Nuclear Magnetic Resonance Study of the Conformation of 2-Substituted 1,3-Dithiolane-1,1,3,3-tetraoxides

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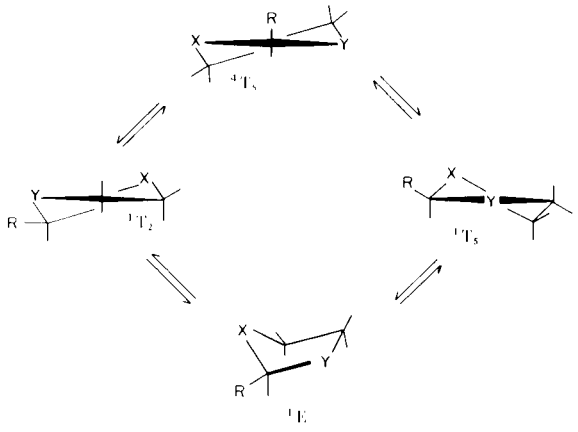
The conformational analysis of 5-membered ring systems by nmr spectroscopy is well-documented in the literature (1,2). External substitution on 5-membered rings or internal substitution with heteroatoms introduces barriers into the pseudorotation circuit (2,3). Although the conformations of 1,3-dioxolanes, 1,3-oxathiolanes and 1,3-dithiolanes have been studied by nmr spectroscopy (1,4,5), no data is available on the effect direct introduction of substituents on heteroatoms exerts on ring conformation.

The pmr spectra of a series of 2-substituted 1,3-dithiolane-1,1,3,3-tetraoxides (**1-3**) (prepared by the direct oxidation of the previously reported 1,3-dithiolanes (1) with *m*-chloroperoxybenzoic acid (6)) have been examined to help assess the influence of substitution on heteroatoms in defining the ring geometry of this system. Vicinal and geminal coupling constants of the C-4,5 methylene protons have been determined by iterative computer analysis in a manner analogous in most details to that reported for the corresponding dithiolanes. Chemical shift assignments for the dithiolane tetraoxides (compiled in Table I) were made by analogy with the paramagnetic shift exerted by substituents in the 2-position observed in 1,3-dioxolanes (4,7,8) and 1,3-dithiolanes (1). Interestingly, a four-bond long range coupling between H-2 and the low-field half of the AA'BB' multiplet of the C-4,5 methylene protons was observed (9). A planar zig-zag (transoid) relationship between the C-2 and C-4,5 protons is required for maximum long-range coupling in saturated five-membered rings (10). Examination of Dreiding models of 1,3-dithiolane-1,1,3,3-tetraoxides reveals that this transoid relationship is best represented by the $^4T_5$, $^1T_5$, ^1E and $^1T_2$ conformers (11) and their enantiomers. In each favored conformation the C-2 substituent is pseudo-equatorial which may be a consequence of the steric restriction imposed by the 1,3-relationship of the disubstituted sulfur atoms.



Ring torsional angles, τ, in the ethylene portion of the disulfone ring system (Table II) were calculated utilizing Lambert's "R" method (Equations 1 and 2)

$$R = (3\text{-}2\cos^2\tau)/4\cos^2\tau \qquad (1)$$

$$\text{where } R = J_{trans}/J_{cis} \qquad (2)$$

and by a modified Karplus analysis of vicinal coupling constants (Equation 3),

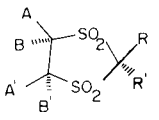
$$J_{cis} = A\cos^2\tau \qquad (3)$$

where A was evaluated to be 9.95 from J_{cis} (7.90 Hz) and τ (27°) in cyclopentane (13).

Lambert (13) has compared these two methods for measuring torsional angles in 5-membered alicyclic and heterocyclic ring systems and concluded that quantitative information could not accurately be obtained for these ring systems using this treatment of the data. However, Lambert indicates that the qualitative usefulness in comparing homologous compounds is retained and this method is valid for qualitative evaluations of 5-membered ring series. Although the two methods yielded different absolute values of τ, the qualitative trend was similar by both methods (Table II). The larger torsional angle determined by the R method may be a reflection of loss of 3-fold symmetry which is assumed to exist in the derivation of Equation 2. Lambert (13) observed that the standard

TABLE I

Nmr Parameters of Some 1,3-Dithiolane 1,1,3,3-Tetraoxides



			-Chemical Shifts, ppm, δ---			----Coupling Constants, Hz----				
	R	R′	H_A, $H_{A'}$	$H_BH_{B'}$	Other	J_{gem}	J_{cis}	J_{trans}	$^4J_{R',A} = {}^4J_{R',A'}$	RMS error
1	CH_3	H	3.97	3.86	2-H = 4.31 $2CH_3$ = 1.56	-14.27	6.90	7.75	0.68	0.024
2	Ph	H	4.20	4.10	2-H = 5.72	-14.05	7.12	7.56	0.48	0.040
3	Ph	CH_3	4.10	3.99	2-CH_3 = 2.14	-13.98	8.23	6.86	--	0.046

TABLE II

Ring Torsional Angles and Lambert "R" Factors for 1,3-Dithiolanes, 1,3-Dioxolanes, and 1,3-Dithiolane 1,1,3,3-tetraoxides

	1,3-Dithiolanes (a)			1,3-Dioxolanes (a)			1,3-Dithiolane 1,1,3,3-tetraoxides		
$C_{(2)}$-Substituents	"R" (b)	τ (c)	τ (d)	"R" (b)	τ (c)	τ (d)	"R" (b)	τ (c)	τ (d)
CH_3, H	1.21	49°	42°	0.84	42°	31°	1.12	47°	33°
Ph, H	1.26	49°	43°	0.86	42°	32°	1.06	46°	32°
Ph, CH_3	1.14	48°	41°	0.86	42°	32°	0.83	41°	24°

(a) See Ref. 1. (b) Lambert "R" factor (12). (c) Calculated from Lambert "R" factor using Equation 1 and 2. (d) Calculated from Karplus Equation (Equation 3), with A = 9.95.

Karplus approach was more reliable for torsional angle determination in 5-membered rings containing one heteroatom. However, difficulty in evaluating A (Equation 3) makes this method quantitatively inaccurate (13,14). Using these methods only for qualitative comparison of ring torsional angles, τ values for the tetraoxides lie between those reported for corresponding 1,3-dioxolanes and 1,3-dithiolanes.

The relative puckering of these ring systems may be a consequence of the intermediacy of the C-SO_2 bond distance compared with C-O and C-S bond distances. This shorter C-O distance with resultant larger C-O-C angles may flatten the ring, while the longer C-S distance may impart greater pucker to the ring system (2). Introduction of oxygen substituents on sulfur ring atoms increases the electronegativity of the sulfur, shortening the C-S bond length (*i.e.* C-SO_2 bond length < C-S bond length), resulting in an apparent flattening of the disulfone ring compared with the parent dithiolane. Steric interactions between 1,3-situated oxygen atoms may be assured to also flatten the ring system to relieve imposed strain. This interpretation is however predicated on the supposition that the phase angle (Δ) between dithiolanes and their tetraoxides is the same. The differences in torsional angles calculated for the varying ring systems may also be a reflection of the two systems occupying different phase angles on the pseudorotation circuit (2).

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