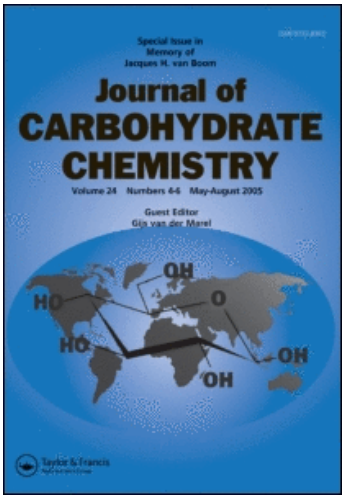


Journal of Carbohydrate Chemistry

Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713617200

Stereoselective Preparation of Allylic Alcohol Intermediates in the Synthesis of Deoxysugars

Giovanni Fronza; Claudio Fuganti; Domenica Pizzi; Stefano Servi

To cite this Article Fronza, Giovanni , Fuganti, Claudio , Pizzi, Domenica and Servi, Stefano(1990) 'Stereoselective Preparation of Allylic Alcohol Intermediates in the Synthesis of Deoxysugars', Journal of Carbohydrate Chemistry, 9: 2, 317 — 332

To link to this Article: DOI: 10.1080/07328309008543835

URL: http://dx.doi.org/10.1080/07328309008543835

J. CARBOHYDRATE CHEMISTRY, 9(2&3), 317-332 (1990)

STEREOSELECTIVE PREPARATION OF ALLYLIC ALCOHOL INTERMEDIATES IN THE SYNTHESIS OF DEOXYSUGARS

Giovanni Fronza, Claudio Fuganti, Domenica Pizzi, and Stefano Servi

CNR Centro di Studio per le Sostanze Organiche Naturali Dipartimento di Chimica, Politecnico di Milano, 20133 Italy

Received February 27, 1989 - Final Form December 18, 1989

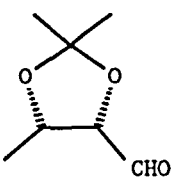
ABSTRACT

4*S*-*cis*-2,2,5-Trimethyl-1,3-dioxolane-4-carboxaldehyde (**1**) undergoes stereoselective nucleophilic addition with different vinyl metals. Allylic alcohols thus obtained are possible intermediates in the synthesis of deoxysugars. By a reiterative 1 C extension cycle, 6-deoxyhexoses can be obtained.

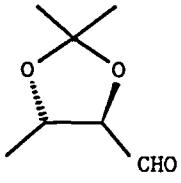
INTRODUCTION

The enantiomeric forms of 4- and 5-deoxytetroses and pentoses have raised much interest due to the opportunity of converting them into biologically important hexoses by means of stereoselective transformations.[1] In this context, the total synthesis of 2,6-dideoxy and 2,3,6-trideoxy-3-amino-hexoses of the L series represents a major task in synthetic carbohydrate chemistry.[2]

To this end we have been using extensively the C4 aldehydes **1** and **2** [3]as starting materials. The key step in our

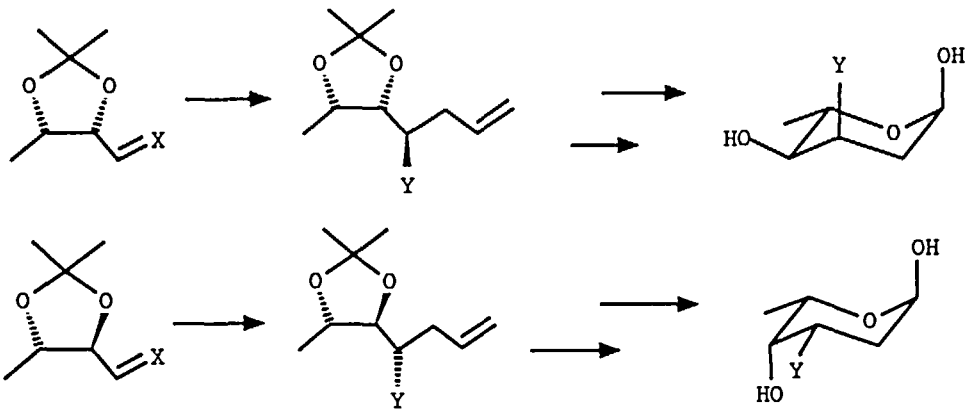


1



2

approach to the above hexoses involved the addition of a suitable allyl metal onto the carbonyl carbon of **1** and **2** or their phenylsulphenimino derivatives[4,5] **(Scheme 1).**

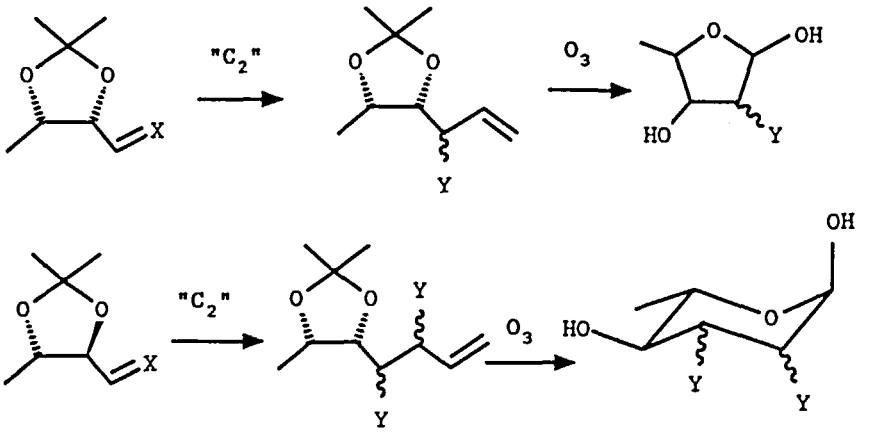


X = O; N-S-C_6H_5
Y = OH; NH_2

Scheme 1

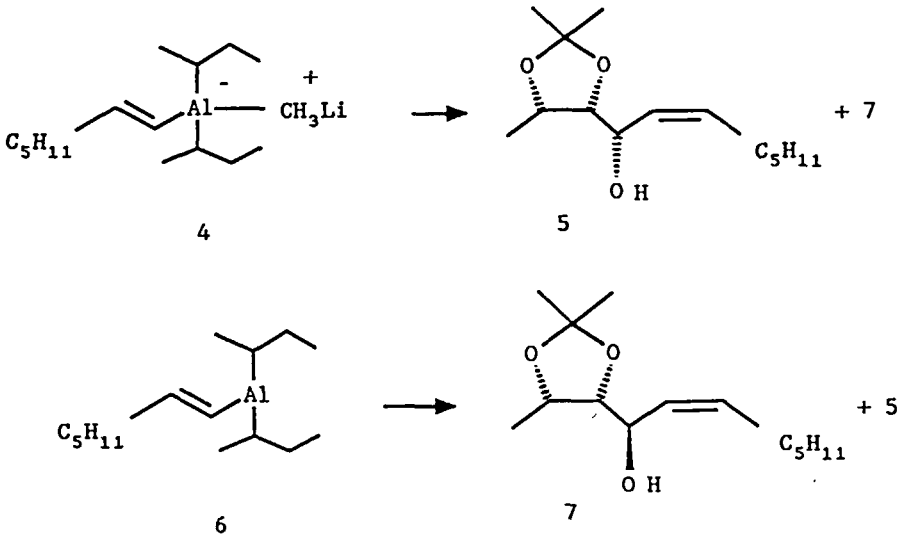
In particular, with diallylzinc as the nucleophile, steric control by the two chiral centers embedded in the dioxolane system was remarkably high, homoallylic amines with *anti* stereochemistry between the α-oxygen and the newly formed chiral center being obtained as almost exclusive reaction products. The latter materials were straightforwardly converted into *ribo* and *lyxo* 2,6-dideoxy or 2,3,6-trideoxy-3-amino-L-hexoses.

In a program directed to obtaining modified anthracycline glycosides of potential antitumor activity, we needed deoxy-, deoxyamino- and deoxydiaminopentoses and hexoses of

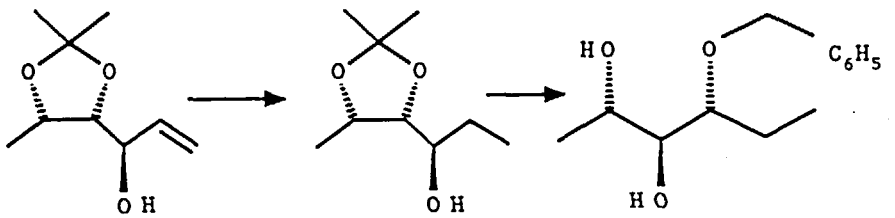


Scheme 2

the L series accessible from diastereoisomerically pure C6 and C7 allylic alcohols and amines. These latter compounds are potentially available from **1** and **2** by addition of vinyl metals to their phenylsulphenimino derivatives (**Scheme 2**). We now report on the results obtained from reacting **1** with a variety of vinyl metals. We turned our attention first to the oxygenated compounds. It has already been shown[6] that addition of ethynyl- and vinylmagnesium halides onto protected glyceraldehyde proceeds with poor diastereoselectivity. Recently we noticed[16] that vinylalane and lithiummethylvinyldiisobutylalanate add to chiral hydroxy aldehydes with opposite stereochemistry, namely with prevalent *anti* relative stereochemistry for the former, and *syn* for the latter (**Scheme 3**). Moreover, it has recently been shown[7] that addition of vinylcoppermagnesium bromide on α-benzyloxy aldehydes[2] in Et_2O/SMe_2 occurs with almost exclusive *syn* stereochemistry whereas the *anti* product is obtained when vinyltitaniumtrisisopropoxide in THF is used as the nucleophile. These observations suggest that the stereocontrolled preparation of C6 and C7 allylic alcohols from amino sugars should be possible. Addition of the lithium alanate **4**,



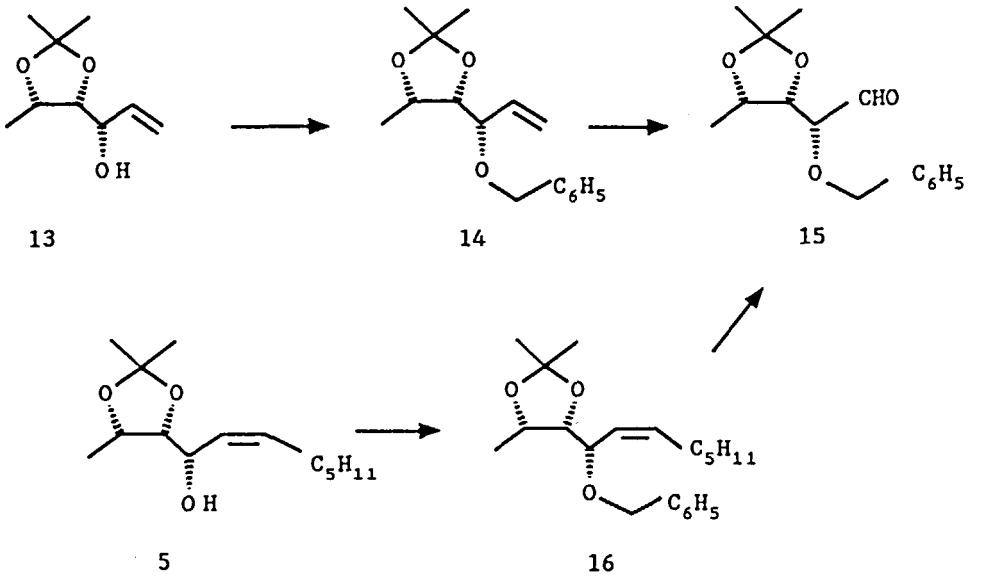
Scheme 3



Scheme 4

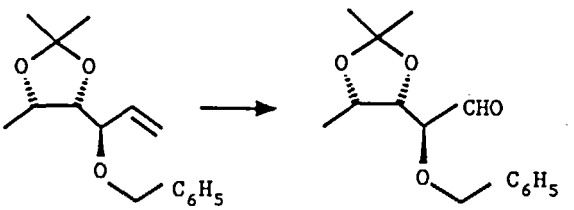
prepared according to Zweifel[8], to the aldehyde **1** gave the *syn* adduct **5** accompained by ca. 10% of the *anti* isomer. Addition of the vinylalane **6** gave predominantly the *anti* stereoisomer **7**. Addition of vinylmagnesium bromide in THF gave an *anti-syn* mixture in a ratio of 7:3. Separation by flash chromatography of the major isomer **8** allowed the correlation of this compound with the known diol[12] **10** as outlined in **Scheme 4**.

Ozonolysis of the benzyl ether of **13**, compound **14**, and treatment with Me_2S gave the corresponding aldehyde **15** which was identical with the one obtained from compound **5** by the same treatment, thus proving the configuration of the newly

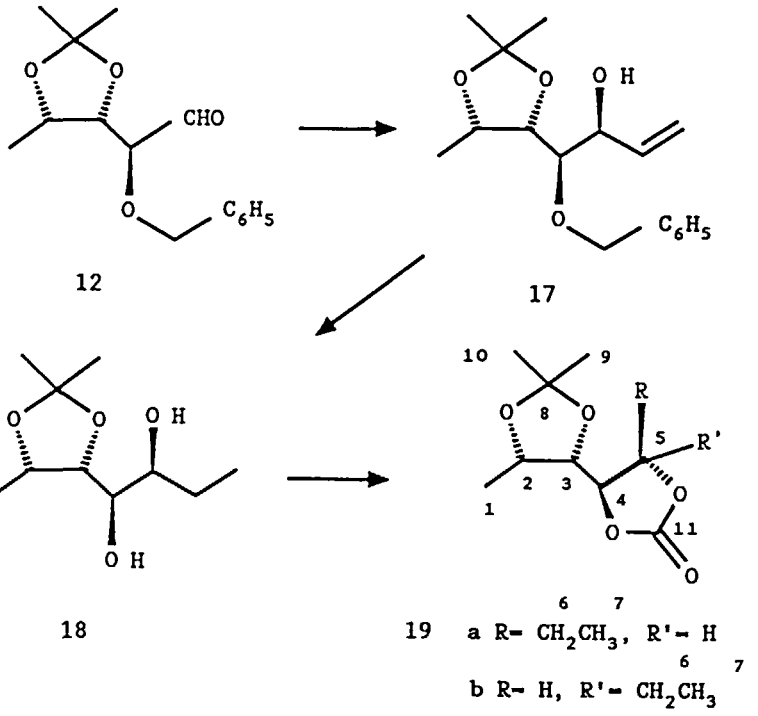


Scheme 5

formed chiral center (**Scheme 5**). The opposite configuration at carbon 4 was assigned to the isomeric alcohol **7**. In this way the two epimeric forms of a masked 5-deoxypentose can be obtained. In order to confirm the stereochemical course of the reaction, aldehyde **12** obtained from **11** after ozonolysis and reductive work up, was treated with vinylcoppermagnesium bromide which should add with *syn* stereochemistry.



Mainly one compound was obtained from the reaction and its stereochemistry was proved as indicated in **Scheme 6**. Aldehyde **12**, treated with vinylcoppermagnesium bromide in ethyl ether at -80 °C, gave a mixture of isomeric diols from which, after flash chromatography, allylic alcohol **17** was



Scheme 6

isolated as the main compound. The diol **18** obtained as the main component of a mixture arising from catalytic hydrogenation of crude **17**, was transformed into the cyclic carbonates **19** by a standard procedure. ^{1}H and ^{13}C NMR studies showed that the protons H-4 and H-5 in the carbonate ring of the major isomer **19a** are in a *trans* arrangement to each other. It is known [13,14] that in pentacyclic rings both protons and carbons in a 1,2-*cis* relationship with an alkyl substituent are shifted upfield with respect to protons and carbons in a 1,2-*trans* relationship. Accordingly, the comparison of the chemical shifts of **19b** *vs.* **19a** (**Table 1**) shows that proton H-4 is shifted upfield by 0.41 ppm and carbon C-3 is shifted downfield by 3.5 ppm, allowing establishment of the relative configuration of C-4 and C-5.

The dibenzyl ether **20** obtained from **17**, was subsequently transformed into the corresponding aldehyde **21** by ozonolysis and Me_2S treatment. This compound was converted into a

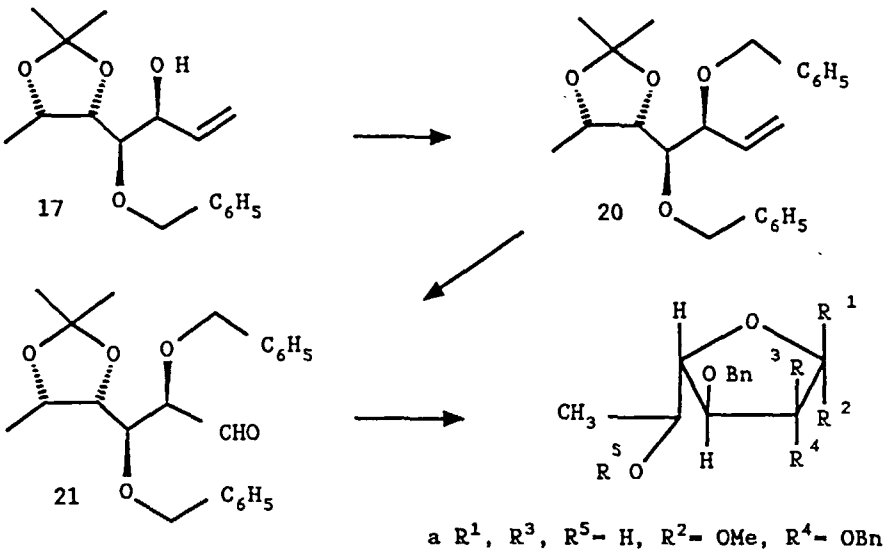
Table 1. ^{1}H and ^{13}C NMR Data of the 2,3-Isopropylidenedioxy-4,5-dihydroxycarbonylheptanes 19a and 19b.[a,b]

	19a	19b		19a	19b
H-1	1.28 ($J_{1,2}$= 6.0 Hz)	c	($J_{1,2}$=6.2)	C-1	14.8	15.2
H-2	4.50 ($J_{2,3}$= 9.0 Hz)	4.46	($J_{2,3}$=10.0 Hz)	C-2	73.6	74.4
H-3	4.20 ($J_{3,4}$=8.7 Hz)	4.30	($J_{3,4}$=5.5 Hz)	C-3	78.4	74.9
H-4	4.36 ($J_{4,5}$= 5.5 Hz)	4.77	($J_{4,5}$=7.0 Hz)	C-4	78.1	76.0
H-5	4.60	4.70		C-5	81.9	82.2
H-6	1.7-1.9	1.8 -2.0		C-6	27.9	23.1
H-7	1.02	1.03		C-7	9.3	10.4
H-9	1.38	c		C-8	109.3	c
H-10	1.32	c		C-9	28.2	28.6
				C-10	25.4	25.8
				C-11	154.9	c

a. Chemical shifts are in ppm from internal TMS; coupling constants in Hz: solvent $(CD_3)_2CO$. The proton and carbon numbering is as shown in the structural formulas. The analysis refers to products in mixture.

b. **19a** and **19b** were obtained as an inseparable mixture in the ratio of 85:15

c. Not detected



22 a R^1, R^3, R^5= H, R^2= OMe, R^4= OBn
b R^2, R^3, R^5= H, R^1= OMe, R^4= OBn
c R^1, R^4, R^5= H, R^2= OMe, R^3= OBn
d R^1, R^3,= H, R^1= OMe, R^4= OBn, R^5= COMe

Scheme 7

mixture of anomeric methyl hexosides (**Scheme 7**): ^1H and ^{13}C NMR spectroscopy data for the mixture of the two methyl furanosides **22a** and **22b** is given in **Table 2**; when the same reaction sequence was carried out on crude **17**, a mixture of the three compounds **22a, b** and **c** was obtained. The isomeric hexoses were identified by high resolution NMR spectroscopy without purification. Acetylation of the mixture derived from **17** gave an ^1H NMR spectrum that was easier to analyze, allowing identification of compound **22d** as the acetate of **22b**. The anomeric carbons of **22b** and **22c** resonate at 107.8 and 107.4 ppm respectively, indicating a *trans* relationship of C-1 and C-2 substituents.[15] A 1,2-*cis* relationship causes anomeric carbon to resonate upfield to about 103 ppm.

Moreover the small value of 2.0 Hz for the vicinal coupling constant J(2,3) of **22d**, indicates a *trans* orientation of H-2 and H-3 for this compound. Thus the α-L-altro configuration can be assigned to **22b** and **22d**. As a conse-

Table 2. ^{1}H and ^{13}C NMR Data From Mixtures of Methyl Hexosides 22.[a]

	22a	22c	22d
H-1	4.68($J_{1,2}$= 4.5 Hz)	4.87 ($J_{1,2}$= 1.0 Hz)	4.93 ($J_{1,2}$= 1.0 Hz)
H-2	4.08($J_{2,3}$= 6.7 Hz)	3.86 ($J_{2,3}$= 4.7 Hz)	3.97 ($J_{2,3}$= 2.0 Hz)
H-3	4.36($J_{3,4}$= 5.5 Hz)	4.19 ($J_{3,4}$= 6.6 Hz)	3.92 ($J_{3,4}$= 5.7 Hz)
H-4	3.84($J_{4,5}$= 3.5 Hz)	4.11 ($J_{4,5}$= 3.4 Hz)	4.03 ($J_{4,5}$= 4.1 Hz)
H-5	3.91($J_{5,6}$= 6.5 Hz)	3.96 ($J_{5,6}$= 6.5 Hz)	5.12 ($J_{5,6}$= 6.1 Hz)
Me-5	1.17	1.18	1.24
OMe	3,41	3.37	3.38
COMe	-	-	1.97

	22a	22b	22c
C-1	102.6	107.8	107.4
C-2	85.6	87.6	80.8
C-3	80.9	82.2	77.3
C-4	86.0	86.7	86.2
C-5	68.6	67.4	68.1
C-6	18.9	18.7	18.3
OMe	56.6	55.4	56.4

a. Chemical shifts in ppm from internal TMS; coupling constants in Hz; solvent $CDCl_3$.

quence it follows that **22c** is the β-L-allo isomer. Finally, compound **22a** was assigned the β-L-altro structure from comparison with the ^{13}C chemical shifts of **22b**. Changing from the α -L- to the β -L-altro configuration, an upfield shift of about 3.2 and 1 ppm is predicted [15]for carbons C-2, C-3 and C-4 respectively, as can be observed going from **22b** to **22a** **(Table 2)**.

In conclusion, allylic alcohols of different stereochemistry can be obtained from α-hydroxy aldehydes by stereoselective addition of the proper vinyl metal. This method can be considered an iterative extension of alkoxy aldehyde to higher aldoses.

EXPERIMENTAL

General Procedures. Specific rotations were recorded on a Jasco DIP-181 digital polarimeter. The values refer to c = 2 in $CHCl_3$ unless otherwise stated. NMR spectra were recorded on a Varian EM-390 (90 MHz) and on a Bruker CXP (300 MHz) instrument. Purification of products was performed by flash chromatography on silica gel (Merck 60, 0.040-0.063 mm) with mixtures of n-hexane and ethyl acetate. Analytical samples were prepared by bulb-to-bulb distillation under reduced pressure. Aldehyde **1** was prepared as previously described.[9] Vinylmagnesium bromide was prepared according to ref. 10. Vinylalane and methyllithium vinyl alanate were prepared following the procedure described in ref. 8 and 11 respectively. Benzyl ethers were prepared by the following standard procedure: a 10% DMF solution of the alcohols was treated with 1.2 equivalents of a 50% suspension of NaH in paraffin oil at room temperature, under nitrogen with stirring. The mixture was heated at 50 °C for 1 h , cooled to 0-5 °C, 1.1 equivalent of benzyl bromide was then added and the mixture heated at 50 °C for 1 h. The reaction mixture was then poured into 4-5 times the volume of water and the

aqueous mixture extracted with ethyl ether. The crude benzyl ethers were purified by flash chromatography.

(2S,3S,4S,5E)-2,3-Isopropylidenedioxy-4-hydroxyundec-5-ene (5). To a solution of 0.057 mol of the lithium methyl diisobutyl-1-heptenylalanate **(4)** prepared from 1-heptyne, DIBAH in hexane and CH_3Li in hexane at -30 °C and in an inert atmosphere, according to the literature[8], 8.2 g of **1** (0.057 mol) in 20 mL of ethyl ether were added. The mixture was stirred at -30 °C during 1 h, cooled to -50 °C and quenched with water (50 mL). The mixture was allowed to come to room temperature, the salts filtered and the residue extracted with ethyl ether to give 9.2 g of a residue which was chromatographed to give 6.2 g (45%) of compound **5** as a colorless oil: $[\alpha]_D^{20}$ +8°; ^1H NMR ($CDCl_3$) δ 0.83 (t, 3H), 1.25 (d, 3H), 1.33 (s, 3H), 1.47 (s, 3H), 1.1-1.4 (m, 8H), 2 (m, 2H), 3.95 (5 lines, 1H), 4.12 (m, 1H), 4.25 (5 lines, 1H), 5.1-6 (m, 2H), 5.58 (dd, 1H), 5.55 (dd, 1H). The slightly more polar compound (800 mg, 5%) was identified as **7** (see below).

Anal. Calcd for $C_{14}H_{26}O_3$: C, 69.38; H, 10.81. Found: C, 69.11; H, 10.70.

(2S,3S,4R,5E)-2,3-Isopropylidenedioxy-4-hydroxy-undec-5-ene (7). To a solution of 0.09 mol of 1- heptenyldiisobutylalane **(6)** in hexane prepared as described,[11] 13 g of **1** in anhydrous ethyl ether were added at 0 °C and the mixture stirred under nitrogen for 1 h. The reaction was then quenched with dilute HCl and the organic phase dried and concentrated. The residue (19 g) was purified by chromatography to give 2.2 g (10%) of a compound identified as **5** and 8.2 g (38%) of **7**: $[\alpha]_D^{20}$ +14.3°; ^1H NMR ($CDCl_3$) δ 0.80 (t, 3H), 1.21 (d, 3H), 1.36 (s, 3H), 1.45 (s, 3H), 1.2-1.8 (m, 6H), 2.08 (m, 2H), 3.8-4.5 (m, 4H), 5.6-5.9 (m, 2H).

Anal. Calcd for $C_{14}H_{26}O_3$: C, 69.38; H, 10.81. Found: C, 69.23; H, 10.72.

(2S,3S,4R)-2,3-Isopropylidenedioxy-4-hydroxyhex-5-ene (8) and (2S,3S,4S) stereoisomer (13). To a THF solution of vinylmagnesium bromide (0.08 mol) prepared according to a

known procedure,[10] 11.2 g (0.08 moles) of **1** in THF (40 mL) were added at -5 °C while stirring and under nitrogen. The mixture was allowed to come to room temperature, treated with a solution of NH_4Cl and extracted with ether. The organic layer was dried and concentrated to give a crude oil which after chromatography gave **8** (4.3 g, 31%) as a yellowish oil: $[\alpha]_D^{20}$ +41.2°; ^1H NMR ($CDCl_3$) δ 1.24 (d, 3H), 1.35 (s, 3H), 1.41 (s, 3H), 3.9 (m, 1H), 4.1 (m, 2H), 4.3 (dd, 1H), 5.2-5.5 (m, 2H), 5.85-6.3 (m, 1H).

Anal. Calcd for $C_9H_{10}O_3$: , 62.76; H, 9.36. Found: C, 62.72; H, 9.38. The minor isomer was then isolated (1.8 g, 13%) to which structure **13** was attributed: $[\alpha]_D^{20}$ +12.8°; ^1H NMR ($CDCl_3$) δ 1.24 (d, 3H), 1.32 (d, 3H), 1.48 (s, 3H), 4.0 (dd, 1H), 4.15 (m, 2H),4.32 (dd, 1H), 5.3 (m, 2H), 5.8 (m, 1H).

Anal. Calcd for $C_9H_{16}O_3$: C, 62.76; H, 9.36. Found: C, 62.62; H, 9.39.

(2S,3S,4R)-2,3-Isopropylidenedioxy-4-hydroxyhexane (9). Compound **8** (520 mg, 0.03 mol) in 20 mL of ethyl acetate, was catalytically reduced at atmospheric pressure in the presence of 70 mg of 10% Pd/charcoal. The catalyst was then removed by filtration and the residue distilled *in vacuo* to give **9** (410 mg, 80%): $[\alpha]_D^{20}$ -9.2°; ^1H NMR ($CDCl_3$) δ 0.95 (t, 3H), 1.3 (d, 3H), 1.4 (s, 3H), 1.8 (m, 2H), 3.4-3.9 (m, 2H), 4.3 (dd, 1H).

Anal. Calcd for $C_9H_{18}O_3$: C, 62.04, H, 10.41. Found: C, 61.91; H, 10.32.

(2S,3S,4R)-2,3-Dihydroxy-4-benzyloxyhexane (10). Compound **9** (780 mg, 0.045 mol) was benzylated following a standard methodology, and the intermediate benzyl ether directly hydrolyzed in 20 mL of a 1:1 mixture of 50% acetic acid and acetonitrile at 60 °C for 1 h. The solution was then extracted with ether to give crude **10** (650 mg, 60%) whose spectral data were identical with those described in the literature for the compound:[13] $[\alpha]_D^{20}$ -18.4°; ^1H NMR ($CDCl_3$)
δ 1.0 (t, 3H), 1.2 (d, 3H), 1.7 (m, 2H), 2.2 (m, 2H), 3.6 (m, 2H), 3.95 (m, 1H), 4.6 (d, 2H), 7.37 (s, 5H).

Anal. Calcd for $C_{13}H_{20}O_3$: C, 69.61; H, 8.99. Found : C, 69.43; H, 9.08.

(2S,3S,4R)-2,3-Isopropylidenedioxy-4-benzyloxyhex-5-ene (11). Compound **8** (1.1 g, 0.06 mol) was benzylated following the standard procedure, to give 1.28 g of purified **11** (82%): $[\alpha]_D^{20}$ +7.8°; ^1H NMR ($CDCl_3$) δ 1.25 (d, 3H), 1.30 (s, 3H), 1.43 (s,3H), 3.35-4.1 (m, 2H), 4.2-4.6 (q, 2H), 5.2-5.35 (dd, 2H), 5.45 (d, 1H), 5.65-6 (m, 1H), 7.35 (s, 5H).

Anal. Calcd for $C_{16}H_{22}O_3$: C, 73.25; H, 8.45. Found: C, 73.16; H, 8,27.

(2R,3S,4S)-3,4-Isopropylidenedioxy-2-benzyloxypentanal (12). Compound **11** (995 mg, 0.038 mol) in 20 mL of methylene chloride, was treated at -70 °C with excess ozone. The unreac ted ozone was removed from the solution with nitrogen and the mixture treated with excess Me_2S (3 mL). The solution was allowed to come to room temperature and then heated at 60 °C for 1 h. The solvent was then evaporated and the residue distilled *in vacuo* to give the aldehyde **12** (645 mg, 65%) which was directly used for further reaction: ^1H NMR ($CDCl_3$) δ 1.2 (s, 3H), 1.3 (s, 3H), 1.4 (s, 3H), 2.15 (s, 1H), 3.8 (dd, 2H), 4.2-4.7 (m, 2H), 7.4 (s, 5H), 9.75(d,1H).

(2S,3S,4S)-2,3-Isopropylidenedioxy-4-benzyloxyhex-5-ene (14). This compound was prepared as described above for the epimeric **11**: $[\alpha]_D^{20}$ +13.5°; ^1H NMR ($CDCl_3$) δ 1.25 (d, 3H), 1.38 (s, 3H), 1.5 (s, 3H), 3.7-4.35 (m, 2H), 4.58 (q, 2H), 5.2-5.35 (dd, 2H), 5.4 (s, 1H), 5.6-6.0 (m, 1H), 7.2-7.45 (m, 5H).

Anal. Calcd for $C_{16}H_{22}O_3$: C, 73.25; H, 8.45. Found: C, 73.29; H,8.19.

(2R,3S,4R)-3,4-Isopropylidenedioxy-2-benzyloxypentanal (15). This aldehyde was prepared as described above for the epimeric compound **12** in 60% yield. $[\alpha]_D^{20}$ +42.5°; ^1H NMR ($CDCl_3$) δ 1.23 (d, 3H), 1.3 (s, 3H), 1.50 (s, 3H), 3.8 (m, 1H), 4.2-4.6 (m, 2H), 4.7 (d, 2H), 7.3 (m, 5H), 9.8 (d, 1H).

(2S,3S,4S,5E)-2,3-Isopropylidenedioxy-4-benzyloxyundec-5-ene (16). Compound **5** (1.33 g, 0.055 mol) was benzylated following the standard procedure to give oily **16** (1.3 g,

75%): ^{1}H NMR ($CDCl_3$) δ 0.96 (t, 3H), 1.2 (d, 3H), 1.36 (s, 3H), 1.5 (s, 3H), 2.1 (m, 2H), 3.8 (m, 2H), 4.16 (m, 1H), 4.51 (q, 2H), 5.5 (dd, 1H), 5.68 (dd, 1H), 7.35 (s, 5H).

Anal. Calcd for $C_{21}H_{32}O_3$: C, 75.86; H, 9.70. Found: C, 75.83; H, 9.82. Ozonolysis of compound **16** in methylene chloride at -70 °C and reductive work up with Me_2S as described in the preparation of the epimeric aldehyde **(12)**, gave a product (58%) which was identical with **15** obtained from the olefin **14**.

(2S,3S,4R,5S)-2,3-Isopropylidenedioxy-4-benzyloxy-5-hydroxyhept-6-ene (17). Aldehyde **12** (1.2 g, 0.0045 mol) was treated at -80 °C with vinylcoppermagnesium bromide in anhydrous ethyl ether according to the literature[7] to give a mixture of epimeric allylic alcohols from which compound **17** (854 mg, 65%) was isolated as the main component by chromatography: $[\alpha]_D^{20}$ -44.1°; ^{1}H NMR ($CDCl_3$) δ 1.25 (s, 3H), 1.3 (d, 3H), 1.5 (s, 3H), 2.9 (s, broad, 1H), 3.6(d, 1H), 3.7 (d, 1H), 4.1-4.4 (m, 2H), 4.8 (q, 2H), 5.2-5.5 (dd, 2H), 6.0-6.3 (m, 1H), 7.38 (s, 5H).

Anal. Calcd for $C_{17}H_{24}O_4$: C , 69.83; H, 8.27. Found: C, 70.04; H, 8.24. Standard benzylation of compound **17** gave after column chromatography compound **20** in 55% yield: $[\alpha]_D^{20}$ -4.5°; ^{1}H NMR, ($CDCl_3$) δ 1.25(d, 3H), 1.35 (s, 3H), 1.45 (s, 3H), 3.55-3.75 (dd, 2H), 4.1-4.9 (m, 2H), 4.6 (q, 4H), 5.2-5.5 (dd, 2H), 5.85-6.2 (m, 1H), 7.35 (s, 10H).

Anal. Calcd for $C_{24}H_{30}O_4$: C, 75.36; H, 7.91. Found: C, 75.39; H, 7.96. The ratio of the two epimeric alcohols and the relative configuration of the newly formed chiral carbon, were assessed in the following way: 850 mg of the crude material obtained prior to purification, was catalytically hydrogenated in a Parr bottle under 2 atm of H_2, in ethyl acetate, and 10% Pd/charcoal as catalyst. The saturated diol **18** and its epimer were transformed into cyclic carbonates through treatment with carbonyldiimidazole in benzene at reflux. Partial purification of the reaction products gave the mixture of the two cyclic carbonates. High resolution NMR analysis allowed assignment of the **R** absolute configuration

to C5 in the major isomer **19a** (*anti* relative to C4) and established an 85:15 ratio between the two epimeric alcohols in the reaction mixture.

Mixture of Methyl Furanosides (22a) and (22b). Compound **20** (1.6 g, 0.004 mol) in 80 mL of CH_2Cl_2 at -70 °C was saturated with ozone. The resulting solution was flushed with nitrogen for 10 min and then treated with excess Me_2S (3 mL). The solution was heated at 60 °C for 1 h, then taken to dryness and the intermediate aldehyde dissolved in a 1% dry MeOH solution of HCl. The products **22a** and **22b** from this reaction were analysed by high resolution NMR spectroscopy in order to confirm the relative arrangement of the hydrogen atoms as discussed in the text and described in **Table 2.**

REFERENCES

1. G. J. McGarvey, M. Kimura, T. Oh, and J. Williams, *J. Carbohydr. Chem.*, **3**, 125 (1984).

2. F. M. Hauser, and S. R. Ellenberger, *Chem. Rev.*, **86**, 35 (1986).

3. G. Fronza, C. Fuganti, and P. Grasselli, *J. Chem. Soc. Chem. Commun.*, 442 (1980); C. Fuganti, P. Grasselli, and G. Pedrocchi-Fantoni, *Tetrahedron Lett.*, 4017 (1981).

4. G. Fronza, C. Fuganti, P. Grasselli, G. Pedrocchi-Fantoni, and C. Zirotti, *Tetrahedron Lett.*, 4143 (1982).

5. C. Fuganti, P. Grasselli and G. Pedrocchi-Fantoni, *J. Org. Chem.*, **48**, 909 (1983).

6. D. Horton, J. B. Hughes, and J. K. Thomson, *J. Org. Chem.*, **33**, 728 (1968); D. J. Walton, *Can. J. Chem.*, 2921, (1967).

7. K. Mead, and T. L. McDonald, *J. Org. Chem.*, **50**, 422 (1985).

8. G. Zweifel, and R. B. Steele, *J. Am. Chem. Soc.*, **89**, 2754 (1967).

9. S. Servi, *J. Org. Chem.*, **50**, 909 (1985).

10. H. Normant, *Advances in Organic Chemistry*, Vol. II; Interscience Publishers, New York, 1960, p 1.

11. H. Newman, *Tetrahedron Lett.*, **47**, 4571 (1971).

12. R. Bernardi, C. Fuganti, and P. Grasselli, *Tetrahedron Lett.* 4021 (1981).

13. M. Anteunis, and D. Danneels, *J. Magn. Res.*, **7**, 345 (1975).

14. M. Christl, H. J. Reich, and J. D. Roberts, *J. Am. Chem. Soc.*, **93**, 3463 (1971).

15. R. G. S. Ritchie, N. Cyr, B. Korsch, H. J. Koch, and A. S. Perlin, *Can. J. Chem.*, **53**, 1424, (1975).

16. Unpublished results from this laboratory.