A General and Enantioselective Approach to Pentoses: A Rapid Synthesis of PSI-6130, the Nucleoside Core of Sofosbuvir

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Supporting Information

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I. General Information. Commercial reagents were purified prior to use following the guidelines of Perrin and Armarego.[1] All solvents were purified according to the method of Grubbs.[2] Organic solutions were concentrated under reduced pressure on a Büchi rotary evaporator. Chromatographic purification of products was accomplished using flash chromatography on Silicycle, Davisil, or Fluka silica gel according to the method of Still.[33] Analytical thin-layer chromatography (TLC) was performed on Silicycle or Analtech 250 mm silica gel plates; preparative thin-layer chromatography on Silicycle or Analtech 1000 mm silica gel plates. TLC visualization was performed by fluorescence quenching or $KMnO_4$, ceric ammonium molybdate, or anisaldehyde stains. ^{1}H NMR spectra were recorded on a Bruker 500 (500 MHz) and are referenced relative to residual $CDCl_3$ proton signals at δ 7.26, C_6D_6 at δ 7.16 ppm, or D_2O at δ 4.79 ppm. Data for ^{1}H NMR spectra are reported as follows: chemical shift (δ ppm), multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, quint = quintet, h = heptet, sept = septet, m = multiplet), integration, coupling constant (Hz), and assignment. ^{13}C spectra were recorded on a Bruker 500 (125 MHz) and are referenced relative to $CDCl_3$ at δ 77.16 ppm, C_6D_6 at δ 128.06 ppm, or DMSO at δ 39.52. Data for ^{13}C NMR are reported in terms of chemical shift and assignment. IR spectra were recorded on a Perkin Elmer Paragon 1000 spectrometer and are reported in terms of frequency of absorption (cm^{-1}). High-resolution mass spectra were obtained from the

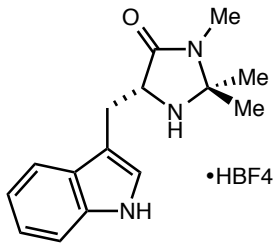
[1] Perrin, D. D.; Armarego, W. L. F. *Purification of Laboratory Chemicals*; 3rd ed., Pergamon Press, Oxford, 1988.
[2] Pangborn, A. B.; Giardello, M. A.; Grubbs, R. H.; Rosen, R. K.; Timmers, F. J. *Organometallics* **1996**, *15*, 1518.
[3] Still, W. C.; Kahn, M.; Mitra, A. J. *J. Org. Chem.* **1978**, *43*, 2923.

Princeton University Mass Spectral Facility. High-performance liquid chromatography (HPLC) was performed on Hewlett-Packard 1100 Series chromatographs using a chiral column (25 cm) and guard column (5 cm). Optical rotations were measured on a Jasco P-1010 polarimeter with $[a]_D$ values reported in degrees; concentration (c) is in g/100 mL.

II. Synthesis of Starting Materials.

Synthesis of Organocatalyst.

(*R*)-5-((1-Benzyl-1*H*-indol-3-yl)methyl)-2,2,3-trimethylimidazolin-4-one·HBF$_4$.[4] Metallic Na (2.59 g, 113 mmol, 2.3 equiv.) was added, in small pieces, to liquid NH_3 (250 mL) containing $Fe(NO_3)_3 \cdot 9H_2O$ (158 mg, 0.39 mmol, 0.8 mol%) cooled to –78 °C. The mixture was stirred for 30 minutes, over which time it turned gray/black in color. D-tryptophan (10.0 g, 49.0 mmol, 1.0 equiv.) was then added in small portions. The mixture was allowed to come to reflux, treated dropwise with benzyl chloride (5.64 mL, 49.0 mmol, 1.0 equiv.) over 10 minutes and stirred overnight to allow the solvent to evaporate. The resulting grey solid was dissolved in hot water (375 mL) and the product was precipitated by the addition of glacial acetic acid (17.5 mL). The solid was filtered and washed with water (100 mL), 1:1 EtOH:H_2O (100 mL), 19:1 EtOH:H_2O (100 mL), and Et_2O (100 mL). The product was dried under vacuum to yield D-1-benzyl-tryptophan (12.8 g, 89% yield) as a tan solid. To a dried round bottom flask were added crude D-1-benzyl-tryptophan (12.8 g, 43.5 mmol, 1.0 equiv.), $SOCl_2$ (6.31 mL, 86.9 mmol, 2.0 equiv.), and MeOH (87 mL). The resulting mixture was stirred vigorously at room temperature for 40 h, over which time it turned clear then heterogeneous again. The mixture was concentrated under vacuum to provide the solid ester·HCl salt as a pale brown solid. This solid was treated with $MeNH_2$ (40% in MeOH, 30 mL), and the resulting solution was stirred at room temperature for 16 hours. The mixture was concentrated under vacuum, treated with Et_2O, and concentrated again. This procedure was performed three times to remove excess $MeNH_2$. The crude amide was then suspended in CH_2Cl_2 (200 mL) and washed with of sat. aq. $NaHCO_3$ (200 mL). The aqueous layer was extracted with CH_2Cl_2 (2 × 100 mL), and the combined organic layers were dried over $MgSO_4$, filtered, and concentrated under vacuum to yield a pale brown foam. The crude, freebased amide was dissolved in MeOH (87 mL), and treated with TSA·H_2O (414 mg, 2.18 mmol, 5 mol%) and acetone (15.9 mL, 218 mmol, 5.0 equiv.). The mixture was stirred at reflux for 16 h then cooled to room temperature and concentrated under vacuum. The crude catalyst was purified by flash chromatography using EtOAc to yield the freebase catalyst (12.5 g, 73% yield over four steps from D-tryptophan) as a pale brown oil. The experimental data is in agreement with the literature.[4] The catalyst (12.5 g, 35.9 mmol, 1.0 equiv.) was then added to a dried round bottom flask with 300 mL of Et_2O and was cooled to –78 °C. While stirring vigorously, $HBF_4 \cdot Et_2O$ (5.57 mL, 37.7 mmol, 1.05 equiv.) was added dropwise over 15 minutes, and the cooling



[4] Simonovich, S. P.; Van Humbeck, J. F.; MacMillan, D. W. C. *Chem. Sci.* **2012**, *3*, 58.

bath was removed. The mixture was stirred for 30 minutes until it reached room temperature, then decanted. The residue was dissolved in a minimum amount of MeOH and added dropwise to stirring Et_2O (1 L). The off-white precipitate was filtered and the solid washed with small quantities of Et_2O. The filtrate was evaporated, dissolved in a miniumum amount of MeOH and precipitated from Et_2O again. The suspension was filtered, washed with small quantities of Et_2O and the solids were combined with the ones of the first precipitation. The solid was transferred into a round bottom flask and dissolved in a minimal amount of hot MeOH. Et_2O was added at reflux until small amounts of a white solid started to precipitate. The title compound crystallized as colorless crystals at 0 °C. These crystals were filtered off and dried under vacuum.

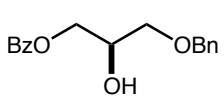
Synthesis of Enantioenriched α-OTMP-Aldehyde.

3-(Benzyloxy)propanal.[4] To a suspension of NaH (7.89 g, 197 mmol, 1.5 equiv., 60% in mineral oil) in DMF (260 mL) at 0 °C was added dropwise 1,3-propanediol (9.52 mL, 131 mmol, 1.0 equiv.) and the mixture was stirred for 30 minutes at 0 °C. Benzyl bromide (16.4 mL, 138 mmol, 1.05 equiv.) was added dropwise and the reaction was warmed to room temperature and stirred for 16 h. The yellow solution was poured over ice/sat. aq. NH_4Cl and extracted with EtOAc (3 × 100 mL). The combined organic fractions were washed with brine (3 × 100 mL), dried over $MgSO_4$, filtered and concentrated under vacuum. The crude product was purified by flash chromatography using 4:1 to 1:1 hexanes:EtOAc to yield 1-(benzyloxy)-3-propanol (9.50 g, 87% yield) as a yellow liquid. The experimental data is in agreement with the literature.[5] ^{1}H NMR (500 MHz, $CDCl_3$): δ 8.01 (s, 1H, O**H**), 7.39–7.27 (m, 5H, Ar**H**), 4.52 (s, 2H, C$\mathbf{H_2}$Ph), 3.79 (dt, 2H, *J* = 5.4, 5.4 Hz, OHC$\mathbf{H_2}$), 3.67 (t, 2H, *J* = 5.8 Hz, C$\mathbf{H_2}$OBn), 1.87 (tt, 2H, *J* = 5.4, 5.8 Hz, C$\mathbf{H_2}$$CH_2$OBn). To a solution of TEMPO (940 mg, 6.02 mmol, 10 mol%) and (diacetoxy)iodobenzene (23.3 g, 72.2 mmol, 1.2 equiv.) in CH_2Cl_2 (120 mL) was added 1-(benzyloxy)-3-propanol (10.0 g, 60.2 mmol, 1.0 equiv.) in one portion and the resulting red solution was stirred at room temperature for 16 h. The crude mixture was washed with sat. aq. $NaHCO_3$ (100 mL), dried over $MgSO_4$, filtered, and concentrated under vacuum. The crude product was purified by flash chromatography using 7:1 to 4:1 hexanes:EtOAc to yield the title compound (8.79 g, 89% yield) as a colorless oil. The experimental data is in agreement with the literature.[6] ^{1}H NMR (500 MHz, $CDCl_3$): δ 9.80 (t, 1H, *J* = 1.8 Hz, C**H**(O)), 7.39–7.27 (m, 5H, Ar**H**), 4.54 (s, 2H, C$\mathbf{H_2}$Ph), 3.82 (t, 2H, *J* = 6.1 Hz, C$\mathbf{H_2}$OBn), 2.71 (dt, 2H, *J* = 1.9, 6.1 Hz, C$\mathbf{H_2}$CH(O)).

***(R)*-3-(Benzyloxy)-2-(2,2,6,6-tetramethylpiperidin-1-yloxy)propanal (1, 90% ee)**.[4] To an oven dried vial were added (*R*)-5-((1-benzyl-1*H*-indol-3-yl)methyl)-2,2,3-trimethylimidazolin-4-one·HBF_4 (87.0 mg, 0.20 mmol, 0.2 equiv.), oven-dried 4Å molecular sieves (5 mg), $CuCl_2$ (13.5 mg, 0.10 mmol, 0.1 equiv.), and ethyl acetate (0.60 mL). 3-(Benzyloxy)propanal (164 mg, 1.00 mmol 1.00 equiv.) was added in one

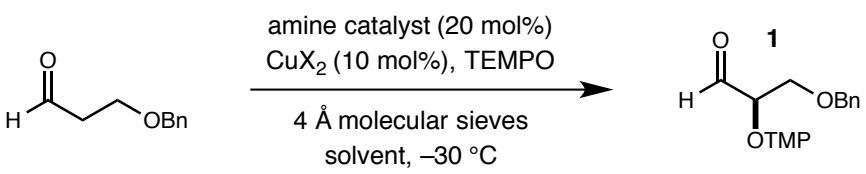
[5] Anchoori, R. K.; Harikumar, K. B.; Batchu, V. R.; Aggerwal, B. B.; Khan, S. R. *Bioorg. Med. Chem.* **2010**, *18*, 229.
[6] Nielsen, L.; Lindsay, K. B.; Faber, J.; Nielsen, N. C.; Skrydstrup, T. *J. Org. Chem.* **2007**, *72*, 10035.

portion and the resulting brown suspension was cooled to –30 °C. The mixture was treated dropwise with a solution of TEMPO (188 mg, 1.20 mmol, 1.2 equiv.) in ethyl acetate (0.32 mL). An ambient air inlet line was then pierced through the septum and the mixture was stirred for 24 h. The reaction was quenched with 2 mL of sat. aq. NH_4Cl and the aqueous layer was extracted with Et_2O (3 × 5 mL). The combined organic layers were dried over Na_2SO_4 and concentrated under vacuum. The residue was dissolved in toluene and washed vigorously with a 1 M solution of NaOH/ascorbic acid. The organic layer was immediately subjected to flash chromatography using 9:1 hexanes:Et_2O to give the title compound (247 mg, 77% yield, 90% ee) as a colorless liquid. The experimental data is in agreement with the literature.[4] The enantiomeric excess was determined from the corresponding TMP-deprotected benzoyl ester. This compound was prepared by treating the corresponding alcohol (1.0 equiv.) with triethylamine (2.0 equiv.), benzoyl chloride (1.2 equiv.), and DMAP (5 mol%) in CH_2Cl_2 (0.5 M) at 0 °C. Upon complete consumption of starting material (1 h), the reaction mixture was diluted with CH_2Cl_2 and quenched with water. The organic layer was dried over Na_2SO_4 and concentrated under vacuum. The crude mixture was purified by flash chromatography. The ester was then treated with Zn (10 equiv.) and 1:1 AcOH:H_2O (0.5 M) at 50 °C until the starting material was consumed. The mixture was cooled to room temperature and extracted with CH_2Cl_2. The organic layer was washed with sat. aq. $NaHCO_3$ and the organic layer was dried over Na_2SO_4, filtered, and concentrated under vacuum. The crude mixture was purified by preparative TLC. HPLC analysis of the alcohol (AS, 10% IPA/hexanes, 1.0 mL/min, 233 nm) indicated 90% ee: t_R (minor) = 14.2 minutes, t_R (major) = 17.0 minutes. Aldehyde **1** prepared using these conditions was employed in the synthesis of compounds **2a**–**16c**.



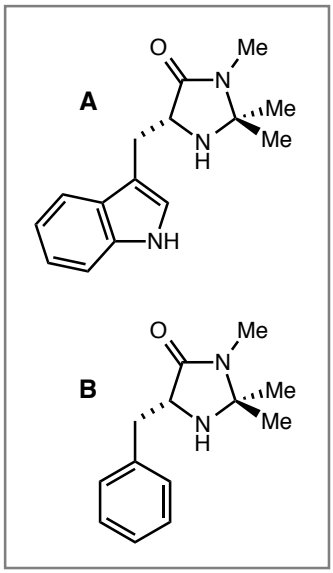
Alternative Preparation of Enantioenriched α-OTMP-Aldehyde. As illustrated above, our laboratory recently reported a general approach to the enantioselective α-oxidation of aldehydes via the merger of amine catalysis and copper catalysis.[4] In this report, the synthesis of aldehyde **1** from commercially available β-benzyloxypropanal was reported in high yield and enantioselectivity using imidazolidinone catalyst **A** (entry 1). This catalyst provided high yield and asymmetric induction for a broad scope of aldehydes; however, it is is not currently commercially available. In order to increase the utility and practicality of our method for the synthetic community, we investigated the replacement of catalyst **A** with the commercially available organocatalyst **B**.[7] Evaluation of the reaction conditions afforded a synthetically useful level of efficiency and enantiomeric excess (entries 3 and 4, 56% yield, 87% ee and 68% yield, 86% ee) with catalyst **B**. Higher levels of enantiocontrol (93% ee, entry 5) was obtained using $Cu(OTf)_2$, albeit in lower yield (36% yield). We found that our modified conditions were quite scaleable, facilitating the synthesis of large amounts of aldehyde **1** in one synthetic operation (see below).

[7] Sigma-Aldrich catalogue number 569763 (HCl salt).

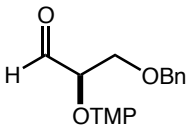


entry	catalyst [salt]	CuX_2	solvent	yield	ee
1	A [HBF_4]	$CuCl_2$	EtOAc	77%	90%
2	B [HBF_4]	$CuCl_2$	EtOAc	59%	82%
3	B [HBF_4]	$CuCl_2$	Et_2O	56%	87%
4	B [TfOH]	$CuCl_2$	Et_2O	68%	86%
5	B [TfOH]	$Cu(OTf)_2$	Et_2O	36%	93%

[a]Yields determined by ^{1}H NMR analysis of crude reaction mixtures. [b] ee determined by chiral HPLC analysis after chemical derivatization.



***(R)*-3-(Benzyloxy)-2-(2,2,6,6-tetramethylpiperidin-1-yloxy)propanal (1, 83% ee), large scale**. An



oven-dried 500 mL three-necked round-bottom flask equipped with a mechanical stirrer and under N_2 atmosphere was charged with copper(II) chloride (0.843 g, 6.27 mmol), catalyst **B•**TfOH (4.62 g, 12.55 mmol), 310 mg 4 Å molecular sieves, and 32 mL Et_2O to give a mustard yellow suspension. 3-(benzyloxy)propanal (10.3 g, 62.7 mmol) was then added as a solution in 16 mL Et_2O and the stirring suspension was cooled to –30 °C. TEMPO (11.76 g, 75 mmol) was then added dropwise as a solution in 16 mL Et_2O to give a brown suspension. The flask was fitted with a drying tube packed with $CaCl_2$ and the suspension was allowed to stir open to air for 48 h. The reaction was quenched with sat. aq. NH_4Cl and poured over H_2O. The aqueous layer was extracted with three portions of Et_2O. The combined organic layers were then dried over $MgSO_4$, filtered, and concentrated. The residue was taken up in toluene, washed with a 1 M ascorbic acid/NaOH solution, and immediately chromatographed on silica eluting with 10% Et_2O/hexanes to afford the title compound as a colorless liquid (11.6 g, 36.3 mmol, 58% yield). The experimental data is in agreement with the literature.[4] The enantiomeric excess was determined from the corresponding TMP-deprotected benzoyl ester (see above). HPLC analysis of the alcohol (AS, 10% IPA/hexanes, 1.0 mL/min, 233 nm) indicated 83% ee: t_R (minor) = 14.2 minutes, t_R (major) = 17.0 minutes. Aldehyde **1** prepared using these conditions was employed in the synthesis of compounds **18**–**37**, gemcitabine, and PSI-6130.

Synthesis of Dichlorotitanium diisopropoxide. The reagent can either be obtained commercially from TCI or prepared by the reaction of $TiCl_4$ and $Ti(O^iPr)_4$. As the quality of commercially supplied $TiCl_2(O^iPr)_2$ can be variable, we highly recommend preparing the reagent freshly.[8] To a solution of distilled $Ti(O^iPr)_4$ (6.37 mL, 21.0 mmol, 1.05 equiv.) in a flame-dried Schlenk flask under an

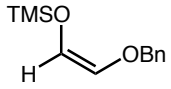
[8] Mikami, K.; Terada, M.; Nakai, T. *J. Am. Chem. Soc.* **1990**, 112, 3949.

atmosphere of dry N_2 was added dry hexanes (20 mL), followed by the dropwise addition of $TiCl_4$ (2.20 mL, 20.0 mmol, 1.0 equiv.) at room temperature. The warm solution was stirred for 15 minutes then left for crystallization (usually 2–3 hours). The colorless crystals were separated from the supernatant liquid by decantation under a stream of dry N_2 and washed with dry hexanes (5 × 2 mL). Drying in vacuum afforded the title compound (6.54 g, 69% yield) as colorless crystals. $TiCl_2(O^iPr)_2$ can be handled on air for weighting and can be kept in a closed container for several months without loss in performance. Upon extended exposure to moisture, crystals of $TiCl_2(O^iPr)_2$ turn from a sticky paste into a liquid.

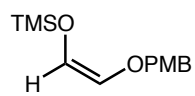
III. Synthesis of Derivatives of Ribose from Enol Silanes

General Procedure for the Synthesis of Enol Silanes.[9] To a solution of Et_3N (4.0 equiv.) and trimethylsilyl chloride (2.0 equiv.) in CH_3CN (0.5 M) was added the aldehyde (1.0 equiv.) in one portion and the resulting colorless suspension was stirred for 16 hours at 50 °C, over which time it became yellow in color. The solvent was evaporated under vacuum and the residue was taken up in anhydrous Et_2O then filtered. The solvent was removed under vacuum and the residue distilled under vacuum.

(*Z*)-((2-(Benzyloxy)vinyl)oxy)trimethylsilane. The enol silane was synthesized following the general procedure using Et_3N (11.1 mL, 80.0 mmol, 4.0 equiv.), trimethylsilyl chloride (5.05 mL, 40.0 mmol, 2.0 equiv.), 2-(benzyloxy)acetaldehyde (3.00 g, 20.0 mmol, 1.0 equiv.) and CH_3CN (40 mL). The crude material was distilled under vacuum (60 mTorr, 120 °C) to yield the title compound (3.60 g, 81% yield, >20:1 *Z*:*E*) as a colorless liquid. IR (thin film): 3033, 2959, 2896, 2866, 1667, 1494, 1455, 1397, 1362, 1297, 1250, 1121, 1020, 840, 731, 695 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$): δ 7.39–7.27 (m, 5H, Ar**H**), 5.47 (d, 1H, *J* = 3.3), 5.43 (d, 1H, *J* = 3.4 Hz, **H**C=C**H**), 4.82 (s, 2H, C$\mathbf{H_2}$Ph), 0.20 (s, 9H, Si(C$\mathbf{H_3}$)$_3$); ^{13}C NMR (125 MHz, $CDCl_3$): δ 137.7 (**C**HOBn), 137.5, 130.9, 128.5, 128.0 (Ar**C**), 122.6 (**C**HOTMS), 74.0 (**C**H_2Ph), 0.28 (Si(**C**H_3)$_3$); HRMS (ESI-TOF) calculated for $C_{12}H_{18}O_2Si$ $[M+Na]^+$ m/z 245.0968, found 245.0966.



(*Z*)-((2-((4-Methoxybenzyl)oxy)vinyl)oxy)trimethylsilane. The enol silane was synthesized following the general procedure using Et_3N (7.63 mL, 55.0 mmol, 4.0 equiv.), trimethylsilyl chloride (3.48 mL, 27.5 mmol, 2.0 equiv.), 2-((4-methoxybenzyl)oxy)acetaldehyde (2.48 g, 13.8 mmol, 1.0 equiv.) and CH_3CN (28 mL). The crude material was distilled under vacuum (60 mTorr, 210 °C) to yield the title compound (3.20 g, 92% yield, >20:1 *Z*:*E*) as a pale yellow liquid along with minor impurities. IR (thin film): 3043, 3003, 2957, 2906, 2835, 1666, 1613, 1585, 1514, 1464, 1397, 1361, 1302, 1247, 1173, 1119, 1082, 1033, 1006, 963, 841, 750, 681 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$): δ 8.18 (d, 2H, *J* = 8.5 Hz, Ar**H**), 7.78 (d, 2H, *J* = 8.6 Hz, Ar**H**),



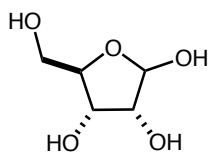
[9] (a) Northrup, A. B.; MacMillan, D. W. C. *Science* **2004**, *305*, 1752. (b) Denmark, S. E.; Ghosh, S. K. *Tetrahedron* **2007**, *63*, 8636.

6.35, 6.32 (2d, 2H, J = 3.4, 3.4 Hz, **H**C=C**H**), 5.63 (s, 2H, C**H**$_2$Ar), 4.70 (s, 3H, OC**H**$_3$), 1.08 (s, 9H, Si(C**H**$_3$)$_3$); ^{13}C NMR (125 MHz, $CDCl_3$): δ 159.4 (Ar**C**), 130.7 (**C**HOPMB), 129.7, 129.5 (Ar**C**), 122.4 (**C**HOTMS), 113.9 (Ar**C**), 73.7 (**C**H$_2$Ph), 55.4 (O**C**H$_3$), 0.27 (Si(**C**H$_3$)$_3$); HRMS (ESI-TOF) calculated for $C_{13}H_{20}O_3Si$ $[M+Na]^+$ m/z 275.1074, found 275.1071.

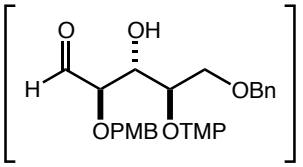
General Procedure for the Mukaiyama Aldol Reaction of Enantioenriched α-OTMP-Aldehyde and Enol Silanes followed by OTMP-Cleavage and Cyclization. An oven-dried vial was flushed with dry N_2 and charged with $TiCl_2(O^iPr)_2$ (4.0 equiv.), CH_2Cl_2 (0.2 M), and H_2O (2.0 equiv.), then cooled to –20 °C. *(R)*-3-(benzyloxy)-2-(2,2,6,6-tetramethylpiperidin-1-yloxy)propanal (90% ee, 1.0 equiv.) and the enol silane (4.0 equiv.) were weighed into an Eppendorf tube, dissolved in a minimal amount of CH_2Cl_2 and added to the suspension of $TiCl_2(O^iPr)_2$ via a microliter syringe. The mixture was stirred for 20 hours at –20 °C, then quenched by the addition of sat. aq. NH_4Cl (1 mL) and poured over H_2O (10 mL). The aqueous layer was extracted with Et_2O (3 × 5 mL) and the combined organic layers were dried over $MgSO_4$, filtered, and concentrated under vacuum. To a solution of the crude Mukaiyama aldol product in toluene (0.20 M) was added H_2O:AcOH (8:1, 0.20 M) and Zn powder (10 equiv.). The resulting biphasic suspension was stirred vigorously at room temperature until the reaction was judged to be finished by TLC-analysis (usually 16 hours). The mixture was neutralized with sat. aq. $NaHCO_3$ (2 mL) and poured over H_2O. The aqueous layer was extracted with Et_2O (3 × 5 mL) and the combined organic layers were dried over $MgSO_4$, filtered, and concentrated under vacuum. The crude product was purified by flash chromatography.

2,5-Dibenzyloxy-1-hydroxy-3-hydroxy-D-ribose. The compound was synthesized following the general procedure using $TiCl_2(O^iPr)_2$ (379 mg, 1.60 mmol, 4.0 equiv.), *(R)*-3-(benzyloxy)-2-(2,2,6,6-tetramethylpiperidin-1-yloxy)propanal (90% ee, 128 mg, 400 μmol, 1.0 equiv.), (*Z*)-((2-(benzyloxy)vinyl)oxy)trimethylsilane (356 mg, 1.60 mmol, 4.0 equiv.), H_2O (14.4 μL, 800 μmol, 2.0 equiv.) and CH_2Cl_2 (2.0 mL). Analysis of the crude reaction mixture by ^{1}H-NMR using 1,3-benzodioxole as an internal standard indicated for a 72% yield of the corresponding β-hydroxyaldehyde that was obtained as a single diastereoisomer. ^{1}H NMR (500 MHz, $CDCl_3$): δ 9.75 (d, 1H, J = 1.4 Hz, C**H**(O)), 7.42–7.27 (m, 10H, Ar**H**), 4.74, 4.64, 4.53, 4.44 (4d, 4H, J = 11.9, 11.8, 11.7, 11.6 Hz, CH$_2$OC**H**$_2$Ph, CHOC**H**$_2$Ph), 4.31–4.16 (m, 2H, CH(O)C**H**C**H**), 4.01–3.83 (m, 3H, C**H**C**H**$_2$OBn), 3.59 (d, 1H, J = 4.3 Hz, O**H**), 1.67–0.94 (m, 18H, O**TMP**); ^{13}C NMR (125 MHz, $CDCl_3$): δ 202.1 (**C**H(O)), 137.50, 137.44, 128.57, 128.48, 128.15, 128.01, 128.00, 127.93 (Ar**C**), 84.6 (CH(O)**C**H), 78.2 (**C**HOTMP), 74.8 (**C**HOH), 73.6, 73.4 (CH$_2$O**C**H$_2$Ph, CHO**C**H$_2$Ph), 69.9 (**C**H$_2$OCH$_2$Ph), 60.9, 59.7 ((CH$_3$)$_2$**C**N**C**(CH$_3$)$_2$), 40.7, 40.4 (**C**H$_2$CH$_2$**C**H$_2$), 34.0, 33.2 ((**C**H$_3$)$_a$CNC(**C**H$_3$)$_a$), 20.8 ((**C**H$_3$)$_b$CNC(**C**H$_3$)$_b$), 17.4 (CH$_2$**C**H$_2$CH$_2$). The crude material was reacted following the general procedure using Zn (262 mg, 4.00 mmol, 10 equiv.), toluene (2.0 mL) and H_2O:AcOH (8:1, 2.0 mL). The crude product was purified by flash chromatography using 1:1 hexanes:EtOAc to yield the title compound (86.3 mg, 65% yield over two steps, >20:1 dr, 1:1 mixture of α- and β-anomers) as colorless crystals. IR (thin film): 3382, 2922, 2861, 1454, 1274, 1261, 1120, 1078, 1027, 749, 698 cm^{-1}; ^{1}H NMR

(500 MHz, $CDCl_3$), α-isomer: 7.41–7.24 (m, 10H, Ar**H**), 5.37 (dd, 1H, *J* = 9.7, 4.2 Hz, C**H**(1)), 4.79–4.46 (m, 4H, CH(2)OC**H**$_2$Ph, CH_2(5)OC**H**$_2$Ph), 4.29–4.25 (m, 1H, C**H**(4)), 4.16–4.10 (m, 1H, C**H**(3)), 3.98 (dd, 1H, *J* = 5.2, 4.4 Hz, C**H**(2)), 3.73 (d, 1H, *J* = 9.7 Hz, CH(1)O**H**), 3.56 (d, 2H, *J* = 3.6 Hz, C**H**$_2$(5)), 2.69 (d, 1H, *J* = 4.3 Hz, CH(3)O**H**); β-isomer: 7.41–7.24 (m, 10H, Ar**H**), 5.29 (d, 1H, *J* = 8.2 Hz, C**H**(1)), 4.79–4.46 (m, 4H, CH(2)OC**H**$_2$Ph, CH_2(5)OC**H**$_2$Ph), 4.41–4.36 (m, 1H, C**H**(3)), 4.16–4.10 (m, 1H, C**H**(4)), 3.87 (dd, 1H, *J* = 5.3, 0.8 Hz, C**H**(2)), 3.70 (dd, 1H, *J* = 10.3, 2.7 Hz, C**H**$_a$(5)), 3.62 (dd, 1H, *J* = 10.3, 2.7 Hz, C**H**$_b$(5)), 3.64–3.60 (d, 1H, hidden by C**H**$_b$(5), CH(1)O**H**), 2.77 (d, 1H, *J* = 8.5 Hz, CH(3)O**H**); ^{13}C NMR (125 MHz, $CDCl_3$), aryl carbons : δ 138.01, 137.13, 137.10, 137.08, 128.83, 128.76 (2C), 128.56, 128.54, 128.37, 128.37, 128.24, 128.13, 128.01, 127.86, 127.69 (Ph**C**); α-isomer: 96.4 (**C**(1)), 82.8 (**C**(4)), 78.2 (**C**(2)), 73.9, 73.9 (2 **C**H_2Ph), 71.8 (**C**(3)), 70.2 or 70.1 (**C**(5)); β-isomer: 100.4 (**C**(1)), 84.5 (**C**(4)), 83.7 (**C**(2)), 73.9, 73.9 (2 **C**H_2Ph), 71.3 (**C**(3)), 70.2 or 70.1 (**C**(5)); HRMS (ESI-TOF) calculated for $C_{19}H_{22}O_5$ $[M+Na]^+$ m/z 353.1359, found 353.1356. α_D^{21} = +35.6 (c = 1.00, $CHCl_3$). The configuration of the title compound was determined from the corresponding debenzylated pentose. This compound was prepared by dissolving the title compound (25.8 mg, 78.1 μmol, 1.0 equiv.) in MeOH (2.6 mL) and treating it with Pd/C (10%, 5 mg). Hydrogen gas was bubbled through the reaction mixture for 5 minutes and the suspension was stirred at room temperature for 20 hours under H_2 atmosphere. The reaction mixture was filtered through Celite and the filtrate was evaporated to yield a white powder. Although not pure, the ^{1}H- and ^{13}C-NMR data of this crude product matched an authentic sample of ribose and showed no trace of arabinose, xylose, or lyxose. ^{13}C NMR (125 MHz, D_2O, α- and β-anomers, multiple conformers): δ 100.8, 96.1, 93.6, 93.4, 82.9, 82.3, 75.1, 70.9, 70.8, 70.3, 69.9, 69.8, 69.1, 69.0, 67.2, 67.0, 62.8, 62.4, 61.1.



5-Benzyloxy-1-hydroxy-3-hydroxy-2-(4-methoxybenzyloxy)-D-ribose. The compound was synthesized following the general procedure using $TiCl_2(O^iPr)_2$ (379 mg, 1.60 mmol, 4.0 equiv.), *(R)*-3-(benzyloxy)-2-(2,2,6,6-tetramethylpiperidin-1-yloxy)propanal (90% ee, 128 mg, 400 μmol, 1.0 equiv.), (*Z*)-((2-((4-methoxybenzyl)oxy)vinyl)oxy)trimethylsilane (404 mg, 1.60 mmol, 4.0 equiv.), H_2O (14.4 μL, 800 μmol, 2.0 equiv.) and CH_2Cl_2 (2.0 mL). Analysis of the crude reaction mixture by ^{1}H NMR using 1,3-benzodioxole as an internal standard indicated for a 70% yield of the corresponding β-hydroxyaldehyde, which was obtained as a single diastereoisomer. ^{1}H NMR (500 MHz, $CDCl_3$): δ 9.72 (d, 1H, *J* = 1.7 Hz, C**H**(O)), 7.40–6.79 (m, 9H, Ar**H**), 4.66 (d, 1H, *J* = 11.6, C**H**$_2$Ar), 4.57 (d, 1H, *J* = 11.5, C**H**$_2$Ar), 4.53 (d, 1H, *J* = 11.7, C**H**$_2$Ar), 4.44 (d, 1H, *J* = 11.7 Hz, C**H**$_2$Ar), 4.29–4.16 (m, 2H, CH(O)C**H**C**H**), 3.96–3.78 (m, 4H, C**H**C**H**$_2$OBn, O**H**), 3.80 (s, 3H, OC**H**$_3$), 1.55–0.97 (m, 18H, OTMP); ^{13}C NMR (125 MHz, $CDCl_3$): δ 202.3 (**C**H(O)), 159.42, 137.47, 129.91, 129.51, 128.56, 127.99, 127.91, 113.82. (Ar**C**), 84.2 (CH(O)**C**H), 78.3 (**C**HOTMP), 74.6 (**C**HOH), 73.6, 72.9 (CH_2OCH_2Ph, $CHOCH_2Ph$), 69.8 (CH_2OCH_2Ph), 60.9, 59.7 ($(CH_3)_2CNC(CH_3)_2$), 55.3 (OCH_3), 40.7, 40.4 ($CH_2CH_2CH_2$), 34.0 and 33.2 ($(CH_3)_aCNC(CH_3)_a$), 20.8 and 20.8 ($(CH_3)_bCNC(CH_3)_b$), 17.2 ($CH_2CH_2CH_2$). The crude material was reacted following the general procedure using Zn (262 mg, 4.00 mmol, 10 equiv.), toluene (2.0 mL) and H_2O:AcOH (8:1, 2.0 mL). The crude product was purified by flash chromatography using 1:1 hexanes:EtOAc to yield the title compound (91.9 mg, 64% yield over

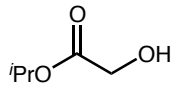


two steps, >20:1 dr, 1:1 mixture of α- and β-anomers) as colorless crystals. Due to the similar structural features and the consistent NMR-data of the title compound to 2,5-dibenzyloxy-3-hydroxy-D-ribose (see above) the configuration of the title compound was assigned as ribo. IR (thin film): 3419, 2925, 2861, 1612, 1585, 1514, 1455, 1302, 1249, 1173, 1075, 822, 739, 699 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$), α-isomer: δ 7.39–6.85 (m, 9H, Ar**H**), 5.35 (dd, 1H, *J* = 9.7, 4.2 Hz, C**H**(1)), 4.72–4.45 (m, 4H, C**H**$_2$PMB, C**H**$_2$Ph), 4.27–4.23 (m, 1H, C**H**(4)), 4.13–4.08 (m, 1H, C**H**(3)), 3.95 (dd, 1H, *J* = 5.2, 4.4 Hz, C**H**(2)), 3.83–3.79 (d, 1H, hidden by OC**H**$_3$, CH(1)O**H**), 3.81 (s, 3H, OC**H**$_3$), 3.55 (d, 2H, *J* = 3.6 Hz, C**H**$_2$(5)), 2.74 (d, 1H, *J* = 4.4 Hz, CH(3)O**H**); β-isomer: δ 7.39–6.85 (m, 9H, Ar**H**), 5.26 (d, 1H, *J* = 8.2 Hz, C**H**(1)), 4.72–4.45 (m, 4H, C**H**$_2$Ph, C**H**$_2$Ph), 4.38–4.33 (m, 1H, C**H**(3)), 4.13–4.08 (m, 1H, C**H**(4)), 3.84 (dd, 1H, *J* = 5.4, 0.8 Hz, C**H**(2)), 3.81 (s, 3H, OC**H**$_3$), 3.74 (d, 1H, *J* = 8.2 Hz, CH(1)O**H**), 3.68 (dd, 1H, *J* = 10.3, 2.7 Hz, C**H**$_a$(5)), 3.61 (dd, 1H, *J* = 10.3, 3.0 Hz, C**H**$_b$(5)), 2.80 (d, 1H, *J* = 8.5 Hz, CH(3)O**H**); ^{13}C NMR (125 MHz, $CDCl_3$), aryl carbons: δ 159.78, 159.67, 137.98, 137.10, 130.10, 129.88, 129.11, 129.09, 128.72, 128.53, 128.21, 127.99, 127.83, 127.67, 114.13, 114.08 (Ar**C**) α-isomer: δ 96.3 (**C**(1)), 82.7 (**C**(4)), 77.8 (**C**(2)), 73.8, 72.7 (2 **C**H_2Ar), 71.7 (**C**(3)), 70.2 or 70.1 (**C**(5)), 55.4 (O**C**H_3); β-isomer: δ 100.4 (**C**(1)), 84.3 (**C**(4)), 83.3 (**C**(2)), 73.8, 72.7 (2 **C**H_2Ar), 71.2 (**C**(3)), 70.2 or 70.1 (**C**(5)), 55.4 (O**C**H_3); HRMS (ESI-TOF) calculated for $C_{20}H_{24}O_6$ $[M+Na]^+$ m/z 383.1465, found 383.1466; α_D^{21} = +35.8 (c = 1.00, $CHCl_3$).

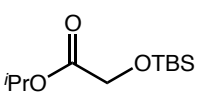
IV. Synthesis of Derivatives of Ribose and Arabinose from Silyl Ketene Acetals

General Procedure for the Synthesis of Isopropyl Esters. A solution of the carboxylic acid in HCl/^{i}PrOH (6–7 M, 50 mL for 10 mL of aldehyde) was heated at reflux for 12 hours. The solution was cooled to room temperature and carefully poured over sat. aq. $NaHCO_3$ (100 mL). The aqueous layer was extracted with Et_2O (3 × 50 mL) and the combined organic layers were dried over $MgSO_4$, filtered, and concentrated under vacuum. The crude product was distilled at atmospheric pressure.

Isopropyl 2-hydroxyacetate. The isopropyl ester was synthesized following the general procedure using 2-hydroxyacetic acid (10.0 mL, 167 mmol, 1.0 equiv.) and HCl/^{i}PrOH (6–7 M, 50 mL). The crude product was distilled at atmospheric pressure (190 °C) to yield the title compound (12.2 g, 62% yield) as a colorless liquid. The experimental data is in agreement with the literature.[10] ^1H NMR (500 MHz, $CDCl_3$): δ 5.13 (sept, 1H, *J* = 6.3 Hz, C**H**$(CH_3)_2$), 4.11 (d, 2H, *J* = 5.4 Hz, C**H**$_2$), 2.43 (br s, 1H, O**H**), 1.28 (d, 6H, *J* = 6.3 Hz, CH(C**H**$_3$)$_2$).



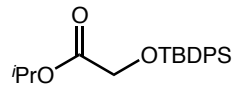
Isopropyl 2-((*tert*-butyldimethylsilyl)oxy)acetate. To a solution of isopropyl 2-hydroxyacetate (1.00 g, 8.47 mmol, 1.0 equiv.) in CH_2Cl_2 (42 mL) at 0 °C was added imidazole (694 mg, 10.2 mmol, 1.2 equiv.) and *tert*-butyldimethylsilyl chloride (1.53 g, 12.0 mmol, 1.2 equiv.). The reaction mixture was warmed to room temperature and stirred for 16 hours. The resulting white suspension was washed with aq. HCl (1 M, 2 × 100 mL) and sat. aq.



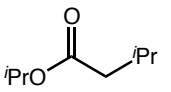
[10] Pounder, R. J.; Dove, A. P. *Biomacromolecules* **2010**, *11*, 1930.

$NaHCO_3$ (2 × 100 mL) and the combined organic layers were dried over $MgSO_4$, filtered, and concentrated under vacuum. The crude product was purified by flash chromatography using 9:1 hexanes:Et_2O to yield the title compound (1.77 g, 90% yield) as a colorless oil. IR (thin film): 2982, 2952, 2931, 2856, 1756, 1729, 1472, 1274, 1259, 1211, 1146, 1107, 837, 812, 764, 750 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$): δ 5.07 (sept, 1H, J = 6.3 Hz, C**H**$(CH_3)_2$), 4.20 (s, 2H, C**H**$_2$), 1.25 (d, 6H, J = 6.3 Hz, CH(C**H**$_3)_2$), 0.92 (s, 9H, SiC(C**H**$_3)_3$, 0.10 (s, 6H, Si(C**H**$_3)_2$); ^{13}C NMR (125 MHz, $CDCl_3$): δ 171.5 (**C**$O_2{}^i$Pr), 68.5 (**C**H$(CH_3)_2$), 62.2 (**C**H_2), 25.9 (SiC(**C**$H_3)_3$), 22.0 (CH(**C**$H_3)_2$), 18.6 (Si**C**$(CH_3)_3$), –5.3 (Si(**C**$H_3)_2$); HRMS (ESI-TOF) calculated for $C_{11}H_{24}O_3Si$ $[M+H]^+$ m/z 233.1568, found 233.1567.

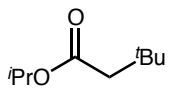
Isopropyl 2-((*tert*-butyldiphenylsilyl)oxy)acetate. To a solution of isopropyl 2-hydroxyacetate (1.15 g, 9.69 mmol, 1.0 equiv.) in CH_2Cl_2 (49 mL) at 0 °C was added imidazole (792 mg, 11.6 mmol, 1.2 equiv.) and *tert*-butyldiphenylsilyl chloride (2.99 mL, 11.6 mmol, 1.2 equiv.). The reaction mixture was warmed to room temperature and stirred for 16 hours. The white suspension was washed with aq. HCl (1 M, 2 × 100 mL) and aq. sat. $NaHCO_3$ (2 × 100 mL) and the combined organic layers were dried over $MgSO_4$, filtered, and concentrated under vacuum. The crude product was purified by flash chromatography using 9:1 hexanes:Et_2O to yield the title compound (3.40 g, 98% yield) as a colorless oil. IR (thin film): 2978, 2967, 2933, 2896, 2859, 1756, 1731, 1472, 1428, 1276, 1213, 1143, 1106, 842, 823, 792, 764, 749, 702 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$): δ 7.79–7.32 (m, 10H, Ar**H**), 5.03 (sept, 1H, J = 6.2 Hz, C**H**$(CH_3)_2$), 4.20 (s, 2H, C**H**$_2$), 1.19 (d, 6H, J = 6.3 Hz, CH(C**H**$_3)_2$), 1.09 (s, 9H, SiC(C**H**$_3)_3$; ^{13}C NMR (125 MHz, $CDCl_3$): δ 170.9 (**C**$O_2{}^i$Pr), 135.7, 133.0, 130.0, 127.9 (Ar**C**), 68.4 (**C**H$(CH_3)_2$), 62.6 (**C**H_2), 26.8 (SiC(**C**$H_3)_3$), 21.9 (CH(**C**$H_3)_2$), 19.4 (Si**C**$(CH_3)_3$); HRMS (ESI-TOF) calculated for $C_{21}H_{28}O_3Si$ $[M+Na]^+$ m/z 379.1700, found 379.1703.



Isopropyl 3-methylbutanoate. The isopropyl ester was synthesized following the general procedure using 3-methylbutanoic acid (10.0 mL, 91.1 mmol, 1.0 equiv.) and HCl/^{i}PrOH (6–7 M, 50 mL). The crude product was distilled at atmospheric pressure (170 °C) to yield the title compound (6.67 g, 72% yield) as a colorless liquid. IR (thin film): 2962, 2871, 1729, 1710, 1464, 1411, 1386, 1372, 1294, 1254, 1191, 1143, 1109, 980, 938 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$): δ 5.00 (sept, 1H, J = 6.3 Hz, OC**H**$(CH_3)_2$), 2.14 (d, 2H, J = 6.5 Hz, C**H**$_2{}^i$Pr), 2.13–2.03 (m, 1H, CH_2C**H**$(CH_3)_2$), 1.22 (d, 6H, J = 6.3 Hz, OCH(C**H**$_3)_2$), 0.94 (d, 6H, J = 6.5 Hz, CH_2CH(C**H**$_3)_2$); ^{13}C NMR (125 MHz, $CDCl_3$): δ 172.9 (**C**$O_2{}^i$Pr), 67.4 (O**C**H$(CH_3)_2$), 44.0 (**C**$H_2{}^i$Pr), 25.9 (CH_2**C**H$(CH_3)_2$), 22.5, 22.0 (CH_2CH(**C**$H_3)_2$), OCH(**C**$H_3)_2$); HRMS (ESI-TOF) calculated for $C_8H_{16}O_2$ $[M+H]^+$ m/z 145.1223, found 145.1224.



Isopropyl 3,3-dimethylbutanoate. The isopropyl ester was synthesized following the general procedure using 3,3-dimethylbutanoic acid (10.0 mL, 78.3 mmol, 1.0 equiv.) and HCl/^{i}PrOH (6–7 M, 50 mL). The crude product was distilled at atmospheric pressure (180 °C) to yield the title compound (6.79 g, 75% yield) as a colorless liquid. IR (thin film): 2960, 2906, 2871, 1728, 1468, 1368, 1335, 1320, 1230, 1178, 1132, 1107, 1044, 974, 933, 888, 822 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$): δ 5.00 (sept, 1H, J = 6.3 Hz, C**H**$(CH_3)_2$), 2.15 (s, 2H, C**H**$_2{}^t$Bu),



1.23 (d, 6H, J = 6.3 Hz, CH(C**H**$_3$)$_2$), 1.01 (s, 9H, CH$_2$CH(C**H**$_3$)$_2$); ^{13}C NMR (125 MHz, $CDCl_3$): δ 172.1 (**C**O$_2$^{i}Pr), 67.3 (**C**H(CH$_3$)$_2$), 48.5 (**C**H$_2$CO$_2$^{i}Pr), 29.8 (C(**C**H$_3$)$_3$), 29.8 (CH(**C**H$_3$)$_2$); HRMS (ESI-TOF) calculated for $C_9H_{18}O_2$ $[M+H]^+$ m/z 159.1380, found 159.1379.

Isopropyl 3-phenylpropanoate. The isopropyl ester was synthesized following the general procedure using 3-phenylpropanoic acid (10.0 mL, 66.6 mmol, 1.0 equiv.) and HCl/^{i}PrOH (6–7 M, 50 mL). The crude product was distilled under vacuum (60 mTorr, 110 °C) to yield the title compound (7.06 g, 71% yield) as a colorless liquid. IR (thin film): 3063, 3028, 2980, 2937, 2871, 1727, 1603, 1497, 1467, 1455, 1419, 1373, 1340, 1291, 1257, 1180, 1145, 1106, 1078, 1029, 984, 966, 902, 862, 824, 748, 697 cm^{-1}; ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.39–7.24 (m, 5H, Ar**H**), 5.07 (sept, 1H, J = 6.3 Hz, C**H**(CH$_3$)$_2$), 3.02 (t, 2H, J = 7.9 Hz, C**H**$_2$Ph), 2.67 (t, 2H, J = 7.9 Hz, C**H**$_2$Bn), 1.28 (d, 6H, J = 6.3 Hz, CH(C**H**$_3$)$_2$); ^{13}C NMR (125 MHz, $CDCl_3$): δ 172.6 (**C**O$_2$^{i}Pr), 140.7, 128.6, 128.5, 126.3 (Ar**C**), 67.9 (**C**H(CH$_3$)$_2$), 36.4 (**C**H$_2$Bn), 31.1 (**C**H$_2$Ph), 22.0 (CH(**C**H$_3$)$_2$); HRMS (ESI-TOF) calculated for $C_{12}H_{16}O_2$ $[M+H]^+$ m/z 193.1223, found 193.1224.

Isopropyl pent-4-enoate. The isopropyl ester was synthesized following the general procedure using pent-4-enoic acid (5.0 mL, 48.9 mmol, 1.0 equiv.) and HCl/^{i}PrOH (6–7 M, 50 mL). The crude product was distilled at atmospheric pressure (160 °C) to yield the title compound (4.73 g, 68% yield) as a colorless liquid. IR (thin film): 3078, 2981, 2932, 2876, 1778, 1730, 1641, 1467, 1449, 1421, 1375, 1340, 1257, 1178, 1146, 1109, 999, 956, 941, 914, 822 cm^{-1}; ^{1}H NMR (500 MHz, $CDCl_3$): δ 5.87–5.76 (m, 1H, C**H**=CH$_2$), 5.09–4.96 (m, 3H, CH=C**H**$_2$, C**H**(CH$_3$)$_2$), 2.40–2.33 (m, 4H, C**H**$_2$C**H**$_2$CO$_2$^{i}Pr), 1.22 (d, 6H, J = 6.3 Hz, CH(C**H**$_3$)$_2$); ^{13}C NMR (125 MHz, $CDCl_3$): δ 172.8 (**C**O$_2$^{i}Pr), 136.9 (**C**H=CH$_2$), 115.5 (CH=**C**H$_2$), 67.7 (**C**H(CH$_3$)$_2$), 34.0 (**C**H$_2$CO$_2$^{i}Pr), 29.1 (**C**H$_2$CH$_2$CO$_2$^{i}Pr), 22.0 (CH(**C**H$_3$)$_2$). HRMS (ESI-TOF) calculated for $C_8H_{14}O_2$ $[M+H]^+$ m/z 143.1067, found 143.1066.

Isopropyl cyclobutanecarboxylate. The isopropyl ester was synthesized following the general procedure using cyclobutanecarboxylic acid (5.0 mL, 63.3 mmol, 1.0 equiv.) and HCl/^{i}PrOH (6–7 M, 50 mL). The crude product was distilled at atmospheric pressure (190 °C) to yield the title compound (5.24 g, 74% yield) as a colorless liquid. IR (thin film): 2981, 2942, 2871, 1725, 1468, 1451, 1373, 1340, 1325, 1267, 1251, 1177, 1145, 1108, 1051, 951, 909, 832, 794, 741, 685 cm^{-1}; ^{1}H NMR (500 MHz, $CDCl_3$): δ 4.99 (sept, 1H, J = 6.3 Hz, C**H**(CH$_3$)$_2$), 3.08 (quint, 1H, J = 8.5 Hz, C**H**CO$_2$^{i}Pr), 2.33–1.80 (m, 6H, (C**H**$_2$)$_3$), 1.22 (d, 6H, J = 6.3 Hz, CH(C**H**$_3$)$_2$); ^{13}C NMR (125 MHz, $CDCl_3$): δ 175.3 (**C**O$_2$^{i}Pr), 67.4 (**C**H(CH$_3$)$_2$), 38.5 (**C**HCO$_2$^{i}Pr), 25.3 (**C**H$_2$CH$_2$**C**H$_2$), 22.0 (CH(**C**H$_3$)$_2$), 26.0 (CH$_2$**C**H$_2$CH$_2$). HRMS (ESI-TOF) calculated for $C_8H_{14}O_2$ $[M+H]^+$ m/z 143.1067, found 143.1066.

Isopropyl cyclopentanecarboxylate. The isopropyl ester was synthesized following the general procedure using cyclopentanecarboxylic acid (5.0 mL, 46.0 mmol, 1.0 equiv.) and HCl/^{i}PrOH (6–7 M, 50 mL). The crude product was distilled at atmospheric pressure (210 °C) to yield the title compound (5.37 g, 75% yield) as a colorless liquid. IR (thin

film): 2934, 2873, 1726, 1467, 1454, 1373, 1343, 1305, 1264, 1187, 1146, 1107, 1037, 982, 941, 909, 826, 756 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$): δ 4.98 (sept, 1H, *J* = 6.3 Hz, C**H**$(CH_3)_2$), 2.67 (quint, 2H, *J* = 8.0 Hz, C**H**$CO_2{}^i$Pr), 1.93–1.49 (m, 8H, (C$\mathbf{H_2}$)$_4$), 1.22 (d, 6H, *J* = 6.2 Hz, CH(C$\mathbf{H_3}$)$_2$); ^{13}C NMR (125 MHz, $CDCl_3$): δ 176.5 (**C**$O_2{}^i$Pr), 67.3 (**C**H$(CH_3)_2$), 44.2 (**C**H$CO_2{}^i$Pr), 30.1 (**C**$H_2(CH_2)_2$**C**H_2), 26.0 (CH_2(**C**H_2)$_2$$CH_2$), 22.0 (CH(**C**$H_3$)$_2$).

Isopropyl 2-methoxyacetate. The isopropyl ester was synthesized following the general procedure using 2-methoxyacetic acid (10.0 mL, 130 mmol, 1.0 equiv.) and HCl/^{i}PrOH (6–7 M, 50 mL). The crude product was distilled at atmospheric pressure (180 °C) to yield the title compound (13.1 g, 76% yield) as a colorless liquid. IR (thin film): 2983, 2937, 2896, 2825,1750, 1729, 1467, 1454, 1424, 1376, 1275, 1211, 1195, 1129, 1104, 1019, 994, 955, 921, 900, 832, 820, 728 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$): δ 5.11 (sept, 1H, *J* = 6.3 Hz, C**H**$(CH_3)_2$), 3.99 (s, 2H, C$\mathbf{H_2}CO_2{}^i$Pr), 3.44 (s, 3H, OC$\mathbf{H_3}$), 1.26 (d, 6H, *J* = 6.3 Hz, CH(C$\mathbf{H_3}$)$_2$); ^{13}C NMR (125 MHz, $CDCl_3$): δ 169.9 (**C**$O_2{}^i$Pr), 70.2 (**C**$H_2CO_2{}^i$Pr), 68.4 (**C**H$(CH_3)_2$), 49.4 (O**C**H_3), 21.9 (CH(**C**H_3)$_2$); HRMS (ESI-TOF) calculated for $C_6H_{12}O_3$ $[M+Na]^+$ m/z 155.0679, found 155.0678.

Isopropyl 2-(dimethylamino)acetate. The isopropyl ester was synthesized following the general procedure using 2-(dimethylamino)acetic acid (5.00 g, 48.5 mmol, 1.0 equiv.) and HCl/^{i}PrOH (6–7 M, 50 mL). The crude product was distilled at atmospheric pressure (190 °C) to yield the title compound (5.50 g, 78% yield) as a colorless liquid. IR (thin film): 2980, 2937, 2871, 2820, 2773, 1745, 1729, 1464, 1455, 1413, 1375, 1328, 1285, 1248, 1199, 1166, 1146, 1107, 1060, 1042, 948, 938, 869, 813, 750 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$): δ 5.07 (sept, 1H, *J* = 6.3 Hz, C**H**$(CH_3)_2$), 3.11 (s, 2H, C$\mathbf{H_2}CO_2{}^i$Pr), 2.33 (s, 6H, N(C$\mathbf{H_3}$)$_2$), 1.24 (d, 6H, *J* = 6.3 Hz, CH(C$\mathbf{H_3}$)$_2$); ^{13}C NMR (125 MHz, $CDCl_3$): δ 170.4 (**C**$O_2{}^i$Pr), 68.1 (**C**H$(CH_3)_2$), 61.0 (**C**$H_2CO_2{}^i$Pr), 45.5 (N(C$\mathbf{H_3}$)$_2$), 22.0 (CH(**C**H_3)$_2$); HRMS (ESI-TOF) calculated for $C_7H_{15}NO_2$ $[M+H]^+$ m/z 146.1176, found 146.1176.

General Procedure for the Synthesis of Silyl ketene Acetals with an α-O-Atom.[11] To a solution of potassium bis(trimethylsilyl)amide (1.1 equiv.) in THF (0.15 M) at –78 °C was added dropwise the ester (1.0 equiv.) over 15 minutes and the viscous solution was stirred for 30 minutes. *tert*-butyldimethylsilyl chloride (1.1 equiv.) dissolved in a minimum amount of THF was added over 15 minutes and the solution was stirred for 1 hour at –78 °C then warmed to room temperature. The solvent was evaporated under vacuum and the residue taken up in hexanes then filtered. The solvent was removed under vacuum and the residue distilled under vacuum.

(*Z*)-5-Isopropoxy-2,2,3,3,8,8,9,9-octamethyl-4,7-dioxa-3,8-disiladec-5-ene. The silyl ketene acetal was synthesized following the general procedure using potassium bis(trimethylsilyl)amide (1.05 g, 5.28 mmol, 1.1 equiv.), isopropyl 2-((*tert*-butyldimethylsilyl)oxy)acetate (1.12 g, 4.80 mmol, 1.0 equiv.), *tert*-

[11] Denmark, S. E.; Chung, W. J *J. Org. Chem.* **2008**, *73*, 4582.

butyldimethylsilyl chloride (796 mg, 5.28 mmol, 1.1 equiv.) and THF (32 mL). The crude product was distilled under vacuum (60 mTorr, 200 °C) to yield the title compound (1.56 g, 94% yield, >20:1 *Z*:*E*) as a colorless liquid. IR (thin film): 2952, 2930, 2859, 1705, 1473, 1462, 1323, 1253, 1203, 1160, 1138, 1107, 1019, 918, 833, 809, 781, 688 cm^{-1}; ^1H NMR (500 MHz, C_6D_6): δ 5.80 (s, 1H, C**H**OTBS), 4.16 (sept, 1H, *J* = 6.2 Hz, C**H**$(CH_3)_2$), 1.12 (d, 6H, *J* = 6.2 Hz, CH(C**H$_3$**)**$_2$**), 1.08 (s, 18H, SiC(C**H$_3$**)**$_3$**), 0.99 (s, 18H, SiC(C**H$_3$**)**$_3$**), 0.31 (s, 12H, Si(C**H$_3$**)**$_2$**), 0.11 (s, 12H, Si(C**H$_3$**)**$_2$**); ^{13}C NMR (125 MHz, C_6D_6): δ 146.1 (**C**O^{i}Pr), 111.5 (C**H**OTBS), 69.8 (**C**H$(CH_3)_2$), 26.1 and 26.0 (2 × SiC(**C**H$_3$)**$_3$**), 21.7 (CH(**C**H$_3$)**$_2$**), 18.7 and 18.5 (2 × Si**C**$(CH_3)_3$), –4.2, and –5.1 (2 × Si(**C**H$_3$)**$_2$**).

(*Z*)-5-Isopropoxy-2,2,3,3,9,9-hexamethyl-8,8-diphenyl-4,7-dioxa-3,8-disiladec-5-ene. The silyl ketene acetal was synthesized following the general procedure using potassium bis(trimethylsilyl)amide (1.05 g, 5.28 mmol, 1.1 equiv.), isopropyl 2-((*tert*-butyldiphenylsilyl)oxy)acetate (1.71 g, 4.80 mmol, 1.0 equiv.), *tert*-butyldimethylsilyl chloride (796 mg, 5.28 mmol, 1.1 equiv.) and THF (32 mL). The crude product (2.24 g, 99% yield, >20:1 *Z*:*E*) was obtained as a pale yellow oil that was used without further purification. IR (thin film): 2957, 2931, 2891, 2858, 1704, 1473, 1462, 1428, 1324, 1252, 1204, 1151, 1138, 1106, 1017, 1004, 917, 825, 807, 782, 740, 699 cm^{-1}; ^1H NMR (500 MHz, C_6D_6): δ 7.93–7.18 (m, 10H, Ar**H**); 5.85 (s, 1H, C**H**OTBS), 4.01 (sept, 1H, *J* = 6.1 Hz, C**H**$(CH_3)_2$), 1.21 (s, 18H, SiC(C**H$_3$**)**$_3$**), 1.12 (s, 18H, SiC(C**H$_3$**)**$_3$**), 0.97 (d, 6H, *J* = 6.2 Hz, CH(C**H$_3$**)**$_2$**), 0.37 (s, 6H, Si(C**H$_3$**)**$_2$**); ^{13}C NMR (125 MHz, C_6D_6): δ 145.9 (**C**O^{i}Pr), 135.94, 133.56, 130.12, 128.12 (Ar**C**), 112.0 (**C**HOTBDPS), 70.1 (**C**H$(CH_3)_2$), 26.9 and 26.0 (2 × SiC(**C**H$_3$)**$_3$**), 21.6 (CH(**C**H$_3$)**$_2$**), 19.4 and 18.5 (2 × Si**C**$(CH_3)_3$), –4.0 (Si(**C**H$_3$)**$_2$**).

(*Z*)-*tert*-Butyl((1-isopropoxy-2-methoxyvinyl)oxy)dimethylsilane. The silyl ketene acetal was synthesized following the general procedure using potassium bis(trimethylsilyl)amide (1.66 g, 8.33 mmol, 1.1 equiv.), isopropyl 2-methoxyacetate (1.00 g, 7.57 mmol, 1.0 equiv.), *tert*-butyldimethylsilyl chloride (1.25 g, 8.33 mmol, 1.1 equiv.) and THF (50 mL). The crude product was distilled under vacuum (60 mTorr, 120 °C) to yield the title compound (1.78 g, 95% yield, >20:1 *Z*:*E*) as a colorless liquid. IR (thin film): 2952, 2931, 2891, 2859, 2825, 1706, 1472, 1464, 1371, 1360, 1348, 1317, 1252, 1204, 1128, 1105, 1030, 998, 938, 911, 828, 811, 782, 691, 650 cm^{-1}; ^1H NMR (500 MHz, C_6D_6): δ 5.42 (s, 1H, C**H**OCH_3), 4.16 (sept, 1H, *J* = 6.1 Hz, C**H**$(CH_3)_2$), 3.16 (s, 3H, CHOC**H$_3$**), 1.11 (d, 6H, *J* = 6.2 Hz, CH(C**H$_3$**)**$_2$**), 1.07 (s, 9H, SiC(C**H$_3$**)**$_3$**), 0.30 (s, 6H, Si(C**H$_3$**)**$_2$**); ^{13}C NMR (125 MHz, C_6D_6): δ 145.8 (**C**O^{i}Pr), 118.1 (C**H**OCH_3), 69.8 (**C**H$(CH_3)_2$), 59.5 (O**C**H$_3$), 26.0 (SiC(**C**H$_3$)**$_3$**), 21.8 (CH(**C**H$_3$)**$_2$**), 18.6 (Si**C**$(CH_3)_3$), –4.3 (Si(**C**H$_3$)**$_2$**).

General Procedure for the Synthesis of Silyl ketene Acetals with an α-C-Atom.[12] To a solution of ^{i}Pr$_2$NH (1.2 equiv.) in THF (0.4 M) at 0 °C was added dropwise *n*-butyllithium (1.1 equiv.) and the mixture was stirred for 30 min then cooled to –78 °C. The ester (1.0 equiv.) was added dropwise and the solution was stirred for 30 minutes. DMPU (1.0 equiv.) was added in one portion followed by the

[12] Wenzel, A. G.; Jacobsen, E. N. *J. Am. Chem. Soc.* **2002**, *124*, 12964.

dropwise addition of trimethylsilyl chloride or *tert*-butyldimethylsilyl chloride (1.2 equiv.) dissolved in a minimum amount of THF. The solution was stirred for 30 minutes at –78 °C, then warmed to room temperature and stirred for an additional 2 hours. The solvent was evaporated under vacuum and the residue suspended in hexanes and filtered. The solvent was removed under vacuum and the residue was distilled.

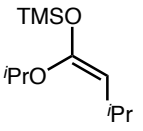
***tert*-Butyl((1-isopropoxyvinyl)oxy)dimethylsilane**. The silyl ketene acetal was synthesized following the general procedure using $^{i}Pr_2NH$ (1.69 mL, 12.0 mmol, 1.2 equiv.), *n*-butyllithium (2.5 M in hexanes, 4.40 mL, 11.0 mmol, 1.1 equiv.), isobutyl acetate (1.17 mL, 10.0 mmol, 1.0 equiv.), DMPU (1.20 mL, 10.0 mmol, 1.0 equiv.), *tert*-butyldimethylsilyl chloride (1.81 g, 12.0 mmol, 1.2 equiv.) and THF (25 mL). The crude product was distilled under vacuum (60 mTorr, 70 °C) to yield the title compound (2.01 g, 93% yield) as a colorless liquid. IR (thin film): 2952, 2931, 2886, 2856, 1652, 1606, 1469, 1274, 1254, 1178, 1118, 1049, 999, 898, 836, 812, 784 cm^{-1}; ^1H NMR (500 MHz, C_6D_6): δ 3.97 (sept, 1H, *J* = 6.1 Hz, C**H**$(CH_3)_2$), 3.61 (d, 1H, *J* = 2.2 Hz, C=C$\mathbf{H_a}$), 3.20 (d, 1H, *J* = 2.0 Hz, C=C$\mathbf{H_b}$), 1.05 (d, 6H, *J* = 6.1 Hz, CH(C$\mathbf{H_3}$)$_2$), 0.99 (s, 9H, SiC(C$\mathbf{H_3}$)$_3$), 0.22 (s, 6H, Si(C$\mathbf{H_3}$)$_2$); ^{13}C NMR (125 MHz, C_6D_6): δ 160.1 (**C**=CH_2), 69.9 (**C**H$(CH_3)_2$), 62.1 (C=**C**H_2), 25.9 (SiC(**C**H_3)$_3$), 21.6 (CH(**C**H_3)$_2$), 18.4 (Si**C**$(CH_3)_3$), –4.2 (Si(**C**H_3)$_2$).

(*E*)-*tert*-Butyl((1-isopropoxyprop-1-en-1-yl)oxy)dimethylsilane. The silyl ketene acetal was synthesized following the general procedure using $^{i}Pr_2NH$ (1.69 mL, 12.0 mmol, 1.2 equiv.), *n*-butyllithium (2.5 M in hexanes, 4.40 mL, 11.0 mmol, 1.1 equiv.), isopropyl propionate (1.33 mL, 10.0 mmol, 1.0 equiv.), DMPU (1.20 mL, 10.0 mmol, 1.0 equiv.), *tert*-butyldimethylsilyl chloride (1.81 g, 12.0 mmol, 1.2 equiv.) and THF (25 mL). The crude product was distilled under vacuum (60 mTorr, 80 °C) to yield the title compound (2.10 g, 91% yield, 6:1 *E*:*Z*) as a colorless liquid. IR (thin film): 2972, 2957, 2931, 2891, 2861, 1683, 1473, 1464, 1371, 1304, 1255, 1204, 1138, 1110, 1041, 938, 898, 839, 804, 782, 764, 750 cm^{-1}; ^1H NMR (500 MHz, C_6D_6), *E*-isomer (major): δ 4.43 (sept, 1H, *J* = 6.2 Hz, C**H**$(CH_3)_2$), 3.99 (q, 1H, *J* = 6.6 Hz, C=C**H**), 1.72 (d, 3H, *J* = 6.6 Hz, CHC$\mathbf{H_3}$), 1.15 (d, 6H, *J* = 6.2 Hz, CH(C$\mathbf{H_3}$)$_2$), 0.96 (s, 9H, SiC(C$\mathbf{H_3}$)$_3$), 0.15 (s, 6H, Si(C$\mathbf{H_3}$)$_2$); *Z*-isomer (minor): δ 3.92 (sept, 1H, *J* = 6.1 Hz, C**H**$(CH_3)_2$), 3.52 (q, 1H, *J* = 6.4 Hz, C=C**H**), 1.77 (d, 3H, *J* = 6.4 Hz, CHC$\mathbf{H_3}$), 1.15 (d, 6H, *J* = 6.2 Hz, CH(C$\mathbf{H_3}$)$_2$), 1.03 (s, 9H, SiC(C$\mathbf{H_3}$)$_3$), 0.24 (s, 6H, Si(C$\mathbf{H_3}$)$_2$); ^{13}C NMR (125 MHz, C_6D_6, *E*-isomer (major): δ 152.9 (**C**=CH), 82.2 (C=**C**H), 68.9 (**C**H$(CH_3)_2$), 25.8 (SiC(**C**H_3)$_3$), 22.1 (CH(**C**H_3)$_2$), 18.3 (Si**C**$(CH_3)_3$), 10.3 (CH**C**H_3), –4.9 (Si(**C**H_3)$_2$); *Z*-isomer (minor): δ 152.9 (**C**=CH), 72.0 (C=**C**H), 69.2 (**C**H$(CH_3)_2$), 26.0 (SiC(**C**H_3)$_3$), 21.7 (CH(**C**H_3)$_2$), 18.3 (Si**C**$(CH_3)_3$), 9.3 (CH**C**H_3), –3.8 (Si(**C**H_3)$_2$).

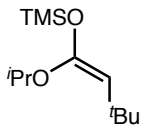
(*E*)-*tert*-Butyl((1-isopropoxybut-1-en-1-yl)oxy)dimethylsilane. The silyl ketene acetal was synthesized following the general procedure using $^{i}Pr_2NH$ (1.69 mL, 12.0 mmol, 1.2 equiv.), *n*-butyllithium (2.5 M in hexanes, 4.40 mL, 11.0 mmol, 1.1 equiv.), isopropyl butyrate (1.51 mL, 10.0 mmol, 1.0 equiv.), DMPU (1.20 mL, 10.0 mmol, 1.0 equiv.), *tert*-butyldimethylsilyl chloride (1.81 g, 12.0 mmol, 1.2 equiv.) and THF (25 mL). The crude product was distilled under vacuum (60 mTorr, 90 °C) to yield the title compound (2.20 g, 90% yield, 7:1 *E*:*Z*) as a colorless liquid. IR (thin film): 2961, 2932, 2891, 2856, 1678, 1472, 1462, 1371,

1363, 1274, 1260, 1199, 1130, 1110, 1044, 996, 921, 888, 840, 807, 781, 764, 751 cm^{-1}; ^1H NMR (500 MHz, C_6D_6), *E*-isomer (major): δ 4.42 (sept, 1H, *J* = 6.2 Hz, C**H**$(CH_3)_2$), 4.01 (t, 1H, *J* = 7.2 Hz, C=C**H**), 2.27–2.18 (m, 2H, C$\mathbf{H_2}$), 1.15 (d, 6H, *J* = 6.2 Hz, CH(C$\mathbf{H_3}$)$_2$), 1.05 (t, 3H, *J* = 7.6 Hz, $CH_2C\mathbf{H_3}$), 0.97 (s, 9H, SiC(C$\mathbf{H_3}$)$_3$), 0.17 (s, 6H, Si(C$\mathbf{H_3}$)$_2$); *Z*-isomer (minor): δ 3.93 (sept, 1H, *J* = 6.0 Hz, C**H**$(CH_3)_2$), 3.53 (t, 1H, *J* = 7.0 Hz, C=C**H**), 2.32–2.24 (m, 2H, C$\mathbf{H_2}$), 1.15 (d, 6H, *J* = 6.2 Hz, CH(C$\mathbf{H_3}$)$_2$), 1.05 (t, 3H, *J* = 7.6 Hz, $CH_2C\mathbf{H_3}$), 1.03 (s, 9H, SiC(C$\mathbf{H_3}$)$_3$), 0.24 (s, 6H, Si(C$\mathbf{H_3}$)$_2$); ^{13}C NMR (125 MHz, C_6D_6), *E*-isomer (major): δ 152.1 (**C**=CH), 90.4 (C=**C**H), 68.7 (**C**H$(CH_3)_2$), 25.9 (SiC(**C**H_3)$_3$), 22.1 (CH(**C**H_3)$_2$), 18.8 ($\mathbf{C}H_2CH_3$), 15.8 ($CH_2\mathbf{C}H_3$), 18.4 (Si**C**$(CH_3)_3$), –4.9 (Si(**C**H_3)$_2$); *Z*-isomer (minor): δ 154.1 (**C**=CH), 79.8 (C=**C**H), 69.2 (**C**H$(CH_3)_2$), 26.0 (SiC(**C**H_3)$_3$), 21.7 (CH(**C**H_3)$_2$), 18.9 ($\mathbf{C}H_2CH_3$), 16.1 ($CH_2\mathbf{C}H_3$), 18.4 (Si**C**$(CH_3)_3$), –3.8 (Si(**C**H_3)$_2$).

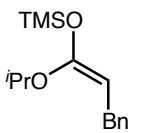
(*E*)-((1-Isopropoxy-3-methylbut-1-en-1-yl)oxy)trimethylsilane. The silyl ketene acetal was synthesized following the general procedure using ^{i}Pr$_2$NH (1.69 mL, 12.0 mmol, 1.2 equiv.), *n*-butyllithium (2.5 M in hexanes, 4.40 mL, 11.0 mmol, 1.1 equiv.), isopropyl isobutyrate (1.44 g, 10.0 mmol, 1.0 equiv.), DMPU (1.20 mL, 10.0 mmol, 1.0 equiv.), trimethylsilyl chloride (1.52 g, 12.0 mmol, 1.2 equiv.) and THF (25 mL). The crude product was distilled under vacuum (60 mTorr, 100 °C) to yield the title compound (2.01 g, 93% yield, >20:1 *E*:*Z*) as a colorless liquid. IR (thin film): 3058, 3028, 2976, 2937, 2896, 1732, 1712, 1674, 1621, 1494, 1453, 1372, 1358, 1252, 1261, 1169, 1139, 1107, 1070, 1018, 901, 841, 752, 697 cm^{-1}; ^1H NMR (500 MHz, C_6D_6): δ 4.38 (sept, 1H, *J* = 6.2 Hz, OC**H**$(CH_3)_2$), 3.87 (d, 1H, *J* = 9.1 Hz, C=C**H**), 2.93–2.82 (m, 1H, CHC**H**$(CH_3)_2$), 1.15 (d, 6H, *J* = 6.2 Hz, CHCH(C$\mathbf{H_3}$)$_2$), 1.11 (d, 6H, *J* = 7.8 Hz, OCH(C$\mathbf{H_3}$)$_2$), 0.18 (s, 9H, Si(C$\mathbf{H_3}$)$_3$); ^{13}C NMR (125 MHz, C_6D_6): δ 151.0 (**C**=CH), 96.3 (C=**C**H), 68.4 (O**C**H$(CH_3)_2$), 25.3 (CH**C**H$(CH_3)_2$), 24.5 (CHCH(**C**H_3)$_2$), 22.2 (OCH(**C**H_3)$_2$), –0.19 (Si(**C**H_3)$_3$).



(*E*)-((1-Isopropoxy-3,3-dimethylbut-1-en-1-yl)oxy)trimethylsilane. The silyl ketene acetal was synthesized following the general procedure using ^{i}Pr$_2$NH (1.69 mL, 12.0 mmol, 1.2 equiv.), *n*-butyllithium (2.5 M in hexanes, 4.40 mL, 11.0 mmol, 1.1 equiv.), isopropyl 3,3-dimethylbutanoate (1.58 g, 10.0 mmol, 1.0 equiv.), DMPU (1.20 mL, 10.0 mmol, 1.0 equiv.), trimethylsilyl chloride (1.52 g, 12.0 mmol, 1.2 equiv.) and THF (25 mL). The crude product was distilled under vacuum (60 mTorr, 100 °C) to yield the title compound (2.22 g, 96% yield, >20:1 *E*:*Z*) as a colorless liquid. IR (thin film): 2958, 2866, 1675, 1464, 1451, 1380, 1274, 1254, 1197, 1127, 1110, 1028, 906, 865, 846, 752 cm^{-1}; ^1H NMR (500 MHz, C_6D_6): δ 4.44 (sept, 1H, *J* = 6.2 Hz, C**H**$(CH_3)_2$), 3.92 (s, 1H, C=C**H**), 1.31 (s, 9H, C(C$\mathbf{H_3}$)$_3$), 1.15 (d, 6H, *J* = 6.2 Hz, CH(C$\mathbf{H_3}$)$_2$), 0.17 (s, 9H, Si(C$\mathbf{H_3}$)$_3$); ^{13}C NMR (125 MHz, C_6D_6): δ 151.0 (**C**=CH), 96.9 (C=**C**H), 68.0 (**C**H$(CH_3)_2$), 31.8 (C(**C**H_3)$_3$), 30.2 (**C**$(CH_3)_3$), 22.2 (CH(**C**H_3)$_2$), –0.26 (Si(**C**H_3)$_3$).

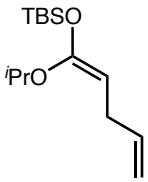


(*E*)-((1-Isopropoxy-3-phenylprop-1-en-1-yl)oxy)trimethylsilane. The silyl ketene acetal was synthesized following the general procedure using ^{i}Pr$_2$NH (1.69 mL, 12.0 mmol, 1.2 equiv.), *n*-butyllithium (2.5 M in hexanes, 4.40 mL, 11.0 mmol, 1.1 equiv.), isopropyl 3-phenylpropanoate (1.92 g, 10.0 mmol, 1.0 equiv.), DMPU (1.20 mL, 10.0 mmol, 1.0 equiv.), trimethylsilyl chloride (1.52 g, 12.0 mmol, 1.2 equiv.) and THF (25 mL). The

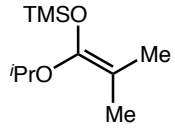


crude product was distilled under vacuum (60 mTorr, 180 °C) to yield the title compound (2.40 g, 91% yield, 6:1:3 *E*:*Z*:*C*-silylated) as a colorless liquid. IR (thin film): 2956, 2901, 2866, 1665, 1477, 1456, 1371, 1355, 1320, 1254, 1234, 1159, 1135, 1112, 1042, 1031, 897, 869, 844, 753 cm^{-1}; ^1H NMR (500 MHz, C_6D_6), *E*-isomer (major): δ 7.40–6.98 (m, 5H, Ar**H**), 4.42 (sept, 1H, *J* = 6.2 Hz, C**H**$(CH_3)_2$), 4.16 (t, 1H, *J* = 7.3 Hz, C=C**H**), 3.56 (d, 2H, *J* = 7.4 Hz, C$\mathbf{H_2}$Ph), 1.13 (d, 6H, *J* = 6.2 Hz, CH(C$\mathbf{H_3}$)$_2$), 0.14 (s, 9H, Si(C$\mathbf{H_3}$)$_3$); ^{13}C NMR (125 MHz, C_6D_6): δ 153.1 (**C**=CH), 143.64, 128.83, 128.79, 126.13 (Ar**C**), 86.7 (C=**C**H), 68.9 (**C**H$(CH_3)_2$), 31.7 (**C**H_2Ph), 22.2 (CH(**C**H_3)$_2$), –0.19 (Si(**C**H_3)$_3$).

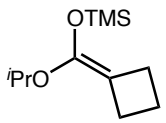
(*Z*)-*tert*-Butyl((1-isopropoxypenta-1,4-dien-1-yl)oxy)dimethylsilane. The silyl ketene acetal was synthesized following the general procedure using $^iPr_2NH$ (1.69 mL, 12.0 mmol, 1.2 equiv.), *n*-butyllithium (2.5 M in hexanes, 4.40 mL, 11.0 mmol, 1.1 equiv.), isopropyl pent-4-enoate (1.42 g, 10.0 mmol, 1.0 equiv.), DMPU (1.20 mL, 10.0 mmol, 1.0 equiv.), *tert*-butyldimethylsilyl chloride (1.81 g, 12.0 mmol, 1.2 equiv.) and THF (25 mL). The crude product was distilled under vacuum (60 mTorr, 180 °C) to yield the title compound (2.22 g, 87% yield, 5:1 *E*:*Z*) as a colorless liquid. IR (thin film): 2972, 2957, 2931, 2891, 2860, 1675, 1638, 1473, 1462, 1371, 1362, 1317, 1290, 1253, 1234, 1191, 1138, 1108, 1072, 1044, 1005, 991, 933, 902, 837, 807, 781, 726, 671 cm^{-1}; ^1H NMR (500 MHz, C_6D_6), *E*-isomer (major): δ 6.00–5.90 (m, 1H, C**H**=CH_2), 5.21–4.99 (m, 1H, CH=C$\mathbf{H_2}$), 4.43 (sept, 1H, *J* = 6.2 Hz, C**H**$(CH_3)_2$), 4.01 (t, 1H, *J* = 7.3 Hz, C=C**H**), 2.99–2.94 (m, 2H, C$\mathbf{H_2}$), 1.13 (d, 6H, *J* = 6.2 Hz, CH(C$\mathbf{H_3}$)$_2$), 0.95 (s, 9H, SiC(C$\mathbf{H_3}$)$_3$), 0.15 (s, 6H, Si(C$\mathbf{H_3}$)$_2$; *Z*-isomer (minor): δ 6.05–5.96 (m, 1H, C**H**=CH_2), 5.24–5.02 (m, 1H, CH=C$\mathbf{H_2}$), 3.92 (sept, 1H, *J* = 6.1 Hz, C**H**$(CH_3)_2$), 3.53 (t, 1H, *J* = 7.1 Hz, C=C**H**), 3.05–2.97 (m, 2H, C$\mathbf{H_2}$), 1.13 (d, 6H, *J* = 6.1 Hz, CH(C$\mathbf{H_3}$)$_2$), 1.01 (s, 9H, SiC(C$\mathbf{H_3}$)$_3$), 0.22 (s, 6H, Si(C$\mathbf{H_3}$)$_2$); ^{13}C NMR (125 MHz, C_6D_6), *E*-isomer (major): δ 153.0 (**C**=CH), 139.2 (**C**H=CH_2), 113.7 (CH=**C**H_2), 85.4 (C=**C**H), 68.9 (**C**H$(CH_3)_2$), 29.8 (**C**H_2), 25.8 (SiC(**C**H_3)$_3$), 22.1 (CH(**C**H_3)$_2$), 18.3 (Si**C**$(CH_3)_3$), –4.9 (Si(**C**H_3)$_2$); *Z*-isomer (minor): δ 154.9 (**C**=CH), 139.5 (**C**H=CH_2), 113.4 (CH=**C**H_2), 75.0 (C=**C**H), 69.4 (**C**H$(CH_3)_2$), 29.9 (**C**H_2), 26.0 (SiC(**C**H_3)$_3$), 21.7 (CH(**C**H_3)$_2$), 18.3 (Si**C**$(CH_3)_3$), –3.8 (Si(**C**H_3)$_2$).



((1-Isopropoxy-2-methylprop-1-en-1-yl)oxy)trimethylsilane. The silyl ketene acetal was synthesized following the general procedure using $^iPr_2NH$ (1.69 mL, 12.0 mmol, 1.2 equiv.), *n*-butyllithium (2.5 M in hexanes, 4.40 mL, 11.0 mmol, 1.1 equiv.), isopropyl isobutyrate (1.53 mL, 10.0 mmol, 1.0 equiv.), DMPU (1.20 mL, 10.0 mmol, 1.0 equiv.), trimethylsilyl chloride (1.52 g, 12.0 mmol, 1.2 equiv.) and THF (25 mL). The crude product was distilled under vacuum (60 mTorr, 80 °C) to yield the title compound (1.96 g, 97% yield) as a colorless liquid. IR (thin film): 2975, 2916, 2861, 1705, 1659, 1451, 1381, 1371, 1253, 1188, 1160, 1138, 1108, 994, 913, 873, 845, 751, 706 cm^{-1}; ^1H NMR (500 MHz, C_6D_6): δ 4.23 (sept, 1H, *J* = 6.2 Hz, C**H**$(CH_3)_2$), 1.75 (s, 3H, C=C(C$\mathbf{H_3}$)$_a$), 1.70 (s, 3H, C=C(C$\mathbf{H_3}$)$_b$), 1.13 (d, 6H, *J* = 6.2 Hz, CH(C$\mathbf{H_3}$)$_2$), 0.20 (s, 9H, Si(C$\mathbf{H_3}$)$_3$); ^{13}C NMR (125 MHz, C_6D_6): δ 147.4 (**C**=C$(CH_3)_2$), 92.5 (C=**C**$(CH_3)_2$), 69.5 (**C**H$(CH_3)_2$), 21.9 (CH(**C**H_3)$_2$), 17.5, 17.1 (C(**C**H_3)$_2$), 0.22 (Si(**C**H_3)$_3$).

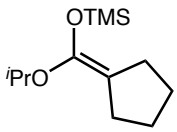


(Cyclobutylidene(isopropoxy)methoxy)trimethylsilane. The silyl ketene acetal was synthesized



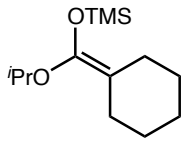
following the general procedure using $^{i}Pr_2NH$ (1.69 mL, 12.0 mmol, 1.2 equiv.), *n*-butyllithium (2.5 M in hexanes, 4.40 mL, 11.0 mmol, 1.1 equiv.), isopropyl cyclobutanecarboxylate (1.42 g, 10.0 mmol, 1.0 equiv.), DMPU (1.20 mL, 10.0 mmol, 1.0 equiv.), trimethylsilyl chloride (1.52 g, 12.0 mmol, 1.2 equiv.) and THF (25 mL). The crude product was distilled under vacuum (60 mTorr, 130 °C) to yield the title compound (2.11 g, 98% yield, 1.5:1 *O*-silylated:*C*-silylated) as a colorless liquid. IR (thin film): 2976, 2871, 2841, 1722, 1707, 1467, 1451, 1381, 1372, 1248, 1207, 1178, 1128, 1107, 1070, 943, 911, 879, 842, 753, 693 cm^{-1}; ^1H NMR (500 MHz, C_6D_6): δ 4.32 (sept, 1H, *J* = 6.1 Hz, C**H**$(CH_3)_2$), 2.90–2.80 (m, 4H, C**H**$_2$C**H**$_2$C**H**$_2$), 1.96 (q, 2H, *J* = 7.8 Hz, CH_2C**H**$_2$$CH_2$), 1.23 (d, 6H, *J* = 6.2 Hz, CH(C**H**$_3$)$_2$), 0.32 (s, 9H, Si(C**H**$_3$)$_3$); ^{13}C NMR (125 MHz, C_6D_6): δ 146.0 (**C**=C$(CH_2)_2$), 95.7 (C=**C**$(CH_2)_2$), 69.4 (**C**H$(CH_3)_2$), 28.1, 27.3 (**C**H_2CH_2**C**H_2), 17.9 (CH_2**C**$H_2$$CH_2$), 22.3 (CH(**C**$H_3$)$_2$), 0.51 (Si(**C**$H_3$)$_3$).

(Cyclopentylidene(isopropoxy)methoxy)trimethylsilane. The silyl ketene acetal was synthesized



following the general procedure using $^{i}Pr_2NH$ (1.69 mL, 12.0 mmol, 1.2 equiv.), *n*-butyllithium (2.5 M in hexanes, 4.40 mL, 11.0 mmol, 1.1 equiv.), isopropyl cyclopentanecarboxylate (1.56 g, 10.0 mmol, 1.0 equiv.), DMPU (1.20 mL, 10.0 mmol, 1.0 equiv.), trimethylsilyl chloride (1.52 g, 12.0 mmol, 1.2 equiv.) and THF (25 mL). The crude product was distilled under vacuum (60 mTorr, 200 °C) to yield the title compound (2.22 g, 97% yield) as a colorless liquid. IR (thin film): 2971, 2922, 2830, 2852, 1695, 1448, 1381, 1371, 1249, 1237, 1185, 1126, 1107, 1050, 1022, 976, 916, 895, 869, 844, 753, 698 cm^{-1}; ^1H NMR (500 MHz, C_6D_6): δ 4.27 (sept, 1H, *J* = 6.2 Hz, C**H**$(CH_3)_2$), 2.42 (m, 2H, C=C(**C**H_2)$_2$), 2.34 (m, 2H, C=C(**C**H_2)$_2$), 1.65–1.54 (m, 4H, C=C$(CH_2)_2$(**C**H_2)$_2$), 1.16 (d, 6H, *J* = 6.2 Hz, CH(C**H**$_3$)$_2$), 0.22 (s, 9H, Si(C**H**$_3$)$_3$); ^{13}C NMR (125 MHz, C_6D_6): δ 145.3 (**C**=C$(CH_2)_2$), 102.9 (C=**C**$(CH_2)_2$), 69.4 (**C**H$(CH_3)_2$), 28.9, 28.5, 27.5, 27.4 (C=C(**C**H_2)$_2$(**C**H_2)$_2$), 22.2 (CH(**C**H_3)$_2$), 0.41 (Si(**C**H_3)$_3$).

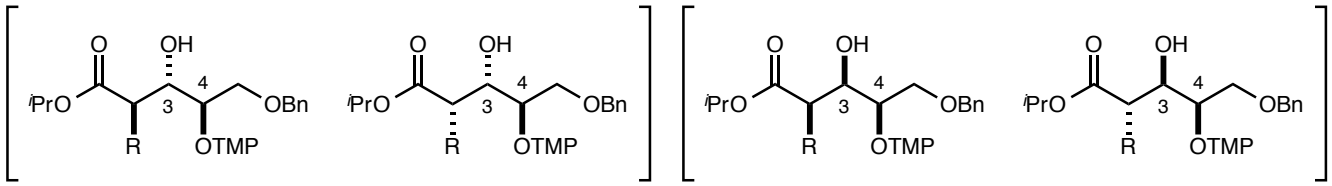
(Cyclohexylidene(isopropoxy)methoxy)trimethylsilane. The silyl ketene acetal was synthesized



following the general procedure using $^{i}Pr_2NH$ (1.69 mL, 12.0 mmol, 1.2 equiv.), *n*-butyllithium (2.5 M in hexanes, 4.40 mL, 11.0 mmol, 1.1 equiv.,), isopropyl cyclohexanecarboxylate (1.81 g, 10.0 mmol, 1.0 equiv.), DMPU (1.20 mL, 10.0 mmol, 1.0 equiv.), trimethylsilyl chloride (1.52 g, 12.0 mmol, 1.2 equiv.) and THF (25 mL). The crude product was distilled under vacuum (60 mTorr, 170 °C) to yield the title compound (2.26 g, 93% yield) as a colorless liquid. IR (thin film): 2956, 2861, 1708, 1659, 1464, 1451, 1381, 1371, 1275, 1261, 1232, 1216, 1166, 1138, 1107, 1069, 1010, 950, 916, 873, 840, 751, 698 cm^{-1}; ^1H NMR (500 MHz, C_6D_6): δ 4.34 (sept, 1H, *J* = 6.1 Hz, C**H**$(CH_3)_2$), 2.43 (t, 2H, *J* = 6.1 Hz, C=C(**C**H_2)$_a$), 2.36 (t, 2H, *J* = 6.1 Hz, C=C(**C**H_2)$_b$), 1.71–1.53 (m, 6H, C=C$(CH_2)_2$(**C**H_2)$_3$), 1.23 (d, 6H, *J* = 6.2 Hz, CH(C**H**$_3$)$_2$), 0.30 (s, 9H, Si(C**H**$_3$)$_3$); ^{13}C NMR (125 MHz, C_6D_6): δ 145.0 (**C**=C$(CH_2)_2$), 101.1 (C=**C**$(CH_2)_2$), 69.2 (**C**H$(CH_3)_2$), 28.1, 28.0, 27.9, 27.6, and 27.3 (C=C(**C**H_2)$_5$), 21.8 (CH(**C**H_3)$_2$), 0.16 (Si(**C**H_3)$_3$).

General Procedure for the Mukaiyama Aldol Reaction of α-OTMP-Aldehyde and Silyl ketene Acetals. An oven-dried vial was flushed with dry N_2, charged with $TiCl_2(O^iPr)_2$ (2.0 equiv.) and CH_2Cl_2 (0.2 M), and cooled to –20 °C. *(R)*-3-(benzyloxy)-2-(2,2,6,6-tetramethylpiperidin-1-yloxy)propanal *(*90% ee, 1.0 equiv.) and the silyl ketene acetal (2.0 equiv.) were weighed into an Eppendorf tube, dissolved in a minimum amount of CH_2Cl_2, and added to the solution of $TiCl_2(O^iPr)_2$ via a microliter syringe. The mixture was stirred for 16 hours at –20 °C, then quenched by the addition of sat. aq. NH_4Cl (2 mL) and poured over H_2O (10 mL). The aqueous layer was extracted with Et_2O (3 × 5 mL) and the combined organic layers were dried over $MgSO_4$, filtered, and concentrated under vacuum. The crude product was purified by flash chromatography.

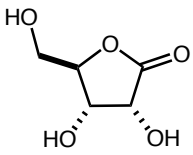
Note: For aldol products bearing three stereocenters, only two diastereomers were ever observed (see depiction below). The stereochemical relationship between substituents at C(3) and C(4) was found to be exclusively *anti*, while that between substituents at C(2) and C(3) was variable.



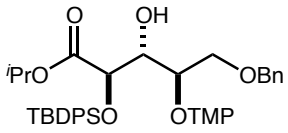
3,4-*anti* observed **3,4-*syn* not observed**

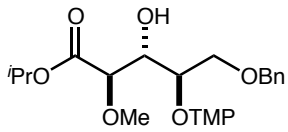
(2*R*,3*S*,4*R*)-Isopropyl-5-(benzyloxy)-3-hydroxy-2-((*tert*-butyldimethylsilyl)oxy)-4-(2,2,6,6-tetramethylpiperidin-1-yloxy)-pentanoate (2a). The compound was synthesized following the general procedure using $TiCl_2(O^iPr)_2$ (190 mg, 800 μmol, 2.0 equiv.), *(R)*-3-(benzyloxy)-2-(2,2,6,6-tetramethylpiperidin-1-yloxy)propanal (90% ee, 128 mg, 400 μmol, 1.0 equiv.), (*Z*)-5-isopropoxy-2,2,3,3,8,8,9,9-octamethyl-4,7-dioxa-3,8-disiladec-5-ene (277 mg, 800 μmol, 2.0 equiv.) and CH_2Cl_2 (2 mL). The crude product was purified by flash chromatography using 7:1 hexanes:Et_2O to yield the title compound (183 mg, 83% yield, >20:1 dr, 95% pure) along with minor unidentified impurities as a colorless oil. IR (thin film): 3494, 3003, 2984, 2932, 2856, 1747, 1727, 1464, 1373, 1360, 1276, 1261, 1133, 1105, 837, 761, 750 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$): δ 7.39–7.25 (m, 5H, Ar**H**), 5.06 (sept, 1H, *J* = 6.3 Hz, C**H**$(CH_3)_2$), 4.60 (d, 1H, *J* = 11.9 Hz, C$\mathbf{H_a}$Ph), 4.46 (d, 1H, *J* = 11.9 Hz, C$\mathbf{H_b}$Ph), 4.28–4.21 (m, 2H, C**H**OH, C**H**OTBS), 4.06–4.01 (m, 1H, C**H**OTMP), 4.40 (dd, 2H, *J* = 3.4, 1.0 Hz, C$\mathbf{H_2}$OBn), 3.75 (d, 1H, *J* = 6.7 Hz, O**H**), 1.71–1.03 (m, 18H, OTMP)), 1.27 (d, 6H, *J* = 6.2 Hz, CH(C$\mathbf{H_3}$)$\mathbf{_2}$), 0.87 (s, 9H, SiC(C$\mathbf{H_3}$)$\mathbf{_3}$), 0.04, 0.03 (2s, 6H, Si(C$\mathbf{H_3}$)$\mathbf{_2}$; ^{13}C NMR (125 MHz, $CDCl_3$): δ 171.6 (**C**$O_2{}^i$Pr), 137.8, 128.6, 127.9, 127.9 (Ar**C**), 78.9 (**C**HOTMP), 75.5 (**C**HOTBS), 74.8 (**C**HOH), 73.5 (**C**H_2Ph), 70.0 (**C**H_2OBn), 68.5 (**C**H$(CH_3)_2$), 60.6, 59.9 ($(CH_3)_2$**C**N**C**$(CH_3)_2$), 40.6, 40.5 (**C**H_2**C**H_2**C**H_2), 34.2, 33.5 ($(\mathbf{C}H_3)_\mathbf{a}CNC(\mathbf{C}H_3)_\mathbf{a}$), 25.8 (SiC(C$\mathbf{H_3}$)$\mathbf{_3}$), 22.0 (CH(C$\mathbf{H_3}$)$\mathbf{_2}$), 20.7, 20.6 ($(\mathbf{C}H_3)_\mathbf{b}CNC(\mathbf{C}H_3)_\mathbf{b}$), 17.3 ($CH_2\mathbf{C}H_2CH_2$), –4.8, –5.3 (Si(C$\mathbf{H_3}$)$\mathbf{_2}$); HRMS (ESI-TOF) calculated for $C_{30}H_{53}NO_6Si$ $[M+H]^+$ m/z 552.3715, found 552.3717; $\alpha_D{}^{21}$ = –0.73 (c = 1.00, $CHCl_3$). The ribo-configuration of the title compound was determined from the corresponding deprotected lactone. This compound was prepared by dissolving the title compound (45.9 mg, 83.2 μmol, 1.0 equiv.) in toluene

(415 μL), followed by the addition of H_2O:TFA (4:1, 415 μL) and Zn (46 mg). The biphasic mixture was stirred vigorously at room temperature for 3 days. The mixture was neutralized with aq. sat. $NaHCO_3$ (2 mL) and poured over H_2O. The aqueous layer was extracted with Et_2O (3 × 5 mL) and the combined organic layers were dried over $MgSO_4$, filtered, and concentrated under vacuum to yield 5-benzyloxy-2-hydroxy-3-hydroxy-D-ribonolactone. The benzyloxy-group was cleaved by dissolving 5-benzyloxy-2-hydroxy-3-hydroxy-D-ribonolactone (8.30 mg, 34.8 μmol, 1.0 equiv.) in 1:1 EtOAc:EtOH (1.2 mL) and treating it with Pd/C (10%, 5 mg). Hydrogen gas was bubbled through the reaction mixture for 5 minutes and the suspension was stirred for 20 hours at room temperature under H_2 atmosphere. The reaction mixture was filtered through Celite and the filtrate was evaporated to yield the fully deprotected lactone corresponding to the title compound (D-ribonolactone) as a white powder. The ^{1}H- and ^{13}C-NMR data of this lactone matched an authentic sample of D-ribonolactone. ^{1}H NMR (500 MHz, D_2O): δ 4.67 (d, 1H, J = 5.5 Hz, C**H**(2)), 4.50 (t, 1H, J = 3.5, 3.4 Hz, C**H**(4)), 4.36 (d, 1H, J = 5.6 Hz, C**H**(3)), 3.80 (dd, 1H, J = 13.0, 2.6 Hz, C**H**$(5)_a$), 3.73 (dd, 1H, J = 12.8, 3.7 Hz, C**H**$(5)_b$); ^{13}C NMR (125 MHz, D_2O): δ 178.5 (**C**(1)), 86.7 (**C**(4)), 69.4, 68.9 (**C**(2), **C**(3)), 60.4 (**C**(5)).

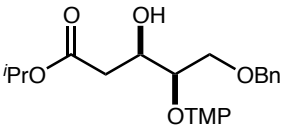


(2*R*,3*S*,4*R*)-Isopropyl-5-(benzyloxy)-3-hydroxy-2-((*tert*-butyldiphenylsilyl)oxy)-4-(2,2,6,6-tetramethylpiperidin-1-yloxy)-pentanoate (3a). The compound was synthesized following the general procedure using $TiCl_2(O^iPr)_2$ (190 mg, 800 μmol, 2.0 equiv.), *(R)*-3-(benzyloxy)-2-(2,2,6,6-tetramethylpiperidin-1-yloxy)propanal (90% ee, 128 mg, 400 μmol, 1.0 equiv.), (*Z*)-5-isopropoxy-2,2,3,3,9,9-hexamethyl-8,8-diphenyl-4,7-dioxa-3,8-disiladec-5-ene (377 mg, 800 μmol, 2.0 equiv.) and CH_2Cl_2 (2 mL). The crude product was purified by flash chromatography using 7:1 hexanes:Et_2O to yield the title compound (222 mg, 82% yield, >20:1 dr, 95% pure) along with minor impurities as a colorless oil. Due to the similar structural features and the consistent NMR-data of the title compound to (2*R*,3*S*,4*R*)-isopropyl-5-(benzyloxy)-3-hydroxy-2-((*tert*-butyldimethylsilyl)oxy)-4-(2,2,6,6-tetramethylpiperidin-1-yloxy)-pentanoate (see above) the configuration of the title compound was assigned as ribo. IR (thin film): 2972, 2932, 2856, 1746, 1469, 1454, 1428, 1362, 1373, 1276, 1261, 1191, 1130, 1105, 958, 822, 764, 750, 701 cm^{-1}; ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.61–7.13 (m, 15H, Ar**H**), 4.72 (sept, 1H, J = 6.3 Hz, C**H**$(CH_3)_2$), 4.33 (d, 1H, J = 11.8 Hz, C**H**$_a$Ph), 4.26–4.19 (m, 2H, C**H**OTBDPS, C**H**OH), 4.42 (d, 1H, J = 11.7 Hz, C**H**$_b$Ph), 3.99–3.94 (m, 1H, C**H**OTMP), 3.82 (dd, 1H, J = 10.4, 3.6 Hz, C**H**$_a$OBn), 3.73 (d, 1H, J = 6.4 Hz, O**H**), 3.72 (dd, 1H, J = 10.3, 3.7 Hz, C**H**$_b$OBn), 1.48–0.89 (m, 21H, O**TMP** and CH(C**H**$_3$)$_a$), 0.99 (s, 9H, SiC(C**H**$_3$)$_3$), 0.84 (d, 3H, J = 6.2 Hz, CH(C**H**$_3$)$_b$); ^{13}C NMR (125 MHz, $CDCl_3$): δ 170.9 (**C**$O_2{}^i$Pr), 137.84, 136.32, 136.25, 133.17, 133.05, 129.90, 129.82, 128.47, 127.76, 127.73, 127.68, 127.52. (Ar**C**), 79.0 (**C**HOTMP), 75.6, 75.3 (**C**HOTBDPS, **C**HOH), 73.4 (**C**H_2Ph), 70.3 (**C**H_2OBn), 68.4 (**C**H$(CH_3)_2$), 60.5, 59.9 ($(CH_3)_2$**C**N**C**$(CH_3)_2$), 40.6, 40.5 (**C**H_2**C**H_2**C**H_2), 34.3, 33.4 ($(\mathbf{C}H_3)_a$CNC$(\mathbf{C}H_3)_a$), 27.1 (SiC(C**H**$_3$)$_3$), 21.8, 21.7 (CH(C**H**$_3$)$_2$), 20.7, 20.6 ($(\mathbf{C}H_3)_b$CNC$(\mathbf{C}H_3)_b$), 17.3 (CH_2**C**H_2**C**H_2); HRMS (ESI-TOF) calculated for $C_{40}H_{57}NO_6Si$ $[M+H]^+$ m/z 676.4028, found 676.4032; $\alpha_D{}^{21}$ = –1.13 (c = 1.00, $CHCl_3$).



(2*R*,3*S*,4*R*)-Isopropyl 5-(benzyloxy)-3-hydroxy-2-methoxy-4-((2,2,6,6-tetramethylpiperidin-1-yl)oxy)pentanoate (4a). 

The compound was synthesized following the general procedure using $TiCl_2(O^iPr)_2$ (190 mg, 800 μmol, 2.0 equiv.), *(R)*-3-(benzyloxy)-2-(2,2,6,6-tetramethylpiperidin-1-yloxy)propanal (90% ee, 128 mg, 400 μmol, 1.0 equiv.), (*Z*)-*tert*-butyl((1-isopropoxy-2-methoxyvinyl)oxy)dimethylsilane (197 mg, 800 μmol, 2.0 equiv.) and CH_2Cl_2 (2 mL). The crude product was purified by flash chromatography using 4:1 hexanes:Et_2O to yield the title compound (147 mg, 81% yield, >20:1 dr) as a colorless oil. The ribo-configuration of the title compound was determined from the corresponding lactone (see below). IR (thin film): 3489, 2972, 2931, 2871, 1746, 1729, 1467, 1454, 1373, 1362, 1276, 1259, 1242, 1194, 1130, 1105, 1067, 1027, 1017, 974, 958, 926, 888, 764, 750, 698 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$): δ 7.36–7.23 (m, 5H, Ar**H**), 5.15 (sept, 1H, *J* = 6.3 Hz, C**H**$(CH_3)_2$), 4.53 (d, 1H, *J* = 11.8 Hz, C$\mathbf{H_a}$Ph), 4.47 (d, 1H, *J* = 11.8 Hz, C$\mathbf{H_b}$Ph), 4.21–4.11 (m, 2H, C**H**OTMP, C**H**OH), 4.08 (d, 1H, *J* = 2.0 Hz, C**H**$CO_2{}^i$Pr), 3.98 (dd, 1H, *J* = 9.8, 2.7 Hz, C$\mathbf{H_a}$OBn), 3.93 (dd, 1H, *J* = 9.8, 4.6 Hz, C$\mathbf{H_b}$OBn), 3.48 (s, 3H, OC$\mathbf{H_3}$), 3.07 (d, 1H, *J* = 4.8 Hz, O**H**), 1.65–1.01 (m, 18H, OTMP), 1.30 (d, 3H, *J* = 6.1 Hz, OCH(C$\mathbf{H_3}$)$_\mathbf{a}$), 1.29 (d, 3H, *J* = 6.0 Hz, OCH(C$\mathbf{H_3}$)$_\mathbf{b}$); ^{13}C NMR (125 MHz, $CDCl_3$): δ 171.1 (**C**$O_2{}^i$Pr), 138.0, 128.4, 127.8, and 127.7 (Ar**C**), 80.3 (**C**H$CO_2{}^i$Pr), 78.4 (**C**HOTMP), 73.6 (**C**HOH), 73.3 (**C**H_2Ph), 69.5 (**C**H_2OBn), 68.8 (**C**H$(CH_3)_2$), 60.9, 59.7 ($(CH_3)_2$**C**N**C**$(CH_3)_2$), 58.5 (O**C**H_3), 40.7, 40.5 (**C**H_2**C**H_2**C**H_2), 34.0, 33.1 (($\mathbf{CH_3}$)$_\mathbf{a}$CNC($\mathbf{CH_3}$)$_\mathbf{a}$), 22.0, 21.9 (CH($\mathbf{CH_3}$)$_\mathbf{2}$), 20.9, 20.6 (($\mathbf{CH_3}$)$_\mathbf{b}$CNC($\mathbf{CH_3}$)$_\mathbf{b}$), 17.2 (CH_2**C**H_2CH_2); HRMS (ESI-TOF) calculated for $C_{25}H_{41}NO_6$ $[M+H]^+$ m/z 452.3007, found 452.3008; $\alpha_D{}^{20}$ = –56.0 (c = 1.00, $CHCl_3$).

(3*R*,4*R*)-Isopropyl-5-(benzyloxy)-3-hydroxy-4-((2,2,6,6-tetramethylpiperidin-1-yl)oxy)pentanoate (5a). 

The compound was synthesized following the general procedure using $TiCl_2(O^iPr)_2$ (190 mg, 800 μmol, 2.0 equiv.), *(R)*-3-(benzyloxy)-2-(2,2,6,6-tetramethylpiperidin-1-yloxy)propanal (90% ee, 128 mg, 400 μmol, 1.0 equiv.), *tert*-butyl((1-isopropoxyvinyl)oxy)dimethylsilane (173 mg, 800 μmol, 2.0 equiv.) and CH_2Cl_2 (2 mL), but at –40 °C. The title compound was obtained as a 3:1 diastereoisomeric mixture which was separated by flash chromatography using 4:1 hexanes:Et_2O to yield the title compound (108 mg, 64% yield, >20:1 dr) and its corresponding diastereoisomer with *S*-configuration at C(3) (33.5 mg, 20%, >20:1 dr) as colorless oils. The lyxo/xylo-configuration of the title compound was determined from the corresponding lactone (see below). Experimental data for the major diastereoisomer: IR (thin film): 3494, 2972, 2931, 2871, 1732, 1467, 1454, 1376, 1363, 1257, 1209, 1178, 1130, 1109, 956, 736, 698 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$): δ 7.37–7.25 (m, 5H, Ar**H**), 5.55 (br. s, 1H, O**H**), 5.03 (sept, 1H, *J* = 6.3 Hz, C**H**$(CH_3)_2$), 4.58–4.46 (m, 1H, C**H**OH), 4.55 (d, 1H, *J* = 12.1 Hz, C$\mathbf{H_a}$Ph), 4.49 (d, 1H, *J* = 12.0 Hz, C$\mathbf{H_b}$Ph), 4.07 (dt, 1H, *J* = 6.8, 4.4 Hz, C**H**OTMP), 3.67 (dd, 1H, *J* = 10.6, 3.7 Hz, C$\mathbf{H_a}$OBn), 3.65 (dd, 1H, *J* = 10.5, 3.9 Hz, C$\mathbf{H_b}$OBn), 2.56 (dd, 1H, *J* = 15.0, 3.9 Hz, C$\mathbf{H_a}CO_2{}^i$Pr), 3.45 (dd, 1H, *J* = 15.0, 8.4 Hz, C$\mathbf{H_b}CO_2{}^i$Pr), 1.66–1.06 (m, 18H, OTMP), 1.24 (d, 3H, *J* = 3.8 Hz, CH(C$\mathbf{H_3}$)$_\mathbf{a}$), 1.23 (d, 3H, *J* = 3.6 Hz, CH(C$\mathbf{H_3}$)$_\mathbf{b}$); ^{13}C NMR (125 MHz, $CDCl_3$): δ 171.4 (**C**$O_2{}^i$Pr), 138.2, 128.4, 127.7, and 127.6 (Ar**C**), 82.3 (**C**HOTMP), 73.4 (**C**H_2Ph), 70.1 (**C**HOH), 69.1 (**C**H_2OBn), 67.9 (**C**H$(CH_3)_2$), 61.0, 60.7 ($(CH_3)_2$**C**N**C**$(CH_3)_2$), 40.3, 40.2 (**C**H_2**C**H_2**C**H_2), 39.3 (**C**$H_2CO_2{}^i$Pr), 33.9, 33.0 (($\mathbf{CH_3}$)$_\mathbf{a}$CNC($\mathbf{CH_3}$)$_\mathbf{a}$), 22.0, 21.9 (CH($\mathbf{CH_3}$)$_\mathbf{2}$), 20.7, 20.6 (($\mathbf{CH_3}$)$_\mathbf{b}$CNC($\mathbf{CH_3}$)$_\mathbf{b}$), 17.2 (CH_2**C**H_2CH_2); HRMS (ESI-TOF) calculated for $C_{24}H_{39}NO_5$ $[M+H]^+$ m/z 422.2901, found

422.2902; α_D^{21} = +10.2 (c = 1.00, $CHCl_3$).

(3*S*,4*R*)-Isopropyl-5-(benzyloxy)-3-hydroxy-4-((2,2,6,6-tetramethylpiperidin-1-yl)oxy)pentanoate (6a). The compound was synthesized following the general procedure using *(R)*-3-(benzyloxy)-2-(2,2,6,6-tetramethylpiperidin-1-yloxy)propanal (90% ee, 128 mg, 400 μmol, 1.0 equiv.), *tert*-butyl((1-isopropoxyvinyl)oxy)dimethylsilane (173 mg, 800 μmol, 2.0 equiv.) and CH_2Cl_2 (2 mL), but employing $BF_3{\cdot}Et_2O$ (100 μL, 800 μmol, 2.0 equiv.) as the Lewis acid and running the reaction at –40 °C. The title compound was obtained as a 3:1 diastereomeric mixture which was separated by flash chromatography using 4:1 hexanes:Et_2O to yield the title compound (111 mg, 66% yield, >20:1 dr) and its corresponding diastereoisomer with *R*-configuration at C(3) (35.2 mg, 21%, >20:1 dr) as colorless oils. The ribo/arabino-configuration of the title compound was determined from the corresponding lactone (see below). Experimental data for the major diastereoisomer: IR (thin film): 3509, 2972, 2935, 2876, 1732, 1467, 1454, 1373, 1363, 1257, 1178, 1130, 1108, 956, 736, 698 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$): δ 7.38–7.23 (m, 5H, Ar**H**), 5.05 (sept, 1H, *J* = 6.3 Hz, C**H**$(CH_3)_2$), 4.53 (d, 1H, *J* = 11.8 Hz, C$\mathbf{H_a}$Ph), 4.48 (d, 1H, *J* = 11.8 Hz, C$\mathbf{H_b}$Ph), 4.42–4.36 (m, 1H, C**H**OH), 4.01–3.96 (m, 1H, C**H**OTMP), 3.89 (dd, 1H, *J* = 9.9, 3.4 Hz, C$\mathbf{H_a}$OBn), 3.80 (dd, 1H, *J* = 9.9, 5.8 Hz, C$\mathbf{H_b}$OBn), 3.27 (d, 1H, *J* = 4.1 Hz, O**H**), 2.68 (dd, 1H, *J* = 15.9, 3.8 Hz, C$\mathbf{H_a}$$CO_2{}^i$Pr), 3.80 (dd, 1H, *J* = 15.9, 9.2 Hz, C$\mathbf{H_b}$$CO_2{}^i$Pr), 1.64–1.01 (m, 18H, OTMP), 1.25 (d, 3H, *J* = 3.4 Hz, CH(C$\mathbf{H_3}$)$_\mathbf{a}$), 1.26 (d, 3H, *J* = 3.4 Hz, CH(C$\mathbf{H_3}$)$_\mathbf{b}$); ^{13}C NMR (125 MHz, $CDCl_3$): δ 172.2 (**C**$O_2{}^i$Pr), 138.0, 128.5, 127.8 (2C) (Ar**C**), 82.0 (**C**HOTMP), 73.4 (**C**H_2Ph), 69.4 (**C**HOH), 69.1 (**C**H_2OBn), 68.1 (**C**H$(CH_3)_2$), 60.9, 59.9 ($(CH_3)_2$**C**N**C**$(CH_3)_2$), 40.6, 40.5 ($\mathbf{C}H_2\mathbf{C}H_2\mathbf{C}H_2$), 38.7 (**C**$H_2CO_2{}^i$Pr), 34.4, 33.4 ($(\mathbf{C}H_3)_\mathbf{a}CNC(\mathbf{C}H_3)_\mathbf{a}$), 22.0, 21.9 (CH$(\mathbf{C}H_3)_\mathbf{2}$), 20.7, 20.6 ($(\mathbf{C}H_3)_\mathbf{b}CNC(\mathbf{C}H_3)_\mathbf{b}$), 17.2 ($CH_2\mathbf{C}H_2CH_2$); HRMS (ESI-TOF) calculated for $C_{24}H_{39}NO_5$ $[M+H]^+$ m/z 422.2901, found 422.2906; α_D^{21} = –36.9 (c = 1.00, $CHCl_3$).

(2*S*,3*S*,4*R*)-Isopropyl-5-(benzyloxy)-3-hydroxy-2-methyl-4-(2,2,6,6-tetramethylpiperidin-1-yloxy)-pentanoate (7a). The compound was synthesized following the general procedure using $TiCl_2(O^iPr)_2$ (190 mg, 800 μmol, 2.0 equiv.), *(R)*-3-(benzyloxy)-2-(2,2,6,6-tetramethylpiperidin-1-yloxy)propanal (90% ee, 128 mg, 400 μmol, 1.0 equiv.), (*E*)-*tert*-butyl((1-isopropoxyprop-1-en-1-yl)oxy)dimethylsilane (184 mg, 800 μmol, 2.0 equiv.) and CH_2Cl_2 (2 mL). The crude product was purified by flash chromatography using 5:1 hexanes:Et_2O to yield the title compound (167 mg, 96% yield, 11:1 dr) as a colorless oil. The arabino-configuration of the title compound was determined from the corresponding lactone (see below). IR (thin film): 3499, 2972, 2934, 2871, 1725, 1455, 1375, 1360, 1259, 1181, 1130, 1107, 1039, 984, 956, 923, 822, 749, 698 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$), (2*S*)-isomer (major): δ 7.38–7.24 (m, 5H, Ar**H**), 4.97 (sept, 1H, *J* = 6.3 Hz, C**H**$(CH_3)_2$), 4.55 (d, 1H, *J* = 11.7 Hz, C$\mathbf{H_a}$Ph), 4.47 (d, 1H, *J* = 11.7 Hz, C$\mathbf{H_b}$Ph), 4.20–4.14 (m, 1H, C**H**OH), 4.00 (dd, 1H, *J* = 10.0, 2.9 Hz, C$\mathbf{H_a}$OBn), 3.93 (dd, 1H, *J* = 10.0, 5.1 Hz, C$\mathbf{H_b}$OBn), 3.90–3.86 (m, 1H, C**H**OTMP), 3.32 (d, 1H, *J* = 5.3 Hz, O**H**), 2.66 (quint, 1H, *J* = 6.9 Hz, C**H**$CO_2{}^i$Pr), 1.66–0.99 (m, 18H, OTMP), 1.28 (d, 3H, *J* = 7.0, C$\mathbf{H_3}$$CHCO_2{}^i$Pr), 1.21 (d, 3H, *J* = 6.2 Hz, CH(C$\mathbf{H_3}$)$_\mathbf{a}$), 1.19 (d, 3H, *J* = 6.3 Hz, CH(C$\mathbf{H_3}$)$_\mathbf{b}$); (2*R*)-isomer (minor): δ 7.38–7.24 (m, 5H, Ar**H**), 5.04 (sept, 1H, *J* = 6.2 Hz, C**H**$(CH_3)_2$), 4.53 (d, 1H, *J* = 11.9 Hz, C$\mathbf{H_a}$Ph), 4.47 (d, 1H, *J* = 11.9 Hz, C$\mathbf{H_b}$Ph), 4.09–4.05 (m, 1H, C**H**OH), 4.05–3.85 (m, 3H,

C**H**$_2$OBn, C**H**OTMP), 3.55 (d, 1H, J = 6.7 Hz, O**H**), 2.78 (quint, 1H, J = 7.1 Hz, C**H**CO$_2$^{i}Pr), 1.66–0.99 (m, 18H, OTMP), 1.28 (d, 3H, J = 7.0, C**H**$_3$CHCO$_2$^{i}Pr), 1.24 (d, 3H, J = 6.5 Hz, CH(C**H**$_3$)$_a$), 1.23 (d, 3H, J = 6.3 Hz, CH(C**H**$_3$)$_b$); ^{13}C NMR (125 MHz, $CDCl_3$), (2*S*)-isomer (major): δ 174.9 (**C**O$_2$^{i}Pr), 137.7, 128.5, 127.8, (Ar**C**), 79.9 (**C**HOTMP), 74.2 (**C**HOH), 73.6 (**C**H$_2$Ph), 69.8 (**C**H$_2$OBn), 67.7 (**C**H(CH$_3$)$_2$), 60.7, 59.7 ((CH$_3$)$_2$**C**N**C**(CH$_3$)$_2$), 42.9 (**C**HCO$_2$^{i}Pr), 40.5, 40.3 (**C**H$_2$CH$_2$**C**H$_2$), 34.3, 33.3 ((**C**H$_3$)$_a$CNC(**C**H$_3$)$_a$), 21.8 (CH(**C**H$_3$)$_2$), 20.6 ((**C**H$_3$)$_b$CNC(**C**H$_3$)$_b$), 17.2 (CH$_2$**C**H$_2$CH$_2$), 12.8 (**C**H$_3$CHCO$_2$^{i}Pr); (2*R*)-isomer (minor): δ 175.5 (**C**O$_2$^{i}Pr), 138.1, 128.4, 127.8 (2C) (Ar**C**), 81.0 (**C**HOTMP), 74.9 (**C**HOH), 73.3 (**C**H$_2$Ph), 68.8 (**C**H$_2$OBn), 67.8 (**C**H(CH$_3$)$_2$), 60.7, 59.7 ((CH$_3$)$_2$**C**N**C**(CH$_3$)$_2$), 41.7 (**C**HCO$_2$^{i}Pr), 40.5, 40.3 (**C**H$_2$CH$_2$**C**H$_2$), 34.3, 33.3 ((**C**H$_3$)$_a$CNC(**C**H$_3$)$_a$), 21.8 (CH(**C**H$_3$)$_2$), 20.6 ((**C**H$_3$)$_b$CNC(**C**H$_3$)$_b$), 17.2 (CH$_2$**C**H$_2$CH$_2$), 15.0 (**C**H$_3$CHCO$_2$^{i}Pr); HRMS (ESI-TOF) calculated for $C_{25}H_{41}NO_5$ $[M+H]^+$ m/z 436.3058, found 436.3064; α_D^{21} = –19.3 (c = 1.00, $CHCl_3$).

(2*S*,3*S*,4*R*)-Isopropyl-5-(benzyloxy)-3-hydroxy-2-ethyl-4-(2,2,6,6-tetramethylpiperidin-1-yloxy)-pentanoate (8a). The compound was synthesized following the general procedure using $TiCl_2(O^iPr)_2$ (190 mg, 800 μmol, 2.0 equiv.), *(R)*-3-(benzyloxy)-2-(2,2,6,6-tetramethylpiperidin-1-yloxy)propanal (90% ee, 128 mg, 400 μmol, 1.0 equiv.), (*E*)-*tert*-butyl((1-isopropoxybut-1-en-1-yl)oxy)dimethylsilane (196 mg, 800 μmol, 2.0 equiv.) and CH_2Cl_2 (2 mL). The crude product was purified by flash chromatography using 5:1 hexanes:Et_2O to yield the title compound (176 mg, 98% yield, 13:1 dr) as a colorless oil. Due to the similar structural features and the consistent NMR-data of the title compound to (2*S*,3*S*,4*R*)-isopropyl-5-(benzyloxy)-3-hydroxy-2-methyl-4-(2,2,6,6-tetramethylpiperidin-1-yloxy)-pentanoate (see above) the configuration of the title compound was assigned as arabino. IR (thin film): 3499, 2967, 2934, 2871, 1724, 1455, 1375, 1360, 1260, 1237, 1180, 1130, 1107, 1027, 956, 822, 747, 698 cm^{-1}; ^{1}H NMR (500 MHz, $CDCl_3$), (2*S*)-isomer (major): δ 7.38–7.25 (m, 5H, Ar**H**), 4.96 (sept, 1H, J = 6.3 Hz, C**H**(CH$_3$)$_2$), 4.55 (d, 1H, J = 11.8 Hz, C**H**$_a$Ph), 4.46 (d, 1H, J = 11.8 Hz, C**H**$_b$Ph), 4.16–4.06 (m, 1H, C**H**OH), 3.40 (dd, 1H, J = 10.5, 3.6 Hz, C**H**$_a$OBn), 3.91 (dd, 1H, J = 10.5, 2.8 Hz, C**H**$_b$OBn), 3.81–3.75 (m, 1H, C**H**OTMP), 3.39 (d, 1H, J = 7.4 Hz, O**H**), 2.41–2.32 (m, 1H, C**H**CO$_2$^{i}Pr), 2.01–1.91 (m, 1H, CH$_3$C**H**$_a$CHCO$_2$^{i}Pr), 1.76–1.63 (m, 1H, CH$_3$C**H**$_b$CHCO$_2$^{i}Pr), 1.63–1.02 (m, 18H, OTMP), 1.21 (d, 3H, J = 6.3, CH(C**H**$_3$)$_a$), 1.17 (d, 3H, J = 6.3 Hz, CH(C**H**$_3$)$_b$), 0.91 (t, 3H, J = 7.5 Hz, C**H**$_3$CH$_2$CHCO$_2$^{i}Pr); (2*R*)-isomer (minor): δ 7.38–7.25 (m, 5H, Ar**H**), 5.06 (sept, 1H, J = 6.3 Hz, C**H**(CH$_3$)$_2$), 4.53 (d, 1H, J = 11.7 Hz, C**H**$_a$Ph), 4.47 (d, 1H, J = 11.7 Hz, C**H**$_b$Ph), 4.09–4.03 (m, 1H, C**H**OH), 3.87 (dd, 1H, J = 9.9, 3.3 Hz, C**H**$_a$OBn), 3.83 (dd, 1H, J = 10.0, 5.5 Hz, C**H**$_b$OBn), 3.81–3.75 (m, 1H, C**H**OTMP), 3.54 (d, 1H, J = 7.2 Hz, O**H**), 2.62–2.55 (m, 1H, C**H**CO$_2$^{i}Pr), 2.01–1.91 (m, 1H, CH$_3$C**H**$_a$CHCO$_2$^{i}Pr), 1.76–1.63 (m, 1H, CH$_3$C**H**$_b$CHCO$_2$^{i}Pr), 1.63–1.02 (m, 18H, OTMP), 1.25 (d, 3H, J = 6.3, CH(C**H**$_3$)$_a$), 1.25 (d, 3H, J = 6.2 Hz, CH(C**H**$_3$)$_b$), 0.91 (t, 3H, J = 7.5 Hz, C**H**$_3$CH$_2$CHCO$_2$^{i}Pr); ^{13}C NMR (125 MHz, $CDCl_3$), (2*S*)-isomer (major): δ 173.9 (**C**O$_2$^{i}Pr), 137.6, 128.5, 127.9, 127.9 (Ar**C**), 80.7 (**C**HOTMP), 73.9 (**C**HOH), 73.5 (**C**H$_2$Ph), 69.4 (**C**H$_2$OBn), 67.6 (**C**H(CH$_3$)$_2$), 60.6, 59.9 ((CH$_3$)$_2$**C**N**C**(CH$_3$)$_2$), 51.6 (**C**HCO$_2$^{i}Pr), 40.5 (**C**H$_2$CH$_2$**C**H$_2$), 34.3, 33.3 ((**C**H$_3$)$_a$CNC(**C**H$_3$)$_a$), 22.2 (CH$_3$**C**H$_2$CHCO$_2$^{i}Pr), 21.9, 21.8 (CH(**C**H$_3$)$_2$), 20.6 ((**C**H$_3$)$_b$CNC(**C**H$_3$)$_b$), 17.2 (CH$_2$**C**H$_2$CH$_2$), 11.7 (**C**H$_3$CH$_2$CHCO$_2$^{i}Pr); (2*R*)-isomer (minor): δ 175.0 (**C**O$_2$^{i}Pr), 137.2, 128.4, 127.7, 127.6 (Ar**C**), 81.4 (**C**HOTMP), 73.3 (**C**H$_2$Ph), 73.2 (**C**HOH), 68.8 (**C**H$_2$OBn), 67.8 (**C**H(CH$_3$)$_2$), 60.6, 59.9 ((CH$_3$)$_2$**C**N**C**(CH$_3$)$_2$), 48.8 (**C**HCO$_2$^{i}Pr), 40.5 (**C**H$_2$CH$_2$**C**H$_2$),

34.3, 33.3 (($\mathbf{C}H_3)_\mathbf{a}CNC(\mathbf{C}H_3)_\mathbf{a}$), 23.2 ($CH_3\mathbf{C}H_2CHCO_2{}^i$Pr), 21.9, 21.8 ($CH(\mathbf{C}H_3)_\mathbf{2}$), 20.6 (($\mathbf{C}H_3)_\mathbf{b}CNC(\mathbf{C}H_3)_\mathbf{b}$), 17.2 ($CH_2\mathbf{C}H_2CH_2$), 11.9 ($\mathbf{C}H_3CH_2CHCO_2{}^i$Pr); HRMS (ESI-TOF) calculated for $C_{26}H_{43}NO_5$ $[M+H]^+$ m/z 450.3214, found 450.3222; $\alpha_D{}^{21} = -5.54$ (c = 1.00, $CHCl_3$).

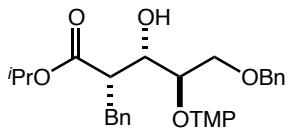
(2*S*,3*S*,4*R*)-*Iso*-propyl-5-(benzyloxy)-3-hydroxy-2-isopropyl-4-(2,2,6,6-tetramethylpiperidin-1-yloxy)-pentanoate (9a). The compound was synthesized following the general procedure using $TiCl_2(O^iPr)_2$ (190 mg, 800 μmol, 2.0 equiv.), *(R)*-3-(benzyloxy)-2-(2,2,6,6-tetramethylpiperidin-1-yloxy)propanal (90% ee, 128 mg, 400 μmol, 1.0 equiv.), (*E*)-((1-isopropoxy-3-methylbut-1-en-1-yl)oxy)trimethylsilane (173 mg, 800 μmol, 2.0 equiv.) and CH_2Cl_2 (2 mL). The crude product was purified by flash chromatography using 9:1 hexanes:Et_2O to yield the title compound (175 mg, 94% yield, >20:1 dr) as a colorless oil. Due to the similar structural features and the consistent NMR-data of the title compound to (2*S*,3*S*,4*R*)-isopropyl-5-(benzyloxy)-3-hydroxy-2-methyl-4-(2,2,6,6-tetramethylpiperidin-1-yloxy)-pentanoate (see above) the configuration of the title compound was assigned as arabino. IR (thin film): 3504, 2967, 2933, 2871, 1721, 1464, 1455, 1375, 1360, 1274, 1258, 1242, 1206, 1179, 1130, 1108, 1087, 971, 936, 819, 748, 698 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$): δ 7.39–7.24 (m, 5H, Ar**H**), 4.93 (sept, 1H, *J* = 6.3 Hz, O**C**$\mathbf{H}(CH_3)_2$), 4.57 (d, 1H, *J* = 11.8 Hz, C$\mathbf{H}_\mathbf{a}$Ph), 4.44 (d, 1H, *J* = 11.8 Hz, C$\mathbf{H}_\mathbf{b}$Ph), 4.32–4.25 (m, 1H, C**H**OH), 3.99 (dd, 1H, *J* = 10.6, 3.4 Hz, C$\mathbf{H}_\mathbf{a}$OBn), 3.82 (dd, 1H, *J* = 10.6, 2.7 Hz, C$\mathbf{H}_\mathbf{b}$OBn), 3.80–3.76 (m, 1H, C**H**OTMP), 3.28 (d, 1H, *J* = 7.4 Hz, O**H**), 2.43–2.32 (m, 2H, $(CH_3)_2$C**H**C**H**$CO_2{}^i$Pr), 1.66–1.07 (m, 18H, OTMP), 1.20 (d, 3H, *J* = 6.3 Hz, OCH(C$\mathbf{H}_\mathbf{3})_\mathbf{a}$), 1.14 (d, 3H, *J* = 6.2 Hz, OCH(C$\mathbf{H}_\mathbf{3})_\mathbf{b}$), 0.10 (d, 3H, *J* = 7.2 Hz, (C$\mathbf{H}_\mathbf{3})_\mathbf{a}$CHCHCO$_2{}^i$Pr), 0.98 (d, 3H, *J* = 7.0 Hz, (C$\mathbf{H}_\mathbf{3})_\mathbf{b}$CHCHCO$_2{}^i$Pr); ^{13}C NMR (125 MHz, $CDCl_3$): δ 172.2 (**C**O$_2{}^i$Pr), 137.7, 128.5, 127.9, 127.9 (Ar**C**), 81.1 (**C**HOTMP), 73.5 (**C**H$_2$Ph), 71.8 (**C**HOH), 69.2 (**C**H$_2$OBn), 67.4 (O**C**H$(CH_3)_2$), 60.5, 60.0 (($CH_3)_2$**C**N**C**$(CH_3)_2$), 54.6 (**C**HCO$_2{}^i$Pr), 40.5 ($\mathbf{C}H_2CH_2\mathbf{C}H_2$), 34.3, 33.3 (($\mathbf{C}H_3)_\mathbf{a}CNC(\mathbf{C}H_3)_\mathbf{a}$), 26.9 ($(CH_3)_2\mathbf{C}HCHCO_2{}^i$Pr), 22.1, 22.0 ($OCH(\mathbf{C}H_3)_\mathbf{2}$), 21.7 (($\mathbf{C}H_3)_\mathbf{a}$CHCHCO$_2{}^i$Pr), 20.6 (($\mathbf{C}H_3)_\mathbf{b}CNC(\mathbf{C}H_3)_\mathbf{b}$), 17.4 (($\mathbf{C}H_3)_\mathbf{b}$CHCHCO$_2{}^i$Pr), 17.2 ($CH_2\mathbf{C}H_2CH_2$); HRMS (ESI-TOF) calculated for $C_{27}H_{45}NO_5$ $[M+H]^+$ m/z 464.3371, found 464.3368; $\alpha_D{}^{20} = +2.66$ (c = 1.00, $CHCl_3$).

(2*S*,3*S*,4*R*)-Isopropyl-5-(benzyloxy)-3-hydroxy-2-*tert*-butyl-4-(2,2,6,6-tetramethylpiperidin-1-yloxy)-pentanoate (10a). The compound was synthesized following the general procedure using $TiCl_2(O^iPr)_2$ (190 mg, 800 μmol, 2.0 equiv.), *(R)*-3-(benzyloxy)-2-(2,2,6,6-tetramethylpiperidin-1-yloxy)propanal (90% ee, 128 mg, 400 μmol, 1.0 equiv.), (*E*)-((1-isopropoxy-3,3-dimethylbut-1-en-1-yl)oxy)trimethylsilane (184 mg, 800 μmol, 2.0 equiv.) and CH_2Cl_2 (2 mL). The crude product was purified by flash chromatography using 9:1 hexanes:Et_2O to yield the title compound (184 mg, 96% yield, >20:1 dr) as a colorless oil. Due to the similar structural features and the consistent NMR-data of the title compound to (2*S*,3*S*,4*R*)-isopropyl-5-(benzyloxy)-3-hydroxy-2-methyl-4-(2,2,6,6-tetramethylpiperidin-1-yloxy)-pentanoate (see above) the configuration of the title compound was assigned as arabino. IR (thin film): 3504, 2972, 2934, 2871, 1720, 1467, 1455, 1373, 1363, 1317, 1259, 1211, 1181, 1158, 1130, 1095, 1032, 976, 954, 928, 821, 747, 698 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$): δ 7.39–7.27 (m, 5H, Ar**H**), 4.88 (sept, 1H, *J* = 6.3 Hz, C**H**$(CH_3)_2$), 4.57 (d, 1H, *J* = 11.7 Hz, C$\mathbf{H}_\mathbf{a}$Ph),

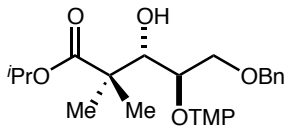
4.45 (d, 1H, *J* = 11.7 Hz, C**H**$_b$Ph), 4.45–4.38 (m, 1H, C**H**OH), 4.07 (br. dd, 1H, *J* = 10.9 Hz, C**H**$_a$OBn), 3.87 (dd, 1H, *J* = 11.0, 2.9 Hz, C**H**$_b$OBn), 3.62–3.57 (m, 1H, C**H**OTMP), 3.41 (d, 1H, *J* = 8.7 Hz, O**H**), 2.26 (d, 1H, *J* = 11.0 Hz, C**H**CO$_2$^{i}Pr), 1.66–1.11 (m, 18H, O**TMP**), 1.19 (d, 3H, *J* = 6.3, CH(C**H**$_3$)$_a$), 1.15 (d, 3H, *J* = 6.3 Hz, CH(C**H**$_3$)$_b$), 1.09 (s, 9H, C(C**H**$_3$)$_3$); ^{13}C NMR (125 MHz, $CDCl_3$): δ 173.1 (**C**O$_2$^{i}Pr), 137.6, 128.5, 128.1, 128.0 (Ar**C**), 81.3 (**C**HOTMP), 73.7 (**C**H$_2$Ph), 73.3 (**C**HOH), 69.6 (**C**H$_2$OBn), 67.5 (**C**H(CH$_3$)$_2$), 60.4, 60.2 ((CH$_3$)$_2$**C**N**C**(CH$_3$)$_2$), 58.4 (**C**HCO$_2$^{i}Pr), 40.6 (**C**H$_2$CH$_2$**C**H$_2$), 34.2, ((**C**H$_3$)$_a$CNC(CH$_3$)$_2$), 33.3 ((CH$_3$)$_2$CNC(**C**H$_3$)$_b$), 33.7 (**C**(CH$_3$)$_3$), 29.0 (C(**C**H$_3$)$_3$), 22.0 (CH(**C**H$_3$)$_a$), 21.9 (CH(**C**H$_3$)$_b$), 20.6 ((**C**H$_3$)$_b$CNC(**C**H$_3$)$_b$), 17.2 (CH$_2$**C**H$_2$CH$_2$); HRMS (ESI-TOF) calculated for $C_{28}H_{47}NO_5$ $[M+H]^+$ m/z 478.3527, found 478.3527; α_D^{20} = +8.54 (c = 1.00, $CHCl_3$).

(2*S*,3*S*,4*R*)-Isopropyl-2-allyl-5-(benzyloxy)-3-hydroxy-4-(2,2,6,6-tetramethylpiperidin-1-yloxy)-pentanoate (11a). The compound was synthesized following the general procedure using $TiCl_2(O^iPr)_2$ (190 mg, 800 μmol, 2.0 equiv.), *(R)*-3-(benzyloxy)-2-(2,2,6,6-tetramethylpiperidin-1-yloxy)propanal (90% ee, 128 mg, 400 μmol, 1.0 equiv.), (*Z*)-*tert*-butyl((1-isopropoxypenta-1,4-dien-1-yl)oxy)dimethylsilane (205 mg, 800 μmol, 2.0 equiv.) and CH_2Cl_2 (2 mL). The crude product was purified by flash chromatography using 9:1 hexanes:Et_2O to yield the title compound (186 mg, 89% yield, 13:1 dr) as a colorless oil. Due to the similar structural features and the consistent NMR-data of the title compound to (2*S*,3*S*,4*R*)-isopropyl-5-(benzyloxy)-3-hydroxy-2-methyl-4-(2,2,6,6-tetramethylpiperidin-1-yloxy)-pentanoate (see above) the configuration of the title compound was assigned as arabino. IR (thin film): 3494, 3078, 3063, 2972, 2933, 2871, 1726, 1641, 1467, 1454, 1373, 1360, 1257, 1237, 1206, 1178, 1130, 1108, 991, 979, 956, 913, 822, 736, 698 cm^{-1}. ^{1}H NMR (500 MHz, $CDCl_3$), (2*S*)-isomer (major): δ 7.41–7.23 (m, 5H, Ar**H**), 5.85–5.71 (m, 1H, C**H**=CH$_2$), 5.07 (d, 1H, *J* = 17.1 Hz, CH=C**H**$_a$), 5.00 (d, 1H, *J* = 10.2 Hz, CH=C**H**$_b$), 4.94 (sept, 1H, *J* = 6.3 Hz, C**H**(CH$_3$)$_2$), 4.56 (d, 1H, *J* = 11.8 Hz, C**H**$_a$Ph), 4.46 (d, 1H, *J* = 11.8 Hz, C**H**$_b$Ph), 4.19–4.08 (m, 1H, C**H**OH), 4.00 (dd, 1H, *J* = 9.2, 3.8 Hz, C**H**$_a$OBn), 3.94 (dd, 1H, *J* = 10.5, 2.6 Hz, C**H**$_b$OBn), 3.85–3.76 (m, 1H, C**H**OTMP), 3.45 (d, 1H, *J* = 6.6 Hz, O**H**), 2.74–2.35 (m, 3H, C**H**$_2$C**H**CO$_2$^{i}Pr), 1.68–0.95 (m, 18H, OTMP), 1.19 (d, 3H, *J* = 6.3, CH(C**H**$_3$)$_a$), 1.16 (d, 3H, *J* = 6.3 Hz, CH(C**H**$_3$)$_b$). ^{13}C NMR (125 MHz, $CDCl_3$, (2*S*)-isomer (major): δ 173.2 (**C**O$_2$^{i}Pr), 137.6 (Ar**C**), 135.8 (**C**H=CH$_2$), 128.5, 127.9 (2C) (Ar**C**), 116.6 (CH=**C**H$_2$), 80.5 (**C**HOTMP), 73.7 (**C**HOH), 73.6 (**C**H$_2$Ph), 69.5 (**C**H$_2$OBn), 67.9 (**C**H(CH$_3$)$_2$), 60.6, 60.0 ((CH$_3$)$_2$**C**N**C**(CH$_3$)$_2$), 49.7 (**C**HCO$_2$^{i}Pr), 40.5 (C**C**H$_2$CH$_2$**C**H$_2$C), 34.3, 33.3 ((**C**H$_3$)$_a$CNC(**C**H$_3$)$_a$), 33.3 (**C**H$_2$CHCO$_2$^{i}Pr), 22.0, 21.9 (CH(**C**H$_3$)$_2$), 20.6 ((**C**H$_3$)$_b$CNC(**C**H$_3$)$_b$), 17.2 (CH$_2$**C**H$_2$CH$_2$); (2*R*)-isomer (minor): δ 174.4 (**C**O$_2$^{i}Pr), 138.1 (Ar**C**), 135.3 (**C**H=CH$_2$), 128.4, 127.7 (2C) (Ar**C**), 117.1 (CH=**C**H$_2$), 81.3 (**C**HOTMP), 73.3 (**C**H$_2$Ph), 73.0 (**C**HOH), 68.9 (**C**H$_2$OBn), 68.0 (**C**H(CH$_3$)$_2$), 60.6, 60.0 ((CH$_3$)$_2$**C**N**C**(CH$_3$)$_2$), 46.5 (**C**HCO$_2$^{i}Pr), 40.5 (C**C**H$_2$CH$_2$**C**H$_2$C), 34.3, 33.3 ((**C**H$_3$)$_a$CNC(**C**H$_3$)$_a$), 33.3 (**C**H$_2$CHCO$_2$^{i}Pr), 22.0, 21.9 (CH(**C**H$_3$)$_2$), 20.6 ((**C**H$_3$)$_b$CNC(**C**H$_3$)$_b$), 17.2 (CH$_2$**C**H$_2$CH$_2$); HRMS (ESI-TOF) calculated for $C_{27}H_{43}NO_5$ $[M+H]^+$ m/z 462.3214, found 462.3219; α_D^{21} = –1.48 (c = 1.00, $CHCl_3$).

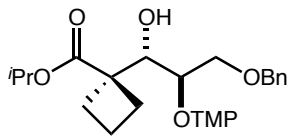
(2*S*,3*S*,4*R*)-Isopropyl-2-benzyl-5-(benzyloxy)-3-hydroxy-4-(2,2,6,6-tetramethylpiperidin-1-yloxy)-pentanoate (12a). The compound was synthesized following the general procedure using $TiCl_2(O^iPr)_2$ (190 mg, 800 μmol, 2.0 equiv.), *(R)*-3-(benzyloxy)-2-(2,2,6,6-tetramethylpiperidin-1-yloxy)propanal (90% ee, 128 mg, 400 μmol, 1.0 equiv.), (*E*)-((1-isopropoxy-3-phenylprop-1-en-1-yl)oxy)trimethylsilane (212 mg, 800 μmol, 2.0 equiv.) and CH_2Cl_2 (2 mL). The crude product was purified by flash chromatography using 9:1 to 4:1 hexanes:Et_2O to yield the title compound (186 mg, 91% yield, 16:1 dr) as a colorless oil. Due to the similar structural features and the consistent NMR-data of the title compound to (2*S*,3*S*,4*R*)-isopropyl-5-(benzyloxy)-3-hydroxy-2-methyl-4-(2,2,6,6-tetramethylpiperidin-1-yloxy)-pentanoate (see above) the configuration of the title compound was assigned as arabino. IR (thin film): 3489, 3003, 2979, 2927, 2871, 1722, 1494, 1464, 1455, 1375, 1360, 1276, 1261, 1206, 1182, 1130, 1106, 1027, 986, 923, 822, 764, 750, 699 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$), (2*S*)-isomer (major): δ 7.47–7.13 (m, 10H, Ar**H**), 4.82 (sept, 1H, *J* = 6.3 Hz, C**H**$(CH_3)_2$), 4.64 (d, 1H, *J* = 11.8 Hz, OC$\mathbf{H_a}$Ph), 4.52 (d, 1H, *J* = 11.8 Hz, OC$\mathbf{H_b}$Ph), 4.30–4.22 (m, 1H, C**H**OH), 4.08 (dd, 1H, *J* = 10.6, 3.4 Hz, C$\mathbf{H_a}$OBn), 4.00 (dd, 1H, *J* = 10.6, 2.7 Hz, C$\mathbf{H_b}$OBn), 3.89–3.81 (m, 1H, C**H**OTMP), 3.68 (d, 1H, *J* = 6.8 Hz, O**H**), 3.39 (dd, 1H, *J* = 13.6, 3.5 Hz, C$\mathbf{H_a}$CHAr), 2.96 (dd, 1H, *J* = 13.5, 11.3 Hz, C$\mathbf{H_b}$CHAr), 2.83 (ddd, 1H, *J* = 11.1, 8.8, 3.7 Hz, C**H**$CO_2{}^i$Pr), 1.71–1.14 (m, 18H, OTMP), 1.08 (d, 3H, *J* = 6.3, CH(C$\mathbf{H_3})_a$), 0.94 (d, 3H, *J* = 6.3 Hz, CH(C$\mathbf{H_3})_b$); ^{13}C NMR (125 MHz, $CDCl_3$), (2*S*)-isomer (major): δ 173.2 (**C**$O_2{}^i$Pr), 139.6, 137.6, 129.2, 128.6, 128.2, 128.0 (2C), 126.2 (Ar**C**), 80.5 (**C**HOTMP), 74.3 (**C**HOH), 73.6 (O**C**H_2Ph), 69.5 (**C**H_2OBn), 67.7 (**C**H$(CH_3)_2$), 60.6, 60.0 ($(CH_3)_2$**C**N**C**$(CH_3)_2$), 51.3 (**C**H$CO_2{}^i$Pr), 40.5 (**C**H_2**C**H_2**C**H_2), 35.3 (**C**H_2CHAr), 34.3 ($(\mathbf{C}H_3)_a$CNC$(CH_3)_2$), 33.4 ($(CH_3)_2$CNC(**C**$H_3)_a$), 21.7, 21.6 (CH(**C**$\mathbf{H_3})_2$), 20.6 (2C, $(\mathbf{C}H_3)_b$CNC$(\mathbf{C}H_3)_b$), 17.2 (CH_2**C**H_2**C**H_2); (2*R*)-isomer (minor): δ 174.4 (**C**$O_2{}^i$Pr), 138.8, 138.1, 129.2, 128.4, 128.3, 127.8, 127.7, 126.3 (Ar**C**), 81.2 (**C**HOTMP), 73.4 (O**C**H_2Ph), 73.1 (**C**HOH), 68.9 (**C**H_2OBn), 67.9 (**C**H$(CH_3)_2$), 60.6, 60.0 ($(CH_3)_2$**C**N**C**$(CH_3)_2$), 48.5 (**C**H$CO_2{}^i$Pr), 40.5 (**C**H_2**C**H_2**C**H_2), 36.0 (**C**H_2CHAr), 34.3 ($(\mathbf{C}H_3)_a$CNC$(CH_3)_2$), 33.4 ($(CH_3)_2$CNC(**C**$H_3)_a$), 21.7, 21.6 (CH(**C**$\mathbf{H_3})_2$), 20.6 ($(\mathbf{C}H_3)_b$CNC$(\mathbf{C}H_3)_b$), 17.2 (CH_2**C**H_2**C**H_2); HRMS (ESI-TOF) calculated for $C_{31}H_{45}NO_5$ $[M+H]^+$ m/z 512.3371, found 512.3378; $\alpha_D{}^{20} = -11.5$ (c = 1.00, $CHCl_3$).



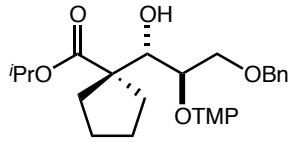
(3*S*,4*R*)-Isopropyl 5-(benzyloxy)-3-hydroxy-2,2-dimethyl-4-((2,2,6,6-tetramethylpiperidin-1-yl)oxy)pentanoate (13a). The compound was synthesized following the general procedure using $TiCl_2(O^iPr)_2$ (190 mg, 800 μmol, 2.0 equiv.), *(R)*-3-(benzyloxy)-2-(2,2,6,6-tetramethylpiperidin-1-yloxy)propanal (90% ee, 128 mg, 400 μmol, 1.0 equiv.), ((1-isopropoxy-2-methylprop-1-en-1-yl)oxy)trimethylsilane (162 mg, 800 μmol, 2.0 equiv.) and CH_2Cl_2 (2 mL). The crude product was purified by flash chromatography using 9:1 hexanes:Et_2O to yield the title compound (172 mg, 96% yield, >20:1 dr) as a colorless oil. The ribo/arabino-configuration of the title compound was determined from the corresponding lactone (see below). IR (thin film): 3489, 2977, 2931, 2871, 1725, 1469, 1455, 1375, 1363, 1260, 1244, 1209, 1181, 1140, 1130, 1107, 1072, 1042, 981, 936, 878, 736, 698 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$): δ 7.39–7.24 (m, 5H, Ar**H**), 4.97 (sept, 1H, *J* = 6.3 Hz, C**H**$(CH_3)_2$), 4.55 (d, 1H, *J* = 11.6 Hz, C$\mathbf{H_a}$Ph), 4.50 (d, 1H, *J* = 11.6 Hz, C$\mathbf{H_b}$Ph), 4.25 (dd, 1H, *J* = 9.5, 3.0 Hz, C$\mathbf{H_a}$OBn), 4.13 (dd, 1H, *J* = 6.3, 4.2 Hz, C**H**OH), 3.97 (dt, 1H, *J* = 6.6, 2.9 Hz, C**H**OTMP), 3.83 (dd, 1H, *J* = 9.5,



7.0 Hz, C**H**$_b$OBn), 3.73 (d, 1H, *J* = 4.2 Hz, O**H**), 1.62–0.98 (m, 18H, OTMP), 1.26 (s, 3H, (C**H**$_3$)$_a$CCO$_2$^{i}Pr), 1.23 (s, 3H, (C**H**$_3$)$_b$CCO$_2$^{i}Pr), 1.20 (d, 3H, *J* = 6.2 Hz, CH(C**H**$_3$)$_a$), 1.20 (d, 3H, *J* = 6.2 Hz, CH(C**H**$_3$)$_b$); ^{13}C NMR (125 MHz, $CDCl_3$): δ 176.4 (**C**O$_2$^{i}Pr), 137.7, 128.5, 127.9, and 127.9 (4Ar**C**), 80.0 (**C**HOTMP), 78.0 (**C**HOH), 73.6 (**C**H$_2$Ph), 71.1 (**C**H$_2$OBn), 67.5 (**C**H(CH$_3$)$_2$), 60.6, 59.5 ((CH$_3$)$_2$**C**N**C**(CH$_3$)$_2$), 46.0 (**C**CO$_2$^{i}Pr), 40.7, 40.3 (**C**H$_2$CH$_2$**C**H$_2$), 34.2, 33.3 ((**C**H$_3$)$_a$CNC(**C**H$_3$)$_a$), 22.9 ((**C**H$_3$)$_a$CCO$_2$^{i}Pr), 21.7, 21.6 (CH(**C**H$_3$)$_2$), 21.0, 20.8 ((**C**H$_3$)$_b$CNC(**C**H$_3$)$_b$), 20.6 ((**C**H$_3$)$_b$CCO$_2$^{i}Pr), 17.2 (CH$_2$**C**H$_2$CH$_2$); HRMS (ESI-TOF) calculated for $C_{26}H_{43}NO_5$ $[M+H]^+$ m/z 450.3214, found 450.3219; α_D^{21} = –30.4 (c = 1.00, $CHCl_3$).



Isopropyl 1-((1*S*,2*R*)-3-(benzyloxy)-1-hydroxy-2-((2,2,6,6-tetramethylpiperidin-1-yl)oxy)propyl)cyclobutanecarboxylate (14a). The compound was synthesized following the general procedure using $TiCl_2(O^iPr)_2$ (190 mg, 800 μmol, 2.0 equiv.), *(R)*-3-(benzyloxy)-2-(2,2,6,6-tetramethylpiperidin-1-yloxy)propanal (90% ee, 128 mg, 400 μmol, 1.0 equiv.), (cyclobutylidene(isopropoxy)methoxy)trimethylsilane (172 mg, 800 μmol, 2.0 equiv.) and CH_2Cl_2 (2 mL). The crude product was purified by flash chromatography using 9:1 hexanes:Et_2O to yield the title compound (174 mg, 94% yield, >20:1) as a colorless oil. Due to the similar structural features and the consistent NMR-data of the title compound to (3*S*,4*R*)-isopropyl 5-(benzyloxy)-3-hydroxy-2,2-dimethyl-4-((2,2,6,6-tetramethylpiperidin-1-yl)oxy)pentanoate (see above) the configuration of the title compound was assigned as ribo/arabino. IR (thin film): 3499, 2977, 2937, 2871, 1719, 1467, 1454, 1373, 1360, 1274, 1259, 1209, 1181, 1130, 1088, 1044, 956, 926, 824, 764, 750, 698 cm^{-1}; ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.40–7.24 (m, 5H, Ar**H**), 5.00 (sept, 1H, *J* = 6.2 Hz, C**H**(CH$_3$)$_2$), 4.50 (d, 1H, *J* = 11.6 Hz, C**H**$_a$Ph), 4.47 (d, 1H, *J* = 11.6 Hz, C**H**$_b$Ph), 4.15 (dd, 1H, *J* = 7.6, 4.9 Hz, C**H**OH), 3.91 (dd, 1H, *J* = 10.0, 4.2 Hz, C**H**$_a$OBn), 3.85–3.75 (m, 3H, C**H**$_b$OBn, C**H**OTMP, O**H**), 2.61–0.94 (m, 24H, OTMP, (C**H**$_2$)$_3$CCO$_2$^{i}Pr), 1.25 (d, 3H, *J* = 6.2 Hz, CH(C**H**$_3$)$_a$), 1.24 (d, 3H, *J* = 6.0 Hz, CH(C**H**$_3$)$_b$); ^{13}C NMR (125 MHz, $CDCl_3$): δ 175.8 (**C**O$_2$^{i}Pr), 137.8, 128.5, 127.8, 127.8 (Ar**C**), 81.0 (**C**HOTMP), 75.4 (**C**HOH), 73.5 (**C**H$_2$Ph), 70.2 (**C**H$_2$OBn), 67.9 (**C**H(CH$_3$)$_2$), 60.6, 59.7 ((CH$_3$)$_2$**C**N**C**(CH$_3$)$_2$), 51.4 (**C**CO$_2$^{i}Pr), 40.6, 40.5 (C**C**H$_2$CH$_2$**C**H$_2$C), 34.4, 33.3 ((**C**H$_3$)$_a$CNC(**C**H$_3$)$_a$), 28.7, 25.3 (**C**H$_2$CH$_2$**C**H$_2$CCO$_2$^{i}Pr), 21.8, 21.7 (CH(**C**H$_3$)$_2$), 20.7, 20.7 ((**C**H$_3$)$_b$CNC(**C**H$_3$)$_b$), 17.2 ((CH$_3$)$_2$CCH$_2$**C**H$_2$CH$_2$C(CH$_3$)$_2$), 16.4 (CH$_2$**C**H$_2$CH$_2$CCO$_2$^{i}Pr); HRMS (ESI-TOF) calculated for $C_{27}H_{43}NO_5$ $[M+H]^+$ m/z 462.3214, found 462.3212; α_D^{21} = –43.7 (c = 1.00, $CHCl_3$).



Isopropyl-1-((1*S*,2*R*)-3-(benzyloxy)-1-hydroxy-2-((2,2,6,6-tetramethylpiperidin-1-yl)oxy)propyl)cyclopentanecarboxylate (15a). The compound was synthesized following the general procedure using $TiCl_2(O^iPr)_2$ (190 mg, 800 μmol, 2.0 equiv.), *(R)*-3-(benzyloxy)-2-(2,2,6,6-tetramethylpiperidin-1-yloxy)propanal (90% ee, 128 mg, 400 μmol, 1.0 equiv.), (cyclopentylidene(isopropoxy)methoxy)trimethylsilane (183 mg, 800 μmol, 2.0 equiv.) and CH_2Cl_2 (2 mL). The crude product was purified by flash chromatography using 9:1 hexanes:Et_2O to yield the title compound (183 mg, 96% yield, >20:1) as a colorless oil. Due to the similar structural features and the consistent NMR-data of the title compound to (3*S*,4*R*)-isopropyl 5-(benzyloxy)-3-hydroxy-2,2-dimethyl-4-((2,2,6,6-tetramethylpiperidin-1-yl)oxy)pentanoate (see above) the configuration of the title

compound was assigned as ribo/arabino. IR (thin film): 3489, 2967, 2934, 2871, 1723, 1494, 1467, 1454, 1375, 1360, 1259, 1237, 1206, 1181, 1130, 1107, 1075, 1047, 991, 956, 910, 878, 824, 787, 735, 698 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$): δ 7.42–7.26 (m, 5H, Ar**H**), 4.97 (sept, 1H, *J* = 6.2 Hz, C**H**$(CH_3)_2$), 4.56 (d, 1H, *J* = 11.6 Hz, C$\mathbf{H_a}$Ph), 4.52 (d, 1H, *J* = 11.6 Hz, C$\mathbf{H_b}$Ph), 4.23 (dd, 1H, *J* = 5.7, 5.6 Hz, C**H**OH), 4.15–4.08 (m, 1H, C**H**OTMP), 3.95–3.88 (m, 2H, C$\mathbf{H_2}$OBn), 3.86 (d, 1H, *J* = 6.3 Hz, O**H**), 2.29–0.99 (m, 26H, OTMP, (C$\mathbf{H_2}$)$_\mathbf{4}$), 1.24 (d, 3H, *J* = 6.3 Hz, CH(C$\mathbf{H_3}$)$_\mathbf{a}$), 1.22 (d, 3H, *J* = 6.3 Hz, CH(C$\mathbf{H_3}$)$_\mathbf{b}$); ^{13}C NMR (125 MHz, $CDCl_3$): δ 176.1 (**C**$O_2{}^i$Pr), 137.7, 128.4, 127.8, 127.8 (Ar**C**), 81.0 (**C**HOTMP), 76.9 (**C**HOH), 73.5 (**C**H_2Ph), 70.7 (**C**H_2OBn), 67.7 (**C**H$(CH_3)_2$), 60.6, 59.6 ($(CH_3)_2$**C**N**C**$(CH_3)_2$), 57.5 (**C**$CO_2{}^i$Pr), 40.7, 40.4 (C**C**H_2CH_2**C**H_2C), 35.3 (CH_2**C**$H_2CCH_2CH_2$), 34.3, 33.3 ($(\mathbf{C}H_3)_\mathbf{a}CNC(\mathbf{C}H_3)_\mathbf{a}$), 30.6 ($CH_2CH_2$C**C**$H_2CH_2$), 25.7, 25.4 (**C**$H_2CH_2CCH_2$**C**$H_2$), 21.6, 21.6 (CH(**C**$H_3)_\mathbf{2}$), 20.8, 20.8 ($(\mathbf{C}H_3)_\mathbf{b}CNC(\mathbf{C}H_3)_\mathbf{b}$), 17.2 (CC$H_2$**C**$H_2CH_2$C); HRMS (ESI-TOF) calculated for $C_{28}H_{45}NO_5$ $[M+H]^+$ m/z 476.3371, found 476.3368; $\alpha_D{}^{21}$ = –35.2 (c = 1.00, $CHCl_3$).

Isopropyl-1-((1*S*,2*R*)-3-(benzyloxy)-1-hydroxy-2-((2,2,6,6-tetramethylpiperidin-1-yl)oxy)propyl)cyclohexanecarboxylate (16a). The compound was synthesized following the general procedure using $TiCl_2(O^iPr)_2$ (190 mg, 800 μmol, 2.0 equiv.), *(R)*-3-(benzyloxy)-2-(2,2,6,6-tetramethylpiperidin-1-yloxy)propanal (90% ee, 128 mg, 400 μmol, 1.0 equiv.), (cyclohexylidene(isopropoxy)methoxy)trimethylsilane (194 mg, 800 μmol, 2.0 equiv.) and CH_2Cl_2 (2 mL). The crude product was purified by flash chromatography using 9:1 hexanes:Et_2O to yield the title compound (190 mg, 97% yield, >20:1) as a colorless oil. Due to the similar structural features and the consistent NMR-data of the title compound to (3*S*,4*R*)-isopropyl 5-(benzyloxy)-3-hydroxy-2,2-dimethyl-4-((2,2,6,6-tetramethylpiperidin-1-yl)oxy)pentanoate (see above) the configuration of the title compound was assigned as ribo/arabino. IR (thin film): 3489, 2972, 2930, 2861, 1717, 1467, 1453, 1374, 1360, 1300, 1259, 1216, 1181, 1133, 1108, 1044, 971, 958, 936, 913, 852, 822, 736, 698 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$): δ 7.42–7.25 (m, 5H, Ar**H**), 5.00 (sept, 1H, *J* = 6.2 Hz, C**H**$(CH_3)_2$), 4.54 (d, 1H, *J* = 11.6 Hz, C$\mathbf{H_a}$Ph), 4.49 (d, 1H, *J* = 11.6 Hz, C$\mathbf{H_b}$Ph), 4.08 (dd, 1H, *J* = 9.7, 2.5 Hz, C$\mathbf{H_a}$OBn), 4.02–3.91 (m, 3H, C$\mathbf{H_b}$OBn, C**H**OTMP, C**H**OH), 3.71 (d, 1H, *J* = 6.3 Hz, O**H**), 2.24–1.03 (m, 28H, OTMP, (C$\mathbf{H_2}$)$_\mathbf{5}$), 1.25 (d, 3H, *J* = 6.3 Hz, CH(C$\mathbf{H_3}$)$_\mathbf{a}$), 1.22 (d, 3H, *J* = 6.3 Hz, CH(C$\mathbf{H_3}$)$_\mathbf{b}$); ^{13}C NMR (125 MHz, $CDCl_3$): δ 174.8 (**C**$O_2{}^i$Pr), 137.0, 128.4, 127.8, 127.8 (Ar**C**), 80.0 (**C**HOTMP), 79.0 (**C**HOH), 73.5 (**C**H_2Ph), 70.4 (**C**H_2OBn), 67.7 (**C**H$(CH_3)_2$), 60.3, 59.8 ($(CH_3)_2$**C**N**C**$(CH_3)_2$), 51.4 (**C**$CO_2{}^i$Pr), 40.6, 40.4 (C**C**H_2CH_2**C**H_2C), 34.2, 33.4 ($(\mathbf{C}H_3)_\mathbf{a}CNC(\mathbf{C}H_3)_\mathbf{a}$), 31.4, 30.1 (**C**$H_2(CH_2)_3$**C**$H_2$), 25.8 ($(CH_2)_2$**C**$H_2(CH_2)_2$), 23.2, 23.2 (**C**$H_2CH_2CCH_2$**C**$H_2$), 21.8, 21.8 (CH(**C**$H_3)_\mathbf{2}$), 20.8, 20.7 ($(\mathbf{C}H_3)_\mathbf{b}CNC(\mathbf{C}H_3)_\mathbf{b}$), 17.2 (CC$H_2$**C**$H_2CH_2$C); HRMS (ESI-TOF) calculated for $C_{29}H_{47}NO_5$ $[M+H]^+$ m/z 490.3527, found 490.3529; $\alpha_D{}^{21}$ = –10.5 (c = 1.00, $CHCl_3$).

General Procedure for the OTMP-Cleavage and Cyclization of the Mukaiyama Aldol Products to the Corresponding Ribono- and Arabinolactones. To a solution of the Mukaiyama aldol product in toluene (c = 0.2 M) was added H_2O:TFA (4:1, c = 0.2 M) and Zn powder (10 equiv.) and the resulting biphasic suspension was stirred vigorously at room temperature until the reaction was judged to be complete by TLC analysis (usually 16 hours unless indicated otherwise). The mixture was neutralized

with sat aq. $NaHCO_3$ (2 mL) and poured over H_2O. The aqueous layer was extracted with Et_2O (3 × 5 mL) and the combined organic layers were dried over $MgSO_4$, filtered, and concentrated under vacuum. The crude product was purified by flash chromatography.

5-Benzyloxy-2-(*tert*-butyldimethylsilyl)oxy-3-hydroxy-D-ribonolactone (2b). The compound was synthesized following the general procedure using (2*R*,3*S*,4*R*)-isopropyl-5-(benzyloxy)-3-hydroxy-2-((*tert*-butyldimethylsilyl)oxy)-4-(2,2,6,6-tetramethylpiperidin-1-yloxy)-pentanoate (>20:1 dr, 166 mg, 300 μmol, 1.0 equiv.), Zn (196 mg, 3.00 mmol, 10 equiv.) and toluene (1.5 mL), but with H_2O:TFA (8:1, 1.5 mL), and needed up to 3 days for completion. The crude product was purified by flash chromatography using 5:1 hexanes:EtOAc to yield the title compound (76.0 mg, 72% yield, >20:1 dr) as a white powder. HPLC analysis (OJ, 5% IPA/hexanes, 1.0 mL/min, 220 nm) indicated 90% ee: t_R (major) = 9.7 minutes, t_R (minor) = 12.8 minutes. The configuration of the title compound was assigned as ribo (see above). IR (thin film): 3524, 2952, 2929, 2881, 2856, 1788, 1494, 1472, 1462, 1454, 1388, 1360, 1328, 1254, 1209, 1154, 1120, 1099, 1039, 1006, 974, 928, 870, 839, 784, 733, 698, 673 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$): δ 7.25–7.09 (m, 5H, Ar**H**), 4.56 (d, 1H, *J* = 5.4 Hz, C**H**(2)), 4.43–4.38 (m, 2H, C$\mathbf{H_a}$Ph, C**H**(4)), 4.34 (d, 1H, *J* = 11.5 Hz, C$\mathbf{H_b}$Ph), 4.13 (dd, 1H, *J* = 5.4, 0.6 Hz, C**H**(3)), 3.63 (dd, 1H, *J* = 10.9, 2.3 Hz, C**H**$(5)_\mathbf{a}$), 3.59 (dd, 1H, *J* = 10.9, 2.1 Hz, C**H**$(5)_\mathbf{b}$), 2.90 (d, 1H, *J* = 9.7 Hz, O**H**), 0.77 (s, 9H, C(C$\mathbf{H_3})_\mathbf{3}$), 0.06, 0.00 (2s, 6H, Si(C$\mathbf{H_3})_\mathbf{2}$); ^{13}C NMRS (125 MHz, $CDCl_3$): δ 174.8 (**C**(1)), 137.3, 128.7, 128.2, 127.7 (Ar**C**), 83.1 (**C**(4)), 73.9 (**C**H_2Ph), 70.6 (**C**(3)), 70.0 (**C**(2)), 69.6 (**C**(5)), 25.8 (C(**C**$H_3)_3$), 18.4 (**C**$(CH_3)_\mathbf{3}$), –4.5, –5.3 (Si(**C**$H_3)_\mathbf{2}$); HRMS (ESI-TOF) calculated for $C_{18}H_{28}O_5Si$ $[M+H]^+$ m/z 353.1779, found 353.1776; α_D^{21} = +30.9 (c = 1.00, $CHCl_3$).

5-Benzyloxy-2-(*tert*-butyldiphenylsilyl)oxy-3-hydroxy-D-ribonolactone (3b). The compound was synthesized following the general procedure using (2*R*,3*S*,4*R*)-isopropyl-5-(benzyloxy)-3-hydroxy-2-((*tert*-butyldiphenylsilyl)oxy)-4-(2,2,6,6-tetramethylpiperidin-1-yloxy)-pentanoate (>20:1 dr, 203 mg, 300 μmol, 1.0 equiv.), Zn (196 mg, 3.00 mmol, 10 equiv.) and toluene (1.5 mL), but with H_2O:TFA (8:1, 1.5 mL), and needed up to 3 days for completion. The crude product was purified by flash chromatography using 5:1 hexanes:EtOAc to yield the title compound (119 mg, 83% yield, >20:1 dr) as a colorless oil. HPLC analysis (AS, 5% IPA/hexanes, 1.0 mL/min, 220 nm) indicated 91% ee: t_R (major) = 13.8 minutes, t_R (minor) = 25.3 minutes. Due to the similar structural features and the consistent NMR-data of the title compound to 5-benzyloxy-2-(*tert*-butyldimethylsilyl)oxy-3-hydroxy-D-ribonolactone (see above) the configuration of the title compound was assigned as ribo. IR (thin film): δ 3534, 3048, 2952, 2932, 2859, 1788, 1588, 1472, 1454, 1428, 1391, 1360, 1328, 1204, 1151, 1113, 1095, 1039, 1027, 1009, 974, 931, 862, 840, 822, 740, 701 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$): δ 7.64–7.58 (m, 2H, Ar**H**), 7.48–7.40 (m, 2H, Ar**H**), 7.33–7.25 (m, 2H, Ar**H**), 7.25–7.12 (m, 4H, Ar**H**), 7.08–7.02 (m, 1H, Ar**H**), 6.99 (dd, *J* = 7.3, 7.3 Hz, 2H, Ar**H**), 6.77 (d, *J* = 7.0 Hz, 2H, Ar**H**), 4.56 (d, 1H, *J* = 5.3 Hz, C**H**(2)), 4.27 (d, 1H, *J* = 2.2 Hz, C**H**(4)), 4.16 (d, 1H, *J* = 11.8 Hz, C$\mathbf{H_a}$Ph), 4.03 (d, 1H, *J* = 11.8 Hz, C$\mathbf{H_b}$Ph), 3.67 (d, 1H, *J* = 5.3 Hz, C**H**(3)), 3.40 (dd, 1H, *J* = 10.9, 2.4 Hz, C**H**$(5)_\mathbf{a}$), 3.30 (dd, 1H, *J* = 10.9, 2.1 Hz, C**H**$(5)_\mathbf{b}$), 2.81 (s, 1H, O**H**), 0.96 (s, 9H, C(C$\mathbf{H_3})_\mathbf{3}$); ^{13}C NMR (125 MHz, $CDCl_3$): δ 174.4 (**C**(1)), 137.1, 136.0, 135.6, 132.6, 131.4, 130.5, 130.4, 128.5, 128.1, 128.0, 127.9,

127.4 (Ar**C**), 82.9 (**C**(4)), 73.5 (**C**H_2Ph), 70.6, 70.5 (**C**(2), **C**(3)), 69.1 (**C**(5)), 26.9 (C(**C**H_3)$_3$), 19.5 (**C**(CH_3)$_3$); HRMS (ESI-TOF) calculated for $C_{28}H_{32}O_5Si$ $[M+Na]^+$ m/z 499.1911, found 499.1911; α_D^{21} = +32.2 (c = 1.00, $CHCl_3$).

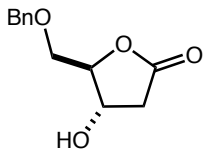
5-Benzyloxy-3-hydroxy-2-methoxy-D-ribonolactone (4b). The compound was synthesized following the general procedure using (2*R*,3*S*,4*R*)-isopropyl 5-(benzyloxy)-3-hydroxy-2-methoxy-4-((2,2,6,6-tetramethylpiperidin-1-yl)oxy)pentanoate (>20:1 dr, 135 mg, 300 μmol, 1.0 equiv.), Zn (196 mg, 3.00 mmol, 10 equiv.), toluene (1.5 mL) and H_2O:TFA (4:1, 1.5 mL), and needed up to 3 days for completion. The crude product was purified by flash chromatography using 2:1 hexanes:EtOAc to yield the title compound (66.1 mg, 87% yield, >20:1 dr) as a colorless oil. HPLC analysis (AD, 10% IPA/hexanes, 1.0 mL/min, 220 nm) indicated 89% ee: t_R (major) = 19.0 minutes, t_R (minor) = 15.1 minutes. IR (thin film): 3443, 2932, 2916, 2866, 2851, 1785, 1494, 1454, 1365, 1315, 1196, 1173, 1128, 1052, 981, 946, 878, 741, 698 cm^{-1}; ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.40–7.28 (m, 5H, Ar**H**), 4.60 (d, 1H, *J* = 11.9 Hz, C$\mathbf{H_a}$Ph), 4.57 (d, 1H, *J* = 11.9 Hz, C$\mathbf{H_b}$Ph), 4.39 (ddd, 1H, *J* = 8.2, 8.2, 3.8 Hz, C**H**(3)), 4.25 (dt, 1H, *J* = 7.9, 4.5 Hz, C**H**(4)), 4.09 (d, 1H, *J* = 8.5 Hz, C**H**(2)), 3.76 (dd, 1H, *J* = 10.8, 4.6 Hz, C**H**(5)$_\mathbf{a}$), 3.71 (dd, 1H, *J* = 10.9, 4.4 Hz, C**H**(5)$_\mathbf{b}$), 3.67 (s, 3H, OC$\mathbf{H_3}$), 2.88 (d, 1H, *J* = 5.0 Hz, O**H**); ^{13}C NMR (125 MHz, $CDCl_3$): δ 172.0 (**C**(1)), 137.3, 128.7, 128.2, 128.0 (Ar**C**), 82.1 (**C**(2)), 78.8 (**C**(4)), 73.9 (**C**H_2Ph), 73.8 (**C**(3)), 68.2 (**C**(5)), 59.2 (O**C**H_3); HRMS (ESI-TOF) calculated for $C_{13}H_{16}O_5$ $[M+H]^+$ m/z 253.1071, found 253.1076; α_D^{21} = –2.54 (c = 1.00, $CHCl_3$). The configuration of the title compound was determined from the corresponding debenzylated pentose. This compound was prepared by dissolving the title compound (10.0 mg, 39.6 μmol, 1.0 equiv.) in EtOH (790 μL) and treating it with Pd/C (10%, 5 mg). Hydrogen gas was bubbled through the reaction mixture for 5 minutes and the suspension was stirred for 20 hours at room temperature under H_2 atmosphere. The reaction mixture was filtered through Celite and the filtrate was evaporated. The crude product was purified by flash chromatography using EtOAc to yield the title compound as a colorless oil. The experimental data is in disagreement with the title compound in the arabino-configuration.[13] Due to the consistent facial selectivity observed for the formation of the other Mukaiyama aldol products, the configuration of the title compound was assigned as ribo. ^{1}H NMR (500 MHz, $CDCl_3$): δ 4.50 (ddd, 1H, *J* = 8.3, 8.3, 4.5 Hz, C**H**(3)), 4.21 (dt, 1H, *J* = 8.0, 3.4 Hz, C**H**(4)), 4.13 (d, 1H, *J* = 8.5 Hz, C**H**(2)), 3.99 (ddd, 1H, *J* = 12.8, 5.0, 3.2 Hz, C**H**(5)$_\mathbf{a}$), 3.84 (ddd, 1H, *J* = 12.8, 7.8, 3.6 Hz, C**H**(5)$_\mathbf{b}$), 3.71 (s, 3H, OC$\mathbf{H_3}$), 2.74 (br. d, 1H, *J* = 3.8 Hz, CH(3)O**H**), 2.03 (br. t, 1H, *J* = 6.1 Hz, CH_2(5)O**H**); ^{13}C NMR (125 MHz, $CDCl_3$): δ 172.0 (**C**(1)), 82.5 (**C**(2)), 80.1 (**C**(4)), 72.4 (**C**(3)), 60.5 (**C**(5)), 59.3 (O**C**H_3).

5-Benzyloxy-2-desoxy-3-hydroxy-D-lyxolactone (5-Benzyloxy-2-desoxy-3-hydroxy-D-xylolactone) (5b). The compound was synthesized following the general procedure using (3*R*,4*R*)-isopropyl-5-(benzyloxy)-3-hydroxy-4-((2,2,6,6-tetramethylpiperidin-1-yl)oxy)pentanoate (>20:1 dr, 126 mg, 300 μmol, 1.0 equiv.), Zn (196 mg, 3.00 mmol, 10 equiv.), toluene (1.5 mL) and H_2O:TFA (4:1, 1.5 mL). Due to incomplete

[13] He, Y. Q.; Xue, J. J.; Zhou, Y. M.; Yang, J. S.; Yu, X. M. *Tetrahedron Lett*. **2009**, *50*, 2317.

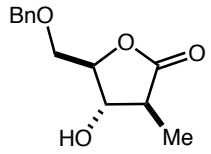
cyclization after 16 hours, the biphasic mixture was treated with additional TFA (1 mL) and stirred for a further 16 hours at room temperature. Following the usual workup (see general procedure), the crude product was purified by flash chromatography using 1:1 hexanes:EtOAc to yield the title compound (60.8 mg, 91% yield, >20:1 dr) as colorless crystals. Due to differences in the between this compound and 5-Benzyloxy-2-desoxy-3-hydroxy-D-ribonolactone (above), the configuration of the product was assigned as lyxo/xylo. HPLC analysis (OD, 5% IPA/hexanes, 1.0 mL/min, 220 nm) indicated 91% ee: t_R (major) = 22.9 minutes, t_R (minor) = 18.2 minutes. IR (thin film): 3429, 3063, 3028, 2932, 2866, 1781, 1494, 1454, 1401, 1371, 1330, 1290, 1231, 1204, 1164, 1125, 1091, 1054, 941, 784, 743, 700 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$): δ 7.42–7.28 (m, 5H, Ar**H**), 4.68–4.62 (m, 1H, C**H**(3)), 4.59 (s, 2H, C$\mathbf{H_2}$Ph), 4.56 (dt, 1H, *J* = 5.0, 5.0 Hz, C**H**(4)), 3.92 (dd, 1H, *J* = 10.6, 4.6 Hz, C**H**$(5)_\mathbf{a}$), 3.87 (dd, 1H, *J* = 10.5, 5.3 Hz, C**H**$(5)_\mathbf{b}$), 3.01 (d, 1H, *J* = 5.5 Hz, O**H**), 2.77 (dd, 1H, *J* = 17.9, 6.6 Hz, C**H**$(2)_\mathbf{a}$), 2.57 (dd, 1H, *J* = 17.9, 2.8 Hz, C**H**$(2)_\mathbf{b}$); ^{13}C NMR (125 MHz, $CDCl_3$): δ 175.3 (**C**(1)), 137.0, 128.8, 128.4, 128.0 (Ar**C**), 81.1 (**C**(4)), 74.1 (**C**H_2Ph), 68.8 (**C**(3)), 67.7 (**C**(5)), 38.5 (**C**(2)); HRMS (ESI-TOF) calculated for $C_{12}H_{14}O_4$ $[M+H]^+$ m/z 223.0965, found 223.0961; α_D^{22} = +22.9 (c = 1.00, $CHCl_3$).

5-Benzyloxy-2-desoxy-3-hydroxy-D-ribonolactone (5-Benzyloxy-2-desoxy-3-hydroxy-D-arabinolactone) (6b). The compound was synthesized following the general procedure using (3*S*,4*R*)-isopropyl-5-(benzyloxy)-3-hydroxy-4-((2,2,6,6-tetramethylpiperidin-1-yl)oxy)pentanoate (>20:1 dr, 126 mg, 300 μmol, 1.0 equiv.), Zn (196 mg, 3.00 mmol, 10 equiv.), toluene (1.5 mL) and H_2O:TFA (4:1, 1.5 mL). Due to incomplete cyclization after 16 hours, the biphasic mixture was treated with additional TFA (1 mL) and stirred for a further 16 hours at room temperature. Following the usual workup (see general procedure), the crude product was purified by flash chromatography using 1:1 hexanes:EtOAc to yield the title compound (61.6 mg, 92% yield, >20:1 dr) in the ribo/arabino-configuration as colorless crystals. HPLC analysis (AD, 7% IPA/hexanes, 1.0 mL/min, 220 nm) indicated 90% ee: t_R (major) = 20.0 minutes, t_R (minor) = 24.2 minutes. The experimental data is in agreement with the literature.[14] IR (thin film): 3442, 3028, 2927, 2866, 1762, 1494, 1454, 1364, 1188, 1169, 1113, 1091, 1039, 1027, 943, 740, 699 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$): δ 7.40–7.22 (m, 5H, Ar**H**), 4.48 (d, 1H, *J* = 12.1 Hz, C$\mathbf{H_a}$Ph), 4.48–4.38 (m, 2H, C**H**(3) and C**H**(4)), 4.41 (d, 1H, *J* = 11.9 Hz, C$\mathbf{H_b}$Ph), 3.61 (dd, 1H, *J* = 10.7, 3.0 Hz, C**H**$(5)_\mathbf{a}$), 3.58 (dd, 1H, *J* = 10.7, 3.5 Hz, C**H**$(5)_\mathbf{b}$), 2.87 (dd, 1H, *J* = 18.0, 6.7 Hz, C**H**$(2)_\mathbf{a}$), 2.81 (d, 1H, *J* = 3.6 Hz, O**H**), 2.37 (dd, 1H, *J* = 18.0, 2.5 Hz, C**H**$(2)_\mathbf{b}$); ^{13}C NMR (125 MHz, $CDCl_3$): δ 176.4 (**C**(1)), 137.3, 128.7, 128.1, 127.8 (Ar**C**), 86.5 (**C**(4)), 73.8 (**C**H_2Ph), 69.9 (**C**(3)), 69.5 (**C**(5)), 38.6 (**C**(2)); HRMS (ESI-TOF) calculated for $C_{12}H_{14}O_4$ $[M+H]^+$ m/z 223.0965, found 223.0967; α_D^{22} = +1.55 (c = 1.00, $CHCl_3$).

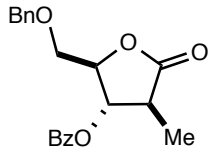


[14] Fazio, F.; Schneider, M. P. *Tetrahedron: Asymmetry* **2000**, 11, 1869.

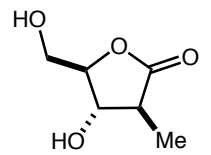
5-Benzyloxy-3-hydroxy-2-methyl-D-arabinolactone (7b). The compound was synthesized



following the general procedure using (2*S*,3*S*,4*R*)-isopropyl-5-(benzyloxy)-3-hydroxy-2-methyl-4-(2,2,6,6-tetramethylpiperidin-1-yloxy)-pentanoate (11:1 dr, 131 mg, 300 μmol, 1.0 equiv.), Zn (196 mg, 3.00 mmol, 10 equiv.), toluene (1.5 mL) and H_2O:TFA (4:1, 1.5 mL). The crude product was purified by flash chromatography using 2:1 hexanes:EtOAc to yield the title compound (69.5 mg, 98% yield, 11:1 dr) as a colorless oil. IR (thin film): 3440, 3063, 3028, 2972, 2932, 2871, 1757, 1494, 1455, 1378, 1363, 1307, 1237, 1176, 1120, 1051, 956, 923, 817, 740, 699 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$), arabino-isomer (major): δ 7.42–7.22 (m, 5H, Ar**H**), 4.57 (s, 2H, C**H**$_2$Ph), 4.24 (dt, 1H, *J* = 7.4, 4.4 Hz, C**H**(4)), 4.03 (dd, 1H, *J* = 7.9, 7.9 Hz, C**H**(3)), 3.73 (dd, 1H, *J* = 10.8, 4.7 Hz, C**H**$(5)_a$), 3.70 (dd, 1H, *J* = 10.8, 4.3 Hz, C**H**$(5)_b$), 3.03 (br. s, 1H, O**H**), 2.61 (dq, 1H, *J* = 7.2, 7.2, C**H**(2)), 1.28 (d, 3H, *J* = 7.2 Hz, C**H**$_3$); ribo-isomer (minor): δ 7.42–7.22 (m, 5H, Ar**H**), 4.53 (d, 1H, *J* = 12.0 Hz, C**H**$_a$Ph), 4.47 (d, 1H, *J* = 12.0 Hz, C**H**$_b$Ph), 4.45–4.39 (m, 1H, C**H**(4)), 3.73 (dd, 1H, *J* = 10.8, 4.7 Hz, C**H**$(5)_a$), 3.70 (dd, 1H, *J* = 10.8, 4.3 Hz, C**H**$(5)_b$), 3.67–3.64 (m, 1H, C**H**(3)), 3.03 (br. s, 1H, O**H**), 2.91 (dq, 1H, *J* = 7.4, 7.4, C**H**(2)), 1.21 (d, 3H, *J* = 7.5 Hz, C**H**$_3$); ^{13}C NMR (125 MHz, $CDCl_3$), arabino-isomer (major): δ 176.9 (**C**(1)), 137.4, 128.7, 128.1, 127.9 (Ar**C**), 82.1 (**C**(4)), 75.6 (**C**(3)), 73.8 (**C**H_2Ph), 68.8 (**C**(5)), 43.5 (**C**(2)), 12.6 (**C**H_3); ribo-isomer (minor): δ 179.6 (**C**(1)), 137.2, 128.7, 128.1, 127.7 (Ar**C**), 85.0 (**C**(4)), 73.8 (**C**H_2Ph), 71.9 (**C**(3)), 69.5 (**C**(5)), 39.9 (**C**(2)), 8.30 (**C**H_3); HRMS (ESI-TOF) calculated for $C_{13}H_{16}O_4$ $[M+H]^+$ m/z 237.1121, found 237.1124; α_D^{21} = +11.3 (c = 1.00, $CHCl_3$). The enantiomeric excess of the



title compound was determined by HPLC analysis of the corresponding benzoyl ester. To prepare this derivative, a 0 °C solution of the title compound in dichloromethane (0.20 M) was treated with 4-dimethylaminopyridine (5 mol%), triethylamine (2.0 equiv.), and benzoyl chloride (1.2 equiv.) The mixture was allowed to warm to rt and stir for 2 h before being quenched with water. The aqueous layer was extracted with three portions of dichloromethane and the combined organic layers were dried over $MgSO_4$ and concentrated. The residue was purified by preparative TLC to afford the fully protected lactone. HPLC analysis (AS, 6% EtOH/hexanes, 1.0 mL/min, 254 nm) indicated 89% ee: t_R (major) = 12.5 minutes, t_R (minor) = 17.5 minutes. The configuration of the title compound was determined from



the corresponding debenzylated pentose. This compound was prepared by dissolving the title compound (11.5 mg, 48.7 μmol, 1.0 equiv.) in 1:1 EtOAc/EtOH (1.6 mL) and treating it with Pd/C (10%, 5 mg). Hydrogen gas was bubbled through the reaction mixture for 5 minutes and the suspension was stirred for 20 hours at room temperature under H_2 atmosphere. The reaction mixture was filtered through Celite and the filtrate was evaporated to yield the debenzylated lactone corresponding to the title compound in the arabino-configuration as the major isomer along with the title compound in the ribo-configuration as the minor isomer as a white powder. The experimental data is in agreement with the literature.[15] ^1H NMR (500 MHz, D_2O); arabino-configured isomer: δ 4.31–4.24 (m, 1H, C**H**(4)), 4.01 (t, 1H, *J* = 7.8 Hz, C**H**(3)), 3.91 (ddd, 1H, *J* = 13.1, 1.7, 1.3 Hz, C**H**$(5)_a$), 3.68 (dd, 1H, *J* = 13.1, 5.0 Hz, C**H**$(5)_b$), 2.80–2.71 (m, 1H, C**H**(2)), 1.20 (d, 1H, *J* = 7.2 Hz, C**H**$_3$); ^{13}C NMR (125 MHz, d^6-DMSO), arabino-configured

[15] Heathcock, C. H.; Young, S. D.; Hagen, J. P.; Pirrung, M. C.; White, C. T.; Vanderveer, D. *J. Org. Chem.* **1980**, *45*, 3846.

isomer: δ 176.9 (**C**(1)), 84.5 (**C**(4)), 72.8 (**C**(3)), 59.7 (**C**(5)), 43.0 (**C**(2)), 12.4 (**C**H_3); ribo-configured isomer: δ 179.1 (**C**(1)), 86.8 (**C**(4)), 69.9 (**C**(3)), 60.7 (**C**(5)), 39.0–40.0 (hidden by d^6-DMSO, **C**(2)), 8.40 (**C**H_3).

5-Benzyloxy-2-ethyl-3-hydroxy-D-arabinolactone (8b). The compound was synthesized following the general procedure using (2*S*,3*S*,4*R*)-isopropyl-5-(benzyloxy)-3-hydroxy-2-ethyl-4-(2,2,6,6-tetramethylpiperidin-1-yloxy)-pentanoate (13:1 dr, 135 mg, 300 μmol, 1.0 equiv.), Zn (196 mg, 3.00 mmol, 10 equiv.), toluene (1.5 mL) and H_2O:TFA (4:1, 1.5 mL). The crude product was purified by flash chromatography using 2:1 hexanes:EtOAc to yield the title compound (74.5 mg, 99% yield, 13:1 dr) as a colorless oil. Due to the similar structural features and the consistent NMR-data of the title compound to 5-benzyloxy-3-hydroxy-2-methyl-D-arabinolactone (see above) the configuration of the title compound was assigned as arabino. IR (thin film): 3448, 3063, 3028, 2962, 2932, 2871, 1757, 1494, 1454, 1363, 1317, 1211, 1173, 1115, 1053, 951, 910, 862, 740, 699 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$), arabino-isomer (major): δ δ 7.32-7.15 (m, 5H, Ar**H**), 4.48 (s, 2H, C$\mathbf{H_2}$Ph), 4.17 (dt, 1H, *J* = 6.8, 4.3 Hz, C**H**(4)), 4.09 (dd, 1H, *J* = 6.9, 6.9 Hz, C**H**(3)), 3.64 (dd, 1H, *J* = 10.9, 4.4 Hz, C**H**$(5)_\mathbf{a}$), 3.61 (dd, 1H, *J* = 10.9, 4.3 Hz, C**H**$(5)_\mathbf{b}$), 3.07 (br. s, 1H, O**H**), 2.45 (dt, 1H, *J* = 7.2, 7.2, C**H**(2)), 1.83–1.51 (m, 2H, C$\mathbf{H_2}CH_3$), 0.96 (t, 3H, *J* = 7.5 Hz, C$\mathbf{H_3}$); ribo-isomer (minor): δ 7.32–7.15 (m, 5H, Ar**H**), 4.50 (d, 1H, *J* = 11.9 Hz, C$\mathbf{H_a}$Ph), 4.50 (d, 1H, *J* = 11.9 Hz, C$\mathbf{H_b}$Ph), 4.36–4.32 (m, 1H, C**H**(4)), 3.64 (dd, 1H, *J* = 10.9, 4.4 Hz, C**H**$(5)_\mathbf{a}$), 3.61 (dd, 1H, *J* = 10.9, 4.3 Hz, C**H**$(5)_\mathbf{b}$), 3.57–3.53 (m, 1H, C**H**(3)), 3.07 (br. s, 1H, O**H**), 2.62 (dt, 1H, *J* = 10.0, 5.8, C**H**(2)), 1.83–1.51 (m, 2H, C$\mathbf{H_2}CH_3$), 0.96 (t, 3H, *J* = 7.5 Hz, C$\mathbf{H_3}$); ^{13}C NMR (125 MHz, $CDCl_3$), arabino-isomer (major): δ 176.6 (**C**(1)), 137.4, 128.6, 128.1, 127.9 (Ar**C**), 82.4 (**C**(4)), 73.8 (**C**H_2Ph), 73.4 (**C**(3)), 68.8 (**C**(5)), 49.5 (**C**(2)), 21.3 (**C**H_2CH_3), 11.5 (**C**H_3); ribo-isomer (minor): δ 178.9 (**C**(1)), 137.3, 128.7, 128.1, 127.7 (Ar**C**), 85.3 (**C**(4)), 73.8 (**C**H_2Ph), 70.7 (**C**(3)), 69.3 (**C**(5)), 49.5 (**C**(2)), 17.1 (**C**H_2CH_3), 12.4 (**C**H_3); HRMS (ESI-TOF) calculated for $C_{14}H_{18}O_4$ $[M+H]^+$ m/z 251.1278, found 251.1279; α_D^{21} = +13.4 (c = 1.00, $CHCl_3$). The enantiomeric excess of the title compound was determined by HPLC analysis of the corresponding benzoyl ester. To prepare this derivative, a 0 °C solution of the title compound in dichloromethane (0.20 M) was treated with 4-dimethylaminopyridine (5 mol%), triethylamine (2.0 equiv.), and benzoyl chloride (1.2 equiv.) The mixture was allowed to warm to rt and stir for 2 h before being quenched with water. The aqueous layer was extracted with three portions of dichloromethane and the combined organic layers were dried over $MgSO_4$ and concentrated. The residue was purified by preparative TLC to afford the fully protected lactone. HPLC analysis (AS, 6% EtOH/hexanes, 1.0 mL/min, 254 nm) indicated 89% ee: t_R (major) = 11.1 minutes, t_R (minor) = 18.6 minutes.

5-Benzyloxy-3-hydroxy-2-*iso*-propyl-D-arabinolactone (9b). The compound was synthesized following the general procedure using (2*S*,3*S*,4*R*)-isopropyl-5-(benzyloxy)-3-hydroxy-2-isopropyl-4-(2,2,6,6-tetramethylpiperidin-1-yloxy)-pentanoate (>20:1 dr, 139 mg, 300 μmol, 1.0 equiv.), Zn (196 mg, 3.00 mmol, 10 equiv.), toluene (1.5 mL) and H_2O:TFA (4:1, 1.5 mL). The crude product was purified by flash chromatography using 2:1 hexanes:EtOAc to yield the title compound (77.9 mg, 98% yield, >20:1 dr)

as a colorless oil. HPLC analysis (AS, 10% IPA/hexanes, 1.0 mL/min, 220 nm) indicated 89% ee: t_R (major) = 20.5 minutes, t_R (minor) = 26.9 minutes. Due to the similar structural features and the consistent NMR-data of the title compound to 5-benzyloxy-3-hydroxy-2-methyl-D-arabinolactone (see above) the configuration of the title compound was assigned as arabino. IR (thin film): 3448, 3063, 3028, 2963, 2932, 2876, 1753, 1494, 1464, 1451, 1391, 1368, 1333, 1279, 1171, 1123, 1105, 1053, 986, 936, 867, 747, 699 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$): δ δ 7.40–7.27 (m, 5H, Ar**H**), 4.59 (d, 1H, *J* = 12.1 Hz, C$\mathbf{H_a}$Ph), 4.56 (d, 1H, *J* = 12.0 Hz, C$\mathbf{H_b}$Ph), 4.32 (dd, 1H, *J* = 8.5, 7.2 Hz, C**H**(3)), 4.21 (dt, 1H, *J* = 6.9, 4.7 Hz, C**H**(4)), 3.76 (dd, 1H, *J* = 10.6, 4.5 Hz, C$\mathbf{H}(5)_a$), 3.68 (dd, 1H, *J* = 10.6, 4.9 Hz, C$\mathbf{H}(5)_b$), 2.58 (br. s, 1H, O**H**), 2.55 (dd, 1H, *J* = 8.7, 4.7 Hz, C**H**(2)), 2.29–2.18 (m, 1H, C$\mathbf{H}(CH_3)_2$), 1.09 (d, 3H, *J* = 7.0 Hz, CH(C$\mathbf{H_3}$)$_a$), 0.99 (d, 3H, *J* = 6.9 Hz, CH(C$\mathbf{H_3}$)$_b$); ^{13}C NMR (125 MHz, $CDCl_3$): δ 175.3 (**C**(1)), 137.5, 128.7, 128.1, 127.9 (Ar**C**), 81.6 (**C**(4)), 73.9 (**C**H_2Ph), 71.0 (**C**(3)), 69.0 (**C**(5)), 53.8 (**C**(2)), 27.0 (**C**H$(CH_3)_2$), 20.0 (CH(**C**H_3)$_a$), 19.0 (CH(**C**H_3)$_b$); HRMS (ESI-TOF) calculated for $C_{15}H_{20}O_4$ $[M+H]^+$ m/z 265.1434, found 265.1436; α_D^{21} = +21.3 (c = 1.00, $CHCl_3$).

5-Benzyloxy-3-hydroxy-2-*tert*-butyl-D-arabinolactone (10b). The compound was synthesized following the general procedure using (2*S*,3*S*,4*R*)-isopropyl-5-(benzyloxy)-3-hydroxy-2-*tert*-butyl-4-(2,2,6,6-tetramethylpiperidin-1-yloxy)-pentanoate (>20:1 dr, 143 mg, 300 μmol, 1.0 equiv.), Zn (196 mg, 3.00 mmol, 10 equiv.), toluene (1.5 mL) and H_2O:TFA (4:1, 1.5 mL). The crude product was purified by flash chromatography using 2:1 hexanes:EtOAc to yield the title compound (80.9 mg, 97% yield, >20:1 dr) as a colorless oil. HPLC analysis (AD, 5% IPA/hexanes, 1.0 mL/min, 220 nm) indicated 91% ee: t_R (major) = 19.1 minutes, t_R (minor) = 22.5 minutes. Due to the similar structural features and the consistent NMR-data of the title compound to 5-benzyloxy-3-hydroxy-2-methyl-D-arabinolactone (see above) the configuration of the title compound was assigned as arabino. IR (thin film): 3448, 2960, 2871, 1770, 1747, 1494, 1469, 1454, 1398, 1368, 1274, 1260, 1209, 1158, 1128, 1095, 1057, 1027, 969, 750, 698 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$): δ 7.41–7.24 (m, 5H, Ar**H**), 4.57 (s, 2H, C$\mathbf{H_2}$Ph), 4.32 (dd, 1H, *J* = 8.4, 7.2 Hz, C**H**(3)), 4.16 (dt, 1H, *J* = 7.0, 4.5 Hz, C**H**(4)), 3.78–3.71 (m, 1H, C$\mathbf{H}(5)_a$), 3.68 (dd, 1H, *J* = 10.7, 4.5 Hz, C$\mathbf{H}(5)_b$), 2.70 (br. s, 1H, O**H**), 2.40 (d, 1H, *J* = 8.6 Hz, C**H**(2)), 1.08 (s, 9H, C(C$\mathbf{H_3}$)$_3$); ^{13}C NMR (125 MHz, $CDCl_3$): δ 174.7 (**C**(1)), 137.5, 128.6, 128.1, 127.9 (Ar**C**), 81.1 (**C**(4)), 73.9 (**C**H_2Ph), 71.2 (**C**(3)), 68.9 (**C**(5)), 57.3 (**C**(2)), 32.2 (**C**$(CH_3)_3$), 57.3 (**C**(2)), 27.5 (C(**C**H_3)$_3$); HRMS (ESI-TOF) calculated for $C_{16}H_{22}O_4$ $[M+H]^+$ m/z 279.1591, found 279.1584; α_D^{22} = +21.1 (c = 1.00, $CHCl_3$).

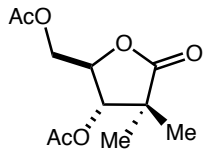
2-Allyl-5-benzyloxy-3-hydroxy-D-arabinolactone (11b). The compound was synthesized following the general procedure using (2*S*,3*S*,4*R*)-isopropyl-2-allyl-5-(benzyloxy)-3-hydroxy-4-(2,2,6,6-tetramethylpiperidin-1-yloxy)-pentanoate (13:1 dr, 138 mg, 300 μmol, 1.0 equiv.), Zn (196 mg, 3.00 mmol, 10 equiv.), toluene (1.5 mL) and H_2O:TFA (4:1, 1.5 mL). The crude product was purified by flash chromatography using 2:1 hexanes:EtOAc to yield the title compound (77.3 mg, 98% yield, 13:1 dr) as a colorless oil. Due to the similar structural features and the consistent NMR-data of the title compound to 5-benzyloxy-3-hydroxy-2-methyl-D-arabinolactone (see above) the configuration of the title compound was assigned as arabino. HPLC analysis (AS, 15% IPA/hexanes, 1.0 mL/min, 220 nm) indicated 91% ee: t_R (major)

= 16.1 minutes, t_R (minor) = 18.1 minutes. IR (thin film): 3448, 3078, 3063, 3028, 2922, 2866, 1760, 1641, 1494, 1454, 1363, 1325, 1252, 1173, 1118, 1054, 1027, 1017, 921, 740, 699 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$), arabino-isomer (major): δ 7.39–7.24 (m, 5H, Ar**H**), 5.88–5.76 (m, 1H, C**H**=CH_2), 5.19–5.09 (m, 2H, CH=C$\mathbf{H_2}$), 4.58 (d, 1H, *J* = 11.9 Hz, C$\mathbf{H_a}$Ph), 4.55 (d, 1H, *J* = 11.9 Hz, C$\mathbf{H_b}$Ph), 4.27 (dt, 1H, *J* = 6.8, 4.2 Hz, C**H**(4)), 4.21 (br. ddd, 1H, *J* = 4.1, 7.7, 7.7 Hz, C**H**(3)), 3.71 (d, 2H, *J* = 4.2 Hz, C$\mathbf{H_2}$(5)), 2.84 (br. d, 1H, *J* = 3.3 Hz, O**H**), 2.69 (ddd, 1H, *J* = 4.9, 8.2, 8.2 Hz, C**H**(2)), 2.65–2.33 (m, 2H, CH(2)C$\mathbf{H_2}$); ^{13}C NMR (125 MHz, $CDCl_3$), arabino-isomer (major): δ 175.7 (**C**(1)), 137.4 (Ar**C**), 134.2 (**C**H=CH_2), 128.6, 128.1, 127.9 (Ar**C**), 118.4 (CH=**C**H_2), 82.4 (**C**(4)), 73.8 (**C**H_2Ph), 73.0 (**C**(3)), 68.7 (**C**(5)), 48.1 (**C**(2)), 32.2 (CH(2)**C**H_2); ribo-isomer (minor): δ 178.1 (**C**(1)), 137.4 (Ar**C**), 135.7 (**C**H=CH_2), 128.7, 128.1, 127.7 (Ar**C**), 117.0 (CH=**C**H_2), 85.1 (**C**(4)), 73.8 (**C**H_2Ph), 71.0 (**C**(3)), 69.4 (**C**(5)), 44.5 (**C**(2)), 28.2 (CH(2)**C**H_2); HRMS (ESI-TOF) calculated for $C_{15}H_{18}O_4$ $[M+H]^+$ m/z 263.1278, found 263.1281; α_D^{21} = +38.3 (c = 1.00, $CHCl_3$).

2-Benzyl-5-benzyloxy-3-hydroxy-D-arabinolactone (12b). The compound was synthesized following the general procedure using (2*S*,3*S*,4*R*)-isopropyl-2-benzyl-5-(benzyloxy)-3-hydroxy-4-(2,2,6,6-tetramethylpiperidin-1-yloxy)-pentanoate (16:1 dr, 154 mg, 300 μmol, 1.0 equiv.), Zn (196 mg, 3.00 mmol, 10 equiv.), toluene (1.5 mL) and H_2O:TFA (4:1, 1.5 mL). The crude product was purified by flash chromatography using 2:1 hexanes:EtOAc to yield the title compound (87.9 mg, 94% yield, >20:1 dr) as a colorless oil. HPLC analysis (AS, 15% IPA/hexanes, 1.0 mL/min, 220 nm) indicated 90% ee: t_R (major) = 20.9 minutes, t_R (minor) = 24.4 minutes. Due to the similar structural features and the consistent NMR-data of the title compound to 5-benzyloxy-3-hydroxy-2-methyl-D-arabinolactone (see above) the configuration of the title compound was assigned as arabino. IR (thin film): 3448, 3084, 3058, 3028, 2922, 2861, 1754, 1603, 1494, 1455, 1363, 1325, 1244, 1168, 1110, 1080, 1053, 1027, 1004, 953, 913, 743, 699 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$): δ 7.43–7.21 (m, 10H, Ar**H**), 4.57 (d, 1H, *J* = 11.9 Hz, OC$\mathbf{H_a}$Ph), 4.53 (d, 1H, *J* = 11.9 Hz, OC$\mathbf{H_b}$Ph), 4.28 (dt, 1H, *J* = 6.4, 3.9 Hz, C**H**(4)), 4.22 (ddd, 1H, *J* = 4.4, 4.3, 6.5 Hz, C**H**(3)), 3.68–3.60 (m, 2H, C$\mathbf{H_2}$(5)), 2.55 (dt, 1H, *J* = 9.0, 8.6 Hz, C**H**(2)), 2.99–2.91 (m, 2H, CH(2)C$\mathbf{H_2}$), 2.49 (d, 1H, *J* = 4.3 Hz, O**H**); ^{13}C NMR (125 MHz, $CDCl_3$): δ 175.8 (**C**(1)), 137.7, 137.4, 129.2, 128.9, 128.6, 128.0, 127.9, 127.0 (Ar**C**), 82.7 (**C**(4)), 73.7 (O**C**H_2Ph), 72.6 (**C**(3)), 68.6 (**C**(5)), 50.1 (**C**(2)), 33.7 (C(2)**C**H_2); HRMS (ESI-TOF) calculated for $C_{19}H_{20}O_4$ $[M+H]^+$ m/z 313.1434, found 313.1431; α_D^{22} = +70.1 (c = 1.00, $CHCl_3$).

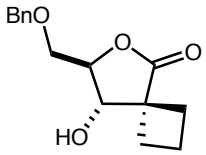
5-Benzyloxy-2-dimethyl-3-hydroxy-D-ribonolactone (5-Benzyloxy-2-dimethyl-3-hydroxy-D-arabinolactone) (13b). The compound was synthesized following the general procedure using (3*S*,4*R*)-isopropyl 5-(benzyloxy)-3-hydroxy-2,2-dimethyl-4-((2,2,6,6-tetramethylpiperidin-1-yl)oxy)pentanoate (>20:1 dr, 135 mg, 300 μmol, 10 equiv.), Zn (196 mg, 3.00 mmol, 4.0 equiv.), toluene (1.5 mL) and H_2O:TFA (4:1, 1.5 mL). The crude product was purified by flash chromatography using 2:1 hexanes:EtOAc to yield the title compound (72.7 mg, 97% yield, >20:1 dr) as colorless crystals. HPLC analysis (OJ, 5% IPA/hexanes, 1.0 mL/min, 220 nm) indicated 90% ee: t_R (major) = 62.6 minutes, t_R (minor) = 58.8 minutes. IR (thin film): 3430, 3063, 3028, 2972, 2935, 2871, 1778, 1753, 1494, 1455, 1388, 1365, 1328, 1287, 1213, 1121, 1105, 1055, 1027, 958, 921, 741, 699 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$): δ

7.40–7.27 (m, 5H, Ar**H**), 4.57 (s, 2H, C**H**$_2$Ph), 4.25 (dt, 1H, *J* = 8.0, 4.2 Hz, C**H**(4)), 4.04 (dd, 1H, *J* = 8.0, 5.1 Hz, C**H**(3)), 3.75 (dd, 1H, *J* = 10.9, 3.8 Hz, C**H**(5)$_{\mathbf{a}}$), 3.71 (dd, 1H, *J* = 10.9, 4.8 Hz, C**H**(5)$_{\mathbf{b}}$), 3.03 (d, 1H, *J* = 4.9 Hz, O**H**), 1.23 (s, 3H, C(2)(C**H**$_3$)$_{\mathbf{a}}$), 1.17 (s, 3H, C(2)(C**H**$_3$)$_{\mathbf{b}}$); ^{13}C NMR (125 MHz, $CDCl_3$): δ 180.4 (**C**(1)), 137.5, 128.6, 128.1, 127.9 (Ar**C**), 80.4 (**C**(4)), 76.0 (**C**(3)), 73.8 (**C**H$_2$Ph), 68.9 (**C**(5)), 43.6 (**C**(2)), 22.6 (C(2)(**C**H$_3$)$_{\mathbf{a}}$), 17.9 (C(2)(**C**H$_3$)$_{\mathbf{b}}$); HRMS (ESI-TOF) calculated for $C_{14}H_{18}O_4$ $[M+H]^+$ m/z 251.1278, found 251.1282; α_D^{21} = +34.4 (c = 1.00, $CHCl_3$). The configuration



of the title compound was determined from the corresponding debenzylated and diacetylated pentose. This compound was prepared by dissolving the title compound (13.6 mg, 54.3 μmol, 1.0 equiv.) in EtOH (1.1 mL) and treating it with Pd/C (10%, 5 mg). Hydrogen gas was bubbled through the reaction mixture for 5 minutes and the suspension was stirred at room temperature for 16 hours under H_2 atmosphere. The reaction mixture was filtered through Celite and the filtrate was evaporated to yield a colorless oil. The crude debenzylated product was dissolved in acetic anhydride (1mL) and pyridine (1mL), and stirred at room temperature for 16 hours. The mixture was concentrated in vacuum and co-evaporated with toluene (3 × 2 mL). The crude product was purified by flash chromatography using 1:1 hexanes:Et_2O to yield the title compound in the ribo/arabino-configuration as a colorless oil. The experimental data is in agreement with the literature.[16] ^{1}H NMR (500 MHz, $CDCl_3$): δ 5.11 (d, 1H, *J* = 6.1 Hz, C**H**(3)), 4.47–4.40 (m, 2H, C**H**$_2$(5)), 4.23–4.17 (m, 1H, C**H**(4)), 2.14, 2.10 (2s, 6H, 2 × C(O)C**H**$_3$), 1.36 (s, 3H, C(2)(C**H**$_3$)$_{\mathbf{a}}$), 1.22 (s, 3H, C(2)(C**H**$_3$)$_{\mathbf{b}}$); ^{13}C NMR (125 MHz, $CDCl_3$): δ 178.7 (**C**(1)), 170.5, 170.2 (2 × **C**(O)CH_3), 77.9 (**C**(4)), 76.4 (**C**(3)), 63.0 (**C**(5)), 43.2 (**C**(2)), 24.0 (C(2)(**C**H$_3$)$_{\mathbf{a}}$), 20.8, 20.8 (2 × C(O)**C**H_3), 19.4 (C(2)(**C**H$_3$)$_{\mathbf{b}}$). The configuration was confirmed by single-crystal X-ray analysis (see appendix).

5-Benzyloxy-3-hydroxy-2-spirocyclobutyl-D-ribonolactone (5-Benzyloxy-3-hydroxy-2-spirocyclobutyl-D-arabinolactone) (14b). The compound was synthesized following the general procedure using isopropyl 1-((1*S*,2*R*)-3-(benzyloxy)-1-hydroxy-2-((2,2,6,6-tetramethylpiperidin-1-yl)oxy)propyl)cyclobutanecarboxylate (>20:1 dr, 138 mg, 300 μmol, 1.0 equiv.), Zn (196 mg, 3.00 mmol, 10 equiv.), toluene (1.5 mL) and H_2O:TFA (4:1, 1.5 mL). The crude product was purified by flash chromatography using 3:1 hexanes:EtOAc to yield the title compound (77.7 mg, 99% yield, >20:1 dr) as a white powder. HPLC analysis (OJ, 5% IPA/hexanes, 1.0 mL/min, 220 nm) indicated 90% ee: t_R (major) = 23.7 minutes, t_R (minor) = 26.7 minutes. Due to the similar structural features and the consistent NMR-data of the title compound to 5-benzyloxy-2-dimethyl-3-hydroxy-D-ribonolactone (see above) the configuration of the title compound was assigned as ribo/arabino. IR (thin film): 3438, 3058, 3028, 2987, 2943, 2861, 1749, 1494, 1454, 1363, 1328, 1290, 1244, 1195, 1120, 1052, 1006, 948, 918, 740, 699 cm^{-1}; ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.39–7.25 (m, 5H, Ar**H**), 4.52 (s, 2H, C**H**$_2$Ph), 4.25 (dt, 1H, *J* = 4.6, 4.6 Hz, C**H**(4)), 4.18 (dd, 1H, *J* = 4.9, 4.9 Hz, C**H**(3)), 3.64 (dd, 1H, *J* = 10.8, 4.5 Hz, C**H**(5)$_{\mathbf{a}}$), 3.61 (dd, 1H, *J* = 10.7, 4.4 Hz, C**H**(5)$_{\mathbf{b}}$), 3.18 (br d, 1H, *J* = 4.9 Hz, O**H**), 2.57–1.85 (m, 6H, (C**H**$_2$)$_3$); ^{13}C NMR (125 MHz, $CDCl_3$): δ 180.2 (**C**(1)), 137.4 128.6, 128.1, 127.9 (Ar**C**), 82.5



[16] Ghosh, A. K.; Kass, J.; Anderson, D. D.; Xu, X. M.; Marian, C. *Org. Lett.* **2008**, *10*, 4811.

(**C**(4)), 75.1 (**C**(3)), 73.7 (**C**H_2Ph), 68.9 (**C**(5)), 48.2 (**C**(2)), 28.7, 23.5 (**C**H_2(CH_2)**C**H_2), 16.4 (CH_2(**C**H_2)CH_2); HRMS (ESI-TOF) calculated for $C_{15}H_{18}O_4$ $[M+H]^+$ m/z 263.1278, found 263.1283; α_D^{22} = +19.8 (c = 1.00, $CHCl_3$).

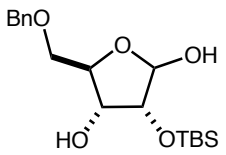
5-Benzyloxy-3-hydroxy-2-spirocyclopentyl-D-ribonolactone (5-Benzyloxy-3-hydroxy-2-spirocyclopentyl-D-arabinolactone) (15b). The compound was synthesized following the general procedure using isopropyl-1-((1*S*,2*R*)-3-(benzyloxy)-1-hydroxy-2-((2,2,6,6-tetramethylpiperidin-1-yl)oxy)propyl)cyclopentanecarboxylate (>20:1 dr, 143 mg, 300 μmol, 1.0 equiv.), Zn (196 mg, 3.00 mmol, 10 equiv.), toluene (1.5 mL) and H_2O:TFA (4:1, 1.5 mL). The crude product was purified by flash chromatography using 3:1 hexanes:EtOAc to yield the title compound (81.1 mg, 98% yield, >20:1 dr) as a colorless oil. HPLC analysis (OJ, 7% IPA/hexanes, 1.0 mL/min, 220 nm) indicated 90% ee: t_R (major) = 18.1 minutes, t_R (minor) = 20.3 minutes. Due to the similar structural features and the consistent NMR-data of the title compound to 5-benzyloxy-2-dimethyl-3-hydroxy-D-ribonolactone (see above) the configuration of the title compound was assigned as ribo/arabino. IR (thin film): 3429, 3063, 3028, 2931, 2862, 1747, 1494, 1452, 1362, 1325, 1312, 1269, 1242, 1185, 1151, 1117, 1080, 1053, 1029, 948, 908, 845, 738, 698 cm^{-1}; ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.39–7.24 (m, 5H, Ar**H**), 4.56 (s, 2H, C$\mathbf{H_2}$Ph), 4.21 (dt, 1H, *J* = 7.2, 4.8 Hz, C**H**(4)), 4.10 (dd, 1H, *J* = 7.1, 5.1 Hz, C**H**(3)), 3.71 (dd, 1H, *J* = 10.9, 4.2 Hz, C**H**$(5)_\mathbf{a}$), 3.68 (dd, 1H, *J* = 10.9, 4.9 Hz, C**H**$(5)_\mathbf{b}$), 3.18 (br. d, 1H, *J* = 3.7 Hz, O**H**), 2.31–1.53 (m, 8H, $(C\mathbf{H_2})_\mathbf{4}$); ^{13}C NMR (125 MHz, $CDCl_3$): δ 181.2 (**C**(1)), 137.4 128.6, 128.0, 127.8 (Ar**C**), 81.4 (**C**(4)), 75.6 (**C**(3)), 73.7 (**C**H_2Ph), 68.9 (**C**(5)), 53.5 (**C**(2)), 35.4, 29.8 (**C**H_2(CH_2)$_2$**C**H_2), 26.1, 26.1 (CH_2(**C**H_2)$_\mathbf{2}$$CH_2$); HRMS (ESI-TOF) calculated for $C_{16}H_{20}O_4$ $[M+H]^+$ m/z 277.1434, found 277.1432. α_D^{22} = +19.4 (c = 1.00, $CHCl_3$).

5-Benzyloxy-3-hydroxy-2-spirocyclohexyl-D-ribonolactone (5-Benzyloxy-3-hydroxy-2-spirocyclohexyl-D-arabinolactone) (16b). The compound was synthesized following the general procedure using isopropyl-1-((1*S*,2*R*)-3-(benzyloxy)-1-hydroxy-2-((2,2,6,6-tetramethylpiperidin-1-yl)oxy)propyl)cyclohexanecarboxylate (>20:1 dr, 147 mg, 300 μmol, 1.0 equiv.), Zn (196 mg, 3.00 mmol, 10 equiv.), toluene (1.5 mL) and H_2O:TFA (4:1, 1.5 mL). The crude product was purified by flash chromatography using 3:1 hexanes:EtOAc to yield the title compound (85.0 mg, 98% yield, >20:1 dr) as a white powder. HPLC analysis (OJ, 10% IPA/hexanes, 1.0 mL/min, 220 nm) indicated 89% ee: t_R (major) = 19.1 minutes, t_R (minor) = 21.8 minutes. Due to the similar structural features and the consistent NMR-data of the title compound to 5-benzyloxy-2-dimethyl-3-hydroxy-D-ribonolactone (see above) the configuration of the title compound was assigned as ribo/arabino. IR (thin film): 3433, 3063, 3028, 2956, 2866, 1750, 1497, 1451, 1363, 1330, 1276, 1259, 1209, 1156, 1113, 1053, 989, 948, 913, 764, 750, 699 cm^{-1}; ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.40–7.23 (m, 5H, Ar**H**), 4.56 (s, 2H, C$\mathbf{H_2}$Ph), 4.29 (dt, 1H, *J* = 7.2, 4.6 Hz, C**H**(4)), 4.03 (dd, 1H, *J* = 6.8, 5.8 Hz, C**H**(3)), 3.71 (dd, 1H, *J* = 11.1, 4.4 Hz, C**H**$(5)_\mathbf{a}$), 3.68 (dd, 1H, *J* = 10.9, 4.9 Hz, C**H**$(5)_\mathbf{b}$), 3.00 (br. s, 1H, O**H**), 2.12–1.20 (m, 10H, $(C\mathbf{H_2})_\mathbf{5}$); ^{13}C NMR (125 MHz, $CDCl_3$): δ 179.4 (**C**(1)), 137.5 128.6, 128.0, 127.8 (Ar**C**), 80.7 (**C**(4)), 76.2 (**C**(3)), 73.7 (**C**H_2Ph), 69.2 (**C**(5)), 46.3 (**C**(2)), 32.3, 26.6 (**C**H_2(CH_2)$_3$**C**H_2), 25.3 ((CH_2)$_2$**C**H_2(CH_2)$_2$), 21.6, 21.5 (**C**$H_2$$CH_2CCH_2$**C**$H_2$); HRMS (ESI-TOF) calculated for $C_{17}H_{22}O_4$

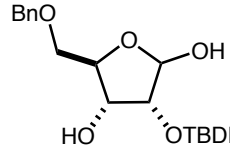
$[M+H]^+$ m/z 291.1591, found 291.1593; α_D^{21} = +36.8 (c = 1.00, $CHCl_3$).

General Procedure for the Reduction of Ribono- and Arabinolactones to the Corresponding Lactols. To a solution of the lactone in toluene (c = 0.1 M) was added diisobutylaluminum hydride (DIBAL-H, 4.0 equiv.) slowly over 1 hour at –78 °C. The solution was stirred for 1 hour at –78 °C, then quenched by the slow addition of MeOH (10 equiv.) over 15 minutes under vigorous stirring. The solution was stirred for 15 minutes at –78 °C, then warmed to room temperature and stirred for an additional 30 minutes, resulting in a gel. This material was transferred into an separatory funnel and diluted with aq. sat. NH_4Cl (5 mL) and H_2O (5 mL). The aqueous layer was extracted vigorously with Et_2O (4 × 5 mL) and the combined organic layers were dried over $MgSO_4$, filtered, and concentrated under vacuum. The crude product was purified by flash chromatography.

5-Benzyloxy-2-(*tert*-butyldimethylsilyl)oxy-1-hydroxy-3-hydroxy-D-ribose (2c). The compound was synthesized following the general procedure using 5-benzyloxy-2-(*tert*-butyldimethylsilyl)oxy-3-hydroxy-D-ribonolactone (>20:1 dr, 88.1 mg, 250 μmol, 1.0 equiv.), DIBAL-H (1.0 M in toluene, 1.00 mL, 1.00 mmol, 4.0 equiv.) and toluene (2.5 mL). The crude product was purified by flash chromatography using 4:1 hexanes:EtOAc to yield the title compound (56.6 mg, 64% yield, >20:1 dr with respect to the configuration at C(2), C(3) and C(4), 1:1 mixture of α- and β-anomers) as a colorless oil. IR (thin film): 3423, 2952, 2931, 2896, 2856, 1494, 1472, 1462, 1454, 1406, 1388, 1360, 1254, 1211, 1125, 1085, 1047, 1024, 910, 838, 779, 736, 698 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$), α-isomer: δ 7.40–7.24 (m, 5H, Ar**H**), 5.24 (dd, 1H, *J* = 10.0, 4.4 Hz, C**H**(1)), 4.59 (d, 1H, *J* = 12.0 Hz, C$\mathbf{H_a}$Ph), 4.52 (d, 1H, *J* = 12.0 Hz, C$\mathbf{H_b}$Ph), 4.23–4.18 (m, 2H, C**H**(2), C**H**(4)), 4.06–4.01 (m, 1H, C**H**(3)), 3.66–3.61 (m, 2H, C$\mathbf{H_a}$(5), CH(1)O**H**), 3.60 (dd, 1H, *J* = 10.6, 3.7 Hz, C$\mathbf{H_b}$(5)), 2.57 (d, 1H, *J* = 4.3 Hz, CH(3)O**H**), 0.93 (s, 9H, C(C$\mathbf{H_3}$)$_3$)), 0.15 (s, 6H, Si(C$\mathbf{H_3}$)$_2$); β-isomer: δ 7.40–7.24 (m, 5H, Ar**H**), 5.10 (d, 1H, *J* = 8.2 Hz, C**H**(1)), 4.63 (d, 1H, *J* = 11.7 Hz, C$\mathbf{H_a}$Ph), 4.58 (d, 1H, *J* = 11.7 Hz, C$\mathbf{H_b}$Ph), 4.29 (ddd, 1H, *J* = 8.4, 5.0, 4.9 Hz, C**H**(3)), 4.10 (dt, 1H, *J* = 4.8, 2.7 Hz, C**H**(4)), 4.06–4.01 (m, 1H, C**H**(2)), 3.71 (dd, 1H, *J* = 10.2, 2.6 Hz, C$\mathbf{H_a}$(5)), 3.66–3.61 (m, 2H, C$\mathbf{H_b}$(5), CH(1)O**H**), 2.72 (d, 1H, *J* = 8.4 Hz, CH(3)O**H**), 0.92 (s, 9H, C(C$\mathbf{H_3}$)$_3$)), 0.15, 0.13 (2s, 6H, Si(C$\mathbf{H_3}$)$_2$); ^{13}C NMR (125 MHz, $CDCl_3$), α-isomer: δ 137.1, 128.8, 128.2, 128.0 (Ar**C**), 97.1 (**C**(1)), 81.8 (**C**(4)), 73.7 (**C**H_2Ph), 72.6 (**C**(2)), 72.3 (**C**(3)), 70.3 (**C**(5)), 25.9 (C(**C**H_3)$_3$), 18.4 (**C**(CH$_3$)$_3$), –4.83, –4.92 (2s, 6H, Si(C$\mathbf{H_3}$)$_2$); β-isomer: δ 138.0, 128.5, 127.8, 127.7 (Ar**C**), 102.9 (**C**(1)), 84.3 (**C**(4)), 78.2 (**C**(2)), 73.9 (**C**H_2Ph), 71.7 (**C**(3)), 70.2 (**C**(5)), 25.9 (C(**C**H_3)$_3$), 18.3 (**C**(CH$_3$)$_3$), –4.46, –4.70 (2s, 6H, Si(C$\mathbf{H_3}$)$_2$); HRMS (ESI-TOF) calculated for $C_{18}H_{30}O_5Si$ $[M+Na]^+$ m/z 377.1755, found 377.1753; α_D^{21} = +233.0 (c = 1.00, $CHCl_3$).

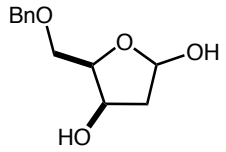


5-Benzyloxy-2-(*tert*-butyldiphenylsilyl)oxy-1-hydroxy-3-hydroxy-D-ribose (3c). The compound was synthesized following the general procedure using 5-benzyloxy-2-(*tert*-butyldiphenylsilyl)oxy-3-hydroxy-D-ribonolactone (>20:1 dr, 119 mg, 250 μmol, 1.0 equiv.), DIBAL-H (1.0 M in toluene, 1.00 mL, 1.00 mmol, 4.0 equiv.) and toluene (2.5 mL). The crude product was purified by flash chromatography using 5:1 to 4:1 hexanes:EtOAc to yield the title compound (73.9 mg, 62% yield, >20:1 dr with respect

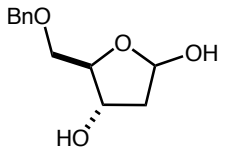


to the configuration at C(2), C(3) and C(4), 1:1 mixture of α- and β-anomers) as a colorless oil. IR (thin film): 3409, 3070, 2930, 2893, 2857, 1589, 1472, 1454, 1427, 1362, 1112, 1072, 1044, 1026, 999, 906, 822, 740, 700, 621, 612 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$), α-isomer: δ 7.68–6.98 (m, 15H, Ar**H**), 4.85 (dd, 1H, *J* = 9.6, 4.4 Hz, C**H**(1)), 4.35 (d, 1H, *J* = 12.1 Hz, C$\mathbf{H_a}$Ph), 4.28 (d, 1H, *J* = 12.0 Hz, C$\mathbf{H_b}$Ph), 4.22 (dt, 1H, *J* = 3.4, 1.9 Hz, C**H**(4)), 4.16–4.07 (m, 1H, C**H**(2)), 3.87–3.83 (m, 1H, C**H**(3)), 2.58 (d, 1H, *J* = 9.8 Hz, CH(1)O**H**), 3.38 (d, 2H, *J* = 3.5 Hz, C$\mathbf{H_2}$(5)), 2.69 (d, 1H, *J* = 2.3 Hz, CH(3)O**H**), 1.04 or 1.05 (s, 9H, C(C$\mathbf{H_3}$)$_3$)); β-isomer: δ 7.68–6.98 (m, 15H, Ar**H**), 4.95 (d, 1H, *J* = 8.0, Hz, C**H**(1)), 4.48 (d, 1H, *J* = 11.8 Hz, C$\mathbf{H_a}$Ph), 4.44 (d, 1H, *J* = 11.7 Hz, C$\mathbf{H_b}$Ph), 4.16–4.07 (m, 2H, C**H**(3), C**H**(4)), 4.05 (dd, 1H, *J* = 4.8, 0.9 Hz, C**H**(2)), 2.60 (dd, 1H, *J* = 10.2, 2.8 Hz, C$\mathbf{H_a}$(5)), 2.50 (dd, 1H, *J* = 10.2, 3.1 Hz, C$\mathbf{H_b}$(5)), 3.25 (d, 1H, *J* = 8.0 Hz, CH(1)O**H**), 2.68 (d, 1H, *J* = 8.2 Hz, CH(3)O**H**), 1.04 or 1.05 (s, 9H, C(C$\mathbf{H_3}$)$_3$)); ^{13}C NMR (125 MHz, $CDCl_3$), α-isomer: δ 137.9–127.6 (several Ar**C**), 97.2 (**C**(1)), 82.7 (**C**(4)), 73.5 (**C**H_2Ph), 73.3 (**C**(2)), 72.5 (**C**(3)), 70.2 or 70.3 (**C**(5)), 27.1 (C(**C**H_3)$_3$), 19.4 or 19.5 (**C**(CH$_3$)$_3$); β-isomer: δ 137.9–127.6 (several Ar**C**), 102.2 (**C**(1)), 84.2 (**C**(4)), 78.8 (**C**(2)), 73.8 (**C**H_2Ph), 72.0 (**C**(3)), 70.2 or 70.3 (**C**(5)), 27.1 (C(**C**H_3)$_3$), 19.4 or 19.5 (**C**(CH$_3$)$_3$); HRMS (ESI-TOF) calculated for $C_{28}H_{34}O_5Si$ $[M+Na]^+$ m/z 501.2068, found 501.2067; α_D^{21} = +107.2 (c = 1.00, $CHCl_3$).

5-Benzyloxy-1-hydroxy-3-hydroxy-2-methoxy-D-ribose (4c). The compound was synthesized following the general procedure using 5-benzyloxy-3-hydroxy-2-methoxy-D-ribonolactone (>20:1 dr, 63.1 mg, 250 μmol, 1.0 equiv.), DIBAL-H (1.0 M in toluene, 1.00 mL, 1.00 mmol, 4.0 equiv.) and toluene (2.5 mL). The crude product was purified by flash chromatography using 1:1 hexanes:EtOAc to yield the title compound (44.7 mg, 70% yield, >20:1 dr with respect to the configuration at C(2), C(3) and C(4), 1:2 mixture of α- and β-anomers) as a colorless oil. IR (thin film): 3395, 2928, 2832, 1640, 1497, 1454, 1364, 1195, 1087, 1028, 980, 741, 699, 606 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$), α-isomer: δ 7.39–7.25 (m, 5H, Ar**H**), 5.32 (dd, 1H, *J* = 8.7, 4.4 Hz, C**H**(1)), 4.60 (d, 1H, *J* = 11.9 Hz, C$\mathbf{H_a}$Ph), 4.57 (d, 1H, *J* = 11.8 Hz, C$\mathbf{H_b}$Ph), 4.28 (ddd, 1H, *J* = 6.0, 6.0, 4.1 Hz, C**H**(3)), 4.00–3.93 (m, 1H, C**H**(4)), 3.87 (d, 1H, *J* = 8.7 Hz, CH(1)O**H**), 3.70 (dd, 1H, *J* = 6.2, 4.4 Hz, C**H**(2)), 3.58 (dd, 1H, *J* = 10.0, 4.2 Hz, C$\mathbf{H_a}$(5)), 3.63 (dd, 1H, *J* = 10.0, 4.8 Hz, C$\mathbf{H_b}$(5)), 3.46 (s, 3H, C$\mathbf{H_3}$), 2.71 (d, 1H, *J* = 3.9 Hz, CH(3)O**H**); β-isomer: δ 7.39–7.25 (m, 5H, Ar**H**), 5.36 (d, 1H, *J* = 4.8 Hz, C**H**(1)), 4.58 (d, 1H, *J* = 12.0 Hz, C$\mathbf{H_a}$Ph), 4.52 (d, 1H, *J* = 12.0 Hz, C$\mathbf{H_b}$Ph), 4.31 (dt, 1H, *J* = 6.0, 4.0 Hz, C**H**(4)), 4.00–3.93 (m, 1H, C**H**(4)), 3.77 (d, 1H, *J* = 4.4 Hz, CH(1)O**H**), 3.70–3.68 (m, 1H, C**H**(2)), 3.58 (dd, 1H, *J* = 8.8, 3.4 Hz, C$\mathbf{H_a}$(5)), 3.55 (dd, 1H, *J* = 8.8, 4.8 Hz, C$\mathbf{H_b}$(5)), 3.36 (s, 3H, C$\mathbf{H_3}$), 2.97 (d, 1H, *J* = 7.2 Hz, CH(3)O**H**); ^{13}C NMR (125 MHz, $CDCl_3$), α-isomer: δ 137.4, 128.7, 128.2, 128.1 (Ar**C**), 95.5 (**C**(1)), 86.8 (**C**(2)), 80.9 (**C**(4)), 75.0 (**C**(3)), 73.8 (**C**H_2Ph), 70.5 (**C**(5)), 58.3 (**C**H_3); β-isomer: δ 137.8, 128.6, 128.0, 128.0 (Ar**C**), 100.7 (**C**(1)), 90.1 (**C**(2)), 84.1 (**C**(4)), 76.3 (**C**(3)), 73.6 (**C**H_2Ph), 70.6 (**C**(5)), 57.7 (**C**H_3); HRMS (ESI-TOF) calculated for $C_{13}H_{18}O_5$ $[M+Na]^+$ m/z 277.1046, found 277.1049; α_D^{21} = +102.9 (c = 1.00, $CHCl_3$).

5-Benzyloxy-2-desoxy-1-hydroxy-3-hydroxy-D-lyxose (5-Benzyloxy-2-desoxy-1-hydroxy-3-hydroxy-D-xylose) (5c). 

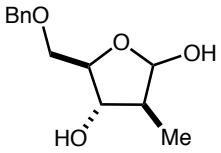
The compound was synthesized following the general procedure using 5-benzyloxy-2-desoxy-3-hydroxy-D-lyxolactone (>20:1 dr, 55.6 mg, 250 μmol, 1.0 equiv.), DIBAL-H (1.0 M in toluene, 1.00 mL, 1.00 mmol, 4.0 equiv.) and toluene (2.5 mL). The crude product was purified by flash chromatography using 1:2 hexanes:EtOAc to yield the title compound (42.3 mg, 75% yield, >20:1 dr with respect to the configuration at C(3) and C(4), 1:3 mixture of α- and β-anomers along with minor quantities of open aldehyde corresponding to the title compound (4%) as a white powder. IR (thin film): 3406, 3057, 3027, 2924, 2869, 1494, 1454, 1367, 1205, 1099, 1068, 1028, 1009, 836, 742, 699, 614 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$), α-isomer: δ 7.40–7.27 (m, 5H, Ar**H**), 5.71 (dt, 1H, *J* = 4.0, 3.2 Hz, C**H**(1)), 4.59 (s, 2H, C$\mathbf{H_2}$Ph), 4.59–4.51 (m, 1H, C**H**(3)), 4.28 (dt, 1H, *J* = 4.7, 4.6 Hz, C**H**(4)), 3.79 (d, 2H, *J* = 4.7 Hz, C$\mathbf{H_2}$(5)), 2.96 (d, 1H, *J* = 2.4 Hz, CH(1)O**H**), 2.74 (d, 1H, *J* = 5.3 Hz, CH(3)O**H**), 2.20–2.07 (m, 2H, C$\mathbf{H_2}$(2)); β-isomer: δ 7.40–7.27 (m, 5H, Ar**H**), 5.47 (dd, 1H, *J* = 8.1, 4.4 Hz, C**H**(1)), 4.62 (d, 1H, *J* = 11.9 Hz, C$\mathbf{H_a}$Ph), 4.59 (d, 1H, *J* = 11.9 Hz, C$\mathbf{H_b}$Ph), 4.59–4.51 (m, 1H, C**H**(3)), 4.09 (dt, 1H, *J* = 5.7, 3.8 Hz, C**H**(4)), 3.86 (dd, 1H, *J* = 10.2, 5.6 Hz, C$\mathbf{H_a}$(5)), 3.84 (dd, 1H, *J* = 10.2, 5.8 Hz, C$\mathbf{H_b}$(5)), 3.77 (d, 1H, *J* = 8.2 Hz, CH(1)O**H**), 3.15 (d, 1H, *J* = 5.9 Hz, CH(3)O**H**), 2.17–1.91 (m, 2H, C$\mathbf{H_2}$(2)); ^{13}C NMR (125 MHz, $CDCl_3$), α-isomer: δ 137.5, 128.7, 128.0, 128.0 (Ar**C**), 98.0 (**C**(1)), 78.8 (**C**(4)), 74.0 (**C**H_2Ph), 72.8 (**C**(3)), 68.8 (**C**(5)), 43.7 (**C**(2)); β-isomer: δ 137.6, 128.7, 128.1, 128.0 (Ar**C**), 99.2 (**C**(1)), 82.0 (**C**(4)), 73.9 (**C**(3)), 72.3 (**C**H_2Ph), 69.9 (**C**(5)), 42.1 (**C**(2)); HRMS (ESI-TOF) calculated for $C_{12}H_{16}O_4$ $[M+Na]^+$ m/z 247.0941, found 247.0939; α_D^{21} = –225.7 (c = 1.00, $CHCl_3$).

5-Benzyloxy-2-desoxy-1-hydroxy-3-hydroxy-D-ribose (5-Benzyloxy-2-desoxy-1-hydroxy-3-hydroxy-D-arabinose) (6c). 

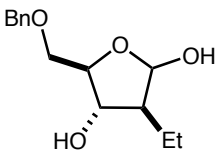
The compound was synthesized following the general procedure using 5-benzyloxy-2-desoxy-3-hydroxy-D-ribonolactone (>20:1 dr, 55.6 mg, 250 μmol, 1.0 equiv.), DIBAL-H (1.0 M in toluene, 1.00 mL, 1.00 mmol, 4.0 equiv.) and toluene (2.5 mL). The crude product was purified by flash chromatography using 1:2 hexanes:EtOAc to yield the title compound (43.1 mg, 77% yield, >20:1 dr with respect to the configuration at C(3) and C(4), 1:3 mixture of α- and β-anomers) as a colorless oil. IR (thin film): 3392, 3028, 2922, 2861, 1494, 1454, 1363, 1259, 1209, 1178, 1077, 1027, 961, 915, 842, 741, 699 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$), α-isomer: δ 7.33–7.18 (m, 5H, Ar**H**), 5.48 (ddd, 1H, *J* = 8.0, 5.4, 2.4 Hz, C**H**(1)), 4.53 (d, 1H, *J* = 11.7 Hz, C$\mathbf{H_a}$Ph), 4.48 (d, 1H, *J* = 11.8 Hz, C$\mathbf{H_b}$Ph), 4.44–4.38 (m, 1H, C**H**(3)), 4.01 (dt, 1H, *J* = 3.7, 3.6 Hz, C**H**(4)), 3.84 (d, 1H, *J* = 8.1 Hz, CH(1)O**H**), 3.55 (d, 2H, *J* = 3.9 Hz, C$\mathbf{H_2}$(5)), 2.18 (d, 1H, *J* = 5.0 Hz, CH(3)O**H**), 2.17–1.91 (m, 2H, C$\mathbf{H_2}$(2)); β-isomer: δ 7.33–7.18 (m, 5H, Ar**H**), 5.50 (t, 1H, *J* = 5.0 Hz, C**H**(1)), 4.47 (d, 1H, *J* = 11.9 Hz, C$\mathbf{H_a}$Ph), 4.44 (d, 1H, *J* = 12.1 Hz, C$\mathbf{H_b}$Ph), 4.29 (dt, 1H, *J* = 4.9, 1.4 Hz, C**H**(4)), 4.21–4.16 (m, 1H, C**H**(3)), 3.64 (d, 1H, *J* = 5.5 Hz, CH(1)O**H**), 3.43 (dd, 1H, *J* = 10.1, 4.8 Hz, C$\mathbf{H_a}$(5)), 3.34 (dd, 1H, *J* = 10.1, 4.8 Hz, C$\mathbf{H_b}$(5)), 2.94 (d, 1H, *J* = 7.6 Hz, CH(3)O**H**), 2.17–1.91 (m, 2H, C$\mathbf{H_2}$(2)); ^{13}C NMR (125 MHz, $CDCl_3$), α-isomer: δ 137.2, 128.7, 128.3, 128.1 (Ar**C**), 99.3 (**C**(1)), 85.2 (**C**(4)), 73.9 (**C**H_2Ph), 73.5 (**C**(3)), 71.3 (**C**(5)), 44.2 (**C**(2)); β-isomer: δ 137.9, 128.6, 127.9, 127.8 (Ar**C**), 99.5 (**C**(1)), 86.3 (**C**(4)), 73.6 (**C**(3)), 73.6 (**C**H_2Ph), 70.6 (**C**(5)), 41.4 (**C**(2)); HRMS (ESI-TOF) calculated for $C_{12}H_{16}O_4$

$[M+Na]^+$ m/z 247.0941, found 247.0939; α_D^{20} = +325.5 (c = 1.00, $CHCl_3$).

5-Benzyloxy-1-hydroxy-3-hydroxy-2-methyl-D-arabinose (7c). The compound was synthesized following the general procedure using 5-benzyloxy-3-hydroxy-2-methyl-D-arabinolactone (11:1 dr, 59.1 mg, 250 μmol, 1.0 equiv.), DIBAL-H (1.0 M in toluene, 1.00 mL, 1.00 mmol, 4.0 equiv.) and toluene (2.5 mL). The crude product was purified by flash chromatography using 1:1 hexanes:EtOAc to yield the title compound (48.8 mg, 82% yield, >20:1 dr with respect to the configuration at C(2), C(3) and C(4), 1:1.5 mixture of α- and β-anomers) as colorless crystals. IR (thin film): 3380, 3028, 2962, 2922, 2871, 1494, 1454, 1363, 1274, 1259, 1211, 1054, 1029, 980, 750, 698 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$), α-isomer: δ 7.39–7.25 (m, 5H, Ar**H**), 5.22 (br. dd, 1H, *J* = 6.6, 5.2 Hz, C**H**(1)), 4.61 (d, 1H, *J* = 11.9 Hz, C$\mathbf{H_a}$Ph), 4.57 (d, 1H, *J* = 11.8 Hz, C$\mathbf{H_b}$Ph), 4.03–3.95 (m, 2H, C**H**(3), C**H**(4)), 3.63 (d, 2H, *J* = 4.0 Hz, C$\mathbf{H_2}$(5)), 3.49 (d, 1H, *J* = 6.6 Hz, CH(1)O**H**), 2.30 (br. s, 1H, CH(3)O**H**), 2.20–2.08 (m, 1H, C**H**(2)), 1.10 (d, 3H, *J* = 6.9 Hz, C$\mathbf{H_3}$); β-isomer: δ 7.39–7.25 (m, 5H, Ar**H**), 5.12 (br. s, 1H, C**H**(1)), 4.58 (d, 1H, *J* = 12.3 Hz, C$\mathbf{H_a}$Ph), 4.55 (d, 1H, *J* = 12.2 Hz, C$\mathbf{H_b}$Ph), 4.23 (dt, 1H, *J* = 5.4, 4.9 Hz, C**H**(4)), 4.73–3.65 (m, 2H, C**H**(3), CH(1)O**H**), 3.59 (d, 2H, *J* = 5.7 Hz, C$\mathbf{H_2}$(5)), 2.77 (br. s, 1H, CH(3)O**H**), 2.20–2.08 (m, 1H, C**H**(2)), 1.03 (d, 3H, *J* = 7.4 Hz, C$\mathbf{H_3}$); ^{13}C NMR (125 MHz, $CDCl_3$), α-isomer: δ 137.4, 128.7, 128.1, 127.9 (Ar**C**), 100.0 (**C**(1)), 83.6 (**C**(4)), 77.6 (**C**(3)), 73.8 (**C**H_2Ph), 70.8 (**C**(5)), 47.3 (**C**(2)), 11.0 (**C**H_3); β-isomer: δ 137.9, 128.6, 128.0, 127.9 (Ar**C**), 104.0 (**C**(1)), 84.4 (**C**(4)), 79.3 (**C**(3)), 73.6 (**C**H_2Ph), 71.1 (**C**(5)), 49.1 (**C**(2)), 15.1 (**C**H_3); HRMS (ESI-TOF) calculated for $C_{13}H_{18}O_4$ $[M+Na]^+$ m/z 261.1097, found 261.1100; α_D^{21} = +2.55 (c = 1.00, $CHCl_3$).



5-Benzyloxy-2-ethyl-1-hydroxy-3-hydroxy-D-arabinose (8c). The compound was synthesized following the general procedure using 5-benzyloxy-2-ethyl-3-hydroxy-D-arabinolactone (13:1 dr, 62.6 mg, 250 μmol, 1.0 equiv.), DIBAL-H (1.0 M in toluene, 1.00 mL, 1.00 mmol, 4.0 equiv.) and toluene (2.5 mL). The crude product was purified by flash chromatography using 1:1 hexanes:EtOAc to yield the title compound (52.8 mg, 84% yield, >20:1 dr with respect to the configuration at C(2), C(3) and C(4), 1:2 mixture of α- and β-anomers) as colorless crystals. The configuration was confirmed by single-crystal X-ray analysis (see appendix). IR (thin film): 3382, 3058, 3028, 2957, 2928, 2871, 1494, 1454, 1360, 1330, 1269, 1244, 1209, 1061, 1022, 971, 910, 867, 802, 735, 698 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$), α-isomer: δ 7.38–7.25 (m, 5H, Ar**H**), 5.30 (dd, 1H, *J* = 6.8, 4.9 Hz, C**H**(1)), 4.60 (d, 1H, *J* = 11.8 Hz, C$\mathbf{H_a}$Ph), 4.56 (d, 1H, *J* = 11.8 Hz, C$\mathbf{H_b}$Ph), 4.04 (br. dd, 1H, C**H**(3)), 3.98 (dt, 1H, *J* = 6.0, 4.0 Hz, C**H**(4)), 3.62 (d, 2H, *J* = 4.0 Hz, C$\mathbf{H_2}$(5)), 3.62 (br. d, 1H, CH(1)O**H**), 2.38 (br. d, 1H, *J* = 4.0 Hz, CH(3)O**H**), 2.20–1.93 (m, 1H, C**H**(2)), 1.64–1.50 (m, 2H, CH(2)C$\mathbf{H_2}$), 0.99 (t, 3H, *J* = 7.4 Hz, C$\mathbf{H_3}$); β-isomer: δ 7.38–7.25 (m, 5H, Ar**H**), 5.18 (dd, 1H, *J* = 3.9, 1.8 Hz, C**H**(1)), 4.57 (d, 1H, *J* = 12.2 Hz, C$\mathbf{H_a}$Ph), 4.54 (d, 1H, *J* = 12.0 Hz, C$\mathbf{H_b}$Ph), 4.22 (dt, 1H, *J* = 5.2, 5.2 Hz, C**H**(4)), 3.86 (br. d, 1H, CH(1)O**H**), 4.74 (br. dd, 1H, C**H**(3)), 3.57 (d, 2H, *J* = 5.4 Hz, C$\mathbf{H_2}$(5)), 2.85 (d, 1H, *J* = 6.8 Hz, CH(3)O**H**), 2.20–1.93 (m, 1H, C**H**(2)), 1.41 (dq, 2H, *J* = 7.6, 7.5 Hz, CH(2)C$\mathbf{H_2}$), 0.97 (t, 3H, *J* = 7.4 Hz, C$\mathbf{H_3}$); ^{13}C NMR (125 MHz, $CDCl_3$), α-isomer: δ 137.4, 128.7, 128.1, 128.0 (Ar**C**), 99.1 (**C**(1)), 83.9 (**C**(4)), 76.8 (**C**(3)), 73.8 (**C**H_2Ph), 71.2 (**C**(5)), 45.5 (**C**(2)), 20.3 (CH(2)**C**H_2), 12.5 (**C**H_3); β-



isomer: δ 137.8, 128.5, 128.1, 127.9 (Ar**C**), 102.7 (**C**(1)), 83.8 (**C**(4)), 77.9 (**C**(3)), 73.6 (**C**H_2Ph), 70.7 (**C**(5)), 56.4 (**C**(2)), 20.4 (CH(2)**C**H_2), 12.3 (**C**H_3); HRMS (ESI-TOF) calculated for $C_{14}H_{20}O_4$ $[M+Na]^+$ m/z 275.1254, found 275.1256; α_D^{22} = –1.24 (c = 1.00, $CHCl_3$).

5-Benzyloxy-1-hydroxy-3-hydroxy-2-isopropyl-D-arabinose (9c). The compound was synthesized following the general procedure using 5-benzyloxy-3-hydroxy-2-isopropyl-D-arabinolactone (>20:1 dr, 66.1 mg, 250 μmol, 1.0 equiv.), DIBAL-H (1.0 M in toluene, 1.00 mL, 1.00 mmol, 4.0 equiv.) and toluene (2.5 mL). The crude product was purified by flash chromatography using 1:1 hexanes:EtOAc to yield the title compound (59.4 mg, 89% yield, >20:1 dr with respect to the configuration at C(2), C(3) and C(4), 1:2.5 mixture of α- and β-anomers) as a colorless crystals. IR (thin film): 3378, 3033, 2964, 2956, 2945, 2927, 2874, 1466, 1454, 1387, 1374, 1358, 1287, 1144, 1117, 1069, 1043, 1030, 985, 874, 854, 749, 695, 611 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$), α-isomer: δ 7.38–7.25 (m, 5H, Ar**H**), 5.31 (dd, 1H, *J* = 7.5, 4.8 Hz, C**H**(1)), 4.61 (d, 1H, *J* = 11.8 Hz, C$\mathbf{H_a}$Ph), 4.57 (d, 1H, *J* = 11.8 Hz, C$\mathbf{H_b}$Ph), 4.22–4.15 (m, 1H, C**H**(3)), 3.81 (dt, 1H, *J* = 5.4, 3.9 Hz, C**H**(4)), 3.76 (d, 1H, *J* = 7.6 Hz, CH(1)O**H**), 3.65–3.57 (m, 2H, C$\mathbf{H_2}$(5)), 2.22 (d, 1H, *J* = 5.7 Hz, CH(3)O**H**), 1.91–1.59 (m, 2H, C**H**(2)C**H**), 1.06 (d, 3H, *J* = 6.8 Hz, CH(C$\mathbf{H_3}$)$_\mathbf{a}$), 0.97 (d, 3H, *J* = 6.5 Hz, CH(C$\mathbf{H_3}$)$_\mathbf{b}$); β-isomer: δ 7.38–7.25 (m, 5H, Ar**H**), 5.22 (dd, 1H, *J* = 4.1, 2.6 Hz, C**H**(1)), 4.57 (d, 1H, *J* = 12.1 Hz, C$\mathbf{H_a}$Ph), 4.54 (d, 1H, *J* = 12.1 Hz, C$\mathbf{H_b}$Ph), 4.22–4.15 (m, 1H, C**H**(4)), 3.95 (br. d, 1H, *J* = 3.3 Hz, CH(1)O**H**), 3.81 (dd, 1H, *J* = 6.6, 5.6 Hz, C**H**(3)), 3.65–3.57 (m, 2H, C$\mathbf{H_2}$(5)), 2.76 (d, 1H, *J* = 6.9 Hz, CH(3)O**H**), 1.91–1.59 (m, 2H, C**H**(2)C**H**), 0.98 (d, 3H, *J* = 6.7 Hz, CH(C$\mathbf{H_3}$)$_\mathbf{a}$), 0.96 (d, 3H, *J* = 6.7 Hz, CH(C$\mathbf{H_3}$)$_\mathbf{b}$); ^{13}C NMR (125 MHz, $CDCl_3$), α-isomer: δ 137.8, 128.7, 128.2, 128.0 (Ar**C**), 99.8 (**C**(1)), 85.0 (**C**(4)), 76.2 (**C**(3)), 73.8 (**C**H_2Ph), 71.2 (**C**(5)), 60.0 (**C**(2)), 27.8 (CH(2)**C**H), 22.0, 21.2 (CH(**C**H_3)$_2$); β-isomer: δ 137.2, 128.5, 127.9, 127.9 (Ar**C**), 101.3 (**C**(1)), 82.4 (**C**(4)), 76.4 (**C**(3)), 73.7 (**C**H_2Ph), 70.5 (**C**(5)), 61.6 (**C**(2)), 28.7 (CH(2)**C**H), 21.1, 20.6 (CH(**C**H_3)$_2$); HRMS (ESI-TOF) calculated for $C_{15}H_{22}O_4$ $[M+Na]^+$ m/z 289.1410, found 289.1406; α_D^{21} = +123.1 (c = 1.00, $CHCl_3$).

5-Benzyloxy-1-hydroxy-3-hydroxy-2-*tert*-butyl-D-arabinose (10c). The compound was synthesized following the general procedure using 5-benzyloxy-3-hydroxy-2-*tert*-butyl-D-arabinolactone (>20:1 dr, 69.6 mg, 250 μmol, 1.0 equiv.), DIBAL-H (1.0 M in toluene, 1.00 mL, 1.00 mmol, 4.0 equiv.) and toluene (2.5 mL). The crude product was purified on a CHIRALPAK IC SFC column (21×150 mm, 5 μm particle size) using 20% EtOH/hexanes (60 mL/min, 100 bar, 30 °C)[17] to yield the title compound (62.4 mg, 89% yield, >20:1 dr with respect to the configuration at C(2), C(3) and C(4), 1:15 mixture of α- and β-anomers) as a colorless oil. IR (thin film): 3390, 2959, 2905, 2869, 1497, 1473, 1454, 1370, 1244, 1206, 1180, 1142, 1081, 1015, 974, 937, 922, 866, 736, 698, 605 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$), α-isomer: δ 7.39–7.24 (m, 5H, Ar**H**), 5.31 (dd, 1H, *J* = 7.9, 4.7 Hz, C**H**(1)), 4.62 (d, 1H, *J* = 11.7 Hz, C$\mathbf{H_a}$Ph), 4.56 (d, 1H, *J* = 11.7 Hz, C$\mathbf{H_b}$Ph), 3.43 (ddd, 1H, *J* = 7.2, 5.7, 5.6 Hz, C**H**(3)), 4.02 (dt, 1H, *J* = 5.3, 3.7 Hz, C**H**(4)), 3.97 (br. s, 1H, CH(1)O**H**), 3.74 (d, 2H, *J* = 7.8 Hz, C$\mathbf{H_2}$(5)), 2.12 (d, 1H, *J* =

[17] Lotus Separations, Department of Chemistry, Frick Laboratory, Princeton University

6.1 Hz, CH(3)O**H**), 1.90 (dd, 1H, *J* = 9.4, 4.7 Hz, C**H**(2)), 1.05 (s, 9H, C(C**H**$_3$)$_3$); β-isomer: δ 7.39–7.24 (m, 5H, Ar**H**), 5.23 (dd, 1H, *J* = 3.2, 3.1 Hz, C**H**(1)), 4.56 (s, 2H, C**H**$_2$Ph), 4.21 (ddd, 1H, *J* = 7.8, 6.1, 4.2 Hz, C**H**(4)), 3.97 (br. s, 1H, CH(1)O**H**), 3.82 (dd, 1H, *J* = 14.2, 6.7 Hz, C**H**(3)), 3.67 (dd, 1H, *J* = 10.2, 4.2 Hz, C**H**$_a$(5)), 3.62 (dd, 1H, *J* = 10.2, 6.1 Hz, C**H**$_b$(5)), 2.72 (d, 1H, *J* = 6.5 Hz, CH(3)O**H**), 1.83 (dd, 1H, *J* = 6.3, 2.6 Hz, C**H**(2)), 0.94 (s, 9H, C(C**H**$_3$)$_3$); ^{13}C NMR (125 MHz, $CDCl_3$), α-isomer: δ 137.1, 128.7, 128.2, 127.1 (Ar**C**), 100.5 (**C**(1)), 84.7 (**C**(4)), 73.8 (**C**H$_2$Ph), 73.2 (**C**(3)), 71.2 (**C**(5)), 61.4 (**C**(2)), 31.0 (**C**(CH$_3$)$_3$), 29.0 (C(**C**H$_3$)$_3$); β-isomer: δ 137.8, 128.5, 128.0, 127.9 (Ar**C**), 99.7 (**C**(1)), 81.5 (**C**(4)), 74.6 (**C**(3)), 73.7 (**C**H$_2$Ph), 70.5 (**C**(5)), 65.3 (**C**(2)), 31.2 (**C**(CH$_3$)$_3$), 27.8 (C(**C**H$_3$)$_3$); HRMS (ESI-TOF) calculated for $C_{16}H_{24}O_4$ $[M+Na]^+$ m/z 303.1567, found 303.1569; α_D^{21} = +225.6 (c = 1.00, $CHCl_3$).

2-Allyl-5-benzyloxy-1-hydroxy-3-hydroxy-D-arabinose (11c). The compound was synthesized following the general procedure using 2-allyl-5-benzyloxy-3-hydroxy-D-arabinolactone (13:1 dr, 65.6 mg, 250 μmol, 1.0 equiv.), DIBAL-H (1.0 M in toluene, 1.00 mL, 1.00 mmol, 4.0 equiv.) and toluene (2.5 mL). The crude product was purified by flash chromatography using 2:1 hexanes:EtOAc to yield the title compound (53.0 mg, 80% yield, >20:1 dr with respect to the configuration at C(2), C(3) and C(4), 1:1.5 mixture of α- and β-anomers) as colorless crystals. The configuration was confirmed by single-crystal X-ray analysis (see appendix). IR (thin film): 3387, 3068, 3028, 2918, 2866, 1641, 1494, 1454, 1363, 1310, 1269, 1206, 1072, 1027, 989, 974, 918, 865, 736, 699 cm^{-1}; ^{1}H NMR (500 MHz, $CDCl_3$), α-isomer: δ 7.39–7.25 (m, 5H, Ar**H**), 5.94–5.84 (m, 1H, C**H**=CH$_2$), 5.28 (br. dd, 1H, *J* = 5.9, 5.0 Hz, C**H**(1)), 5.18–5.01 (m, 2H, CH=C**H**$_2$), 4.62 (d, 1H, *J* = 11.8 Hz, C**H**$_a$Ph), 4.58 (d, 1H, *J* = 11.8 Hz, C**H**$_b$Ph), 4.11 (br. dd, 1H, *J* = 8.1, 6.5 Hz, C**H**(3)), 4.01 (dt, 1H, *J* = 6.1, 3.9 Hz, C**H**(4)), 3.57–3.65 (hidden by C**H**$_2$(5), 1H, CH(1)O**H**), 3.64 (d, 2H, *J* = 3.9 Hz, C**H**$_2$(5)), 2.40–2.24 (m, 1H, C**H**(2)), 2.23–2.07 (m, 2H, CH(2)C**H**$_2$), 1.92 (br. s, 1H, CH(3)O**H**); β-isomer: δ 7.39–7.25 (m, 5H, Ar**H**), 5.84–5.74 (m, 1H, C**H**=CH$_2$), 5.20 (br. s, 1H, C**H**(1)), 5.18–5.01 (m, 2H, CH=C**H**$_2$), 4.57 (s, 2H, C**H**$_2$Ph), 4.25 (dt, 1H, *J* = 5.1, 5.1 Hz, C**H**(4)), 3.80 (br. s, 1H, C**H**(3)), 3.57–3.65 (hidden by C**H**$_2$(5), 1H, CH(1)O**H**), 3.59 (d, 2H, *J* = 5.2 Hz, C**H**$_2$(5)), 2.69 (br. s, 1H, CH(3)O**H**), 2.40–2.24 (m, 1H, C**H**(2)), 2.23–2.07 (m, 2H, CH(2)C**H**$_2$); ^{13}C NMR (125 MHz, $CDCl_3$), α-isomer: δ 137.4 (Ar**C**), 136.7 (**C**H=CH$_2$), 128.7, 128.2, 127.9 (Ar**C**), 116.5 (CH=**C**H$_2$), 99.2 (**C**(1)), 83.7 (**C**(4)), 76.4 (**C**(3)), 73.8 (**C**H$_2$Ph), 71.0 (**C**(5)), 52.5 (**C**(2)), 31.8 (CH(2)**C**H$_2$); β-isomer: δ 137.8 (Ar**C**), 135.7 (**C**H=CH$_2$), 128.6, 128.0, 127.9 (Ar**C**), 117.1 (CH=**C**H$_2$), 102.3 (**C**(1)), 84.2 (**C**(4)), 77.5 (**C**(3)), 73.7 (**C**H$_2$Ph), 70.5 (**C**(5)), 54.0 (**C**(2)), 34.3 (CH(2)**C**H$_2$); HRMS (ESI-TOF) calculated for $C_{15}H_{20}O_4$ $[M+Na]^+$ m/z 287.1254, found 287.1254; α_D^{22} = +4.41 (c = 1.00, $CHCl_3$).

2-Benzyl-5-benzyloxy-1-hydroxy-3-hydroxy-D-arabinose (12c). The compound was synthesized following the general procedure using 2-benzyl-5-benzyloxy-3-hydroxy-D-arabinolactone (>20:1 dr, 78.1 mg, 250 μmol, 1.0 equiv.), DIBAL-H (1.0 M in toluene, 1.00 mL, 1.00 mmol, 4.0 equiv.) and toluene (2.5 mL). The crude product was purified by flash chromatography using 2:1 hexanes:EtOAc to yield the title compound (67.0 mg, 85% yield, >20:1 dr with respect to the configuration at C(2), C(3) and C(4),

1:1.5 mixture of α- and β-anomers) as a colorless oil. IR (thin film): 3400, 3062, 3028, 2914, 2861, 1603, 1496, 1453, 1363, 1207, 1100, 1053, 1028, 972, 944, 912, 865, 737, 698, 613 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$), α-isomer: δ 7.46–7.12 (m, 10H, Ar**H**), 5.20 (dd, 1H, *J* = 6.7, 4.7 Hz, C**H**(1)), 4.65 (d, 1H, *J* = 11.9 Hz, OC$\mathbf{H_a}$Ph), 4.61 (d, 1H, *J* = 11.8 Hz, OC$\mathbf{H_b}$Ph), 4.22 (ddd, 1H, *J* = 8.9, 5.8, 4.7 Hz, C**H**(3)), 4.03 (dt, 1H, *J* = 6.1, 4.0 Hz, C**H**(4)), 3.71–3.63 (m, 3H, C$\mathbf{H_2}$(5), CH(1)O**H**), 2.94 (dd, 1H, *J* = 13.7, 9.0 Hz, CH(2)C$\mathbf{H_a}$), 2.85 (dd, 1H, *J* = 13.6, 6.7 Hz, CH(2)C$\mathbf{H_b}$), 2.39 (ddt, 1H, *J* = 9.0, 6.6, 4.7 Hz, C**H**(2)), 1.97 (d, 1H, *J* = 4.5 Hz, CH(3)O**H**); β-isomer: δ 7.46–7.12 (m, 10H, Ar**H**), 5.25 (dd, 1H, *J* = 4.1, 1.3 Hz, C**H**(1)), 4.62 (d, 1H, *J* = 12.1 Hz, OC$\mathbf{H_a}$Ph), 4.59 (d, 1H, *J* = 12.1 Hz, OC$\mathbf{H_b}$Ph), 4.29 (dt, 1H, *J* = 4.8, 4.8 Hz, C**H**(4)), 3.88 (ddd, 1H, *J* = 7.1, 4.2, 3.2 Hz, C**H**(3)), 3.71–3.63 (m, 3H, C$\mathbf{H_2}$(5), CH(1)O**H**), 2.74 (dd, 1H, *J* = 14.1, 8.5 Hz, CH(2)C$\mathbf{H_a}$), 2.68 (dd, 1H, *J* = 14.1, 8.2 Hz, CH(2)C$\mathbf{H_b}$), 2.63 (d, 1H, *J* = 7.2 Hz, CH(3)O**H**), 2.48 (ddt, 1H, *J* = 8.3, 2.8, 1.4 Hz, C**H**(2)); ^{13}C NMR (125 MHz, $CDCl_3$), aryl carbons: δ 140.04, 139.12, 137.80, 137.35, 128.98, 128.94, 128.73, 128.71, 128.68, 128.54, 128.13, 128.01, 127.98, 127.92, 126.49, 126.36 (Ar**C**); α-isomer: δ 99.0 (**C**(1)), 83.7 (**C**(4)), 76.1 (**C**(3)), 73.8 (O**C**H_2Ph), 71.0 (**C**(5)), 54.7 (**C**(2)), 33.3 (CH(2)**C**H_2); β-isomer: δ 102.2 (**C**(1)), 84.6 (**C**(4)), 77.2 (**C**(3)), 73.7 (O**C**H_2Ph), 70.4 (**C**(5)), 55.9 (**C**(2)), 35.9 (CH(2)**C**H_2); HRMS (ESI-TOF) calculated for $C_{19}H_{22}O_4$ $[M+Na]^+$ m/z 337.1410, found 337.1411; α_D^{21} = +97.5 (c = 1.00, $CHCl_3$).

5-Benzyloxy-2-dimethyl-1-hydroxy-3-hydroxy-D-ribose (5-Benzyloxy-2-dimethyl-1-hydroxy-3-hydroxy-D-arabinose) (13c). The compound was synthesized following the general procedure using 5-benzyloxy-2-dimethyl-3-hydroxy-D-ribonolactone (>20:1 dr, 62.6 mg, 250 μmol, 1.0 equiv.), DIBAL-H (1.0 M in toluene, 1.00 mL, 1.00 mmol, 4.0 equiv.) and toluene (2.5 mL). The crude product was purified by flash chromatography using 2:1 hexanes:EtOAc to yield the title compound (45.3 mg, 72% yield, >20:1 dr with respect to the configuration at C(2), C(3) and C(4), 1:1.5 mixture of α- and β-anomers) as a colorless oil. IR (thin film): 3389, 2963, 2914, 2871, 1497, 1469, 1453, 1368, 1332, 1311, 1204, 1087, 1074, 1012, 978, 948, 910, 854, 805, 737, 698, 604 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$), α-isomer: δ 7.38–7.26 (m, 5H, Ar**H**), 4.98 (d, 1H, *J* = 4.9 Hz, C**H**(1)), 4.60 (d, 1H, *J* = 12.0 Hz, C$\mathbf{H_a}$Ph), 4.56 (d, 1H, *J* = 12.0 Hz, C$\mathbf{H_b}$Ph), 4.23 (dt, 1H, *J* = 5.7, 3.9, Hz, C**H**(4)), 3.68–3.61 (m, 2H, C$\mathbf{H_2}$(5)), 3.98 (dd, 1H, *J* = 8.3, 3.8 Hz, C**H**(3)), 3.30 (d, 1H, *J* = 4.7 Hz, CH(1)O**H**), 2.43 (d, 1H, *J* = 8.3 Hz, CH(3)O**H**), 1.10 (s, 3H, CH(2)(C$\mathbf{H_3}$)$_a$), 0.99 (s, 3H, CH(2)(C$\mathbf{H_3}$)$_b$); β-isomer: δ 7.38–7.26 (m, 5H, Ar**H**), 4.86 (d, 1H, *J* = 6.5 Hz, C**H**(1)), 4.62 (d, 1H, *J* = 11.9 Hz, C$\mathbf{H_a}$Ph), 4.58 (d, 1H, *J* = 11.8 Hz, C$\mathbf{H_b}$Ph), 4.07 (dd, 1H, *J* = 6.9, 6.1 Hz, C**H**(3)), 3.96 (dt, 1H, *J* = 7.2, 3.8, Hz, C**H**(4)), 3.68–3.61 (m, 2H, C$\mathbf{H_2}$(5)), 3.34 (d, 1H, *J* = 6.5 Hz, CH(1)O**H**), 1.90 (d, 1H, *J* = 6.0 Hz, CH(3)O**H**), 1.07 (s, 3H, (CH(2)(C$\mathbf{H_3}$)$_a$), 1.00 (s, 3H, (CH(2)(C$\mathbf{H_3}$)$_b$); ^{13}C NMR (125 MHz, $CDCl_3$), α-isomer: δ 137.9, 128.5, 128.1, 128.0 (Ar**C**), 105.0 (**C**(1)), 85.2 (**C**(4)), 80.0 (**C**(3)), 73.8 or 73.6 (**C**H_2Ph), 71.2 (**C**(5)), 46.0 (**C**(2)), 24.8 (CH(2)(**C**H_3)$_a$), 16.4 (CH(2)(**C**H_3)$_b$); β-isomer: δ 137.5, 128.7, 128.1, 127.9 (Ar**C**), 105.1 (**C**(1)), 82.0 (**C**(4)), 77.8 (**C**(3)), 73.8 or 73.6 (**C**H_2Ph), 70.8 (**C**(5)), 46.3 (**C**(2)), 26.2 (CH(2)(**C**H_3)$_a$), 18.9 (CH(2)(**C**H_3)$_b$); HRMS (ESI-TOF) calculated for $C_{14}H_{20}O_4$ $[M+Na]^+$ m/z 275.1254, found 275.1252; α_D^{21} = +108.2 (c = 1.00, $CHCl_3$).

5-Benzyloxy-1-hydroxy-3-hydroxy-2-spirocyclobutyl-D-ribose (5-Benzyloxy-1-hydroxy-3-hydroxy-2-spirocyclobutyl-D-arabinose) (14c). The compound was synthesized following the general procedure using 5-benzyloxy-3-hydroxy-2-spirocyclobutyl-D-ribonolactone (>20:1 dr, 65.6 mg, 250 μmol, 1.0 equiv.), DIBAL-H (1.0 M in toluene, 1.00 mL, 1.00 mmol, 4.0 equiv.) and toluene (2.5 mL). The crude product was purified by flash chromatography using 2:1 hexanes:EtOAc to yield the title compound (46.4 mg, 70% yield, >20:1 dr with respect to the configuration at C(2), C(3) and C(4), 1:3 mixture of α- and β-anomers) as a colorless oil. IR (thin film): 3394, 3030, 2931, 2862, 1650, 1497, 1453, 1432, 1367, 1249, 1208, 1178, 1097, 1063, 1027, 984, 908, 873, 847, 736, 697, 605 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$), α-isomer: δ 7.39–7.24 (m, 5H, Ar**H**), 5.23 (d, 1H, *J* = 6.2 Hz, C**H**(1)), 4.59 (d, 1H, *J* = 11.9 Hz, C$\mathbf{H_a}$Ph), 4.56 (d, 1H, *J* = 11.9 Hz, C$\mathbf{H_b}$Ph), 4.11 (br. dd, 1H, *J* = 6.5, 5.8 Hz, C**H**(3)), 3.80 (dt, 1H, *J* = 6.9, 4.2, Hz, C**H**(4)), 3.65 (d, 1H, *J* = 6.2 Hz, CH(1)O**H**), 3.61 (d, 2H, *J* = 4.2 Hz, C$\mathbf{H_2}$(5)), 2.46 (d, 1H, *J* = 5.6 Hz, CH(3)O**H**), 2.44–1.64 (m, 6H, (C$\mathbf{H_2}$)$_3$); β-isomer: δ 7.39–7.24 (m, 5H, Ar**H**), 5.31 (d, 1H, *J* = 5.9 Hz, C**H**(1)), 4.56 (d, 1H, *J* = 11.9 Hz, C$\mathbf{H_a}$Ph), 4.50 (d, 1H, *J* = 12.0 Hz, C$\mathbf{H_b}$Ph), 4.33 (dt, 1H, *J* = 6.2, 1.4, Hz, C**H**(4)), 3.86 (br. d, 1H, *J* = 7.8 Hz, C**H**(3)), 3.84 (br. d, 1H, *J* = 6.0 Hz, CH(1)O**H**), 3.46 (dd, 1H, *J* = 10.0, 6.4 Hz, C$\mathbf{H_a}$(5)), 3.38 (dd, 1H, *J* = 10.0, 6.0 Hz, C$\mathbf{H_b}$(5)), 2.97 (d, 1H, *J* = 8.0 Hz, CH(3)O**H**), 2.44–1.64 (m, 6H, (C$\mathbf{H_2}$)$_3$); ^{13}C NMR (125 MHz, $CDCl_3$), α-isomer: δ 137.6, 128.6, 128.0, 127.9 (Ar**C**), 103.7 (**C**(1)), 81.1 (**C**(4)), 75.5 (**C**(3)), 73.7 (**C**H_2Ph), 70.9 (**C**(5)), 52.5 (**C**(2)), 24.3, 23.7 (**C**H_2(CH_2)**C**H_2), 16.2 (CH_2(**C**H_2)CH_2); β-isomer: δ 137.8, 128.5, 128.0, 128.0 (Ar**C**), 104.7 (**C**(1)), 86.2 (**C**(4)), 79.4 (**C**(3)), 73.5 (**C**H_2Ph), 70.8 (**C**(5)), 52.0 (**C**(2)), 30.5, 22.2 (**C**H_2(CH_2)**C**H_2), 16.1 (CH_2(**C**H_2)CH_2); HRMS (ESI-TOF) calculated for $C_{15}H_{20}O_4$ $[M+Na]^+$ m/z 287.1254, found 287.1254; α_D^{21} = +170.4 (c = 1.00, $CHCl_3$).

5-Benzyloxy-1-hydroxy-3-hydroxy-2-spirocyclopentyl-D-ribose (5-Benzyloxy-1-hydroxy-3-hydroxy-2-spirocyclopentyl-D-arabinose) (15c). The compound was synthesized following the general procedure using 5-benzyloxy-3-hydroxy-2-spirocyclopentyl-D-ribonolactone (>20:1 dr, 69.1 mg, 250 μmol, 1.0 equiv.), DIBAL-H (1.0 M in toluene, 1.00 mL, 1.00 mmol, 4.0 equiv.) and toluene (2.5 mL). The crude product was purified by flash chromatography using 2:1 hexanes:EtOAc to yield the title compound (50.7 mg, 73% yield, >20:1 dr with respect to the configuration at C(2), C(3) and C(4), 1:2 mixture of α- and β-anomers) as a colorless oil. IR (thin film): 3407, 2952, 2867, 1497, 1453, 1208, 1103, 1048, 1028, 984, 945, 859, 739, 698 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$), α-isomer: δ 7.37–7.25 (m, 5H, Ar**H**), 4.87 (d, 1H, *J* = 5.1 Hz, C**H**(1)), 4.60 (d, 1H, *J* = 11.8 Hz, C$\mathbf{H_a}$Ph), 4.57 (d, 1H, *J* = 11.8 Hz, C$\mathbf{H_b}$Ph), 4.23 (br. dd, 1H, C**H**(3)), 3.84 (dt, 1H, *J* = 7.5, 4.1, Hz, C**H**(4)), 3.64 (d, 2H, *J* = 4.1 Hz, C$\mathbf{H_2}$(5)), 3.59–3.52 (m, 1H, CH(1)O**H**), 2.20 (d, 1H, *J* = 5.0 Hz, CH(3)O**H**), 2.05–1.20 (m, 8H, (C$\mathbf{H_2}$)$_4$); β-isomer: δ 7.37–7.25 (m, 5H, Ar**H**), 5.02 (d, 1H, *J* = 3.7 Hz, C**H**(1)), 4.59 (d, 1H, *J* = 12.0 Hz, C$\mathbf{H_a}$Ph), 4.53 (d, 1H, *J* = 12.0 Hz, C$\mathbf{H_b}$Ph), 4.33 (dt, 1H, *J* = 6.1, 1.7, Hz, C**H**(4)), 3.76 (d, 1H, *J* = 4.7 Hz, CH(1)O**H**), 3.62 (d, 1H, *J* = 7.9 Hz, C**H**(3)), 3.59–3.52 (m, 2H, C$\mathbf{H_2}$(5)), 2.90 (d, 1H, *J* = 8.7 Hz, CH(3)O**H**), 2.05–1.20 (m, 8H, (C$\mathbf{H_2}$)$_4$); ^{13}C NMR (125 MHz, $CDCl_3$), α-isomer: δ 137.6, 128.6, 128.0, 127.9 (Ar**C**), 103.9 (**C**(1)), 81.4 (**C**(4)), 76.3 (**C**(3)), 73.7 (**C**H_2Ph), 70.9 (**C**(5)), 57.8 (**C**(2)), 30.6, 28.6 (**C**H_2(CH_2)$_2$**C**H_2), 25.9, 25.5 (CH_2(**C**H_2)$_2$$CH_2$); β-isomer: δ 137.9, 128.5, 128.0, 127.9 (Ar**C**),

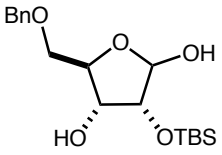
104.8 (**C**(1)), 86.4 (**C**(4)), 80.1 (**C**(3)), 73.5 (**C**H_2Ph), 70.9 (**C**(5)), 58.4 (**C**(2)), 35.7, 27.3 ($\mathbf{C}H_2(CH_2)_2\mathbf{C}H_2$), 25.5, 25.1 ($CH_2(\mathbf{C}H_2)_2CH_2$); HRMS (ESI-TOF) calculated for $C_{16}H_{22}O_4$ $[M+Na]^+$ m/z 301.1410, found 301.1413; α_D^{21} = +73.9 (c = 1.00, $CHCl_3$).

5-Benzyloxy-1-hydroxy-3-hydroxy-2-spirocyclohexyl-D-ribose (5-Benzyloxy-1-hydroxy-3-hydroxy-2-spirocyclohexyl-D-arabinose) (16c). The compound was synthesized following the general procedure using 5-benzyloxy-3-hydroxy-2-spirocyclohexyl-D-ribonolactone (>20:1 dr, 72.6 mg, 250 μmol, 1.0 equiv.), DIBAL-H (1.0 M in toluene, 1.00 mL, 1.00 mmol, 4.0 equiv.) and toluene (2.5 mL). The crude product was purified by flash chromatography using 2:1 hexanes:EtOAc to yield the title compound (53.5 mg, 73% yield, >20:1 dr with respect to the configuration at C(2), C(3) and C(4), 1:1 mixture of α- and β-anomers) as a colorless oil. IR (thin film): 3395, 3030, 2924, 2855, 1497, 1452, 1362, 1310, 1257, 1208, 1173, 1094, 1078, 1047, 1028, 999, 930, 906, 858, 849, 793, 737, 698, 636, 613 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$), α-isomer: δ 7.37–7.26 (m, 5H, Ar**H**), 5.24 (d, 1H, *J* = 6.2 Hz, C**H**(1)), 4.61 (d, 1H, *J* = 11.8 Hz, C$\mathbf{H}_a$Ph), 4.57 (d, 1H, *J* = 11.9 Hz, C$\mathbf{H}_b$Ph), 3.98–3.92 (m, 2H, C**H**(3), C**H**(4)), 3.68–3.57 (m, 2H, C$\mathbf{H}_2$(5)), 3.43 (d, 1H, *J* = 6.2 Hz, CH(1)O**H**), 2.05–1.99 (m, 1H, CH(3)O**H**), 1.83–1.12 (m, 10H, (C$\mathbf{H}_2$)$_5$); β-isomer: δ 7.37–7.26 (m, 5H, Ar**H**), 5.13 (d, 1H, *J* = 4.0 Hz, C**H**(1)), 4.59 (d, 1H, *J* = 12.1 Hz, C$\mathbf{H}_a$Ph), 4.54 (d, 1H, *J* = 12.0 Hz, C$\mathbf{H}_b$Ph), 4.27 (ddd, 1H, *J* = 2.8, 4.4, 6.7 Hz, C**H**(4)), 3.68–3.57 (m, 3H, C**H**(3), C$\mathbf{H}_2$(5)), 3.51 (d, 1H, *J* = 4.1 Hz, CH(1)O**H**), 2.53 (d, 1H, *J* = 9.3 Hz, CH(3)O**H**), 1.83–1.12 (m, 10H, (C$\mathbf{H}_2$)$_5$); ^{13}C NMR (125 MHz, $CDCl_3$), α-isomer: δ 137.9, 128.6, 127.9, 127.8 (Ar**C**), 103.6 (**C**(1)), 81.2 (**C**(4)), 78.0 (**C**(3)), 73.7 (**C**H_2Ph), 71.1 (**C**(5)), 49.2 (**C**(2)), 30.0 ($(CH_2)_2\mathbf{C}H_2(CH_2)_2$), 26.2, 26.0 ($\mathbf{C}H_2(CH_2)_3\mathbf{C}H_2$), 23.5, 22.6 ($\mathbf{C}H_2CH_2CCH_2\mathbf{C}H_2$); β-isomer: δ 137.5, 128.5, 128.0, 127.9 (Ar**C**), 101.2 (**C**(1)), 86.2 (**C**(4)), 78.0 (**C**(3)), 73.5 (**C**H_2Ph), 71.2 (**C**(5)), 49.7 (**C**(2)), 32.9 ($(CH_2)_2\mathbf{C}H_2(CH_2)_2$), 26.6, 25.9 ($\mathbf{C}H_2(CH_2)_3\mathbf{C}H_2$), 23.3, 22.7 ($\mathbf{C}H_2CH_2CCH_2\mathbf{C}H_2$); HRMS (ESI-TOF) calculated for $C_{17}H_{24}O_4$ $[M+Na]^+$ m/z 315.1567, found 315.1572; α_D^{21} = +5.74 (c = 1.00, $CHCl_3$).

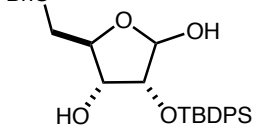
Alternative Procedure for the Synthesis of Ribono- and Arabinolactols from Mukaiyama Aldol Products. Due to the slow cyclization of the three Mukaiyama aldol products (2*R*,3*S*,4*R*)-isopropyl-5-(benzyloxy)-3-hydroxy-2-((*tert*-butyldimethylsilyl)oxy)-4-(2,2,6,6-tetramethylpiperidin-1-yloxy)-pentanoate, (2*R*,3*S*,4*R*)-isopropyl-5-(benzyloxy)-3-hydroxy-2-((*tert*-butyldiphenylsilyl)oxy)-4-(2,2,6,6-tetramethylpiperidin-1-yloxy)-pentanoate, and (2*R*,3*S*,4*R*)-isopropyl 5-(benzyloxy)-3-hydroxy-2-methoxy-4-((2,2,6,6-tetramethylpiperidin-1-yl)oxy)pentanoate, an alternative procedure is given. To a solution of the Mukaiyama aldol product in toluene (c = 0.2 M) was added H_2O:AcOH (8:1, c = 0.2 M) and Zn powder (10 equiv.), and the resulting biphasic suspension was stirred vigorously at room temperature until the reaction was judged to be finished by TLC-analysis (usually 16 hours). The mixture was neutralized with aq. sat. $NaHCO_3$ (2 mL) and poured over H_2O. The aqueous layer was extracted with Et_2O (3 × 5 mL) and the combined organic layers were dried over $MgSO_4$, filtered, and concentrated under vacuum to yield the corresponding TMP-deprotected Mukaiyama aldol product. To a solution of the crude reaction product in toluene (c = 0.1 M) was added diisobutylaluminum hydride (DIBAL-H, 4.0 equiv.) slowly over 1 hour at –78 °C. The solution was stirred for 1.5 hours at –78 °C,

then quenched by the addition of MeOH (10 equiv.) over 15 minutes under vigorous stirring. The solution was stirred for 15 minutes at –78 °C, then warmed to room temperature and stirred for an additional 30 minutes, resulting in a gel. This material was transferred into an extraction funnel and diluted with sat. aq. NH_4Cl (5 mL) and H_2O (5 mL). The aqueous layer was extracted vigorously with Et_2O (3 × 5 mL) and the combined organic layers were dried over $MgSO_4$, filtered, and concentrated under vacuum. The crude product was purified by flash chromatography.

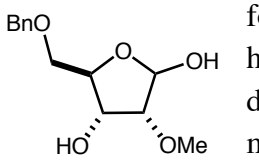
5-Benzyloxy-2-(*tert*-butyldimethylsilyl)oxy-1-hydroxy-3-hydroxy-D-ribose (2c). The compound was synthesized following the general procedure using (2*R*,3*S*,4*R*)-isopropyl-5-(benzyloxy)-3-hydroxy-2-((*tert*-butyldimethylsilyl)oxy)-4-(2,2,6,6-tetramethylpiperidin-1-yloxy)-pentanoate (>20:1 dr, 166 mg, 300 μmol, 1.0 equiv.), Zn (196 mg, 3.00 mmol, 10 equiv.), toluene (1.5 mL) and H_2O:AcOH (8:1, 1.5 mL) then DIBAL-H (1.0 M in toluene, 1.20 mL, 1.20 mmol, 4.0 equiv.) and toluene (3 mL). The crude product was purified by flash chromatography using 4:1 hexanes:EtOAc to yield the title compound (64.2 mg, 60% yield, >20:1 dr with respect to the configuration at C(2), C(3) and C(4), 1:1 mixture of α- and β-anomers) as a colorless oil. For characterization data, see above.



5-Benzyloxy-2-(*tert*-butyldiphenylsilyl)oxy-1-hydroxy-3-hydroxy-D-ribose (3c). The compound was synthesized following the general procedure using (2*R*,3*S*,4*R*)-isopropyl-5-(benzyloxy)-3-hydroxy-2-((*tert*-butyldiphenylsilyl)oxy)-4-(2,2,6,6-tetramethylpiperidin-1-yloxy)-pentanoate (>20:1 dr, 203 mg, 300 μmol, 1.0 equiv.), Zn (196 mg, 3.00 mmol, 10 equiv.), toluene (1.5 mL) and H_2O:AcOH (8:1, 1.5 mL) then DIBAL-H (1.0 M in toluene, 1.20 mL, 1.20 mmol, 4.0 equiv.) and toluene (3 mL). The crude product was purified by flash chromatography using 5:1 to 4:1 hexanes:EtOAc to yield the title compound (87.2 mg, 61% yield, >20:1 dr with respect to the configuration at C(2), C(3) and C(4), 1:1 mixture of α- and β-anomers) as a colorless oil. For characterization data, see above.

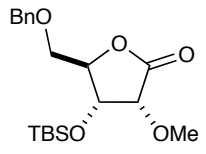


5-Benzyloxy-1-hydroxy-3-hydroxy-2-methoxy-D-ribose (4c). The compound was synthesized following the general procedure using (2*R*,3*S*,4*R*)-isopropyl 5-(benzyloxy)-3-hydroxy-2-methoxy-4-((2,2,6,6-tetramethylpiperidin-1-yl)oxy)pentanoate (>20:1 dr, 135 mg, 300 μmol, 1.0 equiv.), Zn (196 mg, 3.00 mmol, 10 equiv.), toluene (1.5 mL) and H_2O:AcOH (8:1, 1.5 mL) then DIBAL-H (1.0 M in toluene, 1.20 mL, 1.20 mmol, 4.0 equiv.) and toluene (3 mL). The crude product was purified by flash chromatography using 1:1 hexanes:EtOAc to yield the title compound (48.8 mg, 64% yield, >20:1 dr with respect to the configuration at C(2), C(3) and C(4), 1:2 mixture of α- and β-anomers) as a colorless oil. For characterization data, see above.



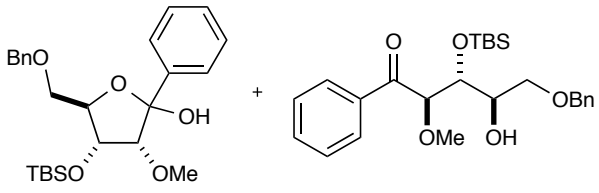
V. Synthesis of *C*-Nucleosides. All compounds reported in this section were prepared from aldehyde **1**, 83% ee.

Synthesis of Fully Protected Lactone Substrate

5-Benzyloxy-3-(*tert*-butyldimethylsilyl)oxy-2-methoxy-D-ribonolactone (17). 

A flame-dried round-bottom flask under N_2 atmosphere was charged with lactone **4b** (564 mg, 2.24 mmol, 1.0 equiv.) and dichloromethane (5.59 mL, 0.40 M) to give a colorless solution. The solution was cooled to 0 °C before 2,6-lutidine (519 μl, 4.47 mmol, 2.0 equiv.) and TBSOTf (771 μl, 3.35 mmol, 1.5 equiv.) were added. The solution was allowed to stir at 0 °C for 15 min, then warmed to rt and allowed to stir for an additional 2 h. The reaction was then quenched with sat. aq. $NaHCO_3$. The resulting mixture was poured over H_2O and the aqueous layer was extracted with three portions of Et_2O. The combined organic layers were dried over $MgSO_4$, filtered, and concentrated. The residue was chromatographed on silica eluting with 10% Et_2O/hexanes to afford the title compound as a colorless oil (751 mg, 2.05 mmol, 92% yield). IR (thin film): 2931, 2858, 1792, 1497, 1472, 1454, 1407, 1362, 1319, 1252, 1195, 1124, 1053, 1028, 1006, 983, 940, 888, 837, 779, 736, 697, 673 cm^{-1}. ^1H NMR (500 MHz, $CDCl_3$): δ 7.37–7.27 (m, 5H, C**H**Ph), 4.59 (d, J = 12.1 Hz, 1H, C$\mathbf{H}_a$Ph), 4.56 (d, J = 12.0 Hz, 1H, C$\mathbf{H}_b$Ph), 4.37 (dd, J = 7.9, 7.9 Hz, 1H, C(3)**H**), 4.20 (ddd, J = 7.7, 4.3, 2.4 Hz, 1H, C(4)**H**), 3.96 (d, J = 8.1 Hz, 1H, C(2)**H**), 3.74 (dd, J = 11.5, 2.4 Hz, 1H, C(5)$\mathbf{H}_a$), 3.66 (s, 3H, OC$\mathbf{H}_3$), 3.61 (dd, J = 11.5, 4.3 Hz, 1H C(5)$\mathbf{H}_b$), 0.86 (s, 9H, (C$\mathbf{H}_3$)$_3$CSi), 0.10 (s, 3H, (C$\mathbf{H}_3$)$_a$Si), 0.05 (s, 3H, (C$\mathbf{H}_3$)$_b$Si). ^{13}C NMR (125 MHz, $CDCl_3$): δ 172.60 (**C**=O), 137.43 (Ph**C**), 128.47 (Ph**C**), 127.86 (Ph**C**), 127.78 (Ph**C**), 83.02 (**C**(2)), 80.52 (**C**(4)), 73.57 (**C**H_2Ph), 72.64 (**C**(3)), 67.19 (**C**(5)), 59.14 (O**C**H_3), 25.58 ((**C**H_3)$_3$CSi), 17.88 ((CH$_3$)$_3$**C**Si), –4.61 (**C**H_3)$_a$Si, –5.17 (**C**H_3)$_b$Si. HRMS (ESI-TOF) calculated for $C_{19}H_{30}O_5Si$ $[M+Na]^+$ m/z 389.1755, found 389.1754. a_D^{20} = +7.19 (c = 1.00, $CHCl_3$)

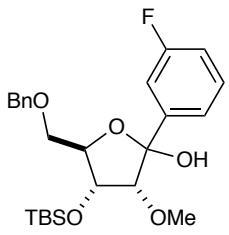
Preparation of C(1)-Arylated Lactols

5-Benzyloxy-3-(*tert*-butyldimethylsilyl)oxy-1-phenyl-2-methoxy-D-ribofuranose (18). 

An oven-dried vial under N_2 atmosphere was charged with lactone **17** (100 mg, 0.273 mmol, 1.0 equiv.) and THF (2.73 ml, 0.10 M) to give a colorless solution. The solution was cooled to –78 °C with stirring before phenyllithium (1.8 M in dibutyl ether, 167 μl, 0.300 mmol, 1.1 equiv.) was added dropwise. The resulting solution was stirred for 1 h at –78 °C. The reaction was quenched with sat. aq. NH_4Cl and diluted with H_2O. The aqueous layer was then extracted with three portions of Et_2O. The combined organic layers were then dried over $MgSO_4$, filtered, and concentrated. The residue was chromatographed on silica eluting with 10% Et_2O/hexanes to afford the product as a colorless oil and a 22:1 lactol:ketone mixture (110 mg, 0.247 mmol, 91% yield). Characterization was carried out on the isolated mixture of lactol anomers and ketone. IR (thin film): 3420, 3064, 3032, 2952, 2929, 2857, 1496, 1472, 1450, 1388, 1361, 1312, 1252, 1192, 1101, 1049,

1027, 1003, 916, 867, 836, 777, 762, 735, 697, 672 cm^{-1}. ^1H NMR (500 MHz, $CDCl_3$): Lactol anomer 1: δ 7.69–7.63 (m, 2H, Ph**H**), 7.39–7.27 (m, 8H, Ph**H**), 4.69 (d, *J* = 12.0 Hz, 1H, C**H**$_a$Ph), 4.58 (d, *J* = 12.0 Hz, 1H, C**H**$_b$Ph), 4.43 (dd, *J* = 6.7, 5.9 Hz, 1H, C(3)**H**), 4.26 (s, 1H, O**H**), 4.17 (ddd, *J* = 5.8, 3.3, 3.3 Hz, 1H, C(4)**H**), 3.72 (d, *J* = 6.7 Hz, 1H, C(2)**H**), 3.68–3.57 (m, 2H, C(5)**H**$_2$), 3.22 (s, 3H OC**H**$_3$), 0.84 (s, 9H, (C**H**$_3$)$_3$CSi), 0.06 (s, 3H, (C**H**$_3$)$_a$Si), 0.01 (s, 3H, (C**H**$_3$)$_b$Si); Lactol anomer 2: δ 7.61–7.58 (m, 2H, Ph**H**), 7.39–7.27 (m, 8H, Ph**H**), 4.64 (d, *J* = 12.1 Hz, 1H, C**H**$_a$Ph), 4.58 (d, *J* = 12.0 Hz, 1H, C**H**$_b$Ph), 4.45 (s, 1H, O**H**), 4.40 (ddd, *J* = 7.3, 5.6, 2.5 Hz, 1H, C(4)**H**), 4.27 (dd, *J* = 2.6, 1.7 Hz, 1H C(3)**H**), 3.75–3.70 (m, 1H, C(5)**H**$_a$), 3.68–3.63 (m, 1H, C(5)**H**$_b$), 3.58 (d, *J* = 1.7 Hz, 1H, C(2)**H**), 2.90 (s, 3H OC**H**$_3$), 0.93 (s, 9H, (C**H**$_3$)$_3$CSi), 0.16 (s, 3H, (C**H**$_3$)$_a$Si), 0.15 (s, 3H, (C**H**$_3$)$_b$Si); Ketone: δ 8.06–8.02 (m, 2H, Ph**H**), 7.39–7.27 (m, 8H, Ph**H**), 4.60–4.56 (m, 2H, C**H**$_a$Ph, C(2/3)**H**), 4.51 (d, *J* = 11.7 Hz, 1H, C**H**$_b$Ph), 4.29–4.25 (m, 1H, C(3/2)**H**), 3.91 (dddd, *J* = 5.7 Hz, 1H, C(4)**H**), 3.68–3.57 (m, 2H, C(5)**H**$_2$), 3.31 (s, 3H, OC**H**$_3$), 2.92 (d, *J* = 6.0 Hz, 1H, O**H**), 0.80 (s, 9H, (C**H**$_3$)$_3$CSi), –0.04 (s, 3H, (C**H**$_3$)$_a$Si), –0.20 (s, 3H, (C**H**$_3$)$_b$Si). ^{13}C NMR (125 MHz, $CDCl_3$): Lactol anomer 1: δ 142.18 (Ph**C**), 137.32 (Ph**C**), 128.66 (Ph**C**), 128.22 (Ph**C**), 128.18 (Ph**C**), 128.09 (Ph**C**), 127.30 (Ph**C**), 125.99 (Ph**C**), 101.84 (**C**(1)), 93.84 (**C**(2)), 82.03 (**C**(4)), 75.68 (**C**(3)), 73.80 (**C**H$_2$Ph), 69.62 (**C**(5)), 59.71 (O**C**H$_3$), 25.77 ((**C**H$_3$)$_3$CSi), 18.00 ((CH$_3$)$_3$**C**Si), –4.47 ((**C**H$_3$)$_a$Si), –4.73 ((**C**H$_3$)$_a$Si); Lactol anomer 2: δ 138.65 (Ph**C**), 138.31 (Ph**C**), 128.47 (Ph**C**), 128.35 (Ph**C**), 128.26 (Ph**C**), 127.79 (Ph**C**), 127.74 (Ph**C**), 127.30 (Ph**C**), 107.22 (**C**(1)), 91.84 (**C**(2)), 84.25 (**C**(4)), 77.49 (**C**(3)), 73.40 (**C**H$_2$Ph), 70.12 (**C**(5)), 58.46 (O**C**H$_3$), 25.84 ((**C**H$_3$)$_3$CSi), 18.07 ((CH$_3$)$_3$**C**Si), –4.77 ((**C**H$_3$)$_a$Si), –4.79 ((**C**H$_3$)$_b$Si). HRMS (ESI-TOF) calculated for $C_{25}H_{36}O_5Si$ [M–OH]$^+$ m/z 427.2299, found 427.2300.

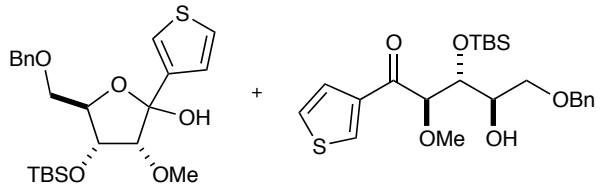
5-Benzyloxy-3-(*tert*-butyldimethylsilyl)oxy-1-(3-fluorophenyl)-2-methoxy-D-ribofuranose (19). An



oven-dried vial was charged with 1-bromo-3-fluorobenzene (60.8 μl, 0.546 mmol, 2.0 equiv.) and THF (5.46 mL, 0.050 M). The resulting colorless solution was cooled to –78 °C before the reaction mixture was added to *tert*-butyllithium (1.7 M in pentane, 642 μl, 1.09 mmol 4.0 equiv.). The resulting solution was stirred for 1 h before lactone **17** (100 mg, 0.273 mmol, 1.0 equiv.) was added as a solution in THF and the mixture was allowed to stir for 30 min. The reaction was quenched with sat. aq. NH_4Cl and diluted with water and Et_2O. The aqueous layer was extracted with three portions of Et_2O. The combined organic layers were dried over $MgSO_4$, filtered, and concentrated. The residue was chromatographed on silica eluting with 15% Et_2O/hexanes to afford the title compound as a colorless oil (118 mg, 0.255 mmol, 93% yield). Characterization was carried out on the isolated mixture of lactol anomers. IR (thin film): 3408, 3031, 2953, 2930, 2857, 1616, 1592, 1488, 1472, 1444, 1389, 1362, 1251, 1099, 1052, 1028, 1004, 974, 939, 836, 778, 734, 697, 671 cm^{-1}. ^1H NMR (500 MHz, $CDCl_3$): Anomer 1: δ 7.46–7.41 (m, 1H, Ar$_F$**H**), 7.41–7.27 (m, 7H, Ar**H**), 7.04–6.97 (m, 1H, Ar$_F$**H**), 4.68 (d, *J* = 12.0 Hz, 1H, C**H**$_a$Ph), 4.60–4.55 (m, 1H, C**H**$_b$Ph), 4.44–4.37 (dd, *J* = 6.0, 6.0 Hz 1H, C(3)**H**), 4.36 (s, 1H, O**H**), 4.16 (ddd, *J* = 5.8, 3.3, 3.3 Hz, 1H, C(4)**H**), 3.74–3.67 (m, 1H, C(2)**H**), 3.66–3.58 (m, 2H, C(5)**H**), 3.24 (s, 3H, OC**H**$_3$), 0.84 (s, 9H, (C**H**$_3$)$_3$CSi), 0.06 (s, 3H, (C**H**$_3$)$_a$Si), 0.01 (s, 3H, (C**H**$_3$)$_b$Si); Anomer 2: δ 7.41–7.27 (m, 8H, Ar**H**), 7.04–6.97 (m, 1H, Ar$_F$**H**), 4.64 (d, *J* = 12.1 Hz, 1H, C**H**$_a$Ph), 4.60–4.55 (m, 1H, C**H**$_b$Ph), 4.54 (s, 1H, O**H**), 4.44–4.37 (ddd, *J* = 7.6, 5.4, 2.2 Hz, 1H, C(4)**H**), 4.28 (dd, *J* = 1.9, 1.9 Hz, 1H, C(3)**H**), 3.74–3.67 (m, 1H, C**H**$_a$Ph), 3.66–3.58 (m, 1H, C**H**$_b$Ph), 3.56 (d, *J* = 1.6 Hz, 1H, C(2)**H**), 2.93 (s, 3H, OC**H**$_3$), 0.93 (s, 9H, (C**H**$_3$)$_3$CSi), 0.16 (s, 3H, (C**H**$_3$)$_a$Si),

0.15 (s, 3H, (C**H**$_3$)$_b$Si). ^{13}C NMR (125 MHz, $CDCl_3$): Anomer 1: δ 163.79, 163.48 (Ar$_F$**C**), 141.26, 141.20 (Ar$_F$**C**), 137.21 (Ph**C**), 129.82, 129.75 (Ar$_F$**C**), 128.69–127.79 (Ph**C**), 121.75, 121.73 (Ar$_F$**C**), 115.16, 115.08 (Ar$_F$**C**), 113.49, 113.31 (Ar$_F$**C**), 106.76–101.47 (**C**(1)), 93.77 (**C**(2)), 82.32 (**C**(4)), 75.60 (**C**(3)), 73.83, (**C**H$_2$Ph), 69.44 (**C**(5)), 59.75 (O**C**H$_3$), 25.82 ((**C**H$_3$)$_3$CSi), 17.97 ((CH$_3$)$_3$**C**Si), –4.50 ((**C**H$_3$)$_a$Si), –4.73 ((**C**H$_3$)$_b$Si); Anomer 2: δ 161.84, 161.54 (Ar$_F$**C**), 144.97, 144.91 (Ar$_F$**C**), 138.22 (Ph**C**), 129.18, 129.12 (Ar$_F$**C**), 128.69–127.79 (Ph**C**), 123.07, 123.05 (Ar$_F$**C**), 115.16, 115.08 (Ar$_F$**C**), 114.83, 114.65 (Ar$_F$**C**), 106.76–101.47 (**C**(1)), 91.61 (**C**(2)), 84.63 (**C**(4)), 77.26 (**C**(3)), 73.42 (**C**H$_2$Ph), 70.01 (**C**(5)), 58.47 (O**C**H$_3$), 25.74 ((**C**H$_3$)$_3$CSi), 18.06 ((CH$_3$)$_3$**C**Si), –4.77 ((**C**H$_3$)$_a$Si), –4.82 ((**C**H$_3$)$_b$Si). HRMS (ESI-TOF) calculated for $C_{25}H_{35}FO_5Si$ [M–OH]$^+$ m/z 445.2205, found 445.2205.

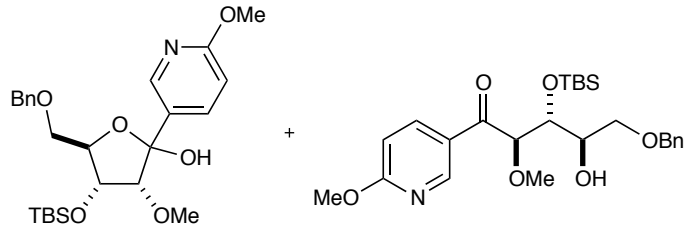
5-Benzyloxy-3-(*tert*-butyldimethylsilyl)oxy-2-methoxy-1-(thiophen-3-yl)-D-ribofuranose (20). An



oven-dried vial was charged with 3-bromothiophene (51.1 μl, 0.546 mmol, 2.0 equiv.) and THF (5.46 mL, 0.050 M). The resulting colorless solution was cooled to –78 °C before the reaction mixture was added to *tert*-butyllithium (1.7 M in pentane, 642 μl, 1.09 mmol, 4.0 equiv.). The solution was stirred for 30 min before lactone **17** (100 mg, 0.273 mmol, 1.0 equiv.) was added as a solution in THF and the mixture was allowed to stir for 30 min. The reaction was quenched with sat. aq. NH_4Cl and diluted with H_2O. The aqueous layer was extracted with three portions of Et_2O. The combined organic layers were dried over $MgSO_4$, filtered, and concentrated. The residue was chromatographed on silica eluting with 20% Et_2O/hexanes to afford the title compound as a colorless oil (4:1 lactol:ketone, 111 mg, 0.246 mmol, 90% yield). Characterization was carried out on the isolated mixture of lactol anomers and ketone. IR (thin film): 3411, 2952, 2928, 2856, 1666, 1497, 1472, 1463, 1454, 1410, 1388, 1361, 1251, 1097, 1052, 1028, 1004, 973, 939, 867, 835, 795, 777, 735, 697, 670 cm^{-1}. ^{1}H NMR (500 MHz, $CDCl_3$): Lactol anomer 1: δ 7.50 (dd, *J* = 3.0, 1.2 Hz, 1H, Ar$_S$**H**), 7.38–7.27 (m, 6H, Ar**H**), 7.21 (dd, *J* = 5.1, 1.2 Hz, 1H, Ar$_S$**H**), 4.68 (d, *J* = 12.0 Hz, 1H, C**H**$_a$Ph), 4.57 (d, *J* = 12.1 Hz, 1H, C**H**$_b$Ph), 4.40 (dd, *J* = 6.2, 6.2 Hz, 1H, C(3)**H**), 4.27 (s, 1H, O**H**), 4.11 (ddd, *J* = 6.1, 3.2, 3.2 Hz, 1H, C(4)**H**), 3.75 (d, *J* = 6.6 Hz, 1H, C(2)**H**), 3.65–3.61 (m, 1H C(5)**H**$_a$), 3.60–3.55 (m, 1H, C(5)**H**$_b$), 3.28 (s, 3H, OC**H**$_3$), 0.85 (s, 9H, (C**H**$_3$)$_3$CSi), 0.06 (s, 3H, (C**H**$_3$)$_a$Si), 0.01 (s, 3H, (C**H**$_3$)$_b$Si); Lactol anomer 2: δ 7.43 (dd, *J* = 3.1, 1.2 Hz, 1H, Ar$_S$**H**), 7.38–7.27 (m, 5H, Ph**H**), 7.23 (dd, *J* = 5.0, 3.1 Hz, 1H, Ar$_S$**H**), 7.15 (dd, *J* = 5.0, 1.2 Hz, 1H, Ar$_S$**H**), 4.62 (d, *J* = 12.1 Hz, 1H, C**H**$_a$Ph), 4.59–4.54 (m, 1H, C**H**$_b$Ph), 4.37 (s, 1H, O**H**), 4.32 (ddd, *J* = 7.0, 5.6, 2.7 Hz, 1H, C(4)**H**), 4.25 (dd, *J* = 2.3, 2.3 Hz, 1H, C(3)**H**), 3.67 (dd, *J* = 9.9, 5.6 Hz, 1H, C(5)**H**$_a$), 3.65–3.61 (m, 1H, C(5)**H**$_b$), 3.60–3.56 (m, 1H, C(2)**H**), 3.00 (s, 3H, OC**H**$_3$), 0.91 (s, 9H, (C**H**$_3$)$_3$CSi), 0.14 (s, 3H, (C**H**$_3$)$_a$Si), 0.13 (s, 3H, (C**H**$_3$)$_b$Si); Ketone: δ 8.39 (dd, *J* = 3.0, 1.2 Hz, 1H, Ar$_S$**H**), 7.63 (dd, *J* = 5.1, 1.2 Hz, 1H, Ar$_S$**H**), 7.38–7.27 (m, 6H, Ar**H**), 4.60–4.57 (m, 1H, C**H**$_a$Ph), 4.51 (d, *J* = 11.8 Hz, 1H, C**H**$_b$Ph), 4.29 (d, *J* = 4.0 Hz, 1H, C(2)**H**), 4.20 (dd, *J* = 5.6, 4.0 Hz, 1H, C(3)**H**), 3.90 (m, 1H, C(4)**H**), 3.65–3.61 (m, 2H, C(5)**H**$_2$), 3.34 (s, 3H, OC**H**$_3$), 2.89 (d, *J* = 5.9 Hz, 1H, O**H**), 0.79 (s, 9H, (C**H**$_3$)$_3$CSi), –0.02 (s, 3H, (C**H**$_3$)$_a$Si), –0.22 (s, 3H, (C**H**$_3$)$_b$Si). ^{13}C NMR (125 MHz, $CDCl_3$): Lactol anomer 1: δ 144.14 (Ar$_S$**C**), 137.31 (Ph**C**), 128.66 (Ar**C**), 128.17 (Ar**C**), 128.10 (Ar**C**), 127.79 (Ar**C**), 125.88 (Ar$_S$**C**), 122.99 (Ar$_S$**C**), 100.65 (**C**(1)), 93.09 (**C**(2)), 81.76 (**C**(4)), 75.46 (**C**(3)), 73.80 (**C**H$_2$Ph), 69.57, (**C**(5)), 59.56 (O**C**H$_3$), 25.78 ((**C**H$_3$)$_3$CSi), 18.01 ((CH$_3$)$_3$**C**Si), –4.46 ((**C**H$_3$)$_a$Si), –4.74, (**C**H$_3$)$_b$Si; Lactol anomer 2: δ 140.81 (Ar$_S$**C**),

138.28 (Ph**C**), 128.62 (Ar**C**), 128.47 (Ar**C**), 127.54 (Ar**C**), 126.07 (Ar**C**), 124.91 (Ar_S**C**), 123.82 (Ar_S**C**), 105.78 (**C**(1)), 91.77 (**C**(2)), 83.87 (**C**(4)), 77.31 (**C**(3)), 73.41 **C**H_2Ph, 70.07, (**C**(5)), 58.57, OC**H**$_3$, 25.83, ((**C**H_3)$_3$CSi), 18.32 ((CH$_3$)$_3$**C**Si), –4.43 (**C**H_3)$_a$Si, –4.78, (**C**H_3)$_b$Si; Ketone: δ 194.37 (**C**=O), 140.40 (Ar_S**C**), 137.84 (Ph**C**), 134.63 (Ar_S**C**), 128.02 (Ar_S**C**), 127.99 (Ar_S**C**), 127.75 (Ph**C**), 125.67 (Ph**C**), 125.65 (Ph**C**), 88.98 (**C**(2)), 74.45 (**C**(3)), 73.58, (**C**H_2Ph), 71.75 (**C**(4)), 71.01 (**C**(5)), 58.90 (O**C**H_3), 25.97 ((**C**H_3)$_3$CSi), 18.06 ((CH$_3$)$_3$**C**Si), –4.80 ((**C**H_3)$_a$Si), –4.85 ((**C**H_3)$_b$Si). HRMS (ESI-TOF) calculated for $C_{24}H_{34}O_5SSi$ $[M–OH]^+$ m/z 433.1863, found 433.1864.

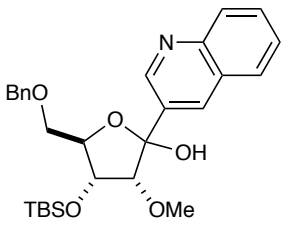
5-Benzyloxy-3-(*tert*-butyldimethylsilyl)oxy-2-methoxy-1-(6-methoxpyridin-3-yl)-D-ribofuranose



(21). An oven-dried vial under N_2 atmosphere was charged with 5-bromo-2-methoxypyridine (106 μl, 0.819 mmol, 2.0 equiv.) and THF (4.09 mL, 0.10 M). The resulting solution was cooled to –78 °C with stirring before being added to a flame-dried 50 mL round-bottom flask containing *tert*-butyllithium (1.7 M in pentane, 963 μl, 1.64 mmol, 4.0 equiv.). The resulting mixture was allowed to stir for 30 min before lactone **17** (150 mg, 0.409 mmol, 1.0 equiv.) was added. The mixture was allowed to stir for an additional 30 min before it was quenched with sat. aq. NH_4Cl and diluted with water. The aqueous layer was extracted with three portions of Et_2O. The combined organic layers were dried over $MgSO_4$, filtered, and concentrated. Purification by column chromatography on silica eluting with 15% EtOAc/hexanes afforded the title compound as a colorless oil and a 10:1 lactol:ketone mixture (179 mg, 0.376 mmol, 92% yield). Characterization was carried out on the isolated mixture of lactol anomers and ketone. IR (thin film): 3402, 2929, 2857, 1607, 1575, 1495, 1463, 1375, 1284, 1254, 1101, 1051, 1023, 989, 938, 866, 834, 778, 735, 697, 671 cm^{-1}. ^{1}H NMR (500 MHz, $CDCl_3$): Lactol anomer 1: δ 8.36 (d, *J* = 2.3 Hz, 1H, Ar_N**H**), 7.74 (dd, *J* = 8.7, 2.4 Hz, 1H, Ar_N**H**), 7.38–7.27 (m, 5H, Ph**H**), 6.68 (d, *J* = 8.6 Hz, 1H, Ar_N**H**), 4.63 (d, *J* = 12.1 Hz, 1H, C**H**$_a$Ph), 4.54 (d, *J* = 12.0 Hz, 1H, C**H**$_b$Ph), 4.54 (s, 1H, O**H**), 4.38 (ddd, *J* = 7.6, 5.6, 1.9 Hz, 1H, C(4)**H**), 4.28 (dd, *J* = 1.8, 1.8 Hz, 1H, C(3)**H**), 3.94 (s, 3H, Ar_NOC**H**$_3$), 3.70–3.57 (m, 2H, C(5)**H**$_2$), 3.51 (d, *J* = 1.5 Hz, 1H, C(2)**H**), 2.98 (s, 3H, C(2)OC**H**$_3$), 0.92 (s, 9H, (C**H**$_3$)$_3$CSi), 0.16 (s, 3H, (C**H**$_3$)$_a$Si), 0.15 (s, 3H, (C**H**$_3$)$_b$Si); Lactol anomer 2: δ 8.44 (d, *J* = 2.4 Hz, 1H, Ar_N**H**), 7.81 (dd, *J* = 8.7, 2.5 Hz, 1H, Ar_N**H**), 7.38–7.27 (m, 5H, Ph**H**), 6.72 (d, *J* = 8.7 Hz, 1H, Ar_N**H**), 4.68 (d, *J* = 12.1 Hz, 1H, C**H**$_a$Ph), 4.61–4.55 (m, 1H, C**H**$_b$Ph), 4.41 (dd, *J* = 6.0 Hz, 1H, C(3)**H**), 4.34 (s, 1H, O**H**), 4.14 (ddd, *J* = 6.3, 3.3, 3.3 Hz, 1H, C(4)**H**), 3.94 (s, 3H, Ar_NOC**H**$_3$), 3.70–3.57 (m, 3H, C(5)**H**$_2$ and C(2)**H**), 3.27 (s, 3H, C(2)HOC**H**$_3$), 0.83 (s, 9H, (C**H**$_3$)$_3$CSi), 0.05 (s, 3H, (C**H**$_3$)$_a$Si), 0.00 (s, 3H, (C**H**$_3$)$_b$Si); Ketone: δ 8.99 (d, *J* = 2.3 Hz, 1H, Ar_N**H**), 8.25 (dd, *J* = 8.8, 2.4 Hz, 1H, Ar_N**H**), 7.38–7.27 (m, 5H, Ph**H**), 6.75 (d, *J* = 8.9 Hz, 1H, Ar_N**H**), 4.57–4.52 (m, 1H, C**H**$_a$Ph), 4.50 (d, *J* = 11.8 Hz, 1H, C**H**$_b$Ph), 4.35–4.33 (m, 1H, C(2)**H**), 4.20 (dd, *J* = 6.0, 4.5 Hz, 1H, C(3)**H**), 4.01 (s, 3H, Ar_NOC**H**$_3$), 3.87 (dddd, *J* = 5.9, 5.9, 5.9, 5.9 Hz, 1H, C(4)**H**), 3.70–3.57 (m, 2H, C(5)**H**$_2$), 3.29 (s, 3H, C(2)OC**H**$_3$), 2.81 (d, *J* = 5.9 Hz, 1H, O**H**), 0.80 (s, 9H, (C**H**$_3$)$_3$CSi), 0.01 (s, 3H, (C**H**$_3$)$_a$Si), –0.17 (s, 3H, (C**H**$_3$)$_b$Si). ^{13}C NMR (125 MHz, $CDCl_3$): Lactol anomer 1: δ 164.21 (Ar_N**C**), 146.19 (Ar_N**C**), 138.32 (Ar_N**C**), 138.19 (Ph**C**), 128.49 (Ph**C**), 127.83 (Ph**C**), 127.80 (Ph**C**), 127.21 (Ar_N**C**), 109.60 (Ar_N**C**), 106.43 (**C**(1)), 91.36 (**C**(2)), 84.56 (**C**(4)), 77.05 (**C**(3)), 73.45 (**C**H_2Ph), 70.01 (**C**(5)), 58.38 (C(2)HO**C**H_3), 53.60 (Ar_NO**C**H_3), 25.83 ((**C**H_3)$_3$CSi), 18.06

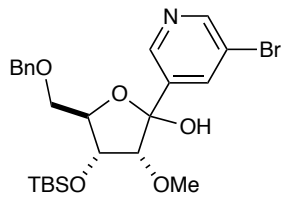
($(CH_3)_3$**C**Si), –4.76 ($(CH_3)_a$Si, –4.82 ($(CH_3)_b$Si; Lactol anomer 2: δ 164.15 (Ar_N**C**), 145.18 (Ar_N**C**), 137.21 (Ph**C**), 136.92 (Ar_N**C**), 130.75 (Ar_N**C**), 128.69 (Ph**C**), 128.20 (Ph**C**), 128.16 (Ph**C**), 110.20 (Ar_N**C**), 101.25 (**C**(1)), 93.58 (**C**(2)), 82.26 (**C**(4)), 75.54 (**C**(3)), 73.81 (CH_2Ph), 69.45 (**C**(5)), 59.77 (C(2)HOCH_3), 53.67 (Ar_NOCH_3), 25.75 (($CH_3)_3$CSi), 17.97 (($CH_3)_3$**C**Si), –4.51 (($CH_3)_a$Si), –4.71 (($CH_3)_b$Si); Ketone: δ 198.20 (**C**=O), 166.71 (Ar_N**C**), 150.51 (Ar_N**C**), 139.48 (Ar_N**C**), 137.79 (Ph**C**), 128.59 (Ph**C**), 128.07 (Ph**C**), 127.99 (Ph**C**), 126.19 (Ar_N**C**), 110.98 (Ar_N**C**), 89.11 (**C**(2)), 74.48 (**C**(3)), 73.55 (CH_2Ph), 71.72 (**C**(4)), 70.87 (**C**(5)), 58.72 (C(2)HOCH_3), 54.21 (Ar_NOCH_3), 25.99 (($CH_3)_3$CSi), 18.32 (($CH_3)_3$**C**Si), –4.12 (($CH_3)_a$Si), –4.80 (($CH_3)_b$Si). HRMS (ESI-TOF) calculated for $C_{25}H_{37}NO_6Si$ $[M+H]^+$ m/z 476.2463, found 476.2465.

5-Benzyloxy-3-(*tert*-butyldimethylsilyl)oxy-2-methoxy-1-(quinolin-3-yl)-D-ribofuranose (22). A



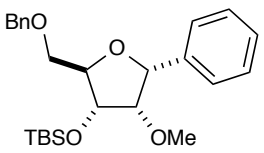
flame-dried round-bottom flask under N_2 atmosphere was charged with lactone **17** (100 mg, 0.273 mmol, 1.0 equiv.), 3-bromoquinoline (74.1 μl, 0.546 mmol, 2.0 equiv.) and THF (2.73 mL, 0.10 M). The resulting solution was cooled to –78 °C with stirring before *n*-butyllithium (2.5 M in hexanes, 218 μl, 0.546 mmol, 2.0 equiv.) was added over 30 min. The resulting mixture was allowed to stir for 5 min before it was quenched with sat. aq. NH_4Cl and diluted with water and Et_2O. The aqueous layer was extracted with three portions of Et_2O. The combined organic layers were dried ($MgSO_4$), filtered, and concentrated. The residue was chromatographed on silica eluting with 20% EtOAc/hexanes to afford the title compound as a viscous orange oil (110 mg, 0.222 mmol, 81% yield). Characterization was carried out on the isolated mixture of lactol anomers. IR (thin film): 3382, 2929, 2857, 1576, 1498, 1463, 1362, 1252, 1099, 1055, 1005, 957, 916, 836, 778, 734, 697, 672 cm^{-1}. ^1H NMR (500 MHz, $CDCl_3$): Lactol anomer 1: δ 9.16 (d, *J* = 2.2 Hz, 1H, Ar_N**H**), 8.45 (d, *J* = 2.1 Hz, 1H, Ar_N**H**), 8.13–8.09 (m, 1H, Ar_N**H**), 7.85 (dd, *J* = 8.2, 1.7 Hz, 1H, Ar_N**H**), 7.74–7.69 (m, 1H, Ar_N**H**), 7.58–7.51 (m, 1H), Ar_N**H**, 7.40–7.28 (m, 5H, Ph**H**), 4.71 (d, *J* = 12.0 Hz, 1H, C$\mathbf{H}_a$Ph), 4.65 (s, 1H, O**H**), 4.63–4.56 (m, 1H, C$\mathbf{H}_b$Ph), 4.52–4.46 (m, 1H, C(3)**H**), 4.27 (ddd, *J* = 5.2, 3.2, 3.2 Hz, 1H, C(4)**H**), 3.79 (d, *J* = 6.2 Hz, 1H, C(2)**H**), 3.72–3.63 (m, 2H, C(5)$\mathbf{H}_2$), 3.26 (s, 3H, OC$\mathbf{H}_3$), 0.83 (s, 9H, (C$\mathbf{H}_3)_3$CSi), 0.06 (s, 3H, (C$\mathbf{H}_3)_a$Si), 0.02 (s, 3H, (C$\mathbf{H}_3)_b$Si). Lactol anomer 2: δ 9.06 (d, *J* = 2.1 Hz, 1H, Ar_N**H**), 8.39 (d, *J* = 2.1 Hz, 1H, Ar_N**H**), 8.11 (dd, *J* = 8.5, 4.6 Hz, 1H, Ar_N**H**), 7.82 (dd, *J* = 8.1, 1.6 Hz, 1H, Ar_N**H**), 7.74–7.69 (m, 1H, Ar_N**H**), 7.58–7.51 (m, 1H, Ar_N**H**), 7.40–7.28 (m, 5H, Ph**H**), 4.83 (s, 1H, O**H**), 4.68 (d, *J* = 12.2 Hz, 1H, C$\mathbf{H}_a$Ph), 4.63–4.56 (m, 1H, C$\mathbf{H}_b$Ph), 4.52–4.46 (m, 1H, C(4)**H**), 4.36 (dd, *J* = 1.7, 1.7 Hz, 1H, C(3)**H**), 3.80–3.76 (m, 1H, C(5)$\mathbf{H}_a$), 3.72–3.62 (m, 2H, C(5)$\mathbf{H}_b$, C(2)**H**), 2.95 (s, 3H, OC$\mathbf{H}_3$), 0.95 (s, 9H, (C$\mathbf{H}_3)_3$CSi), 0.19 (s, 3H, (C$\mathbf{H}_3)_a$Si), 0.18 (s, 3H, (C$\mathbf{H}_3)_b$Si). ^{13}C NMR (125 MHz, $CDCl_3$): Lactol anomer 1: δ 149.19 (Ar_N**C**), 147.92 (Ar_N**C**), 137.12 (Ph**C**), 134.90 (Ar_N**C**), 133.53 (Ar_N**C**), 129.82 (Ar_N**C**), 129.26 (Ar_N**C**), 128.74 (Ph**C**), 128.54 (Ar_N**C**), 128.22 (Ph**C**), 127.88 (Ph**C**), 127.45 (Ar_N**C**), 126.90 (Ar_N**C**), 101.37 (**C**(1)), 93.78 (**C**(2)), 82.72 (**C**(4)), 75.71 (**C**(3)), 73.88 (CH_2Ph), 69.41 (**C**(5)), 59.92 (OCH_3), 25.73 (($CH_3)_3$CSi), 17.97 (($CH_3)_3$CSi), –4.52 (($CH_3)_a$Si), –4.67 (($CH_3)_b$Si); Lactol anomer 2: δ 150.50 (Ar_N**C**), 147.89 (Ar_N**C**), 138.17 (Ph**C**), 134.63 (Ar_N**C**), 131.43 (Ar_N**C**), 129.71 (Ar_N**C**), 129.23 (Ar_N**C**), 128.50 (Ar_N**C**), 128.41 (Ph**C**), 128.22 (Ph**C**), 127.86 (Ph**C**), 127.38 (Ar_N**C**), 126.61 (Ar_N**C**), 106.46 (C(1)), 91.45 (**C**(2)), 85.17 (**C**(4)), 76.84 (**C**(3)), 73.51 (CH_2Ph), 69.99 (**C**(5)), 58.34 (OCH_3), 25.84 (($CH_3)_3$CSi), 18.08 (($CH_3)_3$**C**Si), –4.73 (($CH_3)_a$Si), –4.81 (($CH_3)_b$Si). HRMS (ESI-TOF) calculated

for $C_{28}H_{37}NO_5Si$ $[M+H]^+$ m/z 496.2514, found 496.2518.

5-Benzyloxy-1-(5-bromopyridin-3-yl)-3-(*tert*-butyldimethylsilyl)oxy-2-methoxy-D-ribofuranose (23). 

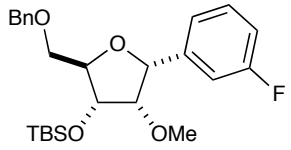
A flame-dried round-bottom flask under N_2 atmosphere was charged with lactone **17** (100 mg, 0.273 mmol, 1.0 equiv.), 3,5-dibromopyridine (78 mg, 0.327 mmol, 1.2 equiv.), and THF (2.73 mL, 0.10 M). The resulting solution was cooled to –78 °C with stirring before *n*-butyllithium (2.4 M in hexanes, 136 μl, 0.327 mmol, 1.2 equiv.) was added over 30 min. The resulting mixture was allowed to stir for 5 min before it was quenched with sat. aq. NH_4Cl and diluted with H_2O and Et_2O. The aqueous layer was extracted with three portions of Et_2O. The combined organic layers were dried over $MgSO_4$, filtered, and concentrated. The residue was purified by column chromatography eluting with 15% EtOAc/hexanes to afford the title compound as a colorless oil (103 mg, 0.196 mmol, 72% yield). Characterization was carried out on the isolated mixture of lactol anomers. IR (thin film): 3347, 3064, 2929, 2857, 1585, 1497, 1472, 1454, 1418, 1389, 1361, 1305, 1252, 1215, 1097, 1051, 1023, 1000, 939, 865, 835, 777, 735, 697, 672 cm^{-1}. ^1H NMR (500 MHz, $CDCl_3$): Anomer 1: δ 8.69 (d, *J* = 1.9 Hz, 1H, Ar_N**H**), 8.62 (dd, *J* = 2.0, 2.0 Hz, 1H, Ar_N**H**), 8.02 (dd, *J* = 2.0 Hz, 1H, Ar_N**H**), 7.39–7.27 (m, 5H, Ph**H**), 4.79 (s, 1H, O**H**), 4.64 (d, *J* = 12.2 Hz, 1H, C$\mathbf{H}_a$Ph), 4.55 (d, *J* = 12.1 Hz, 1H, C$\mathbf{H}_b$Ph), 4.43–4.39 (m, 1H, C(4)**H**), 4.31 (dd, *J* = 1.5, 1.5 Hz, 1H C(3)**H**), 3.70 (dd, *J* = 9.6, 5.6 Hz, 1H, C(5)$\mathbf{H}_a$), 3.66–3.57 (m, 1H, C(5)$\mathbf{H}_b$), 3.54 (d, *J* = 1.3 Hz, 1H, C(2)**H**), 2.99 (s, 3H, OC$\mathbf{H}_3$), 0.93 (s, 9H (C$\mathbf{H}_3$)$_3$CSi), 0.17 (s, 3H, (C$\mathbf{H}_3$)$_a$Si), 0.17 (s, 3H, (C$\mathbf{H}_3$)$_b$Si). Anomer 2: δ δ 8.78 (d, *J* = 1.9 Hz, 1H, Ar_N**H**), 8.62 (dd, *J* = 2.0, 2.0 Hz, 2H, Ar_N**H**), 8.10 (dd, *J* = 2.1, 2.1 Hz, 1H, Ar_N**H**), 7.39–7.27 (m, 5H, Ph**H**), 4.67 (d, *J* = 12.1 Hz, 1H, C$\mathbf{H}_a$Ph), 4.62 (s, 1H, O**H**), 4.59 (d, *J* = 12.0 Hz, 1H, C$\mathbf{H}_b$Ph), 4.43 (dd, *J* = 5.4, 5.4 Hz, 1H, C(3)**H**), 4.19 (ddd, *J* = 4.9, 3.5, 3.5 Hz, 1H, C(4)**H**), 3.65 (d, *J* = 5.7 Hz, 1H, C(2)**H**), 3.63–3.56 (m, 2H, C$\mathbf{H}_2$Ph), 3.30 (s, 3H, OC$\mathbf{H}_3$), 0.83 (s, 9H, (C$\mathbf{H}_3$)$_3$CSi), 0.05 (s, 3H, (C$\mathbf{H}_3$)$_a$Si), 0.01 (s, 3H, (C$\mathbf{H}_3$)$_b$Si). ^{13}C NMR (125 MHz, $CDCl_3$): Anomer 1: δ 150.53 (Ar_N**C**), 146.30 (Ar_N**C**), 138.06 (Ph**C**), 137.95 (Ar_N**C**), 135.80 (Ar_N**C**), 128.55 (Ph**C**), 127.88 (Ph**C**), 127.85 (Ph**C**), 120.03 (Ar_N**C**), 105.74 (**C**(1)), 91.01 (**C**(2)), 85.34 (**C**(4)), 76.54 (**C**(3)), 73.45 (**C**H_2Ph), 69.81 (**C**(5)), 58.21 (O**C**H_3), 25.80 ((**C**H_3)$_3$CSi), 18.04 ((CH$_3$)$_3$**C**Si), –4.75 ((**C**H_3)$_a$Si), –4.86 ((**C**H_3)$_b$Si). Anomer 2: δ 150.55 (Ar_N**C**), 146.30 (Ar_N**C**), 139.65 (Ar_N**C**), 137.05 (Ph**C**), 136.76 (Ar_N**C**), 128.74 (Ph**C**), 128.26 (Ph**C**), 128.20 (Ph**C**), 120.44 (Ar_N**C**), 100.95 (**C**(1)), 93.46 (**C**(2)), 83.10 (**C**(4)), 75.60 (**C**(3)), 73.86 (**C**H_2Ph), 69.26 (**C**(5)), 59.84 (O**C**H_3), 25.71 ((**C**H_3)$_3$CSi), 17.94 ((CH$_3$)$_3$**C**Si), –4.59 ((**C**H_3)$_a$Si), –4.68 ((**C**H_3)$_b$Si). HRMS (ESI-TOF) calculated for $C_{24}H_{34}BrNO_5Si$ $[M+H]^+$ m/z 524.1462, found 524.1464.

Reduction of Lactols to α-*C*-Nucleosides

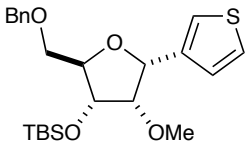
5-Benzyloxy-3-(*tert*-butyldimethylsilyl)oxy-1-deoxy-2-methoxy-1a-phenyl-D-ribofuranose (24α). 

An oven-dried vial under N_2 atmosphere was charged with lactol **18** (100 mg, 0.225 mmol 1.0 equiv.), triethylsilane (71.8 μl, 0.450 mmol, 2.0 equiv.), and dichloromethane (1.13 ml, 0.20 M). The mixture was cooled to –40 °C before boron trifluoride etherate (56.5 μl, 0.450 mmol, 2.0 equiv.) was added and the

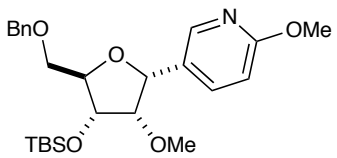
mixture was allowed to stir for 2 h. Sat. aq. K_2CO_3 was then added and the mixture was allowed to warm to rt. The resulting mixture was diluted with H_2O and the aqueous layer was extracted with three portions of Et_2O. The combined organic layers were dried over $MgSO_4$, filtered, and concentrated. ^{1}H NMR analysis of the crude mixture indicated >20:1 α:β. The residue was chromatographed on silica eluting with 10% Et_2O/hexanes to afford the title compound as a colorless oil (93 mg, 0.217 mmol, 96% yield, >20:1 α:β). IR (thin film): 3065, 3032, 2891, 2929, 2857, 1604, 1496, 1472, 1454, 1388, 1362, 1310, 1252, 1189, 1097, 1066, 1028, 1005, 939, 835, 776, 756, 733, 696, 670 cm^{-1}. ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.45–7.41 (m, 2H, Ar**H**), 7.38–7.24 (m, 8H, Ar**H**), 4.88 (d, *J* = 5.4 Hz, 1H, C(1)**H**), 4.62 (d, *J* = 12.3 Hz, 1H, C$\mathbf{H}_a$Ph), 4.59 (d, *J* = 12.3 Hz, 1H, C$\mathbf{H}_b$Ph), 4.28 (dd, *J* = 4.4, 4.4 Hz, 1H, C(3)**H**), 4.22 (ddd, *J* = 5.0, 5.0. 5.0 Hz, 1H, C(4)**H**), 3.72 (dd, *J* = 5.4, 4.1 Hz, 1H, C(2)**H**), (dd, *J* = 10.3, 4.8 Hz, 1H, C(5)$\mathbf{H}_a$), 3.62 (dd, *J* = 10.3, 5.4 Hz, 1H, C(5)$\mathbf{H}_b$), 3.29 (s, 3H, OC$\mathbf{H}_3$), 0.82 (s, 9H, (C$\mathbf{H}_3$)$_3$CSi), 0.04 (s, 3H, (C$\mathbf{H}_3$)$_a$Si), 0.04 (s, 3H (C$\mathbf{H}_3$)$_b$Si). ^{13}C NMR (125 MHz, $CDCl_3$): δ 141.29 (Ph**C**), 138.33 (Ph**C**), 128.46 (Ph**C**), 128.44 (Ph**C**), 127.85 (Ph**C**), 127.69 (Ph**C**), 126.59 (Ph**C**), 94.32 (**C**(2)), 84.12 and 84.12 (**C**(1) and **C**(4)), 77.57 (**C**(3)), 73.50 (**C**H$_2$Ph), 69.93 (**C**(5)), 58.60 (O**C**H$_3$), 25.73 ((**C**H$_3$)$_3$CSi), 17.96 ((CH$_3$)$_3$**C**Si), –4.63 ((**C**H$_3$)$_a$Si), –4.69 ((**C**H$_3$)$_b$Si). HRMS (ESI-TOF) calculated for $C_{25}H_{36}O_4Si$ [M+Na]$^+$ m/z 451.2275, found 451.2272. a_D^{22} = +0.11 (c = 1.00, $CHCl_3$).

5-Benzyloxy-3-(*tert*-butyldimethylsilyl)oxy-1-deoxy-1a-(3-fluorophenyl)-2-methoxy-D-ribofuranose (25α). 

An oven-dried vial under N_2 atmosphere was charged with lactol **19** (100 mg, 0.216 mmol, 1.0 equiv.) and dichloromethane (1.08 mL, 0.20 M). The mixture was cooled to –40 °C before triethylsilane (69.0 μl, 0.432 mmol, 2.0 equiv.) and boron trifluoride etherate (54.3 μl, 0.432 mmol, 2.0 equiv.) were added. The mixture was allowed to stir for 2 h. Sat. aq. K_2CO_3 was then added and the mixture was allowed to warm to rt. The resulting mixture was diluted with H_2O and the aqueous layer was extracted with three portions of Et_2O. The combined organic layers were dried over $MgSO_4$, filtered, and concentrated. ^{1}H NMR analysis of the crude mixture indicated >20:1 α:β. The residue was chromatographed on silica to afford the title compound as a colorless oil (94 mg, 0.210 mmol, 97% yield, >20:1 α:β). IR (thin film): 3033, 2929, 2894, 2857, 1616, 1592, 1488, 1472, 1452, 1389, 1362, 1251, 1190, 1095, 1029, 1005, 972, 938, 8852, 836, 776, 734, 695, 670 cm^{-1}. ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.39–7.27 (m, 6H, PhC**H**), 7.20–7.14 (m, 2H, Ar$_F$**H**), 6.98–6.90 (m, 1H, Ar$_F$**H**), 4.90 (d, *J* = 4.8 Hz, 1H, C**H**Ar$_F$), 4.62 (d, *J* = 12.2 Hz, 1H, C$\mathbf{H}_a$Ph), 4.58 (d, *J* = 12.2 Hz, 1H, C$\mathbf{H}_b$Ph), 4.27 (dd, *J* = 3.9, 3.9 Hz, 1H, C(3)**H**), 4.23 (ddd, *J* = 5.0, 5.0, 5.0 Hz, 1H, (C(4)**H**), 3.68 (dd, *J* = 4.9, 3.6 Hz, 1H, C(2)**H**), 3.65–3.62 (m, 1H, C(5)$\mathbf{H}_a$), 3.62–3.59 (m, 1H, C(5)$\mathbf{H}_b$) 3.32 (s, 3H, OC$\mathbf{H}_3$), 0.80 (s, 9H, (C$\mathbf{H}_3$)$_3$CSi), 0.03 (s, 3H, (C$\mathbf{H}_3$)$_a$Si), 0.03 (s, 3H, (C$\mathbf{H}_3$)$_b$Si). ^{13}C NMR (125 MHz, $CDCl_3$): δ 163.05 (d, *J* = 245.4 Hz, Ar$_F$**C**), 144.11 (d, *J* = 7.0 Hz, Ar$_F$**C**), 138.27 (Ph**C**), 129.87 (d, *J* = 8.2 Hz, Ar$_F$**C**), 128.48 (Ph**C**), 127.85 (Ph**C**), 127.73 (Ph**C**), 121.98 (d, *J* = 2.8 Hz, Ar$_F$**C**), 114.43 (d, *J* = 21.3 Hz, Ar$_F$**C**), 113.39 (d, *J* = 22.2 Hz), 94.32 (**C**(2)), 84.64 (**C**(4)), 83.67, 83.65 (**C**(1)), 77.40 (**C**(3)), 73.50 (**C**H$_2$Ph), 69.88 (**C**(5)), 58.54 (O**C**H$_3$), 25.68 ((**C**H$_3$)$_3$CSi), 17.91 ((CH$_3$)$_3$**C**Si), –4.69, ((**C**H$_3$)$_2$Si). HRMS (ESI-TOF) calculated for $C_{25}H_{35}FO_4Si$ [M+Na]$^+$ m/z 469.2181, found 469.2183. a_D^{21} = +3.09 (c = 1.00, $CHCl_3$).

5-Benzyloxy-3-(*tert*-butyldimethylsilyl)oxy-1-deoxy-2-methoxy-1a-(thiophen-3-yl)-D-ribofuranose (26α). 

An oven-dried vial under N_2 atmosphere was charged with lactol **20** (as a mixture with the corresponding open-chain ketone, 100 mg, 0.222 mmol, 1.0 equiv.), triethylsilane (70.9 μl, 0.444 mmol, 2.0 equiv.), and dichloromethane (1.11 mL, 0.20 M). The mixture was cooled to –40 °C before boron trifluoride etherate (55.7 μl, 0.444 mmol, 2.0 equiv.) was added. The mixture was allowed to stir for 2 h. Sat. aq. K_2CO_3 was then added and the mixture was allowed to warm to rt. The resulting mixture was diluted with H_2O and the aqueous layer was extracted with three portions of Et_2O. The combined organic layers were dried over $MgSO_4$, filtered, and concentrated. ^{1}H NMR analysis of the crude mixture indicated >20:1 α:β. The residue was chromatographed on silica eluting with 10% Et_2O/hexanes to afford the title compound as a colorless oil (90 mg, 0.207 mmol, 93% yield, >20:1 α:β). IR (thin film): 3031, 2929, 2893, 2856,1496, 1472, 1462, 1454, 1408, 1388, 1361, 1251, 1190, 1096, 1072, 1029, 1005, 938, 852, 836, 776, 734, 697, 670 cm^{-1}. ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.38–7.31 (m, 4H, Ph**H**), 7.31–7.27 (m, 3H, Ph**H**), 7.16 (dd, *J* = 5.0, 1.3 Hz, 1H, Ar_S**H**), 4.97 (d, *J* = 5.0 Hz, 1H, C(1)**H**), 4.60 (s, 2H, C**H**$_2$Ph), 4.25 (dd, *J* = 5.1, 3.9 Hz, 1H, C(3)**H**), 4.14 (ddd, *J* = 5.0, 5.0, 5.0 Hz, 1H, C(4)**H**), 3.78 (dd, *J* = 5.0, 3.9 Hz, 1H, C(2)**H**), 3.63 (dd, *J* = 10.4, 4.7 Hz , 1H, C(5)**H**$_a$), 3.59 (dd, *J* = 10.4, 5.5 Hz, 1H, C(5)**H**$_b$), 3.32 (s, 3H, OC**H**$_3$), 0.84 (s, 9H, (C**H**$_3$)$_3$CSi), 0.06 (s, 3H, (C**H**$_3$)$_a$Si), 0.04 (s, 3H, (C**H**$_3$)$_b$Si). ^{13}C NMR (125 MHz, $CDCl_3$): δ 142.34 (Ar_S**C**), 138.29 (Ph**C**), 128.46 (Ph**C**), 127.87 Ph**C**), 127.70 (Ph**C**), 126.33 (Ar_S**C**), 126.15 (Ar_S**C**), 122.18 (Ar_S**C**), 93.48 (**C**(2)), 83.65 (**C**(4)), 80.35 (**C**(1)), 77.69 (**C**(3)), 73.51 (**C**H$_2$Ph), 69.86 (**C**(5)), 58.48 (O**C**H$_3$), 25.78 ((**C**H$_3$)$_3$CSi), 18.00 ((CH$_3$)$_3$**C**Si), –4.60 ((**C**H$_3$)$_a$Si), –4.70 ((**C**H$_3$)$_b$Si). HRMS (ESI-TOF) calculated for $C_{23}H_{34}O_4SSi$ $[M+Na]^+$ m/z 457.18393, found 457.18330. a_D^{21} = +7.87 (c = 1.00, $CHCl_3$).

5-Benzyloxy-3-(*tert*-butyldimethylsilyl)oxy-1-deoxy-2-methoxy-1a-(6-methoxypyridin-3-yl)-D-ribofuranose (27α). 

An oven-dried vial under N_2 atmosphere was charged with lactol **21** (100 mg, 0.210 mmol, 1.0 equiv.), triethylsilane (67.2 μl, 0.420 mmol, 2.0 equiv.) and dichloromethane (1.05 mL, 0.20 M). The mixture was cooled to 0 °C before boron trifluoride etherate (79 μl, 0.631 mmol, 3.0 equiv.) was added. The mixture was allowed to stir for 2 h. Sat. aq. K_2CO_3 was then added and the mixture was allowed to warm to rt. The resulting mixture was diluted with H_2O and the aqueous layer was extracted with three portions of Et_2O. The combined organic layers were dried over $MgSO_4$, filtered, and concentrated. ^{1}H NMR analysis of the crude mixture indicated >20:1 α:β. The residue was chromatographed on silica eluting with 20% Et_2O/hexanes to afford the title compound as a colorless oil (78 mg, 0.170 mmol, 81% yield, >20:1 α:β). IR (thin film): 2930, 2895, 2857, 1609, 1575, 1494, 1472, 1462, 1388, 1361, 1332, 1309, 1282, 1252, 1189, 1099, 1071, 1026, 1006, 938, 874, 834, 801, 735, 697, 670 cm^{-1}. ^{1}H NMR (500 MHz, $CDCl_3$): δ 8.10 (d, *J* = 2.3 Hz, 1H, Ar_N**H**), 7.67 (dd, *J* = 8.6, 2.4 Hz, 1H, Ar_N**H**), 7.34–7.22 (m, 5H, Ph**H**), 6.69 (d, *J* = 8.6 Hz, 1H, Ar_N**H**), 4.79 (d, *J* = 5.4 Hz, 1H, C(1)**H**), 4.57 (d, 12.2 Hz, 1H, C**H**$_a$Ph), 4.54 (d, 12.2 Hz, 1 H, C**H**$_b$Ph), 4.23 (dd, *J* = 4.2 Hz, 1H, C(3)**H**), 4.15 (ddd, *J* = 5.0 Hz, 1H, C(4)**H**), 3.88 (s, 3H, Ar_NOC**H**$_3$), 3.62 (dd, *J* = 5.4, 3.9 Hz, 1H, C(2)**H**), 3.58 (dd, *J* = 10.3, 5.0 Hz 1H, C(5)**H**$_a$), 3.55 (dd, *J* = 10.3, 5.6 Hz 1H, C(5)**H**$_b$), 3.24 (s, 3H, OC**H**$_3$), 0.79 (s, 9H, (C**H**$_3$)$_3$CSi), 0.01 (s, 3H,

(CH_3)$_a$Si), 0.00 (s, 3H, (CH_3)$_b$Si). ^{13}C NMR (125 MHz, $CDCl_3$): δ 164.03 (Ar_N**C**), 145.30 (Ar_N**C**), 138.22 (Ph**C**), 137.41 (Ar_N**C**), 129.50 (Ar_N**C**), 128.48 (Ph**C**), 127.86 (Ph**C**), 127.74 (Ph**C**), 110.97 (Ar_N**C**), 93.96 (**C**(2)), 84.25 (**C**(4)), 81.90 (**C**(1)), 77.43 (**C**(3)), 73.50 (**C**H_2Ph), 69.77 (**C**(5)), 58.66 (CHO**C**H_3), 53.62 (ArO**C**H_3), 25.75 ((**C**H_3)$_3$CSi), 17.99 ((CH$_3$)$_3$**C**Si), –4.62 ((**C**H_3)$_a$Si), –4.68 ((**C**H_3)$_b$Si). HRMS (ESI-TOF) calculated for $C_{25}H_{37}NO_5Si$ $[M+H]^+$ m/z 460.2514, found 460.2511. a_D^{21} = –3.80 (c = 1.00, $CHCl_3$).

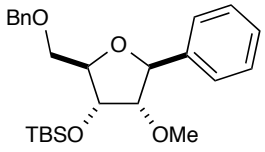
5-Benzyloxy-3-(*tert*-butyldimethylsilyl)oxy-1-deoxy-2-methoxy-1a-(quinolin-3-yl)-D-ribofuranose (28α). An oven-dried vial under N_2 atmosphere was charged with lactol **22** (100 mg, 0.202 mmol, 1.0 equiv.), dichloromethane (1.01 mL, 0.20 M), and triethylsilane (64.4 μl, 0.403 mmol, 2.0 equiv.), and boron trifluoride etherate (101 μl, 0.807 mmol, 4.0 equiv.). The mixture was allowed to stir for 2 h at rt. Sat. aq. K_2CO_3 was then added and the resulting mixture was diluted with H_2O and Et_2O. The aqueous layer was extracted with three portions of Et_2O. The combined organic layers were dried over $MgSO_4$, filtered, and concentrated. 1H NMR analysis of the crude mixture indicated >20:1 α:β. The residue was chromatographed eluting with 15% EtOAc/hexanes to afford the title compound as a yellow oil (77 mg, 0.161 mmol, 80% yield, >20:1 α:β). IR (thin film): 3031, 2929, 2895, 2857, 1738, 1607, 1572, 1496, 1471, 1462, 1455, 1388, 1361, 1323, 1251, 1190, 1094, 1071, 1029, 1006, 955, 939, 908, 836, 777, 749, 697, 670 cm^{-1}. ^{1}H NMR (500 MHz, $CDCl_3$): δ 8.95 (d, *J* = 2.1 Hz, 1H, Ar_N**H**), 8.22 (d, *J* = 2.4 Hz, 1H, Ar_N**H**), 8.10 (d, *J* = 8.5 Hz, 1H, Ar_N**H**), 7.84–7.78 (m, 1H, Ar_N**H**), 7.73–7.65 (m, 1H, Ar_N**H**), 7.57–7.49 (m, 1H, Ar_N**H**), 7.41–7.27 (m, 5H, Ph**H**), 5.13 (d, *J* = 4.8 Hz, 1H, C(1)**H**), 4.65 (d, *J* = 12.2 Hz, 1H, C**H**$_a$Ph), 4.61 (d, *J* = 12.2 Hz, 1H, C**H**$_b$Ph), 4.36-4.32 (m, 2H, C(3)**H** and C(4)**H**), 3.79 (dd, *J* = 4.7, 4.0 Hz, 1H, C(2)**H**), 3.67 (m, 2H, C(5)**H**$_2$), 3.35 (s, 3H, OC**H**$_3$), 0.77 (s, 9H, (C**H**$_3$)$_3$CSi), 0.04 (s, 3H, (C**H**$_3$)$_a$Si), 0.02 (s, 3H, (C**H**$_3$)$_b$Si). ^{13}C NMR (125 MHz, $CDCl_3$): δ 149.59 (Ar_N**C**), 147.87 (Ar_N**C**), 138.19 (Ph**C**), 134.05 (Ar_N**C**), 133.38 (Ar_N**C**), 129.40 (Ar_N**C**), 129.33 (Ar_N**C**), 128.52 (Ph**C**), 127.99 (Ar_N**C**), 127.91 (Ar_N**C**), 127.89 (Ph**C**), 127.80 (Ph**C**), 126.88 (Ar_N**C**), 94.24 (**C**(2)), 85.02 (**C**(4)), 82.55 (**C**(1)), 77.54 (**C**(3)), 73.55 (**C**H_2Ph), 69.83 (**C**(5)), 58.70 (O**C**H_3), 25.66, ((**C**H_3)$_3$CSi) 17.90 ((CH$_3$)$_3$**C**Si), –4.66 ((**C**H_3)$_a$Si), –4.69 ((**C**H_3)$_b$Si). HRMS (ESI-TOF) calculated for $C_{28}H_{37}NO_4Si$ $[M+H]^+$ m/z 480.2565, found 480.2562. a_D^{21} = +9.48 (c = 1.00, $CHCl_3$).

5-Benzyloxy-1a-(5-bromopyridin-3-yl)-3-(*tert*-butyldimethylsilyl)oxy-1-deoxy-2-methoxy-D-ribofuranose (29α). An oven-dried vial under N_2 atmosphere was charged with lactol **23** (100 mg, 0.191 mmol, 1.0 equiv.), dichloromethane (0.953 mL, 0.20 M), triethylsilane (60.9 μl, 0.381 mmol, 2.0 equiv.) and boron trifluoride etherate (96 μl, 0.763 mmol, 4.0 equiv.). The mixture was heated to 35 °C and allowed to stir for 2 h, then allowed to cool to rt and quenched with sat. aq. K_2CO_3. The resulting mixture was poured over H_2O and the aqueous layer was extracted with three portions of Et_2O. The combined organic layers were dried over $MgSO_4$, filtered, and concentrated. ^{1}H NMR analysis of the crude mixture indicated >20:1 α:β. The residue was chromatographed on silica eluting with 25% Et_2O/hexanes to afford the title compound as a colorless oil (64 mg, 0.126 mmol, 66% yield, >20:1 α:β). IR (thin film): 3032, 2929, 2857, 1583, 1557, 1496,

1471, 1462, 1455, 1421, 1389, 1362, 1252, 1199, 1093, 1071, 1020, 1006, 939, 883, 836, 776, 735, 696, 671 cm^{-1}. ^1H NMR (500 MHz, $CDCl_3$): δ 8.56 (d, *J* = 2.2 Hz, 1H, Ar_N**H**), 8.50 (d, *J* = 1.8 Hz, 1H, Ar_N**H**), 7.98–7.96 (m, 1H, Ar_N**H**), 7.37–7.27 (m, 5H, Ph**H**), 4.96 (d, *J* = 4.0 Hz, 1H, C(1)**H**), 4.63 (d, *J* = 12.1 Hz, 1H, C$\mathbf{H}_a$Ph), 4.57 (d, *J* = 12.1 Hz, 1H, C$\mathbf{H}_b$Ph), 4.30–4.24 (m, 2H, C(3)**H**, C(4)**H**), 3.67–3.64 (m, 1H, C(2)**H**), 3.63–3.58 (m, 2H, C(5)$\mathbf{H}_2$), 3.35 (s, 3H, OC$\mathbf{H}_3$), 0.79 (s, 9H, (C$\mathbf{H}_3$)$_3$CSi), 0.04 (s, 3H, (C$\mathbf{H}_3$)$_a$Si), 0.02 (s, 3H, (C$\mathbf{H}_3$)$_b$Si). ^{13}C NMR (125 MHz, $CDCl_3$): δ 149.99 (Ar_N**C**), 146.06 (Ar_N**C**), 138.82 (Ar_N**C**), 138.13 (Ph**C**), 136.79 (Ar_N**C**), 128.52 (Ph**C**), 127.86 (Ph**C**), 127.82 (Ph**C**), 120.94 (Ar_N**C**), 94.10 (**C**(2)), 85.69 (**C**(4)), 81.92 (**C**(1)), 77.24 (**C**(3)), 73.51 (**C**H_2Ph), 69.71 (**C**(5)), 58.45 (O**C**H_3), 25.66 ((**C**H_3)$_3$CSi), 17.89 ((CH$_3$)$_3$**C**Si), –4.68 ((**C**H_3)$_a$Si), –4.79 ((**C**H_3)$_b$Si). HRMS (ESI-TOF) calculated for $C_{24}H_{34}BrNO_4Si$ $[M+H]^+$ m/z 508.1513, found 508.1509. a_D^{21} = +16.9 (c = 1.00, $CHCl_3$) .

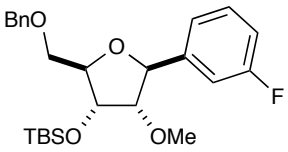
Reduction of Lactols to β-*C*-Nucleosides

5-Benzyloxy-3-(*tert*-butyldimethylsilyl)oxy-1-deoxy-2-methoxy-1b-phenyl-D-ribofuranose (24β). An oven-dried vial under N_2 atmosphere was charged with lactol **18** (100 mg, 0.225 mmol 1.0 equiv.),



Hantzsch ester (diethyl 1,4-dihydro-2,6-dimethyl-3,5-pyridinedicarboxylate, 114 mg, 0.450 mmol, 2.0 equiv.), and dichloromethane (2.25 ml, 0.10 M). The mixture was cooled to –40 °C before boron trifluoride etherate (56.5 μl, 0.450 mmol, 2.0 equiv.) was added and the mixture was allowed to stir for 2 h. Sat. aq. K_2CO_3 was then added and the mixture was allowed to warm to rt. The resulting mixture was diluted with H_2O and the aqueous layer was extracted with three portions of Et_2O. The combined organic layers were dried over $MgSO_4$, filtered, and concentrated. ^1H NMR analysis of the crude mixture indicated >20:1 β:α. The residue was chromatographed on silica eluting with 5% Et_2O/hexanes to afford the product as a colorless oil (88 mg, 0.205 mmol, 91% yield, >20:1 β:α). IR (thin film): 3032, 2952, 2928, 2891, 2857, 1496, 1472, 1454, 1362, 1310, 1206, 1189, 1084, 1061, 1028, 1006, 939, 908, 854, 835, 777, 730, 696, 670 cm^{-1}. ^1H NMR (500 MHz, $CDCl_3$): δ 7.42–7.24 (m, 10H, Ph**H**), 5.10 (d, *J* = 3.8 Hz, 1H, C(1)**H**), 4.65 (d, *J* = 12.1 Hz, 1H, C$\mathbf{H}_a$Ph), 4.59 (d, *J* = 12.1 Hz, 1H, C$\mathbf{H}_b$Ph), 4.23 (dd, *J* = 3.0, 1.5 Hz, 1H, C(3)**H**), 4.03 (ddd, *J* = 6.2, 6.2, 3.0 Hz, 1H, C(4)**H**), 3.71 (dd, *J* = 10.0, 6.1 Hz, 1H, C(5)$\mathbf{H}_a$), 3.67 (dd, *J* = 10.0, 6.3 Hz, 1H, C(5)$\mathbf{H}_b$), 3.59 (dd, *J* = 3.9, 1.5 Hz, 1H, C(2)**H**), 2.96 (s, 3H, OC$\mathbf{H}_3$), 0.91 (s, 9H, (C$\mathbf{H}_3$)$_3$CSi), 0.12 (s, 3H, (C$\mathbf{H}_3$)$_a$Si), 0.11 (s, 3H, (C$\mathbf{H}_3$)$_b$Si). ^{13}C NMR (125 MHz, $CDCl_3$): δ 138.47 (Ph**C**), 137.06 (Ph**C**), 128.44 (Ph**C**), 127.95 (Ph**C**), 127.86 (Ph**C**), 127.66 (Ph**C**), 127.54 (Ph**C**), 89.61 (**C**(2)), 84.77 (**C**(4)), 82.72 (**C**(1)), 77.75 (**C**(3)), 73.42 (**C**(5)), 70.45 (**C**H_2Ph), 58.30 (O**C**H_3), 25.89 ((**C**H_3)$_3$CSi), 18.13 ((CH$_3$)$_3$**C**Si), –4.55 ((**C**H_3)$_a$Si), –4.62 ((**C**H_3)$_b$Si). HRMS (ESI-TOF) calculated for $C_{25}H_{36}O_4Si$ $[M+Na]^+$ m/z 451.2275, found 451.2277. a_D^{21} = +25.0 (c = 1.00, $CHCl_3$).

5-Benzyloxy-3-(*tert*-butyldimethylsilyl)oxy-1-deoxy-1b-(3-fluorophenyl)-2-methoxy-D-ribofuranose (25β). An oven-dried vial under N_2 atmosphere was charged with lactone **19** (100 mg, 0.216 mmol, 1.0 equiv.), Hantzsch ester (diethyl 1,4-dihydro-2,6-dimethyl-3,5-pyridinedicarboxylate, 110 mg, 0.432 mmol,



2.0 equiv.), and dichloromethane (2.16 mL, 0.10 M). The mixture was cooled to –40 °C before boron trifluoride etherate (81 μl, 0.648 mmol, 3.0 equiv.) was added. The mixture was allowed to stir for 1 h. Sat. aq. K_2CO_3 was then added and the mixture was allowed to warm to rt. The resulting mixture was diluted with H_2O and the aqueous layer was extracted with three portions of Et_2O. The combined organic layers were dried over $MgSO_4$, filtered, and concentrated. ^{1}H NMR analysis of the crude mixture indicated >20:1 β:α. The residue was chromatographed on silica to afford the title compound as a colorless oil (91 mg, 0.204 mmol, 94% yield, 17:1 β:α). IR (thin film): 2952, 2929, 2896, 2858, 1617, 1593, 1490, 1472, 1451, 1363, 1251, 1191, 1111, 1090, 1030, 1006, 978, 940, 836, 777, 750, 735, 696, 670 cm^{-1}. ^{1}H NMR (500 MHz, $CDCl_3$): β-Anomer: δ 7.39–7.24 (m, 6H, Ar**H**), 7.16–7.11 (m, 2H, Ar_F**H**), 6.98–6.92 (m, 1H, Ar_F**H**), 5.09 (d, *J* = 3.8 Hz, 1H, C(1)**H**), 4.65 (d, *J* = 12.1 Hz, 1H, C**H**$_a$Ph), 4.58 (d, *J* = 12.1 Hz, 1H, C**H**$_b$Ph), 4.22 (dd, *J* = 2.8, 1.5 Hz, 1H, C(3)**H**), 4.04 (ddd, *J* = 6.2, 6.2, 2.7 Hz, 1H C(4)**H**), 3.69 (dd, *J* = 9.9, 6.0 Hz, 1H, C(5)**H**$_a$), 3.65 (dd, *J* = 9.9, 6.5 Hz, 1H, C(5)**H**$_b$), 3.58 (dd, *J* = 3.8, 1.5 Hz, 1H, C(2)**H**), 2.99 (s, 3H, OC**H**$_3$), 0.91 (s, 9H, (C**H**$_3$)$_3$CSi), 0.12 (s, 3H, (C**H**$_3$)$_a$Si), 0.11 (s, 3H, (C**H**$_3$)$_b$Si). α-Anomer: see compound **25α** above. ^{13}C NMR (125 MHz, $CDCl_3$): β-Anomer: δ 162.78 (d, *J* = 244.6 Hz, Ar_F**C**), 139.92 (d, *J* = 7.6 Hz, Ar_F**C**), 138.39 (Ph**C**), 129.33 (d, *J* = 8.2 Hz, Ar_F**C**), 128.47 (Ph**C**), 127.86 (Ph**C**), 127.71 (Ph**C**), 122.94 (d, *J* = 2.8 Hz, Ar_F**C**), 114.63 (d, *J* = 22.2 Hz, Ar_F**C**), 114.39 (d, *J* = 21.2 Hz, Ar_F**C**), 89.44 (**C**(2)), 85.01 (**C**(4)), 82.09 (**C**(1)), 77.45 (**C**(3)), 73.43 (**C**H$_2$Ph), 70.36, (**C**(5)), 58.29 (O**C**H$_3$), 25.88 (**C**H$_3$)$_3$CSi, 18.12 (CH$_3$)$_3$**C**Si, –4.57 (**C**H$_3$)$_a$Si, –4.61, (**C**H$_3$)$_b$Si. α-Anomer: see compound **25α** above. HRMS (ESI-TOF) calculated for $C_{25}H_{35}FO_4Si$ [M+H]$^+$ m/z 469.2181, found 469.2180. a_D^{21} = +20.9 (c = 1.00, $CHCl_3$).

5-Benzyloxy-3-(*tert*-butyldimethylsilyl)oxy-1-deoxy-2-methoxy-1b-(thiophen-3-yl)-D-ribofuranose (26β). An oven-dried vial under N_2 atmosphere was charged with lactol **20** (as a mixture with the corresponding open-chain ketone, 100 mg, 0.222 mmol, 1.0 equiv.), Hantzsch ester (diethyl 1,4-dihydro-2,6-dimethyl-3,5-pyridinedicarboxylate, 112 mg, 0.444 mmol, 2.0 equiv.) and dichloromethane (2.22 mL, 0.10 M). The mixture was cooled to –40 °C before boron trifluoride etherate (55.7 μl, 0.444 mmol, 2.0 equiv.) was added. The mixture was allowed to stir for 2 h. Sat. aq. K_2CO_3 was then added and the mixture was allowed to warm to rt. The resulting mixture was diluted with H_2O and the aqueous layer was extracted with three portions of Et_2O. The combined organic layers were dried over $MgSO_4$, filtered, and concentrated. ^{1}H NMR analysis of the crude mixture indicated 10:1 β:α. The residue was purified on silica gel eluting with 4% Et_2O/hexanes to afford the title compound as a colorless oil (87.4 mg, 0.201 mmol, 91 % yield, 10:1 β:α). Characterization was carried out on the isolated mixture of anomers. IR (thin film): 2952, 2928, 2891, 2857, 1497, 1472, 1462, 1408, 1388, 1362, 1252, 1191, 1109, 1088, 1030, 1006, 939, 835, 775, 734, 697, 670 cm^{-1}. ^{1}H NMR (500 MHz, $CDCl_3$): β-Anomer : δ 7.38–7.32 (m, 4H, Ar**H**), 7.30–7.24 (m, 3H, Ar**H**), 7.11 (dd, *J* = 5.0, 1.2 Hz, 1H, Ar_S**H**), 5.14 (d, *J* = 3.8 Hz, 1H, C(1)**H**), 4.63 (d, *J* = 12.1 Hz, 1H, C**H**$_a$Ph), 4.57 (d, *J* =12.1Hz, 1H, C**H**$_b$Ph), 4.22 (dd, *J* = 3.1, 1.7 Hz, 1H, C(3)**H**), 3.98 (ddd, *J* = 6.1, 6.1, 3.1 Hz, 1H, C(4)**H**), 3.66 (dd, *J* = 8.9, 4.8 Hz, 1H, C(5)**H**$_a$), 3.63 (dd, *J* = 8.9, 5.1 Hz, 1H, C(5)**H**$_b$), 3.58 (dd, *J* = 3.8, 1.7 Hz, 1H, C(2)**H**), 3.06 (s, 3H, OC**H**$_3$), 0.90 (s, 9H, (C**H**$_3$)$_3$CSi), 0.11 (s, 3H, (C**H**$_3$)$_a$Si), 0.10 (s, 3H, (C**H**$_3$)$_b$Si); α-Anomer: see compound **26α** above. ^{13}C NMR (125 MHz, $CDCl_3$): β-Anomer : δ 138.42 (Ar**C**), 138.10

(Ar**C**), 128.43 (Ar**C**), 127.87 (Ar**C**), 127.66 (Ar**C**), 127.58 (Ar_S**C**), 125.06 (Ar**C**), 122.94 (Ar**C**), 89.20 (**C**(2)), 84.56 (**C**(4)), 79.13 (**C**(1)), 77.52 (**C**(3)), 73.41 (**C**H_2Ph), 70.42 (**C**(5)), 58.23 (O**C**H_3), 25.88 (($\mathbf{C}H_3)_3$CSi), 18.11 (($CH_3)_3$**C**Si), –4.56 (($\mathbf{C}H_3)_a$Si), –4.64 (($\mathbf{C}H_3)_b$Si); α-Anomer: see compound **26α** above. HRMS (ESI-TOF) calculated for $C_{23}H_{34}O_4SSi$ $[M+Na]^+$ m/z 457.1839, found 457.1839. a_D^{21} = +16.3 (c = 1.00, $CHCl_3$).

5-Benzyloxy-3-(*tert*-butyldimethylsilyl)oxy-1-deoxy-2-methoxy-1b-(6-methoxypyridin-3-yl)-D-ribofuranose (27β). An oven-dried vial under N_2 atmosphere was charged with lactol **21** (100 mg, 0.210 mmol, 1.0 equiv.), Hantzsch ester (diethyl 1,4-dihydro-2,6-dimethyl-3,5-pyridinedicarboxylate, 160 mg, 0.631 mmol, 3.0 equiv.), and dichloromethane (2.10 mL, 0.10 M). boron trifluoride etherate (79 μl, 0.631 mmol, 3.0 equiv.) was added and the mixture was allowed to stir for 2 h. Sat. aq. K_2CO_3 was then added and the resulting mixture was poured over H_2O. The aqueous layer was extracted with three portions of Et_2O. The combined organic layers were dried over $MgSO_4$, filtered, and concentrated. ^{1}H NMR analysis of the crude mixture indicated 17:1 β:α. The residue was chromatographed by column chromatography on silica gel eluting with 2% Et_2O/toluene, then by preparative TLC eluting with 10% EtOAc/toluene to afford the title compound as a colorless oil (71 mg, 0.154 mmol, 74 % yield, >20:1 β:α). IR (thin film): 2947, 2929, 2896, 2857, 1611, 1577, 1495, 1462, 1392, 1362, 1333, 1284, 1253, 1207, 1190, 1109, 1089, 1026, 938, 834, 776, 735, 697, 671 cm^{-1}. ^{1}H NMR (500 MHz, $CDCl_3$): δ 8.11 (d, *J* = 2.3 Hz, 1H, Ar_N**H**), 7.65 (dd, *J* = 8.5, 2.3 Hz, 1H, Ar_N**H**), 7.38–7.27 (m, 5H, Ph**H**), 6.70 (d, *J* = 8.5 Hz, 1H, Ar_N**H**), 5.03 (d, *J* = 4.0 Hz, 1H, C(1)**H**), 4.63 (d, *J* = 12.1 Hz, 1H, C$\mathbf{H}_a$Ph), 4.57 (d, *J* = 12.1 Hz, 1H, C$\mathbf{H}_b$Ph), 4.22 (dd, *J* =3.2, 1.7 Hz, 1H, C(3)**H**), 4.00 (ddd, *J* = 6.0, 3.2 Hz, 1H, C(4)**H**), 3.93 (s, 3H, Ar_NOC$\mathbf{H}_3$), 3.67 (dd, *J* = 10.5, 6.1 Hz, 1H, C(5)$\mathbf{H}_a$), 3.63 (dd, *J* = 10.5, 6.3 Hz, 1H, C(5)$\mathbf{H}_b$), 3.53 (dd, *J* = 4.0, 1.7 Hz, 1H, C(2)**H**), 3.02 (s, 3H, C(1)OC$\mathbf{H}_3$), 0.90 (s, 9H, ($\mathbf{C}H_3)_3$CSi), 0.11 (s, 3H, ($\mathbf{C}H_3)_a$Si), 0.10 (s, 3H, ($\mathbf{C}H_3)_b$Si). ^{13}C NMR (125 MHz, $CDCl_3$): δ 164.00 (Ar_N**C**), 145.97 (Ar_N**C**), 139.26 (Ar_N**C**), 138.34 (Ph**C**), 128.46 (Ph**C**), 127.87 (Ph**C**), 127.71 (Ph**C**), 125.45 (Ar_N**C**), 110.30 (Ar_N**C**), 89.32 (**C**(2)), 84.63 (**C**(4)), 80.39 (**C**(1)), 77.46 (**C**(3)), 73.45 (**C**H_2Ph), 70.27 (**C**(5)), 58.20 (C(2)O**C**H_3), 53.56 (Ar_NO**C**H_3), 25.88 (($\mathbf{C}H_3)_3$CSi), 18.13 (($CH_3)_3$**C**Si), –4.55 (($\mathbf{C}H_3)_a$Si), –4.63 (($\mathbf{C}H_3)_b$Si). HRMS (ESI-TOF) calculated for $C_{25}H_{37}NO_5Si$ $[M+H]^+$ m/z 460.2514, found 460.2516. a_D^{21} = +27.3 (c = 1.00, $CHCl_3$).

5-Benzyloxy-3-(*tert*-butyldimethylsilyl)oxy-1-deoxy-2-methoxy-1b-(quinolin-3-yl)-D-ribofuranose (28β). An oven-dried vial under N_2 atmosphere was charged with lactol **22** (100 mg, 0.202 mmol, 1.0 equiv.), Hantzsch ester (diethyl 1,4-dihydro-2,6-dimethyl-3,5-pyridinedicarboxylate, 204 mg, 0.807 mmol, 4.0 equiv.), and dichloromethane (2.02 mL, 0.10 M). Boron trifluoride etherate (152 μl, 1.210 mmol, 6.0 equiv.) was added and the mixture was allowed to stir for 2 h. Sat. aq. K_2CO_3 was then added and the resulting mixture was poured over H_2O. The aqueous layer was extracted with three portions of Et_2O. The combined organic layers were dried over $MgSO_4$, filtered, and concentrated. ^{1}H NMR analysis of the crude mixture indicated 5:1 β:α. The residue was chromatographed on silica eluting with 15% EtOAc/hexanes to afford the title compound as a pale

yellow oil (66 mg, 0.132 mmol, 66% yield, 6:1 β:α). Characterization was carried out on the isolated mixture of anomers. IR (thin film): 2929, 2891, 2857, 1607, 1572, 1496, 1471, 1462, 1362, 1321, 1253, 1191, 1088, 1068, 1029, 1005, 956, 939, 908, 836, 777, 747, 697, 670 cm^{-1}. ^1H NMR (500 MHz, $CDCl_3$): β-Anomer : δ 8.88 (d, *J* = 2.1 Hz, 1H, Ar_N**H**), 8.20 (d, *J* = 2.0 Hz, 1H, Ar_N**H**), 8.09 (d, *J* = 8.4 Hz, 1H, Ar_N**H**), 7.78 (m, 1H, Ar_N**H**), 7.69 (ddd, *J* = 8.4, 6.8, 1.5 Hz, 1H, Ar_N**H**), 7.53 (ddd, *J* = 8.0, 6.8, 1.1 Hz, 1H, Ar_N**H**), 7.43–7.28 (m, 5H, Ph**H**), 5.31 (d, *J* = 3.8 Hz, 1H, C(1)**H**), 4.69 (d, *J* = 12.1 Hz, 1H, C$\mathbf{H}_a$Ph)), 4.61 (d, *J* = 12.0 Hz, 1H, C$\mathbf{H}_b$Ph), 4.31 (dd, *J* = 2.8, 1.5 Hz, 1H, C(3)**H**), 4.12 (ddd, *J* = 6.2, 2.8 Hz, 1H, C(4)**H**), 3.78–3.64 (m, 3H, C(5)$\mathbf{H}_2$ and C(2)**H**), 3.01 (s, 3H, OC$\mathbf{H}_3$), 0.93 (s, 9H, (C$\mathbf{H}_3$)$_3$CSi), 0.14 (s, 3H, (C$\mathbf{H}_3$)$_a$Si), 0.13 (s, 3H (C$\mathbf{H}_3$)$_b$Si); α-Anomer: see compound **28α** above. ^{13}C NMR (125 MHz, $CDCl_3$): β-Anomer : δ 150.49 (Ar_N**C**), 147.76 (Ar_N**C**), 138.32 (Ph**C**), 134.72 (Ar_N**C**), 130.27 (Ar_N**C**), 129.28 (2C, 2Ar_N**C**), 128.51 (Ph**C**), 128.07 (Ar_N**C**), 127.90 (2C, Ar_N**C** and Ph**C**)), 127.77 (Ph**C**), 126.63 (Ar_N**C**), 89.27 (**C**(2)), 85.24 (**C**(4)), 81.03 (**C**(1)), 77.23 (**C**(3)), 73.49 (**C**H_2Ph), 70.30 (**C**(5)), 58.21 (O**C**H_3), 25.90 ((**C**H_3)$_3$CSi), 18.15 ((CH$_3$)$_3$**C**Si), –4.53 ((**C**H_3)$_a$Si), –4.58 ((**C**H_3)$_b$Si); α-Anomer: see compound **28α** above. HRMS (ESI-TOF) calculated for $C_{28}H_{37}NO_4Si$ $[M+H]^+$ m/z 480.2565, found 480.2561. a_D^{21} = +8.03 (c = 1.00, $CHCl_3$).

5-Benzyloxy-1b-(5-bromopyridin-3-yl)-3-(*tert*-butyldimethylsilyl)oxy-1-deoxy-2-methoxy-D-ribofuranose (29β). An oven-dried vial under N_2 atmosphere was charged with lactol **23** (100 mg, 0.191 mmol, 1.0 equiv.), Hantzsch ester (diethyl 1,4-dihydro-2,6-dimethyl-3,5-pyridinedicarboxylate, 386 mg, 1.53 mmol, 8.0 equiv.), and nitromethane (1.91 mL, 0.10 M). Boron trifluoride etherate (239 μl, 1.91 mmol, 10.0 equiv.) was added before the mixture was heated to 50 °C and allowed to stir for 2 h, then allowed to cool to rt and quenched with sat. aq. K_2CO_3. The resulting mixture was poured over H_2O and the aqueous layer was extracted with three portions of Et_2O. The combined organic layers were dried over $MgSO_4$, filtered, and concentrated. ^1H NMR analysis of the crude mixture indicated 2:1 β:α. The residue was purified twice by column chromatography (10-20% Et_2O/hexanes) and once by preparative TLC (40% Et_2O/hexanes) to afford the title compound as a pale yellow oil (66 mg, 0.130 mmol, 68% yield, 2:1 β:α). Characterization was carried out on the isolated mixture of anomers. IR (thin film): 2952, 2929, 2896, 2857, 1585, 1557, 1496, 1471, 1462, 1422, 1362, 1295, 1252, 1206, 1090, 019, 1006, 938, 883, 836, 776, 735, 696, 671 cm^{-1}. ^1H NMR (500 MHz, $CDCl_3$): β-Anomer : δ 8.57 (d, *J* = 2.3 Hz, 1H, Ar_N**H**), 8.47 (d, *J* = 1.7 Hz, 1H, Ar_N**H**), 7.90 (dd, *J* = 2.0, 2.0 Hz, 1H, Ar_N**H**), 7.39 – 7.33 (m, 4H, Ph**H**), 7.33–7.27 (m, 1H, Ph**H**), 5.09 (d, *J* = 3.8 Hz, 1H C(1)**H**), 4.65 (d, *J* = 12.1 Hz, 1H, C$\mathbf{H}_a$Ph), 4.58 (d, *J* = 12.2 Hz, 1H C$\mathbf{H}_b$Ph), 4.26 (dd, *J* = 2.4, 1.4 Hz, 1H C(3)**H**), 4.06 (ddd, *J* = 6.3, 2.4 Hz, 1H C(4)**H**), 3.67 (dd, *J* = 9.9, 6.1 Hz, 1H, C(5)$\mathbf{H}_a$), 3.65–3.60 (m, 1H, C(5)$\mathbf{H}_b$), 3.58 (dd, *J* = 3.9, 1.4 Hz, 1H, C(2)**H**), 3.05 (s, 3H (OC$\mathbf{H}_3$), 0.91 (s, 9H, (C$\mathbf{H}_3$)$_3$CSi), 0.12 (s, 3H, (C$\mathbf{H}_3$)$_a$Si), 0.11 (s, 3H, (C$\mathbf{H}_3$)$_b$Si); α-Anomer: see compound **29α** above. ^{13}C NMR (125 MHz, $CDCl_3$): β-Anomer : δ 150.05 (Ar_N**C**), 147.04 (Ar_N**C**), 138.31 (Ar_N**C**), 138.26 (Ph**C**), 134.86 (Ar_N**C**), 128.52 (Ph**C**), 127.87 (Ph**C**), 127.80 (Ph**C**), 120.56 (Ar_N**C**), 89.06 (**C**(2)), 85.43 (**C**(4)), 80.03 (**C**(1)), 76.97 (**C**(3)), 73.47 (**C**H_2Ph), 70.19 (**C**(5)), 58.09 (O**C**H_3), 25.88 ((**C**H_3)$_3$CSi), 18.12 ((CH$_3$)$_3$**C**Si), –4.56 ((**C**H_3)$_a$Si), –4.58 ((**C**H_3)$_b$Si); α-Anomer: see compound **29α** above. HRMS (ESI-TOF) calculated for $C_{24}H_{34}BrNO_4Si$ $[M+H]^+$ m/z 508.1513, found 508.1513. a_D^{22} = +11.9 (c = 1.00, $CHCl_3$).

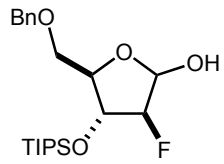
VI. Synthesis of Fluorinated Pentose Derivatives. All compounds reported in this section were prepared from aldehyde **1**, 83% ee.

Preparation of C(2)-Fluorinated Lactols

(4*S*,5*R*)-5-(benzyloxymethyl)-4-(triisopropylsilyloxy)-dihydrofuran-2(3H)-one. To a solution of 5-benzyloxy-2-desoxy-3-hydroxy-D-ribonolactone (380 mg, 1.71 mmol, 1.0 equiv.) in CH_2Cl_2 (4 mL) was added imidazole (466 mg, 6.85 mmol, 4.0 equiv.), DMAP (21 mg, 171 μmol, 0.1 equiv.) and triisopropylsilyl chloride (990 mg, 5.14 mmol, 3 equiv.). The reaction mixture was stirred 24 h at room temperature then quenched by the addition of water (5 mL). The aqueous layer was extracted with EtOAc (3 x 10 mL) and the combined organic layers were washed with brine then dried over Na_2SO_4, filtered, and concentrated under vacuum. The crude product was purified by flash chromatography using 4:1 hexanes/EtOAc to yield the title compound (597 mg, 92% yield) as a colorless oil. IR (thin film): 2943, 2866, 1787, 1453, 1362, 1166, 1100, 1014, 882, 740, 688 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$): δ 7.38–7.26 (m, 5H, Ar**H**), 4.58–4.55 (m, 1H, C**H**(3)), 4.55 (s, 1H, C**H**$_2$Ar), 4.50 (s, 1H, C**H**$_2$Ar), 4.48–4.44 (m, 1H, C**H**(4)), 3.70–3.62 (m, 2H, C**H**$_2$(5)), 2.90 (dd, *J* = 17.6, 6.5 Hz, 1H, C**H**$_2(2)_a$), 2.43 (dd, *J* = 17.7, 2.1 Hz, 1H, C**H**$_2(2)_b$), 1.08–0.95 (m, 21H, C**H**$_3$, C**H**$(CH_3)_2$); ^{13}C NMR (125 MHz, $CDCl_3$): δ 176.1 (C(1)), 137.5 (CAr), 128.6 (CHAr), 128.1 (CHAr), 127.8 (CHAr), 87.6 (CH(4)), 73.8 (CH_2Ar), 70.4 (CH(3)), 69.3 (CH_2(5)), 39.5 (CH_2(2)), 18.0 (CH_3), 12.0 ($CH(CH_3)_2$); HRMS (ESI-TOF) calculated for $C_{21}H_{34}O_4Si$ $[M+H]^+$ m/z 379.2299, found 379.2300; α_D^{21} = +14.1 (c = 1.10, $CHCl_3$).

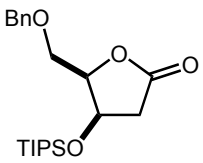
(3*S*,4*R*,5*R*)-5-(benzyloxymethyl)-3-fluoro-4-(triisopropylsilyloxy)-dihydrofuran-2(3H)-one (31a). A solution of (4*S*,5*R*)-5-(benzyloxymethyl)-4-(triisopropylsilyloxy)-dihydrofuran-2(3H)-one (100 mg, 264 μmol, 1.0 equiv.) and *N*-fluorodibenzenesulfonamide (125 mg, 396 μmol, 1.5 equiv.) in dry THF (2.6 mL) was cooled to –78 °C. To the solution was slowly added LiHMDS (343 μL, 343 μmol, 1 M in THF, 1.5 equiv.) and the mixture was stirred at –78 °C for 1.5 h before being quenched by the addition of a sat. aq. sol. of NH_4Cl (1 mL) and allowed to warm up to room temperature. The aqueous layer was extracted with EtOAc (3 x 5 mL) and the combined organic layers were washed with a sat. aq. sol. of $NaHCO_3$ then dried over Na_2SO_4, filtered, and concentrated under vacuum. The crude product was purified by flash chromatography using 25:1 hexanes/EtOAc to yield the title compound (75.3 mg, 72% yield, dr >20:1), as a colorless oil. IR (thin film): 2945, 2868, 1808, 1463, 1239, 1165, 1110, 1069, 883, 799, 685 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$): δ 7.39–7.27 (m, 5H, Ar**H**), 5.12 (dd, *J* = 51.3, 7.5 Hz, 1H, C**H**(2)), 4.82 (ddd, *J* = 18.0, 7.5, 7.5 Hz, 1H, C**H**(3)), 4.62–4.53 (m, 2H, C**H**$_2$Ar), 4.26 (ddd, *J* = 7.3, 2.9, 2.9 Hz, 1H, C**H**(4)), 3.81 (ddd, *J* = 11.6, 2.1, 2.1 Hz, 1H, C**H**$_2(5)_a$), 3.70 (dd, *J* = 11.6, 3.5 Hz, 1H, C**H**$_2(5)_b$), 1.12–0.99 (m, 21H, C**H**$_3$, C**H**$(CH_3)_2$); ^{13}C NMR (125 MHz, $CDCl_3$): δ 168.5 (d, *J* = 23.1 Hz, C(1)), 137.1 (CAr), 128.5 (CHAr), 128.0 (CHAr), 127.9 (CHAr), 92.4 (d, *J* = 199.4 Hz, CH(2)), 80.4 (d, *J* = 10.7 Hz, CH(4)), 73.7 (CH_2Ar), 72.5 (d, *J* = 20.5 Hz, CH(3)), 66.5 (CH_2(5)), 17.8 (CH_3), 17.7 (CH_3), 12.1 ($CH(CH_3)_2$); ^{19}F NMR (282 MHz, $CDCl_3$): δ –201.2 (ddd, *J* = 51.4, 17.6, 1.6 Hz); HRMS (ESI-TOF) calculated for $C_{21}H_{33}FO_4Si$ $[M+H]^+$ m/z 397.2205, found 397.2209; α_D^{21} = +31.4 (c = 1.36, $CHCl_3$).

(3*S*,4*R*,5*R*)-5-(benzyloxymethyl)-3-fluoro-4-(triisopropylsilyloxy)-tetrahydrofuran-2-ol (31b).



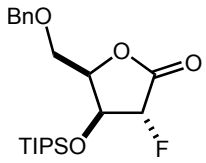
To a solution of (3*S*,4*R*,5*R*)-5-(benzyloxymethyl)-3-fluoro-4-(triisopropylsilyloxy)-dihydrofuran-2(3H)-one (28.2 mg, 71 μmol, 1.0 equiv.) in toluene (0.7 mL) at –78 °C was slowly added DIBAL-H (284 μL, 284 μmol, 1 M in toluene, 4.0 equiv.). The reaction was stirred at –78 °C for 2 h then quenched by the slow addition of MeOH (29 μL, 711 μmol, 10 equiv.) and allowed to warm up to room temperature. A 0.1 M HCl solution (1 mL) was added and the mixture was stirred vigorously for 10 min. The aqueous layer was extracted with Et_2O (3 x 5 mL) and the combined organic layers were washed with a sat. aq. sol. of $NaHCO_3$, water and brine, then dried over Na_2SO_4, filtered, and concentrated under vacuum. The crude product was purified by preparative TLC plate using 2:1 hexanes/Et_2O to yield the title compound (25.5 mg, 90% yield as a 1:4 mixture of anomers) as a colorless oil. IR (thin film): 3431, 2872, 2866, 1463, 1383, 1258, 1097, 1027, 882, 822, 736, 684 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$): major anomer: δ 7.38–7.28 (m, 5H, Ar**H**), 5.42 (dd, *J* = 9.8, 9.8 Hz, 1H, C**H**(1)), 4.83 (d, *J* = 50.3 Hz, 1H, C**H**(2)), 4.61–4.50 (m, 2H, C**H**$_2$Ar), 4.41 (t, *J* = 6.7 Hz, 1H, C**H**(4)), 4.36 (d, *J* = 14.1 Hz, 1H, C**H**(3)), 3.62–3.56 (m, 1H, C**H**$_2$(5)$_a$), 3.52–3.46 (m, 1H, C**H**$_2$(5)$_b$), 3.43 (d, *J* = 10.4 Hz, 1H, OH), 1.16–0.95 (m, 21H, C**H**$_3$, C**H**(CH$_3$)$_2$); minor anomer: δ 7.38–7.28 (m, 5H, Ar**H**), 5.31 (dt, *J* = 10.8, 4.0 Hz, 1H, C**H**(1)), 4.77 (ddd, *J* = 52.6, 4.2, 4.2 Hz, 1H, C**H**(2)), 4.66 (d, *J* = 11.9 Hz, 1H, C**H**(3)), 4.61–4.50 (m, 2H, C**H**$_2$Ar), 4.03–3.95 (m, 1H, C**H**(4)), 3.81 (s, 1H, OH), 3.62–3.56 (m, 2H, C**H**$_2$(5)), 1.16–0.95 (m, 21H, C**H**$_3$, C**H**(CH$_3$)$_2$); ^{13}C NMR (125 MHz, $CDCl_3$): major anomer: δ 137.9 (CAr), 128.5 (CHAr), 127.8 (CHAr), 127.8 (CHAr), 100.8 (d, *J* = 31.6 Hz, CH(1)), 98.2 (d, *J* = 186.2 Hz, CH(2)), 85.7 (CH(4)), 76.3 (d, *J* = 26.0 Hz, CH(3)), 73.5 (CH$_2$Ar), 69.8 (d, *J* = 2.4 Hz, CH$_2$(5)), 17.9 (CH$_3$), 11.9 (**C**H(CH$_3$)$_2$); minor anomer: δ 137.0 (CAr), 128.7 (CHAr), 128.3 (CHAr), 128.2 (CHAr), 97.4 (d, *J* = 193.3 Hz, CH(2)), 95.8 (d, *J* = 19.0 Hz, CH(1)), 83.2 (d, *J* = 7.8 Hz, CH(4)), 74.7 (d, *J* = 24.0 Hz, CH(3)), 73.8 (CH$_2$Ar), 69.4 (CH$_2$(5)), 17.9 (CH$_3$), 12.1 (**C**H(CH$_3$)$_2$); ^{19}F NMR (282 MHz, $CDCl_3$): major-anomer: δ –189.0 (ddd, *J* = 50.4, 14.3, 9.8 Hz), minor anomer: δ –204.1 (dd, *J* = 52.2, 17.1 Hz); HRMS (ESI-TOF) calculated for $C_{21}H_{33}FO_4Si$ $[M+Na]^+$ m/z 421.2181, found 421.2191.

(4*R*,5*R*)-5-(benzyloxymethyl)-4-(triisopropylsilyloxy)-dihydrofuran-2(3H)-one. To a solution of 5-benzyloxy-2-desoxy-3-hydroxy-D-lyxolactone (74.7 mg, 336 μmol, 1.0 equiv.) and 2,6-di-*tert*-butylpyridine (302 μL, 1.34 mmol, 4.0 equiv.) in dry THF (3.4 mL) at 0 °C was slowly added triisopropylsilyltrifluoromethanesulfonate (182 μL, 672 μmol, 2.0 equiv.) The reaction was allowed to slowly warm up to room temperature and stirred for 5 h then was quenched by the addition of water (2 mL). The aqueous layer was extracted with Et_2O (3 x 5 mL) and the combined organic layers were dried over Na_2SO_4, filtered, and concentrated under vacuum. The crude product was purified by flash chromatography using 10:1 hexanes/Et_2O to yield the title compound (112 mg, 88% yield) as a colorless oil. IR (thin film): 2943, 2867, 1789, 1463, 1365, 1205, 1161, 1132, 1099, 1062, 940, 882, 697 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$): δ 7.40–7.27 (m, 5H, Ar**H**), 4.77–4.71 (m, 1H, C**H**(4)), 4.62–4.52 (m, 3H, C**H**$_2$Ar, C**H**(3)), 3.85 (dd, *J* = 10.7, 3.9 Hz, 1H, C**H**$_2$(2)$_a$), 3.81 (dd, *J* = 10.7, 5.5 Hz, 1H, C**H**$_2$(2)$_b$), 2.71 (dd, *J* = 17.2, 6.1 Hz, 1H, C**H**$_2$(5)$_a$), 2.63 (dd, *J* = 17.1, 4.1 Hz, 1H, C**H**$_2$(5)$_b$), 1.06–1.01 (m, 21H, C**H**$_3$, C**H**(CH$_3$)$_2$); ^{13}C NMR (125 MHz, $CDCl_3$): δ 175.0 (C(1)), 137.8 (CAr), 128.5 (CHAr), 127.9 (CHAr), 127.9 (CHAr), 83.0 (CH(3)), 73.8 (CH$_2$Ar), 69.4 (CH(4)), 68.1 (CH$_2$(2)), 39.2 (CH$_2$(5), 18.0 (CH$_3$), 12.2



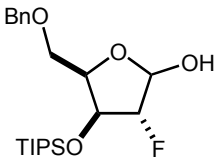
($CH(CH_3)_2$); HRMS (ESI-TOF) calculated for $C_{21}H_{34}O_4Si$ $[M+H]^+$ m/z 379.2299, found 379.2293; α_D^{21} = +8.16 (c = 1.06, $CHCl_3$).

(3*R*,4*S*,5*R*)-5-(benzyloxymethyl)-3-fluoro-4-(triisopropylsilyloxy)-dihydrofuran-2(3H)-one (32a).



To a solution of manganese(II) bromide (68 mg, 317 μmol, 4.0 equiv.)[18] and *N*-fluorodibenzenesulfonamide (100 mg, 317 μmol, 4.0 equiv.) in dry THF (0.8 mL) was added a solution of (4*R*,5*R*)-5-(benzyloxymethyl)-4-(triisopropylsilyloxy)-dihydrofuran-2(3H)-one (30 mg, 79 μmol, 1.0 equiv.) and the solution was cooled to –78 °C. To the solution was slowly added LiHMDS (396 μL, 396 μmol, 1 M in THF, 5.0 equiv.) and the mixture was stirred at –78 °C for 1.5 h then quenched by the addition of a sat. aq. sol. of NH_4Cl (1 mL). The aqueous layer was extracted with Et_2O (3 x 5 mL) and the combined organic layers were washed with a sat. aq. sol. of $NaHCO_3$ then dried over Na_2SO_4, filtered, and concentrated under vacuum. The crude product was purified by flash chromatography using 10:1 hexanes/Et_2O to yield the title compound (28.3 mg, 90% yield, dr >20:1), as a colorless oil. IR (thin film): 2923, 2867, 1803, 1463, 1362, 1340, 1231, 1162, 1106, 1077, 1056, 911, 882, 810, 739, 686 cm^{-1}; ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.37–7.26 (m, 5H, Ar**H**), 5.43 (dd, *J* = 53.5, 7.8 Hz, 1H, C**H**(2)), 4.82 (ddd, *J* = 22.1, 7.9, 7.9 Hz, 1H, C**H**(3)), 4.60–4.49 (m, 3H, C$\mathbf{H}_2$Ar, C**H**(4)), 3.84 (dd, *J* = 10.6, 1.5 Hz, 1H, C$\mathbf{H}_2(5)_a$), 3.72 (ddd, *J* = 10.6, 2.5, 2.5 Hz, 1H, C$\mathbf{H}_2(5)_b$), 1.20–0.99 (m, 21H, C$\mathbf{H}_3$, C$\mathbf{H}(CH_3)_2$); ^{13}C NMR (125 MHz, $CDCl_3$): δ 169.9 (d, *J* = 22.9 Hz, C(1)), 137.4 (CAr), 128.6 (CHAr), 128.0 (CHAr), 127.7 (CHAr), 90.6 (d, *J* = 193.0 Hz, CH(2)), 77.7 (d, *J* = 10.4 Hz, CH(4)), 74.1 (d, *J* = 20.4 Hz, CH(3)), 73.8 (CH_2Ar), 66.4 (CH_2(5)), 18.0 (CH_3), 17.8 (CH_3), 12.1 ($CH(CH_3)_2$); ^{19}F NMR (282 MHz, $CDCl_3$): δ –195.97 (ddd, *J* = 53.4, 22.3, 2.1 Hz); HRMS (ESI-TOF) calculated for $C_{21}H_{33}FO_4Si$ $[M+Na]^+$ m/z 419.2024, found 419.2022; α_D^{21} = +25.0 (c = 1.07, $CHCl_3$).

(3*R*,4*S*,5*R*)-5-(benzyloxymethyl)-3-fluoro-4-(triisopropylsilyloxy)-tetrahydrofuran-2-ol (32b). To a solution of (3*R*,4*S*,5*R*)-5-(benzyloxymethyl)-3-fluoro-4-(triisopropylsilyloxy)-dihydrofuran-2(3H)-one (18.9 mg, 48 μmol, 1.0 equiv.) in toluene (0.5 mL) at –78 °C was slowly added DIBAL-H (191 μL, 191 μmol, 1 M in toluene, 4.0 equiv.). The reaction was stirred at –78 °C for 2 hours then quenched by the slow addition of MeOH (20 μL, 480 μmol, 10 equiv.) and allowed to warm up to room temperature. A 0.1 M HCl solution (1 mL) was added and the mixture was stirred vigorously for 10 min. The aqueous layer was extracted with Et_2O (3 x 5 mL) and the combined organic layers were washed with a sat. aq. sol. of $NaHCO_3$, water and brine, then dried over Na_2SO_4, filtered, and concentrated under vacuum. The crude product was purified by preparative TLC plate using 2:1 hexanes/Et_2O to yield the title compound (13.4 mg, 70% yield) 1:3.5 mixture of anomers as a colorless oil. IR (thin film): 3440, 2943, 2866, 1463, 1384, 1365, 1238, 1145, 1100, 1028, 997, 881, 827, 735, 681 cm^{-1}; ^{1}H NMR (500 MHz, $CDCl_3$) major isomer: δ 7.41–7.28 (m, 5H, Ar**H**), 5.24 (ddd, *J* = 14.3, 12.5, 1.5 Hz, 1H, C**H**(1)), 4.86 (ddd, *J* = 53.5, 4.1, 1.5 Hz, 1H, C**H**(2)), 4.65–4.49 (m, 3H, C$\mathbf{H}_2$Ar, C**H**(3)), 4.33 (dt, *J* = 6.5, 3.4 Hz, 1H, C**H**(4)), 4.22 (d, *J* = 12.4 Hz, 1H, OH), 3.78–3.67 (m, 2H, C$\mathbf{H}_2$(5)), 1.20–0.92 (m, 21H, C$\mathbf{H}_3$, C$\mathbf{H}(CH_3)_2$); minor isomer: δ 7.41–7.28 (m, 5H, Ar**H**), 5.52 (ddd, *J* = 9.4, 9.4, 3.5 Hz, 1H, C**H**(1)), 4.81



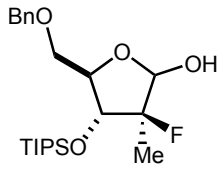
[18] Nakano, T.; Makino, M.; Morizawa, Y.; Matsumura, Y. *Angew. Chem. Int. Ed. Engl.* **1996**, *35*, 1019.

(ddd, *J* = 52.4, 3.4, 3.4 Hz, 1H, C**H**(2)), 4.65–4.49 (m, 3H, C**H**$_2$Ar, C**H**(3)), 4.45–4.39 (m, 1H, C**H**(4)), 3.72–3.67 (m, 1H, C**H**$_2$(5)$_a$), 3.62 (dd, *J* = 10.2, 5.9 Hz, 1H, C**H**$_2$(5)$_b$), 1.20–0.92 (m, 21H, C**H**$_3$, C**H**(CH$_3$)$_2$); ^{13}C NMR (125 MHz, $CDCl_3$): major isomer: δ 136.9 (CAr), 128.8 (CHAr), 128.3 (CHAr), 128.3 (CHAr), 102.2 (d, *J* = 185.5 Hz, CH(2)), 101.1 (d, *J* = 35.5 Hz, CH(1)), 80.9 (d, *J* = 5.7 Hz, CH(4)), 76.1 (d, *J* = 24.7 Hz, CH(3)), 74.1 (CH_2Ar), 68.4 (CH_2(5)), 18.0 (CH_3), 17.9 (CH_3), 12.2 (CH(CH_3)$_2$); minor isomer: δ 138.1 (CAr), 128.5 (CHAr), 128.0 (CHAr), 127.8 (CHAr), 95.8 (d, *J* = 17.1 Hz, CH(1)), 95.4 (d, *J* = 190.0 Hz, CH(2)), 78.5 (d, *J* = 4.1 Hz, CH(4)), 74.9 (d, *J* = 24.9 Hz, CH(3)), 73.6 (CH_2Ar), 68.8 (CH_2(5)), 18.0 (CH_3), 17.9 (CH_3), 12.3 (CH(CH_3)$_2$); ^{19}F NMR (282 MHz, $CDCl_3$): major-isomer: δ –189.2 (ddd, *J* = 53.5, 21.1, 14.7 Hz); minor-isomer: δ –203.7 to –205.1 (m); HRMS (ESI-TOF) calculated for $C_{21}H_{35}FO_4Si$ $[M+Na]^+$ m/z 421.2181, found 421.2182.

(3*S*,4*S*,5*R*)-5-(benzyloxymethyl)-3-methyl-4-(triisopropylsilyloxy)-dihydrofuran-2(3H)-one. To a solution of 5-benzyloxy-3-hydroxy-2-methyl-D-arabinolactone (49.3 mg, 209 μmol, 1.0 equiv.) in CH_2Cl_2 (0.5 mL) was added imidazole (85 mg, 1.25 mmol, 6.0 equiv.), DMAP (2.5 mg, 21 μmol, 0.1 equiv.) and triisopropylsilyl chloride (161 mg, 835 μmol, 4.0 equiv.). The reaction mixture was stirred for 24 h at room temperature then quenched by the addition of water (2 mL). The aqueous layer was extracted with EtOAc (3 x 5 mL) and the combined organic layers were washed with brine then dried over Na_2SO_4, filtered, and concentrated under vacuum. The crude product was purified by flash chromatography using 15:1 hexanes/EtOAc to yield the title compound (76.1 mg, 93% yield), as a colorless oil. IR (thin film): 2942, 2866, 1780, 1455, 1381, 1238, 1170, 1121, 1064, 957, 918, 881, 840, 786, 735 cm^{-1}; ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.39–7.27 (m, 5H, Ar**H**), 4.55 (dd, *J* = 12.0, 12.0 Hz, 2H, C**H**$_2$Ar), 4.30 (dt, *J* = 5.6, 3.1 Hz, 1H, C**H**(4)), 4.26 (t, *J* = 5.4 Hz, 1H, C**H**(3)), 3.73 (dd, *J* = 11.1, 2.7 Hz, 1H, C**H**$_2$(5)$_a$), 3.63 (dd, *J* = 11.1, 3.6 Hz, 1H, C**H**$_2$(5)$_b$), 2.65–2.56 (m, 1H, C**H**(2)), 1.32 (d, *J* = 7.5 Hz, 3H, C**H**$_3$), 1.02 (m, 21H, CH(C**H**$_3$)$_2$, C**H**(CH$_3$)$_2$); ^{13}C NMR (125 MHz, $CDCl_3$): δ 177.8 (C(1)), 137.5 (CAr), 128.5 (CHAr), 128.1 (CHAr), 128.0 (CHAr), 84.9 (CH(4)), 75.8 (CH(3)), 73.7 (CH_2Ar), 68.3 (CH_2(5)), 45.2 (CH(2)), 18.1 (CH(**C**H$_3$)$_2$), 13.8 (CH_3), 12.4 (**C**H(CH$_3$)$_2$); HRMS (ESI-TOF) calculated for $C_{22}H_{36}O_4Si$ $[M+H]^+$ m/z 393.2456, found 393.2457; α_D^{21} = +14.1 (c = 1.03, $CHCl_3$).

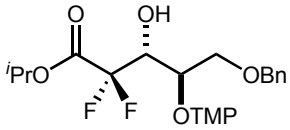
(3*S*,4*R*,5*R*)-5-(benzyloxymethyl)-3-fluoro-3-methyl-4-(triisopropylsilyloxy)-dihydrofuran-2(3H)-one (33a). To a solution of (3*S*,4*S*,5*R*)-5-(benzyloxymethyl)-3-methyl-4-(triisopropylsilyloxy)-dihydrofuran-2(3H)-one (60 mg, 153 μmol, 1.0 equiv.) in CH_2Cl_2 (1.5 mL) at 0 °C was added triethylamine (68 μL, 489 μmol, 3.2 equiv.) followed by *tert*-butyldimethylsilyl trifluoromethanesulfonate (56 μL, 245 μmol, 1.6 equiv.). The reaction was stirred at 0 °C for 30 min then quenched by the addition of water (2 mL). The aqueous layer was extracted with CH_2Cl_2 (3 x 5 mL) and the combined organic layers were dried over Na_2SO_4, filtered, and concentrated under vacuum. The product was carried forward. The crude silyl ketene acetal was dissolved in DMF (1.5 mL) and cooled to –40 °C and Selectfluor® (108 mg, 306 μmol, 2.0 equiv.) was added. The reaction was stirred at this temperature for 1 h then quenched by the addition of water (5 mL). The aqueous layer was extracted with EtOAc (3 x 5 mL) and the combined organic layers were dried over Na_2SO_4, filtered, and concentrated under vacuum. The crude product was purified by flash chromatography using gradient elution 15:1 to 12:1

hexanes/Et_2O to yield the title compound (45.1 mg, 72% yield, dr >20:1), as a colorless oil. IR (thin film): 2925, 2867, 1802, 1463, 1364, 1322, 1208, 1139, 1102, 1057, 883, 820, 769, 740, 685 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$): δ 7.39–7.29 (m, 5H, Ar**H**), 4.80 (dd, *J* = 18.8, 7.6 Hz, 1H, CH(3)), 4.57 (s, 2H, C**H**$_2$Ar), 4.13–4.05 (m, 1H, C**H**(4)), 3.83–3.77 (m, 1H, C**H**$_2$(5)$_a$), 3.69 (dd, *J* = 11.5, 3.8 Hz, 1H, C**H**$_2$(5)$_b$), 1.58 (d, *J* = 19.8 Hz, 3H, C(2)C**H**$_3$), 1.08–1.01 (m, 21H, CH(C**H**$_3$)$_2$, C**H**(CH$_3$)$_2$); ^{13}C NMR (125 MHz, $CDCl_3$): δ 172.0 (d, *J* = 26.3 Hz, C(1)), 137.2 (CAr), 128.5 (CHAr), 128.0 (CHAr), 128.0 (CHAr), 95.6 (d, *J* = 194.1 Hz, C(2)), 80.9 (d, *J* = 10.0 Hz, CH(4)), 73.8 (CH_2Ar), 73.7 (CH(3)), 66.7 (CH_2(5)), 17.8 (d, *J* = 4.1 Hz, CH(**C**H$_3$)$_2$), 16.1 (d, *J* = 25.9 Hz, CH_3), 12.4 (**C**H(CH$_3$)$_2$); ^{19}F NMR (282 MHz, $CDCl_3$): δ –157.62 (dtd, *J* = 24.1, 22.6, 21.9, 18.5 Hz); HRMS (ESI-TOF) calculated for $C_{22}H_{35}FO_4Si$ $[M+H]^+$ m/z 411.2361, found 411.2361; α_D^{21} = +26.7 (c = 0.49, $CHCl_3$).

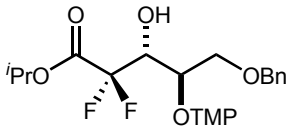
(3*S*,4*R*,5*R*)-5-(benzyloxymethyl)-3-fluoro-3-methyl-4-(triisopropylsilyloxy)-tetrahydrofuran-2-ol (33b). 

To a solution of (3*S*,4*R*,5*R*)-5-(benzyloxymethyl)-3-fluoro-3-methyl-4-(triisopropylsilyloxy)-dihydrofuran-2(3H)-one (45.1 mg, 110 μmol, 1.0 equiv.) in toluene (0.6 mL) at –78 °C was slowly added DIBAL-H (439 μL, 440 μmol, 1 M in toluene, 4.0 equiv.). The reaction was stirred at –78 °C for 1 h then quenched by the slow addition of MeOH (44 μL, 1.10 mmol, 10 equiv.) and allowed to warm up to room temperature. A 0.1 M HCl solution (1 mL) was added and the mixture was stirred vigorously for 10 min. The aqueous layer was extracted with Et_2O (3 x 10 mL) and the combined organic layers were washed with a sat. aq. sol. of $NaHCO_3$, water and brine, then dried over Na_2SO_4, filtered, and concentrated under vacuum. The crude product was purified by preparative TLC plate using 5:1 hexanes/Et_2O to yield the title compound (38.8 mg, 86% yield as a 1:1 mixture of anomers) as a colorless oil. IR (thin film): 3438, 2923, 2866, 1463, 1380, 1068, 882, 822, 733, 682 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$): major anomer: δ 7.41–7.28 (m, 5H, Ar**H**), 5.16 (brdd, *J* = 9.1, 9.1 Hz, 1H, C**H**(1)), 4.66–4.47 (m, 2H, C**H**$_2$Ar)), 4.37 (t, *J* = 6.6 Hz, 1H, C**H**(4)), 4.17 (d, *J* = 13.0 Hz, 1H, C**H**(3)), 3.63–3.57 (m, 1H, C**H**$_2$(5)$_a$), 3.53 (ddd, *J* = 9.7, 6.9, 1.5 Hz, 1H, C**H**$_2$(5)$_b$), 3.22 (d, *J* = 10.7 Hz, 1H, O**H**), 1.59 (d, *J* = 23.3 Hz, 3H, C**H**$_3$), 1.16–0.96 (m, 21H, C**H**$_3$, C**H**(CH$_3$)$_2$); minor anomer: δ 7.41–7.28 (m, 5H, Ar**H**), 4.94 (brs, 1H, C**H**(1)), 4.66–4.47 (m, 3H, C**H**$_2$Ar, C**H**(3)), 3.89 (ddd, *J* = 5.1, 3.5, 3.5 Hz, 1H, C**H**(4)), 3.63–3.57 (m, 3H, C**H**$_2$(5), O**H**), 1.45 (d, *J* = 22.9 Hz, 3H, C**H**$_3$), 1.16–0.96 (m, 21H, CH(C**H**$_3$)$_2$, C**H**(CH$_3$)$_2$); ^{13}C NMR (125 MHz, $CDCl_3$): major anomer: δ 137.1 (CAr), 128.7 (CHAr), 128.3 (CHAr), 127.9 (CHAr), 102.2 (d, *J* = 33.7 Hz, C(2)), 102.0 (d, *J* = 163.3 Hz, CH(1)), 85.9 (CH(4)), 77.9 (d, *J* = 31.2 Hz, CH(3)), 73.8 (CH_2Ar), 70.5 (d, *J* = 4.1 Hz, CH_2(5)), 18.1 (CH(**C**H$_3$)$_2$), 18.1 (CH(**C**H$_3$)$_2$), 15.8 (d, *J* = 23.0 Hz, CH_3), 12.3 (**C**H(CH$_3$)$_2$); minor anomer: δ 138.1 (CAr), 128.4 (CHAr), 128.2 (CHAr), 127.8 (CHAr), 100.5 (d, *J* = 176.4 Hz, C(2)), 100.0 (d, *J* = 20.6 Hz, CH(1)), 82.6 (d, *J* = 7.9 Hz, CH(4)), 75.1 (d, *J* = 27.6 Hz, CH(3)), 73.5 (CH_2Ar), 69.2 (CH_2(5)), 18.0 (CH(**C**H$_3$)$_2$), 18.0 (CH(**C**H$_3$)$_2$), 17.0 (d, *J* = 24.7 Hz, CH_3), 12.4 (**C**H(CH$_3$)$_2$); ^{19}F NMR (282 MHz, $CDCl_3$): α-isomer: δ –153.66 to –154.22 (m), β-isomer: δ –165.58 to –166.01 (m); HRMS (ESI-TOF) calculated for $C_{22}H_{37}FO_4Si$ $[M+Na]^+$ m/z 435.2337, found 435.2344.

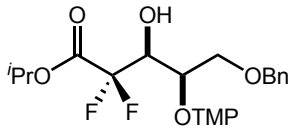
Synthesis of Gemcitabine from Aldehyde 1



(2*R*,3*R*,4*R*)-isopropyl 5-(benzyloxy)-2-fluoro-3-hydroxy-2-methyl-4-(2,2,6,6-tetramethylpiperidin-1-yloxy)pentanoate. To a solution of (*R*)-3-(benzyloxy)-2-((2,2,6,6-tetramethylpiperidin-1-yloxy)propanal (83% ee, 1.7 g, 5.32 mmol, 1.0 equiv.) and isopropyl 2-bromo-2,2-difluoroacetate (2.3 g, 10.6 mmol, 2.0 equiv.) in THF (27 mL) was added zinc (696 mg, 10.6 mmol, 2.0 equiv.) and the reaction was stirred at reflux for 2 h. The mixture was then allowed to cool down to room temperature before being quenched by the addition of a sat. aq. sol. of NH_4Cl (15 mL). The aqueous layer was extracted with EtOAc (3 x 20 mL) and the combined organic layers were washed with brine, then dried over Na_2SO_4, filtered, and concentrated under vacuum. The crude product was obtained as a 1:2.6 mixture of diastereomers and was purified by flash chromatography using gradient elution 4:1 to 1:1 hexanes/Et_2O to yield the title compound (1.44 g, 3.15 mmol, 59% yield) as a colorless solid and the minor diastereomer (712.9 mg, 1.55 mmol, 29%) as a colorless solid. *anti*-

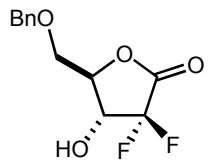


diastereomer: IR (thin film): 3450, 2980, 2933, 2872, 1771, 1755, 1454, 1376, 1362, 1300, 1209, 1183, 1088, 1059, 914, 823, 735, 697 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$): δ 7.37–7.27 (m, 5H, Ar**H**), 5.17 (hept, *J* = 6.3 Hz, 1H, C**H**$(CH_3)_2$), 4.70–4.59 (m, 1H, C**H**OHCF_2), 4.55 (s, 2H, C$\mathbf{H}_2$Ar), 4.48 (d, *J* = 7.6 Hz, 1H, O**H**), 4.22–4.12 (m, 1H, C**H**OTMP), 4.08 (dd, *J* = 10.9, 3.0 Hz, 1H, C$\mathbf{H}_2$OBn), 4.04 (dd, *J* = 10.9, 2.1 Hz, 1H, C$\mathbf{H}_2$OBn), 1.62–1.09 (m, 24H, CH(C$\mathbf{H}_3)_2$, TMP); ^{13}C NMR (125 MHz, $CDCl_3$): δ 163.2 (dd, *J* = 33.4, 29.7 Hz, CO), 137.3 (CAr), 128.6 (CHAr), 128.0 (CHAr), 127.9 (CHAr), 114.9 (dd, *J* = 258.9, 254.8 Hz, CF_2), 77.6 (**C**HOTMP), 73.9 (**C**H_2Ar), 72.7 (dd, *J* = 27.4, 22.3 Hz, CHOH), 71.4 (**C**H$(CH_3)_2$), 70.9 (d, *J* = 3.5 Hz, **C**H_2OBn), 60.6, 60.4 ($(CH_3)_2$**C**N**C**$(CH_3)_2$), 40.6, 40.5 (**C**H_2CH_2**C**H_2), 33.8, 33.7 ($(\mathbf{C}H_3)_a$CNC(**C**$H_3)_a$), 21.7, 21.6 ($(\mathbf{C}H_3)_b$CNC(**C**$H_3)_b$), 20.7 (CH(**C**$H_3)_2$), 17.2 (CH_2**C**H_2CH_2); ^{19}F NMR (282 MHz, $CDCl_3$): δ –113.59 (dd, *J* = 257.3, 6.4 Hz), –123.10 (dd, *J* = 256.9, 21.4 Hz). HRMS (ESI-TOF) calculated for $C_{24}H_{37}F_2NO_5$ $[M+H]^+$ m/z 458.2713, found 458.2719; α_D^{20} = +8.58 (c = 1.00, $CHCl_3$). *syn*-diastereomer: IR (thin film): 3558, 2981, 2932, 1771, 1454, 1376, 1363,



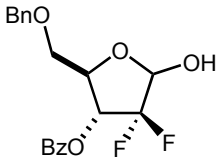
1300, 1208, 1182, 1093, 1027, 927, 821, 804, 735, 697 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$): δ 7.47–7.27 (m, 5H, Ar**H**), 6.31 (br s, 1H, O**H**), 5.18 (p, *J* = 6.3 Hz, 1H, C**H**$(CH_3)_2$), 4.72–4.50 (m, 3H, C**H**OH, C$\mathbf{H}_2$Ar), 4.38 (dt, *J* = 6.4, 4.3 Hz, 1H, CHOTMP), 3.82 (dd, *J* = 10.5, 4.0 Hz, 1H, C$\mathbf{H}_2$OBn), 3.75 (ddd, *J* = 10.9, 4.7, 1.3 Hz, 1H, C$\mathbf{H}_2$OBn), 1.66–1.04 (m, 24H, CH(C$\mathbf{H}_3)_2$, TMP); ^{13}C NMR (125 MHz, $CDCl_3$): δ 163.1 (dd, *J* = 33.3, 29.8 Hz, CO), 138.5 (CAr), 128.4 (CHAr), 127.6 (CHAr), 127.5 (CHAr), 114.7 (dd, *J* = 259.1, 253.2 Hz, CF_2), 77.7 (d, *J* = 2.1 Hz, **C**HOTMP), 73.4 (**C**H_2Ar), 72.3 (dd, *J* = 28.9, 23.2 Hz, CHOH), 71.2 (**C**H$(CH_3)_2$), 68.1 (d, *J* = 3.2 Hz, **C**H_2OBn), 61.2, 61.0 ($(CH_3)_2$**C**N**C**$(CH_3)_2$), 40.3, 40.1 (**C**H_2CH_2**C**H_2), 33.8, 32.3 ($(\mathbf{C}H_3)_a$CNC(**C**$H_3)_a$), 21.7, 21.6 ($(\mathbf{C}H_3)_b$CNC(**C**$H_3)_b$), 20.6 (CH(**C**$H_3)_2$), 17.1 (CH_2**C**H_2CH_2); ^{19}F NMR (282 MHz, $CDCl_3$): δ –111.02 (dd, *J* = 257.4, 6.4 Hz), –123.48 (dd, *J* = 257.5, 17.9 Hz); HRMS (ESI-TOF) calculated for $C_{24}H_{38}F_2NO_5$ $[M+H]^+$ m/z 458.2713, found 458.2707; α_D^{21} = –3.14 (c = 1.00, $CHCl_3$).

(4*R*,5*R*)-5-(benzyloxymethyl)-3,3-difluoro-4-hydroxy-dihydrofuran-2(3H)-one. To a solution of



(2*R*,3*R*,4*R*)-isopropyl 5-(benzyloxy)-2-fluoro-3-hydroxy-2-methyl-4-(2,2,6,6-tetramethylpiperidin-1-yloxy)pentanoate (2.16 g, 4.72 mmol, 1 equiv.) in water (15 mL), ethanol (3 mL), EtOAc (3 mL) and glacial acetic acid (9 mL) was added zinc powder (3.1 g, 47.2 mmol, 10 equiv.) and the reaction mixture was sonicated at room temperature for 4 h. The reaction was then diluted with EtOAc (20 mL) and poured into a sat. aq. sol. of $NaHCO_3$ (20 mL). The aqueous layer was extracted with EtOAc (3 x 20 mL) and the combined organic layers were washed with brine then dried over Na_2SO_4, filtered, and concentrated under vacuum. To the crude product was added acetonitrile (10 mL) and glacial acetic acid (1 mL) and the mixture was stirred under reflux for 2 days. Once the cyclization was complete the volatiles were removed *in vacuo* to yield the title compound (1.03 g, 3.99 mmol, 85% yield), as a colorless solid. IR (thin film): 3441, 3030, 2871, 1809, 1454, 1364, 1311, 1205, 1105, 1039, 933, 910, 821, 803, 739, 697 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$): δ 7.43–7.28 (m, 5H, Ar**H**), 4.64–4.51 (m, 3H, C**H**$_2$Ar, C**H**(3)), 4.45 (dt, *J* = 6.7, 3.8 Hz, 1H, C**H**(4)), 3.81 (ddd, *J* = 11.5, 3.5, 1.6 Hz, 1H, C**H**$_2$(5)$_a$), 3.77 (dd, *J* = 11.3, 3.4 Hz, 1H, C**H**$_2$(5)$_b$), 2.74 (s, 1H, O**H**); ^{13}C NMR (125 MHz, $CDCl_3$): δ 163.6 (dd, *J* = 33.9, 30.6 Hz, C(1)), 136.9 (CAr), 128.8 (CHAr), 128.3 (CHAr), 128.0 (CHAr), 112.5 (dd, *J* = 261.3, 254.1 Hz, CF_2(2)), 80.6 (d, *J* = 8.0 Hz, CH(4)), 73.9 (CH_2Ar), 69.2 (dd, *J* = 25.8, 17.5 Hz, CH(3)), 66.5 (CH_2(4)); ^{19}F NMR (282 MHz, $CDCl_3$): δ –118.44 (dd, *J* = 280.2, 10.6 Hz), –124.33 (dd, *J* = 280.3, 10.9 Hz); HRMS (ESI-TOF) calculated for $C_{12}H_{12}F_2O_4$ $[M+H_2O+Na]^+$ m/z 299.0702, found 299.0704.

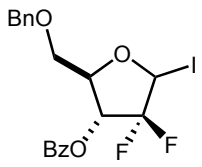
(2*R*,3*R*)-2-(benzyloxymethyl)-4,4-difluoro-5-hydroxy-tetrahydrofuran-3-yl benzoate (34). To a



solution of (4*R*,5*R*)-5-(benzyloxymethyl)-3,3-difluoro-4-hydroxy-dihydrofuran-2(3H)-one (456 mg, 1.76 mmol, 1.0 equiv.) and pyridine (0.43 mL, 5.30 mmol, 3.0 equiv.) in CH_2Cl_2 (8.83 mL) at 0 °C was added benzoyl chloride (307 μL, 2.65 mmol, 1.5 equiv.). The reaction was stirred at 0 °C for 1 h then quenched by the addition of water (10 mL) and diluted with CH_2Cl_2 (10 mL). The aqueous layer was extracted with CH_2Cl_2 (3 x 10 mL) and the combined organic layers were washed with brine then dried over Na_2SO_4, filtered, and concentrated under vacuum. The crude product was then used immediately for the next step. To a solution of the crude (2*R*,3*R*,4*S*)-2-(benzyloxymethyl)-4-fluoro-5-oxo-tetrahydrofuran-3-yl benzoate in a mixture of THF (1.4 mL) and Et_2O (5.6 mL) at 0 °C was slowly added lithium tri-*tert*-butoxyaluminum hydride (2.29 mL, 2.29 mmol, 1.2 equiv.). The reaction mixture was stirred for 1 h at 0 °C before being quenched by the slow addition of MeOH (143 μL, 3.53 mmol, 2.0 equiv.). The mixture was allowed to warm up to room temperature and a solution of 1 M HCl (3 mL) was added. The aqueous layer was extracted with Et_2O (3 x 10 mL) and the combined organic layers were washed with a sat. aq. sol. of $NaHCO_3$, water and brine then dried over Na_2SO_4, filtered, and concentrated under vacuum. The crude product was purified by flash chromatography using 1:1 hexanes/Et_2O to yield the title compound (486 mg, 1.33 mmol, 76% yield) as a colorless liquid. IR (thin film): 3406, 3032, 2923, 2870, 1730, 1601, 1585, 1496, 1452, 1362, 1264, 1215, 1088, 1068, 1026, 871, 822, 736, 708, 697 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$): major anomer δ 8.13–7.98 (m, 2H, C**H**Ar), 7.67–7.58 (m, 1H, C**H**Ar), 7.52–7.45 (m, 2H, C**H**Ar), 7.42–7.27 (m, 5H, C**H**Ar), 5.72 (ddd, *J* = 10.1, 10.1, 4.9 Hz, 1H, C**H**(3)), 5.18 (dd, *J* = 10.7, 6.3 Hz, 1H, C**H**(1)), 4.75 (d, *J* = 11.7 Hz, 1H, C**H**$_2$Ar), 4.70 (d, *J* = 11.7 Hz, 1H, C**H**$_2$Ar), 4.67–4.50 (m, 1H, O**H**), 4.40–4.34 (m, 1H, C**H**(4)), 3.84 (dd, *J* = 10.4, 2.2 Hz,

1H, C**H**$_2$(5)$_a$), 3.81–3.73 (m, 1H, C**H**$_2$(5)$_b$); minor anomer δ 8.13–7.98 (m, 2H, C**H**Ar), 7.67–7.58 (m, 1H, C**H**Ar), 7.52–7.45 (m, 2H, C**H**Ar), 7.42–7.27 (m, 5H, C**H**Ar), 5.48–5.40 (m, 2H, C**H**(1) and C**H**(3)), 4.67–4.50 (m, 3H, C**H**$_2$Ar, C**H**(4)), 3.81–3.73 (m, 2H, C**H**$_2$(5)), 3.26 (d, *J* = 5.5 Hz, 1H, O**H**); ^{13}C NMR (125 MHz, $CDCl_3$): major anomer δ 165.3 (CO), 136.2 (CAr), 134.1 (CHAr), 130.2 (CHAr), 128.8 (CHAr), 128.7 (CAr), 128.6 (CHAr), 128.2 (CHAr), 127.8 (CHAr), 124.6–121.5 (m, CF_2(2)), 96.5–96.1 (m, CH(1)), 80.9 (d, *J* = 7.8 Hz, CH(4)), 74.3 (**C**H$_2$Ar), 72.2–71.5 (CH(3)), 69.2 (CH$_2$(5)); minor anomer δ 165.7 (CO), 137.6 (CAr), 134.0 (CHAr), 130.2 (CHAr), 128.9 (CHAr), 128.7 (CHAr), 128.6 (CAr), 128.6 (CHAr), 128.0 (CHAr), 122.5–118.7 (m, CF_2(2)), 96.3 (dd, *J* = 64.5, 30.6 Hz, CH(1)), 80.5–80.3 (m, CH(4)), 73.8 (**C**H$_2$Ar), 71.9 (dd, *J* = 16.9, 6.1 Hz, CH(3)), 69.1 (CH$_2$(5)); ^{19}F NMR (282 MHz, $CDCl_3$): major anomer δ –109.76 (ddd, *J* = 250.4, 16.1, 6.7 Hz), –125.17 (dd, *J* = 250.8, 1.7 Hz); minor anomer δ –120.98 (dd, *J* = 241.8, 9.7 Hz), –122.18 (ddd, *J* = 241.8, 10.5, 5.8 Hz), HRMS (ESI-TOF) calculated for $C_{19}H_{18}F_2O_5$ $[M+H]^+$ m/z 365.1195, found 364.1122.

(2*R*,3*R*)-2-(benzyloxymethyl)-4,4-difluoro-5-iodo-tetrahydrofuran-3-ylbenzoate.[19] To a solution of



(2*R*,3*R*)-2-(benzyloxymethyl)-4,4-difluoro-5-hydroxy-tetrahydrofuran-3-yl benzoate (300 mg, 823 μmol, 1.0 equiv.) and Et_3N (230 μL, 1.647 mmol, 2.0 equiv.) in CH_2Cl_2 (8.2 mL) at 0 °C was added methanesulfonyl chloride (76 μL, 988 μmol, 1.2 equiv.). The reaction was stirred for 2 h at 0 °C then allowed to warm up to room temperature and stirred 1 h before being quenched by the addition of a sat. aq. sol. of $NaHCO_3$ and diluted with CH_2Cl_2 (10 mL). The aqueous layer was extracted with CH_2Cl_2 (3 x 10 mL) and the combined organic layers were washed with brine then dried over Na_2SO_4, filtered, and concentrated under vacuum. The crude product was then used immediately for the next step. To a solution of the crude (2*R*,3*R*)-2-(benzyloxymethyl)-4,4-difluoro-5-(methylsulfonyloxy)-tetrahydrofuran-3-yl benzoate in acetone (5.5 mL) was added sodium iodide (1.23 g, 8.23 mmol, 10 equiv.) and the reaction was stirred under reflux for 2 h. The reaction was then cooled to room temperature and filtered through celite, the filtrate was concentrated *in vacuo*. The residue was diluted with CH_2Cl_2 (10 mL) and water (10 mL), the aqueous layer was extracted with CH_2Cl_2 (3 x 10 mL) and the combined organic layers were washed with a 5% aq. sol. of $NaHSO_3$, 1:1 mixture brine:water, brine, then dried over Na_2SO_4, filtered, and concentrated under vacuum. The crude product was purified by flash chromatography using 20:1 hexanes/Et_2O to yield the title compound (337 mg, 711 μmol, 86% yield) as a colorless liquid. IR (thin film): 3032, 2865, 1731, 1601, 1495, 1452, 1320, 1264, 1219, 1178, 1112, 1094, 1053, 863, 737, 696, 679 cm^{-1}; ^{1}H NMR (500 MHz, $CDCl_3$): δ 8.20–8.11 (m, 2H, Ar**H**), 7.67–7.60 (m, 1H, Ar**H**), 7.51–7.48 (m, 2H, Ar**H**), 7.39–7.27 (m, 5H, Ar**H**), 6.91 (dd, *J* = 10.9, 1.3 Hz, 1H, C**H**(1)), 5.53 (ddd, *J* = 17.1, 5.1, 1.2 Hz, 1H, C**H**(3)), 4.66–4.59 (m, 2H, C**H**$_2$Ar), 4.50 (dd, *J* = 4.5, 4.5 Hz, 1H, C**H**(4)), 3.93–3.81 (m, 2H, C**H**$_2$(5)); ^{13}C NMR (125 MHz, $CDCl_3$): δ 165.1 (CO), 137.5 (CAr), 134.1 (CHAr), 130.3 (CHAr), 128.8 (CHAr), 128.6 (CHAr), 128.5 (CAr), 128.0 (CHAr), 127.8 (CHAr), 121.4 (dd, *J* = 269.7, 254.7 Hz, CF_2(2)), 84.3 (CH(4)), 73.9 (**C**H$_2$Ar), 71.7 (dd, *J* = 37.5, 17.7 Hz, CH(3)), 67.5 (CH$_2$(5)), 67.1 (d, *J* = 31.0 Hz, CH(1)); ^{19}F NMR (282 MHz, $CDCl_3$): δ –100.63 (ddd, *J* = 235.5, 16.9, 10.9 Hz), –104.01 (d, *J* = 235.5 Hz); HRMS (ESI-TOF) calculated for $C_{19}H_{17}F_2IO_4$ $[M+H]^+$ m/z 475.0212, found 475.0213.

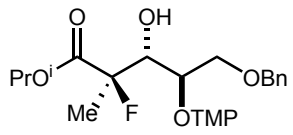
[19] Chien, C.; Chien, P.-S.; Hwang, C.-K.; Stereoselective Synthesis of Beta-Nucleosides. European Patent 2,508,528, Oct 10, 2012.

(2*R*,3*R*,5*R*)-5-(4-amino-2-oxopyrimidin-1(2H)-yl)-2-(benzyloxymethyl)-4,4-difluoro-tetrahydrofuran-3-yl benzoate. To a suspension of cytosine (0.2 g, 1.8 mmol, 1.0 equiv.), in hexamethyldisilazane (2.0 mL) was added diammonium sulfate (5.95 mg, 45 μmol, 0.025 equiv.). The reaction was stirred at 150 °C for 2 h after complete dissolution of the reagents, and then allowed to cool down to room temperature. The volatiles were removed in vacuo. The residue was co-evaporated 3 times with toluene, and dried under high vacuum for 3 h to obtain a colorless gummy solid. To a solution of (2*R*,3*R*)-2-(benzyloxymethyl)-4,4-difluoro-5-iodo-tetrahydrofuran-3-yl benzoate (20.7 mg, 44 μmol, 1.0 equiv.), freshly prepared *N*-(trimethylsilyl)-2-((trimethylsilyl)oxy)pyrimidin-4-amine (112 mg, 436 μmol, 10 equiv.) in DCE (0.6 mL) was added potassium persulfate (5.9 mg, 22 μmol, 0.5 equiv.). The white suspension was stirred at 80 °C for 50 h. Upon completion, the reaction mixture was diluted with EtOAc and a sat. aq. sol. of $NaHCO_3$ was slowly added. The mixture was stirred for 30 min at room temperature then filtered through a pad of celite. The filtrate was washed with water and brine, then dried over Na_2SO_4, filtered, and concentrated under vacuum. The crude product was obtained as a 4:1 mixture of β:α anomers. It was purified by flash chromatography using 20:1 CH_2Cl_2/MeOH to yield the title compound as a 4:1 mixture of β:α anomers (15.7 mg, 34 μmol, 79% yield). IR (thin film): 3336, 3200, 1735, 1647, 1491, 1453, 1400, 1269, 1205, 1100, 1070, 785, 709 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$): β-anomer δ 8.11–8.06 (m, 2H, Ar**H**), 7.70 (d, *J* = 7.5 Hz, 1H, C**H**(6)), 7.66–7.59 (m, 1H, Ar**H**), 7.51–7.43 (m, 2H, Ar**H**), 7.39–7.27 (m, 5H, Ar**H**), 6.53 (t, *J* = 8.3 Hz, 1H, C**H**(1')), 5.70 (ddd, *J* = 12.4, 7.0, 7.0 Hz, 1H, C**H**(3')), 5.56 (d, *J* = 7.5 Hz, 1H, C**H**(5)), 4.71–4.53 (m, 2H, C$\mathbf{H}_2$Ar), 4.35 (ddd, *J* = 6.5, 3.1, 3.1 Hz, 1H, C**H**(4')), 3.92 (dd, *J* = 11.0, 2.7 Hz, 1H, C$\mathbf{H}_2(5')_a$), 3.82–3.51 (m, 1H, C$\mathbf{H}_2(5')_b$); α-anomer δ 8.03–7.96 (m, 2H, Ar**H**), 7.66–7.59 (m, 2H, C**H**(6), Ar**H**), 7.51–7.43 (m, 2H, Ar**H**), 7.39–7.27 (m, 5H, Ar**H**), 6.63 (t, *J* = 7.6 Hz, 1H, C**H**(1')), 5.81–5.74 (m, 2H, C**H**(3') and C**H**(5)), 4.71–4.53 (m, 3H, C**H**(4'), C$\mathbf{H}_2$Ar), 3.82–3.51 (m, 2H, C$\mathbf{H}_2$(4')); ^{13}C NMR (125 MHz, $CDCl_3$): β-anomer δ 165.7 (CO), 164.9 (CO), 155.4 (C(4)), 141.6 (CH(6)), 137.3 (CAr), 134.1 (CHAr), 130.1 (CHAr), 128.7 (CHAr), 128.6 (CHAr), 128.2 (CAr), 128.0 (CHAr), 127.8 (CHAr), 121.3 (t, *J* = 262.0 Hz, CF_2(2')), 95.2 (CH(5)), 84.6–83.6 (m, CH(1')), 78.6 (CH(4')), 73.7 (**C**H_2Ar), 70.8–70.0 (m, CH(3')), 67.7 (CH_2(5')); α-anomer δ 165.9 (CO), 164.7 (CO), 155.5 (C(4)), 140.7 (CH(6)), 137.2 (CAr), 134.1 (CHAr), 130.0 (CHAr), 128.7 (CHAr), 128.6 (CHAr), 128.2 (CAr), 128.0 (CHAr), 124.6–119.6 (CF_2(2')), 95.2 (CH(5)), 85.0 (dd, *J* = 39.8, 21.2 Hz, CH(1')), 81.3 (CH(4')), 73.8 (**C**H_2Ar), 72.5 (dd, *J* = 31.6, 17.2 Hz, CH(3')), 69.1 (CH_2(5')); ^{19}F NMR (282 MHz, $CDCl_3$): β-anomer δ –115.21 (dt, *J* = 244.8, 10.1 Hz), –118.00 (d, *J* = 247.4 Hz); α-anomer δ –110.45 (d, *J* = 246.9 Hz), –122.51 (d, *J* = 247.5 Hz); HRMS (ESI-TOF) calculated for $C_{23}H_{21}F_2N_3O_5$ $[M+H]^+$ m/z 458.1522, found 458.1530.

Gemcitabine. To a solution of (2*R*,3*R*,5*R*)-5-(4-amino-2-oxopyrimidin-1(2H)-yl)-2-(benzyloxymethyl)-4,4-difluoro-tetrahydrofuran-3-yl benzoate (37 mg, 81 μmol, 1.0 equiv.) in CH_2Cl_2 (0.8 mL) at –78 °C was added boron trichloride (404 μL, 404 μmol, 1M in CH_2Cl_2, 5.0 equiv.). The reaction was stirred for 1 h at –78 °C then allowed to slowly warm up to 0 °C. The reaction was monitored by LCMS. Once the LCMS analysis showed total cleavage of the Bn protecting group, MeOH (0.7 mL) was added at 0 °C and the reaction was allowed to warm up to

room temperature and stirred for 1 h. Then the reaction was cooled to –40 °C and a solution of freshly condensed ammonia in MeOH at –20 °C was added. The resulting mixture was stirred at 0 °C for 2 h then at room temperature 24 h. Once the LCMS showed total cleavage of the Bz protecting group, the volatiles were removed in vacuo. The crude product was purified by flash chromatography using gradient elution 85:15:1 to 75:25:1 CH_2Cl_2/MeOH/NH_4OH. The purified product was then dissolved in isopropanol, filtered through a 40 μm filter and concentrated to yield the title compound as a 4:1 mixture of β:α anomers (19.5 mg, 74 μmol, 92% yield). IR (thin film): 3131, 3040, 2851, 2290, 1728, 1644, 1603, 1489, 1400, 1288, 1251, 1199, 1122, 1054, 783 cm^{-1}; ^1H NMR (500 MHz, DMSO, D_2O): β-anomer δ 7.70 (d, *J* = 7.6 Hz, 1H,C**H**(6)), 6.08 (dd, *J* = 7.9, 7.9 Hz, 1H, C**H**(1')), 5.81 (d, *J* = 7.5 Hz, 1H, C**H**(5)), 4.15–4.04 (m, 1H, C**H**(3')), 3.80–3.75 (m, 2H, C**H**(4'), $CH_2(5')_a$), 3.59 (dd, *J* = 12.7, 3.6 Hz, 1H, C**H**$_2(5')_b$); α-anomer δ 7.53 (d, *J* = 7.6 Hz, 1H, C**H**(6)), 6.23 (dd, *J* = 10.3, 6.2 Hz, 1H, C**H**(1')), 5.82 (d, *J* = 7.5 Hz, 1H, C**H**(5)), 4.34–4.25 (m, 1H, C**H**(3')), 3.80–3.73 (m, 2H, C**H**(4'), $CH_2(5')_a$ 3.50 (dd, *J* = 12.4, 4.5 Hz, 1H, C**H**$_2(5')_b$); ^{13}C NMR (125 MHz, DMSO, D_2O): β-anomer δ 166.1 (CO), 155.6 (C(4)), 141.4 (CH(6)), 123.6 (t, *J* = 257.9 Hz, $CF_2(2')$), 95.3 (CH(5)), 86.0–82.6 (CH(1')), 81.0 (CH(4')), 69.2 (t, *J* = 22.4 Hz, CH(3')), 59.4 ($CH_2(5')$); α-anomer δ 166.1 (CO), 155.8 (C(4)), 142.0 (CH(6)), 123.6 (t, *J* = 257.9 Hz, $CF_2(2')$), 95.1 (CH(5)), 84.7–83.5 (m, CH(1')), 80.9 (CH(4')), 70.2 (t, *J* = 22.3 Hz, CH(3')), 60.4 ($CH_2(5')$); ^{19}F NMR (282 MHz, DMSO, D_2O): β-anomer δ –116.78 (s); α-anomer δ –114.57 (d, *J* = 233.0 Hz), –123.75 to –125.13 (m); HRMS (ESI-TOF) calculated for $C_9H_{11}F_2N_3O_4$ $[M+H]^+$ m/z 264.0790, found 264.0789.

Synthesis of PSI-6130 from Aldehyde 1



(2*R*,3*R*,4*R*)-isopropyl 5-(benzyloxy)-2-fluoro-3-hydroxy-2-methyl-4-(2,2,6,6-tetramethylpiperidin-1-yloxy)pentanoate (36). The compound was synthesized following the general Mukaiyama aldol procedure with α-OTMP-aldehyde and silylketene acetals using $TiCl_2(O^iPr)_2$ (2.36 g, 9.94 mmol, 3.0 equiv.), *(R)*-3-(benzyloxy)-2-(2,2,6,6-tetramethylpiperidin-1-yloxy)propanal (83% ee, 1.06 g, 3.31 mmol, 1.0 equiv.), tert-butyl((2-fluoro-1-isopropoxyprop-1-en-1-yl)oxy)dimethylsilane (2.47 g, 9.94 mmol, 3.0 equiv.) and CH_2Cl_2 (17 mL). The title compound was obtained as a 9:1 diastereoisomeric mixture which was separated by flash chromatography using gradient elution 15:1 to 5:1 hexanes/Et_2O to yield the title compound (1.18 g, 79% yield, dr >20:1). IR (thin film): 3464, 2978, 2930, 1751, 1731, 1453, 1375, 1362, 1272, 1182, 1130, 1089, 958, 935, 835, 821, 734, 697 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$): δ 7.36–7.27 (m, 5H, Ar**H**), 5.05 (hept, *J* = 6.3 Hz, 1H, C**H**$(CH_3)_2$), 4.56 (d, *J* = 11.6 Hz, 1H, C**H**$_2$Ar), 4.51 (d, *J* = 11.5 Hz, 1H, C**H**$_2$Ar), 4.35 (d, *J* = 7.7 Hz, 1H, O**H**), 4.29 (ddd, *J* = 27.9, 7.7, 3.5 Hz, 1H, C**H**OH), 4.12–4.07 (m, 1H, CHC**H**$_2$O), 4.06–4.00 (m, 1H, CHC**H**$_2$O), 3.86–3.77 (m, 1H, CH_2C**H**O), 1.67 (d, *J* = 22.0 Hz, 3H, C**H**$_3$), 1.61–1.22 (m, 18H, OTMP), 1.18 (d, *J* = 8.7 Hz, 3H, CH(C**H**$_3)_2$), 1.09 (d, *J* = 6.7 Hz, 3H, CH(C**H**$_3)_2$); ^{13}C NMR (125 MHz, $CDCl_3$): δ 170.8 (d, *J* = 24.6 Hz, O**C**O), 137.6 (CAr), 128.5 (CHAr), 127.9 (CHAr), 127.9 (CHAr), 96.1 (d, *J* = 192.4 Hz, **C**FCH_3), 79.5 (**C**HOTMP), 75.7 (d, *J* = 20.1 Hz, **C**HOH), 73.8 (**C**H_2Ar), 71.4 (d, *J* = 5.0 Hz, **C**H_2OBn), 69.7 (**C**H$(CH_3)_2$), 60.5, 60.1 ($(CH_3)_2$**C**N**C**$(CH_3)_2$), 40.6, 40.5 (**C**H_2CH_2**C**H_2), 34.2, 33.5 ($(\mathbf{C}H_3)_a$CNC$(\mathbf{C}H_3)_a$), 21.8, 21.8 ($(\mathbf{C}H_3)_b$CNC$(\mathbf{C}H_3)_b$), 21.4 (d, *J* = 25.0 Hz, CF**C**H_3), 20.7, 20.7 (CH(**C**$H_3)_2$), 17.2

($CH_2\mathbf{C}H_2CH_2$); ^{19}F NMR (282 MHz, $CDCl_3$): δ –172.18 (dq, *J* = 29.7, 22.0 Hz); HRMS (ESI-TOF) calculated for $C_{25}H_{40}FNO_5$ $[M+H]^+$ m/z 454.2963, found 454.2965; α_D^{21} = –4.00 (c = 0.34, $CHCl_3$).

(3*R*,4*R*,5*R*)-5-(benzyloxymethyl)-3-fluoro-4-hydroxy-3-methyl-dihydrofuran-2(3H)-one (37). To a solution of (2*R*,3*R*,4*R*)-isopropyl 5-(benzyloxy)-2-fluoro-3-hydroxy-2-methyl-4-(2,2,6,6-tetramethylpiperidin-1-yloxy)pentanoate (1.49 g, 3.28 mmol, 1.0 equiv.) in water (20 mL), ethanol (4 mL), EtOAc (4 mL) and glacial acetic acid (7 mL) was added zinc powder (2.15 g, 32.8 mmol, 10 equiv.) and the reaction mixture was sonicated at room temperature for 2 h. The reaction was then diluted with EtOAc (20 mL) and poured into a sat. aq. sol. of $NaHCO_3$ (20 mL). The aqueous layer was extracted with EtOAc (3 x 20 mL) and the combined organic layers were washed with brine then dried over Na_2SO_4, filtered, and concentrated under vacuum. To the crude product was added toluene (10 mL) and trifluoroacetic acid (1 mL) and the mixture was stirred at room temperature for 1 day. Once the cyclization was completed, the volatiles were removed *in vacuo* and the crude product was purified by flash chromatography using 5:1 hexanes/EtOAc to yield the title compound (667 mg, 80% yield), as a colorless solid. Recrystallization was carried out as follows: the purified solid was dissolved in a minimum of refluxing EtOAc, then a small quantity of hexanes was added to the solution which was left standing to cool down to room temperature. After crystal growth had stopped (2 days) the remaining solvent was removed and the crystals were rinsed with a cold mixture of hexanes and EtOAc. Chiral HPLC analysis of the crystal showed 99.9% ee. Chiral HPLC analysis of the filtrate gave 70% ee. The recovered product in the filtrate was crystallized and the all process repeated 3 times to afford 514.8 mg of crystals with ee 99% and 156 mg of filtrate (ee 33%). IR (thin film): 3444, 2918, 2866, 1795, 1454, 1385, 1206, 1148, 1106, 1051, 953, 868, 741, 699 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$): δ 7.40–7.28 (m, 5H, Ar**H**), 4.64–4.54 (m, 2H, C$\mathbf{H}_2$Ar), 4.41 (ddd, *J* = 6.9, 3.7, 2.7 Hz, 1H, C**H**(4)), 4.20–4.07 (m, 1H, C**H**(3)), 3.86 (dd, *J* = 11.5, 2.8 Hz, 1H, C$\mathbf{H}_2(5)_a$), 3.76 (dd, *J* = 11.5, 3.7 Hz, 1H, C$\mathbf{H}_2(5)_b$), 2.30 (brd, *J* = 8.4 Hz, 1H, O**H**), 1.64 (d, *J* = 24.1 Hz, 3H, C$\mathbf{H}_3$); ^{13}C NMR (125 MHz, $CDCl_3$): δ 170.1 (d, *J* = 21.7 Hz, C(1)), 137.3 (CAr), 128.7 (CHAr), 128.2 (CHAr), 127.9 (CHAr), 92.3 (d, *J* = 179.2 Hz, C(2)), 81.9 (CH(4)), 73.8 (CH_2Ar), 72.6 (d, *J* = 17.4 Hz, CH(3)), 67.1 (CH_2(5)), 17.7 (d, *J* = 25.2 Hz, CH_3); ^{19}F NMR (282 MHz, $CDCl_3$): δ –171.23 (qd, *J* = 24.0, 23.6, 18.0 Hz); HRMS (ESI-TOF) calculated for $C_{13}H_{15}FO_4$ $[M+H]^+$ m/z 255.1027, found 255.1023; α_D^{22} = +82.3 (c = 0.97, $CHCl_3$). The configuration and absolute stereochemistry was confirmed by single-crystal X-ray analysis (see appendix).

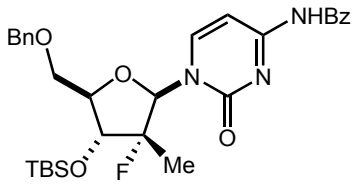
(3*R*,4*R*,5*R*)-5-(benzyloxymethyl)-4-(tert-butyldimethylsilyloxy)-3-fluoro-3-methyl-dihydrofuran-2(3H)-one. To a solution of (3*R*,4*R*,5*R*)-5-(benzyloxymethyl)-3-fluoro-4-hydroxy-3-methyl-dihydrofuran-2(3H)-one (200 mg, 787 μmol, 1.0 equiv.) in CH_2Cl_2 (2.6 mL) at 0 °C was added 2,6-lutidine (183 μL, 1.57 mmol, 2.0 equiv.) and *tert*-butyldimethylsilyl trifluoromethanesulfonate (271 mL, 1.18 μmol, 1.5 equiv.). The reaction mixture was stirred for 15 min at 0 °C then warmed to room temperature and allowed to stir for an additional hour. It was then quenched by the addition of a sat. aq. sol. of NaHCO3 (3 mL). The resulting mixture was added to water, the aqueous layer was extracted with Et_2O (3 x 20 mL) and the combined organic layers were washed with brine then dried over Na_2SO_4, filtered, and concentrated under vacuum. The crude product was purified by flash chromatography using 10:1 hexanes/Et_2O to

yield the title compound (275.8 mg, 748 μmol, 95 % yield) as a colorless solid. IR (thin film): 2954, 2932, 2893, 2859, 1798, 1473, 1454, 1384, 1362, 1254, 1210, 1157, 1109, 1056, 839, 780, 698 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$): δ 7.41–7.28 (m, 5H, Ar**H**), 4.56 (s, 2H, C**H**$_2$Ar), 4.42 (dt, *J* = 7.3, 2.7 Hz, 1H, C**H**(4)), 4.16 (dd, *J* = 19.4, 7.3 Hz, 1H, C**H**(3)), 3.84 (dd, *J* = 11.7, 2.2 Hz, 1H, C**H**$_2$(5)$_a$), 3.66 (dd, *J* = 11.7, 3.1 Hz, 1H, C**H**$_2$(5)$_b$), 1.56 (d, *J* = 22.9 Hz, 3H, C**H**$_3$), 0.90 (s, 9H, C(C**H**$_3$)$_3$), 0.12 (s, 3H, SiC**H**$_3$), 0.06 (s, 3H, SiC**H**$_3$); ^{13}C NMR (125 MHz, $CDCl_3$): δ 170.9 (d, *J* = 21.5 Hz, C(1)), 137.3 (CAr), 128.6 (CHAr), 128.1 (CHAr), 128.0 (CHAr), 91.7 (d, *J* = 185.1 Hz, C(2)), 81.8 (CH(4)), 73.8 (CH_2Ar), 72.4 (d, *J* = 16.3 Hz, CH(3)), 66.2 (CH_2(5)), 25.7 (C(**C**H$_3$)), 18.2 (d, *J* = 25.5 Hz, CH_3), 18.1 ((**C**(CH$_3$)), –4.3 ($SiCH_3$), –4.7 ($SiCH_3$); ^{19}F NMR (282 MHz, $CDCl_3$): δ –171.34 (qd, *J* = 23.0, 19.1 Hz); HRMS (ESI-TOF) calculated for $C_{19}H_{29}FO_4Si$ $[M+Na]^+$ m/z 391.1711, found 391.1704; α_D^{21} = +86.3 (c = 1.05, $CHCl_3$).

(3*R*,4*R*,5*R*)-5-(benzyloxymethyl)-4-(tert-butyldimethylsilyloxy)-3-fluoro-3-methyl-tetrahydrofuran-2-yl acetate. To a solution of (3*R*,4*R*,5*R*)-5-(benzyloxymethyl)-4-(tert-butyldimethylsilyloxy)-3-fluoro-3-methyl-dihydrofuran-2(3H)-one (228 mg, 619 μmol, 1.0 equiv.) in CH_2Cl_2 (4.2 mL) at –78 °C was slowly added DIBAL-H (1.54 mL, 1.55 mmol, 1 M in toluene, 2.5 equiv.). The mixture was allowed to stir at –78 °C for 2 h, then pyridine (188 μL, 2.32 mmol, 3.75 equiv.) was added followed by DMAP (189 mg, 1.55 mmol, 2.5 equiv.) as a solution in CH_2Cl_2 (0.3 mL) and acetic anhydride (467 μL, 4.95 mmol, 8.0 equiv.). The resulting solution was allowed to stir for 2 h at –78 °C before being warmed to 0 °C over several hours. The mixture was stirred at 0 °C for another hour before being quenched by the addition of a sat. aq. sol. of NH_4Cl (5 mL) and allowed to warm up to room temperature. The aqueous layer was extracted with CH_2Cl_2 (3 x 10 mL) and the combined organic layers were washed with brine, then dried over Na_2SO_4, filtered, and concentrated under vacuum. The crude product was purified by flash chromatography using 15:1 hexanes/Et_2O to yield the title compound (234.9 mg, 569 μmol, 92% yield as a 1:1.1 anomeric mixture) as a colorless solid. IR (thin film): 2954, 2930, 2858, 1749, 1473, 1454, 1373, 1252, 1227, 1155, 1089, 1011, 872, 839, 778, 736, 698 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$): minor isomer: δ 7.38–7.27 (m, 5H, Ar**H**), 6.04 (s, 1H, CH(1)), 4.62–4.52 (m, 2H, C**H**$_2$Ar), 4.11 (dt, *J* = 7.9, 2.5 Hz, 1H, CH(4)), 3.89 (dd, *J* = 11.0, 6.8 Hz, 1H, CH(3)), 3.74 (dd, *J* = 11.4, 2.2 Hz, 1H, C**H**$_2$(5)$_a$), 3.61–3.54 (m, 1H, C**H**$_2$(5)$_b$), 2.13 (s, 3H, COC**H**$_3$), 1.47 (d, *J* = 22.0 Hz, 3H, CH_3), 0.90 (s, 9H, C(C**H**$_3$)$_3$), 0.08 (s, 3H, SiC**H**$_3$), 0.02 (s, 3H, SiC**H**$_3$); major isomer: δ 7.38–7.27 (m, 5H, Ar**H**), 6.03 (d, *J* = 4.8 Hz, 1H, C**H**(1)), 4.62–4.52 (m, 2H, C**H**$_2$Ar), 4.24–4.20 (m, 1H, C**H**(4)), 4.17 (d, *J* = 8.3 Hz, 1H, C**H**(3)), 3.70 (dd, *J* = 11.2, 2.7 Hz, 1H, C**H**$_2$(5)$_a$), 3.61–3.54 (m, 1H, C**H**$_2$(5)$_b$), 1.94 (s, 3H, COC**H**$_3$), 1.40 (d, *J* = 22.3 Hz, 3H, C**H**$_3$), 0.88 (s, 9H, C(C**H**$_3$)$_3$), 0.12 (s, 3H, SiC**H**$_3$), 0.06 (s, 3H, SiC**H**$_3$); ^{13}C NMR (125 MHz, $CDCl_3$): minor isomer: δ 170.2 (O**C**O), 137.8 (CAr), 128.5 (CHAr), 127.9 (CHAr), 127.7 (CHAr), 98.8 (d, *J* = 17.2 Hz, CH(1)), 95.0 (d, *J* = 201.3 Hz, C(2)), 82.3 (d, *J* = 1.7 Hz, CH(4)), 74.2 (d, *J* = 16.9 Hz, CH(3)), 73.6 (CH_2Ar), 68.1 (CH_2(5)), 25.7 (C(**C**H$_3$)), 21.2 (CO**C**H$_3$), 21.0 (d, *J* = 25.8 Hz, CH_3), 18.1 (**C**(CH$_3$)), –4.3 ($SiCH_3$), –4.7 ($SiCH_3$); major isomer: δ 169.6 (O**C**O), 138.3 (CAr), 128.4 (CHAr), 127.9 (CHAr), 127.5 (CHAr), 99.4 (d, *J* = 181.7 Hz, C(2)), 98.5 (d, *J* = 35.7 Hz, CH(1)), 84.0 (d, *J* = 1.1 Hz, CH(4)), 73.3 (CH_2Ar), 73.0 (d, *J* = 16.3 Hz, CH(3)), 68.3 (CH_2C(5)), 25.7 (C(**C**H$_3$)), 21.2 (CO**C**H$_3$), 18.1 (**C**(CH$_3$)), 16.5 (d, *J* = 24.7 Hz, CH_3), –4.1 ($SiCH_3$), –4.5 ($SiCH_3$); ^{19}F NMR (282 MHz, $CDCl_3$): δ –173.11 (qdd,

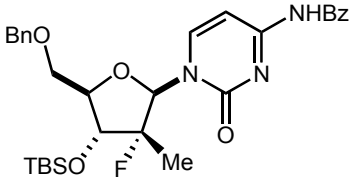
J = 22.3, 22.4, 10.4 Hz), –173.81 (qdd, *J* = 22.0, 10.8, 5.5 Hz); HRMS (ESI-TOF) calculated for $C_{21}H_{33}FO_5Si$ $[M+NH_4]^+$ m/z 430.2420, found 430.2417.

***N*-(1-((2*R*,3*R*,4*R*,5*R*)-5-(benzyloxymethyl)-4-(tert-butyldimethylsilyloxy)-3-fluoro-3-methyl-tetrahydrofuran-2-yl)-2-oxo-1,2-dihydropyrimidin-4-yl)benzamide.**

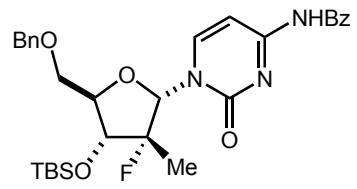


To a suspension of *N*-(2-oxo-1,2-dihydropyrimidin-4-yl)benzamide (300 mg, 1.39 mmol), hexamethyldisilazane (3.0 mL) was added diammonium sulfate (4.61 mg, 35 μmol). The reaction was stirred at 150 °C for 2 h after complete dissolution of the reagents, and then allowed to cool down to room temperature. The volatiles were removed in vacuo. The residue was co-evaporated 3 times with toluene, and dried under high vacuum for 3 h to obtain a colorless gummy solid.

To a solution of (3*R*,4*R*,5*R*)-5-(benzyloxymethyl)-4-(tert-butyldimethylsilyloxy)-3-fluoro-3-methyl-tetrahydrofuran-2-yl acetate (100 mg, 242 μmol, 1.0 equiv;) and freshly prepared *N*-(2-((trimethylsilyl)oxy)pyrimidin-4-yl)benzamide (279 mg, 970 μmol, 4.0 equiv.) in chlorobenzene (1.2 mL) at 70 °C was added freshly distilled stannic chloride (56.7 μL, 485 μmol, 2.0 equiv.) and the reaction was stirred at 70 °C for 15 h. Upon completion, the reaction mixture was diluted with EtOAc and a sat. aq. sol. of $NaHCO_3$ was added slowly. The mixture was stirred for 30 min at room temperature then filtered through a pad of celite. The filtrate was washed with water and brine, then dried over Na_2SO_4, filtered, and concentrated under vacuum. The crude product was purified by flash chromatography using 20:1 CH_2Cl_2/MeOH to yield the title compound β-anomer (84.7 mg, 149 μmol, 62% yield) as a colorless solid and the α-anomer (36.7 mg, 65 μmol, 27% yield). β-anomer: IR (thin



film): 3067, 2957, 2930, 2859, 1668, 1618, 1482, 1384, 1372, 1313, 1250, 1159, 1095, 1081, 1028, 841, 777, 731 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$): δ 8.63 (br s, 1H, N**H**), 8.54 (d, *J* = 7.0 Hz, 1H, C**H**(6)), 7.98–7.34 (m, 10H, Ar**H**), 7.21 (br s, 1H, CH(5)), 6.38 (d, *J* = 16.8 Hz, 1H, C**H**(1')), 4.64–4.56 (m, 2H, C$\mathbf{H}_2$(Ar)), 4.17 (d, *J* = 8.0 Hz, 1H, C**H**(4')), 4.10–4.04 (m, 1H, C**H**(3')), 4.03 (d, *J* = 9.2 Hz, 1H, C$\mathbf{H}_2$(5')$_a$), 3.76 (d, *J* = 10.7 Hz, 1H, C$\mathbf{H}_2$(5')$_b$), 1.32 (d, *J* = 22.0 Hz, 3H, C$\mathbf{H}_3$), 0.91 (s, 9H, C(C$\mathbf{H}_3$)$_3$), 0.09 (s, 3H, SiC$\mathbf{H}_3$), 0.08 (s, 3H, SiC$\mathbf{H}_3$); ^{13}C NMR (125 MHz, $CDCl_3$): δ 166.1 (CO), 162.2 (CO), 155.3 (C(4)), 145.3 (CH(6)), 137.0 (CAr), 133.3 (CHAr), 133.0 (CAr), 129.1 (CHAr), 128.9 (CHAr), 128.6 (CHAr), 128.2 (CHAr), 127.5 (CHAr), 100.3 (d, *J* = 186.4 Hz, C(2')), 96.5 (CH(5)), 89.7 (d, *J* = 38.7 Hz, CH(1')), 80.8 (d, *J* = 1.7 Hz, CH(4')), 73.8 (CH_2Ar), 71.4 (d, *J* = 17.2 Hz, CH(3')), 66.8 (CH_2(5')), 25.6 (C(**C**H_3)), 18.0 (**C**(CH_3)), 16.6 (d, *J* = 25.5 Hz, CH_3), –4.2 ($SiCH_3$), –4.7 ($SiCH_3$); ^{19}F NMR (282 MHz, $CDCl_3$): δ –164.10 to –164.73 (m); HRMS (ESI-TOF) calculated for $C_{30}H_{38}FN_3O_5Si$ $[M+H]^+$ m/z 568.2638, found 568.2627; α_D^{20} = +101.1 (c = 0.51, $CHCl_3$). α-anomer: IR (thin film): 2955, 2930, 2857, 1665, 1621, 1552, 1482,



1383, 1301, 1246, 1187, 1130, 1082, 1063, 1040, 1003, 865, 838, 777 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$): δ 8.62 (s, 1H, N**H**), 7.88 (br s, 3H, Ar**H**, Ar**H**, C**H**(6)), 7.65–7.57 (m, 2H, Ar**H**, C**H**(5)), 7.53 (dd, *J* = 7.7, 7.7 Hz, 2H, Ar**H**), 7.41–7.28 (m, 5H, Ar**H**), 6.41 (d, *J* = 19.5 Hz, 1H, C**H**(1')), 4.60 (s, 2H, C$\mathbf{H}_2$Ar), 4.38–4.15 (m, 2H, C**H**(3'), C**H**(4')), 3.78 (dd, *J* = 11.2, 1.7 Hz, 1H, C**H**(5')$_a$), 3.61 (dd, *J* = 11.2, 3.1 Hz, 1H, C**H**(5')$_b$), 1.51 (d, *J* = 22.2 Hz, 3H, C$\mathbf{H}_3$), 0.89 (s, 9H, C(C$\mathbf{H}_3$)$_3$), 0.11 (s, 3H, SiC$\mathbf{H}_3$), 0.03 (s, 3H, SiC$\mathbf{H}_3$); ^{13}C NMR (125 MHz, $CDCl_3$): δ

166.2 (CO), 162.5 (CO), 155.6 (C(4)), 146.7 (CH(6)), 137.7 (CAr), 133.4 (CHAr), 133.0 (CAr), 129.2 (CHAr), 128.6 (CHAr), 128.0 (CHAr), 128.0 (CHAr), 127.6 (CHAr), 98.7 (d, J = 193.3 Hz, C(2')), 96.2 (CH(5)), 87.6 (d, J = 14.7 Hz, CH(1')), 82.5 (CH(4')), 74.4 (d, J = 16.4 Hz, CH(3')), 73.8 (CH_2Ar), 68.0 (CH_2(5')), 25.7 (C(**C**H_3)), 18.1 (**C**(CH$_3$)), 18.0 (d, J = 25.8 Hz, CH_3), –4.1 ($SiCH_3$), –4.5 ($SiCH_3$); ^{19}F NMR (282 MHz, $CDCl_3$): δ –177.56 (qd, J = 21.5, 20.9 Hz); HRMS (ESI-TOF) calculated for $C_{30}H_{38}FN_3O_5Si$ $[M+H]^+$ m/z 568.2638, found 568.2636; α_D^{21} = –74.4 (c = 0.61, $CHCl_3$).

PSI-6130. To a solution of *N*-(1-((2*R*,3*R*,4*R*,5*R*)-5-(benzyloxymethyl)-4-(tert-butyldimethylsilyloxy)-3-fluoro-3-methyl-tetrahydrofuran-2-yl)-2-oxo-1,2-dihydropyrimidin-4-yl)benzamide (40.9 mg, 72 μmol, 1.0 equiv.) in CH_2Cl_2 (0.7 mL) at –78 °C was added boron trichloride (360 μL, 360 μmol, 1 M in CH_2Cl_2, 5.0 equiv.). The reaction was stirred 1 h at –78 °C then allowed to slowly warm up to 0 °C. The reaction was followed by LCMS. Once the LCMS analysis showed total cleavage of the Bn protecting group MeOH (0.7 mL) was added at 0 °C and the reaction was allowed to warm up to room temperature and stir for 1 h. HCl (0.3 mL, 1.2 mmol, 4 M in dioxane, 16 equiv.) was added and the reaction was stirred overnight. Once the LCMS showed total cleavage of the TBS protecting group the reaction was cooled at –40 °C and a solution of freshly condensed ammonia in MeOH at –20 °C was added. The resulting mixture was stirred at 0 °C for 2 h then overnight at room temperature. Once the LCMS showed total cleavage of the Bz protecting group the volatiles were removed in vacuo. The crude product was purified by flash chromatography using gradient elution 85:15:1 to 75:25:1 CH_2Cl_2/MeOH/NH_4OH. The purified product was then dissolved in isopropanol, filtered through a 40 μm filter and concentrated to yield the title compound (17.5 mg, 68 μmol, 94% yield). IR (thin film): 3121, 3038, 2805, 1718, 1662, 1613, 1534, 1399, 1285, 1211, 1107, 1088, 1071, 984, 851, 791, 761 cm^{-1}; ^{1}H NMR (500 MHz, DMSO): δ 7.90 (d, J = 7.5 Hz, 1H, C**H**(6)), 7.27 (d, J = 25.6 Hz, 2H, N**H**$_2$), 6.09 (d, J = 19.6 Hz, 1H, C**H**(1')), 5.72 (d, J = 7.5 Hz, 1H, C**H**(5)), 3.85–3.71 (m, 3H, C**H**(3'), C**H**(4'), C**H**$_2$(5')$_a$), 3.62 (dd, J = 12.5, 2.2 Hz, 1H, C**H**$_2$(5')$_b$), 1.16 (d, J = 22.4 Hz, 3H, C**H**$_3$); ^{13}C NMR (125 MHz, DMSO): δ 165.5 (CO), 155.2 (C(4)), 140.3 (CH(6)), 101.2 (d, J = 180.1 Hz, CF(2')), 94.3 (CH(5)), 88.5 (d, J = 39.1 Hz, CH(1')), 81.3 (CH(4')), 70.4 (d, J = 17.8 Hz, CH(3')), 58.4 (CH(5')), 16.6 (d, J = 25.4 Hz, CH_3); ^{19}F NMR (282 MHz, DMSO): δ –155.48; HRMS (ESI–TOF) calculated for $C_{10}H_{14}FN_3O_4$ $[M+H]^+$ m/z 260.1041, found 260.1045; α_D^{20} = +103.6 (c = 0.97, $CHCl_3$).

VII. Tables

Table 1: Chemical shifts (ppm) of selected ^{13}C-NMR signals of pentolactone derivatives*

Substituent at C(2)	***C(1)***	***C(2)***	***C(3)***	***C(4)***	***C(5)***
OTBS (ribo)[1]	174.8	70.0	70.6	83.1	69.6
OTBDPS (ribo)[3]	174.4	70.5	70.6	82.9	69.1
OMe (ribo)[1]	172.0	82.1	73.8	78.8	68.2

H (B-catalyzed, ribo/arabino)[1]	176.4	38.6	69.9	86.5	69.5
H (Ti-catalyzed, lyxo/xylo)[2]	175.3	38.5	68.8	81.1	67.7
Me_2 (ribo/arabino)[1, 2]	180.4	43.6	76.0	80.4	68.9
spiro c-butyl (ribo/arabino)[3]	180.2	48.2	75.1	82.5	68.9
spiro c-pentyl (ribo/arabino)[3]	181.2	53.5	75.6	81.4	68.9
spiro c-hexyl (ribo/arabino)[3]	179.4	46.3	76.2	80.7	69.2
Me (arabino, major)[1]	176.9	43.5	75.6	82.1	68.8
Me (ribo, minor)[1]	**179.6**	39.9	71.9	**85.0**	69.5
Et (arabino, major)[3]	176.6	49.5	73.4	82.4	68.8
Et (ribo, minor)[3]	**178.9**	46.6	70.7	**85.3**	69.3
iPr (arabino)[3]	175.3	53.8	71.0	81.6	69.0
tBu (arabino)[3]	174.7	57.3	71.2	81.1	68.9
Bn (arabino)[3]	175.8	50.1	72.6	82.7	68.6
Allyl (arabino, major)[3]	175.7	48.1	73.0	82.4	68.7
Allyl (ribo, minor)[3]	**178.1**	44.5	71.0	**85.1**	69.4

[*]Assigned by HSQC, HMBC and NOESY in $CDCl_3$. [1]Configuration determined by chemical correlation. [2]Configuration determined by X-ray analysis. [3]Configuration deduced by analogy with other representatives within the column.

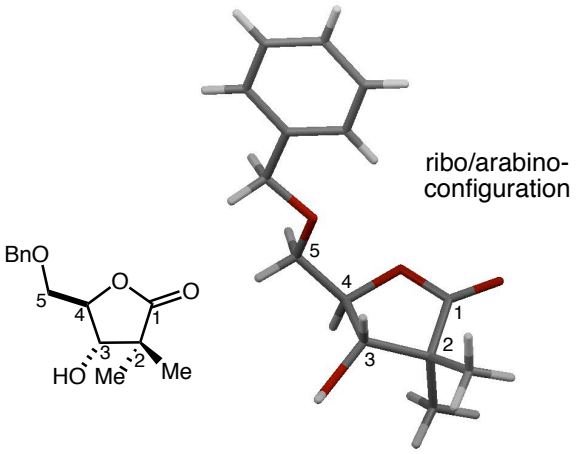
Table 2: Chemical shifts [ppm] of selected ^{13}C-NMR signals of pentose-derivatives*

Substituent at C(2)	***C(1)***	***C(2)***	***C(3)***	***C(4)***	***C(5)***
2-OBn[1,5]: α (β)	96.4 (100.4)	78.2 (83.7)	71.8 (71.3)	82.8 (84.5)	70.2 (70.1)
2-OPMB[1,7]: α (β)	96.3 (100.4)	77.8 (83.3)	71.7 (71.2)	82.7 (84.3)	70.2 (70.1)
OTBS[1]: α (β)	97.1 (102.9)	72.6 (78.2)	72.3 (71.7)	81.8 (84.3)	70.3 (70.2)
OTBDPS[1]: α (β)	97.2 (102.2)	73.3 (78.8)	72.5 (72.0)	82.7 (84.2)	70.3 (70.2)
OMe[1]: α (β)	95.5 (100.7)	86.8 (90.1)	75.0 (76.3)	80.9 (84.1)	70.5 (70.6)
H (B-cat)[2]: α (β)	99.3 (99.5)	44.2 (41.4)	73.5 (73.6)	85.2 (86.3)	71.3 (70.6)
H (Ti-cat)[3]: α (β)	98.0 (99.2)	43.7 (42.1)	72.8 (73.9)	78.8 (82.0)	68.8 (69.9)
Me_2[2]: α (β)	105.1 (105.0)	46.3 (46.0)	77.8 (80.0)	82.0 (85.2)	70.8 (71.2)
c-butyl[2]: α (β)	103.7 (104.7)	52.5 (52.0)	75.5 (79.4)	81.1 (86.2)	70.9 (70.8)
c-pentyl[2]: α (β)	103.9 (104.8)	57.8 (58.4)	76.3 (80.1)	81.4 (86.4)	70.9 (70.9)
c-hexyl[2]: α (β)	103.6 (101.2)	49.2 (49.7)	78.0 (78.0)	81.2 (86.2)	71.1 (71.2)
Me[4]: α (β)	100.0 (104.0)	47.3 (49.1)	77.6 (79.3)	83.6 (84.4)	70.8 (71.1)
Et[4,6]: α (β)	99.1 (102.7)	45.5 (56.4)	76.8 (77.9)	83.9 (83.8)	71.2 (70.7)
iPr[4]: α (β)	99.8 (101.3)	60.0 (61.6)	76.2 (76.4)	85.0 (82.4)	71.2 (70.5)
tBu[4]: α (β)	100.5 (99.7)	61.4 (65.3)	73.2 (74.6)	84.7 (81.5)	71.2 (70.5)
Benzyl[4]: α (β)	99.0 (102.2)	54.7 (55.9)	76.1 (77.2)	83.7 (84.6)	71.0 (70.4)
Allyl[4,6]: α (β)	99.2 (102.3)	52.5 (54.0)	76.4 (77.5)	83.7 (84.2)	71.0 (70.5)

[*]Assigned by HSQC, HMBC, and NOESY in $CDCl_3$. [1]ribo. [2]ribo/arabino. [3]lyxo/xylo. [4]arabino. [5]Configuration determined by chemical correlation. [6]Configuration determined by X-ray analysis. [7]Configuration deduced by analogy with other representatives within the column.

VIII. Appendix A: X-ray Crystallographic Analysis

5-Benzyloxy-2-dimethyl-3-hydroxy-D-ribonolactone (5-Benzyloxy-2-dimethyl-3-hydroxy-D-arabinolactone) (13b). Crystals were grown by Manuel Peifer from Et_2O. The data was collected and the structure solved and refined by Dr. Zoë R. Turner (postdoctoral fellow in the group of Prof. Paul Chirik at Princeton University). **Geometry**. All s.u.'s (except the s.u. in the dihedral angle between two l.s. planes) are estimated using the full covariance matrix. The cell s.u.'s are taken into account individually in the estimation of s.u.'s in distances, angles and torsion angles; correlations between s.u.'s in cell parameters are only used when they are defined by crystal symmetry. An approximate (isotropic) treatment of cell s.u.'s is used for estimating s.u.'s involving l.s. planes. **Refinement**. Refinement of F^2 against all reflections. The weighted R-factor wR and goodness of fit S are based on F^2, conventional R-factors R are based on F, with F set to zero for negative F^2. The threshold expression of $F^2 > 2\sigma(F^2)$ is used only for calculating R-factors(gt) etc. and is not relevant to the choice of reflections for refinement. R-factors based on F^2 are statistically about twice as large as those based on F, and R-factors based on all data will be even larger.



Crystal data

$C_{14}H_{18}O_4$	$F(000) = 536$
$M_r = 250.28$	$D_x = 1.307$ Mg m^{-3}
Orthorhombic, $P2_12_12_1$	Mo $K\alpha$ radiation, $\lambda = 0.71073$ Å
Hall symbol: P 2ac 2ab	Cell parameters from 2187 reflections
$a = 7.0402$ (13) Å	$\theta = 6.6$–$27.5°$
$b = 8.8190$ (16) Å	$\mu = 0.10$ mm^{-1}
$c = 20.478$ (4) Å	$T = 100$ K
$V = 1271.5$ (4) Å^3	Block, colourless
$Z = 4$	0.58 × 0.27 × 0.16 mm

Data collection

Bruker APEX-II CCD diffractometer	2905 independent reflections
Radiation source: fine-focus sealed tube	2881 reflections with $I > 2\sigma(I)$
graphite	$R_{int} = 0.011$
phi and ω scans	$\theta_{max} = 27.6°$, $\theta_{min} = 2.5°$
Absorption correction: multi-scan *SADABS* 2008/2	$h = -7 \rightarrow 9$
$T_{min} = 0.947$, $T_{max} = 0.985$	$k = -11 \rightarrow 11$

6915 measured reflections	$l = -26 \rightarrow 23$

Refinement

Refinement on F^2	Secondary atom site location: difference Fourier map
Least-squares matrix: full	Hydrogen site location: inferred from neighbouring sites
$R[F^2 > 2\sigma(F^2)] = 0.026$	H-atom parameters constrained
$wR(F^2) = 0.068$	$w = 1/[\sigma^2(F_o^2) + (0.043P)^2 + 0.2409P]$ where $P = (F_o^2 + 2F_c^2)/3$
$S = 1.02$	$(\Delta/\sigma)_{max} = 0.001$
2905 reflections	$\Delta\rangle_{max} = 0.24$ e Å^{-3}
166 parameters	$\Delta\rangle_{min} = -0.19$ e Å^{-3}
0 restraints	Absolute structure: Flack H D (1983), Acta Cryst. A39, 876-881., 1197 Friedel pairs
Primary atom site location: structure-invariant direct methods	Flack parameter: 0.2 (6)

Fractional atomic coordinates and isotropic or equivalent isotropic displacement parameters (Å^2)

Atom	*x*	*y*	*z*	U_{iso}*/U_{eq}
C1	0.25206 (15)	0.64764 (11)	0.66791 (5)	0.01792 (19)
H1A	0.3504	0.6461	0.6340	0.027*
H1B	0.2821	0.7263	0.7001	0.027*
H1C	0.1286	0.6695	0.6479	0.027*
C2	0.24441 (13)	0.49200 (10)	0.70202 (4)	0.01329 (18)
C3	0.09899 (13)	0.49039 (11)	0.75842 (4)	0.01360 (18)
H3	0.0658	0.3836	0.7703	0.016*
C4	0.21021 (13)	0.56508 (11)	0.81382 (4)	0.01401 (18)
H4	0.2015	0.6776	0.8088	0.017*
C5	0.15042 (14)	0.52354 (11)	0.88220 (5)	0.01566 (19)
H5A	0.2330	0.5760	0.9142	0.019*
H5B	0.0179	0.5567	0.8898	0.019*
C6	0.09906 (15)	0.32324 (11)	0.95438 (4)	0.01579 (18)
H6A	–0.0393	0.3418	0.9576	0.019*
H6B	0.1633	0.3865	0.9876	0.019*
C7	0.14000 (13)	0.15791 (11)	0.96743 (5)	0.01350 (18)
C8	0.23658 (14)	0.06791 (11)	0.92264 (4)	0.01493 (19)
H8	0.2724	0.1085	0.8815	0.018*
C9	0.28088 (15)	–0.08242 (12)	0.93824 (5)	0.01728 (19)
H9	0.3464	–0.1438	0.9075	0.021*

C10	0.22972 (15)	–0.14253 (11)	0.99845 (5)	0.0181 (2)
H10	0.2622	–0.2441	1.0092	0.022*
C11	0.13064 (14)	–0.05311 (12)	1.04293 (5)	0.01714 (19)
H11	0.0942	–0.0941	1.0840	0.021*
C12	0.08482 (14)	0.09611 (11)	1.02742 (5)	0.01527 (18)
H12	0.0158	0.1563	1.0577	0.018*
C13	0.21601 (15)	0.36570 (11)	0.65233 (5)	0.0184 (2)
H13A	0.2185	0.2674	0.6746	0.028*
H13B	0.3181	0.3694	0.6198	0.028*
H13C	0.0932	0.3789	0.6305	0.028*
C14	0.42836 (14)	0.47427 (10)	0.73997 (4)	0.01395 (18)
O1	–0.06795 (10)	0.57502 (8)	0.74642 (4)	0.01848 (15)
H1	–0.1577	0.5156	0.7377	0.028*
O2	0.58030 (10)	0.43127 (9)	0.71985 (3)	0.01867 (15)
O3	0.40659 (10)	0.51864 (8)	0.80264 (3)	0.01584 (15)
O4	0.16413 (10)	0.36444 (8)	0.89118 (3)	0.01534 (15)

Atomic displacement parameters (Å^2)

Atom	U^{11}	U^{22}	U^{33}	U^{12}	U^{13}	U^{23}
C1	0.0189 (4)	0.0172 (4)	0.0177 (4)	–0.0012 (4)	–0.0018 (4)	0.0045 (4)
C2	0.0121 (4)	0.0150 (4)	0.0127 (4)	–0.0004 (4)	–0.0007 (3)	0.0001 (3)
C3	0.0116 (4)	0.0147 (4)	0.0144 (4)	0.0003 (4)	–0.0005 (3)	0.0005 (3)
C4	0.0125 (4)	0.0147 (4)	0.0148 (4)	0.0007 (3)	–0.0006 (3)	–0.0003 (3)
C5	0.0184 (4)	0.0144 (4)	0.0142 (4)	0.0016 (3)	0.0010 (3)	–0.0006 (3)
C6	0.0159 (4)	0.0185 (4)	0.0131 (4)	0.0024 (4)	0.0032 (3)	0.0014 (3)
C7	0.0101 (4)	0.0165 (4)	0.0139 (4)	–0.0008 (3)	–0.0016 (3)	–0.0001 (3)
C8	0.0141 (4)	0.0186 (4)	0.0121 (4)	–0.0012 (4)	0.0004 (3)	0.0001 (3)
C9	0.0170 (4)	0.0183 (4)	0.0165 (4)	0.0012 (4)	0.0011 (4)	–0.0030 (4)
C10	0.0190 (4)	0.0161 (4)	0.0191 (4)	0.0000 (4)	–0.0005 (4)	0.0009 (3)
C11	0.0164 (4)	0.0208 (5)	0.0142 (4)	–0.0023 (4)	0.0004 (3)	0.0021 (4)
C12	0.0120 (4)	0.0201 (4)	0.0137 (4)	–0.0003 (3)	0.0010 (4)	–0.0007 (3)
C13	0.0186 (4)	0.0201 (4)	0.0166 (4)	–0.0025 (4)	–0.0002 (4)	–0.0045 (4)
C14	0.0138 (4)	0.0130 (4)	0.0150 (4)	–0.0021 (3)	–0.0009 (3)	0.0024 (3)
O1	0.0115 (3)	0.0200 (3)	0.0239 (3)	0.0021 (3)	–0.0024 (3)	–0.0003 (3)
O2	0.0131 (3)	0.0240 (3)	0.0189 (3)	0.0010 (3)	0.0017 (3)	0.0013 (3)
O3	0.0121 (3)	0.0211 (3)	0.0143 (3)	–0.0006 (3)	–0.0011 (2)	0.0002 (3)
O4	0.0196 (3)	0.0142 (3)	0.0122 (3)	0.0008 (3)	0.0021 (3)	0.0006 (2)

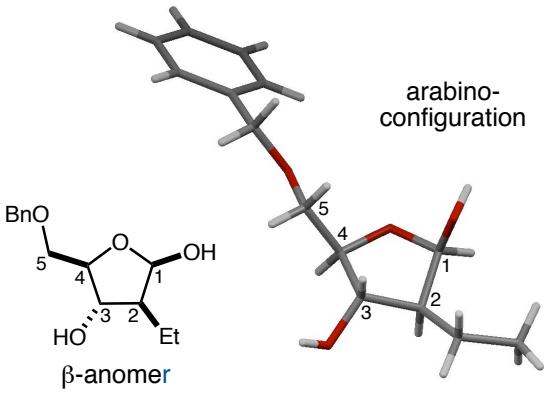
Geometric parameters (Å, º)

C1—C2	1.5411 (13)	C6—H6B	0.9900
C1—H1A	0.9800	C7—C8	1.3905 (13)

C1—H1B	0.9800	C7—C12	1.3990 (13)
C1—H1C	0.9800	C8—C9	1.3989 (14)
C2—C14	1.5183 (13)	C8—H8	0.9500
C2—C13	1.5218 (13)	C9—C10	1.3895 (14)
C2—C3	1.5434 (13)	C9—H9	0.9500
C3—O1	1.4138 (11)	C10—C11	1.3922 (14)
C3—C4	1.5277 (13)	C10—H10	0.9500
C3—H3	1.0000	C11—C12	1.3917 (14)
C4—O3	1.4600 (11)	C11—H11	0.9500
C4—C5	1.5074 (13)	C12—H12	0.9500
C4—H4	1.0000	C13—H13A	0.9800
C5—O4	1.4183 (12)	C13—H13B	0.9800
C5—H5A	0.9900	C13—H13C	0.9800
C5—H5B	0.9900	C14—O2	1.2074 (12)
C6—O4	1.4203 (11)	C14—O3	1.3505 (12)
C6—C7	1.5101 (13)	O1—H1	0.8400
C2—C1—H1A	109.5	O4—C6—H6B	109.6
C2—C1—H1B	109.5	C7—C6—H6B	109.6
H1A—C1—H1B	109.5	H6A—C6—H6B	108.1
C2—C1—H1C	109.5	C8—C7—C12	119.52 (9)
H1A—C1—H1C	109.5	C8—C7—C6	121.86 (9)
H1B—C1—H1C	109.5	C12—C7—C6	118.59 (8)
C14—C2—C13	112.27 (8)	C9—C8—C7	119.95 (9)
C14—C2—C1	107.09 (7)	C9—C8—H8	120.0
C13—C2—C1	110.69 (8)	C7—C8—H8	120.0
C14—C2—C3	100.48 (7)	C8—C9—C10	120.43 (9)
C13—C2—C3	113.98 (8)	C8—C9—H9	119.8
C1—C2—C3	111.75 (8)	C10—C9—H9	119.8
O1—C3—C4	109.12 (8)	C11—C10—C9	119.63 (9)
O1—C3—C2	114.61 (8)	C11—C10—H10	120.2
C4—C3—C2	102.22 (7)	C9—C10—H10	120.2
O1—C3—H3	110.2	C12—C11—C10	120.16 (9)
C4—C3—H3	110.2	C12—C11—H11	119.9
C2—C3—H3	110.2	C10—C11—H11	119.9
O3—C4—C5	109.99 (7)	C11—C12—C7	120.29 (9)
O3—C4—C3	104.36 (7)	C11—C12—H12	119.9
C5—C4—C3	116.23 (8)	C7—C12—H12	119.9
O3—C4—H4	108.7	C2—C13—H13A	109.5
C5—C4—H4	108.7	C2—C13—H13B	109.5
C3—C4—H4	108.7	H13A—C13—H13B	109.5
O4—C5—C4	109.99 (8)	C2—C13—H13C	109.5
O4—C5—H5A	109.7	H13A—C13—H13C	109.5

C4—C5—H5A	109.7	H13B—C13—H13C	109.5
O4—C5—H5B	109.7	O2—C14—O3	121.05 (9)
C4—C5—H5B	109.7	O2—C14—C2	127.83 (8)
H5A—C5—H5B	108.2	O3—C14—C2	111.08 (8)
O4—C6—C7	110.29 (8)	C3—O1—H1	109.5
O4—C6—H6A	109.6	C14—O3—C4	109.74 (7)
C7—C6—H6A	109.6	C5—O4—C6	110.45 (7)

5-Benzyloxy-2-ethyl-1-hydroxy-3-hydroxy-D-arabinose (8c). Crystals were grown by Manuel Peifer from Et_2O. The data was collected and the structure solved and refined by Dr. Zoë R. Turner (postdoctoral fellow in the group of Prof. Paul Chirik at Princeton University). **Geometry**. All s.u.'s (except the s.u. in the dihedral angle between two l.s. planes) are estimated using the full covariance matrix. The cell s.u.'s are taken into account individually in the estimation of s.u.'s in distances, angles and torsion angles; correlations between s.u.'s in cell parameters are only used when they are defined by crystal symmetry. An approximate (isotropic) treatment of cell s.u.'s is used for estimating s.u.'s involving l.s. planes. **Refinement**. Refinement of F^2 against all reflections. The weighted R-factor wR and goodness of fit S are based on F^2, conventional R-factors R are based on F, with F set to zero for negative F^2. The threshold expression of $F^2 > 2\sigma(F^2)$ is used only for calculating R-factors(gt) etc. and is not relevant to the choice of reflections for refinement. R-factors based on F^2 are statistically about twice as large as those based on F, and R-factors based on all data will be even larger.



Crystal data

$C_{14}H_{20}O_4$	$F(000) = 544$
$M_r = 252.30$	$D_x = 1.271$ Mg m^{-3}
Monoclinic, *C*2	Mo *K*α radiation, λ = 0.71073 Å
Hall symbol: C 2y	Cell parameters from 2700 reflections
$a = 21.972$ (4) Å	θ = 3.2–27.5°
$b = 5.2014$ (10) Å	μ = 0.09 mm^{-1}
$c = 12.991$ (2) Å	$T = 100$ K
β = 117.393 (3)°	Block, colourless
$V = 1318.2$ (4) Å^3	0.38 × 0.16 × 0.06 mm
$Z = 4$	

Data collection

Bruker APEX-II CCD diffractometer	2760 independent reflections

Radiation source: fine-focus sealed tube	2701 reflections with $I > 2\sigma(I)$
graphite	$R_{int} = 0.010$
ω scans	$\theta_{max} = 27.5°$, $\theta_{min} = 2.0°$
Absorption correction: multi-scan *SADABS* 2008/2	$h = -27 \rightarrow 28$
$T_{min} = 0.966$, $T_{max} = 0.995$	$k = -6 \rightarrow 6$
3982 measured reflections	$l = -16 \rightarrow 16$

Refinement

Refinement on F^2	Secondary atom site location: difference Fourier map
Least-squares matrix: full	Hydrogen site location: inferred from neighbouring sites
$R[F^2 > 2\sigma(F^2)] = 0.027$	H-atom parameters constrained
$wR(F^2) = 0.069$	$w = 1/[\sigma^2(F_o^2) + (0.0367P)^2 + 0.5117P]$ where $P = (F_o^2 + 2F_c^2)/3$
$S = 1.04$	$(\Delta/\sigma)_{max} = 0.001$
2760 reflections	$\Delta\rangle_{max} = 0.26$ e Å^{-3}
166 parameters	$\Delta\rangle_{min} = -0.14$ e Å^{-3}
1 restraint	Absolute structure: Flack H D (1983), Acta Cryst. A39, 876-881, 1081 Friedel Pairs
Primary atom site location: structure-invariant direct methods	Flack parameter: 0.0 (6)

Fractional atomic coordinates and isotropic or equivalent isotropic displacement parameters (Å^2)

Atom	*x*	*y*	*z*	U_{iso}*/U_{eq}
C1	0.47035 (7)	0.2991 (3)	1.31434 (10)	0.0243 (2)
H1A	0.4548	0.1282	1.2807	0.036*
H1B	0.4772	0.3009	1.3944	0.036*
H1C	0.5137	0.3401	1.3135	0.036*
C2	0.41625 (6)	0.4993 (2)	1.24303 (9)	0.0194 (2)
H2A	0.3752	0.4747	1.2549	0.023*
H2B	0.4346	0.6733	1.2712	0.023*
C3	0.39519 (5)	0.4821 (2)	1.11397 (9)	0.0155 (2)
H3	0.3731	0.3108	1.0857	0.019*
C4	0.34543 (5)	0.6883 (2)	1.03817 (9)	0.0150 (2)
H4	0.3607	0.8606	1.0754	0.018*
C5	0.35251 (5)	0.6765 (2)	0.92592 (9)	0.0152 (2)
H5	0.3150	0.5662	0.8683	0.018*
C6	0.35009 (6)	0.9351 (2)	0.87216 (9)	0.0181 (2)
H6A	0.3064	1.0230	0.8543	0.022*

H6B	0.3884	1.0442	0.9264	0.022*
C7	0.35338 (7)	1.1297 (2)	0.71055 (10)	0.0245 (3)
H7A	0.3944	1.2344	0.7585	0.029*
H7B	0.3122	1.2290	0.6986	0.029*
C8	0.35116 (6)	1.0715 (2)	0.59494 (9)	0.0184 (2)
C9	0.38756 (7)	0.8673 (3)	0.58124 (10)	0.0247 (3)
H9	0.4145	0.7600	0.6454	0.030*
C10	0.38459 (7)	0.8197 (3)	0.47331 (11)	0.0280 (3)
H10	0.4096	0.6801	0.4643	0.034*
C11	0.34529 (6)	0.9751 (3)	0.37909 (10)	0.0258 (3)
H11	0.3430	0.9411	0.3055	0.031*
C12	0.30951 (6)	1.1794 (3)	0.39280 (10)	0.0282 (3)
H12	0.2830	1.2877	0.3288	0.034*
C13	0.31216 (6)	1.2272 (3)	0.50058 (10)	0.0242 (2)
H13	0.2871	1.3670	0.5094	0.029*
C14	0.45285 (5)	0.5110 (2)	1.08000 (9)	0.0168 (2)
H14	0.4812	0.3510	1.0987	0.020*
O1	0.27716 (4)	0.63873 (17)	1.01940 (7)	0.02073 (18)
H1	0.2556	0.7781	1.0074	0.031*
O2	0.49312 (4)	0.72237 (18)	1.13828 (7)	0.02156 (18)
H2	0.5280	0.7272	1.1276	0.032*
O3	0.41769 (4)	0.55386 (16)	0.95673 (6)	0.01799 (17)
O4	0.35572 (4)	0.89396 (16)	0.76853 (7)	0.01977 (18)

Atomic displacement parameters (Å^2)

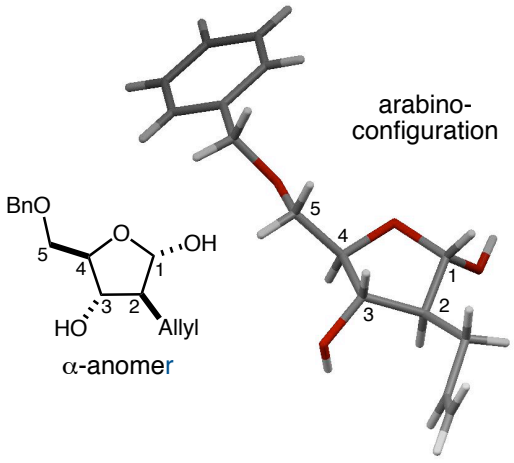
Atom	U^{11}	U^{22}	U^{33}	U^{12}	U^{13}	U^{23}
C1	0.0270 (6)	0.0229 (6)	0.0217 (5)	0.0007 (5)	0.0101 (5)	0.0035 (4)
C2	0.0227 (5)	0.0196 (6)	0.0199 (5)	–0.0008 (5)	0.0133 (4)	–0.0006 (4)
C3	0.0150 (5)	0.0150 (5)	0.0182 (5)	–0.0015 (4)	0.0091 (4)	–0.0016 (4)
C4	0.0129 (4)	0.0142 (5)	0.0206 (5)	–0.0014 (4)	0.0098 (4)	–0.0008 (4)
C5	0.0119 (4)	0.0156 (5)	0.0187 (4)	0.0002 (4)	0.0075 (4)	–0.0014 (4)
C6	0.0209 (5)	0.0167 (6)	0.0196 (5)	0.0008 (4)	0.0118 (4)	–0.0011 (4)
C7	0.0363 (6)	0.0166 (6)	0.0250 (5)	–0.0002 (5)	0.0177 (5)	0.0005 (4)
C8	0.0178 (5)	0.0174 (6)	0.0206 (5)	–0.0034 (4)	0.0093 (4)	–0.0005 (4)
C9	0.0308 (6)	0.0220 (6)	0.0209 (5)	0.0068 (5)	0.0115 (5)	0.0035 (5)
C10	0.0360 (7)	0.0252 (7)	0.0261 (6)	0.0079 (5)	0.0170 (5)	0.0017 (5)
C11	0.0289 (6)	0.0301 (7)	0.0195 (5)	–0.0014 (5)	0.0120 (5)	–0.0006 (5)
C12	0.0248 (6)	0.0343 (8)	0.0217 (5)	0.0052 (6)	0.0074 (5)	0.0077 (5)
C13	0.0217 (5)	0.0245 (6)	0.0277 (6)	0.0057 (5)	0.0124 (4)	0.0040 (5)
C14	0.0143 (4)	0.0196 (6)	0.0167 (5)	0.0002 (4)	0.0073 (4)	–0.0005 (4)
O1	0.0142 (3)	0.0184 (4)	0.0335 (4)	0.0006 (3)	0.0144 (3)	0.0016 (3)

O2	0.0151 (4)	0.0276 (5)	0.0230 (4)	–0.0058 (3)	0.0097 (3)	–0.0042 (3)
O3	0.0146 (3)	0.0237 (4)	0.0167 (3)	0.0035 (3)	0.0081 (3)	–0.0002 (3)
O4	0.0255 (4)	0.0168 (4)	0.0204 (4)	0.0004 (3)	0.0135 (3)	0.0002 (3)

Geometric parameters (Å, º)

C1—C2	1.5304 (17)	C7—C8	1.5108 (16)
C1—H1A	0.9800	C7—H7A	0.9900
C1—H1B	0.9800	C7—H7B	0.9900
C1—H1C	0.9800	C8—C9	1.3895 (18)
C2—C3	1.5229 (14)	C8—C13	1.3876 (16)
C2—H2A	0.9900	C9—C10	1.3954 (16)
C2—H2B	0.9900	C9—H9	0.9500
C3—C14	1.5285 (14)	C10—C11	1.3872 (18)
C3—C4	1.5247 (15)	C10—H10	0.9500
C3—H3	1.0000	C11—C12	1.381 (2)
C4—O1	1.4280 (12)	C11—H11	0.9500
C4—C5	1.5372 (14)	C12—C13	1.3967 (17)
C4—H4	1.0000	C12—H12	0.9500
C5—O3	1.4460 (12)	C13—H13	0.9500
C5—C6	1.5054 (16)	C14—O2	1.3960 (14)
C5—H5	1.0000	C14—O3	1.4396 (12)
C6—O4	1.4236 (12)	C14—H14	1.0000
C6—H6A	0.9900	O1—H1	0.8400
C6—H6B	0.9900	O2—H2	0.8400
C2—C1—H1A	109.5	H6A—C6—H6B	108.5
C2—C1—H1B	109.5	O4—C7—C8	109.23 (10)
H1A—C1—H1B	109.5	O4—C7—H7A	109.8
C2—C1—H1C	109.5	C8—C7—H7A	109.8
H1A—C1—H1C	109.5	O4—C7—H7B	109.8
H1B—C1—H1C	109.5	C8—C7—H7B	109.8
C3—C2—C1	112.61 (9)	H7A—C7—H7B	108.3
C3—C2—H2A	109.1	C9—C8—C13	119.40 (11)
C1—C2—H2A	109.1	C9—C8—C7	121.55 (11)
C3—C2—H2B	109.1	C13—C8—C7	119.06 (11)
C1—C2—H2B	109.1	C8—C9—C10	120.04 (11)
H2A—C2—H2B	107.8	C8—C9—H9	120.0
C14—C3—C2	116.09 (9)	C10—C9—H9	120.0
C14—C3—C4	100.83 (8)	C11—C10—C9	120.38 (12)
C2—C3—C4	115.73 (9)	C11—C10—H10	119.8
C14—C3—H3	107.9	C9—C10—H10	119.8
C2—C3—H3	107.9	C12—C11—C10	119.64 (11)

C4—C3—H3	107.9	C12—C11—H11	120.2
O1—C4—C3	111.60 (9)	C10—C11—H11	120.2
O1—C4—C5	112.81 (8)	C11—C12—C13	120.16 (11)
C3—C4—C5	103.24 (8)	C11—C12—H12	119.9
O1—C4—H4	109.7	C13—C12—H12	119.9
C3—C4—H4	109.7	C8—C13—C12	120.38 (12)
C5—C4—H4	109.7	C8—C13—H13	119.8
O3—C5—C6	109.97 (8)	C12—C13—H13	119.8
O3—C5—C4	105.95 (8)	O2—C14—O3	111.28 (9)
C6—C5—C4	114.02 (9)	O2—C14—C3	108.87 (9)
O3—C5—H5	108.9	O3—C14—C3	104.16 (8)
C6—C5—H5	108.9	O2—C14—H14	110.8
C4—C5—H5	108.9	O3—C14—H14	110.8
O4—C6—C5	107.73 (9)	C3—C14—H14	110.8
O4—C6—H6A	110.2	C4—O1—H1	109.5
C5—C6—H6A	110.2	C14—O2—H2	109.5
O4—C6—H6B	110.2	C14—O3—C5	109.42 (8)
C5—C6—H6B	110.2	C6—O4—C7	111.85 (9)



2-Allyl-5-benzyloxy-1-hydroxy-3-hydroxy-D-arabinose (11c). Crystals were grown by Manuel Peifer from Et_2O/hexanes. The data was collected and the structure solved and refined by Dr. Zoë R. Turner (postdoctoral fellow in the group of Prof. Paul Chirik at Princeton University). **Geometry**. All s.u.'s (except the s.u. in the dihedral angle between two l.s. planes) are estimated using the full covariance matrix. The cell s.u.'s are taken into account individually in the estimation of s.u.'s in distances, angles and torsion angles; correlations between s.u.'s in cell parameters are only used when they are defined by crystal symmetry. An approximate (isotropic) treatment of cell s.u.'s is used for estimating s.u.'s involving l.s. planes. **Refinement**. Refinement of F^2 against all reflections. The weighted R-factor wR and goodness of fit S are based on F^2, conventional R-factors R are based on F, with F set to zero for negative F^2. The threshold expression of $F^2 > 2\sigma(F^2)$ is used only for calculating R-factors(gt) etc. and is not relevant to the choice of reflections for refinement. R-factors based on F^2 are statistically about twice as large as those based on F, and R-factors based on all data will be even larger.

Crystal data

$C_{15}H_{20}O_4$	$F(000) = 568$

M_r = 264.31	D_x = 1.250 Mg m^{-3}
Orthorhombic, $P2_12_12_1$	Cu $K\alpha$ radiation, λ = 1.54178 Å
Hall symbol: P 2ac 2ab	Cell parameters from 3534 reflections
a = 4.7285 (2) Å	θ = 4.2–65.6°
b = 10.6501 (4) Å	μ = 0.73 mm^{-1}
c = 27.8949 (12) Å	T = 100 K
V = 1404.76 (10) Å^3	Plate, colourless
Z = 4	0.45 × 0.13 × 0.05 mm

Data collection

Bruker APEX-II CCD diffractometer	2101 independent reflections
Radiation source: fine-focus sealed tube	2050 reflections with $I > 2\sigma(I)$
graphite	R_{int} = 0.026
phi and ω scans	θ_{max} = 66.1°, θ_{min} = 4.4°
Absorption correction: multi-scan *SADABS* 2008/2	h = –3→5
T_{min} = 0.733, T_{max} = 0.967	k = –10→12
3640 measured reflections	l = –30→31

Refinement

Refinement on F^2	Secondary atom site location: difference Fourier map
Least-squares matrix: full	Hydrogen site location: inferred from neighbouring sites
$R[F^2 > 2\sigma(F^2)]$ = 0.033	H-atom parameters constrained
$wR(F^2)$ = 0.085	$w = 1/[\sigma^2(F_o^2) + (0.0467P)^2 + 0.1514P]$ where $P = (F_o^2 + 2F_c^2)/3$
S = 1.07	$(\Delta/\sigma)_{max} < 0.001$
2101 reflections	$\Delta\rangle_{max}$ = 0.14 e Å^{-3}
174 parameters	$\Delta\rangle_{min}$ = –0.21 e Å^{-3}
0 restraints	Absolute structure: Flack H D (1983), Acta Cryst. A39, 876-881, 1526 Friedel pairs/
Primary atom site location: structure-invariant direct methods	Flack parameter: –0.05 (19)

Fractional atomic coordinates and isotropic or equivalent isotropic displacement parameters (Å^2)

Atom	*x*	*y*	*z*	U_{iso}*/U_{eq}
C1	0.8163 (5)	1.2263 (2)	0.62921 (7)	0.0396 (5)
H1A	0.9648	1.1719	0.6390	0.048*

H1B	0.8277	1.3137	0.6358	0.048*
C2	0.5953 (4)	1.18062 (16)	0.60663 (6)	0.0275 (4)
H2A	0.4513	1.2380	0.5974	0.033*
C3	0.5528 (4)	1.04485 (15)	0.59424 (6)	0.0251 (4)
H3A	0.4263	1.0063	0.6184	0.030*
H3B	0.7373	1.0012	0.5960	0.030*
C4	0.4266 (3)	1.02461 (14)	0.54460 (6)	0.0207 (3)
H4	0.2465	1.0736	0.5428	0.025*
C5	0.6093 (4)	1.06284 (13)	0.50188 (6)	0.0198 (3)
H5	0.8061	1.0309	0.5067	0.024*
C6	0.4704 (3)	0.99111 (14)	0.46098 (6)	0.0201 (3)
H6	0.2963	1.0365	0.4503	0.024*
C7	0.6587 (4)	0.96764 (14)	0.41864 (6)	0.0233 (4)
H7A	0.7384	1.0478	0.4068	0.028*
H7B	0.8170	0.9118	0.4279	0.028*
C8	0.6574 (4)	0.87862 (18)	0.34091 (6)	0.0332 (4)
H8A	0.8212	0.8260	0.3502	0.040*
H8B	0.7287	0.9557	0.3252	0.040*
C9	0.4671 (4)	0.80767 (16)	0.30746 (6)	0.0274 (4)
C10	0.3866 (4)	0.68577 (18)	0.31884 (7)	0.0340 (4)
H10	0.4584	0.6472	0.3470	0.041*
C11	0.2038 (5)	0.62037 (18)	0.28962 (7)	0.0396 (5)
H11	0.1488	0.5374	0.2980	0.048*
C12	0.0993 (5)	0.67493 (19)	0.24805 (7)	0.0388 (5)
H12	–0.0262	0.6296	0.2279	0.047*
C13	0.1798 (5)	0.79567 (19)	0.23636 (7)	0.0385 (5)
H13	0.1100	0.8337	0.2079	0.046*
C14	0.3622 (4)	0.86157 (16)	0.26602 (6)	0.0327 (4)
H14	0.4158	0.9448	0.2578	0.039*
C15	0.3565 (4)	0.88745 (14)	0.53347 (6)	0.0213 (3)
H15	0.4896	0.8306	0.5510	0.026*
O1	0.6184 (3)	1.19407 (9)	0.49246 (4)	0.0233 (3)
H1	0.4564	1.2249	0.4963	0.035*
O2	0.0789 (2)	0.86201 (10)	0.54705 (4)	0.0243 (3)
H2	0.0442	0.7855	0.5427	0.037*
O3	0.3926 (3)	0.87277 (9)	0.48227 (4)	0.0237 (3)
O4	0.4935 (3)	0.91028 (10)	0.38229 (4)	0.0263 (3)

Atomic displacement parameters (Å^2)

Atom	U^{11}	U^{22}	U^{33}	U^{12}	U^{13}	U^{23}
C1	0.0406 (11)	0.0461 (11)	0.0321 (11)	–0.0147 (9)	0.0048 (8)	–0.0067 (8)

C2	0.0265 (9)	0.0312 (9)	0.0248 (9)	–0.0033 (7)	0.0040 (7)	–0.0036 (7)
C3	0.0236 (9)	0.0262 (8)	0.0255 (9)	0.0012 (7)	–0.0004 (7)	0.0002 (6)
C4	0.0183 (8)	0.0181 (8)	0.0257 (9)	–0.0001 (6)	–0.0007 (6)	–0.0003 (6)
C5	0.0181 (8)	0.0145 (7)	0.0268 (9)	0.0008 (6)	–0.0015 (7)	0.0008 (6)
C6	0.0182 (8)	0.0164 (7)	0.0257 (9)	–0.0003 (6)	–0.0004 (6)	0.0006 (6)
C7	0.0193 (8)	0.0219 (8)	0.0288 (9)	–0.0029 (7)	0.0016 (7)	–0.0011 (6)
C8	0.0288 (10)	0.0412 (10)	0.0297 (10)	–0.0044 (9)	0.0068 (7)	–0.0065 (8)
C9	0.0257 (9)	0.0312 (9)	0.0252 (9)	–0.0008 (7)	0.0085 (7)	–0.0052 (7)
C10	0.0391 (11)	0.0332 (9)	0.0299 (10)	–0.0009 (8)	0.0039 (8)	0.0026 (7)
C11	0.0461 (12)	0.0310 (10)	0.0418 (11)	–0.0073 (9)	0.0058 (9)	–0.0053 (8)
C12	0.0351 (11)	0.0464 (11)	0.0349 (11)	–0.0038 (9)	0.0014 (9)	–0.0156 (8)
C13	0.0407 (12)	0.0468 (11)	0.0279 (10)	0.0090 (9)	–0.0028 (8)	–0.0033 (8)
C14	0.0385 (11)	0.0280 (8)	0.0314 (10)	0.0018 (8)	0.0064 (8)	0.0004 (7)
C15	0.0188 (8)	0.0200 (7)	0.0250 (8)	0.0019 (7)	0.0016 (6)	–0.0009 (6)
O1	0.0232 (6)	0.0148 (5)	0.0317 (6)	–0.0004 (4)	0.0000 (5)	0.0007 (4)
O2	0.0204 (6)	0.0183 (5)	0.0344 (7)	–0.0028 (4)	0.0040 (5)	–0.0014 (5)
O3	0.0292 (6)	0.0164 (5)	0.0255 (6)	–0.0035 (5)	0.0021 (5)	–0.0010 (4)
O4	0.0238 (6)	0.0303 (6)	0.0247 (6)	–0.0039 (5)	0.0033 (5)	–0.0057 (5)

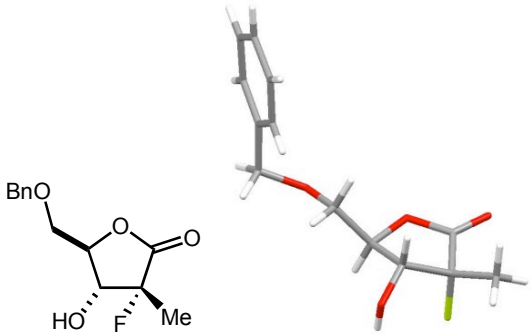
Geometric parameters (Å, º)

C1—C2	1.313 (3)	C8—O4	1.431 (2)
C1—H1A	0.9500	C8—C9	1.500 (2)
C1—H1B	0.9500	C8—H8A	0.9900
C2—C3	1.500 (2)	C8—H8B	0.9900
C2—H2A	0.9500	C9—C14	1.383 (3)
C3—C4	1.523 (2)	C9—C10	1.390 (3)
C3—H3A	0.9900	C10—C11	1.377 (3)
C3—H3B	0.9900	C10—H10	0.9500
C4—C5	1.527 (2)	C11—C12	1.388 (3)
C4—C15	1.530 (2)	C11—H11	0.9500
C4—H4	1.0000	C12—C13	1.380 (3)
C5—O1	1.4228 (17)	C12—H12	0.9500
C5—C6	1.522 (2)	C13—C14	1.386 (3)
C5—H5	1.0000	C13—H13	0.9500
C6—O3	1.4410 (19)	C14—H14	0.9500
C6—C7	1.500 (2)	C15—O2	1.393 (2)
C6—H6	1.0000	C15—O3	1.447 (2)
C7—O4	1.418 (2)	C15—H15	1.0000
C7—H7A	0.9900	O1—H1	0.8400
C7—H7B	0.9900	O2—H2	0.8400
C2—C1—H1A	120.0	H7A—C7—H7B	108.4

C2—C1—H1B	120.0	O4—C8—C9	107.20 (14)
H1A—C1—H1B	120.0	O4—C8—H8A	110.3
C1—C2—C3	125.03 (18)	C9—C8—H8A	110.3
C1—C2—H2A	117.5	O4—C8—H8B	110.3
C3—C2—H2A	117.5	C9—C8—H8B	110.3
C2—C3—C4	113.48 (14)	H8A—C8—H8B	108.5
C2—C3—H3A	108.9	C14—C9—C10	118.72 (17)
C4—C3—H3A	108.9	C14—C9—C8	121.74 (16)
C2—C3—H3B	108.9	C10—C9—C8	119.52 (17)
C4—C3—H3B	108.9	C11—C10—C9	120.61 (19)
H3A—C3—H3B	107.7	C11—C10—H10	119.7
C3—C4—C5	116.74 (13)	C9—C10—H10	119.7
C3—C4—C15	113.87 (13)	C10—C11—C12	120.40 (19)
C5—C4—C15	102.62 (12)	C10—C11—H11	119.8
C3—C4—H4	107.7	C12—C11—H11	119.8
C5—C4—H4	107.7	C13—C12—C11	119.31 (19)
C15—C4—H4	107.7	C13—C12—H12	120.3
O1—C5—C6	111.57 (12)	C11—C12—H12	120.3
O1—C5—C4	115.02 (13)	C12—C13—C14	120.14 (18)
C6—C5—C4	101.94 (12)	C12—C13—H13	119.9
O1—C5—H5	109.3	C14—C13—H13	119.9
C6—C5—H5	109.3	C9—C14—C13	120.81 (17)
C4—C5—H5	109.3	C9—C14—H14	119.6
O3—C6—C7	109.29 (12)	C13—C14—H14	119.6
O3—C6—C5	103.91 (12)	O2—C15—O3	111.00 (13)
C7—C6—C5	114.69 (14)	O2—C15—C4	109.55 (13)
O3—C6—H6	109.6	O3—C15—C4	106.15 (12)
C7—C6—H6	109.6	O2—C15—H15	110.0
C5—C6—H6	109.6	O3—C15—H15	110.0
O4—C7—C6	107.93 (13)	C4—C15—H15	110.0
O4—C7—H7A	110.1	C5—O1—H1	109.5
C6—C7—H7A	110.1	C15—O2—H2	109.5
O4—C7—H7B	110.1	C6—O3—C15	110.02 (11)
C6—C7—H7B	110.1	C7—O4—C8	112.33 (13)
C1—C2—C3—C4	–139.52 (19)	C9—C10—C11—C12	0.6 (3)
C2—C3—C4—C5	66.07 (19)	C10—C11—C12—C13	–0.2 (3)
C2—C3—C4—C15	–174.56 (14)	C11—C12—C13—C14	–0.2 (3)
C3—C4—C5—O1	–77.64 (17)	C10—C9—C14—C13	0.1 (3)
C15—C4—C5—O1	157.11 (13)	C8—C9—C14—C13	–178.01 (17)
C3—C4—C5—C6	161.47 (13)	C12—C13—C14—C9	0.3 (3)
C15—C4—C5—C6	36.22 (15)	C3—C4—C15—O2	90.94 (16)
O1—C5—C6—O3	–161.20 (12)	C5—C4—C15—O2	–141.95 (13)

C4—C5—C6—O3	–37.95 (15)	C3—C4—C15—O3	–149.14 (13)
O1—C5—C6—C7	79.56 (17)	C5—C4—C15—O3	–22.03 (16)
C4—C5—C6—C7	–157.18 (13)	C7—C6—O3—C15	148.00 (13)
O3—C6—C7—O4	68.81 (16)	C5—C6—O3—C15	25.15 (16)
C5—C6—C7—O4	–175.01 (12)	O2—C15—O3—C6	117.15 (13)
O4—C8—C9—C14	106.20 (18)	C4—C15—O3—C6	–1.82 (17)
O4—C8—C9—C10	–71.9 (2)	C6—C7—O4—C8	–177.32 (13)
C14—C9—C10—C11	–0.6 (3)	C9—C8—O4—C7	174.44 (14)
C8—C9—C10—C11	177.58 (18)		

(3*R*,4*R*,5*R*)-5-(benzyloxymethyl)-3-fluoro-4-hydroxy-3-methyl-dihydrofuran-2(3H)-one (37).



Crystals were grown by Raphaëlle Berger. The data was collected and the structure solved and refined by Phil Jeffrey of the Molecular Biology Department at Princeton University. An irregular plate-like specimen of $C_{13}H_{15}FO_4$ was used for the X-ray crystallographic analysis. The X-ray intensity data were measured.

Data collection details for pdjrb1

Axis	dx/ mm	2θ/°	ω/°	φ/°	χ/°	Width/ °	Frames	Time/ s	Wavelength/ Å	Voltage/ kV	Current/ mA	Temperature/ K
Omega	39.854	100.00	–84.00	342.00	54.50	0.50	377	5.00	1.54184	45	0.7	100.04
Phi	39.854	–46.00	–218.00	–280.76	54.50	0.50	469	5.00	1.54184	45	0.7	100.04
Omega	39.854	98.00	–86.00	78.00	54.50	0.50	377	5.00	1.54184	45	0.7	100.04
Omega	39.854	98.00	–82.30	–150.00	54.50	0.50	202	5.00	1.54184	45	0.7	100.04
Omega	39.854	98.00	–86.00	–54.00	54.50	0.50	377	5.00	1.54184	45	0.7	100.04
Omega	39.854	88.00	–95.98	–190.00	54.50	0.50	374	5.00	1.54184	45	0.7	100.04
Phi	39.854	–34.00	–164.00	–356.41	54.50	0.50	723	5.00	1.54184	45	0.7	100.04

A total of 2899 frames were collected. The total exposure time was 4.03 hours. The frames were integrated with the Bruker SAINT software package using a narrow-frame algorithm. The integration of the data using an orthorhombic unit cell yielded a total of 7441 reflections to a maximum θ angle of 66.06° (0.84 Å resolution), of which 2085 were independent (average redundancy 3.569, completeness = 98.7%, R_{int} = 2.00%, R_{sig} = 1.63%) and 2069 (99.23%) were greater than $2\sigma(F^2)$. The final cell constants of a = 6.108(7) Å, b = 7.994(8) Å, c = 25.10(3) Å, volume = 1226.(2) $Å^3$, are based upon the refinement of the XYZ-centroids of 6554 reflections above 20 σ(I) with 7.071° < 2θ < 132.8°. Data were corrected for absorption effects using the multi-scan method (SADABS). The ratio of minimum to maximum apparent transmission was 0.853. The structure was solved and refined using the Bruker SHELXTL Software Package, using the space group $P2_1\ 2_1\ 2_1$, with Z= 4 for the formula unit, $C_{13}H_{15}FO_4$. The final anisotropic full-matrix least-squares refinement on F^2 with 166 variables

converged at R1 = 2.06%, for the observed data and wR2 = 5.38% for all data. The goodness-of-fit was 1.096. The largest peak in the final difference electron density synthesis was 0.184 $e^-/Å^3$ and the largest hole was –0.124 $e^-/Å^3$ with an RMS deviation of 0.028 $e^-/Å^3$. On the basis of the final model, the calculated density was 1.378 g/cm^3 and F(000), 536 e^-.

Sample and crystal data for pdjrb1

Identification code	pdjrb1	
Chemical formula	$C_{13}H_{15}FO_4$	
Formula weight	254.25	
Temperature	273(2) K	
Wavelength	1.54178 Å	
Crystal system	orthorhombic	
Space group	$P\ 2_1\ 2_1\ 2_1$	
Unit cell dimensions	a = 6.108(7) Å	α = 90°
	b = 7.994(8) Å	β = 90°
	c = 25.10(3) Å	γ = 90°
Volume	1226.(2) $Å^3$	
Z	4	
Density (calculated)	1.378 Mg/cm^3	
Absorption coefficient	0.944 mm^{-1}	
F(000)	536	

Data collection and structure refinement for pdjrb1

Theta range for data collection	3.52 to 66.06°
Index ranges	–7<=h<=7, –9<=k<=9, –29<=l<=28
Reflections collected	7441
Independent reflections	2085 [R(int) = 0.0200]
Coverage of independent reflections	98.7%
Absorption correction	multi-scan
Structure solution technique	direct methods
Structure solution program	SHELXS-97 (Sheldrick, 2008)
Refinement method	Full-matrix least-squares on F^2
Refinement program	SHELXL-97 (Sheldrick, 2008)
Function minimized	$\Sigma\ w(F_o^2 - F_c^2)^2$
Data / restraints / parameters	2085 / 0 / 166
Goodness-of-fit on F^2	1.096
Δ/σ_{max}	0.001

Final R indices	2069 data; I>2σ(I)	R1 = 0.0206, wR2 = 0.0536
	all data	R1 = 0.0208, wR2 = 0.0538
Weighting scheme	$w=1/[\sigma^2(F_o^2)+(0.0255P)^2+0.2348P]$ where $P=(F_o^2+2F_c^2)/3$	
Absolute structure parameter	0.1(1)	
Extinction coefficient	0.0021(3)	
Largest diff. peak and hole	0.184 and –0.124 eÅ^{-3}	
R.M.S. deviation from mean	0.028 eÅ^{-3}	

Atomic coordinates and equivalent isotropic atomic displacement parameters (Å^2) for pdjrb1.

U(eq) is defined as one third of the trace of the orthogonalized U_{ij} tensor.

	x/a	y/b	z/c	U(eq)
F1	0.75867(12)	0.28729(9)	0.13698(3)	0.02590(19)
O1	0.99322(13)	0.11717(10)	0.33133(3)	0.01893(19)
O2	0.80544(13)	0.04619(10)	0.22773(3)	0.01808(18)
O3	0.65689(13)	0.48744(9)	0.22506(3)	0.01851(19)
O4	0.62187(14)	0.92096(10)	0.16122(3)	0.0221(2)
C1	0.5996(2)	0.99090(17)	0.50727(5)	0.0267(3)
C2	0.5385(2)	0.12151(17)	0.47379(5)	0.0234(3)
C3	0.6807(2)	0.17703(15)	0.43428(4)	0.0201(3)
C4	0.8848(2)	0.09981(14)	0.42676(4)	0.0180(2)
C5	0.04591(19)	0.16269(16)	0.38556(4)	0.0192(3)
C6	0.8117(2)	0.20789(15)	0.30999(4)	0.0175(2)
C7	0.82493(19)	0.21558(14)	0.25008(5)	0.0165(2)
C8	0.62975(19)	0.31249(14)	0.22617(5)	0.0159(2)
C9	0.5966(2)	0.22587(15)	0.17247(5)	0.0182(3)
C10	0.3749(2)	0.23934(16)	0.14655(5)	0.0272(3)
C11	0.66899(19)	0.04631(15)	0.18493(4)	0.0173(2)
C12	0.8023(2)	0.91356(16)	0.50055(5)	0.0267(3)
C13	0.9426(2)	0.96709(16)	0.46018(5)	0.0212(3)

Bond lengths (Å) for pdjrb1.

F1–C9	1.4194(17)	O1–C6	1.4290(17)
O1–C5	1.4455(19)	O2–C11	1.3597(17)
O2–C7	1.4707(19)	O3–C8	1.409(2)
O3–H3	0.82	O4–C11	1.2005(17)
C1–C2	1.391(2)	C1–C12	1.394(2)
C1–H1	0.93	C2–C3	1.391(2)
C2–H2	0.93	C3–C4	1.404(2)
C3–H3A	0.93	C4–C13	1.398(2)

C4–C5	1.513(2)	C5–H5A	0.97
C5–H5B	0.97	C6–C7	1.507(2)
C6–H6A	0.97	C6–H6B	0.97
C7–C8	1.5433(19)	C7–H7	0.98
C8–C9	1.529(2)	C8–H8	0.98
C9–C10	1.506(2)	C9–C11	1.534(2)
C10–H10A	0.96	C10–H10B	0.96
C10–H10C	0.96	C12–C13	1.394(2)
C12–H12	0.93	C13–H13	0.93

Bond angles (°) for pdjrb1.

C6–O1–C5	113.45(9)	C11–O2–C7	110.51(9)
C8–O3–H3	109.5	C2–C1–C12	119.88(12)
C2–C1–H1	120.1	C12–C1–H1	120.1
C3–C2–C1	120.16(13)	C3–C2–H2	119.9
C1–C2–H2	119.9	C2–C3–C4	120.67(12)
C2–C3–H3A	119.7	C4–C3–H3A	119.7
C13–C4–C3	118.50(11)	C13–C4–C5	119.88(12)
C3–C4–C5	121.54(12)	O1–C5–C4	114.54(11)
O1–C5–H5A	108.6	C4–C5–H5A	108.6
O1–C5–H5B	108.6	C4–C5–H5B	108.6
H5A–C5–H5B	107.6	O1–C6–C7	110.66(10)
O1–C6–H6A	109.5	C7–C6–H6A	109.5
O1–C6–H6B	109.5	C7–C6–H6B	109.5
H6A–C6–H6B	108.1	O2–C7–C6	109.80(10)
O2–C7–C8	104.55(10)	C6–C7–C8	111.54(10)
O2–C7–H7	110.3	C6–C7–H7	110.3
C8–C7–H7	110.3	O3–C8–C9	116.61(10)
O3–C8–C7	114.53(10)	C9–C8–C7	102.59(10)
O3–C8–H8	107.5	C9–C8–H8	107.5
C7–C8–H8	107.5	F1–C9–C10	109.34(12)
F1–C9–C8	107.72(11)	C10–C9–C8	117.87(11)
F1–C9–C11	104.52(10)	C10–C9–C11	114.46(10)
C8–C9–C11	101.88(10)	C9–C10–H10A	109.5
C9–C10–H10B	109.5	H10A–C10–H10B	109.5
C9–C10–H10C	109.5	H10A–C10–H10C	109.5
H10B–C10–H10C	109.5	O4–C11–O2	122.55(11)
O4–C11–C9	127.65(11)	O2–C11–C9	109.78(9)
C1–C12–C13	119.82(13)	C1–C12–H12	120.1
C13–C12–H12	120.1	C12–C13–C4	120.95(13)
C12–C13–H13	119.5	C4–C13–H13	119.5

Anisotropic atomic displacement parameters (Å^2) for pdjrb1

The anisotropic atomic displacement factor exponent takes the form: $-2\pi^2[h^2a^{*2}U_{11} + ... + 2hka^*b^*U_{12}]$

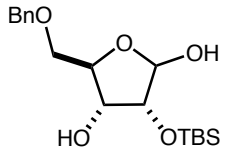
	U_{11}	U_{22}	U_{33}	U_{23}	U_{13}	U_{12}
F1	0.0340(4)	0.0258(4)	0.0180(3)	0.0013(3)	0.0061(3)	–0.0065(3)
O1	0.0178(4)	0.0237(4)	0.0153(4)	–0.0013(3)	–0.0014(3)	0.0043(3)
O2	0.0195(4)	0.0161(4)	0.0187(4)	–0.0016(3)	–0.0013(3)	0.0025(3)
O3	0.0197(4)	0.0138(4)	0.0220(4)	0.0006(3)	0.0035(3)	–0.0007(3)
O4	0.0234(4)	0.0195(4)	0.0235(4)	–0.0051(4)	0.0021(3)	–0.0014(4)
C1	0.0276(7)	0.0302(7)	0.0222(6)	–0.0037(5)	0.0065(5)	–0.0095(6)
C2	0.0176(6)	0.0321(7)	0.0205(6)	–0.0104(5)	–0.0003(5)	–0.0012(5)
C3	0.0202(6)	0.0236(6)	0.0166(6)	–0.0045(5)	–0.0029(5)	0.0014(5)
C4	0.0188(6)	0.0199(6)	0.0152(5)	–0.0056(5)	–0.0028(4)	–0.0025(5)
C5	0.0170(5)	0.0243(6)	0.0163(6)	–0.0011(5)	–0.0029(5)	–0.0005(5)
C6	0.0168(5)	0.0187(5)	0.0169(6)	0.0011(4)	–0.0007(5)	0.0022(5)
C7	0.0166(6)	0.0150(5)	0.0181(6)	–0.0018(4)	0.0011(5)	0.0010(5)
C8	0.0158(5)	0.0148(5)	0.0171(5)	0.0013(4)	0.0008(5)	–0.0002(5)
C9	0.0194(6)	0.0192(6)	0.0162(6)	0.0023(5)	0.0014(5)	–0.0014(5)
C10	0.0286(7)	0.0243(6)	0.0286(7)	–0.0021(5)	–0.0101(6)	0.0039(5)
C11	0.0147(5)	0.0211(6)	0.0159(5)	–0.0006(5)	0.0038(4)	–0.0008(5)
C12	0.0341(8)	0.0226(6)	0.0236(6)	0.0023(5)	0.0004(5)	–0.0031(6)
C13	0.0212(6)	0.0206(6)	0.0217(6)	–0.0027(5)	–0.0013(5)	0.0008(5)

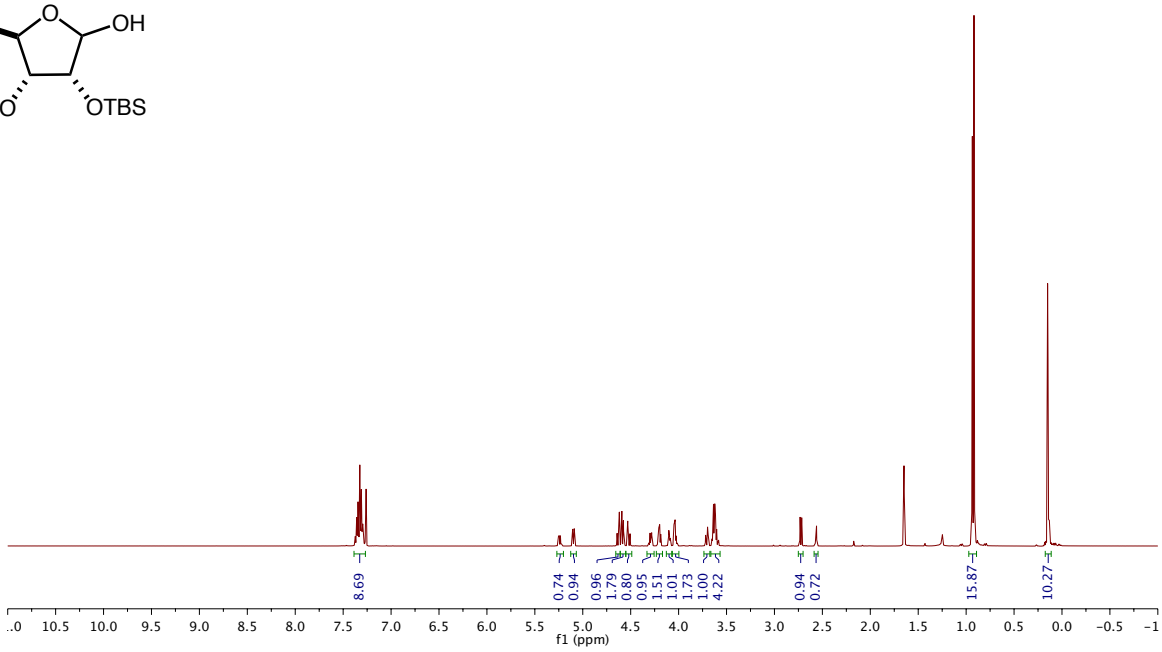
Hydrogen atomic coordinates and isotropic atomic displacement parameters (Å^2) for pdjrb1.

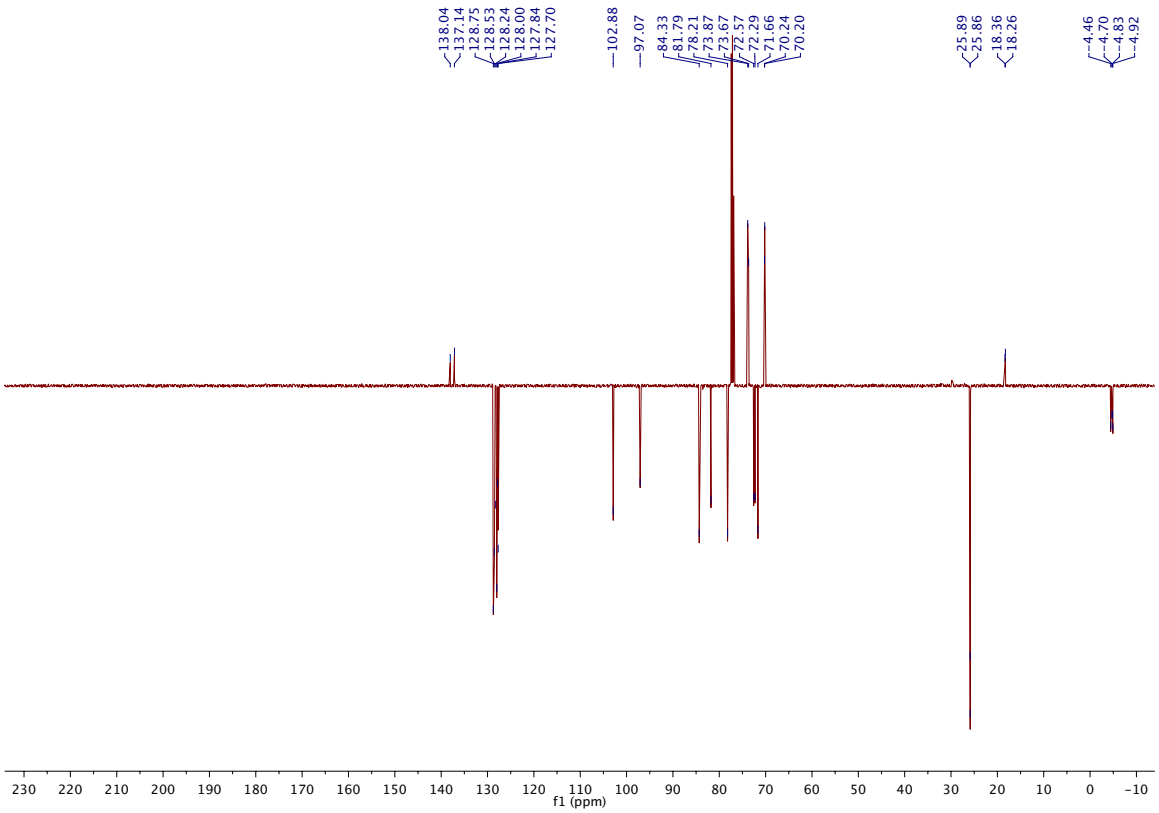
	x/a	y/b	z/c	U(eq)
H3	0.7618	0.5112	0.2061	0.028
H1	0.5055	–0.0447	0.5341	0.032
H2	0.4022	0.1718	0.4778	0.028
H3A	0.6402	0.2662	0.4126	0.024
H5A	1.0533	0.2837	0.3879	0.023
H5B	1.1899	0.1191	0.3941	0.023
H6A	0.8111	0.3205	0.3244	0.021
H6B	0.6762	0.1538	0.3205	0.021
H7	0.9634	0.2668	0.2390	0.02
H8	0.5011	0.2883	0.2482	0.019
H10A	0.3423	0.3548	0.1396	0.041
H10B	0.2657	0.1936	0.1699	0.041
H10C	0.3753	0.1782	0.1136	0.041
H12	0.8439	–0.1735	0.5229	0.032
H13	1.0764	–0.0863	0.4554	0.025

IX. Appendix B: ^{1}H and ^{13}C NMR Spectra

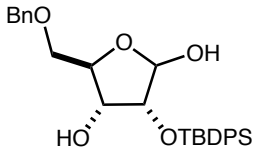
Compound **2c**



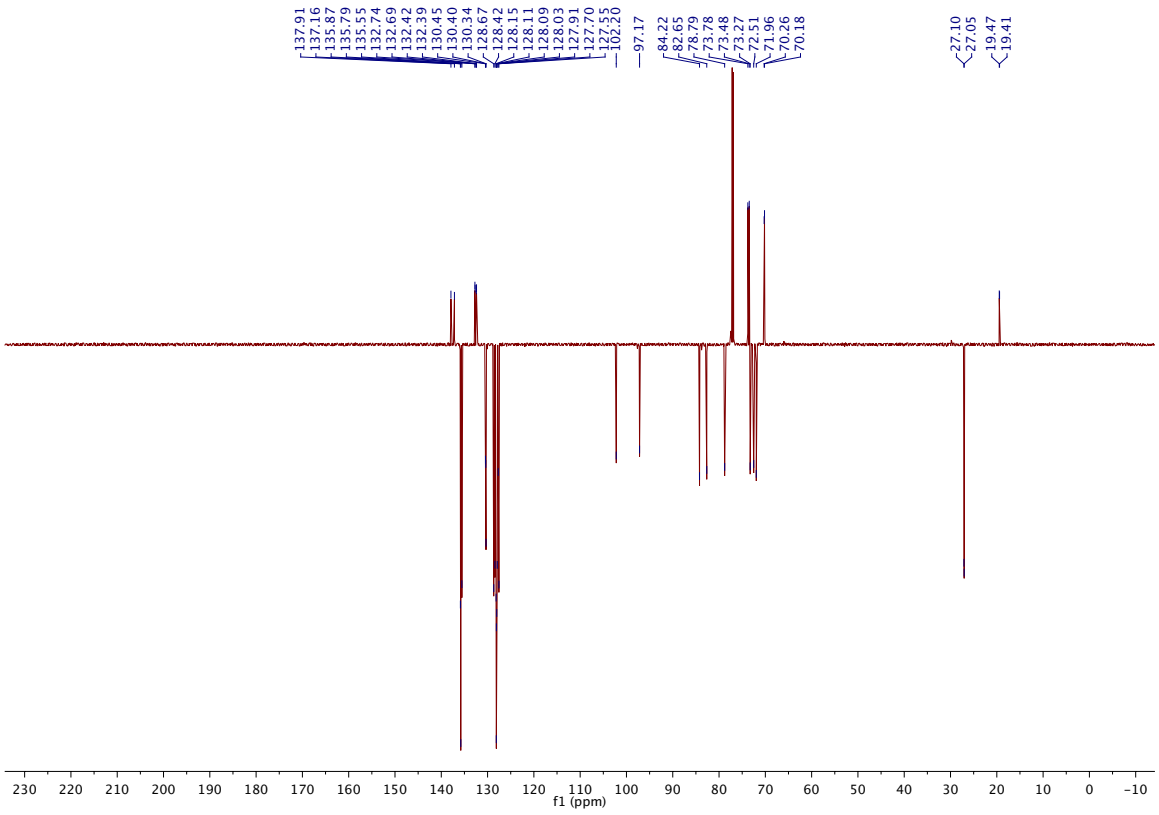




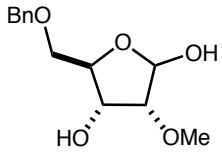
Compound **3c**


BnO
O
OH
HO
OTBDPS

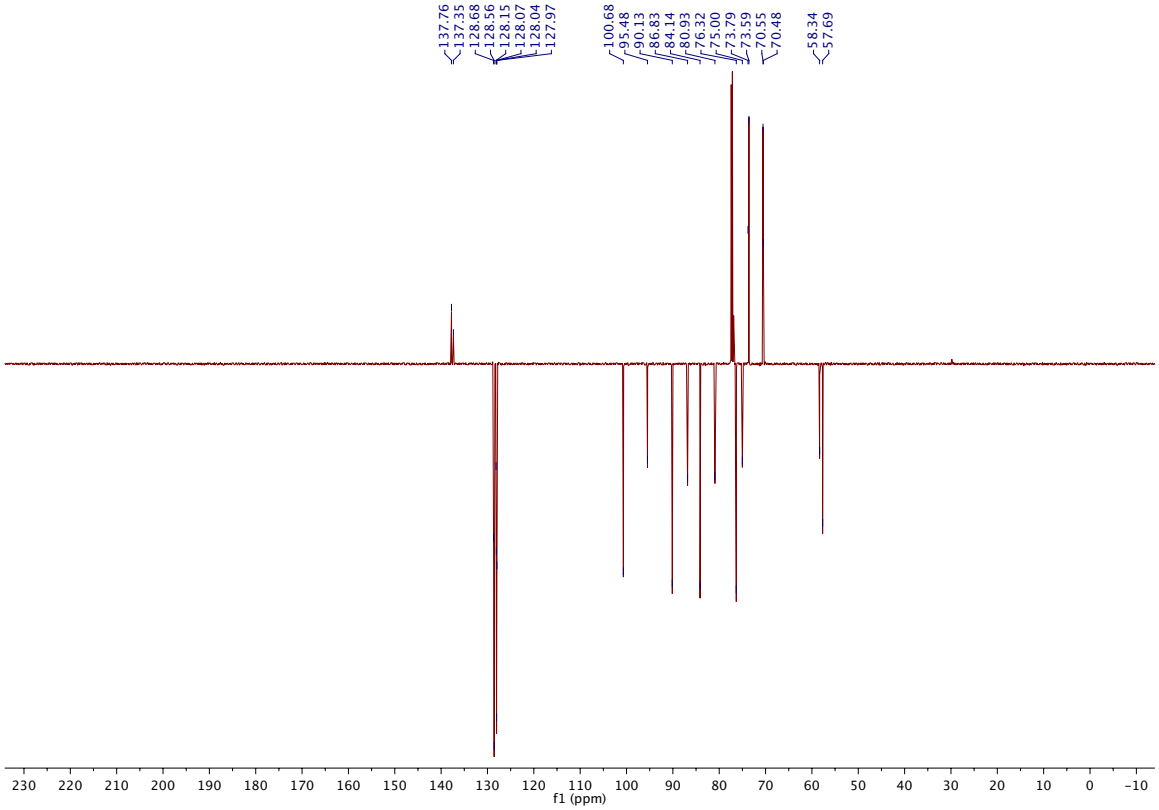
8.08
12.32
8.72
1.94
1.00
0.97
1.03
1.08
0.98
1.00
0.98
3.06
1.04
0.98
1.99
1.12
2.05
1.03
1.99
7.82
10.13
f1 (ppm)


137.91
137.16
135.87
135.79
135.55
132.74
132.69
132.42
132.39
130.45
130.40
130.34
128.67
128.42
128.15
128.11
128.09
128.03
127.91
127.70
127.55
102.20
97.17
84.22
82.65
78.79
73.78
73.48
73.27
72.51
71.96
70.26
70.18
27.10
27.05
19.47
19.41
f1 (ppm)

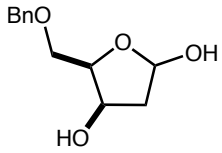
Compound **4c**

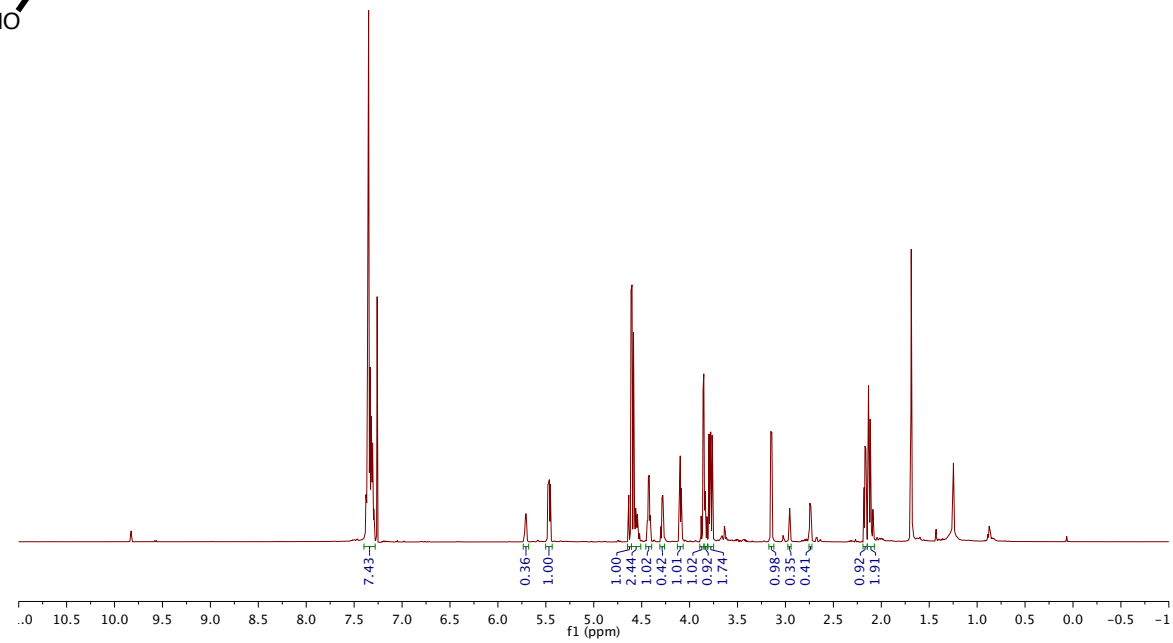

BnO
O
OH
HO
OMe

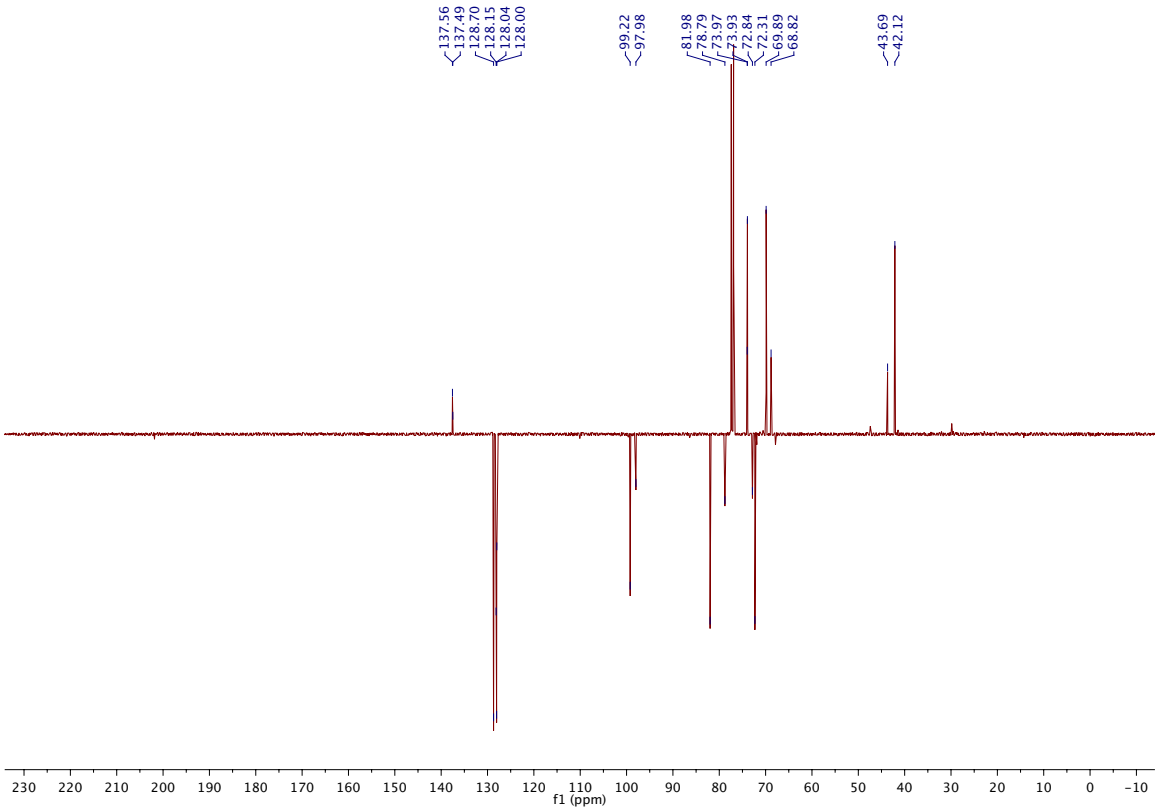
7.67
1.00
0.52
2.08
1.04
1.06
0.48
1.52
0.51
0.95
1.54
0.53
2.64
1.55
3.05
1.02
0.50
f1 (ppm)


137.76
137.35
128.68
128.56
128.15
128.07
128.04
127.97
100.68
95.48
90.13
86.83
84.14
80.93
76.32
75.00
73.79
73.59
70.55
70.48
58.34
57.69
f1 (ppm)

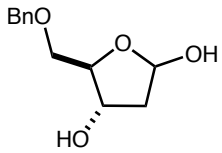
Compound **5c**

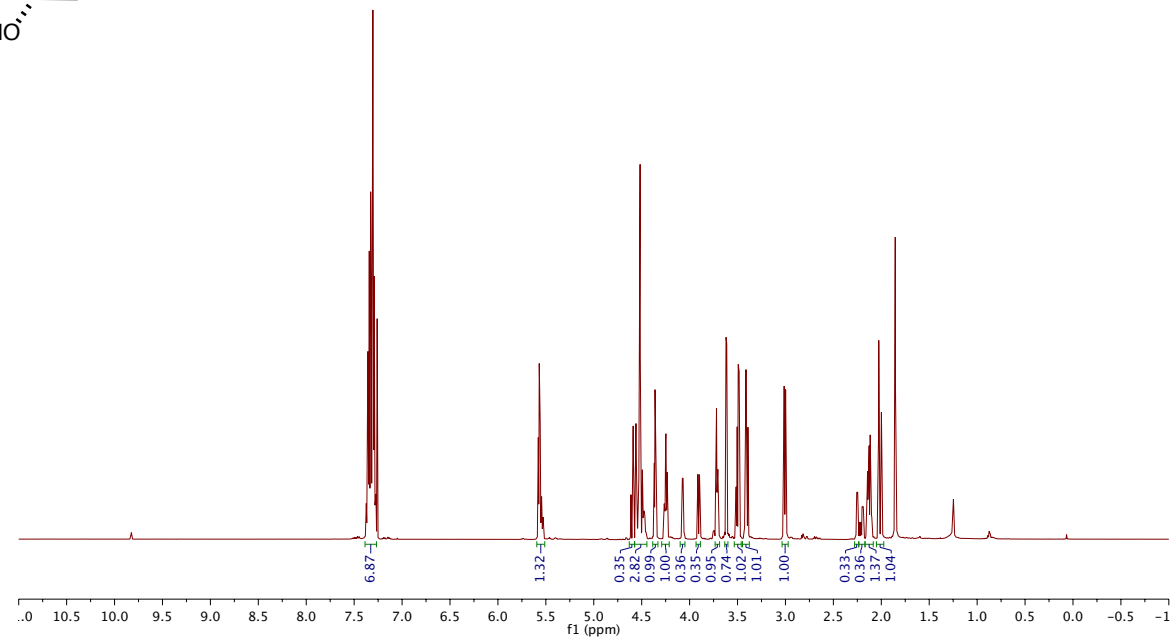

BnO
O
OH
HO

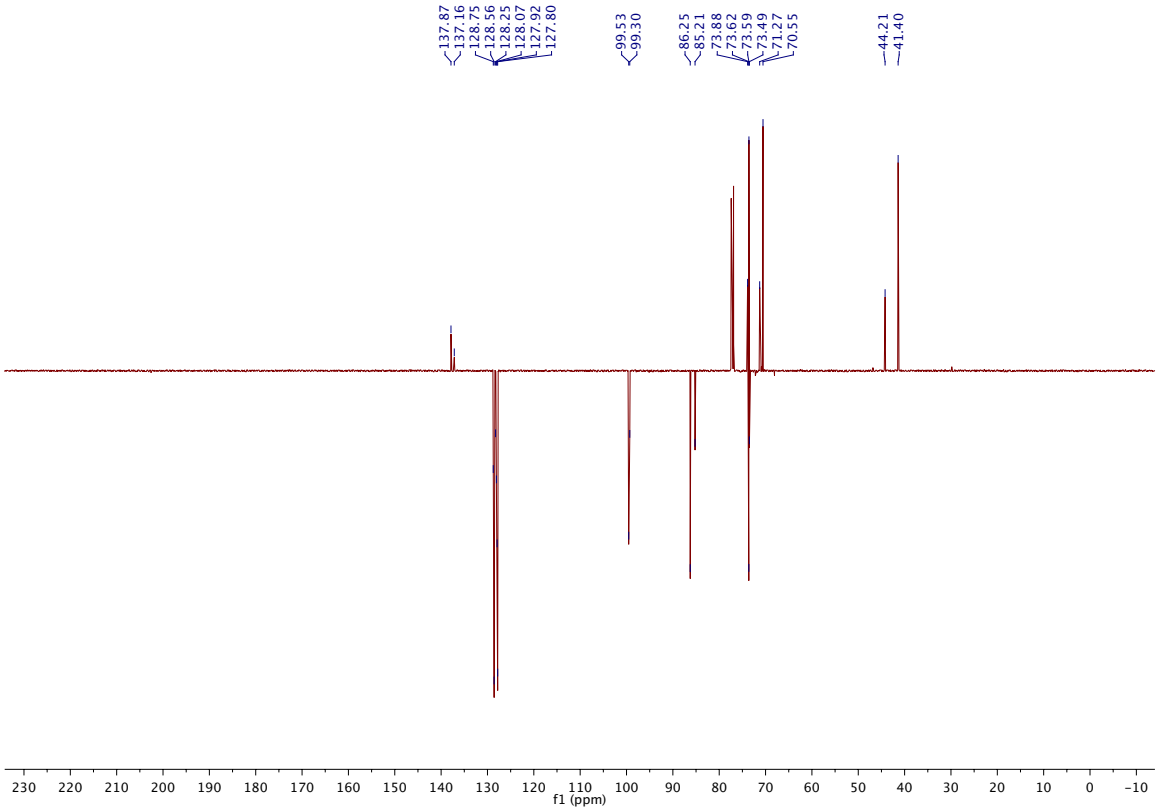

7.43
0.36
1.00
1.00
2.44
1.02
0.42
1.01
1.02
0.92
1.74
0.98
0.35
0.41
0.92
1.91
f1 (ppm)


137.56
137.49
128.70
128.15
128.04
128.00
99.22
97.98
81.98
78.79
73.97
73.93
72.84
72.31
69.89
68.82
43.69
42.12
f1 (ppm)

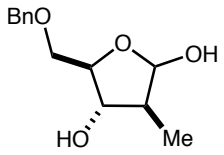
Compound **6c**


BnO
O
OH
HO

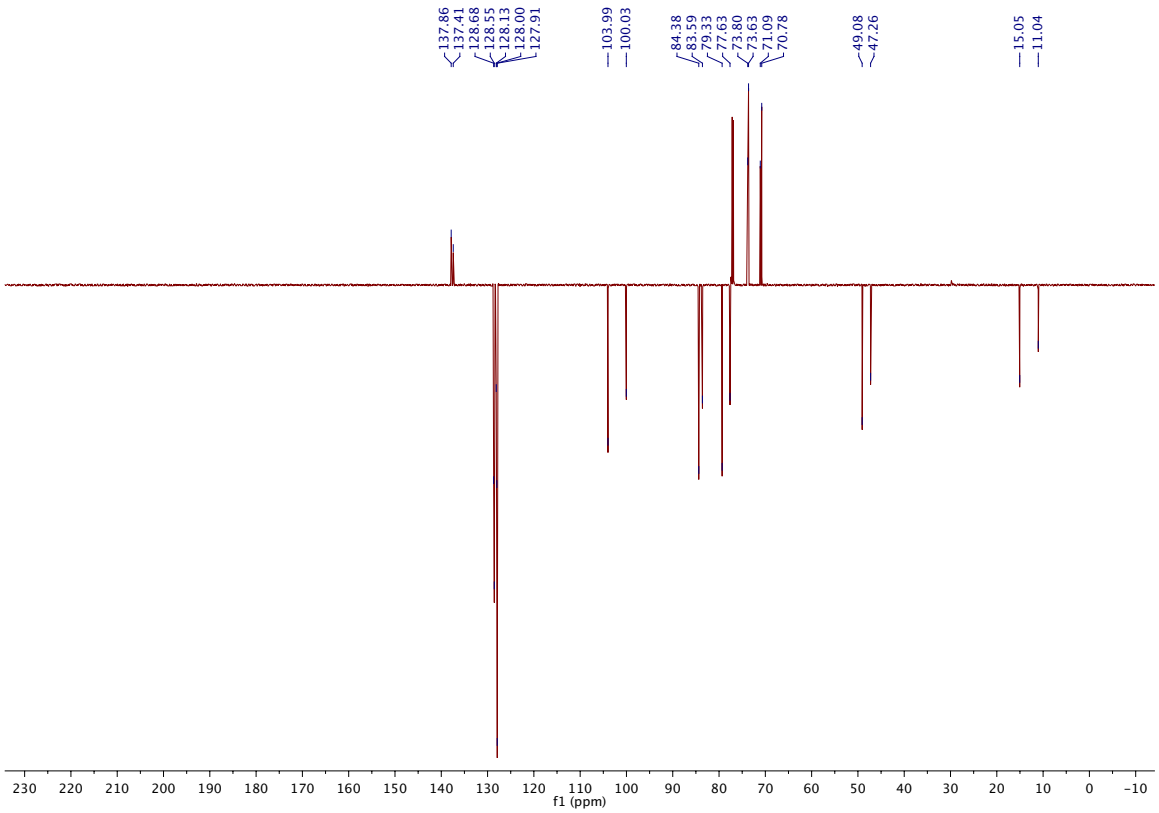

6.87
1.32
0.35
2.82
0.99
1.00
0.36
0.35
0.95
0.74
1.02
1.01
1.00
0.33
0.36
1.37
1.04
f1 (ppm)


137.87
137.16
128.75
128.56
128.25
128.07
127.92
127.80
99.53
99.30
86.25
85.21
73.88
73.62
73.59
73.49
71.27
70.55
44.21
41.40
f1 (ppm)

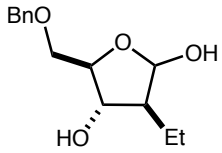
Compound **7c**

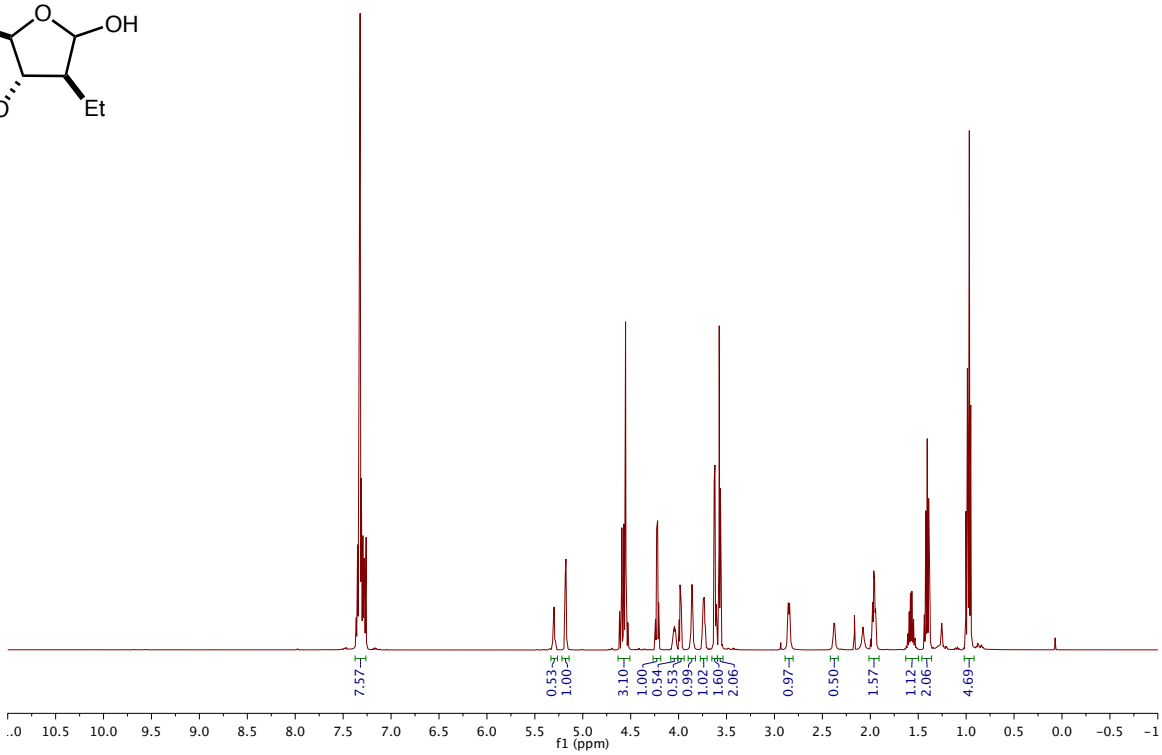

BnO
O
OH
HO
Me

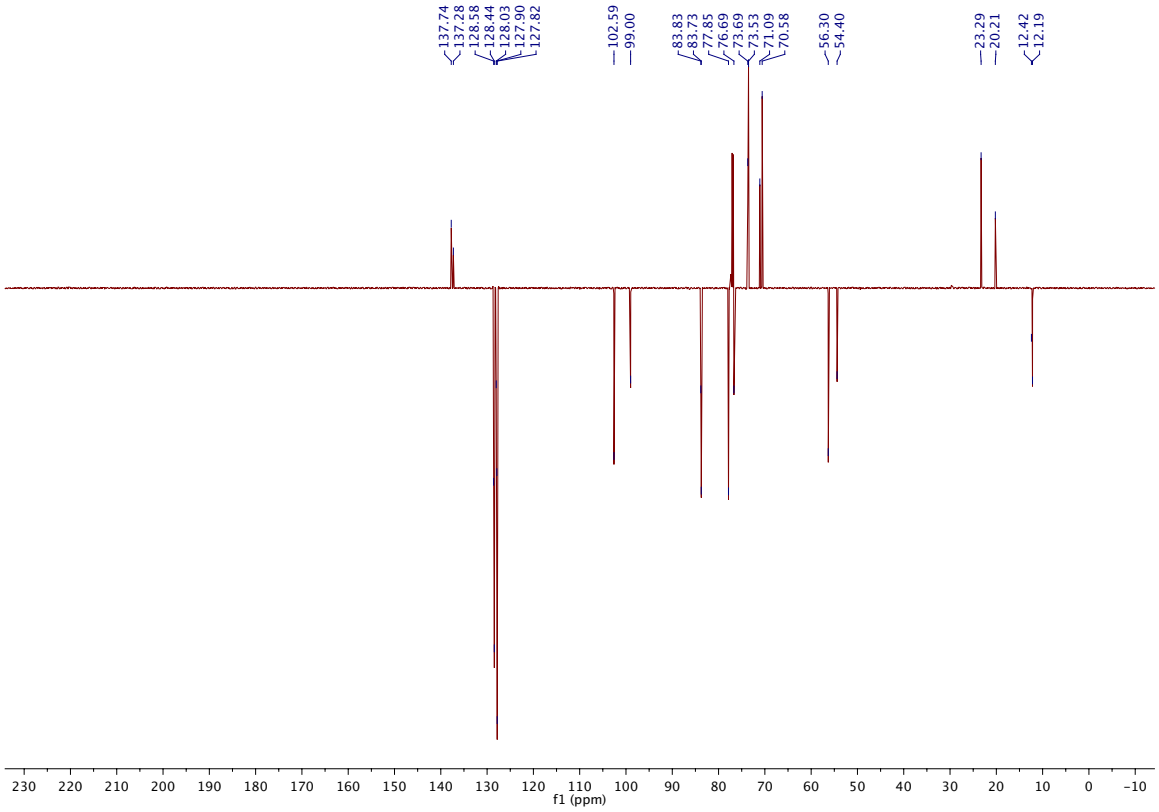
8.19
0.65
1.00
3.36
1.00
1.31
5.37
0.66
0.93
0.61
1.77
1.99
3.07
f1 (ppm)


137.86
137.41
128.68
128.55
128.13
128.00
127.91
103.99
100.03
84.38
83.59
79.33
77.63
73.80
73.63
71.09
70.78
49.08
47.26
15.05
11.04
f1 (ppm)

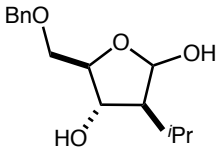
Compound **8c**


BnO
O
OH
HO
Et

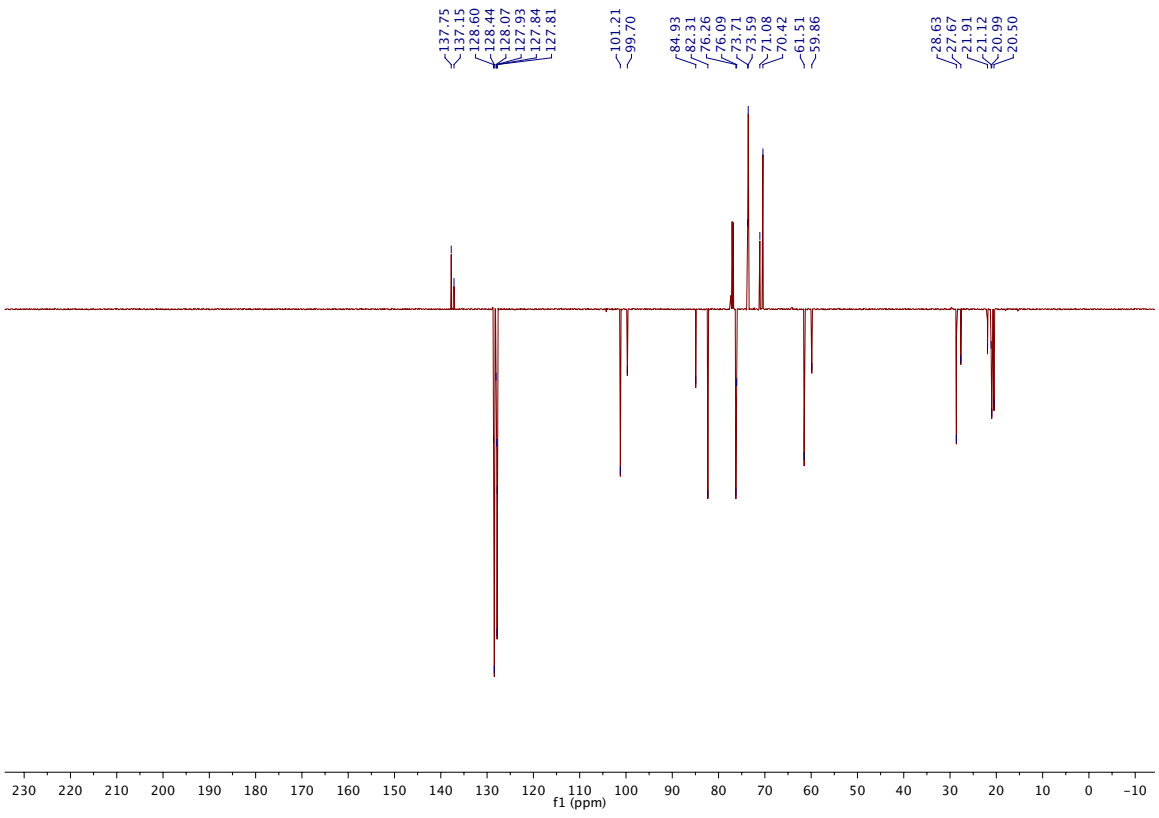

7.57
0.53
1.00
3.10
1.00
0.54
0.53
0.99
1.02
1.60
2.06
0.97
0.50
1.57
1.12
2.06
4.69
f1 (ppm)


137.74
137.28
128.58
128.44
128.03
127.90
127.82
102.59
99.00
83.83
83.73
77.85
76.69
73.69
73.53
71.09
70.58
56.30
54.40
23.29
20.21
12.42
12.19
f1 (ppm)

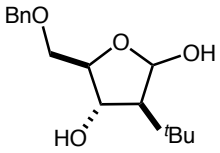
Compound **9c**

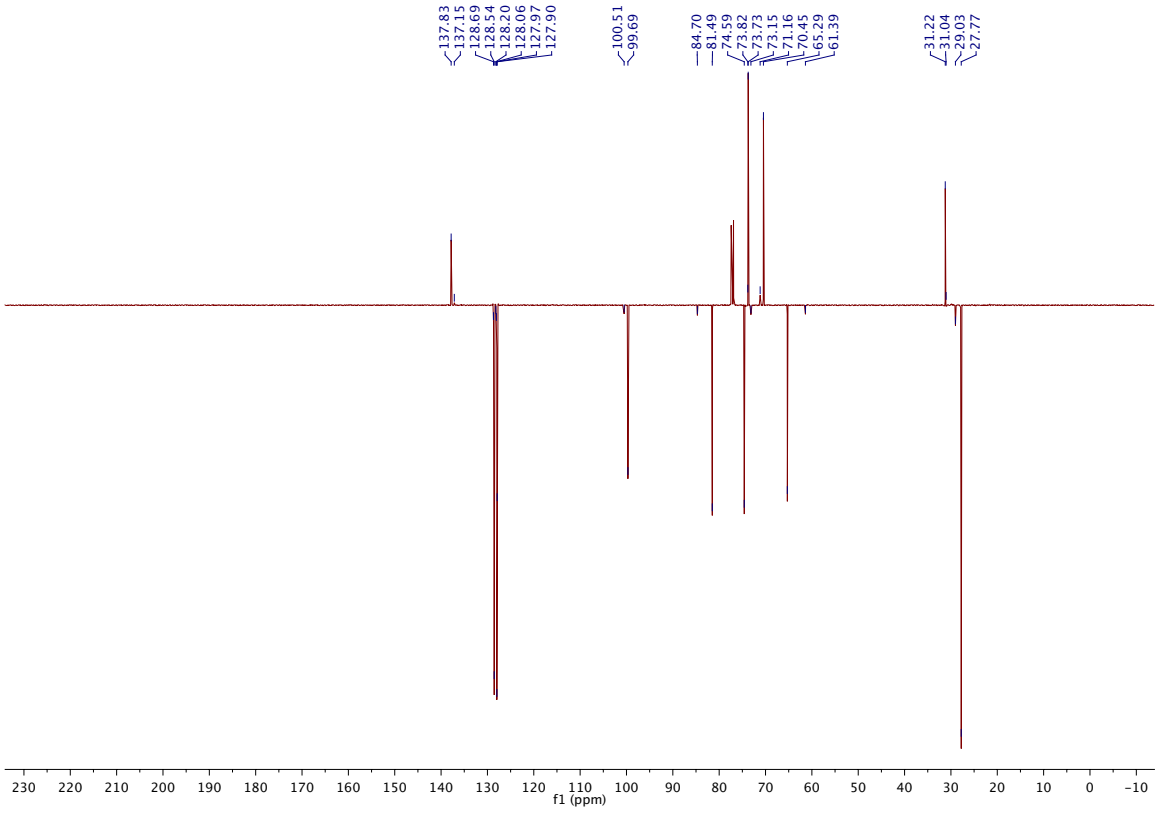

BnO
O
OH
HO
iPr

0.41
1.00
0.42
2.43
1.41
0.41
1.01
1.02
0.43
2.88
0.97
0.41
0.41
1.04
0.39
1.02
1.21
7.26
f1 (ppm)

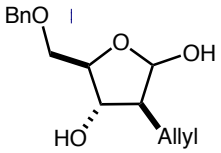

137.75
137.15
128.60
128.44
128.07
127.93
127.84
127.81
101.21
99.70
84.93
82.31
76.26
76.09
73.71
73.59
71.08
70.42
61.51
59.86
28.63
27.67
21.91
21.12
20.99
20.50
f1 (ppm)

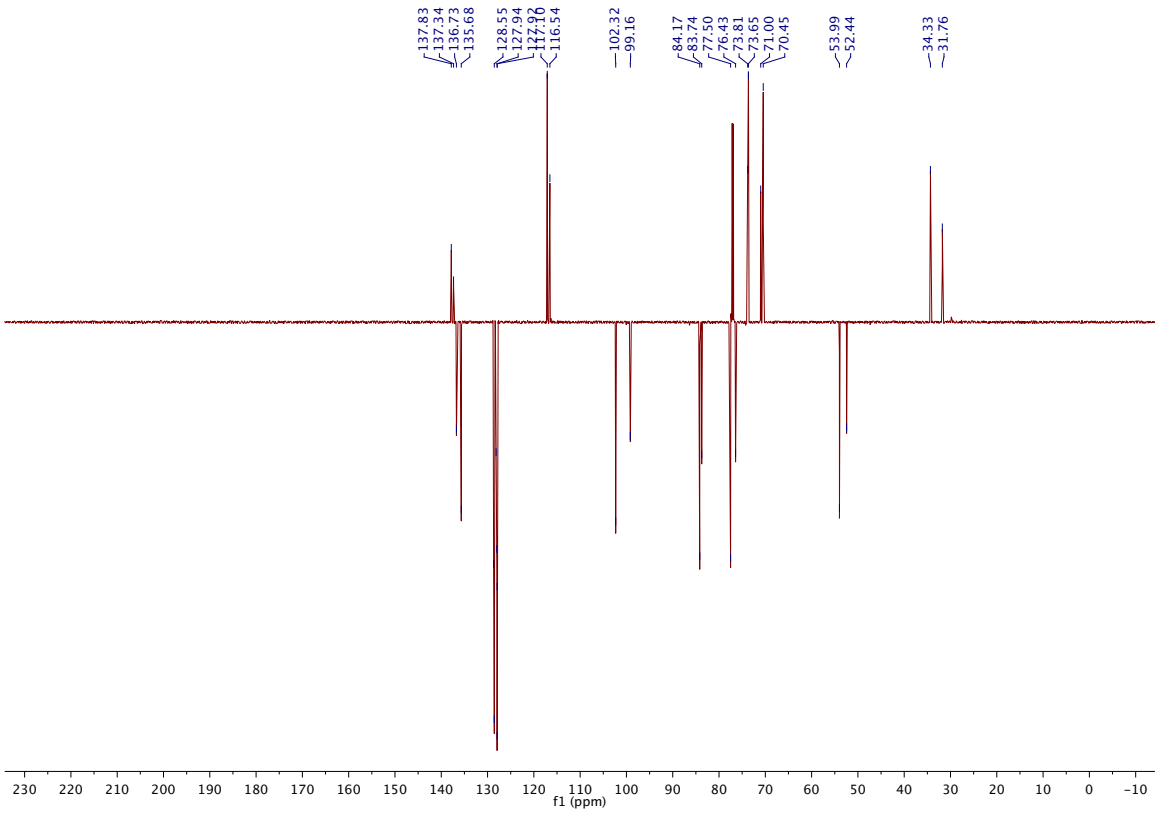
Compound **10c**



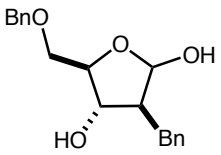


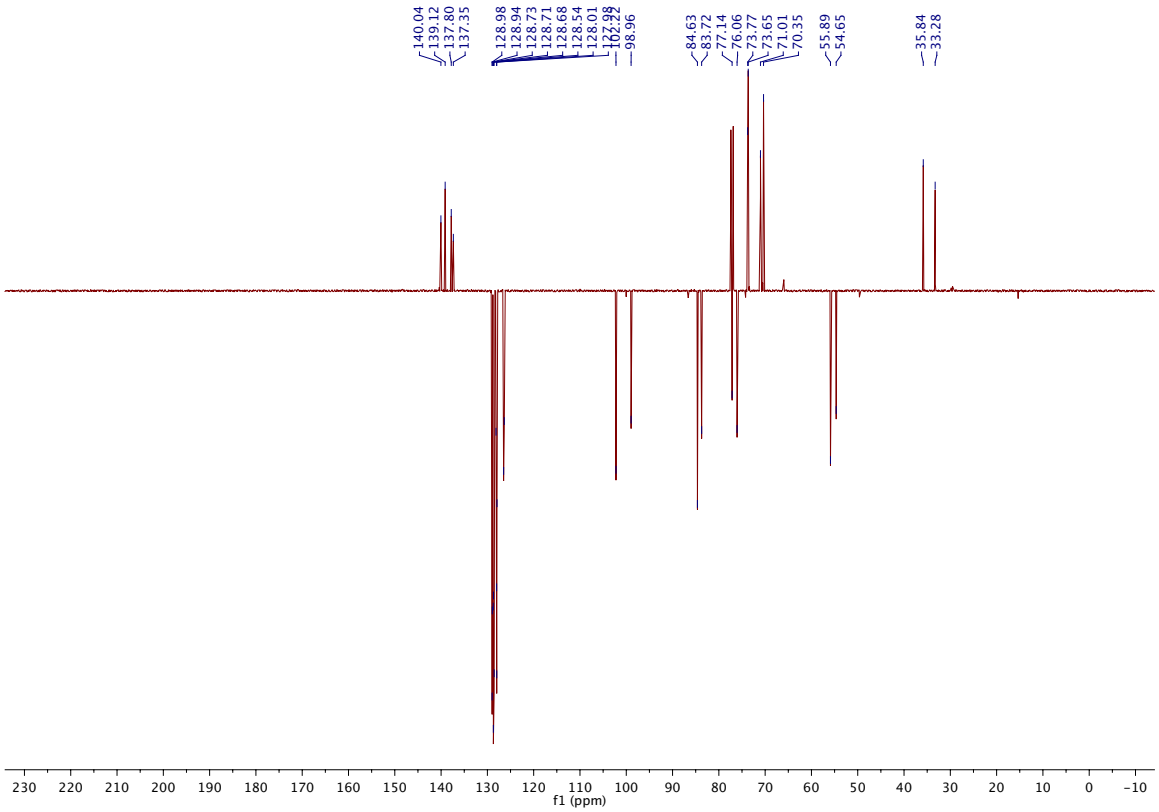
Compound **11c**



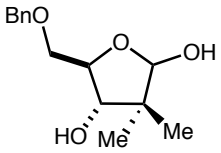


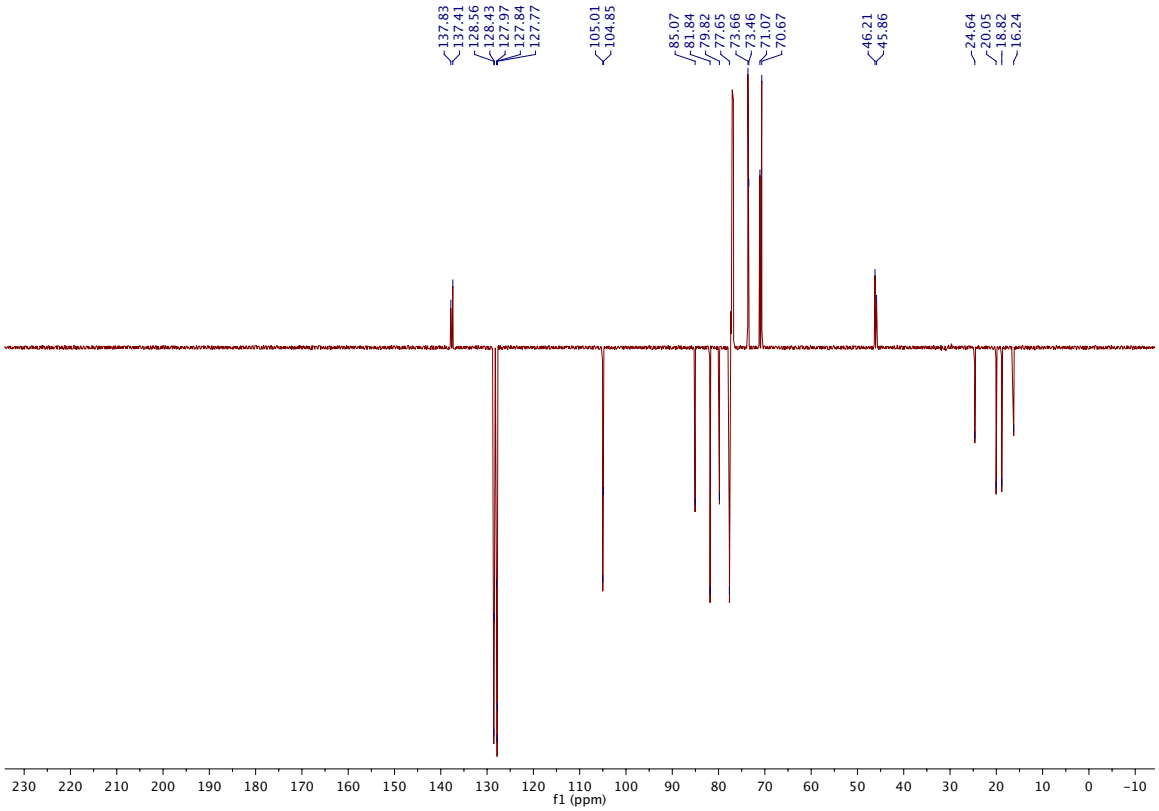
Compound **12c**



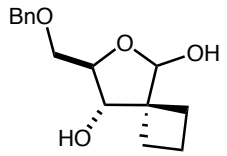


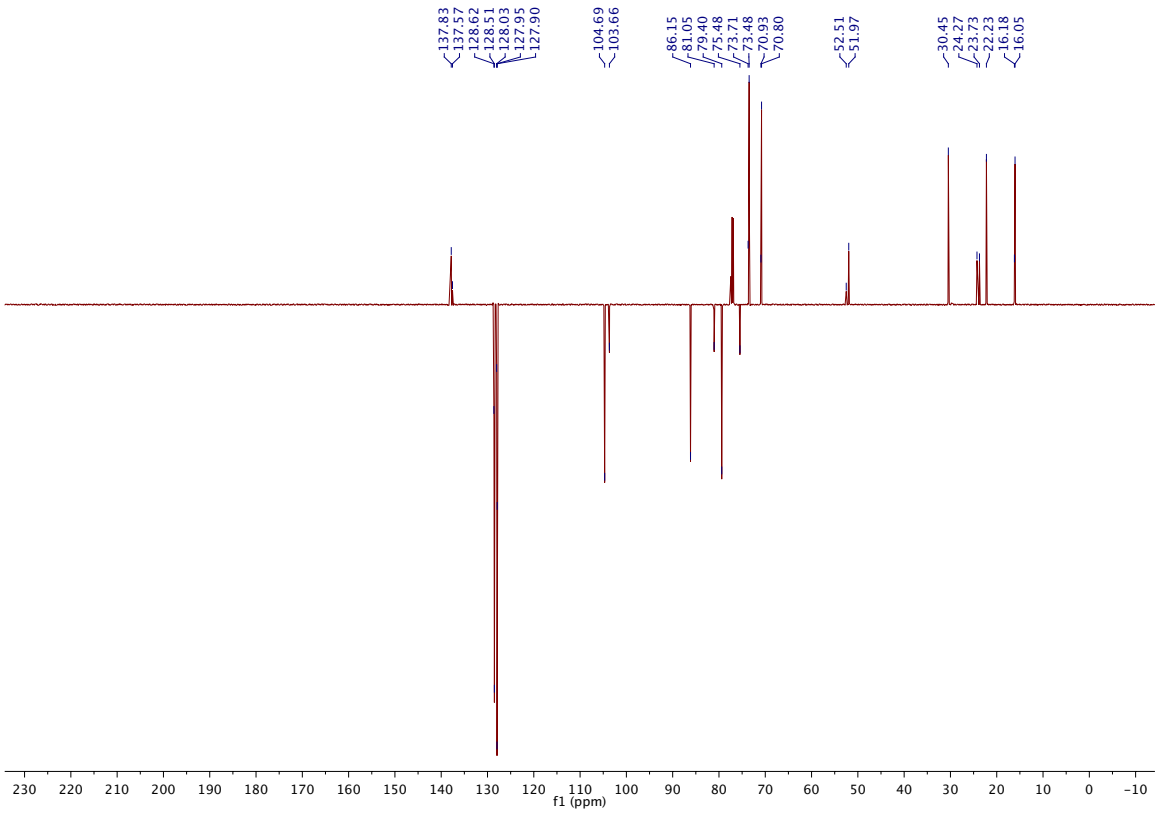
Compound **13c**



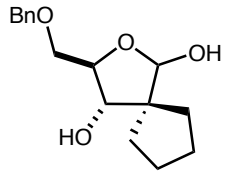


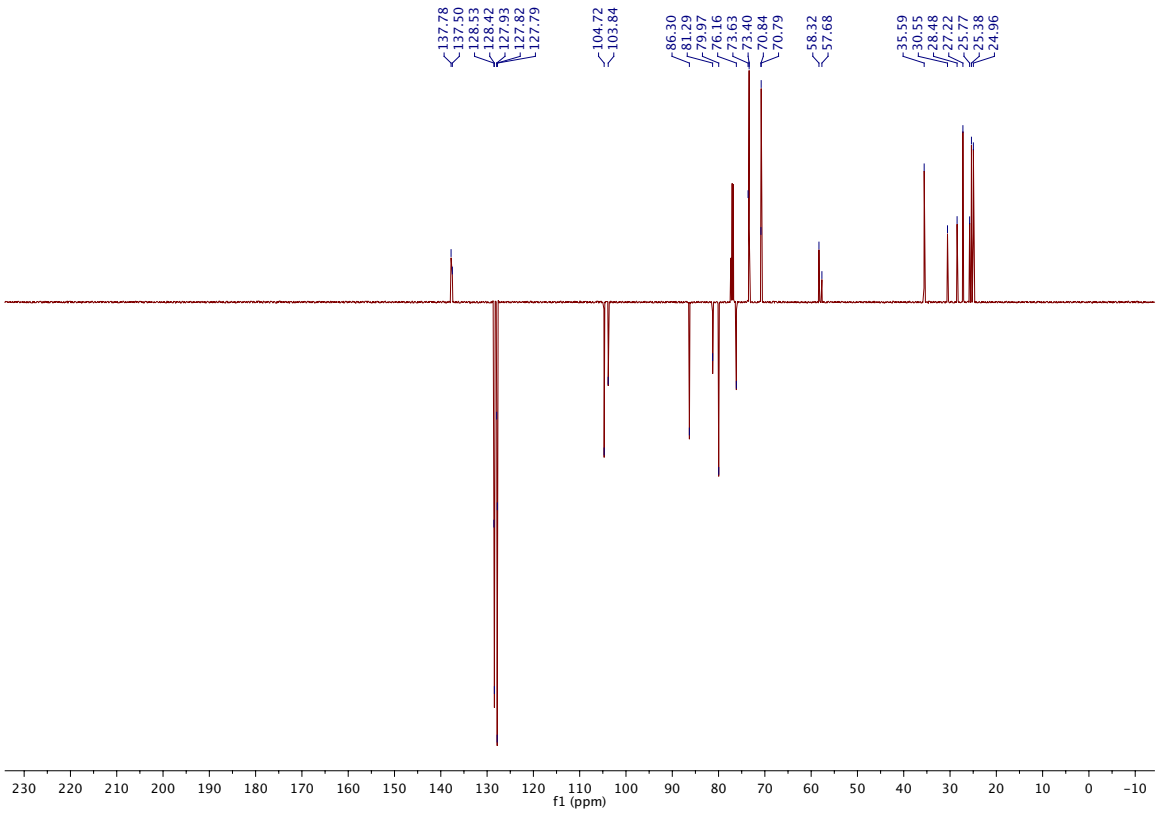
Compound **14c**



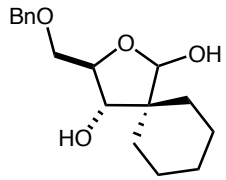


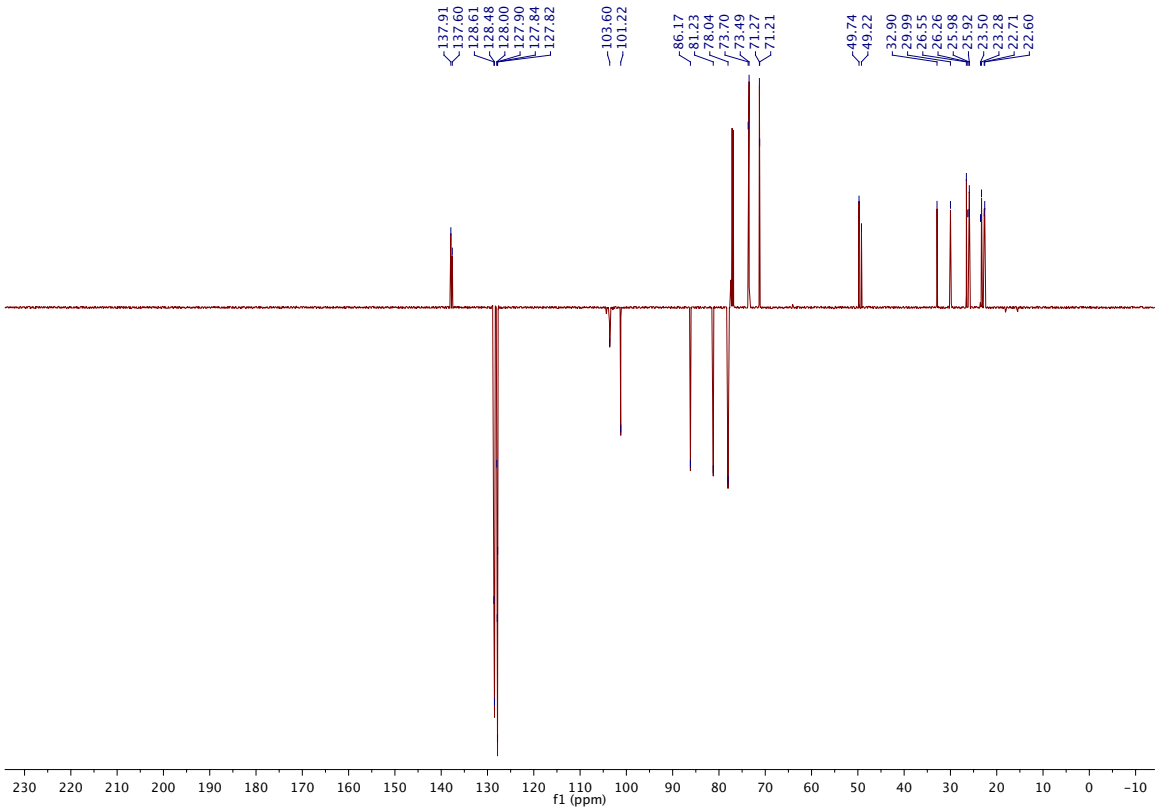
Compound **15c**



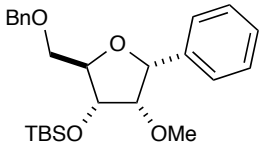


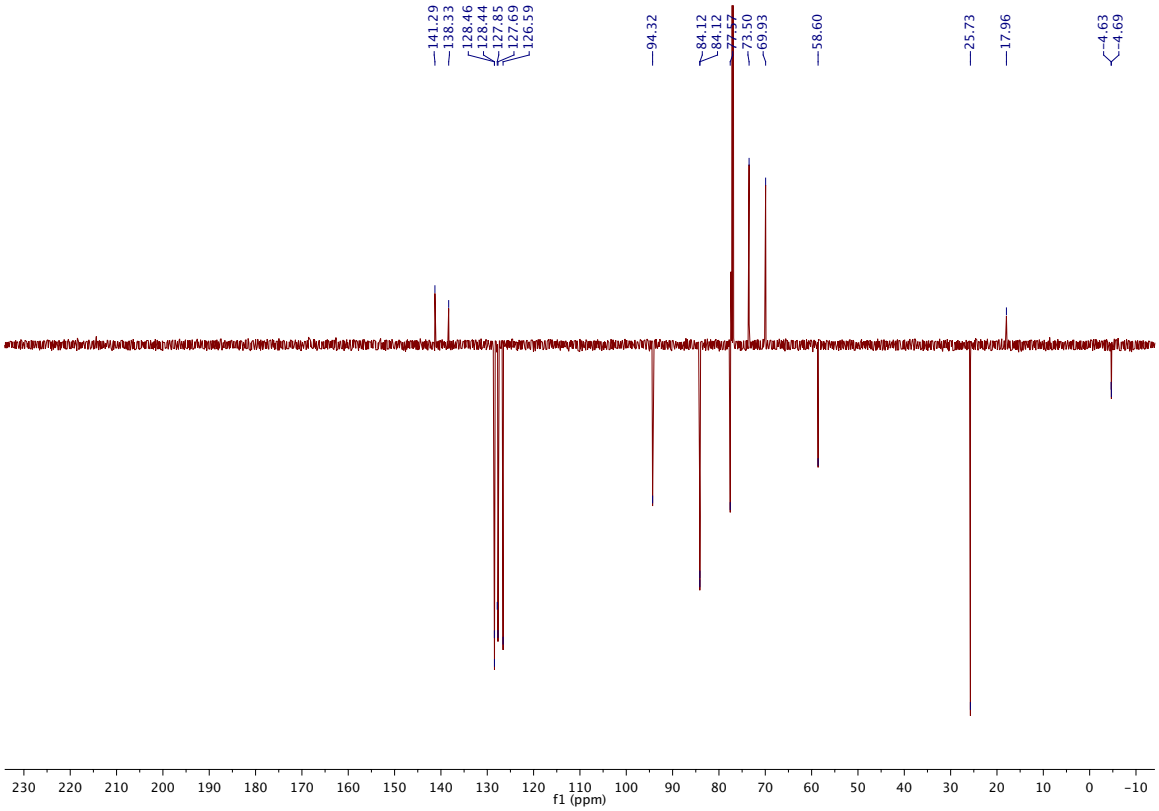
Compound **16c**



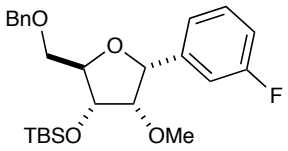


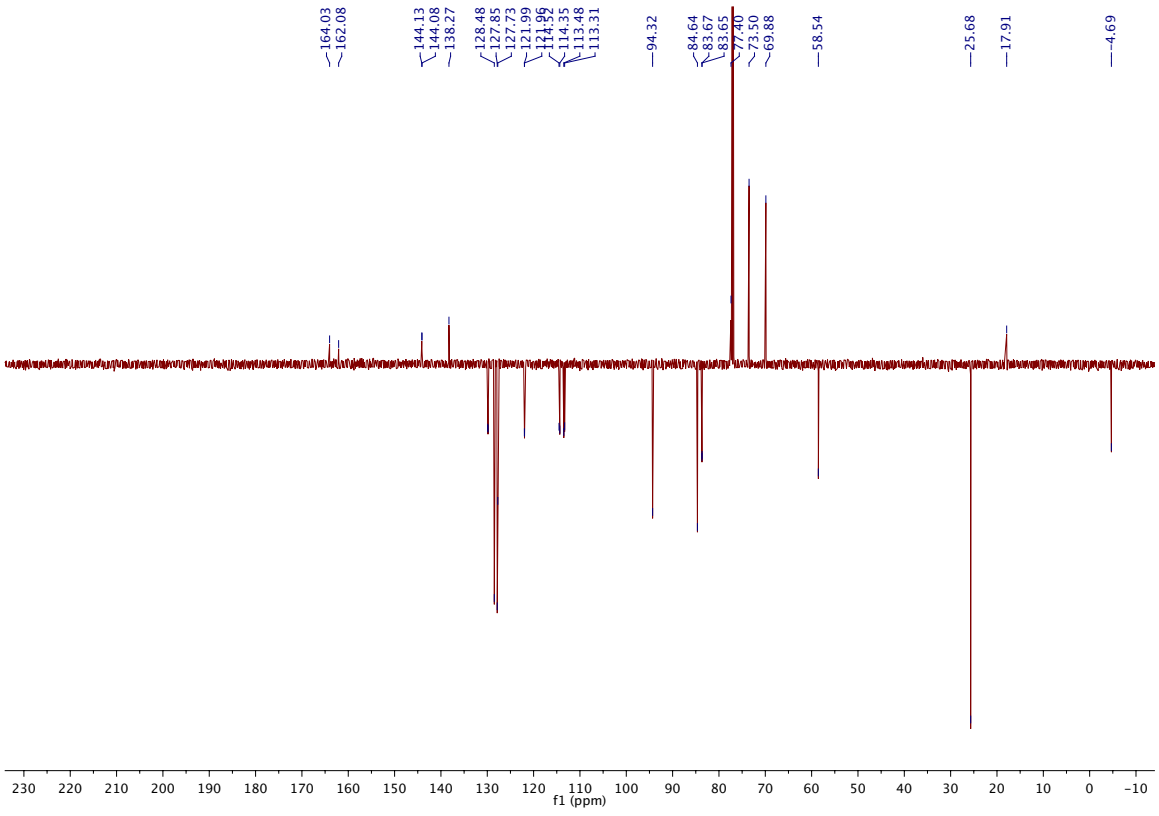
Compound **24α**



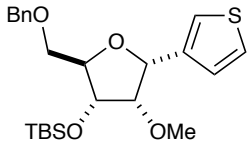


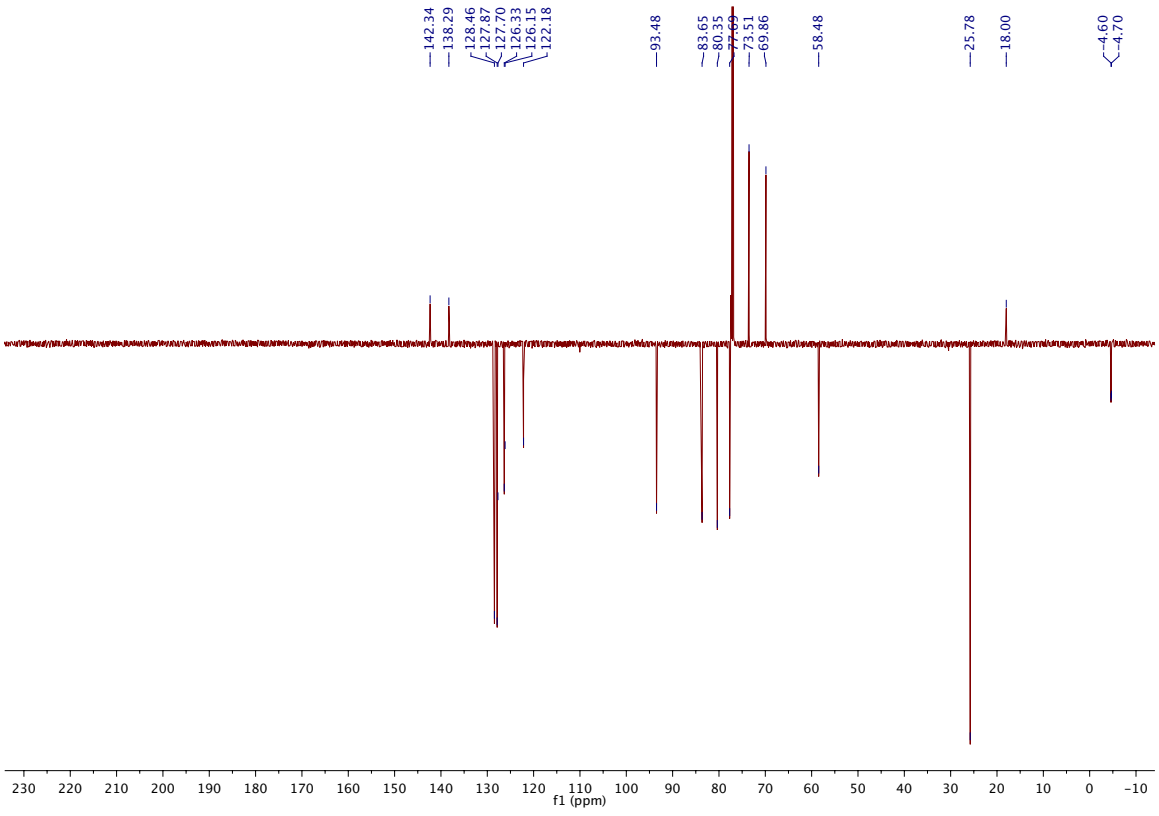
Compound **25α**



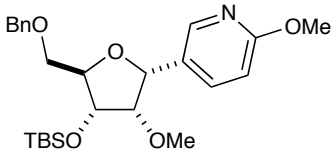


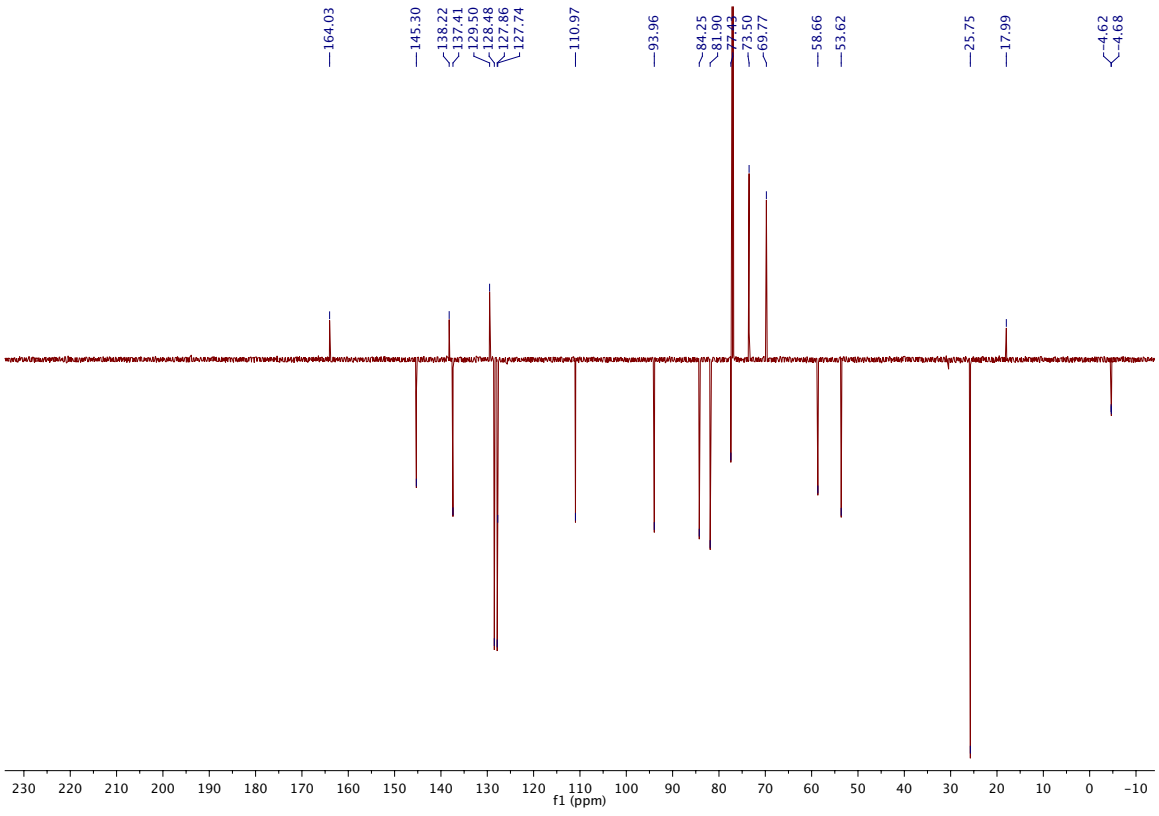
Compound **26α**



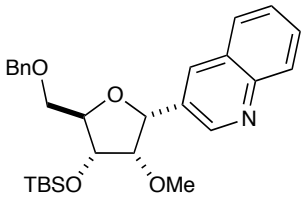


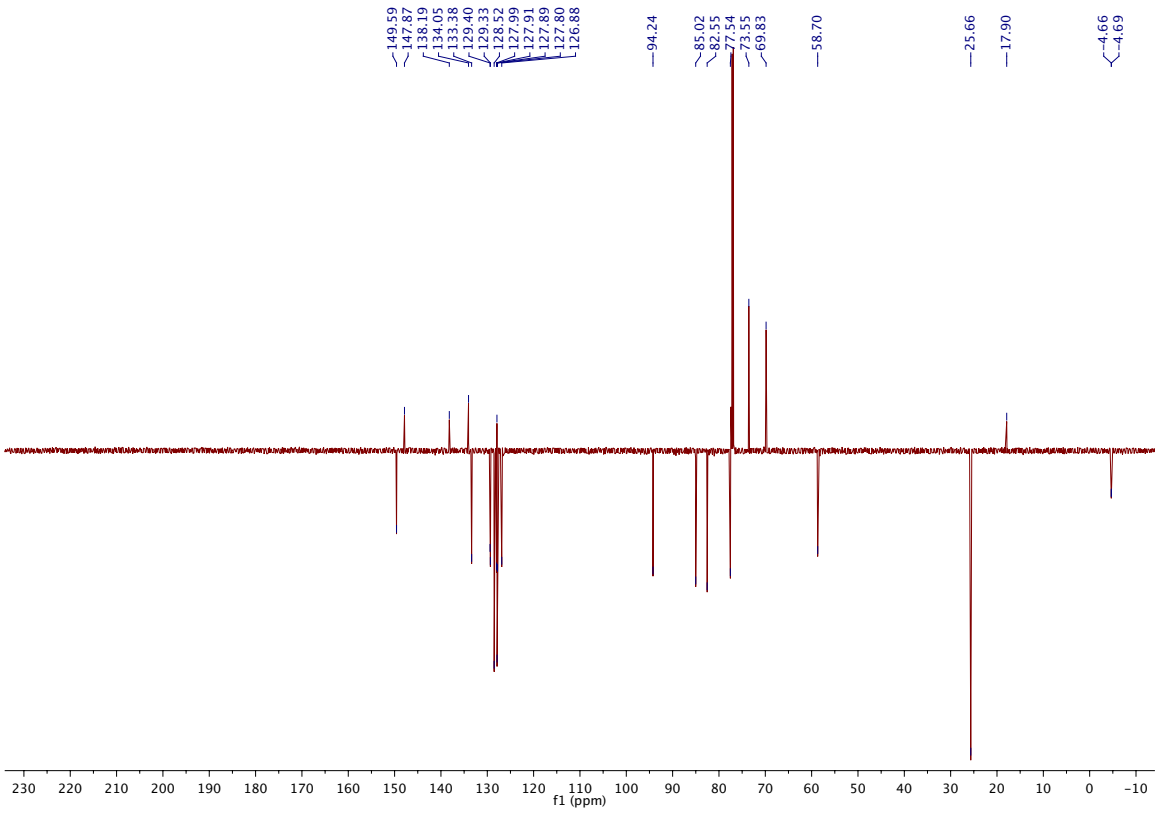
Compound **27α**



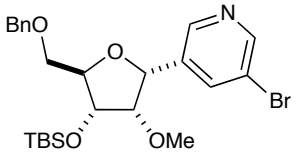


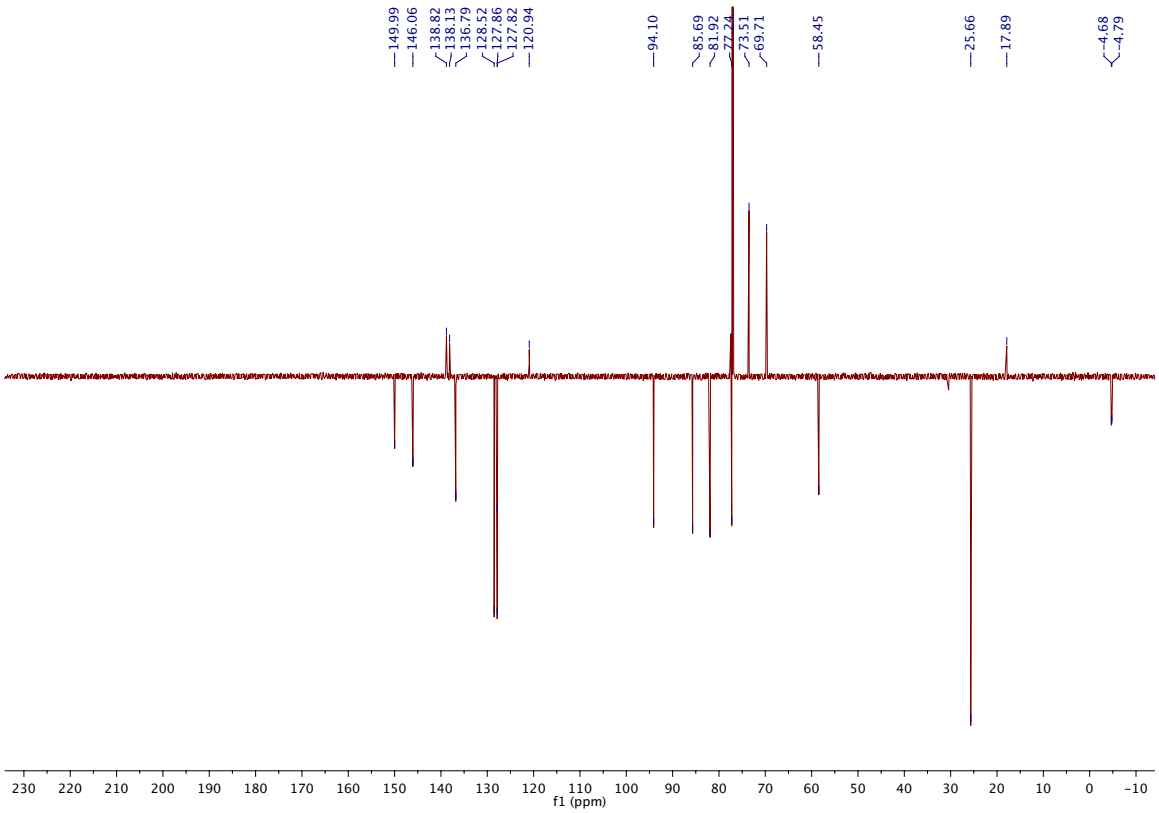
Compound **28α**



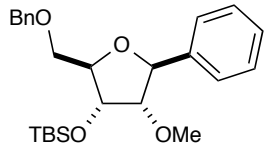


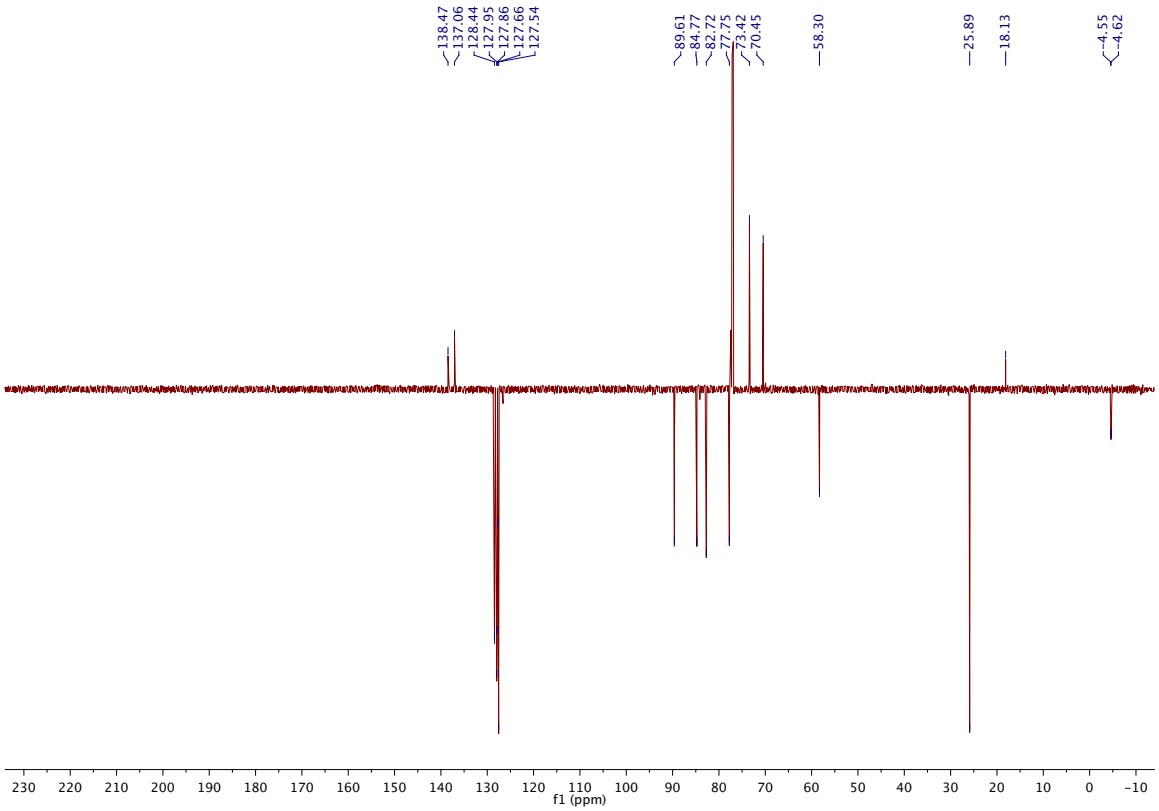
Compound **29α**



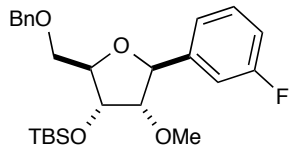


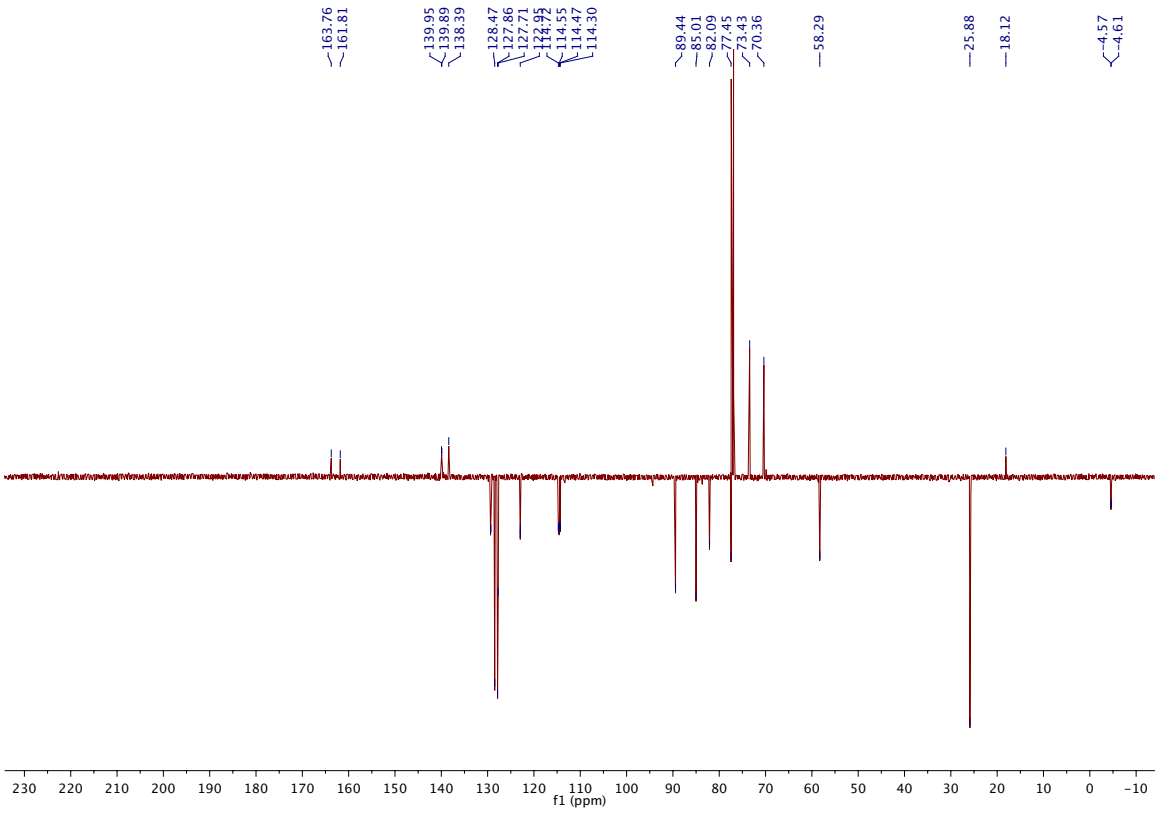
Compound **24β**



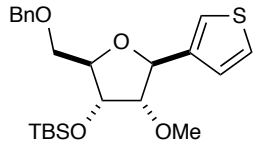


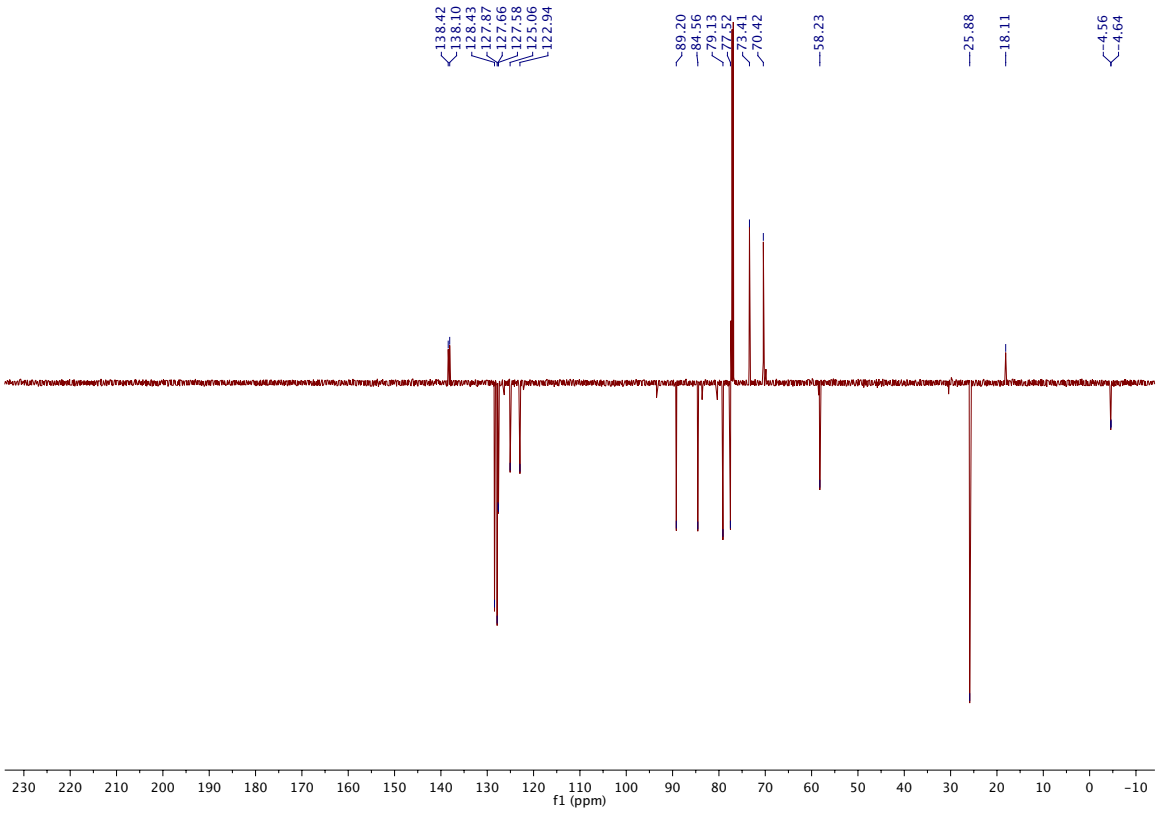
Compound **25β**



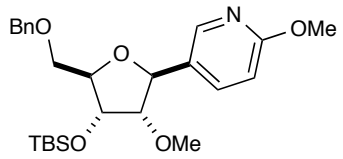


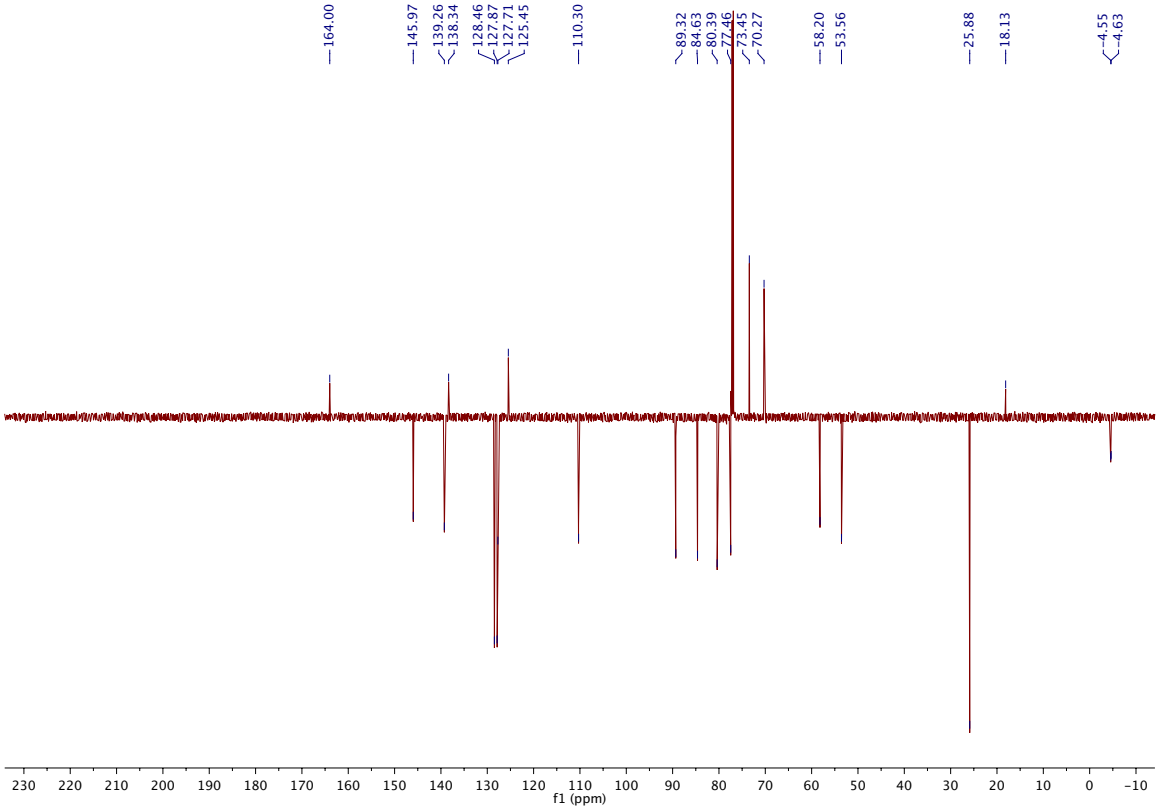
Compound **26β**



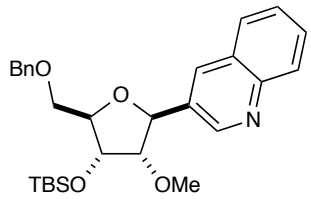


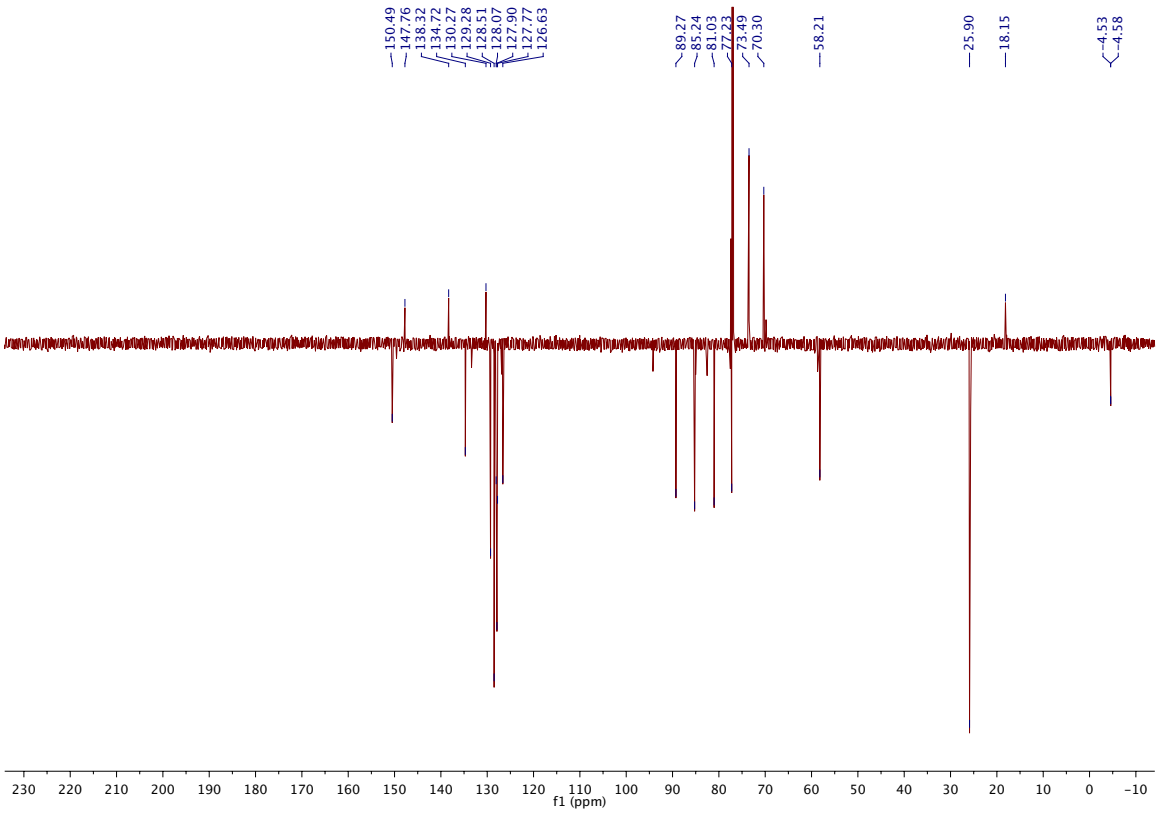
Compound **27β**



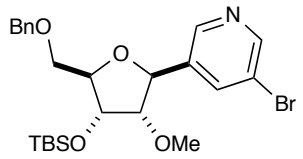


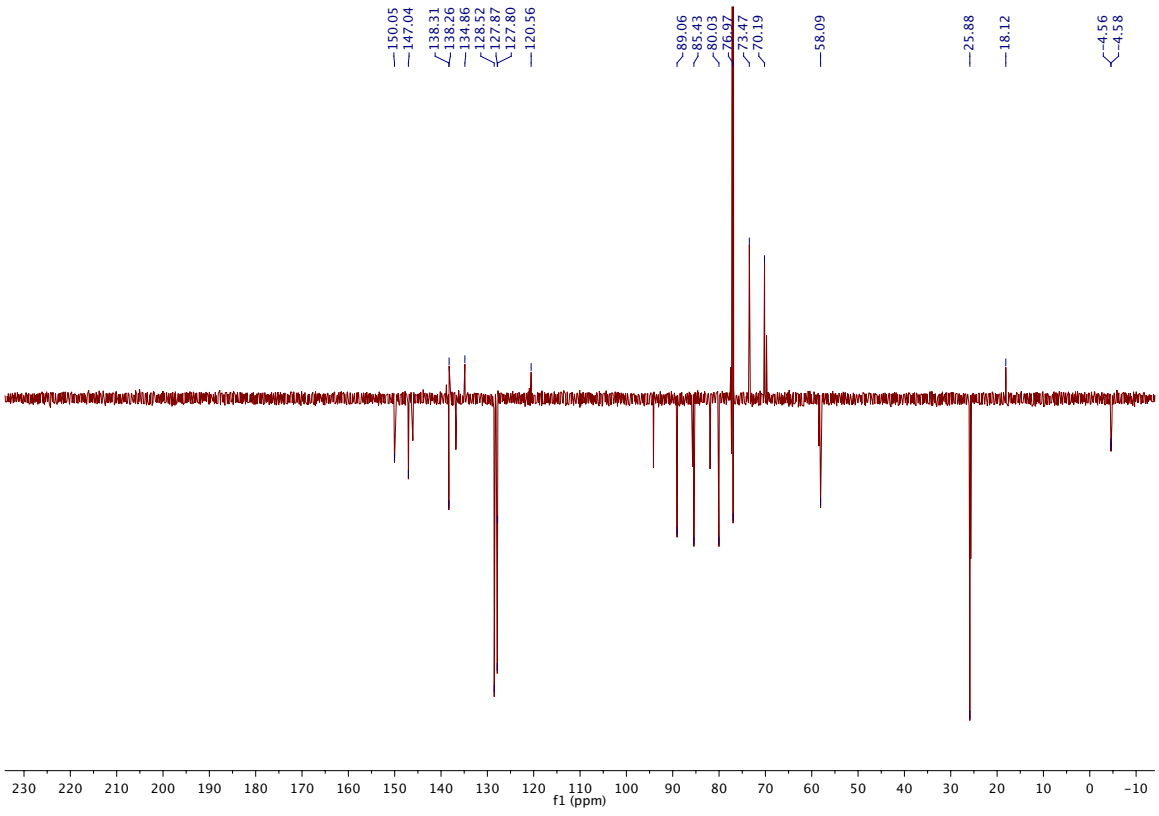
Compound **28β**



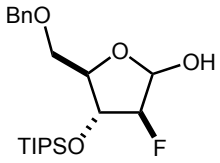


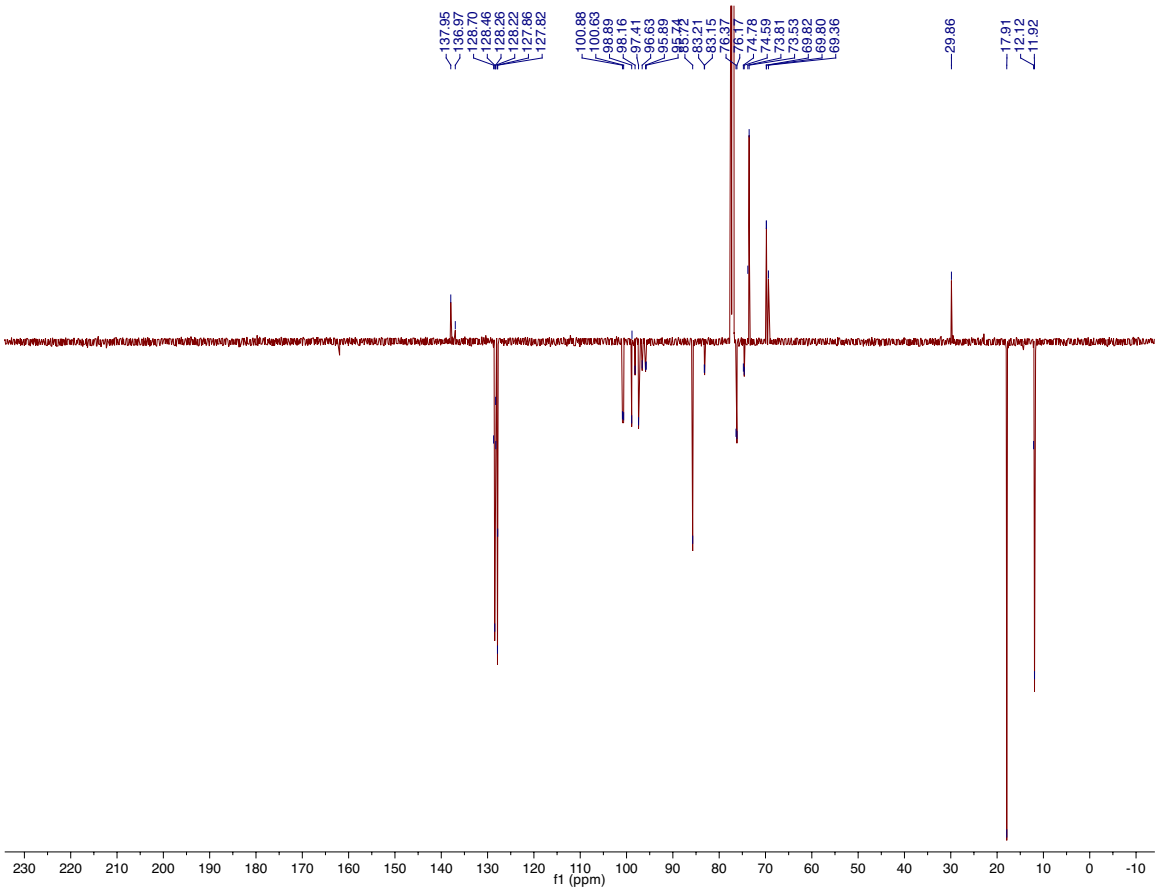
Compound **29β**



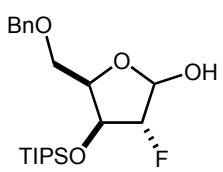


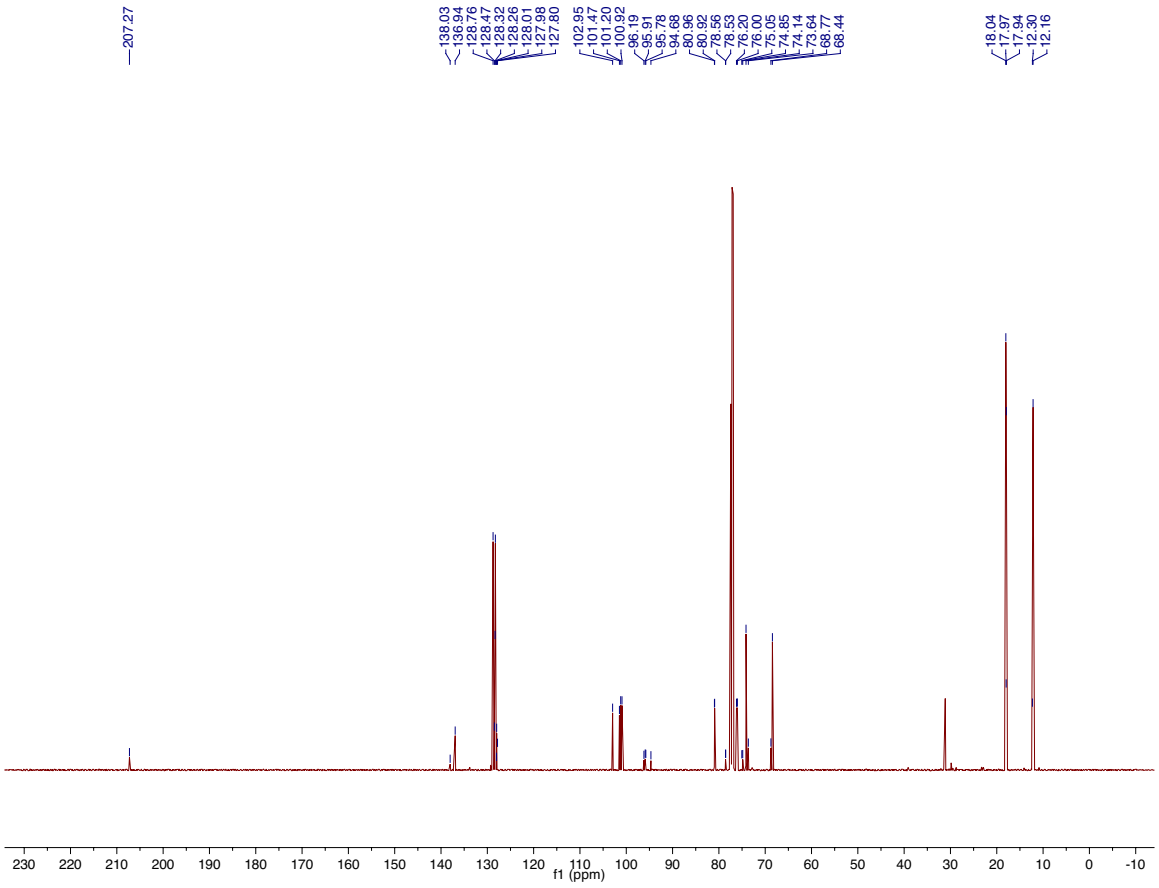
Compound **31b**



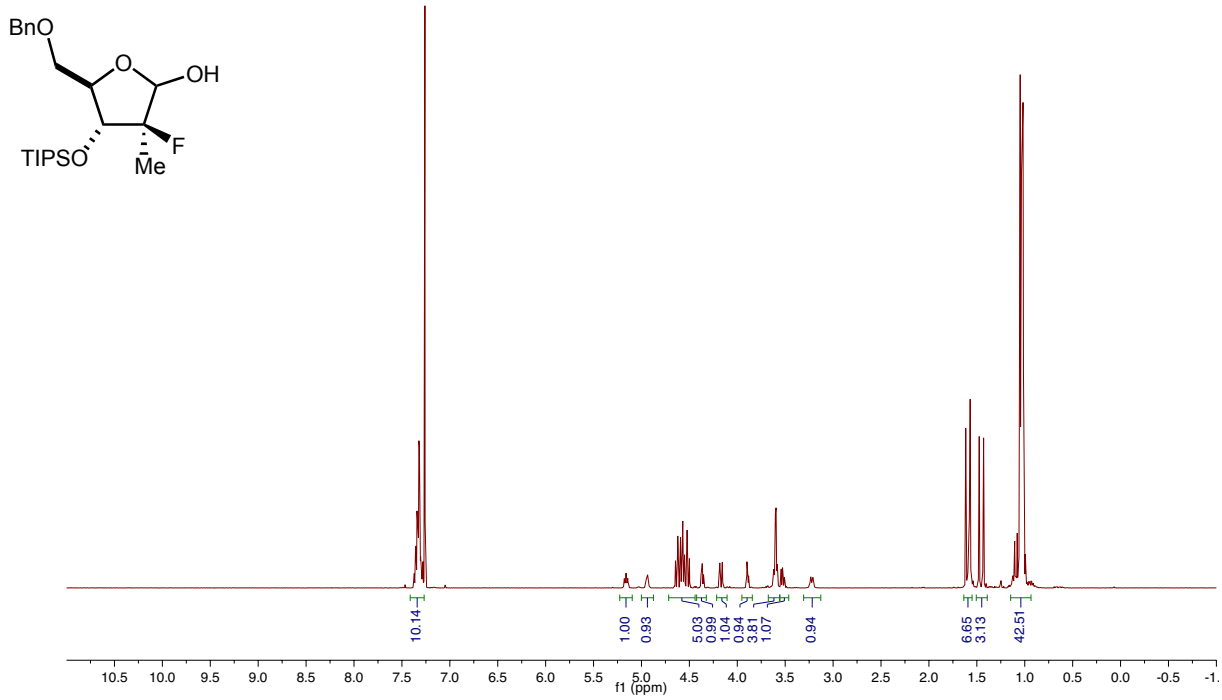


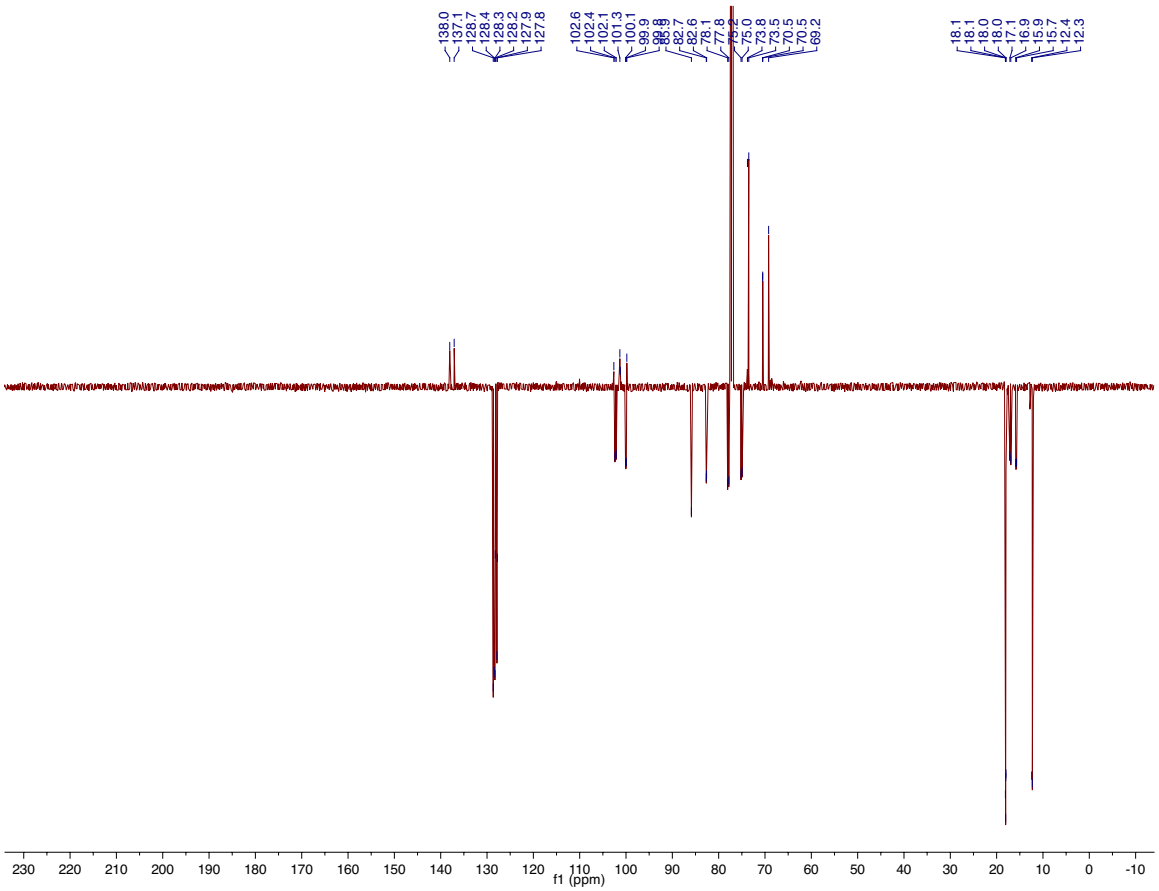
Compound **32b**



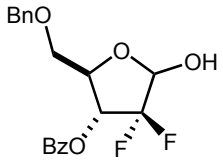


Compound **33b**

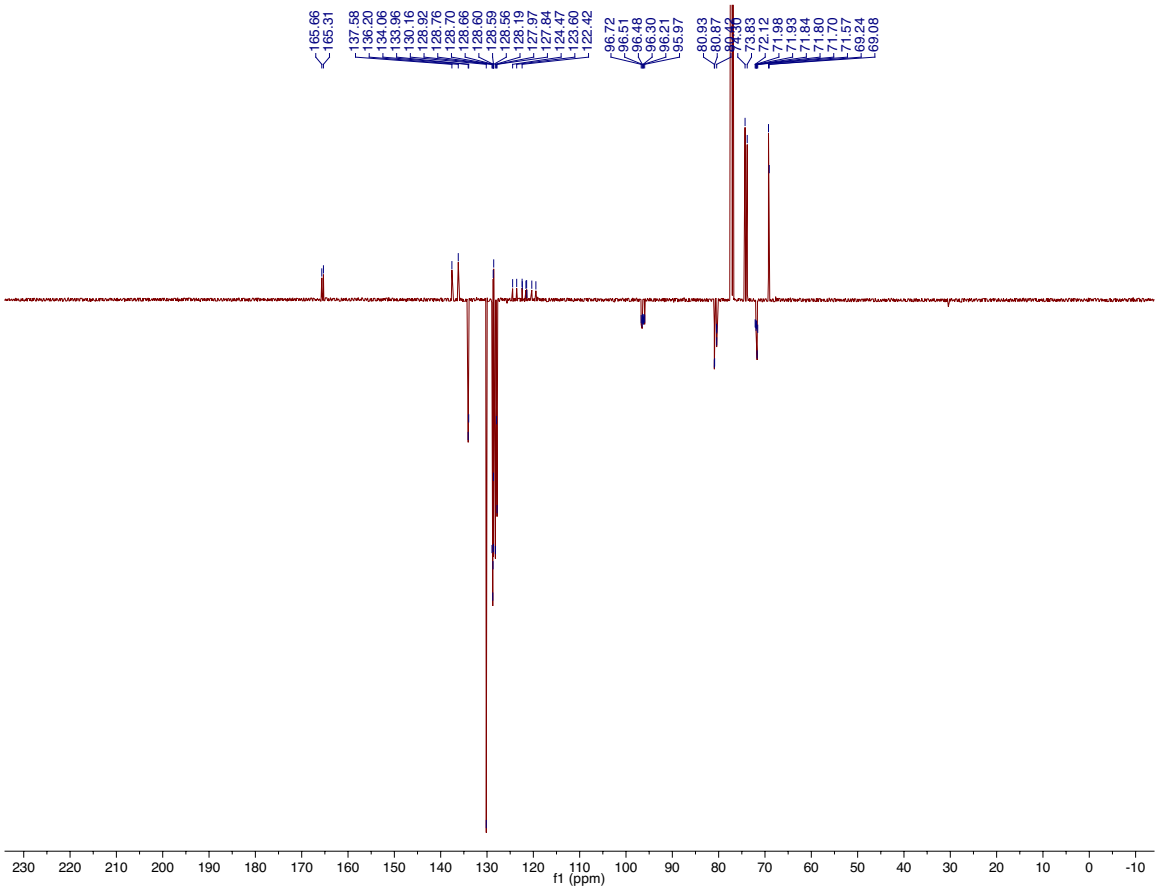




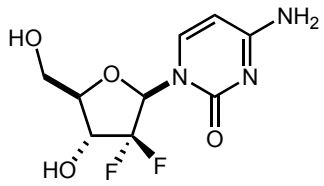
Compound **34**

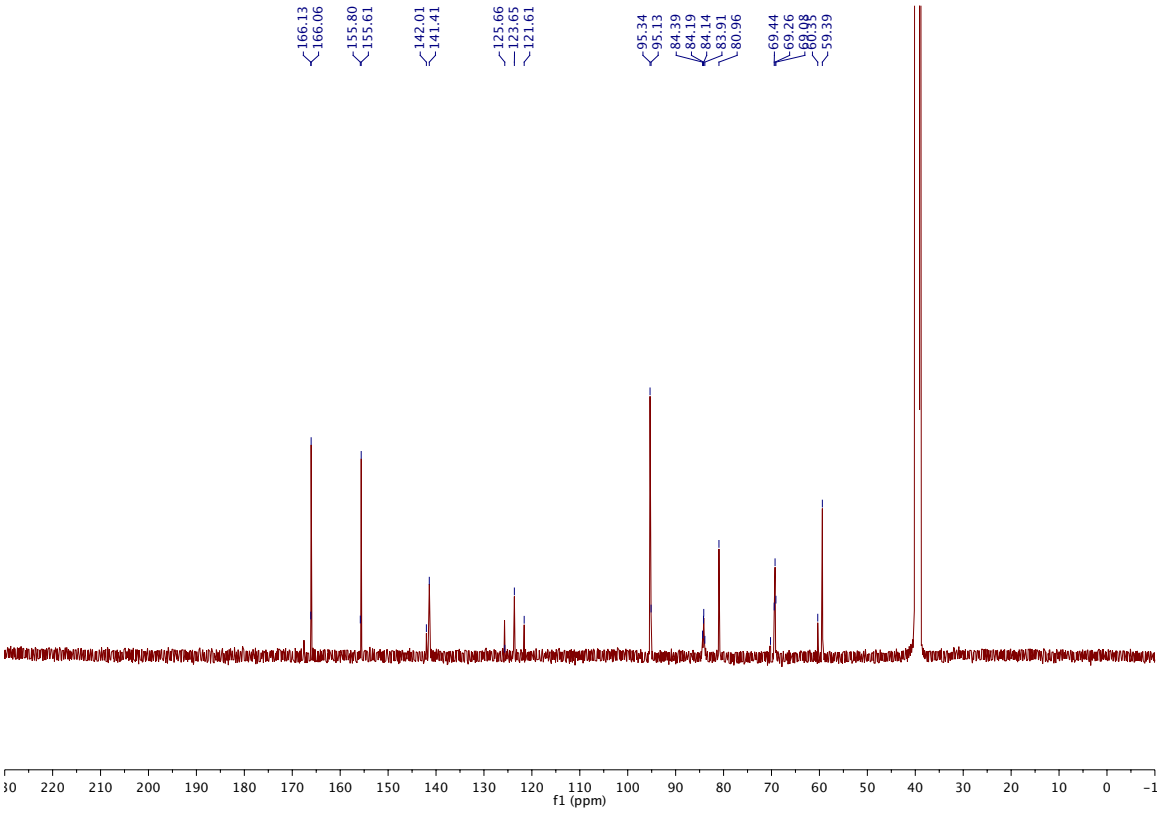

BnO
O
OH
BzO
F
F

2.75
1.44
3.07
6.98
1.00
0.84
0.98
4.38
0.97
2.90
0.41
f1 (ppm)

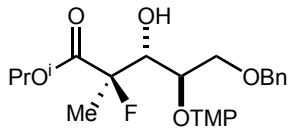

165.66
165.31
137.58
136.20
134.06
133.96
130.16
128.92
128.76
128.70
128.66
128.60
128.59
128.56
128.19
127.97
127.84
124.47
123.60
122.42
96.72
96.51
96.48
96.30
96.21
95.97
80.93
80.87
80.47
74.30
73.83
72.12
71.98
71.93
71.84
71.80
71.70
71.57
69.24
69.08
f1 (ppm)

Gemcitabine

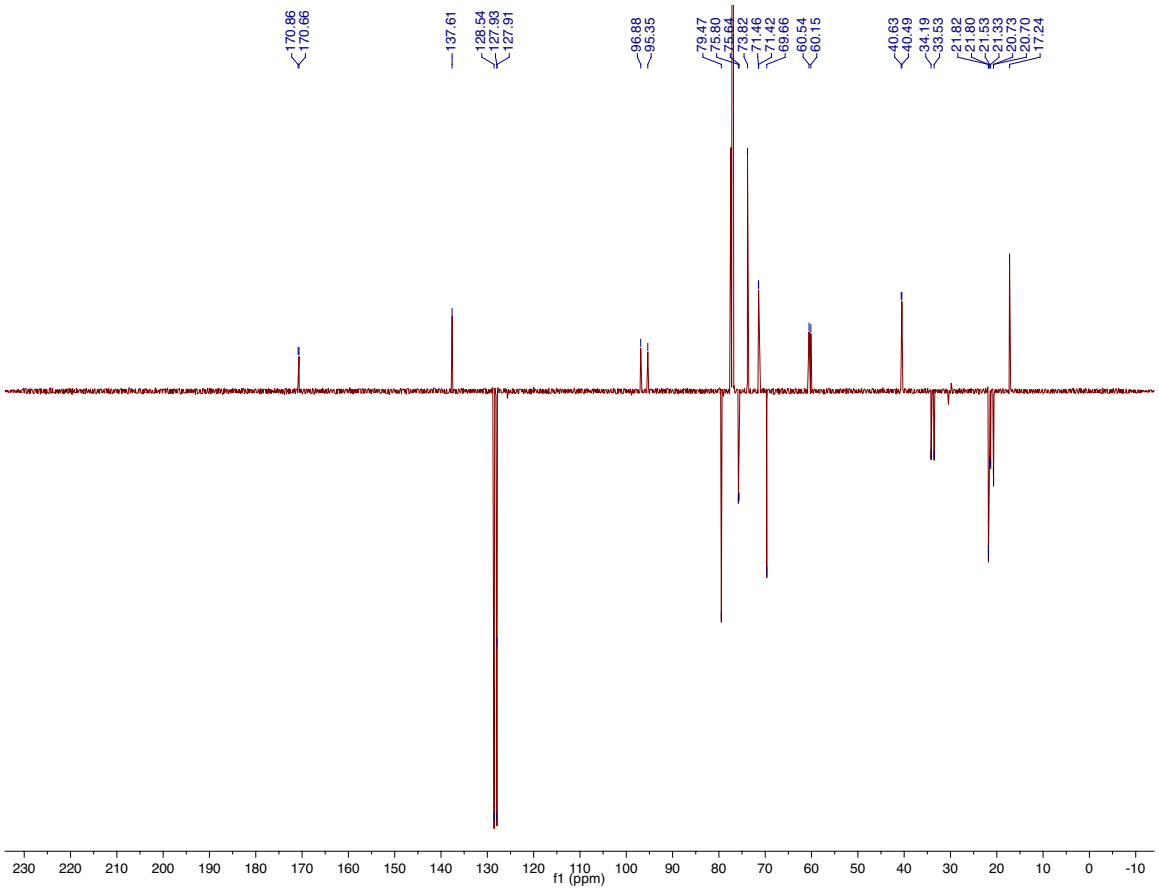




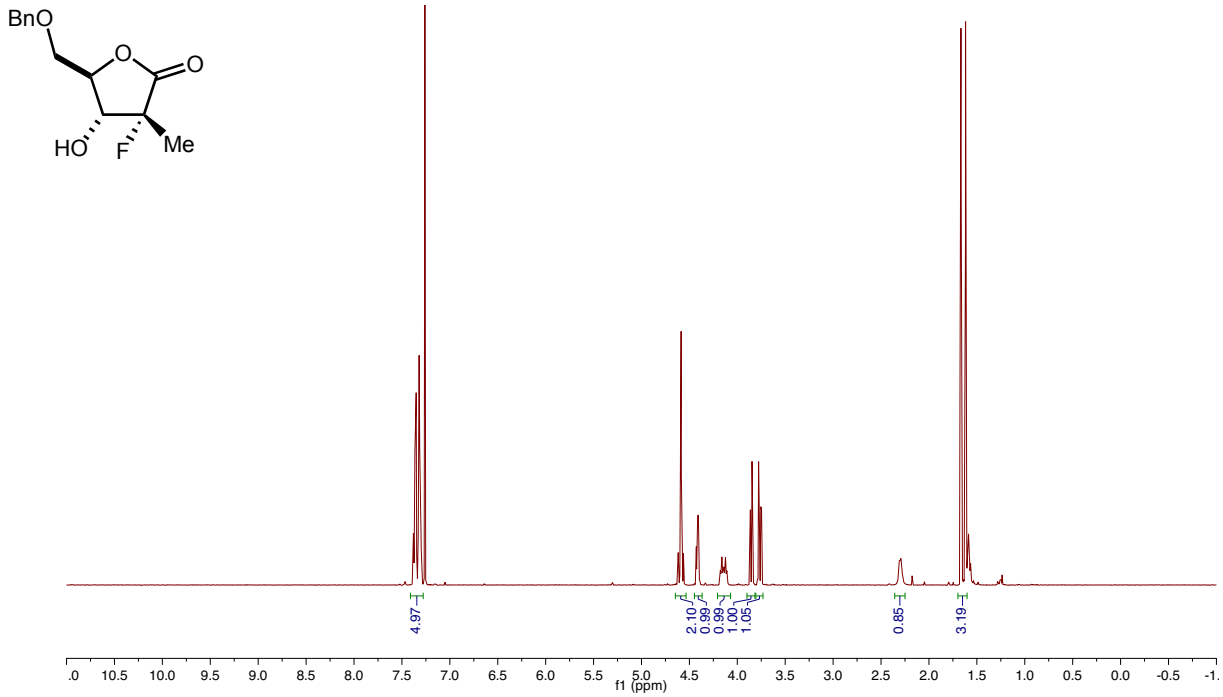
Compound **36**

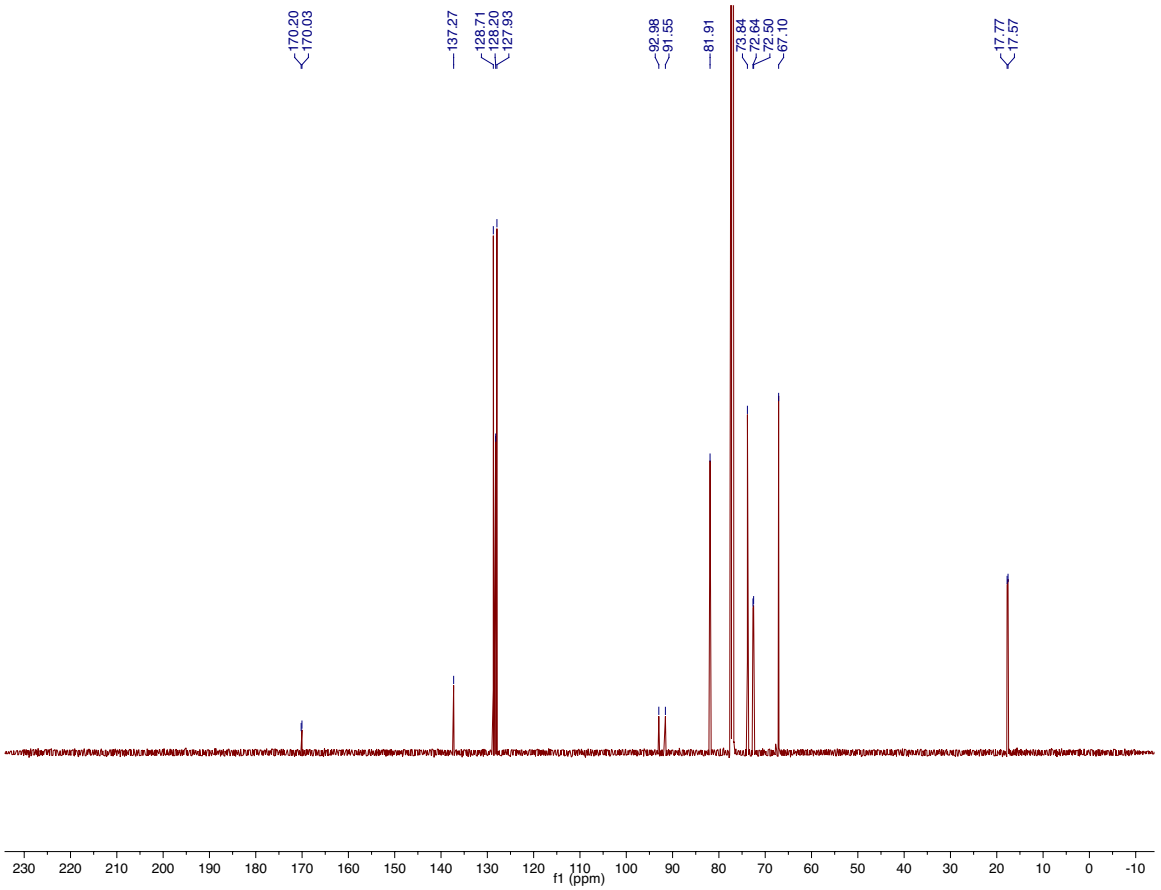

O
OH
PrO^{i}
OBn
Me
F
OTMP

5.12
1.00
2.06
0.96
1.04
1.03
1.03
1.02
3.07
14.32
6.12
6.24
f1 (ppm)

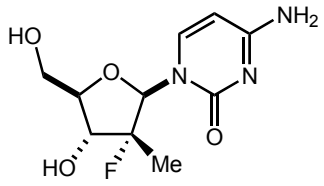

170.86
170.66
137.61
128.54
127.93
127.91
96.88
95.35
79.47
75.80
75.64
73.82
71.46
71.42
69.66
60.54
60.15
40.63
40.49
34.19
33.53
21.82
21.80
21.53
21.33
20.73
20.70
17.24
f1 (ppm)

Compound **37**

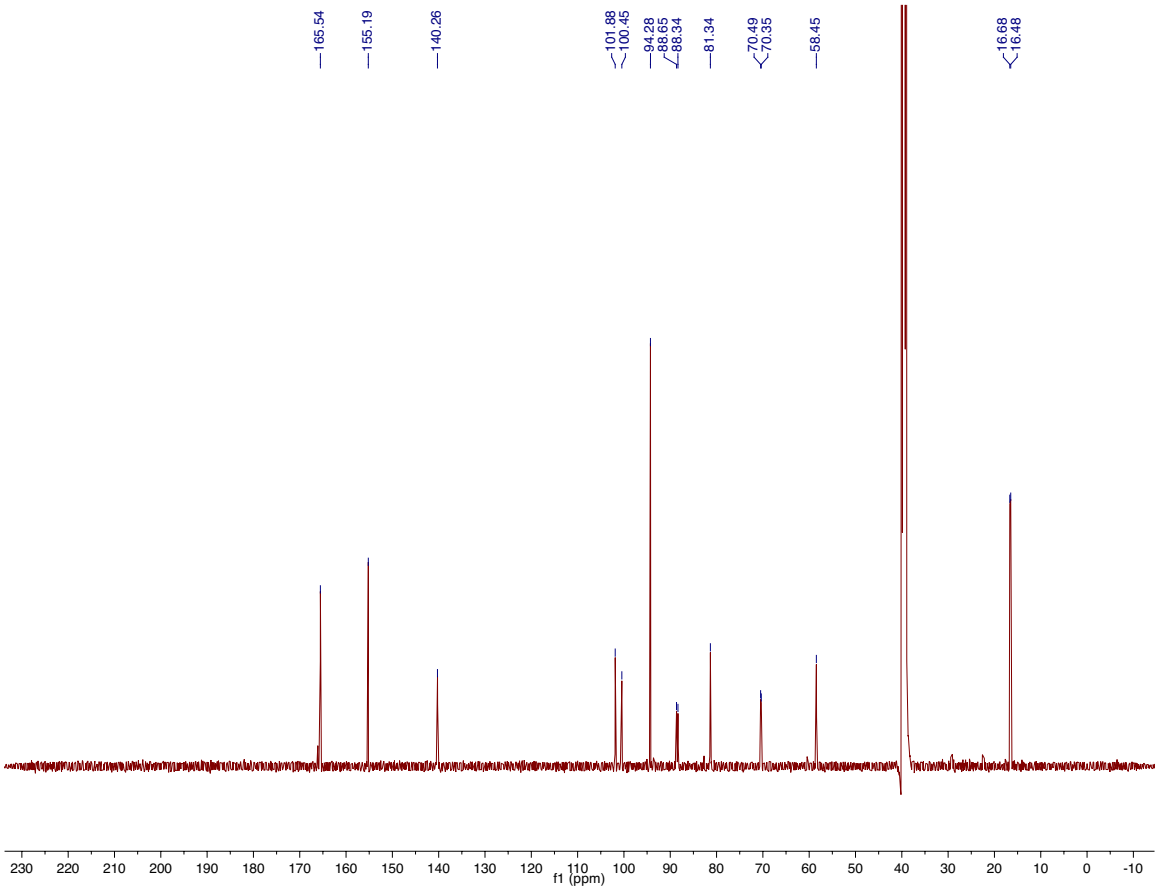

BnO
O
O
HO
F
Me
4.97
2.10
0.99
0.99
1.00
1.05
0.85
3.19
f1 (ppm)


170.20
170.03
137.27
128.71
128.20
127.93
92.98
91.55
81.91
73.84
72.64
72.50
67.10
17.77
17.57
f1 (ppm)

PSI-6130


HO
O
N
N
NH2
O
HO
F
Me

1.00
2.17
1.01
1.94
0.84
3.09
1.11
4.38
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0
f1 (ppm)


165.54
155.19
140.26
101.88
100.45
94.28
88.65
88.34
81.34
70.49
70.35
58.45
16.68
16.48
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)