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Diastereoselective Propargylation of Sugar Aldehydes. New Synthesis of 6-Deoxyheptoses#

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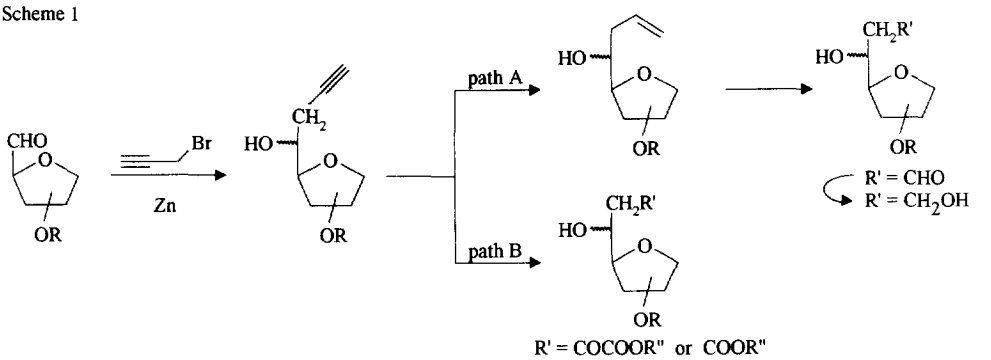
Abstract: *Propargylation of pentofuranose aldehydes by treatment with propargyl bromide in the presence of zinc dust yielded homopropargylic alcohols with a good isolated yield and, in many cases, excellent* anti/syn *selectivity. Catalytic hydrogenation of the triple bond afforded homoallylic alcohols, valuable substrates for the synthesis of 6-deoxyheptoses. Direct ozonolysis of the triple bond yielded uronic acid esters.* © 1997, Elsevier Science Ltd. All rights reserved.

Introduction

The propargylation reaction is known as a method for three carbon atoms chain elongation of organic compounds[1,2]. The addition of propargylic zinc bromides to carbonyl group proceeds readily and in mild reaction conditions. Because propargylic zinc halogenides exist as mixtures of allenic and acetylenic compounds, their reaction with carbonyl group may afford mixtures of homopropargylic and allenic compounds. The proportion of both products strongly depends on nature of substrates and on reaction conditions[1,2]. Stereochemistry of propargylation of prochiral aldehydes and ketones has been well studied[1,3]. In contrast, reaction with chiral, α-alkoxy aldehydes, especially the sugar-type aldehydes, has not been well studied yet. A single product was obtained by Fuganti[4] from a 4-deoxy-erythrose derivative and propargylic zinc bromide in high yield (80%). Recently, Wu[5-9] has published a series of papers on propargylation reaction of other non-cyclic sugar aldehydes (obtained from D- and L-glyceraldehyde, D- and L-tetrose, D-xylose and D-arabinose). In all cases studied, *anti* product was isolated as sole or major product. Allenic compounds have been identified in small quantities (<5%) in a few cases only[8,9].

Scheme 1



Dedicated to Professor Hans Paulsen on the occassion of his 75th birthday.

In this report we present the preparation of homopropargyl alcohols from aldehydes obtained from pentofuranoses (D-arabinose, D-ribose, D-xylose and D-lyxose). These compounds are potentially useful intermediates for the synthesis of 6-deoxy-heptoses (Scheme 1, path A), and 3-deoxy-2-ketoesters or 6-deoxy-hepturonic esters (Scheme 1, path B).

6-Deoxyheptoses are uncommon sugar components of bacterial lipopolysaccharides (LPS) isolated from pathogenic microorganisms like *Eubacterium*, *Camphylobacter*, *Pseudomonas* and *Yersinia* species[10-12]. Several stereoisomers of 6-deoxyheptoses have been synthesized[10]. There are two general methods for the preparation of this type of sugars. Displacement of the sulfonyloxy group with a nitrile ion followed by their reduction was used for one carbon atom chain elongation of hexose derivatives[10,13-15], however, this method is limited to a few, cheap and readily available D-hexoses. The second method - two carbon atoms elongation of carbon chain of pentose derivatives *via* reaction with chiral acetyliron complex led to a wide range of 6-deoxyheptoses[16].

α-Ketoacids play an important role among biologically active natural products[17,18]. The best known are N-acetylneuraminic acid and 3-deoxy-D-*manno*-oct-2-ulosonic acid (KDO).

Results and discussion

Methyl 2,3-O-isopropylidene-β-D-*ribo*-pentodialdo-1,4-furanoside[16] (**1**) was chosen as the first substrate. From the reaction performed with propargyl bromide and zinc in THF as solvent, two isomeric products **2** and **3** were obtained as a readily separable mixture in 1.0 : 5.7 proportion and with a good chemical yield (74%). According to Wu[9] the same reaction performed in a mixed solvent (DMF - ether, 1 : 1) with other chiral aldehydes gave higher *anti/syn* selectivity than in THF. However, in the case of **1** we did not observe any difference of stereochemical results obtained for both solvent systems.

On the contrary, the same reaction with the open-chain aldehyde **11**[8,19] (of D-*arabino* configuration) gave lower *anti/syn* selectivity (3 : 2) in contrast to literature data (reaction in DMF - ether solution gave *anti/syn* 12 : 1 selectivity[9]).

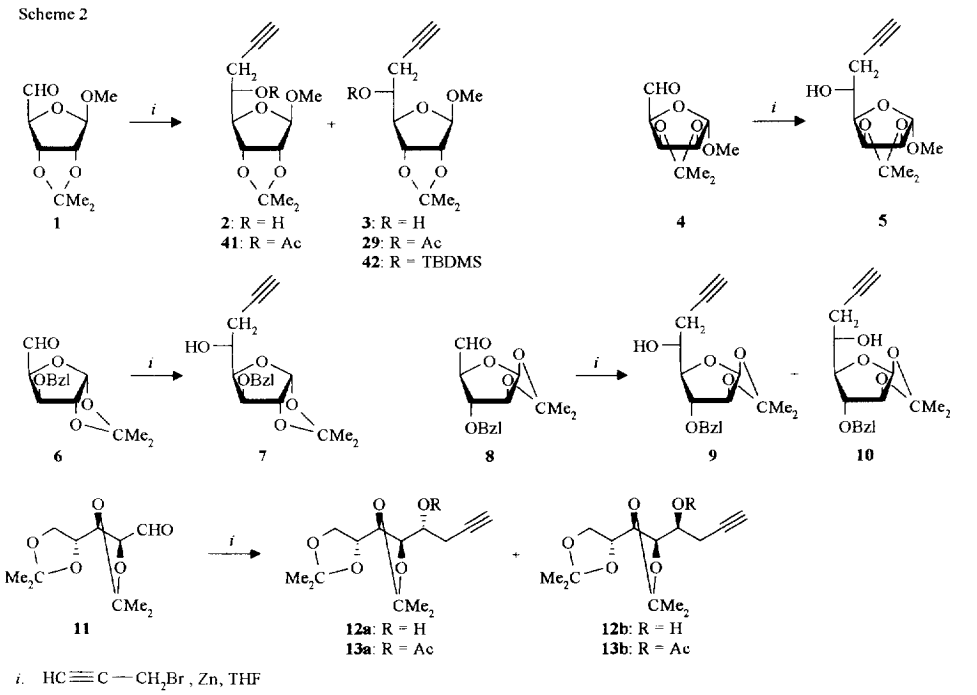
Table 1. Reaction of sugar aldehydes with propargyl bromide in the presence of zinc.

No.	Substrate	Yield [%]	Products	*anti/syn*
1	**1**	74	**2** + **3**	5.7
2	**4**	70	**5**	>20
3	**6**	80	**7**	>20
4	**8**	84	**9** + **10**	>20
5	**11**	81	**12a** + **12b**	1.5

Propargylation reaction of methyl 2,3-O-isopropylidene-α-D-*lyxo*-pentodialdo-1,4-furanoside[16] (**4**) gave an inseparable mixture of **5** and its C-5 epimer with *anti/syn* >20 : 1 selectivity. Similar results were obtained for 3-O-benzyl-1,2-O-isopropylidene-α-D-*xylo*-pentodialdo-1,4-furanose[16] (**6**) and 3-O-benzyl-1,2-O-isopropylidene-β-D-*arabino*-pentodialdo-1,4-furanose[16] (**8**). In the latter case, the separation of both epimers (**9** and **10**) was possible by column chromatography (Table 1, Scheme 2).

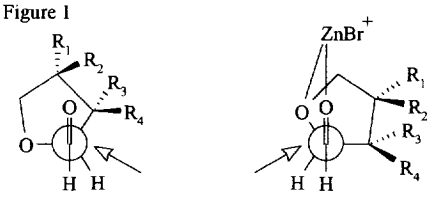
Configurations of the newly formed centers of chirality were confirmed by transformation of compounds **3** and **7** to the known alkenes **14** and **17**, and of compounds **5** and **9** to the known uronic esters **22** and **26** (*vide infra*).

Scheme 2



High *anti* stereoselectivity of propargylation reaction suggests that the major stereoisomer was formed through a Felkin - Anh transition state[20-22] (Figure 1, TS 1). Chelation controlled transition state (TS 2), leading to *syn* addition does not occur. It is possible, that steric hindrance exerted by the *cis* oriented substituents at C-2 and/or C-3 (R_2 and R_4 in **4**, **6**, and **8**) favors the *anti* selectivity. For aldehyde **1**, which contains substituents at C-2 and C-3 carbon atoms which are distant from carbonyl group, *anti/syn* selectivity is lowered.

Figure 1



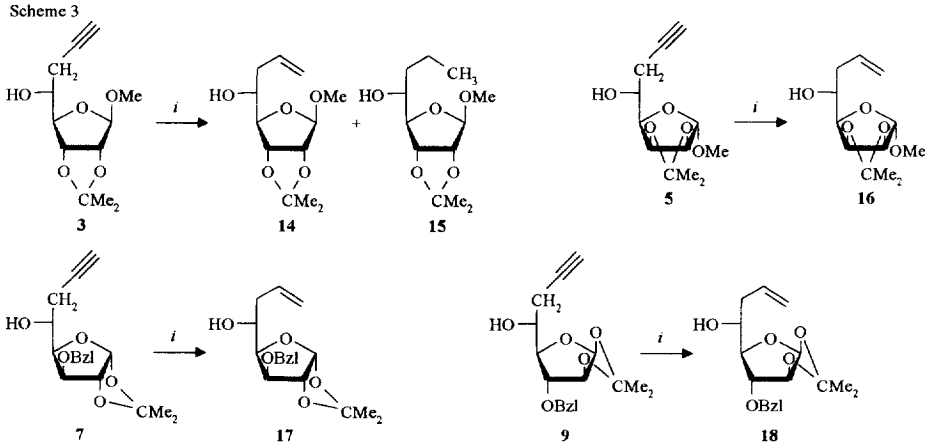
Transformation of homopropargylic alcohols to 6-deoxy-heptoses is possible on two independent ways. Hydrogenation of the triple bond afforded homoallylic alcohols, in which the double bond can be readily

oxidized by ozonolysis to 6-deoxy-hepto-dialdoses by known methods[23,24], and subsequently reduced to 6-deoxy-heptoses (Scheme 1, path A).

On the other hand, direct oxidation of the triple bond (by various oxidants, e.g.: OsO_4 / $KClO_3$[25], RuO_2 / PhIO[26], OsO_4 / t-BuOOH[27,28], O_3[29]) presents a viable method for the preparation of carboxylic acids and esters. Therefore, oxidation of homopropargylic sugar alcohols obtained by us, may be exploited as a useful method for the synthesis of biologically important compounds (Scheme 1, path B).

We examined first the reduction of sugar acetylenes to homoallylic alcohols by treatment with lithium aluminum hydride, however, from the reaction of **3** (THF, reflux 4 h) with $LiAlH_4$ only the unchanged substrate was recovered. Catalytic hydrogenation (with poisoned palladium on barium sulfate as the catalyst) of **3** afforded a separable mixture of **14** and **15** (83% and 7%, respectively). Hydrogenation of other acetylenes (**5**, **7** and **9**) under the same conditions gave alkenes **16**, **17** and **18** in high yield, contaminated with only a small amount of alkane derivatives. Compounds **14** and **17** are identical with those described earlier by Danishefsky[23], what confirmed the *erythro* configuration of C-4 and C-5 atoms in **3** and **7** (Scheme 3).

Scheme 3



i: 10% Pd / $BaSO_4$, quinoline, H_2

Ozonolysis of the acetylene moiety in **5** (see Experimental, *General procedure B*) yielded two products: methyl 6-deoxy-2,3-O-isopropylidene-α-D-*manno*-hepturonate (**22**, 11%) and a 5-O-formyl ester of **22** (**21**, 17%). The origin of the formyl group is unclear, although esterification of the 5-OH group by formic acid released during ozonolysis appears to be a plausible explanation. Configuration of **22** as *manno* (i.e. C-4,C-5 *erythro*) was determined on the basis of spectral data identical with those from literature[16].

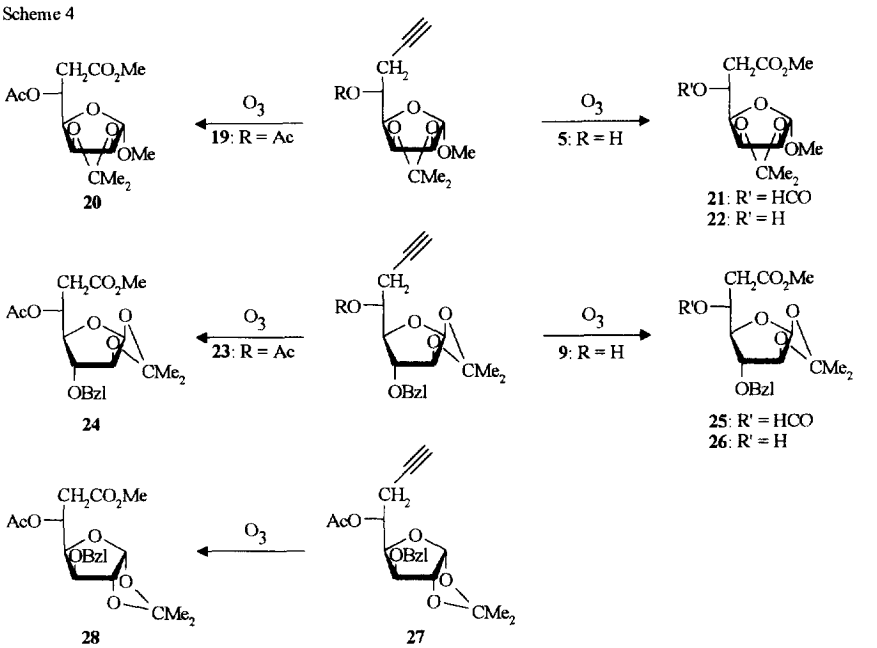
Ozonolysis of 5-O-acetyl **5** (**19**) afforded 5-O-acetyl derivative of **22**, ester **20** (see Experimental, *General procedure A*), in a good yield (61%). Thus, ozone cleaved the triple bond without any α-ketoester formation.

Very similar results have been obtained from ozonolysis of **9** and its 5-O-acetyl derivative **23**: methyl 3-O-benzyl-1,2-O-isopropylidene-β-D-*altro*-hepturonate (**26**[16], 45%) and its 5-O-formyl derivative (**25**, 5%) were formed in the former case, and 5-O-acetyl derivative **24** (41%) in the second (Scheme 4).

Ozonolysis of 5-O-acetyl derivative of **7**, compound **27**, yielded a mixture of products from which methyl 5-O-acetyl-3-O-benzyl-1,2-O-isopropylidene-α-D-*gluco*-hepturonate (**28**) was isolated in 50% yield

however, contaminated with some amounts of inseparable impurities. Here again, the formation of an α-ketoester could not be detected (Scheme 4).

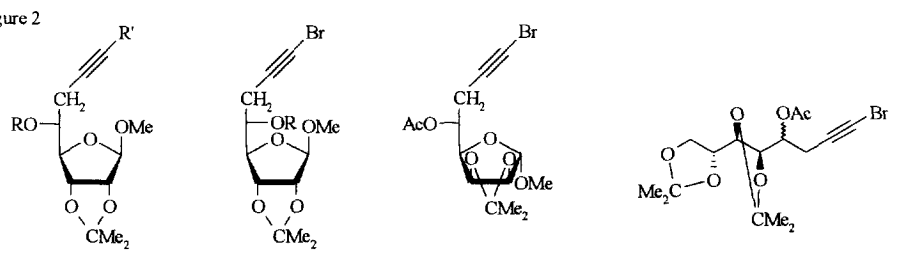
Scheme 4



The replacement of acetylenic hydrogen atom by bromine was earlier recommended for increasing the ester formation during the triple bond ozonolysis[29]. From 5-O-acetylated **3** (**29**), 8-bromo derivative **30** was obtained and ozonolyzed under standard conditions. However, after 1.5 h at -40° only the unchanged substrate was isolated. A similar result has been recorded also for 8-bromo **19**, compound **36**.

We also tried the oxidation of triple bond with the Crich system[28] (oxidation of acetylenic trimethylsilyl derivatives with tert-butyl hydroperoxide and catalytic osmium tetraoxide) useful in synthesis of alkyl α-ketoesters, but oxidation reactions of series of compounds (Figure 2) gave the unchanged substrates as the only isolable products.

Figure 2



30: R = Ac, R' = Br
31: R = Ac, R' = $SiMe_3$
32: R = H, R' = $SiMe_3$
33: R = TBDMS, R' = Br
34: R = TBDMS, R' = $SiMe_3$

35: R = Ac

36

37ab

Conclusion

Three carbon atoms elongation of sugar chain by propargyl bromide in the presence of zinc in THF solution afforded homopropargyl alcohols in high chemical yields. Products with D-*manno*, D-*gluco*, and D-*altro* configurations were obtained in high stereoselectivity (*anti/syn* >20 : 1). Compounds with D-*allo* and L-*talo* configurations (obtained from a D-ribose derivative) gave *anti/syn* 5.7 : 1.0 selectivity. Configuration at newly formed chiral centres were confirmed by transformation of acetylenic sugars to known homoallylic alcohols and uronic acids esters.

Catalytic hydrogenation of triple bond afforded homoallylic alcohols, which may be transformed to 6-deoxyheptoses by the ozonolysis of the double bond followed by reduction as was early described by Danishefsky[23,24]. Ozonolysis of the triple bond yielded only 6-deoxy-hepturonic acids esters. Unfortunately, the oxidation of the triple bond by ozone or catalytic osmium tetraoxide system did not lead to a α-ketoacids.

In our opinion, the method presented above opens a third (cf. Ref. 15, 16), short and efficient way to various stereoisomeric 6-deoxy-heptoses.

Experimental

General methods. Tetrahydrofuran (THF) was distilled from $LiAlH_4$ under a stream of argon prior to use. Other solvents were purified and dried according to literature methods. TLC was performed on Silica Gel HF-254 and column chromatography on Silica Gel 230 - 400 mesh (Merck). ^1H NMR spectra were recorded with a Varian AC-200 (200 MHz) and Bruker AM-500 (500 MHz) spectrometers in deuterochloroform ($CDCl_3$) with Me_4Si as internal standard. High resolution mass spectra (HR-MS) were measured with AMD-604 mass spectrometer. Optical rotations were measured with a JASCO DIP-360 automatic polarimeter.

Reaction of sugar aldehydes with propargyl bromide in the presence of zinc dust

General procedure: To a mixture of pentofuranose aldehyde (4.0 mM) and zinc dust (785 mg, 12.0 mM) in THF (15 mL), a solution of propargyl bromide (0.6 mL, 8.0 mM) in THF (5 mL) was slowly added. After a few minutes, an exothermic reaction occurred. The reaction mixture was stirred for 3 h at room temperature, filtered through a Celite pad, the solvents were evaporated and the residue was dissolved in dichloromethane (50 mL), and 10% solution of ammonium chloride (50 mL) was added. The products were extracted with dichloromethane (2 × 50 mL). Organic extracts were collected, washed with 10% solution of ammonium chloride (2 × 50 mL) and dried (Na_2SO_4). The solvents were evaporated and the syrup left was purified by column chromatography (hexane - ethyl acetate, 8 : 3).

From methyl 2,3-O-isopropylidene-β-D-*ribo*-pentodialdo-1,4-furanoside (**1**) were obtained 106 mg (11%) of *methyl 2,3-O-isopropylidene-6,7,8-trideoxy-α-L*-talo-*oct-7-ynofuranoside* (**2**): m.p. 42 - 43°C; $[\alpha]_D^{20}$ -31.7° (*c* 0.89, chloroform). ^1H NMR ($CDCl_3$), δ 4.99 (s, 1H, H-1), 4.85 (d, 1H, $J_{3,2}$ 6.1 Hz, H-3), 4.64 (d, 1H, $J_{4,5}$ 1.9 Hz, H-4), 4.59 (d, 1H, H-2), 3.73 (m, 1H, H-5), 3.47 (s, 3H, OMe), 2.47 (m, 1H, $J_{6,5}$ 5.6, $J_{6,6'}$ 16.7, $J_{6,8}$ 2.6 Hz, H-6), 2.40 (m, 1H, $J_{6',5}$ 7.6, $J_{6',8}$ 2.6 Hz, H-6'), 2.06 (t, 1H, H-8), 1.49 and 1.32 (2s, 6H, CMe_2). ^{13}C NMR ($CDCl_3$), δ 112.14 (CMe_2); 110.40 (C-1); 88.67, 85.40, 82.30, 70.46 (C-2,3,4,5); 79.97 (C-8); 70.38 (C-7); 55.98 (OMe); 26.26 and 24.62 (Me); 24.10 (C-6). HR-MS/EI calc. for $C_{11}H_{15}O_5$ $(M-15)^+$: 227.0919. Found: 227.0918; and 610 mg (63%) of *methyl 2,3-O-isopropylidene-6,7,8-trideoxy-β-D*-allo-*oct-7-ynofuranoside* (**3**): $[\alpha]_D^{20}$ -71.5° (*c* 0.98, chloroform). ^1H NMR ($CDCl_3$), δ 4.98 (s, 1H, H-1), 4.89 (d, 1H, $J_{3,2}$ 6.0 Hz, H-3), 4.58 (d, 1H, H-2), 4.38 (d, 1H, $J_{4,5}$ 3.8 Hz, H-4), 3.84 (m, 1H, H-5), 3.42 (s, 3H, OMe), 2.53 (m, 1H, $J_{6,5}$ 5.4, $J_{6,6'}$ 16.9, $J_{6,8}$ 2.7 Hz, H-6), 2.46 (m, 1H, $J_{6',5}$ 6.8, $J_{6',8}$ 2.7 Hz, H-6'), 2.07 (t, 1H, H-8), 1.49

and 1.33 (2s, 6H, CMe_2). ^{13}C NMR ($CDCl_3$), δ 112.17 (*C*Me_2); 109.88 (C-1); 89.66, 85.60, 79.95, 70.56 (C-2,3,4,5); 79.73 (C-8), 71.04 (C-7); 55.57 (OMe); 26.27 and 24.63 (Me); 23.15 (C-6). HR-MS/EI calc. for $C_{11}H_{15}O_5$ $(M-15)^+$: 227.0919. Found: 227.0918.

From methyl 2,3-O-isopropylidene-α-D-*lyxo*-pentodialdo-1,4-furanoside (**4**): 690 mg (70%) of *methyl 2,3-O-isopropylidene-6,7,8-trideoxy-α-D*-manno-*oct-7-ynofuranoside* (**5**): $[\alpha]_D^{20}$ +69.4° (*c* 1.0, chloroform). ^1H NMR ($CDCl_3$), δ 4.91 (s, 1H, H-1), 4.85 (dd, 1H, $J_{3,2}$ 5.9, $J_{3,4}$ 3.6 Hz, H-3), 4.58 (d, 1H, H-2), 4.08 (m, 1H, H-5), 3.96 (dd, 1H, $J_{4,5}$ 7.9 Hz, H-4), 3.32 (s, 3H, OMe), 2.67 (m, 1H, $J_{6,5}$ 4.6, $J_{6,6'}$ 16.9, $J_{6,8}$ 2.7 Hz, H-6), 2.57 (m, 1H, $J_{6',5}$ 6.1, $J_{6',8}$ 2.7 Hz, H-6'), 2.07 (t, 1H, H-8), 1.47 and 1.33 (2s, 6H, CMe_2). ^{13}C NMR ($CDCl_3$), δ 112.78 (*C*Me_2); 107.00 (C-1); 84.98, 80.44, 79.86, 68.06 (C-2,3,4,5); 80.40 (C-8); 70.83 (C-7); 54.57 (OMe); 26.05 and 24.54 (Me); 24.54 (C-6). HR-MS/EI calc. for $C_{11}H_{15}O_5$ $(M-15)^+$: 227.0919. Fond: 227.0916.

From 3-O-benzyl-1,2-O-isopropylidene-α-D-*xylo*-pentodialdo-1,4-furanose (**6**): 1.025 g (80%) of *3-O-benzyl-1,2-O-isopropylidene-6,7,8-trideoxy-α-D*-gluco-*oct-7-ynofuranose* (**7**): $[\alpha]_D^{20}$ -53.2° (*c* 1.09, chloroform). ^1H NMR ($CDCl_3$), δ 5.92 (d, 1H, $J_{1,2}$ 3.8 Hz, H-1), 4.62 (d, 1H, H-2), 4.70 and 4.56 (ABq, 2H, *J* 11.7, $PhCH_2$), 4.00 - 4.20 (m, 3H, H-3,4,5), 2.61 (m, 1H, $J_{6,5}$ 4.2, $J_{6,6'}$ 17.0, $J_{6,8}$ 2.6 Hz, H-6), 2.48 (m, 1H, $J_{6',5}$ 5.8, $J_{6',8}$ 2.7 Hz, H-6'), 2.04 (t, 1H, H-8), 1.48 and 1.32 (2s, 6H, CMe_2). ^{13}C NMR ($CDCl_3$), δ 111.97 (*C*Me_2); 105.21 (C-1); 82.37, 81.79, 81.28, 67.18 (C-2,3,4,5); 80.40 (C-8); 72.23 (Ph*C*H_2); 71.00 (C-7); 26.94 and 26.48 (Me); 24.73 (C-6). HR-MS/EI calc. for $C_{17}H_{19}O_5$ $(M-15)^+$: 303.1232. Found: 303.1222.

From 3-O-benzyl-1,2-O-isopropylidene-β-D-*arabino*-pentodialdo-1,4-furanose (**8**) were obtained 1.072 g (84%) of *3-O-benzyl-1,2-O-isopropylidene-6,7,8-trideoxy-β-D*-altro-*oct-7-ynofuranose* (**9**): m.p. 60 - 61°C; $[\alpha]_D^{20}$ +1.8° (*c* 1.75, chloroform).^1H NMR ($CDCl_3$), δ 5.89 (d, 1H, $J_{1,2}$ 4.0 Hz, H-1), 4.64 (d, 1H, H-2), 4.61 (s, 2H, $PhCH_2$), 4.21 (d, 1H, $J_{4,3}$ 2.2 Hz, H-4), 4.06 (d, 1H, H-3), 3.95 (m, 1H, H-5), 2.60 (m, 1H, $J_{6,5}$ 4.5, $J_{6,6'}$ 16.9, $J_{6,8}$ 2.7 Hz, H-6), 2.46 (m, 1H, $J_{6',5}$ 6.5, $J_{6',8}$ 2.7 Hz, H-6'), 2.06 (t, 1H, H-8), 1.49 and 1.31 (2s, 6H, CMe_2). ^{13}C NMR ($CDCl_3$), δ 112.56 (*C*Me_2); 105.93 (C-1); 87.15, 85.09, 82.69, 69.29 (C-2,3,4,5); 80.13 (C-8); 71.71 (Ph*C*H_2); 71.30 (C-7); 27.09 and 26.14 (Me); 23.77 (C-6). HR-MS/EI calc for $C_{17}H_{19}O_5$ $(M-15)^+$: 303.1232. Found: 303.1230; and 50 mg (4%) of *3-O-benzyl-1,2-O-isopropylidene-6,7,8-trideoxy-α-L*-galacto-*oct-7-ynofuranose* (**10**): ^{13}C NMR ($CDCl_3$), δ 113.04 (*C*Me_2); 105.57 (C-1); 87.16, 85.31, 83.21, 69.21 (C-2,3,4,5); 80.24 (C-8); 71.93 (Ph*C*H_2); 70.97 (C-7); 23.93 (C-6); 26.36 and 23.93 (Me).

From 2,3:4,5-di-O-isopropylidene-D-arabinose (**11**): 220 mg (81%) of inseparable mixture of *5,6:7,8-di-O-isopropylidene-1,2,3-trideoxy-D*-manno-*1-yno-octitol* (**12a**) and *5,6:7,8-di-O-isopropylidene-1,2,3-trideoxy-D*-gluco-*1-yno-octitol* (**12b**) in 3 : 2 proportion: ^1H NMR ($CDCl_3$), δ 4.20 (dd, $J_{8,7}$ 6.2, $J_{8,8'}$ 8.7 Hz, H-8a), 4.14 (dd, $J_{8,7}$ 6.1, $J_{8,8'}$ 8.5 Hz, H-8b), 4.04 - 4.10 (m), 4.01 (dd, $J_{8',7}$ 5.3 Hz, H-8'a), 3.96 (dd, $J_{8',7}$ 4.9 Hz, H-8'b), 3.93 (dd, *J* 7,6 and 8.3 Hz), 3.84 (m), 3.76 (m, H-4a,4b), 2.67 (m, $J_{3,4}$ 3.4, $J_{3,3'}$ 16.8, $J_{3,1}$ 2.7 Hz, H-3a), 2.52 (m, H-3b, 3'b), 2.48 (m, $J_{3',4}$ 6.8, $J_{3',1}$ 2.7 Hz, H-3'a), 2.05 (t, H-1a,1b). ^{13}C NMR ($CDCl_3$), δ 81.80 (a), 81.28 (b), 80.96 (a), 80.74 (b), 77.22 (b), 77.07 (b),76.22 (a), 70.66 (a), 70.32 (C-2b), 70.03 (C-2a), 68.75 (b), 67.83 (C-8a), 67.74 (C-8b), 24.74 (C-3b), 23.88 (C-3a). HR-MS/EI calc for $C_{13}H_{19}O_5$ $(M-15)^+$: 255.1232. Found: 255.1233.

Catalytic hydrogenation of the triple bond

To a solution of sugar acetylene (1.0 mM) in toluene (5 mL), quinoline (200 μL) and 10% Pd / $BaSO_4$ (20 mg) were added. The mixture was hydrogenolyzed at atmospheric pressure until no more substrate was

detectable on TLC (20 - 60 min). The whole solution was transferred onto a chromatographic column filled with silica gel, and the products were eluted with hexane - ethyl acetate (8 : 3) mixture.

From **3** were obtained 17 mg (7%) of *methyl 2,3-O-isopropylidene-6,7,8-trideoxy-β-D*-allo-*octofuranoside* (**15**): m.p. 48 - 49°C; $[\alpha]_D^{20}$ -74.8° (*c* 0.97, chloroform). ^{1}H NMR ($CDCl_3$), δ 4.97 (s, 1H, H-1), 4.83 (d, 1H, $J_{3,2}$ 6.0 Hz, H-3), 4.57 (d, 1H, H-2), 4.22 (d, 1H, $J_{4,5}$ 1.6 Hz, H-4), 3.70 (m, 1H, H-5), 3.44 (s, 3H, OMe), 1.48 and 1.32 (2s, 6H, CMe_2), 1.30 - 1.54 (m, 4H, H-6,6'7,7'), 0.95 (t, 3H, *J* 7.0 Hz, H-8). ^{13}C NMR ($CDCl_3$), δ 110.03 (C-1); 91.90, 85.99, 79.94, 71.98 (C-2,3,4,5); 55.64 (OMe); 34.96 (C-6); 26.38 and 24.70 (Me); 19.19 (C-7); 14.08 (C-8). HR-MS/EI calc. for $C_{12}H_{22}O_5$ $(M)^+$: 246.1467. Found: 246.1478. HR-MS/EI calc. for $C_{11}H_{19}O_5$ $(M-15)^+$: 231.1232. Found: 231.1233; and 202 mg (83%) of *methyl 2,3-O-isopropylidene-6,7,8-trideoxy-β-D*-allo-*oct-7-enofuranoside* (**14**): $[\alpha]_D^{20}$ -66.6° (*c* 0.79, chloroform). ^{1}H NMR ($CDCl_3$), δ 5.85 (m, 1H, H-7), 5.10 - 5.23 (m, 2H, H-8,8'), 4.97 (s, 1H, H-1), 4.88 (d, 1H, $J_{3,2}$ 4.0 Hz, H-3), 4.58 (d, 1H, H-2), 4.24 (d, 1H, $J_{4,5}$ 2.6 Hz, H-4), 3.75 (m, 1H, H-5), 3.43 (s, 3H, OMe), 2.31 (m, 2H, H-6,6'), 1.48 and 1.32 (2s, 6H, CMe_2). ^{13}C NMR ($CDCl_3$), δ 134.23 (C-7); 117.95 (C-8); 109.98 (C-1); 90.88, 85.87, 79.99, 71.77 (C-2,3,4,5); 55.61 (OMe); 37.54 (C-6); 26.40 and 24.74 (Me). HR-MS/EI calc. for $C_{11}H_{17}O_5$ $(M-15)^+$: 229.1076. Found: 229.1074.

From **5**: 202 mg (83%) of inseparable mixture of **16** and **38** in 6 : 1 proportion: *methyl 2,3-O-isopropylidene-6,7,8-trideoxy-α-D*-manno-*oct-7-enofuranoside* (**16**): ^{1}H NMR ($CDCl_3$), δ 5.93 (m, 1H, H-7), 5.11 - 5.25 (m, 2H, H-8,8'), 4.92 (s, 1H, H-1), 4.83 (dd, 1H, $J_{3,2}$ 6.0, $J_{3,4}$ 3.6 Hz, H-3), 4.56 (d, 1H, H-2), 4.00 (m, 1H, H-5), 3.80 (dd, 1H, $J_{4,5}$ 7.7 Hz, H-4), 3.32 (s, 3H, OMe), 2.53 (m, 1H, H-6), 2.36 (m, 1H, H-6'), 1.49 and 1.33 (2s, 6H, CMe_2). ^{13}C NMR ($CDCl_3$), δ 134.40 (C-7); 117.98 (C-8); 107.02 (C-1); 84.90, 81.22, 80.06, 69.39 (C-2,3,4,5); 54.60 (OMe); 39.07 (C-6); 26.04 and 24.69 (Me). HR-MS/EI calc. for $C_{11}H_{17}O_5$ $(M-15)^+$: 229.1076. Found: 229.1076; *methyl 2,3-O-isopropylidene-6,7,8-trideoxy-α-D*-manno-*octofuranoside* (**38**): ^{13}C NMR ($CDCl_3$), δ 107.02 (C-1); 84.86, 81.92, 80.26, 70.25 (C-2,3,4,5); 54.60 (OMe); 36.77 (C-6); 26.04 and 24.69 (Me); 18.86 (C-7); 14.22 (C-8).

From **7**: 275 mg (86%) of inseparable mixture of **17** and **39** in 6 : 1 proportion: *3-O-benzyl-1,2-O-isopropylidene-6,7,8-trideoxy-α-D*-gluco-*oct-7-enofuranose* (**17**): ^{1}H NMR ($CDCl_3$), δ 5.96 (d, 1H, $J_{1,2}$ 3.8 Hz, H-1), 5.85 (m, 1H, H-7), 5.05 - 5.18 (m, 2H, H-8,8'), 4.73 and 4.53 (ABq, *J* 11.8, $PhCH_2$), 4.63 (d, 1H, H-2), 3.95 - 4.10 (m, 3H, H-3,4,5), 2.45 (m, 1H, H-6), 2.25 (m, 1H, H-6'), 1.48 and 1.32 (2s, 6H, CMe_2). ^{13}C NMR ($CDCl_3$), δ 134.42 (C-7); 118.17 (C-8); 105.15 (C-1); 82.21, 81.96, 81.84, 68.41 (C-2,3,4,5); 72.09 ($PhCH_2$); 39.08 (C-6); 26.89 and 26.41 (Me). HR-MS/EI calc. for $C_{17}H_{21}O_5$ $(M-15)^+$: 305.1389. Found: 305.1386; *3-O-benzyl-1,2-O-isopropylidene-6,7,8-trideoxy-α-D*-gluco-*octofuranose* (**39**): ^{13}C NMR ($CDCl_3$), δ 36.73 (C-6); 18.79 (C-7); 14.18 (C-8).

From **9**: 247 mg (77%) of inseparable mixture (in 1 : 6 proportion) of *3-O-benzyl-1,2-O-isopropylidene-6,7,8-trideoxy-β-D*-altro-*octofuranose* (**40**) and *3-O-benzyl-1,2-O-isopropylidene-6,7,8-trideoxy-β-D*-altro-*oct-7-enofuranose* (**18**): ^{1}H NMR ($CDCl_3$), δ 5.74 - 5.95 (m, 2H, $J_{1,2}$ 4.0 Hz, H-1,7), 5.17 and 5.10 (2m, 2H, H-8,8'), 4.66 (dd, 1H, $J_{2,3}$ 0.8 Hz, H-2), 4.60 (ABq, 2H, *J* 11.7 Hz, $PhCH_2$), 4.20 (dd, 1H, $J_{3,4}$ 3.1 Hz, H-3), 3.95 (dd, 1H, $J_{4,5}$ 6.5 Hz, H-4), 3.87 (m, 1H, H-5), 2.45 and 2.20 (2m, 2H, H-6,6'), 1.52 and 1.33 (2s, 6H, CMe_2). ^{13}C NMR ($CDCl_3$), δ 134.23 (C-7); 118.42 (C-8); 112.83 (CMe_2); 105.61 (C-1); 87.73, 85.44, 82.50, 70.20 (C-2,3,4,5); 71.79 ($PhCH_2$); 37.62 (C-6); 27.27 and 26.43 (Me). HR-MS/EI calc for $C_{17}H_{21}O_5$ $(M-15)^+$: 305.1389. Found: 305.1404.

Products of acetylation

Acetylation was performed at standard conditions (pyridine, acetic anhydride). Products were purified by column chromatography by using a hexane - ethyl acetate (8 : 3) mixture.

From **2**: *methyl 5-O-acetyl-2,3-O-isopropylidene-6,7,8-trideoxy-α-L*-talo-*oct-7-ynofuranoside* (**41**): yield 78%; m.p. 82 - 84°C; $[\alpha]_D^{20}$ -42.7° (*c* 1.55, chloroform). ^{1}H NMR ($CDCl_3$), δ 5.03 (m, 1H, H-5), 5.00 (s, 1H, H-1), 4.68 (dd, 1H, $J_{3,2}$ 6.1, $J_{3,4}$ 1.7 Hz, H-3), 4.54 (d, 1H, H-2), 4.43 (dd, 1H, $J_{4,5}$ 6.9 Hz, H-4), 3.31 (s, 3H, OMe), 2.65 (m, 1H, $J_{6,5}$ 6.0, $J_{6,6'}$ 17.1, $J_{6,8}$ 2.7 Hz, H-6), 2.53 (m, 1H, $J_{6',5}$ 5.8, $J_{6',8}$ 2.7 Hz, H-6'), 2.11(s, 3H, OAc), 2.05 (t, 1H, H-8), 1.50 and 1.32 (2s, 6H, CMe_2). ^{13}C NMR ($CDCl_3$), δ 170.22 (C=O); 112.73 (CMe_2); 109.46 (C-1); 86.74, 85.33, 81.15, 71.41 (C-2,3,4,5); 78.53 (C-8); 71.14 (C-7); 55.10 (OMe); 26.61, 25.09 and 20.93 (Me); 21.18 (C-6). HR-MS/EI calc. for $C_{13}H_{17}O_6$ $(M-15)^+$: 269.1025. Found: 269.1024.

From **3**: *methyl 5-O-acetyl-2,3-O-isopropylidene-6,7,8-trideoxy-β-D*-allo-*oct-7-ynofuranoside* (**29**): yield 93%; $[\alpha]_D^{20}$ -88.6° (*c* 1.19, chloroform). ^{1}H NMR ($CDCl_3$), δ 4.97 (s, 1H, H-1), 4.93 (m, 1H, H-5), 4.66 (bd, 1H, $J_{3,2}$ 6.0 Hz, H-3), 4.59 (d, 1H, H-2), 4.34 (dd, 1H, $J_{4,3}$ 0.7, $J_{4,5}$ 8.9 Hz, H-4), 3.34 (s, 3H, OMe), 2.71 (m, 1H, $J_{6,5}$ 4.5, $J_{6,6'}$ 17.3, $J_{6,8}$ 2.6 Hz, H-6), 2.57 (m, 1H, $J_{6',5}$ 5.6, $J_{6',8}$ 2.7 Hz, H-6'), 2.13 (s, 3H, OAc), 2.03 (t, 1H, H-8), 1.49 and 1.32 (2s, 6H, CMe_2). ^{13}C NMR ($CDCl_3$), δ 170.24 (C=O); 112.49 (CMe_2); 110.17 (C-1); 86.08, 85.28, 81.35, 70.87 (C-2,3,4,5); 78.66 (C-8); 70.79 (C-7); 55.73 (OMe); 26.43, 24.94 and 21.05 (Me); 21.56 (C-6). HR-MS/EI calc. for $C_{13}H_{17}O_6$ $(M-15)^+$: 269.1025. Found: 269.1021.

From **5**: *methyl 5-O-acetyl-2,3-O-isopropylidene-6,7,8-trideoxy-α-D*-manno-*oct-7-ynofuranoside* (**19**): yield 92%; $[\alpha]_D^{20}$ +29.4° (*c* 1.05, chloroform). ^{1}H NMR ($CDCl_3$), δ 5.14 (m, 1H, H-5), 4.89 (s, 1H, H-1), 4.71 (dd, 1H, $J_{3,2}$ 5.9, $J_{3,4}$ 3.6 Hz, H-3), 4.55 (d, 1H, H-2), 4.21 (dd, 1H, $J_{4,5}$ 8.8 Hz, H-4), 3.35 (s, 3H, OMe), 2.82 (m, 1H, $J_{6,5}$ 3.8, $J_{6,6'}$ 17.5, $J_{6,8}$ 2.6 Hz, H-6), 2.66 (m, 1H, $J_{6',5}$ 4.6, $J_{6',8}$ 2.7 Hz, H-6'), 2.10 (s, 3H, OAc), 1.99 (t, 1H, H-8), 1.42 and 1.29 (2s, 6H, CMe_2). ^{13}C NMR ($CDCl_3$), δ 169.75 (C=O); 112.78 (CMe_2); 106.88 (C-1); 84.88, 79.33, 78.30, 68.43 (C-2,3,4,5); 79.48 (C-8); 70.30 (C-7); 54.49 (OMe); 26.09, 24.97 and 21.12 (Me); 21.36 (C-6). HR-MS/EI calc. for $C_{13}H_{17}O_6$ $(M-15)^+$: 269.1025. Found: 269.1024.

From **7**: *5-O-acetyl-3-O-benzyl-1,2-O-isopropylidene-6,7,8-trideoxy-α-D*-gluco-*oct-7-ynofuranose* (**27**): yield 92%; $[\alpha]_D^{20}$ -106.5° (*c* 0.7, chloroform). ^{1}H NMR ($CDCl_3$), δ 5.91 (d, 1H, $J_{1,2}$ 3.7 Hz, H-1), 5.18 (m, 1H, H-5), 4.62 (d, 1H, H-2), 4.43 (dd, 1H, $J_{4,5}$ 8.8 Hz, H-4), 4.63 and 4.44 (ABq, 2H, *J* 11.7 Hz, $PhCH_2$), 3.96 (d, 1H, $J_{3,4}$ 3.2 Hz, H-3), 2.84 (m, 1H, $J_{6,5}$ 3.8, $J_{6,6'}$ 17.5, $J_{6,8}$ 2.6 Hz, H-6), 2.64 (m, 1H, $J_{6',5}$ 4.8, $J_{6',8}$ 2.7 Hz, H-6'), 1.94 (m, 4H, H-8, OAc), 1.51 and 1.33 (2s, 6H, CMe_2). HR-MS/EI calc for $C_{19}H_{21}O_6$ $(M-15)^+$: 345.1338. Found: 345.1352.

From **9**: *5-O-acetyl-3-O-benzyl-1,2-O-isopropylidene-6,7,8-trideoxy-β-D*-altro-*oct-7-ynofuranose* (**23**): yield 95%; $[\alpha]_D^{20}$ -16.3° (*c* 0.7, chloroform). ^{1}H NMR ($CDCl_3$), δ 5.93 (d, 1H, $J_{1,2}$ 4.0 Hz, H-1), 5.15 (m, 1H, H-5), 4.65 (d, 1H, H-2), 4.59 (s, 2H, $PhCH_2$), 4.29 (dd, 1H, $J_{4,3}$ 2.0, $J_{4,5}$ 9.3 Hz, H-4), 3.95 (d, 1H, H-3), 2.74 (m, 1H, $J_{6,5}$ 4.4, $J_{6,6'}$ 17.4, $J_{6,8}$ 2.7 Hz, H-6), 2.63 (m, 1H, $J_{6',5}$ 5.3, $J_{6',8}$ 2.7 Hz, H-6'), 2.00 (m, 4H, H-8, OAc), 1.54 and 1.31 (2s, 6H, CMe_2). HR-MS/EI calc for $C_{19}H_{21}O_6$ $(M-15)^+$: 345.1338. Found: 345.1342.

From a mixture of **12ab**: an inseparable mixture of *4-O-acetyl-5,6:7,8-di-O-isopropylidene-1,2,3-trideoxy-D*-manno-*1-yno-octitol* (**13a**) and *4-O-acetyl-5,6:7,8-di-O-isopropylidene-1,2,3-trideoxy-D*-gluco-*1-yno-octitol* (**13b**): yield 88%; ^{1}H NMR ($CDCl_3$), δ 5.19 (dt, $J_{4,5}$ 5.3 Hz, H-4a), 5.15 (dt, $J_{4,3'}$ 2.7, $J_{4,5}$ 7.2 Hz, H-4b), 4.25 (dd, *J* 2.7 and 7.1 Hz), 4.13 (m), 4.07 (m), 3.95 (m), 3.74 (dd, *J* 7.2 and 8.0 Hz), 2.57 - 2.71 (m, $J_{3a,3'a}$ 17.1, $J_{3a,4a}$ 5.2, $J_{3'a,4a}$ 6.8, $J_{3b,4b}$ 6.9 Hz, H-3a,3'a,3b,3'b), 2.11 and 2.10 (2s, OAc), 2.01 and 1.99 (2t, H-1a,1b). ^{13}C NMR ($CDCl_3$), δ 80.09 (a), 79.59 (b), 79.42 (a), 79.33 (b), 79.18 (a), 77.31 (b), 77.04 (b), 76.79

(a), 71.05 (a), 70.54 (b), 70.44 (a), 70.35 (b), 67.42 (C-8b), 67.30 (C-8a). HR-MS/EI calc for $C_{15}H_{21}O_6$ (M-15)$^+$: 297.1338. Found: 297.1336.

From **32**: *methyl 5-O-acetyl-2,3-O-isopropylidene-6,7,8-trideoxy-8-C-(trimethylsilyl)-β-D*-allo-*oct-7-ynofuranoside* (**31**): yield 96%; $[\alpha]_D^{20}$ -78.6° (*c* 1.36, chloroform). ^{1}H NMR ($CDCl_3$), δ 4.95 (m, 1H, H-5), 4.94 (s, 1H, H-1), 4.69 (bd, 1H, H-3), 4.56 (d, 1H, $J_{2,3}$ 5.9 Hz, H-2), 4.28 (bd, 1H, $J_{4,5}$ 8.1 Hz, H-4), 3.31 (s, 3H, OMe), 2.69 (dd, 1H, $J_{6,5}$ 4.9, $J_{6,6'}$ 17.3 Hz, H-6), 2.55 (dd, 1H, $J_{6',5}$ 6.1 Hz, H-6'), 2.09 (s, 3H, OAc), 1.48 and 1.31 (2s, 6H, CMe_2), 0.13 (s, 9H, $SiMe_3$). ^{13}C NMR ($CDCl_3$), δ 170.15 (C=O); 112.52 (CMe_2); 110.30 (C-1); 101.11 (C-8); 87.59 (C-7); 86.63, 85.49, 81.37, 71.16 (C-2,3,4,5); 55.75 (OMe), 26.57, 25.13 and 21.08 (Me); 23.13 (C-6); 0.01 (TMS). HR-MS/EI calc for $C_{16}H_{25}O_6Si$ (M-15)$^+$: 341.1420. Found: 341.1420.

Synthesis of sugar bromoalkynes

To a solution of sugar alkyne (0.7 mM) in acetone (3 mL), NBS (165 mg, 0.93 mM) and silver acetate (30 mg) were added. The mixture was stirred overnight in darkness. The solvents were evaporated. Column chromatography (hexane - ethyl acetate, 10 : 1) of the residue gave:

From a mixture of **13ab**: 272 mg (quantitatively) of inseparable mixture of *1-bromo-4-O-acetyl-5,6:7,8-di-O-isopropylidene-1,2,3-trideoxy-D*-manno-*1-yno-octitol* (**37a**) and *1-bromo-4-O-acetyl-5,6:7,8-di-O-isopropylidene-1,2,3-trideoxy-D*-gluco-*1-yno-octitol* (**37b**): ^{1}H NMR ($CDCl_3$), δ 5.16 (m, $J_{4,3}$ 5.4, $J_{4,3'}$ 6.6, $J_{4,5}$ 5.5 Hz, H-4a), 5.12 (m, $J_{4,3}$ 6.8, $J_{4,3'}$ 6.6, $J_{4,5}$ 2.7 Hz, H-4b), 4.20 (dd, $J_{5,6}$ 7.1 Hz, H-5b), 4.13 (dd, $J_{8,7}$ 6.2, $J_{8,8'}$ 8.5 Hz, H-8b), 4.11 (m, H-5a), 4.06 (m, $J_{7,6}$ 8.0, $J_{7,8'}$ 4.6 Hz, H-7b), 3.95 (dd, H-8'b), 3.92 (m), 3.73 (dd, H-6b), 2.59 - 2.72 (m, $J_{3a,3'a}$ 17.1, $J_{3b,3'b}$ 16.5 Hz, H-3a,3'a,3b,3'b), 2.11 and 2.10 (2s, OAc). ^{13}C NMR ($CDCl_3$), δ 80.10 (a), 79.61 (b), 79.19 (a), 77.31 (b), 76.97 (b), 76.76 (a), 75.42 (C-2a), 75.32 (C-2b), 70.90 (a), 70.13 (b), 67.43 (C-8b), 67.35 (C-8a), 40.35 (C-1ab), 21.73 (C-3a), 22.60 (C-3b). HR-MS/EI calc for $C_{15}H_{20}BrO_6$ (M-15)$^+$: 375.0443. Found: 375.0443.

From **19**: 238 mg (94%) of *methyl 5-O-acetyl-8-bromo-2,3-O-isopropylidene-6,7,8-trideoxy-α-D*-manno-*oct-7-ynofuranoside* (**36**): $[\alpha]_D^{20}$ +7.0° (*c* 1.1, chloroform). ^{1}H NMR ($CDCl_3$), δ 5.12 (m, 1H, H-5), 4.88 (s, 1H, H-1), 4.71 (dd, 1H, $J_{3,2}$ 5.8, $J_{3,4}$ 3.6 Hz, H-3), 4.56 (d, 1H, H-2), 4.17 (dd, 1H, $J_{4,5}$ 8.8 Hz, H-4), 3.34 (s, 3H, OMe), 2.84 (dd, 1H, $J_{6,5}$ 3.7, $J_{6,6'}$ 17.6 Hz, H-6), 2.68 (dd, 1H, $J_{6',5}$ 4.5 Hz, H-6'), 2.10 (s, 3H, OAc), 1.42 and 1.29 (2s, 6H, CMe_2). ^{13}C NMR ($CDCl_3$), δ 169.75 (C=O); 112.74 (CMe_2); 106.75 (C-1); 84.87, 79.25, 78.30, 68.42 (C-2,3,4,5); 75.49 (C-7); 54.43 (OMe); 39.45 (C-8); 26.07, 24.94 and 21.16 (Me); 22.59 (C-6). HR-MS/EI calc. for $C_{13}H_{16}BrO_6$ (M-15)$^+$: 347.0130. Found: 347.0130.

From **29**: 254 mg (quantitatively) of *methyl 5-O-acetyl-8-bromo-2,3-O-isopropylidene-6,7,8-trideoxy-β-D*-allo-*oct-7-ynofuranoside* (**30**); m.p. 87 - 90°C; $[\alpha]_D^{20}$ -81.8° (*c* 0.96, chloroform). ^{1}H NMR ($CDCl_3$), δ 4.96 (s, 1H, H-1), 4.90 (m, 1H, H-5), 4.65 (bd, 1H, H-3), 4.58 (d, 1H, $J_{2,3}$ 6.0 Hz, H-2), 4.31 (bd, 1H, $J_{4,5}$ 8.8 Hz, H-4), 3.33 (s, 3H, OMe), 2.72 (dd, 1H, $J_{6,5}$ 4.6, $J_{6,6'}$ 17.3 Hz, H-6), 2.59 (dd, 1H, $J_{6',5}$ 5.2 Hz, H-6'), 2.12 (s, 3H, OAc), 1.50 and 1.32 (2s, 6H, CMe_2). ^{13}C NMR ($CDCl_3$), δ 170.20 (C=O); 112.52 (CMe_2); 110.19 (C-1); 86.04, 85.25, 81.33, 70.72 (C-2,3,4,5); 74.68 (C-7); 55.76 (OMe); 40.81 (C-8); 26.42, 24.90 and 21.07 (Me); 22.72 (C-6). HR-MS/EI calc. for $C_{13}H_{16}BrO_6$ (M-15)$^+$: 347.0130. Found: 347.0128.

From **41**: 216 mg (85%) of *methyl 5-O-acetyl-8-bromo-2,3-O-isopropylidene-6,7,8-trideoxy-α-L*-talo-*oct-7-ynofuranoside* (**35**): yield 93%; $[\alpha]_D^{20}$ -27.2° (*c* 0.60, chloroform). ^{1}H NMR ($CDCl_3$), δ 5.00 (s, 1H, H-1), 4.98 (m, 1H, H-5), 4.66 (dd, 1H, $J_{3,2}$ 6.0, $J_{3,4}$ 1.7 Hz, H-3), 4.53 (d, 1H, H-2), 4.39 (dd, 1H, $J_{4,5}$ 6.8 Hz, H-4), 3.31 (s, 3H, OMe), 2.65 (dd, 1H, $J_{6,5}$ 6.2, $J_{6,6'}$ 17.0 Hz, H-6), 2.56 (dd, 1H, $J_{6',5}$ 5.7 Hz, H-6'), 2.11 (s, 3H, OAc), 1.50 and 1.32 (2s, 6H, CMe_2). ^{13}C NMR ($CDCl_3$), δ 170.22 (C=O); 112.90 (CMe_2); 109.63 (C-1);

86.81, 85.46, 81.30, 71.43 (C-2,3,4,5); 74.77 (C-7); 55.24 (OMe); 41.30 (C-8); 26.76, 25.21 and 21.02 (Me); 22.44 (C-6). HR-MS/EI calc. for $C_{13}H_{16}BrO_6$ $(M-15)^+$: 347.0130. Found: 347.0130.

From **42**: 233 mg (92%) of *methyl 8-bromo-2,3-O-isopropylidene-6,7,8-trideoxy-5-O-(tert-butyldimethylsilyl)-β-D-*allo*-oct-7-ynofuranoside* (**33**): $[\alpha]_D^{20}$ -43.2° (*c* 0.81, chloroform). ^{1}H NMR ($CDCl_3$), δ 4.92 (s, 1H, H-1), 4.58 (dd, 1H, $J_{3,2}$ 6.1, $J_{3,4}$ 1.1 Hz, H-3), 4.46 (d, 1H, H-2), 4.13 (dd, 1H, $J_{4,5}$ 9.5 Hz, H-4), 3.66 (m, 1H, H-5), 3.33 (s, 3H, OMe), 2.59 (dd, 1H, $J_{6,5}$ 3.9, $J_{6,6'}$ 17.0 Hz, H-6), 2.47 (dd, 1H, $J_{6',5}$ 4.9 Hz, H-6'), 1.49 and 1.31 (2s, 6H, CMe_2), 0.92 (s, 9H, ^{t}Bu), 0.14 and 0.11 (2s, 18H, 2 × $SiMe_3$). ^{13}C NMR ($CDCl_3$), δ 112.34 (CMe_2); 110.12 (C-1); 88.29, 85.10, 81.73, 71.05 (C-2,3,4,5); 76.87 (C-7); 55.62 (OMe); 40.03 (C-8); 26.56 and 24.98 (Me); 25.85 (C-6); 25.85 (CMe_3); 18.17 (CMe_3); -3.92 and -4.58 ($SiMe_2$). HR-MS/EI calc for $C_{17}H_{28}BrO_5Si$ $(M-15)^+$: 419.0889. Found: 419.0888.

O-Silylation of 3

To a solution of ^{t}BuMe$_2$SiCl (180 mg, 1.2 mM) in DMF (1 mL) imidazole (164 mg, 2.4 mM) was added and the mixture was stirred at r.t for 30 min, cooled in ice bath, a solution of **3** (242 mg, 1.0 mM) in DMF (1 mL) was added and the stirring was continued for 24 h. The solvents were evaporated. Column chromatography (hexane - ethyl acetate, 8 : 3) of the residue yielded 52 mg (21%) of recovered substrate **3** and 240 mg (67%) of *methyl 2,3-O-isopropylidene-6,7,8-trideoxy-5-O-(tert-butyldimethylsilyl)-β-D-*allo*-oct-7-ynofuranoside* (**42**): $[\alpha]_D^{20}$ -68.8° (*c* 0.71, chloroform). ^{1}H NMR ($CDCl_3$), δ 4.93 (s, 1H, H-1), 4.76 (bd, 1H, $J_{3,2}$ 6.1 Hz, H-3), 4.52 (d, 1H, H-2), 4.15 (dd, 1H, $J_{4,3}$ 1.1, $J_{4,5}$ 9.5 Hz, H-4), 3.68 (m, 1H, H-5), 3.31 (s, 3H, OMe), 2.56 (m, 1H, $J_{6,5}$ 3.9, $J_{6,6'}$ 17.0 Hz, H-6), 2.46 (m, 1H, $J_{6',5}$ 4.9 Hz, H-6'), 1.99 (t, 1H, $J_{8,6} \cong J_{8,6'} \cong 2.7$ Hz, H-8), 1.49 and 1.31 (2s, 6H, CMe_2), 0.92 (s, 9H, ^{t}Bu), 0.15 and 0.11 (2s, 18H, 2 × $SiMe_3$). ^{13}C NMR ($CDCl_3$), δ 112.26 (CMe_2); 110.08 (C-1); 88.07, 85.11, 81.74, 70.87 (C-2,3,4,5); 80.58 (C-8); 70.54 (C-7); 55.54 (OMe); 26.53 and 24.98 (Me); 25.82 (CMe_3); 24.57 (C-6); 18.12 (CMe_3); -3.89 and -4.67 ($SiMe_2$). HR-MS/EI calc for $C_{18}H_{32}O_5Si$ $(M)^+$: 356.2019. Found: 356.2015.

C-Silylation of sugar alkynes

General procedure: To a solution of sugar alkyne (1.0 mM) in THF (3 mL) BuLi (3.0 mM) was added at -78°C, the mixture was stirred for 2 h and Me_3SiCl (0.65 mL, 5.0 mM) was added. A solution was stirred at r.t. for 1 h, sat. aq. ammonium chloride (4 mL) was added, and extracted with dichloromethane (4 × 10 mL). Organic layers were collected, washed with water (2 × 10 mL) and dried (Na_2SO_4). The solvents were evaporated. Column chromatography (hexane - ethyl acetate, 10 : 1) of the residue gave:

From **3**: 15 mg (4%) of *methyl 2,3-O-isopropylidene-6,7,8-trideoxy-8-C-(trimethylsilyl)-5-O-(trimethylsilyl)-β-D-*allo*-oct-7-ynofuranoside* (**43**): $[\alpha]_D^{20}$ -32.6° (*c* 2.26, chloroform). ^{1}H NMR ($CDCl_3$), δ 4.92 (s, 1H, H-1), 4.71 (dd, 1H, $J_{3,2}$ 6.0, $J_{3,4}$ 1.1 Hz, H-3), 4.52 (d, 1H, H-2), 3.98 (dd, 1H, $J_{4,5}$ 9.0 Hz, H-4), 3.68 (m, 1H, H-5), 3.33 (s, 3H, OMe), 2.66 (dd, 1H, $J_{6,5}$ 3.5, $J_{6,6'}$ 17.2 Hz, H-6), 2.35 (dd, 1H, $J_{6',5}$ 6.8 Hz, H-6'), 1.47 and 1.32 (2s, 6H, CMe_2), 0.18 and 0.14 (2s, 18H, 2 × $SiMe_3$). ^{13}C NMR ($CDCl_3$), δ 112.36 (CMe_2); 109.94 (C-1), 104.15 (C-8); 88.94, 85.16, 81.72, 72.14 (C-2,3,4,5); 86.53 (C-7); 55.47 (OMe); 26.66 and 25.22 (Me); 26.30 (C-6); 0.74 and 0.11 (TMS). HR-MS/EI calc for $C_{18}H_{34}O_5Si_2$ $(M)^+$: 386.1945. Found: 386.1943; and 266 mg (85%) of *methyl 2,3-O-isopropylidene-6,7,8-trideoxy-8-C-(trimethylsilyl)-β-D-*allo*-oct-7-ynofuranoside* (**32**): m.p. 32 - 33°C; $[\alpha]_D^{20}$ -55.7° (*c* 0.91, chloroform). ^{1}H NMR ($CDCl_3$), δ 4.96 (s, 1H, H-1), 4.91 (d, 1H, $J_{3,2}$ 6.0 Hz, H-3), 4.56 (d, 1H, H-2), 4.37 (d, 1H, $J_{4,5}$ 3.7 Hz, H-4), 3.79 (m, 1H, H-5), 3.41 (s, 3H, OMe), 2.57 (dd, 1H, $J_{6,5}$ 6.0, $J_{6,6'}$ 17.1 Hz, H-6), 2.50 (dd, 1H, $J_{6',5}$ 7.0 Hz, H-6'), 1.48 and 1.32 (2s, 6H,

CMe_2), 0.15 (s, 9H, $SiMe_3$). ^{13}C NMR ($CDCl_3$), δ 112.25 (CMe_2); 110.07 (C-1); 101.92 (C-8), 89.85, 85.72, 80.22, 70.67 (C-2,3,4,5); 87.94 (C-7), 55.68 (OMe), 26.45 and 24.84 (Me), 24.72 (C-6); 0.10 (TMS). HR-MS/EI calc for $C_{15}H_{26}O_5Si$ $(M)^+$: 314.1549. Found: 314.1551.

From **42**: 372 mg (87%) of *methyl 2,3-O-isopropylidene-6,7,8-trideoxy-5-O-(tert-butyldimethylsilyl)-8-C-(trimethylsilyl)-β-D-*allo*-oct-7-ynofuranoside* (**34**): $[\alpha]_D^{20}$ -47.0° (*c* 0.72, chloroform). ^1H NMR ($CDCl_3$), δ 4.92 (s, 1H, H-1), 4.76 (dd, 1H, $J_{3,2}$ 6.0, $J_{3,4}$ 1.1 Hz, H-3), 4.51 (d, 1H, H-2), 4.08 (dd, 1H, $J_{4,5}$ 9.3 Hz, H-4), 3.65 (m, 1H, H-5), 3.33 (s, 3H, OMe), 2.62 (dd, 1H, $J_{6,5}$ 3.8, $J_{6,6'}$ 17.2 Hz, H-6), 2.45 (dd, 1H, $J_{6',5}$ 4.9 Hz, H-6'), 1.48 and 1.31 (2s, 6H, CMe_2), 0.91 (s, 9H, ^{t}Bu), 0.15 and 0.11 (2s, 18H, 2 × $SiMe_3$). ^{13}C NMR ($CDCl_3$), δ 112.28 (CMe_2); 110.00 (C-1), 103.60 (C-8); 88.21, 85.14, 81.78, 71.36 (C-2,3,4,5); 86.84 (C-7); 55.51 (OMe); 26.59 and 25.09 (Me); 25.90 (C-6); 25.90 (CMe_3); 18.19 (CMe_3); -3.77 and -4.61 ($SiMe_2$). HR-MS/EI calc for $C_{20}H_{37}O_5Si_2$ $(M-15)^+$: 413.2179. Found: 413.2181.

Ozonolysis of triple bond

General procedure A[29]: An ozone stream was passed through a solution of sugar acetylene (1.0 mM) in methanol (15 mL) at -40°C until no more starting material was detectable by TLC. Nitrogen was passed through the solution to remove excessive ozone, and the solvents were removed at low temp. (approx. 20°C - bath temp.) under reduced pressure. The residue was dissolved in chloroform (10 mL), cooled in ice bath, and a solution of pyridine (5.0 mM) and thionyl chloride (2.5 mM) in chloroform (1 mL) was slowly added. The mixture was stirred at room temp. for 1 h, and the solvents were evaporated to dryness. Column chromatography (hexane - ethyl acetate, 8 : 3) of the residue gave pure product.

From **19**: 195 mg (61%) of *methyl (methyl 5-O-acetyl-6-deoxy-2,3-O-isopropylidene-α-D-*manno*-heptofuranosid)uronate* (**20**): $[\alpha]_D^{20}$ +56.3° (*c* 0.94, chloroform); ^1H NMR ($CDCl_3$), δ 5.45 (m, 1H, H-5), 4.87 (s, 1H, H-1), 4.70 (dd, 1H, $J_{3,2}$ 5.9, $J_{3,4}$ 3.7 Hz, H-3), 4.52 (d, 1H, H-2), 4.08 (dd, 1H, $J_{4,5}$ 6.8Hz, H-4), 3.67 (s, 3H, COOMe), 3.30 (s, 3H, OMe), 2.91 (dd, 1H, $J_{6,5}$ 4.1, $J_{6,6'}$ 15.4 Hz, H-6), 2.71 (dd, 1H, $J_{6',5}$ 7.2 Hz, H-6'), 2.05 (s, 3H, OAc), 1.43 and 1.27 (2s, 6H, CMe_2). ^{13}C NMR ($CDCl_3$), δ 170.92 and 169.75 (C=O); 112.84 (CMe_2); 107.01 (C-1), 84.83, 79.51, 79.43, 68.31 (C-2,3,4,5); 54.58 (COO*Me*); 51.71 (OMe), 36.19 (C-6); 25.97, 24.79 and 51.01 (Me). HR-MS/EI calc for $C_{13}H_{19}O_8$ $(M-15)^+$: 303.1080. Found: 303.1075. HR-MS/EI calc for $C_{14}H_{23}O_8$ $(M+H)^+$: 319.1393. Found: 319.1390.

From **23** was obtained 160 mg (41 %) of *methyl (methyl 5-O-acetyl-6-deoxy-2,3-O-isopropylidene-β-D-*altro*-heptofuranosid)uronate* (**24**): $[\alpha]_D^{20}$ +15.3° (*c* 1.0, chloroform). ^1H NMR ($CDCl_3$), δ 5.91 (d, 1H, $J_{1,2}$ 4.0 Hz, H-1), 5.46 (m, 1H, H-5), 4.65 (d, 1H, H-2), 4.57 (ABq, 2H, *J* 12.1 Hz, $PhCH_2$), 4.13 (dd, 1H, $J_{4,3}$ 2.2, $J_{4,5}$ 9.0 Hz, H-4), 3.96 (d, 1H, H-3), 3.65 (s, 3H, COOMe), 2.88 (dd, 1H, $J_{6,5}$ 3.7, $J_{6,6'}$ 15.7 Hz, H-6), 2.58 (dd, 1H, $J_{6',5}$ 8.2 Hz, H-6'), 1.93 (s, 3H, OAc), 1.58 and 1.32 (2s, 6H, CMe_2). ^{13}C NMR ($CDCl_3$), δ 170.75 and 169.70 (C=O); 112.90 (CMe_2); 106.00 (C-1); 84.75, 84.62, 82.59, 69.55 (C-2,3,4,5); 71.54 ($PhCH_2$); 51.82 (COO*Me*); 36.29 (C-6); 26.72, 26.13 and 20.87 (Me). HR-MS/EI calc for $C_{19}H_{23}O_8$ $(M-15)^+$: 379.1393. Found: 379.1395.

From **27**: 195 mg (50%) of *methyl (5-O-acetyl-3-O-benzyl-6-deoxy-1,2-O-isopropylidene-α-D-*gluco*-heptofuranos)uronate* (**28**): ^1H NMR ($CDCl_3$), δ 5.90 (d, 1H, $J_{1,2}$ 3.8 Hz, H-1), 5.48 (m, 1H, H-5), 4.60 and 4.43 (ABq, 2H, *J* 11.7 Hz, $PhCH_2$), 4.59 (d, 1H, H-2), 4.34 (dd, 1H, $J_{4,3}$ 3.3, $J_{4,5}$ 6.8 Hz, H-4), 3.98 (d, 1H, H-3), 3.65 (s, 3H, COOMe), 2.93 (dd, 1H, $J_{6,5}$ 3.5, $J_{6,6'}$ 15.6 Hz, H-6), 2.67 (dd, 1H, $J_{6',5}$ 7.8 Hz, H-6'), 1.93 (s, 3H, OAc), 1.47 and 1.32 (2s, 6H, CMe_2).

General procedure B [29]: An ozone was passed through a solution of sugar acetylene in methanol (15 mL) at -78°C until no more starting material was detectable by TLC. Nitrogen was passed through the solution to remove the excess of ozone, and potassium iodide (3 eq.) was added. The reaction mixture was stirred at room temp. for 15 min., liberated iodine was neutralized by sat. aq. sodium thiosulfate, and the solvents were removed under reduced pressure. Column chromatography (hexane - ethyl acetate, 8 : 3) of the residue gave pure product.

From **5** (0.8 mM): 41 mg (17%) of *methyl (methyl 5-O-formyl-6-deoxy-2,3-O-isopropylidene-α-D-*manno-*heptofuranosid)uronate* (**21**): $[\alpha]_D^{20}$ +51.0° (*c* 0.75, chloroform). ^{1}H NMR ($CDCl_3$), δ 8.10 (s, 1H, HCOO), 5.42 (m, 1H, H-5), 4.89 (s, 1H, H-1), 4.72 (dd, 1H, $J_{3,2}$ 6.0, $J_{3,4}$ 3.7 Hz, H-3), 4.55 (d, 1H, H-2), 4.08 (dd, 1H, $J_{4,5}$ 7.9 Hz, H-4), 3.70 (s, 3H, COOMe), 3.32 (s, 3H, OMe), 2.96 (dd, 1H, $J_{6,5}$ 3.7, $J_{6,6'}$ 16.3 Hz, H-6), 2.76 (dd, 1H, $J_{6',5}$ 8.1 Hz, H-6'), 1.45 and 1.29 (2s, 6H, CMe_2). ^{13}C NMR ($CDCl_3$), δ 170.69 and 160.73 (C=O); 112.96 (*C*Me$_2$); 107.15 (C-1); 84.86, 79.28, 79.13, 69.08 (C-2,3,4,5); 54.69 (COO*Me*); 51.89 (OMe); 36.39 (C-6); 25.95 and 24.70 (Me). HR-MS/EI calc for $C_{12}H_{17}O_8$ (M-15)$^+$: 289.0923. Found: 289.0921; and 25 mg (11%) of *methyl (methyl 6-deoxy-2,3-O-isopropylidene-α-D-*manno-*heptofuranosid)uronate* (**22**): $[\alpha]_D^{20}$ +68.7° (*c* 2.9, chloroform); lit.[16]: $[\alpha]_D^{20}$ +64.5° (*c* 1.4, chloroform).[13]C NMR ($CDCl_3$), δ 172.78 (C=O); 112.80 (*C*Me$_2$); 107.16 (C-1); 84.94, 81.21, 79.67, 66.57 (C-2,3,4,5); 54.55 (COO*Me*); 51.81 (OMe); 38.79 (C-6); 26.05 and 24.74 (Me).

From **9** (1.0 mM): 19 mg (5 %) of *methyl (methyl 5-O-formyl-6-deoxy-2,3-O-isopropylidene-β-D-*altro-*heptofuranosid)uronate* (**25**): $[\alpha]_D^{20}$ +13.2° (*c* 2.0, chloroform). ^{1}H NMR ($CDCl_3$), δ 7.96 (s, 1H, HCOO), 5.92 (d, 1H, $J_{1,2}$ 3.9 Hz, H-1), 5.57 (m, 1H, H-5), 4.65 (dd, 1H, $J_{2,3}$ 0.6 Hz, H-2), 4.57 (ABq, 2H, *J* 11.9 Hz, PhCH_2), 4.16 (dd, 1H, $J_{4,3}$ 2.3, $J_{4,5}$ 8.9 Hz, H-4), 3.99 (dd, 1H, H-3), 3.68 (s, 3H, COOMe), 2.94 (dd, 1H, $J_{6,5}$ 3.4, $J_{6,6'}$ 16.3 Hz, H-6), 2.65 (dd, 1H, $J_{6',5}$ 8.6 Hz, H-6'), 1.57 and 1.33 (2s, 6H, CMe_2). HR-MS/EI calc for $C_{18}H_{21}O_8$ (M-15)$^+$: 365.1236. Found: 365.1235; and 160 mg (45 %) of *methyl (methyl 6-deoxy-2,3-O-isopropylidene-β-D-*altro-*heptofuranosid)uronate* (**26**): $[\alpha]_D^{20}$ +9.0° (*c* 0.95, chloroform); lit.[16]: $[\alpha]_D^{20}$ +9.8° (*c* 1.5, chloroform).[13]C NMR ($CDCl_3$), δ 173.17 (C=O); 112.50 (*C*Me$_2$); 106.02 (C-1); 87.22, 85.01, 82.83, 67.83 (C-2,3,4,5); 71.63 (Ph*C*H$_2$); 51.84 (COO*Me*); 37.67 (C-6); 26.95 and 26.08 (Me).

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