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ENHANCEMENT OF FLUX BY SURFACTANT TREATMENT OF UF MEMBRANE

In ultrafiltration, a flux enhancement due to pretreatment of membranes with various kinds of surfactants has been studied. A fundamental method of approach to the membrane-surfactant interactions is also presented. A nonionic (Triton X-102) surfactant and two anionic (Tencid and Tergitol NP-7) surfactants were investigated. The ultrafiltration experiments were carried out with Sartorius nonsorptive (cellulose triacetate) and sorptive (polysulfone) membranes. The membrane ultrafiltration performance as a function of time, the pressure applied and protein concentration factor was investigated. Sorptive membranes exposed to the surfactants showed neither a pronounced reduction nor increase in fluxes; however, variation in fluxes was observed for nonsorptive membranes. The properties of the membranes depend on the type of polymer material, time of exposure, concentration of surfactant and the extent of change in membrane pores during pretreatment. A pronounced influence of surfactants was demonstrated for surfactant pretreated membrane during ultrafiltration of bovine serum albumin (BSA). Finally, the pure water flux performance of the pretreated membranes for three days and cleaned after a subsequent BSA ultrafiltration was studied.

LIST OF SYMBOLS

- β – compressibility factor (membrane deformation coefficient),
- L_p – membrane hydraulic permeability ($\text{m} \cdot \text{Pa}^{-1} \cdot \text{s}^{-1}$),
- ΔP – transmembrane pressure (kPa),
- R_m – membrane resistance ($\text{Pa} \cdot \text{s} \cdot \text{m}^{-1}$),
- R – fouling layer resistance (due to e.g. protein ultrafiltration) ($\text{Pa} \cdot \text{s}^{-1}$),
- R_i – additional resistance due to membrane-reagent interactions ($\text{Pa} \cdot \text{s} \cdot \text{m}^{-1}$),
- t – current operating time (s),
- Q – rate of flux decline (s^{-1}),
- $J_{(m, t)}$ – permeate flux ($\text{kg} \cdot \text{m}^{-2} \cdot \text{s}$),

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- J_0 – permeate flux of pure solvent ($\text{kg} \cdot \text{m}^{-2} \cdot \text{s}^{-1}$),
 J_s – stress flux after membrane immersion in cleaners at different periods of time ($\text{kg} \cdot \text{m}^{-2} \cdot \text{s}^{-1}$),
 J_f – protein flux ($\text{kg} \cdot \text{m}^{-2} \cdot \text{s}^{-1}$),
 J_{A3} – water flux after membrane immersion in cleaners for 3 days ($\text{kg} \cdot \text{m}^{-2} \cdot \text{s}^{-1}$),
 J_{APF} – water flux after BSA ultrafiltration ($\text{kg} \cdot \text{m}^{-2} \cdot \text{s}^{-1}$),
 ΔPC_1 – percentage increase (or decrease) of J_{A3} in relation to J_0 (%),
 ΔPC_2 – percentage increase (or decrease) of J_{APF} in relation to J_0 (%),
 a – area of the membrane (m^2),
 S – interval (immersion time),
 R_{rej} – membrane rejection.

1. INTRODUCTION

Ultrafiltration (UF) is a widely accepted unit operation in a variety of industries. In principle, UF-operation is based on filtering solution through a semipermeable membrane at such a pressure difference which allows the solvent to pass through the membrane and be collected as the ultrafiltrate, while the macrosolute is retained by the membrane. In order to use the membrane again, it should be cleaned to remove the adsorbed macrosolutes. Generally, different solutions (containing e.g. surfactants) are used to clean ultrafiltration membranes for repeated use. It is obvious that cleaning agents affect the membrane properties in different degree. Comprehensive study [1] of membrane cleaning procedure showed that water flux after detergent treatment was more efficient than the original flux. On other hand, it has been observed that detergent macrosolutes were retained by ultrafiltration membranes [2]–[4]. Further, the widespread idea that cleaning or sanitizing agents do not interact in an effective way with the membrane is questioned by membrane manufacturers [5], [6]. For example, nonionic surfactant (Triton X-100) caused the decrease in flux of the polysulfone membrane [7]. The use of a 1% Ter-g-zyme solution with Amicon PM membrane is termed questionable by the membrane producer [6], while the detergent manufacturer recommends the use of 0.75% Ter-g-zyme. MADSEN [8] warned of a catastrophic irreversible flux decline observed for the cellulose acetate membrane after its contact or treatment with the cationic surfactant solution. It is evident that most studies undertaken to define the interactions between the membrane and the surface active agents were aimed at improving the membrane performance [8], [9]. However, according to the authors' opinion, the lack of systematic studies on the use of surfactant for UF membrane characterization indicates the need for more detailed research in this area. Investigations of the effect of treating or contacting a membrane with surface active agents for several periods of time on the UF performance were therefore carried out with some commercially available synthetic UF membranes and the results are presented in this paper.

2. THEORY

The transport of pure solvent through ultrafiltration membranes is a viscous flow phenomenon characterized by the absence of surface fouling, membrane-solute interaction and concentration polarization. For this reason, the ultrafiltrate flux (solute free water) J depends only on transmembrane pressure ΔP and intrinsic membrane resistance R_m

$$J_0 = \frac{\Delta P}{R_m}. \quad (1)$$

R_m is a function of temperature only, and since water viscosity μ_0 decreases with temperature, J_0 is inversely proportional to μ_0 . In the case of the stress flux J_s measurement, the hydraulic permeability L_p of the membrane was calculated from the usual formula:

$$J_s = L_p \Delta P. \quad (2)$$

The water flux J measured after the membrane treatment with various cleaners (solutions of organic or inorganic compounds) may be relatively higher or lower compared to the original flux due to membrane-cleaner interaction (unblocking of pores or adsorption in the membrane pores) and/or surface fouling

$$J = \frac{\Delta P}{R_0 + R_i}. \quad (3)$$

R_i in equation (3) denotes an additional resistance due to membrane-solute interaction. In the case of unblocking of pores ($R_i = 0$, no membrane-cleaner interaction), the membrane resistance R_m will definitely decrease. Therefore, a considerable increase in membrane water flux J (see eq. (3)) will be observed.

The solute adsorption in membrane pores and/or surfactant fouling (occurring due to physical adsorption in the membrane and/or surfactant micelle formation inside the pores) cause a decrease in permeate flux J (eq. (3)).

In the case of protein ultrafiltration, the permeate flux J_f or water flux after protein ultrafiltration is affected by additional hydraulic resistance, mostly known as the fouling layer resistance R_f :

$$J_f = \frac{\Delta P}{R_m + R_i + R_f}. \quad (4)$$

As a consequence of this, the protein flux is a function of concentration and the type of macrosolutes and/or the presence of suspended solids, transmembrane pressure, channel velocity, gel-layer concentration characteristics and operating time.

According to KOLTUNIEWICZ [11] more reasonable approximation of permeate flux is given by the following equation:

$$J_1 = \frac{\Delta P}{R_m} \exp(-\beta \Delta P) \quad (5)$$

where β denotes the compressibility factor. The additional resistance $R_i = (\Delta P/J)$ deduced from equation (3) was verified by introducing the logarithmic equation of nonlinear function of flux J (eq. (5)) versus pressure difference ΔP :

$$\ln R_i = \ln R_0 + \beta \Delta P \quad (6)$$

where R_m is the normal membrane resistance, and R_i denotes the resulting resistance due to membrane contact with reagents (e.g. cleaners or surface active agents). Linear regression equations can be adjusted by the least square method.

In this paper, the semiempirical surface renewal model developed in our laboratory [11] was applied. This model is based on the definition according to which the unsteady flux $J(t)$ through a membrane of a given surface is equal to the flux decline obtained during unstirred batch cell ultrafiltration (figure 1). By use of

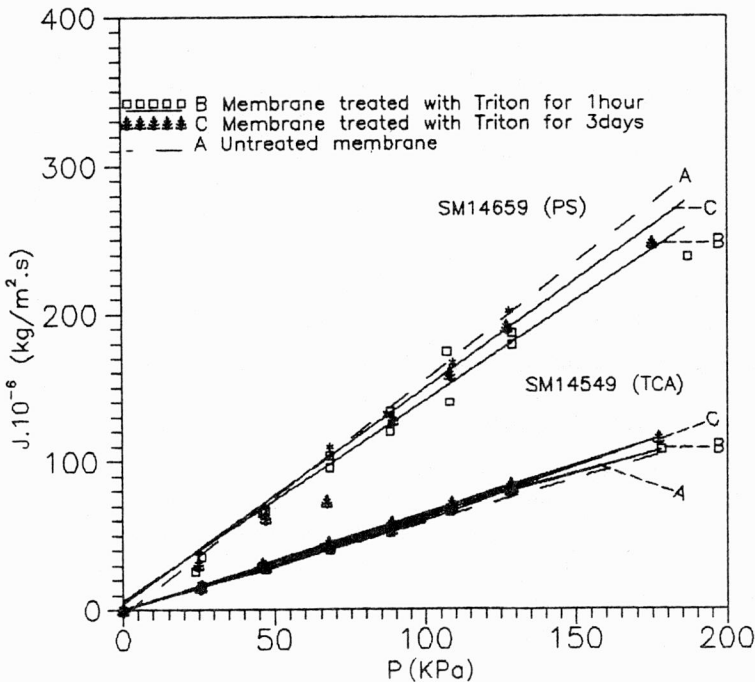


Fig. 1. The effect of Triton X-102 on pure water permeability of membrane after its immersion in the nonionic surfactant for one hour and three days, respectively

this model, much information on both membrane-solute as well as membrane-cleaner interactions can easily be evaluated. For example, the rate of flux decline (Q) as a function of operating time can be calculated from the experimental results

according to the following formula:

$$J_{(m,t)} = (J_0 - J_{\min}) \exp(-Qt) + J_{\min} \quad (7)$$

where Q , J_0 and J_{\min} are the experimental parameters. A straight line is obtained by applying a semilogarithmic scale.

3. MATERIALS AND METHODS

3.1. MEMBRANE

The membranes used were SM 14659 polysulfone (PS) and SM 14549 cellulose triacetate (TCA) membranes manufactured by Sartorius, Germany. The nominal cut-offs of these membranes were 30 000 and 20 000 daltons, respectively. The diameter of each membrane sample was equal to 63 mm.

3.2. CHEMICALS

The chemicals used in this study were: surfactants of Triton series manufactured by Rohm & Haas Co., U.S.A.; Tergitol NP-7 produced by Union Carbide co-operation, U.S.A., Tencid - HC-ST produced by Henkel KGaA in Düsseldorf, Germany. The properties of the surfactants are shown in table 1. The surfactants differ in the structures of hydrocarbon chains (i.e. in the hydrophobicity). In the Triton series, the chains include aromatic rings, while in Tergitol the chains are mainly linear and branched.

Table 1a

Properties of series of surfactants

Surfactant nonionic	Number X^b	mm ($\text{g} \cdot \text{mol}^{-1}$)	hlb	Solubility	ST*	Physical form
Triton X-102	12	756	14.3	readily soluble	32	liquid

*ST - surface tension; X^b - ethylene oxide value.

Table 1b

Properties of series of surfactants

Surfactant anionic	Density ($\text{g}\cdot\text{cm}^{-3}$)	pH	Colour	Solubility	ST*	Physical form
Tergitol NP-7	1.056	5.3	none	miscible	34	liquid
Tencid HC-ST	1.000	1.9	yellow	readily soluble		liquid

*ST – surface tension.

The bovine serum albumin solution used was manufactured by P.P.H. Polskie Odczynniki Chemiczne, Kraków, Poland. The nonionic surfactant–membrane relationship was verified by immersion of each membrane in surfactant solution of concentration below critical micelle concentration (CMC).

3.3. APPARATUS

An Amicon cylindrical UF cell model 8200 characterized by a membrane of 63 mm in diameter and 200 cm^3 capacity was employed. The pressure was controlled by nitrogen gas supplied from the gas cylinder.

The instantaneous permeate flux was measured with the use of an electronic balance (Shimadzu, Japan, Libra EB-3200H, serial BCD).

3.4. ULTRAFILTRATION EXPERIMENTS

Prior to the experiments, clean membranes were first tested for their pure water flux to determine the intrinsic hydraulic resistance R of the membrane. Then, each membrane was immersed in cleaner solutions of different concentrations for various periods of time t (from 1 to 72 hours) and water flux J_0 at constant pressure of 100 kPa was measured after each immersion in cleaning agents. These were follow-stress flux J measurements as a function of transmembrane pressure ΔP in the range of 0–250 kPa. The stress flux was measured after the steady state had been achieved for both increasing and decreasing pressures. After each operation (e.g. ultrafiltration after one hour immersion in cleaner) the same membrane was immersed back in the same reagent for another intervals of time (one day and three days) before repeating the test for water and stress fluxes.

After the final pretreatment test of the membrane, it was washed with water and the ultrafiltration performances of double ultrafiltered water at 50 kPa and 2 $\text{g}\cdot\text{dm}^{-3}$ BSA solution at 20 kPa were investigated with the SM 14659 and 14 549 membranes. The pH value of the solutions was 5.23.

The protein sample concentrations were measured by a sensitive Lowry's method (based on Peterson's modification of the micro-Lowry method [17]), using a Carl Zeiss Jena spectrophotometer (Model VSV2-P).

The mean flux value for each sample collected was calculated as the function of time t and permeate mass m per unit area a of the membrane

$$J_{(m, t)} = \frac{(m_2 - m_1)}{a(t_2 - t_1)} \quad (8)$$

The membrane rejection R_{rej} during ultrafiltration of macromolecules was calculated as follows:

$$R_{rej} = 1 - \frac{C_p}{C_b} \quad (9)$$

The cleaning procedure for these experiments was as follows: after UF process, the membranes were cleaned in 0.1 M NaOH, followed by the passage of double ultrafiltered water for 20 minutes; these membranes were again cleaned in 0.1 M HCl, followed by the passage of double ultrafiltered water for another 20 minutes, and finally they were cleaned in 0.5 M NaCl, followed by the passage of double ultrafiltered water.

4. RESULTS AND DISCUSSION

The results obtained for polysulfone and cellulose triacetate membranes after their treatment with cleaners are presented at first. The experiments involving ultrafiltration of bovine serum albumin are reported in the next paragraph.

4.1. STRESS FLUX

The effect of the surfactant treatment on the membrane flux for PS (SM 14659) and TCA (SM 14549) membranes is shown in figures 1–3. It can be seen that the pure water permeability for the PS membrane slightly decreased after the membrane contact with the nonionic surfactant Triton X-102, while the TCA membrane treated with the same surfactant showed almost no change in the pure water permeability (figures 1 and 2). In the case of membrane treatment with other nonionic surfactant, i.e. Tergitol, a substantial decrease in water permeability was observed for both membranes in the initial period of immersion (one hour), as shown in figure 3.

Membrane treatment with Tergitol solution for three days changes the permeability of both membranes. The initial increase in permeability of the PS

membrane (within the pressure range up to 80 kPa, shown in figure 3) could be attributed to long lasting soaking effect which was produced below the critical micelle concentration (CMC).

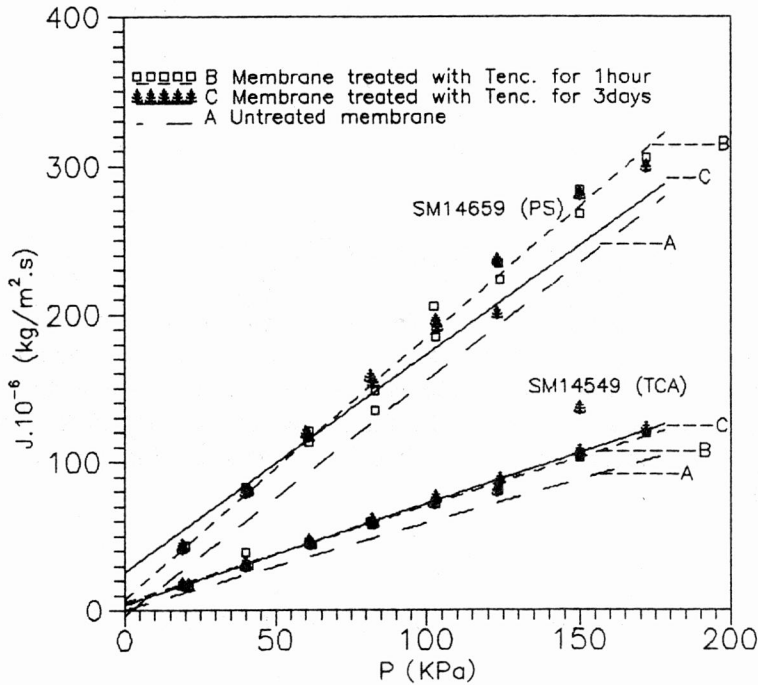


Fig. 2. The effect of Tencid HC-ST on pure water permeability of membrane after its immersion in the surfactant for one hour and three days, respectively

The exceptional behaviour of the PS membrane during its treatment with nonionic surfactants is first of all a consequence of interactions between the membrane and the hydrophobic part of the surfactant molecules, leading to adsorption within the membrane pores, since the membrane pore diameters are much more greater than the size of surfactant molecules. The phenomenon of concentration polarization rather does not occur, since the same experiment on cellulose triacetate membrane showed no significant decrease in flux. Another reason of the exceptional behaviour of the PS membrane (e.g. swelling) involves the PS membrane material during its treatment with the surfactant solutions.

The ultrafiltration performance of the bovine serum albumin solutions for the PS and TCA membranes (treated with surface active agent and untreated) are shown in table 2. Although the shapes of curves representing the protein fluxes for the same membrane materials are similar, they differ substantially after the membrane treatment with various cleaners. This could be conformed to the results of the rate of protein flux decline [11] shown in table 2.

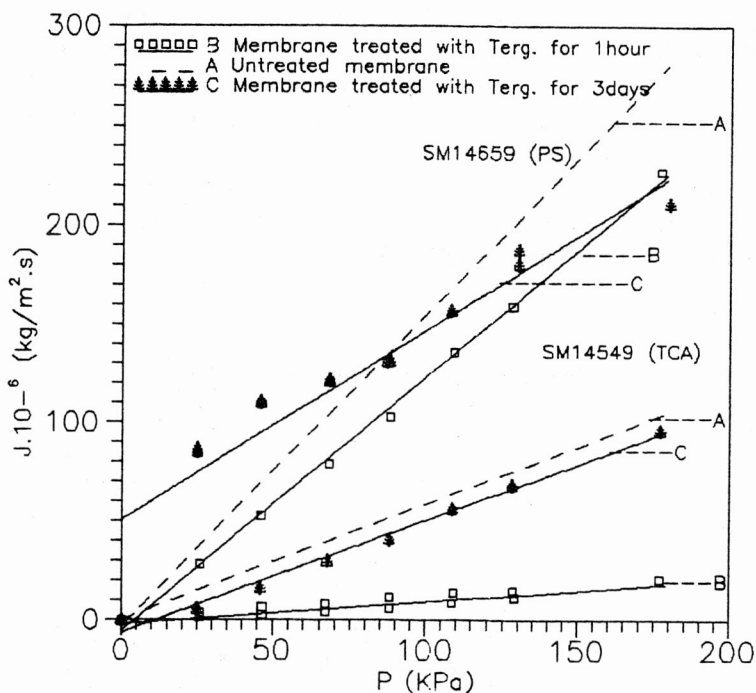


Fig. 3. The effect of Tergitol NP-7 on pure water permeability of membrane after its immersion in the surfactant for one hour and three days, respectively

Table 2

Results of the solute rejection and rate of flux decline Q for bovine serum albumin ultrafiltration through the TCA (SM 14549) and PS (SM 14659) membranes

Membrane	Parameters		Parameters determined experimentally							
	Mean pore radius r (10^{-9} m)	Pre-treatment	R_{rej} (%)	ΔP (kPa)	C_b ($kg \cdot m^{-3}$)	C_p ($kg \cdot m^{-3}$)	Q ($10^3 s^{-1}$)	J_{max} ($10^{-6} kgm^{-2}s^{-1}$)	J_{min} ($10^{-6} kgm^{-2}s^{-1}$)	t_{max} (min)
PS	4.7	none	89.3	20.0	0.956	0.031	0.281	9.64	1.40	850
		Triton	75.1	20.0	0.069	0.003	0.236	7.35	1.31	788
		Tencid	98.1	20.0	0.127	0.006	0.198	6.28	5.08	975
		Tergitol	91.8	20.0	0.075	0.006	0.232	9.25	1.15	707
TCA	5.0	none	98.4	20.0	1.909	0.041	0.176	6.51	0.97	436
		Triton	93.8	20.0	0.069	0.004	0.498	8.63	1.39	1100
		Tencid	95.5	20.0	0.069	0.003	0.341	8.17	1.47	781

The slight decrease in protein flux presented in table 2 (membranes pretreated with Triton X-102 and Tencid) for the BSA ultrafiltration is mostly owing to the changes in membrane matrix as a consequence of modification of its surface by surfactant. For the same reason an inconsiderable increase in pure water flux was observed (table 3). This is in agreement with the papers [12], [13]. It must be considered, however, that the fluxes for the same type of membranes vary, even when experiments are carried out under the same conditions and the values of water fluxes before pretreatment are similar (table 3).

Table 3

Effects of cleaning agents on water flux

Chemicals	J_0 ($\text{m}^3 \cdot \text{m}^{-2} \cdot \text{s}^{-1}$)	J_{A3}	ΔPC_1 (%)	J_{APF} ($\text{m}^3 \cdot \text{m}^{-2} \cdot \text{s}^{-1}$)	ΔPC_2 (%)
SM 14659 (PS)					
BP*	171.17	171.81	+ 0.49	85.25	-50.19
Triton X-102	170.56	191.06	+ 12.02	136.59	-19.92
1% Tencid	171.71	196.03	+ 14.82	102.59	-40.25
Tergitol NP-7	171.26	125.33	-26.82	23.55	-86.25
SM 14549 (TCA)					
BP*	67.46	68.90	+ 2.13	49.39	-27.99
Triton X-102	67.48	70.17	+ 3.99	66.33	-4.19
1% Tencid	67.72	73.90	+ 7.54	70.31	-27.07
Tergitol NP-7	67.62	9.01	-86.87	-	-

*BP - before immersion in cleaning agents.

This behaviour could be a consequence of possible interactions between the protein and the cleaner particles, which depend on the degree of reciprocal affinity of the substances applied (e.g. hydrophobic and hydrophylic conditions, electrostatic charge, surface tension, temperature, etc.). This is also in agreement with other papers [14], [16] that the interactions between various soluble proteins and nonionic surfactant lead to changes in both membrane pores and flux performance.

The results of further investigations on membrane interaction with cleaning agents are summarized in table 2. It can be seen that detergents soak the PS membrane which causes a decrease in rejection of the solute BSA (pretreatment with Triton X-102) and increase in rejection of the same solute (pretreatment with Tencid and Tergitol NP-7). The TCA membranes pretreated with Triton X-102 and Tencid showed a decrease in rejection of BSA.

In the literature, the membrane-solute interactions are often ignored, since the investigations are aimed at the effect of detergent pretreatment on membranes.

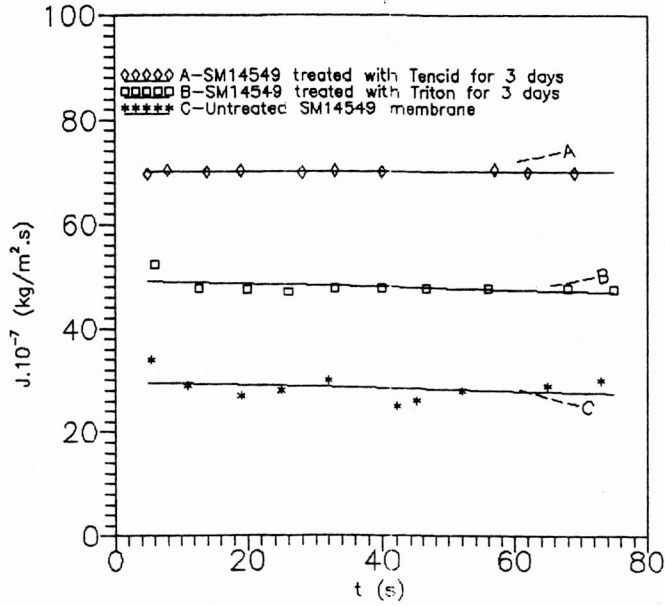


Fig. 4. Pure water flux through surfactant treated membranes cleaned after ultrafiltration of $1 \text{ g} \cdot \text{dm}^{-3}$ BSA. SM 14549 cellulose triacetate membrane

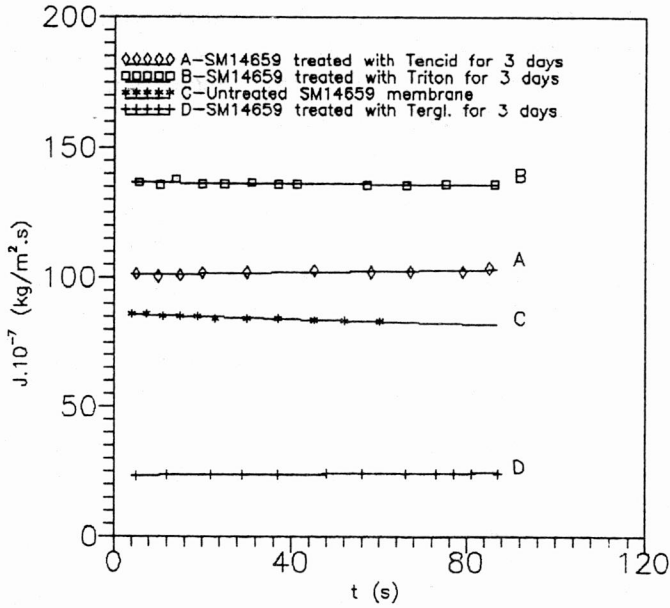


Fig. 5. Pure water flux through surfactant treated membranes cleaned after ultrafiltration of $1 \text{ g} \cdot \text{dm}^{-3}$ BSA. SM 14659 polysulfone membrane

Despite the fact that removal of adsorbed macromolecules by surfactant during UF membrane process is commonly applied, the increase in flux due to surfactant pretreatment has been rarely reported in the membrane separation process.

The influence of surfactant pretreatment on the PS and TCA membrane properties seems to be reversible. This can be deduced from the curves shown in figures 4 and 5. In these figures, the pure water flux of untreated membranes is shown first and then the same pure water flux for the same membranes pretreated with either nonionic or anionic surfactant for three days and cleaned after bovine serum albumin ultrafiltration. It is evident that pure water flux for both pretreated membranes is relatively efficient when compared with the untreated membranes (table 3). This proves that detergent or surfactant could be to some extent helpful in enhancement of flux reversibility of a given ultrafiltration process.

5. CONCLUSIONS

The results obtained in this investigation can be essential in determining some parameters characteristic of ultrafiltration membrane-cleaner interactions.

There is a distinct difference between hydrophilic and hydrophobic UF membranes when they are treated or contacted with surfactants. The water flux of hydrophobic membrane (PS) decreased (after contact with Tergitol NP-7), and increased substantially after three-day pretreatment with surfactant (Tencid HC-ST and Triton X-102). The water flux of TCA membrane contacted with Triton X-102 and Tencid HC-ST was essentially constant.

REFERENCES

- [1] SWAMINATHAN T., Ph.D. Thesis, Indian Institute of Technology, Kanpur 1978.
- [2] PALMER J.A., HOPFENBERG H.B., FELDER R.M., *J. Colloid. Interface Sci.*, 45, 223 (1973).
- [3] BHATTACHARYA D., BEWLEY J.L., GRIEVES R.B., *J. Water Poll. Contr. Fed.*, 46, 2372 (1974).
- [4] BHATTACHARYA D., GARRISON K.A., JUMAWAN A.B., GRIEVES R.B., *AIChEJ*, 21, 1057 (1975).
- [5] *Workshop discussion on ultrafiltration and reversible osmosis*, N.Z.J. Dairy Sci. Technology, 14 (1970), 96.
- [6] Anonymous, *Products for separations technology*, Amicon Publication, No. 553, p. 12.
- [7] DOULIA Q., GEKES V., TRÄGÄRDH G., *Interaction behaviour in ultrafiltration of nonionic surfactants*. Part 1, *J. Membrane Sci.*, 69 (1992), 251–258.
- [8] MADSEN R.F., *Membrane concentration in advances preconcentration and dehydration of foods*, ed. by A. Spicer, Applied Science Publishers, London 1974.
- [9] GIBBS L.L., SCAMEHORN J.F., CHRISTIAN S.D., *Removal of n-alcohols from aqueous streams using micellar enhanced ultrafiltration*, *J. Membrane Sci.*, 30 (1987), 67–74.
- [10] MOREL G., GRACIAA A., LACHAISE J., *Enhanced nitrate ultrafiltration by cationic surfactant*, *J. Membrane Sci.*, 56 (1991), 1–12.

- [11] KOŁTUNIEWICZ A., *Predicting permeate flux in ultrafiltration on the basis of surface renewal concept*, J. Membrane Sci., 68 (1992).
- [12] BHATTACHARYA D. et al., *Ultrafiltration characteristics of oil-detergent-water systems: membrane fouling mechanisms*, Sep. Sci. Technol. 14 (6) (1979), 529-549.
- [13] FANE A.G., FELL C.J.D., KIM K.J., *The effect of surfactant pretreatment on the ultrafiltration of proteins*, Desalination, 53 (1985), 37-55.
- [14] PIERRE A., BAKLOUTI S., SANCHEZ V., *Membrane-solute interaction influence of pure solvent transfer during ultrafiltration*, J. Membrane Sci., 29 (1986), 207-224.
- [15] WELDRING J.A.G., van't RIET K., *Physical properties of sodium carboxymethyl cellulose adsorbed on a polyacrylonitrile UF-membrane*, J. Membrane Sci., 36 (1988), 127-147.
- [16] SKUDLARSKI K., *Podstawy chemii. Ćwiczenia laboratoryjne*, Wrocław 1982.
- [17] Sigma Catalog, *Biochemicals organic compounds and diagnostic reagents - protein assay kit* (Procedure No. P 5656) 1991.

WPLYW ZWIĄZKÓW POWIERZCHNIOWO CZYNNYCH NA WŁAŚCIWOŚCI TRANSPORTOWE MEMBRAN ULTRAFILTRACYJNYCH

Zbadano zjawisko poprawiania właściwości transportowych membran ultrafiltracyjnych w wyniku ich kontaktu z różnymi związkami powierzchniowo czynnymi. Zaprezentowano również podstawową metodę wyjaśnienia oddziaływań membrana-związek powierzchniowo czynny. W badaniach użyto następujących związków powierzchniowo czynnych: niejonowego (Triton X-102) i dwóch anionowych (Tencid i Tergitol NP-7). Proces ultrafiltracji prowadzono z zastosowaniem membran Sartorius: niesorpcyjnych (z trójoctanu celulozy) i sorpcyjnych (z polisulfonu). Określono wpływ czasu pracy membran, stosowanego ciśnienia i stężenia białka na właściwości membran. Nie stwierdzono wpływu związków powierzchniowo czynnych na właściwości transportowe membran sorpcyjnych. Zaobserwowano natomiast zmiany w wartościach strumieni objętościowych dla membran niesorpcyjnych. Właściwości membran zależą od rodzaju materiału polimerycznego, czasu ich kontaktu ze związkiem powierzchniowo czynnym i zakresu zmian w porach membrany w czasie wstępnej obróbki. Wyraźny wpływ związków powierzchniowo czynnych na właściwości membran (wstępnie potraktowanych związkiem powierzchniowo czynnym) zaobserwowano w czasie ultrafiltracji albuminy wołowej. W końcowym etapie badań porównano właściwości transportowe (w stosunku do wody) membran wstępnie potraktowanych związkami powierzchniowo czynnymi i membran oczyszczonych po procesie ultrafiltracji białka.

ВЛИЯНИЕ ПОВЕРХНОСТНО АКТИВНЫХ СОЕДИНЕНИЙ НА ТРАНСПОРТНЫЕ СВОЙСТВА УЛЬТРАФИЛЬТРАЦИОННЫХ МЕМБРАН

Исследовано явление улучшения транспортных свойств ультрафильтрационных мембран в результате их контакта с разными поверхностно активными соединениями. Представлен также основной метод выяснения взаимодействий мембрана-поверхностно активное соединение. В исследованиях были употреблены следующие поверхностно активные соединения: неионное (Triton X-2) и два анионных (Tencid, Tergitol NP-7). Процесс ультрафильтрации протекал с применением мембран Сарториус: несорбционных (из триацетата целлюлозы) и сорбционных (из полисульфона). Определено влияние времени действия мембран, применяемого давления и концентрации белков на свойства мембран. Не установлено влияние поверхностно активных соединений на транспортные свойства сорбционных мембран. Зато наблюдались изменения значений объемных потоков для несорбционных мембран. Свойства мембран зависят от вида полимерного материала, времени их контакта с поверхностно активным соединением и пределов изменений в порах

мембраны во время предварительной обработки. Яркое влияние поверхностно активных соединений на свойства мембран (предварительно подверженных действию поверхностно активного соединения) наблюдалось во время ультраfiltrации альбумина говяжьей сыворотки крови. В конечном этапе исследований были сравнены транспортные свойства (по отношению к воде) мембран предварительно подверженных действию поверхностно активных соединений и мембран, очищенных после процесса ультраfiltrации белков.