HYDROPHOBICIY OF ELECTROSPUN POLYACRYLONITRILE (PAN) NANOFIBER MEMBRANE FOR WATER DESALINATION PROCESS

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DECLARATION

I declare that this project entitled "Hydrophobiciy of Electrospun Polyacrylonitrile (Pan) Nanofiber Membrane for Water Desalination Process" is the result of my own work except as cited in the references.

Signature : ....

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Date : 20 JUNE 2021

APPROVAL

I hereby declare that I have read this project report and, in my opinion, this is sufficient in term of scope and quality for the award of the degree of Bachelor of Mechanical Engineering.

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DEDICATION

To my beloved father, mother and siblings for the endless support

ABSTRACT

The demand for freshwater is crucial as the population of the world is increasing. One of the suggested methods to dealing with this issue is water desalination. Besides reverse osmosis (RO), MD offers good results to desalinate water. MD is a desalination process based on a non-isothermal membrane that is regulated by the temperature differential produced within the membrane. There is also some limitation such as wetting which is a fundamental issue that prevents membrane desalination (MD) from being applied in a wider range of industrial applications. Besides that, fouling can be caused by a variety of factors, including membrane properties. To build a membrane that is ideal for long-term performance, a study is required to investigate the relationship between the MD and mechanical properties. The polyacrylonitrile (PAN) is the polymer and electrospinning has been introduced as one of the highly effective techniques in the production of nanostructures with unique properties such as surface area and high porosity. The concentration of the liquid solution of the material is 10% wt where the results of the electrospun experiment will be analyzed and the properties of the material in PAN-DMF are described by using Scanning Electron Microscopy (SEM). The nature of the material in PAN-DMF shows that it is hydrophobic. This method is carried out using Contact Angle Measurement tools to determine surface hydrophobicity, and the average for fiber size measurement is 1.2μm and 1.4μm. This research aims to provide a brief overview of electrospun PAN nanofiber and how it is used to reach the required properties in polymeric membranes used in desalination in MD.

ABSTRAK

Permintaan air bersih amat penting kerana populasi penduduk dunia semakin meningkat. Salah satu keadah yang disarankan bagi menangani masalah ini adalah peyahgaraman air. Selain osmosis terbalik (RO), MD turut memberikan hasil yang terbaik dalam proses penapisan air. MD adalah proses penyahgaraman berdasarkan membran bukan isothermal yang disusun oleh perbezaan suhu dan dihasilkan di dalam membrane. Terdapat beberapa batasan seperti pembasahan, yang merupakan masalah tunjang dimana ia menyekat daripada diterapkan dalam aplikasi industri pembuatan yang lebih luas. Selain itu, pencemaran boleh disebabkan pelbagai factor, termasuk sifat membrane. Bagi membina membran yang sesuai dan prestasi janga masa yang panjang, Suatu kajian perlu dijalankan bagi mengenal pasti hubungan diantara MD dan sifat mekanikal. Poliakrilonitril (PAN) merupakan polimer yang digunakan dan electrospinning telah diperkenalkan sebagai salah satu teknik yang sangat berkesan dalam penghasilan struktur nano dengan sifat unik seperti luas permukaan dan keliangan yang tinggi. Dalam kajian ini kepekatan larutan cecair bahan adalah 10% wt dimana hasil dari ujikaji ecletrospun akan diselidik dan ciri-ciri sifat bahan yang berada pada PAN-DMF diterangkan dengan menggunakan Scanning Electron Microscopy (SEM). Sifat bahan yang berada pada PAN-DMF menunjukkan ianya bersifat haidrofobic kaedah ini dijalankan menggunakan Contact Angle Measurement tools untuk menentukan permukaan hidrofobik,dan purata bagi ukuran saiz serat adalah 1.2μm dan 1.4μm. Penyelidikan ini bertujuan memberikan gambaran ringkas mengenai serat nano electrospun PAN dan bagaimana ia digunakan untuk mencapai sifat yang diperlukan dalam membran polimer yang digunakan dalam penyahgaraman di dalam MD.

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γSG	=	Dupré equation
γSL	=	Solid liquid interface energy
γLG	=	Liquid gas interface energy
θC	=	Equilibrium contact angle
r	=	radius
μ	=	micro
°	=	degree
Ml/hr	=	feed rate

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Nowadays, the provision of water is crucial for the future of mankind and to ensure an acceptable standard of life. One of the major worldwide concerns that need immediate action is the lack of clean water resources. Increased workforce, Global change and ongoing industrialization are placing pressure on existing water supplies. Van Vlict et al. (2021) claim that many sections of the globe are becoming water-stressed, and it is anticipated that by 2030, more than 40 percent of the world's population would be water-stressed, with this figure potentially rising owing to the influence of climate change. Besides that, Quist-Jensen et al. (2015) state, it is projected with the intention of 50 percent of the world's resident's determination inhabit the water-stressed area in 2025. Numerous approaches to resolving the situation have been offered, such as dam development, water transfer or water conservation.

However, in this century technology can be used to meet global demand, one of the most common techniques for desalination of seawater is membrane separation technology (Pistocchi et al. 2020). This membrane strategy suffers from a reduction in permeation flux caused by the blockage of the pore membrane. Clogging organic substances under the outside of the membrane may cause organic fouling. Ideally, a thin, low-pressure super hydrophobic coating on the surface of the membrane is desired as a means of self-cleaning and anti-fouling protection. Due to their peculiar characteristics, electrospun nanofibers have recently been proposed for the manufacture of highly effective nanofiltration materials. In this study, the application of hydrophobicity of electrospun polyacrylonitrile (PAN) nanofiber membrane studies for the water desalination process.

Lotus leaf is one instance of hydrophobicity while the rainfall land on the lotus leaf, they easily turn around off the plants at a slight slope angle along with catch all the soil and vermin on their technique (Nuraje et al. 2013). Hydrophobic identity clean-up, as well known as the "self-cleaning outcome," uses the perfect mix of ground chemistry with roughness's in the direction of cause rainfall to create a towering make contact with angle on the exterior, with subsequently rotate off effortlessly, catching the whole thing on their technique. Hydrophobic surfaces are not barely nature clean-up, they too contain damage resistance characteristics due to the advanced contact angle as well as small contact region for polluted water droplets (Nuraje et al. 2013).

Polyacrylonitrile (PAN) nanofibers are produced using electrospinning technology. Polyacrylonitrile (PAN), a familiar polymer in the midst of strong constancy as well as mechanical characteristics, former commonly applied in the manufacture of carbon nanofibers (CNFs), which contain drawn a lot fresh interest because of its tremendous uniqueness, for example spin ability, environmental benignity, along with marketable practicality (Nataraj et al. 2012).

Electrospinning is not a modern method but has recently gained much attention as a result of the advancement of nanotechnology along with associated innovations. This is the major incident, where a spherical rainfall resting on a dried-up facade was drawn through a cone while a portion of electrically stimulating rubber yellowish-brown was placed at an acceptable distance, was found away 369 years ago by William Gilbert (G.Taylor et al. 1969). Electrospinning is a technique designed for the manufacture of constant fibers in the submicron to nanometer-scale size. This process is used to produce silicone, metal, ceramic and composite nanofibers. Nanoparticles are combined with polymers and electrospun for the creation of scaffolds. Electrospinning is often used for the assembling of nanoparticles through alignment with fiber. Electrospinning is fundamentally based on strong electrostatic forces. Factors that affect the electrospinning phase are the concentration of polymer, the viscosity along with flow rate of the result, the electrical field voltage, the working distance as well as the humidity of the environment (Varghese et al. 2019).

1.2 Problem statement

The advancement of Membrane technology implementation in the water desalination phase has developed dramatically over the last few decades due to its advantages compared to other water treatment technologies. However, there are still a lot of unknowns in terms of process efficiency and operational costs. According to prior research, membrane desalination technology has a number of flaws. For example, one of the most pressing issues that might impede their progress is the synthesis and processing of their products and additional big obstacle to carbon nanotubes in material (CNT) being widely used in desalination technology is their high cost and operational concerns due several procedures must be followed, and the handling cost is high. (Goh et al. 2013).

Furthermore, wetting is a fundamental issue that prevents membrane desalination (MD) from being used in a wider range of industrial applications, according to Rezaei et al. (2018); once wet, the membrane can no longer be used, and the salt separation process will deteriorate, and commercial hydrophobic membranes still suffer wetting due to capillary condensation. Next, certain cases feature a superhydrophobic coating on the membrane's surface, which acts as a self-cleaning and anti-fouling barrier, self-cleaning, according to

Parvate, S. et al. (2020), prevents or delays the formation of contaminants such as water droplets, pollen, organic debris, and stains by wiping away surface pollutants with the help of gravity.

Moreover, fouling can be caused by a variety of factors, including membrane properties. The investigations discovered that using hydrophilic membranes for protein filtration can assist reduce membrane fouling, and that combining a hydrophobic polymer with a hydrophilic polymer can increase membrane protection (Abdelrasoul et al. 2013).

1.3 Objective

1. To fabricate electrospun polyacrylonitrile nanofiber membrane.
2. To analyze the morphological characteristics of electrospun polyacrylonitrile nanofiber.
3. To evaluate the hydrophobicity of electrospun polyacrylonitrile nanofiber.

1.4 Scope of project

This article would include a summary of the ongoing growth of hydrophobicity of electrospun polyacrylonitrile (PAN) nanofiber membrane studies for the water desalination process. The focus of the study will be on polyacrylonitrile (PAN) polymer as a precursor material and dimethylformamide (DMF) as a solvent for electrospun fiber fabrication. PAN electrospun nanofiber was introduced using the electrospining procedure.

The electrospinning feed rate for morphological characterization (SEM) sample selection ranged from 1.0 ml/hr to 2.0 ml/hr, the voltage applied was 10 kV, the SEM sample running duration was 5 minutes, the distance was 15 cm. The contact angle test sample for elecrospinning feed rate was 1.1 ml/hr, with a voltage of 15 kV, operating times of 60,90, and 120 minutes, and a distance of 15 cm.

Furthermore, analyse the morphological properties of electrospun polyacrylonitrile nanofiber and analyse the hydrophobicity of electrospun polyacrylonitrile nanofiber using scanning electron microscopy (SEM) and Image J software. The picture of the water contact angle (WCA) of electrospun nanofiber was captured using a specialised contact angle measurement (A-CAM) and measured using Image J software.

1.5 Thesis outline

The thesis is separated into five chapters. Introduction and the statement of problems are given in the first chapter. In addition, this chapter highlights the aims, nature and description of the study. The literature review focused on the material used and the method of the electrospinning process is given in chapter two. This chapter also incorporates some of the earlier articles on these studies. A detailed description of the methodology is explained in chapter three. This chapter addresses the collection of materials for the electrospinning process, membrane production, an experiment conducted in this review. The findings of the electrospun PAN nanofiber membrane experiment is discussed in Chapter 4. The morphological features and contact angle behaviour of this substance from the experiment were also included. Ultimately, the findings of the experiments drawn up are set out in Chapter 5 as well as the possible theoretical future study.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Due to technological advancement and strong demand, materials engineering has received a lot of attention throughout the world in recent decades. Mechanical strength, corrosion resistance, lightweight, durability, recyclable, easy to process, easy to operate, and inexpensive material prices are all common requirements in a range of applications. Polymeric materials can fulfil the standards for higher-level applications in general. Polymers are now present in almost every aspect of life. Yalcinkaya (2019) claim that nanotechnology is the study and application of science and technology at the nanoscale. The aspect ratio, which is connected to the ratio of surface area to ratio and the quantum effect, is the most essential property of nanotechnology.

Author also claim that, one of the most useful developments of nanofiber is made of polymeric components. Using external chemical or physical means including an electrical field, drawing force, and breaking into smaller pieces, the polymeric solution or melt is extruded, pulled, or divided into the extremely tiny fiber during the process. The most frequent and widely utilized method for producing nanofibers is electrospinning. Electrospinning is one of the ways for preparing nanofibers that have been documented in the literature. Electrospinning is the record widely utilized industrial manufacturing process so far and processes are used to manufacture more than half of the nanofiber research publications. This argument is supported by Subbiah et al. (2005) stated that electrospinning is advantageous not only because of its adaptability in spinning a wide range of polymeric fibers, but also because of its consistency in creating fibers in the submicron range.

2.1.1 Nanofiber Membrane

Nanofibers are fibers having a diameter of less than 100 nanometers (Subbiah et al. 2005). Nano catalysis, protective gear, filtration, tissue scaffolds and optical electronics all benefit from these fibers, which have smaller holes and a greater surface area than normal fibers. Nanofibers are ultrafine fibers with dimensions ranging from a few micrometers to a few nanometers with a regulated surface shape. The diameter of nanofibers is determined by the production process and the kind of polymer used. Nanofibers may be made using interfacial polymerization and the electrospinning process. Because of their large surface-area-to-volume ratio, high porosity, great mechanical power, and usage flexibility, all polymer nanofibers are unique (Barbosa, M. A. 2017).

Y.cai et al. (2012) found that nanofibers contain generated an immense contract of interest because of their extraordinary properties. Compared to traditional fibrous materials, nanofibers are lightweight with different diameter, pore structures and large pore structures surface in the direction of volume ratio, creation them suitable intended for applications as diverse as filtration, cameras, protective fabrics, tissue engineering, usable materials and energy storage.