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Characteristics of Polyethersulfone Membranes with the Addition of Silver Nitrate; Tensile Strength, Microstructure, and Permeability

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Abstract. This research will be used as raw material for the manufacture of polymer membrane of Polyethersulfone (PES). Properties of a membrane are known about the characteristics of the membrane which can figure out the effectiveness and efficiency of a membrane that is created by the presence of parameter testing. Study of the parameters used, namely tensile strength, microstructure, and permeability of the membrane. This membrane is created using three different aqueous concentrations of Polyethersulfone (PES) (27.5%, 25%, 30% by weight) with the addition of concentrations of silver nitrate (AgNO3) a 1% weight and N, N-Dimethylformamide (DMF) as a solvent. The results of the mechanical strength of Adhesion machine using Tearing Strenght Tester showed an increase in the value of the pull-test of the 523.3626333 kPa to concentrations of 25%, the 593.554966 kPa to 27.5% and the concentration of the 621.5878333 kPa to 30% concentration. For testing of the microstructure using Scanning Electron Microscopy the diameter membrane is varies pores, to range size 1,396 µm up to 2,151 µm, there is for concentrations of 25%, range 645.2 nm up to 967.9 nm at concentrations of 27.5% and 573.5 nm up to 1,950 µm at concentrations of 30%. For the ability of membrane permeability on pressure 2 bar using the Clean Water Permeability for the concentration of 25% 69.9420 $L.m^{-2}.h^{-1}$ for the concentration of 27.5% 18.24575 $L.m^{-2}.h^{-1}$ for the concentration of 30% 14.81776 $L.m^{-2}.h^{-1}$.

INTRODUCTION

The need for clean water is greatly improved so that demand for some people to try and find other alternatives that can be done for the sake of fulfilling the need for clean water. Currently, clean water treatment membrane technology is very promising processing with excellent quality and is also suitable for processing drinking water in developing countries due to the membrane have a myriad of excellence. One type of membrane separation operation is with the ultrafiltration membrane [1].

The process of immersion precipitation phase inversion is known as the most popular techniques for creating asymmetric membranes, especially for membrane process ultrafiltration [2].

There are several polymers that can be used for ultrafiltration membranes, such as the polyester sulfone, polysulfone, cellulose acetate, polyacrylonitrile or alloy between polymers. Polyethersulfone (PES) is one of the most widely used polymers as the material for ultrafiltration membranes. This is because PES resistant to high temperatures, a broad pH tolerance, have the power of a good mechanical and chemical as well as easy in the making [3]. Polyethersulfone (PES) is an amorphous well-known polymer with thermal, chemical and oxidation resistance. This polymer tolerates various acids and alkalis and is compatible with biological substances including blood. All the mentioned properties make (PES) as an attractive material for microfiltration, ultrafiltration and nanofiltration membrane [4, 5].

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N, N-Dimethylformamide (DMF) is used as a solvent without further purification, this is a powerful solvent for polyethersulfone, because it has the desired traits such as low volatility, non-flammable, and relative toxicity low [6].

Application use of silver nitrate (Ag) itself is one of the new innovations in the provision of clean water, one of the mechanisms that make silver is the bacteria can disable attached to the cell membrane of bacteria that makes the onset of enlargement bacterial cell, that makes the death of the bacteria. The addition of silver nitrate in water filtration membrane is able to bind to the bacteria coliform [7].

Basic testing methods of polymer membrane against Polyethersulfone for mechanical strength of polymer material which is used as a water filter membrane, method of testing done on the author's research is the tensile strength, testing Electron Microscopy Scanning (SEM) and Clean Water Permeability (CWP).

METHODOLOGY

Membrane Preparation

The membrane prepared in comparison with fraction form 3 composition (% by weight) mix of different polymer materials at each of the specimens, 27.5%, 25%, 30% shown in table 1. The process of dissolving Polyethersulfone (PES) using N, N-Dimethylformamide (DMF) with addition of silver nitrate ($AgNO_3$) by way of stirring, the third ingredient is stirred using a magnetic stirrer on the temperature of 40°C for 6 hours until the solution is homogeneous, solution considered PES bottled special airtight to be stored and only needs some time to find out if there is still a solvent or polymer fibers has not been homogenized. The solution which is already considered to be homogeneous subsequently poured evenly on prints, glass plates and uses duct tape as a mold of the membrane, the membrane PES phase inversion technique is created by using the method of immersion in a tub of water coagulation membrane printing results with this method of sheet-shaped flat. The layer of the membrane that attaches on the mold is immersed in a tub of water until the coagulation of the mold. The membrane that is already stored in the tube detached desiccator until water levels decrease, then cut using a knife crankcase with the specified dimensions.

TABLE 1. The Composition of the Polyethersulfone Membrane.

Specimens	A Concentration of a Solution		
	PES (wt.%)	$AgNO_3$ (wt.%)	DMF (wt.%)
A	25	0.25	74.75
B	27.5	0.275	72.225
C	30	0.3	69.7

Membrane Characterization

Tensile Strength

The tensile test is a method used to test the strength of a material by providing load coaxial style. This experiment used to measure the mechanical strength with Tearing Adhesion Machine of a material is the force of static given slowly, the results of tensile testing is essential to engineering and product design for yield strength data material tensile testing done to complete the design information is basic mechanical strength of a material and as a data support for material specifications [8]. The purpose of tensile or mechanical testing is to measure the effect of force on a particular material or component, or on the adhesive or fastener that bonds two materials together. The relationship of tensile strength, force and cross-sectional area drawn is shown in equation 1.

$$\sigma = \frac{F_{max}}{A_0} \tag{1}$$

Scanning Electron Microscopy (SEM)

Microstructure test tool with Scanning Electron Microscope (SEM), which uses 9 electron microscope Inspect S50 FEI Company. SEM testing is done in stages on each membrane composition. Scanning Electron Microscopy (SEM) has been used to investigate the resultant membrane morphology [9]. SEM testing is used to view and analyze

surface and texture, shape and size of objects to analyze the sample and analyze the composition of the surface of objects both quantitatively and qualitatively. At this time, through the SEM Test, the size of the pores can be performed. The voids or holes in the membrane and the bond that exists every pore in the membrane were detected as well.

Permeability of Membrane

Water flux is determined as the amount of volume completed by the membrane per unit time and surface area [10]. The film earned cut circular with a diameter of a circle on tools tailored to the CWP. This size is tailored to the design of the tool ultrafiltration. Filtration systems that are used by the method of Dead-end filtration. Before the test, water flux in advance done compacting time against the membrane. Compacting time is done with water flow across the membrane at a pressure of 2 bar so that a constant water flux is obtained. This flux testing functionality that is so obtained has a pore membrane stable. Time measured each one liter of water coming out across the membrane. Determination of the water flux is obtained by measuring the abundance of the volume of water that passes through the membrane per unit surface area per unit of time. To calculate the flux value using the equation below [2].

$$Jv = \frac{V}{A.t} \tag{2}$$

RESULTS AND DISCUSSION

Tensile Strength of the Membrane

Pull-test specimens have the respective concentrations of 25%, 27.5%, and 30% PES. The tensile strength of the specimen showed a rise in the value of 523.36 kPa to 621.59 kPa. Can be seen in Figure 1. that charts the rise in the value of the strong pull of the membrane or the greater the increase in line with the increased concentration of Polyethersulfone. It may caused by fiber braid structure of the membrane which is increasingly interacted [11]. At concentrations of 25% of the value of strong attraction generated amounted to 523.36 kPa, at 27.5% concentration of 593.55 kPa, and the most powerful there is at a concentration of 30% of 621.59 kPa. Standard deviation from the tensile test results is ±580.72143 kPa.

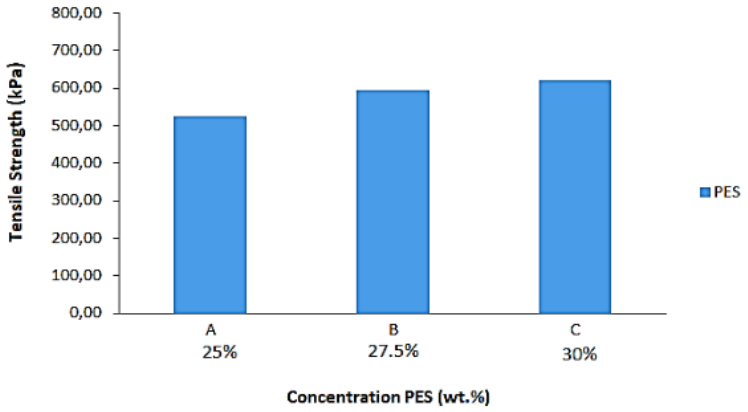
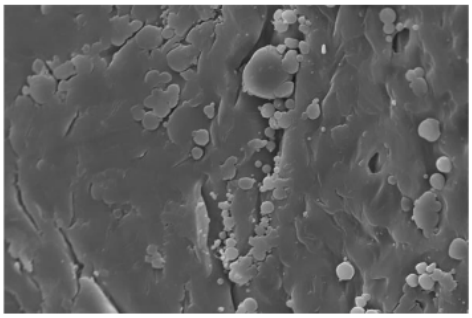
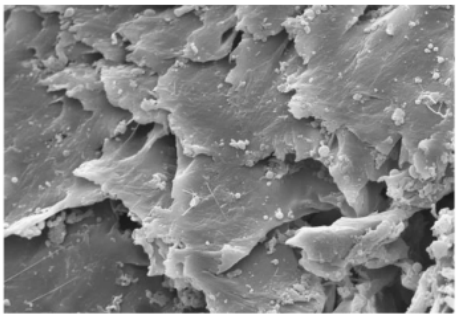


FIGURE 1. The graph of the tensile strength of Polyethersulfone membrane concentration variation by (wt.%) at each of the specimens.

Morphology of Membrane



(A)



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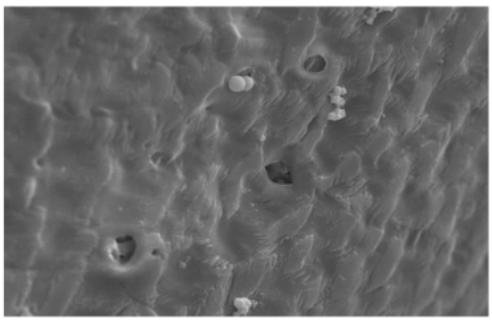

(C)

FIGURE 2. SEM Poliethersulfone membrane concentration of (A) 25%, (B) 27.5%, and (C) 30%.

At concentrations of 25%, Polyethersulfone membrane pores that form has varied in diameter size i.e. ranges 1,396 µm up to 2,151 µm, the structure of the membrane is seen meeting and have ties with pore diameter seem similar to each other, on the composition of this not void or hole in the lining of the membrane. On the composition of 27.5% Polyethersulfone membranes that form has a size that varies from very small sizes worth 645.2 nm to 967.9 nm size. The structure of the membrane-binding each other, bond on each pore has a diameter that is not much different. On the composition of membrane Polyethersulfone 30% formed has a size of the least worth 573.5 nm up to 1,950 µm size. The structure of the membrane-binding each other, bond on each pore has a different diameter size. Can be seen in Figure 2.

Water Permeability of the Membrane

On this test specimen cut circular with a diameter of a circle on tools tailored to the CWP. This size is tailored to the design of the tool ultrafiltration. Following are the results of water permeability or flux in Figure 3. On the results of flux above a flux, value differences can be seen at any concentration of the Polyethersulfone to be tested. At concentrations of 25% PES (A) there is the value of the flux 69.9420 $L.m^{-2}.h^{-1}$ whereas in concentration of 27.5% (B) and 30% Concentration (C) experienced a decline in the value of the flux in 18.2457 value $L.m^{-2}.h^{-1}$ and 14.8177 $L.m^{-2}.h^{-1}$. Standard deviation from the flux test results is ±42.3983 $L.m^{-2}.h^{-1}$. Membrane ultrafiltration has on the operating pressure range 1.0-5.0 bar, with water flux between 10-50 $L.m^{-2}.h^{-1}$ [2]. Thus from Figure 3. It can be said that the water flux shows the eligible rates as an ultrafiltrate, especially for membrane concentration of 27.5% (B) and 30% Concentration (C). While for membrane concentration of 25% (A) does not meet the standards of ultrafiltration.

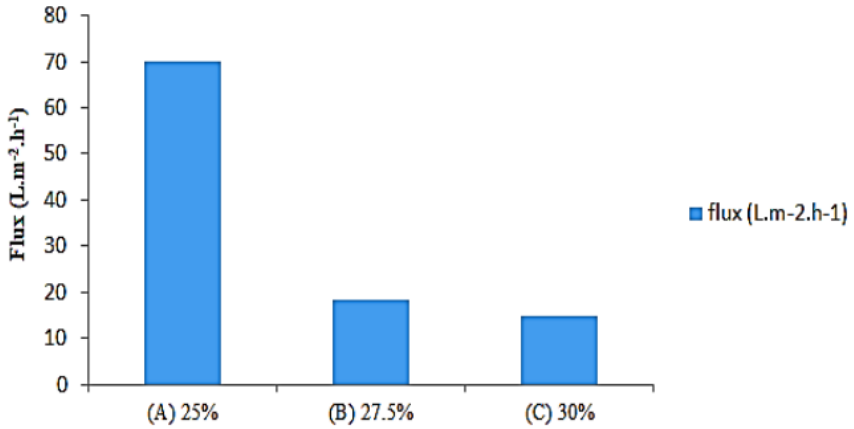

FIGURE 3. Graphing flux or concentration variation of membrane permeability of Polyethersulfone (PES).

CONCLUSIONS

Based on the research results Polyethersulfone membrane tensile testing, as described, it could be concluded as follows. The length of time and the rotation speed of the mixing process of membrane material influence on the results of the homogeneity of the membrane solution. The temperature at the time of stirring is also important to remove residual solvent and trapped air that can cause bubbles on the membrane. Results of testing the best there is in the composition of 30% PES because it can withstand loads of up to 621.59 kPa. On the test membrane microstructure, that increased concentration progressively decrease the occurrence of voids and minimize pore membrane with a smaller size and variety. Membrane ultrafiltration has on the operating pressure range 1.0-5.0 bar, with water flux between 10-50 L. m^{-2}. h^{-1}. Bar^{-1} [2]. It can be said that the water flux shows the price that qualifies as a membrane ultrafiltrate, especially for membrane concentration of 27.5% (B) and 30% concentration (C).

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