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INFRARED SPECTROSCOPY IN THE RESEARCH OF STRUCTURAL FEATURES OF MEMBRANES MADE OF MODIFIED CELLULOSE FIBER

Sergii MYLOKOST[1], Vita HALYSH[1,2], Mykola GOMELYA[1]
[1]*Igor Sikorsky Kyiv Polytechnic Institute*
37 Prospect Beresteiskyi, Kyiv 03056, Ukraine
[2]*Chuiko Institute of Surface Chemistry, NAS of Ukraine*
17 Oleha Mudraka Str., Kyiv 03164, Ukraine
e-mail: mylokost@gmail.com

Abstract
This study explores the use of modified cellulose membranes for water purification, focusing on the removal of color from sodium humate solutions. Cellulose, a renewable and eco-friendly polymer, was modified with a 1:1 mixture of monoethanolamine and epichlorohydrin at consumption of 5%, 10%, and 15%. The membranes (80 g/m²) were tested on 100 mg/dm³ sodium humate solutions. Color removal efficiency was highest (98%) with the 15% modified membrane. The infrared spectra confirmed successful modification by the appearance of a peak at 1598 cm⁻¹. The results demonstrate the potential of chemically modified cellulose membranes for sustainable water treatment applications.

Key words: *membrane, cellulose, modified cellulose fibres, natural polymer, water treatment, infrared spectroscopy, epichlorohydrin, monoethanolamine.*

The fast growth of industry and agriculture, along with the industrialization of production, has increased the need for water and wastewater treatment [1]. As clean water becomes less available and environmental rules become stricter, it is important to find better ways to clean and reuse water. One of the most popular and promising methods is membrane technology [2]. It is widely used because it works well, uses little energy, and can remove many types of pollutants. Membrane systems are often used in water treatment plants and factories, and they continue to be improved and modernized.

Cellulose is a good material for making membranes [3]. It is a natural and renewable polymer, which means it is safe for the environment and not expensive. Cellulose also has useful properties, such as good strength, being water-friendly (hydrophilic), and resisting many chemicals. These features make cellulose-based membranes suitable for filtering water, cleaning industrial waste, and making drinking water safer. Also, cellulose can be changed or mixed with other materials to improve its performance, which makes it a flexible option for new membrane technologies [4].

The modification of the prepared cellulose material was performed using a 4% mass concentration of cellulose in the solution. To improve the structural and functional properties of the resulting membranes, modifying agents were added in amounts ranging from 5% to 15% by weight, relative to the total mass of the cellulose fibers. A mixture of monoethanolamine (MEA) and epichlorohydrin ensuring a balanced interaction between the reactive functional groups of both substances. Modified cellulose with a modifier content of 5, 10, and 15% was used to prepare membrane samples with a mass of 80 g/m², which were formed on a synthetic fabric in a Büchner funnel. The obtained membranes were air-dried and evaluated for their ability to reduce color in model water solutions containing sodium humates at a concentration of 100 mg/dm³.

The results of laboratory studies on the change in permeate color over permeate collection time are presented in Fig.1. The color of the selected permeate samples was measured at 400 nm using a photoelectric colorimeter. While the 15% modifier membrane exhibited the best ability to reduce the color of the sodium humate solution, the 5% and 10% membranes were only slightly less effective in this regard. Ultimately, the 15% modifier membrane provided the highest efficiency (98%) and lowest residual color when filtering a 100 mg/l sodium humate solution.

The infrared spectra of the obtained cellulose membrane samples from modified fiber, in comparison with unmodified fiber, are presented in Fig. 2.

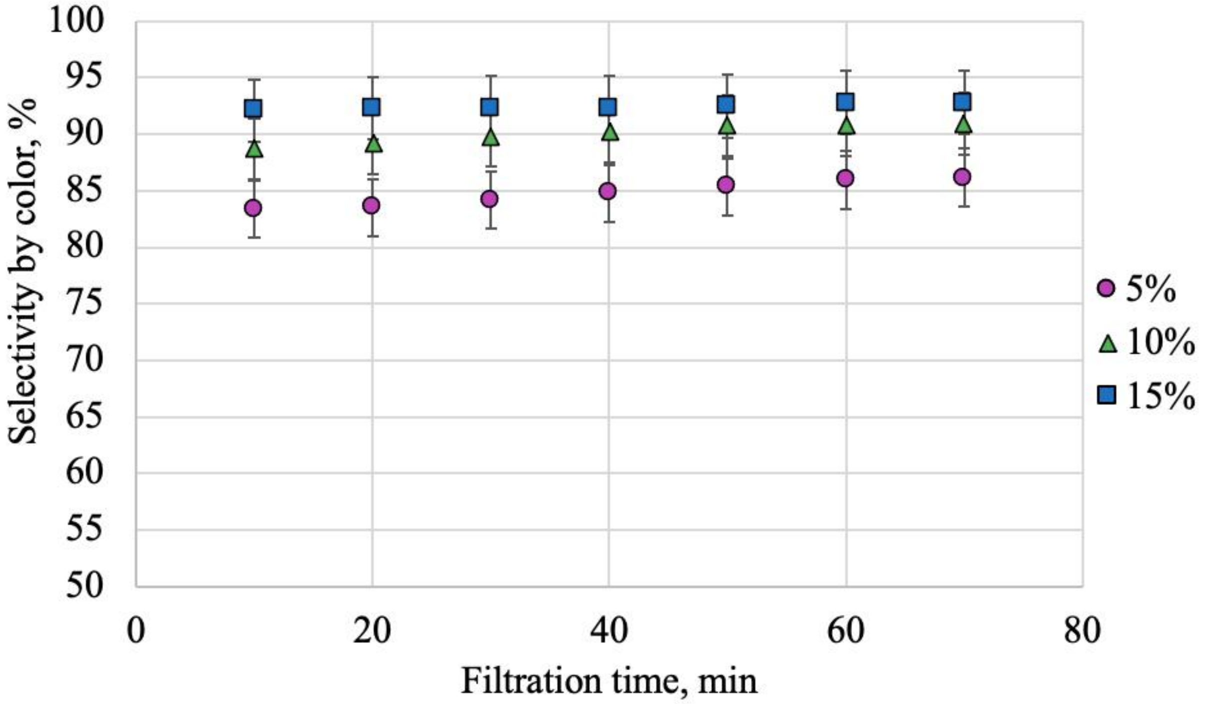

***Figure 1**. Influence of filtration time on color selectivity during filtration of sodium humate solution using cellulose membranes with varying modifier conten*

The presented spectra reveal a new absorption peak at 1598 cm⁻¹ in the modified cellulose samples, a characteristic signal for the N-H bending vibrations in NH_2 groups. This band is absent in the original cellulose spectrum. Furthermore, the intensity of this peak at 1598 cm^{-1} increases with higher modifier content, indicating effective immobilization of the modifier within the membrane structure.

The obtained results will form the basis for further research aimed at optimizing the conditions for obtaining and utilizing membranes made from modified cellulose fiber.

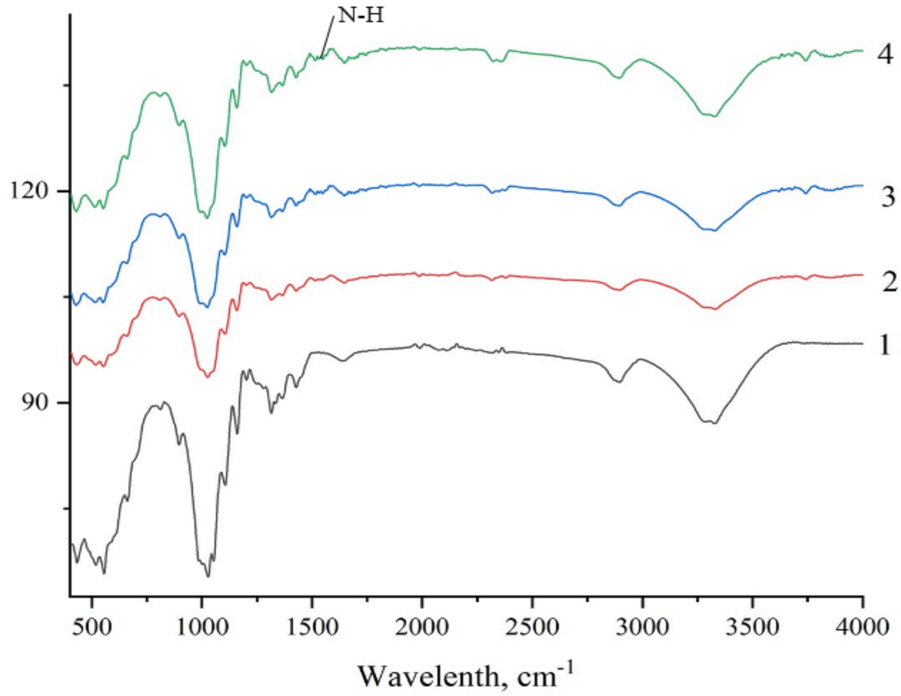

Figure 2*. IR spectra of membranes made from cellulose fiber with different modifier content: 1 - 0, 2 - 5%, 3 - 10%, 4 - 15%.*

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ІНФРАЧЕРВОНА СПЕКТРОСКОПІЯ В ДОСЛІДЖЕННІ СТРУКТУРНИХ ОСОБЛИВОСТЕЙ МЕМБРАН З МОДИФІКОВАНОГО ЦЕЛЮЛОЗНОГО ВОЛОКНА

Сергій МИЛОКОСТ
Київський політехнічний інститут імені Ігоря Сікорського
пр. Берестейський, 37, м. Київ, 03056, Україна
https://orcid.org/0009-0007-8892-8426

Віта ГАЛИШ
Київський політехнічний інститут імені Ігоря Сікорського
пр. Берестейський, 37, м. Київ, 03056, Україна
Інститут хімії поверхні ім. О.О. Чуйка НАН України
вул. Олега Мудрака, 17, м. Київ, 03164, Україна
https://orcid.org/0000-0001-7063-885X

Микола ГОМЕЛЯ
Київський політехнічний інститут імені Ігоря Сікорського
пр. Берестейський, 37, м. Київ, 03056, Україна
https://orcid.org/ 0000-0003-1165-7545

Анотація

Це дослідження стосується використання модифікованих целюлозних мембран для очищення води, зосереджуючись на видаленні кольоровості на прикладі розчину гумату натрію. Целюлозу, відновлюваний та екологічно чистий полімер, модифікували сумішшю моноетаноламіну та епіхлоргідрину у співвідношенні 1:1 з витратами 5%, 10% та 15%. Мембрани (80 г/м²) тестували на розчинах гумату натрію з концентрацією 100 мг/дм³. Ефективність видалення кольоровості була найвищою (98%) для 15% модифікованої мембрани. ІЧ-спектри підтвердили успішну модифікацію появою піку при 1598 см$^{-1}$. Результати демонструють високий потенціал використання модифікованих целюлозних мембран.

Ключові слова: мембрана, целюлоза, модифіковані целюлозні волокна, природний полімер, водоочищення, інфрачервона спектроскопія, епіхлоргідрин, моноетаноламін.