The self-diffusion coefficients of molecules of \( \text{C}_6\text{H}_6 \) and \( \text{C}_6\text{H}_{14} \) adsorbed in two active carbons (AC) are not a function of the observation time in the time range from 1 to 600 msec. These AC have extensive microporous zones, and the AC studied do not exhibit fractal properties in the range of movements of 2-40 \( \mu \text{m} \) for one and 1-100 \( \mu \text{m} \) for the other.

The study of fractal systems [2] opened up new opportunities for describing the structure of solids. The principle of self-similarity has been a useful instrument for finding regularities in apparently unordered systems [3]. Porous adsorbents, for which the geometric parameters determined in adsorption of different substances are a function of the size of the molecules of the adsorbate used, can serve as a typical example of such systems. The use of fractal dimensions allows describing the topology of such adsorbents. The data obtained in measurements of equilibrium adsorption are used for this purpose [4, 5].

Useful information can be obtained on the fractal properties (FP) of systems in studying diffusion processes. It should be noted that there have been no systematic data with an interpretation of the experiments on molecular diffusion in fractal systems in the literature up to now. Nevertheless, deviations from normal diffusion should be expected in such systems. In "classic" homogeneous systems, the mean square of the movement of molecules \( \langle r^2(\Delta) \rangle \) after observation time \( \Delta \) is described by the equation

\[
\langle r^2(\Delta) \rangle = 6D\Delta
\]

where \( D \) is the self-diffusion coefficient. The following relation has been proposed for diffusion in fractal systems [2, 4]

\[
\langle r^2(\Delta) \rangle = \alpha \Delta^x
\]

\( \alpha \) is a proportionality factor which is not dependent on the time, and \( x < 1 \) (for example, for diffusion along channels rolled into coils, \( x = 0.5 \) [6]).

In determining the dependence of \( \langle r^2(\Delta) \rangle \) on time, it is thus possible to draw a conclusion concerning the FP (or their absence) of an adsorbent. The method of NMR pulse gradients (PG) allows studying the smallest movements of molecules [6].

The results obtained using the method of NMR PG for studying possible FP of carbon adsorbents in diffusion of adsorbed molecules of organic substances are reported in the present communication.

EXPERIMENTAL

The method of preparation of the samples and measurement of the self-diffusion coefficients (SDC) is reported in [7]. Laboratory active carbons AC-71 and AC-72 were selected as the adsorbents. The pore structure parameters (\( W_s = 1.44 \text{ cm}^3/\text{g}, S = 1870 \text{ m}^2/\text{g}, \chi = 0.77 \text{ nm} \)) for AC-71 were calculated from the \( \text{N}_2 \) adsorption isotherms at 77 K with the MR method in

*For previous communication, see [1].
Fig. 1. Mean square of the movement of molecules of C₆H₆ in AC-71 at 248 (1), 298 K (2) and C₆H₁₄ in AC-72 at 223 (3) and 343 K (4).

[1] and with the Dubinin-Radushkevich equation for AC-72 (W₀ = 0.445 cm³/g, E₀ = 21.05 kJ/mole, α = 0.59 nm). The selection of the adsorbents was due to the fact that intense spin echo signals were obtained for the adsorption systems AC-71-C₆H₆ and AC-72-C₆H₁₄, and measurements of the decrease in the spin echo amplitude are possible in a wide range of observation times Δ. The primary echo method was used for values of Δ < 4 msec, and the stimulated echo method was used for Δ > 4 msec. Ethylene glycol and n-propanol, whose SDC at 293 K are respectively equal to (2.4 ± 0.2)·10⁻¹⁰ and (7.5 ± 0.2)·10⁻¹⁰ m²·sec⁻¹, were used as the calibration standards. The known values of the SDC permit calculating the mean square of the movement for a given value of Δ with Eq. (1). The values of the SDC of the standard samples and adsorbed substances were measured in identical conditions.

The dependence of the amplitude (ψ) of the spin echo signal in the case of anomalous diffusion (diffusion in fractal systems) is described by the equation

\[ ψ = \exp \left\{ -\frac{\gamma^2 q^2 x}{\delta (x+1)(x+2)} \left[ \frac{1}{2} (\Delta + \delta) x^2 + \frac{1}{2} (\Delta - \delta) x^2 - \Delta x^2 - \delta x^2 \right] \right\} \]  

(3)

In the condition of Δ >> δ, this expression is simplified

\[ ψ = \exp \left\{ -\frac{\gamma^2 q^2 x^2}{6} \Delta x \right\} \]  

(4)

In consideration of Eq. (2), we obtain [8]

\[ ψ = \exp \left\{ -\frac{\gamma^2 q^2 x^2}{6} \langle r^2(\Delta) \rangle / 6 \right\} \]  

(5)

One then calculates \( \langle r^2(\Delta) \rangle \) from (5).

The dependence of (ψ) on (δ) or (g) was investigated in the experiments, and Δ was considered an independent variable [7]. The dependences of the value of \( \langle r^2(\Delta) \rangle \) for molecules of C₆H₆ adsorbed in AC-71 and C₆H₁₄ adsorbed in AC-72 on the value of Δ at different temperatures are shown in Fig. 1.

RESULTS AND DISCUSSION

The evaluation of the diffusion pathway of the adsorbed molecules was conducted with (1). It is clear that the smallest movements of adsorbed molecules are observed for low values of Δ and SDC, and for this reason, it is expedient to perform the measurements of the SDC at low temperatures in this case. Worsening of the spin echo signal for large Δ and T limits the range of observable movements at the top.

As Fig. 1 shows, the linear dependence of \( \langle r^2(\Delta) \rangle \) on Δ (the tangent of the slope is close to one) is obtained for both AC. It follows from this that normal diffusion is observed in the range of movements of the adsorbed molecules investigated, i.e., the adsorbents do not exhibit FP. The range of movements is 2-40 μm for AC-71 and 1-100 μm for AC-72.

It should be noted that similar results were obtained in studying the mobility of molecules of H₂O and C₆H₁₂ adsorbed in AC-71 and molecules of H₂O and C₆H₆ adsorbed in AC-72.