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THE EFFECT OF BASES ON TRANS/CIS RATIOS IN ELIMINATION REACTIONS OF SECONDARY ALKYL BROMIDES IN APROTIC SOLVENTS

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The remarkably facile β-elimination reactions promoted by very weak bases such as Br^-, in dipolar aprotic solvents have generated considerable interest. These reactions are designated E2C by Winstein and Parker[1] to suggest that the base interacts strongly with C_α at the same time it is abstracting the proton from C_β. Similarly, these authors[1] label as E2H elimination reactions promoted by strong bases, such as <u>t</u>-BuOK. This designation indicates that the base interacts exclusively with the proton on C_β as in the classical E2 mechanism. The concept of nucleophilic participation at C_α has been challenged, especially by Bunnett,[2] and is still subject to debate. Our experiments, while supporting neither side of this controversy, clear up the misconception that halide ion-promoted eliminations give unusually high <u>trans</u>/<u>cis</u> ratios.[1]

Based largely on a higher <u>trans</u>/<u>cis</u> 2-butene ratio found in the elimination reaction of 2-butyl bromide with Br^- than with stronger bases, Winstein and Parker conclude[1] that halide ion-promoted elimination reactions generally give abnormally high <u>trans</u>/<u>cis</u> ratios. This trend is considered so reliable that high <u>trans</u>/<u>cis</u> ratios are suggested as a measure of E2C-like character.[1]

We now present evidence that halide ion-promoted elimination reactions do not give high *trans*/*cis* ratios. This conclusion is based on our gas chromatographic measurements of the olefin proportions formed upon treatment of four alkyl bromides with Bu_4NBr in acetone, Et_4NF in acetone and dimethylformamide, and *t*-BuOK in dimethylformamide. Table I lists the *trans*/*cis* ratios of 4-methyl-2-pentene from 4-methyl-2-pentyl and 2-methyl-3-pentyl bromides (column 4) and of 2-pentene from 2- and 3-pentyl bromides (column 7).

Table I

trans/*cis* Ratios from Elimination Reactions of Alkyl Bromides

Base/Solvent	Methylpentyl Isomer	Temp.	*trans*/*cis* 4-Methyl-2-pentene	Pentyl Isomer	Temp.	*trans*/*cis* 2-pentene
Bu_4NBr/Acetone	4-Me-2-Pe	100	11	2-Pentyl	100	4.2
Et_4NF/Acetone	4-Me-2-Pe	60	17	2-Pentyl	70	5.3
Et_4NF/DMF	4-Me-2-Pe	60	21	2-Pentyl	60	5.7
t-BuOK/DMF	4-Me-2-Pe	50	25	2-Pentyl	50	5.8
Bu_4NBr/Acetone	2-Me-3-Pe	75	24	3-Pentyl	100	5.0
Et_4NF/Acetone	2-Me-3-Pe	60	34	3-Pentyl	70	5.3
Et_4NF/DMF	2-Me-3-Pe	60	35	3-Pentyl	60	5.8
t-BuOK/DMF	2-Me-3-Pe	50	59	3-Pentyl	50	5.1

Changes in product proportions with changes in reaction conditions are more distinct for reactions of methylpentyl substrates than of substrates with unbranched alkyl chains.[3] Thus, it is clear from Table I that an increase in the strength of the base leads to a regular increase in the ratio of *trans*/*cis* 4-methyl-2-pentene in elimination reactions of 4-methyl-2-pentyl bromide and 2-methyl-3-pentyl bromide. The bromide ion base gives the lowest *trans*/*cis* ratios while the much stronger *t*-butoxide ion base gives the highest.

The effect of base strength on *trans*/*cis* ratios in the reactions of the pentyl bromides are more ambiguous. Both isomers give slightly higher *trans*/*cis* 2-pentene ratios with Et_4NF than with the weaker base Bu_4NBr. The further increase in the strength of the base to *t*-BuOK, however, causes a negligible increase in the *trans*/*cis* 2-pentene ratio for 2-pentyl bromide and a decrease in the ratio for 3-pentyl bromide. We are currently investigating whether the reactions of 3-pentyl bromide with *t*-BuOK and of 2-butyl bromide with Et_4NBr[1] are genuine exceptions to the general rule that increasing base strength leads to increasing *trans*/*cis* ratios in aprotic solvents.

It is necessary to show that the general trend toward high trans/cis ratios with increasing base strength reflects inherent transition state characteristics and is not the result of spurious changes in experimental conditions. We therefore conducted control experiments to examine the effects of temperature and ion-pairing. The bromide-promoted eliminations were conducted at a higher temperature than those of the other bases. The ratios of trans/cis 4-methyl-2-pentene from the bromide-promoted elimination reactions of 4-methyl-2-pentyl bromide at 120, 100 and 85°C are 8, 11 and 11, respectively. The same ratios from the reaction of 2-methyl-3-pentyl bromide at 120, 100, 85 and 75°C are 25, 24, 22 and 24, respectively. These ratios are not increasing rapidly enough, if at all, at lower temperatures to approach the ratios of the fluoride or t-butoxide-promoted reactions.

We can also show that the trend toward higher trans/cis ratios with stronger bases is not the result of ion-pairing.[4,5] When we varied the concentration of the base by factors of 10-45, we found no significant variation in the trans/cis 2-pentene ratios (±0.2) in the reactions of the pentyl bromides under all four reaction conditions. Increasing trans/cis ratios with decreasing concentrations of the base have been used as a criterion for competing reactions of ion-paired and free bases.[5]

In aprotic solvents, ion association increases with decreasing ionic size.[6] Thus, if ion pairing is a factor in our reactions, it will be more severe for Et_4NF than for Bu_4NBr. Since base ion-pairing leads to lower trans/cis ratios in anti eliminations,[4,5] the higher trans/cis ratios from reactions promoted by F^- than by Br^- cannot be explained by ion-pairing.

Parker has determined that at the concentrations used in our experiments Bu_4NCl is 38% dissociated in acetone.[7] Dissociation of Bu_4NBr in acetone might be expected to be even greater.[6] Since a base is more reactive in its free than in its ion-paired state in anti eliminations,[5,8] a dissociated Br^- is most likely promoting our reactions. Závada has shown that the dissociated form of t-BuOK in dimethylformamide promotes the elimination reactions of acyclic tosylates,[4] and, by implication we believe, also the bromides.

Therefore, comparisons of trans/cis ratios in the t-BuO$^-$ and Br$^-$ promoted elimination reactions are valid.

Less is known about ion-pairing of Et_4NF. It is possible that ion-pairing of this base is responsible for some of the exceptional trans/cis ratios noted above.

The discovery that bromide ion-promoted eliminations give lower trans/cis ratios than alkoxide ion-promoted eliminations requires a reexamination of the generally accepted hypothesis that the transition states of the former reactions have greater double bond character than those of the latter.[1,2] The present results are consistent with less double bond character in reactions with weaker bases. The smaller increase in the rates of elimination reactions promoted by weak bases than those promoted by strong bases on changing an α or β methyl group in the substrate to a phenyl group[1] supports our contention.

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