Nuclear Magnetic Resonance Study of 2-Halogeno-2-deoxyhexopyranosyl Fluorides

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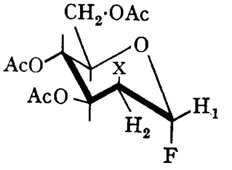
IN a previous communication, we described the synthesis of a series of 2-halogeno-2-deoxyhexopyranosyl fluoride derivatives, together with the chemical evidence for their structures. The ^{1}H n.m.r. parameters of these derivatives confirmed these assigned configurations and, more importantly, indicated that the derivatives all have the same conformational symmetry.

The ^{19}F n.m.r. parameters, which are listed in Table 1, demonstrate several important stereospecific dependencies. As expected,[1–3] the *vicinal* ^{19}F–^{1}H coupling constants show the same angular dependence as that of *vicinal* ^{1}H–^{1}H couplings[4] insofar that, for each particular substituent at C(2), $J_{gauche} < J_{trans}$. More importantly, the *vicinal* ^{19}F–^{1}H couplings appear to have an approximately linear relationship with the Huggins electronegativity of the substituents attached to C(1) and C(2). This is in accord with a previous suggestion[2b] and the linear plots, which represent these relationships, are summarised in Table 2.

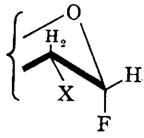
The ^{19}F shifts for each of the three series of compounds increase regularly through the series

TABLE 1

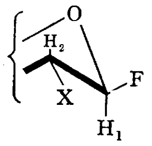
^{19}F *Chemical shifts*[a] *and vicinal* ^{19}F–^{1}H *coupling constants*[b] *for 2-halogeno-2-deoxyhexopyranosyl fluoride triacetates, and related derivatives*



(α-D-*manno*-)



(α-D-*gluco*-)



(β-D-*gluco*-)

Compound	ϕ_c	$J(F,H_{2e})$	ϕ_c	$J(F,H_{2a})$	ϕ_s	$J(F,H_{2a})$
X = H[d]	131·1	5·3[c]	131·1	38·0	125·2	15·3/10·7
X = I	116·9	4·3[c]	139·8	27·8	132·3	9·3
X = Br	123·1	3·0[c]	144·9	25·2	136·0	10·0
X = Cl	127·8	1·9[c]	147·6	24·0	138·9	10·6
X = OAc[e]	138·8	1·5[c]	149·9	23·8	137·8	12·0

[a] Unless otherwise stated spectra were measured in $CDCl_3$ solutions containing *ca.* 20% $CFCl_3$ (ϕ_c values in p.p.m.). A modified Varian HA-100 spectrometer was used; [b] First-order parameters (Hz.); [c] In $(CD_3)_2CO$ solution containing *ca.* 20% $CFCl_3$; [d] See reference 1b; [e] See reference 1a.

TABLE 2

Linear relationships between vicinal ^{19}F–^{1}H *coupling constants and substituent electronegativity*

$$J(H_2,F) = C + m\Sigma\epsilon$$

Configuration of derivatives	Coupling	C	m	$\Sigma\epsilon$	Error (Hz.)
α-D-*gluco*	$J(F_a,H_{2a})$	149·4	−10·9	b	$2{\cdot}2_6$
α-D-*gluco*[a]		78·5	−4·7	b	$0{\cdot}6_7$
α-D-*manno*	$J(F_a,H_{2e})$	38·7	−3·2	b	$0{\cdot}2_8$
α-D-*manno*		23·5	−3·2	c	$0{\cdot}2_8$
β-D-*gluco*[d]	$J(F_e,H_{2a})$	−1·6	+1·1	b	$0{\cdot}7_5$
β-D-*gluco*[a]		−25·7	+3·2	b	$0{\cdot}1_4$

[a] Excluding value for X = H; [b] Huggins electronegativity of all the substituents attached to C(1) and C(2) (excluding F and H_2); [c] Huggins electronegativity of those substituents attached to C(1) and C(2) and oriented antiparallel to F or H_2 (excluding F and H_2); [d] The value 10·7 Hz. was used for $J(F_e,H_{2a})$.

X = I, Br, Cl, which is in accord with the *empirical* "Q-parameter" dependence of Schaefer and his co-workers.[5] However, comparison of the above shifts with those of the 2-deoxy-derivatives (X = H) shows that when a halogen substituent is placed in a *gauche* relationship with respect to the fluorine substituent (α- and β-D-*gluco*-series) the ^{19}F resonance (ϕ_C-value) is shifted to *high field,* whereas a halogen substituent in an anti-planar orientation (α-D-*manno*-series) results in a shift to *low field.* Thus a previously unrecognised factor, which must be angular dependent, plays an important role in determining ^{19}F chemical shifts.

It is interesting to note that there is a systematic difference between the induced shifts of the α- and β-D-*gluco*-series, the ratio being 1·24 ±0·03 : 1, which possibly reflects some distortion of the pyranose ring from the "cyclohexane-chair" symmetry; this possibility is being further investigated.

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