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Effect of pH on Bovine Serum Albumin (BSA) Solution to Polysulfone-based Membrane

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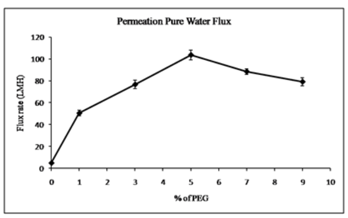
Graphical abstract



Abstract

In this work, polysulfone (PSf) flat sheet membrane was prepared via phase inversion technique. The effects of polyethylene glycol (PEG) additive on membrane performance were observed and investigated. The membrane permeation was evaluated in terms of pure water flux (PWF) and solute rejection at different pHs (pH 3, pH 5, pH 7 and pH 9). Bovine serum albumin (BSA) solution was used to study the performance of the prepared membrane. Results showed that the increase of PEG concentration led to higher PWF. This is due to PEG role as a pore forming agent in casting solution. The PWF was found to increase up to 101.85 LMH at 5% PEG. However, the PWF decrease when the PEG concentration is increased up to 7% and 9%. Similarly, flux rate at different pH showed the same plot as PWF. At pH 9, the PWF is high compared to pH 3, pH 5 and pH 7. The BSA rejection data at pH 3 and pH 5 shows the high rejection compared to pH 7 and pH 9. No significant changes were observed when PEG concentration was increased. As a conclusion, the addition of PEG has improved the performance of membrane in terms of PWF at a certain percentage (with the highest was given at 5%) of PSf membrane. It is also evidenced that the % of BSA rejection increased with decreasing pH.

Keywords: Polysulfone; polyethylene glycol; bovine serum albumin; phase inversion technique

■1.0 INTRODUCTION

Polysulfone (PSf) has excellent transport properties, good mechanical strength, chemical and thermal resistance [1-2]. PSf is also known as low cost polymer and has been widely used in fabrication of ultrafiltation membrane. However, the hydrophobic nature of PSf has somehow given a major problem that is reducing the membrane performance. The decrease in flux flow as a result of the increased in flow resistance is due to pore blocking, concentration polarization and cake formation. Overall, the phenomena may affect the performance of membrane such as flux permeation, water permeability and rejection [3]. The effect on flux decreased depend of factors such as membrane pore size, solute loading and size distribution [4]. The main factor that influence membrane performance are the physicochemical properties of the membrane, feeding solution and operation condition

To overcome the fouling problem on PSf membrane, it is believed that the addition of additive in the membrane solution may somehow prevent the fouling from occurring. From previous study, there are many types of additive such as polyethylene glycol (PEG) [5], polyvinylpyrollidone (PVP) [6], titanium dioxide (TiO_2) [7], water and others that may contribute to improvement of PSf membrane performance. The addition of small amount of additive can affect the membrane characteristics such as enlarging macrovoids formation which then improving the interconnectivity of the pores and resulting in higher porosities in the top layer and sub layer [8].

This study focused on the influence of pH in feeding solution. Because of the electrostatic interaction between feeding solution and membrane, the flux values that permeate increases at high pH. This phenomenon can be observed at a pH equal to the isoelectric point (IEP) of protein. According to Kuzmenko *et al.*, at pH 2.9 and 5.3 the membrane charge are weak and did not interrupt the charge of bovine serum albumin (BSA). But at pH 7.4 where both BSA and PES membrane have the same charge, the repulsion effect held part of BSA at some distance from the membrane surface, thus minimizing flux values [9].

In this study, N-methyl-2-pyrrolidone (NMP) was used as solvent and PEG 35,000 Da were used as an additive in PSf membrane. The effects of additive in membrane casting solution on permeation characteristics of the prepared membrane were investigated. The influence of pH on feed solution on the water permeability and BSA rejection also has been study. Membrane performance was analyzed in terms of pure water flux (PWF) and BSA rejection.

2.0 EXPERIMENTAL

2.1 Membrane Preparation

Flat sheet Polysulfone (PSf) membrane was prepared via phase inversion method using N-methyl-2-pyrrolidone (NMP) as a solvent and Polyethylene glycol (PEG) with molecular weight (M_w) 35,000 Da as additive. PSf were dissolved in NMP and stirred for 4 h. then, PEG additive at differences concentration (0%, 1%, 3%, 5%, 7% and 9%) was subsequently added with continuous stirring and heating at 60°C until the solution was completely dissolved and homogeneous. The solution was further agitated for another 24 h in order to remove all bubbles. The solution was then cast on a clean glass plate with a casting knife maintained at 0.1 ± 0.02 mm at room temperature. The glass plate was then immediately immersed in the water bath and the cast films immediately changed to white colour. Finally, the membrane formed were air-dried at room temperature for 1 day before test.

2.2 Permeation Experiments

The pure water flux (PWF) test was conducted in a permeation cell made of stainless still. Inside the cell, a flat circular membrane was placed over a base support. The membrane was cut into desired shape and fitted in flat sheet membrane permeation cell. The distilled water was fed into the flat sheet membrane permeation cell and the cell was pressurized at 3 bar until the water permeate become constant. After the water permeate becomes constant, the pressure were reduced to operation pressure that is 2 bar.

2.2.1 Pure Water Flux (PWF) and Rejection Test

Pure water flux (PWF) was determined by allowing distilled water to pass through the compacted membrane. Flux values of pure water at 2 bar pressure were measured under steady state condition. The PWF was calculated using the Equation 1:

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

where J_w is the water flux (LMH). Δt is the sampling time (h) and A is the membrane area (m^2).

The solute rejection membranes were evaluated using Bovine serum albumin (BSA) as solute. The absorbance was measured by using the spectrophotometer (Shimadzu UV-160) at a wavelength of 280 nm against a reagent blank. The solute rejection (%R) is defined as Equation 2:

$$\%R = \left(1 - \frac{C_p}{C_f}\right) \times 100 \quad (2)$$

where C_p and C_f are the BSA concentration in the permeate and in the feed, respectively.

The pH of the BSA solution was adjusted by using NaOH and HCl for the effect of BSA solution pH study. The calculation of permeate is same as Equation 2.

3.0 RESULTS AND DISCUSSION

3.1 Water Permeability Test

The performance evaluation results of the membranes were shown in Figure 1.

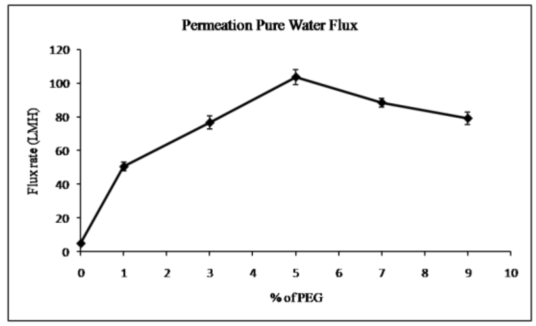


Figure 1 Permeation pure water flux versus percentage (%) of PEG concentration.

Figure 1 shows the effect of PEG concentration on PWF performance. The PWF is increasing with the increment the PEG content from 1% to 5% and slightly decrease when approaching 7% PEG concentration. Based on the experiment results, at 5% PEG, the PWF increased up to 101.85 LMH. The result indicated that the addition of PEG as pore forming agent has improved membrane permeability [5, 10]. Previous studies reported that high molecular weight of additives such as PEG and PVP may remain entrapped in the membrane matrix [11-12]. The trapped PEG in the membrane matrix can change the hydrophobic behaviour to hydrophilic behaviour of PSf membrane. However, in this study, the PWF value is reduced when PEG concentration was further increased. This is due to high concentration of PEG in casting solution that may block the membrane pore formed during casting.

3.2 The Influence of pH on Permeation and Rejection

The flux rate rejection at different pH using polysulfone-based membrane is shown in Figure 2. The studied pH range was from 3 to 9. It can be seen that the flux rate rejection plot at different loading of PEG concentration at different pH is in same pattern. From 1% until 5% PEG concentration, the flux rate is increased. However, the flux rate reduced when the PEG concentration increased to 7%. From the figure, the highest flux rate occurs at pH 9 and followed by pH, pH 5 and pH 3. This is due to higher membrane pH undergoes size contraction which opens up the pores in the skin layer and thus enhances the water flux [13]. In addition, the flux values are also influenced by the electrostatic interactions between membrane surface and BSA solution. At pH 2 (IEP of membrane) and 4.9 (IEP protein), protein and the membrane attract because they are oppositely charged, thus leading to permeate flux decreases [14]. However at high pH the protein tend to have negative charge. Due the same charged to both protein and membrane, the flux value increases [9, 14].

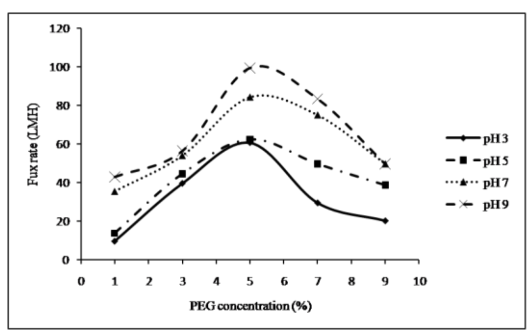


Figure 2 Membrane permeability in rejection of BSA using PSf-based membrane

Figure 3 illustrates the effect of pH to BSA rejection performance (%R). From the plot, at pH 5 shows the highest rejection compared to pH 7 and pH 9. The rejection increases as adsorption of protein on pore wall causes pore narrowing [5]. Membrane with large pores tends to have a high filtration flux but low protein retention.

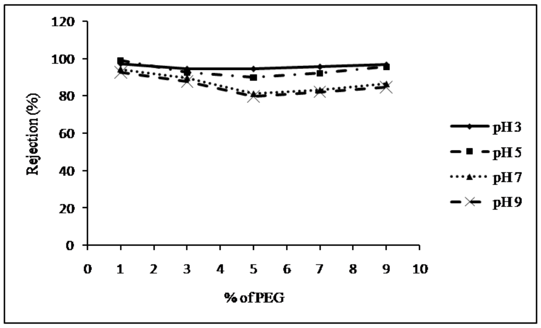


Figure 3 Rejection (%) of BSA using PSf-based membrane

■4.0 CONCLUSION

In this study, the flat sheet PSf membrane was successfully prepared via a phase inversion process. The addition of different PEG concentration (1%, 3% and 5%) into casting solution improved the performance of membrane in term of pure water flux. However, the PWF is reduced as PEG increased from 7% to 9%. At pH 5, the highest rejection was shown compared to other pH. As a conclusion, the addition of PEG has improved the membrane performance in term of PWF at a certain percentage (with the highest was given at 5%). It is also evidenced that the BSA rejections increase with decreasing pH.

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References

[1] J. Y. Kim, H. K. Lee, S. C. Kim. 2000. Liquid-liquid Phase Separation During Polysulfone Membrane Preparation. *Korean Jurnal Chemical Engineering*. 17(5): 564–569.

[2] Y. Haijun,C. Yiming, K. Guodong, L. Jianhui,M. Li ,Q. Yuana. 2009. Enhancing Antifouling Property of Polysulfone Ultrafiltration Membrane by Grafting Zwitterionic Copolymer via UV-initiated Polymerization. *J. Membr. Sci*. 342: 6–13.

[3] L. Yan, Y. Li, C. Xiang, and S. Xianda. 2006. Effect of Nano-sized Al2O3-particle Addition on PVDF Ultrafiltration Membrane Performance. *J. Membr. Sci.* 276(1–2): 162–167.

[4] K. W. L. Kenneth S. McGuire. 1995. Pore Size Distribution Determination from Liquid Permeation Through Microporous Membranes. *J. Membr. Sci*. 99: 127–137.

[5] B. Chakrabarty, A. K. Ghosal, M. K. Purkait. 2008. Effect of Molecular Weight of PEG on Membrane Morphology and Transport Properties. *J. Membr. Sci.* 309: 209–221.

[6] H. Basri, A. F. Ismail, & M. Aziz. 2011. Polyethersulfone (PES)-silver Composite Ultrafiltration Membrane: Effect of Silver Loading and PVP Molecular Weight on Membrane Morphology and Antibacterial Activity. *Desalination*. 273: 72–80.

[7] N. A. A. Hamid, A. F. Ismail, T. Matsuura, A. W. Zularisam, W.J. Lau, E. Yuliwati & M. S. Abdullah. 2011. Morphological & Separation Performance Study of Polysulfone/Titanium Dioxide (PSf/TiO2) Ultrafiltration Membranes for Humic Acid Removal. *Desalination.* 273: 85–92.

[8] B. Jung, J. K. Yoon, B. Kim and H. W. Rhee. 2004. Effects of Molecular Weight of Polymeric Additives on Formation, Permeation Properties and Hypochlorite Treatment of Asymmetric Polyacrylonitrile Membranes. *J. Membr. Sci*. 243: 45–47.

[9] D. Kuzmenko, E.Arkhangelsky, S. Belfer, V. Freger, V. Gitis. 2005. Chemical Cleaning of UF Membranes Fouled by BSA. *Desalination.* 179 323–333.

[10] G. Arthanareeswaran, D. Mohan and M. Raajenthiren. 2007. Preparation and Performance of Polysulfone-sulfonated Poly(Ether Ether Ketone) Blend Ultrafiltration Membranes. Part I. *Applied Surface Science*. 253: 8705–8712.

[11] C. Feng, R. Wang, B. Shi, G. Li and Y. Wu. 2006. Factors Affecting Pore Sturcture and Performance of Poly(vinylidene fluoride-co-hexafluoro propylene) Asymmetric Porous Membrane. *J. Membr. Sci*. 277(1–2): 55–64.

[12] W. L. Chou, D. G. Yu, M. C. Yang and C. H. Jou. 2007. Effect of Molecular Weight and Concentration of PEG Additives on Morphology and Permeation Performance of Cellulose Acetate Hollow Fibers. *Sep. Purif. Technol.* 57: 207–217.

[13] R. Muppalla, H. H. Rana, S. Devi and S. K. Jewrajka. 2013. Adsorption of pH-responsive Amphiphilic Copolymer Micelles and Gel on Membrane Surface as an Approach for Antifouling Coating. *App. Surf. Sci*. 268: 355–367.

[14] S. Fakhfakh, S. Baklouti, Samir Baklouti, J. Bouaziz. 2010. Preparation, Characterization and Application in BSA Solution of Silica Ceramic Membranes. *Desalination*. 262: 188–19.