Preparation, characterization and mechanics of chitosan (CS) and different Polymers nanofiber membranes

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Technology Project
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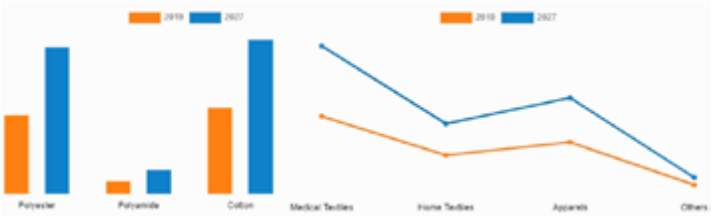
Antimicrobial Textiles Market

The outbreak of the COVID-19 has resulted in increase in R&D activities for antimicrobial textiles. By Fabric the polyester segment garnered 42.6% share, in terms of revenue, in 2019 and is expected to grow at CAGR of 7.8% during the forecast period. (Narune and Prasad, 2020)



Abstract

Electrospinning is an efficient technique used to produce nanofibers from a wide variety of polymers in various forms. Use of environmentally friendly, renewable biomass feedstock for the preparation of nanomaterials. Nanofibrous membrane are prepared by electrospinning attempts using a mixture of different polymers and CS. As well as the use of different polymers to be fabricated nanofibrous membrane to be used as substrates for chitosan deposition. Chitosan was coated onto porous nanofibrous membrane via direct immersion coating method. (Zia et al., 2020) Finally the permeability and mechanical properties of the nanofibrous membranes were then studied.

Experiment

Experimental equipment

Instrument	Type	Manufacturer
Nanofiber Electrospinning Unit	TL-PRO	TONG LI TECH
Steel Hotplate/Stirrer	MS-H280-Pro	Camlab
Air Permeability Tester	MO21A	SDL ATLAS

Experimental materials

Material	Type	Manufacturer
Chitosan	Low molecular weight	Sigma Aldrich
Dimethylformamide	≥ 99%	Sigma Aldrich
Polyacrylonitrile	High molecular weight	Fisher scientific
Acetic acid	≥ 99%	Sigma Aldrich

Spinning solution

Prepare a solution of Polyacrylonitrile at a concentration of 10 wt%. Add 18g of Polyacrylonitrile to 2g of DMF. Place the solution on a magnetic stirrer and stir overnight.

Preparation of nanofibrous membranes

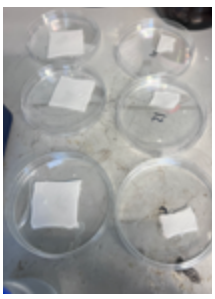
The spinning solution was poured into a syringe with a volume of 20 ml, the spinning needle was 20 gauge, the spinning voltage was 16 kv, the distance between the needle and the drum collection device was 20 cm, the drum speed was 60 rpm and the spinning solution was pushed out at a rate of 1.8 ml/h. After 5 hours, the nanofiber membrane was prepared.

Coating

Prepare a 0.5 wt% chitosan solution as a base solution for coating. Add 0.1g of chitosan to a solvent consisting of 10g of water and 10g of acetic acid. Place on a magnetic stirrer and stir overnight. The completed spun nanofiber membrane was cut into small pieces and immersed in the base solution for 5, 10 and 15 minutes respectively. After reach the expected time, the fibrous membranes were removed and dried.

Spinning solution

Immersion of the nanofiber membrane in the base solution

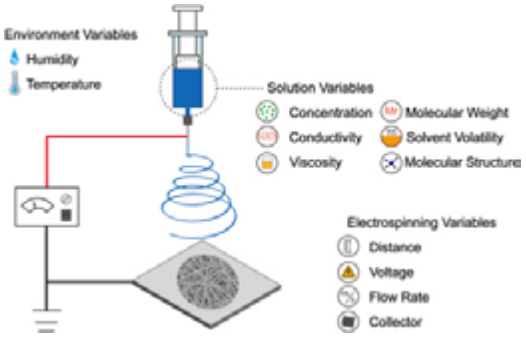


Drying nanofibrous membranes

Introduction

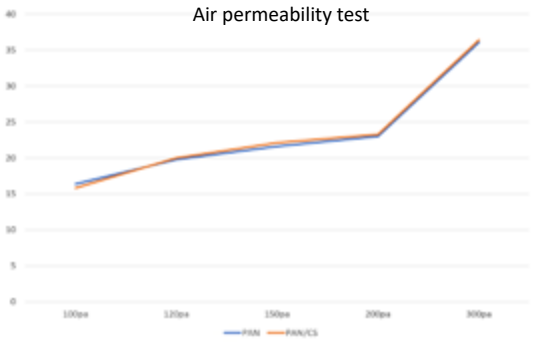
Electrospinning is an efficient technique used to produce nanofibers from a wide variety of polymers in various forms. (Agarwal, Greiner and Wendorff, 2013) The electrospun fibers show the advantages of high porosity and large surface to volume ratio. (Altstädt et al., 2008) This method has an extraordinary advantage over ordinary production techniques since nanofibers can be readily produced from a variety of polymers, polymer blends, sol-gels, suspensions, emulsions, and composite structures. (Persano, Camposeo, Tekmen and Pisignano, 2013).

It is known that the formation of nanofibers through electrospinning is based on the uniaxial stretching or elongation of a viscoelastic jet derived from a polymer solution or melt. (Long et al., 2019) During the electrospinning process, when high voltage is supplied, the polymer solution droplet at the needle tip deforms into a cone shape (generally called a Taylor cone) under the electrostatic forces. The strong electrostatic force has been regarded as the driving force for initiating the electrospinning process. Under the force of a strong electrostatic field, the charged solution jet at the spinneret tip changes its size to maintain the force balance. With increasing electrostatic-field intensity, the induction charges on the surface repel each other and produce shear stresses. These repulsive forces act in the direction opposite to the surface tension, which leads to the extension of the solution drop into a Taylor cone and plays a role in initiating the surface. When the electrostatic field achieves the critical voltage, the balance of repulsive forces is broken and thus a charged jet ejects from the tip of the conical drop.(Taylor, 1969)



Air permeability test

The air permeability of the nanofibrous membrane was tested using the SDLATLAS air permeability tester model MO21A.



Results and Discussion

With the outbreak of the epidemic, the market for antibacterial textiles is also growing gradually. Of these, medical textiles have received the most attention. A combination of polymers and the natural polymer chitosan will be popular. By active agents, the bio-based agent segment is expected to grow at a CAGR of 7.8%, in terms of revenue, during the forecast period. The significant advantage of using bio-based compounds as antimicrobial agents is that they do not exhibit side effects such as toxicity and pollution as synthetic chemicals. By fabric, the polyester segment garnered 42.6% share is expected to grow at CAGR of 7.8% during the forecast period. In this project, the method is to prepare a fibrous membrane by electrospinning and then to post-treat the electrospinning fibrous membrane to make it antimicrobial. The PAN nanofibrous membranes are soaked in a chitosan solution to give them antimicrobial properties.PAN/CS nanofibrous membranes will make better progress in the field of medical textile materials.