

CHROM. 11,566

## Note

### Direct gas chromatographic resolution of enantiomers on optically active mesophases

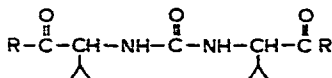
#### III. Further evidence for increased selectivity in the smectogeneous state of carbonyl-bis(amino acid esters)

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(Received October 25th, 1978)

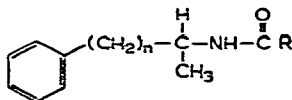
The separation of enantiomers by gas-liquid chromatography (GLC) on optically active stationary phases has been the subject of several reviews (see, for example, Lochmüller and Souter<sup>1</sup>). In a study of carbonyl-bis(amino acid ester) stationary phases of type I, an unexpected variation in the separation of the enantiomeric pairs,  $\alpha_{R,S}$ , of compounds IIa ( $n = 0, 1, 2$ ) was reported<sup>2</sup>. Thus, the enantiomers of compounds IIa ( $n = 0$  and  $n = 2$ ) were well resolved, but no enantiomeric resolution of compound IIa ( $n = 1$ ) was noted. These results are summarized in Table I.



I a, R = OCH<sub>2</sub>CH<sub>2</sub>

b, R = OCH(CH<sub>3</sub>)<sub>2</sub>

both configurations are (S, S)



II a, R = CF<sub>3</sub>

b, R = CF<sub>2</sub>CF<sub>3</sub>

The present study was undertaken to characterize further that behavior by extending the solute series in terms of carbon number and by observing its behavior on a number of stationary phases. The series IIb ( $n = 0, 1, 2, 3$ ) of N-pentafluoropropionylamides were synthesized, and their GLC properties were determined on OV-17, OV-101 and on the smectic and isotropic states of Ib. The results indicate that the variation of  $\alpha_{R,S}$  with  $n$  continues in the series and that it is unique to stationary phases of type I in their liquid-crystalline states.

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TABLE I

ENANTIOMERIC RESOLUTION OF COMPOUNDS IIa ( $n = 0, 1, 2$ ) ON SMECTIC Ia (111.8°, 91 cm  $\times$  3.2 mm PACKED COLUMN)

Compound	$n$	$\alpha_{R,S}$
1-Phenylethane-1-trifluoroacetamide	0	1.173
3-Phenylpropane-2-trifluoroacetamide	1	Unresolved
4-Phenylbutane-2-trifluoroacetamide	2	1.108

## MATERIALS AND METHODS

GLC was performed on a Varian 3700 gas chromatograph. A 91 cm  $\times$  3.2 mm OV-101 conventional packed column, a 37 m  $\times$  0.4 mm I.D. wall-coated open-tubular borosilicate-glass column coated dynamically with Ib, and an 18 m  $\times$  0.4 mm I.D. borosilicate-glass column prepared and coated with OV-17 by the method of Grob and Grob<sup>3</sup> were used. Samples (1  $\mu$ l) of a solution (1 mg ml<sup>-1</sup>) of the N-pentafluoropropionylamides in pentane were injected into glass-lined inlets appropriate to each column. Helium carrier gas was used in all instances, and its flow-rate was adjusted to give the optimum HETP.

The free amines (*R,S*)-1-amino-1-phenylethane and (*R*)- and (*S*)-2-amino-3-phenylpropane were obtained commercially. (*R,S*)-2-amino-4-phenylbutane had been previously synthesized<sup>2</sup>. (*R,S*)-2-Amino-5-phenylpentane was obtained by adapting the condensation of Richer and Perelman<sup>4</sup> as follows. 5-Phenyl-2-pentanone, obtained by using a procedure described by Clark and Johnson<sup>5</sup>, was condensed with one equivalent of benzylamine in benzene, with simultaneous azeotropic removal of water. After removal of solvent and bulb-to-bulb distillation, the benzylimine was hydrogenated in acetic acid-ethanol over 5% palladium on carbon for 8 h at 60–70°, giving the free amine in fair yield after fractional distillation.

The pentafluoropropionyl derivatives were prepared by reaction of the free amines with excess pentafluoropropionic anhydride in diethyl ether at 0°, followed by treatment with water and several washes with aqueous sodium bicarbonate. Removal of solvent from the dried ethereal solution gave crystalline products that were recrystallized from cyclohexane or, for (*R,S*)-5-phenylpentane-2-pentafluoropropionamide, sublimed (60°; 0.01 torr). The structures of the products were confirmed by their mass spectra and by the proton nuclear magnetic resonance spectra of the free amines. All final products gave a single peak in GLC on 20% of QF-1.

## RESULTS AND CONCLUSIONS

The results of the experiments on Ib, on OV-101 and on OV-17 are shown in Figs. 1–3. Fig. 1 illustrates that the variation of  $\alpha_{R,S}$  does continue through the series and demonstrates that increase of the column temperature past the isotropic transition temperature of Ib causes this variation to disappear almost entirely. In Fig. 2, it can be seen that this variation is due mostly to large deviations of the Napierian logarithm of the capacity factor for the *S* antipode ( $\ln k'_S$ ) from the anticipated linearity with respect to  $n$ . A small deviation is expected, as shown in Fig. 3, for "normal" achiral

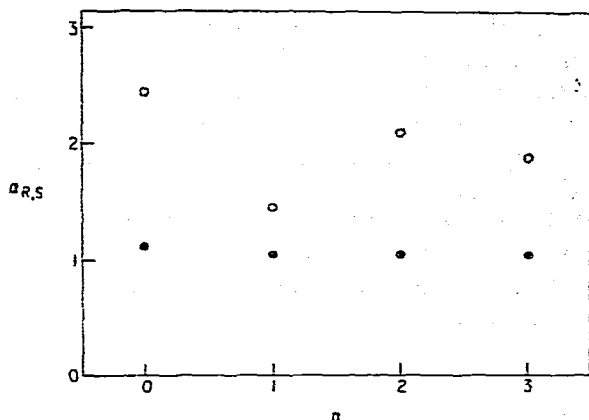


Fig. 1. Enantiomeric separation ( $\alpha_{R,S}$ ) of solutes IIb ( $n = 0-3$ ) vs. carbon number ( $n$ ) on smectic Ib (○, 06.6°) and on isotropic Ib (●, 114.5°).

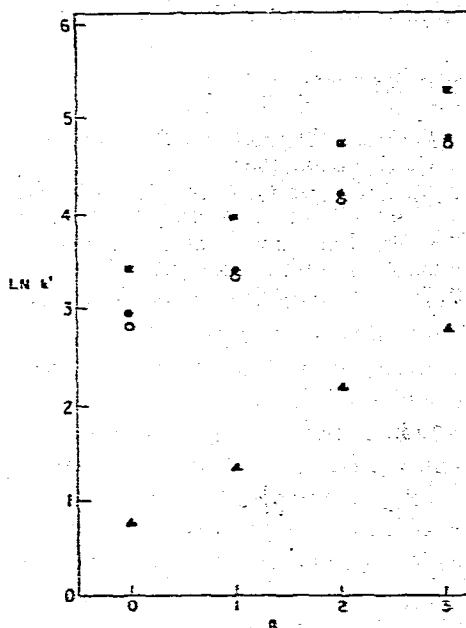
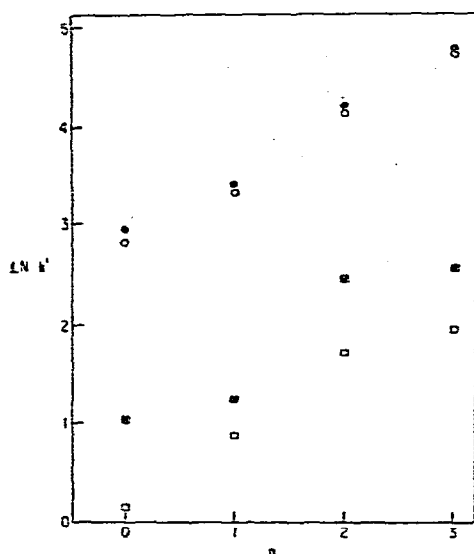


Fig. 2. Plot of the Napierian logarithms of the capacity factors ( $\ln k'$ ) vs. carbon number ( $n$ ) of solutes IIb on smectic (96.6°; □ = R; ■ = S) and on isotropic Ib (114.5°; ○ = R; ● = S).

Fig. 3. Plot of the Napierian logarithms of the capacity factors ( $\ln k'$ ) vs. carbon number ( $n$ ) of solutes Ib ( $n = 0-3$ ) on OV-101 (■, 100.0°), on isotropic Ib (114.5°; ○ = R; ● = S) and on OV-17 (▲, 100.0°).

stationary phases such as OV-101 and OV-17, and essentially the same small deviation is seen for the solutes as was found when the isotropic state of Ib was studied.

The mechanism of this behavior may, in part, involve an effect similar to that manifested when the melting-points of an homologous series of linear fatty acids or their esters are examined. The closeness of packing of the molecules is modulated by steric interference between their ends, alternating in degree between odd and even

chain lengths, and giving rise to the observed deviations in melting-point with chain length<sup>6</sup>. It is known<sup>7</sup> that the primary interaction between molecules of type I and type II involves hydrogen bonding between the amide N-H groups of II and the ester carbonyl groups of I. Thus, the aromatic end of II, in association with I, is left free to assume what conformers it may, within the liquid-crystalline lattice of I, allowing an "end effect" similar to that already described to occur.

It remains to be seen whether the behavior of these solutes on chiral stationary phases is a unique property of these phases or a general property of chiral stationary phases capable of separating such solutes. What is clear is that the effect is exaggerated when the stationary phase is in a liquid-crystalline state.

#### ACKNOWLEDGEMENTS

This work was supported under a grant from the National Science Foundation CHE-75-00939 and acknowledgement is made to the donors of the Petroleum Research Fund administered by the American Chemical Society.

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