The Detection and Isolation of the Rotational Isomers of some Phenanthridinium 5-Vinyloxides

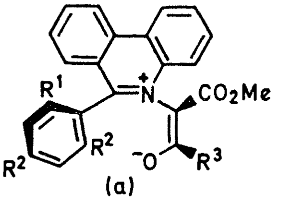
R. M. ACHESON* and I. A. SELBY†

(*Department of Biochemistry, South Parks Road, Oxford* OX1 3QU)

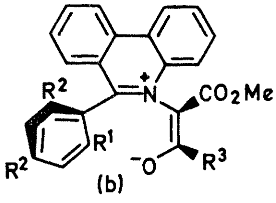
Summary The n.m.r. spectra of suitable 6-aryl- and 6-aralkylphenanthridinium 5-vinyloxides have shown that restricted rotation of the 5- and 6-substituents gives rise to pairs of diastereomeric rotamers and in one case both rotamers were isolated and characterised.

PHENANTHRIDINE 5-oxides with acetylenemono- and dicarboxylic esters give phenanthridinium 5-vinyloxides[1] and products from 3,4-dihydroisoquinoline 2-oxide with these esters, originally given other structures,[2] are now known to be of the same type.[3] A number of 6-aryl- and 6-aralkylphenanthridinium 5-oxides have now been synthesised similarly, and their n.m.r. spectra have revealed the first examples of the hindrance to rotation of *cis*-substituents on a double bond giving rise to isomeric rotamers. For many years it has been known that similar restriction of rotation occurs in many diphenyls and can also occur when groups are attached to the peri-positions of naphthalene and similar systems.[4]

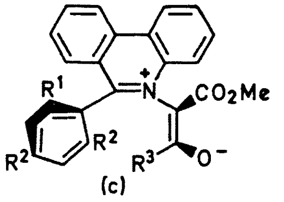
The n.m.r. spectra ($CDCl_3$) of both (**1**) and (**3**) showed two sharp ester resonances, while that of (**2**) showed two sets of two peaks in the ratio 66 : 34 in the τ 6—8·5 region, slightly different ratios being observed in CF_3CO_2H and in $(CD_3)_2SO$. The possibility that *cis–trans* isomerism of the 5-substituent [*e.g.* (2a) $\leftrightharpoons$ (2c)] was responsible is unlikely since (a) the introduction of a second *o*-methyl group in the 6-phenyl substituent to give (**3**) should have increased the effect, and (b) no simplification of the spectrum took place in CF_3CO_2H whereas peak-doubling due to *cis–trans* isomers in phosphorus[5] and sulphur ylides[6] vanishes with traces of acids.



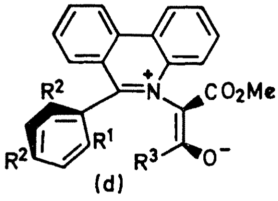
(a)



(b)



(c)



(d)

	R^1	R^2	R^3
(1)	H	H	CO_2Me
(2)	Me	H	CO_2Me
(3)	Me	Me	CO_2Me
(4)	H	H	H
(5)	Me	H	H

The presence of two rotamers [(2a) and (2b)] in which rotation about the bonds joining the 5- and 6-substituents to the heterocyclic ring is sterically restricted accounts for the observations in the *o*-tolyl case since this 6-substituent is unsymmetrical and the two rotamers are diastereoisomeric. At 125° in $(CD_3)_2SO$ the two sets of methyl resonances coalesced, and at 179° three sharp singlets at τ 6·38, 6·68, and 7·80 were formed reversibly. Analysis of the line shape of the τ 6·38 signal showed that the internal energy barrier was approximately 23·5 kcal/mole. The two sets of *C*-methyl resonance for the corresponding diethyl ester, where an examination of Dreiding models suggests there is much more steric interference, did not coalesce at 200° in nitrobenzene. Replacement of methyl groups by ethyl groups in sterically congested situations can cause substantial conformational effects, for example the large dissociation constant differences between dimethyl- and diethyl-malonic acids,[7] but examples involving ester groups appear to be very rare.

The n.m.r. spectrum of (**4**) in $CDCl_3$ showed the correct ratio (14 : 3) of aromatic to methyl protons, but this summed the *two* methoxyl signals (τ 6·44, 6·55) at 34°. These coalesced at 40°, and at 60° a sharp singlet (τ 6·40) was formed reversibly. Exposing the n.m.r. tube to daylight for a few days effected the same change in the n.m.r. spectrum as heating to 60°, but after filtering through calcium oxide the filtrate gave a spectrum identical to that of a freshly prepared solution. It appears that the exposure generated enough DCl to catalyse the *cis–trans* conversion of the 5-substituents [(4a) and (4c)], as with the other ylides,[5,6] and that this type of isomerism was responsible for the doubling of the methoxyl signals.

In confirmation of these two types of rotational isomerism the n.m.r. spectrum of (**5**) at 34° showed seven peaks in the methyl region due to the four species (5a—d) present. At 40°, or in the presence of a trace of acid at 34°, the *cis–trans* isomerisation of the 5-substituent became fast on the n.m.r. time scale and only two pairs of peaks were seen, corresponding to two rotamers [(5a)–(5c) and (5b)–(5d)]. In nitrobenzene at 120°, these pairs coalesced and at 200° the methyl resonances appeared as two sharp singlets.

Lyle and Thomas[8] have recently concluded from a study of methyl substituted *N*-benzylpiperazines that the presence of an AB system for the methylene protons of the benzyl group is positive evidence of chirality. The benzyl methylene protons of the vinyloxide (**6**) appeared as an AB quartet (J = 15 Hz) at 34°, as a broad absorption at 41° and as a singlet of normal half-height width at 100°. The methoxyl resonances showed no changes, indicating constant stereochemistry at the vinyl double bond. This temperature dependent chirality results from hindered rotation. At 41° the libration of the 5- and 6- substituents [(6a) $\rightleftharpoons$ (6b)] becomes fast on the n.m.r. time-scale and rapid exchange of the environments of the methylene protons take place. The synthesis of an analogue with an additional methyl

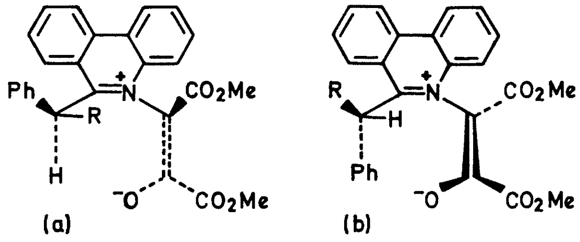
---

† Present address: Reckitt & Sons Ltd., Hull, Yorkshire.

group to give a second chiral centre gave a substance (**7**) possessing a much more complex n.m.r. spectrum which did not vary appreciably between 34° and 150°. This was considered due to the presence of the two possible diastereomeric rotamers [(**7**a) and (**7**b)]. These rotamers were separated chromatographically and characterised by their virtually identical analyses, u.v., and i.r. spectra. The n.m.r. spectra were distinct and each showed the ester methyl groups as sharp singlets and the *C*-methyl group as a doublet, and when combined gave the spectrum of the mixture. The mass spectra of the rotamers showed M^+ at *m/e* **441**, but the details of their fragmentations differed significantly as can happen with different conformers.[9]

Few examples have been reported of the isolation of diastereoisomers which exist solely due to hindered rotation, but these include certain steroids[10] and hydrazones.[11]

We thank the S. R. C. for a studentship (I.S.A.).



(**6**) R = H
(**7**) R = Me

(*Received, November 6th,* 1969; *Com.* 1685.)

---

[1] R. M. Acheson, A. S. Bailey, and I. A. Selby, *Chem. Comm.*, 1966, 835; *J. Chem. Soc.* (*C*), 1967, 2066.

[2] R. Huisgen and H. Seidl, *Tetrahedron Letters*, 1963, 2019; H. Seidl and R. Huisgen, *ibid.*, p. 2023.

[3] H. Seidl, R. Huisgen, and R. Knorr, *Chem. Ber.*, 1969, **102**, 904; R. Huisgen, H. Seidl, and J. Wulff, *ibid.*, p. 915.

[4] R. L. Shriner, R. Adams, and C. S. Marvel, p. 343—382 in "Organic Chemistry," ed. H. Gilman, John Wiley, New York, 1947, vol. I, 2nd edn.

[5] F. J. Randall and A. W. Johnson, *Tetrahedron Letters*, 1969, 2841; P. Crews, *J. Amer. Chem. Soc.*, 1968, **90**, 2961.

[6] K. W. Ratts and A. N. Yao, *J. Org. Chem.*, 1966, **31**, 1185; S. H. Smallcombe, R. J. Holland, R. H. Fish, and M. C. Caserio, *Tetrahedron Letters*, 1968, 5987.

[7] I. L. Finar, p. 457, "Organic Chemistry," 5th edition, Longmans, London 1967, vol. I.

[8] R. E. Lyle and J. J. Thomas, *Tetrahedron Letters*, 1969, 897.

[9] M. M. Green, *J. Amer. Chem. Soc.*, 1968, **90**, 3872.

[10] F. Kohen, R. A. Mallory, and I. Scheer, *Chem. Comm.*, 1969, 580.

[11] A. Mannschreck and U. Kolle, *Angew. Chem.*, 1969, **81**, 540.