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## Note

# Conformation of some derivatives of methyl 4-deoxy-$\alpha$- and -$\beta$-L-*threo*-hex-4-enopyranuronate

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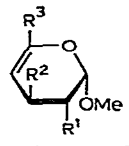
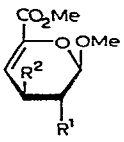
Allylic and homoallylic couplings proportional to the overlap of the $\pi$-orbital of the double bond with the 1*s* CH-proton orbital[1] are of great importance when the conformation of unsaturated substances is to be determined. Other workers[2,3] have determined the sign of these interactions and found their value to be, according to the spatial arrangement of the interacting protons, 0.3–2.1 Hz. Most of the work describing the determination of the conformation of unsaturated, six-membered, cyclic carbohydrate derivatives deals with substances having the double bond located between C-2 and C-3. The less-common 4,5-unsaturated derivatives have recently received more attention since they are major products of $\beta$-elimination reactions of uronic acid derivatives. In the synthesis of 4,5-unsaturated 4-deoxyhexuronates[4–14], p.m.r. data were used only for confirmation of the structure, and we now report on the conformation of these compounds.

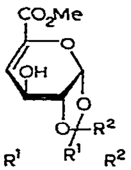
The p.m.r. spectra of **1–11** were amenable to first-order analysis. For each compound, the signal for H-4 appeared at lowest field due to deshielding by the double bond, and was either a well-resolved doublet (**1–5** and **11**) or a quartet due to long-range coupling with H-2. The signal for H-1 was a doublet at 5.89–4.87 p.p.m. for **1–5** and **8–11**, and a quartet for **6** and **7** because of coupling with H-3. The signal for H-2 for **1–5** and **11** was a quartet (at 3.86–3.47 p.p.m.) which, for **6–9**, was split



| | R$^1$ | R$^2$ | R$^3$ |
|---|---|---|---|
| **1** | OH | OMe | CO$_2$Me |
| **2** | OMe | OH | CO$_2$Me |
| **3** | OH | OH | CH$_2$OH |
| **4** | OMe | OMe | CO$_2$Me |
| **5** | OH | OH | CO$_2$Me |
| **11** | OCH$_2$Ph | OMe | CO$_2$Me |



| | | |
|---|---|---|
| **6** | OMe | OMe |
| **7** | OH | OH |



| | R$^1$ | R$^2$ |
|---|---|---|
| **8** | Me | Me |
| **9** | Ph | H |
| **10** | H | Ph |

to an octet by coupling with H-4. For all the compounds except **6** and **7**, the signal for H-3 was a quartet. An upfield shift of 0.3–0.5 p.p.m. was observed for *H*COMe in comparison to *H*COH.

Fig. 1 shows the experimental and theoretical p.m.r. spectra for H-1/H-4 of **8**.

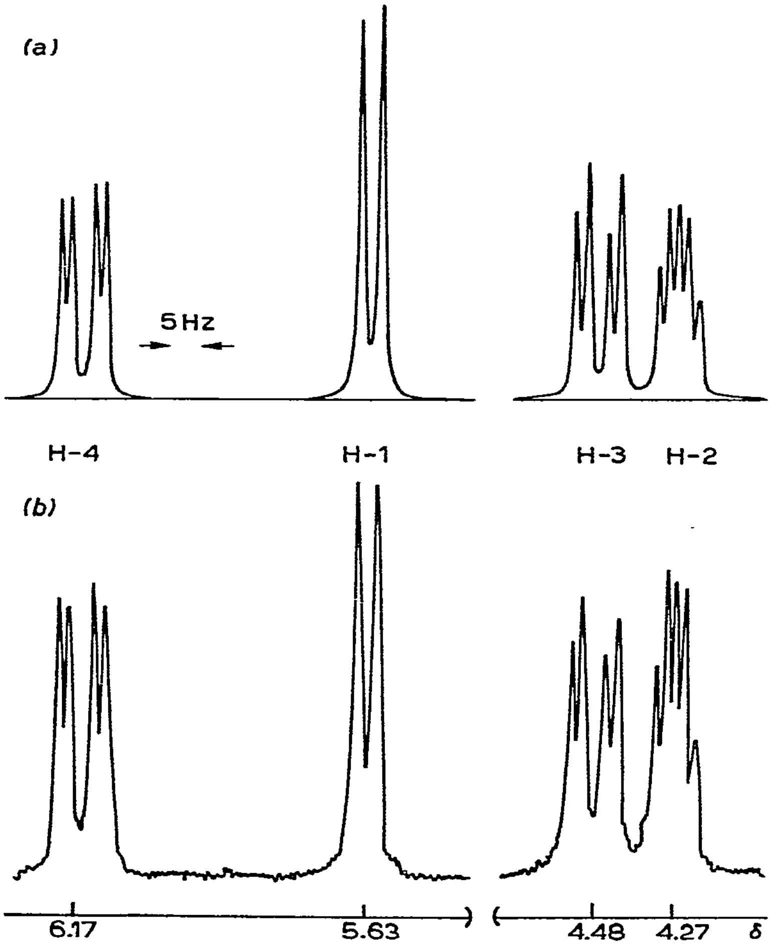


Fig. 1. The p.m.r. spectra for H-1/H-4 of **8**: (*a*) theoretical; (*b*) experimental.

The aromatic protons of **9** resonated at 7.36 p.p.m. as a sharp singlet, and the benzylic proton at 6.23 p.p.m. The aromatic protons of **10** resonated (at 7.33 p.p.m.) as a narrow multiplet because of hindered rotation of the phenyl group, and the benzylic proton resonated at 5.87 p.p.m. Thus the *exo*- and *endo*-phenyl configuration can be assigned to **9** and **10**, respectively[15–16].

Table I shows the first-order coupling constants of **1–11**. The $J_{3,4}$ vinyl–allylic couplings are of value for the determination of conformation[2,17,18]. They are

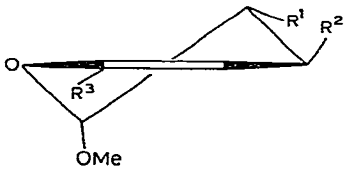
TABLE I

P.M.R. DATA FOR METHYL 4-DEOXY-α- AND -β-L-*threo*-HEX-4-ENOPYRANURONATE DERIVATIVES

| *Compound* | *Solvent* | *Chemical shifts (p.p.m.)* | | | | *Coupling constants (Hz)* | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | *H-1* | *H-2* | *H-3* | *H-4* | $J_{1,2}$ | $J_{2,3}$ | $J_{3,4}$ | $J_{1,3}$ | $J_{2,4}$ |
| **1** | $CDCl_3$ | 5.03d | 3.86q | 3.99q | 6.19d | 2.2 | 7.4 | 2.6 | *a* | *a* |
| **2** | $CDCl_3$ | 5.17d | 3.47q | 4.50q | 6.08d | 2.5 | 8.0 | 2.8 | *a* | *a* |
| **3** | $Me_2SO$-$d_6$+$CDCl_3$ | 4.97d | 3.60q | 4.17q | 5.95d | 2.5 | 7.2 | 3.2 | *a* | *a* |
| **4** | $CDCl_3$ | 5.11d | 3.58q | 4.09q | 6.15d | 2.5 | 7.5 | 2.7 | *a* | *a* |
| **5** | $D_2O$ | 5.10d | 3.84q | 4.34q | 6.13d | 2.5 | 7.2 | 3.0 | *a* | *a* |
| **6** | $CDCl_3$ | 4.95q | 3.51o | 3.76o | 6.21q | 4.5 | 3.7 | 3.5 | 0.7 | 0.8 |
| **7** | $D_2O$ | 5.08q | 3.84o | 4.20o | 6.20q | 4.8 | 4.25 | 4.0 | 1.0 | 0.7 |
| **8** | $CDCl_3$ | 5.63d | 4.27qn | 4.48q | 6.17q | 3.0 | 2.0 | 5.2 | *a* | 1.35 |
| **9** | $CDCl_3$ | 5.89d | 4.37qn | 4.49q | 6.25q | 3.2 | 2.1 | 5.1 | *a* | 1.4 |
| **10** | $CDCl_3$ | 5.75d | 4.23qn | 4.46q | 6.18q | 3.2 | 2.0 | 5.1 | *a* | 1.2 |
| **11** | $CDCl_3$ | 4.87d | 3.59q | 4.14q | 6.10d | 2.5 | 7.5 | 3.0 | *a* | *a* |

Key: d, doublet; q, quartet; o, octet; qn, quintet; *a*, not observed (less than the resolving power of the instrument).

least-pronounced when the torsion angle between the allylic protons and the olefin plane is 90°. Hence, the lower $J_{3,4}$ values (**1–5**, **11**) characterize the quasi-axial, and those $>5$ Hz characterize the quasi-equatorial, orientation of H-3. The values of $J_{2,3}$ for **1–5** and **11** are 7–8 Hz, which is typical for axial–quasi-axial coupling. The axial orientation of H-2 and quasi-axial orientation of H-3 in these substances is further substantiated by the absence of long-range ($J_{1,3}$ and $J_{2,4}$) couplings[22]. Thus **1–5** and **11** exist preferentially in the $^2H_1$ conformation **12**. Long-range ($J_{1,3}$ and $J_{2,4}$) couplings indicative of a planar W arrangement were found for **6** and **7**, and are consistent with the $^1H_2$ conformation **13**. The $J_{3,4}$ value, which is smaller than would be expected for a quasi-equatorial orientation of H-3, shows that the ring may be flattened (*cf.* Ref. 17).



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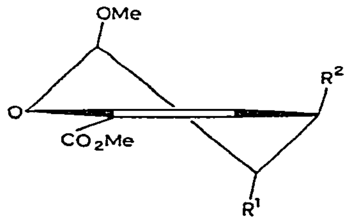

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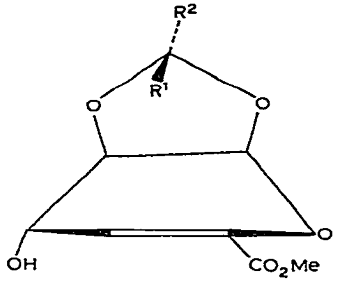

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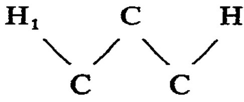
The fact that the half-chair conformation adopted by **6** and **7** is different from that of **1–5** and **11** can be attributed to the anomeric effect[3]. The coupling constants for **8–10**, which contain a fused-ring system, indicate conformations completely different from those of **1–7** and **11**; the dioxolane ring considerably influences the shape of the tetrahydropyran ring in 1,2-cyclic acetals of α-D-glucopyranose$^{19-20}$.

The values (5.1–5.2 Hz) of $J_{3,4}$ for **8–10** confirm the quasi-equatorial orientation of H-3, and those (2.0–2.1 Hz) for $J_{2,3}$ the diquasi-equatorial orientation and indicate the half-boat conformation **14**. The long-range $J_{2,4}$ couplings are also consistent with this conformation. The positive sign for $J_{2,4}$ was confirmed using the INDOR technique and by comparing the experimental and the theoretical spectra; $J_{1,3}$ couplings were not observed, their value being less than the resolving power of the instrument (0.4 Hz) since the zig-zag  fragment is not co-planar ($\phi_{1,3}$ ~90°).

## EXPERIMENTAL

P.m.r. spectra were measured at 80 MHz for solutions in $CDCl_3$ or $D_2O$, with $Me_4Si$ or DSS as the internal standard, using a Tesla BS-487-B spectrometer. The proton-signal assignments were made by the INDOR technique. Chemical shifts are given with an accuracy of ±0.005 p.p.m., and first-order coupling constants with an accuracy of ±0.1 Hz. The theoretical spectra for the four-proton system (H-1/H-4) were calculated using the LAOCN 3 programme$^{21}$ and a CDC 3300 computer. The probable error of the parameters, after five iterations, was 0.003, and the RMS error was 0.005. The theoretical spectra were drawn using N.m.r. PLOT programme (Lorentz curve-shape) with a line width of 0.9 Hz, and were in good agreement with the experimental spectra. Compounds **1–11** were prepared as previously described$^{7-11}$.

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