Tetrahedron Letters,Vol.28,No.20,pp 2299-2300,1987 0040-4039/87 $3.00 + .00
Printed in Great Britain Pergamon Journals Ltd.

AN EFFICIENT SYNTHESIS OF (S)-5-HYDROXYMETHYL-2(5H)-FURANONE

Jozef A.J.M. Vekemans[a], Gabriel A.M. Franken[a],
Gordon J.F. Chittenden[b], Erik F. Godefroi*[a]

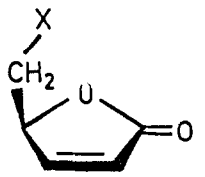
[a]Department of Chemical Technology, Section Technical Organic Synthesis, University of Technology, 5600 MB Eindhoven, The Netherlands

[b]Department of Organic Chemistry, Catholic University of Nijmegen, Toernooiveld, 6525 ED Nijmegen, The Netherlands

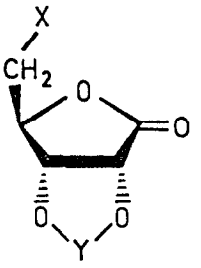
Abstract: A three step synthesis of the title compound 1a from D-ribono-1,4-lactone in 48% yield is described. The concept centers on a novel $NaHSO_3$-induced trans-Br-OAc elimination of the readily prepared bromo-acetate mixture 3a,b to the corresponding butenolides 1e and 1f, the former of which, on hydrolysis and purification, yields pure 1a.

Title compound 1a and its derivatives 1b-d are valuable chiral starting materials for synthesizing natural products such as (+)-trans-burseran[1], (-)-isostegane[1], (+)-steganacin[2], (-)-verrucarinolactone[3] and certain analogues of prostacyclin[4] and chrysanthemic acid[4]. Compounds 1a-c have been obtained[5] from D-ribono-1,4-lactone and its 5-O-substituted derivatives by pyrolysis of the cyclic orthoformate esters 2a-c. Raney nickel desulfurization of 2d and 2e has given 1c[6] and 1d[4] respectively. The intermediacy of 1a during the hydrogenolysis of 2-bromo-2-deoxy-D-arabino-1,4-lactone to 4-(S)-hydroxymethyl-γ-butyrolactone has been demonstrated[7]. Non-carbohydrate-based routes have included a six-step synthesis of 1b,c from L-glutamic acid[8] and of 1b via a route based on the asymmetric epoxidation of (Z)-4-benzyloxy-2-butenol[9]. A straightforward and operationally simple three-step synthesis of 1a from D-ribono-1,4-lactone is reported here.

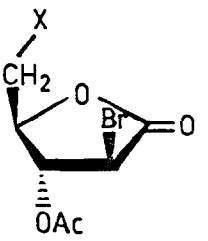
Acetylated bromo-deoxyaldono-1,4-lactones, obtained by treating aldono-1,4-lactones with HBr in acetic acid (HBA), are useful carbohydrate intermediates[10]. Treatment of D-ribono-1,4-lactone (14.8 g, 0.10 mol) with HBA (65 mL of 33% soln)[2 h, room temp; dropwise addn of Ac_2O (65 mL); aq quenching, CH_2Cl_2 extraction and work-up after 2 more h][11] gave an oily 6/1 mixture of 3a/3b (31.9 g): NMR ($CDCl_3$) δ 4.35 (d, $\underline{CH_2}OAc$) / 3.72 (d, $\underline{CH_2}Br$). This material in 2-PrOH (300 mL) produced, on stirring with aq $NaHSO_3$ (41.6 g in 160 mL) [72 h, room temp; aq quenching, CH_2Cl_2 extraction, drying and solvent removal], a syrupy 6/1 mixture of 1e/1f (13,3 g): NMR ($CDCl_3$) δ 4.34 (d, $\underline{CH_2}OAc$) / 3.72 (d, $\underline{CH_2}Br$). Hydrolysis thereof [HCl 0.5M in MeOH, 100 mL; 18 h, 5°C; evaporation and chromatography (silica gel: CH_2Cl_2-EtOAc, 1:2)] then gave essentially pure, oily 1a (5.6 g; 48% overall): NMR ($CDCl_3$-CD_3OD, 3:1) δ 3.75 (dd, J = 12 and 4 Hz, 1H), 3.85 (dd, J = 12 and 4 Hz, 1H), 4.3 (s, 1H), 5.15 (tdd, J = 4, 2 and 1.5 Hz, 1H), 6.13 (dd, J = 5.5 and 2 Hz, 1H), 7.58 (dd, J = 5.5 and 1.5 Hz, 1H). Kugelrohr distillation provided material (bp 135°C/0.2 mm) solidifying at room temp: mp 39-41°C; $[\alpha]_D^{20}$ -140° (c 3.18, H_2O)[12].



1 a-f



2 a-e



3 a,b

1 : a, X = OH; b, X = OCH_2Ph; c, X = $OCPh_3$; d, X = $OSi(t.Bu)Ph_2$; e, X = OAc; f, X = Br.
2 : a, X = OH, Y = CHOEt; b, X = OCH_2Ph, Y = CHOEt; c, X = $OCPh_3$, Y = CHOEt; d, X = $OCPh_3$, Y = C=S; e, X = $OSi(t.Bu)Ph_2$, Y = C=S.
3 : a, X = OAc; b, X = Br.

The $NaHSO_3$-induced elimination of 3a,b to butenolides 1e,f merits comment. Whereas $NaHSO_3$ has been mentioned only briefly as a method for bringing about a related trans-2-H-3-OAc elimination[13], the trans-2-Br-3-OAc elimination described here appears to be unprecedented. Further aspects of the reaction, including its application to other bromo-aldonolactones, are currently under investigation and will be reported shortly.

References and Notes

1. Tomioka, K., Ishiguro, T.; Koga, K. J. Chem. Soc., Chem. Commun. 1979, 652.
2. (a) Tomioka, K.; Ishiguro, T.; Koga, K. Tetrahedron Lett. 1980, 21, 2973. (b) Tomioka, K., Ishiguro, T.; Iitaka, Y.; Koga, K. Tetrahedron 1984, 40, 1303.
3. Tomioka, K.; Sato, F.; Koga, K. Heterocycles 1982, 17, 311.
4. Mann, J.; Thomas, A. J. Chem. Soc., Chem. Commun. 1985, 737.
5. (a) Camps, P.; Font, J.; Ponsati, O. Tetrahedron Lett. 1981, 22, 1471, (b) Camps, P.; Cardellach, J.; Font. J.; Ortuno, R.M.; Ponsati, O. Tetrahedron 1982, 38, 2395.
6. Ireland, R.E.; Anderson, R.G.; Badoub. R.; Fitzsimmons, B.J.; McGarvey, G.J.; Thaisrivongs, S.; Wilcox, C.S. J. Am. Chem. Soc. 1983, 105, 1988.
7. Lundt, I.; Pedersen, C. Synthesis 1986, 1052.
8. (a) Cervinka, O.; Hub, L. Coll. Czech. Chem. Commun. 1968, 33, 2927. (b) Taniguchi, M.; Koga. K; Yamada, S. Tetrahedron 1974, 30, 3547.
9. Takano, S.; Morimoto, M.; Ogasawara, K. Synthesis 1984, 384.
10. Ref. 7, citations 1-4.
11. This is a slight modification of the procedure described by Bock. K.; Lundt, I.; Pedersen, K. Carbohydr, Res. 1981, 90, 17.

12. The authors thank Mr. H. Regeling for assistance with the Kugelrohr distillation.

13. Pedersen, C.; Bock, K.; Lundt, I. Pure Appl. Chem. 1978, 50, 1385.

(Received in UK 24 March 1987)