Carbohydrate Research, 123 (1983) 320–325
Elsevier Science Publishers B. V., Amsterdam – Printed in The Netherlands

Note

Conversion of 2,3-*O*-isopropylidene-D-glyceraldehyde into 2-deoxy-D-*erythro*-pentose*

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(Received February 1st, 1983; accepted for publication, May 25th, 1983)

The addition of carbanions to 2,3-*O*-isopropylidene-D-glyceraldehyde (**1**) is of interest for probing diastereoface selectivity and as a model for the synthesis of higher 2-deoxyaldoses or aldoses[2]. The addition of allylmagnesium bromide to **1** resulted[3,4] in a 2:1 preference for the *erythro* adduct **3**[5]. This unsatisfactory selectivity is typical for the addition[7–11] of various carbanions to **1**, although some such reactions strongly favour formation of the *erythro* diastereomer[4,12]. Also, the conversion of these adducts into 2-deoxypentoses frequently involves elaborate reaction-sequences. However, such simple adducts as **3** can easily be converted[4,8] into 2-deoxy-D-*erythro*-pentose (2-deoxy-D-ribose) (**4**). An ideal solution to the problem would therefore involve a highly selective formation of the homoallyl alcohols **2** and **3**, and we now report that this can be achieved by the addition of allylboronates to **1**.

Homoallyl alcohols are formed in high yield by the addition of such allylboronates as 2-allyl-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (**5**) to aldehydes[13]. Reaction of **5** with **1** gave 60% of a mixture of the alcohols **2** and **3** in the ratio 1:4, and this stereoselectivity was similar to that for the addition[8] of an allyltin compound to **1**. The stereoselectivity can be enhanced by using chiral reagents[14]; thus, (−)-(1*R*,2*S*,3*S*,4*S*)-*exo*-2,*exo*-3-(allylborylenedioxy)-*endo*-3-phenylbornane[13] (**6**) with **1** gave 87% of a mixture of **2** and **3** in the ratio 4:96. The mixture was converted into **4** in high yield by hydrolysis with trifluoroacetic acid[15], followed by ozonolysis and work-up with triphenylphosphine[16]. 2-Deoxy-D-*erythro*-pentose (**4**) was identified by its ^{13}C-n.m.r. spectrum[17] and by transformation into the anilide[3].

This type of synthesis of 2-deoxypentoses[18] is of interest only if a 4,5-disubstituted derivative is desired, since there are easier routes to 2-deoxy-D- and -L-*erythro*-pentose[15,19,20]. However, this approach to pentoses by ascent of the series[2] may be advantageous if such analogues of **4** as 2-deoxy-2-methylpentoses are re-

*Stereoselective Synthesis of Alcohols, Part XIV. For Part XIII, see ref. 1

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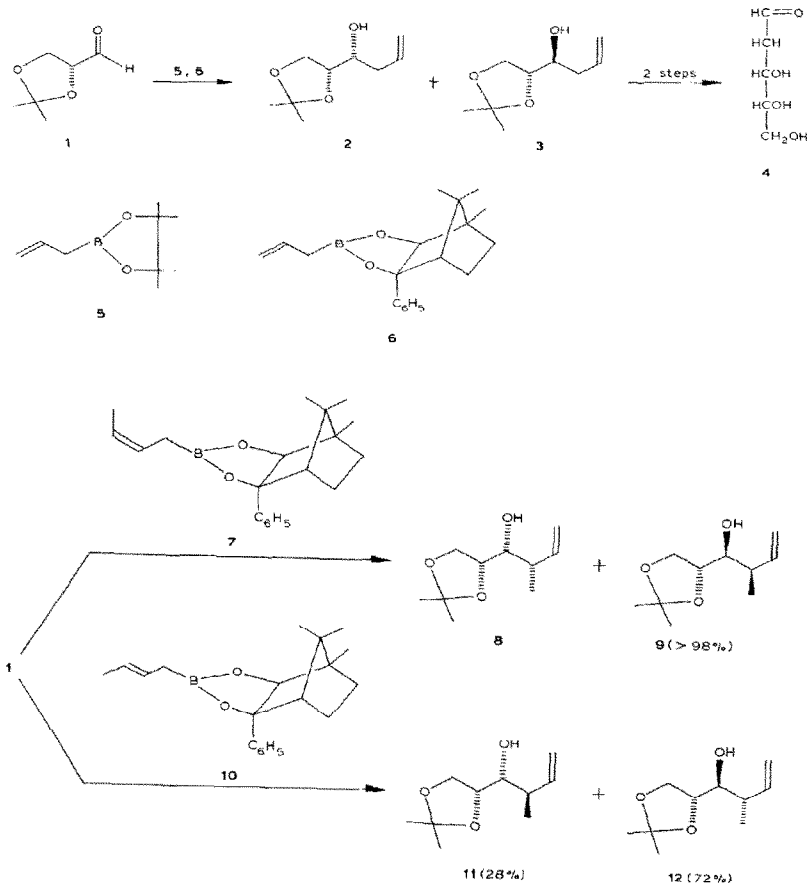

quired. This is illustrated by the conversion of **1** into 2,3-*O*-isopropylidene-1-*C*-[(1*R*)-1-methylprop-2-enyl]-D-*erythro*-glycerol (**9**) by reaction of **1** with (−)-(1*R*,2*S*,3*S*,4*S*)-*exo*-2,*exo*-3-[(*Z*)-2-butenylborylenedioxy]-*endo*-3-phenylbornane[14] (**7**). The relative configuration of the newly formed stereocentres was assigned on the basis of ref. 21.

On using racemic **7**, the ratio of diastereoisomers **8** and **9** was 3:97; with optically active **7** of the proper configuration, a single diastereomer **9** was formed. The addition of (−)-(1*R*,2*S*,3*S*,4*S*)-*exo*-2,*exo*-3-[(*E*)-2-butenylborylenedioxy]-*endo*-3-

phenylbornane (**10**) to **1** was less stereoselective. On changing from racemic **10** to the pure enantiomer, the ratio of diastereomers **11** and **13** changed from 33:67 to 28:72. The homoallyl alcohols **9**, **11**, and **12** could be transformed into 2-deoxy-2-methylpentoses by methods used in the conversion **3**→**4**.

EXPERIMENTAL

General. — Temperatures were not corrected. N.m.r. spectra (internal Me_4Si) were recorded with Jeol FX 100, Varian XL 100, Varian CFT 20, and Bruker WH 400 spectrometers. G.l.c. was performed with a Perkin–Elmer F-900 gas chromatograph. Preparative g.l.c. was effected with a Varian–Aerograph A-90-P-3 instrument.

2-Methoxy-4,4,5,5-tetramethyl-1,3,2-dioxaborolane[22]. — To a solution of pinacol (59.09 g, 0.5 mol) in dry benzene (300 mL) was added trimethyl borate (51.96 g, 0.5 mol) during 10 min at 20°. After stirring for 1 h, the methanol–benzene azeotrope was distilled off, and most of the residual benzene was removed *in vacuo* at 35°. The crude product (79.7 g) was distilled at 30° (bath)/10^{-3} Torr to give the title compound (64.1 g) containing 3.5% of benzene. N.m.r. data ($CDCl_3$): ^{1}H, δ 1.24 (s, 12 H) and 3.56 (s, 3 H); ^{13}C, δ 24.24, 52.12, and 82.31.

2-Allyl-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (**5**). — To a solution of the foregoing dioxaborolane (20 g, 127 mmol) in tetrahydrofuran (400 mL) at −78° was added 1.26M allylmagnesium bromide in ether (155 mL) dropwise under nitrogen during 1 h. After stirring for an additional 3 h at −78°, acetyl chloride[23] (15.7 g, 0.2 mol) was added during 30 min. The mixture was stirred for 30 min, brought to room temperature, filtered, and concentrated *in vacuo*, to give crude **5** (11.8 g), b.p. 53.5–54°/13 Torr. In order to destroy the residual starting-material, a solution of the distillate in ether (50 mL) was washed with water (2 × 15 mL), dried (Na_2SO_4), and concentrated; the residue was distilled to give **5**[24] (8.9 g, 42%). N.m.r. data ($CDCl_3$): ^{1}H, δ 1.25 (s, 12 H), 1.68–1.75 (m, 2 H), 4.8–5.1 (m, 2 H), and 5.6–6.1 (m, 1 H); ^{13}C, δ 16.1, 24.3, 82.6, 114.2, and 133.6.

Anal. Calc. for $C_9H_{17}BO_2$: C, 64.33; H, 10.20. Found: C, 64.18; H, 10.32.

2,3-O-Isopropylidene-1-C-(prop-2-enyl)-D-threo- (**2**) *and* -D-erythro-*glycerol* (**3**). — To a solution of **5** (1.68 g, 10 mmol) in light petroleum (b.p. 40–60°) (10 mL) under nitrogen at −78° was added 1,2-*O*-isopropylidene-D-glyceraldehyde[25] (**1**; 1.3 g, 10 mmol). The mixture was allowed to attain room temperature and then stirred for 13 h. After the addition of triethanolamine (1.49 g, 10 mmol), the mixture was stirred for 2.5 h and then filtered, and the precipitate was washed with light petroleum (6 mL). The combined filtrate and washings were concentrated *in vacuo*, and the residue was eluted from silica gel (30 g) with dichloromethane. The eluate was concentrated *in vacuo*, and the residue was distilled at 120° (bath)/10^{-2} Torr, to give a mixture (1.03 g, 60%) of **2** and **3** in the ratio 22:78, as determined by g.l.c. using a capillary column (150 ft) of UCON. A sample of this mixture was purified by g.l.c. using a column (5 ft × 0.25 in.) of 5% of SE 30 on Chromosorb G (AW

DMCS) at 120°. N.m.r. data ($CDCl_3$): ^1H, δ 1.35–1.36 (2 s, 3 H), 1.42–1.44 (2 s, 3 H), 1.90 (d, 1 H, J 3.1 Hz, OH), 2.15–2.36 (m, 2 H), 3.57–3.60 (m, 0.2 H), 3.71–3.80 (m, 0.8 H), 3.89–4.05 (m, 3 H), 5.09–5.19 (m, 2 H), and 5.78–5.88 (m, 1 H); ^{13}C (*cf.* ref. 4) **3**, δ 25.2, 26.5, 37.6, 65.2, 70.4, 78.0, 109.0, 118.1, and 134.0; **2**, δ 38.1, 65.9, 71.5, 78.4, 109.3, and 117.7, with remaining signals obscured.

(1*R*,2*S*,3*S*,4*S*)-*exo*-2-*exo*-3-(allylborylenedioxy)-*endo*-3-phenylbornane[13] (**6**; 5.94 g, 20 mmol) and **1** (2.60 g, 20 mmol) were reacted as described above. The crude product (3.43 g), which contained 87% of **3** as indicated by n.m.r. spectroscopy, was obtained by distillation at b.p. 120° (bath)/10^{-2} Torr. A sample of **3** was purified by g.l.c. as described above. N.m.r. data ($CDCl_3$): ^1H, δ 1.34 (s, 3 H), 1.41 (s, 3H), 2.07 (d, 1 H, J 2.7 Hz, OH), 2.10–2.35 (m, 2 H), 3.71–3.80 (m, 1 H), 3.87–4.04 (m, 3 H), 5.08–5.18 (m, 2 H), and 5.77–5.88 (m, 1 H) (*cf.* ref. 4).

(4S,5R)-Hex-1-ene-4,5,6-triol. — A mixture of crude **3** (1.54 g), trifluoroacetic acid (1 mL), water (10 mL), and methanol (10 mL) was stirred for 14 h at room temperature and then concentrated *in vacuo*, and the residue was extracted with dichloromethane (3 × 5 mL). The aqueous phase was concentrated *in vacuo* at 35° (bath). Water (2 × 5 mL) was distilled from the residue (0.98 g, 96%), which was then dried over P_2O_5 and recrystallised twice from ethyl acetate, to give the title compound as a colourless solid (0.9 g), m.p. 54–55°, $[\alpha]_D^{20}$ +9.2° (*c* 5.7, D_2O). N.m.r. data (D_2O; relative to HOD, 4.80 p.p.m.): ^1H, δ 2.10–2.45 (m, 2 H), 3.5–3.8 (m, 4 H), 5.11–5.15 (m, 2 H), and 5.79–5.90 (m, 1 H); ^{13}C (D_2O; relative to MeOH, 49.0 p.p.m.), δ 36.6, 62.6, 71.2, 74.2, 117.8 and 135.0 (*cf.* ref. 4).

Anal. Calc. for $C_6H_{12}O_3$: C, 54.53; H, 9.15. Found: C, 54.29; H, 9.17.

2-*Deoxy*-D-erythro-*pentose* (**4**). — A solution of (4*S*,5*R*)-hex-1-ene-4,5,6-triol (0.91 g, 6.9 mmol) in methanol (200 mL) at −78° was ozonised until a blue colour persisted (~20 min). The excess of ozone was removed with a stream of nitrogen (30 min). After adding a solution of triphenylphosphine (3 g) in dichloromethane (100 mL) at −78°, the mixture was stirred for 90 min and slowly allowed to attain room temperature. The solvents were removed *in vacuo*, a solution of the residue in dichloromethane (30 mL) was washed with water (3 × 5 mL), the combined aqueous extracts were washed with ether (3 × 5 mL) and then concentrated *in vacuo*, and the residue was dried over P_2O_5 *in vacuo*, to give **4** (0.93 g) as a syrup, the ^{13}C-n.m.r. data for which corresponded to reported data[17].

This product (139 mg, 1.04 mmol) was treated at 5° for 5 h with a solution of aniline (0.5 mL) in ethanol (2.5 mL). The precipitate was recrystallised thrice from ethanol (3 mL), to give the anilide[3,9,26] (65 mg), m.p. 169–171°.

2,3-O-Isopropylidene-1-C-[(1R)-1-methylprop-2-enyl]-D-erythro-*glycerol* (**9**). — To a solution of (−)-(1*R*,2*S*,3*S*,4*S*)-*exo*-2,*exo*-3-[(*Z*)-2-butenylborylenedioxy]-*endo*-3-phenylbornane[14] (**7**; 775 mg, 2.5 mmol) in light petroleum (b.p. 40–60°, 10 mL) at −78° was added **1** (325 mg, 2.5 mmol), and the mixture was allowed to attain room temperature during 5 h. After stirring overnight, a solution of triethanolamine (375 mg, 2.5 mmol) in dichloromethane (3 mL) was added, and the mixture was stirred for 2 h, filtered through silica gel (20 g), and eluted with di-

chloromethane. The eluate was concentrated *in vacuo*, and the residue was bulb-to-bulb distilled *in vacuo* below room temperature, to give **9** (0.4 g, 86%) as a viscous oil. N.m.r. data ($CDCl_3$): ^1H, δ 1.11 (d, 3 H, J 7 Hz), 1.38 (s, 3 H), 1.45 (s, 3 H), 1.95–2.62 (m, 2 H), 3.45–4.40 (m, 4 H), 4.83–5.32 (m, 2 H), and 5.48–6.18 (m, 1 H); ^{13}C, δ 15.19, 25.25, 26.48, 40.52, 64.59, 73.61, 76.65, 108.62, 115.28, and 140.20. The diastereomeric purity, determined by g.l.c. as described above, was >98%.

Anal. Calc. for $C_{10}H_{18}O_3$: C, 64.49; H, 9.74. Found: C, 64.60; H, 9.81.

*2,3-O-Isopropylidene-1-C-[(1R)-1-methylprop-2-enyl]-*D-threo-*glycerol* (**11**) *and 2,3-O-isopropylidene-1-C-[(1S)-1-methylprop-2-enyl]-*D-erythro-*glycerol* (**12**). — (−)-(1*R*,2*S*,3*S*,4*S*)-*exo*-2,*exo*-3-[(*E*)-2-butenylborylenedioxy]-*endo*-3-phenylbornane[14] (**10**; 775 mg, 2.5 mmol) was reacted with **1**, as described above, to give a mixture (85%) of **11** and **12**. N.m.r. data ($CDCl_3$): ^1H, δ 0.95–1.79 (m, 9 H), 1.95–2.70 (m, 2 H), 3.58–4.52 (m, 4 H), 4.78–5.35 (m, 2 H), and 5.60–6.32 (m, 1 H); ^{13}C, δ 16.46, 16.61, 25.01, 25.26, 26.11, 26.49, 40.15, 41.25, 65.50, 66.04, 74.75, 79.72, 108.58, 109.13, 115.34, 116.01, 139.14, and 139.48; the remaining signals were obscured by the solvent peak. The ratio of **11** and **12**, determined by g.l.c. as described above, was 28:72.

Anal. Calc. for $C_{10}H_{18}O_3$: C, 64.49; H, 9.74. Found: C, 64.53; H, 9.65.

ACKNOWLEDGMENT

Support of this study by the Deutsche Forschungsgemeinschaft is gratefully acknowledged.

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