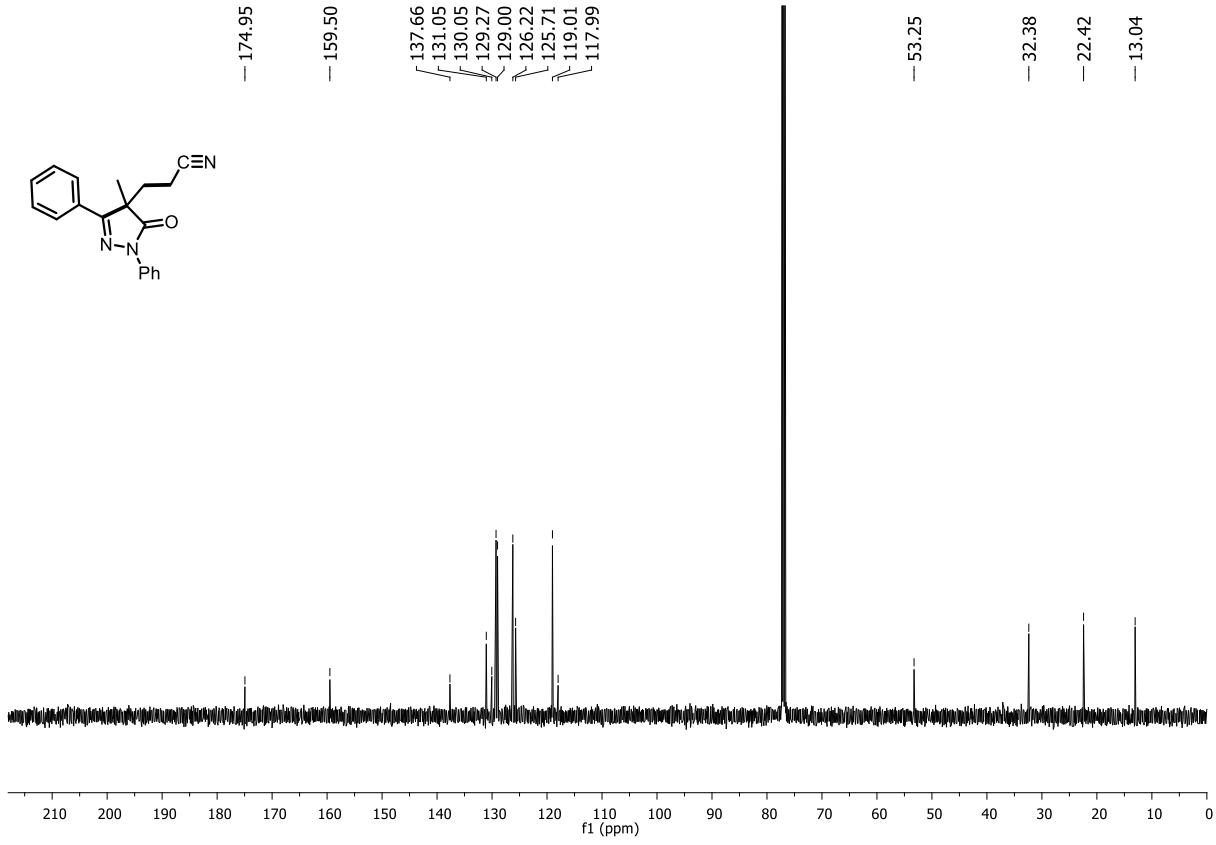
^{13}C{^{1}H} NMR spectrum of 3ac ($CDCl_3$, 126 MHz)



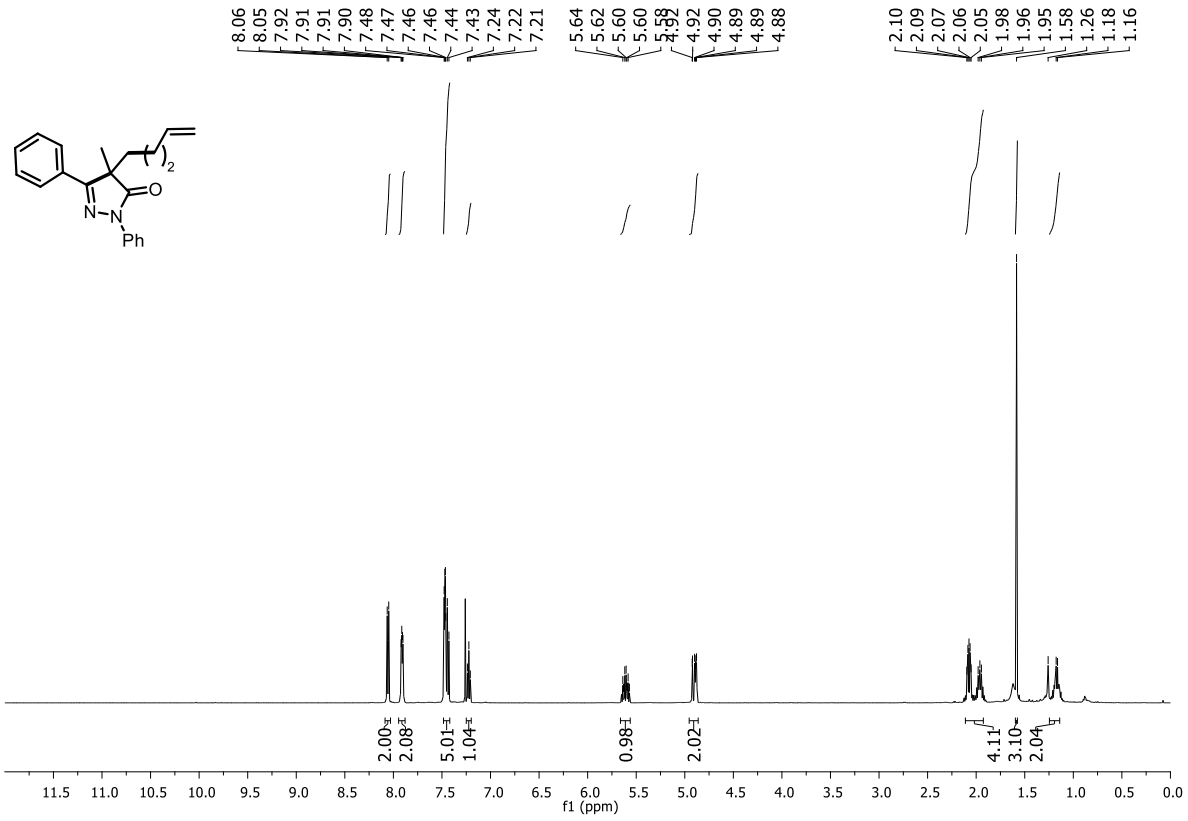
^{1}H NMR spectrum of 3ad ($CDCl_3$, 500 MHz)



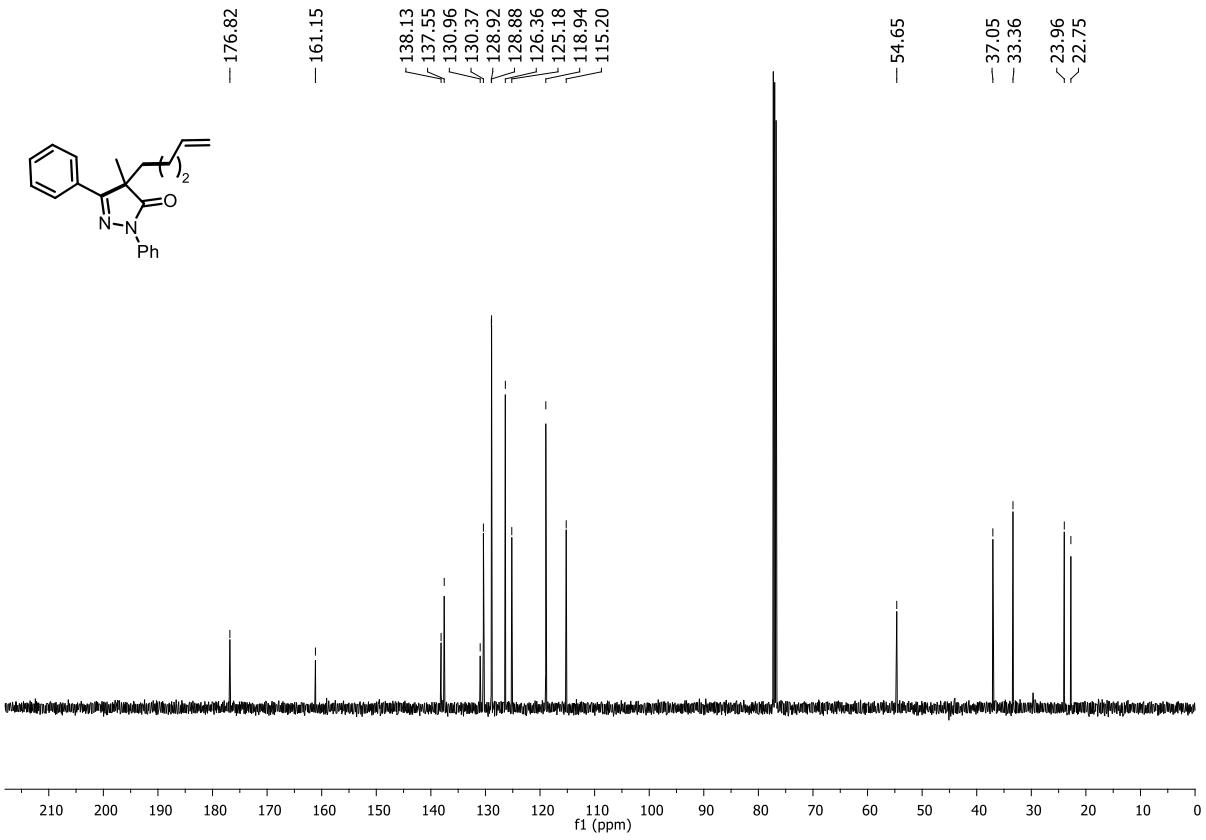
^{13}C{^{1}H} NMR spectrum of 3ad ($CDCl_3$, 126 MHz)



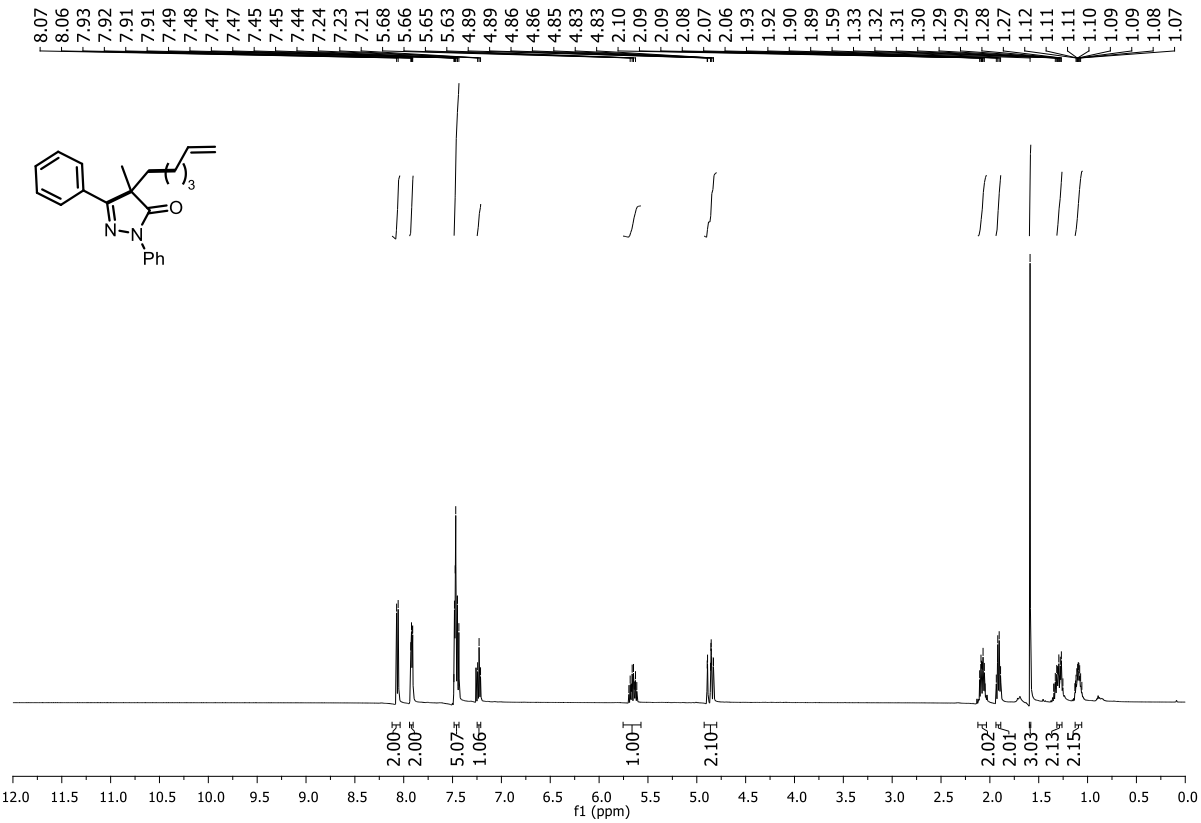
^{1}H NMR spectrum of 3ae($CDCl_3$, 500 MHz)



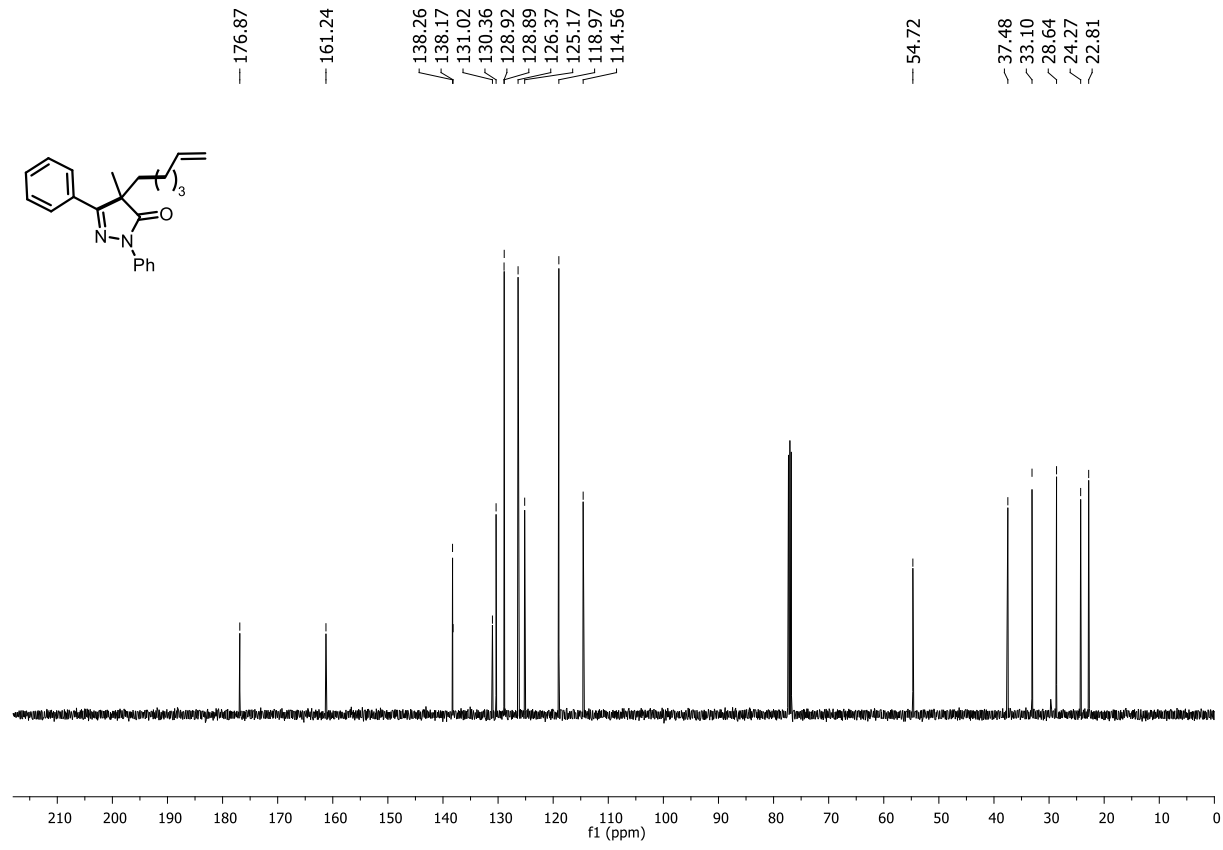
^{13}C{^{1}H} NMR spectrum of 3ae ($CDCl_3$, 126 MHz)



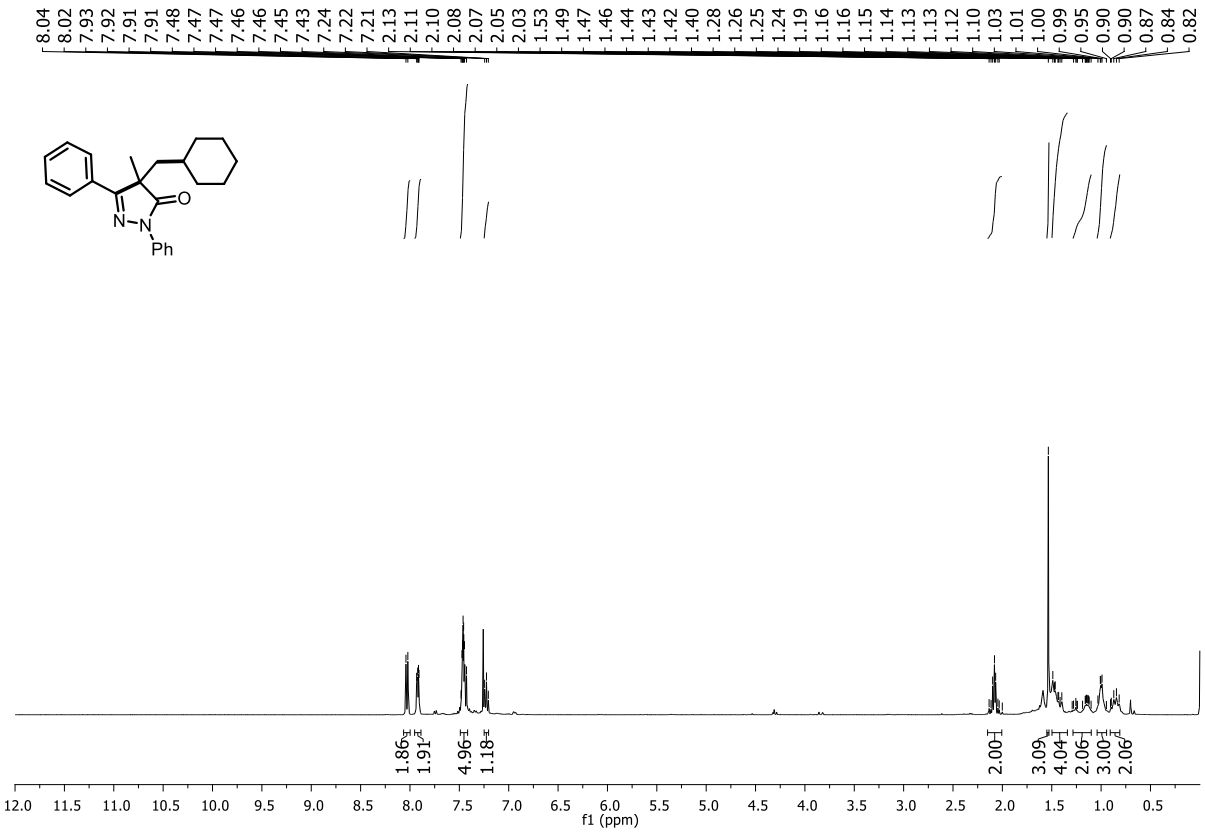
^{1}H NMR spectrum of 3af ($CDCl_3$, 500 MHz)



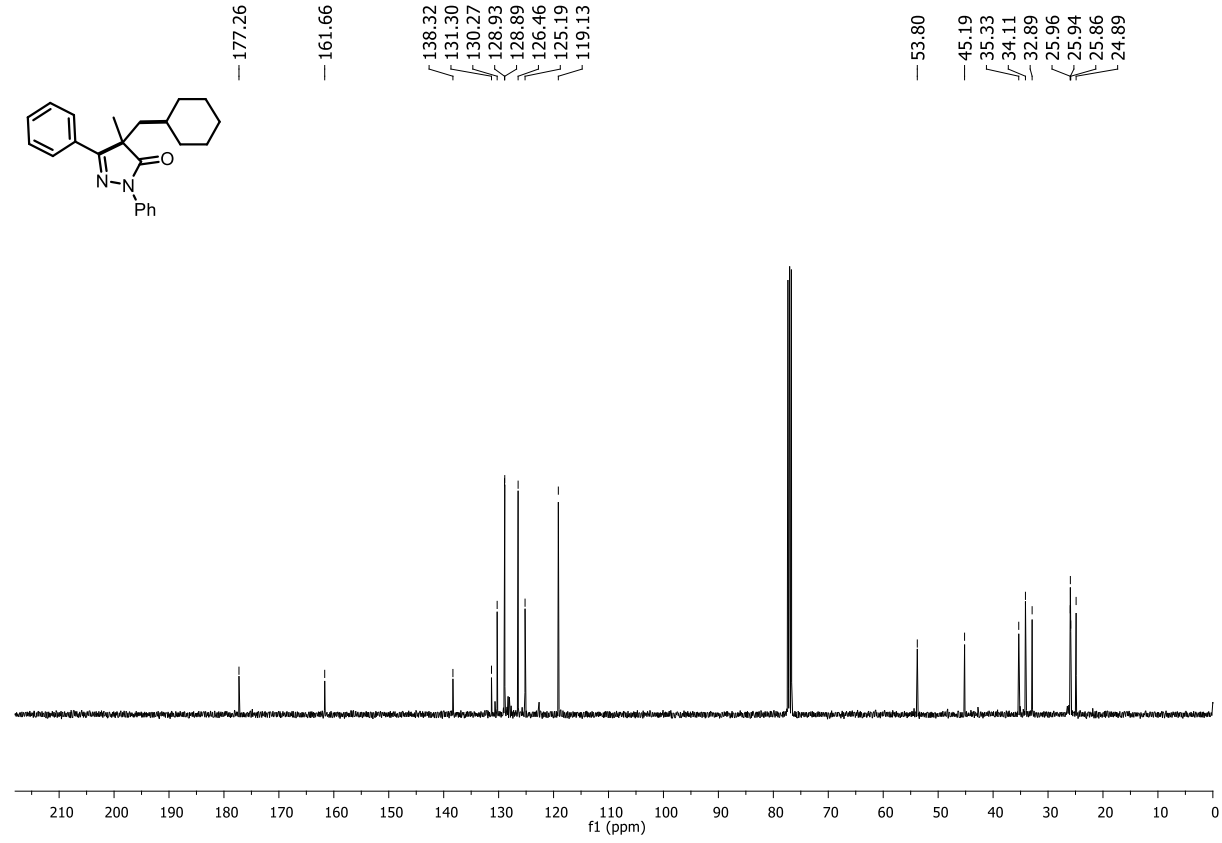
^{13}C{^{1}H} NMR spectrum of 3af ($CDCl_3$, 126 MHz)



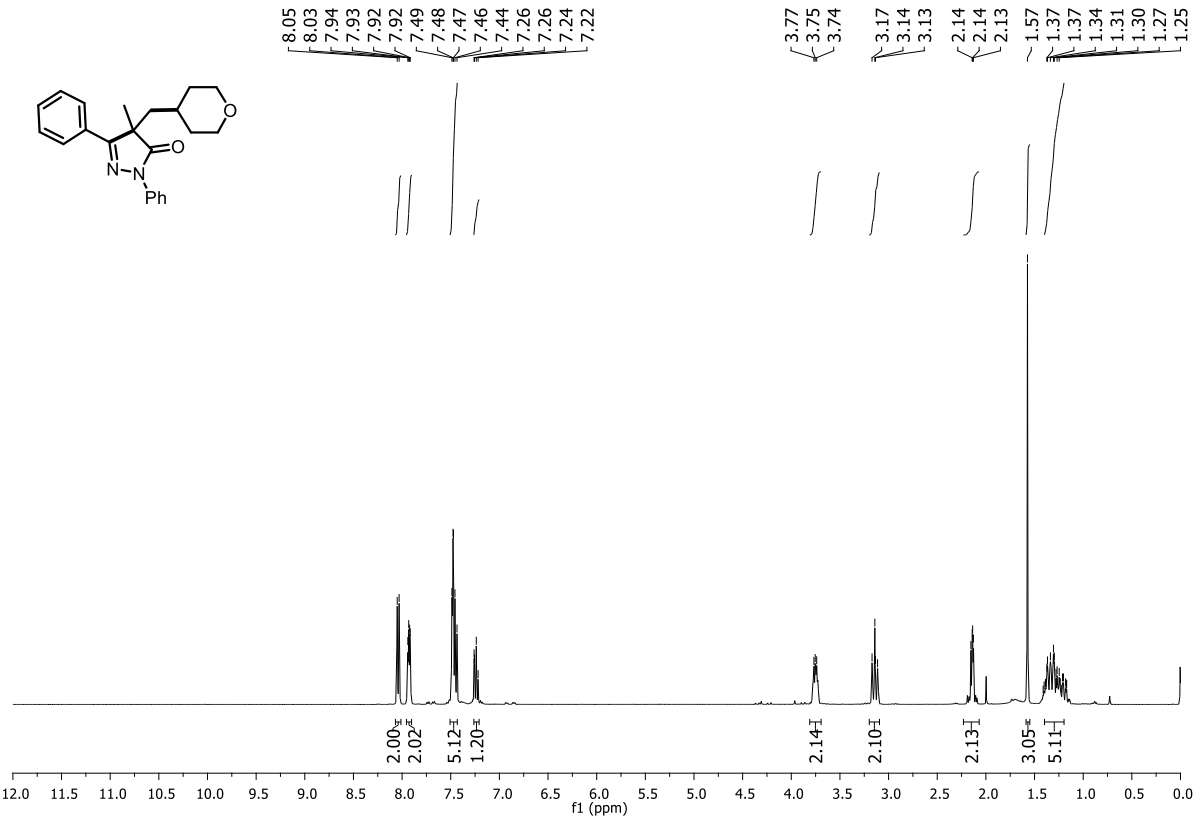
^{1}H NMR spectrum of 3ag ($CDCl_3$, 500 MHz)



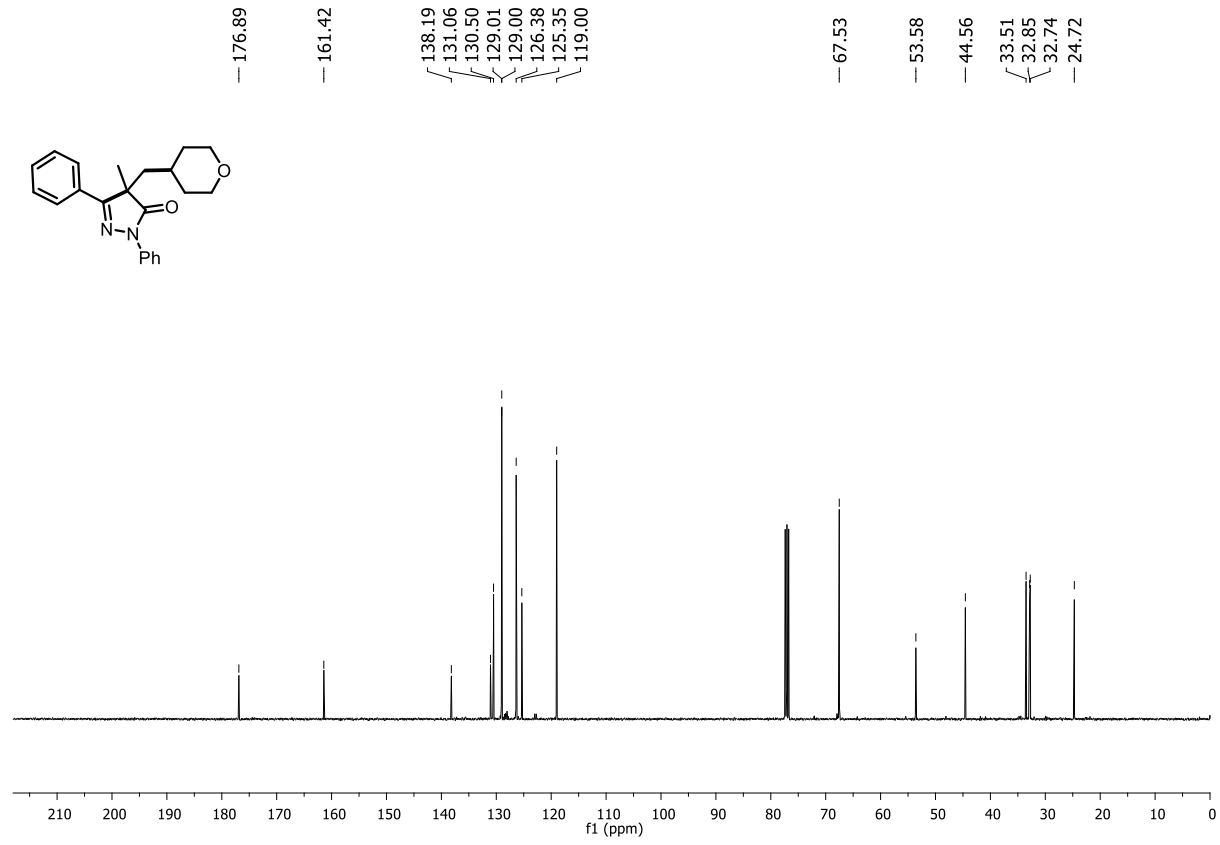
^{13}C{^{1}H} NMR spectrum of 3ag ($CDCl_3$, 126 MHz)



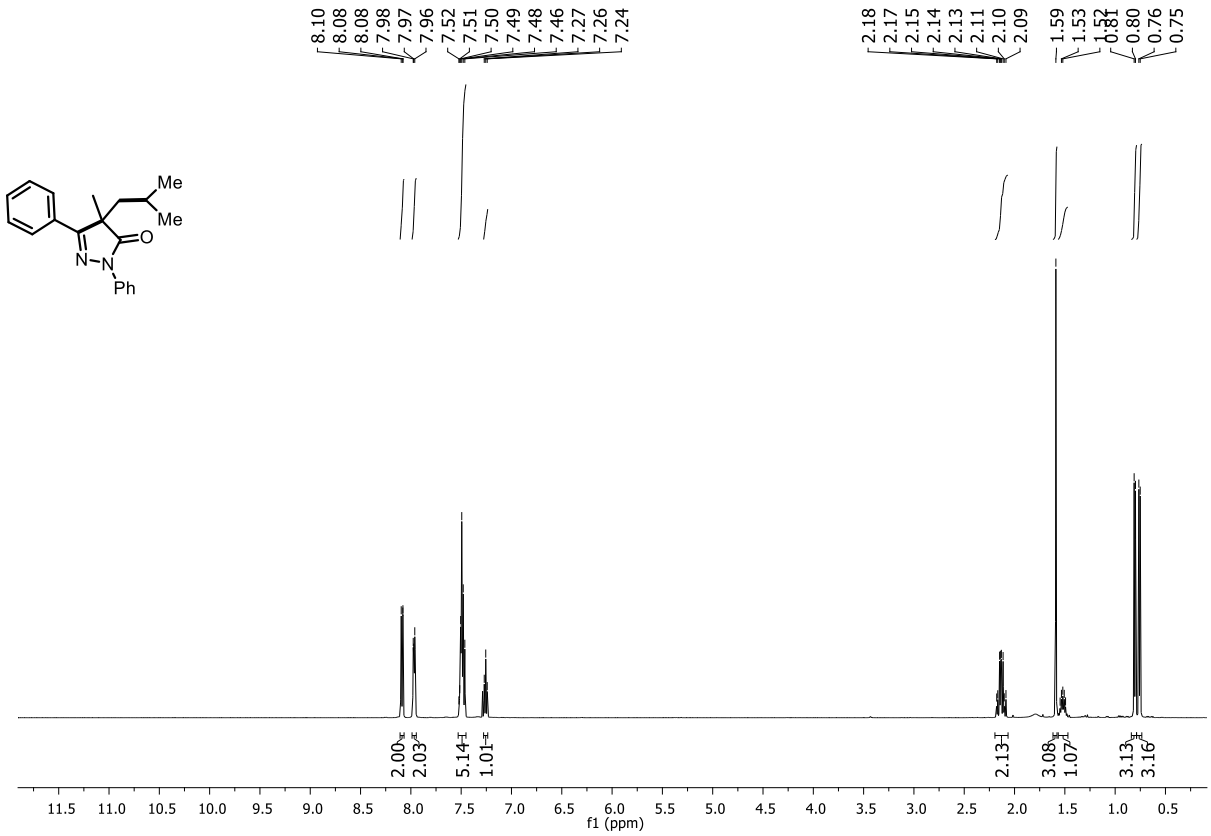
^{1}H NMR spectrum of 3ah ($CDCl_3$, 500 MHz)



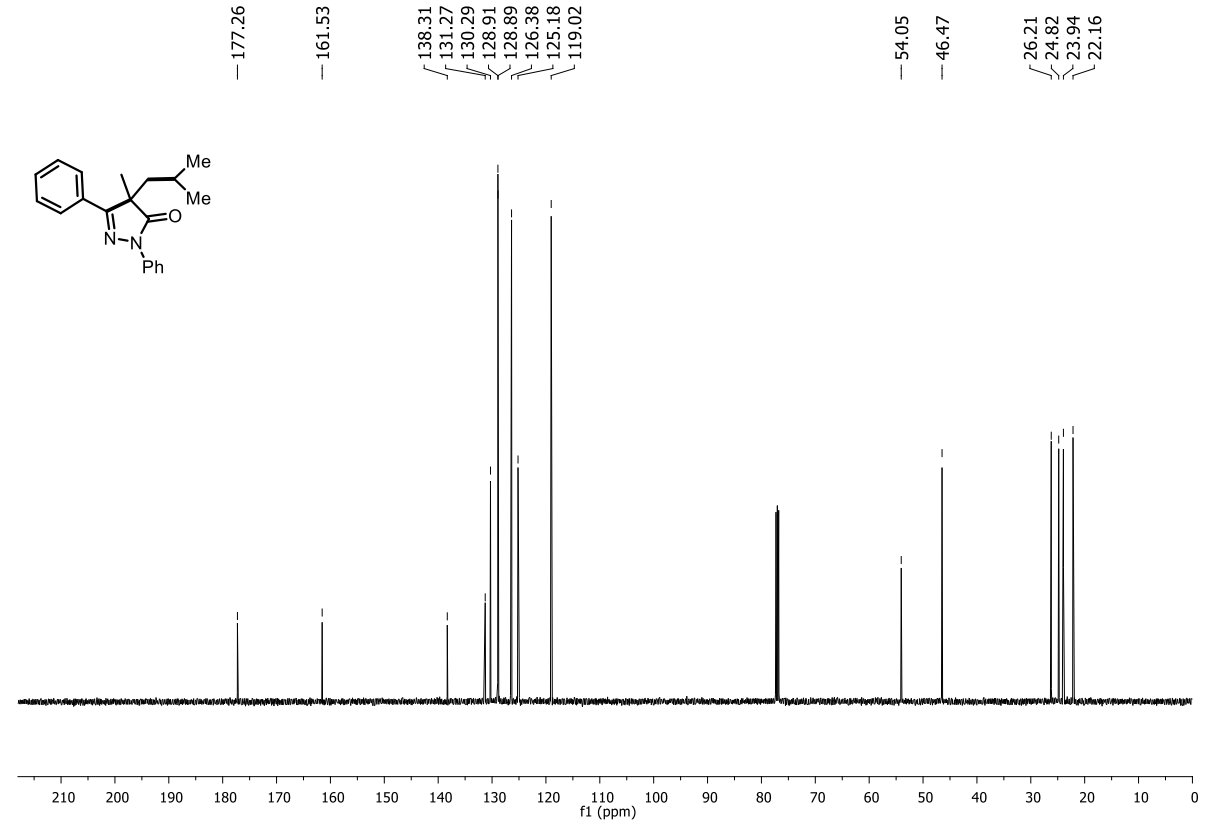
^{13}C{^{1}H} NMR spectrum of 3ah ($CDCl_3$, 126 MHz)



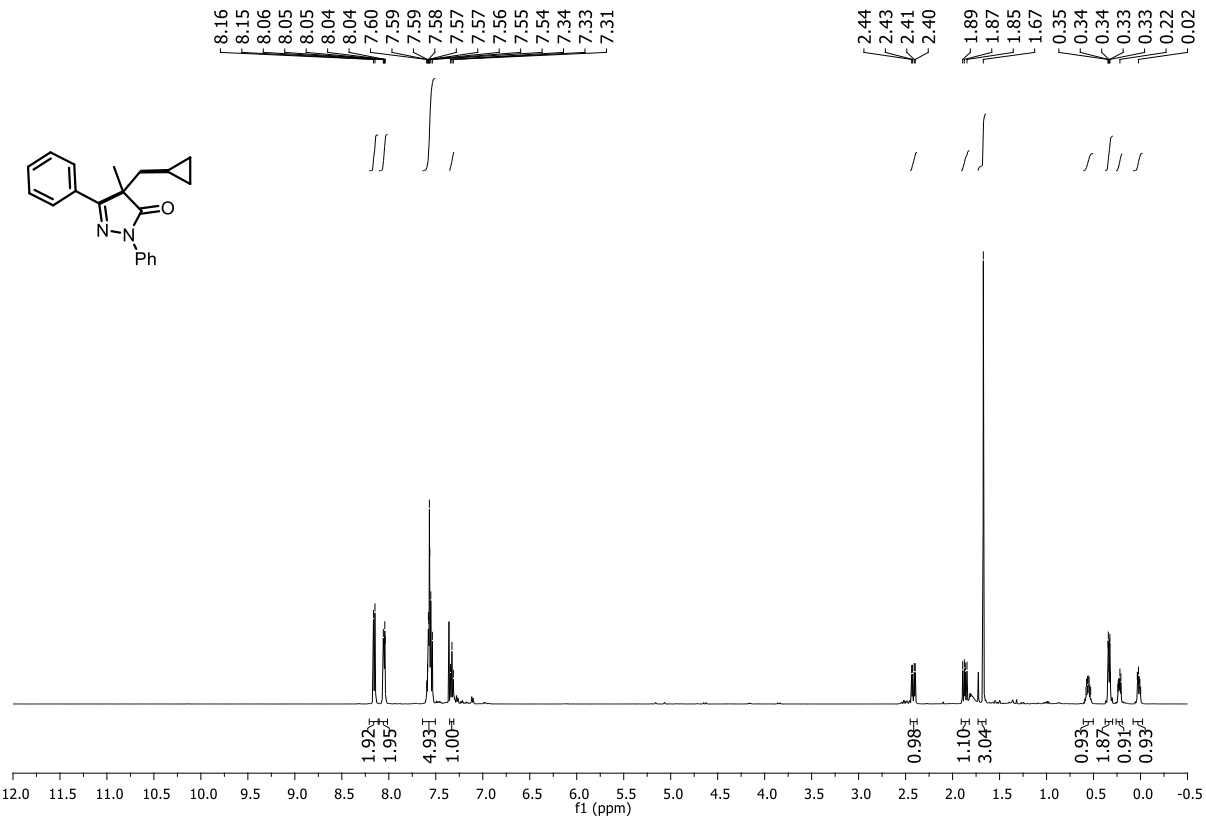
^{1}H NMR spectrum of 3ai ($CDCl_3$, 500 MHz)



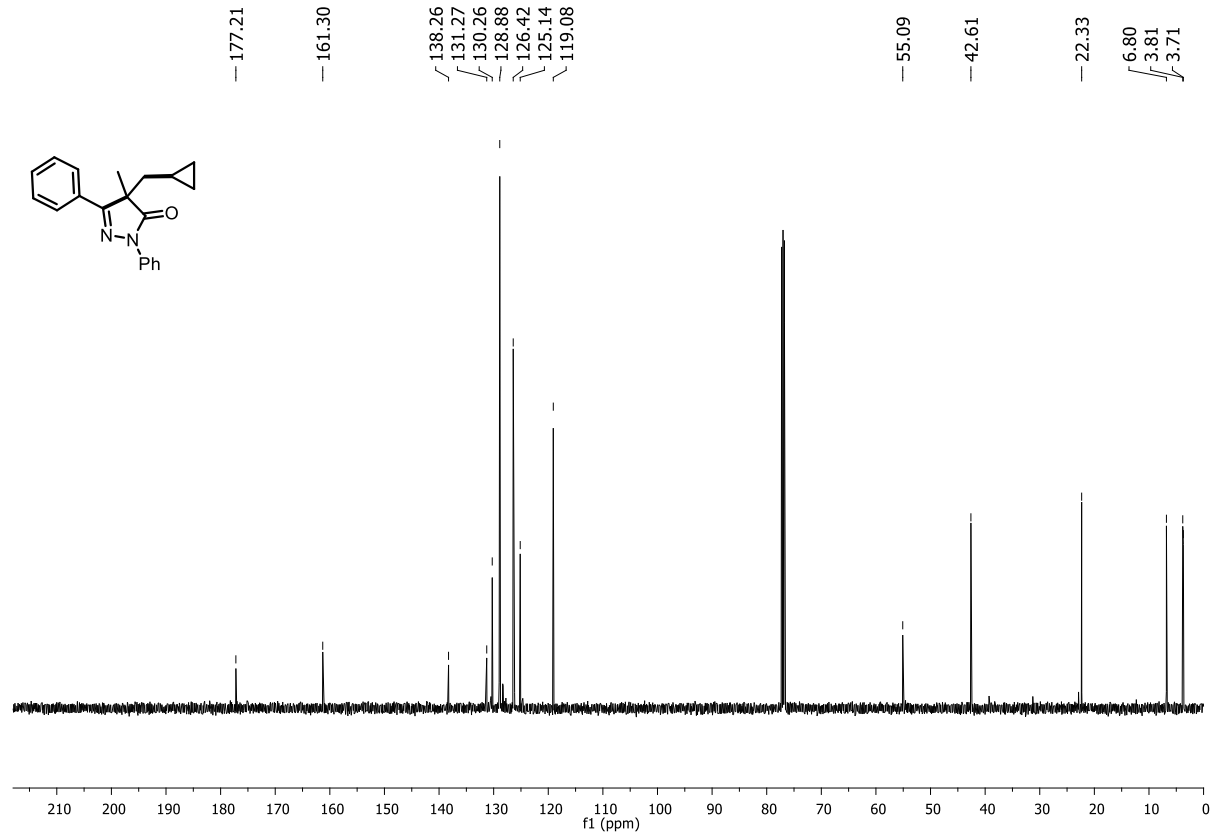
^{13}C{^{1}H} NMR spectrum of 3ai ($CDCl_3$, 126 MHz)



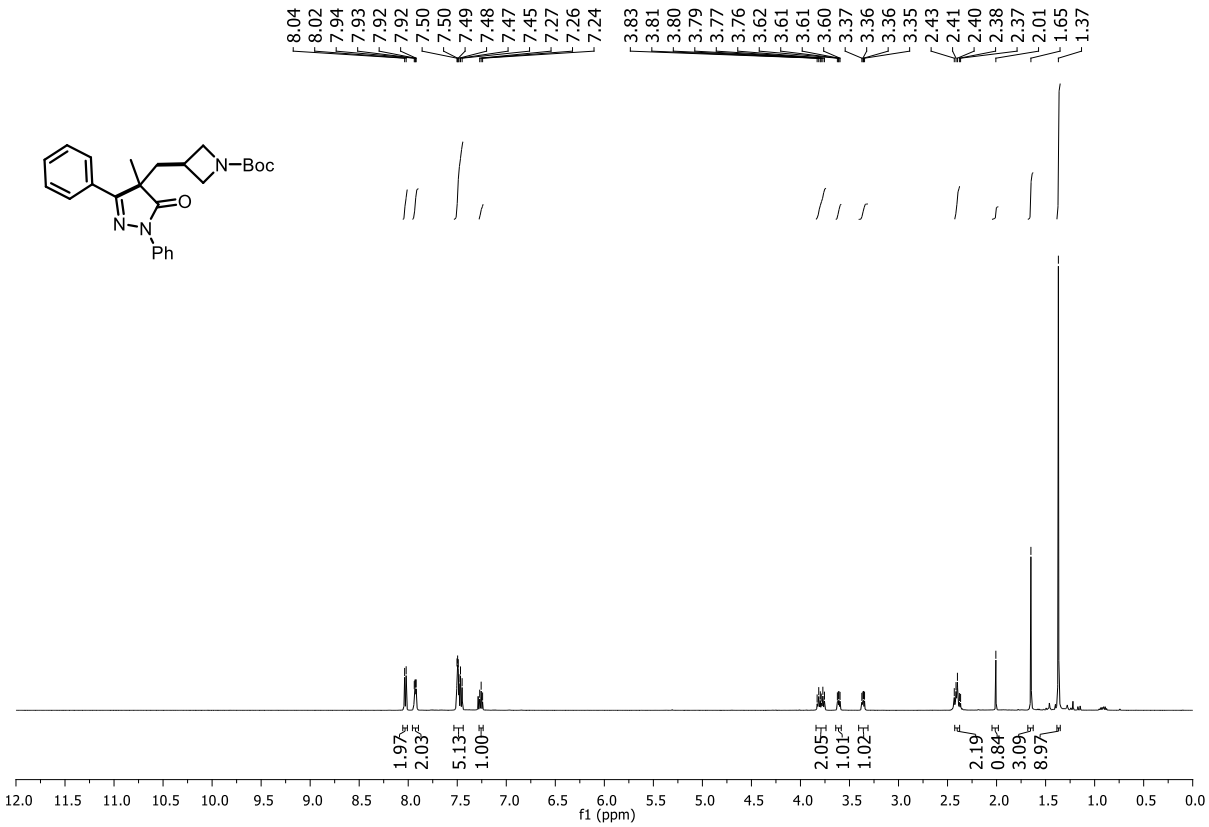
^{1}H NMR spectrum of 3aj ($CDCl_3$, 500 MHz)



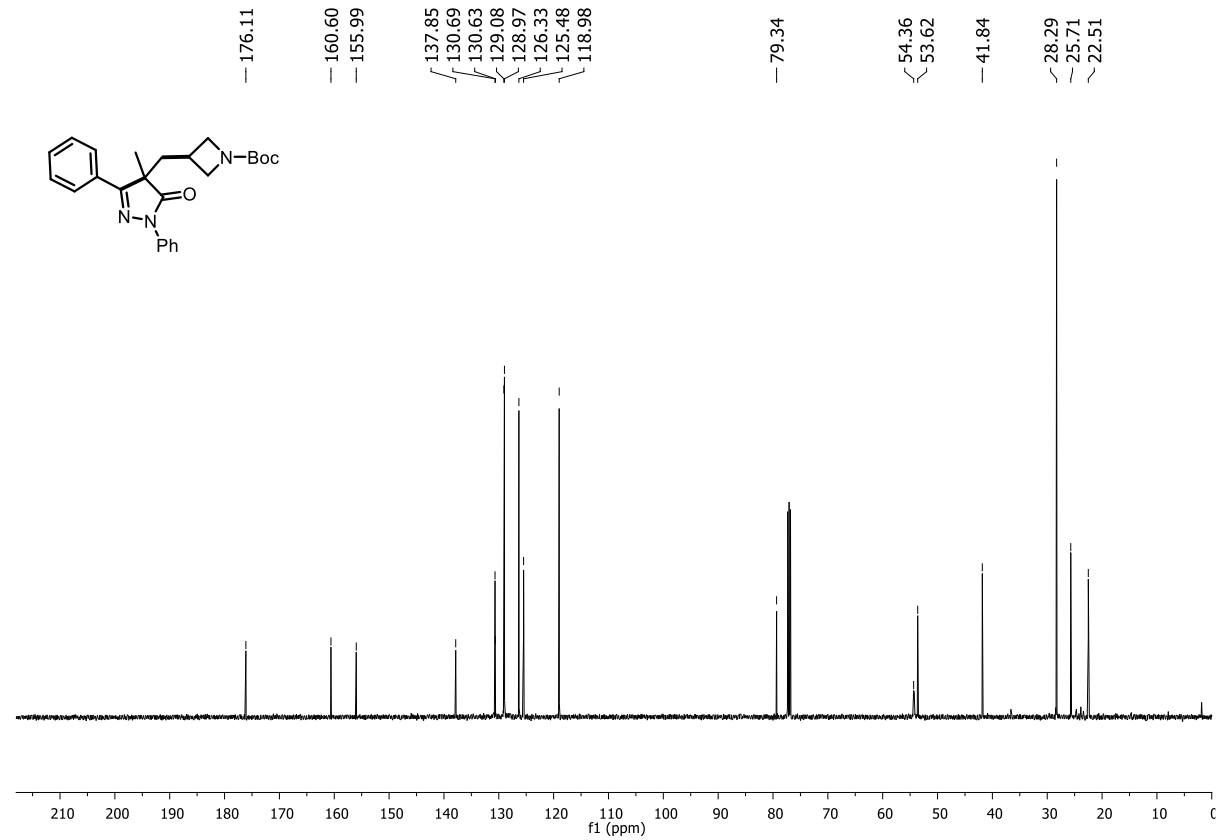
^{13}C{^{1}H} NMR spectrum of 3aj ($CDCl_3$, 500 MHz)



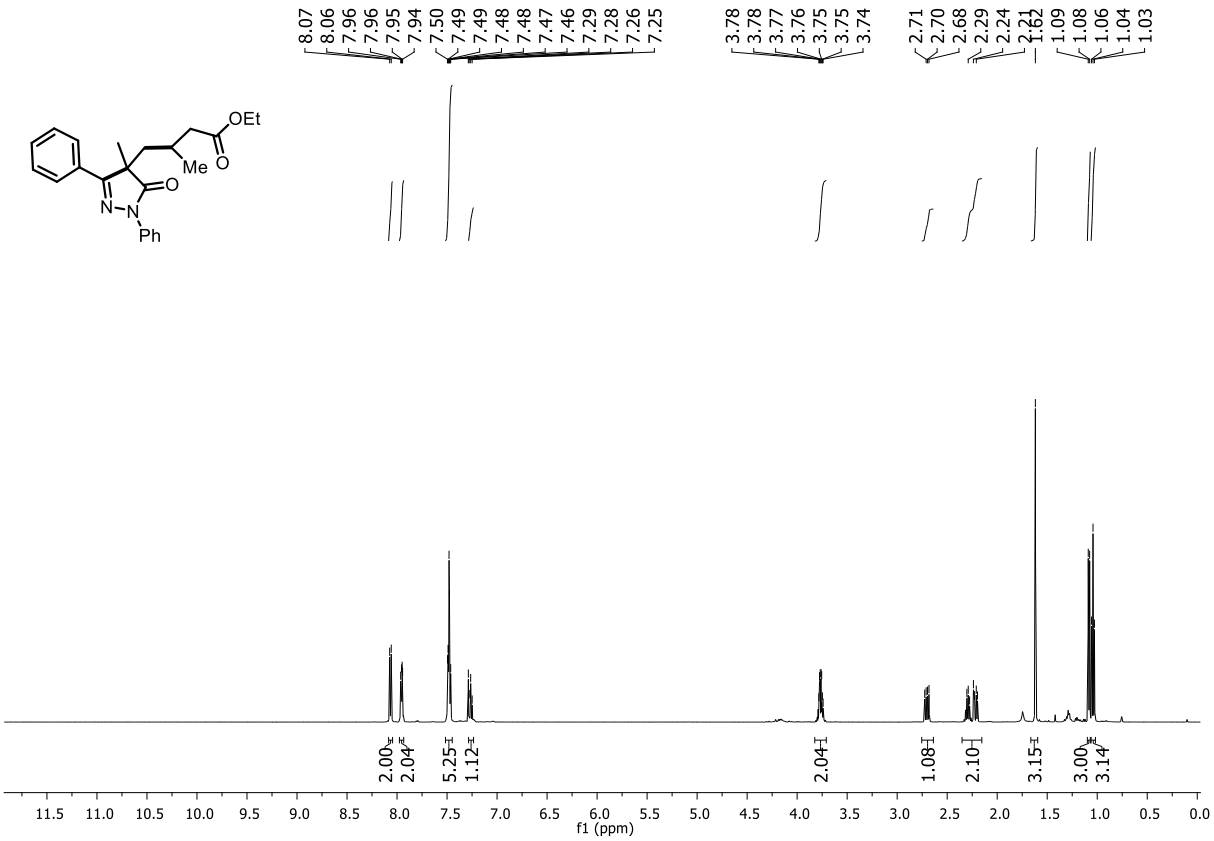
^{1}H NMR spectrum of 3ak ($CDCl_3$, 500 MHz)



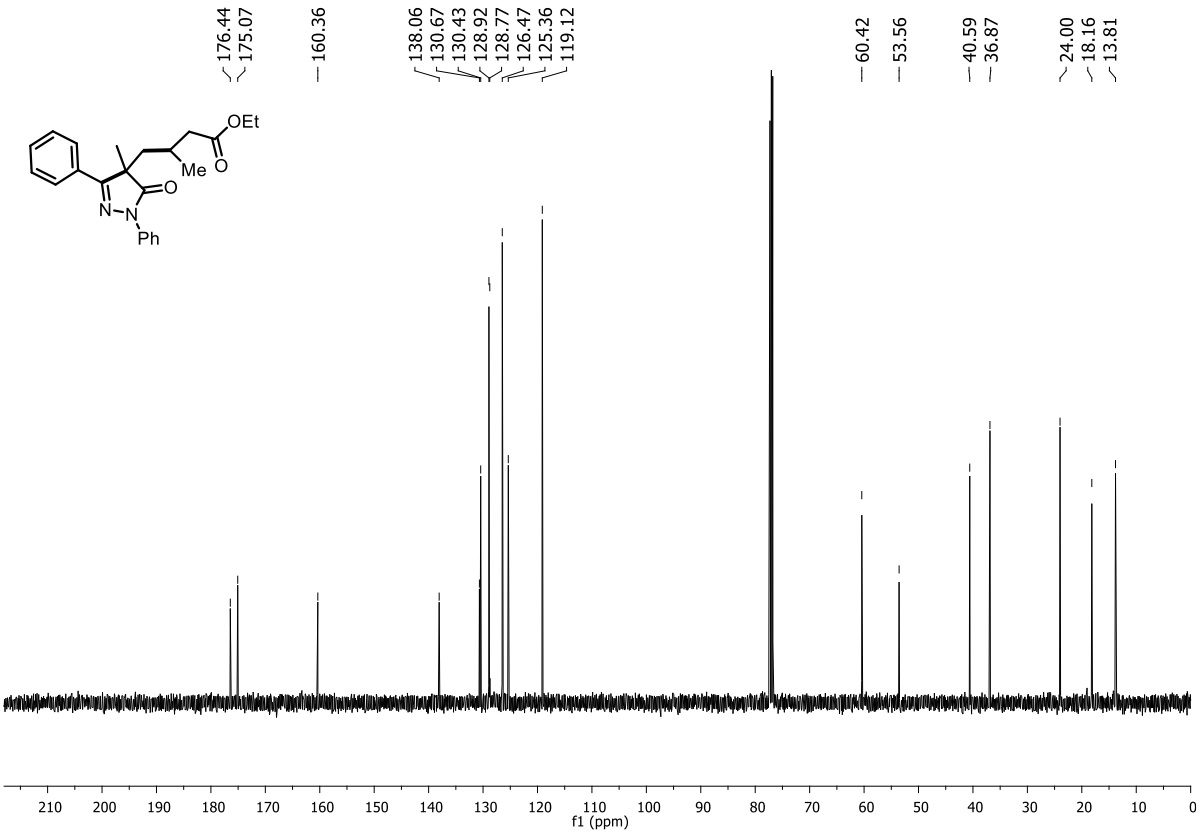
^{13}C{^{1}H} NMR spectrum of 3ak ($CDCl_3$, 126 MHz)



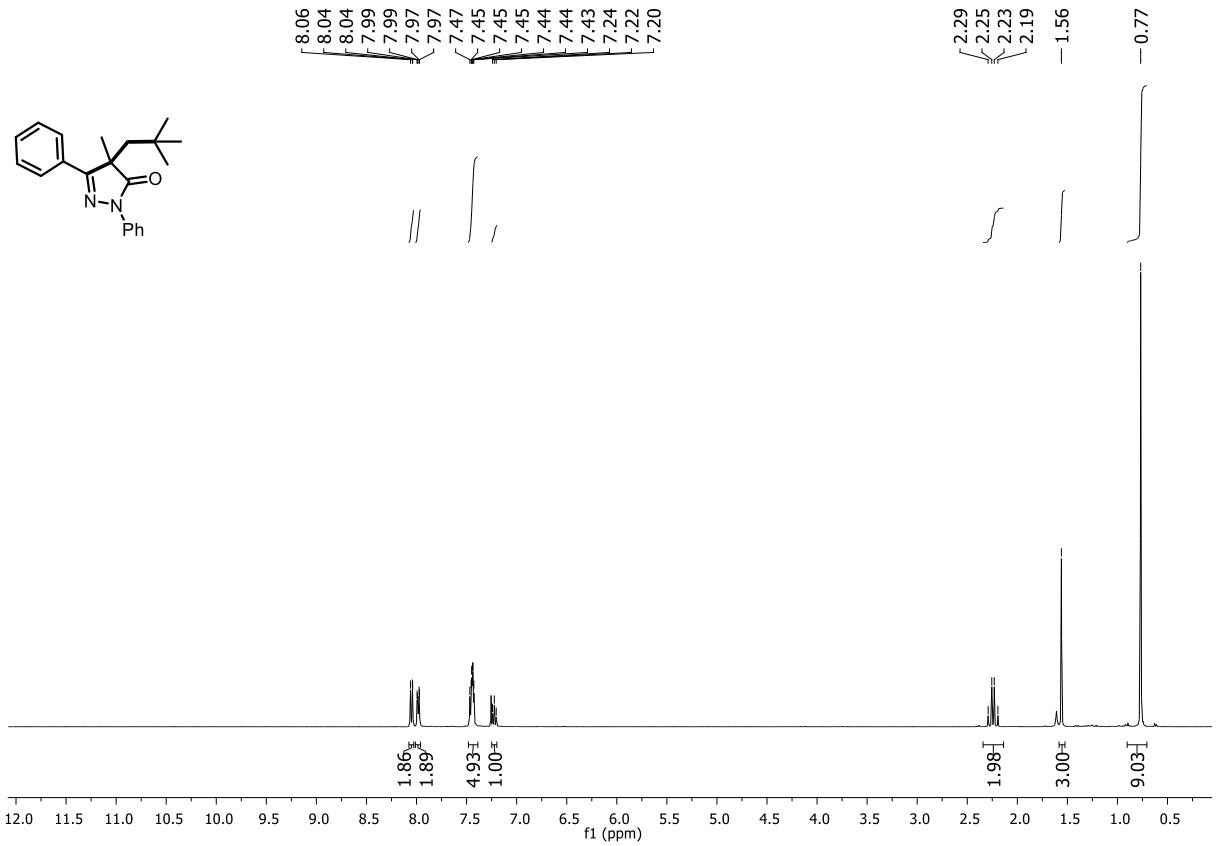
^{1}H NMR spectrum of 3al ($CDCl_3$, 500 MHz)



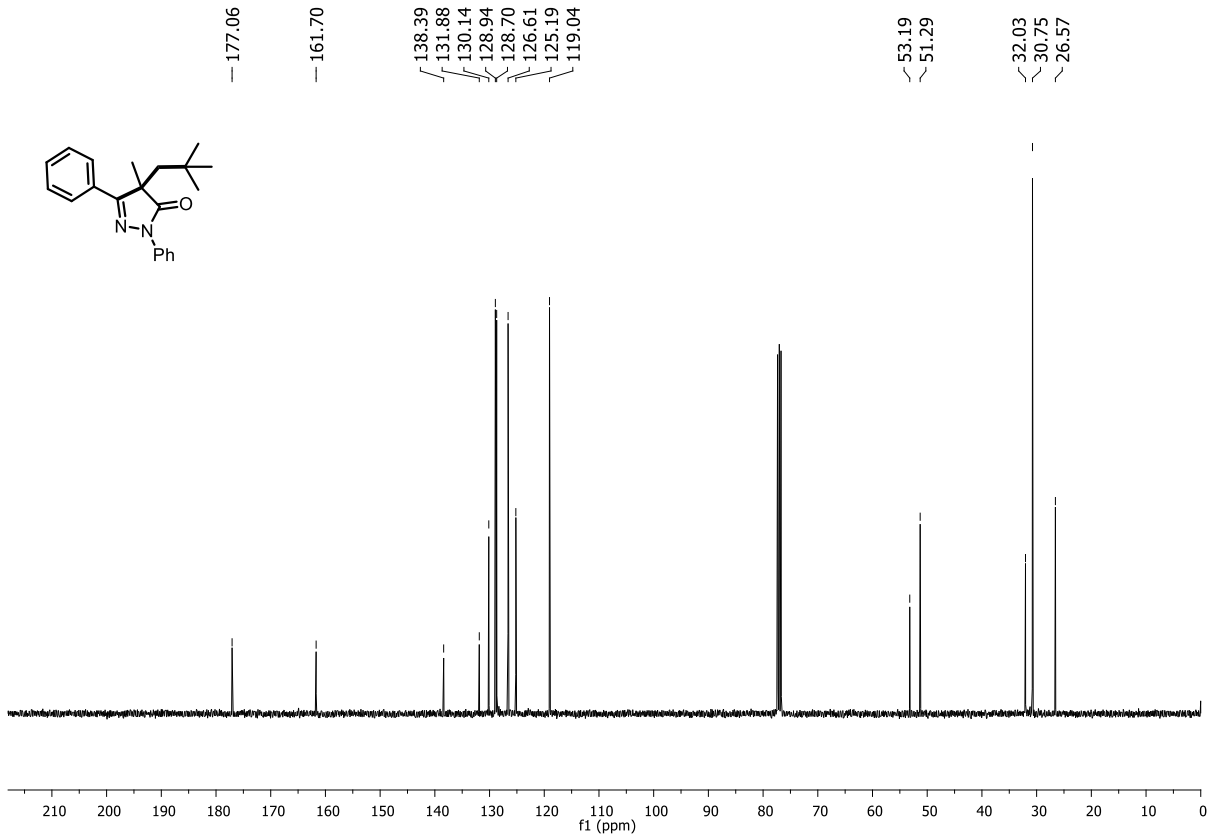
^{13}C{^{1}H} NMR spectrum of 3al ($CDCl_3$, 126 MHz)



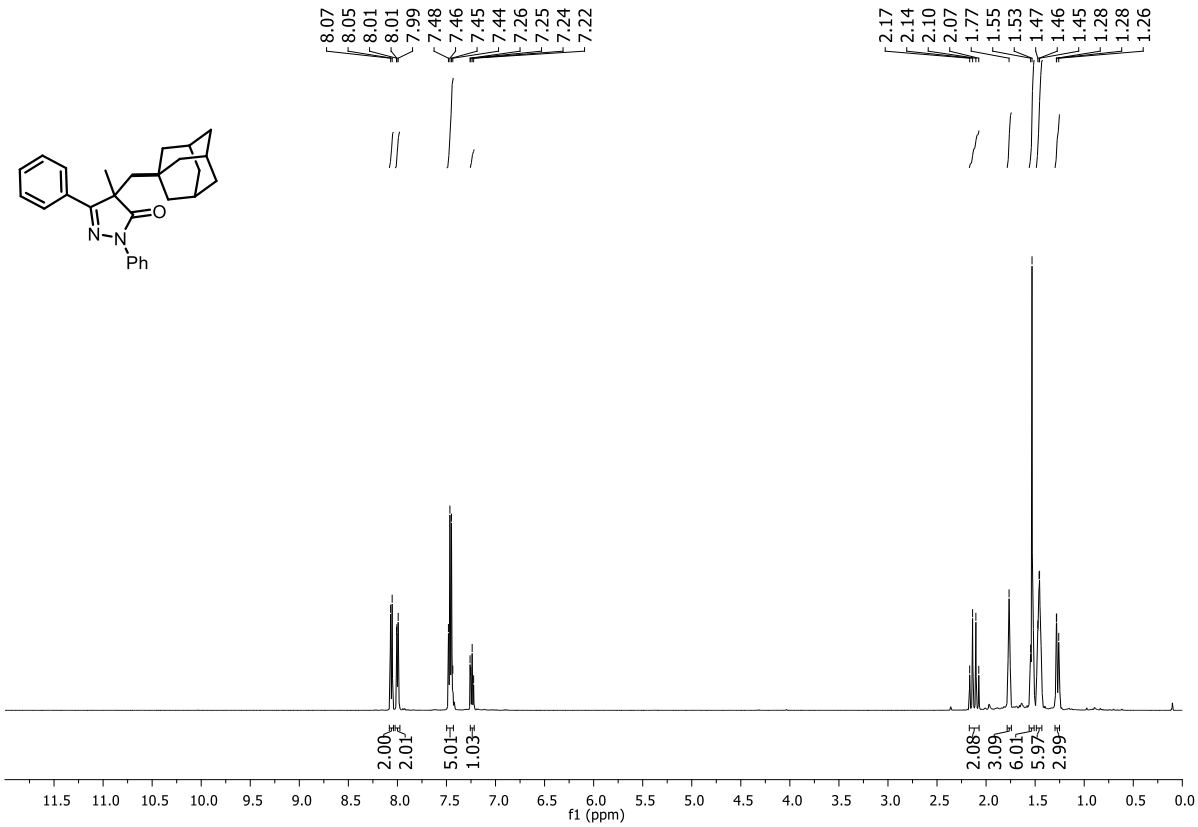
^{1}H NMR spectrum of 3am ($CDCl_3$, 500 MHz)



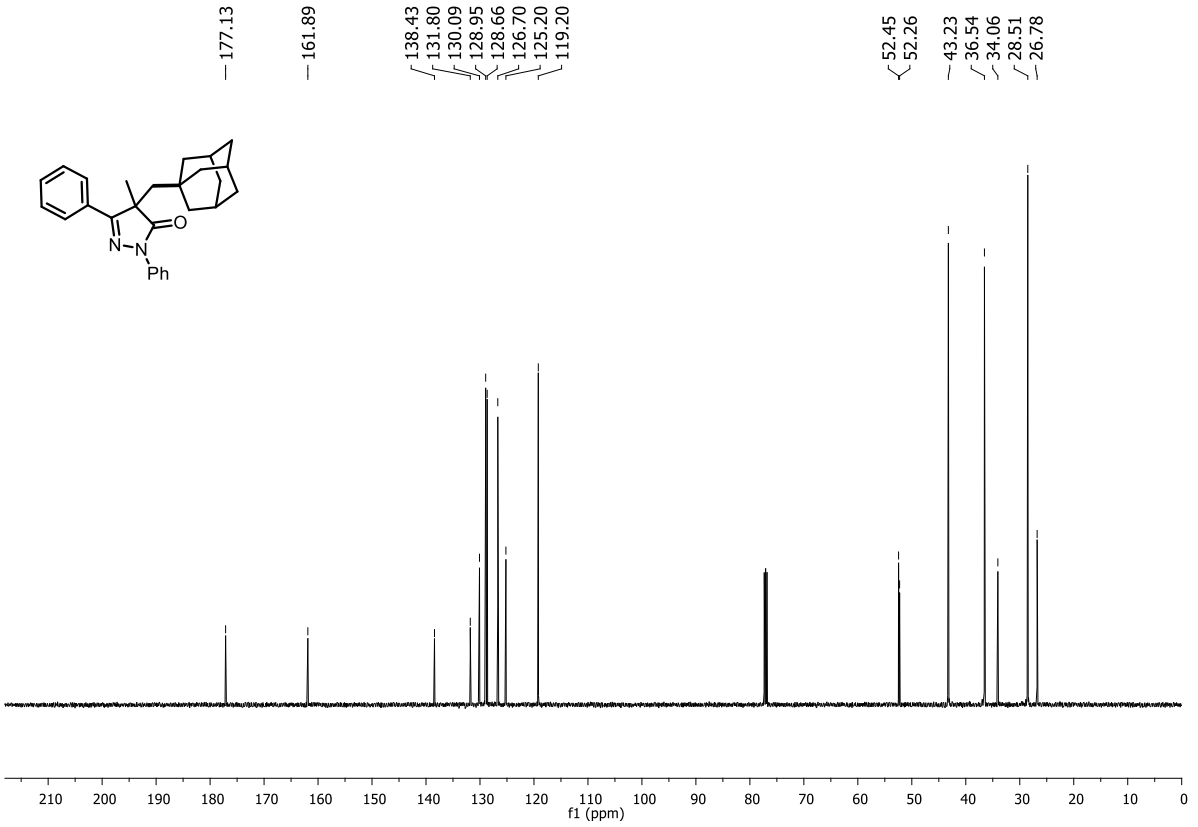
^{13}C{^{1}H} NMR spectrum of 3am ($CDCl_3$, 126 MHz)



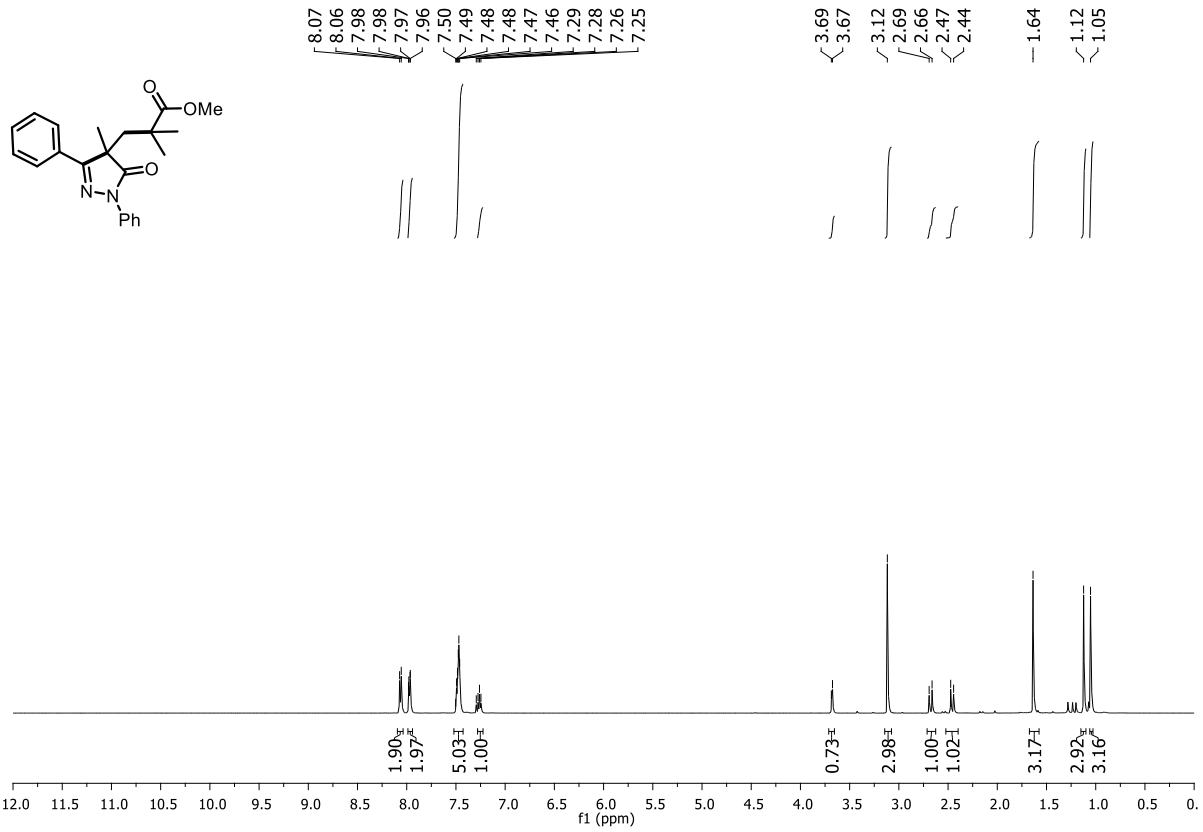
^{1}H NMR spectrum of 3an ($CDCl_3$, 500 MHz)



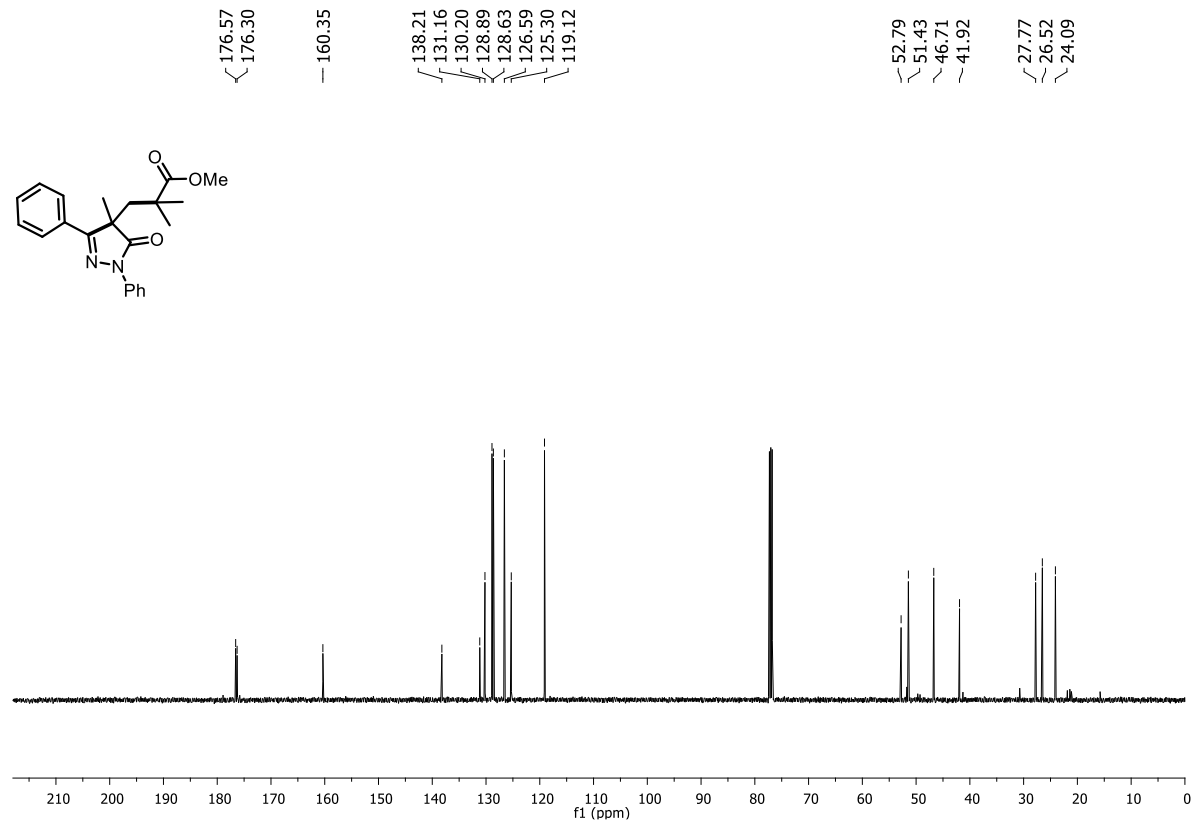
^{13}C{^{1}H} NMR spectrum of 3an ($CDCl_3$, 126 MHz)



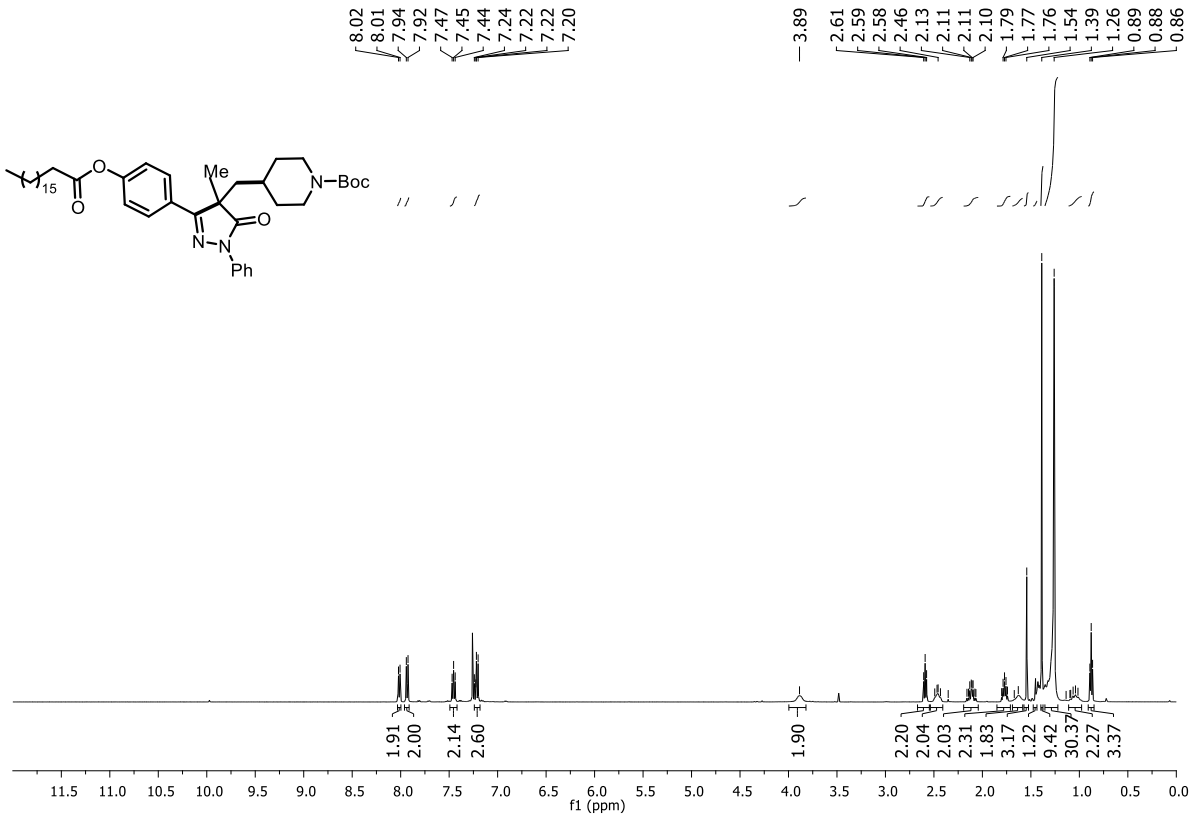
^{1}H NMR spectrum of 3ao ($CDCl_3$, 500 MHz)



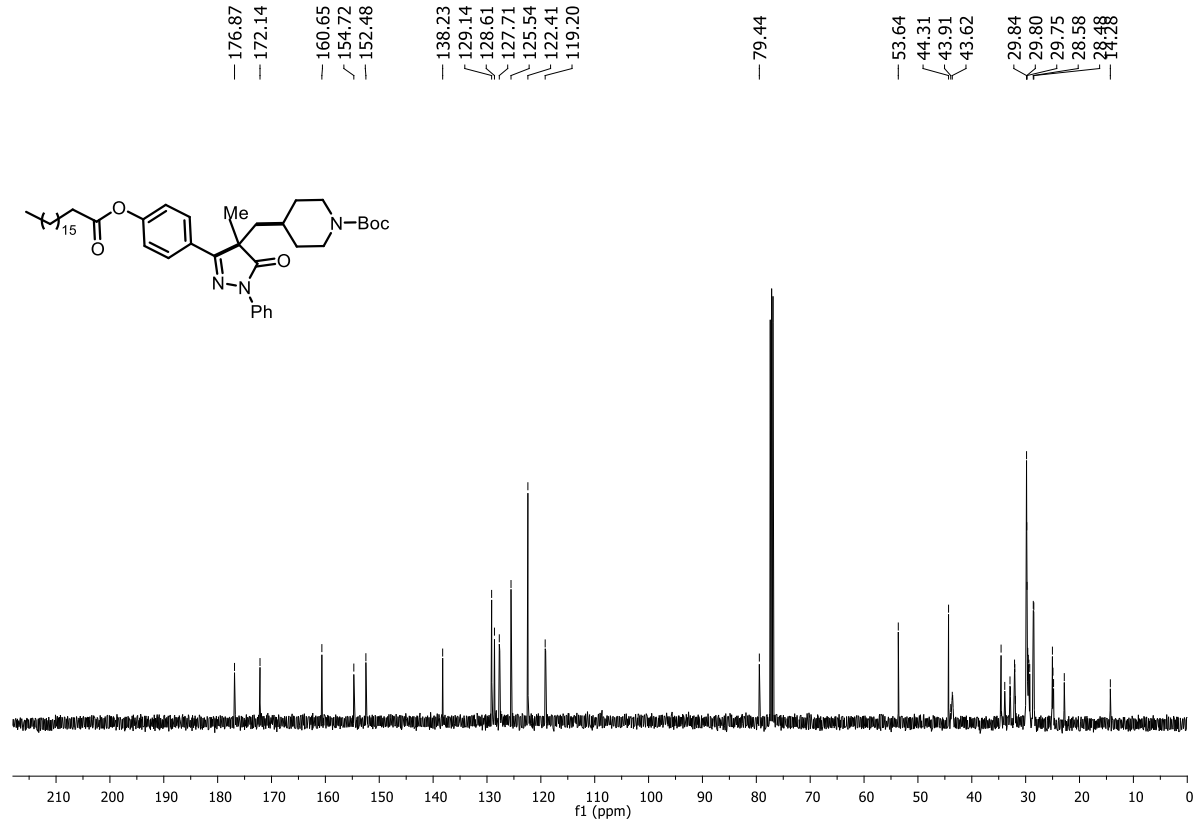
^{13}C{^{1}H} NMR spectrum of 3ao ($CDCl_3$, 126 MHz)



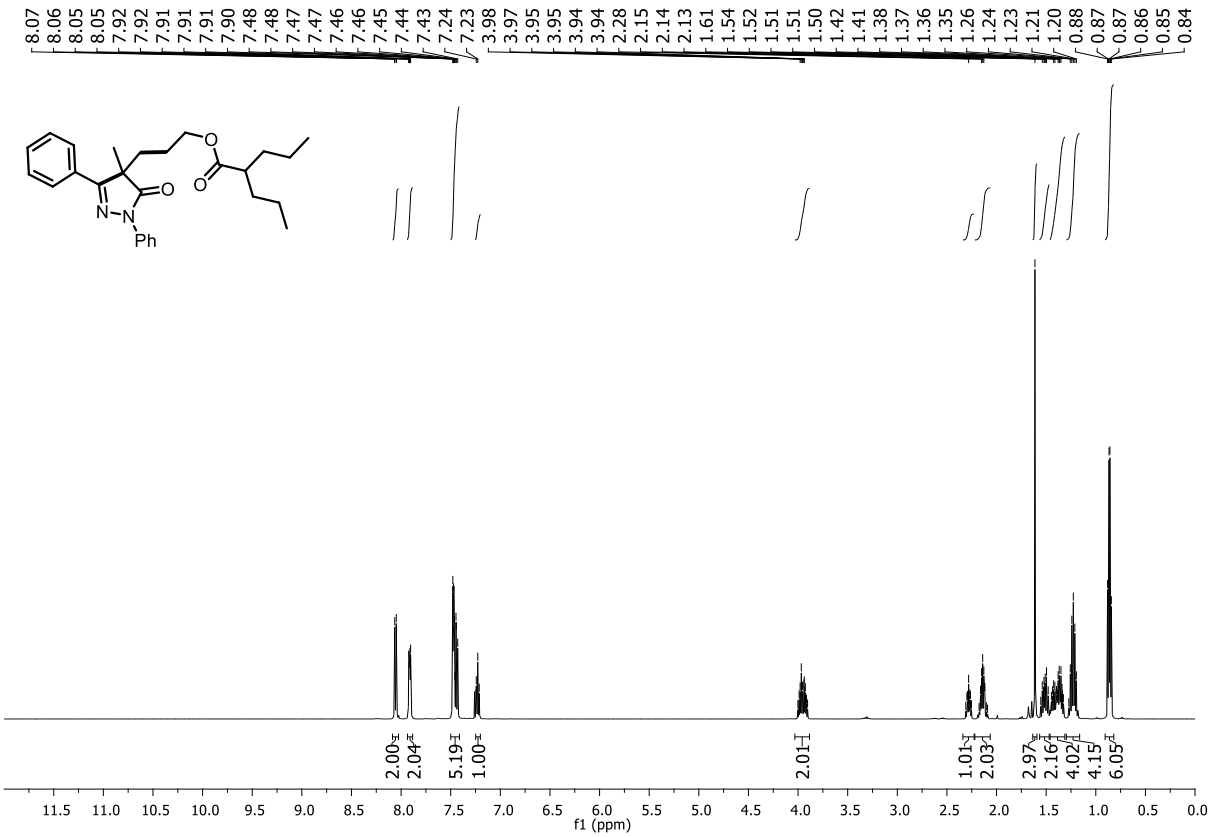
^{1}H NMR spectrum of 3qa ($CDCl_3$, 500 MHz)



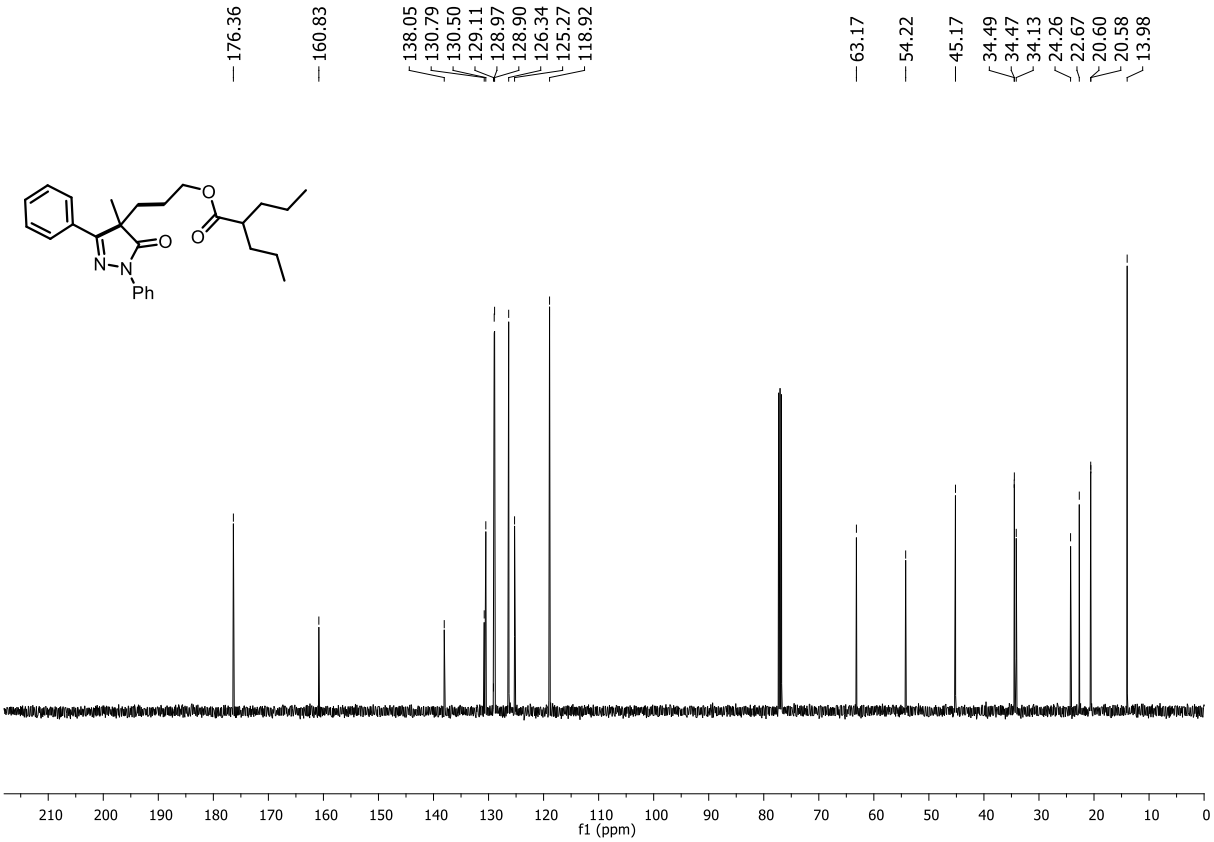
^{13}C{^{1}H} NMR spectrum of 3qa ($CDCl_3$, 126 MHz)



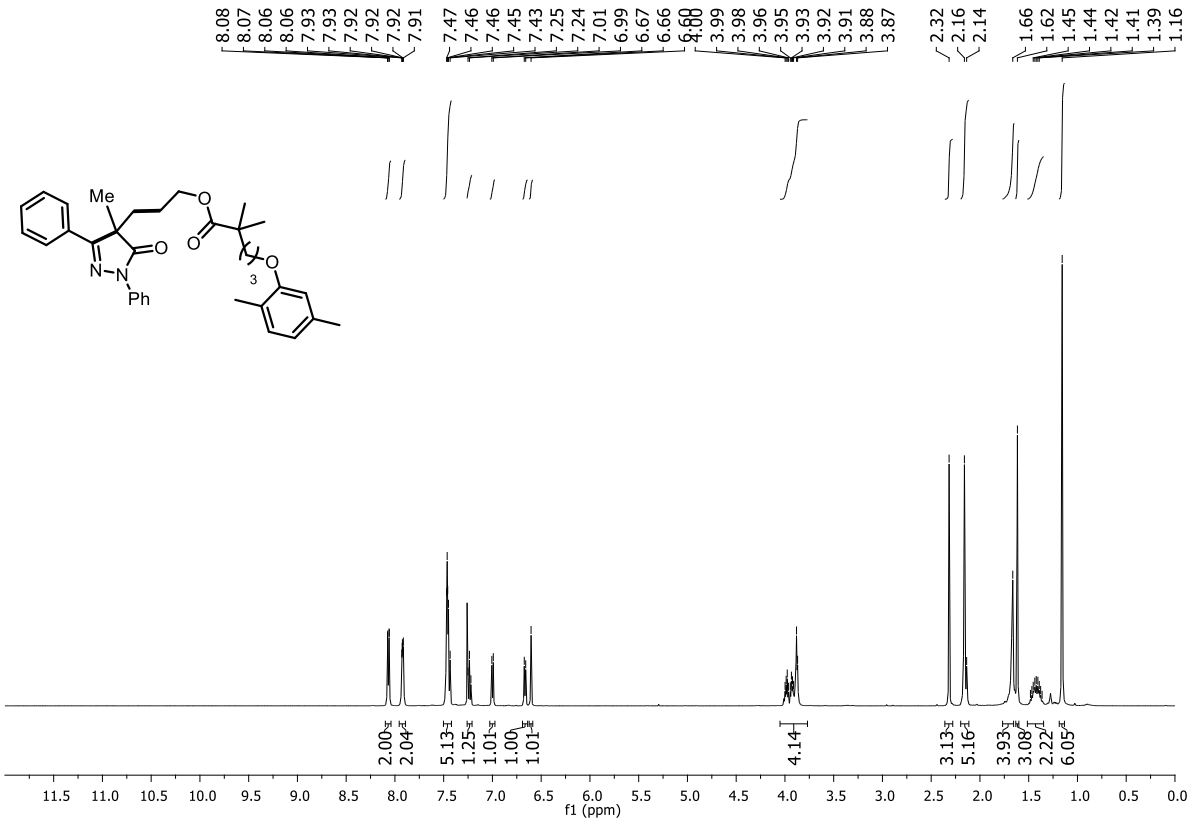
^{1}H NMR spectrum of 3ap ($CDCl_3$, 500 MHz)



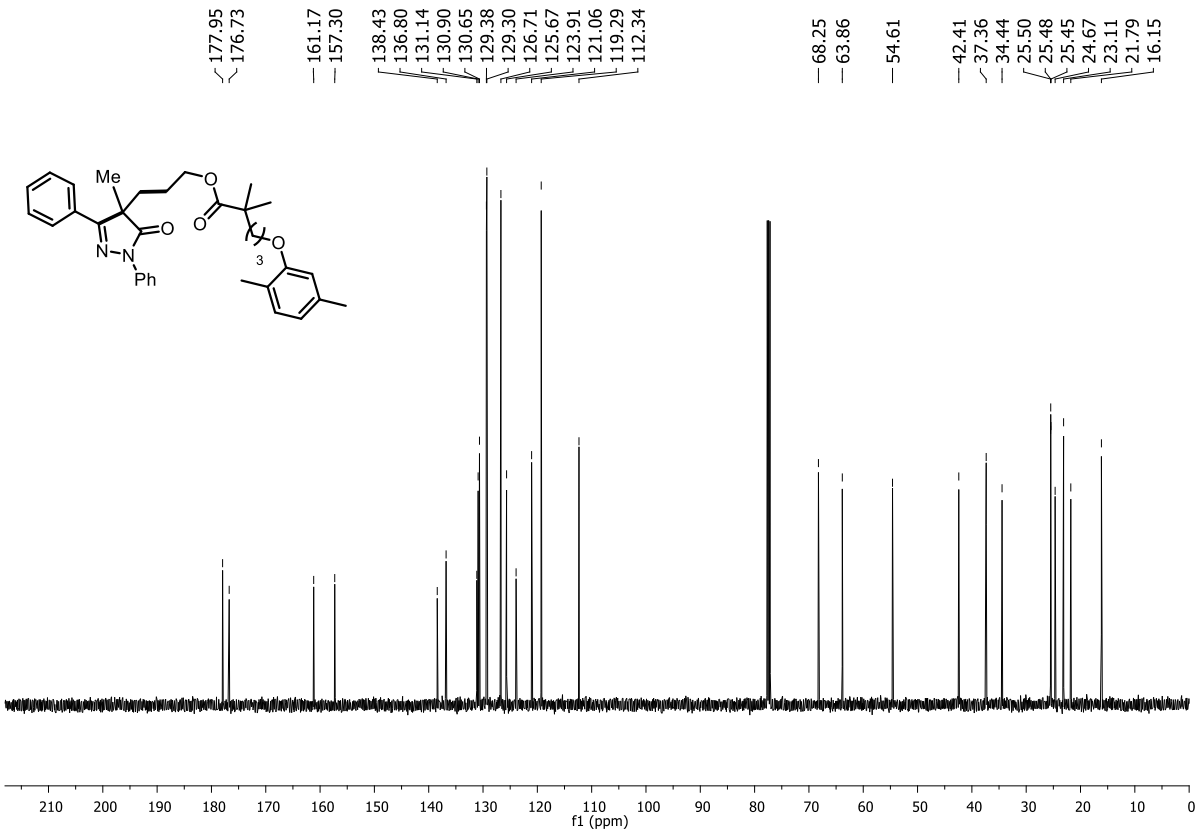
^{13}C{^{1}H} NMR spectrum of 3ap ($CDCl_3$, 126 MHz)



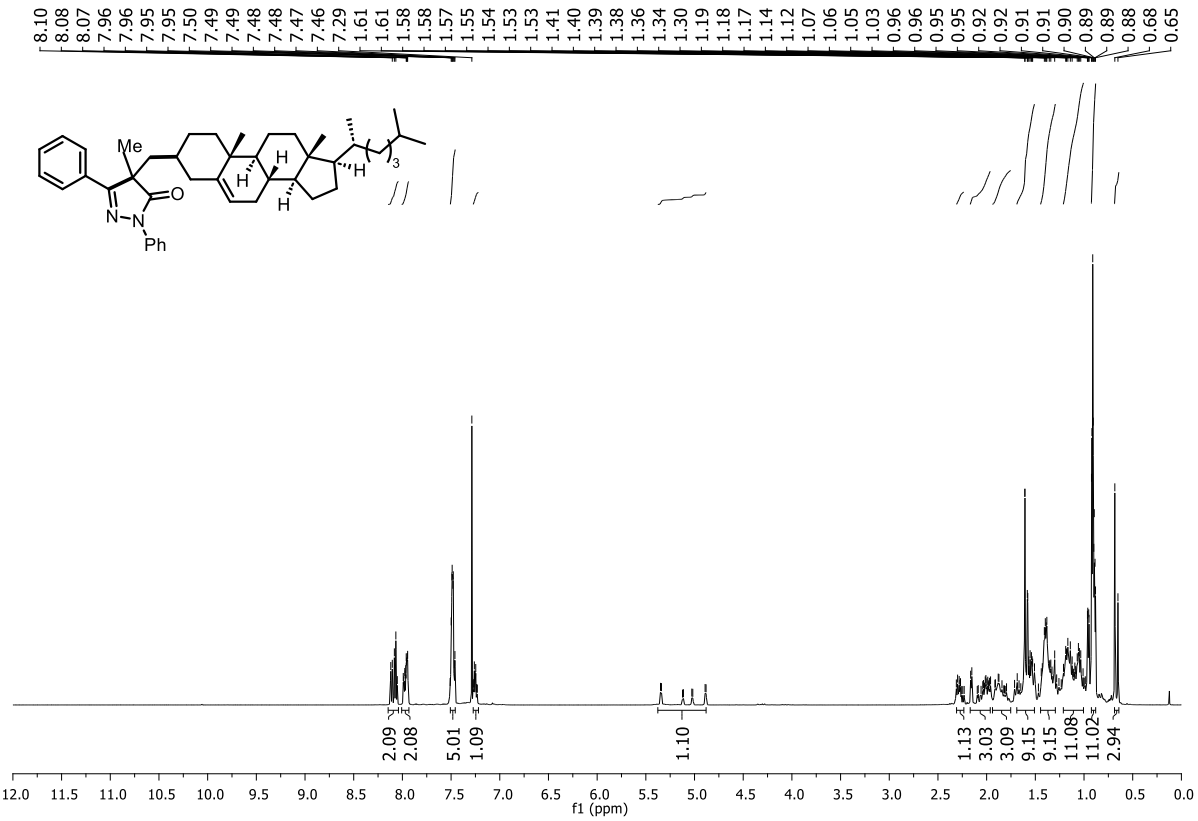
^{1}H NMR spectrum of 3aq ($CDCl_3$, 500 MHz)



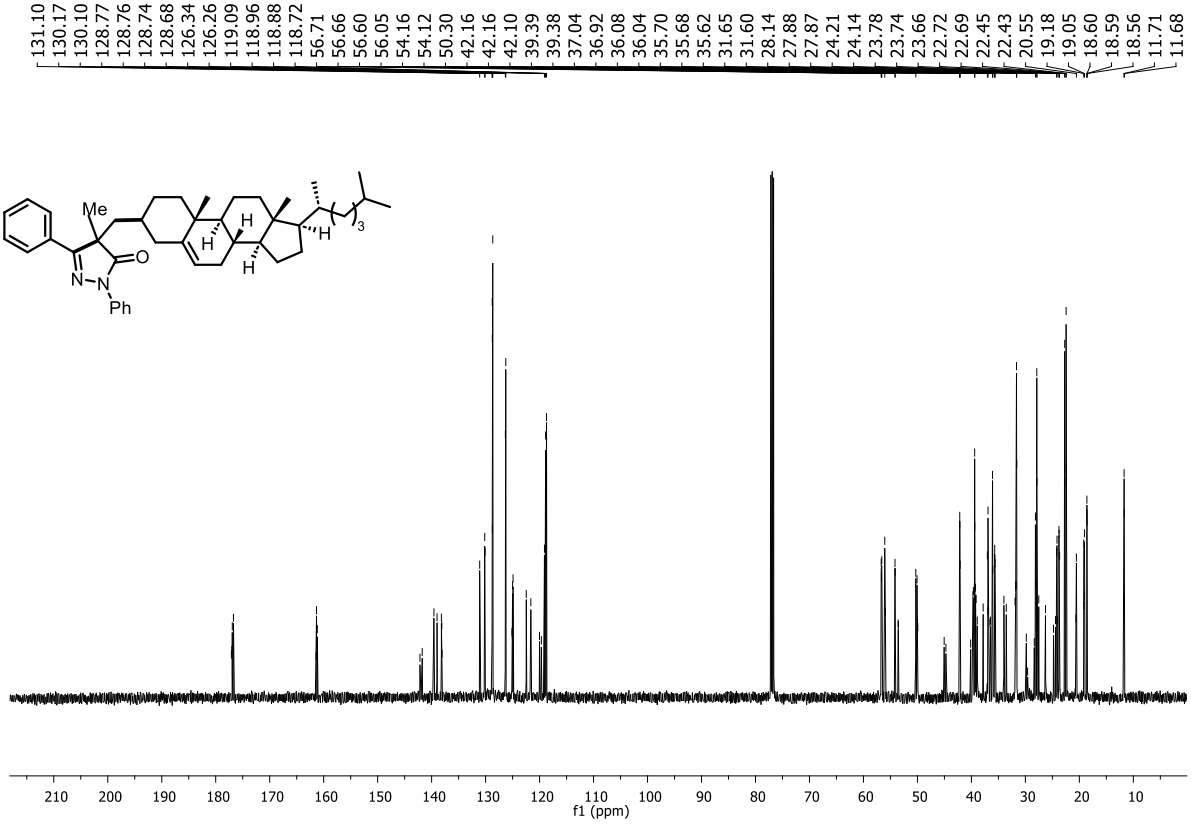
^{13}C{^{1}H} NMR spectrum of 3aq ($CDCl_3$, 126 MHz)



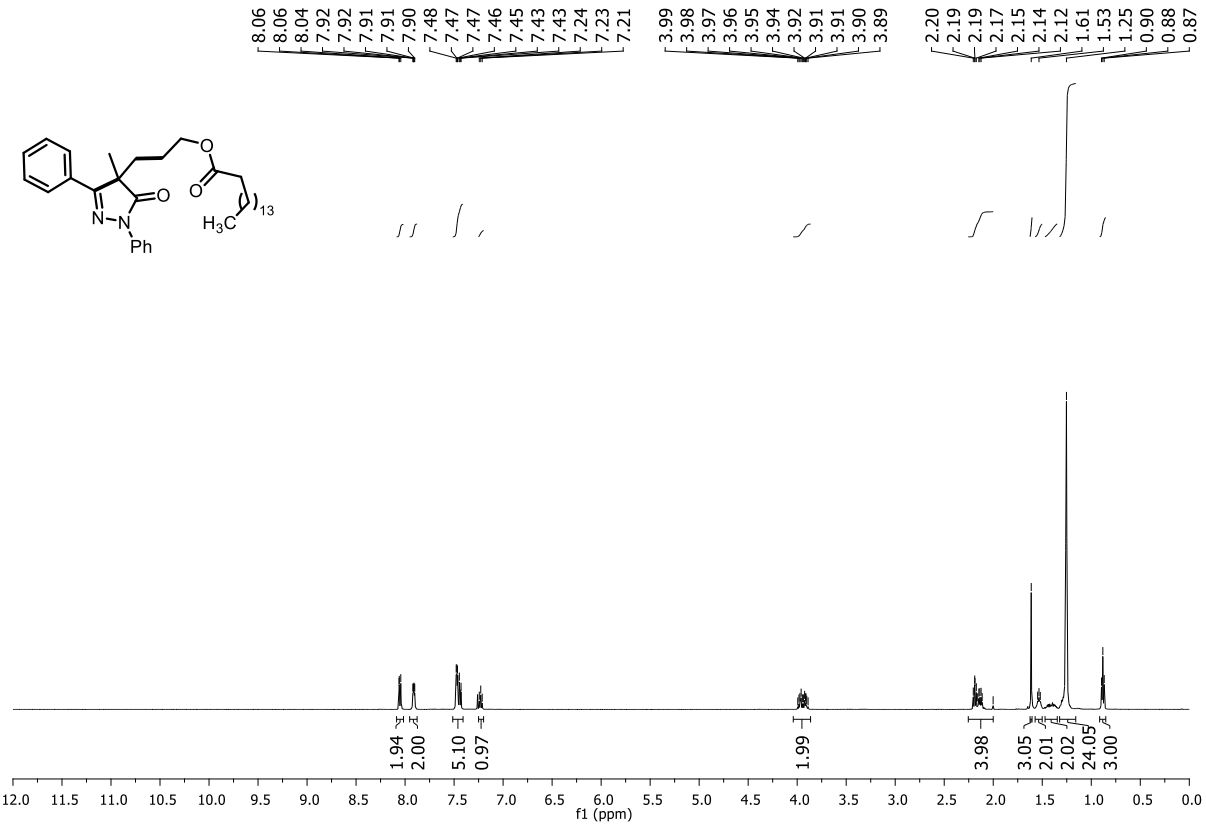
^{1}H NMR spectrum of 3ar ($CDCl_3$, 500 MHz)



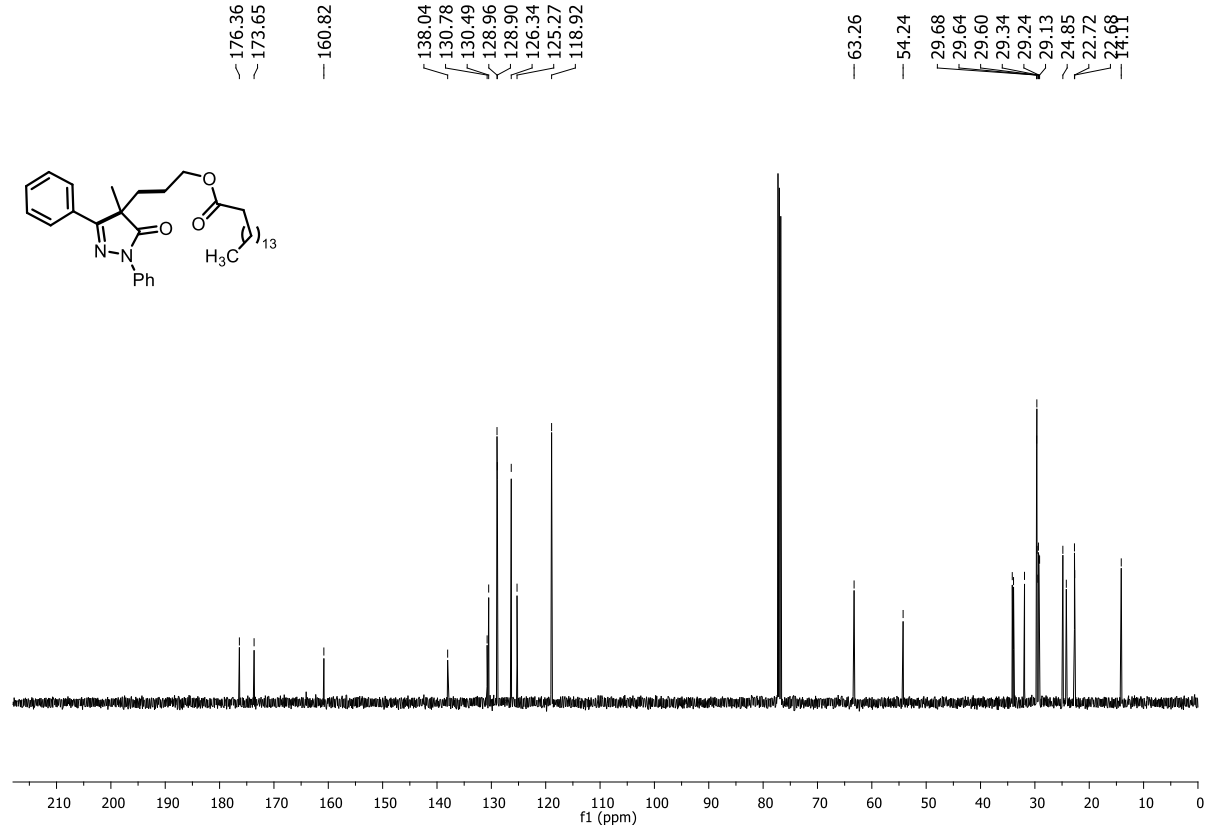
^{13}C{^{1}H} NMR spectrum of 3ar ($CDCl_3$, 126 MHz)



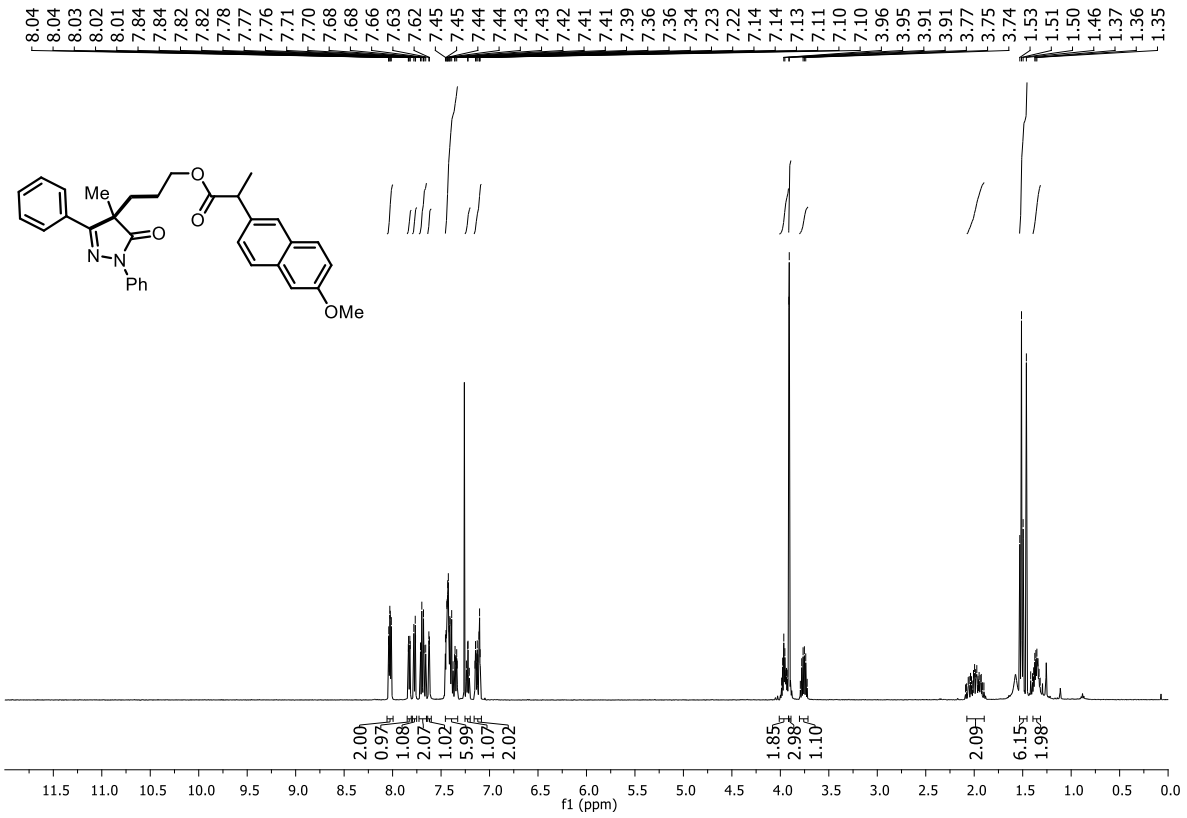
^{1}H NMR spectrum of 3as ($CDCl_3$, 500 MHz)



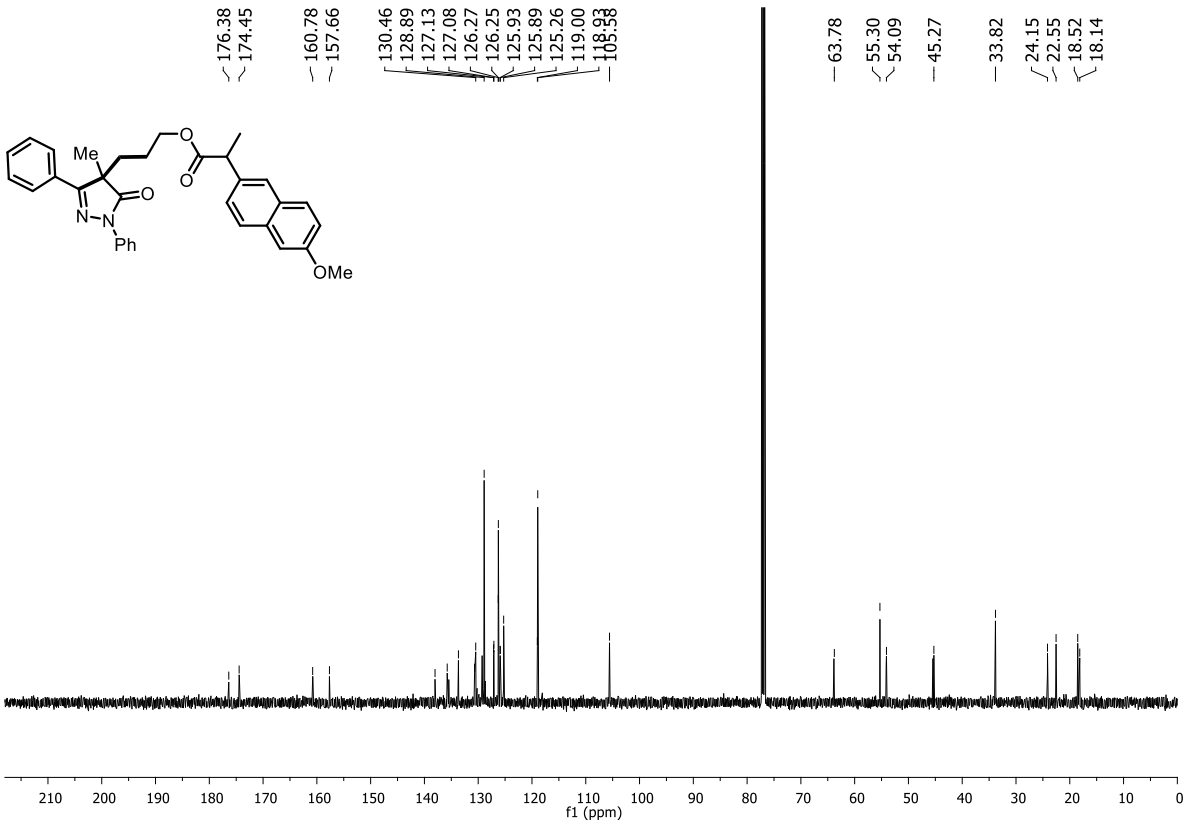
^{13}C{^{1}H} NMR spectrum of 3as ($CDCl_3$, 126 MHz)



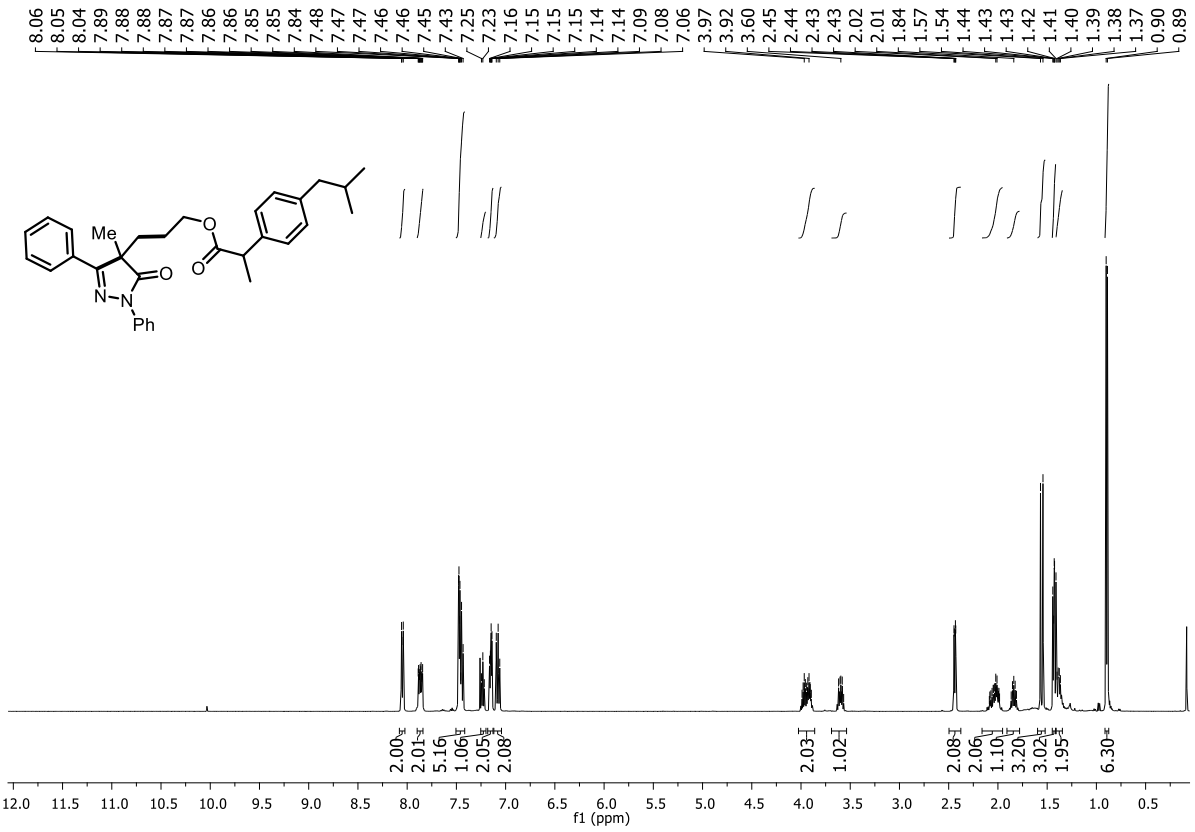
^{1}H NMR spectrum of 3at ($CDCl_3$, 500 MHz)



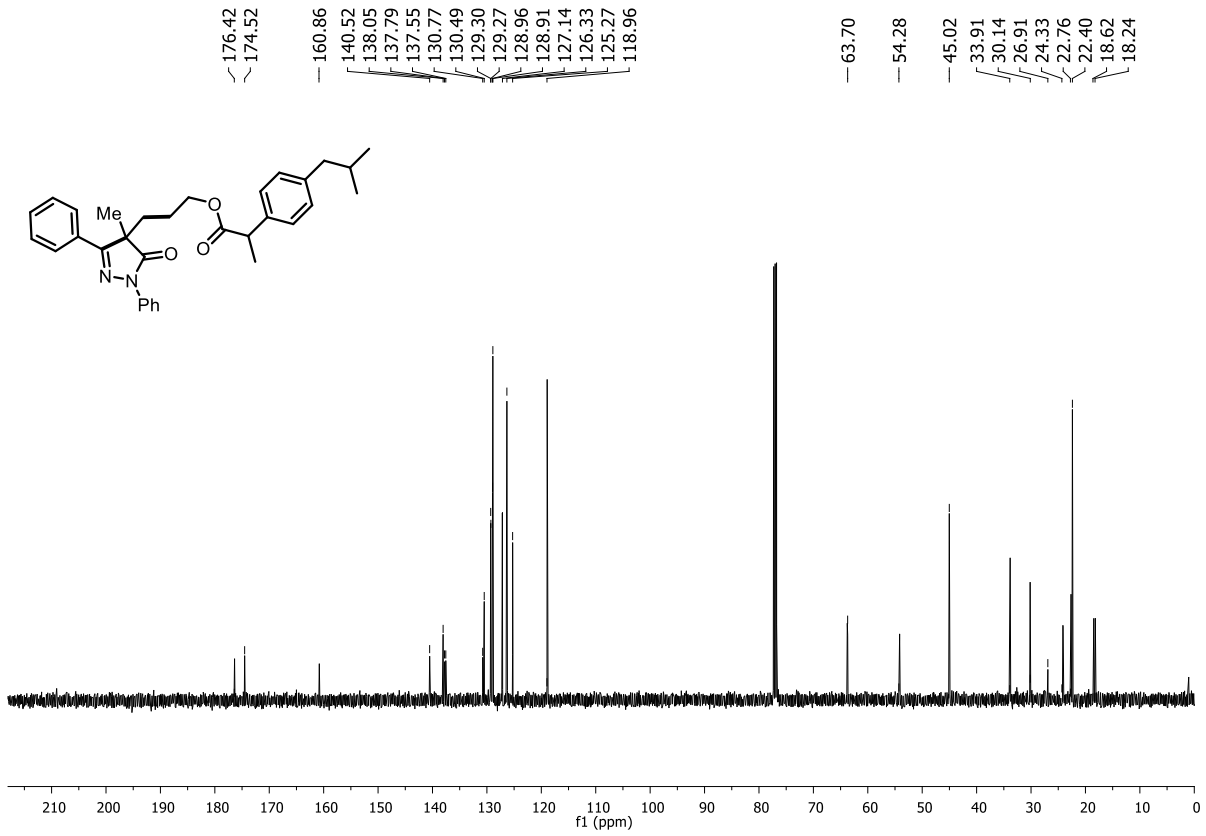
^{13}C{^{1}H} NMR spectrum of 3at ($CDCl_3$, 126 MHz)



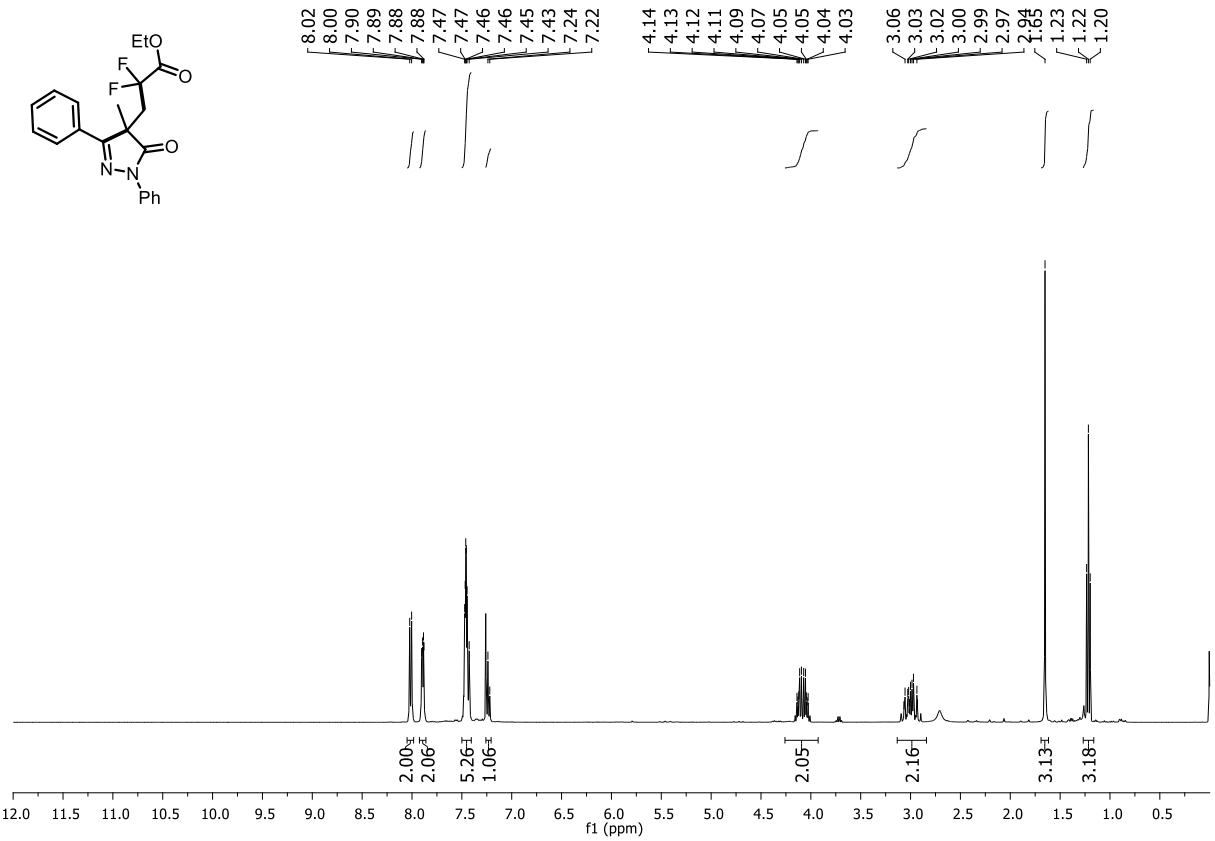
^{1}H NMR spectrum of 3au ($CDCl_3$, 500 MHz)



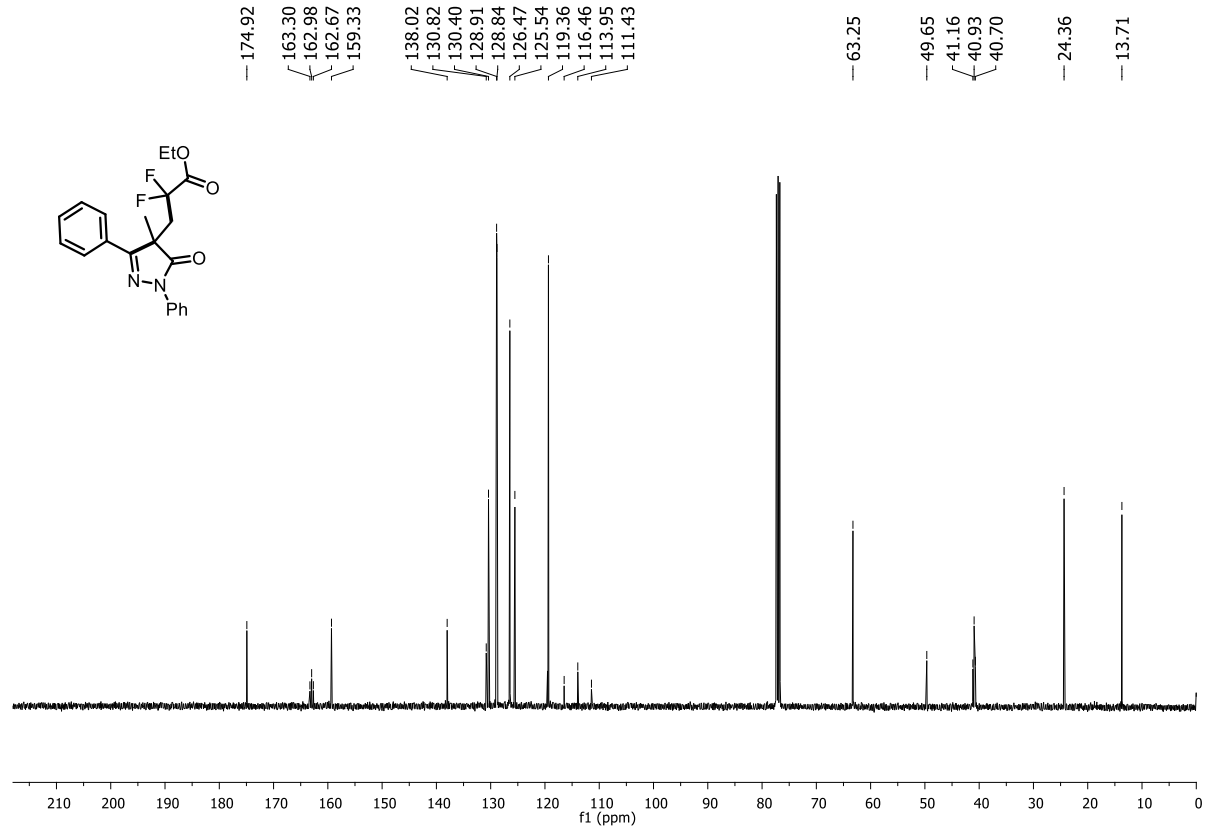
^{13}C{^{1}H} NMR spectrum of 3au ($CDCl_3$, 126 MHz)



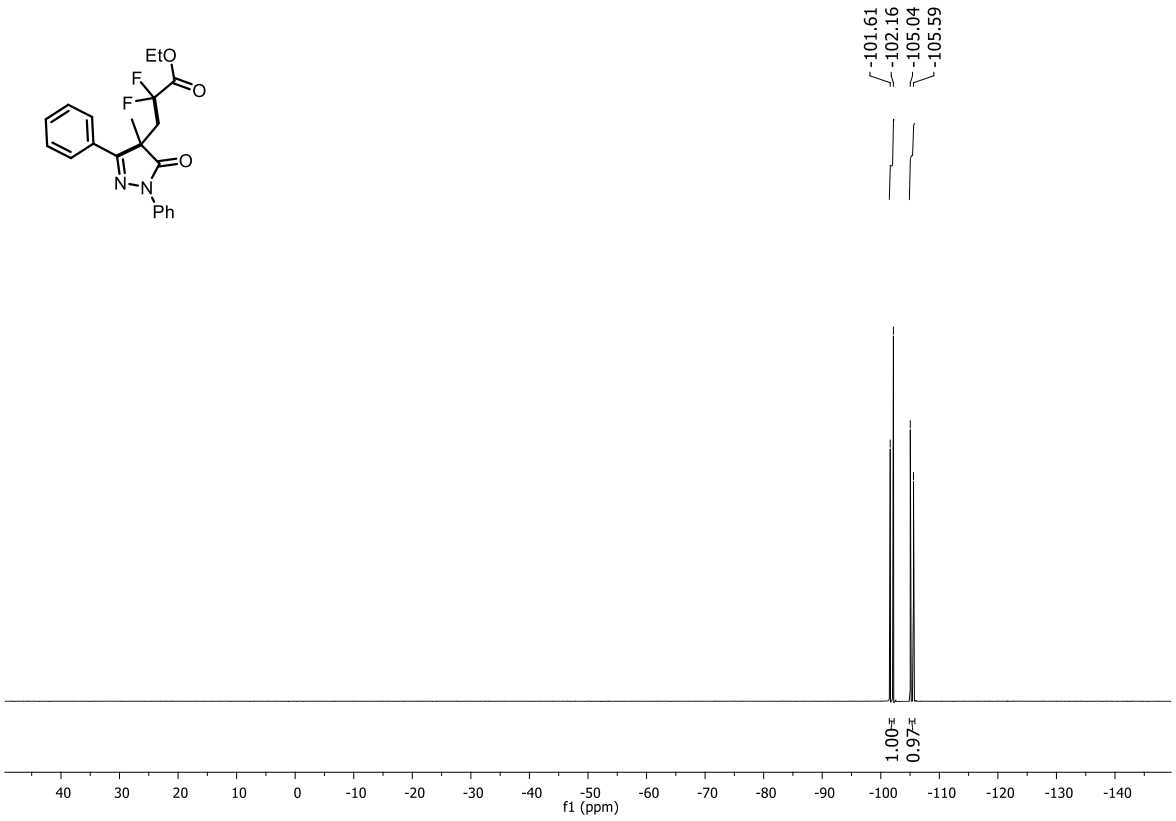
^{1}H NMR spectrum of 5aa ($CDCl_3$, 500 MHz)



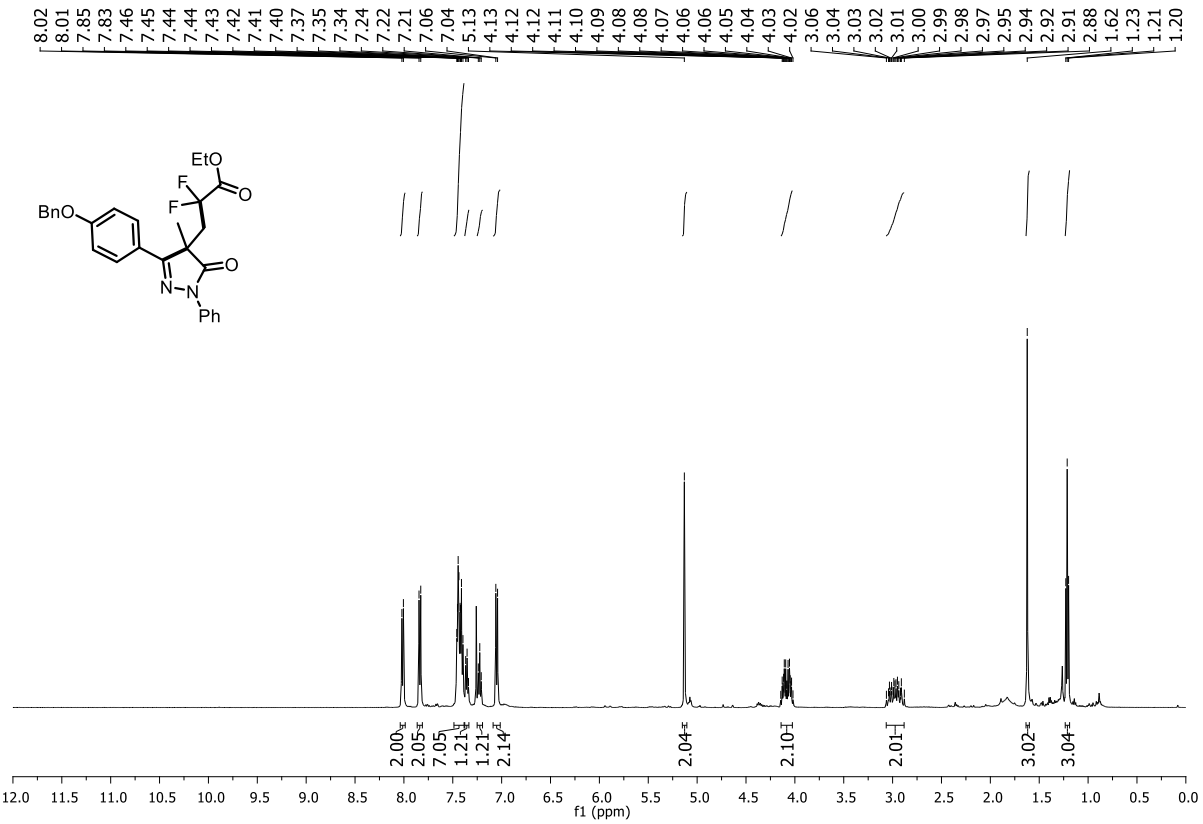
^{13}C{^{1}H} NMR spectrum of 5aa ($CDCl_3$, 126 MHz)



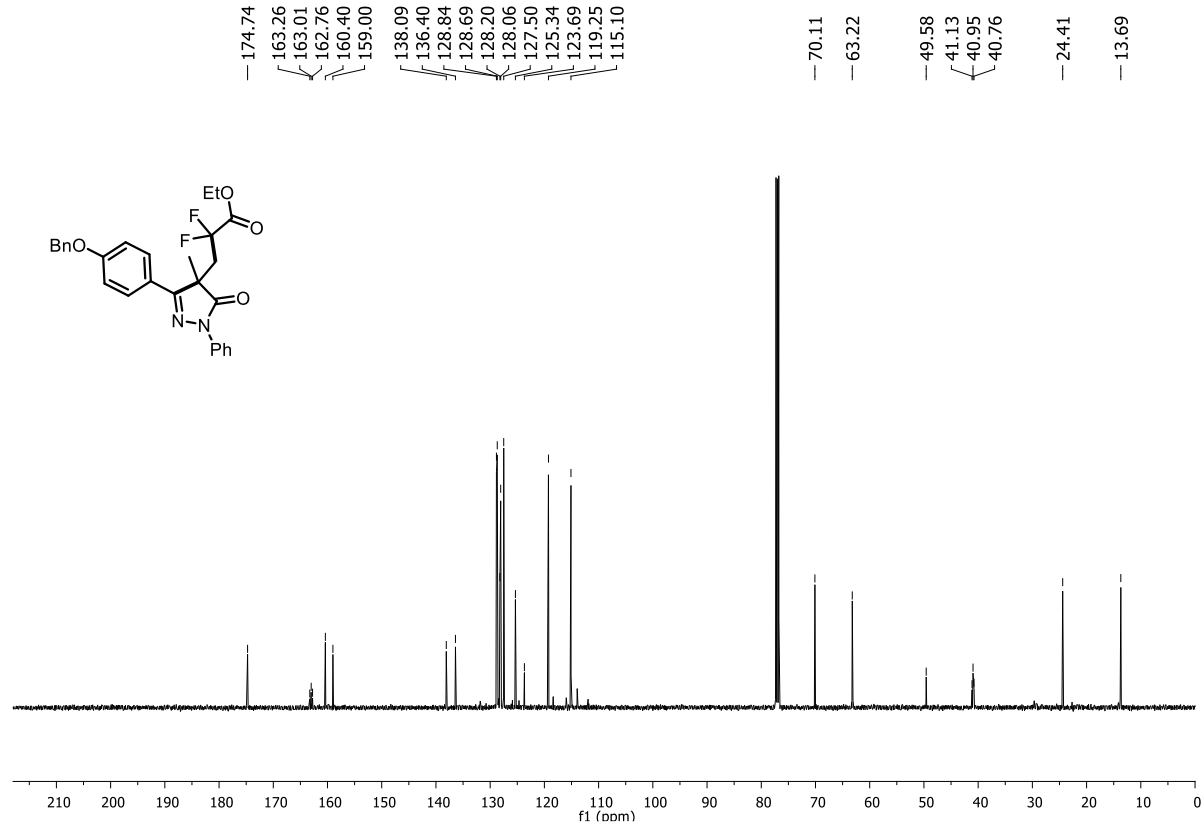
$^{19}F\{^{1}H\}$ NMR spectrum of 5aa ($CDCl_3$, 471 MHz)



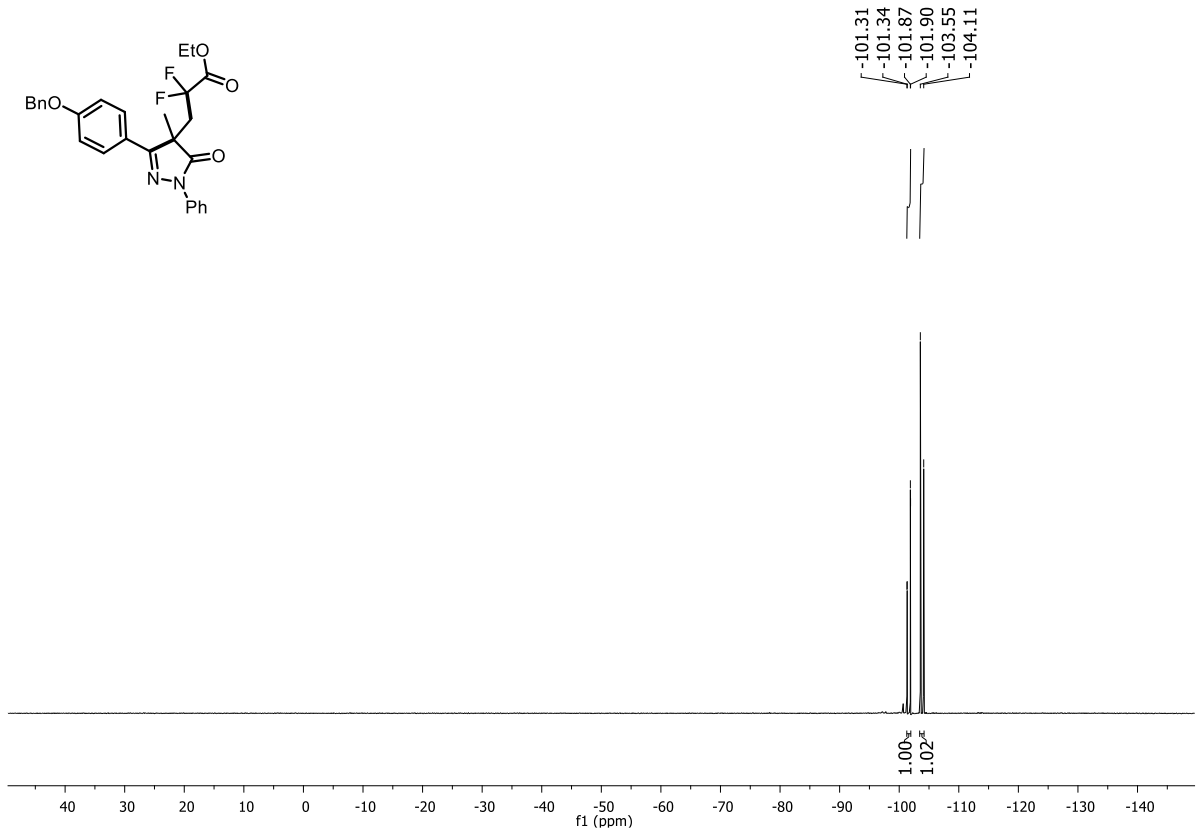
^{1}H NMR spectrum of 5ba ($CDCl_3$, 500 MHz)



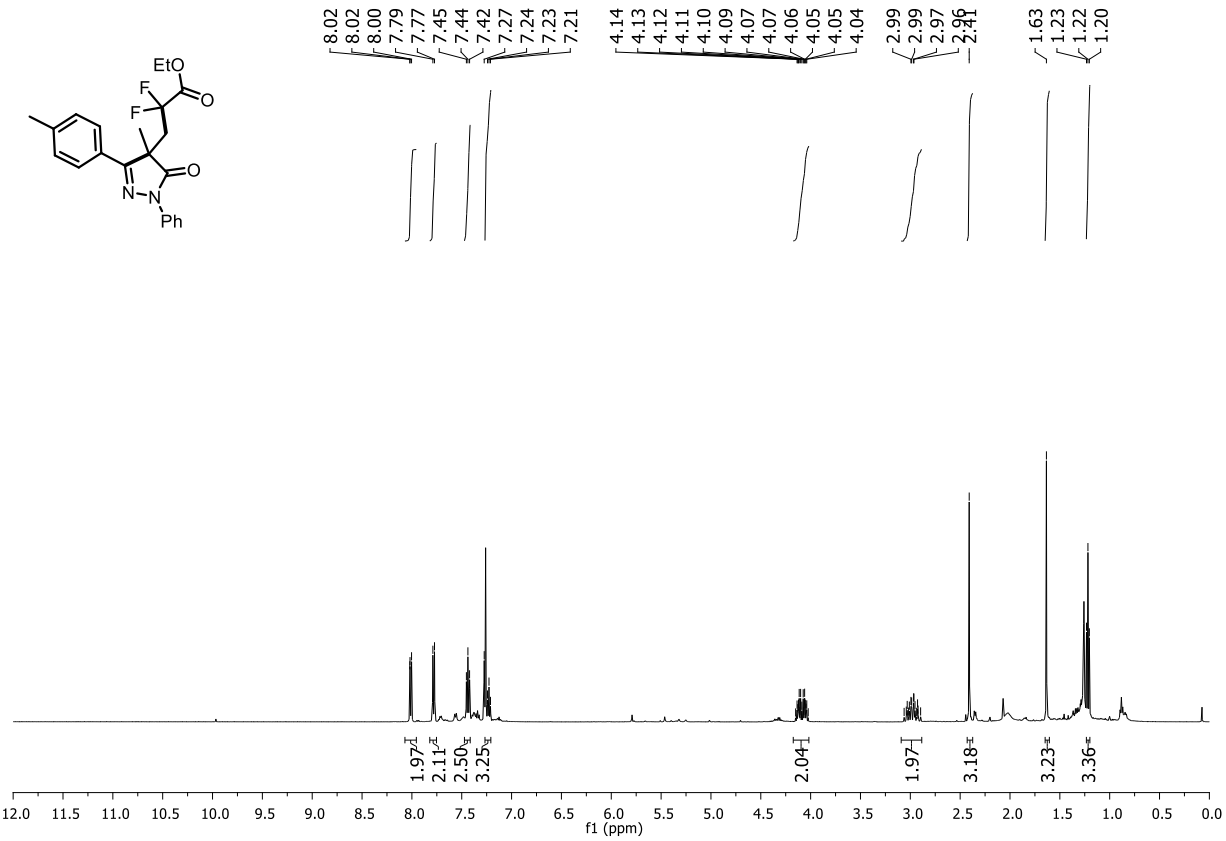
^{13}C{^{1}H} NMR spectrum of 5ba ($CDCl_3$, 126 MHz)



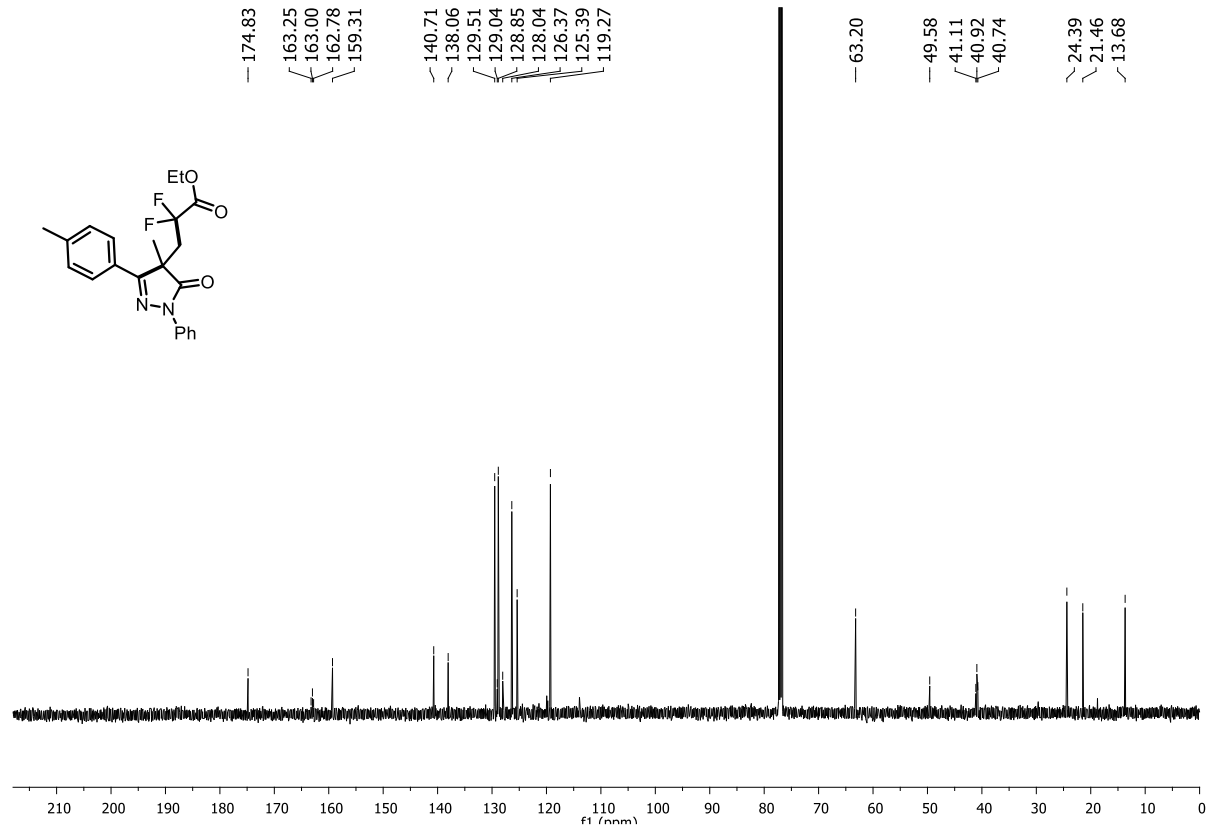
$^{19}F\{^{1}H\}$ NMR spectrum of 5ba ($CDCl_3$, 471 MHz)



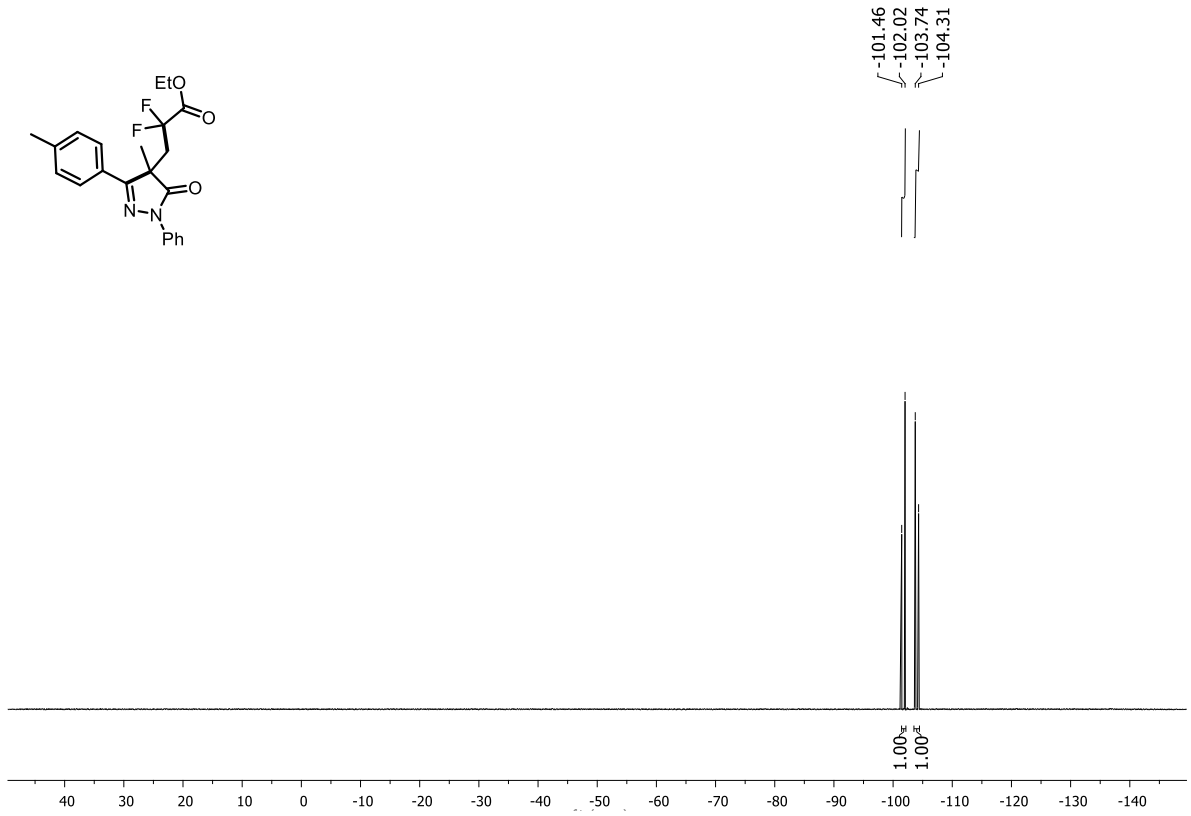
^{1}H NMR spectrum of 5ca ($CDCl_3$, 500 MHz)



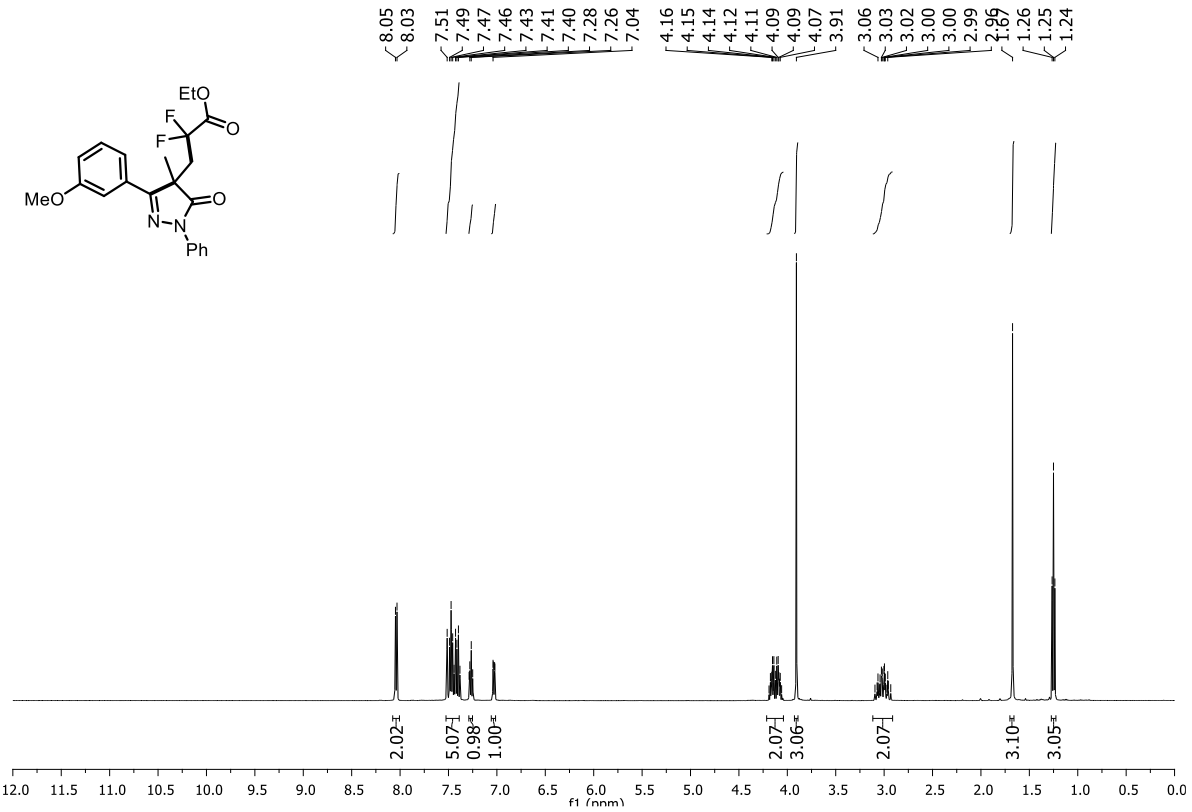
^{13}C{^{1}H} NMR spectrum of 5ca ($CDCl_3$, 126 MHz)



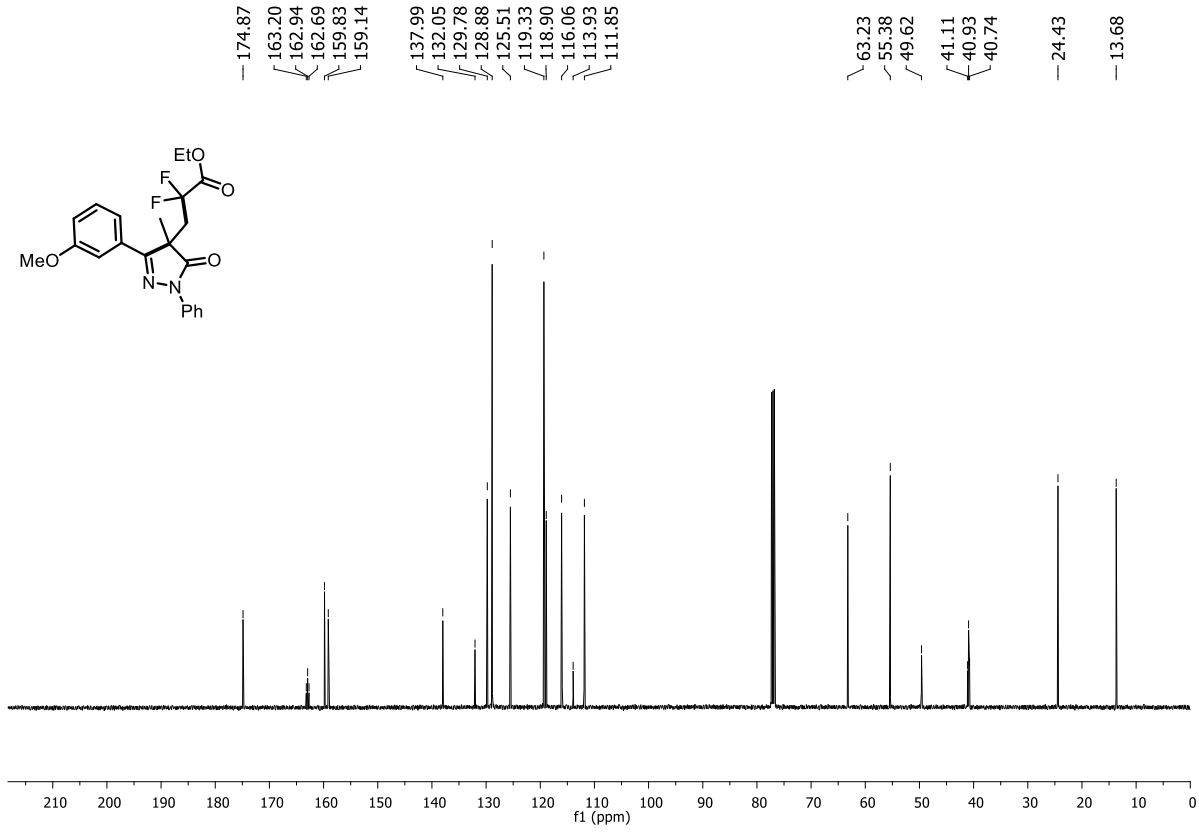
$^{19}F\{^{1}H\}$ NMR spectrum of 5ca ($CDCl_3$, 471 MHz)



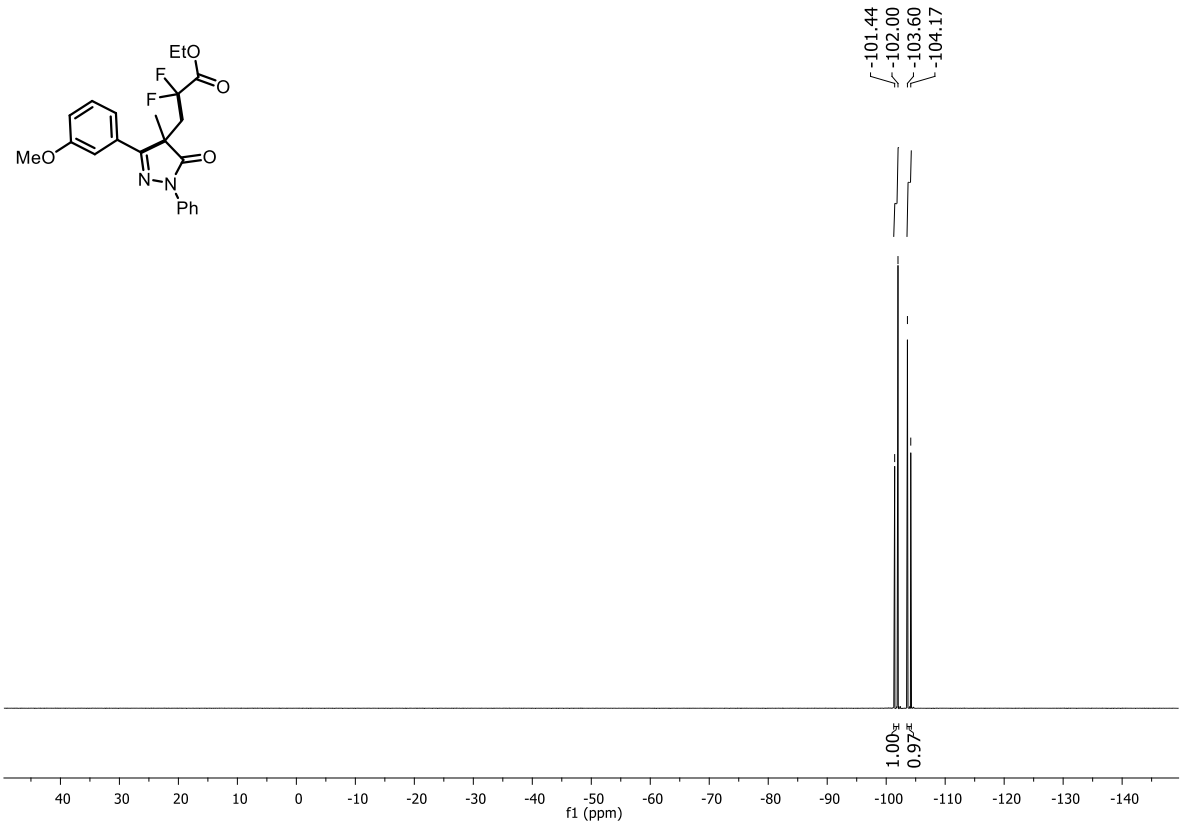
^{1}H NMR spectrum of 5da ($CDCl_3$, 500 MHz)



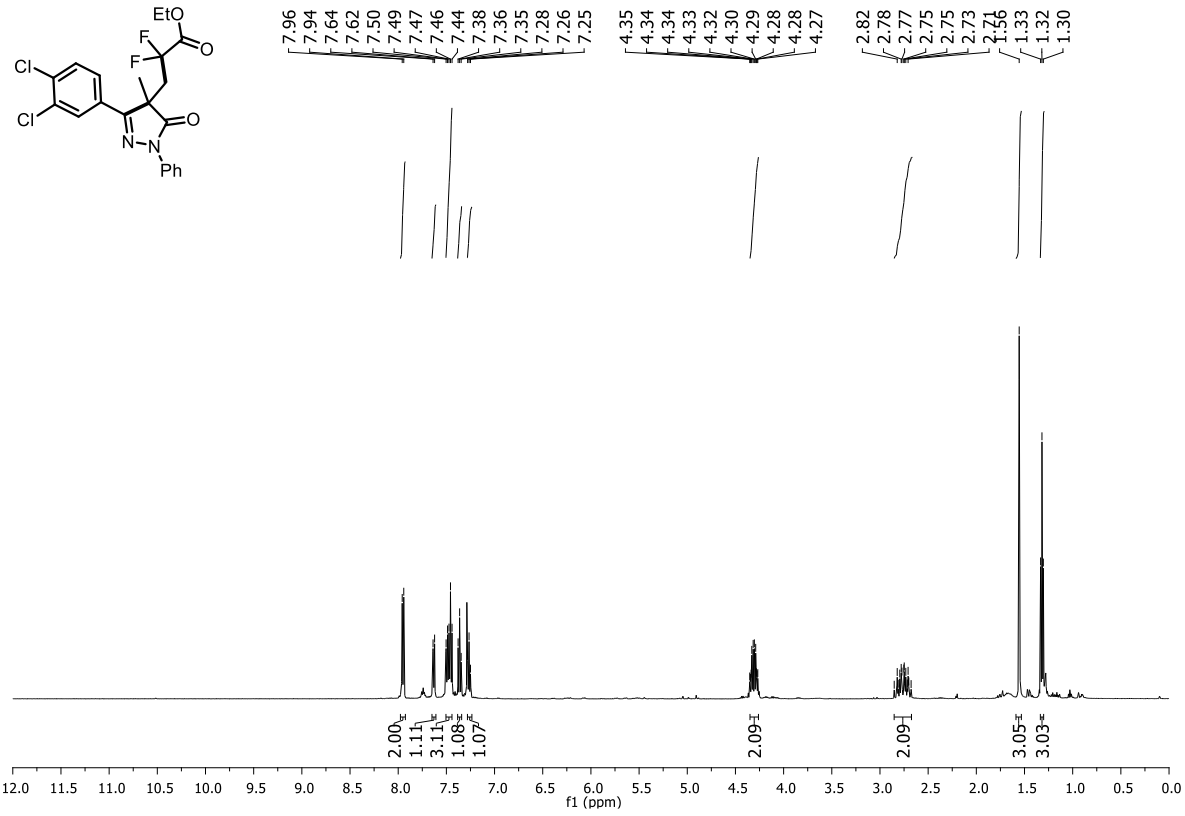
^{13}C{^{1}H} NMR spectrum of 5da ($CDCl_3$, 126 MHz)



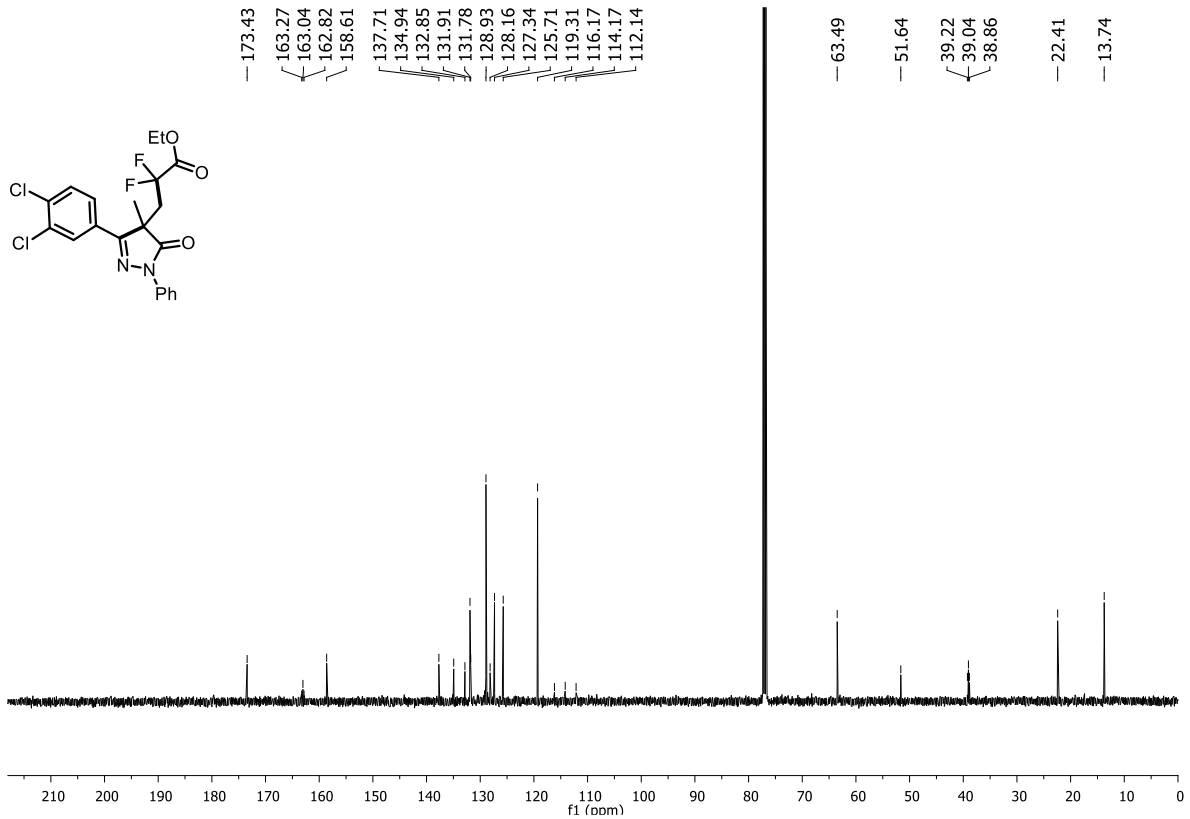
$^{19}F\{^{1}H\}$ NMR spectrum of 5da ($CDCl_3$, 471 MHz)



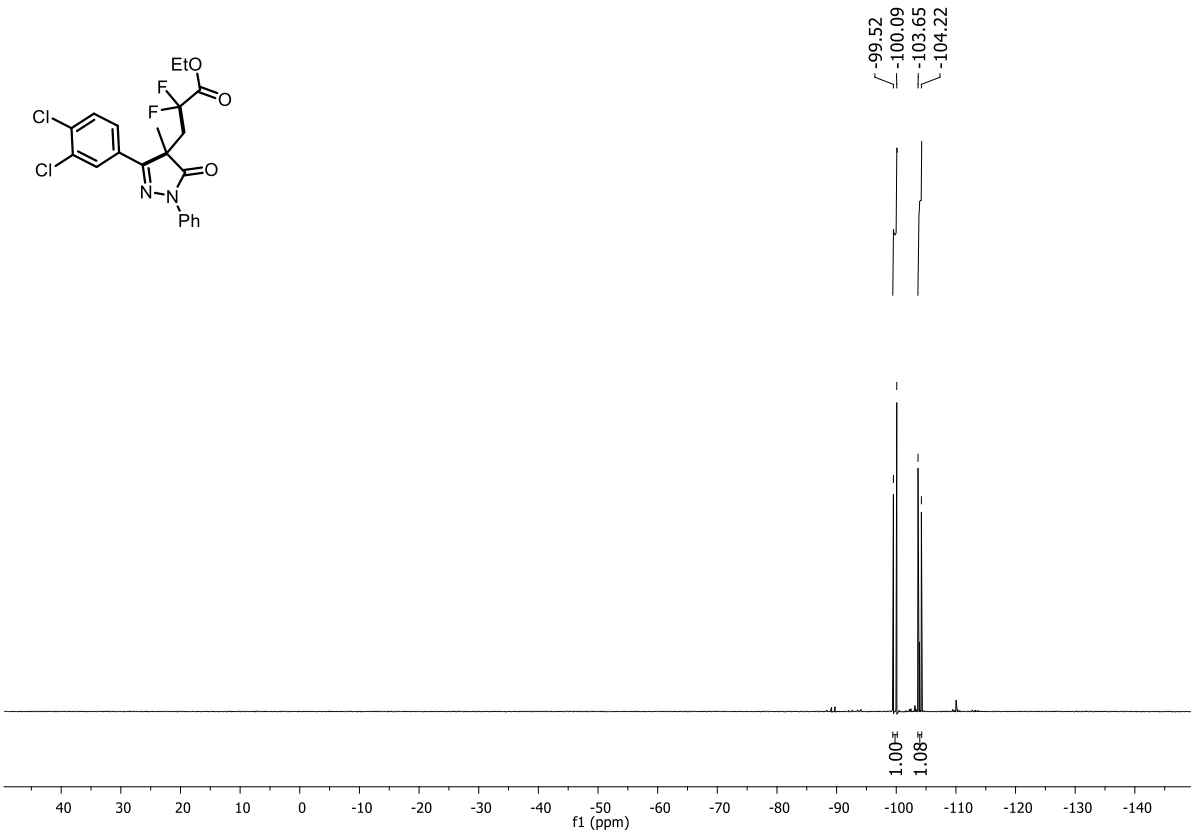
^{1}H NMR spectrum of 5ea ($CDCl_3$, 500 MHz)



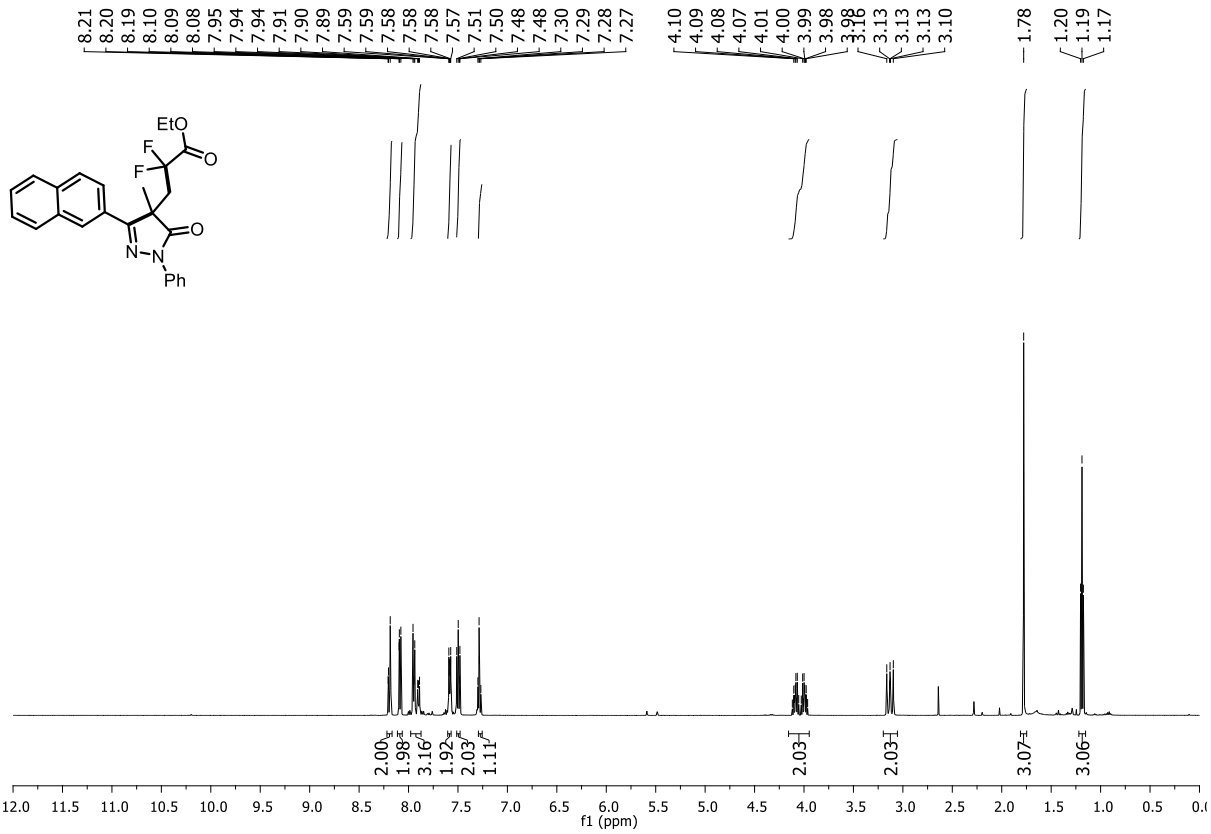
^{13}C{^{1}H} NMR spectrum of 5ea ($CDCl_3$, 126 MHz)



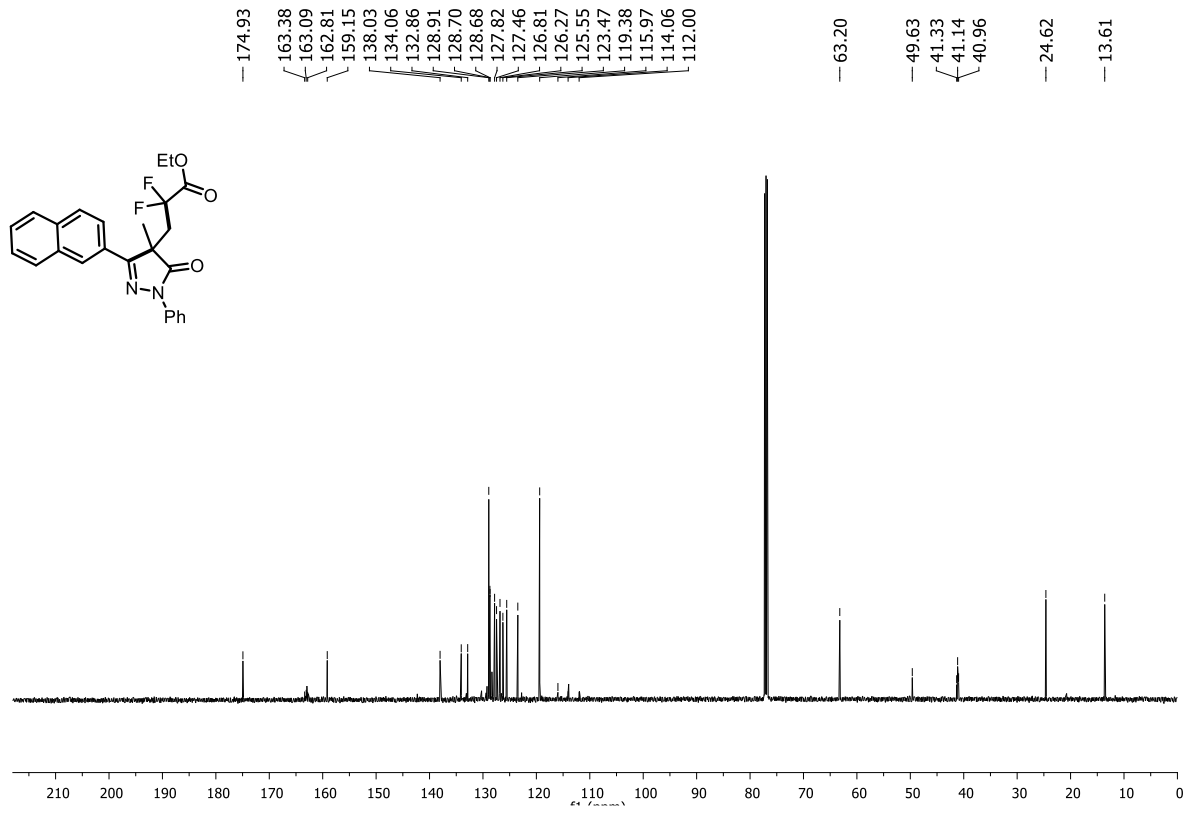
$^{19}F\{^{1}H\}$ NMR spectrum of 5ea ($CDCl_3$, 471 MHz)



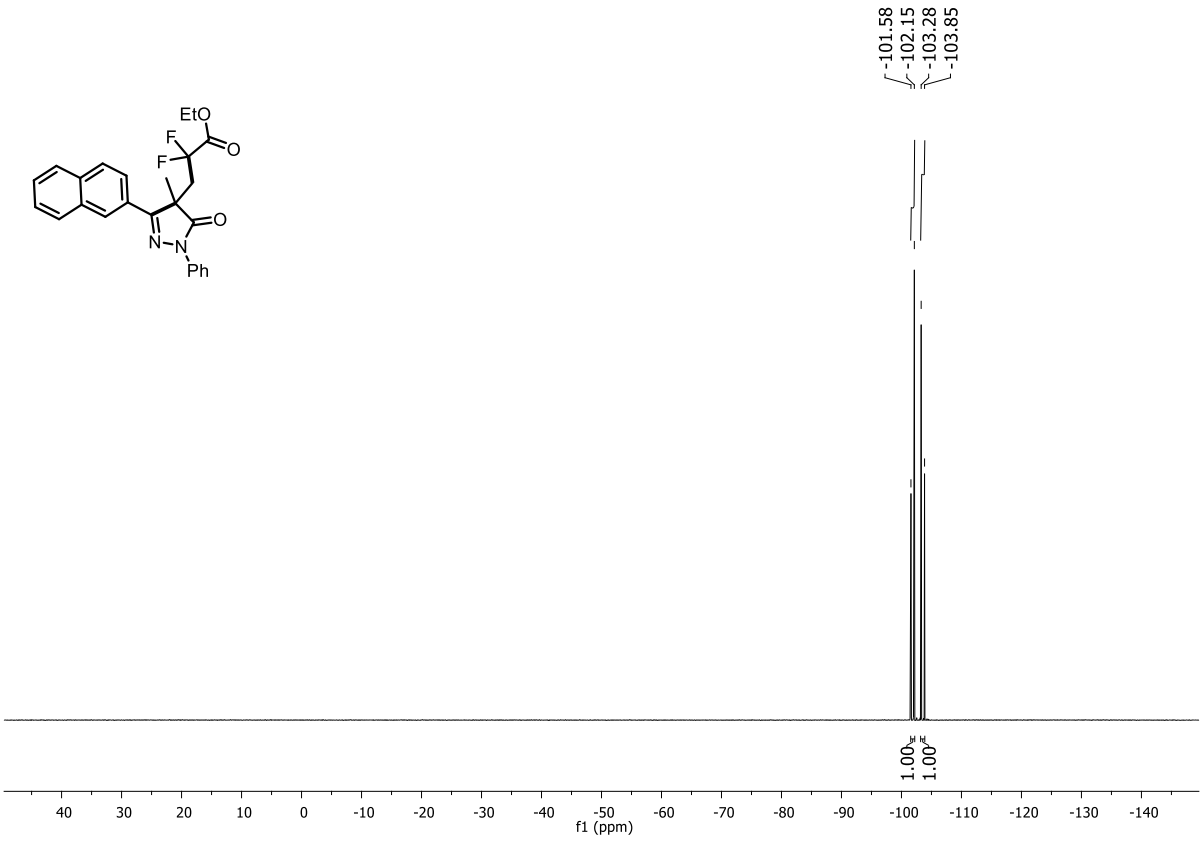
^{1}H NMR spectrum of 5fa ($CDCl_3$, 500 MHz)



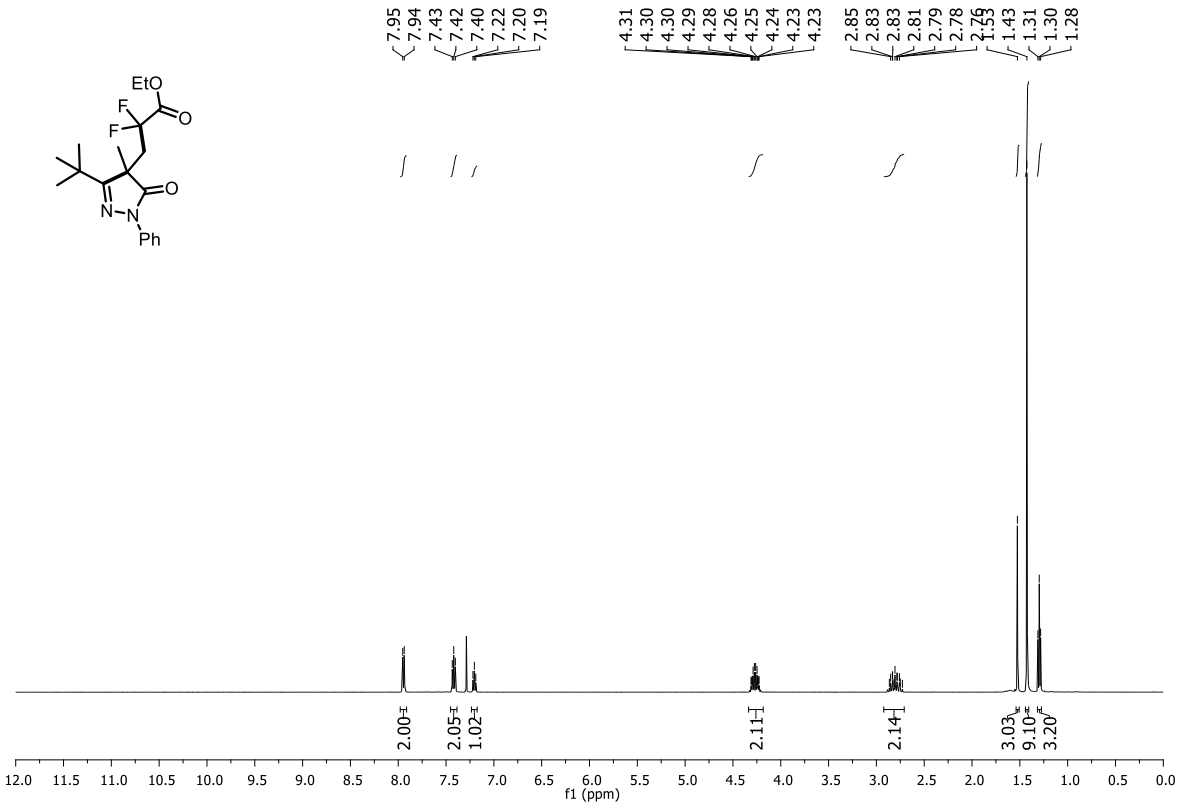
^{13}C{^{1}H} NMR spectrum of 5fa ($CDCl_3$, 126 MHz)



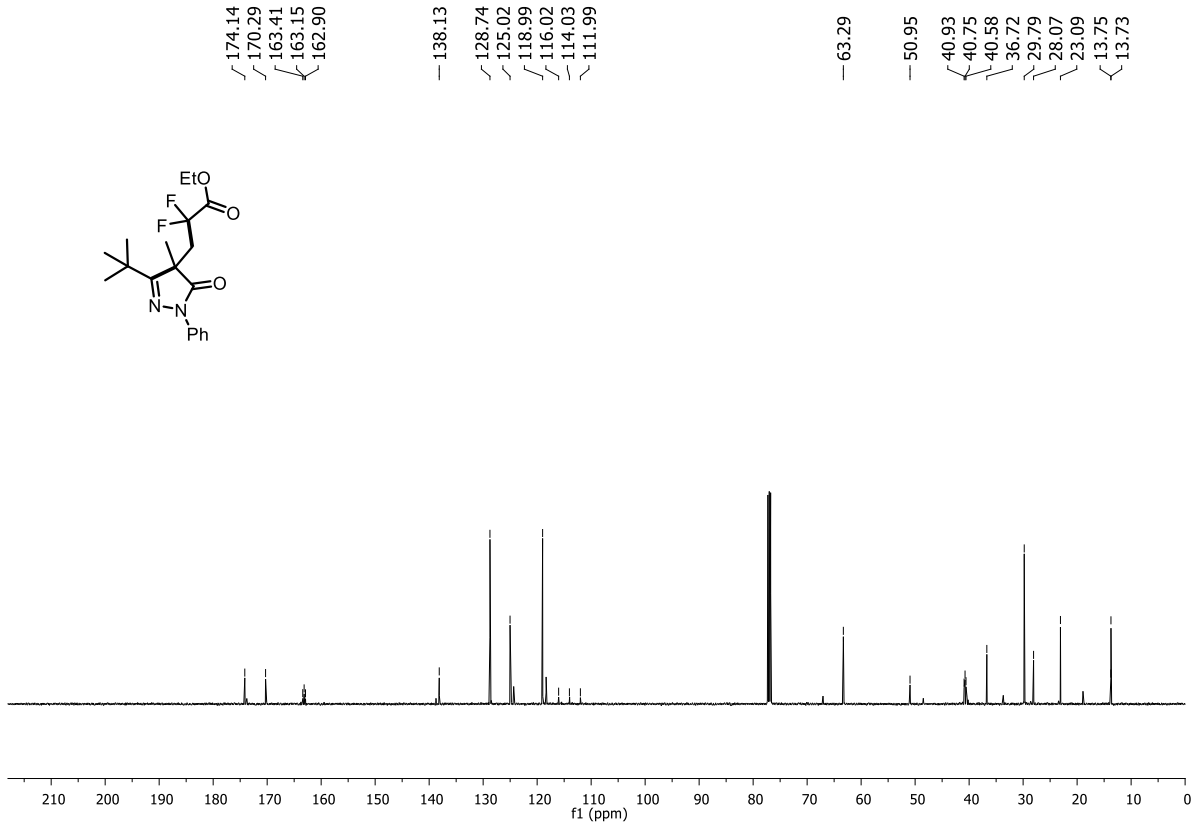
$^{19}F\{^{1}H\}$ NMR spectrum of 5fa ($CDCl_3$, 471 MHz)



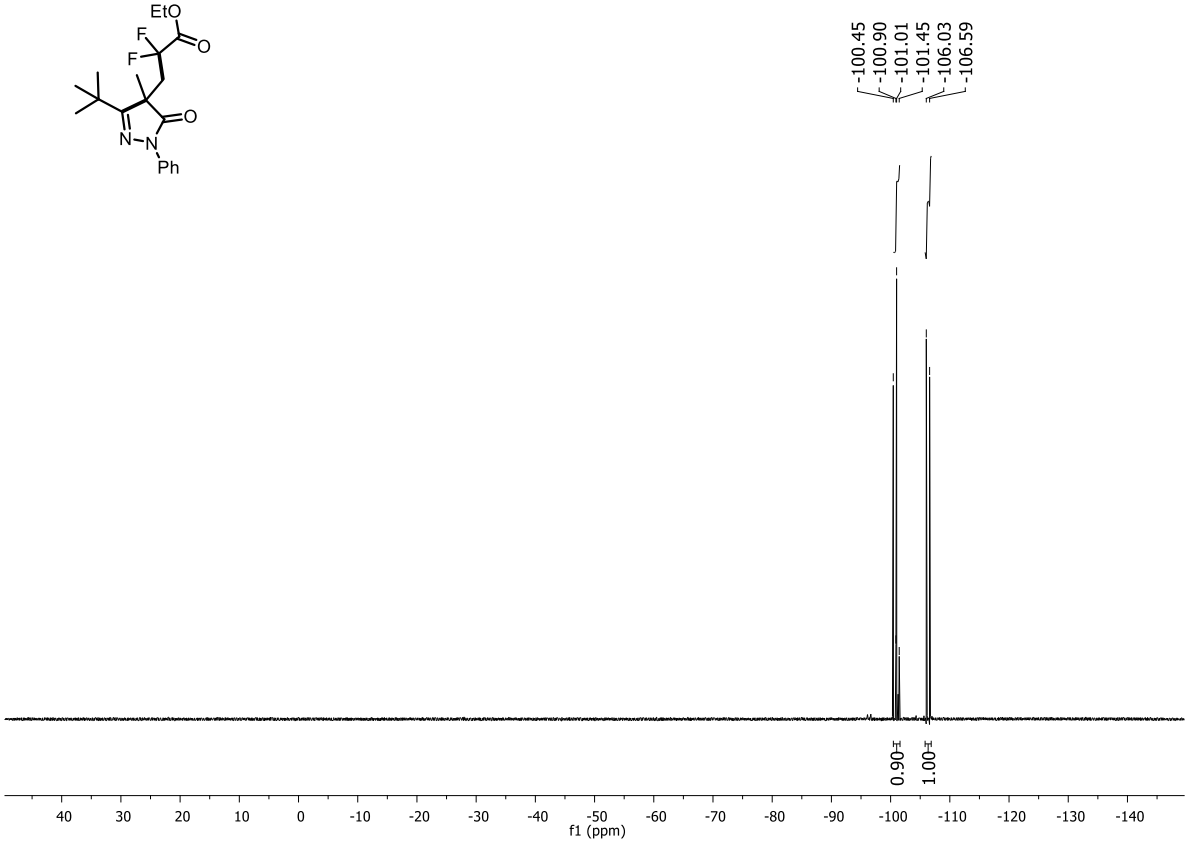
^{1}H NMR spectrum of 5ga ($CDCl_3$, 500 MHz)



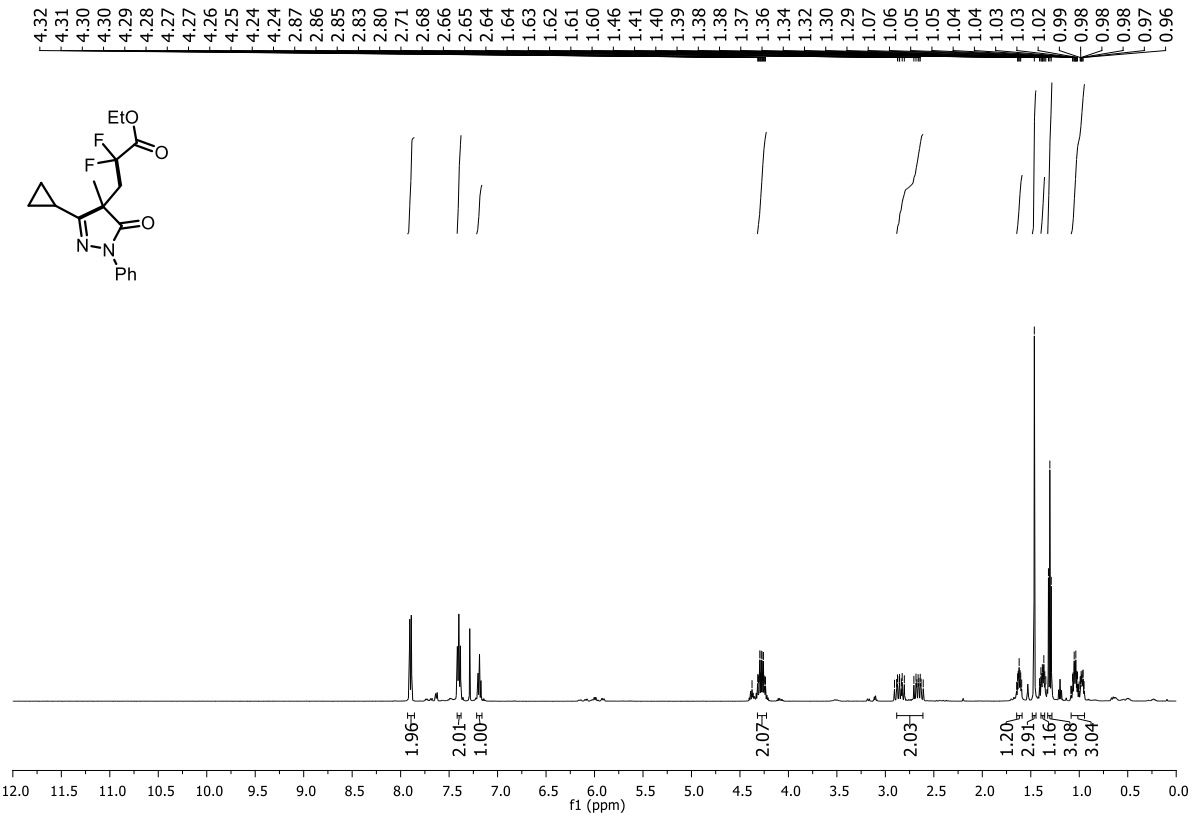
^{13}C{^{1}H} NMR spectrum of 5ga ($CDCl_3$, 126 MHz)



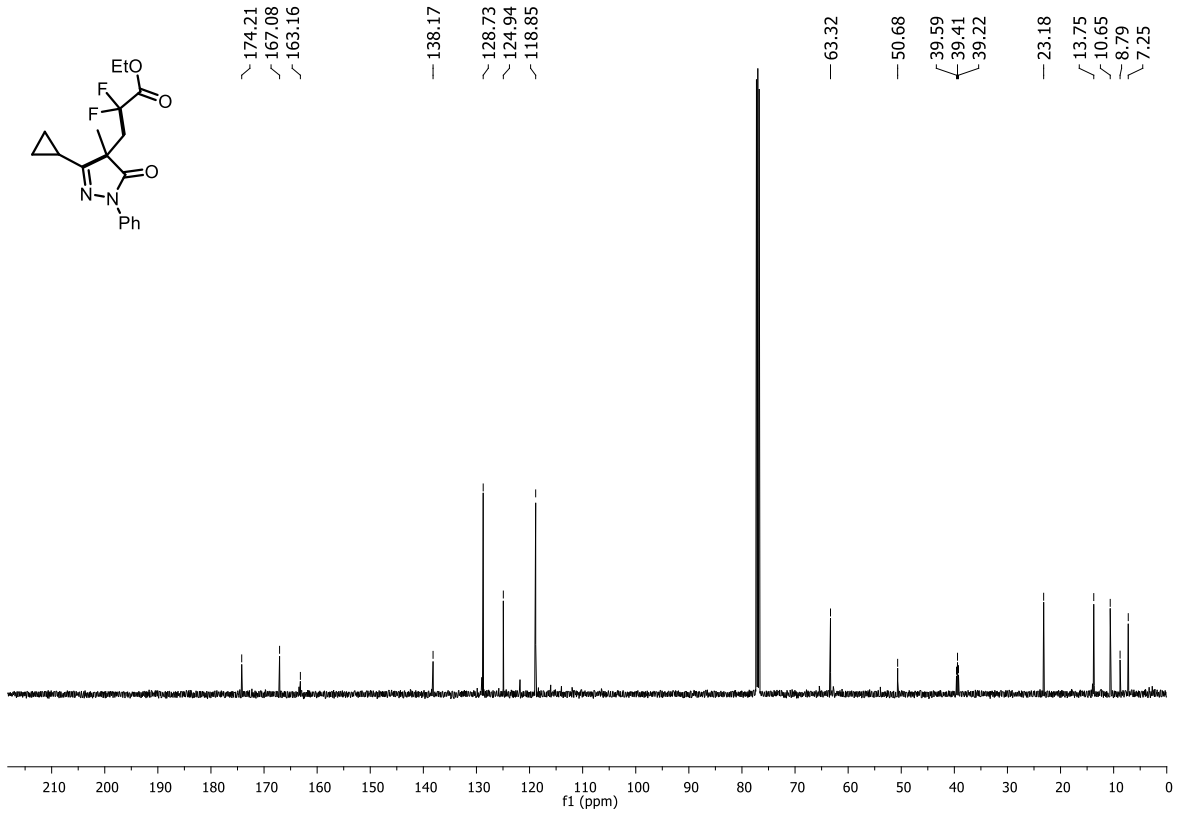
$^{19}F\{^{1}H\}$ NMR spectrum of 5ga ($CDCl_3$, 471 MHz)



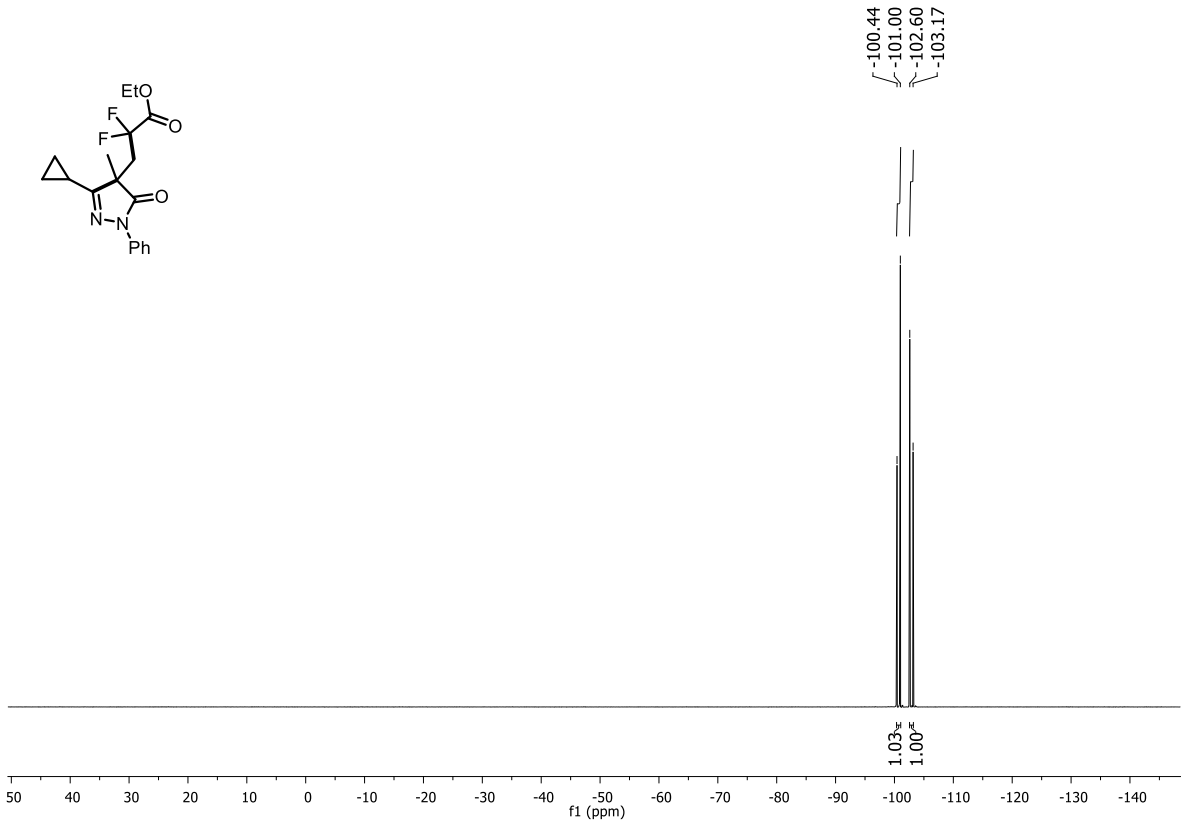
^{1}H NMR spectrum of 5ha ($CDCl_3$, 500 MHz)



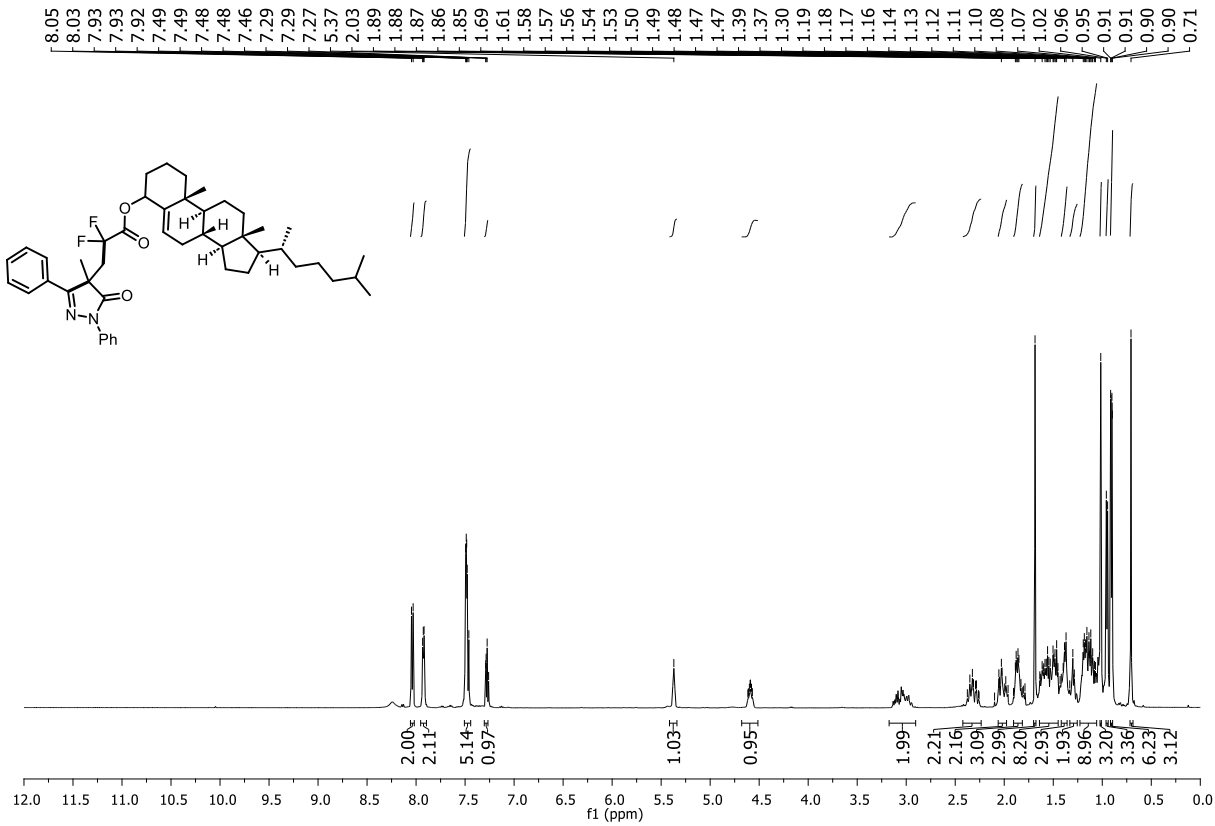
^{13}C{^{1}H} NMR spectrum of 5ca ($CDCl_3$, 126 MHz)



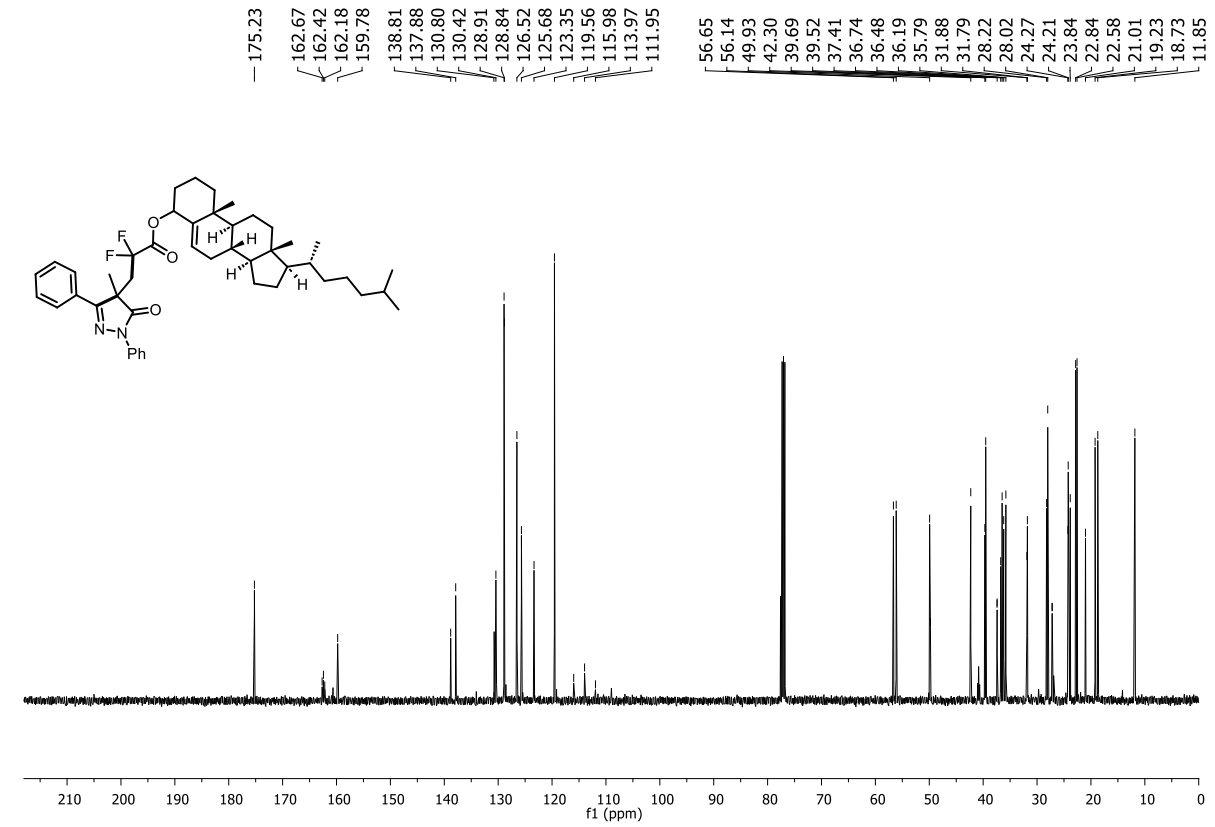
$^{19}F\{^{1}H\}$ NMR spectrum of 5ca ($CDCl_3$, 471 MHz)



^{1}H NMR spectrum of 5ab ($CDCl_3$, 500 MHz)



^{13}C{^{1}H} NMR spectrum of 5ab ($CDCl_3$, 126 MHz)



$^{19}F\{^{1}H\}$ NMR spectrum of 5ab ($CDCl_3$, 471 MHz)