ADSORPTION OF BENZENE VAPOR ON MESOPOROUS SORBENT MATERIALS

[1]Dilnoza Jumaeva, [2]Rano Akhrorova, [3]Sayyora Barnoeva, [4]Bekzod Haydarov

[1]Doctor of Technical Sciences, Professor, Institute of General and Inorganic Chemistry, Republic of Uzbekistan, Tashkent.

[2,3]Basic doctoral student, Institute of General and Inorganic Chemistry, Academy of Sciences of the Republic of Uzbekistan, Republic of Uzbekistan, Tashkent.

[4]Tashkent Institute of Chemical Technology, Yangiyer branch, assistant teacher

Abstract: In this article, the adsorption isotherms of benzene vapors in mesoporous adsorbents synthesized in the presence of silicon dioxide and cetylpyridinium chloride, selected as a mesagenic template, are studied using the McBean-Bakr apparatus. Based on the experimental data obtained, the results of the sorption structure, such as the relative surface areas and pore volumes of mesoporous adsorbents, were obtained. Based on the adsorption isotherms of benzene vapors on adsorbents, the capacity of monolayers am, the saturation volume V_s (or adsorption as) and their specific surfaces Sud were calculated. Based on the results of the structure-sorption indicators of the adsorbents, the specific surface (Ssp.) was determined using the equation of the Brunauer-Emmett-Teller (BET) theory.

Keywords: mesoporous sorbent, benzene, adsorption, isotherm, micropore, pore volume, specific surface.

INTRODUCTION

It is known to scientists from the analysis of the literature that the amount of silicon oxide, which is considered important for the production and chemical industry, is mainly present in quartz rock, kaolinite, granite and sandstone, as well as in various minerals [1-3]. Silicon oxide can also be extracted from siliceous sands. It is known that silica sand contains approximately 95% silicon, and as a result, it is possible to produce high-quality silicon oxide.

In order to ensure the effective implementation of the Decisions of the President of the Republic of Uzbekistan No. PQ-4291 dated 17.04.2019 and No. PQ-2916 dated 21.04.2017, to obtain clean reagent-silicon oxide by processing husk waste from rice grown in our Republic and to activate tree stem waste It serves to solve environmental problems by expanding the range of adsorbents by choosing the optimal mode of the method.

Today, adsorbents obtained on the basis of various raw materials are widely used in various branches of production [4-6]. Adsorbents - the source of raw materials for development is considered important, and its chemical composition meets the requirements is one of the aspects to be taken into account. One of the main requirements for adsorbents is their high porosity and high surface area.

The results of isotherms, which give information about the surface area of sorbents and their sorption-structural characteristics, were studied in the Mak-Ben-Bakra device [7-8].

Research method. Adsorption isotherms of vapors of gases and liquids on adsorbents were studied in a high-vacuum Mc-Ben-Bakra balance. The device is equipped with a highly sensitive quartz spiral. Its sensitivity is $1.78\text{-}10^{-3}$ kg/m. During the research work, the temperature of the adsorption column (tube) containing the adsorbent samples was kept at 20°C with an accuracy of 0.1°C. The structure of the device and the main working parts of the working system are composed as follows: - quartz spring adsorption columns (equipped with cups, which are weighed on an analytical balance with an accuracy of 1 g from the studied adsorbent samples into the cups), - a forvacuum pump (brand BH-461M), - a diffusion pump (creates a vacuum until the residual pressure in the system is $1.33 \cdot 10^{-3}$ Pa.) it is provided with a screw, the pressure in the system is controlled by a thermovacuum meter (VIT - 2 brand). -U-shaped monometers, -trap (functions to trap various gases and water vapors in the system

with liquid nitrogen), -ampoules for adsorbates, and taps for separating device parts are placed. Forvacuum pump and diffusion pump in the adsorption device $1\text{-}10^{-5}$ mm.s.s. creates a vacuum until The pressure difference in U-shaped monometers is measured using a B-630 type cathometer. The accuracy of the catheter is 0.05 mm. The samples prepared for the study were crushed to a powder state in an agate mortar, after mixing thoroughly, 1 g was taken out on a scale and placed in a cup. The pressure in the system is stabilized by vacuum for 6-8 hours. The benzene obtained as adsorbate was purified and dried under vacuum before use in adsorption. It was first frozen and then heated until its vapor pressure was the same as the data of vapor pressure given in the tables for pure benzene.

Research analysis. It can be seen from the adsorption isotherms in Figure 1 that the amount of adsorption increases sharply from the zero value of the relative specific pressure to $P/P_s \approx 0.4$, and then the adsorption slowly increases and approaches the saturation state. From the adsorption isotherms in Figure 2, it can be seen that the amount of adsorption increases sharply from zero relative specific pressure to $P/P_s \approx 0.2$, then from relative specific pressure $P/P_s \approx 0.2$ to $P/P_s \approx 0$ We can see that the equilibrium occurred during the adsorption process up to .6, and after the relative specific pressure $P/P_s \approx 0.6$ at the last stage, the adsorption values increased.

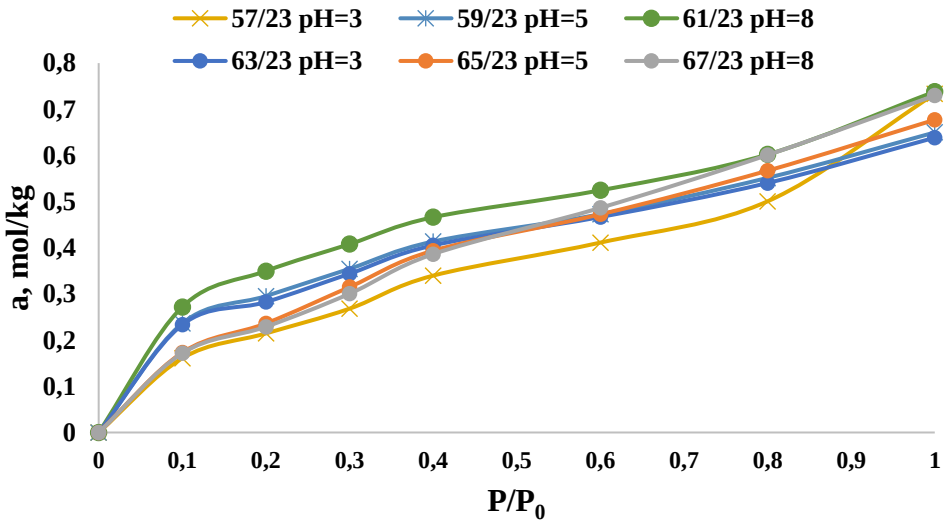

Figure 1. Adsorption isotherms of samples with benzene vapor

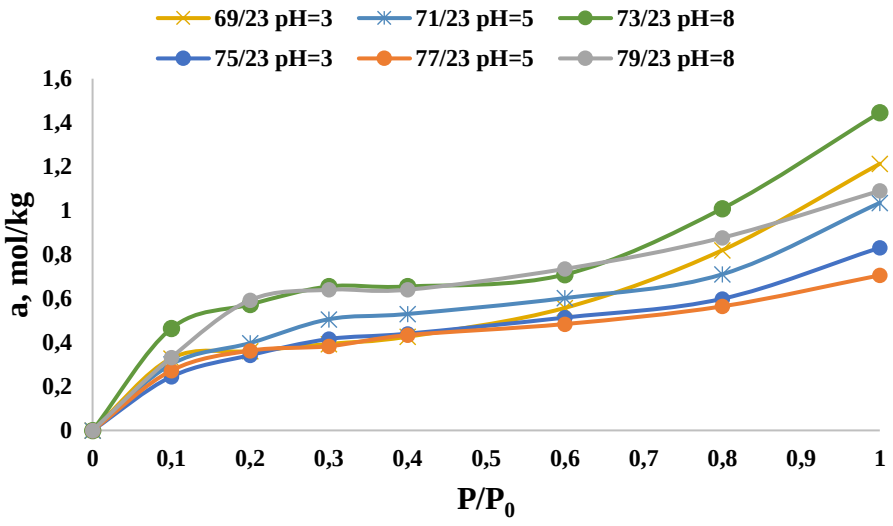

Figure 2. Adsorption isotherms of samples with benzene vapor

A sharp rise of adsorption isotherms at such a low relative pressure ($P/P_s \approx 0.2\text{-}0.4$) indicates that benzene vapors are adsorbed on surfaces with high adsorption potential in the initial fillings. The adsorption values of the samples shown in Fig. 2 are 1.5-2 times higher compared to the samples shown in Fig. 1, which is explained by the processing and activation conditions of the initial samples obtained.

In the sample 61/23 pH=8 given in Figure 1, it is possible to see the steepness of the isotherm due to the high adsorption amount up to $P/P_s=0.4$ at low relative pressures. It can be seen that the adsorption isotherms of all adsorbents belong to type IV of the classification of adsorption isotherms proposed by Brunauer.

The form of adsorption isotherms directly depends on the properties of the adsorbent and absorbed substance and the forces of interaction between them. First, it is related to the size, nature and charge of the exchangeable cations in the samples, and secondly, it is related to the specificity of the interaction of non-polar benzene molecules with modified adsorbents, i.e., the change in the hydrophilic and lyophilic nature of the adsorbents is. 61/23 pH =8 is characterized by the high adsorption amount of benzene vapors compared to other adsorbents, the interaction of non-polar benzene molecules with cations between the adsorbent layers.

In the range of relative pressure $P/P_s=0.6\text{-}1.0$, it can be seen that the adsorption isotherm increases significantly again at 57/23 pH=5. Absorption of adsorbate molecules in this case indicates that adsorption occurred as a result of capillary condensation of benzene vapors in secondary pores or the beginning of the polymolecular adsorption process.

The comparative surface area (S) of mesoporous silicon-based adsorbents was determined using the equation of the Brunauer, Emmet, Teller (BET) theory from the structural adsorption parameters. In this case, if the ordinate is $P/P_s /a(1- P/P_s)$ and the values of P/P_s are placed on the abscissa axis, it will be created according to the straight line coordinates.

The relative surface area of adsorbents is calculated using the following formula:

$$S = a_m \cdot N \cdot \omega_0$$

Here: S-relative relative surface area (m^2/g);

a_m- monomolecular layer (mol/kg);

N_A- Avagadro's number;

ω- surface area occupied by one molecule (nm^2)

On the basis of isotherms of benzene vapor adsorption on the arranged microporous sorbent, the monolayer capacity am, saturation volume V_s (or adsorption α) and their relative surfaces S were calculated from the important parameters of the samples. Based on the adsorption of benzene vapors, the results of the structure-sorption indicators are presented in Table 1.

Table 1

Structure - sorption parameters for adsorption of benzene vapors

Received samples	Single floor capacity, $a_{m,}$ mol/kg	Comparison surface, $S \cdot 10^{-3}$, m^2/kg	Saturation adsorption, a_s, mol/kg
57/23 pH=3	0.191	45.95	0.733
59/23 pH=5	0.245	58.95	0.650
61/23 pH=8	0.28	67.39	0.738
63/23 pH=3	0.238	57.4	0.639
65/23 pH=5	0.219	52.82	0.677
67/23 pH=8	0.213	51.31	0.730
69/23 pH=3	0.267	64.33	1.213
71/23 pH=5	0.326	78.39	1.035
73/23 pH=8	0.42	101.18	1.446
75/23 pH=3	0.271	65.18	0.831
77/23 pH=5	0.266	63.97	0.706
79/23 pH=8	0.408	98.13	1.090

In the samples where the main part of absorption of benzene molecules in mesoporous adsorbents was taken, the absorption indicators: in 57/23 samples - 26.1%, in 59/23 samples - 37.7%, in 61/23 samples - 37.9%, 63 /23 samples - 37.2%, 65/23 samples - 32.3%, 67/23 -29.1%, 69.23 samples - 22%, 71/23 samples - 31.5%, 73/23 samples - 29 %, in 75/23 - 32.6%, in 77/23 - 37.7%, in 79/23 - 37.4%, corresponding to the amount of monolayer capacity of adsorbents was determined based on the results of the ban. The amount of specific surface area (S) and saturation adsorption (a_s) in samples of mesoporous sorbent material is as follows 57/23 > 59/23 > 61/23 > 69/23 > 71/23 > 73/23 > 75/23 > 77/23 > 79/23 is explained by the increase of the line. In this case, the change of the relative surface area and saturation adsorption in the above-ordered microporous sorbent materials in the same sequence as above is explained by the correct selection of the chemical processing conditions of the initial samples and their dependence on the pH environment.

Based on the isotherms of adsorption of benzene vapors in the samples and the micropore volume saturation theory (MHTN) equation, the micropores (W_0) of the adsorbents, the adsorption volumes (V_s) for saturated states and the mesopores volume $W_{me}= V_s- W_0$ formula determined using G'ovaklarning average radius $r_{\text{ўр}} = \frac{2 \cdot V_s \cdot 10^4}{S}$ calculated according to the formula.

Table 2 below shows the results of sorbent pore volumes by studying isotherms of benzene vapor adsorption on ordered mesoporous sorbents.

Table 2

Indicators of pore volumes for adsorption of benzene vapors

Samples	$W_0 \cdot 10^3$	$W_{me} \cdot 10^3$	$V_s \cdot 10^3$	The average radius of the pores r_{aver}, Nm
57/23 pH=3	0.0426	0.02	0.0650	28.3
59/23 pH=5	0.0462	0.01	0.0576	19.5
61/23 pH=8	0.0518	0.01	0.0654	19.4
63/23 pH=3	0.0452	0.01	0.0567	19.8
65/23 pH=5	0.0467	0.01	0.0600	22.7
67/23 pH=8	0.0480	0.02	0.0680	25.2
69/23 pH=3	0.0612	0.05	0.1075	33.4
71/23 pH=5	0.0636	0.03	0.0936	23.4
73/23 pH=8	0.0822	0.05	0.1322	25.3
75/23 pH=3	0.0531	0.02	0.0737	22.6
77/23 pH=5	0.0485	0.01	0.0626	19.6
79/23 pH=8	0.0773	0.02	0.0973	19.7

CONCLUSION

It is known from the results of the isotherm obtained in the sorted mesoporous sorbent materials that the size of the micro and mesopores in samples 57/23, 59/23, 61/23, 63/23, 65/23 and 67/23 is as follows: 69/23, 71/23, 73/23, 75/23, 77/23 are 1.5-2 times lower than samples 79/23, but the volume of meso- and micropores in sample 73/23 is relatively high. It can be seen that the adsorption of the aggregate is higher in this sample compared to the others. The indicator of the average radius of porosity in mesoporous sorbent materials is mesoporous according to the classification of pores proposed by M.M.Dubinin ($2< r <50$ nm) was found to be among adsorbents.

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