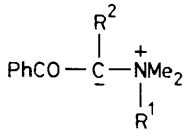
Stereoselectivity in Competing [1,2] and [1,3] Rearrangements

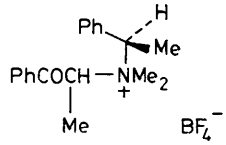
By KAN CHANTRAPROMMA, W. DAVID OLLIS,* and IAN O. SUTHERLAND
(*Department of Chemistry, The University, Sheffield* S3 7HF)

Summary The competing intramolecular [1,2] and [1,3] rearrangements of the chiral ylide [**1**, R^1 = (*R*)-CHMePh, R^2 = Me] are both stereoselective, giving the products (**5**) and (**7**) with predominant retention of the configuration of the migrating phenylethyl group; the stereoselectivity of the [1,2] rearrangement is significantly greater than that of the [1,3] rearrangement.

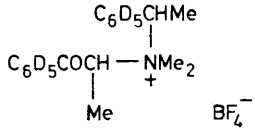
THE [1,2] Stevens rearrangement of ammonium ylides shows surprisingly high stereoselectivity[1] for a rearrangement reaction that involves homolysis and radical pair recombination.[1,2] The recognition[2] of competing [1,2] and [1,3] anionic rearrangements of the ylides (**1**) provided the opportunity to compare directly the stereoselectivities of these two processes.



(1)



(2)



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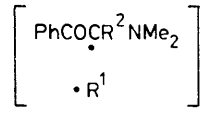
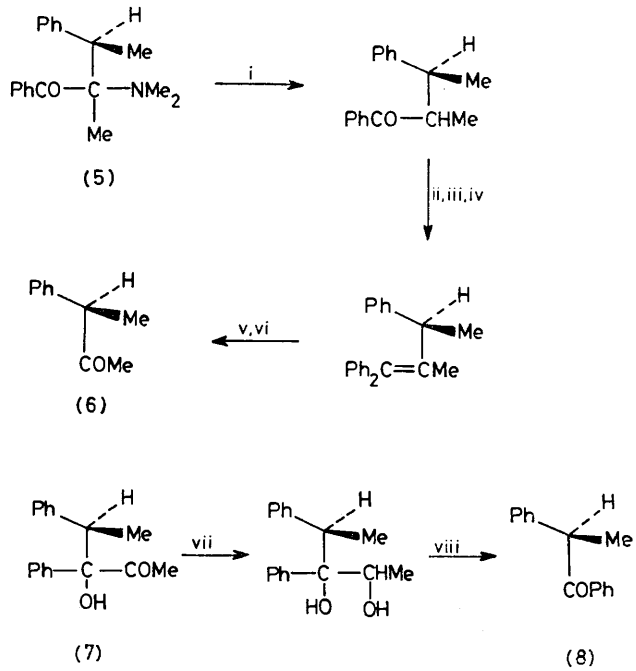


(4)

The chiral ammonium salt (**2**) was synthesised from (*R*)-1-phenylethylamine and a single pure diastereomer of (**2**) was obtained by crystallisation from propan-2-ol giving a product, m.p. 145—147 °C, $[\alpha]_D$ + 108° (*c*, 1·125, $CHCl_3$). This salt (**2**) on treatment with base gave the products (**5**) and (**7**) of [1,2] and [1,3] rearrangements[2] of the ylide (**1**, R^1 = CHMePh, R^2 = Me). The reaction products (**5**) and (**7**) were degraded by the reaction sequences outlined in the Scheme giving the ketones (**6**) and (**8**) with established absolute configurations and optical activities.[3,4] The enantiomeric purities of the designated chiral centres of the products (**6**) and (**8**) (Scheme) could therefore be determined by degradation and the results are summarised in the Table. Both



Reagents: i, Zn, $MeCO_2H$; ii, PhMgBr; iii, $SOCl_2$, pyridine; iv, HCl; v, O_3; vi, H_2, Pd–$CaCO_3$; vii, $NaBH_4$; viii, $NaIO_4$–EtOH–H_2O.

SCHEME. Determination of the absolute configuration and enantiomeric purity of the rearrangement products (**5**) and (**7**). The designated centres of chirality refer to the more abundant epimer, the undesignated centres refer to mixtures of both epimers and are not relevant to the mechanistic examination.

TABLE. Intermolecularity and stereoselectivity of the [1,2] and [1,3] rearrangements of the ylide [**1**, R^1 = (*R*)-CHMePh, R^2 = Me].

	[1,2] Rearrangement			[1,3] Rearrangement		
Reaction conditions	Stereoselectivity[a,b] % ± 2%	Intermolecularity[c] % ± 2%	Intramolecular stereoselectivity[d]	Stereoselectivity[a,b] % ± 2%	Intermolecularity[c] % ± 2%	Intramolecular stereoselectivity[d]
NaOH in H_2O at 55 °C	85	—[e]	—[e]	55	—[e]	—[e]
NaOH in H_2O–MeOH (1 : 1) at 55 °C	68	16	81	47	17	57
NaOMe in MeOH at 40 °C	48	37	76	38	33	57
NaOMe in MeOH at 60 °C	42	41	71	37	34	56

[a] Based upon the observed values of $[\alpha]_D$ for the products (**6**) and (**8**) and the reported values of $[\alpha]_D^{24}$ + 368° (*c*, 2·96, benzene) for (*S*)-(**6**) (ref. 3) and $[\alpha]_D$ + 252° (*c*, 1·4, ethanol) for (*S*)-(**8**) (ref. 4). [b] Stereoselectivity = $(x - y)$% where in the reactions (**2**) → (**5**) and (**2**) → (**7**) the reactions of the (*R*)-salt (**2**) proceed x% with retention and y% with inversion. [c] Intramolecularity = $4z$% and intermolecularity = $100 - 4z$% where an equimolecular mixture of racemic (**2**) and (**3**) gives the following proportions of deuteriated and non-deuteriated products (**5**) or (**7**): $[^2H_0]$ 50 $-z$%; $[^2H_5]$ $2z$%; $[^2H_{10}]$ 50 $-z$%. [d] Intramolecular stereoselectivity = (stereoselectivity/intramolecularity) × 100%. [e] Owing to the incomplete solubility of the salt (**2**) in the reaction medium the mixing experiment was not considered valid.

products (**5**) and (**7**) were formed with predominant retention of the configuration of the migrating 1-phenylethyl group. These stereochemical results refer to both the intramolecular and the intermolecular modes of formation of both products (**5**) and (**7**). Furthermore, they can be corrected to refer to the intramolecular mode only, by determining the extent to which the rearrangements are intermolecular, using an equimolecular mixture of the racemic salt (**2**) and the decadeuterio-derivative (**3**) (*cf.* refs. **1** and 2). The results of this second study are also included in the Table, together with the calculated intramolecular stereoselectivities for both the [1,2] and [1,3] rearrangements. These calculated intramolecular stereoselectivities are based on the assumption that intermolecular radical recombination gives racemic products.

The intermolecularity of both [1,2] and [1,3] rearrangements is similar, as found in our investigation[2] of the corresponding *N*-benzyl ylide (**1**, $R^1 = CH_2Ph$, $R^2 = Me$). However, the intramolecular stereoselectivity is higher for the [1,2] rearrangement than for the [1,3] rearrangement. This suggests that the unusually high stereoselectivity of the [1,2] Stevens rearrangement is a consequence of the limited translational motion required within the radical pair (**4**) before intramolecular [1,2] coupling can occur. The rather greater translational movement which is demanded in order to permit intramolecular [1,3] coupling evidently permits rotation and tumbling within the radical pair, and consequent racemisation, to compete more successfully with the radical coupling process. These experimental results and the above comments may be compared with other reports of stereoselectivity in [1,3] rearrangements.[5,6]

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[1] W. D. Ollis, M. Rey, I. O. Sutherland, and G. L. Closs, *J.C.S. Chem. Comm.*, 1975, 543.
[2] K. Chantrapromma, W. D. Ollis, and I. O. Sutherland, *J.C.S. Chem. Comm.*, 1978, 670 (preceding communication).
[3] D. R. Clark and H. S. Mosher, *J. Org. Chem.*, 1970, **32**, 1114.
[4] O. Cervinka and L. Hub, *Coll. Czech. Chem. Comm.*, 1968, **33**, 1911.
[5] H. Hart and H. S. Eleuterio, *J. Amer. Chem. Soc.*, 1954, **76**, 519; K. B. Wiberg and B. I. Rowland, *ibid.*, 1955, **77**, 1159; J. A. Berson and P. B. Dervan, *ibid.*, 1973, **95**, 269; W. von E. Doering and K. Sachdev, *ibid.*, 1974, **96**, 1168; P. Caramella, R. Huisgen, and B. Schmolke, *ibid.*, pp. 2997, 2999; J. A. Berson, T. Miyashi, and G. Jones, *ibid.*, p. 3468; G. R. Krow and J. Reilly, *ibid.*, 1975, **97**, 3837; J. J. Gajewski in 'Mechanism of Molecular Migration,' ed. B. S. Thyagarajan, Interscience, New York, 1971, vol. 4, p. 1; R. C. Cookson and J. E. Kemp, *J.C.S. Chem. Comm.*, 1971, 385; L. A. Singer and K. W. Lee, *ibid.*, 1974, 962; J. A. Berson, *Accounts Chem. Res.*, 1972, **5**, 406; J. M. Brown in MTP International Review of Science, Organic Chemistry Series 1, vol. 5, ed. W. Parker, Butterworths, London, 1973, p. 159.
[6] W. D. Ollis and M. Rey, unpublished results.