

Development and production of granular carbon sorbents for sorption of toxic gases

Abstract

The possibilities of obtaining the granular sorbent using extruded method from production waste and rice husks for the sorption of toxic gases. As used lignosulfonate industrial waste, which is obtained in the processing timber. The selected optimum granulation regime in different proportions of the binder and flour rice husks. As a result of the research, a technology for obtaining granular sorbents was developed. It was found that the ratio of rice husk (RH) to binder is 3: 1, the carbonization temperature 800°C. A study of the microstructure of the obtained samples showed that the binder has a dense surface and has only a small number of pores of round shape, mostly of large size. Also the starting material (RH) is firmly fixed in the matrix of the binder-lignosulfonate, and the further activation of these pellets from rice husk and lignosulfonate contributed to the formation of more small pores and the development of the spongy structure of the sorbents.

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Introduction

Atmosphere - a system that plays a vital role in many natural processes, such as the formation of the global climate, the composition of the chemical components of the oceans and seas. The penetration of the earth's surface solar radiation and heat the delay in the earthly space, depends on the gas composition of the atmosphere.¹ The problem of air pollution - one of the greatest global challenges faced by humanity. Risk of air pollution - not only in the fact that clean air fall harmful substances harmful to living organisms, but also causes contamination of the Earth's climate change.²⁻³ Air pollution (atmosphere) due to human activities has led to the fact that over the past 200 years, the concentration of carbon dioxide has increased by almost 30%. Nevertheless, humanity continues to burn fossil fuels and destroying forests.⁴⁻⁵ The process is too colossal, that leads to global environmental problems. Air pollution occurs as a result of other human activities. Fuel combustion in thermal power plants is accompanied by the release of sulfur dioxide. With car exhaust gases emitted into the atmosphere of nitrogen oxides. When incomplete combustion carbon monoxide is formed.^{6,7} At the present stage, for the majority of industrial cleaning and suction air emissions of harmful substances is one of the basic measures to protect the air basin. A feature of most industrial emissions is to have them in addition to solid and liquid particles (dust, fumes and mists) a large amount of harmful gaseous components. Clean gas flows from such impurities and requires specific equipment corresponding theoretical knowledge for the development of gas purification technology.⁸ Among the methods of neutralization of industrial emissions increasingly becomes important adsorption way to almost completely remove the impurities from gas streams. In use solid adsorbents as high surface area materials formed into pellets (spheres, tablets, cylinders, etc.), or are in finely divided form.⁹⁻¹⁰

In this connection, the production and consumption of the carbon materials has steadily increased. In particular, the global consumption of carbon materials is about 1.1 million tons per year and continues to grow at 9% per year.¹¹ Thus a major amount of activated carbon (80-85%) is produced from non-renewable resources. Large range of carbon materials obtained on the basis of large-tonnage waste of chemical and mechanical processing of wood: sawdust, bark, logging

waste and technical lignins.¹²⁻¹³ In the laboratories of the Institute of Combustion Problems carried out work on the production of porous carbon materials from waste materials rostitel'nogo. Such as rice hulls, walnut shells, apricot seeds, which are renewable natural materials.¹⁴⁻¹⁵ But it is not carried out work on the development of producing granular sorbents. In this regard, the work order is possible to obtain by extrusion the granular sorbent and determining the physicochemical properties of the pellets.

Experimental part

Development of synthesis technology and production of granular sorption materials

In this work, a synthesis technology and the preparation of granular sorption materials from waste products by extrusion, granulation on a screw granulator was developed. As a waste, lignosulfonate (LS) and rice husk flour were used. To prepare granular carbon sorbents, the raw materials were prepared. To do this, rice husks were grinded on the planetary mill «Activator 4M», when using metal balls with a diameter of 5 mm, in an amount of 300 pieces; The grinding time is 3 minutes. Further, at a ratio of 2:1, 3:1 and 4:1, with the addition of water (40 ml per 100 g) from flour and lignosulfonate, a plastic mass was obtained. Further, from which granules were obtained using a screw granulator. The resulting granules were dried at room temperature for 6-12 hours. The carbonization of the samples was carried out under strictly controlled isothermal conditions, in a rotating reactor in an inert gas-argon medium, which was continuously supplied to the reactor at a rate of 50cm³/min.

Carbonization was carried out at temperatures of 750 and 800°C. In order to improve the sorption characteristics, the granules obtained were activated using chemical reagents. The scheme of the process for obtaining granular sorbents is shown in Figure 1. The influence of the amount of binder on the yield and the properties of the sorbents obtained was investigated in the work. For the study, samples were prepared in which the ratio of the binder and flour of the RH was changed in accordance with the data given in Table 1. Table 1 - Characteristics of the obtained granular samples. According to the data obtained on the Sorbtometer-M analyzer, the specific surface area of the resulting samples after activation was in the range 146-

883m²/g. To determine the optimum ratio of sorbent and binder in the composition of the final product, the values of the yield and the specific surface of the samples were compared. From Table 1 it follows that the ratio of RH and binder is 3: 1, the carbonization temperature

is 800°C. The general view of the obtained carbon sorbent granules is shown in Figure 2. As a result of the research, the technology of obtaining granular sorbents was developed. It was found that the ratio of RH to binder 3:1 is optimal, the carbonation temperature is 800°C.

Table 1 Characteristics of the resulting granular samples

Ratio RH/ LS	t, °C	m ₀ , g	m ₁ ,g	m ² ,g	Exit, %	S ¹ s, m ² /g	S ² s,m ² /g	Volume porosity, cm ³ /g	Sorption activity by methylene blue mg/g
67:33 (2:1)	800(1h30min)	58,12	11,48/10	4,35	37,9	198	684	0,272	368
67:33(2:1)	750(1h30min)	40,39	12,31/ 11,6	7,03	57,1	78	146	0,065	363
80:20(4:1)	800(1h30min)	25,81	8,25	4,33	52,5	204	336	0,147	365
75:25(3:1)	800 (1h30min)	45,56	12,11	6,78	55,9	205	883	0,337	373
75:25(3:1)	800(1h50min)	51,55	12,73	5,14	40,4	239	803	0,344	373

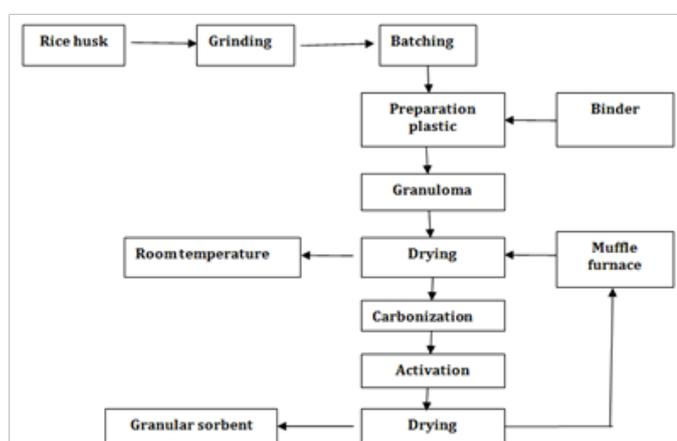


Figure 1 Scheme for the production of granular carbon sorbents.



Figure 2 Granular carbon sorbent from RH and lignosulfonate.

Investigation of the physico-chemical characteristics of the obtained granulated sorption materials

The physico-chemical characteristics of the obtained granular sorption materials were studied by electron microscopy, low-temperature adsorption of nitrogen, adsorption of carbon dioxide. To determine the pore size, the density functional method DFT was used. The BET method was used to determine the specific surface area of the adsorbents. The morphology and surface relief of the investigated

samples of the carbon sorbent was studied by electron microscopy using the electron microscope JSM-6510 LA. To obtain contrasting electronic microimages, the study surfaces were conducted at a voltage of 15-20 kV and in a current strength of 10-30mA. It can be seen from the obtained micrographs that the bonding material has a dense surface and has only a small number of pores of round shape, mostly of large size (Figure 3A). It can be seen from Figure 3B that the starting material (RH) is firmly fixed in the matrix of the binder, lignosulfonate. Further, the activation of these pellets from rice husk and lignosulfonate promotes the formation of more pores of small size and the development of the sponge structure of the sorbents. The device used in this study made it possible to work on the elemental composition of the granular sorbent before and after activation. The research was carried out on a modern JED-2300 EDS energy-dispersive spectrometer by JEOL, Japan, which is an additional device for the scanning electron microscope type JSM-6510 LA, the same firm. These studies are presented in Figure 4.

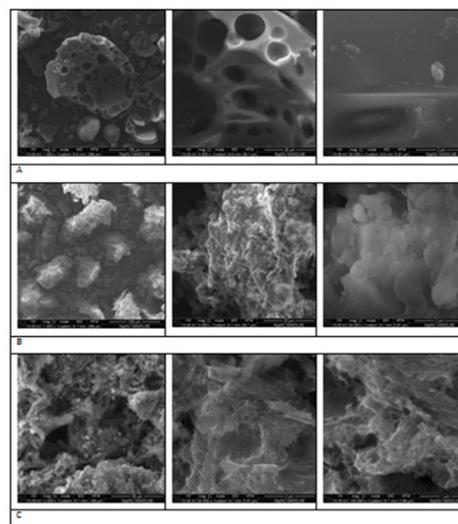


Figure 3 Electronic micrographs.

(A) Binder material – lignosulfonate.

(B) Granules from RH and LS before carbonization.

(C) Granules after activation.

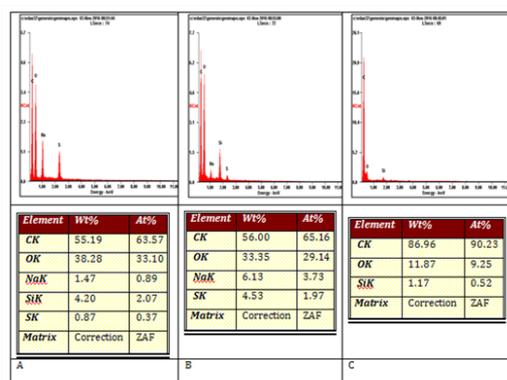


Figure 4 Elemental composition.

(A) Binder material-lignosulfonate.

(B) Granules from RH and LS before carbonization.

(C) Granules after activation.

As can be seen from (Figure 4A-4C), as a result of activation, there is a significant decrease in the amount of oxygen. At the same time, there is a simultaneous decrease in the content of sodium and sulfur to zero, which volatilize during the carbonization process, which has a beneficial effect on the quality of the carbonized material. The analysis made it possible to show that an increase in the carbon content of the activated samples occurs as compared to the initial samples of granular sorbents. Further in Figure 5, data of a more detailed investigation of the elemental composition of activated granules are presented. Where you can see a significant increase in the carbon content to 93%. Adsorption of nitrogen and carbon dioxide is the most important method for studying porous structures, since it permits determination of the specific surface area, pore volume and pore size distribution in the structure of such materials. Despite a wide range of methods for calculating the structural characteristics of samples (BJH, DFT, BET), the problem of accurate and reliable evaluation of the properties of porous structures remains relevant. In particular, this concerns methods for determining the pore size distribution. Our choice was based on the peculiarities of the surface and structural heterogeneity of the synthesized samples.

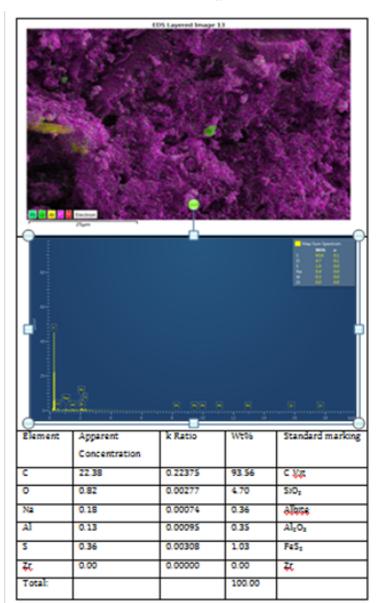


Figure 5 Elemental composition of granular sorbent.

Conclusion

- As a result of the research, the technology for obtaining granular sorbents was developed. It was found that the ratio of RH to binder 3:1 is optimal, the carbonation temperature is 800°C.
- Investigation of the microstructure of the obtained samples showed that the binder material has a dense surface and has only a small number of pores of round shape, mainly of large size, and the starting material (PI) is firmly fixed in the matrix of the binder, lignosulfonate. And the further activation of these pellets from rice husk and lignosulfonate contributed to the formation of more small pores and the development of the spongy structure of the sorbents.

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None.

Conflict of interest

The author declares no conflict of interest.

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