Electronic Supplementary Material (ESI) for ChemComm.

Supporting Information

Asymmetric [3+2]-Cyclization of α-Imino Amide Surrogates to Construct 3,4-Diaminopyrrolidine-2,5-diones

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Content

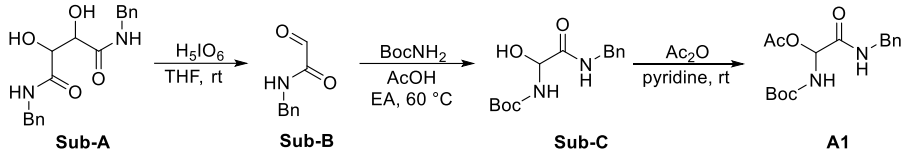
1. General Information

NMR characterization data were collected on Bruker ASCEND™ operating at 400 MHz for ^{1}H NMR, 101 MHz for ^{13}C{^{1}H} NMR (with complete proton decoupling), and 376 MHz for ^{19}F{^{1}H} NMR (with complete proton decoupling). ^{1}H NMR and ^{13}C{^{1}H} NMR: chemical shifts δ were recorded in ppm relative to tetramethylsilane and internally referenced to the residual solvent signal (for ^{1}H NMR: $CDCl_3$ = 7.26 ppm; for ^{13}C NMR: $CDCl_3$ = 77.16 ppm). Data were reported as follows: chemical shift, multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, dd = doublet of doublets, td = triplet of doublets, dt = doublet of triplets, m = multiplet), coupling constants (Hz), integration. Supercritical fluid chromatography (SFC) was performed on Acquity UPC^2 using Daicel Chiralcel OX-3, OD-3, at 25 °C with UV detector at 254 nm and enantiomeric excesses (ee) and enantiomeric ratio (er) were determined in comparison with the authentic racemates. High resolution mass spectra (HRMS) were performed on Thermo Q-Exactive Focus (FTMS+c ESI) and data were reported as (m/z). Infrared spectra (IR) were recorded on Bruker Tensor II spectrometer with Plantium ATR accessory and the peaks are reported as absorption maxima (ν, cm^{-1}). Optical rotations were measured on Rudolph Research Analytic Automatic Polarimeter, and reported as follows: $[\alpha]_D^T$ (*c*: g/100 mL, in CH_2Cl_2). Melting point ranges were determined on OptiMelt. X-ray crystallographic data were collected by a Bruker D8 Venture Photon II.

The experiments requiring substrates azlactone[1], chiral guanidine[1, 2] were synthesized according to known procedures and purified by recrystallization prior to use. All of the starting materials were purchased from TCI, Aladdin, Adamas, Acros, Aldrich and other companies, and used without further purification. All the solvents including toluene, tetrahydrofuran, diethyl ether, dichloromethane, chloroform, 1,2-dichloroethane, ethyl acetate, acetonitrile and so on were pre-dried over appropriate desiccants, and distilled prior to use. Reactions were monitored using thin-layer chromatography (TLC) on GF254 silica gel. Visualization of the developed plates was performed under UV light (254 nm) or using iodine, cobalt thiocyanate or $KMnO_4$. The products were purified by flash column chromatography with silicycle 300-400 mesh silica gel.

2. General procedure for the preparation of the substrates

2.1 General procedure for the preparation of α-imino amide



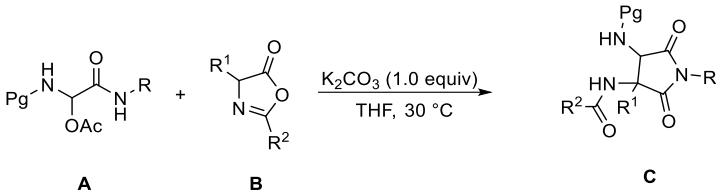
α-Imino amide was prepared using a modified literature procedure[3,4]. Periodic acid (12 mmol, 1.2 equiv) was added to a solution of **Sub-A** (10 mmol) in 20 mL THF at room temperature (rt). After stirring for 4 h, the formed precipitate was filtered, and THF was removed in *vacuo* below 30 °C. Crude **Sub-B** could be purified by flash column chromatography (ethyl acetate as eluent, R_f = 0.7, > 99% yield).

Under N_2, **Sub-B** (13 mmol, 1.3 equiv) was added to a solution of $BocNH_2$ (10 mmol) and EtOAc (20 mL), additional acetic acid (1 mmol, 0.1 equiv) was added as a catalyst. The mixture reacted at 60 °C for 12 h and then solvent was removed in *vacuo*, and pure hemiaminal **Sub-C** was obtained though flash column chromatography (petroleum ether/ethyl acetate = 2/1, v/v as eluent, R_f = 0.5, 65% yield).

Finally, **Sub-C** dissolved in Ac_2O (10 mL) with pyridine (13 mol%) as a catalyst was stirring overnight. Acetic anhydride was removed in *vacuo* at 70 °C, and α-imino amide **A1** was purified by flash column chromatography (petroleum ether/ethyl acetate = 1/1, v/v as eluent, R_f = 0.5, >99% yield) and recrystallization in DCM/PE.

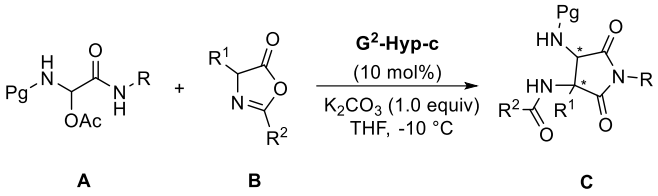
3. General procedures for the preparation of the products

General procedure 1: Preparation of racemic product **C**



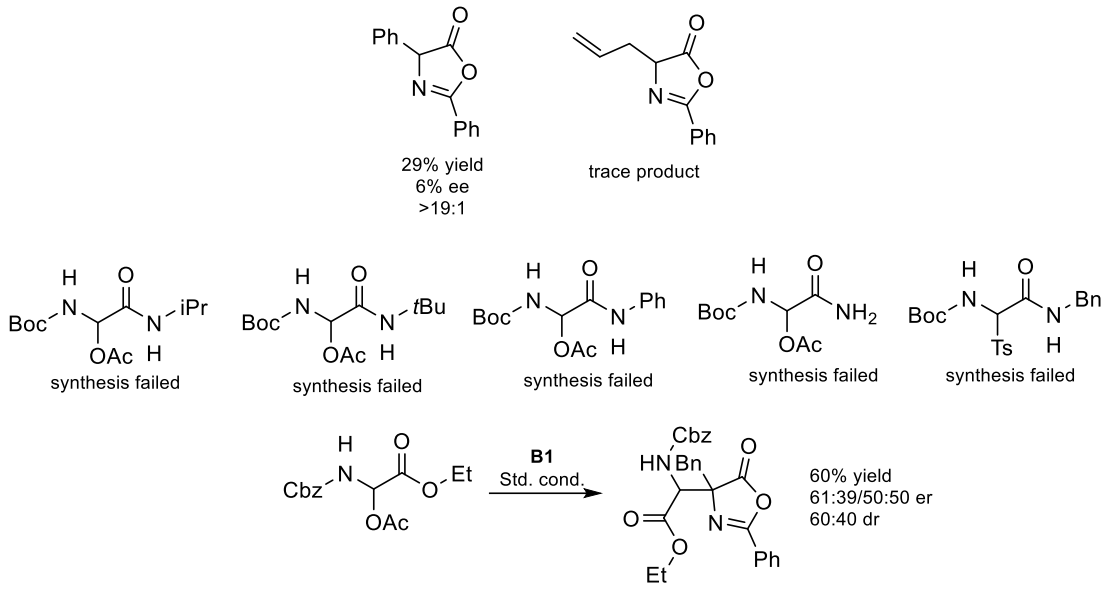
An oven-dried test tube was charged with K_2CO_3 (0.1 mmol), **A** (0.10 mmol), **B** (0.1 mmol) in THF (1 mL). The resulted solution was stirred at 30 °C in a water bath for 12 h. The reaction mixture was subjected to flash column chromatography on silica gel and eluted with petroleum ether/ethyl acetate (5/1 and 3/1, v/v) to afford the corresponding racemic product **C**.

General procedure 2: Preparation of enantioenriched product **C**



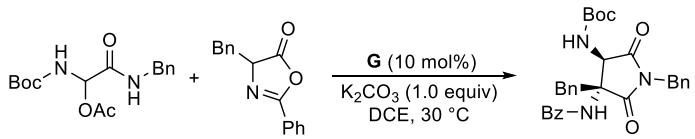
An oven-dried test tube was charged with the catalyst **G^2-Hyp-c** (10 mol %), **A** (0.12 mmol), **B** (0.1 mmol), K_2CO_3 (0.1 mmol), THF (1 mL) under N_2 atmosphere. The resulted solution was stirred at -10 °C for 36-48h. After the reaction was completed analyzed by TLC, flash filtration with a thin silica gel was performed so that dr value could be determined by ^{1}H NMR analysis. The crude product mixture was then subjected to flash column chromatography on silica gel and eluted with petroleum ether/ethyl acetate (5/1 and 3/1, v/v) to afford the corresponding pure product **C.**

4. Scope limitation

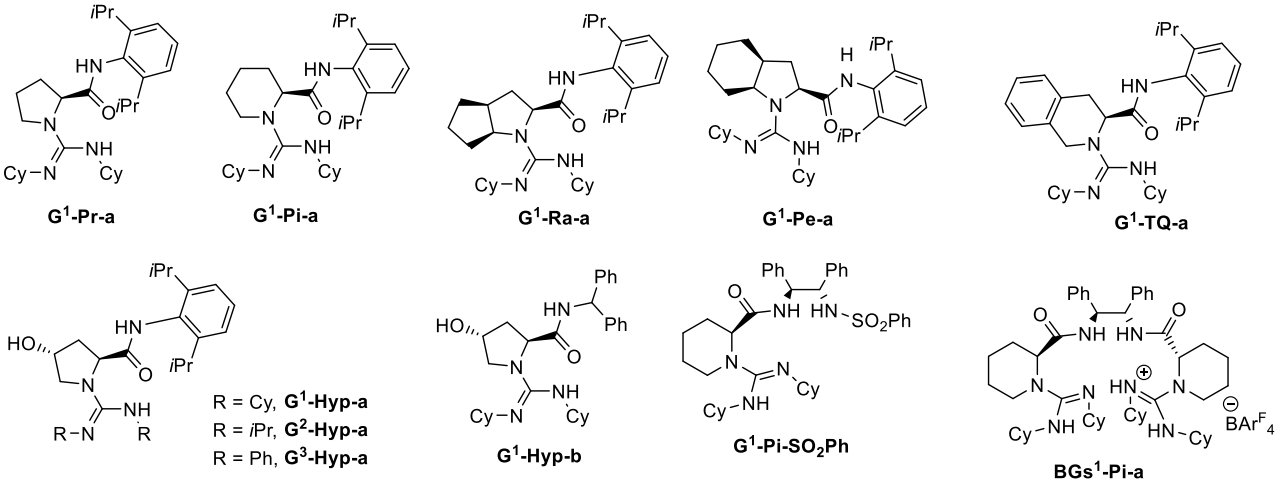


5. Optimization of the reaction conditions

Table S1. Screening of chiral guanidine.



A1 **B1** **C1**

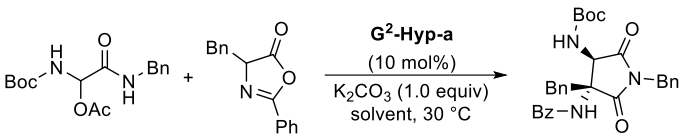


entry[a]	**G**	yield (%)[b]	er[c]	dr[d]
1	**G^1-Pr-a**	97	59:41/50:50	60:40
2	**G^1-Pi-a**	97	60:40/54:46	51:49

3	**G^1-Ra-a**	98	54:46/51:49	62:38
4	**G^1-Pe-a**	91	58:42/54:46	58:42
5	**G^1-TQ-a**	96	56:44/52:48	43:57
6	**BGs^1-Pi-a**	86	28:72/58:42	57:43
7	**G^1-Pi-SO_2Ph**	93	19:81/56:46	40:60
8	**G^1-Hyp-a**	99	71:29/55:45	75:25
9	**G^2-Hyp-a**	88	73:27/59:41	85:15
10	**G^3-Hyp-a**	83	54:46/55:45	62:38
11	**G^1-Hyp-b**	96	72:28/51:49	70:30

[a]The reactions were performed with **A1** (0.10 mmol), **B1** (0.10 mmol), K_2CO_3 (0.1 mmol) and **G** (10 mol %) in DCE (0.1 M) at 30 °C for 16 h. [b]Yield of the isolated product. [c]Determined by SFC analysis on a chiral stationary phase. [d]Determined by ^{1}H NMR analysis.

Table S2. Screening of solvent.

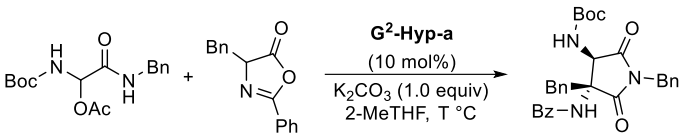


A1 **B1** **C1**

entry[a]	solvent	yield (%)[b]	er (%)[c]	dr[d]
1	toluene	83	79:21/58:42	76:24
2	Et_2O	67	81:9/53:47	74:26
3	EA	81	78:22/51:49	78:22
4	DCM	92	71:29/58:42	78:22
5	$CHCl_3$	65	71:29/61:39	74:26
6	DCE	88	73:27/59:41	85:15
7[e]	DCE	98	--	63:37
8[f]	DCE	trace	--	--
9	THF	97	80:20/53:47	85:15
10[e]	THF	91	--	77:23
11[f]	THF	66	--	88:12
12	2-MeTHF	97	84:16/54:46	85:15

[a]The reactions were performed with **A1** (0.10 mmol), **B1** (0.10 mmol), K_2CO_3 (0.1 mmol) and **G^2-Hyp-a** (10 mol %) in solvent (0.1 M) at 30 °C for 16 h. [b]Yield of the isolated product. [c]Determined by SFC analysis on a chiral stationary phase. [d]Determined by ^{1}H NMR analysis; [e]Without **G^2-Hyp-a**; [f]Without **G^2-Hyp-a** and K_2CO_3;

Table S3. Temperature Screening.

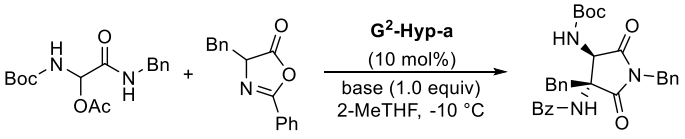


A1 **B1** **C1**

entry[a]	T (°C)	yield (%)[b]	er (%)[c]	dr[d]
1	30	99	83:17/53:47	82:18
2	10	>99	86:14/53:47	85:15
3	0	90	86:14/54:46	84:16
4	-10	94	87:13/52:48	89:11
5	-20	82	87:13/52:48	86:14
6	-30	42	81:19/51:49	83:17
7	-50	35	66:34/51:49	78:22

[a]The reactions were performed with **A1** (0.10 mmol), **B1** (0.10 mmol), K_2CO_3 (0.1 mmol) and **G²-Hyp-a** (10 mol %) in solvent (0.1 M) for 16 h. [b]Yield of the isolated product. [c]Determined by SFC analysis on a chiral stationary phase. [d]Determined by ^{1}H NMR analysis.

Table S4. Screening of base.

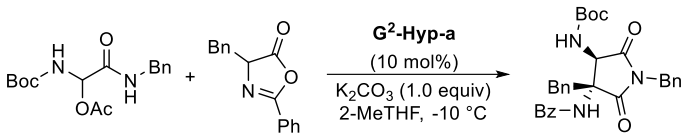


A1 **B1** **C1**

entry[a]	base	yield (%)[b]	er (%)[c]	dr[d]
1	Na_2CO_3	83	88:12/47:53	88:12
2	Cs_2CO_3	73	79:21/54:46	75:25
3	$K_3PO_4{\cdot}7H_2O$	90	82:18/53:47	84:16
4	K_2HPO_4	97	87:13/52:48	86:14
5	KH_2PO_4	58	88:12/53:47	84:16
6	Na_3PO_4	88	85:15/54:5	88:12
7	DMAP	72	66:34/53:47	58:42
8	*t*BuOK	73	64:36/50:50	82:18
9	*i*Pr_2NEt	85	86:14/51:49	84:16
10	*i*Pr_2NH	65	80:20/52:48	82:18
11	Et_3N	87	83:17/53:47	85:15

[a]The reactions were performed with **A1** (0.10 mmol), **B1** (0.10 mmol), base (0.1 mmol) and **G²-Hyp-a** (10 mol %) in 2-MeTHF (0.1 M) at -10 °C for 16 h. [b]Yield of the isolated product. [c]Determined by SFC analysis on a chiral stationary phase. [d]Determined by ^{1}H NMR analysis.

Table S5. Screening of substrates ratio.

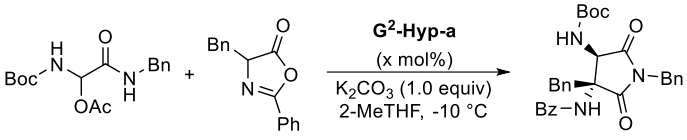


A1 **B1** **C1**

entry[a]	**A1** (X mmol)	**B1** (Y mmol)	yield (%)[b]	er (%)[c]	dr[d]
1	0.12	0.1	93	87:13/53:47	84:16
2	0.1	0.1	84	87:13/52:48	83:17
3	0.1	0.12	87	87:13/53:47	85:15

[a]The reactions were performed with **A1** (X mmol), **B1** (Y mmol), K_2CO_3 (0.1 mmol) and **G²-Hyp-a** (10 mol %) in 2-MeTHF (0.1 M) at -10 °C for 16 h. [b]Yield of the isolated product. [c]Determined by SFC analysis on a chiral stationary phase. [d]Determined by ^{1}H NMR analysis.

Table S6. Screening of catalyst loading.

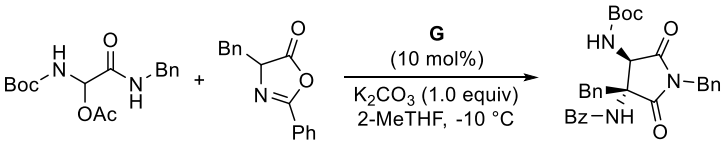


A1 **B1** **C1**

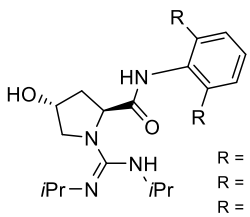
entry[a]	X (mol%)	yield (%)[b]	er (%)[c]	dr[d]
1	7.5	90	86:14/53:47	82:18
2	10	88	87:13/53:47	86:14
3	12.5	88	87:13/53:47	89:11
4	15	89	87:13/53:47	85:15

[a]The reactions were performed with **A1** (0.12 mmol), **B1** (0.10 mmol), K_2CO_3 (0.1 mmol) and **G²-Hyp-a** (X mol %) in 2-MeTHF (0.1 M) at -10 °C for 16 h. [b]Yield of the isolated product. [c]Determined by SFC analysis on a chiral stationary phase. [d]Determined by ^{1}H NMR analysis.

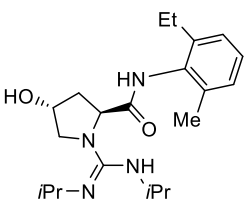
Table S7. Rescreening of chiral guanidines.



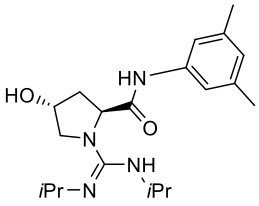
A1 **B1** **C1**



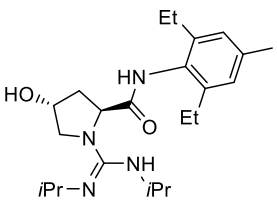
R = Et, **G²-Hyp-c**
R = Me, **G²-Hyp-d**
R = OMe, **G²-Hyp-e**



G²-Hyp-f



G²-Hyp-g



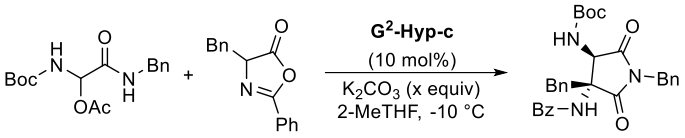
G²-Hyp-h

(mentioned at Table S9)

entry[a]	G	yield (%)[b]	er (%)[c]	dr[d]
1	**G^2-Hyp-c**	88	91:8/60:40	91:9
2	**G^2-Hyp-d**	>99	88:12/58:45	86:14
3	**G^2-Hyp-e**	>99	66:34/50:50	70:30
4	**G^2-Hyp-f**	64	77:23/54:46	83:17
5	**G^2-Hyp-g**	>99	50:50/50:50	57:43

[a]The reactions were performed with **A1** (0.12 mmol), **B1** (0.10 mmol), K_2CO_3 (0.1 mmol) and **G** (10 mol %) in 2-MeTHF (0.1 M) at -10 °C for 16 h. [b]Yield of the isolated product. [c]Determined by SFC analysis on a chiral stationary phase. [d]Determined by ^{1}H NMR analysis.

Table S8. Screening of K_2CO_3 loading.

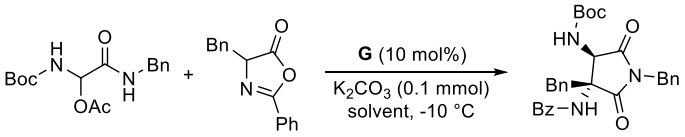


A1 **B1** **C1**

entry[a]	K_2CO_3 (equiv)	yield (%)[b]	er (%)[c]	dr[d]
1	1.5	76	90:10/56:44	89:11
2	1.0	87	91:9/58:42	89:11
3	0.5	79	91:9/57:43	87:13
4[e]	0	75	92:8/59:41	91:9

[a]The reactions were performed with **A1** (0.12 mmol), **B1** (0.10 mmol), K_2CO_3 (X equiv) and **G^2-Hyp-c** (10 mol %) in 2-MeTHF (0.1 M) at -10 °C for 16 h. [b]Yield of the isolated product. [c]Determined by SFC analysis on a chiral stationary phase. [d]Determined by ^{1}H NMR analysis. [e]Reaction time was 60 h

Table S9. Rescreening of chiral guanidine and solvent.



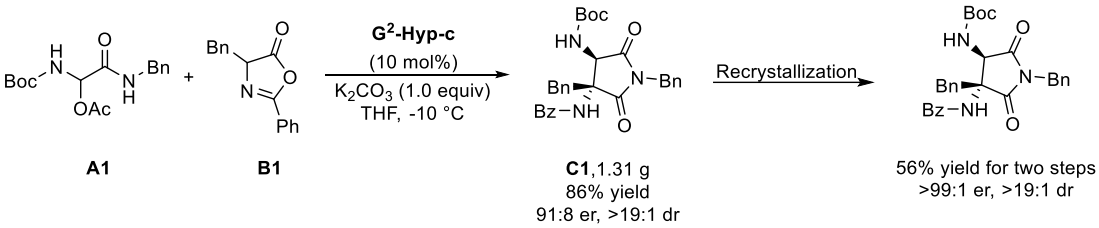
A1 **B1** **C1**

entry[a]	G	solvent	yield (%)[b]	er (%)[c]	dr[d]
1	**G^2-Hyp-c**	2-MeTHF	87	91:9/58:42	89:11
2	**G^2-Hyp-c**	THF	93	90:10/58:42	94:6
3	**G^2-Hyp-h**	THF	91	83:17/53:47	84:16
4[e]	**G^2-Hyp-c**	THF	88	91:9	>19:1
5	**None**	THF	44	--	75:25

[a]The reactions were performed with **A1** (0.12 mmol), **B1** (0.10 mmol), K_2CO_3 (0.1 mmol) and **G** (10 mol %) in solvent (0.1 M) at -10 °C for 16 h. [b]Yield of the isolated product. [c]Determined by SFC analysis on a chiral stationary phase. [d]Determined by ^{1}H NMR analysis. [e]Minor diastereoisomer was removed by flash column chromatography.

6. Gram-scale synthesis

Gram-scale synthesis of C1



A1 **B1**

C1,1.31 g
86% yield
91:8 er, >19:1 dr

56% yield for two steps
>99:1 er, >19:1 dr

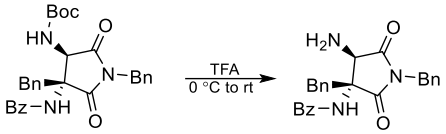
An oven-dried round-bottom flask was charged with catalyst **G²-Hyp-c** (10 mol %), **A1** (3.6 mmol), **B1** (3 mmol), K_2CO_3 (3 mmol) and stir bar under N_2 atmosphere. After the flask was cooled to -10 °C, THF (30 mL) was added when the reaction was stirring. The resulted solution was stirred at -10 °C for 16 h. The reaction mixture was filtered, and concentrated under reduced pressure, the crude product was subjected to flash column chromatography on silica gel and eluted with petroleum ether/ethyl acetate (5/1 and 3/1, v/v) to afford the corresponding product **C1** (1.31 g, 86% yield, 91:8 er).

Obtained **C1** was dissolved in 20 mL DCM, 80 mL petroleum ether was added and slightly shacked the bottom to sure complete mixing. Evaporating solvent slowly at rt for 3 days, no crystal was observed. So additional 80 mL petroleum ether was added and colorless crystal was observed with slow evaporation. When the crystal stopped growing, optically pure **C1** was obtained by filtration, in the meantime, er of filtrate was 59:41.

Significant Self-disproportionation of enantiomers (SDE) was not observed in the flash chromatography separation. The products of the first four tubes, the next four tubes, and all were obtained in 90:10 er, 91:9 er, 92:8 er, separately.

7. Further transformations of the products

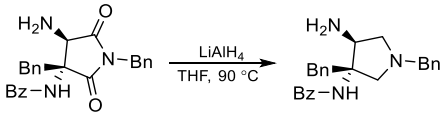
Procedure 1 De-protection of the compound **C1**



C1 **D1**

In an ice water bath, 3 mL TFA was slowly added to a tube charged with **C1** (0.3 mmol, >99:1 er). The mixture was stirring at rt overnight. After the reaction was completed analyzed by TLC, 2 M NaOH (aq) was added at 0 °C and stirred the mixture to sure aqueous phase was basic. Washing aqueous phase with 1-2 mL DCM three times, separating and concentrating organic phase, the crude product was subjected to column chromatography on silica gel and eluted with petroleum ether/ethyl acetate (1/1, v/v) to afford the desired product **D1** (94% yield, >99:1 er).

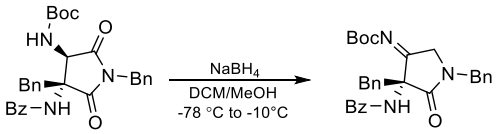
Procedure 2 Reduction of the compound **D1**



D1 **D2**

Under N_2, 2 mL anhydrous THF was added to the mixture of **D1** (0.2 mmol, >99:1 er) and $LiAlH_4$ (0.8 mmol, 4 equiv) in a tube. This mixture was heated to 90 °C and stirring for 4 h. After the reaction was completed analyzed by TLC, hydrated sodium sulfate was added to quench reaction until no more bubble was generated. Pure **D2** was obtained by column chromatography on silica gel (55% yield, >99:1 er, ethyl acetate/MeOH, 10/1, v/v).

Procedure 3 Partly reduction of the compound **C1**



C1 **D3**

Under N_2, 3 mL anhydrous DCM/MeOH (1/1, v/v) was added to a tube charged with **C1** (0.3 mmol, >99:1 er) and this mixture was cold to -78 °C. $NaBH_4$ (0.39 mmol, 1.3 equiv) was added and warming mixture to -10 °C. After stirring at -10 °C overnight, solvent was removed in *vacuo* and pure **D3** was obtained by column chromatography on silica gel (90% yield, >99:1 er, petroleum ether/ethyl acetate, 5/1, v/v).

8. Determination of absolute configurations of compounds

Determination of absolute configuration of compound C1

The colourless crystal in block-shape, with approximate dimensions of 0.182 × 0.340 × 0.409 mm^3, was selected and mounted for the single-crystal X-ray diffraction. The data set was collected by Bruker D8 Venture Photon II diffractometer at 173(2)K equipped with micro-focus Cu radiation source (K_α = 1.54178Å). Applied with face-indexed numerical absorption correction, the structure solution was solved and refinement was processed by SHELXTL (version 6.14) and OLEX 2.3 program package[5, 6, 7, 8]. The structure was analyzed by ADDSYM routine implemented in PLATON suite and no higher symmetry was suggested[9].

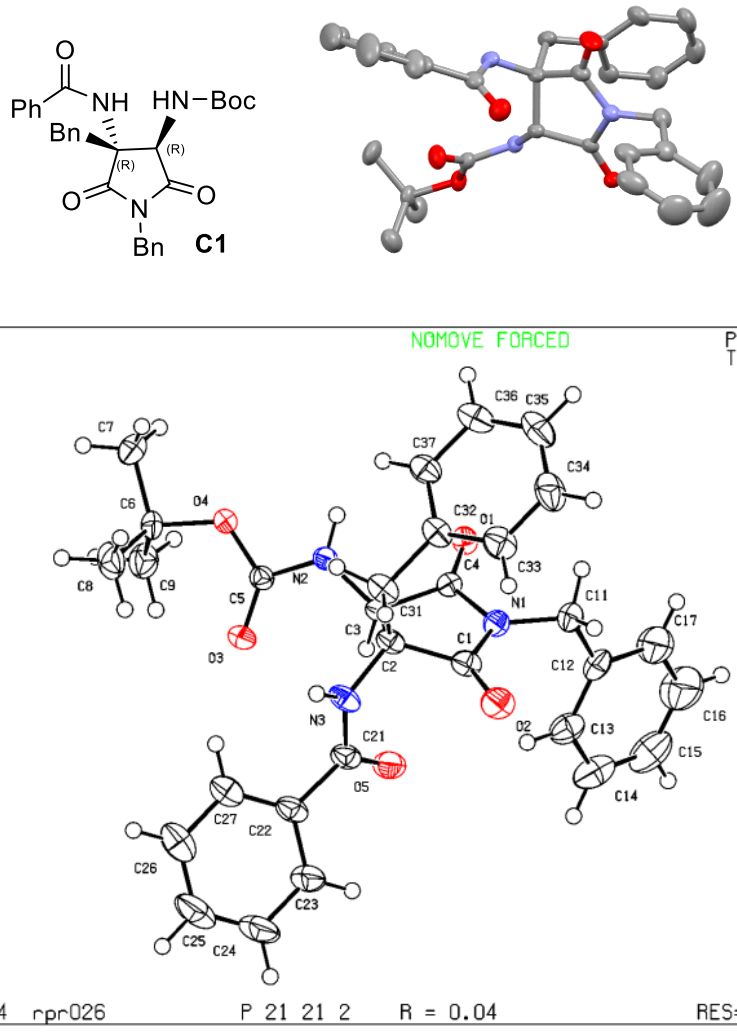


Figure S1. the thermal ellipsoid figure of **C1** with 50% probabilities

Crystallographic Data for C30H31N3O5.

Formula	C30H31N3O5
Formula mass (amu)	513.58
Space group	P 21 21 2
a (Å)	11.3754(3)
b (Å)	21.9762(6)
c (Å)	11.2116(3)
α (deg)	90
β (deg)	90
γ (deg)	90
V (Å^3)	2802.77(13)
Z	4
λ (Å)	1.54178
T (K)	173(2)
ρ_{calcd} (g cm^{-3})	1.217
μ (mm^{-1})	0.679
Transmission factors	0.706–1.000
$2\theta_{max}$ (deg)	68.288
No. of unique data, including $F_o^2 < 0$	5087
No. of unique data, with $F_o^2 > 2\sigma(F_o^2)$	4949
No. of variables	355
$R(F)$ for $F_o^2 > 2\sigma(F_o^2)$ [a]	0.0413
$R_w(F_o^2)$ [b]	0.0979
Goodness of fit	1.070

[a] $R(F) = \sum||F_o| - |F_c|| / \sum|F_o|$.

[b] $R_w(F_o^2) = [\sum[w(F_o^2 - F_c^2)^2] / \sum wF_o^4]^{1/2}$; $w^{-1} = [\sigma^2(F_o^2) + (Ap)^2 + Bp]$, where $p = [\max(F_o^2,0) + 2F_c^2] / 3$.

9. Computational details

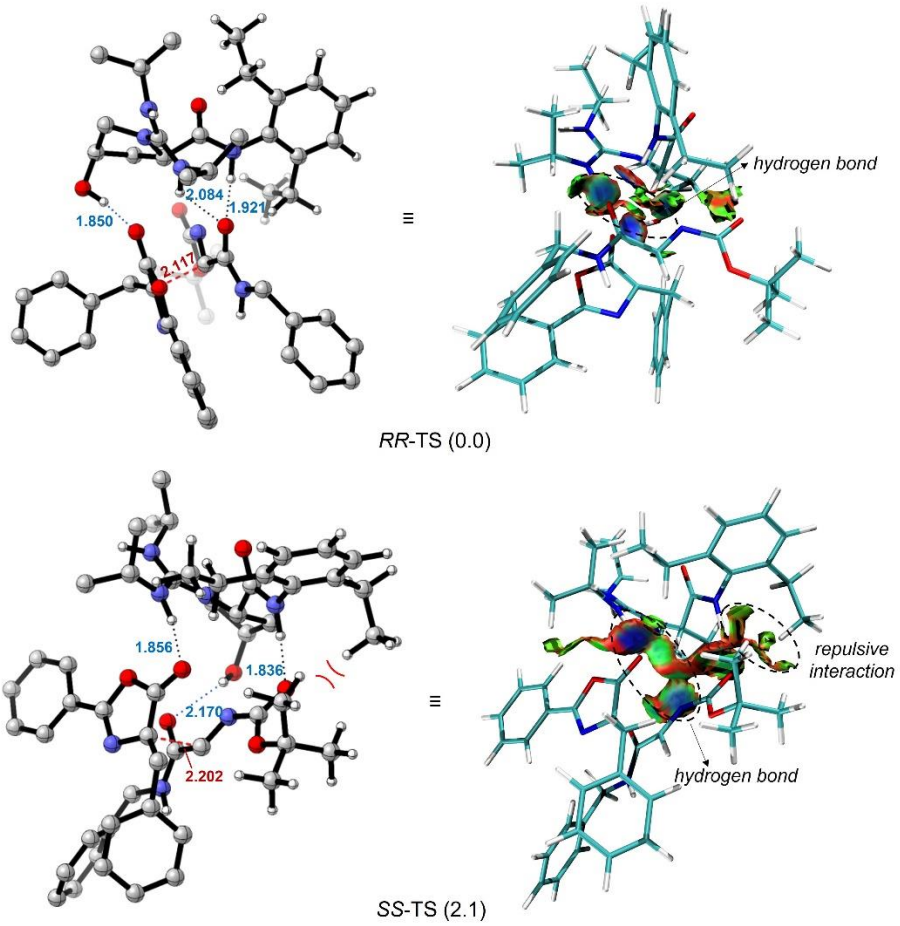


Figure S2. Optimized geometries and non-covalent interaction analysis of ***RR*-TS** and ***SS*-TS.** The relative Gibbs free energy (*ΔG*) is given in kcal mol^{-1} and the bond length is shown in Ångström.

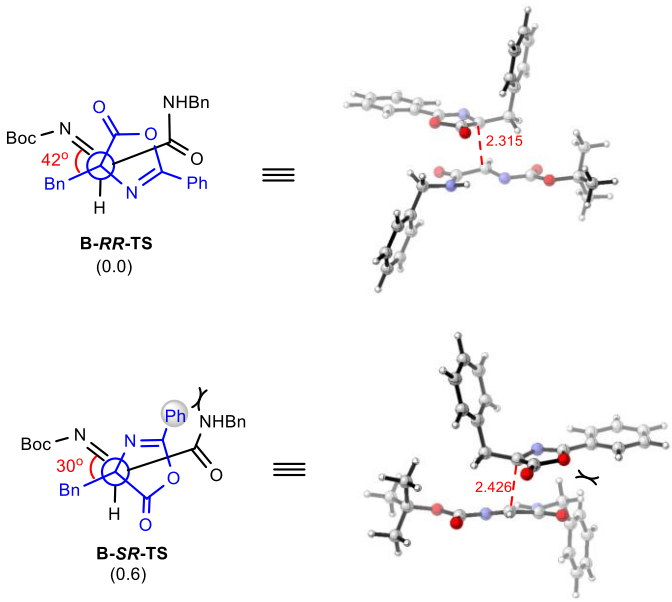


Figure S3. Optimized geometries and non-covalent interaction analysis of **B-*RR*-TS** and **B-*SR*-TS.** The relative Gibbs free energy (*ΔG*) is given in kcal mol^{-1} and the bond length is shown in Ångström.

All calculations were performed using Gaussian 09 program package[10], employing the M06-2X density functional[11] with the 6-31G* basis set[12-13]. Geometries were optimized in THF solvent and characterized by frequency analysis at 263 K. The self-consistent reaction field (SCRF) method based on the universal solvation model PCM[14] was adopted to evaluate the effect of solvent. All single-point energies were computed by using M06-2X density functional with the 6-311G** basis set[15-16], and Gibbs free energies were obtained by Shermo 2.3 program[17]. The non-covalent interaction analysis for transition state was performed using Multiwfn 3.8(dev) program[18] with IGMH method[19], and the isosurface plots were generated by VMD 1.9.3[20]. The three-dimensional structures were generated using CYLView20[21].

Cartesian coordinates of all structures.

RR-TS

N	-3.83807802	0.29939900	-3.25579501
H	-3.59367001	-0.32438500	-4.01473302
N	-1.94994701	-0.47825100	-2.13745801
N	-3.02289201	1.43436301	-1.39954901
C	-2.93438401	0.40398800	-2.26506701
C	-3.37935002	2.80353601	-1.81092801
H	-3.16274001	2.94564202	-2.87167201
H	-4.43528502	3.02131801	-1.61431901
C	-2.46901001	3.65658802	-0.92067000
C	-2.49633001	2.87975501	0.39327600
H	-3.44826501	3.04598801	0.90703600
H	-1.67804001	3.13240602	1.06973001
C	-2.42182901	1.41493001	-0.03873700
H	-1.38686600	1.07066400	-0.05623300
H	-2.86245101	4.67046302	-0.81787800
O	-4.36671602	0.87138701	1.27364901
C	-3.28546501	0.50098300	0.83775701
N	-2.77908801	-0.74702600	0.98494401
C	-3.44706001	-1.80232601	1.66585101
C	-4.71274402	-2.23709501	1.23918301
C	-5.31512301	-3.29427602	1.92867201
H	-6.29216903	-3.64190301	1.60076301
C	-4.68102302	-3.91967202	2.99356301
H	-5.16336103	-4.74475102	3.50868702
C	-3.41489701	-3.49273501	3.38348901
H	-2.90415201	-3.98310202	4.20854902
C	-2.78259001	-2.43439301	2.73356501
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C	-6.14728105	-0.50732600	-3.35420301
C	-5.55946101	1.76001101	-4.26404902
H	-5.39978300	1.13785701	-2.19339601
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H	-5.97734002	-0.98299900	-4.32732602

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H	-5.39688602	1.33306701	-5.25959502
H	-6.60711504	2.06523901	-4.19404102
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C	-3.02607701	-2.71440201	-2.28149501
H	-0.95546300	-2.22386801	-2.16160001
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H	-1.19925900	-2.87463001	-4.45783502
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C	3.35853702	0.07329700	-1.38677201
C	4.37139402	-0.81732200	-1.95158301
C	4.18120802	-1.41008700	-3.20573202
C	5.16652602	-2.23669601	-3.73838202
C	6.33784703	-2.48177001	-3.02368801
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C	2.04925401	2.74562301	0.48407200
C	2.75498601	3.83332602	-0.29619400
C	4.14046002	3.98706302	-0.18738200

C	4.80731702	4.95861602	-0.92800600
C	4.09519402	5.78998801	-1.79167801
C	2.71494501	5.64312704	-1.90521401
C	2.04725901	4.67126302	-1.16119801
H	3.26955602	-1.21153300	-3.76020902
H	5.01888302	-2.68907601	-4.71390802
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H	0.97902101	2.97267101	0.57340500
H	2.46095101	2.67576601	1.49683901
H	4.69589802	3.33322201	0.48058700
H	5.88341705	5.06920502	-0.82987400
H	4.61370002	6.55038804	-2.36796701
H	2.15159401	6.29026505	-2.57140201
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O	1.34426601	1.60659401	3.48595401
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C	0.96994101	-0.98934500	0.44027100
C	0.18001700	1.69049501	2.78687901
C	1.60740001	2.47515101	4.61979802
C	3.03367201	2.09987101	5.00934502
C	0.64466200	2.15781401	5.76077901
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H	2.11162001	0.22661400	1.87679001
H	3.71977702	2.30119001	4.18039902
H	3.09196501	1.03673000	5.26141402
H	3.35209401	2.68401401	5.87754302
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H	0.53335200	4.23266002	3.92430402
H	2.22282001	4.13565202	3.37037701
H	1.86778001	4.56524202	5.05182002
H	2.89809201	-1.55550801	0.77262200
C	3.01187201	-4.01142002	0.00742600
C	4.15132002	-4.30436402	-0.73947000
C	2.83082201	-4.62425502	1.25124501
C	5.09978902	-5.20404302	-0.25368000

H	4.29884002	-3.82416702	-1.70385001
C	3.77468802	-5.52259201	1.73693901
H	1.94485401	-4.39043602	1.83736901
C	4.91245002	-5.81457400	0.98328700
H	5.98539601	-5.42274204	-0.84314400
H	3.62471602	-5.99652905	2.70211601
H	5.64945902	-6.51567602	1.36272500
H	0.98087100	-3.41878002	-0.43821900

Zero-point correction= 1.145236 (Hartree/Particle)

Thermal correction to Energy= 1.209559

Thermal correction to Enthalpy= 1.210503

Thermal correction to Gibbs Free Energy= 1.044700

SS-TS

O	-0.90882103	1.30799305	0.97474201
C	-2.27478004	1.34805407	1.05951302
N	-2.83842306	0.19561507	1.16962102
C	-1.80235307	-0.74721995	1.05222802
C	-0.56415605	-0.03089297	1.06300702
O	0.61427995	-0.37712799	1.03989502
C	-2.90757102	2.66443509	1.02987701
C	-4.29633602	2.76153611	1.17924702
C	-4.90970200	4.00748213	1.15034002
C	-4.14556897	5.16185712	0.97336702
C	-2.76445997	5.06458409	0.81685601
C	-2.14288999	3.82008608	0.84156602
C	-3.29972011	-2.74147093	1.48466002
C	-4.34295811	-2.44072291	2.36642802
C	-5.60122515	-3.01276289	2.20694002
C	-5.84726816	-3.87905489	1.14238802
C	-4.81752914	-4.19058391	0.25969101
C	-3.54928213	-3.63664493	0.43974001
C	-1.94067410	-2.11180595	1.68874302
H	-4.87846004	1.85315312	1.30885002
H	-5.98679298	4.07997515	1.26451602
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H	-2.16990195	5.96069708	0.66807902
H	-1.06894299	3.73584106	0.70251102
H	-4.15792810	-1.75463391	3.18926503
H	-6.39238715	-2.78277888	2.91506302
H	-6.83204615	-4.31659487	1.01011602
H	-4.99175516	-4.88106891	-0.56004899
H	-2.73707213	-3.92611394	-0.22340399
H	-1.76329609	-2.01182396	2.76812403

H	-1.15148910	-2.75186597	1.28849402
N	2.42345403	4.19878100	-0.04290399
H	2.14686504	4.64551601	0.82284201
N	1.93063700	2.15909800	0.97863602
N	2.29208300	2.24409699	-1.29307200
C	2.22211101	2.86884300	-0.10587099
C	1.89066101	2.82576000	-2.58619500
H	0.97336402	3.41019302	-2.47507700
H	2.67876803	3.46109399	-3.00370700
C	1.67132099	1.59001500	-3.48024800
C	2.66914797	0.58365398	-2.89835400
H	3.68660698	0.83208296	-3.22248500
H	2.42977195	-0.44521602	-3.16979000
C	2.53784297	0.80441998	-1.38629300
H	1.90884099	1.84052900	-4.51783401
C	3.41923406	4.93267398	-0.84605999
C	4.52990207	5.45148097	0.06355701
C	2.75035607	6.06202298	-1.62185899
H	3.85603304	4.20125897	-1.52887099
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H	5.25996108	6.01190995	-0.52682599
H	4.12397108	6.12780495	0.82512302
H	1.95461506	5.68593801	-2.26962300
H	2.31320208	6.78801199	-0.92786999
H	3.48758208	6.58390400	-2.23824700
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C	1.01681602	3.36929602	2.96109203
C	3.53190502	3.09633097	2.65611902
H	2.09196199	1.53292399	2.88760302
H	0.04629700	2.89804703	2.78841102
H	1.16212402	3.49639102	4.03803403
H	0.99462703	4.37068802	2.51445202
H	4.28327302	2.61364696	2.02350002
H	3.56629804	4.17525098	2.47745002
H	3.79360002	2.93400497	3.70555603
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H	0.11701096	0.66086802	-2.65048900
H	1.50497298	1.23780000	0.83348202
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N	-0.25246807	-1.13880898	-1.49643599
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C	-6.16777910	-0.32597187	-0.03131299

C	-7.42375708	-0.62957785	0.48928201
C	-8.57639511	-0.36683183	-0.24833599
C	-8.46867707	0.19875518	-1.51674799
C	-7.21360705	0.50082915	-2.03952800
C	-4.70648006	0.62774811	-1.86109499
H	-4.02892509	-1.31855791	-1.31292999
H	-5.26830908	-0.52923789	0.55057802
H	-7.50086413	-1.07386485	1.47681502
H	-9.55322211	-0.60466881	0.16195701
H	-9.36048910	0.40094219	-2.10236500
H	-7.12973008	0.93629415	-3.03214900
H	-4.79401505	0.84836511	-2.93154700
H	-4.33219604	1.53960711	-1.37726699
H	-1.98995409	-2.17294295	-0.91774599
H	1.68620096	0.22519499	-1.00701199
O	4.61997799	1.23591395	-0.21729899
C	3.80391097	0.41486496	-0.61799799
N	3.90570695	-0.92261305	-0.46047799
C	4.95961895	-1.56472907	0.25742201
C	4.98142195	-1.46936108	1.65967102
C	5.98983395	-2.14638709	2.34574302
H	6.03354494	-2.09489009	3.42886803
C	6.94162695	-2.89771811	1.65918302
H	7.71747991	-3.42060613	2.21049302
C	6.90447093	-2.97242211	0.27283301
H	7.65375591	-3.54845213	-0.26441799
C	5.91579994	-2.30093309	-0.45173199
H	3.15288894	-1.49296104	-0.85771499
C	3.92696696	-0.64375905	2.36424602
C	3.95309095	-0.71301005	3.88744403
H	2.93779295	-0.94180904	1.99213002
H	4.05586297	0.39781895	2.04295802
H	3.13851896	-0.11533603	4.30783603
H	3.82912694	-1.74044306	4.24465203
H	4.89249697	-0.32422307	4.29316003
C	5.87601592	-2.39179809	-1.95791400
C	4.87512091	-3.44133608	-2.45532400
H	6.87871292	-2.64216611	-2.32016100
H	5.61445696	-1.41416308	-2.37837700
H	4.92384091	-3.53846208	-3.54428400
H	5.09174090	-4.42021609	-2.01425100
H	3.85030891	-3.16579606	-2.18822299
O	0.01897289	-3.27439599	-0.67366299
C	0.83638188	-4.43189901	-0.32839499
C	-0.12319414	-5.31277499	0.46699301

C	2.01282188	-4.01241403	0.55512501
C	1.28171186	-5.16636502	-1.58956300
C	0.56211792	-2.21436700	-1.31664999
O	1.72225292	-2.24104702	-1.73266000
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H	0.37884184	-6.24384901	0.74500502
H	-0.45212914	-4.81324599	1.38354002
H	2.84099390	-3.60578305	-0.02786399
H	2.37979887	-4.88332404	1.10698802
H	1.68184290	-3.25776602	1.27743602
H	1.81044585	-6.08186702	-1.30496899
H	0.40873985	-5.44612903	-2.18781999
H	1.94609088	-4.54868803	-2.19361900

Zero-point correction= 1.143133 (Hartree/Particle)

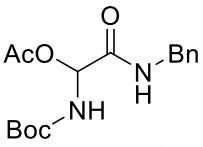
Thermal correction to Energy= 1.208034

Thermal correction to Enthalpy= 1.208978

Thermal correction to Gibbs Free Energy= 1.040472

10. Characterization of some substrates

2-(Benzylamino)-1-[(*tert*-butoxycarbonyl)amino]-2-oxoethyl acetate



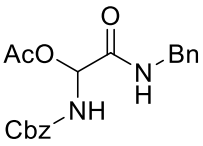
A1

1H NMR (400 MHz, Chloroform-d) δ = 7.41 – 7.15 (m, 5H), 6.81 (s, 1H), 6.39 (d, 1H), 6.23 (s, 1H), 4.51 (dd, J = 15.2, 6.0 Hz, 1H), 4.41 (dd, J = 15.2, 6.0 Hz, 1H), 2.11 (s, 3H), 1.46 (s, 9H).

^{13}C NMR (101 MHz, $CDCl_3$) δ = 171.9, 165.3, 154.0, 137.3, 128.9, 127.9, 127.8, 81.4, 75.5, 43.9, 28.3, 21.1.

IR: 3336, 3209, 3031, 1743, 1701, 1657, 1547 cm^{-1}.

2-(Benzylamino)-1-{[(benzyloxy)carbonyl]amino}-2-oxoethyl acetate



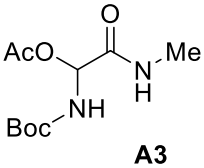
A2

^{1}H NMR (400 MHz, Chloroform-*d*) δ = 7.44 – 7.16 (m, 9H), 6.88 (s, 1H), 6.55 (s, 1H), 6.43 (d, *J* = 8.8 Hz, 1H), 5.12 (dd, *J* = 22.4, 12.4 Hz, 2H), 4.44 (m, 2H), 2.08 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ = 171.8, 165.0, 154.9, 137.2, 135.7, 128.9, 128.7, 128.5, 128.3, 127.9, 127.7, 75.5, 67.7, 43.8, 21.0.

IR: 3355, 3196, 3038, 1757, 1711, 1650, 1553 cm^{-1}.

1-(*Tert*-butoxycarbonyl)amino)-2-(methylamino)-2-oxoethyl acetate



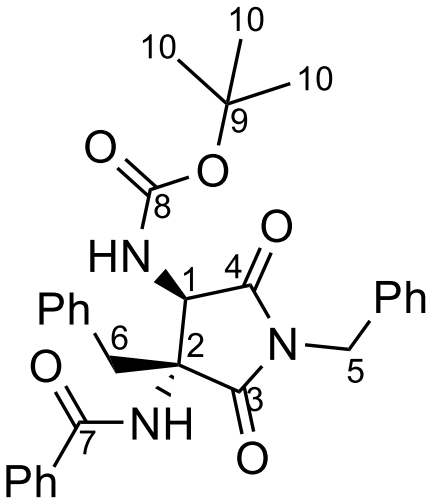
A3

^{1}H NMR (400 MHz, Chloroform-*d*) δ = 6.50 (s, 1H), 6.35 (d, *J* = 8.8 Hz, 1H), 6.23 (s, 1H), 2.86 (d, *J* = 4.8 Hz, 3H), 2.13 (s, 3H), 1.46 (s, 9H).

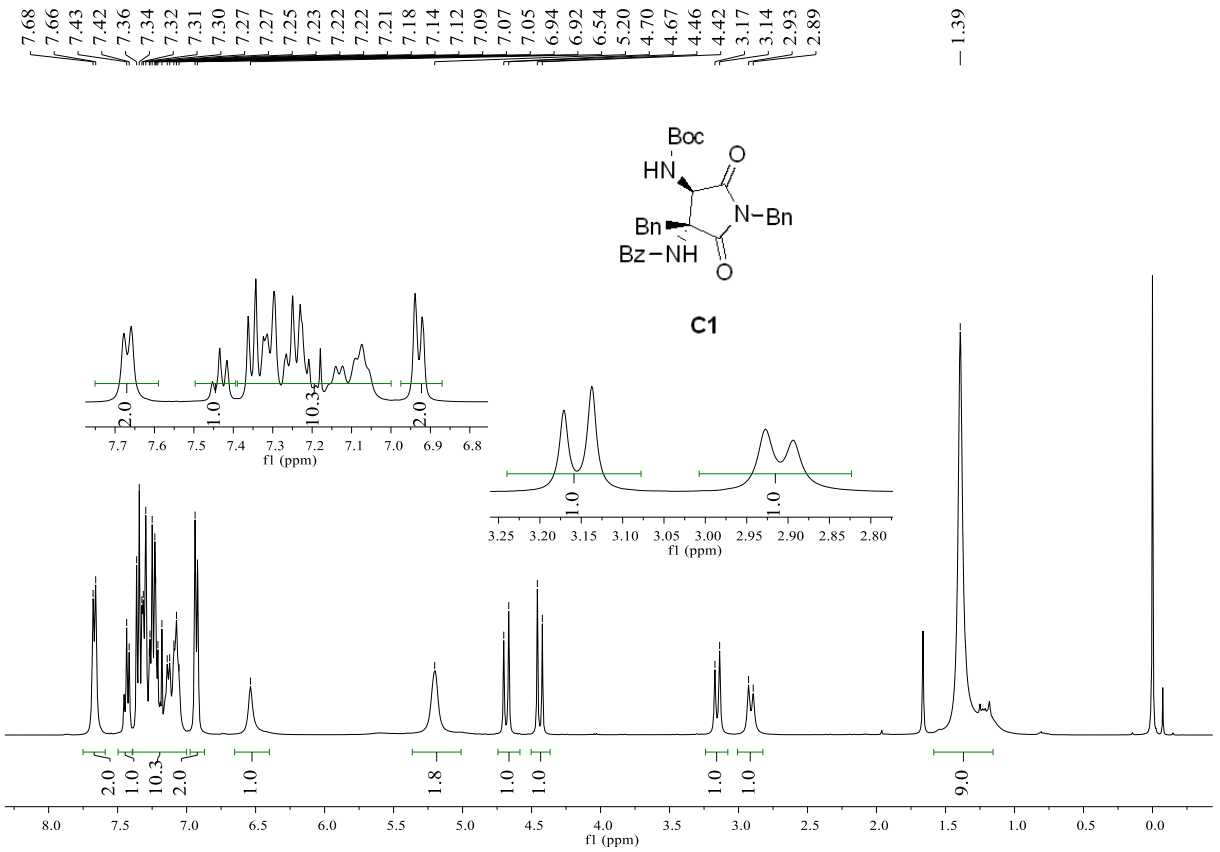
^{13}C NMR (101 MHz, $CDCl_3$) δ = 171.9, 165.9, 154.0, 81.3, 75.4, 28.3, 26.6, 21.2.

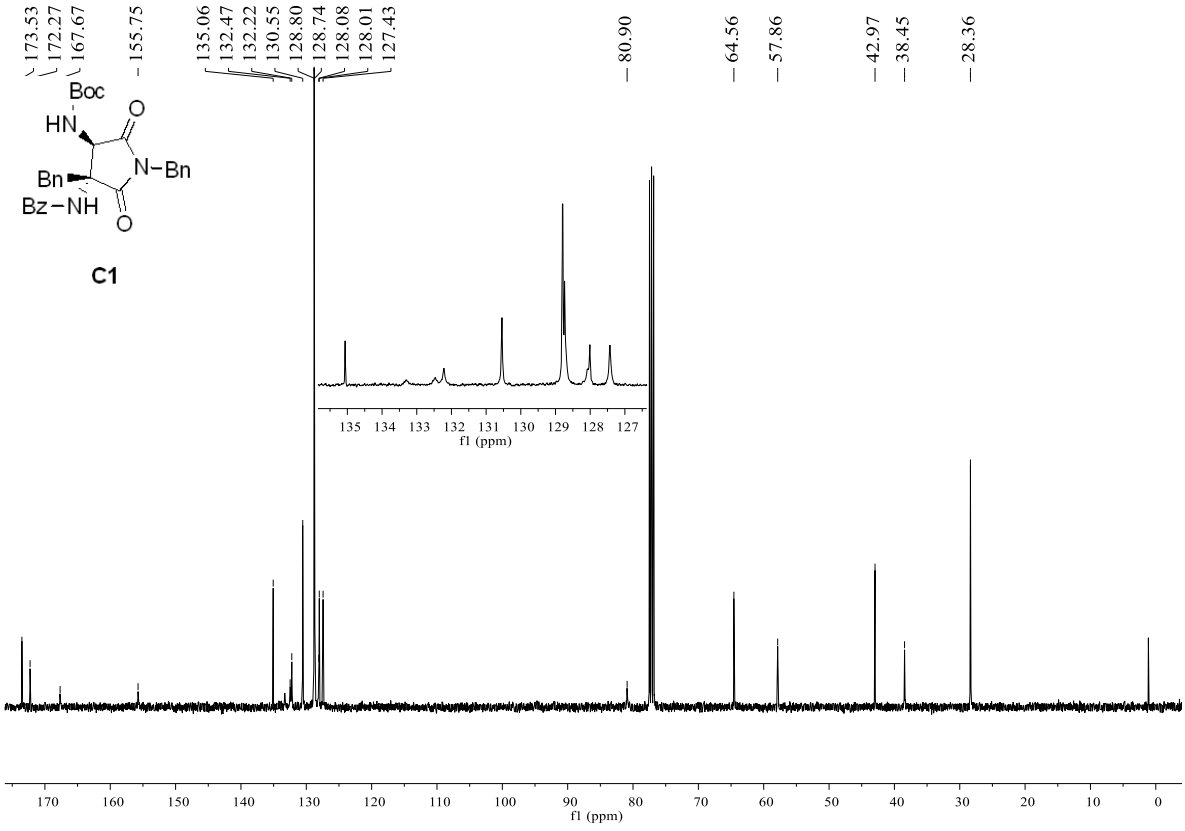
IR: 3354, 3214, 3033, 1745, 1706, 1663, 1552 cm^{-1}.

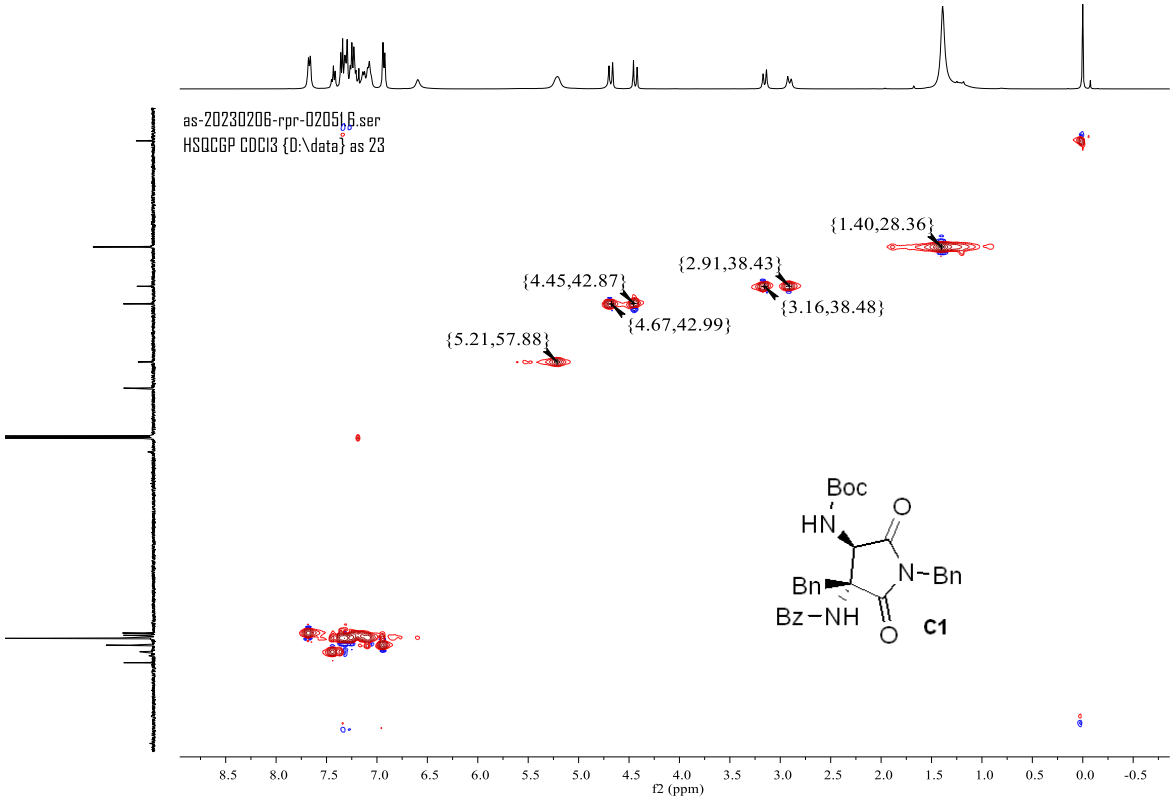
11. Analysis results of 2D NMR spectra of the product C1 and D3

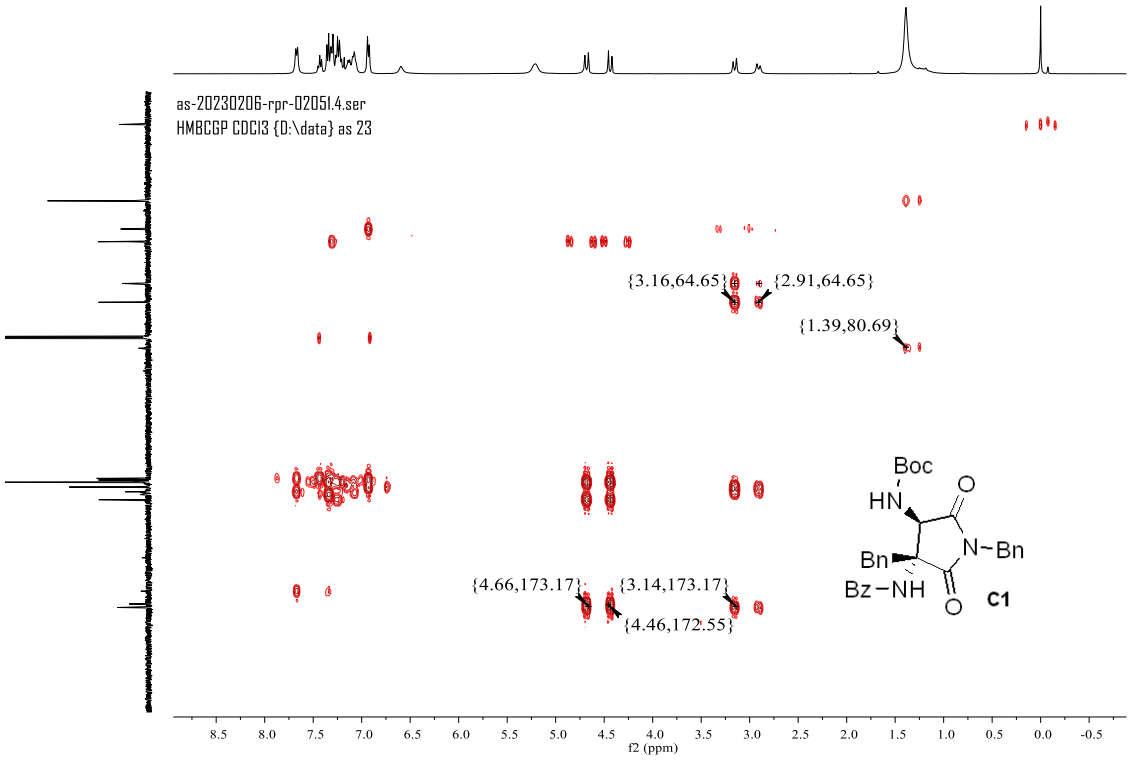


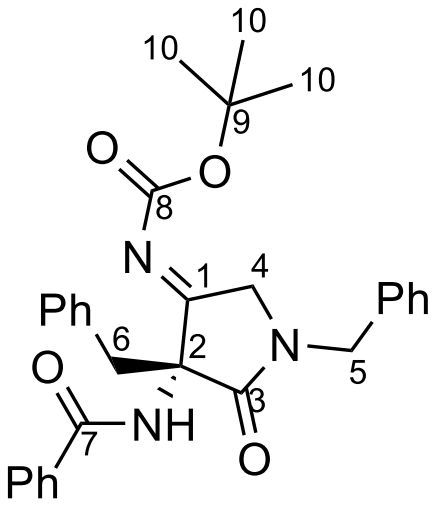
Number of Atom	H (ppm)	C (ppm)
1	5.2	57.9
2	--	64.7
3	--	173.2
4	--	172.6
5	4.4-4.7 (2H)	42.9
6	2.9-3.2 (2H)	38.5
7	--	167.7
8	--	155.7
9	--	80.7
10	1.4 (9H)	28.4


7.68 7.66 7.43 7.42 7.36 7.34 7.32 7.31 7.30 7.27 7.27 7.25 7.23 7.22 7.22 7.21 7.18 7.14 7.12 7.09 7.07 7.05 6.94 6.92 6.54 5.20 4.70 4.67 4.46 4.42 3.17 3.14 2.93 2.89
1.39
Boc
HN
O
N–Bn
Bn
Bz–NH
O
C1
2.0 1.0 10.3 2.0 1.0 1.8 1.0 1.0 1.0 1.0 9.0
fl (ppm)

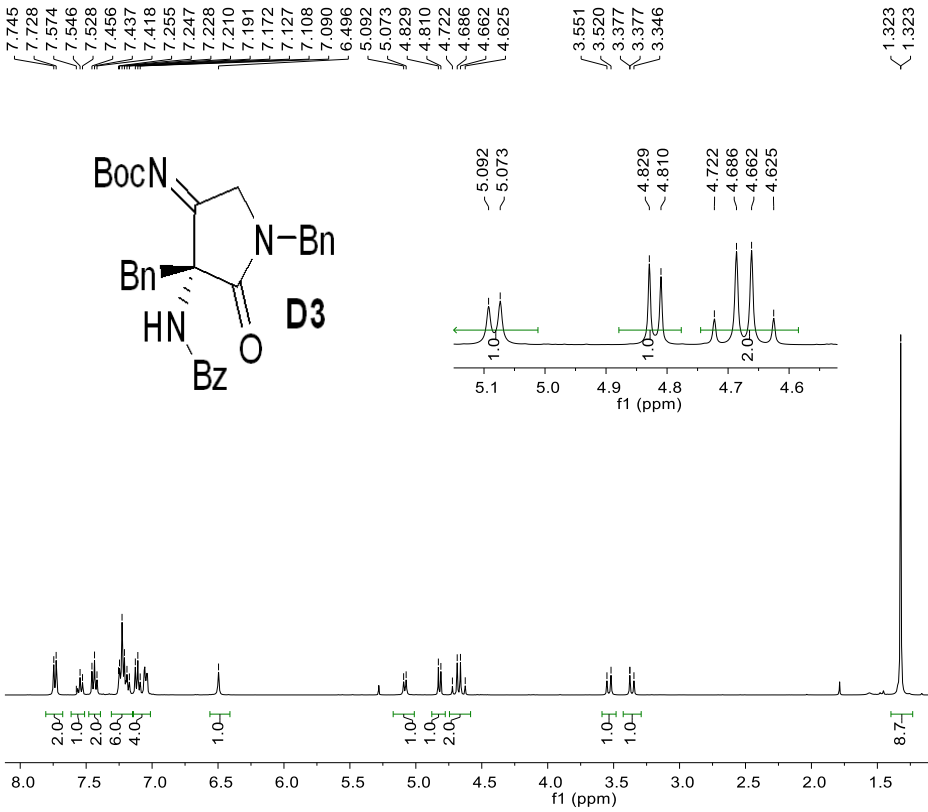

173.53 172.27 167.67 155.75 135.06 132.47 132.22 130.55 128.80 128.74 128.08 128.01 127.43 80.90 64.56 57.86 42.97 38.45 28.36
Boc
HN
O
N–Bn
Bn
Bz–NH
O
C1
fl (ppm)

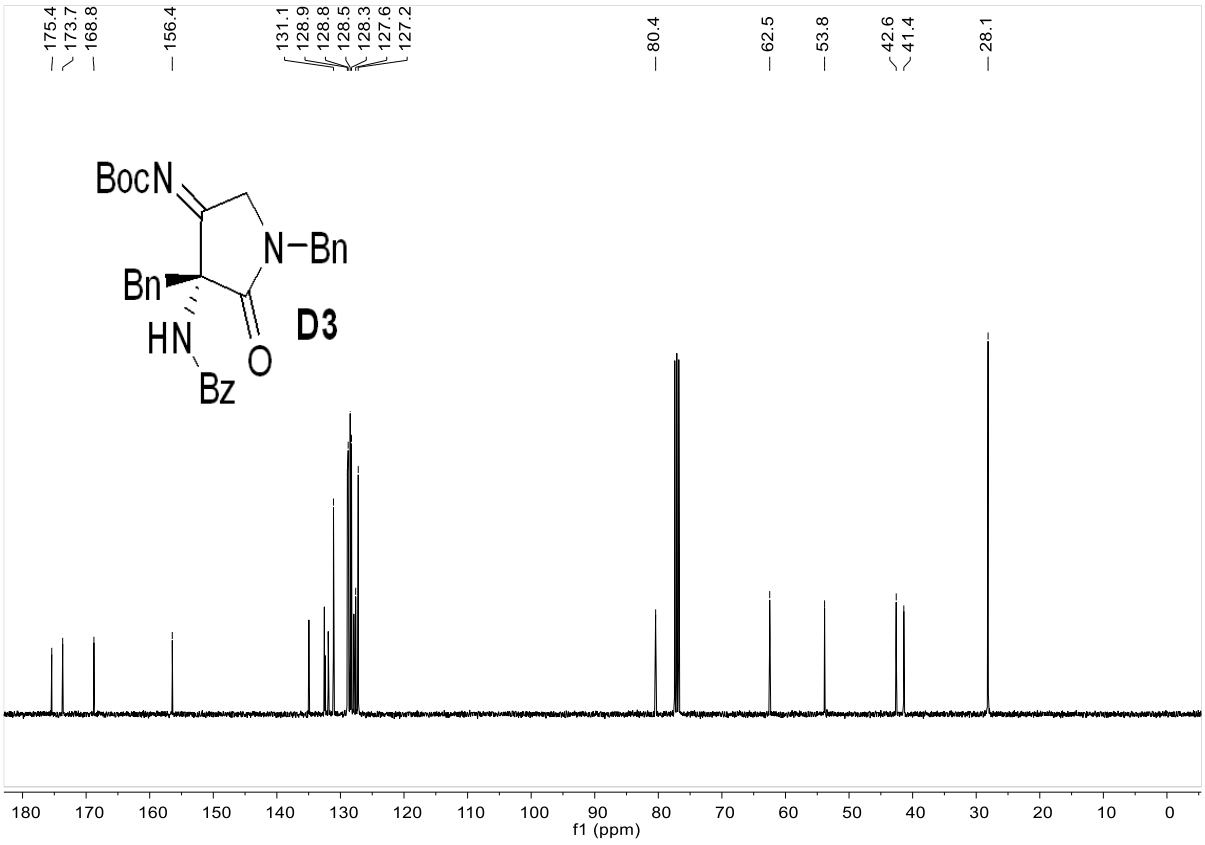

as-20230206-rpr-02051.6.ser
HSQCGP CDCl3 {D:\data} as 23
{1.40,28.36}
{2.91,38.43}
{4.45,42.87}
{3.16,38.48}
{4.67,42.99}
{5.21,57.88}
Boc
HN
N–Bn
Bn
Bz–NH
C1
f2 (ppm)

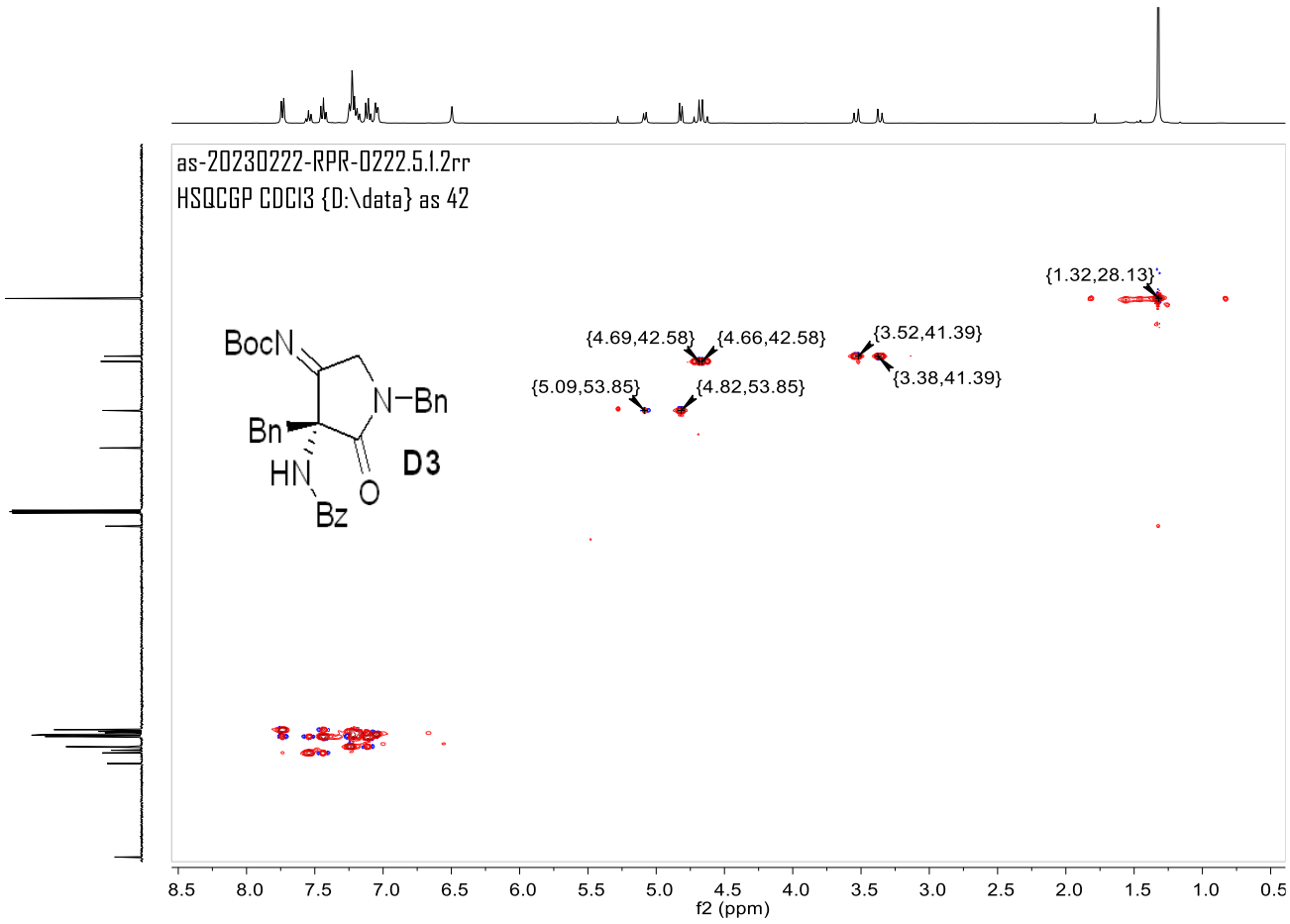

as-20230206-rpr-02051.4.ser
HMBCGP CDCl3 {D:\data} as 23
{3.16,64.65}
{2.91,64.65}
{1.39,80.69}
{4.66,173.17}
{3.14,173.17}
{4.46,172.55}
Boc
HN
N–Bn
Bn
Bz–NH
C1
f2 (ppm)

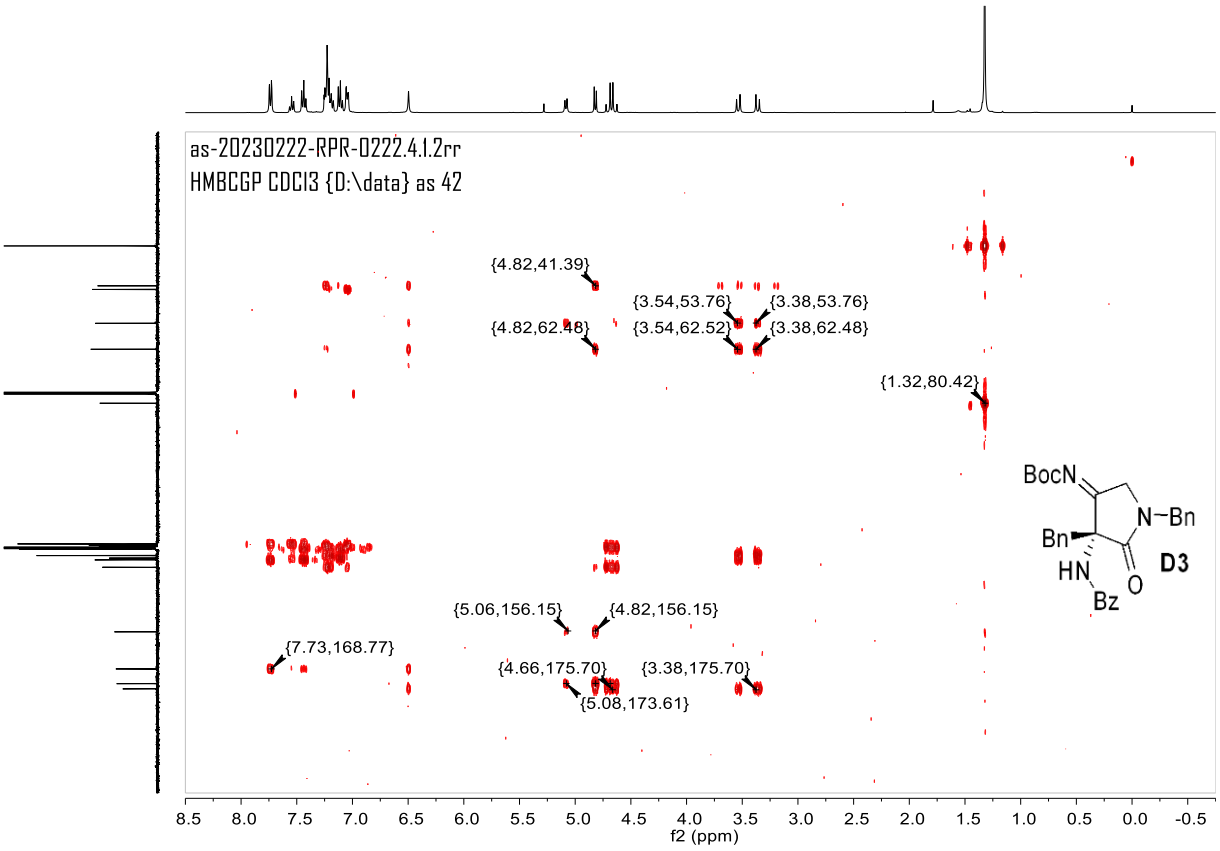


Number of Atom	H (ppm)	C (ppm)
1	--	173.6
2	--	62.4
3	--	175.7
4	5.1 (d, *J* = 7.6 Hz, 1H) 4.8 (d, *J* = 7.6 Hz, 1H).	53.8
5	4.6-4.7 (2H)	42.6
6	3.4-3.6 (2H)	41.4
7	--	168.8
8	--	156.5
9	--	80.4
10	1.3 (9H)	28.1


7.745
7.728
7.574
7.546
7.528
7.456
7.437
7.418
7.255
7.247
7.228
7.210
7.191
7.172
7.127
7.108
7.090
6.496
5.092
5.073
4.829
4.810
4.722
4.686
4.662
4.625
3.551
3.520
3.377
3.377
3.346
1.323
1.323
BocN
N–Bn
Bn
HN
O
Bz
D3
5.092
5.073
4.829
4.810
4.722
4.686
4.662
4.625
1.0
1.0
2.0
5.1
5.0
4.9
4.8
4.7
4.6
f1 (ppm)
2.0
1.0
2.0
6.0
4.0
1.0
1.0
1.0
2.0
1.0
1.0
8.7
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)

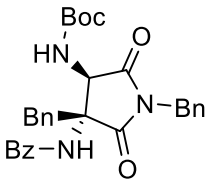

175.4
173.7
168.8
156.4
131.1
128.9
128.8
128.5
128.3
127.6
127.2
80.4
62.5
53.8
42.6
41.4
28.1
BocN
N–Bn
Bn
HN
O
Bz
D3
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


as-20230222-RPR-0222.5.1.2rr
HSQCGP CDCl3 {D:\data} as 42
{1.32,28.13}
{4.69,42.58}
{4.66,42.58}
{3.52,41.39}
{3.38,41.39}
{5.09,53.85}
{4.82,53.85}
BocN
N–Bn
Bn
HN
Bz
O
D3
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
f2 (ppm)


as-20230222-RPR-0222.4.1.2rr
HMBCGP CDCl3 {D:\data} as 42
{4.82,41.39}
{3.54,53.76}
{3.38,53.76}
{4.82,62.48}
{3.54,62.52}
{3.38,62.48}
{1.32,80.42}
{5.06,156.15}
{4.82,156.15}
{7.73,168.77}
{4.66,175.70}
{3.38,175.70}
{5.08,173.61}
BocN
N–Bn
Bn
HN
Bz
O
D3
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 -0.5
f2 (ppm)

13. Characterization of the products

***Tert*-butyl ((3R,4R)-4-benzamido-1,4-dibenzyl-2,5-dioxopyrrolidin-3-yl)carbamate C1**



C1

White solid; 45.1 mg, 88% yield, 91:9 er, melting point: 82–85 °C; $[\alpha]^{17}_D$ = +40.6 (*c* = 0.89 in CH_2Cl_2). Dr value determined by ^{1}H NMR analysis after flash filtration to reaction mixture with a thin silica gel: 94:6.

SFC Daicel chiralcel OX-3, CO_2/MeOH = 80/20, flow rate = 1.5 mL/min, λ = 254 nm, t_R (major) = 3.21 min, t_R (minor) = 4.03 min.

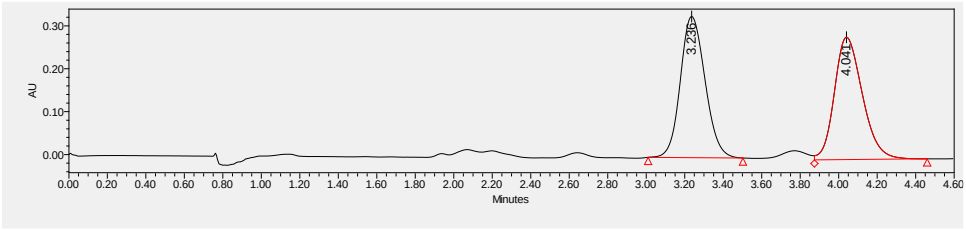
^{1}H NMR (400 MHz, Chloroform-*d*) δ = 7.74 (d, *J* = 7.6 Hz, 2H), 7.50 (d, *J* = 7.3 Hz, 1H), 7.46 – 7.07 (m, 10H), 7.01 (d, 2H), 6.54 (s, 1H), 5.20 (s, 2H), 4.76 (d, *J* = 14.4 Hz, 1H), 4.52 (d, *J* = 14.4 Hz, 1H), 3.15 (d, *J* = 13.6 Hz, 1H), 3.00 (d, *J* = 13.6 Hz, 1H), 1.47 (s, 9H).

^{13}C NMR (101 MHz, $CDCl_3$) δ = 173.5, 172.3, 167.7, 155.8, 135.1, 132.5, 132.2, 130.6, 128.8, 128.7, 128.1, 128.0, 127.4, 80.90, 64.6, 57.9, 43.0, 38.5, 28.4.;

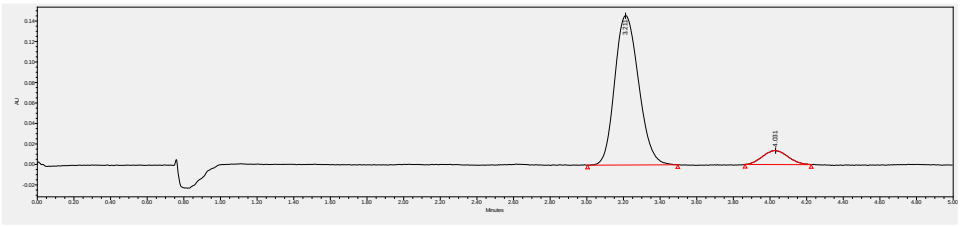
IR: 3352, 1716, 1655, 1508 cm^{-1}.

HRMS (FTMS+c ESI) m/z: $[M + H]^+$ calcd for $C_{30}H_{32}N_3O_5^+$ 514.2336; Found 514.2342.

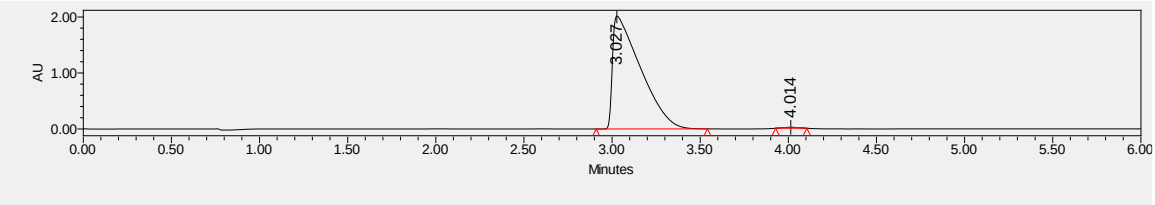
After recrystallization: >99:1 er, $[\alpha]^{22}_D$ = +60.9 (*c* = 1.83 in CH_2Cl_2).



	Retention Time	% Area
1	3.236	50.49
2	4.041	49.51

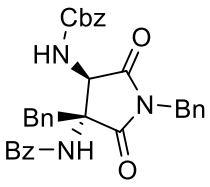


	Retention Time	% Area
1	3.211	90.95
2	4.031	9.05



	Retention Time	% Area
1	3.027	99.54
2	4.014	0.46

Benzyl ((3R,4R)-4-benzamido-1,4-dibenzyl-2,5-dioxopyrrolidin-3-yl)carbamate C2



C2

White solid; 45.4 mg, 83% yield, 81:19 er, melting point: 68–71 °C; $[\alpha]^{16}_{D}$ = +26.5 (*c* = 0.91 in CH_2Cl_2). Dr value determined by ^{1}H NMR analysis: after flash filtration to reaction mixture with a thin silica gel: 87:13; after purification by flash column chromatography: 9:1.

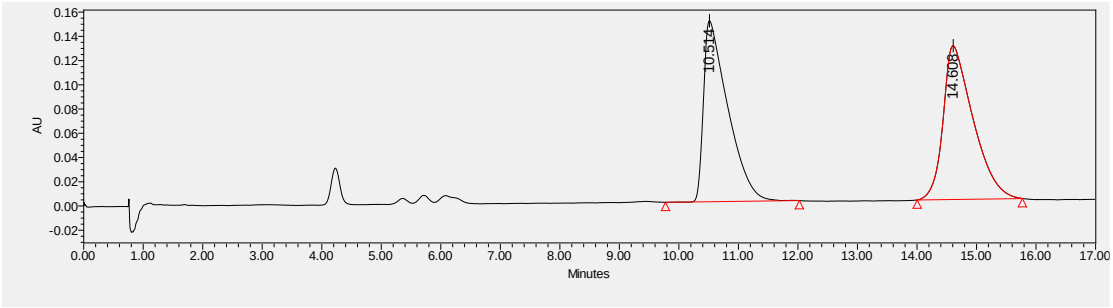
SFC Daicel chiralcel OX-3, CO_2/MeOH = 80/20, flow rate = 1.5 mL/min, λ = 254 nm, t_R (major) = 10.59 min, t_R (minor) = 14.87 min.

^{1}H NMR (400 MHz, Chloroform-*d*) δ = 7.75 (d, J = 7.5 Hz, 2H), 7.58 – 7.03 (m, 17H), 6.94 (d, J = 7.5 Hz, 2H), 6.65 (s, 1H), 5.48 (d, 2H), 5.14 (s, 2H), 4.75 (d, J = 14.4 Hz, 1H), 4.49 (d, J = 14.4 Hz, 1H), 3.21 (d, J = 13.6 Hz, 1H), 2.98 (d, J = 13.6 Hz, 1H).

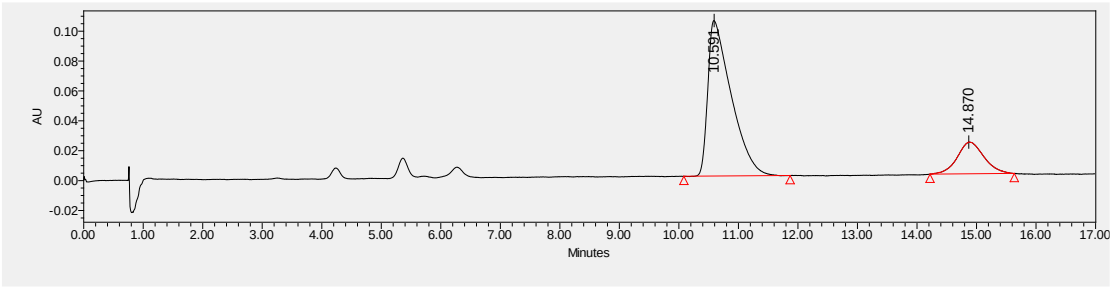
^{13}C NMR (101 MHz, $CDCl_3$) δ = 172.2, 170.7, 166.6, 155.4, 133.8, 131.1, 129.3, 127.7, 127.6, 127.6, 127.4, 127.1, 127.0, 126.9, 126.3, 66.6, 63.5, 56.7, 41.9, 37.3.

IR: 3325, 3032, 1791, 1709, 1655, 1510 cm^{-1}.

HRMS (FTMS+c ESI) m/z: $[M + H]^+$ calcd for $C_{33}H_{30}N_3O_5^+$ 548.2180; Found 548.2178.

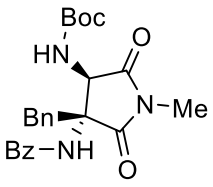


	Retention Time	% Area
1	10.514	48.83
2	14.608	51.17



	Retention Time	% Area
1	10.591	81.16
2	14.870	18.84

***T*ert-butyl ((3R,4R)-4-benzamido-4-benzyl-1-methyl-2,5-dioxopyrrolidin-3-yl)carbamate C3**



C3

White solid; 18.4 mg, 42% yield, 92:8 er; melting point: 79–84 °C; $[\alpha]^{17}_D$ = +35.1 (*c* = 0.28 in CH_2Cl_2). Dr value determined by ^{1}H NMR analysis after flash filtration to reaction mixture with a thin silica gel: 94:6.

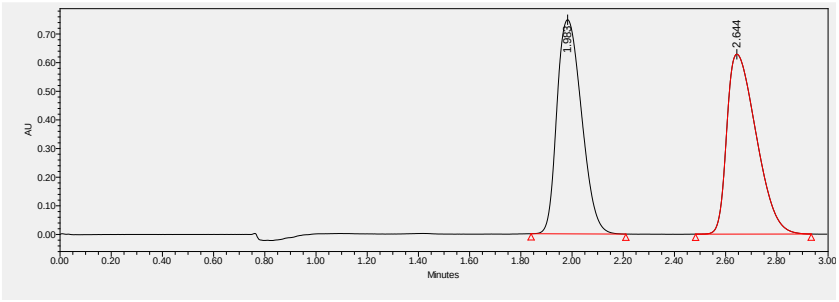
SFC Daicel chiralcel OX-3, CO_2/MeOH = 80/20, flow rate = 1.5 mL/min, λ = 254 nm, t_R (major) = 2.02 min, t_R (minor) = 2.71 min.

^{1}H NMR (400 MHz, Chloroform-*d*) δ = 7.87 – 7.71 (m, 2H), 7.58 – 7.49 (m, 1H), 7.44 (dd, 2H), 7.36 – 7.23 (m, 4H), 7.22 – 7.14 (m, 2H), 6.65 (s, 1H), 5.21 (d, 2H), 3.26 (d, *J* = 13.6 Hz, 1H), 3.15 (d, *J* = 13.6 Hz, 1H), 2.90 (s, 3H), 1.49 (s, 9H).

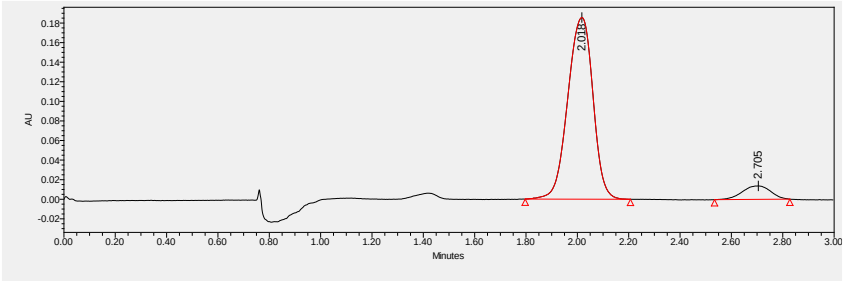
^{13}C NMR (101 MHz, $CDCl_3$) δ = 174.1, 172.5, 167.6, 155.8, 133.2, 132.7, 132.3, 130.6, 128.8, 128.3, 127.5, 81.0, 65.2, 57.6, 38.6, 28.4, 25.1.

IR: 3338, 1707, 1653, 1578, 1521 cm^{-1}.

HRMS (FTMS+c ESI) m/z: $[M + Na]^+$ calcd for $C_{24}H_{27}N_3O_5Na^+$ 460.1843; Found 460.1837.

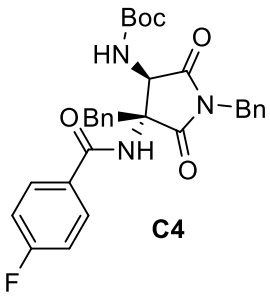


	Retention Time	% Area
1	1.983	49.98
2	2.644	50.02



	Retention Time	% Area
1	2.018	92.31
2	2.705	7.69

***T*ert-butyl ((3R,4R)-1,4-dibenzyl-4-(4-fluorobenzamido)-2,5-dioxopyrrolidin-3-yl)carbamate C4**



C4

White solid; 37.2 mg, 70% yield, 90:10 er; melting point: 89–91 °C; $[\alpha]^{17}_D$ = +39.8 (*c* = 0.65 in CH_2Cl_2).

Dr value determined by ^{1}H NMR analysis after flash filtration to reaction mixture with a thin silica gel: 71:29.

SFC Daicel chiralcel OX-3, CO_2/MeOH = 80/20, flow rate = 1.5 mL/min, λ = 254 nm, t_R (major) = 2.34 min, t_R (minor) = 2.92 min.

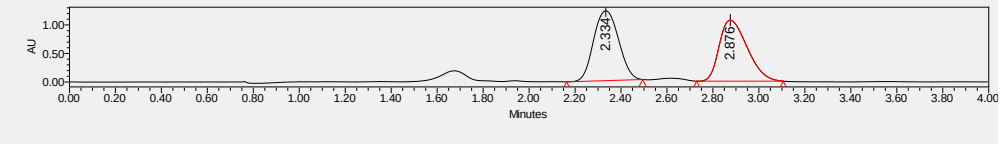
^{1}H NMR (400 MHz, Chloroform-*d*) δ = 7.76 (dd, 2H), 7.47 – 7.05 (m, 10H), 7.04 – 6.93 (m, 2H), 6.56 (s, 1H), 5.27 (s, 2H), 4.75 (d, *J* = 14.4 Hz, 1H), 4.50 (d, *J* = 14.4 Hz, 1H), 3.22 (d, *J* = 13.6 Hz, 1H), 2.98 (d, *J* = 13.6 Hz, 1H), 1.47 (s, 9H).

^{13}C NMR (101 MHz, Chloroform-*d*) δ = 173.5, 172.2, 166.5, 164.0, 135.0, 132.4, 130.5, 129.9 (d, *J* = 36 Hz), 128.8 (d, *J* = 16 Hz), 128.1, 115.9 (d, *J* = 88 Hz), 81.0, 64.7, 57.8, 43.0, 38.5, 28.4.

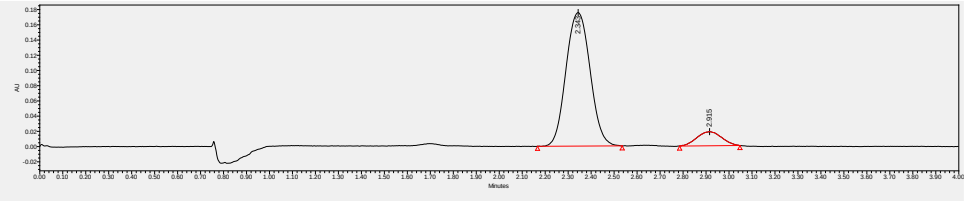
^{19}F NMR (377 MHz, $CDCl_3$) δ = –107.07.

IR: 3308, 1704, 1655, 1495 cm^{-1}.

HRMS (FTMS+c ESI) m/z: $[M + H]^+$ calcd for $C_{30}H_{31}FN_3O_5^+$ 532.2242; Found 532.2233.

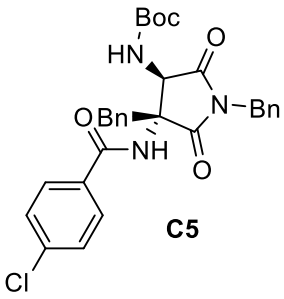


	Retention Time	% Area
1	2.334	50.62
2	2.876	49.38



	Retention Time	% Area
1	2.343	90.21
2	2.915	9.79

***T*ert-butyl ((3R,4R)-1,4-dibenzyl-4-(4-chlorobenzamido)-2,5-dioxopyrrolidin-3-yl)carbamate C5**



C5

White solid; 41.0 mg, 75% yield, 85:15 er; melting point: 95–97 °C; $[\alpha]^{16}_{D}$ = +40.4 (*c* = 0.85 in CH_2Cl_2).

Dr value determined by ^{1}H NMR analysis after flash filtration to reaction mixture with a thin silica gel: 77:23.

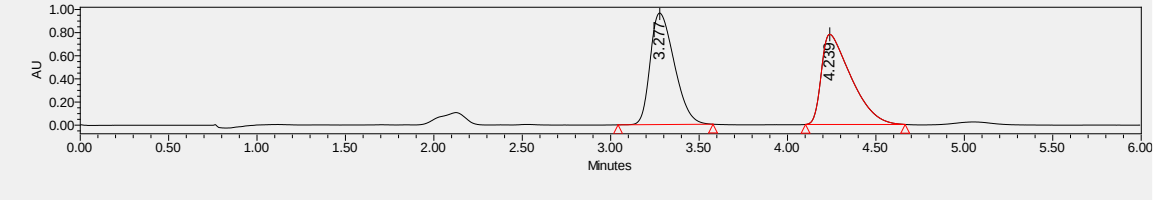
SFC Daicel chiralcel OX-3, CO_2/MeOH = 80/20, flow rate = 1.5 mL/min, λ = 254 nm, t_R (major) = 2.28 min, t_R (minor) = 4.33 min.

^{1}H NMR (400 MHz, Chloroform-*d*) δ = 7.68 (d, *J* = 8.0 Hz, 2H), 7.51 – 7.08 (m, 10H), 7.06 – 6.89 (m, 2H), 6.60 (s, 1H), 5.35 – 5.14 (m, 2H), 4.74 (d, *J* = 14.4 Hz 1H), 4.49 (d, *J* = 14.4 Hz ,1H), 3.22 (d, *J* = 13.6 Hz, 1H), 2.98 (d, *J* = 13.6 Hz, 1H), 1.47 (s, 9H).

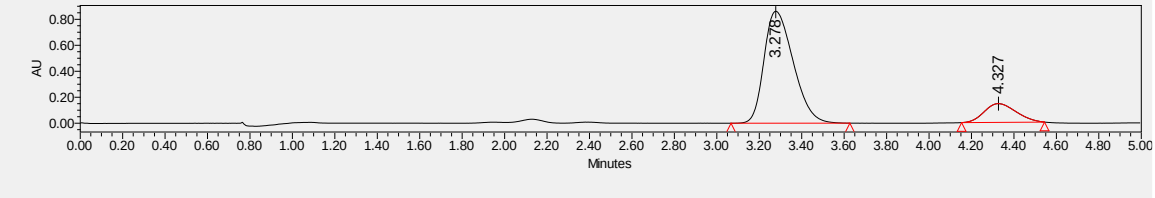
^{13}C NMR (101 MHz, $CDCl_3$) δ = 173.3, 172.1, 166.6, 155.7, 138.4, 134.9, 132.2, 131.6, 130.4, 129.5, 128.9, 128.8, 128.7, 128.7, 128.1, 128.0, 80.9, 64.6, 57.7, 42.9, 38.4, 28.3.

IR: 3325, 1791, 1656, 1596, 1483 cm^{-1}.

HRMS (FTMS+c ESI) m/z: $[M + K]^+$ calcd for $C_{30}H_{30}ClN_3O_5K^+$ 586.1505, 587.1539; Found 586.1501, 587.1542.

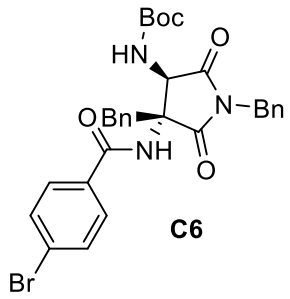


	Retention Time	% Area
1	3.277	50.15
2	4.239	49.85



	Retention Time	% Area
1	3.278	84.58
2	4.327	15.42

***T*ert-butyl ((3R,4R)-1,4-dibenzyl-4-(4-bromobenzamido)-2,5-dioxopyrrolidin-3-yl)carbamate C6**



C6

White solid; 44.9 mg, 76% yield, 80:20 er; melting point: 94–98 °C; $[\alpha]^{17}_{D}$ = +33.9 (*c* = 0.82 in CH_2Cl_2).

Dr value determined by ^{1}H NMR analysis after flash filtration to reaction mixture with a thin silica gel: 83:17.

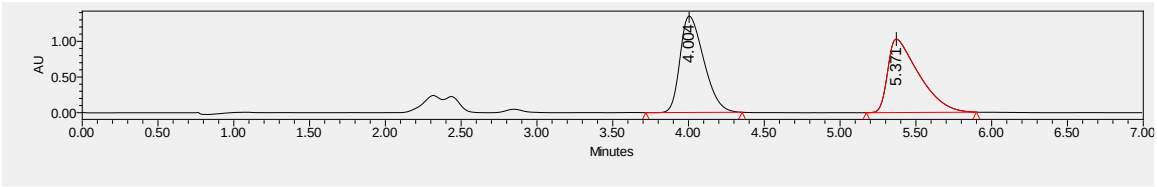
SFC Daicel chiralcel OX-3, CO_2/MeOH = 80/20, flow rate = 1.5 mL/min, λ = 254 nm, t_R (major) = 4.04 min, t_R (minor) = 5.52 min.

^{1}H NMR (400 MHz, Chloroform-*d*) δ = 7.69 – 7.49 (m, 4H), 7.44 – 7.07 (m, 8H), 7.08 – 6.85 (m, 2H), 6.59 (s, 1H), 5.26 (d, 2H), 4.74 (d, *J* = 13.6 Hz, 1H), 4.49 (d, *J* = 13.6 Hz, 1H), 3.21 (d, *J* = 14.4 Hz, 1H), 2.98 (d, *J* = 14.4 Hz, 1H), 1.47 (s, 9H).

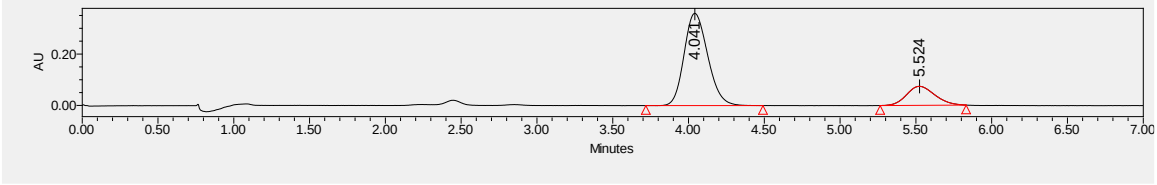
^{13}C NMR (101 MHz, $CDCl_3$) δ = 173.4, 172.2, 166.8, 155.8, 135.0, 132.3, 132.0, 131.78, 130.5, 129.6, 129.1, 128.8, 128.8, 128.2, 128.1, 127.0, 81.0, 64.7, 57.7, 43.0, 38.5, 28.4.

IR:3326, 1791, 1713, 1654, 1498 cm^{-1}.

HRMS (FTMS+c ESI) m/z: $[M + K]^+$ calcd for $C_{30}H_{30}BrN_3O_5K^+$ 630.1000, 631.1034; Found 630.0997, 631.1042.

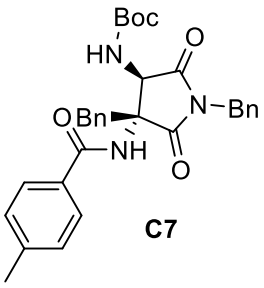


	Retention Time	% Area
1	4.004	50.04
2	5.371	49.96



	Retention Time	% Area
1	4.041	80.19
2	5.524	19.81

***T*ert-butyl ((3R,4R)-1,4-dibenzyl-4-(4-methylbenzamido)-2,5-dioxopyrrolidin-3-yl)carbamate C7**



C7

White solid; 43.2 mg, 82% yield, 91:9 er; melting point: 62–66 °C; $[\alpha]^{17}_{D}$ = +40.6 (*c* = 0.27 in CH_2Cl_2).

Dr value determined by ^{1}H NMR analysis after flash filtration to reaction mixture with a thin silica gel: 82:18.

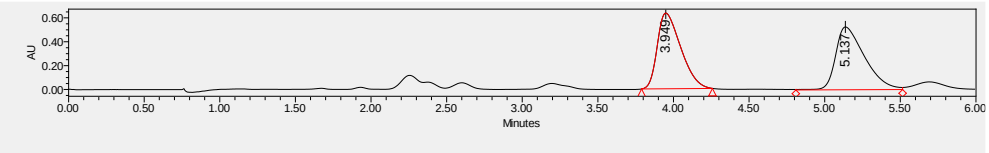
SFC Daicel chiralcel OX-3, CO_2/MeOH = 80/20, flow rate = 1.5 mL/min, λ = 254 nm, t_R (major) = 3.96 min, t_R (minor) = 5.21 min.

^{1}H NMR (400 MHz, Chloroform-*d*) δ = 7.64 (d, *J* = 8.0 Hz, 2H), 7.48 – 7.07 (m, 10H), 7.00 (d, 2H), 6.54 (s, 1H), 5.25 (s, 2H), 4.76 (d, *J* = 13.6 Hz, 1H), 4.52 (d, *J* = 13.6 Hz, 1H), 3.23 (d, *J* = 14.4 Hz, 1H), 2.98 (d, *J* = 14.4 Hz, 1H), 2.39 (s, 3H), 1.47 (s, 9H).

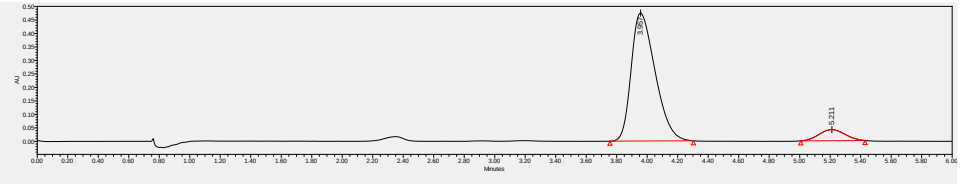
^{13}C NMR (101 MHz, $CDCl_3$) δ = 173.6, 172.3, 167.6, 135.1, 130.6, 129.4, 128.8, 128.8, 128.7, 128.0, 127.5, 82.8, 64.5, 58.0, 43. 0, 38.5, 28.4, 21.7.

IR: 3338, 1712, 1656 cm^{-1}.

HRMS (FTMS+c ESI) m/z: $[M + H]^+$ calcd for $C_{31}H_{34}N_3O_5^+$ 528.2493; Found 528.2491.

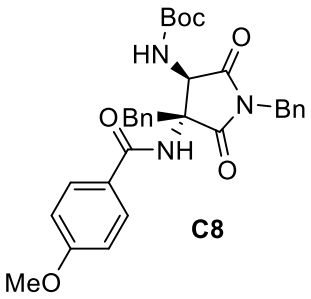


	Retention Time	% Area
1	3.949	49.43
2	5.137	50.57



	Retention Time	% Area
1	3.957	91.46
2	5.211	8.54

***T*ert-butyl ((3R,4R)-1,4-dibenzyl-4-(4-methoxybenzamido)-2,5-dioxopyrrolidin-3-yl)carbamate C8**



C8

White solid; 42.4 mg, 78% yield, 91:9 er; melting point: 81–84 °C; $[\alpha]^{17}_D$ = +29.0 (*c* = 0.88 in CH_2Cl_2).

Dr value determined by ^{1}H NMR analysis after flash filtration to reaction mixture with a thin silica gel: 78:22.

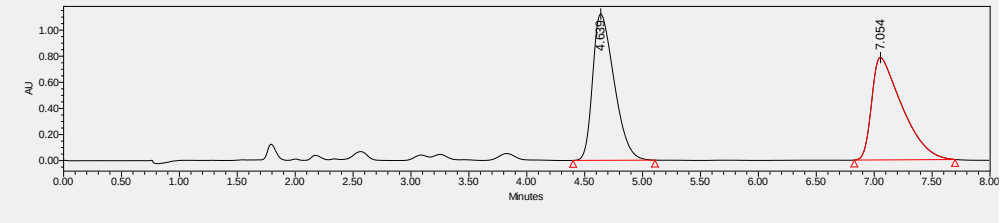
SFC Daicel chiralcel OX-3, CO_2/MeOH = 80/20, flow rate = 1.5 mL/min, λ = 254 nm, t_R (major) = 4.65 min, t_R (minor) = 7.21 min.

^{1}H NMR (400 MHz, Chloroform-*d*) δ = 7.71 (d, 2H), 7.43 – 7.06 (m, 8H), 7.00 (d, 2H), 6.95 – 6.81 (m, 2H), 6.60 – 6.43 (m, 1H), 5.25 (s, 2H), 4.76 (d, *J* = 13.6 Hz, 1H), 4.52 (d, *J* = 13.6 Hz, 1H), 3.84 (s, 3H), 3.23 (d, *J* = 14.4 Hz, 1H), 2.98 (d, *J* = 14.4 Hz, 1H), 1.47 (s, 9H).

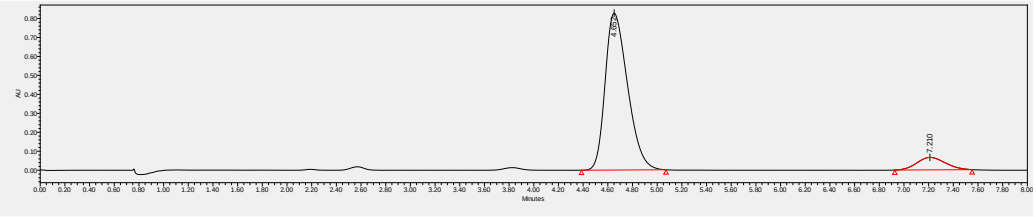
^{13}C NMR (101 MHz, $CDCl_3$) δ= 173.7, 172.3, 162.8, 155.7, 135.1, 132.6, 130.6, 129.4, 128.8, 128.8, 128.7, 128.0, 125.6, 113.9, 80.9, 64.5, 58.0, 55.6, 43.0, 38.5, 28.4.

IR: 3339, 1714, 1652, 1577 cm^{-1}.

HRMS (FTMS+c ESI) m/z: $[M + H]^+$ calcd for $C_{31}H_{34}N_3O_6^+$ 544.2442; Found 544.2437.

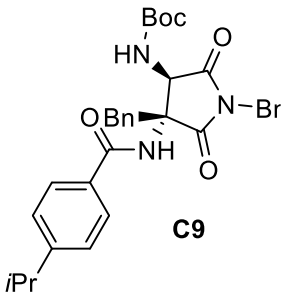


	Retention Time	% Area
1	4.639	50.32
2	7.054	49.68



	Retention Time	% Area
1	4.652	90.85
2	7.210	9.15

***T*ert-butyl ((3R,4R)-1,4-dibenzyl-4-(4-isopropylbenzamido)-2,5-dioxopyrrolidin-3-yl)carbamate C9**



White solid; 43.3 mg, 78% yield, 90:10 er; melting point: 84–89 °C; $[\alpha]^{17}_D$ = +53.0 (*c* = 0.74 in CH_2Cl_2).

Dr value determined by ^{1}H NMR analysis after flash filtration to reaction mixture with a thin silica gel: 85:15.

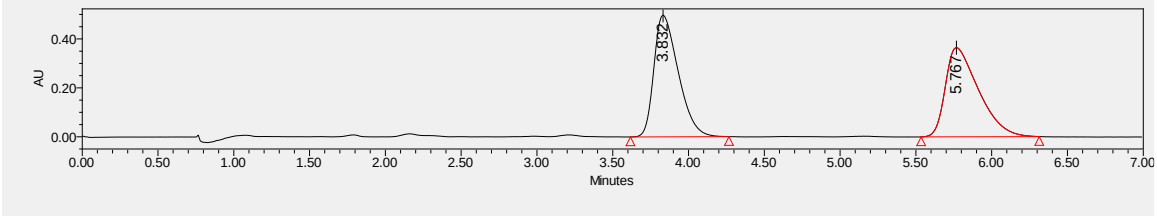
SFC Daicel chiralcel OX-3, CO_2/MeOH = 80/20, flow rate = 1.5 mL/min, λ = 254 nm, t_R (major) = 3.86 min, t_R (minor) = 5.90 min.

^{1}H NMR (400 MHz, Chloroform-*d*) δ = 7.67 (d, *J* = 8.0 Hz, 2H), 7.45 – 7.08 (m, 10H), 7.04 – 6.96 (m, 2H), 6.56 (s, 1H), 5.27 (s, 2H), 4.76 (d, 1H), 4.53 (d, 1H), 3.22 (d, 1H), 3.04 – 2.80 (m, 2H), 1.47 (s, 9H), 1.25 (d, 6H).

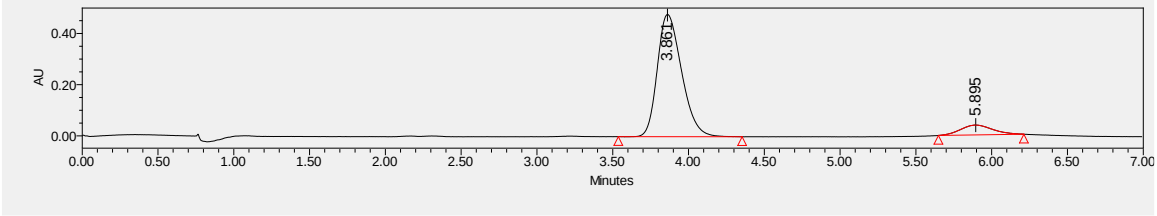
^{13}C NMR (101 MHz, $CDCl_3$) δ 173.6, 172.3, 167.6, 153.5, 135.1, 132.6, 130.8, 130.6, 128.8, 128.8, 128.7, 128.0, 127.6, 126.8, 80.9, 64.5, 58.0, 43.0, 38.4, 34.3, 28.4, 23.9.

IR: 3338, 1713, 1654, 1525 cm^{-1}.

HRMS (FTMS+c ESI) m/z: $[M + H]^+$ calcd for $C_{33}H_{38}N_3O_5^+$ 556.2806; Found 556.2807.

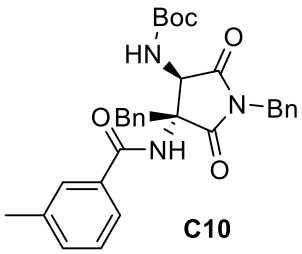


	Retention Time	% Area
1	3.832	50.08
2	5.767	49.92



	Retention Time	% Area
1	3.861	90.46
2	5.895	9.54

***T*ert-butyl ((3R,4R)-1,4-dibenzyl-4-(3-methylbenzamido)-2,5-dioxopyrrolidin-3-yl)carbamate C10**



C10

White solid; 39.5 mg, 75% yield, 92:18 er; melting point: 76–81 °C; $[\alpha]^{16}_{D}$ = +45.5 (*c* = 0.76 in CH_2Cl_2).

Dr value determined by ^{1}H NMR analysis after flash filtration to reaction mixture with a thin silica gel: 81:19.

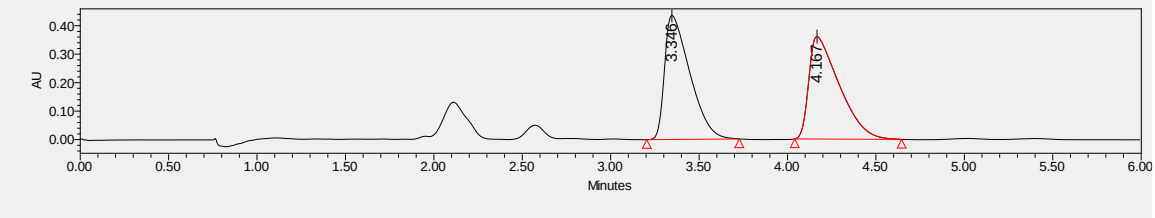
SFC Daicel chiralcel OX-3, CO_2/MeOH = 80/20, flow rate = 1.5 mL/min, λ = 254 nm, t_R (major) = 3.35 min, t_R (minor) = 4.27 min.

^{1}H NMR (400 MHz, Chloroform-*d*) δ = 7.61 – 7.47 (m, 2H), 7.45 – 7.08 (m, 10H), 7.06 – 6.95 (m, 2H), 6.59 (s, 1H), 5.28 (d, 2H), 4.76 (d, *J* = 13.6 Hz, 1H), 4.51 (d, *J* = 13.6 Hz, 1H), 3.24 (d, *J* = 14.4 Hz, 1H), 3.00 (d, *J* = 14.4 Hz, 1H), 2.38 (s, 3H), 1.61 – 1.24 (m, 9H).

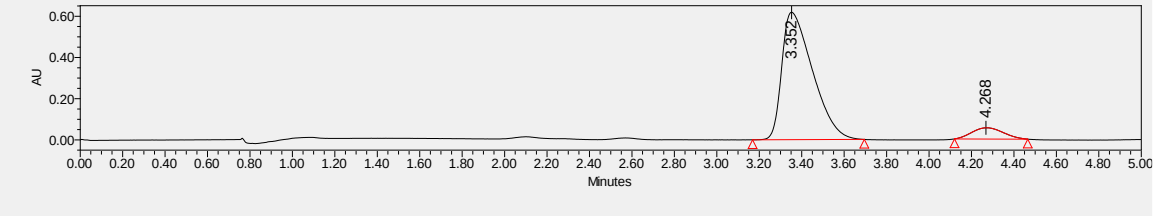
^{13}C NMR (101 MHz, $CDCl_3$) δ = 173.6, 172.3, 167.9, 155.7, 138.6, 135.1, 133.3, 133.0, 132.5, 130.6, 128.8, 128.7, 128.6, 128.3, 128.0, 124.4, 80.9, 64.6, 57.9, 43.0, 38.4, 28.4, 21.4.

IR: 3308, 1708, 1653, 1497 cm^{-1}.

HRMS (FTMS+c ESI) m/z: $[M + H]^+$ calcd for $C_{31}H_{34}N_3O_5^+$ 528.2493; Found 528.2484.

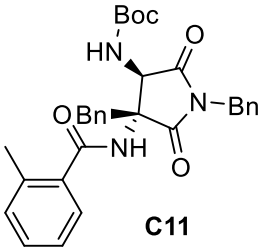


	Retention Time	% Area
1	3.346	50.23
2	4.167	49.77



	Retention Time	% Area
1	3.352	91.72
2	4.268	8.28

***T*ert-butyl ((3R,4R)-1,4-dibenzyl-4-(2-methylbenzamido)-2,5-dioxopyrrolidin-3-yl)carbamate C11**



C11

White solid; 36.9 mg, 70% yield, 87:13 er; melting point: 147–153 °C; $[\alpha]^{17}_D$ = +44.7 (*c* = 0.49 in CH_2Cl_2).

Dr value determined by ^{1}H NMR analysis after flash filtration to reaction mixture with a thin silica gel: 73:27.

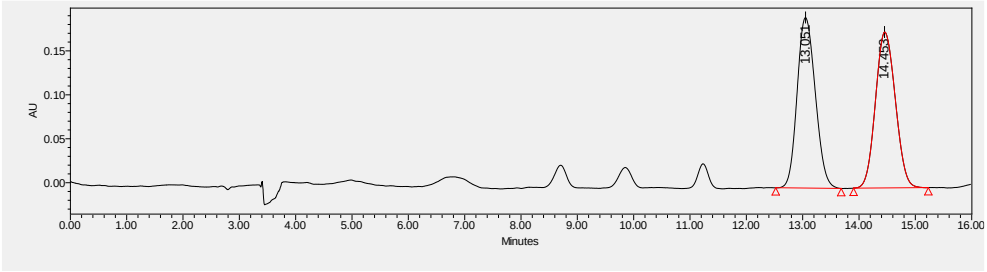
SFC Daicel chiralcel OX-3, CO_2/MeOH = 80/20, flow rate = 1.5 mL/min, λ = 254 nm, t_R (major) = 12.91 min, t_R (minor) = 14.49 min.

^{1}H NMR (400 MHz, Chloroform-*d*) δ = 7.53 – 7.05 (m, 13H), 7.04 – 6.89 (m, 2H), 6.22 (s, 1H), 5.49 (s, 1H), 5.28 (s, 1H), 4.77 (d, *J* = 13.6 Hz, 1H), 4.49 (d, *J* = 13.6 Hz, 1H), 3.14 (d, *J* = 14.4 Hz, 1H), 2.91 (d, *J* = 14.4 Hz, 1H), 2.42 (s, 3H), 1.49 (s, 9H).

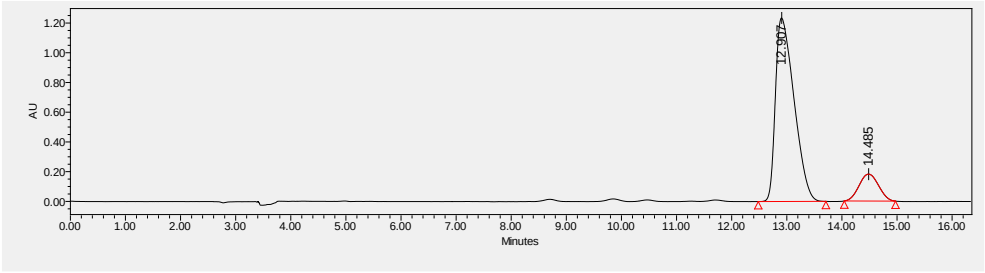
^{13}C NMR (101 MHz, $CDCl_3$) δ = 173.5, 172.4, 170.2, 155.8, 137.0, 135.1, 132.3, 131.1, 130.5, 128.8, 128.7, 128.1, 128.0, 127.3, 125.9, 80.9, 64.7, 57.4, 43.0, 38.5, 28.4, 19.7.

IR: 3325, 1716, 1655, 1498 cm^{-1}.

HRMS (FTMS+c ESI) m/z: $[M + H]^+$ calcd for $C_{31}H_{34}N_3O_5^+$ 528.2493; Found 528.2489.

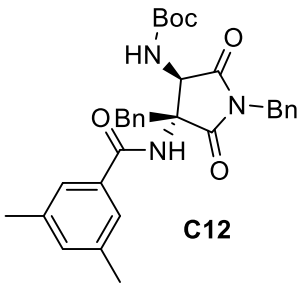


	Retention Time	% Area
1	13.051	50.06
2	14.453	49.94



	Retention Time	% Area
1	12.907	86.64
2	14.485	13.36

***T*ert-butyl ((3R,4R)-1,4-dibenzyl-4-(3,5-dimethylbenzamido)-2,5-dioxopyrrolidin-3-yl)carbamate C12**



C12

White solid; 48.7 mg, 90% yield, 90:10 er; melting point: 83–89 °C; $[\alpha]^{17}_{D}$ = +37.8 (*c* = 0.95 in CH_2Cl_2).

Dr value determined by ^{1}H NMR analysis after flash filtration to reaction mixture with a thin silica gel: 91:9.

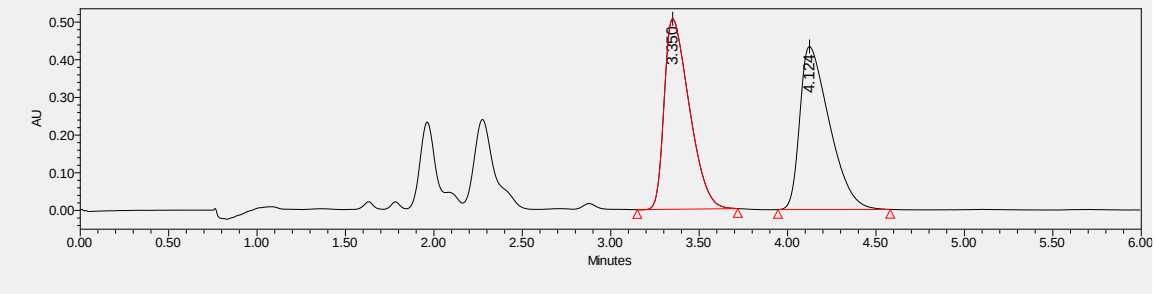
SFC Daicel chiralcel OX-3, CO_2/MeOH = 80/20, flow rate = 1.5 mL/min, λ = 254 nm, t_R (major) = 3.27 min, t_R (minor) = 4.19 min.

^{1}H NMR (400 MHz, Chloroform-*d*) δ = 7.55 – 7.08 (m, 10H), 7.02 (d, *J* = 8.0 Hz, 2H), 6.55 (s, 1H), 5.27 (d, 2H), 4.76 (d, *J* = 14.4 Hz, 1H), 4.51 (d, *J* = 14.4 Hz, 1H), 3.24 (d, *J* = 13.6 Hz, 1H), 3.01 (d, *J* = 13.6 Hz, 1H), 2.34 (s, 6H), 1.47 (s, 8H).

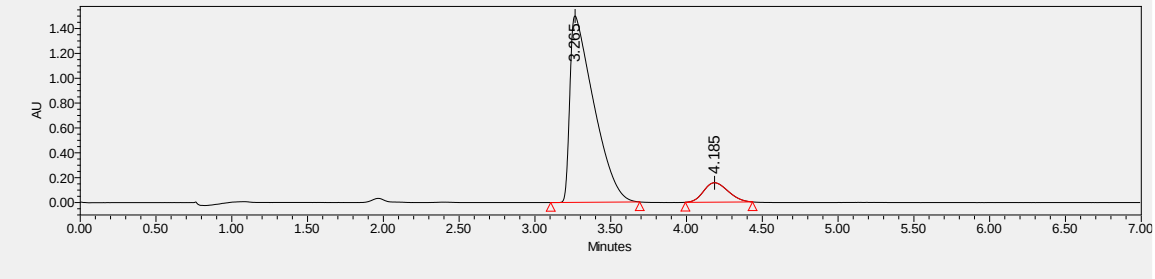
^{13}C NMR (101 MHz, $CDCl_3$) δ = 173.6, 172.3, 168.1, 155.7, 138.4, 135.1, 133.8, 133.26, 132.6, 130.6, 128.8, 128.7, 128.0, 125.2, 80.9, 64.5, 57.9, 43.0, 38.4, 28.4, 21.3.

IR: 3309, 1717, 1654, 1507 cm^{-1}.

HRMS (FTMS+c ESI) m/z: $[M + H]^+$ calcd for $C_{32}H_{36}N_3O_5^+$ 542.2650; Found 542.2641.

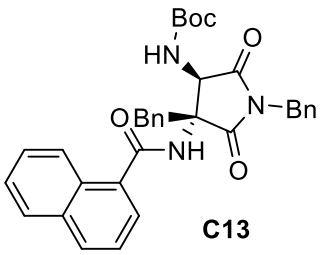


	Retention Time	% Area
1	3.350	49.75
2	4.124	50.25



	Retention Time	% Area
1	3.265	90.33
2	4.185	9.67

***T*ert-butyl ((3R,4R)-4-(1-naphthamido)-1,4-dibenzyl-2,5-dioxopyrrolidin-3-yl)carbamate C13**



C13

White solid; 32.1 mg, 57% yield, 85:15 er; melting point: 86–89 °C; $[\alpha]^{16}_{D}$ = +42.0 (*c* = 0.53 in CH_2Cl_2).

Dr value determined by ^{1}H NMR analysis after flash filtration to reaction mixture with a thin silica gel: 73:27.

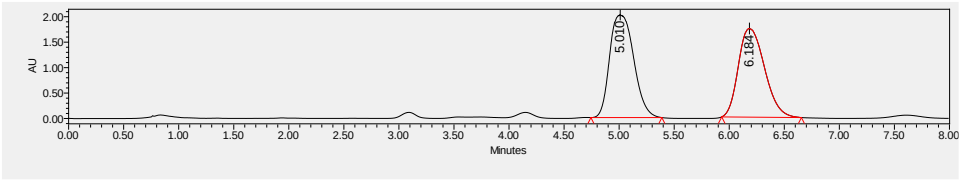
SFC Daicel chiralcel OX-3, CO_2/MeOH = 80/20, flow rate = 1.5 mL/min, λ = 254 nm, t_R (major) = 4.98 min, t_R (minor) = 6.21 min.

^{1}H NMR (400 MHz, Chloroform-*d*) δ = 8.31 – 8.22 (m, 1H), 7.92 – 7.73 (m, 2H), 7.67 (d, *J* = 7.0 Hz, 1H), 7.52 – 7.30 (m, 5H), 7.30 – 7.10 (m, 5H), 7.06 (t, 2H), 6.93 – 6.85 (m, 2H), 6.40 (s, 1H), 5.51 (s, 1H), 5.20 (s, 1H), 4.73 (d, *J* = 14.4 Hz, 1H), 4.45 (d, *J* = 14.4 Hz, 1H), 3.10 (d, *J* = 13.6 Hz, 1H), 2.88 (d, *J* = 13.6 Hz, 1H), 1.43 (s, 9H).

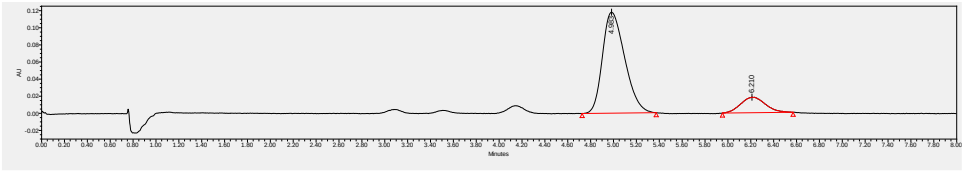
^{13}C NMR (101 MHz, $CDCl_3$) δ= 173.5, 172.4, 169.7, 155.8, 135.1, 133.7, 133.0, 132.3, 131.2, 130.5, 130.3, 128.9, 128.8, 128.3, 128.1, 128.0, 127.5, 126.6, 125.9, 125.6, 124.9, 81.0, 65.1, 57.5, 43.0, 38.6, 28.4.

IR: 3325, 1716, 1655, 1497 cm^{-1}.

HRMS (FTMS+c ESI) m/z: $[M + H]^+$ calcd for $C_{34}H_{34}N_3O_5^+$ 564.2493; Found 564.2498.

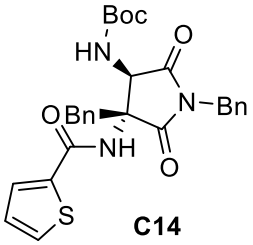


	Retention Time	% Area
1	5.010	51.07
2	6.184	48.93



	Retention Time	% Area
1	4.983	85.48
2	6.210	14.52

***T*ert-butyl ((3R,4R)-1,4-dibenzyl-2,5-dioxo-4-(thiophene-2-carboxamido)pyrrolidin-3-yl)carbamate C14**



C14

White solid; 35.3 mg, 68% yield, 79:21 er; melting point: 95–96 °C; $[\alpha]^{17}_{D}$ = +21.7 (*c* = 0.41 in CH_2Cl_2).

Dr value determined by ^{1}H NMR analysis after flash filtration to reaction mixture with a thin silica gel: 72:28.

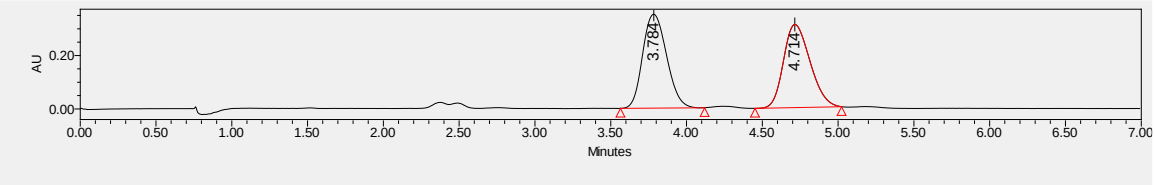
SFC Daicel chiralcel OX-3, CO_2/MeOH = 80/20, flow rate = 1.5 mL/min, λ = 254 nm, t_R (major) = 3.78 min, t_R (minor) = 4.75 min.

^{1}H NMR (400 MHz, Chloroform-*d*) δ = 7.54 – 7.45 (m, 2H), 7.41 – 7.28 (m, 4H), 7.25 – 7.10 (m, 3H), 7.07 (dd, 1H), 6.99 (d, *J* = 7.6 Hz, 2H), 6.47 (s, 1H), 5.48 – 5.09 (m, 2H), 4.75 (d, *J* = 14.4 Hz, 1H), 4.52 (d, *J* = 14.4 Hz, 1H), 3.23 (d, *J* = 13.6 Hz, 1H), 2.98 (d, *J* = 13.6 Hz, 1H), 1.47 (s, 9H).

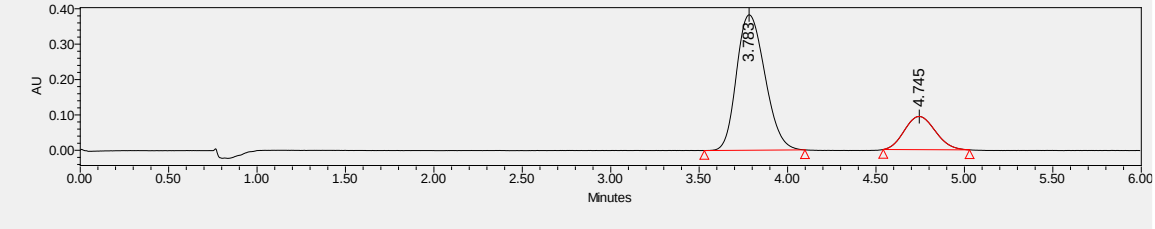
^{13}C NMR (101 MHz, $CDCl_3$) δ = 173.4, 172.1, 162.1, 155.8, 137.3, 135.0, 131.2, 130.6, 129.5, 128.9, 128.8, 128.1, 127.9, 81.1, 64.6, 58.1, 43.1, 38.4, 28.4.

IR: 3350, 1714, 1647, 1533, 1497 cm^{-1}.

HRMS (FTMS+c ESI) m/z: $[M + H]^+$ calcd for $C_{28}H_{30}N_3O_5S^+$ 520.1901; Found 520.1897.

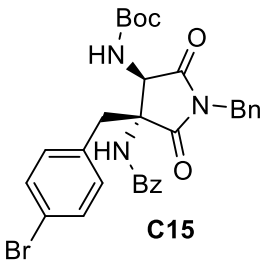


	Retention Time	% Area
1	3.784	50.49
2	4.714	49.51



	Retention Time	% Area
1	3.783	78.95
2	4.745	21.05

***T*ert-butyl ((3R,4R)-4-benzamido-1-benzyl-4-(4-bromobenzyl)-2,5-dioxopyrrolidin-3-yl)carbamate C15**



C15

White solid; 44.3 mg, 75% yield, 91:9 er; melting point: 95–98 °C; $[\alpha]^{17}_{D}$ = +17.0 (*c* = 0.8 in CH_2Cl_2).

Dr value determined by ^{1}H NMR analysis after flash filtration of reaction mixture with a thin silica gel: 76:24.

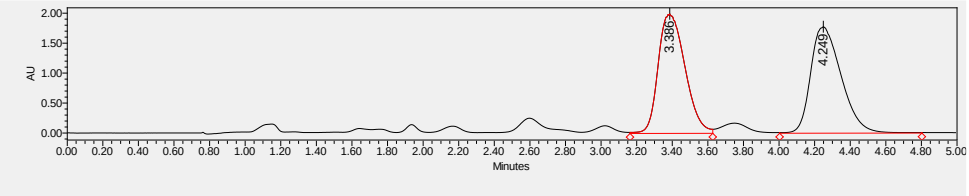
SFC Daicel chiralcel OX-3, CO_2/MeOH = 80/20, flow rate = 1.5 mL/min, λ = 254 nm, t_R (major) = 3.43 min, t_R (minor) = 4.31 min.

^{1}H NMR (400 MHz, Chloroform-*d*) δ = 7.82 – 7.69 (m, 2H), 7.61 – 7.50 (m, 1H), 7.44 (t, *J* = 7.6 Hz, 2H), 7.34 (dt, 5H), 7.16 (d, *J* = 7.9 Hz, 2H), 6.80 (d, *J* = 8.4 Hz, 2H), 6.61 (s, 1H), 5.30 (s, 1H), 5.15 (s, 1H), 4.76 (d, *J* = 14.2 Hz, 1H), 4.56 (d, *J* = 14.2 Hz, 1H), 3.17 (d, *J* = 13.6 Hz, 1H), 2.94 (d, *J* = 13.6 Hz, 1H), 1.47 (s, 9H).

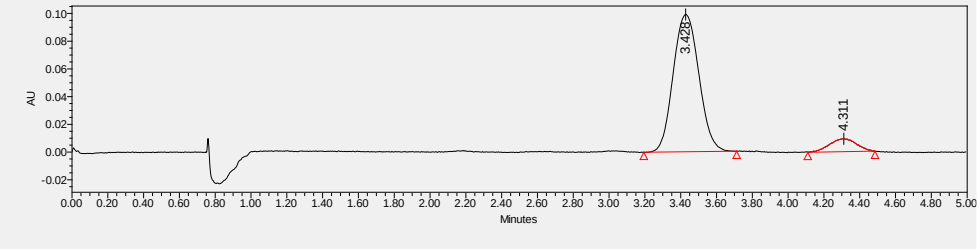
^{13}C NMR (101 MHz, $CDCl_3$) δ = 173.3, 172.1, 167.7, 155.8, 135.0, 132.4, 132.2, 131.7, 131.4, 129.1, 128.8, 128.8, 128.2, 127.4, 122.16, 81.1, 64.5, 58.2, 43.2, 37.8, 28.4.

IR: 1716, 1654, 1488 cm^{-1}.

HRMS (FTMS+c ESI) m/z: $[M + H]^+$ calcd for $C_{30}H_{31}N_3O_5Br^+$ 592.1442, 593.1475; Found 592.1433, 593.1461.

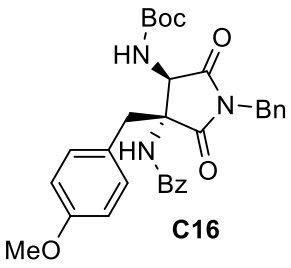


	Retention Time	% Area
1	3.386	49.58
2	4.249	50.42



	Retention Time	% Area
1	3.428	91.04
2	4.311	8.96

***T*ert-butyl ((3R,4R)-4-benzamido-1-benzyl-4-(4-methoxybenzyl)-2,5-dioxopyrrolidin-3-yl)carbamate C16**



C16

White solid; 43.4 mg, 80% yield, 91:9 er; melting point: 83–86 °C; $[\alpha]^{16}_{D}$ = +29.3 (*c* = 0.35 in CH_2Cl_2).

Dr value determined by ^{1}H NMR analysis after flash filtration of reaction mixture with a thin silica gel: 80:20.

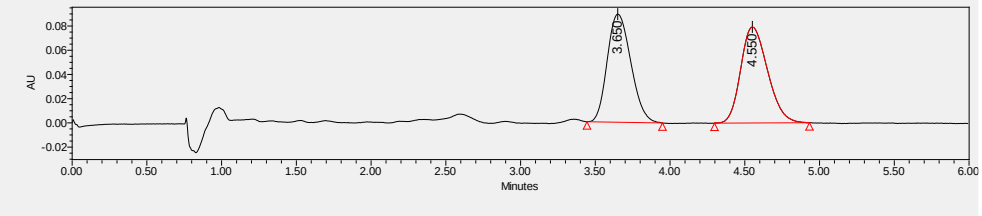
SFC Daicel chiralcel OX-3, CO_2/MeOH = 80/20, flow rate = 1.5 mL/min, λ = 254 nm, t_R (major) = 3.63 min, t_R (minor) = 4.57 min.

^{1}H NMR (400 MHz, Chloroform-*d*) δ = 7.76 (d, *J* = 7.6 Hz, 2H), 7.58 – 7.48 (m, 1H), 7.48 – 7.22 (m, 8H), 6.96 – 6.83 (m, 2H), 6.64 (d, *J* = 8.1 Hz, 2H), 5.25 (s, 2H), 4.76 (d, *J* = 14.4 Hz, 1H), 4.54 (d, *J* = 14.4 Hz, 1H), 3.17 (d, *J* = 13.6 Hz, 1H), 2.94 (d, *J* = 13.6 Hz, 1H), 1.45 (m, 9H).

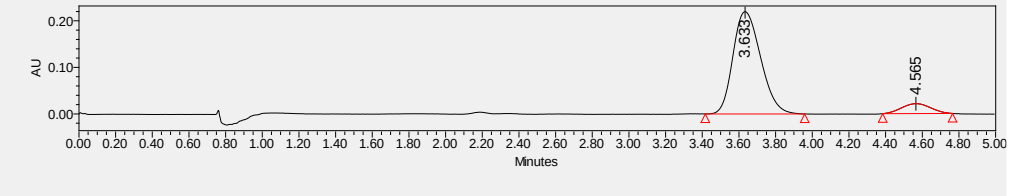
^{13}C NMR (101 MHz, $CDCl_3$) δ = 173.7, 172.4, 159.3, 155.8, 135.1, 132.2, 131.6, 128.9, 1288, 128.0, 127.5, 114.1, 64.7, 57.8, 55.3, 43.0, 37.8, 28.4.

IR: 3649, 1716, 1654, 1513 cm^{-1}.

HRMS (FTMS+c ESI) m/z: $[M + H]^+$ calcd for $C_{31}H_{34}N_3O_6^+$ 544.2442; Found 544.2445.

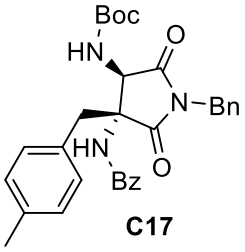


	Retention Time	% Area
1	3.650	49.78
2	4.550	50.22



	Retention Time	% Area
1	3.633	90.81
2	4.565	9.19

***T*ert-butyl ((3R,4R)-4-benzamido-1-benzyl-4-(4-methylbenzyl)-2,5-dioxopyrrolidin-3-yl)carbamate C17**



C17

White solid; 45.3 mg, 86% yield, 90:10 er; melting point: 87–90 °C; $[\alpha]^{16}_{D}$ = +16.0 (*c* = 0.73 in CH_2Cl_2).

Dr value determined by ^{1}H NMR analysis after flash filtration of reaction mixture with a thin silica gel: 87:13.

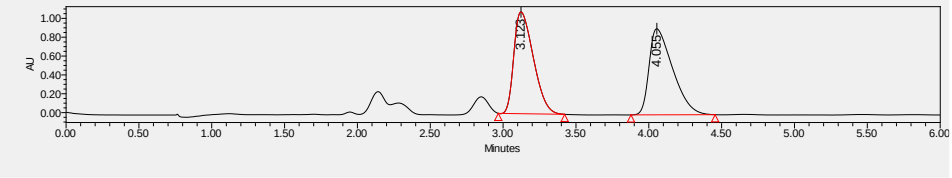
SFC Daicel chiralcel OX-3, CO_2/MeOH = 80/20, flow rate = 1.5 mL/min, λ = 254 nm, t_R (major) = 3.09 min, t_R (minor) = 4.12 min.

^{1}H NMR (400 MHz, Chloroform-*d*) δ = 7.54 – 7.43 (m, 2H), 7.41 – 7.09 (m, 9H), 7.07 (dd, 1H), 6.99 (d, *J* = 7.4 Hz, 2H), 6.53 – 6.38 (m, 1H), 5.24 (d, 2H), 4.75 (d, *J* = 14.4 Hz, 1H), 4.52 (d, *J* = 14.4 Hz, 1H), 3.23 (d, *J* = 13.6 Hz, 1H), 2.98 (d, *J* = 13.6 Hz, 1H), 1.45 (m, 12H).

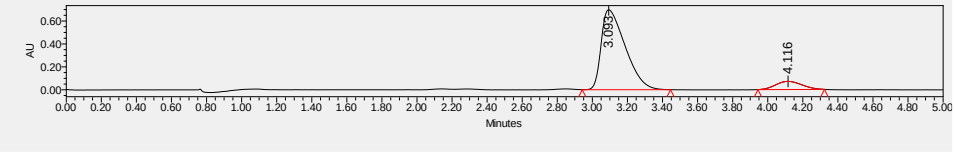
^{13}C NMR (101 MHz, $CDCl_3$) δ = 173.4, 172.1, 137.4, 135.0, 131.2, 130.6, 129.5, 128.9, 128.8, 128.1, 127.9, 127.7, 81.0, 64.6, 58.1, 43.0, 38.4, 28.4, 26.2.

IR:3338, 2926, 1713, 1646, 1534 cm^{-1}.

HRMS (FTMS+c ESI) m/z: $[M + H]^+$ calcd for $C_{31}H_{34}N_3O_5^+$ 528.2493; Found 528.2491.

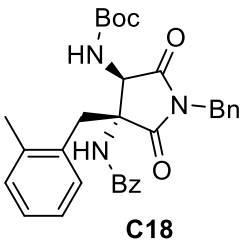


	Retention Time	% Area
1	3.123	49.43
2	4.055	50.57



	Retention Time	% Area
1	3.093	90.01
2	4.116	9.99

***T*ert-butyl ((3R,4R)-4-benzamido-1-benzyl-4-(2-methylbenzyl)-2,5-dioxopyrrolidin-3-yl)carbamate C18**



C18

White solid; 37.4 mg, 71% yield, 91:9 er; melting point: 80–83 °C; $[\alpha]^{17}_{D}$ = +62.0 (*c* = 0.61 in CH_2Cl_2).

Dr value determined by ^{1}H NMR analysis after flash filtration of reaction mixture with a thin silica gel: 75:25.

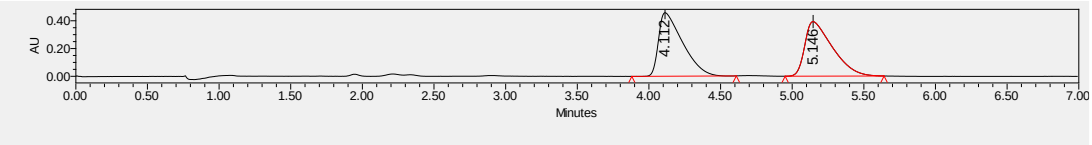
SFC Daicel chiralcel OX-3, CO_2/MeOH = 80/20, flow rate = 1.5 mL/min, λ = 254 nm, t_R (major) = 4.22 min, t_R (minor) = 5.27 min.

^{1}H NMR (400 MHz, Chloroform-*d*) δ = 7.63 (d, *J* = 7.6 Hz, 2H), 7.55 – 7.27 (m, 8H), 7.17 (d, *J* = 5.6 Hz, 2H), 6.94 (d, *J* = 7.6 Hz, 1H), 6.54 (s, 1H), 5.37 (d, 2H), 4.87 (d, *J* = 14.2 Hz, 1H), 4.71 (d, *J* = 14.2 Hz, 1H), 3.30 (d, *J* = 14.6 Hz, 1H), 2.92 (d, *J* = 14.6 Hz, 1H), 2.16 (s, 3H), 1.46 (s, 9H).

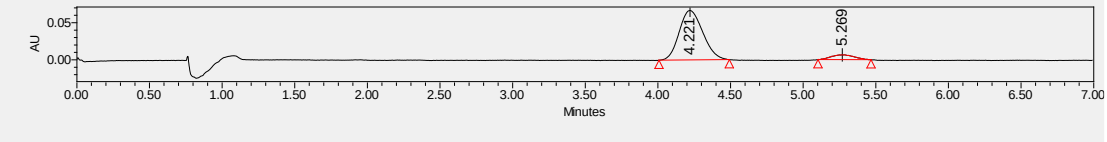
^{13}C NMR (101 MHz, $CDCl_3$) δ = 173.9, 172.3, 167.7, 155.7, 137.7, 135.2, 132.2, 131.2, 131.1, 129.0, 128.8, 128.8, 128.2, 127.3, 126.3, 80.9, 63.6, 58.5, 43.2, 33.6, 28.3, 19.8.

IR: 3325, 1791, 1656, 1508 cm^{-1}.

HRMS (FTMS+c ESI) m/z: $[M + H]^+$ calcd for $C_{31}H_{34}N_3O_5^+$ 528.2493; Found 528.2500.

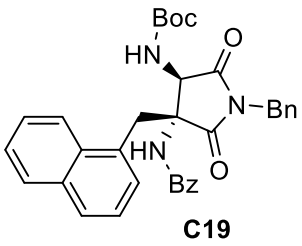


	Retention Time	% Area
1	4.112	50.34
2	5.146	49.66



	Retention Time	% Area
1	4.221	91.30
2	5.269	8.70

***T*ert-butyl ((3R,4R)-4-benzamido-1-benzyl-4-(naphthalen-1-ylmethyl)-2,5-dioxopyrrolidin-3-yl)carbamate C19**



C19

White solid; 37.7 mg, 67% yield, 92:8 er; melting point: 94–100 °C; $[\alpha]^{16}_{D}$ = +30.8 (*c* = 0.70 in CH_2Cl_2).

Dr value determined by ^{1}H NMR analysis after flash filtration of reaction mixture with a thin silica gel: 80:20.

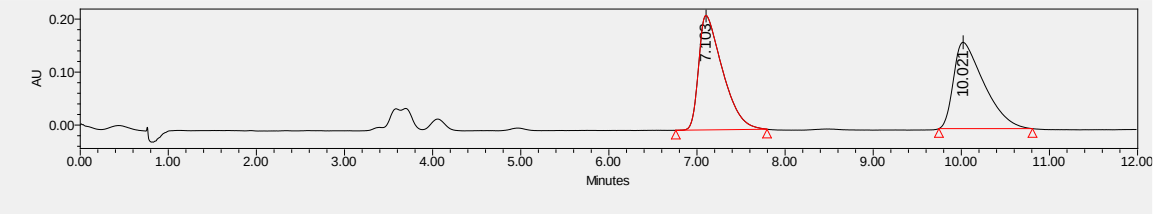
SFC Daicel chiralcel OX-3, CO_2/MeOH = 80/20, flow rate = 1.5 mL/min, λ = 254 nm, t_R (major) = 7.15 min, t_R (minor) = 10.20 min.

^{1}H NMR (400 MHz, Chloroform-*d*) δ = 8.06 (m, 1H), 7.98 – 7.87 (m, 1H), 7.81 (m, 1H), 7.61 – 7.44 (m, 4H), 7.44 – 7.05 (m, 9H), 7.02 – 6.87 (m, 1H), 6.71 (s, 1H), 5.44 (d, 2H), 4.88 (d, *J* = 14.0 Hz, 1H), 4.73 (d, *J* = 14.0 Hz, 1H), 3.90 (d, 1H), 3.09 (d, 1H), 1.50 (s, 9H).

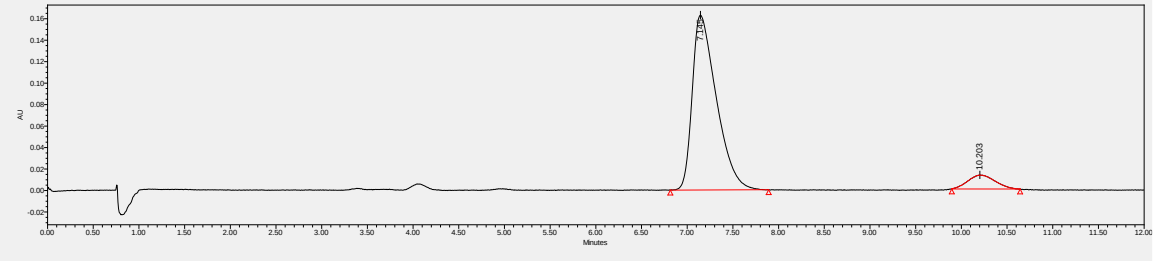
^{13}C NMR (101 MHz, $CDCl_3$) δ = 173.2, 172.4, 167.5, 135.5, 134.1, 132.9, 132.1, 130.3, 129.8, 129.0, 128.9, 128.5, 128.3, 127.2, 127.2, 125.9, 125.5, 122.7, 81.0, 64.2, 58.5, 43.2, 33.0, 28.4.

IR: 3432, 1715, 1663, 1512, 1484 cm^{-1}.

HRMS (FTMS+c ESI) m/z: $[M + H]^+$ calcd for $C_{34}H_{34}N_3O_5^+$ 564.2493; Found 564.2491.

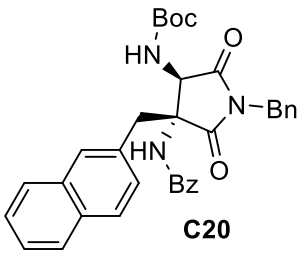


	Retention Time	% Area
1	7.103	51.01
2	10.021	48.99



	Retention Time	% Area
1	7.145	91.77
2	10.203	8.23

***T*ert-butyl ((3R,4R)-4-benzamido-1-benzyl-4-(naphthalen-2-ylmethyl)-2,5-dioxopyrrolidin-3-yl)carbamate C20**



C20

White solid; 38.3 mg, 68% yield, 91:9 er; melting point: 97–101 °C; $[\alpha]^{16}_{D}$ = +6.3 (*c* = 0.73 in CH_2Cl_2).

Dr value determined by ^{1}H NMR analysis after flash filtration of reaction mixture with a thin silica gel: 81:19.

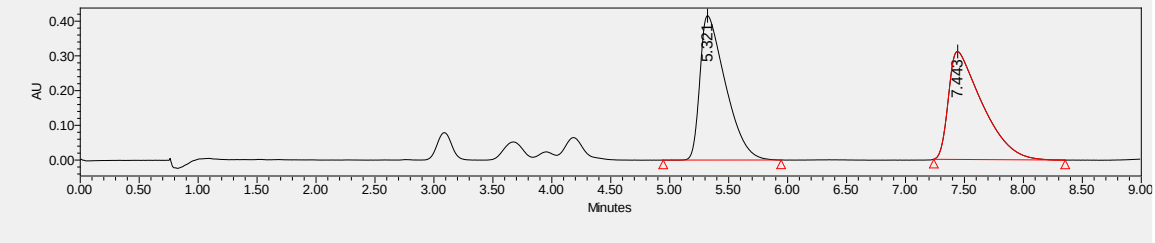
SFC Daicel chiralcel OX-3, CO_2/MeOH = 80/20, flow rate = 1.5 mL/min, λ = 254 nm, t_R (major) = 5.19 min, t_R (minor) = 7.60 min.

^{1}H NMR (400 MHz, Chloroform-*d*) δ = 7.75 – 7.55(m, 5H), 7.55 – 7.21 (m, 12H), 7.06 (dd, 1H), 6.70 (s, 1H), 5.33 (d, 2H), 4.80 (d, *J* = 14.4 Hz, 1H), 4.52 (d, *J* = 14.4 Hz, 1H), 3.41 (d, *J* = 13.6 Hz, 1H), 3.15 (d, *J* = 13.6 Hz, 1H), 1.50 (s, 9H).

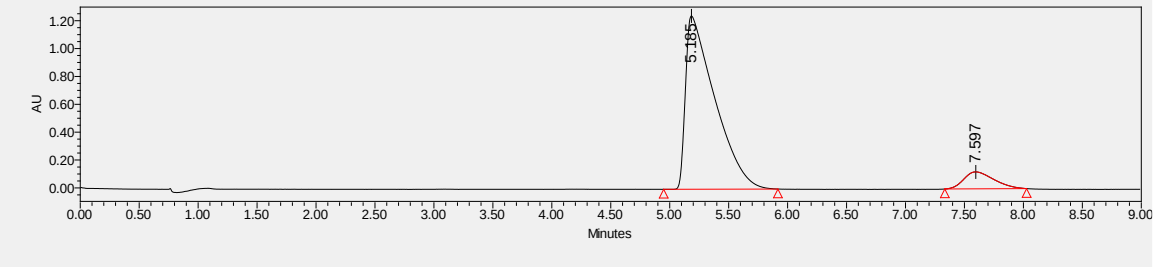
^{13}C NMR (101 MHz, $CDCl_3$) δ = 173.6, 172.3, 167.7, 155.8, 135.1, 133.2, 132.8, 132.2, 129.9, 128.8, 128.7, 128.3, 128.0, 127.8, 127.4, 126.6, 126.4, 80.9, 64.6, 58.1, 43.0, 38.6, 28.4.

IR: 3308, 1655, 1702, 1509 cm^{-1}.

HRMS (FTMS+c ESI) m/z: $[M + H]^+$ calcd for $C_{34}H_{34}N_3O_5^+$ 564.2493; Found 564.2487.

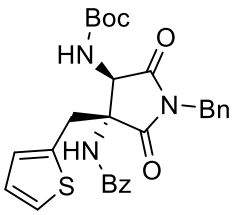


	Retention Time	% Area
1	5.321	50.32
2	7.443	49.68



	Retention Time	% Area
1	5.185	90.85
2	7.597	9.15

***T*ert-butyl ((3R,4R)-4-benzamido-1-benzyl-2,5-dioxo-4-(thiophen-2-ylmethyl)pyrrolidin-3-yl)carbamate C21**



C21

White solid; 41.0 mg, 79% yield, 90:10 er; melting point: 74–79 °C; $[\alpha]^{17}_D$ = +46.1 (*c* = 0.80 in CH_2Cl_2).

Dr value determined by ^{1}H NMR analysis after flash filtration of reaction mixture with a thin silica gel: 81:19.

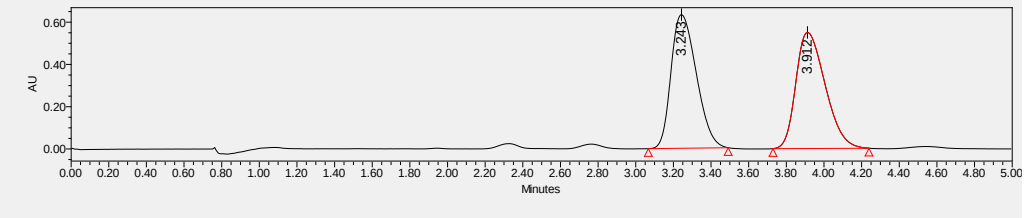
SFC Daicel chiralcel OX-3, CO_2/MeOH = 80/20, flow rate = 1.5 mL/min, λ = 254 nm, t_R (major) = 3.28 min, t_R (minor) = 3.97 min.

^{1}H NMR (400 MHz, Chloroform-*d*) δ = 7.72 (d, *J* = 7.6 Hz, 2H), 7.53 – 7.41 (m, 1H), 7.36 (dd, *J* = 8.2, 6.8 Hz, 2H), 7.30 – 7.14 (m, 5H), 7.04 (d, *J* = 5.1 Hz, 1H), 6.65 (d, 3H), 5.32 (s, 1H), 5.10 (s, 1H), 4.66 (d, *J* = 14.4 Hz, 1H), 4.47 (d, *J* = 14.4 Hz, 1H), 3.36 (d, *J* = 14.4 Hz, 1H), 3.23 (d, *J* = 14.4 Hz, 1H), 1.39 (s, 9H).

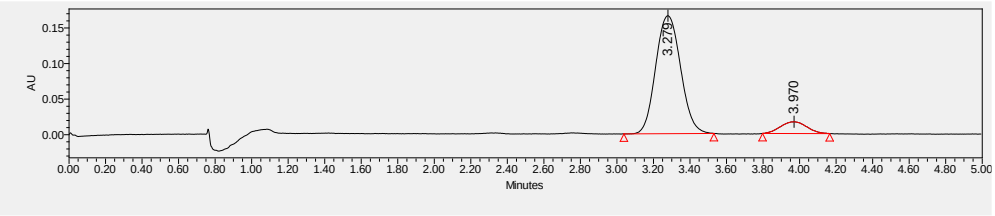
^{13}C NMR (101 MHz, $CDCl_3$) δ = 173.5, 172.3, 167.7, 155.9, 135.0, 133.3, 133.1, 132.3, 129.6, 128.8, 128.7, 127.9, 127.5, 127.4, 126.2, 81.0, 64.4, 57.7, 43.1, 32.7, 28.4.

IR: 3339, 1714, 1654, 1508 cm^{-1}.

HRMS (FTMS+c ESI) m/z: $[M + H]^+$ calcd for $C_{28}H_{30}N_3O_5S^+$ 520.1901; Found 520.1896.

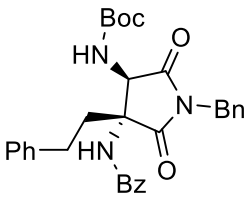


	Retention Time	% Area
1	3.243	49.89
2	3.912	50.11



	Retention Time	% Area
1	3.279	90.47
2	3.970	9.53

***T*ert-butyl ((3R,4R)-4-benzamido-1-benzyl-2,5-dioxo-4-phenethylpyrrolidin-3-yl)carbamate C22**



C22

White solid; 30.0 mg, 57% yield, 87:13 er; melting point: 70–73 °C; $[\alpha]^{17}_D$ = +6.1 (*c* = 0.49 in CH_2Cl_2).

Dr value determined by ^{1}H NMR analysis after flash filtration of reaction mixture with a thin silica gel: 61:39.

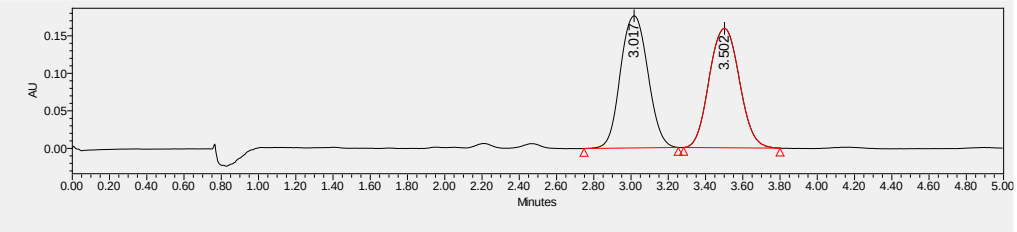
SFC Daicel chiralcel OX-3, CO_2/MeOH = 80/20, flow rate = 1.5 mL/min, λ = 254 nm, t_R (major) = 3.02 min, t_R (minor) = 3.52 min.

^{1}H NMR (400 MHz, Chloroform-*d*) δ = 7.65 (m, 2H), 7.49 (m, 3H), 7.43 – 7.16 (m, 8H), 7.04 (m, 2H), 6.51 (s, 1H), 5.23 (d, 2H), 4.87 (d, *J* = 14.4 Hz, 1H), 4.79 (d, *J* = 14.4 Hz, 1H), 2.66 – 2.31 (m, 2H), 2.19 (m, 1H), 1.92 – 1.78 (m, 1H), 1.41 (s, 9H).

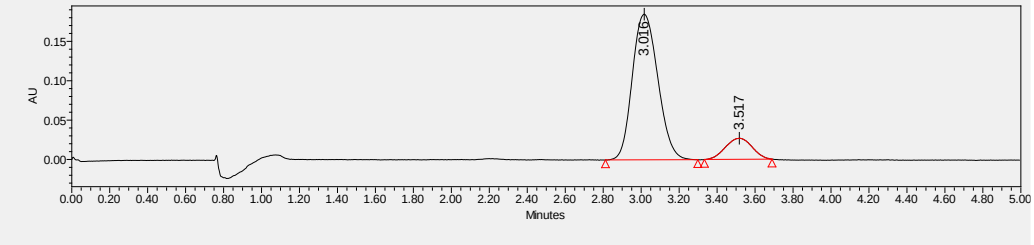
^{13}C NMR (101 MHz, $CDCl_3$) δ = 173.6, 172.8, 167.6, 155.9, 140.3, 135.4, 133.0, 132.2, 128.9, 128.9, 128.7, 128.4, 128.2, 127.5, 126.7, 80.9, 63.7, 58.1, 43.2, 34.6, 29.4, 28.3.

IR: 3337, 1704, 1654, 1521 cm^{-1}.

HRMS (FTMS+c ESI) m/z: $[M + H]^+$ calcd for $C_{31}H_{34}N_3O_5^+$ 528.2493; Found 528.2488.

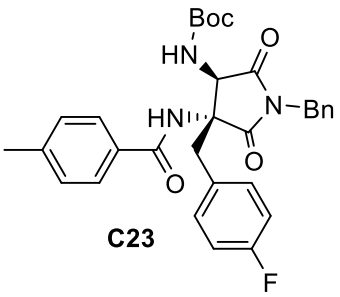


	Retention Time	% Area
1	3.017	50.17
2	3.502	49.83



	Retention Time	% Area
1	3.016	86.94
2	3.517	13.06

***T*ert-butyl ((3R,4R)-1-benzyl-4-(4-fluorobenzyl)-4-(4-methylbenzamido)-2,5-dioxopyrrolidin-3-yl)carbamate C23**



C23

White solid; 46.4 mg, 85% yield, 93:7 er; melting point: 86–88 °C; $[\alpha]^{16}_{D}$ = +40.6 (*c* = 1.02 in CH_2Cl_2).

Dr value determined by ^{1}H NMR analysis after flash filtration of reaction mixture with a thin silica gel: 85:15.

SFC Daicel chiralcel OX-3, CO_2/MeOH = 80/20, flow rate = 1.5 mL/min, λ = 254 nm, t_R (major) = 2.78 min, t_R (minor) = 3.37 min.

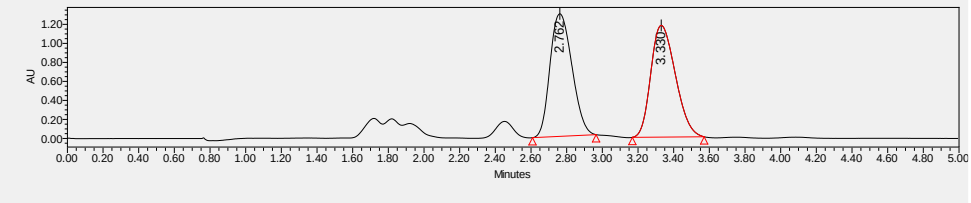
^{1}H NMR (400 MHz, Chloroform-*d*) δ = 7.65 (d, *J* = 7.8 Hz, 2H), 7.41 – 7.27 (m, 5H), 7.23 (d, *J* = 8.0 Hz, 2H), 6.92 (dd, 2H), 6.75 (t, 2H), 6.58 (s, 1H), 5.24 (m, 2H), 4.75 (d, *J* = 14.4 Hz, 1H), 4.54 (d, *J* = 14.4 Hz, 1H), 3.19 (d, *J* = 14.0 Hz, 1H), 2.98 (d, *J* = 14.0 Hz, 1H), 2.39 (s, 3H), 1.46 (s, 9H).

^{13}C NMR (101 MHz, $CDCl_3$) δ = 173.5, 172.3, 167.7, 163.6, 161.1, 142.9, 135.0, 132.2 (d, *J* = 31.6 Hz), 130.3, 129.5, 129.0, 128.8, 128.1, 127.4, 115.5 (d, *J* = 84.0 Hz), 81.0, 64.5, 58.1, 43.1, 37.5, 28.4, 21.7.

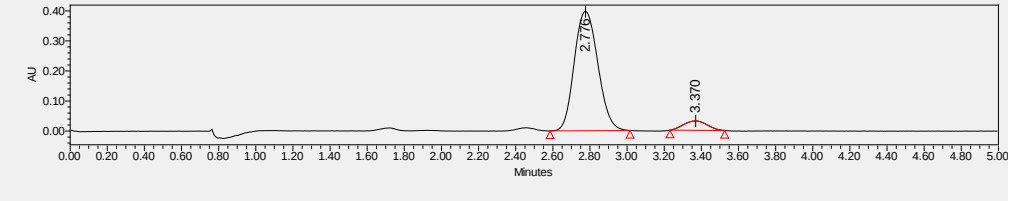
^{19}F NMR (377 MHz, $CDCl_3$) δ = –113.99.

IR: 3325, 1706, 1653, 1498 cm^{-1}.

HRMS (FTMS+c ESI) m/z: $[M + H]^+$ calcd for $C_{31}H_{33}N_3O_5F^+$ 546.2398; Found 546.2394.

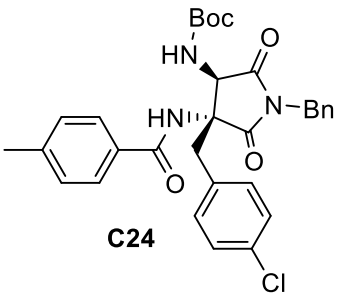


	Retention Time	% Area
1	2.762	49.55
2	3.330	50.45



	Retention Time	% Area
1	2.776	92.70
2	3.370	7.30

***T*ert-butyl ((3R,4R)-1-benzyl-4-(4-chlorobenzyl)-4-(4-methylbenzamido)-2,5-dioxopyrrolidin-3-yl)carbamate C24**



C24

White solid; 43.8 mg, 78% yield, 93:7 er, >19:1 dr; melting point: 96–100 °C; $[\alpha]^{16}_{D}$ = +28.6 (*c* = 0.86 in CH_2Cl_2).

Dr value determined by ^{1}H NMR analysis after flash filtration of reaction mixture with a thin silica gel: 86:14.

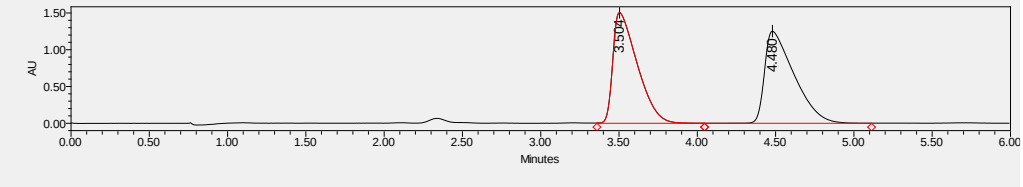
SFC Daicel chiralcel OX-3, CO_2/MeOH = 80/20, flow rate = 1.5 mL/min, λ = 254 nm, t_R (major) = 3.45 min, t_R (minor) = 4.60 min.

^{1}H NMR (400 MHz, Chloroform-*d*) δ = 7.65 (d, *J* = 7.8 Hz, 2H), 7.39 – 7.29 (m, 5H), 7.23 (d, 2H), 7.01 (d, *J* = 8.0 Hz, 2H), 6.86 (d, *J* = 8.4 Hz, 2H), 6.57 (s, 1H), 5.29 (s, 1H), 5.13 (s, 1H), 4.76 (d, *J* = 14.4 Hz, 1H), 4.55 (d, *J* = 14.4 Hz, 1H), 3.19 (d, *J* = 13.6 Hz, 1H), 2.96 (d, *J* = 13.6 Hz, 1H), 2.40 (s, 3H), 1.46 (s, 9H).

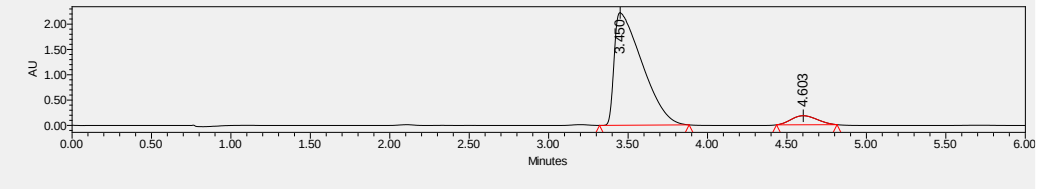
^{13}C NMR (101 MHz, $CDCl_3$) δ = 173.4, 172.2, 167.7, 155.7, 142.9, 135.0, 133.9, 131.9, 131.0, 130.3, 129.5, 129.1, 128.8, 128.7, 128.2, 127.4, 81.1, 64.5, 58.3, 43.2, 37.7, 28.4, 21.7.

IR: 3325, 2927, 1710, 1654, 1524 cm^{-1}.

HRMS (FTMS+c ESI) m/z: $[M + H]^+$ calcd for $C_{31}H_{33}N_3O_5Cl^+$ 562.2103, 563.2137; Found 562.2105, 563.2129.

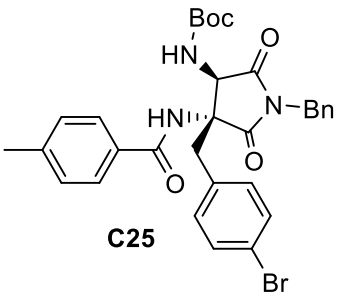


	Retention Time	% Area
1	3.504	49.81
2	4.480	50.19



	Retention Time	% Area
1	3.450	93.08
2	4.603	6.92

***T*ert-butyl ((3R,4R)-1-benzyl-4-(4-bromobenzyl)-4-(4-methylbenzamido)-2,5-dioxopyrrolidin-3-yl)carbamate C25**



C25

White solid; 39.9 mg, 66% yield, 93:7 er; melting point: 98–101 °C; $[\alpha]^{17}_{D}$ = +23.7 (*c* = 1.03 in CH_2Cl_2).

Dr value determined by ^{1}H NMR analysis after flash filtration of reaction mixture with a thin silica gel: 86:14.

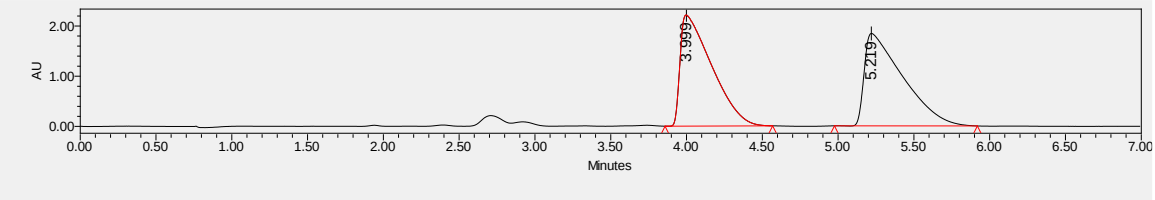
SFC Daicel chiralcel OX-3, CO_2/MeOH = 80/20, flow rate = 1.5 mL/min, λ = 254 nm, t_R (major) = 4.03 min, t_R (minor) = 5.49 min.

^{1}H NMR (400 MHz, Chloroform-*d*) δ = 7.65 (d, *J* = 7.8 Hz, 2H), 7.41 – 7.29 (m, 5H), 7.23 (d, *J* = 8.0 Hz, 2H), 7.16 (d, *J* = 8.0 Hz, 2H), 5.32 (s, 2H), 5.13 (s, 1H), 4.76 (d, *J* = 14.2 Hz, 1H), 4.56 (d, *J* = 14.2 Hz, 1H), 3.17 (d, *J* = 13.6 Hz, 1H), 2.94 (d, *J* = 13.6 Hz, 1H), 2.39 (s, 3H), 1.46 (s, 9H).

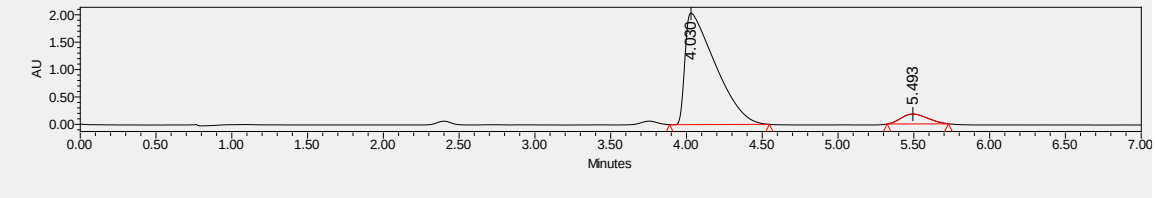
^{13}C NMR (101 MHz, $CDCl_3$) δ = 173.4, 172.2, 167.7, 155.8, 142.9, 135.0, 132.2, 131.6, 130.3, 129.5, 129.1, 128.8, 128.2, 127.4, 122.1, 81.0, 64.4, 58.3, 43.2, 37.7, 28.4, 21.7.

IR: 3326, 2927, 1709, 1653, 1526 cm^{-1}.

HRMS (FTMS+c ESI) m/z: $[M + H]^+$ calcd for $C_{31}H_{33}N_3O_5Br^+$ 606.1598, 607.1632; Found 606.1595, 607.1619.

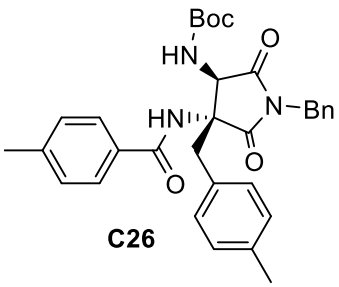


	Retention Time	% Area
1	3.999	49.52
2	5.219	50.48



	Retention Time	% Area
1	4.030	92.81
2	5.493	7.19

***T*ert-butyl ((3R,4R)-1-benzyl-4-(4-methylbenzamido)-4-(4-methylbenzyl)-2,5-dioxopyrrolidin-3-yl)carbamate C26**



C26

White solid; 43.3 mg, 80% yield, 90:10 er; melting point: 78–84 °C; $[\alpha]^{16}_{D}$ = +41.8 (*c* = 0.93 in CH_2Cl_2).

Dr value determined by ^{1}H NMR analysis after flash filtration of reaction mixture with a thin silica gel: 87:13.

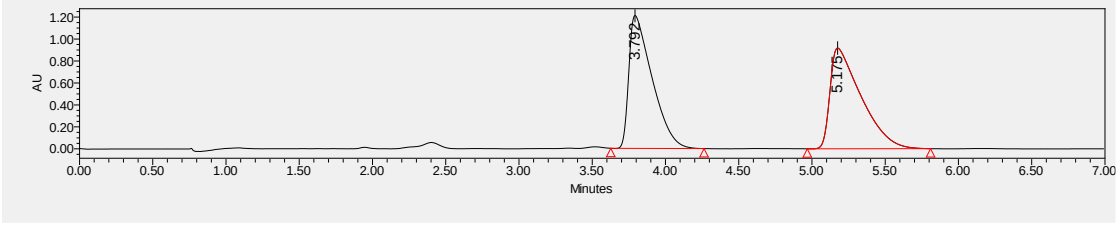
SFC Daicel chiralcel OX-3, CO_2/MeOH = 80/20, flow rate = 1.5 mL/min, λ = 254 nm, t_R (major) = 3.88 min, t_R (minor) = 5.37 min.

^{1}H NMR (400 MHz, Chloroform-*d*) δ = 7.65 (d, 2H), 7.46 – 7.16 (m, 7H), 7.04 – 6.81 (m, 4H), 6.57 (s, 1H), 5.27 (s, 2H), 4.76 (d, *J* = 14.4 Hz, 1H), 4.54 (d, *J* = 14.4 Hz, 1H), 3.19 (d, *J* = 13.6 Hz, 1H), 2.93 (d, *J* = 13.6 Hz, 1H), 2.39 (s, 3H), 2.27 (s, 3H), 1.47 (s, 9H).

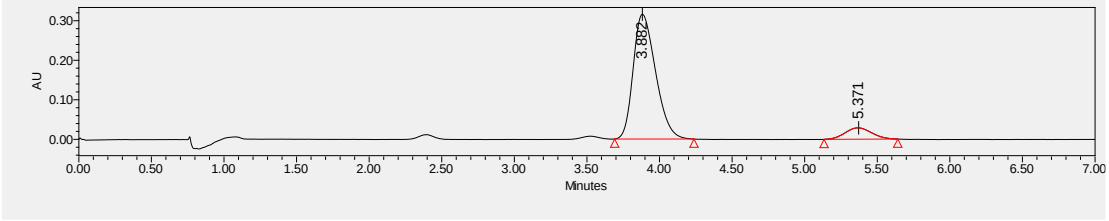
^{13}C NMR (101 MHz, $CDCl_3$) δ = 173.7, 172.4, 167.6, 155.7, 142.7, 137.7, 135.1, 130.4, 129.4, 128.9, 128.7, 128.0, 127.5, 80.9, 64.5, 57.8, 43.0, 38.1, 28.4, 21.6, 21.2.

IR: 3339, 2926, 1713, 1654 cm^{-1}.

HRMS (FTMS+c ESI) m/z: $[M + H]^+$ calcd for $C_{32}H_{36}N_3O_5^+$ 542.2649; Found 542.2643.

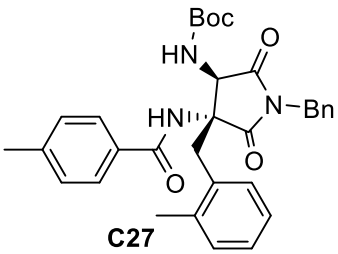


	Retention Time	% Area
1	3.792	49.76
2	5.175	50.24



	Retention Time	% Area
1	3.882	90.25
2	5.371	9.75

***T*ert-butyl ((3R,4R)-1-benzyl-4-(4-methylbenzamido)-4-(2-methylbenzyl)-2,5-dioxopyrrolidin-3-yl)carbamate C27**



C27

White solid; 46.5 mg, 86% yield, 92:8 er; melting point: 77–82 °C; $[\alpha]^{16}_{D}$ = +67.8 (*c* = 0.77 in CH_2Cl_2).

Dr value determined by ^{1}H NMR analysis after flash filtration of reaction mixture with a thin silica gel: 93:17.

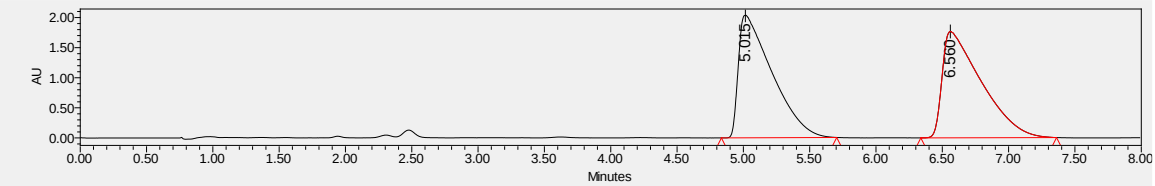
SFC Daicel chiralcel OX-3, CO_2/MeOH = 80/20, flow rate = 1.5 mL/min, λ = 254 nm, t_R (major) = 5.26 min, t_R (minor) = 6.89 min.

^{1}H NMR (400 MHz, Chloroform-*d*) δ = 7.60 – 7.40 (m, 4H), 7.39 – 7.27 (m, 3H), 7.23 – 7.10 (m, 4H), 7.03 (s, 1H), 6.94 (d, *J* = 7.6 Hz, 1H), 6.51 (s, 1H), 5.37 (d, 2H), 4.86 (d, *J* = 14.4 Hz, 1H), 4.71 (d, *J* = 14.4 Hz, 1H), 3.29 (d, 1H), 2.93 (d, 1H), 2.37 (s, 3H), 2.15 (s, 3H), 1.45 (s, 9H).

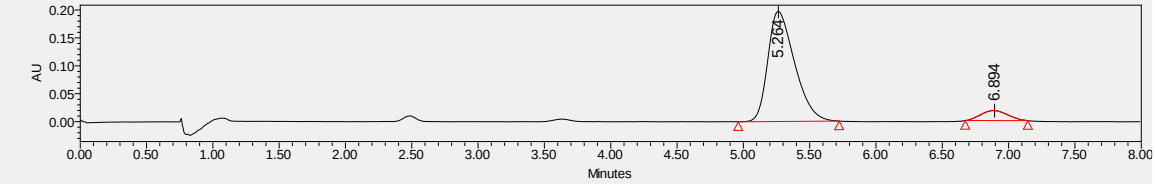
^{13}C NMR (101 MHz, $CDCl_3$) δ = 74.0, 172.3, 167.7, 155.7, 142.8, 137.7, 135.2, 131.2, 131.1, 130.5, 129.4, 129.0, 128.8, 128.12, 127.3, 126.2, 80.8, 63.5, 58.6, 43.2, 33.5, 28.3, 21.6, 19.8.

IR: 3343, 2927, 1711, 1657, 1523 cm^{-1}.

HRMS (FTMS+c ESI) m/z: $[M + H]^+$ calcd for $C_{32}H_{36}N_3O_5^+$ 542.2649; Found 542.2642.

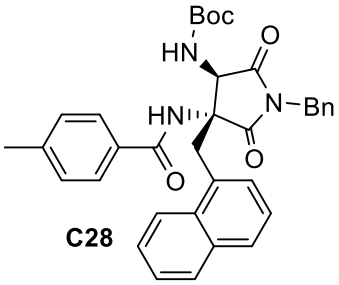


	Retention Time	% Area
1	5.015	49.87
2	6.560	50.13



	Retention Time	% Area
1	5.264	91.62
2	6.894	8.38

***T*ert-butyl ((3R,4R)-1-benzyl-4-(4-methylbenzamido)-4-(naphthalen-1-ylmethyl)-2,5-dioxopyrrolidin-3-yl)carbamate C28**



C28

White solid; 42.2 mg, 78% yield, 92:8 er; melting point: 88–92 °C; $[\alpha]^{16}_{D}$ = +63.3 (*c* = 0.85 in CH_2Cl_2).

Dr value determined by ^{1}H NMR analysis after flash filtration of reaction mixture with a thin silica gel: 79:21.

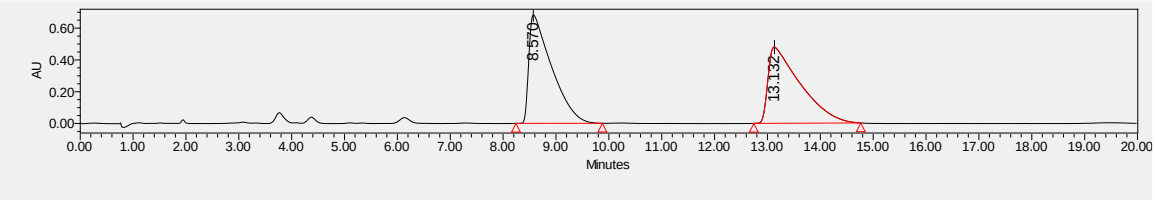
SFC Daicel chiralcel OX-3, CO_2/MeOH = 80/20, flow rate = 1.5 mL/min, λ = 254 nm, t_R (major) = 8.68 min, t_R (minor) = 13.83 min.

^{1}H NMR (400 MHz, Chloroform-*d*) δ = 8.09 – 7.99 (m, 1H), 7.98 – 7.87 (m, 1H), 7.80 (d, 1H), 7.61 – 7.44 (m, 4H), 7.44 – 7.28 (m, 4H), 7.20 (s, 2H), 7.07 – 6.92 (m, 3H), 6.68 (s, 1H), 5.46 (d, 2H), 4.88 (d, 1H), 4.73 (d, 1H), 3.89 (d, *J* = 14.8 Hz, 1H), 3.10 (d, *J* = 14.8 Hz, 1H), 2.30 (s, 3H), 1.66– 1.22 (m, 9H).

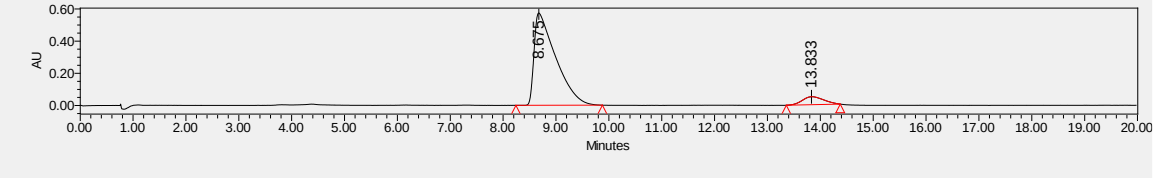
^{13}C NMR (101 MHz, $CDCl_3$) δ = 173.3, 172.4, 167.4, 155.8, 142.6, 135.5, 134.1, 132.9, 130.2, 129.7, 129.2, 129.0, 128.9, 128.2, 127.2, 127.1, 125.9, 125.5, 122.8, 80.9, 64.1, 58.5, 43.1, 32.9, 28.3, 21.5.

IR: 3432, 1715, 1655, 1523, 1492cm^{-1}.

HRMS (FTMS+c ESI) m/z: $[M + H]^+$ calcd for $C_{35}H_{36}N_3O_5^+$ 578.2650; Found 578.2645.

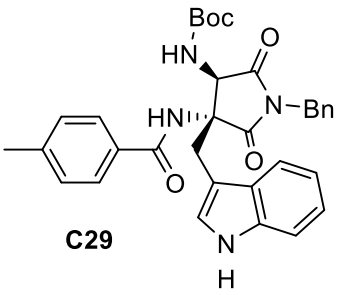


	Retention Time	% Area
1	8.570	50.26
2	13.132	49.74



	Retention Time	% Area
1	8.675	92.09
2	13.833	7.91

***T*ert-butyl ((3R,4R)-4-((1H-indol-3-yl)methyl)-1-benzyl-4-(4-methylbenzamido)-2,5-dioxopyrrolidin-3-yl)carbamate C29**



C29

White solid; 17.0 mg, 30% yield, 90.5:8.5 er; $[\alpha]^{17}_D$ = +23.5 (*c* = 0.26 in CH_2Cl_2).

Dr value determined by ^{1}H NMR analysis after flash filtration, the reaction mixture was too complex to analyze.

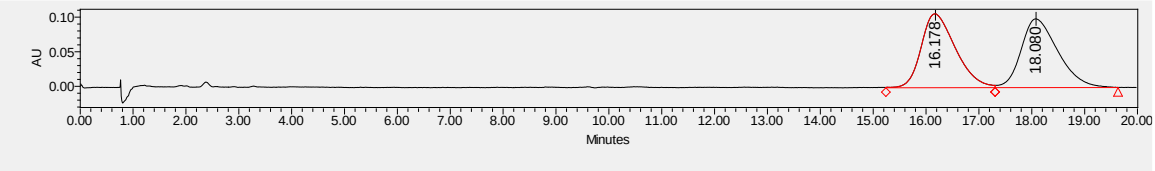
SFC Daicel chiralcel OX-3, CO_2/MeOH = 85/15, flow rate = 1.5 mL/min, λ = 254 nm, t_R (major) = 15.72 min, t_R (minor) = 18.22 min.

^{1}H NMR (400 MHz, Chloroform-*d*) δ = 7.81 (s, 1H), 7.58 (t, *J* = 7.4 Hz, 3H), 7.47 – 7.26 (m, 6H), 7.24 – 7.02 (m, 4H), 6.68 (s, 1H), 6.51 (s, 1H), 5.39 (s, 1H), 5.10 (d, 1H), 4.76 (d, *J* = 14.4 Hz, 1H), 4.55 (d, *J* = 14.4 Hz, 1H), 3.40 (d, *J* = 14.4 Hz, 1H), 3.13 (d, *J* = 14.4 Hz, 1H), 2.36 (s, 3H), 1.48 (s, 9H).

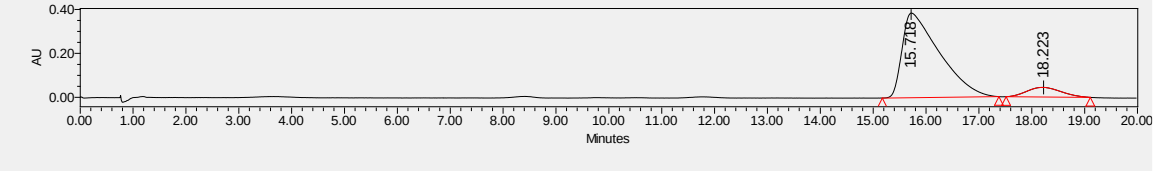
^{13}C NMR (101 MHz, $CDCl_3$) δ = 174.6, 172.8, 142.7, 135.8, 135.5, 129.3, 128.8, 128.0, 127.5, 127.3, 125.3, 122.7, 120.3, 118.3, 111.8, 105.5, 80.7, 64.4, 57.3, 43.1, 28.4, 21.6.

IR: 3408, 2924, 1710, 1648 cm^{-1}.

HRMS (FTMS+c ESI) m/z: $[M + H]^+$ calcd for $C_{33}H_{35}N_4O_5^+$ 567.2602; Found 567.2598.

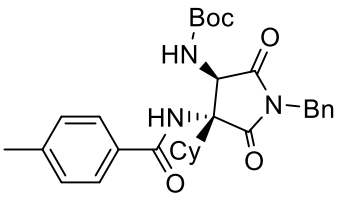


	Retention Time	% Area
1	16.178	50.03
2	18.080	49.97



	Retention Time	% Area
1	15.718	90.51
2	18.223	9.49

***T*ert-butyl ((3R,4R)-1-benzyl-4-cyclohexyl-4-(4-methylbenzamido)-2,5-dioxopyrrolidin-3-yl)carbamate C30**



C30

White solid; 7.8 mg, 15% yield, 84:16 er; $[\alpha]^{16}_{D}$ = +18.7 (*c* = 0.18 in CH_2Cl_2).

Dr value determined by ^{1}H NMR analysis after flash filtration, the reaction mixture was too complex to analyze.

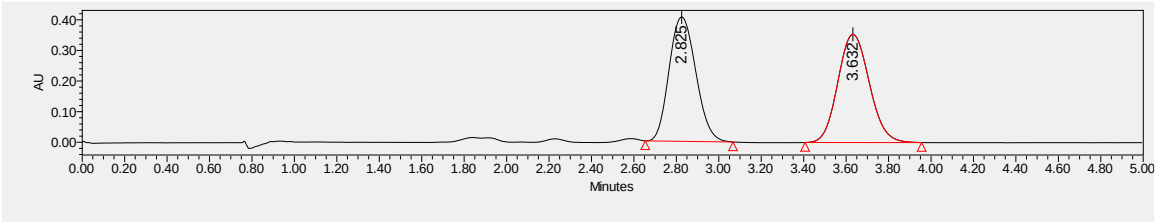
SFC Daicel chiralcel OX-3, CO_2/MeOH = 80/20, flow rate = 1.5 mL/min, λ = 254 nm, t_R (major) = 2.83 min, t_R (minor) = 3.65 min.

^{1}H NMR (400 MHz, Chloroform-*d*) δ = 7.71 (d, *J* = 7.8 Hz, 2H), 7.57 – 7.44 (m, 2H), 7.37 – 7.17 (m, 7H), 6.47 (s, 1H), 5.17 (s, 2H), 4.86 (d, *J* = 14.0 Hz, 1H), 4.73 (d, *J* = 14.0 Hz, 1H), 2.40 (s, 3H), 1.80 (d, 3H), 1.33 (d, 12H), 1.20 – 0.75 (m, 6H), 0.35 (m, 1H).

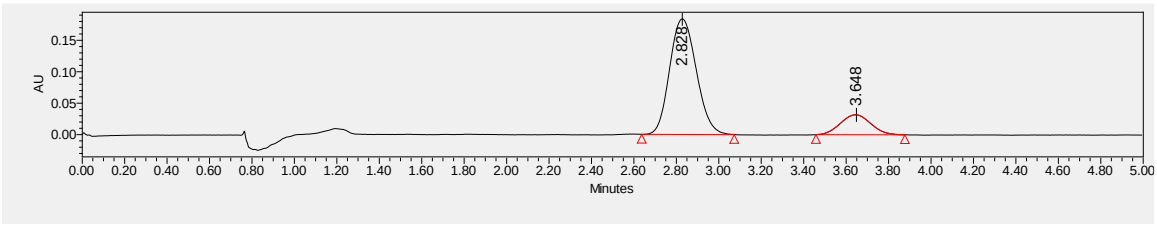
^{13}C NMR (101 MHz, $CDCl_3$) δ = 172.6, 157.9, 135.2, 129.4, 129.3, 128.7, 128.1, 127.5, 65.7, 58.0, 43.1, 41.2, 29.8, 28.3, 26.3, 26.1, 25.9, 21.7.

IR: 3649, 1716, 1653, 1521 cm^{-1}.

HRMS (FTMS+c ESI) m/z: $[M + H]^+$ calcd for $C_{30}H_{38}N_3O_5^+$ 520.2806; Found 520.2813.

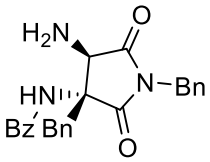


	Retention Time	% Area
1	2.825	49.47
2	3.632	50.53



	Retention Time	% Area
1	2.828	83.59
2	3.648	16.41

***N*-((3R,4R)-4-Amino-1,3-dibenzyl-2,5-dioxopyrrolidin-3-yl)benzamide D1**



D1

White solid; 116.4 mg, 94% yield, >99:1 er, >19:1 dr; melting point: 62–68 °C; $[\alpha]^{24}_{D}$ = +118.3 (*c* = 0.51 in CH_2Cl_2).

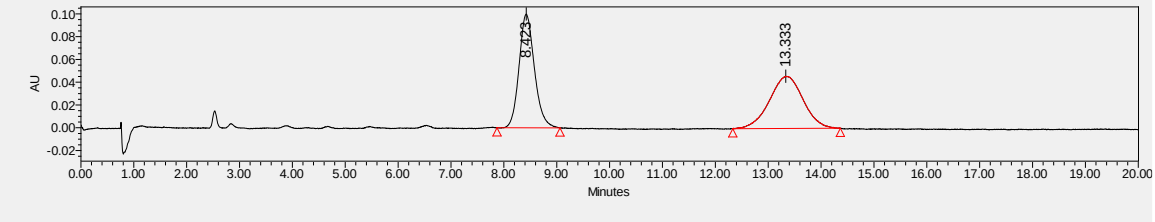
SFC Daicel chiralcel OX-3, CO_2/MeOH = 80/20, flow rate = 1.5 mL/min, λ = 254 nm, t_R (major) = 8.35 min, t_R (minor) = 13.22 min.

^{1}H NMR (400 MHz, Chloroform-*d*) δ = 7.76 – 7.63 (m, 2H), 7.58 – 7.48 (m, 1H), 7.48 – 7.29 (m, 7H), 7.24 – 7.09 (m, 3H), 6.92 – 6.78 (m, 2H), 6.69 (s, 1H), 4.71 (d, *J* = 14.2 Hz, 1H), 4.59 – 4.46 (m, 2H), 3.46 (d, *J* = 13.8 Hz, 1H), 2.92 (d, *J* = 13.8 Hz, 1H), 2.18 (s, 2H).

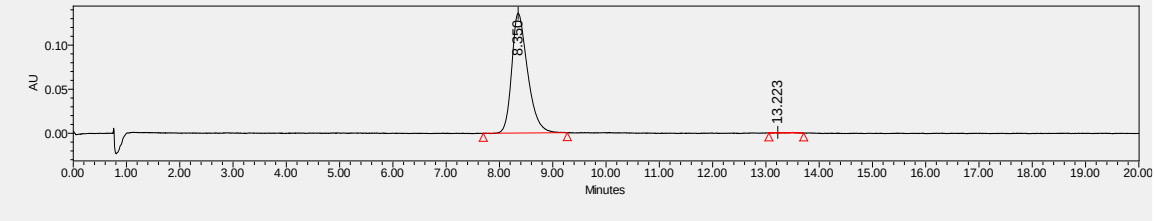
^{13}C NMR (101 MHz, $CDCl_3$) δ = 175.4, 175.1, 167.6, 135.2, 133.8, 133.4, 132.4, 130.6, 129.1, 128.9, 128.9, 128.4, 128.3, 127.7, 127.1, 65.8, 60.2, 42.8, 38.0.

IR: 3385, 1709, 1655, 1523 cm^{-1}.

HRMS (FTMS+c ESI) m/z: $[M + H]^+$ calcd for $C_{25}H_{24}N_3O_3^+$ 414.1812; Found 414.1812.

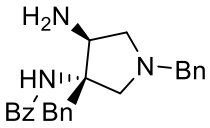


	Retention Time	% Area
1	8.423	49.94
2	13.333	50.06



	Retention Time	% Area
1	8.350	99.70
2	13.223	0.30

***N*-((3S,4S)-4-Amino-1,3-dibenzylpyrrolidin-3-yl)benzamide D2**



D2

White solid; 41.2 mg, 55% yield, >99:1 er, >19:1 dr; melting point: 52–55 °C; $[\alpha]^{21}_{D}$ = +57.9 (*c* = 0.82 in CH_2Cl_2).

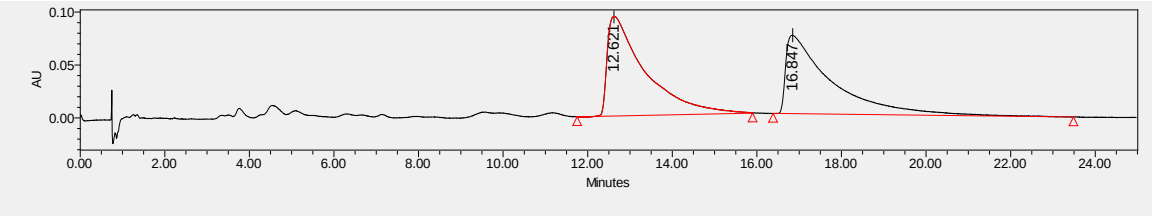
SFC Daicel chiralcel OD-3, CO_2/MeOH = 90/10, flow rate = 1.5 mL/min, λ = 254 nm, t_R (major) = 12.62 min, t_R (minor) = 26.85 min.

^{1}H NMR (400 MHz, Chloroform-*d*) δ = 7.68 – 7.59 (m, 2H), 7.53 – 7.45 (m, 1H), 7.40 (dd, 2H), 7.36 – 7.22 (m, 5H), 7.17 (dd, 3H), 7.08 (dd, 2H), 6.11 (s, 1H), 3.88 (td, 1H), 3.73 (d, 1H), 3.60 (s, 2H), 3.31 (dd, 1H), 2.77 – 2.62 (m, 2H), 2.45 (d, 1H), 2.25 (dd, 1H), 2.08 (s, 2H).

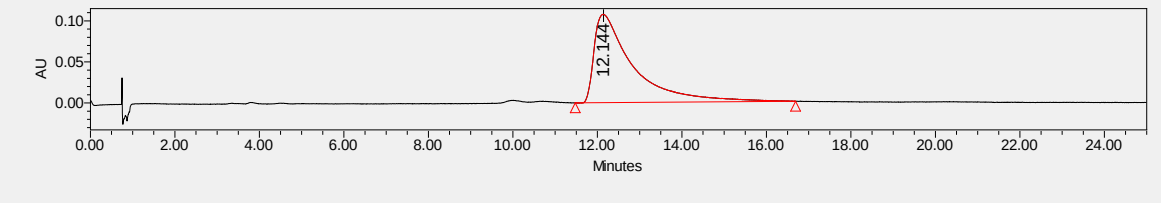
^{13}C NMR (101 MHz, $CDCl_3$) δ = 168.1, 138.1, 138.0, 135.1, 131.4, 130.2, 128.7, 128.6, 128.3, 128.1, 127.2, 126.8, 126.3, 65.3, 64.5, 61.9, 60.7, 59.9, 35.8.

IR:3296, 2799, 1647, 1536, 1494 cm^{-1}.

HRMS (FTMS+c ESI) m/z: $[M + H]^+$ calcd for $C_{25}H_{28}N_3O^+$ 386.2227; Found 386.2228.

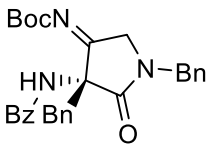


	Retention Time	% Area
1	12.621	51.45
2	16.847	48.55



	Retention Time	% Area
1	12.144	100.00

***T*ert-butyl R-(4-benzamido-1,4-dibenzyl-5-oxopyrrolidin-3-ylidene)carbamate D3**



D3

White solid; 134.6, 90% yield, >99:1 er; melting point: 190–201 °C; $[\alpha]^{21}_{D}$ = +35.8 (*c* = 1.71 in CH_2Cl_2).

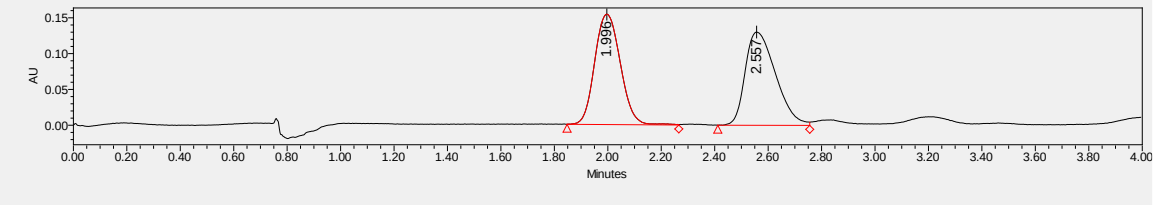
SFC Daicel chiralcel OX-3, CO_2/MeOH = 80/20, flow rate = 1.5 mL/min, λ = 254 nm, t_R (major) = 2.00 min, t_R (minor) = 2.56 min.

^{1}H NMR (400 MHz, Chloroform-*d*) δ = 7.77 – 7.70 (m, 2H), 7.60 – 7.50 (m, 1H), 7.44 (dd, 2H), 7.28 – 7.16 (m, 6H), 7.11 (dd, 2H), 7.05 (dd, 2H), 6.50 (s, 1H), 5.08 (d, *J* = 7.6 Hz, 1H), 4.82 (d, *J* = 7.6 Hz, 1H), 4.74 – 4.61 (m, 2H), 3.54 (d, *J* = 12.4 Hz, 1H), 3.36 (d, *J* = 12.4 Hz, 1H), 1.32 (s, 9H).

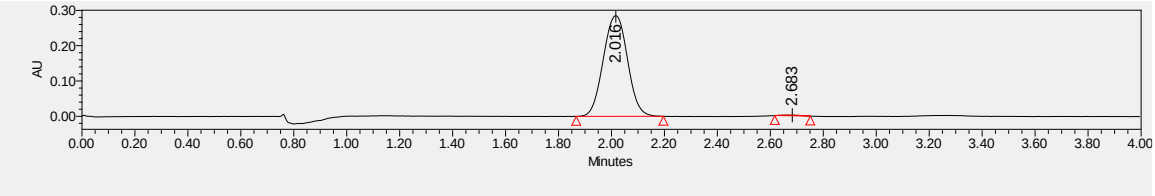
^{13}C NMR (101 MHz, $CDCl_3$) δ = 175.3, 173.6, 168.7, 156.4, 134.9, 132.4, 132.3, 131.8, 131.0, 128.8, 128.7, 128.4, 128.2, 127.8, 127.5, 127.1, 80.3, 62.4, 53.8, 42.5, 41.3, 28.0.

IR: 3359, 1709, 1655, 1580, 1489 cm^{-1}.

HRMS (FTMS+c ESI) m/z: $[M + H]^+$ calcd for $C_{30}H_{38}N_3O_5^+$ 498.2387; Found 498.2390.

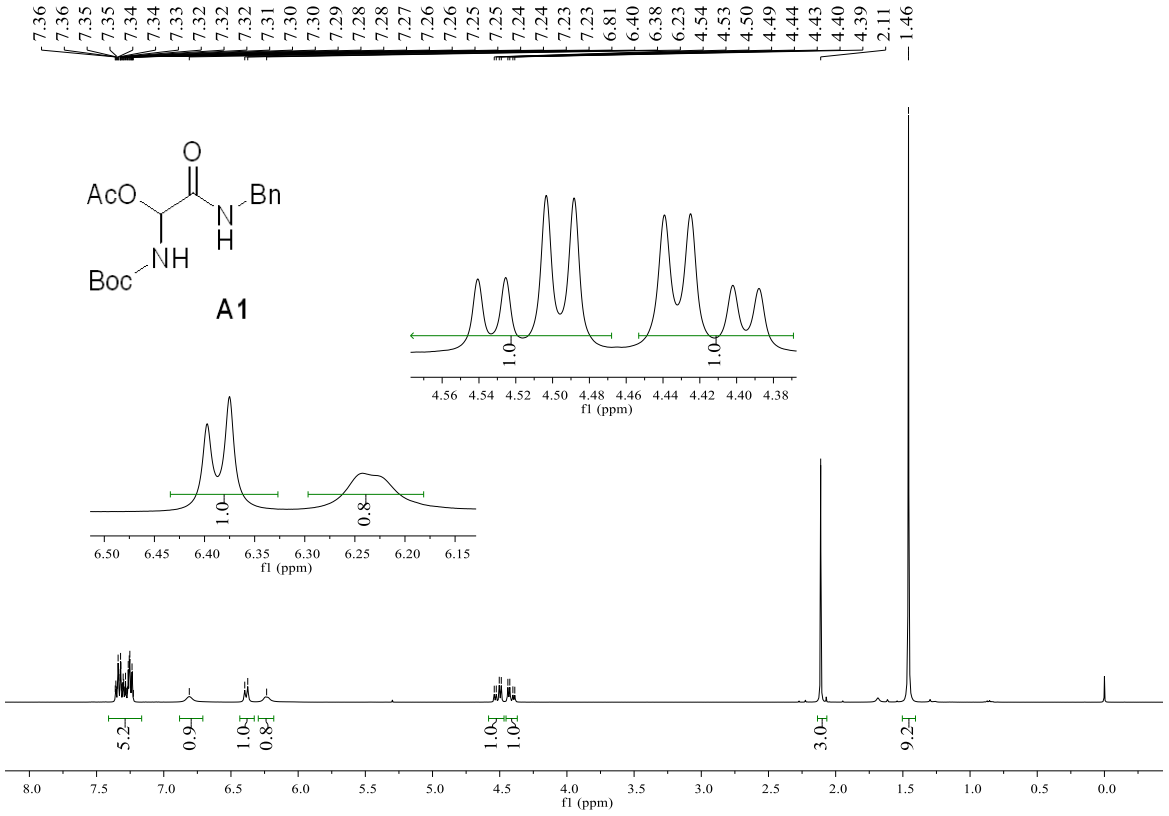


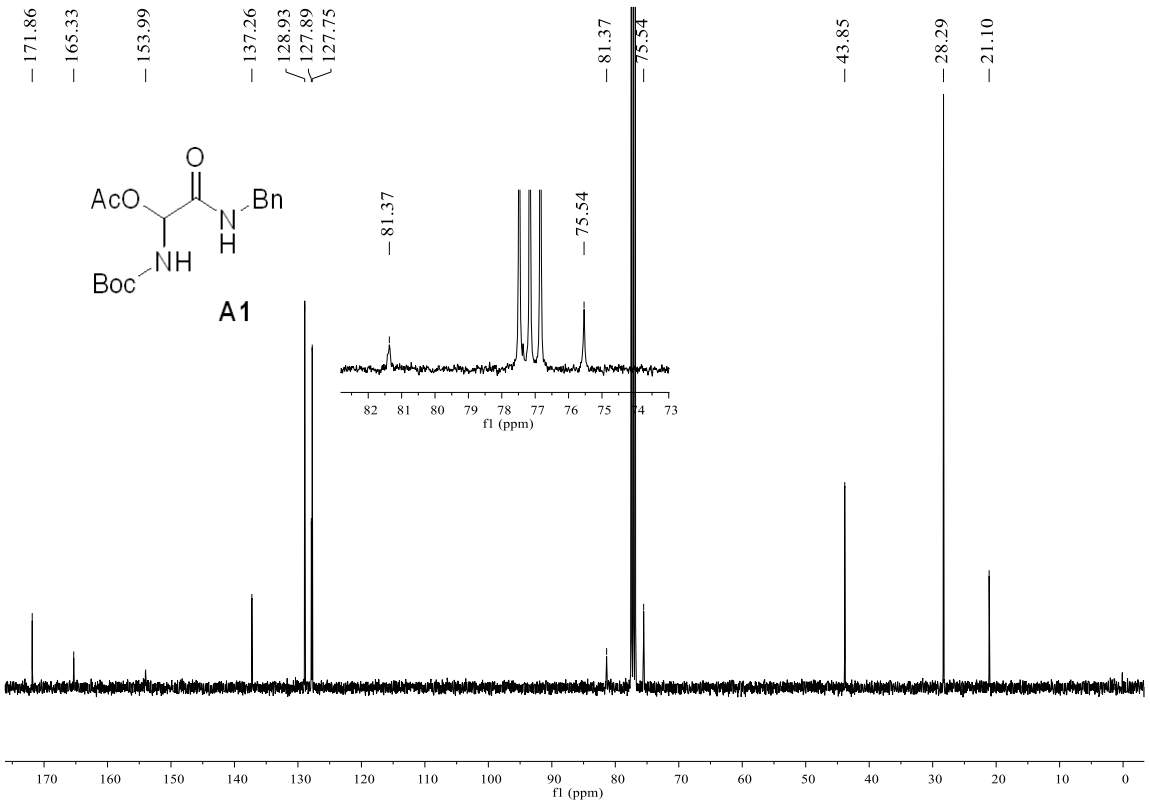
	Retention Time	% Area
1	1.996	49.92
2	2.557	50.08

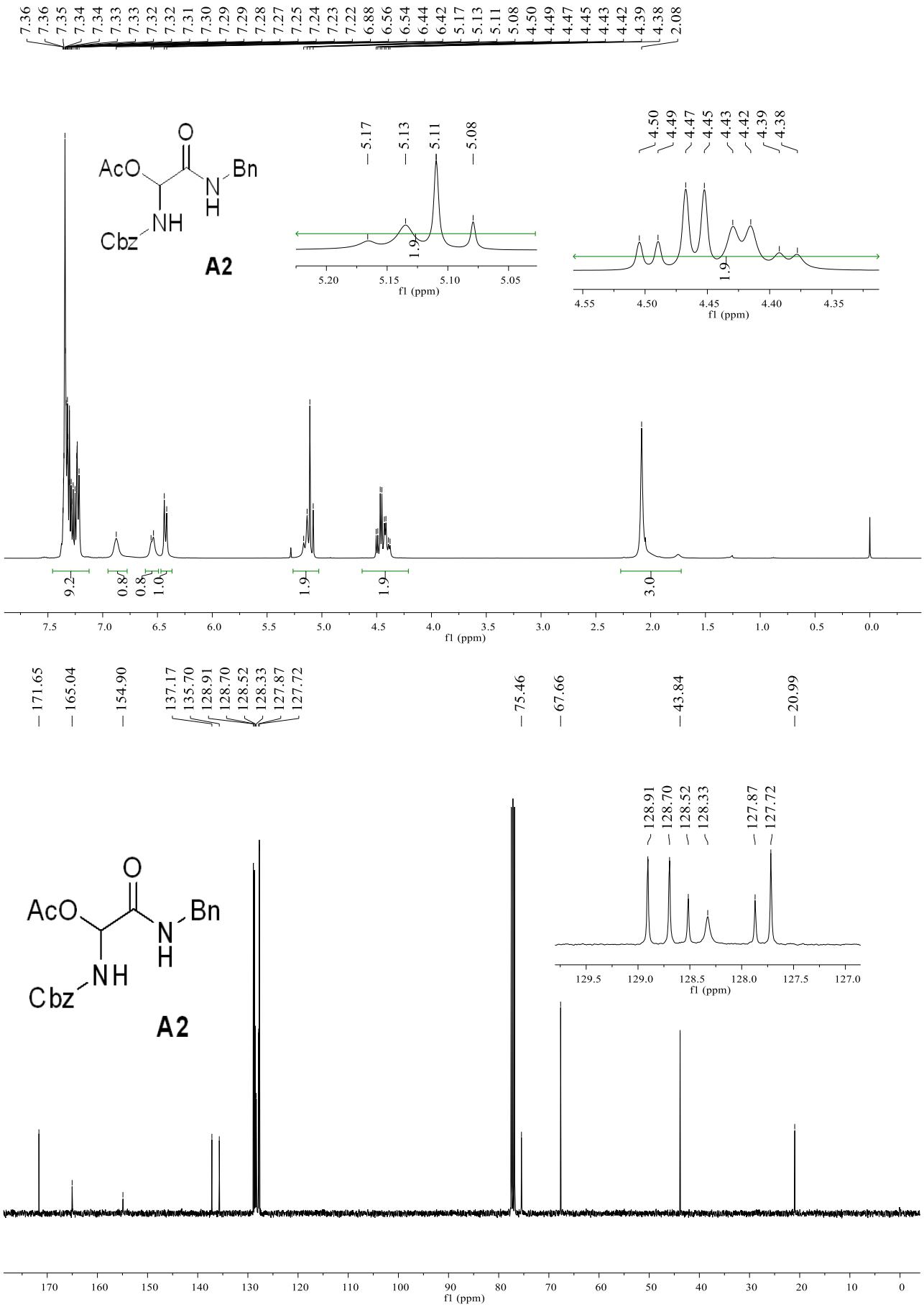


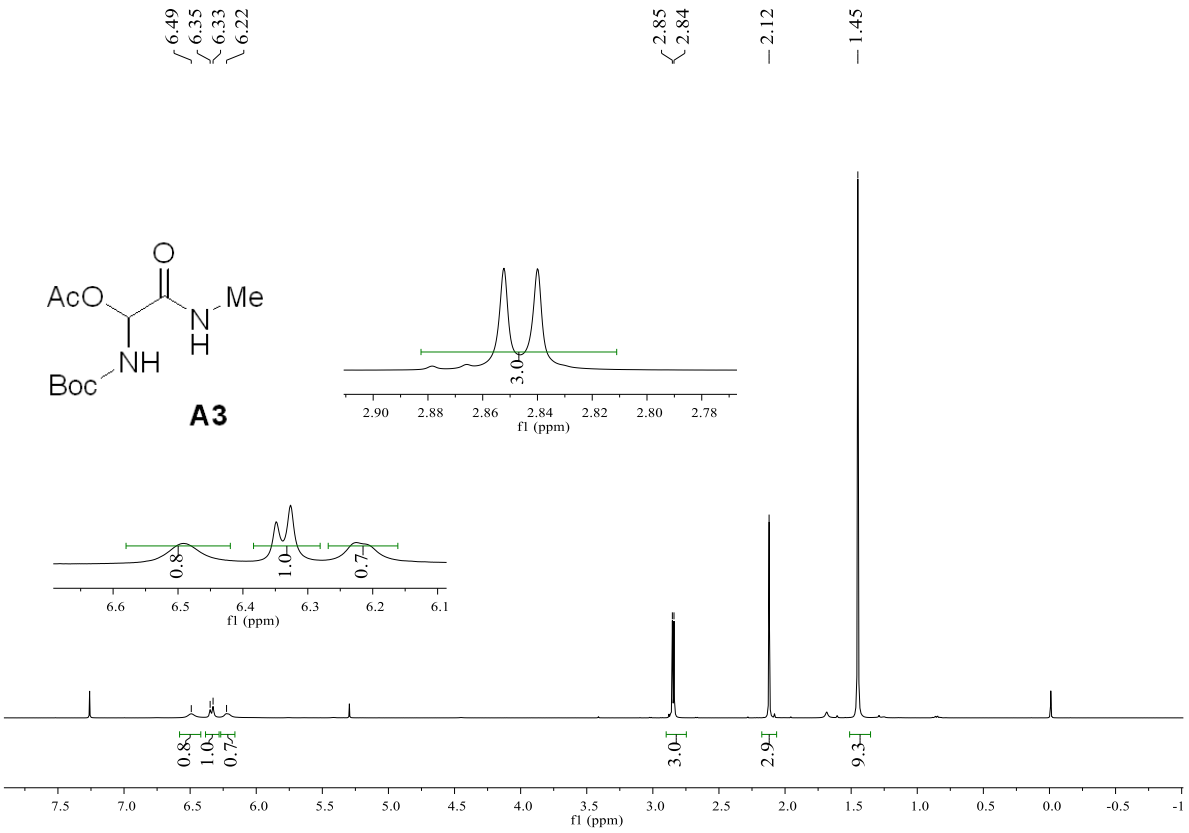
	Retention Time	% Area
1	2.016	99.54
2	2.683	0.46

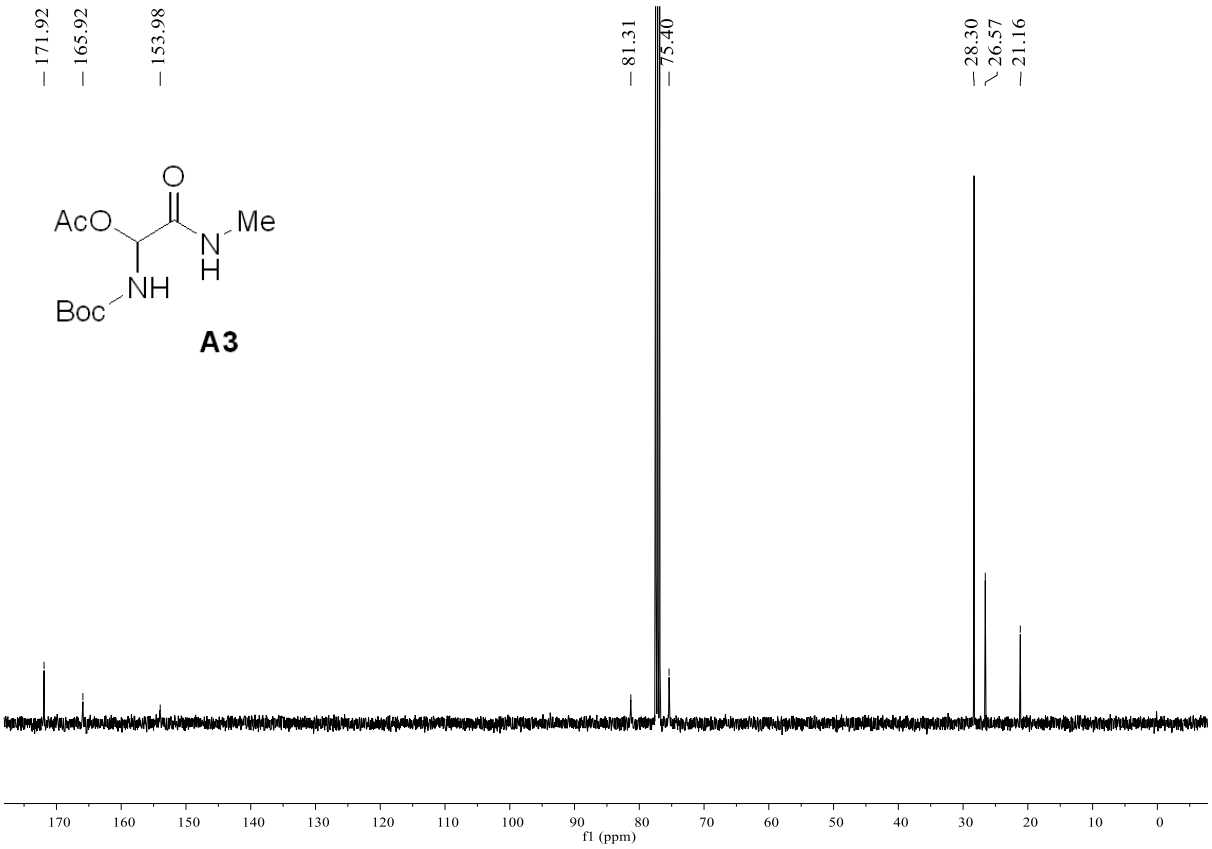
14. Copies of NMR spectra for substrates



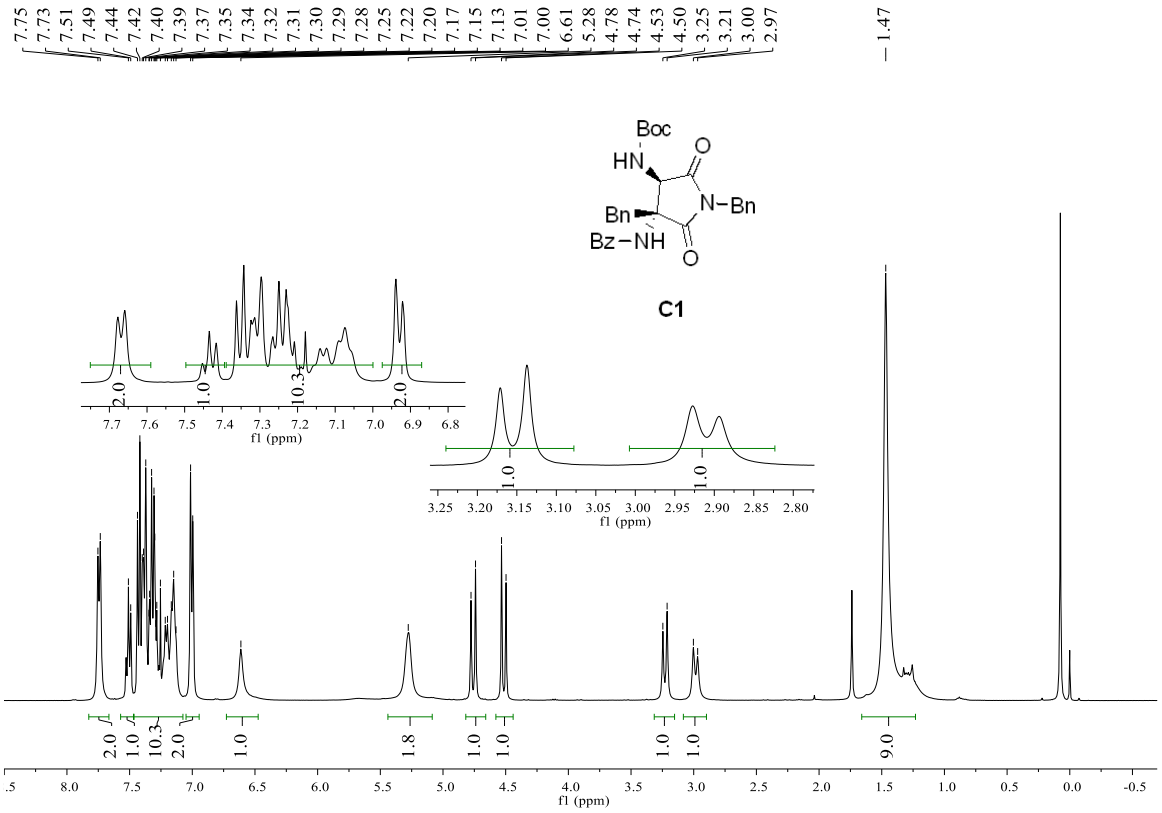


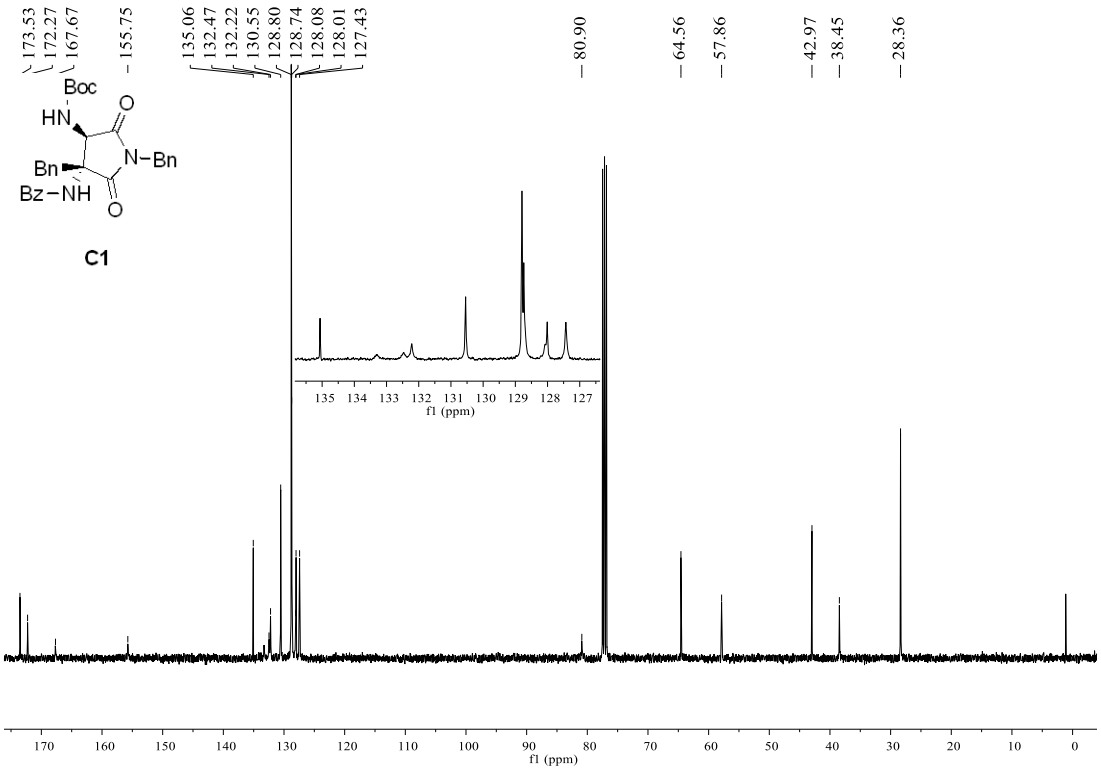

7.36 7.36 7.35 7.34 7.34 7.33 7.33 7.32 7.32 7.31 7.30 7.29 7.29 7.28 7.27 7.25 7.24 7.23 7.22 6.88 6.56 6.54 6.44 6.42 5.17 5.13 5.11 5.08 4.50 4.49 4.47 4.45 4.43 4.42 4.39 4.38 2.08
AcO
O
Bn
N
H
NH
Cbz
A2
5.17 5.13 5.11 5.08
1.9
5.20 5.15 5.10 5.05
f1 (ppm)
4.50 4.49 4.47 4.45 4.43 4.42 4.39 4.38
1.9
4.55 4.50 4.45 4.40 4.35
f1 (ppm)
9.2 0.8 0.8 1.0 1.9 1.9 3.0
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)
171.65 165.04 154.90 137.17 135.70 128.91 128.70 128.52 128.33 127.87 127.72 75.46 67.66 43.84 20.99
128.91 128.70 128.52 128.33 127.87 127.72
129.5 129.0 128.5 128.0 127.5 127.0
f1 (ppm)
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

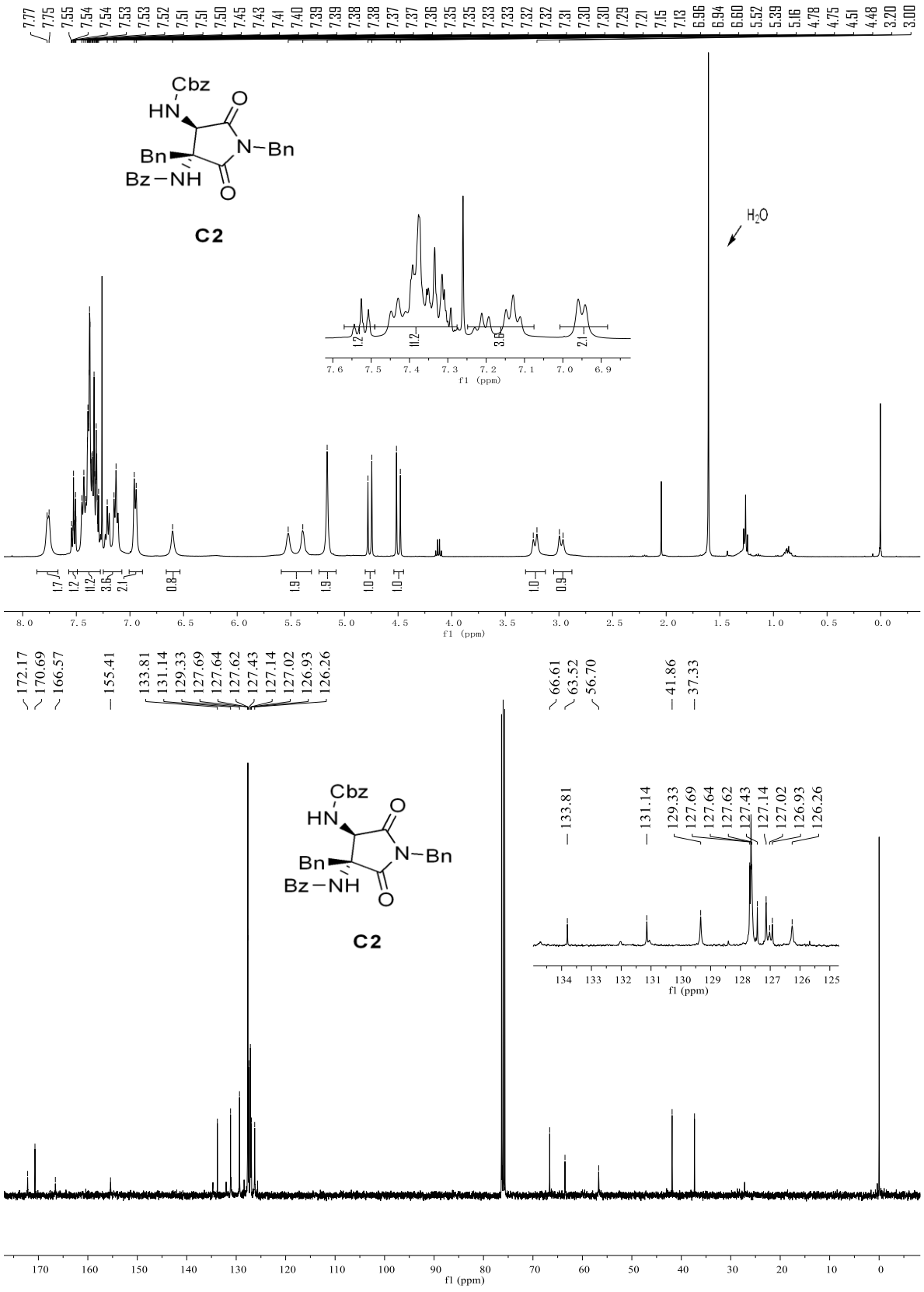

6.49
6.35
6.33
6.22
2.85
2.84
2.12
1.45
AcO
O
Me
N
H
NH
Boc
A3
3.0
2.90 2.88 2.86 2.84 2.82 2.80 2.78
f1 (ppm)
0.8
1.0
0.7
6.6 6.5 6.4 6.3 6.2 6.1
f1 (ppm)
0.8
1.0
0.7
3.0
2.9
9.3
7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1
f1 (ppm)

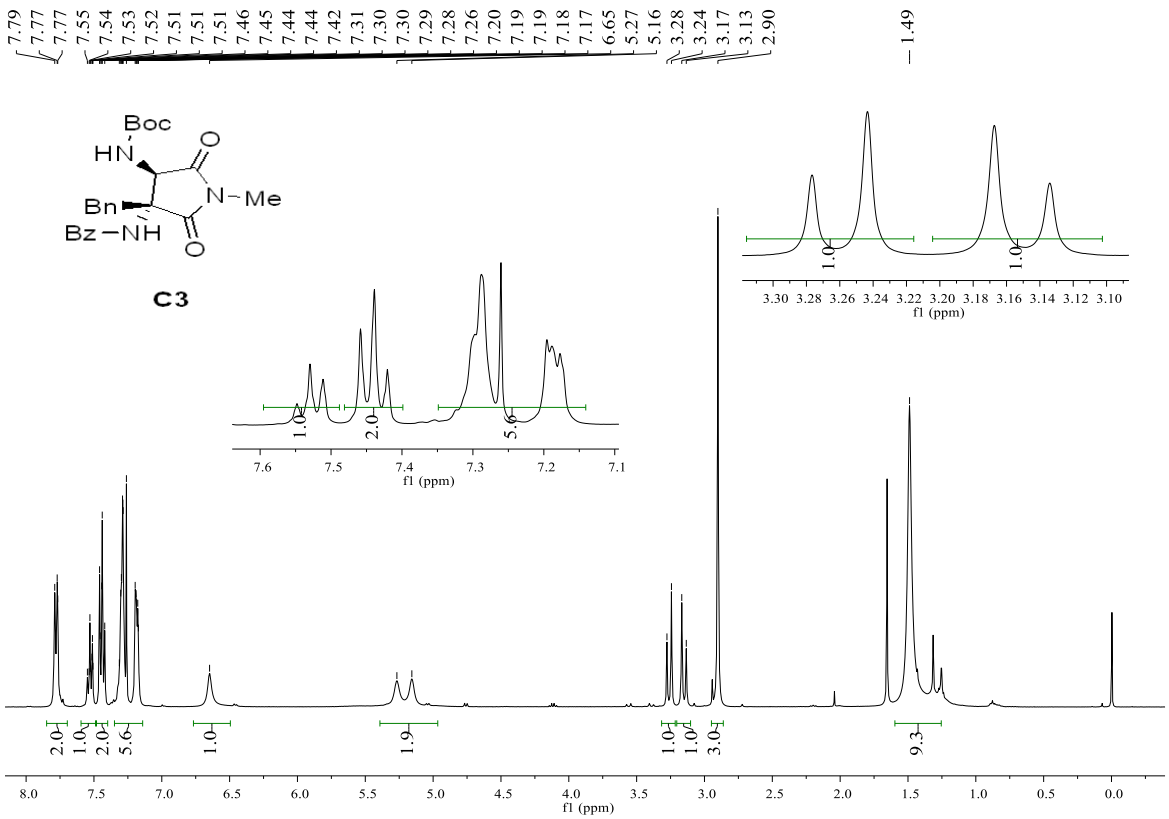

171.92
165.92
153.98
81.31
75.40
28.30
26.57
21.16
AcO
O
Me
N
H
NH
Boc
A3
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

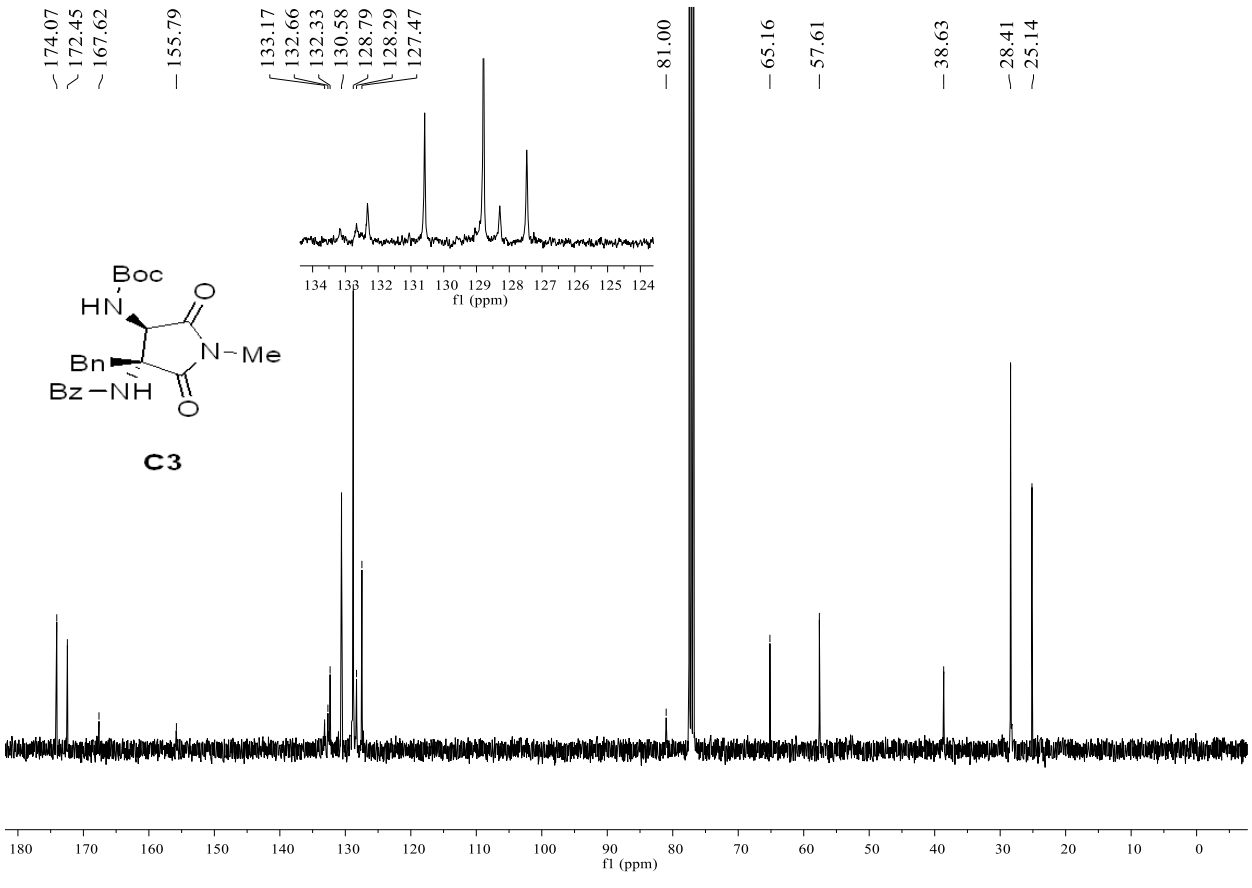
15. Copies of NMR spectra for products

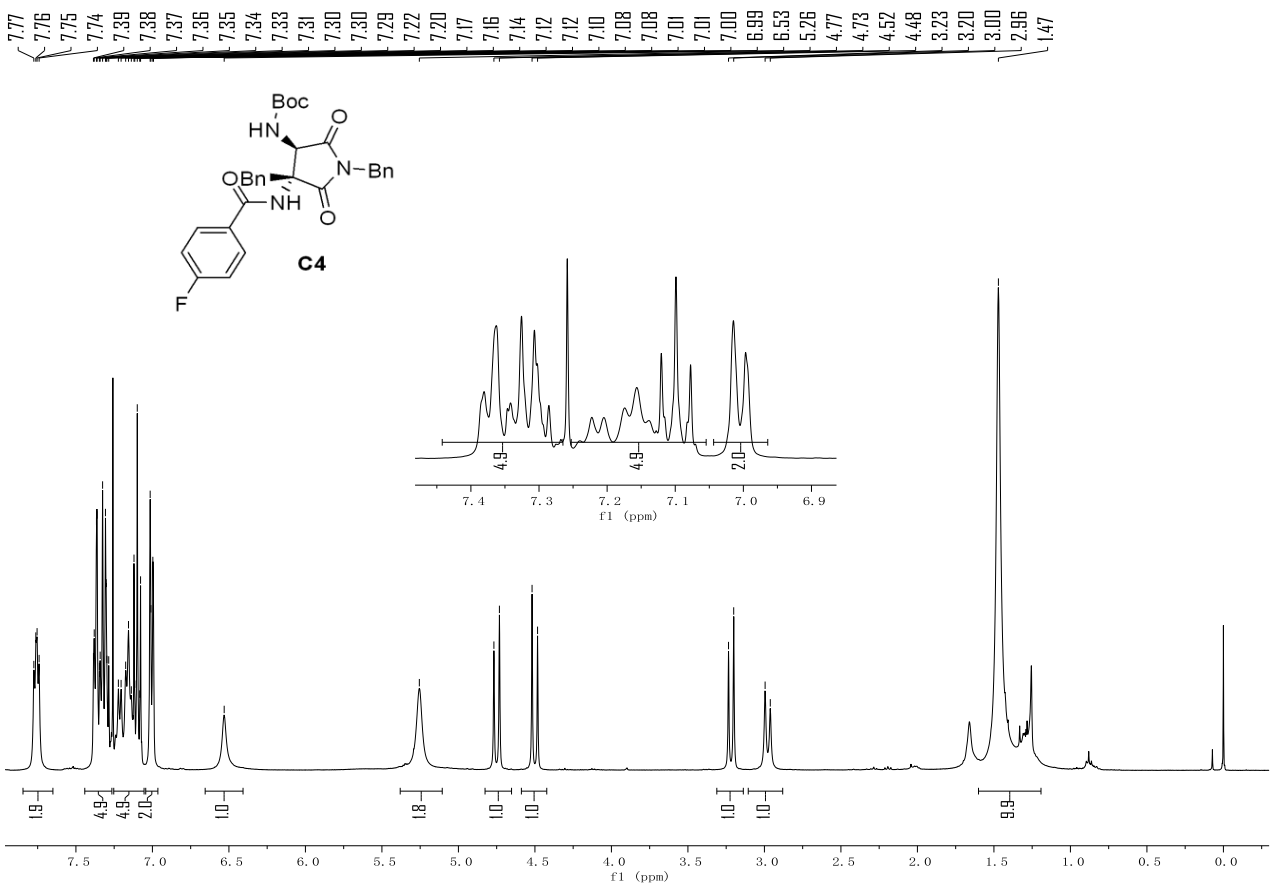


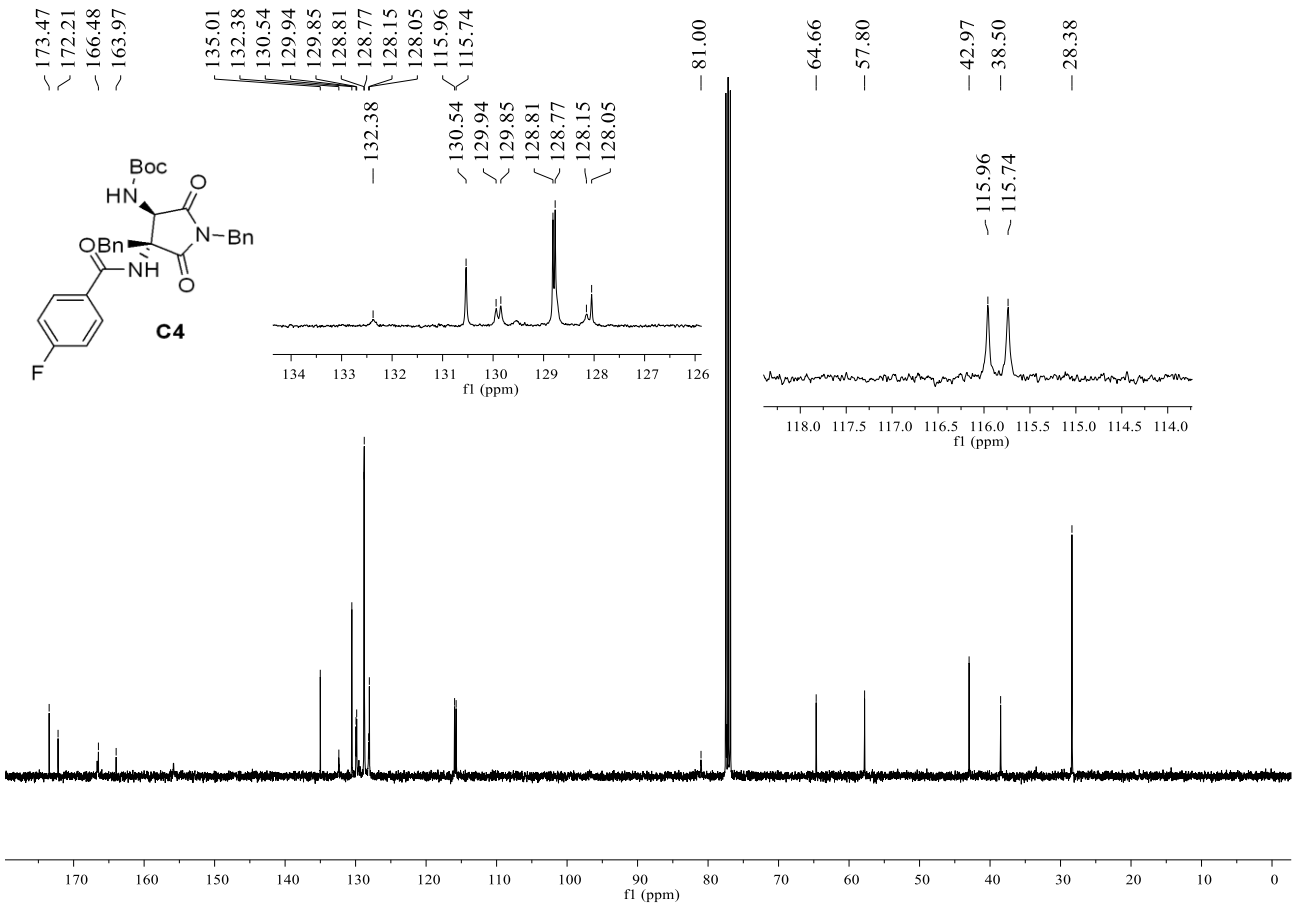


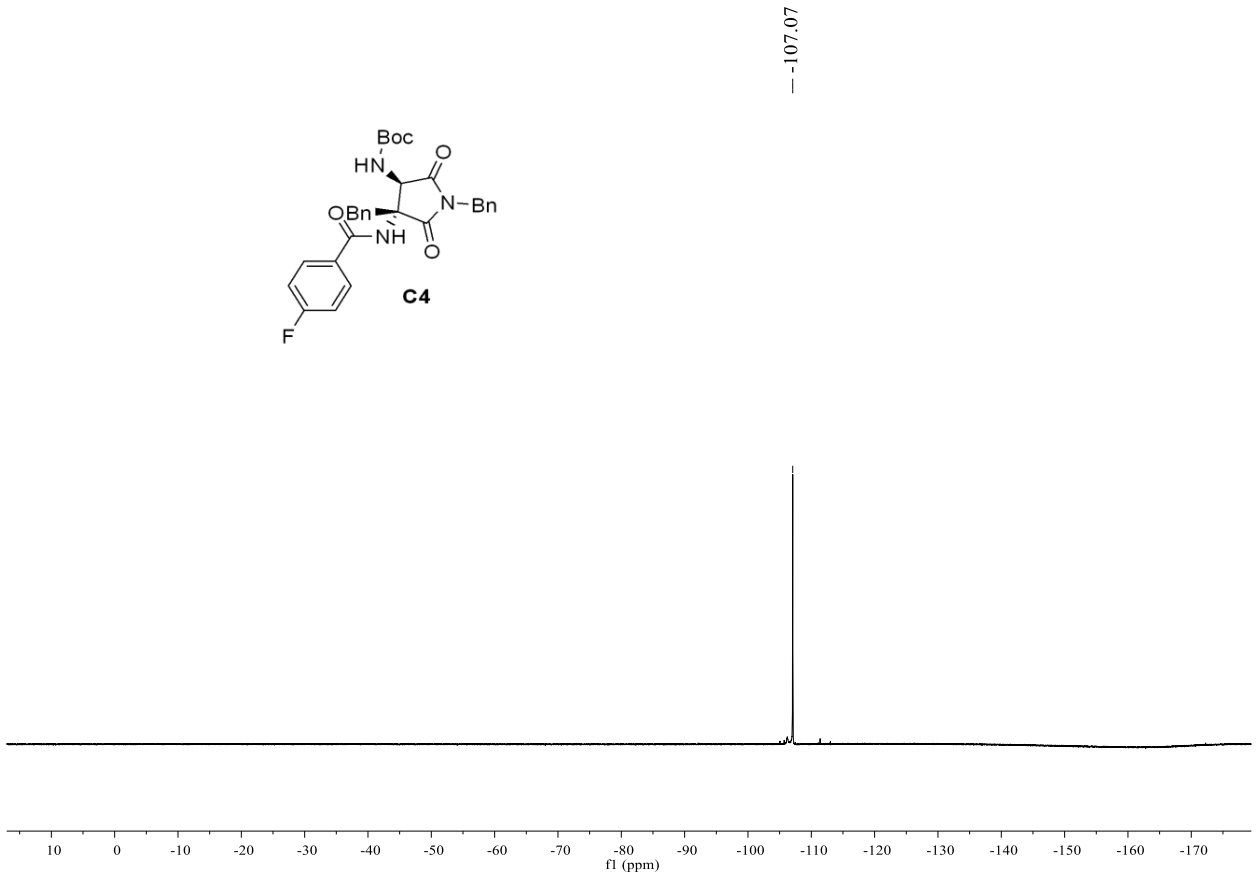

7.77 7.75 7.55 7.54 7.54 7.54 7.53 7.53 7.52 7.51 7.51 7.50 7.45 7.43 7.41 7.40 7.39 7.39 7.38 7.38 7.37 7.37 7.36 7.35 7.35 7.33 7.33 7.32 7.32 7.31 7.30 7.30 7.29 7.21 7.15 7.13 6.96 6.94 6.60 5.52 5.39 5.16 4.78 4.75 4.51 4.48 3.20 3.00
Cbz
HN
O
N–Bn
Bn
Bz–NH
O
C2
H2O
1.7 1.2 11.2 3.6 2.1 0.8 1.9 1.9 1.0 1.0 1.0 0.9
f1 (ppm)
172.17 170.69 166.57 155.41 133.81 131.14 129.33 127.69 127.64 127.62 127.43 127.14 127.02 126.93 126.26 66.61 63.52 56.70 41.86 37.33
f1 (ppm)

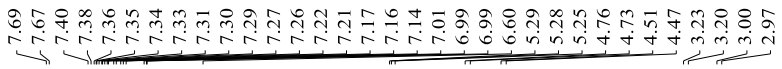

7.79
7.77
7.77
7.55
7.54
7.53
7.52
7.51
7.51
7.51
7.46
7.45
7.44
7.44
7.42
7.31
7.30
7.30
7.29
7.28
7.26
7.20
7.19
7.19
7.18
7.17
6.65
5.27
5.16
3.28
3.24
3.17
3.13
2.90
1.49
Boc
HN
Bn
Bz—NH
N–Me
C3
f1 (ppm)

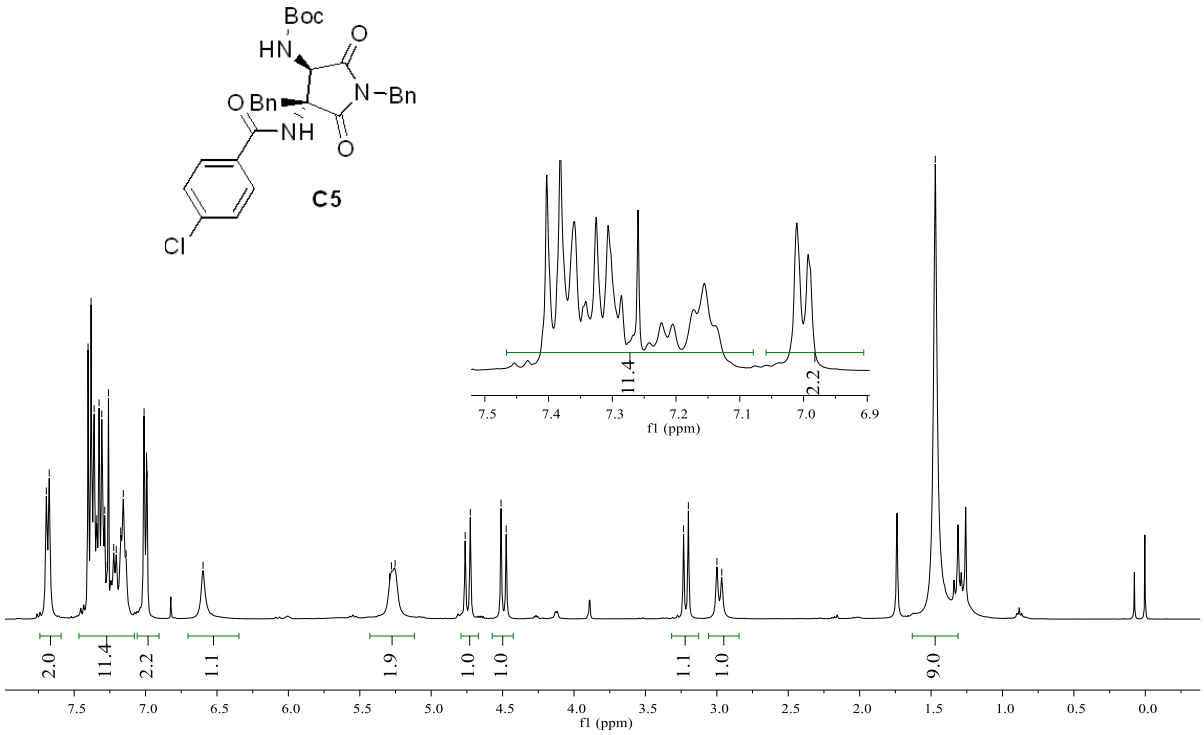

174.07
172.45
167.62
155.79
133.17
132.66
132.33
130.58
128.79
128.29
127.47
81.00
65.16
57.61
38.63
28.41
25.14
Boc
HN
Bn
Bz—NH
N–Me
C3
f1 (ppm)

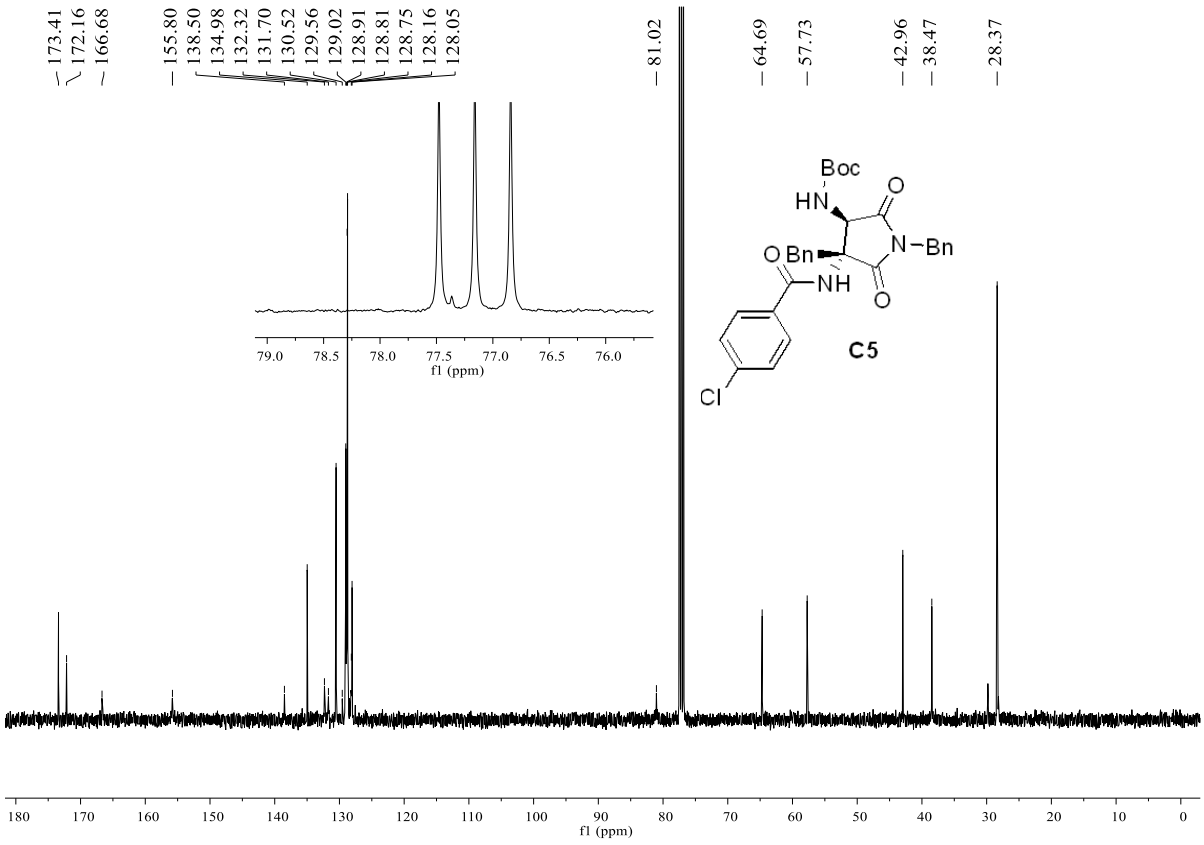

7.77 7.76 7.75 7.74 7.39 7.38 7.37 7.36 7.35 7.34 7.33 7.31 7.30 7.30 7.29 7.22 7.20 7.17 7.16 7.14 7.12 7.12 7.10 7.08 7.08 7.01 7.01 7.00 6.99 6.53 5.26 4.77 4.73 4.52 4.48 3.23 3.20 3.00 2.96 1.47
Boc
HN
OBn
NH
N–Bn
C4
F
f1 (ppm)

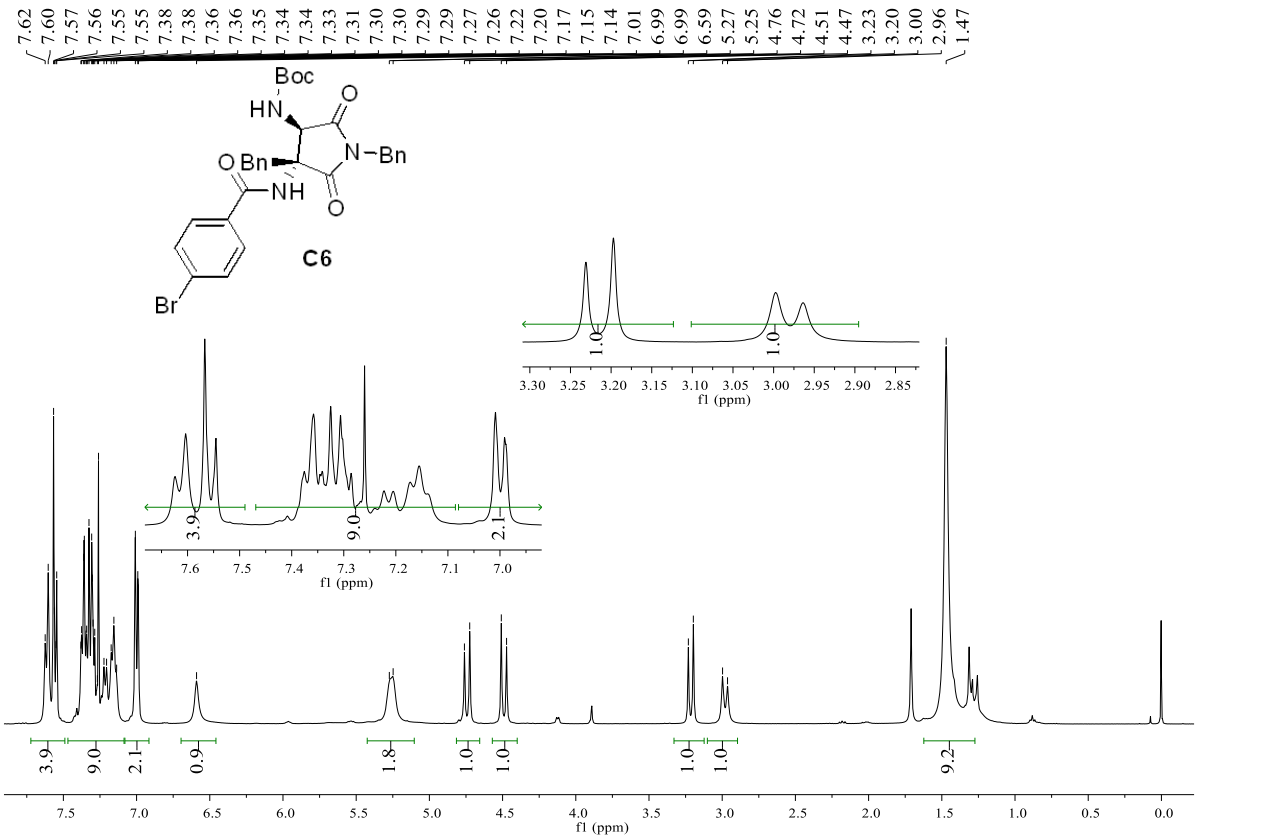

173.47 172.21 166.48 163.97 135.01 132.38 130.54 129.94 129.85 128.81 128.77 128.15 128.05 115.96 115.74 81.00 64.66 57.80 42.97 38.50 28.38
Boc
HN
OBn
NH
N–Bn
C4
F
f1 (ppm)

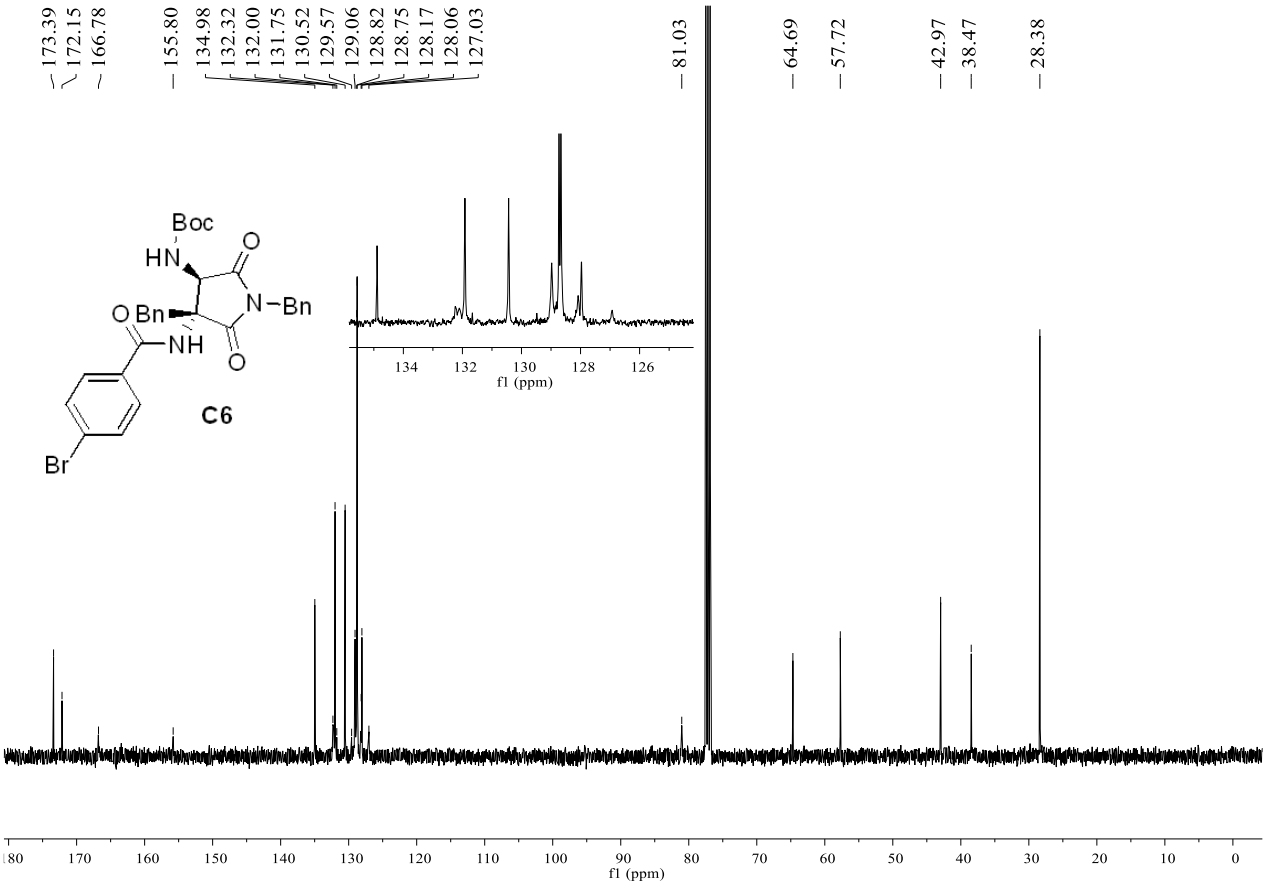

-107.07
Boc
HN
O
N–Bn
OBn
NH
O
C4
F
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
f1 (ppm)

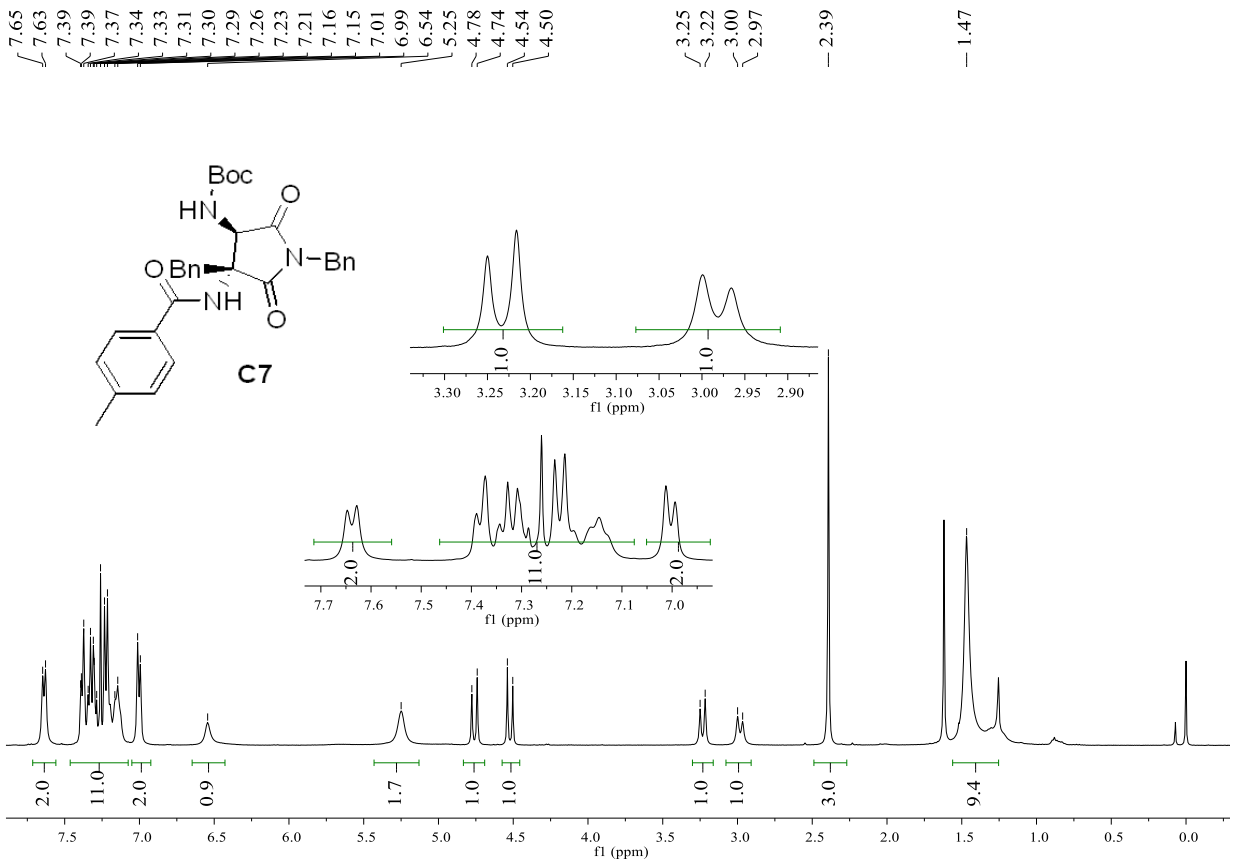

7.69
7.67
7.40
7.38
7.36
7.35
7.34
7.33
7.31
7.30
7.29
7.27
7.26
7.22
7.21
7.17
7.16
7.14
7.01
6.99
6.99
6.60
5.29
5.28
5.25
4.76
4.73
4.51
4.47
3.23
3.20
3.00
2.97
1.47

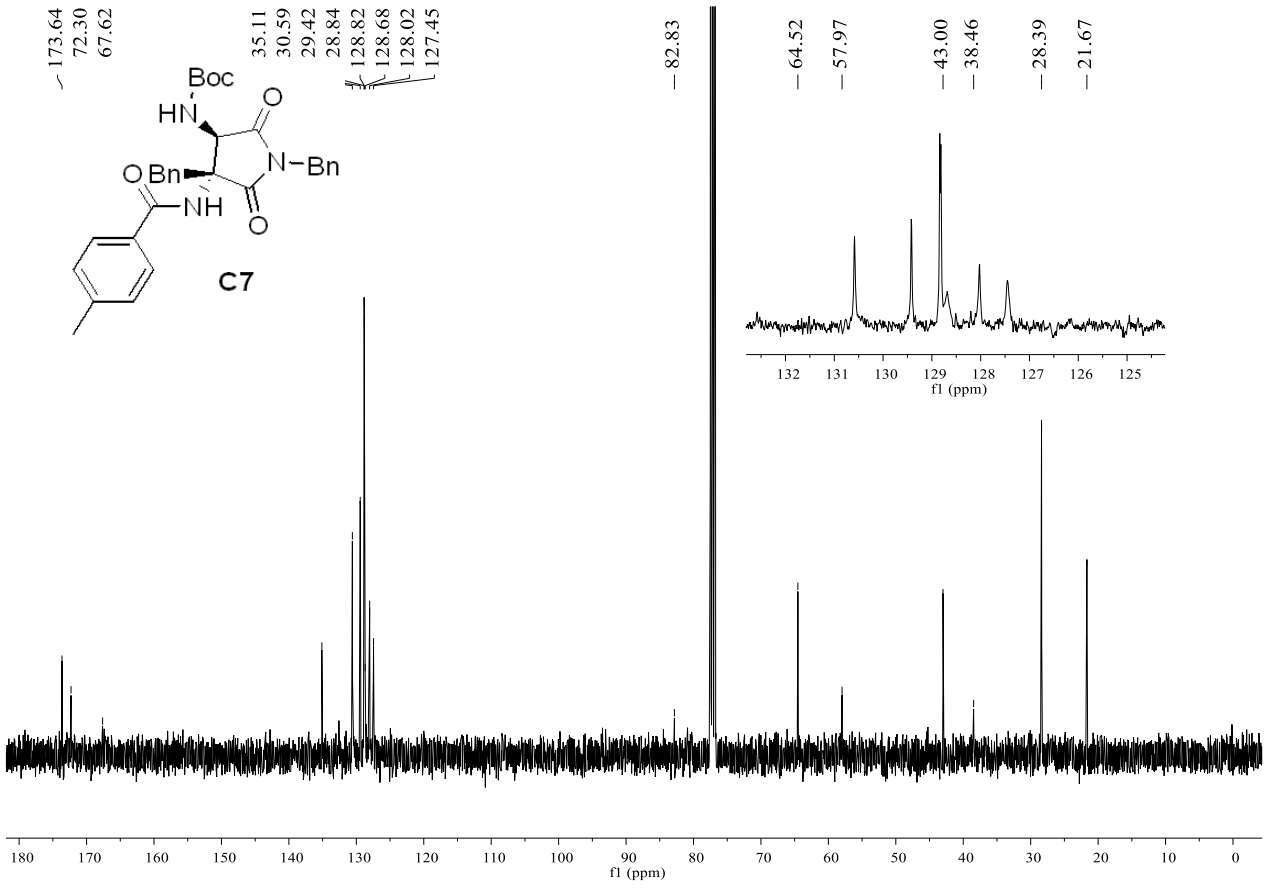

Boc
HN
O
N–Bn
O Bn
NH
O
Cl
C5
11.4
2.2
f1 (ppm)
2.0
11.4
2.2
1.1
1.9
1.0
1.0
1.1
1.0
9.0
f1 (ppm)

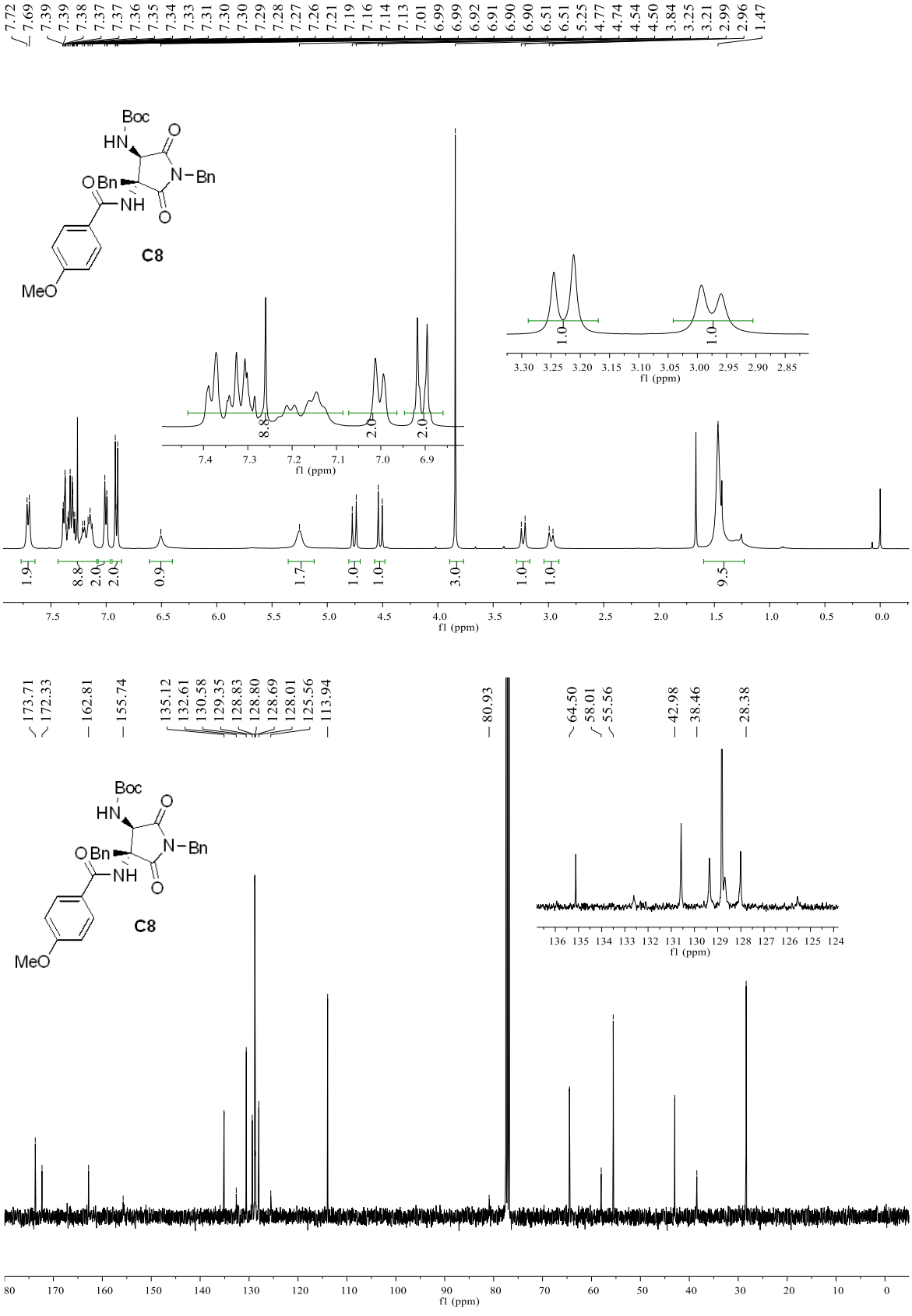

173.41
172.16
166.68
155.80
138.50
134.98
132.32
131.70
130.52
129.56
129.02
128.91
128.81
128.75
128.16
128.05
81.02
64.69
57.73
42.96
38.47
28.37
Boc
HN
O
N–Bn
O Bn
NH
O
Cl
C5
f1 (ppm)
f1 (ppm)

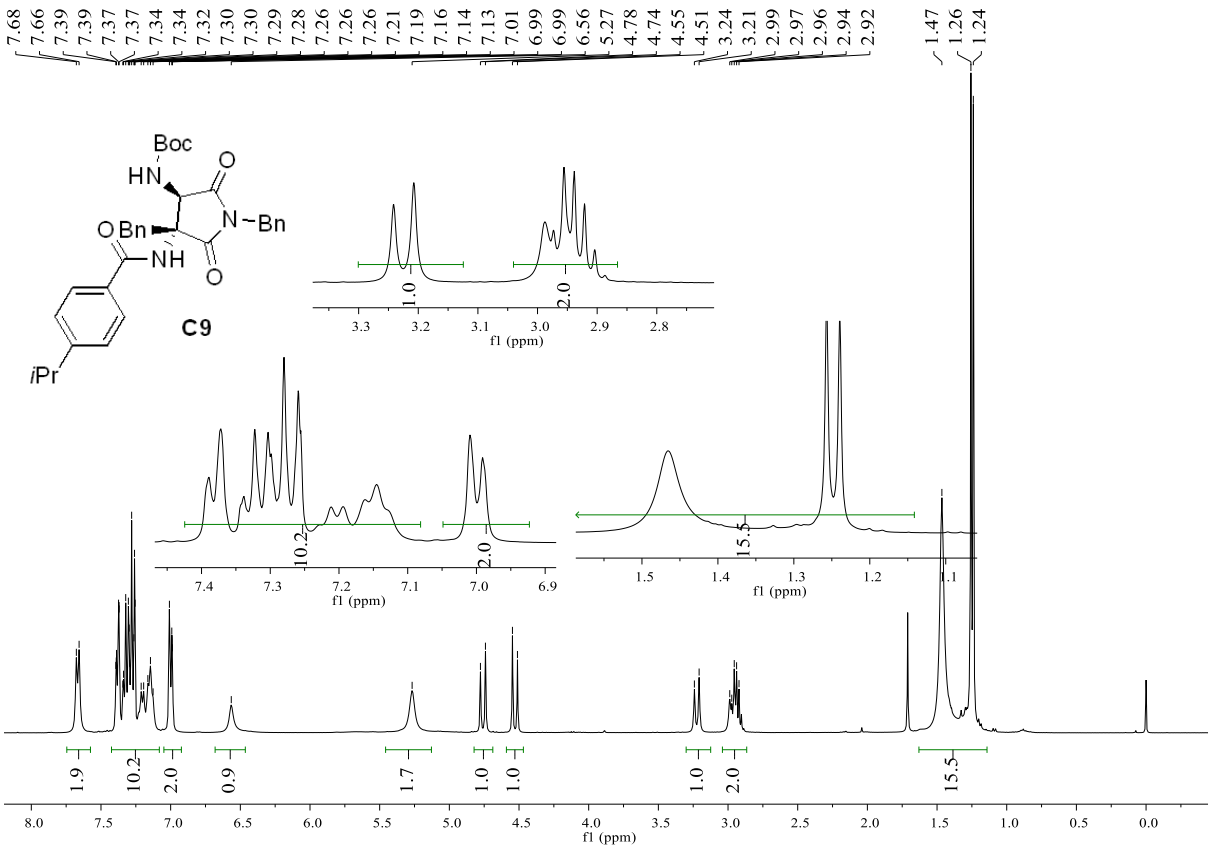

7.62 7.60 7.57 7.56 7.55 7.55 7.38 7.38 7.36 7.36 7.35 7.34 7.34 7.33 7.31 7.30 7.30 7.29 7.29 7.27 7.26 7.22 7.20 7.17 7.15 7.14 7.01 6.99 6.99 6.59 5.27 5.25 4.76 4.72 4.51 4.47 3.23 3.20 3.00 2.96 1.47
Boc
HN
O
N–Bn
O
Bn
NH
O
Br
C6
3.9 9.0 2.1 0.9 1.8 1.0 1.0 1.0 1.0 9.2
f1 (ppm)

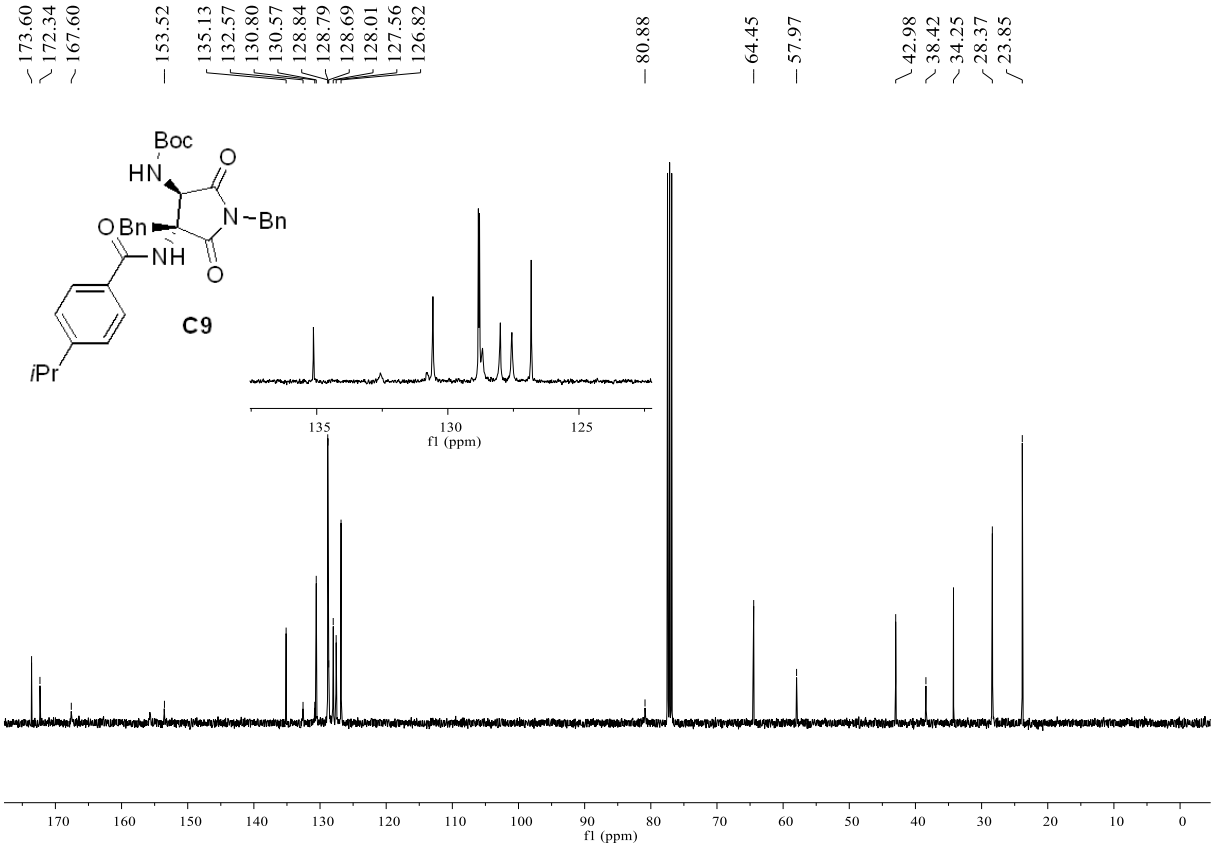

173.39 172.15 166.78 155.80 134.98 132.32 132.00 131.75 130.52 129.57 129.06 128.82 128.75 128.17 128.06 127.03 81.03 64.69 57.72 42.97 38.47 28.38
Boc
HN
O
N–Bn
O
Bn
NH
O
Br
C6
f1 (ppm)

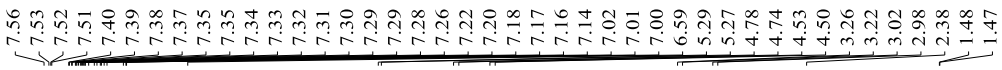

7.65
7.63
7.39
7.39
7.37
7.34
7.33
7.31
7.30
7.29
7.26
7.23
7.21
7.16
7.15
7.01
6.99
6.54
5.25
4.78
4.74
4.54
4.50
3.25
3.22
3.00
2.97
2.39
1.47
Boc
HN
O
N–Bn
O
Bn
NH
O
C7
2.0
11.0
2.0
0.9
1.7
1.0
1.0
1.0
1.0
3.0
9.4
f1 (ppm)

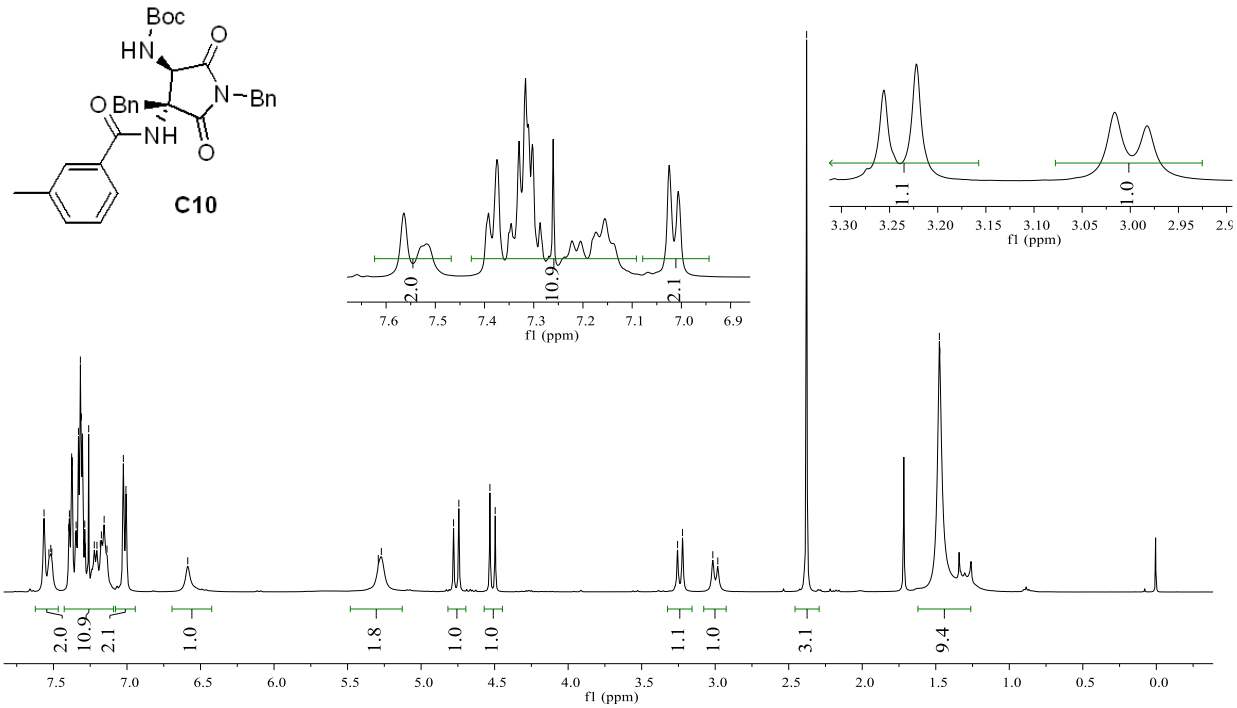

173.64
72.30
67.62
35.11
30.59
29.42
28.84
128.82
128.68
128.02
127.45
82.83
64.52
57.97
43.00
38.46
28.39
21.67
Boc
HN
O
N–Bn
O
Bn
NH
O
C7
f1 (ppm)

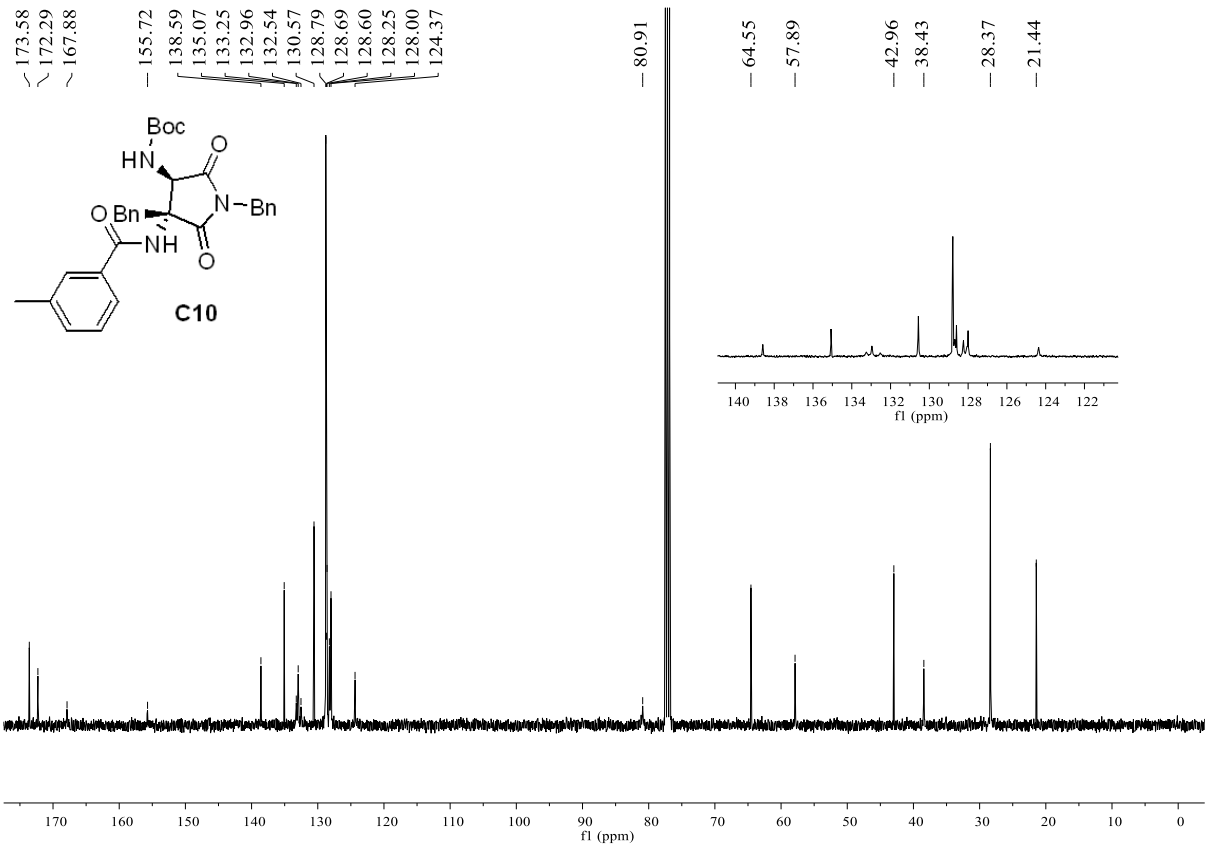

7.72 7.69 7.39 7.39 7.38 7.37 7.37 7.36 7.35 7.34 7.33 7.31 7.30 7.30 7.29 7.28 7.27 7.26 7.21 7.19 7.16 7.14 7.13 7.01 6.99 6.99 6.92 6.91 6.90 6.90 6.51 6.51 5.25 4.77 4.74 4.54 4.50 3.84 3.25 3.21 2.99 2.96 1.47
Boc
HN
O
N–Bn
OBn
NH
O
C8
MeO
1.9 8.8 2.0 2.0 0.9 1.7 1.0 1.0 3.0 1.0 1.0 9.5
f1 (ppm)
173.71 172.33 162.81 155.74 135.12 132.61 130.58 129.35 128.83 128.80 128.69 128.01 125.56 113.94 80.93 64.50 58.01 55.56 42.98 38.46 28.38
f1 (ppm)


7.68 7.66 7.39 7.39 7.37 7.37 7.34 7.34 7.32 7.30 7.30 7.29 7.28 7.26 7.26 7.26 7.21 7.19 7.16 7.14 7.13 7.01 6.99 6.99 6.56 5.27 4.78 4.74 4.55 4.51 3.24 3.21 2.99 2.97 2.96 2.94 2.92 1.47 1.26 1.24
Boc
HN
O
N–Bn
O
Bn
NH
O
C9
iPr
1.0
2.0
f1 (ppm)
10.2
2.0
15.5
1.9 10.2 2.0 0.9 1.7 1.0 1.0 1.0 2.0 15.5
f1 (ppm)


173.60 172.34 167.60 153.52 135.13 132.57 130.80 130.57 128.84 128.79 128.69 128.01 127.56 126.82 80.88 64.45 57.97 42.98 38.42 34.25 28.37 23.85
Boc
HN
O
N–Bn
O
Bn
NH
O
C9
iPr
f1 (ppm)
f1 (ppm)


7.56
7.53
7.52
7.51
7.40
7.39
7.38
7.37
7.35
7.35
7.34
7.33
7.32
7.31
7.30
7.29
7.29
7.28
7.26
7.22
7.20
7.18
7.17
7.16
7.14
7.02
7.01
7.00
6.59
5.29
5.27
4.78
4.74
4.53
4.50
3.26
3.22
3.02
2.98
2.38
1.48
1.47


Boc
HN
O
N–Bn
O
Bn
NH
O
C10
2.0
10.9
2.1
1.1
1.0
f1 (ppm)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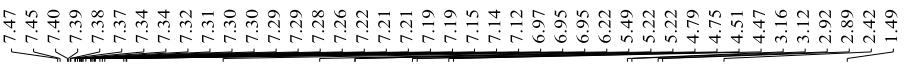
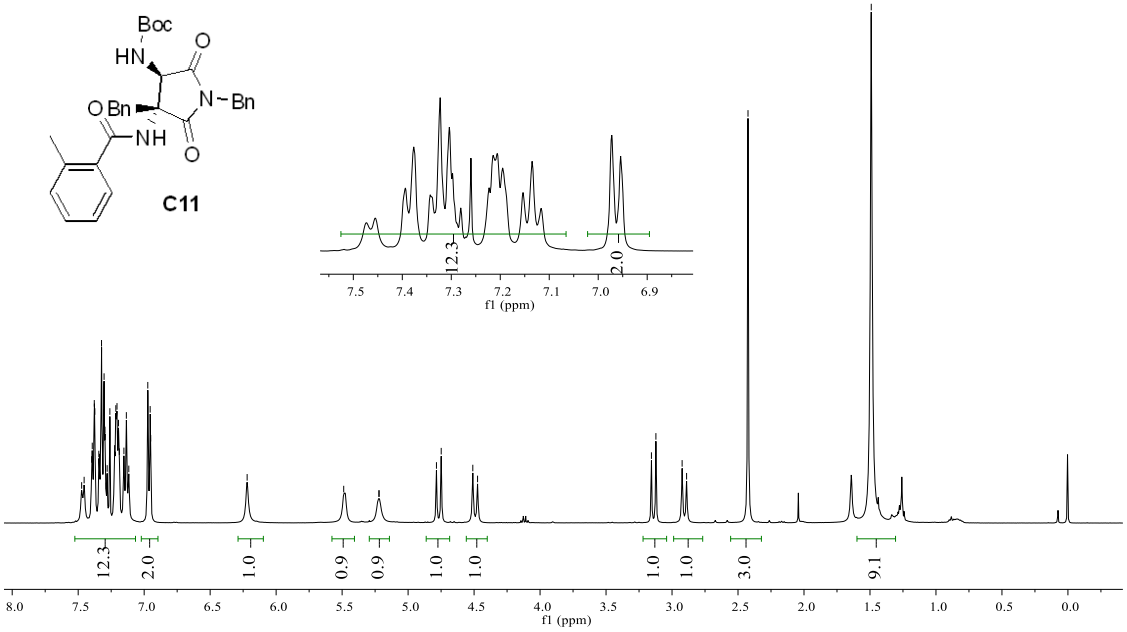
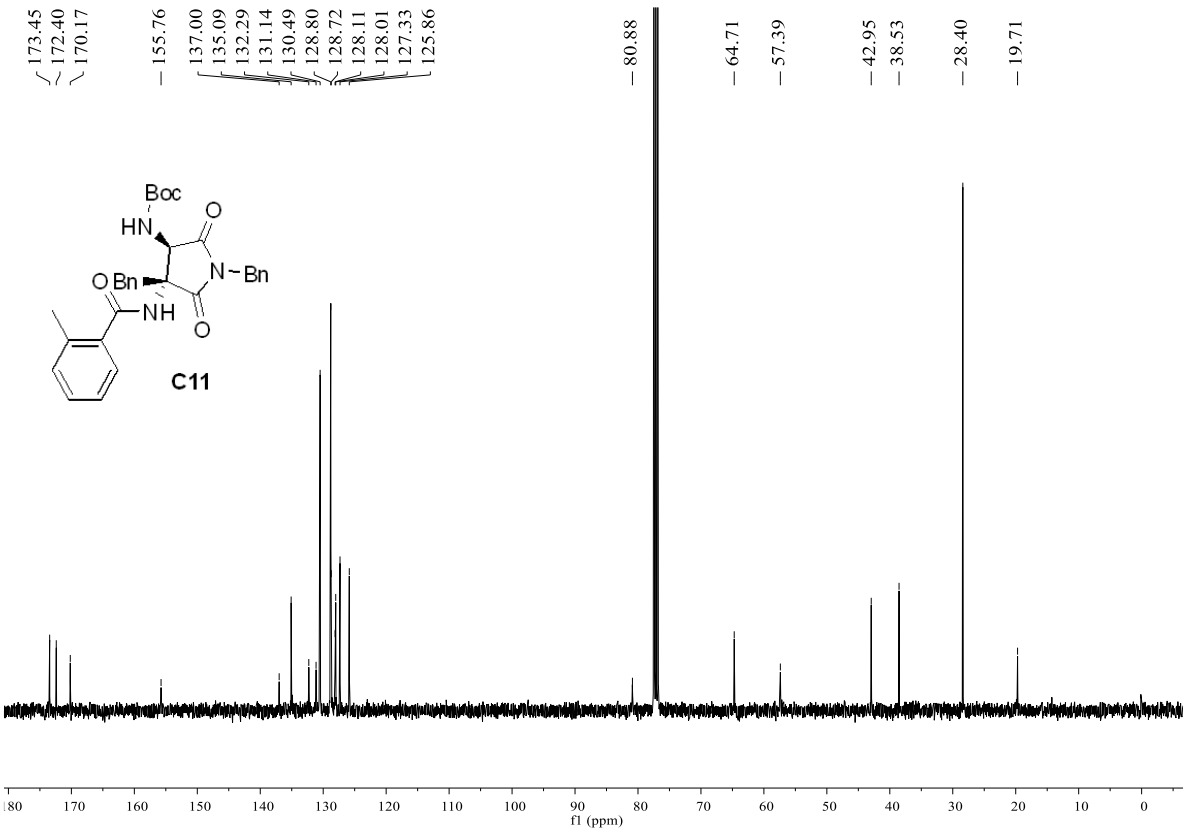
172.29
167.88
155.72
138.59
135.07
133.25
132.96
132.54
130.57
128.79
128.69
128.60
128.25
128.00
124.37
80.91
64.55
57.89
42.96
38.43
28.37
21.44
Boc
HN
O
N–Bn
O
Bn
NH
O
C10
f1 (ppm)


7.47
7.45
7.40
7.39
7.38
7.37
7.34
7.34
7.32
7.31
7.30
7.30
7.29
7.29
7.28
7.26
7.22
7.21
7.21
7.19
7.19
7.15
7.14
7.12
6.97
6.95
6.95
6.22
5.49
5.22
5.22
4.79
4.75
4.51
4.47
3.16
3.12
2.92
2.89
2.42
1.49


Boc
HN
O
N~Bn
O Bn
NH
O
C11
12.3
2.0
7.5
7.4
7.3
7.2
7.1
7.0
6.9
f1 (ppm)
12.3
2.0
1.0
0.9
0.9
1.0
1.0
1.0
1.0
3.0
9.1
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)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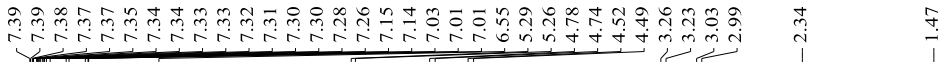
172.40
170.17
155.76
137.00
135.09
132.29
131.14
130.49
128.80
128.72
128.11
128.01
127.33
125.86
80.88
64.71
57.39
42.95
38.53
28.40
19.71
Boc
HN
O
N~Bn
O Bn
NH
O
C11
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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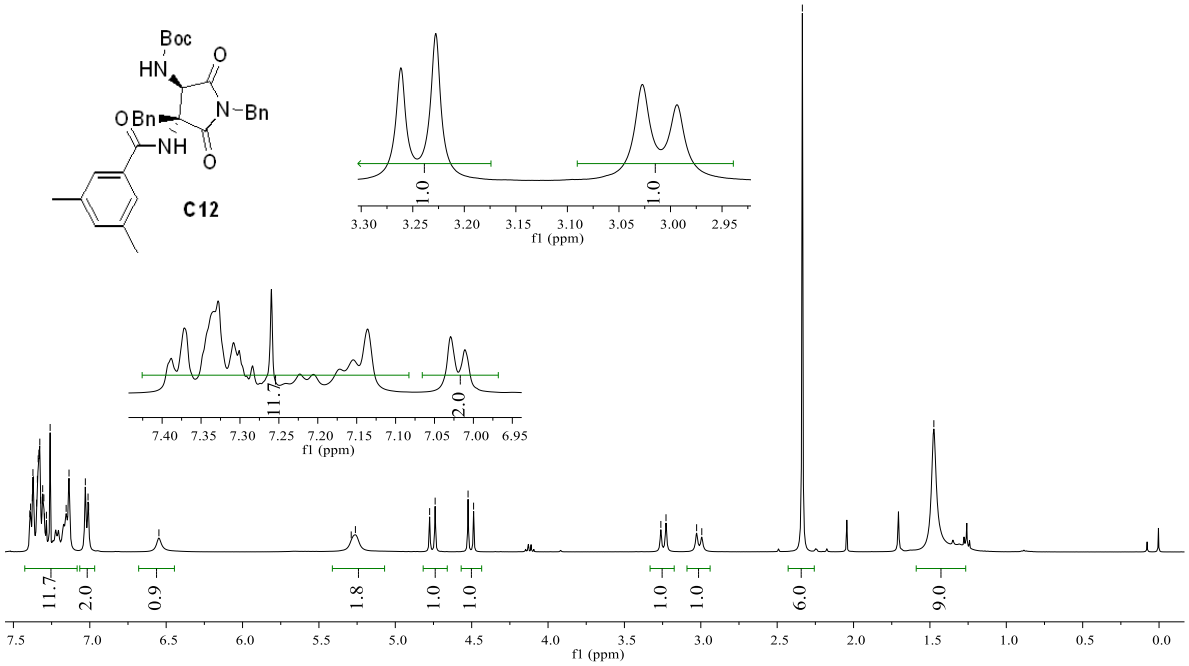
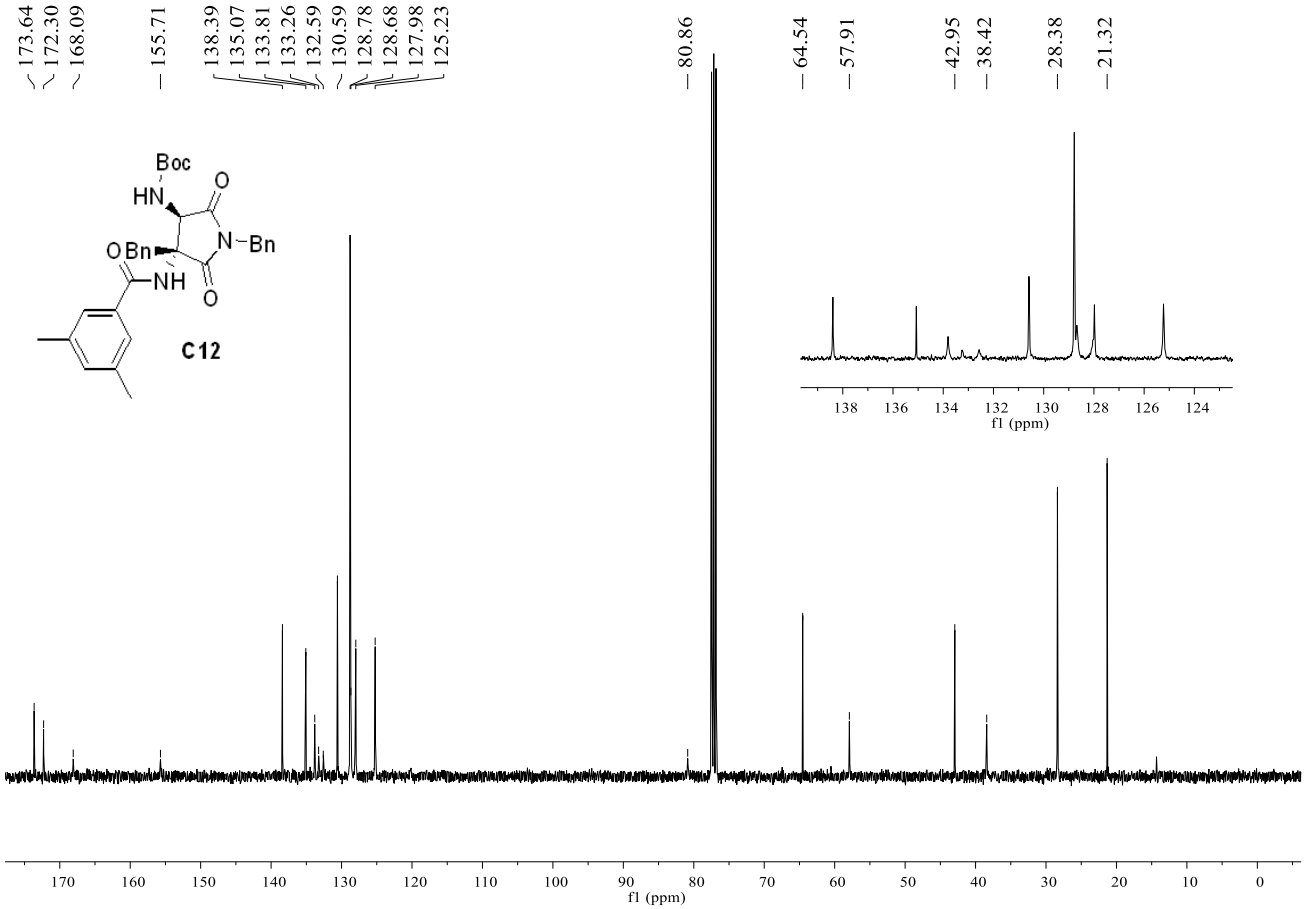
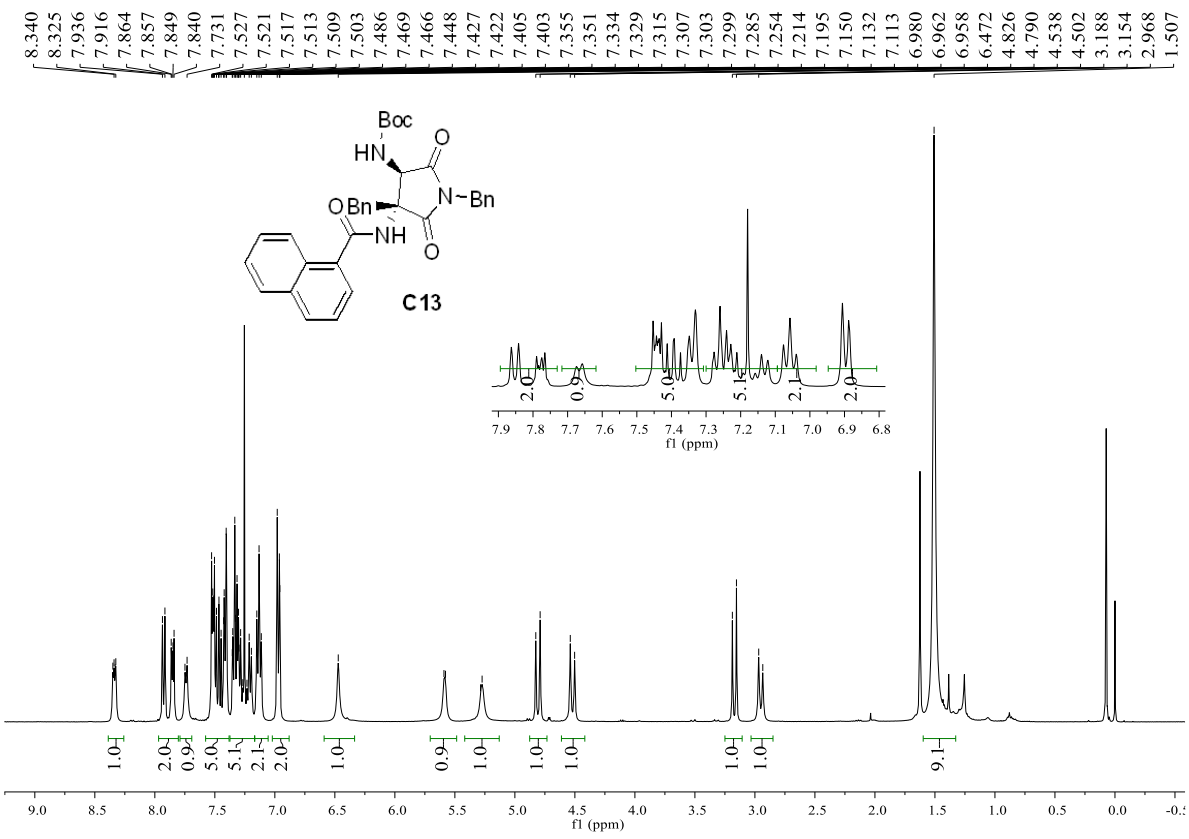
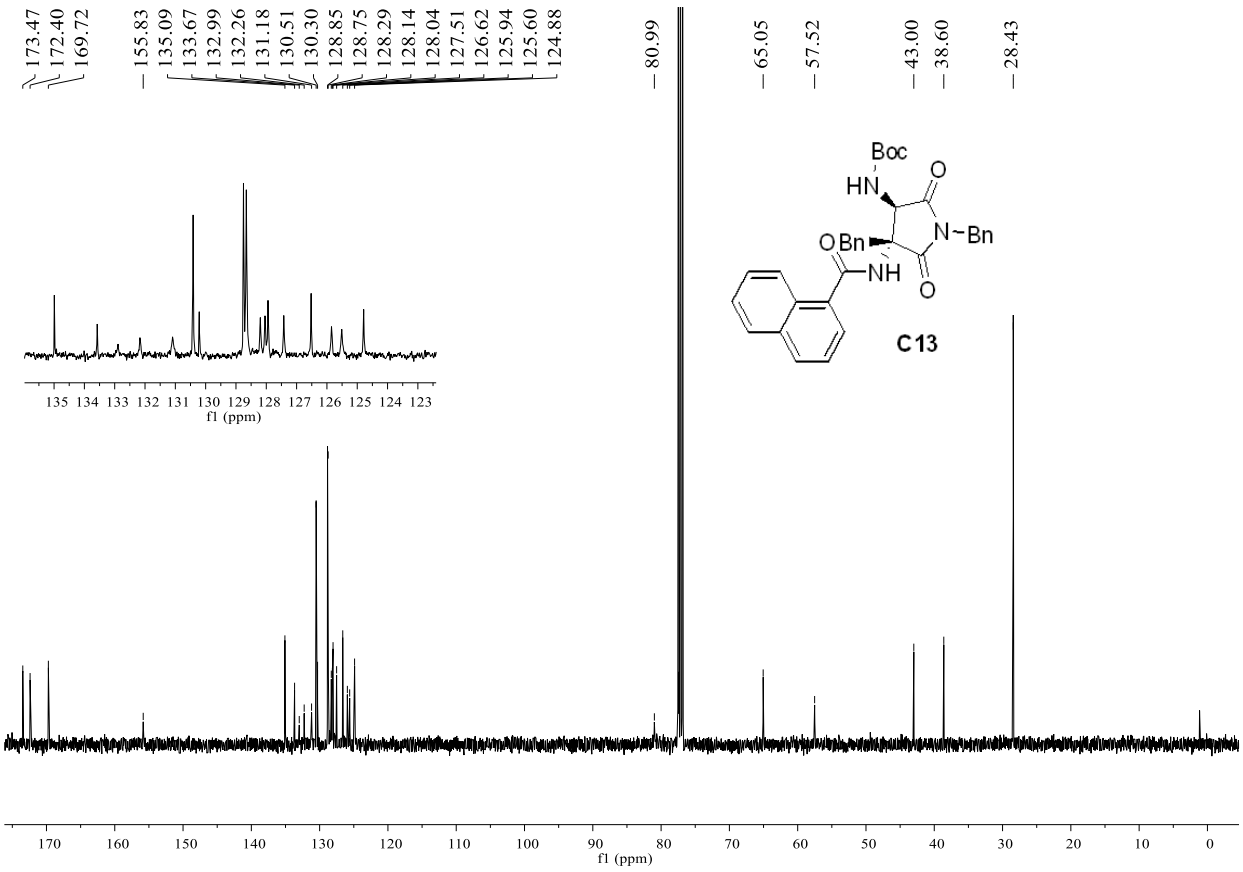
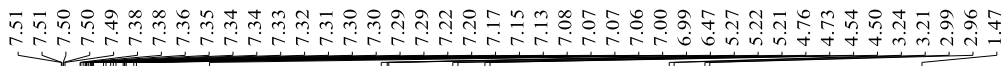
7.39
7.38
7.37
7.37
7.35
7.34
7.34
7.33
7.33
7.32
7.31
7.30
7.30
7.28
7.26
7.15
7.14
7.03
7.01
7.01
6.55
5.29
5.26
4.78
4.74
4.52
4.49
3.26
3.23
3.03
2.99
2.34
1.47

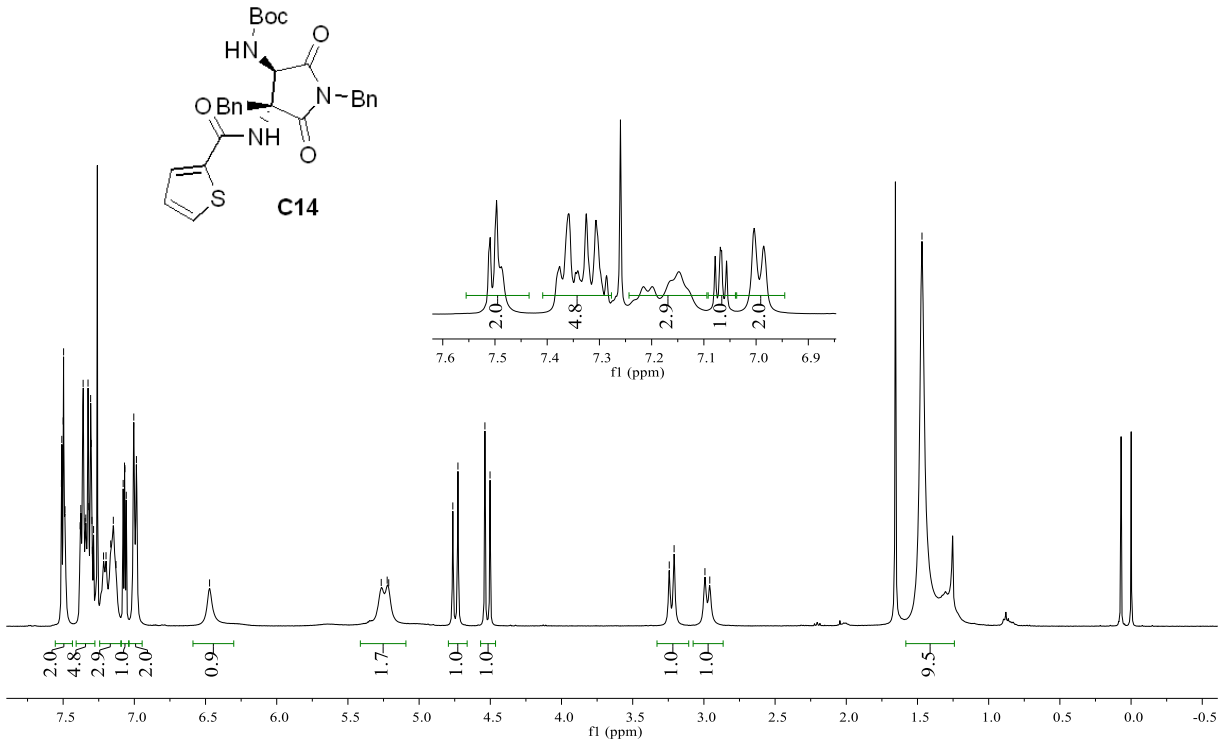

Boc
HN
O
N–Bn
OBn
NH
O
O
C12
1.0
1.0
3.30 3.25 3.20 3.15 3.10 3.05 3.00 2.95
f1 (ppm)
11.7
2.0
7.40 7.35 7.30 7.25 7.20 7.15 7.10 7.05 7.00 6.95
f1 (ppm)
11.7
2.0
0.9
1.8
1.0
1.0
1.0
1.0
6.0
9.0
7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

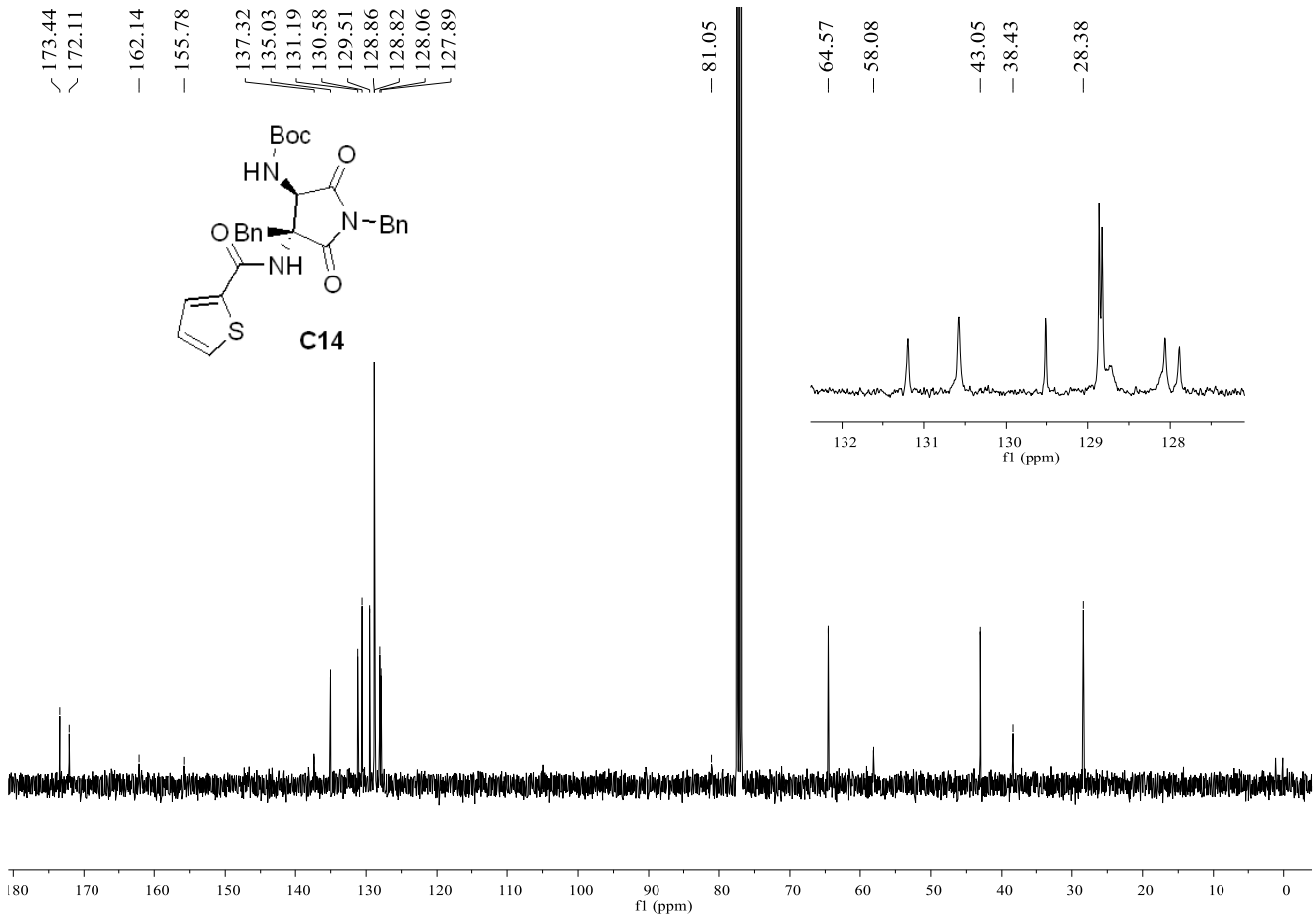

173.64
172.30
168.09
155.71
138.39
135.07
133.81
133.26
132.59
130.59
128.78
128.68
127.98
125.23
80.86
64.54
57.91
42.95
38.42
28.38
21.32
Boc
HN
O
N–Bn
OBn
NH
O
C12
138 136 134 132 130 128 126 124
f1 (ppm)
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

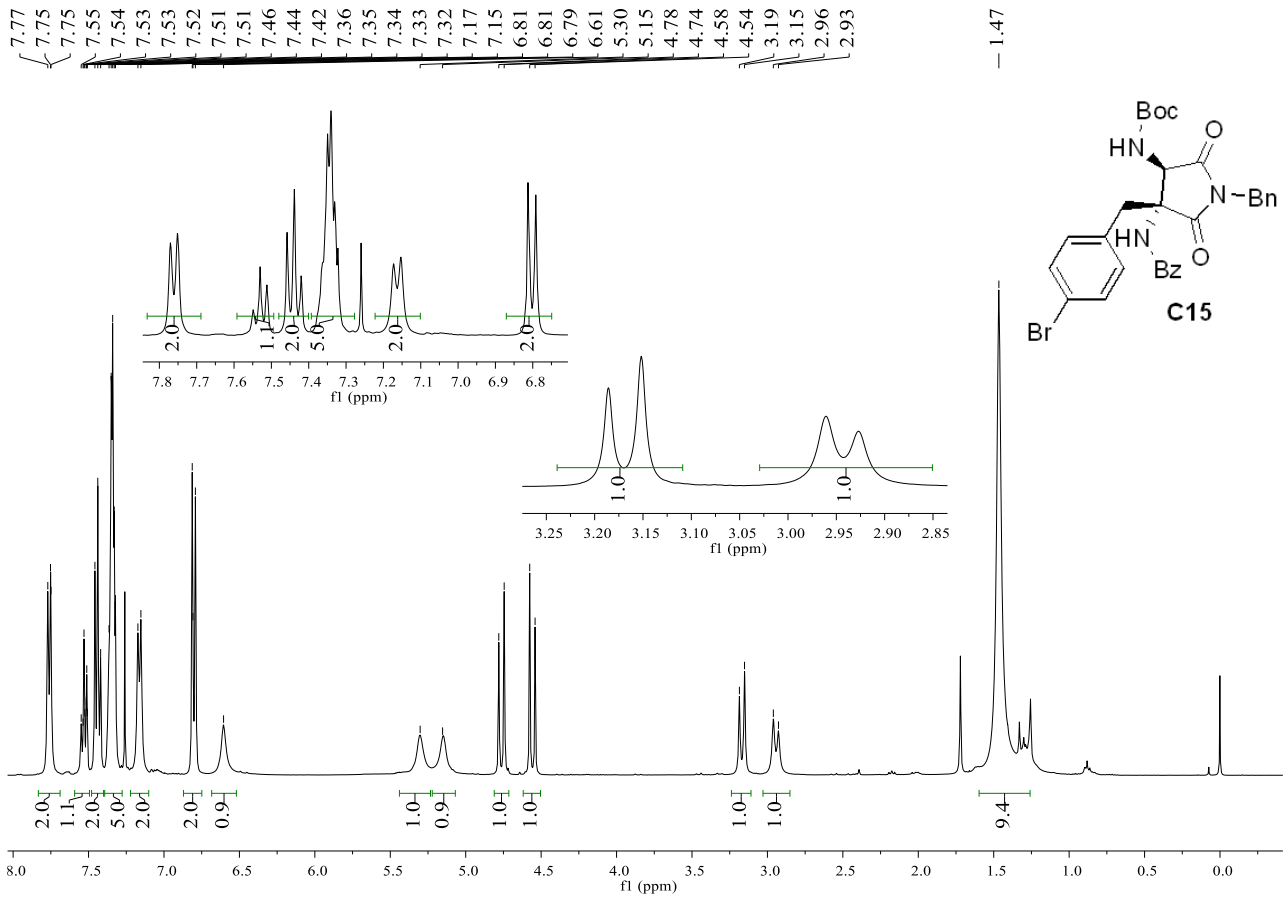

8.340
8.325
7.936
7.916
7.864
7.857
7.849
7.840
7.731
7.527
7.521
7.517
7.513
7.509
7.503
7.486
7.469
7.466
7.448
7.427
7.422
7.405
7.403
7.355
7.351
7.334
7.329
7.315
7.307
7.303
7.299
7.285
7.254
7.214
7.195
7.150
7.132
7.113
6.980
6.962
6.958
6.472
4.826
4.790
4.538
4.502
3.188
3.154
2.968
1.507
Boc
HN
O
N~Bn
OBn
NH
O
C13
f1 (ppm)

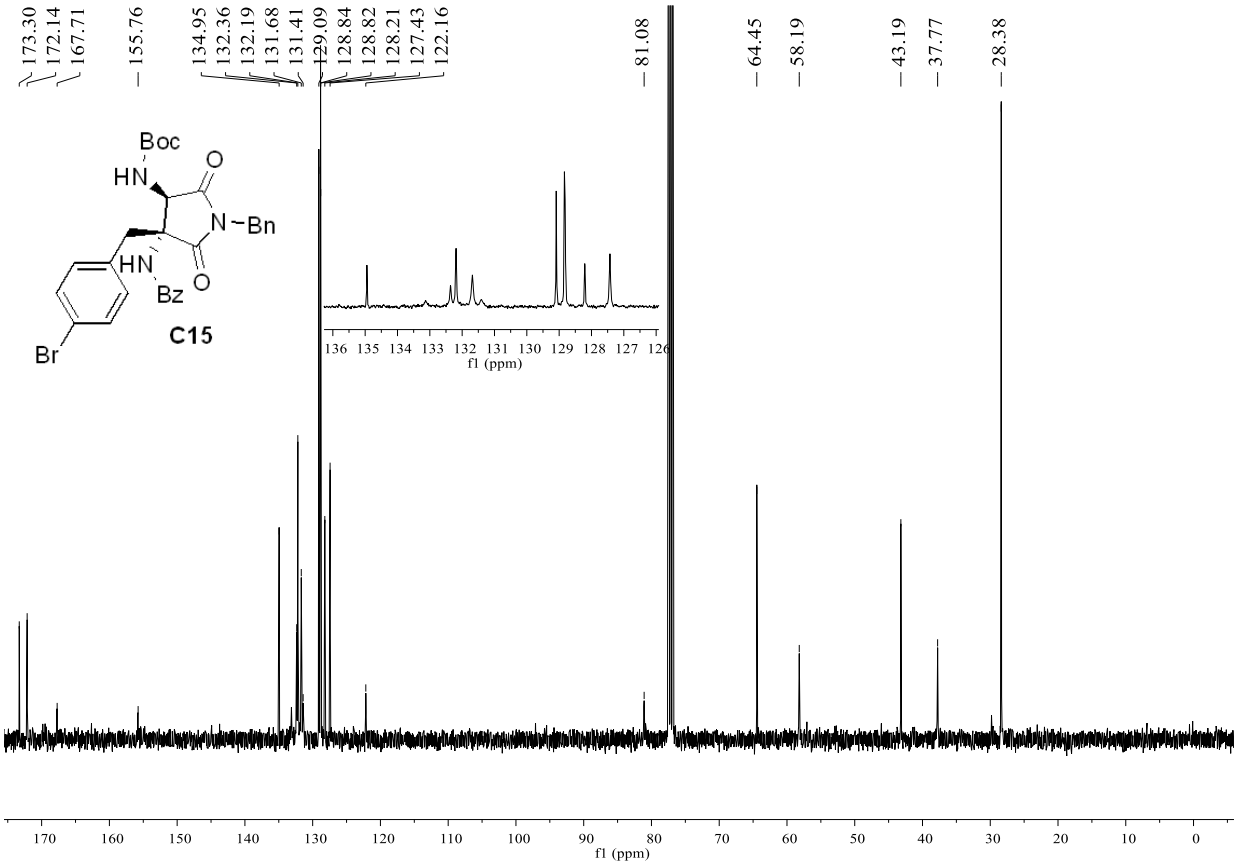

173.47
172.40
169.72
155.83
135.09
133.67
132.99
132.26
131.18
130.51
130.30
128.85
128.75
128.29
128.14
128.04
127.51
126.62
125.94
125.60
124.88
80.99
65.05
57.52
43.00
38.60
28.43
Boc
HN
O
N~Bn
OBn
NH
O
C13
f1 (ppm)

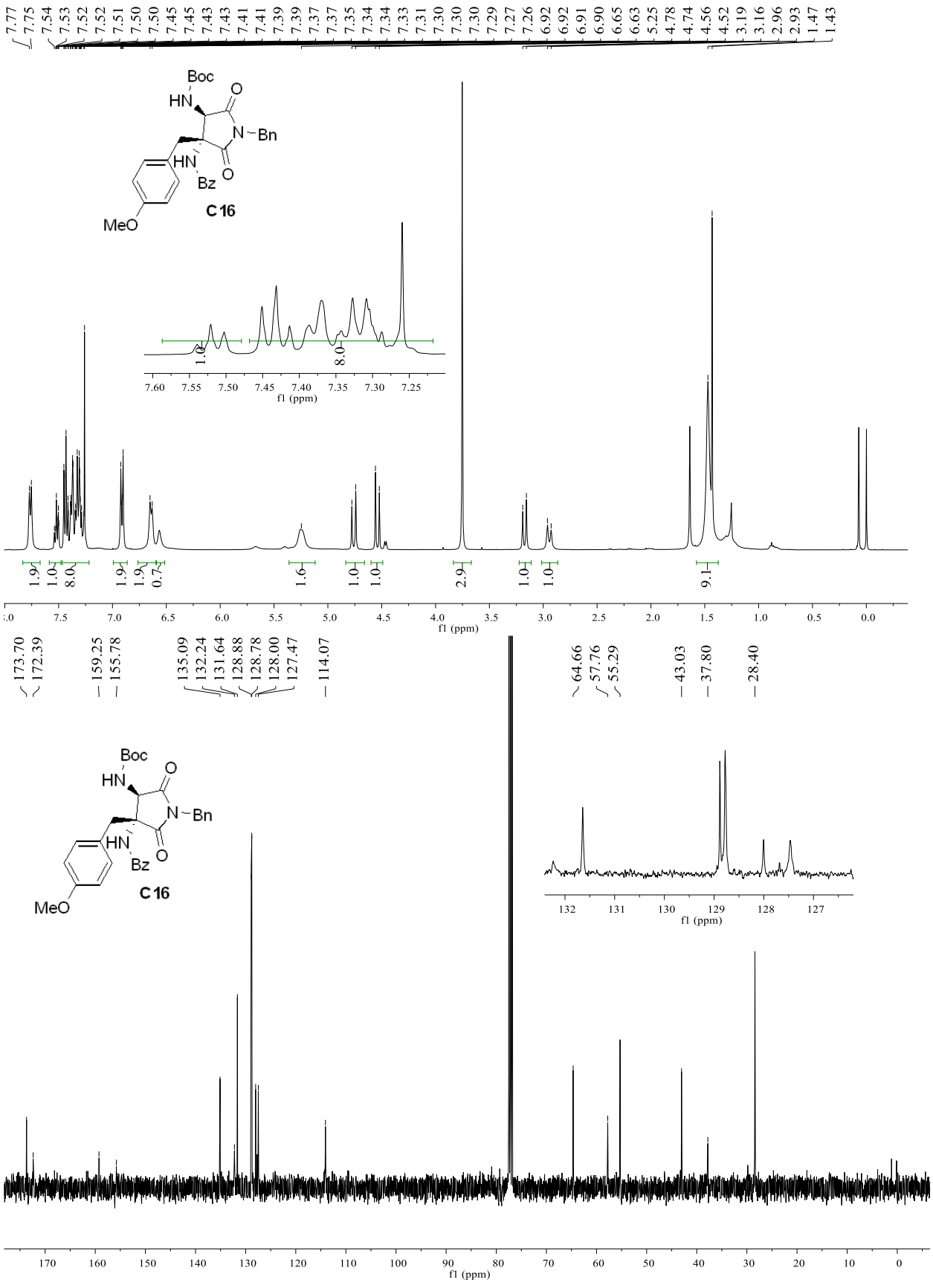

7.51 7.51 7.50 7.50 7.49 7.38 7.38 7.36 7.35 7.34 7.34 7.33 7.32 7.31 7.30 7.30 7.29 7.29 7.22 7.20 7.17 7.15 7.13 7.08 7.07 7.07 7.06 7.00 6.99 6.47 5.27 5.22 5.21 4.76 4.73 4.54 4.50 3.24 3.21 2.99 2.96 1.47

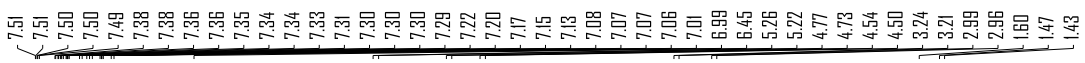

Boc
HN
O
N~Bn
OBn
NH
O
S
C14
2.0 4.8 2.9 1.0 2.0 0.9 1.7 1.0 1.0 1.0 1.0 9.5
f1 (ppm)

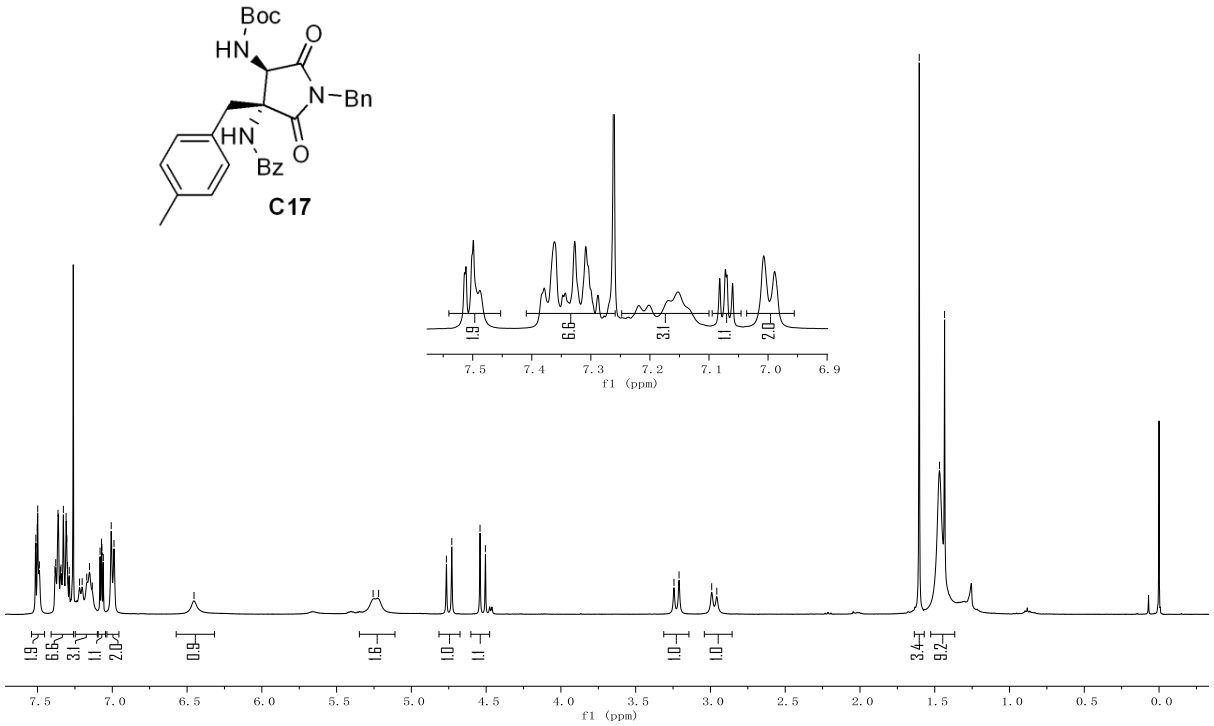

173.44 172.11 162.14 155.78 137.32 135.03 131.19 130.58 129.51 128.86 128.82 128.06 127.89 81.05 64.57 58.08 43.05 38.43 28.38
Boc
HN
O
N~Bn
OBn
NH
O
S
C14
f1 (ppm)

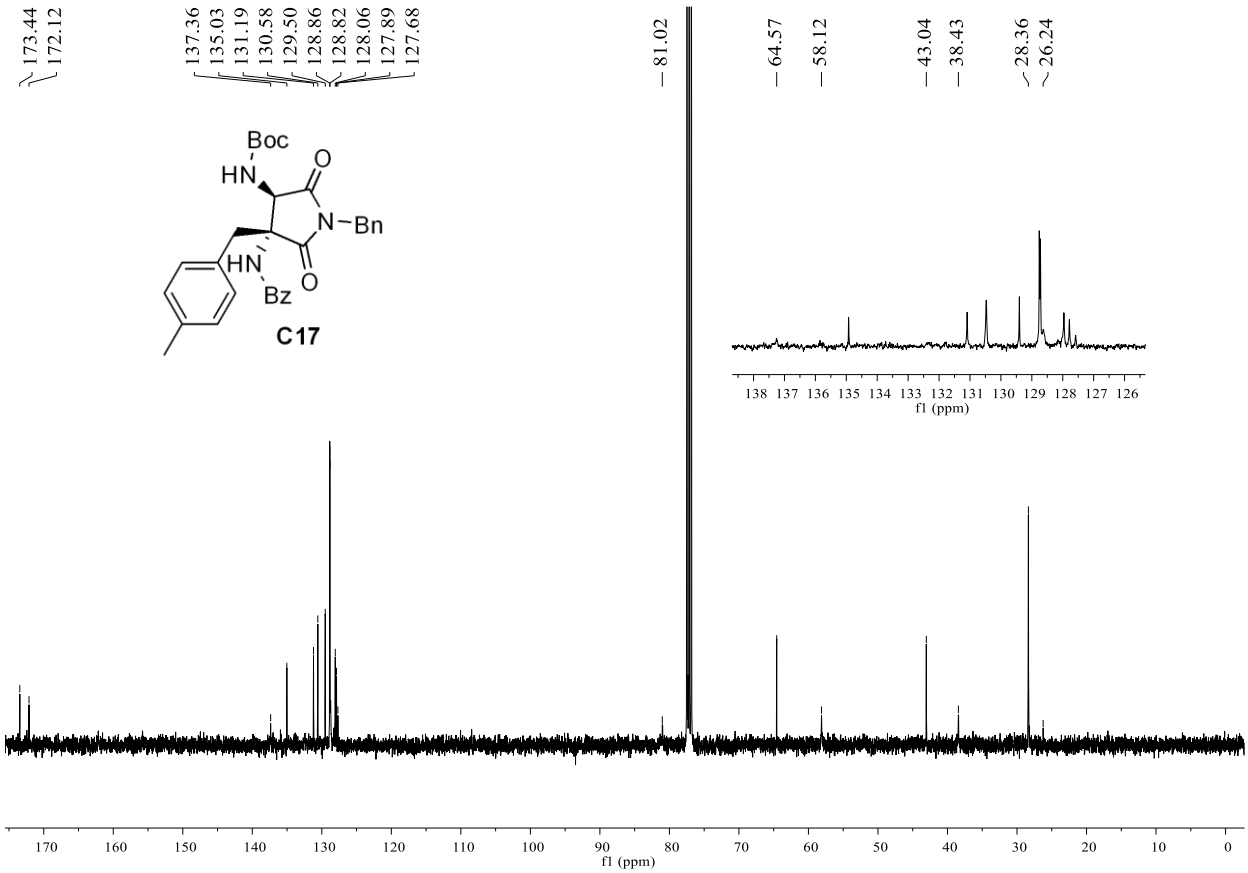

7.77 7.75 7.75 7.55 7.54 7.53 7.53 7.52 7.51 7.51 7.46 7.44 7.42 7.36 7.35 7.34 7.33 7.32 7.17 7.15 6.81 6.81 6.79 6.61 5.30 5.15 4.78 4.74 4.58 4.54 3.19 3.15 2.96 2.93
1.47
Boc
HN
O
N-Bn
HN
Bz
O
Br
C15
f1 (ppm)
f1 (ppm)
f1 (ppm)

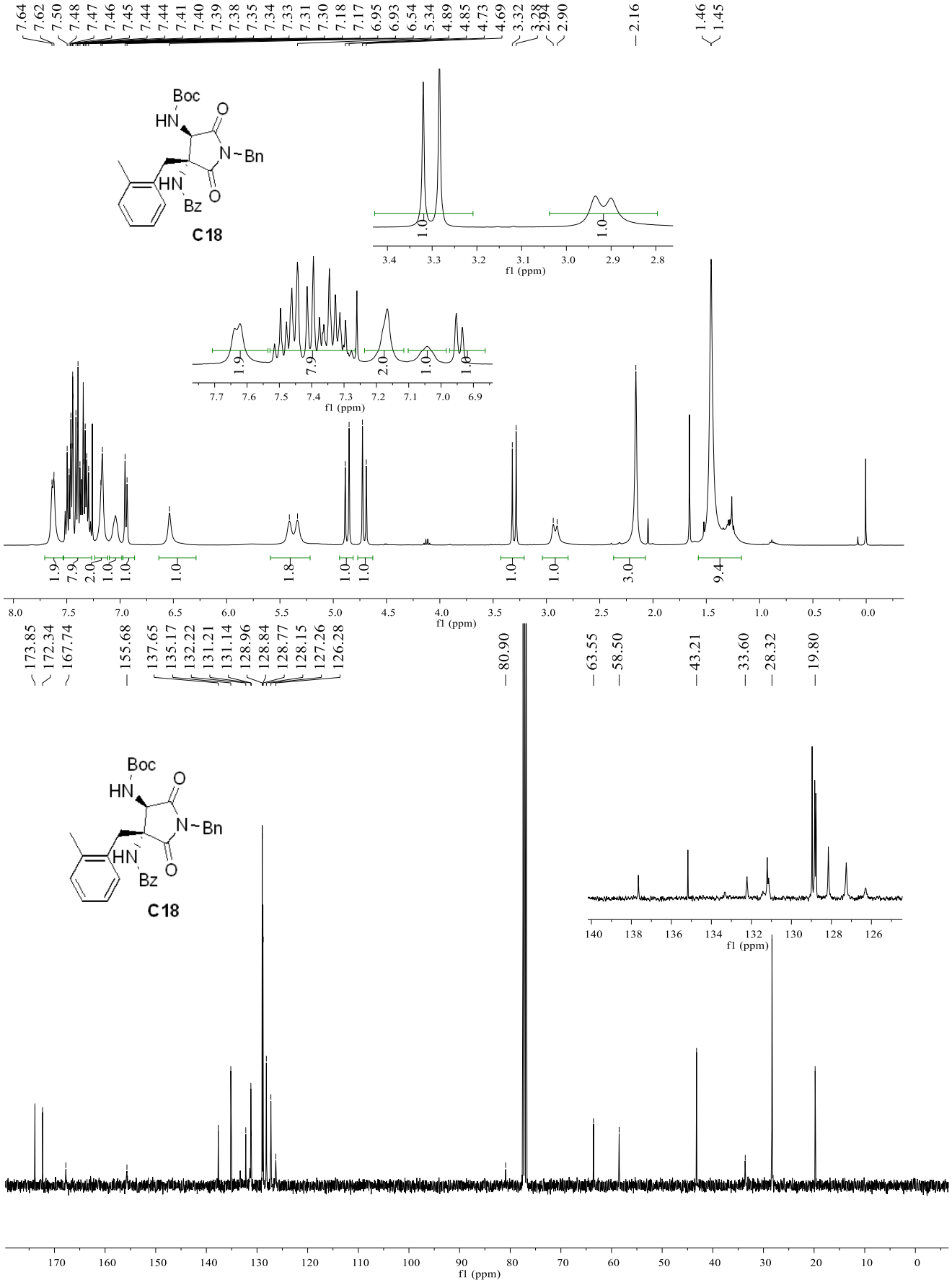

173.30 172.14 167.71 155.76 134.95 132.36 132.19 131.68 131.41 129.09 128.84 128.82 128.21 127.43 122.16
81.08 64.45 58.19 43.19 37.77 28.38
Boc
HN
O
N-Bn
HN
Bz
O
Br
C15
f1 (ppm)
f1 (ppm)

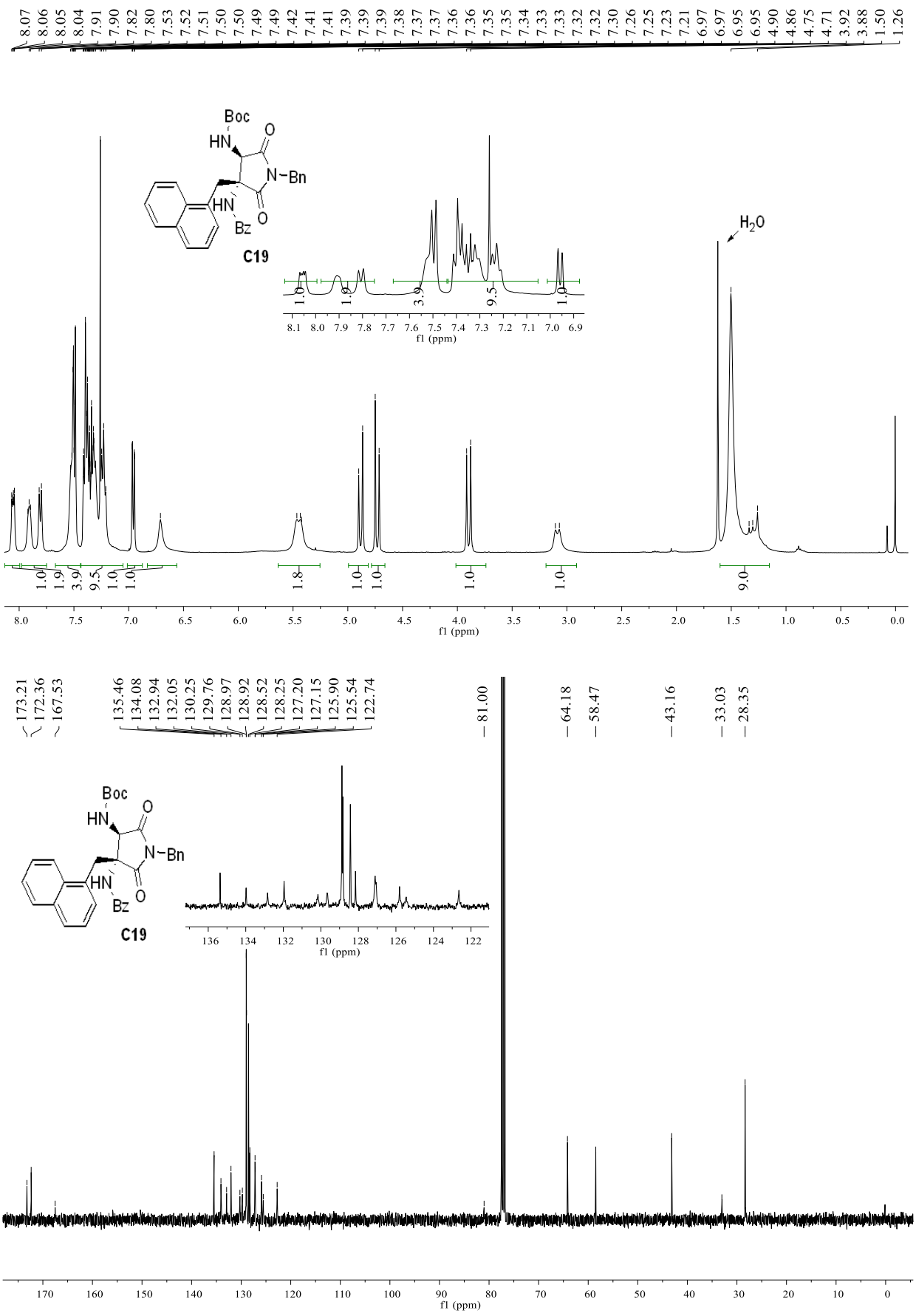

Boc
HN
O
N–Bn
HN
Bz
O
MeO
C16
fl (ppm)

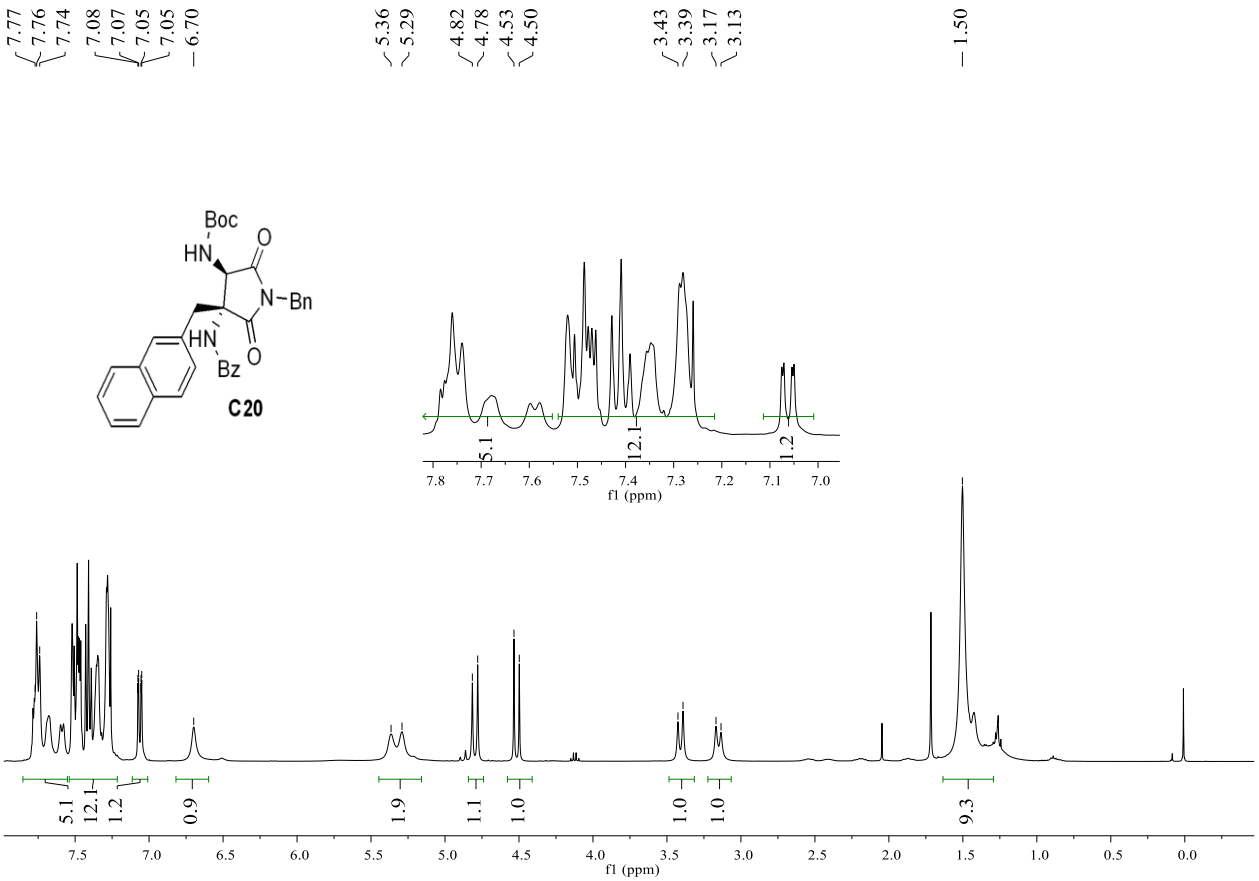

7.51 7.51 7.50 7.50 7.49 7.38 7.38 7.36 7.36 7.35 7.34 7.34 7.33 7.31 7.30 7.30 7.30 7.29 7.22 7.20 7.17 7.15 7.13 7.08 7.07 7.07 7.06 7.01 6.99 6.45 5.26 5.22 4.77 4.73 4.54 4.50 3.24 3.21 2.99 2.96 1.60 1.47 1.43

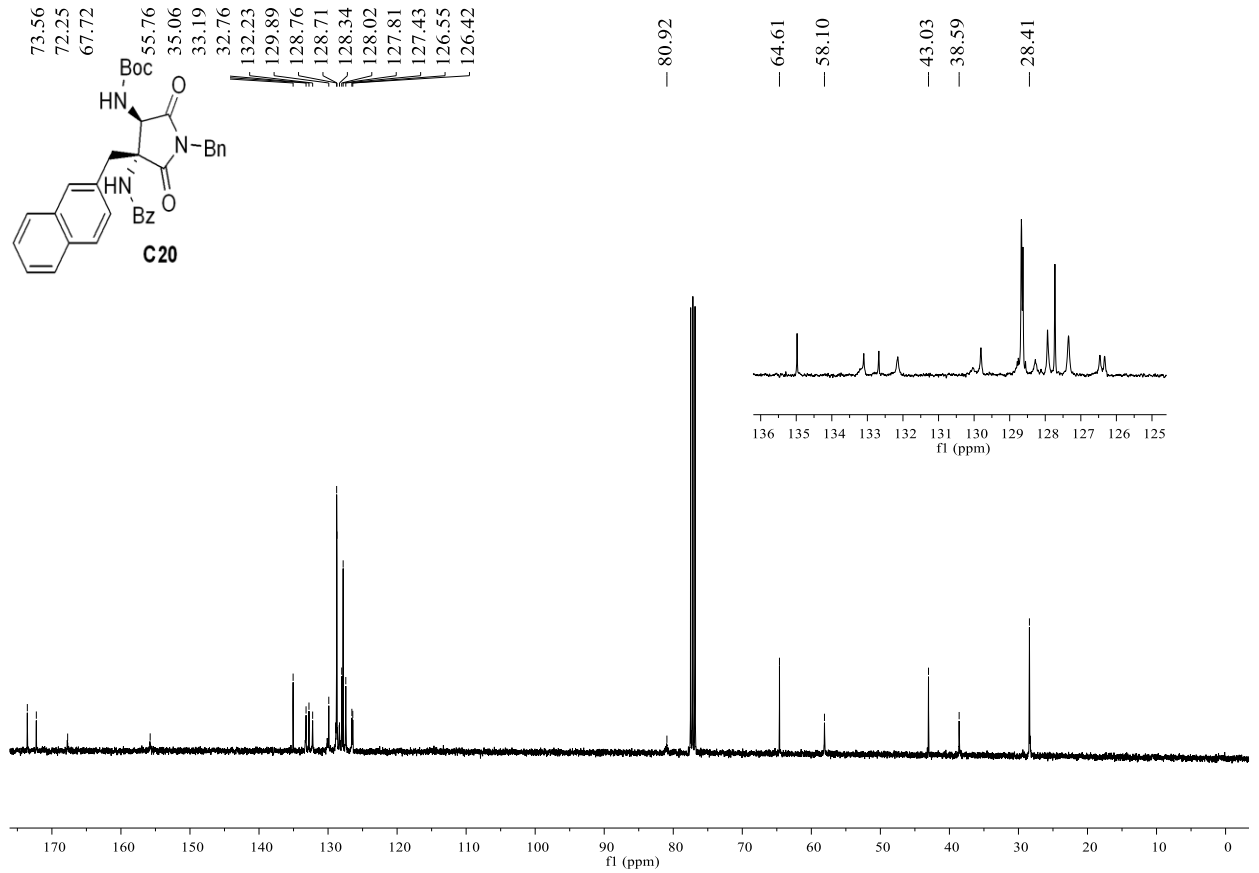

Boc
HN
O
N–Bn
HN
Bz
O
C17
1.9 6.6 3.1 1.1 2.0
0.9
1.6
1.0 1.1
1.0 1.0
3.4 9.2
7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)
1.9 6.6 3.1 1.1 2.0
7.5 7.4 7.3 7.2 7.1 7.0 6.9
f1 (ppm)

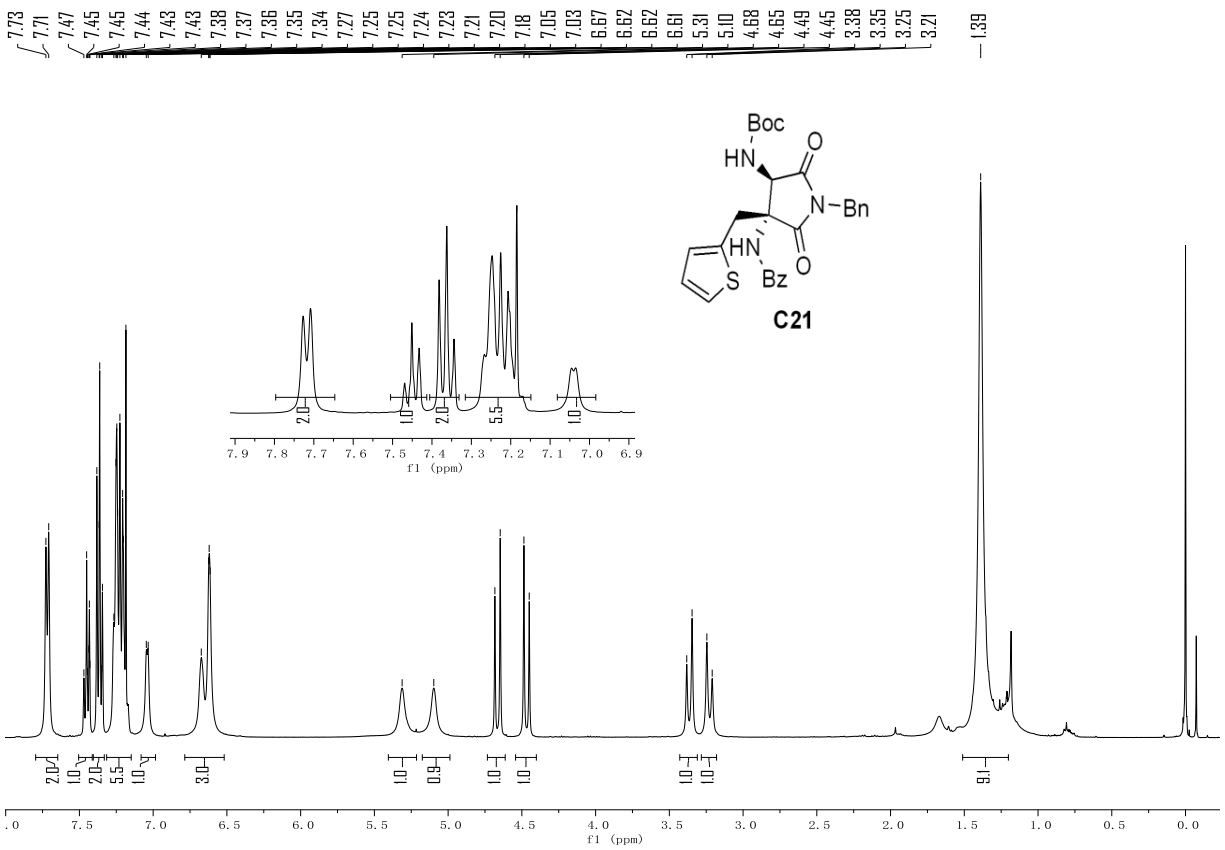

173.44
172.12
137.36
135.03
131.19
130.58
129.50
128.86
128.82
128.06
127.89
127.68
81.02
64.57
58.12
43.04
38.43
28.36
26.24
Boc
HN
O
N–Bn
HN
Bz
O
C17
138 137 136 135 134 133 132 131 130 129 128 127 126
f1 (ppm)
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


7.64
7.62
7.50
7.48
7.47
7.46
7.45
7.44
7.44
7.41
7.40
7.39
7.38
7.35
7.34
7.33
7.31
7.30
7.18
7.17
6.95
6.93
6.54
5.34
4.89
4.85
4.73
4.69
3.32
3.28
2.94
2.90
2.16
1.46
1.45
Boc
HN
O
N~Bn
HN
O
Bz
C18
f1 (ppm)
1.9
7.9
2.0
1.0
1.0
1.0
1.8
1.0
1.0
1.0
1.0
3.0
9.4
173.85
172.34
167.74
155.68
137.65
135.17
132.22
131.21
131.14
128.96
128.84
128.77
128.15
127.26
126.28
80.90
63.55
58.50
43.21
33.60
28.32
19.80


8.07 8.06 8.05 8.04 7.91 7.90 7.82 7.80 7.53 7.52 7.51 7.50 7.50 7.49 7.49 7.42 7.41 7.41 7.39 7.39 7.39 7.38 7.37 7.37 7.36 7.35 7.35 7.34 7.33 7.33 7.32 7.32 7.30 7.26 7.25 7.23 7.21 6.97 6.97 6.95 6.95 4.90 4.86 4.75 4.71 3.92 3.88 1.50 1.26
Boc
HN
O
N-Bn
HN
O
Bz
C19
H2O
1.0 1.9 3.9 9.5 1.0 1.0 1.8 1.0 1.0 1.0 1.0 9.0
f1 (ppm)
173.21 172.36 167.53 135.46 134.08 132.94 132.05 130.25 129.76 128.97 128.92 128.52 128.25 127.20 127.15 125.90 125.54 122.74 81.00 64.18 58.47 43.16 33.03 28.35
f1 (ppm)


7.77
7.76
7.74
7.08
7.07
7.05
7.05
6.70
5.36
5.29
4.82
4.78
4.53
4.50
3.43
3.39
3.17
3.13
1.50
Boc
HN
O
N–Bn
HN
O
Bz
C20
5.1
12.1
1.2
f1 (ppm)
5.1
12.1
1.2
0.9
1.9
1.1
1.0
1.0
1.0
9.3
f1 (ppm)


73.56
72.25
67.72
55.76
35.06
33.19
32.76
132.23
129.89
128.76
128.71
128.34
128.02
127.81
127.43
126.55
126.42
80.92
64.61
58.10
43.03
38.59
28.41
Boc
HN
O
N–Bn
HN
O
Bz
C20
f1 (ppm)
f1 (ppm)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7.71
7.47
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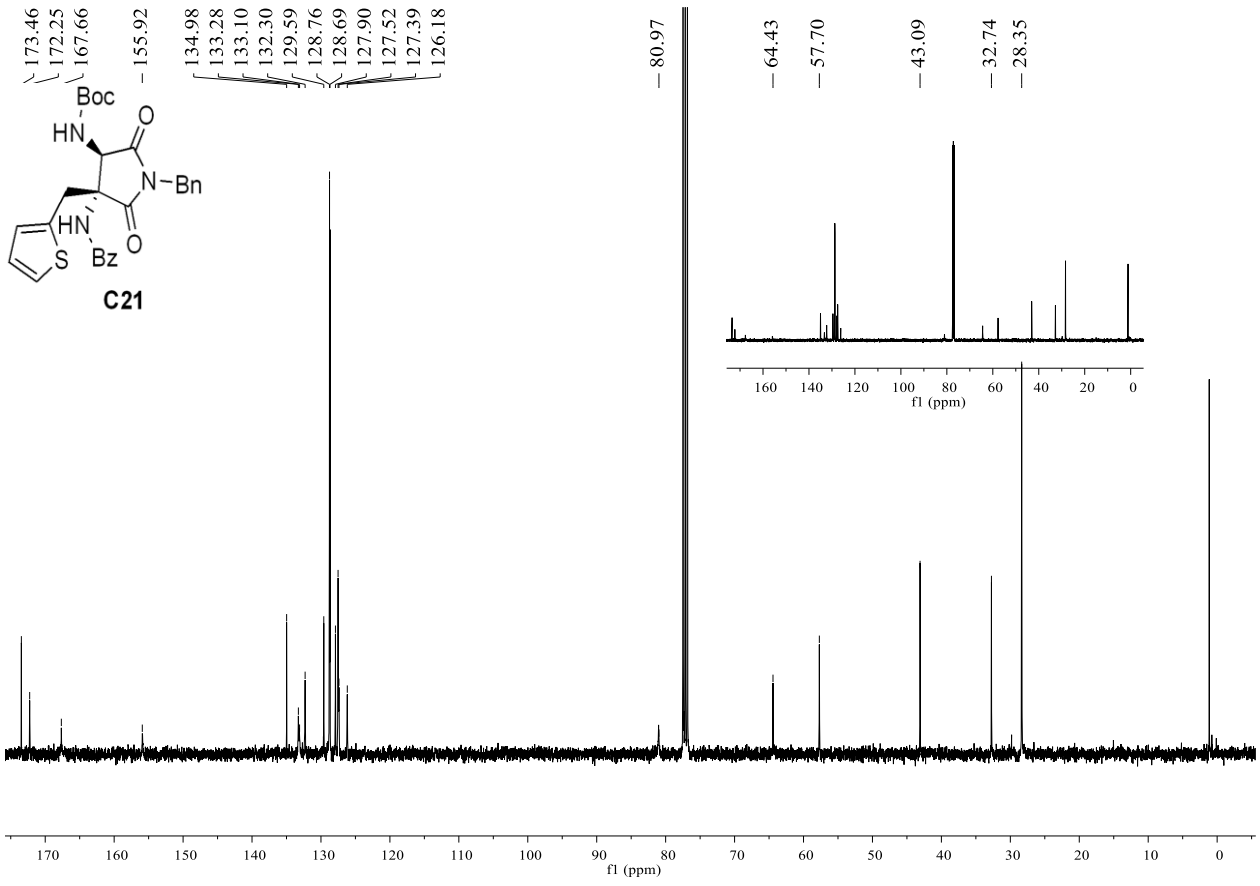
7.45
7.44
7.43
7.43
7.38
7.37
7.36
7.35
7.34
7.27
7.25
7.25
7.24
7.23
7.21
7.20
7.18
7.05
7.03
6.67
6.62
6.62
6.61
5.31
5.10
4.68
4.65
4.49
4.45
3.38
3.35
3.25
3.21
1.39
Boc
HN
O
N−Bn
HN
O
S
Bz
C21
f1 (ppm)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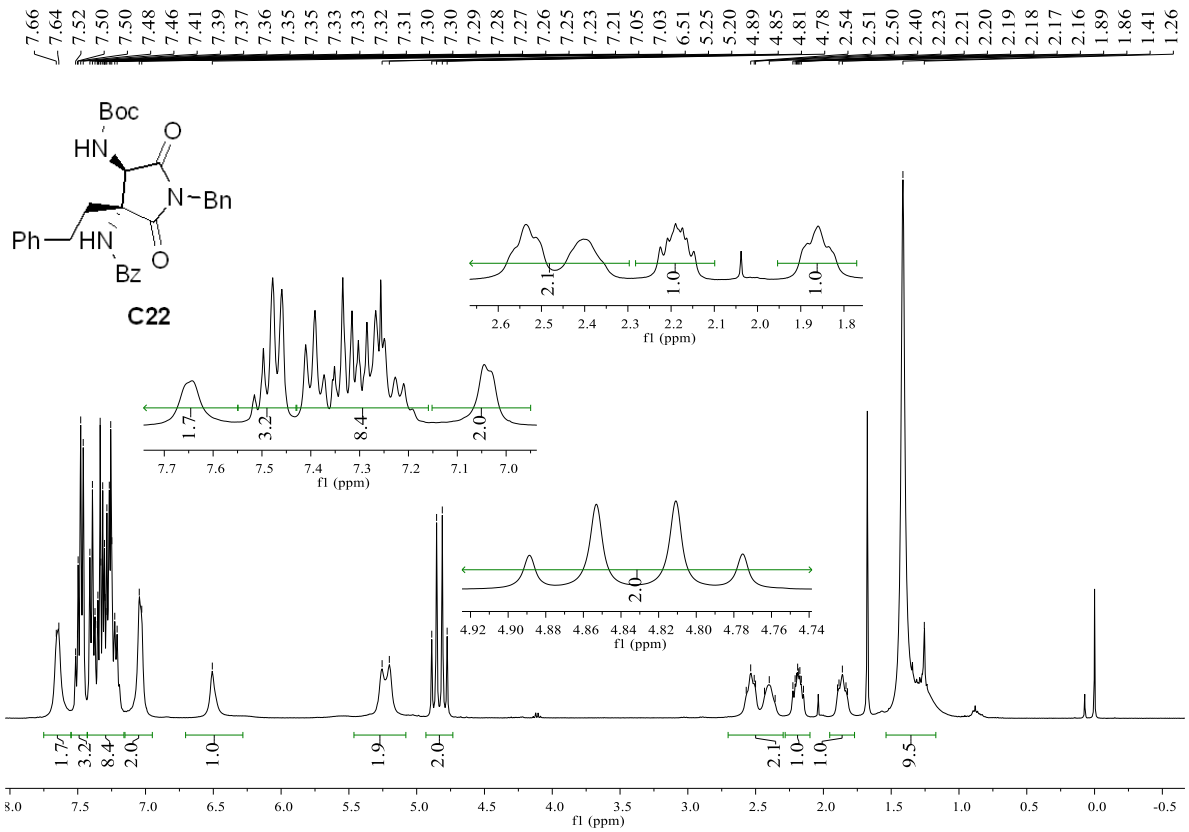
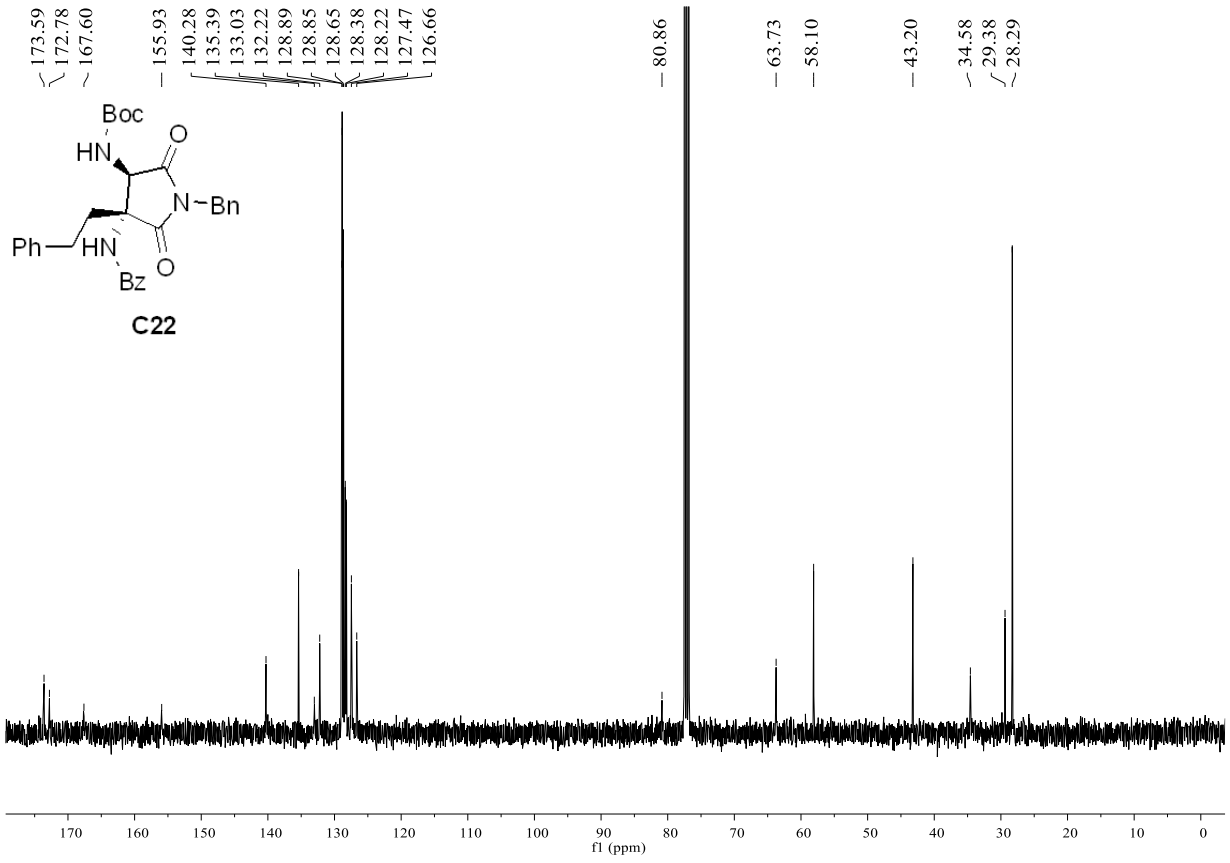
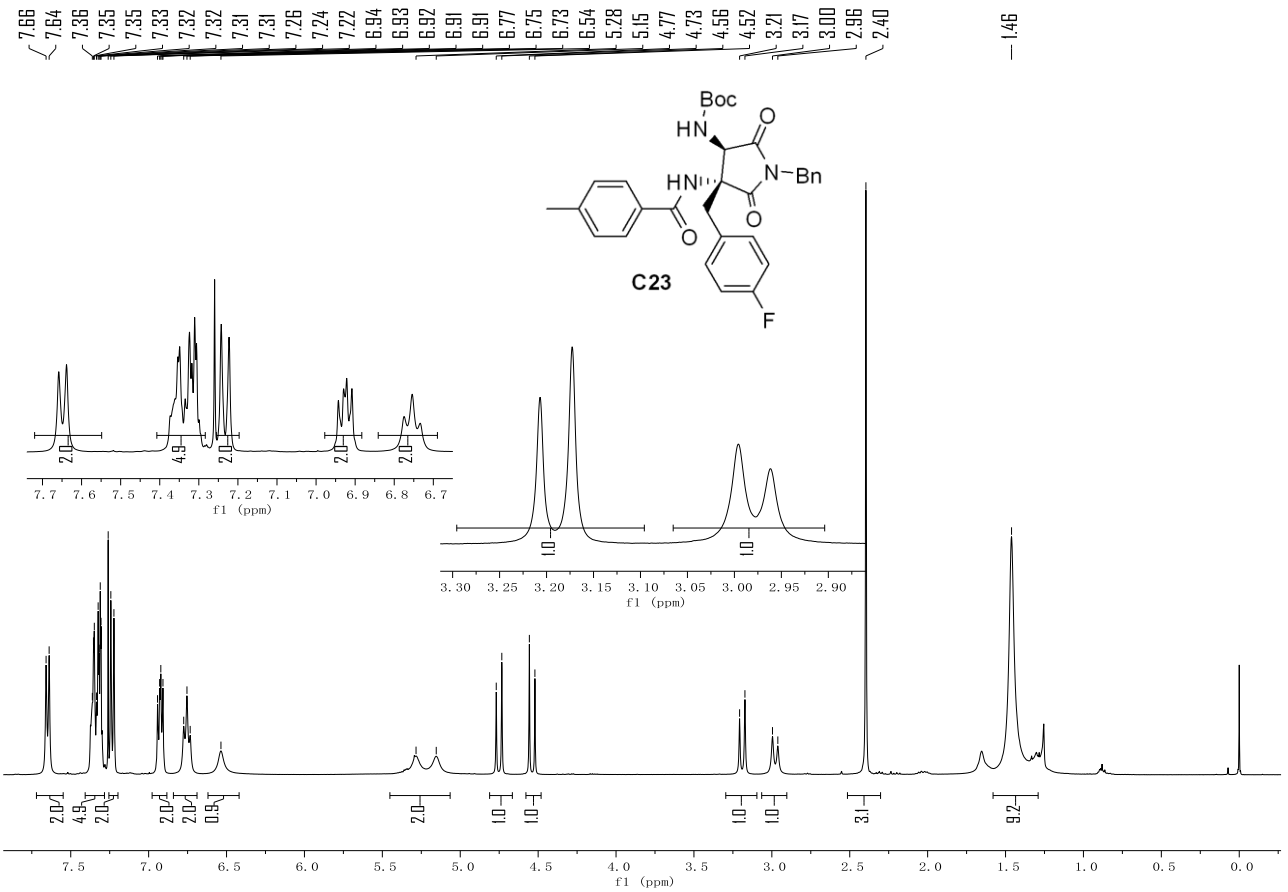
167.66
155.92
134.98
133.28
133.10
132.30
129.59
128.76
128.69
127.90
127.52
127.39
126.18
80.97
64.43
57.70
43.09
32.74
28.35
Boc
HN
O
N−Bn
HN
O
S
Bz
C21
f1 (ppm)


Boc
HN
O
N–Bn
Ph
HN
Bz
O
C22
f1 (ppm)


Boc
HN
O
N–Bn
Ph
HN
Bz
O
C22
f1 (ppm)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7.32
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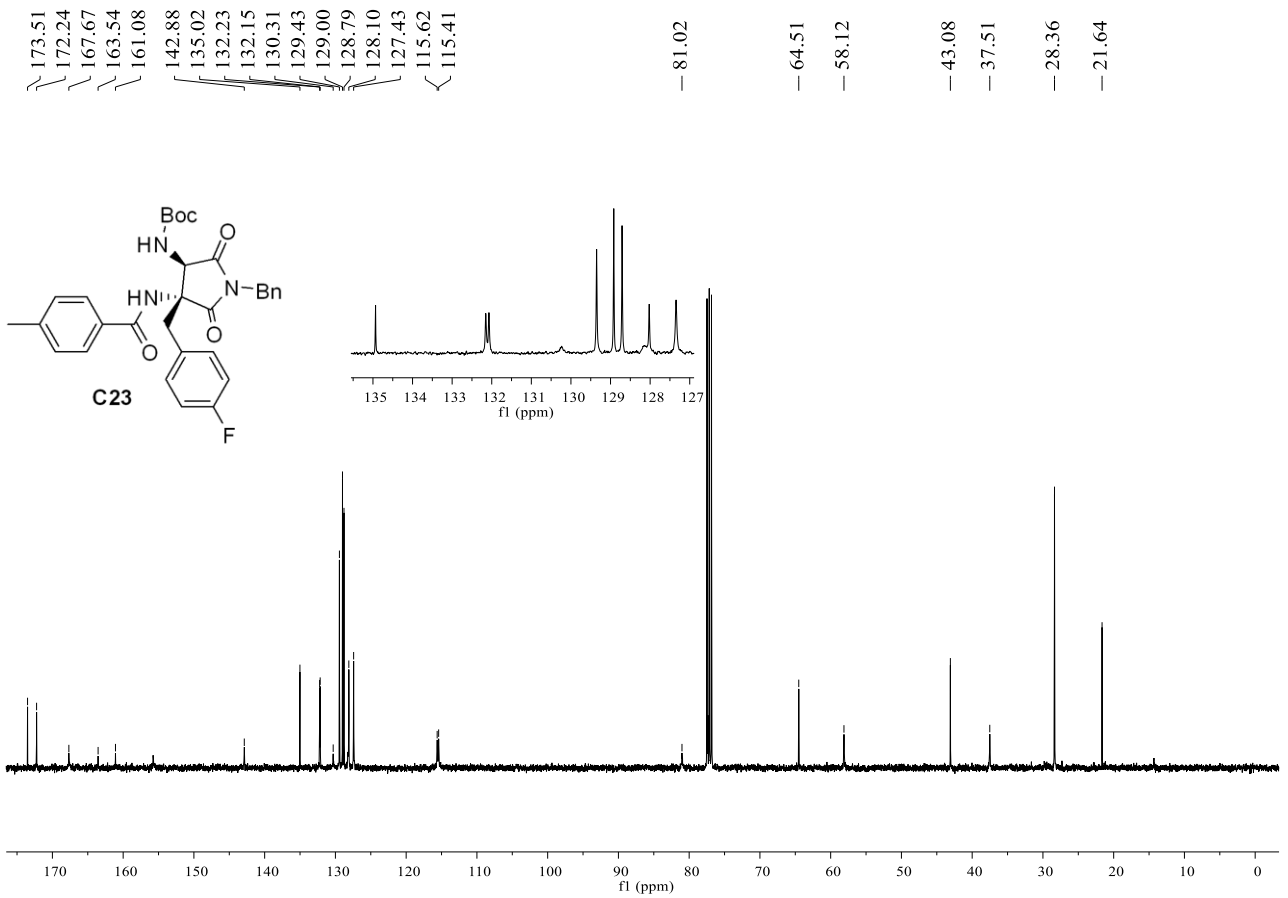
7.31
7.26
7.24
7.22
6.94
6.93
6.92
6.91
6.91
6.77
6.75
6.73
6.54
5.28
5.15
4.77
4.73
4.56
4.52
3.21
3.17
3.00
2.96
2.40
1.46
Boc
HN
HN
N–Bn
O
O
O
O
F
C23
f1 (ppm)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132.23
132.15
130.31
129.43
129.00
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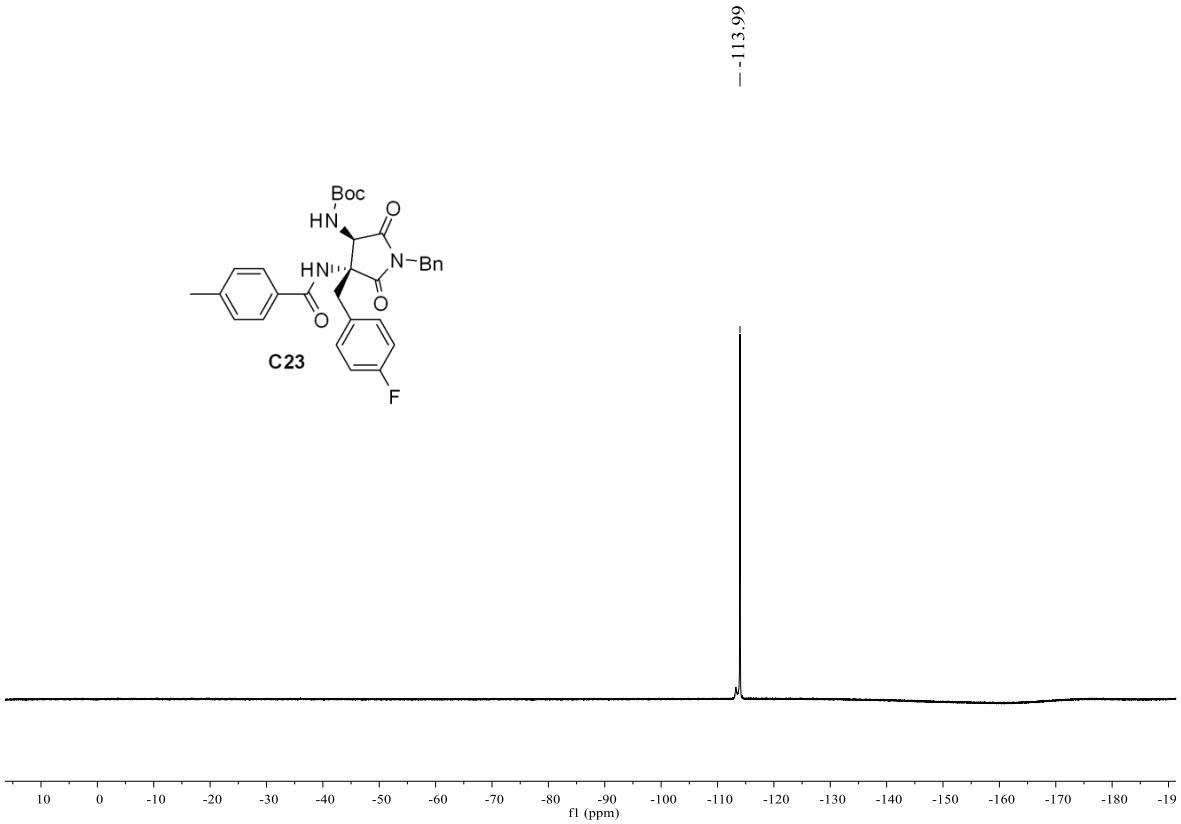
128.10
127.43
115.62
115.41
81.02
64.51
58.12
43.08
37.51
28.36
21.64
Boc
HN
HN
N–Bn
O
O
O
O
F
C23
f1 (ppm)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Boc
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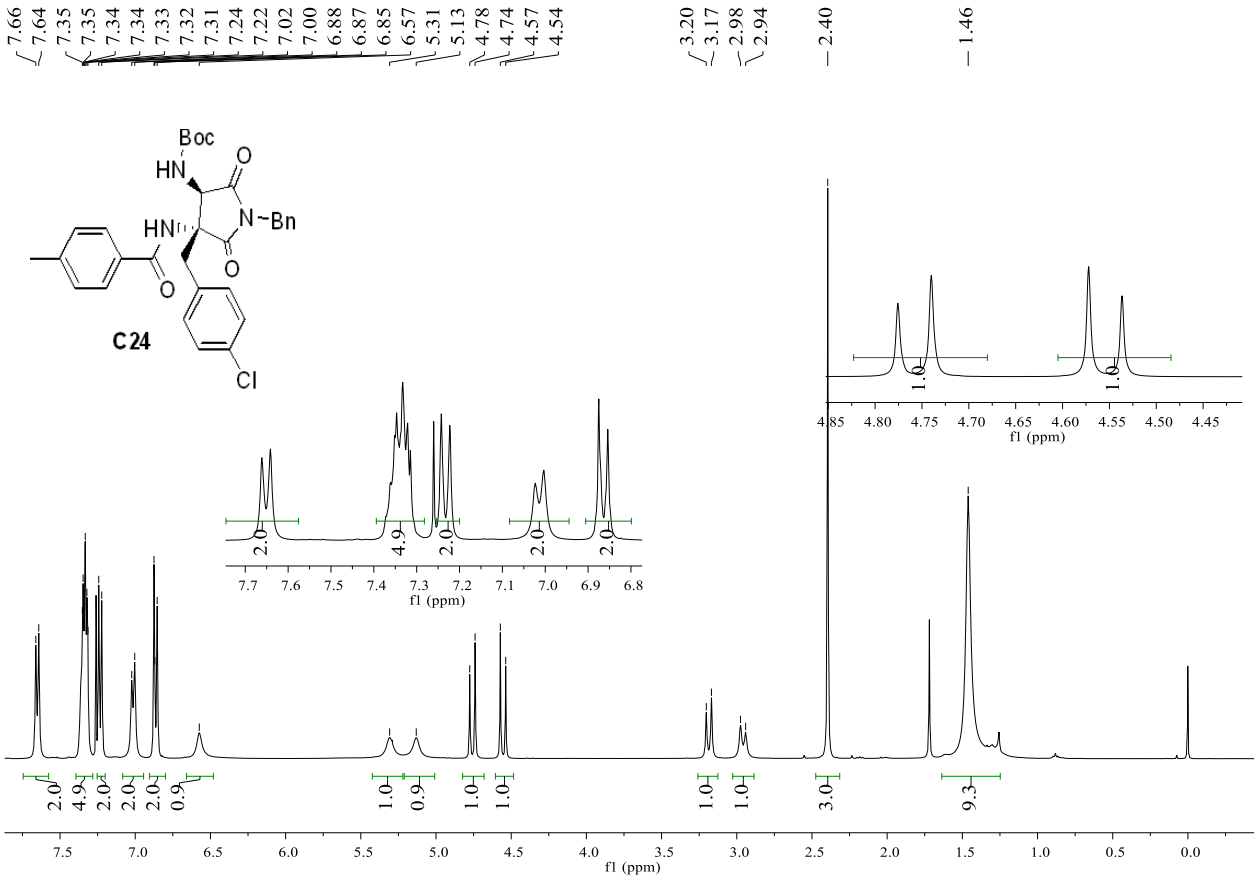
O
O
C23
F
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-19
f1 (ppm)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7.22
7.02
7.00
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6.87
6.85
6.57
5.31
5.13
4.78
4.74
4.57
4.54
3.20
3.17
2.98
2.94
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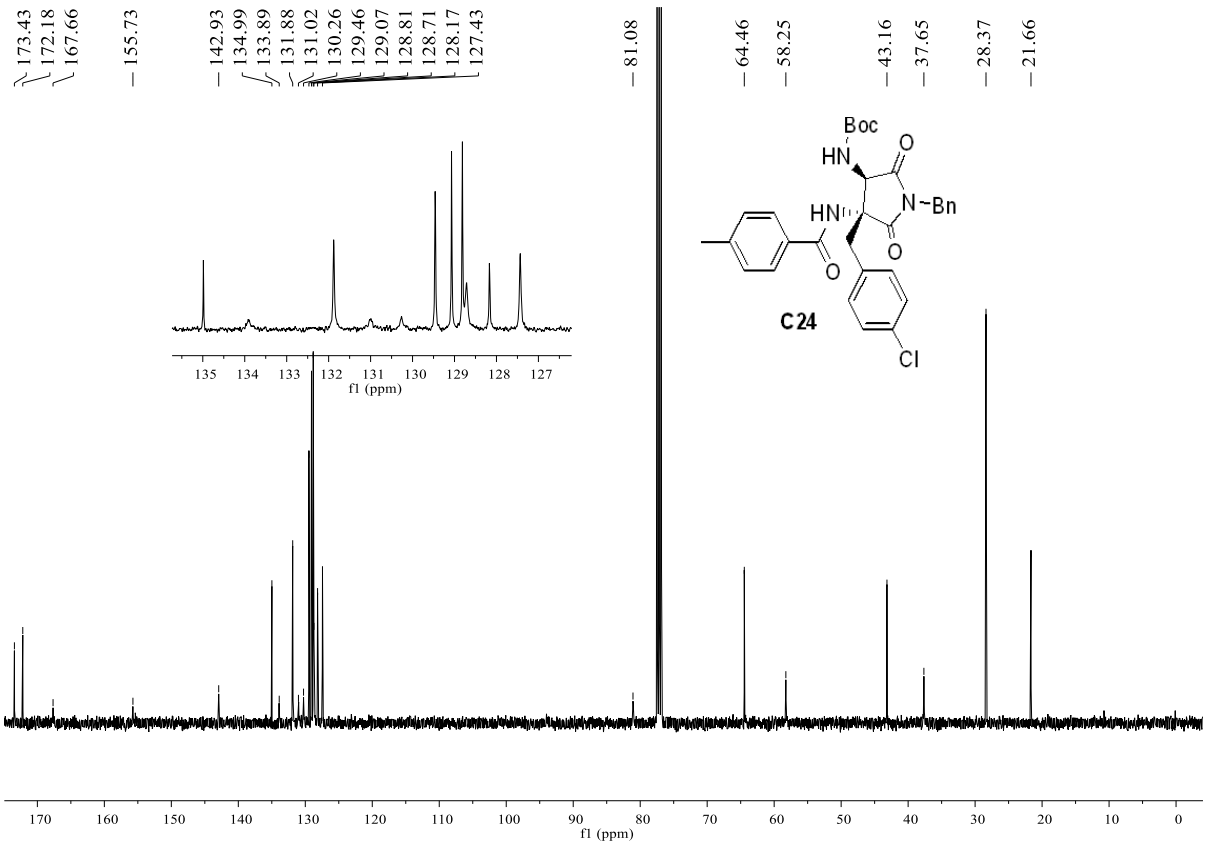
1.46
Boc
HN
O
HN
N-Bn
O
O
O
C24
Cl
f1 (ppm)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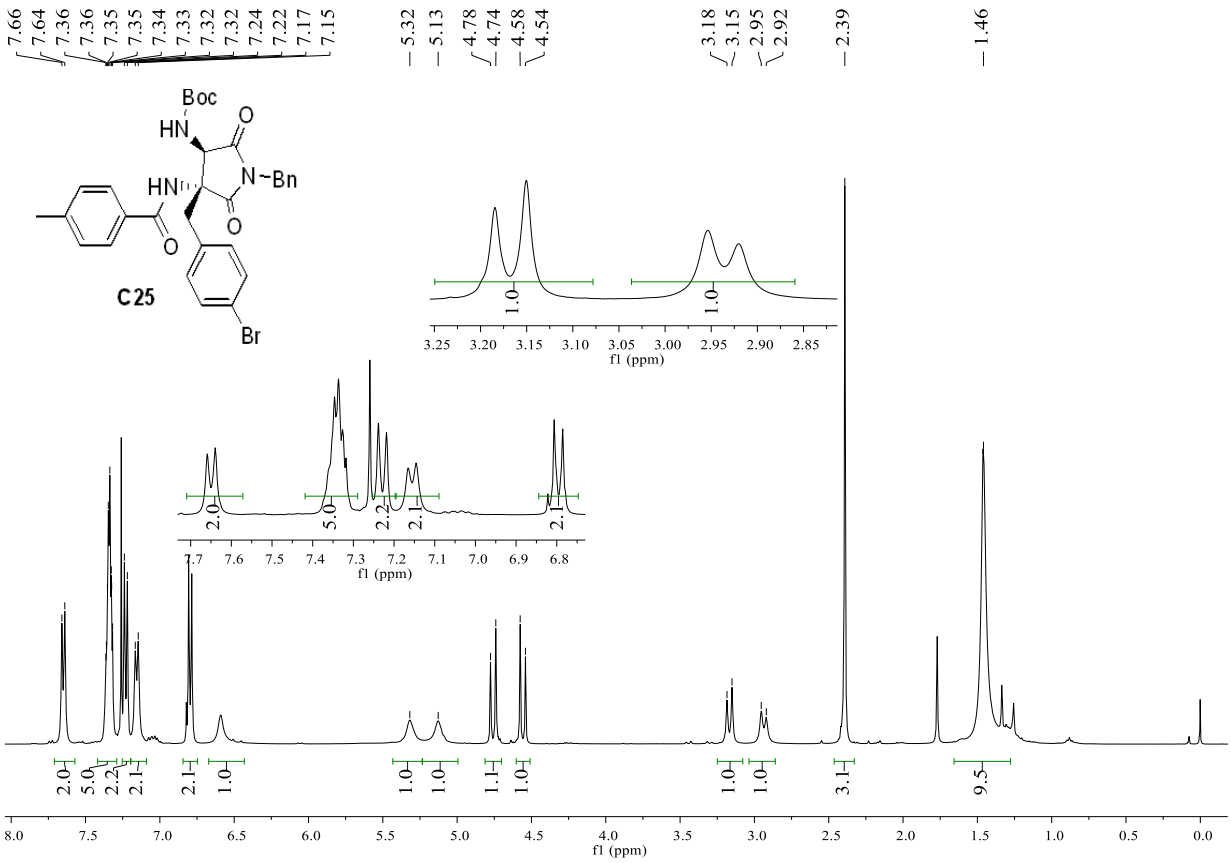
129.07
128.81
128.71
128.17
127.43
81.08
64.46
58.25
43.16
37.65
28.37
21.66
Boc
HN
O
HN
N-Bn
O
O
C24
Cl
f1 (ppm)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7.24
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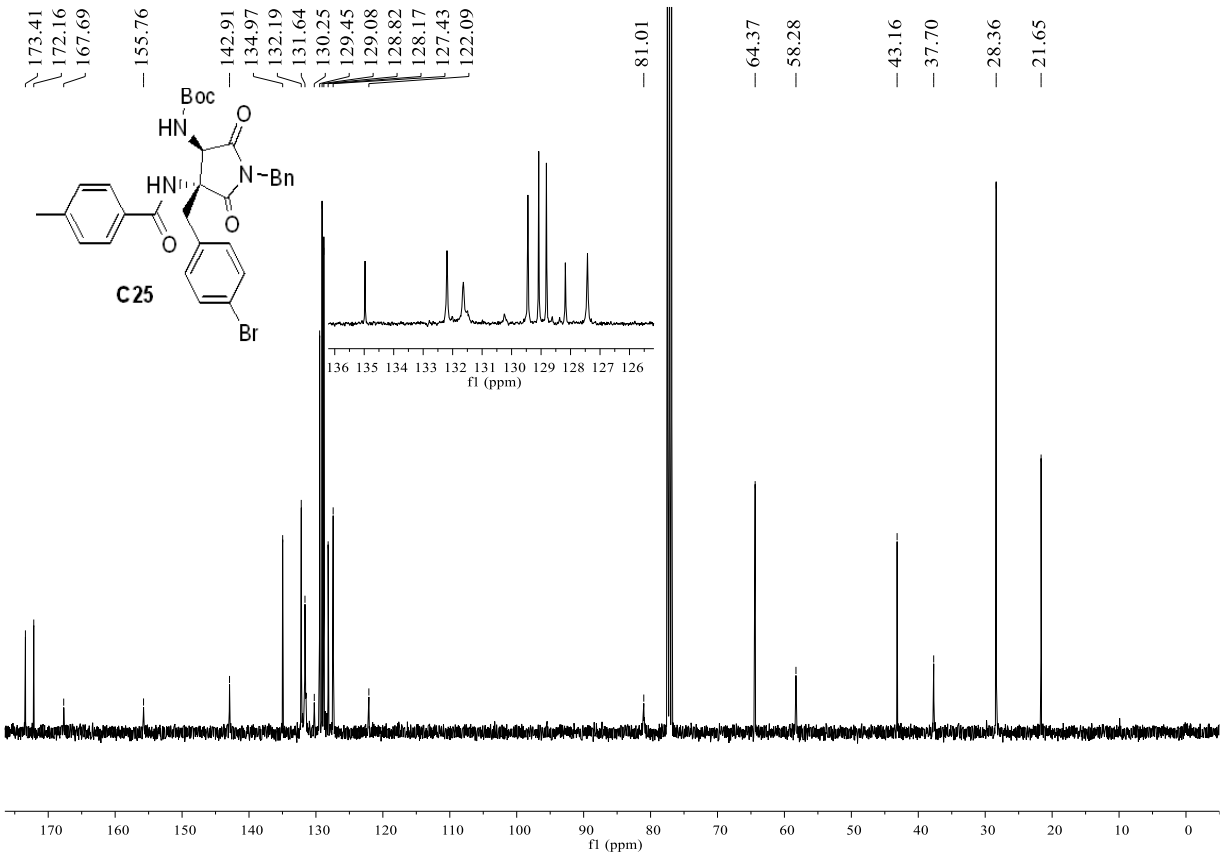
4.74
4.58
4.54
3.18
3.15
2.95
2.92
2.39
1.46
Boc
HN
HN
N-Bn
O
C25
Br
f1 (ppm)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131.64
130.25
129.45
129.08
128.82
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127.43
122.09
81.01
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58.28
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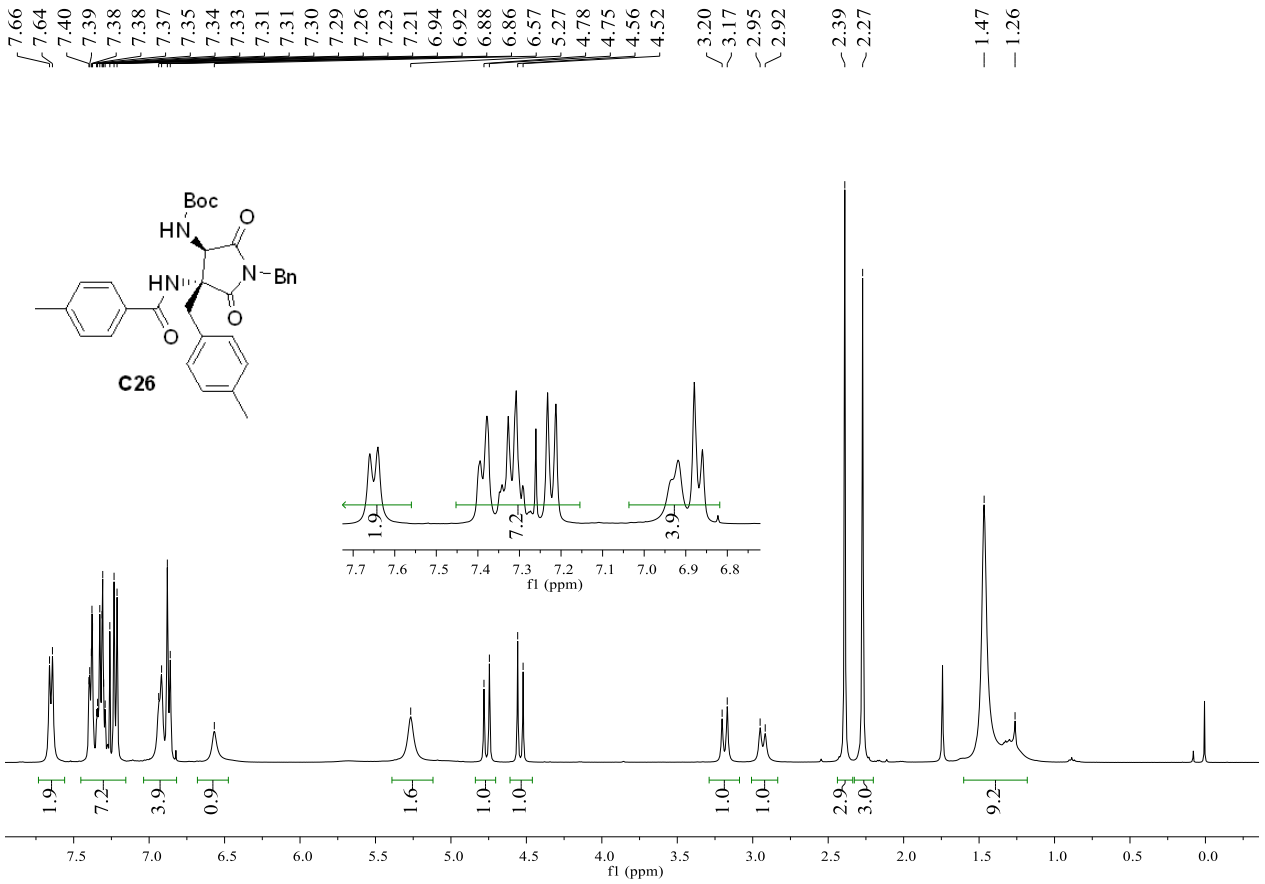
37.70
28.36
21.65
Boc
HN
HN
N-Bn
O
C25
Br
f1 (ppm)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7.64
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7.35
7.34
7.33
7.31
7.31
7.30
7.29
7.26
7.23
7.21
6.94
6.92
6.88
6.86
6.57
5.27
4.78
4.75
4.56
4.52
3.20
3.17
2.95
2.92
2.39
2.27
1.47
1.26
Boc
HN
HN
N–Bn
O
C26
1.9
7.2
3.9
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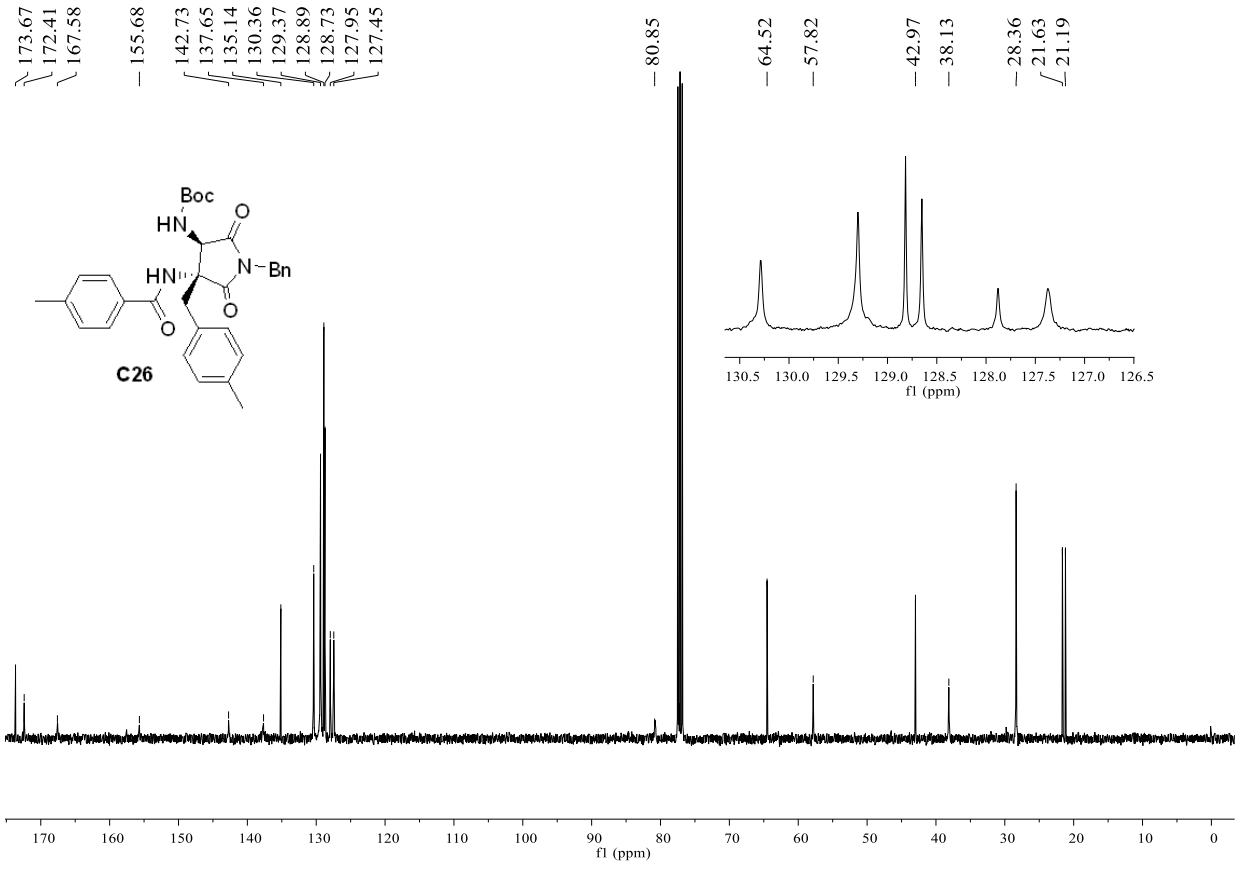
1.6
1.0
1.0
1.0
1.0
2.9
3.0
9.2
fl (ppm)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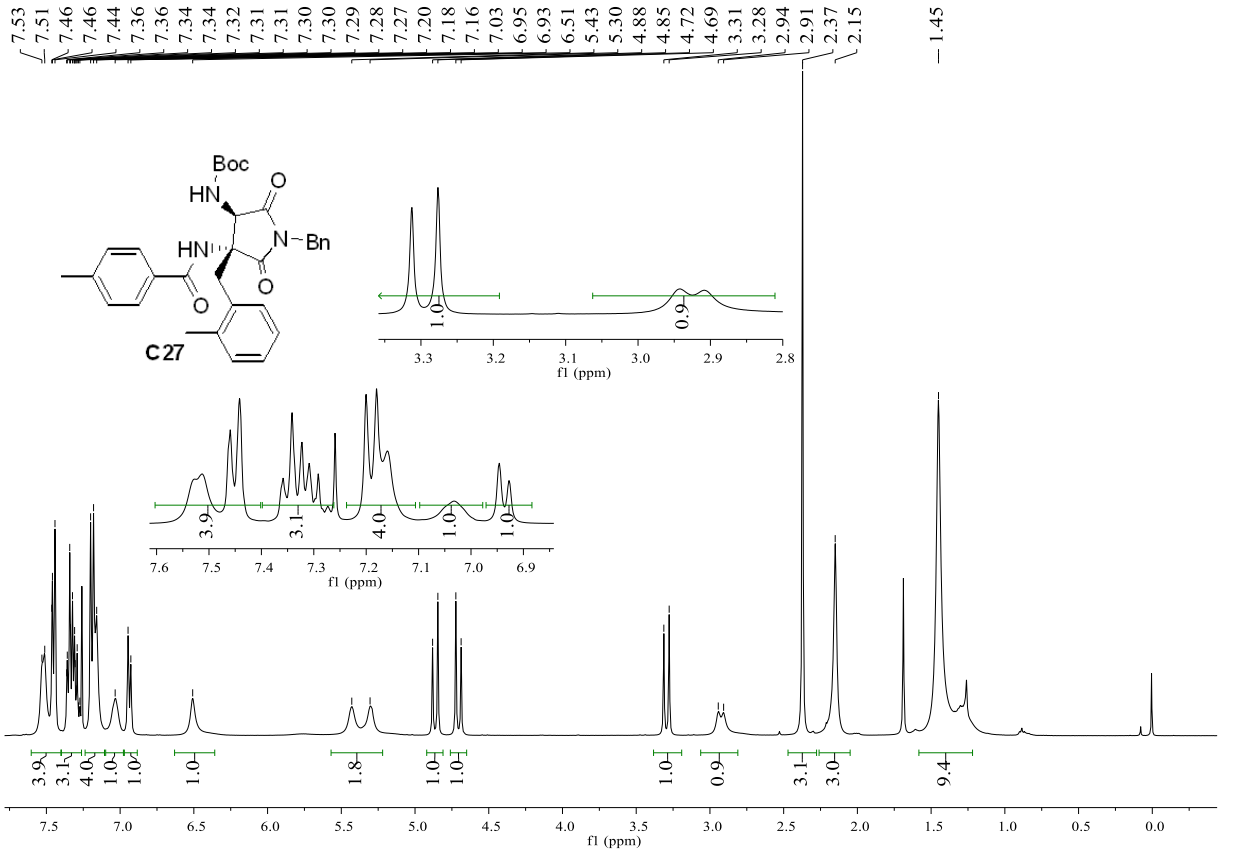
135.14
130.36
129.37
128.89
128.73
127.95
127.45
80.85
64.52
57.82
42.97
38.13
28.36
21.63
21.19
Boc
HN
HN
N–Bn
C26
fl (ppm)


7.53
7.51
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7.46
7.44
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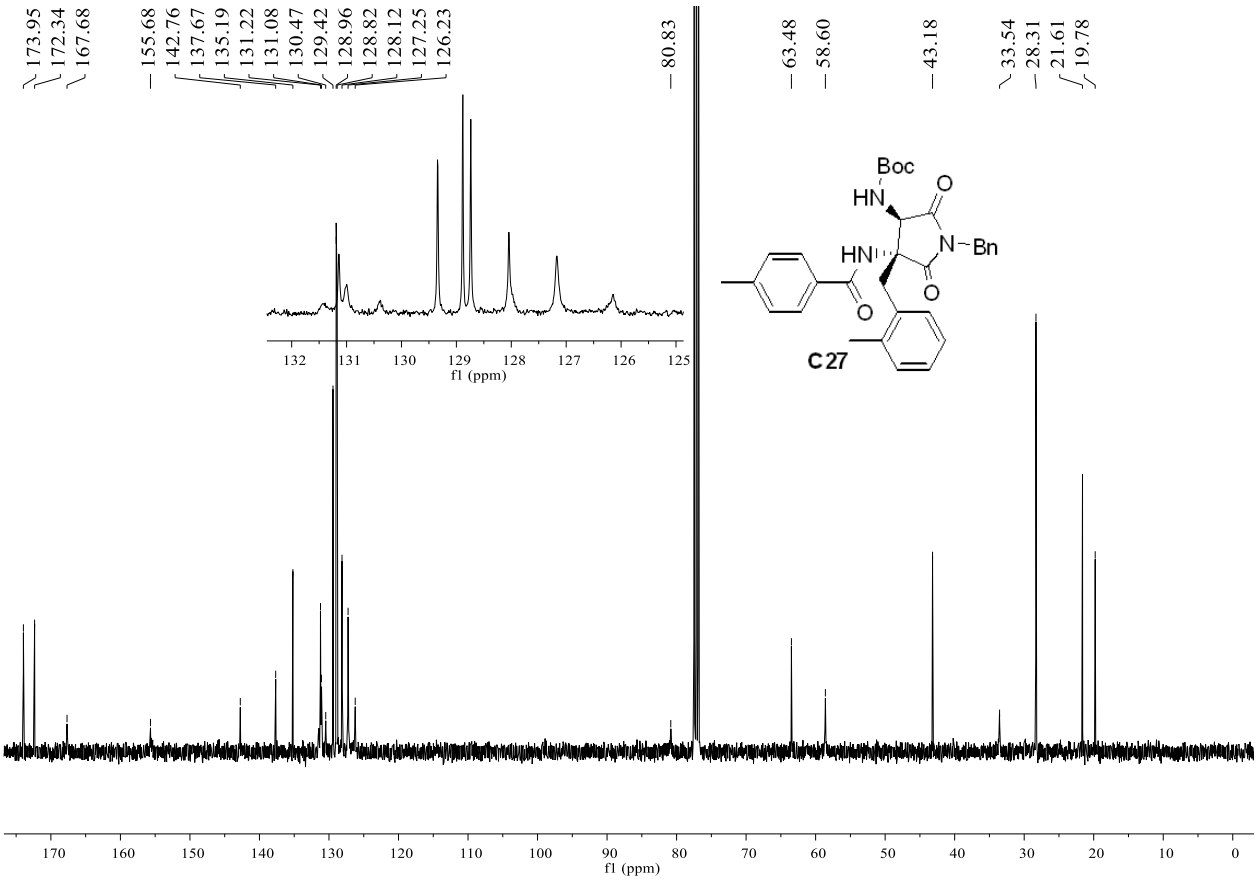
7.36
7.34
7.34
7.32
7.31
7.31
7.30
7.30
7.29
7.28
7.27
7.20
7.18
7.16
7.03
6.95
6.93
6.51
5.43
5.30
4.88
4.85
4.72
4.69
3.31
3.28
2.94
2.91
2.37
2.15
1.45
Boc
HN
HN
N–Bn
O
C27
fl (ppm)
fl (ppm)
fl (ppm)


173.95
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167.68
155.68
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137.67
135.19
131.22
131.08
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129.42
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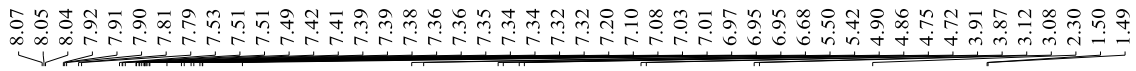
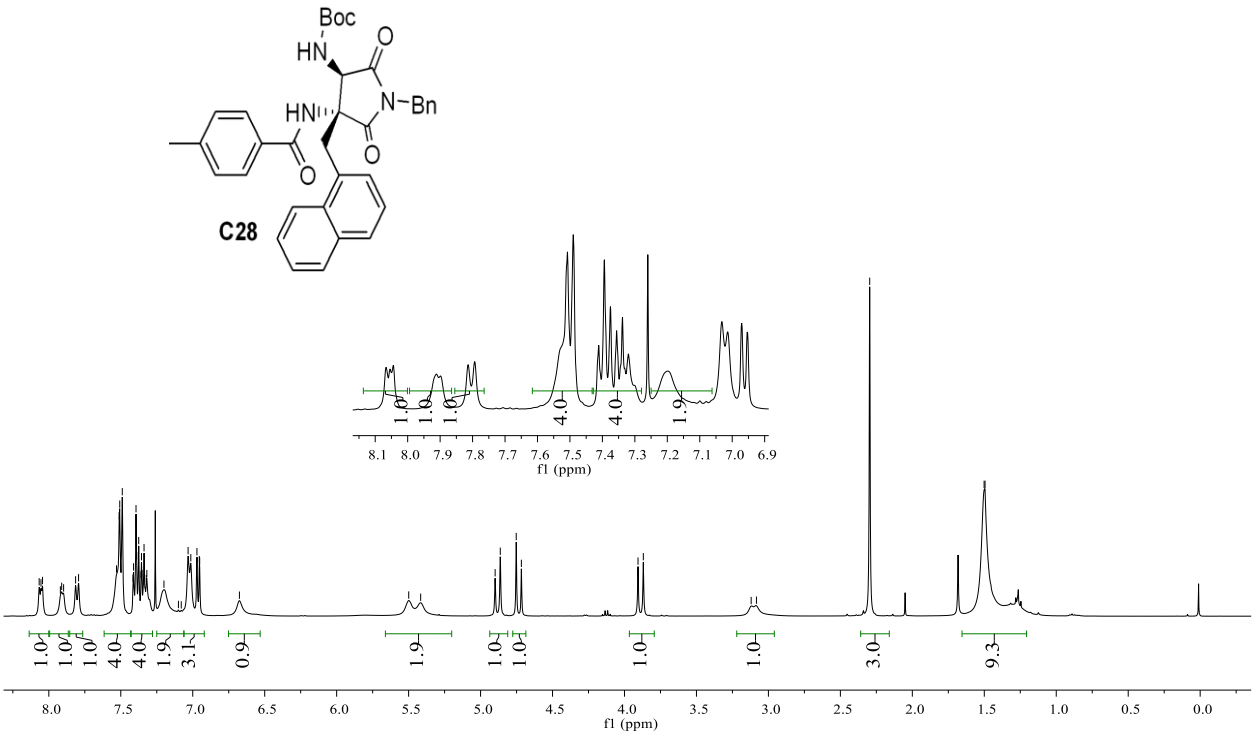
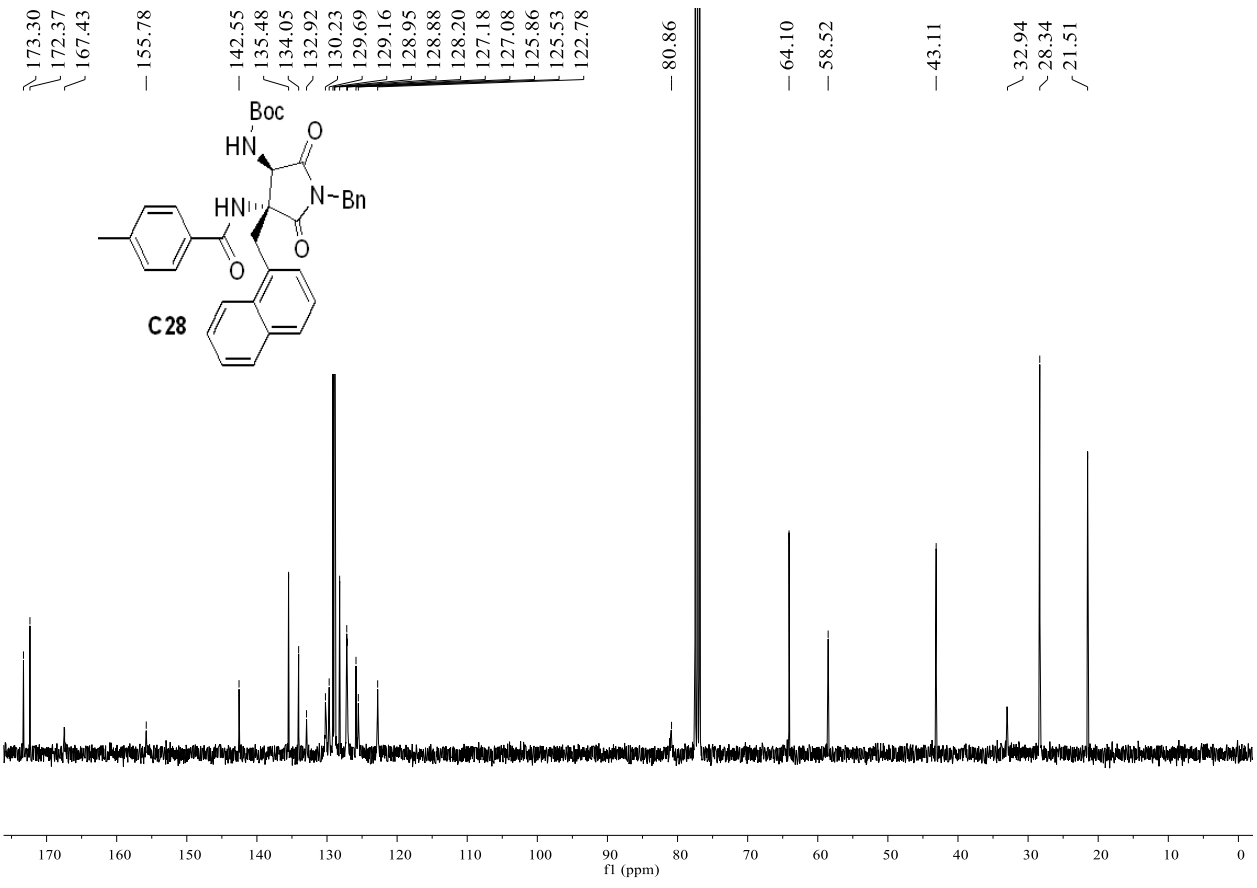
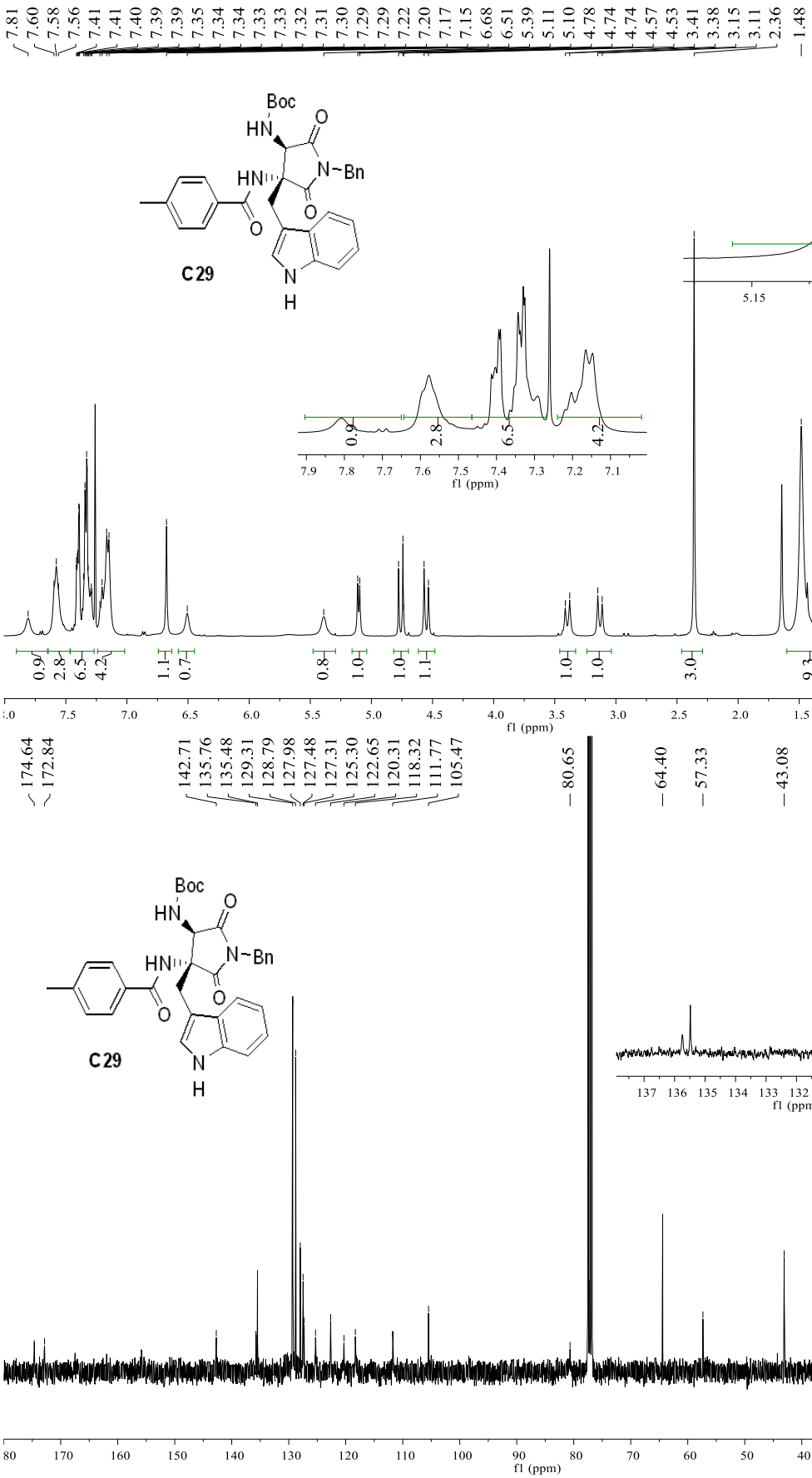
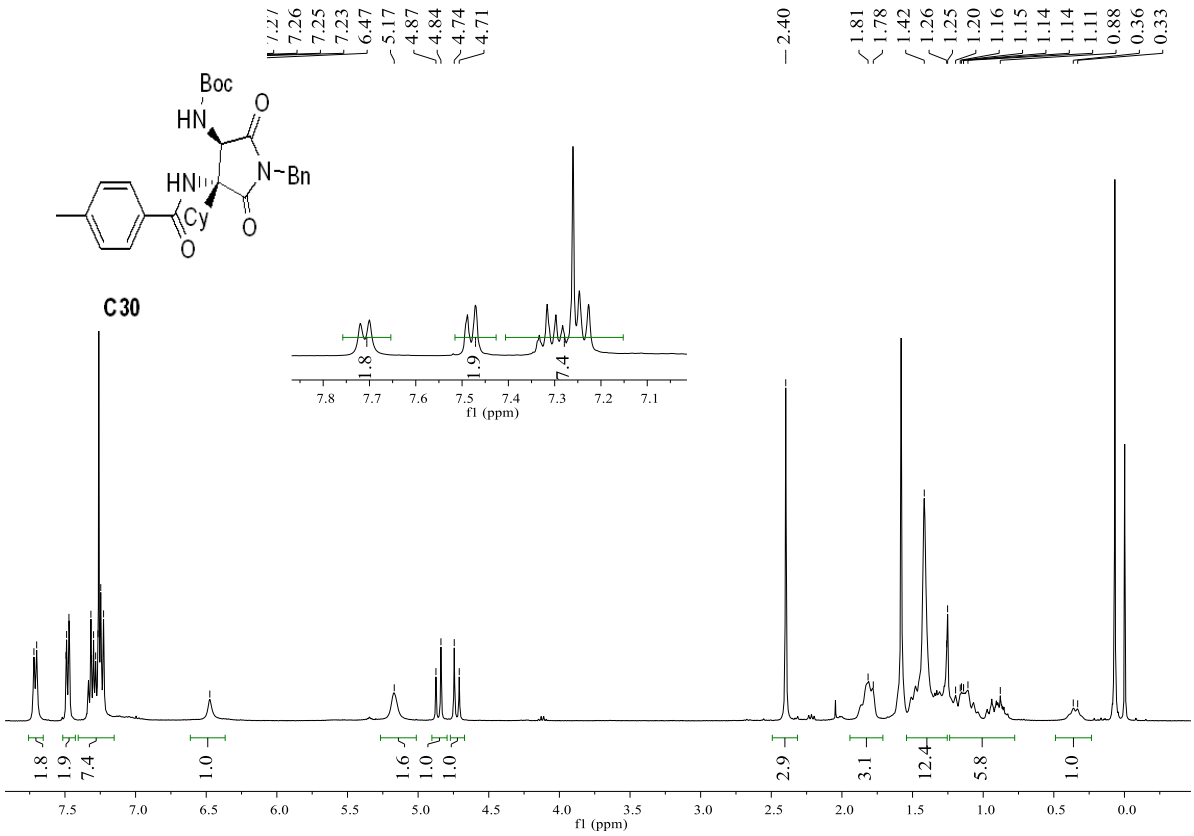
128.82
128.12
127.25
126.23
80.83
63.48
58.60
43.18
33.54
28.31
21.61
19.78
Boc
HN
HN
N–Bn
O
C27
fl (ppm)
fl (ppm)

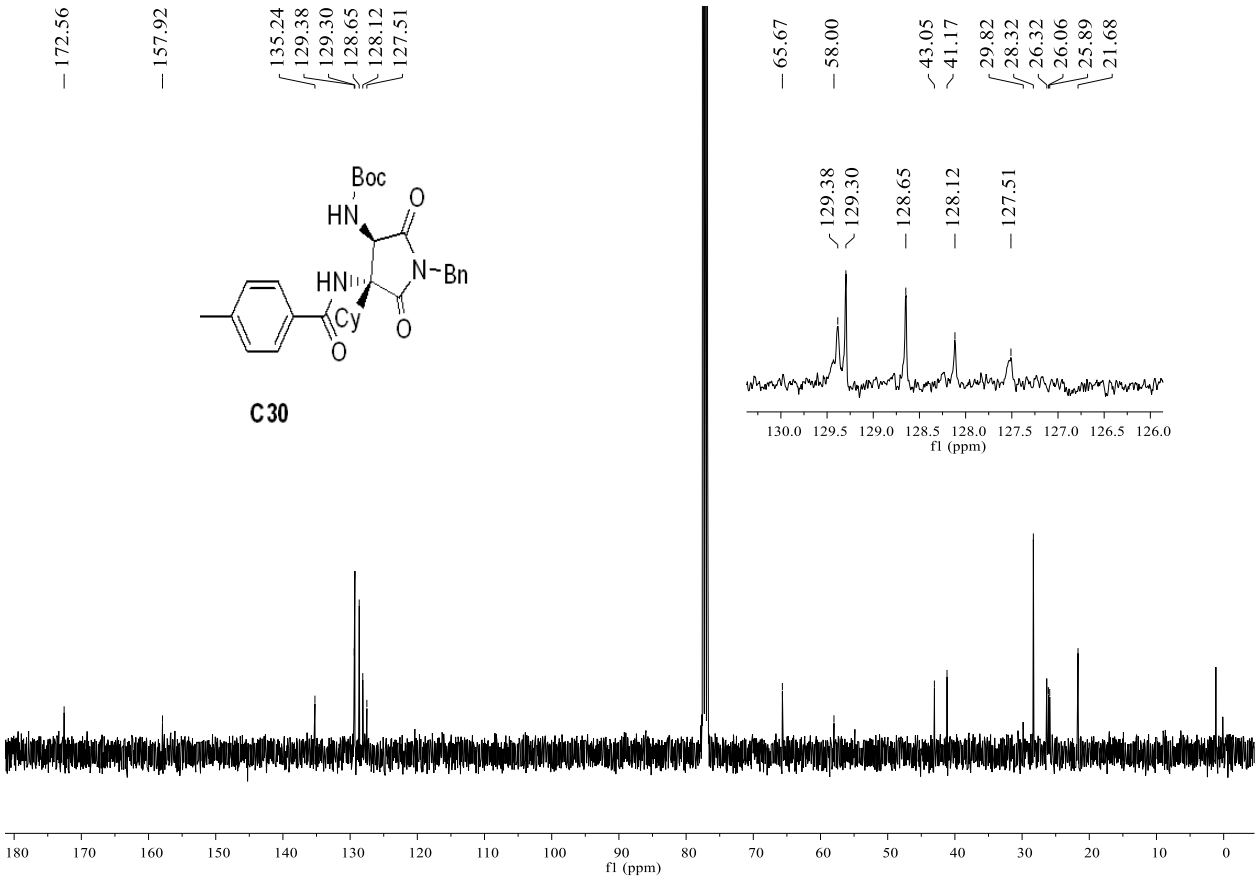

8.07
8.05
8.04
7.92
7.91
7.90
7.81
7.79
7.53
7.51
7.51
7.49
7.42
7.41
7.39
7.39
7.38
7.36
7.36
7.35
7.34
7.34
7.32
7.32
7.20
7.10
7.08
7.03
7.01
6.97
6.95
6.95
6.68
5.50
5.42
4.90
4.86
4.75
4.72
3.91
3.87
3.12
3.08
2.30
1.50
1.49

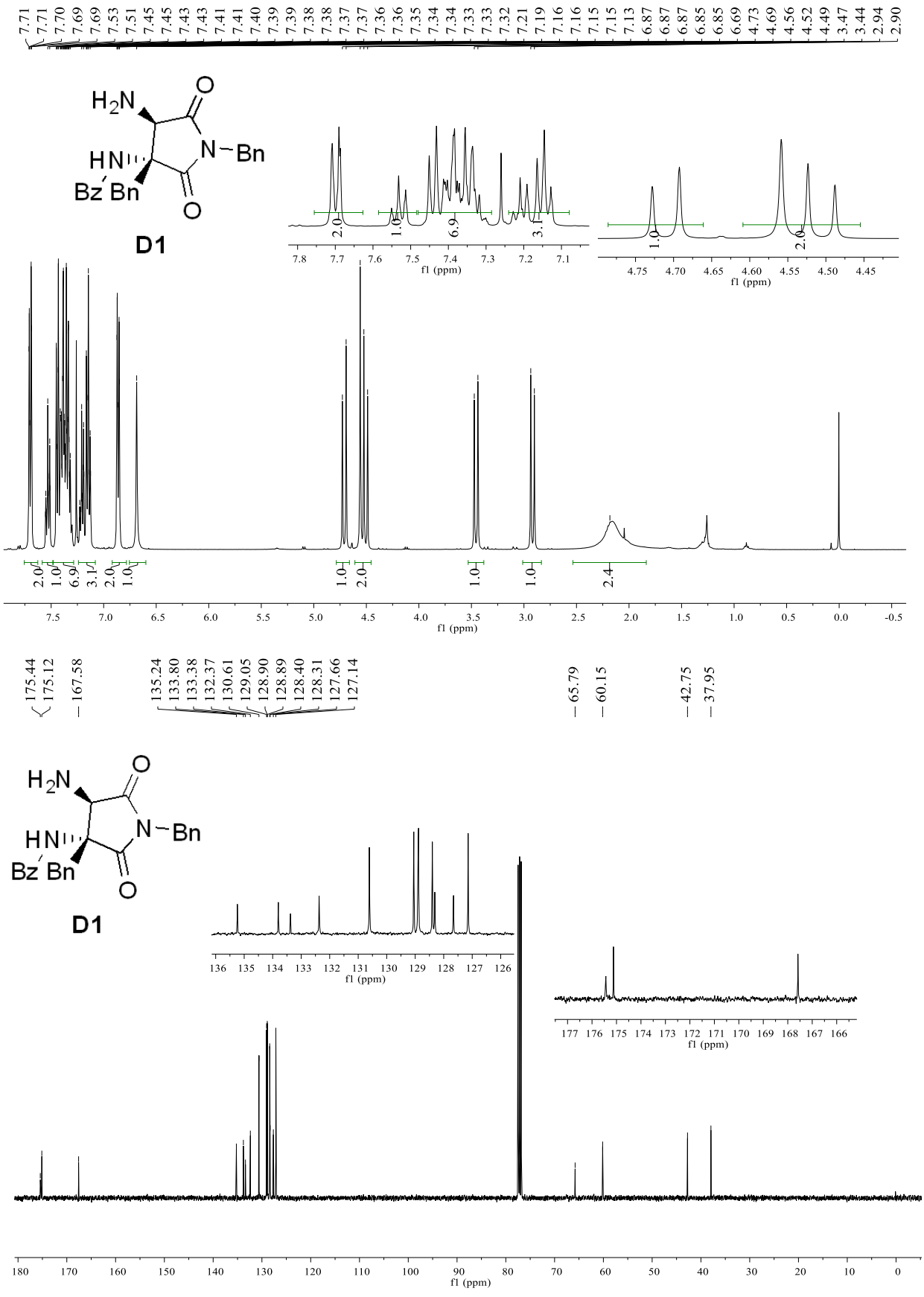

Boc
HN
O
N-Bn
HN
O
O
C28
1.0
1.0
1.0
4.0
4.0
1.9
8.1 8.0 7.9 7.8 7.7 7.6 7.5 7.4 7.3 7.2 7.1 7.0 6.9
f1 (ppm)
1.0
1.0
1.0
4.0
4.0
1.9
3.1
0.9
1.9
1.0
1.0
1.0
1.0
3.0
9.3
8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

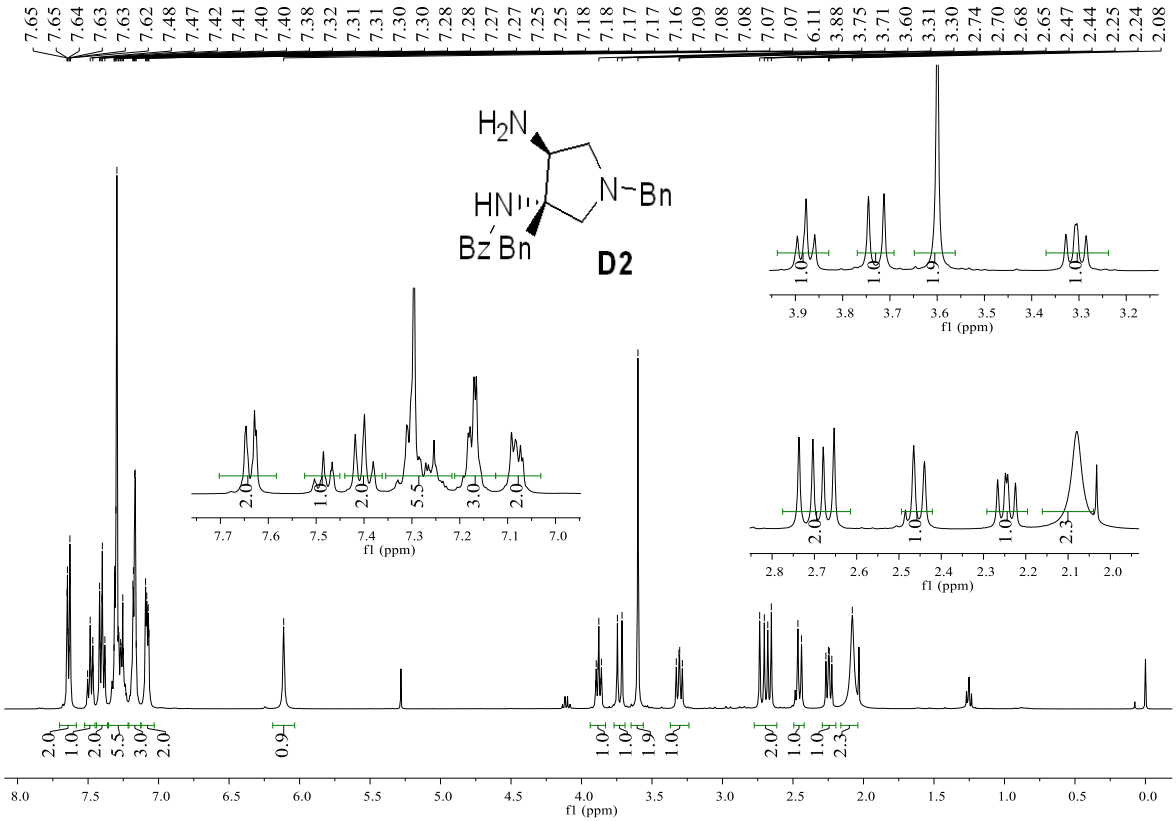

173.30
172.37
167.43
155.78
142.55
135.48
134.05
132.92
130.23
129.69
129.16
128.95
128.88
128.20
127.18
127.08
125.86
125.53
122.78
80.86
64.10
58.52
43.11
32.94
28.34
21.51
Boc
HN
O
N-Bn
HN
O
O
C28
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

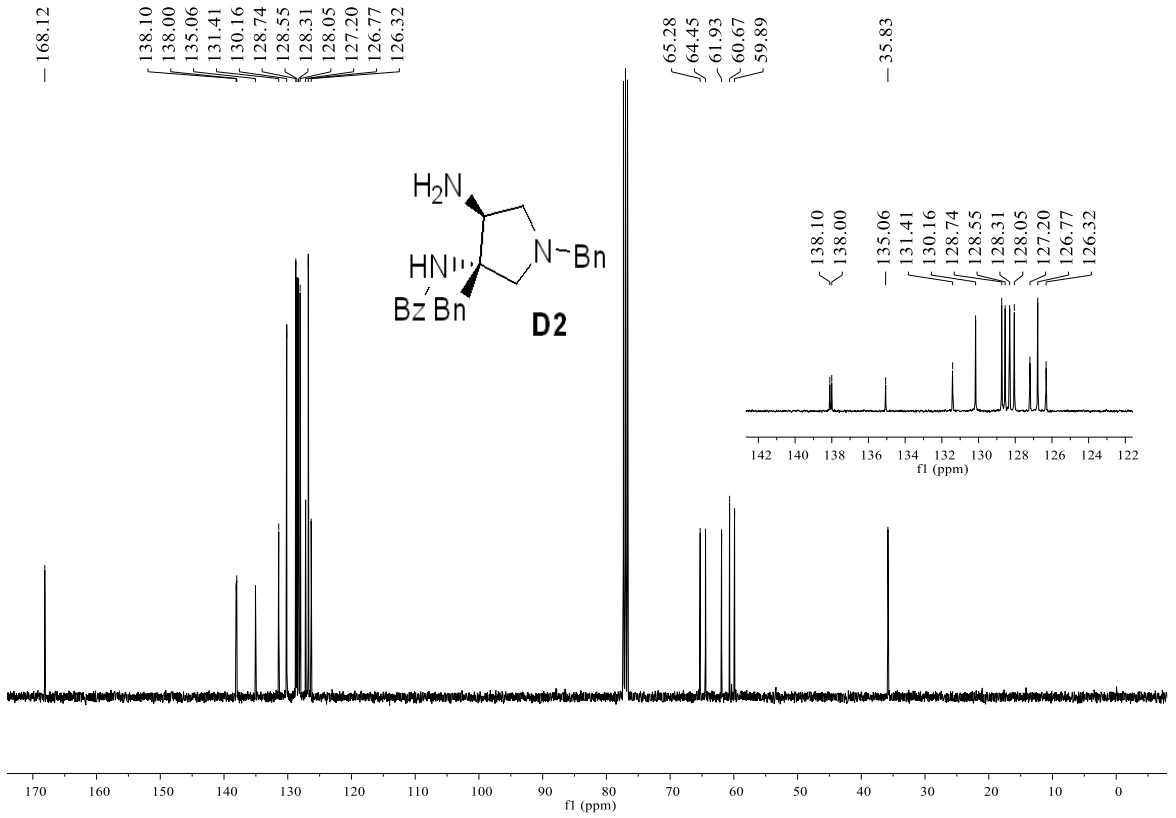

7.81 7.60 7.58 7.56 7.41 7.41 7.40 7.39 7.39 7.35 7.34 7.34 7.33 7.33 7.32 7.31 7.30 7.29 7.29 7.22 7.20 7.17 7.15 6.68 6.51 5.39 5.11 5.10 4.78 4.74 4.74 4.57 4.53 3.41 3.38 3.15 3.11 2.36 1.48
Boc
HN
O
N-Bn
HN
O
O
N
H
C29
0.9 2.8 6.5 4.2 1.1 0.7 0.8 1.0 1.0 1.1 1.0 1.0 3.0 9.3
f1 (ppm)
174.64 172.84 142.71 135.76 135.48 129.31 128.79 127.98 127.48 127.31 125.30 122.65 120.31 118.32 111.77 105.47 80.65 64.40 57.33 43.08 28.40 21.62
f1 (ppm)

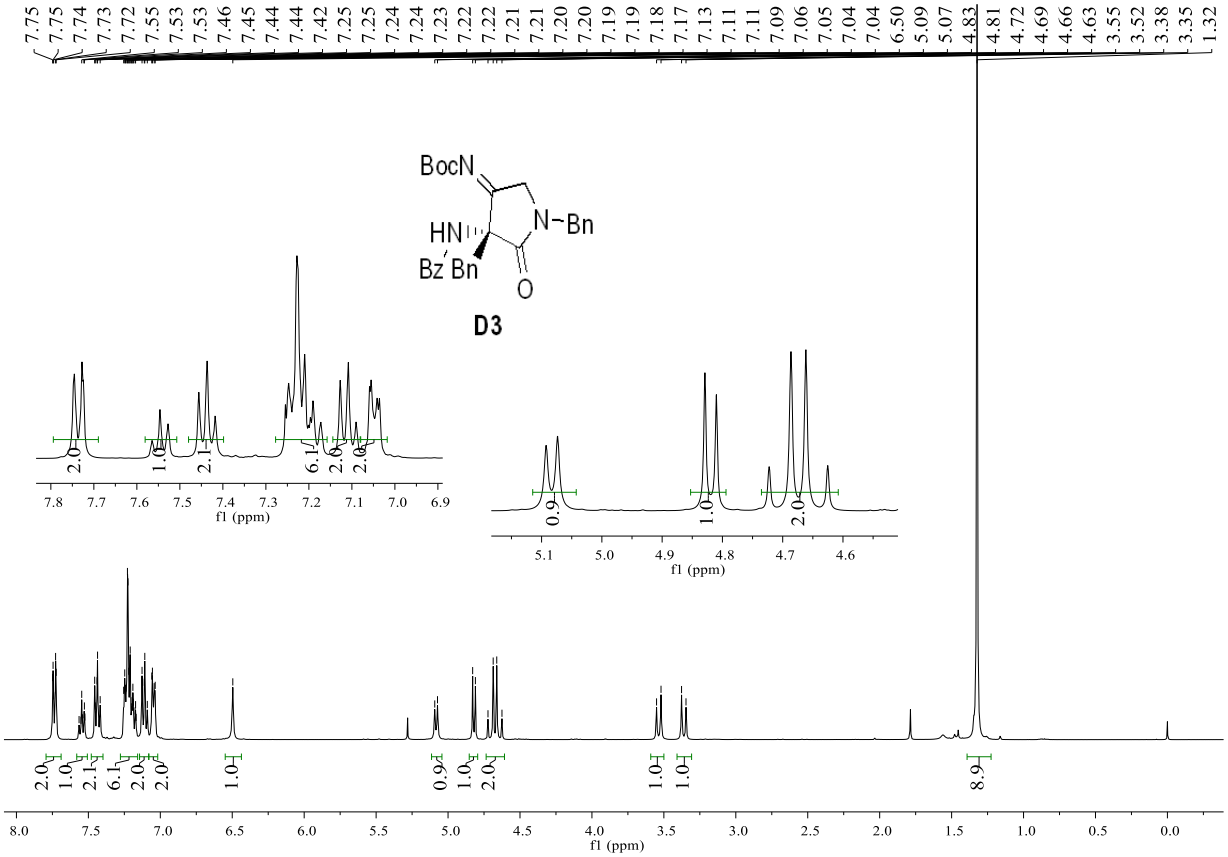

7.27
7.26
7.25
7.23
6.47
5.17
4.87
4.84
4.74
4.71
2.40
1.81
1.78
1.42
1.26
1.25
1.20
1.16
1.15
1.14
1.14
1.11
0.88
0.36
0.33
Boc
HN
HN
Cy
N-Bn
O
C30
1.8
1.9
7.4
1.0
1.6
1.0
1.0
2.9
3.1
12.4
5.8
1.0
f1 (ppm)

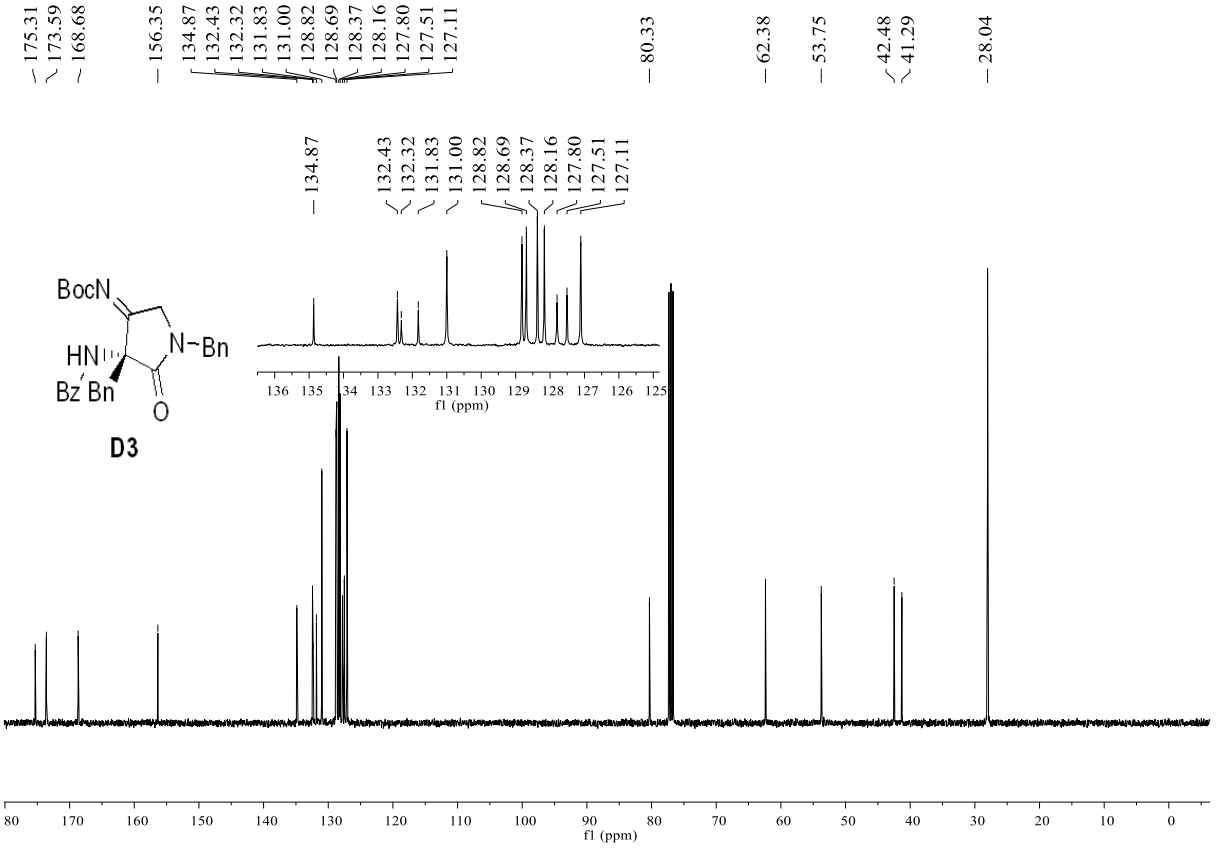

172.56
157.92
135.24
129.38
129.30
128.65
128.12
127.51
65.67
58.00
43.05
41.17
29.82
28.32
26.32
26.06
25.89
21.68
Boc
HN
HN
Cy
N-Bn
O
C30
f1 (ppm)


7.71 7.71 7.70 7.69 7.69 7.53 7.51 7.45 7.43 7.43 7.41 7.41 7.40 7.39 7.38 7.38 7.37 7.37 7.36 7.35 7.34 7.34 7.33 7.33 7.32 7.21 7.19 7.16 7.16 7.15 7.15 7.13 6.87 6.87 6.85 6.85 6.69 4.73 4.69 4.56 4.52 4.49 3.47 3.44 2.94 2.90
H2N
HN
Bz Bn
N–Bn
O
O
D1
2.0 1.0 6.9 3.1 2.0 1.0
1.0 2.0 1.0 1.0 2.4
f1 (ppm)
175.44 175.12 167.58 135.24 133.80 133.38 132.37 130.61 129.05 128.90 128.89 128.40 128.31 127.66 127.14 65.79 60.15 42.75 37.95
f1 (ppm)


D2
f1 (ppm)


D2
f1 (ppm)


BocN
HN
Bz Bn
N-Bn
O
D3
fl (ppm)


BocN
HN
Bz Bn
N-Bn
O
D3
fl (ppm)

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