PHYSICAL CHEMISTRY

INVESTIGATION OF THE DYNAMICS OF ADSORPTION IN A WIDEBAND OF BREAKTHROUGH CONCENTRATIONS
COMMUNICATION 2. CONSIDERATION OF THE GENERAL PICTURE OF THE DYNAMICS OF ADSORPTION

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In the study of the dynamics of adsorption, as a rule, its stationary stage is considered, and the determination of the breakthrough concentrations behind the layer of adsorbent is begun with relatively high values. This does not permit a new picture of the process to be obtained, covering the entire region of the dynamics of adsorption. To resolve this question we must investigate the dynamics of adsorption in a wide range of variation of the basic parameters of the process. Such an investigation is of theoretical interest, together with the solution of a number of practical problems.

In [1,2] the dynamics of the adsorption of vapors of organic substances was studied in a wide range of relative breakthrough concentrations (from the order of $10^{-5}$ to 1) behind layers of activated charcoal with various porous structures. Substantial peculiarities characteristic of the dynamics of adsorption in the investigated region have been noted, in particular, the parallel transport of a front of low concentrations of the order of $10^{-5}$-$10^{-2}$ mg/liter in the presence of a general nonequilibrium character of the process of dynamics of adsorption.

This work was conducted to consider the general picture of the dynamics of adsorption in a wide range of breakthrough concentrations in the presence of variation of the length of the layers of adsorbent.

EXPERIMENTAL SECTION

Benzene, according to which the adsorption properties of adsorbents are customarily evaluated, was selected as the substance to be adsorbed for an investigation of the dynamics of adsorption. The benzene was redistilled twice. Its purity was verified chromatographically. The amount of benzene in the sample was $> 99.95\%$. The dynamics of the adsorption of benzene vapors was studied on activated charcoal AU-2, obtained from peat by the method of potassium sulfite activation with supplementary activation with water vapor under laboratory conditions. Table 1 presents its basic structural characteristics. The structural characteristics $W_0$ and $B$ were determined according to the equation of adsorption of the theory of volume filling of micropores [3]. The experimental isotherms were not corrected for adsorption in transitional pores. The volumes of the micropores were also determined without considering adsorption in transitional pores.

<table>
<thead>
<tr>
<th>Adsorbent</th>
<th>Grain size, mm</th>
<th>Structural characteristics</th>
<th>Volume of pores, $cm^3/g$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>$W_0, cm^3/g$</td>
<td>$B \times 10^6$</td>
</tr>
<tr>
<td>AU-2</td>
<td>0.7-1.2</td>
<td>0.530</td>
<td>0.78</td>
</tr>
</tbody>
</table>

The dynamics of adsorption was investigated by the method of determining the effluent curves. The benzene concentration behind the layer of adsorbent was indicated by a highly sensitive flame-ionization detector, which permitted recording of the concentration of benzene vapors in a broad range (from $10^{-5}$ mg/liter to the initial value) \([1, 4]\). Experiments were conducted with layers of adsorbents of various lengths: from a one-grain layer to 16 cm. The velocity of the vapor–air mixture was 0.5 liter/min-cm\(^2\); the initial concentration of benzene vapors was 5.6 mg/liter. The experimental effluent curve in plots of $\log C/C_0$ versus $t$ and $C/C_0$ versus $t$ are given in Fig. 1. For convenience of consideration of the dynamics of adsorption, the region of short lengths of the adsorbent layers (from a one-grain layer to 2 cm) is shown separately in Fig. 1b. Each effluent curve was constructed according to the results of two to three experiments. The convergence of parallel experiments was quite satisfactory.

To verify the significance of the results obtained, the static activities realizable under the conditions of a dynamic experiment were calculated by various methods: graphically according to the area above the effluent curves constructed in a plot of $C/C_0$ versus $t(a_a)$ and by a calculation method according to the time of reaching of a concentration $C = 0.5 C_0$ ($a_{0.5}$) behind the layer. The essence of the latter was outlined in \([1]\). The results of the calculation are cited in Table 2. For comparison, Table 2 includes the values of the adsorption obtained according to the results of weighing, performed at the end of a dynamic experiment, when $C = C_0$ is reached ($a_w$), as well as the values of the static activity, determined according to the experimental adsorption isotherms ($a_0$) and calculated according to the adsorption equation of the theory of volume filling of micropores ($a_0$). As can be seen from Table 2 the convergence between the values of the adsorption, determined by various methods, is quite satisfactory. This circumstance confirms the significance of the experimental data obtained.

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**Fig. 1.** Effluent curves of the adsorption of benzene vapors by activated charcoal AU-2. Numbers next to the curves: length of the layer of adsorbent, cm.

**Fig. 2.** Isochrones of the adsorption of benzene vapors by activated charcoal AU-2. Numbers next to the curves: time, min.

**Fig. 3.** Isopycnals of the absorption of benzene vapors by activated charcoal AU-2. Numbers next to the curves: relative breakthrough concentrations.