TECHNOLOGICAL ADVANCEMENT OF SORPTION WATER PURIFICATION FOR ALCOHOLIC BEVERAGE INDUSTRY

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ABSTRACT

Introduction. The topicality of technological advancement of water conditioning by means of sorption water purification for alcoholic beverage industry is shown.

Materials and methods. Activated carbon Silcarbon K835spezial compared to Filtrasorb F300 is studied. During the studies standard methods of analysis for alcoholic beverage industry, theoretical generalizations and comparisons, systematic approach were used.

Results. A comparative assessment of physicochemical and sorption characteristics of activated carbons Silcarbon K835spezial and Filtrasorb F300 is made. The efficiency of activated carbon Silcarbon K835spezial usage during water conditioning for alcoholic beverages is investigated.

Conclusion. The topicality of activated carbon Silcarbon K835spezial usage for alcoholic beverage industry is given scientific credence. Enhanced physicochemical and sorption properties of activated carbon Silcarbon K835spezial enable to increase the specific volume of prepared water by 38%.

Investigated carboniferous microcellular activated carbon Silcarbon K835spezial is promising and enables not only to reduce the content of organic compounds in water but also iron, nitrogen-containing compounds, and to improve organoleptic indicators of water and alcoholic beverages with its use.

Key words: water, carbon, activity, efficiency, conditioning.

Introduction

Permanent increasing requirements to the quality of prepared water for the production of alcoholic beverages demand the use of the most effective ways to remove contaminants from the natural source water. Among the methods that have been successfully used to solve this problem is sorption purification. In this case the sorbents with developed or specific surface of natural or synthetic origin are used: resins and granular (crushed) active carbon (AC) [1, 2].

Water filtration through a layer of granular coal is the most general method of removing dissolved organic substances of natural and unnatural origin from water. Deep purification of drinking water is achieved mainly through the adsorption capacity of AC, size of its particles, filtration velocity, size of concentration of pollutants and implementation of a process [1–3].

AC is a porous carbon adsorbent which is produced from raw materials of different degrees of metamorphism: bituminous coal and charcoal, coconut and other nutshells, and fruit pits.

In the process of carbonization of bituminous coal amorphous carbon is produced during an activation of which AC with advanced micromesoporous structure is received. AC from coconut shell is characterized by a greater proportion of micropores. AC from wood, which is characterized by a larger proportion of macropores, is not suitable for effective purification of drinking water.

At present such adsorbents as bituminous AC of Filtrasorb F-300 and F-500 brands produced by the firm "Chemviron Carbon" are widely used for water purification from organic contaminants at the enterprises of alcoholic beverage production. During the use of such brands organoleptic characteristics are improving, permanganate oxidation is reducing. Sorption capacity of AC Filtrasorb of the above brands is 1000 volumes of water to 1 volume of coal. However, while using AC of these brands the content of iron, manganese, nitrate, nitrite, hydrogen sulphide, ammonia hardly reduces, the adsorption activity is restored not more than 50% after the regeneration. AC of such brands is characterized by a higher ash content that requires an increase in the cost of its make-ready and reduction of the filter cycle.

AC from coconut and other nutshells, and fruit pits are not commonly used in water conditioning for the production of alcoholic beverages. However, this AC is promising to reduce the colour of water, remove some inorganic impurities and different surfactants due to its micro- and mesoporous structure and high adsorption capacity.

Materials and Methods

During the laboratory tests AC of the brands Silcarbon K835spezial and Filtrasorb F-300 (control) were used as objects of research.

AC of the brand Silcarbon K835spezial is obtained from coconut shell and is specially prepared from ash minerals. It has a wide micromesoporous structure that provides the acquisitions of organic nitrogen compounds, organic and easily oxidable inorganic impurities which are present in water, and is repeatedly reactivated.

AC of the brand Filtrasorb F-300 is widely used in water sorption purification systems of alcoholic beverage companies in Ukraine.

AC of the brand Filtrasorb F300 is received with the help of the activation of special bituminous coal. It has micro- and mesoporous structure that provides the acquisitions of high and low molecular weight organic compounds found in water. AC Filtrasorb F300 is moistened well with water and reactivated with little mass loss of 10%. During water purification with sorbent Filtrasorb F300 the content of organic compounds reduces, taste and aroma of prepared water improve.

Input water (from municipal water supply) and prepared water were analyzed by organoleptic characteristics and hardness, alkalinity, dry residue, cationic, anionic composition.

During the studies of physical-mechanical and sorption characteristics of AC the methods adopted in chemical and technological control of alcoholic beverage production were used.

The study identified the main physical and mechanical properties of AC: moisture, bulk density, mechanical strength, ash content, particle size distribution.

Sorption properties of the AC samples were determined by the total volume of pores by water, activity by iodine, acid-base properties of coal by aqueous extract.

Water of Kyiv municipal water supply was used for the study.

The study was conducted in a dynamic mode at the facility which included: pressure water collection with the capacity of 10 dm^3, filter with AC with the capacity of 1.0 dm^3, and receiving collection with the capacity of 10 dm^3.

The process of water purification had a cyclic mode and consisted of the following sequential operations:

– AC preparation;

– filtering water through a layer of AC until the achievement of maximum allowable indices of organoleptic characteristics and permanganate oxidation;

– ripping the layer of the corresponding sorption material was carried out to prevent it from caking and to remove dirt. Input water was used for ripping in the upward flow and then it was dumped down the canalization. Monitoring was carried out in terms of water turbidity which was not supposed to exceed 0,5 mg/dm^3.

– AC regeneration.

– AC washing to remove dirt after the regeneration.

– After AC washing the filter was included again into the work.

Results and Discussion

Sorption materials must provide the adsorption of both low and high molecular weight organic compounds, high effect of water purification from organic impurities, not to increase the hardness and alkalinity of prepared water.

Physical, mechanical and sorption properties of carbon AC of the brand Silcarbon K835spezial was investigated in order to improve the sorption method of water conditioning to produce alcoholic beverages.

Basic physical and mechanical characteristics of the studied AC are given in table 1.

Table 1. Basic Physical and Mechanical Characteristics of AC

Index	Name of AC	
	Filtrasorb F300 (Control)	Silcarbon K835spezial
Bulk density, g/dm^3	480	490
Humidity,%	4	4
Mechanical strength, %	70	98
Ash content, %	3,5	1,0
Particle size, mm	0,5-3,0	1,0-2,5

It is determined that in comparison to test samples the studied AC has higher mechanical strength by 28% and lower ash content by 2,5%, which contributes to greater resistance to abrasion and service life, a slight dusting, increasing the number of regenerations and reduce of the start-up period.

Sorption characteristics of AC are shown in Table. 2.

Table 2. Main Sorption Characteristics of the Studied AC

Name of material	Sorption characteristics				
	Total volume of pores by water, cm^3/g	Number of basic oxides, $mole/m^3$	Number of acidic oxides, $mole/m^3$	Adsorption activity by iodine, %	Alkalinity of water infusion, 0,1 cm^3 hydrochloric acid c(HCl)= 0,01 $mole/dm^3$
F300 (control)	0,55	0,85	0,9	65	3,5
Silcarbon K835spezial	0,8	1,15	0,75	90	7,5

It is determined that in comparison to test samples the studied AC has a larger total volume of pores by water by 30%, adsorption activity by iodine by 38%, and alkalinity of water infusion is twice as much that is supported by 35% more of the number of basic oxides.

An optimal technological mode was set up during water conditioning with AC Silcarbon K835spezial that provides to get prepared water which quality meets the standards of SOU 15.9-37-237:2005 “Water prepared for alcoholic beverage production. Specifications” and TP U 18.5084 “Production schedules for the production of vodka and alcoholic beverages”.

The results of water conditioning with sorption method and optimal technological parameters are given in Tables 3, 4.

Table 3. Optimal Technological Parameters of Sorption Purification with the Studied AC

Name of technological operation	Linear speed, m/hour	Relative volume, v/v AC	
		F 300 (control)	Silcarbon K835spezial
AC preparation (washing)	5…10	10	5
Specific yield of water	8…12	800	1100
AC ripping of input water	10…12	6	4
Quick washing of AC	15	6	4
AC regeneration at temperatures 130^o C, hour.	-	6	4

Degree of regeneration, %		38…40	50…55
Number of possible regenerations, pcs.	-	2	4

It is established that due to improved physical, mechanical and sorption characteristics of the studied AC compared to test samples water consumption for the preparation decreases by 1,5 times, for ripping and rapid washing – by 1,5 times, and the specific volume of prepared water increases by 38%.

It was established that during the regeneration of the investigated AC compared to test samples the duration of steaming reduces by 1,5 times that makes possible to reduce steam consumption, with that the degree of regeneration increases by 1,3 times.

Table 4. The Results of Water Conditioning with the Use of AC

Name of index, unit of measure	Requirements of SOU 15.9-37-237, no more	Input water	Prepared water with the use of AC	
			F 300 (control)	Silcarbon K835spezial
1	2	3	4	5
Organoleptic properties				
Taste at 20°C, points	0	2	0	0
Aroma at 20°C, points	0	2	0	0
Colouring, degrees	5	20	5	0
Turbidity, mg/dm^3	0,5	1,0	0,2	0
Physical and chemical properties				
Hardness, mole/m^3	0,1	3,8	4,2	3,8
Total alkalinity, mole/m^3	4,0	4,0	4,5	4,0
Free alkalinity, mole/m^3	not allowed[1)]	not found[1)]	0,4	not found[1)]
Oxidation, mgO_2/dm^3	2,0	4,5	1,0…1,2	0,5…0,7
Contents, mg/dm^3				
- iron	0,1	0,15	0,1	0,07
- ammonium	0,05	0,10	0,07	0,05[1)]
- nitrite	0,1	0,2	0,15	0,05[1)]
- Free residual chlorine	not allowed[1)]	0,6	0,3[1)]	less than 0,3[1)]
- Bound residual chlorine	not allowed[1)]	0,5	0,3[1)]	less than 0,3[1)]
- hydrogen sulphide	not allowed[1)]	0,2	0,15	less than 0,1[1)]

[1)]The results of testing of free alkalinity, ammonium, free residual chlorine and hydrogen sulphide within the sensitivity of the method

It is established that the studied AC provided water conditioning with such parameters: taste, aroma, colouring, turbidity. During water conditioning with AC the mass concentration of iron, ammonium, nitrite decreases almost by 1,5–2 times, with that the permanganate oxidation improves by 40...50% compared to the control sample.

Conclusion

The topicality of activated carbon Silcarbon K835spezial usage for alcoholic beverage industry is given scientific credence. Enhanced physicochemical and sorption properties of activated carbon Silcarbon K835spezial enable to increase the specific volume of prepared water by 38%.

Investigated microporous active carbon Silcarbon K835spezial is promising and allows not only to reduce significantly organic compounds in water content, but also iron, nitrogen-containing compounds, and to improve organoleptic properties of both water and alcoholic beverages with its use.

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