Electronic Supplementary Material (ESI) for Organic & Biomolecular Chemistry.

Chemoselective Room Temperature E1cB *N-N* Cleavage of Oxazolidinone Hydrazides from Enantioselective Aldehyde α-Hydrazination: Synthesis of (+)-1,4-Dideoxyallonojirimycin

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SUPPORTING INFORMATION

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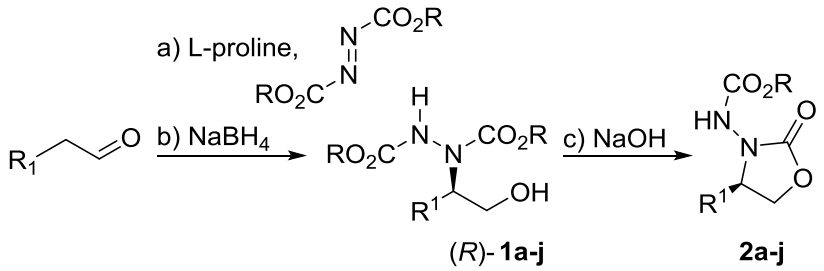
General Information

Column chromatography was performed using silica gel 60 (Merck 7734). Thin layer chromatography was carried out on aluminium-backed Merck silica gel 60 F_{254} plates. Compounds were visualised on TLC by using one or more of the following revealing techniques: UV lamp, iodine vapour or spraying with a 2.5% solution of anisaldehyde in a mixture of sulfuric acid and ethanol (1 : 10 v/v). Nuclear Magnetic Resonance spectra were recorded on a Varian Mercury 300 MHz (75.5 MHz for ^{13}C) or a Bruker 400 MHz (101 MHz for ^{13}C) instrument and were carried out in chloroform-d, dmso-d_6 or acetone-d_6 with the following references respectively in ppm: chloroform-d (δ 7.26 in ^{1}H NMR and δ 77.0 in ^{13}C NMR), dmso-d_6 (2.50 and 39.52), acetone-d_6 (2.05 and 29.84). All chemical shifts are reported in ppm. Infra-Red (IR) absorptions were measured on a Perkin Elmer Spectrum 100 FT-IR Spectrometer. All mass spectra were recorded on a Waters Synapt G2 machine in ESI mode. Melting points were obtained using a Reichert-Jung Thermovar hot-stage microscope and are uncorrected. Elemental analyses were performed using a Fisons EA 1108 CHNS elemental analyser. The enantiomeric excess (ee) of the products were determined by HPLC on an Agilent 1220 Series using a Daicel Chiralcel OD (250 × 4.6 mm) or Daicel Chiralpak AD (250 × 4.6 mm) column. Optical rotations were obtained using a Perkin Elmer 343 polarimeter at λ = 589 nm and 20 °C. The concentration *c* refers to g/100mL.

All solvents were freshly distilled. Dichloromethane was distilled from phosphorus pentoxide under nitrogen. Acetonitrile was distilled from calcium hydride under nitrogen. THF was distilled over sodium wire with benzophenone under nitrogen. All reagents were available by commercial sources (Sigma-Aldrich, Merck) and were used without further purification. The aldehyde starting materials in entries 1-3 and 5 of Table 1 were all purchased commercially. Aldehydes in entries 6 and 7 were prepared from 1,4-butanediol by conventional chemistry. Aldehydes in entries 4 and 8 were obtained by Swern oxidation of 3-phenyl-1-propanol and 3-pyridinepropanol respectively. The aldehyde of entry 9 was prepared by Dess-Martin oxidation[1] following a Wittig / hydrogenation / reduction sequence from 2-thiophenecarboxaldehyde. Finally, the indole aldehyde of entry 10 was synthesised by DIBAL reduction of the ester[2] produced via a formylation[3] / Wittig / hydrogenation sequence from indole.[3]

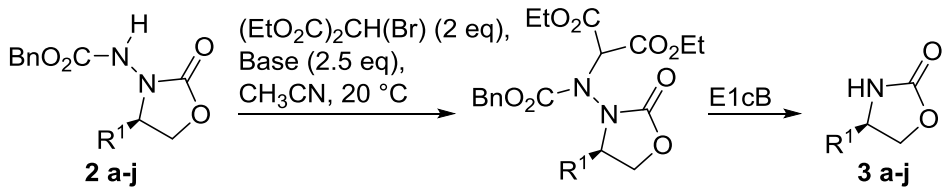
PART I: General Synthesis Procedures Relating to the *N-N* cleavage Methodology.

General Procedure 1 for synthesis of oxazolidinone hydrazides **2a-j**.



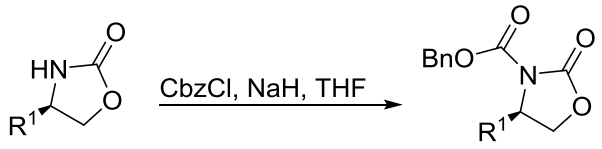
To a solution of the aldehyde (1.66 mmol, 1.66 eq.) and L-proline (13.0 mg, 0.11 mmol, 0.11 eq.) in CH_3CN (3 mL) at 0 °C was added dibenzyl azodicarboxylate (90%, 330 mg, 1.00 mmol, 1.0 eq.) and the reaction mixture was left to stir at 0 °C for 30 minutes, then at room temperature until complete consumption of dibenzyl azodicarboxylate was observed by tlc. The reaction mixture was then cooled to 0 °C, diluted with methanol (20 mL) and sodium borohydride (42 mg, 1.11 mmol, 1.11 eq.) added. After 15 minutes, once intermediate product alcohols **1a-j** had formed, sodium hydroxide (1M, 3.3 mL, 3.30 mmol, 3.3 eq.) was added and after an additional 2 hours once cyclization to oxazolidinones **2a-j** had taken place (tlc) aqueous ammonium chloride (15 mL) was added and the organic material extracted into ethyl acetate (3 x 30 mL). The combined organic layers were washed with brine (20 mL) and dried over magnesium sulfate and concentrated. The residue was chromatographed on silica gel with an ethyl acetate / hexane mixture to afford the products **2a-j** except **2e**, which was run on a larger scale for the iminosugar synthesis.

General Procedure 2 for synthesis of oxazolidinones **3a-j** via *N-N* cleavage.



To a solution of the oxazolidinone hydrazide **2a-j** (0.26 mmol, 1.0 eq.) in dry CH_3CN (1 mL) at 20 °C under nitrogen, was added either Cs_2CO_3 or K_2CO_3 as base (0.65 mmol, 2.5 eq.) followed by the addition of diethyl bromomalonate (0.09 mL, 0.52 mmol, 2.0 eq.). The reaction mixture was left to stir at 20 °C until the starting material was consumed (tlc) before being quenched with aqueous ammonium chloride (5 mL) and extracted with ethyl acetate (3 x 10 mL). The combined organic layers were dried over magnesium sulfate and concentrated. The residue was chromatographed on silica gel with an ethyl acetate / hexane mixture to afford oxazolidinone products **3a-j**.

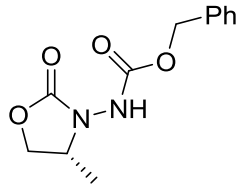
General Procedure 3 for synthesis of Cbz-protected oxazolidinones **3_{Cbz} a-c, f** for HPLC analysis.



3 a-c, f **3_{Cbz} a-c, f**

Sodium hydride (24 mg, 60%, 0.60 mmol, 1.5 eq.) was added to a solution of oxazolidinones **3a-c**, **f** (0.40 mmol, 1.0 eq.) in THF (1 mL) at 0 °C and the reaction stirred for 15 min at 0 °C. A solution of benzyl chloroformate (0.085 mL, 0.60 mmol, 1.5 eq.) in THF (3 mL) was then added dropwise and the reaction stirred for 3 hrs before being quenched with aqueous ammonium chloride (10 mL) and extracted with ethyl acetate (3 x 20 mL). The combined organic layers were dried over magnesium sulfate and concentrated. The crude residue was chromatographed on silica gel with an ethyl acetate / hexane mixture to afford the product.

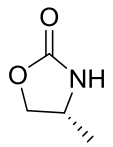
Benzyl (*R*)-(4-methyl-2-oxooxazolidin-3-yl)carbamate (2a)[4]



Synthesized from propanal (0.12 mL) according to **General Procedure 1** to afford compound **2a** (244 mg, 98%) as a colourless solid in 90% ee.

$[\alpha]_D^{20}$ –18.8 (*c* = 1.0, $CHCl_3$); IR (neat) ν_{max} / cm^{-1} 3270 (N–H), 1772 (C=O), 1704 (C=O); HRMS (ESI): *m / z* 251.1036 $[M + H]^+$, $C_{12}H_{15}N_2O_4$ requires 251.1032; δ_H (400 MHz, $CDCl_3$) 7.36 (m, 5H), 6.87 (br s, 1H), 5.18 (m, 2H), 4.48 (m, 1H), 4.10 (br s, 1H), 3.89 (m, 1H), 1.28 (d, *J* = 4.0 Hz, 3H); δ_C (101 MHz, $CDCl_3$) 157.2, 155.3, 135.3, 128.6, 128.5, 128.2, 68.8, 68.1, 52.9, 16.8; Chiralcel OD hexane / *i*-propanol (9 : 1), flow rate = 1 mL / min, λ = 258 nm; R_t(major) = 31.29 min, R_t(minor) = 22.95 min.

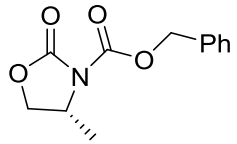
(*R*)-4-Methyloxazolidin-2-one (3a)[5]



According to **General Procedure 2** to afford compound **3a** (20h, 23.6 mg, 89% with Cs_2CO_3; 48h, 16.2 mg, 61% with K_2CO_3) as a colourless solid.

$[\alpha]_D^{20}$ +7.5 (*c* = 1.0, $CHCl_3$); IR (neat) ν_{max} / cm^{-1} 3286 (N–H), 1721 (C=O), 1238 (C–O); HRMS (ESI): *m / z* 102.0541 $[M + H]^+$, $C_4H_8NO_2$ requires 102.0555; δ_H (400 MHz, $CDCl_3$) 6.26 (br s, 1H), 4.48 (t, *J* = 8.0 Hz, 1H), 4.03-3.95 (m, 1H), 3.92 (dd, *J* = 6.2, 8.0 Hz, 1H), 1.27 (d, *J* = 6.4 Hz, 3H); δ_C (101 MHz, $CDCl_3$) 160.0, 71.6, 48.2, 20.7.

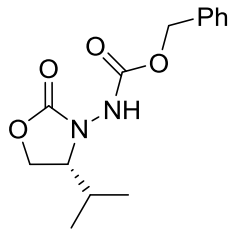
Benzyl (*R*)-4-methyl-2-oxooxazolidine-3-carboxylate (3_{Cbz}a)



Synthesized from **3a** (40.0 mg) according to **General procedure 3** to afford compound $\mathbf{3_{Cbz}a}$ (73.3 mg, 79%) as a colourless oil in 90% ee.

$[\alpha]_D^{20}$ –35.0 (c = 1.0, $CHCl_3$); IR (neat) ν_{max} / cm^{-1} 1735 (C=O), 1718 (C=O), 1251 (C–O); HRMS (ESI): *m / z* 236.0925 $[M + H]^+$, $C_{12}H_{14}NO_4$ requires 236.0923; δ_H (400 MHz, $CDCl_3$) 7.45-7.30 (m, 5H), 5.34 (d, J_{AB} = 12.0 Hz, 1H), 5.29 (d, J_{AB} = 12.0 Hz, 1H), 4.41 (m, 2H), 3.94 (m, 1H), 1.43 (d, J = 8.0 Hz, 3H); δ_C (101 MHz, $CDCl_3$) 151.6, 150.8, 134.9, 128.6, 128.5, 128.2, 68.6, 68.6, 51.3, 19.5; Chiralcel OD hexane / *i*-propanol (4 : 1), flow rate = 1 mL / min, λ = 258 nm; R_t(major) = 14.15 min, R_t(minor) = 7.57 min.

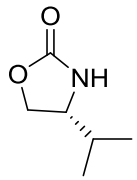
Benzyl (*R*)-(4-isopropyl-2-oxo-3-oxooxazolidin-3-yl)carbamate (2b)[6]



Synthesized from isovaleraldehyde (0.18 mL) according to **General Procedure 1** to afford compound **2b** (281 mg, 100%) as a colourless oil in 91% ee.

$[\alpha]_D^{20}$ –11.0 (c = 1.0, $CHCl_3$); IR (neat) ν_{max} / cm^{-1} 3319 (N–H), 1764 (C=O), 1726 (C=O); HRMS (ESI): *m / z* 279.1345 $[M + H]^+$, $C_{14}H_{19}N_2O_4$ requires 279.1345; δ_H (400 MHz, $CDCl_3$) 7.38-7.31 (m, 5H), 6.90 (br s, 1H), 5.18 (m, 2H), 4.37 (m, 1H), 4.06 (m, 1H), 3.96 (m, 1H), 2.03 (m, 1H), 0.93 (d, J = 6.8 Hz, 1H), 0.91 (d, J = 6.8 Hz, 1H); δ_C (101 MHz, $CDCl_3$) 157.8, 155.1, 135.3, 128.6, 128.5, 128.2, 68.1, 64.0, 60.9, 28.5, 17.8, 15.9; Chiralcel OD hexane / *i*-propanol (9 : 1), flow rate = 1 mL / min, λ = 258 nm; R_t(major) = 24.50 min, R_t(minor) = 15.98 min.

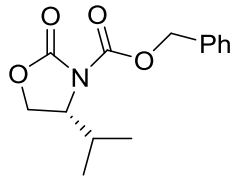
(*R*)-4-Isopropyloxazolidin-2-one (3b)[5]



From hydrazide **2b** (73.0 mg) according to **General procedure 2** to afford compound **3b** (20h, 32.2 mg, 95% with Cs_2CO_3; 48h, 21.0 mg, 62% with K_2CO_3) as a colourless oil.

$[\alpha]_D^{20}$ +3.1 (c = 1.0, $CHCl_3$); IR (neat) ν_{max} / cm^{-1} 3236 (N–H), 1728 (C=O), 1224 (C–O); HRMS (ESI): m / z 130.0873 $[M + H]^+$, $C_6H_{12}NO_2$ requires 130.0868; δ_H (400 MHz, $CDCl_3$) 6.09 (br s, 1H), 4.43 (t, J = 8.6 Hz, 1H), 4.10 (dd, J = 6.4, 8.6 Hz, 1H), 3.61 (m, 1H), 1.73 (m, 1H), 0.96 (d, J = 6.6 Hz, 3H), 0.91 (d, J = 6.6 Hz, 3H); δ_C (101 MHz, $CDCl_3$) 160.0, 68.5, 58.3, 32.6, 17.9, 17.6.

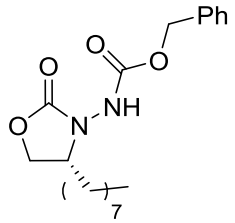
Benzyl (*R*)-4-isopropyl-2-oxooxazolidine-3-carboxylate ($\mathbf{3_{Cbz}b}$)



Synthesized from **3b** (51.7 mg) according to **General procedure 3** to afford compound **$\mathbf{3_{Cbz}b}$** (84.2 mg, 80%) as a colourless oil in 92% ee.

$[\alpha]_D^{20}$ –41.5 (c = 1.0, $CHCl_3$); IR (neat) ν_{max} / cm^{-1} 1800 (C=O), 1714 (C=O); HRMS (ESI): m / z 286.1048 $[M + Na]^+$, $C_{14}H_{17}NNaO_4$ requires 286.1055; δ_H (400 MHz, $CDCl_3$) 7.45-7.30 (m, 5H), 5.34 (d, J_{AB} = 12.4 Hz, 1H), 5.29 (d, J_{AB} = 12.4 Hz, 1H), 4.26 (m, 2H), 4.16 (m, 1H), 2.33 (m, 1H), 0.91 (d, J = 7.2 Hz, 3H), 0.90 (d, J = 7.2 Hz, 3H); δ_C (101 MHz, $CDCl_3$) 152.1, 151.1, 135.0, 128.6, 128.5, 128.1, 68.5, 63.0, 59.3, 29.1, 17.8, 14.7; Chiralcel OD hexane / *i*-propanol (9 : 1), flow rate = 0.5 mL / min, λ = 258 nm; R_t(major) = 26.23 min, R_t(minor) = 29.10 min.

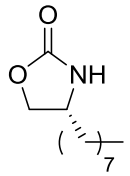
Benzyl (*R*)-(4-octyl-2-oxooxazolidin-3-yl)carbamate (2c)



Synthesized from decanal (0.31 mL) according to **General procedure 1** to give compound **2c** (346 mg, 99%) as a colourless oil in 92% ee.

$[\alpha]_D^{20}$ –18.5 (c = 1.0, $CHCl_3$); IR (neat) ν_{max} / cm^{-1} 3323 (N–H), 1740 (C=O), 1740 (C=O); HRMS (ESI): m / z 349.2131 $[M + H]^+$, $C_{19}H_{29}N_2O_4$ requires 349.2127; δ_H (400 MHz, $CDCl_3$) 7.37-7.29 (m, 5H), 7.12 (br s, 1H), 5.18 (d, J_{AB} = 12.0 Hz, 1H), 5.15 (d, J_{AB} = 12.0 Hz, 1H), 4.44 (m, 1H), 3.94 (m, 2H), 1.77 (m, 1H), 1.48 (m, 1H), 1.25 (m, 12H), 0.88 (t, J = 8.0 Hz, 3H); δ_C (101 MHz, $CDCl_3$) 157.5, 155.3, 135.3, 128.5, 128.4, 128.1, 68.0, 67.6, 56.8, 31.7, 31.6, 29.4, 29.3, 29.1, 24.4, 22.5, 14.0; Chiralcel OD hexane / *i*-propanol (9 : 1), flow rate = 1 mL / min, λ = 258 nm; R_t(major) = 25.43 min, R_t(minor) = 15.58 min.

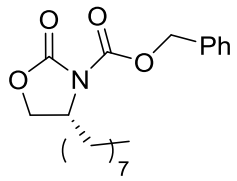
(*R*)-4-Octyloxazolidin-2-one (3c)



Synthesized from hydrazide **2c** (90.0 mg) according to **General Procedure 2** to afford compound **3c** (48h, 33.1 mg, 64% with Cs_2CO_3; 23h, 46.6 mg, 90% with K_2CO_3) as a colourless oil.

$[\alpha]_D^{20}$ +4.5 (*c* = 1.0, $CHCl_3$); IR (neat) ν_{max} / cm^{-1} 3270 (N–H), 1746 (C=O), 1239 (C–O); HRMS (ESI): *m / z* 200.1652 $[M + H]^+$, $C_{11}H_{22}NO_2$ requires 200.1651; δ_H (400 MHz, $CDCl_3$) 5.81 (br s, 1H), 4.47 (t, *J* = 8.4 Hz, 1H), 4.01 (m, *J* = 6.0, 8.4 Hz, 1H), 3.85 (m, 1H), 1.58 (m, 2H), 1.34-1.22 (m, 12H), 0.88 (t, *J* = 7.0 Hz, 3H); δ_C (101 MHz, $CDCl_3$) 159.8, 70.3, 52.6, 35.3, 31.8, 29.3, 29.3, 29.1, 25.2, 22.6, 14.0.

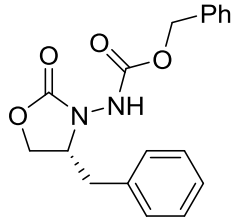
Benzyl (*R*)-4-octyl-2-oxooxazolidine-3-carboxylate (3_{Cbz}c)



Synthesized from **3c** (80.0 mg) according to **General procedure 3** to afford compound **3_{Cbz}c** (96.0 mg, 72%) as a colourless oil in 88% ee.

$[\alpha]_D^{20}$ –34.5 (*c* = 1.0, $CHCl_3$); IR (neat) ν_{max} / cm^{-1} 1792 (C=O), 1725 (C=O); HRMS (ESI): *m / z* 356.1831 $[M + Na]^+$, $C_{19}H_{27}NNaO_4$ requires 356.1838; δ_H (400 MHz, $CDCl_3$) 7.44-7.30 (m, 5H), 5.34 (d, J_{AB} = 12.0 Hz, 1H), 5.27 (d, J_{AB} = 12.0 Hz, 1H), 4.37-4.25 (m, 2H), 4.05 (m, 1H), 1.82 (m, 1H), 1.68 (m, 1H), 1.31-1.22 (m, 12H), 0.88 (t, *J* = 8.0 Hz, 3H); δ_C (101 MHz, $CDCl_3$) 151.8, 150.8, 134.9, 128.6, 128.5, 128.1, 68.5, 66.7, 55.0, 32.7, 31.7, 29.3, 29.2, 29.1, 23.9, 22.5, 14.0; Chiralcel OD hexane / *i*-propanol (9 : 1), flow rate = 1 mL / min, λ = 258 nm; R_t(major) = 59.62 min, R_t(minor) = 42.74 min.

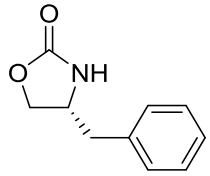
Benzyl (*R*)-(4-benzyl-2-oxo-oxazolidin-3-yl)carbamate (2d)[7]



Synthesized from 3-phenylpropanal (224 mg) using **General Procedure 1** to give **2d** (327 mg, 100%) as a colourless oil in 90% ee.

$[\alpha]_D^{20}$ –19.5 (*c* = 1.0, $CHCl_3$); IR (neat) ν_{max} / cm^{-1} 1774 (C=O), 1728 (C=O), 1217 (C–O); HRMS (ESI): *m / z* 327.1338 $[M + H]^+$, $C_{18}H_{19}N_2O_4$ requires 327.1345; δ_H (400 MHz, $CDCl_3$) 7.40-7.22 (m, 8H), 7.16-7.10 (m, 3H), 5.16 (m, 2H), 4.28 (m, 2H), 4.03 (m, 1H), 3.13 (m, 1H), 2.78 (m, 1H); δ_C (101 MHz, $CDCl_3$) 157.3, 155.3, 135.3, 135.2, 128.8, 128.7, 128.4, 128.2, 128.0, 127.0, 67.8, 67.0, 57.6, 37.6; Chiralcel OD column hexane / *i*-propanol (1 : 1), flow rate = 0.5 mL / min, λ = 258 nm; R_t(major) = 19.21 min, R_t(minor) = 16.55 min.

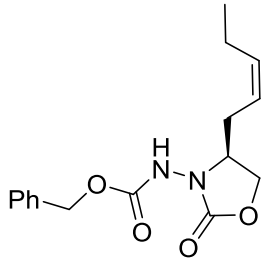
(*R*)-4-Benzyloxazolidin-2-one (3d)[5]



Synthesised using **General Procedure 2** with **2d** (80.0 mg, 0.250 mmol) to afford **3d** (3h, 36.2 mg, 82% with Cs_2CO_3; 20h, 37.2 mg, 84% with K_2CO_3) as a colourless oil in 91% ee.

$[\alpha]_D^{20}$ +51.4 (*c* = 1.0, $CHCl_3$); IR (neat) ν_{max} / cm^{-1} 1738 (C=O), 1246 (C–O); HRMS (ESI): *m / z* 178.0864 $[M + H]^+$, $C_{10}H_{12}NO_2$ requires 178.0868; δ_H (400 MHz, $CDCl_3$) 7.32 (m, 2H), 7.26 (m, 1H), 7.17 (m, 2H), 6.06 (br s, 1H), 4.41 (m, 1H), 4.14-4.05 (m, 2H), 2.93-2.81 (m, 2H); δ_C (101 MHz, $CDCl_3$) 159.6, 135.9, 129.0, 128.9, 127.1, 69.5, 53.7, 41.3; Chiralcel OD column hexane / *i*-propanol (1 : 1), flow rate = 0.5 mL / min, λ = 258 nm; R_t(major) = 13.98 min, R_t(minor) = 12.90 min.

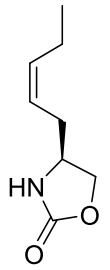
Benzyl (*S*,*Z*)-(2-oxo-4-(pent-2-en-1-yl)oxazolidin-3-yl)carbamate (2e)



Synthesized from (*Z*)-hept-4-enal (0.2 mL) using **General Procedure 1** to give **2e** (295 mg, 97%) as a colourless oil in 88% ee.

$[\alpha]_D^{20}$ +56.2 (*c* = 1.0, $CHCl_3$); IR (neat) ν_{max} / cm^{-1} 3281 (N–H), 1740 (C=O), 1729 (C=O), 1499 (C=C), 1219 (C–O), 1044 (C–N); HRMS (ESI): *m / z* 305.1496 $[M + H]^+$, $C_{16}H_{21}N_2O_4$ requires 305.1501; δ_H (400 MHz, $CDCl_3$) 7.34 (m, 5H), 7.22 (br s, 1H), 5.56 (m, 1H), 5.19 (m, 1H), 5.18 (d, J_{AB} = 12.2 Hz, 1H), 5.14 (d, J_{AB} = 12.2 Hz, 1H), 4.39 (m, 1H), 4.04 (m, 1H), 3.94 (m, 1H), 2.46 (m, 1H), 2.31 (m, 1H), 2.02 (m, 2H), 0.96 (t, *J* = 7.6 Hz, 3H); δ_C (101 MHz, $CDCl_3$) 157.3, 155.3, 136.3, 135.3, 128.5, 128.3, 128.0, 120.8, 67.9, 66.9, 56.3, 28.9, 20.7, 13.9; Chiralcel OD hexane / *i*-propanol (7 : 3), flow rate = 1 mL / min, λ = 250 nm; R_t(major) = 17.13 min, R_t(minor) = 29.56 min.

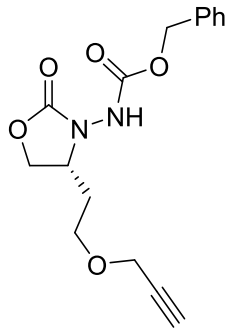
(*S*,*Z*)-4-(Pent-2-en-1-yl)oxazolidin-2-one (3e)



Synthesised using **General Procedure 2** with **2e** (76 mg, 0.25 mmol) to afford **3e** (5h, 32.5 mg, 84% with Cs_2CO_3; 24h, 32.5 mg, 84% with K_2CO_3) as a colourless oil.

$[\alpha]_D^{20}$ +3.6 (*c* = 1.0, $CHCl_3$); IR (neat) ν_{max} / cm^{-1} 3271 (N–H), 1737 (C=O), 1239 (C–O), 1026 (C–N); HRMS (ESI): *m / z* 156.1023 $[M + H]^+$, $C_8H_{14}NO_2$ requires 156.1025; δ_H (400 MHz, $CDCl_3$) 6.59 (br s, 1H), 5.56 (m, 1H), 5.22 (m, 1H), 4.40 (m, 1H), 3.99 (m, 1H), 3.85 (m, 1H), 2.36-2.22 (m, 2H), 2.06-1.98 (m, 2H), 0.93 (t, *J* = 7.6 Hz, 3H); δ_C (101 MHz, $CDCl_3$) 160.1, 136.1, 121.5, 69.6, 52.3, 32.6, 20.6, 13.9. The ee of the dibenzoate of **6a** (**7**) was recorded as 90 %.

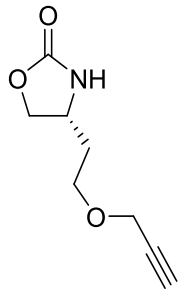
Benzyl (*R*)-(2-oxo-4-(2-(prop-2-yn-1-yloxy)ethyl)oxazolidin-3-yl)carbamate (2f)



Synthesized from 4-(prop-2-yn-1-yloxy)butanal (209 mg) using **General Procedure 1** to give **2f** (304 mg, 96%) as a yellow oil in 87% ee.

$[\alpha]_D^{20}$ –12.9 (*c* = 1.0, $CHCl_3$); IR (neat) ν_{max} / cm^{-1} 1771 (C=O), 1726 (C=O), 1222 (C–O); HRMS (ESI): *m / z* 319.1281 $[M + H]^+$, $C_{16}H_{19}N_2O_5$ requires 319.1294; δ_H (400 MHz, $CDCl_3$) 7.40-7.30 (m, 5H), 6.80 (br s, 1H), 5.18 (s, 2H), 4.53 (m, 1H), 4.08 (m, 4H), 3.66 (m, 1H), 3.56 (m, 1H), 2.42 (t, *J* = 2.4 Hz, 1H), 2.06-1.84 (m, 2H); δ_C (101 MHz, $CDCl_3$) 157.2, 155.3, 135.3, 128.6, 128.5, 128.3, 79.1, 74.9, 68.1, 67.9, 66.0, 58.4, 56.1, 31.7; Chiralcel OD column hexane / *i*-propanol (1 : 1), flow rate = 0.5 mL / min, λ = 258 nm; R_t(major) = 16.93 min, R_t(minor) = 13.41 min.

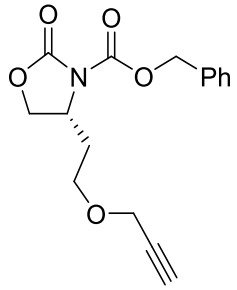
(*R*)-4-(2-(Prop-2-yn-1-yloxy)ethyl)oxazolidin-2-one (3f)



Synthesised using **General Procedure 2** with **2f** (100 mg, 0.310 mmol) to afford **3f** (4h, 42.4 mg, 81% with Cs_2CO_3; 24h, 41.9 mg, 80% with K_2CO_3) as a colourless oil.

$[\alpha]_D^{20}$ +21.3 (c = 1.0, $CHCl_3$); IR (neat) ν_{max} / cm^{-1} 1733 (C=O), 1243 (C–O); HRMS (ESI): m/z 170.0809 $[M + H]^+$, $C_8H_{12}NO_3$ requires 170.0817; δ_H (300 MHz, $CDCl_3$) 6.27 (br s, 1H), 4.47 (m, 1H), 4.11 (d, J = 2.4 Hz, 2H), 4.01 (m, 2H), 3.61 (t, J = 5.7 Hz, 2H), 2.44 (t, J = 2.4 Hz, 1H), 1.83 (m, 2H); δ_C (101 MHz, $CDCl_3$) 159.6, 79.3, 74.8, 70.4, 67.0, 58.3, 51.6, 34.9.

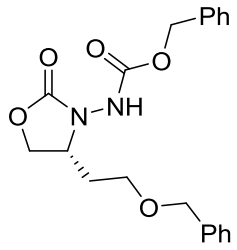
Benzyl (*R*)-2-oxo-4-(2-(prop-2-yn-1-yloxy)ethyl)oxazolidine-3-carboxylate (3_{Cbz}f)



Synthesised using **General Procedure 3** with **3f (**80 mg, 0.47 mmol**)** to afford **3_{Cbz}f** (120 mg, 0.40 mmol, 85%) as a colourless oil in 87% ee.

$[\alpha]_D^{20}$ –34.5 (c = 1.0, $CHCl_3$); IR (neat) ν_{max} / cm^{-1} 1787 (C=O), 1722 (C=O), 1276 (C–O); HRMS (ESI): m/z 304.1177 $[M + H]^+$, $C_{16}H_{18}NO_5$ requires 304.1185; δ_H (400 MHz, $CDCl_3$) 7.46-7.30 (m, 5H), 5.34 (d, J_{AB} = 12.3 Hz, 1H), 5.28 (d, J_{AB} = 12.3 Hz, 1H), 4.47-4.35 (m, 2H), 4.26 (m, 1H), 4.08 (d, J = 2.4 Hz, 2H), 3.68-3.56 (m, 2H), 2.42 (t, J = 2.4 Hz, 1H), 2.23-2.13 (m, 1H), 2.05-1.93 (m, 1H); δ_C (101 MHz, $CDCl_3$) 151.9, 151.0, 134.9, 128.6, 128.5, 128.1, 79.2, 74.8, 68.6, 67.4, 66.0, 58.2, 54.1, 32.5; Chiralcel OD column hexane / *i*-propanol (4 : 1), flow rate = 1 mL / min, λ = 258 nm; R_t(major) = 18.50 min, R_t(minor) = 20.41 min.

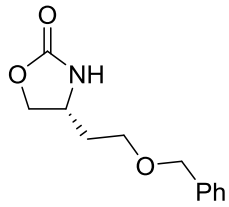
Benzyl (*R*)-(4-(2-(benzyloxy)ethyl)-2-oxooxazolidin-3-yl)carbamate (2g)



Synthesized from 4-(benzyloxy)butanal (295 mg) using **General Procedure 1** to give **2g** (354 mg, 96 %) as a colourless oil in 90% ee.

$[\alpha]_D^{20}$ –8.0 (*c* = 1.0, $CHCl_3$); IR (neat) ν_{max} / cm^{-1} 1774 (C=O), 1730 (C=O), 1221 (C–O); HRMS (ESI): *m / z* 371.1601 $[M + H]^+$, $C_{20}H_{23}N_2O_5$ requires 371.1607; δ_H (300 MHz, $CDCl_3$) 7.40-7.25 (m, 10H), 6.92 (br s, 1H), 5.16 (s, 2H), 4.49 (m, 1H), 4.44 (s, 2H), 4.07 (m, 2H), 3.55 (m, 1H), 3.50 (m, 1H), 2.05-1.84 (m, 2H); δ_C (101 MHz, $CDCl_3$) 157.2, 155.2, 137.6, 135.3, 128.6, 128.5, 128.4, 128.2, 127.9, 127.7, 73.4, 68.0, 68.0, 66.3, 56.1, 31.9; Chiralcel OD column hexane / *i*-propanol (1 : 1), flow rate = 0.75 mL / min, λ = 258 nm; R_t(major) = 31.10 min, R_t(minor) = 12.91 min.

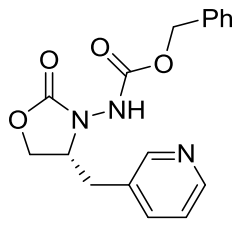
(*R*)-4-(2-(Benzyloxy)ethyl)oxazolidin-2-one (3g)



Synthesised using **General Procedure 2** with **2g** (200 mg, 0.54 mmol) to afford **3g** (5h, 100.3 mg, 84% with Cs_2CO_3; 24h, 98.0 mg, 82% with K_2CO_3) as a colourless oil in 92% ee.

$[\alpha]_D^{20}$ +22.0 (*c* = 1.0, $CHCl_3$); IR (neat) ν_{max} / cm^{-1} 1738 (C=O), 1243 (C–O); HRMS (ESI): *m / z* 222.1119 $[M + H]^+$, $C_{12}H_{16}NO_3$ requires 222.1130; δ_H (300 MHz, $CDCl_3$) 7.38-7.25 (m, 5H), 6.31 (br s, 1H), 4.48 (s, 2H), 4.46 (m, 1H), 4.05-3.95 (m, 2H), 3.56 (t, *J* = 5.7 Hz, 2H), 1.94-1.74 (m, 2H); δ_C (101 MHz, $CDCl_3$) 137.7, 129.7, 128.6, 128.0, 127.7, 73.4, 70.3, 67.6, 52.0, 35.1; Chiralcel OD column hexane / *i*-propanol (7 : 3), flow rate = 1 mL / min, λ = 258 nm; R_t(major) = 8.79 min, R_t(minor) = 9.97 min.

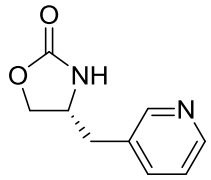
Benzyl (*R*)-(2-oxo-4-(pyridin-3-ylmethyl)oxazolidin-3-yl)carbamate (2h)



Synthesised from 3-(pyridin-3-yl)propanal (328 mg, 2.43 mmol, 1.5 eq.) with dibenzyl azodicarboxylate (90%, 482 mg, 1.46 mmol) and L-proline (17 mg, 0.15 mmol, 0.1 eq.) using **General Procedure 1** to give **2h** (450 mg, 94%) as a colourless oil in 28% ee. A reaction run at 0 °C with L-proline tetrazole raised the ee to 62%.

IR (neat) ν_{max} / cm^{-1} 1777 (C=O), 1718 (C=O), 1215 (C–O); HRMS (ESI): *m / z* 328.1298 $[M + H]^+$, $C_{17}H_{18}N_3O_4$ requires 328.1297; δ_H (400 MHz, $(CD_3)_2CO$) 8.90 (br s, 1H), 8.52 (m, 1H), 8.46 (m, 1H), 7.70 (m, 1H), 7.37 (m, 5H), 7.28 (m, 1H), 5.15 (s, 2H), 4.43 (m, 2H), 4.09 (m, 1H), 3.15 (m, 1H), 2.99 (m, 1H); δ_C (101 MHz, $(CD_3)_2CO$) 157.6, 156.3, 151.4, 149.1, 137.5, 137.3, 132.7, 129.3, 129.0, 128.8, 124.3, 67.8, 67.1, 58.0, 35.4; Chiralcel OD column hexane / *i*-propanol (1 : 1), flow rate = 0.5 mL / min, λ = 258 nm; R_t(major) = 35.74 min, R_t(minor) = 22.58 min.

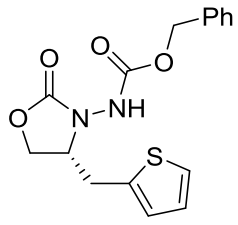
(*R*)-4-(Pyridin-3-ylmethyl)oxazolidin-2-one (3h)



Synthesised using **General Procedure 2** with **2h** (80 mg, 0.25 mmol) to afford **3h** (2h, 39.2 mg, 90% with Cs_2CO_3; 24h, 32.6 mg, 75% with K_2CO_3), but post-reaction filtering through Celite to remove solid material, washing the solid with acetonitrile, removing solvent *in vacuo* and subjecting the residue to column chromatography directly to furnish **3h** as a colourless oil in in 27% ee. The reaction run with the hydrazide from using L-proline tetrazole raised the ee to 61%.

IR (neat) ν_{max} / cm^{-1} 1771 (C=O), 1726 (C=O), 1222 (C–O); HRMS (ESI): *m / z* 179.0819 $[M + H]^+$, $C_9H_{11}N_2O_2$ requires 179.0821; δ_H (400 MHz, $(CD_3)_2CO$) 8.51 (s, 1H), 8.45 (d, *J* = 4.8 Hz, 1H), 7.70 (m, 1H), 7.30 (dd, *J* = 4.8, 7.6 Hz, 1H), 6.81 (br s, 1H), 4.42 (m, 1H), 4.23 (m, 1H), 4.10 (dd, *J* = 5.4, 8.6 Hz, 1H), 2.96 (m, 2H); δ_C (101 MHz, $(CD_3)_2CO$) 159.6, 151.5, 149.0, 137.8, 133.5, 124.4, 69.7, 53.8, 38.9; Chiralcel OD column hexane / *i*-propanol (1 : 1), flow rate = 0.5 mL / min, λ = 258 nm; R_t(major) = 28.57 min, R_t(minor) = 18.95 min.

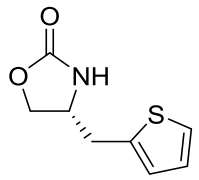
Benzyl (*R*)-(2-oxo-4-(thiophen-2-ylmethyl)oxazolidin-3-yl)carbamate (2i)



Synthesised from 3-(thiophen-2-yl)propanal[1] (210 mg, 1.5 mmol, 1.5 eq.) with dibenzyl azodicarboxylate (90%, 330 mg, 1.00 mmol,) and L-proline (13.0 mg, 0.11 mmol, 0.11 eq.) using **General Procedure 1** to give **2i** (279 mg, 84%) as a colourless oil in 59% ee. A reaction run at 0 °C raised the ee to 85%.

IR (neat) ν_{max} / cm^{-1} 3275 (N–H), 1773 (C=O), 1723 (C=O), 1216 (C–O); HRMS (ESI): *m* / *z* 333.0909 $[M + H]^+$, $C_{16}H_{17}N_2O_4S$ requires 333.0909; δ_H (400 MHz, $CDCl_3$) 7.35 (m, 5H), 7.18 (dd, *J* = 1.2, 5.2 Hz, 1H), 7.15 (br s, 1H), 6.94 (dd, *J* = 3.6, 5.2 Hz, 1H), 6.82 (m, 1H), 5.18 (m, 2H), 4.44-4.21 (m, 2H), 4.06 (m, 1H), 3.28 (dd, *J* = 4.2, 15.0 Hz, 1H), 3.05 (m, 1H); δ_C (101 MHz, $CDCl_3$) 157.0, 155.3, 136.6, 135.2, 128.6, 128.5, 128.2, 127.2, 126.5, 124.9, 68.1, 66.8, 57.3, 31.8; Chiralcel OD Column hexane / *i*-propanol (7 : 3), flow rate = 1 mL / min, λ = 258 nm; R_t(major) = 16.16 min, R_t(minor) = 13.78 min.

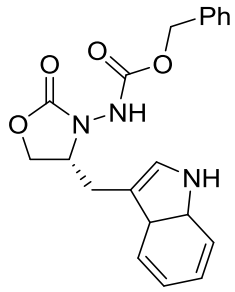
(*R*)-4-(Thiophen-2-ylmethyl)oxazolidin-2-one (3i)



Synthesised using **General Procedure 2** with **2i** (86 mg, 0.26 mmol) to afford **3i** (6h, 38 mg, 81% with Cs_2CO_3; 24h, 38 mg, 81% with K_2CO_3) as a colourless oil in 62 % ee. The sample from the 0 °C run gave an ee of 88%.

IR (neat) ν_{max} / cm^{-1} 3254 (N–H), 2918 (C–H), 1720 (C=O), 1234 (C–O); HRMS (ESI): *m* / *z* 184.0823 $[M + H]^+$, $C_8H_{10}NO_2S$ requires 184.0432; δ_H (400 MHz, $CDCl_3$) 7.20 (dd, *J* = 1.0, 5.0 Hz, 1H), 6.97 (dd, *J* = 3.6, 5.2 Hz, 1H), 6.87 (m, 1H), 6.03 (br s, 1H), 4.47 (m, 1H), 4.13 (m, 2H), 3.09 (m, 1H); δ_C (101 MHz, $CDCl_3$) 159.3, 137.6, 127.3, 126.4, 124.9, 69.3, 53.6, 35.5; Chiralcel OD Column hexane / *i*-propanol (9 : 1), flow rate = 0.5 mL / min, λ = 258 nm; R_t(major) = 53.30 min, R_t(minor) = 51.21 min.

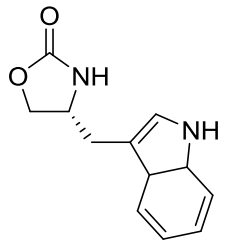
Benzyl ((4*R*)-4-((3a,7a-dihydro-1*H*-indol-3-yl)methyl)-2-oxooxazolidin-3-yl)carbamate (2j)



Synthesised from 3-(3a,7a-dihydro-1*H*-indol-3-yl)propanal[2,3] (395 mg, 2.26 mmol, 1.5 eq.) with dibenzyl azodicarboxylate (90%, 495 mg, 1.5 mmol) and L-proline (19 mg, 0.17 mmol, 0.1 eq.) using **General Procedure 1** to give **2j** (450 mg, 82%) as a colourless oil in 85% ee.

$[\alpha]_D^{20}$ –24.9 (*c* = 1.0, $CHCl_3$); IR (neat) ν_{max} / cm^{-1} 3309 (N–H), 2920 (C–H), 1765 (C=O), 1704 (C=O), 1217 (C–O); HRMS (ESI): *m* / *z* 366.1452 $[M + H]^+$, $C_{20}H_{20}N_3O_4$ requires 366.1454; δ_H (300 MHz, $CDCl_3$) 8.26 (br s, 1H) 7.50-6.95 (m, 10H), 5.15 (s, 2H), 4.45-4.22 (m, 2H), 4.04 (m, 1H), 3.23 (m, 1H), 2.94 (m, 1H); δ_C (101 MHz, $CDCl_3$) 157.6, 155.4, 136.2, 135.3, 128.6, 128.4, 128.2, 127.2, 122.8, 122.3, 119.7, 118.1, 111.5, 108.8, 68.1, 67.4, 56.8, 27.2; Chiralpak AD Column hexane / *i*-propanol (7 : 3), flow rate = 1 mL / min, λ = 258 nm; R_t(major) = 10.85 min, R_t (minor) = 9.25 min.

(4*R*)-4-((3a,7a-Dihydro-1*H*-indol-3-yl)methyl)oxazolidin-2-one (3j)

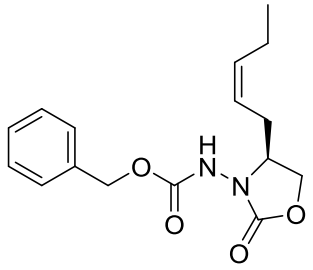


Synthesised using **General Procedure 2** with **2j** (90.2 mg, 0.25 mmol) to afford **3j** (2h, 40.0 mg, 76% with Cs_2CO_3; 24h, 42.0 mg, 78% with K_2CO_3) as a colourless oil in in 84% ee.

$[\alpha]_D^{20}$ +31.8 (*c* = 1.0, $CHCl_3$); IR (neat) ν_{max} / cm^{-1} 3279 (N–H), 2920 (C–H), 1724 (C=O), 1237 (C–O); HRMS (ESI): *m* / *z* 217.0976 $[M + H]^+$, $C_{12}H_{13}N_2O_2$ requires 217.0977; δ_H (300 MHz, $CDCl_3$) 8.36 (br s, 1H), 7.55 (d, *J* = 7.8 Hz, 1H), 7.38 (d, *J* = 7.8 Hz, 1H), 7.22 (m, 1H), 7.14 (m, 1H), 7.04 (s, 1H), 5.72 (br s, 1H), 4.45 (m, 1H), 4.22-4.12 (m, 2H), 2.99 (d, *J* = 6.3 Hz, 2H); δ_C (101 MHz, $CDCl_3$) 159.4, 136.4, 127.0, 122.7, 122.5, 119.8, 118.3, 111.5, 110.2, 70.0, 52.9, 31.3; Chiralcel OD Column hexane / *i*-propanol (1 : 1), flow rate = 0.5 mL / min, λ = 258 nm; R_t(major) = 14.75 min, R_t(minor) = 20.03 min.

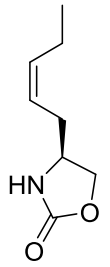
PART II: Synthesis of the Iminosugars **6a** and **6b**.

Benzyl (*S*,*Z*)-(2-oxo-4-(pent-2-en-1-yl)oxazolidin-3-yl)carbamate (2e)



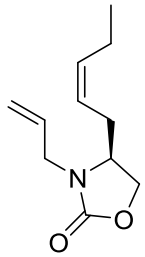
To a suspension of (*Z*)-hept-4-enal (4.80 mL, 36.4 mmol, 1.67 eq.) and catalytic D-proline (280 mg, 2.43 mmol, 0.1 eq.) in acetonitrile (100 mL) was added dibenzyl azodicarboxylate (90%, 7.23 g, 21.8 mmol) at 0 °C. The mixture was allowed to stir for 30 minutes prior to being warmed to room temperature and left to stir until the solution had decolourized. Methanol (50 mL) followed by sodium borohydride (917 mg, 24.2 mmol, 1.11 eq.) was added at 0 °C and the reaction left to stir for 15 minutes before freshly-made sodium hydroxide was added (1M, 72.7 mL, 72.7 mmol, 3.33 eq.). The reaction was then left to warm to room temperature and stirred for an additional 3 hours before being quenched with saturated ammonium chloride solution (100 mL) and the solution concentrated under reduced pressure before the product was extracted into ethyl acetate (3 x 150 mL). The combined organic layers were then washed with brine (50 mL), dried over magnesium sulfate and concentrated. The crude residue was chromatographed on silica gel with an ethyl acetate / hexane mixture to afford **2e** as a viscous, colourless oil (6.54 g, 21.5 mmol, 99%) in 88% ee with spectroscopic data identical to that of the small-scale reaction product.

(*S*,*Z*)-4-(Pent-2-en-1-yl)oxazolidin-2-one (3e)



Potassium carbonate (1.14 g, 8.2 mmol, 2.5 eq.) followed by diethyl bromomalonate (1.12 mL, 6.6 mmol, 2.0 eq.) was added to a solution of carbamate 11 (1.00 g, 3.29 mmol, 1.0 eq.) in dry acetonitrile (20 mL) at 0 °C. The reaction was then allowed to warm to room temperature and stirred for 24 hours before being quenched with ammonium chloride (20 mL) and extracted with ethyl acetate (3 x 60 mL). The combined organic extracts were washed with brine (20 mL), dried over magnesium sulfate and concentrated under reduced pressure before being flash chromatographed on silica gel using ethyl acetate / hexane mixtures as eluent to yield 3e as a colourless oil (326 mg, 2.1 mmol, 64%) with spectroscopic data identical to that of the small-scale reaction product.

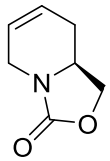
(*S*,*Z*)-3-Allyl-4-(pent-2-en-1-yl)oxazolidin-2-one (4)



Sodium hydride (60% in oil, 697 mg, 17.41 mmol, 1.5 eq.) was added in portions over 30 minutes to a solution of **3e** (1.80 g, 11.61 mmol) in dry THF (50 mL) at 0 °C and allowed to stir at room temperature for a further 30 minutes before allyl bromide (1.50 mL, 17.4 mmol, 1.5 eq.) was syringed into the reaction mixture. The reaction was then refluxed overnight and left to cool before a 50% mixture of THF / water (20 mL) was added slowly. Saturated ammonium chloride solution (50 mL) was then added and the solution concentrated under reduced pressure before the product was extracted into ethyl acetate (3 x 150 mL). The combined organic layers were washed with brine (50 mL), dried over magnesium sulfate, concentrated in vacuo and purified via flash column chromatography on silica gel using ethyl acetate / hexane mixtures as eluent to yield **4** as a colourless oil (1.85 g, 9.49 mmol, 82%).

$[\alpha]_D^{20}$ +12.8 (*c* = 1.0, $CHCl_3$); IR (neat) ν_{max} / cm^{-1} 2964 (C–H), 1740 (C=O), 1250 (C–O), 1068 (C–N); HRMS (ESI): *m / z* 196.1329 $[M + H]^+$, $C_{11}H_{18}NO_2$ requires 196.1338; δ_H (400 MHz, $CDCl_3$) 5.80-5.70 (m, 1H), 5.60-5.52 (m, 1H), 5.26-5.14 (m, 3H), 4.28 (m, 1H), 4.13 (m, 1H), 3.91 (m, 1H), 3.82-3.76 (m, 1H), 3.62-3.56 (m, 1H), 2.45-2.38 (m, 1H), 2.25-2.17 (m, 1H), 2.06-1.98 (m, 2H), 0.95 (3H, t, *J* = 7.5 Hz, 3H); δ_C (101 MHz, $CDCl_3$) 157.9, 136.3, 132.2, 120.8, 118.4, 66.7, 54.2, 44.7, 29.4, 20.7, 13.9.

(*S*)-1,5,8,8a-Tetrahydro-3*H*-oxazolo[3,4-*a*]pyridin-3-one (5)[9]

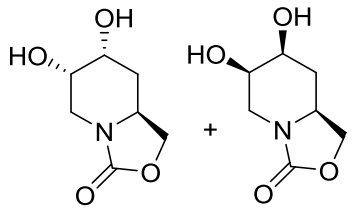


Allylated oxazolidinone **4** (500 mg, 2.56 mmol) was dissolved in dry, deoxygenated DCM (12 mL) followed by the addition of the first-generation Grubbs' catalyst (63 mg, 0.1 mmol, 0.04 eq.) in one portion. The reaction mixture was then refluxed for 2 hours during which the colour of the solution changed from purple to brown. The mixture was concentrated under reduced pressure and the residue purified directly via flash column chromatography on silica gel using ethyl acetate / hexane mixtures as eluent to yield the bicycle **5** as a pale-brown oil (354 mg, 2.51 mmol, 98%).

$[\alpha]_D^{20}$ –186.3 (*c* = 1.0, $CHCl_3$); IR (neat) ν_{max} / cm^{-1} 2908 (C–H), 1734 (C=O), 1238 (C–O), 1070 (C–N); HRMS (ESI): *m / z* 140.0710 $[M + H]^+$, $C_7H_9NO_2$ requires 140.0712; δ_H (400 MHz, $CDCl_3$) 5.82-5.70 (m, 2H), 4.47 (t, *J* = 8.2 Hz, 1H), 4.12-4.05 (m, 1H), 3.98 (dd, *J* = 5.4, 8.6 Hz, 1H), 3.82-3.75 (m, 1H), 3.69-3.62 (m, 1H), 2.30-2.23 (m, 1H), 2.19-2.09 (m, 1H); δ_C (101 MHz, $CDCl_3$) 157.3, 123.8, 123.2, 68.8, 50.1, 40.9, 29.5.

(6*S*,7*R*,8a*S*)-6,7-Dihydroxyhexahydro-3*H*-oxazolo[3,4-*a*]pyridin-3-one (6a)

(6*R*,7*S*,8a*S*)-6,7-Dihydroxyhexahydro-3*H*-oxazolo[3,4-*a*]pyridin-3-one (6b)



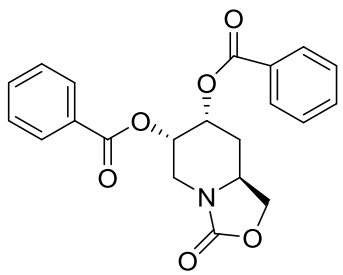
allo- **6a** 4 : 1 *manno-* **6b**

To a solution of cyclized intermediate **5** (350 mg, 2.48 mmol) in a 10% mixture of water / acetonitrile (32 mL) was added *N*-methylmorpholine *N*-oxide (589 mg, 5.0 mmol, 2 eq.) and osmium tetroxide (32 mg, 0.1 mmol, 0.04 eq.) at 0 °C. The reaction was stirred at 0 °C for 10 minutes and then warmed to room temperature and stirred for an additional 3 hours before being quenched with saturated sodium sulfite solution (3 mL). Toluene was then added to the reaction mixture and the mixture concentrated under reduced pressure; this process was repeated a further four times to azeotropically remove the water. The residue was then filtered through a pad of Celite®, rinsed thoroughly with methanol (50 mL) and the filtrate concentrated under vacuum and purified on silica gel using methanol / DCM mixtures as eluent to yield major diol **6a** (275 mg, 1.59 mmol, 64%) and minor diol **6b** (67 mg, 0.39 mmol, 16%) as white solids which were separated in a 4 : 1 ratio.

6a: M.p. 127-129 ˚C (from ethyl acetate / hexane); $[\alpha]_D^{20}$ –57.3 (*c* = 1.0, MeOH); IR (neat) ν_{max} / cm^{-1} 3397 (O–H), 2917 (C–H), 1722 (C=O), 1243 (C–O), 1086 (C–N); (Found C, 48.65; H, 6.40; N, 8.08%; $C_7H_{11}NO_4$ requires C, 48.55; H, 6.40; N, 8.09%); δ_H (400 MHz, $(CD_3)_2SO$) 4.93 (d, *J* = 4.9 Hz, 1H), 4.69 (d, *J* = 3.0 Hz, 1H), 4.33 (t, *J* = 8.1 Hz, 1H), 3.94-3.86 (m, 2H), 3.84 (dd, *J* = 5.1, 8.3 Hz, 1H), 3.44-3.35 (m, 2H), 2.97-2.90 (m, 1H), 1.85 (dt, *J* = 4.0, 13.3 Hz, 1H), 1.49 (m, 1H); δ_C (101 MHz, $(CD_3)_2SO$) 156.5, 67.0, 66.9, 66.5, 47.9, 41.4, 35.5.

6b: δ_H (300 MHz, $(CD_3)_2SO$) 4.69 (d, *J* = 6.2 Hz, 1H), 4.56 (d, *J* = 3.3 Hz, 1H), 4.32 (t, *J* = 8.3 Hz, 1H), 3.86 (dd, *J* = 5.4, 8.3 Hz, 1H), 3.81-3.72 (m, 1H), 3.68-3.64 (m, 1H), 3.57 (dd, *J* = 2.5, 13.6 Hz, 1H), 3.60-3.51 (m, 1H), 2.95 (dd, *J* = 1.8, 13.6 Hz, 1H), 1.72-1.58 (m, 2H).

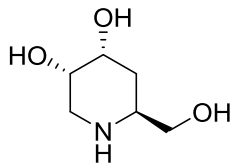
(6*S*,7*R*,8a*S*)-3-Oxohexahydro-3*H*-oxazolo[3,4-*a*]pyridine-6,7-diyl dibenzoate (7)



Excess benzoyl chloride (0.22 mL, 1.9 mmol, 3.0 eq.) was added to a solution of diol **6a** (100 mg, 0.58 mmol) in anhydrous pyridine (5 mL) at 0 °C. The reaction was left to stir at room temperature for 24 hours before being acidified with cold 3M hydrochloric acid, the product extracted into ethyl acetate (3 x 30 mL) and the combined organic layers washed with saturated sodium carbonate solution (10 mL). The organic layer was then dried over magnesium sulfate, concentrated in vacuo and purified via flash column chromatography on silica gel using ethyl acetate / hexane mixtures as eluent to yield dibenzoate **7** (212 mg, 0.56 mmol, 96%) as a white solid in 90% ee.

M.p. 213-214 ˚C (from ethyl acetate / hexane); $[\alpha]_D^{20}$ –170.1 (*c* = 1.0, $CHCl_3$); IR (neat) ν_{max} / cm^{-1} 1717 (C=O), 1173 (C–O); (Found C, 65.87; H, 5.12; N, 3.45%; $C_{21}H_{19}NO_6$ requires C, 66.14; H, 5.02; N, 3.67%); δ_H (400 MHz, $CDCl_3$) 8.07-8.04 (m, 2H), 7.91-7.88 (m, 2H), 7.65-7.60 (m, 1H), 7.54-7.47 (m, 3H), 7.37-7.33 (m, 2H), 5.86-5.84 (m, 1H), 5.24-5.19 (m, 1H), 4.50 (t, *J* = 8.2 Hz, 1H), 4.24-4.13 (m, 2H), 4.01 (dd, *J* = 5.6, 8.7 Hz, 1H), 3.53-3.47 (m, 1H), 2.37 (dt, *J* = 3.9, 14.2 Hz, 1H), 1.98-1.91 (m, 1H); δ_C (101 MHz, $CDCl_3$) 165.3, 165.1, 156.7, 133.5, 133.3, 129.7, 129.6, 129.6, 129.2, 128.7, 128.4, 67.9, 67.9, 67.3, 49.0, 39.9, 33.6; Chiralcel OD Column hexane / *i*-propanol (8.5 : 1.5), flow rate = 0.75 mL / min, λ = 258 nm; R_t(major) = 24.27 min, R_t(minor) = 23.66 min.

(3*S*,4*R*,6*S*)-6-(Hydroxymethyl)piperidine-3,4-diol (8)[10]



Potassium hydroxide (49 mg, 0.87 mmol, 5 eq.) was added to a solution of diol **6a** (30.4 mg, 0.176 mmol) in ethanol at room temperature and then refluxed for 12 hours before being allowed to cool and concentrated under reduced pressure. The crude mixture was then purified on a propylsulfonic acid SiliaPrep™ SPE cartridge by eluting with methanol followed by ammonia solution (2M in methanol) and the fractions then combined and concentrated. The residue was then dried thoroughly under a high pressure vacuum before dry *i*-propanol was added, the insoluble materials removed via filtration through a plug of cotton wool and the filtrate concentrated under reduced pressure to give iminosugar **8** (23.0 mg, 0.156 mmol, 89%) as a colourless solid.

M.p. 162-166 ˚C; $[\alpha]_D^{20}$ +57.8 (*c* = 1.0, H_2O); IR (neat) ν_{max} / cm^{-1} 3410 (O–H), 3277 (N–H), 1136 (C–O); δ_H (400 MHz, D_2O) 4.09 (m, 1H), 3.68 (ddd, *J* = 2.8, 5.0, 10.8 Hz, 1H), 3.53 (dd, *J* = 4.8, 11.3 Hz, 1H), 3.44 (dd, *J* = 6.9, 11.3 Hz, 1H), 2.92 (m, 1H), 2.88 (m, 1H), 2.77 (t, *J* = 11.3 Hz, 1H), 1.83 (ddd, *J* = 3.4, 4.5, 14.7 Hz, 1H), 1.44 (ddd, *J* = 2.7, 11.7, 14.0 Hz, 1H); δ_C (101 MHz, D_2O) 71.5, 70.1, 67.6, 53.1, 47.4, 36.0. This data is in agreement with the literature data.[10]

References

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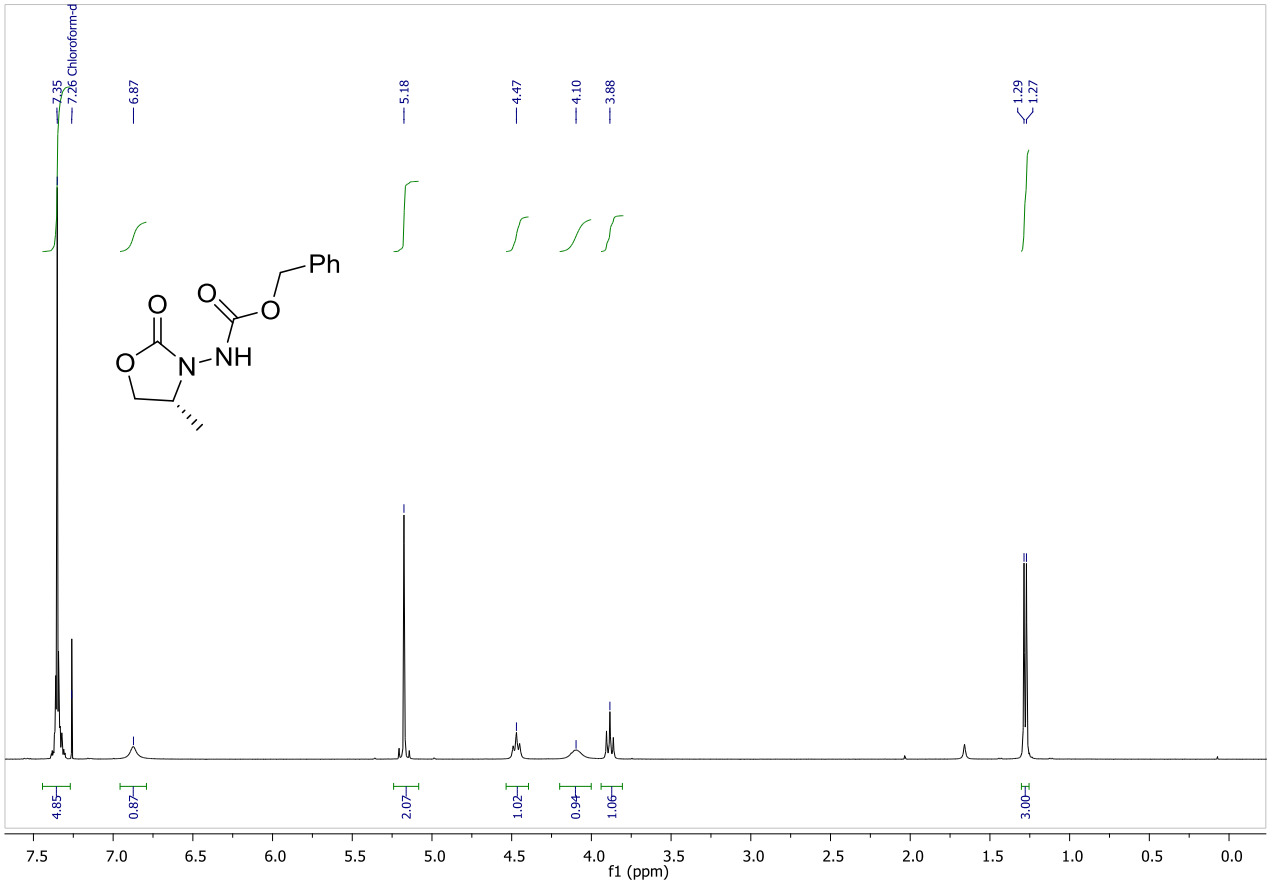
2a ^{1}H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6.87
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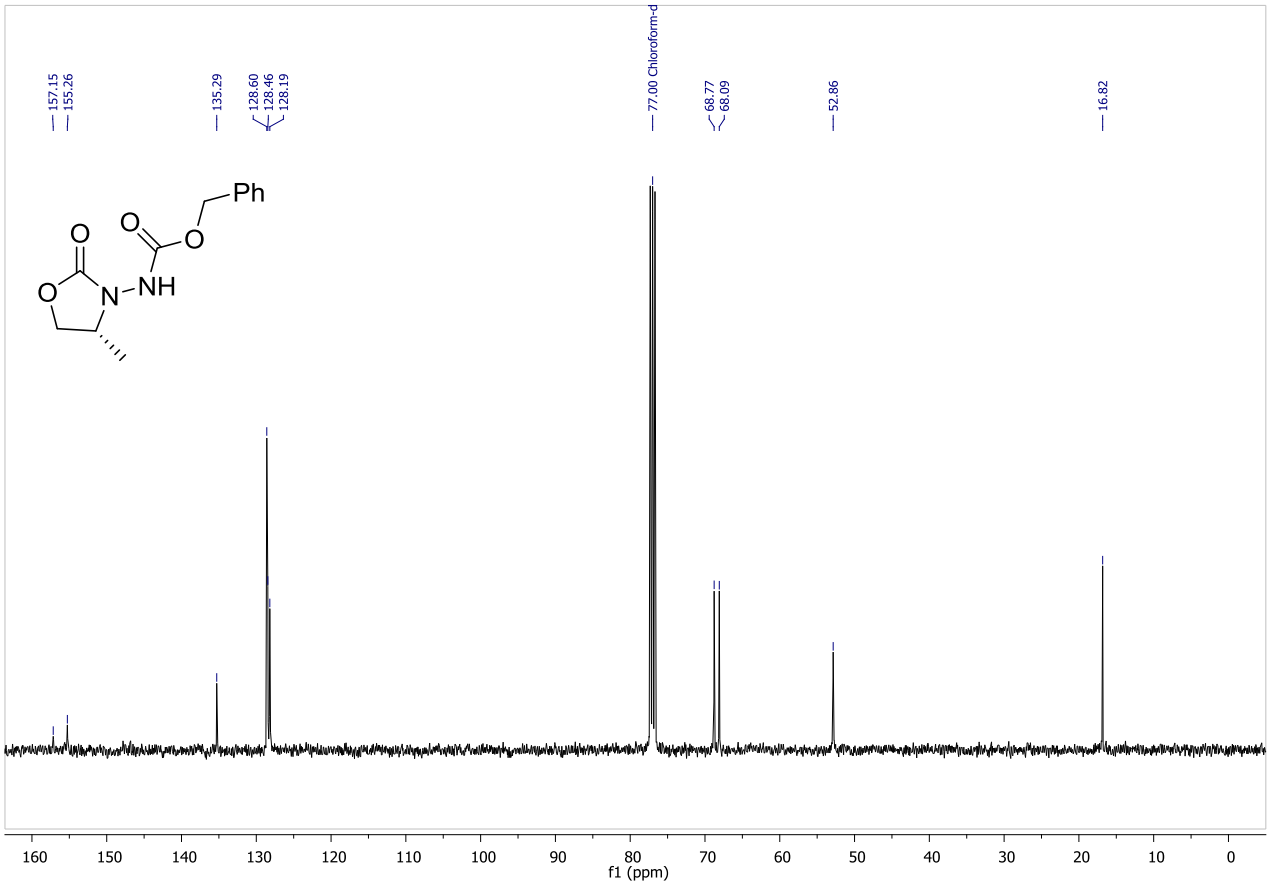
4.47
4.10
3.88
1.29
1.27
Ph
O
O
O
N
NH
4.85
0.87
2.07
1.02
0.94
1.06
3.00
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

2a ^{13}C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155.26
135.29
128.60
128.46
128.19
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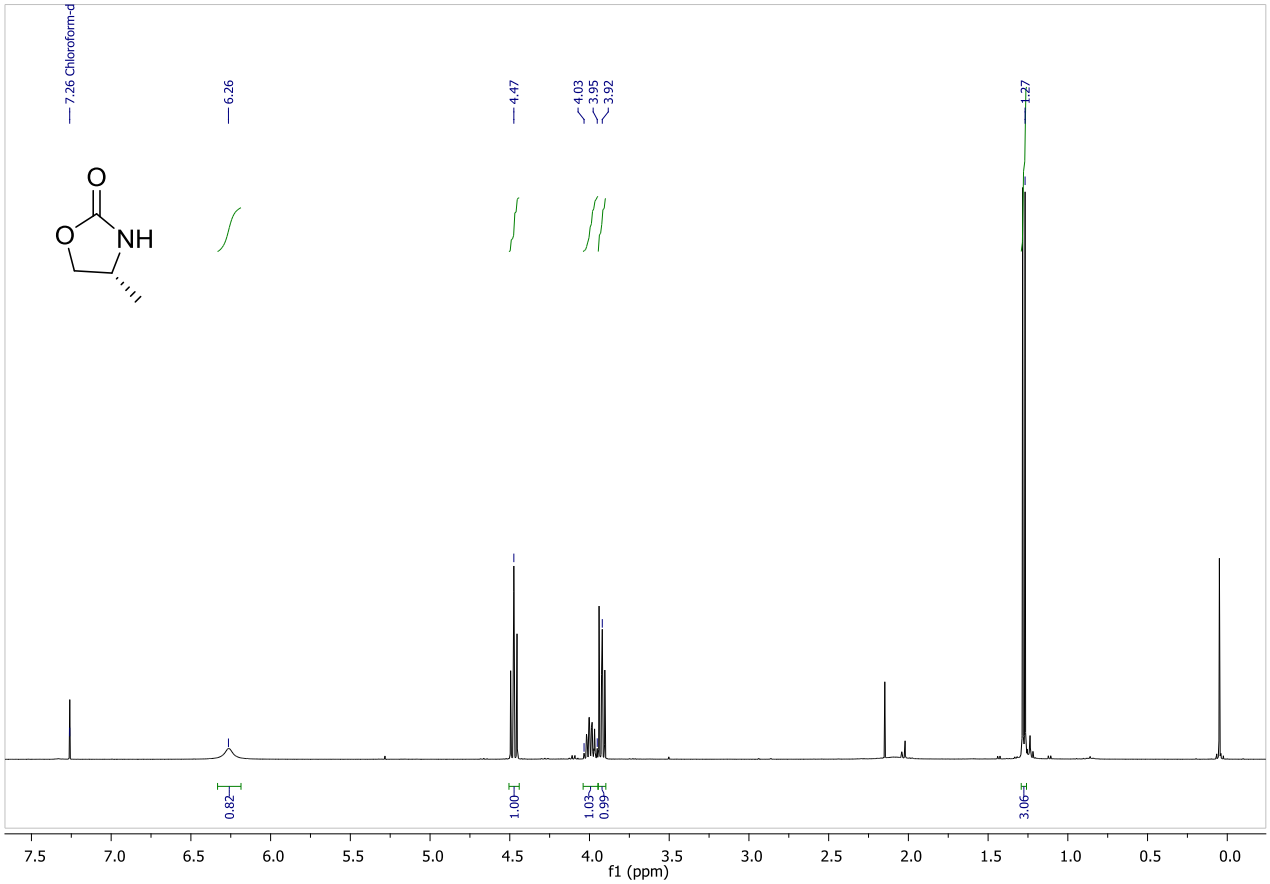
68.77
68.09
52.86
16.82
Ph
O
O
O
N
NH
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

3a ^{1}H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4.47
4.03
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3.92
1.27
O
O
NH
0.82
1.00
1.03
0.99
3.06
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
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3.0
2.5
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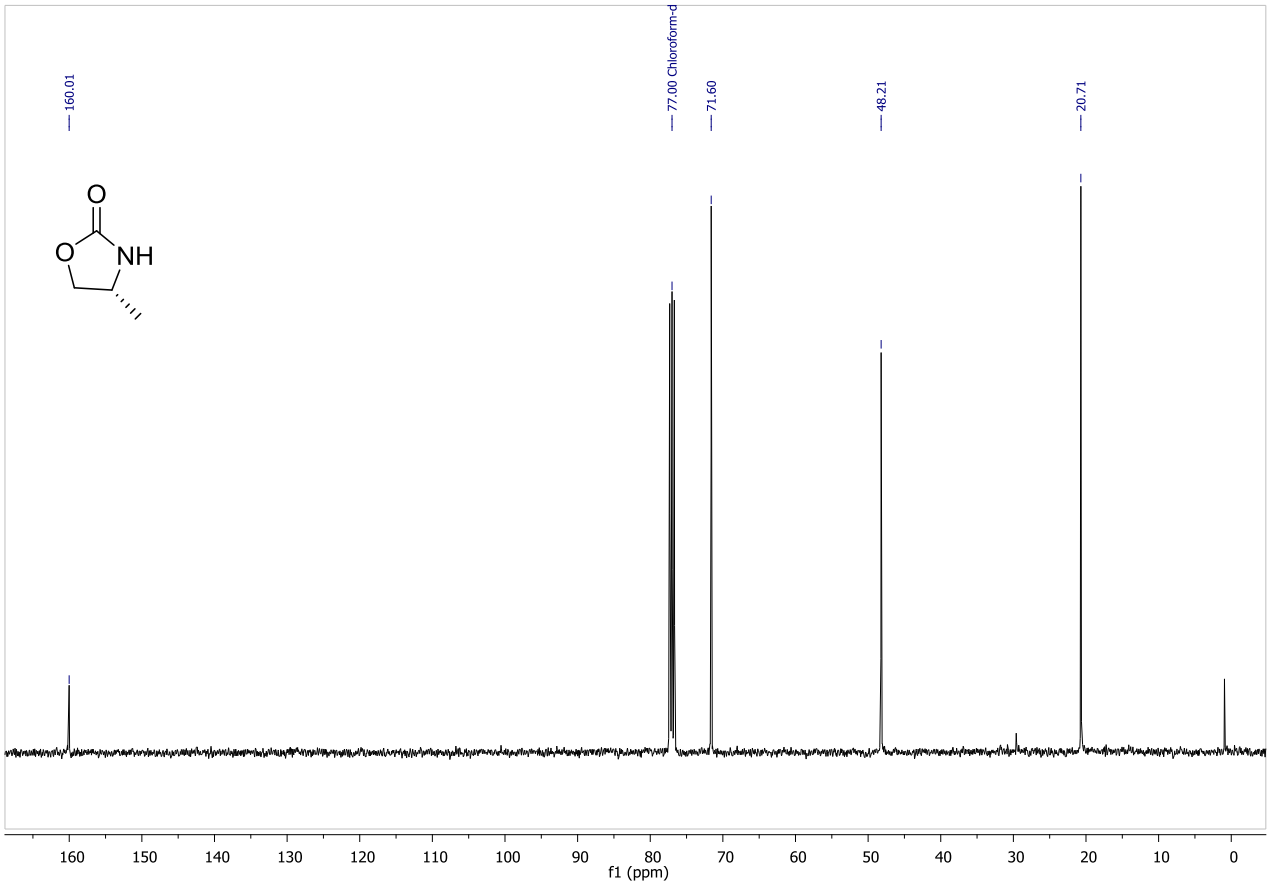
1.0
0.5
0.0
f1 (ppm)

3a ^{13}C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20.71
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NH
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140
130
120
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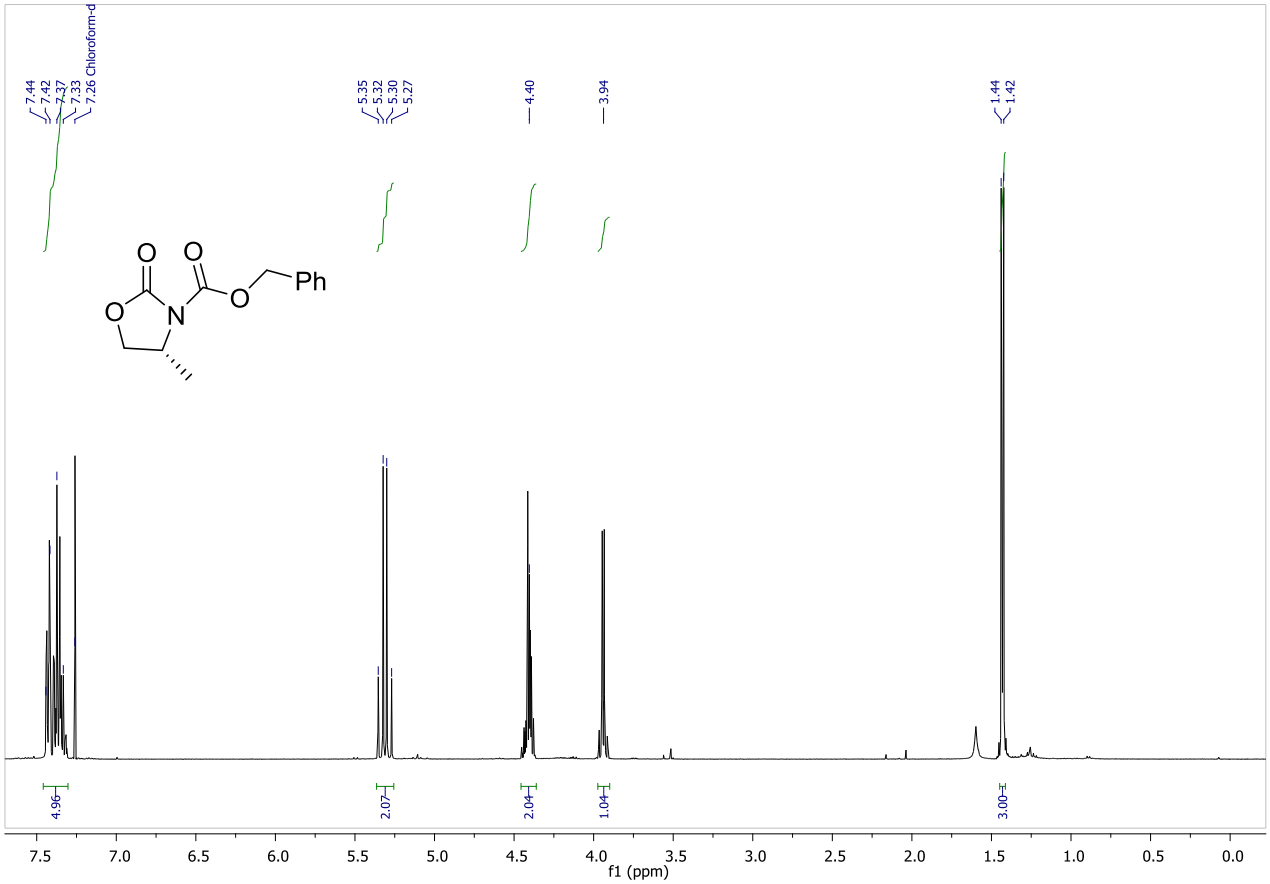
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

3_{Cbz}a ^{1}H



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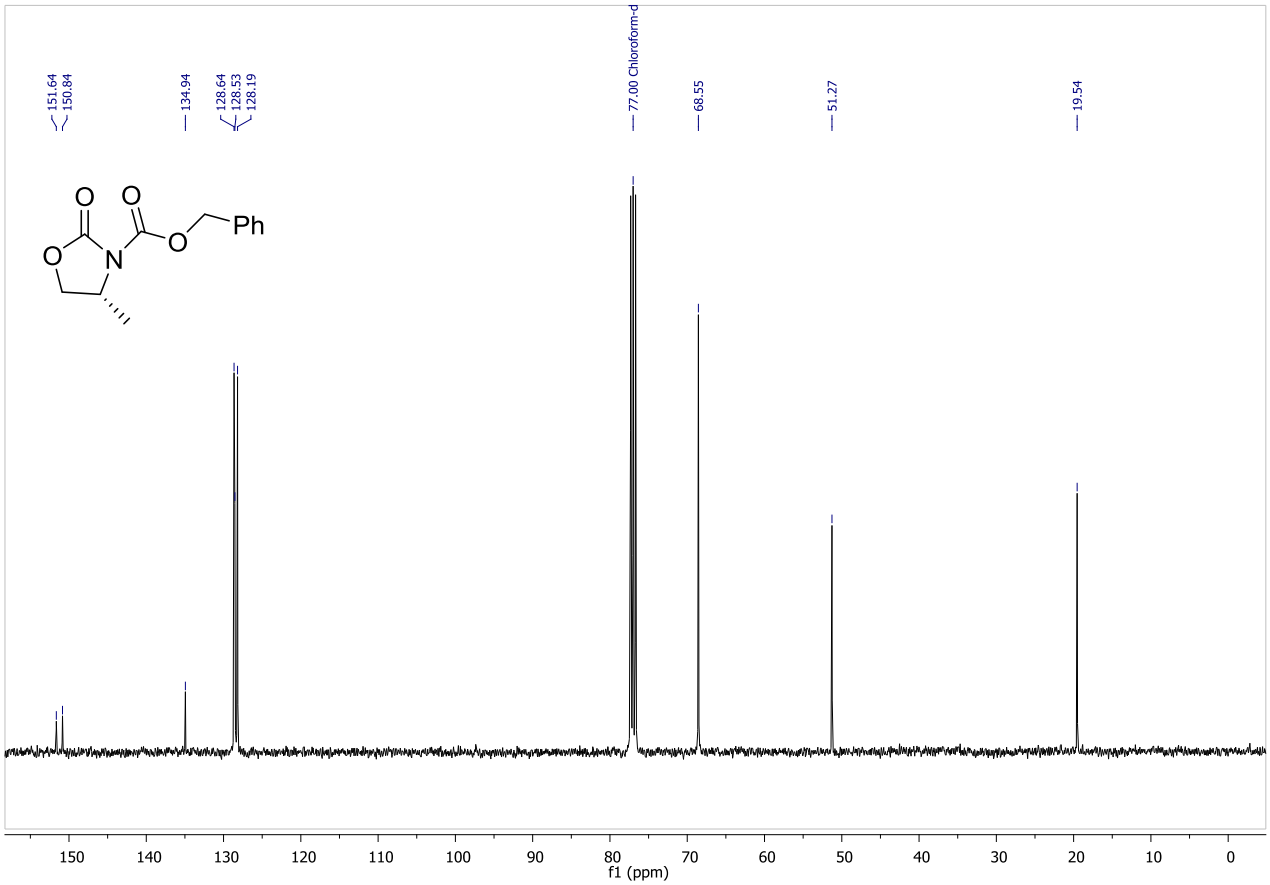
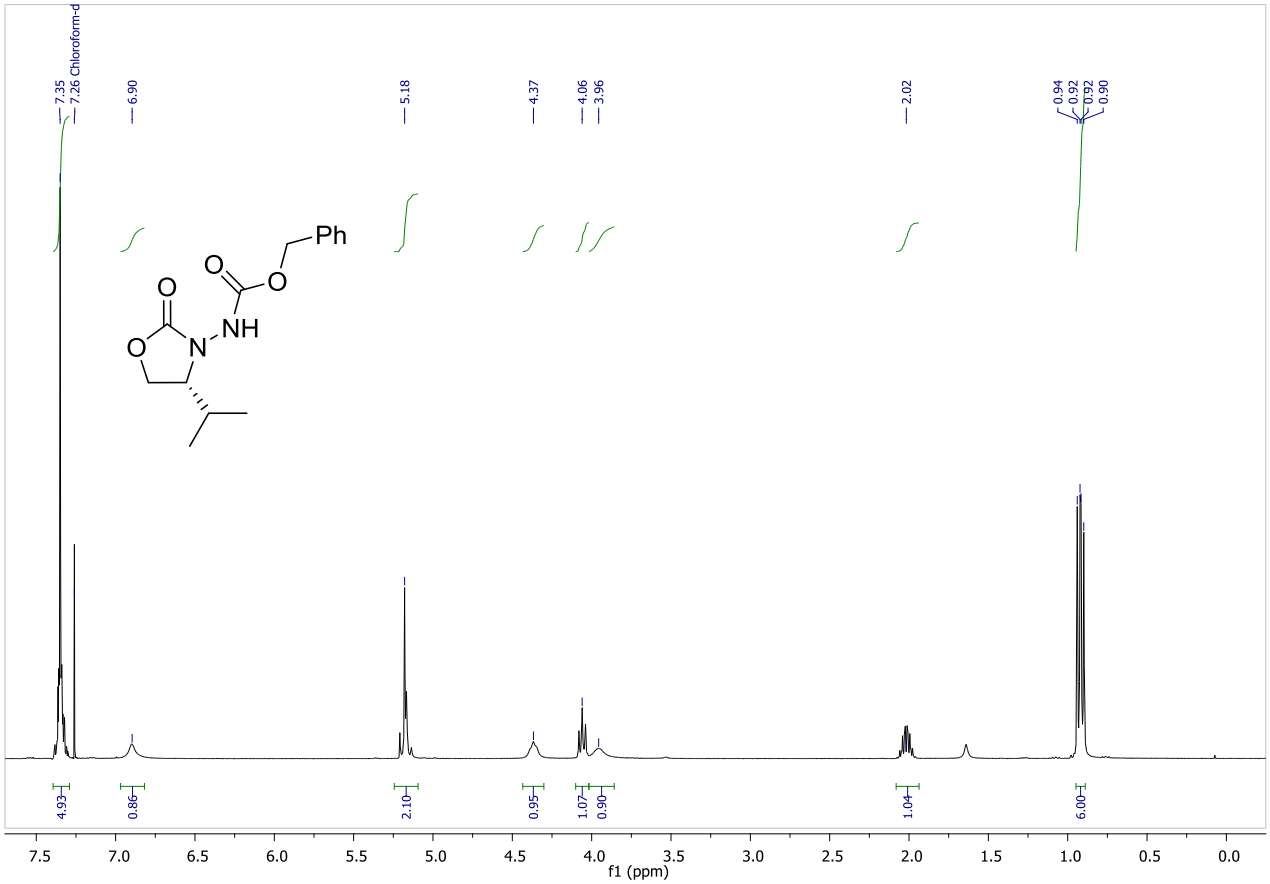


2b ^{1}H


7.35
7.26 Chloroform-d
6.90
5.18
4.37
4.06
3.96
2.02
0.94
0.92
0.92
0.90
Ph
O
O
O
NH
N
O
4.93
0.86
2.10
0.95
1.07
0.90
1.04
6.00
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
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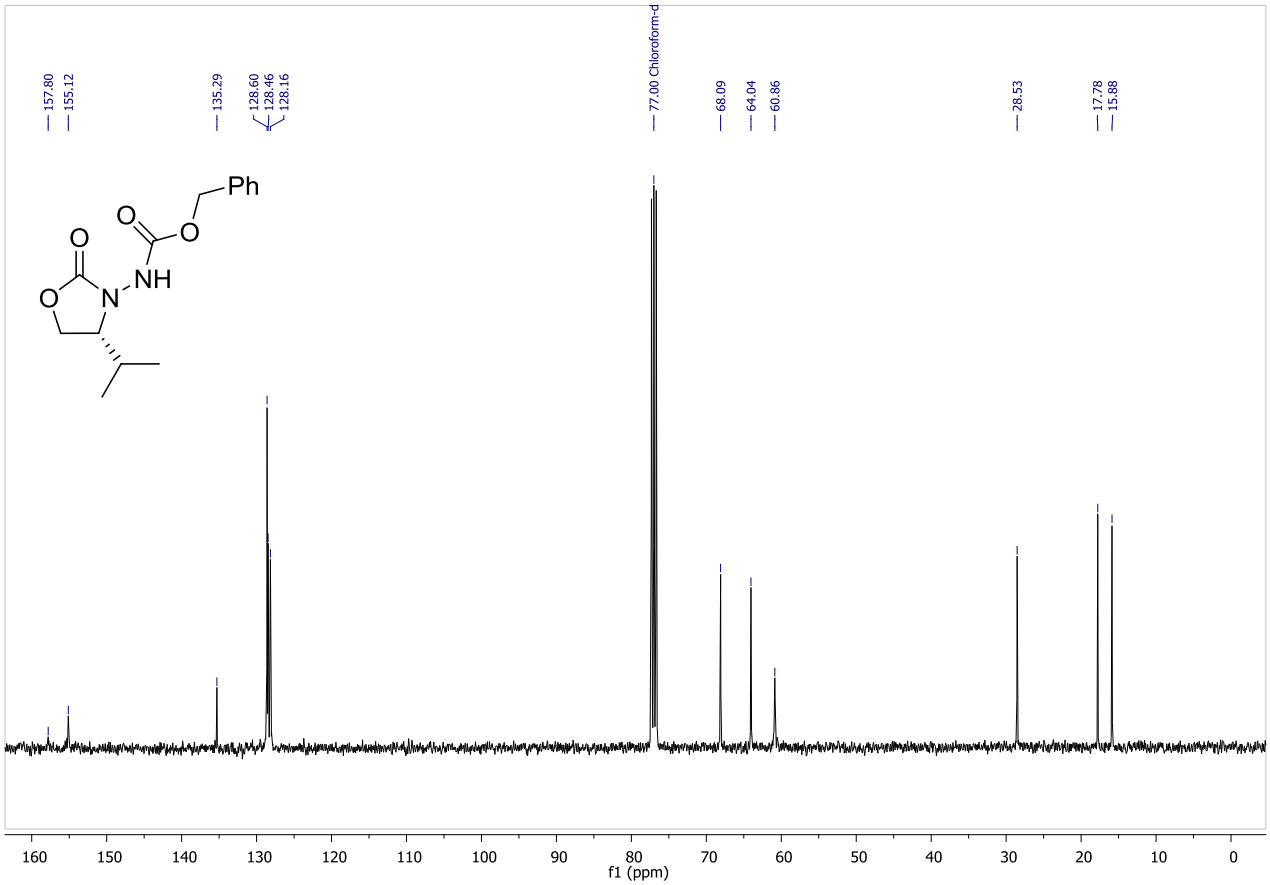
1.5
1.0
0.5
0.0
f1 (ppm)

2b ^{13}C


157.80
155.12
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128.60
128.46
128.16
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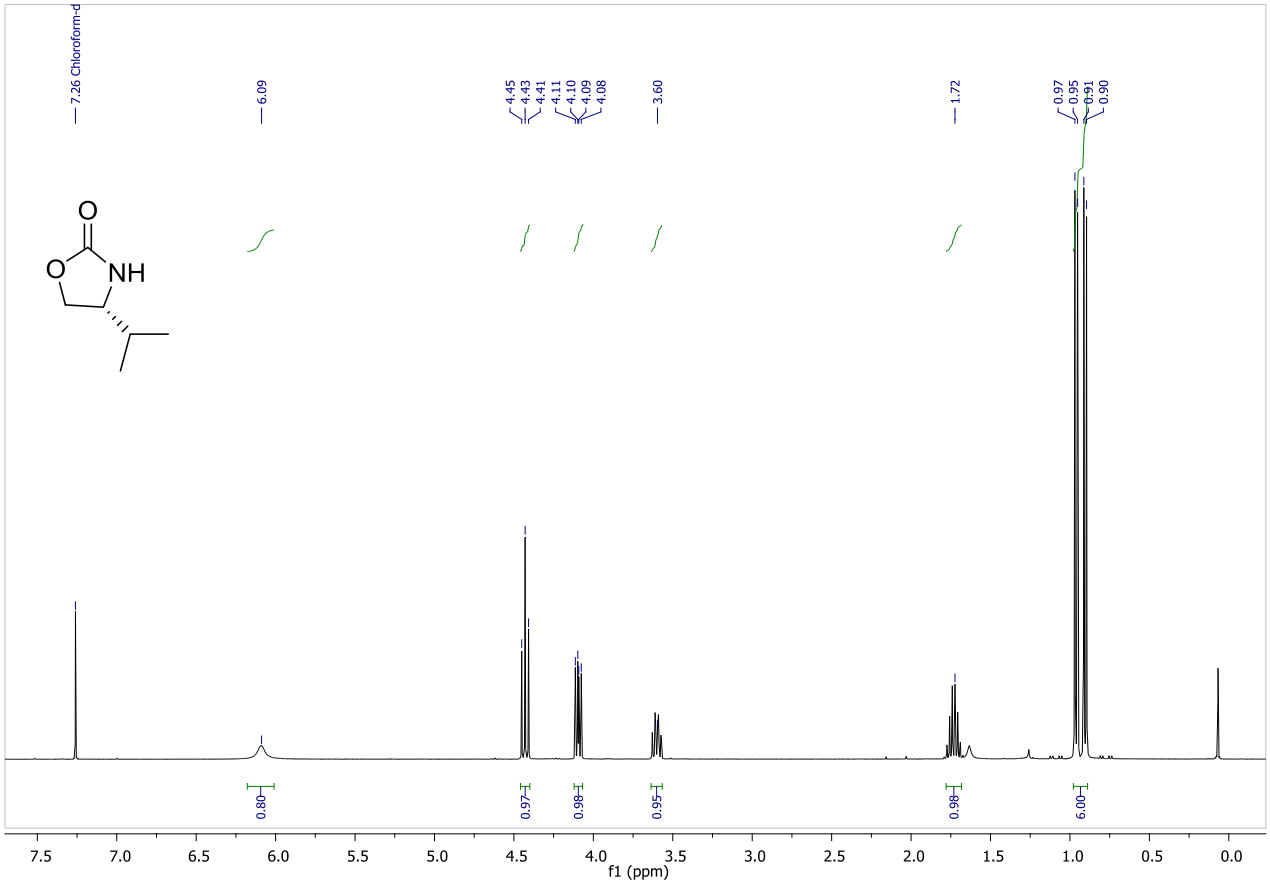
64.04
60.86
28.53
17.78
15.88
Ph
O
O
O
NH
N
O
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

3b ^{1}H


7.26 Chloroform-d
6.09
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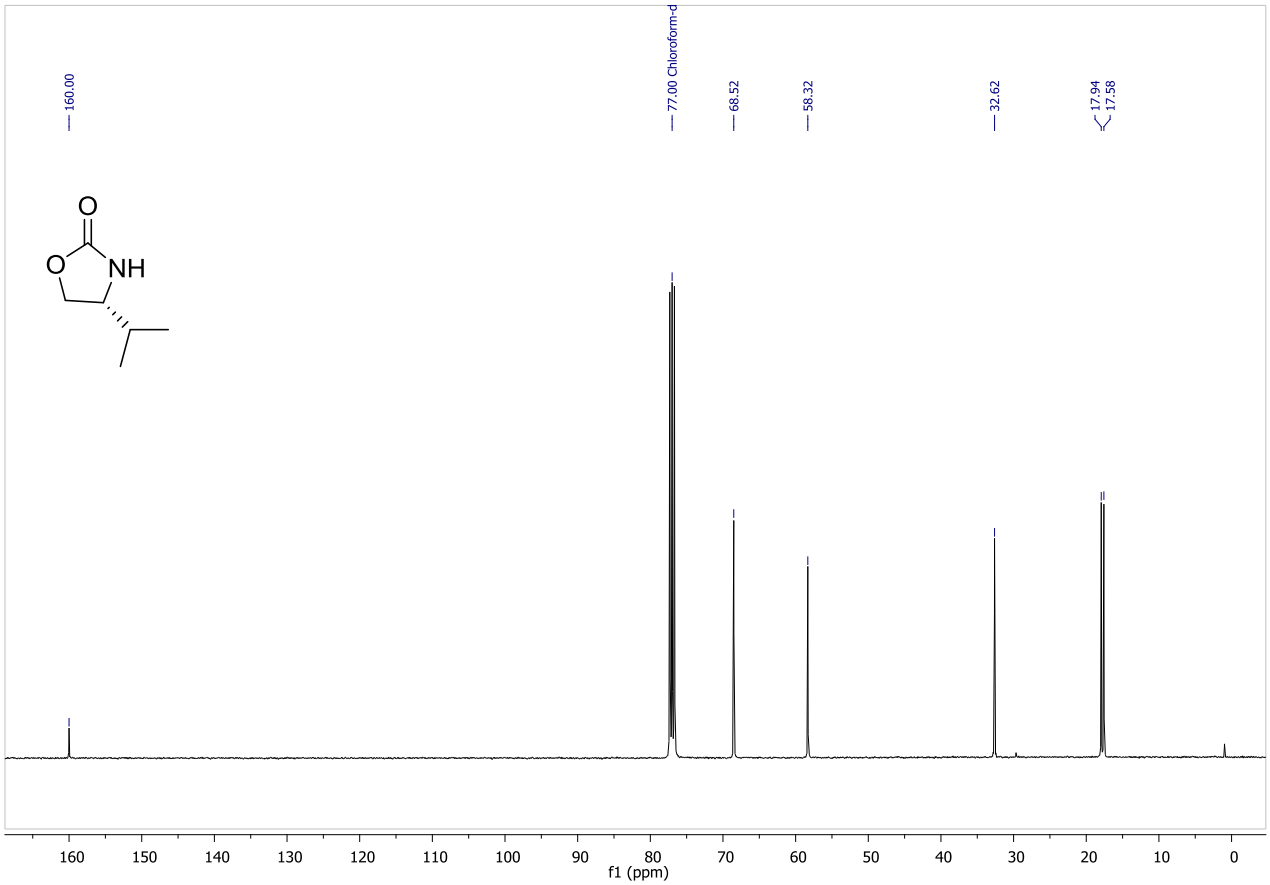
4.43
4.41
4.11
4.10
4.09
4.08
3.60
1.72
0.97
0.95
0.91
0.90
O
O
NH
0.80
0.97
0.98
0.95
0.98
6.00
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

3b ^{13}C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32.62
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17.58
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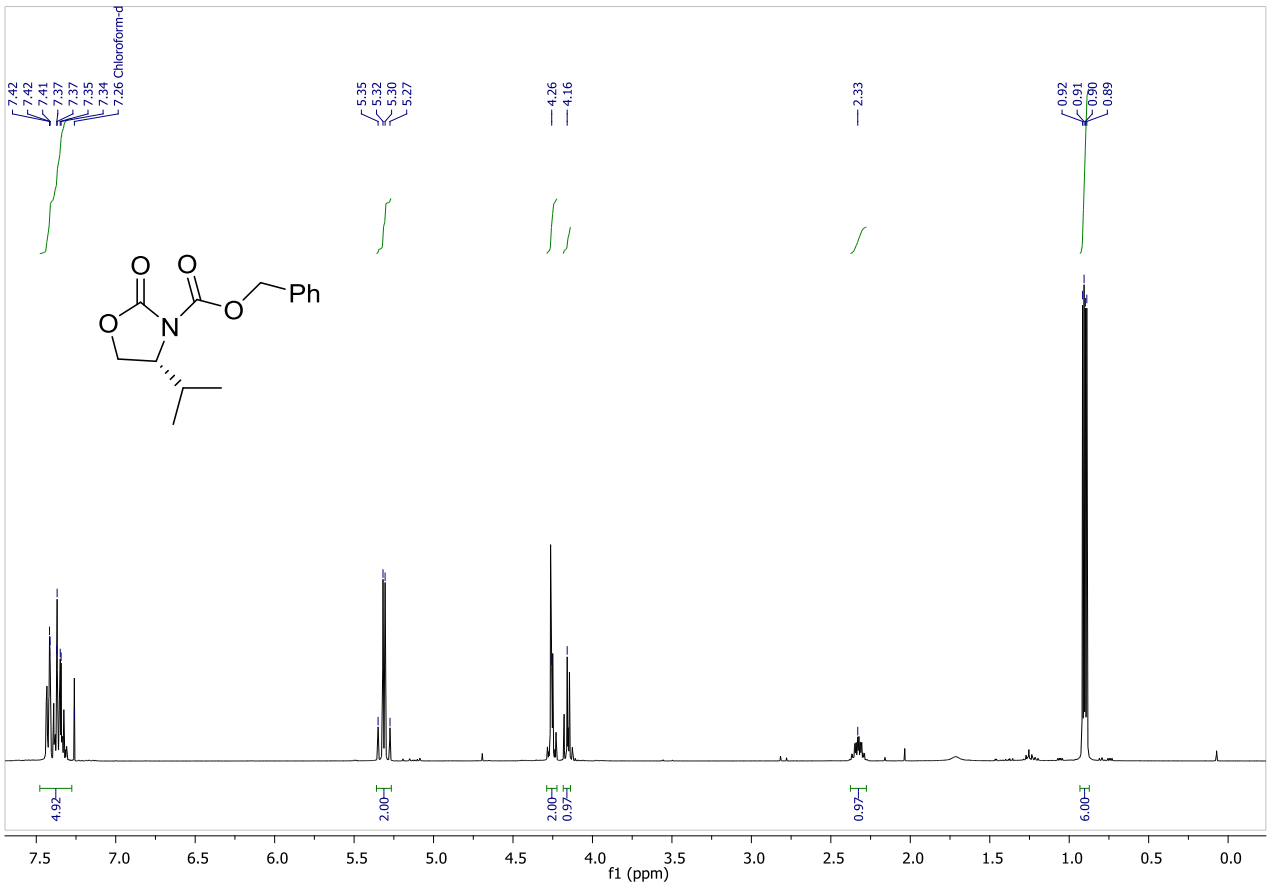
O
NH
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

$3_{Cbz}b$ ^{1}H



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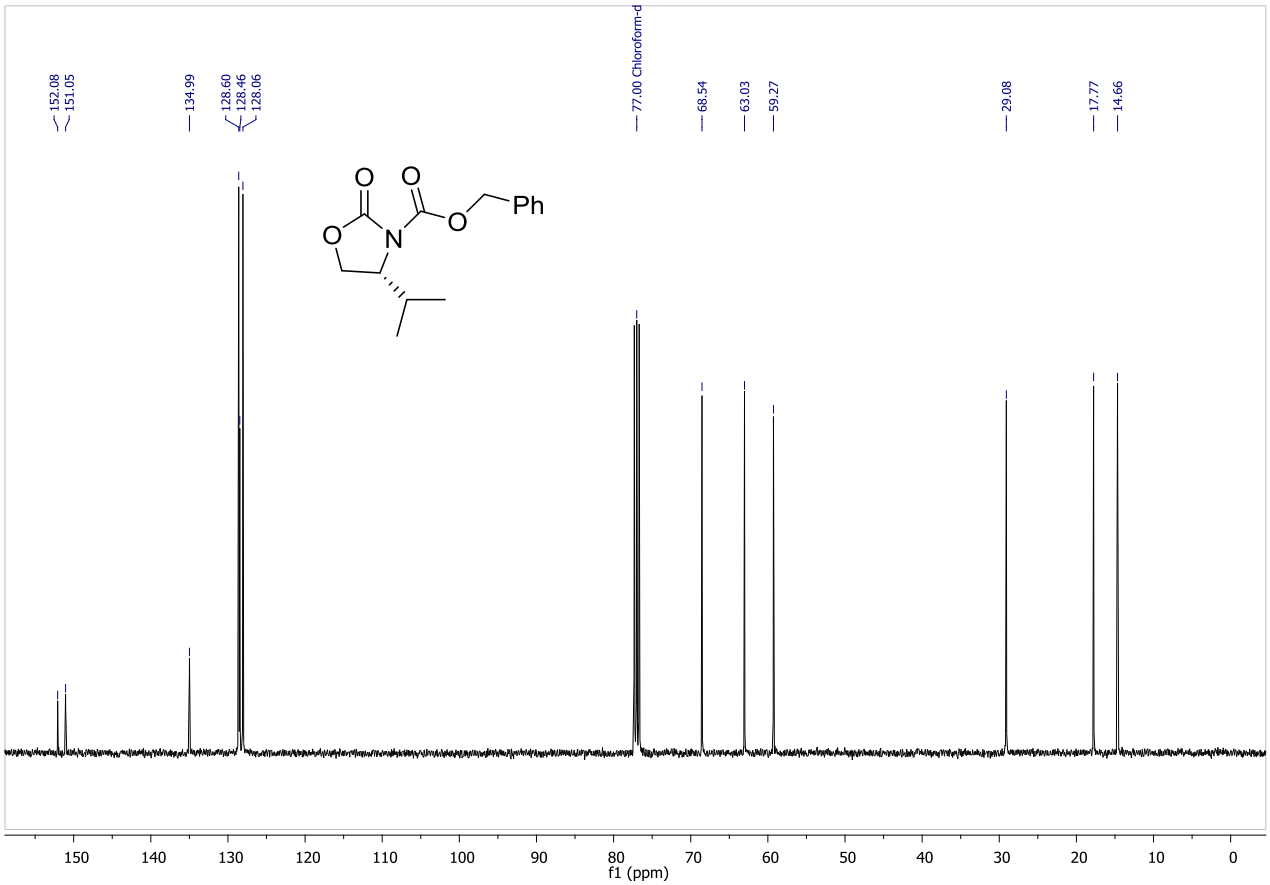
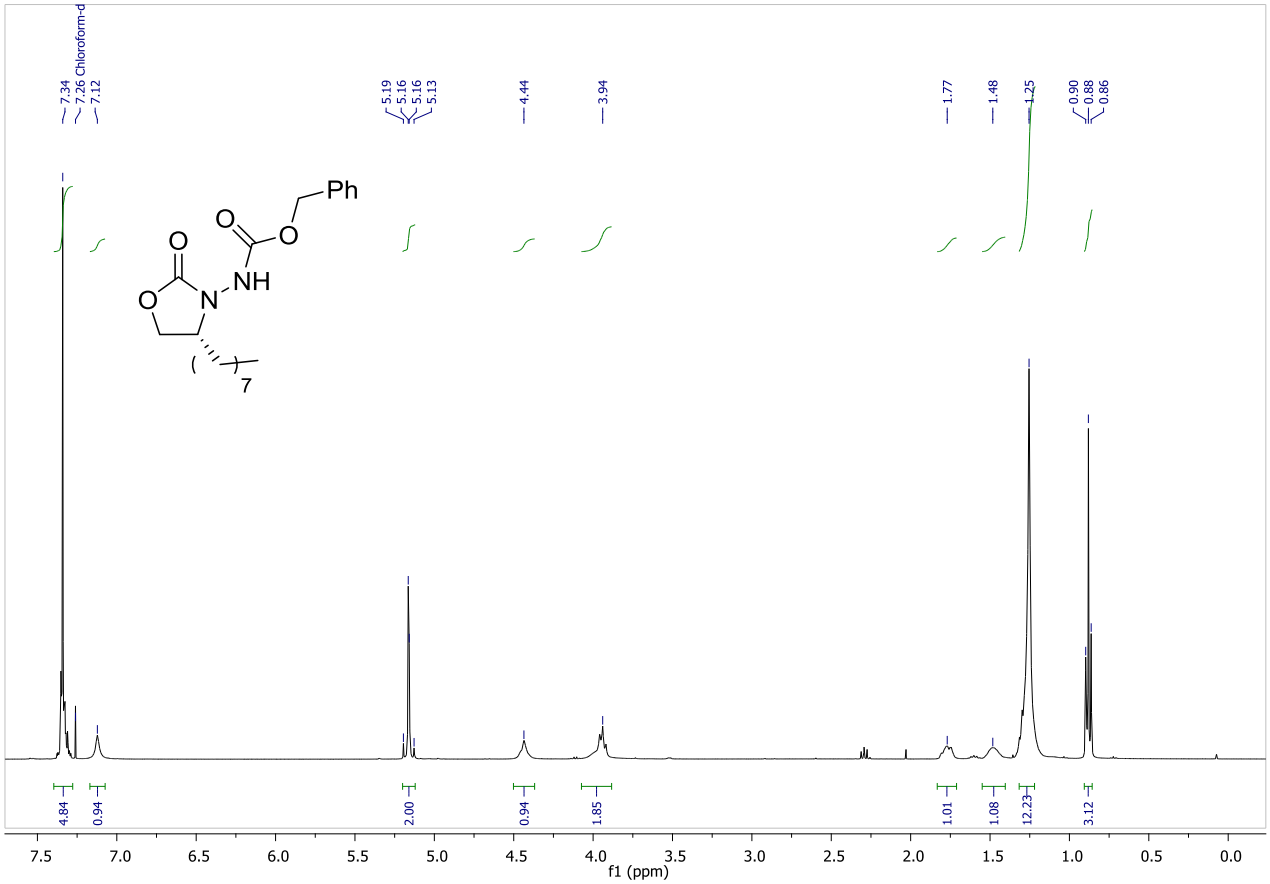
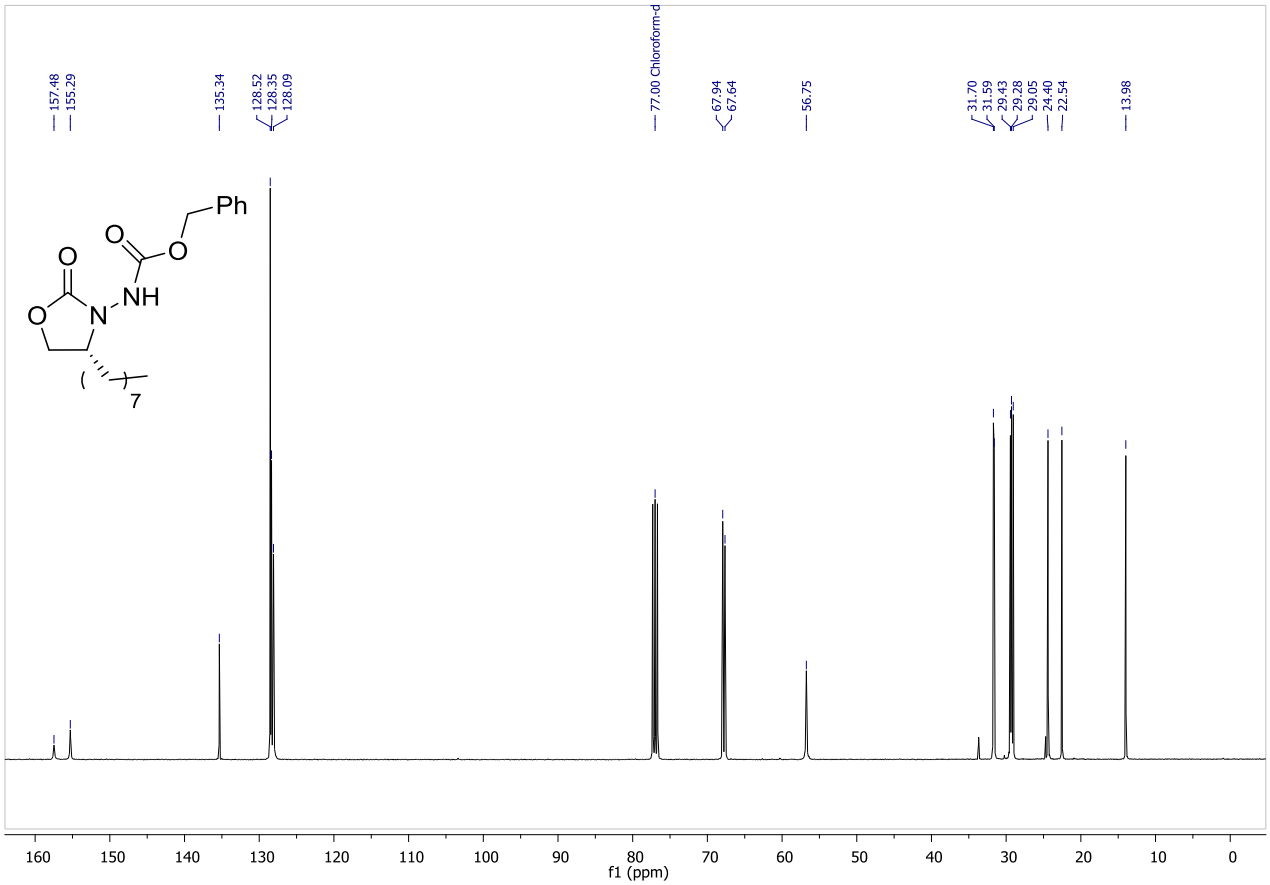


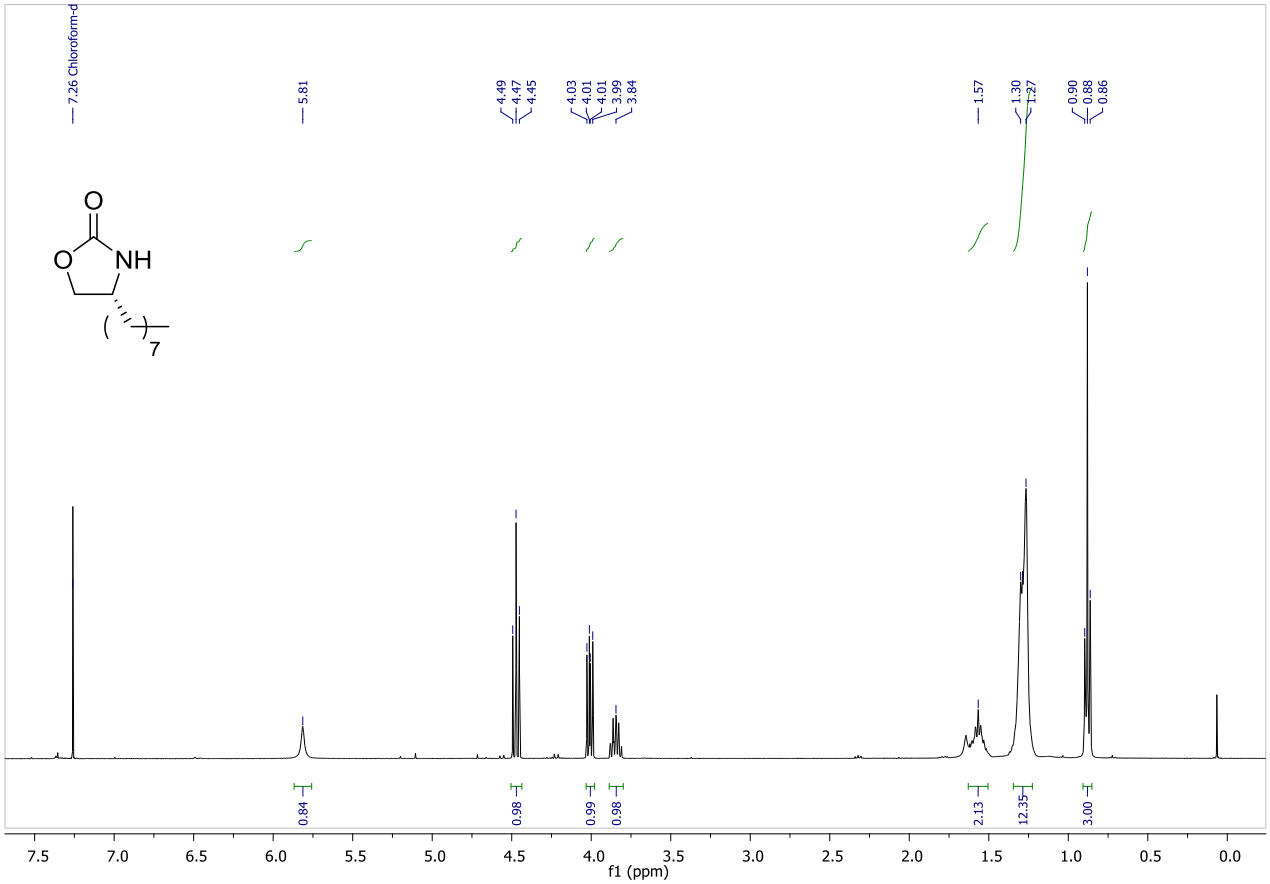
2c ^{1}H


7.34
7.26 Chloroform-d
7.12
5.19
5.16
5.16
5.13
4.44
3.94
1.77
1.48
1.25
0.90
0.88
0.86
Ph
O
O
O
O
NH
N
7
4.84
0.94
2.00
0.94
1.85
1.01
1.08
12.23
3.12
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)

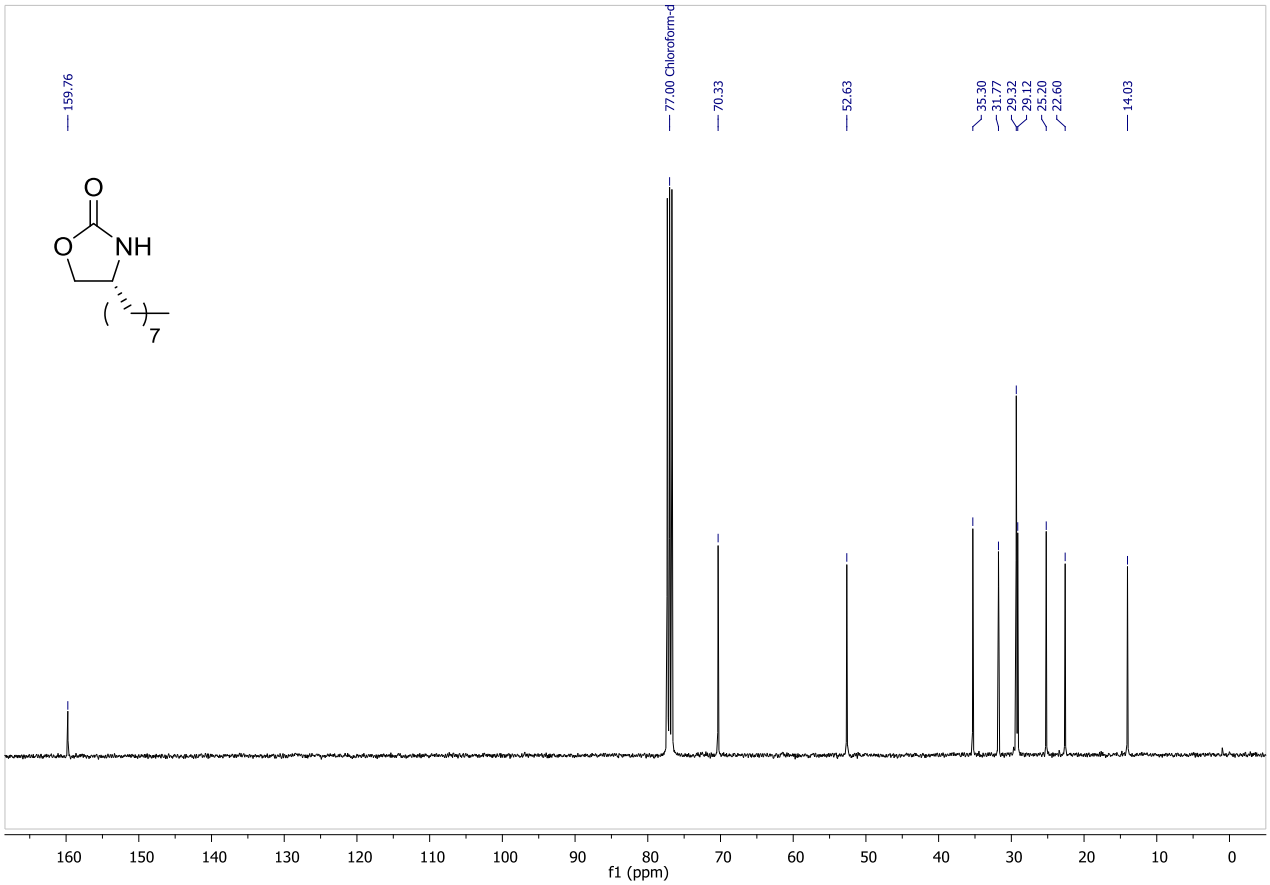
2c ^{13}C


157.48
155.29
135.34
128.52
128.35
128.09
77.00 Chloroform-d
67.94
67.64
56.75
31.70
31.59
29.43
29.28
29.05
24.40
22.54
13.98
Ph
O
O
O
O
NH
N
7
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

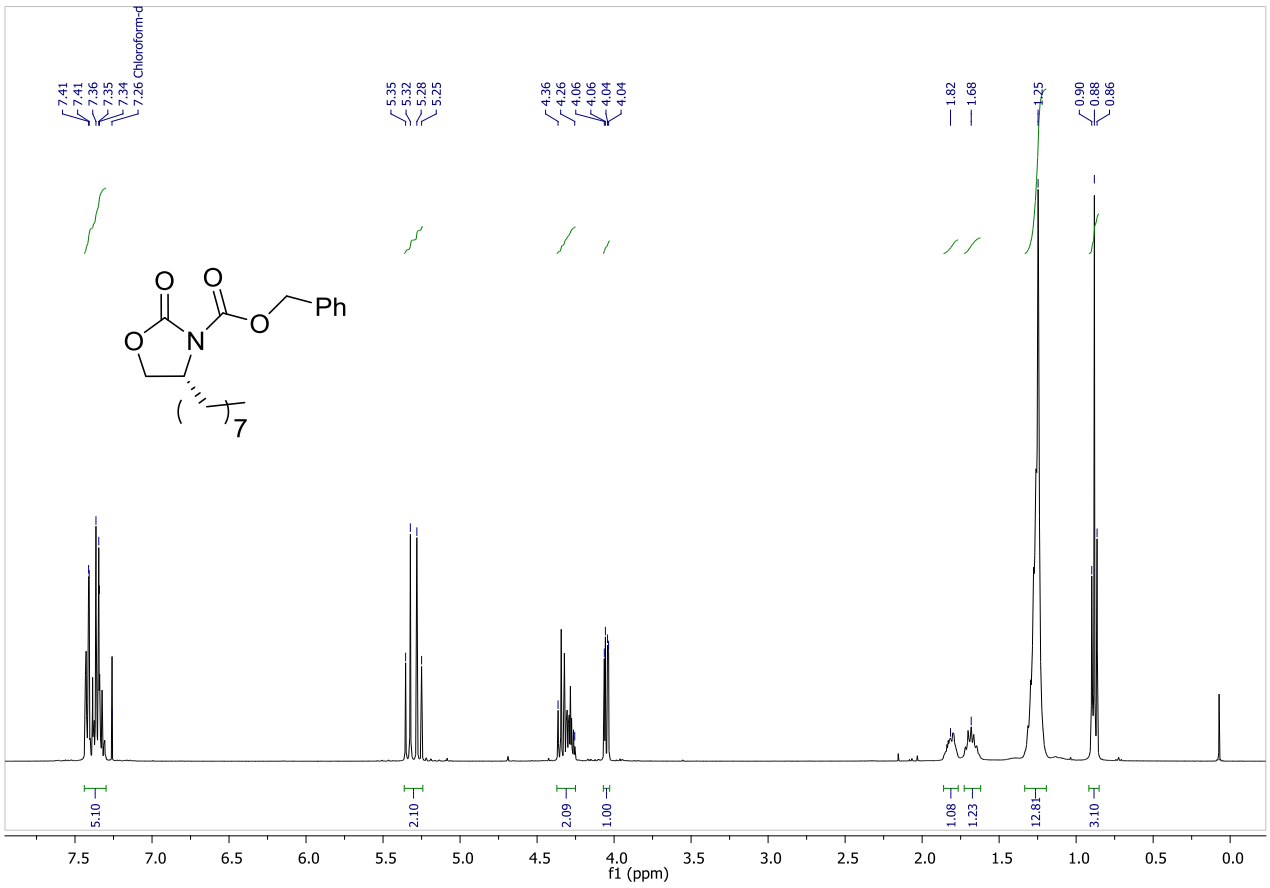
3c ^{1}H


7.26 Chloroform-d
5.81
4.49
4.47
4.45
4.03
4.01
4.01
3.99
3.84
1.57
1.30
1.27
0.90
0.88
0.86
O
O
NH
7
0.84
0.98
0.99
0.98
2.13
12.35
3.00
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)

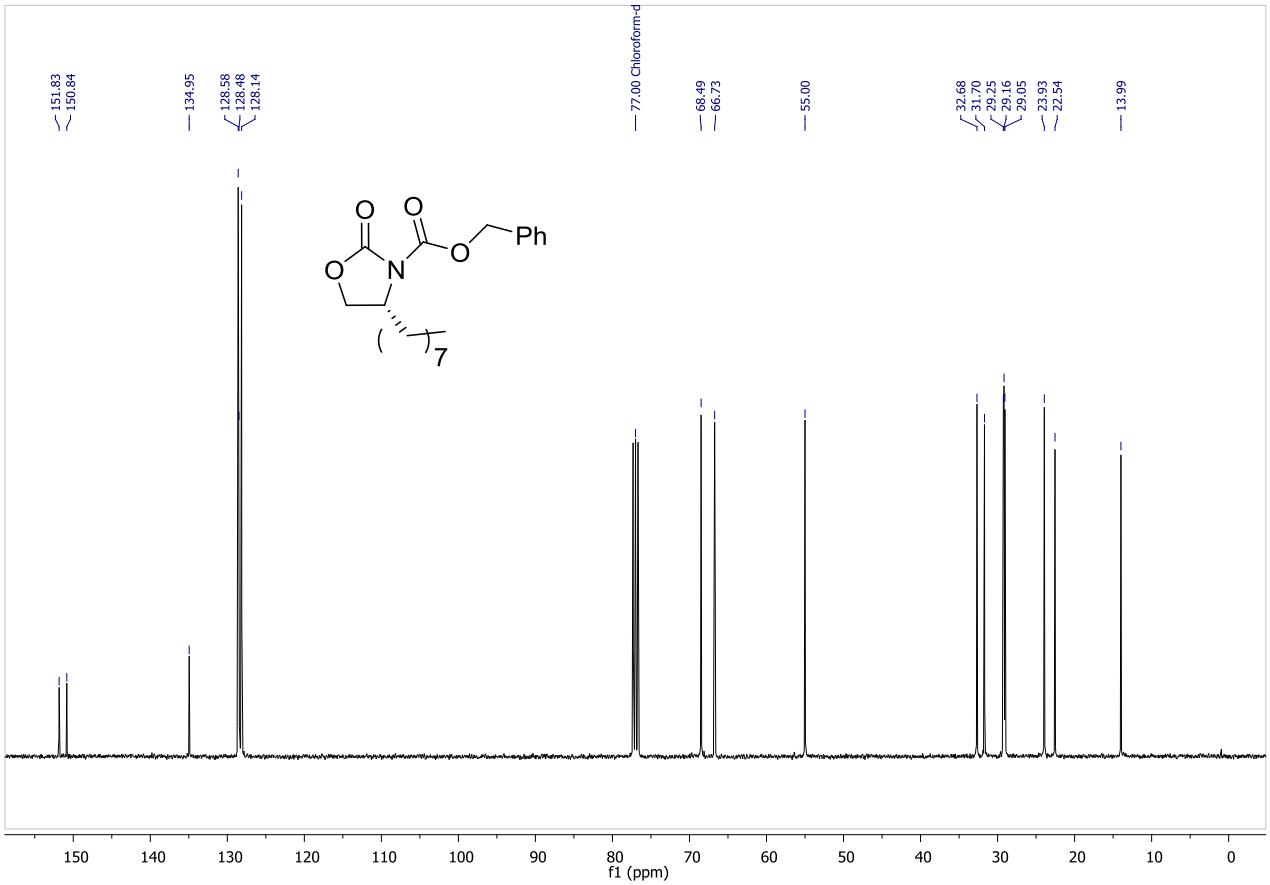
3c ^{13}C


159.76
77.00 Chloroform-d
70.33
52.63
35.30
31.77
29.32
29.12
25.20
22.60
14.03
O
O
NH
7
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

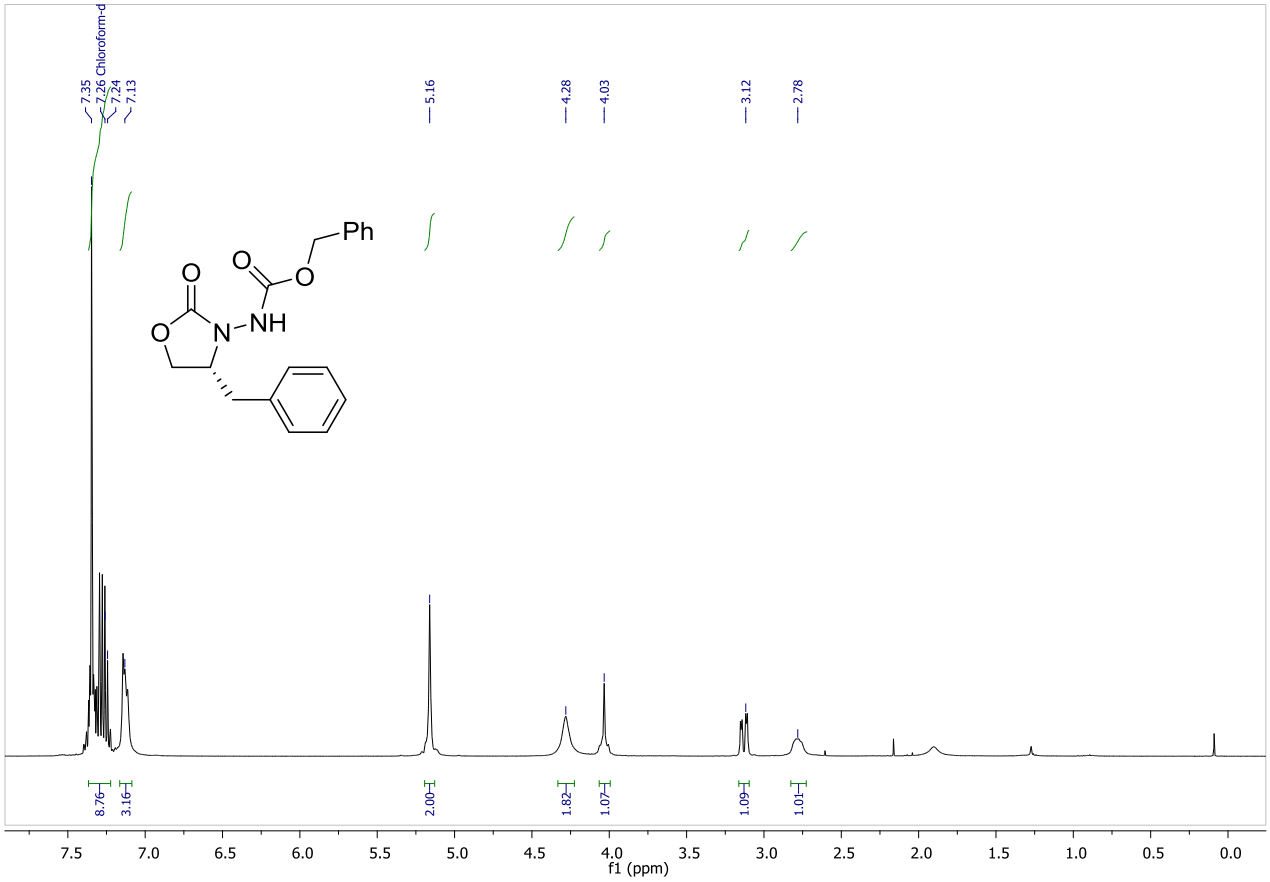
$3_{Cbz}c$ ^{1}H



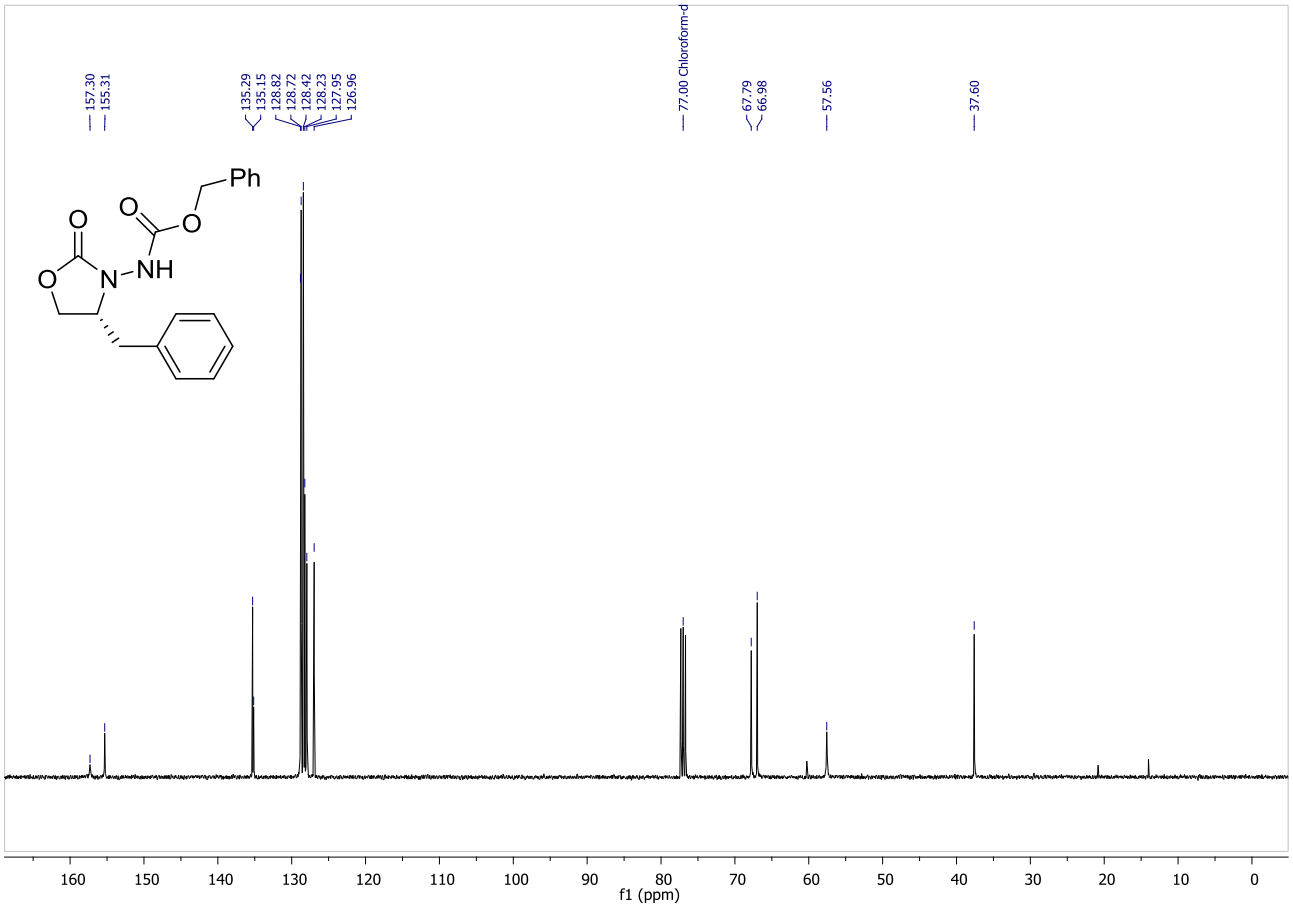
$3_{Cbz}c$ ^{13}C



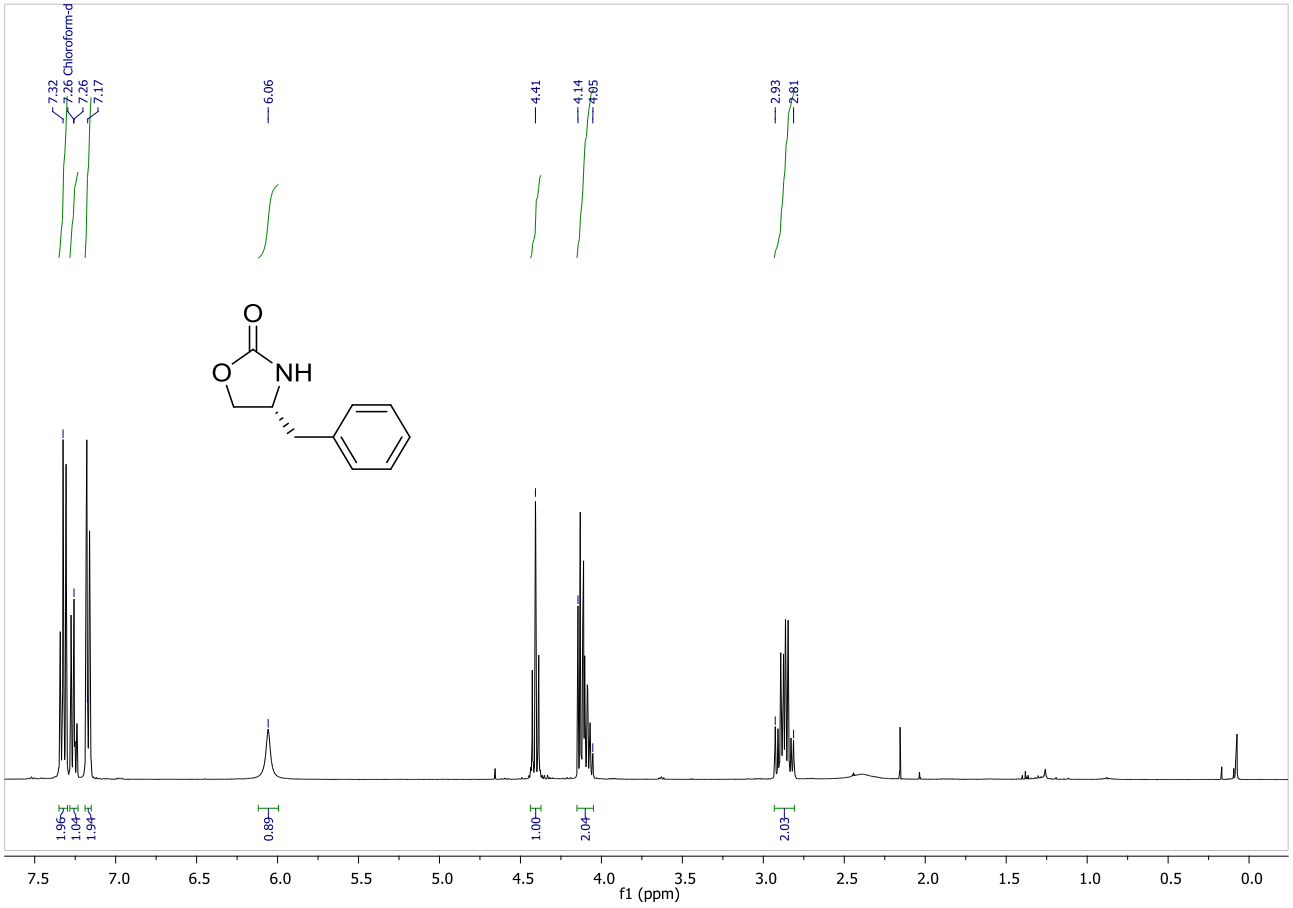
2d ^{1}H


7.35
7.26 Chloroform-d
7.24
7.13
5.16
4.28
4.03
3.12
2.78
Ph
O
O
O
N
NH
8.76
3.16
2.00
1.82
1.07
1.09
1.01
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)

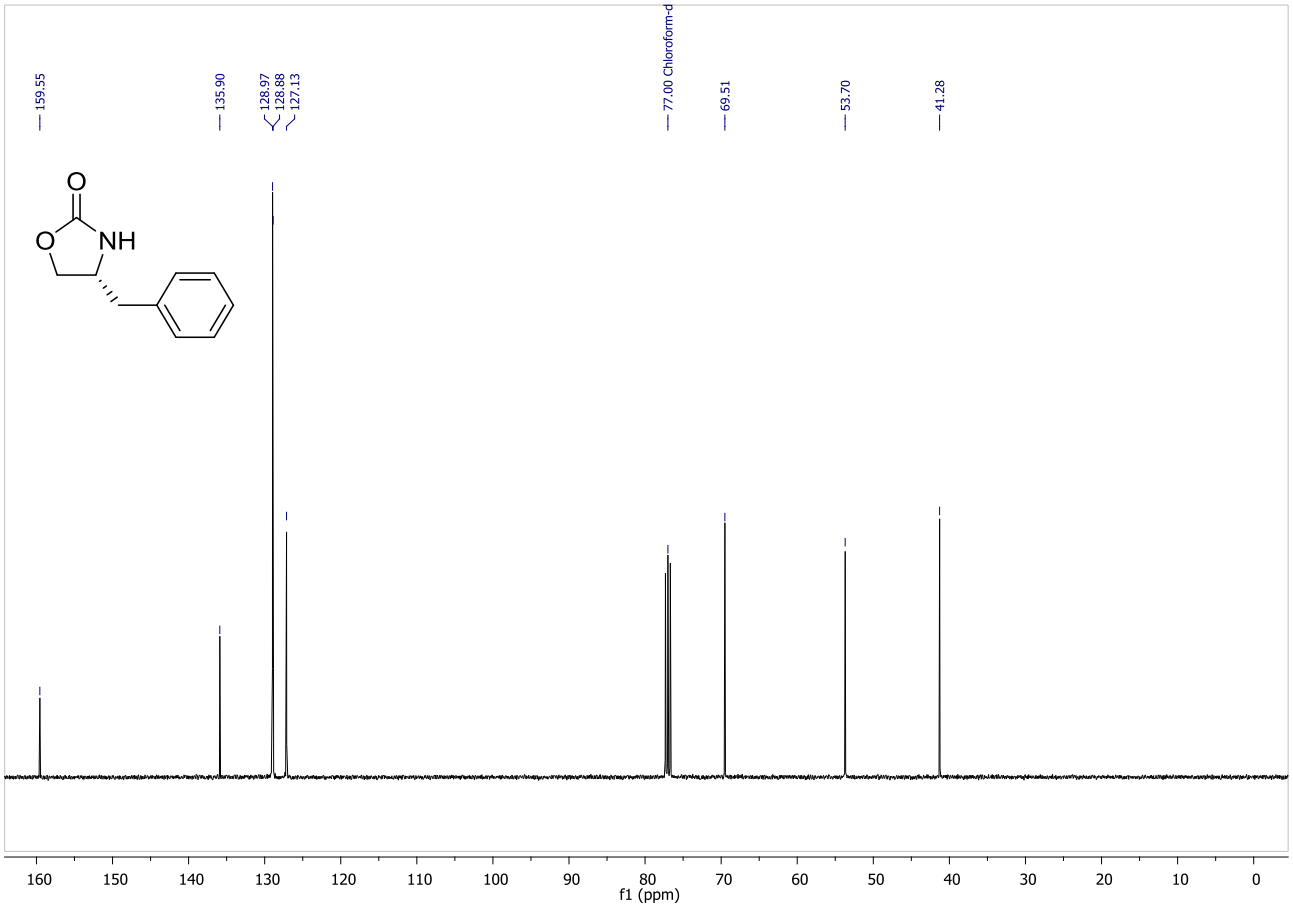
2d ^{13}C


157.30
155.31
135.29
135.15
128.82
128.72
128.42
128.23
127.95
126.96
77.00 Chloroform-d
67.79
66.98
57.56
37.60
Ph
O
O
O
N
NH
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

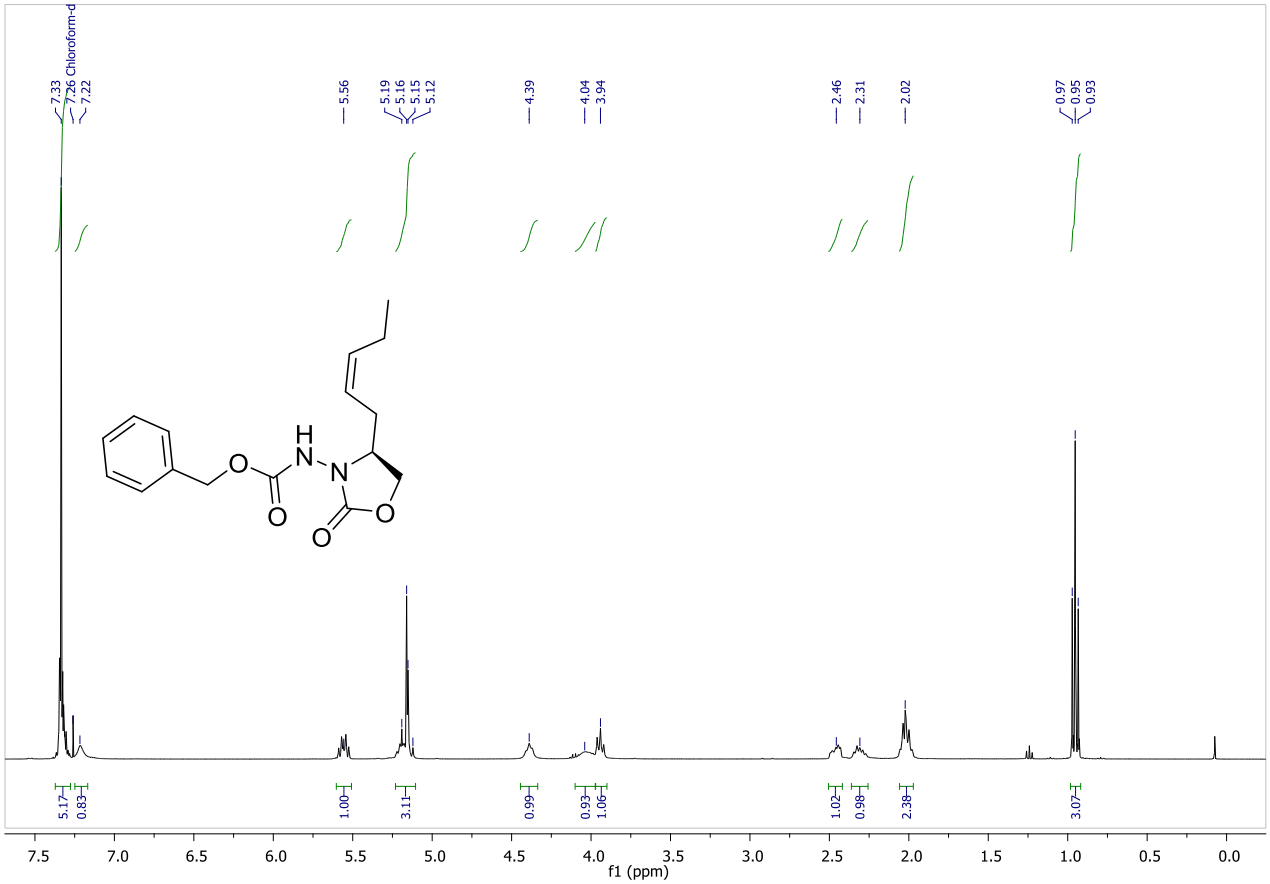
3d ^{1}H


7.32
7.26 Chloroform-d
7.26
7.17
6.06
4.41
4.14
4.05
2.93
2.81
O
O
NH
1.96
1.04
1.94
0.89
1.00
2.04
2.03
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)

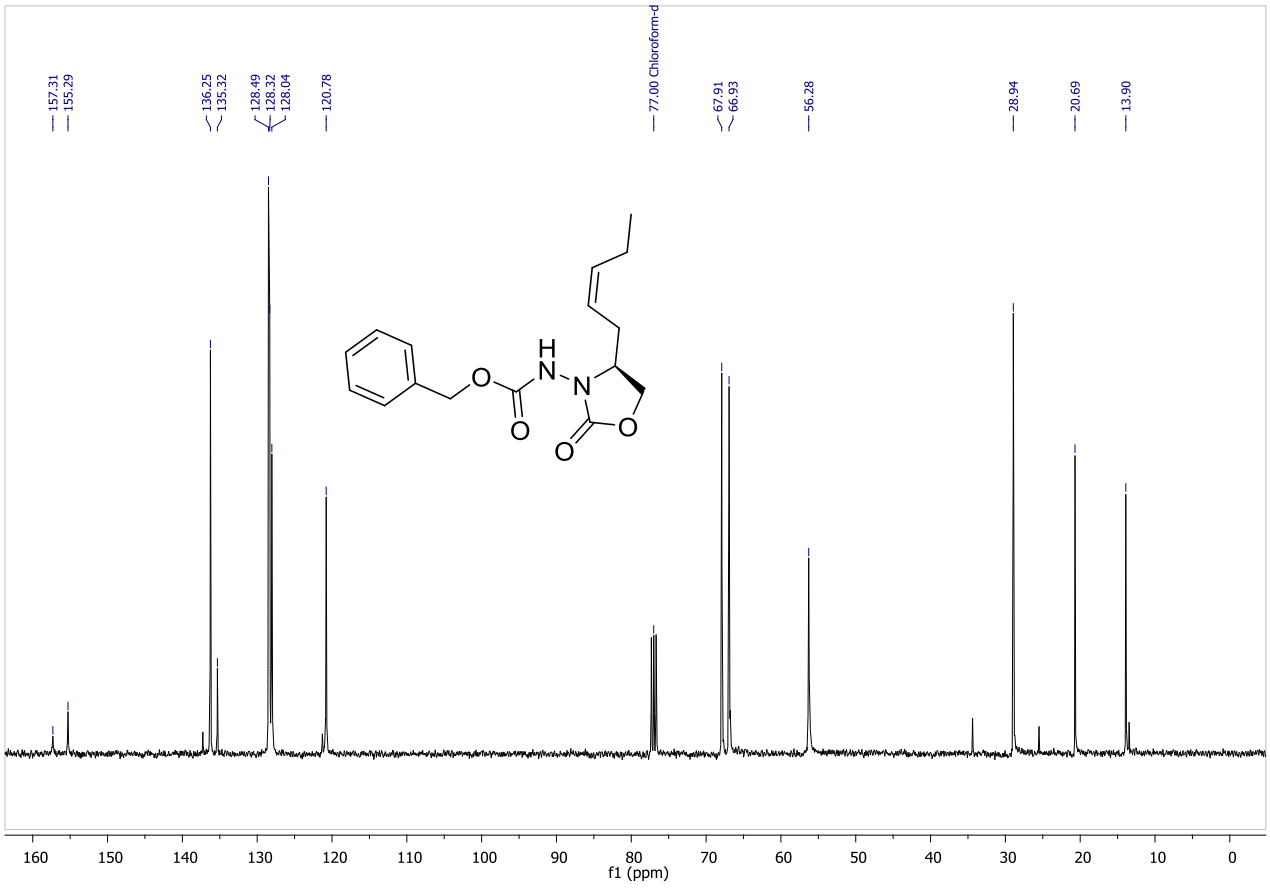
3d ^{13}C


159.55
135.90
128.97
128.88
127.13
77.00 Chloroform-d
69.51
53.70
41.28
O
O
NH
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

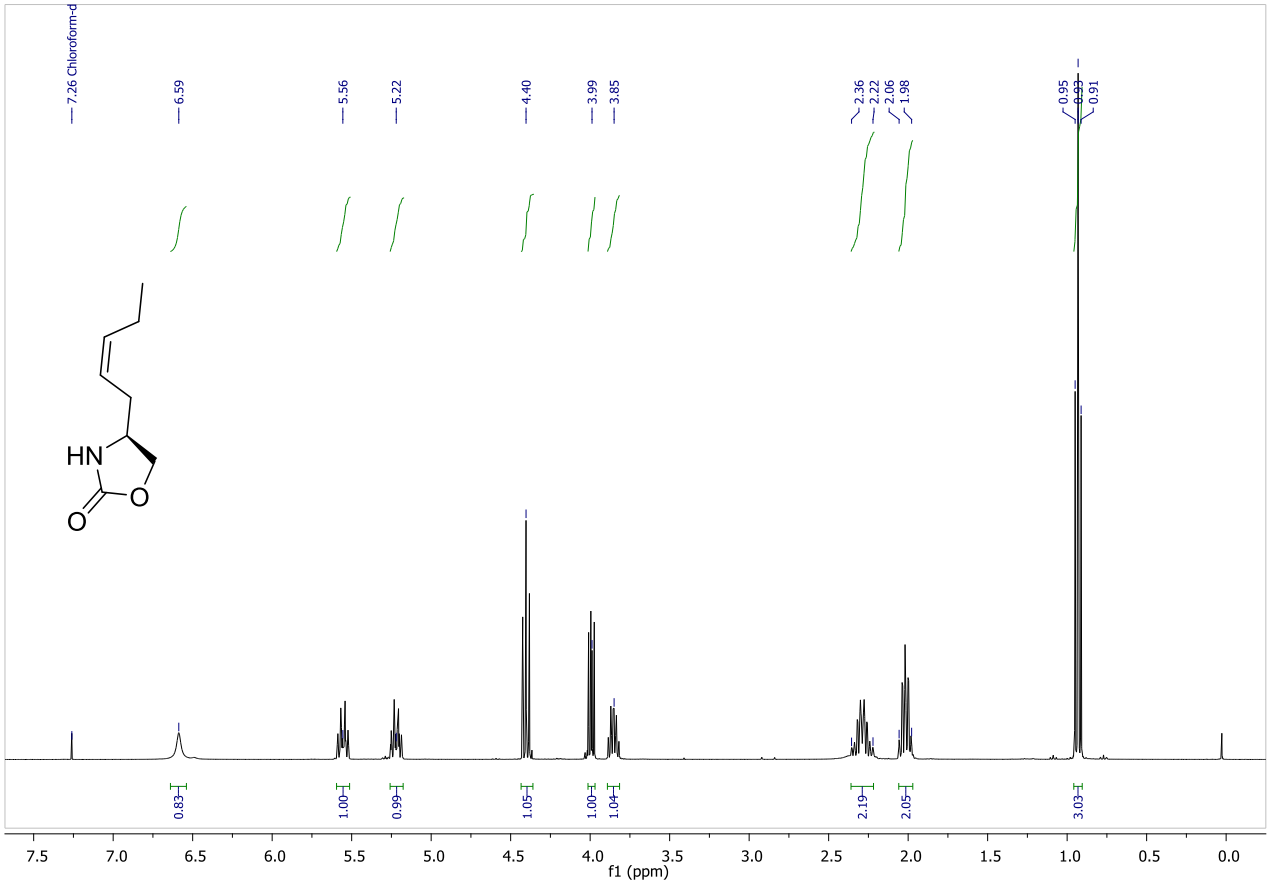
2e ^{1}H


7.33
7.26 Chloroform-d
7.22
5.56
5.19
5.16
5.15
5.12
4.39
4.04
3.94
2.46
2.31
2.02
0.97
0.95
0.93
5.17
0.83
1.00
3.11
0.99
0.93
1.06
1.02
0.98
2.38
3.07
f1 (ppm)

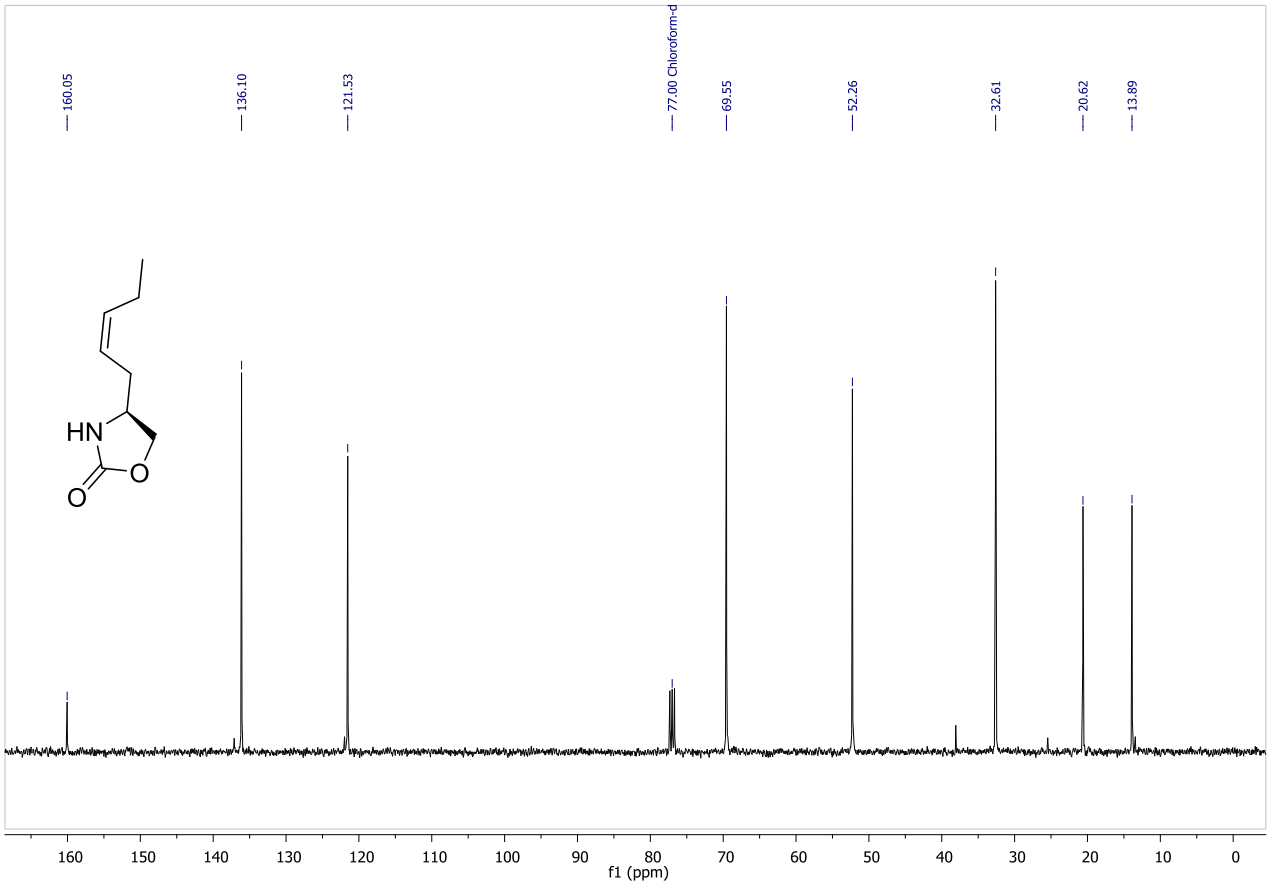
2e ^{13}C


157.31
155.29
136.25
135.32
128.49
128.32
128.04
120.78
77.00 Chloroform-d
67.91
66.93
56.28
28.94
20.69
13.90
f1 (ppm)

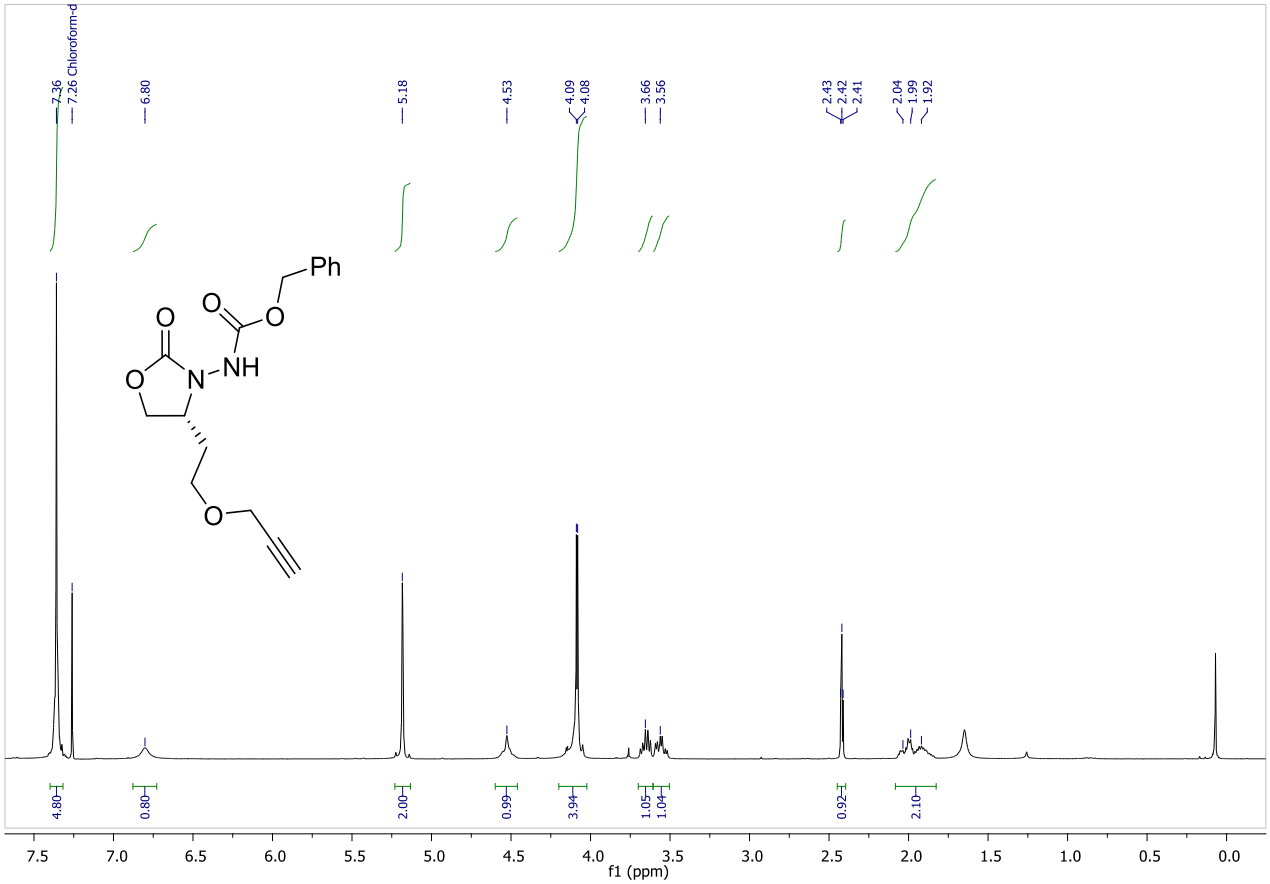
3e ^{1}H


7.26 Chloroform-d
6.59
5.56
5.22
4.40
3.99
3.85
2.36
2.22
2.06
1.98
0.95
0.93
0.91
HN
O
O
0.83
1.00
0.99
1.05
1.00
1.04
2.19
2.05
3.03
f1 (ppm)

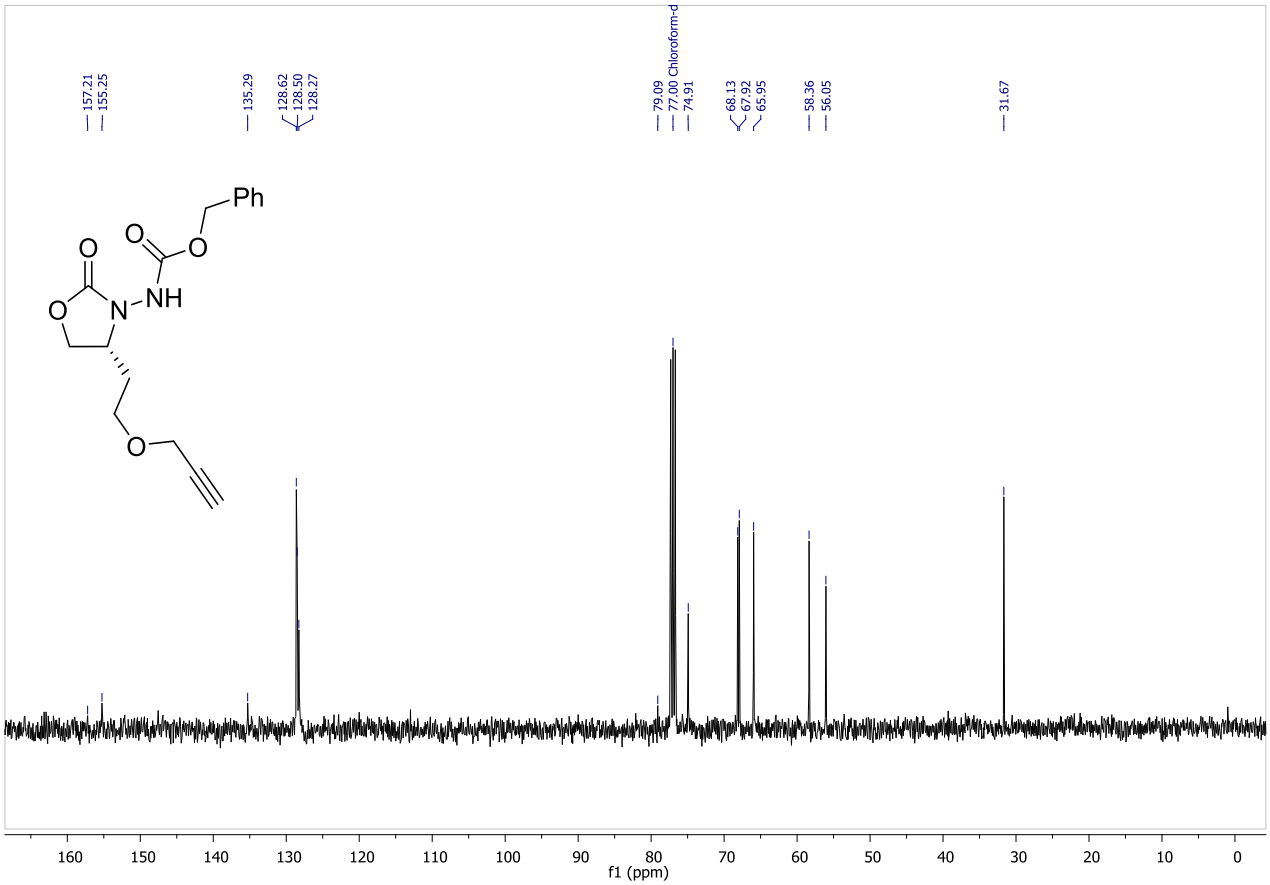
3e ^{13}C


160.05
136.10
121.53
77.00 Chloroform-d
69.55
52.26
32.61
20.62
13.89
HN
O
O
f1 (ppm)

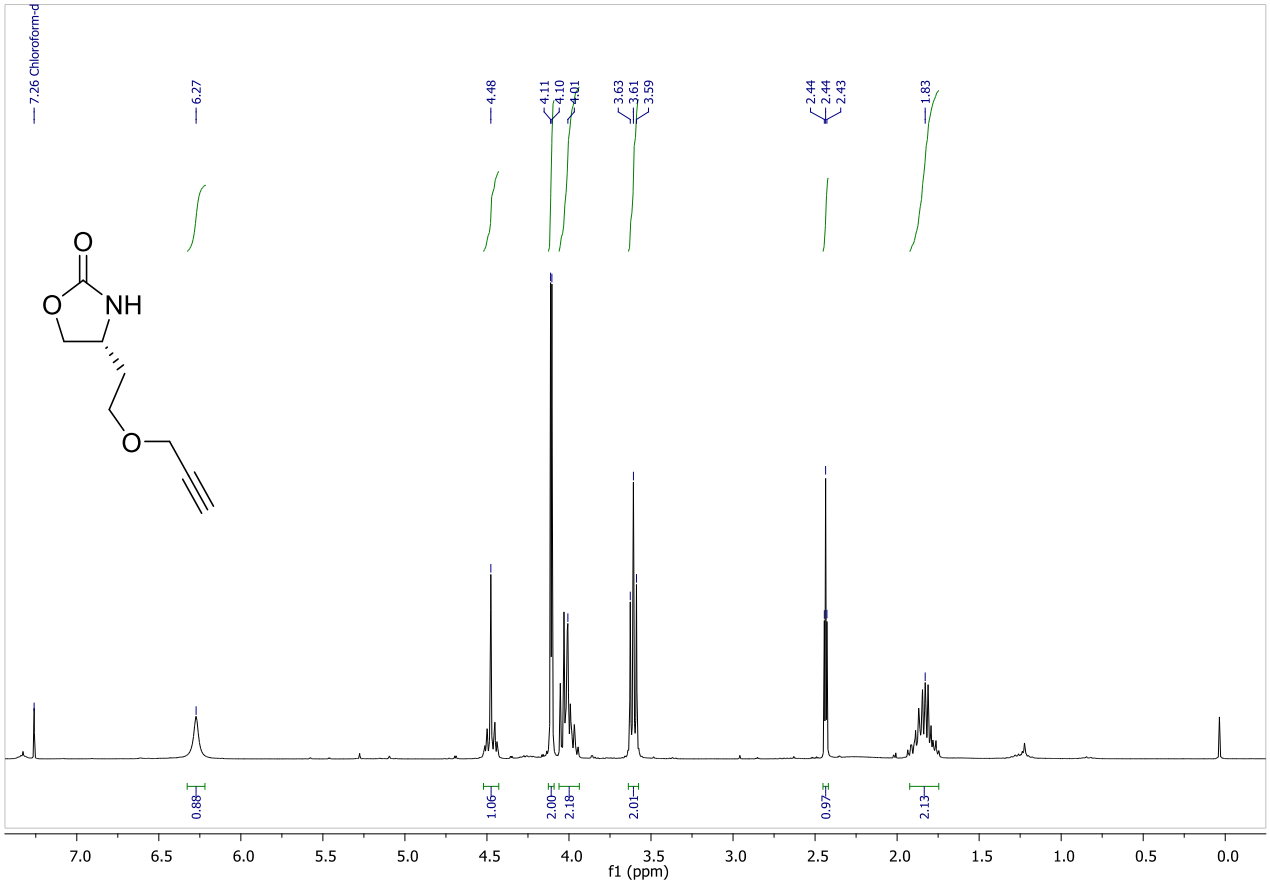
2f ^{1}H


7.36
7.26 Chloroform-d
6.80
5.18
4.53
4.09
4.08
3.66
3.56
2.43
2.42
2.41
2.04
1.99
1.92
Ph
O
O
O
N
NH
O
4.80
0.80
2.00
0.99
3.94
1.05
1.04
0.92
2.10
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)

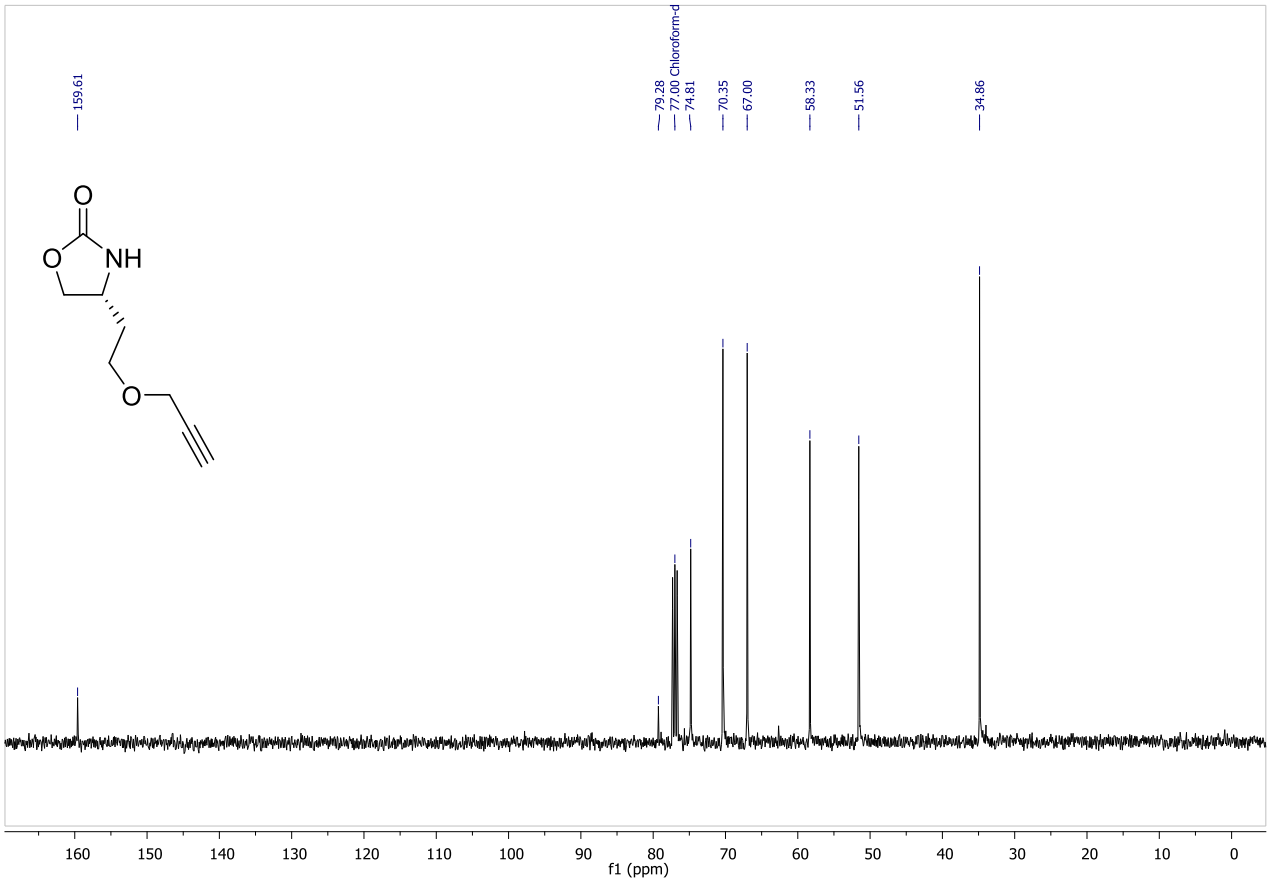
2f ^{13}C


157.21
155.25
135.29
128.62
128.50
128.27
79.09
77.00 Chloroform-d
74.91
68.13
67.92
65.95
58.36
56.05
31.67
Ph
O
O
O
N
NH
O
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

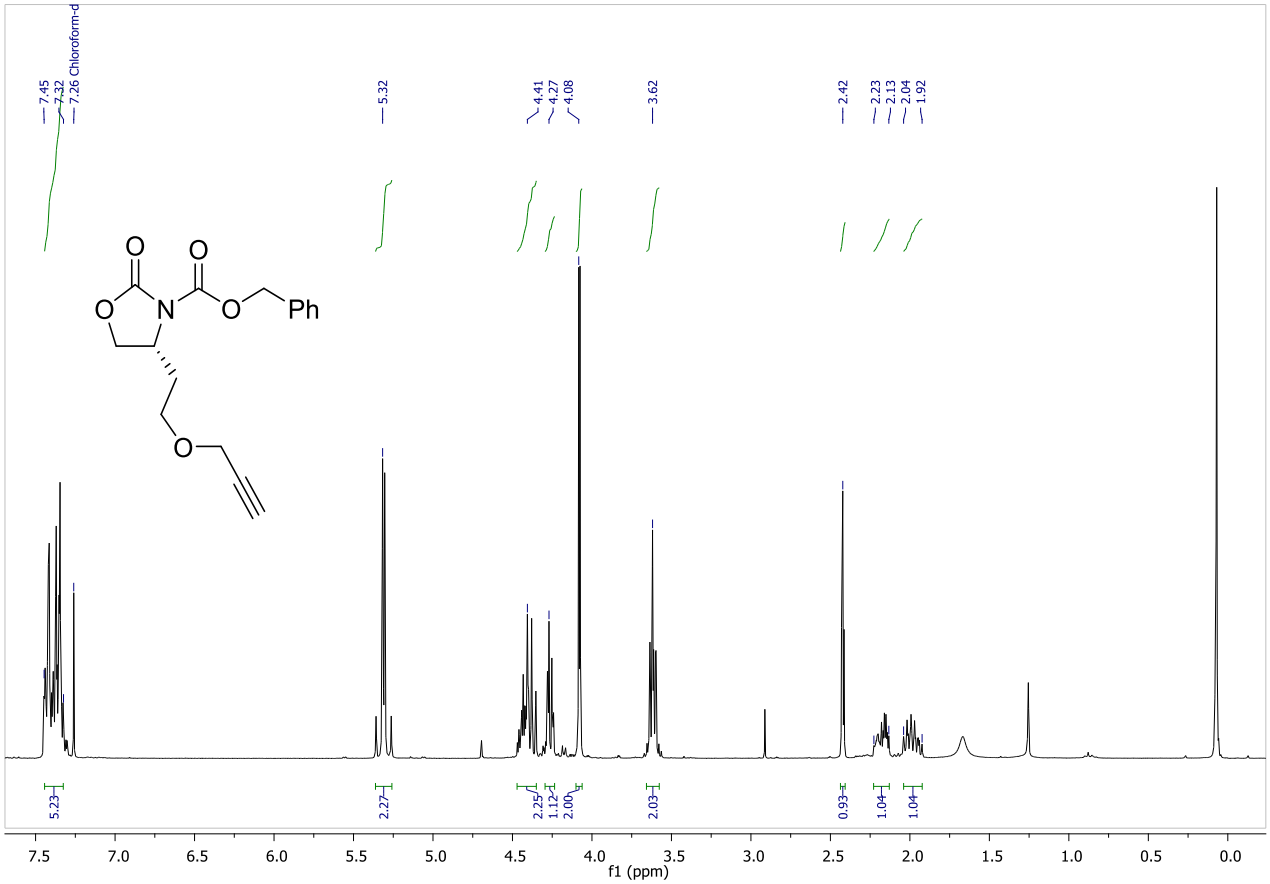
3f ^{1}H


7.26 Chloroform-d
6.27
4.48
4.11
4.10
4.01
3.63
3.61
3.59
2.44
2.44
2.43
1.83
O
NH
O
O
0.88
1.06
2.00
2.18
2.01
0.97
2.13
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)

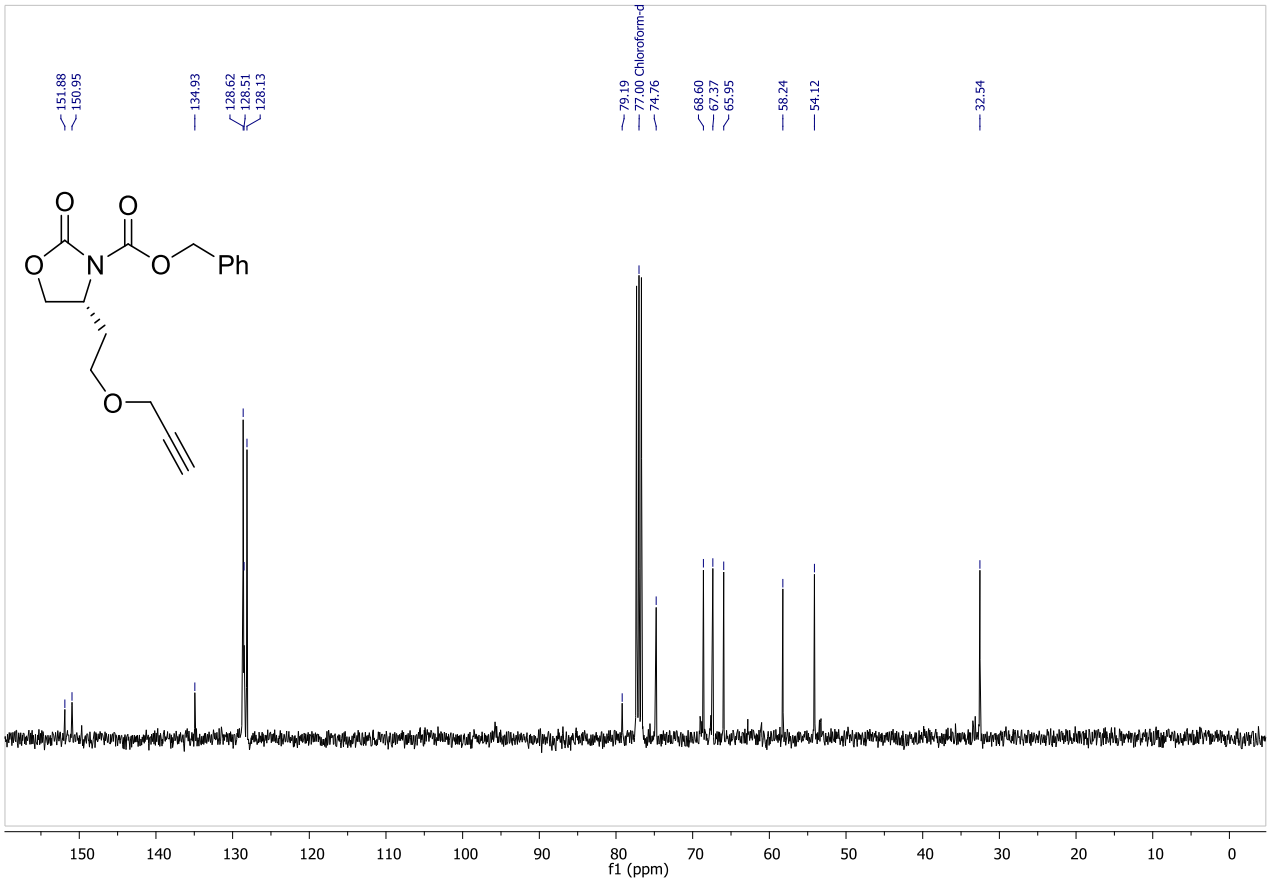
3f ^{13}C


159.61
79.28
77.00 Chloroform-d
74.81
70.35
67.00
58.33
51.56
34.86
O
NH
O
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

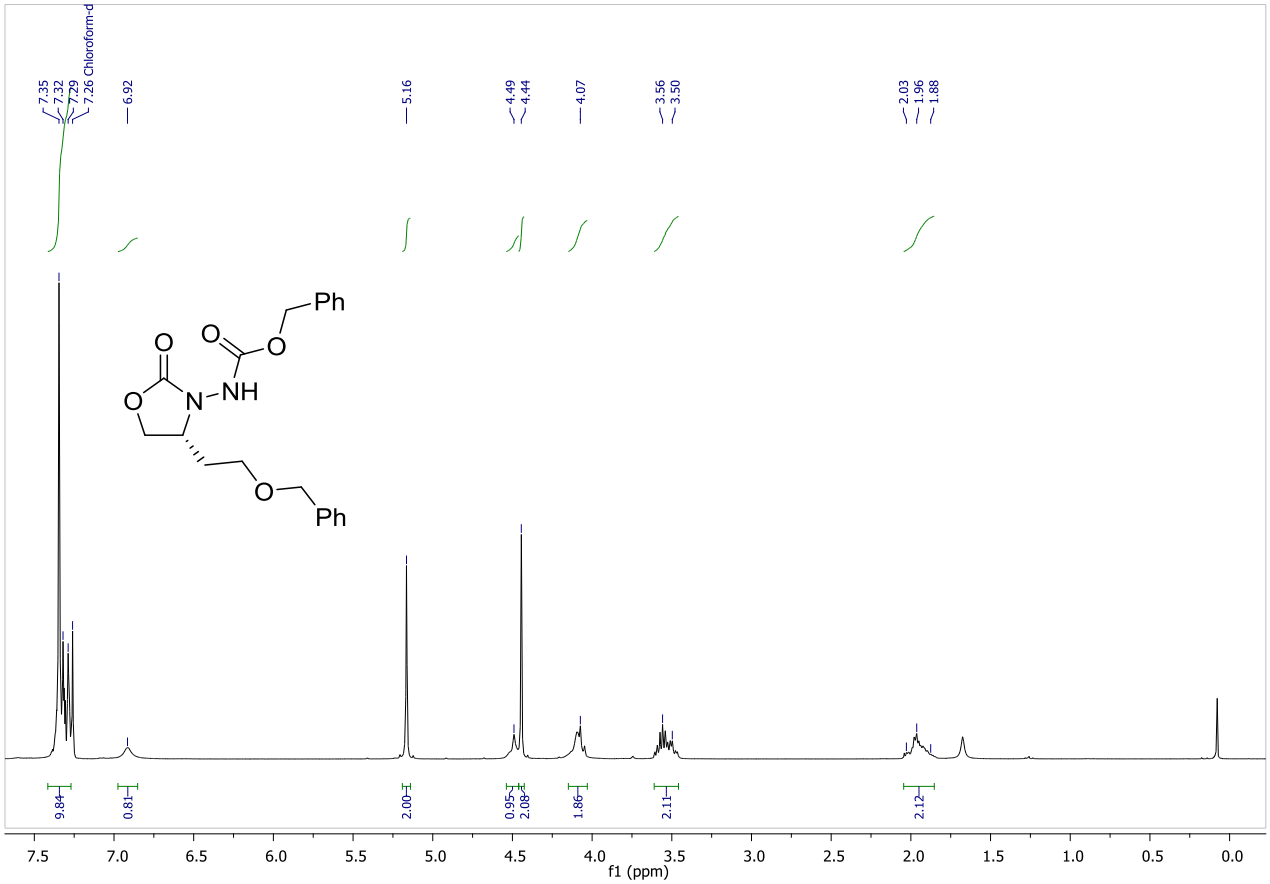
$3_{Cbz}f$ ^{1}H



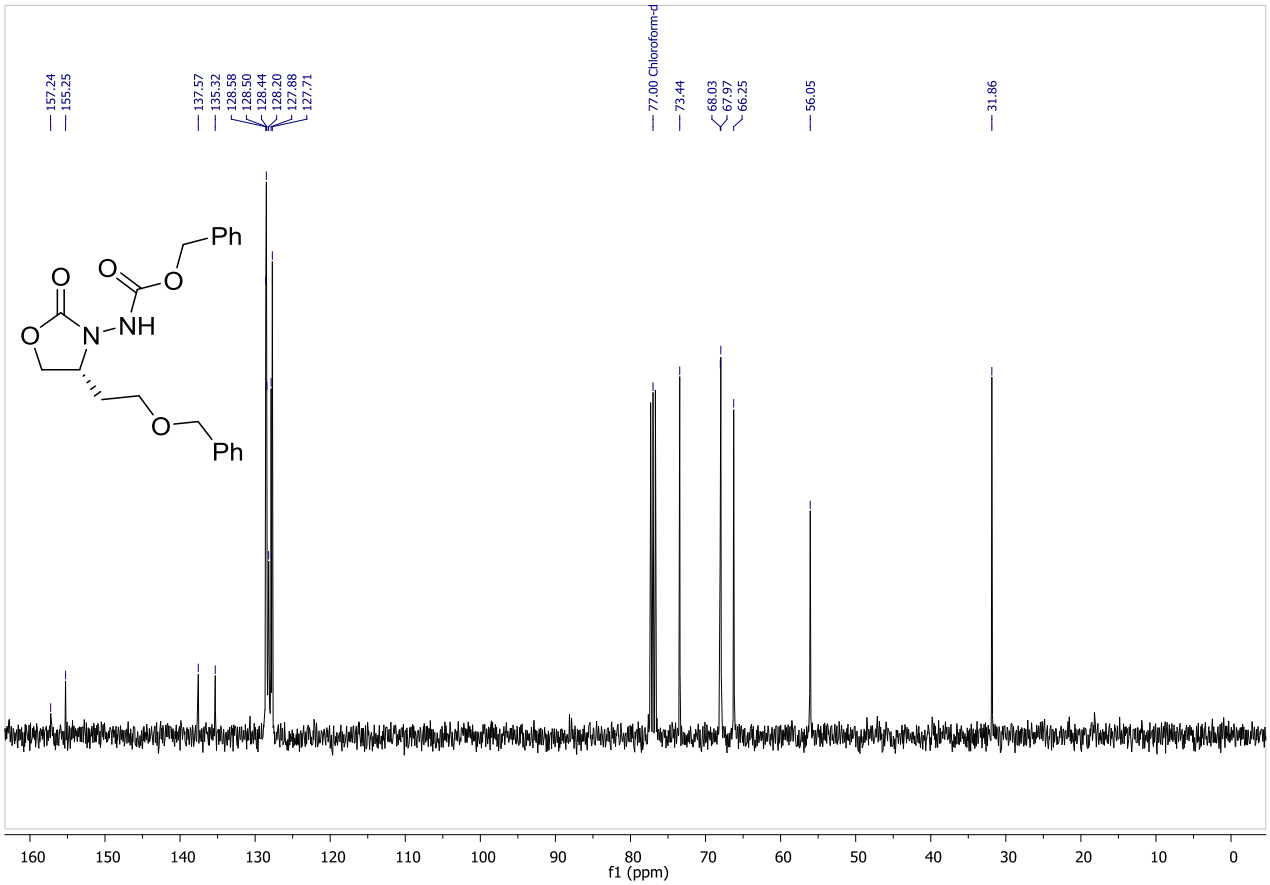
$3_{Cbz}f$ ^{13}C



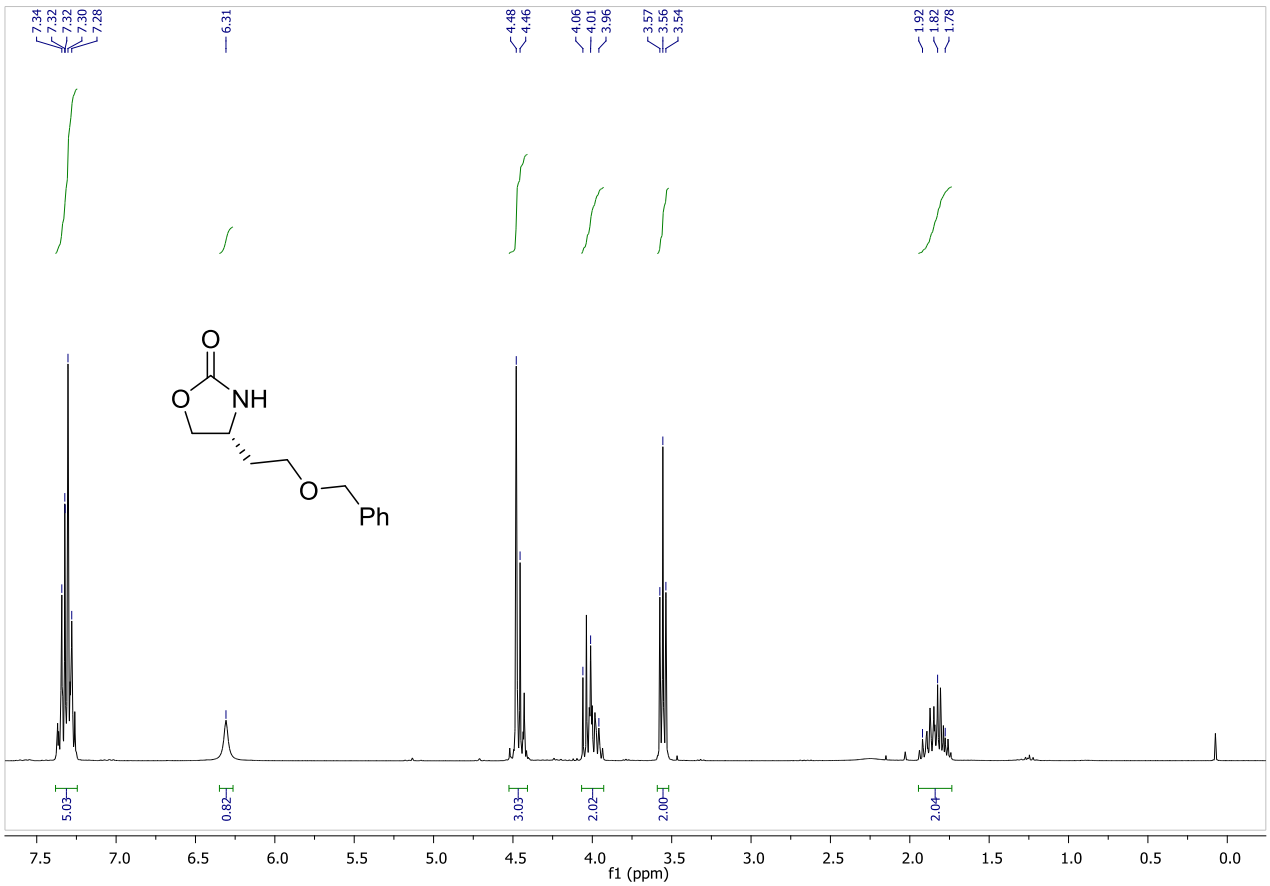
2g ^{1}H


7.35
7.32
7.29
7.26 Chloroform-d
6.92
5.16
4.49
4.44
4.07
3.56
3.50
2.03
1.96
1.88
Ph
O
O
O
N
NH
O
Ph
9.84
0.81
2.00
0.95
2.08
1.86
2.11
2.12
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)

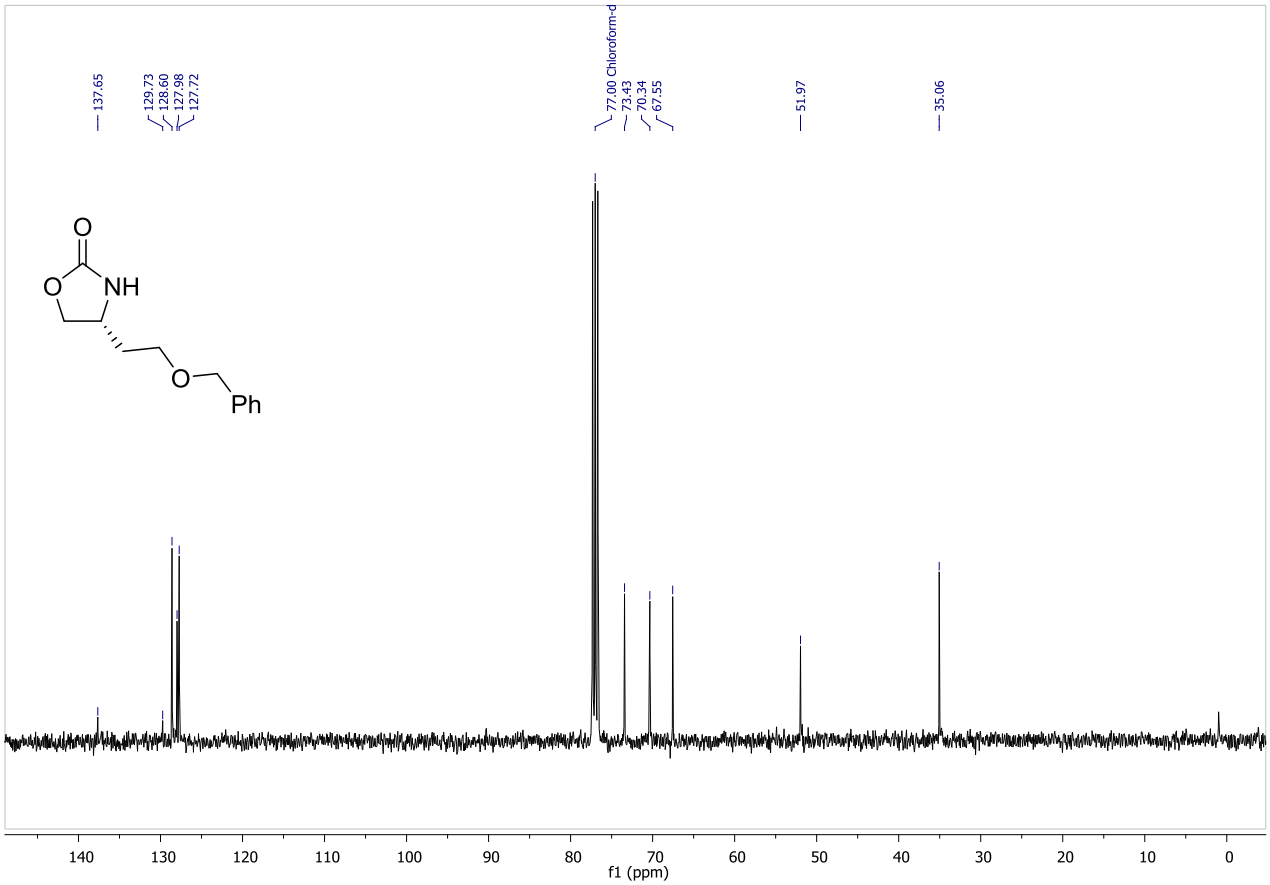
2g ^{13}C


157.24
155.25
137.57
135.32
128.58
128.50
128.44
128.20
127.88
127.71
77.00 Chloroform-d
73.44
68.03
67.97
66.25
56.05
31.86
Ph
O
O
O
N
NH
O
Ph
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

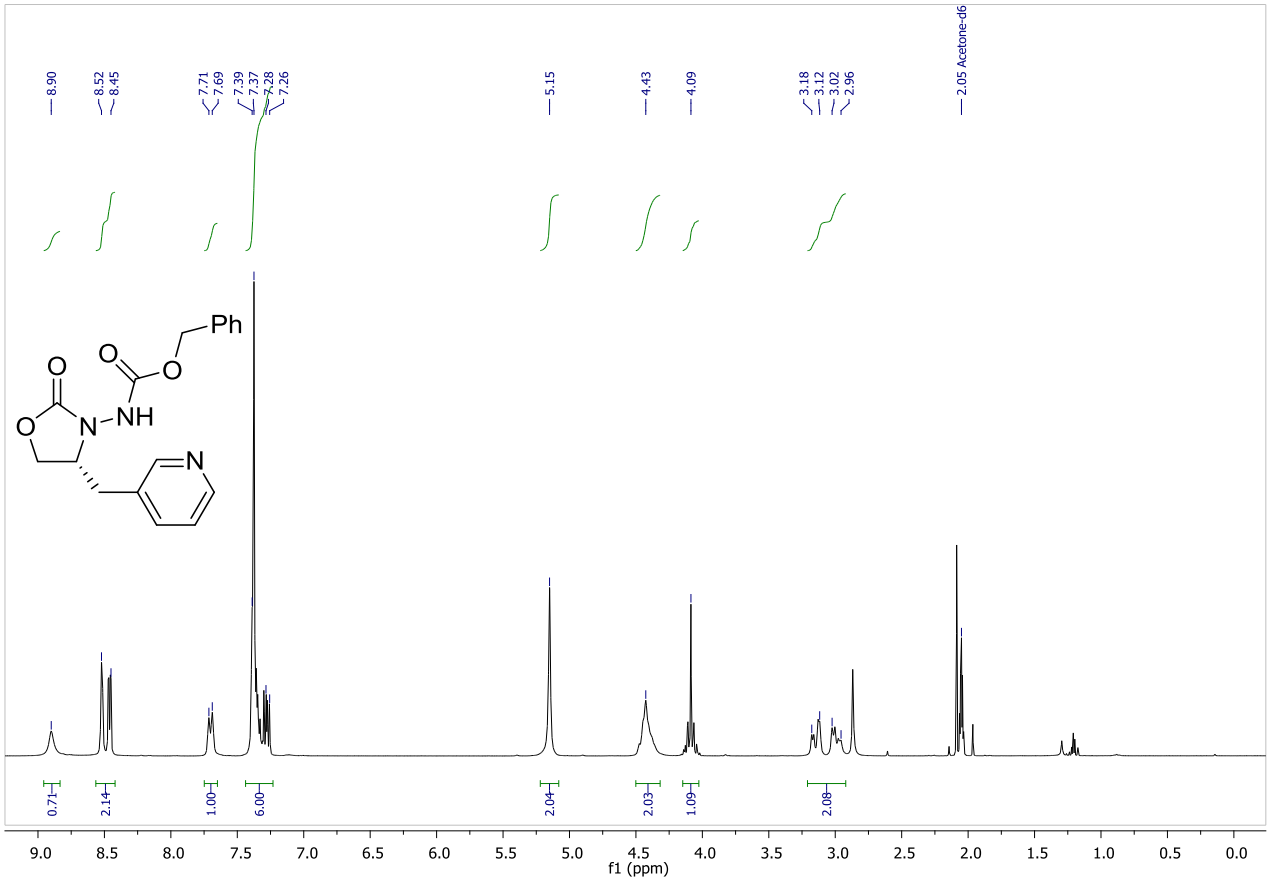
3g ^{1}H


7.34
7.32
7.32
7.30
7.28
6.31
4.48
4.46
4.06
4.01
3.96
3.57
3.56
3.54
1.92
1.82
1.78
O
O
NH
O
Ph
5.03
0.82
3.03
2.02
2.00
2.04
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)

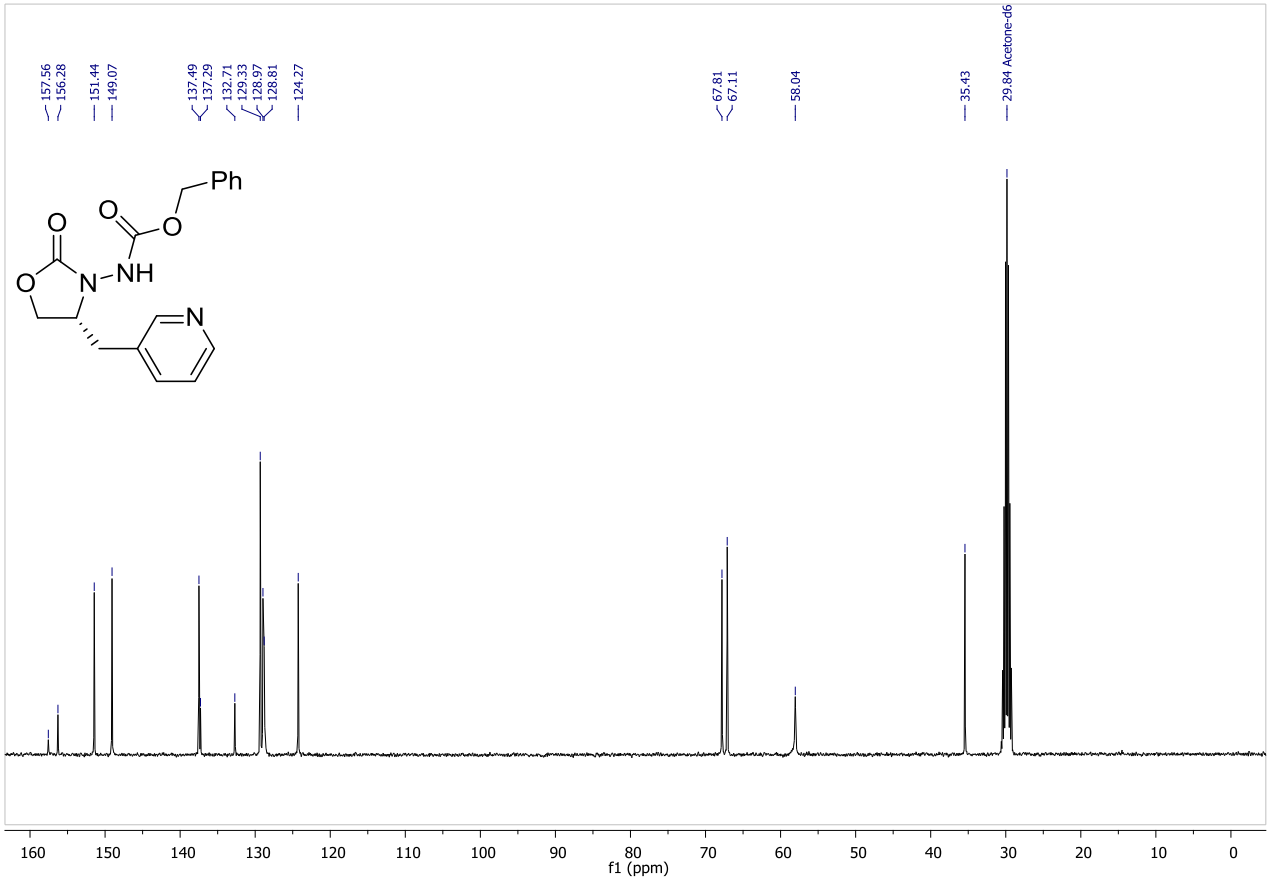
3g ^{13}C


137.65
129.73
128.60
127.98
127.72
77.00 Chloroform-d
73.43
70.34
67.55
51.97
35.06
O
O
NH
O
Ph
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

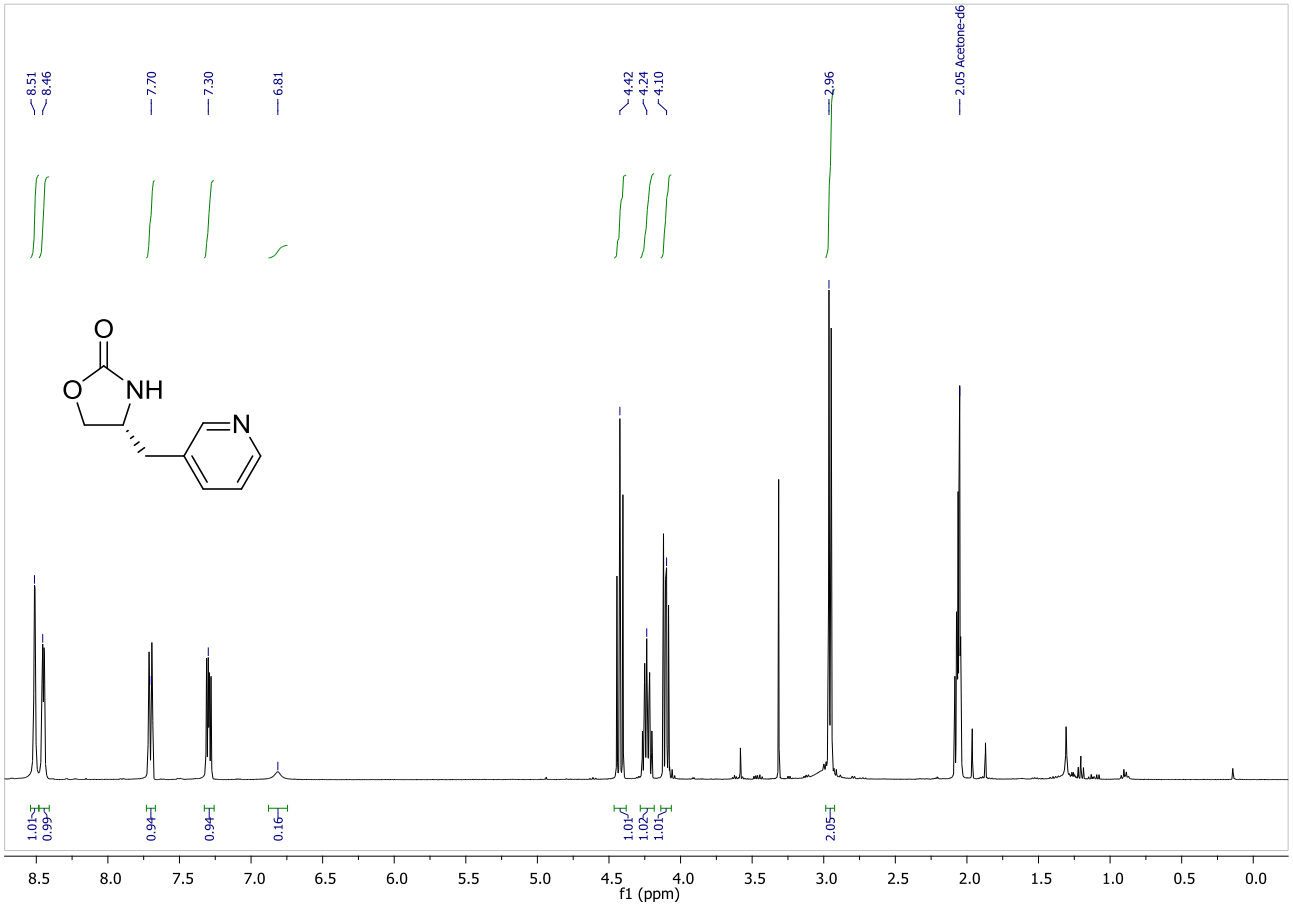
2h ^{1}H


8.90
8.52
8.45
7.71
7.69
7.39
7.37
7.28
7.26
5.15
4.43
4.09
3.18
3.12
3.02
2.96
2.05 Acetone-d6
Ph
O
O
O
N
NH
N
0.71
2.14
1.00
6.00
2.04
2.03
1.09
2.08
f1 (ppm)

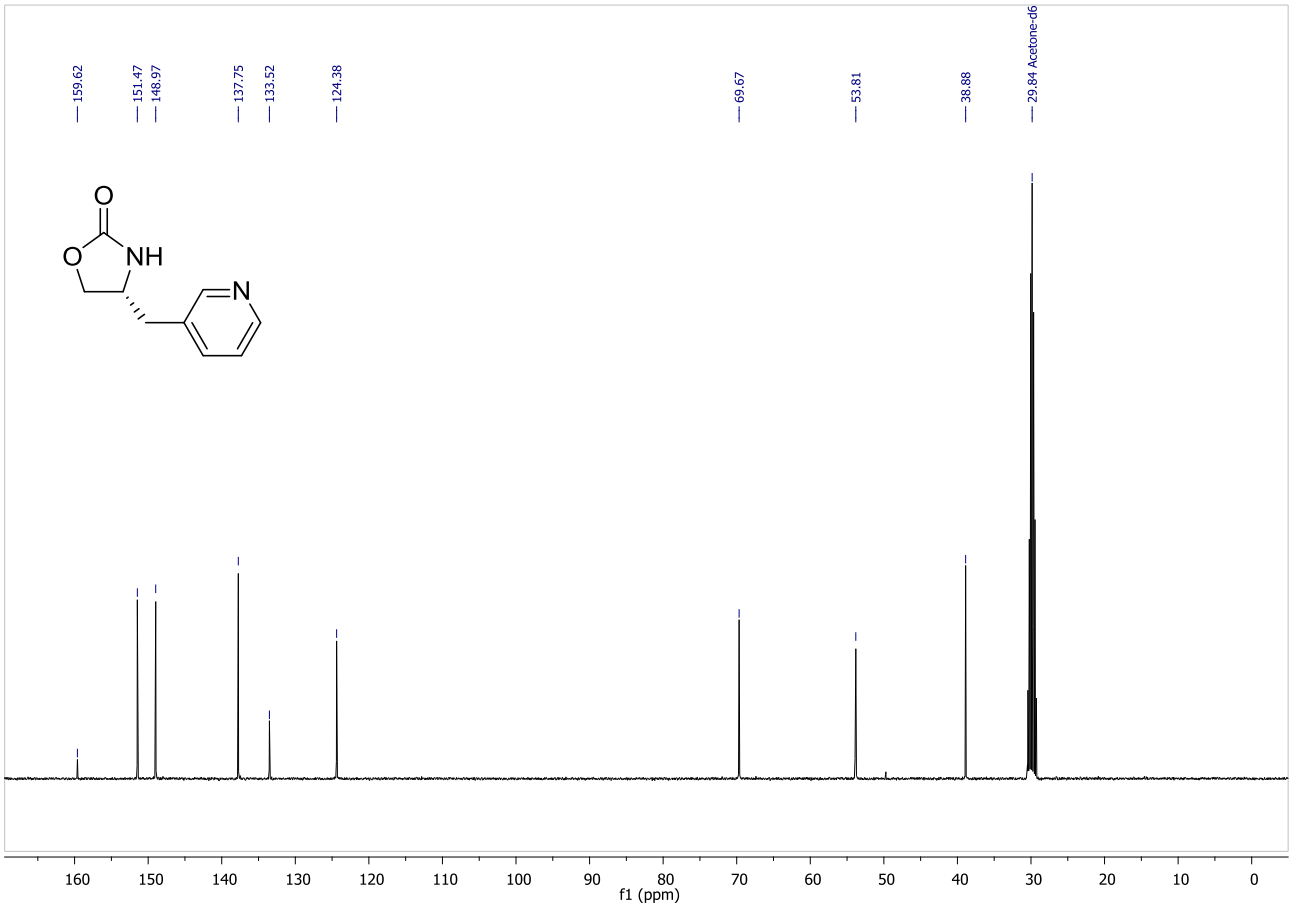
2h ^{13}C


157.56
156.28
151.44
149.07
137.49
137.29
132.71
129.33
128.97
128.81
124.27
67.81
67.11
58.04
35.43
29.84 Acetone-d6
Ph
O
O
O
N
NH
N
f1 (ppm)

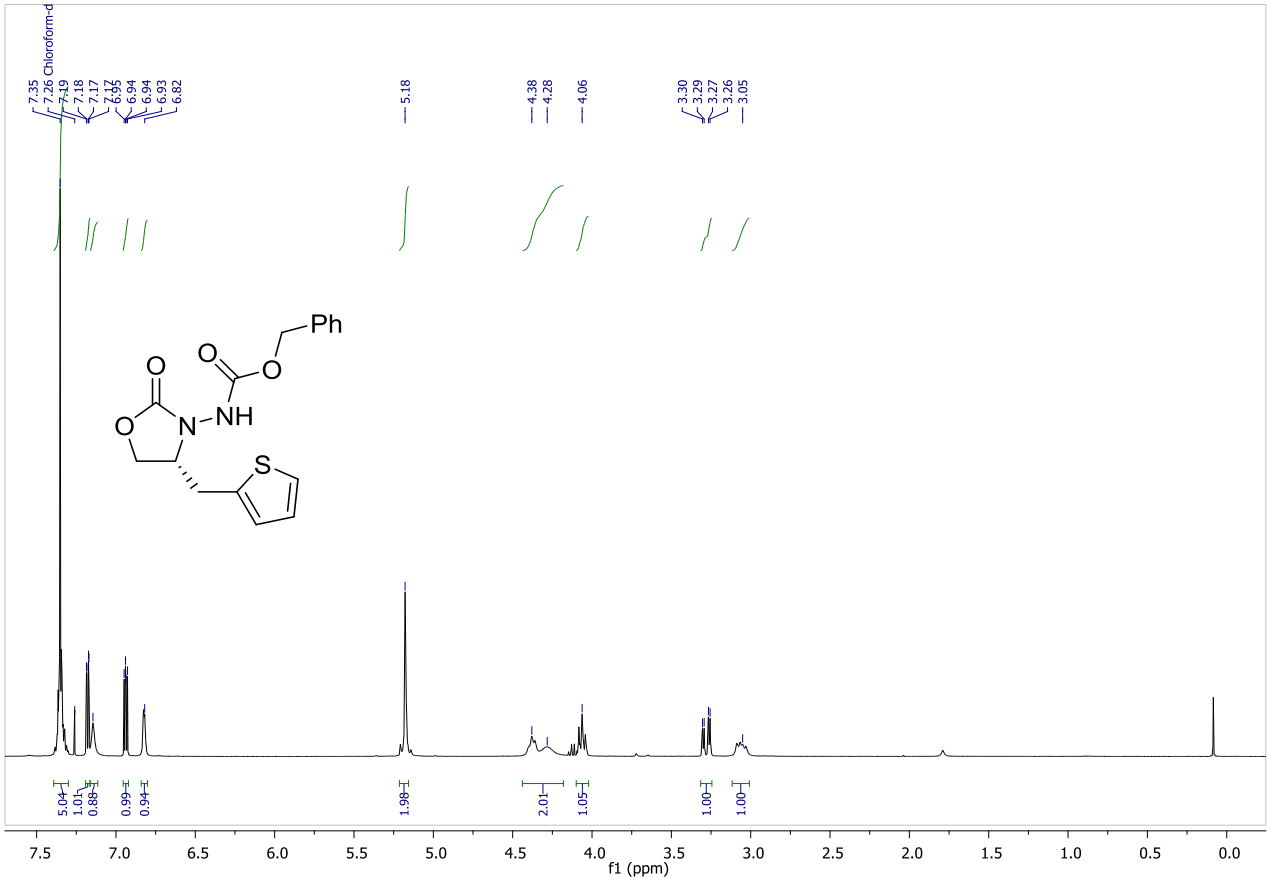
3h ^{1}H


8.51
8.46
7.70
7.30
6.81
4.42
4.24
4.10
2.96
2.05 Acetone-d6
O
O
NH
N
1.01
0.99
0.94
0.94
0.16
1.01
1.02
1.01
2.05
8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

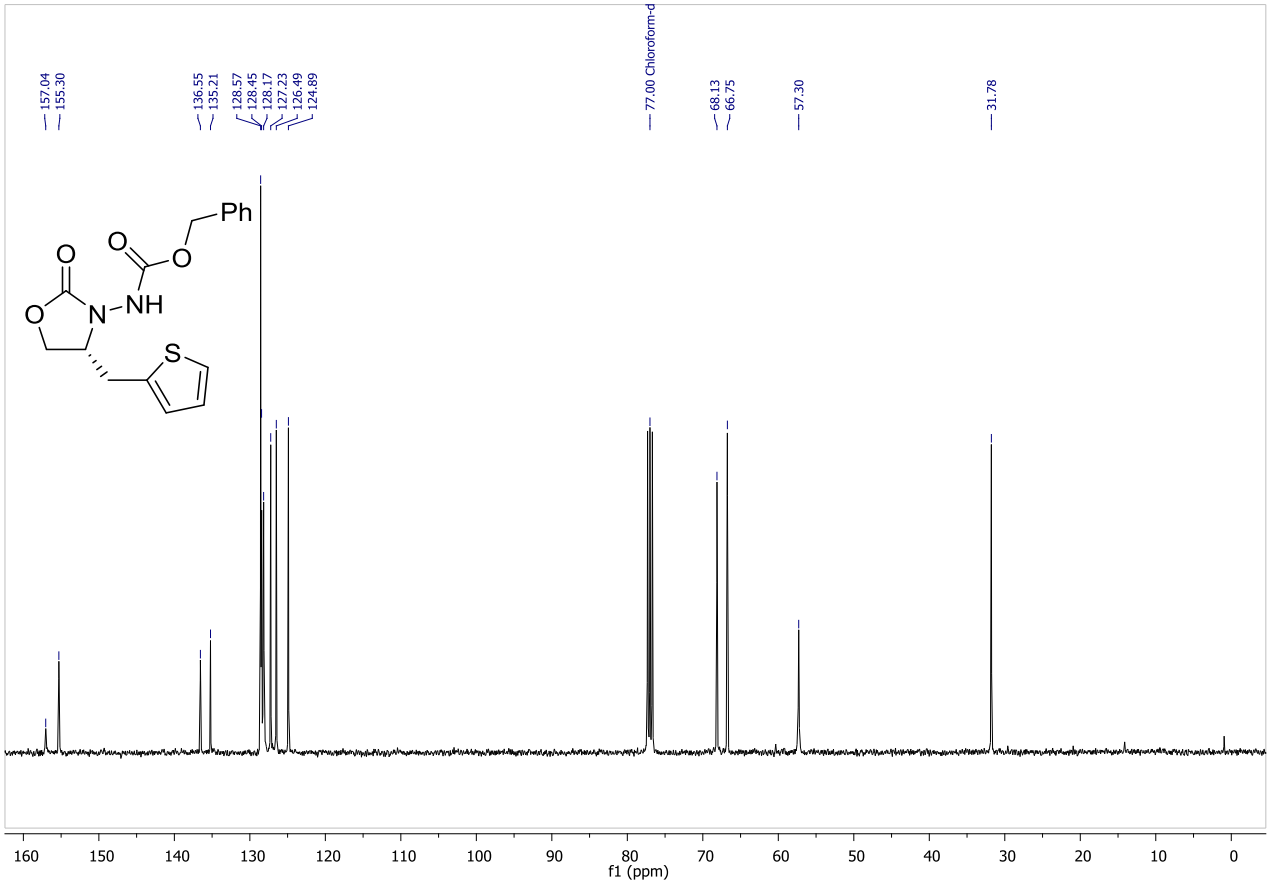
3h ^{13}C


159.62
151.47
148.97
137.75
133.52
124.38
69.67
53.81
38.88
29.84 Acetone-d6
O
O
NH
N
160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

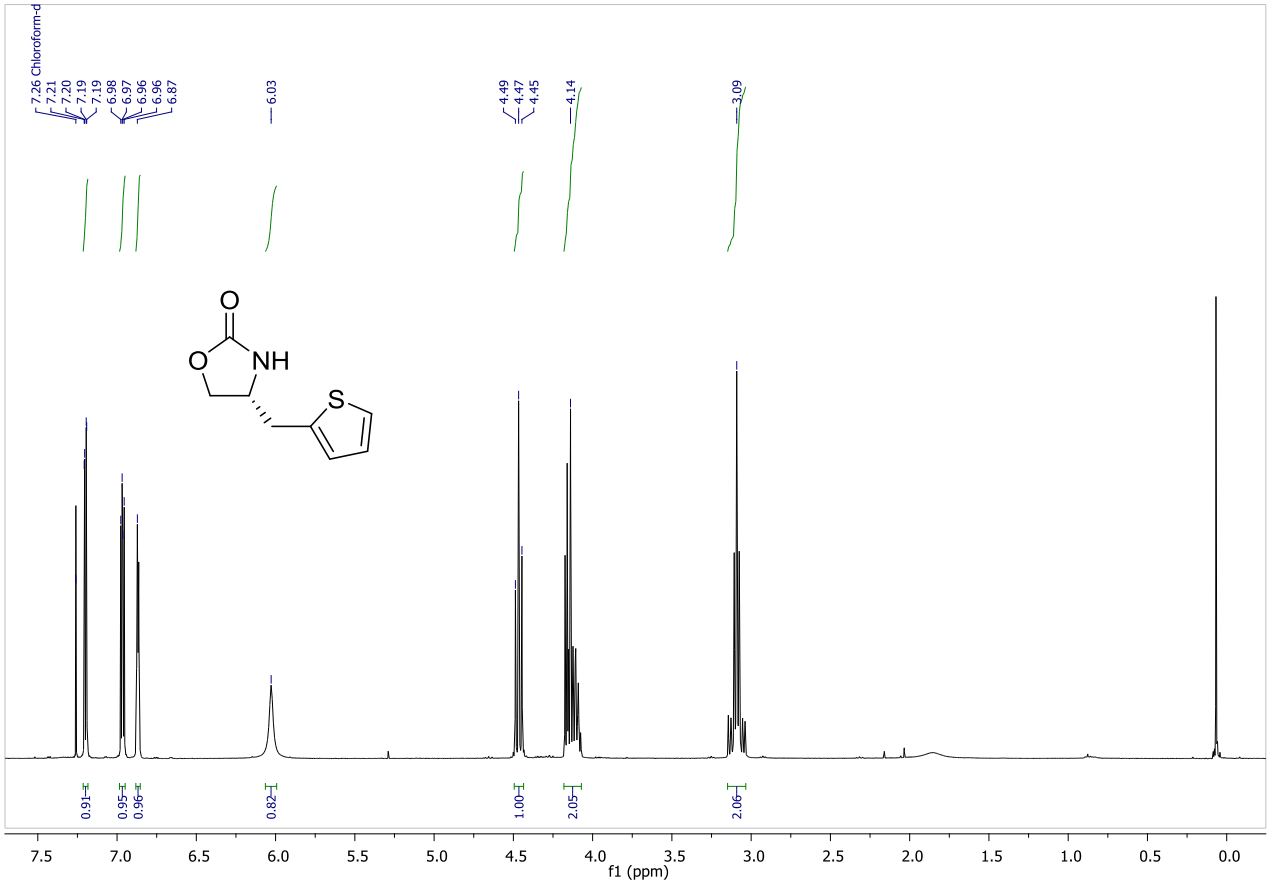
2i ^{1}H


7.35
7.26 Chloroform-d
7.19
7.18
7.17
6.95
6.94
6.94
6.93
6.82
5.18
4.38
4.28
4.06
3.30
3.29
3.27
3.26
3.05
Ph
O
O
O
N
NH
S
5.04
1.01
0.88
0.99
0.94
1.98
2.01
1.05
1.00
1.00
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)

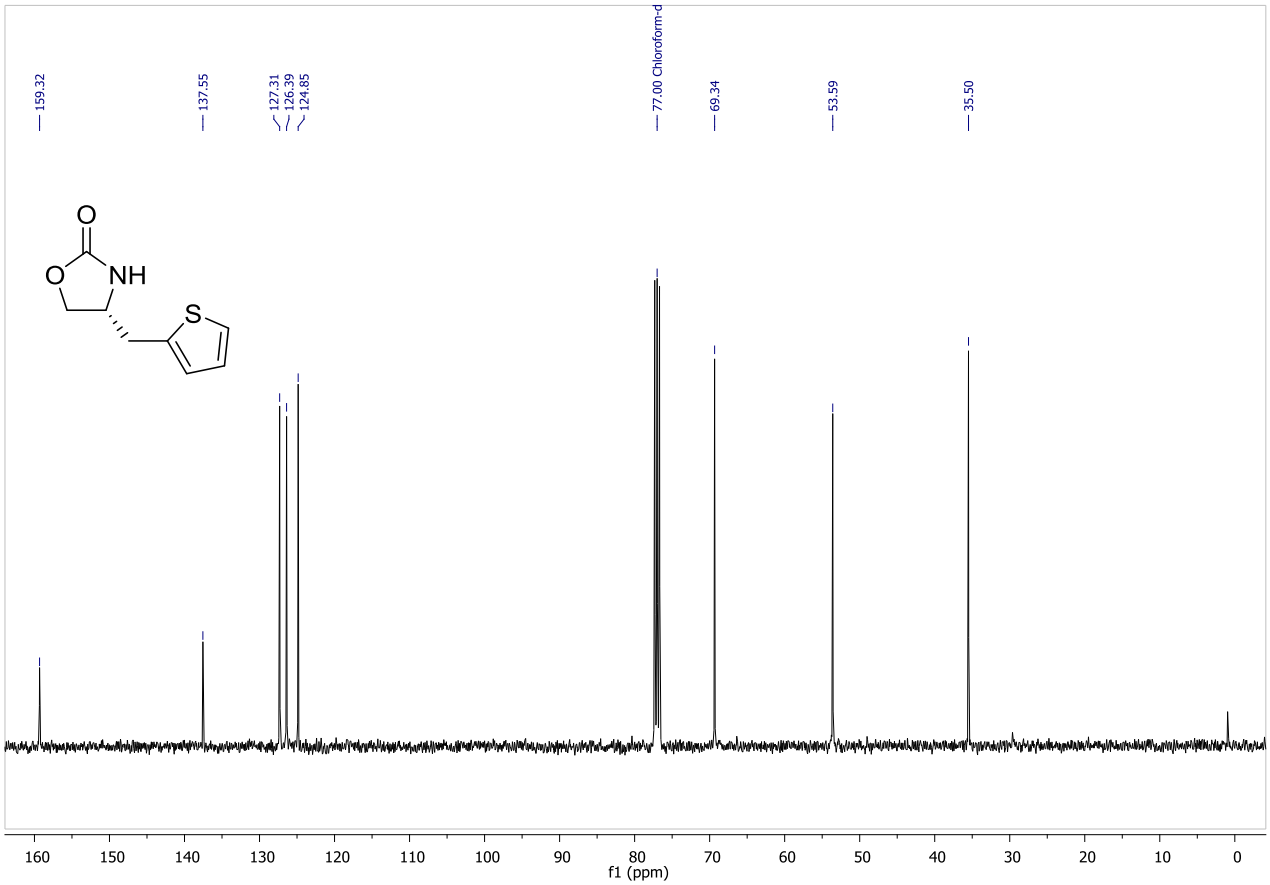
2i ^{13}C


157.04
155.30
136.55
135.21
128.57
128.45
128.17
127.23
126.49
124.89
77.00 Chloroform-d
68.13
66.75
57.30
31.78
Ph
O
O
O
N
NH
S
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

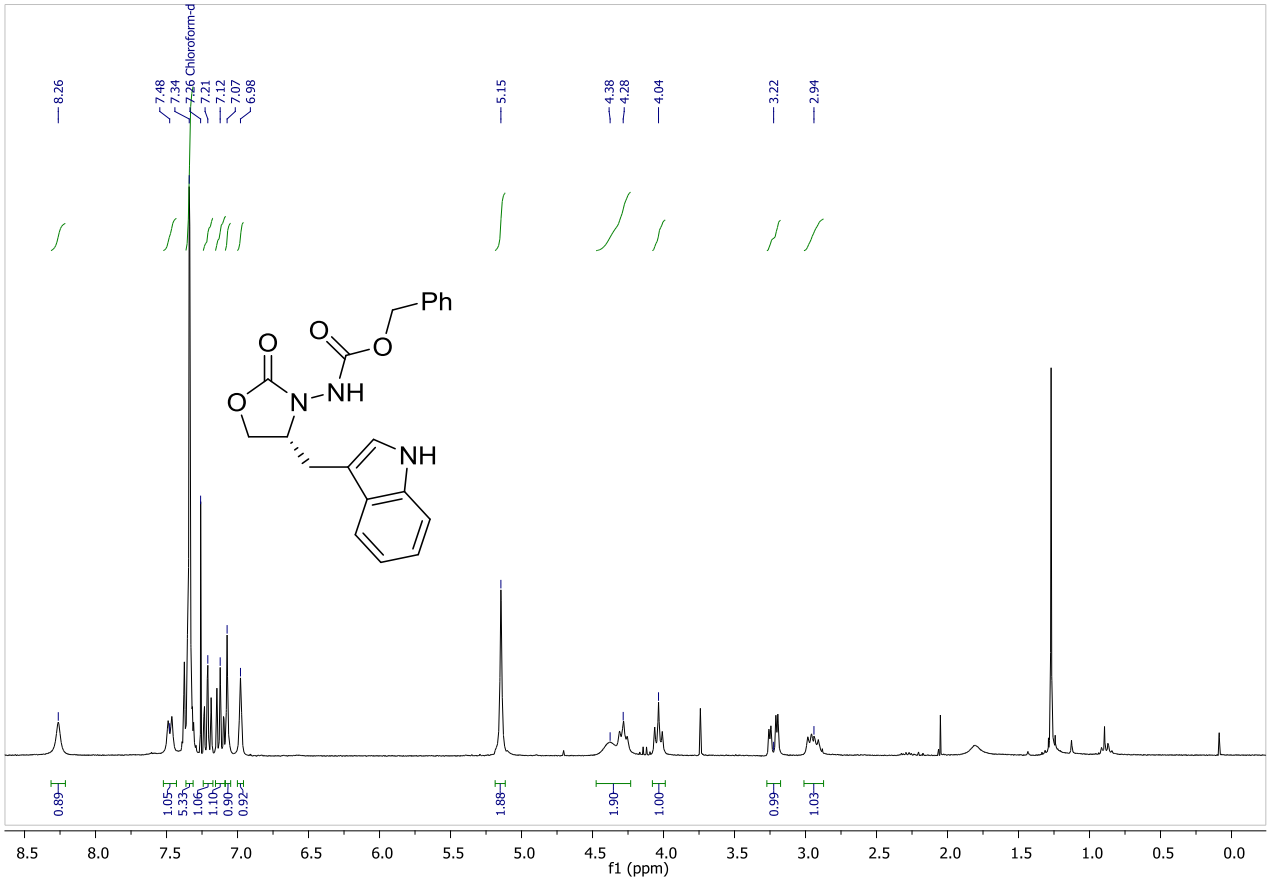
3i ^{1}H


7.26 Chloroform-d
7.21
7.20
7.19
7.19
6.98
6.97
6.96
6.96
6.87
6.03
4.49
4.47
4.45
4.14
3.09
O
O
NH
S
0.91
0.95
0.96
0.82
1.00
2.05
2.06
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)

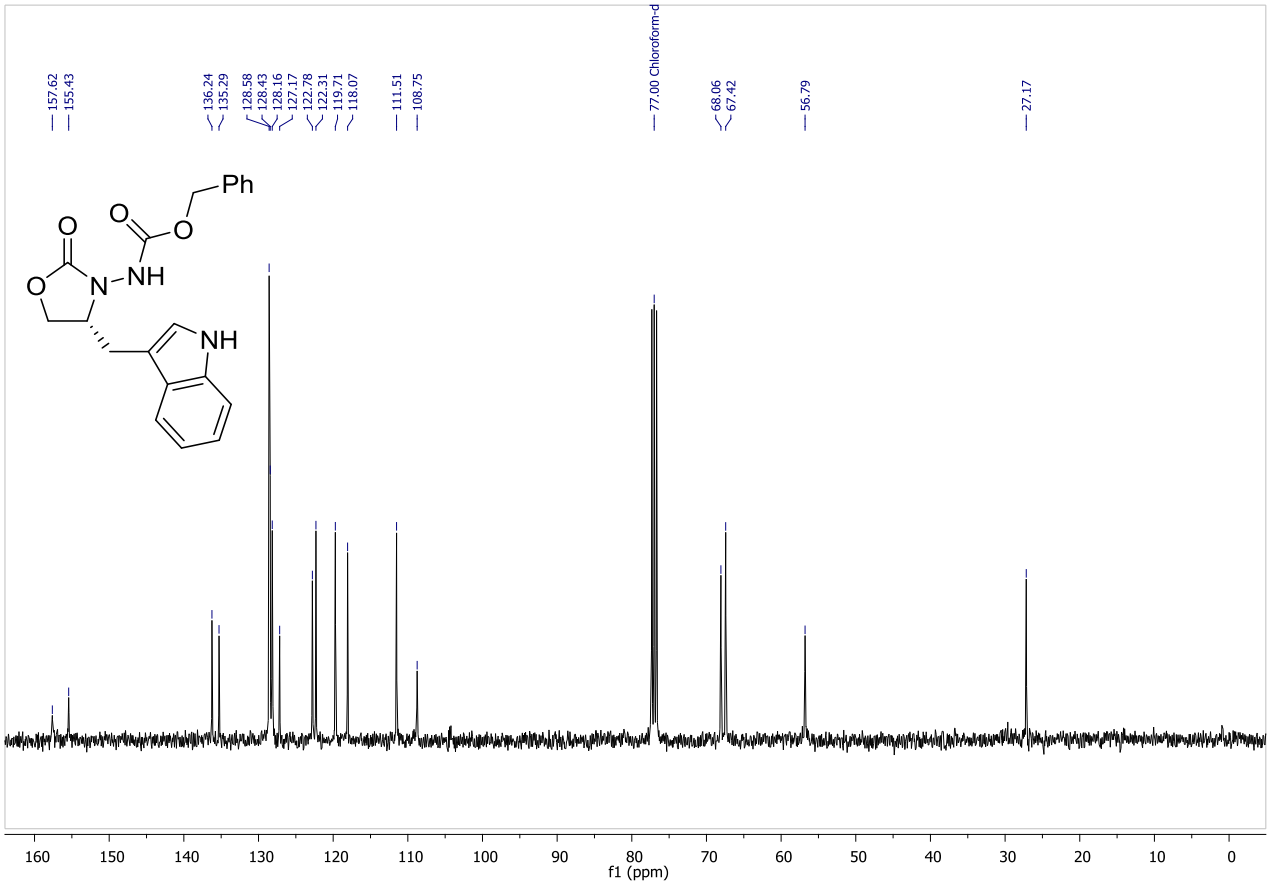
3i ^{13}C


159.32
137.55
127.31
126.39
124.85
77.00 Chloroform-d
69.34
53.59
35.50
O
O
NH
S
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

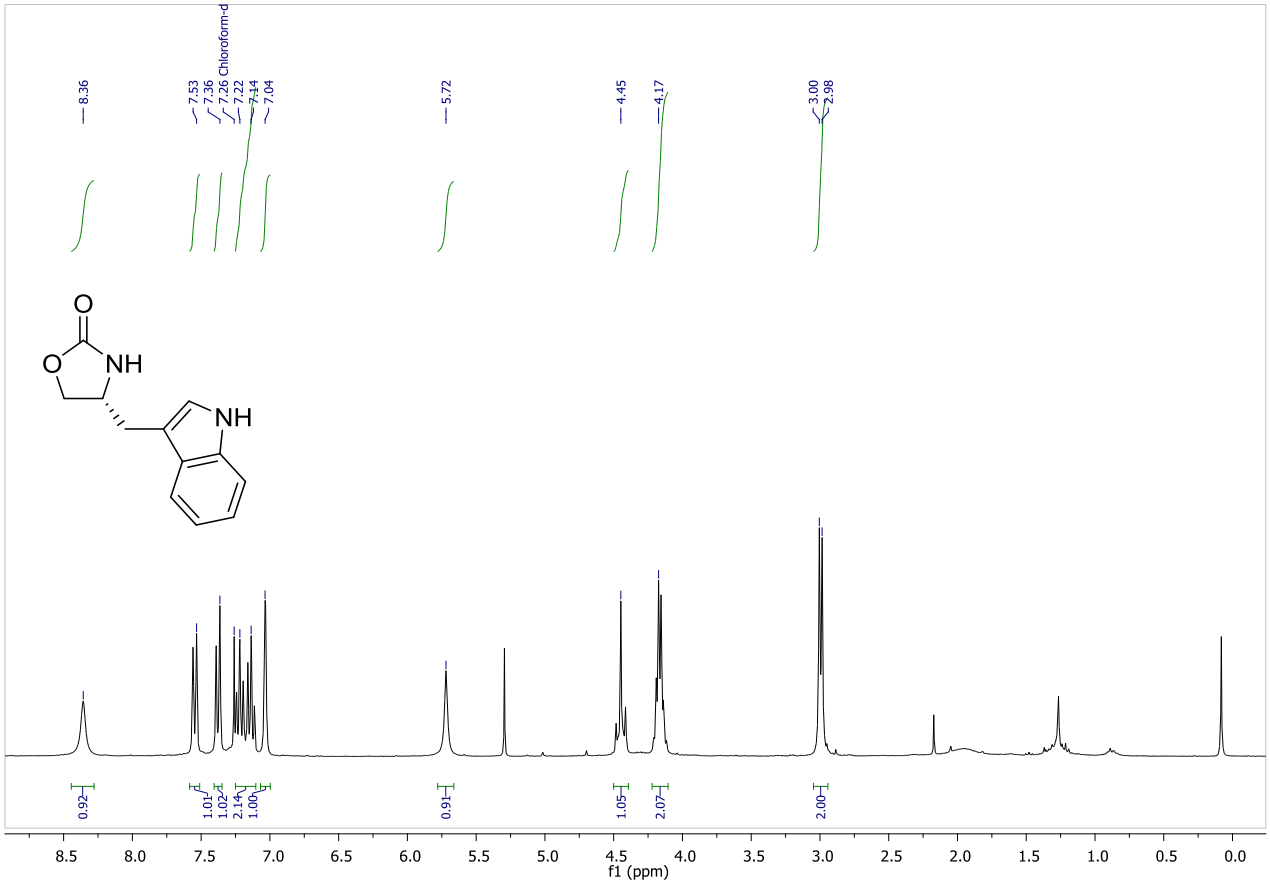
2j ^{1}H


8.26
7.48
7.34
7.26 Chloroform-d
7.21
7.12
7.07
6.98
5.15
4.38
4.28
4.04
3.22
2.94
Ph
O
O
O
N
NH
NH
0.89
1.05
5.33
1.06
1.10
0.90
0.92
1.88
1.90
1.00
0.99
1.03
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

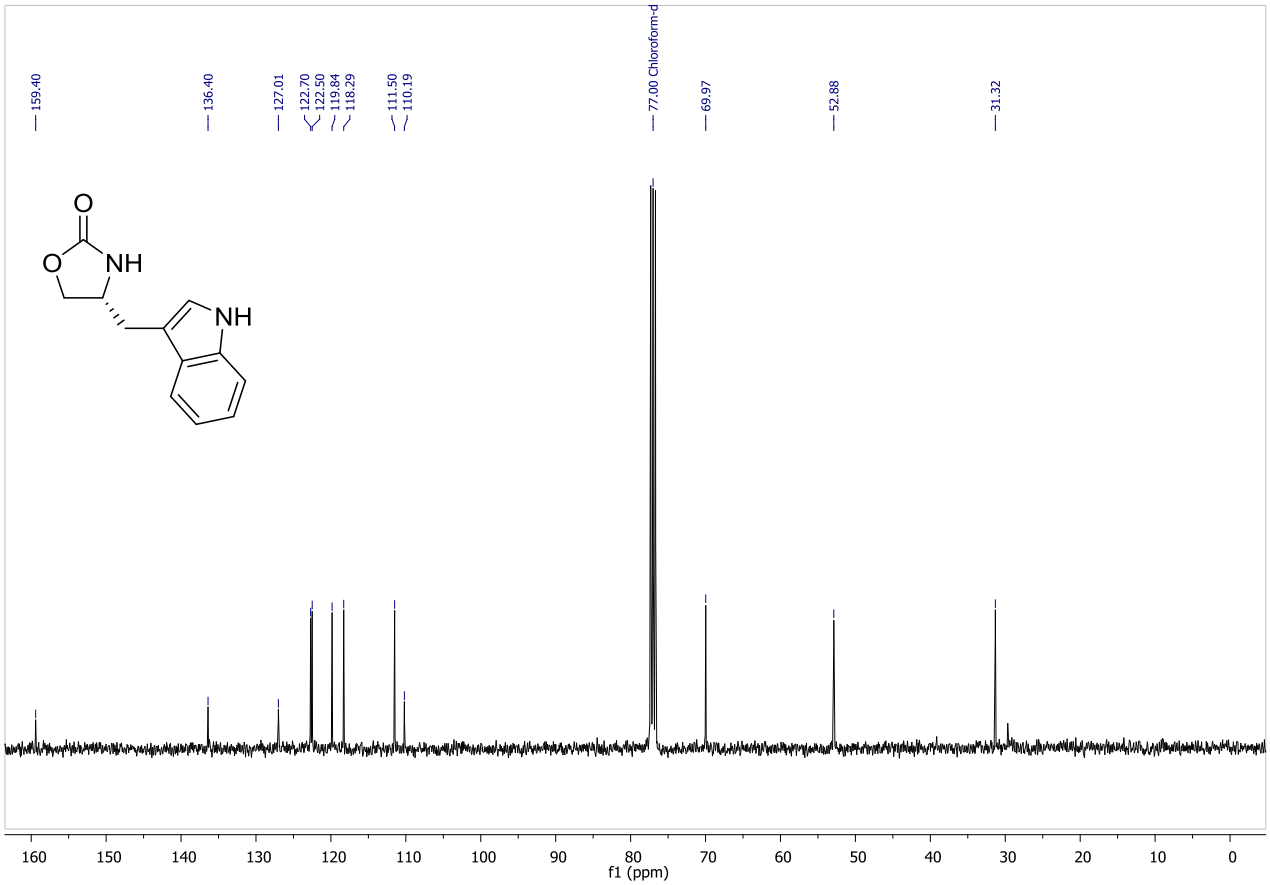
2j ^{13}C


157.62
155.43
136.24
135.29
128.58
128.43
128.16
127.17
122.78
122.31
119.71
118.07
111.51
108.75
77.00 Chloroform-d
68.06
67.42
56.79
27.17
Ph
O
O
O
N
NH
NH
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

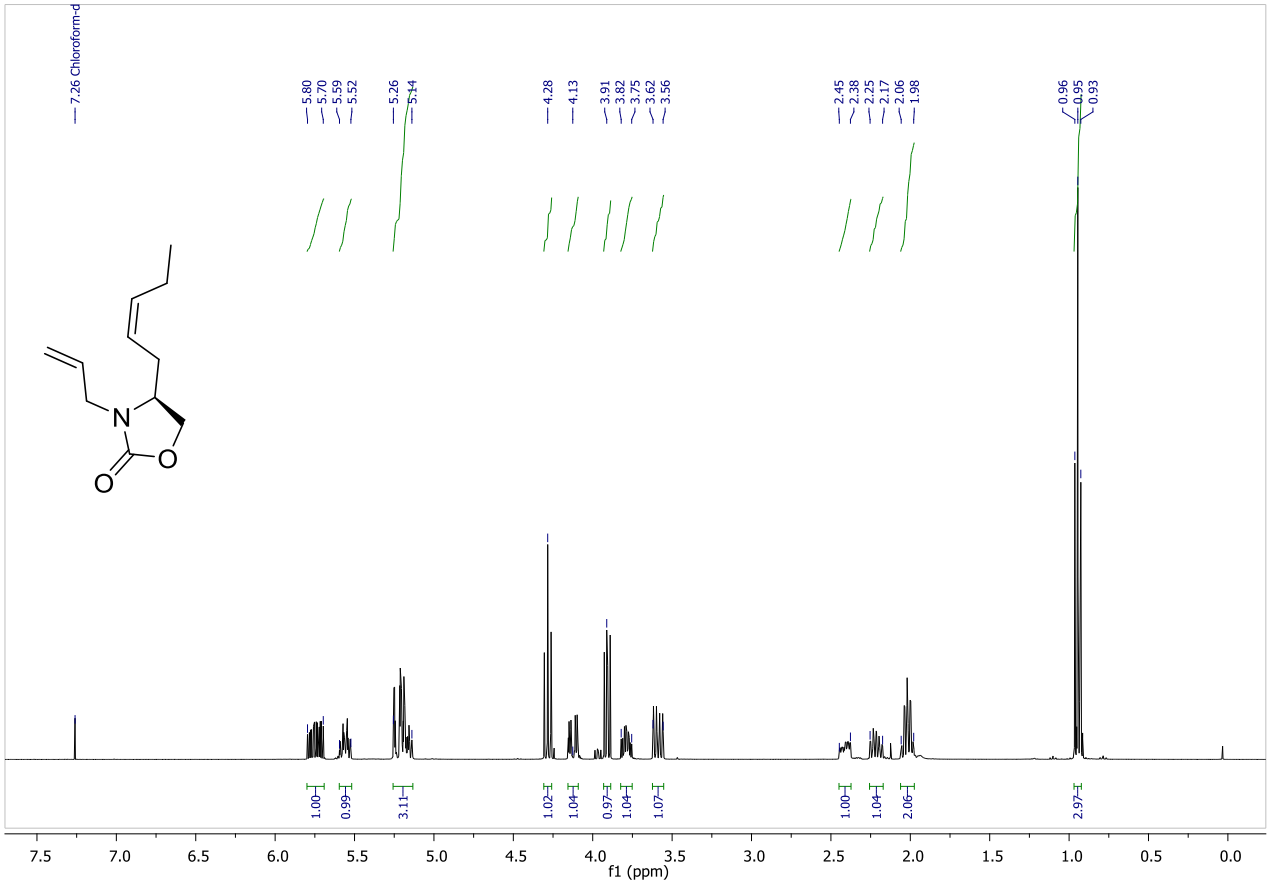
3j ^{1}H


8.36
7.53
7.36
7.26 Chloroform-d
7.22
7.14
7.04
5.72
4.45
4.17
3.00
2.98
O
NH
NH
0.92
1.01
1.02
2.14
1.00
0.91
1.05
2.07
2.00
8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

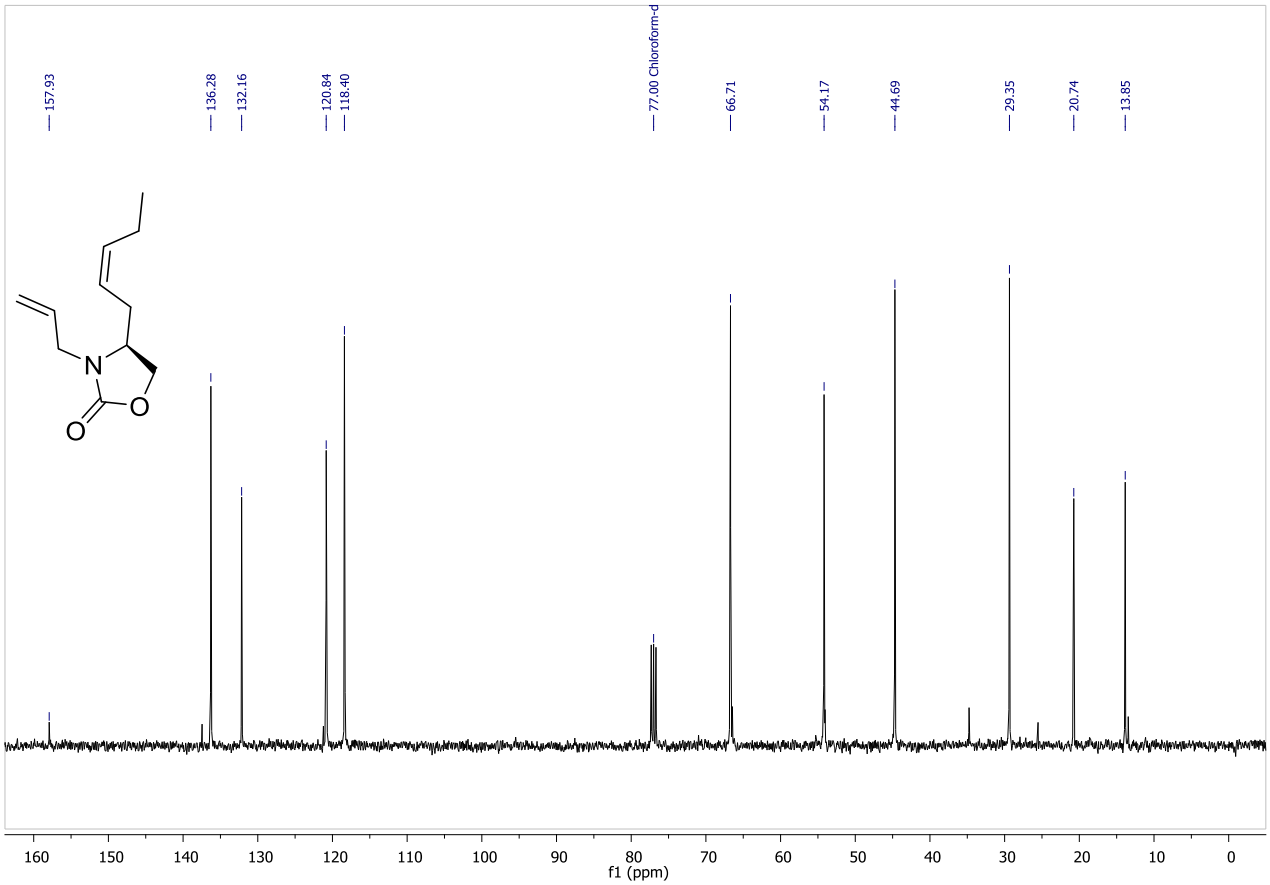
3j ^{13}C


159.40
136.40
127.01
122.70
122.50
119.84
118.29
111.50
110.19
77.00 Chloroform-d
69.97
52.88
31.32
O
NH
NH
160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

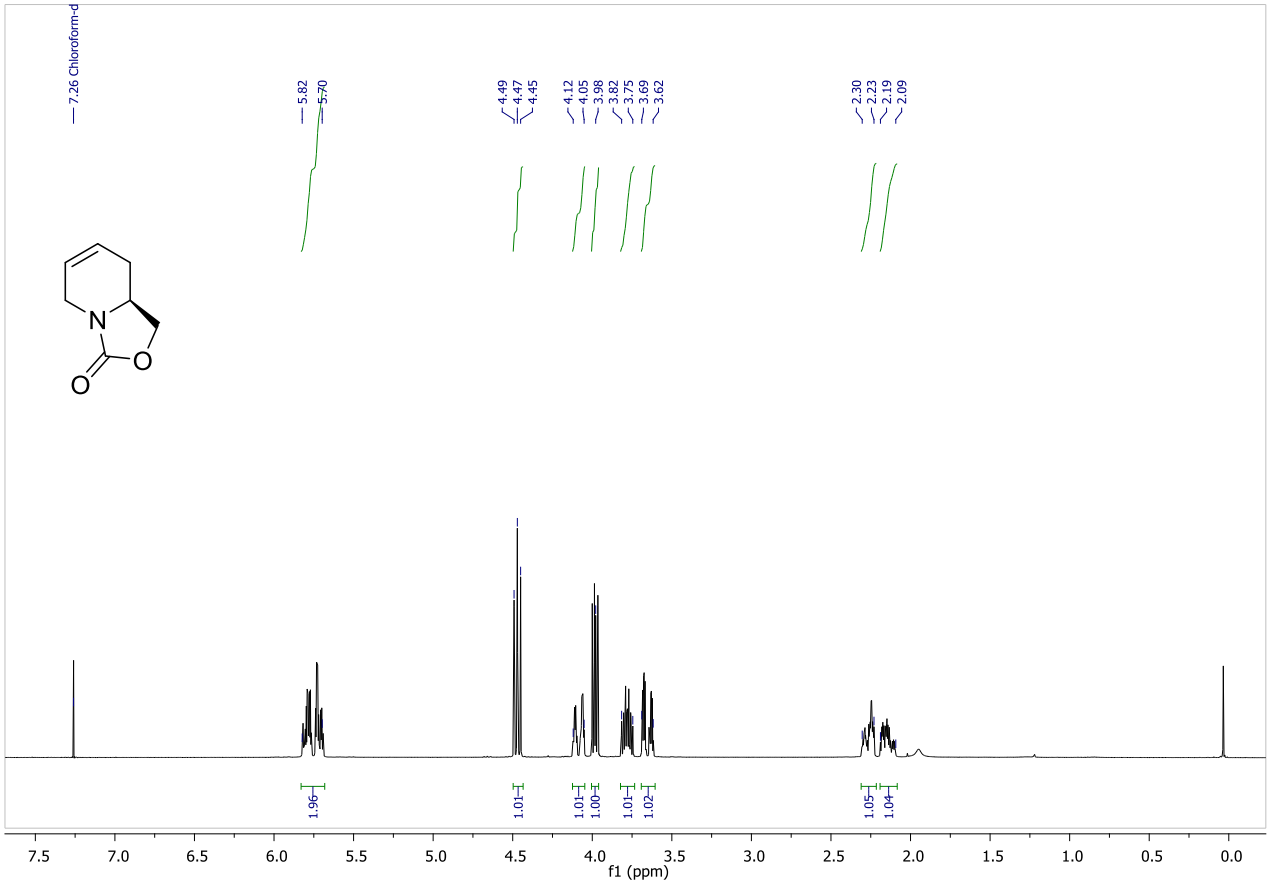
4 ^{1}H


7.26 Chloroform-d
5.80
5.70
5.59
5.52
5.26
5.14
4.28
4.13
3.91
3.82
3.75
3.62
3.56
2.45
2.38
2.25
2.17
2.06
1.98
0.96
0.95
0.93
1.00
0.99
3.11
1.02
1.04
0.97
1.04
1.07
1.00
1.04
2.06
2.97
f1 (ppm)

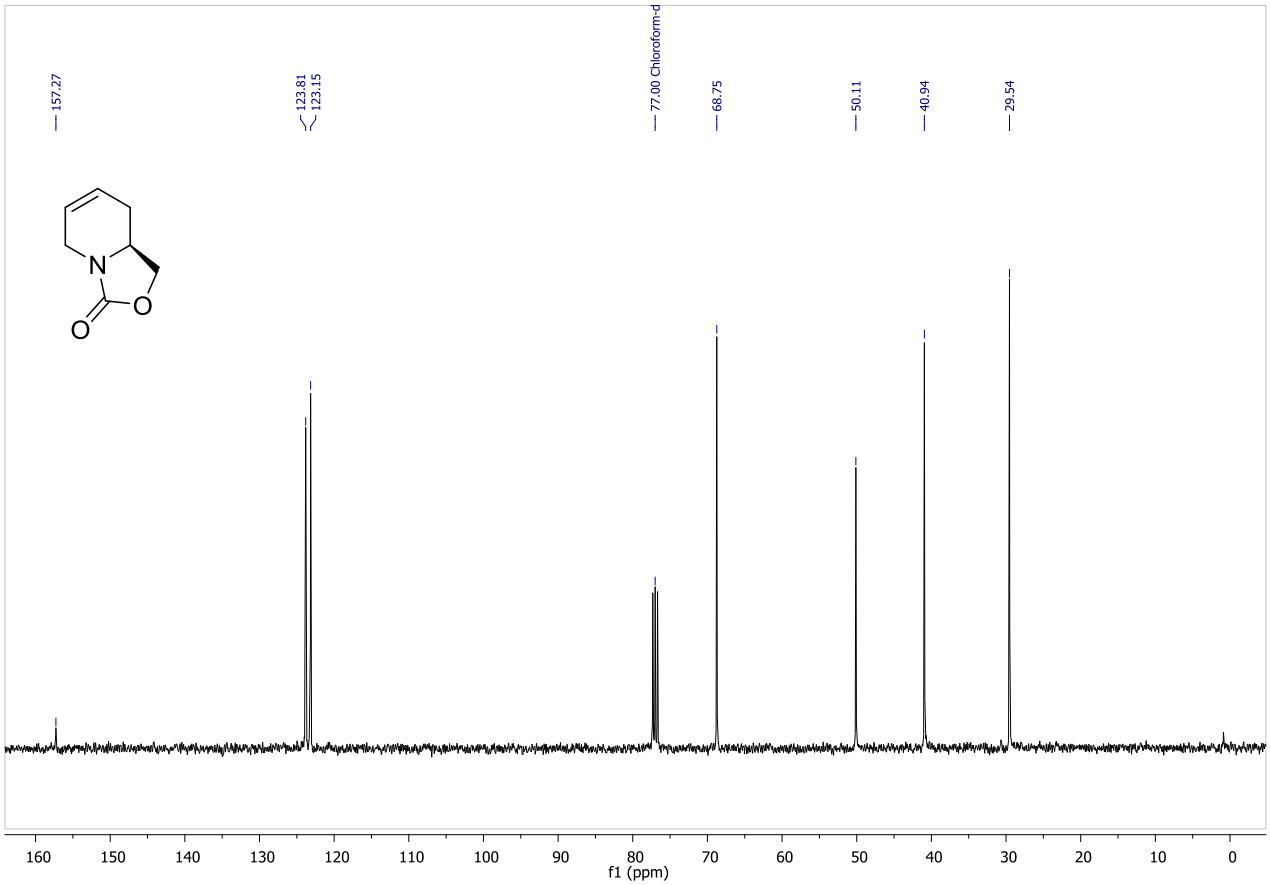
4 ^{13}C


157.93
136.28
132.16
120.84
118.40
77.00 Chloroform-d
66.71
54.17
44.69
29.35
20.74
13.85
f1 (ppm)

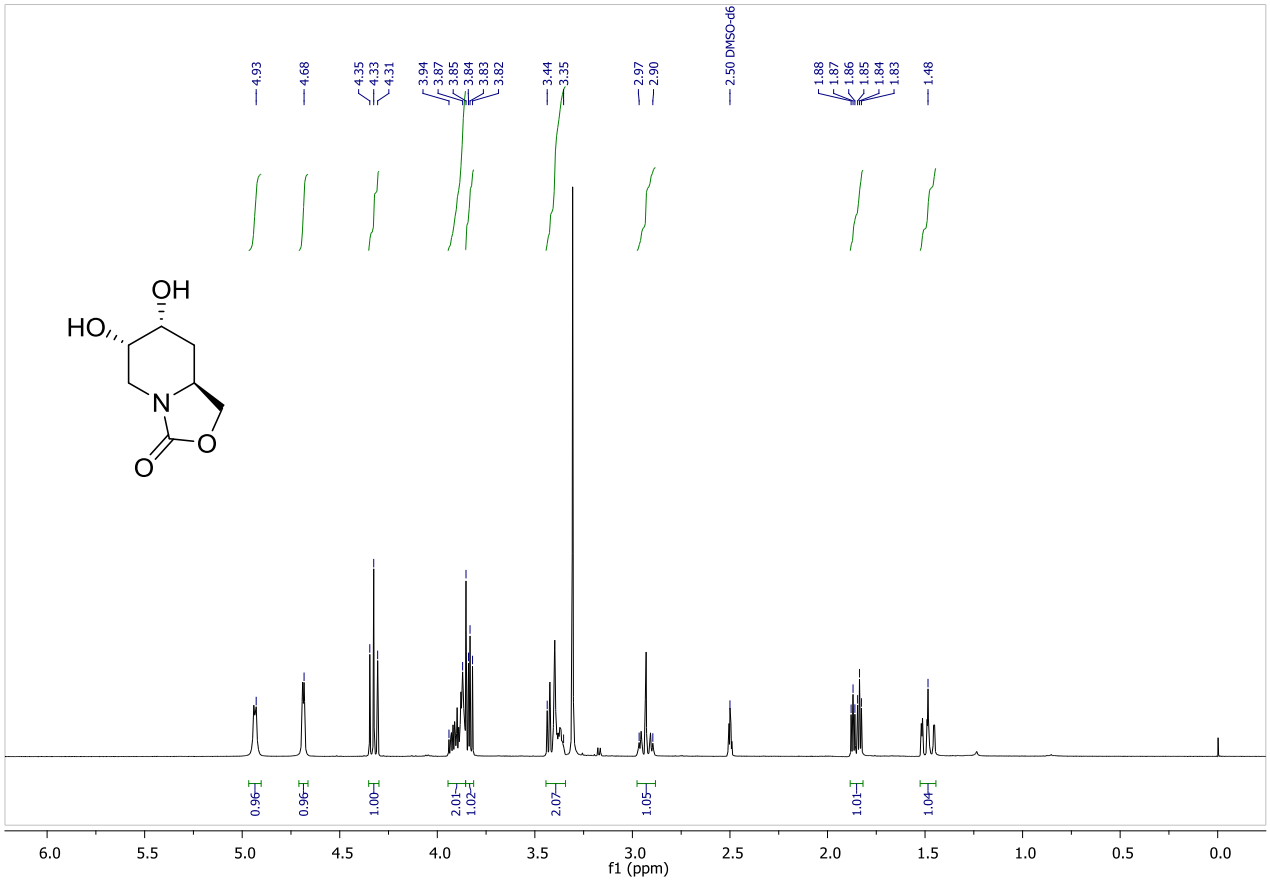
5 ^{1}H


7.26 Chloroform-d
5.82
5.70
4.49
4.47
4.45
4.12
4.05
3.98
3.82
3.75
3.69
3.62
2.30
2.23
2.19
2.09
1.96
1.01
1.01
1.00
1.01
1.02
1.05
1.04
f1 (ppm)

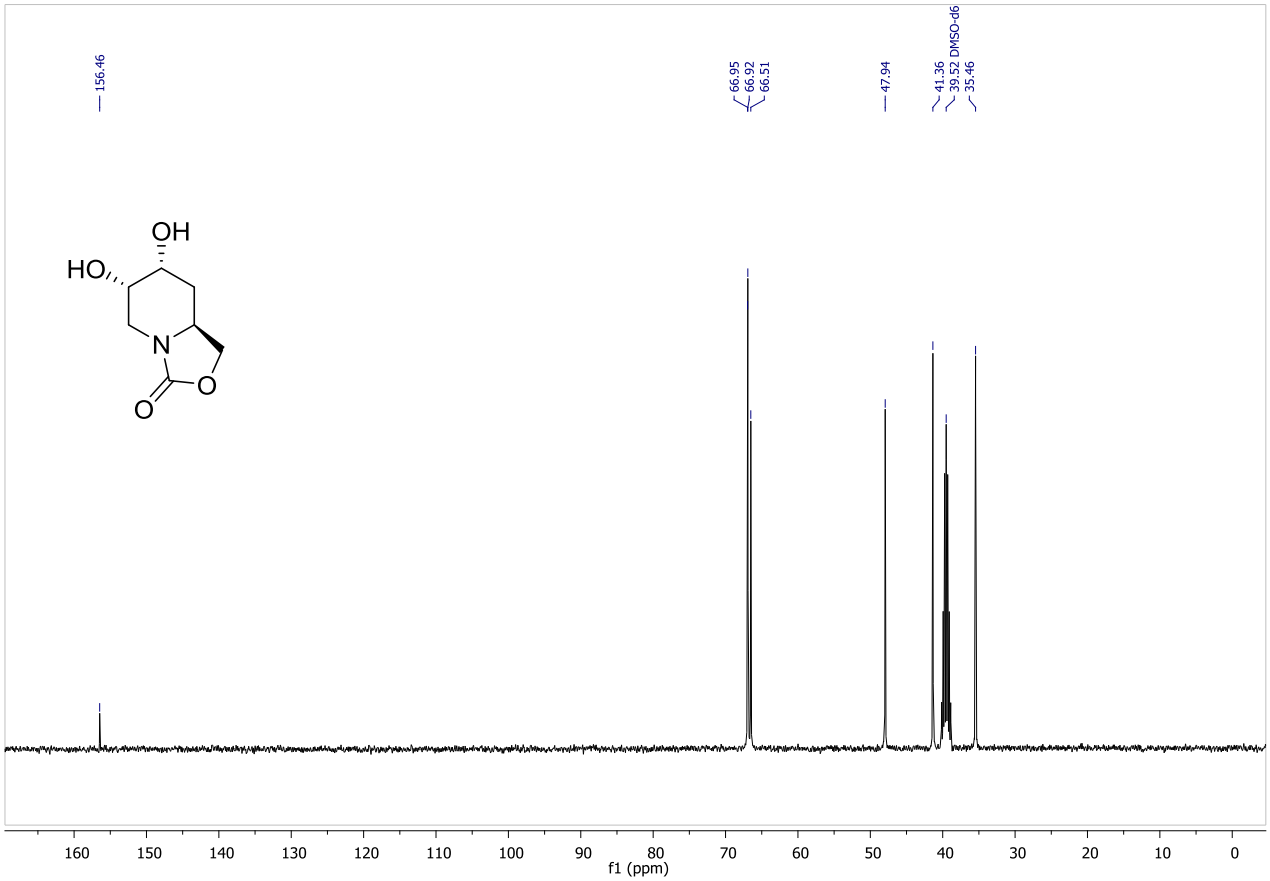
5 ^{13}C


157.27
123.81
123.15
77.00 Chloroform-d
68.75
50.11
40.94
29.54
f1 (ppm)

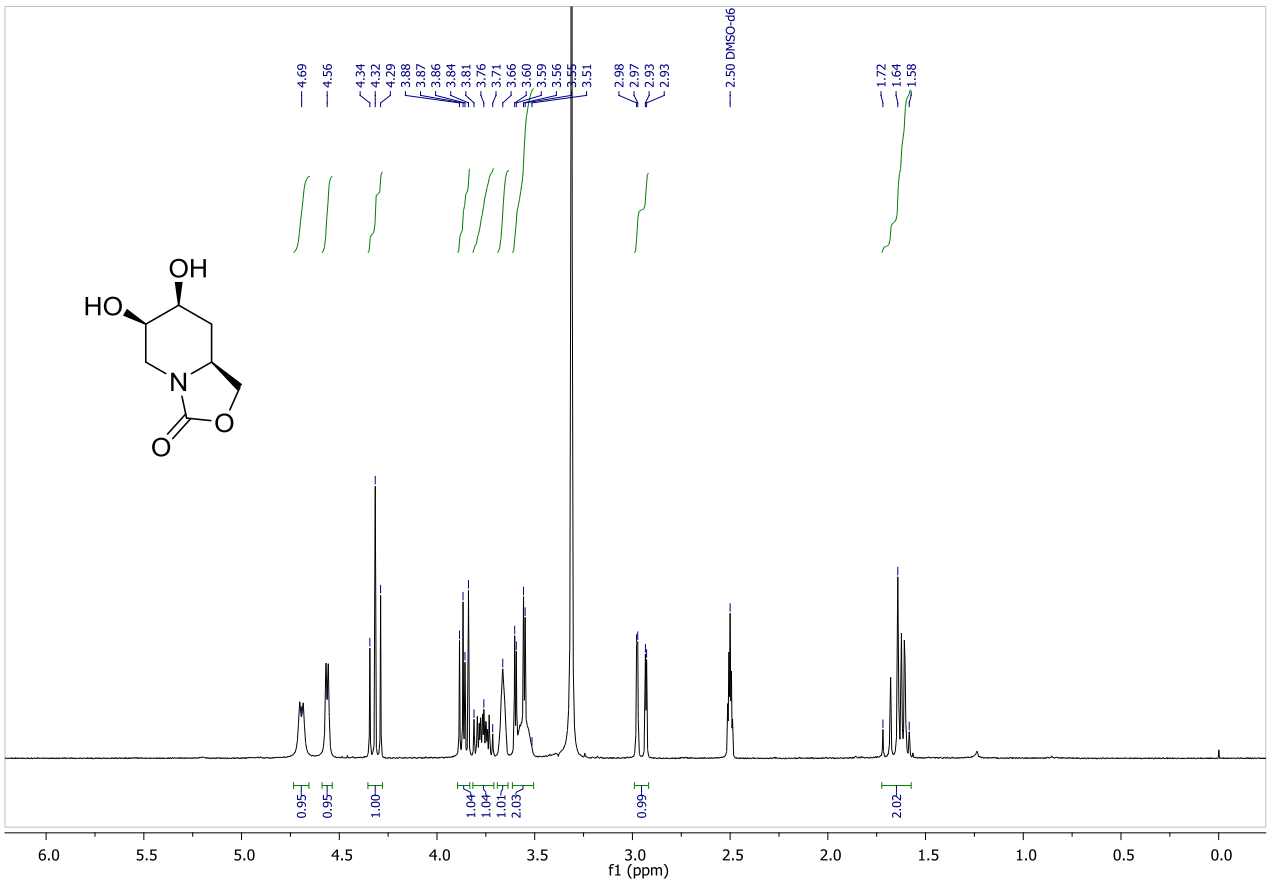
6a ^{1}H


4.93
4.68
4.35
4.33
4.31
3.94
3.87
3.85
3.84
3.83
3.82
3.44
3.35
2.97
2.90
2.50 DMSO-d6
1.88
1.87
1.86
1.85
1.84
1.83
1.48
OH
HO
N
O
O
0.96
0.96
1.00
2.01
1.02
2.07
1.05
1.01
1.04
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)

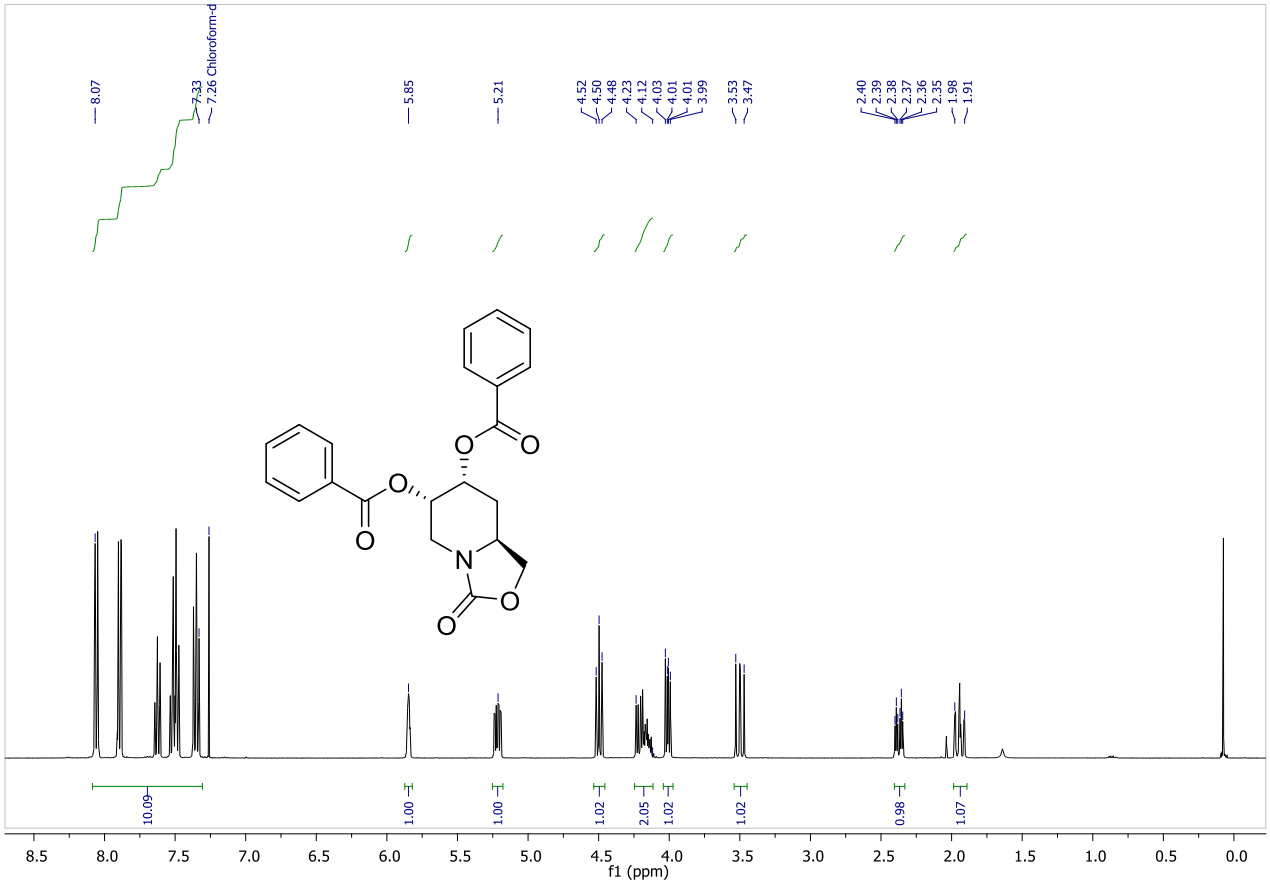
6a ^{13}C


156.46
66.95
66.92
66.51
47.94
41.36
39.52 DMSO-d6
35.46
OH
HO
N
O
O
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

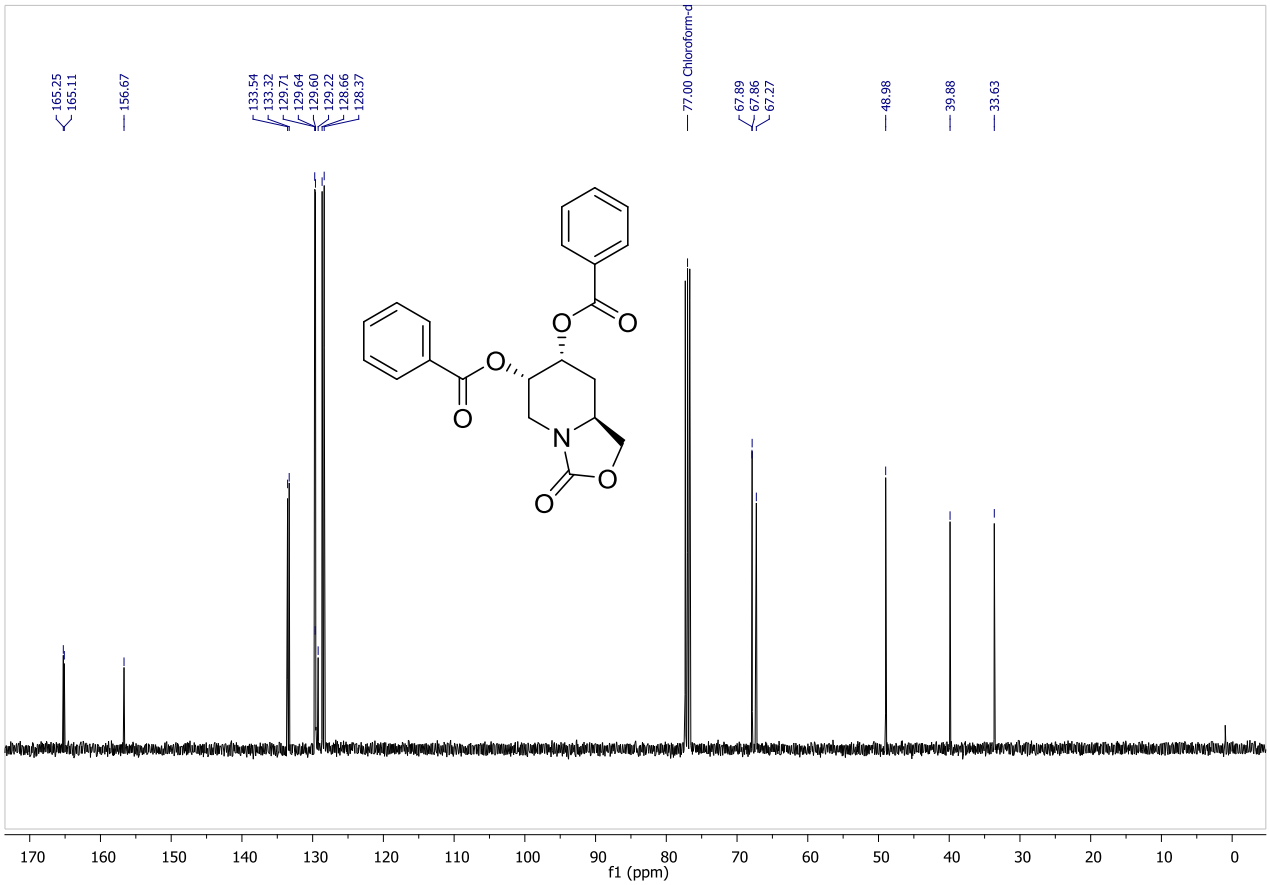
6b ^{1}H


4.69
4.56
4.34
4.32
4.29
3.88
3.87
3.86
3.84
3.81
3.76
3.71
3.66
3.60
3.59
3.56
3.55
3.51
2.98
2.97
2.93
2.93
2.50 DMSO-d6
1.72
1.64
1.58
OH
HO
N
O
O
0.95
0.95
1.00
1.04
1.04
1.01
2.03
0.99
2.02
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)

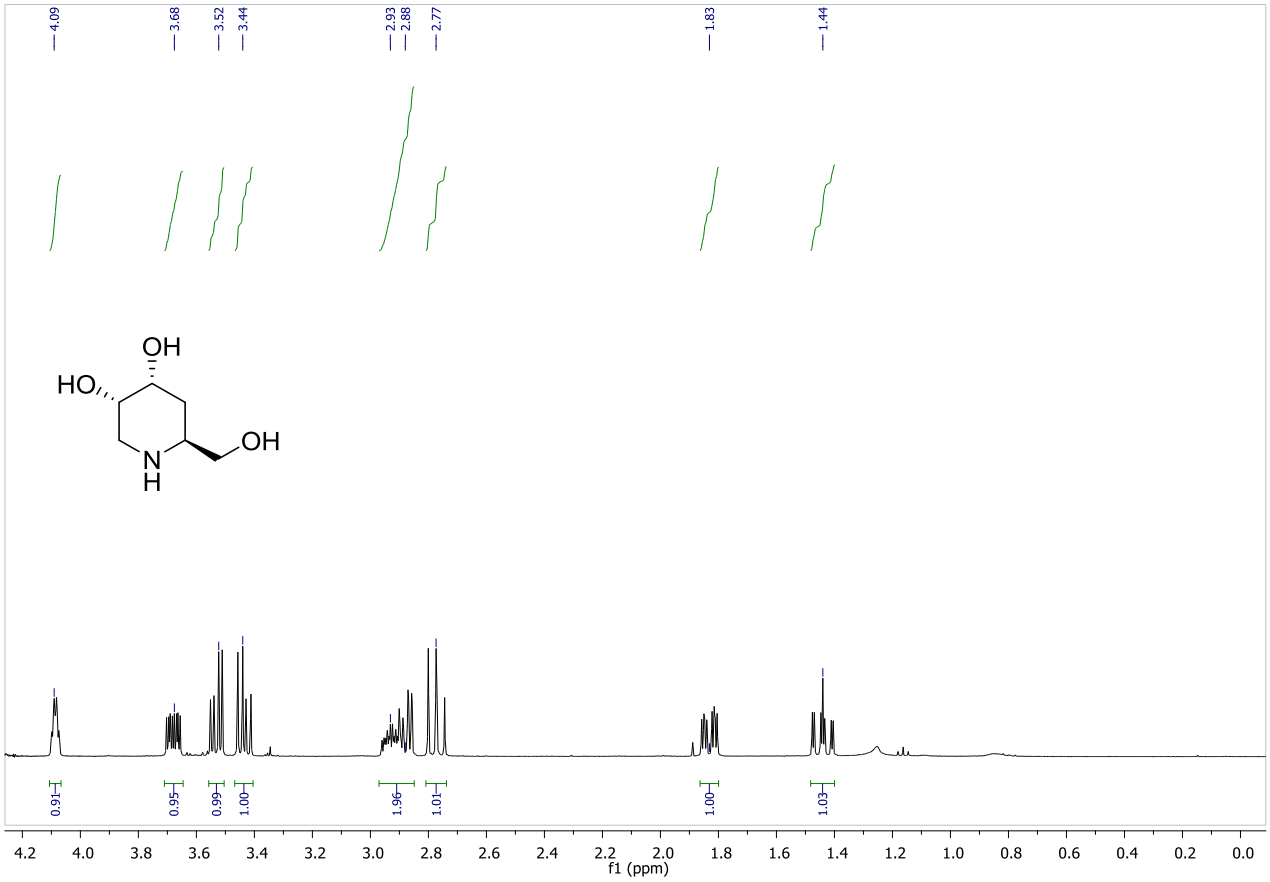
7 ^{1}H


8.07
7.33
7.26 Chloroform-d
5.85
5.21
4.52
4.50
4.48
4.23
4.12
4.03
4.01
4.01
3.99
3.53
3.47
2.40
2.39
2.38
2.37
2.36
2.35
1.98
1.91
10.09
1.00
1.00
1.02
2.05
1.02
1.02
0.98
1.07
f1 (ppm)

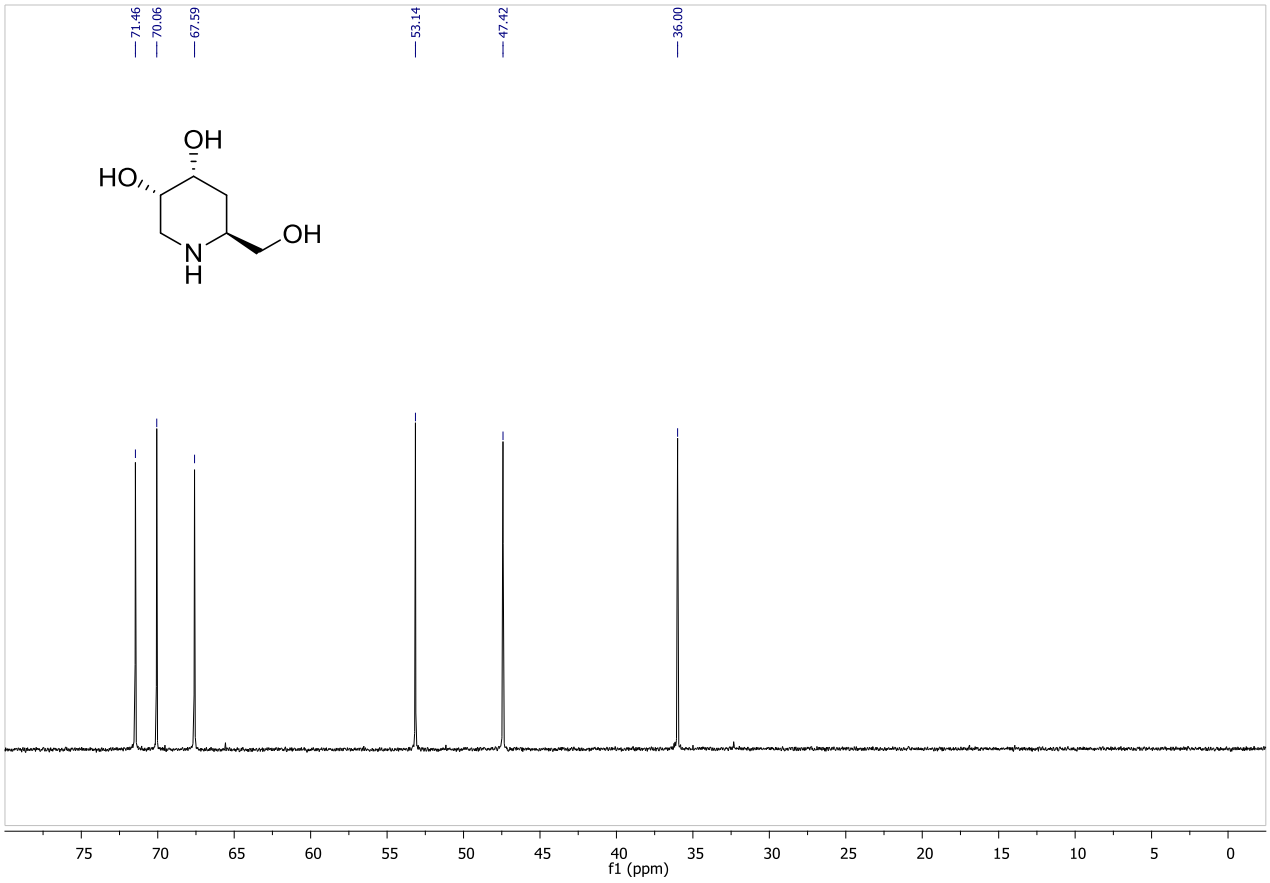
7 ^{13}C


165.25
165.11
156.67
133.54
133.32
129.71
129.64
129.60
129.22
128.66
128.37
77.00 Chloroform-d
67.89
67.86
67.27
48.98
39.88
33.63
f1 (ppm)

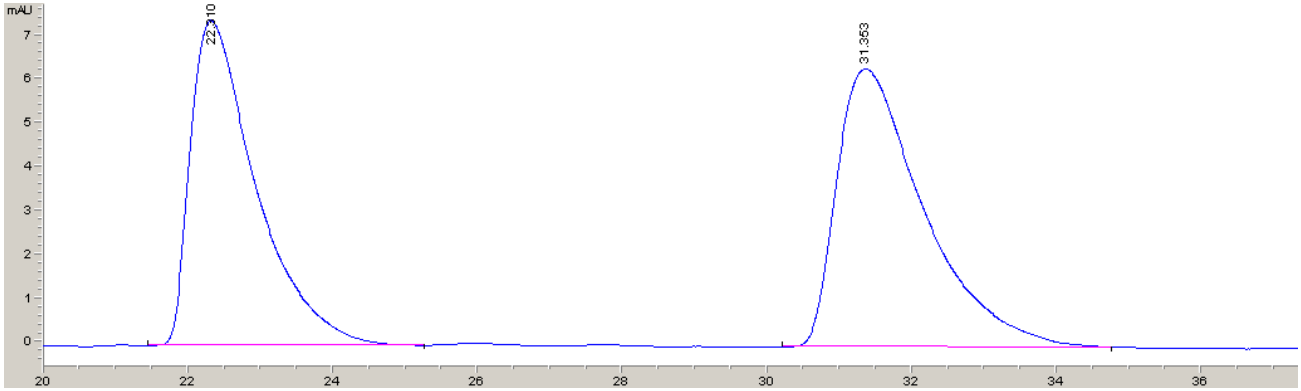
8 ^{1}H


4.09
3.68
3.52
3.44
2.93
2.88
2.77
1.83
1.44
OH
HO
OH
N
H
0.91
0.95
0.99
1.00
1.96
1.01
1.00
1.03
4.2 4.0 3.8 3.6 3.4 3.2 3.0 2.8 2.6 2.4 2.2 2.0 1.8 1.6 1.4 1.2 1.0 0.8 0.6 0.4 0.2 0.0
f1 (ppm)

8 ^{13}C


71.46
70.06
67.59
53.14
47.42
36.00
OH
HO
OH
N
H
75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0
f1 (ppm)

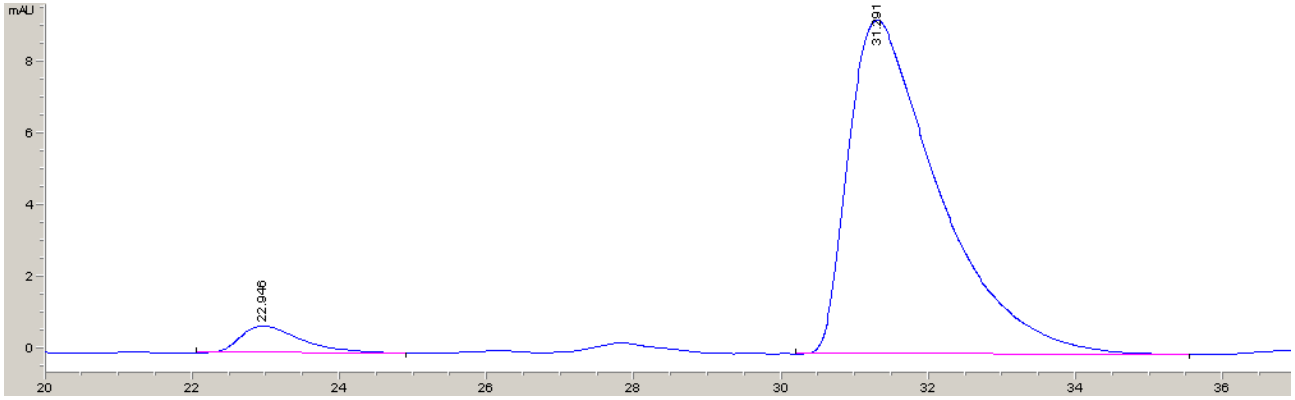
2a (with DL-proline)



Daicel Chiralcel OD 10% *i*-Propanol in *n*-Hexane, 258 nm and 1 mL / min.

Retention time (min)	Area (mAU's)	Area %
22.310	466.22891	46.8032
31.353	529.91864	53.1968

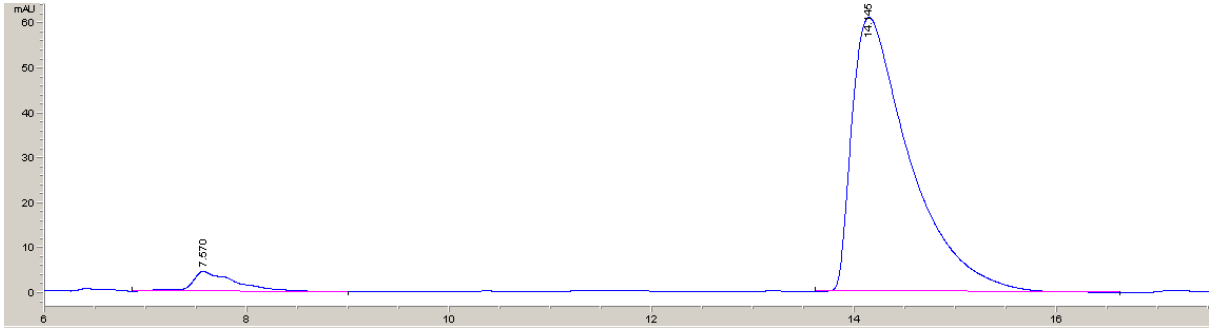
2a



Daicel Chiralcel OD 10% *i*-Propanol in *n*-Hexane, 258 nm and 1 mL / min.

Retention time (min)	Area (mAU's)	Area %
22.946	42.90587	5.1156
31.291	795.82751	94.8844

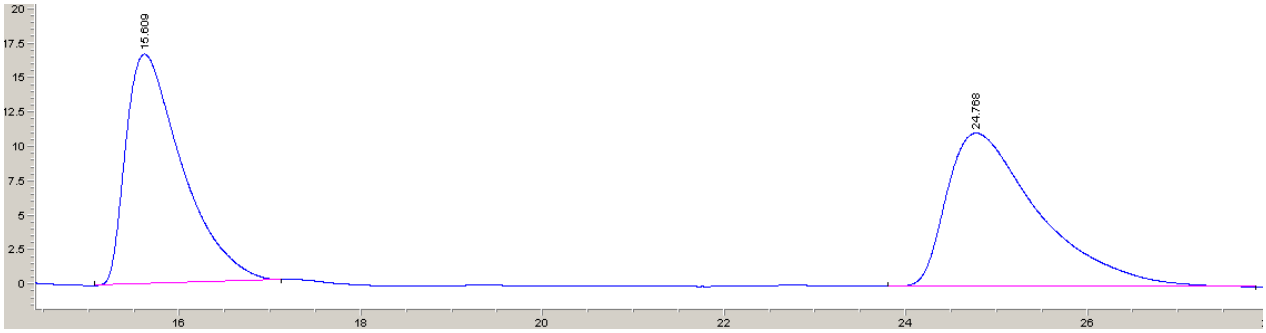
3_{Cbz}a



Daicel Chiralcel OD 20% *i*-Propanol in *n*-Hexane, 258 nm and 1 mL / min.

Retention time (min)	Area (mAU's)	Area %
7.570	134.47743	5.2498
14.145	2427.10376	94.7502

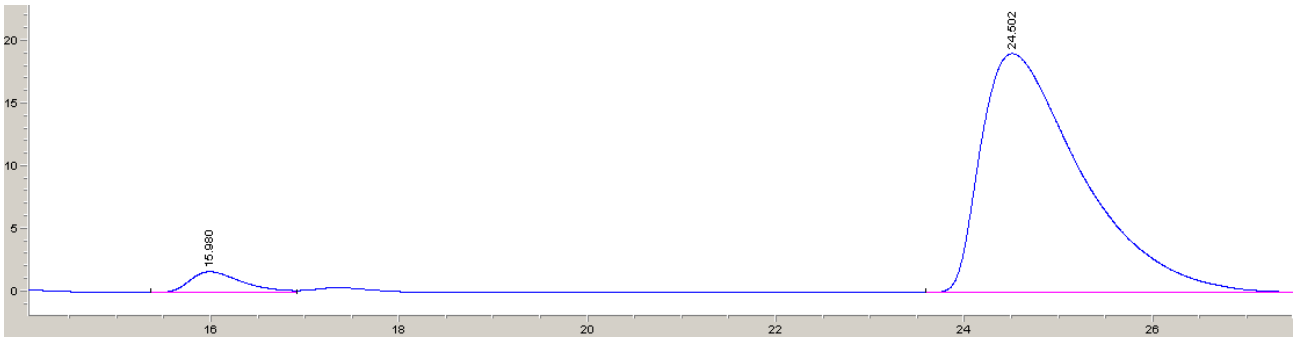
2b (with DL-proline)



Daicel Chiralcel OD 10% *i*-Propanol in *n*-Hexane, 258 nm and 1 mL / min.

Retention time (min)	Area (mAU's)	Area %
15.609	719.35956	47.8220
24.768	784.88470	52.1780

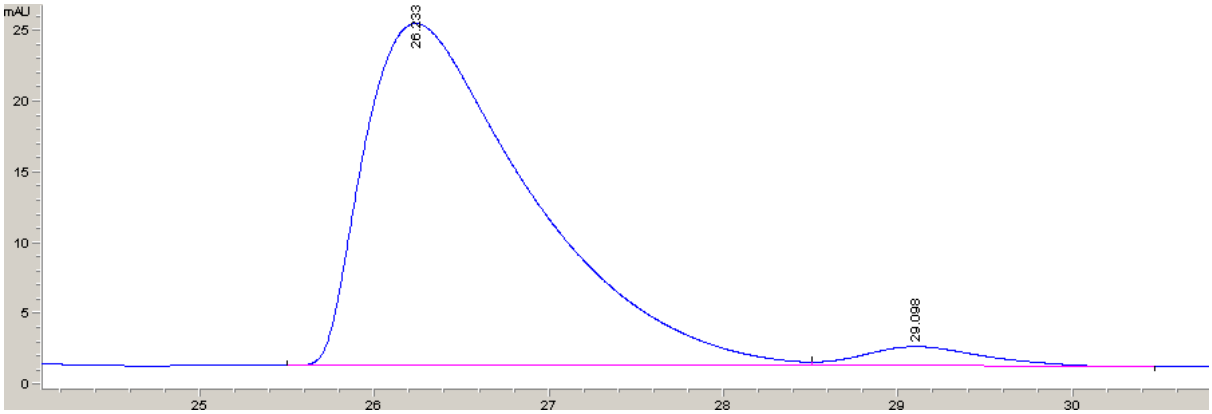
2b



Daicel Chiralcel OD 10% *i*-Propanol in *n*-Hexane, 258 nm and 1 mL / min.

Retention time (min)	Area (mAU's)	Area %
15.980	64.93031	4.3819
24.502	1416.84692	95.6181

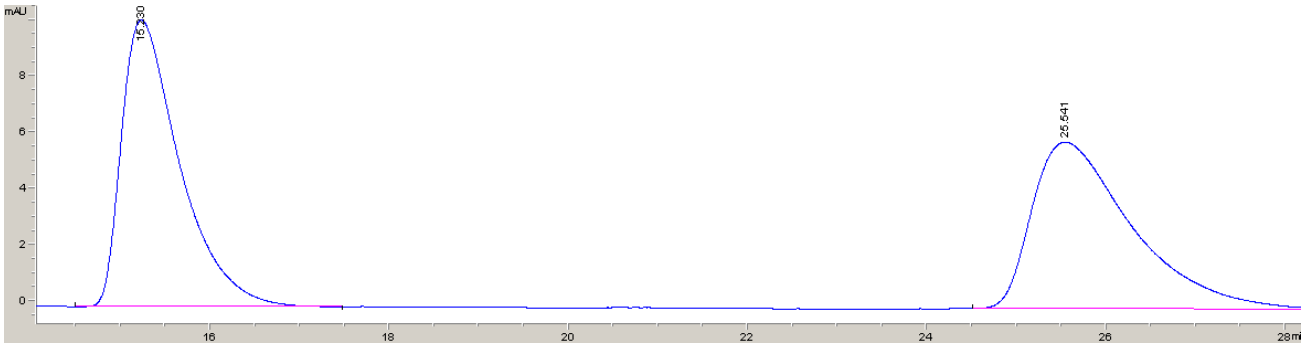
3_{Cbz}b



Daicel Chiralcel OD 10% *i*-Propanol in *n*-Hexane, 258 nm and 0.5 mL / min.

Retention time (min)	Area (mAU's)	Area %
26.233	1604.74609	95.8683
29.098	69.16010	4.1317

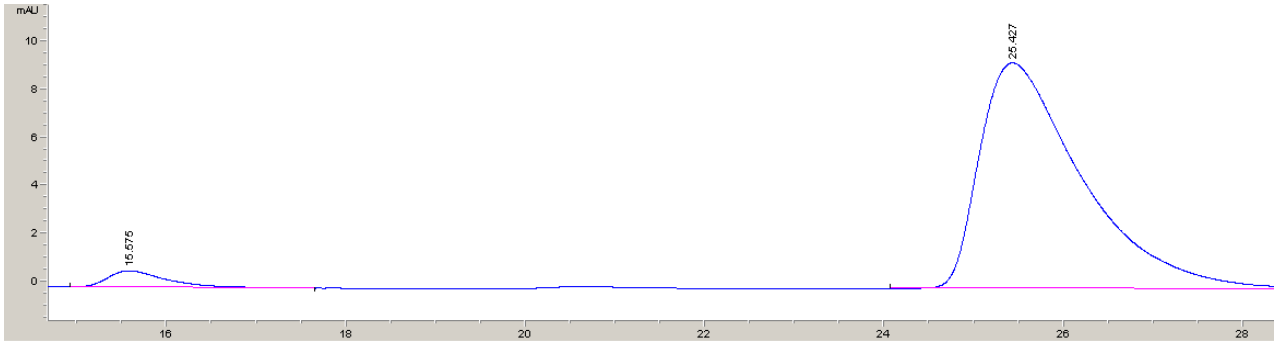
2c (with DL-proline)



Daicel Chiralcel OD 10% *i*-Propanol in *n*-Hexane, 258 nm and 1 mL / min.

Retention time (min)	Area (mAU's)	Area %
15.230	460.56415	49.9620
25.541	461.26459	50.0380

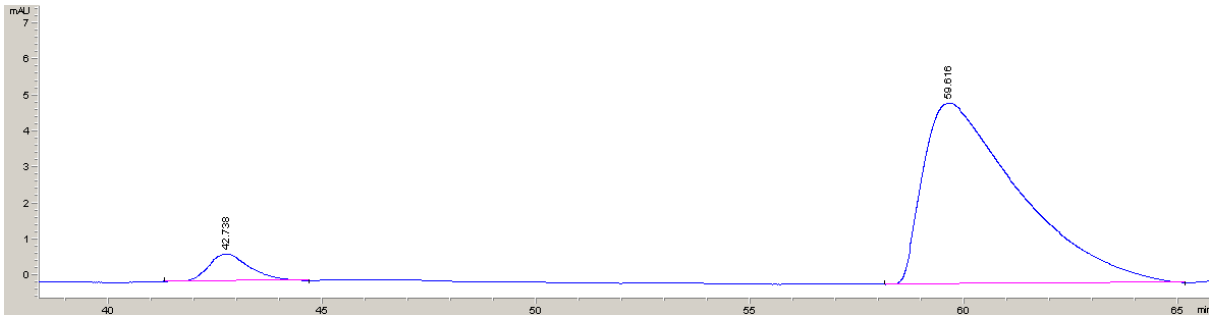
2c



Daicel Chiralcel OD 10% *i*-Propanol in *n*-Hexane, 258 nm and 1 mL / min.

Retention time (min)	Area (mAU's)	Area %
15.575	31.25624	4.0239
25.427	745.50256	95.9761

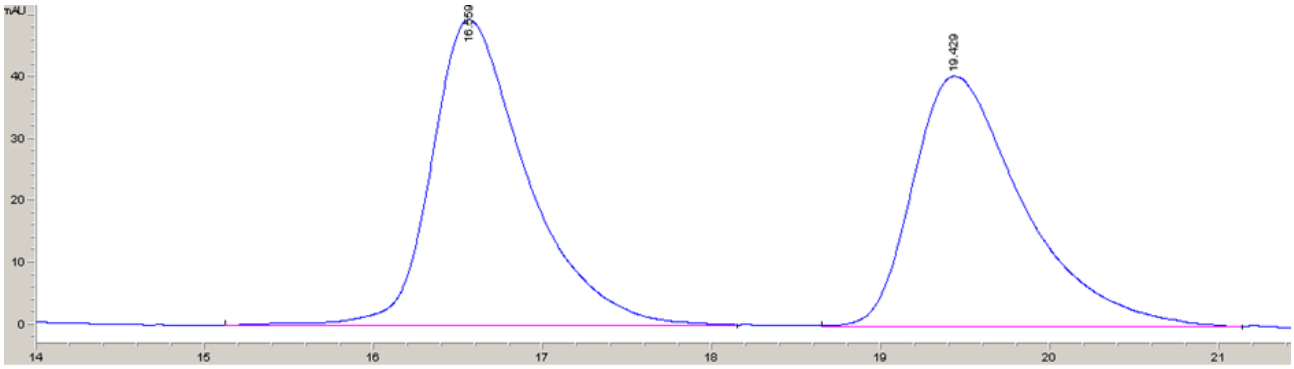
$3_{Cbz}c$



Daicel Chiralcel OD 10% *i*-Propanol in *n*-Hexane, 258 nm and 1 mL / min.

Retention time (min)	Area (mAU's)	Area %
42.738	49.95858	5.9811
59.616	785.31714	94.0189

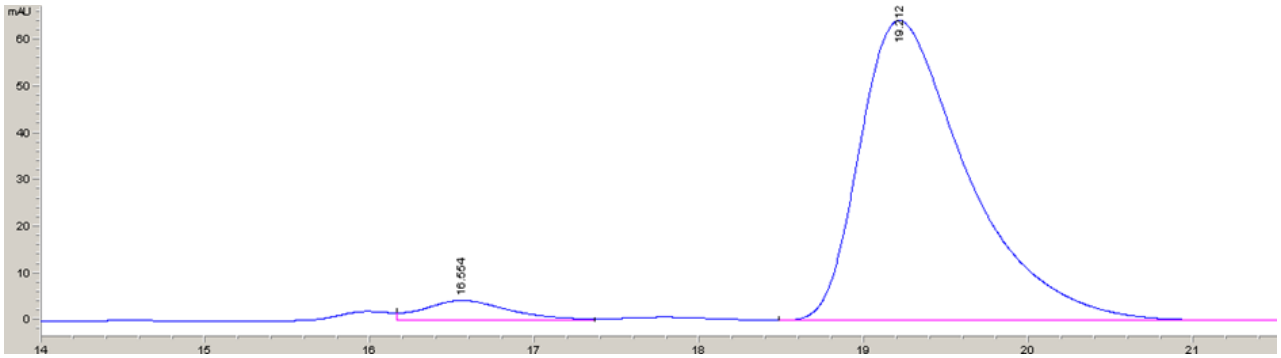
2d (with DL-proline)



Daicel Chiralcel OD 50% *i*-Propanol in *n*-Hexane, 258 nm and 0.5 mL / min.

Retention time (min)	Area (mAU's)	Area %
16.559	1961.54236	51.5366
19.429	1844.57117	48.4634

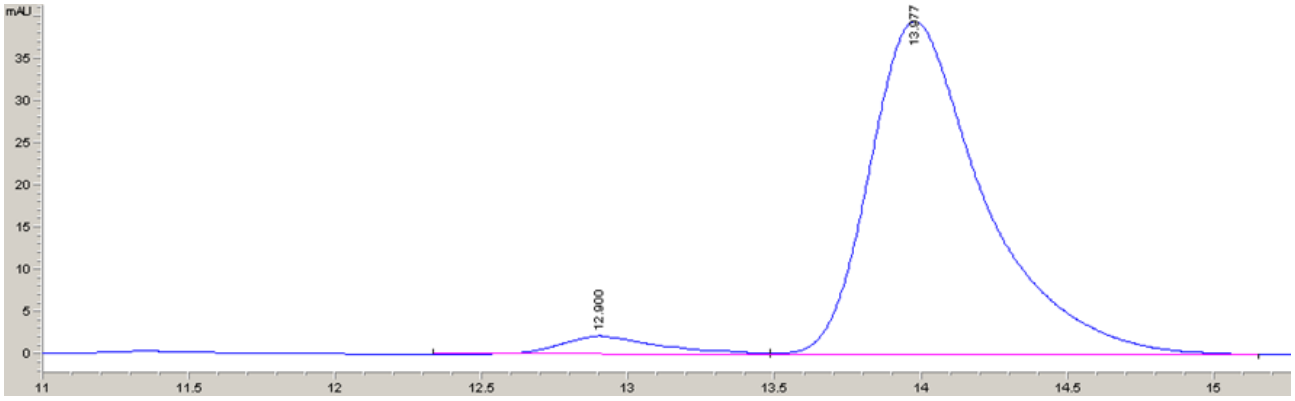
2d



Daicel Chiralcel OD 50% *i*-Propanol in *n*-Hexane, 258 nm and 0.5 mL / min.

Retention time (min)	Area (mAU's)	Area %
16.554	161.14542	5.2374
19.212	2915.66553	94.7626

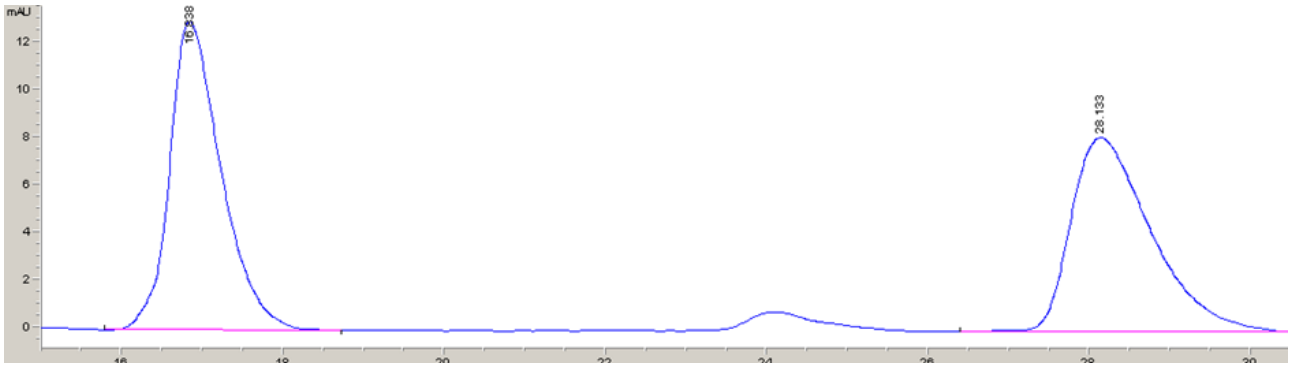
3d



Daicel Chiralcel OD 50% *i*-Propanol in *n*-Hexane, 258 nm and 0.5 mL / min.

Retention time (min)	Area (mAU's)	Area %
12.900	51.22084	4.5569
13.977	1072.81360	95.4431

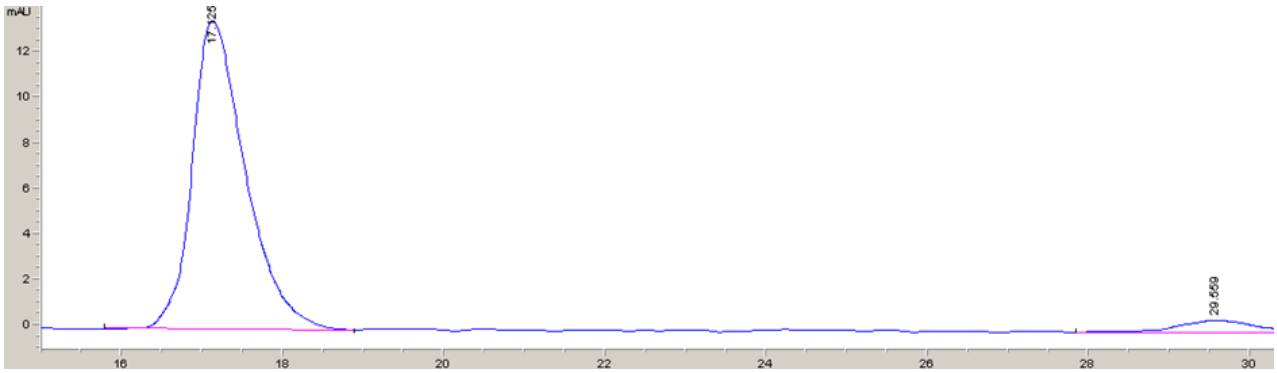
2e (with DL-proline)



Daicel Chiralcel OD 30% *i*-Propanol in *n*-Hexane, 250 nm and 1 mL / min.

Retention time (min)	Area (mAU's)	Area %
16.838	576.41797	50.4615
28.133	562.38092	49.5385

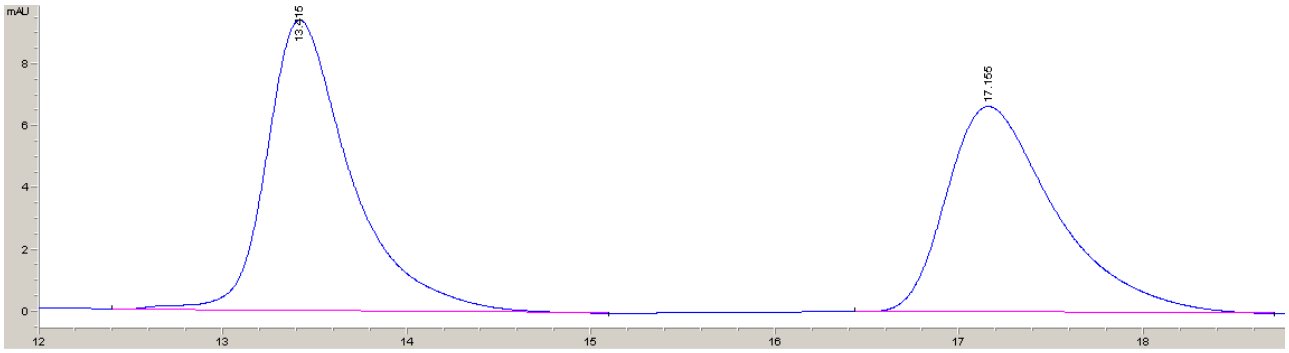
2e



Daicel Chiralcel OD 30% *i*-Propanol in *n*-Hexane, 250 nm and 1 mL / min.

Retention time (min)	Area (mAU's)	Area %
17.125	624.08990	94.1971
29.559	38.44601	5.8029

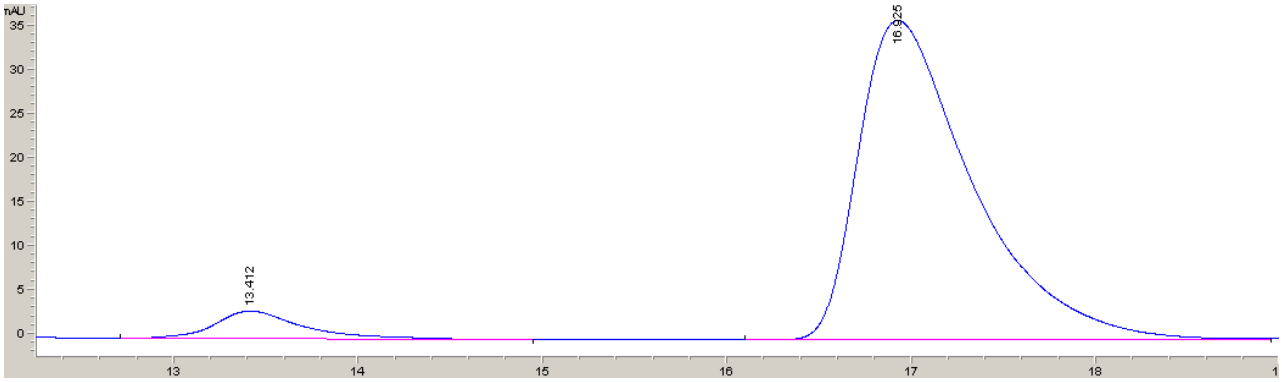
2f (with DL-proline)



Daicel Chiralcel OD 50% *i*-Propanol in *n*-Hexane, 258 nm and 0.5 mL / min.

Retention time (min)	Area (mAU's)	Area %
13.415	300.47369	52.3239
17.155	273.78387	47.6761

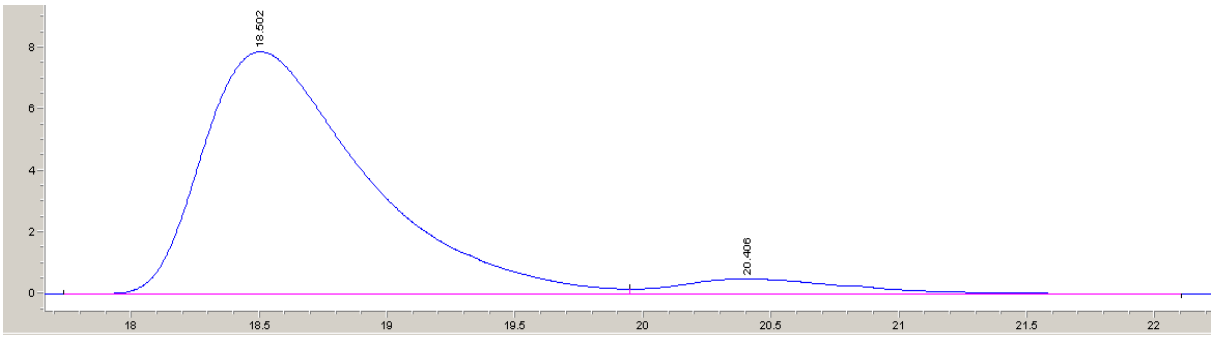
2f



Daicel Chiralcel OD 50% *i*-Propanol in *n*-Hexane, 258 nm and 0.5 mL / min.

Retention time (min)	Area (mAU's)	Area %
13.412	109.42521	6.5349
16.925	1565.05017	93.4651

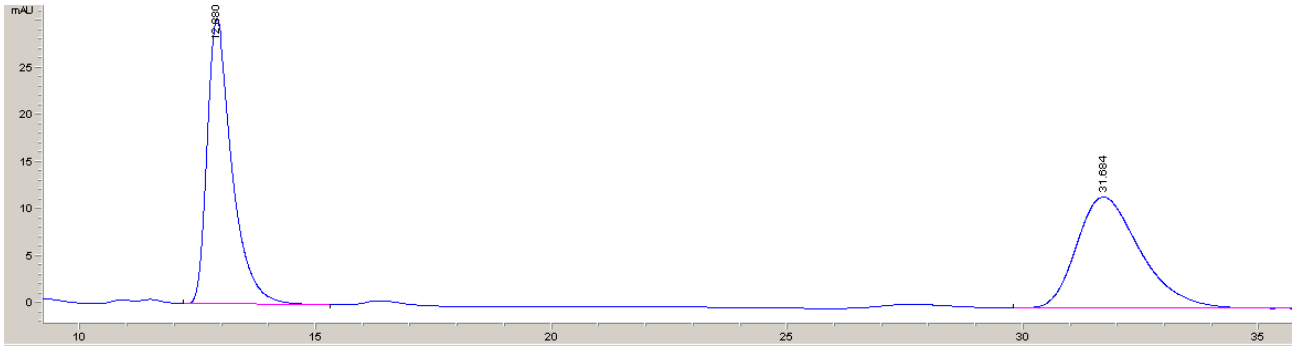
3_{Cbz}f



Daicel Chiralcel OD 20% *i*-Propanol in *n*-Hexane, 258 nm and 1 mL / min.

Retention time (min)	Area (mAU's)	Area %
18.502	349.74927	93.4284
20.406	24.60099	6.5716

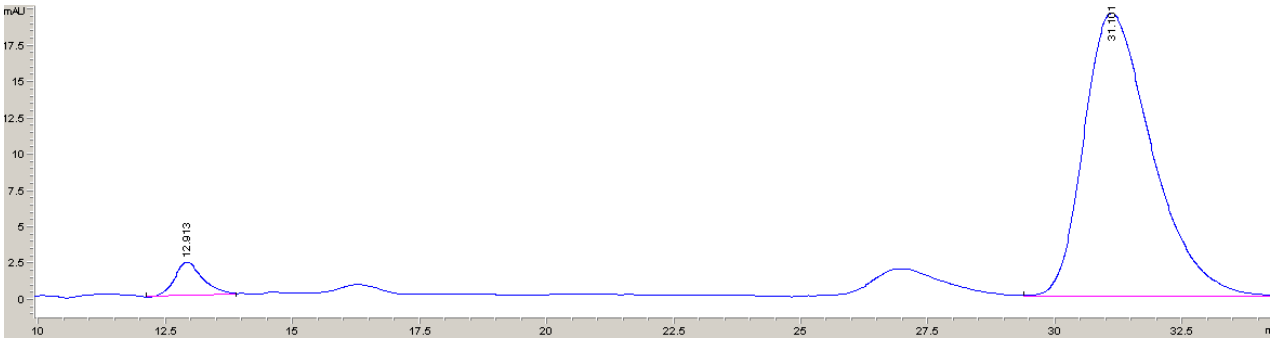
2g (with DL-proline)



Daicel Chiralcel OD 50% *i*-Propanol in *n*-Hexane, 258 nm and 0.75 mL / min.

Retention time (min)	Area (mAU's)	Area %
12.880	1145.34314	50.9065
31.684	1104.55396	49.0935

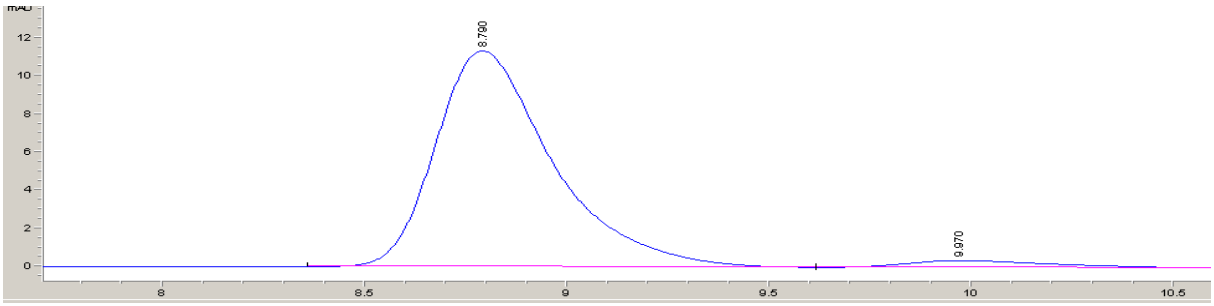
2g



Daicel Chiralcel OD 50% *i*-Propanol in *n*-Hexane, 258 nm and 0.75 mL / min.

Retention time (min)	Area (mAU's)	Area %
12.913	91.77785	4.7813
31.101	1827.75671	95.2187

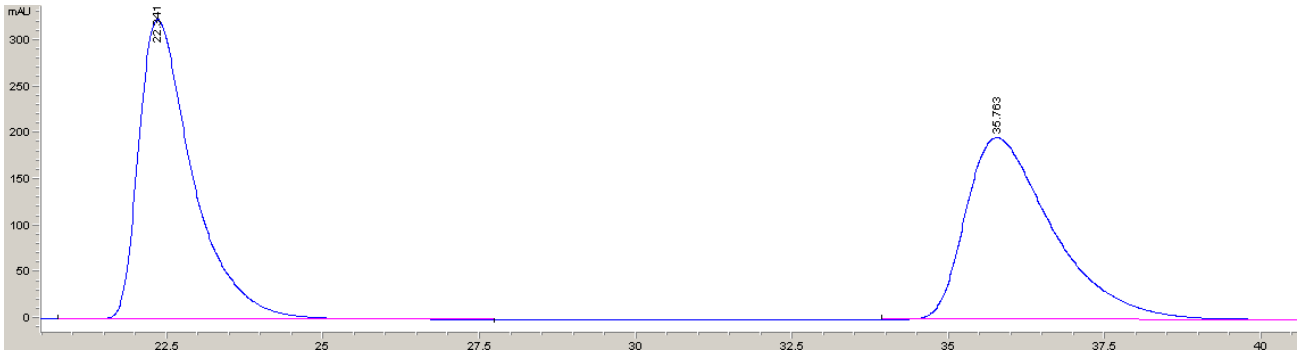
3g



Daicel Chiralcel OD 30% *i*-Propanol in *n*-Hexane, 258 nm and 1 mL / min.

Retention time (min)	Area (mAU's)	Area %
8.790	228.42635	95.9139
9.970	9.73139	4.0861

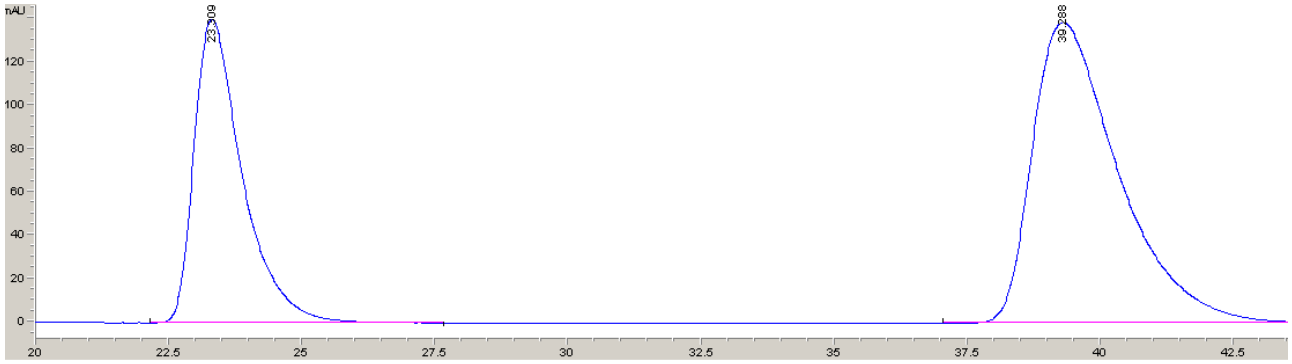
2h (with DL-proline)



Daicel Chiralcel OD 50% *i*-Propanol in *n*-Hexane, 258 nm and 0.5 mL / min.

Retention time (min)	Area (mAU's)	Area %
22.341	1.93895e4	50.5471
35.763	1.89698e4	49.4529

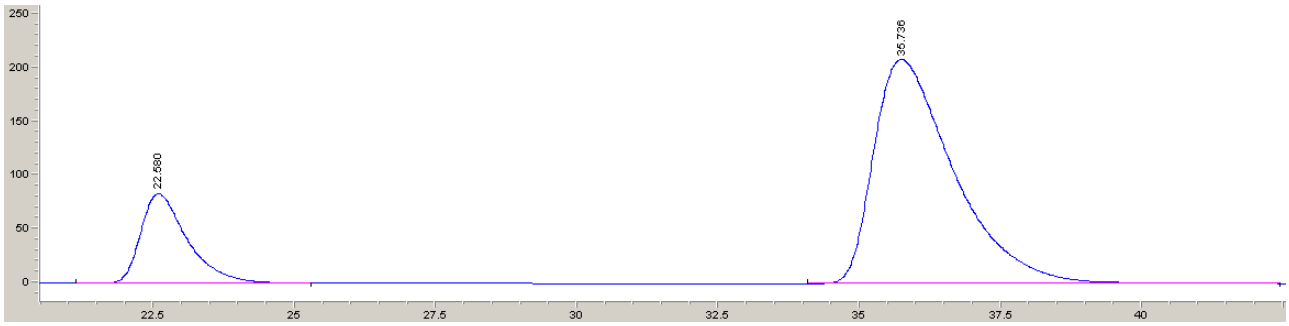
2h (with L-proline at room temperature)



Daicel Chiralcel OD 50% *i*-Propanol in *n*-Hexane, 258 nm and 0.5 mL / min.

Retention time (min)	Area (mAU's)	Area %
23.309	8798.03711	36.1429
39.288	1.55443e4	63.8571

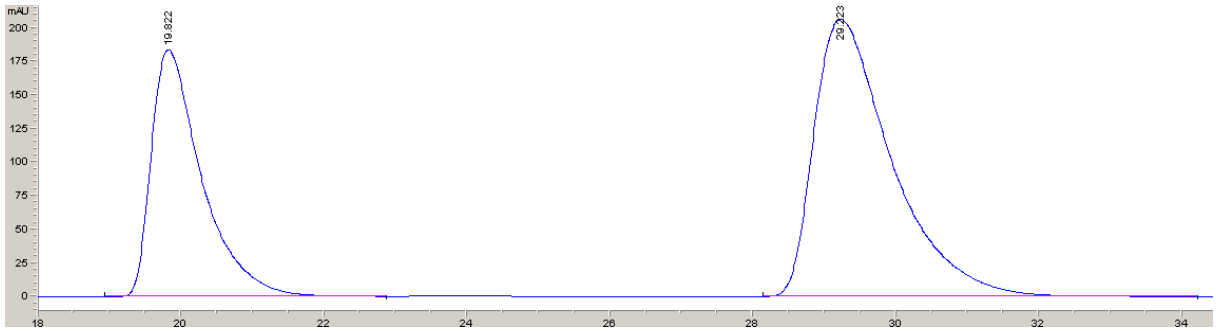
2h (with L-proline tetrazole at 0 ˚C)



Daicel Chiralcel OD 50% *i*-Propanol in *n*-Hexane, 258 nm and 0.5 mL / min.

Retention time (min)	Area (mAU's)	Area %
22.580	4764.35254	18.7848
35.736	2.05984e4	81.2152

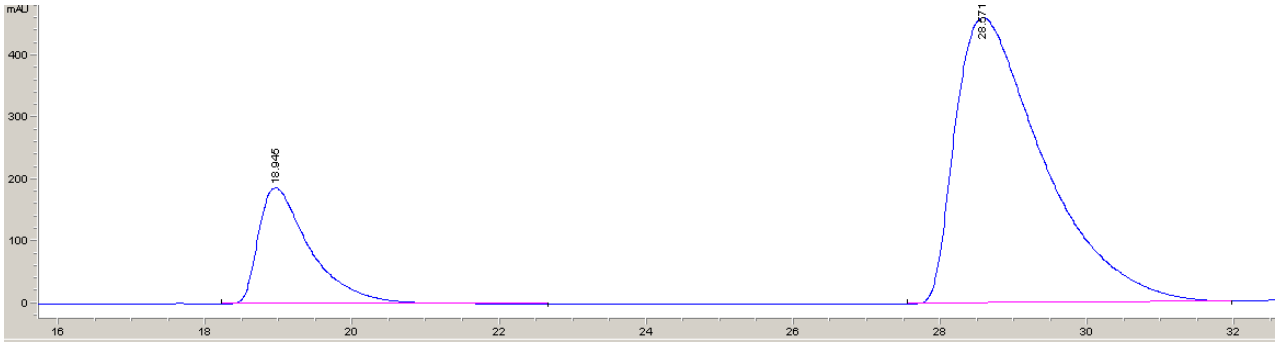
3h (with L-proline at room temperature)



Daicel Chiralcel OD 50% *i*-Propanol in *n*-Hexane, 258 nm and 0.5 mL / min.

Retention time (min)	Area (mAU's)	Area %
19.822	9021.28711	36.6492
29.223	1.55939e4	63.3508

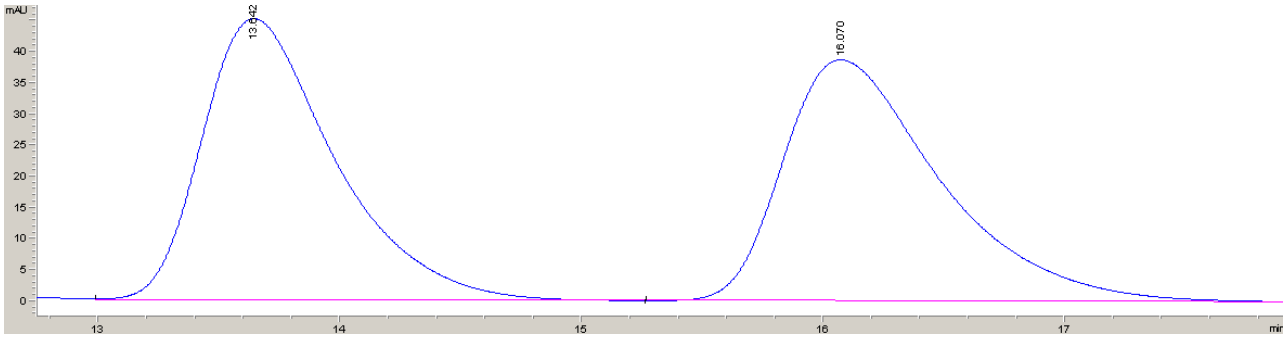
3h (with L-proline tetrazole at 0 ˚C)



Daicel Chiralcel OD 50% *i*-Propanol in *n*-Hexane, 258 nm and 0.5 mL / min.

Retention time (min)	Area (mAU's)	Area %
18.945	9159.91211	19.2877
28.571	3.83309e4	80.7123

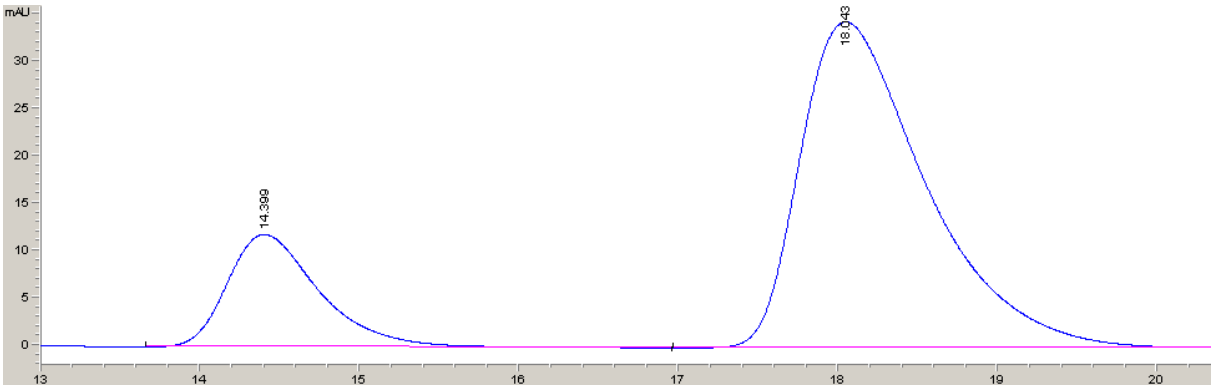
2i (with DL-proline)



Daicel Chiralcel OD 30% *i*-Propanol in *n*-Hexane, 258 nm and 1 mL / min.

Retention time (min)	Area (mAU's)	Area %
13.642	1725.67395	49.6215
16.070	1752.00269	50.3785

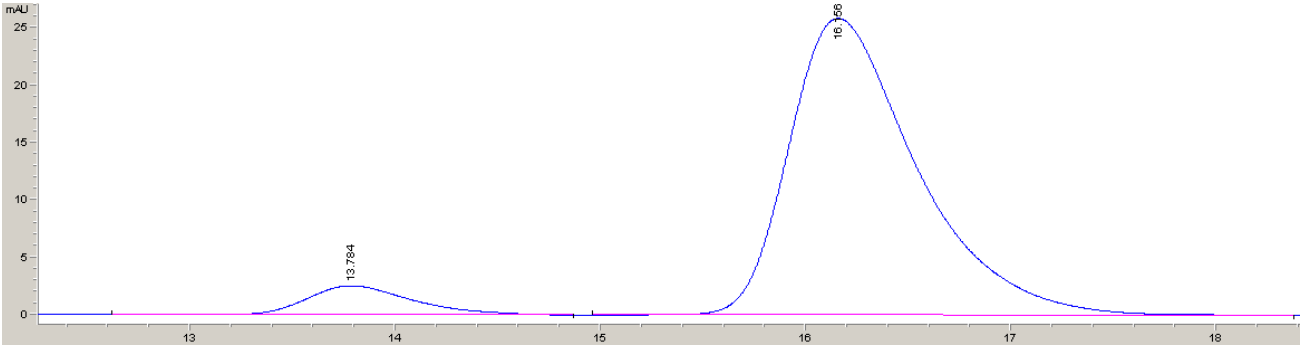
2i (with L-proline at room temperature)



Daicel Chiralcel OD 30% *i*-Propanol in *n*-Hexane, 258 nm and 1 mL / min.

Retention time (min)	Area (mAU's)	Area %
14.399	479.48090	20.3243
18.043	1879.67419	79.6757

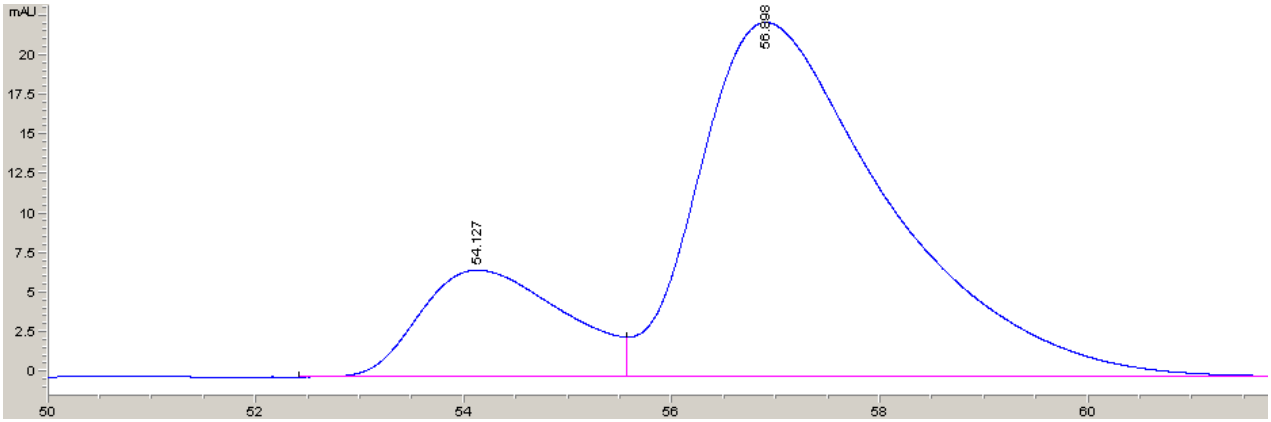
2i (with L-proline at 0 ˚C)



Daicel Chiralcel OD 30% *i*-Propanol in *n*-Hexane, 258 nm and 1 mL / min.

Retention time (min)	Area (mAU's)	Area %
13.784	91.92773	7.5749
16.156	1121.65356	92.4251

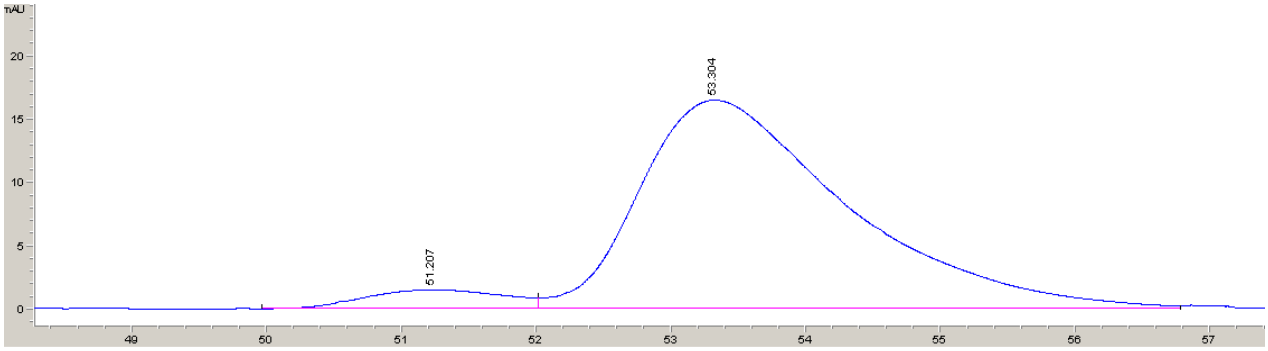
3i (with L-proline at room temperature)



Daicel Chiralcel OD 10% *i*-Propanol in *n*-Hexane, 258 nm and 0.5 mL / min.

Retention time (min)	Area (mAU's)	Area %
54.127	654.47937	18.7562
56.898	2834.91455	81.2438

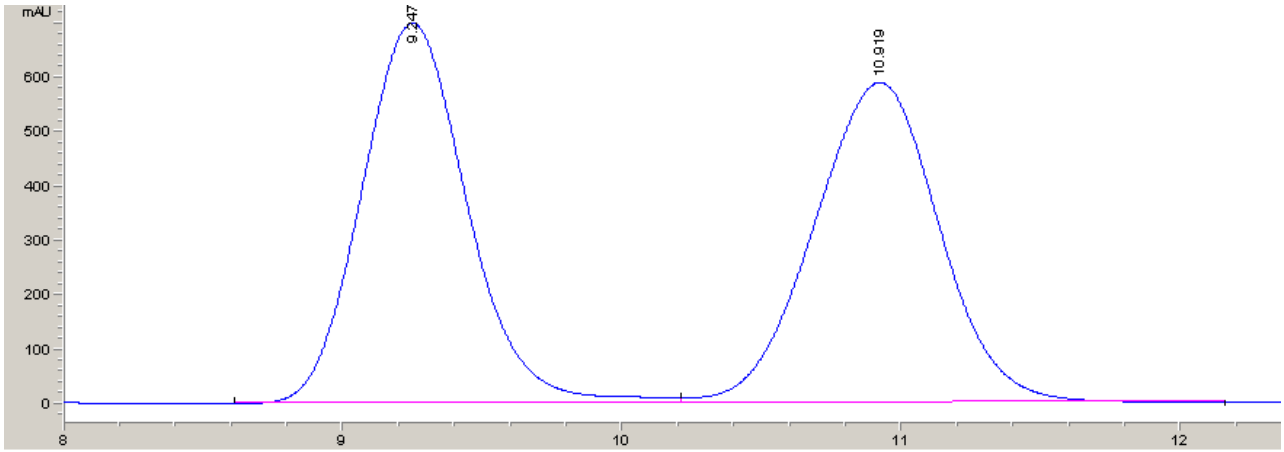
3i (with L-proline at 0 ˚C)



Daicel Chiralcel OD 10% *i*-Propanol in *n*-Hexane, 258 nm and 0.5 mL / min.

Retention time (min)	Area (mAU's)	Area %
51.207	108.82959	5.8030
53.304	1766.58411	94.1970

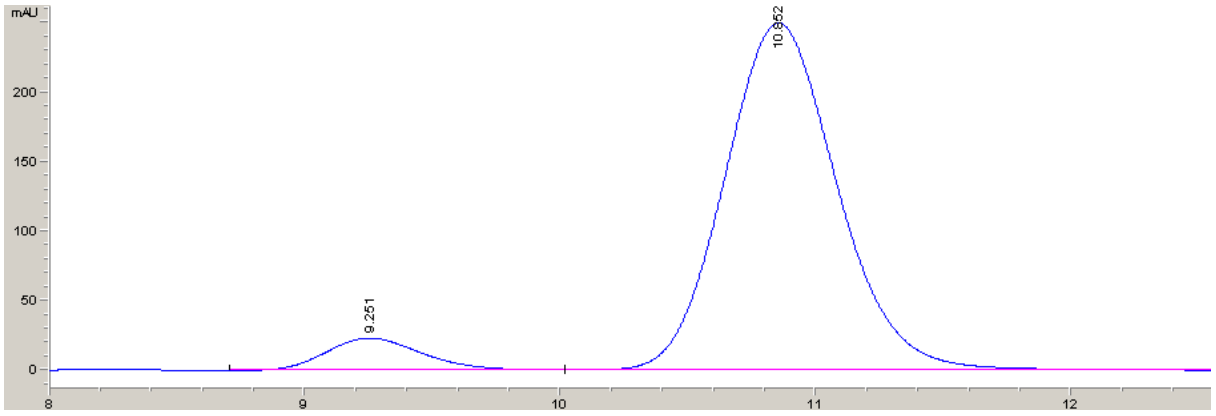
2j (with DL-proline)



Daicel Chiralpak AD 30% *i*-Propanol in *n*-Hexane, 258 nm and 1 mL / min.

Retention time (min)	Area (mAU's)	Area %
9.247	1.83663e4	50.0059
10.919	1.83620e4	49.9941

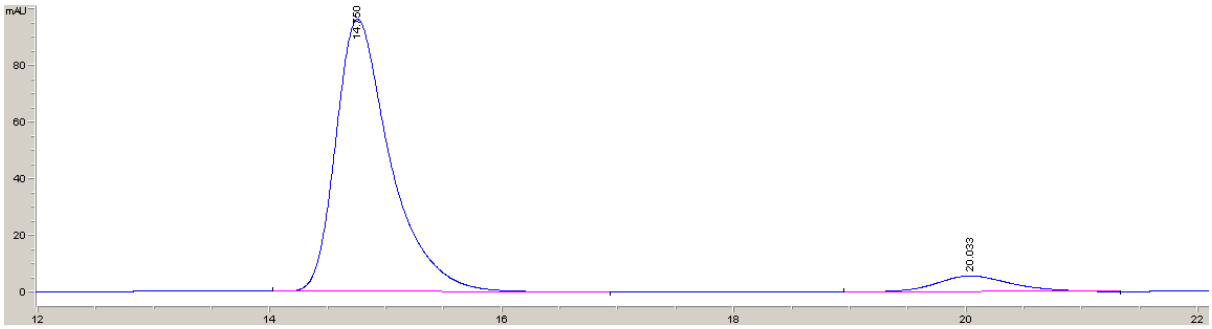
2j



Daicel Chiralpak AD 30% *i*-Propanol in *n*-Hexane, 258 nm and 1 mL / min.

Retention time (min)	Area (mAU's)	Area %
9.251	617.71051	7.4304
10.852	7695.52881	92.5696

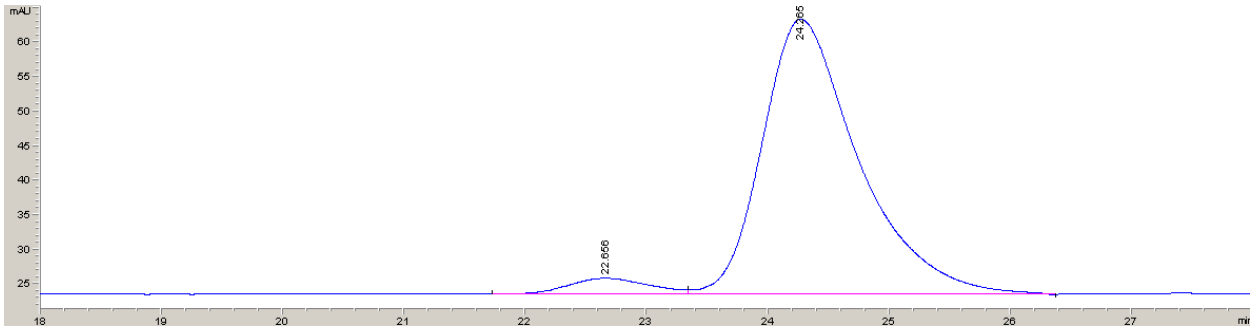
3j



Daicel Chiralcel OD 50% *i*-Propanol in *n*-Hexane, 258 nm and 0.5 mL / min.

Retention time (min)	Area (mAU's)	Area %
14.750	3168.77124	91.9268
20.033	278.28870	8.0732

7



Daicel Chiralcel OD 15% *i*-propanol in *n*-Hexane, 258 nm 0.75 mL / min.

Retention time (min)	Area (mAU's)	Area %
22.656	109.27544	4.7433
24.265	2194.48877	95.2567