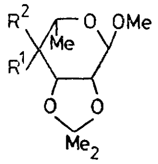
Photochemical Preparations of Deoxy-sugars from Carbohydrate Esters: a Simple Synthesis of Methyl Amicetoside

By PETER M. COLLINS* and V. RANJIT Z. MUNASINGHE
(*Department of Chemistry, Birkbeck College, University of London, Malet Street, London* WC1E 7HX)

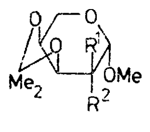
Summary U.v. irradiation of acetates or pivalates derived from carbohydrates in aqueous hexamethylphosphoric triamide gave deoxy-sugars in good yields; by application of this method methyl amicetoside has been prepared.

OUR interest in photochemical reduction of carbohydrate derivatives[1] prompted us to apply a recently reported[2] technique for photochemically transforming esters into paraffins, to convert carbohydrate carboxylic esters into deoxy-sugars.

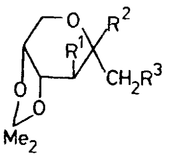
There is a need in deoxy-sugar chemistry for simple methods that will deoxygenate secondary carbinol positions in sugar derivatives.[3] This goal can be achieved satisfactorily by the method reported here. Irradiation of methyl 4-*O*-acetyl-6-deoxy-2,3-*O*-isopropylidene-α-L-mannopyranoside (**1**) (1 g) in water–hexamethylphosphoric triamide (HMPT) (5:95) (200 ml) with u.v. light (λ 254 nm) for 60 h gave upon work-up the 4,6-dideoxy derivative (**3**), $[\alpha]_D^{20}$ − 69°[4] ($CHCl_3$), in 70% yield. The same product was similarly obtained from the C-4 epimeric acetate (**2**). The 2-*O*-acetyl-β-L-arabinopyranoside (**4**) gave the 2-deoxy-sugar derivative (**5**), $[\alpha]_D^{20}$ + 113° ($CHCl_3$) in good yield when irradiated under these conditions. Upon partial hydrolysis (**5**) gave methyl 2-deoxy-β-L-*erythro*-pentopyranoside, m.p. 82° (lit.,[5] for enantiomer, m.p. 83°). The sterically crowded C-3 position in the 3-*O*-acetyl-1,2:4,5-di-*O*-isopropylidene-β-D-fructopyranose (**9**) could also be readily deoxygenated to afford the 3-deoxyhexulose derivative (**10**), m.p. 76°, $[\alpha]_D^{20}$ − 102° ($CHCl_3$), in 55% yield.



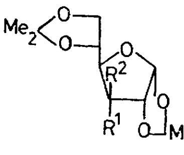
(1) $R^1 = H, R^2 = OAc$
(2) $R^1 = OAc, R^2 = H$
(3) $R^1 = R^2 = H$



(4) $R^1 = H, R^2 = OAc$
(5) $R^1 = R^2 = H$
(6) $R^1 = Me, R^2 = OAc$
(7) $R^1 = Me, R^2 = H$
(8) $R^1 = H, R^2 = Me$

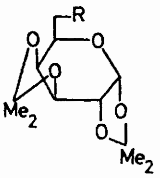


(9) $R^1 = OAc, R^2R^3 = \begin{smallmatrix}O\\O\end{smallmatrix}\!\rangle Me_2$
(10) $R^1 = H, R^2R^3 = \begin{smallmatrix}O\\O\end{smallmatrix}\!\rangle Me_2$
(11) $R^1R^2 = \begin{smallmatrix}O\\O\end{smallmatrix}\!\rangle Me_2, R^3 = H$
(12) $R^1R^2 = \begin{smallmatrix}O\\O\end{smallmatrix}\!\rangle Me_2, R^3 = OAc$

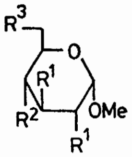


(13) $R^1 = H, R^2 = OAc$
(14) $R^1 = OAc, R^2 = H$
(15) $R^1 = H, R^2 = Bu^tCO_2$
(16) $R^1 = R^2 = H$

The reaction is not restricted to acetoxy-groups attached to pyranose rings, as is illustrated by the ready conversion of the C-5 epimeric pair of 3-*O*-acetyl-1,2:5,6-di-*O*-isopropylidene-α-D-hexofuranose derivatives (**13**) and (**14**) into 3-deoxy-1,2:5,6-di-*O*-isopropylidene-α-D-*ribo*-hexofuranose (**16**), $[\alpha]_D^{20}$ − 7·2°[6] ($CHCl_3$), in 65% yield. The yield of (**16**) was increased to 75% by use of the 3-*O*-pivaloyl glucofuranose derivative (**15**). These conversions could all be carried out on a preparatively useful scale, the 3-deoxysugar derivative (**16**), for example, being easily produced in 15 g batches from either of the glucose esters (**13**) or (**15**). In large-scale reactions water–HMPT (50:50), with extended reaction times, was often employed.



(**17**) R = OAc
(**18**) R = H



(**19**) $R^1 = OAc$, $R^2R^3 = \begin{smallmatrix}O\\O\end{smallmatrix}\!\!>MeH$
(**20**) $R^1 = H$, $R^2R^3 = \begin{smallmatrix}O\\O\end{smallmatrix}\!\!>MeH$
(**21**) $R^1 = R^3 = Bu^tCO_2$, $R^2 = OH$
(**22**) $R^1 = H$, $R^2 = OH$, $R^3 = Bu^tCO_2$
(**23**) $R^1 = R^3 = H$, $R^2 = OH$

Although less challenging, primary carbinol acetates were also deoxygenated as illustrated by the formation of 1-deoxy-2,3:4,5-di-*O*-isopropylidene-*β*-D-fructopyranose (**11**), $[\alpha]_D^{20}$ − 8·5° (lit.,[7] −8·9° (CHCl$_3$), from the corresponding 1-*O*-acetyl derivative (**12**) in 70% yield and the formation of 6-deoxy-1,2:3,4-di-*O*-isopropylidene-*α*-D-galactose (**18**), $[\alpha]_D^{20}$ − 41° (CHCl$_3$), from the 6-acetate (**17**) in 65% yield.

The reaction is of value in branched-chain sugar chemistry for deoxygenation of tertiary carbinols. The 2-*O*-acetyl-3,4-*O*-isopropylidene-2-*C*-methyl-*β*-L-arabinoside (**6**) was converted in 60% yield into the 2-deoxy-2-*C*-methyl branched chain sugar derivatives with the *ribo*- and *arabino*-structures (**7**) and (**8**) in an 85:15 ratio (δ_H values identical to authentic samples[8]). The origins of the stereochemical course of this reaction have yet to be investigated.

The method has been extended to hexoses esterified at more than one hydroxy-group. For example, methyl 2,3-dideoxy-4,6-*O*-ethylidene-*α*-D-*erythro*-hexopyranoside (**20**), $[\alpha]_D^{20}$ + 121° (CHCl$_3$), was isolated in 50% yield from the photolysate of the glucoside 2,3-diacetate (**19**). Therefore the reaction affords a very simple route to amicetose derivatives, since irradiation of an aqueous HMPT solution of methyl 2,3,6-tri-*O*-pivaloyl-*α*-D-glucopyranoside (**21**) (or the corresponding triacetate) gave, upon work-up, and column chromatography, methyl 2,3-dideoxy-6-*O*-pivaloyl-*α*-D-*erythro*-hexopyranoside (**22**), $[\alpha]_D^{20}$ + 59·5° (CHCl$_3$), and methyl *α*-D-amicetoside (**23**), $[\alpha]_D^{20}$ + 140° (lit.,[9] + 142°) (H$_2$O), in 10 and 20% yields respectively.

All compounds gave correct microanalyses and had ^{1}H n.m.r. and i.r. spectra in accordance with the assigned structures.

(*Received*, 26*th September* 1977; *Com.* 996.)

---

[1] P. M. Collins, V. R. N. Munasinghe, and N. N. Oparaeche, *J.C.S. Perkin I*, in the press.

[2] H. Deshayes, J-P. Pete, C. Portella, and D. Scholler, *J.C.S. Chem. Comm.*, 1975, 439.

[3] For some recent advances in this area see: H. Arita, N. Ueda, and Y. Matsushima, *Bull. Chem. Soc. Japan*, 1972, **45**, 567; C. Monneret, J-C. Florent, N. Gladieux, and Q. Khuong-Huu, *Carbohydrate Res.*, 1976, **50**, 35; D. H. R. Barton and R. Subramanian, *J.C.S. Perkin I*, 1977, 1718.

[4] N. K. Kochetkov, A. I. Usov, and L. S. Adamyants, *Tetrahedron*, 1971, **27**, 549.

[5] R. E. Deriaz, W. G. Overend, M. Stacey, and L. F. Wiggins, *J. Chem. Soc.*, 1949, 2836.

[6] W. A. Szarek, A. Zamojski, A. R. Gibson, D. M. Vyas, and J. K. N. Jones, *Canad. J. Chem.*, 1976, **54**, 3783.

[7] C. R. Haylock, L. D. Melton, K. N. Slessor, and A. S. Tracey, *Carbohydrate Res.*, 1971, **16**, 375.

[8] A. Rosenthal and M. Sprinzl, *Canad. J. Chem.*, 1970, **48**, 3253.

[9] E. L. Albano and D. Horton, *J. Org. Chem.*, 1969, **34**, 3519.