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## Note

# P.m.r. spectra of acetylated steroid and triterpenoid glycosides

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As a result of extensive applications of the p.m.r. method to mono- and oligosaccharides[1–3], it is now possible to determine the structure of the carbohydrate components of glycosides and the configuration of the glycoside bond, and to study the mutual effect of the carbohydrate and the aglycon group. Data available in the literature are, in the main, restricted to studies of anomeric proton signals in glycosides with one sugar residue[4–6].

We now report on p.m.r. spectral data for acetylated D-glucosides and maltosides of certain steroids and triterpenes, with a view to establishing the configuration of the glycoside bond and elucidating the characteristics of the proton signals for the carbohydrate ring and aglycon group. The compounds studied were synthesised *via* orthoester glycosylation[7,8] (see preceding paper, this issue, p. 79).

An analysis (Table I) of the spectra for the acetylated D-glucopyranosides of cholesterol (**1**) and β-sitosterol (**2**) showed H-1 of the sugar to have a chemical shift of $\delta$ 4.60 and 4.59 ($J_{1,2}$ 8.0 and 7.9 Hz); for the betulin D-glucopyranosides (Fig. 1), $\delta$ was 4.52 ($J_{1,2}$ 7.8 Hz) and 4.45 ($J_{1,2}$ 7.9 Hz) for the 3- (**3**) and 28-glucosides (**4**), respectively. In the spectrum (Fig. 1) of betulin-3,28-diyl di(D-glucopyranoside) (**5**), both H-1 signals were observed, thus allowing the position of the D-glucopyranoside residues to be identified.

The signal for H-2 in each of the D-glucosides **1**–**5** is a triplet at $\delta$ 4.95–5.05 ($J_{2,1} \approx J_{2,3} \approx 8$ Hz), and the chemical shifts for H-3 and H-5 (Table I) are characteristic of β-D-glycoside bonds in disaccharide octa-acetates[3]. H-6 and H-6′ form the AB part of the ABX-system, with $\Delta\delta_{AB}$ 0.14, $J_{AB}$ 12.5, $J_{AX}$ 5.1, and $J_{BX}$ 1.8 Hz.

All the above data indicate a β-D configuration of the glycoside bonds in compounds **1**–**5**. For the anomeric compound, cholesteryl α-D-glucopyranoside tetraacetate, the H-2 signal is a quartet ($J_{2,1}$ 3.5 and $J_{2,3}$ 10.0 Hz) and has a smaller chemical shift ($\Delta\delta$ 0.16) than for the β-D-glucoside. Furthermore, the signal for H-3 is shifted to low field ($\Delta\delta$ 0.25) due to a 1,3-diaxial deshielding effect of the glycoside bond.

Table I also includes data for the acetylated maltosides of cholesterol (**7**), β-sitosterol (**8**), betulin (Fig. 2) at C-3 (**9**) and C-28 (**10**), and the di-maltoside (**11**). The sugar rings are designated $A_1$ and $A_2$, where $A_1$ is the sugar ring linked to the

TABLE I

N.M.R. DATA FOR ACETYLATED STEROID AND TRITERPENE GLYCOSIDES

Chemical shifts ($\delta$) given in p.p.m.; spin–spin interaction constants ($J$) expressed in Hz given in parentheses.

| *Compound* | *Ring* | *H-1* | *H-2* | *H-3* | *H-4* | *H-5* | *H-6* | *H-6'* |
|---|---|---|---|---|---|---|---|---|
| 1 Cholesteryl β-D-glucopyranoside | A | 4.60 | 4.97 | 5.24[a] | 5.06[a] | 3.66 | 4.27 | 4.13 |
| | | (8.0) | (8.0; 8.5) | — | — | — | (12.5; 5.1) | (12.5; 1.8) |
| 2 β-Sitosteryl β-D-glucopyranoside | A | 4.59 | 4.93 | 5.21[a] | 5.06[a] | 3.68 | 4.27 | 4.13 |
| | | (7.9) | (7.9; 8.5) | — | — | — | (12.5; 5.1) | (12.5; 1.8) |
| 3 Betulin-3-yl β-D-glucopyranoside | A | 4.52 | 5.01[a] | 5.21[a] | 5.09[a] | 3.67 | 4.27 | 4.13 |
| | | (7.8) | — | — | — | — | (12.5; 5.1) | (12.5; 1.8) |
| 4 Betulin-28-yl β-D-glucopyranoside | B | 4.45 | 5.00[a] | 5.25[a] | 5.07[a] | 3.68 | 4.27 | 4.13 |
| | | (7.9) | — | — | — | — | (12.5; 5.1) | (12.5; 1.8) |
| 5 Betulin-3,28-diyl di(β-D-glucopyranoside) | A | 4.52 | 5.01[a] | 5.21[a] | 5.09[a] | 3.67 | — | — |
| | | (7.8) | — | — | — | — | — | — |
| | B | 4.45 | 5.00[a] | 5.21[a] | 5.09[a] | 3.68 | — | — |
| | | (7.9) | — | — | — | — | — | — |
| 6 Cholesteryl α-D-glucopyranoside | A | 5.24 | 4.81 | 5.50 | 5.04 | 3.70–4.40 | 3.70–4.40 | 3.70–4.40 |
| | | (3.5) | (3.5; 10.0) | (10.0; 9.5) | (9.5; 9.5) | — | — | — |
| 7 Cholesteryl β-maltoside | $A_1$ | 4.60 | 4.80 | 5.24 | 3.99 | 3.65 | 3.70–4.40 | 3.70–4.40 |
| | | (8.0) | (8.0; 8.5) | (8.5; 9.0) | (9.0; —) | — | — | — |
| | $A_2$ | 5.40 | 4.84 | 5.36 | 4.0 | 3.70–4.40 | 3.70–4.40 | 3.70–4.40 |
| | | (4.0) | (4.0; 10.2) | (10.2; 9.5) | (9.5; 9.5) | — | — | — |
| 8 β-Sitosteryl β-maltoside | $A_1$ | 4.60 | 4.81 | 5.24 | 4.00 | 3.65 | 3.70–4.40 | 3.70–4.40 |
| | | (7.9) | (7.9; 8.7) | (8.7; 9.5) | (9.0; —) | — | — | — |
| | $A_2$ | 5.40 | 4.83 | 5.35 | 5.02 | 3.70–4.40 | 3.70–4.40 | 3.70–4.40 |
| | | (4.0 | (4.0; 10.0) | (10.0; 9.5) | (9.5; 9.5) | — | — | — |
| 9 Betulin-3-yl β-maltoside | $A_1$ | 4.55 | 4.85 | 5.25 | 4.04 | 3.70–4.40 | 3.70–4.40 | 3.70–4.40 |
| | | (7.9) | (7.9; 8.5) | (8.5; 9.1) | (9.1; —) | — | — | — |
| | $A_2$ | 5.40 | 4.84 | 5.36 | 5.02 | 3.70–4.40 | 3.70–4.40 | 3.70–4.40 |
| | | (3.9) | (3.9; 10.0) | (10.0; 9.5) | (9.5; 9.5) | — | — | — |
| 10 Betulin-28-yl β-maltoside | $A_1$ | 4.47 | 4.82 | 5.26 | 4.04 | 3.69 | 3.70–4.40 | 3.70–4.40 |
| | | (7.8) | (7.8; 8.3) | (8.3; 9.5) | (9.5; —) | — | — | — |
| | $A_2$ | 5.41 | 4.84 | 5.38 | 5.03 | 3.70–4.40 | 3.70–4.40 | 3.70–4.40 |
| | | (4.0) | (4.0; 10.0) | (10.0; 9.5) | (9.5; 9.5) | — | — | — |

[a]In this case, approach to ABXY is not justified.

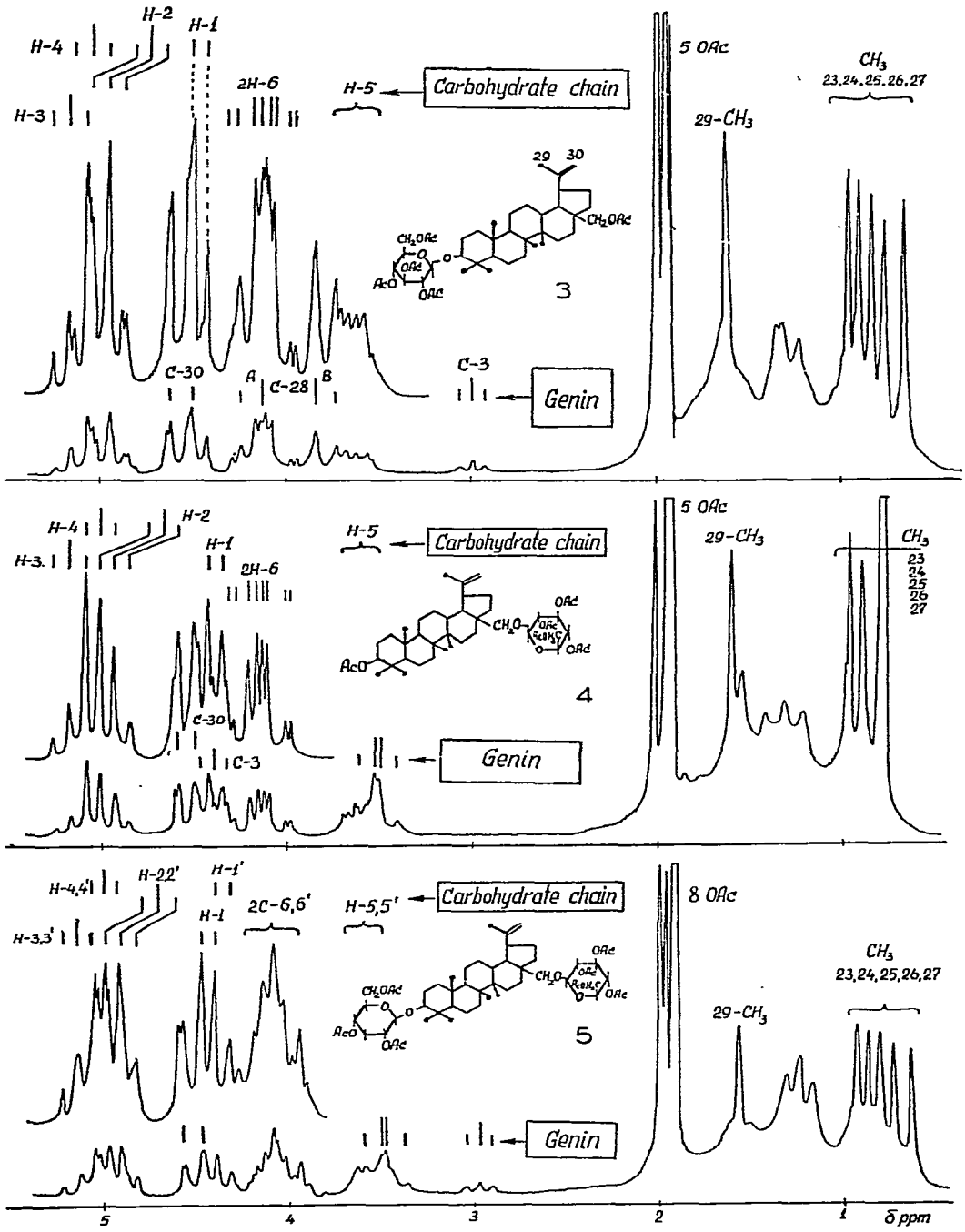


Fig. 1. P.m.r. spectra ($CDCl_3$) for acetylated betulin glucosides at 100 MHz. 3 Betulin-3-yl β-D-glucopyranoside; 4 betulin-28-yl β-D-glucopyranoside; 5 betulin-3,28-diyl di(β-D-glucopyranoside).

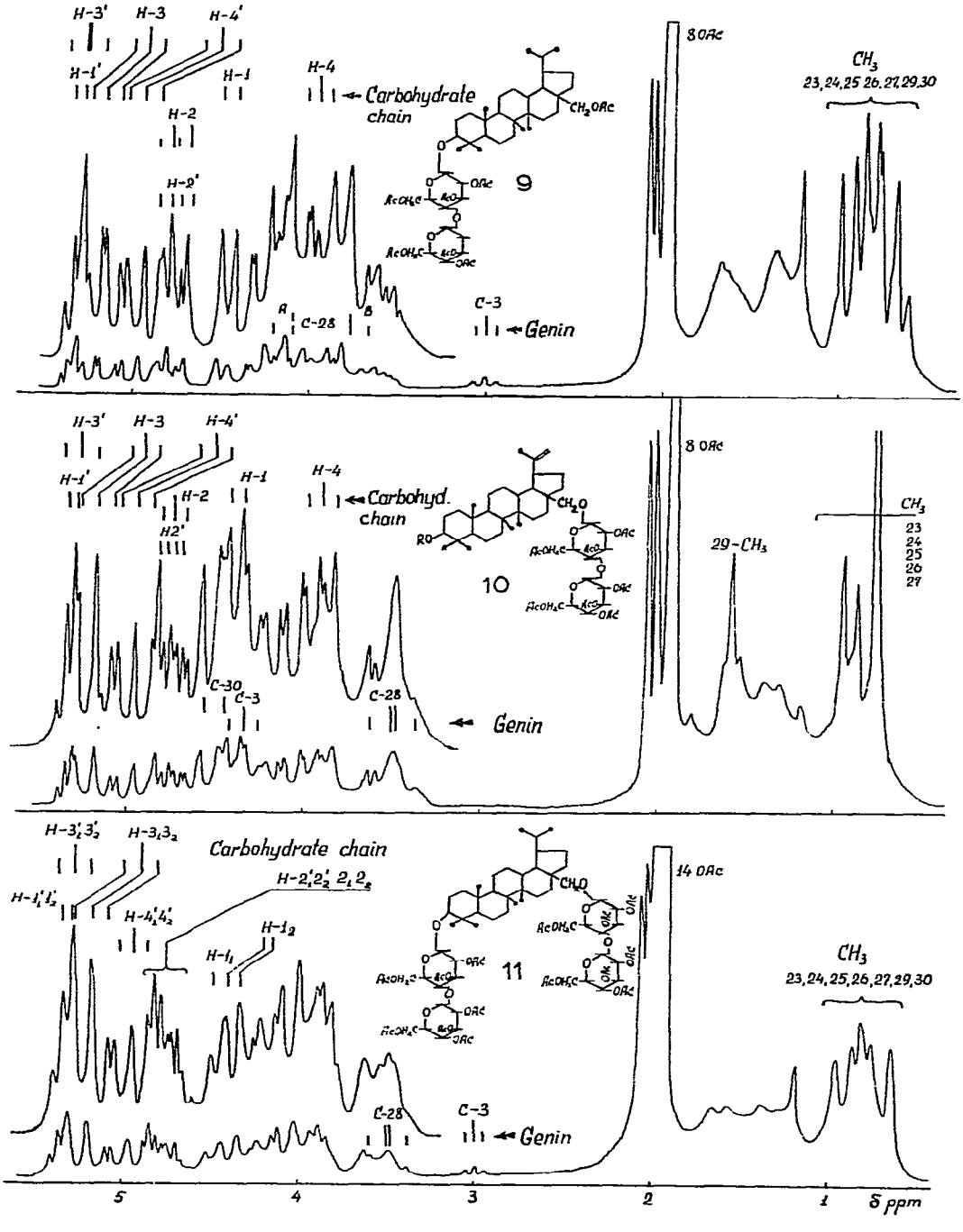


Fig. 2. P.m.r. spectra ($CDCl_3$) for acetylated betulin maltosides at 100 MHz. **9** Betulin-3-yl β-maltoside; **10** betulin-28-yl β-maltoside; **11** betulin-3,28-diyl di(β-maltoside).

aglycon group. H-1 in ring $A_1$ of the steroid maltosides gives a doublet ($J_{1,2}$ 8 Hz) at $\delta$ 4.59–4.60, whereas, for the betulin maltosides (Fig. 2), the chemical shift of H-1 in ring $A_1$ depends on the position of the maltoside residue ($\delta$ 4.55 C-3-maltoside, 4.45 for the C-28-maltoside). Both doublets were observed in the betulin di-maltoside spectrum (Fig. 2).

Due to a 2,4-axial–equatorial interaction, the sugar residue $A_2$ causes the signal for H-2 in ring $A_1$ to shift to higher field ($\Delta\delta$ 0.15) when compared with the position in the D-glucopyranosides. The chemical shifts for H-3 and H-5 in ring $A_1$ (Table I) also indicate a $\beta$-D configuration of the glycoside bond of ring $A_1$ in compounds **7–11**. The signals for H-1 ($\delta$ 5.40, $J_{1,2}$ 4.0 Hz) and H-2 ($\delta$ 4.83, $J_{2,1}$ 4.0 and $J_{2,3}$ 10.0 Hz) in ring $A_2$ are indicative of an $\alpha$-D configuration of the glycoside bond between the sugar residues.

Glycosidation at C-3 in betulin leads to a change in the chemical shifts of methyl groups at C-23, C-24, and C-25, whereas glycosidation at C-28 changes the character of the methylene group signals. In the former glycoside, the signals form an AB-system ($J_{AB}$ 10.8, $\Delta\delta_{AB}$ 0.40 p.p.m.) and, in the latter, a system close to $A_2$ ($J_{AB}$ 10.5 Hz, $\Delta\delta_{AB}$ 0.08 Hz).

Thus, the above data indicate the stereospecificity of the orthoester method of glycoside synthesis which yields only $\beta$-D anomers. The p.m.r. data also allow determination of the position of attachment of the carbohydrate component to the aglycon group.

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