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Adsorption of Benzene Vapors on Carbon Adsorbents Based on Secondary Raw Materials

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ABSTRACT: Car tire recycling is environmentally and economically important. Methods of preparing carbon adsorbents from used tires were studied in the research work. Adsorption of benzene vapors by adsorbents obtained by thermal and chemical activation was studied. Thermal and chemical activation with potassium hydroxide at 900°C significantly increases the specific surface area and micropore size of adsorbents.

KEYWORDS: car tire recycling, pyrolysis, carbon adsorbents, thermal and chemical activation, specific surface area, porosity.

I.INTRODUCTION

Today, the number of cars in the world is steadily growing, and the disposal and recycling of used tires is of great environmental and economic importance for all developed countries in the world.

This is primarily due to the fact that old tires are considered a source of environmental pollution for a long time. In addition, rubber is flammable and non-biodegradable, and a pile of rubber tires is a perfect breeding ground for rodents and insects, which are the source of many infectious diseases.

Instead of storing, burying and burning old tires, the technology of recycling them becomes of great economic importance, because in this case valuable raw material reserves are saved, resources are saved, cheap technologies are developed and environmental conditions are improved, large areas for dumping rubber waste are not needed.

The components of used tires are used in a wide range of applications, such as rubber tiles, sports hall and field coverings, roofing construction materials, backfills for sports equipment, artificial turf surfaces, trap and floor coverings in public areas, road surfaces, and bridge coverings. can be used [1].

Figure 1. Areas of use of used tires. [2]

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A used tire is a valuable secondary raw material consisting of 65-70% rubber (rubber), 15-25% technical carbon, 10-15% metal [3]. Recycling used tires significantly reduces the consumption of some scarce natural resources. Therefore, the use of waste tires is becoming increasingly important.

Pyrolysis of car tires is the cheapest recycling method. The process of decomposition of organic compounds occurs at high temperatures in airless conditions. Products obtained from pyrolysis can be converted into high-quality fuel or used for the production of chemicals. The released gases can serve as fuel in the pyrolysis process. And metal wires are scrap metal and can be reused. Activated carbon adsorbents, which are in high demand in many industries, can be obtained by activating residual carbonaceous material by physical and chemical methods [4-6].

A number of research works are devoted to methods of tire recycling and adsorption of substances of different nature on carbon adsorbents obtained from recycling [7-13].

II. SIGNIFICANCE OF THE SYSTEM

Car tire recycling is environmentally and economically important. Methods of preparing carbon adsorbents from used tires were studied in the research work. The study of methodology is explained in section III, section IV covers the experimental results of the study, and section V discusses the future study and conclusion.

III. METHODOLOGY

Based on the above considerations, it is of particular importance to obtain carbon adsorbents from local secondary raw materials, including from used car tires. For this purpose, used car tires were selected as research objects and adsorbents were prepared using physical and chemical activation methods. First, the raw materials were crushed, the steel wire contained in it was separated, and then it was thermally treated (500-800ºC). The obtained samples were conditionally named as follows: sample obtained at 500ºC AC-1, sample obtained at 600ºC AC-2, sample obtained at 700ºC AC-3, sample obtained at 800ºC AC-4, sample obtained at 900ºC AC-5. In the chemical activation method of obtaining carbon adsorbent, the raw materials were first crushed, the steel wire contained in it was separated, then it was heated to 500 ºC and carbonizate was obtained. The obtained carbonizate was chemically treated with potassium hydroxide solution for 1 day. Then the mixture was filtered and the extracted carbonaceous material was activated with water vapor at a temperature of 800ºC. The resulting carbon adsorbent solution was treated with 0.5 N hydrochloric acid solution until a neutral medium was formed. Then the adsorbent was washed several times with distilled water and dried at a temperature of 100±10°C. The obtained samples were tentatively designated as AC-6 (carbonizate+10% KOH), AS-7 (carbonizate+20% KOH), AS-8 (carbonizate+30% KOH).

Adsorption of the obtained adsorbents with benzene vapors was studied on the basis of ISO 15901-1. Monolayer capacity am, saturation volume Vs (or adsorption as) and their relative surfaces (S), micropores (W0), mesopores Wme = Vs- W0 and the values of the average radius of the pores calculated from the important parameters of adsorbents based on the isotherms of benzene vapor adsorption on coal adsorbents are BET theory and micropores were determined using the volume saturation theory equation [14-15].

IV. EXPERIMENTAL RESULTS

Thermal, steam-gas and chemical activation methods are widely used to increase the activity and functionality of coal and to change its structure and properties. Recently, scientific research has been actively conducted on the problem of forming a microporous structure in mesoporous carbon materials by physical or chemical activation methods. For this purpose, adsorbents were prepared from used car tires using physical and chemical activation methods. Adsorption isotherms of benzene vapors on the resulting carbon adsorbents are presented in Fig. 2.

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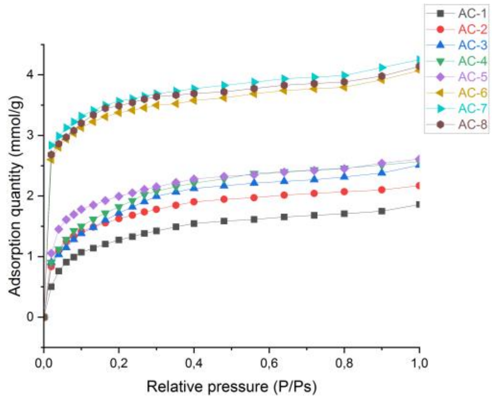

Figure 2. Benzene vapor adsorption isotherms of coal adsorbents.

According to the temperature difference in samples thermally treated from 100°C to 900°C, the sample thermally activated at 900°C showed the highest adsorption activity. It was found that the sample thermally treated at 900°C has 1.5 times more saturation adsorption compared to 500°C activated carbon. It was found that the saturation adsorption amount of samples thermally activated at 900°C did not change much compared to the sample thermally treated at 800°C.

As a result of the increase in the concentration of the activating reagent, the amount of adsorption of benzene molecules of coal was found to be 4.07 mmol/g, 4.25 mmol/g and 4.14 mmol/g, respectively. The benzene adsorption capacity of the samples did not increase significantly with the increase in alkali concentration. The results of these experiments show that the extraction of coal and CON (20%) during the activation process is the optimal amount for this coal sample.

From the obtained data, it can be seen that adsorption on activated carbon adsorbents based on used car tires occurs mainly through the donor-acceptor mechanism due to the formation of Van der Waals forces and a small amount of p-complexes. Such differences in surface activity are considered to be related to the number and nature of surface active centers. Most likely, treatment with alkaline solutions and activation at high temperature with water vapor contribute to the formation of functional groups containing the necessary components to bind more polar molecules. The surface of thermally activated carbon samples has a more hydrophobic character, and the surface does not contain polar particles that participate in the formation of bonds due to Van-Der-Waals forces and mutual electrical interactions. This shows that the change in the amount of adsorption in adsorption processes depends not only on the number of active centers, but also on the size of the pores.

Monolayer capacity am, saturation volume Vs (or adsorption as), relative surface area (S), micropores (W_0), mesopores $W_{me} = V_s$ calculated from textural parameters of adsorbents based on isotherms of benzene vapor adsorption on coal adsorbents, BET theory equation and Dubinin's volume saturation theory equation - W_0 and average pore radius values were determined. The obtained results are presented in Table 1.

Table 1.
On the adsorption of benzene vapors of coal adsorbents structure - sorption indicators

Samples	Single floor capacity, mmol/g	Comparison surface, m²/g	Saturation adsorption capacity, см³	Micropore size, см³	Mesopore size, см³	Average pore radius r_{ave}, Å
AC-1	0,974	234,49	0,165	0,138	0,027	14,1
AC-2	1,217	293,00	0,192	0,164	0,028	13,8
AC-3	1,337	322,01	0,222	0,172	0,05	13,8
AC-4	1,404	338,04	0,228	0,178	0,05	13,5
AC-5	1,473	354,59	0,231	0,181	0,05	13,2
AC-6	2,378	572,65	0,338	0,311	0,028	11,8
AC-7	2,511	604,72	0,357	0,325	0,032	11,8
AC-8	2,465	593,47	0,346	0,320	0,026	11,6

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Chemical activation of the coal sample with potassium alkali was found to significantly increase the specific surface area by BET. According to the obtained results, it can be seen that the relative surface area of the coal adsorbent activated with coal and potassium alkali has increased by almost 2,5 times compared to the AS-1 sample. Chemical activation leads to an increase in the specific surface area and a decrease in the size of micropores and an increase in their quantity compared to thermal activation of the samples. This indicates that during the activation process, chemical reagents play an important role in forming micropores and increasing the specific surface area of coal.

V. CONCLUSION AND FUTURE WORK

In addition to the nature of the raw material, the porosity structure is also affected by the activation process, conditions and regimes. The nature of the activator and modifier also plays an important role. In many scientific works, it is possible to increase the porous structure of coal by means of activation with strong acids and alkali solutions, pyrolysis and modification of coal+alkali mixture at high temperature. In this case, it is possible to obtain coal materials with different adsorptive activity used in various industrial processes.

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