LITERATURE CITED

1. V. I. Ivanskii, The Chemistry of Heterocyclic Compounds [in Russian], Moscow (1978), p. 392.
2. W. K. Hoga, US Patent No. 3148188; Chem. Abstr., 61, 13326 (1964).
3. U. Suminori and N. Hiokyo, Japanese Patent No. 6927588; Chem. Abstr., 72, 66965 (1970).
4. D. Leaver, J. Smoliez, and W. T. Stafford, J. Chem. Soc., 740 (1962).
5. N. V. Sumlivenko, E. A. Ponomareva, G. G. Dyadyusha, and G. F. Dvorko, Khim. Geterotsikl. Soedin., No. 8, 1078 (1975).
6. E. V. Kobylyanskii, I. M. Vasil'kevich, V. P. Tikhonov, and G. F. Dvorko, Zh. Org. Khim., 11, 726 (1975).
7. E. V. Kobylyanskii, I. M. Vasil'kevich, Yu. T. Gordash, and G. F. Dvorko, USSR Inventor's Certificate No. 540865; Byull. Izobr., No. 48 (1976).
8. E. V. Kobylyanskii, I. M. Vasil'kevich, and G. F. Dvorko, Khim. Geterotsikl. Soedin., No. 7, 996 (1975).
9. V. West (editor), Application of Spectroscopy in Chemistry [Russian translation], Inostr. Lit, Moscow (1959), p. 590.
10. J. A. Pople and G. A. Segal, J. Chem. Phys., 44, 3289 (1966).
11. L. E. Sutton and M. A. D. Phil, Tables of Interatomic Distances and Configurations in Molecules and Ions, London (1958).

AZIRIDINYL KETONES AND THEIR HETEROANALOGS.

5.* SYNTHESIS AND STRUCTURES OF 2-ARYL-3-AROYLAZIRIDINES

V. D. Orlov, F. G. Yaremenko,
and V. F. Lavrushin

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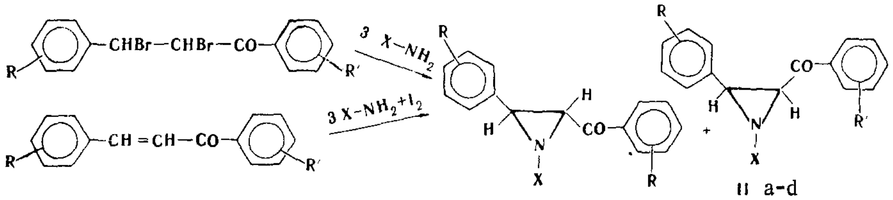
A number of trans- and cis-isomeric 1-R-2-aryl-3-aroylaziridines were synthesized, and their IR spectra were studied. Intramolecular hydrogen bonding is realized in the trans isomers when R = H, and they exist in the only possible conformation (intermediate between a gauche and a cisoid conformation). cis-Isomers II (R = alkyl) exist in solutions in the form of two conformers, viz., gauche and cisoid conformers, and the gauche conformer is thermodynamically preferable.

The chemistry of aziridinyl ketones has been the subject of many studies (for example, see review [2]). However, some problems relative primarily to NH compounds remain unsolved.

The present communication is devoted to a study of 2-aryl-3-aroyl-aziridines of the trans (I) and cis (II) series. Their synthesis was accomplished by the Gabriel–Cromwell method (by reaction of α, β-dibromochalcones with amines [3]) and by the Soutwick method (by reaction of chalcones with iodine and an amine [4]):



I a-m II a-d

(R, R', and X are indicated in Table 1)

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*See [1] for Communication 4.

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TABLE 1. trans- (Ia-l) and cis-Aziridinyl Ketones (IIa-d)

Compound	R[a]	R′	mp, °C	IR spectrum, cm^{-1}						N Found, %	Empirical formula	N calc., %	Yield, %
				KBr		CCl_4		$CHCl_3$					
				CO	NH	CO	NH	CO	NH				
Ia	H	H	101 (97—101) [15]	1663	3227	1676	3278	1673	3275				77
Ib[b]	H	4-Br	101—102	1659	3246	1675	3279	1671	3273	4,5	$C_{15}H_{12}BrNO$	4,6	73
Ic	4-Br	H	112	1681 1660	3225	1676	3274	1674	3271	4,4	$C_{15}H_{12}BrNO$	4,6	88
Id[b]	3-NO_2	H	119	1663	3276	1679	3279	1677	3279	10,3	$C_{15}H_{12}N_2O_3$	10,4	45
Ie	4-NO_2	H	142 (142—143) [15]	1666	3267	1678	3280	1673	3274				97
If	4-NO_2	4-CH_3	149—150	1658	3259	1669	3276	1669	3269	9,8	$C_{16}H_{14}N_2O_3$	9,9	54
Ig	4-NO_2	4-Cl	155—156	1668	3267			1675	3276	9,2	$C_{15}H_{11}ClN_2O_3$	9,3	57
Ih	4-NO_2	4-Br	156—157	1673	3274			1675	3275	7,9	$C_{15}H_{11}BrN_2O_3$	8,1	79
Ii	4-NO_2	4-C_6H_5	153—154	1662	3257			1670	3274	8,2	$C_{21}H_{16}N_2O_3$	8,1	73
Ij	4-NO_2	4-NO_2	161	1677	3262			1682	3276	13,5	$C_{15}H_{11}N_3O_5$	13,4	46
Ik	H	H	58—59 (59—62) [16]	1666	—	1673	—	1671	—				24
Il[b]	4-NO_2	H	127	1666	—	1676	—	1673	—	7,7	$C_{22}H_{18}N_2O_3$	7,8	38
Im	4-NO_2	H	117—118 (117—118) [15]	1677	—	1677	—	1676	—				82
IIa	H	H	103 108 [16]	1684	—	1675 1697	—	1655[c] 1688	—				44
IIb	H	H	89—90 (89—90) [7]	1683	—	1670 1698	—	1659 1690	—				70
IIc	4-NO_2	H	105—107	1680	—	1677 1693	—	1655[c] 1688	—	7,7	$C_{22}H_{18}N_2O_3$	7,8	34
IId	4-NO_2	H	104—105	1687	—	1669 1690	—	1665[c] 1693	—	9,0	$C_{18}H_{18}N_2O_3$	9,0	68

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[a] X = H for Ia-j, X = $CH_2C_6H_5$ for Ik,l and IIa,c, X = CH_3 for Im, and X = $CH(CH_3)_2$ for IIb,d. [b] These compounds are mentioned in the literature (Ib [16], Id [18], and Il [19]); however, their characteristics are not given. [c] Shoulder.

It was found that an NH aziridinyl ketone can be obtained in satisfactory yield only from chalcone by means of the Soutwick method. However, if the chalcone contains electron-donor substituents in the 4 position, rapid deamination of the resulting aziridine occurs under the reaction conditions. One should note the danger involved in these syntheses in connection with the possibility of explosion of the resulting nitrogen triiodide ammoniate, particularly in the case of only slightly soluble and unreactive nitro-substituted chalcones. However, this method can be used without substantial limitations for the syntheses of N-alkylaziridinyl ketones.

The synthesis of NH aziridinyl ketones from slightly soluble chalcone dibromides by the Gabriel—Cromwell method is hindered by the selection of the optimum solvent. The previously recommended dimethyl sulfoxide (DMSO) [5] and acetonitrile [6] were found to be unsuitable in our case. We obtained the best results when we used methanol—chloroform mixtures in ratios of 1:1-1:2 by volume.

In the case of the NH compounds trans isomers I are always the only reaction products. In the case of the N-alkylaziridinyl ketones the ratio of the trans and cis isomers I and II is determined by the solvent; the percentage of I is higher when the reaction is carried out in benzene, while the percentage of II is higher when the reaction is carried out in aqueous alcohol mixtures [2]. In addition, the fraction of the cis isomer increases as the volume of the N-alkyl substituent increases. Thus primarily trans isomer Il is obtained when X = CH_3, while primarily cis isomer IId is obtained when X = $CH(CH_3)_2$; this is probably due to stereochemical control of the reaction in the step involving Michael addition to the intermediate α-bromo-β-aminochalcone [7]. At the same time, the stereochemical result of the Gabriel—Cromwell reaction does not depend on the geometry of the starting α, β-dibromide.

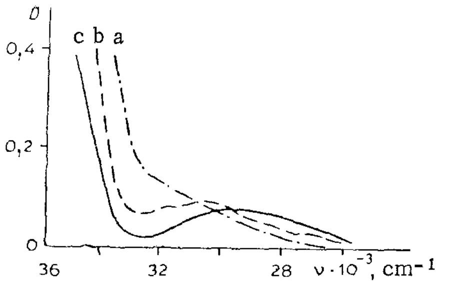

Fig. 1

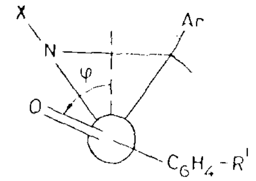

Fig. 2

Fig. 1. Bands of n–π* transitions of Ia in methanol (a) and isooctane (b) and of IIb in isooctane (c).
Fig. 2. Newman projection of 1-X-2-aryl-3-aroylaziridines.

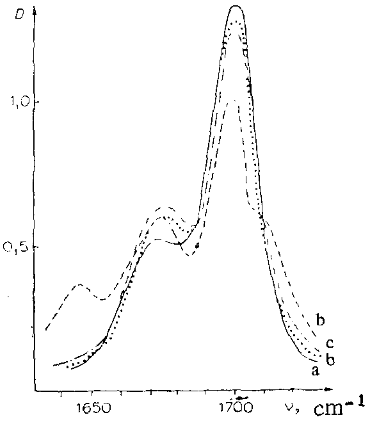

Fig. 3. IR spectra of IIb in tetrachloroethylene at 35, 49, 63, and 85°C.

The reliable assignment of the compounds obtained to the trans or cis series can be made on the basis of the spin–spin coupling constants (SSCC) of the protons of the three-membered ring: the J values for Ia–m are 2.3–2.5 Hz, as compared with 6.7–7.0 Hz for IIa–d. This assignment is also in agreement with the UV spectra, in which the intensity of the absorption band of the aroyl chromophore (272–283 nm in isooctane) is characteristic; it is always higher for the trans isomers.

An analysis of the IR spectra showed that one intense band (the doublet of bands in the spectrum of a KBr pellet of Ic is due in all likelihood to Fermi resonance) is observed for all trans compounds I, regardless of their phase state in the region of carbonyl absorption. This character of the spectra makes it possible to propose the existence of a single conformation for the trans-aziridinyl ketones. In the case of Ia–j (see Table 1) the ν_{NH} values were found to be sharply reduced as compared with ν_{NH} of 2-phenylaziridine 3328 cm^{-1}, 10^{-1} mole/liter, CCl_4 [8]). A change in the concentrations of the solutions from 10^{-1} to $5 \cdot 10^{-4}$ mole/liter does not affect ν_{NH} and $\nu_{C=O}$. The ν_{NH} values also remain unchanged when organic bases (acetone, DMSO, pyridine, and trimethylamine) are added. Thus the addition of an equimolar amount of triethylamine to Ia does not affect the integral intensity of the ν_{NH} band (it is equal to $2.45 \cdot 10^3$ liters/mole-cm^2).

The low sensitivity of Ia–j to intermolecular H complexing is confirmed by the UV spectra; a band of the n–π* type at 328–351 nm, which does not experience a hypsochromic shift on passing from isooctane to methanol and retains its vibrational structure (see Fig. 1), appears distinctly in them.

The facts set forth above make it possible to speak of the existence of a rather strong intramolecular hydrogen bond (IHB) in NH aziridinyl ketones Ia–j. The existence of an IHB is also confirmed by the PMR data [9].

It is apparent from Table 1 that the $\nu_{C=O}$ values are extremely close for the N–H and N-alkyl-substituted derivatives. In the light of the concepts regarding the existence of an

IHB in the N—H compounds, this fact seems anomalous. For its interpretation one should first of all examine the conformational state of the molecules. It has been assumed [10, 11] that the trans compounds, regardless of the X group, exist in a cisoid form, in which conjugation of the C=O group with the aziridine ring is manifested (the transoid form is rejected on the basis of an analysis of the steric hindrance). In our opinion, a conformation close to a cisoid conformation is observed only for N-alkyl derivatives. However, in the case of the NH compounds the cisoid form is unfavorable for the formation of an IHB, and the latter stabilizes the A conformation (see Fig. 2), which is intermediate between the gauche ($\varphi\sim 90°$) and cisoid ($\varphi\sim 0°$) forms. X-ray diffraction analysis of Ie confirmed precisely this conformation with $\varphi \sim 34°$.* Thus the $\nu_{C=O}$ values in the spectra of aziridinyl ketones Ia-j and Ik-m were found to be randomly close under the influence of various factors. This factor was discussed above for Ik-m. In the case of the NH compounds Ia-j the $\nu_{C=O}$ value is determined by intramolecular association. Suffice it to say that in the spectra of the gauche forms $\nu_{C=O}$ lies at 1690-1700 cm^{-1} (for example, see the $\nu_{C=O}$ values of the gauche forms of cis-aziridinyl ketones in Table 1 or of trans-2-aryl-3-aroyloxiranes in [12]).

The IR spectra of cis compounds IIa-d above all confirm the existence of two conformers in solutions. The equilibrium of the cisoid and gauche forms was discussed in [2, 11]. We solved the problem of the thermodynamic preferableness of one of the forms in the case of IIb by a study of the temperature dependence of the IR spectrum (at 35, 49, 63, 77, and 85°C) in tetrachloroethylene (see Fig. 3). The intensity of the low-frequency band corresponding to the cisoid conformer increases as the temperature is raised. The ratio of the cisoid and gauche forms was found to be 0.52 at 35°C and 0.71 at 77°C. The data on the temperature dependence also made it possible to make an approximate estimate of the energy barrier on passing from the cisoid to the gauche form. It was found to be $\sim$3 kcal (in these calculations [13] it was assumed that the integral intensities of the two forms are close). The experimental data obtained unambiguously confirmed the thermodynamic preferableness of the gauche form.

The appearance of a new carbonyl band at 1645 cm^{-1} at temperatures above 80°C was extremely interesting (Fig. 3). The band displays high sensitivity to a change in temperature. Thus rapid cooling of the solution leads to a sharp decrease in the intensity of this band; during this period the ratio of the intensities of the cisoid and gauche forms virtually does not have time to change. We feel that in this experiment we would in all likelihood be able to record the carbonyl absorption of the short-lived azomethine ylid that is formed in the thermal 1,3-dipolar opening of the aziridine ring. The isolation of 1-isopropyl-2-benzoyl-3,4-dichloro-5-phenylpyrrole (III), the formation of which is due to dehydrohalogenation of the product of the reaction of the ylid with the solvent, from a solution of IIb in tetrachloroethylene heated at 100°C for 2-3 h serves as a confirmation of this. The carbonyl absorption in the spectrum of III corresponds to the band at $\sim$1710 cm^{-1} (Fig. 3).

EXPERIMENTAL

The IR spectra were measured with a UR-20 spectrometer at a scanning rate of 10 cm^{-1}-min with slit program 3 and an absorbing-layer thickness of 0.1-1.0 cm. The PMR spectra were recorded with an XL-100 spectrometer (100 MHz) with tetramethylsilane as the internal standard. The UV spectra were measured with a Specord UV-vis spectrophotometer. Data on the chalcone dibromides are contained in [14]. The homogeneity of the aziridines obtained was monitored by thin-layer chromatography (TLC) on Silufol plates with elution with benzene—methanol (20:1).

trans-2-Phenyl-3-benzoylaziridine (Ia). A mixture of 7.0 g (0.019 mole) of chalcone dibromide in 100 ml of methanol and 45 ml of concentrated ammonium hydroxide was stirred for 7-10 h, and the resulting precipitate was removed by filtration and washed with 25% aqueous methanol to give 3.3 g (77%) of a product with mp 96°C. Crystallization from methanol gave colorless prismatic crystals of Ia with mp 101°C (repeated crystallization lowered the melting point to 96-98°C). PMR spectrum: 3.15 (2-H) and 3.46 ppm (3-H) ($J_{2,3}$ = 2.5 Hz). The yield of Ia decreased to 54% under the conditions of the Soutwick reaction [4].

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*This research was carried out jointly with Professor Z. Kaluski (Poznan University, Poland) and is currently in press.

trans-2-(4-Nitrophenyl)-3-(4-phenylbenzoyl)aziridine (Ii). Dry ammonia was passed for 1 h through a solution of 6.2 g (0.013 mole) of 4-nitro-4'-phenylchalcone dibromide in a mixture of 90 ml of chloroform and 70 ml of methanol in a Drexel trap, after which the reaction mixture was allowed to stand at 20°C for 1 h. It was then concentrated in vacuo to half its original volume, and the residue was placed in a refrigerator (at — 5°C) for 24 h. The precipitate was removed by filtration and washed with cold methanol to give 3.3 g (73%) of Ii with mp 148-149°C. Crystallization from methanol—chloroform (10:1) gave light-orange prisms with mp 154-155°C. PMR spectrum: 3.27 (2-H) and 3.52 ppm (3-H) ($J_{2,3}$ = 2.3 Hz).

trans-1-Methyl-2-(4-nitrophenyl)-3-benzoylaziridine (Ii). A suspension of 15 g (0.036 mole) of 4-nitrochalcone dibromide in 150 ml of methanol and 60 ml of a 30% aqueous solution of methylamine was stirred for 6 h, after which it was allowed to stand at 5°C in the dark for 2 days. The precipitate (6.7 g) was removed by filtration, and 150 ml of water was added gradually to the filtrate. An additional amount (3.0 g) of the substance was separated. Crystallization from methanol gave 8.4 g (82%) of colorless crystals of Ii with mp 117-118°C. PMR spectrum: 3.47 (2-H) and 3.58 ppm (3-H) ($J_{2,3}$ = 2.5 Hz).

cis-1-Isopropyl-2-(4-nitrophenyl)-3-benzoylaziridine (IId). A mixture of 18 g (0.043 mole) of 4-nitrochalcone dibromide in 200 ml of methanol and 60 ml of a 30% aqueous solution of isopropylamine was stirred at 20°C for 8 h, after which it was allowed to stand at 5°C for 2 days. Water (100 ml) was added gradually, and the precipitate (10.2 g) was removed by filtration and crystallized from methanol with charcoal to give 9.2 g (68%) of IId with mp 104-105°C. PMR spectrum: 3.24 (2-H) and 3.40 ppm (3-H) ($J_{2,3}$ = 2.5 Hz).

cis- and trans-1-Benzyl-2-(4-nitrophenyl)-3-benzoylaziridines (IIc and Il). A) A solution of 15 ml of benzylamine in 10 ml of benzene was added to a stirred solution of 9.6 g (0.038 mole) of 4-nitrochalcone and 9.6 g (0.038 mole) of iodine in 300 ml of benzene, and the mixture was stirred for 4 h and allowed to stand in the dark at 20°C for 2 days. The hydriodide salt of benzylamine [12.8 g (72%)] was removed by filtration, and the filtrate was washed to neutrality with water and dried with potassium carbonate. The benzene was evaporated in vacuo, and 20 ml of methanol was added to the residue. The mixture was allowed to stand in a refrigerator for 2 days and worked up to give 6.6 g (49%) of Il with mp 120-121°C. Crystallization from a mixture of chloroform with methanol gave pure Il with mp 127°C. PMR spectrum: 3.36 (2-H) and 3.51 ppm (3-H) ($J_{2,3}$ = 6.7 Hz).

The filtrate obtained after isolation of the trans isomer was evaporated in vacuo, and the resulting precipitate was dissolved in the minimum amount of hexane. Freezing out gave 3.8 g (28%) of cis isomer IIc with mp 96-99°C. Crystallization from methanol gave colorless crystals of IIc with mp 105-107°C. PMR spectrum: 3.52 (2-H) and 3.57 ppm (3-H) ($J_{2,3}$ = 2.5 Hz).

B) A 16-ml sample of benzylamine was added gradually at 20°C to a solution of 20 g (0.048 mole) of 4-nitrochalcone dibromide in 60 ml of benzene, and the mixture was allowed to stand for 24 h. After separation of the precipitated benzylamine hydrobromide [15.8 g (84%)], the filtrate was washed with water, dried, and concentrated to half its original volume. The concentrate was mixed with 15 ml of petroleum ether, and the mixture was cooled to −5°C to give 14.2 g of a precipitate, which was crystallized from methanol with charcoal to give 6.6 g (38%) of Il with mp 121-122°C.

The starting mother liquor was evaporated, and the residue was crystallized from hexane. Prolonged cooling gave 5.9 g (34%) of IIc with mp 99-101°C.

Compounds Il and IIc were further purified as in method A. 1-Isopropyl-2-benzoyl-3,4-dichloro-5-phenylpyrrole (III). A solution of 0.5 g (0.002 mole) of IIb in 25 ml of tetrachloroethylene was heated at 100°C for 2 h, after which it was cooled and worked up to give 0.13 g (19%) of III with mp > 200°C (dec.). IR spectrum (KBr): 1699 cm^{-1} (C=O). Found: Cl 19.7; N 4.0%. $C_{20}H_{17}Cl_2NO$. Calculated: Cl 19.8; N 3.9%.

LITERATURE CITED

1. V. D. Orlov, F. G. Yaremenko, N. N. Kolos, N. S. Pivnenko, and V. F. Lavrushin, Khim. Geterotsikl. Soedin., No. 4, 544 (1980).
2. N. H. Cromwell, Lect. Heterocycl. Chem., 3, 1 (1976).
3. N. H. Cromwell, Chem. Rev., 38, 83 (1946).
4. P. L. Soutwick and R. J. Shozda, J. Am. Chem. Soc., 82, 2888 (1960).

5. E. P. Styngach and A. A. Semenov, Izv. Akad. Nauk Moldavsk. SSR, Ser. Biol. Khim. Nauk, 62 (1975).
6. R. G. Kostyanovskii, V. F. Rudchenko, A. V. Prosyanik, M. D. Isobaev, I. I. Chervin, and V. I. Markov, Izv. Akad. Nauk SSSR, Ser. Khim., 628 (1977).
7. P. Tarburton, P. B. Woller, R. C. Badger, E. Doomes, and N. H. Cromwell, J. Heterocycl. Chem., 14, 459 (1977).
8. R. Martino, A. Secoches, A. Lattes, and R. Mathis-Noel, Compt. Rend., Ser. B, 270, 154 (1970).
9. V. D. Orlov, F. G. Yaremenko, Yu. N. Surov, and V. F. Lavrushin, Dokl. Akad. Nauk Ukr. SSR, Ser. B, No. 11, 932 (1979).
10. N. H. Cromwell, R. E. Bambury, and J. I. Adelfang, J. Am. Chem. Soc., 82, 4241 (1960).
11. P. Tarburton, L. J. Wolpa, R. K. Loerch, T. L. Folsom, and N. H. Cromwell, J. Heterocycl. Chem., 14, 1203 (1977).
12. V. D. Orlov, S. A. Korotkov, Yu. A. Sukach, and V. F. Lavrushin, Zh. Obshch. Khim., 43, 1353 (1973).
13. V. G. Orville-Thomas, The Internal Rotation in Molecules, Wiley-Interscience (1974).
14. V. D. Orlov, F. G. Yaremenko, Yu. N. Surov, and V. F. Lavrushin, Zh. Obshch. Khim., 49, 2602 (1979).
15. F. G. Weber and C. Bandlow, Z. Chem., 13, 467 (1973).
16. N. H. Cromwell, N. Barker, R. Wankel, P. Vanderhorst, F. Olson, and J. H. Anglin, J. Amer. Chem. Soc., 73, 1044 (1951).
17. G. Drefahl, K. Ponsold, and B. Schonecker, Ber., 97, 2014 (1964).
18. H. W. Heine, R. H. Weese, R. A. Cooper, and A. J. Durbetaki, J. Org. Chem., 32, 2708 (1967).
19. T. DoMinh and A. M. Trozzolo, J. Am. Chem. Soc., 94, 4046 (1972).

OPTICALLY ACTIVE 1-ALKOXY-2,2-BIS(TRIFLUOROMETHYL)AZIRIDINES*

R. G. Kostyanovskii, G. K. Kadorkina,
I. I. Chervin, Sh. S. Nasibov, and
S. V. Varlamov

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1-Alkoxy-2,2-bis(trifluoromethyl)aziridines containing an ester group in the α position of the alkoxy substituent undergo nucleophilic substitution (ammonolysis and hydrolysis) with retention of the aziridine ring. The corresponding carboxylic acids, which were separated to give the antipodes with an optical purity of 95% through the diastereomeric salts with R- and S-α-phenylethylamine, were obtained.

The configuration stability of 1-hydroxy-2,2-bis(trifluoromethyl)aziridine derivatives is sufficient for their existence in the optically active form under ordinary conditions ($\Delta G^{\neq}$ = 30 kcal/mole) [2]. However, their antipodes have not yet been isolated. Attempts to obtain their enantiomerically enriched arylsulfonates by partial asymmetric destruction by the action of an optically active amine [2, 3] and also by crystallization from optically active solvents [*l*-methyl lactate and (−)-α-pinene] were unsuccessful. Attempts at separation through the diastereomeric carbonates, which are formed in a ratio of 1:1 and are not separated by crystallization from alcohol (the *l*-methyl derivatives) and chromatography on silica gel (the *l*-methyl lactate derivatives), also did not give the desired results [2]. This can be explained by the considerable remoteness of the asymmetric centers (four bonds). In fact, when the latter are close together (up to two bonds) as in O-[2,2-bis(trifluoromethyl)-1-aziridino]lactamides, the racemic diastereomers are separated completely by one crystallization from benzene [1].

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*Communication 22 in the series "Asymmetric Unbridged Nitrogen." See [1] for Communication 21.

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