Preference for *anti* 1,4-Elimination of Hydrochloric Acid Promoted by Base in Systems with Non-cyclic C(1)–C(2) Bonds

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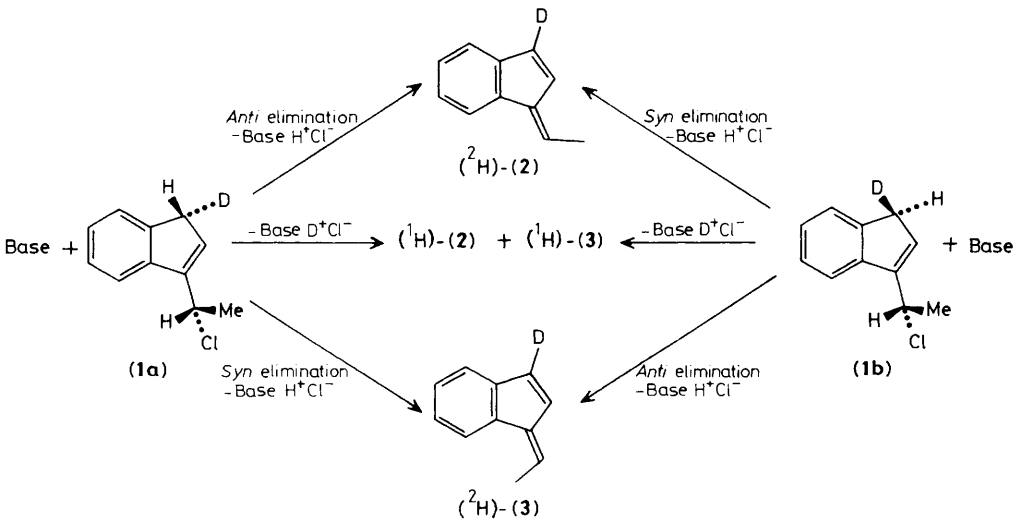
Stereochemical studies of base promoted 1,4-elimination to *transoid* dienes from the designed diastereoisomers (1*R**)-(1-$^2H_1$)-3-[(1*R**)-1-chloroethyl]indene (**1a**) and (1*R**)-(1-$^2H_1$)-3-[(1*S**)-1-chloroethyl]-indene (**1b**) show that *anti* elimination is preferred.

Knowledge of the stereochemistry of 1,4-elimination reactions is limited and there seems to be no earlier studies of systems with non-cyclic C(1)–C(2) bonds. The only stereochemical results published in the literature refer to the cyclohexenyl system.[1,2] The reactions presented here are in the controversial mechanistic borderline area of *E*2 and *E*1*cB*, and our results also contribute to the knowledge of the stereochemistry of elimination reactions involving hydrogen bonded carbanions (ion pairs) as intermediates.[3]

When rotation about the C(1)–C(2) bond is possible in an allylic compound undergoing 1,4-elimination, the *Z*- and *E*-alkenes may be formed through both *syn* and *anti* routes. The elucidation of the stereochemistry of such reactions demands substrates with known relative configuration of remote centres. To solve this intricate problem the isotopically substituted diastereoisomeric pair, (**1a**) and (**1b**), were designed.

Elimination of ^{1}HCl from diastereoisomer (**1a**) can only yield (^{2}H)-(**2**) by *anti* elimination (Scheme 1). On the other hand, the same product can only be formed from (**1b**) by *syn* elimination of ^{1}HCl. Obviously, these substrates allow the determination of rates of *anti* and *syn* elimination respectively.



Scheme 1

Table 1. Second order rate constants for DABCO promoted 1,4-elimination of ^{1}HCl to form products (^{2}H)-(**2**) and (^{2}H)-(**3**) from substrates (**1a**) and (**1b**) at 30.00 ± 0 03 °C in methanol.

Product	k_{anti} /(10^{-4} mol^{-1} dm^3 s^{-1})	k_{syn} /(10^{-4} mol^{-1} dm^3 s^{-1})	k_{anti}/k_{syn}
(^{2}H)-(**2**)	74[a]	20[b]	3.7
(^{2}H)-(**3**)	18[b]	5.6[a]	3.2

[a] Elimination from substrate (**1a**). [b] Elimination from substrate (**1b**).

Compounds (**1a**) and (**1b**) (0.0005 M) react with diazabicyclo[2.2.2]octane (DABCO, 0.030 M) in methanol at 30.00 ± 0.03 °C by pseudo first order kinetics to yield markedly different product ratios of *E*- and *Z*-ethylidenindene [(**2**) and (**3**) respectively]. The rates of elimination of the substrates and the rates of formation of (**2**) and (**3**), respectively, were determined by capillary g.l.c. The isotopic compositions of the products (**2**) and (**3**) were determined by ^{1}H n.m.r. spectroscopy. From these compositions and the rate constants for the formation of (**2**) and (**3**), the data in Table 1 were obtained.

Clearly, *anti* elimination is preferred over *syn* elimination in the formation of both (^{2}H)-(**2**) and (^{2}H)-(**3**). The rate constant ratios k_{anti}/k_{syn} for elimination of ^{1}HCl to (^{2}H)-(**2**) and (^{2}H)-(**3**) are 3.7 and 3.2 respectively.

The elimination of HCl may be either a concerted conjugated 1,4-elimination or a stepwise reaction with initial formation of an allylic carbanion. When dideuteriated chloride (1,1-$^2H_2$)-3-(1-chloroethyl)indene (**1d**) was reacted with DABCO using the same conditions as above, less than 2% of protium was incorporated into the products. This excludes an elimination mechanism involving a free carbanion which is rehydronated by the solvent.

When the rates of 1,4-elimination of 3-(1-chloroethyl)indene (**1c**) and (**1d**) were measured with various bases in methanol, the primary kinetic isotope effect was found to increase with the strength of the base from 2.7 with pyridine to 5.9 with DABCO. These results favour a stepwise reaction through intermediate hydrogen bonded carbanion ion pairs.

The variation of the isotope effect with the base strength indicates the varying degree of reversibility of the ionization. Both the proton transfer step and the expulsion of the leaving group must, therefore, be rate limiting. The preference for *anti* elimination could be due to different rates of ionization of *syn* and *anti* conformers of (**1**) and/or the result of a faster *anti* elimination of Cl^- from the ion pair. Rotation of the chloro ethyl group around the C(1)–C(2) bond may take place within the ion pair. If this rotation is fast compared to the rate of elimination of Cl^- and rehydronation, the stereospecificity must be due to the different stabilities of *anti* and *syn* conformers of the ion pair and to different rates of elimination of Cl^- from the ion pairs to form *syn* and *anti* products, respectively. On the other hand, if rotation is comparably slow, stereospecific interactions in both the ionization and the elimination steps will be reflected in the product composition.

Frontier orbital theory predicts a *syn* relation between the leaving group and the base to be favoured over an *anti* relation in a synchronous concerted 1,4-elimination.[4] Hill and Bock have reported on a potassium t-butoxide promoted 1,4-elimination from a 2,6-dichlorobenzoate derivative of cyclohexene in the presence of crown ether in *m*-xylene.[2] The reaction was found to take place by predominantly *syn* stereochemistry to yield the *cisoid* alkene product, in agreement with the frontier orbital prediction.

The principle of least motion has been applied by Tee *et al.* to 1,4-elimination reactions.[5] *Anti* elimination was predicted to be preferred for the formation of *transoid* dienes, while *cisoid* dienes should be produced by a *syn* pathway.

The importance of rotation around the C(1)–C(2) bond in the ionic intermediate for the stereochemistry of the 1,4-elimination reactions presented here is the subject of further research.

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