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STUDY OF TEXTURAL, PHYSICO-CHEMICAL AND SORPTION CHARACTERISTICS OF ACTIVATED CARBON, PREPARED FROM APRICOT KERNELS

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Abstract

In the work the results of electron microscopic examination of samples of activated carbon, prepared from the shells of apricot kernels, show that their structures have a developed porous surface. According to the results of semi-quantitative elemental analysis of the adsorbents under study by the method of energy dispersive X-ray spectroscopy (EDAX), it was found that the adsorbent based on the shells of apricot kernels has the highest carbon content (92%). The activated carbon prepared from the shells of apricot kernels has the following characteristics: moisture content - 7.5%, total pore volume on water - 0.67 cm^3/g, pH of the aqueous extract - 6.9, bulk density - 289 g/dm^3, adsorption activity on iodine - 62.7%, specific surface area - 884 m^2/g.

Keywords: adsorbent, activated carbon, activation, carbonization, volume, microscopy, apricot, pore, wastes

Introduction

Activated carbons as adsorbents have a high surface with micro-, meso- and macropores [1] and are used in various areas of the chemical industry, ecology and medicine [2,3,4]. According to the authors [5], the main consumers of carbon adsorbents are food production (42%), technological use (38%), environmental protection (10%). On their basis, many problems of recovering valuable components, as well as environmental protection are solved.

Carbonaceous materials of various origins are used as raw materials for the production of activated carbons: peat and coal, polymers and resins, vegetable raw materials (wood, bark, shells, fruit pits and others) [6,7,8]. Technological issues related to the production of multi-purpose carbon sorbents from the above listed raw materials are practically solved and consist of two stages, including carbonization and activation of the raw material [9].

In recent years, the researches on the development of technology for the production of carbon sorbents for special purposes, in particular homogeneous-microporous (pores with a radius of <2 nm) have been most intensively carried out. In this connection, the production of homogeneous microporous carbon sorbents from vegetable raw materials is actual.

Purpose of the research is to study the textural, physicochemical and sorption characteristics of activated carbon produced from shells of apricot kernels.

Material and methods of research. In this work, the shells of apricot kernels grown in Uzbekistan were used to prepare activated carbon, since the plant fiber of apricot kernels shells are low-ash, and its high density determines the possibility of obtaining strong carriers with high specific surface area [5].

The textural characteristics of the activated carbon were determined by scanning electron microscopy (SEM), to determine the chemical composition, semi-quantitative analysis was performed by energy dispersive X-ray spectroscopy using EDAX equipment. The analysis was carried out at the "High Technologies Center" under the Ministry of Innovation Development of the Republic of Uzbekistan.

Determination of the total pore volume on water was carried out according to GOST 17219- 71 [10], bulk density according to GOST R 55959-2014 [11] and moisture content according to GOST P 55956-2014 [12]. In addition to these indicators, the pH of the aqueous extract was determined with a pH meter, the sorption capacity for iodine, as well as the specific surface area and the total pore volume of the activated carbon according to the Brunauer-Emmett-Teller method (BET). Traditional birch-based activated carbon (BAC) (Irbit Chemical Pharmaceutical Plant, Irbit, Russia) was used as reference samples.

The arithmetic average of two parallel determinations was taken as the test result, the allowable discrepancies between them with a confidence probability of P = 0.95, which did not exceed 2.5% relatively to the smaller value.

Results and their discussions.

The apricot kernel shells were crushed and a working fraction of 3 ÷ 5 mm was selected by sieving on the sieve. The process of carbonization of the samples of the apricot kernels shell was carried out in isothermal conditions. Thermic treatment of the raw material was carried out in an inert atmosphere in the temperature range of 650–700°C at a heating rate

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of 15–20°C/min and a holding time of 60 min (at a given temperature). At the next stage, for the formation of micropores in the internal structure of the coal and thus to increase the specific surface area, the resulting raw coal was subjected to activation with water vapor at an activation temperature of 800–850°C for 60 min on a vapor – gas activation device. The gas flow rate was 1 l per 200 g of the adsorbent.

The specific surface area of the samples was estimated by the BET method, the micropore volume by the t-method on the adsorption branch of the isotherm, and the average diameter of the mesopores by the Barrett-Joyner-Halenda method (BDH) on the desorption branch of the isotherm. The total specific pore volume was determined by the nitrogen adsorption isotherm with the value of the relative pressure of 0.99. Before measuring the adsorption isotherms, the samples were degassed at 200°C and a residual pressure of 10^{-3} mm Hg within 2 hours.

To study the morphological features of the surface texture of the samples of activated carbon from the apricot kernel, an analysis was performed using scanning electron microscopy. Pictures and results of semi-quantitative elemental analysis of the studied adsorbents, obtained by the method of energy dispersive X-ray spectroscopy (EDAX), are presented in Figures 1-4.

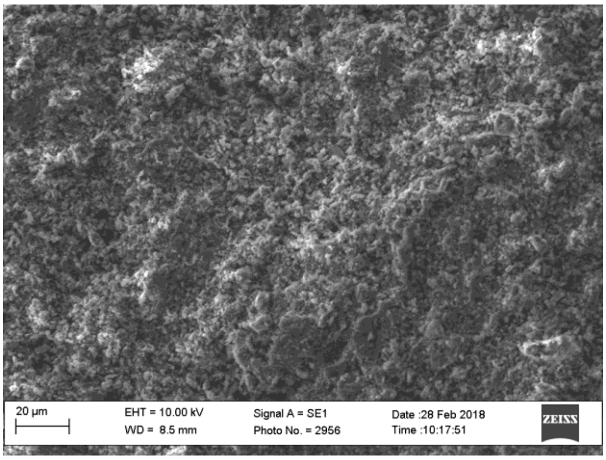


Figure 1.

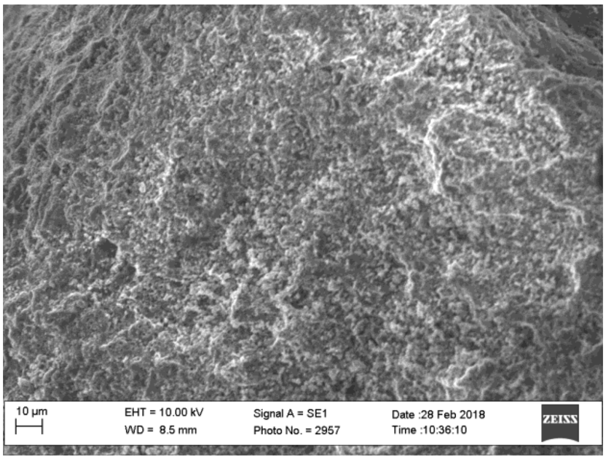
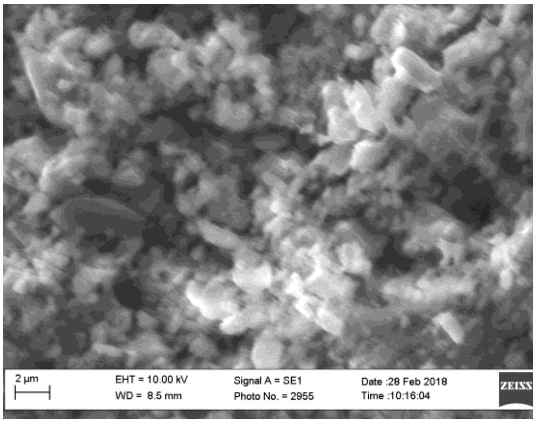


Figure 2.



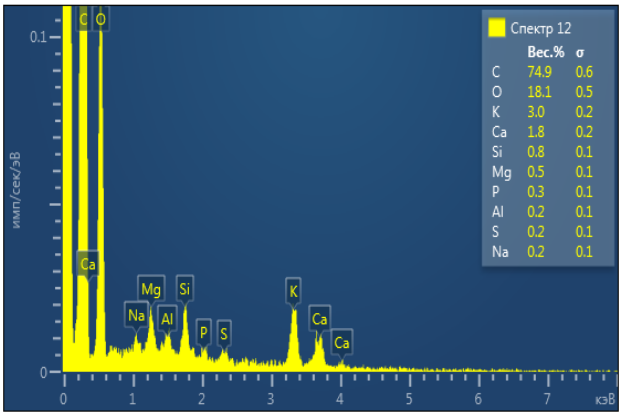


Figure 1-3. Microphotography of surface of the activated carbon prepared from apricot kernels shells

Figure 4. Elemental composition of the activated carbon prepared from apricot kernels shells (before carbonization)

The results of electron microscopic examination of all samples showed that their structures have a developed porous surface. On micrographs of carbonizates based on the shells of apricot kernels, a small number of large pores in the form of cracks, as well as a large number of micropores, are observed.

According to obtained results carbon content in the adsorbents based on the shells of apricot kernels before carbonization is 74.9 %, after carbonization and activation – 92 %.

The physicochemical characteristics of the obtained carbon-containing adsorbents (Table 1) are comparable with those of the adsorbent based on activated carbon (AC), and surpass it on some indicators.

Bulk density is one of the most important indicators of porous carbon materials. The lower this index, the better the adsorption qualities of coal in volume, since an adsorbent in a bulk quantity is poured into an adsorber for gas purification [15]. The indicator of the bulk density of the obtained adsorbent is greater than that of AC and is respectively 289 and 230 g/dm^3. The resulting adsorbents also have a weakly acidic medium, i.e. the pH of the aqueous extract is 6.9.

Table 1

Physico-chemical characteristics of activated carbon produced from apricot kernels

Characteristics	Adsorbent	
	Apricot kernels	AC
Moisture contents, %	7,5	7,9
Total pore volume on water, cm^3/g	0,67	0,58
pH of the aqueous extract	6,9	6,7
Bulk density, g/dm^3	289	230
Adsorption activity on iodine,%	62,7	59,4
Specific surface area (Multipoint BET method), m^2/g	884	725

Iodine number is a relative indicator of the porosity of activated carbons. It does not necessarily correlate with the adsorption capacity of carbon relative to other adsorbates [16]. The iodine number can be considered as an indicator of the free specific surface area, provided, mainly, by larger micropores; the obtained values for iodine number for the adsorbents investigated show that these adsorbents have high microporosity [16]. The highest indicators of adsorption activity on iodine in an adsorbent based on apricot kernels shell are 62.7%. Micropore volume also affects the specific surface area. According to the obtained results, it follows that the adsorbent based on the apricot kernels shell also has the highest indicator of specific surface area - 884 m^2/g.

Conclusions

1. The results of electron microscopic examination of all samples showed that their structures have a developed porous surface. According to the results of semi-quantitative elemental analysis of the adsorbents under study by the method of energy dispersive X-ray spectroscopy (EDAX), it was found that the adsorbent based on the shells of apricot kernels has the highest carbon content (92 %).

2. The activated carbon prepared from the shells of apricot kernels has the following characteristics: moisture content - 7.5%, total pore volume on water - 0.67 cm^3/g, pH of the

aqueous extract - 6.9, bulk density - 289 g/dm^3, adsorption activity on iodine - 62.7%, specific surface area - 884 m^2/g.

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