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STUDY OF PROPERTIES OF MEMBRANES BASED ON CARBOXYMETHYL CELLULOSE AND CHITOSAN

One of the promising directions is the obtaining of biodegradable nanocomposite membranes, which allow to achieve a high level of purification and do not pollute the environment after their using. Anionic polyelectrolyte – Na-carboxymethyl cellulose with molecular weight M_w ~ 90000 and cationic polyelectrolyte – low molecular weight chitosan were used to create these membranes. Polymeric membranes were formed by mixing aqueous solutions of chitosan hydrochloride and Na-carboxymethylcellulose in different ratios. For study of the mechanical properties of membranes based on natural polymers such as chitosan and Na-CMC, the membranes were tested by the AG-Xplus apparatus by breaking. It was established that the membranes based on chitosan and Na-CMC have high mechanical strength. They can withstand a pressure of more than 5 atmospheres without damage. This makes it suitable for using in various conditions, including industrial ones. A barometric device was used to test the effectiveness of the obtained membranes. The study was conducted at different pressures (3, 4, 5 atm). It was established that membranes based on polyelectrolyte complexes with a stoichiometric ratio of anionic and cationic polyelectrolytes were the most productive.

***Key words**: water purification, polysaccharide, polyelectrolyte complex, polymer membrane, structure, mechanical properties, degree of purification*

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Introduction. Among a number of modern water purification technologies, membrane technologies occupy a leading position. This is primarily due to their high efficiency and environmental friendliness. This especially applies to the obtaining of biodegradable nanocomposite membranes that can be used in a wide variety of fields, including pharmaceuticals, food industry, and medicine [1–11]. Non-toxicity, biocompatibility, as well as high biological activity are the main characteristics of such materials, which are very important in today's conditions, when the volume of wastewater, waste, and pollutants increase annually.

Experimental part. For creating of polymer membranes based on polyelectrolyte complexes, an anionic polyelectrolyte – Na-carboxymethyl cellulose (Na-CMC) with a molecular weight of M_w ~ 90000 (a product of Merck company); cationic polyelectrolyte – chitosan of low molecular weight, degree of deacetylation ~ 85 %, M_w ~ 50,000 – 190,000, a product of the Aldrich company were used.

Protonation of amino groups of chitosan was performed by adding HCl to its 5% aqueous solution until complete dissolution (pH = 6,8).

Polymer membranes were formed by mixing aqueous solutions of chitosan hydrochloride (CS-Cl) and Na-CMC in different ratios.

For study of the strength of the membrane based on natural polymers such as chitosan and Na-CMC, the membranes were tested on mechanical properties by the AG-Xplus apparatus by breaking. This test allows to determine such membrane characteristics as tensile strength, elongation at break and modulus of elasticity.

To check the efficiency of the obtained membranes, they were tested in a barometric installation at different pressures (3, 4, and 5 atm). The turbidity and color indicators were determined using a photoelectric concentration CFC colorimeter-2MP.

Results and their discussion. For researching of mechanical properties of the membrane, which was applied on the paper base with a diameter of 12 cm, is compared with a simple paper (Fig. 1). It was established that mechanical stress of ordinary paper is 11 N/mm^2 and noticeable deformation is 2.2 %. At the same time, the paper base, which has a membrane coating, increased mechanical indicators in several times, namely mechanical stress was 36 N/mm^2 and the deformation was 4 %. Such result can be explained by interacting of Na-CMC and chitosan and forming of complexes which have high strength and elasticity.

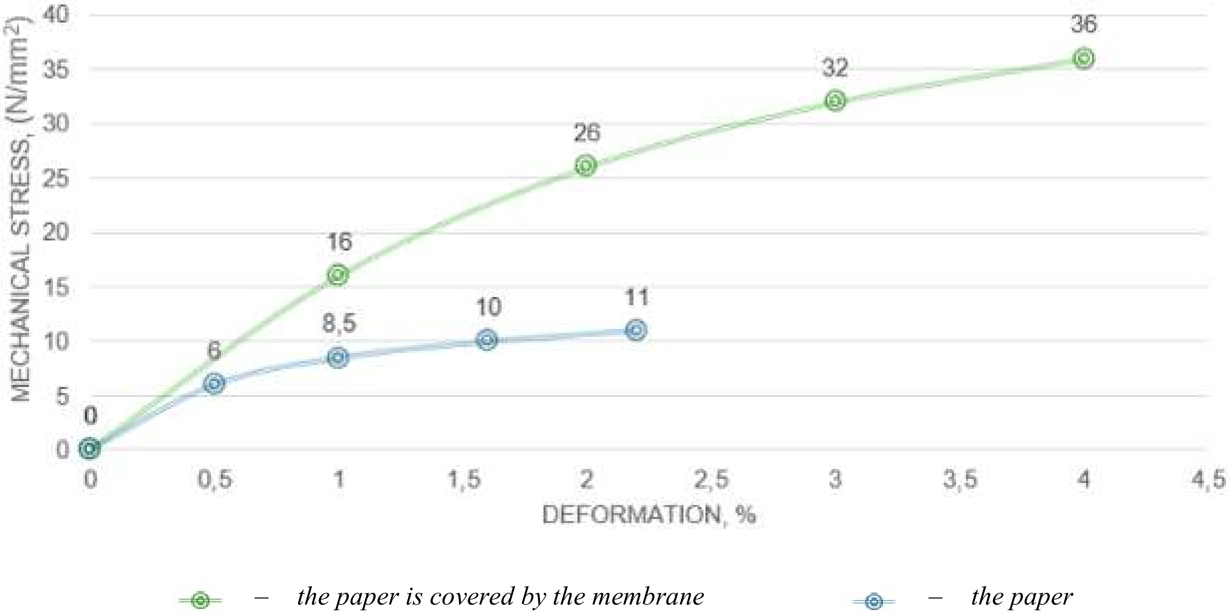

Fig. 1 – Mechanical properties

In the study influence of different factors was also learned on mechanical properties of membranes based on chitosan and Na-CMC. In particular, it was established that tensile strength of membranes increases with increasing of concentration of chitosan in the membrane. In addition, the tensile strength of the membranes also increases with increasing of membrane synthesis temperature.

These results testify that mechanical properties of membranes based on chitosan and Na-CMC are possible regulated by changing the composition and conditions of membrane synthesis. It opens prospects for the development of membranes with improved mechanical properties which will be suitable for a wide range applications.

To check the effectiveness of the obtained membranes, they were tested on a barometric device at different pressures. Membranes based on polyelectrolyte complexes with a stoichiometric ratio of anionic and cationic polyelectrolytes proved to be the most productive. The degree of water purification was checked by indicators of color and color selectivity (Fig. 2), as well as indicators of turbidity and turbidity selectivity (Fig. 3).

From Fig. 2 it can be seen that the selectivity increases at increasing of the duration of cleaning. It can be explained by the fact that at long-term cleaning, the pores of the membrane become clogged, and its permeability decreases, while the cleaning efficiency increases.

On Fig. 2 and 3 we can see that the selectivity increases at increasing of the duration of cleaning. This is explained by the fact that with prolonged cleaning, the pores of the membrane are clogged and its permeability decreases, while the cleaning efficiency increases.

Further, graphs of specific productivity at 4, 5, 6 atmospheres are plotted. The specific productivity (Fig. 4, 5, 6) decreases steadily at 3, 4, 5 atm, which is associated with clogging of the membrane pores.

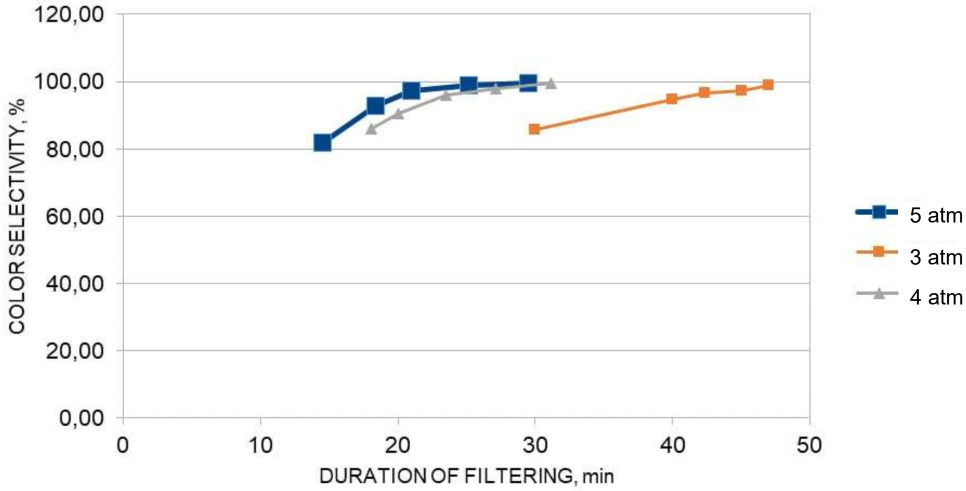

Fig. 2 – Color selectivity

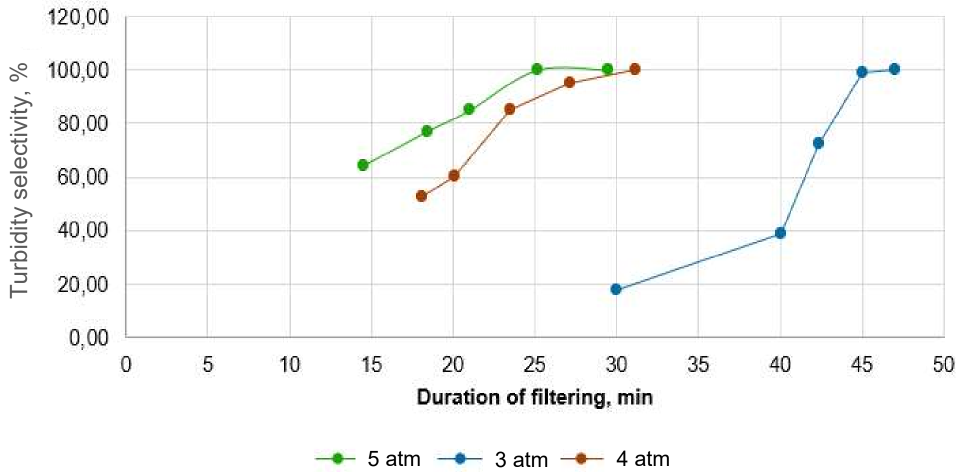

Fig. 3 – Turbidity selectivity

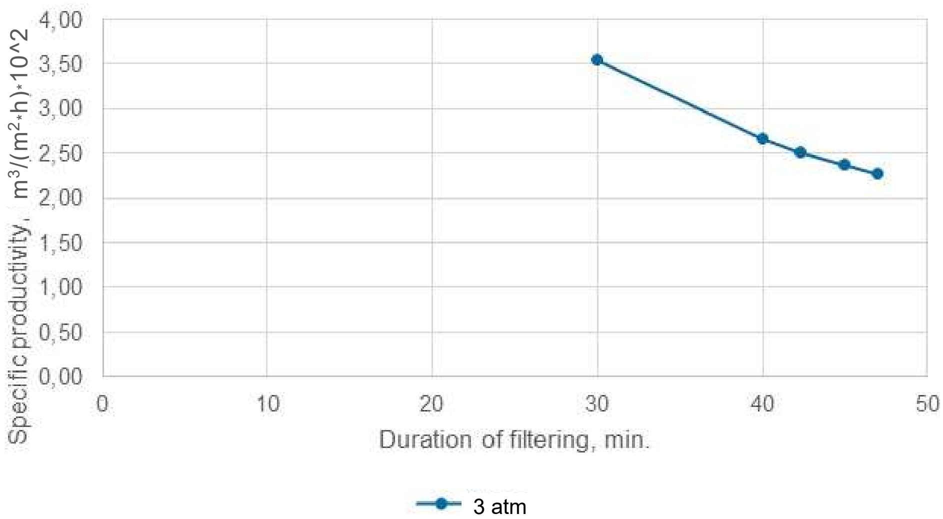

Fig. 4 – Specific productivity at 3 atm

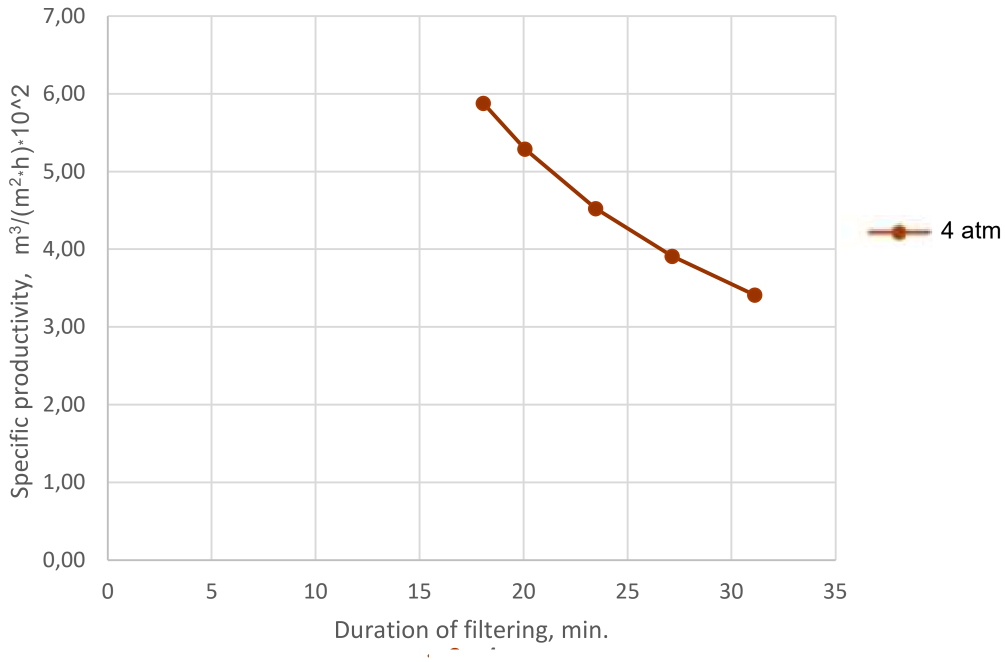

Fig. 5 – Specific productivity at 4 atm

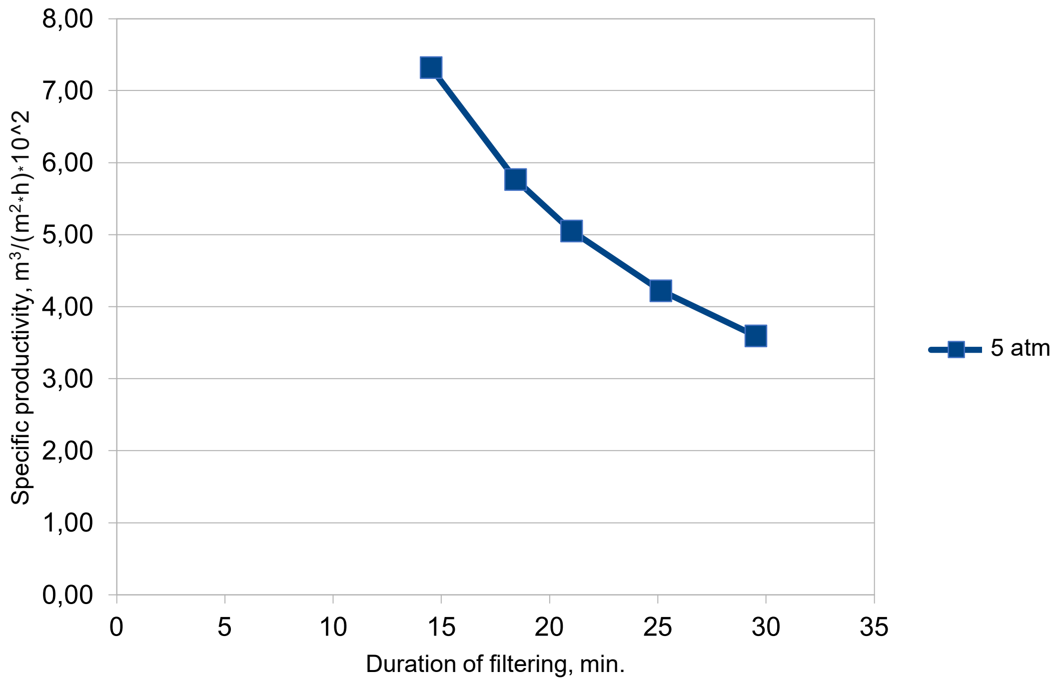

Fig. 6 – Specific productivity at 5 atm

5 atm

Conclusions. Thus, as a result of the researching, it was established that the membranes based on chitosan and Na-CMC have high mechanical strength. They can withstand a pressure of more than 5 atmospheres without damage. This makes it suitable for using in various conditions, including industrial ones.

The cleaning efficiency of the obtained membranes based on chitosan and Na-CMC is also high. The turbidity selectivity of the membranes increases with increasing of cleaning duration. This indicates that the membranes remove more effectively pollutants from the solution during long-term cleaning.

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ДОСЛІДЖЕННЯ ВЛАСТИВОСТЕЙ МЕМБРАН НА ОСНОВІ КАРБОКСИМЕТИЛЦЕЛЮЛОЗИ І ХІТОЗАНУ

З кожним роком споживання води збільшується, і, як наслідок, збільшується кількість як побутових, так і промислових стічних вод. Сучасні технології водопідготовки та водоочищення повинні бути не тільки високопродуктивними, а й екологічними. Тому одним із перспективних напрямків є отримання біорозкладних нанокомпозитних мембран, які дозволяють досягти високого рівня очищення води та не забруднюють навколишнє середовище після їх використання. Для створення цих мембран використовували аніонний *поліелектроліт – Na-карбоксиметилцелюлозу з молекулярною масою M_w ~ 90000 і катіонний поліелектроліт – низькомолекулярний хітозан. Полімерні мембрани формували шляхом змішування водних розчинів гідрохлориду хітозану та Na-карбоксиметилцелюлози в різних співвідношеннях. Для дослідження механічних властивостей мембран на основі природних полімерів, таких як хітозан і Na-карбоксиметилцелюлоза, мембрани випробовували на розрив на апараті AG-Xplus. Цей тест дозволяє визначити такі характеристики мембрани, як міцність на розрив, подовження при розриві та модуль пружності. Встановлено, що мембрани на основі хітозану та Na-карбоксиметилцелюлози мають високу механічну міцність. Вони без пошкоджень витримують тиск понад 5 атмосфер. Це робить їх придатними для використання в різних умовах, в тому числі промислових. Для перевірки ефективності отриманих мембран використовували барометричний прилад. Дослідження проводили при різних тисках (3, 4, 5 атм). Встановлено, що найбільш продуктивними є мембрани на основі поліелектролітних комплексів зі стехіометричним співвідношенням аніонних і катіонних поліелектролітів. Ступінь очищення води перевіряли за показниками кольоровості та каламутності.*

Ключові слова: *очищення води, полісахарид, поліелектролітний комплекс, полімерна мембрана, структура, механічні властивості, ступінь очищення*

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