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Study of Physical Chemical Properties of Activated Coal on the Basis of Red Roots

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ABSTRACT: The process of heat treatment and activation to obtain coal with a high degree of purity from licorice root can be carried out with high yield by applying water vapor in an inert environment. The use of water vapor in the activation process leads to the leaching of resinous substances from the pores of coal, the formation of various functional groups on the surface of coal. The increase in adsorption properties in the obtained coal samples was determined by the results of the study of adsorption of water and benzene vapors. The study of texture properties based on adsorption values showed that the coal samples obtained were mainly meso-porous adsorbents with a relatively high surface area.

KEYWORDS:surface oil, licorice root, adsorbent, benzene, thermal activation, adsorption, thermogravimetric

I. INTRODUCTION

Activated carbon is a versatile material with a large surface area, internal surface, porous volume, chemically stable and various functional groups on the surface. Due to its high adsorption capacity, it is widely used as an adsorbent in many industrial scales, including gas separation and purification, wastewater treatment and catalysis processes [1, 2]. Also, their use as catalysts or their backers in catalytic processes has brought them to the level of a promising material in industries [3]. Today, carbon sorbents are used to remove a number of organic contaminants from the liquid phase, especially organic dyes. It is known that the presence of chemical dyes in very small concentrations in the water also leads to harmful consequences, including a serious threat to the life activity of microorganisms in the water. In addition to their high toxicity and mutagenic effects, most of them are highly stable and biologically virtually indestructible chemically stable substances [4-6]. In the case of such large-scale paints, various surfactants and other contaminants, the use of adsorbents, which are mainly meso-porous and have active centers on the surface against these adsorbents, is considered effective. However, although there is a lot of research on potential materials and methods, the production and regeneration of commercially activated carbon is still an expensive process [7], so the importance of producing activated carbon using cheap raw materials and methods is still relevant [8, 9]. The porous structure and adsorption properties of activated carbon materials depend on the activation process [10]. Heat treatment after chemical washing increases the formation yield of carbon and increases the porosity by affecting the carbonization process [11]. Atmospheric water vapor occurs in 0-4% depending on the change of seasons, which directly interferes with the operation of adsorbents, because activated carbon contains functional groups with hydrophilic and hydrophobic properties [12]. The degree of exposure to water vapor depends on the adsorbent-adsorbate properties and the relative humidity level. As an object of study - anise rootstock was selected. More than 100 medicinal substances are extracted from licorice root stem. It is known that the residue formed in this process is lost by burning as an additional fuel. This leads to environmental pollution and poisoning of the atmosphere with various harmful gases. The authors study the processing of licorice root stem into activated carbon materials with high adsorption properties. It should be noted that the results of the research allow, on the one hand, to solve the problem of waste disposal, and, on the other hand, to obtain sorbents for the treatment of drinking and wastewater.

II. SIGNIFICANCE OF THE SYSTEM

The process of heat treatment and activation to obtain coal with a high degree of purity from licorice root can be carried out with high yield by applying water vapor in an inert environment. The study of literature survey is

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presented in section III, methodology is explained in section IV, section V covers the experimental results of the study, and section VI discusses the future study and conclusion.

III. METHODOLOGY

Coal adsorbents were obtained by thermal activation of 400-800°C in a pyrolysis device designed for laboratory conditions of licorice root waste of a certain size. The coal mining process was carried out in an inert environment - in the presence of argon gas for 2 hours. The temperature-dependent heating rate was changed: heating up to 200°C had a rate of 5°C/min, while heating between 200-700°C had a rate of 10 °C/min, and subsequent heating was reduced to the previous rate. When the process reached 800^{o}C, water vapor was given for 30 min at a pressure of 2,5 kgf/cm^2 (196,133 kPa). Adsorption of benzene and water vapor in aniseed rhizome coal (QIC) at different temperatures was studied by a simple desiccator method. To do this, the pyrolyzed coal samples were passed through a sieve with holes of 0.5 mm and then taken from the net mass (1 g) in benzene-filled desiccators for 30, 60, 90, 120, 240 and 1440 minutes, in desiccators immersed in water 1, 2, 4, It was stored for 8, 12, and 24 h, and mass changes were detected. The moisture content of the obtained coal adsorbents was determined using methods developed on the basis of GOST 11014-2001 and ash content GOST 11022-95. In the adsorption process, water vapor and benzene were selected as adsorbates, the process was carried out at the McBen plant. Electron microscopic images of the samples and data on the elemental composition were obtained using a scanning electron microscope EVO MA10 SEM.Thermogravimetric and differential thermal analysis was carried out on a Q-1500 D derivatograph in the range of 20-1000 °C in an atmosphere of air and argon with a heating rate of 5 °C/min

IV. EXPERIMENTAL RESULTS

In thermal activation of licorice root stem, first water vapor is released, and then as the temperature rises, volatile organic matter also begins to decompose.The change in sample mass as a result of dehydration and decorboxylation processes is shown in Figure 1 below

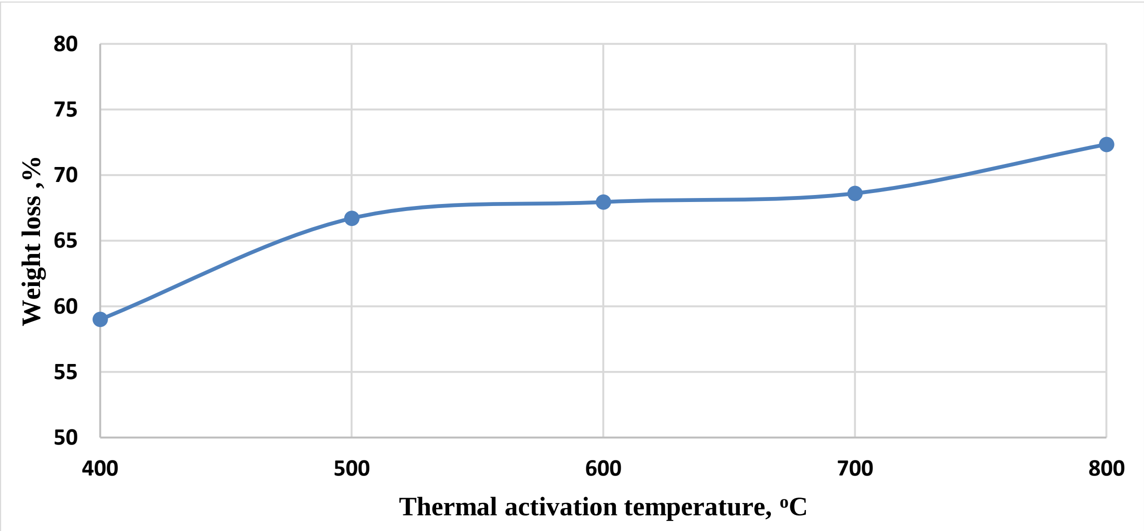

Figure 1. Temperature dependence of the sample mass change during thermal activation, %.

Thermogravimetric and chemical analysis were performed to explain the changes in the structure of the samples during thermal activation. The results obtained are shown in Figure 2.

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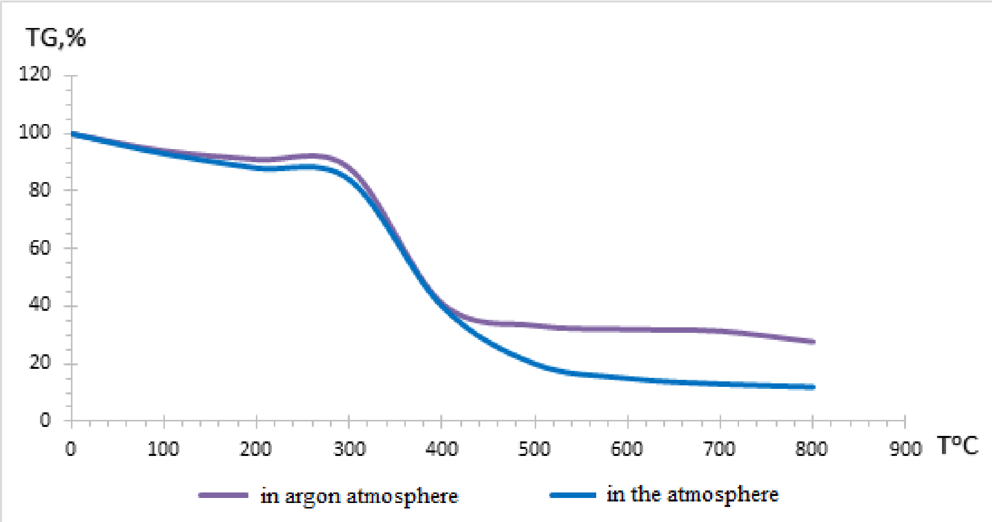

Figure 2.Thermochemical conversion of a sample of licorice root: 1) in the air;2) in an argon atmosphere.

The results obtained show that the yield is low due to the combustion of its components in the thermochemical conversion of the anise root sample in the presence of air (Fig. 2). However, the use of argon gas during the activation process results in the retention of impurities in the coal samples obtained. It was found that it is possible to get rid of these additives by conducting thermal activation in combination with water vapor. The curve shown in Figure 1 shows that when heated to 400°C, the mass of the sample under study increases by 59%, 500; 600; As a result of heat treatment at 700 and 800°C, the decrease in mass was 66,7, respectively; 67,94; 68,6 and 72,33%, respectively. Activation of coals with water vapor at a temperature of 800°C resulted in a further decrease in total mass change by 2,15%. Activation with water vapor proves that chemical changes occur in the composition of coal. This change is due to the fact that the amorphous carbon formed during heat treatment is released from the sample due to its interaction with water vapor [17]. This leads to an increase in the porosity of the adsorbent and an increase in its sorption properties. Elemental analysis of the obtained coal samples was studied and its composition is given in Table 1 below.

Table 1.
Chemical composition of licorice root coal sample,%

Sample heating temperature,C	C	O	Ca	Si	Al	Mg	Fe	Humidity	The amount of ash
800	78.07	11.25	4.76	2.2	0.8	0.85	0.83	2.759	17.5
800+water vapor	75.60	13.49	4.72	2.95	1.05	0.73	0.75	3.362	16.25

In order to study the composition and structure of coal adsorbents obtained on the basis of licorice root waste, the elemental composition and internal structure are shown in an electron microscope using a scanning electron microscope.

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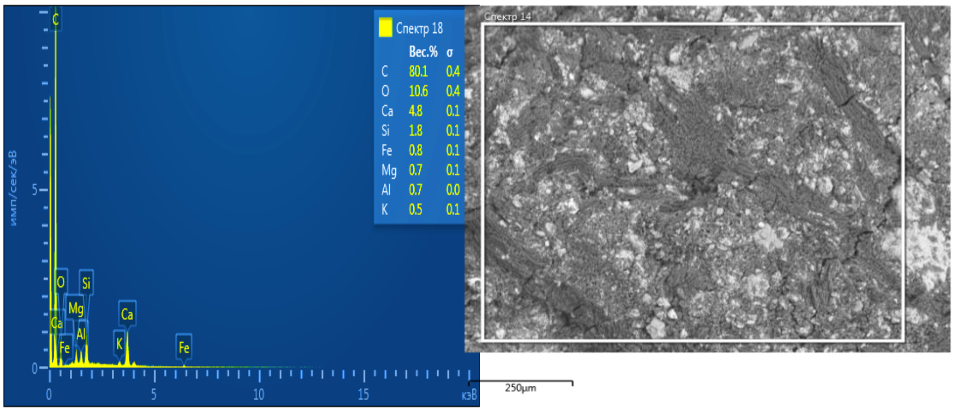
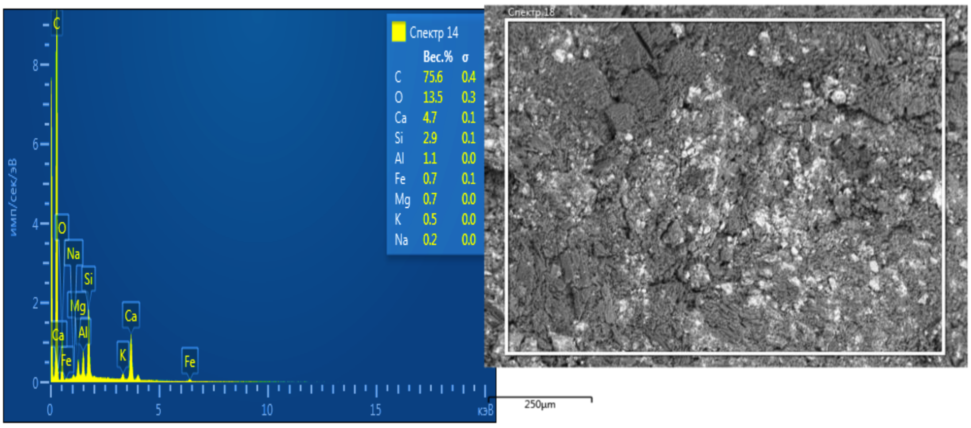


a)



b)

Figure 3. Electron microscopy images of licorice rhizome coal adsorbents: a) FQIK-800; b) FQIK-800 steam

Based on electron microscopic images of coals from licorice root, it can be seen that the decrease in carbon content in a water vapor-activated charcoal sample results in the release of amorphous carbon as a result of exposure to water vapor at high temperatures, while additional pores and cracks are formed. Adsorption of benzene vapors is mainly based on electrophilic-nucleophilic exchange reactions between cation-anion functional groups and the benzene ring in pores of suitable size in activated carbon, while water molecules are adsorbed by binding with hydrogen protons [13,14]. The study of benzene vapor adsorption in adsorbents allows to determine the tendency to non-polar organic molecules in industrial wastewater, and the study of water vapor adsorption to harmful poles and metal cations in wastewater, which allows to use adsorbents effectively [16].

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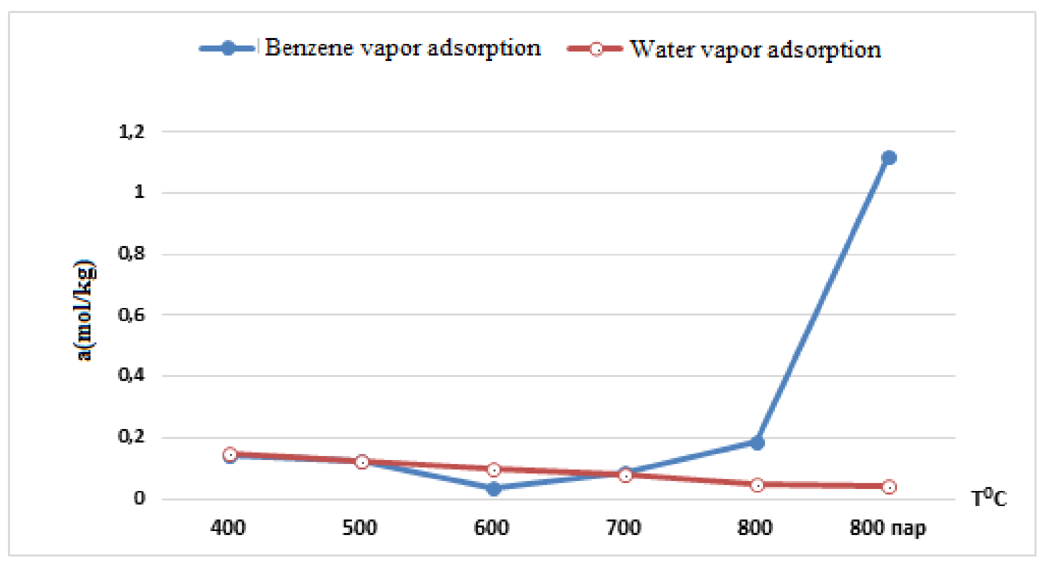

Figure 4.The dependence of the adsorption value of benzene and water vapor on the activation temperature.

The curves of the given diagram show that the sorption property of coal in relation to non-polar molecules depends on the conditions of its activation. A sample of coal heated to 400ºC has the same low sorption activity as non-polar benzene and polar water molecules. An increase in the activation temperature to 600°C led to a further decrease in the adsorption value of benzene (0,07mol/kg). This is due to the fact that in the process of thermal activation, compounds that correspond to the temperature of liquefaction of coal form resinous substances, which leads to a decrease in its porosity. An increase in the heat treatment temperature provides an increase in the adsorption value to 0,2mol/kg. The use of water vapor during the activation process resulted in a sharp increase in benzene adsorption in the samples taken. This is explained by the fact that the resinous substances formed earlier are washed out of the pores. It can also be shown that at the activation temperature, water vapor and coal pores form different functional groups on the surface. However, the low water vapor adsorption in these samples proves this conclusion to be incorrect. One of the important parameters of adsorbents based on benzene and water vapor adsorption isotherms in activated carbon adsorbents is monolayer capacity am, saturation volume V_s, micropolar W_0, mesocellularW_{me}, porosity radius r and their specific surfaces S are determined using the equation of BET theory [15]. The results obtained are given in Table 2.

Table 2

Structure - sorption indicators on the adsorption of benzene vapors of aniseed rhizome coal using thermal and water vapor

Adsorbent	Activation temperature, °C	Monolayer capacity, a_m,mol/kg	Relative surface,$S \cdot 10^{-3}$, m^2/kg	Saturation adsorptiona_s, mol/kg
FQIPK	700	0,18	43,3	0,41
	800	0,7	168,60	1,585
	800+water vapor	1,083	260,87	2,42

It was found that the specific surface area (S), saturation volume (as) and monolayer capacity am increase with increasing activation temperature in our studied coal adsorbent. According to the results obtained, the moisture content of coal adsorbents obtained at different temperatures (400, 500, 600, 700, 800°C) on the basis of licorice root was in the range of 2-4%. It is known that charcoals derived from plants and wood are adsorbents with hydrophobic properties. Therefore, plant and charcoal do not absorb large amounts of water molecules, which is explained by the very small amount of organic functional groups (-ON, $-NH_2$, -COOH, etc.) with hydrophilic properties in adsorbents of charcoal obtained at high temperatures. According to the results obtained, the ash content of coal adsorbents obtained at

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different temperatures (400, 500, 600, 700, 800^oC) on the basis of licorice root was in the range of 10-30%. The results obtained are presented in Table 3 below.

Table 3.
Physical properties of coal adsorbents

Activation temperature, ^oC	The amount of moisture,%, W_A	The amount of slavery, %, Ac	Yield of yield(%).
400	4,3	10,75	41
500	3,4	22,75	33,3
600	3,0	29	32,04
700	2,9	29	31,4
800	2,9	17,5	27,67

VI. CONCLUSION AND FUTURE WORK

The results obtained show that the process of heat treatment and activation to obtain coal with a high degree of purity from the anise root can be carried out with high yield using water vapor in an inert environment. The use of water vapor during the activation process can lead to the leaching of resinous substances from the pores of coal, the formation of various functional groups on the surface of coal. The increase in the adsorption properties of the obtained coal samples was proved by the results of the study of adsorption of water and benzene vapors. The study of texture properties based on adsorption values showed that the carbon samples obtained were mainly meso-porous adsorbents with a relatively high surface area. In turn, the study of benzene vapor adsorption will determine the possibility of purification of non-polar organic molecules in wastewater, which in turn will allow the efficient use of adsorbents. The effect of increasing the activation temperature on the obtained coal adsorbents on their technological properties was determined, and the increase in temperature ensures a decrease in moisture content and ash content and yield, but an increase in its porosity and quality.

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