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THE STEREOCHEMISTRY OF SYNCHRONOUS FRAGMENTATION

C.A. Grob, H.R. Kiefer, H. Lutz and H. Wilkens

Institut für Organische Chemie der Universität Basel

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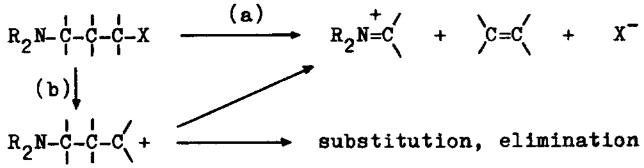
Several years ago the stereochemical requirements for synchronous fragmentation processes of the type: a-b-c-d-X $\longrightarrow$ a-b^+ + c=d + X^- were discussed[1]. In the case of γ-amino halides and arylsulphonates (1, X = halogen or $ArSO_3$-) it was predicted that a synchronous or one-step mechanism (a) would be favoured over a two-step carbonium-ion mechanism (b) if the C_α-X bond and the free electron pair of the nitrogen atom were both orientated anti and parallel (anti-periplanar[2]) with respect to the $C_\beta C_\gamma$ bond which undergoes cleavage.

(1)

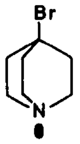


$$R_2N-\overset{|}{\underset{|}{C}}-\overset{|}{\underset{|}{C}}-\overset{|}{\underset{|}{C}}-X \xrightarrow{(a)} R_2\overset{+}{N}{=}C\Big< \; + \; \Big>C{=}C\Big< \; + \; X^-$$

$$\downarrow (b)$$

$$R_2N-\overset{|}{\underset{|}{C}}-\overset{|}{\underset{|}{C}}-\overset{+}{C}\Big< \longrightarrow \text{substitution, elimination}$$

Compounds such as 4-bromo quinuclidine (2) and 3β-chloro tropane (3), which meet these requirements, actually fragment by the synchronous mechanism (a) as shown by their enhanced reactivity when compared with structurally similar cyclic halides not containing a nitrogen atom[1].



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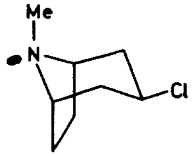

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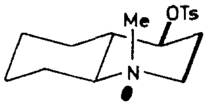

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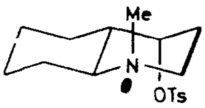

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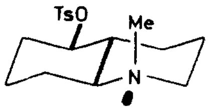

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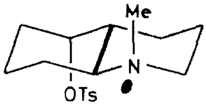

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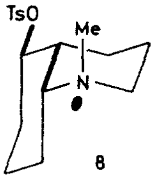

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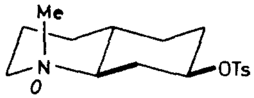

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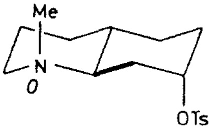

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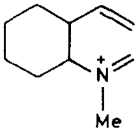

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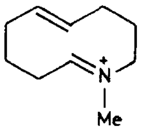

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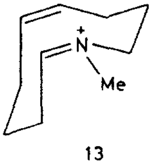

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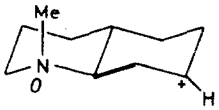

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It remained to be shown that the synchronous mechanism would not be observable in cases where either the C_α-X bond or the N-electron pair or both are prevented from adopting the required orientation.

This has now been demonstrated by studying the solvolysis rates and the products of the stereoisomers of 4-, 5- and 7-tosyloxy N-methyl decahydroquinoline (4) - (10)[3,4] in 80 % (V/V) ethanol and by comparing their first order rate constants with those of the corresponding 1- and 2-decalyl tosylates.

Thus the equatorial tosylates (4), (6) and (8) in which all three electron pairs involved in the synchronous process (a) are able to adopt anti-parallel orientations (indicated in the formulae by heavy lines or spots) afford exclusively the corresponding fragmentation products (11), (12) and (13), respectively. Furthermore, the solvolysis rates of (4), (6) and (8) are 4870, 46 and 56 times those of the corresponding α-decalyl tosylates, respectively. The synchronous nature of the fragmentation process is also reflected in the stereospecific formation of a trans and a cis olefinic bond in the strained products (12) and (13) from (6) and (8), respectively.

Conversely, the axial tosylates (5) and (7) in which the C_α-OTs bond is no longer anti and parallel to the $C_\beta C_\gamma$ bond, react at rates comparable to those of the corresponding axial 1-decalyl tosylate. In accordance with a reaction by way of a carbonium-ion, the tosylate (5) yields elimination product ($\Delta^{4,10}$ N-methyl octahydroquinoline) besides fragmentation product (11), whereas the tosylate (7) affords substitution (alcohol and ether) and elimination products ($\Delta^{5,10}$ N-methyl octahydroquinoline) only.

In the equatorial 7-tosyloxy derivative (9) the N-electron pair is unable to adopt a position anti-periplanar with the $C_\beta C_\gamma$ bond, since it is constrained to oscillate in a plane perpendicular to the ring. In the case of the axial 7-tosyloxy derivative (10) the C_α-OTs bond as well as the N-electron pair are no longer anti-periplanar with respect to the $C_\beta C_\gamma$ bond. Both tosylates, as predictable on stereoelectronic grounds, react more slowly than the corresponding 2-decalyl tosylates and afford substitution and 1,2-elimination products only. Therefore, even in a two-step process via the carbonium ion (14) fragmentation is prevented by a departure from an anti-periplanar orientation of the N-electron pair with respect to the $C_\beta C_\gamma$ bond.

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References

1. C.A. Grob, a) Experientia **13**, 126 (1957);
   b) "Theoretical Organic Chemistry," Report on the Kékulé Symposium, London 1958, p. 114;
   c) Bull.Soc.chim.France **1960**, 1360.
2. W. Klyne and V. Prelog, Experientia **16**, 521 (1960).
3. Syntheses and configurational assignments of these hitherto unknown compounds will be reported together with a detailed account of this work.
4. It is of course recognized that the N-methyl group will be in the equatorial position predominantly.