Chromatographic behaviour of diastereoisomers

XI.* Steric effects and solvent selectivity effects in retentions on silica of esters of maleic and fumaric acids

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ABSTRACT

The thin-layer chromatographic (TLC) retentions on silica of twenty diastereoisomeric compounds of the type ROOCCH = CHCO-OR were studied as the group R varied from methyl to isopentyl and cyclohexyl. Twenty-one mobile phases were used having strengths, ε, in the range 0.215–0.316 and a wide variation of solvent selectivity effects. Owing to a site chelation via the two ester groups, the (Z)-maleate was always more strongly retained than the corresponding (E)-fumarate. An increase in both steric effects and solvent selectivity effects did not change the relative retention but affected the retention of the diastereoisomers. TLC is suitable for assigning the configurations of other compounds from the group studied.

INTRODUCTION

This series of papers [1] is aimed at a better understanding of the relative retentions of diastereoisomeric pairs of compounds on silica because the problem is connected with the use of normal-phase liquid–solid chromatography (LSC) as a method for configuration determination. Thin-layer chromatography (TLC) on silica of over 130 diastereoisomeric pairs of various groups of compounds with known configurations has shown that the relative retention of the diastereoisomers of a given group usually remains unchanged when steric effects and solvent selectivity effects are varied [2–5]. The exceptions seem reasonable and can be predicted on the basis of Snyder's theory [6–8] and Soczewiński's method [9].

In Part X [1] we reported the TLC on silica of two related groups of diastereoisomeric ethenes having two different complex substituents. The relative retentions found, $E > Z$ and $Z > E$, were attributed to two different models of adsorption of each group of compounds ensuring less steric hindrance of the more strongly retained diastereoisomer. In an attempt to find conformationally rigid diastereoisomeric compounds with two equal strongly adsorbing groups in this work, we studied the TLC separation on silica of esters of maleic and fumaric acid of the type 1 shown. This paper reports the separations of twenty such diastereoisomers showing an increase in the effective volume of R with 21 mobile phases.

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* For Part X, see ref. 1.

Z (maleates)   E (fumarates)

type 1
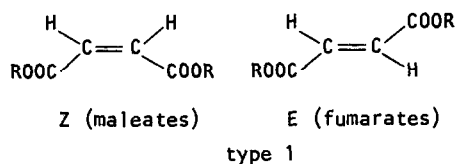
R = CH_3, C_2H_5, $n-C_3H_7$, $iso-C_3H_7$, $n-C_4H_9$,

     $sec.-C_4H_9$, $iso-C_4H_9$, $n-C_5H_{11}$,

     $iso-C_5H_{11}$, cyclohexyl

EXPERIMENTAL

The synthesis of the diastereoisomeric compounds **1–20** studied was done according to ref. 10, with 37–88% yields.

The ^1H NMR spectra of the compounds were measured in chloroform on a Tesla 80-MHz spectrometer. They were similar to those reported in refs. 11 and 12, showing a chemical shift for the olefinic protons in the region of 6.05–6.28 ppm and

6.68–6.85 ppm for Z and E isomers, respectively.

TLC was performed as in ref. 3 on silica gel DG (Riedel-de Haën, Hannover, Germany). The solvents used were of analytical-reagent grade. The R_F values were arithmetic means of three to eight measurements. The reproducibility of the R_F values was ± 0.025.

RESULTS AND DISCUSSION

Table I lists the mobile phases used which were characterized by the three parameters strength, ε, localization, m, and polarity, P', introduced by Snyder [6–8]. The values of these parameters and the molar fraction, N_B, in the case of the binary mobile phases were calculated by means of a microcomputer program [13] based on Snyder's theory [6–8].

Table II summarizes the TLC data showing the structure and configuration of the compounds studied, their R_F values and the derived values of sep-

TABLE I

MOBILE PHASES STUDIED AND THE CORRESPONDING COMPUTER-CALCULATED [13] VALUES OF STRENGTH, ε, LOCALIZATION, m, AND POLARITY, P'

N_B is the molar fraction of the second solvent for binary mobile phases 1–11 and 17–21.

No.	Composition (vol.%)	N_B	ε	m	P'
1	Hexane–diethyl ether (80:20)	0.238	0.286	0.63	0.64
2	Hexane–ethyl acetate (88.4:11.6)	0.148	0.286	0.58	0.60
3	Hexane–tetrahydrofuran (87.2:12.8)	0.190	0.286	0.97	0.60
4	Hexane–acetone (95.4:4.6)	0.078	0.286	0.88	0.33
5	Tetrachloromethane–isopropanol (99.76:0.24)	0.003	0.286	–	1.61
6	Hexane–methyl *tert.*-butyl ether (91.6:8.4)	0.091	0.286	0.76	–
7	Tetrachloromethane–diethyl ether (89.0:11.0)	0.102	0.286	0.53	1.73
8	Tetrachloromethane–acetonitrile (96.14:3.86)	0.062	0.286	0.58	1.76
9	Cyclohexane–diethyl ether (82.4:17.6)	0.181	0.286	0.62	0.33
10	Benzene–methylene chloride (37.99:62.01)	0.306	0.286	0.09	2.95
11	Hexane–diisopropyl ether (37.4:62.6)	0.393	0.286	0.10	1.54
12	Cyclohexane–toluene–diethyl ether (81.8:10.0:8.2)		0.270	0.54	0.31
13	Hexane–tetrachloromethane–chloroform–diethyl ether (75.1:10.0:10.0:4.9)		0.270	0.54	0.78
14	Cyclohexane–tetrachloromethane–benzene–methylene chloride–ethyl acetate (87.32:3.33:3.33:3.33:2.68)		0.270	0.51	0.19
15	Cyclohexane–carbon disulphide–toluene–benzene–methylene chloride (14.74:6.67:6.67:6.67:65.26)		0.270	–	2.35
16	Hexane–toluene–benzene–chloroform–diisopropyl ether–diethyl ether (85.5:2.5:2.5:2.5:2.5:4.5)		0.270	0.54	0.50
17	Hexane–ethyl acetate (98:2)	0.026	0.215	0.54	0.19
18	Hexane–ethyl acetate (94:6)	0.078	0.258	0.57	0.36
19	Hexane–ethyl acetate (91.9:8.1)	0.105	0.270	0.58	0.48
20	Hexane–ethyl acetate (87:13)	0.165	0.292	0.58	0.66
21	Hexane–ethyl acetate (80:20)	0.249	0.316	0.59	0.96

TABLE II

EXPERIMENTAL R_F VALUES AND DERIVED VALUES OF LOG α FOR THE DIASTEREOISOMERIC COMPOUNDS 1–20 OF TYPE 1

For compositions of mobile phases, see Table I. The values of log α were calculated from R_F values of the corresponding Z–E pair using eqns. 1 and 2.

R	Config-uration	No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
			R_F for indicated mobile phase																				
CH$_3$	Z	1	0.22	0.22	0.29	0.12	0.03	0.15	0.26	0.16	0.22	0.28	0.42	0.09	0.10	0.06	0.21	0.09	0.03	0.10	0.13	0.22	0.34
	E	2	0.43	0.40	0.47	0.25	0.06	0.32	0.45	0.33	0.39	0.40	0.66	0.22	0.20	0.12	0.32	0.21	0.08	0.22	0.27	0.40	0.53
CH$_2$CH$_3$	Z	3	0.32	0.33	0.39	0.17	0.03	0.21	0.34	0.22	0.32	0.31	0.59	0.14	0.13	0.08	0.24	0.13	0.04	0.16	0.20	0.34	0.48
	E	4	0.55	0.50	0.57	0.31	0.06	0.40	0.55	0.44	0.52	0.44	0.82	0.31	0.26	0.17	0.38	0.28	0.11	0.32	0.38	0.50	0.64
CH$_2$CH$_2$CH$_3$	Z	5	0.40	0.42	0.47	0.21	0.03	0.28	0.43	0.29	0.41	0.36	0.74	0.21	0.17	0.11	0.30	0.18	0.06	0.23	0.29	0.42	0.58
	E	6	0.62	0.56	0.64	0.35	0.07	0.46	0.65	0.54	0.62	0.51	0.93	0.40	0.33	0.20	0.44	0.36	0.13	0.37	0.45	0.57	0.70
CH(CH$_3$)$_2$	Z	7	0.41	0.43	0.50	0.22	0.03	0.30	0.42	0.31	0.43	0.34	0.75	0.22	0.17	0.12	0.29	0.18	0.07	0.23	0.30	0.44	0.59
	E	8	0.63	0.57	0.65	0.37	0.07	0.48	0.65	0.54	0.63	0.48	0.93	0.40	0.33	0.22	0.42	0.37	0.14	0.38	0.46	0.58	0.72
CH$_2$CH$_2$CH$_2$CH$_3$	Z	9	0.44	0.46	0.53	0.23	0.03	0.33	0.51	0.35	0.47	0.43	0.82	0.24	0.20	0.14	0.35	0.21	0.08	0.26	0.34	0.50	0.64
	E	10	0.68	0.59	0.70	0.38	0.08	0.52	0.71	0.58	0.69	0.57	0.96	0.45	0.36	0.24	0.50	0.42	0.16	0.41	0.49	0.61	0.75
CH(CH$_3$)CH$_2$CH$_3$	Z	11	0.48	0.49	0.54	0.26	0.03	0.35	0.51	0.32	0.49	0.42	0.84	0.27	0.20	0.15	0.33	0.21	0.07	0.27	0.34	0.49	0.64
	E	12	0.71	0.60	0.68	0.42	0.09	0.53	0.72	0.57	0.69	0.55	0.95	0.47	0.36	0.24	0.48	0.41	0.16	0.39	0.48	0.60	0.74
CH$_2$CH(CH$_3$)$_2$	Z	13	0.47	0.48	0.53	0.25	0.03	0.35	0.51	0.35	0.49	0.44	0.83	0.27	0.21	0.16	0.37	0.22	0.08	0.27	0.33	0.49	0.64
	E	14	0.70	0.59	0.68	0.41	0.09	0.52	0.73	0.59	0.69	0.57	0.96	0.46	0.36	0.24	0.52	0.41	0.16	0.39	0.48	0.60	0.74
CH$_2$CH$_2$CH$_2$CH$_2$CH$_3$	Z	15	0.48	0.48	0.54	0.25	0.04	0.35	0.54	0.41	0.51	0.48	0.85	0.29	0.23	0.17	0.40	0.24	0.08	0.28	0.35	0.50	0.65
	E	16	0.72	0.60	0.69	0.41	0.10	0.53	0.78	0.65	0.71	0.61	0.98	0.49	0.38	0.25	0.54	0.43	0.16	0.40	0.49	0.60	0.75
CH$_2$CH$_2$CH(CH$_3$)$_2$	Z	17	0.49	0.48	0.55	0.25	0.05	0.36	0.56	0.44	0.51	0.48	0.86	0.30	0.23	0.17	0.40	0.24	0.08	0.28	0.35	0.50	0.66
	E	18	0.73	0.60	0.71	0.42	0.09	0.54	0.79	0.67	0.72	0.61	0.98	0.50	0.38	0.26	0.54	0.43	0.16	0.41	0.49	0.61	0.76
Cyclohexyl	Z	19	0.46	0.47	0.53	0.24	0.05	0.35	0.57	0.47	0.52	0.46	0.84	0.30	0.21	0.17	0.37	0.21	0.07	0.27	0.35	0.50	0.66
	E	20	0.69	0.60	0.70	0.41	0.10	0.53	0.80	0.69	0.73	0.58	0.96	0.51	0.37	0.26	0.50	0.41	0.16	0.40	0.49	0.61	0.77
			Log α for indicated mobile phases																				Range of log α
		1–2	0.43	0.37	0.36	0.39	0.32	0.42	0.36	0.41	0.36	0.23	0.43	0.45	0.35	0.32	0.25	0.42	0.45	0.40	0.40	0.37	0.23–0.45 (0.22)
		3–4	0.42	0.31	0.32	0.34	0.32	0.40	0.38	0.45	0.36	0.25	0.50	0.44	0.38	0.37	0.29	0.42	0.47	0.39	0.39	0.29	0.25–0.50 (0.25)
		5–6	0.39	0.24	0.32	0.31	0.39	0.34	0.39	0.46	0.37	0.27	0.67	0.40	0.38	0.31	0.27	0.41	0.36	0.29	0.30	0.26	0.23–0.67 (0.44)
		7–8	0.39	0.24	0.29	0.32	0.39	0.34	0.41	0.42	0.35	0.26	0.64	0.41	0.38	0.32	0.25	0.43	0.33	0.31	0.30	0.24	0.24–0.64 (0.40)
		9–10	0.43	0.23	0.34	0.31	0.45	0.34	0.37	0.41	0.40	0.24	0.72	0.39	0.35	0.29	0.27	0.44	0.34	0.29	0.27	0.19	0.19–0.72 (0.53)
		11–12	0.42	0.20	0.26	0.31	0.51	0.32	0.39	0.45	0.37	0.23	0.66	0.38	0.35	0.25	0.28	0.42	0.40	0.24	0.26	0.20	0.20–0.66 (0.46)
		13–14	0.42	0.19	0.28	0.32	0.51	0.30	0.41	0.43	0.37	0.22	0.69	0.36	0.33	0.22	0.26	0.39	0.34	0.24	0.28	0.20	0.19–0.69 (0.50)
		15–16	0.44	0.21	0.28	0.32	0.43	0.32	0.48	0.43	0.37	0.22	0.94	0.37	0.31	0.21	0.25	0.38	0.34	0.23	0.25	0.18	0.18–0.94 (0.76)
		17–18	0.45	0.21	0.30	0.34	0.28	0.32	0.48	0.41	0.39	0.22	0.90	0.37	0.31	0.24	0.25	0.38	0.34	0.25	0.25	0.19	0.19–0.90 (0.71)
		19–20	0.42	0.23	0.32	0.34	0.33	0.32	0.48	0.40	0.40	0.21	0.66	0.39	0.35	0.24	0.23	0.42	0.40	0.25	0.25	0.19	0.19–0.66 (0.47)

aration, α, of Z–E pairs calculated by the following equations:

$$\log \alpha = R_{M(Z)} - R_{M(E)} \qquad (1)$$

$$R_M = \log k' = \log (1/R_F - 1) \qquad (2)$$

where k' is the capacity factor and the subscripts E and Z specify the isomer. Using eqn. 1, the relative retention of the diastereoisomers is expressed in a shorter manner, namely, a positive value of log α corresponds to a stronger retention of the Z compound than that of its E diastereoisomer, as was found (see Table II). This relative retention is valid for all the cases studied independently of the structure of the compounds and mobile phases used.

Table III shows the fit of the data obtained with mobile phases 2 and 17–21 composed of hexane and ethyl acetate in different ratios to Soczewiński's equation [9]:

$$R_M = A - n\log N_B \qquad (3)$$

where A is a constant for a given solute and set of mobile phases, N_B is the molar fraction of the more polar solvent ethyl acetate and the slope of the plot, n, is the number of solvent molecules displaced by a solute molecule from the adsorbent surface. Fig. 1 illustrates some of the data in Table III.

A general view on the variation of the separation, α, of the diastereoisomeric pairs with the use of mobile phases of different m is shown in Table IV. Any mobile phase is represented by the average value log α for all compounds studied. Fig. 2 illustrates this variation.

Microcomputer-aided choice of the mobile phases used

The mobile phases used were selected by means of the microcomputer program [13] mentioned above, having the following three main modes: (1) choice of the solvents for the mobile phase, (2) calculation of the values of the parameters ε, m and P' on the basis of the ratio of the solvents input by the user and (3) choice of mobile phases of given strength, ε, desired by the user.

The R_F values of diastereoisomers 1–20 with hexane–diethyl ether (80:20) (mobile phase 1) were in the favourable range 0.22–0.73. Mode 2 of the microcomputer program showed that ε of this mobile phase was 0.286. Using mode 3 of the microcompu-

TABLE III

FIT OF R_M OF INDIVIDUAL COMPOUNDS OBTAINED WITH BINARY MOBILE PHASES 17–19, 2, 20, 21 OF INCREASING ε TO THE EQUATION $R_M = A - n\text{LOG } N_B$ (EQN. 3), WHERE N_B IS THE MOLAR FRACTION OF THE SECOND SOLVENT

The values of $\Delta A = A_Z - A_E$ were calculated on the basis of A for the indicated isomer.

Solute	n	A	ΔA	S.D.	R
1	−1.24	−0.45	0.28	0.03	−0.998
2	−1.13	−0.73		0.02	−0.999
3	−1.38	−0.81	0.14	0.02	−0.999
4	−1.17	−0.95		0.02	−0.999
5	−1.34	−0.95	0.15	0.03	−0.999
6	−1.21	−1.10		0.02	−0.999
7	−1.30	−0.94	0.18	0.02	−0.999
8	−1.20	−1.12		0.02	−0.999
9	−1.33	−1.04	0.12	0.01	−0.999
10	−1.19	−1.16		0.03	−0.998
11	−1.40	−1.10	0.04	0.03	−0.999
12	−1.18	−1.14		0.02	−0.998
13	−1.33	−1.05	0.08	0.02	−0.999
14	−1.18	−1.13		0.02	−0.999
15	−1.35	−1.08	0.09	0.01	−0.999
16	−1.20	−1.17		0.03	−0.997
17	−1.36	−1.09	0.10	0.02	−0.999
18	−1.21	−1.19		0.03	−0.997
19	−1.42	−1.13	0.07	0.02	−0.999
20	−1.23	−1.20		0.04	−0.996
			Overall	±0.02	−0.999
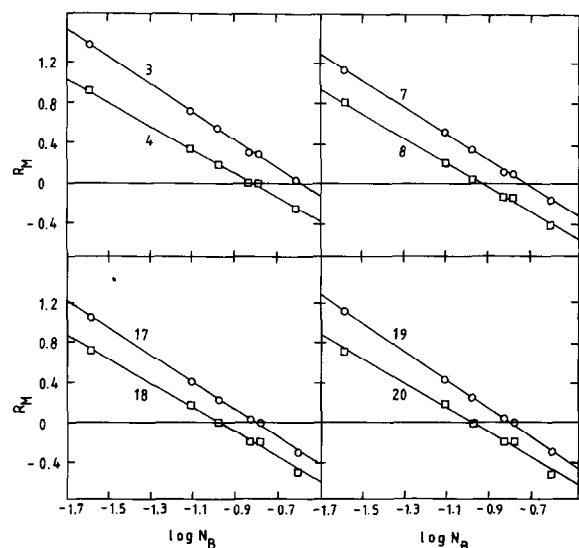
Fig. 1. R_M vs. log [molar fraction (N_B)] plots based on the data in Table III for diastereoisomeric pairs 3–4, 7–8, 17–18 and 19–20.

TABLE IV

VARIATION OF AVERAGE VALUES OF SEPARATION, α, WITH LOCALIZATION, m, OF THE MOBILE PHASES

Log α, $\overline{R_F}$ and $\overline{R_M}$ are average values for compounds 1–20 and a given mobile phase (see Table II). The values of m are taken from Table I. Mobile phases 5 and 15 are not included because their m values cannot be calculated. The mobile phases are arranged in order of increasing m.

ε	Mobile phase	Log α	m	$\overline{R_F}$	$\overline{R_M}$
0.287	10	0.24	0.09	0.47	0.05
	11	0.68	0.10	0.83	−0.69
	7	0.42	0.53	0.57	−0.12
	2	0.24	0.58	0.49	0.02
	8	0.43	0.58	0.45	0.09
	9	0.37	0.62	0.54	−0.07
	1	0.42	0.63	0.53	−0.05
	6	0.34	0.76	0.39	0.19
	4	0.33	0.88	0.30	0.37
	3	0.31	0.97	0.57	−0.12
0.270	14	0.28	0.51	0.18	0.66
	12	0.40	0.54	0.33	0.31
	13	0.35	0.54	0.26	0.45
	16	0.41	0.54	0.28	0.41
0.215–0.316	17	0.38	0.54	0.10	0.95
	18	0.29	0.57	0.30	0.37
	19	0.30	0.58	0.37	0.23
	2	0.24	0.58	0.49	0.02
	20	0.23	0.58	0.50	0.00
	21	0.24	0.59	0.65	−0.27

ter program, we found other binary mobile phases of the same strength. Thus, the set of mobile phases 1–11 are of equal ε (0.286). Similarly, the set of mobile phases 11–16 containing threee to six solvents
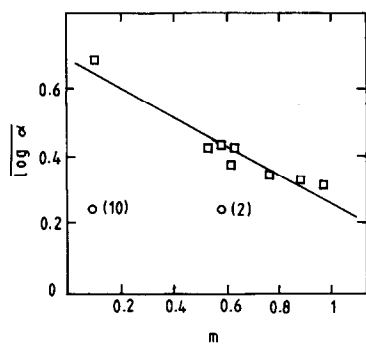
Fig. 2. Log α vs. m plot from Table IV for mobile phases having $\varepsilon = 0.286$. The numbers in parentheses indicate the mobile phase used.

was selected to have ε equal to 0.270. The set of mobile phases 17–21 composed of hexane and ethyl acetate was chosen by mode 2 of the microcomputer program and has ε in the range 0.215–0.316 as a result of the increase in the amount of ethyl acetate and its N_B.

Table I shows that the properties of mobile phases 1–21 composed of two to six non-localizing and localizing solvents are different because of the following changes in the values of the characterizing parameters: $0.215 \leqslant \varepsilon \leqslant 0.316$, $0.09 \leqslant m \leqslant 0.97$, $0.19 \leqslant P' \leqslant 2.95$. The average values $\overline{R_F}$ and $\overline{R_M}$ in Table IV show that the retention of the compounds studied decreases with increase in ε.

Role of solvent selectivity effects

Solvent selectivity effects change significantly the separation of a given diastereoisomeric pair, as can be seen from the corresponding ranges of log α included in Table II.

The solvent selectivity effects were approximated by the localization, m, for mobile phases of constant ε and by the molar fraction of the more polar solvent, N_B, for binary mobile phases with increasing N_B and thus with increasing ε [1, 3–5].

Concerning the set of mobile phases 17–19, 2, 20 and 21, composed of hexane and ethyl acetate and with increasing ε, a very good linear correlation was found between R_M and solvent selectivity effects expressed by N_B, as required by eqn. 3. The mean values of the standard deviation, S.D., and correlation coefficient, R, were $\pm$ 0.02 and 0.999, respectively, as the molar fraction, N_B, of ethyl acetate varied in the range 0.026–0.249. The plots for the diastereoisomers are almost parallel or show a slight tendency for a better separation at lower N_B (see Fig. 1).

According to Table III, the absolute values of the slope n are *ca.* 1, showing that one solute molecule, independently of its configuration, displaces one molecule of the stronger solvent ethyl acetate from the adsorbent surface.

When N_B approaches unity, A in eqn. 3 is equal to R_M and the relative parameter $\Delta A = A_Z - A_E$ is equal to log α. Table III shows that ΔA has positive values in all instances and consequently the relative retention of the diastereoisomers will not alter if the mobile phase is mainly composed of ethyl acetate. The same is valid for the remaining range of N_B

because the R_m vs. log N_B plots for the diastereoisomers do not cross.

According to Snyder's theory [6–8], there is a linear correlation between log α and m when ε is kept constant, and this has been widely verified (e.g., see refs. 1 and 3). Table IV shows that a significant variation of m is characteristic only for mobile phases 1–11 having $\varepsilon = 0.286$. The corresponding plot in Fig. 2 agrees with the theory except for the data obtained with mobile phases 2 and 10 as the overall S.D. is ±0.12. The tendency for maximum separation with minimum m is clearly seen. Table IV also shows that mobile phase 11, composed of hexane and diisopropyl ether, has the best selectivity because $\overline{\log \alpha}$ is greatest (0.68). This mobile phase shows a low m value (0.10) and an intermediate P' value (1.54).

The plot in Fig. 2 does not cross the abscissa when m is in the range 0.1–1, i.e., log $\alpha > 0$. Hence, the retention $Z > E$ established is not expected to alter if other mobile phases with different m are used (cf., refs. 4 and 5).

Role of steric effects

There are examples when a change in steric effects in a series of diastereoisomers of a given type affords a change in the relative retention of the diastereoisomers [2–5]. This phenomenon is attributed to a change in the adsorption model or to the role of solvent selectivity effects in determining the relative retention.

The compounds studied are a good example of diastereoisomers of a given type with varying steric effects because of the significant variation of the group R. Table II shows that the Z isomer is always more strongly retained than the corresponding E isomer independently of the steric effect of R (ref. 14, p. 298). However, the greater the steric effect, the higher is the R_F of the compounds with a given configuration. For instance, the Z isomers show an increase in R_F from 0.22 to 0.49 with mobile phase 1 when R increases from methyl to isopentyl. This decrease in retention should be connected with the corresponding changes in free energy of adsorption with a dominating role of enthalpy over entropy (cf., ref. 6, p. 85). It is interesting that in contrast to this fact, the separation of the diastereoisomers is improved in the same order (see the tendency for increase in the ranges in log α from 0.22 to 0.76 in

Table II when passing from solute pair 1–2 to solute pair 17–18). Thus, a sort of steric acceleration (ref. 14, p. 290) of the separation of the diastereoisomers was established. This could be attributed to relief of steric strain under adsorption (if there is a significant entropy loss when the solutes studied are adsorbed owing to the decrease in their freedom, the steric strain could be reduced).

Deduced model of adsorption

The compounds studied are free from the complication of intramolecular hydrogen bonding because the two ester groups are proton acceptors and a proton-donating group is absent. They are conformationally rigid. The equal values of n for Z and E isomers in Table III indicate that the diastereoisomers adsorb via the same group, which should be the two equal ester groups. Thus, the free energy of adsorption on silica of the ester group is considerably greater than that of the olefinic double bond, being 5.27 and 0.25, respectively (ref. 6, p. 264). In addition, the double bond is conjugated with the two carbonyl groups increasing their adsorption.

Taking into account the two-point adsorption, the stronger adsorption of the Z isomers than that of the corresponding E isomers is a result of the proximity of the two ester groups which adsorb via the so-called site chelation [6] on the same adsorption site. Such a phenomenon is not possible for the
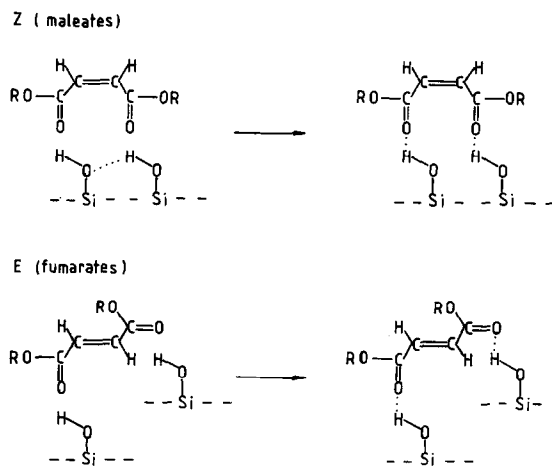

Fig. 3. Schematic representation of the two-point adsorption of the diastereoisomers studied with a site chelation for only Z isomers on a reactive hydroxyl site (ref. 6, p. 315).

E isomers, which also adsorb with the two ester groups but on two separate adsorption sites (see Fig. 3).

The following assumption is possible for the *Z* isomers: site chelation can be compensated for by steric hindrance between the two ester groups at a given effective volume of the group R, leading to the oposite relative retention *Z* < *E*. However, such a phenomenon was not established. Therefore, TLC seems suitable for configurational assignments of other compounds of similar type [2].

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REFERENCES

1 M. D. Palamareva, B. J. Kurtev and I. Kavrakova, *J. Chromatogr.*, 545 (1991) 161; and references cited therein.
2 M. D. Palamareva, B. J. Kurtev, M. Mladenova and B. Blagoev, *J. Chromatogr.*, 235 (1982) 299; and references cited therein.
3 L. R. Snyder, M. D. Palamareva, B. J. Kurtev, L. Z. Viteva and J. N. Stefanovski, *J. Chromatogr.*, 354 (1986) 107.
4 M. D. Palamareva and L. R. Snyder, *Chromatographia*, 19 (1984) 352.
5 M. Palamareva, B. Kurtev and L. Viteva, *God. Sofii. Univ., Khim. Fak.*, 79 (1985) 258.
6 L. R. Snyder, *Principles of Adsorption Chromatography*, Marcel Dekker, New York, 1968.
7 L. R. Snyder and J. J. Kirkland, *Introduction to Modern Liquid Chromatography*, Wiley-Interscience, New York, 2nd ed., 1979.
8 L. R. Snyder, in Cs. Horváth (Editor), *High-Performance Liquid Chromatography*, Vol. 3, Academic Press, New York, 1983, p. 157.
9 E. Soczewiński, *J. Chromatogr.*, 388 (1987) 91; and references cited therein.
10 G. H. Jeffery and A. I. Vogel, *J. Chem. Soc.*, (1948) 664.
11 L. M. Jackman and R. H. Wiley, *Proc. Chem. Soc.*, (1958) 196.
12 L. M. Jackman and R. H. Wiley, *J. Chem. Soc.*, (1960) 2886.
13 M. D. Palamareva and H. E. Palamarev, *J. Chromatogr.*, 477 (1989) 235.
14 N. S. Isaacs, *Physical Organic Chemistry*, Longman, Harlow, 1987.