Supporting Information

Disulfide-Bridged Peptides that Mediate Enantioselective Cycloadditions through Thiyl Radical Catalysis

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I. General information

A. Materials and instrumentation

^{1}H NMR spectra were recorded on 600 MHz, 500 MHz, or 400 MHz Agilent spectrometers at ambient temperature. Samples were prepared in chloroform-*d* ($CDCl_3$), dimethylsulfoxide-d_6 (DMSO-d_6), acetone-d_6, methanol-d_4, or toluene-d_8. ^{1}H NMR data are reported as chemical shift with multiplicity, coupling constant (*J*) in Hz, and integration. Proton chemical shifts are reported in ppm (δ) and referenced to tetramethylsilane (TMS) or residual solvent ($CDCl_3$, δ 7.26 ppm; DMSO-d_6, δ 2.50 ppm; acetone-d_6, δ 2.05; methanol-d_4, δ 3.31; toluene-d_8, δ 2.09).[1] ^{13}C NMR spectra were recorded on 600 (151 MHz) MHz or 500 (126 MHz) MHz Agilent spectrometers with complete proton decoupling at ambient temperature, unless otherwise noted. Carbon chemical shifts are reported in ppm (δ) and referenced to tetramethylsilane (TMS) or solvent ($CDCl_3$, δ 77.16 ppm; DMSO-d_6, δ 39.52 ppm; acetone-d_6, δ 29.84 ppm; methanol-d_4, δ 49.00, toluene-d_8, δ 20.40).[1] ^{19}F NMR spectra were recorded on 400 (376 MHz) or 500 (470 MHz) Agilent spectrometers with complete proton decoupling at ambient temperature, unless otherwise noted. Fluorine chemical shifts are reported in ppm (δ) and referenced to trichlorofluoromethane ($CFCl_3$, δ 0.00 ppm).[2]

Low resolution mass spectrometry (MS) was acquired with UPLC-MS on a Waters Acquity UPLC BEH C8 (1.7 m, 2.1 x 100 mm) column on a Waters XEVO instrument equipped with ESI, a QToF mass spectrometer, and a photodiode array detector. High resolution mass spectrometry (HRMS) was conducted by the Mass Spectrometry Laboratory at the University of Illinois at Urbana-Champaign using electrospray ionization (ESI). Infrared spectra were obtained using a Nicolet ATR/FT-IR spectrometer, and ν_{max} (cm^{-1}) were partially recorded in accordance with convention.

Optical rotations were recorded on a Perkin Elmer Polarimeter 341 at the sodium D line (1.0 dm path length) at 20 °C. Analytical thin-layer chromatography (TLC) was performed using EMD Millipore silica gel 60 F254 pre-coated plates (0.25 mm thickness). The developed plates were visualized by a UV lamp and/or potassium permanganate ($KMnO_4$) stain. Normal-phase column chromatography was performed with either silica gel 60 Å (32-63 microns) or with a Biotage Isolera One flash purification system equipped with Ultra HP-Sphere 25 μm columns. Reversed-phase column chromatography was performed with a Biotage Isolera One flash purification system equipped with KPC18-HS columns. Enantiomeric ratios (er) values and diastereomeric ratios (dr) were acquired using an Agilent 1100 series analytical chiral HPLC equipped with a photodiode array detector (210 nm, 230 nm, and 254 nm) with Daicel Chiralpak IA, IB, IC, AD-H, or OD-H columns (5 μm particle size, 4.5 x 250 mm). Values for dr were also determined by ^{1}H NMR analysis. All reaction solvents were purified using a Seca Solvent Purification System by Glass Contour (in which the solvents were dried over alumina and dispensed under an atmosphere of Ar) with the exception of hexanes, which was HPLC grade and used as received. All reagents were purchased from commercial sources and used as received

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[1] Gottlieb, H. E.; Kotlyar, V.; Nudelman, A. *J. Org. Chem.* **1997**, *62*, 7512–7515

[2] Burton, D. J. and Jairaj, V. 2005. Trichlorofluoromethane. e-EROS Encyclopedia of Reagents for Organic Synthesis.

unless otherwise noted. UV reactions were conducted with an unfiltered BLAK-RAY MODEL B 100AP UV lamp (365 nm filter removed).

B. Abbreviations

Ad = adamantle

app = apparent

ATR = attenuated total reflectance

Boc = *tert*-butoxycarbonyl

comp = overlapping multiplets

COMU = (1-cyano-2-ethoxy-2-oxoethylidenaminooxy)dimethylamino-morpholino-carbenium hexafluorophosphate

CV = column volumes

d = doublet

dd = doublet of doublets

ddd = doublet of doublet of doublets

dddd = doublet of doublet of doublet of doublets

ddt = doublet of doublet of triplets

dr = diastereomeric ratio

dt = doublet of triplets

dtd = doublet of triplet of doublets

dq = doublet of quartets

DCM = dichloromethane

DMF = *N*,*N*-dimethylformamide

DMSO = dimethyl sulfoxide

EDC = 1-(3-(dimethyl-amino)propyl)-3-ethyl-carbodiimide

ee = enantiomeric excess

ESI = electrospray ionization

FT = Fourier transform

h = hour

HATU = *O*-(7-azabenzotriazol-1-yl)-*N,N,N',N'*-tetramethyluronium hexafluorophosphate

HOBt = 1-hydroxybenzotriazole

HRMS = high resolution mass spectrometry

Hz = Hertz

IPA = 2-propanol

IR = infrared

m = multiplet

Mba = methylbenzylamine

MHz = megaHertz

NMR = nuclear magnetic resonance

p = pentet

pd = pentet of doublets

Piv = pivalamide

ppm = parts per million

q = quartet

qd = quartet of doublets

RT = room temperature

s = singlet

t = triplet

td = triplet of doublets

tdd = triplet of doublet of doublets

TFA = trifluoroacetic acid

THF = tetrahydrofuran

TLC = thin-layer chromatography

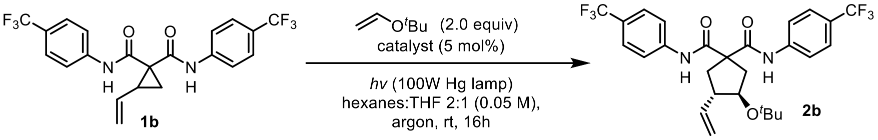
tt = triplet of triplets

VCP = vinylcyclopropane

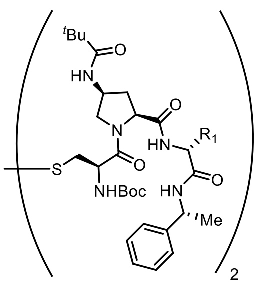
W = Watt

II. Complete data set for peptide structure-function studies

Table S1. Examination of *i+2* position



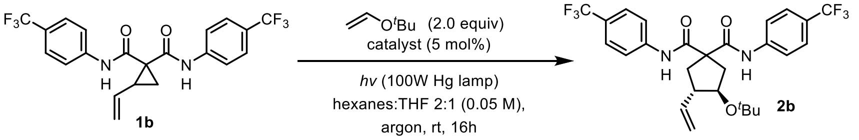
A. i+2 modifications



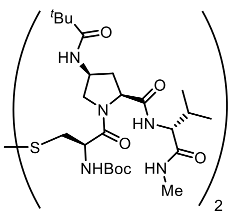
General Catalyst Structure

catalyst	R^1 (*i+2*)	conversion	dr (*trans:cis*)	er (*trans*)	er (*cis*)
P4	D-Val	100%	74:26	86:14	74:26
P21	Gly	100%	76:24	87:13	74:26
P22	Aib	100%	77:23	87:13	73:27
P23	Acpc	100%	76:24	86:14	72:28
P24	D-Pro	100%	77:23	88:12	75:25

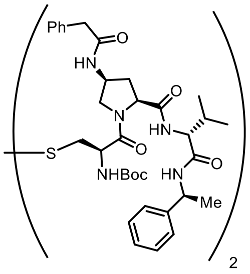
Table S2. Examination of peptide termini



C-terminus modification

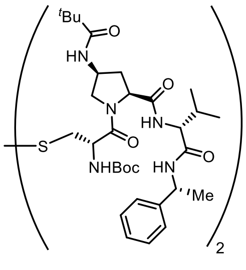


P25
94% Conv.
75:25 dr (*trans:cis*)
82:18 er (*trans*)
73:27 er (*cis*)

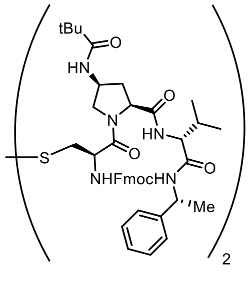


P26
100% Conv.
73:27 dr (*trans:cis*)
80:20 er (*trans*)
70:30 er (*cis*)

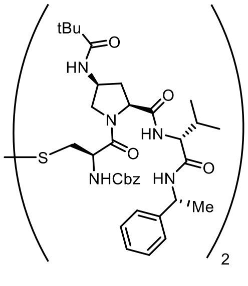
N-terminus modifications



P27
100% Conv.
72:28 dr (*trans:cis*)
38:62 er (*trans*)
49:51 er (*cis*)



P28
100% Conv.
75:25 dr (*trans:cis*)
82:18 er (*trans*)
73:27 er (*cis*)



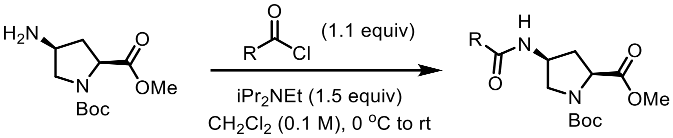
P29
100% Conv.
75:25 dr (*trans:cis*)
83:17 er (*trans*)
74:26 er (*cis*)

III. Synthesis and characterization of 4-substituted Boc-proline derivatives

A. General procedures for 4-substituted Boc-proline methyl ester synthesis

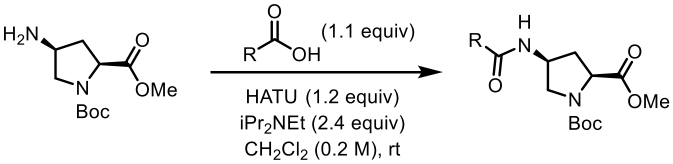
N-Boc-(4*S*)-amino-L-proline methyl ester was prepared from *trans*-Boc-4-hydroxyproline methyl ester according to the literature method.[3]

General Procedure A



To a solution of *N*-Boc-(4*S*)-amino-L-proline methyl ester (1.0 equiv) in CH_2Cl_2 (0.1 M) in a round-bottomed flask equipped with a stir bar was added *i*Pr_2NEt (1.5 equiv). The reaction mixture was cooled in a 0 °C ice bath and the acid chloride (1.1 equiv) was added. The reaction mixture was allowed to stir at rt. Upon reaction completion, the reaction mixture was diluted with CH_2Cl_2 and washed with saturated aqueous $NaHCO_3$ and brine, and then dried over Na_2SO_4. The dried organic phases were then filtered and concentrated *in vacuo*. The crude product was purified by silica gel column chromatography or reversed-phase column chromatography.

General Procedure B



To a solution of the appropriate carboxylic acid (1.1 equiv) in CH_2Cl_2 (0.2 M) in a round-bottomed flask equipped with a stir bar was added *i*Pr_2NEt (2.4 equiv), followed by HATU (1.2 equiv). *N*-Boc-(4*S*)-amino-L-proline methyl ester was added as a solution in CH_2Cl_2, and the reaction mixture was allowed to stir at rt. Upon reaction completion, the reaction mixture was diluted with CH_2Cl_2 and washed with 10% (w/v) aqueous citric acid (2x), saturated aqueous $NaHCO_3$, and brine, and then dried over Na_2SO_4. The dried organic phases were then filtered and concentrated *in vacuo*. The crude product was purified by silica gel column chromatography or reversed-phase column chromatography.

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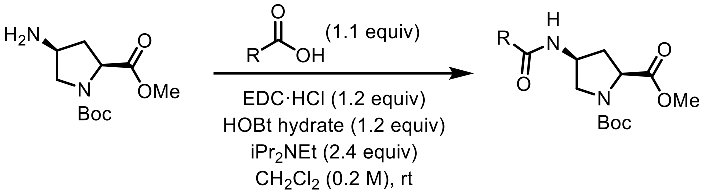
[3] Hollenstein, M. *Chem. Eur. J.* **2012**, *18*, 13320–13330.

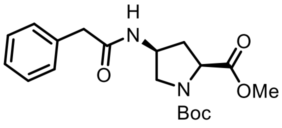
General Procedure C



To a solution of the appropriate carboxylic acid (1.1 equiv) in CH_2Cl_2 (0.2 M) in a round-bottomed flask equipped with a stir bar was added *i*Pr_2NEt (2.4 equiv), followed by HOBt hydrate (1.2 equiv), *N*-Boc-(4*S*)-amino-L-proline methyl ester (1.0 equiv) as a solution in CH_2Cl_2, followed by EDC·HCl (1.2 equiv). The reaction mixture was allowed to stir at RT. Upon reaction completion, the reaction mixture was diluted with CH_2Cl_2 and washed with 10% (w/v) aqueous citric acid (2x), saturated aqueous $NaHCO_3$, and brine, and then dried over Na_2SO_4. The dried organic phases were then filtered and concentrated *in vacuo*. The crude product was purified by silica gel column chromatography or reversed-phase column chromatography.

B. Synthesis and characterization of 4-substituted Boc-proline methyl esters

N-Boc-(4*S*)-(phenylacetamido)-L-proline methyl ester (P3-Pro).



P3-Pro

Prepared according to a modification of General Procedure A, using *N*-Boc-(4*S*)-amino-L-proline methyl ester (2.93 g, 12.0 mmol, 1.0 equiv), CH_2Cl_2 (120 mL, 0.1 M), *i*Pr_2NEt (3.2 mL, 18.0 mmol, 1.5 equiv), and phenylacetyl chloride (2.1 mL, 15.0 mmol, 1.3 equiv). The reaction mixture was stirred for 1 h. The reaction mixture was diluted with EtOAc (200 mL) and washed with 10% citric acid (200 mL), saturated aqueous $NaHCO_3$ (200 mL) and brine (200 mL), and then dried over Na_2SO_4. The dried organic phases were then filtered and concentrated *in vacuo*. The crude product was purified by normal-phase column chromatography (20→100% EtOAc/hexanes). The isolated product was further purified by reversed-phase column chromatography (SNAP C18 120 g column; gradient 1 = Ramp 30–100% MeCN/H_2O over 14 CV, then 5 CV 100% MeCN; gradient 2 = Ramp 20–100% MeOH/H_2O over 15 CV, then 3 CV 100% MeOH; 75 mL/min flow rate; monitored λ = 210, 245 nm; 16 x 150 mm test tubes with 20 mL fractions). Fractions containing product were pooled and concentrated *in vacuo* to provide pure **P3-Pro** as a foamy white solid (3.31 g, 76% yield).

TLC R_f = 0.20 (40% EtOAc/hexanes)

^{1}H NMR (600 MHz, acetone-*d*$_6$) δ (1.4:1 mixture of rotamers, asterisks denote minor rotamer peaks) 7.47–7.04 (m, 5H), 4.43–4.36 (m, 1H), 4.26 (dd, *J* = 8.9, 5.6 Hz, 1H), 3.74 (ddd, *J* = 26.3, 10.7, 6.7 Hz, 1H), 3.67 (s, 1.8H), 3.63* (s, 1.2H), 3.47 (d, *J* = 1.6 Hz, 2H), 3.23 (td, *J* = 11.3, 5.6 Hz, 1H), 2.54 (dddd, *J* = 16.4, 13.0, 8.8, 6.6 Hz, 1H), 1.87 (ddt, *J* = 24.4, 12.4, 5.9 Hz, 1H), 1.42* (s, 3.7H), 1.37 (s, 5.3H).

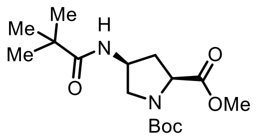
^{13}**C NMR** (151 MHz, acetone-*d*$_6$) (mixture of rotamers) δ 174.3, 174.0, 170.8, 154.5, 153.8, 137.0, 130.0, 129.1, 127.3, 127.3, 80.1, 80.0, 58.6, 58.3, 52.6, 52.3, 52.3, 52.0, 49.5, 48.6, 43.6, 36.8, 35.9, 28.5, 28.4.

IR (thin film, cm^{-1}) ν_{max} 3313, 1747, 1652, 1543, 1496, 1479, 1454, 1436, 1403, 1367, 1311, 1259, 1204, 1159, 1130, 1107, 1031, 990, 899, 770, 730, 697.

HRMS (ESI) (*m/z*) for $[M+H]^+$ $C_{19}H_{27}N_2O_5$ requires 363.1920, observed 363.1911.

[α]$_D$^{20} = +5.7° (*c* = 0.0069 g/mL, $CHCl_3$)

***N*-Boc-(4*S*)-(pivalamido)-L-proline methyl ester (P4-Pro).**



P4-Pro

Prepared according to General Procedure A, using *N*-Boc-(4*S*)-amino-L-proline methyl ester (1.5 g, 6.1 mmol, 1.0 equiv), CH_2Cl_2 (30 mL), *i*Pr_2NEt (1.6 mL, 9.2 mmol, 1.5 equiv), and trimethylacetyl chloride (0.83 mL, 6.75 mmol, 1.1 equiv). The reaction mixture was stirred for 16 h. The reaction mixture was diluted with CH_2Cl_2 (30 mL) and washed with saturated aqueous $NaHCO_3$ (100 mL) and brine (100 mL), and then dried over Na_2SO_4. The dried organic phases were then filtered and concentrated *in vacuo*. The crude product was purified by reversed-phase column chromatography (SNAP C18 60 g column; gradient = Ramp 30–100% MeCN/H_2O over 14 CV, then 3 CV 100% MeCN; 75 mL/min flow rate; monitored λ = 210, 245 nm; 16 x 150 mm test tubes with 22 mL fractions) Fractions containing product were pooled and concentrated *in vacuo* to provide pure **P4-Pro** as a colorless oil (1.22 g, 61% yield).

TLC R_f = 0.33 (40% EtOAc/hexanes)

^{1}**H NMR** (600 MHz, acetone-*d*$_6$) (1.5:1 mixture of rotamers, asterisks denote minor rotamer peaks) δ 6.93 (br s, 1H), 4.48–4.40 (m, 1H), 4.46 (s, 1 H), 4.29 (dd, *J* = 9.1, 4.4 Hz, 1H), 3.74 (s, 1.7H), 3.72–3.69* (m, 0.4H), 3.70* (s, 1.3H), 3.65 (dd, *J* = 11.0, 6.3 Hz, 0.6H), 3.30 (ddd, *J* = 14.7, 10.8, 4.4 Hz, 1H), 2.60–2.47 (m, 1H), 1.91 (ddt, *J* = 27.0, 13.3, 4.8 Hz, 1H), 1.43* (s, 3.6H), 1.38 (s, 5.4H), 1.13 (s, 9H).

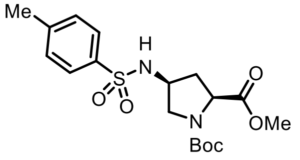
^{13}**C NMR** (151 MHz, acetone-*d*$_6$) (mixture of rotamers) δ 177.9, 175.1, 174.8, 154.6, 153.8, 152.3, 129.9, 121.7, 80.0, 68.8, 58.7, 58.4, 53.1, 52.6, 52.5, 52.4, 49.4, 48.5, 39.0, 36.7, 35.8, 28.5, 28.4, 27.7.

IR (FT-ATR, cm^{-1}) ν_{max} 2973, 1739, 1697, 1651, 1522, 1479, 1394, 1366, 1307, 1203, 1157, 1127, 1103, 988, 917, 805, 772, 729, 645, 554, 502.

HRMS (ESI) (*m/z*) for $[M+H]^+$ $C_{16}H_{29}N_2O_5$ requires 329.2076, observed 329.2068.

[α]$_D$^{20} = +4.5°C (*c* = 0.0089 g/mL, $CHCl_3$)

N-Boc-(4*S*)-(4-methylphenyl)sulfonamido)-L-proline methyl ester (P5-Pro).



P5-Pro

Prepared according to a modification of General Procedure A, using *N*-Boc-(4*S*)-amino-L-proline methyl ester (2.8 g, 11.5 mmol, 1.0 equiv), CH_2Cl_2 (115 mL, 0.1 M), *i*Pr_2NEt (3.0 mL, 17.25 mmol, 1.5 equiv), and *p*-toluenesulfonyl chloride (2.86 g, 14.95 mmol, 1.3 equiv). The reaction mixture was stirred for 1.5 h. The reaction mixture was diluted with EtOAc (200 mL) and washed with 10% citric acid (200 mL), saturated aqueous $NaHCO_3$ (200 mL) and brine (200 mL), and then dried over Na_2SO_4. The dried organic phases were then filtered and concentrated *in vacuo*. The crude product was purified by normal-phase column chromatography (10→70% EtOAc/hexanes) and **P5-Pro** was isolated as a white solid (4.06 g, 88% yield).

TLC R_f = 0.38 (50% EtOAc/hexanes)

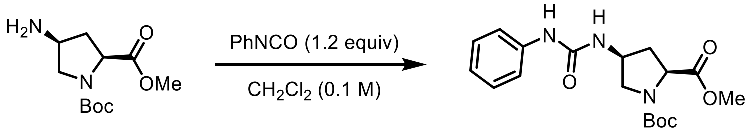
^{1}H NMR (600 MHz, acetone-d_6) (1.5:1 mixture of rotamers, asterisks denote minor rotamer peaks) δ 7.77(dt, *J* = 8.3, 1.7 Hz, 2H), 7.42 (t, *J* = 7.1 Hz, 2H), 6.71 (d = 7.7 Hz, 0.6H), 6.64* (d = 8.0 Hz, 0.4H), 4.17 (ddd, *J* = 12.2, 8.4, 6.9 Hz, 1H), 3.92–3.82 (m, 1H), 3.70 (s, 1.8H), 3.66* (s, 1.2H), 3.57 (ddd, *J* = 13.4, 10.8, 6.7 Hz, 1H), 3.12 (dd, *J* = 10.8, 6.9 Hz, 1H), 2.47–2.39 (m, 1 H), 2.43 (s, 3H), 1.81 (app dt, *J* = 12.9, 7.6 Hz, 0.6H), 1.75* (app dt, *J* = 13.4, 6.8 Hz, 0.4H), 1.38* (s, 3.6H), 1.34 (s, 5.4H).

^{13}C NMR (151 MHz, acetone-d_6) (mixture of rotamers) δ 174.1, 173.9, 154.3, 153.6, 144.2, 139.3, 130.6, 127.8, 80.2, 60.5, 58.3, 58.0, 52.9, 52.8, 52.5, 52.5, 52.4, 52.3, 52.0, 51.9, 51.9, 37.0, 36.0, 28.4, 28.3, 21.4, 20.8, 14.5.

IR (thin film, cm^{-1}) ν_{max} 3476, 1734, 1676, 1599, 1478, 1404, 1368, 1336, 1305, 1266, 1209, 1160, 1092, 1020, 987, 912, 816, 736, 705.

HRMS (ESI) (*m/z*) for $[M+H]^+$ $C_{18}H_{27}N_2O_6S$ requires 399.1590, observed 399.1584.

$[\alpha]_D^{20}$ = −5.6° (*c* = 0.0069 g/mL, $CHCl_3$)



P6-Pro

***N*-Boc-(4*S*)-(phenylureido)-L-proline methyl ester (P6-Pro).** To a solution of *N*-Boc-(4*S*)-amino-L-proline methyl ester (0.47 g, 1.94 mmol, 1.0 equiv) in CH_2Cl_2 (19 mL, 0.1 M) under N_2 was added phenyl isocyanate (0.25 mL, 2.33 mmol, 1.2 equiv). After 1 h, the reaction mixture was concentrated. The crude product was purified by reversed-phase column chromatography on a Biotage Isolera One purification system (SNAP C18 60 g column; gradient = Ramp 20-100% MeCN/H_2O over 15 CV, then 3 CV 100% MeCN; 50 mL/min flow rate; monitored λ = 210, 245 nm; 13 x 100 mm test tubes with 8 mL fractions). Fractions containing product were pooled and concentrated *in vacuo* to provide pure **P6-Pro** as a foamy white solid (0.59 g, 84% yield).

TLC R$_f$ = 0.27 (50% EtOAc/hexanes)

^{1}H NMR (600 MHz, acetone-d_6) (1.5:1 mixture of rotamers, asterisks denote minor rotamer peaks) δ 8.09 (d, *J* = 10.7 Hz, 1H), 7.48 (d, *J* = 7.9 Hz, 2H), 7.26 – 7.17 (m, 2H), 6.92 (tt, *J* = 7.4, 1.2 Hz, 1H), 5.89 (t, *J* = 6.9 Hz, 1H), 4.45–4.38 (m, 1H), 4.29 (dd, *J* = 9.2, 4.9 Hz, 1H), 3.82–3.73 (m, 1H), 3.72 (s, 1.8H), 3.68* (s, 1.2H), 3.29 (app dt, *J* = 10.0, 4.8 Hz, 1H), 2.59 (dddd, *J* = 21.8, 13.4, 9.1, 6.4 Hz, 1H), 1.99–1.85 (m, 1H), 1.44* (s, 3.6H), 1.38 (s, 5.4H).

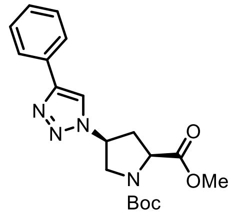
^{13}C NMR (151 MHz, acetone-d_6) (mixture of rotamers) δ 174.7, 174.4, 155.4, 155.4, 154.6, 153.9, 141.4, 129.4, 122.4, 119.0, 80.1, 80.0, 58.7, 58.4, 53.6, 53.0, 52.4, 52.4, 50.1, 49.2, 49.1, 37.4, 36.4, 28.5, 28.4.

IR (FT-ATR, cm^{-1}) ν_{max} 3339, 2975, 1744, 1697, 1653, 1599, 1548, 1499, 1441, 1394, 1366, 1312, 1240, 1203, 1154, 1109, 1031, 990, 894, 855, 751, 693, 571, 506.

HRMS (ESI) (*m/z*) for [M+H]$^+$ $C_{18}H_{26}N_3O_5$ requires 364.1872, observed 364.1867.

$[\alpha]_D^{20}$ = −7.5° (*c* = 0.0067 g/mL, CHCl$_3$)

***N*-Boc-(4*S*)-(4-phenyl-1H-1,2,3-triazol-1-yl)-L-proline methyl ester (P7-Pro)** is a known compound that was synthesized as reported in the literature.[4]



P7-Pro

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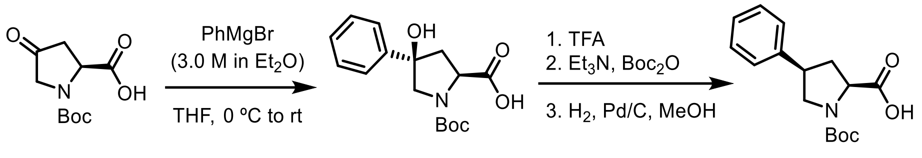
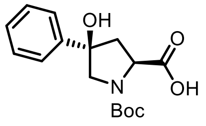
[4] Shi, F.; Zhang, Y.; Xu, W. *Bioorg. Med. Chem.* **2015**, *23*, 5539–5545.



P8-Hyp **P8-Pro**

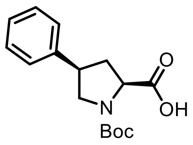
N-Boc-(4*R*)-4-phenyl-4-hydroxy-L-proline (P8-Hyp).



P8-Hyp

Prepared by a modification of a literature procedure.[5] A solution of Boc-4-oxo-L-Pro-OH in THF (21 mL, 0.14 M) was cooled to 0 °C. Phenylmagnesium bromide (4.2 mL, 3.0 M in diethyl ether, 2.5 equiv) was added dropwise over 10 minutes. The reaction mixture was warmed to rt and stirred for 16 h. Saturated aqueous NH_4Cl (10 mL) was added dropwise, and the reaction mixture was transferred to a separatory funnel. The solution was washed with 1 N HCl (100 mL) and was extracted with 3:1 $CHCl_3$/IPA (2 x 100 mL). The combined organic phases were dried over Na_2SO_4, filtered, and concentrated to afford a yellow solid. The crude product was purified by reversed-phase column chromatography (SNAP C18 120 g column; gradient = Ramp 30–100% MeOH/H_2O with 0.1% formic acid over 14 CV, then 5 CV 100% MeOH with 0.1% formic acid; 75 mL/min flow rate; monitored λ = 210, 245 nm; 16 x 150 mm test tubes with 20 mL fractions). Fractions containing product were pooled and concentrated *in vacuo* to provide pure *N*-Boc-(4*R*)-phenyl-4-hydroxy-L-proline[6] as a yellow oil (0.92 g, 60% yield).

N-Boc-(4*S*)-phenyl-L-proline (P8-Pro).



P8-Pro

Trifluoroacetic acid (10 mL) was added to *N*-Boc-(4*R*)-phenyl-4-hydroxy-L-proline (0.92 g, 2.98 mmol, 1.0 equiv) and the reaction mixture was stirred for 38 h. Residual TFA was removed under a stream of N_2 and the reaction mixture was further concentrated *in vacuo*. The resulting brown oil was dissolved in H_2O (30 mL), and Et_3N (1.3 mL, 9.32 mmol, 3.1 equiv) and Boc_2O (1.04 g, 4.77 mmol, 1.6 equiv) were added. The reaction mixture was stirred at rt for 4 h and was transferred to a separatory funnel. The reaction mixture was washed with 1 N HCl (100 mL) and was extracted with 3:1 $CHCl_3$/IPA (2 x 100 mL). The combined organic phases were dried over Na_2SO_4, filtered, and concentrated to afford a brown oil. The crude product was purified by reversed-phase column chromatography (SNAP C18 120 g column; gradient = Ramp 30–100% MeOH/H_2O with 0.1% formic acid over 14 CV, then 5 CV 100% MeOH with 0.1% formic acid; 75 mL/min flow rate; monitored λ = 210, 245 nm; 16 x 150 mm test tubes with 20 mL fractions). Fractions containing product were pooled and concentrated *in vacuo* to provide *N*-Boc-4-phenyl-L-dihydroproline as a mixture of alkene isomers (0.47 g, 55% yield). This product was dissolved in methanol (0.1 M, 16 mL), and the reaction mixture was sparged with N_2. Pd/C (52 mg, 10% on activated carbon, 0.1 equiv) was added, and the reaction mixture was sparged with H_2. The reaction mixture was stirred

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[5] Krapcho, J.; Turk, C.; Cushman, D. W.; Powell, J. R.; DeForrest, J. M.; Spitzmiller, E. R.; Karanewsky, D. S.; Duggan, M.; Rovnvak, G.; Schwartz, J.; Natarajan, S.; Godfrey, J. D.; Ryono, D. E.; Neubeck, R. Atwal, K. S.; Petrillo, Jr., E. W. *J. Med. Chem.* **1988**, *31*, 1148–1160.

[6] *N*-Boc-(4*R*)-phenyl-4-hydroxy-L-proline is a known compound: Tamaki, M.; Han, G.; Hruby, V. J. *J. Org. Chem.* **2001**, *66*, 3593–3596.

under H_2 (1 atm) for 2 h, filtered through celite, and concentrated. The crude product was purified by reversed-phase column chromatography (SNAP C18 120 g column; gradient 1 = Ramp 30–100% MeOH/H_2O with 0.1% formic acid over 14 CV, then 5 CV 100% MeOH with 0.1% formic acid; gradient 2 = Ramp 20–100% MeCN/H_2O over 14 CV with 0.1% formic acid, then 5 CV 100% MeOH with 0.1% formic acid; 75 mL/min flow rate; monitored λ = 210, 245 nm; 16 x 150 mm test tubes with 20 mL fractions). Fractions containing product were pooled and concentrated *in vacuo* to provide pure **P8-Pro** as a foamy white solid (0.30 g, 64% yield).

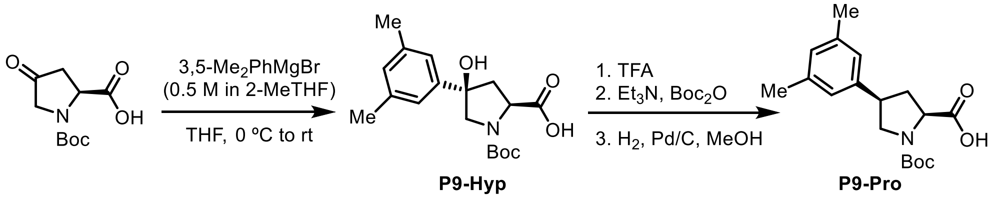
^{1}H NMR (600 MHz, acetone-*d*$_6$) (1.5:1 mixture of rotamers, asterisks denote minor rotamer peaks) δ 7.34 (d, *J* = 4.5 Hz, 4H), 7.30–7.20 (m, 1H), 4.34 (app dt, *J* = 9.6, 6.9 Hz, 1H), 4.04–3.92 (m, 1H), 3.46 (dddd, *J* = 18.6, 14.1, 11.5, 7.1 Hz, 1H), 3.32 (app dt, *J* = 23.5, 10.6 Hz, 1H), 2.81–2.68 (m, 1H), 2.10–2.06 (comp, 1H), 1.45* (s, 3.6H), 1.41 (s, 5.4H).[7]

^{13}C NMR (151 MHz, acetone-*d*$_6$) (mixture of rotamers) δ 174.5, 154.7, 154.0, 141.1, 129.4, 128.1, 127.7, 79.9, 60.2, 60.0, 54.1, 53.5, 44.3, 43.6, 38.9, 38.1, 28.6, 28.5.

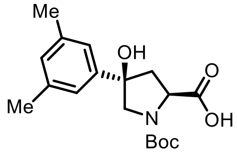
IR (thin film, cm^{-1}) ν_{max} 3445, 2979, 1696, 1605, 1497, 1479, 1456, 1415, 1368, 1337, 1259, 1259, 1162, 1125, 1074, 1055, 1031, 1002, 915, 867, 848, 805, 764, 738, 700, 666, 639.

HRMS (ESI) (*m/z*) for $[M+H]^+$ $C_{16}H_{22}NO_4$ requires 292.1549, observed 292.1554.

$[\alpha]_D^{20}$ = –52.8° (*c* = 0.0065 g/mL, $CHCl_3$)



N-Boc-(4*R*)-4-(3,5-dimethylphenyl)-4-hydroxy-L-proline (P9-Hyp).


P9-Hyp

Prepared by a modification of a literature procedure.[5] A solution of Boc-4-oxo-L-Pro-OH in THF (50 mL, 0.1 M) was cooled to 0 °C. 3,5-Dimethylphenylmagnesium bromide (50 mL, 0.5 M in 2-MeTHF, 2.5 equiv) was added dropwise over 10 minutes. The reaction was warmed to rt and stirred for 19 h. Saturated aqueous NH_4Cl (10 mL) was added dropwise, and the reaction mixture was transferred to a separatory funnel. The solution was washed with 1 N HCl (200 mL) and was extracted with 3:1 $CHCl_3$/IPA (2 x 200 mL). The combined organic phases were dried over Na_2SO_4, filtered, and concentrated to afford a yellow solid. The crude product was purified by reversed-phase column chromatography (SNAP C18 120 g column; gradient 1 = Ramp 20–100% MeCN/H_2O with 0.1% formic acid over 14 CV, then 5 CV 100% MeCN with 0.1% formic acid; gradient 2 = Ramp 30–100% MeOH/H_2O over 14 CV with 0.1% formic acid, then 5 CV 100% MeOH with 0.1% formic acid; 75 mL/min flow rate;

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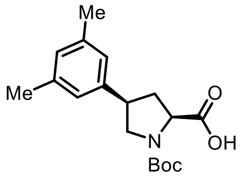
[7] Carboxylic acid proton not visible.

monitored λ = 210, 245 nm; 16 x 150 mm test tubes with 20 mL fractions.) Fractions containing product were pooled and concentrated *in vacuo* to provide pure *N*-Boc-(4*R*)-4-(3,5-dimethylphenyl)-4-hydroxy-L-proline as a white solid (1.58 g, 47% yield).

N-Boc-(4*S*)-(3,5-dimethylphenyl)-L-proline (P9-Pro)



P9-Pro

Trifluoroacetic acid (16 mL) was added to the *N*-Boc-(4*R*)-(3,5-dimethylphenyl-4-hydroxy-L-proline (1.58 g, 4.70 mmol, 1.0 equiv) and the reaction mixture was stirred for 38 h. Residual TFA was removed under a stream of N_2 and the reaction mixture was further concentrated *in vacuo*. The resulting orange solid was dissolved in H_2O (47 mL), and Et_3N (3.0 mL, 21.5 mmol, 4.6 equiv) and Boc_2O (3.12 g, 14.3 mmol, 3.0 equiv) were added. The reaction mixture was stirred at rt for 2 days and was transferred to a separatory funnel. The reaction mixture was washed with 1 N HCl (100 mL) and was extracted with 3:1 $CHCl_3$/IPA (2 x 100 mL). The combined organic phases were dried over Na_2SO_4, filtered, and concentrated to afford a brown solid. The crude product was purified by reversed-phase column chromatography (SNAP C18 120 g column; gradient = Ramp 30–100% MeOH/H_2O with 0.1% formic acid over 14 CV, then 8 CV 100% MeOH with 0.1% formic acid; 75 mL/min flow rate; monitored λ = 210, 245 nm; 16 x 150 mm test tubes with 20 mL fractions). Fractions containing product were pooled and concentrated *in vacuo* to provide *N*-Boc-4-(3,5-dimethylphenyl)-L-dihydroproline as a mixture of alkene isomers (1.18 g, 79% yield). This product was dissolved in methanol (0.1 M, 38 mL), and the reaction mixture was sparged with N_2. Pd/C (120 mg, 10% on activated carbon, 0.1 equiv) was added, and the reaction mixture was sparged with H_2. The reaction mixture was stirred under H_2 (1 atm) for 18 h, filtered through celite, and concentrated. The crude product was purified by reversed-phase column chromatography (SNAP C18 120 g column; gradient = Ramp 30–100% MeOH/H_2O with 0.1% formic acid over 14 CV, then 5 CV 100% MeOH with 0.1% formic acid; 75 mL/min flow rate; monitored λ = 210, 245 nm; 16 x 150 mm test tubes with 20 mL fractions). Fractions containing product were pooled and concentrated *in vacuo* to provide pure **P9-Pro** as a foamy white solid (1.13 g, 93% yield).

^{1}H NMR (600 MHz, acetone-*d*$_6$) (1:1.5 mixture of rotamers, asterisks denote minor rotamer peaks) δ 6.93 (s, 2H), 6.88 (s, 1H), 4.32 (app dt, *J* = 9.6, 7.2 Hz, 1H), 3.99–3.91 (m, 1H), 3.41–3.30 (comp, 1 H), 2.78–2.62 (m, 1H), 2.27 (s, 6H), 2.10–2.06 (m, 1H), 2.04–1.98 (m, 1H), 1.44* (s, 3.6H), 1.41 (s, 5.4H).

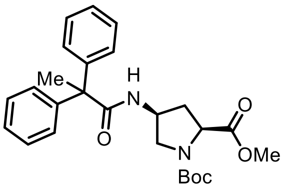
^{13}C NMR (151 MHz, acetone-*d*$_6$) (mixture of rotamers) δ 174.5, 173.9, 154.7, 154.0, 140.9, 138.7, 129.3, 125.8, 79.9, 60.1, 59.9, 54.1, 53.6, 49.7, 44.3, 43.5, 39.0, 38.1, 28.6, 28.4, 21.3.

IR (thin film, cm^{-1}) ν_{max} 3437, 1696, 1606, 1478, 1417, 1368, 1331, 1297, 1265, 1159, 1123, 1067, 1036, 917, 848, 805, 770, 738, 703, 666.

HRMS (ESI) (*m/z*) for $[M+H]^+$ $C_{18}H_{26}NO_4$ requires 320.1862, observed 320.1856.

$[\alpha]_D^{20}$ = –46.8° (*c* = 0.0067 g/mL, $CHCl_3$)

N-Boc-(4*S*)-(2,2-diphenylpropanamido)-L-proline methyl ester (P10-Pro).



P10-Pro

Prepared according to General Procedure B, using 2,2-diphenylpropionic acid (2.67 g, 11.8 mmol, 1.1 equiv), CH_2Cl_2 (54 mL), *i*Pr_2NEt (4.5 mL, 25.8 mmol, 2.4 equiv), HATU (4.9 g, 12.9 mmol, 1.2 equiv), and *N*-Boc-(4*S*)-amino-L-proline methyl ester (2.63 g, 10.8 mmol, 1.0 equiv). The reaction mixture was stirred for 20 h, was diluted with CH_2Cl_2 (100 mL) and washed with 10% (w/v) aqueous citric acid (2 x 100 mL), saturated aqueous $NaHCO_3$ (100 mL), and brine (100 mL), and then dried over Na_2SO_4. The dried organic phases were then filtered and concentrated *in vacuo*. The crude product was purified by silica gel column chromatography (5→50% EtOAc/hexanes) and **P10-Pro** was isolated as a colorless oil (2.44 g, 46% yield).

TLC $R_f = 0.43$ (40% EtOAc/hexanes)

^{1}H NMR (600 MHz, acetone-*d*$_6$) (1.4:1 mixture of rotamers, asterisks denote minor rotamer peaks) δ 7.37–7.28 (m, 4H), 7.28–7.21 (m, 6H), 6.76 (br s, 1 H), 4.57 (app dp, *J* = 11.3, 5.6 Hz, 1H), 4.24 (dd, *J* = 9.3, 4.4 Hz, 1H), 3.68 (ddd, *J* = 19.9, 11.0, 6.4 Hz, 1H), 3.59 (s, 1.8H), 3.55* (s, 1.2H), 3.26 (ddd, *J* = 15.3, 10.9, 4.3 Hz, 1H), 2.63–2.45 (m, 1H), 1.92 (s, 3H), 1.84 (app ddt, *J* = 27.4, 13.3, 4.4 Hz, 1H), 1.42* (s, 3.8H), 1.36 (s, 5.2H).

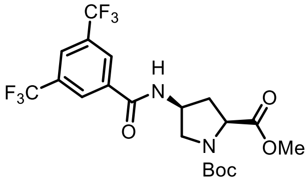
^{13}C NMR (151 MHz, acetone-*d*$_6$) (mixture of rotamers) δ 174.6, 174.5, 174.3, 154.4, 153.7, 152.2, 146.5, 146.1, 145.9, 128.9, 127.4, 127.3, 80.1, 80.0, 58.5, 58.3, 57.2, 53.0, 52.4, 49.7, 48.8, 36.5, 35.6, 28.5, 28.3, 27.45.

IR (FT-ATR, cm^{-1}) ν_{max} 2978, 1742, 1696, 1663, 1599, 1494, 1476, 1444, 1393, 1366, 1303, 1254, 1204, 1156, 1123, 1104, 1028, 987, 911, 859, 762, 729, 698, 646, 556, 506.

HRMS (ESI) (*m/z*) for $[M+H]^+$ $C_{26}H_{33}N_2O_5$ requires 453.2389, observed 453.2389.

$[\alpha]_D^{20}$ = +10.1° (*c* = 0.0092 g/mL, $CHCl_3$)

N-Boc-(4*S*)-(3,5-bis(trifluoromethyl)benzamido)-L-proline methyl ester (P11-Pro).



P11-Pro

Prepared according to General Procedure C, using 3,5-bis(trifluoromethyl)benzoic acid (0.99 g, 3.83 mmol, 1.1 equiv), CH_2Cl_2 (17.4 mL), *i*Pr_2NEt (1.45 mL, 8.35 mmol, 2.4 equiv), EDC·HCl (0.8 g, 4.18 mmol, 1.2 equiv), HOBt hydrate (0.64 g, 4.18 mmol, 1.2 equiv) and *N*-Boc-(4*S*)-amino-L-proline methyl ester (0.85 g, 3.48 mmol, 1.0 equiv). The reaction mixture was stirred for 16 h, was diluted with CH_2Cl_2 (30 mL) and washed with 10% (w/v) aqueous citric acid (2 x 30 mL), saturated aqueous $NaHCO_3$ (30 mL), and brine (30 mL), and then dried over Na_2SO_4. The dried organic phases were then filtered and concentrated *in vacuo*. The crude product was purified by silica gel column chromatography (20→80% EtOAc/hexanes) and **P11-Pro** was isolated as a white solid (0.94 g, 56% yield).

TLC R$_f$ = 0.33 (20% EtOAc/hexanes)

^{1}H NMR (600 MHz, acetone-*d$_6$*) (1.6:1 mixture of rotamers, asterisks denote minor rotamer peaks) δ 8.47 (d, *J* = 1.7 Hz, 1H), 8.45 (s, 1H), 8.27 (t, *J* = 7.1 Hz, 1H), 8.23 (s, 1H), 4.72–4.64 (m, 1H), 4.38 (dd, *J* = 8.9, 5.3 Hz, 1H), 3.89* (dd, *J* = 10.9, 6.6 Hz, 0.4H), 3.82 (dd, *J* = 11.0, 6.5 Hz, 0.6H), 3.73* (s, 1.9H), 3.70 (s, 1.1H), 3.49 (app td, *J* = 10.3, 9.5, 5.2 Hz, 1H), 2.70 (app tdd, *J* = 12.9, 8.9, 6.3 Hz, 1H), 2.19 (app dt, *J* = 13.2, 5.5 Hz, 0.6H), 2.13* (app dt, *J* = 13.1, 5.7 Hz, 0.4H), 1.44 (s, 5.5H), 1.41* (s, 3.5H).

^{13}C NMR (151 MHz, acetone-*d$_6$*) (mixture of rotamers) δ 174.7, 174.4, 164.3, 154.6, 153.9, 137.9, 132.3 (q, *J* = 33.5 Hz), 128.8, 125.6, 124.2 (d, *J* = 272.2 Hz), 80.2, 58.7, 58.5, 52.4, 51.9, 50.5, 49.7, 36.6, 35.7, 28.5, 28.4.

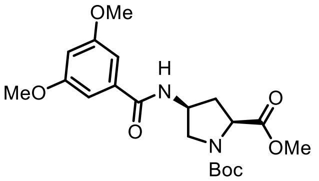
^{19}F NMR (376 MHz, acetone-*d$_6$*) δ –70.5 (s, 3F), –70.6 (s, 3F).

IR (FT-ATR, cm^{-1}) ν_{max} 3338, 2979, 1749, 1703, 1668, 1621, 1544, 1454, 1394, 1368, 1276, 991, 907, 845, 767, 701, 681, 554.

HRMS (ESI) (*m/z*) for [M+H]$^+$ $C_{20}H_{23}F_6N_2O_5$ requires 485.1511, observed 485.1510.

$[\alpha]_D^{20}$ = –4.7° (*c* = 0.007 g/mL, $CHCl_3$)

N-Boc-(4*S*)-(3,5-dimethoxybenzamido)-L-proline methyl ester (P12-Pro).



P12-Pro

Prepared according to a modification of General Procedure B, using 3,5-dimethoxybenzoic acid (0.78 g, 4.26 mmol, 1.1 equiv), DMF (20 mL), *i*Pr$_2$NEt (0.74 mL, 4.26 mmol), COMU (1.82 g, 4.26 mmol, 1.1 equiv), and *N*-Boc-(4*S*)-amino-L-proline methyl ester (0.95 g, 3.88 mmol, 1.0 equiv). The reaction mixture was stirred for 16 h, was diluted with CH_2Cl_2 (25 mL) and washed with 10% (w/v) aqueous citric acid (2 x 50 mL), saturated aqueous $NaHCO_3$ (50 mL), and brine (50 mL), and then dried over Na_2SO_4. The dried organic phases were then filtered and concentrated *in vacuo*. The crude product was purified by silica gel column chromatography (20→100% EtOAc/hexanes) and **P12-Pro** was isolated as a white foamy solid (0.92 g, 58% yield).

TLC R$_f$ = 0.24 (40% EtOAc/hexanes)

^{1}H NMR (600 MHz, acetone-*d$_6$*) (1.5:1 mixture of rotamers, asterisks denote minor rotamer peaks) δ 7.82 (t, *J* = 7.3 Hz, 1H), 7.01 (dd, *J* = 4.9, 2.3 Hz, 2H), 6.61 (app q, *J* = 2.1 Hz, 1H), 4.72–4.58 (m, 1H), 4.34 (dd, *J* = 9.0, 5.2 Hz, 1H), 3.85–3.69 (m, 1H) 3.81 (s, 6H), 3.74 (s, 1.9H), 3.71* (s, 1.1H), 3.45 (app td, *J* = 10.3, 5.0 Hz, 1H), 2.64 (dddd, *J* = 16.1, 13.4, 9.0, 6.4 Hz, 1H), 2.15–2.06 (m, 1H), 1.44* (s, 3.6H), 1.39 (s, 5.4H).

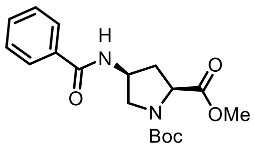
^{13}C NMR (151 MHz, acetone-d_6) (mixture of rotamers) δ 175.0, 174.7, 166.7, 161.7, 154.6, 153.8, 137.5, 105.8, 104.0, 80.2, 80.1, 58.7, 58.5, 55.8, 52.9, 52.5, 52.3, 49.9, 49.1, 36.6, 35.7, 28.5, 28.4.

IR (thin film, cm^{-1}) ν_{max} 3366, 2977, 1740, 1696, 1653, 1595, 1536, 1457, 1402, 1367, 1321, 1260, 1207, 1181, 1367, 1260, 1207, 1158, 1121, 1065, 993, 926, 858, 766, 737, 703, 683, 666.

HRMS (ESI) (*m/z*) for $[M+H]^+$ $C_{20}H_{29}N_2O_7$ requires 409.1975, observed 409.1974.

$[\alpha]_D^{20}$ = –10.4° (*c* = 0.01 g/mL, $CHCl_3$)

N-Boc-(4S)-(benzamido)-L-proline methyl ester (P13-Pro).



P13-Pro

Prepared according to General Procedure C, using benzoic acid (0.27 g, 2.25 mmol, 1.1 equiv), CH_2Cl_2 (10.2 mL), *i*Pr_2NEt (0.85 mL, 4.9 mmol, 2.4 equiv), EDC·HCl (0.47 g, 2.46 mmol, 1.2 equiv), HOBT hydrate (0.38 g, 2.46 mmol, 1.2 equiv) and *N*-Boc-(4*S*)-amino-L-proline methyl ester (0.5 g, 2.04 mmol, 1.0 equiv). The reaction mixture was stirred for 3 h, was diluted with CH_2Cl_2 (30 mL) and washed with 10% (w/v) aqueous citric acid (2 x 30 mL), saturated aqueous $NaHCO_3$ (30 mL), and brine (30 mL), and then dried over Na_2SO_4. The dried organic phases were then filtered and concentrated *in vacuo*. The crude product was purified by silica gel column chromatography (10→60% EtOAc/hexanes) and **P13-Pro** was isolated as a white solid (0.63 g, 88% yield).

TLC R_f = 0.27 (40% EtOAc/hexanes)

^{1}H NMR (600 MHz, acetone-d_6) (1.4:1 mixture of rotamers, asterisks denote minor rotamer peaks) δ 7.86 (dd, *J* = 8.0, 3.7 Hz, 2H), 7.80 (t, *J* = 7.1 Hz, 1H), 7.53 (dd, *J* = 8.3, 6.5 Hz, 1H), 7.46 (t, *J* = 7.6 Hz, 2H), 4.71–4.64 (m, 1H), 4.36 (dd, *J* = 9.0, 5.1 Hz, 1H), 3.81 (ddd, *J* = 30.1, 10.9, 6.4 Hz, 1H), 3.73 (s, 1.9H), 3.70* (s, 1.1H), 3.46 (app td, *J* = 10.2, 5.0 Hz, 1H), 2.73–2.59 (m, 1H), 2.18–2.06 (m, 1H), 1.44* (s, 3.7H), 1.39 (s, 5.3H).

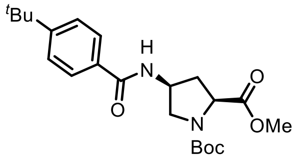
^{13}C NMR (151 MHz, acetone-d_6) (mixture of rotamers) δ 175.0, 174.7, 170.7, 166.9, 154.6, 153.9, 135.5, 132.1, 129.2, 128.0, 80.1, 58.8, 58.5, 53.0, 52.4, 51.9, 50.0, 49.1, 43.8, 36.7, 35.8, 28.5, 28.4.

IR (FT-ATR, cm^{-1}) ν_{max} 3362, 2970, 1744, 1699, 1633, 1601, 1577, 1530, 1479, 1451, 1391, 1360, 1312, 1292, 1206, 1185, 1158, 1128, 1104, 1061, 995, 914, 881, 858, 815, 804, 787, 762, 727, 697, 669, 561, 526.

HRMS (ESI) (*m/z*) for $[M+H]^+$ $C_{18}H_{25}N_2O_5$ requires 349.1763, observed 349.1756.

$[\alpha]_D^{20}$ = –14.4° (c = 0.0067 g/mL, $CHCl_3$)

N-Boc-(4*S*)-(4-*tert*-butylbenzamido)-L-proline methyl ester (P14-Pro).



P14-Pro

Prepared according to General Procedure C, using 4-*tert*-butylbenzoic acid (0.68 g, 3.83 mmol, 1.1 equiv), CH_2Cl_2 (17.4 mL), *i*Pr_2NEt (1.45 mL, 8.35 mmol, 2.4 equiv), EDC·HCl (0.8 g, 4.18 mmol, 1.2 equiv), HOBt hydrate (0.64 g, 4.18 mmol, 1.2 equiv) and *N*-Boc-(4*S*)-amino-L-proline methyl ester (0.85 g, 3.48 mmol, 1.0 equiv). The reaction mixture was stirred for 16 h, was diluted with CH_2Cl_2 (30 mL) and washed with 10% (w/v) aqueous citric acid (2 x 30 mL), saturated aqueous $NaHCO_3$ (30 mL), and brine (30 mL), and then dried over Na_2SO_4. The dried organic phases were then filtered and concentrated *in vacuo*. The crude product was purified by silica gel column chromatography (20→80% EtOAc/hexanes) and **P14-Pro** was isolated as a white solid (0.8 g, 57% yield).

TLC R_f = 0.50 (40% EtOAc/hexanes)

^{1}H NMR (600 MHz, acetone-*d*$_6$) (1.5:1 mixture of rotamers, asterisks denote minor rotamer peaks) δ 7.85–7.77 (m, 2H), 7.75 (d, *J* = 7.4 Hz, 1H), 7.50 (dd, *J* = 8.6, 2.2 Hz, 2H), 4.72–4.61 (m, 1H), 4.36 (dd, *J* = 8.7, 4.9 Hz, 1H), 3.82* (dd, *J* = 10.8, 6.3 Hz, 0.4H), 3.77 (dd, *J* = 10.9, 6.4 Hz, 0.6H), 3.75 (s, 1.7H), 3.71* (s, 1.3H), 3.45 (td, *J* = 10.3, 4.9 Hz, 1H), 2.66 (dddd, *J* = 16.5, 13.2, 9.0, 6.4 Hz, 1H), 2.10 (ddt, *J* = 17.3, 11.6, 5.3 Hz, 1H), 1.44* (s, 3.6H), 1.39 (s, 5.6H), 1.33 (s, 9H).

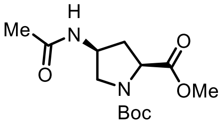
^{13}C NMR (151 MHz, acetone-*d*$_6$) (mixture of rotamers) δ 175.1, 174.8, 166.8, 155.4, 154.7, 153.9, 132.7, 127.8, 126.1, 80.1, 58.8, 58.6, 53.1, 52.5, 49.9, 49.0, 36.7, 35.8, 35.4, 31.4, 28.5, 28.4.

IR (FT-ATR, cm^{-1}) ν_{max} 2963, 1747, 1700, 1645, 1611, 1537, 1502, 1393, 1365, 1310, 1276, 1202, 1156, 1124, 1016, 896, 896, 851, 771, 703, 681, 563, 501.

HRMS (ESI) (*m/z*) for $[M+H]^+$ $C_{22}H_{33}N_2O_5$ requires 405.2389, observed 405.2381.

$[\alpha]_D^{20}$ = –18.7° (*c* = 0.0066 g/mL, $CHCl_3$)

N-Boc-(4*S*)-(acetamido)-L-proline methyl ester (P15-Pro).



P15-Pro

Prepared according to a modification of General Procedure A, using *N*-Boc-(4*S*)-amino-L-proline methyl ester (2.8 g, 11.5 mmol, 1.0 equiv), CH_2Cl_2 (115 mL, 0.1 M), *i*Pr_2NEt (3.0 mL, 17.25 mmol, 1.5 equiv), and acetyl chloride (1.1 mL, 14.95 mmol, 1.3 equiv). The reaction mixture was stirred for 1 h. The reaction mixture was diluted with EtOAc (200 mL) and washed with 10% citric acid (200 mL), saturated aqueous $NaHCO_3$ (200 mL) and brine (200 mL), and then dried over Na_2SO_4. The dried organic phases were then filtered and concentrated *in vacuo*. The crude product was purified by reversed-phase column chromatography (SNAP C18 120 g column; gradient 1 = Ramp 30–100% MeOH/H_2O over 14 CV, then 3 CV 100% MeOH; gradient 2 = Ramp 0–50% MeCN/H_2O over 12 CV, then ramp 50–100% MeCN/H_2O over 6 CV; 75 mL/min flow rate; monitored λ = 210, 245 nm; 16 x 150 mm test tubes with 20 mL fractions). Fractions containing product were pooled and concentrated *in vacuo* to provide pure **P15-Pro** as a white solid (1.75 g, 53% yield).

TLC R$_f$ = 0.19 (50% EtOAc/hexanes)

^{1}H NMR (600 MHz, acetone-d_6) (1.7:1 mixture of rotamers, asterisks denote minor rotamer peaks) δ 7.37 (dd, *J* = 12.2, 7.1 Hz, 1H), 4.40–4.33 (m, 1H), 4.26 (dd, *J* = 8.7, 6.4 Hz, 1H), 3.75 (ddd, *J* = 27.9, 10.6, 6.8 Hz, 1H), 3.71 (s, 1.9H), 3.67* (s, 1.1H), 3.19 (app dt, *J* = 10.7, 6.4 Hz, 1H), 2.55 (dddd, *J* = 16.1, 13.1, 8.5, 6.7 Hz, 1H), 1.91–1.83 (m, 1 H) 1.86 (s, 3H), 1.42* (s, 3.4H), 1.36 (s, 5.6H).

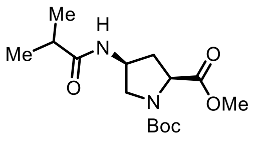
^{13}C NMR (151 MHz, acetone-d_6) (mixture of rotamers) δ 174.2, 173.9, 170.2, 154.5, 153.7, 80.0, 58.5, 58.2, 52.3, 52.2, 51.7, 49.1, 48.3, 36.7, 35.7, 28.5, 28.3, 22.8.

IR (thin film, cm^{-1}) ν$_{max}$ 3375, 2979, 1747, 1663, 1548, 1479, 1437, 1406, 1368, 1308, 1261, 1207, 1160, 1112, 1032, 994, 951, 900, 862, 772, 737, 703.

HRMS (ESI) (*m/z*) for [M+H]$^+$ $C_{13}H_{23}N_2O_5$ requires 287.1607, observed 287.1616.

[α]$_D^{20}$ = –5.0° (*c* = 0.0085 g/mL, CHCl$_3$)

N-Boc-(4*S*)-(isobutyramido)-L-proline methyl ester (P16-Pro).



P16-Pro

Prepared according to General Procedure B, using isobutyric acid (0.1 mL, 1.1 mmol, 1.1 equiv), CH_2Cl_2 (10 mL), *i*Pr$_2$NEt (0.42 mL, 2.4 mmol, 2.4 equiv), HATU (456 mg, 1.2 mmol, 1.2 equiv), and *N*-Boc-(4*S*)-amino-L-proline methyl ester (244 mg, 1.0 mmol, 1.0 equiv). The reaction mixture was stirred for 20 h, was diluted with CH_2Cl_2 (30 mL) and washed with 10% (w/v) aqueous citric acid (2 x 30 mL), saturated aqueous $NaHCO_3$ (30 mL), and brine (30 mL), and then dried over Na_2SO_4. The dried organic phases were then filtered and concentrated *in vacuo*. The crude product was purified by silica gel column chromatography (10→60% EtOAc/hexanes) and **P16-Pro** was isolated as a white solid (274 mg, 60% yield).

TLC R$_f$ = 0.30 (40% EtOAc/hexanes)

^{1}H NMR (500 MHz, acetone-d_6) (1.4:1 mixture of rotamers, asterisks denote minor rotamer peaks) δ 7.03 (s, 1H), 4.42–4.34 (m, 1H), 4.28 (dd, *J* = 8.9, 5.5 Hz, 1H), 3.73 (ddd, *J* = 27.9, 10.7, 6.6 Hz, 1H), 3.72 (s, 1.8H), 3.68* (s, 1.2H), 3.24 (app dt, *J* = 11.7, 6.0 Hz, 1H), 2.62 – 2.46 (m, 1H), 2.44–2.28 (m, 1H), 1.90 (app ddt, *J* = 20.9, 13.5, 5.8 Hz, 1H), 1.43* (s, 3.8H) 1.37 (s, 5.2H), 1.04 (app t, *J* = 6.7 Hz, 6H).

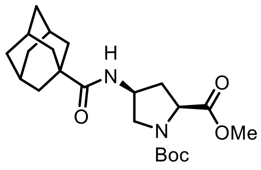
^{13}C NMR (151 MHz, acetone-d_6) (mixture of rotamers) δ 176.8, 174.5, 174.1, 154.5, 153.8, 80.1, 80.0, 58.6, 58.3, 52.6, 52.3, 52.1, 49.2, 48.4, 36.8, 35.9, 35.5, 28.5, 28.4, 19.9, 19.7.

IR (FT-ATR, cm^{-1}) ν$_{max}$ 3278, 2976, 2877, 1754, 1741, 1694, 1671, 1646, 1552, 1481, 1455, 1400, 1368, 1339, 1303, 1258, 1229, 1200, 1151, 1111, 1093, 1037, 1019, 990, 936, 899, 868, 855, 772, 764, 738, 685, 625, 560.

HRMS (ESI) (*m/z*) for [M+H]$^+$ $C_{15}H_{27}N_2O_5$ requires 315.1920, observed 315.1917.

[α]$_D^{20}$ = +7.9° (*c* = 0.0073 g/mL, CHCl$_3$)

N-Boc-(4*S*)-(1-adamantylamido)-L-proline methyl ester (P17-Pro).



P17-Pro

Prepared according to a modification of General Procedure A. To a solution of 1-adamantanecarbonyl chloride (0.44 g, 2.2 mmol, 1.1 equiv) in *N*,*N*-dimethylformamide (10 mL, 0.2 M) at 0 °C was added *i*Pr_2NEt (0.52 mL, 3.0 mmol, 1.5 equiv) and *N*-Boc-(4*S*)-amino-L-proline methyl ester (0.49 g, 2.0 mmol, 1.0 equiv). The reaction mixture was stirred for 16 h, and was diluted with EtOAc (50 mL) and washed with H_2O (3x100 mL), 5% (w/v) aqueous LiCl (2 x 100 mL), and brine (100 mL), and then dried over Na_2SO_4. The dried organic phases were then filtered and concentrated *in vacuo*. The crude product was purified by column chromatography on silica gel (20→100% EtOAc/hexanes) and **P17-Pro** was isolated as a white solid (597 mg, 74% yield).

TLC $R_f = 0.29$ (40% EtOAc/hexanes)

^{1}H NMR (600 MHz, acetone-d_6) (1.5:1 mixture of rotamers, asterisks denote minor rotamer peaks) δ 6.80 (d, *J* = 7.6 Hz, 1H), 4.45 (app qd, *J* = 7.1, 4.1 Hz, 1H), 4.29 (dd, *J* = 9.3, 4.4 Hz, 1H), 3.75 (s, 1.8H), 3.71* (s, 1.2H), 3.65 (dd, *J* = 11.0, 6.3 Hz, 1H), 3.29 (ddd, *J* = 14.5, 10.8, 4.3 Hz, 1H), 2.53 (app tdd, *J* = 18.6, 11.8, 7.6 Hz, 1H), 2.01–1.96 (m, 3H), 1.91 (app ddt, *J* = 26.4, 13.1, 4.7 Hz, 1H), 1.84–1.80 (m, 6H), 1.78–1.64 (m, 6H), 1.43* (s, 3.6H), 1.38 (s, 5.4H).

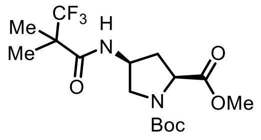
^{13}C NMR (151 MHz, acetone-d_6) (mixture of rotamers) δ 177.4, 175.1, 174.8, 154.6, 153.9, 80.1, 80.0, 58.7, 58.5, 53.2, 52.7, 52.5, 52.4, 49.3, 48.4, 41.1, 39.8, 37.3, 36.9, 36.0, 29.1, 28.5, 28.4.

IR (FT-ATR, cm^{-1}) ν_{max} 3348, 2976, 2905, 2851, 1741, 1701, 1642, 1520, 1478, 1453, 1395, 1366, 1301, 1257, 1204, 1180, 1158, 1110, 990, 899, 770, 672, 615.

HRMS (ESI) (*m/z*) for $[M+H]^+$ $C_{22}H_{35}N_2O_5$ requires 407.2546, observed 407.2538.

$[\alpha]_D^{20}$ = +4.9° rotation (*c* = 0.0019 g/mL, $CHCl_3$)

N-Boc-(4*S*)-(3,3,3-trifluoro-2,2-dimethylpropanamido)-L-proline methyl ester (P18-Pro).



P18-Pro

Prepared according to a modification of General Procedure B, using 3,3,3-trifluoro-2,2-dimethylpropionic acid (0.74 g, 4.8 mmol, 1.2 equiv), CH_2Cl_2 (40 mL, 0.1 M), *i*Pr_2NEt (1.05 mL, 6.0 mmol, 1.5 equiv), HATU (1.84 g, 4.8 mmol, 1.2 equiv), and *N*-Boc-(4*S*)-amino-L-proline methyl ester (0.99 g, 4.0 mmol, 1.0 equiv). The reaction mixture was stirred for 14.5 h, was diluted with EtOAc (100 mL) and washed with 10% (w/v) aqueous citric acid (2 x 75 mL), saturated aqueous $NaHCO_3$ (75 mL), and brine (75 mL), and then dried over Na_2SO_4. The dried organic phases were then filtered and concentrated *in vacuo*. The crude product was purified by reversed-phase column chromatography (SNAP C18 120 g column; gradient = Ramp 30–100% MeOH/H_2O over 14 CV, then 3 CV 100% MeOH; 75 mL/min flow rate; monitored λ = 210, 245 nm; 16 x 150 mm test tubes with 20 mL fractions). Fractions containing product were pooled and concentrated *in vacuo* to provide pure **P18-Pro** as a yellow oil (1.13 g, 73% yield).

TLC $R_f = 0.35$ (30% EtOAc/hexanes)

^{1}H NMR (600 MHz, acetone-d_6) (mixture of rotamers, asterisks denote minor rotamer peaks) δ 7.32 (d, J = 8.1 Hz, 1H), 4.61–4.44 (m, 1H), 4.31 (app dt, J = 9.0, 4.4 Hz, 1H), 3.75 (s, 1.7H), 3.74–3.70* (m, 0.4H), 3.71* (s, 1.3H), 3.67 (dd, J = 11.1, 6.3 Hz, 0.6H), 3.35 (app td, J = 13.5, 12.4, 4.2 Hz, 1H), 2.66–2.51 (m, 1H), 1.95 (app ddt, J = 27.3, 13.5, 4.5 Hz, 1H), 1.43–1.38 (overlapping singlets, 15 H)

^{13}C NMR (151 MHz, acetone-d_6) (mixture of rotamers) δ 175.4, 175.1, 169.1, 154.7, 153.9, 128.3 (q, J = 282.1 Hz), 80.3, 58.6, 53.1, 52.7, 52.6, 52.6, 50.1, 49.3, 49.2, 48.9 (q, J = 24.7 Hz), 36.6, 35.7, 28.6, 28.5, 19.8.

^{19}F NMR (376 MHz, acetone-d_6) δ –58.6 (s, 3F).

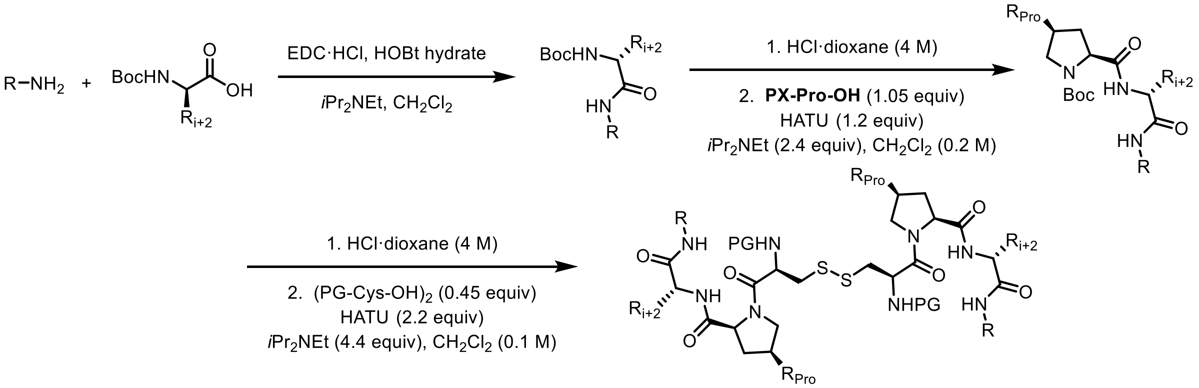
IR (thin film, cm^{-1}) ν_{max} 3376, 2980, 1739, 1701, 1680, 1533, 1480, 1400, 1369, 1293, 1259, 1235, 1207, 1182, 1155, 1127, 1032, 1017, 889, 860, 771, 666.

HRMS (ESI) (m/z) for $[M+H]^+$ $C_{16}H_{26}F_3N_2O_5$ requires 383.1794, observed 383.1777.

$[\alpha]_D^{20}$ = –1.0° (c = 0.016 g/mL, $CHCl_3$)

IV. Solution-phase synthesis of peptide catalysts

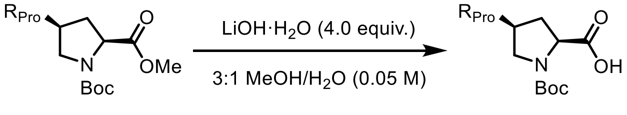
A. General Procedures



General Peptide Coupling Procedure A

The Boc-protected amino acid (1.0 equiv) was dissolved in CH_2Cl_2 (0.2 M), and HOBt·H_2O (1.2 equiv) was added. The amine coupling partner (1.1 equiv) was added, followed by EDC·HCl (1.2 equiv) and iPr$_2$NEt (2.4 equiv), and the reaction mixture was allowed to stir at RT. The reaction mixture was diluted with CH_2Cl_2 and washed with 10% (w/v) aqueous citric acid (2x), saturated aqueous $NaHCO_3$ (1x) and brine (1x), and then dried over Na_2SO_4. The dried organic phases were then filtered and concentrated *in vacuo*. The crude product was purified by reversed-phase column chromatography.

General saponification procedure



PX-Pro **PX-Pro-OH**

The Boc-protected proline methyl ester (1.0 equiv) was dissolved in methanol/H_2O (3:1, 0.05 M) and LiOH·H_2O (4.0 equiv) was added. The reaction mixture was stirred at RT for 1 h and was then acidified to pH = 2 with 1 N HCl, extracted with EtOAc (3x), washed with brine, and back-extracted with EtOAc (1x). The combined organic phases were dried over $MgSO_4$, filtered, and concentrated *in vacuo*.

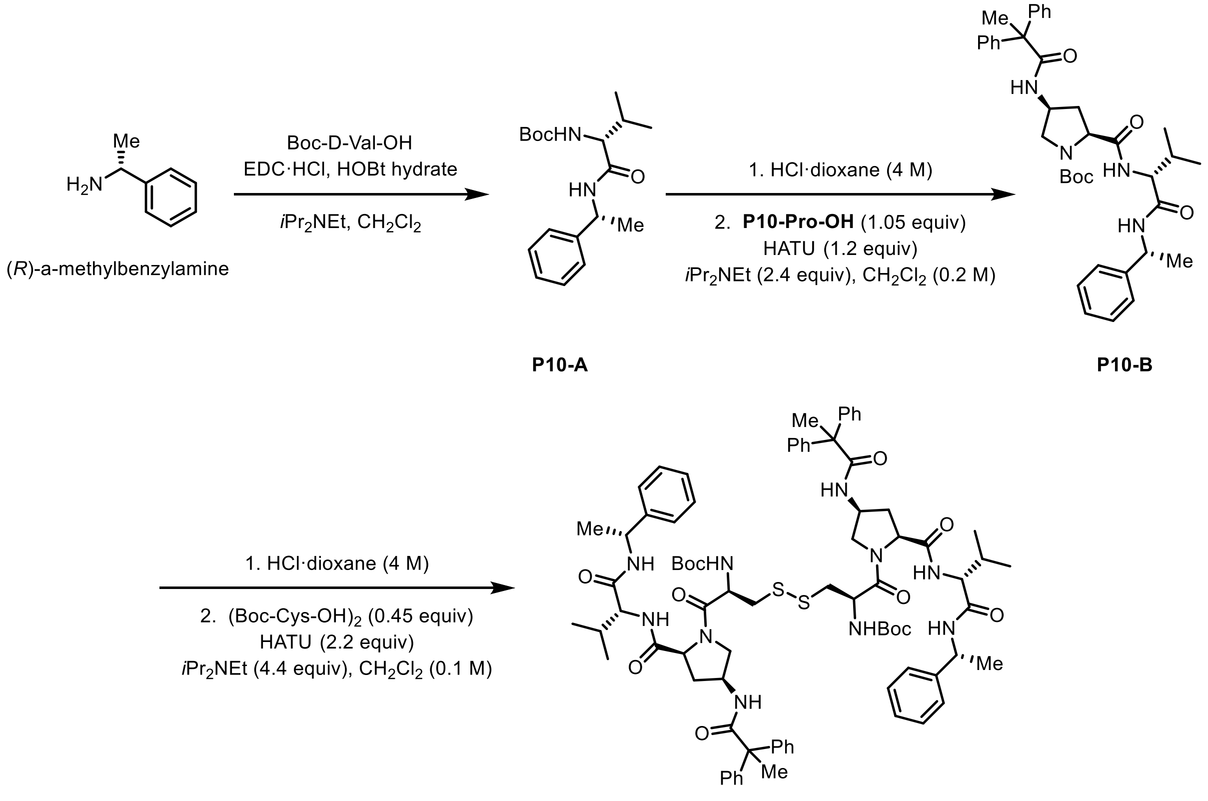
Deprotection and General Peptide Coupling Procedure B

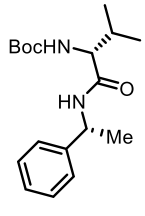
The peptide (1.0 equiv) was treated with HCl·dioxane (4 M, 4.0 equiv) and the reaction mixture was stirred for 1 h. The excess HCl was removed under a stream of N_2, and the reaction mixture was concentrated *in vacuo*. The residue was dissolved in CH_2Cl_2 (0.2 M), and *i*Pr_2NEt (2.4 equiv) was added. The Boc-protected amino acid (1.05 equiv) was added, followed by HATU (1.2 equiv), and the reaction mixture was stirred at RT. The reaction mixture was diluted with CH_2Cl_2, then washed with 10% (w/v) aqueous citric acid (2x), saturated aqueous $NaHCO_3$ (1x), and brine (1x), and then dried over Na_2SO_4. The dried organic phases were filtered and concentrated *in vacuo*. The crude product was purified by reversed-phase column chromatography.

Deprotection and Coupling 3

The peptide (1.0 equiv) was treated with HCl·dioxane (4 M, 4.0 equiv) and the reaction mixture was stirred for 1 h. The excess HCl was removed under a stream of N_2 and the reaction mixture was concentrated *in vacuo*. The residue was dissolved in CH_2Cl_2 (0.1 M) and *i*Pr_2NEt (4.4 equiv) was added. The amine-protected cystine (0.45 equiv) was added, followed by HATU (2.2 equiv), and the reaction mixture was stirred at RT. The reaction mixture was diluted with CH_2Cl_2, washed with 10% (w/v) aqueous citric acid (2x), saturated aqueous $NaHCO_3$ (1x), and brine (1x), and then dried over Na_2SO_4. The dried organic phases were filtered and concentrated *in vacuo*. The crude product was purified by reversed-phase column chromatography.

B. Synthesis and characterization of optimal catalyst P10





P10-A

Peptide Coupling 1 (P10-A). Boc-D-Val-OH (5 g, 23 mmol, 1.0 equiv) was dissolved in CH_2Cl_2 (115 mL, 0.2 M) and HOBt·H_2O (4.2 g, 27.6 mmol, 1.2 equiv) was added. (*R*)-α-Methylbenzylamine (3.2 mL, 25.3 mmol, 1.1 equiv) was added, followed by EDC·HCl (5.3 g, 27.6 mmol, 1.2 equiv) and *i*Pr_2NEt (9.6 mL, 55.2 mmol, 2.4 equiv), and the reaction mixture was allowed to stir at rt for 3 h. The reaction mixture was diluted with CH_2Cl_2 and washed with 10% (w/v) aqueous citric acid (2 x 150 mL), saturated aqueous $NaHCO_3$ (1 x 150 mL) and brine (1 x 150 mL), and then dried over Na_2SO_4. The dried organic phases were then filtered and concentrated *in vacuo*. The crude product was purified by reversed phase column chromatography (SNAP C18 60 g column; gradient = 30% MeCN/H_2O over 3 CV, then ramp 30–100% MeCN/H_2O over 12 CV, then 3 CV 100% MeCN; 75 mL/min flow rate; monitored λ = 210, 245 nm; 16 x 150 mm test tubes with 20 mL fractions). Fractions containing product were pooled and concentrated *in vacuo* to provide **P10-A** as a white solid (5.4 g, 73% yield).

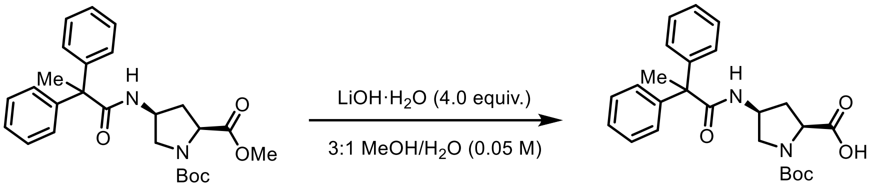
^{1}H NMR (600 MHz, $CDCl_3$) δ 7.32 (dtd, *J* = 14.1, 7.2, 6.8, 1.5 Hz, 4H), 7.28–7.23 (m, 1H), 6.17 (s, 1H), 5.12 (app p, *J* = 7.2 Hz, 1H), 5.08–4.96 (m, 1H), 3.83 (ddd, *J* = 8.0, 6.2, 1.4 Hz, 1H), 2.21–1.98 (m, 1H), 1.49 (dd, *J* = 7.0, 1.2 Hz, 3H), 1.43 (s, 9H), 0.90 (d, *J* = 6.4 Hz, 3H), 0.88 (d, *J* = 6.9 Hz, 3H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 170.8, 156.1, 143.0, 127.5, 126.3, 60.4, 48.9, 30.9, 28.4, 21.8, 19.5, 18.0.

IR (thin film, cm^{-1}) ν_{max} 3318, 2977, 1652, 1521, 1454, 1392, 1367, 1294, 1265, 1248, 1172, 1097, 1044, 1016, 871, 801, 739, 701, 666.

HRMS (ESI) (*m/z*) for $[M+H]^+$ $C_{18}H_{29}N_2O_3$ requires 321.2178, observed 321.2171.

$[\alpha]_D^{23}$ = +56.6° (*c* = 0.0067 g/mL, $CHCl_3$)

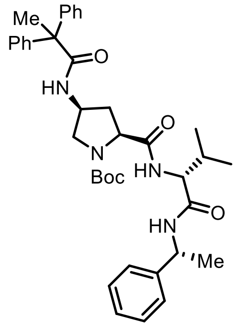


P10-Pro **P10-Pro-OH**

Saponification (P10-Pro-OH). *N*-Boc-(4*S*)-(2,2-diphenylpropanamido)-L-proline methyl ester (**P10-Pro**, 2.34 g, 5.2 mmol, 1.0 equiv) was dissolved in methanol/H_2O (3:1, 104 mL, 0.05 M) and $LiOH \cdot H_2O$ (0.87 g, 20.7 mmol, 4.0 equiv) was added. The reaction mixture was stirred at rt for 1 h, then acidified to pH = 2 with 1 N HCl, extracted with EtOAc (3 x 75 mL), washed with brine, and back-extracted with EtOAc (1 x 75 mL). The combined organic phases were dried over $MgSO_4$, filtered, and concentrated *in vacuo* to afford **P10-Pro-OH** as a white solid which was used without further purification.

HRMS (ESI) (*m/z*) for $[M+H]^+$ $C_{25}H_{31}N_2O_5$ requires 439.2233, observed 439.2227.

Deprotection and Coupling 2 (P10-B). The peptide **P10-A** (214 mg, 0.67 mmol, 1.0 equiv) was treated with HCl·dioxane (4 M, 4.0 equiv) and the reaction mixture was stirred for 1 h. The excess HCl was removed under a stream of N_2 and the reaction mixture was concentrated *in vacuo*. The residue was dissolved in CH_2Cl_2 (3.4 mL, 0.2 M) and *i*Pr_2NEt (0.28 mL, 1.61 mmol, 2.4 equiv) was added. *N*-Boc-(4*S*)-(2,2-diphenylpropanamido)-L-proline (**P10-Pro-OH** 322 mg, 0.73 mmol, 1.1 equiv) was added, followed by HATU (304 mg, 0.80 mmol, 1.2 equiv), and the reaction mixture was stirred at rt for 20 h. The reaction mixture was diluted with CH_2Cl_2, washed with 10% (w/v) aqueous citric acid (2 x 30 mL), saturated aqueous $NaHCO_3$ (30 mL), and brine (30 mL), and then dried over Na_2SO_4. The dried organic phases were filtered and concentrated *in vacuo*. The crude product was purified by reversed-phase column chromatography (SNAP C18 60 g column; gradient = 30% MeCN/H_2O over 3 CV, then ramp 30–100% MeCN/H_2O over 12 CV, then 3 CV 100% MeCN; 75 mL/min flow rate; monitored λ = 210, 245 nm; 16 x 150 mm test tubes with 20 mL fractions). Fractions containing product were pooled and concentrated *in vacuo* to provide the desired product as a white solid (225 mg, 52% yield).



P10-B

^{1}H NMR (600 MHz, methanol-*d*$_4$) (1:1.2 mixture of rotamers, asterisks denote minor rotamer peaks) δ 8.64 (d, *J* = 7.8 Hz, 1H), 8.25 (d, *J* = 8.1 Hz, 1H), 8.06 (d, *J* = 8.1 Hz, 1H), 7.96 (d, *J* = 8.4 Hz, 1H), 7.40 – 7.05 (m, 15H), 4.98 (q, *J* = 7.0 Hz, 1H), 4.91* (q, *J* = 7.0 Hz, 1H), 4.60–4.54 (m, *J* = 14.4, 5.6, 2.9 Hz, 1H), 4.36 (dd, *J* = 9.2, 3.5 Hz, 1H), 4.27* (dd, *J* = 9.3, 3.6 Hz, 1H), 4.21 (d, *J* = 4.8 Hz, 1H), 4.14* (d, *J* = 8.3 Hz, 1H), 3.63 (ddd, *J* = 17.4, 11.1, 5.8 Hz, 1H), 3.37 (ddd, *J* = 11.1, 3.2, 1.1 Hz, 1H), 2.52 (dddd, *J* = 29.3, 13.6, 9.3, 6.6 Hz, 1H), 2.30 (ddd, *J* = 13.9, 9.5, 5.9 Hz, 1H), 1.95 (s, 3H), 1.92* (s, 8H), 1.87* (app. sxt, *J* = 6.7 Hz, 3H), 1.81 (dt, *J* = 13.5, 3.5 Hz, 5H), 1.73 (dt, *J* = 13.5, 3.7 Hz, 4H), 1.54–1.41 (m, 3H), 1.40* (s, 9H), 1.32 (s, 9H), 0.89 (dd, *J* = 7.0, 3.7 Hz, 3H), 0.76 (dd, *J* = 11.0, 6.8 Hz, 3H).

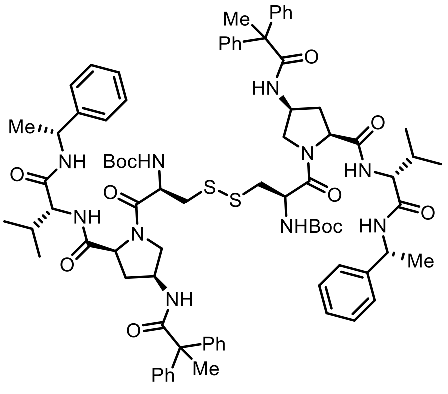
^{13}C NMR (151 MHz, methanol-*d*$_4$) δ 177.5, 177.2, 175.8, 175.0, 172.5, 171.8, 156.0, 155.6, 146.3, 146.2, 146.1, 146.0, 145.2, 145.1, 129.5, 129.4, 129.3, 128.2, 127.9, 127.7, 127.2, 127.0, 81.9, 81.6, 60.3, 60.1, 59.7, 59.6, 57.9, 54.6, 53.8, 50.5, 50.3, 37.5, 35.7, 33.0, 30.7, 28.7, 27.6, 22.6, 22.5, 19.8, 19.7, 19.0, 17.3.

IR (FT-ATR, cm^{-1}) ν_{max} 3294, 3062, 2972, 1641, 1516, 1494, 1445, 1391, 1366, 1306, 1232, 1161, 1128, 1099, 1028, 1002, 980, 895, 849, 761, 734, 697, 654, 547.

HRMS (ESI) (*m/z*) for $[M+H]^+$ $C_{38}H_{49}N_4O_5$ requires 641.3703, observed 641.3705.

$[\alpha]_D^{20}$ = –5.5° (*c* = 0.0067 g/mL, $CHCl_3$)

Deprotection and Coupling 3 (P10). The peptide **P10-B** (225 mg, 0.35 mmol, 1.0 equiv) was treated with HCl·dioxane (4 M, 4.0 equiv) and the reaction mixture was stirred for 1 h. The excess HCl was removed under a stream of N_2 and the reaction mixture was concentrated *in vacuo*. The residue was dissolved in CH_2Cl_2 (3.5 mL, 0.1 M) and *i*Pr_2NEt (0.27 mL, 1.54 mmol, 4.4 equiv) was added. $(Boc\text{-}Cys\text{-}OH)_2$ (70 mg, 0.16 mmol, 0.45 equiv) was added, followed by HATU (293 mg, 0.77 mmol, 2.2 equiv), and the reaction mixture was stirred at rt for 20 h. The reaction mixture was diluted with CH_2Cl_2, washed with 10% (w/v) aqueous citric acid (2 x 30 mL), saturated aqueous $NaHCO_3$ (30 mL), and brine (30 mL), and then dried over Na_2SO_4. The dried organic phases were filtered and concentrated *in vacuo*. The crude product was purified by reversed-phase column chromatography (SNAP C18 60 g column; gradient = 30% MeCN/H_2O over 3 CV, then ramp 30–100% MeCN/H_2O over 12 CV, then 3 CV 100% MeCN; 75 mL/min flow rate; monitored λ = 210, 245 nm; 16 x 150 mm test tubes with 20 mL fractions). Fractions containing product were pooled and concentrated *in vacuo* to provide **P10** as a white solid (170 mg, 36% yield).



P10

^{1}H NMR (600 MHz, methanol-*d*$_4$) (5:1 mixture of rotamers, asterisks denote minor rotamer peaks) δ 7.38–7.11 (m, 15H), 4.97 (q, *J* = 6.9 Hz, 1H), 4.75 (tt, *J* = 9.7, 4.3 Hz, 1H), 4.56 (dd, *J* = 9.5, 3.0

Hz, 1H), 4.43 (dd, $J = 8.3, 5.7$ Hz, 1H), 4.33* (s, 1H), 4.17 (d, $J = 4.6$ Hz, 1H), 3.95 (dd, $J = 11.0, 5.4$ Hz, 1H), 3.86* (s, 1H), 3.64 (d, $J = 10.8$ Hz, 1H), 3.58* (d, $J = 11.1$ Hz, 1H), 2.62 (dd, $J = 13.9, 5.6$ Hz, 1H), 2.59–2.42 (m, 2H), 2.32 (pd, $J = 7.0, 4.7$ Hz, 1H), 1.95 (s, 3H), 1.84* (s, 1H), 1.80 (dt, $J = 13.6, 2.9$ Hz, 1H), 1.49 (d, $J = 7.0$ Hz, 2H), 1.42 (s, 9H), 0.89 (d, $J = 6.9$ Hz, 6H).

^{13}C NMR (151 MHz, methanol-d_4) δ 177.2, 175.0, 172.5, 171.7, 157.5, 146.3, 145.9, 145.2, 129.4, 128.0, 127.9, 127.1, 111.4, 80.9, 61.0, 59.8, 58.0, 55.3, 54.8, 53.1, 51.0, 50.2, 49.6, 41.4, 34.9, 30.7, 28.8, 27.8, 22.7, 19.8, 17.3, 14.5.

IR (FT-ATR, cm^{-1}) ν_{max} 3293, 2972, 1712, 1638, 1494, 1442, 1391, 1367, 1304, 1245, 1160, 1049, 1026, 983, 919, 861, 761, 738, 697, 656, 544.

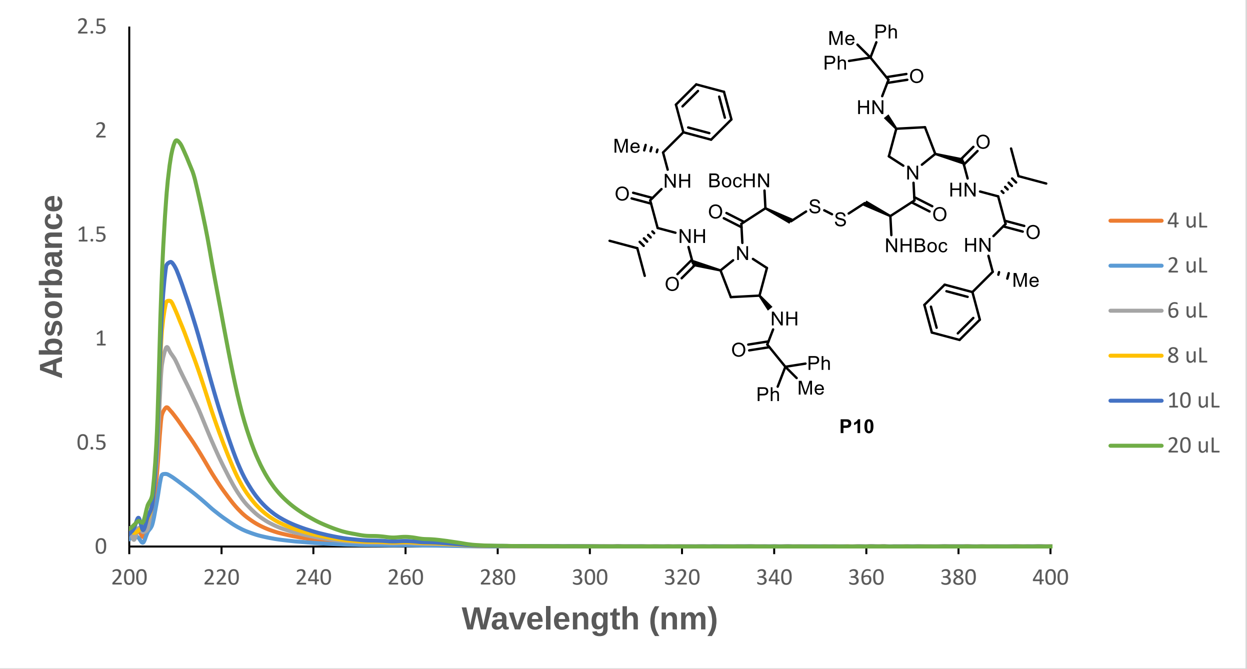
HRMS (ESI) (*m/z*) for $[M+H]^+$ $C_{82}H_{105}N_{10}O_{12}S_2$ requires 1485.7355, observed 1485.7338.

$[\alpha]_D^{20}$ = +35.7° (c = 0.0077 g/mL, $CHCl_3$)

C. UV-Vis Spectra of P10 and (Boc-Cys-OMe)$_2$

UV-Vis Spectrum of P10

Sequential aliquots of a 5 mM stock solution of **P10** in 2:1 hexanes:THF were added to a blank sample of 2:1 hexanes:THF (1.0 mL). Spectra were recorded at 2, 4, 6, 8, 10, and 20 µL (total volume of 5 mM solution added) and normalized by subtraction of the blank sample absorbance. The absorption feature at ~260 nm is consistent with an unhindered alkyl disulfide.[8]



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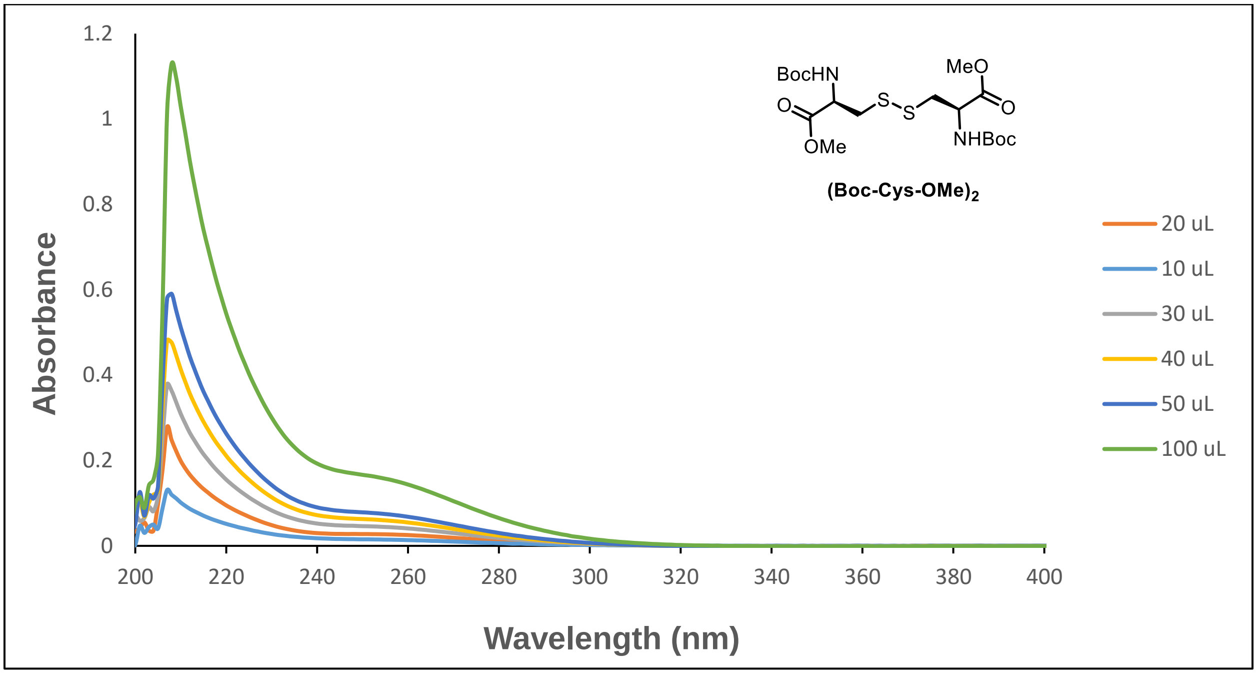
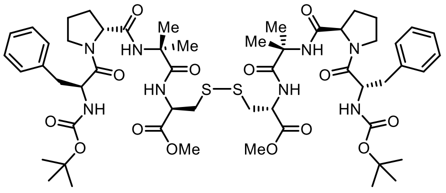
[8] Singleton, D. A.; Church, K. M. *J. Org. Chem.* **1990**, *55*, 4780.

UV-Vis Spectrum of $(Boc\text{-}Cys\text{-}OMe)_2$

Sequential aliquots of a 10 mM stock solution of $(Boc\text{-}Cys\text{-}OMe)_2$ in 2:1 hexanes:THF were added to a blank sample of 2:1 hexanes:THF (1.0 mL). Spectra were recorded at 10, 20, 30, 40, 50, and 100 µL (total volume of 5 mM solution added) and normalized by subtraction of the blank sample absorbance. The absorption feature at ~250 nm is consistent with an unhindered alkyl disulfide.[8]

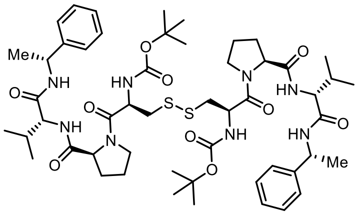


D. HRMS Analysis of Peptide Catalysts P1–P29



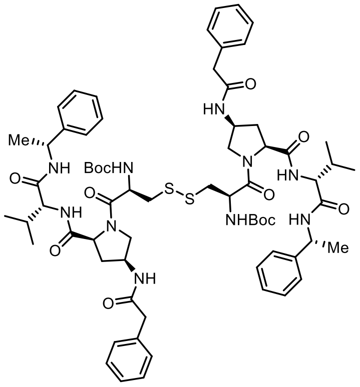
P1

HRMS: (m/z) for $[M+H]^+$ ($C_{54}H_{79}N_8O_{14}S_2$) requires 1127.5157, observed 1127.5142.



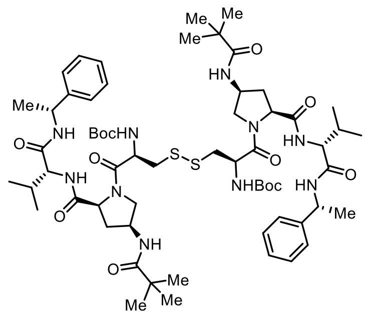
P2

HRMS: (m/z) for $[M+H]^+$ ($C_{52}H_{79}N_8O_{10}S_2$) requires 1039.5361, observed 1039.5352.



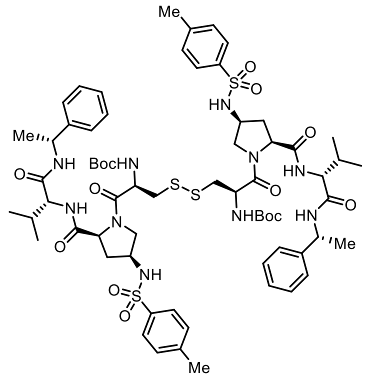
P3

HRMS: (m/z) for $[M+H]^+$ ($C_{68}H_{93}N_{10}O_{12}S_2$) requires 1305.6416, observed 1305.6404.



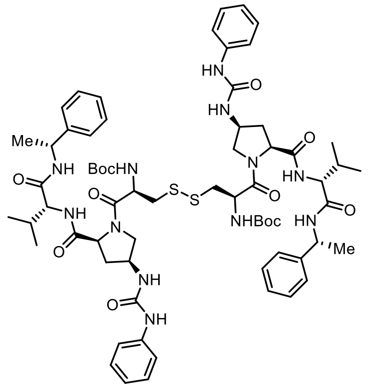
P4

HRMS: (m/z) for $[M+H]^+$ ($C_{62}H_{97}N_{10}O_{12}S_2$) requires 1237.6729, observed 1237.6709.



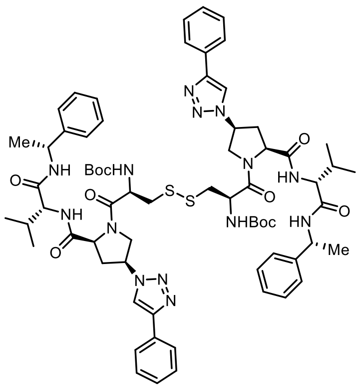
P5

HRMS: (m/z) for $[M+H]^+$ ($C_{66}H_{93}N_{10}O_{14}S_4$) requires 1377.5756, observed 1377.5735.



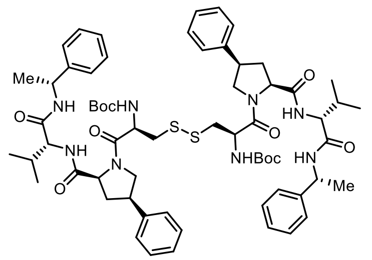
P6

HRMS: (m/z) for $[M+H]^+$ ($C_{66}H_{91}N_{12}O_{12}S_2$) requires 1307.6321, observed 1307.6310.



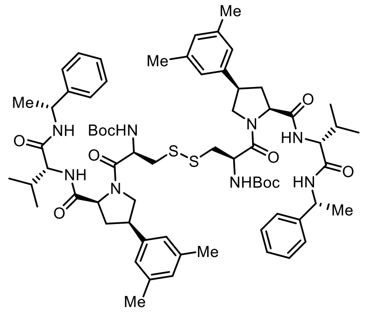
P7

HRMS: (m/z) for $[M+H]^+$ ($C_{68}H_{89}N_{14}O_{10}S_2$) requires 1325.6328, observed 1325.6299.



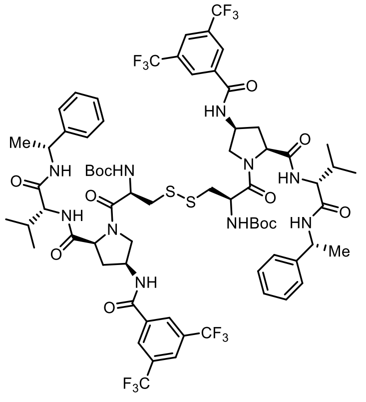
P8

HRMS: (m/z) for $[M+H]^+$ ($C_{64}H_{87}N_8O_{10}S_2$) requires 1191.5987, observed 1191.5979.



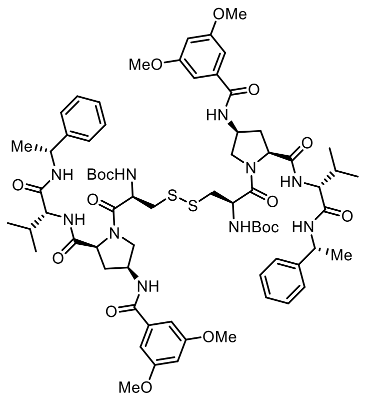
P9

HRMS: (m/z) for $[M+H]^+$ ($C_{68}H_{95}N_8O_{10}S_2$) requires 1247.6613, observed 1247.6610.



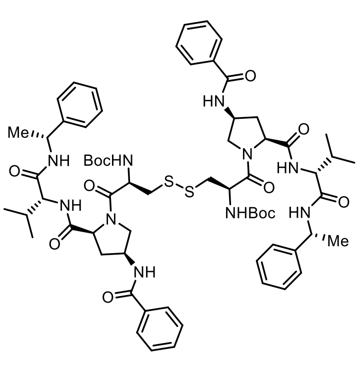
P11

HRMS: (m/z) for $[M+H]^+$ ($C_{70}H_{85}F_{12}N_{10}O_{12}S_2$) requires 1549.5598, observed 1549.5585.



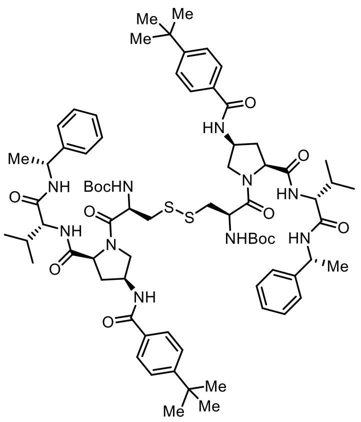
P12

HRMS: (m/z) for $[M+H]^+$ ($C_{70}H_{97}N_{10}O_{16}S_2$) requires 1397.6525, observed 1397.6519.

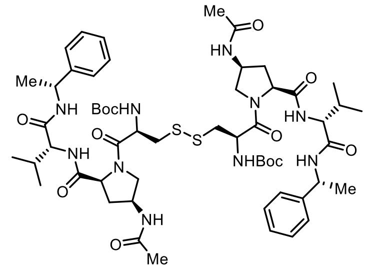


P13

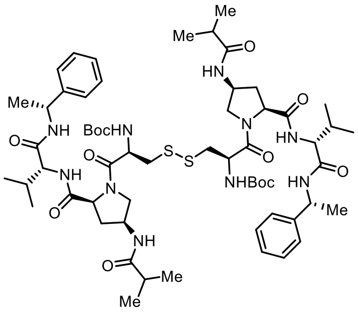
HRMS: (m/z) for $[M+H]^+$ ($C_{66}H_{89}N_{10}O_{12}S_2$) requires 1277.6103, observed 1277.6085.



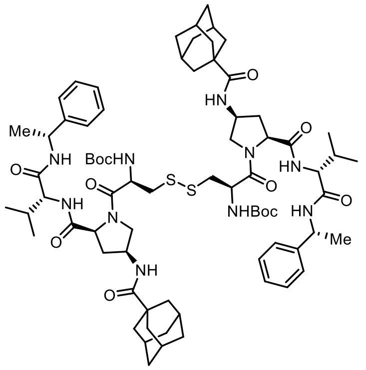
P14
HRMS: (m/z) for $[M+H]^+$ ($C_{74}H_{105}N_{10}O_{12}S_2$) requires 1389.7355, observed 1389.7349.



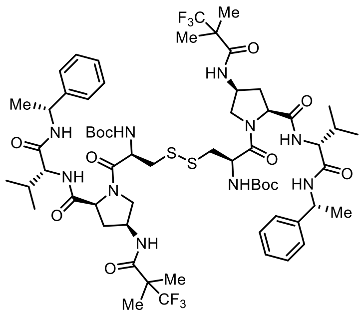
P15
HRMS: (m/z) for $[M+H]^+$ ($C_{56}H_{85}N_{10}O_{12}S_2$) requires 1153.5790, observed 1153.5782.



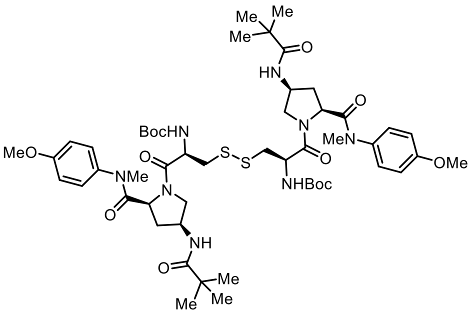
P16
HRMS: (m/z) for $[M+H]^+$ ($C_{60}H_{93}N_{10}O_{12}S_2$) requires 1209.6416, observed 1209.6388.



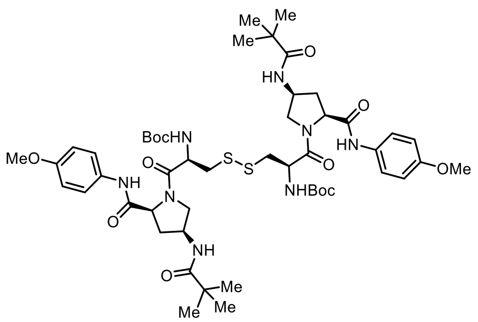
P17
HRMS: (m/z) for $[M+H]^+$ ($C_{74}H_{109}N_{10}O_{12}S_2$) requires 1393.7668, observed 1393.7634.



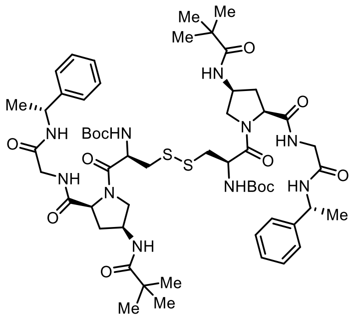
P18
HRMS: (m/z) for $[M+H]^+$ ($C_{62}H_{91}F_6N_{10}O_{12}S_2$) requires 1345.6164, observed 1345.6161.



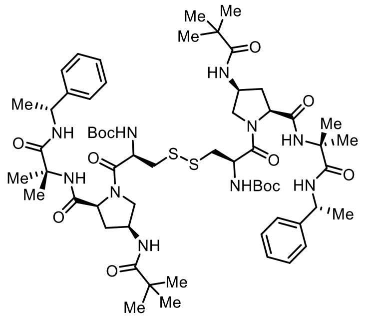
P19
HRMS: (m/z) for $[M+H]^+$ ($C_{52}H_{79}N_8O_{12}S_2$) requires 1071.5259, observed 1071.5251.



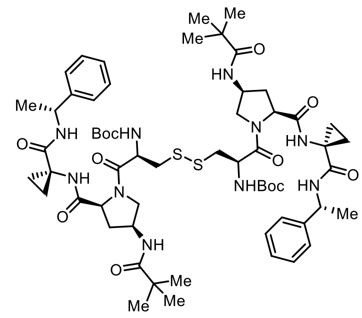
P20
HRMS: (m/z) for $[M+H]^+$ ($C_{50}H_{75}N_8O_{12}S_2$) requires 1043.4946, observed 1043.4941.



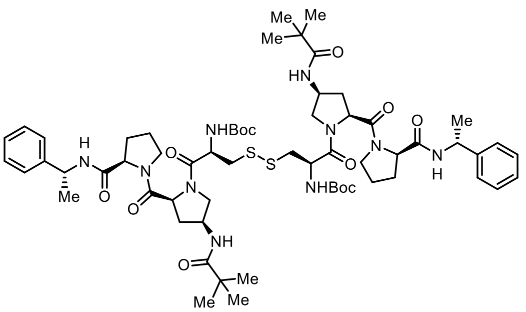
P21
HRMS: (m/z) for $[M+H]^+$ ($C_{56}H_{85}N_{10}O_{12}S_2$) requires 1153.5790, observed 1153.5774.



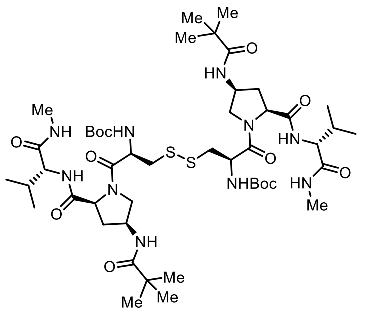
P22
HRMS: (m/z) for $[M+H]^+$ ($C_{60}H_{93}N_{10}O_{12}S_2$) requires 1209.6416, observed 1209.6403.



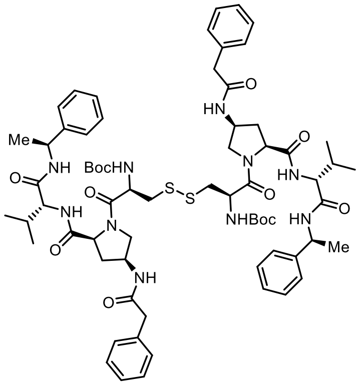
P23
HRMS: (m/z) for $[M+H]^+$ ($C_{60}H_{89}N_{10}O_{12}S_2$) requires 1205.6103, observed 1205.6079.



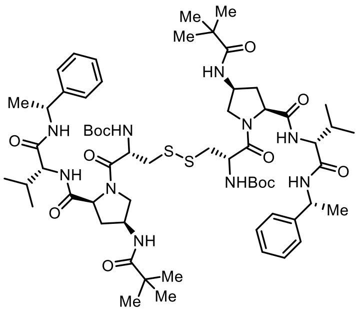
P24
HRMS: (m/z) for $[M+H]^+$ ($C_{62}H_{93}N_{10}O_{12}S_2$) requires 1233.6416, observed 1233.6387.



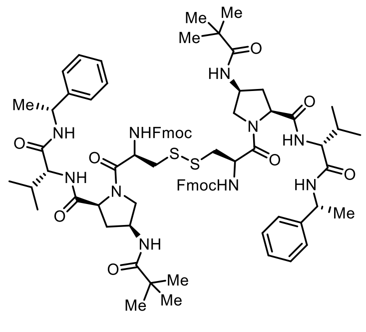
P25
HRMS: (m/z) for $[M+H]^+$ ($C_{48}H_{85}N_{10}O_{12}S_2$) requires 1057.5790, observed 1057.5775.



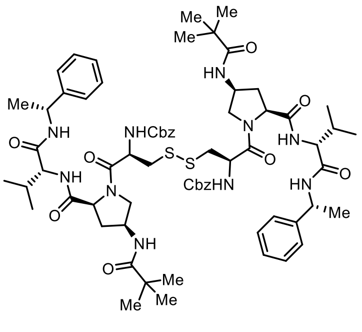
P26
HRMS: (m/z) for $[M+H]^+$ ($C_{68}H_{93}N_{10}O_{12}S_2$) requires 1305.6416, observed 1305.6396.



P27
HRMS: (m/z) for $[M+H]^+$ ($C_{62}H_{97}N_{10}O_{12}S_2$) requires 1237.6729, observed 1237.6702.



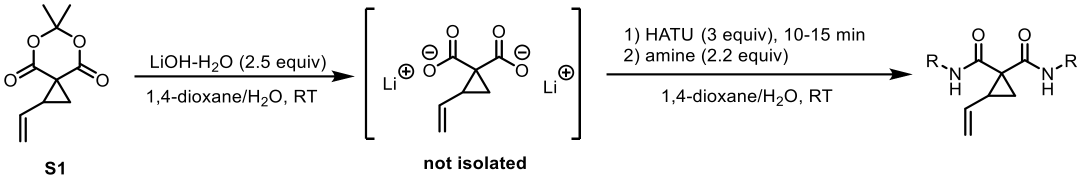
P28
HRMS: (m/z) for $[M+H]^+$ ($C_{82}H_{101}N_{10}O_{12}S_2$) requires 1481.7042, observed 1481.7015.



P29
HRMS: (m/z) for $[M+H]^+$ ($C_{68}H_{93}N_{10}O_{12}S_2$) requires 1305.6416, observed 1305.6394.

V. Synthesis and characterization of vinylcyclopropane substrates 1a–1h

A. General Procedure – Hydrolysis and Coupling

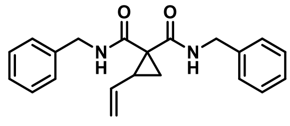


6,6-dimethyl-1-vinyl-5,7-dioxaspiro[2.5]octane-4,8-dione (**S1**) was prepared according to the literature method.[9]

S1 (1.0 equiv) was added to a round bottom flask equipped with a stir bar. 1,4-dioxane (0.3 M) was added and the solution was stirred to dissolve. LiOH•H_2O (2.5 equiv) was added, followed by H_2O (24 equiv). The flask was capped with a septum and purged with N_2. The heterogeneous mixture was stirred for 1–5 h at rt under N_2. The progress of the hydrolysis reaction was monitored by LCMS. Upon completion, the reaction mixture was a colorless, hazy suspension. To this suspension was added HATU (3.0 equiv), and the resulting mixture was stirred for 5–15 min to pre-activate, during which time it became a yellow-green color and precipitated a yellow solid. To this suspension was added the amine (2.2 equiv) and the reaction stirred overnight at rt under N_2. Reaction progress was monitored by LCMS. Upon reaction completion, the reaction mixture was diluted with EtOAc and washed with 10% (w/v) aqueous citric acid (2x), saturated aqueous $NaHCO_3$, and brine, and then dried over Na_2SO_4. The dried organic layers were then filtered through a short silica gel plug and concentrated *in vacuo*. The crude product was purified by silica gel column chromatography (EtOAc/hexanes). Some products contained residual amine after silica gel purification and were further purified by reversed-phase column chromatography.

B. Synthesis of 1a–1h

N,N'-dibenzyl-2-vinylcyclopropane-1,1-dicarboxamide (1a).



1a

Prepared according to a modification of the general procedure, using **S1** (1.73 g, 8.8 mmol), 1,4-dioxane (35 mL, 0.3 M), LiOH•H_2O (0.93 g, 22.1 mmol, 2.5 equiv), and H_2O (3.8 mL, 212 mmol, 24 equiv). The hydrolysis reaction was stirred for 4.5 h, then HATU (10.09 g, 26.5 mmol, 3.0 equiv) and benzylamine (2.15 mL, 19.4 mmol, 2.2 equiv) were added without pre-activation. The coupling reaction was stirred for 19 h, then diluted with EtOAc (100 mL), washed with 10% (w/v) aqueous citric acid (3 x 100 mL), saturated aqueous $NaHCO_3$ (1 x 150 mL), H_2O (1 x 100 mL), and brine (1 x 100 mL). The combined organic layers were dried over

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[9] Trost, B. M.; Morris, P. J.; Sprague, S. J. *J. Am. Chem. Soc.* **2012**, *134*, 17823.

Na_2SO_4, filtered, and solvent was removed *in vacuo* to yield a white solid. The crude product was purified by silica gel column chromatography (20→50% EtOAc/hexanes) to provide pure **1a** as a white solid (1.11 g, 3.3 mmol, 38% yield).

TLC $R_f = 0.57$ (50% EtOAc/hexanes)

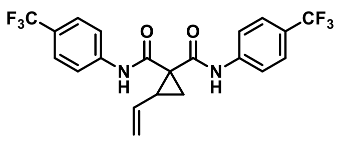
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.42 (s, 1H), 7.37–7.19 (m, 10H), 6.77 (s, 1H), 5.48 (ddd, *J* = 17.2, 10.2, 8.4 Hz, 1H), 5.29 (d, *J* = 17.1 Hz, 1H), 5.14 (d, *J* = 10.2 Hz, 1H), 4.51–4.36 (m, 4H), 2.27 (app. q, *J* = 8.3 Hz, 1H), 1.85 (dd, *J* = 8.9, 5.4 Hz, 1H), 1.46 (dd, *J* = 6.9, 5.4 Hz, 1H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 168.9, 168.3, 138.1, 137.7, 134.0, 128.9, 128.9, 127.9, 127.8, 127.8, 127.6, 118.7, 44.2, 44.1, 37.2, 32.0, 17.7.

IR (FT-ATR, cm^{-1}) ν_{max} 3251, 1660, 1624, 1549, 1495, 1453, 1360, 1335, 1324, 1283, 1230, 1208, 1175, 1080, 1040, 1028, 994, 950, 916, 880, 780, 750, 694, 659, 602, 529, 479.

HRMS (ESI) (*m/z*) for $[M+H]^+$ $C_{21}H_{23}N_2O_2$ requires 335.1760, observed 335.1762.

N,N'-bis(4-(trifluoromethyl)phenyl)-2-vinylcyclopropane-1,1-dicarboxamide (1b).



1b

Prepared according to the general procedure, using **S1** (2.00 g, 10.2 mmol), 1,4-dioxane (34 mL, 0.3 M), LiOH•H_2O (1.08 g, 25.5 mmol, 2.5 equiv), and H_2O (4.4 mL, 244.6 mmol, 24 equiv). The hydrolysis reaction was stirred for 3 h, then HATU (9.69 g, 25.5 mmol, 2.5 equiv) was added. The reaction was pre-activated for 10 min, then 4-(trifluoromethyl)aniline (2.82 mL, 22.4 mmol, 2.2 equiv) was added. The coupling reaction was stirred for 18 h, then diluted with EtOAc (200 mL), washed with 10% (w/v) aqueous citric acid (2 x 150 mL), saturated aqueous $NaHCO_3$ (1 x 150 mL), and brine (1 x 150 mL). The combined organic layers were dried over Na_2SO_4, filtered, and solvent was removed *in vacuo* to yield an orange solid. The crude product was purified by silica gel column chromatography (10→50% EtOAc/hexanes) to yield semi-crude product containing residual 4-(trifluoromethyl)aniline. The semi-crude product was further purified by reversed-phase column chromatography on a Biotage Isolara One purification system (SNAP C18 120 g column; gradient = Ramp 20-100% MeCN/H_2O with 0.1% formic acid over 15 column volumes (CV), then 3 CV 100% MeCN with 0.1% formic acid; 75 mL/min flow rate; monitored λ = 210, 245 nm; 16 x 150 mm test tubes with 20 mL fractions). Fractions containing product were pooled and concentrated *in vacuo* to provide pure **1b** as a white solid (890 mg, 2.01 mmol, 20% yield).

TLC $R_f = 0.33$ (20% EtOAc/hexanes)

^{1}H NMR (400 MHz, $CDCl_3$) δ 9.37 (s, 1H), 8.45 (s, 1H), 7.72–7.56 (m, 8H), 5.63 (ddd, *J* = 17.0, 10.2, 8.0 Hz, 1H), 5.44 (dt, *J* = 17.0, 1.1 Hz, 1H), 5.30 (dt, *J* = 10.2, 1.1 Hz, 1H), 2.49 (app. q, *J* = 8.0 Hz, 1H), 2.16 (dd, *J* = 9.0, 5.8 Hz, 1H), 1.76 (dd, *J* = 7.1, 5.8 Hz, 1H).

^{1}H NMR (600 MHz, DMSO-d_6) δ 10.57 (s, 1H), 10.17 (s, 1H), 7.85 (dd, *J* = 8.6, 4.1 Hz, 4H), 7.66 (d, *J* = 8.1 Hz, 4H), 5.44 (ddd, *J* = 17.1, 10.2, 8.5 Hz, 1H), 5.34 (dd, *J* = 17.1, 1.9 Hz, 1H), 5.11 (dd, *J* = 10.2, 1.9 Hz, 1H), 2.75 (app. q, *J* = 8.3 Hz, 1H), 1.84 (dd, *J* = 7.2, 4.8 Hz, 1H), 1.56 (dd, *J* = 9.0, 4.8 Hz, 1H).

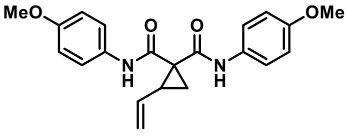
^{13}C NMR (151 MHz, DMSO-d_6) δ 167.5, 165.3, 142.7, 142.5, 134.0, 125.8 (q, *J* = 3.6 Hz), 125.7 (q, *J* = 3.6 Hz), 124.4 (q, *J* = 271.5 Hz), 124.4 (q, *J* = 271.5 Hz), 123.6 (q, *J* = 31.7 Hz), 123.5 (q, *J* = 31.7 Hz), 120.4, 119.8, 118.2, 40.0, 30.1, 19.3.

^{19}F NMR (376 MHz, $CDCl_3$) δ –62.7 (s, 3F), –62.8 (s, 3F).

IR (FT-ATR, cm^{-1}) ν_{max} 3305, 1694, 1635, 1615, 1596, 1523, 1509, 1409, 1322, 1249, 1183, 1161, 1119, 1106, 1066, 1015, 990, 955, 946, 920, 860, 840, 819, 794, 758, 731, 694, 645, 594, 523, 509, 464, 412.

HRMS (ESI) (*m/z*) for $[M+H]^+$ $C_{21}H_{17}F_6N_2O_2$ requires 443.1194, observed 443.1185.

N,*N'*-bis(4-methoxyphenyl)-2-vinylcyclopropane-1,1-dicarboxamide (1c).



1c

Prepared according to the general procedure, using **S1** (1.00 g, 5.1 mmol), 1,4-dioxane (17 mL, 0.3 M), LiOH•H_2O (0.54 g, 12.8 mmol, 2.5 equiv), and H_2O (2.2 mL, 122.4 mmol, 24 equiv). The hydrolysis reaction was stirred for 1 h, then HATU (5.82 g, 15.3 mmol, 3.0 equiv) was added. The reaction was pre-activated for 15 min, then 4-methoxyaniline (1.41 g, 11.2 mmol, 2.2 equiv) was added. The coupling reaction was stirred for 30 h, then diluted with EtOAc (100 mL), washed with 10% (w/v) aqueous citric acid (2 x 100 mL), saturated aqueous $NaHCO_3$ (1 x 100 mL), and brine (1 x 100 mL). The combined organic layers were dried over Na_2SO_4, filtered, and solvent was removed *in vacuo* to yield a brown oil. The crude product was purified by silica gel column chromatography (20→70% EtOAc/hexanes) to provide pure **1c** as an off-white solid (328 mg, 0.89 mmol, 18% yield).

TLC R_f = 0.53 (50% EtOAc/hexanes)

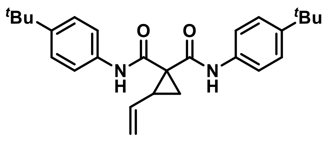
^{1}H NMR (400 MHz, $CDCl_3$) δ 9.10 (s, 1H), 8.26 (s, 1H), 7.48–7.36 (m, 4H), 6.93–6.81 (m, 4H), 5.60 (ddd, *J* = 17.0, 10.2, 8.4 Hz, 1H), 5.38 (d, *J* = 17.2 Hz, 1H), 5.22 (d, *J* = 10.4 Hz, 1H), 3.80 (s, 3H), 3.79 (s, 3H), 2.40 (td, *J* = 8.7, 6.9 Hz, 1H), 2.06 (dd, *J* = 9.0, 5.6 Hz, 1H), 1.64 (dd, *J* = 6.9, 5.6 Hz, 1H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 166.8, 166.7, 157.2, 156.7, 133.7, 130.8, 130.1, 122.5, 122.1, 119.3, 114.4, 114.3, 55.7, 55.6, 38.3, 32.7, 17.9.

IR (FT-ATR, cm^{-1}) ν_{max} 3253, 1664, 1641, 1599, 1529, 1508, 1465, 1441, 1412, 1340, 1302, 1239, 1170, 1144, 1111, 1033, 994, 937, 924, 908, 874, 821, 798, 744, 721, 706, 669, 576, 546, 520, 444.

HRMS (ESI) (*m/z*) for $[M+H]^+$ $C_{21}H_{23}N_2O_4$ requires 367.1658, observed 367.1659.

N,N'-bis(4-(tert-butyl)phenyl)-2-vinylcyclopropane-1,1-dicarboxamide (1d).



1d

Prepared according to a modification of the general procedure, using **S1** (1.00 g, 5.1 mmol), 1,4-dioxane (17 mL, 0.3 M), LiOH•H_2O (0.54 g, 12.8 mmol, 2.5 equiv), and H_2O (2.2 mL, 122.4 mmol, 24 equiv). The hydrolysis reaction was stirred for 2.5 h, then HATU (4.92 g, 12.7 mmol, 2.5 equiv) was added. The reaction was pre-activated for 5 min, then 4-(*tert*-butyl)aniline (1.40 mL, 11.2 mmol, 2.2 equiv) was added. The coupling reaction was stirred for 21 h, then diluted with EtOAc (100 mL), washed with 10% (w/v) aqueous citric acid (2 x 100 mL), saturated aqueous $NaHCO_3$ (1 x 100 mL), and brine (1 x 100 mL). The combined organic layers were dried over Na_2SO_4, filtered, and solvent was removed *in vacuo* to yield a foamy orange solid. The crude product was purified by silica gel column chromatography (10→50% EtOAc/hexanes) to yield semi-crude product containing residual 4-(*tert*-butyl)aniline. The semi-crude product was further purified by reversed-phase column chromatography on a Biotage Isolara One purification system (SNAP C18 120 g column; gradient = Ramp 20-100% MeCN/H_2O with 0.1% formic acid over 15 column volumes (CV), then 3 CV 100% MeCN with 0.1% formic acid; 75 mL/min flow rate; monitored $\lambda = 210, 245$ nm; 16 x 150 mm test tubes with 20 mL fractions). Fractions containing product were pooled and concentrated *in vacuo* to provide pure **1d** as a foamy white solid (652 mg, 1.56 mmol, 30% yield).

TLC $R_f = 0.34$ (20% EtOAc/hexanes)

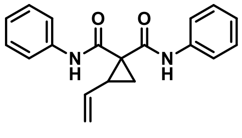
^{1}H NMR (500 MHz, $CDCl_3$) δ 9.12 (s, 1H), 8.37 (s, 1H), 7.48–7.31 (m, 8H), 5.58 (ddd, *J* = 16.7, 10.2, 8.5 Hz, 1H), 5.37 (d, *J* = 17.0 Hz, 1H), 5.21 (d, *J* = 10.2 Hz, 1H), 2.39 (app. q, *J* = 8.2 Hz, 1H), 2.05 (dd, *J* = 9.0, 5.6 Hz, 1H), 1.65 (app. t, *J* = 6.3 Hz, 1H), 1.31 (s, 9H), 1.30 (s, 9H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 166.8, 166.8, 148.4, 147.7, 135.0, 134.5, 133.7, 126.1, 126.0, 120.4, 120.1, 119.3, 38.7, 34.6, 34.5, 32.7, 31.5, 31.5, 18.0.

IR (thin film, cm^{-1}) ν_{max} 3295, 1670, 1653, 1594, 1518, 1408, 1363, 1321, 1301, 1268, 1251, 1194, 1111, 834.

HRMS (ESI) (*m/z*) for $[M+H]^+$ $C_{27}H_{35}N_2O_2$ requires 419.2699, observed 419.2696.

N,N'-diphenyl-2-vinylcyclopropane-1,1-dicarboxamide (1e).



1e

Prepared according to the general procedure, using **S1** (1.01 g, 5.1 mmol), 1,4-dioxane (17 mL, 0.3 M), LiOH•H_2O (0.54 g, 12.8 mmol, 2.5 equiv), and H_2O (2.2 mL, 122.4 mmol, 24 equiv). The hydrolysis reaction was stirred for 1 h, then HATU (5.82 g, 15.3 mmol, 3.0 equiv) was added. The reaction was pre-activated for 15 min, then aniline (1.05 mL, 11.2 mmol, 2.2 equiv) was added. The coupling reaction was stirred for 25 h, then diluted with EtOAc (100 mL), washed with 10% (w/v) aqueous citric acid (2 x 100 mL), saturated aqueous $NaHCO_3$ (1 x 100 mL), and brine (1 x 100 mL). The combined organic layers were dried over Na_2SO_4, filtered, and solvent was removed *in vacuo* to yield an oily brown solid. The crude product was purified by silica gel column chromatography (10→50% EtOAc/hexanes) to provide pure **1e** as an off-white solid (561 mg, 1.83 mmol, 36% yield).

TLC R$_f$ = 0.30 (20% EtOAc/hexanes)

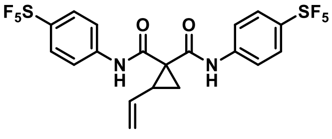
^{1}H NMR (400 MHz, CDCl$_3$) δ 9.21 (s, 1H), 8.42 (s, 1H), 7.58–7.48 (m, 4H), 7.40–7.28 (m, 4H), 7.21 – 7.08 (m, 2H), 5.60 (ddd, *J* = 17.0, 10.2, 8.3 Hz, 1H), 5.39 (d, *J* = 16.7 Hz, 1H), 5.23 (d, *J* = 10.5 Hz, 1H), 2.42 (td, *J* = 8.7, 6.9 Hz, 1H), 2.08 (dd, *J* = 9.0, 5.6 Hz, 1H), 1.67 (dd, *J* = 6.9, 5.6 Hz, 1H).

^{13}C NMR (151 MHz, CDCl$_3$) δ 166.9, 166.8, 137.6, 137.1, 133.6, 129.3, 129.2, 125.4, 124.8, 120.6, 120.3, 119.5, 38.7, 32.9, 18.0.

IR (FT-ATR, cm^{-1}) ν_{max} 3302, 1662, 1595, 1549, 1519, 1500, 1441, 1336, 1313, 1296, 1251, 1184, 985, 943, 920, 877, 835, 786, 751, 737, 712, 688, 677, 664, 601, 579, 509, 497, 455.

HRMS (ESI) (*m/z*) for [M+H]$^+$ $C_{19}H_{19}N_2O_2$ requires 307.1447, observed 307.1459.

N,N'-bis(4-(pentafluoro-λ^6-sulfanyl)phenyl)-2-vinylcyclopropane-1,1-dicarboxamide (1f).



1f

Prepared according to a modification of the general procedure, using **S1** (1.00 g, 5.1 mmol), 1,4-dioxane (17 mL, 0.3 M), LiOH•H$_2$O (0.55 g, 12.7 mmol, 2.5 equiv), and H$_2$O (2.2 mL, 122.3 mmol, 24 equiv). The hydrolysis reaction was stirred for 2.5 h, then HATU (4.28 g, 11.2 mmol, 2.2 equiv) was added. The reaction was pre-activated for 10 min, then 4-(pentafluorothio)aniline (2.47 g, 11.2 mmol, 2.2 equiv) was added. The coupling reaction was stirred for 14 h, then diluted with EtOAc (200 mL), washed with 10% (w/v) aqueous citric acid (2 x 200 mL), saturated aqueous NaHCO$_3$ (1 x 200 mL), and brine (1 x 200 mL). The combined organic layers were dried over Na$_2$SO$_4$, filtered, and solvent was removed *in vacuo* to yield an orange oil. The crude product was purified by silica gel column chromatography (10→50% EtOAc/hexanes) to yield semi-crude product containing residual 4-(pentafluorothio)aniline. The semi-crude product was further purified by reversed-phase column chromatography on a Biotage Isolara One purification system (SNAP C18 120 g column; gradient = Ramp 20-100% MeCN/H$_2$O with 0.1% formic acid over 15 column volumes (CV), then 3 CV 100% MeCN with 0.1% formic acid; 75 mL/min flow rate; monitored λ = 210, 245 nm; 16 x 150 mm test tubes with 20 mL fractions). Fractions containing product were pooled and concentrated *in vacuo* to provide pure **1f** as a white solid (763 mg, 1.37 mmol, 26% yield).

TLC R$_f$ = 0.22 (20% EtOAc/hexanes)

^{1}H NMR (600 MHz, CDCl$_3$) δ 9.39 (s, 1H), 8.44 (s, 1H), 7.77–7.71 (m, 4H), 7.66–7.60 (m, 4H), 5.63 (ddd, *J* = 17.0, 10.2, 7.9 Hz, 1H), 5.44 (d, *J* = 17.0 Hz, 1H), 5.31 (d, *J* = 10.4 Hz, 1H), 2.50 (app. q, *J* = 8.1 Hz, 1H), 2.17 (dd, *J* = 9.1, 5.9 Hz, 1H), 1.78 (dd, *J* = 7.2, 5.9 Hz, 1H).

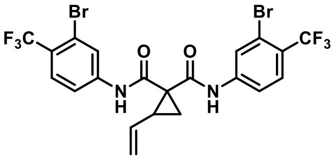
^{13}C NMR (151 MHz, $CDCl_3$) δ 167.2, 166.9, 150.2 (p, *J* = 17.5 Hz), 149.6 (p, *J* = 17.5 Hz), 140.1, 139.4, 132.7, 127.4 (p, *J* = 4.5 Hz), 127.2 (p, *J* = 4.5 Hz), 120.6, 119.9, 119.6, 38.3, 34.0, 18.4.

^{19}F NMR (376 MHz, $CDCl_3$) δ 85.2–83.0 (m, 2F), 63.0 (d, *J* = 38.3 Hz, 4F), 62.6 (d, *J* = 38.3 Hz, 4F).

IR (FT-ATR cm^{-1}) ν_{max} 3378, 3330, 1698, 1637, 1596, 1539, 1515, 1404, 1335, 1315, 1251, 1100, 951, 930, 873, 855, 814, 779, 728, 670, 649, 633, 621, 600, 590, 574, 540, 520, 406.

HRMS (ESI) (*m/z*) for $[M+H]^+$ $C_{19}H_{17}F_{10}N_2O_2S_2$ requires 559.0572, observed 559.0574.

***N,N'*-bis(3-bromo-4-(trifluoromethyl)phenyl)-2-vinylcyclopropane-1,1-dicarboxamide (1g).**



1g

Prepared according to a modification of the general procedure, using **S1** (1.00 g, 5.1 mmol), 1,4-dioxane (17 mL, 0.3 M), LiOH•H_2O (0.55 g, 12.7 mmol, 2.5 equiv), and H_2O (2.2 mL, 122.3 mmol, 24 equiv). The hydrolysis reaction was stirred for 2.5 h, then HATU (4.89 g, 12.7 mmol, 2.5 equiv) was added. The reaction was pre-activated for 10 min, then 3-bromo-4-(trifluoromethyl)aniline (2.86 g, 11.2 mmol, 2.2 equiv) was added. The coupling reaction was stirred for 17 h, then diluted with EtOAc (100 mL), washed with 10% (w/v) aqueous citric acid (2 x 100 mL), saturated aqueous $NaHCO_3$ (1 x 100 mL), and brine (1 x 100 mL). The combined organic layers were dried over Na_2SO_4, filtered, and solvent was removed *in vacuo* to yield an orange oil. The crude product was purified by silica gel column chromatography (10→50% EtOAc/hexanes) to yield semi-crude product containing residual 3-bromo-4-(trifluoromethyl)aniline. The semi-crude product was further purified by reversed-phase column chromatography on a Biotage Isolara One purification system (SNAP C18 120 g column; gradient = Ramp 20-100% MeCN/H_2O with 0.1% formic acid over 15 column volumes (CV), then 3 CV 100% MeCN with 0.1% formic acid; 75 mL/min flow rate; monitored λ = 210, 245 nm; 16 x 150 mm test tubes with 20 mL fractions). Fractions containing product were pooled and concentrated *in vacuo* to provide pure **1g** as a foamy white solid (302 mg, 0.50 mmol, 10% yield).

TLC R_f = 0.30 (20% EtOAc/hexanes)

^{1}H NMR (600 MHz, $CDCl_3$) δ 9.41 (s, 1H), 8.48 (s, 1H), 8.05–7.99 (m, 2H), 7.68–7.62 (m, 2H), 7.59 – 7.51 (m, 2H), 5.63 (ddd, *J* = 17.0, 10.2, 7.8 Hz, 1H), 5.45 (d, *J* = 17.0 Hz, 1H), 5.33 (d, *J* = 10.2 Hz, 1H), 2.51 (app. q, *J* = 7.9 Hz, 1H), 2.16 (dd, *J* = 9.1, 6.0 Hz, 1H), 1.78 (dd, *J* = 7.3, 6.0 Hz, 1H).

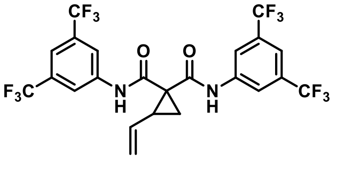
^{13}C NMR (151 MHz, $CDCl_3$) δ 167.2, 166.9, 141.1, 140.5, 132.5, 128.7 (q, *J* = 5.4 Hz), 128.6 (q, *J* = 5.4 Hz), 126.7 (q, *J* = 31.8 Hz), 126.1 (q, *J* = 31.8 Hz), 126.0, 125.8, 123.0 (q, *J* = 272.6 Hz), 122.9 (q, *J* = 272.6 Hz), 121.0, 120.8, 120.8, 118.3, 118.1, 38.1, 34.3, 18.6.

^{19}F NMR (376 MHz, $CDCl_3$) δ –62.5 (s, 3F), –62.6 (s, 3F).

IR (FT-ATR, cm^{-1}) ν_{max} 3274, 3108, 1655, 1594, 1515, 1390, 1309, 1261, 1179, 1123, 1093, 1020, 987, 920, 876, 828, 799, 759, 679, 609, 446.

HRMS (ESI) (*m/z*) for $[M+H]^+$ $C_{21}H_{15}Br_2F_6N_2O_2$ requires 598.9404, observed 598.9404.

***N,N'*-bis(3,5-bis(trifluoromethyl)phenyl)-2-vinylcyclopropane-1,1-dicarboxamide (1h).**



1h

Prepared according to a modification of the general procedure, using **S1** (1.02 g, 5.1 mmol), 1,4-dioxane:MeCN 1:1 (34 mL, 0.15 M), LiOH•H_2O (1.10 g, 25.4 mmol, 5.0 equiv), and H_2O (2.2 mL, 122.3 mmol, 24 equiv). The hydrolysis reaction was stirred for 6.5 h, then HATU (4.85 g, 12.7 mmol, 2.5 equiv) was added. The reaction was pre-activated for 10 min, then 3,5-bis(trifluoromethyl)aniline (1.80 mL, 11.2 mmol, 2.2 equiv) was added. The coupling reaction was stirred for 19 h, then diluted with EtOAc (150 mL), washed with 10% (w/v) aqueous citric acid (2 x 100 mL), saturated aqueous $NaHCO_3$ (1 x 100 mL), and brine (1 x 100 mL). The combined organic layers were dried over Na_2SO_4, filtered, and solvent was removed *in vacuo* to yield an orange oil. The crude product was purified by silica gel column chromatography (10→50% EtOAc/hexanes) to yield semi-crude product containing trace impurities. The semi-crude product was further purified by silica gel column chromatography (5→20% EtOAc/hexanes) to provide pure **1h** as a white solid (203 mg, 0.35 mmol, 7% yield).

TLC R_f = 0.51 (20% EtOAc/hexanes)

^{1}H NMR (400 MHz, $CDCl_3$) δ 9.54 (s, 1H), 8.61 (s, 1H), 8.11–7.99 (m, 4H), 7.71–7.63 (m, 2H), 5.69 (ddd, *J* = 17.5, 10.2, 7.6 Hz, 1H), 5.48 (d, *J* = 17.0 Hz, 1H), 5.37 (d, *J* = 10.2 Hz, 1H), 2.56 (app. q, *J* = 7.9 Hz, 1H), 2.21 (dd, *J* = 9.1, 6.1 Hz, 1H), 1.85 (app. t, J = 6.7 Hz, 1H).

^{13}C NMR (151 MHz, acetone-*d_6*) δ 168.6, 167.1, 141.5, 141.5, 134.5, 132.5 (q, *J* = 33.2 Hz), 132.4 (q, *J* = 33.2 Hz), 124.3 (q, *J* = 271.8 Hz), 124.3 (q, *J* = 271.8 Hz), 121.3–121.1 (m), 120.9– 120.7 (m), 119.2, 117.8 (q, *J* = 3.7 Hz), 117.7 (q, *J* = 3.7 Hz), 40.5, 33.3, 19.6.

^{19}F NMR (376 MHz, $CDCl_3$) δ –63.5 (s, 6F), –63.5 (s, 6F).

IR (FT-ATR cm^{-1}) ν_{max} 3301, 1657, 1629, 1576, 1472, 1442, 1378, 1311, 1274, 1172, 1126, 1110, 927, 886, 847, 746, 730, 722, 700, 680, 624, 605, 592, 464.

HRMS (ESI) (*m/z*) for $[M+H]^+$ $C_{23}H_{15}F_{12}N_2O_2$ requires 579.0942, observed 579.0934.

VI. Enantioselective ring-opening/cycloaddition of vinylcyclopropanes

A. Screening procedure for peptide catalysts

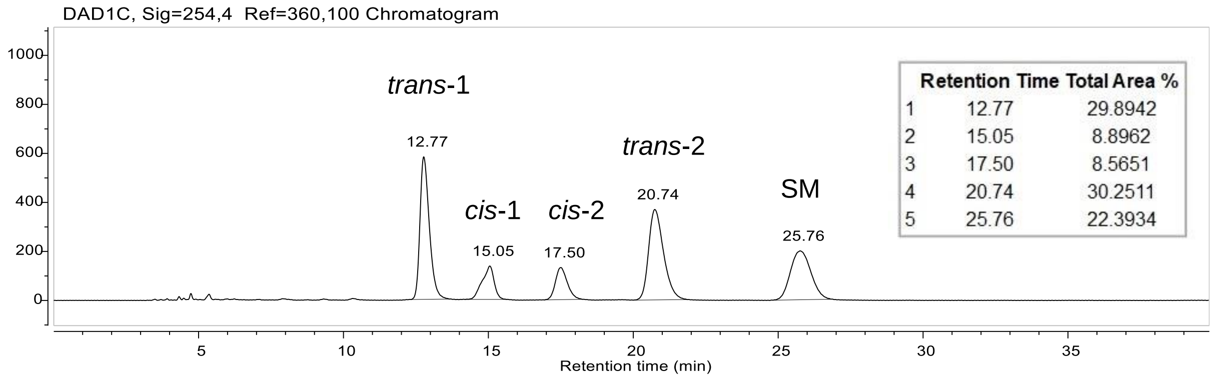
Vinylcyclopropane substrate **1b** (22.1 mg, 0.05 mmol, 1.0 equiv) and disulfide peptide catalyst (0.0025 mmol, 5 mol %) were added to a 5 mL microwave vial equipped with a stir bar. *tert*-butyl vinyl ether (TBVE, 13.1 µL, 0.1 mmol, 2 equiv) was added, then the reactants were dissolved in 1.0 mL of solvent (0.05 M substrate) and the vial was capped with a septum. A vent needle was added and argon was bubbled through solution for > 30 seconds to purge the solution of oxygen. Ar and vent needles were removed and the septum-sealed flask was placed in front of a UV lamp (~6 inches from lamp head). The solution was stirred at ambient temperature (fan-cooled) for 16 h in front of unfiltered UV. After 16 h, the reaction was quenched by exposure to air. The solution was transferred to a 20 mL scintillation vial (rinsing with 5 mL DCM) and solvent was removed *in vacuo*. The crude reaction mixture was then dissolved in 1 mL EtOAc and passed through a silica gel plug to remove the peptide, eluting with 5 mL EtOAc. Solvent was removed *in vacuo*, then the residue was dissolved in 2:1 hexanes:iPrOH (3 mL) and analyzed by chiral HPLC.

Chiral HPLC: Chiralpak IA, 5% iPrOH/hexanes, 1.0 mL/min, 254 nm. Retention: 12.9 min (*trans*, major enantiomer), 15.3 min (*cis*, major enantiomer), 18.3 min (*cis*, minor enantiomer), 21.0 min (*trans*, minor enantiomer).

Conversion was determined by uncorrected direct integration of product and starting material peaks, defined as:

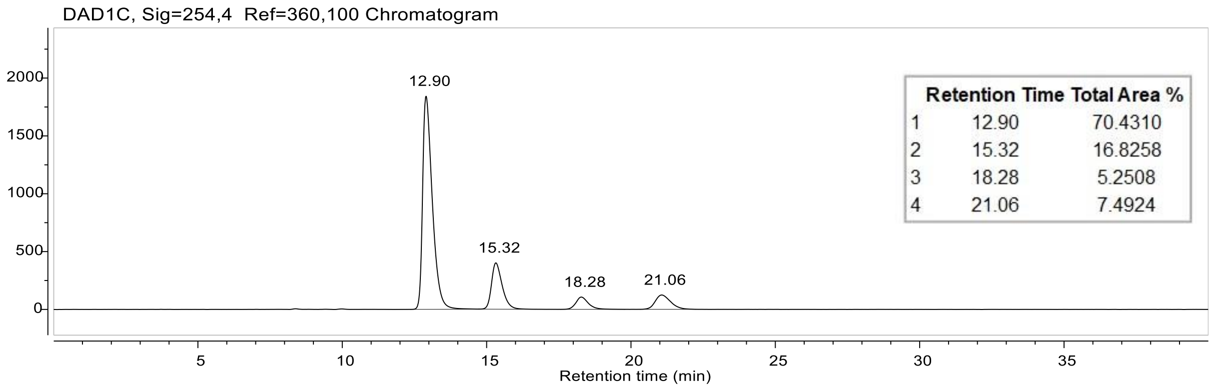
$$\textbf{Conversion} = (I_{trans1} + I_{cis1} + I_{cis2} + I_{trans2})/(I_{trans1} + I_{cis1} + I_{cis2} + I_{trans2} + I_{SM}).$$

100% conversion indicates no observable starting material peak. See representative traces below.



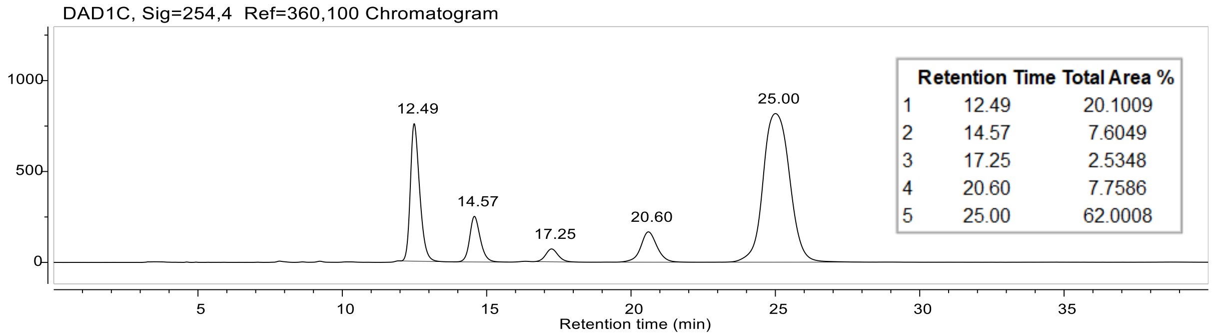
	Retention Time	Total Area %
1	12.77	29.8942
2	15.05	8.8962
3	17.50	8.5651
4	20.74	30.2511
5	25.76	22.3934

Figure S1. Racemic HPLC trace of **2b** with doped-in starting material (SM, **1b**, enantiomers not resolved).



	Retention Time	Total Area %
1	12.90	70.4310
2	15.32	16.8258
3	18.28	5.2508
4	21.06	7.4924

Figure S2. Representative HPLC trace of **2b** for radical cyclization with disulfide peptide catalyst, 100% conversion.



	Retention Time	Total Area %
1	12.49	20.1009
2	14.57	7.6049
3	17.25	2.5348
4	20.60	7.7586
5	25.00	62.0008

Figure S3. Representative HPLC trace of **2b** for radical cyclization with disulfide peptide catalyst, incomplete conversion (38% conversion).

B. Separation of diastereomers from racemic mixture

Analytical quantities of racemic *trans* and *cis* diastereomers were separated by reversed-phase preparative HPLC and characterized.

Preparative HPLC Method A: Column = Waters SymmetryPrep C8 7 µm (19 x 300 mm); solvent A = H_2O (0.1% formic acid); solvent B = MeCN (0.1% formic acid); flow rate = 20 mL/min; gradient: held at 50% B for 5 min, ramped to 95% B over 15 min, held at 95% B for 5 min, ramped to 50% B over 3 min, held at 50% B for 2 min.

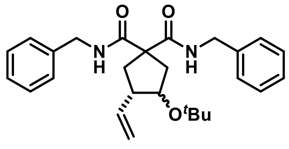
Preparative HPLC Method B: Column = Waters SymmetryPrep C8 7 µm (19 x 300 mm); solvent A = H_2O (0.1% formic acid); solvent B = MeCN (0.1% formic acid); flow rate = 20 mL/min; gradient: held at 50% B for 5 min, ramped to 95% B over 15 min, held at 95% B for 15 min, ramped to 50% B over 3 min, held at 50% B for 2 min.

C. General procedure for isolated yield experiments

Vinylcyclopropane substrate (0.1 mmol) and disulfide peptide catalyst **P10** (7.4 mg, 0.005 mmol, 5 mol %) were added to a 5 mL microwave vial equipped with a stir bar. Alkene (0.2 mol, 2 equiv) was added, then reactants were dissolved in 2.0 mL of pre-mixed 2:1 hexanes:THF (0.05 M substrate) and the vial was capped with a septum. A vent needle was added and argon was bubbled through solution for > 30 seconds to purge the solution of oxygen. Ar and vent needles were removed and the septum-sealed flask was placed in front of a UV lamp (~6 inches from lamp head). The solution was stirred at ambient temperature (fan-cooled) for 16 h in front of unfiltered UV. After 16 h, the reaction was quenched by exposure to air. Solvent was removed *in vacuo* and the crude product was purified by silica gel column chromatography (EtOAc/hexanes).

D. Characterization of cycloaddition products 2a–10

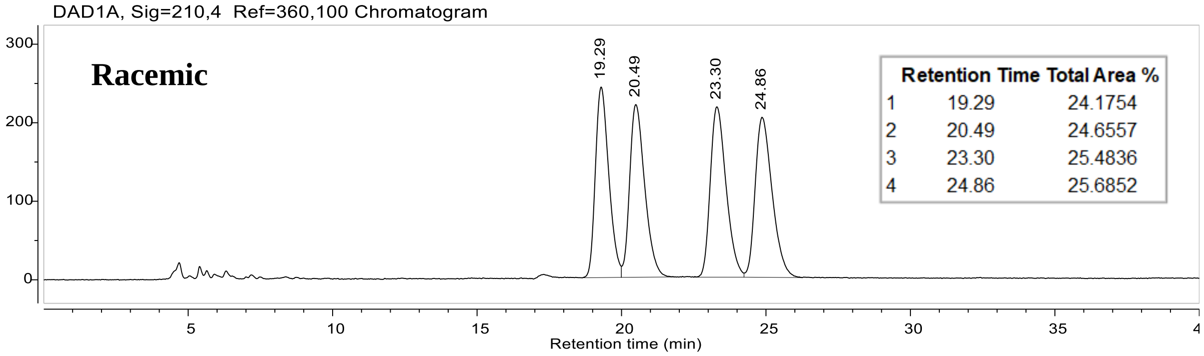
N,N'-dibenzyl-3-(*tert*-butoxy)-4-vinylcyclopentane-1,1-dicarboxamide (2a-*trans* + 2a-cis).



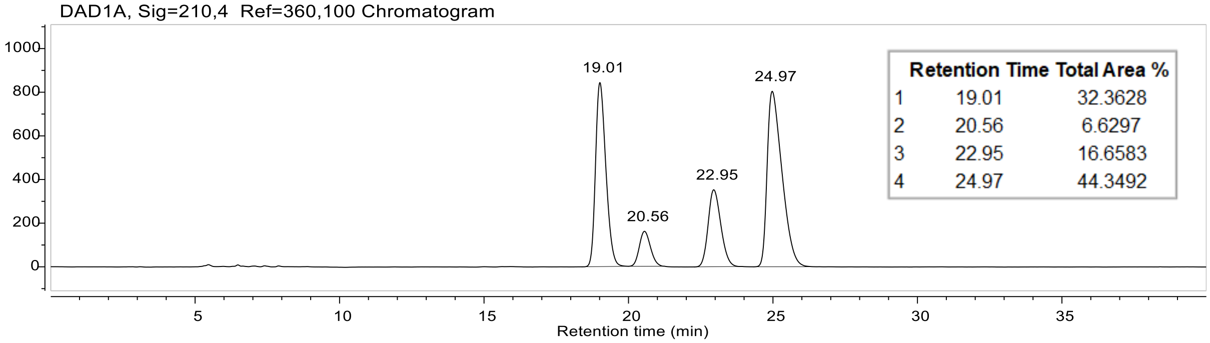
2a-*trans* + 2a-*cis*

Prepared according to the general procedure, using vinylcyclopropane **1a** (0.1 mmol, 33.4 mg), catalyst **P10** (0.005 mmol, 7.4 mg), and *tert*-butyl vinyl ether (0.2 mmol, 26.2 µL) in THF (2.0 mL, 0.05 M). Crude product (40:60 dr) was purified by silica gel column chromatography (0→30% EtOAc/hexanes) to provide **2a** as a white solid. [Average of 2 trials: 70% yield, 40:60 dr (*trans*:*cis*), 83:17 er (*trans*), 72:28 er (*cis*)]. Diastereomers were assigned in analogy to **2b**. The absolute configuration of the major enantiomer of **2a-*trans*** is assigned as (3*R*,4*S*) in analogy to **2g-*trans***.

Chiral HPLC: Chiralpak AD-H, 7.5% EtOH/hexanes, 0.75 mL/min, 210 nm. Retention: 19.0 min (*trans*, major enantiomer), 20.6 min (*trans*, minor enantiomer), 23.0 min (*cis*, minor enantiomer), 25.0 min (*cis*, major enantiomer).



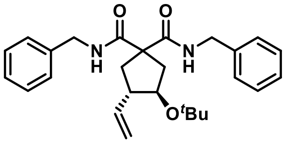
	Retention Time	Total Area %
1	19.29	24.1754
2	20.49	24.6557
3	23.30	25.4836
4	24.86	25.6852



	Retention Time	Total Area %
1	19.01	32.3628
2	20.56	6.6297
3	22.95	16.6583
4	24.97	44.3492

Analytical amounts of racemic **2a-*trans*** and **2a-*cis*** were separated by Preparative HPLC Method A and characterized.

trans-*N*,*N'*-dibenzyl-3-(*tert*-butoxy)-4-vinylcyclopentane-1,1-dicarboxamide (2a-*trans*).



2a-*trans*

TLC R$_f$ = 0.20 (20% EtOAc/hexanes)

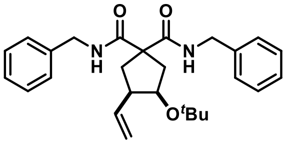
^{1}H NMR (600 MHz, CDCl$_3$) δ 7.88 (t, *J* = 5.4 Hz, 1H), 7.36–7.21 (m, 11H), 5.74 (ddd, *J* = 17.3, 10.3, 7.3 Hz, 1H), 5.05–4.96 (m, 2H), 4.49–4.37 (m, 4H), 3.98 (ddd, *J* = 7.8, 5.8, 4.2 Hz, 1H), 3.01 (dd, *J* = 14.4, 7.8 Hz, 1H), 2.57–2.49 (m, 2H), 1.96–1.87 (m, 2H), 1.08 (s, 9H).

^{13}C NMR (150 MHz, CDCl$_3$) δ 174.4, 172.1, 138.8, 138.4, 137.8, 128.8, 128.8, 128.0, 127.7, 127.6, 127.4, 115.5, 77.3, 74.3, 59.0, 51.6, 44.4, 44.0, 41.2, 41.0, 28.6.

IR (thin film, cm^{-1}) ν_{max} 3304, 1646, 1531, 1496, 1455, 1421, 1389, 1363, 1263, 1192, 1100, 1082, 1028, 912, 730, 701.

HRMS (ESI) (*m/z*) for $[M+H]^+$ $C_{27}H_{35}N_2O_3$ requires 435.2648, observed 435.2645.

cis-*N*,*N'*-dibenzyl-3-(*tert*-butoxy)-4-vinylcyclopentane-1,1-dicarboxamide (2a-*cis*).



2a-*cis*

TLC R$_f$ = 0.20 (20% EtOAc/hexanes)

^{1}H NMR (400 MHz, CDCl$_3$) δ 9.37 (t, *J* = 5.6 Hz, 1H), 8.32 (t, *J* = 5.8 Hz, 1H), 7.37–7.20 (m, 10H), 5.81 (ddd, *J* = 17.2, 10.3, 8.3 Hz, 1H), 5.12–4.99 (m, 2H), 4.53–4.42 (m, 3H), 4.33 (dd, *J* =

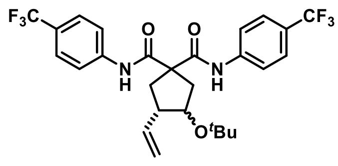
14.9, 5.4 Hz, 1H), 4.20 (t, *J* = 4.3 Hz, 1H), 2.96 (ddd, *J* = 12.2, 8.1, 4.1 Hz, 1H), 2.89 (dd, *J* = 14.5, 4.6 Hz, 1H), 2.33 (dd, *J* = 13.0, 7.6 Hz, 1H), 2.19–2.08 (m, 2H), 1.03 (s, 9H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 177.8, 174.6, 138.8, 138.4, 137.3, 128.8, 128.7, 127.8, 127.7, 127.6, 127.2, 116.3, 77.2, 75.0, 56.2, 50.7, 44.9, 44.8, 43.8, 43.6, 28.2.

IR (thin film, cm^{-1}) ν_{max} 3294, 1646, 1534, 1496, 1455, 1442, 1420, 1388, 1363, 1276, 1262, 1248, 1189, 1114, 1079, 1056, 1028, 998, 698.

HRMS (ESI) (*m/z*) for $[M+H]^+$ $C_{27}H_{35}N_2O_3$ requires 435.2648, observed 435.2642.

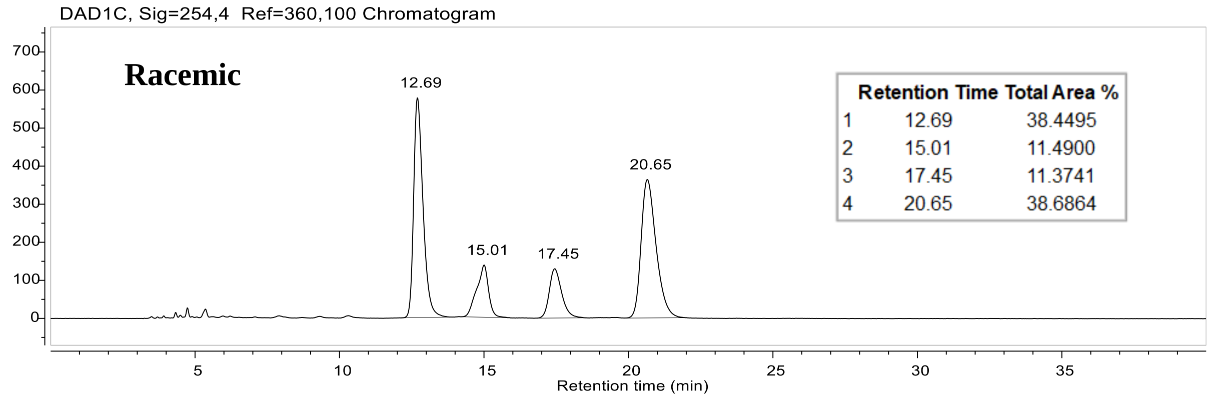
3-(*tert*-butoxy)-*N*,*N'*-bis(4-(trifluoromethyl)phenyl)-4-vinylcyclopentane-1,1-dicarboxamide (2b-*trans* + 2b-cis).

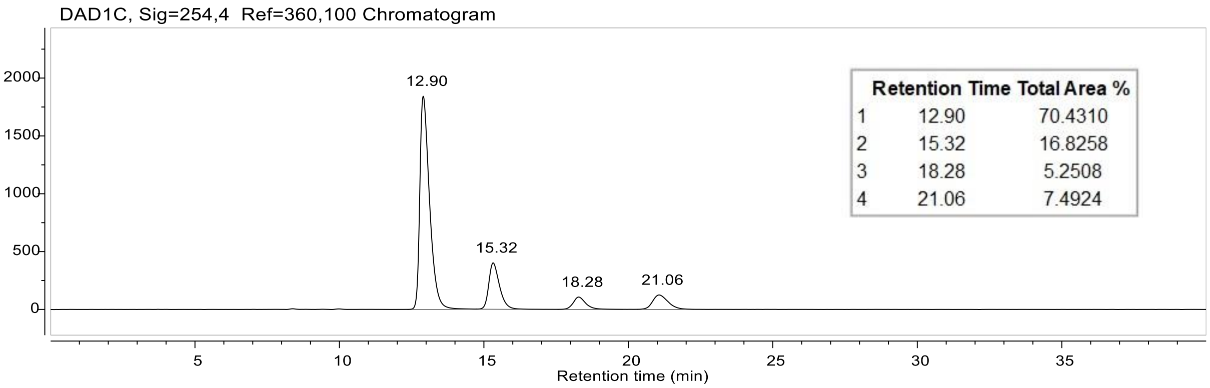


2b-*trans* + 2b-*cis*

Prepared according to the general procedure, using vinylcyclopropane **1b** (0.1 mmol, 44.2 mg), catalyst **P10** (0.005 mmol, 7.4 mg), and *tert*-butyl vinyl ether (0.2 mmol, 26.2 µL). Crude product (79:21 dr) was purified by silica gel column chromatography (0→20% EtOAc/hexanes) to provide **2b** as a flaky white solid. [Average of 2 trials: 84% yield, 79:21 dr (*trans*:*cis*), 90:10 er (*trans*), 75:25 er (*cis*)]. The absolute configuration of the major enantiomer of **2b-*trans*** is assigned as (3*R*,4*S*) in analogy to **2g-*trans***.

Chiral HPLC: Chiralpak IA, 5% iPrOH/hexanes, 1.0 mL/min, 254 nm. Retention: 12.9 min (*trans*, major enantiomer), 15.3 min (*cis*, major enantiomer), 18.3 min (*cis*, minor enantiomer), 21.0 min (*trans*, minor enantiomer).

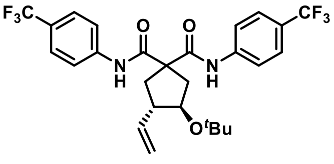




	Retention Time	Total Area %
1	12.90	70.4310
2	15.32	16.8258
3	18.28	5.2508
4	21.06	7.4924

Analytical amounts of racemic **2b-*trans*** and **2b-*cis*** were separated by Preparative HPLC Method A and characterized.

***trans*-3-(*tert*-butoxy)-*N,N'*-bis(4-(trifluoromethyl)phenyl)-4-vinylcyclopentane-1,1-dicarboxamide (2b-*trans*).**



2b-*trans*

TLC R$_f$ = 0.53 (20% EtOAc/hexanes)

^{1}H NMR (400 MHz, CDCl$_3$) δ 10.42 (s, 1H), 9.55 (s, 1H), 7.75–7.55 (m, 8H), 5.81 (ddd, *J* = 17.0, 10.3, 8.0 Hz, 1H), 5.11–5.03 (m, 2H), 4.17 (ddd, *J* = 8.5, 5.0, 1.8 Hz, 1H), 3.34 (dd, *J* = 15.6, 8.4 Hz, 1H), 2.82–2.71 (m, 1H), 2.61 (ddd, *J* = 13.1, 7.4, 1.9 Hz, 1H), 2.18–2.04 (m, 2H), 1.30 (s, 9H).

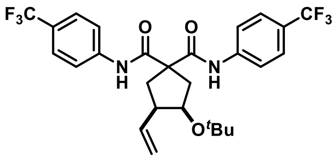
^{13}C NMR (101 MHz, CDCl$_3$) δ 174.3, 169.6, 141.2, 140.6, 137.9, 127.2 (q, *J* = 33.1 Hz), 126.4 (q, *J* = 3.7 Hz), 126.3 (q, *J* = 3.7 Hz), 162.2 (q, *J* = 32.8 Hz), 124.2 (q, *J* = 271.5 Hz), 124.1 (q, *J* = 271.7 Hz), 121.0, 119.9, 116.2, 77.8, 75.7, 61.1, 52.7, 44.1, 40.8, 28.9.

^{19}F NMR (376 MHz, CDCl$_3$) δ –62.6 (s, 3F), –62.8 (s, 3F).

IR (thin film, cm^{-1}) ν_{max} 3290, 1662, 1616, 1602, 1521, 1406, 1362, 1324, 1258, 1185, 1162, 1125, 1112, 1068, 1017, 914, 837, 666.

HRMS (ESI) (*m/z*) for [M+H]$^+$ $C_{27}H_{29}F_6N_2O_3$ requires 543.2082, observed 543.2083.

cis-3-(*tert*-butoxy)-*N,N′*-bis(4-(trifluoromethyl)phenyl)-4-vinylcyclopentane-1,1-dicarboxamide (2b-*cis*).



2b-*cis*

TLC R_f = 0.53 (20% EtOAc/hexanes)

^{1}H NMR (400 MHz, $CDCl_3$) δ 11.35 (s, 1H), 9.94 (s, 1H), 7.78–7.54 (m, 8H), 5.90 (ddd, *J* = 17.3, 10.3, 8.3 Hz, 1H), 5.17 (d, *J* = 17.3 Hz, 1H), 5.12 (dd, *J* = 10.3, 1.8 Hz, 1H), 4.42 (t, *J* = 4.3 Hz, 1H), 3.13 (dd, *J* = 14.9, 4.6 Hz, 1H), 3.07 (ddd, *J* = 12.1, 8.1, 4.1 Hz, 1H), 2.47 (dd, *J* = 13.4, 7.6 Hz, 1H), 2.40–2.25 (m, 2H), 1.30 (s, 9H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 177.0, 172.4, 141.3, 140.4, 136.4, 127.3 (q, *J* = 32.9 Hz), 126.4 (q, *J* = 3.7 Hz), 126.3 (q, *J* = 3.7 Hz), 126.0 (q, *J* = 32.7 Hz), 124.3 (q, *J* = 271.4), 124.1 (q, *J* = 271.4), 122.2, 120.1, 117.2, 77.6, 76.1, 57.1, 50.8, 45.4, 44.9, 28.8.

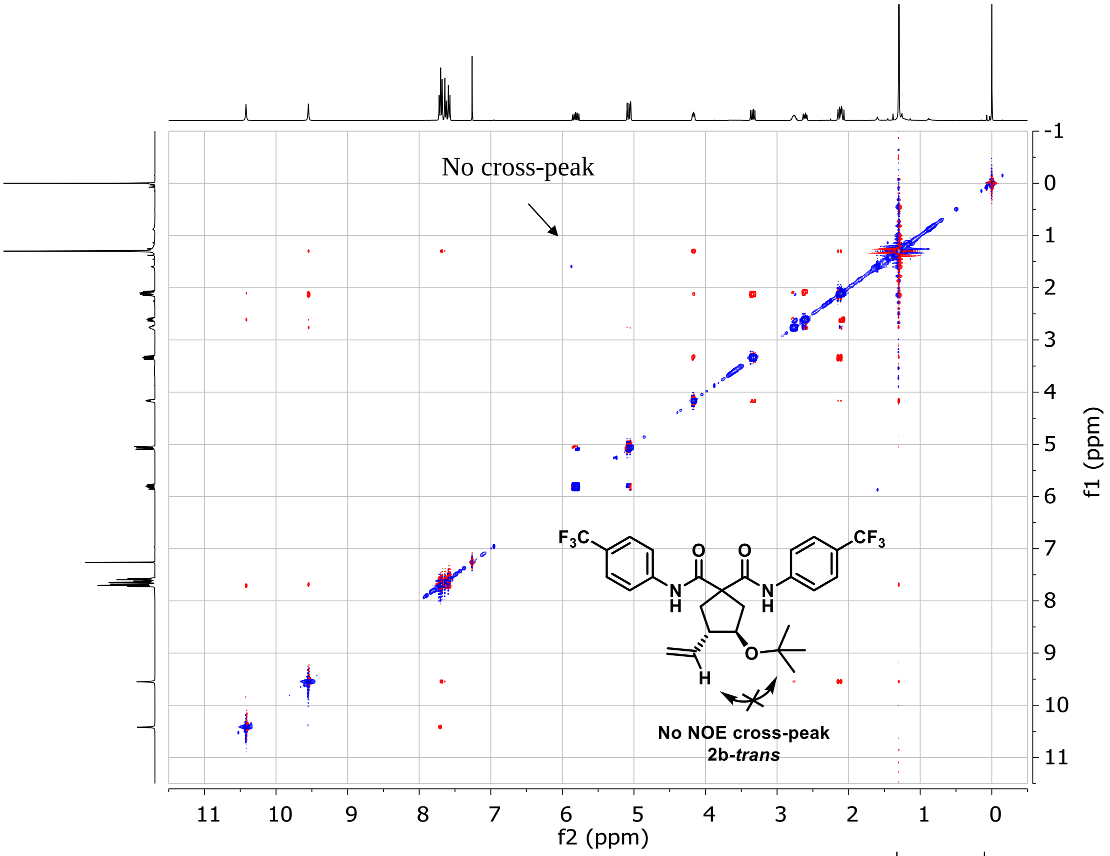
^{19}F NMR (376 MHz, $CDCl_3$) δ –62.6 (s, 3F), –62.8 (s, 3F).

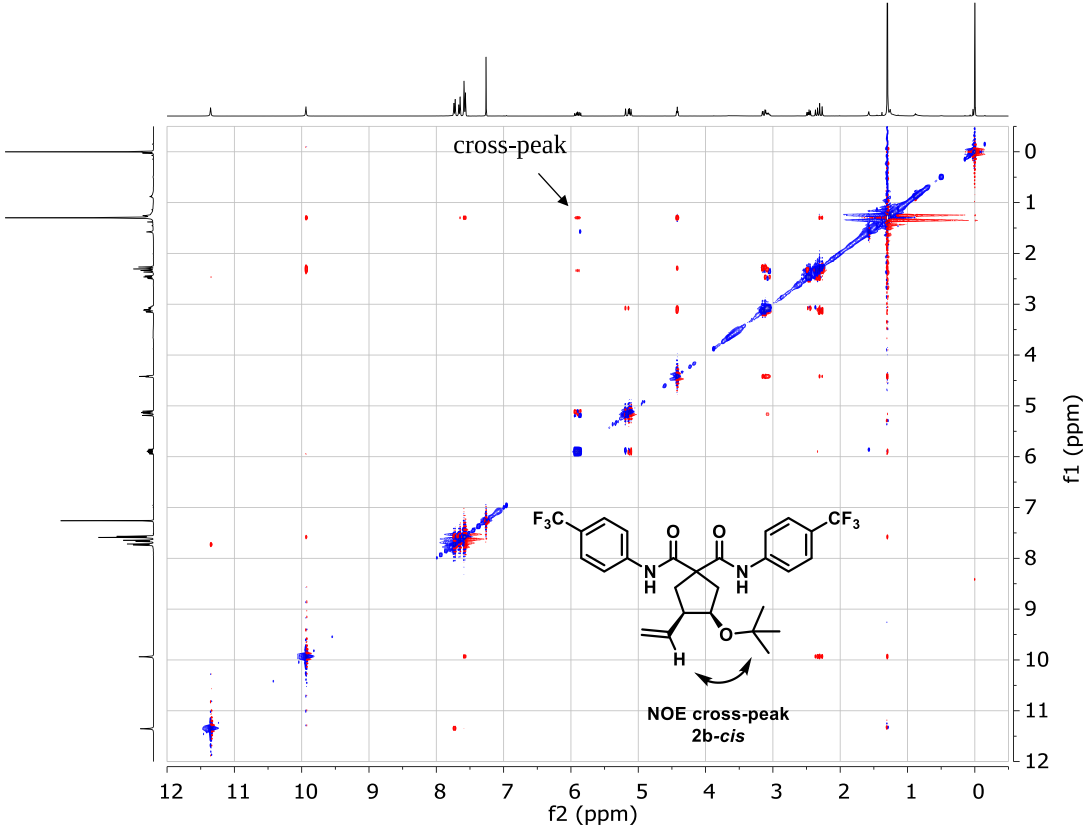
IR (thin film, cm^{-1}) ν_{max} 3285, 1660, 1685, 1603, 1521, 1407, 1325, 1259, 1161, 1124, 1109, 1067, 1018, 836, 800.

HRMS (ESI) (*m/z*) for $[M+H]^+$ $C_{27}H_{29}F_6N_2O_3$ requires 543.2082, observed 543.2085.

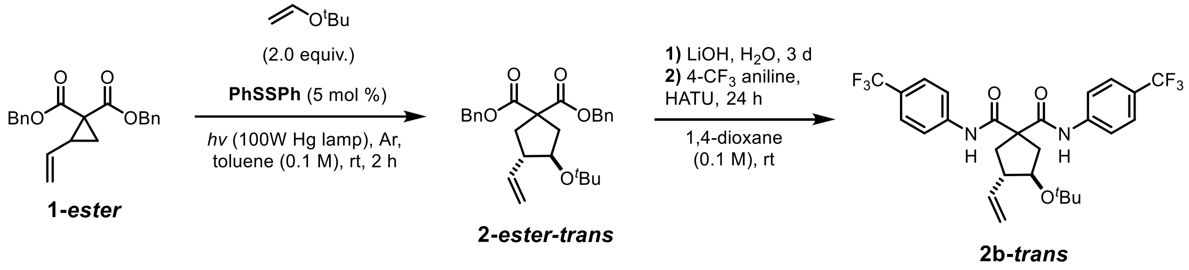
NMR assignment of 2b-*trans*/2b-*cis* diastereomers

Diastereomers were assigned by 2D-NOESY NMR. The minor diastereomer exhibits a cross-peak between the vinyl proton and the *tert*-butyl group while the major diastereomer lacks this cross peak. On this basis, the minor diastereomer is assigned as *cis* while the major diastereomer is assigned as *trans*. This assignment is in agreement with semi-synthesis (see below) and X-ray crystallography (see Section VIII).


No cross-peak
F_3C
CF_3
O
O
N
H
N
H
O
H
No NOE cross-peak
2b-*trans*
f2 (ppm)
f1 (ppm)
11
10
9
8
7
6
5
4
3
2
1
0
-1

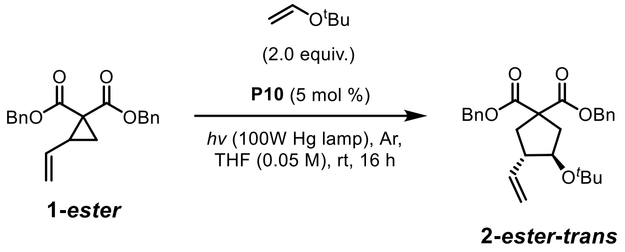

cross-peak
F_3C
CF_3
O
O
N
H
N
H
O
H
NOE cross-peak
2b-*cis*
f2 (ppm)
f1 (ppm)
12
11
10
9
8
7
6
5
4
3
2
1
0

Assignment of 2b-*trans* by semi-synthesis



1-*ester* was prepared according to the literature procedure.[10] **1-*ester*** was converted to **2-*ester*** by the literature conditions (ref. 10), using a 365-nm filtered 100W Hg-lamp (0.2 mmol **1-*ester***, PhSSPh (0.01 mmol, 5 mol %), toluene (0.1 M), 2 h), providing **2-*ester*** in 76% yield [80:20 dr (*trans*:*cis*)]. The **2-*ester-trans*** diastereomer was purified by silica gel column chromatography (20→100% DCM/hexanes) and matched the reported spectral data. **2-*ester-trans*** was subjected to the one-pot hydrolysis and coupling conditions reported above (**General Procedure V.A.**) with 4-(trifluoromethyl)aniline and HATU to yield **2b-*trans***. Spectral data was in accordance with **2b-*trans*** prepared directly from **1b**.

Peptide-catalyzed reaction to form 2-*ester-trans* – diester control



Prepared according to a modification of the general procedure, using vinylcyclopropane **1-*ester*** (0.1 mmol, 33.6 mg), catalyst **P10** (0.005 mmol, 7.4 mg), and *tert*-butyl vinyl ether (0.2 mmol, 26.2 µL) in THF (2.0 mL, 0.05 M). Crude product (78:22 dr) was purified by silica gel column chromatography (40→100% DCM/hexanes) and the minor *ci*s diastereomer was removed at this stage. **2-*ester-trans*** was isolated as a colorless oil. [44% yield, 47:53 er (*trans*)].

Chiral HPLC: Literature conditions (ref. 10): Chiralpak AD-H, 2% EtOH/hexanes, 0.5 mL/min, 210 nm. Retention: 12.4 min (*trans*, minor enantiomer), 13.9 min (*trans*, major enantiomer).

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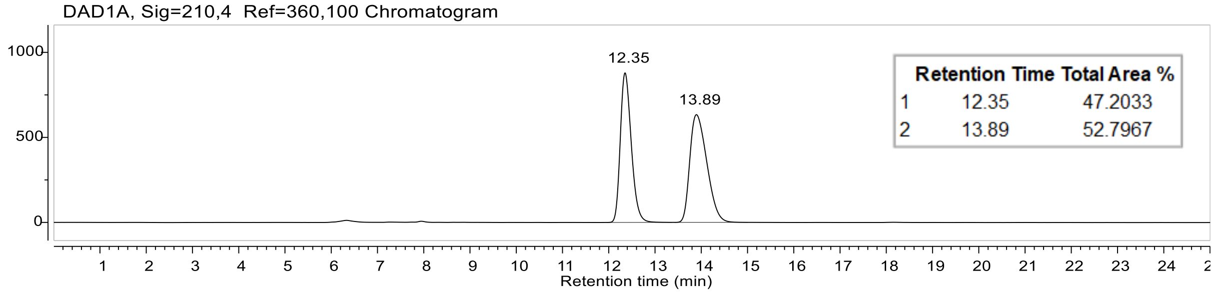
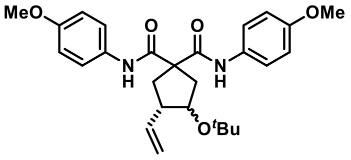
[10] Hashimoto, T.; Kawamata, Y.; Maruoka, K. *Nature Chem*. **2014**, *6*, 702–705.



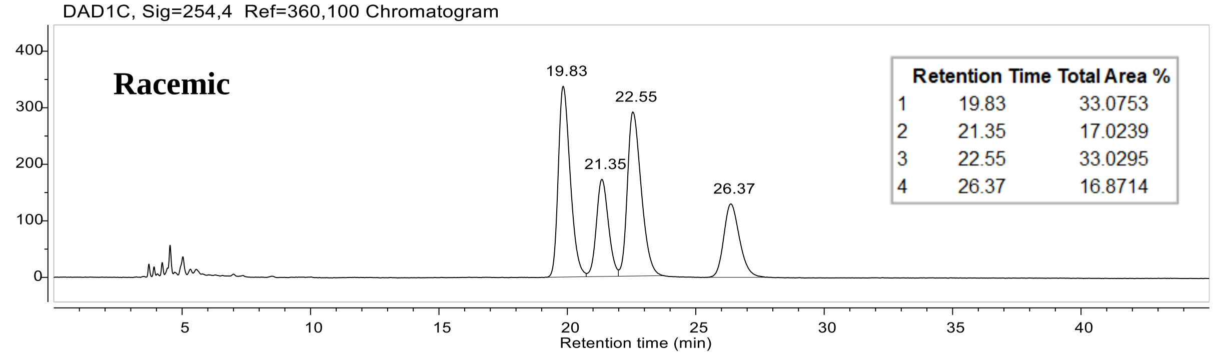
3-(*tert*-butoxy)-*N*,*N′*-bis(4-methoxyphenyl)-4-vinylcyclopentane-1,1-dicarboxamide (2c-*trans* + 2c-cis).

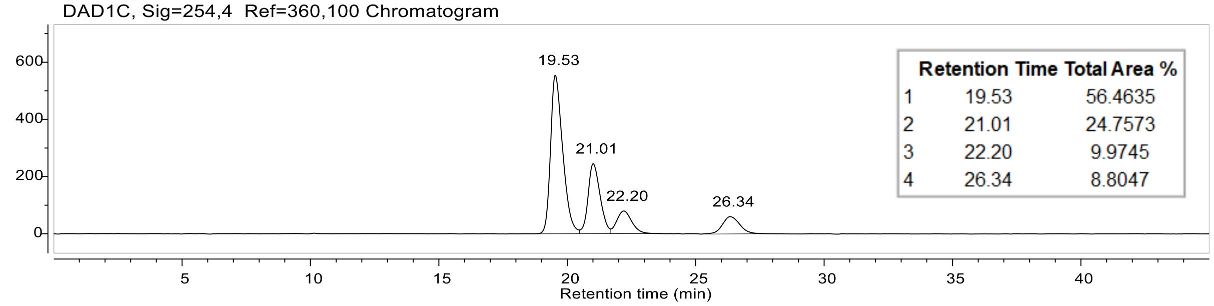


2c-*trans* + 2c-*cis*

Prepared according to the general procedure, using vinylcyclopropane **1c** (0.1 mmol, 36.8 mg), catalyst **P10** (0.005 mmol, 7.4 mg), and *tert*-butyl vinyl ether (0.2 mmol, 26.2 µL) in THF (2.0 mL, 0.05 M). Crude product (68:32 dr) was purified by silica gel column chromatography (0→30% EtOAc/hexanes) to provide **2c** as a white solid. [Average of 2 trials: 79% yield, 68:32 dr (*trans*:*cis*), 85:15 er (*trans*), 75:25 er (*cis*)]. Diastereomers were assigned in analogy to **2b**. The absolute configuration of the major enantiomer of **2c-*trans*** is assigned as (3*R*,4*S*) in analogy to **2g-*trans***.

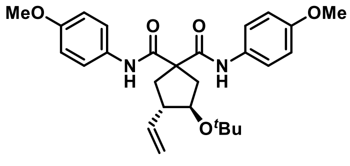
Chiral HPLC: Chiralpak IA, 11% EtOH/hexanes, 1.0 mL/min, 254 nm. Retention: 19.5 min (*trans*, major enantiomer), 21.0 min (*cis*, major enantiomer), 22.2 min (*trans*, minor enantiomer), 26.3 min (*cis*, minor enantiomer).





Analytical amounts of racemic **2c-*trans*** and **2c-*cis*** were separated by Preparative HPLC Method A and characterized.

***trans*-3-(*tert*-butoxy)-*N,N′*-bis(4-methoxyphenyl)-4-vinylcyclopentane-1,1-dicarboxamide (2c-*trans*).**



2c-*trans*

TLC R*f* = 0.19 (20% EtOAc/hexanes)

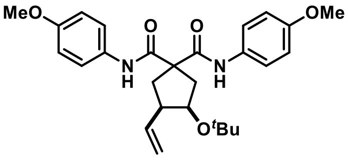
^{1}H NMR (500 MHz, CDCl$_3$) δ 9.89 (s, 1H), 8.97 (s, 1H), 7.50–7.40 (m, 4H), 6.91–6.83 (m, 4H), 5.81 (ddd, *J* = 17.0, 10.2, 7.9 Hz, 1H), 5.09–5.00 (m, 2H), 4.06 (ddd, *J* = 8.5, 5.6, 3.0 Hz, 1H), 3.80 (s, 3H), 3.78 (s, 3H), 3.26 (dd, *J* = 15.1, 8.2 Hz, 1H), 2.76–2.67 (m, 1H), 2.63 (ddd, *J* = 13.1, 7.6, 1.8 Hz, 1H), 2.09 (dt, *J* = 15.0, 2.4 Hz, 1H), 2.04 (dd, *J* = 13.0, 10.5 Hz, 1H), 1.25 (s, 9H).

^{13}C NMR (126 MHz, CDCl$_3$) δ 173.5, 169.5, 157.1, 156.4, 138.5, 131.5, 130.6, 122.9, 121.9, 115.8, 114.3, 114.2, 77.6, 75.0, 60.3, 55.6, 55.6, 52.2, 42.8, 41.1, 28.9.

IR (thin film, cm^{-1}) ν_{max} 3268, 1646, 1602, 1559, 1513, 1409, 1246, 1171, 1100, 1039, 825, 666.

HRMS (ESI) (*m/z*) for [M+H]$^+$ $C_{27}H_{35}N_2O_5$ requires 467.2546, observed 467.2546.

***cis*-3-(*tert*-butoxy)-*N,N′*-bis(4-methoxyphenyl)-4-vinylcyclopentane-1,1-dicarboxamide (2c-*cis*).**



2c-*cis*

TLC R*f* = 0.19 (20% EtOAc/hexanes)

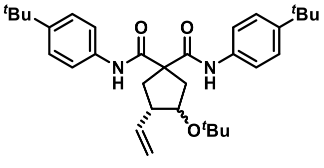
^{1}H NMR (500 MHz, CDCl$_3$) δ 11.19 (s, 1H), 9.68 (s, 1H), 7.53–7.48 (m, 2H), 7.33–7.27 (m, 2H), 6.95–6.89 (m, 2H), 6.87–6.82 (m, 2H), 5.90 (ddd, *J* = 18.0, 10.3, 8.3 Hz, 1H), 5.14 (d, *J* = 17.3 Hz, 1H), 5.08 (dd, *J* = 10.2, 1.9 Hz, 1H), 4.36 (t, *J* = 4.3 Hz, 1H), 3.81 (s, 3H), 3.78 (s, 3H), 3.14 – 3.03 (m, 2H), 2.45 (dd, *J* = 13.2, 7.6 Hz, 1H), 2.37–2.24 (m, 2H), 1.25 (s, 9H).

^{13}C NMR (126 MHz, CDCl$_3$) δ 177.1, 172.2, 157.4, 156.2, 137.0, 131.8, 130.0, 124.5, 122.0, 116.7, 114.4, 114.1, 77.6, 75.6, 56.5, 55.7, 55.6, 50.9, 45.5, 45.0, 28.6.

IR (thin film, cm^{-1}) ν_{max} 3262, 1653, 1646, 1554, 1512, 1240, 1172, 1039, 827, 666.

HRMS (ESI) (*m/z*) for $[M+H]^+$ $C_{27}H_{35}N_2O_5$ requires 467.2546, observed 467.2541.

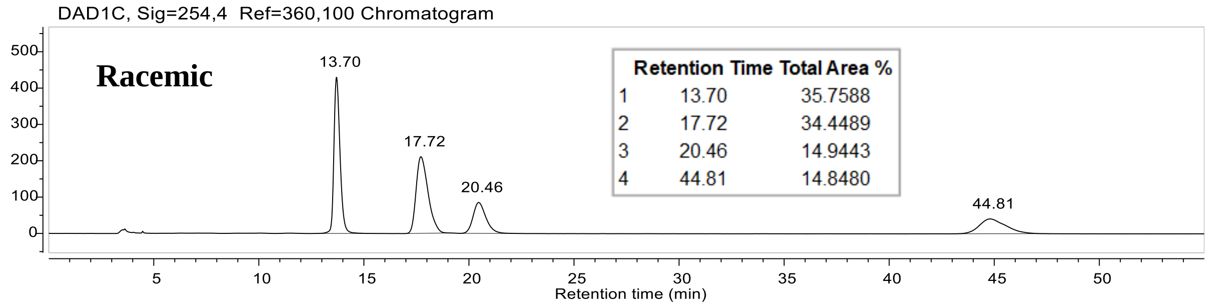
3-(*tert*-butoxy)-*N*,*N'*-bis(4-(*tert*-butyl)phenyl)-4-vinylcyclopentane-1,1-dicarboxamide (2d-*trans* + 2d-*cis*).



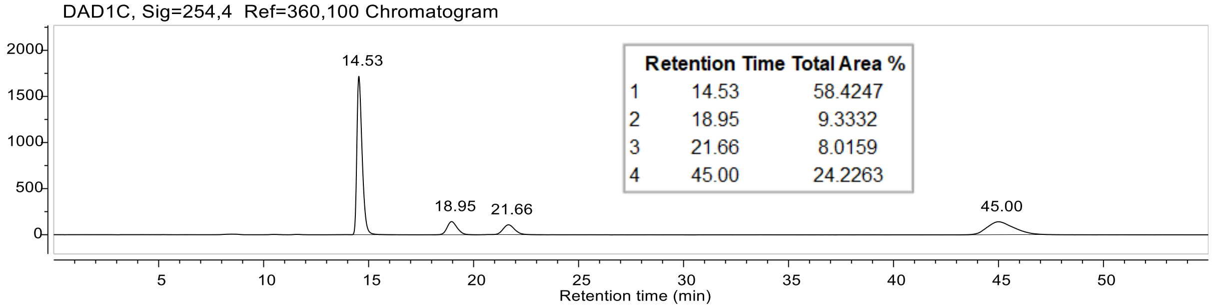
2d-*trans* + 2d-*cis*

Prepared according to the general procedure, using vinylcyclopropane **1d** (0.1 mmol, 41.9 mg), catalyst **P10** (0.005 mmol, 7.4 mg), and *tert*-butyl vinyl ether (0.2 mmol, 26.2 µL). Crude product (66:34 dr) was purified by silica gel column chromatography (0→20% EtOAc/hexanes) to provide **2d** as a flaky white solid. [Average of 2 trials: 32% yield, 68:32 dr (*trans*:*cis*), 86:14 er (*trans*), 75:25 er (*cis*)]. Diastereomers were assigned in analogy to **2b**. The absolute configuration of the major enantiomer of **2d-*trans*** is assigned as (3*R*,4*S*) in analogy to **2g-*trans***.

Chiral HPLC: Chiralpak IC, 1% EtOH/hexanes, 1.0 mL/min, 254 nm. Retention: 14.5 min (*trans*, major enantiomer), 18.9 min (*trans*, minor enantiomer), 21.6 min (*cis*, minor enantiomer), 45.0 min (*cis*, major enantiomer).



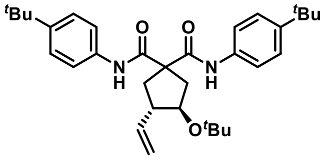
	Retention Time	Total Area %
1	13.70	35.7588
2	17.72	34.4489
3	20.46	14.9443
4	44.81	14.8480



	Retention Time	Total Area %
1	14.53	58.4247
2	18.95	9.3332
3	21.66	8.0159
4	45.00	24.2263

Analytical amounts of racemic **2d-*trans*** and **2d-*cis*** were separated by Preparative HPLC Method B and characterized.

***trans*-3-(*tert*-butoxy)-*N*,*N′*-bis(4-(*tert*-butyl)phenyl)-4-vinylcyclopentane-1,1-dicarboxamide (2d-*trans*).**



2d-*trans*

TLC R$_f$ = 0.49 (20% EtOAc/hexanes)

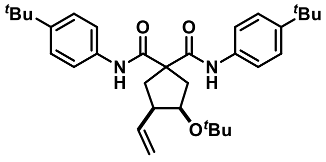
^{1}H NMR (500 MHz, CDCl$_3$) δ 9.89 (s, 1H), 8.97 (s, 1H), 7.52–7.43 (m, 4H), 7.41–7.31 (m, 4H), 5.80 (ddd, *J* = 17.8, 10.2, 7.9 Hz, 1H), 5.09–4.99 (m, 2H), 4.06 (ddd, *J* = 8.6, 5.8, 3.1 Hz, 1H), 3.28 (dd, *J* = 15.1, 8.3 Hz, 1H), 2.76–2.67 (m, 1H), 2.62 (ddd, *J* = 13.1, 7.5, 1.8 Hz, 1H), 2.09 (dt, *J* = 15.2, 2.4 Hz, 1H), 2.03 (dd, *J* = 13.0, 10.7 Hz, 1H), 1.32 (s, 9H), 1.30 (s, 9H), 1.26 (s, 9H).

^{13}C NMR (126 MHz, CDCl$_3$) δ 173.5, 169.6, 148.2, 147.3, 138.5, 135.6, 135.0, 126.0, 125.8, 120.9, 120.0, 115.8, 77.5, 75.0, 60.6, 52.1, 42.8, 41.0, 34.6, 34.5, 31.5, 31.5, 28.9.

IR (FT-ATR, cm^{-1}) ν_{max} 3318, 1658, 1597, 1539, 1516, 1404, 1363, 1317, 1300, 1249, 1194, 1102, 1021, 912, 834, 552.

HRMS (ESI) (*m/z*) for [M+H]$^+$ $C_{33}H_{47}N_2O_3$ requires 519.3587, observed 519.3588.

***cis*-3-(*tert*-butoxy)-*N*,*N′*-bis(4-(*tert*-butyl)phenyl)-4-vinylcyclopentane-1,1-dicarboxamide (2d-*cis*).**



2d-*cis*

TLC R$_f$ = 0.49 (20% EtOAc/hexanes)

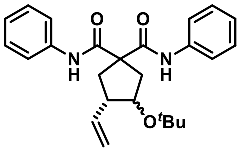
^{1}H NMR (500 MHz, CDCl$_3$) δ 11.13 (s, 1H), 9.61 (s, 1H), 7.54–7.49 (m, 2H), 7.43–7.30 (m, 6H), 5.90 (ddd, *J* = 17.2, 10.3, 8.3 Hz, 1H), 5.13 (d, *J* = 17.2 Hz, 1H), 5.08 (dd, *J* = 10.3, 2.0 Hz, 1H), 4.37 (t, *J* = 4.3 Hz, 1H), 3.11 (dd, *J* = 14.8, 4.7 Hz, 1H), 3.08–3.02 (m, 1H), 2.44 (dd, *J* = 13.3, 7.6 Hz, 1H), 2.37–2.25 (m, 2H), 1.32 (s, 9H), 1.30 (s, 10H), 1.28 (s, 9H).

^{13}C NMR (126 MHz, CDCl$_3$) δ 176.8, 172.3, 148.4, 147.0, 137.0, 135.9, 134.6, 126.0, 125.8, 122.3, 120.2, 116.6, 77.6, 75.6, 56.9, 50.8, 45.3, 44.9, 34.6, 34.5, 31.5, 31.5, 28.7.

IR (FT-ATR, cm^{-1}) ν_{max} 3315, 1656, 1597, 1539, 1516, 1404, 1363, 1317, 1299, 1251, 1192, 1098, 1047, 1020, 913, 832, 798, 731, 702, 553.

HRMS (ESI) (*m/z*) for [M+H]$^+$ $C_{33}H_{47}N_2O_3$ requires 519.3587, observed 519.3589.

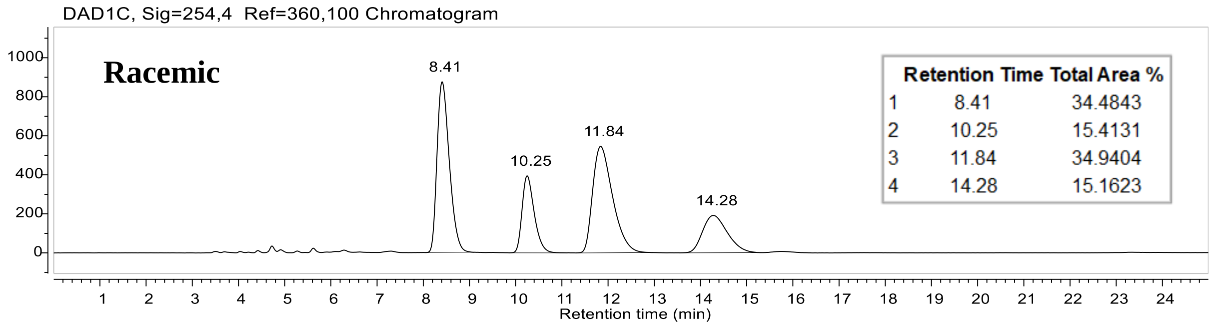
3-(*tert*-butoxy)-*N*,*N'*-diphenyl-4-vinylcyclopentane-1,1-dicarboxamide (2e-*trans* + 2e-*cis*).



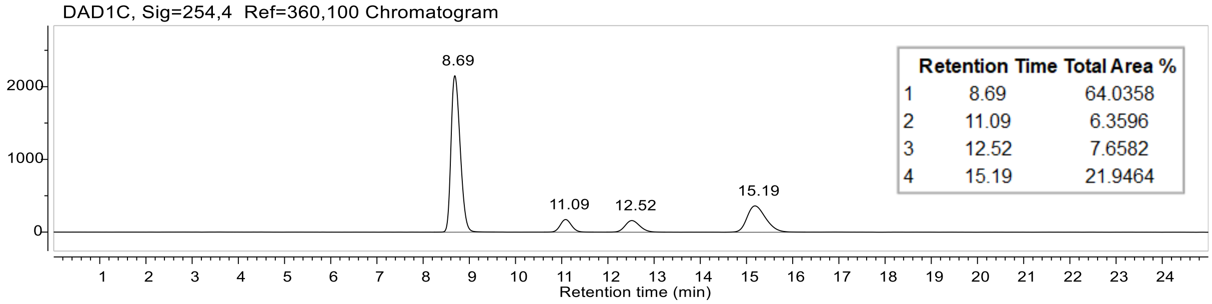
2e-*trans* + 2e-*cis*

Prepared according to the general procedure, using vinylcyclopropane **1e** (0.1 mmol, 30.7 mg), catalyst **P10** (0.005 mmol, 7.4 mg), and *tert*-butyl vinyl ether (0.2 mmol, 26.2 µL). Crude product (73:27 dr) was purified by silica gel column chromatography (0→20% EtOAc/hexanes) to provide **2e** as a flaky white solid. [Average of 2 trials: 77% yield, 73:27 dr (*trans*:*cis*), 90:10 er (*trans*), 79:21 er (*cis*)]. Diastereomers were assigned in analogy to **2b**. The absolute configuration of the major enantiomer of **2e-*trans*** is assigned as (3*R*,4*S*) in analogy to **2g-*trans***.

Chiral HPLC: Chiralpak AD-H, 7% EtOH/hexanes, 1.0 mL/min, 254 nm. Retention: 8.7 min (*trans*, major enantiomer), 11.1 min (*cis*, minor enantiomer), 12.5 min (*trans*, minor enantiomer), 15.2 min (*cis*, major enantiomer).



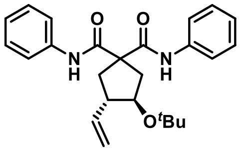
	Retention Time	Total Area %
1	8.41	34.4843
2	10.25	15.4131
3	11.84	34.9404
4	14.28	15.1623



	Retention Time	Total Area %
1	8.69	64.0358
2	11.09	6.3596
3	12.52	7.6582
4	15.19	21.9464

Analytical amounts of racemic **2e-*trans*** and **2e-*cis*** were separated by Preparative HPLC Method A and characterized.

trans-3-(_tert_-butoxy)-_N,N'_-diphenyl-4-vinylcyclopentane-1,1-dicarboxamide (4e-_trans_).


4e-*trans*

TLC R$_f$ = 0.41 (20% EtOAc/hexanes)

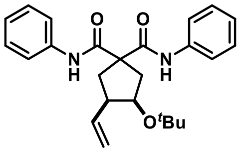
^{1}H NMR (500 MHz, CDCl$_3$) δ 9.97 (s, 1H), 9.06 (s, 1H), 7.62–7.51 (m, 4H), 7.40–7.29 (m, 4H), 7.20–7.14 (m, 1H), 7.13–7.07 (m, 1H), 5.81 (ddd, *J* = 17.0, 10.2, 7.9 Hz, 1H), 5.11–5.00 (m, 2H), 4.09 (ddd, *J* = 8.5, 5.7, 3.0 Hz, 1H), 3.29 (dd, *J* = 15.2, 8.3 Hz, 1H), 2.78–2.69 (m, 1H), 2.65 (ddd, *J* = 13.1, 7.5, 1.9 Hz, 1H), 2.11 (dt, *J* = 15.2, 2.4 Hz, 1H), 2.06 (dd, *J* = 13.0, 10.6 Hz, 1H), 1.27 (s, 9H).

^{13}C NMR (126 MHz, CDCl$_3$) δ 173.6, 169.6, 138.4, 138.2, 137.6, 129.1, 129.1, 125.2, 124.4, 121.2, 120.3, 115.9, 77.6, 75.1, 60.8, 52.2, 42.9, 41.0, 28.9.

IR (thin film, cm^{-1}) ν_{max} 3271, 1647, 1599, 1558, 1533, 1500, 1442, 1390, 1364, 1320, 1260, 1195, 1098, 1022, 910, 892, 800, 749, 692, 666.

HRMS (ESI) (*m/z*) for [M+H]$^+$ $C_{25}H_{31}N_2O_3$ requires 407.2335, observed 407.2328.

cis-3-(_tert_-butoxy)-_N,N'_-diphenyl-4-vinylcyclopentane-1,1-dicarboxamide (4e-_cis_).


4e-*cis*

TLC R$_f$ = 0.45 (20% EtOAc/hexanes)

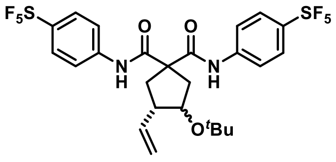
^{1}H NMR (500 MHz, CDCl$_3$) δ 11.18 (s, 1H), 9.68 (s, 1H), 7.63–7.58 (m, 2H), 7.46–7.36 (m, 4H), 7.34–7.29 (m, 2H), 7.23–7.17 (m, 1H), 7.12–7.06 (m, 1H), 5.91 (ddd, *J* = 17.3, 10.3, 8.3 Hz, 1H), 5.15 (d, *J* = 17.3 Hz, 1H), 5.09 (dd, *J* = 10.3, 1.9 Hz, 1H), 4.38 (t, *J* = 4.4 Hz, 1H), 3.12 (dd, *J* = 14.9, 4.8 Hz, 1H), 3.09–3.04 (m, 1H), 2.47 (dd, *J* = 13.3, 7.6 Hz, 1H), 2.40–2.26 (m, 2H), 1.28 (s, 9H).

^{13}C NMR (126 MHz, CDCl$_3$) δ 176.8, 172.3, 138.5, 137.2, 136.9, 129.2, 129.0, 125.5, 124.2, 122.6, 120.5, 116.8, 77.6, 75.7, 57.0, 50.8, 45.3, 44.9, 28.7.

IR (thin film, cm^{-1}) ν_{max} 3269, 1646, 1598, 1558, 1529, 1499, 1441, 1319, 1260, 1101, 1041, 1017, 904, 799, 742, 692.

HRMS (ESI) (*m/z*) for [M+H]$^+$ $C_{25}H_{31}N_2O_3$ requires 407.2335, observed 407.2327.

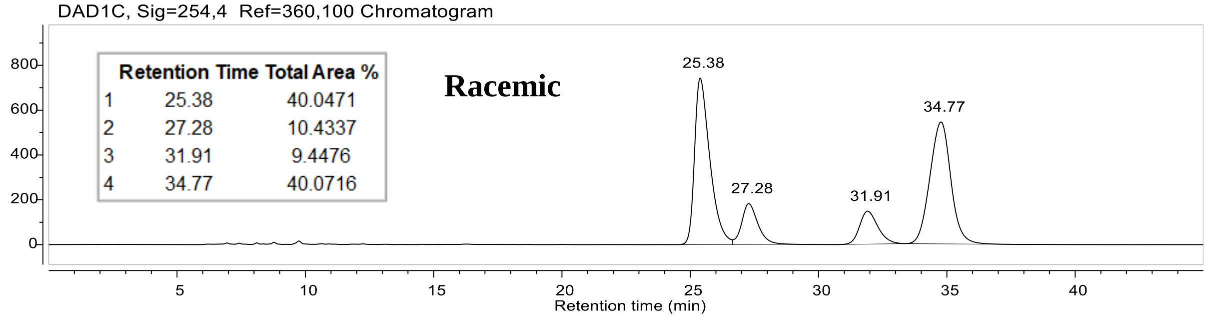
3-(*tert*-butoxy)-*N*,*N'*-bis(4-(pentafluoro-λ^6-sulfaneyl)phenyl)-4-vinylcyclopentane-1,1-dicarboxamide (2f-*trans* + 2f-*cis*).



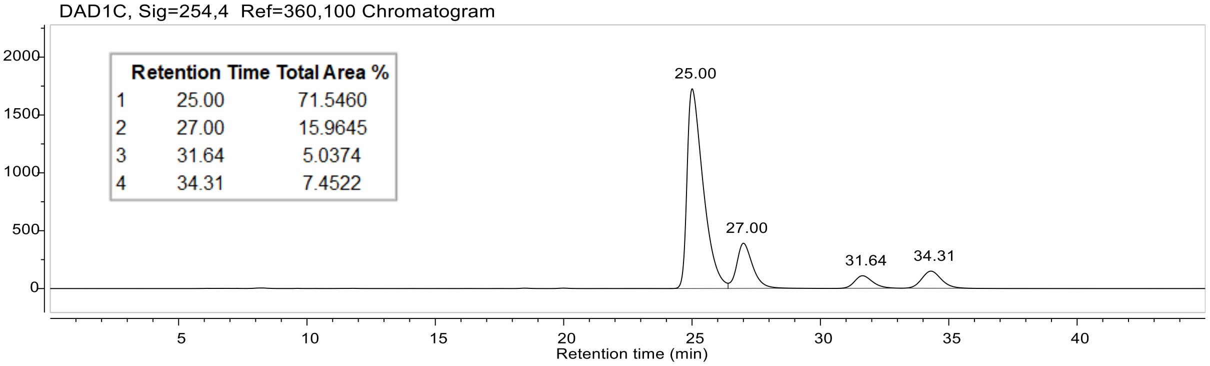
2f-*trans* + 2f-*cis*

Prepared according to the general procedure, using vinylcyclopropane **1f** (0.1 mmol, 55.8 mg), catalyst **P10** (0.005 mmol, 7.4 mg), and *tert*-butyl vinyl ether (0.2 mmol, 26.2 μL). Crude product (80:20 dr) was purified by silica gel column chromatography (0→20% EtOAc/hexanes) to provide **2f** as a flaky white solid. [Average of 2 trials: 83% yield, 80:20 dr (*trans*:*cis*), 90:10 er (*trans*), 76:24 er (*cis*)]. Diastereomers were assigned in analogy to **2b**. The absolute configuration of the major enantiomer of **2f-*trans*** is assigned as (3*R*,4*S*) in analogy to **2g-*trans***.

Chiral HPLC: Chiralpak IA, 10.5% iPrOH/hexanes, 0.5 mL/min, 254 nm. Retention: 25.0 min (*trans*, major enantiomer), 27.0 min (*cis*, major enantiomer), 31.6 min (*cis*, minor enantiomer), 34.3 min (*trans*, minor enantiomer).



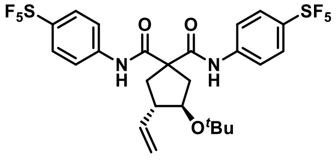
	Retention Time	Total Area %
1	25.38	40.0471
2	27.28	10.4337
3	31.91	9.4476
4	34.77	40.0716



	Retention Time	Total Area %
1	25.00	71.5460
2	27.00	15.9645
3	31.64	5.0374
4	34.31	7.4522

Analytical amounts of racemic **2f-*trans*** and **2f-*cis*** were separated by Preparative HPLC Method B and characterized.

***trans*-3-(*tert*-butoxy)-*N*,*N'*-bis(4-(pentafluoro-λ^6-sulfaneyl)phenyl)-4-vinylcyclopentane-1,1-dicarboxamide (2f-*trans*).**



2f-*trans*

TLC R$_f$ = 0.52 (20% EtOAc/hexanes)

^{1}H NMR (500 MHz, CDCl$_3$) δ 10.47 (s, 1H), 9.65 (s, 1H), 7.80–7.73 (m, 2H), 7.73–7.64 (m, 6H), 5.81 (ddd, *J* = 16.6, 10.3, 8.1 Hz, 1H), 5.11–5.03 (m, 2H), 4.18 (ddd, *J* = 8.5, 4.8, 1.7 Hz, 1H), 3.34 (dd, *J* = 15.7, 8.3 Hz, 1H), 2.80–2.72 (m, 1H), 2.59 (ddd, *J* = 13.4, 7.5, 2.0 Hz, 1H), 2.16–2.06 (m, 2H), 1.30 (s, 9H).

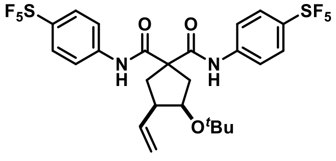
^{13}C NMR (126 MHz, CDCl$_3$) δ 174.5, 169.6, 150.2 (p, *J* = 18.0 Hz), 149.3 (p, *J* = 17.6 Hz), 140.8, 140.2, 137.7, 127.1 (p, *J* = 4.4 Hz), 120.6, 119.5, 116.3, 77.9, 75.9, 61.2, 52.8, 44.3, 40.8, 29.0.

^{19}F NMR (376 MHz, CDCl$_3$) δ 85.7–83.2 (m, 2F), 63.1 (d, *J* = 62.8 Hz, 4F), 62.7 (d, *J* = 62.9 Hz, 4F).

IR (FT-ATR, cm^{-1}) ν_{max} 3312, 1665, 1601, 1549, 1523, 1506, 1402, 1320, 1255, 1194, 1105, 838, 664, 597, 581.

HRMS (ESI) (*m/z*) for [M+H]$^+$ $C_{25}H_{29}F_{10}N_2O_3S_2$ requires 659.1460, observed 659.1454.

***cis*-3-(*tert*-butoxy)-*N*,*N'*-bis(4-(pentafluoro-λ^6-sulfaneyl)phenyl)-4-vinylcyclopentane-1,1-dicarboxamide (2f-*cis*).**



2f-*cis*

TLC R$_f$ = 0.52 (20% EtOAc/hexanes)

^{1}H NMR (600 MHz, CDCl$_3$) δ 11.35 (s, 1H), 9.98 (s, 1H), 7.81–7.76 (m, 2H), 7.73–7.67 (m, 4H), 7.58–7.54 (m, 2H), 5.89 (ddd, *J* = 17.3, 10.3, 8.3 Hz, 1H), 5.17 (d, *J* = 17.3 Hz, 1H), 5.12 (dd, *J* = 10.3, 1.6 Hz, 1H), 4.42 (t, *J* = 4.4 Hz, 1H), 3.12 (dd, *J* = 15.0, 4.7 Hz, 1H), 3.10–3.03 (m, 1H), 2.45 (dd, *J* = 13.5, 7.6 Hz, 1H), 2.35–2.24 (m, 2H), 1.30 (s, 9H).

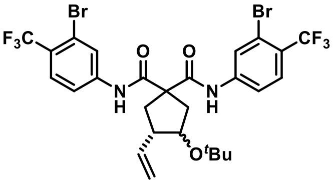
^{13}C NMR (151 MHz, CDCl$_3$) δ 177.0, 172.4, 150.3 (p, *J* = 18.1 Hz), 149.2 (p, *J* = 17.8 Hz) 140.9, 140.0, 136.2, 127.2 (p, *J* = 4.5 Hz), 127.1 (p, *J* = 4.5 Hz), 121.7, 119.7, 117.3, 77.6, 76.2, 57.1, 50.8, 45.4, 44.9, 28.8.

^{19}F NMR (376 MHz, CDCl$_3$) δ 85.8–83.1 (m, 2F), 63.1 (d, *J* = 68.2 Hz, 4F), 62.7 (d, *J* = 68.4 Hz, 4F).

IR (FT-ATR, cm^{-1}) ν_{max} 3322, 1693, 1598, 1530, 1505, 1404, 1370, 1318, 1257, 1194, 1149, 1103, 1040, 948, 841, 670, 593, 580, 542.

HRMS (ESI) (*m/z*) for $[M+H]^+$ $C_{25}H_{29}F_{10}N_2O_3S_2$ requires 659.1460, observed 659.1458.

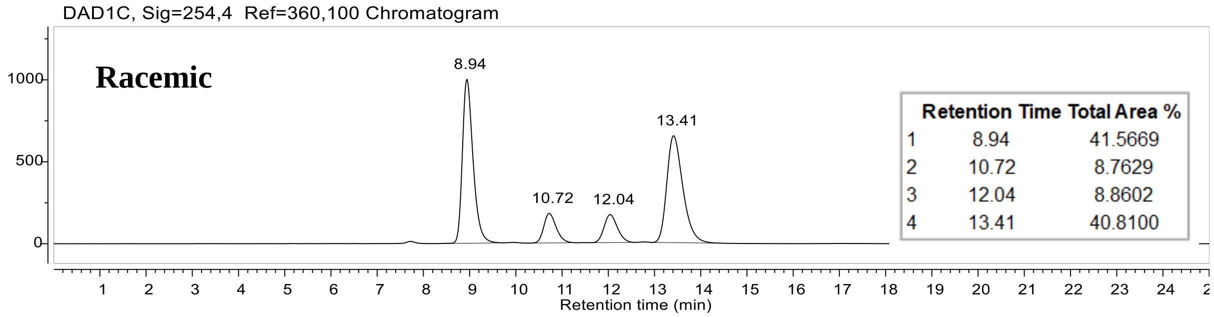
N,*N'*-bis(3-bromo-4-(trifluoromethyl)phenyl)-3-(*tert*-butoxy)-4-vinylcyclopentane-1,1-dicarboxamide (2g-*trans* + 2g-*cis*).



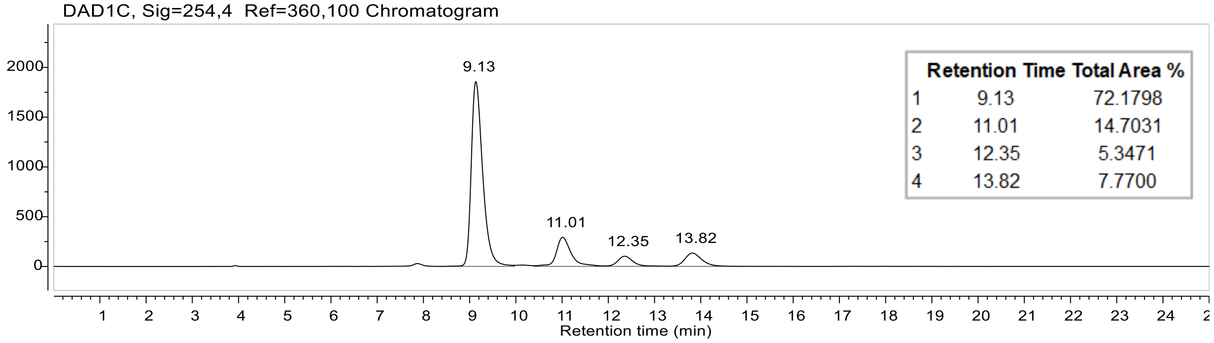
2g-*trans* + 2g-*cis*

Prepared according to the general procedure, using vinylcyclopropane **1g** (0.1 mmol, 60.0 mg), catalyst **P10** (0.005 mmol, 7.4 mg), and *tert*-butyl vinyl ether (0.2 mmol, 26.2 µL). Crude product (81:19 dr) was purified by silica gel column chromatography (0→20% EtOAc/hexanes) to provide **2g** as a flaky white solid. [Average of 2 trials: 81% yield, 81:19 dr (*trans*:*cis*), 90:10 er (*trans*), 73:27 er (*cis*)]. Diastereomers were assigned in analogy to **2b** and confirmed by X-ray crystallography.

Chiral HPLC: Chiralpak IA, 5% iPrOH/hexanes, 1.0 mL/min, 254 nm. Retention: 9.1 min (*trans*, major enantiomer), 11.0 min (*cis*, major enantiomer), 12.3 min (*cis*, minor enantiomer), 13.8 min (*trans*, minor enantiomer).


DAD1C, Sig=254,4 Ref=360,100 Chromatogram

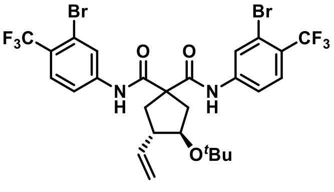
	Retention Time	Total Area %
1	8.94	41.5669
2	10.72	8.7629
3	12.04	8.8602
4	13.41	40.8100


DAD1C, Sig=254,4 Ref=360,100 Chromatogram

	Retention Time	Total Area %
1	9.13	72.1798
2	11.01	14.7031
3	12.35	5.3471
4	13.82	7.7700

Analytical amounts of racemic **2g-*trans*** and **2g-*cis*** were separated by Preparative HPLC Method B and characterized.

trans-*N*,*N'*-bis(3-bromo-4-(trifluoromethyl)phenyl)-3-(*tert*-butoxy)-4-vinylcyclopentane-1,1-dicarboxamide (2g-*trans*).



2g-*trans*

TLC R_f = 0.48 (20% EtOAc/hexanes)

^{1}H NMR (500 MHz, $CDCl_3$) δ 10.52 (s, 1H), 9.72 (s, 1H), 8.05 (s, 1H), 8.00 (s, 1H), 7.70–7.59 (m, 4H), 5.80 (ddd, *J* = 16.8, 10.4, 8.2 Hz, 1H), 5.12–5.03 (m, 2H), 4.20 (ddd, *J* = 8.6, 4.7, 1.5 Hz, 1H), 3.34 (dd, *J* = 15.8, 8.4 Hz, 1H), 2.81–2.71 (m, 1H), 2.57 (ddd, *J* = 13.4, 7.4, 2.0 Hz, 1H), 2.15–2.03 (m, 2H), 1.32 (s, 9H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 174.5, 169.6, 141.9, 141.3, 137.6, 128.6 (q, *J* = 5.3 Hz), 128.5 (q, *J* = 5.4 Hz), 126.6 (s), 126.6 (q, *J* = 31.8 Hz), 125.7, 125.5 (q, *J* = 31.7), 123.1 (q, *J* = 272.5 Hz), 122.9 (q, *J* = 272.6 Hz), 120.6, 119.0, 118.1, 116.4, 78.0, 76.2, 61.2, 52.8, 44.6, 40.7, 28.9.

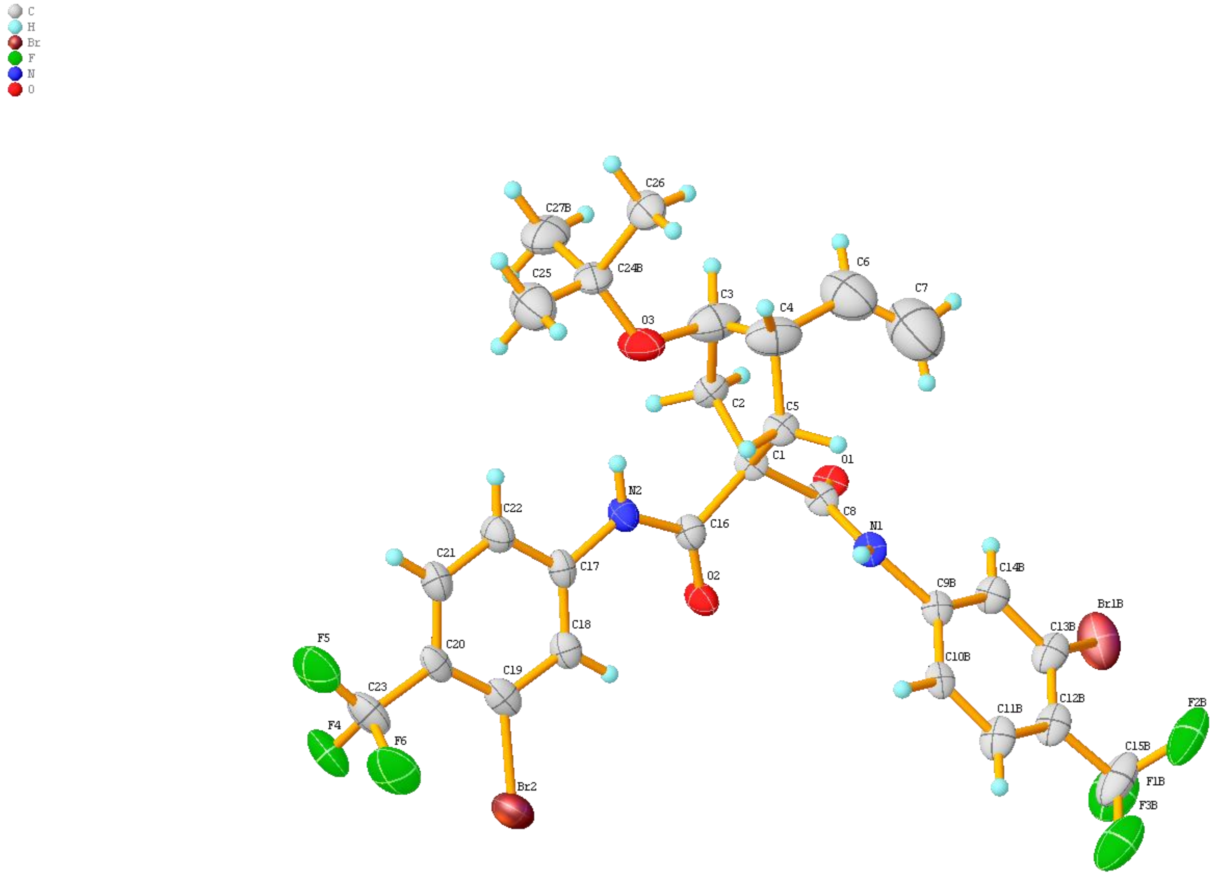
^{19}F NMR (376 MHz, $CDCl_3$) δ –62.4 (s, 3F), –62.6 (s, 3F).

IR (FT-ATR, cm^{-1}) ν_{max} 3290, 1665, 1594, 1504, 1390, 1377, 1309, 1289, 1245, 1178, 1126, 1094, 1021, 989, 913, 881, 830, 754, 682, 626, 609, 445, 415.

HRMS (ESI) (*m/z*) for $[M+H]^+$ $C_{27}H_{27}Br_2F_6N_2O_3$ requires 699.0293, observed 699.0294.

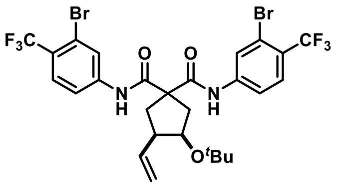
Determination of absolute configuration of 2g-*trans*

Enantioenriched **2g-*trans*** (91:9 er) was purified by Preparative HPLC Method B. Crystals suitable for X-ray crystallography were grown by vapor diffusion of pentane into a solution of **2g-*trans*** in EtOAc. Absolute configuration is (3*R*,4*S*).



Full crystallographic data for **2g-*trans*** is provided in Section VIII.

cis-*N*,*N'*-bis(3-bromo-4-(trifluoromethyl)phenyl)-3-(*tert*-butoxy)-4-vinylcyclopentane-1,1-dicarboxamide (2g-*cis*).



2g-*cis*

TLC R_f = 0.48 (20% EtOAc/hexanes)

^{1}H NMR (600 MHz, $CDCl_3$) δ 11.35 (s, 1H), 9.99 (s, 1H), 8.12 (s, 1H), 7.91 (s, 1H), 7.71–7.58 (m, 3H), 7.53–7.49 (m, 1H), 5.88 (ddd, *J* = 17.3, 10.3, 8.3 Hz, 1H), 5.17 (d, *J* = 17.3 Hz, 1H), 5.13 (dd, *J* = 10.4, 1.7 Hz, 1H), 4.43 (t, *J* = 4.3 Hz, 1H), 3.11 (dd, *J* = 15.0, 4.6 Hz, 1H), 3.09 – 3.03 (m, 1H), 2.44 (dd, *J* = 13.6, 7.7 Hz, 1H), 2.34–2.22 (m, 2H), 1.31 (s, 9H).

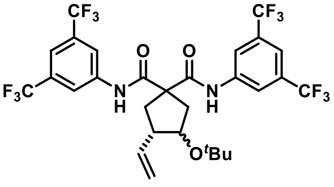
^{13}C NMR (151 MHz, $CDCl_3$) δ 176.9, 172.4, 142.0, 141.1, 136.1, 128.5 (q, J = 5.3 Hz), 128.4 (q, J = 5.4 Hz), 127.8, 126.7 (q, J = 31.8 Hz), 125.9, 125.5 (q, J = 31.7 Hz), 123.1 (q, J = 272.6 Hz), 122.9 (q, J = 272.7 Hz), 120.7, 120.6, 120.0, 118.3, 117.4, 77.7, 76.4, 57.1, 50.8, 45.4, 44.9, 28.8.

^{19}F NMR (376 MHz, $CDCl_3$) δ –62.4 (s, 3F), –62.6 (s, 3F).

IR (FT-ATR, cm^{-1}) ν_{max} 3265, 1696, 1671, 1591, 1521, 1393, 1311, 1266, 1240, 1178, 1124, 1094, 1040, 1021, 946, 920, 826, 610.

HRMS (ESI) (*m/z*) for $[M+H]^+$ $C_{27}H_{27}Br_2F_6N_2O_3$ requires 699.0293, observed 699.0279.

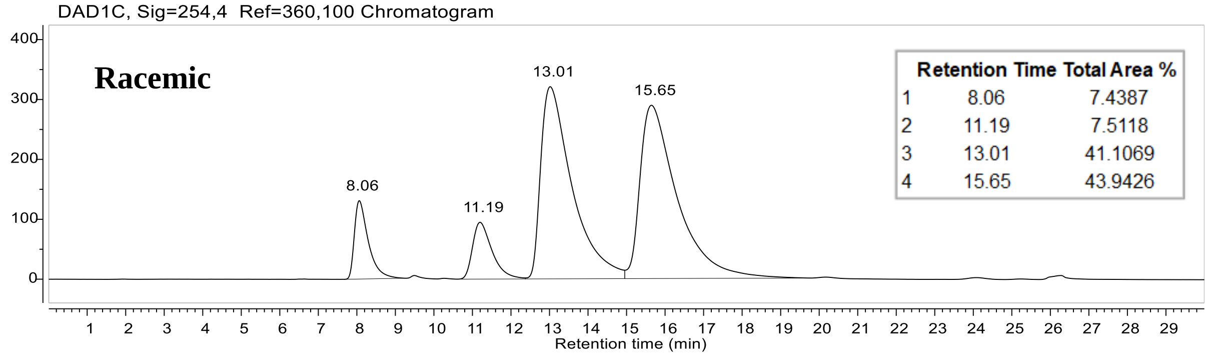
N,N'-bis(3,5-bis(trifluoromethyl)phenyl)-3-(*tert*-butoxy)-4-vinylcyclopentane-1,1-dicarboxamide (2h-*trans* + 2h-*cis*).

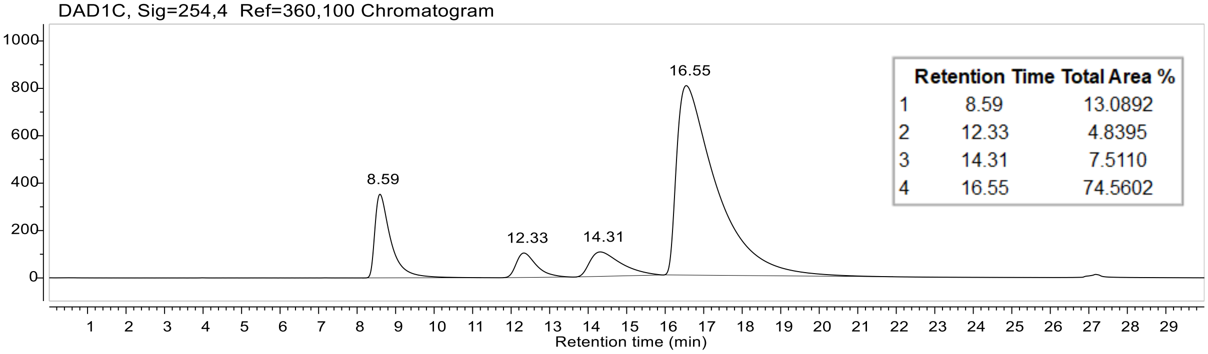


2h-*trans* + 2h-*cis*

Prepared according to the general procedure, using vinylcyclopropane **1h** (0.1 mmol, 57.8 mg), catalyst **P10** (0.005 mmol, 7.4 mg), and *tert*-butyl vinyl ether (0.2 mmol, 26.2 µL). Crude product (82:18 dr) was purified by silica gel column chromatography (0→20% EtOAc/hexanes) to provide **2h** as a flaky white solid. [Average of 2 trials: 94% yield, 82:18 dr (*trans*:*cis*), 90:10 er (*trans*), 73:27 er (*cis*)]. Diastereomers were assigned in analogy to **2b**. The absolute configuration of the major enantiomer of **2h-*trans*** is assigned as (3*R*,4*S*) in analogy to **2g-*trans***.

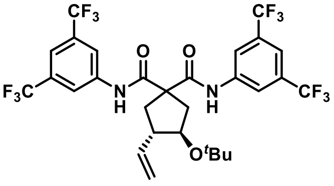
Chiral HPLC: Chiralpak OD-H, 0.1% EtOH/hexanes, 0.8 mL/min, 254 nm. Retention: 8.6 min (*cis*, major enantiomer), 12.3 min (*cis*, minor enantiomer), 14.3 min (*trans*, minor enantiomer), 16.5 min (*trans*, major enantiomer).





Analytical amounts of racemic **2h-*trans*** and **2h-*cis*** were separated by Preparative HPLC Method B and characterized.

trans-_N,N'_-bis(3,5-bis(trifluoromethyl)phenyl)-3-(_tert_-butoxy)-4-vinylcyclopentane-1,1-dicarboxamide (2h-_trans_).



2h-*trans*

TLC $R_f = 0.65$ (20% EtOAc/hexanes)

^{1}H NMR (500 MHz, $CDCl_3$) δ 10.81 (s, 1H), 10.04 (s, 1H), 8.13 (s, 4H), 7.69 (s, 1H), 7.61 (s, 1H), 5.83 (ddd, *J* = 16.8, 10.4, 8.2 Hz, 1H), 5.14–5.04 (m, 2H), 4.25 (dd, *J* = 8.4, 4.4 Hz, 1H), 3.40 (dd, *J* = 15.9, 8.5 Hz, 1H), 2.86–2.77 (m, 1H), 2.60 (ddd, *J* = 13.4, 7.5, 2.1 Hz, 1H), 2.19–2.08 (m, 2H), 1.33 (s, 9H).

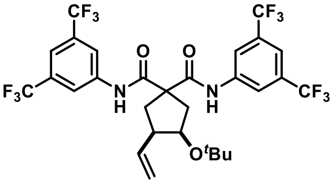
^{13}C NMR (126 MHz, $CDCl_3$) δ 174.8, 169.7, 139.5, 139.0, 137.5, 132.6 (q, *J* = 33.6 Hz), 132.4 (q, *J* = 33.5 Hz), 123.3 (q, *J* = 272.8 Hz), 123.2 (q, *J* = 272.8 Hz), 120.8 (q, *J* = 3.2 Hz), 120.1 (q, *J* = 3.2 Hz), 118.8–118.5 (m), 117.8–117.6 (m), 116.5, 78.1, 76.4, 61.1, 53.0, 45.1, 40.8, 28.9.

^{19}F NMR (376 MHz, $CDCl_3$) δ –63.5 (s, 3F), –63.5 (s, 3F).

IR (FT-ATR, cm^{-1}) ν_{max} 3284, 1660, 1580, 1550, 1471, 1438, 1375, 1272, 1171, 1134, 1110, 935, 923, 889, 724, 701, 681, 408.

HRMS (ESI) (*m/z*) for $[M+H]^+$ $C_{29}H_{27}F_{12}N_2O_3$ requires 679.1830, observed 679.1827.

cis-*N*,*N'*-bis(3,5-bis(trifluoromethyl)phenyl)-3-(*tert*-butoxy)-4-vinylcyclopentane-1,1-dicarboxamide (2h-*cis*).



2h-*cis*

TLC R_f = 0.65 (20% EtOAc/hexanes)

^{1}H NMR (500 MHz, $CDCl_3$) δ 11.55 (s, 1H), 10.23 (s, 1H), 8.14 (s, 2H), 7.99 (s, 2H), 7.71 (s, 1H), 7.61 (s, 1H), 5.90 (ddd, *J* = 18.1, 10.3, 8.3 Hz, 1H), 5.19 (d, *J* = 17.1 Hz, 1H), 5.15 (d, *J* = 10.3 Hz, 1H), 4.46 (t, *J* = 4.3 Hz, 1H), 3.15 (dd, *J* = 15.1, 4.6 Hz, 1H), 3.13–3.06 (m, 1H), 2.48 (dd, *J* = 13.6, 7.7 Hz, 1H), 2.39–2.24 (m, 2H), 1.32 (s, 9H).

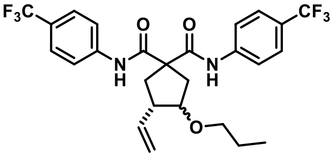
^{13}C NMR (151 MHz, $CDCl_3$) δ 177.0, 172.5, 139.6, 138.8, 136.0, 132.6 (q, *J* = 33.6 Hz), 132.4 (q, *J* = 33.4 Hz), 123.3 (q, *J* = 272.7 Hz), 123.1 (q, *J* = 272.8 Hz), 121.8 (q, *J* = 3.2 Hz), 120.2 (q, *J* = 3.2 Hz), 118.8–118.6 (m), 117.7–117.5 (m), 117.6, 77.8, 76.6, 56.9, 50.9, 45.5, 45.0, 28.8.

^{19}F NMR (376 MHz, $CDCl_3$) δ –63.4 (s, 6F), –63.5 (s, 6F).

IR (FT-ATR, cm^{-1}) ν_{max} 3285, 1662, 1576, 1472, 1443, 1380, 1275, 1174, 1133, 1040, 933, 890, 882, 839, 702, 682, 408.

HRMS (ESI) (*m/z*) for $[M+H]^+$ $C_{29}H_{27}F_{12}N_2O_3$ requires 679.1830, observed 679.1833.

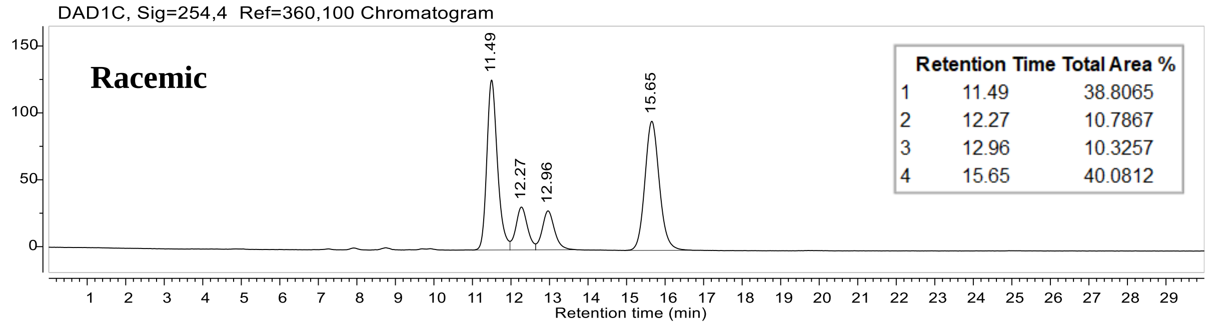
3-propoxy-*N*,*N'*-bis(4-(trifluoromethyl)phenyl)-4-vinylcyclopentane-1,1-dicarboxamide (3-*trans* + 3-*cis*).



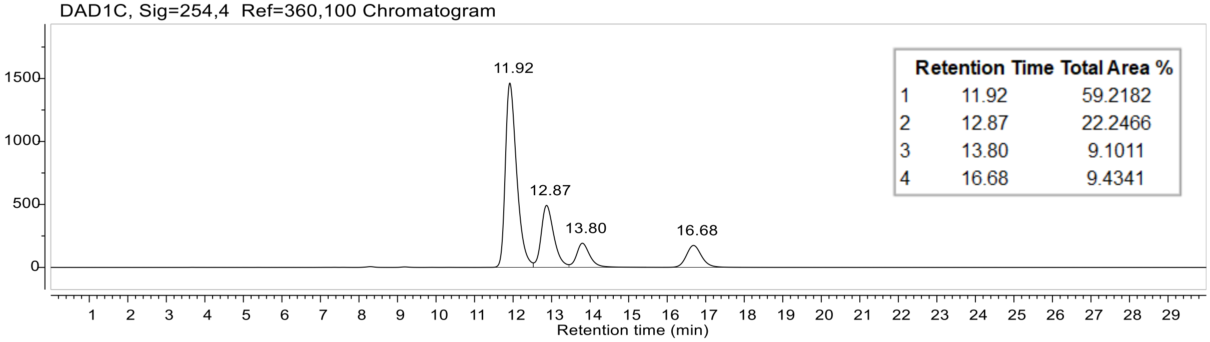
3-*trans* + 3-*cis*

Prepared according to the general procedure, using vinylcyclopropane **1b** (0.1 mmol, 44.2 mg), catalyst **P10** (0.005 mmol, 7.4 mg), and *n*-propyl vinyl ether (0.2 mmol, 22.4 µL). Crude product (73:27 dr) was purified by silica gel column chromatography (0→20% EtOAc/hexanes) to provide **3** as a flaky white solid. [Average of 2 trials: 53% yield, 73:27 dr (*trans*:*cis*), 86:14 er (*trans*), 71:29 er (*cis*)]. Diastereomers were assigned in analogy to **2b**. The absolute configuration of the major enantiomer of **3-*trans*** is assigned as (3*R*,4*S*) in analogy to **2g-*trans***.

Chiral HPLC: Chiralpak IA, 10% iPrOH/hexanes, 0.8 mL/min, 254 nm. Retention: 11.9 min (*trans*, major enantiomer), 12.9 min (*cis*, major enantiomer), 13.8 min (*cis*, minor enantiomer), 16.7 min (*trans*, minor enantiomer).



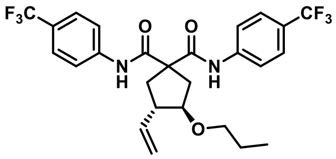
	Retention Time	Total Area %
1	11.49	38.8065
2	12.27	10.7867
3	12.96	10.3257
4	15.65	40.0812



	Retention Time	Total Area %
1	11.92	59.2182
2	12.87	22.2466
3	13.80	9.1011
4	16.68	9.4341

Analytical amounts of racemic **3-*trans*** and **3-*cis*** were separated by silica gel column chromatography (5% EtOAc/hexanes) and characterized.

***trans*-3-propoxy-*N*,*N′*-bis(4-(trifluoromethyl)phenyl)-4-vinylcyclopentane-1,1-dicarboxamide (3-*trans*).**



3-*trans*

TLC R_f = 0.15 (5% EtOAc/hexanes)

^{1}H NMR (600 MHz, CDCl$_3$) δ 10.24 (s, 1H), 9.47 (s, 1H), 7.69 (d, *J* = 8.4 Hz, 2H), 7.63 (app. q, *J* = 8.7 Hz, 4H), 7.57 (d, *J* = 8.5 Hz, 2H), 5.87 (ddd, *J* = 17.7, 10.3, 7.9 Hz, 1H), 5.11 (dd, *J* = 17.1, 1.5 Hz, 1H), 5.06 (d, *J* = 10.3 Hz, 1H), 4.02 (ddd, *J* = 7.7, 3.8, 1.6 Hz, 1H), 3.60 (dt, *J* = 9.4, 6.9 Hz, 1H), 3.51 (dt, *J* = 9.4, 6.8 Hz, 1H), 3.27 (dd, *J* = 15.7, 7.5 Hz, 1H), 2.90 (qd, *J* = 7.9, 3.5 Hz, 1H), 2.65 (ddd, *J* = 13.5, 7.6, 1.6 Hz, 1H), 2.30 (d, *J* = 15.7 Hz, 1H), 2.20 (dd, *J* = 13.5, 8.5 Hz, 1H), 1.69–1.63 (m, 2H), 0.94 (t, *J* = 7.4 Hz, 3H).

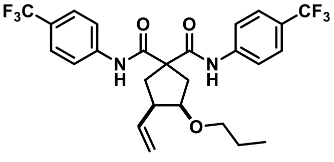
^{13}C NMR (151 MHz, CDCl$_3$) δ 174.1, 169.8, 141.2, 140.7, 138.5, 127.0 (q, *J* = 32.9 Hz), 126.5 (q, *J* = 3.6 Hz), 126.4 (q, *J* = 3.6 Hz), 126.1, 125.9, 121.5 (q, *J* = 272.0 Hz), 121.4 (q, *J* = 271.4), 120.4, 119.9, 116.2, 114.2, 85.9, 72.0, 61.0, 50.5, 43.9, 38.6, 34.0, 32.1, 29.9, 29.7, 29.5, 29.3, 29.1, 23.3, 22.9, 14.3, 10.7.

^{19}F NMR (376 MHz, $CDCl_3$) δ –70.2 (s, 3F), –70.2 (s, 3F).

IR (thin film, cm^{-1}) ν_{max} 3418, 1685, 1664, 1611, 1528, 1410, 1324, 1266, 1167, 1124, 1068, 1017, 922, 896, 843, 738, 705.

HRMS (ESI) (*m/z*) for $[M+H]^+$ $C_{26}H_{27}F_6N_2O_3$ requires 529.1926, observed 529.1929.

cis-3-propoxy-*N*,*N'*-bis(4-(trifluoromethyl)phenyl)-4-vinylcyclopentane-1,1-dicarboxamide (3-*cis*).



3-*cis*

TLC R_f = 0.21 (5% EtOAc/hexanes)

^{1}H NMR (600 MHz, $CDCl_3$) δ 11.29 (s, 1H), 9.80 (s, 1H), 7.72 (d, *J* = 8.4 Hz, 2H), 7.64–7.54 (m, 6H), 5.95 (ddd, *J* = 17.2, 10.3, 7.9 Hz, 1H), 5.20 (app dt, *J* = 17.3, 1.4 Hz, 1H), 5.14 (ddd, *J* = 10.3, 1.7, 0.8 Hz, 1H), 4.15 (t, *J* = 4.1 Hz, 1H), 3.71–3.57 (m, 2H), 3.12–3.07 (m, 1H), 3.04 (dd, *J* = 15.2, 4.5 Hz, 1H), 2.50 (dd, *J* = 13.5, 7.6 Hz, 1H), 2.42–2.31 (m, 2H), 1.77–1.62 (m, 2H), 0.97 (t, *J* = 7.4 Hz, 3H).

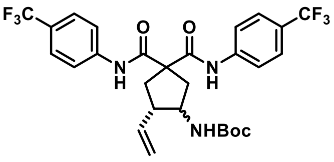
^{13}C NMR (151 MHz, $CDCl_3$) δ 176.4, 172.3, 141.3, 141.0, 135.4, 126.9, 126.7, 126.5 (q, *J* = 3.9 Hz), 126.3 (q, *J* = 3.8 Hz), 126.2, 126.0, 124.3 (q, *J* = 272.0 Hz), 124.2 (q, *J* = 271.1 Hz), 120.4, 120.1, 86.0, 73.5, 57.2, 51.0, 44.3, 42.6, 34.0, 32.1, 29.9, 29.5, 29.3, 29.1, 23.4, 22.9, 14.3, 10.7.

^{19}F NMR (376 MHz, $CDCl_3$) δ –70.2 (s, 3F), –70.2 (s, 3F).

IR (thin film, cm^{-1}) ν_{max} 3424, 1658, 1617, 1522, 1409, 1323, 1264, 1186, 1161, 1112, 1068, 1018, 913, 840, 740.

HRMS (ESI) (*m/z*) for $[M+H]^+$ $C_{26}H_{27}F_6N_2O_3$ requires 529.1926, observed 529.1926.

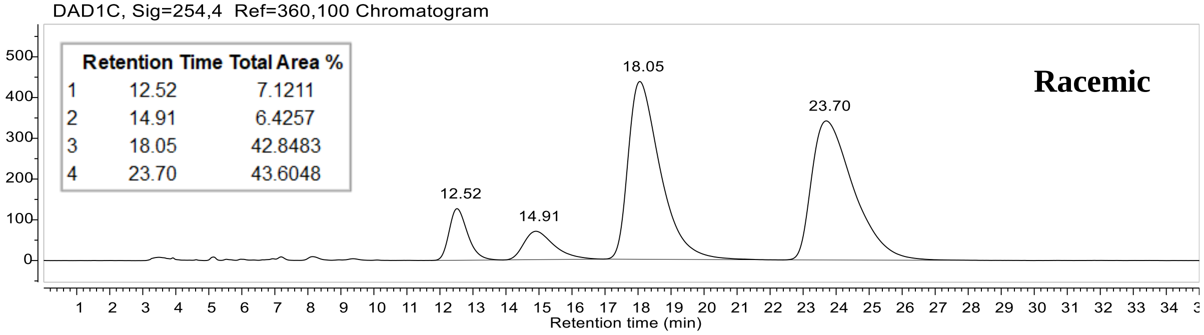
tert-butyl (4,4-bis((4-(trifluoromethyl)phenyl)carbamoyl)-2-vinylcyclopentyl)carbamate (4-*trans* + 4-*cis*).



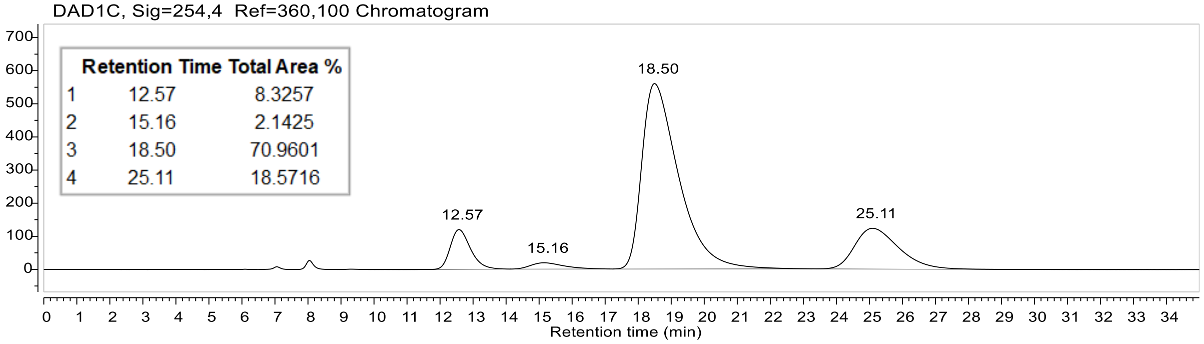
4-*trans* + 4-*cis*

Prepared according to the general procedure, using vinylcyclopropane **1b** (0.1 mmol, 44.2 mg), catalyst **P10** (0.005 mmol, 7.4 mg), and *tert*-butyl vinyl carbamate (0.2 mmol, 28.6 mg). Crude product (89:11 dr) was purified by silica gel column chromatography (0→20% EtOAc/hexanes), then further purified by reversed-phase column chromatography (20→100% MeCN/H_2O) and silica gel column chromatography (0→5% MeOH/DCM) to provide **4** as a foamy white solid. [Average of 2 trials: 72% yield, 88:12 dr (*trans*:*cis*), 80:20 er (*trans*), 80:20 er (*cis*)]. Diastereomers were assigned in analogy to **2b**. The absolute configuration of the major enantiomer of **4-*trans*** is assigned as (1*R*,2*S*) in analogy to **2g-*trans***.

Chiral HPLC: Chiralpak IA, 8% EtOH/hexanes, 1.0 mL/min, 254 nm. Retention: 12.5 min (*cis*, major enantiomer), 15.1 min (*cis*, minor enantiomer), 18.5 min (*trans*, major enantiomer), 25.1 min (*trans*, minor enantiomer).



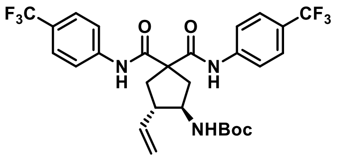
	Retention Time	Total Area %
1	12.52	7.1211
2	14.91	6.4257
3	18.05	42.8483
4	23.70	43.6048



	Retention Time	Total Area %
1	12.57	8.3257
2	15.16	2.1425
3	18.50	70.9601
4	25.11	18.5716

An analytical amount of racemic **4-*trans*** was purified by silica gel column chromatography (2% acetone/toluene) to remove the minor *cis* diastereomer and characterized.

***trans*-*tert*-butyl (4,4-bis((4-(trifluoromethyl)phenyl)carbamoyl)-2-vinylcyclopentyl) carbamate (4-*trans*).**



4-*trans*

TLC R_f(*trans*) = 0.24 (2% acetone/toluene); R_f(*cis*) = 0.29

^{1}H NMR (600 MHz, acetone-d_6) (mixure of rotamers, asterisks denote minor rotamer peaks) δ 9.31 (d, *J* = 2.9 Hz, 2H), 8.91* (s, 0.3H), 8.80 (s, 0.7H), 7.92 (dd, *J* = 8.5, 6.0 Hz, 4H), 7.75–7.53 (m, 4H), 5.90 (ddd, *J* = 17.6, 10.4, 7.3 Hz, 1H), 5.10 (dd, *J* = 17.3, 1.6 Hz, 1H), 5.06 (ddd, *J* = 10.5, 1.4 Hz, 1.4 Hz, 1H), 4.23–4.19 (m, 1H), 2.93–2.86 (m, 1H), 2.84 (dd, *J* = 14.0, 6.9 Hz, 1H), 2.80 (dd, *J* = 13.4, 7.2 Hz, 1H), 2.56 (dd, *J* = 14.0, 5.3 Hz, 1H), 2.43 (dd, *J* = 13.4, 9.9 Hz, 1H), 1.39 (s, 9H).

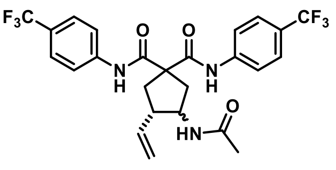
^{13}C NMR (151 MHz, acetone-d_6) δ 171.1, 170.3, 142.5, 142.4, 137.1, 128.6, 125.8 (q, *J* = 3.8 Hz), 125.0 (q, *J* = 32.5 Hz), 124.9 (q, *J* = 32.5 Hz), 124.45 (q, *J* = 271.1 Hz), 124.42 (q, *J* = 271.1 Hz), 120.2, 120.1, 120.0, 118.1, 115.6, 77.9, 64.9, 61.8, 54.3, 46.9, 39.6, 37.2, 27.7, 27.5.

^{19}F NMR (376 MHz, $CDCl_3$) δ –71.4 (s, 3F), –71.4 (s, 3F).

IR (thin film, cm^{-1}) ν_{max} 3318, 2981, 2933, 1685, 1607, 1522, 1440, 1409, 1368, 1324, 1254, 1166, 1123, 1069, 1018, 920, 841, 776, 741, 704, 666.

HRMS (ESI) (*m/z*) for $[M+H]^+$ $C_{28}H_{30}F_6N_3O_4$ requires 586.2141, observed 586.2133.

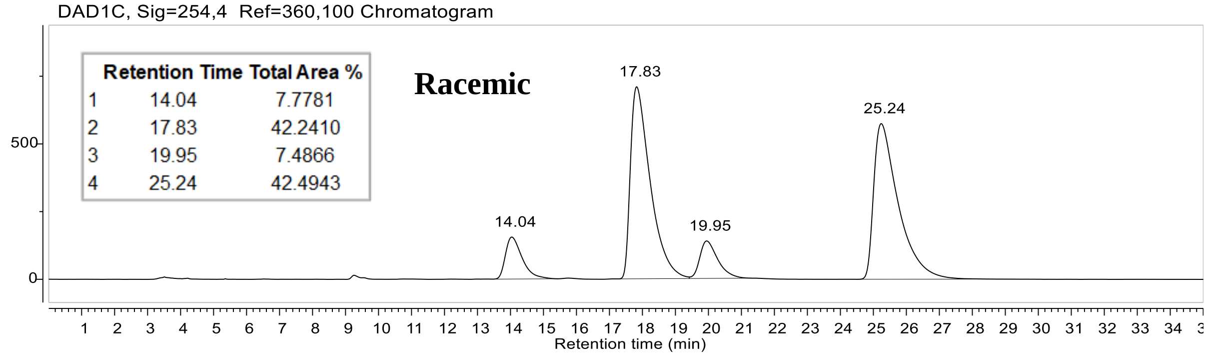
3-acetamido-*N,N'*-bis(4-(trifluoromethyl)phenyl)-4-vinylcyclopentane-1,1-dicarboxamide (5-*trans* + 5-*cis*).



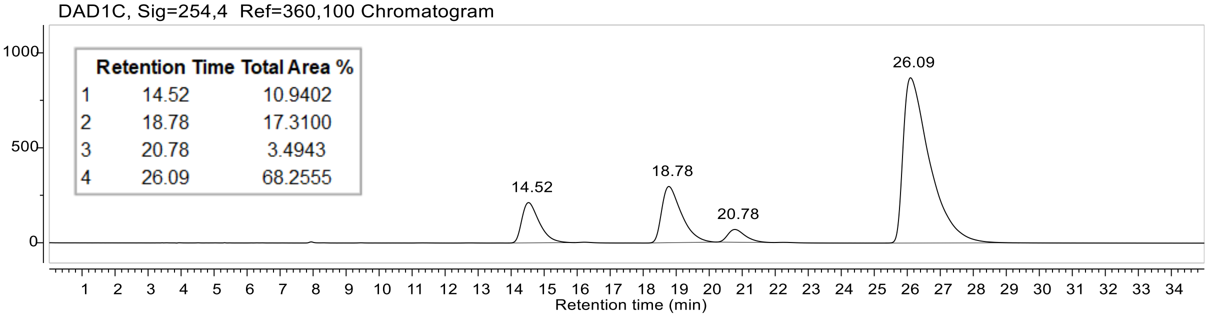
5-*trans* + 5-*cis*

Prepared according to the general procedure, using vinylcyclopropane **1b** (0.1 mmol, 44.2 mg), catalyst **P10** (0.005 mmol, 7.4 mg), and *N*-vinyl acetamide (0.2 mmol, 17.0 mg). Crude product (85:15 dr) was purified by silica gel column chromatography (20→50% EtOAc/hexanes), then further purified by reversed-phase column chromatography (20→100% MeCN/H_2O) to provide **5** as a white solid. [Average of 2 trials: 59% yield, 85:15 dr (*trans*:*cis*), 78:22 er (*trans*), 71:29 er (*cis*)]. Diastereomers were assigned in analogy to **2b**. The absolute configuration of the major enantiomer of **5-*trans*** is assigned as (3*R*,4*S*) in analogy to **2g-*trans***.

Chiral HPLC: Chiralpak IB, 5% EtOH/hexanes, 1.0 mL/min, 254 nm. Retention: 14.5 min (*cis*, major enantiomer), 18.8 min (*trans*, minor enantiomer), 20.8 min (*cis*, minor enantiomer), 26.1 min (*trans*, major enantiomer).



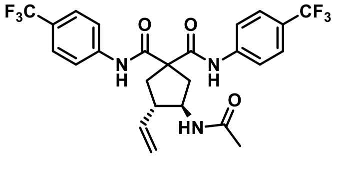
	Retention Time	Total Area %
1	14.04	7.7781
2	17.83	42.2410
3	19.95	7.4866
4	25.24	42.4943



	Retention Time	Total Area %
1	14.52	10.9402
2	18.78	17.3100
3	20.78	3.4943
4	26.09	68.2555

An analytical amount of racemic **5-*trans*** was purified by silica gel column chromatography (2% acetone/toluene) to remove the minor *cis* diastereomer and characterized.

***trans*-3-acetamido-*N*,*N'*-bis(4-(trifluoromethyl)phenyl)-4-vinylcyclopentane-1,1-dicarboxamide (5-*trans*).**



5-*trans*

TLC R_f(*trans*) = 0.08 (2% acetone/toluene); R_f(*cis*) = 0.13

^{1}H NMR (600 MHz, acetone-d_6) δ 9.41 (d, *J* = 4.8 Hz, 1H), 9.31 (d, *J* = 4.6 Hz, 1H), 7.92 (d, *J* = 8.4 Hz, 4H), 7.65 (dd, *J* = 8.7, 4.3 Hz, 4H), 7.04 (d, *J* = 8.3 Hz, 1H), 5.87 (ddd, *J* = 17.5, 10.4, 7.4 Hz, 1H), 5.08 (dt, *J* = 17.4, 1.7 Hz, 1H), 5.04 (dt, *J* = 10.5, 1.4 Hz, 1H), 4.52–4.41 (m, 1H), 2.93–2.86 (m, 2H), 2.81 (dt, *J* = 13.4, 3.7 Hz, 2H), 2.54 (ddd, *J* = 14.1, 5.6, 3.3 Hz, 1H), 2.45 (ddd, *J* = 13.3, 9.9, 2.8 Hz, 1H), 1.85 (s, 3H).

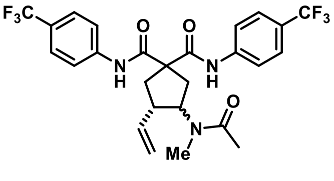
^{13}C NMR (151 MHz, acetone-d_6) δ 171.9, 171.8, 171.2, 171.1, 169.8, 143.4, 143.3, 137.9, 126.72 (q, *J* = 4.0 Hz), 126.69 (q, *J* = 4.0 Hz), 125.9, (q, *J* = 32.4 Hz), 125.8 (q, *J* = 32.4 Hz), 125.4 (q, *J* = 270.8 Hz), 125.3 (q, *J* = 270.7 Hz), 121.0, 120.9, 116.5, 62.9, 53.7, 47.5, 40.2, 38.5, 23.1.

^{19}F NMR (376 MHz, acetone-d_6) δ –71.4 (s, 3F), –71.4 (s, 3F).

IR (thin film, cm^{-1}) ν_{max} 3425, 1657, 1608, 1523, 1409, 1376, 1324, 1265, 1186, 1165, 1114, 1068, 1018, 918, 840, 733.

HRMS (ESI) (*m/z*) for $[M+H]^+$ $C_{25}H_{24}F_6N_3O_3$ requires 528.1722, observed 528.1722.

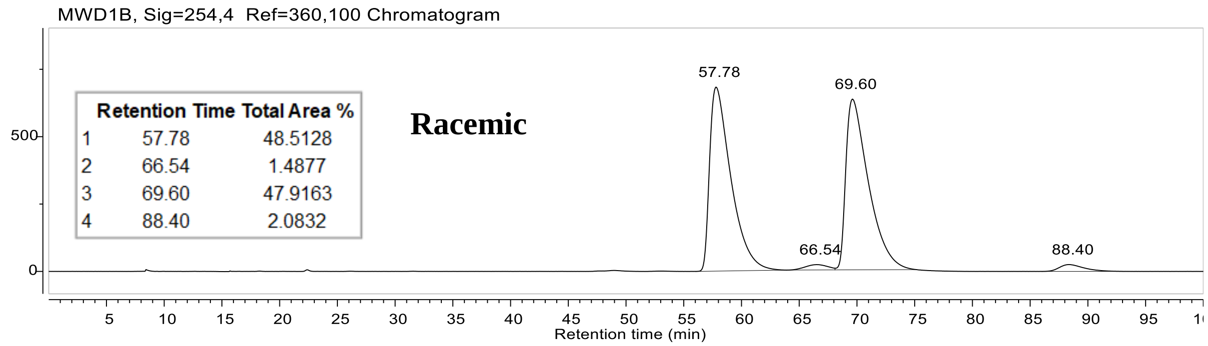
3-(*N*-methylacetamido)-*N*,*N'*-bis(4-(trifluoromethyl)phenyl)-4-vinylcyclopentane-1,1-dicarboxamide (6-*trans* + 6-*cis*).



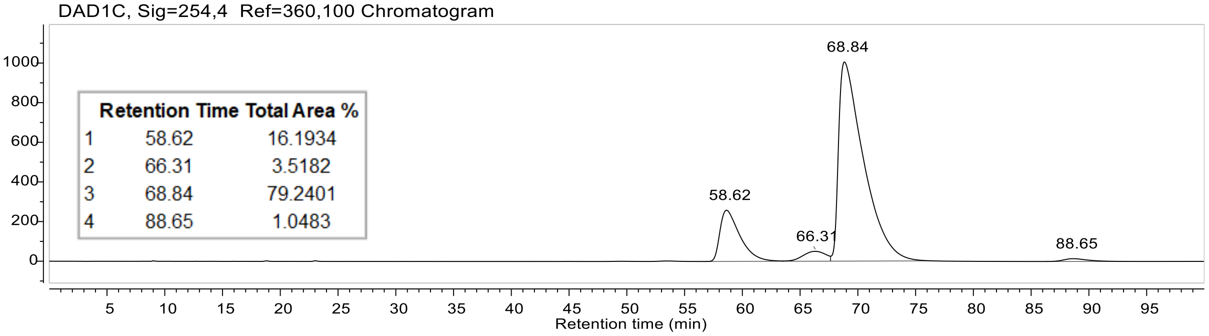
6-*trans* + 6-*cis*

Prepared according to the general procedure, using vinylcyclopropane **1b** (0.1 mmol, 44.2 mg), catalyst **P10** (0.005 mmol, 7.4 mg), and *N*-methyl-*N*-vinyl acetamide (0.2 mmol, 20.7 µL). Crude product (96:4 dr) was purified by silica gel column chromatography (20→70% EtOAc/hexanes) to provide **6** as a white solid. [Average of 2 trials: 71% yield, 96:4 dr (*trans*:*cis*), 83:17 er (*trans*), 77:23 er (*cis*)]. Diastereomers were assigned in analogy to **2b**. The absolute configuration of the major enantiomer of **6-*trans*** is assigned as (3*R*,4*S*) in analogy to **2g-*trans***.

Chiral HPLC: Chiralpak IB, 3% EtOH/hexanes, 0.4 mL/min, 254 nm. Retention: 58.6 min (*trans*, minor enantiomer), 66.3 min (*cis*, major enantiomer), 68.8 min (*trans*, major enantiomer), 88.6 min (*cis*, minor enantiomer).



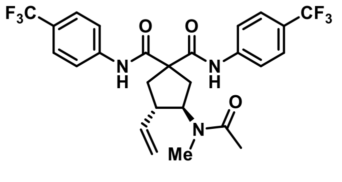
	Retention Time	Total Area %
1	57.78	48.5128
2	66.54	1.4877
3	69.60	47.9163
4	88.40	2.0832



	Retention Time	Total Area %
1	58.62	16.1934
2	66.31	3.5182
3	68.84	79.2401
4	88.65	1.0483

An analytical amount of racemic **6-*trans*** was purified by reversed-phase column chromatography (20→100% MeCN/H_2O) to remove the minor *cis* diastereomer and characterized.

***trans*-3-(*N*-methylacetamido)-*N,N′*-bis(4-(trifluoromethyl)phenyl)-4-vinylcyclopentane-1,1-dicarboxamide (6-*trans*).**



6-*trans*

TLC R$_f$ = 0.35 (50% EtOAc/hexanes)

^{1}H NMR (500 MHz, CDCl$_3$) δ 11.03–10.88 (m, 2H), 7.86–7.80 (m, 2H), 7.75–7.70 (m, 2H), 7.63–7.55 (m, 4H), 5.66 (ddd, *J* = 17.0, 10.2, 8.4 Hz, 1H), 5.16 (dd, *J* = 17.3, 1.6 Hz, 1H), 5.11 (dd, *J* = 10.1, 1.8 Hz, 1H), 4.15 (td, *J* = 9.9, 5.4 Hz, 1H), 3.48–3.36 (m, 1H), 3.07 (s, 3H), 3.01 (dd, *J* = 15.0, 10.0 Hz, 1H), 2.85 (app. t, *J* = 12.4 Hz, 1H), 2.77 (dd, *J* = 15.0, 5.3 Hz, 1H), 2.44 (dd, *J* = 13.1, 7.7 Hz, 1H), 2.18 (s, 3H).

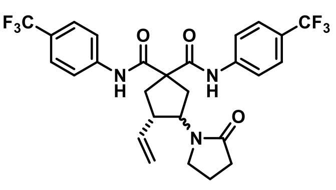
^{13}C NMR (126 MHz, CDCl$_3$) δ 175.3, 172.7, 172.3, 141.7, 141.3, 136.4, 126.3 (q, *J* = 3.5 Hz), 126.1 (q, *J* = 32.7 Hz), 126.0 (q, *J* = 32.7 Hz), 124.3 (q, *J* = 271.4 Hz), 120.1, 119.9, 118.1, 68.1, 60.6, 47.8, 47.0, 41.3, 40.0, 23.8.

^{19}F NMR (376 MHz, CDCl$_3$) δ –62.5 (s, 3F), –62.6 (s, 3F).

IR (FT-ATR, cm^{-1}) ν_{max} 3301, 1663, 1604, 1522, 1407, 1317, 1250, 1162, 1110, 1065, 1016, 920, 838, 734, 703, 593, 510, 412.

HRMS (ESI) (*m/z*) for $[M+H]^+$ $C_{26}H_{26}F_6N_3O_3$ requires 542.1878, observed 542.1882.

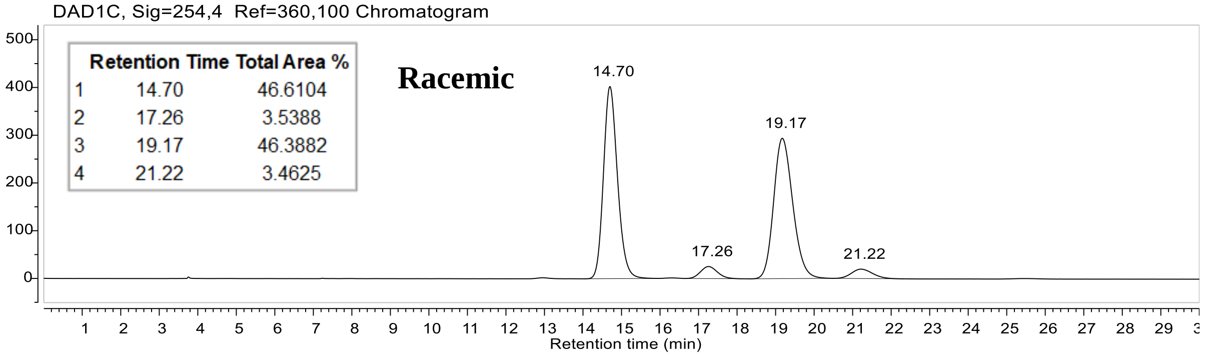
3-(2-oxopyrrolidin-1-yl)-*N,N′*-bis(4-(trifluoromethyl)phenyl)-4-vinylcyclopentane-1,1-dicarboxamide (7-*trans* + 7-*cis*).



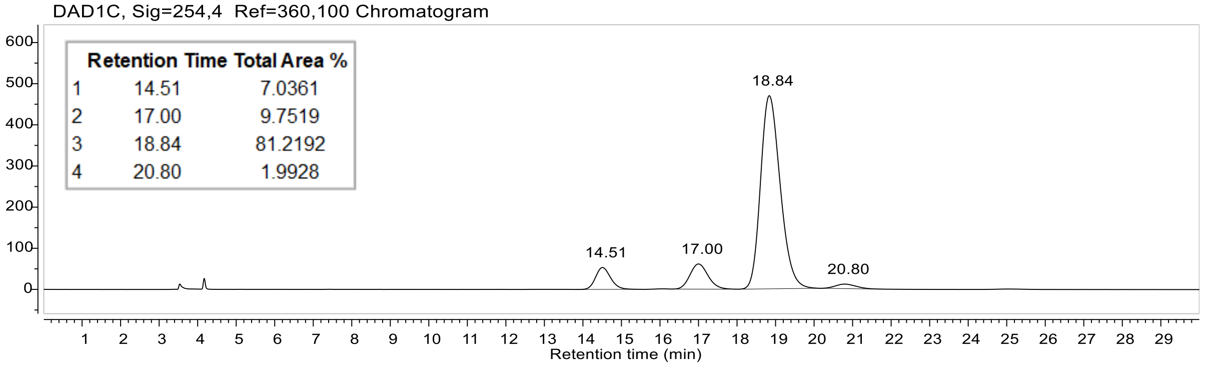
7-*trans* + 7-*cis*

Prepared according to a modification of the general procedure, using vinylcyclopropane **1b** (0.1 mmol, 44.2 mg), catalyst **P10** (10 mol %, 0.01 mmol, 14.9 mg), and *N*-vinyl pyrrolidinone (0.2 mmol, 21.4 µL). Crude product was purified by silica gel column chromatography (20→70% EtOAc/hexanes), then further purified by reversed-phase column chromatography (20→100% MeCN/H$_2$O) to provide **6** as a white solid. [Average of 2 trials: 38% yield, 91:9 dr (*trans*:*cis*), 92:8 er (*trans*), 78:22 er (*cis*)]. Diastereomers were assigned in analogy to **2b**. The absolute configuration of the major enantiomer of **7-*trans*** is assigned as (3*R*,4*S*) in analogy to **2g-*trans***.

Chiral HPLC: Chiralpak IC, 3% EtOH/hexanes, 1.0 mL/min, 254 nm. Retention: 14.5 min (*trans*, minor enantiomer), 17.0 min (*cis*, major enantiomer), 18.8 min (*trans*, major enantiomer), 20.8 min (*cis*, minor enantiomer).



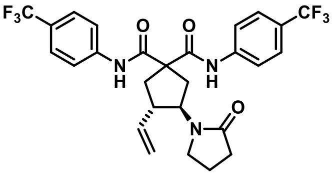
Retention Time		Total Area %
1	14.70	46.6104
2	17.26	3.5388
3	19.17	46.3882
4	21.22	3.4625



Retention Time		Total Area %
1	14.51	7.0361
2	17.00	9.7519
3	18.84	81.2192
4	20.80	1.9928

An analytical amount of racemic **7-*trans*** was purified by silica gel chromatography (10% acetone/toluene) to remove the minor *cis* diastereomer and characterized.

***trans*-3-(2-oxopyrrolidin-1-yl)-*N*,*N'*-bis(4-(trifluoromethyl)phenyl)-4-vinylcyclopentane-1,1-dicarboxamide (7-*trans*).**



7-*trans*

TLC R_f(*trans*) = 0.18 (10% acetone/toluene); R_f(*cis*) = 0.14

^{1}H NMR (600 MHz, $CDCl_3$) δ 11.05 (s, 1H), 10.75 (s, 1H), 7.85 (d, *J* = 8.4 Hz, 2H), 7.72 (d, *J* = 8.5 Hz, 2H), 7.59 (t, *J* = 8.7 Hz, 5H), 5.70 (ddd, *J* = 17.1, 10.2, 8.3 Hz, 1H), 5.20 (dd, *J* = 17.2, 1.2 Hz, 1H), 5.15 (dd, *J* = 10.3, 1.5 Hz, 1H), 4.14 (td, *J* = 9.7, 4.9 Hz, 1H), 3.52 (ddt, *J* = 29.4, 9.7, 6.9 Hz, 2H), 3.35 (dq, *J* = 12.2, 8.2 Hz, 1H), 3.10 (dd, *J* = 15.3, 10.0 Hz, 1H), 2.89 (dd, *J* = 15.3, 5.0 Hz, 1H), 2.83 (t, *J* = 12.7 Hz, 1H), 2.52 (td, *J* = 7.9, 7.5, 2.1 Hz, 2H), 2.47 (dd, *J* = 13.1, 7.2 Hz, 1H), 2.12–2.02 (m, 2H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 176.7, 174.9, 172.2, 141.6, 141.3, 135.6, 126.32 (q, *J* = 3.6 Hz), 126.28 (q, *J* = 3.6 Hz), 126.2 (q, *J* = 33.0 Hz), 126.1 (q, *J* = 33.0 Hz), 124.29 (q, *J* = 271.8 Hz), 124.27 (q, *J* = 271.1 Hz), 121.2, 120.1, 118.4, 61.0, 60.7, 52.5, 48.0, 46.5, 38.7, 32.7, 18.6.

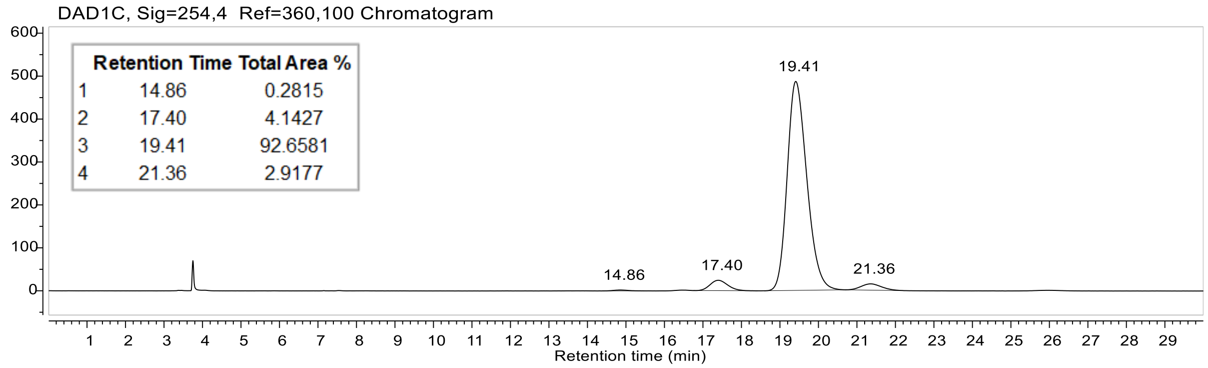
^{19}F NMR (376 MHz, $CDCl_3$) δ –70.2 (s, 3F), –70.3 (s, 3F).

IR (thin film, cm^{-1}) ν_{max} 3426, 1663, 1609, 1522, 1462, 1436, 1409, 1324, 1291, 1266, 1184, 1165, 1117, 1068, 1017, 927, 905, 896, 842, 738, 705.

HRMS (ESI) (*m/z*) for $[M+H]^+$ $C_{25}H_{24}F_6N_3O_3$ requires 554.1878, observed 554.1874.

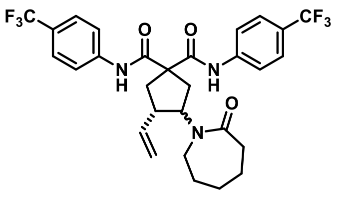
Enantioenrichment of 7-*trans* by filtration

To solid **7-*trans* + 7-*cis*** [19 mg, 87:13 dr (*trans*:*cis*), 92:8 er (*trans*), 77:23 er (*cis*)] was added 4 mL hexanes, 2 mL iPrOH, and 2 mL EtOH. This mixture was sonicated to provide a suspension of fine particles. Syringe-filtration (0.2 µm PTFE) of this suspension provided a clear, colorless solution of enantioenriched **7a-*trans*** [93:7 dr (*trans*:*cis*), 99.5:0.5 er (*trans*), 59:41 er (*cis*)].



	Retention Time	Total Area %
1	14.86	0.2815
2	17.40	4.1427
3	19.41	92.6581
4	21.36	2.9177

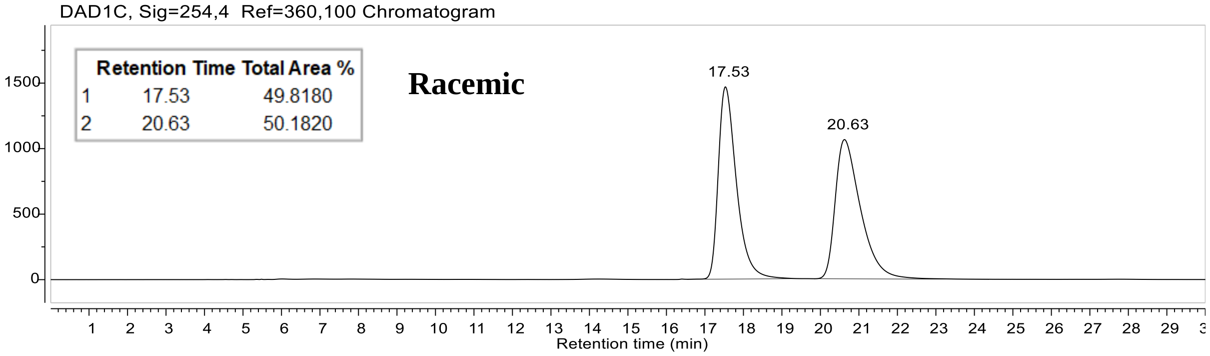
3-(2-oxoazepan-1-yl)-*N,N'*-bis(4-(trifluoromethyl)phenyl)-4-vinylcyclopentane-1,1-dicarboxamide (8-*trans* + 8-*cis*).

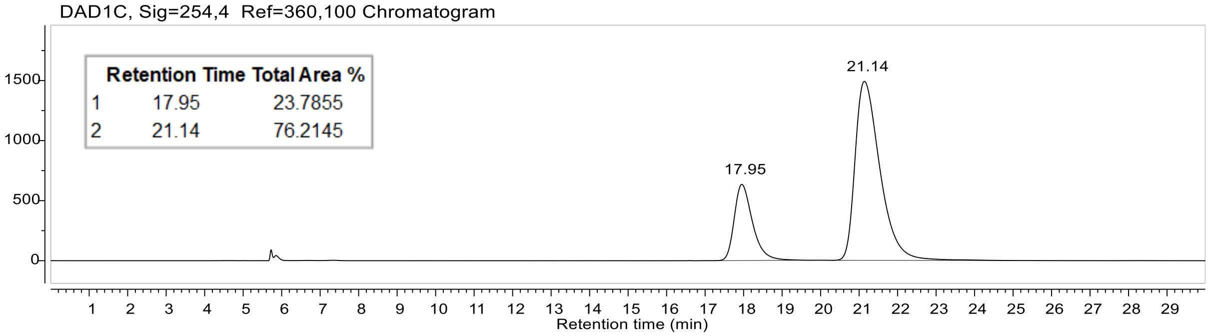


8-*trans* + 8-*cis*

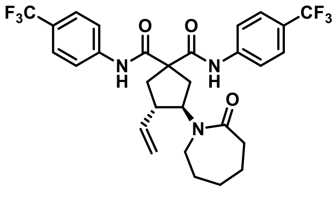
Prepared according to the general procedure, using vinylcyclopropane **1b** (0.1 mmol, 44.2 mg), catalyst **P10** (0.005 mmol, 7.4 mg), and *N*-vinyl caprolactam (0.2 mmol, 27.8 mg). Crude product (85:15 dr) was purified by silica gel column chromatography (0→50% EtOAc/hexanes) and the minor *cis* diastereomer was removed at this stage. The major *trans* diastereomer was further purified by reversed-phase column chromatography (20→100% MeCN/H_2O) to provide **8-*trans*** as a white solid. [Average of 2 trials: 39% yield, >99:1 dr (*trans*:*cis*), 77:23 er (*trans*)]. Diastereomers were assigned in analogy to **2b**. The absolute configuration of the major enantiomer of **8-*trans*** is assigned as (3*R*,4*S*) in analogy to **2g-*trans***.

Chiral HPLC: Chiralpak IC, 1% EtOH/hexanes, 0.8 mL/min, 254 nm. Retention: 17.9 min (*trans*, minor enantiomer), 21.1 min (*trans*, major enantiomer).





***trans*-3-(2-oxoazepan-1-yl)-*N,N′*-bis(4-(trifluoromethyl)phenyl)-4-vinylcyclopentane-1,1-dicarboxamide (8-*trans*).**



8-*trans*

TLC R$_f$ = 0.56 (50% EtOAc/hexanes)

^{1}H NMR (500 MHz, CDCl$_3$) δ 11.03 (s, 1H), 10.99 (s, 1H), 7.86–7.81 (m, 2H), 7.75–7.71 (m, 2H), 7.63–7.56 (m, 4H), 5.70 (ddd, *J* = 17.1, 10.1, 8.5 Hz, 1H), 5.14 (d, *J* = 17.3 Hz, 1H), 5.10 (dd, *J* = 10.1, 1.8 Hz, 1H), 4.20 (td, *J* = 10.0, 5.3 Hz, 1H), 3.52–3.36 (m, 3H), 3.02 (dd, *J* = 15.0, 10.0 Hz, 1H), 2.87 (dd, *J* = 13.1, 11.8 Hz, 1H), 2.71 (dd, *J* = 15.0, 5.4 Hz, 1H), 2.68–2.54 (m, 2H), 2.42 (dd, *J* = 13.1, 7.7 Hz, 1H), 1.86–1.62 (m, 6H).

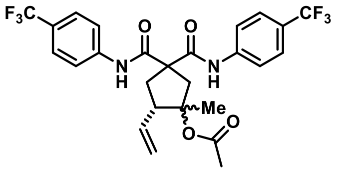
^{13}C NMR (126 MHz, CDCl$_3$) δ 177.5, 175.6, 172.8, 141.7, 141.3, 137.3, 126.3 (q, *J* = 1.4 Hz), 126.3 (q, *J* = 1.4 Hz), 126.1 (q, *J* = 32.7 Hz), 126.0 (q, *J* = 32.7 Hz), 124.3 (q, *J* = 271.5 Hz), 120.1, 119.9, 118.0, 70.4, 60.5, 55.8, 48.3, 47.2, 41.0, 38.6, 29.8, 27.9, 23.3.

^{19}F NMR (376 MHz, CDCl$_3$) δ –62.5 (s, 3F), –62.6 (s, 3F).

IR (FT-ATR, cm^{-1}) ν_{max} 3303, 1666, 1605, 1522, 1445, 1408, 1317, 1252, 1184, 1162, 1111, 1066, 1016, 919, 840, 734, 594, 511.

HRMS (ESI) (*m/z*) for [M+H]$^+$ $C_{29}H_{30}F_6N_3O_3$ requires 582.2191, observed 582.2196.

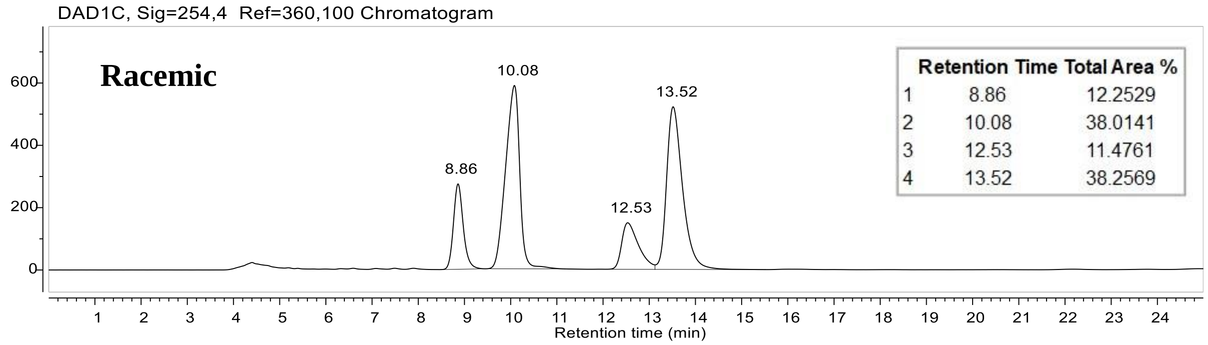
1-methyl-4,4-bis((4-(trifluoromethyl)phenyl)carbamoyl)-2-vinylcyclopentyl acetate (9-*trans* + 9-*cis*).



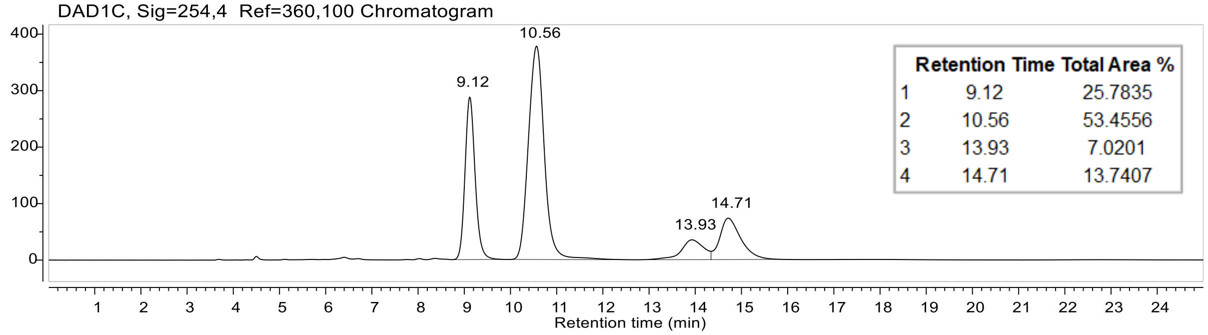
9-*trans* + 9-*cis*

Prepared according to the general procedure, using vinylcyclopropane **1b** (0.1 mmol, 44.2 mg), catalyst **P10** (0.005 mmol, 7.4 mg), and isopropenyl acetate (0.2 mmol, 22.0 µL). Crude product was purified by silica gel column chromatography (0→50% EtOAc/hexanes) to provide **9** as a flaky white solid. [Average of 2 trials: 16% yield, 66:34 dr (*major*:*minor*), 79:21 er (*major*), 80:20 er (*minor*)]. The diastereomers were inseparable and were not assigned.

Chiral HPLC: Chiralpak IA, 20% iPrOH/hexanes, 0.8 mL/min, 254 nm. Retention: 9.1 min (*minor*, major enantiomer), 10.5 min (*major*, major enantiomer), 13.9 min (*minor*, minor enantiomer), 14.7 min (*major*, minor enantiomer).



	Retention Time	Total Area %
1	8.86	12.2529
2	10.08	38.0141
3	12.53	11.4761
4	13.52	38.2569



	Retention Time	Total Area %
1	9.12	25.7835
2	10.56	53.4556
3	13.93	7.0201
4	14.71	13.7407

(9-*trans* + 9-*cis*)

TLC R_f = 0.42 (20% EtOAc/hexanes)

^{1}H NMR, major (600 MHz, $CDCl_3$) δ 8.73 (s, 1H), 8.53 (s, 1H), 7.71 (d, *J* = 8.4 Hz, 1H), 7.67–7.53 (comp, 7H), 5.75 (ddd, *J* = 17.3, 10.2, 7.3 Hz, 1H), 5.18 (app. t, *J* = 1.4 Hz, 1H), 5.15 (app. t, *J* = 1.4 Hz, 1H), 3.18 (app. q, *J* = 8.0 Hz, 1H), 3.08 (d, *J* = 15.1 Hz, 1H), 2.94 (d, *J* = 15.1 Hz, 1H), 2.80 (ddd, *J* = 13.5, 10.7, 7.7 Hz, 1H), 2.28 (dd, *J* = 13.6, 9.7 Hz, 1H), 1.97 (s, 3H), 1.47 (s, 3H).

^{1}H NMR, minor (600 MHz, $CDCl_3$) δ 8.39 (s, 1H), 7.87 (s, 1H), 7.71 (d, *J* = 8.4 Hz, 1H), 7.67–7.53 (comp, 7H), 5.80 (ddd, *J* = 17.2, 10.3, 8.3 Hz, 1H), 5.16 (d, *J* = 1.2 Hz, 1H), 5.12 (app. t, *J* =

1.3 Hz, 1H), 3.60 (d, *J* = 15.3 Hz, 1H), 2.80 (ddd, *J* = 13.5, 10.7, 7.7 Hz, 1H), 2.57 (d, *J* = 12.1 Hz, 1H), 2.55 (d, *J* = 10.0 Hz, 1H), 2.45 (dt, *J* = 11.6, 8.1 Hz, 1H), 1.87 (s, 3H), 1.59 (s, 3H).

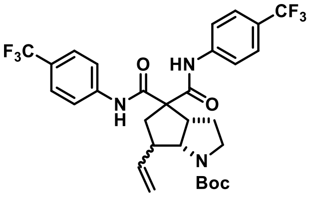
^{13}C NMR, mixture of diastereomers (151 MHz, $CDCl_3$) δ 171.7, 171.4, 170.1, 169.6, 140.6, 140.5, 135.4, 134.4, 127.0 (q, *J* = 33.1 Hz), 126.57 (q, *J* = 3.9 Hz), 126.55 (q, *J* = 3.5 Hz), 126.50 (q, *J* = 4.1 Hz), 126.47 (q, *J* = 4.2 Hz), 124.08 (q, *J* = 271.9 Hz), 124.05 (q, *J* = 271.6 Hz), 120.1, 119.9, 119.8, 119.7, 119.0, 118.1, 110.2, 89.8, 89.5, 61.1, 60.2, 55.4, 53.6, 51.3, 43.0, 42.2, 39.3, 38.0, 30.5, 29.9, 22.4, 22.4, 21.5, 21.3.

^{19}F NMR (376 MHz, $CDCl_3$) δ −70.1 (m, 6F).

IR (FT-ATR, cm^{-1}) ν_{max} 3316, 1738, 1666, 1605, 1551, 1526, 1408, 1324, 1256, 1162, 1113, 1069, 1017, 842.

HRMS (ESI) (*m/z*) for $[M+H]^+$ $C_{25}H_{24}F_6N_3O_3$ requires 543.1719, observed 543.1711.

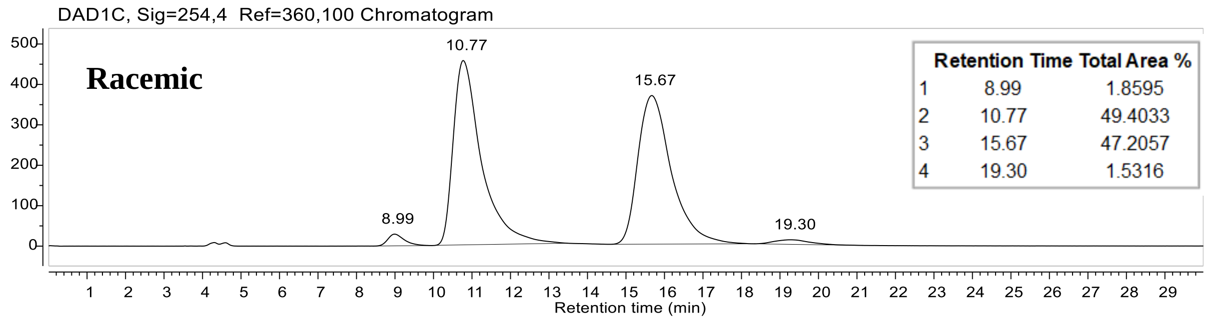
tert-butyl 4,4-bis((4-(trifluoromethyl)phenyl)carbamoyl)-6-vinylhexahydrocyclopenta [b]pyrrole-1(2*H*)-carboxylate: (10-*trans* + 10-*cis*):



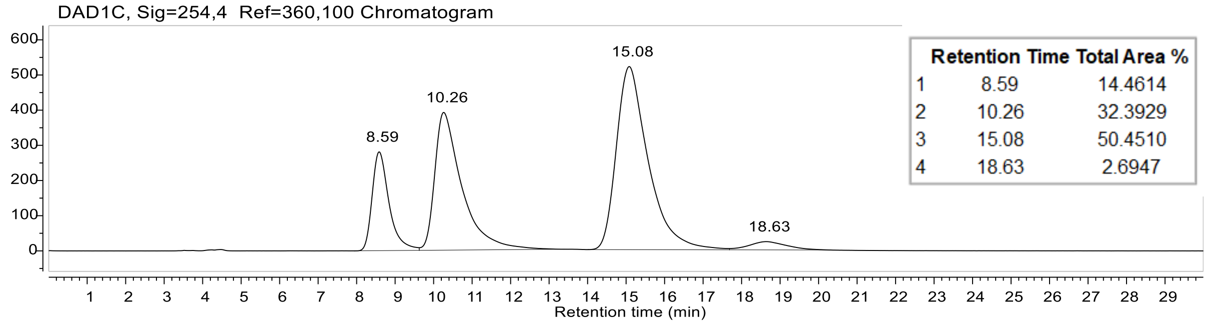
10-*trans* + 10-*cis*

Prepared according to the general procedure, using vinylcyclopropane **1b** (0.1 mmol, 44.2 mg), catalyst **P10** (0.005 mmol, 7.4 mg), and *N*-Boc-2,3-dihydro-1*H*-pyrrole (0.2 mmol, 34.5 µL). Crude product (17:83 dr) was purified by silica gel column chromatography (0→30% EtOAc/hexanes), then further purified by reversed-phase column chromatography (20→100% MeCN/H_2O) to provide **10** as a flaky white solid. [Average of 2 trials: 47% yield, 17:83 (*trans:cis*), 83:17 er (*trans*), 61:39 er (*cis*)]

Chiral HPLC: Chiralpak IC, 3% iPrOH/hexanes, 1.0 mL/min, 254 nm. Retention: 8.6 min (*trans*, major enantiomer), 10.3 min (*cis*, minor enantiomer), 15.1 min (*cis*, major enantiomer), 18.6 min (*trans*, minor enantiomer).



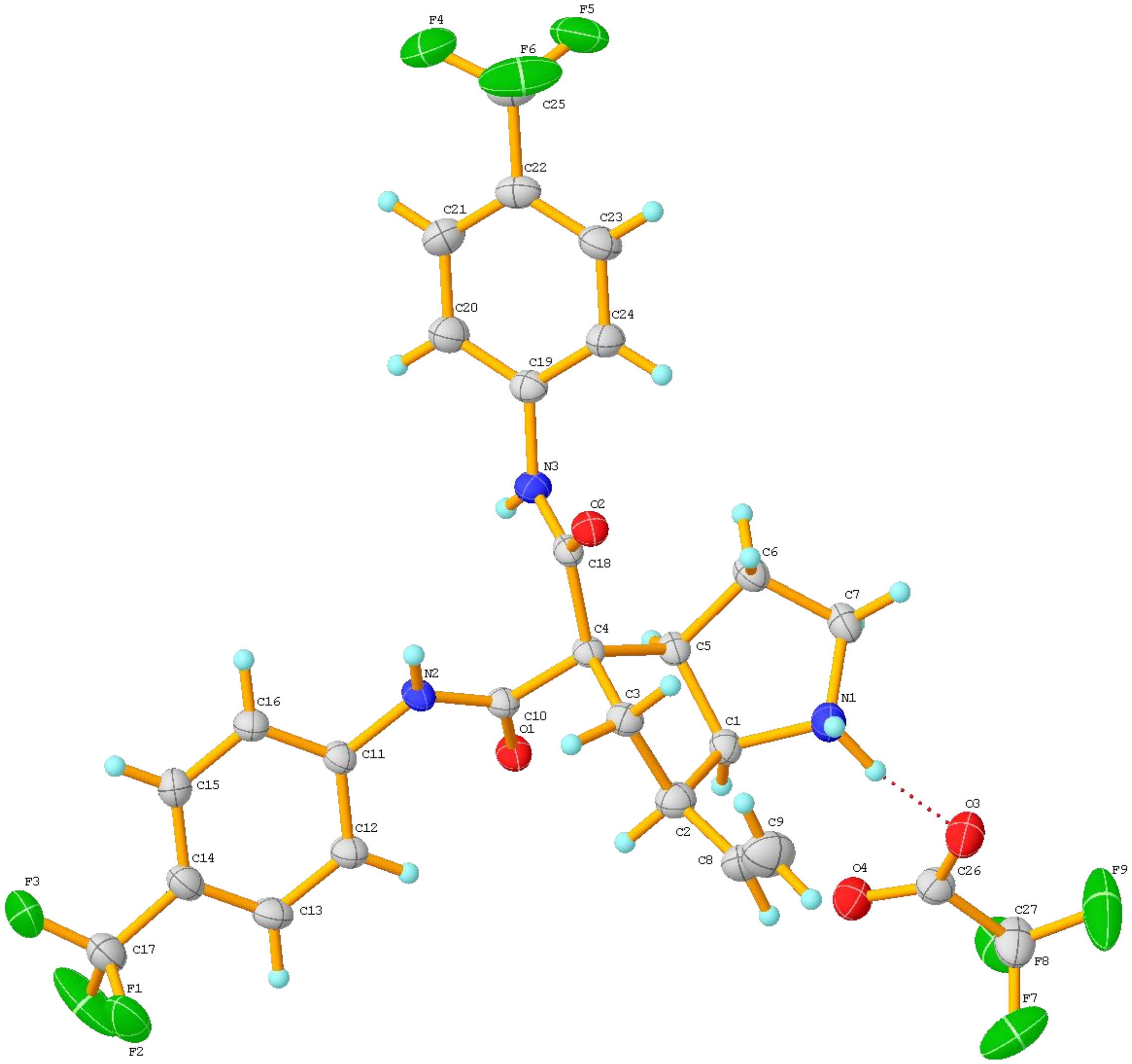
	Retention Time	Total Area %
1	8.99	1.8595
2	10.77	49.4033
3	15.67	47.2057
4	19.30	1.5316



	Retention Time	Total Area %
1	8.59	14.4614
2	10.26	32.3929
3	15.08	50.4510
4	18.63	2.6947

Determination of major diastereomer of 10 (10-*cis*)

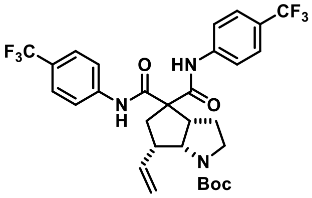
The major diastereomer of **10** was assigned as *cis* by X-ray crystallography. The major diastereomer (>95:5 dr, PhSSPh catalyst) of **10** was subjected to TFA Boc-deprotection (1:1 DCM:TFA, 4 h), then concentrated *in vacuo* to provide the TFA salt (**S2•TFA**) as an off-white solid. Crystals suitable for X-ray crystallography were grown by slow evaporation from methanol-d_4 in an NMR tube.



Full crystallographic data for **S2•TFA** is provided in Section VIII.

Racemic *cis* diastereomer (>95:5 dr, PhSSPh catalyst) was characterized.

***cis-tert*-butyl 4,4-bis((4-(trifluoromethyl)phenyl)carbamoyl)-6-vinylhexahydrocyclopenta[b]pyrrole-1(2*H*)-carboxylate: (10-*cis*):**



10-*cis*

TLC R$_f$ = 0.24 (20% EtOAc/hexanes)

^{1}H NMR (500 MHz, toluene-d$_8$, VT 90 °C) δ 7.86 (s, 1H), 7.39 (s, 1H), 7.34–7.19 (m, 8H), 5.87 (ddd, *J* = 17.3, 10.2, 7.9 Hz, 1H), 5.11–5.00 (m, 2H), 4.57 (t, *J* = 8.1 Hz, 1H), 3.34 (app. q, *J* = 8.6 Hz, 1H), 3.28–3.17 (m, 2H), 3.09–2.98 (m, 1H), 2.33–2.20 (m, 2H), 1.78 (dq, *J* = 12.9, 4.4 Hz, 1H), 1.44 (s, 9H).

^{13}C NMR (126 MHz, toluene-d$_8$, VT 90 °C) δ 169.6, 169.1, 154.2, 141.0, 140.8, 138.0, 126.6 (q, *J* = 3.8 Hz), 124.8 (q, *J* = 271.9 Hz), 120.4, 115.8, 79.6, 65.8, 63.7, 50.9, 47.2, 45.4, 35.8, 28.7, 28.1.

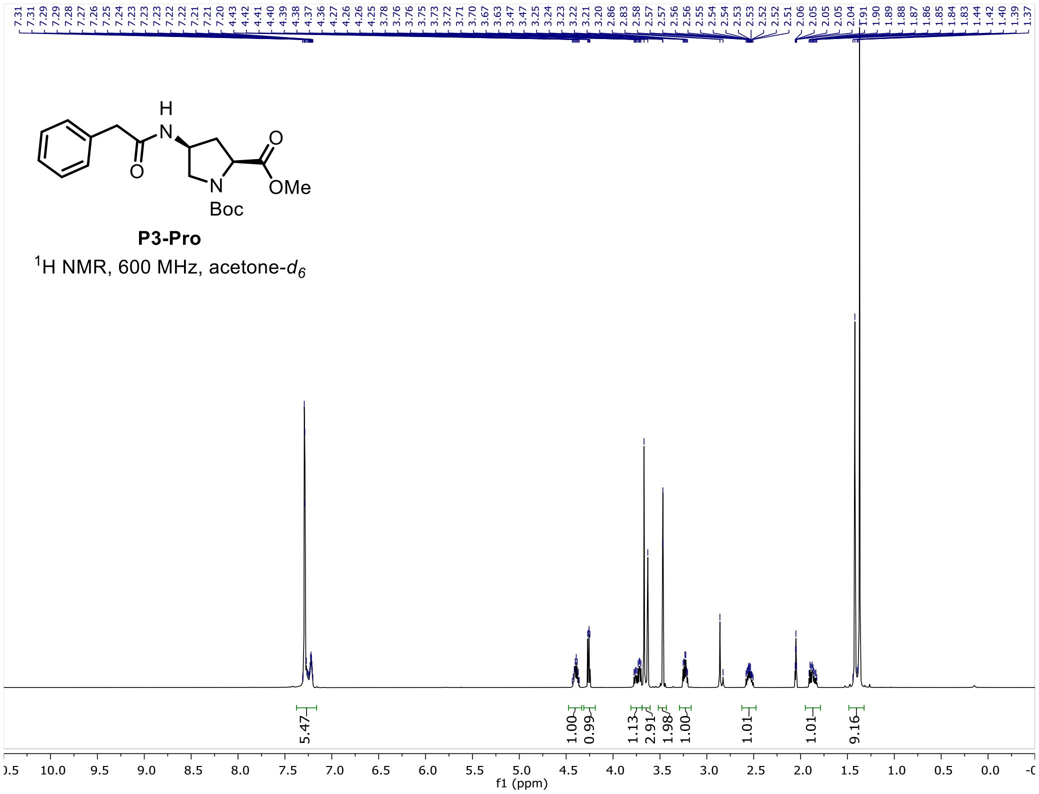
^{19}F NMR (470 MHz, toluene-d$_8$, VT 90 °C) δ –62.7 (s, 3F), –62.7 (s, 3F).

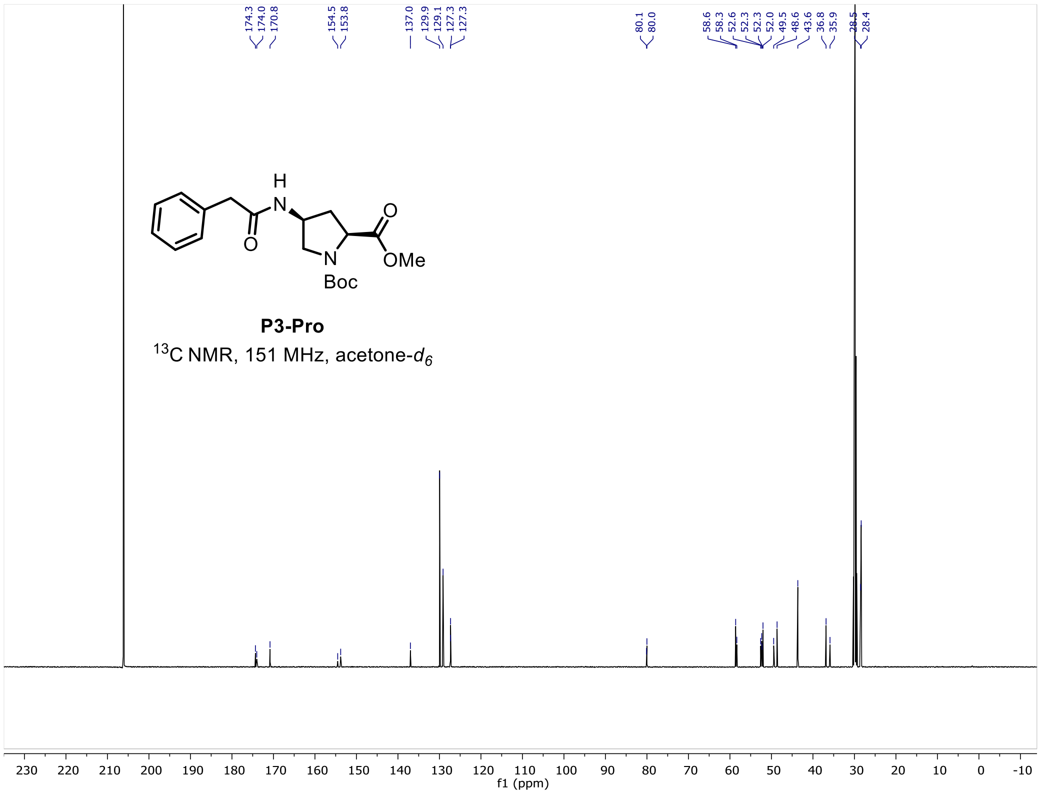
IR (FT-ATR, cm^{-1}): 1662, 1606, 1544, 1521, 1408, 1369, 1321, 1251, 1163, 1118, 1068, 1017, 921, 847, 837, 798, 770, 754, 593, 509, 410.

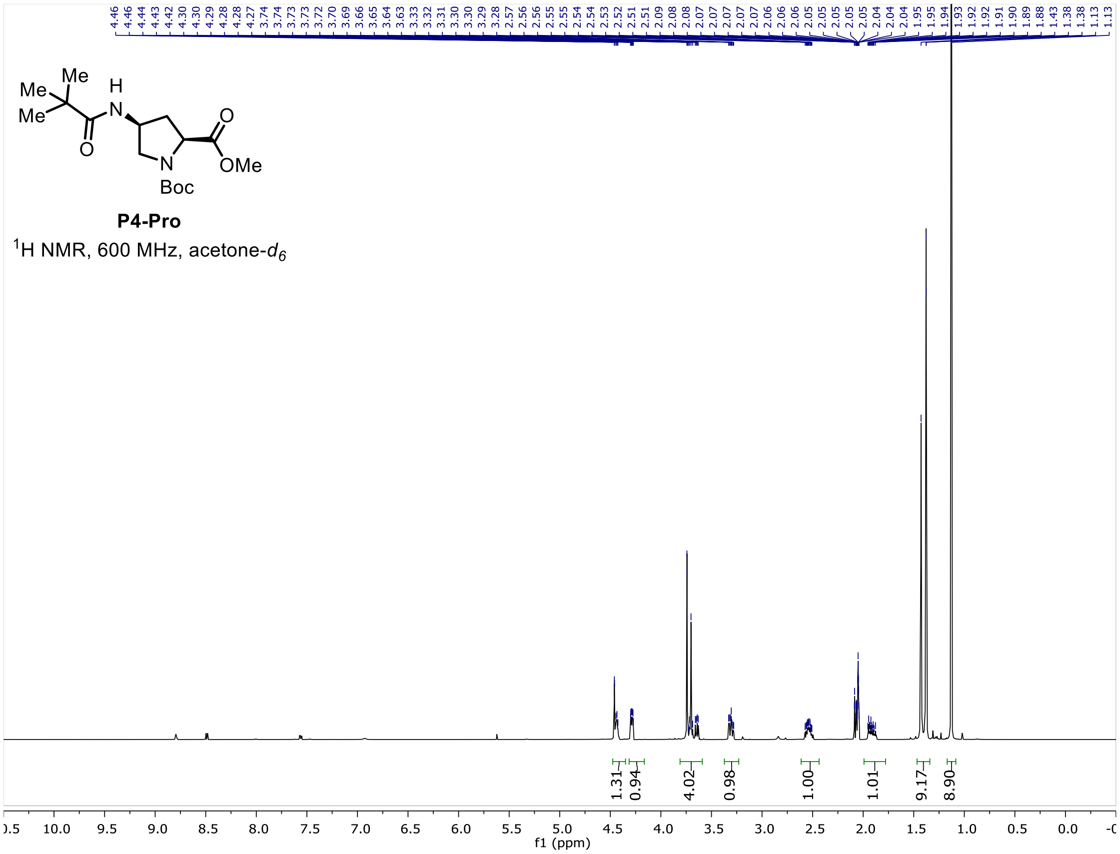
HRMS (ESI) (*m/z*) for [M+H]$^+$ $C_{30}H_{32}F_6N_3O_4$ requires 612.2297, observed 612.2288.

VII. ^{1}H, ^{13}C, and ^{19}F NMR spectra

A. NMR spectra for 4-substituted Boc-proline methyl esters

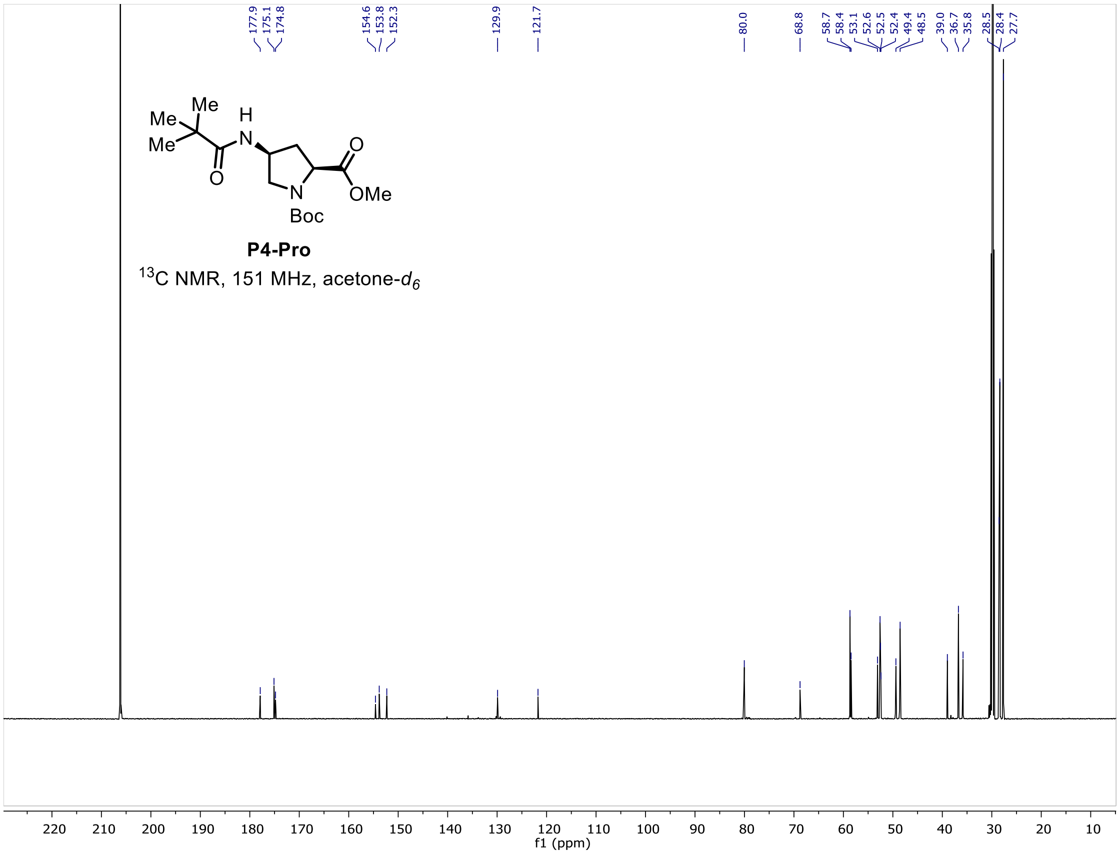






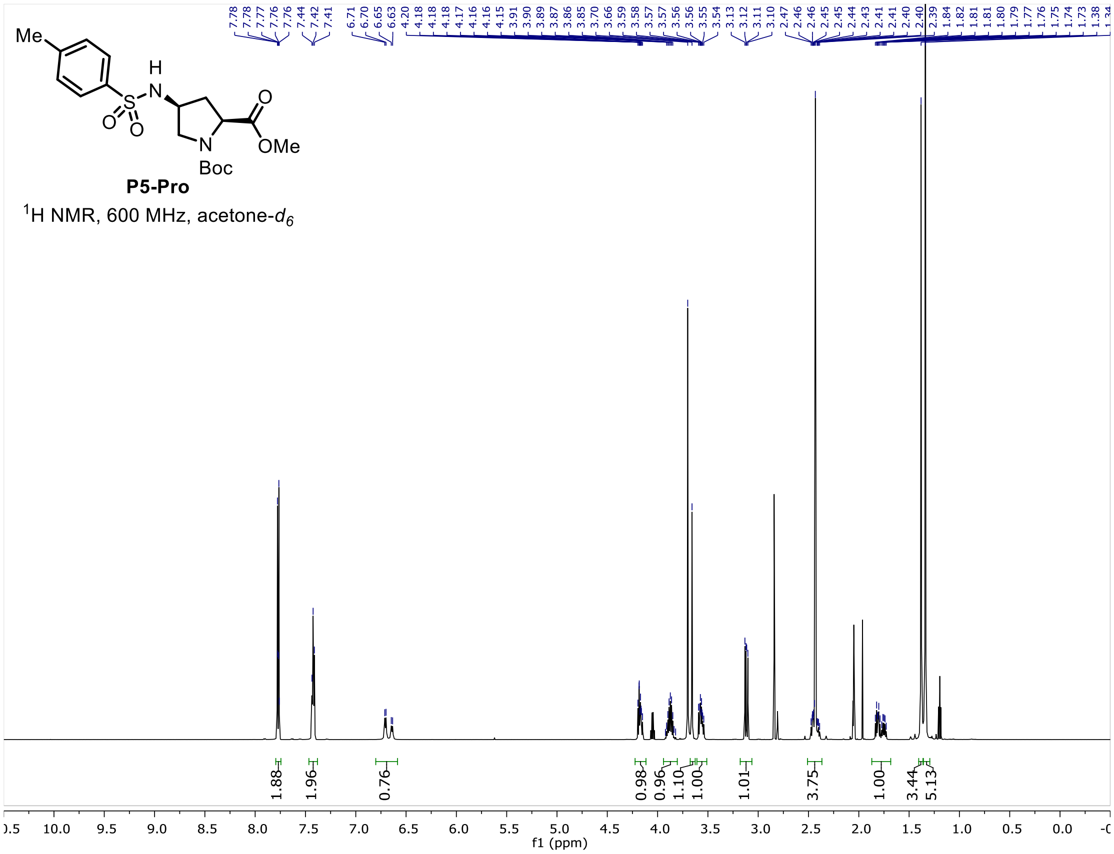
P4-Pro

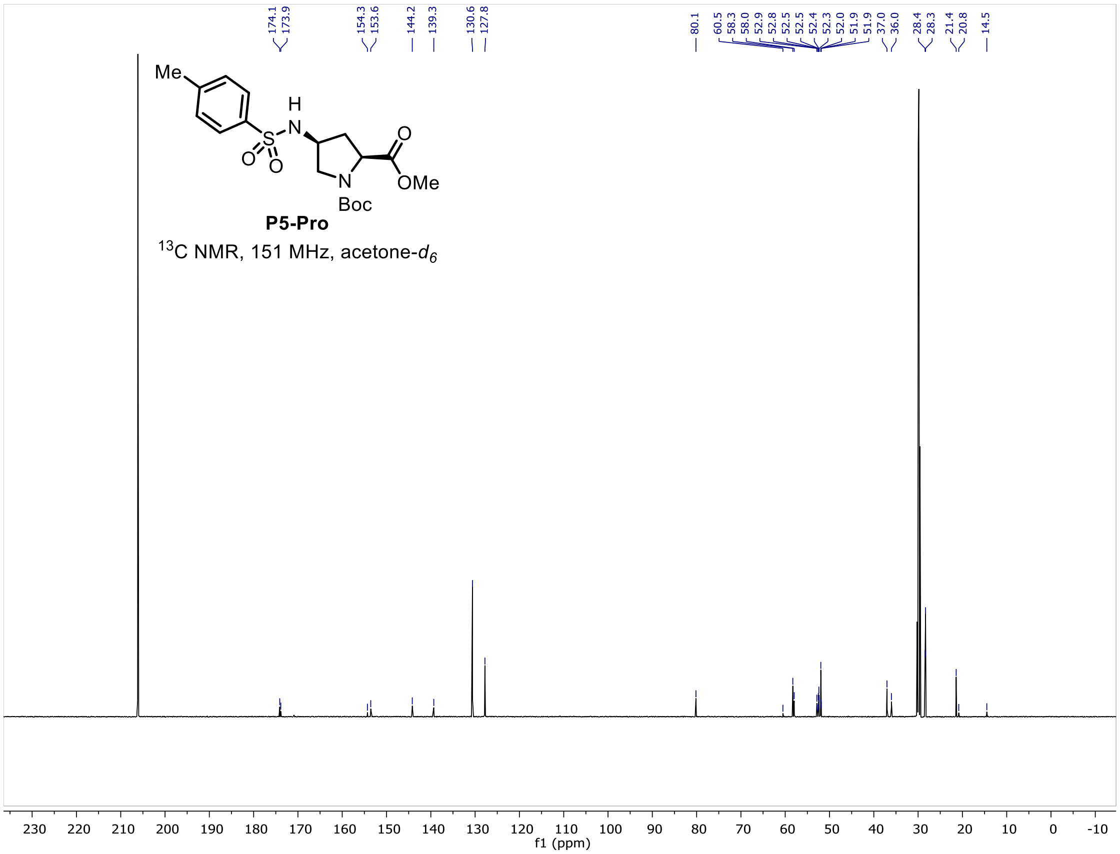
^{1}H NMR, 600 MHz, acetone-d_6

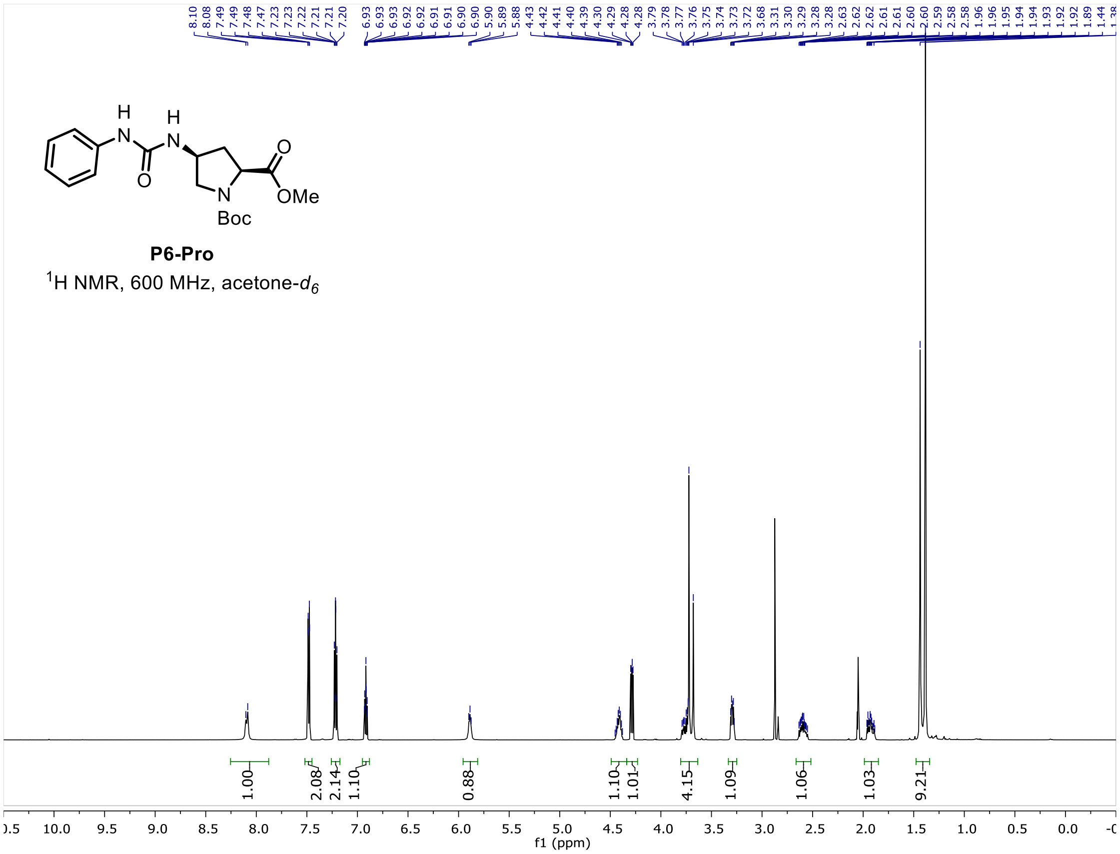


P4-Pro

^{13}C NMR, 151 MHz, acetone-d_6

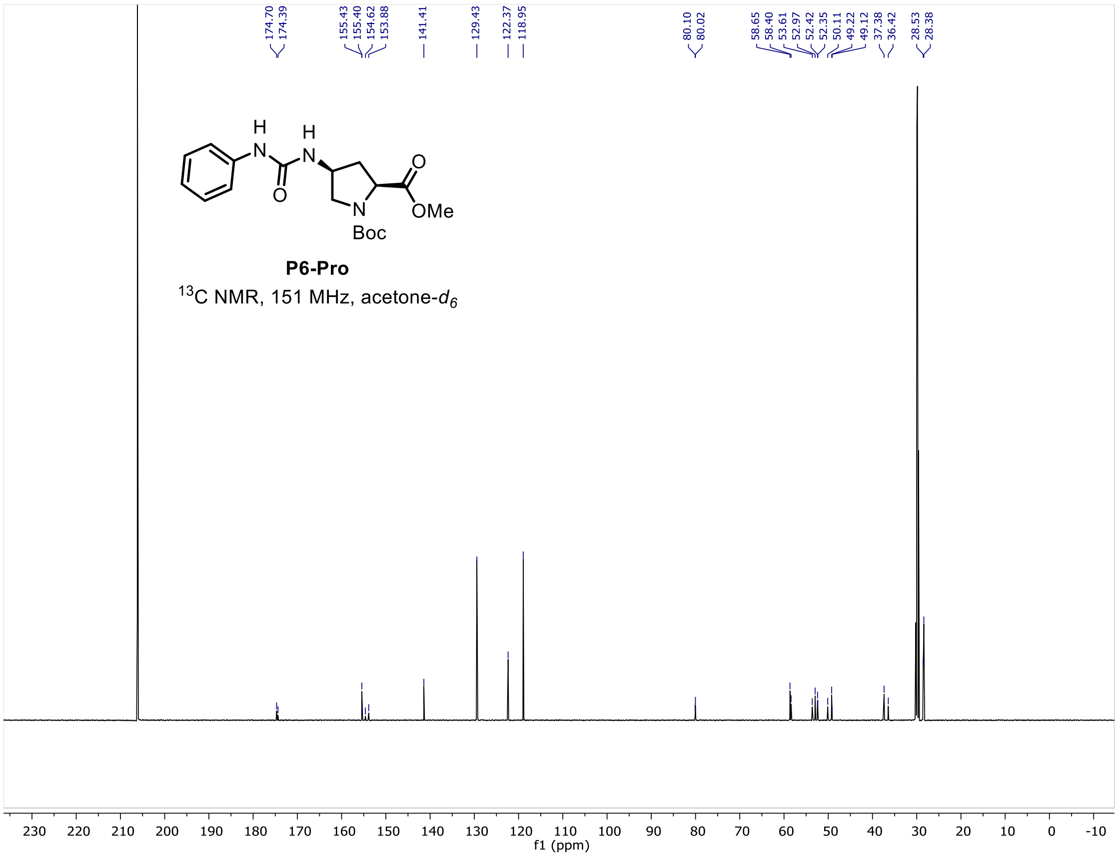

7.78
7.78
7.77
7.76
7.76
7.44
7.42
7.41
6.71
6.70
6.65
6.63
4.20
4.18
4.18
4.18
4.17
4.16
4.16
4.15
3.91
3.90
3.89
3.87
3.86
3.85
3.70
3.66
3.59
3.58
3.57
3.57
3.56
3.56
3.55
3.54
3.13
3.12
3.11
3.10
2.47
2.46
2.46
2.45
2.45
2.44
2.43
2.41
2.41
2.40
2.40
2.39
1.84
1.82
1.81
1.81
1.80
1.79
1.77
1.76
1.75
1.74
1.73
1.38
1.34
Me
H
S
N
O
O
O
N
OMe
Boc
P5-Pro
^{1}H NMR, 600 MHz, acetone-d_6
1.88
1.96
0.76
0.98
0.96
1.10
1.00
1.01
3.75
1.00
3.44
5.13
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


174.1
173.9
154.3
153.6
144.2
139.3
130.6
127.8
80.1
60.5
58.3
58.0
52.9
52.8
52.5
52.5
52.4
52.3
52.0
51.9
51.9
37.0
36.0
28.4
28.3
21.4
20.8
14.5
Me
H
S
N
O
O
O
N
OMe
Boc
P5-Pro
^{13}C NMR, 151 MHz, acetone-d_6
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)



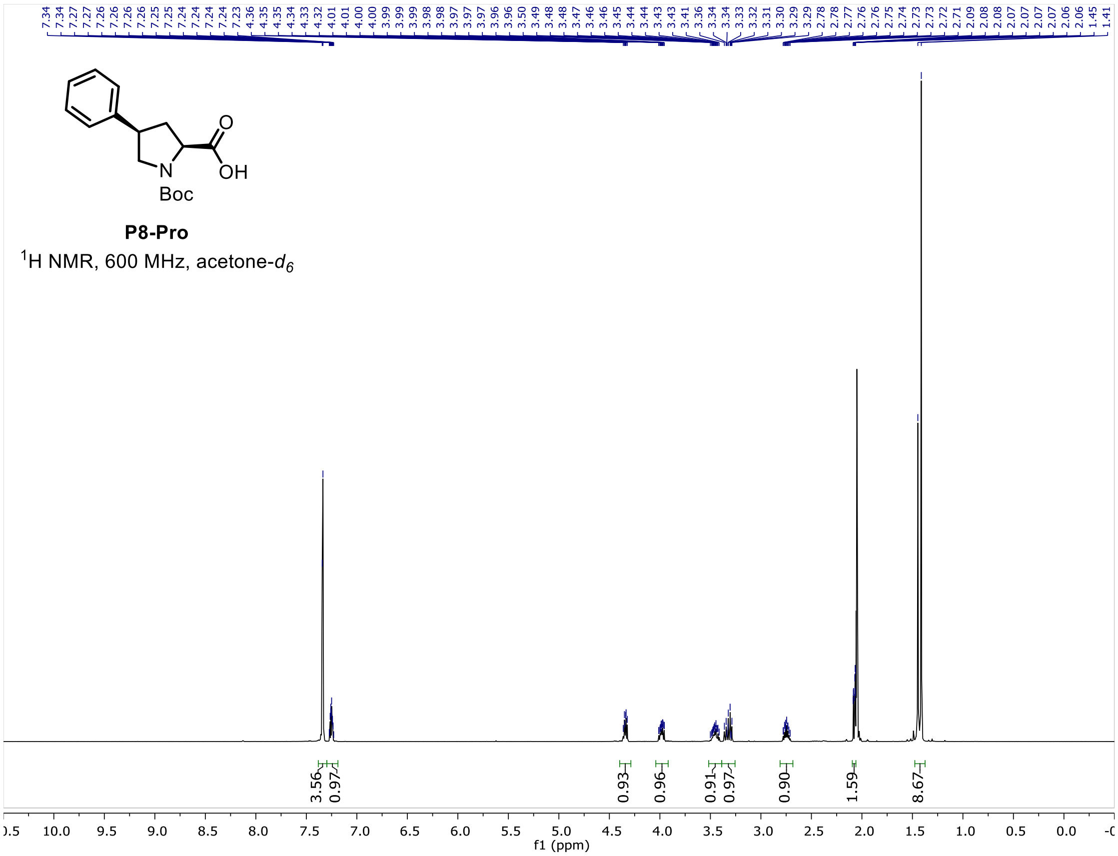
P6-Pro

^{1}H NMR, 600 MHz, acetone-d_6



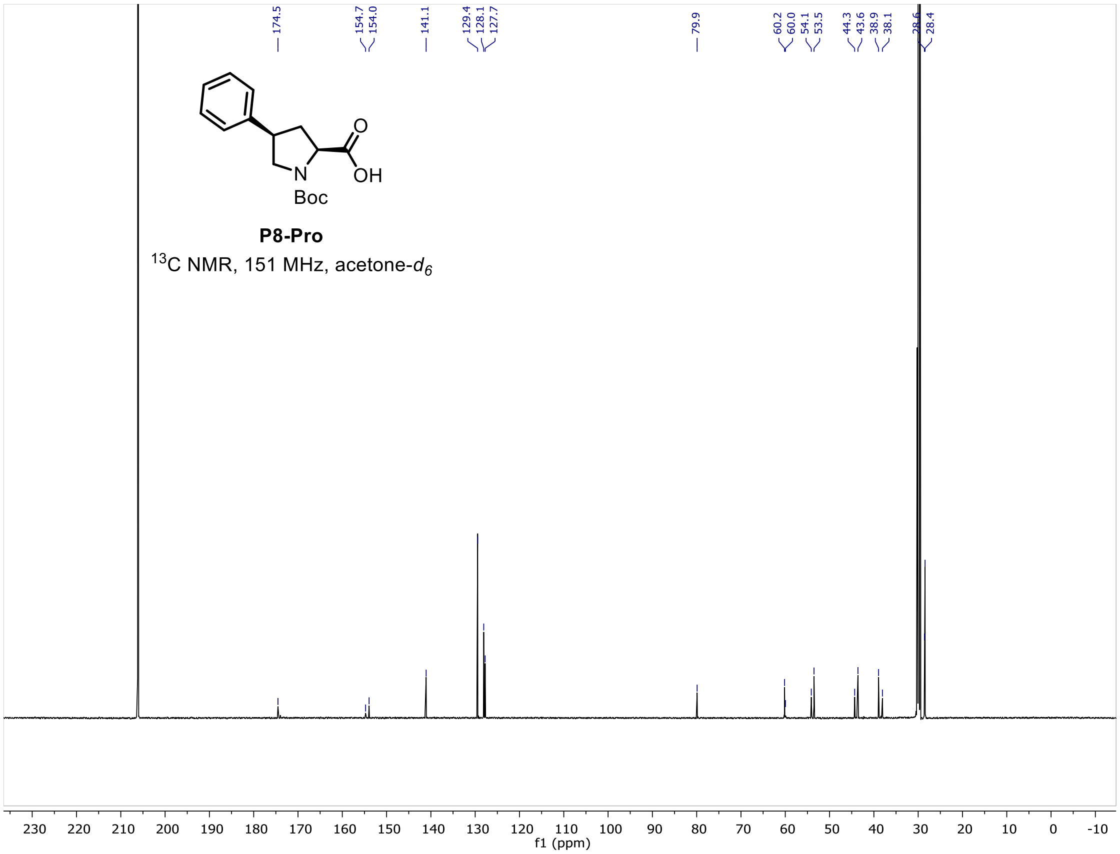
P6-Pro

^{13}C NMR, 151 MHz, acetone-d_6



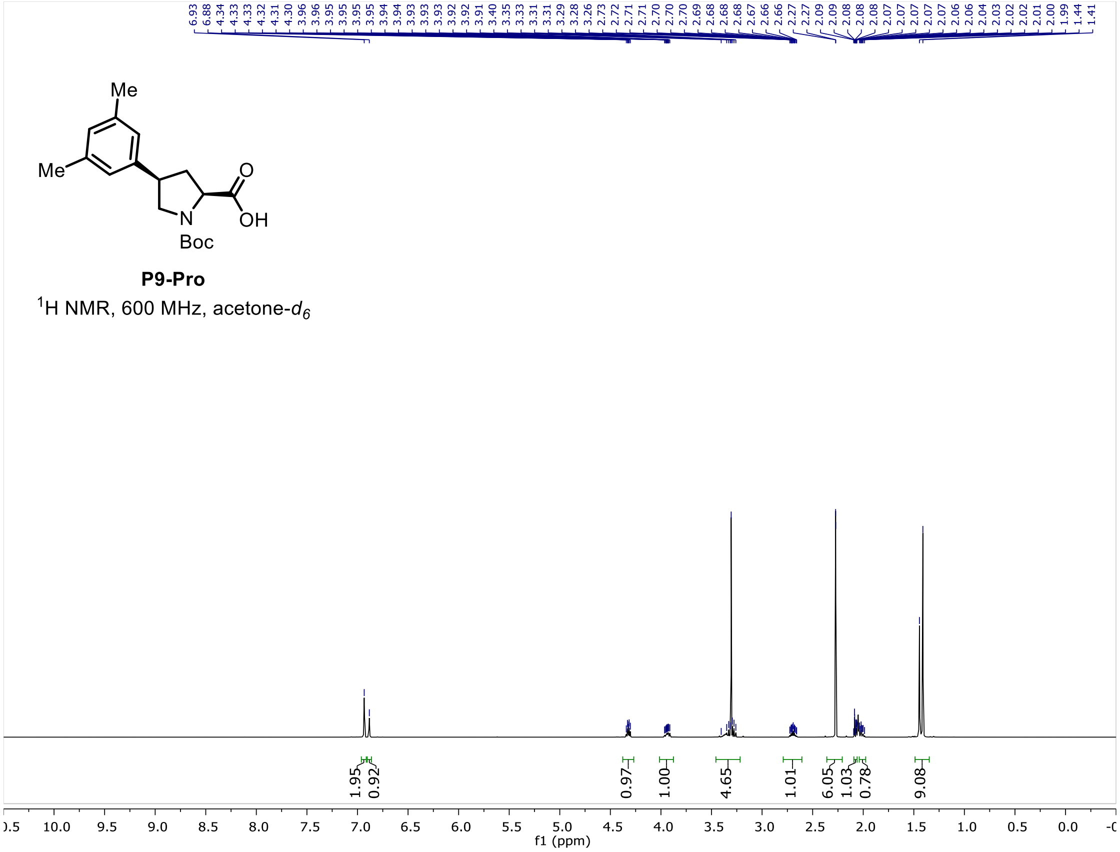
P8-Pro

^{1}H NMR, 600 MHz, acetone-d_6



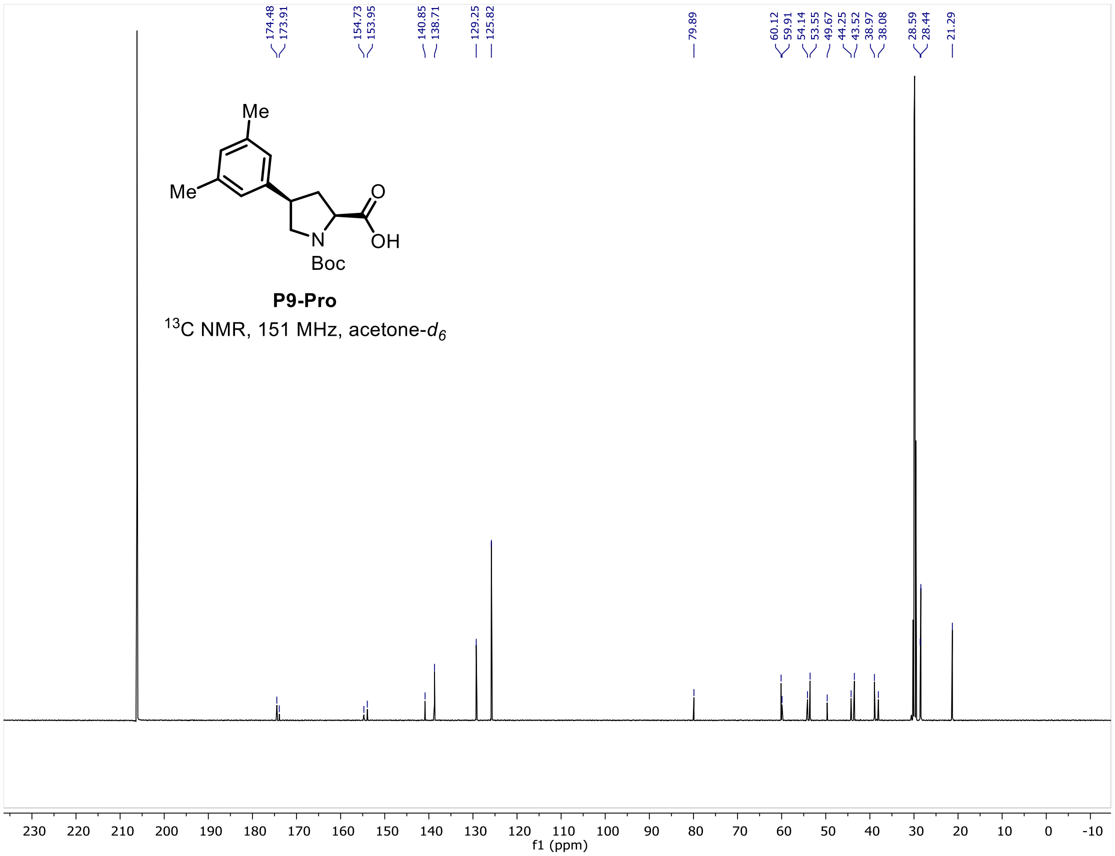
P8-Pro

^{13}C NMR, 151 MHz, acetone-d_6



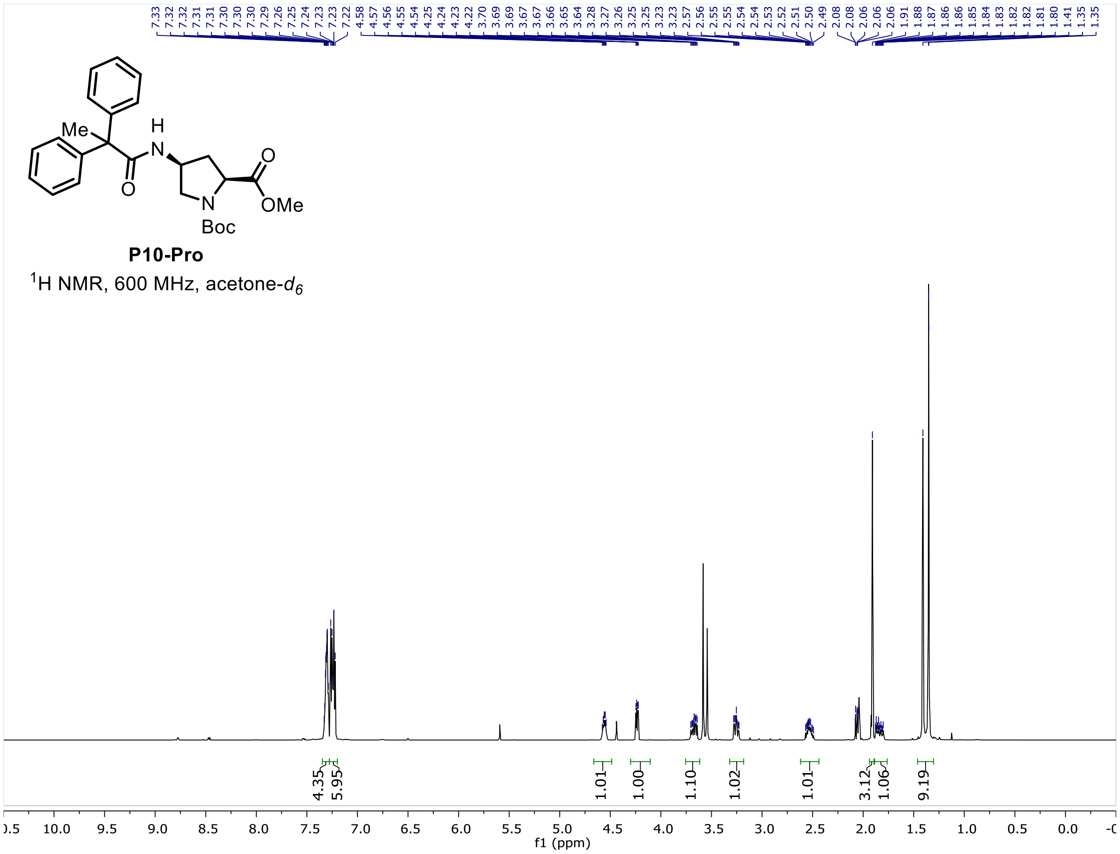
P9-Pro

^{1}H NMR, 600 MHz, acetone-d_6



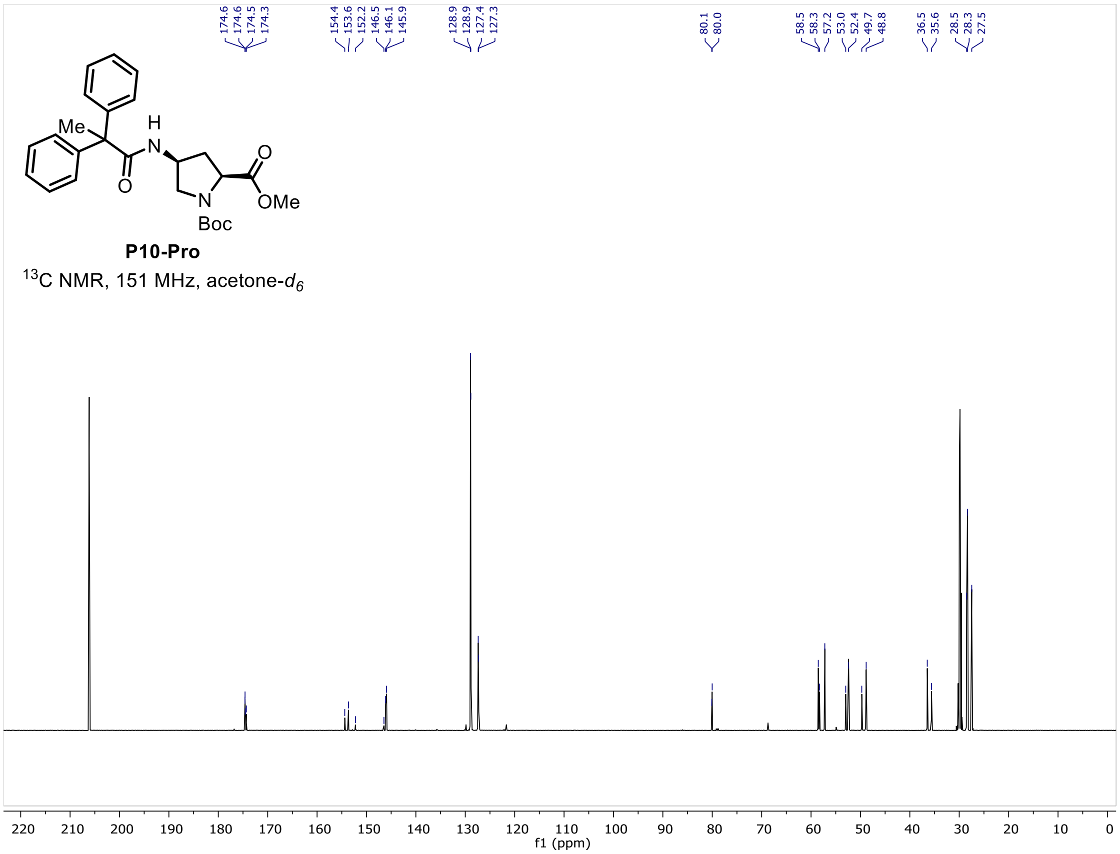
P9-Pro

^{13}C NMR, 151 MHz, acetone-d_6



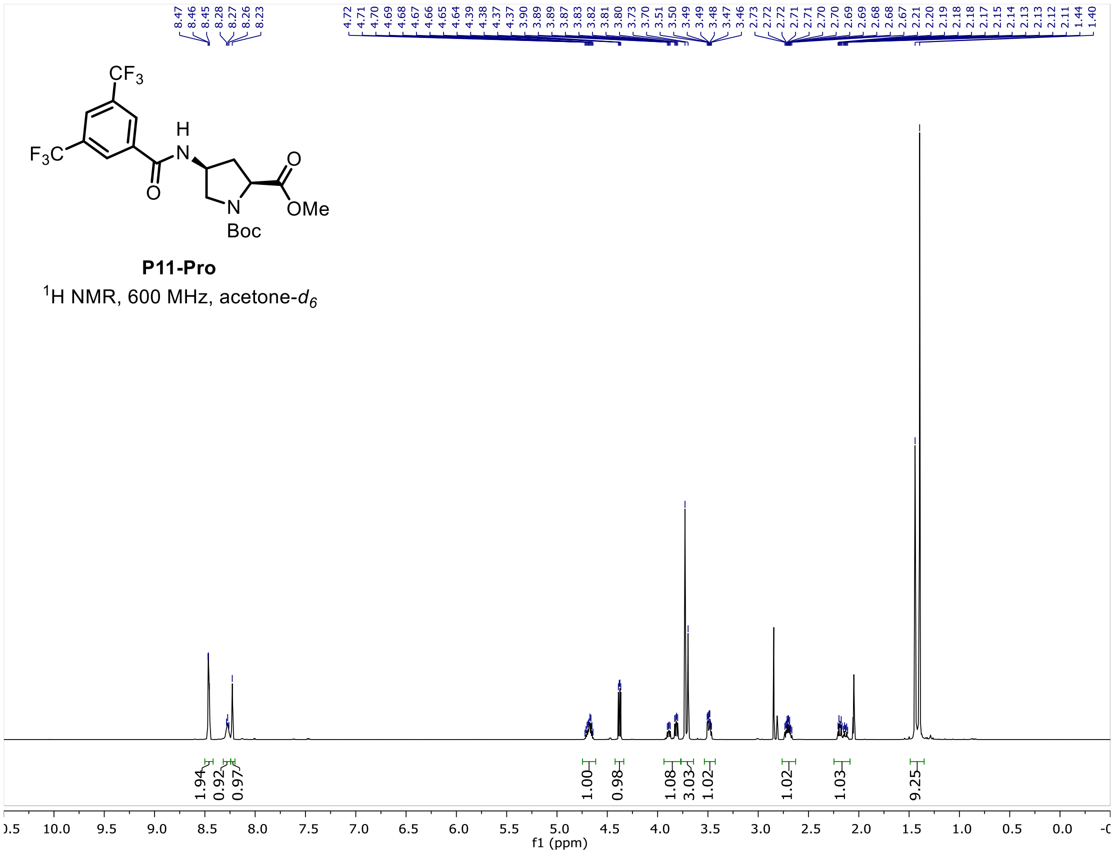
P10-Pro

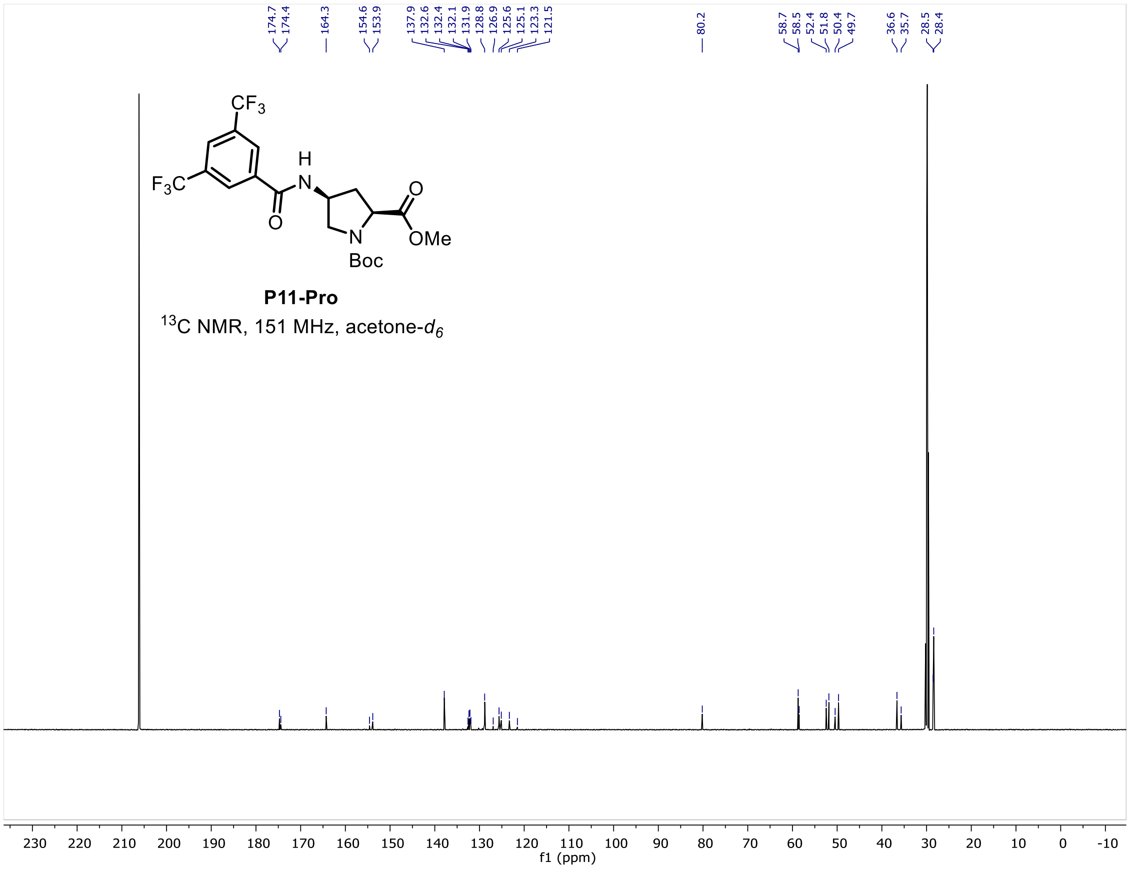
^{1}H NMR, 600 MHz, acetone-d_6

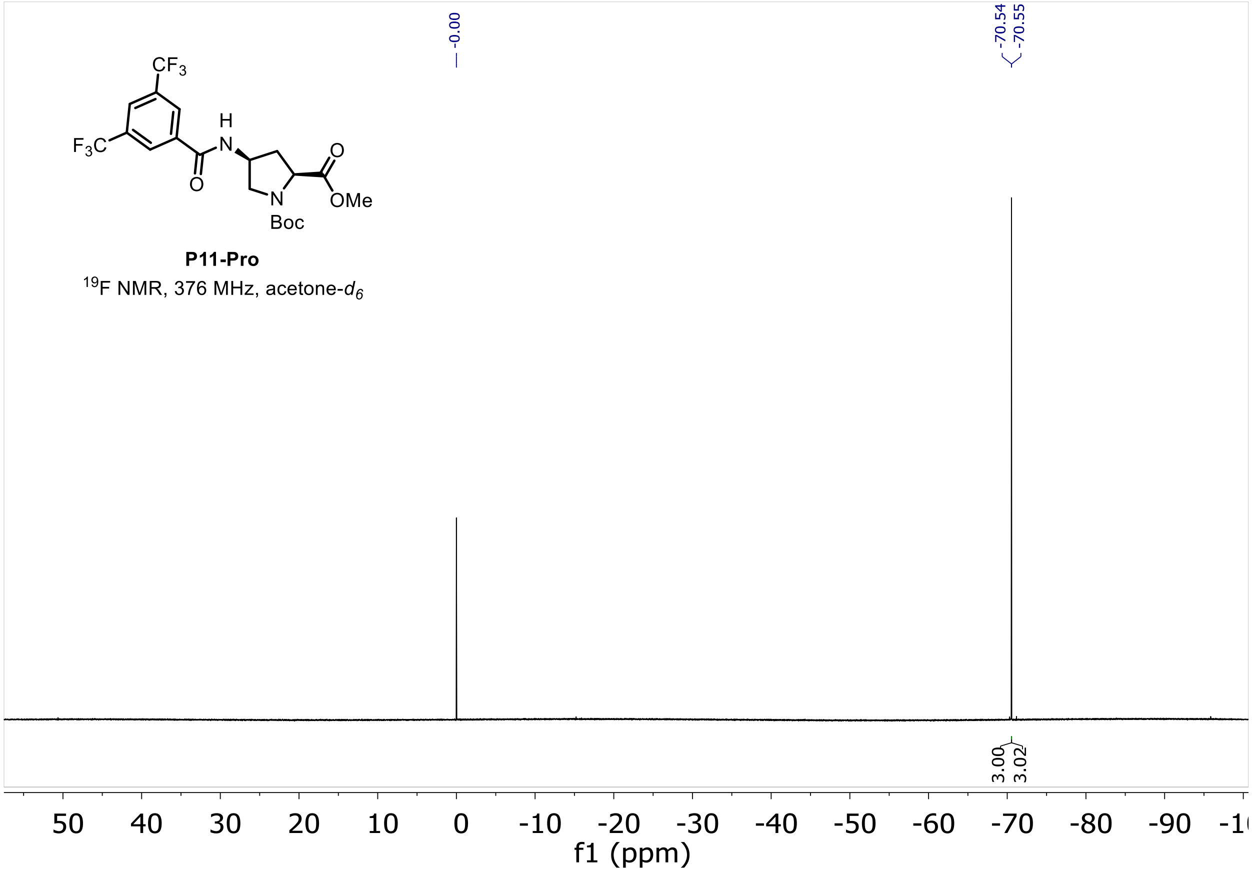


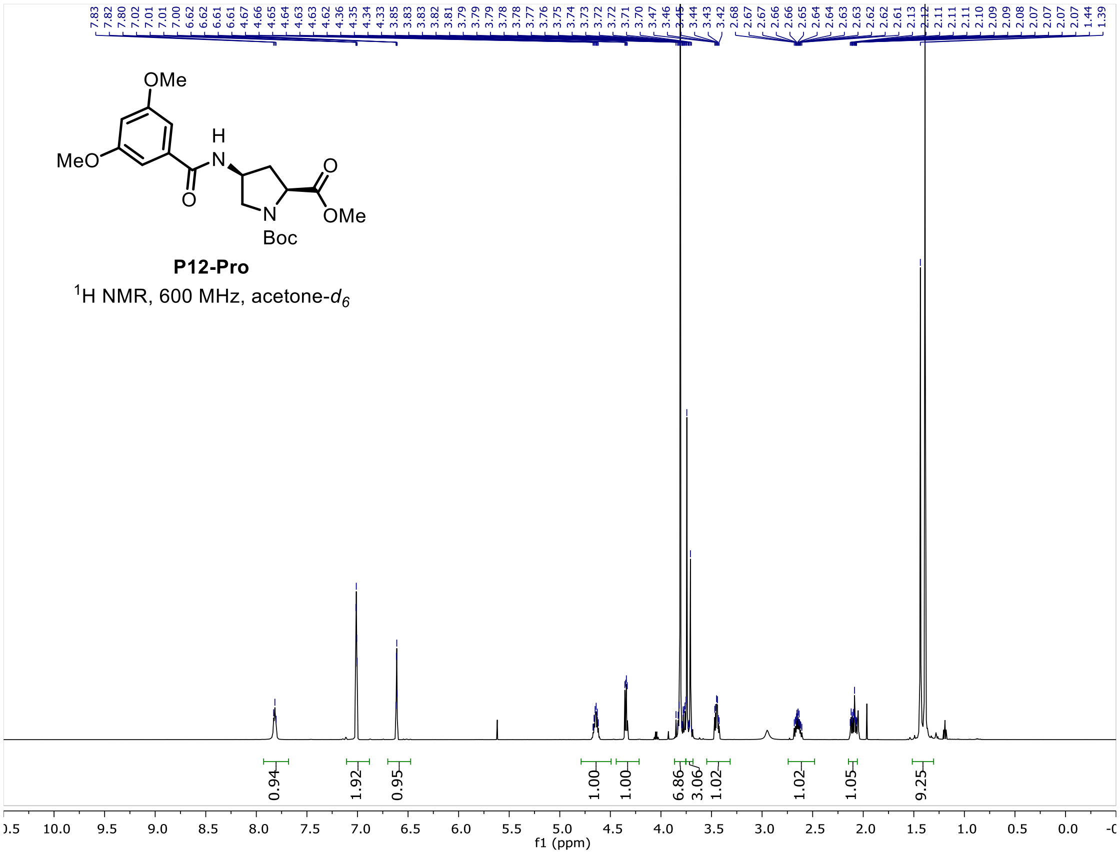
P10-Pro

^{13}C NMR, 151 MHz, acetone-d_6


8.47
8.46
8.45
8.28
8.27
8.26
8.23
4.72
4.71
4.70
4.69
4.68
4.67
4.66
4.65
4.64
4.39
4.38
4.37
4.37
3.90
3.89
3.89
3.87
3.83
3.82
3.81
3.80
3.73
3.70
3.51
3.50
3.49
3.49
3.48
3.47
3.46
2.73
2.72
2.72
2.71
2.71
2.70
2.70
2.69
2.69
2.68
2.68
2.67
2.21
2.20
2.19
2.18
2.18
2.17
2.15
2.14
2.13
2.13
2.12
2.11
1.44
1.40
CF3
F3C
H
N
O
N
O
OMe
Boc
P11-Pro
^{1}H NMR, 600 MHz, acetone-d_6
1.94
0.92
0.97
1.00
0.98
1.08
3.03
1.02
1.02
1.03
9.25
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

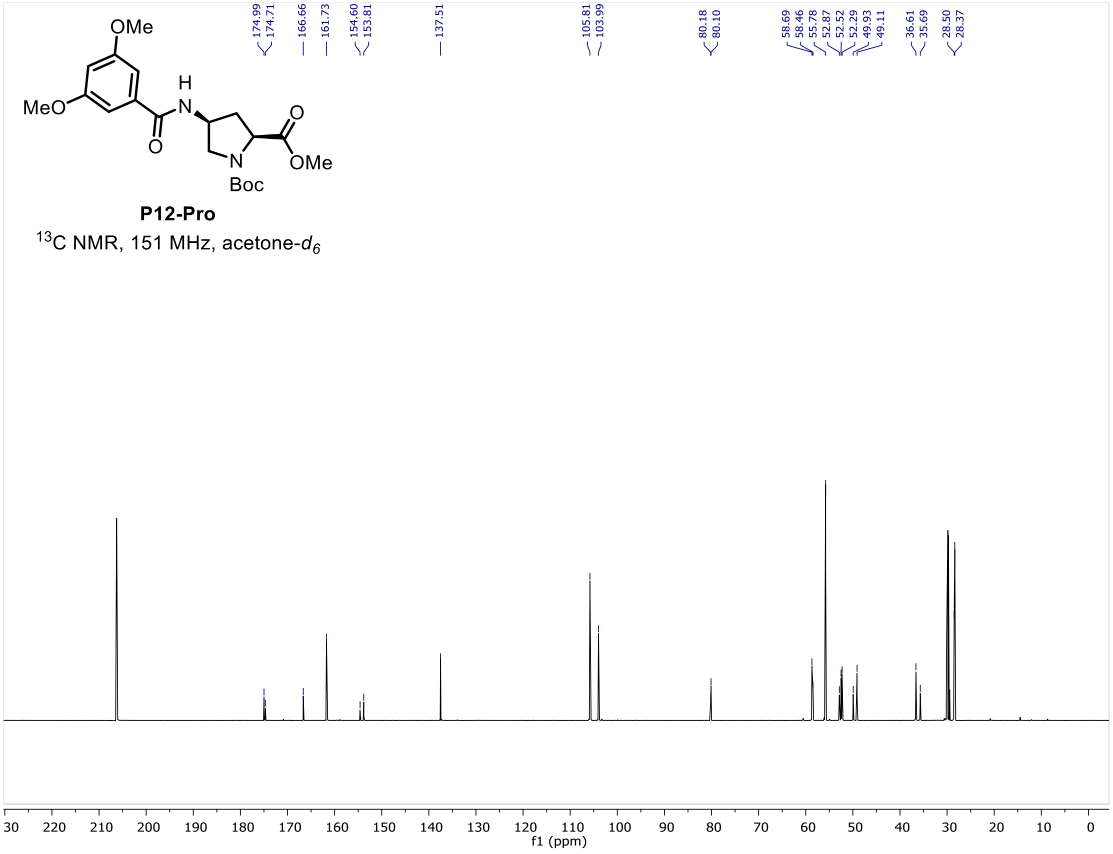

174.7
174.4
164.3
154.6
153.9
137.9
132.6
132.4
132.1
131.9
128.8
126.9
125.6
125.1
123.3
121.5
80.2
58.7
58.5
52.4
51.8
50.4
49.7
36.6
35.7
28.5
28.4
CF3
F3C
H
N
O
N
O
OMe
Boc
P11-Pro
^{13}C NMR, 151 MHz, acetone-d_6
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)


CF3
F3C
H
N
O
O
N
OMe
Boc
P11-Pro
^{19}F NMR, 376 MHz, acetone-d_6
-0.00
-70.54
-70.55
3.00
3.02
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
f1 (ppm)



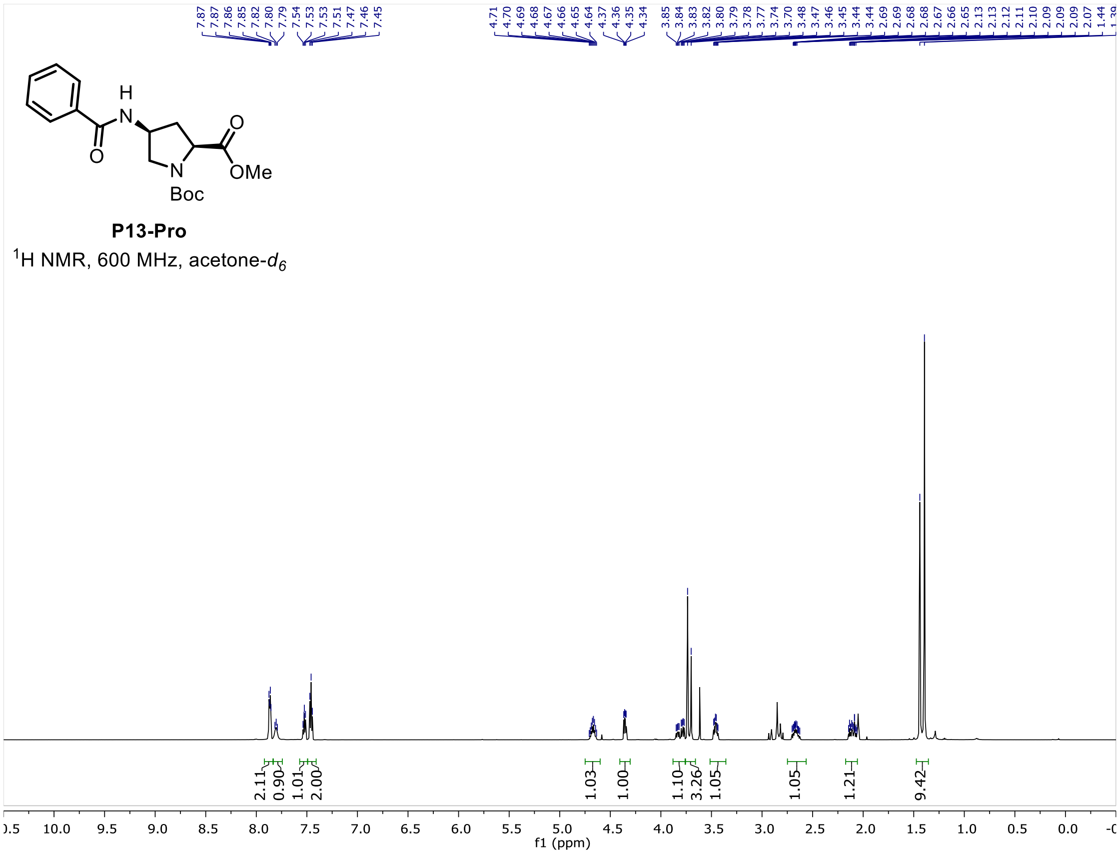
P12-Pro

^{1}H NMR, 600 MHz, acetone-d_6



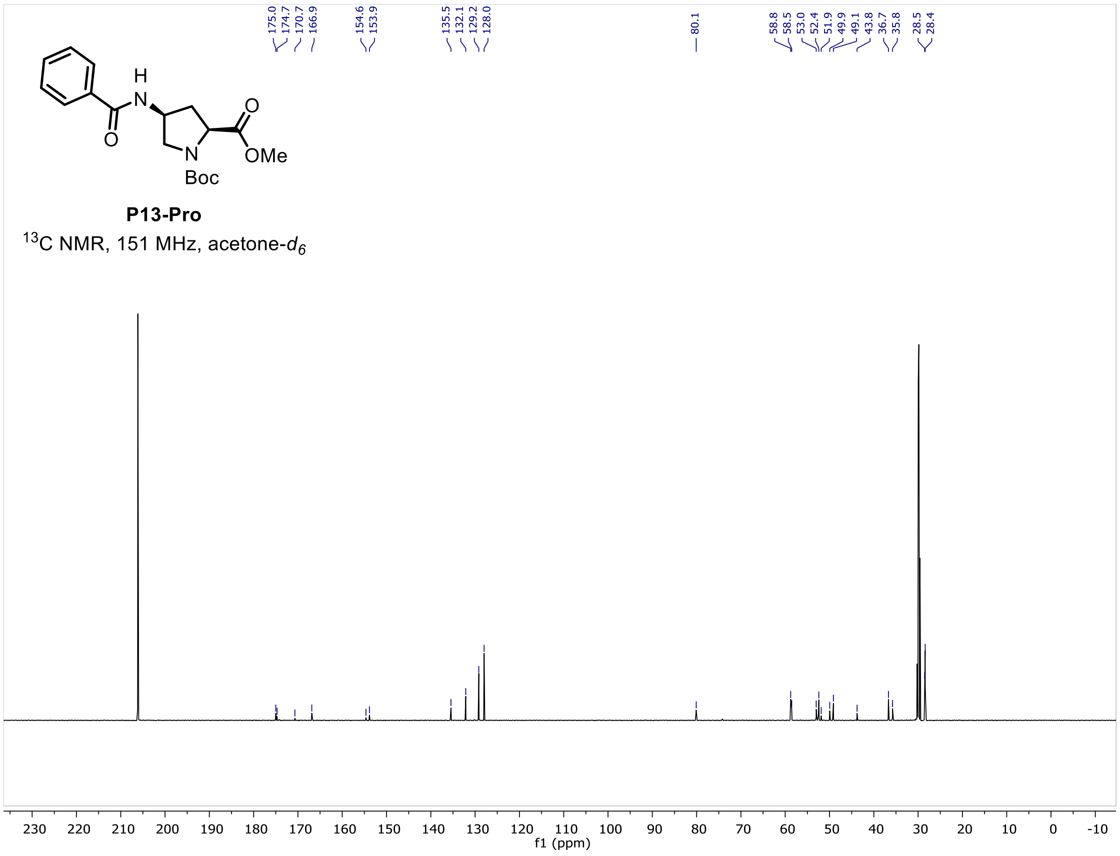
P12-Pro

^{13}C NMR, 151 MHz, acetone-d_6



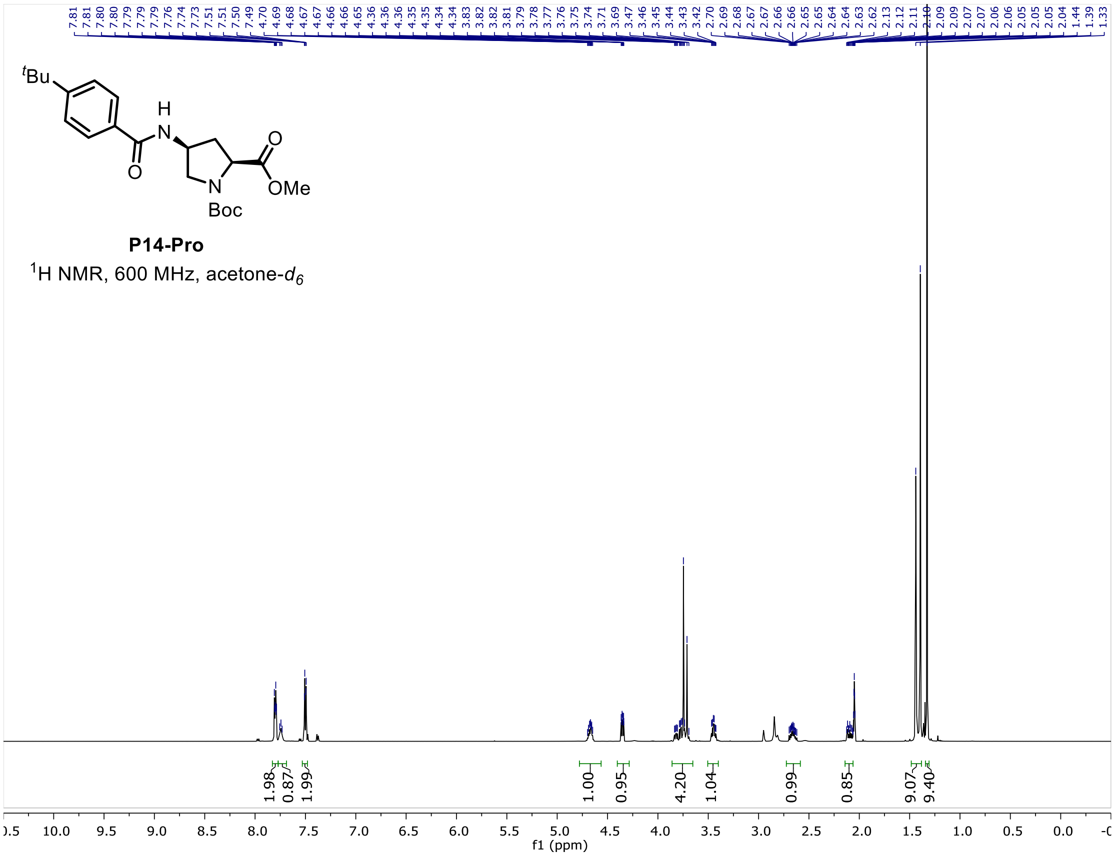
P13-Pro

^{1}H NMR, 600 MHz, acetone-d_6



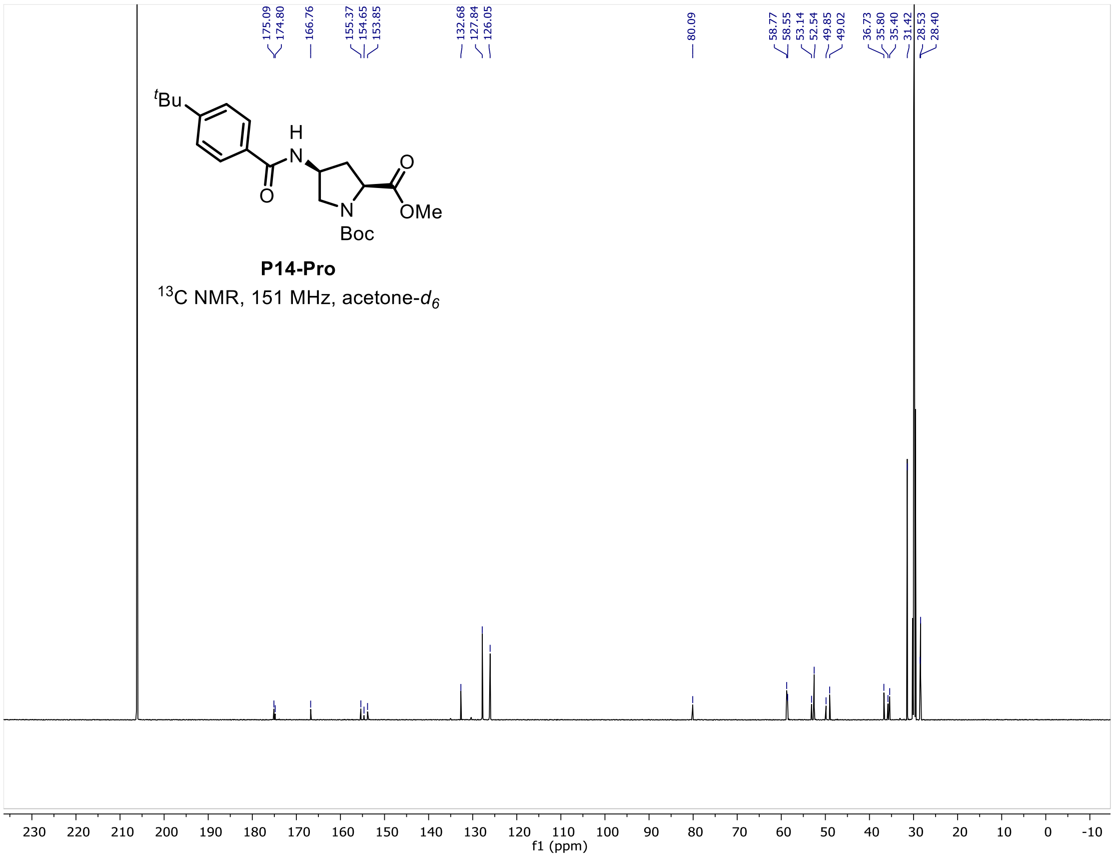
P13-Pro

^{13}C NMR, 151 MHz, acetone-d_6



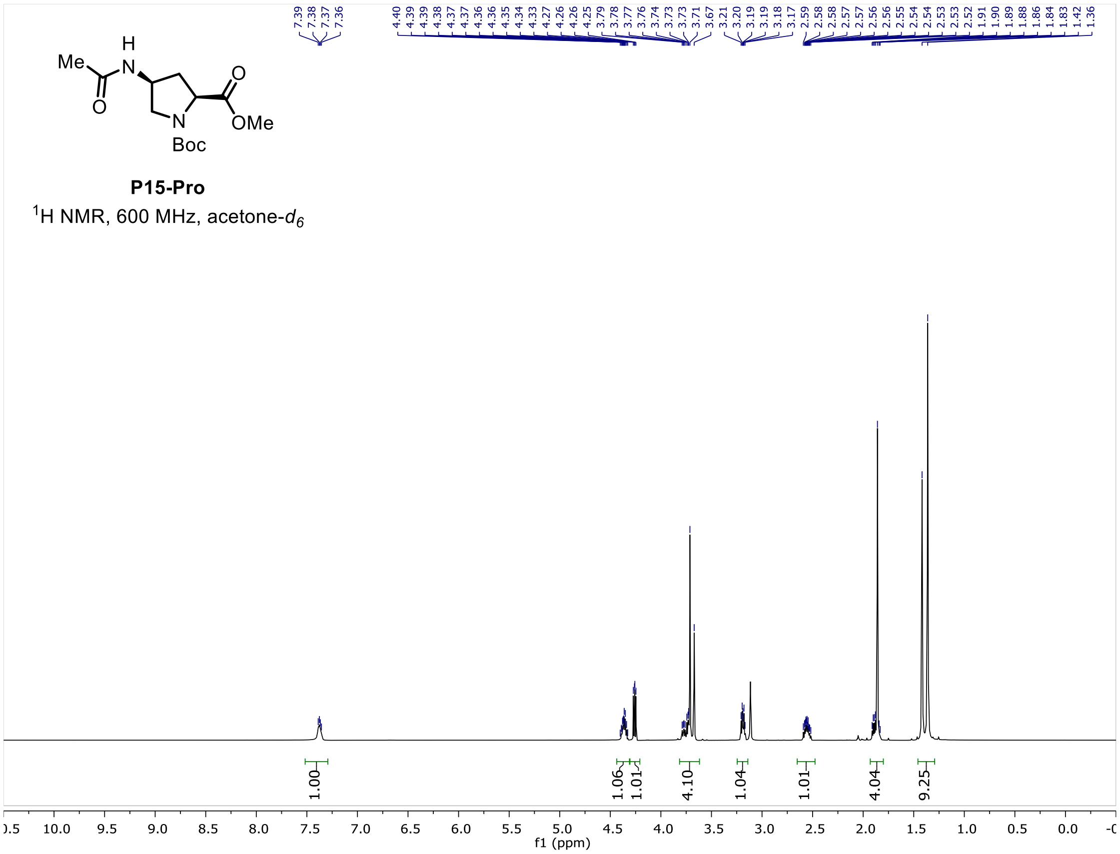
P14-Pro

^{1}H NMR, 600 MHz, acetone-d_6



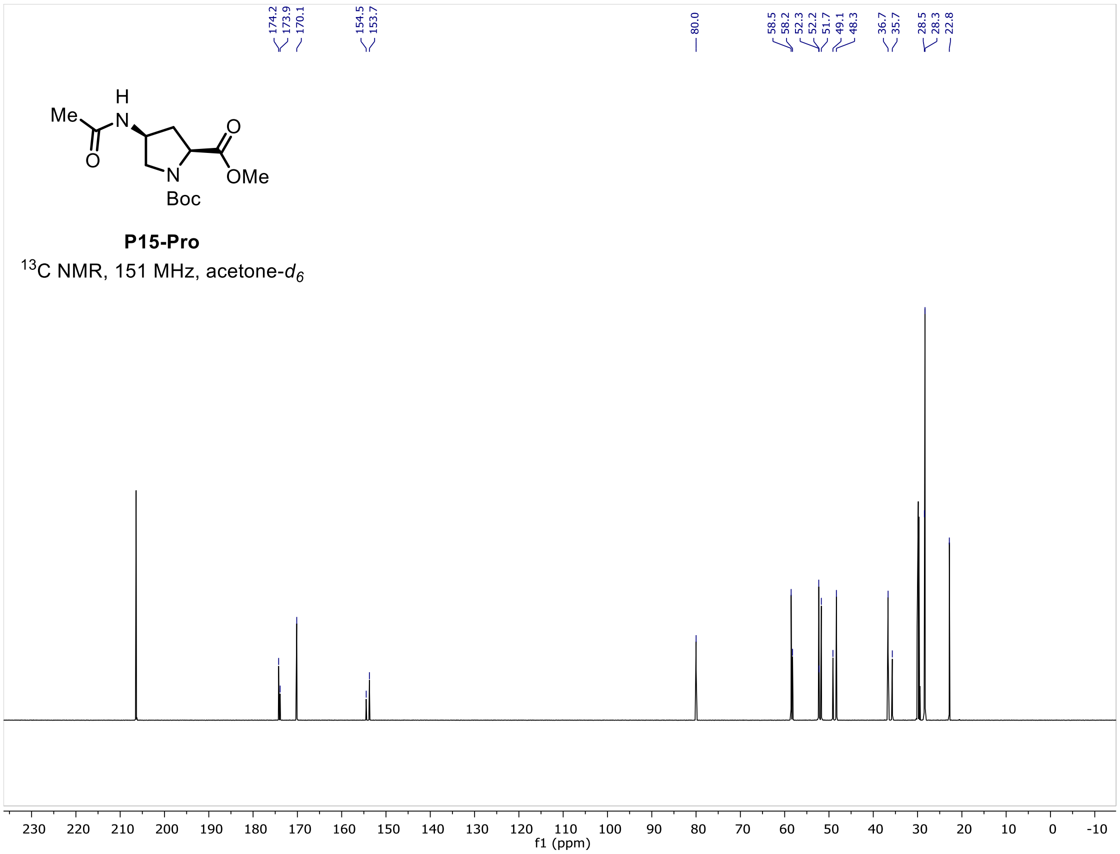
P14-Pro

^{13}C NMR, 151 MHz, acetone-d_6



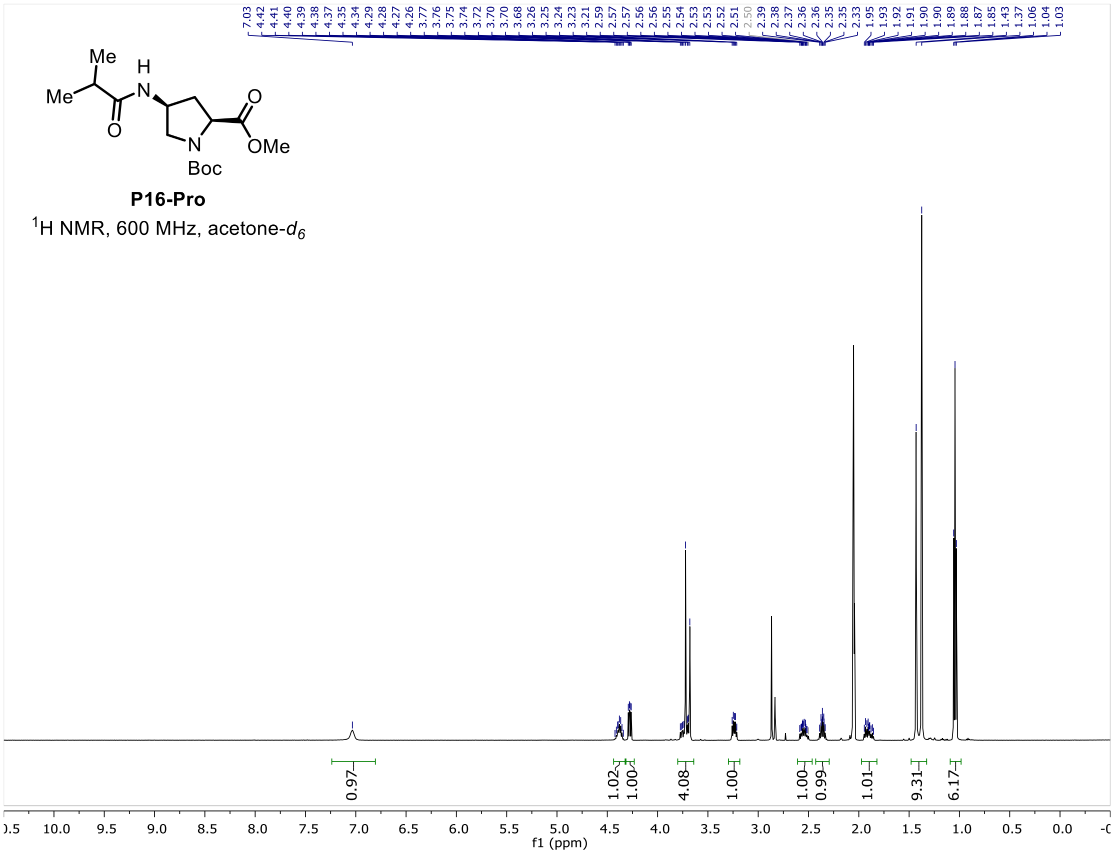
P15-Pro

^{1}H NMR, 600 MHz, acetone-d_6



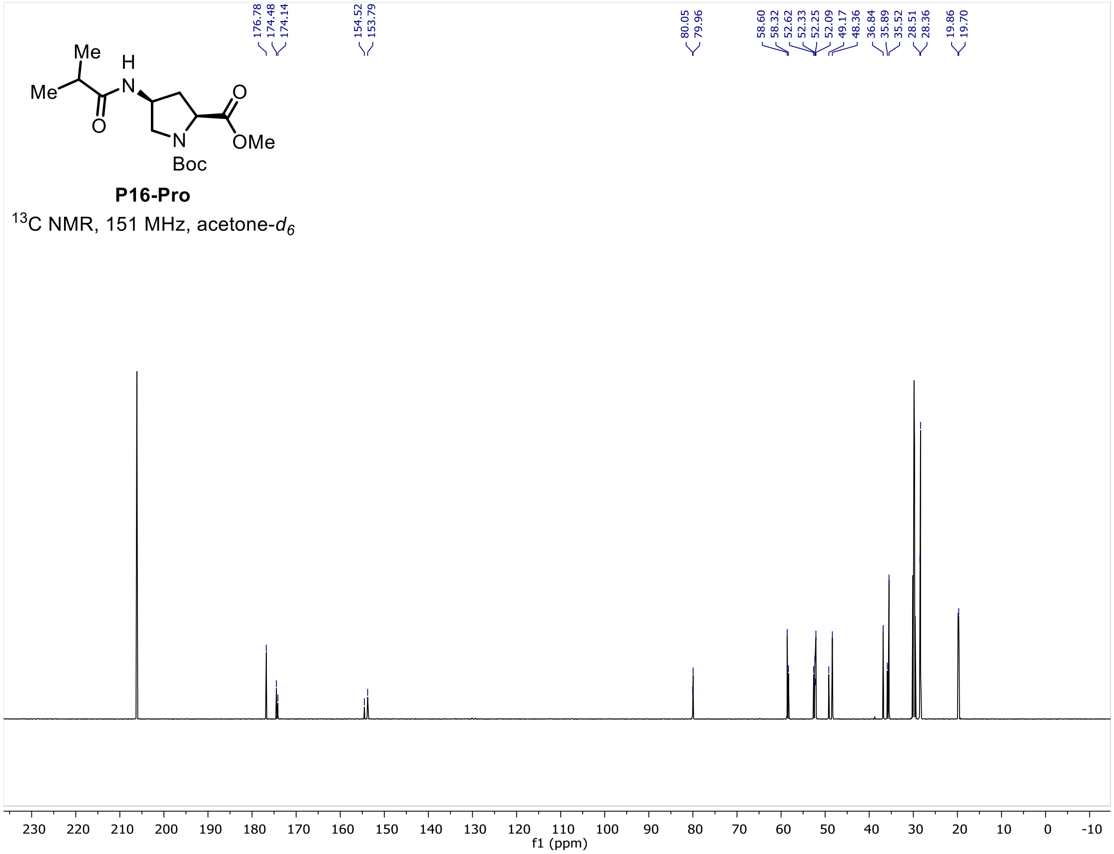
P15-Pro

^{13}C NMR, 151 MHz, acetone-d_6



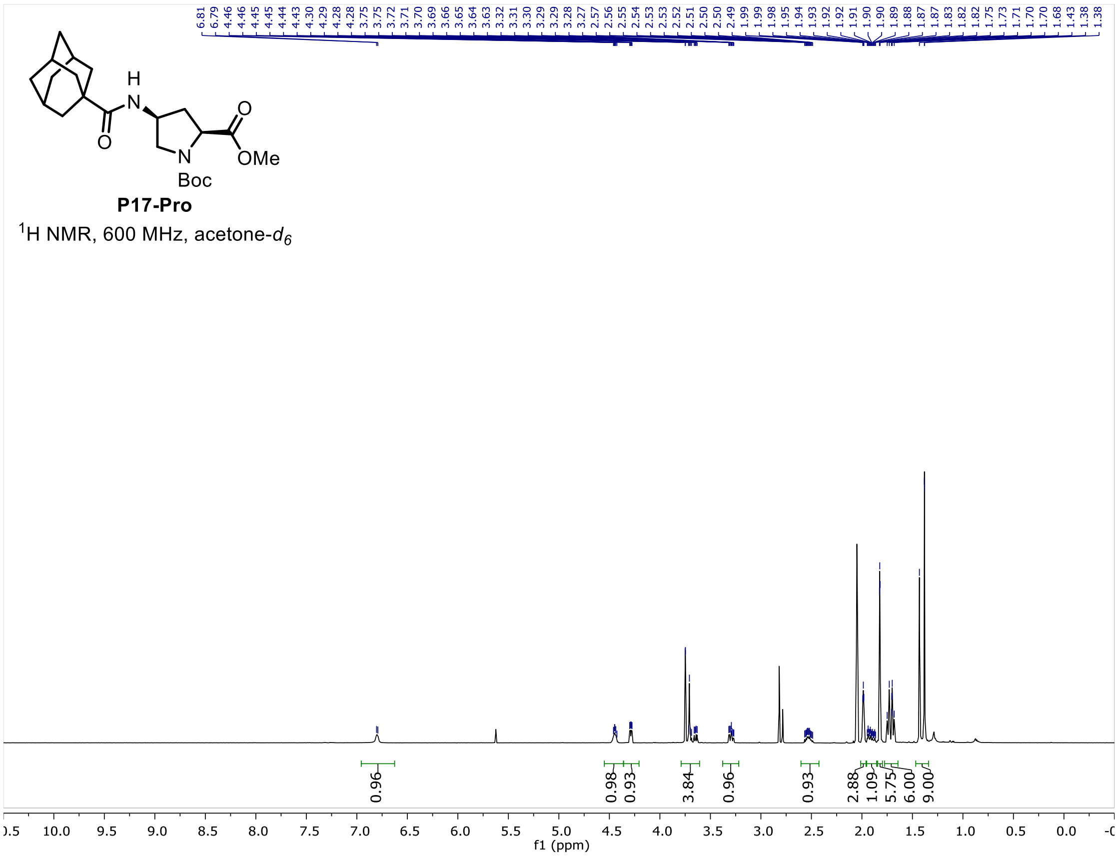
P16-Pro

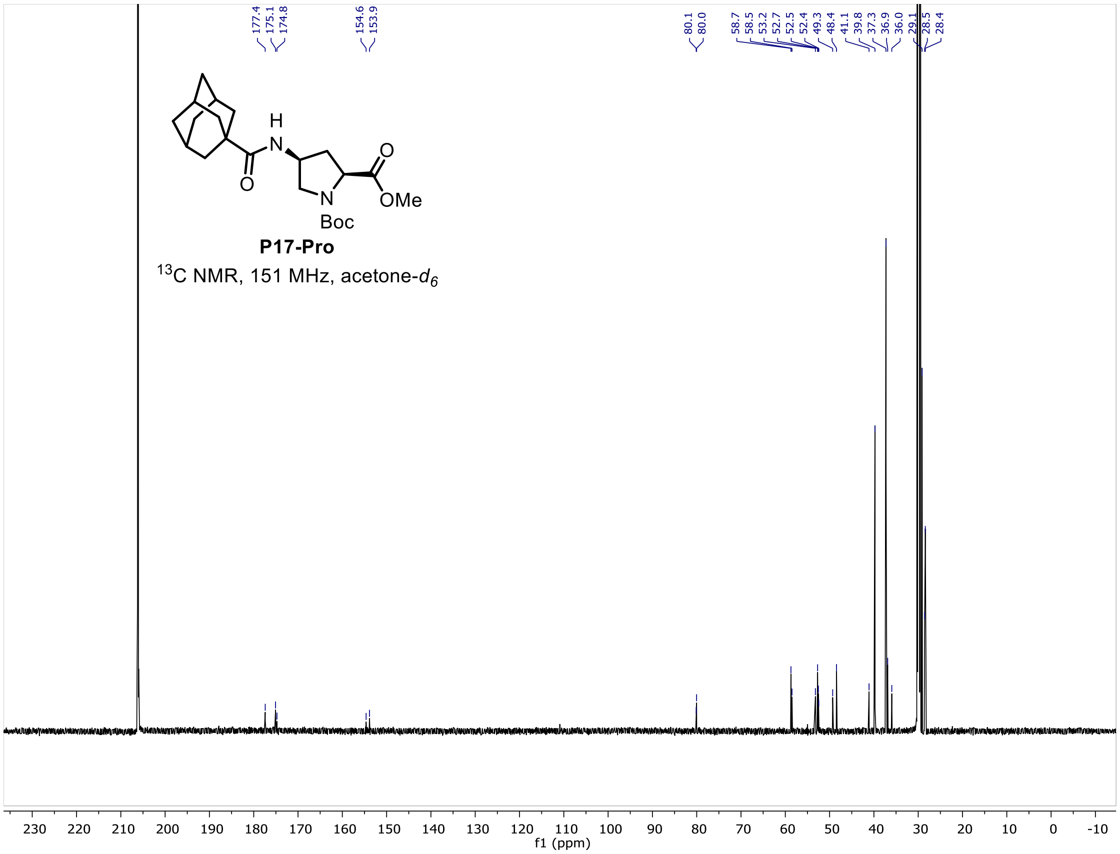
^{1}H NMR, 600 MHz, acetone-d_6

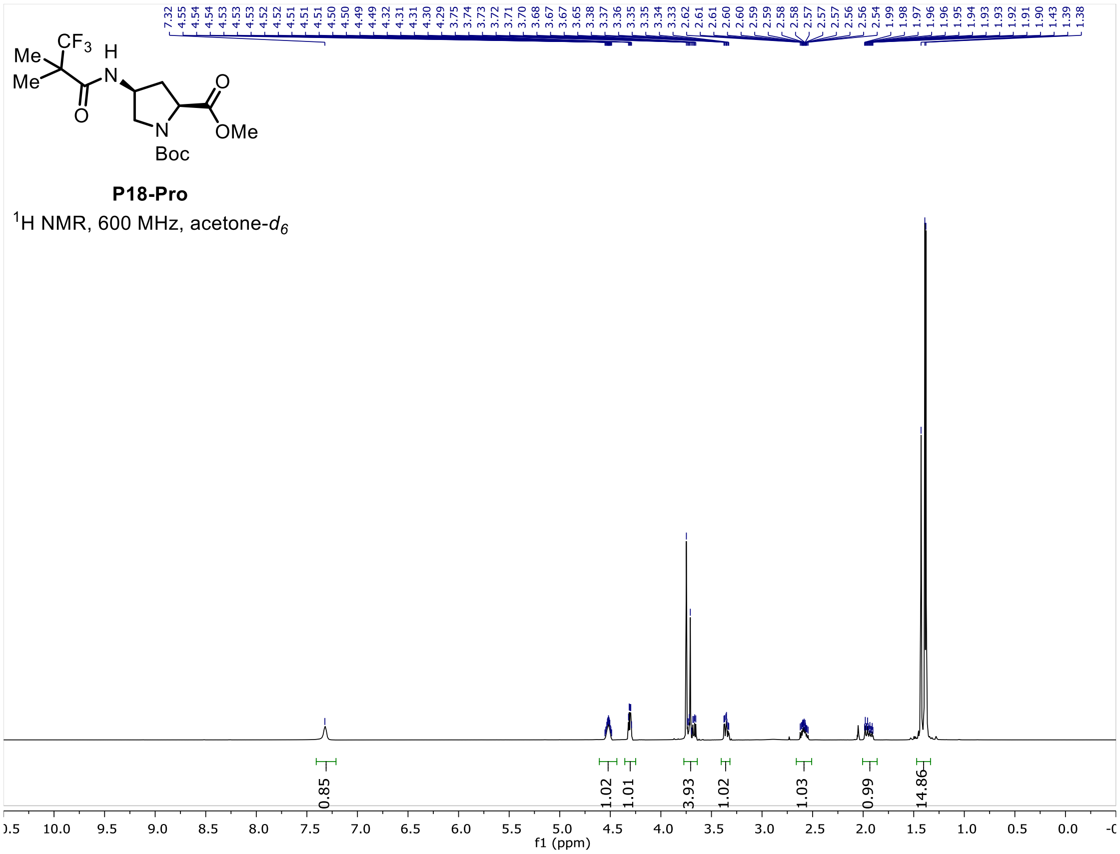


P16-Pro

^{13}C NMR, 151 MHz, acetone-d_6

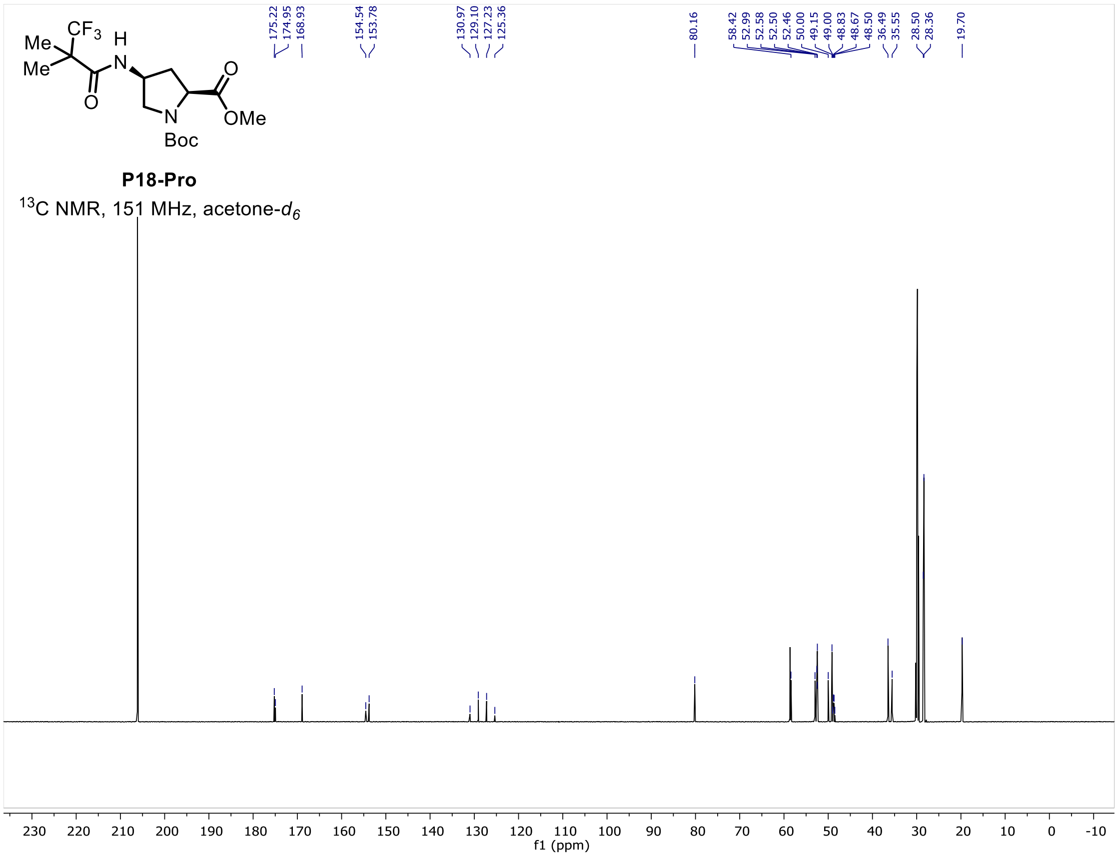

6.81 6.79 4.46 4.46 4.45 4.45 4.44 4.43 4.30 4.29 4.28 4.28 3.75 3.75 3.72 3.71 3.70 3.69 3.66 3.65 3.64 3.63 3.32 3.31 3.30 3.29 3.29 3.28 3.27 2.57 2.56 2.55 2.54 2.53 2.53 2.52 2.51 2.50 2.50 2.49 1.99 1.99 1.98 1.95 1.94 1.93 1.92 1.92 1.91 1.90 1.90 1.89 1.88 1.87 1.87 1.83 1.82 1.75 1.73 1.71 1.70 1.70 1.68 1.43 1.38 1.38
H
N
O
O
OMe
N
Boc
P17-Pro
^{1}H NMR, 600 MHz, acetone-d_6
0.96
0.98
0.93
3.84
0.96
0.93
2.88
1.09
5.75
6.00
9.00
.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -(
f1 (ppm)


177.4 175.1 174.8
154.6 153.9
80.1 80.0
58.7 58.5 53.2 52.7 52.5 52.4 49.3 48.4 41.1 39.8 37.3 36.9 36.0 29.1 28.5 28.4
H
N
O
O
OMe
N
Boc
P17-Pro
^{13}C NMR, 151 MHz, acetone-d_6
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)



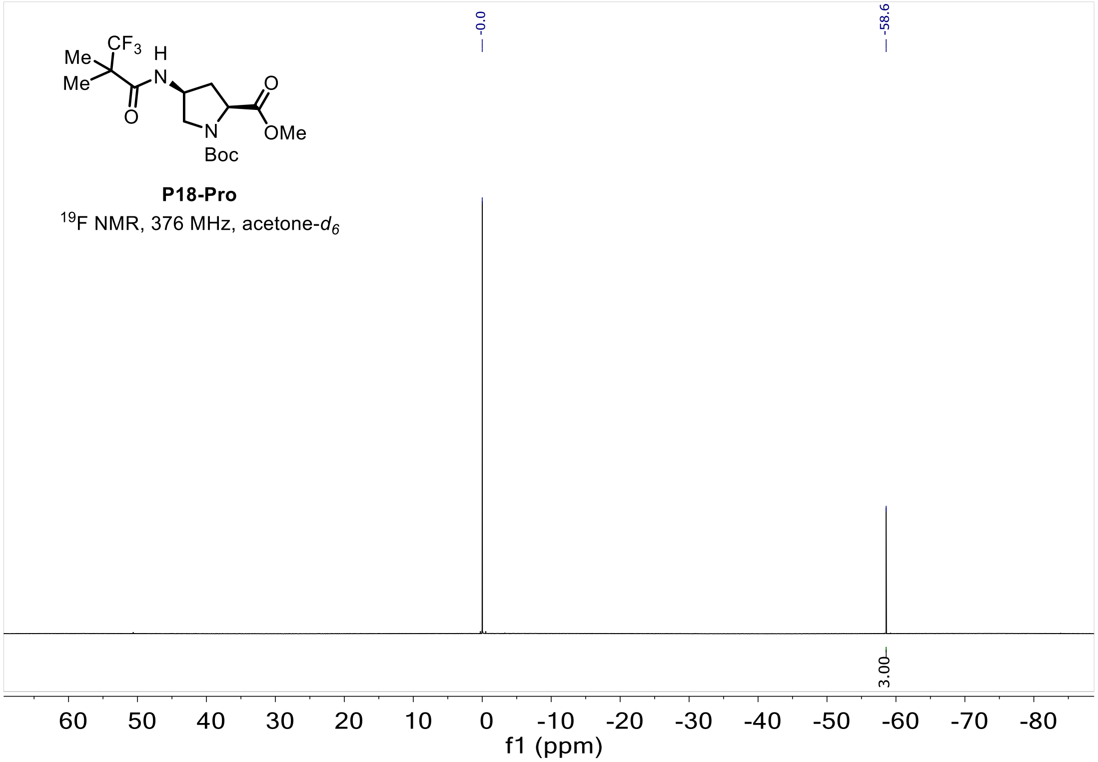
P18-Pro

^{1}H NMR, 600 MHz, acetone-d_6

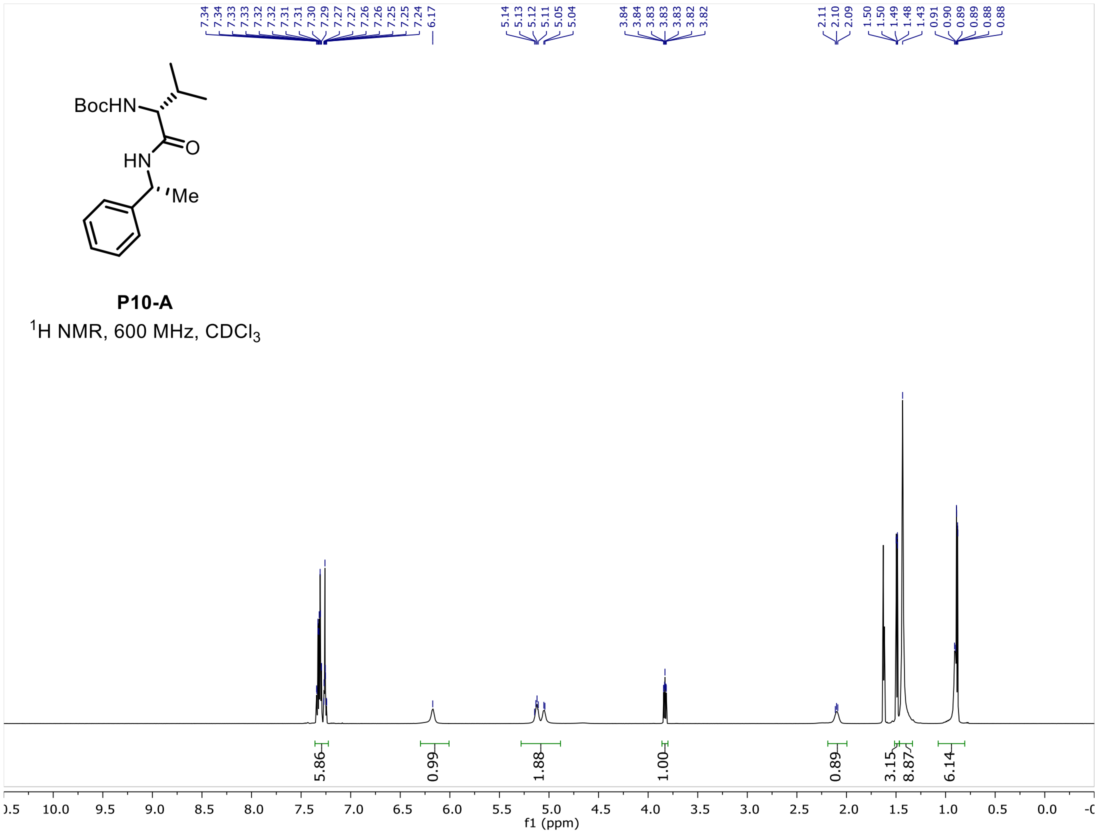


P18-Pro

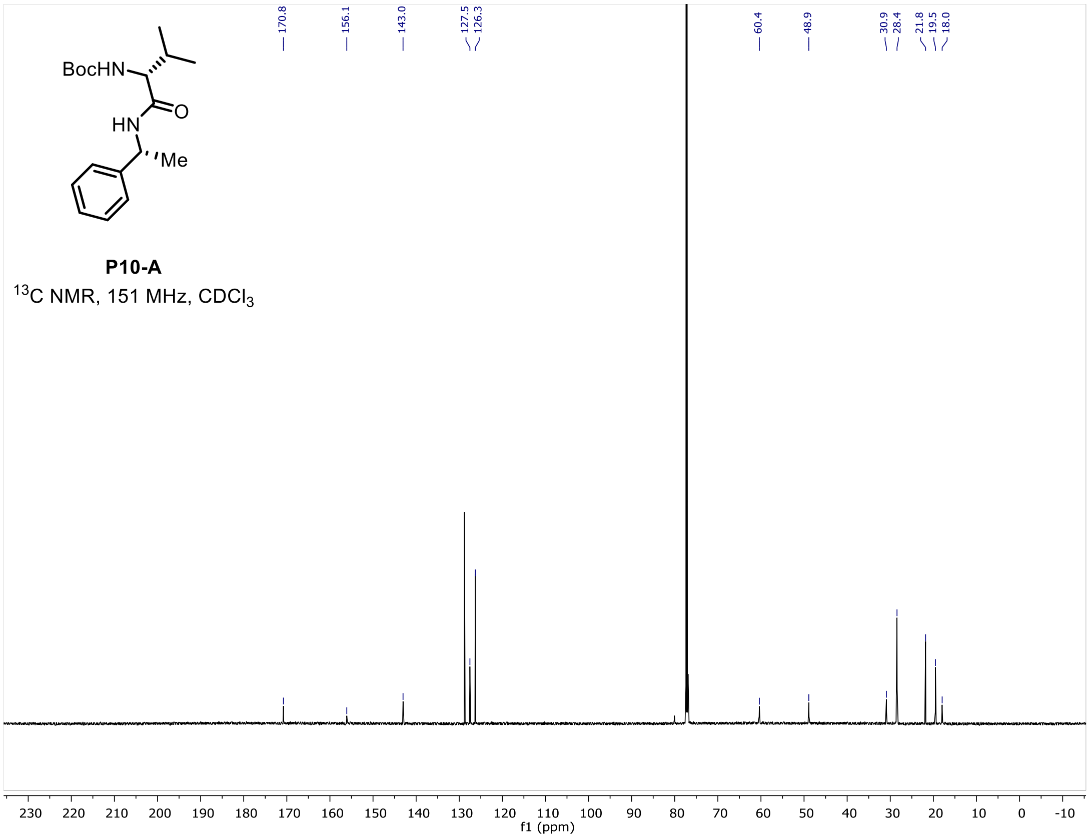
^{13}C NMR, 151 MHz, acetone-d_6


CF3
Me
Me
H
N
O
O
N
OMe
Boc
P18-Pro
19F NMR, 376 MHz, acetone-d6
-0.0
-58.6
3.00
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
f1 (ppm)

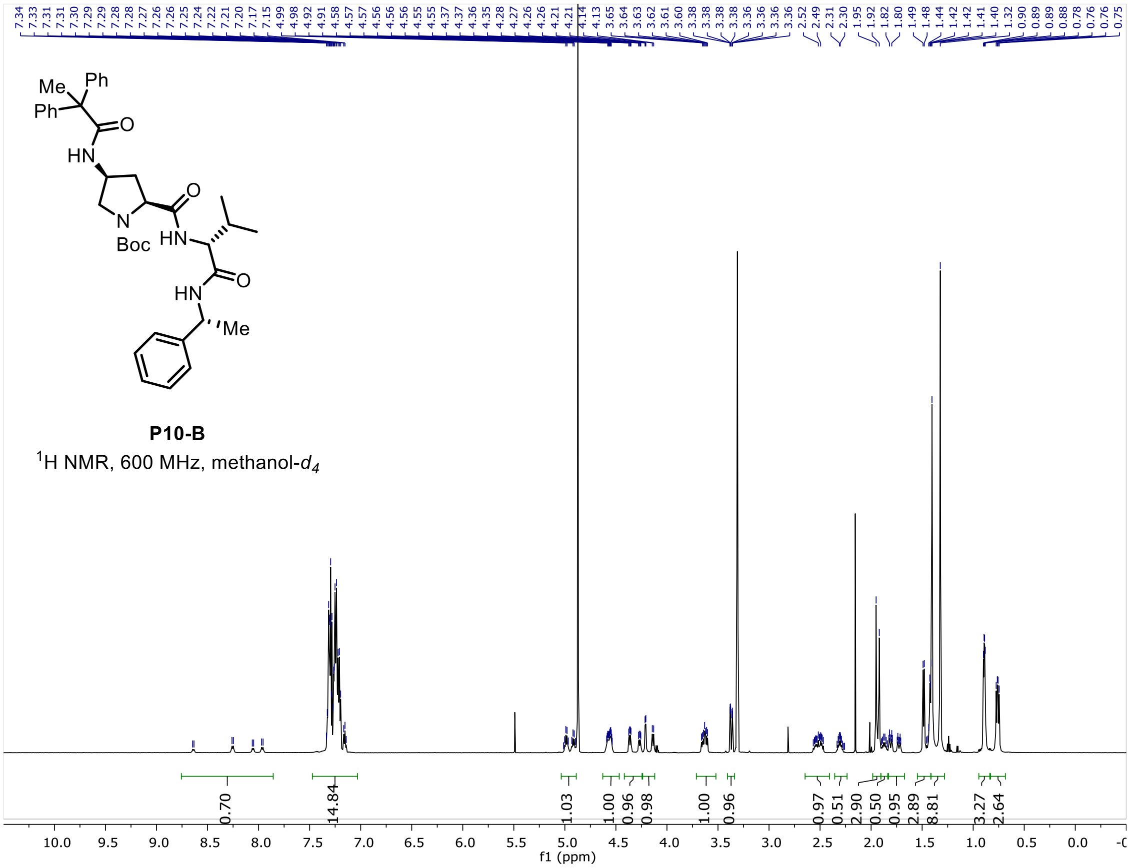
B. NMR Spectra for catalyst P10 and synthetic intermediates



P10-A
^{1}H NMR, 600 MHz, CDCl$_3$

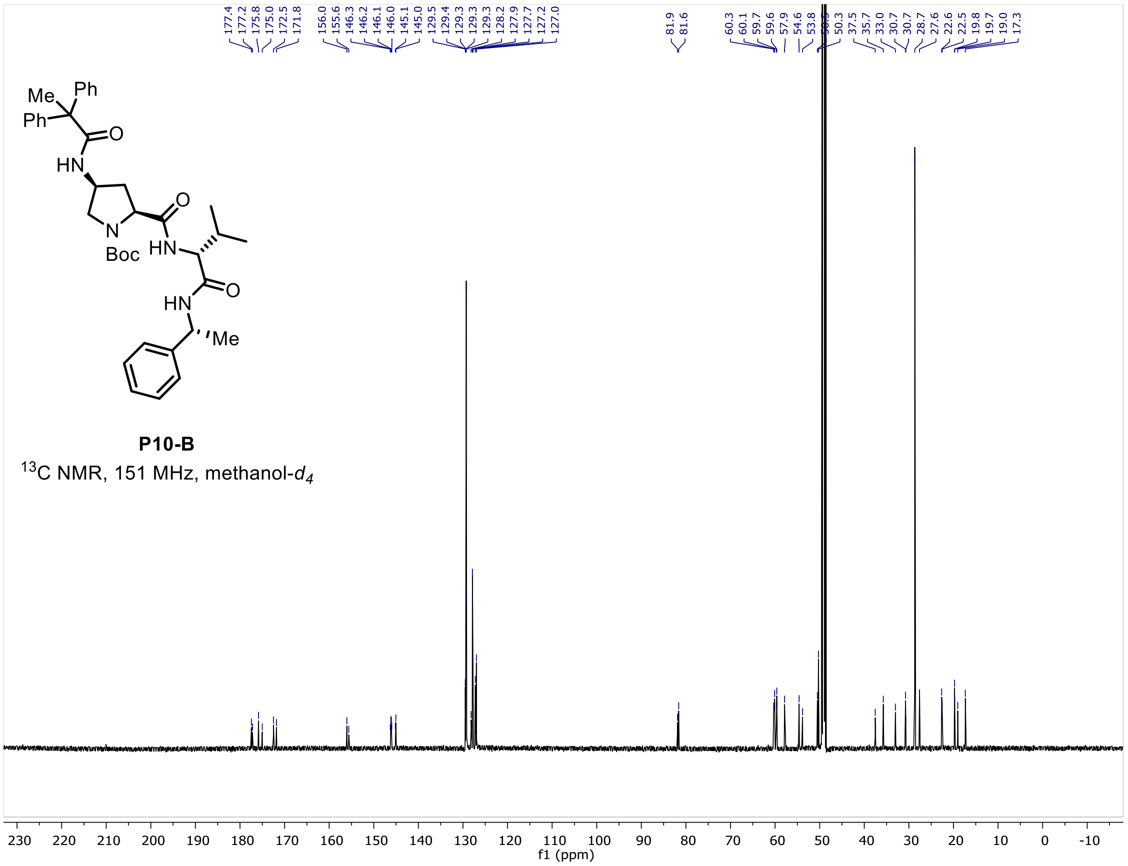


P10-A
^{13}C NMR, 151 MHz, CDCl$_3$



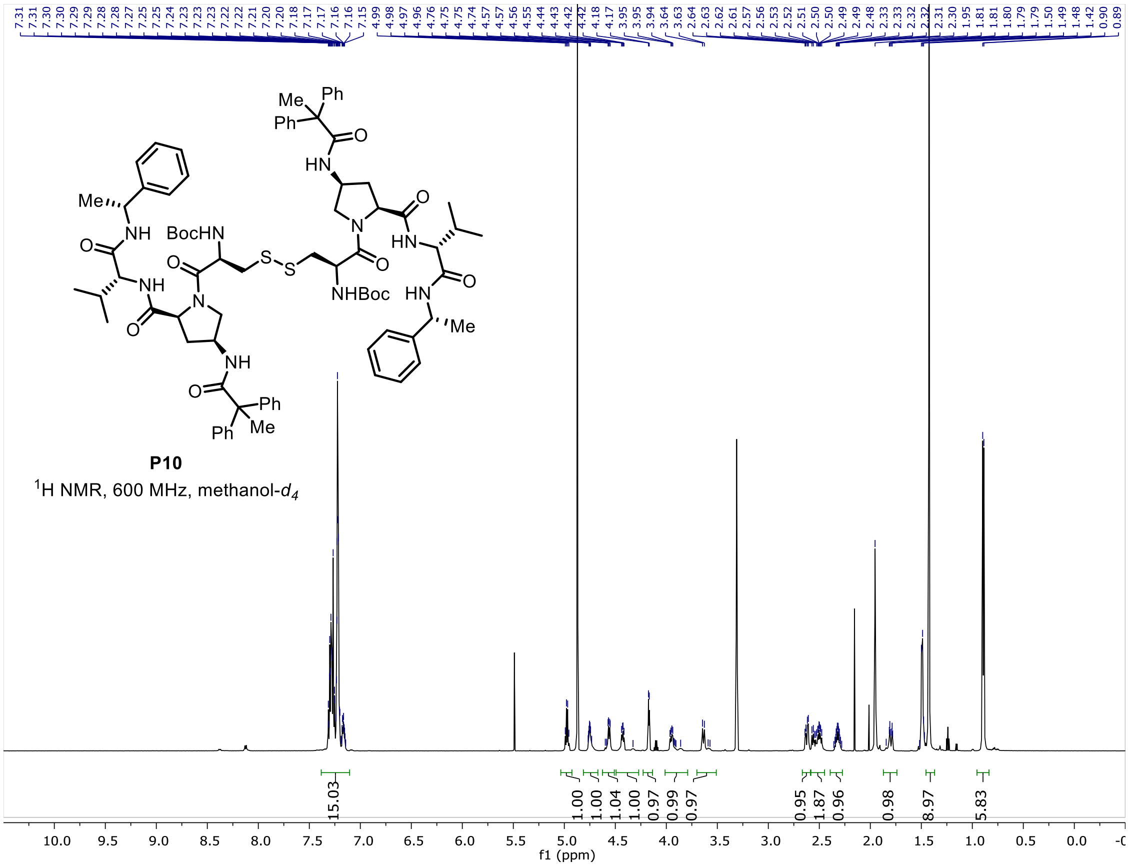
P10-B

^{1}H NMR, 600 MHz, methanol-d_4



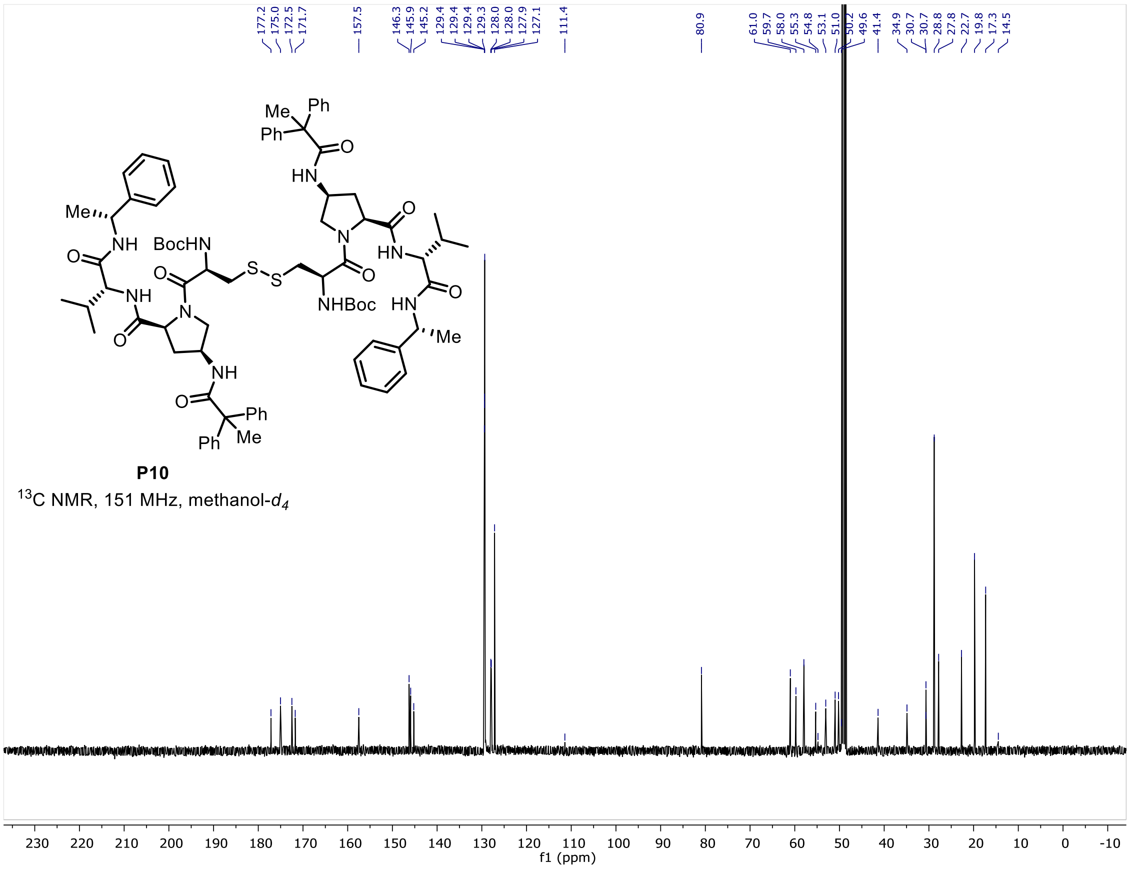
P10-B

^{13}C NMR, 151 MHz, methanol-d_4



P10

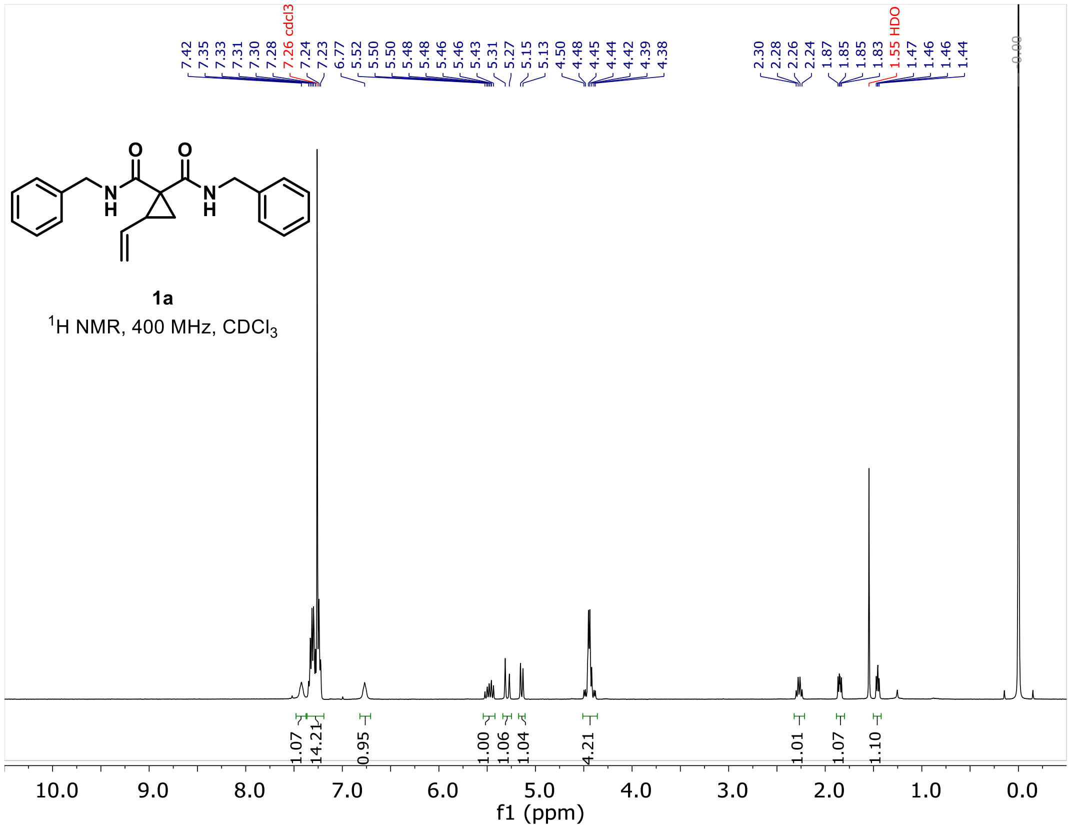
^{1}H NMR, 600 MHz, methanol-d_4

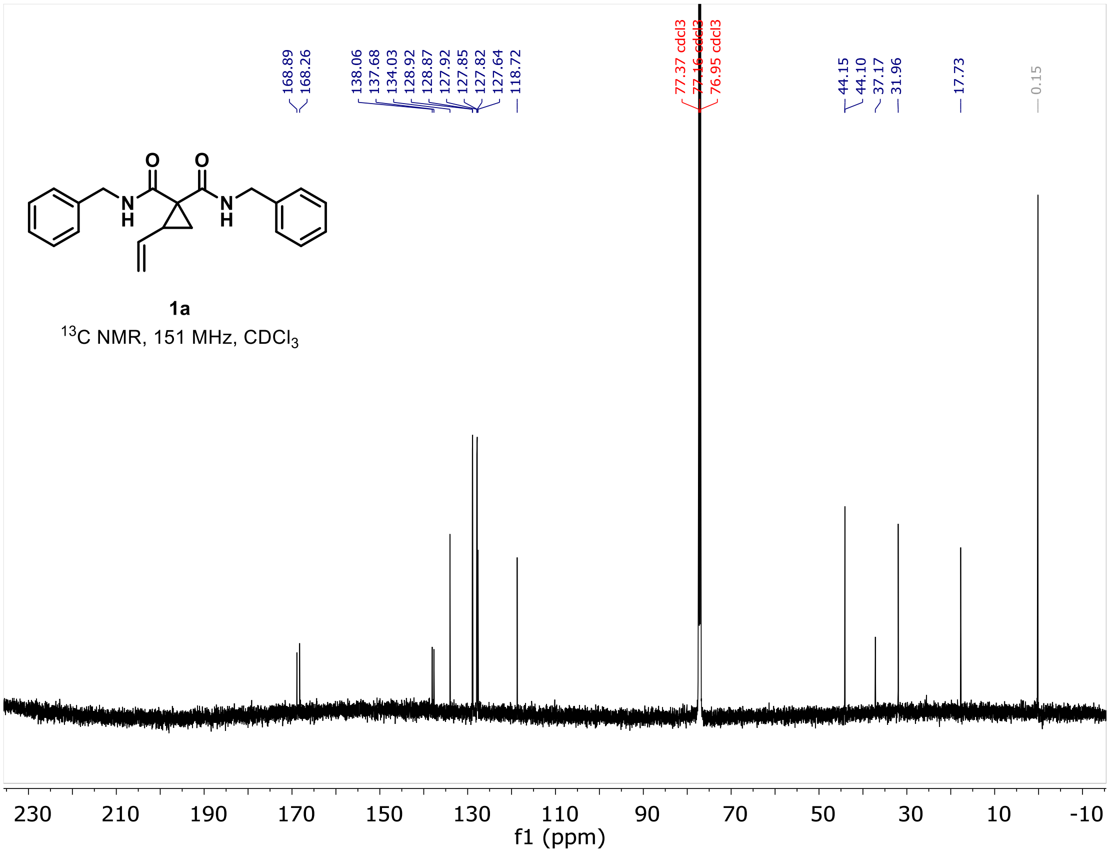


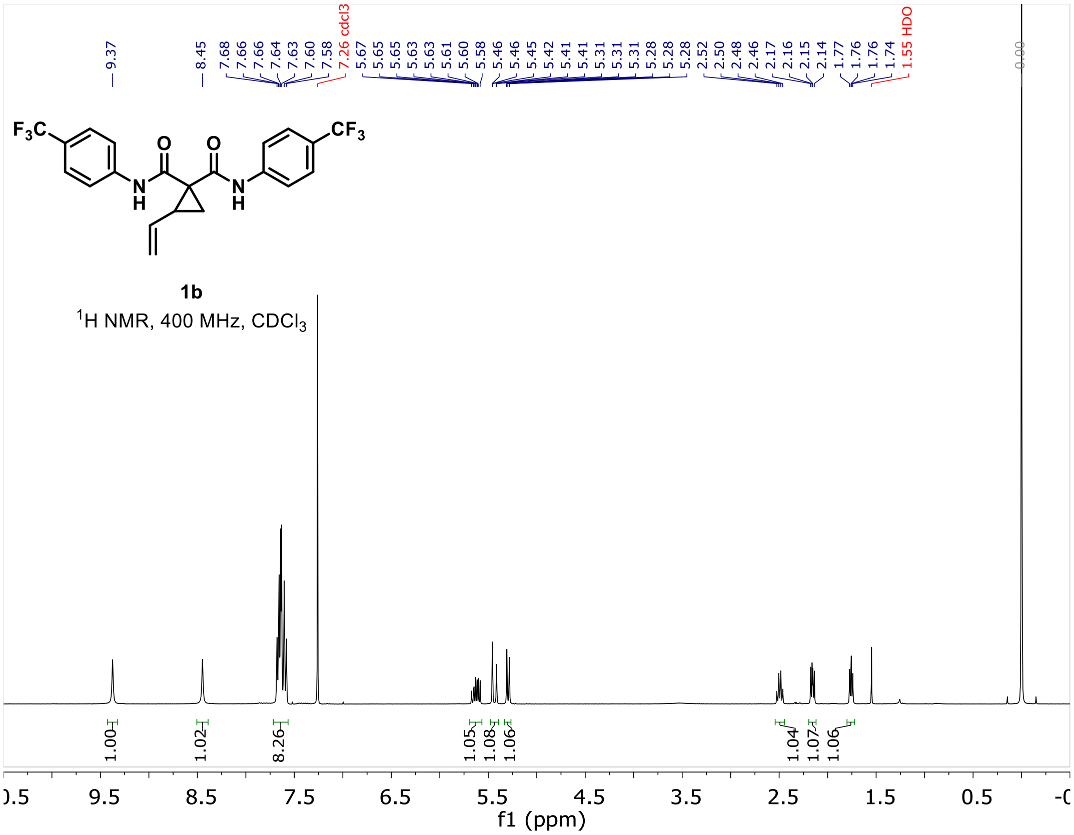
P10

^{13}C NMR, 151 MHz, methanol-d_4

C. NMR Spectra for vinylcyclopropane substrates 1a–1h

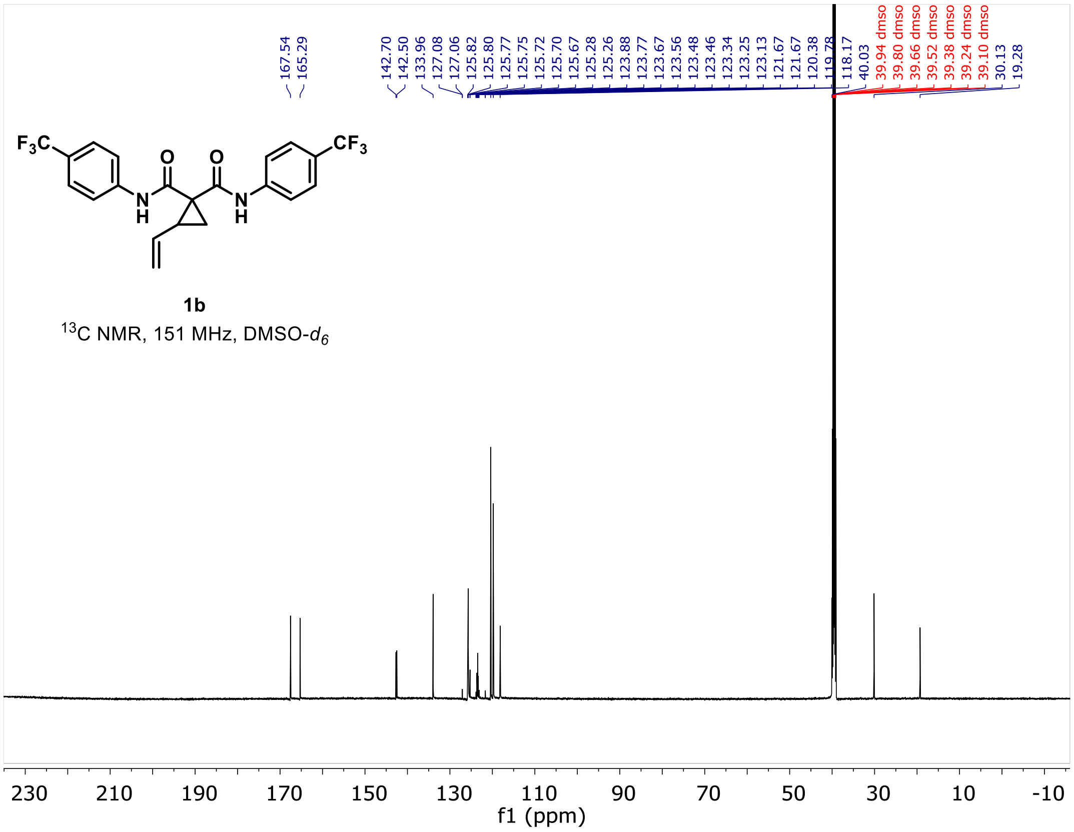






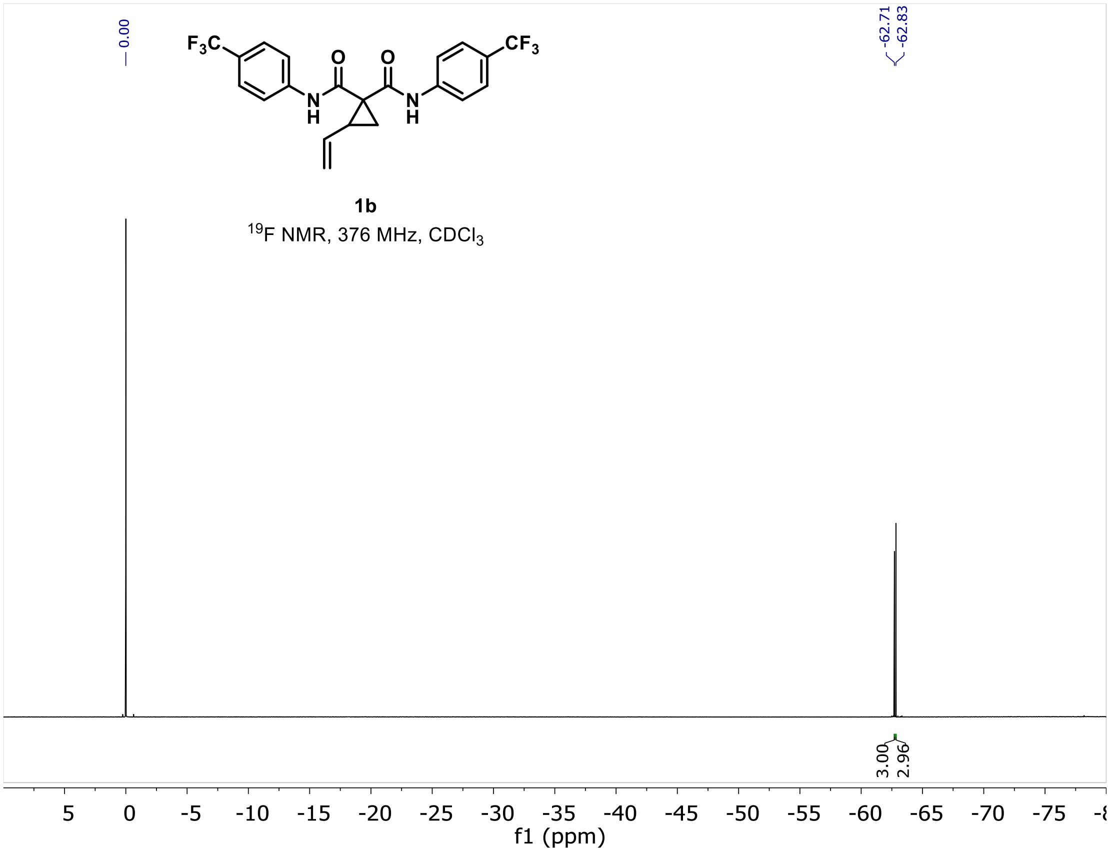
1b

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

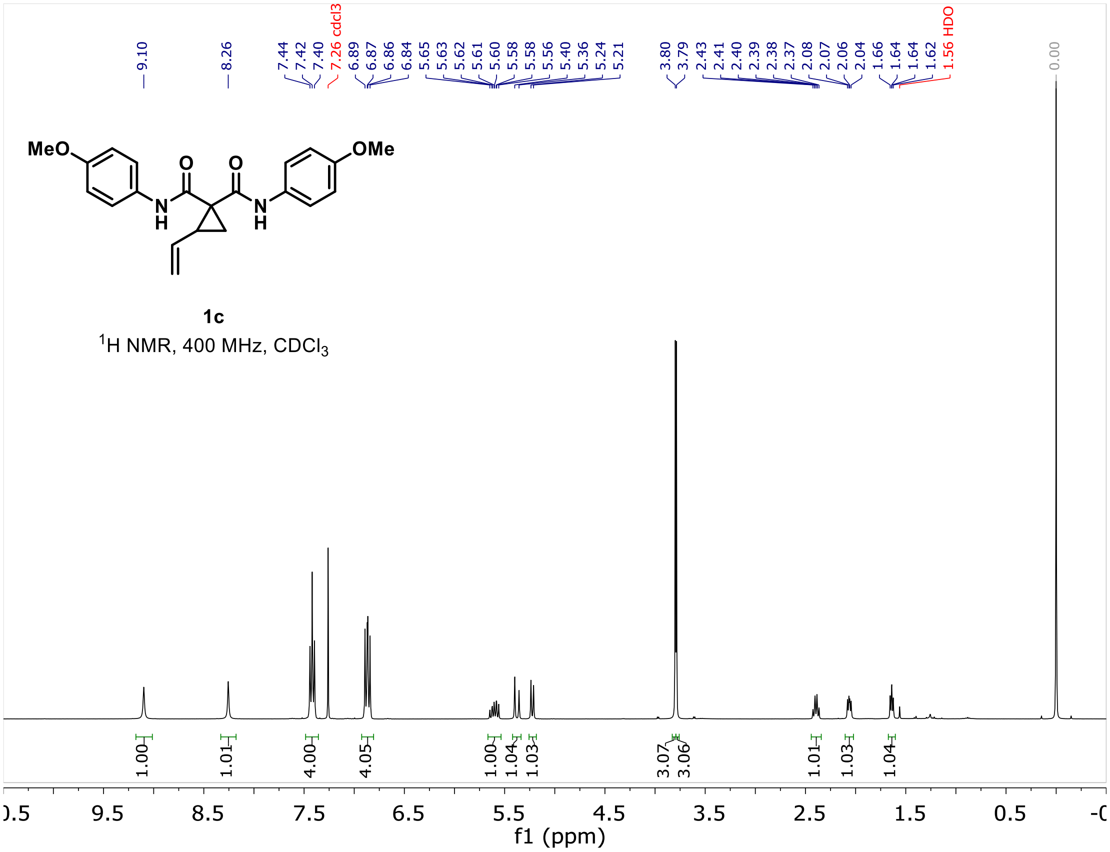


1b

^{13}C NMR, 151 MHz, DMSO-*d*$_6$

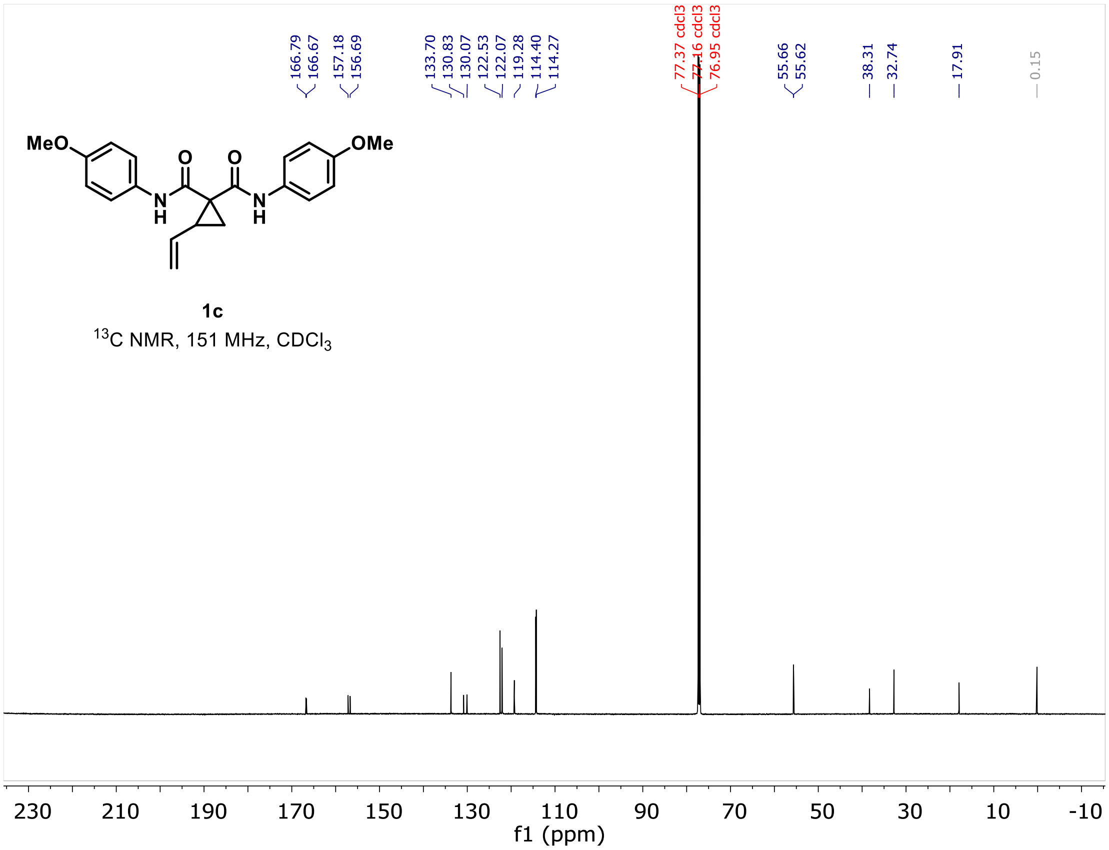


— 0.00
-62.71
-62.83
F3C
CF3
O
O
N
H
N
H
1b
19F NMR, 376 MHz, CDCl3
3.00
2.96
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
-55
-60
-65
-70
-75
f1 (ppm)



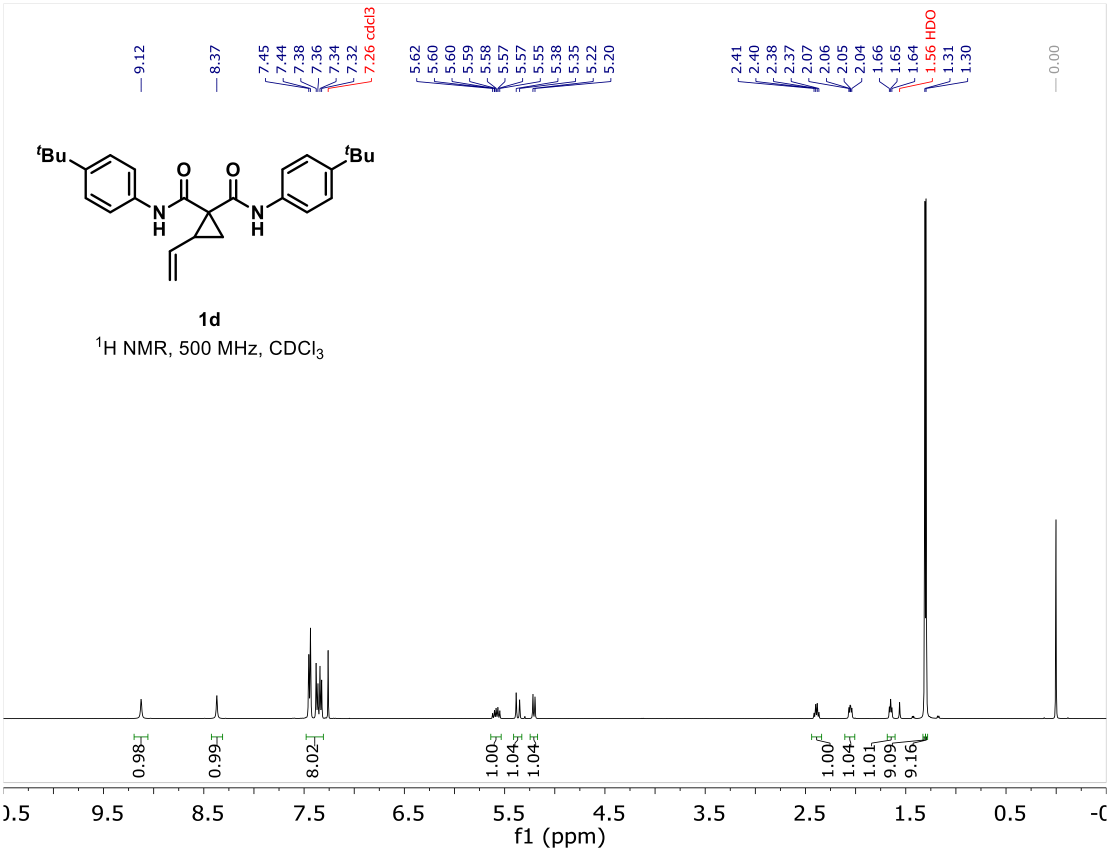
1c

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



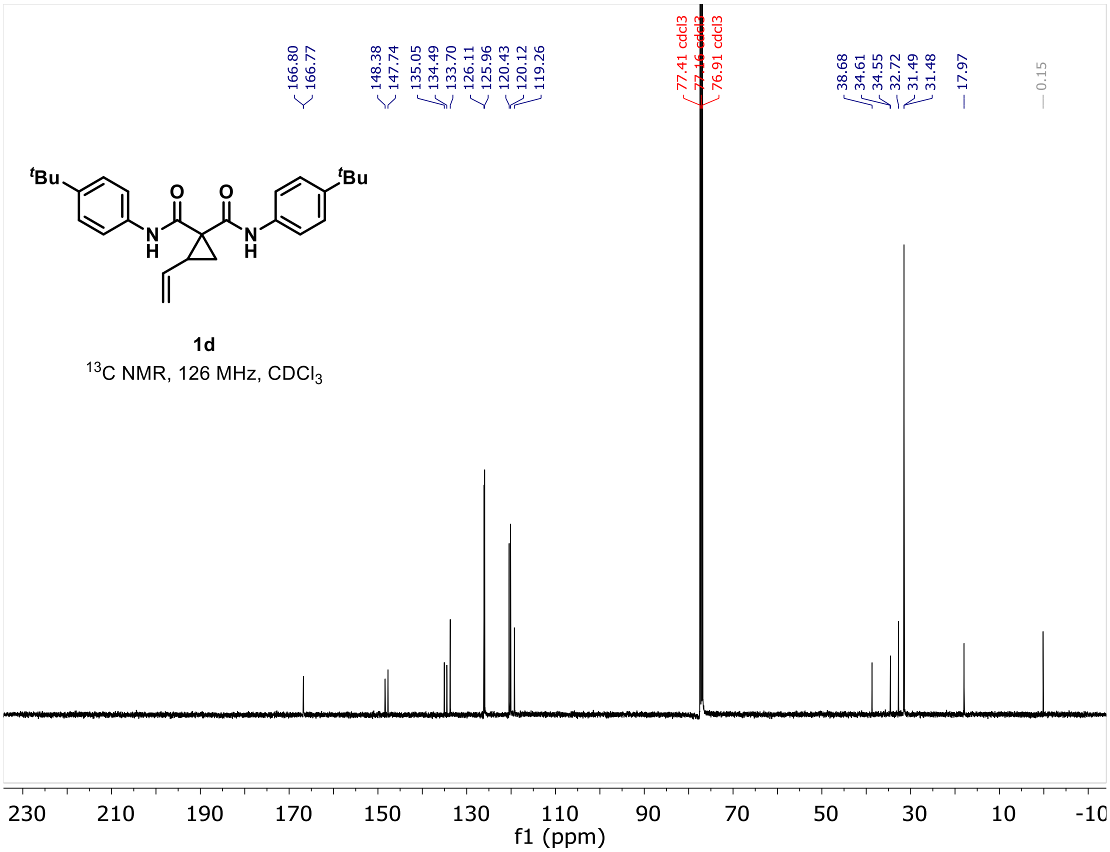
1c

^{13}C NMR, 151 MHz, $CDCl_3$



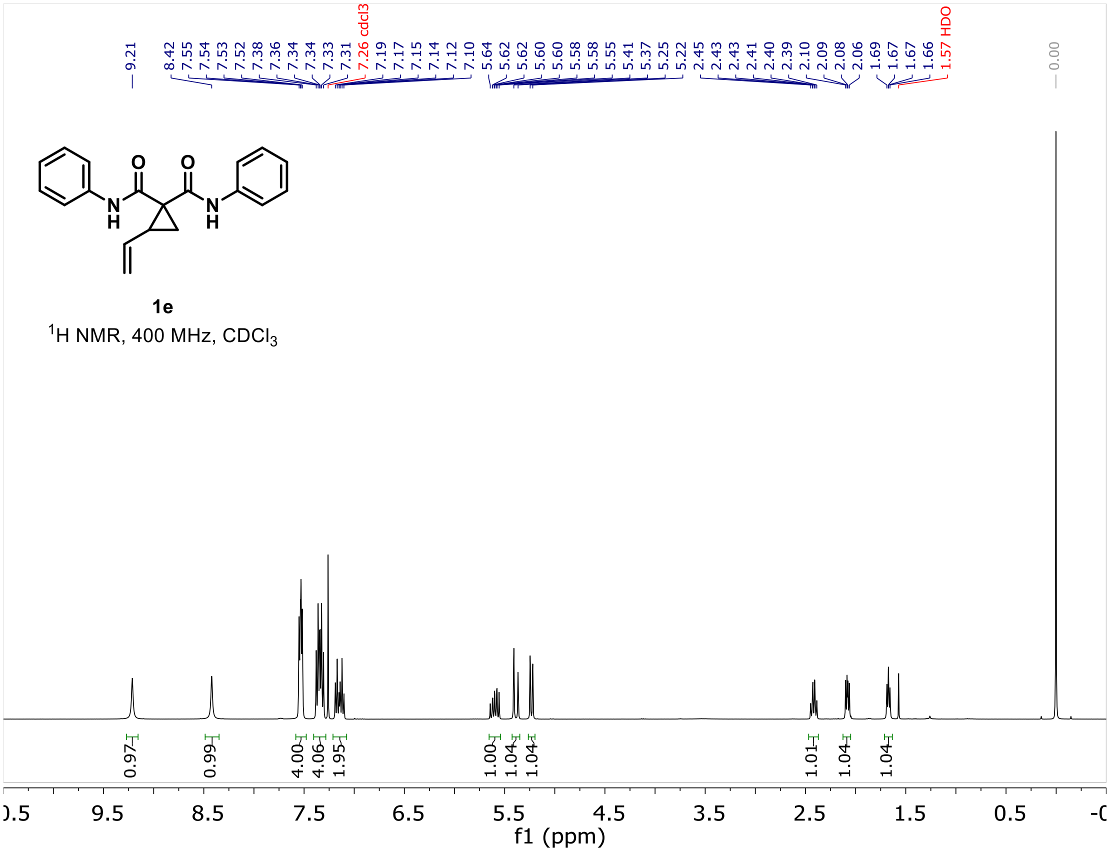
1d

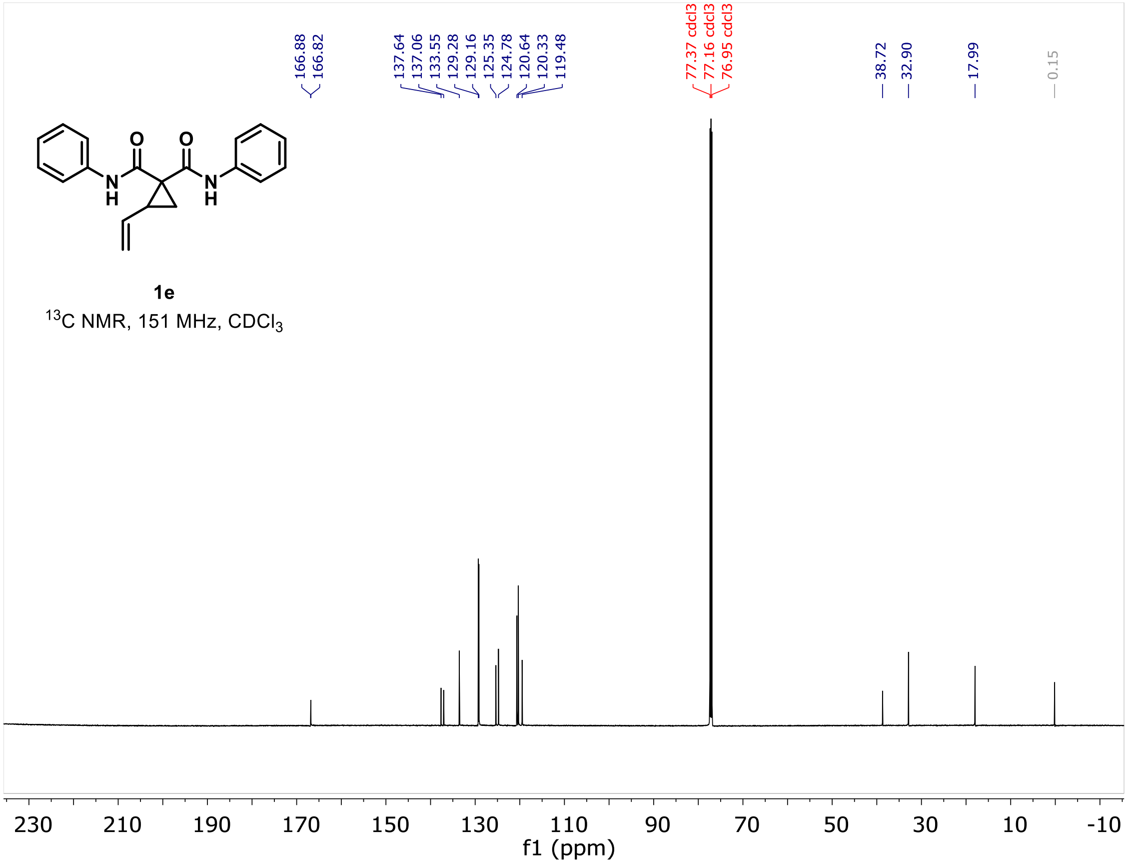
^{1}H NMR, 500 MHz, CDCl$_3$

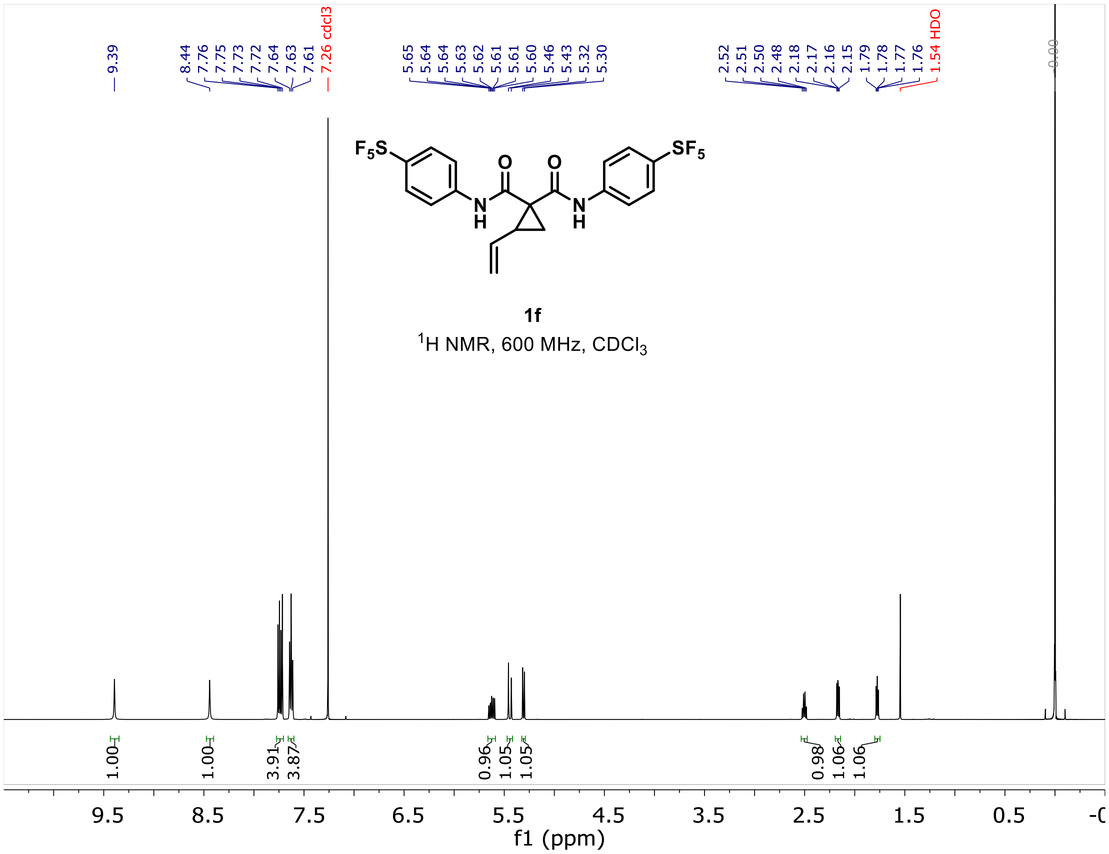


1d

^{13}C NMR, 126 MHz, CDCl$_3$

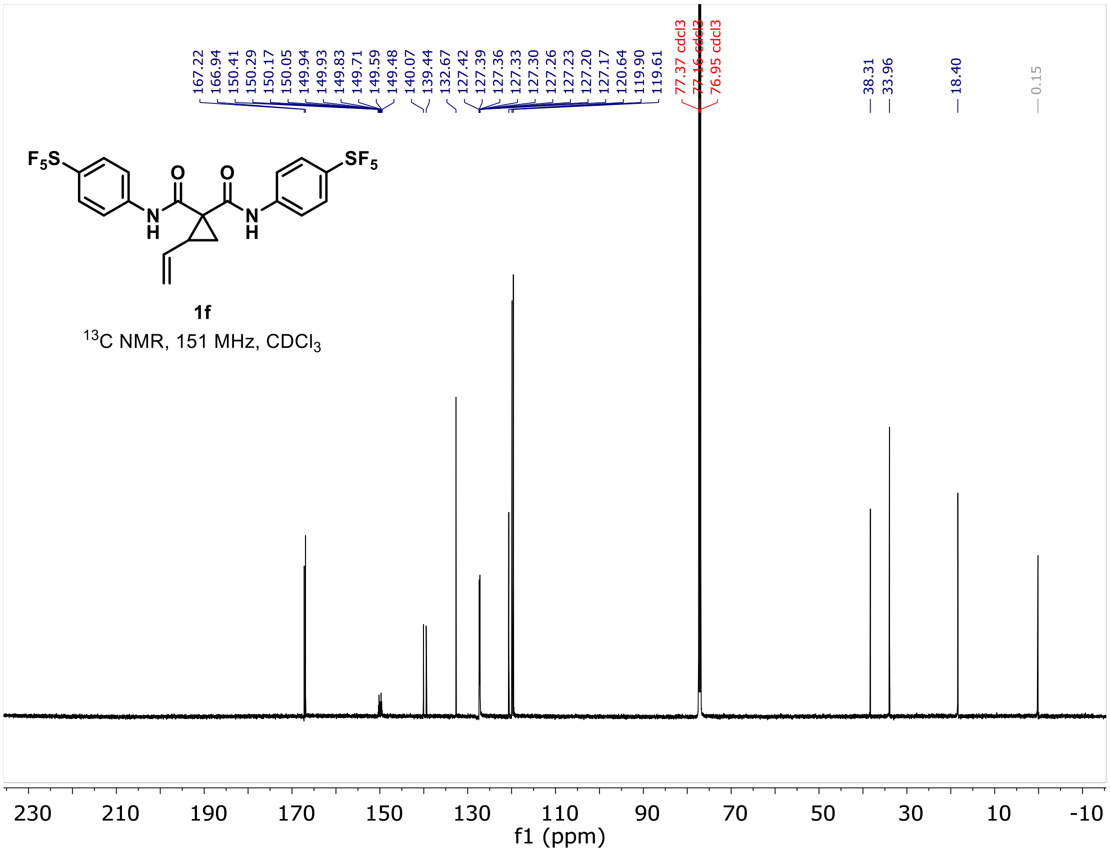

9.21
8.42
7.55
7.54
7.53
7.52
7.38
7.36
7.34
7.34
7.33
7.31
7.26 cdcl3
7.19
7.17
7.15
7.14
7.12
7.10
5.64
5.62
5.62
5.60
5.60
5.58
5.58
5.55
5.41
5.37
5.25
5.22
2.45
2.43
2.41
2.40
2.39
2.10
2.09
2.08
2.06
1.69
1.67
1.67
1.66
1.57 HDO
0.00
O
O
N
H
N
H
1e
^{1}H NMR, 400 MHz, CDCl$_3$
0.97
0.99
4.00
4.06
1.95
1.00
1.04
1.04
1.01
1.04
1.04
9.5
8.5
7.5
6.5
5.5
4.5
3.5
2.5
1.5
0.5
f1 (ppm)


166.88
166.82
137.64
137.06
133.55
129.28
129.16
125.35
124.78
120.64
120.33
119.48
77.37 cdcl3
77.16 cdcl3
76.95 cdcl3
38.72
32.90
17.99
0.15
O
O
N
H
N
H
1e
^{13}C NMR, 151 MHz, CDCl$_3$
230
210
190
170
150
130
110
90
70
50
30
10
-10
f1 (ppm)



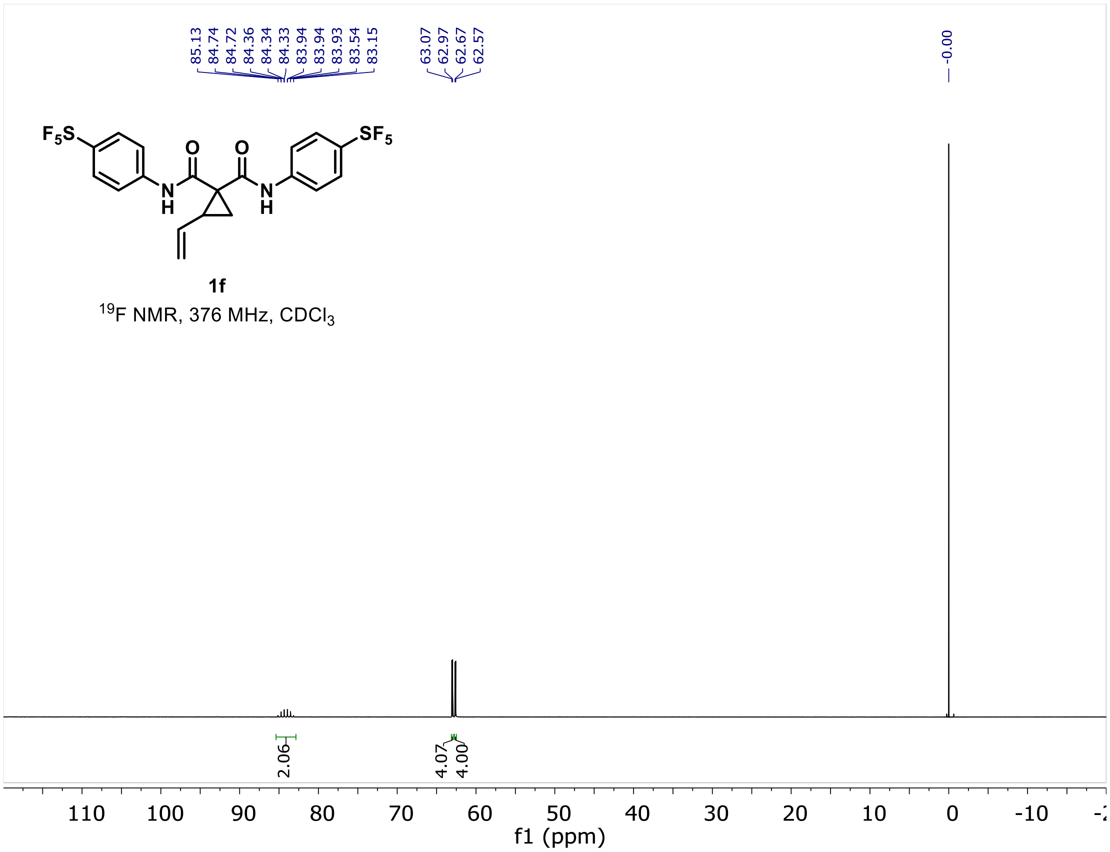
1f

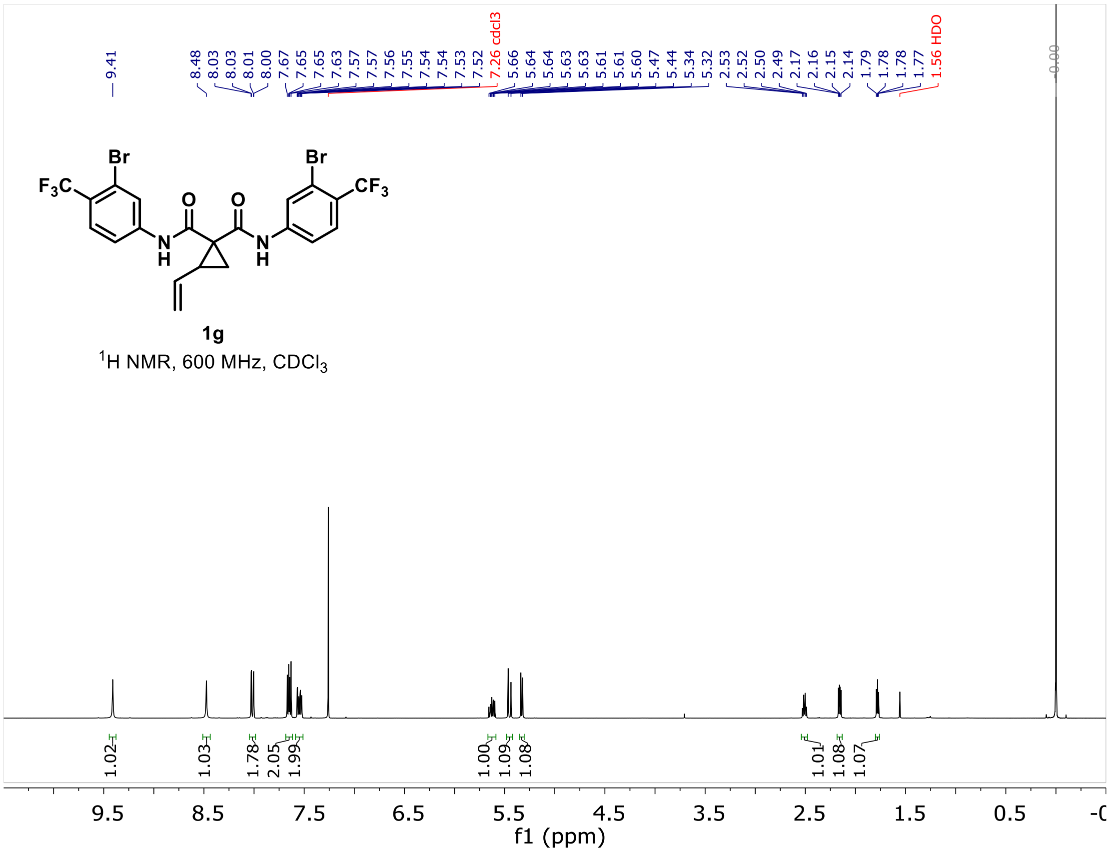
^{1}H NMR, 600 MHz, $CDCl_3$

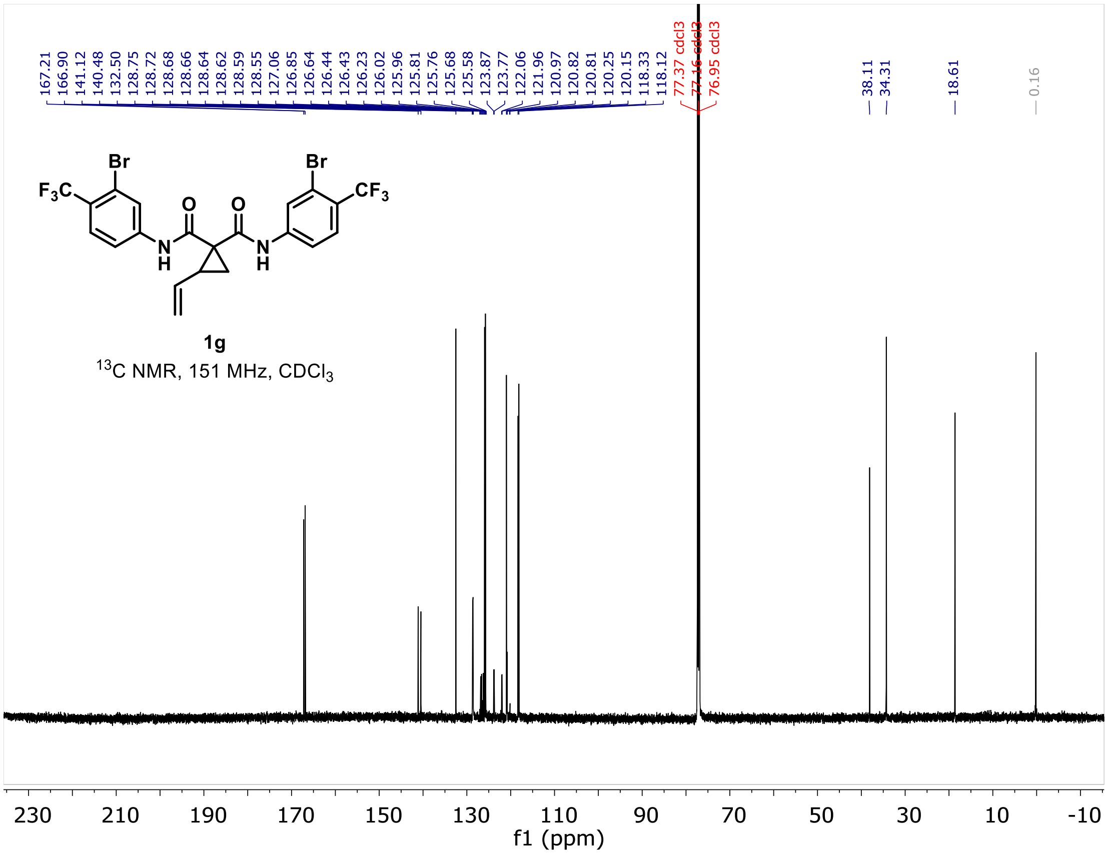


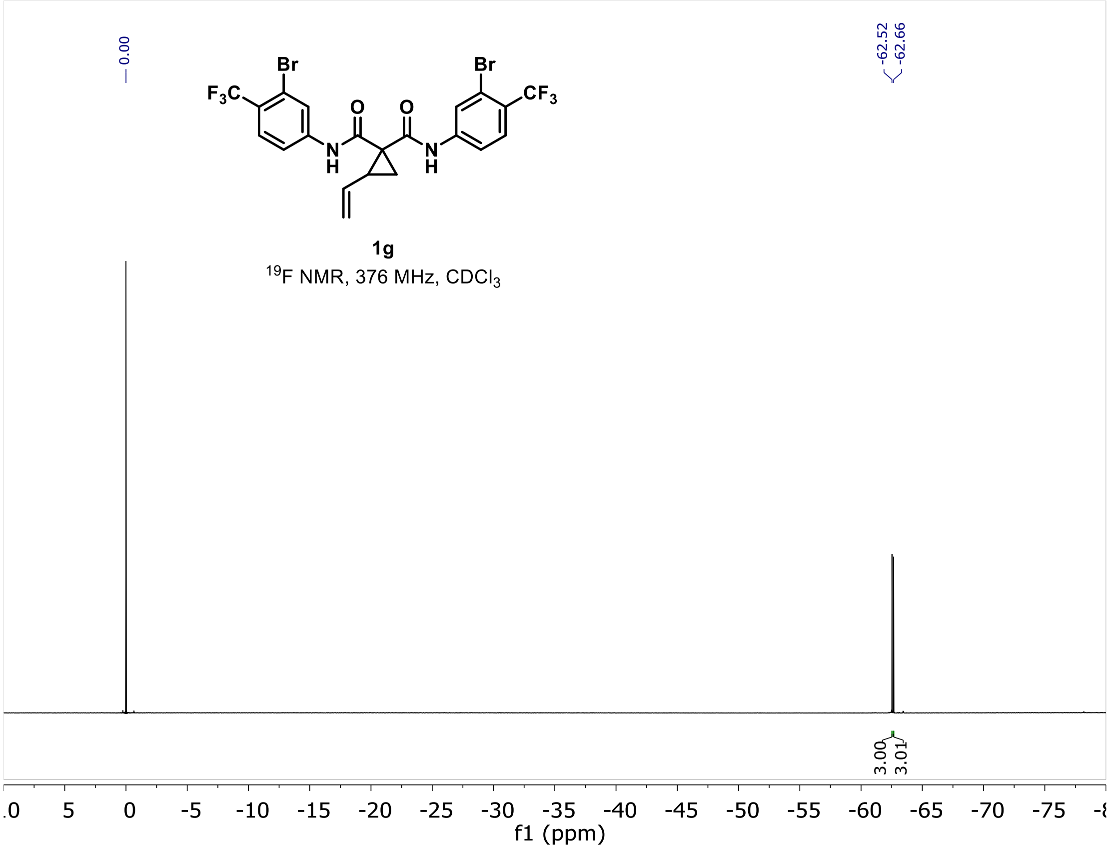
1f

^{13}C NMR, 151 MHz, $CDCl_3$

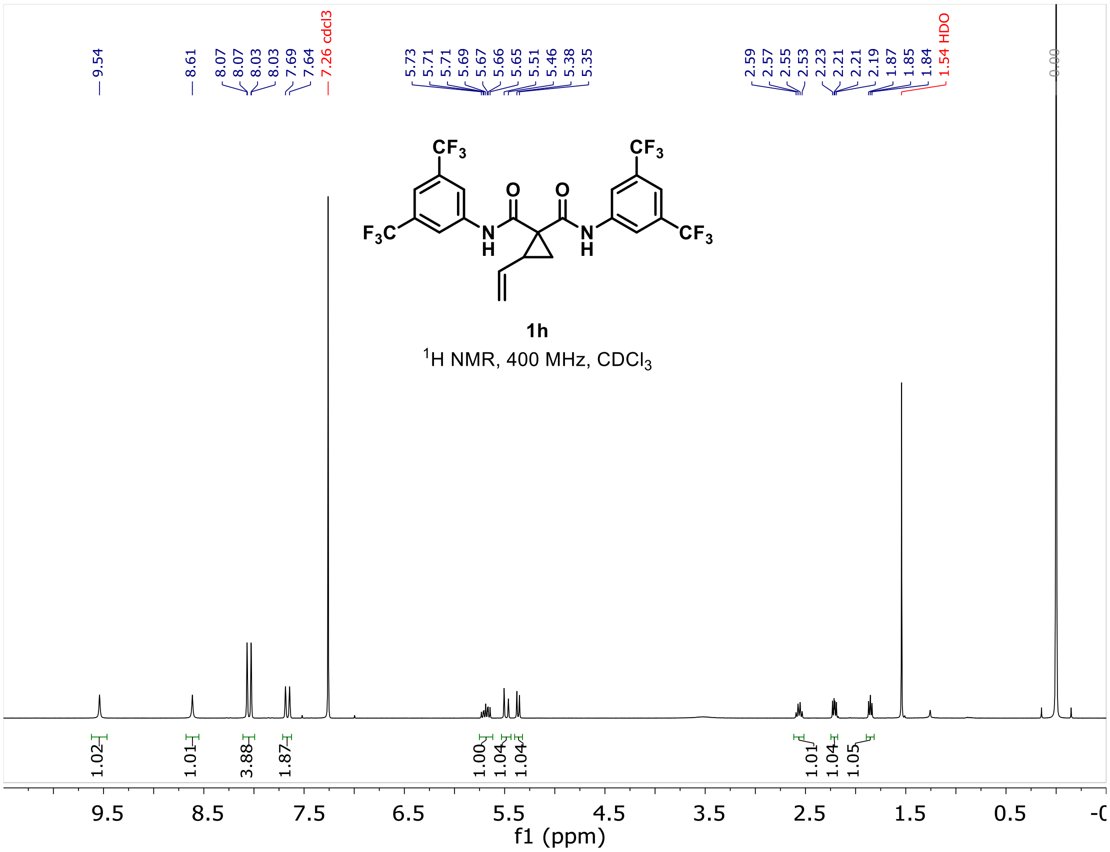

F5S
SF5
O
O
N
H
N
H
1f
19F NMR, 376 MHz, CDCl3
85.13
84.74
84.72
84.36
84.34
84.33
83.94
83.94
83.93
83.54
83.15
63.07
62.97
62.67
62.57
-0.00
2.06
4.07
4.00
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)


9.41
8.48
8.03
8.03
8.01
8.00
7.67
7.65
7.65
7.63
7.57
7.57
7.56
7.55
7.54
7.54
7.53
7.52
7.26 cdcl3
5.66
5.64
5.64
5.63
5.63
5.61
5.61
5.60
5.47
5.44
5.34
5.32
2.53
2.52
2.50
2.49
2.17
2.16
2.15
2.14
1.79
1.78
1.78
1.77
1.56 HDO
0.00
Br
F3C
O
O
N
H
Br
CF3
N
H
1g
1H NMR, 600 MHz, CDCl3
1.02
1.03
1.78
2.05
1.99
1.00
1.09
1.08
1.01
1.08
1.07
9.5
8.5
7.5
6.5
5.5
4.5
3.5
2.5
1.5
0.5
-0
f1 (ppm)


167.21
166.90
141.12
140.48
132.50
128.75
128.72
128.68
128.66
128.64
128.62
128.59
128.55
127.06
126.85
126.64
126.44
126.43
126.23
126.02
125.96
125.81
125.76
125.68
125.58
123.87
123.77
122.06
121.96
120.97
120.82
120.81
120.25
120.15
118.33
118.12
77.37 cdcl3
77.16 cdcl3
76.95 cdcl3
38.11
34.31
18.61
0.16
Br
F3C
O
O
N
H
Br
CF3
N
H
1g
13C NMR, 151 MHz, CDCl3
230
210
190
170
150
130
110
90
70
50
30
10
-10
f1 (ppm)

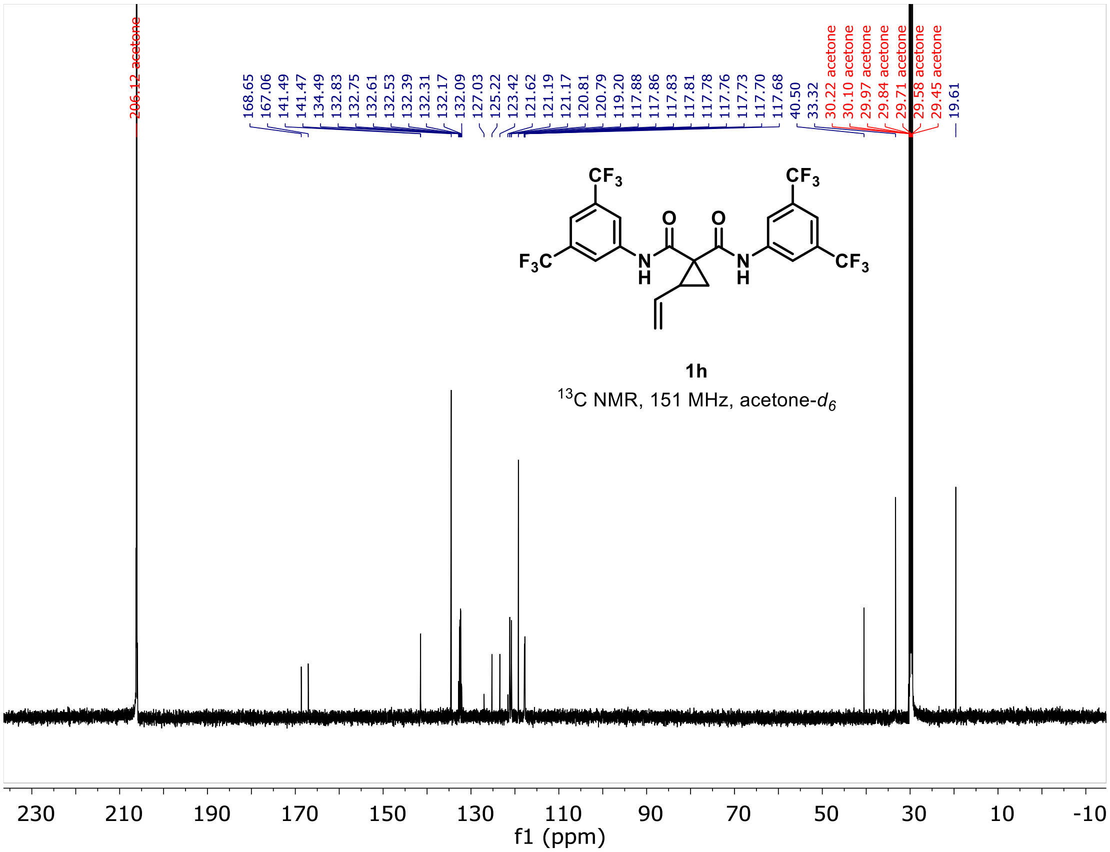


0.00
-62.52
-62.66
Br
F$_3$C
O
O
Br
CF$_3$
N
H
N
H
1g
^{19}F NMR, 376 MHz, CDCl$_3$
3.00
3.01
.0
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
-55
-60
-65
-70
-75
f1 (ppm)



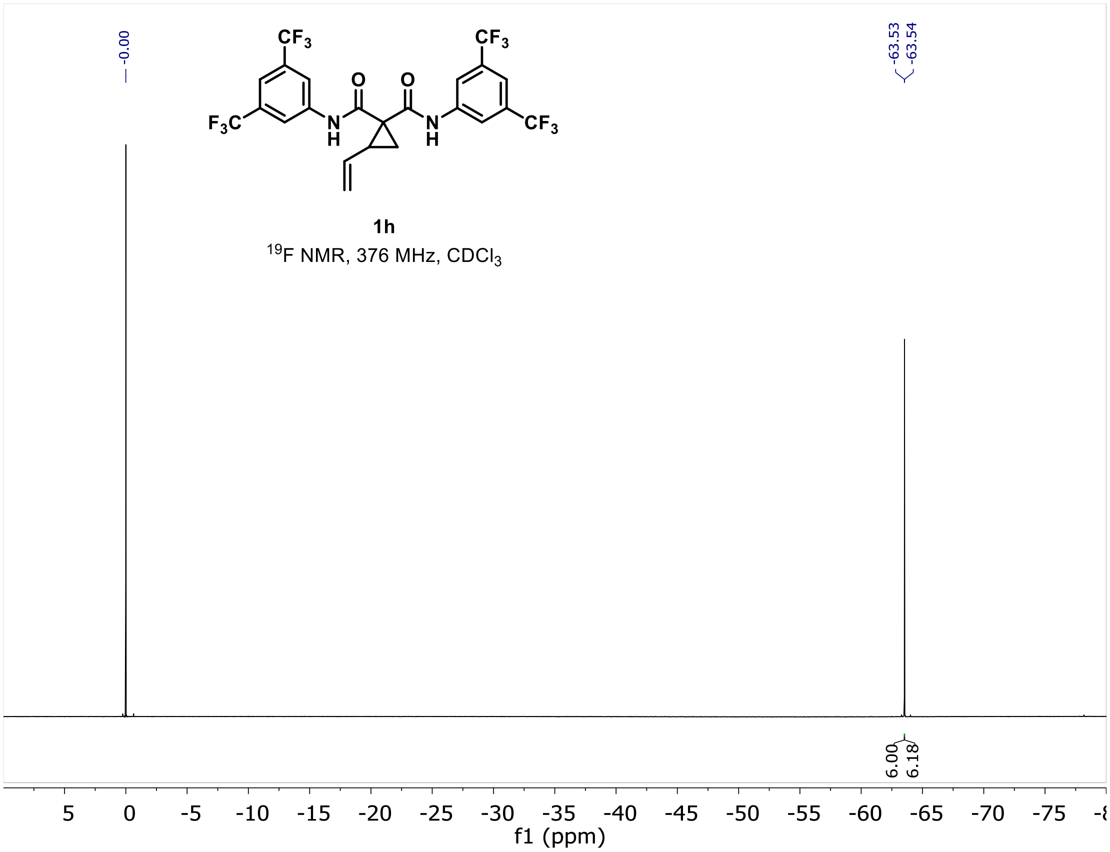
1h

^{1}H NMR, 400 MHz, CDCl$_3$

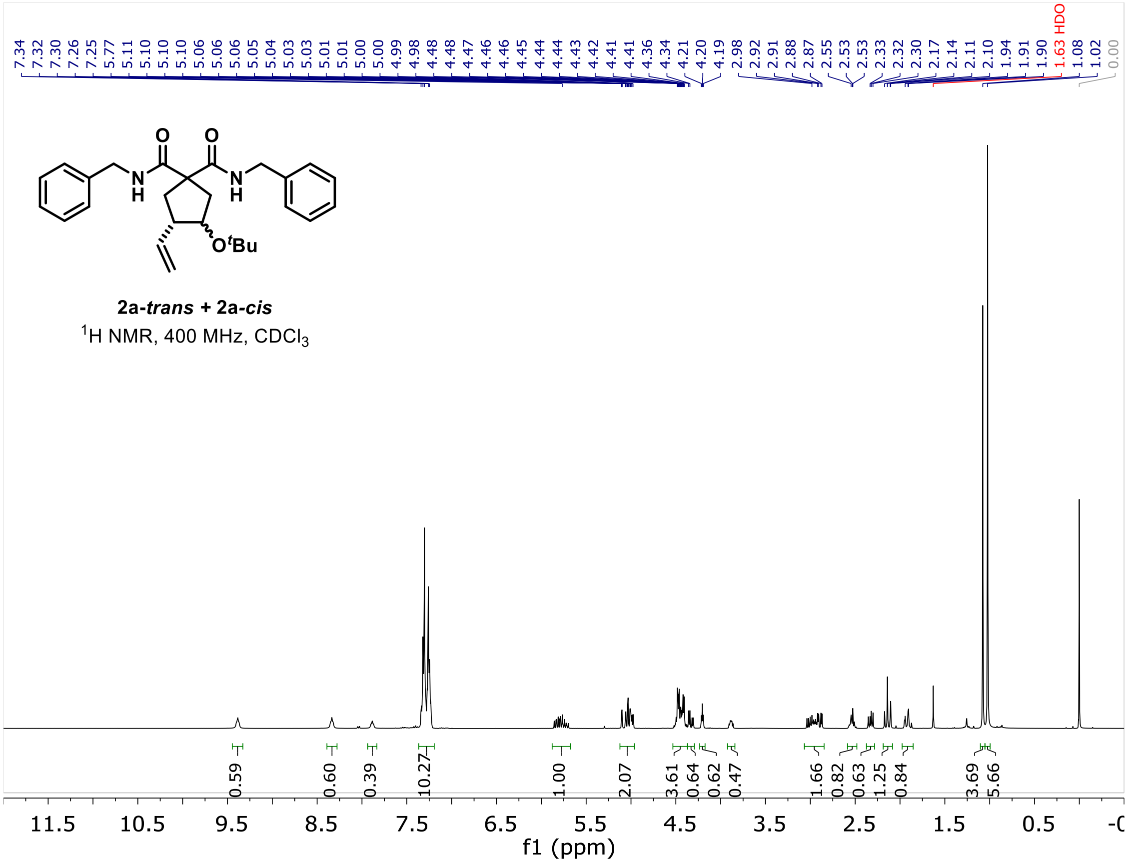


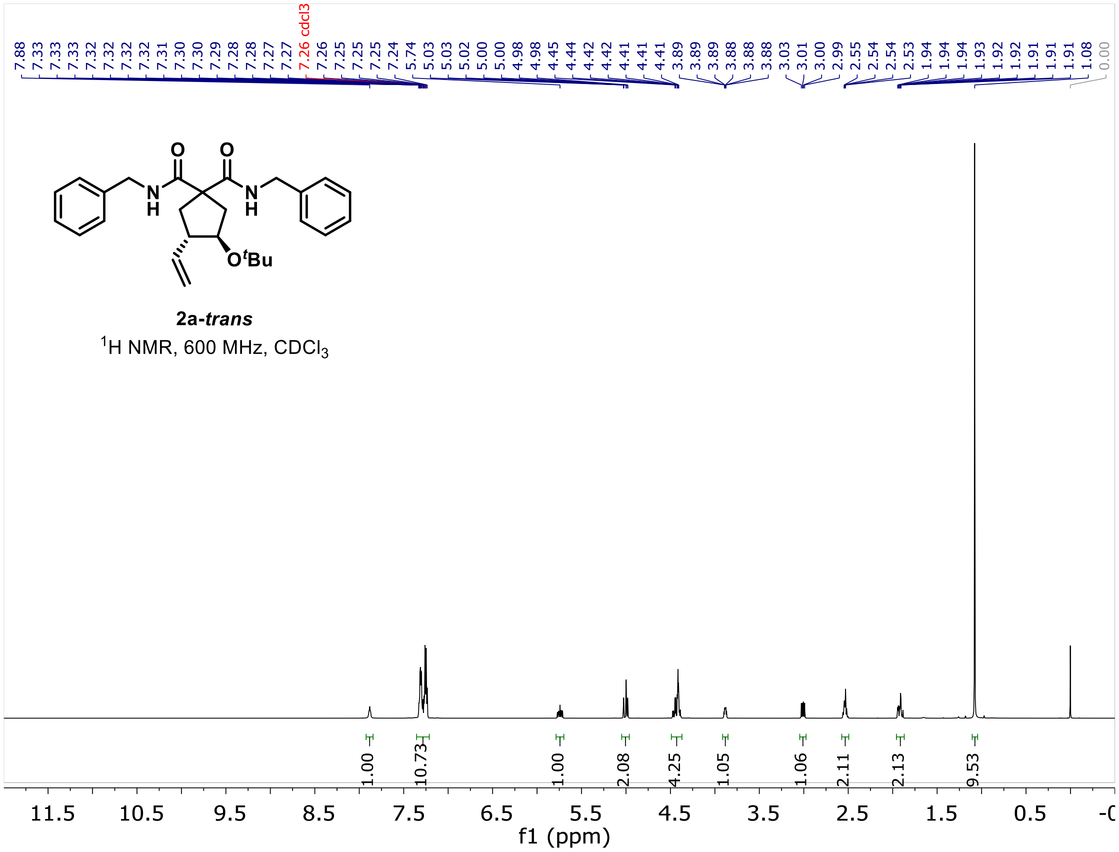
1h

^{13}C NMR, 151 MHz, acetone-d_6


-0.00
-63.53
-63.54
CF3
CF3
O
O
F3C
N
H
N
H
CF3
1h
19F NMR, 376 MHz, CDCl3
6.00
6.18
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
-55
-60
-65
-70
-75
f1 (ppm)

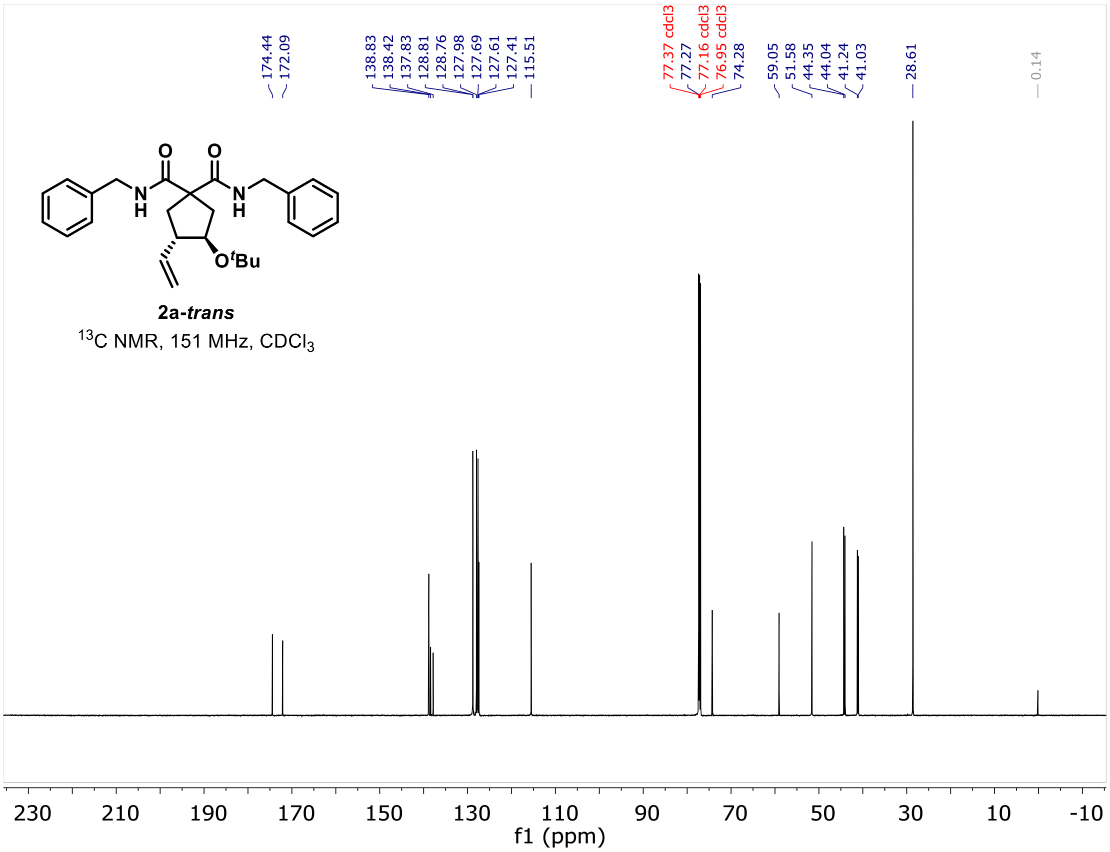
D. NMR Spectra for cycloaddition products 2a-10





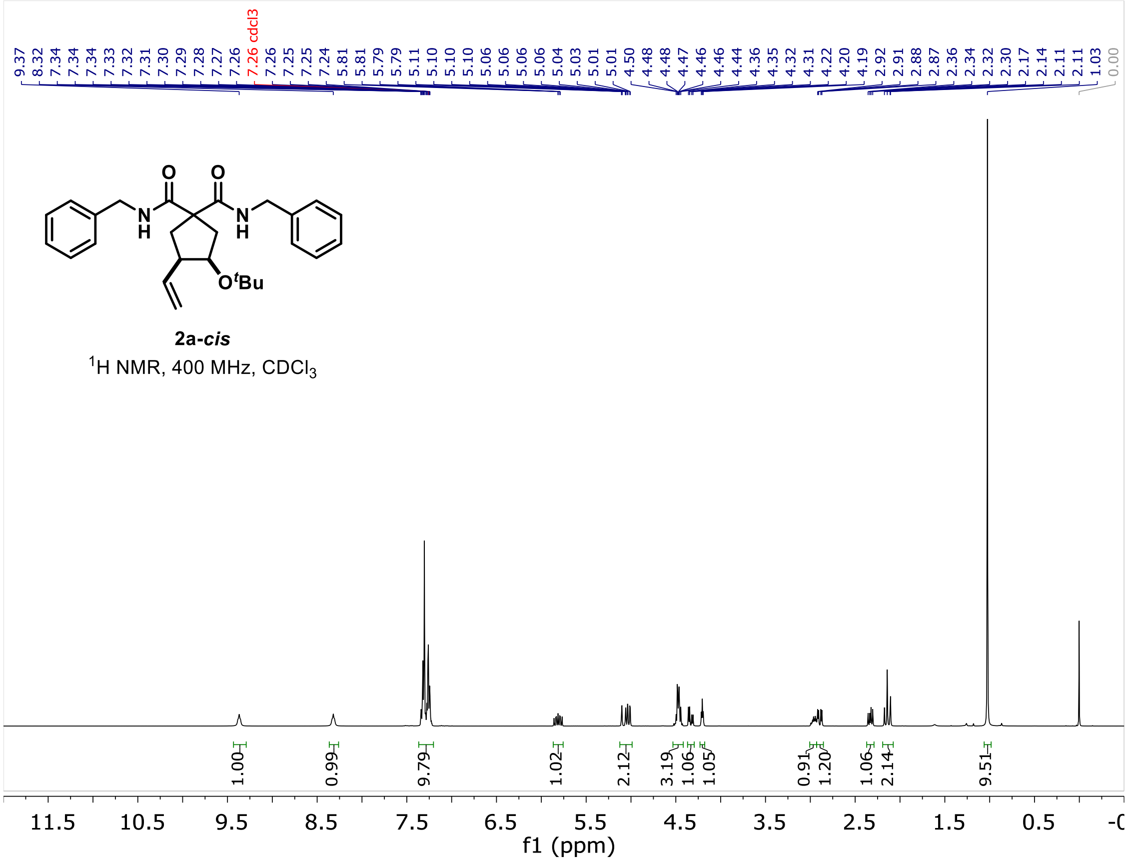
2a-*trans*

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



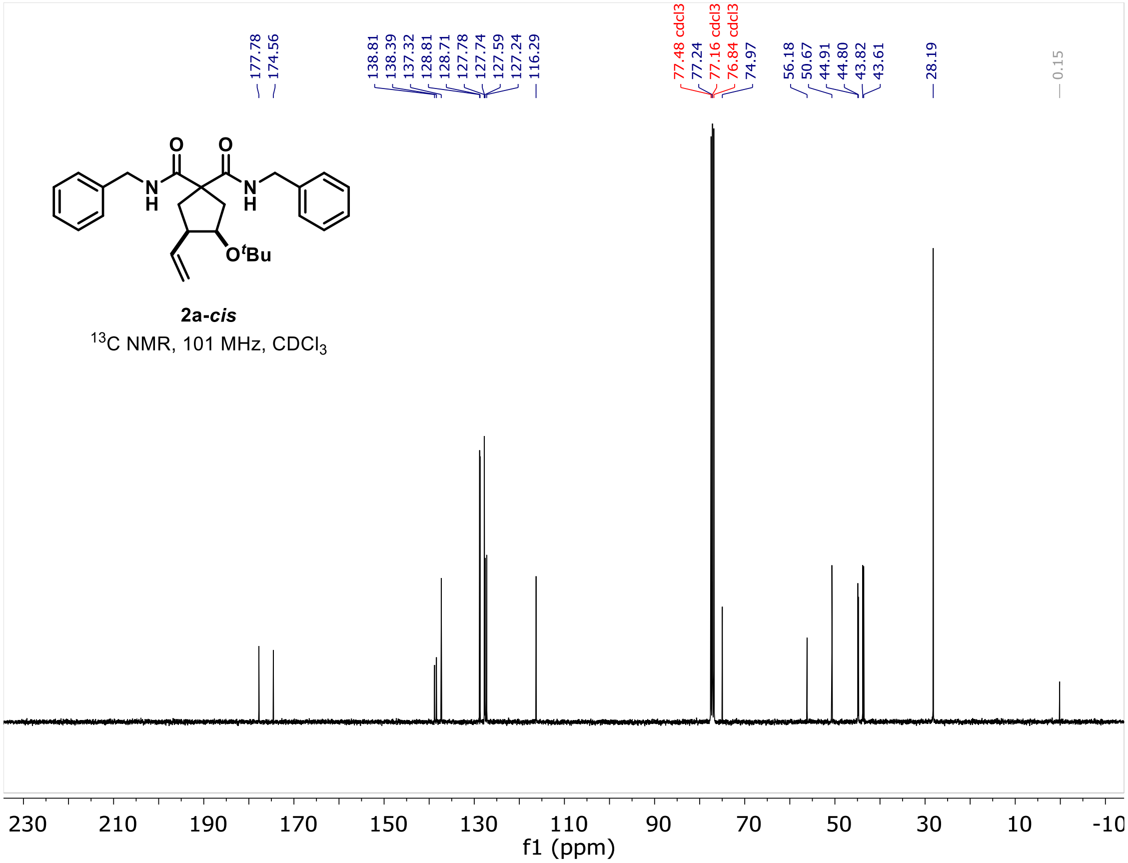
2a-*trans*

^{13}C NMR, 151 MHz, $CDCl_3$



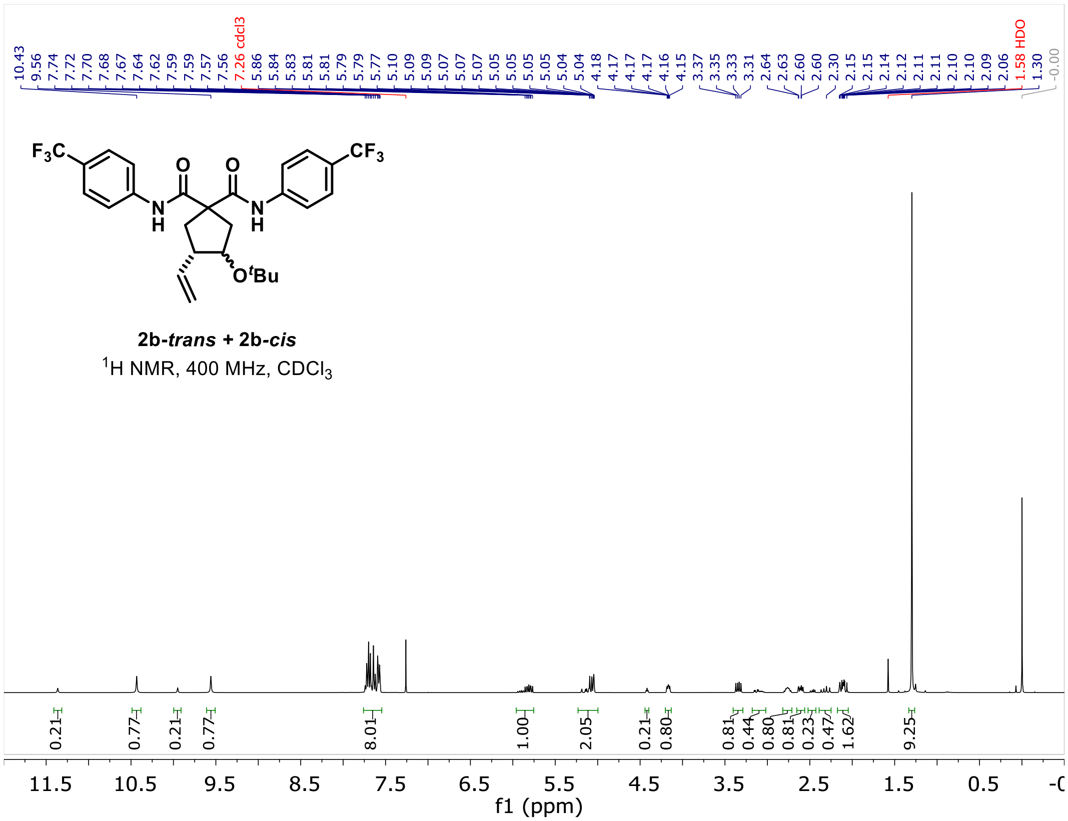
2a-*cis*

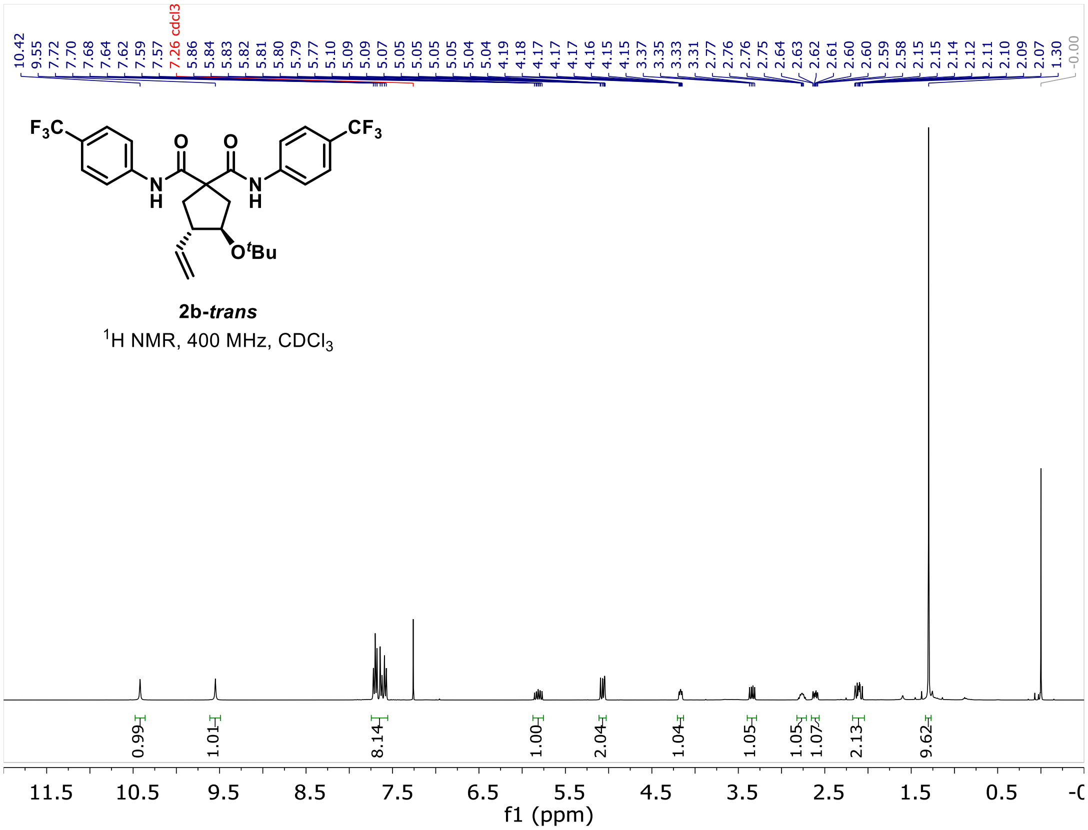
^{1}H NMR, 400 MHz, CDCl$_3$

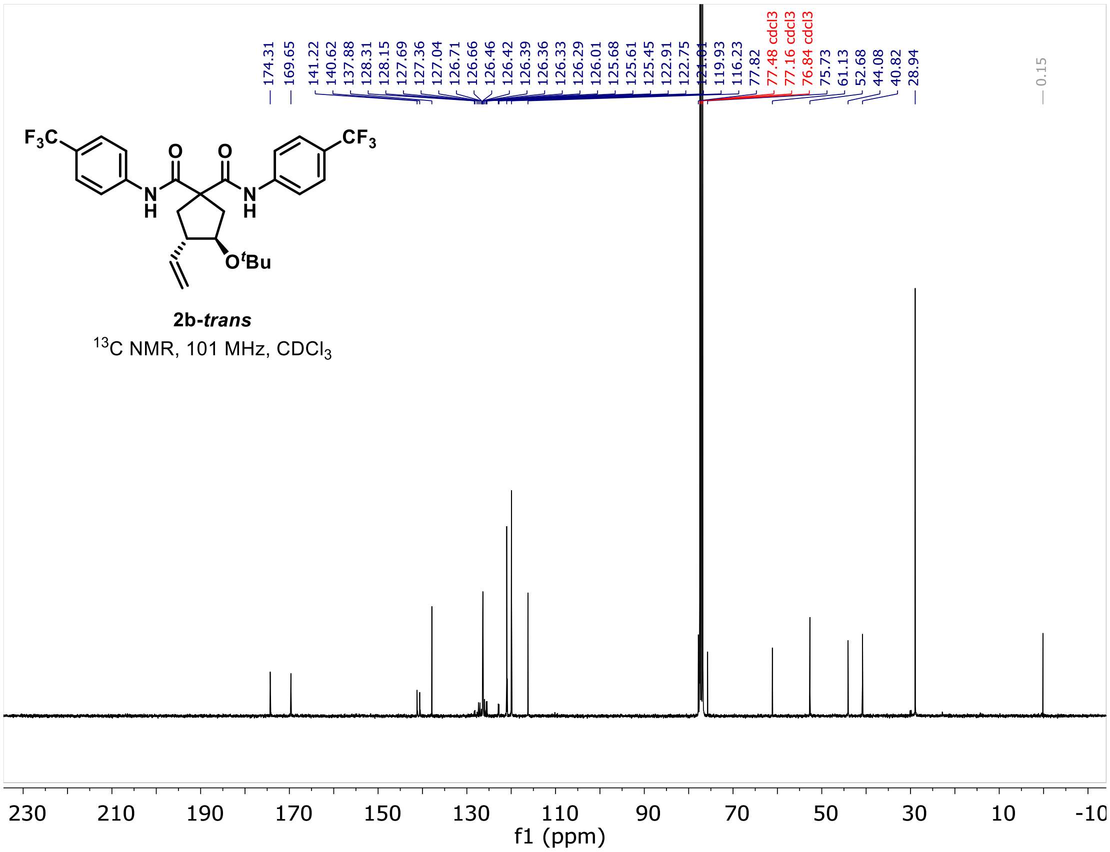


2a-*cis*

^{13}C NMR, 101 MHz, CDCl$_3$

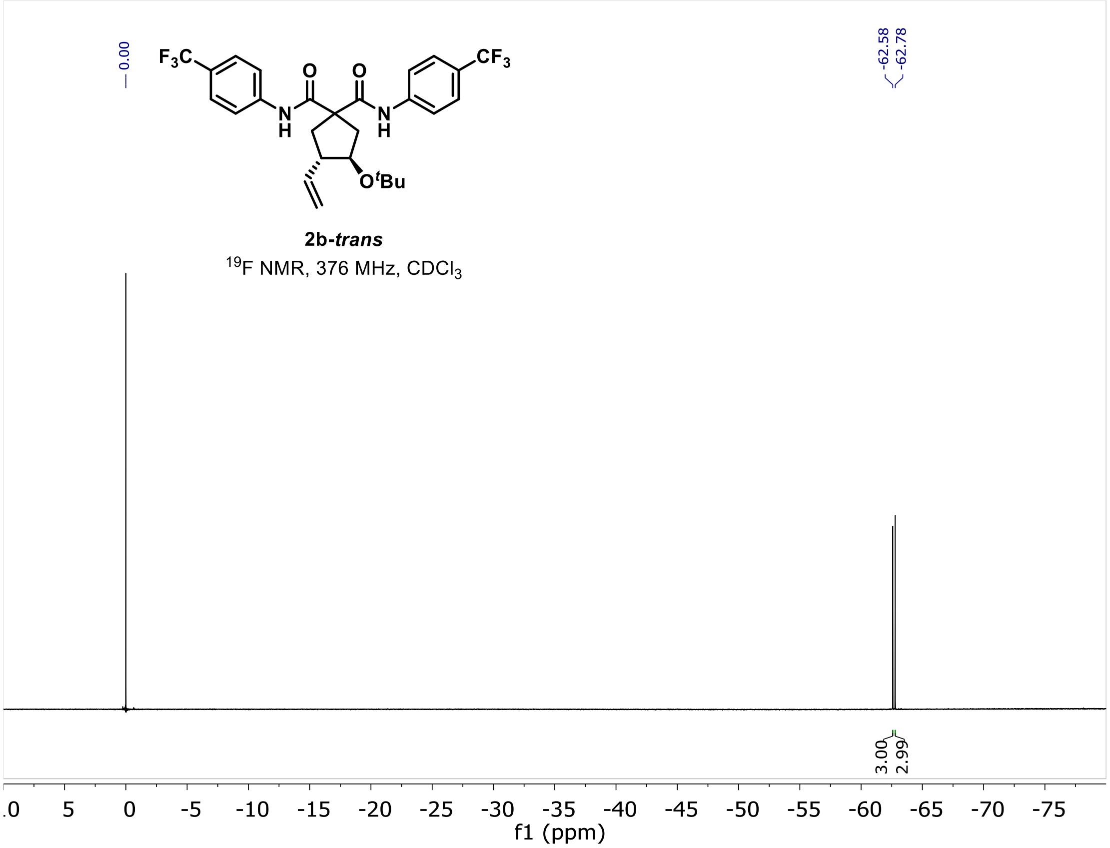

10.43
9.56
7.74
7.72
7.70
7.68
7.67
7.64
7.62
7.59
7.59
7.57
7.56
7.26 cdcl3
5.86
5.84
5.83
5.81
5.81
5.79
5.79
5.77
5.10
5.09
5.09
5.07
5.07
5.07
5.05
5.05
5.05
5.05
5.04
5.04
4.18
4.17
4.17
4.17
4.16
4.15
3.37
3.35
3.33
3.31
2.64
2.63
2.60
2.60
2.30
2.15
2.15
2.14
2.12
2.11
2.11
2.10
2.10
2.09
2.06
1.58 HDO
1.30
-0.00
F3C
CF3
O
O
N
H
N
H
O^tBu
2b-*trans* + 2b-*cis*
1H NMR, 400 MHz, CDCl3
0.21
0.77
0.21
0.77
8.01
1.00
2.05
0.21
0.80
0.81
0.44
0.80
0.81
0.23
0.47
1.62
9.25
11.5
10.5
9.5
8.5
7.5
6.5
5.5
4.5
3.5
2.5
1.5
0.5
f1 (ppm)


10.42
9.55
7.72
7.70
7.68
7.64
7.62
7.59
7.57
7.26 cdcl3
5.86
5.84
5.83
5.82
5.81
5.80
5.79
5.77
5.10
5.09
5.09
5.07
5.05
5.05
5.05
5.04
5.04
4.19
4.18
4.17
4.17
4.16
4.15
4.15
3.37
3.35
3.33
3.31
2.77
2.76
2.75
2.64
2.63
2.62
2.61
2.60
2.60
2.59
2.58
2.15
2.15
2.14
2.12
2.11
2.10
2.09
2.07
1.30
-0.00
F3C
CF3
O
O
N
H
N
H
O^tBu
2b-*trans*
1H NMR, 400 MHz, CDCl3
0.99
1.01
8.14
1.00
2.04
1.04
1.05
1.05
1.07
2.13
9.62
11.5
10.5
9.5
8.5
7.5
6.5
5.5
4.5
3.5
2.5
1.5
0.5
f1 (ppm)



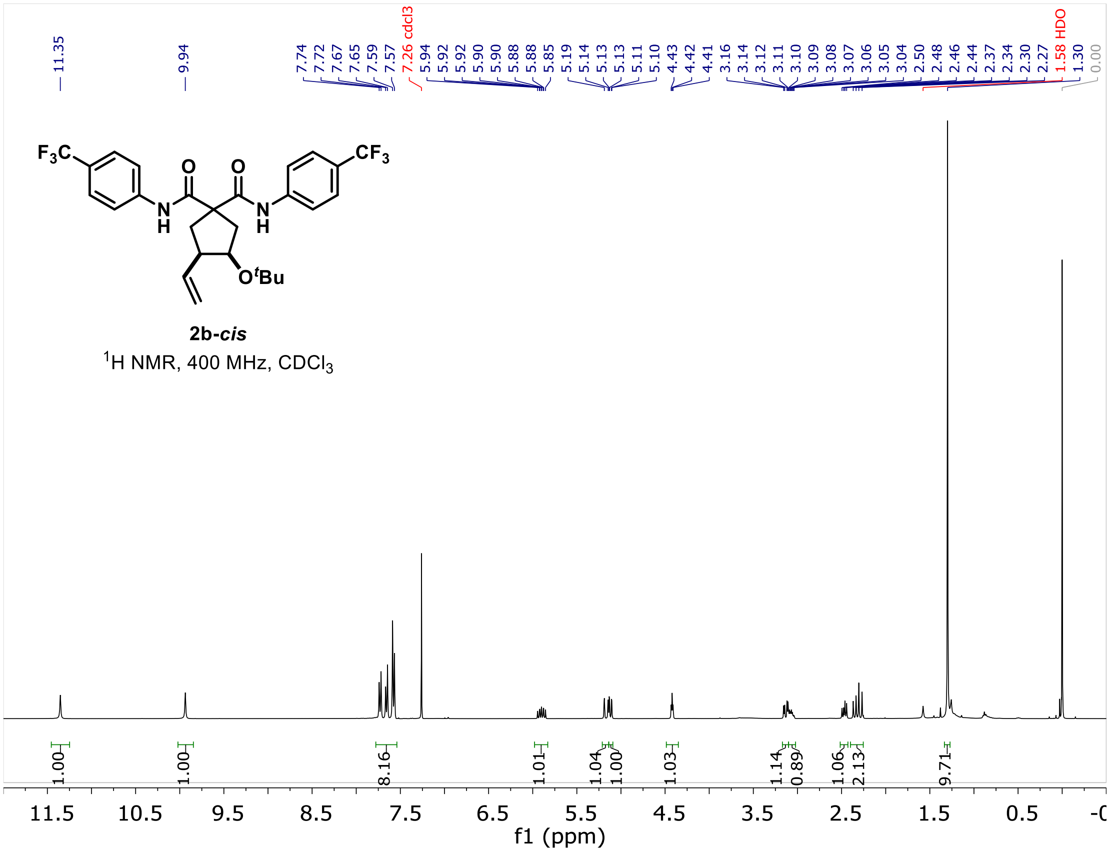
2b-*trans*

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



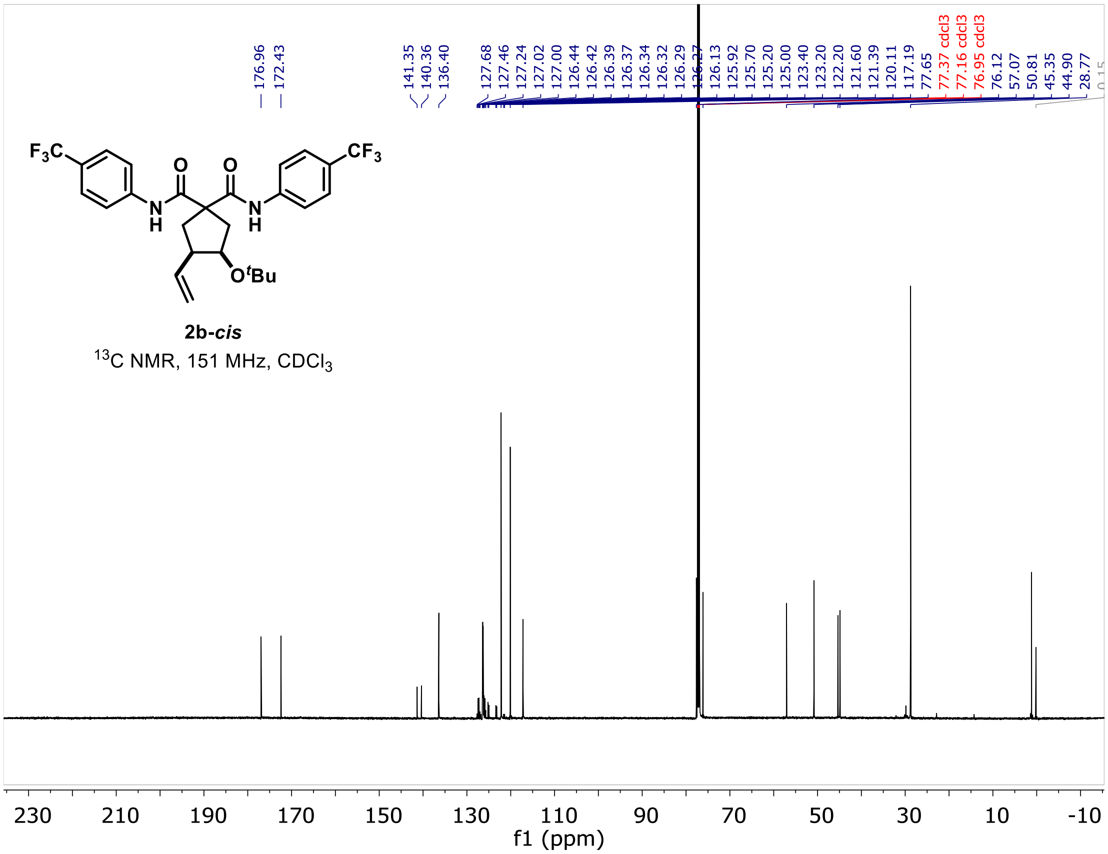
2b-*trans*

^{19}F NMR, 376 MHz, $CDCl_3$



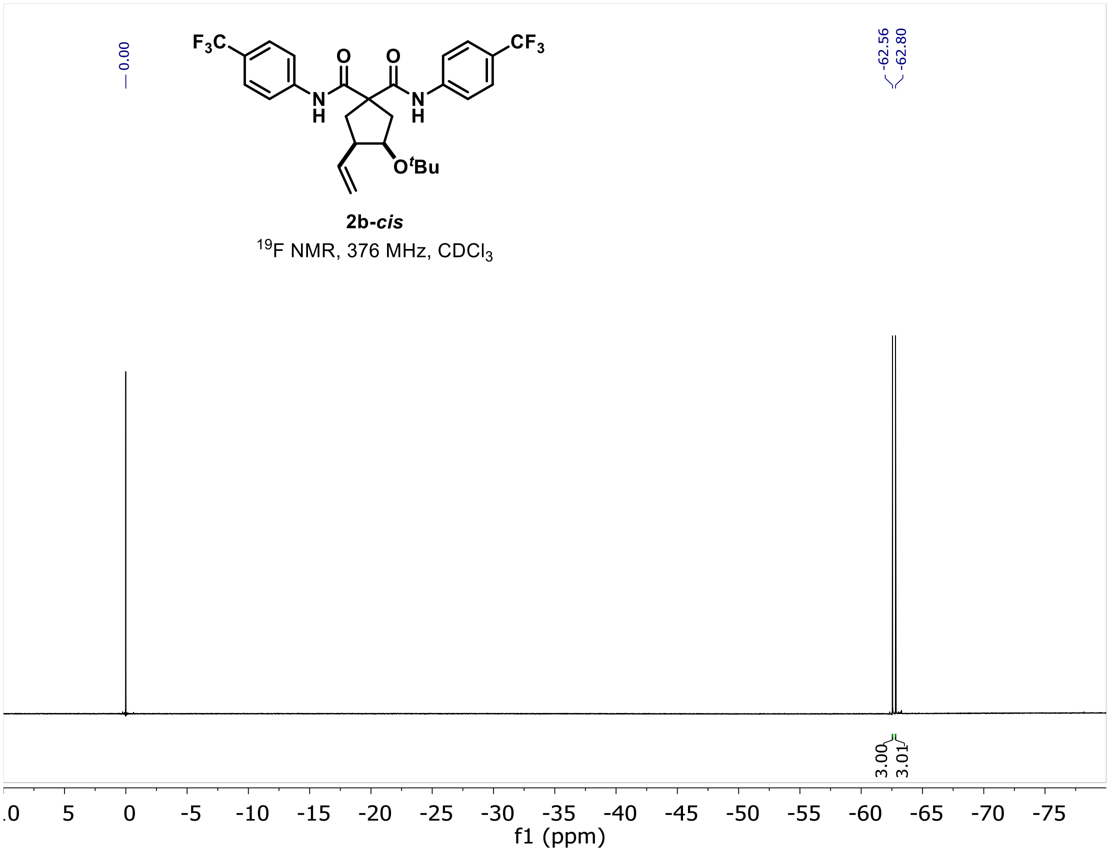
2b-*cis*

^{1}H NMR, 400 MHz, CDCl$_3$



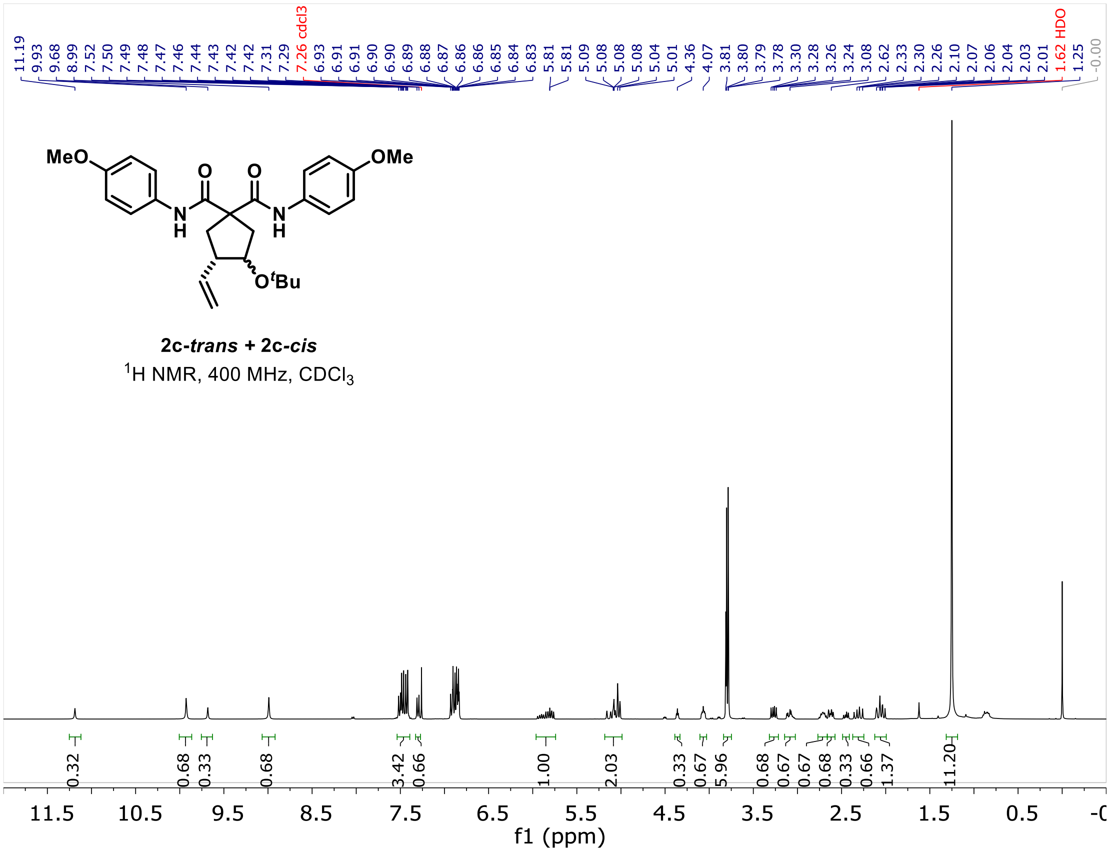
2b-*cis*

^{13}C NMR, 151 MHz, CDCl$_3$



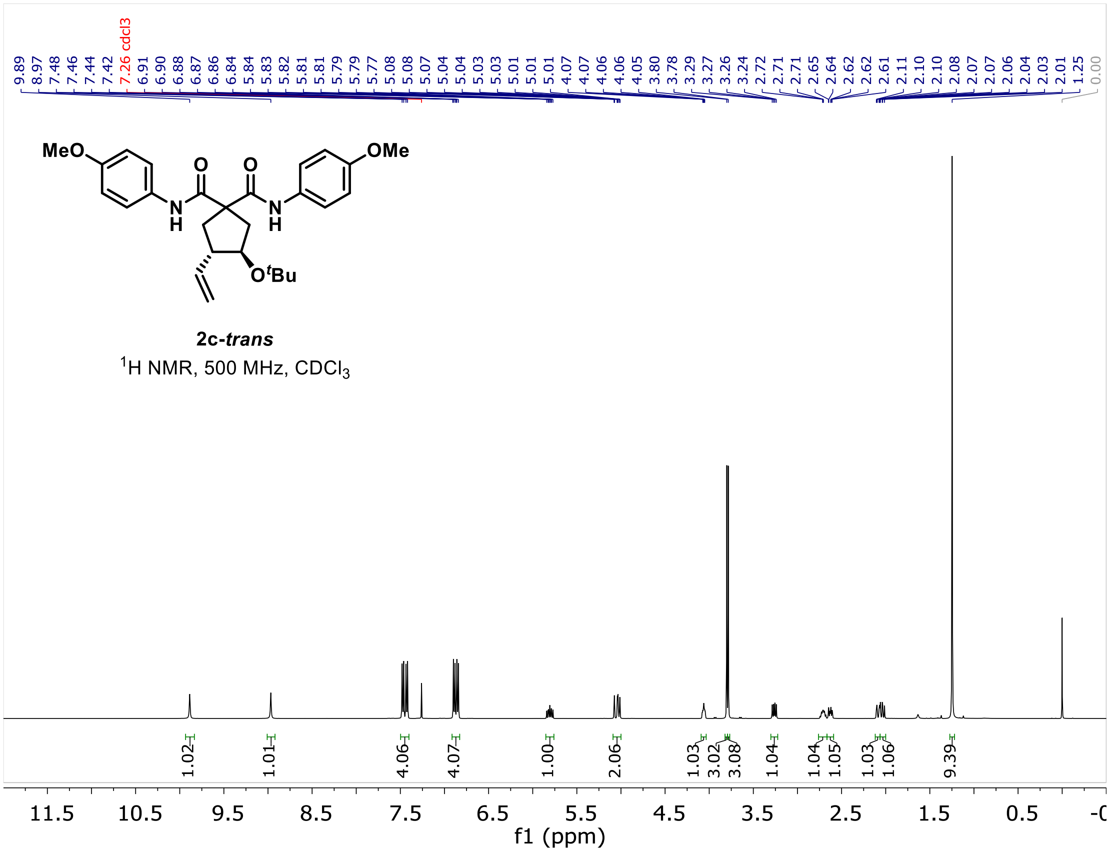
2b-*cis*

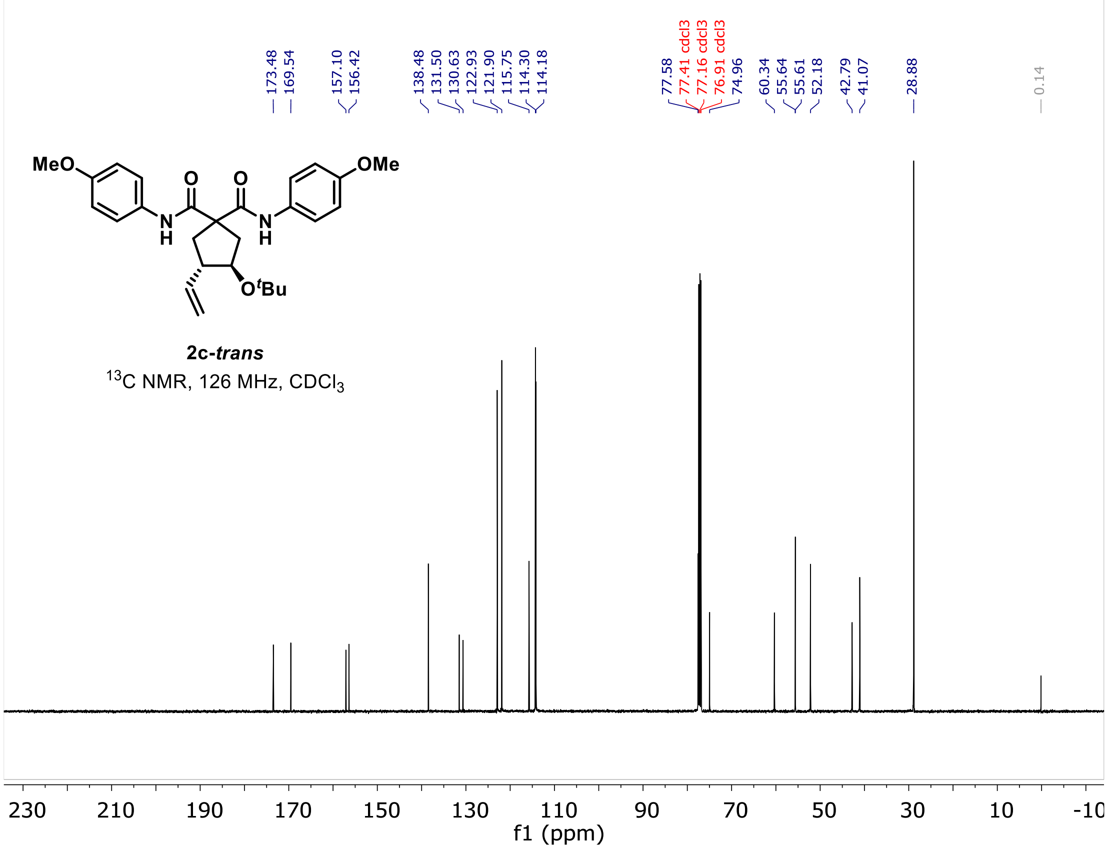
^{19}F NMR, 376 MHz, $CDCl_3$

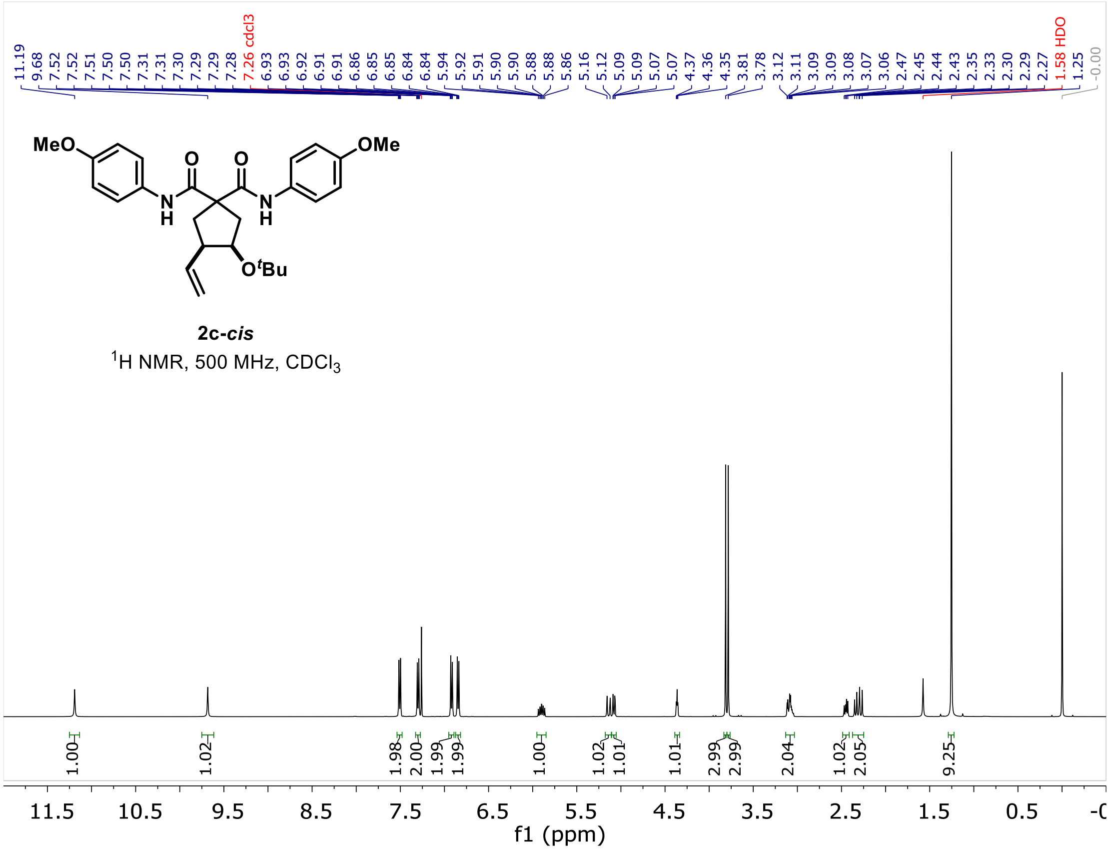


2c-*trans* + 2c-*cis*

^{1}H NMR, 400 MHz, CDCl$_3$

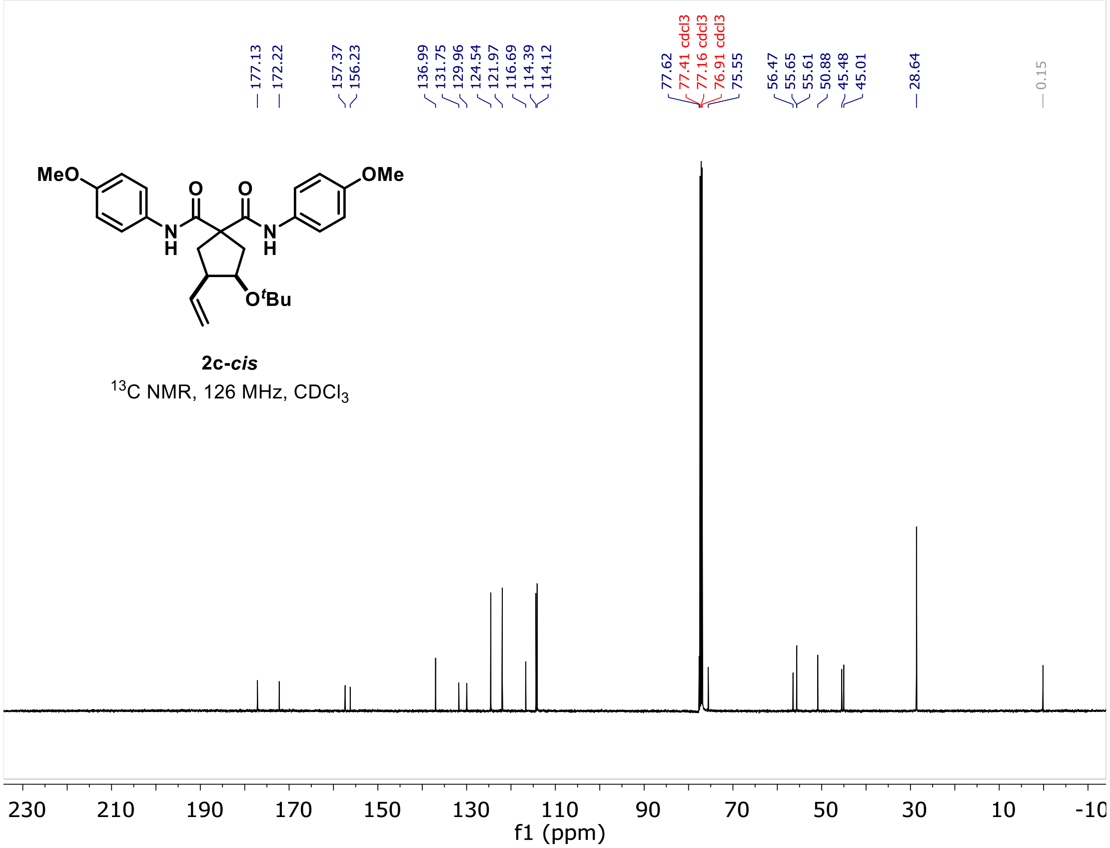

9.89
8.97
7.48
7.46
7.44
7.42
7.26 cdcl3
6.91
6.90
6.88
6.87
6.86
6.84
5.84
5.83
5.82
5.81
5.81
5.79
5.79
5.77
5.08
5.08
5.07
5.04
5.04
5.03
5.03
5.01
5.01
5.01
4.07
4.07
4.06
4.06
4.05
3.80
3.78
3.29
3.27
3.26
3.24
2.72
2.71
2.71
2.65
2.64
2.62
2.62
2.61
2.11
2.10
2.10
2.08
2.07
2.07
2.06
2.04
2.03
2.01
1.25
0.00
MeO
OMe
O
O
N
H
N
H
O^tBu
2c-trans
¹H NMR, 500 MHz, CDCl3
1.02
1.01
4.06
4.07
1.00
2.06
1.03
3.02
3.08
1.04
1.04
1.05
1.03
1.06
9.39
11.5
10.5
9.5
8.5
7.5
6.5
5.5
4.5
3.5
2.5
1.5
0.5
-0
f1 (ppm)


173.48
169.54
157.10
156.42
138.48
131.50
130.63
122.93
121.90
115.75
114.30
114.18
77.58
77.41 cdcl3
77.16 cdcl3
76.91 cdcl3
74.96
60.34
55.64
55.61
52.18
42.79
41.07
28.88
0.14
MeO
OMe
O
O
N
H
N
H
O^tBu
2c-trans
¹³C NMR, 126 MHz, CDCl3
230
210
190
170
150
130
110
90
70
50
30
10
-10
f1 (ppm)



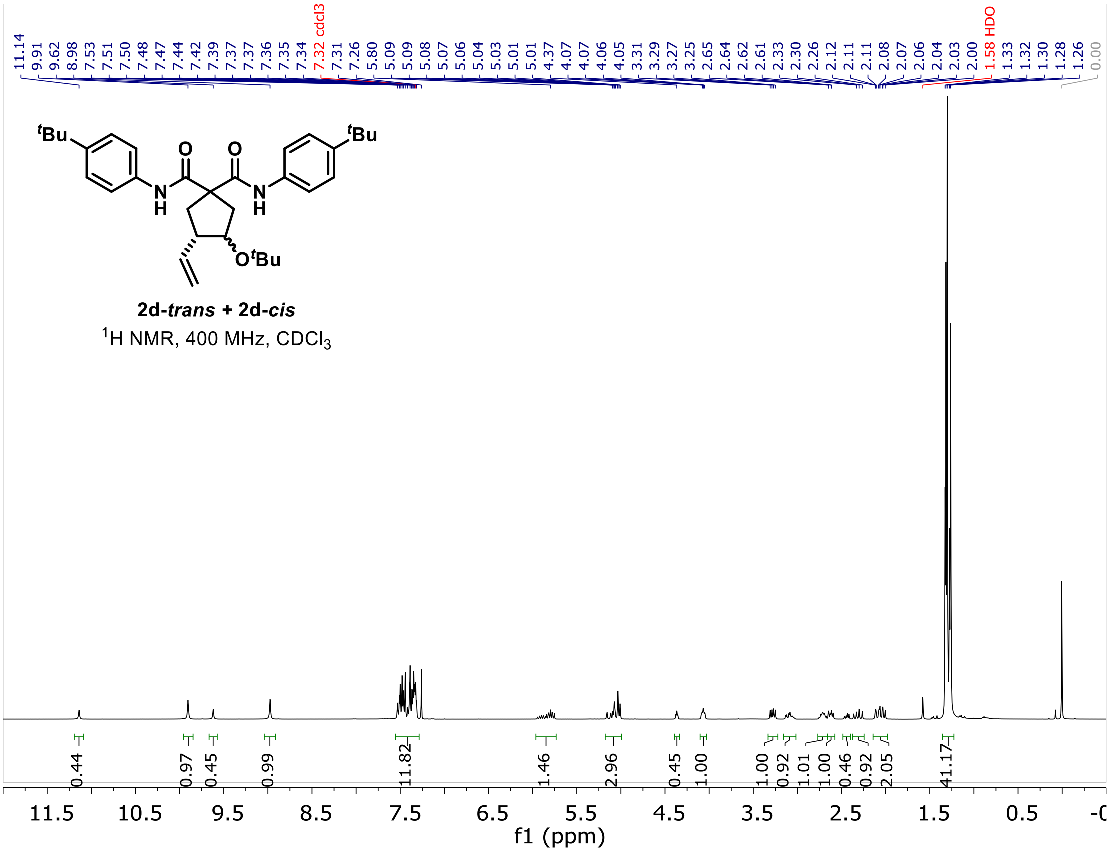
2c-*cis*

^{1}H NMR, 500 MHz, $CDCl_3$



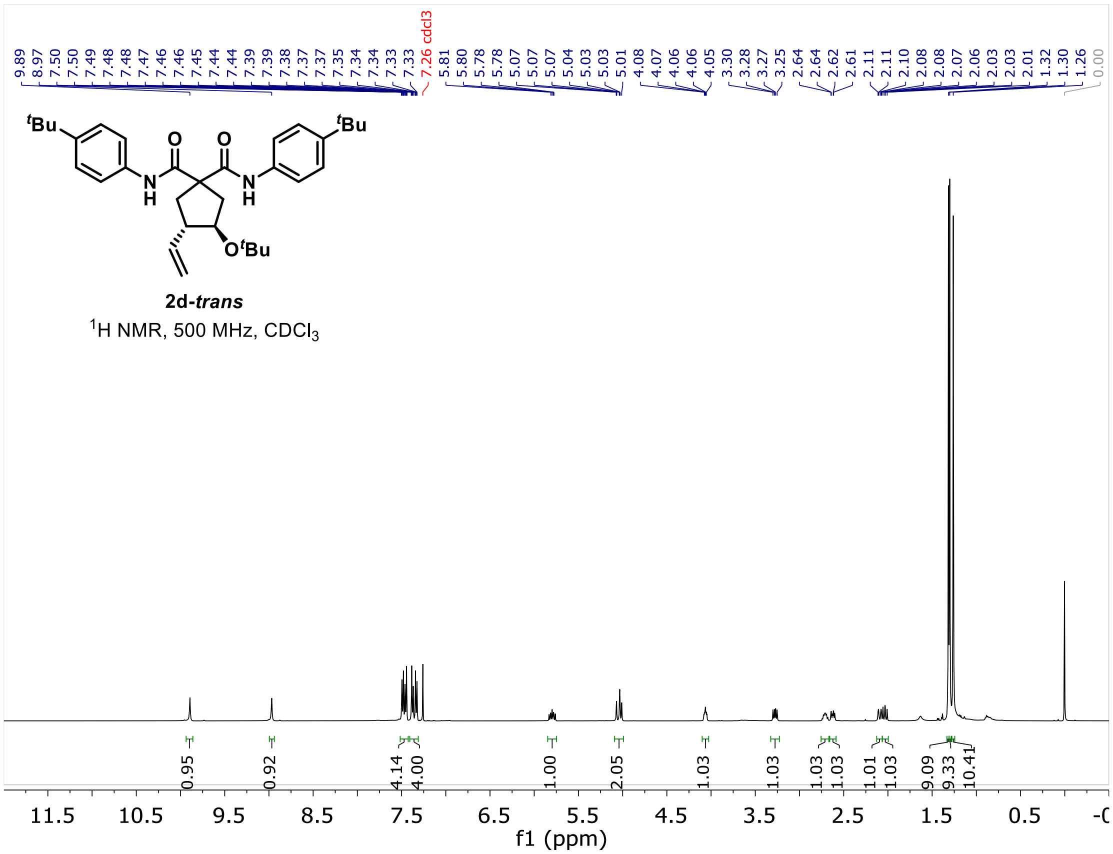
2c-*cis*

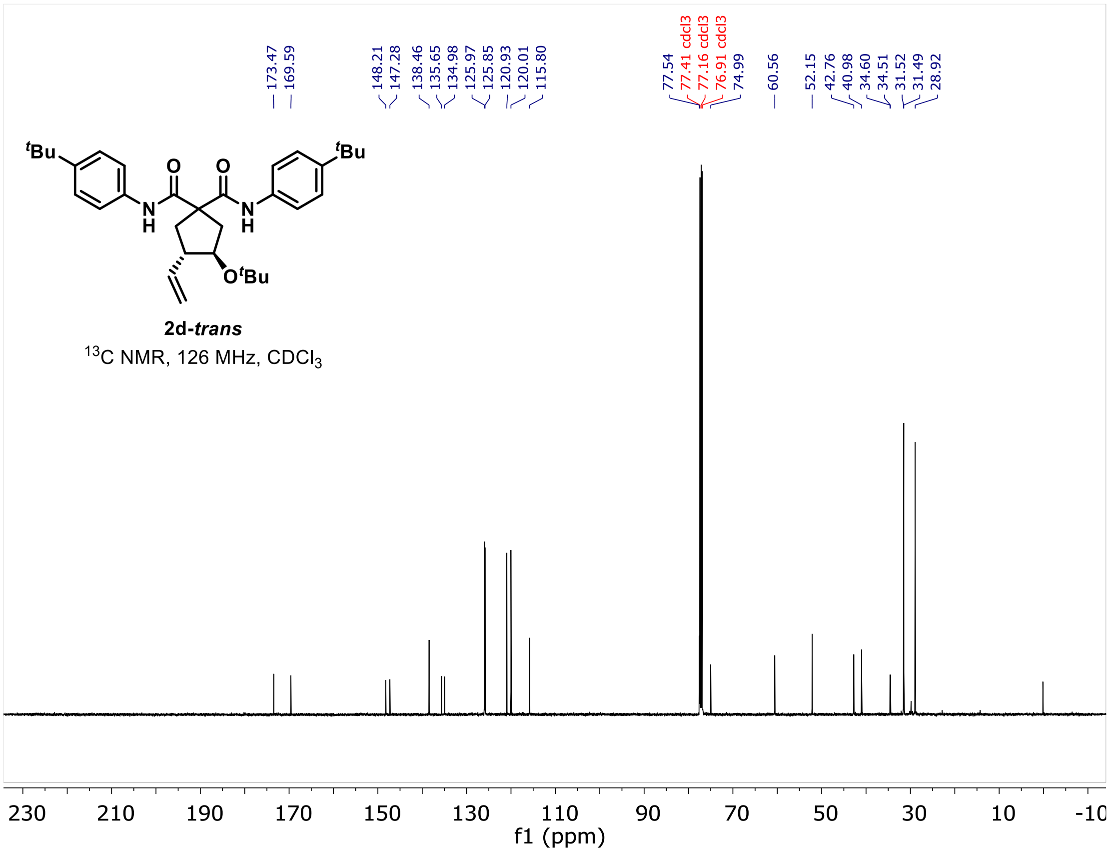
^{13}C NMR, 126 MHz, $CDCl_3$

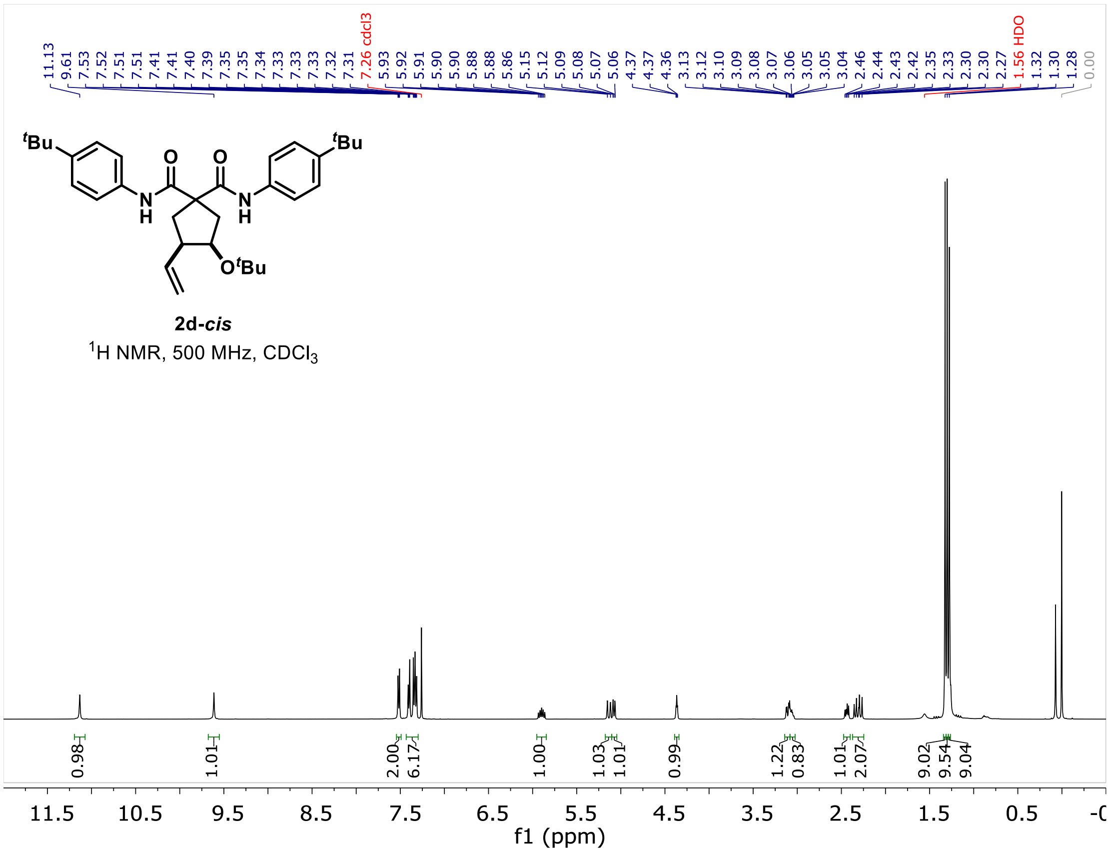


2d-*trans* + 2d-*cis*

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

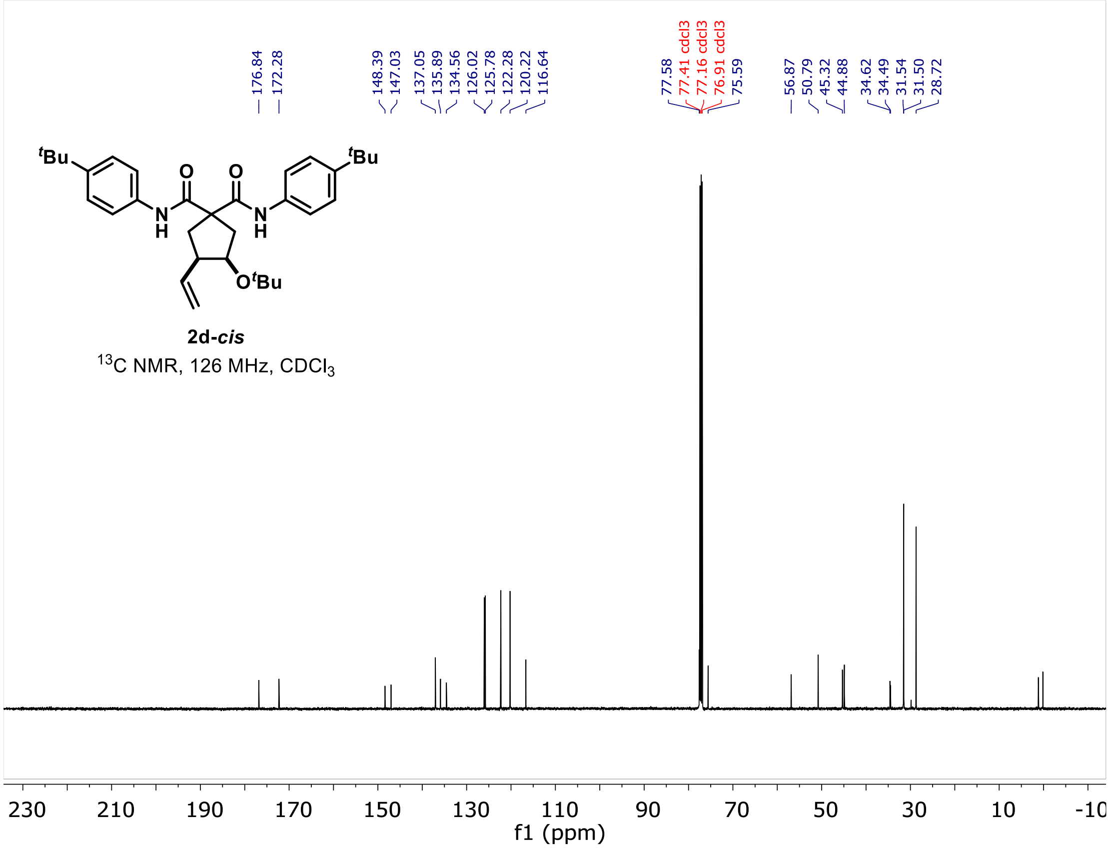

9.89
8.97
7.50
7.50
7.49
7.48
7.48
7.47
7.46
7.46
7.45
7.44
7.44
7.39
7.39
7.38
7.37
7.37
7.35
7.34
7.34
7.33
7.33
7.26 cdcl3
5.81
5.80
5.78
5.78
5.07
5.07
5.04
5.03
5.03
5.01
4.08
4.07
4.06
4.06
4.05
3.30
3.28
3.27
3.25
2.64
2.64
2.62
2.61
2.11
2.11
2.10
2.08
2.08
2.07
2.06
2.03
2.03
2.01
1.32
1.30
1.26
0.00
^{t}Bu
O
O
^{t}Bu
N
H
N
H
O^{t}Bu
2d-*trans*
^{1}H NMR, 500 MHz, CDCl$_3$
0.95
0.92
4.14
4.00
1.00
2.05
1.03
1.03
1.03
1.03
1.01
1.03
9.09
9.33
10.41
11.5
10.5
9.5
8.5
7.5
6.5
5.5
4.5
3.5
2.5
1.5
0.5
f1 (ppm)


173.47
169.59
148.21
147.28
138.46
135.65
134.98
125.97
125.85
120.93
120.01
115.80
77.54
77.41 cdcl3
77.16 cdcl3
76.91 cdcl3
74.99
60.56
52.15
42.76
40.98
34.60
34.51
31.52
31.49
28.92
^{t}Bu
O
O
^{t}Bu
N
H
N
H
O^{t}Bu
2d-*trans*
^{13}C NMR, 126 MHz, CDCl$_3$
230
210
190
170
150
130
110
90
70
50
30
10
-10
f1 (ppm)



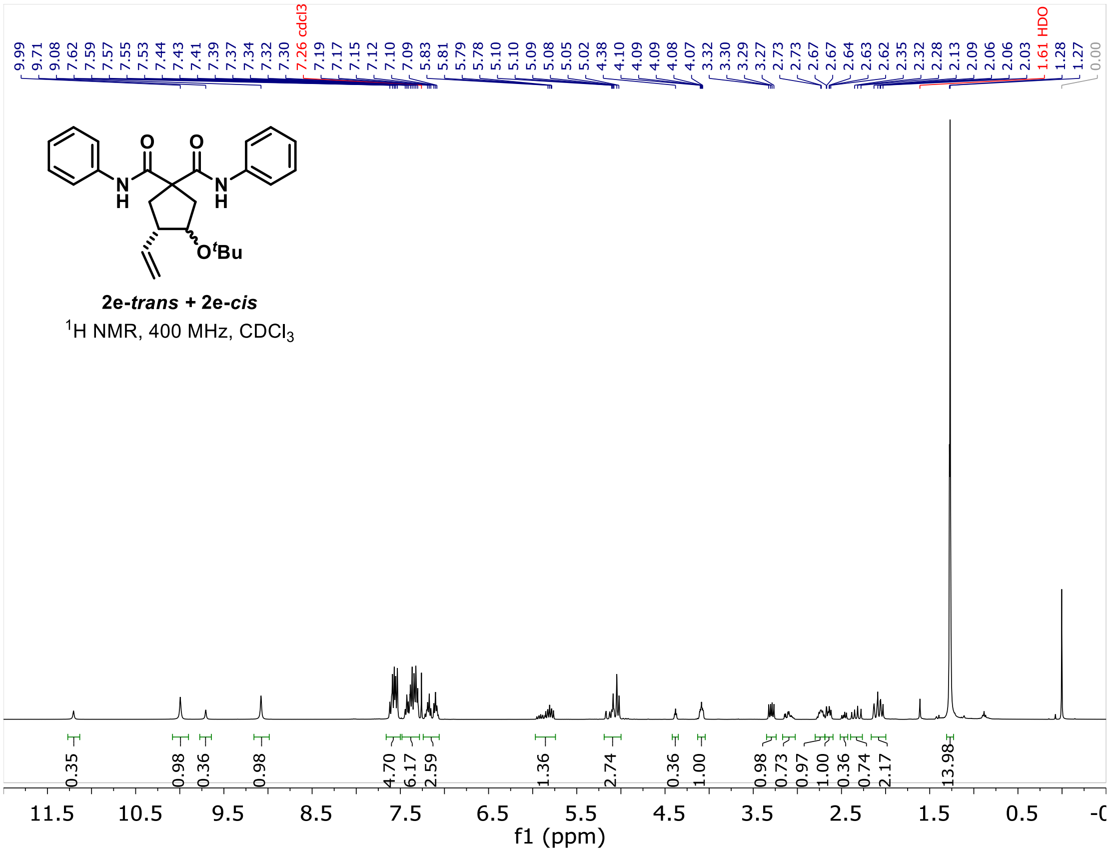
2d-*cis*

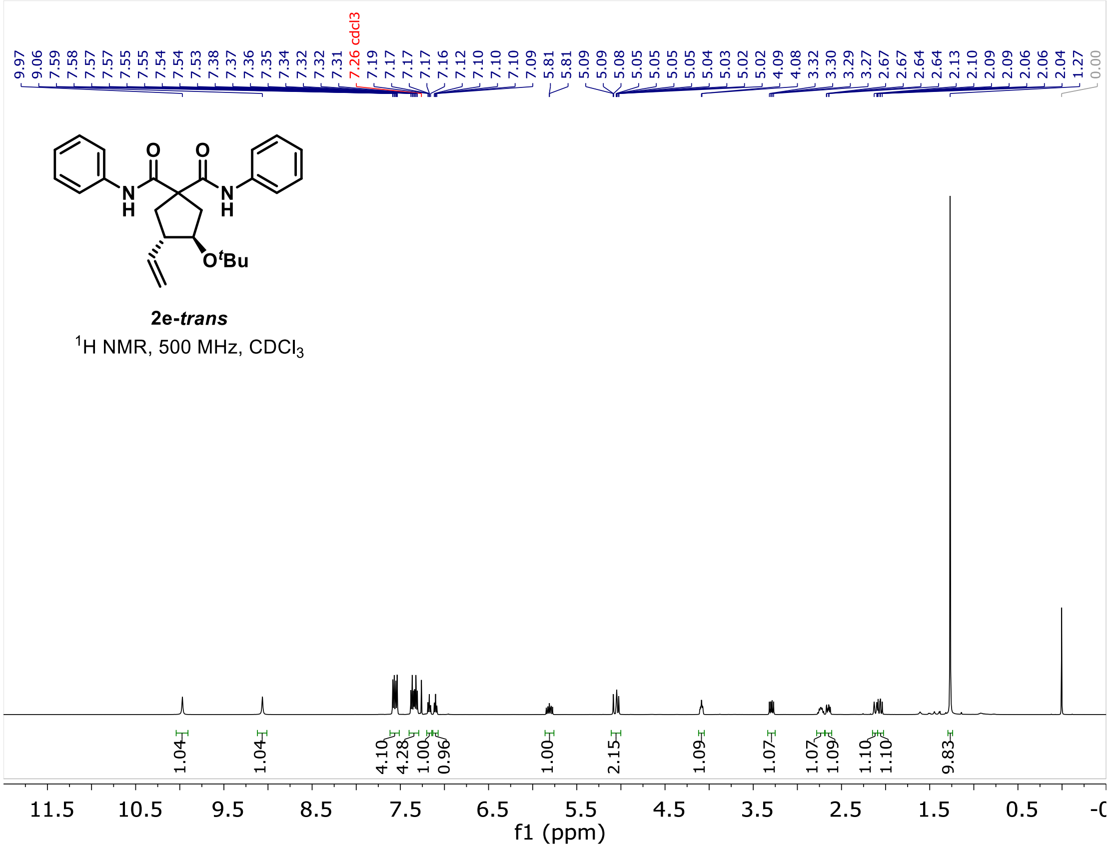
^{1}H NMR, 500 MHz, $CDCl_3$



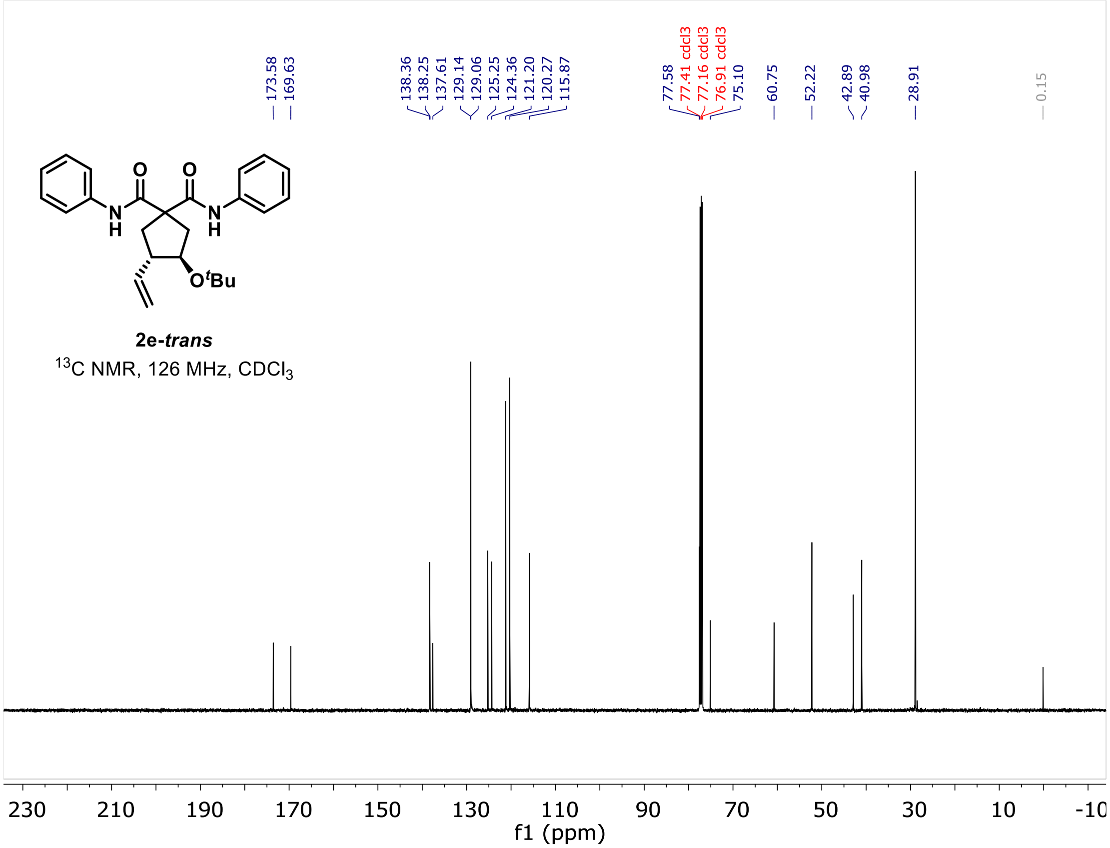
2d-*cis*

^{13}C NMR, 126 MHz, $CDCl_3$

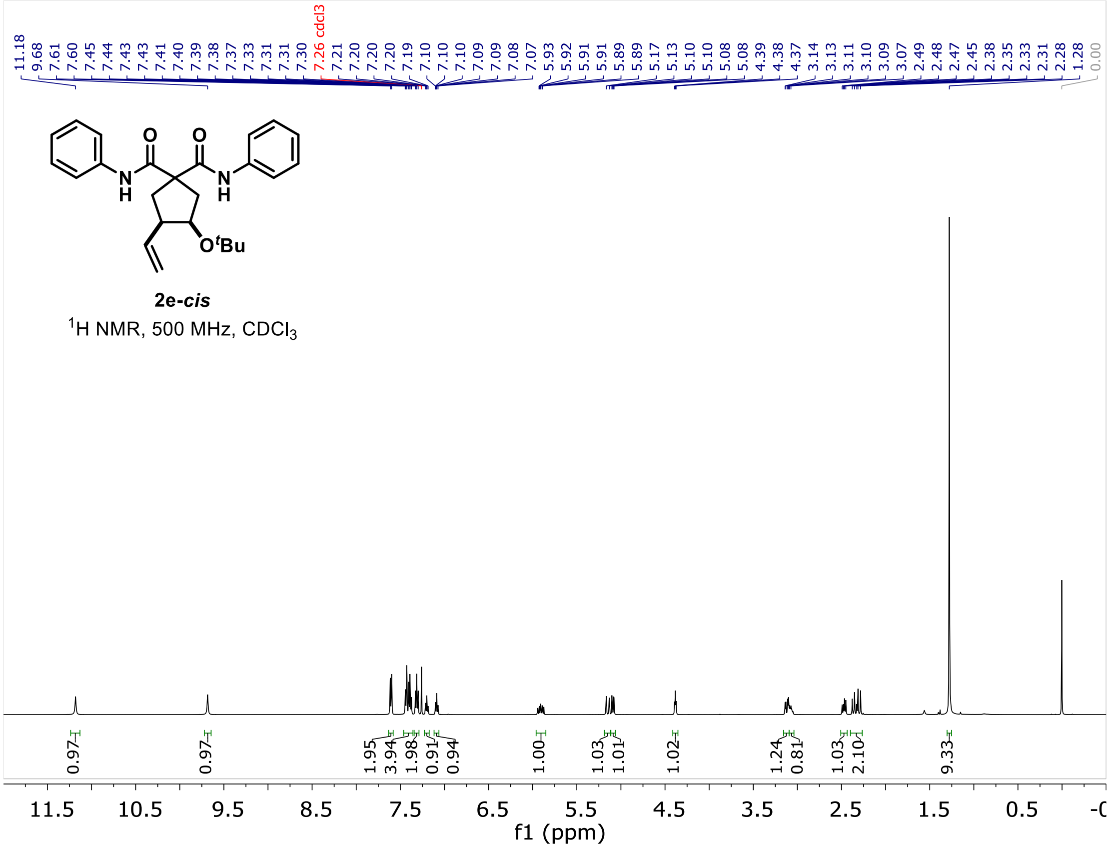

9.99 9.71 9.08 7.62 7.59 7.57 7.55 7.53 7.44 7.43 7.41 7.39 7.37 7.34 7.32 7.30 7.26 cdcl3 7.19 7.17 7.15 7.12 7.10 7.09 5.83 5.81 5.79 5.78 5.10 5.09 5.08 5.05 5.02 4.38 4.10 4.09 4.09 4.08 4.07 3.32 3.30 3.29 3.27 2.73 2.73 2.67 2.67 2.64 2.63 2.62 2.35 2.32 2.28 2.13 2.09 2.06 2.03 1.61 HDO 1.28 1.27 0.00
O
O
N
H
N
H
O^{t}Bu
2e-*trans* + 2e-*cis*
^{1}H NMR, 400 MHz, CDCl$_3$
0.35
0.98
0.36
0.98
4.70
6.17
2.59
1.36
2.74
0.36
1.00
0.98
0.73
0.97
1.00
0.36
0.74
2.17
13.98
11.5
10.5
9.5
8.5
7.5
6.5
5.5
4.5
3.5
2.5
1.5
0.5
-(
f1 (ppm)


2e-*trans*

^{1}H NMR, 500 MHz, $CDCl_3$

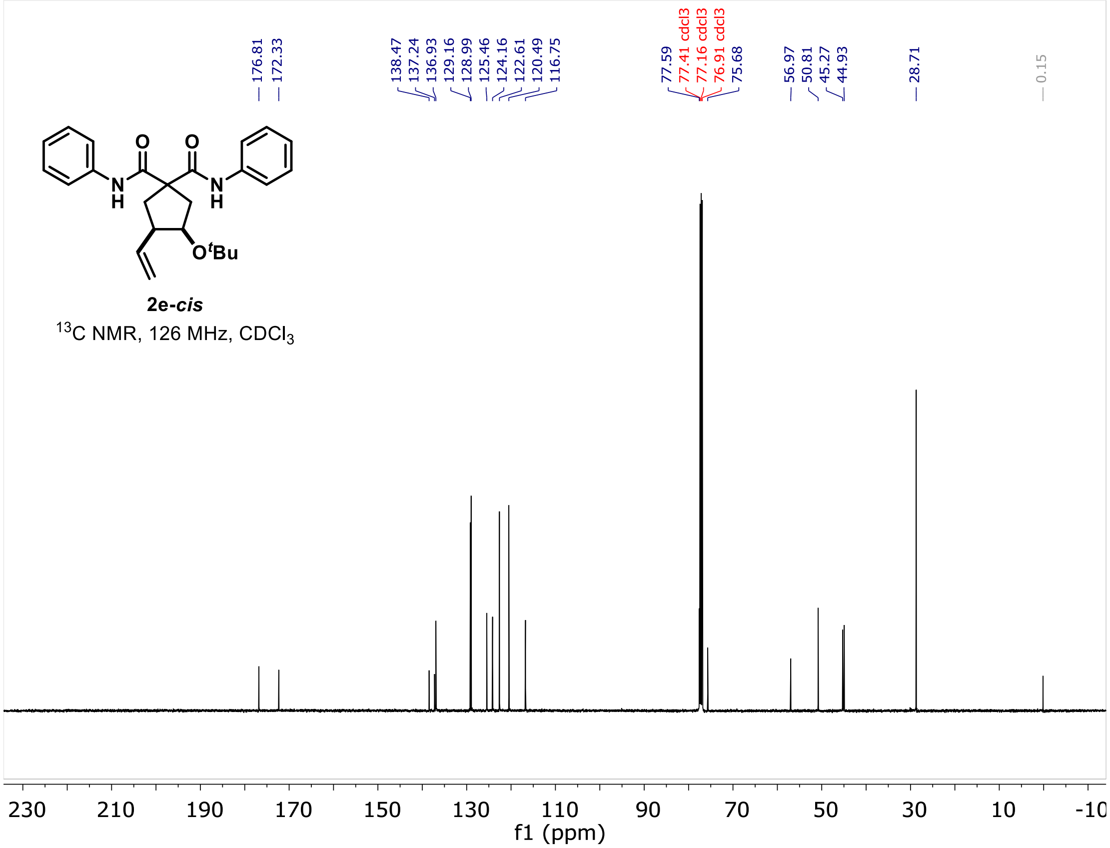

2e-*trans*

^{13}C NMR, 126 MHz, $CDCl_3$



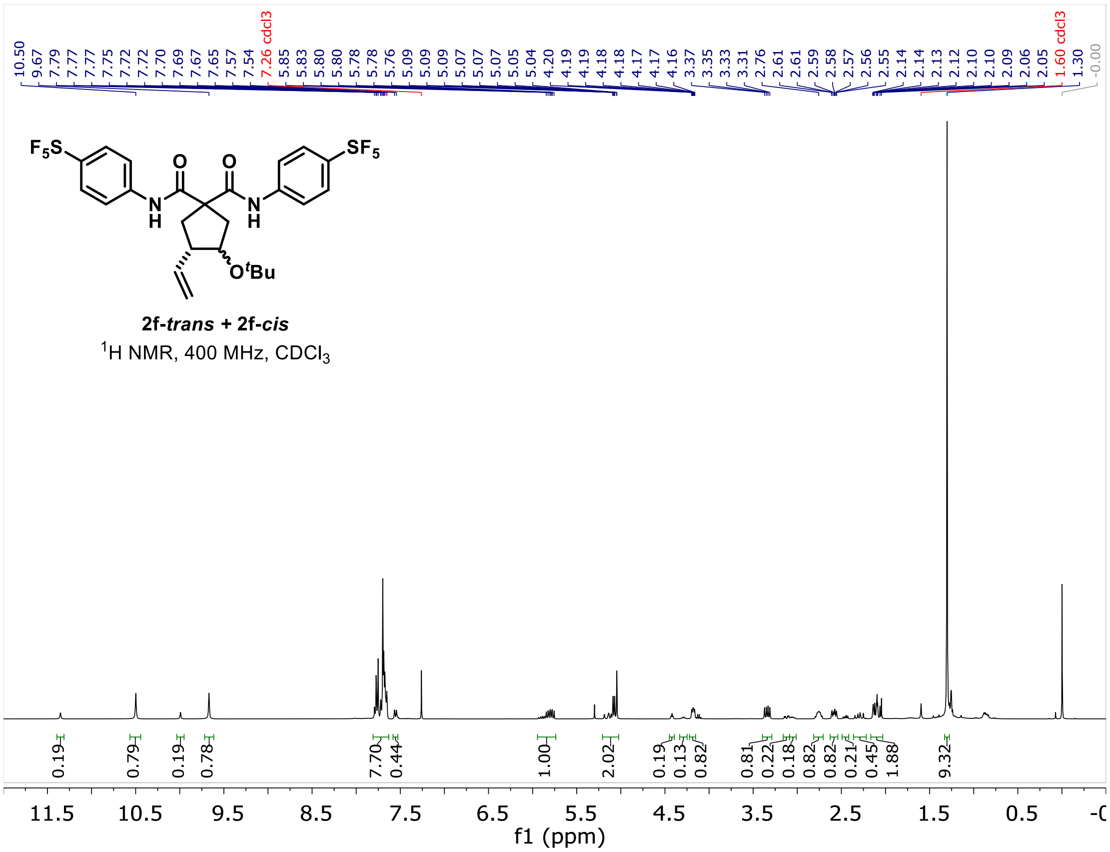
2e-*cis*

^{1}H NMR, 500 MHz, $CDCl_3$

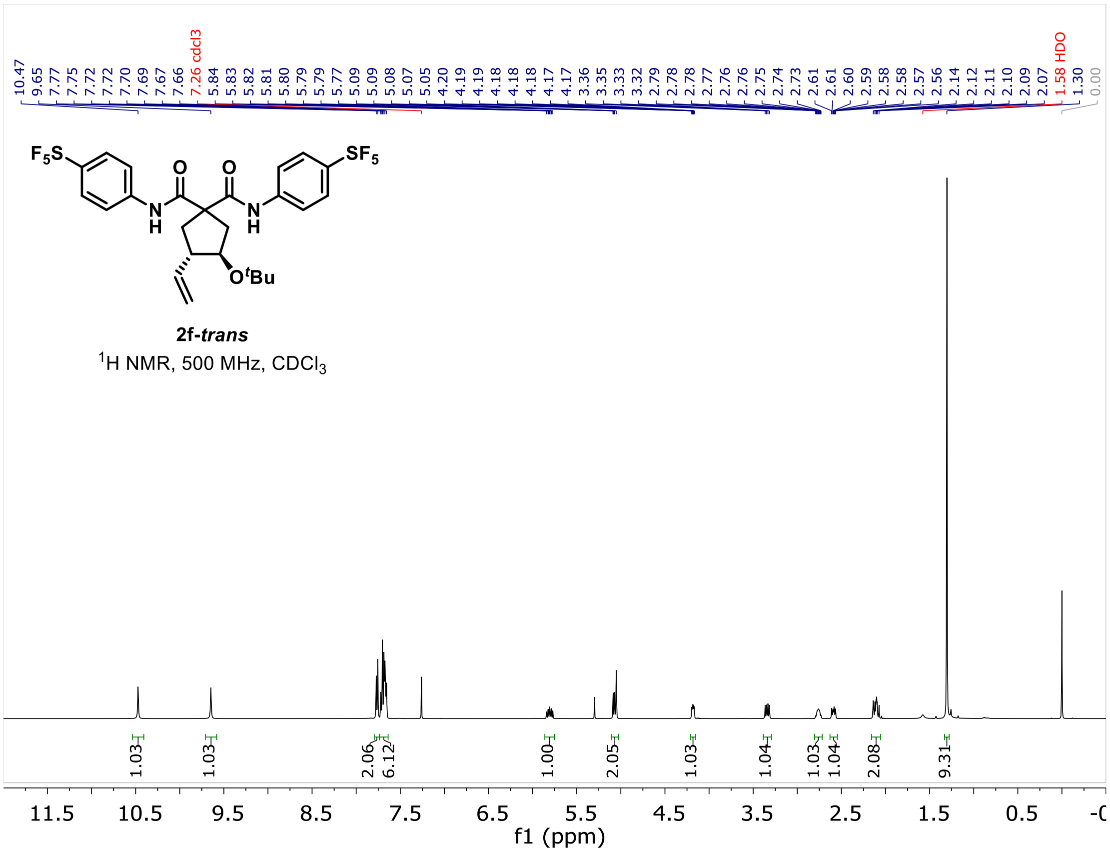


2e-*cis*

^{13}C NMR, 126 MHz, $CDCl_3$

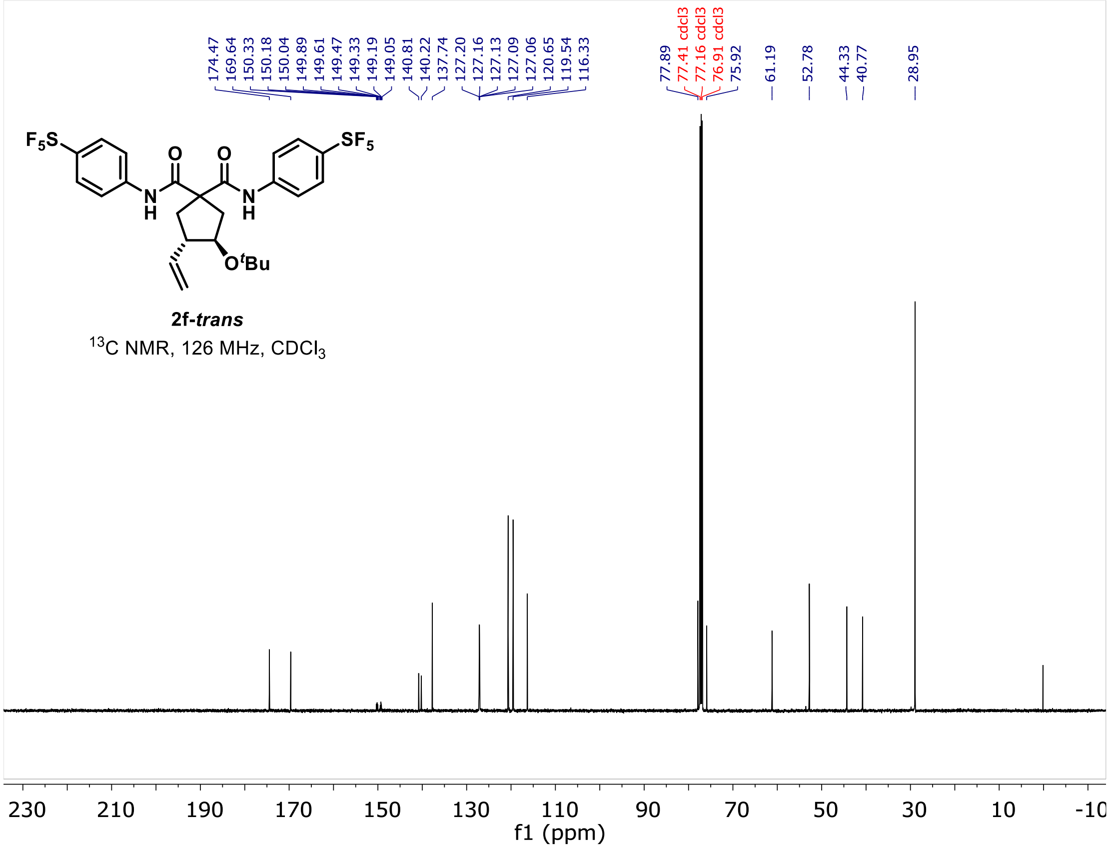

2f-*trans* + 2f-*cis*

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



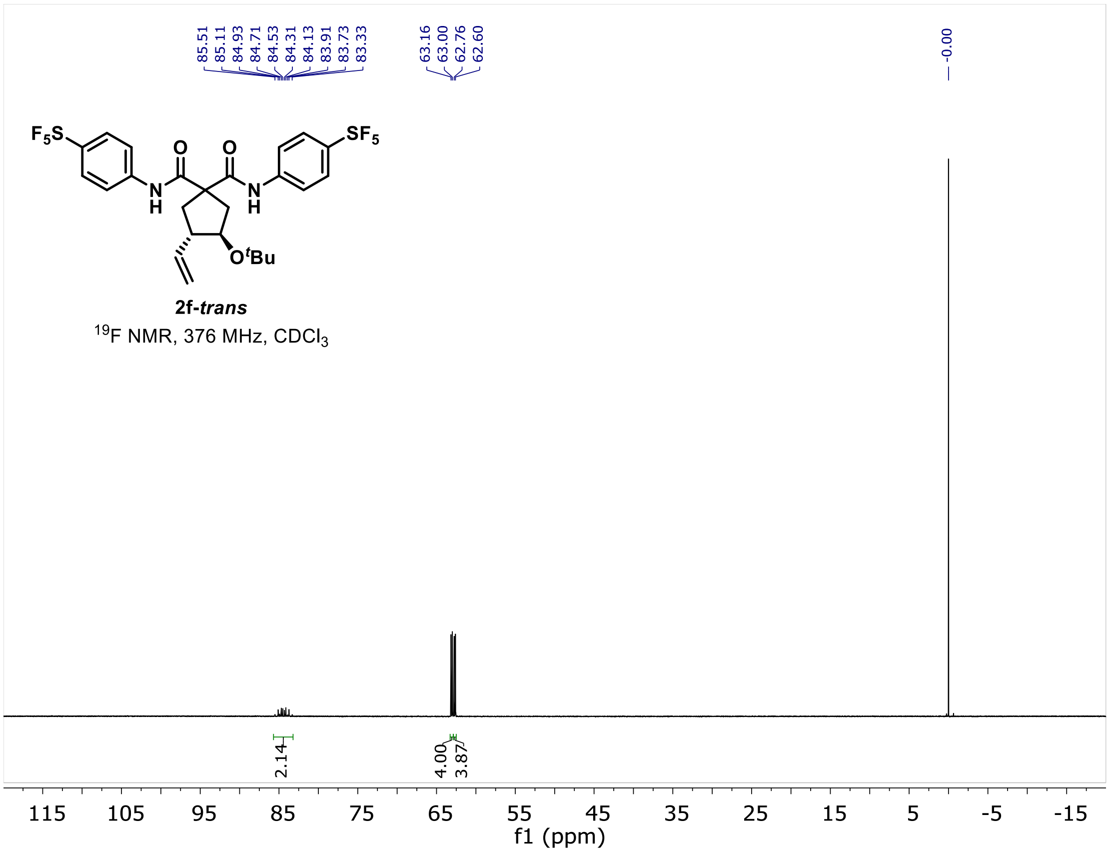
2f-*trans*

^{1}H NMR, 500 MHz, $CDCl_3$



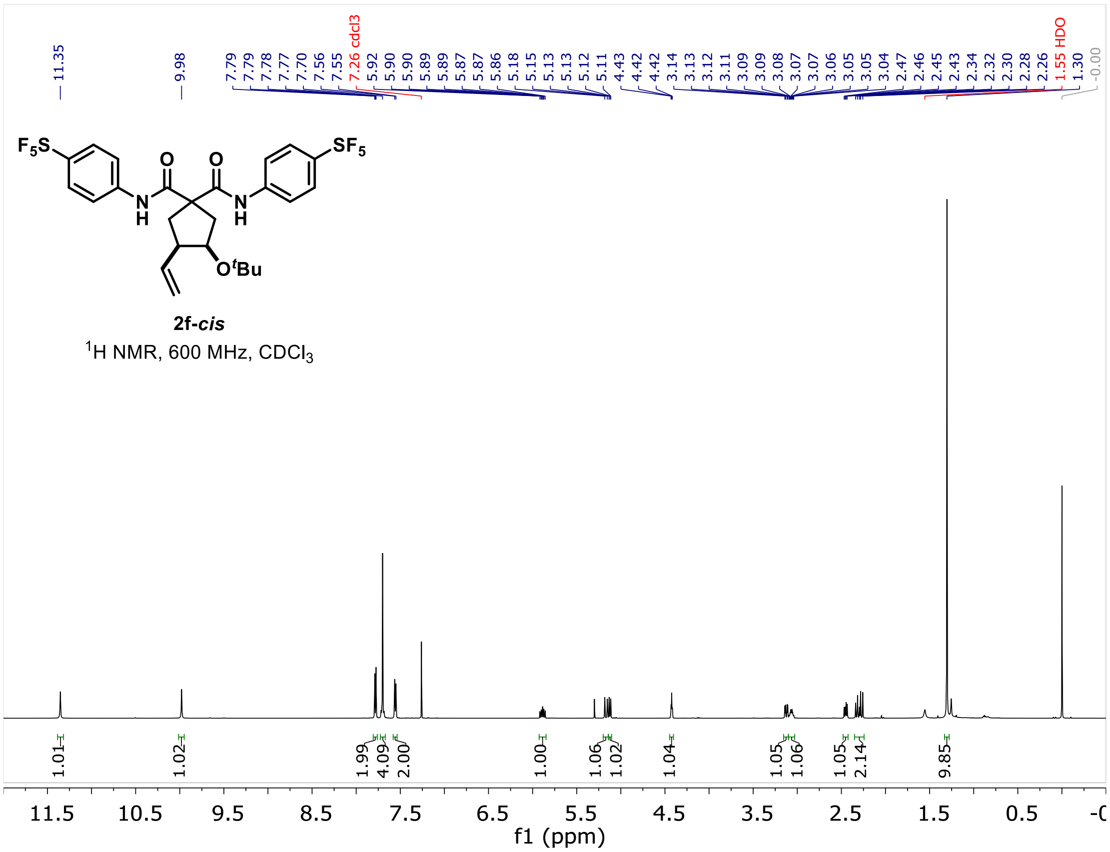
2f-*trans*

^{13}C NMR, 126 MHz, $CDCl_3$



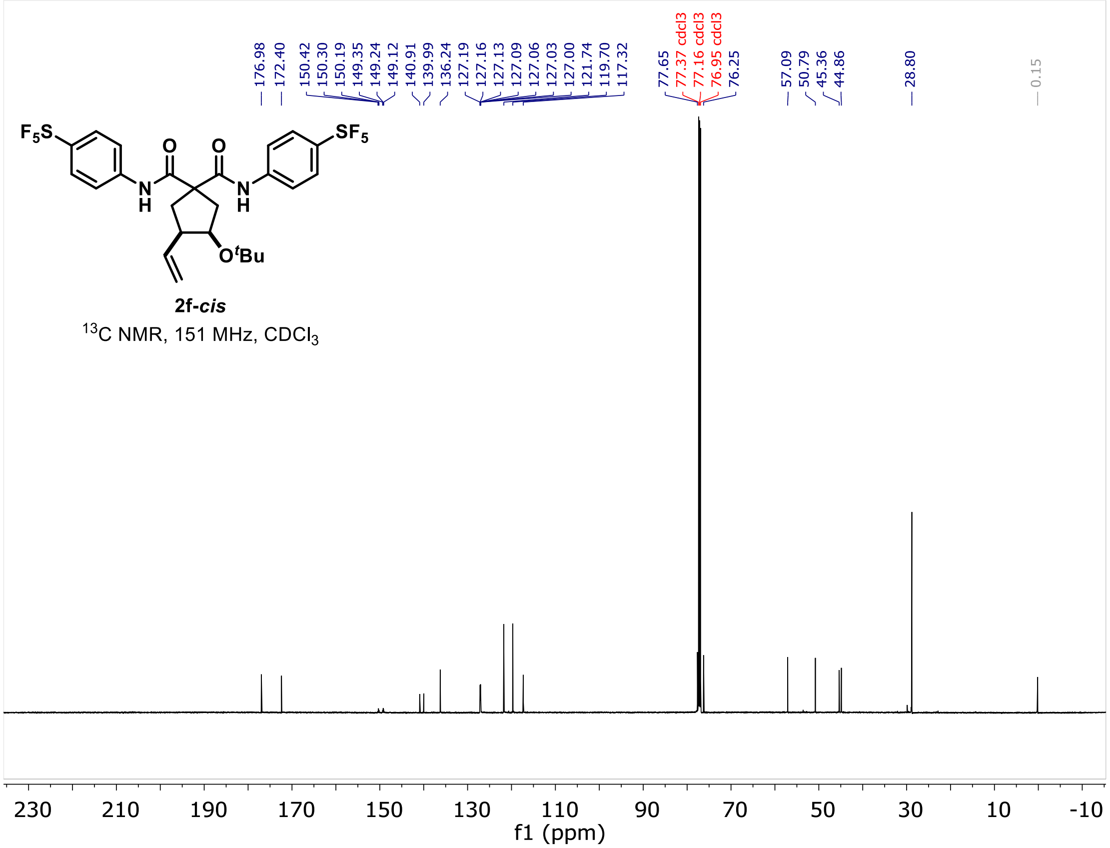
2f-*trans*

^{19}F NMR, 376 MHz, $CDCl_3$



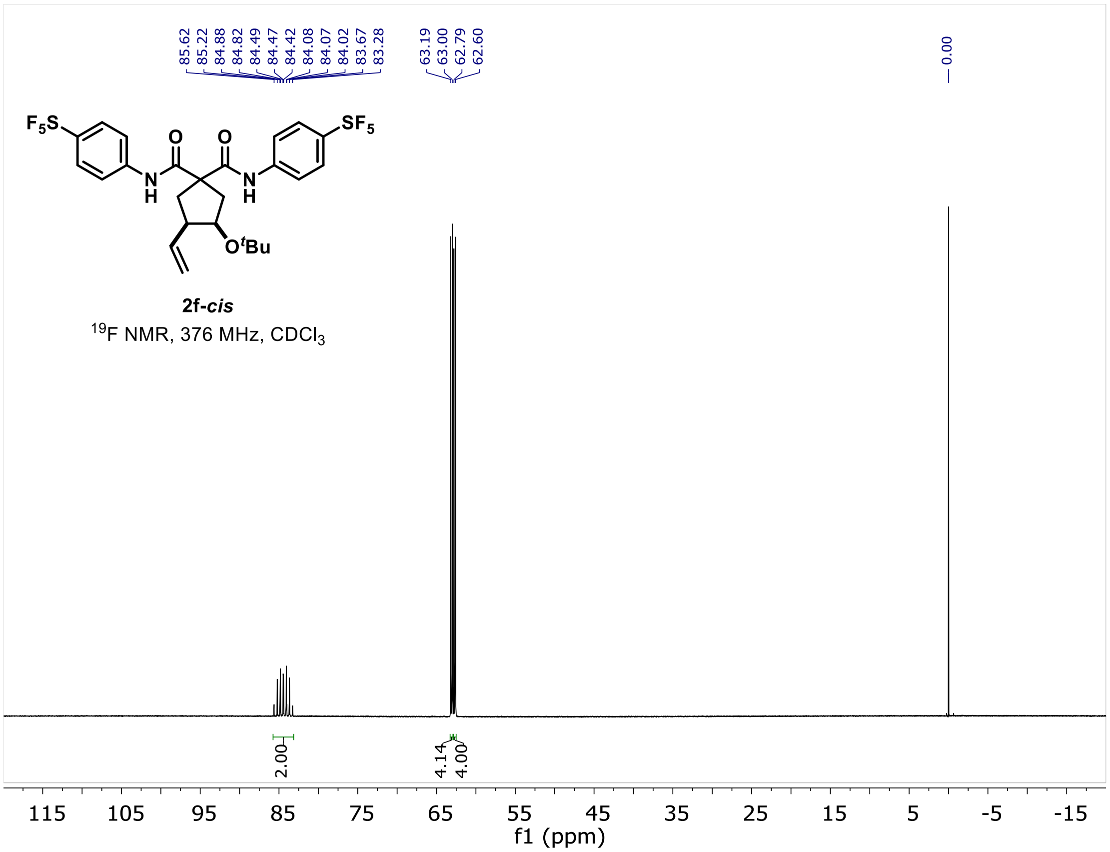
2f-*cis*

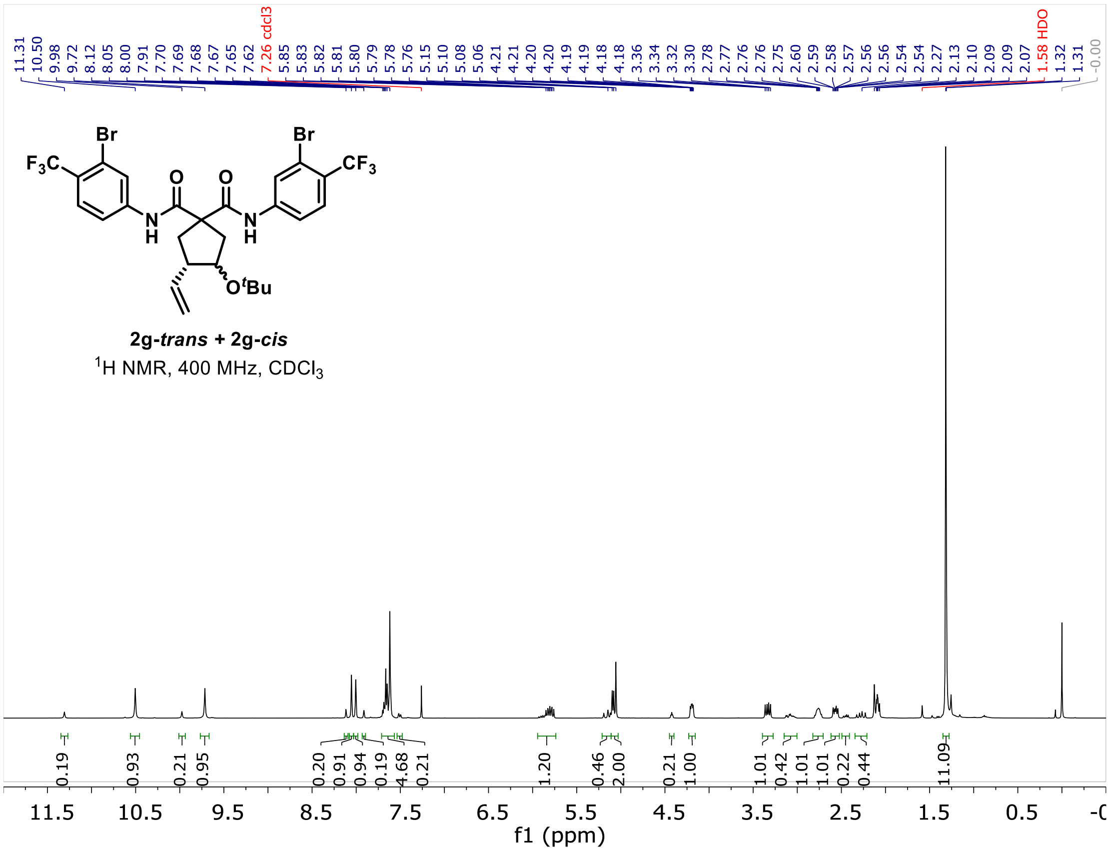
^{1}H NMR, 600 MHz, $CDCl_3$



2f-*cis*

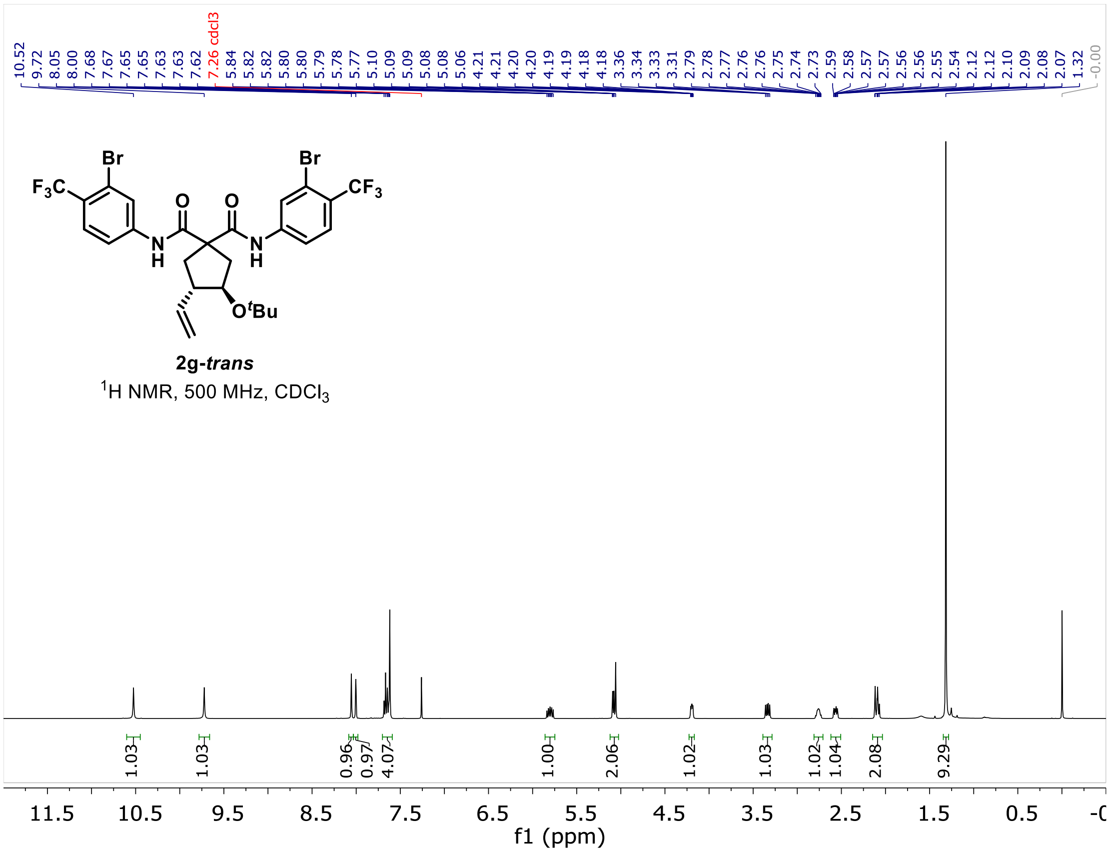
^{13}C NMR, 151 MHz, $CDCl_3$


85.62
85.22
84.88
84.82
84.49
84.47
84.42
84.08
84.07
84.02
83.67
83.28
63.19
63.00
62.79
62.60
0.00
F5S
SF5
O
O
N
H
N
H
O^tBu
2f-cis
19F NMR, 376 MHz, CDCl3
2.00
4.14
4.00
115
105
95
85
75
65
55
45
35
25
15
5
-5
-15
f1 (ppm)



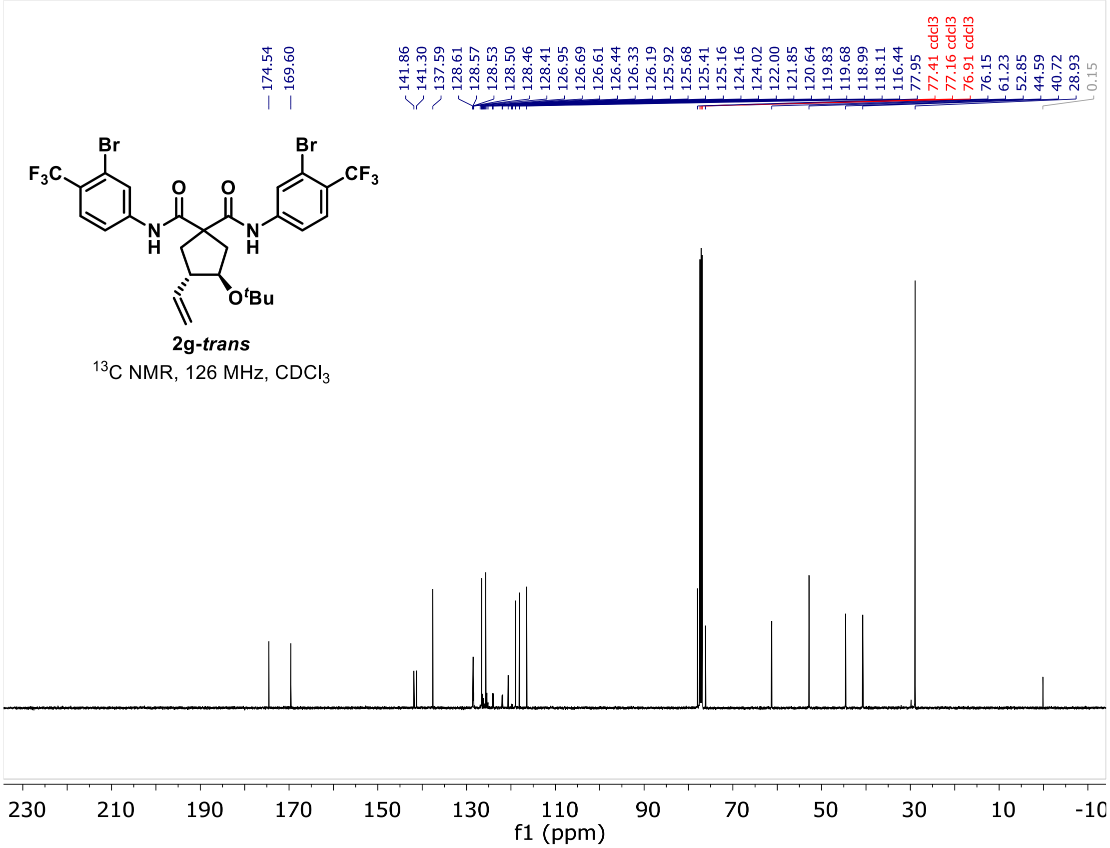
2g-*trans* + 2g-*cis*

^{1}H NMR, 400 MHz, CDCl$_3$



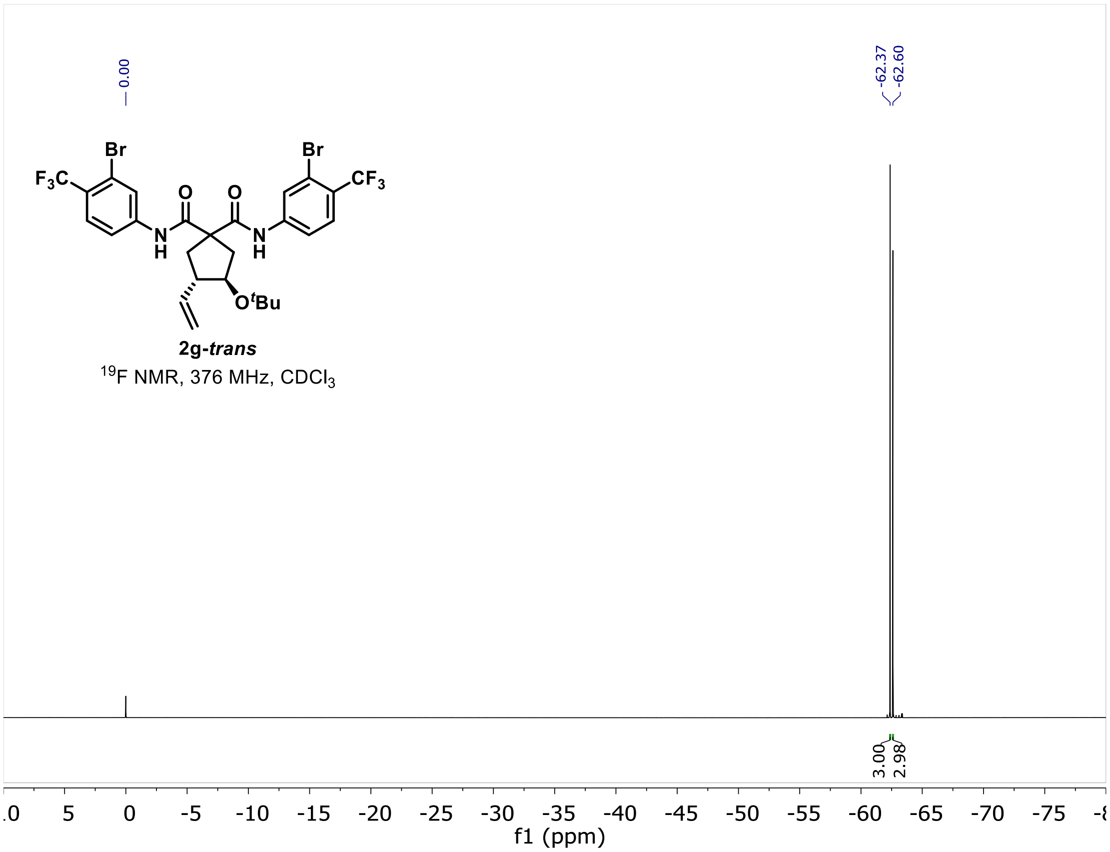
2g-*trans*

^{1}H NMR, 500 MHz, $CDCl_3$



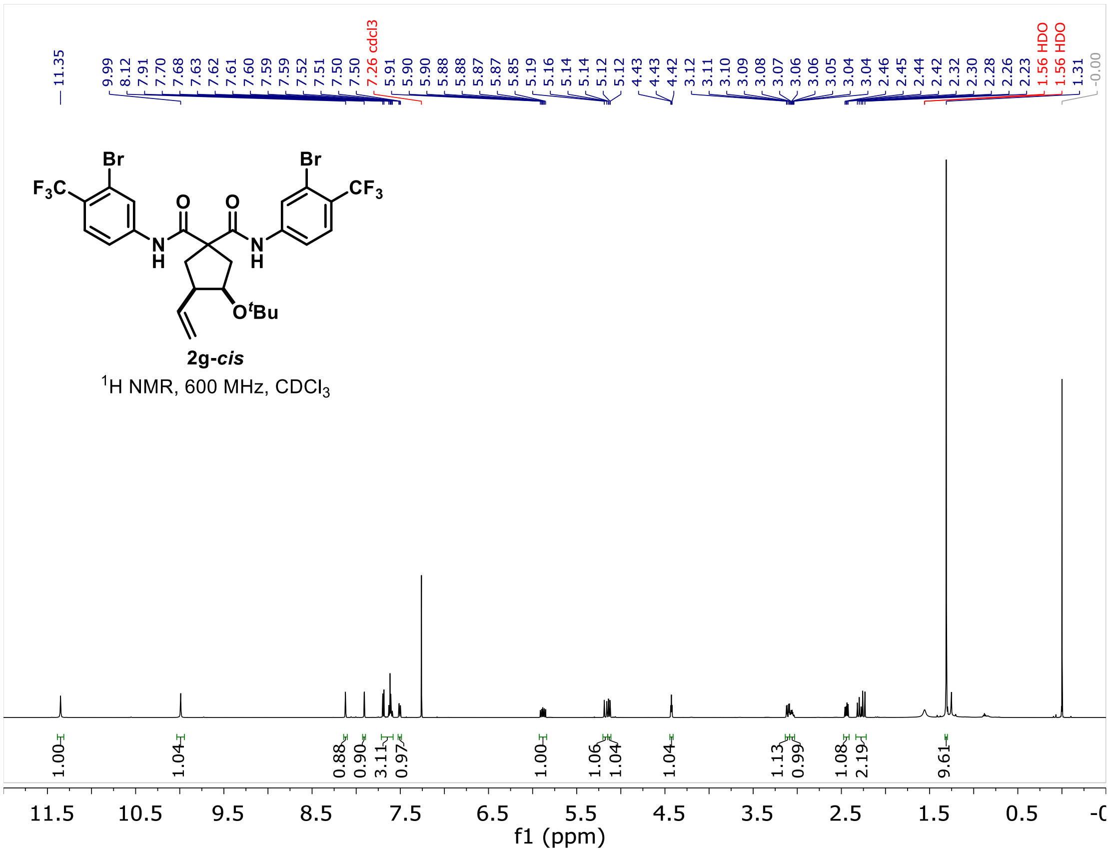
2g-*trans*

^{13}C NMR, 126 MHz, $CDCl_3$



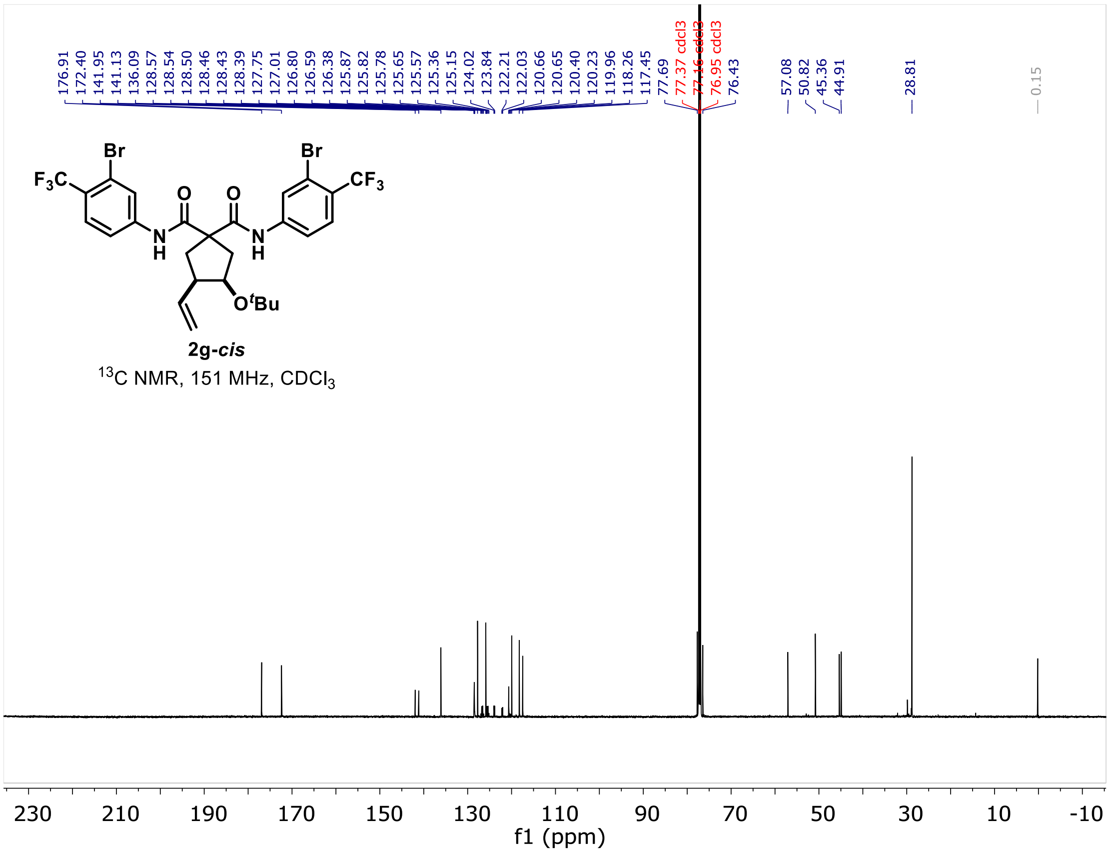
2g-*trans*

^{19}F NMR, 376 MHz, $CDCl_3$



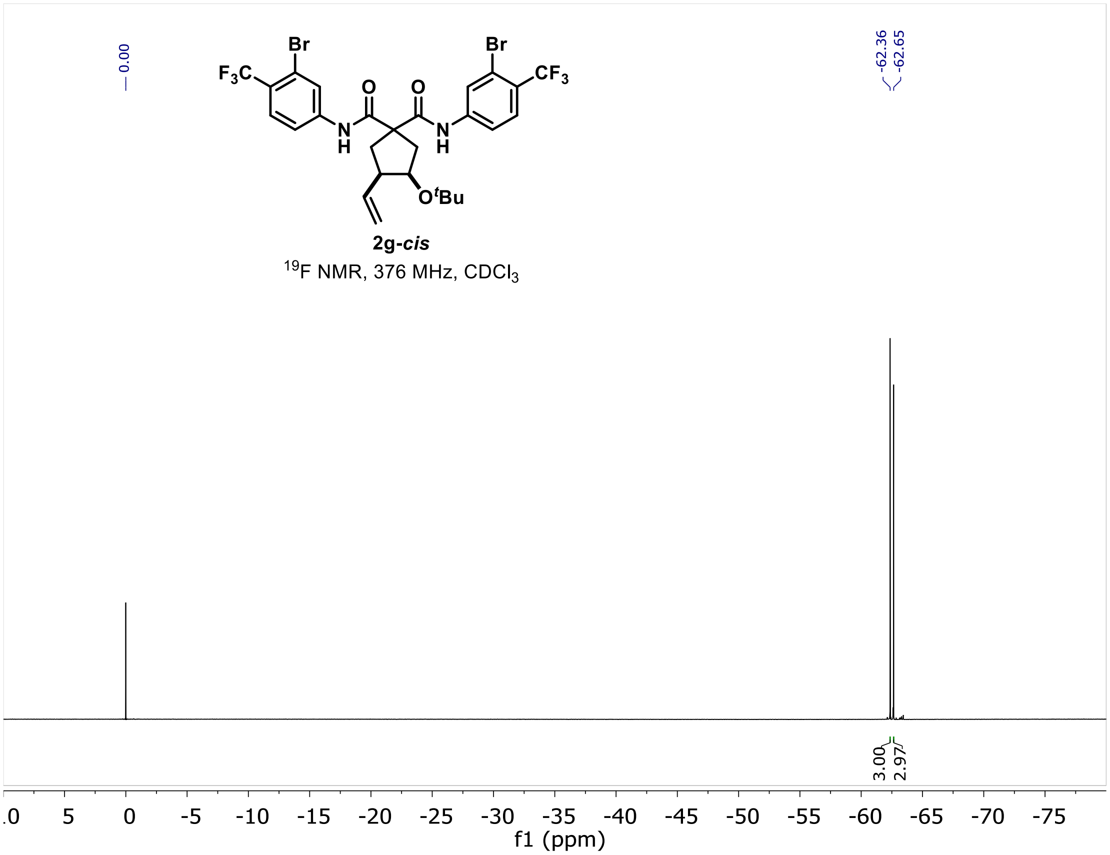
2g-*cis*

^{1}H NMR, 600 MHz, CDCl$_3$

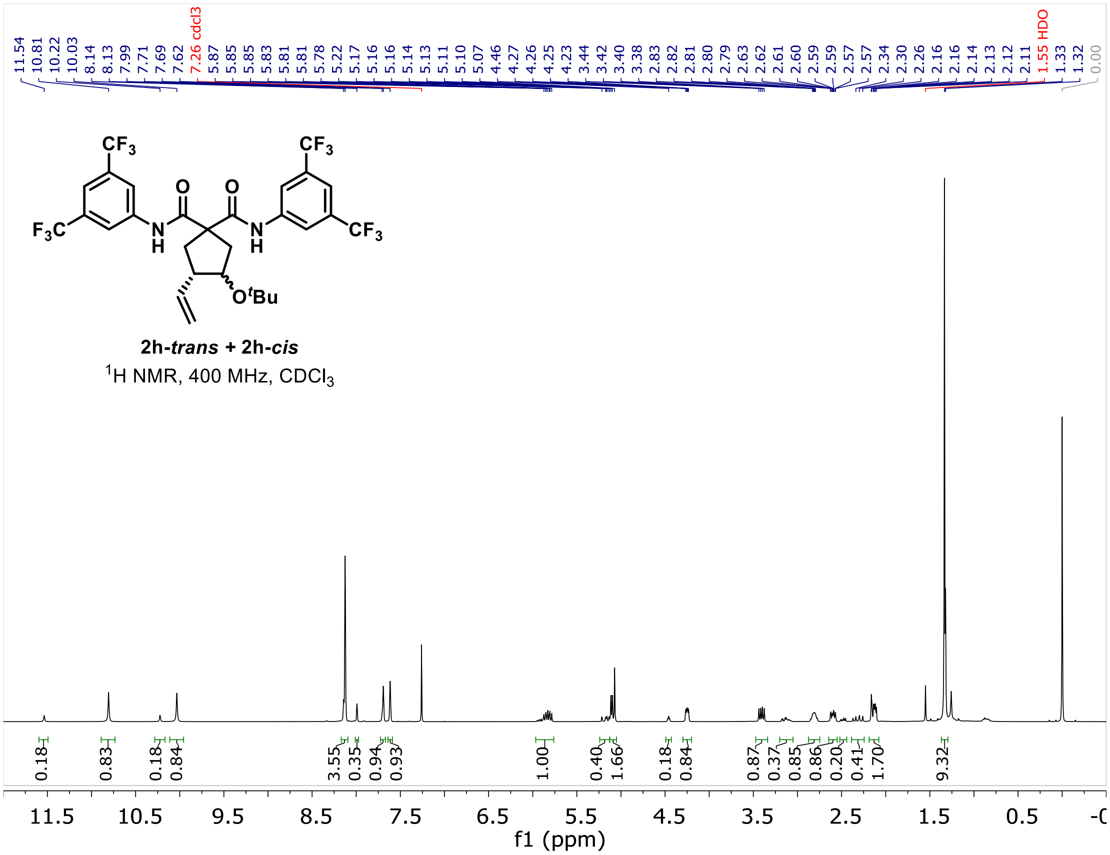


2g-*cis*

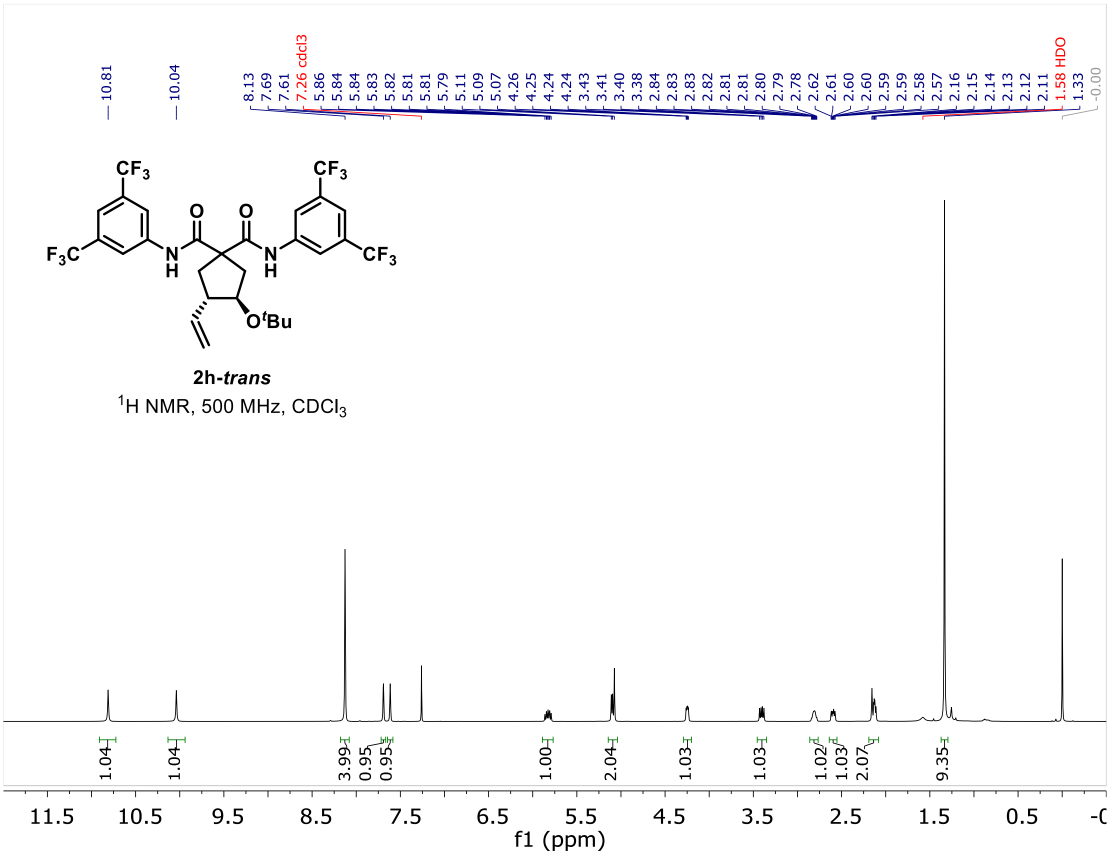
^{13}C NMR, 151 MHz, CDCl$_3$



— 0.00
-62.36
-62.65
Br
F3C
O
O
Br
CF3
N
H
N
H
O^tBu
2g-cis
19F NMR, 376 MHz, CDCl3
3.00
2.97
.0
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
-55
-60
-65
-70
-75
f1 (ppm)

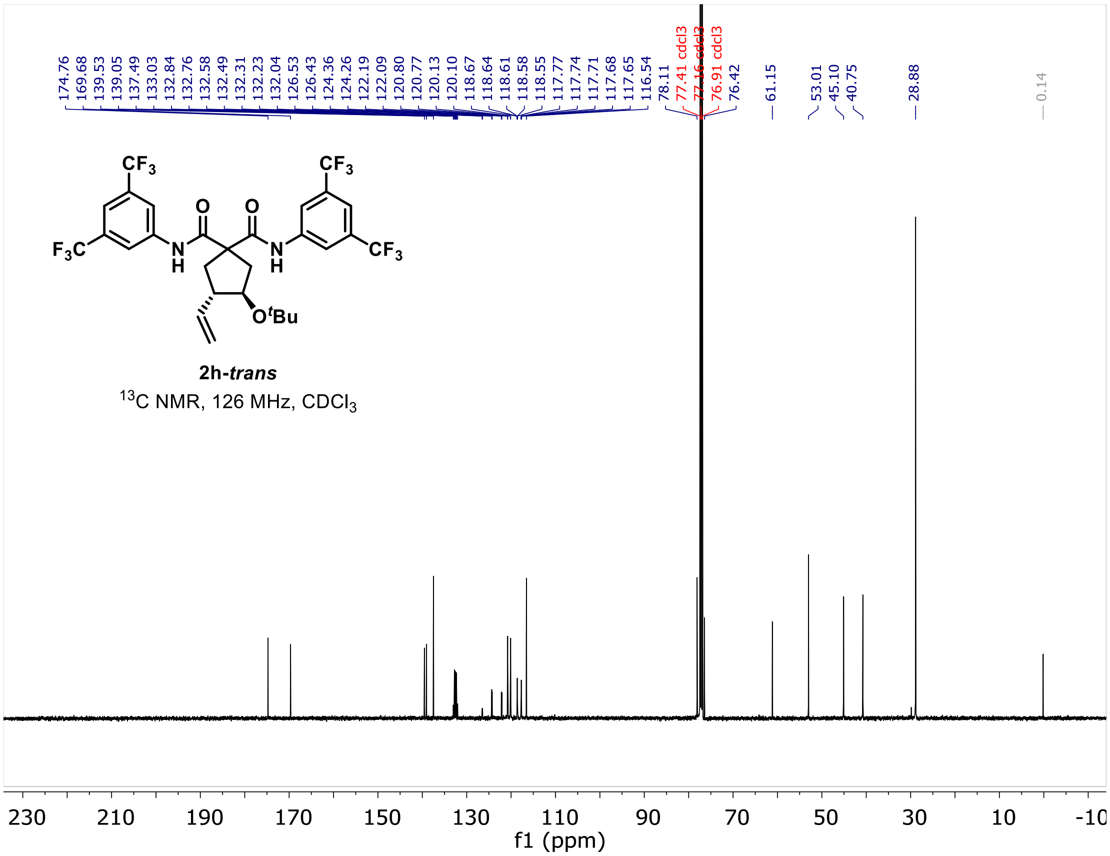


11.54
10.81
10.22
10.03
8.14
8.13
7.99
7.71
7.69
7.62
7.26 cdcl3
5.87
5.85
5.85
5.83
5.81
5.81
5.78
5.22
5.17
5.16
5.16
5.14
5.13
5.11
5.10
5.07
4.46
4.27
4.26
4.25
4.23
3.44
3.42
3.40
3.38
2.83
2.82
2.81
2.80
2.79
2.63
2.62
2.61
2.60
2.59
2.59
2.57
2.57
2.34
2.30
2.26
2.16
2.16
2.14
2.13
2.12
2.11
1.55 HDO
1.33
1.32
0.00
CF3
CF3
F3C
CF3
O
O
N
H
N
H
O^tBu
2h-trans + 2h-cis
1H NMR, 400 MHz, CDCl3
0.18
0.83
0.18
0.84
3.55
0.35
0.94
0.93
1.00
0.40
1.66
0.18
0.84
0.87
0.37
0.85
0.86
0.20
0.41
1.70
9.32
11.5
10.5
9.5
8.5
7.5
6.5
5.5
4.5
3.5
2.5
1.5
0.5
-(
f1 (ppm)



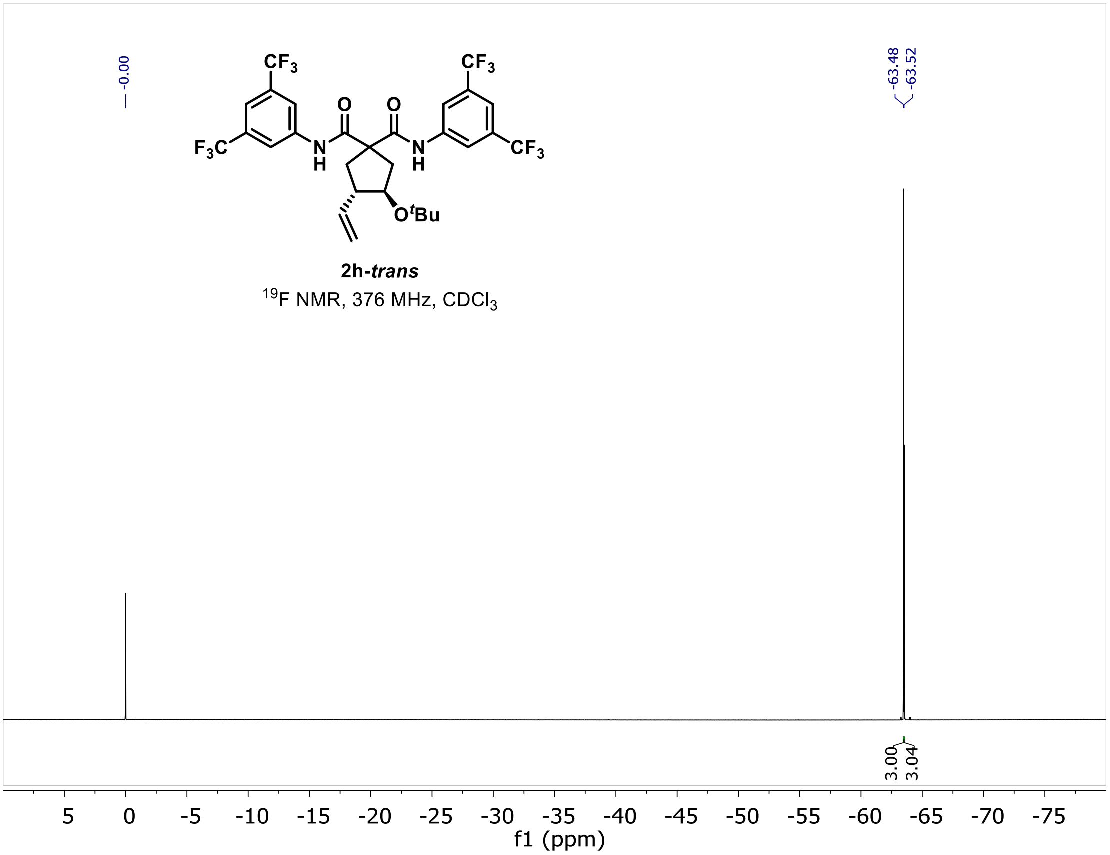
2h-*trans*

^{1}H NMR, 500 MHz, CDCl$_3$



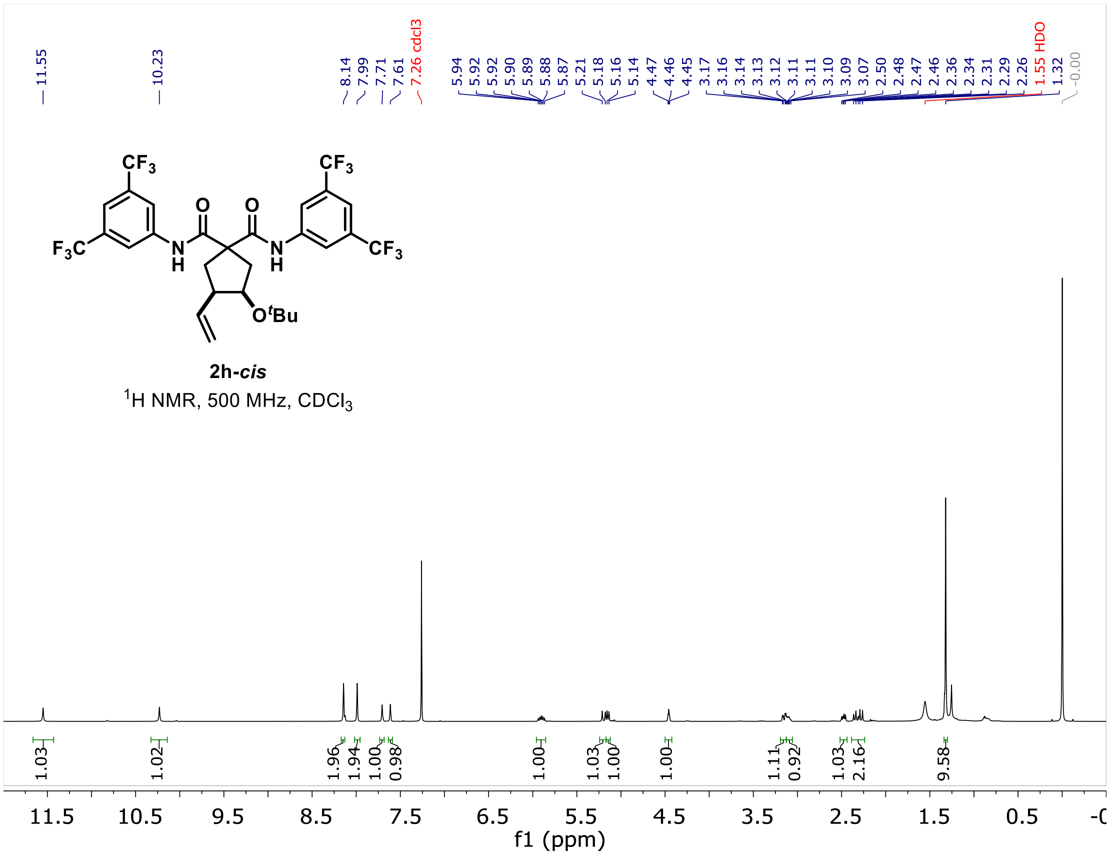
2h-*trans*

^{13}C NMR, 126 MHz, CDCl$_3$



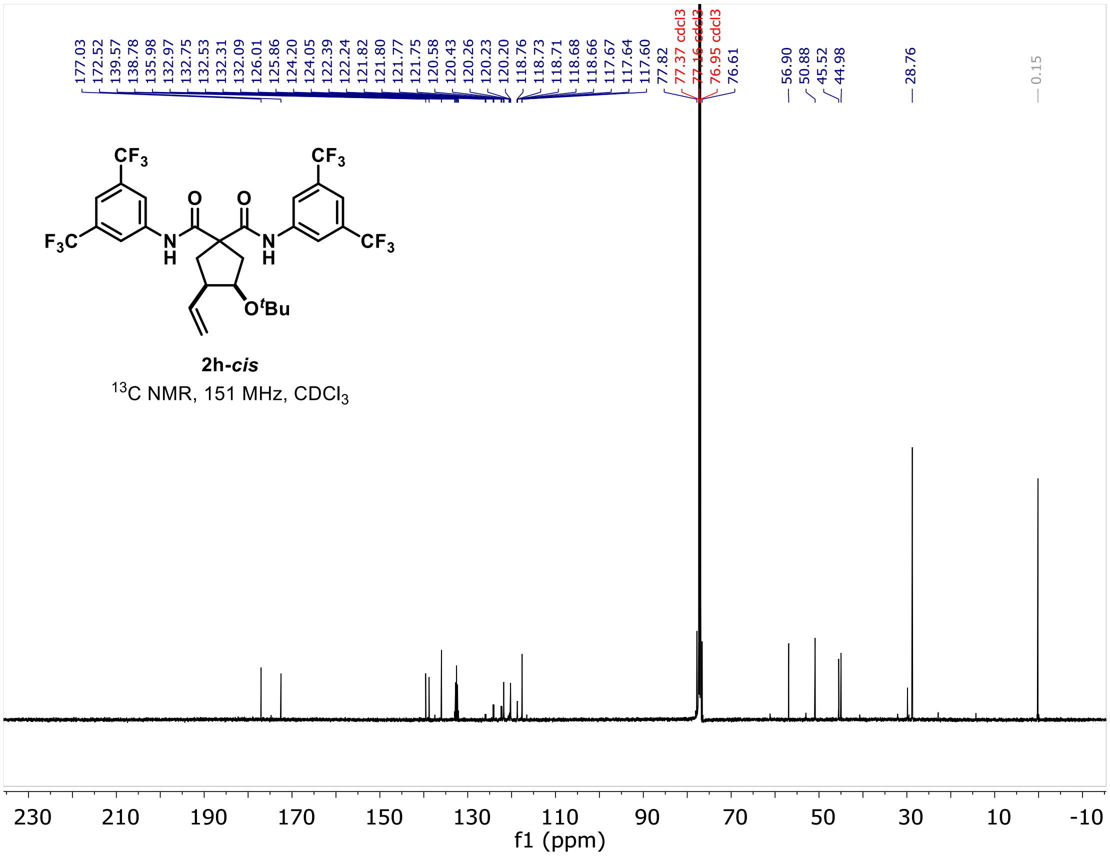
2h-*trans*

^{19}F NMR, 376 MHz, CDCl$_3$



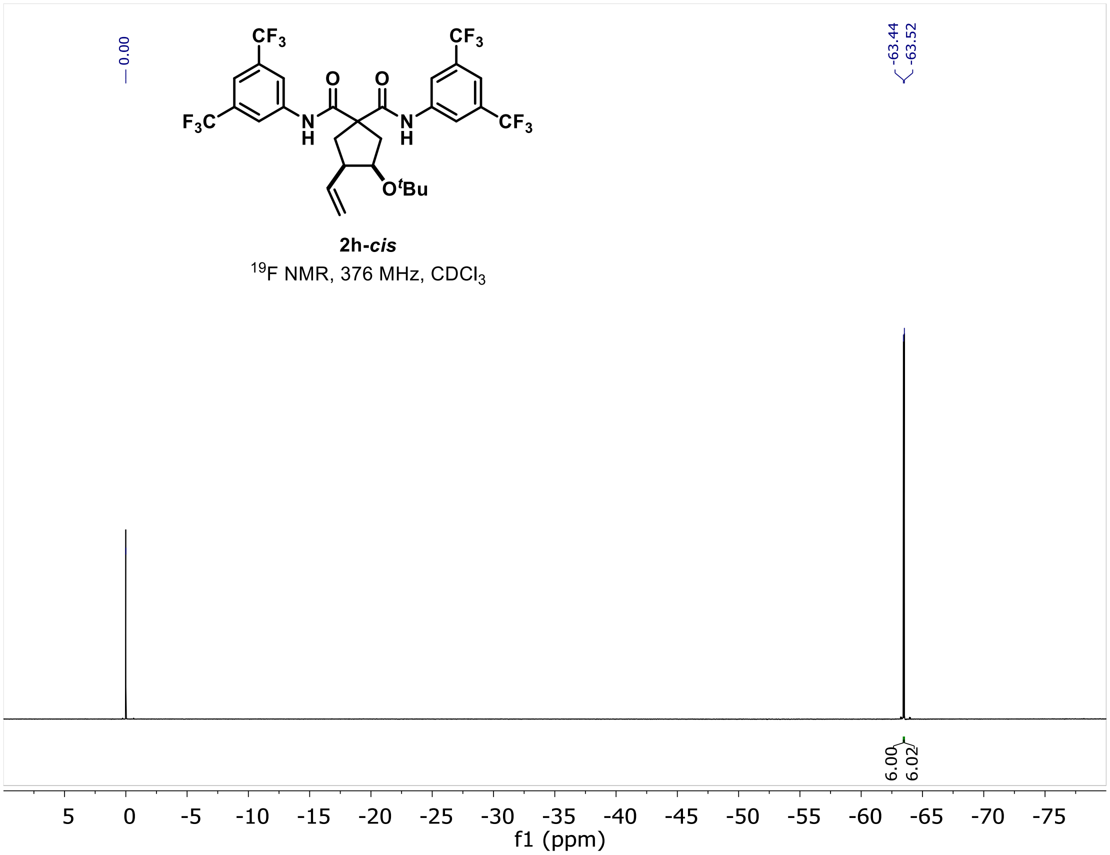
2h-*cis*

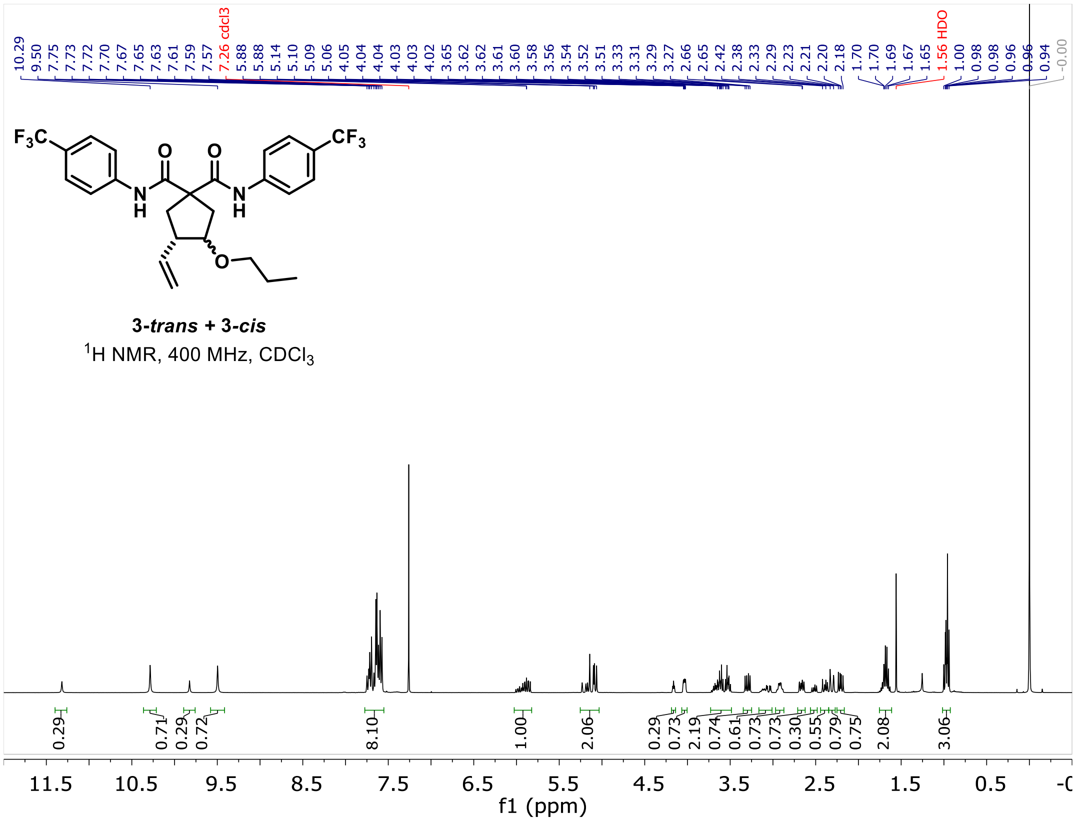
^{1}H NMR, 500 MHz, $CDCl_3$



2h-*cis*

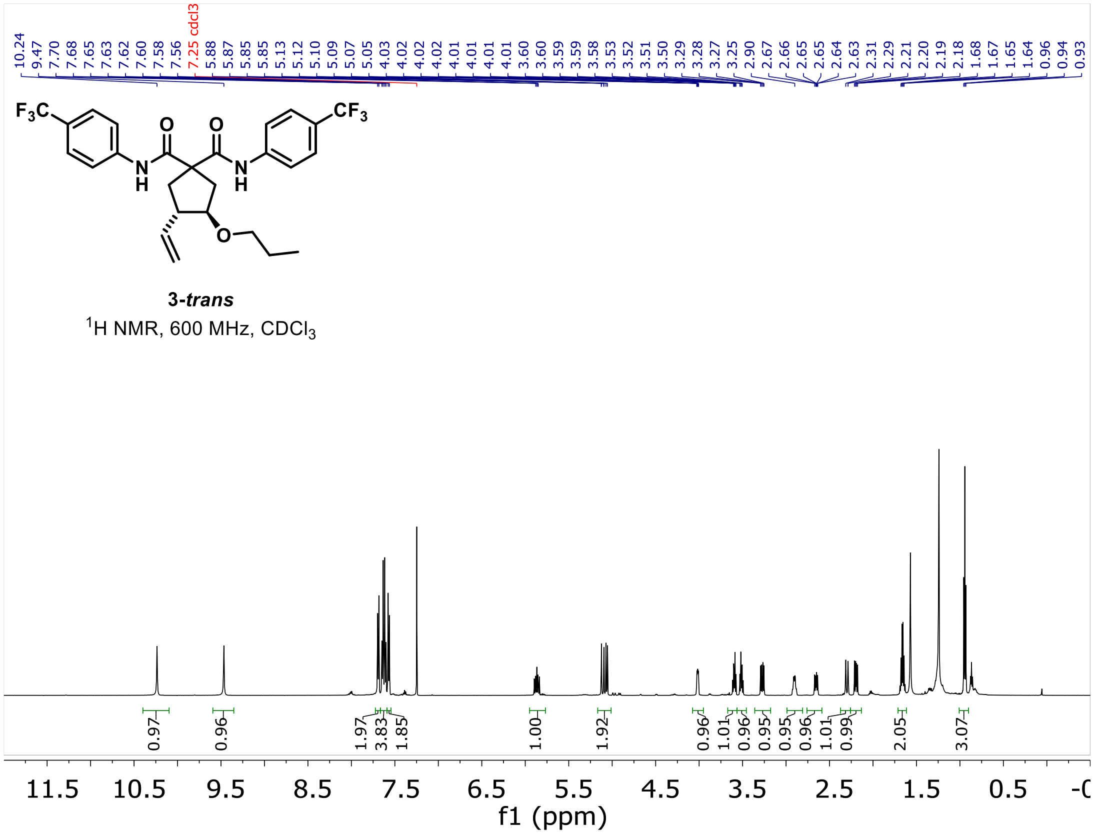
^{13}C NMR, 151 MHz, $CDCl_3$


0.00
-63.44
-63.52
CF3
CF3
F3C
CF3
O
O
N
H
N
H
O^tBu
2h-*cis*
19F NMR, 376 MHz, CDCl3
6.00
6.02
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
-55
-60
-65
-70
-75
f1 (ppm)



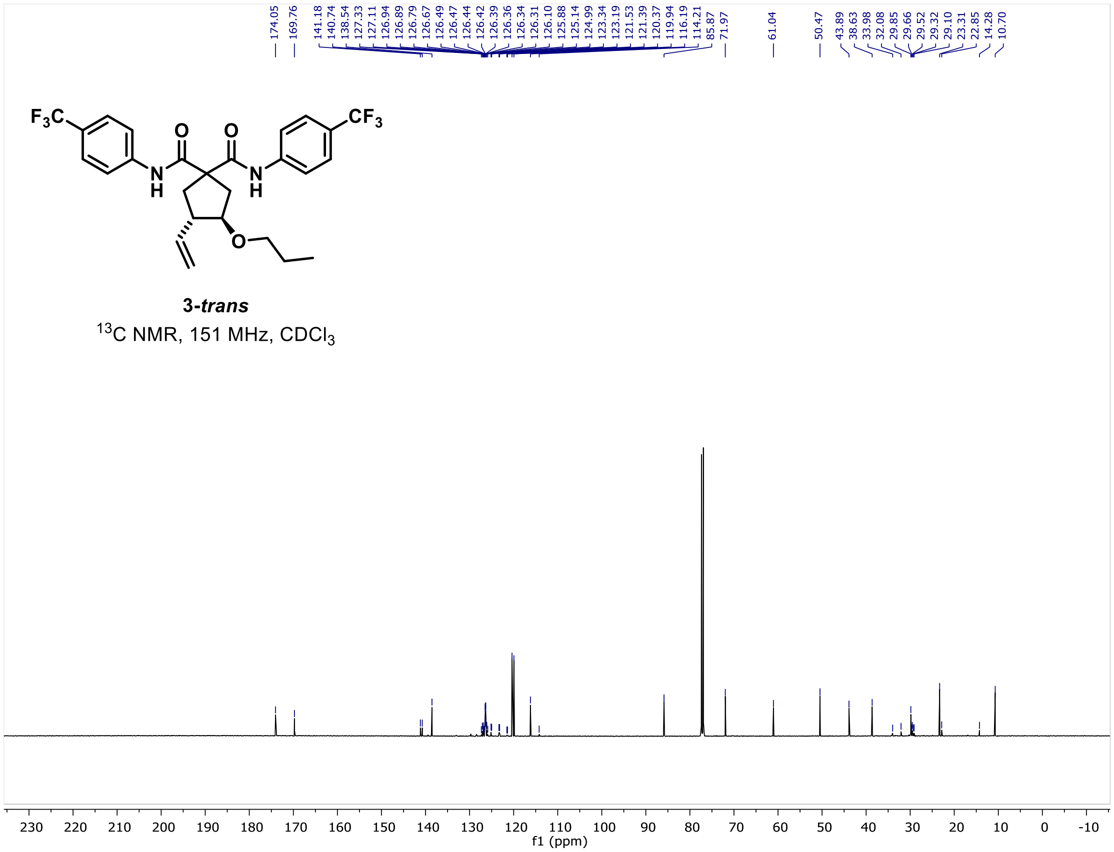
3-*trans* + 3-*cis*

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



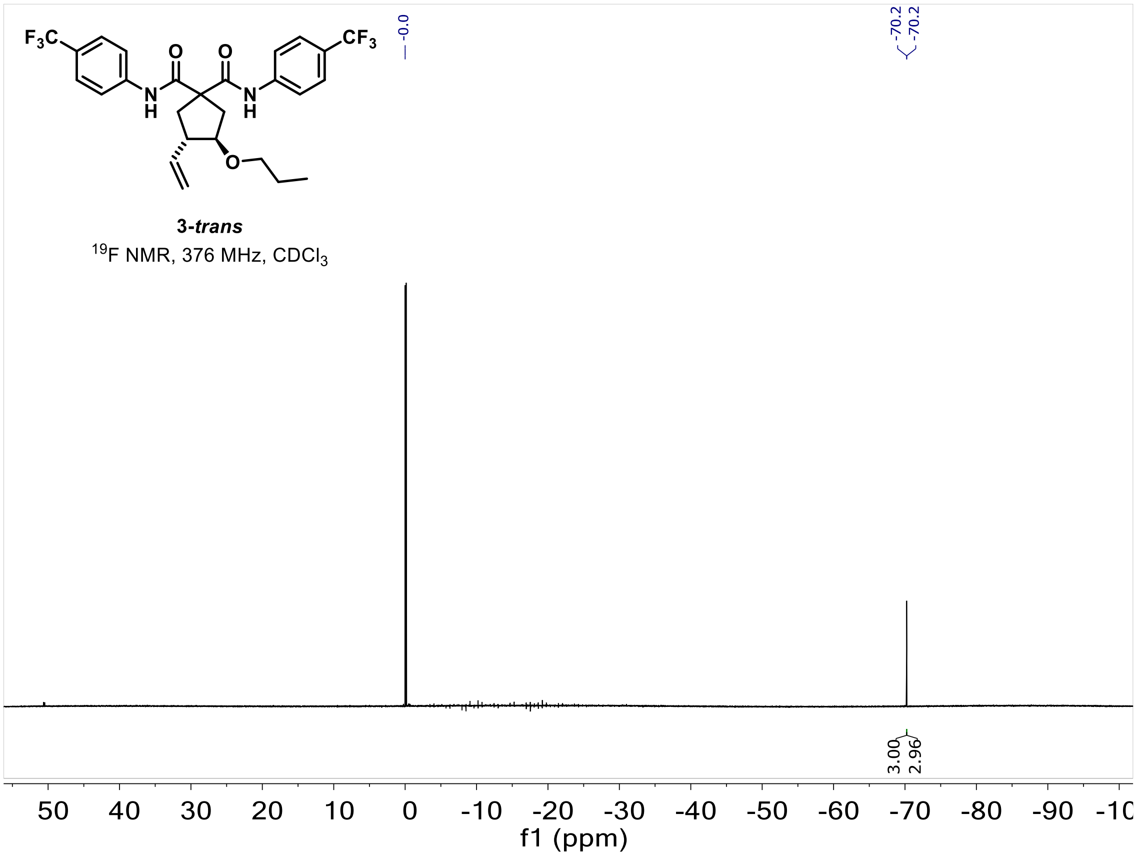
3-*trans*

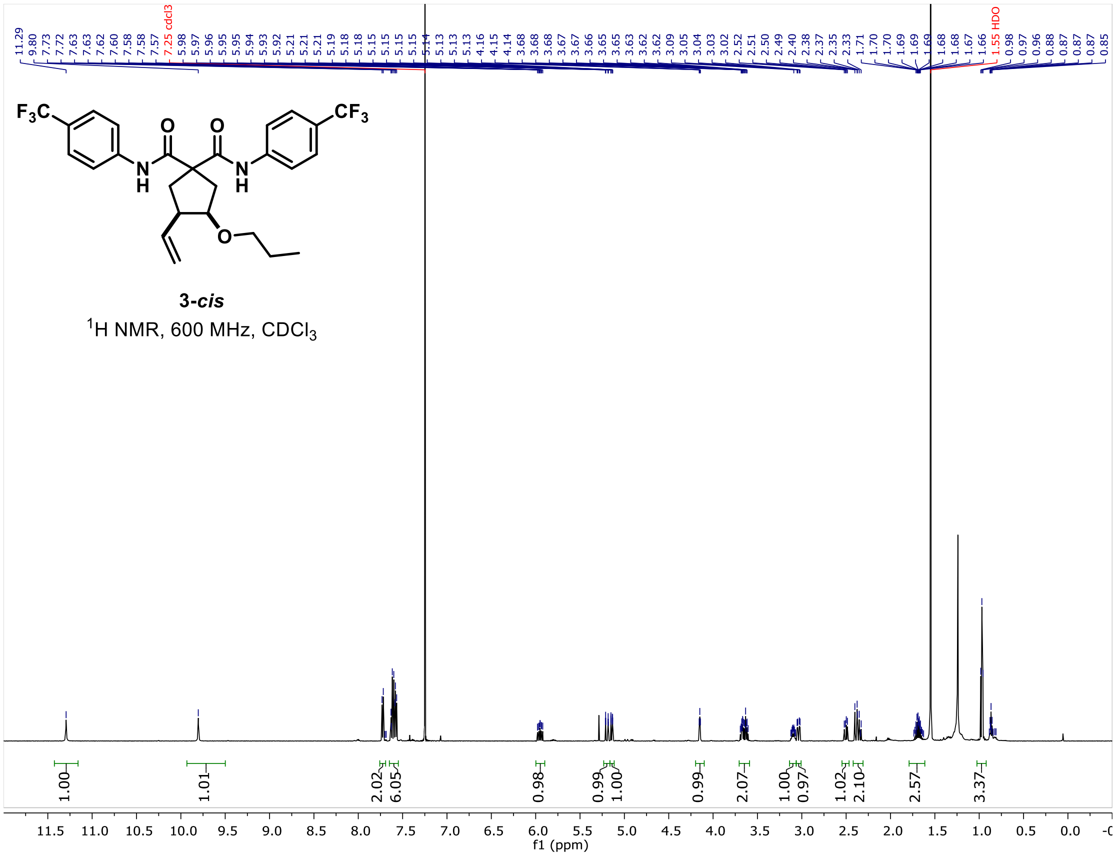
^{1}H NMR, 600 MHz, CDCl$_3$

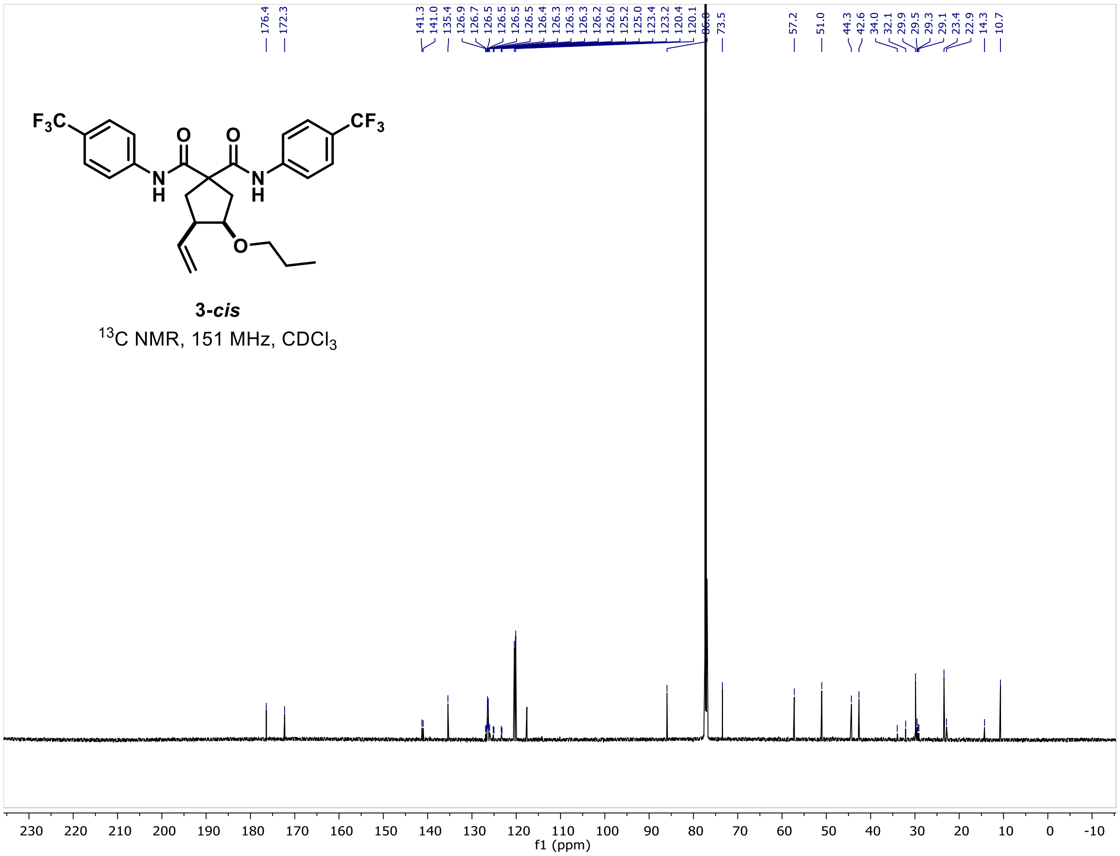


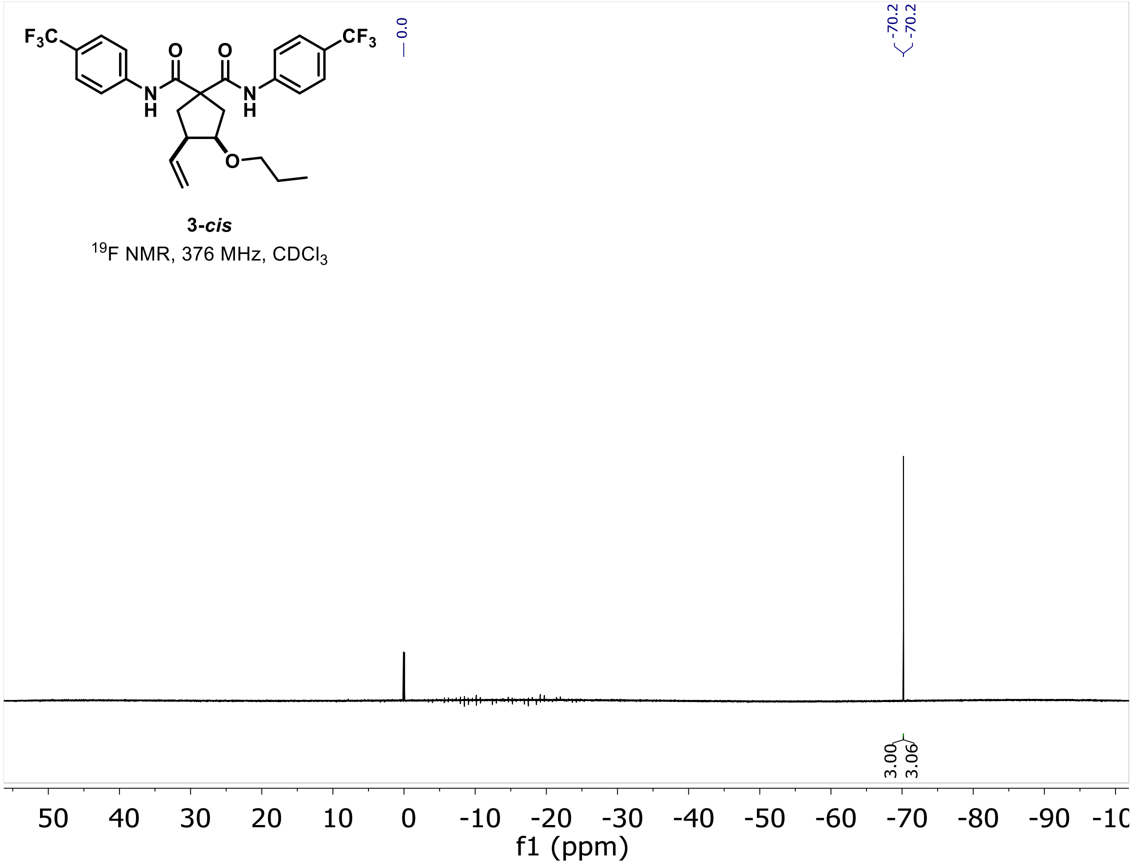
3-*trans*

^{13}C NMR, 151 MHz, CDCl$_3$


F3C
CF3
O
O
N
H
N
H
O
3-*trans*
19F NMR, 376 MHz, CDCl3
-0.0
-70.2
-70.2
3.00
2.96
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
f1 (ppm)

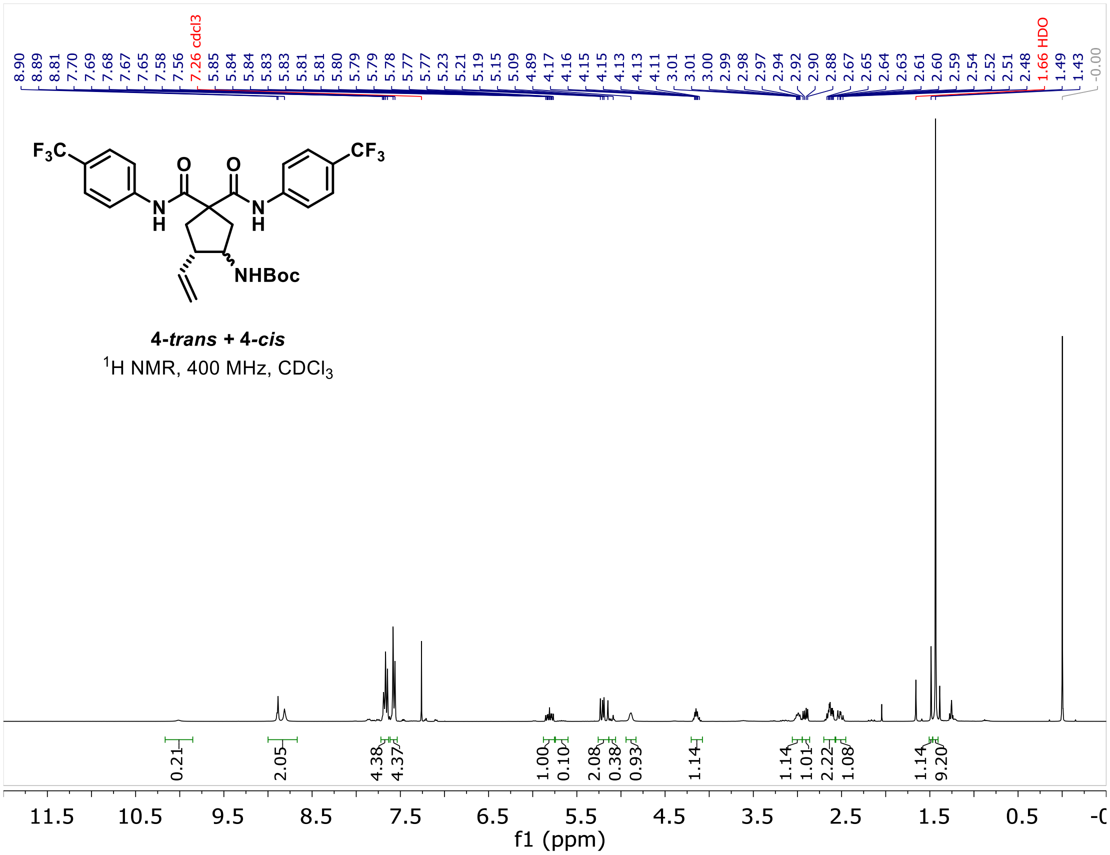

11.29
9.80
7.73
7.72
7.63
7.63
7.62
7.60
7.58
7.58
7.57
7.25 cdcl3
5.98
5.97
5.96
5.95
5.95
5.94
5.93
5.92
5.21
5.21
5.21
5.19
5.18
5.18
5.15
5.15
5.15
5.15
5.14
5.13
5.13
5.13
4.16
4.15
4.14
3.68
3.68
3.68
3.67
3.67
3.66
3.65
3.65
3.63
3.62
3.62
3.09
3.05
3.04
3.03
3.02
2.52
2.51
2.50
2.49
2.40
2.38
2.37
2.35
2.33
1.71
1.70
1.69
1.69
1.69
1.68
1.68
1.67
1.66
1.55 HDO
0.98
0.97
0.96
0.88
0.87
0.87
0.87
0.85
F3C
CF3
O
O
N
H
N
H
O
3-cis
1H NMR, 600 MHz, CDCl3
1.00
1.01
2.02
6.05
0.98
0.99
1.00
0.99
2.07
1.00
0.97
1.02
2.10
2.57
3.37
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


176.4
172.3
141.3
141.0
135.4
126.9
126.7
126.5
126.5
126.5
126.4
126.3
126.3
126.3
126.2
126.0
125.2
125.0
123.4
123.2
120.4
120.1
86.0
73.5
57.2
51.0
44.3
42.6
34.0
32.1
29.9
29.5
29.3
29.1
23.4
22.9
14.3
10.7
F3C
CF3
O
O
N
H
N
H
O
3-cis
13C NMR, 151 MHz, CDCl3
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)



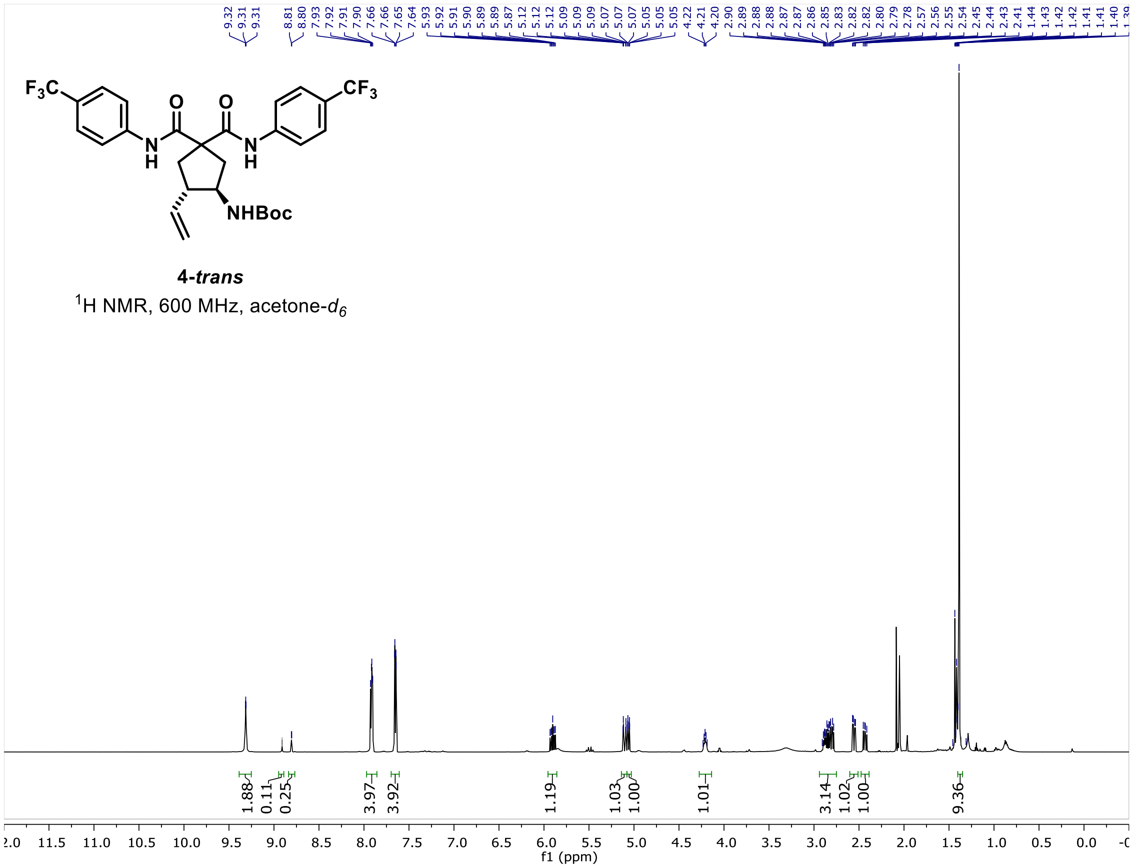
3-*cis*

^{19}F NMR, 376 MHz, $CDCl_3$



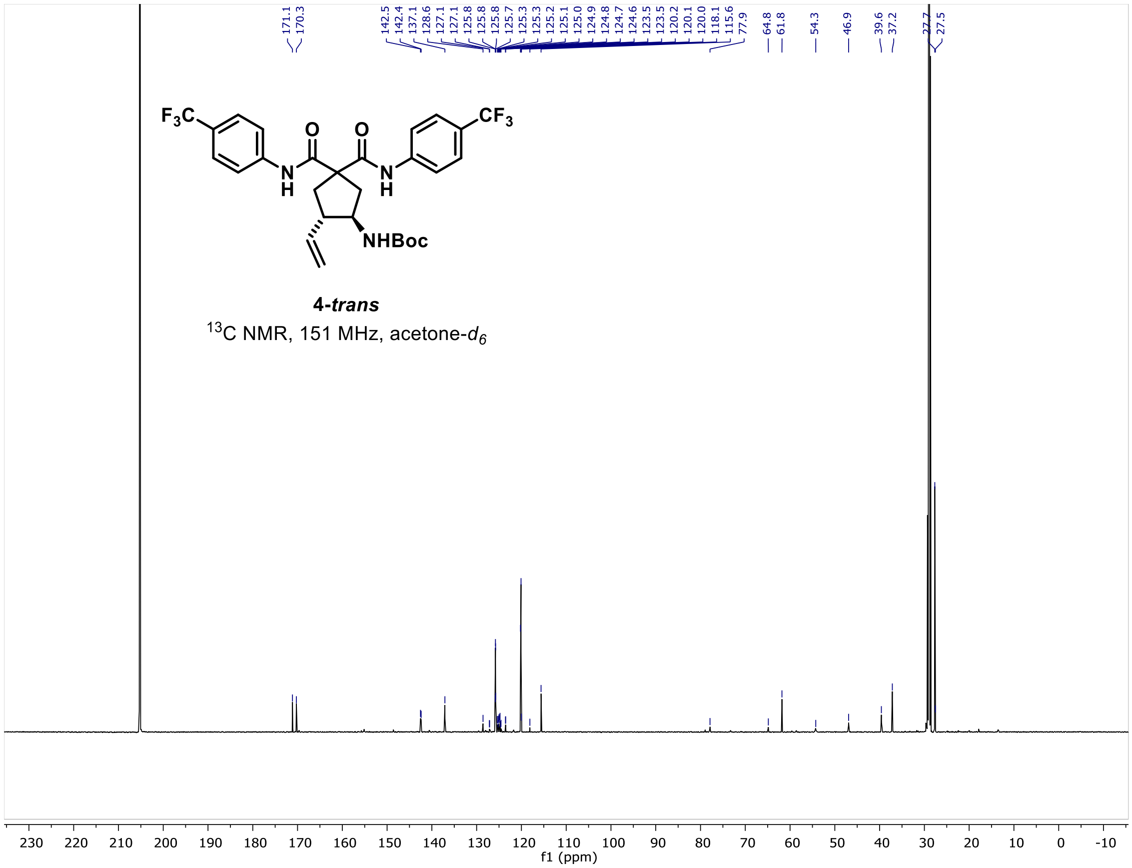
4-*trans* + 4-*cis*

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



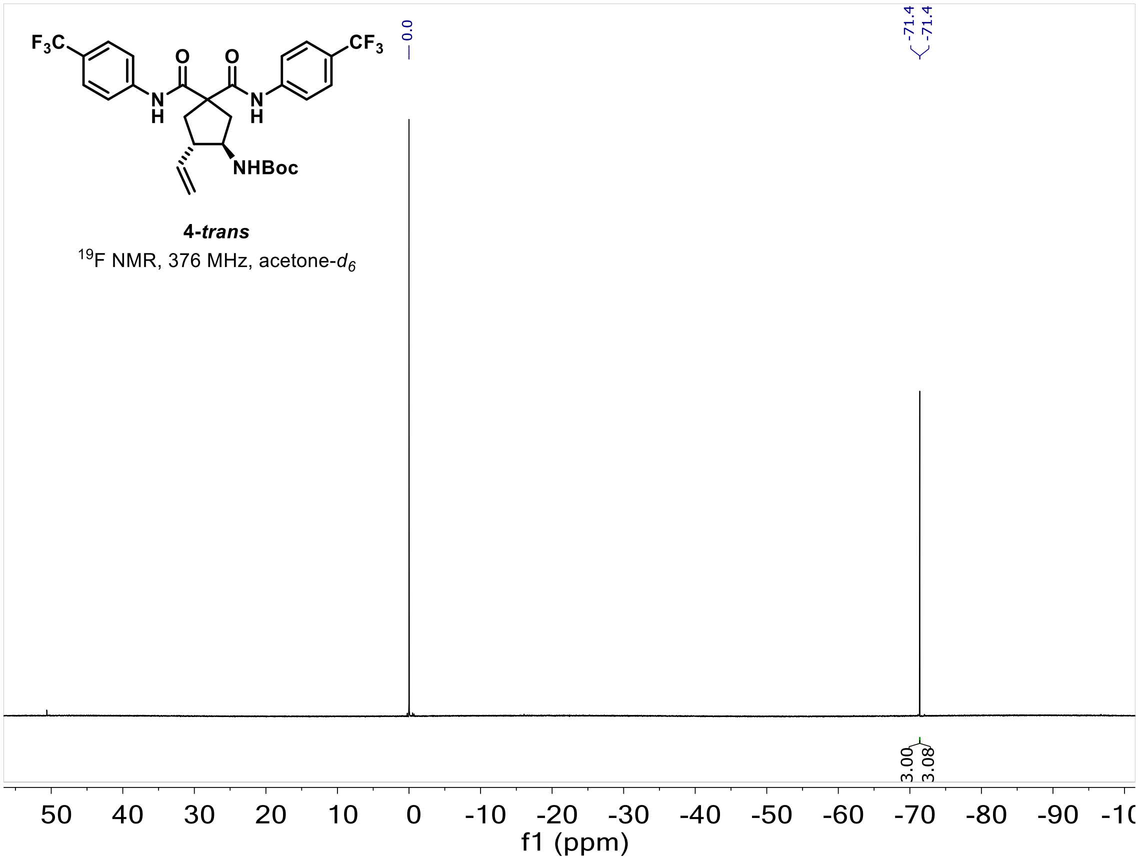
4-*trans*

^{1}H NMR, 600 MHz, acetone-d_6

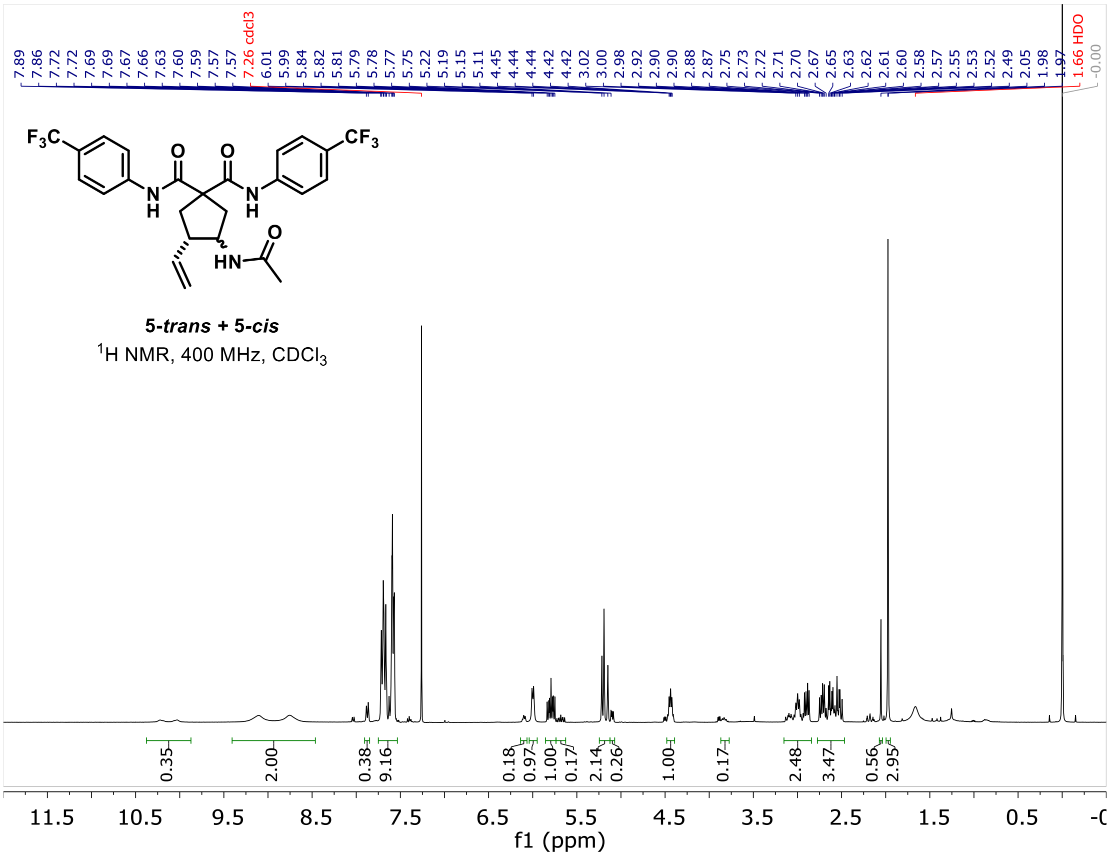


4-*trans*

^{13}C NMR, 151 MHz, acetone-d_6

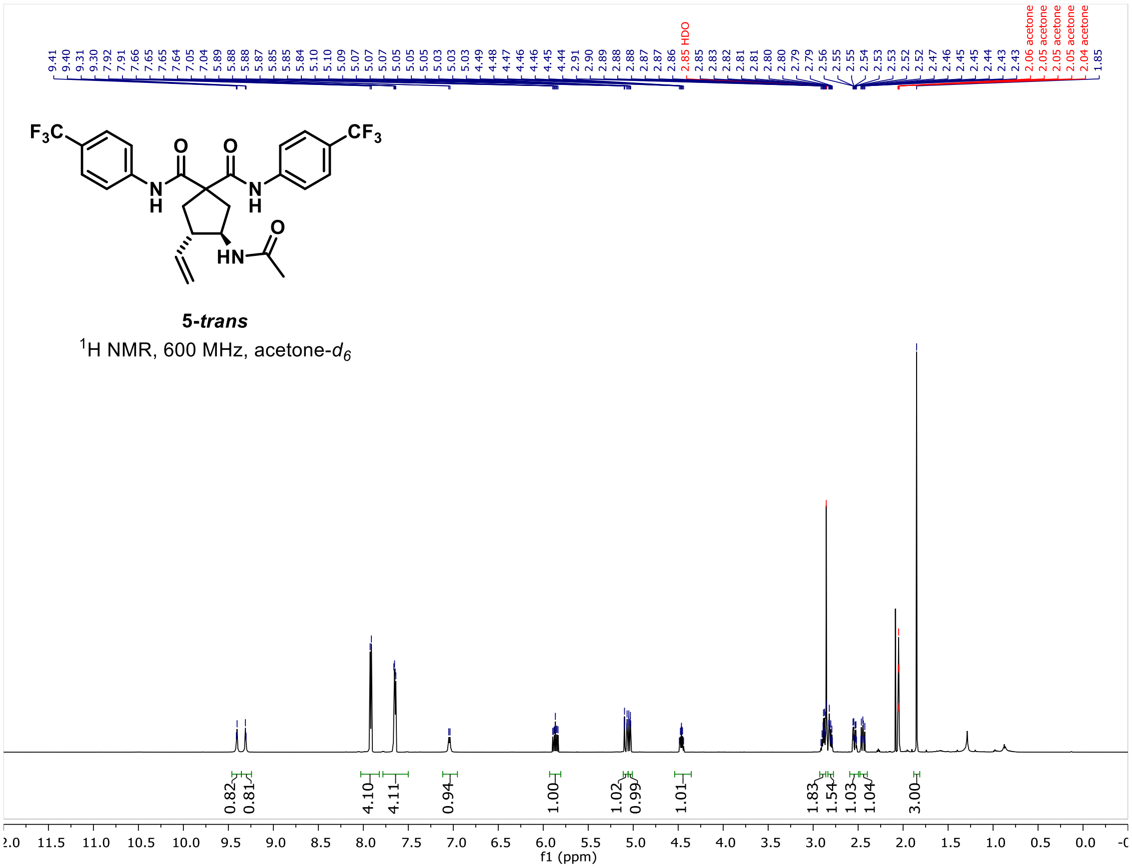


4-*trans*
^{19}F NMR, 376 MHz, acetone-d_6
0.0
-71.4
-71.4
3.00
3.08
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-1(
f1 (ppm)



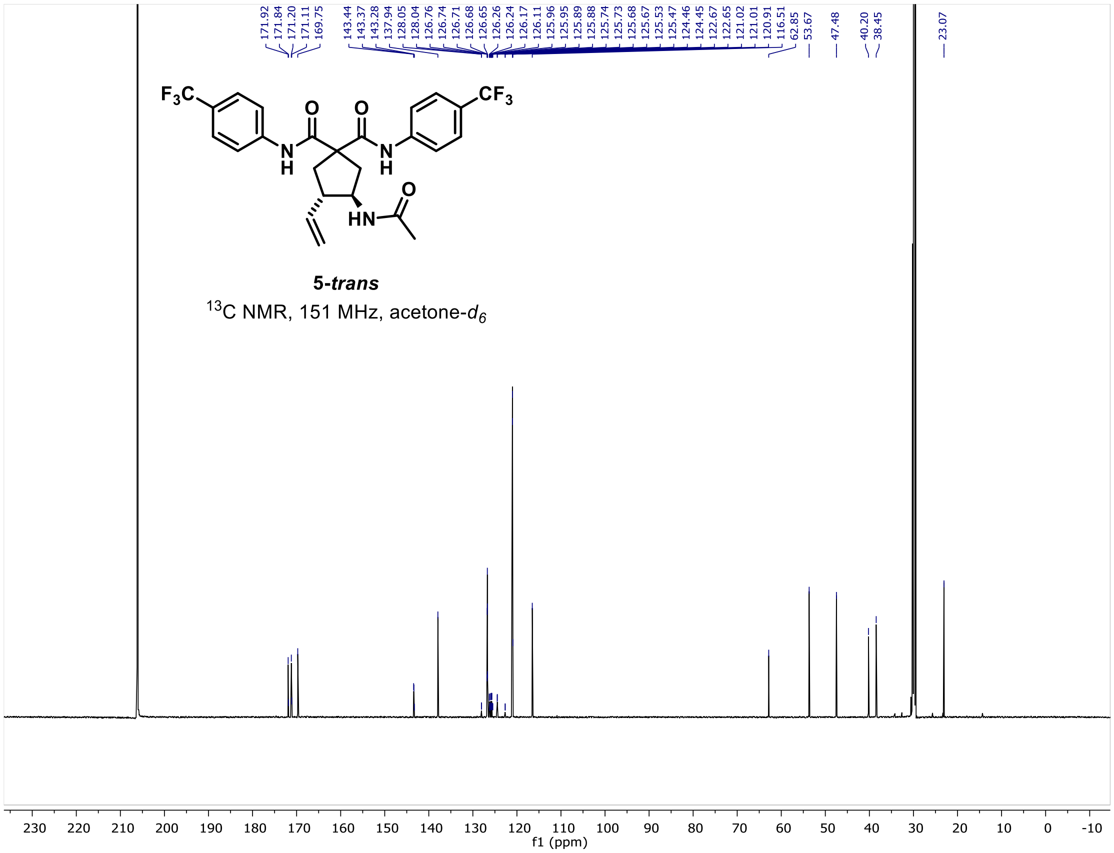
5-*trans* + 5-*cis*

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



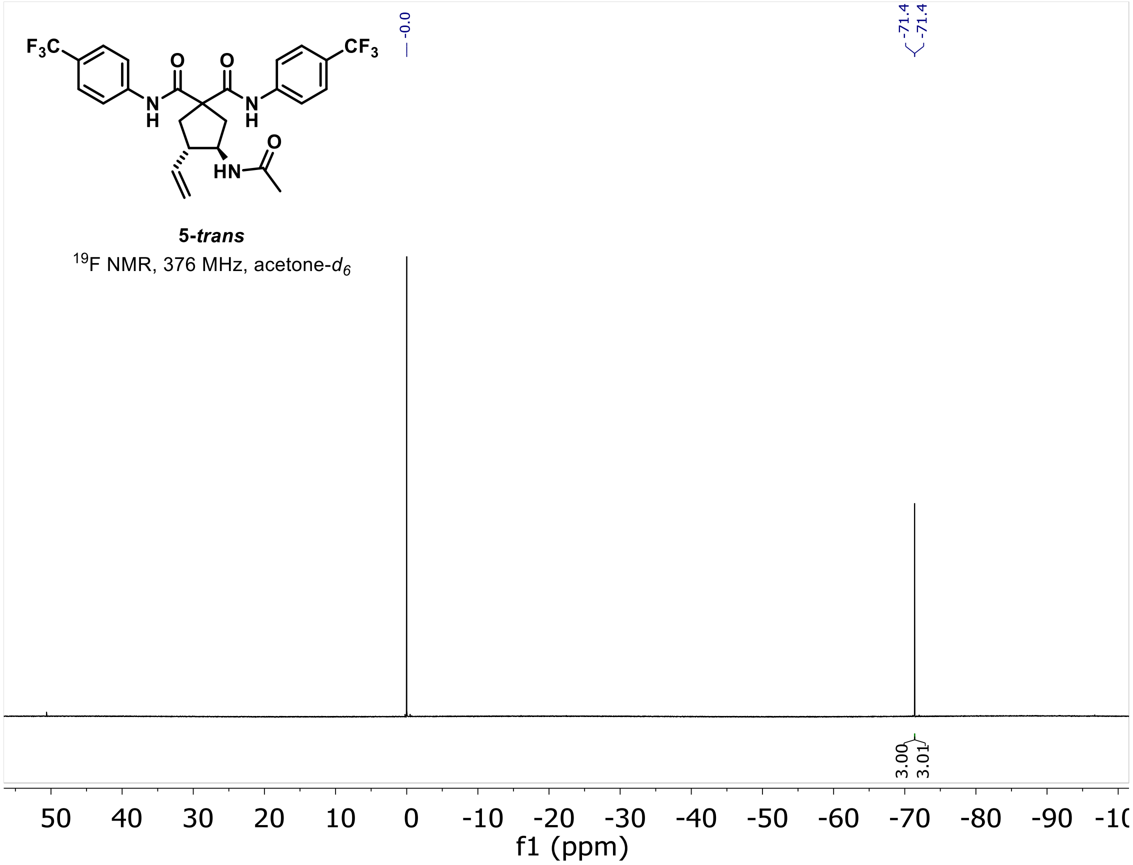
5-*trans*

^{1}H NMR, 600 MHz, acetone-d_6



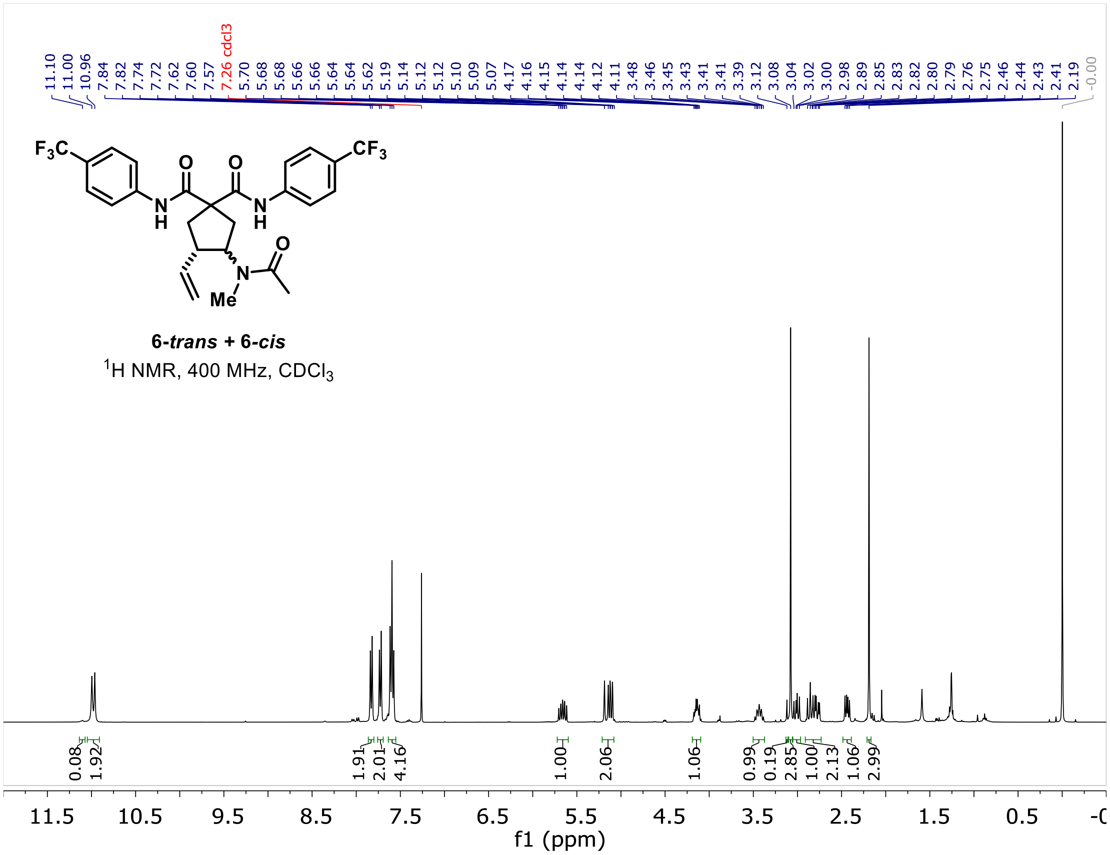
5-*trans*

^{13}C NMR, 151 MHz, acetone-d_6



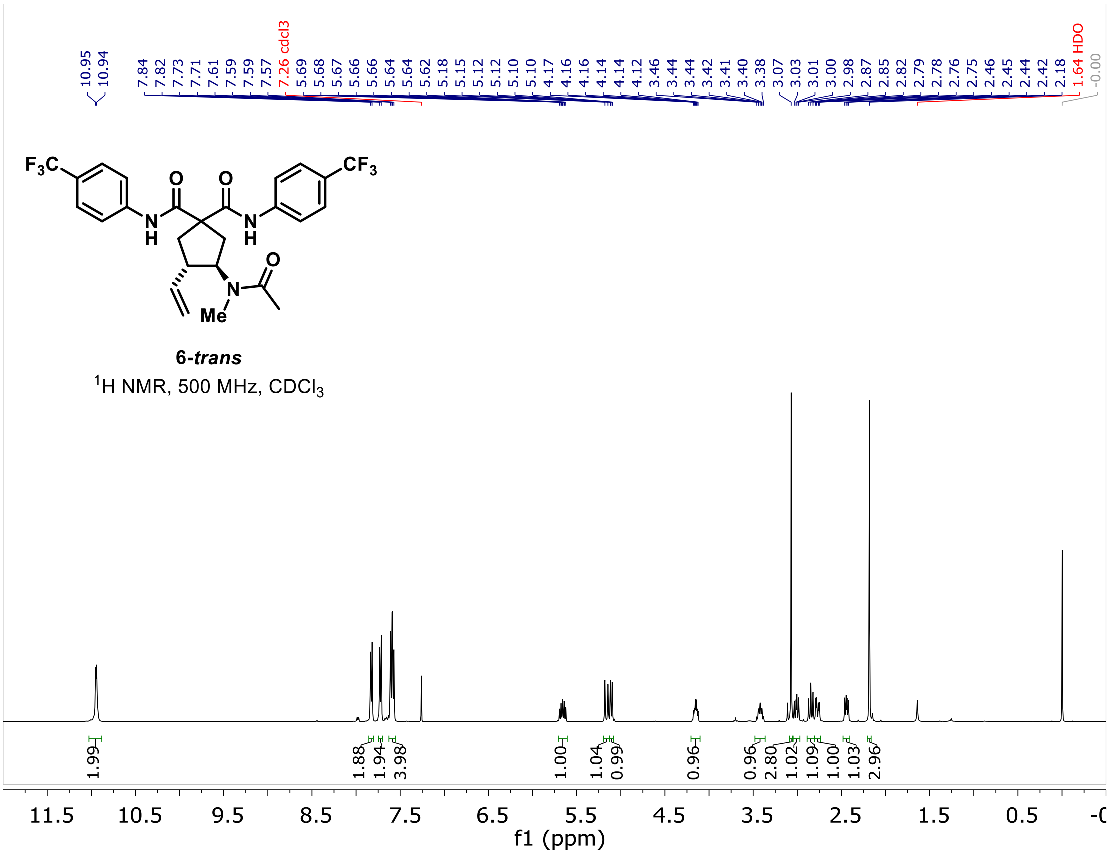
5-*trans*

^{19}F NMR, 376 MHz, acetone-d_6

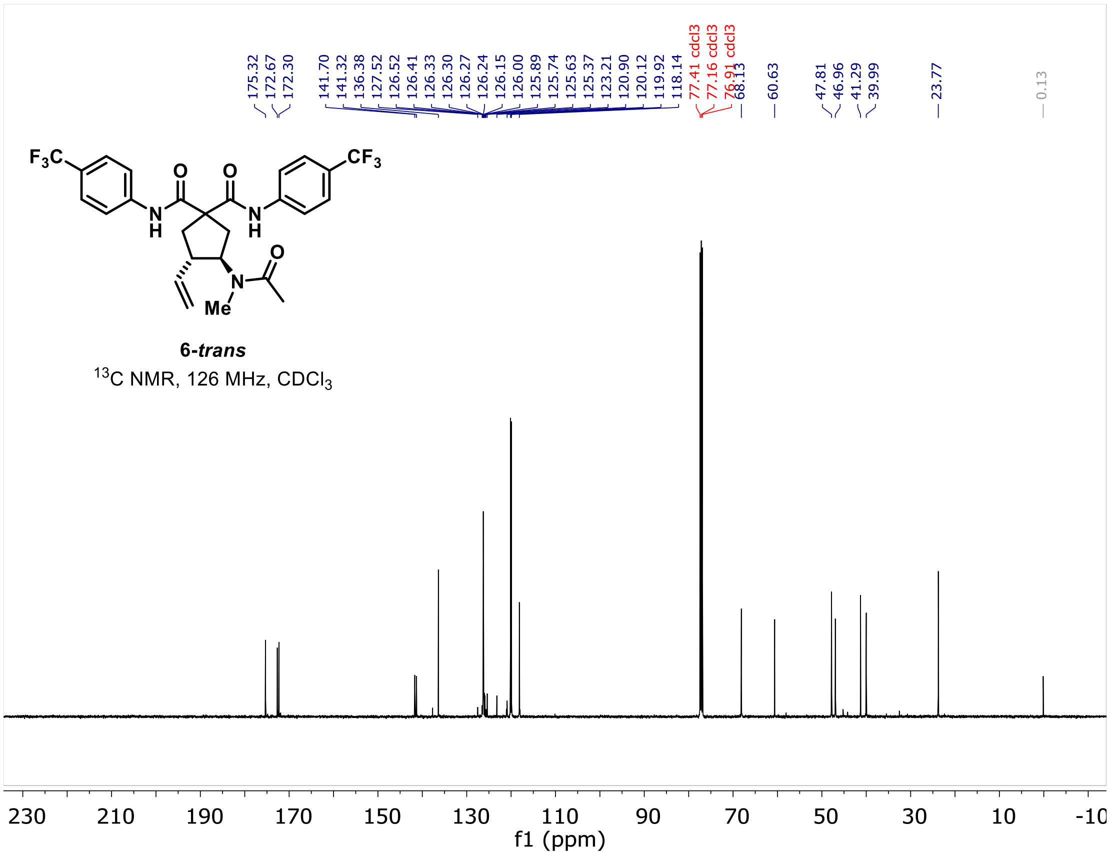


6-*trans* + 6-*cis*

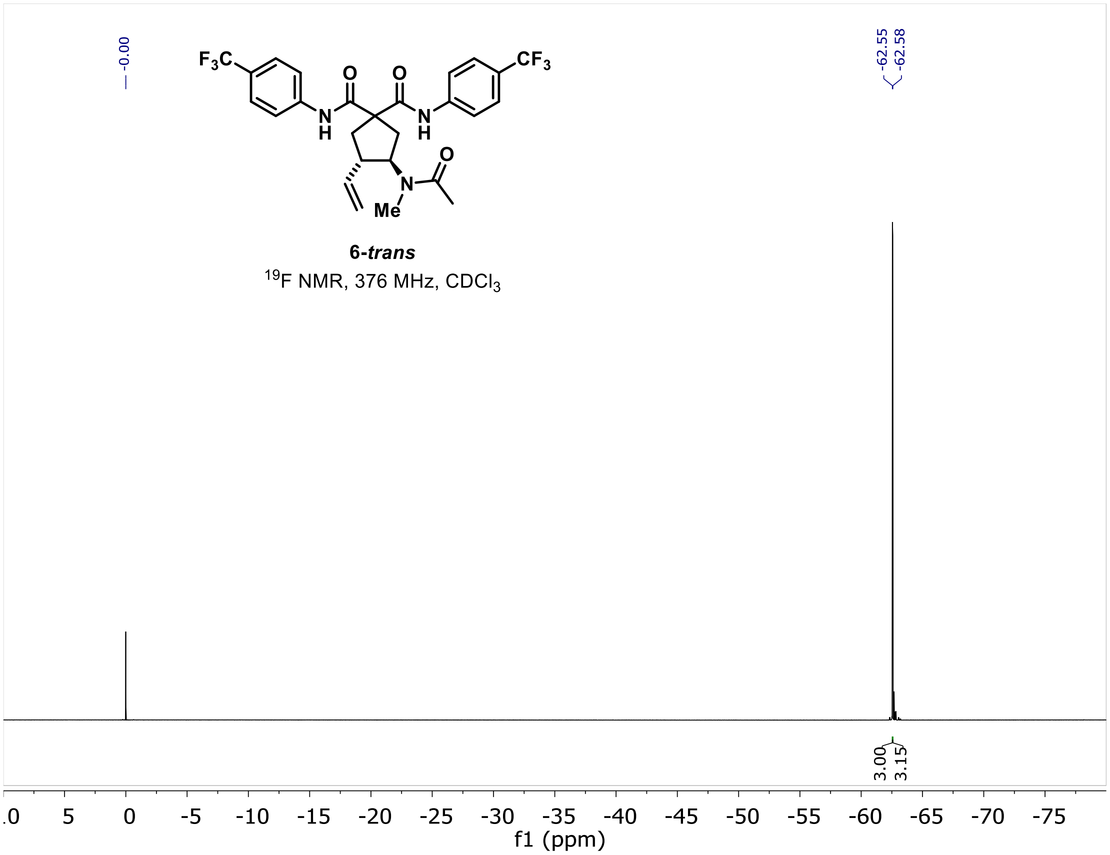
^{1}H NMR, 400 MHz, CDCl$_3$


6-*trans*

^{1}H NMR, 500 MHz, $CDCl_3$

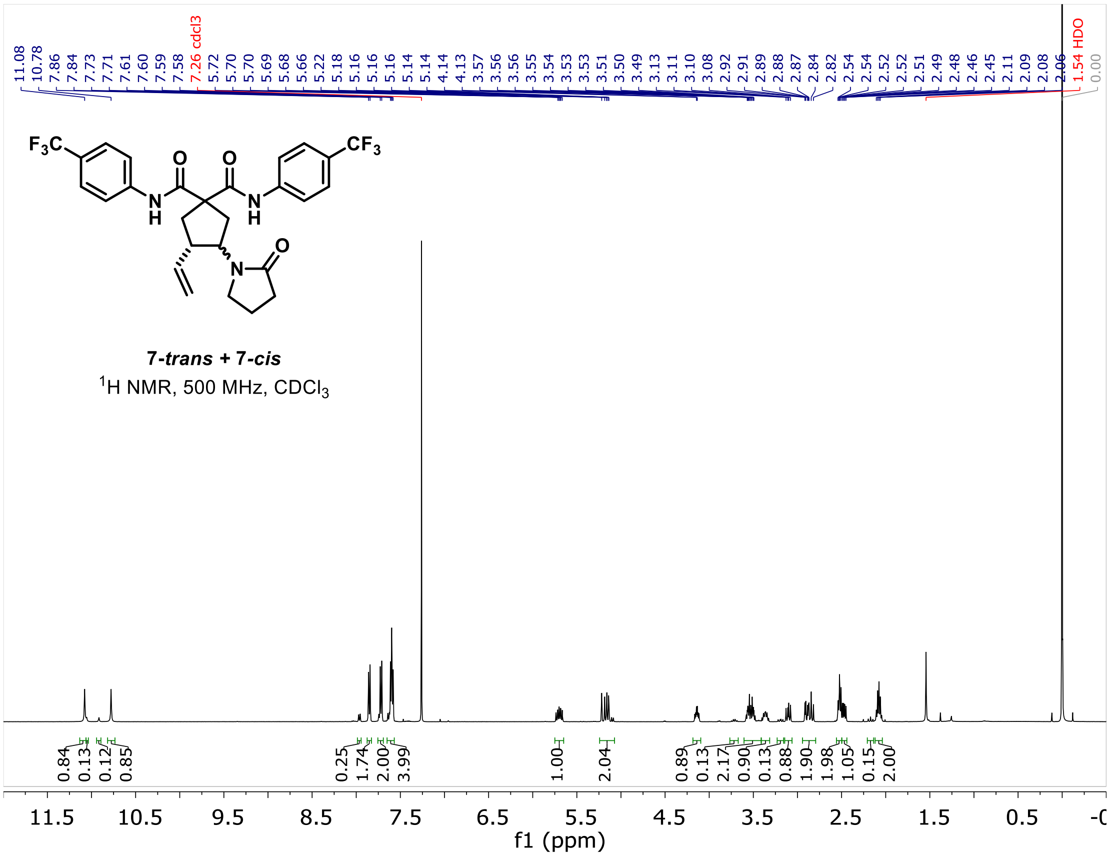

6-*trans*

^{13}C NMR, 126 MHz, $CDCl_3$



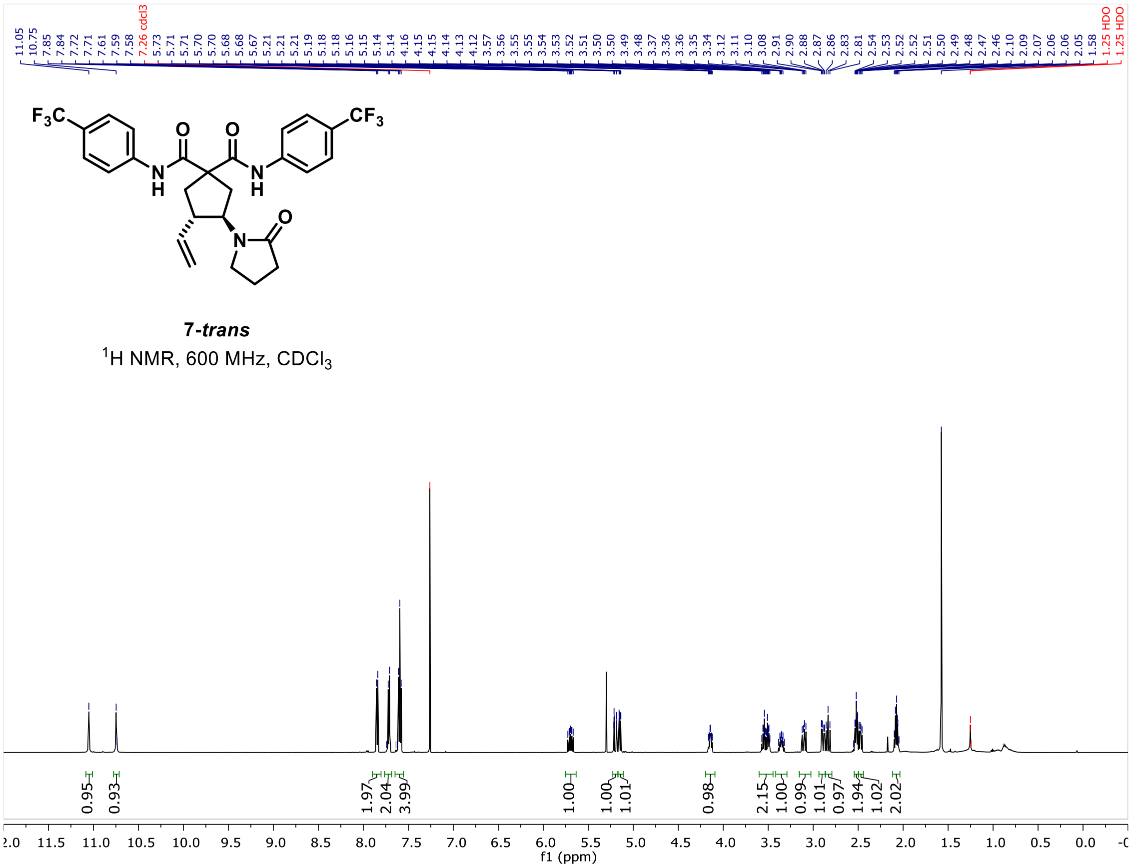
6-*trans*

^{19}F NMR, 376 MHz, $CDCl_3$



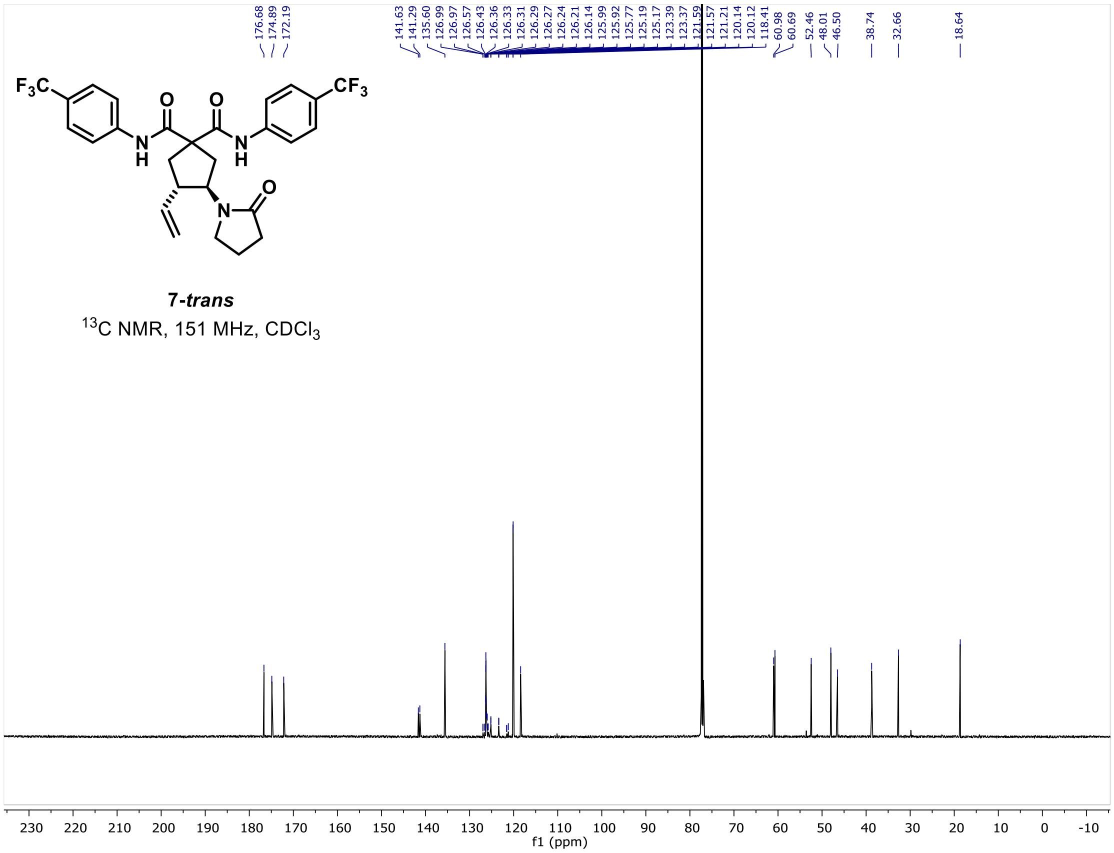
7-*trans* + 7-*cis*

^{1}H NMR, 500 MHz, CDCl$_3$



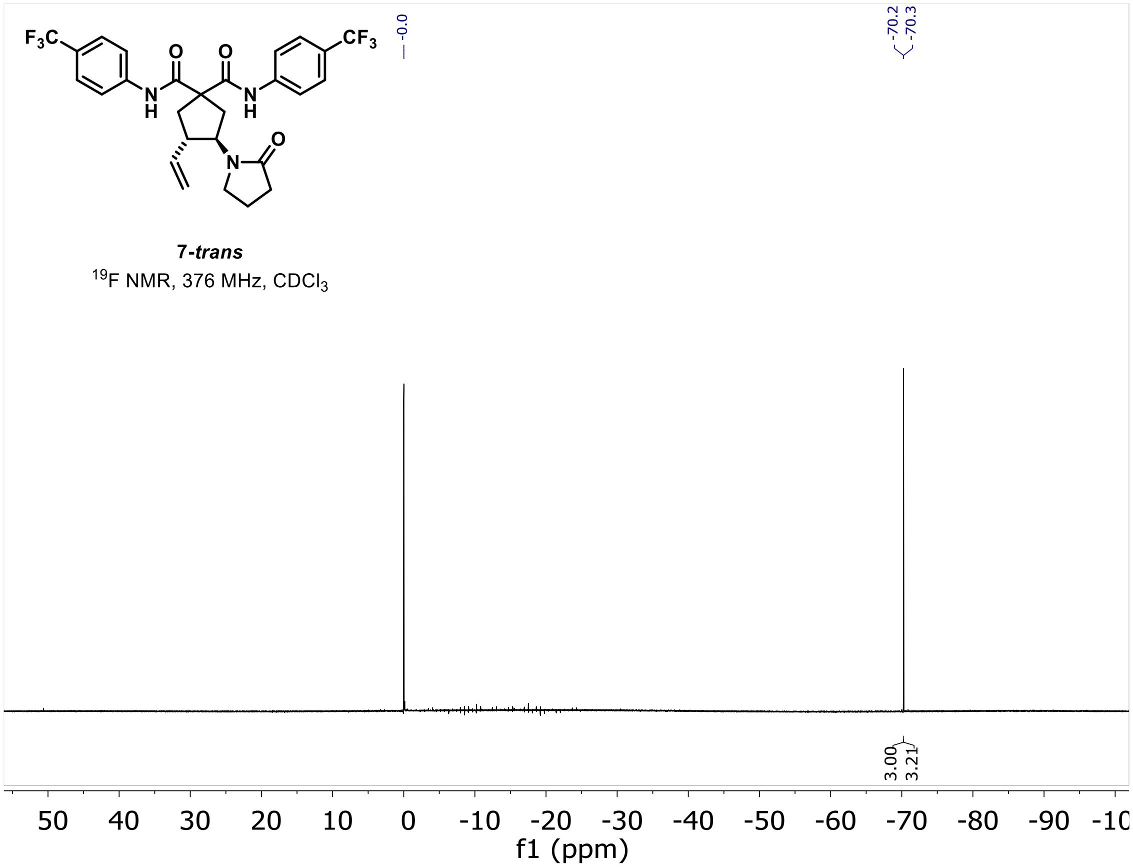
7-trans

^1H NMR, 600 MHz, $CDCl_3$



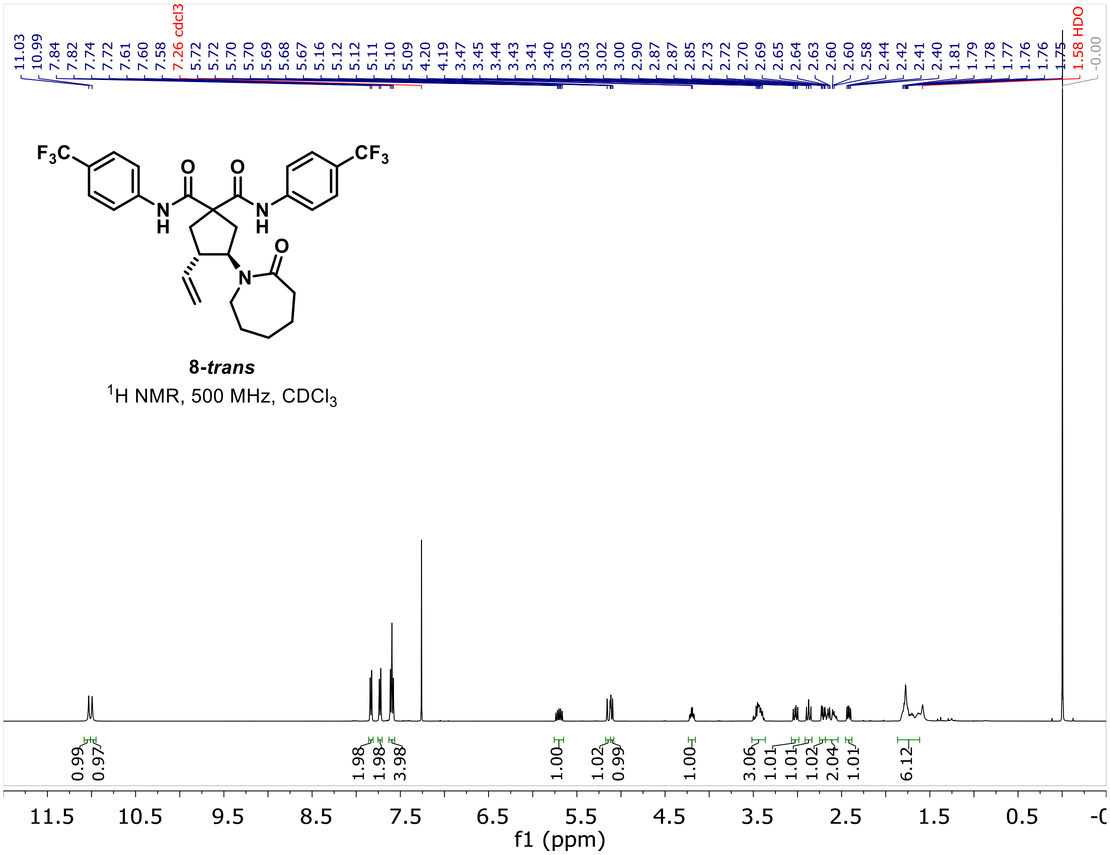
7-trans

^{13}C NMR, 151 MHz, $CDCl_3$



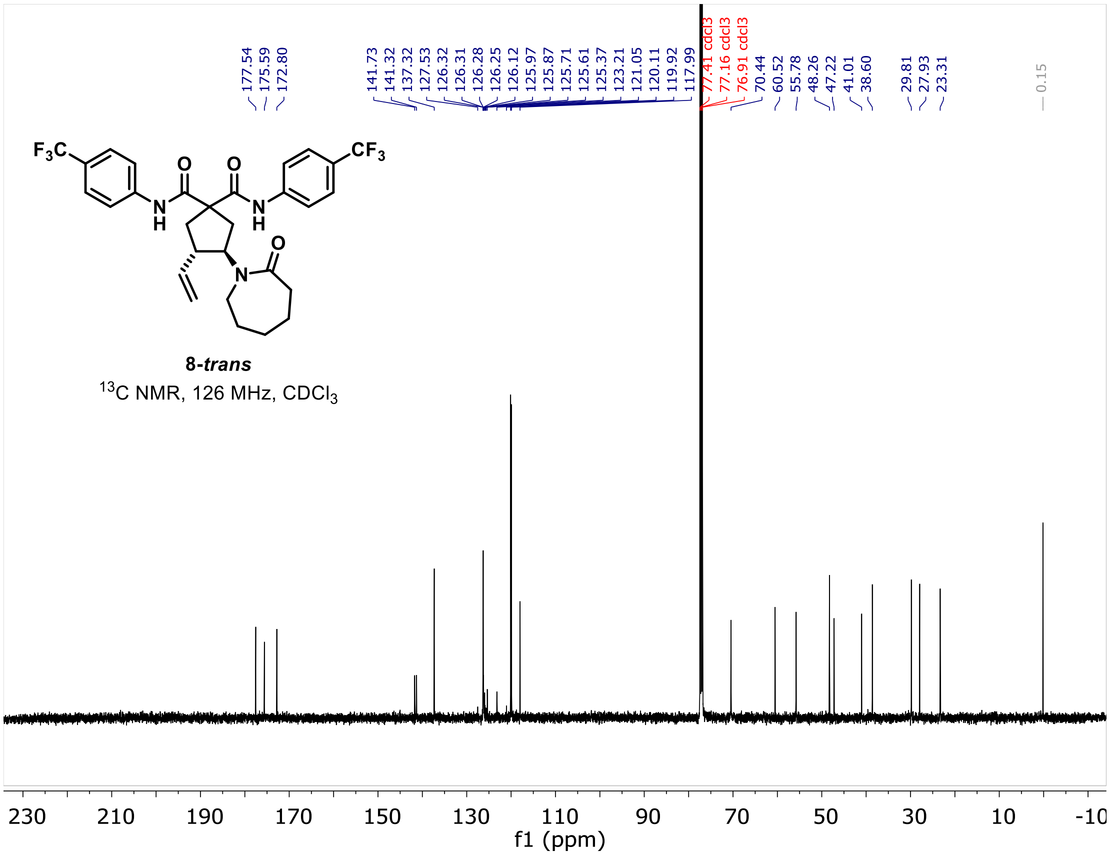
7-trans

^{19}F NMR, 376 MHz, CDCl$_3$



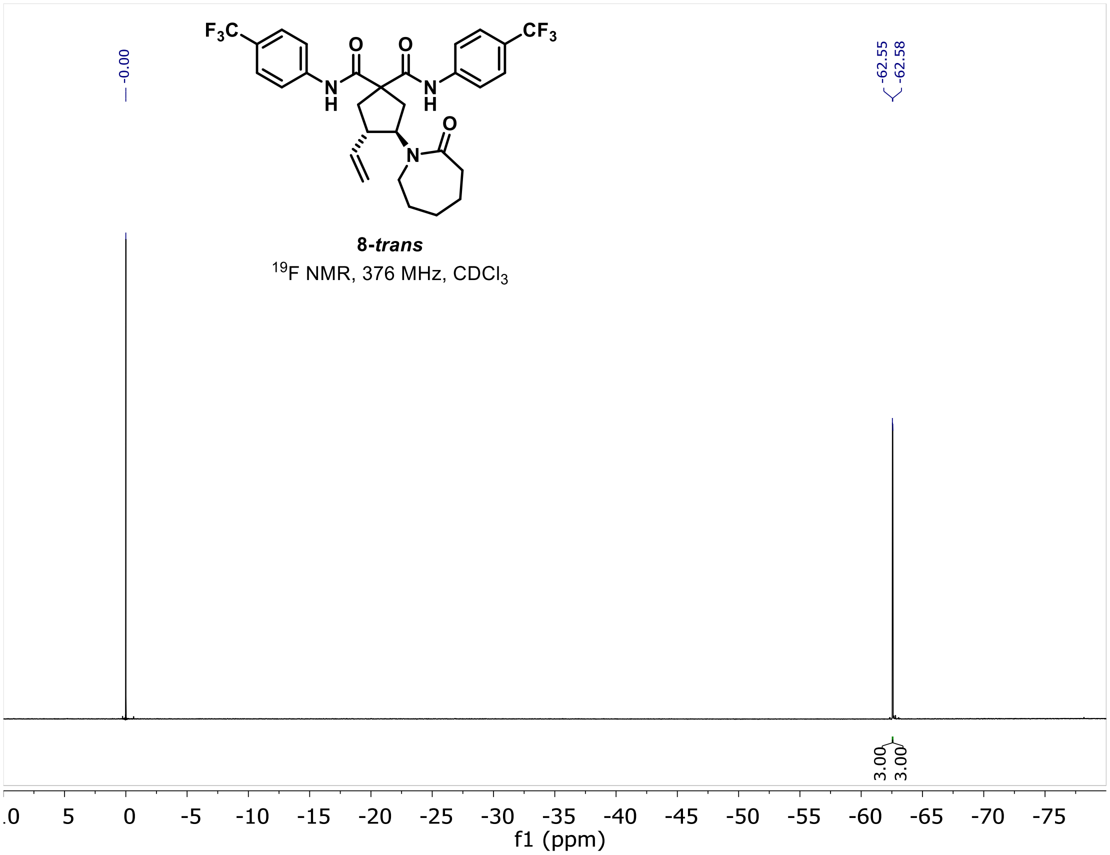
8-*trans*

^{1}H NMR, 500 MHz, CDCl$_3$



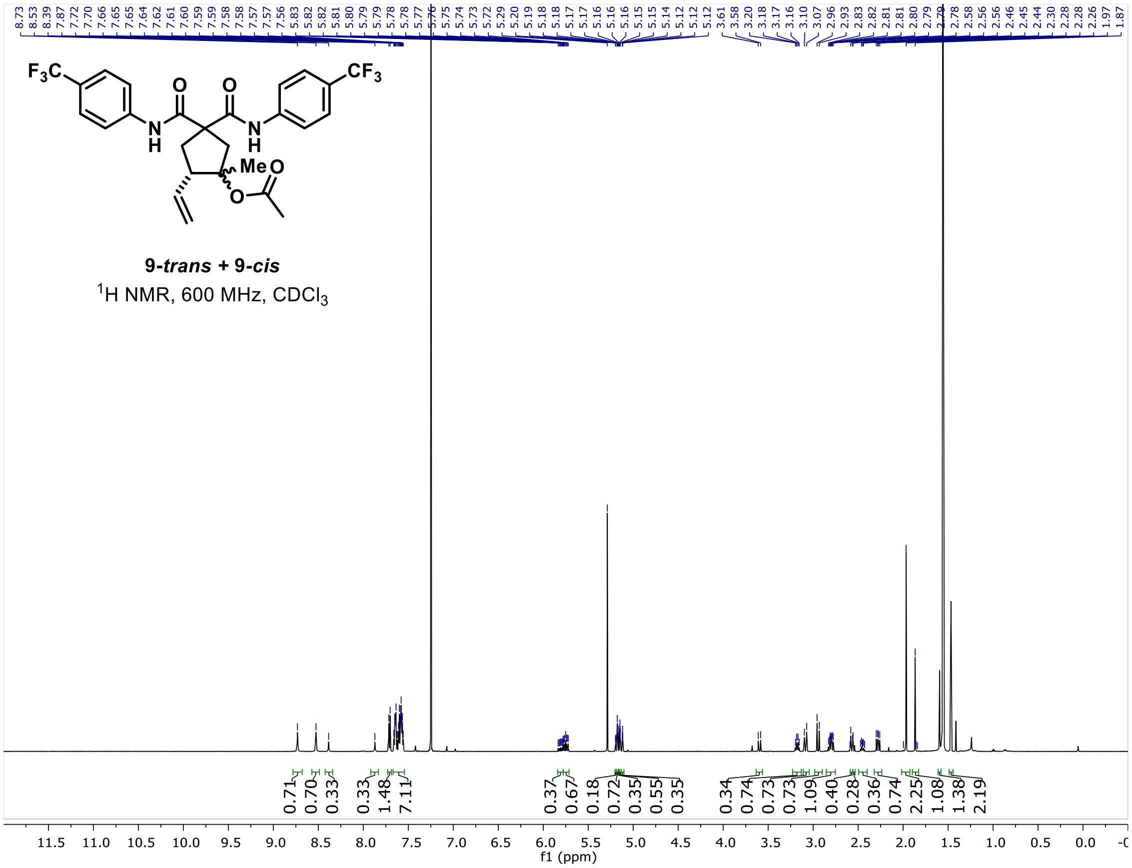
8-*trans*

^{13}C NMR, 126 MHz, CDCl$_3$



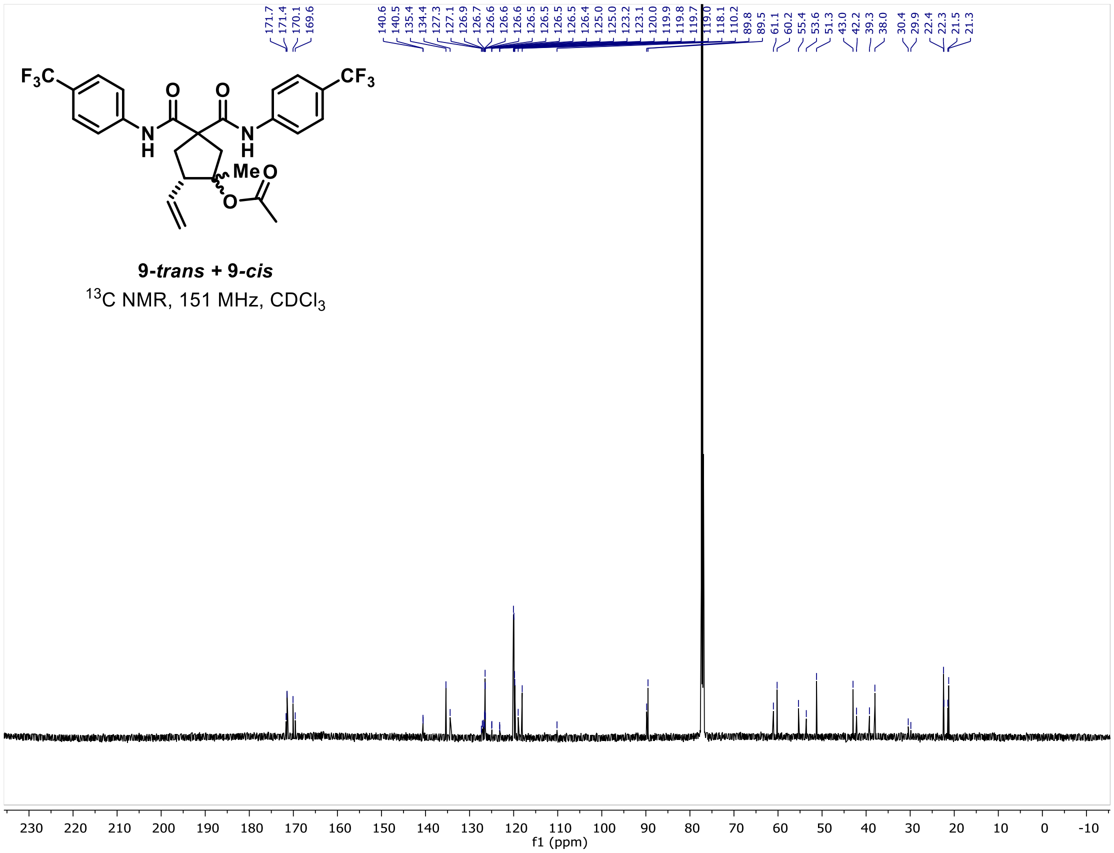
8-*trans*

^{19}F NMR, 376 MHz, CDCl$_3$



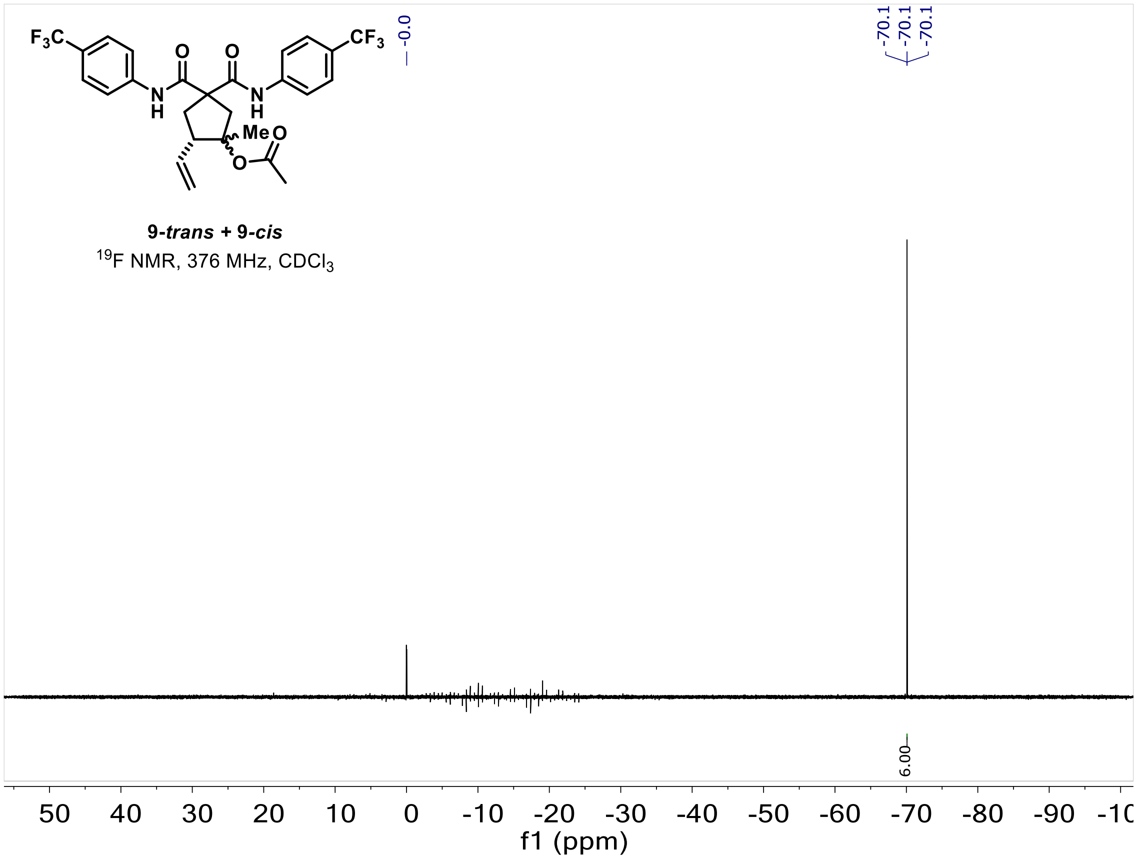
9-*trans* + 9-*cis*

^{1}H NMR, 600 MHz, CDCl$_3$

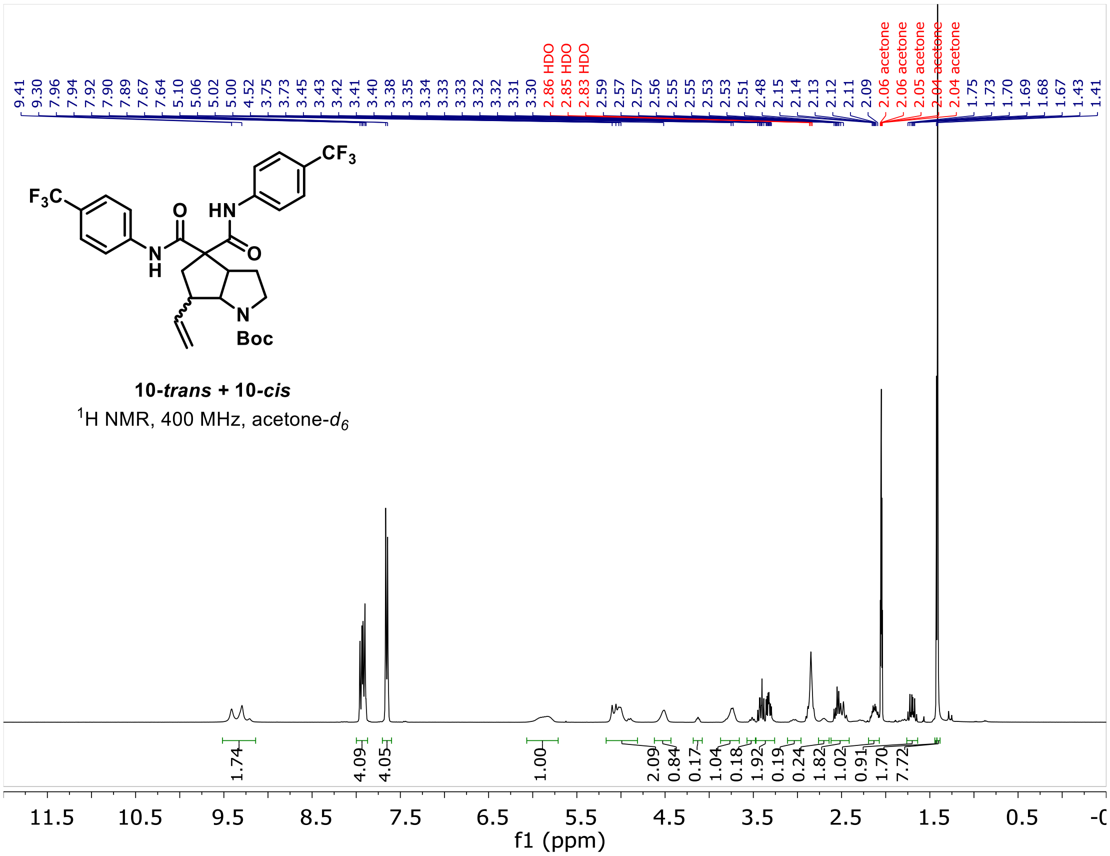


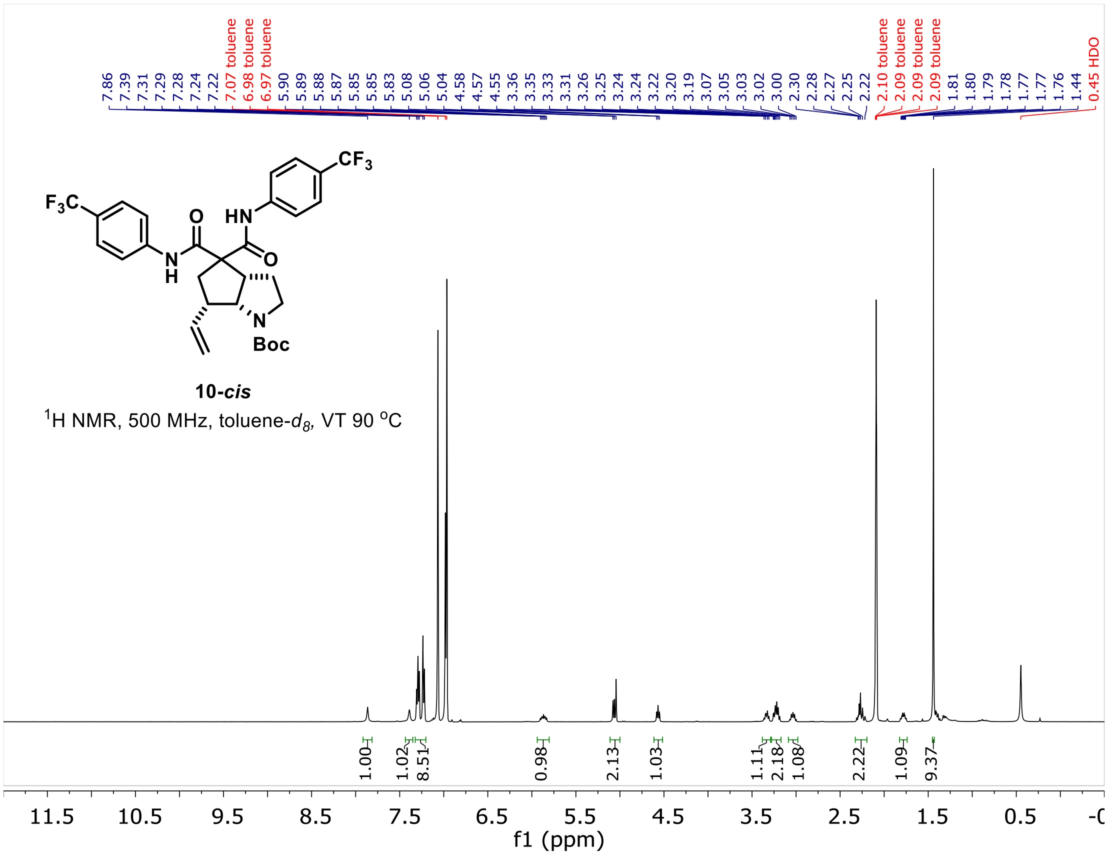
9-*trans* + 9-*cis*

^{13}C NMR, 151 MHz, CDCl$_3$



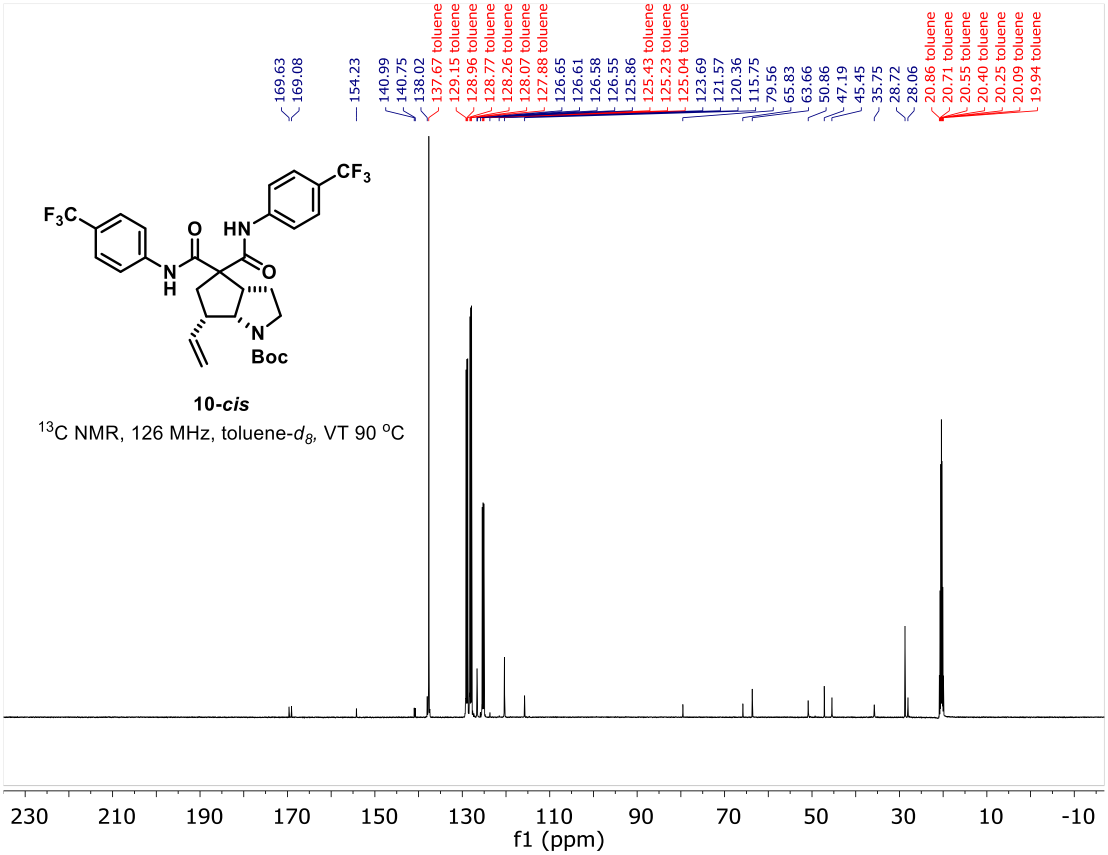
F$_3$C
CF$_3$
O
O
N
H
N
H
Me
O
O
9-*trans* + 9-*cis*
^{19}F NMR, 376 MHz, CDCl$_3$
-0.0
-70.1
-70.1
-70.1
6.00
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
f1 (ppm)


9.41
9.30
7.96
7.94
7.92
7.90
7.89
7.67
7.64
5.10
5.06
5.02
5.00
4.52
3.75
3.73
3.45
3.43
3.42
3.41
3.40
3.38
3.35
3.34
3.33
3.33
3.32
3.32
3.31
3.30
2.86 HDO
2.85 HDO
2.83 HDO
2.59
2.57
2.57
2.56
2.55
2.55
2.53
2.53
2.51
2.48
2.15
2.14
2.13
2.12
2.11
2.09
2.06 acetone
2.06 acetone
2.05 acetone
2.04 acetone
2.04 acetone
1.75
1.73
1.70
1.69
1.68
1.67
1.43
1.41
F_3C
CF_3
O
HN
N
H
O
N
Boc
10-*trans* + 10-*cis*
^{1}H NMR, 400 MHz, acetone-d_6
1.74
4.09
4.05
1.00
2.09
0.84
0.17
1.04
0.18
1.92
0.19
0.24
1.82
1.02
0.91
1.70
7.72
11.5
10.5
9.5
8.5
7.5
6.5
5.5
4.5
3.5
2.5
1.5
0.5
f1 (ppm)



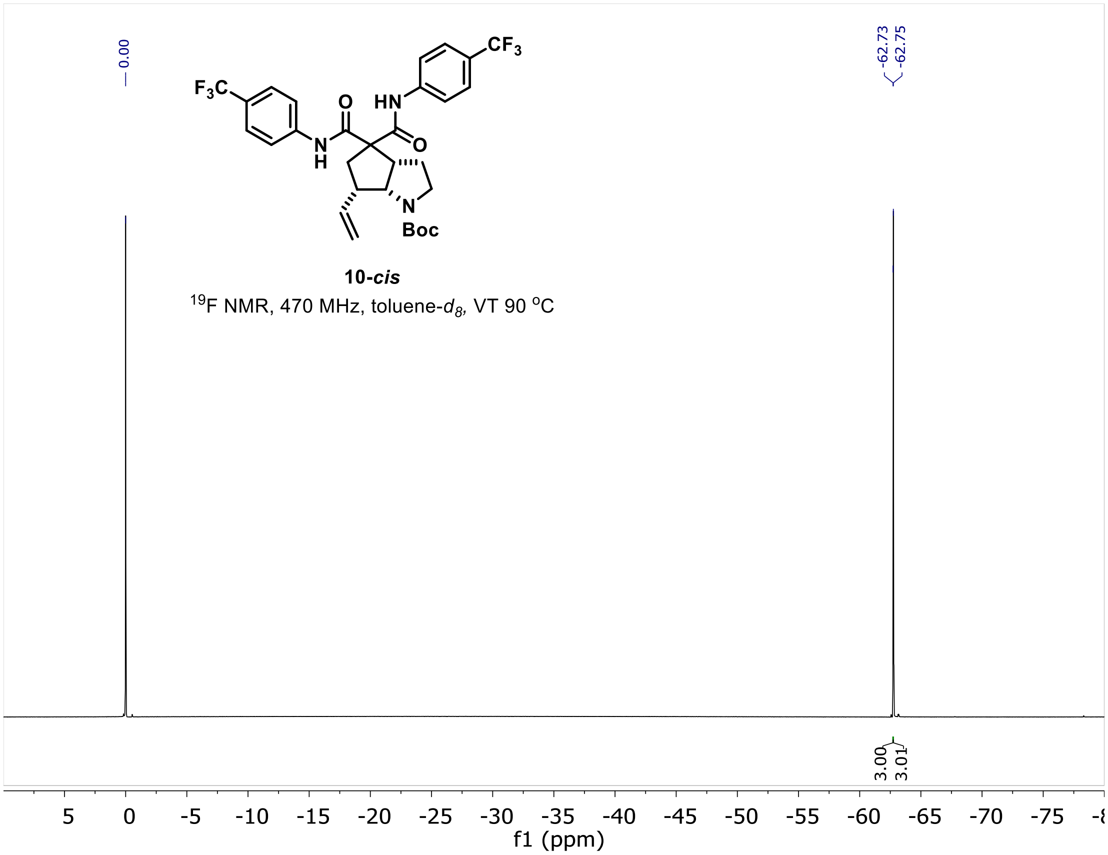
10-*cis*

^{1}H NMR, 500 MHz, toluene-d_8, VT 90 ^{o}C



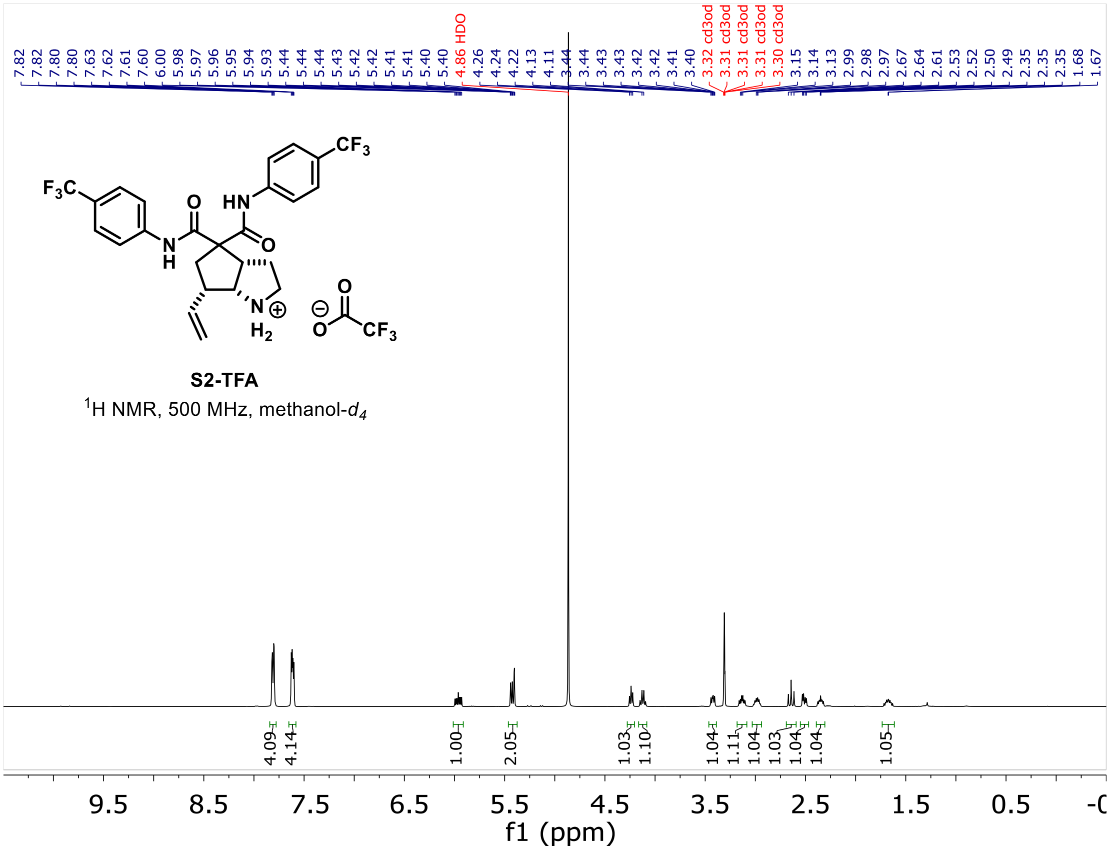
10-*cis*

^{13}C NMR, 126 MHz, toluene-d_8, VT 90 ^{o}C



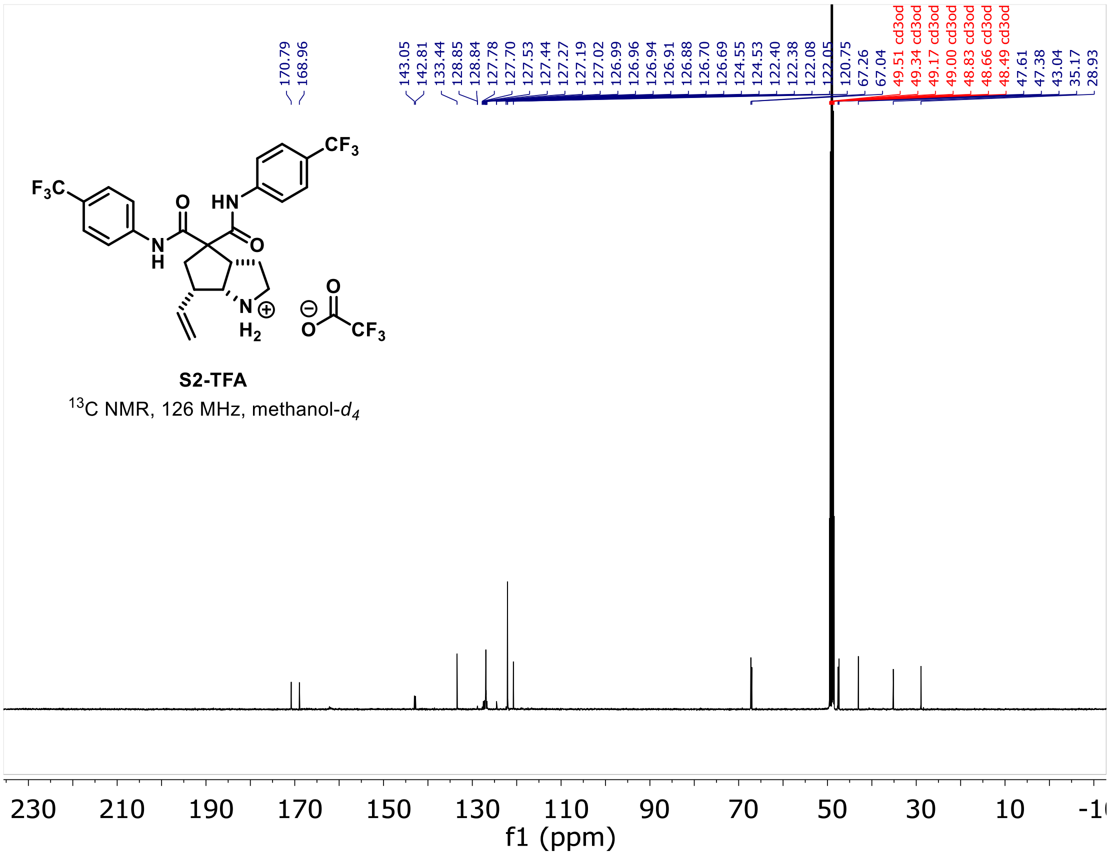
10-*cis*

^{19}F NMR, 470 MHz, toluene-*d$_8$*, VT 90 ^{o}C



S2-TFA

^{1}H NMR, 500 MHz, methanol-*d$_4$*



S2-TFA

^{13}C NMR, 126 MHz, methanol-*d$_4$*

VIII. Crystallographic data

A. Determination of absolute configuration of 2g-*trans*

Enantioenriched **2g-*trans*** (91:9 er) was purified by Preparative HPLC Method B. Crystals suitable for X-ray crystallography were grown by vapor diffusion of pentane into a solution of **2g-*trans*** in EtOAc. Absolute configuration is (3*R*,4*S*).

Low-temperature diffraction data (ω-scans) were collected on a Rigaku MicroMax-007HF diffractometer coupled to a Saturn994+ CCD detector with Cu Kα (λ = 1.54178 Å) for the structure of 007b-17085. The diffraction images were processed and scaled using Rigaku Oxford Diffraction software (CrysAlisPro; Rigaku OD: The Woodlands, TX, 2015). The structure was solved with SHELXT and was refined against F^2 on all data by full-matrix least squares with SHELXL (Sheldrick, G. M. Acta Cryst. 2008, A64, 112–122). All non-hydrogen atoms were refined anisotropically. Hydrogen atoms were included in the model at geometrically calculated positions and refined using a riding model. The isotropic displacement parameters of all hydrogen atoms were fixed to 1.2 times the U value of the atoms to which they are linked (1.5 times for methyl groups). The two of the four aryl ring with CF3 and Br are disordered. The occupancies of the disordered atoms were freely refined to occupancies of 0.930(5) and 0.070(5). The major component has atom label suffixes of "a"; the minor has "b". Chemically equivalent C-C, F-C, and Br-C bonds were restrained to be similar. The thermal ellipsoids of the entire model were restrained to have similar tensor directions; a requirement due to the poor data quality. Additionally, the small occupancy of the disordered aryl required that the thermal ellipsoids be constrained to their chemically equivalent counterparts in the major component. Finally, the tert-butyl group with atoms C24 to C27 is disordered over two positions. The chemically equivalent C-C bonds were restrained to be similar. The full numbering scheme of compound 007b-17085 can be found in the full details of the X-ray structure determination (CIF), which is included as Supporting Information. CCDC number 1577970 (007b-17085) contains the supplementary crystallographic data for this paper. These data can be obtained free of charge from The Cambridge Crystallographic Data Center via www.ccdc.cam.ac.uk/data_request/cif.

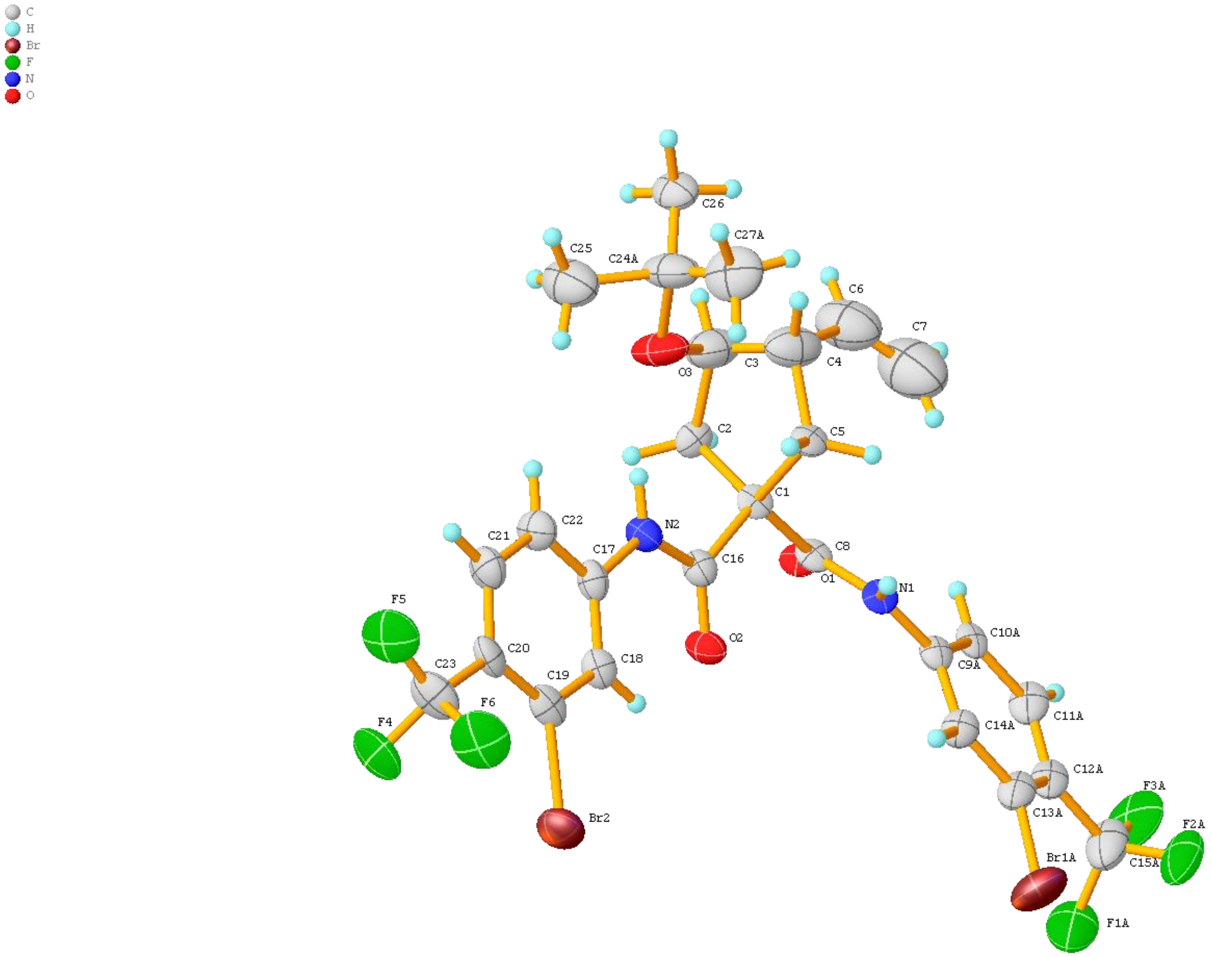


Figure S4. The complete numbering scheme of part 1 of 007b-17085 with 50% thermal ellipsoid probability levels. The hydrogen atoms are shown as spheres for clarity.

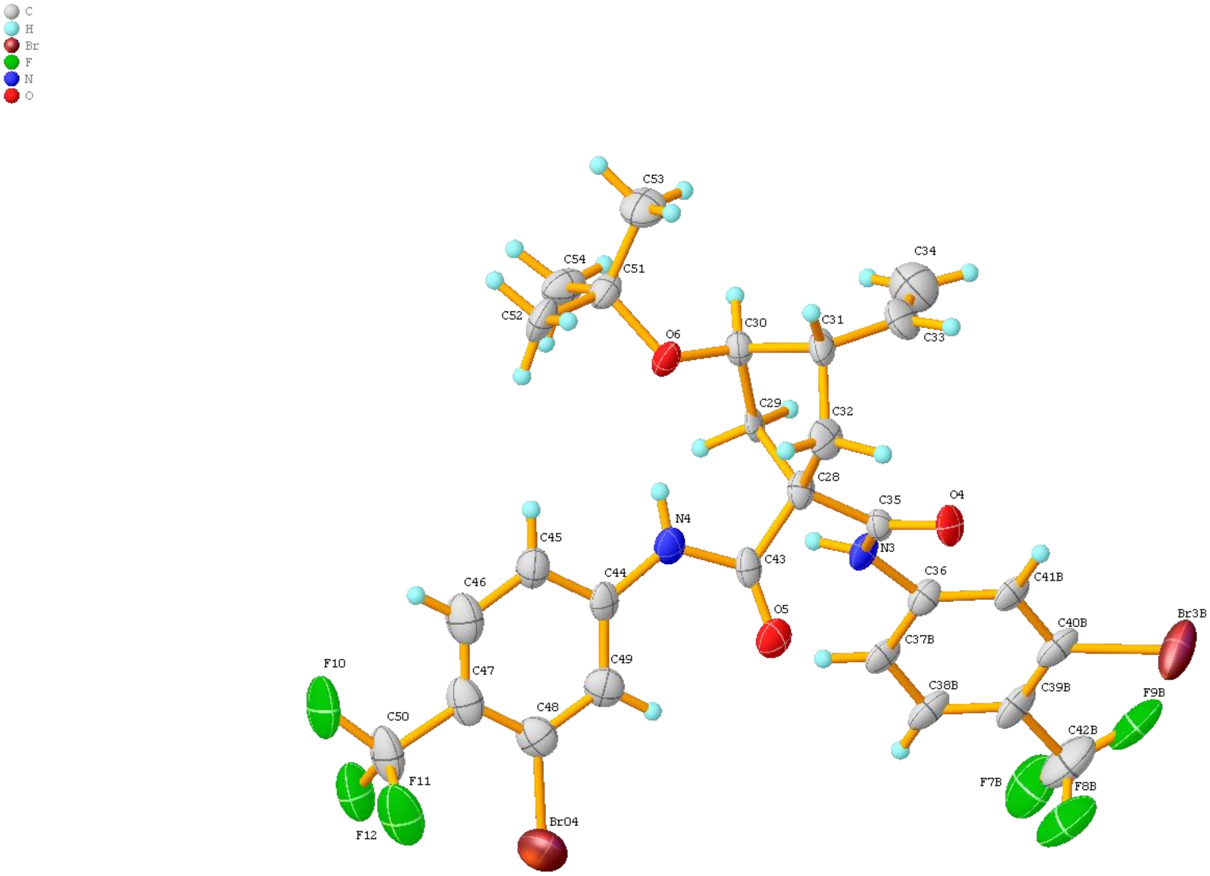


Figure S5. The complete numbering scheme of part 2 of 007b-17085 with 50% thermal ellipsoid probability levels. The hydrogen atoms are shown as spheres for clarity.

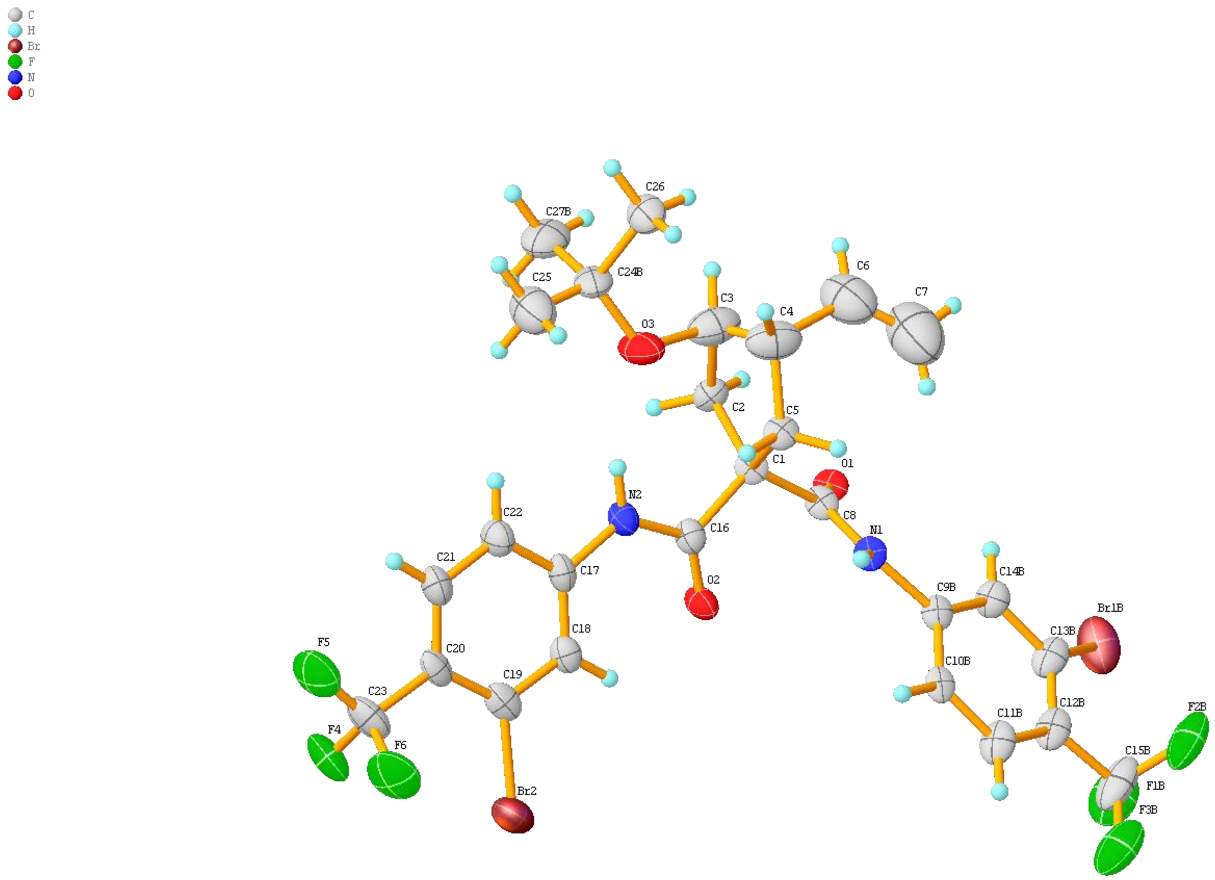


Figure S6. The complete numbering scheme of part 1 of 007b-17085 with 50% thermal ellipsoid probability levels. The hydrogen atoms are shown as spheres for clarity.

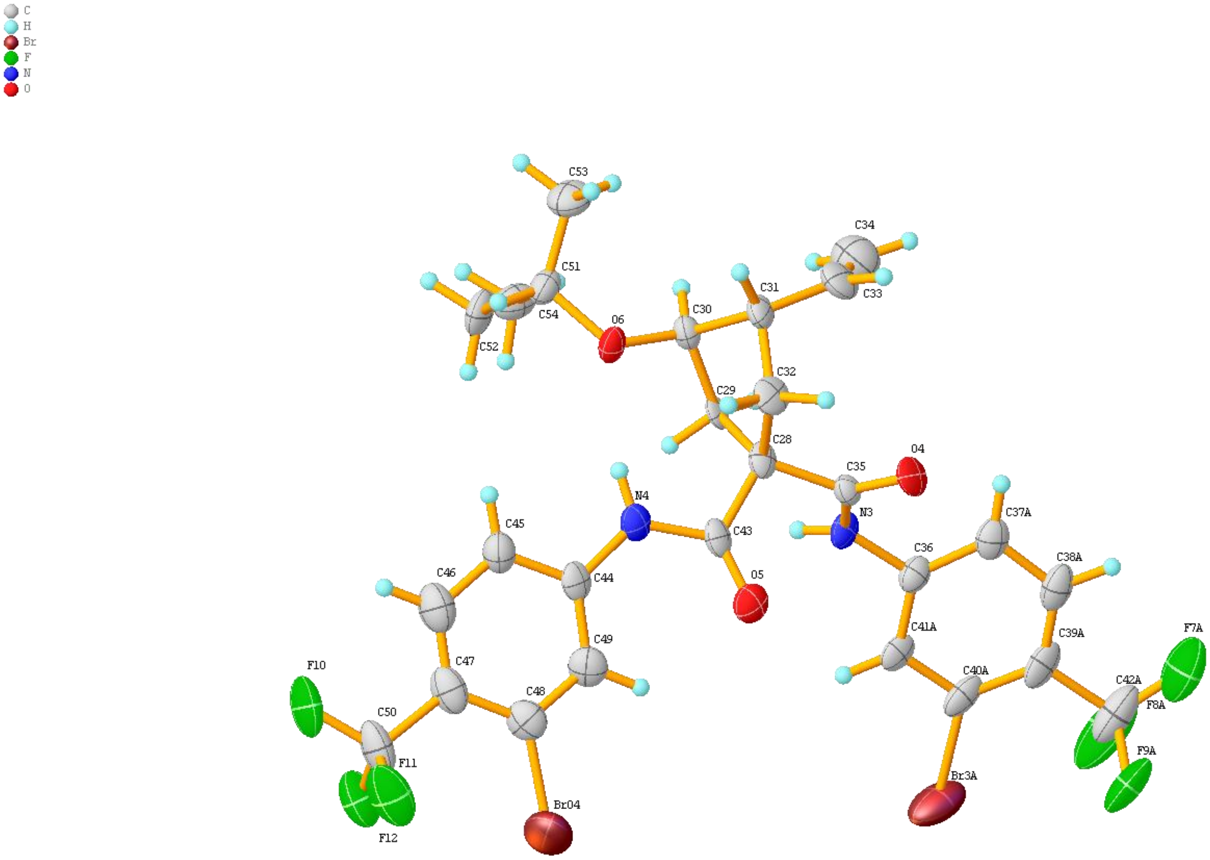


Figure S7. The complete numbering scheme of part 1 of 007b-17085 with 50% thermal ellipsoid probability levels. The hydrogen atoms are shown as spheres for clarity.

Table S3. Crystal data and structure refinement for 007b-17085

Identification code	007b-17085	
Empirical formula	C27 H26 Br2 F6 N2 O3	
Formula weight	700.32	
Temperature	93(2) K	
Wavelength	1.54184 Å	
Crystal system	Orthorhombic	
Space group	$P2_12_12_1$	
Unit cell dimensions	a = 8.8852(2) Å	α= 90°.
	b = 24.6027(7) Å	β= 90°.
	c = 26.0792(7) Å	γ = 90°.
Volume	5700.9(3) Å^3	
Z	8	
Density (calculated)	1.632 Mg/m^3	
Absorption coefficient	4.251 mm^{-1}	
F(000)	2800	
Crystal size	0.300 x 0.010 x 0.010 mm^3	
Crystal color and habit	Colorless Needle	
Diffractometer	Rigaku Saturn 944+ CCD	
Theta range for data collection	2.469 to 66.586°.	
Index ranges	-10<=h<=10, -29<=k<=29, -31<=l<=31	
Reflections collected	204401	
Independent reflections	10085 [R(int) = 0.2362]	
Observed reflections (I > 2sigma(I))	6951	
Completeness to theta = 66.586°	100.0 %	
Absorption correction	Semi-empirical from equivalents	
Max. and min. transmission	1.00000 and 0.66725	
Solution method	SHELXT-2014/5 (Sheldrick, 2014)	
Refinement method	SHELXL-2014/7 (Sheldrick, 2014)	
Data / restraints / parameters	10085 / 997 / 822	
Goodness-of-fit on F^2	1.087	
Final R indices [I>2sigma(I)]	R1 = 0.0750, wR2 = 0.1422	
R indices (all data)	R1 = 0.1167, wR2 = 0.1612	
Absolute structure parameter	0.07(2)	
Largest diff. peak and hole	0.786 and -0.647 e.Å^{-3}	

Table S4. Atomic coordinates (x 10^4) and equivalent isotropic displacement parameters ($Å^2$x 10^3) for 007b-17085. U(eq) is defined as one third of the trace of the orthogonalized U^{ij} tensor.

	x	y	z	U(eq)
C(1)	7009(13)	5602(5)	3409(5)	25(2)
O(1)	4659(10)	5381(3)	2995(3)	29(2)
Br(2)	9508(2)	3438(1)	5008(1)	52(1)
N(1)	6746(11)	4961(4)	2704(4)	25(2)
N(2)	8303(13)	5352(4)	4202(4)	32(2)
O(2)	6879(12)	4711(4)	3796(3)	38(2)
C(2)	6144(15)	6088(5)	3663(5)	32(3)
O(3)	8589(12)	6497(4)	3997(4)	61(3)
C(3)	7225(18)	6575(6)	3573(6)	63(3)
F(4)	10363(12)	3933(4)	6125(3)	63(3)
C(4)	8181(18)	6480(6)	3167(7)	62(4)
C(5)	8442(15)	5860(5)	3154(5)	32(3)
F(5)	12068(13)	4549(4)	6096(4)	71(3)
F(6)	12270(12)	3837(4)	5648(4)	75(3)
C(6)	6880(20)	6687(8)	2713(8)	85(5)
C(7)	6440(30)	6414(10)	2322(8)	114(8)
C(8)	6019(14)	5307(5)	3015(5)	28(2)
C(16)	7400(15)	5177(6)	3818(5)	31(3)
C(17)	8976(15)	5033(5)	4596(5)	32(3)
C(18)	8877(15)	4480(6)	4614(5)	33(3)
C(19)	9654(14)	4212(5)	5011(6)	35(3)
C(20)	10471(16)	4491(5)	5390(5)	33(3)
C(21)	10552(18)	5046(6)	5345(6)	42(3)
C(22)	9791(16)	5318(5)	4961(6)	40(3)
C(23)	11320(19)	4208(7)	5815(7)	52(3)
C(25)	10150(20)	6845(8)	4615(7)	74(5)
C(26)	9533(19)	7424(6)	3869(6)	48(3)
Br(1A)	6978(3)	3018(1)	1976(1)	72(1)
F(1A)	3709(16)	3002(7)	1539(6)	76(4)
F(2A)	5128(17)	3285(5)	945(5)	75(4)
F(3A)	3050(16)	3691(6)	1040(5)	91(4)

C(9A)	6136(17)	4620(6)	2359(7)	28(3)
C(10A)	4923(14)	4772(6)	2037(5)	28(3)
C(11A)	4349(18)	4392(6)	1694(6)	42(3)
C(12A)	4861(17)	3862(6)	1665(6)	39(3)
C(13A)	6087(17)	3715(6)	1968(6)	41(3)
C(14A)	6671(18)	4092(6)	2311(6)	35(3)
C(15A)	4191(19)	3470(7)	1309(6)	66(4)
C(24A)	10170(40)	6873(12)	4003(13)	62(6)
C(27A)	11440(40)	6733(15)	3728(13)	72(8)
F(1B)	3480(110)	3120(60)	1390(50)	76(4)
Br(1B)	2687(16)	4131(8)	1435(6)	60(5)
F(2B)	4860(150)	3510(50)	840(40)	75(4)
F(3B)	6020(90)	2850(30)	1290(30)	77(12)
C(9B)	6280(100)	4520(30)	2320(40)	28(3)
C(14B)	5020(80)	4550(30)	2010(40)	35(3)
C(13B)	4670(50)	4130(40)	1680(30)	41(3)
C(12B)	5580(80)	3670(30)	1670(30)	39(3)
C(11B)	6840(80)	3630(30)	1980(30)	42(3)
C(10B)	7190(80)	4060(40)	2310(30)	28(3)
C(15B)	4960(100)	3250(30)	1300(30)	64(6)
C(24B)	9040(40)	6977(11)	4257(11)	45(5)
C(27B)	7650(40)	7254(13)	4586(14)	63(8)
N(3)	1845(13)	4979(4)	2706(4)	30(2)
N(4)	3318(12)	4597(5)	4179(4)	32(2)
O(4)	-346(10)	4562(4)	2943(4)	38(2)
Br(04)	4324(2)	6502(1)	5016(1)	76(1)
O(5)	1709(11)	5218(4)	3827(4)	38(2)
O(6)	4068(8)	3473(3)	3857(3)	31(2)
F(7A)	-1777(17)	6289(6)	1038(5)	90(4)
F(8A)	286(18)	6723(7)	977(5)	110(5)
F(9A)	-1308(14)	6956(5)	1540(5)	77(3)
F(10)	7181(11)	5421(5)	6045(4)	70(3)
F(11)	5400(13)	6005(5)	6101(4)	77(3)
F(12)	7251(11)	6147(4)	5587(4)	67(3)
C(28)	1955(15)	4348(5)	3413(5)	29(2)
C(29)	3385(13)	4082(5)	3171(5)	25(2)

C(30)	3411(13)	3500(5)	3368(4)	29(2)
C(31)	1658(13)	3355(5)	3384(5)	35(3)
C(32)	1081(16)	3862(6)	3642(6)	39(3)
C(33)	869(15)	3257(5)	2888(5)	46(3)
C(34)	1390(20)	3212(7)	2457(7)	71(5)
C(35)	1018(14)	4642(5)	3004(5)	26(2)
C(37A)	67(15)	5193(6)	2002(5)	38(3)
C(38A)	-565(19)	5591(6)	1686(6)	44(4)
C(39A)	7(17)	6117(6)	1676(7)	45(3)
C(40A)	1150(16)	6251(6)	2013(7)	41(3)
C(41A)	1768(16)	5884(5)	2349(6)	32(3)
C(42A)	-712(18)	6528(7)	1305(7)	69(4)
C(43)	2297(14)	4780(6)	3817(5)	30(3)
C(44)	3950(15)	4903(6)	4579(5)	31(3)
C(45)	4845(15)	4632(6)	4929(6)	41(3)
C(46)	5570(20)	4919(7)	5310(7)	54(4)
C(47)	5448(19)	5466(7)	5345(5)	46(3)
C(48)	4537(17)	5746(6)	4999(6)	43(3)
C(49)	3821(18)	5467(6)	4625(6)	42(3)
C(50)	6296(19)	5760(8)	5772(6)	56(3)
C(51)	5208(15)	3062(5)	3953(5)	35(3)
C(52)	5530(15)	3111(6)	4515(5)	45(3)
C(53)	4714(19)	2497(6)	3814(6)	51(4)
C(54)	6623(16)	3235(6)	3641(6)	45(3)
Br(3A)	1952(3)	6966(1)	2051(1)	79(1)
C(37B)	2050(90)	5830(20)	2320(50)	32(3)
C(36)	1192(14)	5358(5)	2335(5)	33(3)
C(41B)	-120(90)	5320(30)	2050(40)	32(3)
C(40B)	-570(120)	5750(50)	1740(60)	41(3)
C(39B)	290(130)	6220(50)	1720(70)	45(3)
C(38B)	1600(130)	6260(30)	2010(70)	41(3)
Br(3B)	-2460(30)	5733(12)	1392(12)	65(9)
C(42B)	-180(190)	6680(40)	1350(40)	80(7)
F(7B)	900(190)	6990(70)	1160(70)	90(4)
F(8B)	-900(200)	6920(70)	1750(60)	86(13)
F(9B)	-800(190)	6520(60)	910(60)	77(3)

Table S5. Bond lengths [Å] and angles [°] for 007b-17085.

C(1)-C(16)	1.533(18)
C(1)-C(8)	1.537(17)
C(1)-C(2)	1.568(18)
C(1)-C(5)	1.571(17)
O(1)-C(8)	1.223(14)
Br(2)-C(19)	1.909(13)
N(1)-C(8)	1.341(16)
N(1)-C(9A)	1.344(17)
N(1)-C(9B)	1.53(5)
N(1)-H(1)	0.8800
N(2)-C(16)	1.354(17)
N(2)-C(17)	1.425(16)
N(2)-H(2)	0.8800
O(2)-C(16)	1.239(17)
C(2)-C(3)	1.554(19)
C(2)-H(2A)	0.9900
C(2)-H(2B)	0.9900
O(3)-C(24B)	1.42(3)
O(3)-C(3)	1.65(2)
O(3)-C(24A)	1.68(3)
C(3)-C(4)	1.38(2)
C(3)-H(3)	1.0000
F(4)-C(23)	1.354(19)
C(4)-C(5)	1.542(19)
C(4)-C(6)	1.73(3)
C(4)-H(4)	1.0000
C(5)-H(5A)	0.9900
C(5)-H(5B)	0.9900
F(5)-C(23)	1.30(2)
F(6)-C(23)	1.318(19)
C(6)-C(7)	1.28(3)
C(6)-H(6)	0.9500
C(7)-H(7A)	0.9500
C(7)-H(7B)	0.9500

C(17)-C(18)	1.363(18)
C(17)-C(22)	1.386(19)
C(18)-C(19)	1.408(19)
C(18)-H(18)	0.9500
C(19)-C(20)	1.41(2)
C(20)-C(21)	1.372(18)
C(20)-C(23)	1.51(2)
C(21)-C(22)	1.38(2)
C(21)-H(21)	0.9500
C(22)-H(22)	0.9500
C(25)-C(24B)	1.40(3)
C(25)-C(24A)	1.60(4)
C(25)-H(25A)	0.9800
C(25)-H(25B)	0.9800
C(25)-H(25C)	0.9800
C(25)-H(25D)	0.9800
C(25)-H(25E)	0.9800
C(25)-H(25F)	0.9800
C(26)-C(24A)	1.51(3)
C(26)-C(24B)	1.56(3)
C(26)-H(26A)	0.9800
C(26)-H(26B)	0.9800
C(26)-H(26C)	0.9800
C(26)-H(26D)	0.9800
C(26)-H(26E)	0.9800
C(26)-H(26F)	0.9800
Br(1A)-C(13A)	1.888(16)
F(1A)-C(15A)	1.367(17)
F(2A)-C(15A)	1.342(16)
F(3A)-C(15A)	1.349(17)
C(9A)-C(14A)	1.389(14)
C(9A)-C(10A)	1.415(14)
C(10A)-C(11A)	1.392(14)
C(10A)-H(10A)	0.9500
C(11A)-C(12A)	1.382(15)
C(11A)-H(11A)	0.9500

C(12A)-C(13A)	1.394(15)
C(12A)-C(15A)	1.47(2)
C(13A)-C(14A)	1.390(14)
C(14A)-H(14A)	0.9500
C(24A)-C(27A)	1.38(5)
C(27A)-H(27A)	0.9800
C(27A)-H(27B)	0.9800
C(27A)-H(27C)	0.9800
F(1B)-C(15B)	1.37(2)
Br(1B)-C(13B)	1.87(3)
F(2B)-C(15B)	1.37(2)
F(3B)-C(15B)	1.37(2)
C(9B)-C(14B)	1.3900
C(9B)-C(10B)	1.3900
C(14B)-C(13B)	1.3900
C(14B)-H(14B)	0.9500
C(13B)-C(12B)	1.3900
C(12B)-C(11B)	1.3900
C(12B)-C(15B)	1.49(4)
C(11B)-C(10B)	1.3900
C(11B)-H(11B)	0.9500
C(10B)-H(10B)	0.9500
C(24B)-C(27B)	1.65(5)
C(27B)-H(27D)	0.9800
C(27B)-H(27E)	0.9800
C(27B)-H(27F)	0.9800
N(3)-C(35)	1.354(16)
N(3)-C(36)	1.463(16)
N(3)-H(3A)	0.8800
N(4)-C(43)	1.385(17)
N(4)-C(44)	1.405(17)
N(4)-H(4A)	0.8800
O(4)-C(35)	1.238(14)
Br(04)-C(48)	1.870(14)
O(5)-C(43)	1.198(17)
O(6)-C(30)	1.403(13)

O(6)-C(51)	1.452(15)
F(7A)-C(42A)	1.315(17)
F(8A)-C(42A)	1.323(16)
F(9A)-C(42A)	1.328(15)
F(10)-C(50)	1.35(2)
F(11)-C(50)	1.32(2)
F(12)-C(50)	1.36(2)
C(28)-C(43)	1.528(19)
C(28)-C(35)	1.534(18)
C(28)-C(32)	1.545(18)
C(28)-C(29)	1.562(18)
C(29)-C(30)	1.522(16)
C(29)-H(29A)	0.9900
C(29)-H(29B)	0.9900
C(30)-C(31)	1.598(15)
C(30)-H(30)	1.0000
C(31)-C(33)	1.490(17)
C(31)-C(32)	1.507(19)
C(31)-H(31)	1.0000
C(32)-H(32A)	0.9900
C(32)-H(32B)	0.9900
C(33)-C(34)	1.22(2)
C(33)-H(33)	0.9500
C(34)-H(34A)	0.9500
C(34)-H(34B)	0.9500
C(37A)-C(36)	1.385(14)
C(37A)-C(38A)	1.397(14)
C(37A)-H(37A)	0.9500
C(38A)-C(39A)	1.391(15)
C(38A)-H(38A)	0.9500
C(39A)-C(40A)	1.384(15)
C(39A)-C(42A)	1.54(2)
C(40A)-C(41A)	1.372(14)
C(40A)-Br(3A)	1.902(16)
C(41A)-C(36)	1.391(14)
C(41A)-H(41A)	0.9500

C(44)-C(45)	1.380(19)
C(44)-C(49)	1.399(19)
C(45)-C(46)	1.38(2)
C(45)-H(45)	0.9500
C(46)-C(47)	1.35(2)
C(46)-H(46)	0.9500
C(47)-C(48)	1.39(2)
C(47)-C(50)	1.53(2)
C(48)-C(49)	1.35(2)
C(49)-H(49)	0.9500
C(51)-C(52)	1.496(19)
C(51)-C(53)	1.502(19)
C(51)-C(54)	1.558(18)
C(52)-H(52A)	0.9800
C(52)-H(52B)	0.9800
C(52)-H(52C)	0.9800
C(53)-H(53A)	0.9800
C(53)-H(53B)	0.9800
C(53)-H(53C)	0.9800
C(54)-H(54A)	0.9800
C(54)-H(54B)	0.9800
C(54)-H(54C)	0.9800
C(37B)-C(36)	1.3900
C(37B)-C(38B)	1.3900
C(37B)-H(37B)	0.9500
C(36)-C(41B)	1.3900
C(41B)-C(40B)	1.3900
C(41B)-H(41B)	0.9500
C(40B)-C(39B)	1.3900
C(40B)-Br(3B)	1.91(3)
C(39B)-C(38B)	1.3900
C(39B)-C(42B)	1.55(4)
C(38B)-H(38B)	0.9500
C(42B)-F(7B)	1.33(3)
C(42B)-F(8B)	1.33(2)
C(42B)-F(9B)	1.33(2)

C(16)-C(1)-C(8)	105.8(10)
C(16)-C(1)-C(2)	109.7(10)
C(8)-C(1)-C(2)	111.3(10)
C(16)-C(1)-C(5)	112.8(10)
C(8)-C(1)-C(5)	111.8(10)
C(2)-C(1)-C(5)	105.6(10)
C(8)-N(1)-C(9A)	127.3(11)
C(8)-N(1)-C(9B)	135(4)
C(8)-N(1)-H(1)	116.3
C(9A)-N(1)-H(1)	116.3
C(16)-N(2)-C(17)	127.4(11)
C(16)-N(2)-H(2)	116.3
C(17)-N(2)-H(2)	116.3
C(3)-C(2)-C(1)	102.8(11)
C(3)-C(2)-H(2A)	111.2
C(1)-C(2)-H(2A)	111.2
C(3)-C(2)-H(2B)	111.2
C(1)-C(2)-H(2B)	111.2
H(2A)-C(2)-H(2B)	109.1
C(24B)-O(3)-C(3)	115.4(15)
C(3)-O(3)-C(24A)	123.8(13)
C(4)-C(3)-C(2)	111.4(13)
C(4)-C(3)-O(3)	92.4(12)
C(2)-C(3)-O(3)	105.3(12)
C(4)-C(3)-H(3)	115.1
C(2)-C(3)-H(3)	115.1
O(3)-C(3)-H(3)	115.1
C(3)-C(4)-C(5)	106.2(13)
C(3)-C(4)-C(6)	93.8(13)
C(5)-C(4)-C(6)	112.1(13)
C(3)-C(4)-H(4)	114.3
C(5)-C(4)-H(4)	114.3
C(6)-C(4)-H(4)	114.3
C(4)-C(5)-C(1)	105.5(11)
C(4)-C(5)-H(5A)	110.6

C(1)-C(5)-H(5A)	110.6
C(4)-C(5)-H(5B)	110.6
C(1)-C(5)-H(5B)	110.6
H(5A)-C(5)-H(5B)	108.8
C(7)-C(6)-C(4)	127(2)
C(7)-C(6)-H(6)	116.7
C(4)-C(6)-H(6)	116.7
C(6)-C(7)-H(7A)	120.0
C(6)-C(7)-H(7B)	120.0
H(7A)-C(7)-H(7B)	120.0
O(1)-C(8)-N(1)	123.1(12)
O(1)-C(8)-C(1)	121.5(12)
N(1)-C(8)-C(1)	115.4(11)
O(2)-C(16)-N(2)	123.4(12)
O(2)-C(16)-C(1)	121.0(11)
N(2)-C(16)-C(1)	115.6(12)
C(18)-C(17)-C(22)	121.1(13)
C(18)-C(17)-N(2)	123.2(12)
C(22)-C(17)-N(2)	115.7(11)
C(17)-C(18)-C(19)	117.4(13)
C(17)-C(18)-H(18)	121.3
C(19)-C(18)-H(18)	121.3
C(20)-C(19)-C(18)	122.8(12)
C(20)-C(19)-Br(2)	121.7(10)
C(18)-C(19)-Br(2)	115.6(11)
C(21)-C(20)-C(19)	116.9(12)
C(21)-C(20)-C(23)	119.6(15)
C(19)-C(20)-C(23)	123.4(13)
C(20)-C(21)-C(22)	121.2(15)
C(20)-C(21)-H(21)	119.4
C(22)-C(21)-H(21)	119.4
C(21)-C(22)-C(17)	120.5(13)
C(21)-C(22)-H(22)	119.8
C(17)-C(22)-H(22)	119.8
F(5)-C(23)-F(6)	107.8(14)
F(5)-C(23)-F(4)	107.8(15)

F(6)-C(23)-F(4)	104.7(13)
F(5)-C(23)-C(20)	111.9(14)
F(6)-C(23)-C(20)	113.4(15)
F(4)-C(23)-C(20)	110.8(13)
C(24A)-C(25)-H(25A)	109.5
C(24A)-C(25)-H(25B)	109.5
H(25A)-C(25)-H(25B)	109.5
C(24A)-C(25)-H(25C)	109.5
H(25A)-C(25)-H(25C)	109.5
H(25B)-C(25)-H(25C)	109.5
C(24B)-C(25)-H(25D)	109.5
C(24B)-C(25)-H(25E)	109.5
H(25D)-C(25)-H(25E)	109.5
C(24B)-C(25)-H(25F)	109.5
H(25D)-C(25)-H(25F)	109.5
H(25E)-C(25)-H(25F)	109.5
C(24A)-C(26)-H(26A)	109.5
C(24A)-C(26)-H(26B)	109.5
H(26A)-C(26)-H(26B)	109.5
C(24A)-C(26)-H(26C)	109.5
H(26A)-C(26)-H(26C)	109.5
H(26B)-C(26)-H(26C)	109.5
C(24B)-C(26)-H(26D)	109.5
C(24B)-C(26)-H(26E)	109.5
H(26D)-C(26)-H(26E)	109.5
C(24B)-C(26)-H(26F)	109.5
H(26D)-C(26)-H(26F)	109.5
H(26E)-C(26)-H(26F)	109.5
N(1)-C(9A)-C(14A)	120.4(12)
N(1)-C(9A)-C(10A)	122.6(12)
C(14A)-C(9A)-C(10A)	117.0(14)
C(11A)-C(10A)-C(9A)	118.9(14)
C(11A)-C(10A)-H(10A)	120.6
C(9A)-C(10A)-H(10A)	120.6
C(12A)-C(11A)-C(10A)	123.3(15)
C(12A)-C(11A)-H(11A)	118.4

C(10A)-C(11A)-H(11A)	118.4
C(11A)-C(12A)-C(13A)	118.1(14)
C(11A)-C(12A)-C(15A)	121.5(14)
C(13A)-C(12A)-C(15A)	120.3(14)
C(14A)-C(13A)-C(12A)	118.8(14)
C(14A)-C(13A)-Br(1A)	116.3(11)
C(12A)-C(13A)-Br(1A)	124.8(11)
C(9A)-C(14A)-C(13A)	123.7(14)
C(9A)-C(14A)-H(14A)	118.1
C(13A)-C(14A)-H(14A)	118.1
F(2A)-C(15A)-F(3A)	103.6(14)
F(2A)-C(15A)-F(1A)	102.6(15)
F(3A)-C(15A)-F(1A)	109.5(15)
F(2A)-C(15A)-C(12A)	114.8(14)
F(3A)-C(15A)-C(12A)	111.6(14)
F(1A)-C(15A)-C(12A)	113.9(14)
C(27A)-C(24A)-C(26)	114(3)
C(27A)-C(24A)-C(25)	121(3)
C(26)-C(24A)-C(25)	106(2)
C(27A)-C(24A)-O(3)	123(3)
C(26)-C(24A)-O(3)	100(2)
C(25)-C(24A)-O(3)	89(2)
C(24A)-C(27A)-H(27A)	109.5
C(24A)-C(27A)-H(27B)	109.5
H(27A)-C(27A)-H(27B)	109.5
C(24A)-C(27A)-H(27C)	109.5
H(27A)-C(27A)-H(27C)	109.5
H(27B)-C(27A)-H(27C)	109.5
C(14B)-C(9B)-C(10B)	120.0
C(14B)-C(9B)-N(1)	124(6)
C(10B)-C(9B)-N(1)	116(6)
C(9B)-C(14B)-C(13B)	120.0
C(9B)-C(14B)-H(14B)	120.0
C(13B)-C(14B)-H(14B)	120.0
C(12B)-C(13B)-C(14B)	120.0
C(12B)-C(13B)-Br(1B)	123(5)

C(14B)-C(13B)-Br(1B)	114(5)
C(11B)-C(12B)-C(13B)	120.0
C(11B)-C(12B)-C(15B)	129(6)
C(13B)-C(12B)-C(15B)	111(6)
C(12B)-C(11B)-C(10B)	120.0
C(12B)-C(11B)-H(11B)	120.0
C(10B)-C(11B)-H(11B)	120.0
C(11B)-C(10B)-C(9B)	120.0
C(11B)-C(10B)-H(10B)	120.0
C(9B)-C(10B)-H(10B)	120.0
F(2B)-C(15B)-F(3B)	110(9)
F(2B)-C(15B)-F(1B)	101(9)
F(3B)-C(15B)-F(1B)	120(10)
F(2B)-C(15B)-C(12B)	106(8)
F(3B)-C(15B)-C(12B)	105(6)
F(1B)-C(15B)-C(12B)	115(9)
C(25)-C(24B)-O(3)	109(2)
C(25)-C(24B)-C(26)	113(2)
O(3)-C(24B)-C(26)	111(2)
C(25)-C(24B)-C(27B)	106(2)
O(3)-C(24B)-C(27B)	112(2)
C(26)-C(24B)-C(27B)	105(2)
C(24B)-C(27B)-H(27D)	109.5
C(24B)-C(27B)-H(27E)	109.5
H(27D)-C(27B)-H(27E)	109.5
C(24B)-C(27B)-H(27F)	109.5
H(27D)-C(27B)-H(27F)	109.5
H(27E)-C(27B)-H(27F)	109.5
C(35)-N(3)-C(36)	123.7(11)
C(35)-N(3)-H(3A)	118.1
C(36)-N(3)-H(3A)	118.1
C(43)-N(4)-C(44)	126.5(12)
C(43)-N(4)-H(4A)	116.8
C(44)-N(4)-H(4A)	116.8
C(30)-O(6)-C(51)	118.8(9)
C(43)-C(28)-C(35)	105.0(10)

C(43)-C(28)-C(32)	111.9(11)
C(35)-C(28)-C(32)	111.1(11)
C(43)-C(28)-C(29)	114.1(10)
C(35)-C(28)-C(29)	111.0(10)
C(32)-C(28)-C(29)	103.9(10)
C(30)-C(29)-C(28)	105.7(10)
C(30)-C(29)-H(29A)	110.6
C(28)-C(29)-H(29A)	110.6
C(30)-C(29)-H(29B)	110.6
C(28)-C(29)-H(29B)	110.6
H(29A)-C(29)-H(29B)	108.7
O(6)-C(30)-C(29)	110.9(9)
O(6)-C(30)-C(31)	111.8(9)
C(29)-C(30)-C(31)	101.8(9)
O(6)-C(30)-H(30)	110.7
C(29)-C(30)-H(30)	110.7
C(31)-C(30)-H(30)	110.7
C(33)-C(31)-C(32)	111.2(11)
C(33)-C(31)-C(30)	118.2(11)
C(32)-C(31)-C(30)	99.1(9)
C(33)-C(31)-H(31)	109.3
C(32)-C(31)-H(31)	109.3
C(30)-C(31)-H(31)	109.3
C(31)-C(32)-C(28)	107.3(11)
C(31)-C(32)-H(32A)	110.3
C(28)-C(32)-H(32A)	110.3
C(31)-C(32)-H(32B)	110.3
C(28)-C(32)-H(32B)	110.3
H(32A)-C(32)-H(32B)	108.5
C(34)-C(33)-C(31)	129.2(15)
C(34)-C(33)-H(33)	115.4
C(31)-C(33)-H(33)	115.4
C(33)-C(34)-H(34A)	120.0
C(33)-C(34)-H(34B)	120.0
H(34A)-C(34)-H(34B)	120.0
O(4)-C(35)-N(3)	123.7(12)

O(4)-C(35)-C(28)	123.0(12)
N(3)-C(35)-C(28)	113.2(11)
C(36)-C(37A)-C(38A)	117.1(14)
C(36)-C(37A)-H(37A)	121.5
C(38A)-C(37A)-H(37A)	121.5
C(39A)-C(38A)-C(37A)	121.1(14)
C(39A)-C(38A)-H(38A)	119.5
C(37A)-C(38A)-H(38A)	119.5
C(40A)-C(39A)-C(38A)	118.5(14)
C(40A)-C(39A)-C(42A)	123.2(13)
C(38A)-C(39A)-C(42A)	118.2(13)
C(41A)-C(40A)-C(39A)	122.9(14)
C(41A)-C(40A)-Br(3A)	115.2(11)
C(39A)-C(40A)-Br(3A)	121.9(10)
C(40A)-C(41A)-C(36)	116.6(13)
C(40A)-C(41A)-H(41A)	121.7
C(36)-C(41A)-H(41A)	121.7
F(7A)-C(42A)-F(8A)	107.6(16)
F(7A)-C(42A)-F(9A)	108.2(15)
F(8A)-C(42A)-F(9A)	106.2(15)
F(7A)-C(42A)-C(39A)	109.7(14)
F(8A)-C(42A)-C(39A)	111.5(14)
F(9A)-C(42A)-C(39A)	113.5(14)
O(5)-C(43)-N(4)	124.3(12)
O(5)-C(43)-C(28)	123.8(12)
N(4)-C(43)-C(28)	111.9(12)
C(45)-C(44)-C(49)	118.1(13)
C(45)-C(44)-N(4)	117.6(12)
C(49)-C(44)-N(4)	124.2(13)
C(44)-C(45)-C(46)	119.9(14)
C(44)-C(45)-H(45)	120.1
C(46)-C(45)-H(45)	120.1
C(47)-C(46)-C(45)	121.2(16)
C(47)-C(46)-H(46)	119.4
C(45)-C(46)-H(46)	119.4
C(46)-C(47)-C(48)	119.8(15)

C(46)-C(47)-C(50)	118.6(16)
C(48)-C(47)-C(50)	121.6(15)
C(49)-C(48)-C(47)	119.3(14)
C(49)-C(48)-Br(04)	118.2(12)
C(47)-C(48)-Br(04)	122.4(11)
C(48)-C(49)-C(44)	121.8(15)
C(48)-C(49)-H(49)	119.1
C(44)-C(49)-H(49)	119.1
F(11)-C(50)-F(10)	106.9(14)
F(11)-C(50)-F(12)	106.7(15)
F(10)-C(50)-F(12)	104.8(13)
F(11)-C(50)-C(47)	113.3(14)
F(10)-C(50)-C(47)	112.4(15)
F(12)-C(50)-C(47)	112.3(13)
O(6)-C(51)-C(52)	104.4(10)
O(6)-C(51)-C(53)	113.4(11)
C(52)-C(51)-C(53)	111.5(12)
O(6)-C(51)-C(54)	106.4(10)
C(52)-C(51)-C(54)	109.7(12)
C(53)-C(51)-C(54)	111.2(12)
C(51)-C(52)-H(52A)	109.5
C(51)-C(52)-H(52B)	109.5
H(52A)-C(52)-H(52B)	109.5
C(51)-C(52)-H(52C)	109.5
H(52A)-C(52)-H(52C)	109.5
H(52B)-C(52)-H(52C)	109.5
C(51)-C(53)-H(53A)	109.5
C(51)-C(53)-H(53B)	109.5
H(53A)-C(53)-H(53B)	109.5
C(51)-C(53)-H(53C)	109.5
H(53A)-C(53)-H(53C)	109.5
H(53B)-C(53)-H(53C)	109.5
C(51)-C(54)-H(54A)	109.5
C(51)-C(54)-H(54B)	109.5
H(54A)-C(54)-H(54B)	109.5
C(51)-C(54)-H(54C)	109.5

H(54A)-C(54)-H(54C)	109.5
H(54B)-C(54)-H(54C)	109.5
C(36)-C(37B)-C(38B)	120.00(6)
C(36)-C(37B)-H(37B)	120.0
C(38B)-C(37B)-H(37B)	120.0
C(37B)-C(36)-C(41B)	120.0
C(37A)-C(36)-C(41A)	123.6(13)
C(37A)-C(36)-N(3)	120.9(11)
C(37B)-C(36)-N(3)	110(2)
C(41B)-C(36)-N(3)	130(2)
C(41A)-C(36)-N(3)	115.5(11)
C(40B)-C(41B)-C(36)	120.0
C(40B)-C(41B)-H(41B)	120.0
C(36)-C(41B)-H(41B)	120.0
C(39B)-C(40B)-C(41B)	120.00(5)
C(39B)-C(40B)-Br(3B)	119(4)
C(41B)-C(40B)-Br(3B)	121(4)
C(40B)-C(39B)-C(38B)	120.0
C(40B)-C(39B)-C(42B)	119(8)
C(38B)-C(39B)-C(42B)	121(8)
C(39B)-C(38B)-C(37B)	120.0
C(39B)-C(38B)-H(38B)	120.0
C(37B)-C(38B)-H(38B)	120.0
F(7B)-C(42B)-F(8B)	112(10)
F(7B)-C(42B)-F(9B)	99(10)
F(8B)-C(42B)-F(9B)	128(10)
F(7B)-C(42B)-C(39B)	117(10)
F(8B)-C(42B)-C(39B)	87(10)
F(9B)-C(42B)-C(39B)	115(10)

Symmetry transformations used to generate equivalent atoms:

Table S6. Anisotropic displacement parameters ($Å^2 x 10^3$) for 007b-17085. The anisotropic displacement factor exponent takes the form: $-2\pi^2[h^2 a^{*2}U^{11} + ... + 2 h k a^* b^* U^{12}]$

	U^{11}	U^{22}	U^{33}	U^{23}	U^{13}	U^{12}
C(1)	7(5)	34(5)	34(5)	1(4)	0(4)	-3(4)
O(1)	16(3)	32(4)	39(5)	1(4)	-6(4)	-8(3)
Br(2)	62(1)	42(1)	53(1)	12(1)	-6(1)	5(1)
N(1)	7(4)	35(5)	34(5)	0(3)	-1(4)	-8(3)
N(2)	31(6)	35(5)	30(5)	5(4)	-8(4)	-9(4)
O(2)	42(5)	34(4)	36(5)	9(4)	-13(4)	-9(4)
C(2)	24(6)	33(6)	38(6)	-6(5)	0(5)	2(4)
O(3)	81(7)	31(5)	71(6)	3(4)	-31(5)	-11(4)
C(3)	63(7)	42(6)	85(8)	-9(6)	10(6)	-9(6)
F(4)	69(6)	72(6)	48(5)	32(4)	-6(5)	2(5)
C(4)	47(7)	46(7)	93(8)	0(5)	13(6)	-5(6)
C(5)	23(6)	33(6)	39(7)	1(5)	6(5)	-12(4)
F(5)	73(6)	69(6)	70(6)	18(4)	-28(5)	9(5)
F(6)	65(6)	75(6)	85(7)	17(5)	-12(5)	30(5)
C(6)	80(11)	75(11)	100(10)	18(8)	-24(9)	-21(9)
C(7)	123(18)	115(16)	104(12)	24(10)	-36(12)	-43(14)
C(8)	15(4)	35(5)	35(5)	5(4)	-2(4)	-10(4)
C(16)	26(6)	38(5)	30(5)	3(4)	-3(4)	-3(4)
C(17)	26(6)	46(6)	24(5)	4(4)	-2(5)	2(5)
C(18)	24(6)	43(5)	31(6)	4(4)	-2(5)	1(5)
C(19)	22(5)	46(5)	38(6)	10(5)	7(5)	8(4)
C(20)	27(6)	44(5)	28(5)	12(4)	8(4)	7(4)
C(21)	46(8)	49(6)	30(6)	6(5)	-6(6)	1(5)
C(22)	41(7)	43(6)	36(6)	3(5)	-11(6)	-2(5)
C(23)	43(7)	59(7)	53(7)	25(5)	-8(5)	10(5)
C(25)	85(11)	67(10)	69(8)	10(7)	-26(7)	-22(8)
C(26)	51(8)	45(6)	49(7)	-1(5)	-15(7)	-17(6)
Br(1A)	88(2)	42(1)	85(2)	-23(1)	-2(1)	3(1)
F(1A)	67(7)	84(8)	77(9)	-16(6)	14(6)	-42(6)
F(2A)	77(7)	90(9)	56(6)	-35(5)	10(5)	-37(6)
F(3A)	91(8)	102(8)	79(8)	-38(6)	-34(6)	-36(6)

C(9A)	19(5)	37(5)	29(5)	2(4)	2(4)	-9(4)
C(10A)	17(5)	40(5)	26(6)	3(5)	2(4)	-11(4)
C(11A)	29(7)	55(6)	41(7)	-7(5)	-4(5)	-18(5)
C(12A)	29(6)	50(5)	39(6)	-6(4)	3(5)	-22(4)
C(13A)	35(6)	46(5)	43(7)	-9(5)	4(5)	-18(5)
C(14A)	25(7)	42(5)	38(7)	-3(5)	-3(6)	-6(5)
C(15A)	65(8)	81(8)	52(7)	-23(6)	5(6)	-37(6)
C(24A)	77(10)	36(10)	72(11)	8(8)	-24(8)	-16(8)
C(27A)	65(12)	79(18)	74(15)	-2(12)	-35(10)	-5(11)
F(1B)	67(7)	84(8)	77(9)	-16(6)	14(6)	-42(6)
Br(1B)	29(7)	96(12)	54(9)	11(8)	-5(6)	-25(6)
F(2B)	77(7)	90(9)	56(6)	-35(5)	10(5)	-37(6)
F(3B)	70(17)	81(15)	80(20)	-38(14)	8(15)	-27(13)
C(9B)	19(5)	37(5)	29(5)	2(4)	2(4)	-9(4)
C(14B)	25(7)	42(5)	38(7)	-3(5)	-3(6)	-6(5)
C(13B)	35(6)	46(5)	43(7)	-9(5)	4(5)	-18(5)
C(12B)	29(6)	50(5)	39(6)	-6(4)	3(5)	-22(4)
C(11B)	29(7)	55(6)	41(7)	-7(5)	-4(5)	-18(5)
C(10B)	17(5)	40(5)	26(6)	3(5)	2(4)	-11(4)
C(15B)	58(11)	77(11)	58(11)	-32(8)	9(8)	-35(8)
C(24B)	59(12)	28(8)	47(9)	1(7)	-5(8)	-18(7)
C(27B)	74(14)	43(14)	72(16)	-1(11)	8(11)	-21(10)
N(3)	16(4)	37(5)	36(5)	6(4)	1(4)	4(4)
N(4)	21(5)	41(5)	35(5)	-3(4)	2(4)	3(4)
O(4)	14(4)	45(5)	55(6)	-2(4)	-4(4)	-8(4)
Br(04)	89(1)	66(1)	72(1)	-30(1)	-18(1)	13(1)
O(5)	25(5)	44(5)	45(5)	0(4)	4(4)	3(4)
O(6)	24(4)	41(4)	29(4)	-4(3)	-3(3)	12(3)
F(7A)	88(7)	107(8)	74(7)	31(6)	-15(6)	29(6)
F(8A)	96(9)	128(11)	107(9)	79(8)	40(7)	54(7)
F(9A)	68(7)	72(6)	91(7)	25(5)	0(5)	43(5)
F(10)	57(6)	108(7)	45(5)	1(5)	-25(4)	-7(5)
F(11)	64(6)	121(8)	46(5)	-30(5)	3(5)	-10(6)
F(12)	43(5)	94(7)	62(6)	-7(5)	-7(4)	-18(5)
C(28)	17(5)	38(5)	33(5)	6(4)	-1(4)	-5(4)
C(29)	10(5)	34(5)	32(6)	-3(4)	-5(4)	-8(4)

C(30)	23(5)	36(5)	27(5)	-3(4)	-3(4)	-1(4)
C(31)	25(5)	32(5)	49(6)	4(4)	-13(4)	-9(4)
C(32)	21(6)	41(6)	55(7)	6(5)	4(5)	-11(4)
C(33)	34(7)	42(7)	63(6)	-7(5)	-7(5)	-15(6)
C(34)	70(11)	70(11)	74(8)	-6(7)	-3(7)	-3(9)
C(35)	19(4)	29(5)	29(5)	-4(4)	-2(4)	-2(4)
C(37A)	26(7)	51(7)	37(7)	0(5)	4(5)	8(5)
C(38A)	31(7)	63(7)	38(8)	4(6)	3(6)	19(6)
C(39A)	26(6)	57(5)	52(6)	13(5)	9(4)	20(4)
C(40A)	29(6)	43(5)	50(7)	14(4)	12(6)	17(4)
C(41A)	20(5)	37(5)	40(6)	4(4)	9(5)	11(4)
C(42A)	61(8)	84(8)	62(8)	28(6)	13(6)	38(6)
C(43)	17(5)	44(6)	30(5)	0(4)	-2(4)	-6(4)
C(44)	16(5)	46(6)	32(6)	-2(4)	4(5)	-1(5)
C(45)	34(7)	51(6)	37(6)	-2(5)	-5(5)	4(5)
C(46)	51(9)	73(7)	39(7)	-1(5)	-8(7)	-5(6)
C(47)	44(7)	68(6)	28(6)	-4(5)	0(5)	-9(5)
C(48)	48(7)	50(5)	32(6)	-4(5)	4(6)	-1(5)
C(49)	43(8)	50(6)	33(6)	-6(5)	5(6)	5(5)
C(50)	46(7)	92(8)	31(6)	-8(5)	-8(5)	-12(5)
C(51)	28(5)	34(6)	43(6)	7(5)	-3(4)	4(4)
C(52)	25(6)	61(8)	49(6)	4(5)	-5(5)	17(6)
C(53)	56(9)	35(6)	61(9)	9(5)	1(7)	-4(6)
C(54)	35(6)	36(7)	65(8)	2(6)	12(6)	3(5)
Br(3A)	58(1)	41(1)	138(2)	32(1)	15(1)	1(1)
C(37B)	20(5)	37(5)	40(6)	4(4)	9(5)	11(4)
C(36)	25(5)	37(5)	36(6)	5(4)	3(4)	5(4)
C(41B)	20(5)	37(5)	40(6)	4(4)	9(5)	11(4)
C(40B)	29(6)	43(5)	50(7)	14(4)	12(6)	17(4)
C(39B)	26(6)	57(5)	52(6)	13(5)	9(4)	20(4)
C(38B)	29(6)	43(5)	50(7)	14(4)	12(6)	17(4)
Br(3B)	31(10)	72(16)	93(18)	46(13)	-11(10)	-5(9)
C(42B)	80(13)	73(11)	85(10)	26(8)	-3(8)	37(9)
F(7B)	88(7)	107(8)	74(7)	31(6)	-15(6)	29(6)
F(8B)	90(30)	74(18)	91(16)	24(12)	2(15)	46(16)
F(9B)	68(7)	72(6)	91(7)	25(5)	0(5)	43(5)

Table S7. Hydrogen coordinates (x 10^4) and isotropic displacement parameters (Å^{2}x 10^3) for 007b-17085.

	x	y	z	U(eq)
H(1)	7734	4957	2729	30
H(2)	8495	5703	4210	39
H(2A)	5160	6149	3495	38
H(2B)	5980	6023	4034	38
H(3)	6734	6941	3574	76
H(4)	9125	6701	3174	74
H(5A)	9360	5763	3348	38
H(5B)	8555	5732	2796	38
H(6)	6460	7038	2757	102
H(7A)	6828	6060	2260	137
H(7B)	5716	6565	2094	137
H(18)	8305	4283	4368	39
H(21)	11142	5246	5582	50
H(22)	9826	5704	4946	48
H(25A)	9164	6958	4742	111
H(25B)	10359	6471	4725	111
H(25C)	10929	7088	4752	111
H(25D)	10471	7174	4796	111
H(25E)	9751	6582	4861	111
H(25F)	11019	6685	4437	111
H(26A)	8638	7495	4078	73
H(26B)	10291	7704	3936	73
H(26C)	9257	7431	3505	73
H(26D)	8707	7498	3630	73
H(26E)	9789	7757	4055	73
H(26F)	10415	7298	3677	73
H(10A)	4507	5127	2056	33
H(11A)	3568	4502	1468	50
H(14A)	7483	3983	2524	42
H(27A)	11634	6344	3769	109

H(27B)	12301	6941	3856	109
H(27C)	11279	6816	3365	109
H(14B)	4397	4866	2016	42
H(11B)	7463	3320	1970	50
H(10B)	8052	4039	2522	33
H(27D)	6828	7352	4352	95
H(27E)	8011	7581	4761	95
H(27F)	7276	6993	4840	95
H(3A)	2831	4971	2737	36
H(4A)	3600	4255	4155	39
H(29A)	3324	4088	2792	30
H(29B)	4304	4278	3279	30
H(30)	3953	3257	3123	35
H(31)	1496	3037	3616	43
H(32A)	1248	3841	4016	47
H(32B)	-11	3904	3578	47
H(33)	-194	3224	2911	56
H(34A)	2451	3241	2406	85
H(34B)	748	3149	2173	85
H(37A)	-261	4826	1990	46
H(38A)	-1397	5500	1474	53
H(41A)	2550	5984	2578	39
H(45)	4959	4249	4907	49
H(46)	6174	4729	5553	65
H(49)	3214	5660	4387	50
H(52A)	5766	3489	4598	68
H(52B)	6389	2879	4603	68
H(52C)	4645	2995	4710	68
H(53A)	3793	2407	4002	76
H(53B)	5509	2238	3905	76
H(53C)	4519	2479	3445	76
H(54A)	6428	3183	3274	68
H(54B)	7484	3011	3744	68
H(54C)	6846	3618	3707	68
H(37B)	2951	5856	2512	39
H(41B)	-710	4998	2061	39

H(38B)	2189	6584	1997	49

Table S8. Torsion angles [°] for 007b-17085.

C(16)-C(1)-C(2)-C(3)	116.9(12)
C(8)-C(1)-C(2)-C(3)	-126.3(12)
C(5)-C(1)-C(2)-C(3)	-4.8(14)
C(1)-C(2)-C(3)-C(4)	22.7(17)
C(1)-C(2)-C(3)-O(3)	-76.2(12)
C(24B)-O(3)-C(3)-C(4)	110.6(18)
C(24A)-O(3)-C(3)-C(4)	58(2)
C(24B)-O(3)-C(3)-C(2)	-136.4(17)
C(24A)-O(3)-C(3)-C(2)	171.2(18)
C(2)-C(3)-C(4)-C(5)	-30.8(18)
O(3)-C(3)-C(4)-C(5)	76.6(12)
C(2)-C(3)-C(4)-C(6)	83.5(14)
O(3)-C(3)-C(4)-C(6)	-169.1(10)
C(3)-C(4)-C(5)-C(1)	26.1(17)
C(6)-C(4)-C(5)-C(1)	-75.0(15)
C(16)-C(1)-C(5)-C(4)	-131.5(13)
C(8)-C(1)-C(5)-C(4)	109.4(13)
C(2)-C(1)-C(5)-C(4)	-11.7(14)
C(3)-C(4)-C(6)-C(7)	-126(2)
C(5)-C(4)-C(6)-C(7)	-17(3)
C(9A)-N(1)-C(8)-O(1)	-5(2)
C(9B)-N(1)-C(8)-O(1)	-11(6)
C(9A)-N(1)-C(8)-C(1)	173.9(13)
C(9B)-N(1)-C(8)-C(1)	169(6)
C(16)-C(1)-C(8)-O(1)	105.0(14)
C(2)-C(1)-C(8)-O(1)	-14.1(17)
C(5)-C(1)-C(8)-O(1)	-131.8(13)
C(16)-C(1)-C(8)-N(1)	-74.1(13)
C(2)-C(1)-C(8)-N(1)	166.8(11)
C(5)-C(1)-C(8)-N(1)	49.0(14)
C(17)-N(2)-C(16)-O(2)	9(2)
C(17)-N(2)-C(16)-C(1)	-172.3(12)
C(8)-C(1)-C(16)-O(2)	-2.9(17)
C(2)-C(1)-C(16)-O(2)	117.2(14)

C(5)-C(1)-C(16)-O(2)	-125.4(13)
C(8)-C(1)-C(16)-N(2)	178.8(11)
C(2)-C(1)-C(16)-N(2)	-61.1(14)
C(5)-C(1)-C(16)-N(2)	56.3(15)
C(16)-N(2)-C(17)-C(18)	5(2)
C(16)-N(2)-C(17)-C(22)	-176.7(14)
C(22)-C(17)-C(18)-C(19)	-1(2)
N(2)-C(17)-C(18)-C(19)	177.1(12)
C(17)-C(18)-C(19)-C(20)	2(2)
C(17)-C(18)-C(19)-Br(2)	-178.7(11)
C(18)-C(19)-C(20)-C(21)	-3(2)
Br(2)-C(19)-C(20)-C(21)	177.6(11)
C(18)-C(19)-C(20)-C(23)	-179.5(13)
Br(2)-C(19)-C(20)-C(23)	1.3(19)
C(19)-C(20)-C(21)-C(22)	4(2)
C(23)-C(20)-C(21)-C(22)	180.0(14)
C(20)-C(21)-C(22)-C(17)	-3(2)
C(18)-C(17)-C(22)-C(21)	2(2)
N(2)-C(17)-C(22)-C(21)	-176.8(13)
C(21)-C(20)-C(23)-F(5)	-1(2)
C(19)-C(20)-C(23)-F(5)	175.6(14)
C(21)-C(20)-C(23)-F(6)	-122.8(16)
C(19)-C(20)-C(23)-F(6)	53(2)
C(21)-C(20)-C(23)-F(4)	119.9(16)
C(19)-C(20)-C(23)-F(4)	-64(2)
C(8)-N(1)-C(9A)-C(14A)	-137.5(15)
C(8)-N(1)-C(9A)-C(10A)	41(2)
N(1)-C(9A)-C(10A)-C(11A)	-179.4(16)
C(14A)-C(9A)-C(10A)-C(11A)	0(2)
C(9A)-C(10A)-C(11A)-C(12A)	3(2)
C(10A)-C(11A)-C(12A)-C(13A)	-5(2)
C(10A)-C(11A)-C(12A)-C(15A)	177.9(15)
C(11A)-C(12A)-C(13A)-C(14A)	4(2)
C(15A)-C(12A)-C(13A)-C(14A)	-178.4(15)
C(11A)-C(12A)-C(13A)-Br(1A)	-178.8(13)
C(15A)-C(12A)-C(13A)-Br(1A)	-2(2)

N(1)-C(9A)-C(14A)-C(13A)	179.1(17)
C(10A)-C(9A)-C(14A)-C(13A)	0(2)
C(12A)-C(13A)-C(14A)-C(9A)	-2(2)
Br(1A)-C(13A)-C(14A)-C(9A)	-179.2(13)
C(11A)-C(12A)-C(15A)-F(2A)	116.3(18)
C(13A)-C(12A)-C(15A)-F(2A)	-61(2)
C(11A)-C(12A)-C(15A)-F(3A)	-1(2)
C(13A)-C(12A)-C(15A)-F(3A)	-178.2(15)
C(11A)-C(12A)-C(15A)-F(1A)	-125.7(18)
C(13A)-C(12A)-C(15A)-F(1A)	57(2)
C(3)-O(3)-C(24A)-C(27A)	-88(3)
C(3)-O(3)-C(24A)-C(26)	39(3)
C(3)-O(3)-C(24A)-C(25)	144.8(14)
C(8)-N(1)-C(9B)-C(14B)	36(10)
C(8)-N(1)-C(9B)-C(10B)	-143(4)
C(10B)-C(9B)-C(14B)-C(13B)	0.0
N(1)-C(9B)-C(14B)-C(13B)	-179(10)
C(9B)-C(14B)-C(13B)-C(12B)	0.0
C(9B)-C(14B)-C(13B)-Br(1B)	162(7)
C(14B)-C(13B)-C(12B)-C(11B)	0.0
Br(1B)-C(13B)-C(12B)-C(11B)	-161(7)
C(14B)-C(13B)-C(12B)-C(15B)	178(9)
Br(1B)-C(13B)-C(12B)-C(15B)	17(8)
C(13B)-C(12B)-C(11B)-C(10B)	0.0
C(15B)-C(12B)-C(11B)-C(10B)	-177(10)
C(12B)-C(11B)-C(10B)-C(9B)	0.0
C(14B)-C(9B)-C(10B)-C(11B)	0.0
N(1)-C(9B)-C(10B)-C(11B)	179(9)
C(11B)-C(12B)-C(15B)-F(2B)	-125(9)
C(13B)-C(12B)-C(15B)-F(2B)	57(10)
C(11B)-C(12B)-C(15B)-F(3B)	-8(12)
C(13B)-C(12B)-C(15B)-F(3B)	174(7)
C(11B)-C(12B)-C(15B)-F(1B)	125(9)
C(13B)-C(12B)-C(15B)-F(1B)	-53(11)
C(3)-O(3)-C(24B)-C(25)	177.7(17)
C(3)-O(3)-C(24B)-C(26)	-57(3)

C(3)-O(3)-C(24B)-C(27B)	60(3)
C(43)-C(28)-C(29)-C(30)	110.6(11)
C(35)-C(28)-C(29)-C(30)	-131.0(10)
C(32)-C(28)-C(29)-C(30)	-11.5(13)
C(51)-O(6)-C(30)-C(29)	-132.4(11)
C(51)-O(6)-C(30)-C(31)	114.8(11)
C(28)-C(29)-C(30)-O(6)	-83.3(11)
C(28)-C(29)-C(30)-C(31)	35.8(11)
O(6)-C(30)-C(31)-C(33)	-167.9(10)
C(29)-C(30)-C(31)-C(33)	73.6(12)
O(6)-C(30)-C(31)-C(32)	72.0(12)
C(29)-C(30)-C(31)-C(32)	-46.4(11)
C(33)-C(31)-C(32)-C(28)	-84.8(13)
C(30)-C(31)-C(32)-C(28)	40.3(12)
C(43)-C(28)-C(32)-C(31)	-142.8(11)
C(35)-C(28)-C(32)-C(31)	100.2(12)
C(29)-C(28)-C(32)-C(31)	-19.2(14)
C(32)-C(31)-C(33)-C(34)	122.3(17)
C(30)-C(31)-C(33)-C(34)	9(2)
C(36)-N(3)-C(35)-O(4)	10.7(19)
C(36)-N(3)-C(35)-C(28)	-171.6(11)
C(43)-C(28)-C(35)-O(4)	-108.1(13)
C(32)-C(28)-C(35)-O(4)	13.0(18)
C(29)-C(28)-C(35)-O(4)	128.1(13)
C(43)-C(28)-C(35)-N(3)	74.2(13)
C(32)-C(28)-C(35)-N(3)	-164.7(11)
C(29)-C(28)-C(35)-N(3)	-49.6(14)
C(36)-C(37A)-C(38A)-C(39A)	5(2)
C(37A)-C(38A)-C(39A)-C(40A)	-4(2)
C(37A)-C(38A)-C(39A)-C(42A)	178.1(15)
C(38A)-C(39A)-C(40A)-C(41A)	2(2)
C(42A)-C(39A)-C(40A)-C(41A)	178.8(16)
C(38A)-C(39A)-C(40A)-Br(3A)	-177.3(14)
C(42A)-C(39A)-C(40A)-Br(3A)	0(2)
C(39A)-C(40A)-C(41A)-C(36)	0(2)
Br(3A)-C(40A)-C(41A)-C(36)	179.2(12)

C(40A)-C(39A)-C(42A)-F(7A)	-179.1(15)
C(38A)-C(39A)-C(42A)-F(7A)	-2(2)
C(40A)-C(39A)-C(42A)-F(8A)	62(2)
C(38A)-C(39A)-C(42A)-F(8A)	-120.9(18)
C(40A)-C(39A)-C(42A)-F(9A)	-58(2)
C(38A)-C(39A)-C(42A)-F(9A)	119.3(18)
C(44)-N(4)-C(43)-O(5)	-7(2)
C(44)-N(4)-C(43)-C(28)	175.3(11)
C(35)-C(28)-C(43)-O(5)	10.9(17)
C(32)-C(28)-C(43)-O(5)	-109.8(15)
C(29)-C(28)-C(43)-O(5)	132.6(13)
C(35)-C(28)-C(43)-N(4)	-171.5(10)
C(32)-C(28)-C(43)-N(4)	67.9(14)
C(29)-C(28)-C(43)-N(4)	-49.8(14)
C(43)-N(4)-C(44)-C(45)	174.2(13)
C(43)-N(4)-C(44)-C(49)	-11(2)
C(49)-C(44)-C(45)-C(46)	0(2)
N(4)-C(44)-C(45)-C(46)	175.7(13)
C(44)-C(45)-C(46)-C(47)	-1(2)
C(45)-C(46)-C(47)-C(48)	2(3)
C(45)-C(46)-C(47)-C(50)	-179.3(15)
C(46)-C(47)-C(48)-C(49)	-2(2)
C(50)-C(47)-C(48)-C(49)	179.4(14)
C(46)-C(47)-C(48)-Br(04)	-179.2(13)
C(50)-C(47)-C(48)-Br(04)	2(2)
C(47)-C(48)-C(49)-C(44)	1(2)
Br(04)-C(48)-C(49)-C(44)	178.6(11)
C(45)-C(44)-C(49)-C(48)	0(2)
N(4)-C(44)-C(49)-C(48)	-175.4(13)
C(46)-C(47)-C(50)-F(11)	-116.5(19)
C(48)-C(47)-C(50)-F(11)	62(2)
C(46)-C(47)-C(50)-F(10)	5(2)
C(48)-C(47)-C(50)-F(10)	-176.4(14)
C(46)-C(47)-C(50)-F(12)	122.6(18)
C(48)-C(47)-C(50)-F(12)	-59(2)
C(30)-O(6)-C(51)-C(52)	-174.1(11)

C(30)-O(6)-C(51)-C(53)	-52.6(15)
C(30)-O(6)-C(51)-C(54)	70.0(13)
C(38A)-C(37A)-C(36)-C(41A)	-4(2)
C(38A)-C(37A)-C(36)-N(3)	175.7(13)
C(38B)-C(37B)-C(36)-C(41B)	0.0
C(38B)-C(37B)-C(36)-N(3)	-176(5)
C(40A)-C(41A)-C(36)-C(37A)	1(2)
C(40A)-C(41A)-C(36)-N(3)	-178.5(12)
C(35)-N(3)-C(36)-C(37A)	-45.9(19)
C(35)-N(3)-C(36)-C(37B)	145(7)
C(35)-N(3)-C(36)-C(41B)	-31(8)
C(35)-N(3)-C(36)-C(41A)	133.5(13)
C(37B)-C(36)-C(41B)-C(40B)	0.0
N(3)-C(36)-C(41B)-C(40B)	176(6)
C(36)-C(41B)-C(40B)-C(39B)	0.0
C(36)-C(41B)-C(40B)-Br(3B)	-174(14)
C(41B)-C(40B)-C(39B)-C(38B)	0.0
Br(3B)-C(40B)-C(39B)-C(38B)	175(14)
C(41B)-C(40B)-C(39B)-C(42B)	176(16)
Br(3B)-C(40B)-C(39B)-C(42B)	-9(14)
C(40B)-C(39B)-C(38B)-C(37B)	0.0
C(42B)-C(39B)-C(38B)-C(37B)	-176(16)
C(36)-C(37B)-C(38B)-C(39B)	0.0
C(40B)-C(39B)-C(42B)-F(7B)	-150(14)
C(38B)-C(39B)-C(42B)-F(7B)	26(21)
C(40B)-C(39B)-C(42B)-F(8B)	97(15)
C(38B)-C(39B)-C(42B)-F(8B)	-87(16)
C(40B)-C(39B)-C(42B)-F(9B)	-34(20)
C(38B)-C(39B)-C(42B)-F(9B)	142(15)

Symmetry transformations used to generate equivalent atoms:

Table S9. Hydrogen bonds for 007b-17085 [Å and °].

D-H...A	d(D-H)	d(H...A)	d(D...A)	<(DHA)
N(1)-H(1)...O(4)#1	0.88	2.04	2.834(14)	149.2
N(2)-H(2)...O(3)	0.88	2.03	2.880(14)	160.8
N(3)-H(3A)...O(1)	0.88	2.03	2.792(14)	144.7
N(4)-H(4A)...O(6)	0.88	2.12	2.967(14)	161.9

Symmetry transformations used to generate equivalent atoms:

#1 x+1,y,z

B. Diastereomer Assignment of S2-TFA

The major diastereomer (>95:5 dr, PhSSPh catalyst) of **10** was subjected to TFA Boc-deprotection (1:1 DCM:TFA, 4 h), then concentrated *in vacuo* to provide the TFA salt (**S2•TFA**) as an off-white solid. Crystals suitable for X-ray crystallography were grown by slow evaporation from methanol-d_4 in an NMR tube.

Experimental

Low-temperature diffraction data (ω-scans) were collected on a Rigaku MicroMax-007HF diffractometer coupled to a Saturn994+ CCD detector with Cu Kα (λ = 1.54178 Å) for the structure of 007a-17137. The diffraction images were processed and scaled using Rigaku Oxford Diffraction software (CrysAlisPro; Rigaku OD: The Woodlands, TX, 2015). The structure was solved with SHELXT and was refined against F^2 on all data by full-matrix least squares with SHELXL (Sheldrick, G. M. Acta Cryst. 2008, A64, 112–122). All non-hydrogen atoms were refined anisotropically. Hydrogen atoms were included in the model at geometrically calculated positions and refined using a riding model. The isotropic displacement parameters of all hydrogen atoms were fixed to 1.2 times the U value of the atoms to which they are linked (1.5 times for methyl groups). The full numbering scheme of compound 007a-17137 can be found in the full details of the X-ray structure determination (CIF), which is included as Supporting Information. CCDC number 1586383 (007a-17137) contains the supplementary crystallographic data for this paper. These data can be obtained free of charge from The Cambridge Crystallographic Data Center via www.ccdc.cam.ac.uk/data_request/cif.

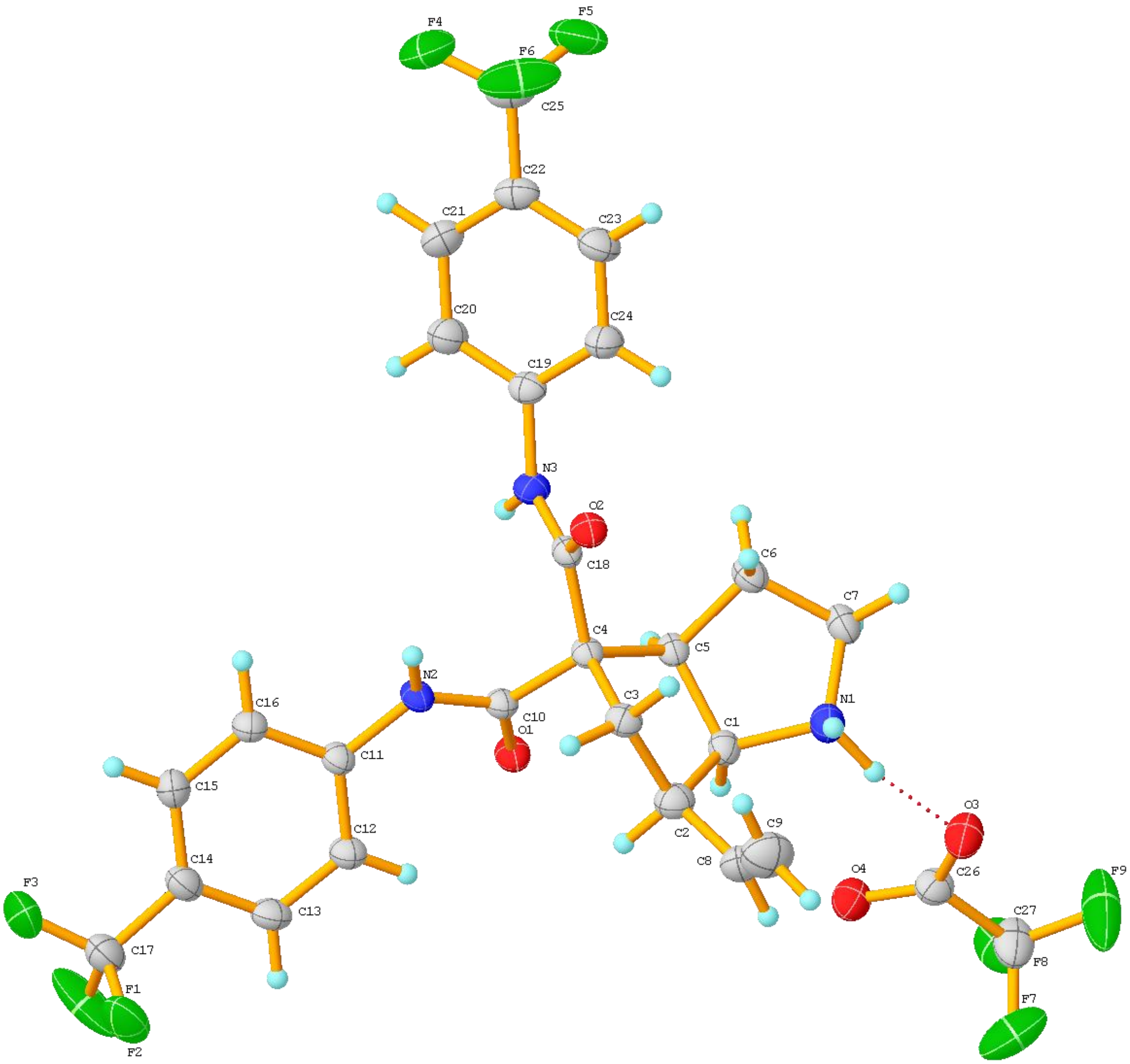


Figure S8. The complete numbering scheme of 007a-17137 with 50% thermal ellipsoid probability levels. The hydrogen atoms are shown as circles for clarity.

Table S10. Crystal data and structure refinement for 007a-17137.

Identification code	007a-17137	
Empirical formula	C27 H24 F9 N3 O4	
Formula weight	625.49	
Temperature	93(2) K	
Wavelength	1.54184 Å	
Crystal system	Triclinic	
Space group	P-1	
Unit cell dimensions	a = 10.6604(5) Å	α= 73.635(4)°.
	b = 11.5428(5) Å	β= 86.849(3)°.
	c = 11.5796(5) Å	γ = 82.919(4)°.
Volume	1356.42(11) Å^3	
Z	2	
Density (calculated)	1.531 Mg/m^3	
Absorption coefficient	1.277 mm^{-1}	
F(000)	640	
Crystal size	0.200 x 0.200 x 0.050 mm^3	
Crystal color and habit	Colorless Plate	
Diffractometer	Rigaku Saturn 944+ CCD	
Theta range for data collection	3.980 to 66.588°.	
Index ranges	-12<=h<=12, -13<=k<=13, -13<=l<=13	
Reflections collected	50654	
Independent reflections	4733 [R(int) = 0.0355]	
Observed reflections (I > 2sigma(I))	4426	
Completeness to theta = 66.588°	98.6 %	
Absorption correction	Semi-empirical from equivalents	
Max. and min. transmission	1.00000 and 0.90531	
Solution method	SHELXT-2014/5 (Sheldrick, 2014)	
Refinement method	SHELXL-2014/7 (Sheldrick, 2014)	
Data / restraints / parameters	4733 / 2 / 404	
Goodness-of-fit on F^2	1.028	
Final R indices [I>2sigma(I)]	R1 = 0.0507, wR2 = 0.1270	
R indices (all data)	R1 = 0.0531, wR2 = 0.1288	
Largest diff. peak and hole	0.567 and -0.517 e.Å^{-3}	

Table S11. Atomic coordinates (x 10^4) and equivalent isotropic displacement parameters (Å^{2}x 10^3) for 007a-17137. U(eq) is defined as one third of the trace of the orthogonalized U^{ij} tensor.

	x	y	z	U(eq)
F(1)	9369(2)	-1483(1)	2868(2)	58(1)
F(2)	10688(2)	-853(2)	3792(2)	84(1)
F(3)	10837(2)	-529(2)	1892(2)	66(1)
F(4)	6347(2)	10916(2)	-3516(2)	61(1)
F(5)	4651(2)	11704(1)	-2854(2)	63(1)
F(6)	4565(2)	10463(2)	-3886(1)	73(1)
O(1)	6033(1)	3844(1)	3996(1)	27(1)
O(2)	3811(1)	5726(1)	449(1)	27(1)
N(1)	1837(2)	5074(2)	4379(2)	32(1)
N(2)	6486(2)	3658(2)	2110(2)	25(1)
N(3)	5350(2)	6574(2)	1101(2)	26(1)
C(1)	3178(2)	4486(2)	4333(2)	26(1)
C(2)	3270(2)	3351(2)	3865(2)	32(1)
C(3)	3575(2)	3856(2)	2519(2)	26(1)
C(4)	4493(2)	4809(2)	2477(2)	22(1)
C(5)	3889(2)	5456(2)	3413(2)	23(1)
C(6)	2853(2)	6506(2)	2905(2)	29(1)
C(7)	1892(2)	6412(2)	3935(2)	30(1)
C(8)	2137(2)	2669(2)	4193(2)	36(1)
C(9)	1316(3)	2506(3)	3481(3)	52(1)
C(10)	5766(2)	4088(2)	2938(2)	23(1)
C(11)	7453(2)	2676(2)	2364(2)	25(1)
C(12)	7499(2)	1770(2)	3463(2)	29(1)
C(13)	8355(2)	747(2)	3595(2)	32(1)
C(14)	9170(2)	613(2)	2651(2)	32(1)
C(15)	9159(2)	1532(2)	1577(2)	32(1)
C(16)	8312(2)	2569(2)	1439(2)	29(1)
C(17)	10017(2)	-542(2)	2795(2)	40(1)
C(18)	4543(2)	5726(2)	1231(2)	23(1)
C(19)	5325(2)	7630(2)	96(2)	26(1)
C(20)	6442(2)	8023(2)	-445(2)	34(1)

C(21)	6416(2)	9028(2)	-1448(2)	37(1)
C(22)	5275(2)	9640(2)	-1901(2)	32(1)
C(23)	4154(2)	9281(2)	-1322(2)	35(1)
C(24)	4183(2)	8282(2)	-323(2)	32(1)
C(25)	5210(3)	10678(2)	-3027(2)	40(1)
F(7)	521(2)	2922(2)	9145(2)	77(1)
F(8)	1396(2)	4378(2)	9399(1)	60(1)
F(9)	-424(2)	4716(3)	8592(2)	104(1)
O(3)	629(2)	4624(2)	6533(1)	40(1)
O(4)	2499(1)	3850(2)	7393(1)	35(1)
C(26)	1356(2)	4202(2)	7399(2)	32(1)
C(27)	701(2)	4074(3)	8635(2)	47(1)

Table S12. Bond lengths [Å] and angles [°] for 007a-17137.

F(1)-C(17)	1.338(3)
F(2)-C(17)	1.329(3)
F(3)-C(17)	1.324(3)
F(4)-C(25)	1.336(3)
F(5)-C(25)	1.320(3)
F(6)-C(25)	1.333(3)
O(1)-C(10)	1.219(2)
O(2)-C(18)	1.227(2)
N(1)-C(7)	1.491(3)
N(1)-C(1)	1.510(3)
N(1)-H(1A)	1.02(3)
N(1)-H(1B)	1.04(3)
N(2)-C(10)	1.359(3)
N(2)-C(11)	1.411(3)
N(2)-H(2)	0.854(16)
N(3)-C(18)	1.353(3)
N(3)-C(19)	1.427(3)
N(3)-H(3)	0.865(17)
C(1)-C(2)	1.544(3)
C(1)-C(5)	1.553(3)
C(1)-H(1)	1.0000
C(2)-C(8)	1.495(3)
C(2)-C(3)	1.534(3)
C(2)-H(2A)	1.0000
C(3)-C(4)	1.549(3)
C(3)-H(3A)	0.9900
C(3)-H(3B)	0.9900
C(4)-C(18)	1.533(3)
C(4)-C(10)	1.540(3)
C(4)-C(5)	1.551(3)
C(5)-C(6)	1.541(3)
C(5)-H(5)	1.0000
C(6)-C(7)	1.518(3)
C(6)-H(6A)	0.9900

C(6)-H(6B)	0.9900
C(7)-H(7A)	0.9900
C(7)-H(7B)	0.9900
C(8)-C(9)	1.300(4)
C(8)-H(8)	0.9500
C(9)-H(9A)	0.9500
C(9)-H(9B)	0.9500
C(11)-C(16)	1.393(3)
C(11)-C(12)	1.399(3)
C(12)-C(13)	1.377(3)
C(12)-H(12)	0.9500
C(13)-C(14)	1.390(3)
C(13)-H(13)	0.9500
C(14)-C(15)	1.389(3)
C(14)-C(17)	1.489(3)
C(15)-C(16)	1.383(3)
C(15)-H(15)	0.9500
C(16)-H(16)	0.9500
C(19)-C(20)	1.381(3)
C(19)-C(24)	1.384(3)
C(20)-C(21)	1.390(3)
C(20)-H(20)	0.9500
C(21)-C(22)	1.380(3)
C(21)-H(21)	0.9500
C(22)-C(23)	1.388(3)
C(22)-C(25)	1.499(3)
C(23)-C(24)	1.384(3)
C(23)-H(23)	0.9500
C(24)-H(24)	0.9500
F(7)-C(27)	1.328(4)
F(8)-C(27)	1.328(3)
F(9)-C(27)	1.326(3)
O(3)-C(26)	1.250(3)
O(4)-C(26)	1.236(3)
C(26)-C(27)	1.534(3)

C(7)-N(1)-C(1)	106.40(17)
C(7)-N(1)-H(1A)	112.7(16)
C(1)-N(1)-H(1A)	112.3(16)
C(7)-N(1)-H(1B)	112.9(17)
C(1)-N(1)-H(1B)	105.3(17)
H(1A)-N(1)-H(1B)	107(2)
C(10)-N(2)-C(11)	125.90(17)
C(10)-N(2)-H(2)	119.8(16)
C(11)-N(2)-H(2)	113.5(16)
C(18)-N(3)-C(19)	122.69(17)
C(18)-N(3)-H(3)	119.2(17)
C(19)-N(3)-H(3)	117.8(17)
N(1)-C(1)-C(2)	112.70(18)
N(1)-C(1)-C(5)	105.21(16)
C(2)-C(1)-C(5)	107.76(16)
N(1)-C(1)-H(1)	110.3
C(2)-C(1)-H(1)	110.3
C(5)-C(1)-H(1)	110.3
C(8)-C(2)-C(3)	117.08(19)
C(8)-C(2)-C(1)	113.24(19)
C(3)-C(2)-C(1)	103.03(17)
C(8)-C(2)-H(2A)	107.7
C(3)-C(2)-H(2A)	107.7
C(1)-C(2)-H(2A)	107.7
C(2)-C(3)-C(4)	103.99(16)
C(2)-C(3)-H(3A)	111.0
C(4)-C(3)-H(3A)	111.0
C(2)-C(3)-H(3B)	111.0
C(4)-C(3)-H(3B)	111.0
H(3A)-C(3)-H(3B)	109.0
C(18)-C(4)-C(10)	115.47(16)
C(18)-C(4)-C(3)	111.80(16)
C(10)-C(4)-C(3)	106.37(16)
C(18)-C(4)-C(5)	109.97(16)
C(10)-C(4)-C(5)	109.74(15)
C(3)-C(4)-C(5)	102.68(16)

C(6)-C(5)-C(4)	114.26(16)
C(6)-C(5)-C(1)	104.47(16)
C(4)-C(5)-C(1)	105.02(16)
C(6)-C(5)-H(5)	110.9
C(4)-C(5)-H(5)	110.9
C(1)-C(5)-H(5)	110.9
C(7)-C(6)-C(5)	103.52(16)
C(7)-C(6)-H(6A)	111.1
C(5)-C(6)-H(6A)	111.1
C(7)-C(6)-H(6B)	111.1
C(5)-C(6)-H(6B)	111.1
H(6A)-C(6)-H(6B)	109.0
N(1)-C(7)-C(6)	101.93(17)
N(1)-C(7)-H(7A)	111.4
C(6)-C(7)-H(7A)	111.4
N(1)-C(7)-H(7B)	111.4
C(6)-C(7)-H(7B)	111.4
H(7A)-C(7)-H(7B)	109.2
C(9)-C(8)-C(2)	128.3(2)
C(9)-C(8)-H(8)	115.9
C(2)-C(8)-H(8)	115.9
C(8)-C(9)-H(9A)	120.0
C(8)-C(9)-H(9B)	120.0
H(9A)-C(9)-H(9B)	120.0
O(1)-C(10)-N(2)	123.68(18)
O(1)-C(10)-C(4)	121.04(17)
N(2)-C(10)-C(4)	114.98(16)
C(16)-C(11)-C(12)	120.01(19)
C(16)-C(11)-N(2)	117.63(18)
C(12)-C(11)-N(2)	122.12(18)
C(13)-C(12)-C(11)	119.4(2)
C(13)-C(12)-H(12)	120.3
C(11)-C(12)-H(12)	120.3
C(12)-C(13)-C(14)	120.6(2)
C(12)-C(13)-H(13)	119.7
C(14)-C(13)-H(13)	119.7

C(15)-C(14)-C(13)	120.1(2)
C(15)-C(14)-C(17)	120.7(2)
C(13)-C(14)-C(17)	119.1(2)
C(16)-C(15)-C(14)	119.7(2)
C(16)-C(15)-H(15)	120.1
C(14)-C(15)-H(15)	120.1
C(15)-C(16)-C(11)	120.07(19)
C(15)-C(16)-H(16)	120.0
C(11)-C(16)-H(16)	120.0
F(3)-C(17)-F(2)	106.5(2)
F(3)-C(17)-F(1)	105.2(2)
F(2)-C(17)-F(1)	105.5(2)
F(3)-C(17)-C(14)	114.1(2)
F(2)-C(17)-C(14)	112.9(2)
F(1)-C(17)-C(14)	112.00(19)
O(2)-C(18)-N(3)	123.44(18)
O(2)-C(18)-C(4)	120.41(18)
N(3)-C(18)-C(4)	115.90(17)
C(20)-C(19)-C(24)	119.7(2)
C(20)-C(19)-N(3)	120.10(19)
C(24)-C(19)-N(3)	120.21(19)
C(19)-C(20)-C(21)	120.1(2)
C(19)-C(20)-H(20)	120.0
C(21)-C(20)-H(20)	120.0
C(22)-C(21)-C(20)	120.1(2)
C(22)-C(21)-H(21)	119.9
C(20)-C(21)-H(21)	119.9
C(21)-C(22)-C(23)	119.8(2)
C(21)-C(22)-C(25)	121.5(2)
C(23)-C(22)-C(25)	118.7(2)
C(24)-C(23)-C(22)	119.9(2)
C(24)-C(23)-H(23)	120.0
C(22)-C(23)-H(23)	120.0
C(23)-C(24)-C(19)	120.3(2)
C(23)-C(24)-H(24)	119.9
C(19)-C(24)-H(24)	119.9

F(5)-C(25)-F(6)	106.0(2)
F(5)-C(25)-F(4)	106.3(2)
F(6)-C(25)-F(4)	105.7(2)
F(5)-C(25)-C(22)	113.1(2)
F(6)-C(25)-C(22)	112.26(19)
F(4)-C(25)-C(22)	113.0(2)
O(4)-C(26)-O(3)	129.2(2)
O(4)-C(26)-C(27)	116.80(19)
O(3)-C(26)-C(27)	113.99(19)
F(9)-C(27)-F(7)	106.5(3)
F(9)-C(27)-F(8)	107.8(2)
F(7)-C(27)-F(8)	105.6(2)
F(9)-C(27)-C(26)	113.8(2)
F(7)-C(27)-C(26)	110.0(2)
F(8)-C(27)-C(26)	112.6(2)

Symmetry transformations used to generate equivalent atoms:

Table S13. Anisotropic displacement parameters ($Å^2$x 10^3) for 007a-17137. The anisotropic displacement factor exponent takes the form: $-2\pi^2[h^2 a^{*2}U^{11} + ... + 2 h k a^* b^* U^{12}]$

	U^{11}	U^{22}	U^{33}	U^{23}	U^{13}	U^{12}
F(1)	49(1)	30(1)	92(1)	-15(1)	0(1)	1(1)
F(2)	94(2)	65(1)	95(2)	-38(1)	-62(1)	48(1)
F(3)	55(1)	40(1)	89(1)	-7(1)	25(1)	15(1)
F(4)	68(1)	54(1)	48(1)	9(1)	10(1)	-15(1)
F(5)	91(1)	30(1)	55(1)	4(1)	7(1)	4(1)
F(6)	119(2)	61(1)	36(1)	10(1)	-28(1)	-44(1)
O(1)	29(1)	33(1)	18(1)	-5(1)	-4(1)	3(1)
O(2)	29(1)	31(1)	19(1)	-5(1)	-4(1)	0(1)
N(1)	28(1)	37(1)	28(1)	-6(1)	1(1)	2(1)
N(2)	29(1)	26(1)	16(1)	-3(1)	-3(1)	6(1)
N(3)	27(1)	27(1)	20(1)	-1(1)	-5(1)	-1(1)
C(1)	24(1)	30(1)	23(1)	-6(1)	-2(1)	2(1)
C(2)	34(1)	32(1)	29(1)	-4(1)	-2(1)	-4(1)
C(3)	29(1)	25(1)	24(1)	-6(1)	-4(1)	-2(1)
C(4)	24(1)	24(1)	17(1)	-4(1)	-2(1)	1(1)
C(5)	24(1)	26(1)	19(1)	-6(1)	-2(1)	1(1)
C(6)	30(1)	28(1)	27(1)	-6(1)	-4(1)	3(1)
C(7)	29(1)	31(1)	30(1)	-11(1)	-3(1)	5(1)
C(8)	37(1)	30(1)	40(1)	-5(1)	2(1)	-6(1)
C(9)	51(2)	46(2)	59(2)	-9(1)	-4(1)	-16(1)
C(10)	25(1)	22(1)	20(1)	-3(1)	0(1)	0(1)
C(11)	25(1)	24(1)	23(1)	-4(1)	-3(1)	1(1)
C(12)	32(1)	26(1)	24(1)	-2(1)	-2(1)	-1(1)
C(13)	35(1)	25(1)	30(1)	0(1)	-5(1)	-1(1)
C(14)	27(1)	25(1)	40(1)	-5(1)	-4(1)	0(1)
C(15)	27(1)	32(1)	35(1)	-7(1)	3(1)	1(1)
C(16)	30(1)	28(1)	25(1)	-1(1)	1(1)	1(1)
C(17)	34(1)	31(1)	49(1)	-5(1)	-2(1)	2(1)
C(18)	24(1)	23(1)	19(1)	-5(1)	0(1)	4(1)
C(19)	34(1)	24(1)	20(1)	-6(1)	-2(1)	-2(1)
C(20)	32(1)	31(1)	36(1)	-4(1)	-3(1)	-4(1)

C(21)	38(1)	33(1)	37(1)	-5(1)	4(1)	-10(1)
C(22)	45(1)	24(1)	26(1)	-6(1)	-2(1)	-8(1)
C(23)	37(1)	28(1)	35(1)	-1(1)	-7(1)	0(1)
C(24)	31(1)	32(1)	30(1)	-1(1)	-1(1)	-2(1)
C(25)	53(2)	32(1)	33(1)	-4(1)	-3(1)	-13(1)
F(7)	92(1)	91(2)	45(1)	-3(1)	17(1)	-45(1)
F(8)	79(1)	66(1)	36(1)	-22(1)	-6(1)	10(1)
F(9)	64(1)	181(2)	41(1)	-18(1)	2(1)	60(1)
O(3)	30(1)	58(1)	27(1)	-6(1)	-2(1)	1(1)
O(4)	29(1)	44(1)	31(1)	-8(1)	-5(1)	-2(1)
C(26)	29(1)	34(1)	29(1)	-4(1)	-4(1)	-3(1)
C(27)	38(1)	66(2)	30(1)	-9(1)	-5(1)	9(1)

Table S14. Hydrogen coordinates (x 10^4) and isotropic displacement parameters (Å^{2}x 10^3) for 007a-17137.

	x	y	z	U(eq)
H(1A)	1430(30)	4820(30)	5220(30)	48(8)
H(1B)	1340(30)	4750(30)	3820(30)	59(9)
H(2)	6290(20)	3900(20)	1370(16)	29(6)
H(3)	5960(20)	6440(20)	1600(20)	33(6)
H(1)	3566	4276	5143	31
H(2A)	4021	2792	4239	39
H(3A)	2799	4241	2068	31
H(3B)	3983	3205	2176	31
H(5)	4553	5734	3817	28
H(6A)	3198	7299	2690	35
H(6B)	2473	6402	2185	35
H(7A)	2182	6736	4568	36
H(7B)	1059	6849	3649	36
H(8)	2001	2310	5029	44
H(9A)	1399	2842	2636	62
H(9B)	632	2050	3807	62
H(12)	6946	1861	4111	34
H(13)	8388	128	4338	38
H(15)	9731	1450	939	39
H(16)	8316	3208	713	35
H(20)	7229	7606	-132	41
H(21)	7185	9294	-1822	44
H(23)	3368	9721	-1612	42
H(24)	3416	8042	78	39

Table S15. Torsion angles [°] for 007a-17137.

C(7)-N(1)-C(1)-C(2)	-138.69(18)
C(7)-N(1)-C(1)-C(5)	-21.5(2)
N(1)-C(1)-C(2)-C(8)	-32.1(2)
C(5)-C(1)-C(2)-C(8)	-147.78(18)
N(1)-C(1)-C(2)-C(3)	95.29(19)
C(5)-C(1)-C(2)-C(3)	-20.3(2)
C(8)-C(2)-C(3)-C(4)	163.27(19)
C(1)-C(2)-C(3)-C(4)	38.3(2)
C(2)-C(3)-C(4)-C(18)	-159.62(16)
C(2)-C(3)-C(4)-C(10)	73.50(19)
C(2)-C(3)-C(4)-C(5)	-41.78(19)
C(18)-C(4)-C(5)-C(6)	33.6(2)
C(10)-C(4)-C(5)-C(6)	161.66(17)
C(3)-C(4)-C(5)-C(6)	-85.53(19)
C(18)-C(4)-C(5)-C(1)	147.47(16)
C(10)-C(4)-C(5)-C(1)	-84.46(18)
C(3)-C(4)-C(5)-C(1)	28.34(18)
N(1)-C(1)-C(5)-C(6)	-5.0(2)
C(2)-C(1)-C(5)-C(6)	115.42(18)
N(1)-C(1)-C(5)-C(4)	-125.62(16)
C(2)-C(1)-C(5)-C(4)	-5.2(2)
C(4)-C(5)-C(6)-C(7)	143.30(18)
C(1)-C(5)-C(6)-C(7)	29.1(2)
C(1)-N(1)-C(7)-C(6)	39.8(2)
C(5)-C(6)-C(7)-N(1)	-42.3(2)
C(3)-C(2)-C(8)-C(9)	-4.7(4)
C(1)-C(2)-C(8)-C(9)	115.0(3)
C(11)-N(2)-C(10)-O(1)	15.7(3)
C(11)-N(2)-C(10)-C(4)	-158.00(18)
C(18)-C(4)-C(10)-O(1)	142.07(19)
C(3)-C(4)-C(10)-O(1)	-93.3(2)
C(5)-C(4)-C(10)-O(1)	17.1(3)
C(18)-C(4)-C(10)-N(2)	-44.0(2)
C(3)-C(4)-C(10)-N(2)	80.6(2)

C(5)-C(4)-C(10)-N(2)	-169.00(17)
C(10)-N(2)-C(11)-C(16)	-162.8(2)
C(10)-N(2)-C(11)-C(12)	22.9(3)
C(16)-C(11)-C(12)-C(13)	-3.5(3)
N(2)-C(11)-C(12)-C(13)	170.7(2)
C(11)-C(12)-C(13)-C(14)	0.3(3)
C(12)-C(13)-C(14)-C(15)	2.2(3)
C(12)-C(13)-C(14)-C(17)	-175.6(2)
C(13)-C(14)-C(15)-C(16)	-1.6(3)
C(17)-C(14)-C(15)-C(16)	176.2(2)
C(14)-C(15)-C(16)-C(11)	-1.6(3)
C(12)-C(11)-C(16)-C(15)	4.2(3)
N(2)-C(11)-C(16)-C(15)	-170.3(2)
C(15)-C(14)-C(17)-F(3)	8.4(3)
C(13)-C(14)-C(17)-F(3)	-173.8(2)
C(15)-C(14)-C(17)-F(2)	130.2(3)
C(13)-C(14)-C(17)-F(2)	-52.0(3)
C(15)-C(14)-C(17)-F(1)	-110.9(3)
C(13)-C(14)-C(17)-F(1)	66.9(3)
C(19)-N(3)-C(18)-O(2)	7.5(3)
C(19)-N(3)-C(18)-C(4)	-166.81(17)
C(10)-C(4)-C(18)-O(2)	129.1(2)
C(3)-C(4)-C(18)-O(2)	7.3(3)
C(5)-C(4)-C(18)-O(2)	-106.1(2)
C(10)-C(4)-C(18)-N(3)	-56.4(2)
C(3)-C(4)-C(18)-N(3)	-178.18(17)
C(5)-C(4)-C(18)-N(3)	68.4(2)
C(18)-N(3)-C(19)-C(20)	-138.4(2)
C(18)-N(3)-C(19)-C(24)	43.2(3)
C(24)-C(19)-C(20)-C(21)	-3.7(3)
N(3)-C(19)-C(20)-C(21)	177.9(2)
C(19)-C(20)-C(21)-C(22)	0.4(4)
C(20)-C(21)-C(22)-C(23)	2.7(4)
C(20)-C(21)-C(22)-C(25)	-176.0(2)
C(21)-C(22)-C(23)-C(24)	-2.6(4)
C(25)-C(22)-C(23)-C(24)	176.2(2)

C(22)-C(23)-C(24)-C(19)	-0.7(4)
C(20)-C(19)-C(24)-C(23)	3.8(3)
N(3)-C(19)-C(24)-C(23)	-177.8(2)
C(21)-C(22)-C(25)-F(5)	-120.4(3)
C(23)-C(22)-C(25)-F(5)	60.9(3)
C(21)-C(22)-C(25)-F(6)	119.7(3)
C(23)-C(22)-C(25)-F(6)	-59.0(3)
C(21)-C(22)-C(25)-F(4)	0.4(3)
C(23)-C(22)-C(25)-F(4)	-178.4(2)
O(4)-C(26)-C(27)-F(9)	164.8(3)
O(3)-C(26)-C(27)-F(9)	-17.2(4)
O(4)-C(26)-C(27)-F(7)	-75.7(3)
O(3)-C(26)-C(27)-F(7)	102.2(3)
O(4)-C(26)-C(27)-F(8)	41.8(3)
O(3)-C(26)-C(27)-F(8)	-140.3(2)

Symmetry transformations used to generate equivalent atoms:

Table S16. Hydrogen bonds for 007a-17137 [Å and °].

D-H...A	d(D-H)	d(H...A)	d(D...A)	<(DHA)
N(1)-H(1A)...O(3)	1.02(3)	1.68(3)	2.689(2)	170(3)
N(3)-H(3)...O(4)#1	0.865(17)	2.005(17)	2.867(2)	174(2)
N(2)-H(2)...O(2)#2	0.854(16)	2.033(17)	2.872(2)	167(2)
N(1)-H(1B)...O(3)#3	1.04(3)	2.15(3)	2.832(2)	121(2)

Symmetry transformations used to generate equivalent atoms:

#1 -x+1,-y+1,-z+1 #2 -x+1,-y+1,-z #3 -x,-y+1,-z+1