Stereochemistry of Hofmann Elimination in a Simple Acyclic System

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THE observation that some trimethylammonium salts when treated with alkoxides in the corresponding alcohol and dimethyl sulphoxide produce *cis*-olefin exclusively by *trans*-elimination and *trans*-olefin exclusively by *cis*-elimination led to the suggestion that this behaviour is a common feature in Hofmann elimination.[1] Some simple monocyclic trimethylammonium hydroxides undergo Hofmann elimination to give *cis*-olefin by both *cis*- and *trans*-elimination.[2]

TABLE 1

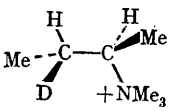
Isotopic composition of the olefinic products (%) *from the elimination of* threo-1-*methyl*[2-^2H]*propyltrimethylammonium toluene*-p-*sulphonate with potassium ethoxide in dimethyl sulphoxide*†

	But-1-ene	*trans*-But-2-ene	*cis*-But-2-ene
$^2H_0$	3	11	73
$^2H_1$	95	87	23
$^2H_2$	2	2	4
Uncertainty‡	1	9	3

† Measured by mass spectrometry at reduced ionizing voltage.
‡ Estimated from noise level in the spectra.

An extrapolated mechanistic similarity concerning the carbanionic character of the transition state between Hofmann elimination and our studies of toluene-*p*-sulphonate eliminations in dimethyl sulphoxide with alkoxide bases[3] prompted us to report our preliminary results from studies of the elimination of *erythro*- and *threo*-1-methyl[2-^2H]propyl toluene-*p*-sulphonate.[4] Our investigation showed that 1-methylpropyl toluene-*p*-sulphonate in dimethyl sulphoxide forms both *cis*- and *trans*-but-2-enes exclusively by *trans*-elimination.

We now report our preliminary results with *threo*-1-methyl[2-^2H]propyltrimethylammonium toluene-*p*-sulphonate (I) in dimethyl sulphoxide, which demonstrate that Hofmann elimination in the 1-methylpropyl system yields both *cis*- and *trans*-but-2-ene chiefly by *trans*-elimination.



threo-1-Methyl[2-^2H]propyltrimethylammonium toluene-*p*-sulphonate was prepared by reaction of trimethylamine with *erythro*-1-methylpropyl [2-^2H]toluene-*p*-sulphonate in anhydrous diethyl ether in a sealed ampoule. Although we have not established unequivocally that this preparation proceeds with complete inversion, the conditions used and the results obtained leave little doubt that the reaction proceeds to give principally the inverted product. The salt when treated with potassium ethoxide in dimethyl sulphoxide yielded olefinic products consisting of 98·3% but-1-ene, 1·2% *trans*-but-2-ene, and 0·5% *cis*-but-2-ene. Unlabelled 1-methylpropyltrimethylammonium toluene-*p*-sulphonate yielded 97·4% but-1-ene, 1·2% *trans*-but-2-ene, and 1·4% *cis*-but-2-ene. By assuming that the deuterium in the 2-position does not affect the rate of formation of but-1-ene, one can calculate primary deuterium isotope effects for the formation of both *trans*- and *cis*-olefin. The values calculated for k_H/k_D in this manner are 1·0 for the formation of *trans*-olefin and 2·8 for the formation of *cis*-olefin. These values demonstrate that deuterium was not removed during the formation of *trans*-olefin but was removed during the formation of *cis*-olefin. This conclusion is supported by the isotopic analysis of the olefins (Table 1). Essentially all the labelled *cis*-but-2-ene apparently arises from isomerization of but-1-ene; control experiments[5] have demonstrated that under the conditions employed in this reaction 0·1% of the but-1-ene is isomerized to *cis*-but-2-ene. The butenes were separated and collected individually for low-voltage mass-spectral analysis. Water contamination during collection of the small amount of but-2-enes reduced the butene concentrations in the samples for isotopic analysis to the point where the normal noise level introduced relatively large uncertainties into the results. Nevertheless, the data demonstrate quite clearly that both *cis*- and *trans*-olefins are formed principally by *trans*-elimination. Because of the uncertainty in the isotopic analysis we cannot determine if indeed *cis*-elimination does occur.

Mass-spectral analysis of the trimethylamine revealed no deuterium incorporation and thus no evidence for any contribution to the products by an $\alpha'\beta$-mechanism.[6] However, even if elimination had occurred solely by this mechanism, only 1·2% of the trimethylamine would have been labelled; trimethylamine produced by substitution would decrease this value.

TABLE 2

Isotopic composition of trimethylsilyl ether (%)†

$^2H_0$	1·1
$^2H_1$	97·6
$^2H_2$	1·3

† Measured by mass spectrometry on parent-less-methyl ions at 70 ionizing volts.

Comparison of the isotopic composition of the but-1-ene formed with that of the trimethylsilyl ether (Table 2) of the precursor alcohol reveals no significant β-exchange prior to elimination.

These results demonstrate that the formation

of *cis*- and *trans*-olefin by different stereochemical pathways is not a characteristic feature of Hofmann eliminations. Instead it is clear that the preferred mode of elimination in this simple acyclic system is *trans*-elimination and all isomeric olefins are formed by this mode.

The dependence of stereochemistry on solvent and base observed[7] in a slightly more complicated system is presently being tested in our 1-methylpropyl system.

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