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USE OF PACKED THERMAL DIFFUSION COLUMNS TO DETERMINE THE SORET COEFFICIENT IN A BENZENE—CARBON TETRACHLORIDE MIXTURE

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Experimental results of the determination of the Soret coefficient of a benzene—carbon tetrachloride mixture in a packed column with reservoirs at the ends are presented.

The theory of thermal diffusion in a packed cylindrical column is presented and analyzed in [1, 2]. The virtual absence of parasitic convection in this type of column is one of the most important results, which permits using a packed column to determine the thermal diffusion constant. The expressions for the transport coefficients in a packed column differ from those in [3, 4] by their dependence on the parameters of the porous medium and contain corrections for the cylindrical geometry and the influence of sampling. An experimental check of the theory gave favorable results [1].

In what follows, the investigation of the C_6H_6—CCl_4 mixture was continued over the entire range of concentrations. The experimental setup and the technique remained as before [1], but in order to increase the accuracy of the experimental results, the results were processed on a computer using the method of least squares and, in so doing, the asymptotic solutions in [5], which describe the separation kinetics on the initial part of the curve of the transient separation process in the column, were used.

We will write this solution in the form

$$\Delta c = c_0 (1 - c_0) A\tau v (A\tau, \; by\omega), \tag{1}$$

where τ is the time from the beginning of the experiment; $A = H/M$; $b = 1 - 2c_0 - \Delta c$; v is a known (from [5]) function approaching 1 as $\tau \to 0$.

We form the functional

$$\Phi (A, \; y\omega) = \frac{1}{n} \sum_{i=1}^{n} [\overline{\Delta c}_i - c_0 (1 - c_0) A\tau_i v (A\tau_i, \; b_i y\omega)]^2, \tag{2}$$

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TABLE 1. Geometric and Percolation Characteristics of the Column

No. of column	$\delta \cdot 10^3$, m	$k \cdot 10^{11}$, m^2	$V \cdot 10^6$, m^2	$d \cdot 10^6$, m
1	1,52	1,07	18,0	100—130
2	2,03	1,96	30,5	150—200
3	2,03	1,96	37,5	150—200
4	2,52	5,87	40,5	250—300
5	2,52	3,22	40,5	200—250

TABLE 2. Characteristics of the Working Benzene—Carbon Tetrachloride Mixture at $\overline{T}$ = 40°C

c_0, mass fraction of CCl_4	$\eta \cdot 10^3$, $N \cdot sec/m^2$	$\beta \cdot 10^3$, deg^{-1}	$\rho \cdot 10^{-3}$, kg/m^3
0,1	0,508	1,28	0,896
0,5	0,541	1,26	1,11
0,805	0,652	1,25	1,32
0,95	0,719	1,24	1,49

TABLE 3. Results of the Calculation of the Soret Coefficient Using Eq. (3)

No. of column	c_0, mass fraction of CCl_4	$\frac{H}{M} \cdot 10^6$, sec^{-1}	$s \cdot 10^3$, deg^{-1}	$s_{av} \cdot 10^3$, deg^{-1}
1	0,5	2,62	6,72	6,69
3		3,0	6,60	
5		5,82	6,75	
2	0,1	5,1	8,88	8,88
4	0,805	11,4	6,8	6,92
5		6,5	7,05	

which depends on the two parameters A and yω, with respect to which the minimum is determined; $\overline{\Delta c_i}$ are the experimentally observed displacements of the concentration from the initial value. Calculations using (1) are performed using the method of successive approximations by substituting Δc = 0 as a first approximation.

Thus, as a result of the calculation, we find the values $h = A_{min}$ and $n = (y\omega)_{min}$, which lead to a minimum of the functional (2) [6]. Using the value of h and the expression for the transport coefficient H, we obtain the computational equation

$$s = 12\eta h V / g\beta\rho\delta k\,(\Delta T)^2 B, \tag{3}$$

which includes the volume of the reservoir at the positive end of the column V and the permeability of the packing k.

The experiments were carried out using the technique described in [1] with five columns, whose geometric and percolating characteristics are presented in Table 1. The dependence of the permeability of the glass balls on their diameter is shown in Fig. 1, where, in addition to our results [1], the results in [7, 8] are presented. The characteristics of the working benzene—carbon tetrachloride mixture at $\overline{T}$ = 40°C are given in Table 2.

The experimental curves are presented in Figs. 2 and 3, while Table 3 displays the results of calculations of the Soret coefficient using Eq. (3).

The present results together with the results in [1, 9-12] are illustrated in Fig. 4. It is evident that when the CCl_4 concentration decreases, there is a tendency for the Soret coefficient to increase, which was discovered in experiments by Korsching and was not manifested in the work of other researchers.

In addition, it should be noted that the results of the determination of the Soret coefficient obtained in the present work agree better with the data obtained by Turner and Tyrrell [10, 11] at 25°C than with the results obtained by Tichacek [12] at $\overline{T}$ = 40°C, This is

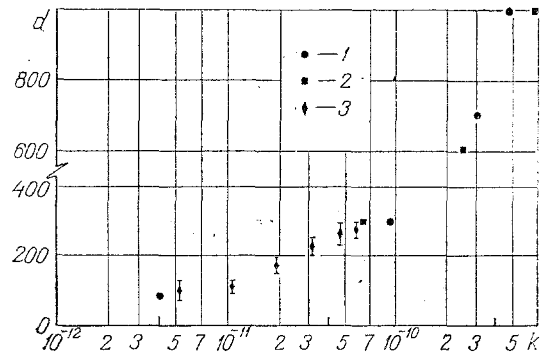

Fig. 1. Dependence of the permeability of glass balls on their diameter: 1) [7]; 2) [8]; 3) present work. d, μm; k, m^2.

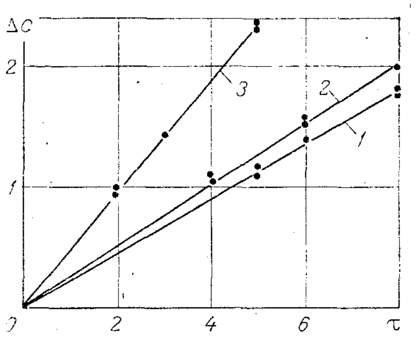

Fig. 2

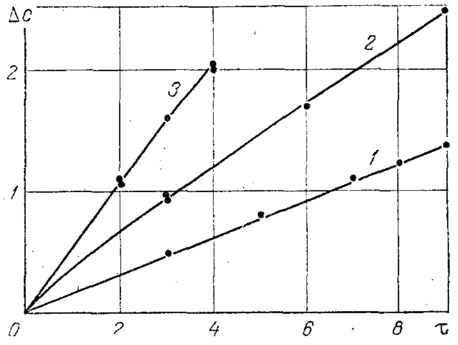

Fig. 3

Fig. 2. Kinetic curves 1, 2, and 3 obtained with columns Nos. 1, 3, and 5, respectively, with $c_0 = 0.5$ mass fraction of CCl_4. Δc, mass fraction; τ, h.

Fig. 3. Kinetic curves 1, 2, and 3 obtained, respectively, with columns Nos. 4, 5, and 2 with $c_0 = 0.805$ mass fraction of CCl_4 and $c_0 = 0.1$ in column No. 2.

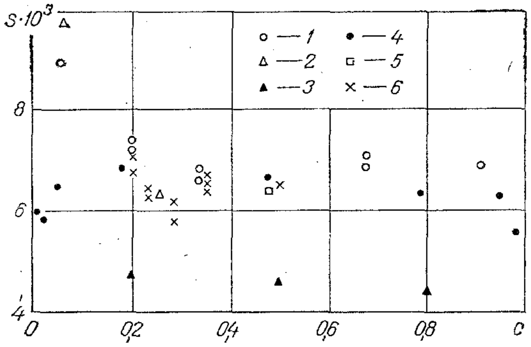

Fig. 4. Dependence of the Soret coefficient on the CCl_4 concentration: 1) present work at $\bar{T} = 40°C$; 2) Korsching [9] at $\bar{T} = 33°C$; 3) Tichacek [12] at $\bar{T} = 40°C$; 4) Turner [10] at 25°C and 5) at 35°C; 6) Tyrrel [11] at $\bar{T} = 25°C$. $s \cdot 10^3$, deg^{-1}; c, mole fraction of CCl_4.

explained by the fact that the apparatus used in [12] was less refined than the cells used by Turner, Tyrrell and Korsching, as well as the technique proposed in the present work.

NOTATION

c, concentration; ρ, density; z, vertical coordinate; L, length of the column; d, diameter of the glass balls; η, coefficient of dynamic viscosity; β, coefficient of thermal expansion; k, permeability of the packing; T, temperature; B, perimeter of the working gap; H and K, transport coefficients; M, mass of the fluid in the reservoir at the end of the column; $\omega = M/\rho B\delta L$; $y = Hz/K$; $H = sg\rho^2\beta k(\Delta T)^2 B\delta/12\eta$.

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