Carbohydrate Research
Elsevier Publishing Company, Amsterdam
Printed in Belgium

4,6-*O*-BENZYLIDENE-1,2-DIDEOXY-D-*erythro*-HEX-1-ENOPYRAN-3-ULOSE

P. M. Collins
Chemistry Department, Birkbeck College, Malet Street, London, W.C.1 (Great Britain)

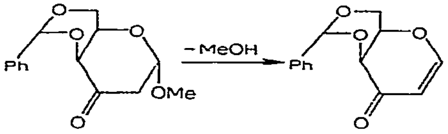
(Received February 18th, 1969)

ABSTRACT

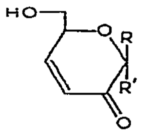
4,6-*O*-Benzylidene-1,2-dideoxy-D-*erythro*-hex-1-enopyran-3-ulose has been prepared in good yield from 4,6-*O*-benzylidene-1,2-dideoxy-D-*ribo*-hex-1-enopyranose. Chromium trioxide in pyridine is the most satisfactory oxidant. The n.m.r. spectra of this and other unsaturated pyranoid derivatives suggest that the magnitude of the *cis* vicinal vinylic coupling constant is reduced when the double bond is between C-1 and C-2. This is attributed to the electronic properties of the ring oxygen atom.

RESULTS AND DISCUSSION

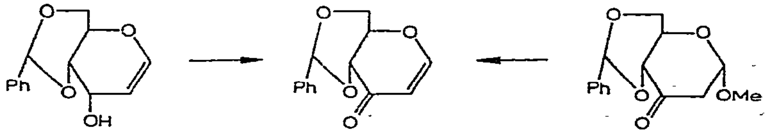
Recent work in this laboratory showed that 4,6-*O*-benzylidene-1,2-dideoxy-D-*threo*-hex-1-enopyran-3-ulose **1** could be readily formed in high yield by mild, acid-catalysed elimination of methanol from the pyranosid-3-ulose **2**. Similar treatment of pyranosid-3-ulose **3** resulted in a low conversion into enone **4**, as indicated by spectroscopic examination of the crude product. Isolation of enone **4** was not achieved, because the chromatographic mobilities of compounds **3** and **4** on silica gel were identical.



2 1



6 R'=OMe, R=H
7 R'=H, R=OMe



5 4 3

In connection with a photochemical project[2], it became necessary to obtain enone **4**, and the preparation of this compound is now reported. Two methods of synthesis appeared to be suitable. One method involved selective oxidation[3] of the axial C-3 hydroxyl group in 1,2-dideoxy-D-*ribo*-hex-1-enopyranose, followed by benzylidenation. Alternatively, the C-3 hydroxyl group in 4,6-*O*-benzylidene-1,2-dideoxy-D-*ribo*-hex-1-enopyranose **5** could be oxidized. The latter method seemed favourable, since compound **5** is now readily available[4a,b].

The most satisfactory reagent was found to be chromium trioxide in pyridine[5,6]. Treatment of compound **5** with this reagent gave a 75–80% yield of product that was virtually uncontaminated with starting material. Recrystallisation gave pure 4,6-*O*-benzylidene-1,2-dideoxy-D-*erythro*-hex-1-enopyran-3-ulose **4** which showed an intense ultraviolet absorption at 262 nm, typical of α,β-unsaturated ketones[1], and infrared maxima at 1700 and 1600 cm^{-1}, also characteristic of this structural feature. The n.m.r. spectrum ($CDCl_3$) is consistent with the structure assigned to compound **4**: H-2 appeared at τ 4.52 as a doublet ($J_{1,2}$ 6.0 Hz), and the diagnostic[7] enone β hydrogen H-1, at τ 2.70, was partly obscured by the signals for the phenyl protons. In C_6D_6 (Table I), the signal for H-1 (τ 3.60, doublet, $J_{1,2}$ 6 Hz) is separated from the phenyl signals, and the same splitting is found in the H-2 doublet now observed at τ 4.95. In all these respects, the compound clearly resembles the enone with the *threo* structure **1**, and, for comparison, the n.m.r. parameters of enone **1** in $CDCl_3$ and C_6D_6 are recorded in Table I.

TABLE I

N.M.R. PARAMETERS[a] OF *erythro*- AND *threo*-4,6-*O*-BENZYLIDENE-1,2-DIDEOXY-D-HEX-1-ENOPYRAN-3-ULOSES

Enone	*C_6H_5*	*H-7*	*H-1*	*H-2*	*H-4*	*H-5*	*H-6*	*H-6′*
4[b]($CDCl_3$)	2.3–2.8 m	4.4 s	2.7 d $J_{1,2}$ (6.0)	4.52 d $J_{2,1}$ (6.0)	5.3–6.2 m			
4(C_6D_6)	2.2–2.9 m	4.82 s	3.6 d $J_{1,2}$ (6.0)	4.95 d $J_{2,1}$ (6.0)	5.85–6.7 m			
1($CDCl_3$)	2.4–2.7 m	4.35 s	2.47 d $J_{1,2}$ (6.5)	4.44 d $J_{2,1}$ (6.5)	5.30–6.0 m			
1(C_6D_6)	2.3–3.0 m	4.80 s	3.33 d $J_{1,2}$ (6.5)	4.80 q $J_{2,1}$ (6.5) $J_{2,4}$ (1.3)	6.26 bt $J_{4,5}$ (2.0) $J_{4,2}$ (1.3)	6.88 bs 5.0†	6.06 AB (q of d) $J_{6,6'}$ (13.0) $J_{6,5}$ (2.0) $J_{6',5}$ (2.0)	6.78

[a]Measured with a Varian A-60D spectrometer; chemical shifts on τ scale; s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet † = width at half height, b = broad. Values in parentheses are splittings in Hz; these will be very close to J values, since Δ/J is large enough for first-order analysis to apply[16]. [b]These chemical shifts supersede those reported earlier[1].

A significant difference in the n.m.r. spectra of enones **1** and **4** is the long-range splitting of 1.3 Hz observed in the H-2 quartet of compound **1**, compared to the smaller splitting (less than 0.2 Hz) in the H-2 doublet of compound **4**. This splitting is due to long-range coupling between H-2 and H-4. The difference in magnitude of the couplings must arise from the change in configuration at C-4 in these compounds. Anet[8] has observed a difference, similar to that described above, for $J_{1,3}$ in the α **6** and β anomers **7** of methyl 3,4-dideoxy-6-*O*-methyl-D-*glycero*-hex-3-enopyranosidulose; the values reported[8] were 0.7 and 0.2 Hz, respectively. Thus, a quasi equatorial* proton shows strong (~1.0 Hz) ^4J coupling through the carbonyl group to the vinylic proton, as illustrated by compounds **1** and **6**, whereas the quasi axial* proton couples only weakly, as shown by compounds **4** and **7**. These changes in coupling constant with changes in orientation of protons are in agreement with observations in cyclohexanones[9].

There is a striking difference between the magnitude of the vicinal vinyl couplings reported[8] for compounds **6** and **7** and the enones **1** and **4**. Compounds **6** and **7** have $J_{3,4}$ 10.7 Hz. This is a reasonable value for a *cis* vicinal coupling constant. For compounds **1** and **4**, however, the values for $J_{1,2}$ are only 6.5 and 6.0 Hz, respectively. Thus, the splitting is diminished by *ca.* 4 Hz when the double bond is between C-1 and C-2. We find that this difference is not restricted to the enones discussed above. The reported[4b,10] vicinal vinylic couplings ($J_{2,3}$) in several isomeric hex-2-enopyranosides are 10 Hz, whereas, for several derivatives of 1,2-dideoxyhex-1-enopyranoses, the values for $J_{1,2}$ are all very close to 6 Hz, and for tri-*O*-acetyl-D-glucal[11] $J_{1,2}$ is 6.4 Hz, again a difference of *ca.* 4 Hz.

The electronegativity of the ring oxygen atom is probably responsible for the diminished coupling. This conclusion is supported by the observation[12] that coupling of the *cis*-vicinal protons in substituted ethylenes ($CH_2{=}CHX$) is 10.3 Hz when X is an alkyl group, but decreases to 6.7 Hz when X is an alkoxyl group.

The suitability of other oxidants for the conversion of compound **5** into **4** was examined. Manganese dioxide, a reagent recommended[13] for oxidation of allylic alcohols, had little effect, and ruthenium dioxide attacked the double bond[14]. Methyl sulphoxide and the sulphur trioxide–pyridine complex, recently introduced by Parikh and Doering[15], did produce some enone, but the yield of **4** could not be increased above 30%.

EXPERIMENTAL

*4,6-O-Benzylidene-1,2-dideoxy-*D-ribo-*hex-1-enopyranose* (**5**). — This compound was prepared in two steps[4b] from methyl 4,6-*O*-benzylidene-2,3-anhydro-α-D-allopyranoside.

*4,6-O-benzylidene-1,2-dideoxy-*D-erythro-*hex-1-enopyran-3-ulose* (**4**). — A solution of compound **5** (5 g) in pyridine (10 ml) was added to the oxidant prepared from chromium trioxide (15 g) and pyridine (500 ml) at −5°. The mixture was

---

*Dreiding models of compounds **1** and **4** indicated these orientations for H-4. The conformation is more certain in the case of compound **4**, where the two six-membered rings are *trans* fused. Anet has proposed these orientations for H-1 in compounds **6** and **7**.

stirred for 18 h at room temperature, ether (700 ml) was added, and the mixture was filtered. The filtrate was evaporated to low bulk, methylene dichloride (100 ml) was added followed by ether (200 ml), and the mixture was filtered. The filtrate was again treated as described above. This afforded an off-white solid (3.8 g, 76%). Recrystallisation from isopropyl alcohol afforded compound **4**, identical to the material prepared photochemically[2]. It had m.p. 128–129°, $[\alpha]_D$ +189° (chloroform); ν_{max} 1700 and 1600 cm^{-1} (C=C–C=O); λ_{max} 262 nm (ε 8.4×10^3, ethanol); and the n.m.r. parameters are shown in Table I (Found: C, 67.5; H, 5.3. $C_{13}H_{12}O_4$ calc.: C, 67.2; H, 5.2%).

ACKNOWLEDGMENT

I thank Professor W. G. Overend for his encouragement.

REFERENCES

1 P. J. Beynon, P. M. Collins, P. T. Doganges, and W. G. Overend, *J. Chem. Soc.* (*C*), (1966) 1131.
2 P. M. Collins and P. Gupta, *Chem. Commun.*, (1969) 90.
3 K. Heyns and H. Gottschalck, *Ber.*, 99 (1966) 3718.
4 (*a*) A. A. Feast, W. G. Overend, and N. A. Williams, *J. Chem. Soc.*, (1965) 7378; (*b*) R. U. Lemieux, E. Fraga, and K. A. Watanabe, *Can. J. Chem.*, 46 (1968) 59.
5 G. I. Poos, G. E. Arth, R. E. Beyler, and L. H. Sarett, *J. Amer. Chem. Soc.*, 75 (1953) 422.
6 J. S. Burton, W. G. Overend, and N. R. Williams, *J. Chem. Soc.*, (1965) 3433.
7 J. N. Shoolery and M. T. Rogers, *J. Amer. Chem. Soc.*, 80 (1958) 5121.
8 E. F. L. J. Anet, *Carbohyd. Res.*, 1 (1966) 348.
9 N. S. Bhacca and D. H. Williams, *Applications of NMR Spectroscopy in Organic Chemistry*, Holden-Day, San Francisco, 1964, p. 121.
10 M. Sharma and R. K. Brown, *Can. J. Chem.*, 44 (1966) 2825.
11 L. D. Hall and L. F. Johnson, *Tetrahedron*, 20 (1964) 883.
12 W. Brügel, Th. Angel, and F. Krückeberg, *Z. Elektrochem.*, 64 (1960) 1121.
13 R. M. Evans, *Quart. Rev.* (London), 13 (1959) 61.
14 L. W. Berkowitz and P. N. Rylander, *J. Amer. Chem. Soc.*, 80 (1958) 6682.
15 J. R. Parikh and W. von E. Doering, *J. Amer. Chem. Soc.*, 89 (1967) 5505.
16 D. E. McGreer and M. M. Mocek, *J. Chem. Educ.*, 40 (1963) 358.