Study Of Textural, Sorption And Physicochemical Characteristics Of Kaolin And Bentonite

[1]**Fayzullaev Normurot Ibodullayevich,**

[2]**Mamadoliev Ikromjon Ilkxomidinovich,**

[3]**Kiyamova Dilfuza Sharifovna**

[1]**Samarkand State University,** [2,3]**Samarkand Medical Institute**

Abstract. The sorption, textural, and physicochemical characteristics of bentonite and kaolin are studied. To determine the relative surface of the samples, the Brunauer-Emmett-Teller method (BET) was used, and the Barret-Joyner-Helend method (BLC) was used to determine the volume and size of pores. As a result of the research, a relationship was established between the volume of adsorbed gas and the relative pressure and pore radius. It has been established that at $P/P_0 = 0\text{-}0.05$ in the mesopores monomolecular adsorption is observed, at $P/P_0 = 0.05$ simultaneously mono- and multimolecular adsorption, at $P/P_0 = 0.05\text{-}0.4$ there is a polymolecular adsorption.

Keywords: kaolin, bentonite, colloidality, swelling, adsorbed gas volume, adsorption capacity, meso and micropores.

1.Introduction

Adsorption methods for industrial hydrocarbon purification are one of the most common methods in the industry. Their use allows a number of valuable compounds to be returned to production in order to reuse. The most important requirements for adsorption materials are: high specific surface area, selective responsiveness and easy regeneration [1-4]. In addition, the adsorbent should be cheap and harmless, with no corrosive properties, should retain its adsorption feature for a long time, and be highly mechanically durable. One of the most common adsorbents is activated carbon and is produced by various brands. In recent years, natural and artificial zeolites have been widely used in the purification of hydrocarbons. One of the most important areas for now is the development of environmentally friendly sorbents, catalysts and catalysts based on local raw materials [5 - 9].

Experimental

To determine the chemical and physicochemical characteristics, we placed sample granules in 100 g of mass in a 250-cm glass tube and poured 150 cm^3 of distilled water. The flask was stirred for 24 hours on the AVU-6 unit at 120 rpm.

After drying, the adsorbent was passed through a sieve with 0.5- and 0.25-mm diameter, and the mechanical and physicochemical properties were studied. Before acid treatment, we grinded the soilsamples until to reach particle size 0.08 mm. We added 40 ml H_2SO_4 heated to 10 g of grinded soil and stir in a water bath. After processing, the soil was filtered through a paper filter in the Buchner funnel and washed with distilled water at pH = 5.4-5.7. The soil was then dried with the filter paper in the dryer for 12 hours at 120ºC. Specific surface area and the distribution of pore sizes were found in the automatic adsorbometer ASAB 2010 by the low-temperature nitrogen desorption method. Sediment analysis was performed on water and glycerol mixture in different dispersion environments using the Oden method.

X-ray diffraction analysis (Co-Kα-radiation) was performed on the DRON-4 diffractometer with a cobalt X-ray tube. The PDF-2 database of the International Center for Diffraction Data (JCPDS, 1999) was used for the analysis of diffractograms. The porosity of the samples was determined by Quantrome NOVA (USA) analyzer of low-temperature nitrogen desorption. Each sample was dehydrated for 2 hours at 250ºC under vacuum prior to measurement.

The Brunauer-Emmett-Teller (BET) method was used to determine the relative surface of solid samples. This method is used by the following BET equations:

$$\frac{1}{W \cdot (\frac{P_0}{P} - 1)} = \frac{1}{W_m \cdot C} + \frac{C - 1}{W_m \cdot C} \cdot \frac{P}{P_0}$$

where W-P/P_0 is the adsorbed mass at a relative pressure, W_m- the adsorbed mass on the surface coated a monolayer; S – is a BET constant, which shows the adsorption effect of adsorbents and represents the adsorption energy of the first adsorption layer.

The Barrett-Joyner-Halenda(BJH) method was used to determine the volume and the size distribution of pores. In the calculations, the desorption and adsorption areas of the isotherm with a pressure range of 0.967-0.4 P/P_0 were used.

To determine the shear density, the sorbent weighed 500 g and was kept in the dryer for 600 h at 60ºC. 400 g of the dried sample was weighed and placed in a 500 ml cylinder, measured a volume V_1. We then densified th sorbent by light tapping under the cylinder and t and again measured a volume V_2.

The bulk density of the sorbent was determined by the following formula:

$$\gamma_1 = \frac{P}{V_1} \qquad \gamma_2 = \frac{P}{V_2} \qquad [\text{g/cm}^3]$$

where P is the mass of the sorbent; , Density of -sorbent and subsequent bulk density, g/cm^3.

Results and discussion

The subject of the study was the Navbakhor bentonite and Pahtachi kaolin.

Table 1.

Chemical content of bentonite in Bavbakhor district.

Name	SiO$_2$	TiO$_2$	Al$_2$O$_3$	Fe$_2$O$_3$	MgO	CaO	Na$_2$O	K$_2$O	P$_2$O$_5$	SO$_3$
Alkali bentonite soil	57.91	0.35	13.69	5.10	1.84	0.48	1.53	1.75	0.43	0.75
Alkali earth soil	56.23	0.61	13.56	6.50	3.76	0.69	0.98	2.20	0.92	0.49

Prior to acidification of bentonite or kaolin, the sample was heated at 150ºC for 30 min to remove water.

Mass% after acidic acid:

$SiO_2 – 70.17, Al_2O_3-9.49, Fe_2O_3-1.39, MgO-0.64, Na_2O-0.17, K_2O-1.27, CaO-0.20, TiO_2-1.63, MnO-0.01.$

Table 2.

Dependence of the activation mode on the physicochemical properties of soil

Porperties of soil	Activation time, seconds								
	0	10	20	40	60	80	100	120	180
Navbakhor bentonite									
Swelling, mg/g	15	18	19.6	22	24	26	27	28	25
Colloid property, %	49	51.6	55	62.2	67.7	70.2	74.7	80	70.9
Water absorption,	2.5	2.46	2.42	2.38	2.36	2.34	2.32	2.3	2.45
Pakhtachi kaolin									
Swelling, mg/g	25	28	29,6	30	33	36	38	42	44
Colloid property, %	89	90	92	94	96	96	99	100	100
Water absorption	10	12	14	16	18	20	22	28	30

Table 3.

Physical characteristics of natural soil

Name		
	Pakhtachikaolin	Navbakhorbentonite
Specific surface are, m^2/g	250-300	125-200
Bulk density, kg/m^2	600-700	570-650
Pore volume, cm^3/g	0.028-0.041	0.048
Pore size, nm	2.6-2.8	3.4-4.3

In the equilibrium mode, the adsorption test allows to determine the maximum adsorption rate and to calculate the thermodynamic parameters of adsorption at low temperature fluctuations.

Adjusting the adsorption equation by the experimental design of adsorption isotherms is accepted. The expression of adsorption by Langmuir and Freundlich models is widely used in the literature:

$$\frac{a}{a_\infty} = \frac{K_L \cdot C_0}{1 + K_L \cdot C_0} \qquad a = K_F \cdot C^{on} \qquad \frac{a}{a_\infty} = \frac{K_L \cdot C^{on}}{1 + K_L \cdot C^{on}} \qquad \frac{C/C^0}{a(1 - \frac{C}{C^0})} = \frac{1}{a_\infty \cdot C} + \frac{k-1}{a_\infty kC^0}$$

where $k = e^{\frac{Q-\lambda}{RT}}$ thus Q-λ-adsorption heat

$$\frac{a}{a_\infty} = \frac{K_R \cdot C^0}{1 + a \cdot C^{0\beta}}$$

α, β-Redlich-Peterson equation parameters

There is a relationship between the adsorption equation and the change in adsorption enthalpy and entropy:

$$K_{ads} = e^{\frac{\Delta S_{ads}}{R}} \cdot e^{\frac{\Delta H_{ads}}{RT}}$$

The rate of adsorption process can be expressed in time units by changing the amount of adsorbed substance in the mass of the adsorbent as follows:

$$r_{ads} = \frac{da}{d\tau} \quad [(mg/g)/s]$$

Thus, the mass of adsorbed substance in a-1 g of adsorbent, -the time.

The following expression is important for the dynamic system in an open system, such as the flow adsorber:

$$V = \frac{W}{S}\frac{dC}{dL} = \frac{W \cdot dC}{dV_{ads}}$$

where V – is the rate of the adsorption process, W – the volume rate of the current; C – reactor cross-section surface, l-adsorbent layer height; V_{ads} - the volume of adsorbent.

Studies have shown that the adsorption process is subject to a 2-order reaction equation:

$$\frac{da}{d\tau} = \frac{k_2 \cdot (a_\infty - a_\tau)^2}{1 + k_2 \cdot (a_\infty - a_\tau)} \approx k_2(a_\infty - a_\tau)^2$$

Or its integrated form is as follows:

$$\frac{\tau}{a_\infty} = \frac{1}{k_2 \cdot a_\infty^2} + \frac{\tau}{a_\tau}$$

Diffusion model for the adsorption process:

$$a_\tau = k_{diff} \cdot \tau^{\frac{1}{2}} + S$$

k_{diff}- diffusion constant of the adsorption rate, S-constant number.

Dynamic capacity of the adsorbent is found using the formula:

$$a_d = \frac{P_m \cdot V \cdot [S]}{m_{ads}}$$

Comparison of surface and microwave size was calculated by BET method for mesoporous sorbents and Dubinin method for mesoporous sorbents. To confirm the structure of the sorbents, we present the nitrogen adsorption desorption curves for mesoporous sorbents:

Figure 1. Adsorption-desorption isotherms of nitrogen in mesopores of synthesized sorbents.

As shown in Figure 1, the adsorption-desorption isotherms presented are typical of type IV isotherms. We consider the distribution of pore size for the synthesized porous sorbents (calculated by the BJH method).

Figure 2. Pore volume distribution depending on diameters of mesoporous sorbents.

As Figure 2 shows, the synthesized porous sorbents consist mainly of porevolume around 2 nm.
Microporous sorbents provide characteristic isotherms of nitrogen adsorption.

Figure 3. Nitrogen adsorption-dsorption isotherms in micropores of microporous sorbents.

International Journal of Research

Available at https://edupediapublications.org/journals

p-ISSN: 2348-6848
e-ISSN: 2348-795X
Volume 07 Issue 04
April 2020

As can be seen from Figure 3, the isotherms present are of the first type of isotherms (horizontal planes present).

In the equilibrium mode, the adsorption test allows to determine the maximum adsorption rate and to calculate the thermodynamic parameters of adsorption at low temperature fluctuations.

Comparison of surface and microwave size was calculated by BET method for mesoporous sorbents and Dubinin method for mesoporous sorbents.

Adsorption isotherms are typical of type IV according to the de Bour classification and characterize the adsorption of mesoporous materials. In the isotherm, monomolecular adsorption in the shells and $P-P_0 = 0-0.05$, as well as adsorption in microwave microwaves are observed. At $P/P_0 = 0.05$, mono- and multimolecular adsorption in the pores is observed. Area $P/P_0 = 0.05–0.4$ is the polymolecular adsorption that is used to compare surface surfaces (S_{sol}) in the BET equation. Adsorption isotherms characterize capillary condensation in the intermediate shells $P/P_0 = 0.4-1.0$.

The paper presents the results of the influence of thermal activation factors on zeolites with different cationic composition. Silicon enriched zeolite obtained from Navbakhar bentonite was used as sorbent.
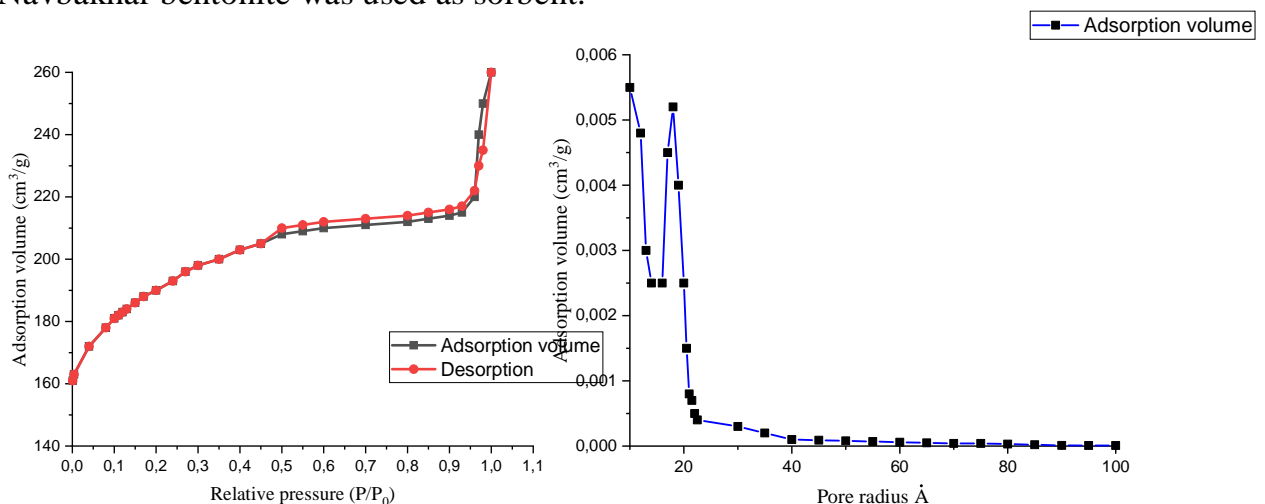

Figure 4. Adsorption-desorption isotherms and pore size distribution differential curves related to radius of synthesized sorbents.

Conclusions

1) The sorption, texture and physicochemical characteristics of bentonite and kaolin were studied.

2) The Brunauer-Emmett-Teller (BET) method was used to determine the specificsurface areasof the samples, and the Barrett-Joyner-Halenda(BJH) method to determine the pore volume and size distribution.

3) The study investigated the relationship between adsorption volume and relative pressure and pore radius.

4) Monomolecular adsorption at the interval $P/P_0 = 0 - 0.05$, mono- and polymolecular adsorption at the interval $P/P_0 = 0.05$, and $P/P_0 = 0.05-0.4$ polymer molecular adsorption processes have been proven.

References

1. B.Sh.Shukurov., Sh.B.Rakhmatov., N.I.Fayzullayev. High silicon zeolite preparation from kaolin. //Scientific journal of SamSU, 2018, 5(109), 106-111 pp.

2. Ayari F., Srasra E., Trabelsi-Ayadi M. Characterization ofbentonitic clays and their use as adsorbent // Desalination. 2005. V. 185. N. 1-3. P. 391–397.

3. Vezentsev A.I., Volovicheva N.A. The material composition and sorptioncharacteristics of montmorillonite containing clay // Sorption and chromatographic processes. 2007.V. 7. No. 4. P. 639–643.c

4. Sadykov T.F., Konkova T.V., Alekhina M.B. Montmorillonite with a laminated structure for the fenton process // Advances in Chemistry and Chemical Technology. 2012.Vol. 26. No. 8 (137). 50–54 pp.

5. Mostalygina L.V., Chernova E.A., Bukhtoyarov O.I. Acid activation of bentonite clay // Bulletin of the South Ural State University. Series "Chemistry". 2012. No. 24. 57–61 pp.

6. Volkov V.A. Colloid chemistry. Surface phenomena and disperse systems // Moscow: Lan, 2015.256 pp.

7. Kosarev A.V. Modeling the kinetics of adsorption of natural structures on a polymer matrix / A.V. Kosarev, N.V. Vedeneeva, E.I. Tikhomirova // Modern bioengineering and nuclear-physical technologies in medicine: Sat. Mater. vseros. young scientific conf. / holes ed. V.N. Lyasnikov. M .: Prondo, 2014. 305–308 pp.

8. Fayzullayev N.I., Mamadoliyev I.I. Optimization of the activation of high silicon zeolite // Scientific journal of Samarkand State University. (2019),V 3 (115), 8-12 pp (*in Uzbek*).

9. Volkov V.A. Colloid chemistry. Surface phenomena and disperse systems // V.A. Volkov. M .: Lan, (2015).256 pp (*in Russian*).