Thermal Decomposition of Stereoisomeric 3-Aroyl- and 3-Carbomethoxyaziridines in Acetonitrile

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The thermal decomposition of 1-alkyl-3-benzoyl-2-(*m*-nitrophenyl)aziridines in dry acetonitrile results in a series of autocatalytic hydrolytic cleavages, 1,3-dipolar additions, condensations, and rearrangements to give products including oxazolidines, 1,2-dihydropyrazines, pyrrolo-[3,4-*d*]-4-oxazolines, and α-aminoketones. The marked differences in product type and distribution from *cis*- and *trans*-aziridines are ascribed to preferential hydrolytic opening at the aziridinium ion stage. Complete equilibration of the stereoisomeric azomethine ylides takes place prior to 1,3-dipolar additions.

Thermal decomposition of *cis*- and *trans*-methyl 1-isopropyl-2-(*m*-nitrophenyl)aziridine-3-carboxylates in acetonitrile is not autocatalytic (and can be suppressed) and produces three stereoisomeric oxazolidines in identical yields and ratios, and methyl *N*-isopropylglycine by selective hydrolytic attack at the 2-aziridine position. This result is ascribed to equilibration of the stereoisomeric aziridines prior to hydrolytic cleavage by adventitious moisture only.

La décomposition thermique des alkyl-1 benzoyl-3 *m*-nitrophényl-2 aziridines dans l'acétonitrile sec conduit à une série de clivages hydrolytiques autocatalysés, d'additions dipolaires-1,3, de condensations et de réarrangements donnant des produits comprenant des oxazolidines, des dihydro-1,2 pyrazines, des pyrroles[3,4-*d*] oxazolines-4 et des α-aminocétones. Les différences notables dans le type de produit et leur distribution à partir des aziridines *cis* et *trans* sont attribuées à l'ouverture préférentielle par hydrolyse au stade de l'ion aziridinium. L'équilibration complète des ylures azométhine stéréoisomères se fait avant les additions dipolaires-1,3. La décomposition thermique des carboxylates d'isopropyl-1 *m*-nitrophényl-2 aziridine-3 de méthyle *cis* et *trans*, n'est pas autocatalytique (et peut être supprimée) et conduit à trois oxazolidines stéréoisomères dans des rapports et des rendements identiques et à la méthyl-*N*-isopropylglycine par hydrolyse sélective sur la position-2 de l'aziridine. Ce résultat est attribué à l'équilibration des aziridines stéréoisomères avant clivage par hydrolyse causée seulement par une humidité accidentelle.

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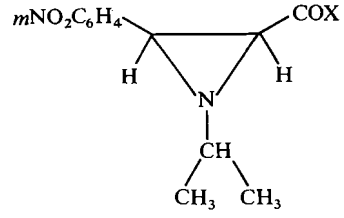
The thermal conrotatory and photochemical disrotatory cleavage of the carbon–carbon bond of aziridines to azomethine ylides proceeding according to strict orbital symmetry control is now firmly established (1). Hitherto such reactions and the subsequent 1,3-dipolar additions have been examined largely in nonpolar solvents, *e.g.* benzene or toluene, in which many *cis*- and *trans*-aziridines undergo configurational equilibration without complication (2–6).

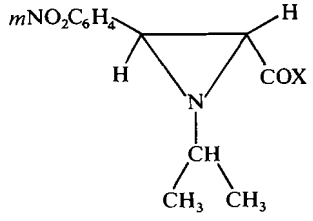
For many cycloadditions, particularly with heterocumulene dipolarophiles, more polar solvents, *e.g.* CH_3CN or CH_3NO_2, are desirable for reasons of solubility. It was therefore necessary to examine the controlled decomposition of aziridines in such solvents and elucidate possible side reactions which would be particularly important in cycloadditions of aziridines with less reactive dipolarophiles.

The decomposition of certain aziridines in dry acetonitrile shows a surprisingly facile series of hydrolytic cleavages, 1,3-dipolar additions, condensations, and rearrangements and a marked difference in behavior of *cis*- and *trans*-aziridines is apparent. Configurational assign-



1

a X = C_6H_5
b X = OCH_3



2

a X = C_6H_5
b X = OCH_3

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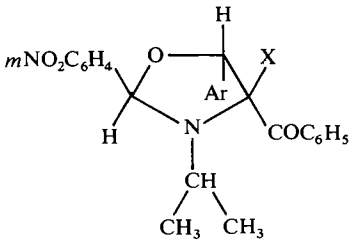
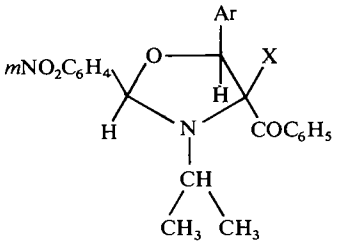
ments of *cis* and *trans* pairs of aziridines in this paper are based on the n.m.r. correlations of Pohland *et al.* (7).

Heating of a solution of pure **1***a* in dry acetonitrile under reflux for 24 h and chromatographic separation of the products afforded (*i*) the stereoisomeric oxazolidines **3***a* and **4***a* in a ratio of (80:20) (one of which could be obtained stereoisomerically pure) in 56% yield, (*ii*) the 1,2-dihydropyrazine derivative **5** in 10% yield,



3
a X = H
b X = D



4
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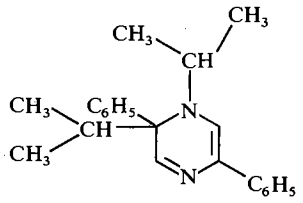
b X = D



5

(*iii*) *N*-(isopropyl)phenacylamine **6** in 20% yield, and (*iv*) an incompletely characterized basic fraction which probably contains *m*-nitrobenzylisopropylamine **7**, isopropylamine,

$C_6H_5COCH_2NH—CH(CH_3)_2$

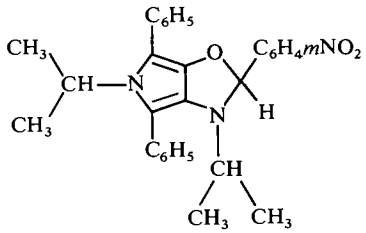
6

m-$NO_2C_6H_4CH_2NHCH(CH_3)_2$

7

and other minor basic products to the extent of 10%.

In contrast, reaction of pure **2***a* under precisely the same conditions gave a mixture of products which were separable by column chromatography affording (*i*) the oxazolidines **3***a* and **4***a* in only 5.4% yield, (*ii*) the pyrrolo-[3,4-*d*]-4-oxazoline **8** in 8.5% yield, (*iii*) the 1,2-dihydropyrazine **5** in 12.5% yield, (*iv*) *N*-(isopropyl)phenacylamine **6** in 26.5% yield, (*v*) *m*-nitrobenzaldehyde **9** in 6.3% yield, and (*vi*) a fraction consisting of a mixture of amines in 8% yield, which was very similar to that obtained from **1***a*.

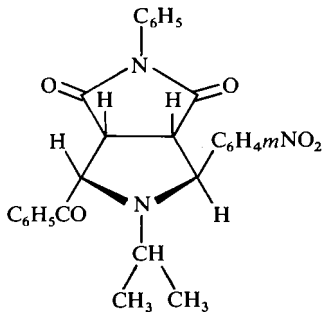


8

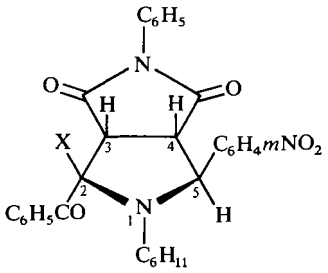
It was demonstrated independently that both **1***a* and **2***a* suffer cleavage of the 2–3 carbon–carbon bond in acetonitrile under the reaction conditions since reaction of each separately with an equimolar quantity of *N*-phenylmaleimide gave a single pyrrolidine **10**. Similar products formed in benzene have been reported by Woller and Cromwell (2). The n.m.r. spectrum of **10** closely resembled that of the *N*-cyclohexyl analog **11***a* which was similarly prepared and the full stereochemistry of which was established by examination of the deuterated analog **11***b*, prepared from 1-cyclohexyl-3-benzoyl-3-deutero-2-(*m*-nitrophenyl)aziridine (containing 54% of deuterium label).

Diminution of the 8.5 Hz doublet at 5.30 confirmed the assignment of the 5-pyrrolidine proton. The smaller H_2–H_3 coupling (4.5 Hz) established a *trans* arrangement and proved that the larger groups at the 2- and 5-positions are *trans* related. The assignments of the *cis* and *trans* couplings in these pyrrolidines are based on strong literature analogies (2, 8, 9).

The structures of **3***a* and **4***a* were proven by independent reaction of either **1***a* or **2***a* with an equimolar quantity of *m*-nitrobenzaldehyde. Precisely the same 80:20 ratio of **3***a* to **4***a* was obtained as from the decomposition experiment. The regiospecific cycloaddition of activated



10



11

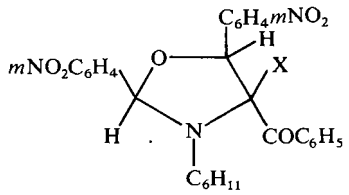
a X = H
b X = D

aldehydes to azomethine ylides to form oxazolidines in nonpolar solvents is firmly established (10–12).

The orientation of addition of the *m*-nitrobenzaldehyde was proven by deuterium labelling at the 3-position of the aziridine. The 2-oxazolidine singlets were unaffected while the 4.66 and 5.61 branches of the AB quartets due to the 4,5-protons were diminished. The magnitude of the two 4,5-proton couplings was not sufficiently characteristic to allow for an unambiguous assignment of the position of the 5-*m*-nitrophenyl group relative to the succinimide bridge.

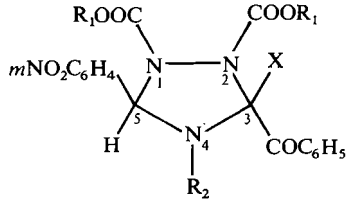
When *cis*-3-benzoyl-1-cyclohexyl-3-deutero-2-(*m*-nitrophenyl)aziridine was heated in acetonitrile it afforded the single oxazolidine **12***b* in 53% yield containing the deuterium label at the 4-position. It is noteworthy that in the experiments involving deuterium labelled aziridines in acetonitrile in this study, quantitative transfer of the deuterium was often observed. This is in contrast to previous work in nonpolar solvents where appreciable leakage of deuterium label was observed (10, 13–16).

The relative positions of the 2 and 4 oxazolidine substituents in **3***a*, **4***a*, and **12** were assigned *trans* by analogy with **10** and **11**, the stereochemistry of which is unambiguous. Aromatic aldehydes are relatively weak dipolarophiles and in the case of addition to *cis*- and *trans*-3-aroylaziridines the corresponding azomethine ylides equilibrate to the more stable *trans*-azomethine ylide prior to cycloaddition. Confirmation is obtained by employing much more reactive dipolarophiles, namely azoesters which even in a 15 *M* equiv excess in acetonitrile are unable to suppress the equilibration of the *cis*-azomethine ylide to the *trans*. The products of these reactions are the 1,2,4-triazolidines **13** consisting of single 3,5-*trans*-configurations in each case.



12

a X = H
b X = D



13

a $R_1 = CH_3CH_2$; $R_2 = C_6H_{11}$; X = H
b $R_1 = CH_3CH_2$; $R_2 = C_6H_{11}$; X = D
c $R_1 = CH_3CH_2$; $R_2 = CH(CH_3)_2$; X = H
d $R_1 = C_6H_5$; $R_2 = CH(CH_3)_2$; X = H

Assignment of the 3 and 5 ring protons in **13** is simplified by the observation of significant line broadening of the former due to coupling to the ortho protons of the adjacent *m*-nitrophenyl ring and was confirmed by deuterium labelling.

The deuterated compounds **12***b* and **13***b* did not epimerize nor exchange any deuterium label upon separate refluxing in acetonitrile with either an equivalent of the aziridine or of the corresponding primary amine, isopropylamine, or cyclohexylamine. It is concluded that epimeri-

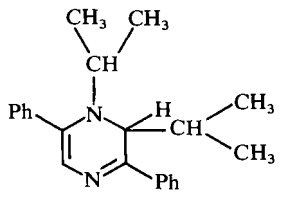
zation at the 4-position of these compounds does not occur under the reaction conditions compared with those in **20** despite the greater acidity of the C-4 hydrogen in **3**, **4**, and **12** and **13**. Therefore cycloaddition of the *m*-nitrobenzaldehyde has taken place to the more stable *trans*-azomethine ylide exclusively from either *cis*- or *trans*-aziridine. Even the most stringent precautions to exclude moisture did not suppress formation of the various products indicated above, although examination of the nature of some of the products, *e.g.* **3**, **4**, **6**, **8**, and *m*-nitrobenzaldehyde clearly indicates that hydrolysis is involved. A clue to the course of the reaction in anhydrous acetonitrile is provided by the isolation of the pyrrolo[3,4-*d*]-4-oxazoline **8**. Previous work has shown **8** can arise in the addition of *p*-nitrosophenol to 3-aroylaziridines in two consecutive 1,3-dipolar additions in which the second regiospecific addition is autocatalytic in that the subsequent Paal–Knorr condensation releases 2 equiv of water to further promote hydrolysis in an earlier step (6). The water thus released in the formation of **8** and of **5** (see Scheme 1) becomes available to initiate the hydrolysis of the aziridines. These reactions are interpreted in Scheme 1.

Previous work has shown that uncatalyzed hydrolysis of 2,3-disubstituted aziridines takes place via the aziridinium ion by a predominantly S_N2 process (17–19). Water is sufficiently acidic to provide a very low concentration of the aziridinium ion **14** from most aziridines which initiates attack by the weakly nucleophilic water (20). The nature of the products requires hydrolytic opening at both C-2 and -3 of the aziridinium ion **14** as was found previously by Cromwell and Wankel, in that hydrolysis of *trans*-1-benzyl-2-phenyl-3-*p*-toluoylaziridine results in almost equal attack at these two positions (21).

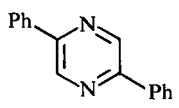
Water made available in the formation of **5** and **8** therefore, hydrolyzes **14** by attack at C-2 to give *m*-nitrobenzaldehyde **9** and *N*-isopropylphenacylamine **6**. Part of the *m*-nitrobenzaldehyde is trapped regiospecifically by the *trans*-azomethine ylide (which has a low equilibrium concentration relative to the aziridine); the rest of the *m*-nitrobenzaldehyde is isolated.

The structure of **6** was proven by its preparation from phenacyl bromide and isopropylamine and careful neutralization of the salt with base. The n.m.r. spectrum of **6** indicates the presence in solution of a large number of tautomers, the position of equilibrium of which depends on solvent polarity. Such a phenomenon is characteristic of substituted α-aminoketones (22–25). Compound **6** self-condenses very readily at room temperature to a 1,4-dihydropyrazine **15** which is not isolated but rearranges to the 1,2-dihydropyrazine **5**. The latter was identical with the material isolated from the controlled decomposition of the aziridine. Chen and Fowler have recently shown that the 1,4-dihydropyrazine structure previously assumed to be isolated from such dimerizations is incorrect in that the intermediate 1,4-dihydropyrazine suffers a 1,3-alkyl shift to the more stable (*i.e.*, possibly not antiaromatic) 1,2-dihydro form (26).

The n.m.r. spectrum of **5** shows two distinct isopropyl group doublets and two clean septets for the corresponding methines. This discounts the alternative structure **16** which would correspond to migration of the isopropyl group to an unsubstituted position. Chen and Fowler found, for a structure comparable with **16**, appreciable



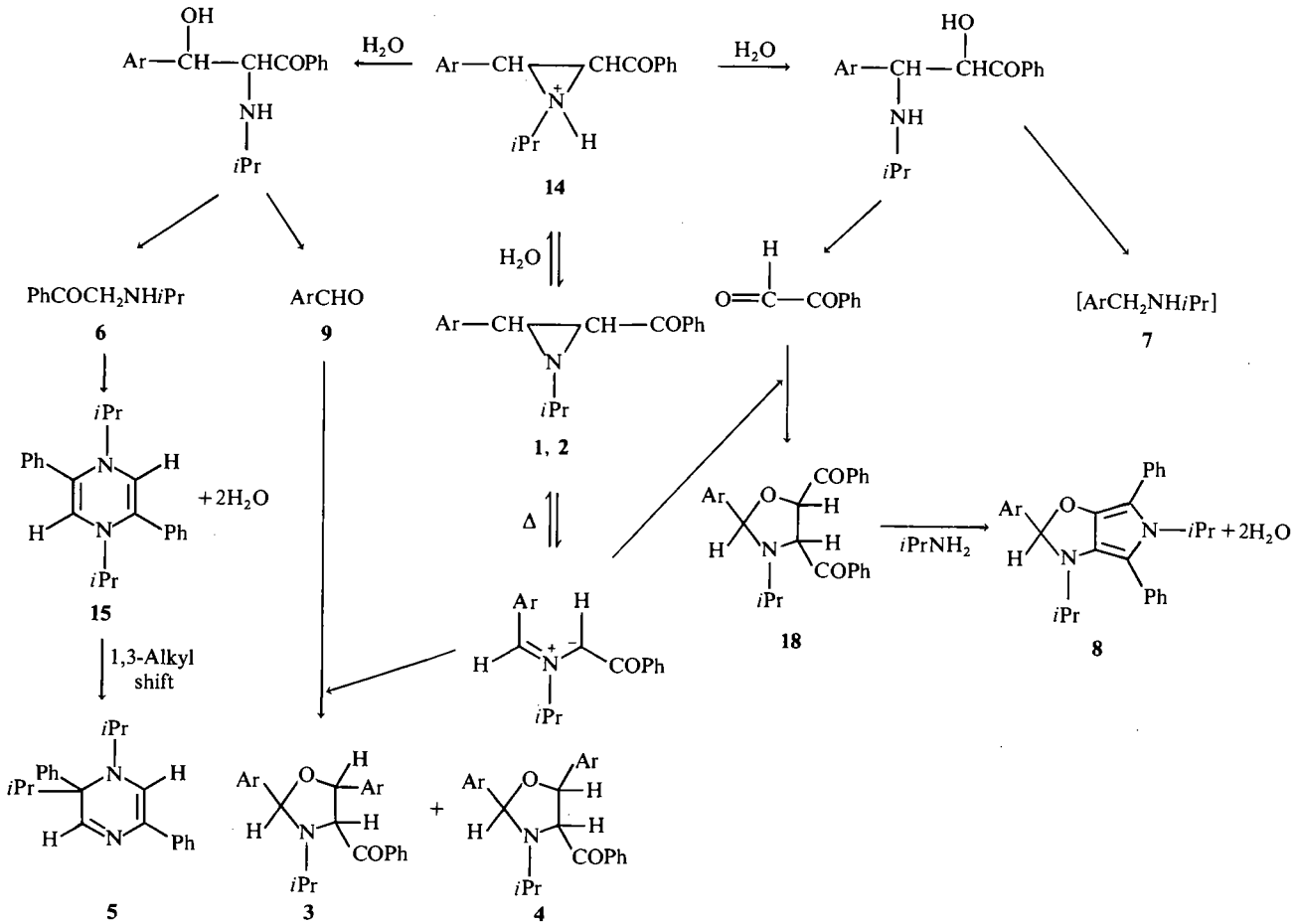
16



17

coupling between the adjacent methine protons. Additionally no signal ascribable to the N—C*H*—R proton is seen in the n.m.r. spectrum of **5**. Finally pyrolysis of **3** at 280° resulted in elimination of the elements of 2,3-dimethylbutane and afforded the known 2,5-diphenylpyrazine **17**.

Hydrolytic cleavage of the aziridinium ion **14** at C-3 would give rise to phenylglyoxal and *m*-nitrobenzylisopropylamine. It has been demonstrated independently that phenylglyoxal will undergo a regiospecific 1,3-dipolar addition to aziridines to form intermediates like **18** which may in certain cases be isolated and characterized (6). Subsequent treatment with a primary amine results in a rapid Paal–Knorr condensation (28) to form pyrrolo [3,4-*d*]-4-oxazolines like **8** with the release of 2 equiv of water. The source of the isopropylamine in the scheme is



Ar = mNO$_2$C$_6$H$_4$—

SCHEME 1

not clear at the present time. However it may be noted that often in the direct reaction of phenylglyoxal with aziridines, pyrrolo[3,4-*d*]-4-oxazolines are isolated directly, indicating the aziridine is readily hydrolyzed to provide sufficient primary amine.

A control decomposition of **2***a* in dry acetonitrile at 50° (*i.e.* at a temperature below that at which the 2–3 aziridine bond suffers cleavage indicated by the lack of equilibration of the recovered aziridine) gave rise only to products of hydrolysis, *i.e.* **6** and **9** and not to those of cycloaddition **3**, **4**, and **8**. This suggests, but does not prove, that the primary products of hydrolysis arise from the aziridinium ion **14** and not from the azomethine ylide. Also since it has been shown that the *cis*-azomethine ylide equilibrates rapidly to the *trans* form prior to cycloaddition to form **3**, **4**, and presumably **18**, then the differences in the nature and distribution of the products from *cis*- and *trans*-aziridines result mainly from hydrolysis at the aziridine stage.

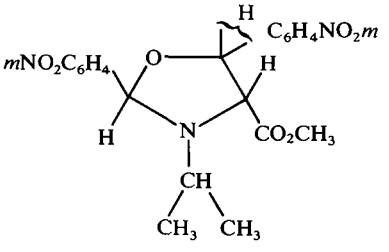
Precedents exist for differences in the preferred position of attack and rates of hydrolysis of *cis–trans* pairs of aziridines (18, 21). For example in the case of 1-benzyl-3-*p*-toluoyl-2-phenylaziridine, whereas the *trans* gave rise to hydrolysis at both positions to approximately equal extents, the *cis* isomer resulted in nucleophilic cleavage at C-3 only. In the present work, the *cis*-3-benzoylaziridine shows a marked preference for hydrolytic cleavage at C-2 leading to *ca.* 10 times as much oxazolidine (via *m*-nitrobenzaldehyde) as for the *trans* isomers.

A different situation obtains in the case of 3-carbomethoxyaziridines. Aziridine **1***b*, upon refluxing in acetonitrile, afforded a mixture of three stereoisomeric oxazolidines **20***a*, *b*, and *c*, and methyl *N*-isopropylglycine isolated as the acid. Compounds **20***a*, *b*, *c* were separable and were found in the ratio of 58:35.5:6.5 (*a*:*b*:*c*). Their structures as oxazolidines were proven by independent reaction of the *cis*- or *trans*-aziridines with *m*-nitrobenzaldehyde which afforded **20***a*, *b*, and *c* in virtually the same proportion 54:39:7.0 (*cis*) and 52:40:8.0 (*trans*). The orientation of addition of the aldehyde to the intermediate azomethine ylides was established unambiguously as before by specific deuterium labelling at the 3-position of the aziridine. The fact that all three oxazolidines correspond to the same orientation of addition of the aldehyde requires that in this instance both *cis*- and *trans*-azomethine ylides have been trapped (see below for supporting evidence). The same series of product oxazolidines **20***a*, *b*, and *c* in virtually the same ratio 55:37.5:7.5 are also obtained from **2***b*, implying that the *m*-nitrobenzaldehyde produced by hydrolysis of the aziridines adds to an equilibrium mixture containing both *trans*- and *cis*-azomethine ylides.

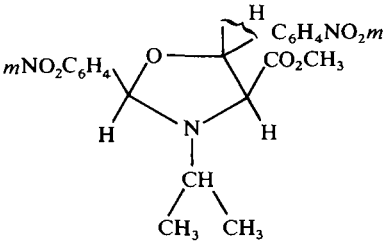
The compounds **20***a*, *b*, and *c* did not epimerize upon separate refluxing in acetonitrile with either an equivalent of the corresponding aziridine or isopropylamine, *i.e.* under the conditions of their formation. This confirms that the ratio of products observed is derived by the addition of *m*-nitrobenzaldehyde to the equilibrium mixture of ylides.

The configurational assignments with respect to the aziridine moiety in **20***a*, *b*, and *c* were established by experiments in which aziridines **1***b* and **2***b* were respectively treated with a large excess of *m*-nitrobenzaldehyde to trap the predominant ylide prior to complete equilibration. The pure *trans*-aziridine with 10.5 equiv of *m*-nitrobenzaldehyde in acetonitrile at 115–117° afforded **20***a*, *b*, and *c* in a ratio of 20.5:18:61.5 confirming that **20***c* arises from the predominant *cis*-azomethine ylide.

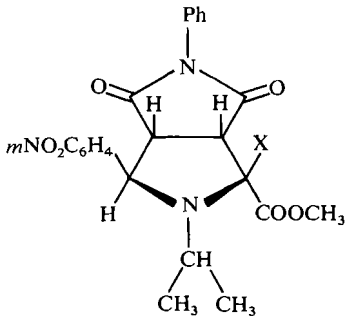
Similarly the pure *cis*-aziridine reacted with 7.5 *M* equiv of *m*-nitrobenzaldehyde to give



20*a* and *b*



20*c*



21
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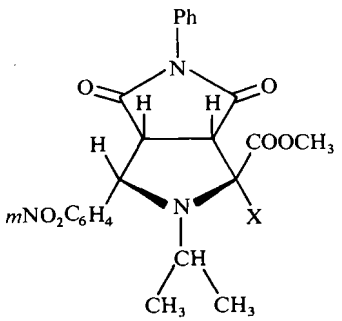
b X = D



22
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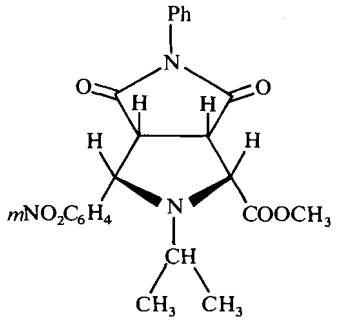
b X = D



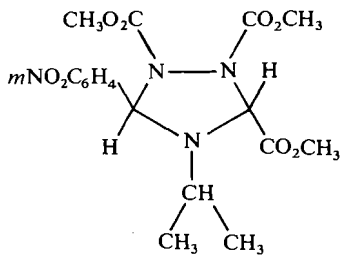
23
a X = H
b X = D

20*a*, *b*, and *c* in the proportion 60:40:0 with no **20***c* detectable. This proves that like **3***a* and **4***a*, both **20***a* and *b* arise from the more stable *trans*-azomethine ylide. A constant orientation of addition of the aldehyde having been established by deuterium labelling, this requires **20***a* and *b* to differ only in the mode of addition of the aldehyde. However the n.m.r. evidence does not allow a distinction between the *trans–cis* and *trans–trans* structures for **20***a* and *b*. Aziridine **1***b* reacted with *N*-phenylmaleimide in refluxing acetonitrile to give a mixture of the two pyrrolidines **21***a* and **22***a* in a ratio of 63:37. The isomeric **2***b* in contrast gave **21***a*, **22***a*, and **23***a* in a ratio of 54:40:6 indicating a small amount of the *cis*-azomethine ylide has been captured.

The n.m.r. line assignments of the methine protons were proven by deuterium labelling at the 3-position of the aziridine ring from which the stereochemical assignments could be made unambiguously. The major product in each case **21***a* corresponded in structural type to that of the sole products **10** and **11***a* obtained from the 3-aroylaziridines. Thus the *N*-phenylmaleimide is only marginally successful in suppressing the equilibration to the *trans*-azomethine ylide. The more reactive dipolarophile dimethyl azodicarboxylate with **1***b* in equimolar proportion gave a mixture of the stereoisomeric triazolidines **24** and **25** in a ratio of 62:38. An experiment performed with 3 equiv of the dipolarophile and **1***b* now gave **24**:**25** in a ratio of 82:18 showing as the concentration of the dipolarophile is increased more of the orbital symmetry controlled *trans*-azomethine ylide is trapped, proving **24** has the stereochemistry shown. Reaction of **2***b* with 1 equiv of dimethyl azodicarboxylate gave **24** and **25** in a ratio of 43:57 while an experiment using 3 equiv of the dipolarophile gave **24** and **25** in a ratio of 25:75. This similarly confirms **25** as having the *cis* geometry of the aziridine moiety.

Control reactions were carried out involving reaction of **1***b* and **2***b* separately with one added equivalent of water in acetonitrile at 115–117° for 24 h. Identical results were obtained, *i.e.* all three stereoisomeric oxazolidines **20***a*, *b*, and *c* were obtained in the proportion of 26:20:54 together with some *m*-nitrobenzaldehyde.

In contrast to the case of the 3-benzoylaziridines stringent exclusion of water from the system succeeded in suppressing the hydrolysis



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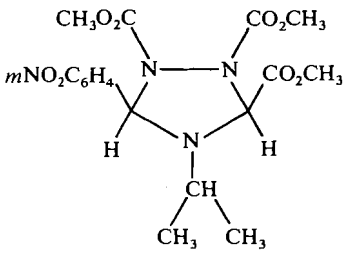

25

of the ester aziridines to a great extent. After 24 h refluxing of the *trans* ester aziridine in dry acetonitrile only 15% decomposition occurred whereas the recovered 85% of aziridine had equilibrated to give a *cis–trans* mixture of 63:37, *i.e.* virtually identical with the equilibrium composition obtained in toluene 64:36. Identical results were obtained starting with pure **1***b*. These results are consistent with the scheme in that decomposition of the ester aziridine, since it does not involve autocatalytic condensations and decompositions, is entirely dependent on adventitious moisture. Hydrolysis is therefore slower than for the aroylaziridines, allowing prior equilibration of the stereoisomeric aziridines and accounting for the identity of the products from **1***b* and **2***b* in contrast to the case of **1***a* and **2***a*. Hydrolysis is also more selective in **1***b* and **2***b* than in **1***a* and **2***a* occurring exclusively at the 2-position of the former.

Experimental

Melting points were determined on a Fisher–Johns apparatus and are uncorrected. The i.r. spectra were recorded on a Perkin–Elmer model 421 spectrophotometer, and only the principal, sharply defined peaks are reported. The n.m.r. spectra were recorded on Varian A-60 and A-100 analytical spectrometers. The spectra were measured on approximately 10–15% (W/V) solutions in $CDCl_3$, with tetramethylsilane as a standard. Line positions are reported in p.p.m. from the reference. Mass spectra were determined on an Associated Electrical Industries MS-9 double focusing high resolution mass spectrometer. The ionization energy, in general, was 70 eV. Peak measurements were made by comparison with perfluorotributylamine at a resolving power of 15 000. Kieselgel DF-5 (Camag, Switzerland) and Eastman Kodak precoated sheets were used for t.l.c. Microanalyses were carried out by Dr. C. Daesslé, Organic Microanalysis Ltd., Montreal, Quebec and by Mrs. D. Mahlow of this department.

General Preparation of 3-Aroylaziridines

The 3-aroylaziridines used in this study were prepared by the Gabriel synthesis involving Claisen–Schmidt condensations to form chalcones, addition of bromine to form the dibromochalcones, and treatment of the dibromochalcones with an excess of a primary aliphatic amine to provide 3-aroylaziridines (29).

Synthesis of cis- and trans-Methyl 1-Isopropyl-2-(m-nitrophenyl)-3-aziridinecarboxylate (1b, 2b)

(a) Methyl 2,3-Dibromo-3-(m-nitrophenyl)propionate

This compound, m.p. 87–89°, was obtained in 90% yield by the bromination of methyl *m*-nitrophenyl cinnamate in chloroform.

Anal. Calcd. for $C_{10}H_9Br_2NO_4$ (mol. wt. 364.8888): C, 32.71; H, 2.47; N, 3.81; Br, 43.57. Found (364.8898, mass spectrum): C, 32.89; H, 2.50; N, 3.75; Br, 43.63.

The n.m.r. spectrum δ_{TMS} ($CDCl_3$): 3.92 (s, 3H, CO_2CH_3); 4.83 and 5.43 (d each, 1H, $J = 12.5$ Hz, C_2H and C_3H respectively). The i.r. spectrum ν_{max} ($CHCl_3$): 1745 (C=O); 1525 and 1350 cm^{-1} (NO_2).

(b) Methyl α-Bromo-m-nitrophenylcinnamate

Dehydrohalogenation of methyl 2,3-dibromo-3-(*m*-nitrophenyl)propionate with potassium acetate in refluxing methanol for 18 h gave methyl α-bromo-*m*-nitrophenyl cinnamate in 90% yield, m.p. 97–98.5°.

Anal. Calcd. for $C_{10}H_8BrNO_4$ (mol. wt: 284.9636): C, 42.0; H, 2.85; N, 4.88; Br, 28.30. Found (284.9630, mass spectrum): C, 41.87; H, 3.10; N, 4.81; Br, 28.17.

The n.m.r. spectrum δ_{TMS} ($CDCl_3$): 3.91 (s, 3H, CO_2CH_3); 7.44–8.63 (m, 5H, aromatic protons).

(c) cis- and trans-Methyl 1-Isopropyl-2-(m-nitrophenyl)-aziridine-3-carboxylate

A solution of 18.25 g (0.05 mol) of methyl 2,3-dibromo-3-(*m*-nitrophenyl)propionate in 50 ml of dry benzene containing 17.7 g (0.3 mol) of isopropylamine was stirred at room temperature for 24 h. The reaction mixture was diluted with ether, the precipitated salt collected, and the filtrate washed with water. Removal of the solvent *in vacuo* gave a red oil trituration of which with methanol precipitated pure *trans*-methyl 1-isopropyl-2-(*m*-nitrophenyl)aziridine-3-carboxylate (**2***b*) 6.2 g (48.1% yield), m.p. 87–88.5°.

Anal. Calcd. for $C_{13}H_{16}N_2O_4$ (mol. wt. 264.1110): C, 59.09; H, 6.10; N, 10.57. Found (264.1108, mass spectrum): C, 58.84; H, 6.23; N, 10.23.

The n.m.r. spectrum δ_{TMS} ($CDCl_3$): 1.04, 1.16 (2d, 6H, $J = 6.5$ Hz, $CH(CH_3)_2$); 2.74 (d, 1H, $J = 2.5$ Hz, C_3H); 3.02 (m, 1H, $J = 6.5$ Hz, $CH(CH_3)_2$; 3.33 (d, 1H, $J = 2.5$ Hz, C_2H); 3.79 (s, 3H, CO_2CH_3); 7.35–8.22 (m, 4H, aromatic protons). The i.r. spectrum ν ($CHCl_3$): 1725 (C=O); 1525 and 1343 cm^{-1} (NO_2).

The methanol extract was evaporated and the remaining oil was diluted with benzene–hexane (40:60). Chilling of the solution produced a low melting solid which was recrystallized twice from benzene–hexane to give the pure methyl *cis*-1-isopropyl-2-(*m*-nitrophenyl)aziridine-3-carboxylate (**1***b*) 3.2 g (24.2% yield), m.p. 52–53.5°.

Anal. Calcd. for $C_{13}H_{16}N_2O_4$ (mol. wt. 264.1110): C, 59.09; H, 6.10; N, 10.57. Found (264.1110, mass spectrum): C, 58.82; H, 6.14; N, 10.73.

The n.m.r. spectrum δ_{TMS} ($CDCl_3$): 1.25 (d, 6H, $J = 5.2$ Hz); 1.96 (m, 1H, $CH(CH_3)_2$); 2.61 (d, 1H, $J = 6.5$ Hz, C_3H); 3.06 (d, 1H, $J = 6.5$ Hz, C_2H); 3.49 (s, 3H, CO_2CH_3); 7.25–8.33 (m, 4H, aromatic). The i.r. spectrum ν ($CHCl_3$): 1730 (CO); 1520 and 1342 cm^{-1} (NO_2).

(d) cis- and trans-Methyl 1-Isopropyl-2-(m-nitrophenyl)-3-deuteroaziridine-3-carboxylates

These compounds were prepared by reaction of methyl α-bromo-β-(*m*-nitrophenyl)cinnamate with a 15 fold excess of isopropylamine-*N*-d_2 in ether. The isomeric aziridines were isolated as described above. The integrals of the ring proton spectra indicated 82% deuterium incorporation at C-3.

Thermal Decomposition of cis-3-Benzoyl-1-isopropyl-2-(m-nitrophenyl)aziridine (1a) in Acetonitrile

(a) At Reflux

A solution of 0.932 g (3 mmol) of the pure *cis*-aziridine **1***a* in 50 ml of dry acetonitrile was heated under reflux for 24 h. Removal of the solvent *in vacuo* and trituration of the residue with methanol deposited a white crystalline solid,

TABLE 1. Cycloaddition adducts of aziridines

Adduct no.	Melting point (°C)	Yield (%)	Found C	Found H	Found N	Found Molecular ion (mass spectrum)	Calculated C	Calculated H	Calculated N	Calculated Molecular ion (mass spectrum)
3	158–162	12	—	—	—	310.1321*	—	—	—	310.1317*
4	138–140	44	65.24	4.88	9.47	310.1314*	65.08	4.99	9.11	310.1317*
10	248–249	90	69.20	5.42	8.77	483.1790*	69.55	5.21	8.68	483.1794
11	197–198	91	71.11	5.57	8.23	523.2100	71.10	5.57	8.02	523.2107
12	148–149	50	67.21	5.21	8.37	350.1632*	67.10	5.42	8.41	350.1632*
13*a*	138–139.5	90	62.13	6.56	10.61	419.1935†	61.82	6.15	10.68	419.1931†
13*c*	110–112	89	59.14	5.82	11.66	379.1610†	59.48	5.78	11.56	379.1618†
13*d*	163–164.5	51	66.20	5.08	9.44	475.1610†	66.19	4.86	9.64	475.1618†
20*a,b*	114–115.5	34	57.73	5.11	10.03	415.1374	57.82	5.09	10.11	415.1386
20*a,b*	Liquid		57.62	5.17	10.29	415.1381	57.82	5.09	10.11	415.1386
20*c*	110–112	5	57.78	5.11	10.12	415.1384	57.82	5.09	10.11	415.1386
21	169–171	62	63.13	5.61	9.30	437.1587	63.15	5.25	9.60	437.1586
22	139–140	37	63.08	5.47	9.41	437.1582	63.15	5.25	9.60	437.1586
23	117–119	6	63.21	5.63	9.29	437.1584	63.15	5.25	9.60	437.1586
24	112–113.5	57	49.90	5.42	13.71	410.1459	49.75	5.40	13.65	410.1438
25	105–107	35	49.87	5.28	13.54	410.1439	49.75	5.40	13.65	410.1438

*Parent molecular ion minus *m*-nitrobenzaldehyde ion.
†Parent molecular ion minus benzoyl.

m.p. 148–153°. The t.l.c. and n.m.r. analyses confirmed the presence of the two stereoisomeric oxazolidines **3***a* and **4***a* (80:20), 0.386 g (56% yield).

The solid was subjected to chromatography on 50 g of BDH alumina. Elution with benzene–hexane (40:60) gave a fraction (100 mg) consisting of a 70:30 mixture of **3***a*:**4***a* which crystallized from methanol as a white solid, m.p. 159–162.5°.

Mol. Wt. Calcd. for $C_{25}H_{23}N_3O_6$ (base peak $C_{25}H_{23}N_3O_6$—$C_7H_5NO_3$): 310.1317. Found (mass spectrum): 310.1321.

The n.m.r. spectrum ($CDCl_3$) δ_{TMS} major component (**3***a*) 0.92 (2d, 6H, $CH(CH_3)_2$, $J = 6.5$ Hz); 3.33 (m, 1H, $CH(CH_3)_2$); 5.70 (ABq, 2H, $J = 6.2$ Hz, C_4H and C_5H); 6.30 (s, 1H, C_2H); and 7.18–8.62 (m, 13H, aromatic). The i.r. spectrum ($CHCl_3$) 1667 (C=O), 1530 and 1350 cm^{-1} (NO_2).

Further elution with benzene gave a second fraction (260 mg) of pure **4***a* which crystallized from methanol, m.p. 139–140.5°.

Anal. Calcd. for $C_{25}H_{23}N_3O_6$ (base peak $C_{25}H_{23}N_3O_6$—$C_7H_5NO_3$ = 310.1317): C, 65.08; H, 4.99; N, 9.11. Found (310.1314, mass spectrum): C, 65.24; H, 4.88; N, 9.47.

The n.m.r. spectrum ($CDCl_3$) δ: 1.16 (d, 6H, $CH(CH_3)_2$, $J = 6.5$ Hz); 3.26 (m, 1H, $CH(CH_3)_2$); 4.66 (d, 1H, $J = 6.0$ Hz, C_4H); 5.57 (d, 1H, $J = 6.0$ Hz, C_5H); 6.24 (s, 1H, C_2H); and 7.12–8.64 (m, 13H, aromatic). The i.r. spectrum ν ($CHCl_3$): 1664 (C=O), 1527 and 1345 cm^{-1} (NO_2).

The original filtrate was evaporated and the residue subjected to chromatography on 50 g of BDH alumina. Elution with hexane–benzene (25:75) gave 1,6-diisopropyl-3,6-diphenyl-1,2-dihydropyrazine **5**, 0.043 g (10% yield). The n.m.r. and i.r. spectra of this material were superimposable with those of the independently synthesized material (see below).

Further elution of the column with benzene gave *N*-(isopropyl)phenacylamine **6**, 0.107 g (20% yield), m.p. 71–74°. The n.m.r. and i.r. spectra of this material were superimposable with those of an authentic sample of *N*-(isopropyl)phenacylamine (see below).

Further elution with benzene–chloroform (60:40) gave a red oil, 0.132 g. This basic nitrogen-containing fraction is as yet unidentified but the n.m.r. spectrum shows δ_{TMS} ($CDCl_3$): 1.01–1.86 (m, 6H, $CH(CH_3)_2$); 4.73 (s, 2H); 5.12–5.45 (b, 2H; exchangeable by D_2O, NH_2?); and 7.04–8.35 (m, 12H aromatic).

(b) At 50 ± 1°

A solution of 0.622 g (2 mmol) of the aziridine **1***a* in 40 ml of acetonitrile was heated at 50 ± 1° for 24 h. Removal of the solvent *in vacuo* gave a light orange oil which was subjected to chromatography on 75 g of BDH alumina. Elution with hexane–benzene (75:25) gave some unreacted *cis*-aziridine, 0.341 g (55% yield).

Further elution with hexane–benzene (50:50) gave *m*-nitrobenzaldehyde as an oil which solidified on standing 0.097 g (32% yield), m.p. 51–53°. The n.m.r. and i.r. spectra of this material were superimposable with those of an authentic sample.

Continued elution with benzene gave *N*-(isopropyl)-phenacylamine **6** as an orange oil 0.124 g (35% yield). This material was identical with an authentic sample.

Thermal Decomposition of cis-3-Benzoyl-1-cyclohexyl-3-deutero-2-(m-nitrophenyl)aziridine in Acetonitrile

A solution of 0.350 g (1 mmol) of the labelled aziridine (54% deuterium) in 50 ml of acetonitrile was heated under reflux for 24 h. Work-up of the reaction mixture as described above gave **12***b*, 0.132 g (52.8% yield) of 4-benzoyl-3-cyclohexyl-3-deutero-2,5-di(*m*-nitrophenyl)oxazolidine, m.p. 147–149°.

The n.m.r. spectrum δ_{TMS} ($CDCl_3$): 0.83–2.20 (m, 10H,

cyclohexyl CH_2); 2.51–3.17 (m, 1H, cyclohexyl CH); 4.74 (d, 0.57 H, $J = 7$ Hz, C_4H); 5.47 (d, 1H, $J = 7$ Hz, C_5H); 6.23 (s, 1H, C_2H); and 7.25–8.53 (m, 13H, aromatic).

*Thermal Decomposition of trans-3-Benzoyl-1-isopropyl-2-(m-nitrophenyl)aziridine (**2a**) in Acetonitrile*

(a) At Reflux Temperature

A solution of 3.11 g (10 mmol) of the aziridine **2a** in 100 ml of acetonitrile was heated under reflux for 24 h. Removal of the solvent *in vacuo* gave an orange oil, which was subjected to chromatography on 160 g of BDH alumina. Elution with hexane–benzene (75:25) gave 1,6-diisopropyl-3,6-diphenyl-1,2-dihydropyrazine **5** as an oil which solidified on trituration with methanol to an orange solid, m.p. 82–84°, 0.201 g (12.5% yield). The identity of this material was established by comparison with an authentic sample (see below).

Further elution with hexane–benzene (50:50) gave *m*-nitrobenzaldehyde 0.095 g (6.3% yield) as an oil which solidified on standing 48–51°.

Continued elution with benzene gave light orange oil, 0.467 g (26.5% yield) which was identified as *N*-(isopropyl)-phenacylamine **6** by comparison with an authentic sample.

Further elution with benzene–chloroform (90:10) gave a mixture of the stereoisomeric oxazolidines **3a** and **4a** as a solid, m.p. 138–140.5°, 0.124 g (5.4% yield).

Continued elution with benzene–chloroform (75:25) gave a red oil, 0.341 g. This basic nitrogen-containing fraction is as yet unidentified but the n.m.r. spectrum shows δ_{TMS} ($CDCl_3$): 1.04–1.61 (m, 6H); 4.73 (s, 2H); 5.52–5.81 (b, 2H, exchangeable by D_2O, NH_2?).

Further elution with benzene–chloroform (50:50) gave 3,5-diisopropyl-2-(*m*-nitrophenyl)-4,6-diphenylpyrrolo-[3,4-*d*]-4-oxazoline **8** as an orange oil, 0.198 g (8.5% yield) which resisted crystallization. The identity of this compound was established by its independent synthesis by a previously described procedure from the reaction of the aziridine with phenylglyoxal and then treating the 1,3-dipolar addition product with isopropylamine (6).

Anal. Calcd. for $C_{29}H_{29}N_3O_3$ (mol. wt. 467.2209): C, 74.51; H, 6.21; N, 8.99. Found (467.2197, mass spectrum): C, 74.04; H, 6.41; N, 9.21.

The n.m.r. spectrum δ_{TMS} ($CDCl_3$): 1.01 (d, 6H, $CH(CH_3)_2$, $J = 6.0$ Hz); 1.22 (d, $CH(CH_3)_2$, $J = 6.0$ Hz); 2.81–3.22 (septet, 1H, $CH(CH_3)_2$); 3.93–4.21 (septet, 1H, $CH(CH_3)_2$); 6.85–8.03 (m, 15H, aromatic and C-2 proton). The i.r. spectrum ($CHCl_3$): 1530 and 1348 cm^{-1} (NO_2).

(b) At 50 ± 1°

A solution of 1.57 g (5 mmol) of the pure *trans*-aziridine **2a** in 50 ml of dry acetonitrile was heated at 50 ± 1° for 24 h. Removal of the solvent *in vacuo* gave an orange oil which was subjected to chromatography on 80 g of BDH alumina. Elution with hexane–benzene (25:75) gave some unreacted *trans*-aziridine **2a**, 0.98 g (62.5% yield). Further elution with hexane–benzene (50:50) gave *m*-nitrobenzaldehyde as a light yellow oil which solidified on standing, m.p. 53–54°, 0.160 g (20% yield). The n.m.r. and i.r. spectra of this material were superimposable with those of an authentic sample.

Further elution with benzene gave *N*-(isopropyl)phenacylamine **6** as a light orange oil, 0.214 g (24.5% yield) which on trituration with petroleum ether crystallized as yellowish-white needles, m.p. 72–74.5°. This material was identified by comparison with an authentic sample. The mass spectrum of this fraction also exhibits a peak at *m/e* 318 ascribed to 1,6-diisopropyl-3,6-diphenyl-1,2-dihydropyrazine **5** which is expected owing to the facile dimerization and rearrangement of *N*-(isopropyl)phenacylamine recorded below.

General Procedure for Preparation of 1,3-Dipolar Adducts in Acetonitrile

The reactions of aziridines with aldehydes to form oxazolidines and with *N*-phenylmaleimide and diethyl azodicarboxylate to form adducts were carried out according to established procedures. The analytical and spectral data on these compounds are summarized in Tables 1 and 2.

Control Attempted Epimerization/Exchange of 1,3-Dipolar Adducts

Experiments were performed with **12b**, **13a**, **13b**, **24**, and **25** in which solutions of 0.100 g of the adducts in 10 ml of acetonitrile were refluxed for 24 h in the presence of 1 equiv of the corresponding aziridine or primary amine. In all cases examination of the product by n.m.r. showed no detectable evidence of deuterium exchange or epimerization.

*Preparation of N-(Isopropyl)phenacylamine (**6**) and 1,6-Diisopropyl-3,6-diphenyl-1,2-dihydropyrazine (**5**)*

Isopropylamine (5.9 g, 10 mmol) was added to a cold ethereal solution of 10 g (5 mmol) of phenacyl bromide and the mixture allowed to react for 24 h. The precipitated salt was removed and the filtrate washed successively with 10% aqueous potassium carbonate solution, twice with cold water, and dried ($MgSO_4$). Removal of the solvent *in vacuo* afforded an orange oil. Trituration with methanol deposited 1,6-diisopropyl-3,6-diphenyl-1,2-dihydropyrazine (**5**) as an orange solid, m.p. 83–84.5°, 1.42 g (17.9% yield).

Anal. Calcd. for $C_{22}H_{26}N_2$ (mol. wt. 318.2096): C, 82.96; H, 8.22; N, 8.82. Found (318.2101, mass spectrum): C, 82.63; H, 8.14; N, 8.74.

The n.m.r. spectrum δ_{TMS} ($CDCl_3$): 0.79 (d, 3H, $CH(CH_3)_2$, $J = 6.5$ Hz); 1.31 (d, 3H, $CH(CH_3)_2$, $J = 6.5$ Hz); 2.90 (septet, 1H, $CH(CH_3)_2$); 6.81 (s, 1H, C-2 proton); 7.23–7.85 (m, 11H, aromatic and C-5 protons).

Concentration of the methanol filtrate left a red oil which on dilution with petroleum ether (30–60°) and chilling for 2 days deposited *N*-(isopropyl)phenacylamine **6**, m.p. 73–75.5°, 2.64 g (30% yield).

Mol. Wt. Calcd. for $C_{11}H_{15}NO$: 177.1154. Found (mass spectrum): 177.1157.

The i.r. spectrum ($CHCl_3$): 3410 (NH), 1658 cm^{-1} (C=O).

*Thermolysis of 1,6-Diisopropyl-3,6-diphenyl-1,2-dihydropyrazine (**5**)*

The dihydropyrazine **5** (0.500 g) was heated in a sealed tube at 280° for 1 h. The resulting red oil solidified on cooling and was taken up in chloroform. Removal of the solvent *in vacuo* and examination of the oil by n.m.r. revealed the presence of a small amount of unreacted 1,2-dihydropyrazine. The crude reaction mixture was subjected to sublimation at 80°/10 mm to give 2,5-diphenylpyrazine **17** as a light orange solid, m.p. 187–189° (lit. (26) m.p. 192–194°). The melting point of this material was not depressed by admixture with an authentic sample prepared by heating a solution of ω-aminoacetophenone hydrochloride (Aldrich Chemicals, Ltd.) and 10% aqueous potassium carbonate at 100° for 2 h according to a literature procedure (26).

TABLE 2. The n.m.r. data on adducts

Adduct	*N*-Substituent	Methine chemical shifts and coupling constants; TMS (δ)						
		C_2H	C_3H	C_4H	C_5H	$J_{2,3}$	$J_{3,4}$	$J_{4,5}$
3	1.16(6H) 3.26(1H)	6.24	—	4.66	5.57	—	—	6.0
4	0.93(6H) 3.33(1H)	6.30	—	5.70*	5.70*	—	—	6.2
10	0.87(6H) 2.83(1H)	5.59	3.92	3.42	5.25	8.2	9.5	5.0
11	0.53–2.03(10H) 2.12–2.74(1H)	5.59	3.93	3.37	5.30	8.5	9.5	4.5
12	0.83–2.20(10H) 2.50–3.16(1H)	6.23	—	4.74	5.47	—	—	7.0
13*a*	0.83–1.77(16H)† 2.84–3.34(1H)	—	6.22§	—	6.73	—	—	—
13*c*	0.99(12H) 3.42(1H)	—	6.16§	—	6.66	—	—	—
13*d*	0.99(6H) 3.48(1H)	—	6.36§	—	6.85	—	—	—
20*a,b*	1.06(6H) 3.34(4H)	6.10	—	4.57	5.71	—	—	5.0
20*a,b*	0.96(6H) 3.12(1H) 3.91(ester)	6.01	—	4.26	5.37	—	—	3.0
20*c*	1.13(6H) 3.25(1H) 3.78(ester)	5.93	—	3.75	5.12	—	—	7.0
21	1.05(6H) 2.88(1H) 3.70(ester)	4.59	3.85	3.33	4.93	8.5	10.0	5.5
22	1.07(6H) 2.98(1H) 3.76(ester)	4.65	4.12	3.40	5.15	—	10.0	9.5
23	1.06(6H) 2.97(1H) 3.83(ester)	4.17	3.47‡	3.47‡	4.54	8.5	—	9.5
24	1.16(6H) 3.08(1H) 3.77, 3.82 (ester)	—	5.71	—	5.83§	—	—	—
25	1.25(6H) 3.28(1H) 3.41, 3.68, 3.85 (ester)	—	5.07	—	6.12§	—	—	—

*AB quartet.
†Cyclohexyl and methyl protons of ester groups.
‡Multiplet with identical chemical shift.
§Broad.

Decomposition of cis-Methyl 1-Isopropyl-2-(m-nitrophenyl)-aziridine-3-carboxylate (1b) in Acetonitrile

A solution of 2.64 g (10 mmol) of the aziridine **1***b* in 100 ml of acetonitrile was heated at 115–117° in a pressure vessel for 24 h. Removal of the solvent *in vacuo* gave a red oil. The n.m.r. and t.l.c. analysis of the crude reaction mixture confirmed the formation of three products **20***a*, *b*, and *c* in the ratio of 58:35.5:6.5. Trituration of the oil with methanol

resulted in the precipitation of a solid **20***c* 0.104 g (5.1% yield), m.p. 110–112°.

Anal. Calcd. for $C_{20}H_{21}N_3O_7$ (mol. wt. 415.1386): C, 57.82; H, 5.09; N, 10.11. Found (415.1366, mass spectrum): C, 57.78; H, 5.11; N, 10.12.

The n.m.r. spectrum δ_{TMS} ($CDCl_3$): 1.13 (d, 6H, $J = 6.5$ Hz, $CH(CH_3)_2$); 3.25 (m, 1H, $CH(CH_3)_2$); 3.75 (d, 1H, $J = 7.0$ Hz, C_4H); 3.78 (s, 3H, OCH_3); 5.12 (d, 1H, $J =$ 7.0 Hz, C_5H); 5.93 (s, 1H, C_2H); and 7.02–8.63 (m, 8H, aromatic). The i.r. spectrum ν ($CHCl_3$): 1730 (C=O), 1525 and 1350 cm^{-1} (NO_2).

Concentration of the methanol filtrate left a red oil which was subjected to chromatography on 80 g of BDH alumina. Elution with benzene–hexane (60:40) gave a pale yellow oil, 1.07 g (51.5% yield) which on trituration with methanol – petroleum ether crystallized to give a white solid **20***a*, *b*, m.p. 114–115.5°.

Anal. Calcd. for $C_{20}H_{21}N_3O_7$ (mol. wt. 415.1386): C, 57.82; H, 5.09; N, 10.11. Found (415.1374, mass spectrum): C, 57.75; H, 5.11; N, 10.03.

The n.m.r. spectrum δ_{TMS} ($CDCl_3$): 1.06 (2d, 6H, $CH(CH_3)_2$, $J = 6.5$ Hz); 3.34 (m, 4H, $CH(CH_3)_2$ and CO_2CH_3); 4.57 (d, 1H, $J = 5.0$ Hz, C_4H); 5.71 (d, 1H, $J =$ 5.0 Hz, C_5H); 6.10 (s, 1H, C_2H); and 7.31–8.62 (m, 8H, aromatic). The i.r. spectrum ($CHCl_3$) ν ($CHCl_3$): 1730 (C=O); 1520 and 1350 cm^{-1} (NO_2).

Further elution with benzene gave light yellow oil of **20***a*, *b*, 0.627 g (30.2%), which resisted crystallization.

Anal. Calcd. for $C_{20}H_{21}N_3O_7$: (mol. wt. 415.1386): C, 57.82, H, 5.09; N, 10.11. Found (415.1391, mass spectrum): C, 57.61; H, 5.21; N, 9.98.

The n.m.r. spectrum δ_{TMS} ($CDCl_3$): 0.95 (2d, 6H, $CH(CH_3)_2$, $J = 6.2$ Hz); 3.12 (m, 1H, $CH(CH_3)_2$); 3.92 (s, 3H, CO_2CH_3); 4.25 (d, 1H, C_4H $J = 3.0$ Hz); 5.36 (d, 1H, C_5H, $J = 3.0$ Hz); 6.02 (s, 1H, C_2H); and 7.50–8.66 (m, 8H, aromatic). The i.r. spectrum ν ($CHCl_3$): 1727 (C=O), 1530 and 1345 cm^{-1} (NO_2).

Similarly the decomposition of *trans*-methyl 1-isopropyl-2-(*m*-nitrophenyl)-3-aziridine carboxylate **2***b* in acetonitrile gave the same compounds in the ratio of 55:37.5:7.5 by n.m.r. analysis.

Decomposition of trans-Methyl 1-Isopropyl-2-(m-nitrophenyl)aziridine-3-carboxylate (2b) in Acetonitrile

A solution of 1.34 g (5 mmol) of the aziridine **2***b* in 50 ml of acetonitrile was heated at 115–117° for 24 h. The bulk of the liquid was distilled into a flask containing 2 ml of concentrated hydrochloric acid. The distillate was allowed to evaporate at room temperature to give methyl *N*-isopropylglycine hydrochloride as a white solid, 0.187 g, m.p. 134–138°. The n.m.r. spectrum of this salt in deuterium oxide showed δ: 1.28 (d, 6H, $J = 6.0$ Hz, $(CH_3)_2CH$); 3.48 (septet, 1H, $(CH_3)_2CH$); 3.78 (s, ester); 3.89 (s, $CH_2CO_2CH_3$); 4.0 (s, CH_2CO_2H). The spectrum suggested that the methyl ester group had been partially hydrolyzed. The hydrolysis was completed by heating an acidified aqueous solution of the salt at 80° for 14 h. Removal of the solvent *in vacuo* gave a white solid which had an n.m.r. spectrum in deuterium oxide δ: 1.27 (d, 6H, $J = 6.0$ Hz, $(CH_3)_2CH$); 3.48 (septet, 1H, $(CH_3)_2CH$); 4.05 (s, 2H, CH_2CO_2H) which was superimposable with that of an authentic sample of *N*-isopropylglycine hydrochloride obtained by the reaction of equimolar quantities of chloroacetic acid and isopropylamine in ether.

Traces of acetonitrile were removed *in vacuo* from the distillation residue to give a mixture of the stereoisomeric oxazolidines **20***a*, *b*, and *c*.

Decomposition of trans-Methyl 1-Isopropyl-2-(m-nitrophenyl)aziridine-3-carboxylate (2b) in Acetonitrile with Water Added

A solution of 0.265 g (1 mmol) of the aziridine **2***b* and 18 mg (1 mmol) of water in 50 ml of acetonitrile was refluxed for 24 h. Removal of the solvent *in vacuo* gave an oil. The n.m.r. analysis of the crude reaction mixture showed the formation of all three oxazolidines **20***a*, *b*, and *c* in the ratio of 26:20:54, and that all the *m*-nitrobenzaldehyde had been trapped.

Thermal Decomposition of trans-Methyl 1-Isopropyl-2-(m-nitrophenyl)aziridine-3-carboxylate (2b) in Absolute Acetonitrile

A solution of 0.790 g (3 mmol) of the aziridine **2***b* in 50 ml of absolute acetonitrile (freshly distilled over calcium hydride) was heated at 115–117° in a sealed vessel for 24 h. Removal of the solvent *in vacuo* gave a red oil, n.m.r. analysis of which showed the isomeric aziridines **1***b* and **2***b* in a ratio of 63:37 to the extent of 85% yield and the oxazolidines **20***a* and *b* in a ratio of 60:40 in 15% yield.

Similarly thermal decomposition of **1***b* in absolute acetonitrile afforded the same products in virtually identical ratios.

In a separate control experiment both **1***b* and **2***b* equilibrated at the reflux temperature of toluene to give a mixture of **1***b*: **2***b* of (64:36).

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