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Processing of rice husk and straw into activated carbon

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A method of processing rice waste (husk, straw) into activated carbon is proposed in the study. The thermolysis of the raw material and the activation of the carbonizate were carried out at 500ºC and 800ºC, respectively. The properties of the obtained activated carbon were determined by standard methods. The porous structure of the activated carbon was studied using scanning electron microscopy. According to the results of the experimental studies, activated charcoal obtained from rice husk corresponds to the WAC brand, whereas activated charcoal obtained from rice straw corresponds to BAU-A grade. This research proposes a rational method of using agricultural waste to obtain useful secondary adsorbent products for adsorption in liquid media.

Keywords: carbonization, rice husk and straw, activation of carbonizate, sorbent, activated carbon.

INTRODUCTION

Rice is one of the most important agricultural food products in the world. Nowadays, the estimated world production of rice is more than 485 million tons per year. According to Kazagromarketing JSC, rice-growing regions of Kazakhstan are Kyzylorda, Almaty and Turkestan. Kyzylorda is the leading rice-growing region of the country, which produces more than 85% of the local crop.

During harvesting and industrial rice processing, a waste in the form of husk (up to 20% of mass) and straw (up to 50% of mass) is formed in large numbers. The utilization of straw and husk, in fact, remains the main problem for rice producers. The majority of rice husk and straw are incinerated which leads to a deterioration of the ecological situation. A joint solution for ecological and technological problems is the utilization of rice husk and straw, as well as the production of demanded solid products.

There are some works in the literature on the thermal processing of rice husk and the production of phenol-containing products from it [1, 2].

In this research, using rice husk and straw to obtain the widely applicable adsorbent activated carbon is suggested. Activated carbon is produced from various carbon-containing materials of organic origin: charcoal (BAU, DAK, etc.) [3], coal coke (activated carbon brand AG, AR, etc.) [4], petroleum coke, coconut shells, fruit pits, agricultural waste, paper production waste, garbage, sewage sludge, worn rubber tires, synthetic polymer waste and so on [5-13].

The use of agricultural waste to produce activated carbon is environmentally friendly because the use of wood as a raw material is excluded, which in turn, minimizes deforestation and promotes the rational use of agricultural waste. Method of producing activated carbon from barley waste by pre-drying in hot air and performing one-step carbonization in a cylindrical reactor at 290-320°C for 7-15 minutes was discovered [14], another method of activated carbon production is using rapeseed straw and carrying out carbonization in an inert nitrogen atmosphere at a temperature of 450-500°C and activation by steam at a temperature of 820-850°C [15].

There are some works on obtaining highly porous activated carbon from rice husk, where the product has a selective sorption activity of lead ions [16-17]. In another research [18] it is reported that the co-processing of rice husks and polytetrafluoroethylene gives a highly porous structured product.

EXPERIMENTAL

10 g of raw material was placed in a stainless steel tube furnace with a height of 250 mm and an internal diameter of 25 mm. The tube was sealed and carbonization was carried out. The temperature of carbonization was increased at a rate of 10°C per minute up to 500°C. This temperature was kept for 100 minutes. The yield of carbonizate obtained from husk and straw was 44 and 37%, respectively.

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Afterwards, a vessel was connected to the bottom of the tube furnace to supply the system with steam, keeping a ratio of water:carbonizate 2:1 by weight. The activation was carried out at a temperature of 800°C, the yield of activated carbon was 27% and 29%, depending on the weight of the husk and straw used.

The surface of the obtained activated carbon was analyzed with a scanning electron microscope JSM-6510 LV from JEOL Company(Japan).

The properties of the obtained activated carbon: iodine adsorption activity, water total pore volume, mass fraction of moisture and bulk density were determined by the known methods [3,19-21].

RESULTS AND DISCUSSION

Microphotographs of activated carbon (500-fold magnification) are shown in Figures 1 and 2, where developed porous structure of the obtained sorbents can be observed.

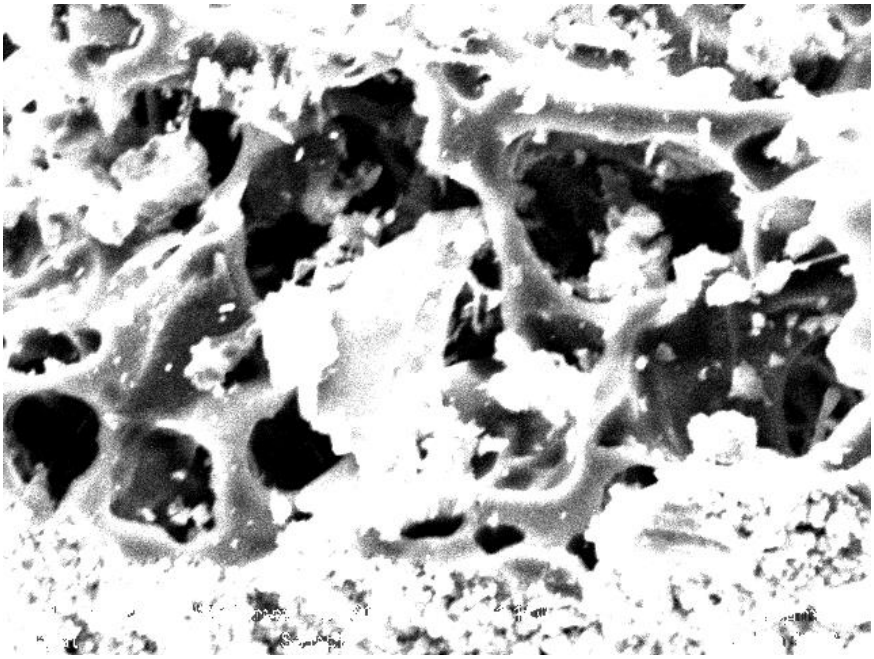

Figure 1. Photomicrograph of activated carbon obtained from rice husk

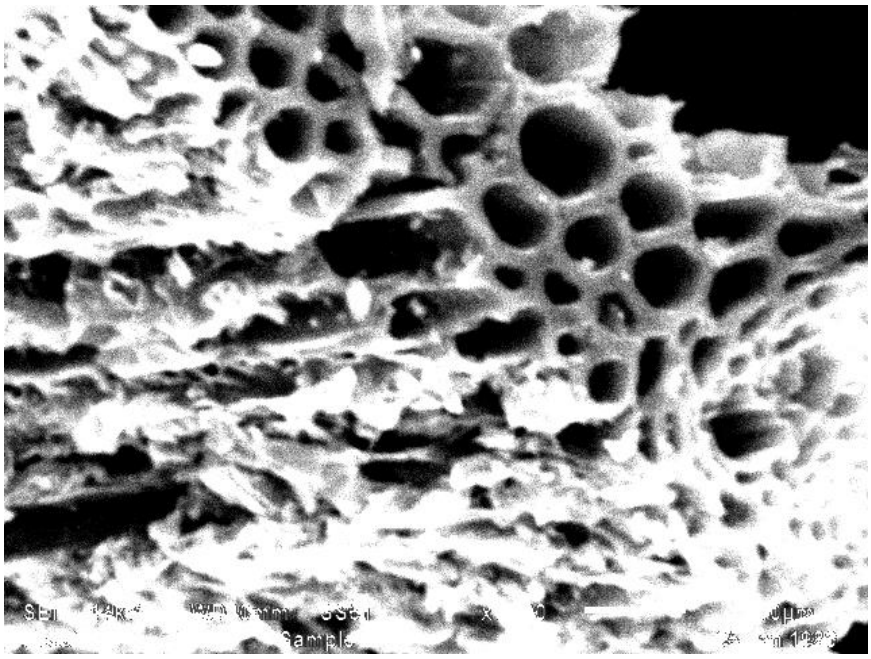

Figure 2. Photomicrograph of activated carbon obtained from rice straw

Table 1. Properties of activated carbons obtained from rice husk and straw

Activated carbon	Iodine absorption activity, %	Water total pore volume, cm^3/g	Mass fraction of moisture, %	Bulk density, g/dm^3
Activated carbon obtained from rice husk	51	1.57	3.6	236.1
Activated carbon obtained from rice straw	64	1.63	3.6	181.3
BAU-A grade	More than 60	1.60	Less than 10.0	Less than 240.0
WAC brand	More than 30	1.40	Less than 10.0	Less than 220.0-250.0

The properties of the obtained activated carbon were determined by the following methods: iodine adsorption activity by a titrimetric method, water total pore volume by filling pores with water and removing excess water from the surface of the sample by suction, mass fraction of moisture by drying the sample to constant weight, bulk density by a weighing method. The data are given in Table 1.

According to the results, activated charcoal obtained from rice husk corresponds to WAC activated charcoal, whereas activated charcoal obtained from rice straw corresponds to BAU-A grade, which are used for adsorption in liquid media [3].

CONCLUSIONS

Activated carbon was obtained from rice husk and straw. The properties of the products obtained were determined. According to certain properties, the obtained sorbents can replace wood activated charcoal, which makes possible the rational dispose of agricultural waste, reduces deforestation, and helps to produce value-added products.

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