

CHROMATOGRAPHIC SEPARATION OF HOMOLOGUES, VINYLOGUES AND GEOMETRICAL ISOMERS OF SUBSTITUTED VINYL METHYL ETHERS

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INTRODUCTION

The formation of alk-1-enyl methyl ethers during gas-liquid chromatography (GLC) of dimethyl acetals (DMA) of fatty aldehydes and elucidation of their structure by infrared (I.R.) spectroscopy, mass spectrometry and chemical means was reported earlier from this laboratory¹. These substituted vinyl ethers, which are composed of almost equimolar proportions of *cis*- and *trans*-isomers, were separated by preparative argentation thin-layer chromatography (TLC) and characterized by infrared- and nuclear magnetic resonance (NMR) spectroscopy². A recent report by STEIN AND SLAWSON³ confirms conversion of DMA during GLC on some columns to the corresponding methyl-1-alkenyl ethers (both *cis*- and *trans*-configuration and/or parent aldehyde³).

The present communication describes TLC and GLC separations of homologues, vinylogues and geometric isomers of these substituted vinyl methyl ethers.

EXPERIMENTAL

Palmityl and stearyl aldehydes, as well as oleyl, elaidyl, linoleyl and linolenyl aldehydes were prepared as described earlier⁴. They were converted to dimethyl acetals by cold methylation technique⁵. The substituted vinyl methyl ethers were prepared by decomposition of the dimethyl acetals during GLC as described previously¹. The acetals were injected in 20–25 mg quantities and recovered as alk-1-enyl methyl ethers in 80–85% yields.

Separation of substituted vinyl methyl ethers by argentation chromatography was carried out on glass plates (20 × 20 cm) which were first coated with a well-stirred aqueous slurry of Silica Gel G to give a layer of approximately 250 μ in thickness. After air drying for 15 min and activating in an oven at 110° for 1 h the plates were cooled to room temperature and then impregnated with 95% aqueous methanol solution saturated with silver nitrate. These plates were subsequently activated at 110° for 2 ½ h. After spotting the substances the plates were developed with toluene. The substances were made visible by spraying with 50% aqueous sulphuric acid solution and subsequent charring for 10 min at 160° in an oven.

Separations by GLC were carried out on a Beckman GC-4 apparatus equipped with a 1/8 in. × 6 ft. aluminum column packed with 20% ethylene glycol succinate

containing 2% phosphoric acid on Gas-Chrom P, 80-100 mesh. The gas chromatograph was operated isothermally at 125° with helium as a carrier gas at a flow rate of 30 ml/min.

RESULTS

The separation of the homologues and vinylogues of the substituted vinyl methyl ethers into *cis*- and *trans*-isomers by argentation adsorption TLC is shown in Fig. 1. The *trans*-isomers show a higher R_F value than the corresponding *cis*-isomers.

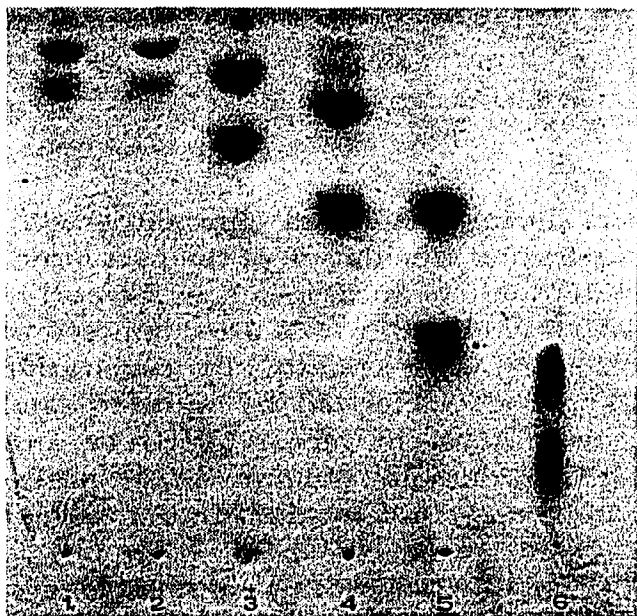


Fig. 1. Photograph of an argentation adsorption thin-layer chromatogram of substituted vinyl ethers. The plate was developed with toluene up to a distance of 14 cm. The components were visualized by spraying with 50% aqueous sulphuric acid and subsequent charring. 1 = Mixture of *cis*-1- and *trans*-1-hexadecenyl methyl ether; 2 = mixture of *cis*-1- and *trans*-1-octadecenyl methyl ether; 3 = mixture of *cis,trans*-1,9- and *trans,trans*-1,9-octadecadienyl methyl ether; 4 = mixture of *cis,cis*-1,9- and *trans,cis*-1,9-octadecadienyl methyl ether; 5 = mixture of *cis,cis,cis*-1,9,12- and *trans,cis,cis*-1,9,12-octadecatrienyl methyl ether; 6 = mixture of *cis,cis,cis,cis*-1,9,12,15- and *trans,cis,cis,cis*-1,9,12,15-octadecatetraenyl methyl ether.

The top fractions in 1 to 6 represent the *trans*-isomers and the corresponding bottom fractions represent the *cis*-isomers.

Here the following critical pairs will be formed if different homologues, vinylogues and their geometrical isomers of the substituted vinyl methyl ethers are spotted as a mixture:

- (1) *trans*-1-Hexadecenyl and *trans*-1-octadecenyl methyl ether.
- (2) *cis*-1-Hexadecenyl, *cis*-1-octadecenyl and *trans,trans*-1,9-octadecadienyl methyl ether.
- (3) *cis,cis*-1,9-Octadecadienyl and *trans,cis,cis*-1,9,12-octadecatrienyl methyl ether.
- (4) *cis,cis,cis*-1,9,12-Octadecatrienyl and *trans,cis,cis,cis*-1,9,12,15-octadecatetraenyl methyl ether.

The same substituted vinyl methyl ethers separate equally well during GLC into *cis*- and *trans*-isomers as shown in Fig. 2 (A-F). The chromatogram (Fig. 3B)

shows the separation of a mixture of *cis*-1- and *trans*-1-hexadecenyl, *cis*-1- and *trans*-1-octadecenyl-, *cis,cis*-1,9- and *trans,cis*-1,9-octadecadienyl, *cis,cis,cis*-1,9,12- and *trans,cis,cis*-1,9,12-octadecatrienyl, *cis,cis,cis,cis*-1,9,12,15- and *trans,cis,cis,cis*-1,9,12,15-octadecatetraenyl methyl ethers where only one critical pair results between *trans,cis*-1,9-octadecadienyl and *cis,cis,cis*-1,9,12-octadecatrienyl methyl ether (compare Fig. 3B with Fig. 2 (A-F)). When *cis,trans*-1,9- and *trans,trans*-1,9-octadecadienyl methyl ether is added to the above mixture and a gas chromatogram obtained (Fig. 3A) then two critical pairs result (compare Fig. 3A with Fig. 2 (A-F)), viz. (1) *cis,cis*-1,9- and *cis,trans*-1,9-octadecadienyl methyl ether and (2) *trans,cis*-1,9- and *trans,trans*-1,9-octadecadienyl and *cis,cis,cis*-1,9,12-octadecatrienyl methyl ether.

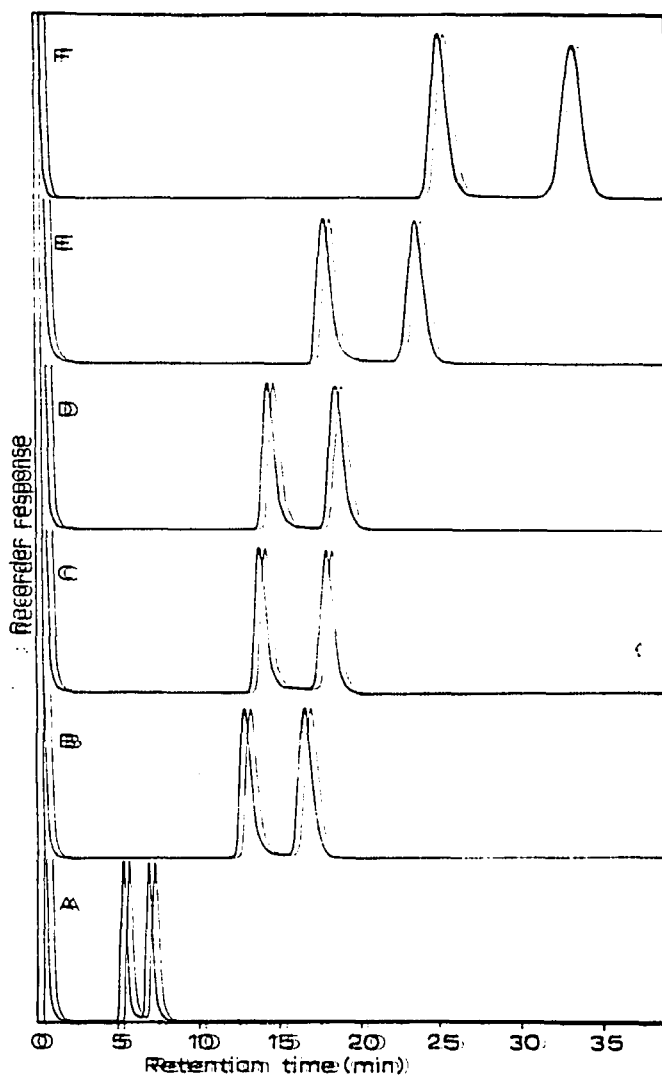


Fig. 2. Gas-liquid chromatography of substituted vinyl ethers on an ethylene glycol succinate-phosphoric acid column. A = Mixture of *cis*-1- and *trans*-1-hexadecenyl methyl ether; B = mixture of *cis*-1- and *trans*-1-octadecenyl methyl ether; C = mixture of *cis,trans*-1,9- and *trans,trans*-1,9-octadecadienyl methyl ether; D = mixture of *cis,cis*-1,9- and *trans,cis*-1,9-octadecadienyl methyl ether; E = mixture of *cis,cis,cis*-1,9,12- and *trans,cis,cis*-1,9,12-octadecatrienyl methyl ether; F = mixture of *cis,cis,cis,cis*-1,9,12,15- and *trans,cis,cis,cis*-1,9,12,15-octadecatetraenyl methyl ether. The fractions with smaller retention values in A to F represent the *cis*-isomers and the corresponding fractions with greater retention values represent the *trans*-isomers.

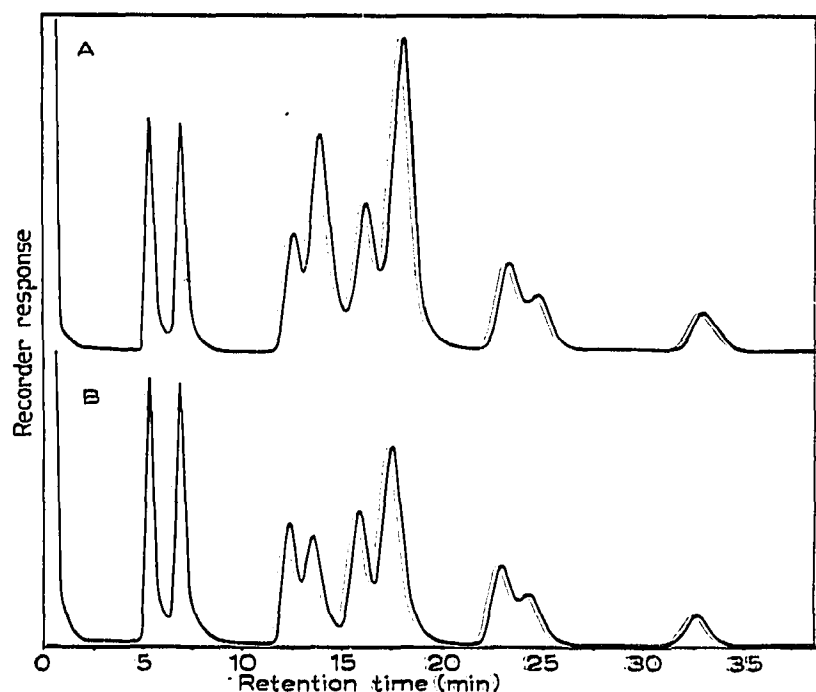


Fig. 3. (B) Gas-liquid chromatograph of alk-1-enyl methyl ethers on an ethylene glycol succinate-phosphoric acid column. Mixture of *cis*-1- and *trans*-1-hexadecenyl methyl ether; plus *cis*-1- and *trans*-1-octadecenyl methyl ether; plus *cis,cis*-1,9- and *trans,cis*-1,9-octadecadienyl methyl ether; plus *cis,cis,cis*-1,9,12- and *trans,cis,cis*-1,9,12-octadecatrienyl methyl ether; plus *cis,cis,cis,cis*-1,9,12,15- and *trans,cis,cis,cis*-1,9,12,15-octadecatetraenyl methyl ether. ((A) Same as in Fig. 3B with the addition of a mixture of *cis,trans*-1,9- and *trans,trans*-1,9-octadecadienyl methyl ether.

DISCUSSION

The separation by argentation adsorption thin-layer chromatography of substituted vinyl methyl ethers is entirely dependent upon the number and geometrical configuration of the double bonds per molecule, whereas the separation by gas-liquid partition chromatography on a polar phase is dependent not only on the unsaturation and its geometrical configuration in the molecule but also on the chain length of the molecule. Thus the first two critical pairs resulting on argentation adsorption thin-layer chromatography are separated by gas-liquid chromatography.

In argentation adsorption thin-layer chromatography the *trans*-isomers move ahead of the corresponding *cis*-isomers whereas in this gas-liquid chromatographic system the *trans*-isomers are eluted much later than the corresponding *cis*-isomers. However, in both systems the lower vinylogue is followed by its next higher vinylogue. This results in the critical pair formation between *cis*-isomers of lower vinylogue with the *trans*-isomer of next higher vinylogue in argentation adsorption thin-layer chromatography. This type of critical pair is completely separated in polar phase partition gas-liquid chromatography where a partial or complete overlapping takes place between the *trans*-isomers of lower vinylogue with the *cis*-isomers of the next higher vinylogue. Thus critical pairs resulting from argentation adsorption thin-layer chromatography get separated on polar-phase partition gas-liquid chromatography and vice-versa.

It is of interest to note the ease with which the geometrical isomers of vinyl ethers are separated on simple GLC columns whereas special columns^{6,7} are required to separate the geometrical isomers of fatty acid methyl esters.

WARNER AND LANDS⁸, while studying the rate of formation of the methyl α -chloroalkyl ether by gas-liquid chromatography, observed the formation of *cis*- and *trans*-isomers of methyl-1-dodecenyl ethers which also were easily separated. The decomposition they observed was attributed to thermal dehydrohalogenation.

The analysis of free or bound aldehydes as their dimethyl acetals by GLC resulted in their quantitative conversion to substituted vinyl ethers. These compounds might be used with advantage to characterize free and bound aldehydes in tissue lipids, in conjunction with other techniques such as reduction of the aldehydes to the alcohol or oxidation to the corresponding acids.

Preparative argentation adsorption chromatography has been also used by us to obtain pure *cis*- or *trans*-substituted vinyl ethers. The pure *cis*-isomers are of importance in the transesterification studies for the synthesis of neutral, as well as phospholipid plasmalogens. Our recent observations² of increasing the *cis* content in the mixture by using acetals containing higher alcohol homologues up to butyl and its subsequent catalytic decomposition to substituted vinyl butyl ethers hold promise for this type of investigation. It has so far been possible to increase the *cis* content from 50 to 80 %.

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SUMMARY

A combination of argentation adsorption thin-layer chromatography and polar phase partition gas-liquid chromatography has been developed to separate twelve components of homologues, vinylogues and geometrical isomers of alk-1-enyl methyl ethers in a mixture. Their usefulness in the plasmalogen analysis and synthesis has been suggested.

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