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RESEARCH ARTICLE

Physical and mechanical properties of membrane polyvinilidene flouride with the addition of silver nitrate

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Abstract

The membrane is a layer formed from fine fibers that are used as a filter. In the development of membrane material, polymer can be interesting material and great potential as membrane filtration of contaminated water. This study tested the tensile strength and microstructure of membranes made by three variations of the specimens with different mixtures of polyvinilidene fluoride (PVDF) (17.5%, 20%, 22,5%). With an assumed value (% by weight), a membrane was made by using PVDF polymer granules and N,N-Dimethylformamide as solvent and silver nitrate. The use of a nanofiber microfiltration membrane with an innovative electrospinning technique contained in water filtration was the goal of this study, which could be developed by using the electrospinning technique for flat sheet membrane on the application of water filtration. The removal of pathogens was investigated by functioning or not functioning in bacterial cultures and mechanisms presented in wastewater. The use of an electrospun membrane could be used in water filtration determined by the clean water permeability (CWP) examination and its strength. Membrane molded into standardized test specimens and tested with a device called Adhesion Tearring Strength Tester. The results showed an increase in the value of the tensile test of 404.8356 KPa to the composition of 17.5%, 507.3598 KPa for composition of 20% and 603.7218 KPa to a composition of 22.5%. Maximum fluxes encountered in the membrane state might indicate a water permeability (CWP).

Keywords: Tensile, electrospun

INTRODUCTION

According to the researchers, the contamination of clean water and waste has been a worrying issue due to the consequences of microbiological contamination [1,2]. Membrane is a suitable application to improve water quality. The coated layer of fine fiber composition is the definition of the membrane as a water filter including a polymer which can be developed as a water-filter membrane [3]. The purpose of the research; (a) to develop a new method in the production of membrane and (b) determine the mechanical properties of the membrane of Polyvinylidene Fluoride (PVDF) against tensile testing. The membrane is a layer formed from the composition or the tangle of fine fibers used as filter or barrier for a variety of applications in the industrial world. Polymer has been the material of interest to be analyzed and developed due to its potential as a membrane filter and application examples that are of concern at this time is a membrane filter water. In this work, membrane polymer was produced by using *Polyvinylidene Fluoride* as fiber polymer and DMF as a solvent while the process of printing the membrane was performed by the method of a flat sheet. The membrane of this type is typically used in ultrafiltration process due to higher porosity and pore structure that are interconnected, resulting in higher for water filtration [4]. In order to determine the characteristics of the membrane, there are a number of ways, but commonly used methods are permeability and permeselectivity.

METHODOLOGY

Materials

Polyvinylidene fluoride is dominated by carbon fibers presented in polymer combinations while the strength of good tensile testing indicates good mechanical properties [3]. Having a high melting point (the fibers contained in decomposed PVDF tend to be below the melting point, Tm of 317°C -330°C), the orientation of the higher molecular yields better results than that of the carbon fiber [5]. As shown in Fig. 1, the physical and mechanical properties examination was performed by the authors on the membrane material based of the PVDF.

Fig. 1 Polyvinilidene fluoride (PVDF).

The molecular structure which can be formed by polyvinylidene fluoride tends to be thermally stable and if oriented receiving heat treatment at low temperatures, the decrease is not significant at the time of high temperature processing carbonization, it will be seen that the resulting fiber has a mechanical fiber properties very good [6,7].

Ag is a symbol of the chemical element contained in the periodic table for silver with atomic number 47. Silver itself comes from the argentum latin. By having shiny, white, soft transition metals, and in free form, silver has the highest electrical conductivity and heat across the metal. Silver includes precious metals such as gold. Silver is also used in jewelry, photography, table equipment, and coins [8]. As shown in Fig. 2, silver nitrate molecule can be dissolved in nitric acid and sulfuric acid but insoluble in dilute acid solution.

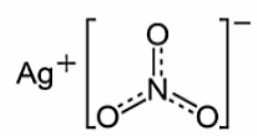

Fig. 2 Molecular structure of silver nitrate.

Silver and silver compounds are all soluble in cyanide as the alkali metal ion $Ag(CN)_2^-$ in the free air, which is then released by adding zinc silver or aluminum as reluctant. Being less reactive than copper, sulfur and hydrogen sulfide are rapidly discolored the silver surface. For example, the addition of $Ag^+ OH^-$ will precipitate silver (I) oxide, hence it can be expressed in the Equation (1) as follow

$$2Ag^+_{(aq)} + 2OH^-_{(aq)} \rightarrow Ag_2O_{(s)} + H_2O \qquad (1)$$

Anions can precipitate because most of the anions form insoluble silver salts. does not react with water and water at normal temperatures and is very stable in pure water.

N,N-Dimethylformamide (DMF) was supplied by MERCK, as shown in Fig. 3, and used as a solvent without further purification. It is a strong solvent for PVDF polymer as it has desirable properties such as low volatility, non-flammable, and relatively low toxicity.

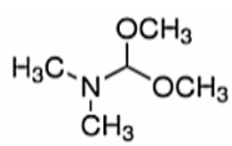

Fig. 3 N,N-dimethylformamide.

Preparation of polymer membranes

In this research, membrane preparation was consisted of two ingredients that used as mixed variations on each of the different specimens ie PVDF and DMF as solvent. Magnetic stirrer was used for mixing the two materials, with a rotation system that would mix PVDF and DMF so that the mixture became homogeneous [9].

Using a glass plate and masking tape as a template, a flat sheet method is a method of preparation carried out by the authors in this study, the resulting flat sheet of the printing membrane by this method was formed, phase inversion method in a PVDF membrane water freezing bath is made [9].

For testing the strength of the material by means of a load coaxial force, a tensile test method was used in this study. The static power was given slowly to measure the mechanical strength of a material in this experiment. Engineering and product design, the result of tensile testing is essential for testing the strength of the yield strength and as supporting data for material specifications to complement the material design information.

Microstructure Test tool SEM (Scanning Electron Microscope), which uses an electron microscope. SEM testing was done in stages on each membrane composition. SEM testing was used to view and analyze surface and texture, shape and size of objects, both quantitatively and qualitatively. At this time, SEM test was used to see the size of the pores, voids or holes in the membrane. For preparation of the membrane, Polyvinilidene fluoride and N, N-Dimethylformamide and prepare materials stirrer (magnetic stirrer). Considering mixture of PVDF and DMF prior to the mixing process takes place. Stir the two ingredients for 6 hours under on each specimen. Print the membrane solution that has been homogenized using glass mold that has been provided. The preparation of the tensile testing machine for performing a tearing adhesion strength test is schematically illustrated in Fig. 4. The Fig. 4 shows the test results or charts after performing the overall testing stages or procedures. The specimen was then prepared for the SEM test for micro- to nano-structural examination once it has completed the tensile testing.

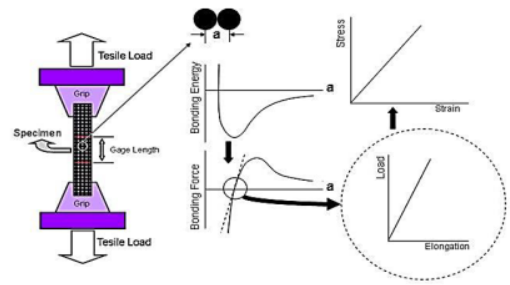

Fig 4 Schematic of tensile test.

Removal of pathogens

Culture mechanism of bacterial spot

To evaluate the removal of pathogens by filtration, before filtration by using nanofibers mats, the sample water was checked for the content of E. coli. Cultural microorganisms were identified inoculation in an agar nutrient culture medium (NA). The water samples were added by swapping method into nutrient agar medium in petri dish. Then, the samples were left for 24 hour at room temperature.

The bacteria spots were then identified in the nutrient agar medium for all three water samples. The water samples, as showed in Fig. 5, were then filtered by nanofibers membrane by the filtration system.

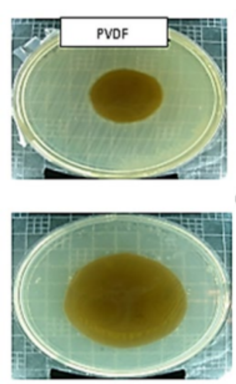

Fig 5 Filtration system illustrated.

Antibacterial activity

Adopting a technique from Zodrow *et al*. [13], vacuum filtration cells were used in this work. The membranes used in filtration were fed to the medium in order to investigate the inhibition of bacterial growth at 37°C for 24 hours. Given the sterile membrane prior to filtration, E. coli growth must be derived from the filtration process.

It can be concluded that good retention of the silver nanoparticle membrane demonstrates the successful application of silver nanoparticles to the nanofiber membrane.

Evaluation of the physical characteristics

Clean water permeability

Clean water permeability (CWP) that used the water permeation system was used to represent the achievable maximum flux that depended on the state of the membrane. It could be determined by measuring the flux at different Trans Membrane Pressures (TMP). The slope of the resulting curve was considered as the CWP. The CWP test was performed at 25°C.

RESULTS AND DISCUSSION

In order to study the properties of the material PVDF in term of mechanical, the specimens were tested using a tensile testing machine on each specimen to determine the tensile strength of the membrane. This study also examined on the surface properties of membrane by using Scanning Electron Microscopy (SEM). As shown in Fig. 6, the figures represent the SEM micrographs that had been performed on the surface of PVDF fiber with the varying PVDF fiber contents at 17.5%, 20%, and 22.5%. PVDF nanoparticle dispersions were relatively homogeneous, but with the added amount pf PVDF in a solution with a composition of 20%, excessive agglomeration was occurred resulting solution to be more difficult to homogeneous [10,11].

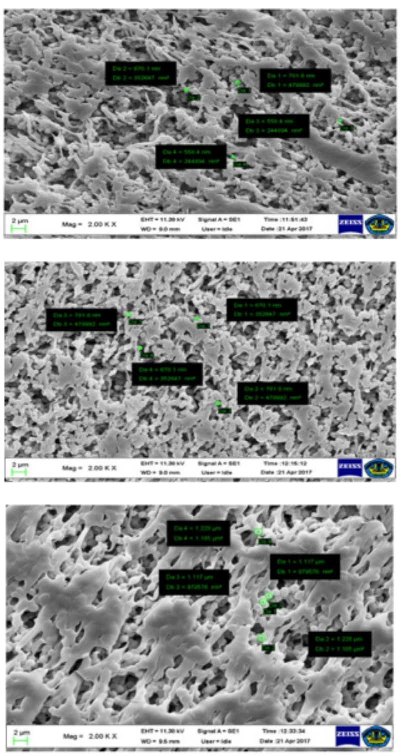

Fig 6 SEM comparison PVDF fibers with different variations 17.5% by weight, 20% by weight and 22.5% by weight.

Tensile test specimens with compositions of 17.5%, 20%, 22.5% of PVDF shown in graph (Fig. 7). The strength of the specimen tensile test showed the value of 404.8256 kPa to 603.7218 kPa when the specimen with PVDF fiber composition increased from 17.5% to 20%. The tensile strength value of the fiber membrane with the composition (% weight) 22.5% PVDF also showed an increase of strength by 603.7218 Kpa. PVDF in each specimen yielded a fiber braid structure of the closer membrane [12].

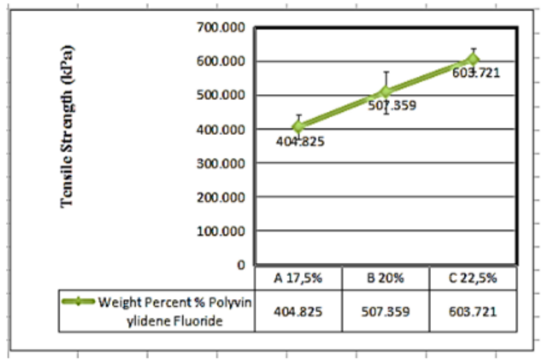

Fig 7 Tensile strength of graph (A) fiber composite PVDF with change of composition (% of PVDF weight) in each example.

Physical characteristics of the nanofiber membrane

Clean water permeability

This value was high enough to improve the volume of water in large quantities in the absence of particles that could block the nanofiber membrane. Furthermore, this high CWP showed that the nanofiber membrane could save energy (2001 l/m^2. H.bar).

Tensile strength test

After producing specimens of experiments by comparing the volume fraction, the composite materials usually will do some testings in load testing, drag, tap, slide or latitude, bending, and density, in order to describe the physical and mechanical of properties of the examined material. However, this research only focused on characters generated by the tensile test results.

Tensile test is a test stress-strain (stress straintest) to find the stress and strain that aims to determine the tensile strength of the material. Composite tensile strength (ultimate tensile strength) is one of the important properties of a material. Step tensile test was carried out by providing a tensile load on both ends of the test specimen slowly until the specimen was splited into two parts. With a tensile test, we can determine tensile strength, yield load (creep) and modulus (Young's modulus) voltage, and by pulling the complete profile of a curve, the curve is a graph of the results

A tension test machine (LR x 2.5 KN LLYOD load cell 1 N, with ASTM D 3379) was tested for the tensile strength test of the nanofiber membrane The specific test strip (5 cm) was stretched at a tensile speed of 50 mm / min until it broke It produced maximum tensile strain Test tensile strength was carried out at ambient temperature. The tensile stress was calculated as follows: $\sigma = P / A$, where P is the maximum load and A is the cross-sectional area.

The strength of the membrane did not depend on the direction in dry conditions as the result shown. It could also be concluded that in wet conditions, the membrane was strongly elongated. This value indicated that the strength of the nanofibres membrane satisfied 902 KPa.

CONCLUSION

Based on the research results, Polyvinylidene Fluoride membrane, as described, it could be concluded as follows: temperature at the time of stirring was also important to remove residual solvent and trapped air that can cause bubbles on the membrane. Results of testing indicated that the best composition was 20% PVDF because it could withstand loads of up to 312.2881 kPa and silver containing polymer exhibited better antibacterial activity due to content of silver ion released from the system.

The challenge with waste water treatment is to remove the useless organic in the water. CWP provides an overview of the impurities on the membrane. Values indicate very high CWP value may be beneficial for membrane nanofiber membrane capability. Furthermore, this high CWP indicated that the nanofiber membrane could save energy (2001 l/m^2. H.bar). Temperature at stirring is also important to remove solvent residue and trapped air which can cause bubbles in the membrane. The duration and speed of rotation of membrane mixing process on the homogeneity of membrane solution. The best test results are in the 20% PVDF composition because it can withstand loads of up to 312,2881 kPa.

SUGGESTIONS

When the test takes place, the specimen should not move, if moving, results affect the cycle and to further regulate the clamping arm in order to get very accurate tear resistance. After the casting, membrane should be placed immediately in the tube desiccator until the water content is reduced, if no water remains, it should be soaked in coagulation so that the membrane does not become brittle and thus, reducing the mechanical capability of membrane.

In the microstructure test, to get better results, the SEM input power to the SEM device must be stable and when testing is done to cut the small pieces and flat and flat membranes.

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