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CHROMATOGRAPHIC BEHAVIOR OF DIASTEREOISOMERS

VIII. SOLVENT SELECTIVITY EFFECTS IN SEPARATIONS ON SILICA

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SUMMARY

Solvent strength values and solvent selectivity effects have been studied for twenty diastereoisomeric compounds (ten *threo* and *erythro* pairs) as a function of mobile phase composition, in thin-layer chromatography on silica. Forty-six different mobile phases were studied, composed of twelve different solvents, and comprising almost 500 k' values. These data are compared with predictions from a previous model and found to give generally good agreement between experiment and theory. The general importance of solvent–solute localization in determining changes in band-spacing (α-values) was confirmed.

INTRODUCTION

Previous papers in this series[1–8] have dealt with various aspects of the separation of diastereoisomers on silica. It has been shown for over 100 diastereoisomeric pairs that steric hindrance to adsorption controls which isomer (*threo* or *erythro*) will be preferentially retained. The choice of mobile phase can have a profound effect on the relative separation of a given diastereoisomeric pair[6], and our paper[7] has provided a theoretical analysis of these mobile-phase selectivity effects. It appears that *solvent–solute localization* as described in refs. 9–11 accounts for change in separation factor α as the composition of the mobile phase in varied, allowing quantitative prediction of these solvent effects for given diastereoisomers.

In the present study we have broadened our data base for the separation of diastereoisomers by different mobile phases, in an effort to confirm further the basic model of separation, and to provide more information on the specific selectivity effects of a broad range of solvent types. Our findings are expected to be applicable beyond the special case of diastereoisomers as solutes; *i.e.*, these results should be

generally useful for all samples in the optimization of band-spacing in separations on silica. In this paper we will look mainly at solvent effects *per se*. In the following paper we will examine the implications of these data concerning the *a priori* prediction of retention order in this series of diastereoisomers.

THEORY

Previous experimental work with columns of silica and alumina[9,12] has established the importance of solvent–solute localization: a major contributor to solvent selectivity effects in separations by liquid–solid chromatography (LSC). These localization effects are particularly important in LSC systems that involve solute band-pairs of similar molecular size and mobile phases where strong hydrogen-bonding between sample and solvent molecules does not occur. The diastereoisomeric solutes described here, and most of the mobile phases used by us, fit these latter requirements closely. Therefore the present LSC systems are well suited as probes for the effects of solvent–solute localization.

Localization in LSC systems is based on the tendency of polar molecules of sample or of mobile phase to attach to specific adsorption sites on the adsorbent surface: surface silanols in the case of silica[13]. For sufficiently polar molecules (more specifically, molecules with very polar *groups* or substituents), this attachment of adsorbed molecules to the surface will be strong enough to result in *localization* of the molecule over an adsorption site (silanol). Localized molecules are restricted in their movement across the surface (slower diffusion; see ref. 14), and more importantly have a higher energy of adsorption than for the non-localized state. The consequences of localized adsorption as regards solvent selectivity effects is then as follows. Assume first a non-localizing mobile phase B and two solutes of equal retention (k') in that mobile phase: a localizing solute X and a non-localizing solute Y. Now replace mobile phase B with a localizing mobile phase C of similar strength. Because localizing molecules cover only a fraction of the total adsorbent surface (*ca.* 75% maximum), non-localizing solute molecules Y can continue to adsorb without competing with localizing mobile phase molecules C. However, localizing solute molecules X must now compete with localizing solvent molecules C for a place on the adsorbent surface. Because the adsorption energy of localized molecules is larger, and because LSC retention involves a competition between adsorbing molecules of sample and of solvent[10,13], this means that the net adsorption energy of solute X will be smaller in mobile phase C *vs.* B. Therefore while X and Y have similar k' values in mobile phase B, k' for X will be much smaller in mobile phase C. This leads then to a change in band-position or band-spacing of the compounds X and Y; *i.e.*, a change in their separation factor α.

Previous work[9,10,12] has developed a quantitative model for solvent-solute localization and its effect on solute α-values. The model predicts that as the mobile phase composition is changed by substituting different solvents or by changing their concentrations, the separation of two compounds will vary as

$$\log \alpha = A + Bm \tag{1}$$

Here α is the separation factor of the two compounds in question, m is the localization

parameter of the mobile phase (increasing with increased localization of the mobile phase), and A and B are constants for a given combination of sample and specific localizing solvents. To a first approximation, A and B will be constant for a given pair of solutes and for all mobile phases.

The mobile phase localization parameter m can in turn be calculated from a knowledge of the composition of the mobile phase[9,10], where for a binary mobile phase A/C

$$m = m^0 \, f(\theta_C) \tag{2}$$

Here m^0 is the m value of pure solvent C as mobile phase, $f(\theta_C)$ is some function of the surface coverage θ of localizing solvent C, and solvent A is assumed not to localize. For the case of more than one localizing solvent in the mobile phase, a slightly more complicated version of eqn. 2 results[9,10], but we can ignore this here. The function $f(\theta_C)$ varies from 0 to 1 as θ_C varies from 0 (no C in the mobile phase) to 1 (pure solvent C). The surface coverage θ_C can in turn be calculated from a knowledge of certain other properties of the LSC system:

$$\theta_C = K_{ca}N_C/(N_A + K_{ca}N_C) \tag{3}$$

Here N_A and N_C are mole fractions of A and C in the mobile phase, and K_{ca} is the equilibrium constant for the competitive adsorption of A and C onto the surface of the adsorbent:

$$K_{ca} = 10^{\alpha' n_b (\varepsilon_C - \varepsilon_A)} \tag{4}$$

Here α' is the adsorbent activity parameter (equal to 0.57 for silica), n_b is the relative molecular area of solvent C, and ε_A and ε_C are the solvent strength parameters ε^0 for pure solvents A and C. Values of these latter solvent parameters are given in ref. 10 for numerous common solvents. Values of m^0 are available for a few solvents and silica[10], and approximate values can be estimated for other solvents from similar data for alumina as adsorbent. However, one of the objectives of the present study is to obtain additional m^0 values for various solvents and silica as adsorbent.

Data were also obtained from the present study on the solvent strength values ε^0 for various mobile phases. It was of interest to compare these experimental values of ε^0 with values that can be calculated from the model described in refs. 10 and 13. Experimental R_F values can be converted to values of the capacity factor k':

$$R_M = \log[(1 - R_F)/R_F] = \log k' \tag{5}$$

and the relative solvent strengths ε_1 and ε_2 of two mobile phases 1 and 2 can be obtained from

$$\log(k_2/k_1) = \alpha' A_s (\varepsilon_1 - \varepsilon_2) \tag{6}$$

Here, for a given solute, k_1 and k_2 are k' values obtained for mobile phases 1 and 2, respectively, α' is the adsorbent activity factor cited above, A_s is the relative molecular area of the solute. Non-polar solvents such as hexane are assigned an ε^0 value

of zero, which permits measurement of ε^0 for other mobile phases from eqn. 6. We can also calculate values of ε^0 for various mobile phase mixtures from

$$\varepsilon^0 = \varepsilon_A + \log(N_A/\theta_A) \tag{7}$$

Here θ_A is the surface mole-fraction of adsorbed solvent A, equal to $(1 - \theta_C)$ for binary-solvent mobile phases A/C. Values of θ_A are obtained from eqn. 3. It should be further noted that the value of ε_C (localizing solvents) is not constant, but varies both with the values of θ_C (and therefore N_C) and the nature of solvent A (its solvent strength). These details are described in ref. 10 and will not be repeated here.

EXPERIMENTAL

Silica gel (Riedel de Haen, Hannover, F.R.G.) was used as previously[1-6]. A slurry of 30 g of adsorbent and 80 ml of distilled water was spread on four plates (20 × 20 cm) by means of an apparatus according to Stahl; the coating thickness was *ca.* 0.5 mm. The coated plates were air-dried (see p. 374 of ref. 15). The samples were applied at a distance of 2 cm from the edge of the plate, with a separation of 1.5 cm between samples. The length of run was 18 cm. Chromatograms were developed in a glass chamber (20 × 10 × 20 cm) using 30 ml of mobile phase. Separation at ambient temperature without presaturation of the chamber was employed; however, equivalent results were obtained with and without presaturation. Developed plates were sprayed with iodine–ether solutions to effect detection of separated compounds. The reproducibility of measured R_F values was ± 0.02 units. The R_F values of Tables II and III are arithmetic means of two to six measurements.

The solvents used were p.a. grade or were treated with molecular sieve 4A and distilled in glass. Methyl *tert.*-butyl ether was prepared by modification of the procedure of ref. 16.

The amidoesters and diamides of the diastereoisomeric 2,3-diphenylglutaric acids (compounds 1–20 of Tables II and III) were prepared by Michael addition reaction and their relative configurations have been assessed by NMR spectroscopy[17-19].

RESULTS AND DISCUSSION

Ten pairs (twenty solutes) of diastereomeric compounds were investigated, as summarized in Table I. These compounds were run as groups of ten in 46 different mobile phases. Compounds 1–10 of Table I are less strongly retained, and were run in mobile phases having $0.31 \leqslant \varepsilon^0 \leqslant 0.38$. Compounds 11–20 required mobile phases that were stronger: $0.42 \leqslant \varepsilon^0 \leqslant 0.49$. Retention data for these various LSC systems are summarized in Tables II and III. In this study we focused on the separation of individual diastereoisomeric pairs, although the separation of different compounds (non-isomer pairs) could also have been examined as a function of mobile phase composition. A cursory examination of the R_F values and separation factors α in Tables II and III demonstrates large changes in separation as a function of mobile phase composition. For example, log α for diastereomers 11 and 12 of Table I varies from 0.08 to 0.90 — a variation in α of almost seven-fold.

TABLE I

DIASTEREOISOMERIC SOLUTES USED IN THE PRESENT STUDY

C_6H_5-$CH(X)$-$CH(Y)$-C_6H_5

X	Y	Configuration	Compound No.	A_s*
CH_2COOCH_3	$CON(CH_3)_2$	threo	1	37.5
		erythro	2	
CH_2COO-tert.-butyl	$CON(CH_3)_2$	threo	3	38.6
		erythro	4	
CH_2COOCH_3	$CON(C_2H_5)_2$	threo	5	38.3
		erythro	6	
CH_2COOCH_3	$CON(isopropyl)_2$	threo	7	38.9
		erythro	8	
CH_2COOCH_3	$CON(cyclohexyl)_2$	threo	9	46.3
		erythro	10	
$CH_2CON(CH_3)_2$	$CON(CH_3)_2$	threo	11	39.3
		erythro	12	
$CH_2CON(CH_3)_2$	$CON(C_2H_5)_2$	threo	13	40.1
		erythro	14	
$CH_2CON(CH_3)_2$	$CON(n$-propyl$)_2$	threo	15	40.7
		erythro	16	
$CH_2CON(CH_3)_2$	$CON(isopropyl)_2$	threo	17	40.7
		erythro	18	
$CH_2CON(CH_3)_2$	$CON(cyclohexyl)_2$	threo	19	48.1
		erythro	20	

* Values of A_s are calculated as in ref. 13.

Solvent strength values

The present study offers additional opportunity to test the accuracy of eqn. 7 for predictions of solvent strength as a function of mobile phase composition. For 46 mobile phases, which include nine localizing solvents and three non-localizing solvents, experimental ε^0-values (eqns. 5 and 6) agree with calculated values (eqn. 7) within ±0.04 units in ε^0. This is slightly poorer than in previous studies[20], where almost 200 different mobile phases gave agreement between experiment and theory of ±0.02 units. Estimates of ε^0 for the pure solvents diisopropyl ether, tetrahydrofuran and ethanol reported in ref. 10 were replaced here with more accurate (measured) values:

Solvent	ε'	ε''
Diisopropyl ether	0.45	0.35
Tetrahydrofuran	0.73	0.48
Ethanol	2.0	0.65

TABLE II

EXPERIMENTAL VALUES OF R_F AND DERIVED VALUES OF log α FOR DIASTEREOISO-MERIC COMPOUNDS 1–10 OF TABLE I, IN DIFFERENT MOBILE PHASES

Solute*	R_F for indicated mobile phase**									
	PE	10% EE/B	14% EE/B	16% EE/B	18% EE/B	50% EE/B	60% EE/B	33% EE/H	20% EE/CS	50% PE/H
1	0.10	0.09	0.13	0.18	0.18	0.44	0.54	0.04	0.09	0.02
2	0.24	0.15	0.21	0.28	0.29	0.61	0.68	0.08	0.21	0.06
3	0.25	0.14	0.20	0.24	0.27	0.60	0.68	0.08	0.16	0.06
4	0.37	0.21	0.27	0.33	0.36	0.69	0.74	0.13	0.25	0.11
5	0.34	0.19	0.24	0.30	0.33	0.67	0.74	0.13	0.21	0.09
6	0.52	0.23	0.31	0.37	0.40	0.73	0.78	0.18	0.29	0.19
7	0.74	0.34	0.45	0.52	0.54	0.86	0.89	0.33	0.39	0.47
8	0.73	0.34	0.45	0.52	0.54	0.86	0.89	0.33	0.39	0.47
9	0.83	0.53	0.63	0.67	0.69	0.94	0.94	0.44	0.51	0.68
10	0.81	0.48	0.57	0.62	0.64	0.94	0.94	0.39	0.47	0.58
ε^0_{expt}***	0.348	0.328	0.336	0.341	0.343	0.373	0.378	0.320	0.331	0.321
ε^0_{calc}§	0.340	0.305	0.322	0.330	0.337	0.397	0.403	0.313	0.301	0.261
	log α for indicated mobile phase									
1/2§§	0.45	0.25	0.25	0.25	0.27	0.29	0.26	0.32	0.42	0.50
3/4	0.25	0.21	0.17	0.19	0.18	0.17	0.12	0.23	0.24	0.28
5/6	0.32	0.10	0.15	0.14	0.13	0.12	0.10	0.17	0.19	0.37
7/8	−0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9/10	−0.06	−0.08	−0.11	−0.10	−0.10	0.00	0.00	−0.09	−0.07	−0.19

	R_F for indicated mobile phase**								
	25% PE/CS	33% PE/CS	30% MBE/H	20% EA/H	30% EA/H	40% EA/H	4% AN/B	10% AN/B	18% AN/B
1	0.06	0.08	0.14	0.06	0.16	0.31	0.06	0.20	0.45
2	0.14	0.20	0.21	0.13	0.28	0.47	0.07	0.27	0.51
3	0.11	0.15	0.23	0.14	0.33	0.55	0.08	0.31	0.53
4	0.23	0.31	0.27	0.21	0.43	0.64	0.10	0.36	0.56
5	0.14	0.22	0.27	0.18	0.40	0.60	0.10	0.37	0.54
6	0.29	0.42	0.32	0.26	0.49	0.68	0.10	0.37	0.54
7	0.52	0.67	0.49	0.44	0.65	0.83	0.18	0.47	0.69
8	0.56	0.72	0.49	0.44	0.65	0.83	0.17	0.46	0.69
9	0.77	0.91	0.63	0.56	0.75	0.90	0.32	−0.61	0.82
10	0.73	0.89	0.58	0.53	0.71	0.90	0.28	0.56	0.82
ε^0_{expt}***	0.333	0.345	0.337	0.329	0.348	0.366	0.313	0.341	0.360
ε^0_{calc}§	0.178	0.196	0.339	0.316	0.348	0.379	0.296	0.348	0.395
	log α for indicated mobile phase								
1/2§§	0.40	0.46	0.21	0.36	0.31	0.30	0.07	0.17	0.11
3/4	0.38	0.40	0.10	0.21	0.19	0.16	0.11	0.10	0.05
5/6	0.40	0.41	0.10	0.21	0.16	0.15	0.00	0.00	0.00
7/8	0.07	0.10	0.00	0.00	0.00	0.00	−0.03	−0.02	0.00
9/10	−0.10	−0.09	−0.09	−0.05	−0.09	0.00	−0.08	−0.09	0.00

TABLE II *(continued)*

Solute[*]	R_F for indicated mobile phase[**]							
	4% AC/B	8% AC/B	17% AC/B	25% THF/H	30% THF/H	40% THF/H	6% PA/H	3% EAL/B
1	0.13	0.28	0.50	0.21	0.32	0.51	0.20	0.18
2	0.20	0.36	0.58	0.28	0.37	0.58	0.27	0.22
3	0.18	0.37	0.59	0.33	0.45	0.65	0.28	0.21
4	0.22	0.43	0.64	0.36	0.48	0.65	0.31	0.25
5	0.20	0.40	0.62	0.40	0.53	0.68	0.32	0.23
6	0.24	0.44	0.65	0.40	0.53	0.68	0.34	0.26
7	0.32	0.56	0.80	0.58	0.73	0.84	0.39	0.32
8	0.32	0.56	0.80	0.54	0.69	0.84	0.39	0.32
9	0.42	0.72	0.91	0.68	0.80	0.88	0.42	0.43
10	0.38	0.66	0.91	0.62	0.76	0.88	0.39	0.39
ε^0_{expt} [***]	0.329	0.348	0.368	0.345	0.355	0.372	0.336	0.331
ε^0_{calc} [§]	0.318	0.363	0.417	0.368	0.403	0.438	0.364	0.464
log α for indicated mobile phase								
1/2[§§]	0.23	0.16	0.14	0.17	0.10	0.12	0.17	0.11
3/4	0.11	0.11	0.09	0.06	0.06	0.00	0.06	0.10
5/6	0.10	0.08	0.06	0.00	0.00	0.00	0.04	0.08
7/8	0.00	0.00	0.00	−0.07	−0.08	0.00	0.00	0.00
9/10	−0.07	−0.12	0.00	−0.12	−0.10	0.00	−0.05	−0.07

  [*] Compound numbers as in Table I.
  [**] Solvent abbreviations (% indicates vol. %): PE, diisopropyl ether; EE, diethyl ether; B, benzene; H, hexane; CS, carbon disulphide; MBE, methyl-*tert.*-butyl ether; EA, ethyl acetate; AN, acetonitrile; AC, acetone; THF, tetrahydrofuran; PA, isopropyl alcohol; EAL, ethyl alcohol.
  [***] Measured from experimental R_F values according to eqn. 5.
  [§] Calculated as described in ref. 10 from parameters given in Table I of that reference.
  [§§] Diastereoisomer pairs for corresponding α-values.

These latter values (see Table I of ref. 10) agree within a few hundredths of a unit with ε' and ε'' values reported earlier. So our confidence in other estimated values of these solvent parameters (in ref. 10) remains high.

Solvent selectivity effects

We initially attempted to calculate values of the localization parameter m for the various mobile phases of Tables II and III, using eqns. 2–4 and estimated values of m^0 from ref. 10. Eqn. 1 was then tested for its ability to predict values of log α for the various diastereoisomeric solute pairs of Table I. The resulting plots showed more scatter than we had observed for similar studies earlier[7,9,12], and so we examined the data more closely. One difference in the mobile phases reported here *vs.* those studied earlier in terms of solvent–solute localization and eqn. 1 is the use of more polar non-localizing solvents such as benzene and carbon disulphide, in place of the usual non-polar mobile-phase carriers such as pentane and hexane. Whereas moderate concentrations of polar solvents such as acetonitrile ($N_C > 0.05$) in mobile phases composed mainly of non-polar solvents lead to large θ_C values with $m \approx m_C^0$ for the mobile phase, the model of ref. 10 does not predict this to be true for mobile phases

TABLE III

EXPERIMENTAL VALUES OF R_F AND DERIVED VALUES OF log α FOR DIASTEREOISOMERIC COMPOUNDS 11–20 OF TABLE I, IN DIFFERENT MOBILE PHASES

Solute*	R_F for indicated mobile phase**										
	PE	60% EE/B	65% EE/B	75% EE/B	EE	90% MBE/H	80% EA/H	90% EA/H	50% AN/B	60% AN/B	70% AN/B
11	0.00	0.02	0.02	0.02	0.03	0.15	0.03	0.08	0.19	0.22	0.59
12	0.00	0.10	0.12	0.13	0.18	0.42	0.19	0.41	0.33	0.39	0.71
13	0.00	0.07	0.07	0.08	0.10	0.48	0.11	0.30	0.41	0.49	0.81
14	0.02	0.16	0.18	0.21	0.31	0.64	0.30	0.60	0.41	0.49	0.81
15	0.01	0.18	0.18	0.22	0.36	0.77	0.27	0.64	0.56	0.65	0.91
16	0.03	0.25	0.27	0.31	0.48	0.82	0.43	0.72	0.51	0.61	0.91
17	0.05	0.30	0.31	0.35	0.57	0.90	0.43	0.74	0.62	0.71	0.92
18	0.05	0.30	0.31	0.35	0.51	0.82	0.43	0.74	0.59	0.63	0.92
19	0.11	0.45	0.47	0.51	0.76	0.96	0.68	0.88	0.76	0.84	0.96
20	0.06	0.34	0.36	0.41	0.61	0.90	0.57	0.82	0.66	0.74	0.96
ε^0_{expt} ***		0.425	0.426	0.429	0.441	0.471	0.437	0.460	0.453	0.458	0.489
ε^0_{calc} §		0.403	0.425	0.407	0.430	0.470	0.461	0.472	0.467	0.478	0.487
log α for indicated mobile phase											
11/12 §§	–	0.74	0.82	0.86	0.85	0.61	0.88	0.90	0.32	0.36	0.23
13/14	–	0.40	0.46	0.48	0.60	0.28	0.54	0.55	0.00	0.00	0.00
15/16	0.49	0.18	0.23	0.20	0.22	0.13	0.31	0.16	−0.08	−0.08	0.00
17/18	0.00	0.00	0.00	0.00	−0.10	−0.29	0.00	0.00	−0.05	−0.16	0.00
19/20	−0.28	−0.20	−0.20	−0.18	−0.31	−0.43	−0.21	−0.21	−0.21	−0.27	0.00

Solute*	R_F for indicated mobile phase**								
	36% AC/B	50% AC/B	15% AC/EE	50% THF/H	60% THF/H	70% THF/H	28% PA/H	7% EAL/B	10% EAL/B
11	0.31	0.62	0.11	0.14	0.26	0.45	0.19	0.19	0.28
12	0.50	0.70	0.51	0.28	0.43	0.70	0.48	0.23	0.30
13	0.51	0.74	0.56	0.40	0.53	0.79	0.52	0.24	0.32
14	0.58	0.77	0.68	0.47	0.58	0.83	0.70	0.27	0.34
15	0.62	0.83	0.79	0.61	0.75	0.89	0.77	0.28	0.36
16	0.62	0.83	0.70	0.61	0.75	0.89	0.77	0.28	0.36
17	0.66	0.86	0.84	0.68	0.83	0.91	0.82	0.30	0.41
18	0.62	0.86	0.78	0.60	0.77	0.91	0.74	0.27	0.38
19	0.71	0.94	0.88	0.79	0.89	0.93	0.89	0.35	0.45
20	0.66	0.82	0.76	0.67	0.84	0.93	0.83	0.30	0.42
ε^0_{expt} ***	0.459	0.479	0.467	0.454	0.467	0.484	0.467	0.435	0.443
ε^0_{calc} §	0.459	0.482	0.455	0.465	0.485	0.500	0.460	0.483	0.496
log α for indicated mobile phases									
11/12 §§	0.35	0.16	0.93	0.38	0.33	0.28	0.60	0.10	0.04
13/14	0.12	0.08	0.23	0.13	0.09	0.11	0.34	0.07	0.04
15/16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17/18	−0.08	0.00	−0.17	−0.15	−0.16	0.00	−0.21	−0.06	−0.05
19/20	−0.10	−0.53	−0.37	−0.27	−0.19	0.00	−0.22	−0.10	−0.05

* Compound numbers as in Table I.
** Solvent abbreviations as in Table II.
*** Measured from experimental R_F values according to eqn. 6.
§ Calculated as described in ref. 10 from parameters given in Table I of that reference.
§§ Diastereoisomer pairs for corresponding α-values.

TABLE IV

COMPARISON OF SELECTED α-VALUES FOR SOLUTES 1 AND 2 OF TABLE I AND DIFFERENT MOBILE PHASES (DATA OF TABLE II)

Mobile phase	N_C	Calc. m	$\log \alpha$
Diethyl ether–benzene (10:90)	0.09	0.11	0.25
Diethyl ether–benzene (16:84)	0.14	0.18	0.25
Diethyl ether–benzene (50:50)	0.46	0.39	0.29
Diethyl ether–benzene (60:40)	0.56	0.40	0.26
Acetonitrile–benzene (4:96)	0.07	0.16	0.07
Acetonitrile–benzene (10:90)	0.16	0.43	0.17
Acetonitrile–benzene (18:82)	0.27	0.81	0.11

TABLE V

FIT OF DATA OF TABLES II AND III TO EQN. 1

Assuming $m = m^0$ for the various mobile phases; values of m^0 derived from these data.

Solute pair*	A**	B**	Standard deviation
1/2	0.51	−0.36	±0.05
3/4	0.36	−0.28	0.04
5/6	0.40	−0.38	0.04
7/8	0.04	−0.06	0.03
9/10	−0.10	0.04	0.05
11/12	1.8	−1.5	0.16
13/14	1.3	−1.2	0.05
15/16	0.57	−0.58	0.04
17/18	0.02	−0.12	0.09
19/20	−0.32	0.12	0.13
	overall agreement		±0.07

Localizing solvent	m^0 (expt)***	m^0 (10)§
Diisopropyl ether	0.10	
Ethyl acetate	0.60	0.60
Diethyl ether	0.66	0.43
Methyl-*tert.*-butyl ether	0.82	0.82
Isopropyl alcohol	(0.85)§§	
Acetone	0.95	0.87
Tetrahydrofuran	1.00	0.65
Acetonitrile	1.05	1.19
Ethyl alcohol	1.05	

 * From Table I.
 ** Best fit to eqn. 1; data of Tables II and III.
 *** Best fit to eqn. 1; assumes $m = m^0$.
 § Predicted values from ref. 10.
 §§ Value derived on the basis of two mobile phases only.

composed mainly of solvents such as benzene. One reason, despite the large difference in ε^0-values for solvents such as acetonitrile and benzene, is that so-called *site-competition delocalization* predicts that the ε^0-value for acetonitrile will be reduced by the co-adsorption of molecules of benzene on the surface. This in turn reduces K_{ca} and θ_C, and consequently also reduces m (eqn. 2).

The present study suggests that this reduction in m predicted above does not occur for the case of mobile phases such as acetonitrile–benzene when N_C (acetonitrile) > 0.05. This is illustrated in Table IV, using data from Table II for solutes 1 and 2 (Table I) and several mobile phases. At first glance, there appears to be no correlation between log α and m, as predicted by eqn. 1. However, if $\theta_C \approx 1$ and $m = m^0$, as would be the case in the absence of site-competition delocalization, then the data make reasonable sense. The m^0 values of pure diethyl ether and acetonitrile are 0.66 and 1.05, respectively (see below); *i.e.*, quite different. The corresponding log α-values for mixtures of diethyl ether and acetonitrile (Table IV) are respectively 0.26 $\pm$ 0.02 and 0.12 $\pm$ 0.05. That is, the data agree within ± 0.02–0.05 units with a
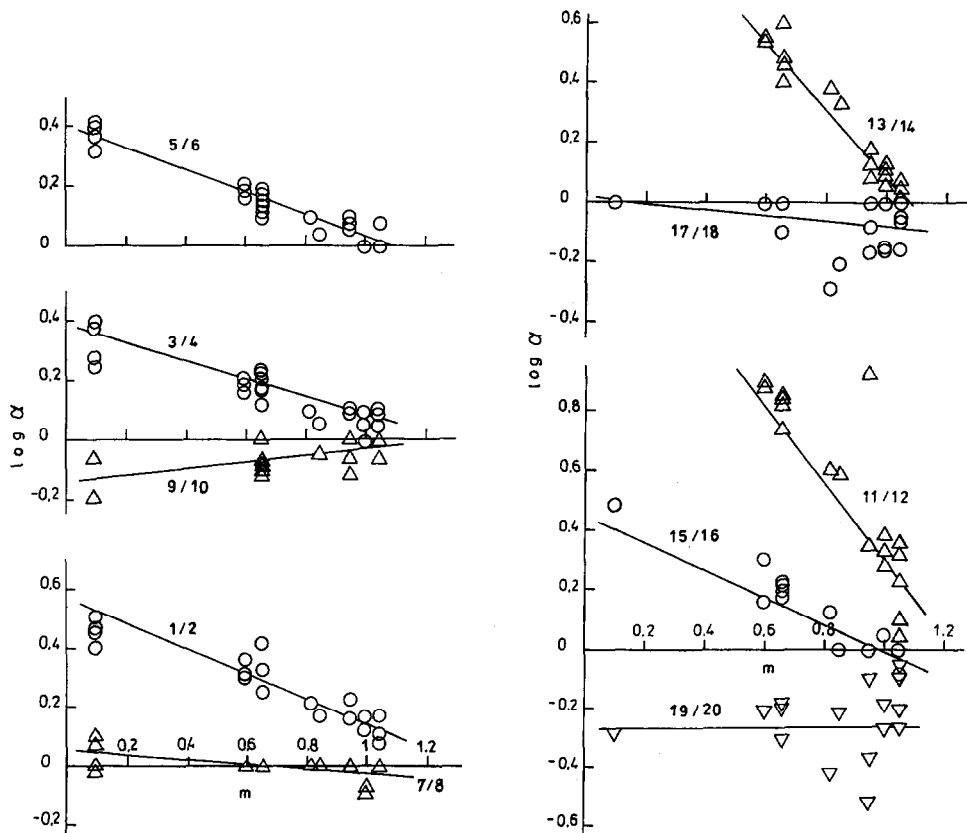

Fig. 1. Comparison of experimental data of Table II in terms of eqn. 1. Parameter values of Table V assumed, with $m = m^0$.

Fig. 2. Comparison of experimental data of Table III in terms of eqn. 1. Parameter values of Table V used, with $m = m^0$.

model that assumes $m \approx m^0$ for these mobile phase systems. Carrying this hypothesis further, we have fit the data of Tables II and III to eqn. 1 with the assumption that in each case $m \approx m^0$. Resulting values of A and B from eqn. 1 are listed in Table V, along with the deviation of experimental points from eqn. 1. The data of Tables II and III are also plotted in terms of eqn. 1 in Figs. 1 and 2.

The resulting plots show somewhat more scatter than for similar plots reported in ref. 7 for other diastereoisomers, but the agreement of the data with eqn. 1 is adequately precise to clearly see the importance of solvent–solute localization in these LSC systems (overall S.D. = ±0.07 units). The greater scatter here *vs.* ref. 7 can be attributed to the stronger solvent systems used (where other effects become more important —see discussion of ref. 10). We also see general verification of the rule that maximum separation will occur either for mobile phases of large m or small m— but not for solvents of intermediate m value. Other correlations parallel to those drawn in ref. 7 can be made, but we will defer discussion of these to a later time.

Values of m^0 derived from these studies are presented in Table V. These can be compared with values from ref. 10, and it is seen that agreement is generally good; *i.e.*, we were successful in ref. 10 in predicting which solvents will exhibit large solvent–solute localization effects.

CONCLUSIONS

Almost 500 retention measurements were made for twenty diastereoisomeric solutes, using 46 different mobile phases composed of twelve different solvents. These data were used to test a previous theory of solvent selectivity effects in LSC. Agreement of experimental data with the theory was found to be acceptable, but the data suggest that the combination of polar non-localizing and localizing solvents (*e.g.*, benzene, non-localizing; acetonitrile, localizing) is generally dominated by the localizing solvent. Specifically, when the mole-fraction of the localizing solvent is greater than 0.05, solvent selectivity effects are constant and characteristic of the pure localizing solvent. This result was not predicted by our previous model, and constitutes an effect that should be studied further.

The previous model also predicts solvent strength as a function of composition. This was tested here for these 46 different mobile phases, and the model was found to predict ε^0-values within ±0.04 units (1 S.D.). Thus our model has now been tested for almost 300 different mobile phases (binary, ternary, quaternary; silica and alumina) and found to give generally good agreement with experimental data.

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