Journal of Chromatography, 135 (1977) 473–476

CHROM. 9902

Note

Elution behaviour of some derivatives of 2-phenyl-2-(4-hydroxyphenyl)propane on Sephadex LH-20 with acetone and 1,4-dioxan as eluents

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(Received December 14th, 1976)

In a previous paper[1] we discussed the elution behaviour of 2-phenyl-2-(4-hydroxyphenyl)propane (cumylphenol) and eleven of its derivatives on Sephadex LH-20 with methanol and N,N-dimethylformamide. It was found that with methanol all of the compounds examined were adsorbed on the gel, showing π-bonding and, in some instances, also hydrogen bonding with Sephadex LH-20. With N,N-dimethylformamide, the cumylphenol derivatives in which the hydroxyl group was free or substituted by an amino group partially permeated the gel, while those in which a chlorine atom or a methoxy group replaced the hydroxyl group were completely excluded.

This work is an extension of the investigations to the elution behaviour of cumylphenol derivatives on Sephadex LH-20 in with acetone and 1,4-dioxan as eluents.

EXPERIMENTAL

The experiments were carried out in two glass columns of the same diameter filled with Sephadex LH-20 swollen under identical conditions in acetone and 1,4-dioxan. The apparatus, the procedure and the syntheses of cumylphenol and its derivatives were described in the previous paper[1]. The main characteristics of the gel bed and some of the experimental conditions are given in Table I.

RESULTS AND DISCUSSION

The K_D values of cumylphenol and its derivatives obtained from their elution on Sephadex LH-20 with acetone and 1,4-dioxan are given in Table II.

Elution behaviour in acetone

From the low K_D values for compounds V and VI, which are not able to undergo hydrogen bonding with the gel, it can be seen that these compounds permeate the gel to some extent, without considerable retardation, and that low K_D values show there is even a tendency for them to be excluded from the gel pores. Hence, in acetone a π-interaction of cumylphenol derivatives with Sephadex LH-20 does not take place.

According to Berek and Bakoš[3], alcohols and phenols are very strongly retarded when eluted on Sephadex LH-20 with acetone. Our results indicate that

TABLE I

COLUMN CHARACTERISTICS AND EXPERIMENTAL CONDITIONS

Parameter	*Eluent*	
	Acetone	*1,4-Dioxan*
Column diameter (cm)	2.7	2.7
Height of gel bed (cm)	41.7	39.5
Dry weight of gel (g)	95.2	67.5
Total volume of gel bed, V_t (ml)	238	226
Void volume, V_0 (ml)	84*	77*
Inner volume, V_i (ml)	76**	94**
Sample size (mg)	5.6	5.6
Sample volume (ml)	0.8	0.8
Flow-rate (ml/h)	60	60

* Determined by elution of high-molecular-weight poly(methyl methacrylate).

** Calculated as the product of the corresponding solvent regains (manufacterer's values[2]) and the dry weights of the gels.

TABLE II

K_D VALUES OF CUMYLPHENOL AND ITS DERIVATIVES ON SEPHADEX LH-20 IN ACETONE AND 1,4-DIOXAN

No.	*Cumylphenol derivative*	*Eluent*	
		Acetone	*1,4-Dioxan*
I	2-Phenyl-2-(4-hydroxyphenyl)propane (cumylphenol)	0.92	0.47
II	2-Phenyl-2-(3-nitro-4-hydroxyphenyl)propane (mononitrocumylphenol)	1.04	0.69
III	2-Phenyl-2-(3,5-dinitro-4-hydroxyphenyl)propane (dinitrocumylphenol)	22.6	0.76
IV	2-(4-Nitrophenyl)-2-(3,5-dinitro-4-hydroxyphenyl)propane (trinitrocumylphenol)	23.8	0.94
V	2-Phenyl-2-(3,5-dinitro-4-methoxyphenyl)propane	0.64	0.56
VI	2-(4'-Nitrophenyl)-2-(3,5-dinitro-4-methoxyphenyl)propane	0.57	0.56
VII	2-Phenyl-2-(3,5-dinitro-4-chlorophenyl)propane	0.95	0.36
VIII	2-(4'-Nitrophenyl)-2-(3,5-dinitro-4-chlorophenyl)propane	0.84	0.33
IX	2-Phenyl-2-(3-nitro-4-hydroxy-5-aminophenyl)propane	1.33	0.74
X	2-Phenyl-2-(3,5-dinitro-4-aminophenyl)propane	0.98	0.61
XI	2-(4'-Nitrophenyl)-2-(3,5-dinitro-4-aminophenyl)propane	0.86	0.79

cumylphenol shows only a very slight retardation. The retardation increases slightly with mononitrocumylphenol and is extremely high with dinitrocumylphenol and trinitrocumylphenol. Such a difference in the K_D values of mononitrocumylphenol and dinitrocumylphenol also occurs with methanol, but it is not so great. Obviously, with both acetone and methanol[1] the cumylphenol derivatives in which the hydroxyl group is not substituted interact with Sephadex LH-20 by means of hydrogen bonding, and this interaction increases as a result of additional protonation of the hydroxyl group when one and especially two nitro groups are in the *ortho*-positions. With acetone, however, the ability of these compounds to undergo hydrogen bonding is higher than with methanol. Because of the substantial retardation, the elution of

dinitrocumylphenol and trinitrocumylphenol is subject to considerable zone broadening.

With methanol[1], compounds X and XI interact with Sephadex LH-20 by hydrogen bonding through the amino group, while in acetone their K_D values (0.98 and 0.86, respectively) are too low for it to be confirmed that the amino group shows the same tendency in this instance. Nevertheless, the K_D values for both of the compounds mentioned above are higher than those for the corresponding methoxy derivatives (V and VI). On the other hand, if we compare the K_D values for mononitrocumylphenol and 2-phenyl-2-(3-nitro-4-hydroxy-5-aminophenyl)propane, it can be seen that the latter compound is more strongly adsorbed than the former. This effect can be explained only by the presence of one additional amino group in the molecule. These results indicate that in acetone the amino group has some, but not a very high, ability to form hydrogen bonds with Sephadex LH-20 (lower than in methanol[1]).

It is interesting that only with acetone are the cumylphenol derivatives in which a chlorine atom is substituted for the hydroxyl group (VII and VIII) eluted later than the corresponding methoxy derivatives (V and VI), while with the other solvents the first group of compounds are eluted almost simultaneously with the second group (with methanol and N,N-dimethylformamide[1]) or even earlier (with 1,4-dioxan).

Elution behaviour in 1,4-dioxan

With 1,4-dioxan, all of the compounds have K_D values of less than 0.8. Obviously, in this solvent aromatic adsorption of the cumylphenol derivatives on Sephadex LH-20 does not occur. In fact, with both 1,4-dioxan and N,N-dimethylformamide[1] they are eluted earlier than would be expected from their molecular dimensions, showing a tendency to be excluded from the gel.

If we consider the K_D values of cumylphenol, mononitrocumylphenol, dinitrocumylphenol and trinitrocumylphenol, it can be seen that here also these compounds are eluted in an order contrary to that predicted by the exclusion mechanism, and the same effect is also observed for X and XI. Further, the last two compounds, and also dinitrocumylphenol and trinitrocumylphenol, are eluated considerably later than the corresponding derivatives in which a chlorine atom or a methoxy group is substituted for the hydroxyl group (V, VI, VII and VIII). Hence, independent of the tendency of cumylphenol and its derivatives to be excluded from the pores of Sephadex LH-20 with 1,4-dioxan, their ability to interact with the gel by means of hydrogen bonding influences the elution behaviour of those of them which have a free hydroxyl or amino group.

Possibilities of separating some pairs of successively obtained cumylphenol derivatives

The elution characteristics of cumylphenol and its derivatives observed when using acetone and 1,4-dioxan enable us to consider the possibility of separating some pairs of these compounds. From the point of view of their synthesis[4], it is of interest to attempt to separate twelve pairs of cumylphenol derivatives in which the second compound is the product of an appropriate chemical treatment of the first (or *vice versa*). The separation volumes $[V_S = (K'_D - K''_D) \cdot V_i]$ of these pairs when acetone and 1,4-dioxan are used are listed in Table III. Bearing in mind that the maximum peak width in these experiments was 20 ml with acetone (except that for dinitrocumylphenol and trinitrocumylphenol) and 18 ml with 1,4-dioxan, it is clear that nine of

TABLE III

SEPARATION VOLUMES OF SOME PAIRS OF CUMYLPHENOL DERIVATIVES ON SEPHADEX LH-20 USING METHANOL AND N,N-DIMETHYLFORMAMIDE

No.	*Pairs of cumylphenol derivatives*	*Separation volume (V_S) (ml)*	
		Acetone	*1,4-Dioxan*
1	I, II	15	13
2	II, III	1640	13
3	III, V	1670	23
4	III, VII	1647	11
5	III, IX	1618	11
6	IV, VIII	1747	15
7	IV, XI	1745	34
8	V, VII	24	19
9	V, X	27	10
10	VI, XII	21	25
11	VII, X	3	9
12	VIII, XII	21	49

these pairs can be easily separated with methanol and five with 1,4-dioxan. The peak widths of dinitrocumylphenol and trinitrocumylphenol when using acetone exceed 20 ml but, because of their extremely high K_D values, they can always be separated from the other components of the corresponding pairs.

From the data adduced above it is evident that the specific interaction of cumylphenol derivatives with Sephadex LH-20, which is influenced considerably by the nature of the solvent, makes possible the separation of their mixtures.

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