Synthesis of Aziridines by Reduction of Oximes and *O*-Alkyl Oximes with Sodium Dihydrobis-(2-methoxyethoxy)aluminate

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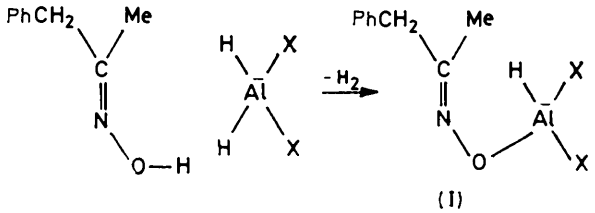
Reduction of aryl ketone oximes and their *O*-alkyl derivatives with sodium dihydrobis-(2-methoxyethoxy)aluminate, gives aziridines in up to 90% yield. Stereochemical relationships and mechanisms for the formation of amines and *cis*- and *trans*-disubstituted aziridines are discussed.

THE formation of aziridines by reduction of aryl ketone oximes, their *O*-acetyl and *O*-alkyl derivatives, and the corresponding isoxazolines with lithium aluminium hydride (LAH) in tetrahydrofuran has been reported.[1] In connection with our interest in stereoselective reductions with alkoxyaluminium hydrides [2] we have investigated the reduction of oximes and *O*-alkyl oximes with sodium dihydrobis-(2-methoxyethoxy)aluminate (SDA),[3] which is less reactive but more selective than LAH.[4] A detailed comparison of the two reducing agents has shown that the yields of aziridines are usually more than doubled by using SDA in tetrahydrofuran or dimethoxyethane (glyme), and that the new reagent provides a reasonable preparative method for aryl-substituted aziridines (Table 1). No aziridine was formed when ether or diglyme was used as solvent. The presence of a methyl or methylene group adjacent to the oxime system was found to be essential; compounds with an alkyl-substituted methine group next to the oxime function, *e.g.* isobutyrophenone oxime, did not give any aziridine, probably owing to the lower acidity of the methine hydrogen atom and to steric compression in the transition state.‡

An investigation into the relationship between the stereochemistry of the oxime and the formation and stereochemistry of the aziridine has shown appreciable and significant differences between the results from LAH and SDA reductions. As a typical example the pure *anti*-isomer of the oxime of 1-phenylpropan-2-one with LAH gave mainly primary amine (2-aminophenylpropane, 81·6%) together with 2-benzylaziridine (16%) and traces of *cis*-2-methyl-3-phenylaziridine (2·1%). A 50 : 50 mixture of the *syn*- and *anti*-forms gave slightly less primary amine (72·2%) and nearly equal quantities of 2-benzyl- and *cis*-2-methyl-3-phenylaziridine (12·2 and 15·5%). However, reduction of pure *anti*-isomer with SDA gave mainly *cis*-2-methyl-3-phenylaziridine (60·2%), together with a little 2-benzylaziridine (6·8%) and primary amine (32·7%). A 50 : 50 mixture of *syn*- and *anti*-isomers gave nearly the same yield of *cis*-2-methyl-3-phenylaziridine and a trace of 2-benzylaziridine, but, for the first time, a substantial quantity of *trans*-2-methyl-3-phenylaziridine (24·4%) was formed together with a smaller quantity of primary amine (18·2%).

Several mechanistic pathways may be envisaged for the reduction of oximes, but no single mechanistic scheme accounts for all the known facts. The initial reaction of the oxime with either LAH (X = H) or SDA (X = O·CH_2·CH_2·OMe) is undoubtedly nucleophilic attack by aluminium hydride on the hydroxy-group §



(I)

followed by complex formation of the resulting anion with the aluminium [structure (I)]. The oxime-

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‡ However Kitahonoki and Kotera [1] did obtain an aziridine from Ph_2CH·CMe=NOH, cyclisation occurring exclusively on the activated benzylic carbon atom. It is probable that the oxime was in the *anti*-form, which suggests insertion by saturated nitrene [mechanism (*c*)] rather than elimination to unsaturated nitrene [mechanism (*e*)].

§ Copious and immediate evolution of 1 mol. equiv. of hydrogen is observed (*cf.* ref. 1).

[1] K. Kitahonoki and K. Kotera, *Organic Preparations and Procedures*, 1961, **1**(4), 305, and references quoted therein; for a recent brief review see J. P. Freeman, *Chem. Rev.*, 1973, **73**, 283.

[2] S. R. Landor, B. J. Miller, and A. R. Tatchell, *J. Chem. Soc.*, 1966, 1822, 2280; 1967, 197; 1971, 2339; S. R. Landor and J. P. Regan, *ibid.*, 1967, 1159.

[3] J. Vit, B. Casinsky, and J. Machacek, Fr.P. 1,515,582/1968.

[4] M. Cerny, J. Malek, and M. Capra, *Coll. Czech. Chem. Comm.*, 1969, **34**, 1025, 1033.

aluminium complex may then react further by one of the following routes:

(*a*) Intermolecular † hydride ion attack by a second molecule of reducing agent on the oxime carbon atom of (I) from the sterically least hindered side followed by formation of the saturated nitrene (II). This is probably the preferred mode of reaction for both LAH and SDA.

(*b*) Reduction of the nitrene (II) to the primary amine by insertion into an Al–H bond of the complex. This depends on the availability of hydride ion and the steric arrangement of the complex. For LAH both factors are favourable and result in primary amine being the principal product. Bulky substituents in both the oxime and the reducing agent reduce the yield of primary amine and increase the yield of aziridine.

(*c*) Insertion of the nitrene into a neighbouring C–H bond to give the aziridine (IV), (V), or (VI). Concerted insertion of the nitrene from the *anti*-form of the oxime would be expected to give the *cis*-disubstituted aziridine before any rotation can take place. Experimentally it was found that the *cis*-aziridine is the main product from the reduction of the *anti*-oxime with SDA. There is a 10 : 1 preference for insertion into the benzylic C–H bond rather than into a methyl C–H bond to give 2-benzylaziridine (VI), as is usual for carbene and nitrene insertion reactions. The *syn*-form of the oxime [*syn*-(I)] is sterically overcrowded and less favourable for concerted insertion owing to interference by the leaving $\geq$Al–O group. Consequently there is time for rotation about the C–C bond in the nitrene, resulting in a more favourable conformation with phenyl and methyl groups *anti*, and insertion now yields *trans*-aziridine in addition to *cis*-aziridine. Insertion into Al–H and therefore primary amine formation from the *syn*-oxime and SDA is further suppressed by the highly congested transition state.

(*d*) A 1,2-shift of an aromatic substituent on a carbon atom next to the nitrene (VII) resulting in a Schiff's base (VIII), which is reduced further by hydride ion to the secondary amine (IX). Secondary amines were found to be minor products of the reduction of phenyl alkyl ketone oximes. Only aromatic substituents which are known to possess a high migratory aptitude undergo this shift.

(*e*) Elimination of a proton from the α-methyl or methylene group of the oxime either by intramolecular hydride attack or by 1,4-sigmatropic rearrangement, followed by formation of an unsaturated nitrene intermediate [(X) or (XII)], cyclisation to the azirine [(XI) or (XIII)], and

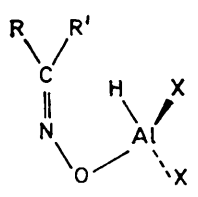
TABLE 1

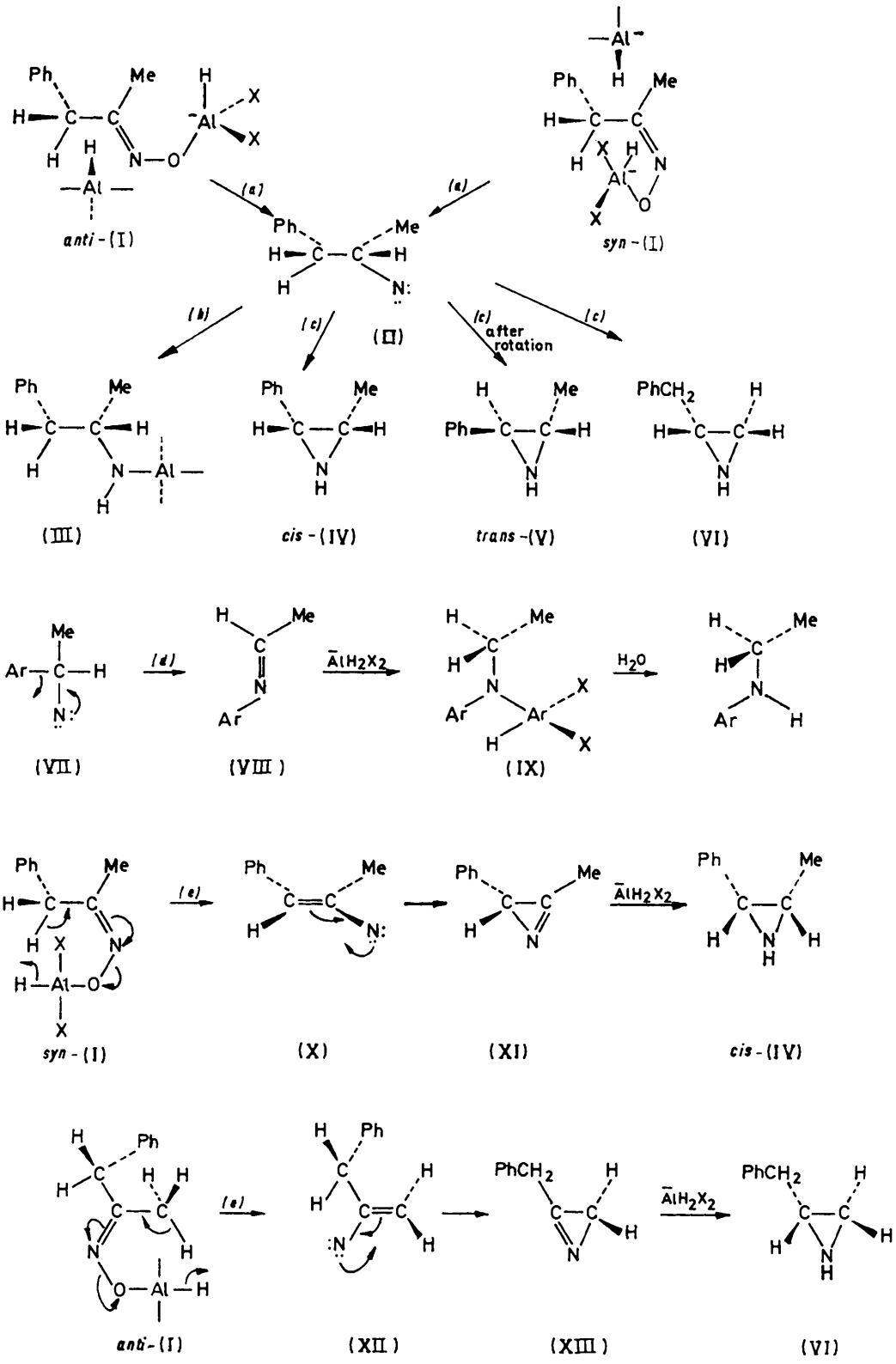
Ratios of reduction products from oximes and *O*-alkyl derivatives

Oxime $R^1R^2C{=}NOH$	G.l.c. temp. (°C)	$NaAlH_2(O[CH_2]_2OMe)_2$–THF Prim. amine (%)	Sec. amine (%)	Aziridine * (%)	$LiAlH_4$–THF Prim. amine (%)	Sec. amine (%)	Aziridine * (%)	Lit.[6] aziridine
(1) R^1 = Me, R^2 = Ph	120	43	4·6	52	58	14	27	17·3
O-Me	120	66	1·0	32	58	32	9·5	
O-Thp	120	56	6·2	37·8	90	1·0	9·0	
(2) R^1 = Me, R^2 = *p*-ClC_6H_6	130	55		45	75	1·0	24	11
(3) R^1 = Me, R^2 = 1-naphthyl	170	25		75	33	1·0	66	64
O-Me	170	36		63	40		60	
O-Thp	170	28	1·0	71	36	1·0	63	
(4) R^1 = R^2 = $PhCH_2$	170	8		91	20		80	77
O-Me	170	45		55	36		64	90
O-Thp	170	12		87·5	40		60	
(5) R^1 = $PhCH_2$, R^2 = Ph		45		55	73		27	25
O-Thp		52		48	68		32	
(6) R^1 = Pr, R^2 = Ph	120	60	25	15	86·1	12·4	1·5	
O-Thp	120	73	8·8	18·2	83·2	16·1	1	
(7) R^1 = Et, R^2 = Ph	120	70	10	20	67·4	32·6	Nil	3·3
O-Thp	120	67	10·5	22·5	71	28	1	
(8) R^1 = $PhCH_2$, R^2 = Me	120	32·6		(i) 60·2	81·6		(i) 2·1	4·7
(*a*) *anti*				(ii) 6·8			(ii) 16·0	18·0
O-Me	120	43·4		(i) 53·2	78·3		(i) 8·1	
				(ii) 2·8			(ii) 13·4	
O-Thp	120	35·2		(i) 60·1	82·6		(i) 4·8	
				(ii) 4·5			(ii) 12·1	
(*b*) *syn*–*anti* mixture	120	18·2		(i) 54·8	72·2		(i) 15·5	23
				(ii) 2·6			(ii) 12·2	8·8
				(iii) 24·3				
O-Me		20·5		(i) 56·3	78·4		(i) 10·1	
				(ii) 2·1			(ii) 11·2	
				(iii) 20·0				
(9) R^1 = Pr^i, R^2 = Ph	120	62·1	37·9					

* (i) *cis*-2-Methyl-3-phenylaziridine. (ii) 2-Benzylaziridine. (iii) *trans*-2-Methyl-3-phenylaziridine.

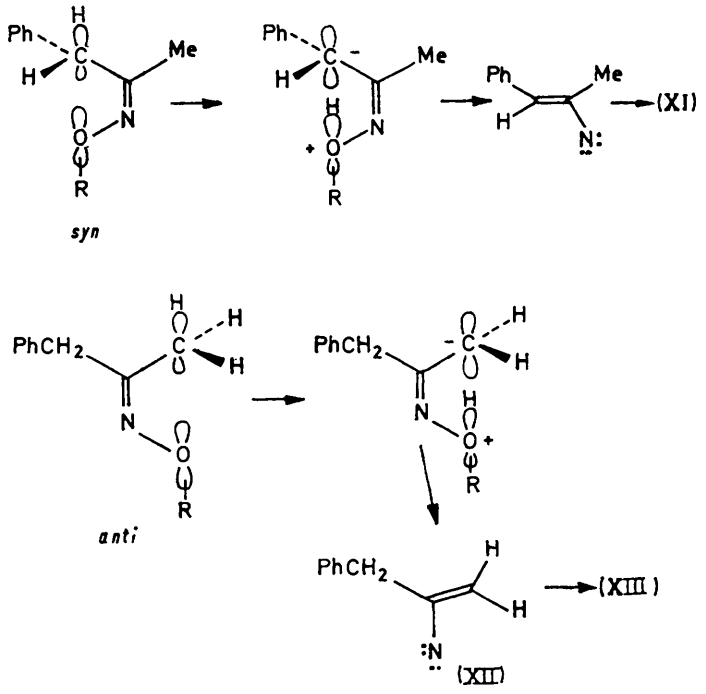
† Planarity of the system H–Al–O–N=C– renders intramolecular H^- transfer improbable and energetically unfavourable.





SCHEME Only one enantiomer is shown throughout

reduction to the *cis*-disubstituted aziridines.* In this scheme proton elimination and cyclisation always occur on the methyl or methylene substituent which is on the same side as the oxygen atom of the *syn*- or *anti*-oxime. Experimentally, reduction with LAH of *syn*- and *anti*-oximes predominantly gives the aziridine derived from elimination of a proton and ring closure on the same side, with little preference for benzylic protons (in contrast with the marked preference shown in reductions with SDA). Hydride ion attack from the sterically least hindered side would be expected to give mainly *cis*-disubstituted aziridine; no *trans*-isomer has ever been detected in the products from LAH reductions of *syn*- or *anti*-oximes.



SCHEME 2

The reduction of *O*-alkyl oximes follows the same pattern as that of the oximes themselves, and may be explained by the same mechanistic scheme. As the the complex (I) cannot be formed from the ethers, OAl⩽ is replaced in the scheme by OR. Generally, more primary amine and less aziridine is formed with SDA from *O*-alkyl oximes in which the oxime carbon atom is more accessible to hydride ion attack. *anti*- and *syn*-Forms of *O*-alkyl oximes with LAH give mainly aziridines which are derived from the elimination of a proton and ring closure on the same side, although the reaction may not be as specific as it is for the oxime complex. A symmetry-allowed [1,4] sigmatropic hydrogen shift followed by formation of the unsaturated nitrene [(X) or (XII)] and ring closure to the azirine [(XI) or (XIII)] would explain preferential ring closure onto the *syn*-substituent.

Finally, the temperature and time of reaction appears to have little effect on the ratio of products although a minimum average time of 2 h under reflux was necessary to effect complete reduction. However, the solvent has a dramatic effect on the yield of aziridine, formation of which was completely suppressed in both ether and diglyme, with either LAH or SDA. The role of the solvent can perhaps be rationalised by postulating that the formation of aziridine depends on nitrene formation by elimination of ⩾Al–O in the transition state. Efficient solvation of the \ ) fragment helps its separation and therefore helps aziridine formation. Tetrahydrofuran and glyme are known to be better solvents of alkoxyaluminium hydride complexes [5] and therefore give aziridines in good yield.

The stereochemistry of the *cis*- and *trans*-disubstituted aziridines was established both by n.m.r.[6-8] and by degradation to the known *threo*- and *erythro*-amino-alcohols.[9] The difference in chemical shifts of the *cis*- and *trans*-methyl protons was 0·30 p.p.m., which agrees well with a similar shift observed by previous workers.[8]

EXPERIMENTAL

N.m.r. spectra were obtained for solutions in deuteriochloroform with a Varian A60 spectrometer (60 MHz)

* Previous authors [1] have suggested that this is followed by an intramolecular nucleophilic substitution by the carbanion on the oxime nitrogen atom from the same side as the leaving group. This is energetically unfavourable and seems unlikely.

[5] S. R. Landor, B. J. Miller, and A. R. Tatchell, unpublished work.
[6] K. Kotera, T. Okada, S. Miyazaki, *Tetrahedron*, 1968, **24**, 5677.
[7] M. Y. Shandala, M. D. Solomon, and E. S. Wright, *J. Chem. Soc.*, 1965, 892.
[8] A. Laurent and A. Muller, *Tetrahedron Letters*, 1969, 759.
[9] M. Kojima, *J. Pharm. Soc. Japan*, 1959, **79**, 11.

(tetramethylsilane as internal reference). The compositions of mixtures of reduction products were determined with a Pye 104 gas chromatograph fitted with a 5 ft glass column of Carbowax 20M on Chromosorb W, unless otherwise stated. Preparative g.l.c. was carried out with a 7 ft preparative column of Carbowax 20M. Tetrahydrofuran was dried by keeping over sodium wire; solutions of reduction products in tetrahydrofuran were dried over magnesium sulphate monohydrate.

Preparation of Oximes and their O-Methyl and O-Tetrahydropyranyl Derivatives.—Oximes were prepared by standard methods [10] and were purified by recrystallisation or, in the case of liquid oximes, by distillation. They were characterised by m.p. and i.r. and n.m.r. spectra. N.m.r. measurements showed that all except 1-phenylpropan-2-one oxime were in the *anti*-form.

O-Methyl oximes were prepared by the methods of French and Harrison [11] and Karabatsos and Hsi [10] and purified by fractional distillation. They were characterised by g.l.c. and i.r. and n.m.r. spectra and were found to be pure *anti*-isomers except for the *O*-methyl compound prepared from a mixture of *syn*- and *anti*-1-phenylpropan-2-one oximes, which consisted of a mixture of *syn*- and *anti*-forms although it contained less *syn*-isomer than the oxime.

O-Tetrahydropyranyl oximes were prepared by treating the oxime with an excess of 2,3-dihydropyran in the presence of a catalytic quantity of toluene-*p*-sulphonic acid, shaking, cooling, leaving overnight, and fractionally distilling the products under reduced pressure with the aid of a mercury diffusion pump. If the preparation was carried out in the presence of hydrochloric acid as catalyst some hydrolysis of oxime to ketone was always observed. The products were characterised by elemental analysis, g.l.c., and i.r. and n.m.r. spectra (see Table 2). All were found to be in the *anti*-form.

Reduction of Oximes and their O-Methyl and O-Tetrahydropyranyl Derivatives.—(i) A solution of oxime or derivative (0·01 mol) in tetrahydrofuran (THF) was added dropwise to a previously standardised solution of sodium dihydrobis-(2-methoxyethoxy)aluminate in benzene (10 ml; containing *ca.* 0·03 mol of reagent) and sodium-dried THF (40 ml), which was heated under reflux and stirred. Stirring and heating were continued for a further 2 h, then the excess of reagent was decomposed with aqueous sodium hydroxide (5 ml; 2N). Insoluble inorganic material was filtered off and washed with ether (50 ml), and the combined ether–THF solution was washed with water (3 × 10 ml), dried, and evaporated. The crude organic product was analysed by g.l.c. (temperatures in Table 1). In the case of the reduction product from compound (5) (Table 1) the ratio of components was determined by weight after recrystallisation of the aziridine. The components of the mixtures were separated, according to the complexity and physical constants of the mixture, by preparative g.l.c., by column chromatography, by ' dry column ' chromatography, or by recrystallisation as described later. The components were characterised by n.m.r. and i.r. spectroscopy. The analytical results from the g.l.c. are corrected for detector response. The analytical data are summarised in Table 1.

TABLE 2

Physical constants and n.m.r. data for *O*-tetrahydropyranyl (Thp) oximes

	B.p. (°C) [mmHg]	Yield (%)	G.l.c. t_R/min	R^1 (Ph or $PhCH_2$)	R^2	Thp
				$R^1R^2C{=}N{-}OThp$; τ Values		
PhC(=NOThp)·CH_3	122–124 [0·5]	70	17·2	2·2—2·70	7·70 (3H, s, CH_3)	8·25 (6H, m, $[CH_2]_3$), 6·25 (2H, m, CH), 4·55br (1H, s, 6-H)
PhC(=NOThp)·CH_2CH_3	96—100 [10^{-2}]	66	34·2	2·2—2·70	8·82 (3H, t, CH_3), 7·25 (2H, dd, CH_2)	8·30 (6H, m, $[CH_2]_3$), 6·25 (2H, m, 2-H), 4·60br (1H, s, 6-H)
PhC(=NOThp)·CH_2·CH_2·CH_3	108—110 [10^{-2}]	60	38·4	2·2—2·80	9·05 (3H, t, CH_3), 8·6 (2H, m, CH_2), 7·25 (2H, t, CH_2)	8·35 (6H, m, $[CH_2]_3$), 6·25 (2H, m, CH), 4·55br (1H, s, 6-H)
$PhCH_2$·C(=NOThp)·CH_3	100—102 [10^{-2}]	62	31·8	2·72 (5H, s), 6·5 (2H, s)	8·20 (3H, s, CH_3)	8·35 (6H, m, $[CH_2]_3$), 6·25 (2H, d, CH), 4·70br (1H, s, 6-H)
$PhCH_2$·C(=NOThp)·CH_2Ph	145—150 [10^{-2}]	61		2·75 (5H, m), 6·35 (2H, s)	2·75 (5H, m, Ph), 6·55 (2H, s, CH_2)	8·35 (6H, m, $[CH_2]_3$), 6·25 (2H, m, CH), 4·50br (1H, s, 6-H)

(ii) A solution of the oxime or derivative (0·016 mol) in THF (10 ml) was added dropwise to a stirred suspension of lithium aluminium hydride (0·068 mol) in THF (125 ml) which was heated under reflux. Stirring and heating were continued for 3 h, then unchanged reducing agent was decomposed with water (5—10 ml). The crude product was isolated by a procedure similar to that in (i) and analysed by g.l.c. The results are given in Table 1.

Isolation and Characterisation of Reduction Products.—The crude product from compound (1) (Table 1) (1·0 g) and SDA was separated by preparative g.l.c. at 170°. The first fraction was 1-phenylethylamine, τ 8·6 (3H, d, Me), 8·45 (2H, s, NH_2), 5·7—6·1 (1H, dd, CH), and 2·7 (5H, s, Ph) [benzoyl derivative, m.p. 119° (lit.,[12] 120°)]. The second fraction was *N*-ethylaniline, τ 8·8 (3H, t, Me), 6·7—7·1 (2H, dd, CH_2), 6·75 (1H, s, NH), and 2·75—3·55 (5H, m, Ph) [benzoyl derivative, m.p. 59° (lit.,[13] 60°)]. The third, isolated as an oil, was 2-phenylaziridine, τ 8·5 (1H, s, NH), 8·3 (1H, d, C*H*H), 7·9 (1H, d, CH*H*), 6·9—7·2 (1H, dd, CH), and 2·7 (5H, s, Ph) [*p*-nitrobenzoyl derivative, m.p. 118—120° (lit.,[14] m.p. 120—122°)].

[10] C. J. Karabatsos and N. Hsi, *Tetrahedron*, 1967, **23**, 1079.
[11] C. M. French and D. Harrison, *J. Chem. Soc.*, 1855, 3513.
[12] A. I. Vogel, ' A Textbook of Practical Organic Chemistry,' Longmans, London, 1954.
[13] Heilbron's ' Dictionary of Organic Compounds,' Eyre and Spottiswoode, London, 1965.
[14] M. Kotera, S. Miyazaki, T. Okoda, and K. Kitahonoki, *Tetrahedron*, 1968, **24**, 3681.

The crude product from compound (2) was initially separated by preparative g.l.c. (7 ft Carbowax 20M; 170°) and subsequently (1 g sample) by ' dry column ' chromatography (basic Al_2O_3, 20 g; ether; detection by u.v.) to give 1-*p*-chlorophenylethylamine, τ 8·68 (3H, d, Me) 8·35 (2H, s, NH_2), 5·78—6·1 (1H, dd, CH), 8·35 (1H, d, C*H*H), 7·9 (1H, d, CH*H*), 6·8—7·1 (1H, dd, CH), and 2·75 (4H, s, C_6H_4) [benzoyl derivative, m.p. 142° (lit.,[13] 144°)], and 2-*p*-chlorophenylaziridine, τ 8·45 (1H, s, NH), 8·35 (1H, d, C*H*H), 7·9 (1H, d, CH*H*), 6·8—7·1 (1H, dd, CH), and 2·75 (4H, s, C_6H_4).

The crude product from compound (3) was refrigerated for 2 days; crystalline material was then removed, washed with light petroleum (b.p. 40—60°) and recrystallised from ether to give 2-(1-naphthyl)aziridine, m.p. 63° (lit.,[14] 66—67°), τ 8·8 (1H, s, NH), 8·25 (1H, d, C*H*H), 7·75 (1H, d, CH*H*), 6·56 (1H, dd, CH), and 1·75—2·8 (7H, m, $C_{10}H_7$) [phenylcarbamoyl derivative m.p. 131—134° (lit.,[14] 134—135°)]. The mother liquor from the original crystallisation was chromatographed on alumina with benzene–chloroform (1 : 1) and then with chloroform as eluant. The material isolated from the first solvent system was the aziridine; that from the second was 1-(1-naphthyl)ethylamine, b.p. 108—110° at 0·5 mmHg, [benzoyl derivative, m.p. 163—165° (lit.,[13] 166°)].

The crude product from compound (4) was extracted with warm light petroleum (b.p. 40—60°) and the extract was evaporated and refrigerated; crystallisation occurred. Recrystallisation from the same solvent gave *cis*-2-benzyl-3-phenylaziridine, m.p. 43° (lit.,[14] 44—45°), τ 8·7 (1H, s, NH), 7·56 (3H, m, CH and CH_2), 6·7 (1H, d, CH), and 2·5—3·1 (10H, m, Ph) [phenylcarbamoyl derivative, m.p. 121° (lit.,[14] 123°)]. The residues from the mother liquors were chromatographed on an alumina column; elution with benzene–chloroform (1 : 1) yielded more aziridine, and subsequent elution with chloroform gave 1-benzylphenethylamine (benzoyl derivative, m.p. 163—164°).

The crude product from compound (5) was refrigerated overnight. The crystalline *cis*-2,3-diphenylaziridine was filtered off, washed with light petroleum (b.p. 40—60°), and recrystallised from hexane; m.p. 82—83° (lit.,[14] 83—84°), τ 8·45 (1H, s, NH), 6·45 (2H, s, CH), and 2·75—2·95 (10H, m, Ph) [phenylcarbamoyl derivative, m.p. 161° (lit.,[14] 163—164°)]. The oily residue which remained after the removal of the aziridine was distilled under reduced pressure (b.p. 129° at 0·5 mmHg) to give 1,2-diphenylethylamine [benzoyl derivative, m.p. 175—176° (lit.,[13] 177—179°)].

The crude product from compound (6) was separated by preparative g.l.c. at 150° to give (i) 1-phenylbutylamine, τ 8·2—9·15 (7H, m, C_3H_7), 8·45 (2H, s, NH_2), 6·12 (1H, t, CH), and 2·70 (5H, s, Ph) [benzoyl derivative, m.p. 126° (lit.,[13] 128°)]; (ii) *N*-butylaniline, τ 8·4—9·2 (7H, m, C_3H_7), 7·0 (1H, s, NH) 6·9 (2H, t, CH_2), and 2·75—3·5 (5H, m, Ph) [benzoyl derivative, m.p. 52° (lit.,[12] 52—53°)]; (iii) *cis*-2-ethyl-3-phenylaziridine, τ 8·75—9·2 (5H, m, Et), 8·75 (1H, s, NH), 7·5—8·1 (1H, m, CH), 6·74 (1H, d, CH), and 2·65 (5H, s, Ph) [phenylcarbamoyl derivative (from hexane) m.p. 95° (lit.,[14] 95—96°)].

The crude product from compound (7) (1·5 g) was initially separated by ' dry column ' chromatography (basic Al_2O_3, 20 g; deactivated with 2% H_2O–methylene chloride; detection by u.v.), and subsequently by preparative g.l.c. at 150° to give (i) 1-phenylpropylamine, τ 9·17 (3H, t, Me), 8·45 (2H, s, NH_2), 8·08—8·55 (2H, m, CH_2), 6·2 (1H, t, CH), and 2·72 (5H, s, Ph) [benzoyl derivative, m.p. 114—115° (lit.,[13] 115—116°)]; (ii) *cis*-2-methyl-3-phenylaziridine, m.p. 42° (lit.,[14] 41—43°), τ 9·12 (3H, d, Me), 8·85 (1H, s, NH), 7·45—7·88 (1H, dd, CH), and 2·70 (5H, s, Ph) [phenylcarbamoyl derivative (from hexane–ether, 2 : 1), m.p. 92° (lit.,[14] 92—94°)]; (iii) *N*-propylaniline, τ 9·05 (3H, t, Me), 8·1—8·68 (2H, m, CH_2), 6·91 (2H, t, CH), 6·83 (1H, s, NH), and 2·70—3·50 (5H, m, Ph) [phenylcarbamoyl derivative, m.p. 90°, τ 9·10 (3H, t, Me), 8·2—8·58 (2H, m, CH_2), 6·30 (2H, t, CH), 3·90 (1H, s, NH), and 2·50—3·05 (10H, m, Ph)].

The crude product from compound (8a) was separated by preparative g.l.c. at 130° giving (i) α-methylphenethylamine, τ 8·90 (3H, d, Me), 8·70 (2H, s, NH_2), 7·32—7·50 (2H, dd, CH_2), 6·65—7·20 (1H, m, CH), and 2·75 (5H, s, Ph) [acetyl derivative (from ethanol), m.p. 90—92° (lit.,[13] 93°)]; (ii) *cis*-2-methyl-3-phenylaziridine, τ 9·12 (3H, d, Me), 8·85 (1H, s, NH), 7·45—7·88 (1H, dd, CH), 6·82 (1H, d, CH), and 2·70 (5H, s, Ph) [phenylcarbamoyl derivative (from hexane–ether), m.p. 92° (lit.,[13] 92—94°)]; (iii) 2-benzylaziridine, τ 8·6 (1H, d, C*H*H), 8·35 (1H, s, NH), 8·25 (1H, d, CH*H*), 7·75 (1H, m, CH), 7·30 (2H, d, CH_2), and 2·20 (5H, m, Ph).

The crude product from the mixture (8b) showed four components on analytical g.l.c. Three of these had retention times identical with those of the three products from (8a) and were similarly separated by preparative g.l.c. and characterised by comparison of their n.m.r. spectra and the m.p.s of their derivatives. The fourth component, separated by preparative g.l.c., was *trans*-2-methyl-3-phenylaziridine, τ 8·82 (3H, d, Me), 7·98 (1H, s, NH), 7·25 (1H, d, CH), 5·85—6·15 (1H, dd, CH), and 2·75 (5H, s, Ph).

The crude product from compound (9) showed two components which were separated by preparative g.l.c. at 130° to give (i) 2-methyl-1-phenylpropylamine, τ 9·25 (3H, d, Me), 9·35 (3H, d, Me), 8·51 (2H, s, NH_2), 8·21 (1H, m, C*H*Me_2), 6·41 (1H, d, C*H*·NH_2), and 2·72 (m, Ph) [picrate, m.p. 165° (lit.,[13] 166—168°)]; (ii) *N*-isobutylaniline, τ 9·3 (6H, d, Me_2), 8·20 (1H, m, C*H*Me_2), 7·10 (2H, d, CH_2·CH), 6·55br (1H, s, NH), and 3·31 and 2·79 (5H, m, Ph) [*p*-tolylsulphonyl derivative, m.p. 122° (lit.,[11] 122°)].

Confirmation of the Stereochemistry of cis- *and* trans-*Disubstituted Aziridines.*—*cis*-2-Methyl-3-phenylaziridine (250 mg) and sulphuric acid (1N; 12·5 ml) were heated under reflux for 1 h. The solution was made alkaline with ammonium hydroxide and extracted with ether (3 × 10 ml). The extracts were dried (Na_2SO_4) and evaporated to give an oily liquid which crystallised on cooling. Recrystallisation from light petroleum (b.p. 60—80°) afforded (±)-*threo*-2-amino-1-phenylpropan-1-ol, m.p. 68—70° (lit.,[15] 71°), which was heated under reflux for 0·5 h with concentrated hydrochloric acid (2 ml) to give the hydrochloride, m.p. 167° (lit.,[15] 169°).

Similarly, a mixture of *trans*-2-methyl-3-phenylaziridine (0·2 g) and sulphuric acid (1N; 10 ml) was boiled under reflux for 1 h, after which the solution was made alkaline with ammonium hydroxide. The mixture was extracted with ether (3 × 7·5 ml) and the extracts were dried (Na_2SO_4) and evaporated to give an oily residue which crystallised on cooling. Recrystallisation from ethanol yielded (±)-*erythro*-2-amino-1-phenylpropan-1-ol (0·22 g), m.p. 103° (lit.,[15] 104°); hydrochloride, m.p. 191—193° (from ethanol) (lit.,[15] 194°).

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[15] W. Nagai and S. Kanao, *Annalen*, 1929, **470**, 157.