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Research Article

PREPARATION OF THERMOCHEMICALLY ACTIVATED CARBON ADSORBENTS BASED ON COTTON STEM AND COTTON SHELL AND THEIR IR SPECTROSCOPY ANALYSIS

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ABSTRACT

This article discusses the practical importance of adsorbents today, areas of application, and methods of obtaining activated carbon adsorbents based on local raw materials. Preparation of adsorbents activated by the method of thermochemical activation based on cotton stalks and cotton bolls, functional groups in the obtained adsorbents were analyzed by IR spectroscopy.

KEYWORDS

Activated adsorbent, cotton stalk, cotton boll, thermal activation, chemical activation, IR spectroscopy.

INTRODUCTION

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Currently, activated carbons are used for the purpose of cleaning various waste substances contained in industrial waters. Production of these used adsorbents based on local raw materials is one of the urgent problems of today.

Activated carbon is a carbonaceous material processed by special methods, during which organic raw materials are thermally and chemically activated. In an airless environment, it is heated to reduce the non-carbon components (a process called carbonization) and then reacts with the gas, corroding the surface to form a microporous structure (a process called activation) [1]. Wastewater treatment using the adsorption method is recognized as the most effective method, due to the large number of its sources, variety of types, low cost from the economic point of view, regeneration properties, high efficiency in cleaning and ease of use, etc.

At present, methods such as adsorption, chemical treatment, ion exchange, and coagulation are widely used for the purpose of wastewater treatment [2]. Wastewater treatment using the adsorption method is recognized as the most effective method, due to which it has a number of advantages, such as the large number of sources, variety of types, low cost from the economic side, regeneration properties, high efficiency in cleaning, and ease of use. . It has been proven that the efficiency of the adsorption process can be reached up to 99.9% [3]. At the same time, this method is a simple and economical method compared to other methods, and it has the characteristics of good purification of wastewater from many types of pollutants, including dyes.

Cotton stalks are a global agricultural residue with limited economic importance, with annual production of approximately 50 million tons. The fruit (cotton fiber), stem, pod and leaf of Goza plant are distinguished by the storage of different amounts of cellulose, and this is shown as a promising and ecologically stable raw material for obtaining cellulose [4]. As a result of studies from the literature, the composition of various components of the cotton stem was studied. According to their results, the content of α-cellulose in cotton stalk was 42.25%, which is higher than other lignocellulosic resources, and the contents of lignin and ash were 20.62% and 2.71%, respectively. is [5]. In the climatic conditions of Uzbekistan, cotton is one of the most cultivated types of plants. More than 60% of the agricultural areas of our republic are specialized in cotton cultivation, especially for the cotton crop of 2024, fertile cotton varieties obtained by various genetic methods were planted on nearly 1 million hectares. After the cotton crop is harvested, some of the cotton stalks, which are abundant in the fields, are harvested as fuel, and the rest is left in the fields, which becomes a problem for replanting.

METHODS

In the production of activated carbon, the starting material is first heat-treated in an airless environment, as a result of which volatile substances (moisture and partial resins) are removed from it. As a result of thermochemical activation, part of the organic matter burns, and the rest turns into coal with a large internal surface, characterized by a porous structure [6].

The cotton stem (P.P) was crushed in 2-3 cm sizes, and the cotton stalk (P.Ch) was separated and crushed (picture: 1).

Picture 1: cotton stem and cotton shell

It was dried in a drying cabinet for 24 hours at a temperature of 105℃ to get rid of moisture. 200g (accurate to 0.1g) was taken from the dried cotton boll. The raw material was sent to the pyrolysis unit for pyrolysis. The part of the pyrolysis device where raw materials are placed is made of stainless steel. In the production of activated carbon, the starting material was first pyrolyzed for 1.5 hours at different temperatures in an airless environment. As a result, volatile substances (moisture and partial resins) were removed from it (figure 2). The obtained coal product was crushed using a porcelain mortar. The production yield of cotton-based charcoal adsorbent was calculated.

$$A_U = \frac{M_{AC}}{M_B} * 100\% \quad [1]$$

A_U – Product of activated adsorbent, %

M_{AC} – Activated adsorbent mass, g

M_B – Initial raw material mass, g

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Picture: 2 After thermal treatment of cotton steam

The obtained coal product was crushed using a porcelain mortar. Then it was transferred to the chemical activation process. A chemical method was chosen for activation. Solutions of different concentrations of KOH and NaOH were used as chemical activators. Chemically activated at 400°C for 1.5 hours. After the activation, it was boiled and washed with distilled water in order to get rid of excess alkali in the coal. The boiling wash was carried out for 30 minutes, then filtered. This process was carried out 3 times (500 ml of water was used for each wash). Then it was treated with 0.n HCl for de-ashing. It was washed again with distilled water. The change in pH was monitored on an indicator piece of paper. It was dried at 105°C for 24 hours (to absolute dry mass). The mesh was passed through a sieve with a size of 0.1 mm. The mass was measured.

Analysis of the structure of adsorbents obtained on the basis of plant residues by the IR-spectroscopy method. Infrared spectroscopy is the measurement of the interaction of infrared radiation with matter through absorption, emission, or reflection. It is used to study and identify chemical substances or functional groups in solid, liquid or gaseous form. The method or technique of infrared spectroscopy is performed using a device called an infrared spectrometer (or spectrophotometer) that produces an infrared spectrum.

RESULTS AND DISCUSSION

Quantitative and qualitative composition of functional groups in coal adsorbents obtained on the basis of plant residues was determined using the IR-spectroscopy method. Traces were analyzed by infrared (IR) spectroscopic analysis on a Shimadzu IRTracer100, Japan in the range of 400-4000 cm-1.

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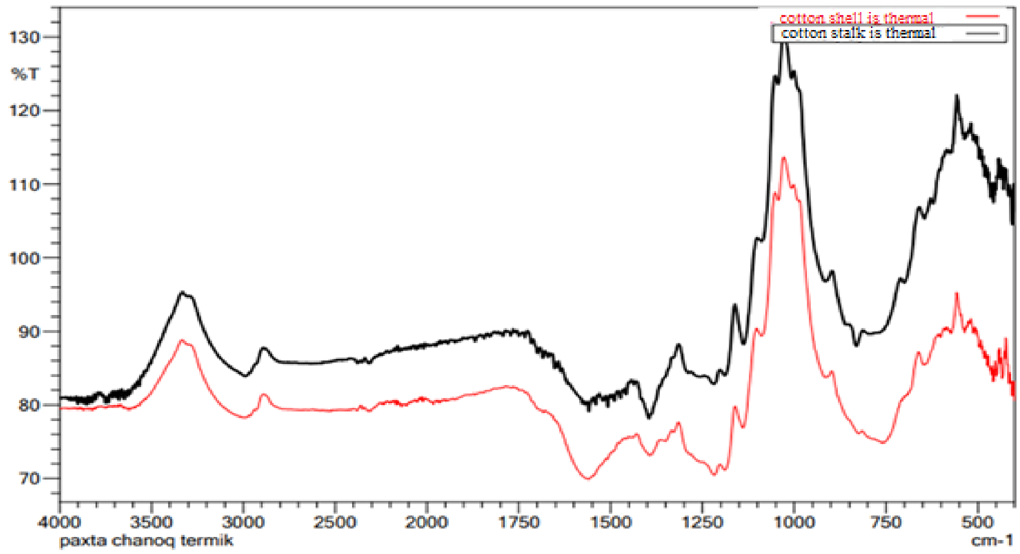

Picture: 3 IR spectra of adsorbents obtained by thermal treatment of cotton stalk and cotton shell

IR spectroscopy of thermally activated adsorbents based on cotton stalks and cotton bolls was studied. Since the structure of the raw materials is close to each other, the results of IR spectra are also similar to each other.

According to the IR spectra, valence vibrations specific to the OH group were detected in the 3335 cm-1 region, and these valence vibrations indicate the presence of partial water molecules between the coal pores. Valence vibrations characteristic of C-H bonds of saturated and unsaturated hydrocarbons were observed in the peaks of the 2884 cm-1 spectrum. Valence vibrations characteristic of unconfigured C=O group in lignin and hemicellulose were observed in 1673cm-1 and 1653 cm-1 areas, respectively. The formation of aromatic compounds such as aldehydes, ketones, aromatic hydrocarbons here occurs as a result of the thermal decomposition of lignin and hemicellulose, which are the main components of raw materials. In the 1394 cm-1 area, deformational vibrations characteristic of the C-H bond of saturated hydrocarbons were observed. The deformation vibrations observed in the 1219cm-1, 1189cm-1, 1137cm-1 areas represent the C-C bonds in the structure of cellulose, hemicellulose and lignin, which are the main components of raw materials.

We have chosen 400°C as the optimal temperature in the thermal and thermochemical activation processes for obtaining activated adsorbents, and the activation processes were carried out at this temperature. For this reason, thermally activated adsorbents based on cotton stalks and cotton wicks, adsorbents activated

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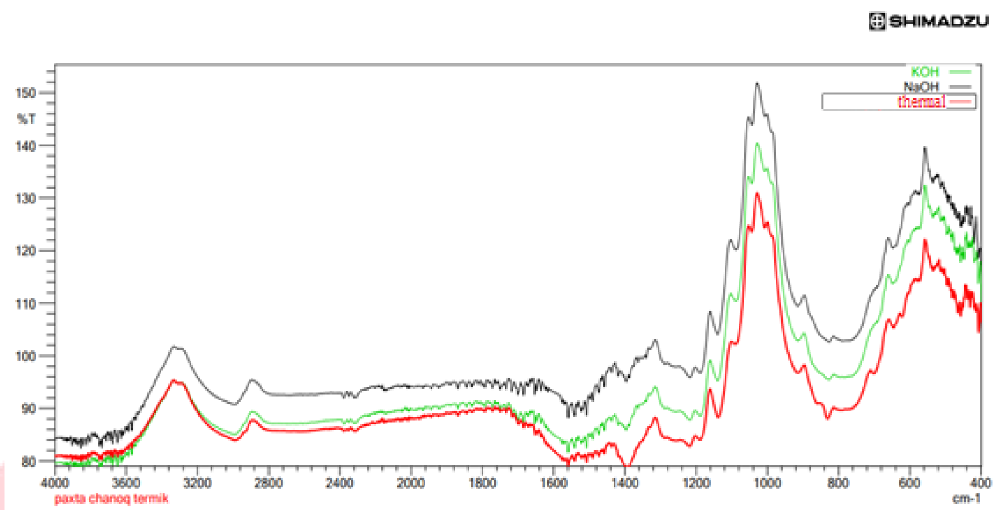
with sodium hydroxide on the basis of cotton stalks and cotton wicks, and adsorbents based on cotton stalks and cotton wicks In adsorbents activated with potassium hydroxide, valence and deformation fluctuations of IR spectra were also shown in similar areas.



Picture 4: Thermally activated adsorbent based on cotton wick (red), adsorbent activated with NaOH on the basis of cotton wick (green), adsorbent activated with KOH on the basis of cotton wick (black) IR spectra of adsorbents

CONCLUSION

We have chosen 400°C as the optimal temperature in the thermal and thermochemical activation processes for obtaining activated adsorbents, and the activation processes were carried out at this temperature. For this reason, thermally activated adsorbents based on cotton stalks and cotton wicks, adsorbents activated with sodium hydroxide on the basis of cotton stalks and cotton wicks, and adsorbents based on cotton stalks and cotton wicks In adsorbents activated with potassium hydroxide, valence and deformation fluctuations of IR spectra were also shown in similar areas.

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