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Obtaining activated carbon from the shells of apricot and peach seeds

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Abstract*- The article presents the results of a study to determine the optimal mode of the process of obtaining activated carbon from the shell of fruit seeds. The conditions of the processes of carbonization and activation of the shell of apricot and peach seeds were studied, determining the bulk density, ash content and adsorption activity of the resulting product for each temperature regime. Based on the obtained experimental results, the corresponding nomograms were compiled.*

Keywords: *alkanolamine, activated carbon, seed shells, carbonization, activation, bulk density, ash content, adsorption activity.*

1. INTRODUCTION

The production of natural gas and gas condensate has been rapidly increasing in Uzbekistan in recent years.

At gas processing plants of the Republic, the absorption method of purification using various amine solutions, such as monoethanolamine (MEA), diethanolamine (DEA) and methyldiethanolamine (MDEA), is widely used to purge natural gas from acidic components. It should be considered that these alkanolamines are not produced in the Republic. According to Uzbekneftegaz JSC, for the purification of natural gas in 2018, 312 tons of DEA and 3522 tons of MDEA were imported at a cost of 1780 and 1950 US dollars per ton, appropriately.

The use of amine solutions in gas purification processes has a number of shortcomings, the main of which is the foaming of the absorbent, and in some cases - a decrease in its absorbability over time [1]. Foaming results in the violation of the operating mode of installations, degradation of the quality of the purified gas and, consequently, to the need to reduce the productivity of the sorption system, accordingly, during foaming, losses of expensive amines increase as a result of entrainment with gas [2].

The causes of foaming can be the following [3]: increase in the temperature regime in the system; supply to the unit of various inhibitors used in gas production; decomposition of amines under the influence of high temperatures; accumulation of hydration products in amine solutions; falling into the absorber of tarred hydrocarbons in the form of drops; the availability of a mineralized aqueous dispersion in the gas at the inlet to the absorber; entrance to the system of acidic components.

To regenerate and prevent foaming of used alkanolamine solutions, they are purified by adsorption methodwith the use of activated carbon. At the units for the amine purification of natural gas from acidic components of gas processing plants of the Republic, activated carbons are used for the adsorption purification of regenerated amine solutions: AG-3 (Russia), HX-30 (China). The requirement for these carbons in Uzbekistan is about 300 tons / year. These activated carbons are not produced in the Republic and are imported for USD 2500-3000 per ton, accordingly. Along with this, substantial masses of about 2000-8000 tons of waste from the processing of apricots and peaches are generated annually at the fruit processing enterprises of the Republic. According to the literature [4, 5], mentioned wastes can serve as a good raw material for the production of activated carbon.

Considering the above, in the present work, the goal was to study the optimal mode of obtaining activated carbon from the shell of fruit seeds for the purification of amine solutions.

2. OBJECTS AND RESEARCH METHODS

The object of the study was the shells of apricot and peach seeds.

For the purpose of import substitution for the adsorptive purification of regenerated amine solutions, a laboratory unit was assembled to produce activated carbon

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based on local waste raw materials - the shells of apricot and peach seeds (Fig. 1).

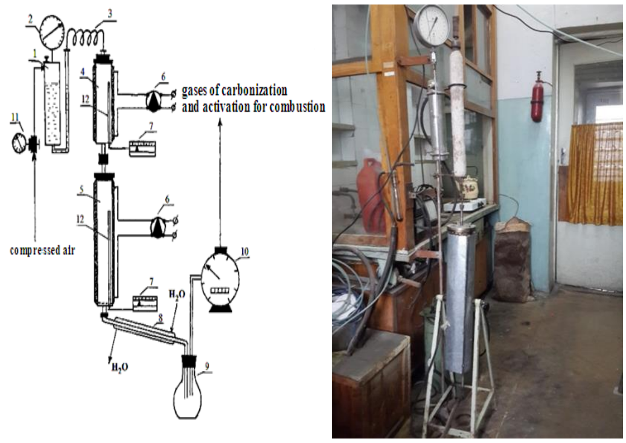

Figure. 1. Laboratory installation for obtaining activated carbon from the shell of fruit seeds: 1 - water tank; 2 - manometer (exemplary); 3 - copper capillary; 4 - steam generator; 5 - furnace for carbonization and activation; 6 - lators; 7 - millivoltmeters; 8 - refrigerator; 9 - receiver; 10 - gas meter; 11 - pressure stabilizer; 12 - thermocouple pocket

In the course of the research, the shells of apricot and peach seeds were carbonized in a laboratory tubular reactor with a capacity of 0.25 m3 with electric heating without access to air. The oven temperature was controlled with a thermocouple and a potentiometer. Fractions 0.2-5.0 mm and dried at 110 °C to constant weight were processed. After loading the dried granules, the upper part of the reactor was hermeticallyclosed, and the lower part had a tubular branch for the removal of resinous and gaseous products of thermal pyrolysis. The carbonization process was carried out at a temperature of 400-800 °C, which was controlled by a thermocouple, located in the middle of the reactor. The temperature rise rate was 7-10 °C per minute. Upon reaching the required temperature of the experiment, thesample had been kept in the reactor for 1-2 hours and then cooled to room temperature. The evolved gaseous pyrolysis products were evacuated from the reactor through a gas outlet tube and sent to a cooled condenser for condensation of water vapoursand resin. Cooled carbonizates were discharged from the reactor and their absorption properties were determined using standard methods. The activation process of the carbonizate was carried out in the same reactor (Fig. 1). In order to carry out the activation, carbonized granules were loaded into a tubular reactor, which was purged with a stream of gaseousnitrogen within 15 minutes to remove oxygen from the reaction zone. The upper flange of the reactor is equipped with a branch pipe for the inlet of superheated water vapour, and the lower one has a branch pipe for inlet of superheated water vapour, and the lower one has a branch pipe for removing the steam-gas mixture. The superheated steam required for activation was obtained in a steam generator. The flow rate of water vapour for activation was controlled by the amount of water entering the steam generator by changing the rate of its outflow in the capillary depending on the pressure above the water created in the dosing tank using nitrogen. The activation temperature was controlled by heating the reactor and the steam generator. The sample was heated to the final activation temperature, which was in the range 800-950 ° C. When the given temperature was reached, water vapour was fed into the reactor from the generator for 1-2 hours. The volume of activation gases containing hydrogen, carbon oxides, and methane after separation from unreacted water vapour was measured with a gas meter, and the chemical composition was measured by the method of chromatography using a carbon column and a thermal conductivity detector. After heat treatment, the resulting activated carbon was left to cool to room temperature without air access.

3. RESEARCH RESULTS

In the course of the study, samples of activated carbons were obtained from the shell of apricot seeds (further AC-AS) and the shell of peach seeds (further AC-PS). To determine the optimal mode of the activated carbon production process, the bulk density, ash content and adsorption activity of the obtained target products were measured for each temperature mode. The following results were obtained (Tables 1-4).

Table 1

Conditions for carbonization of the shell of apricot seeds

(The preliminary weight of raw materials is 1000 g, the rate of temperature rise is 7-10°C per minute)

Process temperature, °C	Weight of carbonizate, g	Bulk density, g / dm³	Ash content, %	Adsorption activity by C_6H_6, g / 100 g
400	613	623	4,8	0,24
500	521	596	5,0	0,46
600	405	562	5,1	0,52
700	376	533	5,2	0,87
800	353	514	5,5	1,25

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Table 2

Conditions for the activation of apricot carbonizate

(for all temperature conditions, the process continues 120 min.)

Process temperature,°C	Power burnt,%	Bulk density, g / dm³	Ash content, %	Adsorption activity by C_6H_6, g / 100 g
800	27	488	6,5	1,45
850	29	453	7,3	1,87
900	34	412	8,8	1,92
950	40	376	10,2	1,98

Table 3

Conditions for carbonization of the shell of peach seeds

(The preliminary weight of raw materials is 1000 g, the rate of temperature rise is 7-10 °C per minute)

Process temperature, °C	Weight of carbonizate, g	Bulk density, g / dm³	Ash content, %	Adsorption activity by C_6H_6, g / 100 g
400	676	687	6,3	0,12
500	581	655	6,8	0,26
600	463	627	7,4	0,34
700	446	605	7,9	0,47
800	381	583	8,3	0,65

Table 4

Conditions for the activation of peach carbonizate

(for all temperature conditions, the process continues 120 min.)

Process temperature,°C	Power burnt,%	Bulk density, g / dm³	Ash content, %	Adsorption activity by C_6H_6, g / 100 g
800	28	512	8,8	0,87
850	30	476	9,5	1,18
900	35	447	10,7	1,23
950	47	413	11,6	1,25

Based on the experimental results obtained, the corresponding nomograms were drawn up (Figs. 2 and 3).

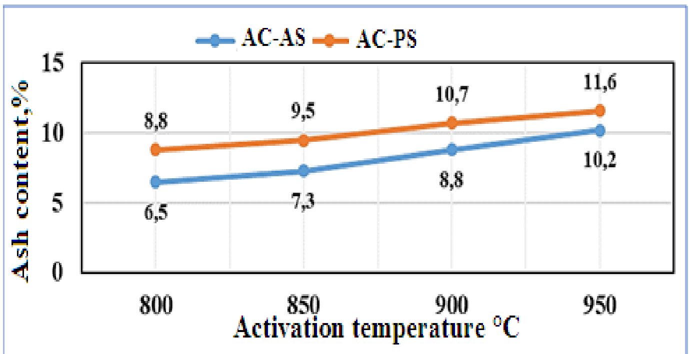

Figure: 2. Dependence of the ash content of activated carbons AC-AS and AC-PS on their activation temperature

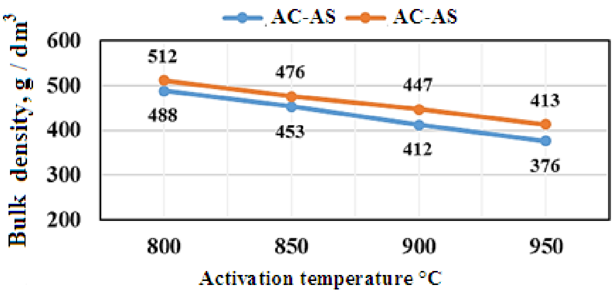

Figure: 3. Dependence of the bulk density of activated carbons AC-AS and AC-PS on their activation temperature

4. CONCLUSION

From the results given in Tables 1-4 and Figures 2-3, it can be seen that with an increase in the temperature of carbonization and activation processes, respectively, in the range 400-800 ° C and 800-950 °C, the sorption capacity and ash content of activated carbons increase, but their bulk density decreases. It should be taken into account that the purification of spent alkanolamines requires activated carbons with a high bulk density and sorption activity, as well as reduced ash content. Based on these requirements and on the basis of the results of experimental studies, it was found that the optimal conditions for carbonization of stone fruit are a temperature of 800 °C, the duration of the process is 1 hour, and the activation of carbonizates occurs at a temperature of 850 °C, the duration of the process is 2 hours.

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