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Formation Of Polythersulfone (PES) Membrane With Silver Nitrate (AgNo3) Mixture Characteristics, Mechanical Properties And Water Treatment Performance

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Abstract:
This research will be used as raw material for making Polyethersulfone (PES) polymer membranes. The properties of the membrane are known by knowing the characteristics of the membrane which can determine the effectiveness and efficiency of the membrane made by testing the parameters. The parameter studies used are tensile strength, microstructure, and membrane permeability. This membrane was made using three different concentrations of Polyethersulfone (PES) solution (15%, 20%, 30% by weight) with the addition of 1% silver nitrate (AgNO3) concentration and N,N-Dimethylformamide (DMF) as a solvent. The membrane formation method is phase inversion. The method used is phase inversion, in which the polymer, reinforcement, and solvent are mixed homogeneously for about 2-3 hours, and the membrane is directly printed on a glass plate. Three tests were conducted for membrane formation: tensile test, microscopic test using scanning electron microscope, and flux value test using clean water permeability (CWP). This study concluded that membrane expansion by increasing the concentration of polyetherculfones at concentrations of 15 wt%, 20 wt% and 30 wt%, and 1 wt% Silver nitrate can increase the tensile stress and pore density on the membrane surface.
Keywords: *Membrane; Polyethersulfone; Silver Nitrate; N,N Dimethylformamide, Tensile Strength; SEM; Clean Water Permeability.*

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I. Introduction

Water is the most important substance on earth. All plants and animals must have water to survive. Without water, there would be no life on earth [1] . Water is used by all living things to survive, especially for humans, in addition to survival, it is also used in various other activities such as washing, bathing, cooking, and so on. In its use, if the water used is contaminated by bacteria or other substances, it will cause disease in humans [2] . This source of life is limited in supply and is increasingly polluted by human activities themselves, but there are still too many people who do not have access to water . To maintain the quantity and quality of water so that it remains adequate for humans and the ecosystem, we as academics must be wise in managing this valuable resource [3] . Filtration using membranes, in addition to functioning as a means of separation, also functions as a means of concentration and purification of a solution that is passed through the membrane [4] . In membrane development, fouling control is a competitive and challenging step in membrane development, because research has shown that increasing membrane hydrophilicity reduces the hydrophobicity between fouling in the feed and the membrane surface.

Although Polyethersulfone (PES) has good thermal and mechanical stability, PES has limitations in its hydrophobic properties which cause high water permeability and fouling. In many studies, Polyethersulfone has proven its efficiency in nanofiltration, gas separation, and other wastewater purification [5] . The development of membranes using polyethylene polymers with silver nitrate as a reinforcement has been widely used. This is done by adding a reinforcing matrix, namely silver nitrate. Silver nitrate has the properties of a colorless, odorless crystalline solid, and is one of the low costs in membrane formation [6] . In the formation of membranes with polyethersulfone polymers with silver nitrate as a reinforcement, a solvent is needed to dissolve the homogeneous bonds between the two materials. The solvent N,N Dimethylformamide combines extraction, distillation, and reverse osmosis [7] .

At concentrations of 15% by weight, 20% by weight, and 30% by weight. The formation of this membrane aims to determine the maximum tensile strength value of the membrane, the surface area of the membrane produced in microscopic testing using a scanning electron microscope, and the flux value produced by the membrane. With several series of tests and concentration limits used, it is expected that the results obtained are that the membrane has better mechanical and microscopic properties.

II. Materials And Methods

Research on membrane development, membrane manufacturing and printing, and clean water permeability testing were conducted at the Master of Mechanical Engineering Department, Faculty of Engineering, Sriwijaya University, South Sumatra, Indonesia. The materials used in the test were Polyethersulfone Polymer with concentrations of 15wt%, 20wt%, 30wt%, Silver nitrate with a concentration of 1wt%, and N,N Dimethylformamide solvent.

The method in question is mixing the materials to produce a membrane with a homogeneous mixture of materials. The membrane formation method used is polyetherculfon, silver nitrate and DMF solvent, mixing is done by stirring the mixture without a specified time limit. In this study, stirring took about 4-6 hours, so that the membrane was formed and mixed evenly. Then the membrane was printed using the phase inversion method and then soaked in water. The resulting membrane is a flat sheet of membrane printing results.

Figure 1 membrane manufacturing process.

After the forming process is carried out, the membrane that has been formed on a flat sheet is made by forming a membrane sample according to the tests that have been carried out. In this study, three tests were carried out, namely tensile tests, microscopic tests, and clean water permeability tests.

Tensile test:

This tensile test was conducted to determine the mechanical properties of the membrane. Before the membrane test was conducted, the test sample was measured according to the standard. The test equipment used was a WP 310 Gunt Hamburg Material Testing Machine tensile test machine. The samples used in this tensile test were 9 samples. Each concentration of polyethylene polymer that had been mixed with silver nitrate and DMF was three samples. Each concentration used in the test was 15wt% with three samples, a concentration of 20wt% with three samples, and a concentration of 30wt% with three samples.

Scanning Electron Microscope Test

SEM is an electron microscope designed to observe and analyze the surface of a material directly. A tool for analyzing the surface of a material. SEM testing was carried out at one of the campuses in South Sumatra , namely Sriwijaya University. Samples taken were 1 sample for each concentration. The tool used was the Zeiss EVO 10 I Scanning Electron Microscope (SEM). The results can be seen in Figures 4-2, 4-3 and 4-4 with a magnification of 5000x.

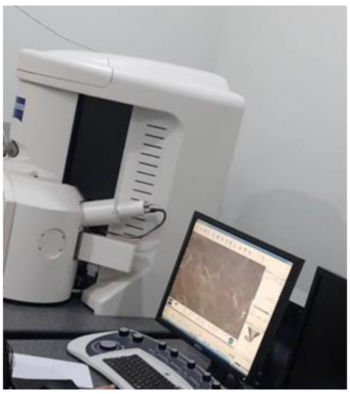

Figure 3. Scanning electron microscope test equipment

Clean Water Permeability Test:

This test aims to measure the flux parameters of the fouling membrane formation. This test was conducted at the Mechanical Engineering, Faculty of Engineering, Sriwijaya University, Palembang. The tool used is a clean water permeability tool that uses a 2 bar pressure pump. The membrane sample used in this test has a diameter of 56.2 cm or a circle radius of 28.1 m, where the collected water will flow through the pipes. The water passes through the tap for 0.694 hours and will record how much water is released from the pipe into the measuring cup. This test uses 1 sample for each concentration of polyethersulfone polymer and silver nitrate.

III. Results

Figure 4. Clean Water Permeability

Tension Test

Table 1 PES 15wt%, AgNO3 1wt%, and DMF membranes

Example	Material Composition (% weight)			Area (mm2)	Maximum Load (kN)	Tensile Stress (kN/mm2)
	PES (gr)	DMF	AgNO3 (gr)			
A1	7.5	40,425	0.075	2.4	0.0067	0.002972
A2	7.5	40,425	0.075	2.4	0.0036	0.0015
A3	7.5	40,425	0.075	2.4	0.0044	0.001833
Average Maximum Tensile Stress					0.0049	0.00242

Table 2 PES 20wt%, AgNO3 1wt %, and DMF membranes

Example	Material Composition (% weight)			Area (mm2)	Maximum Load (kN)	Tensile Stress (kN/mm2)
	PES (gr)	DMF	AgNO3 (gr)			
A1	10	39.90	0.15	2.4	0.0041	0.001708
A2	10	39.90	0.15	2.4	0.0036	0.001500
A3	10	39.90	0.15	2.4	0.0033	0.001375
Average Maximum Tensile Stress					0.011	0.001528

Table 3 PES membrane 30 wt%, AgNO3 1 wt%, and DMF

Example	Material Composition (% weight)			Area (mm2)	Maximum Load (kN)	Tensile Stress (kN/mm2)
	PES (gr)	DMF	AgNO3 (gr)			
A1	15	40,425	0.15	2.4	0.0032	0.001333
A2	15	40,425	0.15	2.4	0.0044	0.001833
A3	15	40,425	0.15	2.4	0.0031	0.0012916
Average Maximum Tensile Stress					0.0107	0.001486

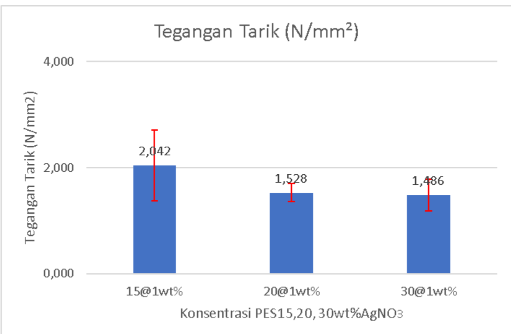

Figure 5-Graph of Tensile Stress Increase of Sulfone Polymer

Clean Water Permeability Test

The membrane was tested at a pressure of 2 bar per hour and room temperature. The test was conducted at the Department of Mechanical Engineering, Sriwijaya University. Each sample was tested using a clean water permeability tool, with the aim of determining the flux value of each polymer concentration produced for 0.5 hours. To analyze the results as in table 4-4. By providing a dead-end system with an effective membrane area of 18.08 cm² is used to analyze the performance of the prepared membrane.

The following test results:

Table 4 Tire Test Results Using CWP

No	Membrane	Permeate Volume (L)	Membrane area (m^2)	Time (h)	Pressure (Bar)	Flux L/ ^{m2}.h.bar
1	PES 15%	1	0.001809	0.694	2	4,607
2	PES 20%	1	0.001809	0.694	2	3,317
3	PES 30%	1	0.001809	0.694	2	2,948

Microscopic Test

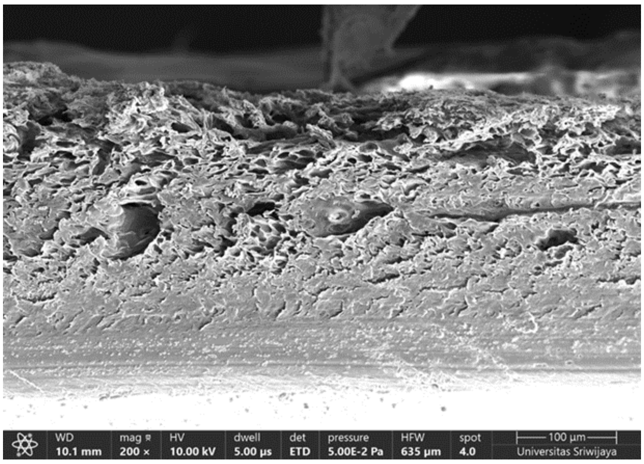

Figure 6. SEM results for PES 15wt%, NN-dimethylformamide and AgNO3 at 5000x magnification.

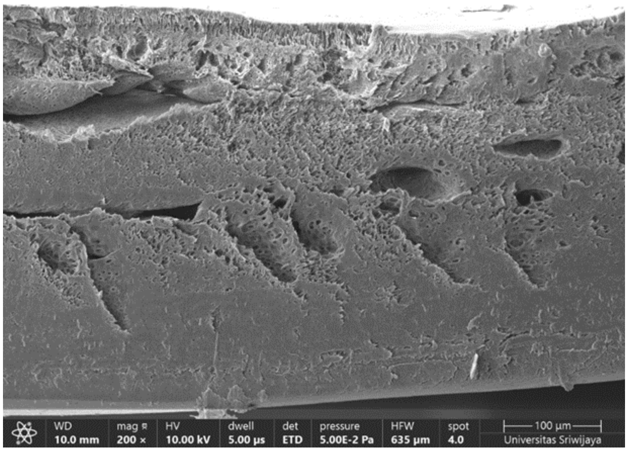

Figure 7 SEM results for PES 30wt%, NN-dimethylformamide, and AgNO $_3$ at 5000x magnification.

IV. Discussion

Based on table 1, table 2, table 3 and figure 5, the results obtained at a PES concentration of 15 wt% obtained an average tensile stress value of 0.00242 kN/mm2. In the membrane with a PES concentration of 20 wt%, the average maximum tensile stress value was obtained at 0.001528 kN/mm2, while the average maximum tensile stress value at a concentration of 30 wt% was 0.001486 kN/mm2. Based on these data, it can be concluded that the highest average maximum tensile stress value is at a concentration of 15 wt%, which is 0.00242 kN/mm2. The average maximum load value and the lowest maximum stress value are at a concentration of 15%, which is 0.0049 kN and 0.00242 kN/mm2.

Microscopic test results (Figure 6-8) PES, NN-dimethylformamide, and AgNO3 membranes with a concentration of 15% have a pore shape with a homogeneous size. At a concentration of 30%, it appears to have a less homogeneous pore surface size compared to the membrane at a concentration of 15%. The higher the concentration of Polyethersulfone contained in the membrane, the greater the pore density formed on the membrane. Increasing porosity causes increased membrane hydroactivity.[6].

In the clean water permeability test, it was shown that the greater the concentration of PES polymer added, the greater the pore density that occurs, which causes the flux value or water flow rate to decrease. This is supported by research conducted by Eryildiz and colleagues that membranes with high hydrophilicity properties have higher membrane stability. When hydrophobic membranes are tested for water filtration, the mass transfer of water will be significantly reduced, and as a result the flux permeability of the membrane will decrease.[7]

V. Conclusion

Based on the results of tests that have been carried out on the formation of Polyethersulfone (PES) membranes with the addition of the addictive substance Silver Nitrate (AgNO) it can be concluded that the formation of membranes with polyethersulfone polymers with concentrations of 15 wt%, 20 wt%, and 30 wt% and silver nitrate with a concentration of 1 wt% can be done. In tensile testing, Polyethersulfone and silver nitrate membranes showed higher maximum tensile stress values with a value of 0.00242 kN/mm2 at a concentration of 15 wt%, and the lowest maximum tensile stress value occurred at a concentration of 30 wt% with a value of 0.00142 kN/mm2. In testing the maximum water flow rate value on the membrane, namely at a concentration of 15 wt%, which is 4.607L/m2.h.bar while the lowest water flow rate value is at a concentration of 30 wt%, which is 2.948 L/m2.h.bar.

Reference

[1] B. Brunekreef, "Air Pollution And Human Health: From Local To Global Issues," Procedia - Soc. Behav. Sci. , Vol. 2, No. 5, Pp. 6661–6669, 2010, Doi: 10.1016/J.Sbspro.2010.05.010.

[2] C. Paper, "Membrane Technology In Industrial Water And Waste Treatment. Case Study: Utilization Of Ultrafiltration For Pond Water Treatment," No. October, 2015.

[3] A. Herlambang, "Water Pollution And Its Control Strategies," J. Air Indones. , Vol. 2, No. 1, Pp. 16–29, 2018, Doi: 10.29122/Jai.V2i1.2280.

[4] Dd Putri, "Water Treatment Technology Innovation In Several Countries And Leading Companies," No. December, Pp. 0–13, 2017.

[5] I. Prihatiningtyas And Tamrin, "Application Of Membrane Technology For Wastewater Treatment And Air Pollutant Removal," Gunung Djati Conf. Ser. , Vol. 34, No. 9, Pp. 97–105, 2023.

[6] N. Shahkaramipour, Tn Tran, S. Ramanan, And H. Lin, "Membranes With Surface-Enhanced Antifouling Properties For Water Purification," Membranes (Basel). , Vol. 7, No. 1, 2017, Doi: 10.3390/Membranes7010013.

[7] N. Arahman, S. Aprilia, And T. Maimun, "Study Of Solidification Of Polyethersulfone In N-Methyl-2- Solvent," Jur. Tech. Kim. Usu , Vol. 3, No. 3, Pp. 18–23, 2014.