

Annealing optimization in the process of making membrane PSF19%DMFEVA2 for wastewater treatment of palm oil mill effluent

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Abstract. A small proportion of the Palm Oil Mill Effluent (POME) treatment has used its wastewater to converted to methane gas which will then be converted again into electrical energy. However, for Palm Oil Mill whose has a value of Chemical Oxygen Demand in its wastewater is less than 60.000 mg / L this can't so that the purpose wastewater treatment only to reach the standard that can be safe to dispose into the environment. Wastewater treatment systems that are general applied by Palm Oil Mill especially in North Sumatera are aerobic and anaerobic, this method takes a relatively long time due to very dependent on microbial activity. An alternative method for wastewater treatment offered is membrane technology because the process is much more effective, the time is relatively short, and expected to give more optimal result. The optimum membrane obtained is PSF19%DMFEVA2T75 membrane, while the parameter condition of the permeate analysis produced in the treatment of POME wastewater with membrane PSF19%DMFEVA2T75 obtained at pH = 7.0; TSS = 148 mg / L; BOD = 149 mg / L; And COD = 252 mg / L. The results obtained is accordance with the standard of the quality of POME.

1. Introduction

The liquid waste of the Palm Oil Mill (POM) which contain Chemical Oxygen Demand (COD) above 60.000 mg/L currently by some Palm Oil industry has been processed into methane biogas which then will be converted into electrical energy [1]. A large number of industries especially in the Zone North Sumatera, COD content in the liquid waste has not reached 60.000 mg/L, so it is not possible to convert into electrical energy, but the waste must still be processed to get the standard quality of waste to be disposed safely into the environment [2].

Handling of wastewater carried out during this time in the POM generally by accommodating the waste in aerobic and anaerobic pond. However, this method is considered less effective because, in addition to requiring relatively long time and highly dependent on microbial activity [3]. This method also requires a large area of land for the pond. Alternative waste treatment offered as a new solution that is estimated to be much effective in waste water treatment systems especially for the POM wastewater is a purification method using membranes because the process is much effective, the time is relatively short, independent of microbial activity, broad, and the results of processing is much optimal.

Based on some previous research, membrane technology has been used to treat/purify the POM wastewater. The optimum membrane obtained for purification of the POM wastewater in the previous study was PSF19%DMFEVA2 [4] membrane type, but the result of the test parameters for the effluent treatment was considered to be optimum when compared to the standard of quality of liquid waste. It must be fulfilled yet is still less than targeted because the processing results of each test parameter is still above 100 mg/L. For that purpose, membrane optimization is needed, especially in annealing



process in making PSF19%DMFEVA2 membrane for wastewater treatment of the POME. The resulting PSF (Polysulfone) membrane is expected to purify the POM wastewater more optimally and able to get the liquid waste quality standards set at the same time by the final value of the targeted test parameters.

The objectives include optimizing the optimum annealing temperature in PSF19%DMFEVA2 membrane making the process for the wastewater POM treatment and simultaneously optimizing membrane performance of PSF19% DMFEVA2 in purification operation of the wastewater of POME.

2. Methodology

The stages of this research consist preparation of membrane polymer with phase inversion technique which used PSF as polymer and DMF (Dimethyl formamide) as solvent. After than was done the preliminary analysis of feedstock of the wastewater POME derived from aerobic ponds, tested of membrane performance with membrane module, and for the last was done permeate analysis for some parameter as pH, TSS, COD, and BOD and membrane characterization with SEM (Scanning Electron Microscopy).

The materials used in this study were PSF as a mixed polymer solution dope, DMF as the solvent, Aquadest as nonsolvent, Solution dope PSF as the casting solution, and the wastewater POME derived from Aerobic ponds effluent as feedstock sample. While the membrane operating equipment consists of a set of membrane module. The membrane operating apparatus was a set of membrane modules to testing the membrane performance as follows.



Figure 1. Membrane module

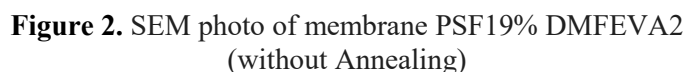
1. Mixer
2. Membrane Cell
3. Pressure gauge
4. Pump

Process variables in membrane making include temperature Annealing 75°C and without Annealing whereas the variables on the important membrane performance test operation are operating pressure with variation 5; 10; 15; 20 and 25 psia.

3. Result and Discussion

3.1 Structure of Membrane Morphology

Based on SEM analysis was gotten the pore distribution as follow on the Table 1. PSF19%DMFEVA2 membrane has the range average pore diameter wider, 0.0004-0.0011 μm (0.0007 μm) than PSF19%DMFEVA2T75, 0.00075-0.00125 μm (0.0005 μm), while on the average space pore of PSF19%DMFEVA2 membrane has space pore more dense, 0.000632 μm than PSF19%DMFEVA2T75, 0.00147 μm .



No	Types of Membrane	Parameter of Analysis	
		Range of Pore Diameter (μm)	Average Space Pore (μm)
1	PSFDMF19%EVA2	0.0004 – 0.0011	0.000632
2	PSFDMF19%EVA2T75	0.00075 – 0.00125	0.00147

Based on analyzed for the membrane performance was gotten the permeability as follow on the Table 2. PSF19%DMFEVA2 membrane has the permeability lower, $77.19 \times \text{cm}^3/\text{cm}^2.\text{det}.\text{psia} \times 10^{-5}$ with the maximum flux was $471.80 \text{ cm}^3/\text{cm}^2.\text{det}$ on 20 psia than PSF19%DMFEVA2T75, $144.3 \times 10^{-5} \text{ cm}^3/\text{cm}^2.\text{det}.\text{psia}$ with the maximum flux was $522.35 \text{ cm}^3/\text{cm}^2.\text{det} \times 10^{-5}$

Types of Membrane	Permeability	Flux				
	cm ³ /cm ² .det.psia). 10 ⁻⁵	(cm ³ /cm ² .det) x 10 ⁻⁵				
		5	10	15	20	25
PSF19%DMFEVA2	77.19	274.83	274.83	353.86	471.80	425.67
PSFDMF19%EVA2T75	144.3	324.36	350.43	434.71	471.81	522.35

Table 3. Average Rejection of permeate for each membrane

Types of Membrane	Average Rejection				
	5 psia	10 psia	15 psia	20 psia	25 psia
PSF19%DMFEVA2	968.590	968.383	968.122	967.607	967.165
PSF19%DMFEVA2T75	975.160	974.616	974.567	974.205	974.193

Table 4. pH, TSS, BOD, and COD of The Wastewater POME Feedstock

Types of Membrane	Wastewater POME Feedstock			
	pH	TSS	BOD	COD
PSF19%DMFEVA2	3.6	13.67	4,214	8,427
PSF19%DMFEVA2T75				

Table 5. pH, TSS, BOD, and COD of Permeate

Types of Membrane	Permeate			
	pH	TSS	BOD	COD
PSF19%DMFEVA2	7.7	177	172	360
PSF19%DMFEVA2T75	7	148	149	252

Table 6. Limitation of Wastewater POME before Flue to River

Types of Membrane	Permeate			
	pH	TSS	BOD	COD
PSF19%DMFEVA2	6-9	Max.250	Max.250	Max.500
PSF19%DMFEVA2T75				

3.3 Effect of The Annealing Temperature on Morphological Structure

Annealing temperatures have important role in the formation of membrane morphological structures. This can be seen in Figures 2 and 3 which were the result of the SEM analysis. If both membranes are compared the PSF19%DMFEVA2 membrane (without annealing) in Fig. 2 has a less stable pore diameter range and more varies between 0.0004 - 0.0011 μm of membrane PSF19%DMFEVA2T75 (with annealing) in Fig. 3 (see Table 1) is between 0.00075 - 0.00125 μm . It was caused the annealing process will be affected the pore stability of the obtained membrane became more stable and more uniform the pore size of the membrane was formed than membrane without Annealing like PSF19%DMFEVA2 [5]. The annealing process on the casted membrane will minimize the swelling at the edges of the membrane pores, due to frequent use as a filter medium in the separation operation [6].

3.4 Effects of The Operating Pressure on Flux and Permeability

In Table 2 above can be seen the value of permeability on each membrane by using pure water feed. The permeability value will be directly proportional to the flux value and the increase in operating pressure will usually also directly affect the increase in flux value. It can be explain that pressure is the driving force for the nanofiltration process (NF) so that with the increase in operating pressure causes an increase in total flux [7]. The high total flux was due to increased operating pressure and flow rate and caused the solute to carry as well.

3.5 Effects of The Operation Pressure of Rejection on the Membranes

The flux is directly proportional to the operating pressure and the rejection is inversely proportional to the operating pressure on each membrane. Rejection ratio values on both membrane can be seen in Table 3. The PSF19% DMFEVA2T75 membrane has a higher rejection value with rejection optimum at a PSF membrane is 97.42% when compared with not annealed membrane is PSF19% DMFEVA2 membrane. This is because the pore of the transgene membrane is much more stable and the degree of swelling on the pores of the membrane is much smaller so has a much less soluble solubility rate than not annealed membrane, for which the membrane considered more effective for purification of the wastewater POME is a PSF19% DMFEVA2T75 membrane, where the optimum state is obtained at 20 psia with permeability of $144 \times 10^{-5} \text{ cm}^3 / \text{cm}^2 \cdot \text{det} \cdot \text{Psia}$, the flux value is $472 \times 10^{-5} \text{ cm}^3 / \text{cm}^2 \cdot \text{det}$ and the rejection value is 97,42%. While the parameter condition of the analysis of the waste processing results obtained pH = 7.0; TSS = 148 mg/L; BOD = 1149 mg/L; And COD = 252 mg/L.

4. Conclusions

1. The most optimization membrane obtained is a PSF19%DMFEVA2T75 membrane having a pore diameter range 0.00075 - 0.00125 μm and an average pore spacing of 0.00147 μm .
2. Optimization operating conditions obtained from the treatment of POM liquid waste with membrane PSF19% DMFEVA2T75 at P = 20 psia; Value of flux (J_v) = $472 \times 10^{-5} \text{ cm}^3 / \text{cm}^2 \cdot \text{det}$; Permeability (L_p) = $144 \times 10^{-5} \text{ cm}^3 / \text{cm}^2 \cdot \text{det} \cdot \text{psia}$; and rejection (R) = 97.42%.
3. The permeate condition produced in the treatment of POM liquid waste with membrane PSF19%DMF EVA2T75 as follows: P = 20 psia; PH = 7.0; TSS = 148 mg/L; BOD = 149 mg/L; and COD = 252 mg/L
4. The processing of liquid waste POM by using Polysulfone membrane on this research was quite effective, because the result was accordance with the standard quality set.

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