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MOBILE PHASE EFFECTS ON AROMATIC HYDROXYL COMPOUNDS WITH AN AMINOPROPYL COLUMN AND INTERPRETATION BY THE SNYDER MODEL

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SUMMARY

The Snyder chromatographic model was employed to correlate and interpret the retention data of hydroxyl aromatics on a high-performance aminopropyl bonded-phase column. Several *n*-heptane–2-propanol and *n*-heptane–ethyl acetate mobile phases were used to obtain the retention data. Plots of the logarithm of the capacity factor (log k') *vs.* solvent strength and log k' *vs.* log (mole fraction of the strong solvent) showed good linearity for all the hydroxyl aromatics studied. Because a value of the solvent strength for 2-propanol on the aminopropyl bonded-phase was not available, the solvent strength for 2-propanol on silica was used in an empirical fashion. The slopes from the plots of log k' *vs.* solvent strength for ethyl acetate from an aminopropyl bonded-phase column were used to obtain experimental areas of the solutes. The experimental molecular areas were compared with calculated values, and the results showed that the localization of the solutes and the polarity of the mobile phases were important considerations. The results also indicated that the *n*-heptane–ethyl acetate data correlated very well with the Snyder model.

INTRODUCTION

Reversed- and normal-phase high-performance liquid chromatography (HPLC) can provide information on highly complex mixtures. As retention and selectivity are dependent on specific functional group–stationary phase interactions, normal-phase HPLC offers some advantages in separating functional classes and isomers[1]. Normal-phase HPLC has been found to be very useful in separating coal-derived liquids because frequently coal liquids are not soluble in the water-based solvents often used in reversed-phase HPLC[2].

A number of models have been developed to explain the roles of the solvent, solute and stationary phase in normal-phase HPLC[3–16]. If a given model is capable of describing the retention of solutes, then the model can be used to predict retention for similar chromatographic systems. In addition, mobile phases that would provide the best resolution and selectivity could then be predicted from the model.

Scott and co-workers[10–13] have considered solute–mobile phase and solute–

stationary phase interactions for silica gel. The Snyder adsorption model is based on displacement of solvent molecules by solute molecules from the stationary phase surface[8,9]. The model of Soczewiński and co-workers[3–7] is similar to that developed by Snyder. The Hennion *et al.*[14] approach for aminopropyl-bonded silica contains elements from the Snyder, Soczewiński and Scott models. Snyder and co-workers[8,17] have reviewed the first three models and all four models were summarized by Snyder and Schunk[18]. Hydrogen bonding and other interactions were used by Chang and co-workers[15,16] to explain the retention behavior on an aminopropyl bonded-phase column.

The models developed by Snyder and Soczewiński have been used to describe a number of interactions in several chromatographic systems. The approaches of Snyder and Soczewiński were used by Hurtubise *et al.*[19] to explain some of the retention characteristics of alkylphenols on an aminopropyl bonded-phase column and by Hussain *et al.*[20] to interpret retention results for alkylphenols on a cyanopropyl bonded-phase column and a silica column. Some of the interactions of polar solutes on a silica column and a nitrophenyl bonded-phase column were described by Ruckmick and Hurtubise[21,22] using the Snyder approach. Scolla and Hurtubise[23] concluded that elements of the Snyder model could describe the retention behavior of aromatic nitrogen compounds on an aminopropyl bonded-phase column. Olsen and Hurtubise[24] used the Snyder concepts to characterize the retention properties of several aromatic hydroxyl compounds on a silica stationary phase. Snyder[25] found that the behavior of diastereomers on a silica column could be evaluated by his model. In addition, Snyder and Schunk[18] employed the Snyder model to characterize an amino bonded-phase column. Hammers *et al.*[26] concluded that an amino bonded-phase column behaved like partially deactivated silica gel. Weiser *et al.*[27] reached similar conclusions for a cyanopropyl bonded-phase column. Smith and Cooper[28] applied Snyder's concepts to amino, cyano, and diol bonded-phase columns to describe solute retention with several different mobile phase systems.

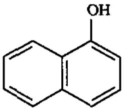
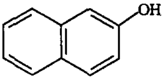
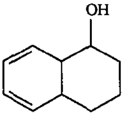
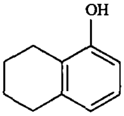
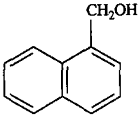
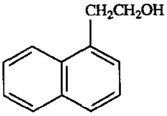
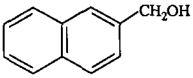
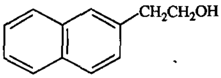
In this study, aromatic hydroxyl compounds were investigated on an aminopropyl bonded-phase column using different solvent compositions of *n*-heptane–2-propanol and *n*-heptane–ethyl acetate. The data were interpreted with the Snyder displacement model. The compounds studied were selected on the basis of similar size and structure but differing acidities, polarities and hydrogen-bonding abilities.

EXPERIMENTAL

The equipment, experimental conditions and procedures have been reported previously[24]. However, there were a few differences, and these are indicated as follows. The detector was set at 254 nm. The columns used were 30 cm × 3.9 mm I.D. prepacked μBondapak NH_2 columns obtained from Waters Assoc. (Milford, MA, U.S.A.). The μBondapak NH_2 columns contained aminopropyl groups chemically bonded to irregular-shaped 10-μm porous silica. The compositions of the *n*-heptane–2-propanol mobile phases were 99:1, 98:2, 97:3, 96:4, 95:5, 94:6, 93:7, 92:8, 91:9, 90:10 and 89:11 (v/v), and those of the *n*-heptane–ethyl acetate mobile phases were 85:15, 82:18, 80:20, 77:23, 75:25, 73:27, 70:30, 65:35, 60:40, 55:45 and 50:50 (v/v). Table I gives the names, structures and pK_a values of the compounds investigated.

TABLE I

COMPOUNDS STUDIED ON AN AMINOPROPYL COLUMN AND THEIR pK_a VALUES

No.	*Compound*	*Structure*	*pK_a*
1	1-Naphthol		9.3[a]
2	2-Naphthol		9.6[a]
3	1,2,3,4-Tetrahydro-1-naphthol		15.7[b]
4	5,6,7,8-Tetrahydro-1-naphthol		10.3[a]
5	1-Naphthalenemethanol		15.3[b]
6	1-Naphthaleneethanol		15.2[b]
7	2-Naphthalenemethanol		15.3[b]
8	2-Naphthaleneethanol		15.2[b]

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[a] From ref. 29.

[b] Calculated from information in ref. 30.

RESULTS AND DISCUSSION

Theoretical considerations

The following equation is fundamental to the Snyder model:

$$X_m + nS_a \rightleftharpoons X_a + nS_m \qquad (1)$$

where the subscripts m and a refer to the mobile phase and adsorbed phase, respectively. The adsorption of a solute molecule, X, causes the displacement of n solvent molecules, S. The solvent strength of a non-localizing binary mobile phase on a bonded-phase column can be calculated with eqn. 2 according to Snyder and Schunk[18] and Snyder[31] if the adsorbent activity, α', is known

$$\varepsilon_{AB} = \varepsilon_A + \log[N_B 10^{\alpha' n_b(\varepsilon_A - \varepsilon_B)} + 1 - N_B]/\alpha' n_b \qquad (2)$$

where ε_{AB} is the solvent strength of the binary eluent, ε_A and ε_B are the solvent strengths of the pure weak and strong solvent, respectively, N_B is the mole fraction of solvent B and n_b is the relative molecular area of a molecule of solvent B. The ε_B term can vary with N_B owing to restricted-access delocalization of the strong solvent on silica and alumina according to Snyder and Schunk[18] and Snyder[32]. However, restricted-access delocalization should be minimal for aminopropyl bonded-phases because of the flexible nature of the bonded functional group in the stationary phase[18]. Therefore, ε_B in eqn. 2 should be a constant for an aminopropyl bonded-phase according to Snyder and Schunk[18] and Snyder[32].

Snyder[17] has shown that the retention of a solute will vary in a binary mobile phase of two different compositions according to the following equation:

$$\log (k'_2/k'_1) = \alpha' A_s(\varepsilon_1 - \varepsilon_2) \qquad (3)$$

where k'_1 is the capacity factor of the solute in mobile phase 1 of solvent strength ε_1 and k'_2 is the capacity factor of the solute in the second mobile phase of solvent strength ε_2. If mobile phase 1 is *n*-heptane then ε_1 is zero. The α' term is defined arbitrarily as being equal to unity for the aminopropyl bonded-phase column[18]. The slope of $\log k'_2$ *vs.* ε_2 is equal to $\alpha' A_s$; hence experimental A_s values can be obtained from the slope. If the solutes are polar, they can localize and site-competition delocalization can occur on an aminopropyl bonded-phase column owing to the exposed nature of the functional group. Thus, the experimental A_s values will be larger than expected[18,33].

Another equation that can be derived from the Snyder approach is

$$\log k' = \log k'_0 - (A_s/n_b) \log X_s \qquad (4)$$

where A_s is the molecular area of the solute, n_b is the strong solvent molecular area, k' is the capacity factor of the solute eluted in the binary mobile phase, k'_0 is the capacity factor of the solute eluted in the pure strong solvent, and X_s is the mole fraction of the strong solvent in the binary mobile phase[17]. In the derivation of eqn. 4, it is assumed that the $1 - N_B$ term in the logarithmic expression in eqn. 2 is small and ε_B does not vary with N_B. Eqn. 4 has been shown to be valid if very polar binary mobile phases are being used[17,25].

In this study, A_s values were calculated using the following equation developed by Snyder[34] for unsubstituted aromatic hydrocarbons:

$$A_s = 6 + 0.80(h - 6) + 0.25(c - h) \quad (5)$$

where h is the number of aromatic hydrogens in the solute and c is the number of aromatic carbons in the solute. The A_s values increase by 7.6 and 8.5 units for aromatic and aliphatic OH groups, respectively, for a silica stationary phase[34].

Plots of log k' vs. solvent strength

The solvent strength values used in this work were taken from data published by Snyder and Glajch[33] and Scolla and Hurtubise[23]. Snyder and Glajch[33] listed solvent strength values for *n*-hexane–2-propanol and *n*-hexane–ethyl acetate mobile phases on chromatographic silica. Scolla and Hurtubise[23] gave solvent strength values for *n*-heptane–ethyl acetate mobile phases on an aminopropyl bonded-phase column. To our knowledge, the solvent strength for 2-propanol has not been calculated for an aminopropyl bonded-phase column. The calculation of a solvent strength value for 2-propanol is complicated by the fact that 2-propanol can behave both as a hydrogen-bond donor and as a hydrogen-bond acceptor. In the past, the retention properties of polycyclic aromatic hydrocarbons have been used as a basis for the calculation of the solvent strengths for *n*-heptane–ethyl acetate[18,23]. However, with *n*-heptane–2-propanol the retention times of polycyclic aromatic hydrocarbons are so small that they cannot easily be used as a means of calculating solvent strengths. Therefore, in this work it was assumed that the solvent strengths for the *n*-hexane–2-propanol solvents from silica would be applicable to an aminopropyl bonded-phase column. In addition, a similar assumption was made for *n*-hexane–ethyl acetate when using solvent strengths from silica. The main reason for these assumptions was to determine if empirical correlations could be developed between the solvent strengths from silica and the capacity factors from the aminopropyl bonded-phase column.

The solvent strength of a given mole fraction of strong solvent should be almost the same whether *n*-hexane or *n*-heptane is used, as both solvents have essentially the same solvent strength (zero) and selectivity. The solvent strengths were determined for this work by plotting the solvent strength values against the mole fraction of the strong solvent listed by Snyder and Glajch[33] or Scolla and Hurtubise[23]. Then, by knowing the mole fraction of the strong solvent used in this work, the solvent strength values were obtained from the graphs. Tables II and III list the various mobile phase compositions, log k' values for the solutes, and the solvent strength values used in this work for *n*-heptane–2-propanol and *n*-heptane–ethyl acetate mobile phases, respectively.

Using eqn. 3, plots of log k' from the aminopropyl bonded-phase column *vs.* solvent strength values from silica for the solutes listed in Table I yielded linear correlation coefficients ranging from -0.994 to -0.996 for the 2-propanol binary mobile phases and from -0.987 to -0.990 for the ethyl acetate binary mobile phases (Table IV). The graphs for the standards were linear for a wide range of 2-propanol compositions, with one point well off each line for the weakest solvent compositions used. These points were from the capacity factor values for the solutes in the weakest mobile phase. These capacity factor values were near to or greater than 10, except for compound 3. The graphs for the ethyl acetate mobile phases were not as good since all

TABLE II

LOG k' VALUES FOR THE MODEL COMPOUNDS ON AN AMINOPROPYL BONDED-PHASE COLUMN WITH *n*-HEPTANE–2-PROPANOL MOBILE PHASES (25°C)

Compound No.	*Mole fraction 2-propanol*										
	0.019 (99:1)[a]	*0.038 (98:2)*	*0.056 (97:3)*	*0.074 (96:4)*	*0.094 (95:5)*	*0.109 (94:6)*	*0.126 (93:7)*	*0.143 (92:8)*	*0.159 (91:9)*	*0.175 (90:10)*	*0.191 (89:11)*
1	1.263	0.916	0.738	0.597	0.497	0.418	0.321	0.280	0.222	0.169	0.125
2	1.360	0.998	0.788	0.651	0.559	0.456	0.385	0.316	0.258	0.203	0.155
3	0.642	0.368	0.222	0.109	0.000	−0.07	−0.12	−0.19	−0.24	−0.28	−0.32
4	0.874	0.564	0.402	0.280	0.182	0.109	0.040	−0.02	−0.09	−0.12	−0.18
5	1.000	0.711	0.541	0.418	0.331	0.246	0.168	0.109	0.058	0.020	−0.02
6	0.940	0.637	0.463	0.340	0.258	0.155	0.093	0.040	0.010	−0.07	−0.12
7	1.045	0.738	0.564	0.441	0.350	0.246	0.183	0.125	0.076	0.020	−0.02
8	0.947	0.651	0.484	0.350	0.280	0.169	0.109	0.040	0.000	−0.07	−0.09
Log X_s	−1.721	−1.420	−1.252	−1.131	−1.036	−0.962	−0.900	−0.845	−0.799	−0.757	−0.719
$\varepsilon_{AB}{}^b$	0.308	0.322	0.338	0.348	0.360	0.370	0.378	0.387	0.393	0.401	0.406

[a] *n*-Heptane–2-propanol composition (v/v) in parentheses.

[b] Solvent strength values on silica taken from information in ref. 33.

of the graphs had a slight curvature. However, the lowest correlation coefficient was −0.987, which indicated that they were approximately linear. The slopes, intercepts and correlation coefficients obtained for these log k' values from the aminopropyl bonded-phase column *vs.* solvent strength values from silica are given in Table IV. These results are strictly empirical and at present have no firm theoretical basis.

TABLE III

LOG k' VALUES FOR MODEL COMPOUNDS ON AN AMINOPROPYL BONDED-PHASE COLUMN WITH *n*-HEPTANE–ETHYL ACETATE MOBILE PHASES (25°C)

Compound No.	*Mole fraction ethyl acetate*										
	0.209 (85:15)[a]	*0.248 (82:18)*	*0.273 (80:20)*	*0.309 (77:23)*	*0.333 (75:25)*	*0.357 (73:27)*	*0.391 (70:30)*	*0.447 (65:35)*	*0.500 (60:40)*	*0.551 (55:45)*	*0.600 (50:50)*
1	0.787	0.679	0.612	0.522	0.468	0.422	0.369	0.258	0.179	0.111	0.045
2	0.888	0.780	0.701	0.615	0.561	0.506	0.449	0.340	0.260	0.179	0.124
3	0.655	0.554	0.481	0.401	0.344	0.294	0.248	0.140	0.064	0.000	−0.08
4	0.455	0.344	0.276	0.199	0.130	0.083	0.037	−0.08	−0.13	−0.21	−0.28
5	0.910	0.797	0.721	0.630	0.572	0.519	0.456	0.336	0.260	0.173	0.111
6	1.015	0.906	0.820	0.739	0.678	0.624	0.567	0.449	0.365	0.288	0.230
7	0.390	0.845	0.770	0.680	0.621	0.566	0.508	0.389	0.305	0.223	0.164
8	1.005	0.892	0.812	0.724	0.669	0.615	0.554	0.435	0.352	0.270	0.212
Log X_s	−0.680	−0.605	−0.564	−0.510	−0.478	−0.447	−0.408	−0.350	−0.301	−0.259	−0.222
$\varepsilon_{AB}{}^b$	0.321	0.330	0.337	0.343	0.348	0.355	0.363	0.377	0.389	0.402	0.413
$\varepsilon_{AB}{}^c$	0.054	0.060	0.063	0.068	0.070	0.073	0.076	0.080	0.083	0.086	0.090

[a] *n*-Heptane–ethyl acetate composition (v/v) in parentheses.

[b] Solvent strength values on silica taken from information in ref. 33.

[c] Solvent strength values on an aminopropyl bonded-phase column taken from information in ref. 23.

TABLE IV

SLOPES, INTERCEPTS AND CORRELATION COEFFICIENTS FOR LOG k' *VS.* SOLVENT STRENGTH DATA FOR 2-PROPANOL AND ETHYL ACETATE BINARY MOBILE PHASES

Log k' values are from an aminopropyl bonded-phase column with solvent strength values from silica.

Mobile phase component	*Compound No.*	*Slope*	*Intercept*	*Correlation coefficient*
2-Propanol	1	−9.19	3.83	−0.994
	2	−9.67	4.06	−0.995
	3	−8.06	2.94	−0.996
	4	−8.57	3.29	−0.996
	5	−8.56	3.43	−0.995
	6	−8.67	3.39	−0.996
	7	−8.84	3.54	−0.996
	8	−8.75	3.43	−0.996
Ethyl acetate	1	−7.84	3.45	−0.989
	2	−8.18	3.45	−0.988
	3	−7.68	3.06	−0.989
	4	−7.67	2.85	−0.987
	5	−8.51	3.58	−0.990
	6	−8.38	3.64	−0.989
	7	−8.50	3.63	−0.989
	8	−8.46	3.65	−0.989

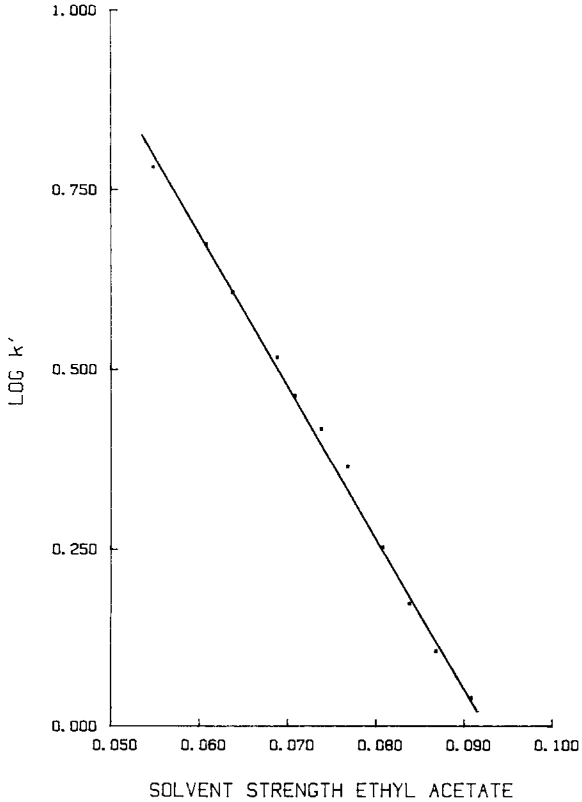

Fig. 1. Plot of log k' *vs.* solvent strength (ε) data from the aminopropyl bonded-phase column for 1-naphthol using *n*-heptane–ethyl acetate mobile phases.

TABLE V

SLOPES, INTERCEPTS AND CORRELATION COEFFICIENTS FOR LOG k' *VS.* SOLVENT STRENGTH FOR *n*-HEPTANE–ETHYL ACETATE MOBILE PHASES

Log k' and solvent strength values are from an aminopropyl bonded-phase column.

Compound No.	*Slope*	*Intercept*	*Correlation coefficient*
1	−20.66	1.92	−0.998
2	−21.45	2.06	−0.999
3	−20.21	1.76	−0.998
4	−20.24	1.56	−0.998
5	−22.40	2.14	−0.998
6	−22.07	2.22	−0.998
7	−22.40	2.19	−0.999
8	−22.27	2.22	−0.998

However, the results can be used in a practical fashion to predict the retention of hydroxyl aromatics.

If the solvent strength values for *n*-heptane–ethyl acetate mobile phases from an aminopropyl bonded-phase column from Scolla and Hurtubise[23] were used, plots of log k' *vs.* solvent strength yielded excellent correlation coefficients ranging from −0.998 to −0.999 (Fig. 1). The results for the slopes, intercepts and correlation coefficients are given in Table V. The main reason why the correlation coefficients are better in Table V than in Table IV is that the solvent strength data for an aminopropyl bonded-phase column were used rather than solvent strength values from silica. Use of

TABLE VI

SLOPES, INTERCEPTS AND CORRELATION COEFFICIENTS FOR LOG k' *VS.* LOG (MOLE FRACTION) PLOTS FOR 2-PROPANOL AND ETHYL ACETATE BINARY MOBILE PHASES

Mobile phase component	*Compound No.*	*Slope*	*Intercept*	*Correlation coefficient*
2-Propanol	1	−1.13	−0.68	−1.00
	2	−1.19	−0.70	−1.00
	3	−0.96	−1.00	−0.999
	4	−1.04	−0.90	−0.999
	5	−1.01	−0.73	−0.999
	6	−1.05	−0.85	−0.999
	7	−1.07	−0.78	−1.00
	8	−1.05	−0.84	−0.999
Ethyl acetate	1	−1.63	−0.31	−1.00
	2	−1.69	−0.25	−1.00
	3	−1.59	−0.42	−0.999
	4	−1.60	−0.62	−0.999
	5	−1.77	−0.28	−1.00
	6	−1.74	−0.16	−1.00
	7	−1.77	−0.23	−1.00
	8	−1.76	−0.18	−1.00

the solvent strength values from an aminopropyl bonded-phase column has a strong theoretical basis[9,18].

Plots of log k′ vs. log (mole fraction of the strong solvent)

For polar mobile phases, eqn. 4 should give a linear relationship for log *k*′ *vs.* log (mole fraction of the strong solvent)[17]. Results from the graphs of log *k*′ *vs.* log (mole fraction of the strong solvent) are given in Table VI. The high correlation coefficients, ranging from −0.999 to −1.00, indicate that the plots are linear. Figs. 2 and 3 show log *k*′ *vs.* log (mole fraction of the strong solvent) graphs for 1-naphthol in *n*-heptane–2-propanol and *n*-heptane–ethyl acetate mobile phases, respectively. This approach should be applicable to predicting retention for polar solutes with polar mobile phases on an aminopropyl bonded-phase column. The theoretical aspects of the graphs of log *k*′ *vs.* log (mole fraction of the strong solvent) for aminopropyl bonded-phase columns have not been fully developed. In the remaining part of the paper, only the relationship between log *k*′ and solvent strength values from an aminopropyl bonded-phase column will be discussed.

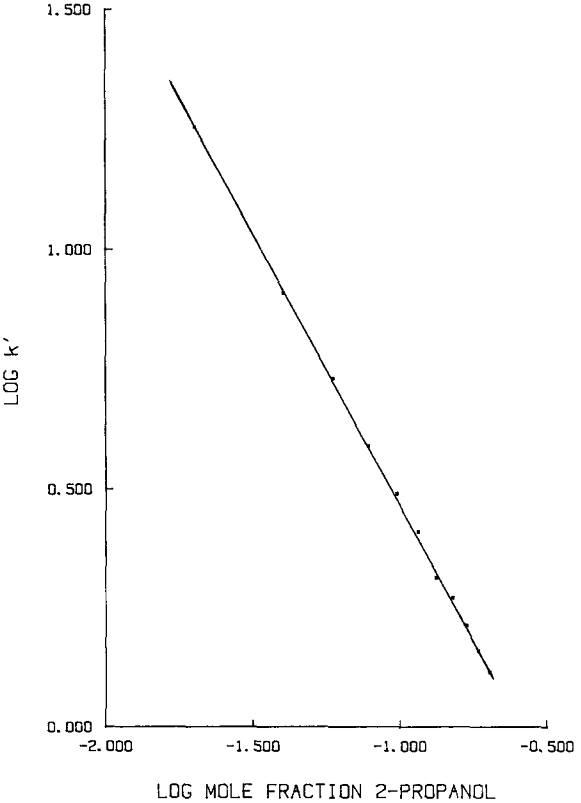

Fig. 2. Plot of log *k*′ *vs.* log (mole fraction of 2-propanol) for 1-naphthol using *n*-heptane–2-propanol mobile phases.

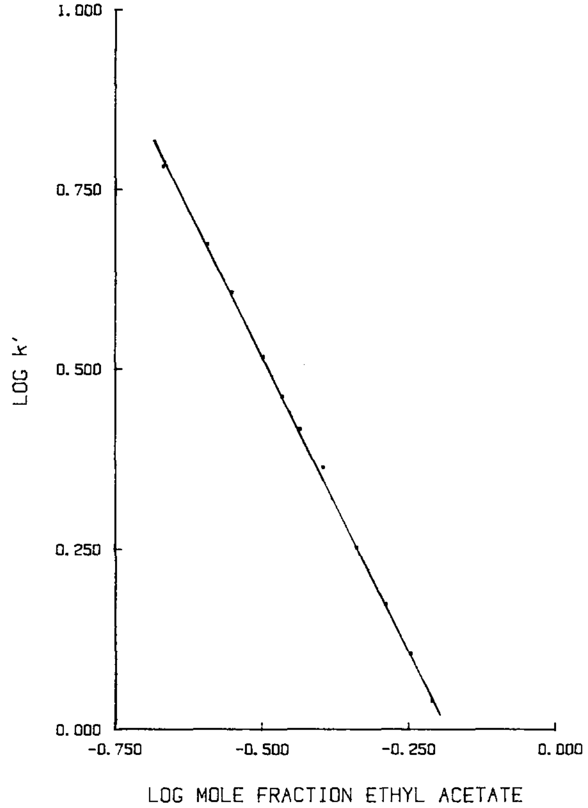

Fig. 3. Plot of log k' *vs.* log (mole fraction of ethyl acetate) for 1-naphthol using *n*-heptane–ethyl acetate mobile phases.

Theoretical interpretations

Snyder and Schunk[18]. in comparing aminopropyl bonded-phase and silica columns, noted that retention on an aminopropyl bonded-phase column is generally lower. This means that the solutes and the solvents do not localize as strongly on an aminopropyl bonded-phase column. Also, the solvent strength values will differ on the two types of columns as restricted-access delocalization is minimal on an aminopropyl bonded-phase column[18] and therefore the solvent strength values will not be as large on the aminopropyl column. This is supported by the solvent strength data reported in Table III for the *n*-heptane–ethyl acetate mobile phases and other data reported in the literature[9,18].

Owing to the polar nature of the solutes (see Table I), localization and hydrogen bonding of these solutes to the stationary phase are expected. If localization or hydrogen bonding does occur, the experimental A_s values will be larger than the calculated A_s values[25,32,33]. Other factors to consider are interactions among solvent and solute molecules and their effects on solvent strength. Snyder[9] has shown that with an aminopropyl bonded-phase column the contribution of molecular interactions to solvent strength should be reduced by about half in comparison with silica.

The slopes in Table V are equal to $\alpha' A_s$, according to eqn. 3; α' will be arbitrarily

TABLE VII

CALCULATED AND EXPERIMENTAL A_s VALUES USING LOG k' *VS.* SOLVENT STRENGTH DATA FOR *n*-HEPTANE–ETHYL ACETATE MOBILE PHASES

Log k' and solvent strength values are from an aminopropyl bonded-phase column.

Compound No.	A_s *(calc.)*	A_s *(exptl.)*	ΔA_s
1	15.7	20.7	−5.0
2	15.7	21.4	−5.7
3	18.1	20.2	−2.1
4	17.2	20.2	−3.1
5	17.5	22.4	−4.9
6	18.4	22.1	−3.7
7	17.5	22.4	−4.9
8	18.4	22.3	−3.9

assumed to have a value of unity[18]. Using this information, the slopes in Table V and eqns. 3 and 5, the experimental and calculated A_s values can be determined. Table VII contains a list of the calculated A_s, experimental A_s and ΔA_s (calculated A_s − experimental A_s) values from plots of log k' from the aminopropyl bonded-phase column *vs.* solvent strength values from an aminopropyl bonded-phase column for the *n*-heptane–ethyl acetate mobile phases. In Table VII, all of the experimental A_s values are larger than the calculated A_s values, which indicates that site-competition delocalization is occurring[9,18]. It is expected that the compounds with the smaller pK_a values would donate a proton more readily and therefore more strongly localize or hydrogen bond with the stationary phase and have larger ΔA_s values. However, if the ΔA_s values are compared with the pK_a values in Table I, no pattern appears to stand out. This indicates that other factors are more important than pK_a values. This is not surprising, given the overall complexity of the chromatographic interactions.

CONCLUSIONS

The linearity for plots of log k' *vs.* solvent strength and log k' *vs.* log (mole fraction of the strong solvent) for both the aminopropyl bonded-phase column and earlier results with a silica column[24] would be useful for predicting the retention of hydroxyl aromatics. Because a solvent strength value for 2-propanol is not available for the aminopropyl bonded-phase column, it was not possible to correlate the *n*-heptane–2-propanol retention data directly with the Snyder model. However, the linear plots acquired for log k' *vs.* solvent strength for ethyl acetate from an aminopropyl bonded-phase column and the relatively large A_s (exptl.) values for the aminopropyl bonded-phase column showed that the Snyder model readily described the retention characteristics of the hydroxyl aromatics for this chromatographic system. Similar conclusions were reached for the *n*-heptane–ethyl acetate mobile phases on a silica column[24].

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