Proton magnetic resonance spectra of benzylidene derivatives of deoxysugars in the presence of the shift reagent Eu(DPM)₃

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Proton magnetic resonance spectra of 4,6-benzylidene-2-deoxy-β-methyl--D-gulopyranoside and 4,6-benzylidene-3-deoxy-α-methyl-D-mannopyranoside were measured in the presence of Eu(DPM)₃. Chemical shifts induced by the Eu complex depend both on the concentration of Eu(DPM)₃ and on the temperature.

Some difficulties are often encountered when studying the conformation of saccharides by means of p.m.r. spectroscopy: the spectra are rather complex so that coupling constants and chemical shifts of the particular protons cannot be distinguished.

The introduction of certain complexes of lanthanides possessing paramagnetic properties, so-called "shift reagents", into this field was of great importance. Pioneer papers [1, 2] reported that substantial downfield shifts were observed in the p.m.r. spectrum of cholesterol in the presence of pyridine—Eu(DPM)₃* complex, or upfield shifts [3] due to Pr(DPM)₃ as a shift reagent. The shift reagent technique has also been extended to some derivatives of saccharides [4—6].

This paper refers to p.m.r. spectra of 4,6-benzylidene-2-deoxy-β-methylgulopyranoside (*I*) and 4,6-benzylidene-3-deoxy-α-methyl-D-mannopyranoside (*II*) recorded in the presence of Eu(DPM)₃ at various temperatures. The goal of this paper was to separate the overlapping signals and to get information on the convenience of Eu(DPM)₃ in conformation determination of saccharides.

Experimental

Proton magnetic resonance spectra of compounds *I* and *II* were measured in deuteriochloroform at 80 MHz with a Tesla BS-487B apparatus, tetramethylsilane being the internal reference substance.

The identity of protons was evidenced by the double-resonance technique INDOR. The coupling constant reading was accurate to ± 0.1 Hz.

The heatable cell was calibrated with methanol and ethylene glycol during measurement. Temperatures were recorded within $\pm 0.2°C$.

Eu(DPM)₃ (Diaprep. Inc., Atlanta) was vacuum sublimed before use; deuteriochloroform (Merck) was dried with fused calcium chloride.

Compound *I* was prepared from β-methyl-2,3-anhydro-4,6-benzylidene-D-gulopyranoside by reduction with lithium aluminium hydride in anhydrous ether according to [9] modified as follows.

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* Tris(dipivalomethanato)europium.

a) The excess of unchanged LiAlH₄ was decomposed with the minimal amount of water.

b) The final product, obtained by crystallization of the evaporated reaction mixture from ether, showing almost the same m.p. as reported [9], had a satisfactory elemental analysis but differed slightly in optical rotation ($[\alpha]_D^{24}$ −86.8° ($c = 1$, chloroform), $[\alpha]_D$ −79.2° (chloroform) [9]).

Compound *II* was synthesized according to [10]. The product obtained was found to be chromatographically pure and its physicochemical constants were consistent with those reported.

Results and discussion

P.m.r. spectra of 4,6-benzylidene-2-deoxy-β-methyl-D-gulopyranoside (*I*) and 4,6--benzylidene-3-deoxy-α-methyl-D-mannopyranoside (*II*) are complex. From the original p.m.r. spectrum of *I* only a doublet attributable to H-1 at δ 4.72 and signals of geminal H-6, H-6′ at δ 4.05 could be distinguished, whereas in that of *II* signals ascribable to H-1, H-3, H-4, H-5, H-6, H-6′ occurred in the δ 5.37−3.64 range. In the latter there was possible to read directly the coupling constant $J_{1,2} = 3.5$ Hz only; 5 aromatic protons form a complex multiplet at $\delta = 7.37$.

Eu(DPM)₃ was added to the solution of the examined compound aiming to separate signals of particular protons. Chemical shift associated with Eu(DPM)₃ is probably due to pseudocontact mechanism [3].

As it follows from papers so far published [1, 2, 7, 8], the greatest chemical shift caused by Eu(DPM)₃ reveals the proton nearest to Eu ion; this shift decreases with increasing distance. Our results plotted in Fig. 1 are in accordance with those mentioned. The curve showing the dependence of chemical shifts of particular protons in substance *II* on the amount of Eu(DPM)₃ has, up to 0.52 mole of the Eu(DPM)₃/saccharide ratio, a linear course.

Table 1 lists induced chemical shifts (p.p.m.) of both substances at the mole ratio Eu(DPM)₃/saccharide = 1 and 35°C.

Fig. 1 shows that after extrapolation to zero concentration of Eu(DPM)₃ the majority of signals of single protons is too close so that they overlap each other. This agrees with

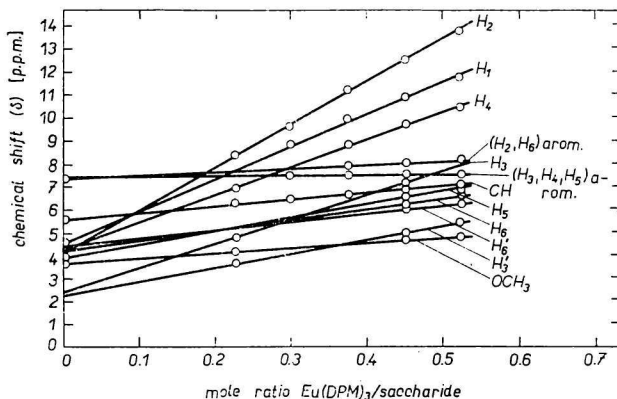*Fig. 1.* The dependence of induced chemical shift on the mole ratio Eu(DPM)₃/saccharide at 35°C for substance *II*.

Table 1

Induced chemical shifts of protons in p.p.m. at the mole ratio Eu(DPM)₃/saccharide = 1
(35°C)

Com-pound	H-1	H-2	H-2′	H-3	H-3′	H-4	H-5	H-6	H-6′	CH	OCH₃	arom.	arom.′
I	12.67	12.50	7.71	18.56	—	13.96	11.76	3.12	2.75	2.38	2.56	1.27	0.55
II	12.75	17.28	—	10.12	6.16	11.75	5.91	4.68	3.27	2.87	2.62	1.20	0.37

the finding that both values of chemical shift for H-1 of compound *II* obtained directly from the spectrum and by extrapolation are consistent (Fig. 1). The extrapolated values of chemical shifts could be considered correct in the very case when measured in the absence of moisture; otherwise one obtains lower values.

The greatest chemical shift in both substances under study was observed with the proton at the carbon atom bearing a hydroxyl group to which Eu complex is bound, *i.e.* 18.56 and 17.28 p.p.m. for substance *I* and *II*, respectively. This fact evidences that Eu(DPM)₃ is rather associated with the OH group than with other potential centres of the molecule (Table 1). The OH proton signal of substance *I* is about 61.93 p.p.m. downfield shifted.

Geminal protons adjacent to the OH group were found to have the following chemical shifts: H-2 = 12.5 p.p.m., H-2′ = 7.71 p.p.m. (substance *I*) and H-3 = 10.12 p.p.m., H-3′ = 6.16 p.p.m. (substance *II*). The relatively great differences in shifts of geminal protons adjacent to the C—OH are in agreement with findings so far made: A greater chemical shift belongs evidently to such a proton which is on the same side of the ring as is the OH group at the adjacent carbon atom, in which case the proton is nearer to the Eu ion.

The original phenyl multiplet was split into two parts after addition of Eu(DPM)₃ (2 protons + 3 protons); greater chemical shift belonging to two-proton multiplet (1.27 p.p.m. for *I* and 1.20 p.p.m. for *II*) is likely ascribable to protons 2 and 6 of aromatic ring, as they are nearer to the Eu ion, than other protons.

The above-mentioned Eu(DPM)₃-induced chemical shifts were recorded at 35°C. As known, chemical shifts are temperature dependent and that is why we measured
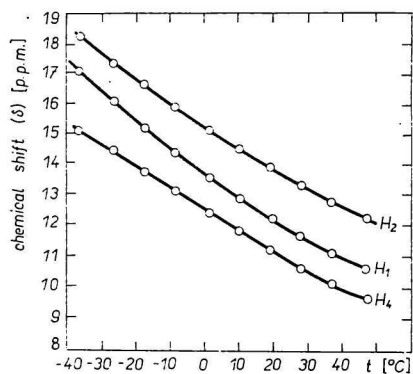

Fig. 2. The dependence of induced chemical shift on the temperature (mole ratio Eu(DPM)₃ : substance *II* = 0.5).

them in the -40 to $+50°C$ range in the presence of 0.52 mole ratio of Eu(DPM)$_3$ to saccharide. The dependence for protons H-1, H-2, H-4 of substance II is plotted in Fig. 2. Chemical shifts increase with decreasing temperature; nevertheless at about 0°C they become broader due to the faster spin-lattice relaxation. Broader signals are, however, unadvantageous for exact coupling constant readings. The temperature dependence is of practical importance (particularly at temperatures above 0°C) because the appropriate chemical shift or separation of overlapping signals could be achieved by a combination of concentration of Eu(DPM)$_3$ added and temperature used.

The determination of conformation by means of a shift reagent is closely related with the problem to what extent the complex thus formed influences the conformation, since it is assumed that labile conformation systems could be completely distorted [8]. The following experimental data for substance I were found after addition of Eu(DPM)$_3$: $J_{1,2} = 2$ Hz*, $J_{1,2'} = 9.5$ Hz, $J_{2,2'} = 13$ Hz, $J_{3,2} \sim 2$ Hz, $J_{3,2'} = 2.5$ Hz, $J_{4,3} \sim 3$ Hz, $J_{5,6} = 1.2$ Hz, $J_{5,6'} = 1.5$ Hz, $J_{6,6'} = 12.5$ Hz. The obtained data entitle us to conclude that both substances are under the given measurement conditions in a C1 conformation.

Basing upon the coupling constants $J_{5,6} = 1.2$ Hz, $J_{5,6'} = 1.5$ Hz of substance I and $J_{5,6} = 5.5$ Hz, $J_{5,6'} = 9.0$ Hz of substance II it is impossible to determine unambiguously either the chair or boat conformation of the six-membered 1,3-dioxan ring. The calculated coupling constants refer to dihedral angles of a part of the 1,3-dioxan ring only.

References

1. Hinckley, C. C., *J. Amer. Chem. Soc.* **91**, 5160 (1969).
2. Sanders, J. K. M. and Williams, D. H., *Chem. Commun.* **1970**, 422.
3. Briggs, J., Frost, G. H., Hart, F. A., Moss, G. P., and Stainforth, M. L., *Chem. Commun.* **1970**, 749.
4. Girard, P. and Kagan, H., *Bull. Soc. Chim. Fr.* **1970**, 4515.
5. Girard, P., Kagan, H., and Davis, S., *Tetrahedron* **27**, 5911 (1971).
6. Armitage, I. and Hall, L. D., *Can. J. Chem.* **49**, 2770 (1971).
7. Demarco, P. V., Elzey, T. K., Lewis, R. B., and Wenkert, E., *J. Amer. Chem. Soc.* **92**, 5734 (1970).
8. *Perkin—Elmer NMR Quarterly* **1**, 2 (1970).
9. Golab, T. and Reichstein, T., *Helv. Chim. Acta* **44**, 618 (1961).
10. Bolliger, H. R. and Prins, D. A., *Helv. Chim. Acta* **29**, 1061 (1946).

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* $J_{1,2} = 3.5$ Hz without addition of Eu(DPM)$_3$.