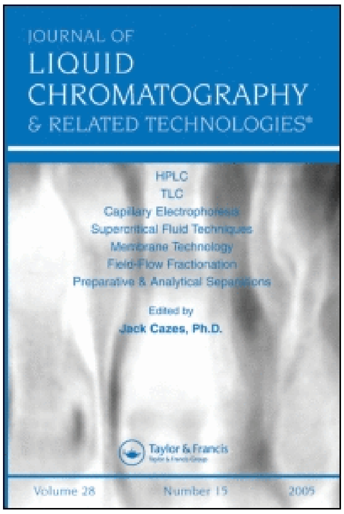


Journal of Liquid Chromatography & Related Technologies
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713597273

RETENTION BEHAVIOR OF SOME PHENOXYACETIC ACID DERIVATIVES ON SILICA GEL AND DIOL BONDED SILICA GEL HPTLC PRECOATED PLATES

Maria L. Bieganowska; Anna Rompała

To cite this Article Bieganowska, Maria L. and Rompała, Anna(1999) 'RETENTION BEHAVIOR OF SOME PHENOXYACETIC ACID DERIVATIVES ON SILICA GEL AND DIOL BONDED SILICA GEL HPTLC PRECOATED PLATES', Journal of Liquid Chromatography & Related Technologies, 22: 10, 1443 — 1456

To link to this Article: DOI: 10.1081/JLC-100101743

URL: http://dx.doi.org/10.1081/JLC-100101743

J. LIQ. CHROM. & REL. TECHNOL., 22(10), 1443–1456 (1999)

RETENTION BEHAVIOR OF SOME PHENOXYACETIC ACID DERIVATIVES ON SILICA GEL AND DIOL BONDED SILICA GEL HPTLC PRECOATED PLATES

Maria L. Bieganowska, Anna Rompała

Department of Inorganic and Analytical Chemistry
Medical Academy, Staszica 6
20-081 Lublin, Poland

ABSTRACT

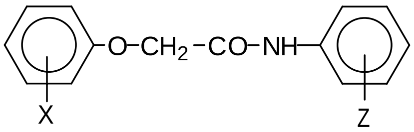
The HPTLC behavior of closely related N-phenylamide derivatives of phenoxyacetic acid has been studied on silica gel and diol-modified silica gel layers developed with binary non-aqueous mobile phases (ethyl acetate, dioxane, or methyl ethyl ketone in n-heptane or dichloromethane). The influence of the different polar modifiers on the retention was illustrated as linear plots of $R_M = f(\log c)$. The separation selectivities of the investigated compounds on silica gel and diol phases were compared as $R_{M(silica)}$ vs. $R_{M(diol)}$ relationships.

INTRODUCTION

The chromatographed N-phenylamides of phenoxyacetic acid are an interesting group of biologically active compounds. They have been widely analyzed by reversed-phase thin-layer and column chromatography. Their retention was compared with their pharmacological activity expressed by two effects, the inhibition of prostaglandin synthetase and the strength of binding to albumins.[1-3]

Table 1

Constants for $R_M = R_M^0 - m \log c$; Intercept (R_M^0); and Slope (m)
Structures of Investigated Compounds



			HPTLC Diol-Modified Silica			
			MEK n-Heptane		**Dioxane n-Heptane**	
No.	**X**	**Z**	**m**	**R_M^0**	**m**	**R_M^0**
1	---	o-COOH	-2.28	-1.03	-2.18	-0.87
2	o-Me	o-COOH	-2.91	-1.02	-2.59	-0.75
3	o-Me	p-COOH	-2.45	-1.16	-2.01	-0.89
4	m-Me	o-COOH	-1.99	-0.99	-2.13	-0.93
5	p-Me	o-COOH	-2.46	-1.12	-2.12	-0.86
6	p-Me	m-COOH	-2.15	-1.05	-1.95	-0.81
7	p-Me	o-COOH, 4-Me	-2.50	-0.91	-2.53	-0.87
8	p-Me	o-COOH, 6-Me	-2.13	-1.06	-1.97	-0.88
9	p-Me	o-COOH, 4-Cl	-2.74	-0.90	-2.37	-0.67
10	p-Me	o-COOH, 6-Cl	-2.29	-1.01	-1.90	-0.73
11	p-Me	o-COOH, 4-Br	---	---	---	---
12	p-Me	o-COOH, 5-NO_2	---	---	---	---
13	p-Cl	o-COOH	-2.06	-0.96	-2.01	-0.93
14	p-Cl	o-COOH, 4-Cl	-2.23	-0.79	-2.51	-0.79

Many phenoxycarboxylic acids applied as pesticides have been analyzed on different adsorbents: silica gel;[4-6] cellulose;[7] silver nitrate impregnated silica gel;[8] and NH_2-, CN-, and diol-modified silica gel.[9] Our studies were performed using silica gel and diol phases and different non-aqueous mobile phase systems.

The compounds investigated (including positional isomers), differing from one another by one functional group in the ring (hydrophobic and hydrophilic substituents), provide information on molecular interactions in these systems. The effects of individual substituents on retention were quantified by ΔR_M values.

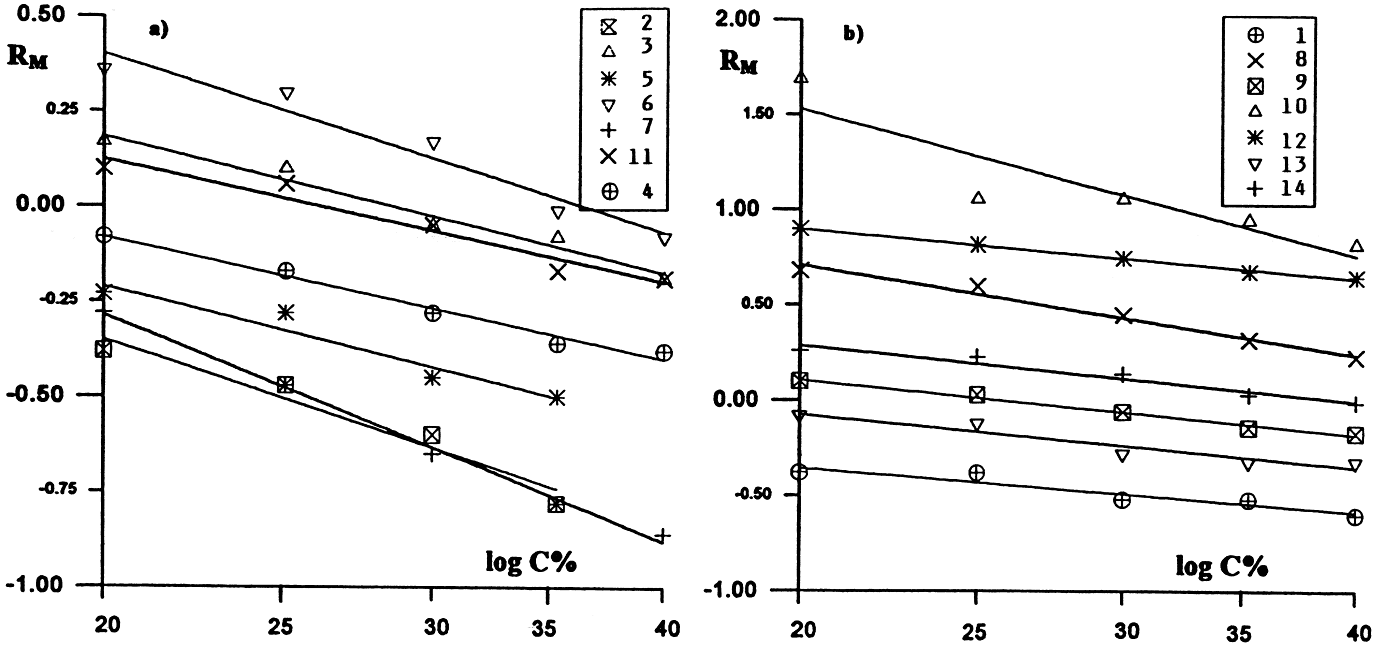


Figure 1. Plots of R_M against the logarithm of modifier concentration, c (% v/v) in the mobile phase for the investigated compounds on silica gel HPTLC plates. Mobile phase: dioxane in dichloromethane. Compound numbers as in Table 1.

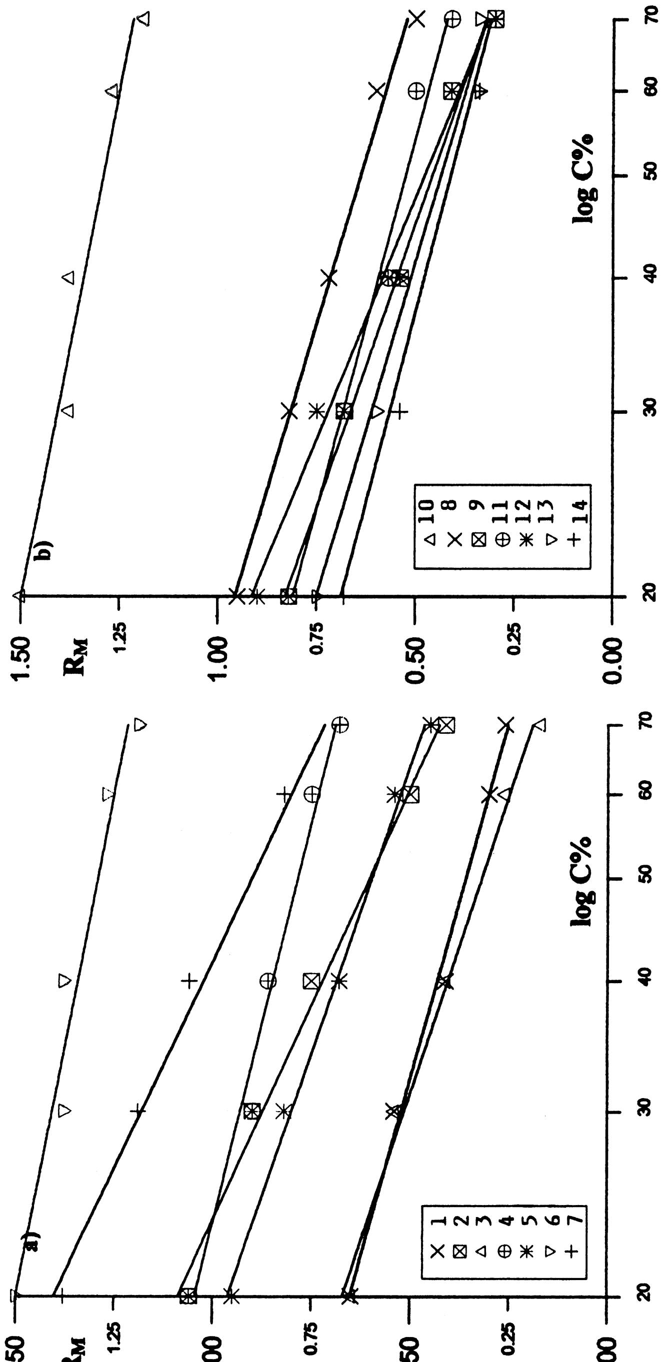


Figure 2. As in Figure 1. Mobile phase: ethyl acetate in dichloromethane.

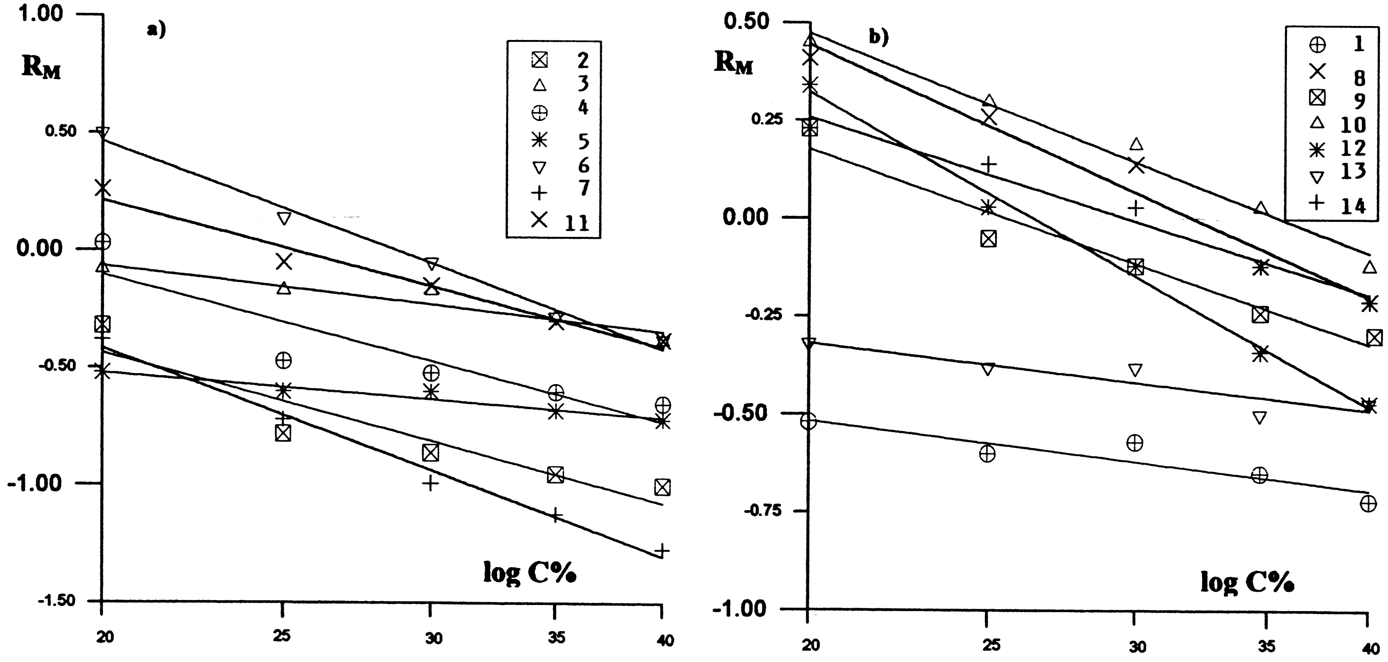


Figure 3. As in Figure 1. Mobile phase: dioxane in dichloromethane + 0.25% triisopentylamine.

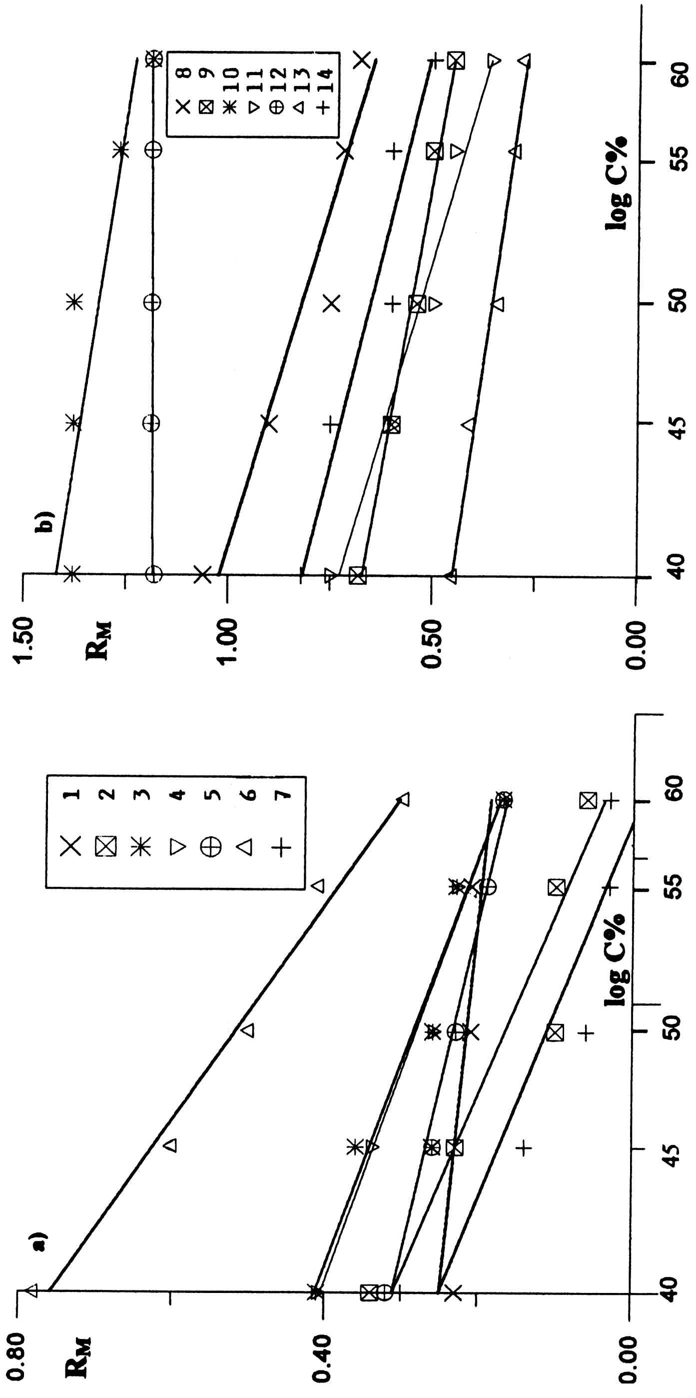


Figure 4. As in Figure 1. Mobile phase: ethyl acetate in dichloromethane + 0.25 % triisopentylamine.

EXPERIMENTAL

The solutes were chromatographed at 20 ± 22°C on HPTLC silica gel and HPTLC diol plates 10 x 10 cm from E. Merck (Darmstadt, Germany) in a horizontal sandwich chamber with a glass mobile phase distributor.[10] Samples (2 μL) of solutions (0.2% w/v) of the solutes in methanol were spotted 1 cm from the bottom edge of the plate. The development distance was 8 cm. The spots were located under UV light at $\lambda = 254$ nm. The other chromatographic conditions used are given either in the figure captions or in the text. All solvents were pro analysis grade from Polish Reagents (POCh, Gliwice).

RESULTS AND DISCUSSION

The investigated compounds listed in Table 1 have been chromatographed on silica gel and diol-modified silica HPTLC plates using non-aqueous binary mobile phase sometimes containing the ion-association reagent triisopentylamine. It seemed worthwhile to extend our previous chromatographic investigations of these compounds[1-3,11] on hydrophilic adsorbents in order to evaluate the retention selectivity and mechanism of adsorption. The mechanistic model of competitive adsorption of solute and solvent molecules for the polar adsorbents (silica and alumina) elaborated by Snyder-Soczewiński can also be applied for interpretation of the solute behavior on diol-modified silica gel. This model is quantitatively described by the following, linear equation:[12-15]

$$R_M = \log (1-R_F)/R_F = R_M^o - m \log c \qquad (1)$$

where c is the volume percentage concentration of the more polar solvent in the mobile phase; R_M^o (intercept) = R_M for pure modifier c = 1 (i.e., the right-hand ordinate) is related to the strength of solute stationary phase binding. The slope (m), which is constant for the system, represents the average number of solute molecule-active adsorption sites.

The equation enables the interpretation of the retention mechanism relative to solute, solvent, and adsorbent characteristics. The retention vs solvent composition relationships are very important for selection of an optimal system for a given set of chromatographed compounds.

The experimental data are presented as plots of R_M values against volume percentage concentration of dioxane or ethyl acetate as modifiers in pure dichloromethane (Figs. 1 and 2) or in dichloromethane containing low amounts

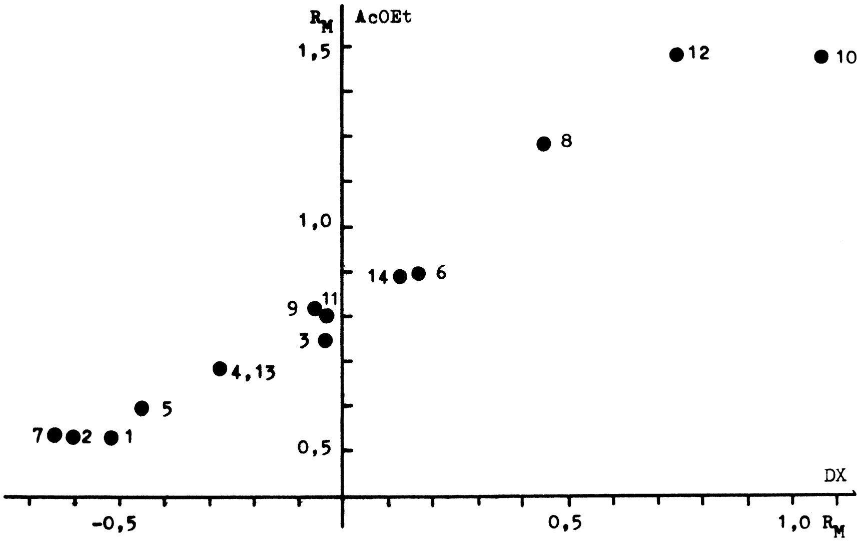


Figure 5. Correlation of R_{M1} for 30% ethyl acetate in dichloromethane with R_{M2} for 30% dioxane in dichloromethane. Adsorbent: silica gel. Compound numbers as in Table 1.

of triisopentylamine (Figs. 3 and 4) and also as diagrams of R_{M1} vs R_{M2} correlations for modifiers 1 and 2 (Figs. 5-7) and for adsorbents (diol and silica, Fig. 8). Linear relationships $R_M = f(\log c)$ (Figs. 1 and 2) were obtained for almost all the modifier concentrations used, in accordance with equation 1.

The differentiated slopes depending on the difference in mobile phase strength and number of polar groups in the analyte molecule caused the individual lines plotted in the figures to sometimes cross (changes in spot sequence), giving the possibility of optimizing the systems for separation of particular pairs of compounds. The majority of the solutes were well separated in both systems. R_M values in the optimum range of 0.2-0.8 were obtained in most cases (lower R_M values are indicative of faster migration). For some individual pairs of compounds, better separation was obtained with higher modifier concentration and for other pairs with lower.

Dioxane is a significantly stronger modifier than ethyl acetate, so that for its lower concentration comparable R_M values for both systems were obtained. In all cases, R_M values decreased with increasing amount of polar modifier in the mobile phase.

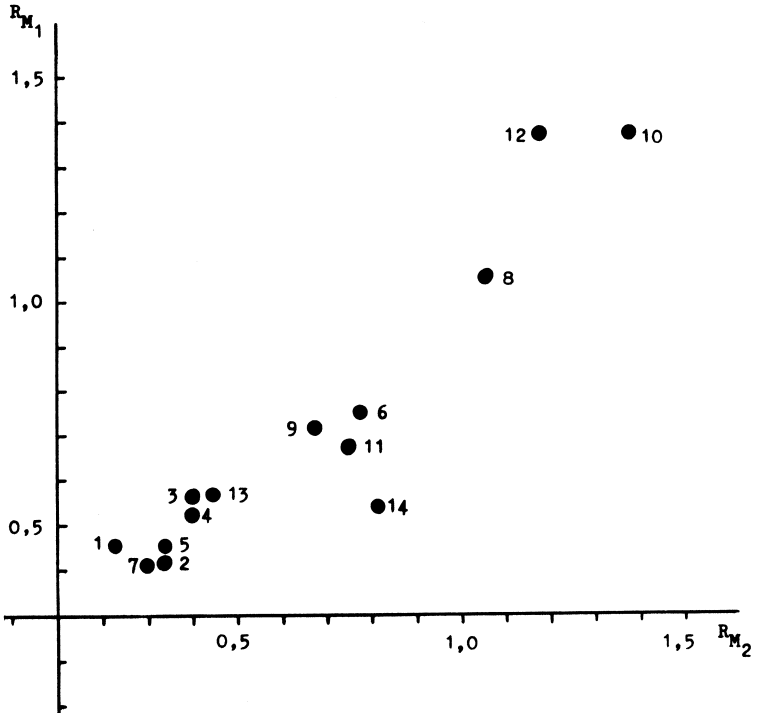


Figure 6. Correlation of R_{M1} for 40% ethyl acetate in dichloromethane with R_{M2} for 40% ethyl acetate in dichloromethane + 0.25% triisopentylamine. Adsorbent: silica gel. Compound numbers as in Table 1.

The highest R_F values were obtained for solutes with ortho carboxylic group. Their hydrophilic properties were decreased owing to intramolecular H-bonds formed between vicinal carboxylic and amido groups (compounds 1,2,5); similarly, a halogen atom introduced into the molecule (especially in the para position) also caused a decrease in hydrophilic properties. The compounds with free proton-donor carboxylic group forming hydrogen bond linkages with silanol groups as active centers of silica gel were strongly adsorbed. Somewhat better separation for some isomers was obtained when ion-associating triisopentylamine was added to the mobile phase (Figs. 3 and 4).

For comparison of the selectivities of the systems used, the difference between retention parameters (R_M) was quantitatively expressed by ΔR_M (R_{Mn} - R_{M1}) values in Table 2, and also by diagrams of R_{M1} vs R_{M2} relationships (Figs 5-7).

Table 2

Retention and Selectivity Parameters, ΔR_M (R_{Mn} - R_{M1}) Values For Silica Gel Adsorbent

	Diluent: Dichloromethane								Diluent: n-Heptane			
	30% Dioxane		30% Dioxane +0.25% Triisopentyl Amine		40% Ethyl Acetate		40% Ethyl Acetate + 25% Triisopentyl Amine		50% Dioxane		50% Dioxane +0.25% Triisopentyl Amine	
No.	R_F	ΔR_M	R_F	ΔR_M	R_F	ΔR_M	R_F	ΔR_M	R_F	ΔR_M	R_F	ΔR_M
1	0.77	---	0.79	---	0.26	---	0.37	---	0.33	---	0.42	---
2	0.80	-0.08	0.88	-0.29	0.28	-0.04	0.32	0.11	0.53	-0.35	0.60	0.31
3	0.53	0.47	0.60	0.40	0.21	0.13	0.28	0.18	0.28	0.11	0.35	0.12
4	0.66	0.24	0.77	0.05	0.22	0.09	0.28	0.18	0.40	-0.13	0.53	-0.19
5	0.74	0.07	0.80	-0.03	0.26	0.00	0.32	0.11	0.44	-0.20	0.53	-0.19
6	0.40	0.69	0.53	0.52	0.15	0.30	0.14	0.55	0.28	0.11	0.33	0.16
7	0.82	-0.13	0.92	-0.42	0.28	-0.04	0.33	0.07	0.48	-0.27	0.55	-0.22
8	0.26	0.97	0.42	0.71	0.08	0.61	0.08	0.83	0.33	0.00	0.44	-0.04
9	0.54	0.45	0.57	0.45	0.16	0.27	0.17	0.45	0.28	0.11	0.62	-0.35
10	0.08	1.58	0.39	0.76	0.04	0.93	0.04	1.15	0.13	0.52	0.22	0.40
11	0.53	0.47	0.59	0.42	0.17	0.23	0.15	0.52	0.33	0.00	0.75	-0.61
12	0.15	1.27	0.57	0.45	0.04	0.93	0.06	0.96	0.04	1.08	0.26	0.31
13	0.66	0.24	0.71	0.19	0.21	0.12	0.26	0.22	0.33	0.00	0.47	-0.09
14	0.42	0.66	0.48	0.60	0.22	0.09	0.13	0.59	0.24	0.20	0.56	-0.24

Fig. 5 shows the comparison two modifiers, ethyl acetate and dioxane. The points are widely dispersed. A pair of solutes at similar abscissa values and different ordinates is poorly separated in system 2 (abscissa coordinate) but separated much better in system 1, and vice versa.

For ethyl acetate, the dispersion of correlation points is less pronounced. In this instance, the R_M values are in the range of 0.88 units for ethyl acetate and 1.68 units for dioxane and, hence, dioxane is more selective solvent. Compounds 1,2,7 and 10,12 were not separated by use of ethyl acetate but were well separated by use of dioxane, but for compounds 1,5 and 3,11, ethyl acetate was the more selective solvent.

Figs. 6 and 7 depict that the retention and selectivity of investigated compounds can be affected not only by the nature and concentration of modifier, but also by addition of an ion-associating reagent to the mobile phase.

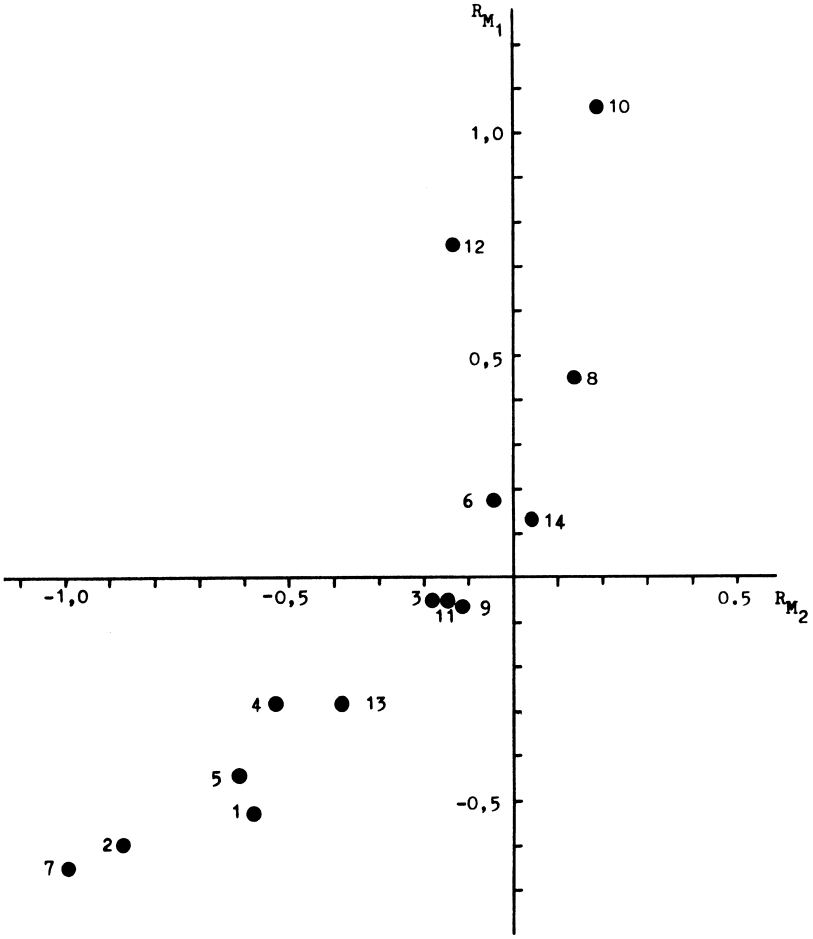


Figure 7. Correlation of R_{M1} for 30% dioxane in dichloromethane with R_{M2} for 30 % dioxane in dichloromethane + 0.25% triisopentylamine. Adsorbent: silica gel. Compound numbers as in Table 1.

The majority of the solutes were better separated in these systems (see solutes 1,2,7 and 10,12 in Fig. 6 and 4,13 in Fig. 7). The experimental results obtained on diol-modified silica gel layers are presented in Table 1 as the parameters of Eq. 1. In accordance with the mechanistic model based on the law of mass action, the R_M vs log c plots are linear ($r > 0.984$) for almost all investigated concentration ranges of modifiers.

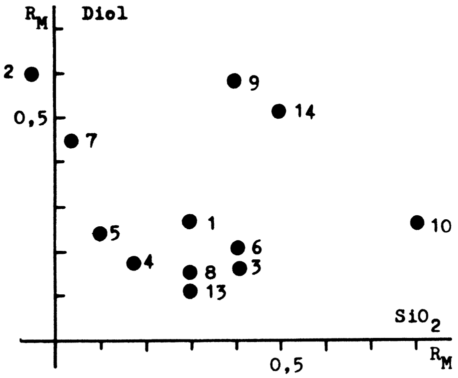


Figure 8. Correlation of R_M for 30% dioxane in *n*-heptane (adsorbent: diol silica gel) with R_M for 50% dioxane in *n*-heptane (adsorbent: silica gel). Compound numbers as in Table 1.

The absolute slope values of about 2-3 indicate two or three point interactions with the adsorbent surface as well as the solvation equilibria. The retention behavior and separation selectivity of the solutes on silica gel and diol-modified silica phases was directly compared by R_{M1} vs R_{M2} correlation (Fig. 8) obtained using the same solvents in both systems.

A lower concentration of dioxane was needed for elution with comparable R_F values on diol phase; the adsorptive properties of diol surface are weaker.[16]

The correlation line of the strongly dispersed points in the diagram is expressed by the following equation:

$$R_{M(silica)} = 0.47 - 0.54\, R_{M(diol)} \qquad n = 12;\ r = 0.230 \qquad (2)$$

The very low correlation coefficient indicates individual differences in selectivity of both adsorbents and that the chemical character of the surface-active centers (acidic silanol groups on the silica surface and alcoholic OH groups on the diol surface) is quite different.[17-20] The proton-donor-acceptor groups of the solute molecule play a significant role in the mechanism of adsorption on polar sorbents but, in case of diol layers, also non-polar methyl groups or halogen cause non-specific interactions with non-polar fragment of diol-ligands (dihydroxy alkyl groups) and, thereby, this stationary phase can be also used in the reversed-phase mode. Non-specific interactions cause a weakened strength of polar properties of the diol-silica phase.

CONCLUSIONS

The results obtained show the usefulness of silica gel and diol-silica adsorbents for chromatographic analysis of the investigated compounds. The comparison the data obtained for different mobile phases and adsorbents permits the choice of selective systems for two-dimensional chromatography and also for re-chromatography, especially for difficult separations of closely related compounds.

ACKNOWLEDGMENT

Thanks are due to Beata Skrzypiec for participation in the experiments.

REFERENCES

1. M. L. Bieganowska, A. Petruczynik, M. Gadzikowska, J. Chromatogr., **520**, 403-410 (1990).
2. W. Markowski, M. L. Bieganowska, Chromatographia, **26**, 97-100 (1988).
3. M. L. Bieganowska, E. Soczewiński, in **Quantitative Structure Activity Analysis**, Symposium in Suhl, 1976, R. Franke, P. Oehme, eds., Academic Verlag, Berlin, 1978, p. 29.
4. V. N. Kavetskii, L. I. Bublic, G. V. Fuzik, Zh. Anal. Khim., **42**, 1302-1304 (1987).
5. M. D. Osselton, R. D. Snelling, J. Chromatogr., **368**, 265-271 (1986).
6. M. Siegel, M. Schmitt, H. Jork, J. Planar Chromatogr.-Mod. TLC, **2**, 304-309 (1997).
7. H. E. Hauck, E. Amadori, in **Pesticide Analytical Methodology,** J. Harvey, G. Zweig, eds., ACS Symposium Series No. 136, 1980, pp. 159-176.
8. J. Sherma, J. Liq. Chromatogr., **9**, 3433-3438 (1986).
9. H. E. Hauck, M. Mack, S. Reuke, H. Herbert, J. Planar Chromatogr.-Mod. TLC, **2**, 268-275 (1989).
10. T. H. Dzido, J. Planar Chromatogr.-Mod. TLC, **3**, 199-200 (1990).

11. M. L. Bieganowska, A. Petruczynik, A. Doraczyńska, J. Liq. Chromatogr., **13**, 2661-2676 (1990).

12. E. Soczewiński, W. Gołkiewicz, Chromatographia, **6**, 269-273 (1973).

13. E. Soczewiński, Anal. Chem., **41**, 179-182 (1969).

14. L. R. Snyder, Anal. Chem., **46**, 1384-1393 (1974).

15. L. R. Snyder, H. Poppe, J. Chromatogr., **184**, 363-413 (1980).

16. M. L. Bieganowska, J. Liq. Chromatogr. Rel. Technol., **20**, 2089-2098 (1997).

17. T. Cserhati, H. E. Hauck, J. Chromatogr., **514**, 45-55 (1990).

18. H. E. Hauck, M. Mack, W. Yost, in **Handbook of Thin Layer Chromatography**, J. Sherma, B. Fried, eds., Chromatographic Science Series, Vol. 55, Marcel Dekker, Inc. New York, 1991, p. 87.

19. L. Witherow, R. J. Thorp, I. D. Wilson, A. Warrander, J. Planar Chromatogr.-Mod. TLC, **3**, 169-172 (1990).

20. S. Reuke, H. E. Hauck, Fresenius J. Anal. Chem., **351**, 739-744 (1995).

Received May 29, 1998
Accepted July 23, 1998
Manuscript 4907-TLC

Downloaded At: 10:27 24 January 2011

Request Permission or Order Reprints Instantly!

Interested in copying and sharing this article? In most cases, U.S. Copyright Law requires that you get permission from the article's rightsholder before using copyrighted content.

All information and materials found in this article, including but not limited to text, trademarks, patents, logos, graphics and images (the "Materials"), are the copyrighted works and other forms of intellectual property of Marcel Dekker, Inc., or its licensors. All rights not expressly granted are reserved.

Get permission to lawfully reproduce and distribute the Materials or order reprints quickly and painlessly. Simply click on the "Request Permission/Reprints Here" link below and follow the instructions. Visit the U.S. Copyright Office for information on Fair Use limitations of U.S. copyright law. Please refer to The Association of American Publishers' (AAP) website for guidelines on Fair Use in the Classroom.

The Materials are for your personal use only and cannot be reformatted, reposted, resold or distributed by electronic means or otherwise without permission from Marcel Dekker, Inc. Marcel Dekker, Inc. grants you the limited right to display the Materials only on your personal computer or personal wireless device, and to copy and download single copies of such Materials provided that any copyright, trademark or other notice appearing on such Materials is also retained by, displayed, copied or downloaded as part of the Materials and is not removed or obscured, and provided you do not edit, modify, alter or enhance the Materials. Please refer to our Website User Agreement for more details.

Order now!

Reprints of this article can also be ordered at

http://www.dekker.com/servlet/product/DOI/101081JLC100101743