

THERMODYNAMICS OF ADSORPTION OF CARBON MONOXIDE (IV) ON NATURAL BENTONITE SORBENT

**Uchqunbek Askarov¹, Mohfora Mamajonova¹, Eldor Abdurakhmonov^{2 a}, Dilnoza
Salihanova², Shakhnoza Kuldasheva²**

¹Namangan Engineering and Technological Institute, Namangan, Uzbekistan

²Institute of General and Inorganic Chemistry of the Academy of Sciences of the Republic of
Uzbekistan,

Tashkent, Uzbekistan

a)Corresponding author: eldor8501@gmail.com

Abstract. Bentonite adsorbents from clay minerals are now used in many industries. At present, bentonites are one of the most important adsorbents in the food industry for the purification of various gas fields and other organic compounds. In addition, local bentonites are widely used in oil drilling. However, to date, there are few data on the presence of certain active centers or their dependence on the properties of the surface structure. Since the catalytic activity of clay minerals is not scientifically substantiated, it is necessary to produce highly efficient adsorbents that meet international requirements. Fundamental research is constantly needed to study adsorption processes in bentonites at the level of molecular systems. The adsorption mechanism on the bentonite surface has been described in complete thermodynamic processes using the volumetric method in a highly sensitive microcalorimetric adsorption device.

Keywords: Adsorption, dehqanobod bentonite, carbon monoxide (IV), adsorption calorimeter.

INTRODUCTION

Due to the low charge value and weak electrostatic interaction between the three-layer surface and multilayer cations, the minerals of the montmorillonite group are capable of multilayer sorption of various substances - cations, water molecules, and many organic compounds. In other words, the reactions of metabolism, absorption and desorption of substances of this group of minerals can occur not only on the outer, but also on the inner surface of crystallites. A significant part of the cation exchange capacity of montmorillonites depends on isomorphic exchanges in the lattice and, therefore, does not depend on pH, but there are hydroxyl groups on the side faces of montmorillonite particles, which can be a source of pH and acidity [1]. The adsorption of metal cations on the surface of aluminosilicates can take three forms: intra-atmospheric complexes (specific adsorption), external spherical complexes (nonspecific adsorption), and a diffuse layer [2].

In the study of the adsorption processes of polar and non-polar molecules of concrete and the study of sorption processes, a number of studies were carried out by the calorimetric method in a high-vacuum adsorption unit [3-9].

When determining the sorption centers of active adsorbents, such quantities as isotherm, differential heat, entropy, and equilibrium time required for calculating the adsorption volume are some of the most important parameters.

MATERIALS AND METHODS

The differential heat of adsorption was measured on a TAK-Kalve model DAK 1-1 calorimeter. When determining by the volumetric method, the adsorption isotherm was used. The convenience of this method is that it helps to enrich the theoretical knowledge of adsorption based on thermodynamic laws. This device is only suitable for the determination of adsorption quantities. The accuracy of the adsorption isotherm is 0.1%, and that of heat is up to 1% [17]. Carbon monoxide obtained as an adsorbate was purified and dried under vacuum before being used in sorption. The dissolved gases were removed until their vapor pressure was the same as the vapor pressure data shown in the tables for pure carbon monoxide (IV). It was then determined that this is consistent with the data presented in the literature [18]. The adsorption of carbon monoxide on Dekhkanabad bentonite was carried out at 303 K.

RESULTS AND DISCUSSION

A sample of Dekhkanabad bentonite was placed in chemical containers and distilled for 6 hours. The sample was split into two parts. Initially, the adsorption properties of the upper part were studied in a natural way, that is, experimental work was carried out in the case of inactivation without physical and chemical influences. First of all, it should be noted that, due to the high pressure of saturated CO₂ vapor at an experiment temperature of $R^{\circ} = 54086 \text{ mm } 30^{\circ} \text{ C}$, it is impossible to obtain a complete CO₂ adsorption isotherm in Dekhkanabad bentonite. This is due to the fact that the adsorption device is capable of determining pressure up to atmospheric, that is, pressure up to 760 mm.cm.set. The adsorption isotherm of carbon monoxide (IV) in Dekhkanabad bentonite is shown in Figure 1.

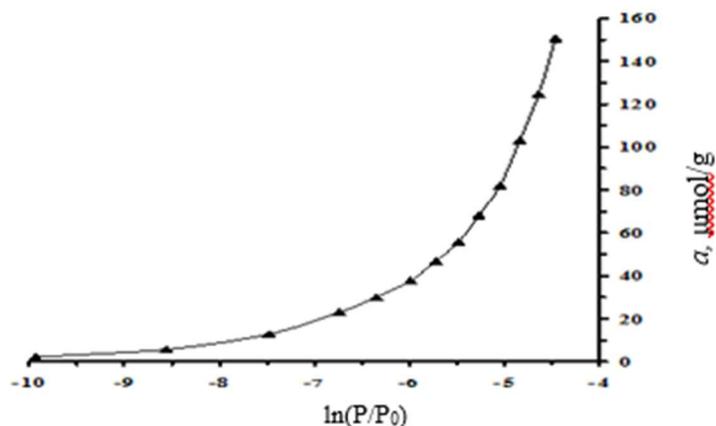


FIGURE 1. Isotherms of adsorption of carbon monoxide (IV) in Dekhkanabad bentonite at 303 K.

The isotherm in the initial region is adjacent, and at a filling of $\sim 40 \mu\text{mol} / \text{g}$ it rapidly grows upward. Adsorption up to $\sim 40 \mu\text{mol} / \text{g}$ is strongly adsorbed on the active sites of the adsorbent. In subsequent stages of adsorption, the adsorption of carbon monoxide (IV) tends to be perpendicular to the adsorption axis, since it is mobile on the surface. Since clay minerals are usually adsorbed on more surfaces, the sample showed a net surface area of $88.8 \text{ m}^2 / \text{g}$ when described using the BET equation using the adsorption isotherm value and adsorption values.

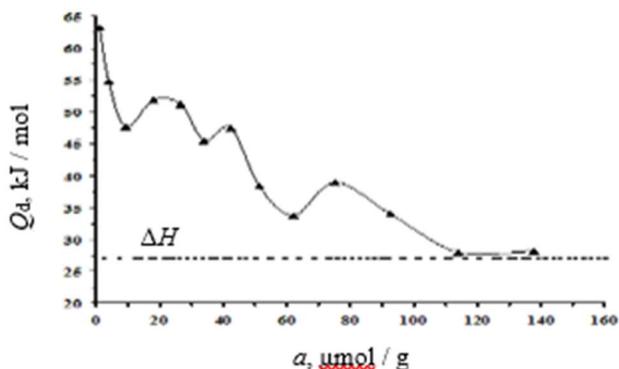


FIGURE 2. Differential heat of adsorption of carbon monoxide (IV) in Dekhkanabad bentonite at 303 K. Adsorption of benzene at 303 K Horizontal dotted lines - heat condensation.

In Dekhkanabad bentonite, the differential heat of adsorption of carbon monoxide (IV) has a stepwise shape, and the graph is shown in Figure 2. In this adsorbent, the initial saturation starts from $73.2 \text{ kJ} / \text{mol}$ and gradually decreases at the adsorption temperature in a wave-like manner. In the next molecule of carbon monoxide (IV), the heat of adsorption is $10 \mu\text{mol} / \text{g}$ at $47.5 \text{ kJ} / \text{mol}$, reaching a maximum value of $63 \text{ kJ} / \text{mol}$ at $15 \mu\text{mol} / \text{g}$. At $60 \mu\text{mol}$, it is $35 \text{ kJ} / \text{mol}$, then increases to $40 \text{ kJ} / \text{mol}$, and the adsorption is $80 \mu\text{mol}$. From the graphs and values of the differential heat of adsorption in processes up to this value, it can be seen that the heat of adsorption is in the minimum and maximum state in the form of a wavy step. Initially, there is a high heat of adsorption due to the large number of voids on the surface. As a result of gradual saturation, the adsorbate molecules are in a mobile state. Then it is equal to the heat of condensation when the adsorption reaches $120 \mu\text{mol}$. Due to the low content of metallic sodium in clay minerals, the heat of adsorption is below $65 \text{ kJ} / \text{mol}$. The filling of bentonite with active metals occurs relatively quickly due to the high heat of adsorption and the formation of an ion-molecular complex. It has been observed that the heat of adsorption fluctuates due to the migration of small amounts of alkali metal cations.

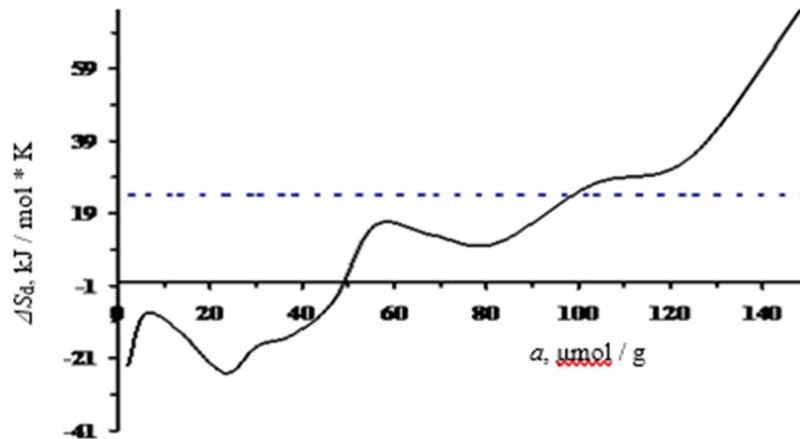


FIGURE 3. Differential entropy of adsorption of carbon monoxide (IV) in Dekhkanabad bentonite at a temperature of 303 K. The horizontal lines are the mean integral entropy.

In fig. 3 shows the entropy of adsorption of carbon monoxide (IV) by Dekhkanabad concrete. In the process, up to 50 $\mu\text{mol} / \text{g}$, carbon monoxide (IV) falls below the entropy of the standard state. Then the entropy plot shows that the standard state exceeds the entropy. The average integral entropy is 24.11 J / mol *

K. The fact that in the initial cases the entropy values are lower than the standard state indicates a strong localization of the bentonite of this farm on the surface. at subsequent stages of adsorption, the entropy is higher than 0, since carbon monoxide (IV) is in a highly excited state. At the stages of adsorption after 50 $\mu\text{mol} / \text{g}$, the adsorption energy is low due to the interaction of adsorbate molecules under the action of Wander-Waltz forces. The magnitude of the energy values causes these absorbed molecules to become mobile.

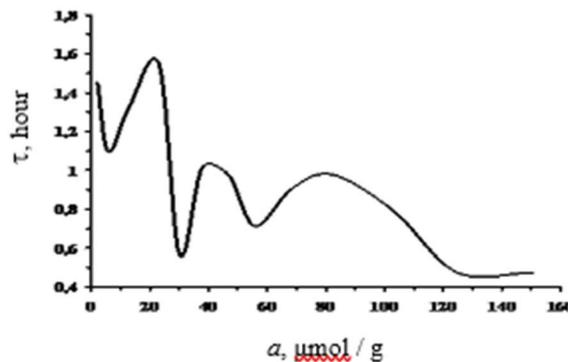


FIGURE 4. Equilibrium time of adsorption of carbon monoxide (IV) in Dekhkanabad bentonite at 303 K

In fig. 4 shows the equilibrium time of adsorption of carbon monoxide (IV) in Dekhkanabad bentonite. It can be seen that the adsorption equilibrium time initially starts at 1.5 hours and decreases to a few minutes when the process is complete. Initially, more time is spent on the distribution of carbon monoxide (IV) molecules over the surface.

As the adsorbate molecules gradually saturate the surface, the equilibrium time also decreases. From the time graph of the equilibrium of adsorption and the heat of adsorption, it can be explained that carbon monoxide (IV) is initially adsorbed on the surface of clay minerals, and at the end of the process - on the side layers.

CONCLUSION

First of all, in order to obtain experimental results, the results obtained using a high-vacuum adsorption device help to divide the adsorbent into types, i.e. microporous adsorbents help to determine the adsorption processes occurring on the surface. The differential heat of adsorption of carbon monoxide (IV) in Dekhkanabad bentonite has a wave-like character. It differs from other local adsorbents of bentonite by a

1.1 times higher heat of adsorption. The adsorption isotherm was used to determine the surface area of this sorbent using the BET equation. Initially, molecules of carbon monoxide (IV) with a concentration of 40 $\mu\text{mol} / \text{g}$ are localized on the surface of farm bentonite.

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