Prosimy cytować jako: Inż. Ap. Chem. 2014, 53, 4, 237-238

Urszula GABRIEL-PÓŁROLNICZAK[1], Daniela SZANIAWSKA[2], Konrad ĆWIRKO[1]

e-mail: u.polrolniczak@am.szczecin.pl

[1] Chair of Physics and Chemistry, Marine Engineering Faculty, Maritime University of Szczecin

[2] Institute of Transport Engineering, Transport Engineering and Economics Faculty, Maritime University of Szczecin

Cross-flow ultrafiltration of model bovine serum albumin solutions on a laboratory scale

Introduction

The presented studies have been undertaken in order to investigate possibilities of applying ultrafiltration for treatment of salted water produced in fish processing industry. The results could be a basis for elaboration of a treatment technology enabling recycling of both regenerated salted water and proteins, thus decreasing water use and wastewater discharge by closure of water loops [*Afonso, Borquez, 2002; Kuca, Szaniawska, 2009a,b*]. Development of membrane processes for waste brine purification requires studies on model solutions of individual proteins including analysis of the membrane selectivity and performance.

The model proteins were selected taking into account molecular weight range of fish proteins and their solubility in water and solutions of low and high ionic strength. One of the basic groups of proteins found in fish, in respect of their behavior in solvents, are proteins soluble in water and dilute, neutral salt solutions. These include albumins representing approximately 30% of the total protein content in fish meat. Due to the unavailability of fish albumin the most commonly applied bovine serum albumin was used.

In the first step of the present research the assessment of operating parameters influence on permeability in ultrafiltration processes of aqueous bovine serum albumin (BSA) solutions using laboratory-scale membrane installation working in pseudo-cross-flow regime was performed.

Experimental

The measurements were carried out in the laboratory-scale installation working in a tangential flow mode. In the research flat ceramic Al_2O_3/ZrO_2 membranes were used. Investigated membranes are thoroughly characterized in Tab. 1.

Tab. 1. Characteristics of flat ceramic membranes [*TAMI, 2014*]

Cut-off [kDa]	150
Support material	TiO_2
UF active layer	TiO_2/ZrO_2
Filtration area [m^2]	0.0056
Diameter [mm]	90
Thickness [mm]	2.5
Average pores [μm]	3.5
Bursting pressure [MPa]	> 9
Operating pressure [MPa]	1
Operating temperature [^{0}C]	< 350
Operating *pH*	0÷14
Solvents	insensitive

The following were the main elements of the ultrafiltration installations: the membrane module, pressure pump enabling circulation of the solution in the system and feed tank of 2 dm^3 volume. Additionally, the installation was thermostated using heat exchanger joined with cooling water. Ultrafiltration tests were performed at temperature range of 20÷24^{o}C within the range of transmembrane pressure, TMP, 0,1÷0,2 MPa and the volume velocity of 60 dm^3/h with cross-flow velocity CFV, at the membrane surface of 2,4 m/s (Tab. 2). Model feed solutions contained 0,05% of BSA. In order to obtain a constant concentration of protein in the feed solution, the retentate and permeate were recirculated to the feed tank.

In order to restore the primary transport properties of the membranes and modules NaOH and H_3PO_4 solutions were used as cleaning agents. Afterwards, the membranes were rinsed with deionized water until the flux value was obtained that varied by a maximum of 8% of the initial value.

Tab. 2. Operating parameters of ultrafiltration process

C_{BSA} [g/dm^3]	0.5
NaCl [%]	0, 10, 15
pH	4÷4.7, 6.7÷7.9
TMP [MPa]	0.1, 0.2
V_N [L/h]	60
CFV [m/s]	2.4
t [^{0}C]	20÷24

Results and discussion

Membrane permeability for water

Membrane permeability for pure water was determined in order to determine the membrane resistance R_M for different TMP values. The membrane resistance was calculated according the equation:

$$R_M = \frac{TMP}{J_W} \ [\text{MPa·s·m}^2/\text{m}^3] \tag{1}$$

where:
J_W – water permeate flux through clean membrane [m^3/m^{2}s]
R_M – membrane resistance [MPa s/m]

Using the values of permeate fluxes J_V, and water fluxes of clean membranes J_W, presented in Tab. 3, fouling resistances, R_F, were calculated according to the equation:

$$R_F = \frac{TMP}{J_W} - R_M \tag{2}$$

where:
J_V – average permeate flux in the process of UF of BSA taken from 3 measurements every 5 minutes [m^3/m^{2}s]
R_F – fouling resistance [MPa s/m]

to shortly analyse the fouling phenomenon in investigated ceramic membrane systems.

The results of membrane permeability for water are presented in Fig. 1 and the calculated values of R_M and R_F, are listed in Tab. 3.

Ultrafiltration of BSA model solutions using laboratory scale system

Transport properties of flat ceramic membranes working in pseudo-cross-flow regime in relation to the model BSA solutions for different NaCl concentrations are presented in tab. 3. ·

Tab. 3. Dependence of permeate flux J_v on NaCl concentration *pH*, and TMP

NaCl [%]	CFV [m/s]	*pH*	TMP [MPa]	*Jv* [m³/sm²]	*Jw* [m³/sm²]	*Jv/Jw*	$J_{FD}=1 - Jv/Jw$	R_M [MPa·s·m²/m³]	R_F [MPa·s·m²/m³]
0	2.4	6.8÷7.9	0.1	$1.39\cdot10^{-05}$	$5.92\cdot10^{-05}$	0.235	0.765	1690	5507
			0.2	$1.53\cdot10^{-05}$	$1.12\cdot10^{-04}$	0.137	0.863	1785	11276
		4.0÷4.2	0.1	$1.66\cdot10^{-05}$	$5.92\cdot10^{-05}$	0.280	0.720	1690	4350
			0.2	$2.54\cdot10^{-05}$	$1.12\cdot10^{-04}$	0.226	0.774	1785	6097
10		6.7	0.1	$1.19\cdot10^{-05}$	$5.92\cdot10^{-05}$	0.201	0.799	1690	6714
			0.2	$1.28\cdot10^{-05}$	$1.12\cdot10^{-04}$	0.115	0.885	1785	13799
		4.7	0.1	$8.79\cdot10^{-06}$	$5.92\cdot10^{-05}$	0.149	0.851	1690	9688
			0.2	$1.03\cdot10^{-05}$	$1.12\cdot10^{-04}$	0.092	0.908	1785	17632
15		6.7	0.1	$9.49\cdot10^{-06}$	$5.92\cdot10^{-05}$	0.160	0.840	1690	8848
			0.2	$1.06\cdot10^{-05}$	$1.12\cdot10^{-04}$	0.094	0.906	1785	17131

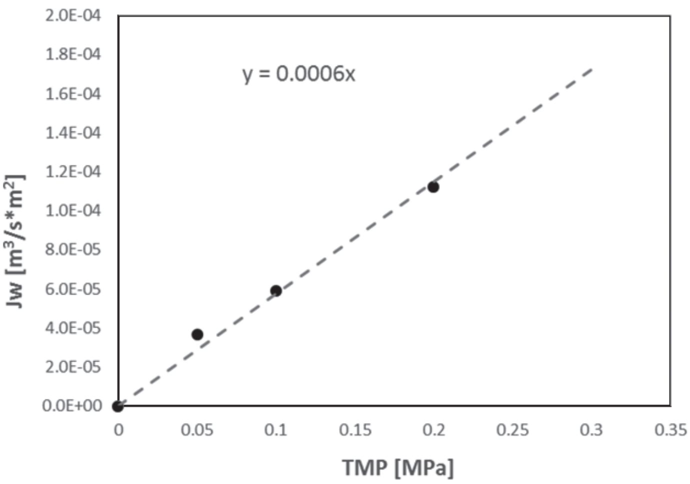

Fig. 1. Water permeate flux through clean membrane versus TMP

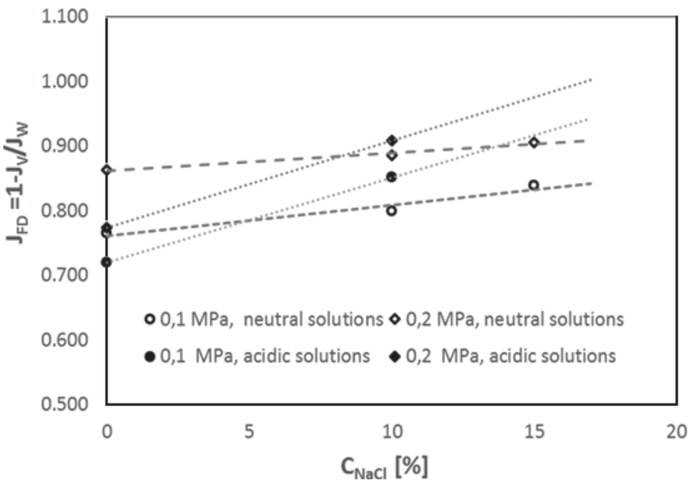

Fig. 2. Effect of NaCl concentration in the feed solution and transmembrane pressure on flux decline for ultrafiltration of model BSA solution

There was observed (Fig. 2) decline in permeate flux with increasing NaCl concentration and decreasing *pH* during UF tests of BSA solutions.

Analysis of fouling resistance R_F and flux decline J_{FD} shows that in case of investigated process $R_F >> R_M$, thus $J_{FD} \to 1$ and noticeable decrease in permeate flux J_v is observed.

Conclusion

In order to perform preliminary tests with proteins solutions laboratory scale measurements were planned because of the lower volume of the feed solutions (lower cost of preparation of protein solutions).

The study on permeability of ceramic membranes with 150 kD cut-off showed that in a short time after the start of measurement, the significant permeate flux decline was observed, the greater the higher the TMP and sodium chloride concentration, and the greater the lower the *pH*. Therefore, further studies on the selectivity and permeability of investigated ceramic membranes in ultrafiltration process with BSA solutions are planned using pilot scale membrane installation.

LITERATURE

Afonso M.D., Borquez R., 2002. Review of the treatment of seafood processing wastewaters and recovery therein by membrane separation processes – prospect of ultrafiltration of wastewaters from the fish meal industry, *Desalination* **142**, 29-45. DOI: 10.1016/S0011-9164(01)00423-4

Kuca M., Szaniawska D., 2009a. Application of microfiltration and ceramic membranes for treatment of salted aqueous effluents from fish processing. *Desalination*, **241**, 227-235. .DOI:10.1016/S0011-9164(01)00423-4

Kuca M., Szaniawska D., 2009b. Ultrafiltracja odpadowej solanki z przetwórstwa ryb. *Inż. Ap. Chem.*, **48**, nr 5, 60-61

TAMI Industries, France, 2014. *Ceramic disc membranes*. INTERMASZ, Poland – producer's representative: (05.2014) http://intermasz.com/cms/js/xinha/plugins/ExtendedFileManager/upload/Spirlab.pdf

This work was financially supported by the Polish Ministry of Science and Higher Education (Grant N N523 740840).