

CHIROPTICAL STUDIES ON 1-THIO-D-GLYCOFURANOSIDES,
AN INTERPRETATION OF HUDSON'S ISOROTATION RULE.

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(Received in Japan 26 September 1977; received in UK for publication 11 October 1977)

Hudson's isorotation rule has been used for the determination of the anomeric configuration of sugars.¹⁾ Fundamentally sugars have functional groups of two types -OH and -O-C-O-. In spite of the recent progress of circular dichroism (CD) and optical rotatory dispersion (ORD) studies,²⁻⁵⁾ the rule remains still empirical, partly because of the lack of the Cotton effect in the measurable wavelength region together with the difficulty in differentiating several bands at similar wavelengths. In the UV the hydroxyl (-OH) and alkoxy (-OR) groups have the first band at 180-195 nm and the second band at 140-175 nm in the vacuum ultraviolet region.^{6,7)} The replacement of the oxygen by a sulfur atom is known to cause a red shift of about 30-40 nm. Thus thioalkyl (-SR) and thiol (-SH) groups gave the corresponding first and second band at 220-250 nm and 180-200 nm.⁸⁾ On the hypothetical basis of the resemblance of sulfur and oxygen here we report ORD and CD of 1-thio-D-glycofuranosides (I)-(V) in Fig.1 as model compounds of glycofuranosides taking advantage of the above red shift.

These compounds have the functional group -O-C-S- instead of -O-C-O- of glycofuranosides. The -O-C-S- is considered to have four bands, the first band of C-S at 220-250 nm, the first band of C-O and the second band of C-S at 180-200 nm, and the second band of C-O at 140-170 nm.

Among them the first bands of C-S (220-250 nm) have been studied in steroidal oxothiolanes⁹⁾ by Kuriyama et al. and methyl 5-thio-D-xylopyranosides (VI)¹⁰⁾ by Rao et al.. However, no study has been made on the other three bands.

By our CD measurements all the compounds (I)-(V) gave CD maximum at 205-230 nm (Band A) probably due to the first band of C-S. They also gave increases or decreases near 200 nm which showed the signs of the nearest Cotton effects below 200 nm (Band B). Below 200 nm region, the signs, the wavelengths and the rotational strengths (k) at the Cotton effects were calculated using one term and two term Drude equations based on the ORD data between 300-600 nm region according to the graphic method by Iizuka et al.¹¹⁾ The method gave negligible small rotational strengths between 170-205 nm (Band B) which were assumed to be combined the first band of C-O and the second band of C-S. It also showed a strong band at 140-170 nm (Band C).

The results are shown in Table and are summarized as follows.

- (1) Band A and B were weak and the signs of the former were not associated with the anomeric configurations while those of the latter gave opposite signs to those of Band C.
- (2) Band C were the strongest bands and their rotational strengths (k_c) were more than 10 times larger than those of Band A.
- (3) Band C (140-170 nm) were regarded as the second band of the ring oxygens since in this wavelength region neither of the other three bands could be located.
- (4) The signs of Band C were associated with the anomeric configurations, α

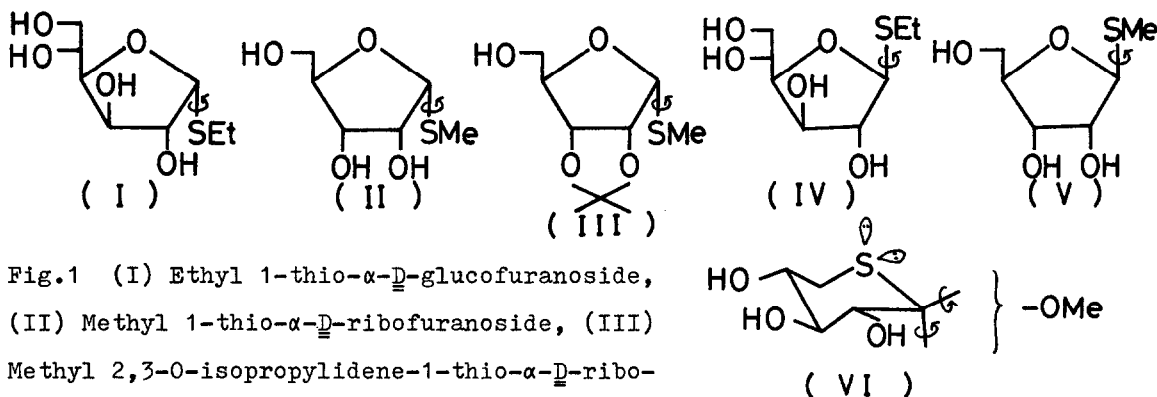


Fig.1 (I) Ethyl 1-thio- α -D-glucopyranoside, (II) Methyl 1-thio- α -D-ribofuranoside, (III) Methyl 2,3-O-isopropylidene-1-thio- α -D-ribofuranoside, (IV) Ethyl 1-thio- β -D-glucopyranoside, (V) Methyl 1-thio- β -D-ribofuranoside and (VI) Methyl 5-thio- α - and β -D-xylopyranosides

Comp.	Anom. Conf-ig.	Solv.	Band A		Band B		Band C			[M] _D	kc/[M] _D X10 ⁻⁵	
			λ _{max} (nm)	Sign [θ] X10 ⁻³	λ _{max} (nm)	Sign	λ _{max} (nm)	Sign	kc X10 ⁻⁸			[θc] X10 ⁻³
I ¹²⁾	α	W			200	-	150	+	0.82	32	+272	3.01
		M			200	-	150	+	1.06	41		
II ¹³⁾	α	W	214	- 2	200	-	140	+	1.02	42	+360	3.47
		M			202	-	140	+	1.25	52		
III ¹⁴⁾	α	W	212	- 1	200	+	170	+	0.67	23	+286	3.25
		M	208	- 1		?	160	+	0.93	34		
IV ¹²⁾	β	W			200	+	140	-	1.18	49	-307	3.84
		M	228	- 1	200	+	150	-	1.20	47		
V ¹³⁾	β	W			200	+	160	-	0.41	15	-156	3.07
		M	222	+ 2	202	+	160	-	0.48	17		

Solvent(W:Water,M:Methanol). CD measurements: On a Jasco J-20, 1 mm cell, about 1 mg/ml. [M]_D measurements: On a Jasco ORD/UV-5, 1 cm cell, about 10 mg/ml. ORD measurements: On a Jasco ORD/UV-5, 1 cm cell, about 1 mg/ml. [θc] were calculated from kc assuming that Band C were Gaussian.¹⁵⁾

gave positive signs and β gave negative signs, suggesting an application for the determination of the anomeric configurations.

(5) The kc seemed to be less affected by the structural changes at C-2 or C-3, suggesting the contribution of the second band of the -OH at C-2 or C-3 might be smaller.

(6) The kc were proportional to the molecular rotations at 589 nm ([M]_D). The ratios between the two gave constant values of (3.0-3.8 X 10⁵). It suggests that [M]_D which have been used in Fuuson's isorotation rule might be better replaced by the kc.

Similar results were also shown in 1-thio-D-glycopyranosides by us.¹⁶⁾

It is worth while to discuss the -O-C-S- in methyl 5-thio-α- and β-D-xylopyranosides (VI) where sulfur is fixed in the ring instead of the oxygen. Our calculations based on the ORD data of (VI) by Rao et al.¹⁰⁾ gave strong bands

associated with the anomeric configurations at 180 nm which could be regarded as the second band of the ring sulfur rather than that of the glycosidic oxygen. These results strongly suggest that in sugars the optical rotation might be associated mostly with the second band of the ring heteroatoms and not with those of the glycosidic heteroatoms.

References

- 1) C.S.Hudson, J.Am.Chem.Soc.,52,1680,1707 (1930) and previous papers.
- 2) I.Listowsky, G.Avigad and S.Englard, J.Am.Chem.Soc.,87,1765 (1965)
- 3) W.Klyne, W.P.Mose, P.M.Scopes, G.M.Holder and W.Whalley, J.Chem.Soc.(C), 1273 (1967)
- 4) I.Listowsky and S.Englard, Biochem.Biophys.Res.Comm.,30,329 (1968)
- 5) R.G.Nelson and W.C.Johnson,Jr., J.Am.Chem.Soc.,98,4296 (1976)
- 6) L.W.Pickett, N.J.Hoeflich and T.-C.Liu, J.Am.Chem.Soc.,73,4865 (1951)
- 7) A.J.Harrison and D.R.W.Price, J.Chem.Phys.,30,357 (1959) and their previous papers.
- 8) S.D.Thompson, D.G.Carroll, F.Watson, M.O'Donnel and S.P.McGlyne, J.Chem. Phys.,45,1367 (1966)
- 9) K.Kuriyama and T.Koméno, ORD and CD in Organic Chemistry, G.Snatzke, ed., Heiden and Son Ltd., London, 1967.
- 10) V.S.R.Rao and J.F.Foster, Nature,200,570 (1963)
- 11) E.Iizuka and J.T.Yang, Biochem.,3,1519 (1964)
- 12) E.Pacsu and E.J.Wilson,Jr., J.Am.Chem.Soc.,61,1450 (1939)
- 13) C.J.Clayton, N.A.Hughes and S.A.Saeed, J.Chem.Soc.(C),644 (1967)
- 14) (III) was prepared by us by treating (II) with anhydrous acetone in the presense of sulfuric acids. (III) gave a correct elementary analysis data. $[\alpha]_D^{19} 130.1^\circ$ (c 1.16, methanol).
- 15) C.Djerassi, Optical Rotatory Dispersion, Chap.12, McGraw-Hill, New York, 1960.
- 16) Sabssequent paper in this journal.
- 17) We thank Prof.L.Hough and Dr.A.C.Richardson of the Queen Elizabeth College for reading and correcting the manuscript.