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MEMBRANE AND SORPTION MATERIALS AND TECHNOLOGIES: PRESENT AND FUTURE

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CHAPTER 11

DEEP PROCESSING OF PERMEATE AFTER NANO-FILTRATION (NF) OF MILKY WHEY

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Abstract. *The method of deep processing of nano-filtration permeate of milk whey is proposed and scientifically substantiated, using ozonation and electrodialysis processes. The ozonation station can remove up to 96 % of organic compounds of NF permeate, and the amount of dissolved ozone in this case should be 20...28 mg/dm^3. This treatment allows us to fully utilize NF permeate in the future. It has been established that in order to achieve the posteffect of the impossibility of microflora in the ozone-treated nanofiltration permeate, the minimum amount of dissolved ozone should not be less than 2,5 mg/dm^3.*

Keywords: *membrane separation, ozone, ozone-gas mixture, nanofiltration permeate, organic pollution.*

Introduction. During the production of cheeses, a large amount of whey is produced, which in most cases is processed at the nanofiltration station (NF). The essence of the process implies in concentrating of milk whey to the content of dry matter of 20±3 % while simultaneously desalting it by 25-.30 %. The thus obtained concentrate is preferably dewatered during spray drying and has improved organoleptic properties. Nevertheless, the formation of NF permeate requires further processing due to the high value of chemical oxygen demand (COD) and the content of monovalent ions, which can be further used in remineralization and mineralization of drinking water. This required appropriate research, due to the lack of effective processing technologies for NF permeate. The purpose of this work was to develop a scheme for maximally deep processing of nano-filtration permeate of milk whey.

Experimental. The installation for experimental studies is shown in Figure 11.1. Its principle of action is the following. The compressor, which is mounted in the body of the concentrator of oxygen 1, is absorbed by air from the environment. First, the air goes through a coarse filter for separating large suspended impurities, and then into a dehumidifier, to reduce the moisture content. Further, there is concentration of oxygen in the air to 90-95 %. The resulting oxygen concentrate enters the ozonator 2. Due to the electrical discharge in the discharge chamber, the ozonator is produced by ozone. Its content in the gas mixture was about 4-6 %.

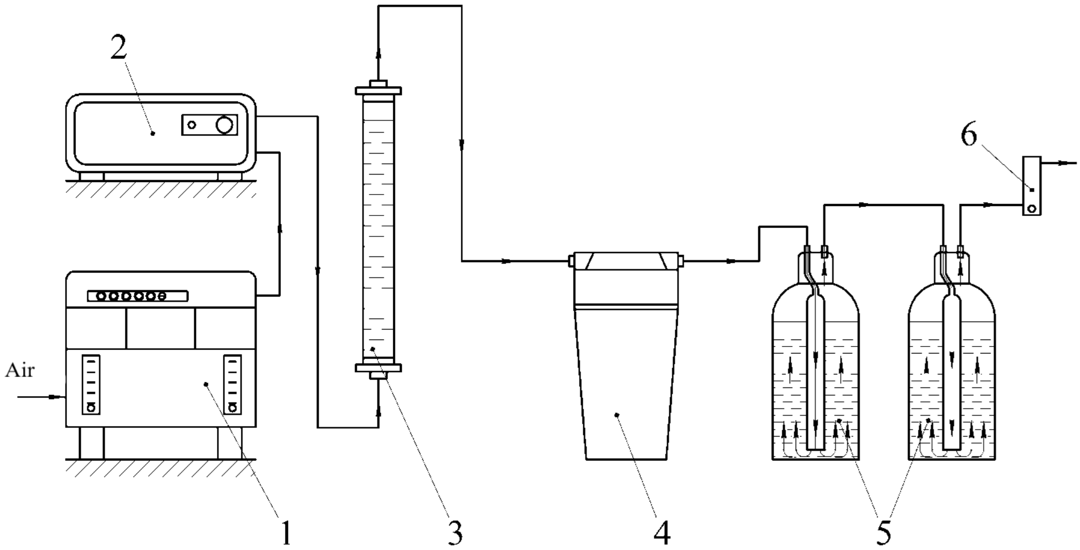

Fig. 11.1. *Scheme of laboratory installation for ozonation.*

The ozonation process took place in the contact capacitance 3. This is a cylindrical reactor with a body height of 0,34 m, an internal diameter of 0,032 m. The total volume of the contact capacity is 0,5 dm^3, the working volume is 0,4 dm^3. Through the connecting tube, the ozone-gas mixture came to the bottom of the contact tank, where the grid-distributor was installed, and fell into the working volume of the apparatus. Passing through the layer of the processed solution, the residual ozone proceeded from the upper part of the apparatus, passed through the foam trapper 4 and two glasses of Drexel 5 with a solution of potassium iodide (KI). The amount of ozone was determined by the iodometric method. Its essence is captured in determining the amount of iodine, which in the equivalent amount ($I:O_3$ = 1:1) is formed when the ozone-gas mixture passes through the KI solution.

Results and discussion. The application of the ozonation station is due to the following:

1. Ozone is a very powerful oxidant.
2. The production of ozone occurs at the place of its use and without the use of any additional reagents.
3. The main product of the decay of ozone is oxygen, which is safe for humans.

On the basis of new experimental data and previous studies the hardware-technological scheme of NF permeate processing was proposed [1]. The principle of the proposed scheme is as follows.

After the baths, the milk serum is sent to the NF station, where it is divided into NF permeate and concentrate. The latter, with a content of dry matter of 20±3 %, is sent to the final condensation in vacuum evaporators and dried to further obtain valuable components from it. The resulting NF permeate is fed to an ozonation station, where it is treated with ozone in the contact capacity. It contributes to the oxidation of organic compounds and the disinfection of the solution. It was found that the combination of ozonation and subsequent sorption purification reduces the COD in NF permeate by 96 % (Figure 11.2) [2, 3].

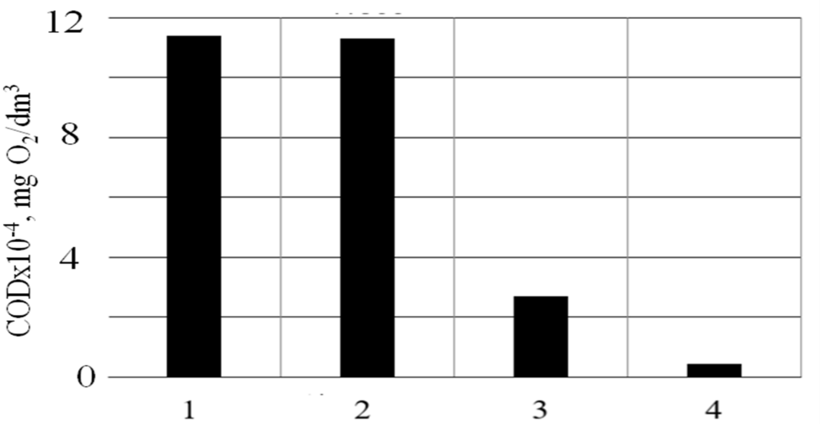

Fig. 11.2. *Chemical oxygen demand. 1 – output NF permeate; 2 – NF after ozonation; 3 – NF permeate after sorption; 4 – NF permeate after ozonation and sorption (adapted from [4]).*

The treated solution after the ozonation and filtration through the layer of activated carbon is concentrated to the state, which is needed for reverse osmosis. Due to the preliminary removal of organic components, the performance of reverse osmosis membranes rises by 25-30 % (Figure 11.3) [4], in comparison with the processing method without the ozonation station. This increases the amount of purified water obtained, and the amount of concentrate is reduced twice.

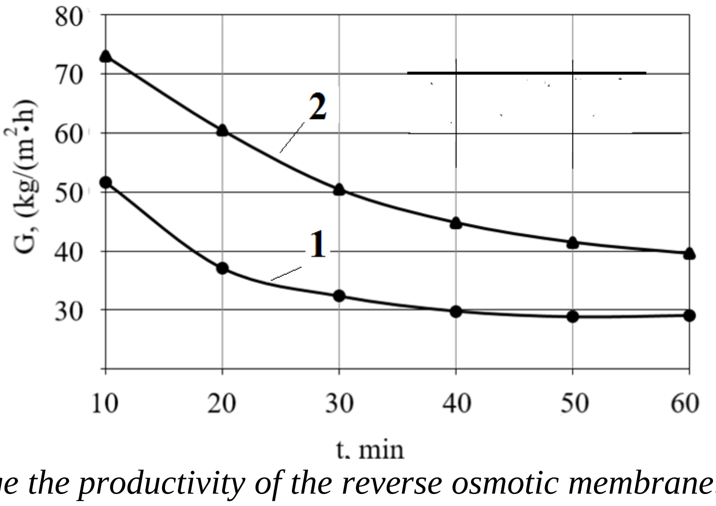

Fig. 11.3*. Change the productivity of the reverse osmotic membrane. G, over time, t (adapted from [4]). The permeate is before (1) and after (2) ozonation.*

The resulting concentrate goes to the electrodialysis station (ED), where the concentration of salts occurs, which can then be used for the mineralization and remineralization of potable water. The use of ED is due to the lack of phase transition of treated substances and direct action on mineral salts during the process of their concentration. The filtrate after reverse osmosis and after ED diluent mixes with residual ozone, which can reach 40-70 % of the initial values at the ozonation station, and is used for washing the equipment. Mixing with residual ozone is necessary for two reasons: first, such a scheme allows to save on the establishment of an ozone destructor for the residual gas mixture; second, such an operation allows the solution to saturate with ozone with a residual concentration of 0,1 mg/dm^3, which makes it impossible to develop pathogenic microflora in such water for 30-60 minutes [5-8] and allows it to be used for washing the equipment. According to the results of experiments (Figure 11.4), in order to determine the required minimum values of the transferred ozone dose (TOD), the total transmitted ozone dose is 2,5 mg/dm^3 in order to achieve the minimum required ozone dose of 0,1 mg/dm^3.

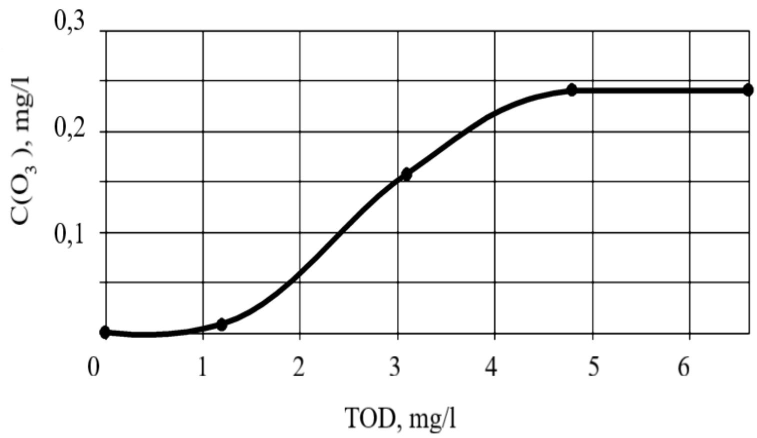

Fig. 11.4. *Dependence of changes in the residual concentration of ozone C(O_3) from transferred ozone dose (TOD).*

Conclusions. According to the results of the work, rational parameters were determined during the processing of NF of milk whey in the ozonation station and the hardware and process scheme of NF permeate treatment was proposed. The ozonation station allows removal of up to 96 % of organic compounds of NF permeate, TOD = 20...28 mg/dm^3. It was established that the ozone using factor, in the case of ozonation of NF permeate, is within 40...60 %. The TOD should be 2,5 mg/dm^3 for a minimum required ozone dose of 0,1 mg/dm^3. The significant benefit of the proposed scheme is the deep processing of NF permeate of milk whey.

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ГЛИБОКА ПЕРЕРОБКА ПЕРМЕАТУ ПІСЛЯ НАНОФІЛЬТРАЦІЇ (НФ) МОЛОЧНОЇ СИРОВАТКИ

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Резюме. *В роботі запропоновано і науково обґрунтовано спосіб глибокої переробки нанофільтраційного пермеату молочної сироватки, шляхом використання процесів озонування та електродіалізу. Станція озонування дозволяє видаляти до 96 % органічних сполук НФ пермеату, кількість розчиненого озону має складати 20…28 мг/дм*^{3} *Встановлено, що для досягнення постефекту унеможливлення розвитку мікрофлори у обробленому озоном нанофільтраційному пермеаті мінімальна кількість TOD не повинна бути меншою 2,5 мг/дм*^{3}.

Ключові слова*: мембранне розділення, озон, озоно-газова суміш, нанофільтраційний пермеат, органічне забруднення.*