

Preliminary communication

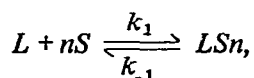
Evaluation of the binding of lanthanide shift reagents with carbohydrate derivatives

IAN ARMITAGE and L. D. HALL★

Department of Chemistry The University of British Columbia, Vancouver 8, British Columbia (Canada)

(Received May 22nd, 1972, accepted for publication, June 9th, 1972)

Basic to an understanding of the ways in which a lanthanide shift reagent (L) induces changes in the chemical shifts of the nuclear magnetic resonance (n.m.r.) signals of a carbohydrate derivative (S), is the evaluation of the equilibrium process



in terms of the equilibrium binding constant (K_B), the stoichiometry (n), and the bound chemical shifts (Δ_B). An accurate measurement of the latter parameters is mandatory for conformational studies¹. We now report the first evaluations of K_B , n , and Δ_B values for carbohydrate derivatives.

Measurements were made of the p.m.r. spectra of a series of solutions ($[S]_0 = 0.02$ to $0.1M$) of 1,2:5,6-di-*O*-isopropylidene- α -D-glucofuranose (1) in carbon tetrachloride containing a constant amount of tris(dipivalomethanato)europium(III) $\{Eu(DPM)_3, [L]_0 = 4.3mM\}$. The resultant chemical-shift data were then plotted as $1/\delta$ versus $[S]_0$, the resultant linear plots have² slope $[L]_0\Delta_B$ and y-axis intercept $-\{(1/K_B) + [L]_0\}$, and hence give the values for Δ_B and K_B . The stoichiometry can be trivially determined³ to be 1:1. The parameters obtained for the above experiment are listed in Table I. In accord with an earlier, qualitative observation⁴, the Δ_B -value for H-5 is greater than that for H-3, thus, it is not necessarily the proton nearest to the donor atom that undergoes the largest shift⁵.

Measurements on each individual resonance constitute independent evaluations for K_B , and the scatter of values obtained illustrates the magnitude of the experimental errors associated with the determination of K_B . Unfortunately, these errors increase rapidly with increase in K_B , and hence it is not always possible to make accurate determinations of K_B for tris(2,2-dimethyl-6,6,7,7,8,8,8-heptafluoro-3,5-octanedionato)-europium(III).

★ Alfred P. Sloan Foundation Research Fellow.

TABLE I

VALUES ^a OF BOUND CHEMICAL SHIFTS (Δ_B , p p m.) AND EQUILIBRIUM BINDING-CONSTANTS (K_B , ℓ , mole⁻¹)

Substrate	Lanthanide	Stoichiometry	Parameter	Proton studied				
				H-1	H-2	H-3	H-4	H-5
1 ^b	Eu(DPM) ₃	1 1	Δ_B	4.46	6.06	15.70	8 61	22.14
			K_B	33	31	29		30
2 ^c	Eu(FOD) ₃	1 1 ^d	Δ_B	3 00	2 60	3 67	7 83	14 21
			K_B	$\leftarrow \text{---} > 100 \text{---} \rightarrow$				

^a Measured with a Varian XL-100 instrument, at 38 8°. ^b In carbon tetrachloride. ^c In deuteriochloroform.

^d This value should be regarded with some scepticism.

[Eu(FOD)₃] interactions, which are known² to be substantially higher than those of Eu(DPM)₃. Even so, it is possible to evaluate accurate Δ_B -values and make a lower-limit estimate for K_B . A typical experiment involves the interaction of 1,2 3,5-di-*O*-methylene- α -D-glucofuranose (2, 0 02–0 102M) with Eu(FOD)₃ (5 9mM) in deuteriochloroform solution. The values of Δ_B and K_B are also listed in Table I, together with the approximate³ stoichiometry. When the concentration range of (*S*) is sufficiently large, as in the above study, our method does not permit an accurate evaluation of the stoichiometry. In agreement with theoretical behavior in this range, identical values of Δ_B were obtained when the data were treated on the basis of 2 1 binding.

In the light of the many experiments we have performed, several cautionary statements may be made. It must be emphasised that the reproducibility of these data, especially with alcohol substrates, is critically dependent on the experimental care exercised in the preparation of the solutions, which should be rigorously anhydrous. It is also important to control the temperature at which individual experiments are performed. It must also be pointed out that measurements of δ as a function of $[L]_0$, with $[S]_0$ held constant, are unreliable⁶, for example, the Δ -values obtained in this way vary^{2,7} with $[S]_0$.

ACKNOWLEDGMENT

We thank the National Research Council of Canada for their generous financial support.

REFERENCES

- 1 I. Armitage, L. D. Hall, A. G. Marshall and L. Werbelow, *J. Amer. Chem. Soc.*, submitted for publication.
 - 2 I. Armitage, G. Dunsmore, L. D. Hall and A. G. Marshall, *Chem. Commun.*, (1971) 1281.
- Carbohydr. Res.*, 24 (1972) 221–223

- 3 I Armitage, G Dunsmore, L D Hall and A G Marshall, *Can J Chem.*, 50 (1972) 2119
- 4 I Armitage and L D Hall, *Chem. Ind (London)*, (1970) 1537, *Can. J Chem* , 49 (1970) 2770
- 5 J. K. M. Sanders and D. H. Williams, *J. Amer. Chem. Soc.*, 93 (1971) 641.
- 6 P. V. Demarco, T. K. Elzey, R B. Lewis and E Wenkert, *J Amer Chem. Soc.*, 92 (1970) 5734, 5737
- 7 D. R. Crump, J. K. M. Sanders and D. H. Williams, *Tetrahedron Lett* , (1970) 4419, K. K. Andersen and J. J. Uebel, *ibid.*, (1970) 5253.

Carbohydr Res , 24 (1972) 221–223