

SEPARATION OF *cis*- AND *trans*-ALKYL SUBSTITUTED OXIRANES AND AZIRIDINES

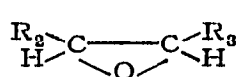
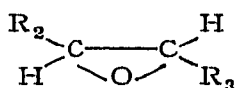
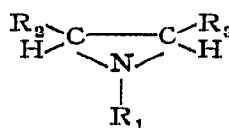
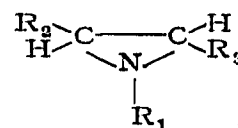
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INTRODUCTION

In connection with an investigation of the conformational equilibria¹ and stereochemistry of quaternization of aziridines^{2,3} a number of isomeric *cis*- and *trans*-oxiranes (I) and 1,2,3,-trialkyl aziridines (II) were required. While a stereospecific synthesis of many of these compounds can be carried out⁴, such preparations require

*cis*-I*trans*-I*cis*-II*trans*-II

pure *cis*- and *trans*-olefins which in many instances are difficult to obtain. Because of the utility of these compounds and derived quaternary aziridinium salts in synthetic and mechanistic studies we have investigated their chromatographic behavior with a view towards employing preparative scale gas chromatography. While there are scattered reports on the chromatographic properties of isomeric dialkyloxiranes⁵⁻⁷ and of a pair of 2,3-disubstituted aziridines⁸, such data have not been reported for uniform conditions of analysis. Until the present investigation no data have appeared on the elution characteristics of 1,2,3-trisubstituted aziridines. We therefore sought to determine the optimum conditions for preparative scale separation of the oxiranes and aziridines by using short narrow-bore columns since VERZELE and coworkers have shown that the sample size may be increased by an amount at least as great as an accompanying increase in column length⁹.

EXPERIMENTAL

The synthesis and properties of most of the oxiranes and aziridines have been described^{1,4}. The properties of *cis*- and *trans*-1,2-diisopropyl-3-methylaziridine, hitherto undescribed, are: *cis*, b.p. 136–138°, n_D^{25} 1.4106, d_4^{25} 0.7557; *trans*, b.p. 143–144°, n_D^{25} 1.4161, d_4^{25} 0.7704. The *trans* isomer could be readily converted to a white perchlorate salt, m.p. 162–164°. 1-*tert*-Butyl-2-methyl-3-ethylaziridine, iso-

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lated as an approximately 50:50 mixture of the *cis* and *trans* isomers, had b.p. 140–145°, n_D^{25} 1.4184. Satisfactory analyses were obtained for all new compounds, and their infrared and nuclear magnetic resonance spectra were completely compatible with the assigned structures.

The adjusted retention times ($t_{\text{compound}} - t_{\text{air}}$) were determined using a Wilkens Aerograph Model A-700 equipped with a thermal conductivity detector and a Leeds and Northup Speedomax H recorder. Helium was employed as a carrier gas, and flow rates were determined at the outlet with a soap bubble flowmeter. Unless otherwise indicated a sample size of 10 μ l was employed. All columns were of 6 mm O.D. copper tubing packed with 15% (w/w) liquid phase on 60/80 mesh Chromasorb W-HMDS. Columns were filled while being tapped vertically and were then coiled.

RETENTION DATA

The adjusted retention times of a number of isomeric oxiranes and aziridines on several columns are given in Table I. At a given temperature and flow rate better separations are obtained with di-*n*-decyl phthalate than with Dow 550 silicone fluid. Mixtures of these two liquid phases exhibit intermediate retention characteristics.

TABLE I
RETENTION TIMES OF OXIRANES AND AZIRIDINES

		Retention time (min) on column			
		A	B	C	D
2-Methyl-3-ethyloxirane	<i>cis</i>				
	<i>trans</i>		1.74		
2-Methyl-3- <i>n</i> -propyloxirane	<i>cis</i>	3.64	4.67	6.42	
	<i>trans</i>	3.01	3.88	5.38	
2-Methyl-3-isopropyloxirane	<i>cis</i>	2.35		4.20	
	<i>trans</i>	1.86	2.49	3.40	
2-Methyl-3- <i>tert.</i> -butyloxirane	<i>cis</i>	4.23	5.46	7.68	
	<i>trans</i>	2.56	3.48	5.00	
1,2-Dimethyl-3-ethylaziridine	<i>cis</i>				1.51
	<i>trans</i>	2.37			2.22
1,2-Dimethyl-3-isopropylaziridine	<i>cis</i>	1.98	2.53		1.74
	<i>trans</i>	3.08	3.80	4.83	2.97
1,2-Dimethyl-3- <i>tert.</i> -butylaziridine	<i>cis</i>	3.06			2.51
	<i>trans</i>	3.84			3.15
1- <i>tert.</i> -Butyl-2,3-dimethylaziridine	<i>cis</i>	—	—	—	—
	<i>trans</i>	3.64		3.17	
1- <i>tert.</i> -Butyl-2-methyl-3-ethylaziridine	<i>cis</i>	5.46	6.73	10.4	4.52
	<i>trans</i>	7.04	8.56	13.0	5.92
1,2-Diisopropyl-3-methylaziridine	<i>cis</i>	5.06	6.38		4.51
	<i>trans</i>	7.20	8.60		6.48
<i>n</i> -Hexylamine					7.13
Cyclohexylamine					10.2

Column A: 15% Dow 550 fluid, length 3 m, column temp. 97°, injection port temp. 140°, detector temp. 175°, flow rate 46 ml/min.

Column B: 10% Dow 550 fluid + 5% di-*n*-decyl phthalate, length 3 m, column temp. 102°, injection port temp. 136°, detector temp. 175°, flow rate 39 ml/min.

Column C: 15% di-*n*-decyl phthalate, length 3 m, column temp. 103°, injection port temp. 143°, flow rate 39 ml/min, detector temp. 175°.

Column D: 15% Amine 220, length 1.8 m, other conditions same as for C.

While *cis*-2,3-dialkyl substituted oxiranes exhibit longer retention times than the corresponding *trans* oxiranes, the reverse is true for the 1,2,3-trialkylaziridines. Significantly, when there is no substituent on nitrogen, *cis*-2,3-dialkyl substituted aziridines appear to have the longer retention times⁸.

Although the isomeric aziridines are well resolved with phthalate ester liquid phases, the retention times are relatively long. Furthermore, primary and secondary amines exhibit varying degrees of tailing which, in many cases, precludes the use of these columns for analysis and separation of complex mixtures. Unsatisfactory liquid phases which were tried include phenyl diethanolamine succinate, LAC-446 and Carbowax 20M. The use of alkaline-washed firebrick did not reduce the tailing significantly, contrary to observations made in the case of Chromasorb supports used for the separation¹⁰ of isomeric cyclohexylamines. It appears that much of the effect of alkaline-washed supports is in fact upon the liquid phase¹¹ since the use of basic packings such as polymerized aziridines¹¹ or *o*-toluidine¹² results in reduced tailing. The importance of using an inert support has been stressed by VERZELE⁹.

It appeared that basic amine liquid phases such as Armeen S.D. or Amine 220 on silanized Chromasorb would be particularly well suited for the separation of isomeric amines. Indeed, Amine 220 on Chromasorb W-HMDS was found to give particularly efficient separations of the isomeric aziridines. As may be seen from the

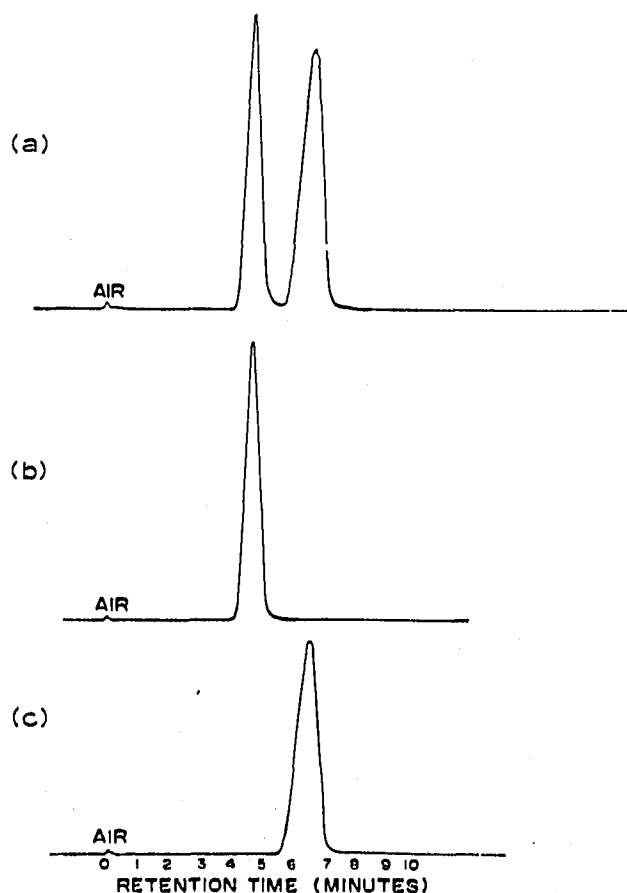


Fig. 1. Vapor phase chromatograms of *cis*- and *trans*-1,2-dimethyl-3-*tert.*-butylaziridine showing synthetic purity and peak shape. Experimental conditions: column used: 6 ft. \times $\frac{1}{4}$ in. Amine 220 on 60/80 Chromasorb W-HMDS; temperature: 98°; flow rate: 30 ml/min. Sample: (a) 10 μ l of *cis* and 10 μ l of *trans*; (b) 10 μ l of *cis*; (c) 10 μ l of *trans*.

data of Table I, good separations are achieved even with very short retention times on this column. Further, even primary amines exhibit nearly symmetric peaks when chromatographed on this column. In contrast to the behavior of a 3-m column packed with silicone 550, a 1.8-m column packed with Amine 220 was readily able to separate 50 μ l samples of the isomeric aziridines. *cis*- and *trans*-1-*tert*-butyl-2-methyl-3-ethylaziridine, which could not be separated on a spinning-band distillation column, were readily separated on the 1.8-m. Amine 220 column. While columns packed with Armeen S.D. were equally efficient in the separation of volatile isomeric amines, the high vapor pressure of the liquid phase above 80–100° greatly limits its utility. Columns packed with Amine 220 may be operated at 160–180° before the bleed-rate becomes large. The importance of the short retention times is stressed because this permits us not only to increase the length of the column but also to increase the percentage of the stationary phase in order to separate large samples and still not have excessive retention times.

As anticipated, the retention times of the individual isomers increase considerably when large samples of a 50:50 mixture of isomers are injected. The effect of sample size on peak front retention times is of interest in view of the recent findings by VERZELE and co-workers⁹ of an effective increase in column loading capacity resulting from retention effects on second peaks. As shown in Table II, even with this

TABLE II

SEPARATION OF *cis*- AND *trans*-1-*tert*-BUTYL 2-METHYL-3-ETHYL AZIRIDINE ON COLUMN D

Isomer	Sample size (μ l)	Retention time (min)	Peak front retention distance (mm)
<i>cis</i>	10	4.5	50
<i>trans</i>		5.9	67
<i>cis</i>	30	4.7	50
<i>trans</i>		6.3	69
<i>cis</i>	50	5.1	49
<i>trans</i>		7.1	72

short column there is an increase in the peak front retention distance of the second peak as the sample size is increased, but there is little effect on the first peak. This is accompanied by a transition of the peak shape from symmetrical to leading such as is found for type III isotherms. VERZELE has suggested that this is a consequence of temperature effects resulting from the condensation and evaporation of the individual bands. It is surprising to find that this effect is as important in short copper columns as in the glass columns used by those workers.

In view of the good separations and short retention times of isomeric oxiranes and aziridines observed in the course of the present study, preparative scale separations appear to be readily feasible. While quantities of up to 70 μ l have been separated on the columns described, it is anticipated that the use of instruments with automatic collection and injection capabilities together with long columns should permit the separation of large quantities of pure isomers from reaction mixtures obtained by reaction of commercially available mixtures of *cis/trans* alkenes.

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SUMMARY

The retention times of a number of *cis*- and *trans*-2,3-dialkyloxiranes (I) and 1,2,3-trialkylaziridines (II) on columns packed with di-*n*-decyl phthalate, silicone 550 fluid and Amine 220 on Chromasorb W-HMDS are given. The latter liquid phase was found to be particularly efficient in the separation of the volatile amines. *cis*-I exhibit longer retention times than *trans*-I, but *trans*-II exhibit longer retention times than the corresponding *cis*-II. The utility of preparative scale gas chromatography using long narrow-bore columns is discussed.

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