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Comparison Analysis of Tensile Strength of Polyethersulfone (PES) Membrane by Titanium Dioxide and Polyvinylidene Fluoride (PVDF) Membrane by Titanium Dioxide

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Abstract:
Background*: Water is a very important requirement for humans. Water is used both for daily life and for small and large industries. One of the greatest challenges facing mankind in the future is how to ensure that people achieve universal access to clean water. The threat of a clean water crisis is in sight as a result of climate change, infrastructure development that is not environmentally friendly, waste from various industries and many bad human acts that have damaged nature. The rate of population growth is also directly proportional to water demand, but inversely proportional to the ability of land to provide a source of clean water for humans. The use of membrane technology as a solution for clean water treatment is widely used by people and factories to meet their clean water needs. The manufacture of membranes made from the main material of Polyethersulfone (PES) and Polyvinylidene fluoride (PVDF) membranes with the mixing of cheap and simple Titanium Dioxide is interesting for research and a comparison of the tensile strength of the results of the manufacture of these membranes will be carried out.*
Materials and Methods*: The main material of the membrane is Polyethersulfone (PES) and Polyvinylidene fluoride (PVDF) membrane with a mixture of 2% Titanium Dioxide and made using 15000V DC of Electric Field method. Then performed a tensile test to determine the mechanical strength of the membrane and a comparative analysis of the two membranes was carried out.*
Results*: The maximum tensile test results of the Polyvinylidene fluoride (PVDF @ TiO_2) membrane produced tensile strength with a sample concentration of 21 wt% is 2.335 Mpa, 22 wt% is 3.153 Mpa and 23wt% is 3.20 Mpa. Tensile Testing of the Polyethersulfone membrane (PES @ TiO_2), the sample concentration of 25 wt% is 0.414 Mpa, 30 wt% is 0.418 Mpa, and 35 wt% is 0.617 Mpa. The test shows an increase in tensile strength with increasing concentrations of Polyvinylidene Fluoride and Polyethersulfone*
Conclusion: *From the results of the tensile test of the two membranes, PES @ TiO_2 and PVDF @ TiO_2, it shows that the maximum tensile strength of the PVDF @ TiO_2 membrane at a concentration of 23 wt% with a maximum tensile strength of 3.20 Mpa is greater than PES @ TiO_2, a concentration of 35 wt%, this shows the results of the PVDF membrane have better mechanical strength than the PES membrane with the addition of the same titanium dioxide, which is 2%.*
Key Word*: Polyvinylidene fluoride membrane ; Polyethersulfone membrane ; Electric Field method; Membrane tensile testing*

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I. Introduction

Water is a very important requirement for humans. The rate of population growth is also directly proportional to water demand, but inversely proportional to the ability of land to provide a source of clean water[1]. Membrane technology is a technology that has been discovered for a long time since several decades ago. Membrane technology is used in the water industry to improve the quality of water and applied in for conventional drinking water production, wastewater treatment, ultrapure water production, desalination and water reuse [2], [3], [4]. Membrane technology is not difficult to manufacture, the equipment used is not much, the energy consumption is small because the separation process is at room temperature and can be carried out continuously and its properties vary according to need and improve water quality [5]-[8]. However, the success of applying membrane systems for water treatment is limited due to membrane impurities (fouling), the main factor being the surface properties of the membrane such as hydrophilicity [9]. Fouling also occurs due to the sticking of inorganic materials.To improve the quality of the research membranes using the main and organic base materials in the water which results in reduced membrane performance damage (reduced membrane flux) [10].

This research was conducted with the two polymer materials, Polyvinylidene fluoride (PVDF) and Polyethersulfone (PES), both of which have anti-fouling properties and are known to be widely used for the manufacture of membranes. PVDF membranes have high hydrofibicity, high thermal stability, chemical resistance and excellent mechanical strength making them suitable for use in membrane materials [11], [12]. Polyethersulfone (PES) have chemical stability, thermal stability and mechanical stability and PES shows oxidative stability and tolerance to solvents [13], [14]. PES has an asymmetric structure, and is applied by the phase inversion method. The final membrane structure is influenced by the composition (concentration, solvent, additive) and temperature of the PES solution, non-solvent or non-solvent mixture, and the coagulation bath or environment [15]. However, PES polymers are very susceptible to fouling (impurity) so that PES requires nanoparticles which are used as binders for antifouling properties [16].

N, N Dimethylformamide (DMF) is a liquid, has a colorless characteristic, has the ability to dissolve easily with water and many organic liquids, besides that DMF has characteristics such as fire resistance, volatility and toxicity values [23]. Titanium dioxide (TiO_2) is an addictive substance that is resistant to fouling, increases hydrophilicity, self-cleaning, and antibacterial properties of the membrane itself [17], [18]. In addition, TiO2 has long-term membrane stability properties, non-toxic, low price and UV resistant [19]-[21]. Despite the many advantages of titanium dioxide (TiO_2), it also has its drawbacks [22], the ratio of titanium dioxide (TiO_2) is locked with a composition of 2wt%. This research will focus on the Comparative Analysis of the Tensile Strength of Polyethersulfone (PES) and Polyvinylidene fluoride (PVDF) membranes with mixing of Titanium Dioxide in Water Treatment.

II. Material And Methods

Membrane preparation was carried out by preparing 3 specimens in the ratio fraction by weight (wt%) of the combination and addictive substances in each sample. PES and PVDF polymers, N, N-Dimethylformamide (DMF) solvents, and titanium dioxide (TiO2) addictive substances obtained from Aldrich chemical (Indonesia) with no further purification processes. Polyvinylidene fluoride (PVDF) with a weight composition of 21 wt%, 22 wt% and 23 wt%. Polyethersulfone (PES) sample concentration of 25 wt%, 30 wt% and 35 wt% with the addition of 2% Titanium Dioxide.

Membrane formation begins with the process of mixing the PVDF polymers into the DMF solvent with Titanium dioxide and PES polymers into the DMF solvent with Titanium dioxide. Mixing using a magnetic stirrer with a time of 8 hours until it is homogeneous. Each solvent was stirred at a speed of 100 rpm and with a span of 8 hours using a magnetic stirrer (FAITHFUL Magnetic Stirrer SH-3, Palembang, Indonesia). The shape of the specimen is a flat-sheet method using a copper plate which was supplied with a 15000V DC electric field modification for 3 minutes before immersion in deionized water. The printing illustration can be seen in Figure 1 below:

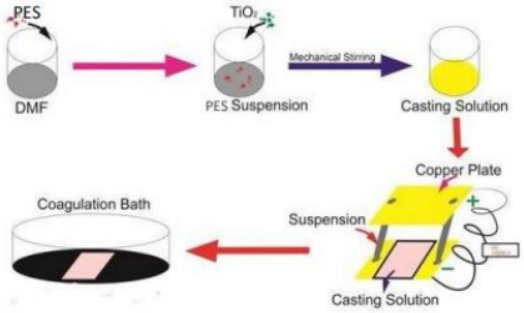


Fig 1. Membrane manufacturing process

III. Result

With the ASTM D638 standard using the ZWICK ROEL Material Testing Machine (Type BT2-FR020TH.A60) at the Manufacturing Polytechnic, Bangka Belitung. The results of the PES @ TiO_2 membrane tensile test are shown in Tables below:

Table 1: PES @ TiO_2

Specimen	Material Composition (%. Weight)			Tensile Test (MPa)
	PES (gr)	DMF (gr)	TiO_2 (gr)	
PES @ TiO_2 25 wt%	12.5	37.25	0.25	0.414
PES@TiO_2 30 wt%	15	34.7	0.3	0.418
PES@TiO_2 35wt%	17.5	32.15	0.35	0.617

The mixed membrane of Polyethersulfone (PES) and Titanium Dioxide (TiO_2) was analyzed by tensile testing with 3 tests to obtain the average value of membrane tensile strength. From the test results, the best average value is obtained by the PES @ TiO_2 membrane with a concentration of 35wt% of 0.617 MPa and the lowest value is the concentration of the membrane PES @ TiO_2 25wt% of 0.414 Mpa.

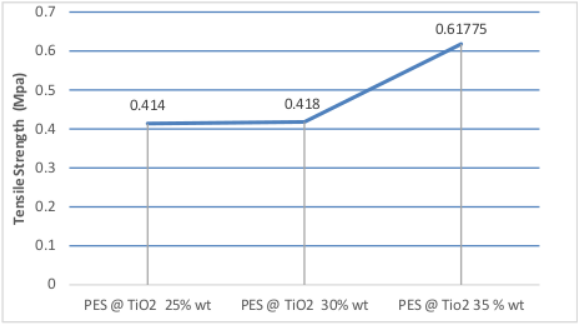
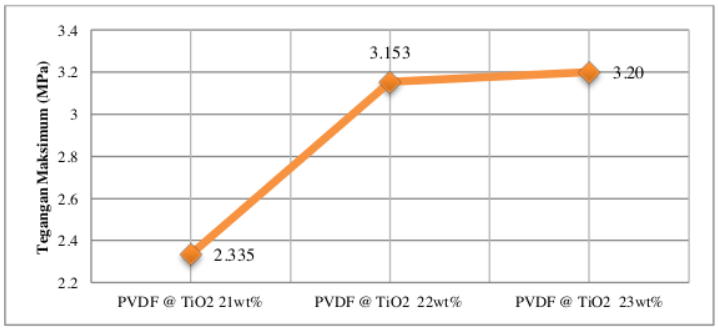


Fig 2. Graph of the Increase in Tensile Strength of PES @ TiO_2

From the data contained in tables below, it can be seen the difference of maximum stress obtained by each PVDF @ TiO_2 membrane.

Table 2 : Membran PVDF@TiO_2 21 wt%

Specimen	Material Composition (%. Weight)			Tensile Test (MPa)
	PVDF(gr)	DMF (gr)	TiO_2 (gr)	
PVDF@TiO_2 21 wt%	10.5	39.29	0.21	2.335
PVDF@TiO_2 22 wt%	11	38.78	0.22	3.153
PVDF@TiO_2 23 wt% %	11.5	38.27	0.23	3.20



Each concentration of the mixed membrane that has been subjected to tensile testing has a different tensile strength value. can be seen in Table 2. The tensile test graph has increased along with the increasing concentration of Polyvinylidene Fluoride (PVDF). At the highest concentration, 23wt%, the maximum stress produced was 3.20 MPa, at a concentration of 22wt% of 3.153 MPa and for a concentration of 21wt%, it was 2.335 MPa. The data that has been obtained from this tensile test is directly proportional to previous studies, the addition of TiO_2 additives to the membrane-making mixture clearly shows that there is an increase in the mechanical strength of the membrane which also affects the service life of the membrane [24].

IV. Discussion

Tensile test analysis using the ZWICK ROEL Material Testing Machine (Type BT2-FR020TH.A60), the results of the Tensile test on the mixed membrane sample of Polyethersulfone (PES) and Titanium Dioxide (TiO2) were analyzed by tensile testing with 3 times of testing to get an average value. Average membrane tensile strength. From the test results, the best average value was obtained by the PES @ TiO2 membrane with a concentration of 35wt% of 0.617 MPa and the lowest value was at the concentration of 25wt% PES @ TiO2 membrane of 0.414 Mpa while the highest concentration of Polyvinylidene Fluoride (PVDF) was 23wt% of stress. The maximum produced is 3.2 MPa, at a concentration of 22wt% of 3,153 MPa and for a concentration of 21wt% of 2,335 MPa.

Both samples showed an increase in the value of tensile strength at each concentration of increase in sample weight, for the results of the PES @ TiO_2 membrane, the maximum tensile test results at 35wt% were 0.617 Mpa while for PVDF @ TiO_2 23wt% was 3.153 MPa.

The tensile strength value of the PVDF mixed membrane has a much greater tensile strength than the PES mixed membrane with a difference of 2.563 MPa. As a result, the effect of adding TiO2 on PES and PVDF significantly increases the mechanical strength of the membrane, which also influences membrane life[25].

V. Conclusion

The mixture of PES and PVDF membranes with the addition of TiO_2 was successfully made using the 15000 volt DC electric field method. The influence of TiO_2 and electric fields over the specified PES and PVDF membrane concentration ranges was investigated the mechanical properties of the membrane. Observation shows that with the addition of TiO2 and electric field, the membrane is directly proportional to the tensile strength of PES and PVDF membranes the higher the concentration the greater the maximum stress obtained. The results of research show that the addition of TiO2 and the use of a 15000 volt DC Electric Field are one of the effective methods to improve the mechanical properties of membranes and water treatment performance with low TiO2 concentrations.

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