FOULING PROPERTIES OF PES/LICL/MWCNT MEMBRANES FABRICATED VIA TIPS AND NIPS

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ABSTRACT

Membrane filtration has been long used for solid-liquid separation and for algae harvesting. However, the issue of using membrane is it prone to fouling of solute. Microalga usually releases transparent exopolymer particles (TEP) in an aquatic condition which are the source of fouling. This paper represented the study of microalgae fouling mechanism on blend polyethersulfone (PES) polymer with lithium chloride (LiCl) and functionalized multiwall carbon nanaotubes (F-MWCNT) as additives membranes fabricated via temperature induced separatinon (TIPS) and non-solvent induced separation (NIPS). The membrane was prepared by blending 18wt% of PES, 1-4wt% of LiCl and 1wt% of F-MWCNT into a homogenous solution. All membranes were having molecular weight cut off at 145 kDA which indicated ultrafiltration/microfiltration. Increased of LiCl content in membrane does not help to increased membrane hydrophilicity further. Water permeation results shows that membrane fabricated via TIPS demonstrated higher flux compare to membrane fabricated via NIPS. Although no significant effect observed in membrane contact angle, the water permeability result from membranes with LiCl additives were improved. In the other hand, F-MWCNT has help to maintained LiCl additives in the membrane matrices. In this study NIPS membrane of PES 18/MWCNT/LiCl 4wt% is preferable since it demonstrated acceptable flux and good antifouling.

Keywords: ultrafiltration; lithium chloride; functionalized multiwall carbon nanotubes; microalgae harvesting; algae fouling.

1. INTRODUCTION

Membrane filtration has long been used for solid-liquid separation. The advantage of membrane filtration is it is simple and flexible in operation. Microalgae are a unique unicellular organism that contains many valuable components for green product such as biofuel Ultrafiltration and microfiltration are both membrane filtration that their separation is based on sieving mechanism and are suitable for algae harvesting. However, the issue of using membrane is it prone to fouling. Microalga usually releases transparent exopolymer particles (TEP) in an aquatic condition. TEP are in gel form and consist of largely acidic polysaccharides. TEP are highly sticky and tend to agglomerate with other particles. The stickiness of TEP is due to the presence of half-ester groups which can form metal ion bridges and hydrogen bonds with other substances. Therefore TEP is easy to deposit on membrane surface and created fouling.

There are only a few works reported related to membrane modification with antifouling property for microalgae harvesting application. Generally, membranes can be modified through the addition of additives via blending and surface coating. However, blending has more advantages than surface coating Hwang et al. 2015. Thus, this paper represented the study of microalgae fouling mechanism on blend polyethersulfone (PES) polymer with lithium chloride (LiCl) and functionalized multiwall carbon nanaotubes (F-MWCNT) as additives membranes.

2. MATERIALS AND METHODS

2.1 Membrane Fabrication

The membrane was prepared by blending 18wt% of PES, 1-4wt% of LiCl and 1wt% of F-MWCNT into a homogenous solution. The solution was casted on a glass plate and immediately immersed into the coagulation bath. For temperature induced phase separation (TIPS), casting solution was at ≈ 90^0C while for non-solvent induced phase separation (NIPS) casting solution was at room temperature. The fabricated membranes were store in distilled water before used.

2.2 Membrane Characterization

The membrane was characterized on their pore size, hydrophilicity and chemical content properties through molecular weight cut-off (MWCO) experiment, contact angle and Fourier transform infrared spectroscopy (FTIR) and energy dispersive x-ray spectroscopy (EDX) analysis respectively.

2.3 Membrane flux

A flat sheet ultrafiltration module was to determined membrane fluxes. The membrane flux during filtration can be described by Darcy's law equation.

2.4 Fouling Determination

Algae fouling behavior on membranes were determined in term of irreversible fouling (IF) and reversible fouling (RF) using equation stated elsewhere.

3. RESULTS AND DISCUSSIONS

3.1 Membrane Characteristics

PES/MWCNT/LiCL membranes have been successfully fabricated via TIPS and NIPS process. The additives used have their own function on the membrane characteristic. F-MWCNT act as an anchoring agent for LiCL when EDX results (Table 1) shows that without F-MWCNT, chlorine compound in membrane was less. Meanwhile, the role of LiCl is to form membrane with pores of UF/MF as shows in Figure 1. The Figure 1 depicted that all membranes were 100% rejected PVA with molecular weight of 145 kDA which indirectly represent the pore size of membrane. Increased of LiCl content in membrane does not help to increased membrane hydrophilicity further. However all membranes were hydrophilic since contact angle results were below 80^0.

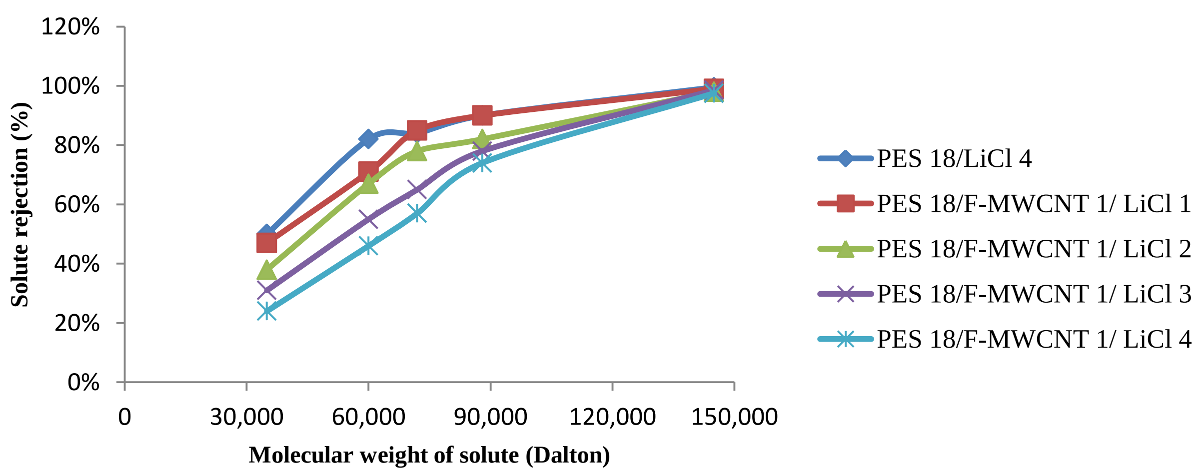

Figure 1. PVA rejection of PES membranes for MWCO determination

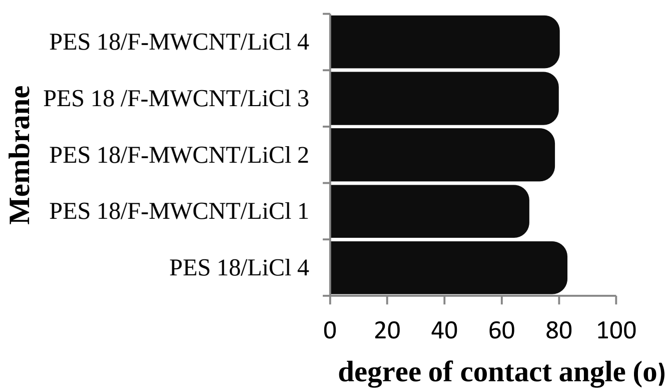

Figure 2. Contact angle analysis of varies membranes

Table 1. Chlorine content in various membranes from EDX

PES Membrane	Chlorine weight%
PES 18 /LiCl 4	0.02
PES 18 /LiCl 1 /F-MWCNT 1	0.42
PES 18 /LiCl 4/F-MWCNT 1	1.30
PES 18/ Licl 4/ F-MWCNT 0.2	0.35

3.2 Permeation

Water permeation results shows that membrane fabricated via TIPS demonstrated higher flux compare to membrane fabricated via NIPS. This proves that membranes from TIPS were highly porous.

Membrane thickness = 0.1mm Pressure = 3 bar	Water Flux rate (L/m^{2}h)	
Membrane	TIPS	NIPS
PES 18/LiCl 4	31.3	10.5
PES 18/MWCNT/LiCl 1wt%	52.0	29.2
PES 18/MWCNT/LiCl 2wt%	244.4	38.9
PES 18 /MWCNT/LiCl 3wt%	313.3	83.3
PES 18/MWCNT/LiCl 4wt%	548.2	161.2

Table 2. Water permeation of membranes of NIPS and TIPS

3.3 Fouling properties

Fouling occurred in all types of the membranes (Table 3). Reversible fouling is better in any process since it can be easily removed by simple washing that would not damage the membrane. In this study, membrane with less licl performed no reversible fouling and fouling that occurred was the irreversible type which is undesired. Overall, the NIPS membranes have low fouling and compared to TIPS which can be related to the terminology of highest flux, highest fouling. Since NIPS membranes does not permeated higher flux so it had low fouling. No occurance of irreversible fouling was recorded for NIPS membrane with highest Licl.

Membrane thickness = 0.1mm Pressure = 3 bar		
	NIPS	
Membrane	IF	RF
PES 18/MWCNT/LiCl 1wt%	0.13	0
PES 18/MWCNT/LiCl 4wt%	0.00	16.61
	TIPS	
PES 18/MWCNT/LiCl 1wt%	0.38	0.00
PES 18/MWCNT/LiCl 4wt%	17.24	52.54

Table 3. Irreversible and reversible fouling properties of the membranes

4. CONCLUSION

LiCl additives has improve the membrane permeation and helped to reduced fouling. Although no significant effect observed in membrane contact angle, the water permeabilities result from membranes with LiCl additives were improved. In the other hand, F-MWCNT has help to maintained LiCl additives in the membrane matrices. In this study NIPS membrane of PES 18/MWCNT/LiCl 4wt% is preferable since it demonstrated acceptable flux and good antifouling property.

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