Asymmetric Induction in the Allylic Rearrangement of Chiral Amine Oxide

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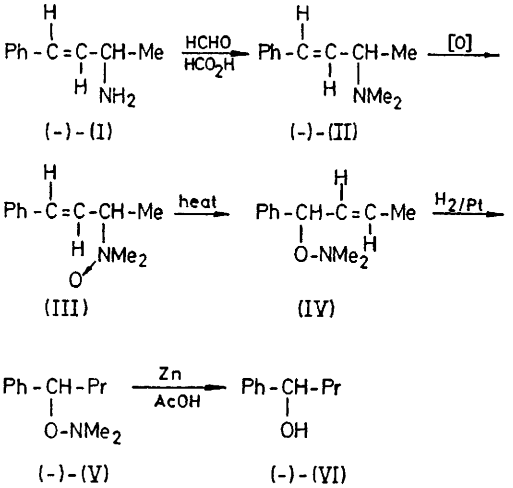
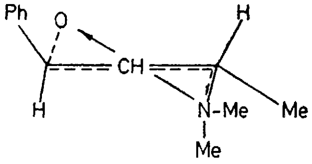
Summary The [2,3]-sigmatropic rearrangement of (*R*)-*NN*-dimethyl-3-(1-phenyl-*trans*-but-1-enyl)amine oxide to give (*S*)-*O*-*trans*-1-phenyl-but-2-enyl-*NN*-dimethylhydroxylamine was effected thermally with nearly complete transfer of chirality from tetrahedral carbon to trigonal carbon *via* a cyclic half-chair transition state conformation.

NEARLY complete conservation of optical activity has been shown in asymmetric induction[1] through intramolecular cyclic concerted processes such as the Cope and Claisen rearrangements, which are now defined as [3,3]- or [2,3]-sigmatropic rearrangements according to the Woodward–Hoffmann rule.

In the rearrangement of an allylic amine oxide, the chirality on tetraco-ordinate nitrogen atom was transferred nearly completely to trigonal carbon atom in the course of thermal process.[2]



(−)-(I) (−)-(II) (III) (IV) (−)-(V) (−)-(VI)



(VII)

We now describe another example of the same type of rearrangement in which the chirality on an asymmetric carbon atom was transferred to a trigonal carbon atom during the allylic rearrangement of chiral amine oxide.

N-Methylation of the *trans*-butene† [(I),[3] b.p. 120—122°/20 mm, n_D^{21} 1·5614, $[\alpha]_D^{20}$ −7·8° (*c*, 10·0, benzene)] w ith formaldehyde and formic acid gave (II), b.p. 133—134°/21 mm, n_D^{22} 1·5351, $[\alpha]_D^{20}$ −34·0° (*c*, 10·0, benzene). Oxidation of (−)-(II) with 40% peracetic acid in chloroform at −40° afforded the corresponding amine oxide (III).‡ On standing in chloroform at −20° for 24 days, the amine oxide (III) rearranged into the hydroxylamine (IV) in an overall yield of 44% from (−)-(II) through (IV). Since (IV) was not so stable as to permit one to observe constant rotation at room temperature, it was at once hydrogenated over platinum oxide to give (V), n_D^{25} 1·4842, $[\alpha]_D^{26}$ −83·4° (*c*, 6·02, benzene). Reductive N–O bond fission with zinc dust in acetic acid[4] afforded the butanol (VI), m.p. 36—37°, $[\alpha]_D^{22}$ −31·6° (*c*, 9·97, benzene).

Since the *S*-configuration of (−)-(VI) has been unambiguously established,[5] the same configuration can be assigned to the parent (−)-(V) and (IV), and the optical purity of (−)-(VI) proved to be 69% based on the reported maximum rotation $[\alpha]_D$ −45·9°.[6]

Catalytic hydrogenation of (−)-(I) yielded (*R*)-(+)-3-amino-1-phenylbutane,[7] so that the parent compound (−)-(I) and hence (−)-(II) and (III) derived therefrom can be assigned the *R*-configuration. The optical purity of (−)-(I) was assessed to be 81% on the basis of the maximum rotation found.§

Consequently, the optical yield of the present asymmetric synthesis is 85% and if one takes into account the probable racemisation inherent to the zinc–acetic acid reduction method for N–O cleavage (*ca.* 16% racemisation reported[4]), the conservation of optical activity during the present rearrangement can be looked upon as being nearly complete.

It can be safely concluded from the nearly complete transfer of chirality that the present rearrangement proceeds through a 5-membered cyclic transition state by the concerted mechanism, in accord with *a priori* consideration of the conservation of orbital symmetry.

The absolute configurations found for the amine oxide (*R*)-(III) and the rearrangement product (*S*)-(IV) enable one to formulate the transition state topology in which phenyl and methyl groups are oriented *trans* to each other in a half-chair conformation as shown in (VII). The stereochemistry of the present system can be accommodated well by this postulate.

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† Correct elemental analyses and i.r. and n.m.r. spectra were obtained for all the compounds reported.

‡ In a parallel run starting with (−)-(II) having a rotation $[\alpha]_D^{18}$ −36·4°, the amine oxide (III) was identified by its picrate m.p. 144—145°, $[\alpha]_D^{21}$ −54·4° (*c*, 0·50, methanol).

§ Repeated crystallisations from ethanol of the L-malate of (±)-(I) yielded a salt fraction melting at 157— 158° and having a rotation $[\alpha]_D^{26}$ +35·1° (*c*, 1·00, ethanol), which did not alter on further crystallisations. Optically pure (+)-(I) liberated from the salt had the rotation $[\alpha]_D^{27}$ +9·6° (*c*, 9·81, benzene).

[1] E. N. Marvell, J. L. Stephenson, and J. Ong, *J. Amer. Chem. Soc.*, 1965, **87**, 1267; R. K. Hill and N. W. Gilman, *Chem. Comm.*, 1967, 619; R. K. Hill and A. G. Edwards, *Tetrahedron Letters*, 1964, 3239; R. K. Hill and N. W. Gilman, *ibid.*, 1967, 1421; P. Bickart, F. W. Carson, J. Jacobus, E. G. Miller, and K. Mislow, *J. Amer. Chem. Soc.*, 1962, **90**, 4869; B. M. Trost and R. F. Hammen, *ibid.*, 1973, **95**, 962.
[2] M. Moriwaki, S. Sawada, and Y. Inouye, *Chem. Comm.*, 1970, 419.
[3] C. Harries and A. S. de Osa, *Chem. Ber.*, 1903, **36**, 2997.
[4] U. Schöllkopf and I. Hoppe, *Annalen*, 1972, **765**, 153.
[5] R. MacLeod, F. J. Welch, and H. S. Mosher, *J. Amer. Chem. Soc.*, 1960, **82**, 876.
[6] J. Kenyon and S. M. Partridge, *J. Chem. Soc.*, 1936, 128; K. Mislow and C. L. Hamermesh, *J. Amer. Chem. Soc.*, 1955, **77**, 1590.
[7] O. Červinká, E. Kroupová, and O. Bělovský, *Coll. Czech. Chem. Comm.*, 1968, **33**, 3551.