Configurational Criteria for Cyclic Sulphilimines

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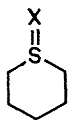
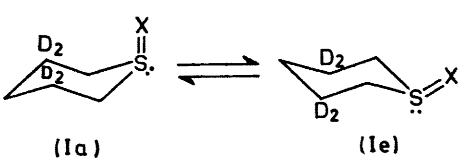
Summary In thian 1-imine and its sulphonyl derivatives, chemical-shift differences and coupling constants between the α protons are found to provide consistent criteria for the configuration of sulphilimines in the same manner as for the isoelectronic sulphoxides.

IT was first recognized in thian 1-oxide (I; X=O) that the axial–equatorial chemical-shift difference between the α-protons, $\delta_{ae}(\alpha)$, is indicative of the sulphoxide configuration.[1] Invariably, $\delta_{ae}(\alpha)$ is larger for the equatorial oxide (Ie) than for the axial oxide (Ia). The generality of this phenomenon was established by Foster *et al.*,[2] and the method has found utility in many studies, including biologically important molecules such as the penicillin oxides.[3] A parallel correlation has been found for the α geminal coupling constants, with $J_{ae}(\alpha)$ larger (more negative) for (Ia) than for (Ie).[4] There has been interest recently in the chemistry of sulphilimines (iminosulphuranes),[5] the nitrogen analogues of sulphoxides (I; X = NR), which may also be of general biological importance. We have prepared the parent six-membered system, thian 1-imine (I; X = NH), and several *N*-substituted derivatives, in order to investigate their spectral properties as a function of the imine configuration. We find that both the chemical shift and the coupling constant criteria for configuration are valid. We also report results pertaining to the conformational preference of the imine group and its *N*-tosyl (Ts and *N*-benzenesulphonyl (Bs) derivatives (I; X = NTs or NBs).



(I)



(Ia) (Ie)

The parent, unsubstituted sulphilimine was prepared from thian by the method of Appel and Büchner for open-chain sulphilimines.[6] The *N*-arenesulphonyl compounds were obtained by treatment of thian with chloramine-T or chloramine-B.[5] [3,3,5,5-$^2H_4$]Thian was used[1] in order that the α-protons be free of coupling to the β-protons. To obtain the spectra of the separate isomers (Ia) and (Ie), operation at low temperature is required. At −80° all three compounds (I; X = NH, NTs, or NBs) have α-proton resonances consisting of two distinct AB spectra of unequal areas, due to (Ia) and (Ie). Values of $\delta_{ae}(\alpha)$ and $J_{ae}(\alpha)$ and the relative proportions of isomers are obtained from the low-temperature spectra; activation parameters for ring reversal are obtained from complete line-shape analysis of the spectra as a function of temperature. These parameters are given in the Table.

Spectral parameters for thian sulphilimines and sulphoxides

	$S{=}O$[a]	$S{=}NH$[b]	$S{=}NTs$[c]	$S{=}NBs$[d]
$\delta_{ae}(\alpha)$[e]	78·3	49·8	33·2	30·8
$J_{ae}(\alpha)$[e]	11·7	12·0	12·0	12·4
Pop.[e]	0·38	0·55	0·40	0·45
$\delta_{ae}'(\alpha)$[e]	43·2	14·4	2·0	3·2
$J_{ae}'(\alpha)$[e]	13·7	13·8	14·4	14·7
Pop.′[e]	0·62	0·45	0·60	0·55
E_a kcal/mol[f] ..	14·2	13·9	14·2	—
log A[f]	17·1	16·1	16·4	—

[a] Thian 1-oxide in CH_2Cl_2 at −90°; taken from ref. 1. [b] Thian 1-imine in CH_2Cl_2–$CHClF_2$ at −85°. [c] Thian 1-(*N*-tosyl)imine in $CHClF_2$ at −90°. [d] Thian 1-(*N*-benzenesulphonyl)imine in $CHClF_2$ at −90°. [e] All chemical shifts are in Hz at 90 MHz and coupling constants are in Hz; δ, J, and Pop. (population) refer to the lower field isomer (Ie); δ', J', and Pop.′ refer to the higher field isomer (Ia). [f] Average values for the two conformers.

In each case the isomer with the larger chemical-shift difference also has the smaller coupling constant. This isomer, which always appears at lower field, may therefore be confidently assigned the equatorial structure (Ie).[1–4] The axial isomer invariably has the smaller chemical-shift difference and the larger coupling constant, and appears at higher field. For these simple systems, a direct correlation may thus be made between configuration and n.m.r. parameters. In more highly substituted systems, some caution must be exercised. For example, in the 4,4-dimethyl derivative of the *N*-tosyl compound, we have observed that the chemical-shift difference criterion fails, because $\delta_{ae}(\alpha)$ is sensitive to substitution at the 4-position. The equatorial isomer in this compound has the smaller value of $\delta_{ae}(\alpha)$. In all cases studied so far, however, the coupling-constant criterion remains valid. We suggest that in cases for which contradictory results are obtained, greater weight should be given to the coupling-constant criterion. In any event, it is dangerous to draw configurational conclusions unless both diastereoisomers are available.

The observed isomeric populations are of some interest. The sulphoxide has a small preference (175 cal/mol) for the axial isomer.[1] This unusual preference has been attributed to an attractive interaction between the axial 1-oxide and the axial 3,5-hydrogens.[7] Replacement of the 1-oxide with tosylimine or benzenesulphonylimine has only a small effect on the equilibrium constant. In both cases the axial position remains preferred, though to a slightly smaller extent (150 cal/mol for NTs, 70 for NBs). The arylsulphonyl group must be directed away from the ring. The parent 1-imine (I; X = NH) might be expected to have similar attractive interactions with the axial 3,5-hydrogens. Unexpectedly, the unsubstituted imine shows a small but real (75 cal/mol) preference for the equatorial position. We can only conjecture at present on the reasons for this reversal in preference. It may result from more effective imine hydrogen bonds in the equatorial isomer. The activation energies to ring reversal for the sulphilimines are similar to that for the sulphoxide (Table).[1]

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