Research Articles

Octanol/Water Partition Coefficients for Environmentally Important Organic Compounds

– Test of Three RP-HPLC-Methods and New Experimental Results

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Abstract

Partition coefficients $P_{O,W}^{(i)}$ describing the distribution of a solute i onto coexisting phases of 1-octanol and water are needed in a large variety of applications. They can be measured directly by HPLC as long as $\log P_{O,W}^{(i)} \geqq 3.5$. For more hydrophobic substances, several experimental procedures have been proposed in the literature. The reliability of those methods is questionable. Therefore, in the present work, $P_{O,W}^{(i)}$ is determined experimentally by three HPLC methods using reversed-phase HPLC [1]. Results from different procedures are compared critically. The method of Braumann [2] proved to be superior over the OECD-guidelines [3]. It was therefore applied to determine octanol/water partition coefficients for 23 substances at 25 °C. For eight of those substances (4-methylindole; 9-(hydroxymethyl)anthracene; N-ethylcarbazol; ethylcyclohexane; trans-2-octene; 1,1-dimethyl-(ethyl)cyclohexane; heptylbenzene; 4-dodecyl-1,3-benzenediol) no experimentally determined number for $P_{O,W}^{(i)}$ has been published before.

1 Introduction

Reliable data for the 1-octanol/water partition coefficient $P_{O,W}^{(i)}$, e.g. for the distribution of an organic component i onto coexisting liquid phase of water and 1-octanol, are required in many applications. They are needed, for example, in quantitative structure-activity relationships (QSAR) in pharmaceutical chemistry [4, 5], biochemistry [6, 7] and medicine [8]. They are also required in the modeling of the fate of environmentally harmful compounds [9 – 11] as well as for the prediction of such other indicators used in environmental science as, for example, indicators for bioavailability/bioindication [12 – 18], water solubility [12,19 – 20], adsorption behavior [12, 21], toxicity [18, 22, 23], etc. In chromatographic separations, they are often discussed in connection with the understanding of retention mechanisms [24 – 26]. The wide use of 1-octanol/water partition coefficients has promoted the elaboration of some data collections and data banks [9, 27 – 33], and many correlations as well as predictive methods (see for example [12, 27, 32, 34, 35]). Nevertheless, the results of such correlations and predictions have to be verified experimentally, especially when accurate numbers for $P_{O,W}^{(i)}$ are required. Reversed-phase high performance liquid chromatography (RP-HPLC) (see for example [1 – 3, 34, 36]) is a very efficient procedure for the experimental determination of such partition coefficients. However, the direct experimental investigation can only be achieved as long as $\log P_{O,W}^{(i)}$ is smaller than about 3.5. For more hydrophobic – and therefore often also environmentally more important – compounds, indirect RP-HPLC methods have to be applied. One of the most recommended procedures is using methanol/water mixtures of varying composition as a mobile phase. Several procedures have been recommended to evaluate the experimental results for the capacity factors measured with that method to determine 1-octanol/water partition coefficients. Different procedures generally resulting in different numbers for the partition coefficient. Therefore the reliability of such procedures is at least questionable and should be tested further. Such a test is performed here. 1-octanol/water partition coefficients are reported for 66 substances. For 43 substances, the new results confirm earlier measurements performed by our group [1]. For 23 solutes, new data are reported. For 8 hydrocarbons, no 1-octanol/water partition coefficients have been published before.

2 Chemicals

Details of 23 chemicals investigated in the present work are given in **Table 1**. For 8 substances (underlined in **Table 1**), no 1-octanol/water partition coefficients have been published before. Information on other chemicals investigated in the present work, but not mentioned in **Table 1**, can be taken from a previous publication [1]. In **Table 1**, the following abbreviations are used: fs, for synthesis; pa, for analysis; GC, gas chromatography; A, Aldrich-Chemie; F, Fluka; J, Janssen Chimica; M, Merck and S, Schuchard.

3 Experimental Details

The experimental arrangement has been described in detail previously [1], therefore only some details are given here. In the direct determination of 1-octanol/water partition coef-

Table 1: Substances investigated

Substance	CAS-No.	Formula	Purity %	Supplier
1,5-hexadiene	[592-42-7]	C_6H_{10}	97 (GC)	F
1-heptene	[592-76-7]	C_7H_{14}	>96 (GC)	S
methylcyclohexane	[108-87-2]	C_7H_{14}	>98 (GC)	S
ethylcyclohexane	[1678-91-7]	C_8H_{16}	99+ (GC)	A
1-octene	[111-66-0]	C_8H_{16}	> 97	S
trans-2-octene	[13389-42-9]	C_8H_{16}	98	J
4-methylindole	[16096-32-5]	C_9H_9N	99	J
1,2-diethylbenzene	[135-01-3]	$C_{10}H_{14}$	95 (GC)	S
1,3-diethylbenzene	[141-93-5]	$C_{10}H_{14}$	99 (GC)	A
1,4-diethylbenzene	[105-05-5]	$C_{10}H_{14}$	98 (GC)	J
(1,1-dimethylethyl)-cyclohexane	[3178-22-1]	$C_{10}H_{20}$	99+ (GC)	A
dibenzofuran	[132-64-9]	$C_{12}H_8O$	99+	J
dibenzothiophene	[132-65-0]	$C_{12}H_8S$	>98 (GC)	F
9H-carbazole	[86-74-8]	$C_{12}H_9N$	99	A
2-ethylnaphthalene	[939-27-5]	$C_{12}H_{12}$	99+ (GC)	A
4-hexyl-1,3-benzene-diol	[136-77-6]	$C_{12}H_{18}O_2$	99	A
heptylbenzene	[1078-71-3]	$C_{13}H_{20}$	>99 (GC)	F
N-ethylcarbazole	[86-28-2]	$C_{14}H_{13}N$	99 (GC)	A
octylbenzene	[2189-60-8]	$C_{14}H_{22}$	>99 (GC)	F
9-(hydroxymethyl) anthracene	[1468-95-7]	$C_{15}H_{12}O$	97	A
nonylbenzene	[1081-77-2]	$C_{15}H_{24}$	96	A
decylbenzene	[104-72-3]	$C_{16}H_{26}$	>98 (GC)	F
4-dodecyl-1,3-benzenediol	[24305-56-4]	$C_{18}H_{30}O_2$	97	J

ficients, reversed-phase columns (Eurospher C-18, Knauer, Berlin, Germany; internal diameter: 4 mm; particle size: 5 μm) were coated with water satured 1-octanol as described previously [1] and aqueous solutions satured with 1-octanol were used as eluents. In all other experiments, the same (although uncoated columns), material and methanol/water eluents were used. Column temperature was maintained at 25 ± 0.5 °C. Retention times were determined using either an UV-VIS detector (which was operated at 254 and 220 nm) or a refractive index detector. Experimentally determined retention times $t_R^{(i)}$ were used to calculate the capacity factor $k'^{(i)}$:

$$k'^{(i)} = (t_R^{(i)} - t_0) / t_0. \tag{1}$$

t_0 is the so called dead time which was determined by using thiourea as the partitioning solute.

Several different procedures were applied. One set of experiments was carried out following the OECD-guidelines [3] for the measurement of 1-octanol/water partition coefficient. In those experiments, the length of the reversed-phase column was 120 mm and a mixture of methanol and water (volume ratio 3:1) with flow rates of 1 and 2 ml/min was selected as an eluent. For all other experiments, the same columns were used. The eluent in those experiments was an aqueous solution of methanol of different composition. Methanol concentrations ranged between 40 and 80 per cent by volume.

4 Evaluation of Measured Capacity Factors

The 1-octanol/water partition coefficient, $P_{O,W}^{(i)}$, is defined as:

$$\log P_{O,W}^{(i)} = \lim_{c_i \to 0} \frac{c_i \text{ in 1-octanol phase}}{c_i \text{ in aqueous phase}} \tag{2}$$

where c_i stands for molarity of solute i.

Partition coefficients are related to capacity factors by

$$\log P_{O,W}^{(i)} = a \log k'^{(i)} + b \tag{3}$$

where, for a special set of experimental conditions, a and b are constants. They have to be determined in a calibration procedure where capacity factors are measured for a number of solutes with known 1-octanol/water partition coefficients. Solutes used in those calibrations are given in **Table 2** (cf. Table 1 for abbreviation); the corresponding partition coefficients were taken from the literature [3, 27, 29].

Table 2: Substances used for calibration

Substance	CAS-No.	Synonym	Formula	Purity %	Supplier	log $P_{O,W}$	Reference log $P_{O,W}$
benzene	[71-43-2]		C_6H_6	99.8	A	2.13	[29]
phenol	[108-95-2]		C_6H_6O	99.5 pa	M	1.50	[3,29]
1,2-benzenediol	[120-80-9]	catechol	$C_6H_6O_2$	> 99 (GC)	J	0.88	[3,27]
1,3-benzenediol	[108-46-3]	resorcinol	$C_6H_6O_2$	> 99	F	0.80	[3,27]
methylbenzene	[108-88-3]	toluene	C_7H_8	pa	-	2.70	[3]
2-methylphenol	[95-48-7]	o-cresol	C_7H_8O	> 99 fs	S	1.98	[29]
4-methylphenol	[106-44-5]	p-cresol	C_7H_8O	> 99 fs	F	1.94	[29]
etylbenzene	[100-41-4]		C_8H_{10}	-	-	3.15	[3]
propylbenzene	[103-65-1]		C_9H_{12}	98 (GC)	A	3.69	[29]
naphthalene	[91-20-3]		$C_{10}H_8$	-	-	3.35	[29]
2-isopropyl-5-methylphenol	[89-83-8]	thymol	$C_{10}H_{14}O$	> 99 (GC)	M	3.30	[3,29]
1,1'-biphenyl	[92-52-4]		$C_{12}H_{10}$	99	A	4.00	[3]
anthracene	[120-12-7]		$C_{14}H_{10}$	-	-	4.50	[29]

Retention time and capacity factors both increase with decreasing solubility (and consequently with increasing log $P_{O,W}^{(i)}$ of solute i in the aqueous phase). The retention time restricts the experimentally accessible range of partition coefficients.

For water as an eluent, the upper limit is log $P_{O,W}^{(i)} \cong 3.5$. To circumvent that problem, OECD- guidelines recommend the use of a methanol/water mixture with a volume ratio of 3/1 instead of water alone. The enhanced solubility of hydrophobic solutes i in methanol reduces retention time and therefore allows measurements for solutes whose partition coefficients are as high as 10^8. To apply the method, constants a and b of Eq. (3) have again to be determined by calibration. Substances used in the present work for calibrations covered the following range

$$0.8 \; (i = \text{resorcinol}) \leqq \log P_{O,W}^{(i)} \leqq 4.5 \; (i = \text{anthracene}).$$

As shown for example by BRAUMANN [2], however, that procedure is of questionable accuracy. BRAUMANN proved that better results are obtained when capacity factors are measured for several aqueous solutions of methanol differing in the methanol concentration and the experimental data are extrapolated to zero methanol concentration. That procedure was also applied in the present work *(→ Fig. 1)*.

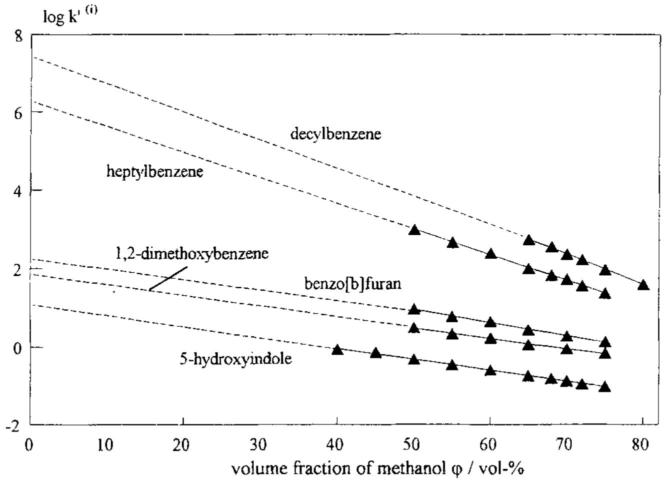

Fig. 1: Extrapolation of log $k'^{(i)}$ to 0 % methanol in the eluent for several compounds (log $k_W^{(i)}$ obtained according Eq. (4))

For some aqueous solutions of methanol with differing methanol volume fractions φ, the capacity factor k' was measured. The experimental data were used to determine a property k_w as proposed by BRAUMANN:

$$\log k_w^{(i)} = \log k'^{(i)} + S^{(i)} \varphi \tag{4}$$

where $S^{(i)}$ is a slope parameter which is to be determined from experimental results for capacity factor $k'^{(i)}$ at different volume fractions φ. Property $k_w^{(i)}$ is the partition coefficient between the column material (e.g. C-18) and pure water. It is related to the 1-octanol/water coefficient $P_{O,W}^{(i)}$ through

$$\log P_{O,W}^{(i)} = c \log k_w^{(i)} + d. \tag{5}$$

Coefficients c and d have to be determined from calibrations and should be close to unity (c) and zero (d), respectively.

The experimental results were also evaluated to characterize the hydrophobicity of a solute i following a proposal by VALKÓ and SLÉGEL [37]. Those authors introduced a parameter $\varphi_0^{(i)}$ defined as the volume fraction of organic solvent (either methanol or acetone) in the aqueous eluent required to result in k' = 1 (or $t_R = 2 \, t_0$). As can be seen from Eq. (4)

$$\varphi_0^{(i)} = \log k_w^{(i)} / S^{(i)} \tag{6}$$

5 Results

Table 3 reports experimental results for log $P_{O,W}^{(i)}$ determined for 66 hydrocarbons by HPLC.

Experimental results were determined using an Eurospher C-18 column coated with water satured 1-octanol for 43 substances. Those results have already been published recently [1]. They are compared with new data measured following the OECD-guidelines (designated with log $P_{O,W}^{(i)}$,[3]) as well as with numbers for log $k_w^{(i)}$ determined as described before. For another 23 substances, new experimental results (log $P_{O,W}^{(i)}$,[3] and log $k_w^{(i)}$) are reported. As far as possible, experimental results are also compared to literature data. As can be seen from **Table 3**, different experimental HPLC-procedures yield different numbers for partition coefficients. Differences between log $P_{O,W}^{(i)}$,[3] and log $P_{O,W}^{(i)}$ are smaller than 0.51, with the exception of four substances: 2,6-naphthalenediol (0.65), 1,5-naphthalenediol (0.76), 2,3-dimethylindole (0.54) and biphenyl-4-ol (0.62). Differences are below ± 0.1 for only 15 (out of 43) substances. As is shown in **Fig. 2**, there is a rough correlation between log $P_{O,W}^{(i)}$ and log $P_{O,W}^{(i)}$,[3] which can be approximated (regression coefficient r = 0.808) by

$$\log P^{(i)}{}_{O,W},[3] = 0{,}852 \log P^{(i)}{}_{O,W},[3] + 0{,}361 \tag{7}$$

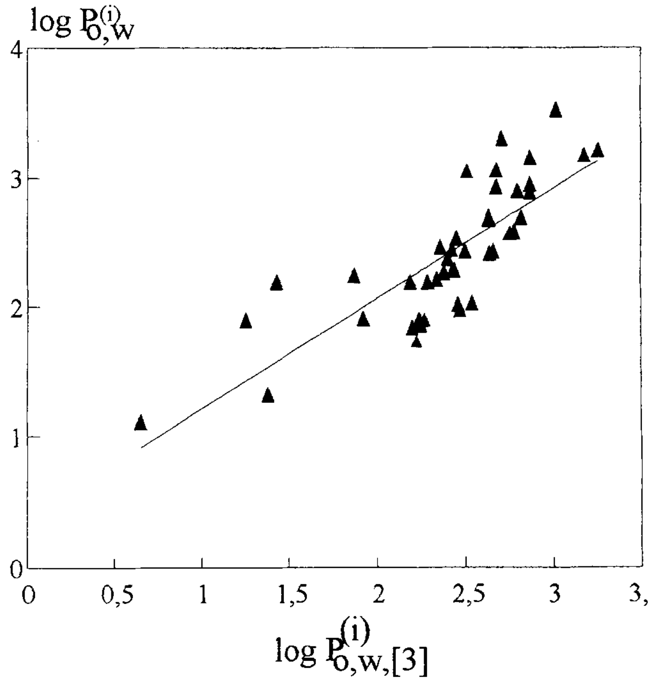

Fig. 2: Relationship between log $P_{O,W}^{(i)}$ and log $P_{O,W},[3]^{(i)}$, for the compounds given in **Table 3** by Eq. (7)

Table 3: Comparsion of the log P_{ow} measured with various chromatographic methods

Substance	log $P_{O,W}^{(i)}$ see also [1]	log $P_{O,W}$[3]$^{(i)}$	log $k_W^{(i)}$	log $P_{O,W}$ [literature]	$\varphi_0^{(i)}$
5-hydroxyindole	1.11	0.65	1.10		38.7
4-methyl-1,2-benzenediol	1.32	1.38	1.39	1.37 [30]	50.9
1,2-dimethoxybenzene	1.75	2.22	1.82	2.21 [27] 1.12, 1.79 [30]	68.2
1-fluoro-2-nitrobenzene	1.84	2.20	1.90	1.69 [30]	67.9
2,5-difluoronitrobenzene	1.86	2.25	1.91		69.4
1-fluoro-4-nitrobenzene	1.89	2.27	1.95	1.80 [30]	69.4
1,4-naphthalenediol	1.90	2.24	1.93		68.7
2,6-naphthalenediol	1.90	1.25	1.65		48.8
3-methylphenol	1.91	1.92	1.89	1.95, 1.96, 2.01 [27] 1.98 [29] 1.94, 2.06 [30]	63.4
1,2,3,4-tetrahydro-1-naphthole	1.98	2.47	2.15		72.6
1-fluoro-3-nitrobenzene	2.02	2.46	2.05	1.90 [30]	73.0
3,5-difluoronitrobenzene	2.03	2.54	2.15		74.4
2-bromo-1-phenylethanone	2.19	2.29	2.17		69.8
indole	2.19	2.19	2.02	2.00, 2.25 [27] 2.14 [27, 29] 1.66, 1.81, 1.92, 2.06, 2.14, 2.27 [30]	67.6
1,5-naphthalenediol	2.19	1.43	1.75	1.82 [30]	52.2
4-chlorobenzaldehyde	2.21	2.34	2.24	2.10, 2.16 [30]	72.7
2,3-naphthalenediol	2.24	1.87	2.19		62.2
3-chlorobenzaldehyde	2.26	2.38	2.25		73.5
1(2-bromophenyl)ethanone	2.28	2.43	2.28		72.4
2-chlorobenzaldehyde	2.28	2.44	2.32	2.33 [30]	74.4
1-(hydroxymethyl)naphthalene	2.37	2.40	2.39		71.8
1(4-chlorophenyl)ethanone	2.41	2.64	2.42	2.32 [27] 2.28, 2.35 [30]	76.1
1(3-chlorophenyl)ethanone	2.43	2.66	2.42	2.51 [30]	75.9
1-hydroxynaphthalene	2.43	2.50	2.50	2.70 [3]; 2.84 [27,29] 2.31, 2.98 [27] 2.28, 2.81, 3.02, 3.09, 3.13 [30]	73.1
2-(hydroxymethyl)-naphthalene	2.45	2.42	2.47		71.8
2-ethylphenol	2.46	2.36	2.31	2.47 [3]; 2.64 [30]	71.1
2-methylindole	2.53	2.45	2.47	2.53 [29]	72.2
1(4-bromophenyl)ethanone	2.57	2.76	2.58	2.43 [27, 30] 2.60 [30]	77.7
1(3-bromophenyl)ethanone	2.58	2.78	2.65		77.5
1-(2-naphthyl)ethanol	2.68	2.64	2.74		75.1

Table 3: continued

Substance	log $P_{O,W}^{(i)}$ see also [1]	log $P_{O,W}[3]^{(i)}$	log $k_W^{(i)}$	log $P_{O,W}$ [literature]	$\varphi_0^{(i)}$
benzo[b]furan	2.69	2.82	2.64	2.67 [27, 29, 30] 2.53, 2.86 [30]	78.3
3-methylindole	2.70	2.58	2.65	2.60 [30]	74.0
9-(hydroxymethyl)fluorene	2.89	2.87	3.21		77.9
5,6,7,8-tetrahydro-2- naphthol	2.90	2.80	2.94		76.6
2-propylphenol	2.93	2.68	2.92	2.93 [29, 30]	76.4
5,6,7,8-tetrahydro-1-naphthol	2.95	2.87	2.87		77.6
2,3-dimethylindole	3.05	2.51	3.05		77.2
biphenyl-2-ol	3.06	2.68	3.04	3.09 [30]	76.2
4-(1,1-dimethylethyl)phenol	3.16	2.87	3.15	3.04 [27, 29, 30] 2.94, 3.31 [27, 30]	78.2
1-benzothiophene	3.18	3.18	3.06	3.12 [29] 3.05, 3.09, 3.26 [30]	82.9
2-methylbenzo[b]furan	3.22	3.26	3.19		83.7
biphenyl-4-ol	3.31	2.71	3.25	2.88, 3.20, 3.63 [30]	76.1
2-(1,1-dimethylethyl)phenol	3.53	3.02	3.50	3.31 [27, 30]	79.6
4-methylindole	–	2.54	2.55		73.3
1,5-hexadiene	–	3.28	3.07	2.80 [29]	84.6
carbazole	–	3,07	3,34	3.72 [29] 3,01, 3.29, 3.34, 3.59, 3.74, 3.84 [30]	79.9
9-(hydroxymethyl)anthracene	–	3.04	3.64		79.0
4-hexyl-1,3-benzenediole	–	3.07	3.84	3.45 [30]	79.7
dibenzofuran	-	3.91	4.02	3.81, 3.96, 4.12, 4.17, 4.21, 4.31 [30]	89.5
1,2-diethylbenzene	–	4.10	4.03	4.42 [30]	92.0
1,3-diethylbenzene	–	4.16	4.15	4.57 [30]	92.2
methylcyclohexane	–	4.17	4.19	3.88 [29], 2.76 [30]	92.5
1,4-diethylbenzene	–	4.22	4.22	4.58 [30]	92.5
1-heptene	–	4.06	4.26	3.99 [29, 30] 4.06 [30]	90.4
dibenzothiophene	–	4.17	4.32	4.38 [29, 30] 4.33, 4.49 [30]	91.1
2-ethylnaphthalene	–	4.00	4.44	4.38 [29, 30]	90.2
N-ethylcarbazole	–	3.97	4.49		88.6
ethylcyclohexane	–	4.56	4.81		94.5
1-octene	–	4.47	4.89	4.56, 4.57, 4.72, 4.76, 4.88 [30]	92.6
trans-2-octene	–	4.51	4.92		92.7
(1,1-dimethylethyl)-cyclohexane	–	5.04	5.71		96.0
heptylbenzene	–	5.37	6.24		96.0
octylbenzene	–	5.89	6.97	6.30 [29, 30] 6.60 [30]	96.5
nonylbenzene	–	6.41	7.25	7.11 [30]	99.4
4-dodecyl-1,3-benzenediol	–	5.32	7.55		91.2
decylbenzene	–	6.94	7.74	7.35 [29, 30] 7.38, 7.69 [30]	100.6

However, differences between log $k_w^{(i)}$ - determined by extrapolation according to Eq. (4) – and log $P_{O,W}^{(i)}$ are remarkably smaller. Futhermore, both properties can be correlated by Eq. (5) resulting in

$$\log P_{O,W}^{(i)} = 0{,}972 \log k_W^{(i)} + 0{,}075 \qquad (5\ a)$$

with a regression coefficient of r = 0.978 when all 43 substances are included *(→ Fig. 3).*

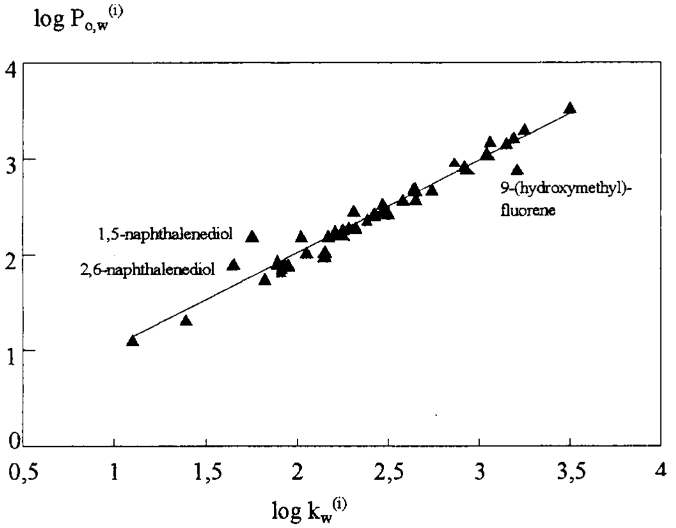

Fig. 3: Relationship between log $P_{O,W}^{(i)}$ and log $k_W^{(i)}$ for the compounds given in Tabel 3 by Eq. (5 a)

If the comparison does not include 1,5-naphthalenediol, 2,6-naphthalenediol and 9-hydroxymethyl-fluorene, a still better correlation is found (r = 0.993):

$$\log P_{O,W}^{(i)} = 1.039 \log k_W^{(i)} - 0.096. \qquad (5\ b)$$

That excellent correlation is also shown in **Figure 3**. It proves that partition coefficients in 1-octanol/water can be determined reliably by measuring capacity factors with aqueous solutions of methanol as eluents and properly extrapolating the results to methanol free eluents *(→ Fig. 1).* The improvement can be enhanced by applying Eqs. (5 a) or (5 b). For less hydrophobic solutes (log $P_{O,W}^{(i)} \geqq 3.5$), results from the direct measurement by RP-HPLC and the indirect measurement (extrapolating experimental results for aqueous solutions of methanol as eluent) are in very good agreement. For more hydrophobic solutes ($3.5 \geqq$ log $P_{O,W}^{(i)} \geqq 6$) where the direct experimental investigation by RP-HPLC is no longer possible, aqueous solutions of methanol with volume fractions of methanol as small as 40 per cent can be used within a series of eluents with different concentrations. An extrapolation to zero volume fraction methanol is therefore very reliable (cf. also *Fig. 1).* For still more hydrophobic solutes (log $P_{O,W}^{(i)} \geq 6$, for example for heptylbenzene, octylbenzene, nonylbenzene, decylbenzene, 4-dodecyl-1,3-benzenediol), the extrapolation is more difficult since eluents containing more methanol have to be used. Nevertheless, the uncertainty due to the extrapolation is still rather small, resulting in more reliable numbers for log $P_{O,W}^{(i)}$ than those determined following the OECD-guidelines.

Table 3 also reports numbers for the new chromatographic hydrophobicity parameter $\varphi_0^{(i)}$ as determined from the experimental data of the present work according to Eq. (6). For 7 substances, the new results for $\varphi_0^{(i)}$ can be compared with the figures reported by VALKÓ and SLÉGEL [37]. As is shown in **Table 4**, a nice agreement between both sources can be seen. Average and maximum relative deviations in $\varphi_0^{(i)}$ are about 6 and 12 %, respectively.

Table 4: Hydrophobicity parameter $\varphi_0^{(i)}$ – Comparsion of results by VALKÓ and SLÉGEL [37] with those of the present work

Substance	$\varphi_0^{(i)}$	
	VALKÓ and SLÉGEL [37]	this work
2,6-naphthalenediol	45.1	48.8
2,3-naphthalenediol	56.3	62.2
1-hydroxynaphthalene	64.8	73.1
heptylbenzene	103.0	96.0
octylbenzene	95.3	96.5
nonylbenzene	96.8	99.4
decylbenzene	98.1	100.6

6 Discussion

Although the agreement between numbers for log $P_{O,W}^{(i)}$ determined by RP-HPLC using different methods is convincing, it has to be mentioned that several aspects of the methods applied here are currently under discussion. CARR et al. [38], for example, state that essential aspects of reversed-phase retention are still not understood. Furthermore, the evaluation of measured capacity factors k' according to Eq. (4) has received some criticism [39 – 42]. Although there is a general consensus about methanol being the most suitable organic modifier for an aqueous eluent, TAN and CARR [41] argue that extra-thermodynamic relationships as for example in Eq. (4) are only artifacts since retention in RP-HPLC is the result of very complex intermolecular interactions and such relations are not consistent with observed changes in elution sequence when the volume fraction of the organic modifier in the eluent is changed. Some methods try to account for intermolecular forces, for example through group contribution methods like UNIFAC [43], while others like the "Linear Solvation Energy Relationship" (LSER) (c.f. [44 – 47], for example, assume that retention is the result of several types of intermolecular forces which may be separated [6, 48 – 51]. The applicability of all those methods, however, remains questionable (see for example [4]).

7 Conclusions

1-octanol/water partition coefficients $P_{O,W}^{(i)}$ have been determined at 25 °C for a large number of derivatives of phenol, indole, alkylbenzene, biphenyl and naphthalene by reversed-phase high performance liquid chromatography (RP-HPLC). For 43 substances, earlier direct measurements (e.g. using a C-18 support coated with water satured

1-octanol and 1-octanol satured water as an eluent) were complemented by performing measurements with two indirect methods. In those methods, the RP-18 support remained uncoated and aqueous solutions of methanol were used as eluents. The procedure applied follow OECD-guidelines [3] as well as a proposal by BRAUMANN [2]. It was shown that the procedure by BRAUMANN which starts from experimental results for the capacity factor determined for eluents with varying methanol concentrations and requires an extrapolation, results in a better agreement with directly measured data than results from OECD-guidelines. The procedure of BRAUMANN was therefore applied to determine $P_{O,W}^{(i)}$ for another 23 substances which due to otherwise extremely long retention times (corresponding to $\log P_{O,W}^{(i)} \geq 6$) cannot be investigated by direct RP-HPLC methods. For 8 out of those 23 substances, no numbers for $P_{O,W}^{(i)}$ have been published in the literature. The new results were also evaluated to determine a chromatographic hydrophobicity parameter introduced recently by VALKÓ and SLÉGEL [37]. That parameter could be compared with results of those authors for seven substances; relative deviations are on the average below 6 %. Finally, the adequacy of the experimental procedure is discussed shortly.

8 Nomenclature

a, b	– coefficients in equation (3)
c, d	– coefficients in equation (5)
c	– molarity
k'	– capacity factor
k_w	– capacity factor, extrapolated to 100 % water in the eluent
n	– number of experimental points
P	– partition coefficient
r	– regression coefficient
S	– slope parameter
t_0	– dead time
t_R	– retention time
φ	– volume of methanol in the eluent (vol-%)
φ_0	– volume of methanol in the eluent (vol-%) which corresponds to log k' = 0

Subscripts

o	– 1-octanol
w	– water
OECD	– corresponding to OECD-guideline [ref. 3]

Superscript

(i)	– solute i

Definition

$$\text{regression coefficient} \equiv r = \frac{n\sum x_i y_i - \sum x_i \sum y_i}{\sqrt{\left[n\sum x_i^2 - \left(\sum x_i\right)^2\right]\left[n\sum y_i^2 - \left(\sum y_i\right)^2\right]}}$$

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