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STUDY OF STRUCTURE PARAMETERS AND OF ABSORBTION CAPACITY OF ACTIVATED CARBON OBTAINED FROM WOOD CHARCOAL

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Abstract. *This paper presents the results of scientific research aimed at studying processes of obtaining activated carbon from wood charcoal. We presented methods for determining the structure parameters and specific surface of carbonic adsorbents. Scientific research results allow concluding that wood charcoal is a cheap and effective material for the synthesis of activated charcoal.*

Key words: *activated carbon, wood charcoal, physico-chemical activation, pore volume, specific surface area.*

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Introduction

Active charcoal is a product that is increasingly sought after and increasingly used in the economy by various industries, and its special qualities, especially in the medical field, have definitively imposed it on the world market. Carbon adsorbents in this field are used as enterosorbents and hemosorbents for the detoxification of the human body. These opportunities for active coal characterize it as a product of prime importance in the economy.

The production of the wide assortment of activated carbon and the rapid development of activated carbon production is due to the numerous applications in the various branches of the economy, the considerable advantages it offers to the activated charcoal vis-à-vis other adsorbents as well as to the more frequent use in various technological processes. The volume of active coal production continues to increase, while improving its qualitative parameters [1, p.224].

The activated charcoal consists of a carbon framework with very fine channels and pores of varying depths and diameters. They exhibit the property of fixing and retaining on the surface the organic and inorganic substances with which they come into contact [2, p.216; 3, pp. 37-42].

Due to their physical and chemical properties, activated charcoal are specific and ideal sorbent materials, which solve many problems of chemical and biological purification of the human organism as well as of the environment. Active charcoal, being extremely porous materials, has a considerable internal surface. Due to the adsorption forces, in the porous structures of active coals (in the volume of micropores and mesopores) adsorption of different types of contaminants takes place [4, pp.425-435].

Activated charcoal can be obtained by three physico-chemical, chemical and mixed processes. The most commonly used is the physico-chemical activation process, which is based on the interaction of oxygen, carbon dioxide or water vapor with heavy hydrocarbons filling the pores of the activated carbonized material and/or amorphous carbon atoms in the charcoal skeleton. This process applies only when plant substances are already charred [5, pp 170-175]. As an example, wood charcoal, fruit kernels, nut shells, earth charcoals, synthetic organic polymers, etc., can be considered as a combination of amorphous coal and hydrocarbons. The activation process is carried out at temperatures of 800-1100^{o}C in special furnaces.

Various materials rich in carbon are used as a raw material for the production of activated carbon, e.g. wood, peat, and coal. In the production of active coals used for anti-gas masks and other specific uses, which must have increased mechanical strength and high volume of micro- and super-microporous material as raw material, coconut shell is used. It also mentions the use of metal carbides, carbon black, lignin, waste tires, waste from the production of polyvinyl chloride and other synthetic polymers [6, pp.803-804].

It has been established that with increasing the ratio of the number of H: C to O: C atoms, the activation process of the feedstock is facilitated. On the other hand, in the case of a fairly pronounced ratio, it is necessary to remove a considerable part of the volatile substances from the raw material. For these purposes, the coaling process is used [7, 592 p.; 8, 264 p.].

Methods and materials

For the production of activated coal wood charcoal made in Straseni (M-S) and Calarasi (M-C) was used, intended for the preparation of meat and fish dishes. It is more widespread and accessible than other raw materials.

Structural parameters and adsorption capacity of activated carbon depends on many factors, among which the most important are: activity time, activation temperature, steam flow, quality and origin of charcoal [9, p.271].

It was established that with increasing ratio H:C and O:C, the raw material activation is enhanced. However, a significant ratio requires the elimination from the raw material of a large proportion of volatile substances. The charcoal burning procedure is used for such purposes [10, p.469-474].

The structure parameters and the geometric surface of the carbon adsorbents were determined from the adsorption-nitrogen desorption isotherms at 77°K [11]. Research has been done on the 1 MP Autosorb. The structure parameters and the active carbon adsorption capacity depend on several factors among which the most important are: time of activity, activation temperature, water vapor flow. An example of such adsorption-desorption isotherms is shown in Figure 1.

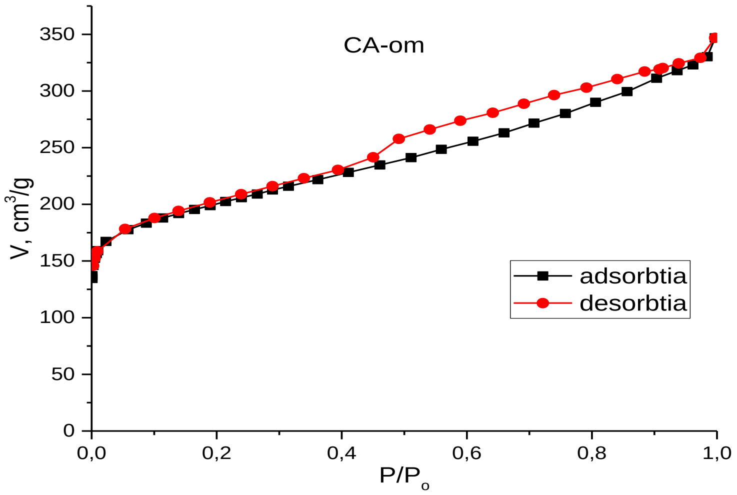

Figure 1. Adsorption and desorption isotherms of nitrogen (77K) on activated carbon of Straseni wood charcoal activated 60 min at 850 °C

The precise and objective determination of the maximum adsorption value (am) can be ensured by applying the Brunauer, Emmet, Teller (BET) adsorption isotherm [12, pp 1934-1936; 13, pp.165-190].

The geometric surface area of the active coals was calculated using the BET equation in its linear form:

$$\frac{P/P_s}{a(1-P/P_s)} = \frac{1}{a_m c} + \frac{c-1}{a_m c} \cdot P/P_s \qquad (1)$$

where

a represents the adsorption at relative P/Ps pressure;

am - adsorption at P/Ps = 1 pressure;

C - the constant that depends on adsorption heat and adsorption condensation.

In fact, the following correlation is set:

$$\frac{P/P_s}{a(1-P/P_s)} \text{ from } P/P_s \quad (2)$$

As seen in Figure 2 it is a linear correlation.

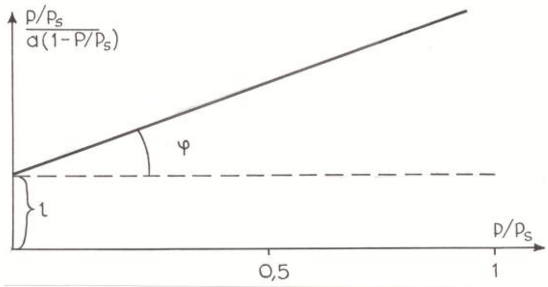

Figure 2. Adsorption isotherm in the coordinates of the linearized BET equation.

The values a_m and C from the presented equations are determined using this figure:

$$\operatorname{tg}\varphi = \frac{c-1}{a_m c} \quad (3)$$

$$l = \frac{1}{a_m c} \quad (4)$$

The geometric surface (S) of the activated carbons was calculated using the following correlation:

$$\mathbf{S = a_m \cdot \omega \cdot N} \quad (5)$$

Where

ω is the area occupied by an adsorption molecule in the compact monomolecular adsorption layer;

N is the Avogadro number.

The volume of adsorbed and desorbed nitrogen is used in special programs to determine the adsorption capacity and active carbon structure parameters.

The sorption volume (V_s) of pores is calculated from the mathematical relation:

$$\mathbf{V_s = a_m \cdot V^*} \quad (6)$$

where V * is the molar volume of the adsorbate.

In order to determine the quality of the activated carbon thus obtained, a number of determinations, including the iodine and methylene blue indices, were performed. As a result of the investigations, it was determined that the iodine value was 1015 mg I_2/g, whereas the adsorption capacity to methylene blue was 110 mg I_2/g. In this type of active coal predominate micro- and mesopores.

The dimensions of the activated carbon pores were determined from adsorption-desorption isotherms. An example of a pore distribution curve on their dimensions is shown in Figure 3.

Pore size distribution of the homogenised activated carbon sample obtained from Straseni wood charcoal activated 60 min at 850 ^oC.

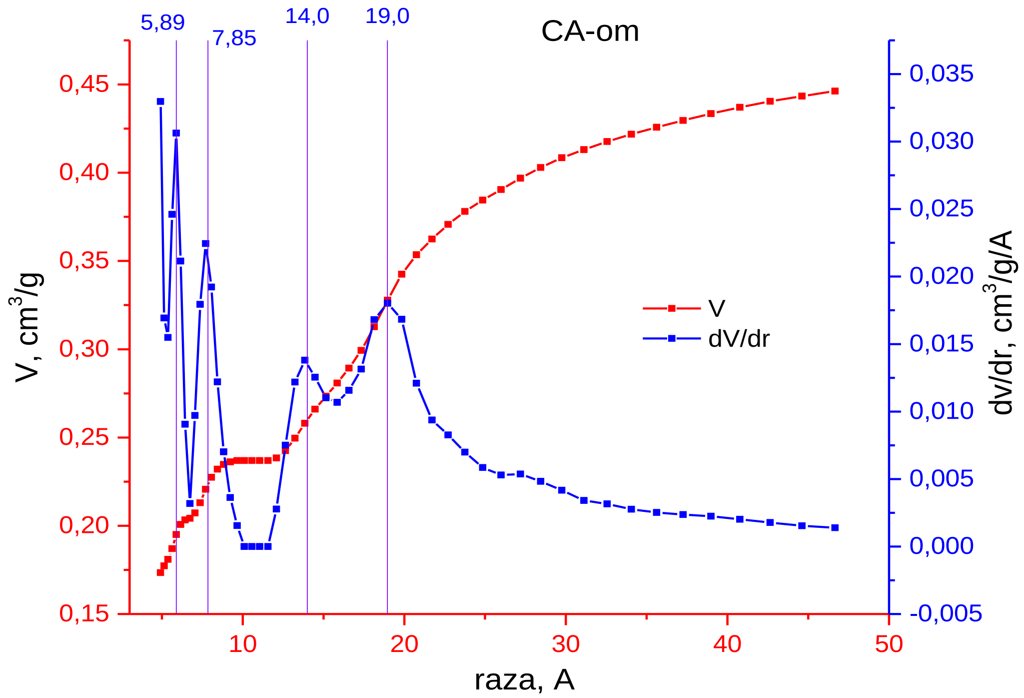

Figure 3.
Pore size distribution of the homogenized activated carbon sample obtained from Straseni wood charcoal activated 60 min at 850°C

Results and discussions

The results obtained with respect to geometric surfaces, process yield, pore absorption volume according to activation temperature, water vapor flow, activation time and charcoal type are shown in Table 1.

Table 1: Quality indices of activated carbon charcoal obtained by physico-chemical activation

Type of CA	Temperature, °C	Time, min	Vapor flow, mL/min	Rate, %	Specific surface, m^2/g	Sorption volume, cm^3/g
S-1	850	30	6	78,1	625	0,402
S-2	**850**	**50**	**6**	**69,2**	**633**	**0,416**
S-3	850	70	6	43,4	833	0,574
S-4	850	90	6	21,3	947	0,631
S-5	850	120	6	-	-	-
C-1	850	30	6	70,6	580	0,332
C-2	**850**	**50**	**6**	**69,0**	**698**	**0,425**
C-3	850	70	6	54,4	807	0,612
C-4	850	90	6	44,4	794	0,592
C-5	850	120	6	30,3	649	0,624
T-1	950	30	6	20,0	1249	0,825
T-2	950	50	6	-	-	-
T-3	750	30	6	69,0	563	0,340
T-4	750	50	6	65,3	644	0,381
T-5	750	70	6	59,3	660	0,490
D-1	850	30	12	51,3	643	0,406

D-2	*850*	*50*	*12*	*44,4*	*892*	*0,683*
D-3	850	70	12	30	963	0,755
D-4	850	90	12	18,8	1216	0,837
D-5	850	120	12	6,0	1007	0,783

The analysis of the results presented in the above tables allows us to conclude that the geometric surface of the active coals depends on the activation time, the water vapor flow, the temperature of the chemical process. Thus, increasing the activation time at 850 ^oC from 30 to 90 minutes leads to an increase of the geometric surface of the active coils from 625 to 947 m^2/g for a water flow rate of 6 mL/min. (Table 1).

The geometric surface area of carbon adsorbents increases under similar activation conditions from 643 to 1126 m^2/g increasing the water vapor flow from 6 mL/min to 12 mL/min.

This is explained by the fact that the increase in water flow leads to an increase in vapor mass that reacts more intensely with amorphous carbon, volatile substances in charcoal moving the chemical equilibrium of the reactions below to the right.

$$C(\text{carbon amorf}) + H_2O \xrightarrow{t^oC} CO + H_2 + \Delta H$$

$$C_x H_yO_z\,(\text{substanţe volatile}) + H_2O \xrightarrow{t^oC} XCO + YH_2 + \Delta H$$

The increase in the geometric surface of the active coals is synchronized with the increase in the sorbtive volume of the pores. Thus, the sorbent volume of the pores increases from 0.402 to 0.631 cm^3/g for water flow rate of 6 mL/min (tab.1) and from 0.406 to 0.783 cm^3/g for water flow rate of 12 mL/min. A special role in the process of producing activated carbon has its activation temperature.

Thus, the results presented in Table 1 show eloquently that increasing the activation temperature under the same conditions leads to an increase in the active carbon quality indices. Increasing the activation temperature from 750 °C to 950 °C results in an increase in the geometric surface of the active carbon from 563 to 1249 m^2/g for activation time 30 min and vapor flow rate 6 ml/min. Under the same conditions, the sorbent volume of carbonic adsorbents increases from 0.340 to 0.825 cm^3/g. This is explained by the fact that the increase of the activation temperature increases the water vapor diffusion coefficient in the porous structure of the charcoal, which interacts more intensely with the amorphous carbon atoms and with the volatile substances in the carbonized wood [14, pp.93-97].

The analysis of the results presented in the table shows that the increase in the geometric surface area and the volume of active carbon pores is proportional to the increase of the temperature and the activation time up to certain values after which these quality indices diminish. This is explained by the fact that under such conditions the carbon atoms are intensely oxidized in the graphite structure of the charcoal. Another quality index that influences the efficiency of carbon dioxide production is the yield of the process of producing activated carbon. This parameter decreases proportionally with increasing the time, activation temperature and water vapor flow. The efficiency of the activated carbon production process decreases as the surface area increases and the pore volume of the carbonate adsorbents increases.

Conclusions

- Quality of activated carbons, determined and presented in the current paper, shows that the charcoal obtained from Straseni wood and that obtained from Calarasi wood represents a good and cheap source of obtaining carbonic adsorbents.
- Quality indices of carbonic adsorbents can be programmed depending on the application, by varying the temperature and activation time and the flow of water vapor.
- The geometric surface and pore volume of activated carbons is proportional to the increase of temperature and activation time up to certain values and then these indices decrease.

- Activation time, temperature, vapor flow was established to produce activated carbon with high specific structure and surface parameters. Activated charcoal can be used in various environmental treatment processes.

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