

Polyurethane and Carboxylated Polysulfone Blend Ultrafiltration Membranes. I. Preparation and Characterization

C. S. Latha,¹ D. Shanthanalakshmi,¹ D. Mohan,¹ K. Balu,¹ M. D. K. Kumarasamy²

¹Membrane Laboratory, Department of Chemical Engineering, A. C. College of Technology, Anna University, Chennai-600 025, India

²Department of Physical Science, M. N. M. Jain Engineering College, Chennai 600 096, India

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ABSTRACT: Polysulfone was functionalized by carboxylation and blended with polyurethane (ether type). Blend membranes were prepared in the presence and absence of the additive poly(ethylene glycol) 600 and subjected to ultrafiltration characterizations such as compaction, pure water flux, water content, and hydraulic resistance. Morphological studies of the membranes were performed with scan-

ning electron microscopy. The effects of the polymer composition and additive concentrations on the above parameters were analyzed and the results compared. © 2005 Wiley Periodicals, Inc. *J Appl Polym Sci* 97: 1307–1315, 2005

Key words: ultrafiltration; polyurethane; carboxylated polysulfone; membrane characterization

INTRODUCTION

Polyurethane (PU) has been widely applied in many industries for the removal of dyes, organic solvents, and so forth.¹ Many researchers have used PU for the preparation of membranes because of its high flux, high salt rejection properties, relatively easy manufacture, cost effectiveness, property as a renewable source of raw material, and more hydrophilicity.^{2,3} However, PU itself lacks certain properties such as mechanical, thermal, and nonporous behavior, making its use limited, and there is a need for a blend component compatible with PU to circumvent these problems.

In contrast, polysulfone (PSf), because of its superior properties such as chemical, mechanical, and thermal resistance, is considered as an ideal candidate in the membrane industry. Moreover, because of emerging problems, such as fouling, either pretreatment⁴ or modification of membrane polymers has been found to be necessary. A modification in the structure of PSf was found to produce less fouling behavior than their unmodified structure and the protection is extended to a wide range of retentate pH values.⁵ Further, modified and unmodified PSf ultrafiltration membranes

were used for the fractionation of egg protein solution.⁶ The modified membranes increased the water flux because of their hydrophilic carboxyl and sulfonic groups.^{7–9}

Attempts have been made to prepare charged ultrafiltration membranes made of carboxylated PSf (PSf-COOH or CPSf).¹⁰ Ultrafiltration membranes manufactured from CPSf have shown enhanced hydrophilicity over their unmodified PSf precursor.

The properties of membranes prepared from homopolymers may be enhanced through blending with other polymers with desirable properties. Thus, it was found that in the blending of CPSf with cellulose acetate,¹¹ the degree of carboxylation plays a key role in dictating the pore size of membranes.¹² Further, the presence of additive also improved the flux behavior of membranes.¹³ A broad variety of morphologically different polymeric membranes have been reported by changing the parameters such as the composition and concentrations of the polymer, solvent, and additive.^{3,14–16}

The surface morphology is a membrane surface phenomenon, which mainly describes the qualitative nature of the membranes. Moreover, the cross-sectional morphology of membranes may be used to ascertain the type and structure of pores and subsequently would be helpful in identifying the mechanism of the formation of pores.^{13,17–20}

Hence, the objective of the present work is to prepare blend membranes based on PU and CPSf with different additive concentrations and to determine the pure water flux, water content, membrane resistance,

Correspondence to: D. Mohan (mohantarun@yahoo.com).

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and morphology. The results of the investigation are discussed in terms of the effect of the polymer blend compositions and additive concentrations.

EXPERIMENTAL

Materials

Commercial grade PU [weight-average molecular weight = 160 kDa, glass-transition temperature = 23°C, grade 58311, M/s. Chemplast Ltd., India, Merck (I) Ltd.] was used as received. CPSf with a 0.43 degree of carboxylation was procured from the National Research Council of Canada.

Analar grade *N,N*-dimethylformamide (DMF, Qualigens Fine Chemicals, Glaxo India Ltd.) was sieved through 4-Å molecular sieves to remove moisture and stored in dry conditions prior to use. Acetone (Qualigens Fine Chemicals Ltd.) was used as received. Sodium lauryl sulfate (SLS, analar grade, Qualigens Fine Chemicals Ltd.) was used as a surfactant. Poly(ethylene glycol) 600 [PEG 600, Merck (I) Ltd.] was used as supplied as a nonsolvent additive for the entire study.

Deionized and distilled water was employed for the ultrafiltration experiments and for the preparation of the gelation bath.

Preparation of solution blending

The blend solutions based on PU and CPSf polymers (total polymer concentration = 17.5 wt %) were prepared by dissolving the two polymers with different compositions (Table I) in the presence and absence of PEG 600 additive in a polar solvent (DMF) under constant mechanical stirring at a moderate speed of rotation in a round-bottomed flask for 3–4 h at 40°C. The homogeneous solution that was obtained was allowed to stand for at least 3 h in an air tight condition to get rid of air bubbles.

Membrane preparation

The method of preparation involved is the same as that of the phase inversion method employed in earlier works.^{13,21–23} The casting environment (relative humidity and temperature) was standardized for the preparation of membranes with better physical properties such as the homogeneity, thickness, and smoothness. The relative humidity was maintained between 50 and 2% and the temperature was kept at 25 ± 1°C for all casting experiments.

The total polymer concentration was maintained at 17.5 wt % in order to have a balanced casting solution viscosity to yield membranes between a spongy type and a high macrovoidal type. The membrane film thickness was maintained at 0.22 ± 0.02 mm, which

was measured with a micrometer having a precision of 0.01 mm. The casting and gelation conditions were maintained constant throughout, because the thermodynamic conditions would largely affect the morphology and performance of the resulting membranes.²⁴

Prior to casting, a 2-L gelation bath, consisting of 2.5 (v/v) DMF solvent (to reduce the rate of liquid–liquid demixing and macrovoids) and 0.2 wt % SLS surfactant (to reduce surface tension at the polymer–nonsolvent interface) in distilled water (nonsolvent), was prepared and kept at 20 ± 1°C. The membranes were cast over a glass plate using a doctor blade. After casting, the solvent present in the cast film was allowed to evaporate for 30 s, and the cast film along with the glass plate was gently immersed in the gelation bath. After 30 min of gelation, the membranes were removed from the gelation bath and washed thoroughly with distilled water to remove all DMF and surfactant from the membranes. The membrane sheets were subsequently stored in distilled water, containing 0.1% formalin solution to prevent microbial growth.

Experimental setup

The ultrafiltration experiments were carried out in a batch type, dead end cell (ultrafiltration cell, Amicon model 8400, Millipore Ltd., Bangalore, India) with a diameter of 76 mm, fitted with a Teflon coated magnetic paddle. This cell was connected to a compressor with a pressure control valve and gauge through a feed reservoir.

Characterization of membranes

The prepared membranes were cut into the necessary size for use in the ultrafiltration cell for the following various studies.

Compaction

The compaction of fresh membranes was carried out by loading the thoroughly washed membranes in the necessary size in the ultrafiltration stirred test cell connected to the pressure reservoir with water at a pressure of 414 kPa. The water flux was measured every hour until it leveled off after 3–4 h. These compacted membranes were then used in the subsequent ultrafiltration experiments at 345 kPa.²⁵

Pure water flux

Afterward, the compaction membranes were subjected to pure water flux studies at a transmembrane pressure of 345 kPa. The flux was measured under steady-state flow. The pure water flux is determined as follows²⁶:

$$J_w = \frac{Q}{A \cdot \Delta T} \quad (1)$$

where Q is the quantity of permeate collected (L), J_w is the water flux ($\text{L m}^{-2} \text{h}^{-1}$), ΔT is the sampling time (h), and A is the membrane area (m^2).

Water content

The water content of the membranes was determined by soaking the membranes in water for 24 h and weighing after mopping with blotting paper. The wet membranes were placed in a vacuum oven at 60°C for 48 h and the dry weights were determined. From these values, the percent water content was derived as follows²⁷:

$$\begin{aligned} \% \text{ water content} \\ = \frac{\text{wet sample weight} - \text{dry sample weight}}{\text{wet sample weight}} \times 100 \end{aligned} \quad (2)$$

Membrane hydraulic resistance

To determine the hydraulic resistance of the membrane (R_m), the pure water flux of the membranes was measured at transmembrane pressures (ΔP) of 69, 138, 207, 276, and 345 kPa after compaction. The R_m was evaluated from the slope of J_w versus ΔP using the following equation²⁸:

$$J_w = \frac{\Delta P}{R_m} \quad (3)$$

Morphological studies

The top surfaces of the PU/CPSf blend membranes were studied with a scanning electron microscopy (SEM) microscope (FEI Quanta 200, Holland). The membranes were cut into pieces of various sizes and mopped with filter paper. These pieces were immersed in liquid nitrogen for 20–30 s and frozen. The frozen bits of membranes were broken and kept in a desiccator. These membrane samples were used for SEM studies.

The samples were gold sputtered for producing electrical conductivity, and photomicrographs of the samples were taken under very high vacuum conditions operating between 15 and 25 kV, depending on the physical nature of the sample.²⁹ Various SEM images were taken for top surface and cross section views of the polymeric membranes.

RESULTS AND DISCUSSION

Ultrafiltration membranes based on PU and CPSf with various compositions were prepared and the maximum possible blend composition was found to be 75/25%, beyond which phase separation takes place. Further, the hydrophilic polymeric additive PEG 600 was introduced at 2.5 wt % (2.5 wt % increments) into the casting solution. Beyond 7.5 wt % (i.e., 10 wt % PEG 600), although the casting solution was homogeneous, when the membrane was cast and immersed in a gelation bath, two separate layers of upper and lower skin were observed. This ensured that at a higher PEG 600 (10 wt %) concentration there is incompatibility between the two polymer components. Hence, in the present investigation the maximum additive concentration was restricted to 7.5 wt %.

With these preliminary optimizations, studies of the effects of various polymer blend compositions and additive concentrations on the compaction, pure water flux, water content, membrane hydraulic resistance, and morphology were performed and the results discussed.

Effect of compaction time on flux

Role of polymer blend composition

Blend membranes were prepared based on different compositions of PU and CPSf (Table I) and subjected to compaction at 414-kPa transmembrane pressure. The compaction was carried out for 5 h under stirred conditions to attain steady-state flux and the flux was measured at 1-h intervals. The run was carried out in triplicate, and the average values are given in Table II.

The 95/5, 90/10, and 85/15% PU/CPSf blend membranes in the absence of PEG 600 additive were found to have very low flux at the initial hours of compaction; upon further compaction, a negligible amount of flux was observed. Hence, the membranes with the above polymer compositions were eliminated for further studies. The pure PU membranes (100%) in the absence of PEG 600 did not result in appreciable flux values and thus were rejected for further characterization and application studies. Further, the pure CPSf (100%) membrane in the absence of additive showed very high flux, and it was also rejected for further studies.

However, the 80/20 and 75/25% PU/CPSf blend membranes in the absence of additive showed initial fluxes of 36.23 and 85.71 $\text{L m}^{-2} \text{h}^{-1}$, respectively, when subjected to compaction at 414-kPa transmembrane pressure. For both blend membranes, the steady-state flux was attained within 3–4 h of compaction and the values were 22.18 and 31.82 $\text{L m}^{-2} \text{h}^{-1}$ for the 80/20 and 75/25% blends, respectively (Figs. 1, 2). This may be due to the fact that during compaction, the walls of the pores become closer, denser, and

TABLE I
Compositions and Casting Conditions of Polyurethane/
Carboxylated Polysulfone Blend Membranes

Blend composition			
Polyurethane (%)	Carboxylated polysulfone (%)	PEG 600 additive (wt %)	DMF Solvent (wt %)
100	0	0	82.5
95	5	0	82.5
90	10	0	82.5
85	15	0	82.5
80	20	0	82.5
75	25	0	82.5
00	100	0	82.5
100	0	2.5	80.0
95	5	2.5	80.0
90	10	2.5	80.0
85	15	2.5	80.0
80	20	2.5	80.0
75	25	2.5	80.0
00	100	2.5	80.0
100	0	5.0	77.5
95	5	5.0	77.5
90	10	5.0	77.5
85	15	5.0	77.5
80	20	5.0	77.5
75	25	5.0	77.5
00	100	5.0	77.5
100	0	7.5	75.0
95	5	7.5	75.0
90	10	7.5	75.0
85	15	7.5	75.0
80	20	7.5	75.0
75	25	7.5	75.0
00	100	7.5	75.0
100	0	10	72.5
95	5	10	72.5
90	10	10	72.5
85	15	10	72.5
80	20	10	72.5
75	25	10	72.5
00	100	10	72.5

Casting solution temperature = $40 \pm 2^\circ\text{C}$; casting temperature = $25 \pm 1^\circ\text{C}$; casting relative humidity = $50 \pm 2\%$; solvent evaporation time = 30 s; total polymer concentration = 17.5 wt %.

TABLE II
Effect of Compaction Time on Pure Water Flux of Polyurethane/Carboxylated Polysulfone 80/20 and 75/25% Blend Membranes

Blend composition (%)			Pure water flux ($\text{L m}^{-2} \text{h}^{-1}$) at 414 kPa					
PU	CPSf	PEG 600 (wt %)	0	1	2	3	4	5
80	20	0	36.23	23.90	22.18	22.18	22.18	22.18
80	20	2.5	51.43	28.46	24.35	23.29	23.29	23.29
80	20	5.0	179.23	141.82	71.69	43.64	43.64	43.64
80	20	7.5	202.60	159.09	76.36	49.87	46.68	46.68
75	25	0	85.71	51.43	43.64	31.82	31.82	31.82
75	25	2.5	197.92	74.81	63.90	40.52	40.52	40.52
75	25	5.0	202.60	84.16	72.41	60.78	60.78	60.78
75	25	7.5	222.86	140.26	109.09	75.84	75.84	75.84

Total polymer concentration = 17.5 wt %.

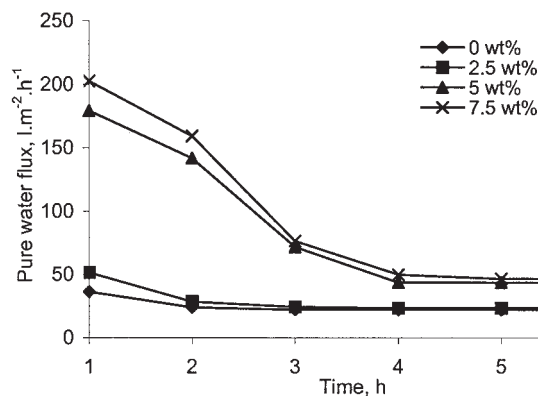


Figure 1 The effect of the compaction time on the pure water flux of 80/20% PU/CPSf blend membranes with different additive concentrations.

uniform, which results in the reduction of the pore size and consequently the flux.³⁰ The increase in flux upon the increase in the CPSf composition may be attributable to the hydrophilic nature and formation of inhomogeneity and second phase separation, which results in the formation of voids between the polymer components.³¹

Role of additive concentration

Additives are chosen to improve the pore statistics and morphology of the membranes. In general, the additives used in membrane preparations are hydrophilic and hygroscopic in nature. Thus, PEG 600 was added to the PU/CPSf casting solutions of all compositions from 2.5 wt % to the maximum compatible extent of 7.5 wt %. The polymeric additive was also expected to offer enhancement in the pure water flux without a loss of the rejection efficiency of the membranes. Hence, in this investigation, the PU/CPSf blend membranes with different additive concentrations were subjected to compaction.

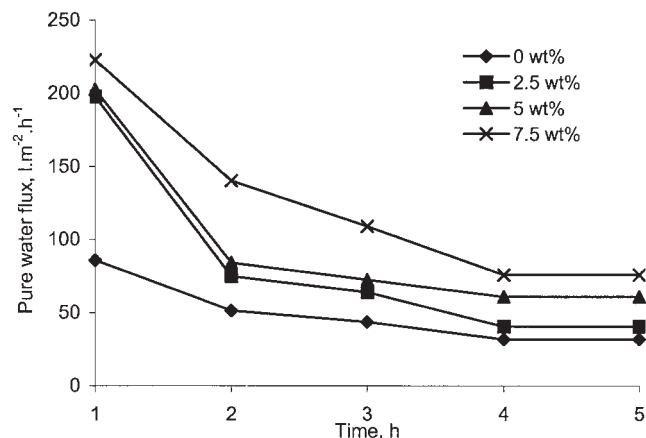


Figure 2 The effect of the compaction time on the pure water flux of 75/25% PU/CPSf blend membranes with different additive concentrations.

Because of negligible flux, comparisons between the 95/5 and 90/10% blend membranes without and with additive were eliminated from the study. However, the 85/15% PU/CPSf blend membrane with 2.5 wt % additive was subjected to study and the initial flux was found to be $24.23 \text{ L m}^{-2} \text{ h}^{-1}$. However, upon compaction, a negligible flux value was obtained and hence this composition was also eliminated from further studies. Blend compositions such as 80/20 and 75/25% with 2.5 wt % additive exhibited initial fluxes of 51.43 and $197.92 \text{ L m}^{-2} \text{ h}^{-1}$, respectively, as depicted in Figures 1 and 2. The flux attained steady state with values of 23.29 and $40.52 \text{ L m}^{-2} \text{ h}^{-1}$, respectively, for the above membranes. The flux value increased linearly when the additive concentration was increased to 5 and 7.5 wt %. This increase in flux with an increase in additive concentration may be due to the fact that additives are leached out of the membranes upon gelation, leading to the formation of macrovoids.^{13,32} All membranes attained steady-state flux within 3–4 h of compaction, and the values are given in Table II.

However, pure PU membranes did not show any considerable increase in flux upon increases of the PEG 600 concentration. This may be due to the formation of closer segmental arrangements of two different polymers (PU and PEG 600), thereby not facilitating pore formation. Similar results were also observed by Boom et al.³³

Effect of polymer blend composition and additive concentration on pure water flux

The pure water flux was measured at 345-kPa pressure under steady-state conditions and at a constant sampling period. The pure water fluxes of all compacted membranes were measured after an initial stabilization period of 30–60 min. The run was carried

out in triplicate, and the average values are given in Table III.

Role of polymer blend composition

Due to negligible flux on compaction, 100/0, 95/5, 90/10, and 85/15% compositions of PU/CPSf in the absence of PEG 600 additive were not considered for further characterization and application studies in this investigation. Hence, the pure water flux was measured only for blend membranes with 80/20 and 75/25% compositions at 345-kPa pressure.

When the CPSf composition was increased from 20 to 25% in the blend, there was an appreciable increase in the flux of the blend membrane, from 14.03 to $21.82 \text{ L m}^{-2} \text{ h}^{-1}$, as shown in Table III. This enhancement in flux may be attributable to the fact that the presence of a higher amount of the two polymeric components results in phase separation and inhomogeneity, leading to the formation of cavities in the sublayer, which gives way to the mobility of water molecules.³⁴

Role of additive concentration

As the PEG concentration was increased from 0 to 2.5 wt %, the 80/20% blend membrane showed an increase in pure water flux of 34.29 from $14.03 \text{ L m}^{-2} \text{ h}^{-1}$. Similarly, when the PEG concentration was increased further, there was a linear increase as seen from Table III. Thus, membranes with 5 and 7.5 wt % PEG have higher pure water fluxes of 101.30 and $144.94 \text{ L m}^{-2} \text{ h}^{-1}$, respectively. This increase in flux upon the increase in additive concentration may be due to the hygroscopic nature of PEG 600 that is leached out during gelation, leading to the formation of pores.³⁵ Similar reports with PEG 600 as an additive have been described for other polymer systems.^{36,37}

Effect of polymer blend composition and additive concentration on water content

Role of polymer blend composition

The prepared membranes were subjected to the determination of water content and the results are given in Table IV.

TABLE III
Pure Water Flux of Polyurethane/Carboxylated Polysulfone 80/20 and 75/25% Blend Membranes

Blend composition (%)		Pure water flux ($\text{L m}^{-2} \text{ h}^{-1}$)			
		PEG 600 concentration (wt %)			
PU	CPSf	0	2.5	5	7.5
80	20	14.03	34.29	101.30	144.94
75	25	21.82	60.78	132.47	249.35

Total polymer concentration = 17.5 wt %.

TABLE IV
Water Content of Polyurethane/Carboxylated Polysulfone 80/20 and 75/25% Blend Membranes

Blend composition (%)		Water content (%)			
		PEG 600 concentration (wt %)			
PU	CPSf	0	2.5	5	7.5
80	20	65.18	68.18	69.23	72.73
75	25	68.36	70.19	71.32	73.94

Total polymer concentration = 17.5 wt %.

The water content of the blend membranes with 20% CPSf in the absence of additive was found to be 65.18%. When the CPSf composition was further increased to 25%, the water content also increased and reached a value of 68.36%. This increase in water content with the increase in CPSf composition confirmed that the hydrophilicity is directly proportional to the water content.

Role of additive concentration

The effect of the concentration of PEG 600 additive on the water content of the blend membranes with different compositions of PU/CPSf (such as 80/20 and 75/25%) is represented in Table IV. When the additive concentration was increased to 2.5 wt % in 80/20% PU/CPSf, the percentage of water content of the membrane also increased. Thus, the water content for the 80/20% composition was 68.18% at 2.5 wt % and increased to 72.73% at 7.5 wt % additive concentration. A similar trend was also observed for blend membranes with a 75/25% composition of PU/CPSf. This increase in water content, irrespective of the polymer blend composition, may be due to the addition of PEG 600 to the casting solution, which is leached out upon gelation, leading to pore formation, and becomes the domain of water molecules.³⁸ Further, when the CPSf content in the blend was increased from 20 to 25%, the water content also increased from 68.18 to 70.19% at 2.5 wt % additive and 72.73 to 73.94% at 7.5 wt % additive. This trend was observed for all additive concentrations as shown in Table IV, because of the increase in the hydrophilic nature of the blend membrane.

Effect of polymer blend composition and additive concentration on hydraulic resistance

The membrane hydraulic resistance is an important parameter for membranes used in pressure-driven membrane processes. It indicates the tolerance of membranes toward hydraulic pressure. The variation of pressure ranges are important conditions to be studied for ultrafiltration operations.³⁹ Hence, the ef-

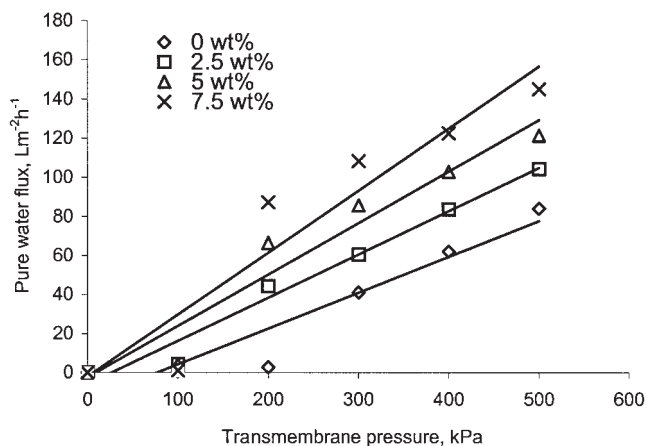


Figure 3 The effect of the transmembrane pressure on the pure water flux of 80/20% PU/CPSf blend membranes with different additive concentrations.

fect of the polymer composition and additive concentration on the hydraulic resistance was investigated.

Role of polymer blend composition

In the present investigation, the R_m value was measured by subjecting the membranes to various pressures from 69 to 414 kPa and measuring the pure water flux. The plot of the pressure versus pure water flux gives a linear relationship⁴⁰ and the inverse of the slope is the membrane hydraulic resistance.

From Figures 3 and 4, it is evident that the pure water flux increased with the increase in the transmembrane pressure, because an increase in the operating pressure increases the driving force for permeation of water. Table V shows the membrane hydraulic resistance of PU/CPSf blend membranes with 80/20 and 75/25% compositions. As the CPSf compo-

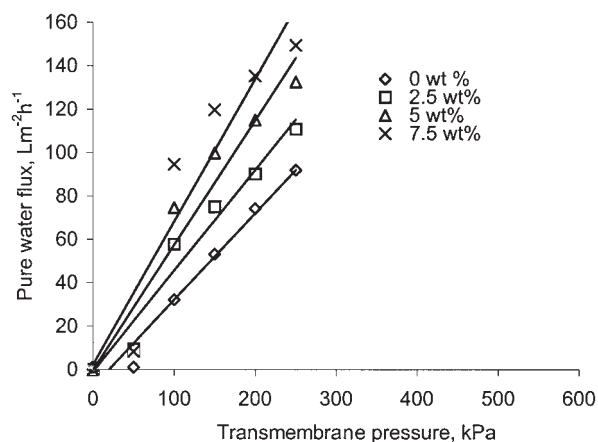


Figure 4 The effect of the transmembrane pressure on the pure water flux of 75/25% PU/CPSf blend membranes with different additive concentrations.

TABLE V
Membrane Hydraulic Resistance of
Polyurethane/Carboxylated Polysulfone 80/20 and 75/25%
Blend Membranes

Blend composition (%)		R_m (kPa/Lm ⁻² h ⁻¹)			
		PEG 600 concentration (wt %)			
PU	CPSf	0	2.5	5	7.5
80	20	5.44	4.51	3.80	3.15
75	25	2.50	2.15	1.74	1.52

Total polymer concentration = 17.5 wt %.

sition was increased from 20 to 25%, the hydraulic resistance decreased from 5.44 to 2.50 kPa/L m⁻² h⁻¹. The decrease in membrane resistance may be due to the presence of CPSf in the blend, which forms a segmental gap between PU, which can reduce the hydraulic resistance toward hydraulic pressure.⁴¹

Role of additive concentration

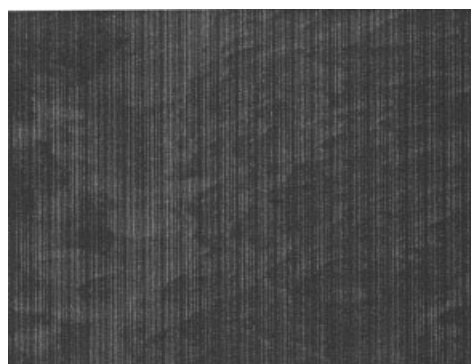
Table V shows that the presence of additive in the casting solution has a considerable effect on the R_m .

The effects of the PEG concentration (from 2.5 to 7.5 wt %) in the casting solution of PU/CPSf blend membranes on the hydraulic resistance are shown in Table V.

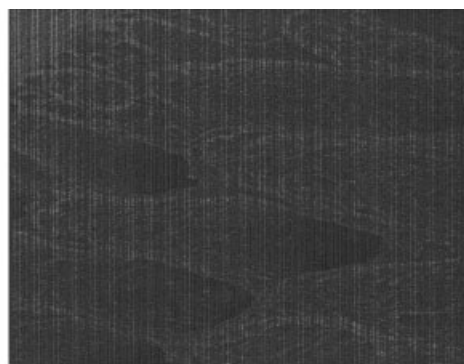
From Table V it is evident that for the 80/20% PU/CPSf blend membrane, as the PEG concentration was increased from 0 to 7.5 wt %, there was a corresponding decrease in the resistance of the membrane from 5.44 to 3.15 kPa/L m⁻² h⁻¹. A similar trend was also observed for the 75/25% PU/CPSf blend membrane. This may be attributable to the fact that the addition of a pore former in the casting solution results in the formation of macropores on the membrane surface because of thermodynamic instability, which enhances precipitation and a porous nature.¹⁴ This can also be supported by the observation that an increase in the PEG content can increase the flux because of higher and larger pore formation, thereby reducing the membrane resistance.

Morphological studies

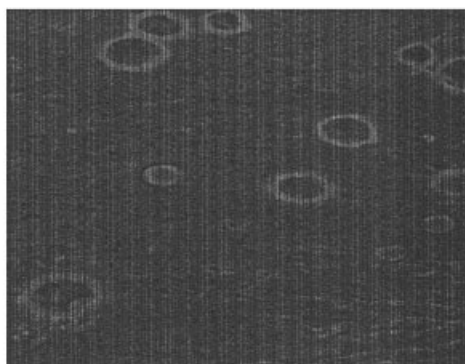
The surface structure of a flat sheet, ultrafiltration membrane is the most critical part in helping to iden-



5a



5b



5c

Figure 5 SEM micrographs of (a) the top surface and (b) cross section of 80/20% PU/CPSf with 0 wt % PEG 600 and (c) the top surface of 80/20% PU/CPSf with 7.5 wt % PEG 600.

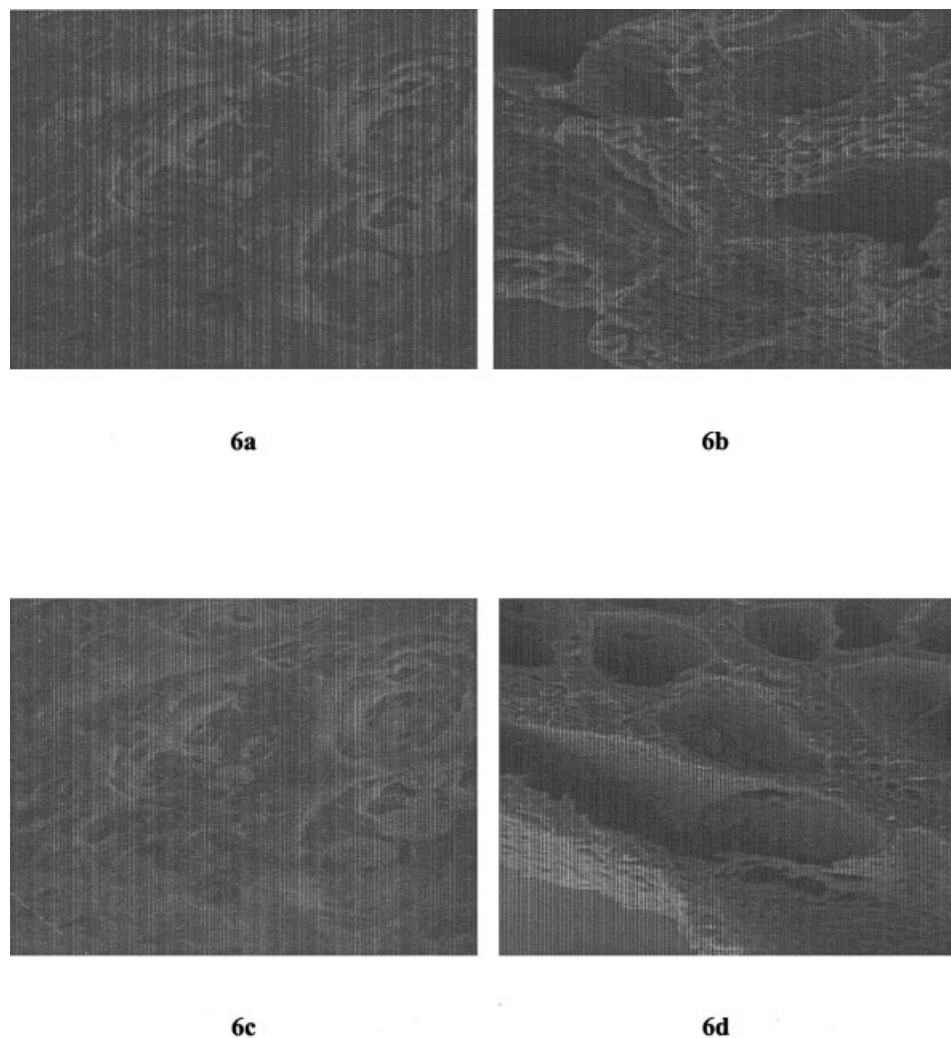


Figure 6 SEM micrographs of (a) the top surface and (b) cross section of 75/25% PU/CPSf with 0 wt % PEG 600 and (c) the top surface and (d) cross section of 75/25% PU/CPSf with 7.5 wt % PEG 600.

tify the role of the membrane in the mechanism of permeation and rejection. An SEM microscope is an important tool in the determination of the morphology of the membranes. To attain high-performance membranes for specific applications, it is essential to manipulate the morphological structures of the membranes.⁴² Hence, the morphological studies of the blend membranes were made by using SEM.

PU-CPSf system

The morphology of the blend membranes with different compositions and additive concentrations was analyzed by SEM and the results are depicted in Figures 5 and 6. Figure 5(a,c) shows the top surface of PU/CPSf blend membranes with 80/20% composition with 0 and 7.5 wt % PEG 600 concentrations, respectively. Figure 6 (b,d) shows the cross section of PU/CPSf blend membranes with 75/25% composition with 0 and 7.5 wt % PEG 600 concentrations, respec-

tively. In the absence of additive the pores are very small. However, the observed negligible flux insists that these pores are dummy pores.⁴³ As the PEG 600 concentration was increased in the casting solution, the porosity also increased linearly as could be observed from the scanned skin surface of the respective membranes. In addition, as the concentration of PEG 600 was increased, the number of voids and thicknesses of the membranes also increased. Similar observations were noted by other researchers.⁴⁴ The observations made by SEM are in good correlation with the pure water flux, water content, and membrane resistance of corresponding membranes.

CONCLUSION

Blends of PU and CPSf in the absence and presence of PEG 600 additive were prepared. Suitable compositions were found to be 80/20 and 75/25% PU/CPSf and the extent of additive compatibility was found to

be 7.5 wt %. This blending enhances the ultrafiltration characteristics such as higher water content and lower hydraulic resistance values coupled with higher pure water flux. SEM microscope analyses showed that in the blend membranes the pore size increased with increasing CPSf concentration in the blend. Moreover, the incorporation of the additive in the blend system changed the morphology of the membranes extensively. In general, the PEG 600 additive played a major role in improving the flux performance and in altering the structural properties of the resulting membranes.

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