expected to occupy a $3sp^3$ orbital of sulfur.[11] From models it is estimated that the 1,3-oxygen–axial hydrogen internuclear distance is 2.6 Å., a value within the range of the sum of the van der Waal's contact radii of hydrogen and oxygen. It is possible that attractive terms outweigh repulsions and create a favorable interaction between the oxygen and the ring. The evidence presented in this report does not allow a conclusion to be made. It is noteworthy that trimethylene sulfite is reported to exist almost exclusively with the oxide in the axial position,[12] that *trans*-1,4-dithiane 1,4-dioxide prefers the form with two axial S=O bonds,[13] and that both *cis*- and *trans*-4-chlorothiane 1-oxide appear to prefer the conformer bearing an axial oxide.[14]

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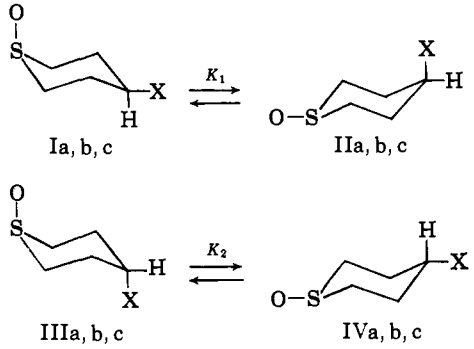
Conformational Equilibria and Solvolyses of Six-Membered Ring Sulfoxide Derivatives

Sir:

Structures of the *cis*- and *trans*-4-chlorothiane 1-oxides (Ia and IIIa) have been well established through dipole moment studies and solvolysis rate and product studies. Structures for Ib, Ic, IIIb, and IIIc may be assigned by analogy.



a, X = Cl
b, X = OH
c, X = p-$OSO_2C_6H_4CH_3$

Spectroscopic evidence (n.m.r., infrared) suggests that these compounds exhibit a surprising conformational preference for forms I and III with sulfoxide oxygen axial. This is to be contrasted with the recent report[1] assigning the *cis* geometry to the less stable (and lower melting) of the isomers of 4-*t*-butylthiane 1-oxide, V. Our data lead to a conclusion parallel to that of Johnson,[2] who has presented evidence suggesting the opposite assignment for the isomers of V. For all of the compounds of our work and those of Johnson the *cis* isomer is higher melting than the *trans* (Ia, m.p. 120–121°, and IIIa, 104–105°; Ic, 136.5–138°, and IIIc, 112–113°).

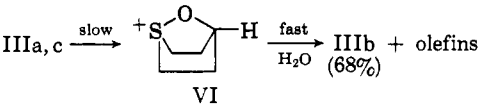
(1) H. B. Henbest and S. A. Khan, *Proc. Chem. Soc.*, 56 (1964).

(2) C. R. Johnson and D. McCants, Jr., *J. Am. Chem. Soc.*, **86**, 2935 (1964).

The sulfoxides I and III, prepared by oxidation of the corresponding sulfides with ozone or sodium metaperiodate,[3] were separated by column chromatography, the *trans* isomers being eluted first in every case. (In the case of Johnson,[2] the isomers postulated to have a preponderance of axial sulfoxide oxygen were also eluted first.)

Electric dipole moments for Ia and IIIa were compared with those calculated using thiane, thiane 1-oxide, and cyclohexyl chloride as models. The assumption was made[4] that the sulfoxide group dipole moment is directed at an angle of 38° out of the C–S–C plane toward the oxygen atom. Dipole moments, measured at 25° in CCl_4, were: for 4-chlorothiane, 1.63 ± 0.13 D. (calcd. 1.8); for Ia–IIa, 4.18 ± 0.22 (calcd. 4.8); and for IIIa–IVa, 2.12 ± 0.15 (calcd. 2.2).

Structural evidence from solvolytic rate studies is based on the large values of the k_{trans}/k_{cis} ratio (about 630 for chlorides Ia and IIIa at 140° in 50% v./v. aqueous ethanol and about 150 for *p*-toluenesulfonates Ic and IIIc in 80% v./v. aqueous ethanol at 100°). This is interpreted in terms of oxygen participation in the ionization of the *trans* isomer to give intermediate VI. Attack of water on VI either on S[5] or on C would be expected to give cleanly the only observed alcohol product, IIIb, with over-all retention of configuration. No 4-thianone, from elimination involving the bridgehead proton, could be detected in the reaction mixture.



The proton of the CHX group in these derivatives gives rise to a multiplet in the n.m.r. spectrum which is broader and at lower field for the *cis* than for the *trans* isomer, as would be expected[6] for a predominantly axial proton. This suggests a conformational preference for the forms (Ia–c or IIIa–c) having sulfoxide oxygen axial over those with sulfoxide oxygen equatorial (IIa–c or IVa–c).

TABLE I

NUCLEAR MAGNETIC RESONANCE DATA FOR THE CHX PROTON IN 4-SUBSTITUTED THIANE 1-OXIDES

Compound	Chemical shift[a]	Multiplet width (half-height)[b]
Ia	251	14
IIIa	271	9
Ib	227	16
IIIb	242	12
Ic	277	17
IIIc	288	10

[a] C.p.s. from tetramethylsilane at 60 Mc. [b] C.p.s.

The absorption intensities at the infrared C–Cl stretching frequencies (748 and 719 $cm.^{-1}$ for Ia–IIa

(3) N. J. Leonard and C. R. Johnson, *J. Org. Chem.*, **27**, 282 (1962).

(4) In a method similar to that described by C. W. N. Cumper and S. Walker, *Trans. Faraday Soc.*, **52**, 193 (1956), and C. W. N. Cumper and A. I. Vogel, *J. Chem. Soc.*, 3521 (1959).

(5) C. R. Johnson, *J. Am. Chem. Soc.*, **85**, 1020 (1963).

(6) J. A. Pople, W. G. Schneider, and H. J. Bernstein, "High Resolution Nuclear Magnetic Resonance," McGraw-Hill Book Company, Inc., New York, N. Y., 1959, Chapter 14.

and 747 and 714 cm.$^{-1}$ for IIIa–IVa in CS_2) also support the postulated axial conformational preference for the sulfoxide oxygen. Assigning the higher frequency absorption in each pair to the equatorial C–Cl and the lower frequency absorption to axial C–Cl,[7] one finds a ratio of *axial*-chlorine to *equatorial*-chlorine absorption intensity of 0.6 for the *cis* isomer and 3.9 for the *trans* isomer. Assuming the extinction coefficient for the equatorial C–Cl stretch to be about twice that for the axial C–Cl stretch, in analogy with the results of other work[8,9] on conformational equilibria of six-ring chlorides, we conclude that there exists a large predominance of Ia for the *trans* isomer (8:1) and a very slight predominance of IIIa (*ca.* 1:1) for the *cis* isomer.

Energetically unfavorable dipole–dipole interactions have been postulated[9,10] to explain the unexpectedly large amounts of the diaxial conformers found in *trans*-1,4-disubstituted cyclohexanes when, as in the present case, both substituents are strongly electronegative. The strong parallel between the behavior of our compounds and those of Johnson which have only one electronegative substituent suggests, however, that the dipole–dipole interaction is not the only factor favoring the axial disposition of sulfoxide oxygen.

Using structural parameters determined[11] by X-ray diffraction work on an analogous sulfoxide and applying the assumptions outlined above concerning the directions of dipole moments, calculations[12] were carried out on the size of these dipole–dipole interactions for Ia, IIa, IIIa, and IVa. From these calculated values and the experimental value of ΔF, assuming[8,9] the A value for C–Cl to be 0.4 kcal., we conclude that the axial preference of the sulfoxide oxygen, in the absence of interactions with the C–Cl dipole, is real. These calculations give an A value of -0.2 to -0.6 kcal.

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Synthesis of 4-Amino-4,6-dideoxy-D-galactose and Identification with the 4-Amino-4,6-dideoxyhexose from *Escherichia coli* Strain Y-10

Sir:

Recently 4-amino-4,6-dideoxy sugars have been isolated from the antibiotic amicetin,[1] the lipopolysaccharide of *Chromobacterium violaceum*,[2] and from several strains of *E. coli* as sugars linked to thymidine diphosphate.[3,4] Amosamine, the sugar from the antibiotic, is 4,6-dideoxy-4-dimethylamino-D-glucose; viosamine, the sugar from *C. violaceum*, is 4-amino-4,6-dideoxy-D-glucose.[5] In the work reported here the 4-amino sugar isolated from *E. coli* strain Y-10 was shown to be 4-amino-4,6-dideoxy-D-galactose by comparison with a synthetic sample.

The isolation of a thymidine nucleotide from *E. coli* strain Y-10 containing an unusual acetamido sugar has been reported.[3,6,7] Oxidation of the sugar from this nucleotide with periodate resulted in uptake of two moles of periodate with formation of two moles of formic acid and one mole of an acetamido aldehyde. The latter was further oxidized with hypoiodite and then deacetylated to yield L-threonine.[8] These data established that the sugar was in the D-series and were compatible with the D-*galacto* configuration. Moreover, the sugar has been shown to be synthesized enzymatically by a pyridoxal phosphate dependent stereospecific transamination of thymidine diphosphate 4-keto-6-deoxy-D-glucose.[9]

4-Amino-4,6-dideoxy-D-galactose, its N-acetyl derivative, and crystalline tetraacetates have now been synthesized chemically and shown to be identical with the natural materials synthesized enzymatically.

Methyl 4,6-*O*-benzylidine-α-D-glucopyranoside was benzylated to give the dibenzyl derivative,[10] m.p. 97–98°, $[\alpha]^{25}D$ −27.0° (*c* 3.13, $CHCl_3$). Mild hydrolysis gave 98% yield of methyl 2,3-di-*O*-benzyl-α-D-glucopyranoside,[10] m.p. 78.5–80°, $[\alpha]^{25}D$ +17.3° (*c* 1.23, $CHCl_3$). Mesylation gave the crystalline methyl 2,3-di-*O*-benzyl-4,6-di-*O*-methylsulfonyl-α-D-glucopyranoside (I), m.p. 121–122°, $[\alpha]^{25}D$ +57° (*c* 1.14, $CHCl_3$) in 98% yield. Sodium iodide in methyl ethyl ketone at the reflux temperature selectively displaced the primary mesyl group to give 80% of methyl 2,3-di-*O*-benzyl-6-deoxy-6-iodo-4-*O*-methylsulfonyl-α-D-glucopyranoside, m.p. 133–134°, $[\alpha]^{25}D$ +41.3° (*c* 3.15, $CHCl_3$).

The primary iodo group could be smoothly reduced to the 6-deoxy derivative in 88% yield using lithium aluminum hydride in tetrahydrofuran. The resulting methyl 2,3-di-*O*-benzyl-6-deoxy-4-*O*-methylsulfonyl-α-D-glucopyranoside (II), m.p. 110–111°, $[\alpha]^{25}D$ +37.8° (*c* 2.38, $CHCl_3$) was heated with lithium azide in dimethylformamide to give in 83% yield methyl 4-azido-2,3-di-*O*-benzyl-4,6-dideoxy-α-D-galactopyranoside (III), m.p. 54°, $[\alpha]^{25}D$ +11.3° (*c* 1.94, $CHCl_3$). Compound III was reduced with lithium aluminum hydride in refluxing dioxane to methyl 4-amino-2,3-di-*O*-benzyl-4,6-dideoxy-α-D-galactopyrano-

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