

ISOTHERM OF HYDROGEN SULFIDE ADSORPTION IN ACTIVATED
SORBENT FROM THE HYBRID VARIETY OF TOMENTOSA TREE

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Abstract: *In the present article, the regularities of the adsorption isotherm and of hydrogen sulfide molecules on an activated carbon adsorbent obtained from the bark of the Paulownia tomentosa tree at a temperature of 303 K, depending on the adsorption value, as well as the mechanism of the sorption process, were investigated. It was experimentally established that the adsorption capacity of the studied adsorbent with respect to hydrogen sulfide at a pressure of P=588 torr is -1.43 mmol/g.*

Keywords: *adsorption, adsorbent, isotherm, relative pressure, enthalpy, microcalorimeter, hydrogen sulfide.*

INTRODUCTION

In the world, a number of industrial sectors, in particular the chemical, metallurgical, oil and gas industries, are considered the main sources of waste gas emissions that contain toxic and hazardous impurities and pollute the atmosphere and the environment. In gas purification, adsorbents, including natural and synthetic zeolites, are widely used in various sectors of production [1–6].

In many branches of industry, in the production of different assortments of activated adsorbents, mainly carbonaceous materials with an initial carbon content above 76.0–86.0%, as well as stems and branches of plants, fruit pits recycled as waste (including apricot, peach, and walnut), clay minerals and other related raw material residues are used. In order to employ them as adsorbents, extensive scientific research is being carried out to improve their physicochemical properties and adsorption capacity, since the application of efficient adsorbents in various branches of industry is of great importance.

In Uzbekistan, the problem can be solved by activating wood wastes of trees grown in the country, which are considered a type of raw material that meets the requirements for adsorbents, by various methods, thereby enhancing their high adsorption capacity and studying their indicators that meet industrial demand for adsorbents [7–8].

METHODOLOGY AND MATERIALS. In this article, the adsorption isotherm of hydrogen sulfide at 303 K on activated carbon derived from the bark of the Paulownia-Tomentosa tree are presented. Activated carbon was obtained from the waste of

Paulownia-Tomentosa tree, in particular from waste branches generated as a result of additional pruning three or four times a year and from the bark part of the tree, through a conventional activation method in two stages: The first stage consists of 1. pyrolysis of waste wood; 2. activation with steam.

During the pyrolysis process, pieces of Paulownia-Tomentosa bark of 50–100 mm in size are placed into the pyrolysis unit. The unit is connected to an electric supply with a voltage of 60–65 V, and the temperature is set between 300°C and 800°C. Once the designated temperature is reached, the mass inside the unit is kept for 1.5–2 hours until a thermally active adsorbent is formed. During the thermal activation of the adsorbents, resinous tars and carbonaceous gases such as CO, CO₂, CH₄, and others are released in the range of 250–400°C.

In the second stage, the carbonaceous mass obtained after the pyrolysis process is activated with steam at 800°C for 1.5–2 hours to produce the final adsorbent.

RESULTS AND DISCUSSION. The regular relationship between the adsorption isotherm of hydrogen sulfide molecules on the activated carbon adsorbent obtained from the bark of the Paulownia Tomentosa tree at a temperature of 303 K, as well as the mechanism of the sorption process, was determined.

The logarithmic function isotherm of hydrogen sulfide adsorption obtained from the Paulownia Tomentosa tree is presented in Figure 1. At low saturation, the adsorption isotherm is equal to $\ln(P/P_0) = -10$ ($P/P_s = 4 \cdot 10^{-5}$, $P = 0.76$ torr). This indicates weak sorption of hydrogen sulfide molecules on the adsorbent. The adsorption isotherm reached an adsorption capacity of 1.43 mmol/g at a relative pressure of $P/P_s = 0.033$ ($P = 588$ torr). The isotherm corresponds to the IV-type of Brunauer isotherms. Thus, hydrogen sulfide molecules are adsorbed in the pores of the adsorbent.

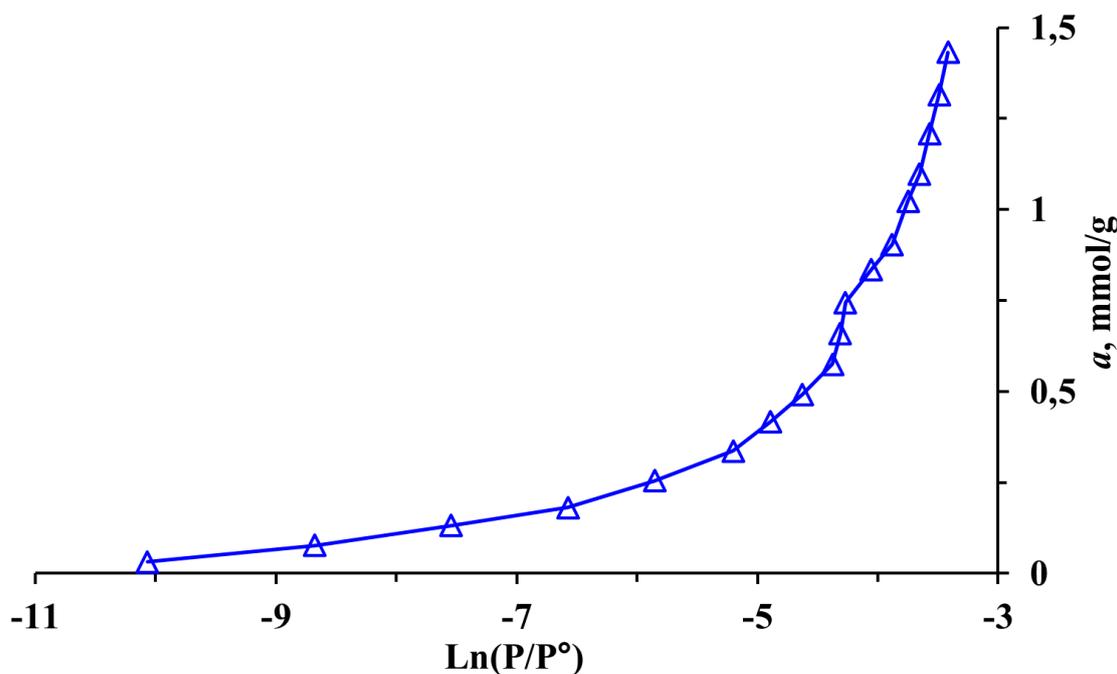


Figure 1. Adsorption isotherm of hydrogen sulfide molecules on an activated adsorbent obtained from the Paulownia tomentosa tree.

Up to 0.25 mmol/g adsorption, the isotherm shows an initial linear change with $\ln(P/P_0)=-6.6$ ($P/P_s=0.0029$, $P=25$ torr); at 0.5 mmol/g adsorption and $\ln(P/P_0)=-4.5$ ($P/P_s=0.01$, $P=180$ torr), the isotherm exhibits a second linear change; at 0.75 mmol/g adsorption and $\ln(P/P_0)=-4.27$ ($P/P_s=0.014$, $P=251$ torr), the isotherm shows a third linear change with a sharp upward rise; and up to 1 mmol/g adsorption, a fourth linear change with partial bending is observed. This indicates that the number of active sites of the activated adsorbent derived from the bark of the Paulownia tomentosa tree with respect to hydrogen sulfide molecules is equal to 0.25 mmol/g. Thus, up to 1 mmol/g adsorption, four hydrogen sulfide molecules are sequentially adsorbed, forming a tetramer $4H_2S$:adsorbent complex.

Starting from 1 mmol/g adsorption, the equilibrium relative pressure increases sharply, and at 1.25 mmol/g adsorption, a $5H_2S$:adsorbent pentamer complex is formed. At a relative pressure of $P/P_s=0.033$ ($P=588$ torr) and adsorption amount of 1.43 mmol/g, the sorption process is completed.

CONCLUSION. The isotherm of adsorption of hydrogen sulfide molecules on an activated adsorbent obtained from the bark of the Paulownia tomentosa tree were studied by the adsorption-calorimetric research method.

In the interval from low saturations up to the experimental pressure (587 torr), the thermodynamics of the sorption process on an activated carbon adsorbent derived from local raw material, as well as the regularity of hydrogen sulfide molecules filling the volume of the adsorbent, were determined. It was experimentally established that the adsorption capacity of the studied adsorbent with respect to hydrogen sulfide at a pressure of $P=588$ torr is 1.43 mmol/g.

From the stepwise change of the adsorption isotherm of hydrogen sulfide molecules on the activated carbon adsorbent from the bark of the Paulownia tomentosa tree, it was determined that the number of active sites with respect to hydrogen sulfide is 0.25 mmol/g, and the formation of a pentamer complex of adsorbate/adsorbent in the ratio of $5H_2S$:adsorbent was established.

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