Fiber Diameter Dependency of Electrospun Polysulfone/SiO_2/TiO_2 Nanocomposite Membranes on the Solution Properties

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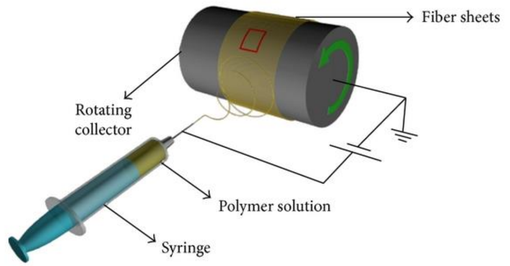
ABSTRACT

Polysulfone (PSU) is one of the most frequently used polymers in membranes technology, and it can be electrospun to form nonwoven fibers. However, its hydrophilicity should be improved for water purification purposes. The fiber diameter in electrospun membranes can affect the physical properties of the product. The electrospinning parameters can largely control the average fiber diameter in electrospun membranes. In this study, PSU/SiO2/TiO2 nanocomposite membranes were fabricated via the electrospinning method, and the effect of the introduced nanoparticles on the properties of the primary solutions and hence the average fiber diameter has been investigated. Silica and Titania nanoparticles (0, 0.5, 1wt%) were added to 20 wt.% PSU solution and were electrospun at a constant voltage and feed rate of 15.5 kV and 2 ml/h, respectively. The conductivity of the prepared solutions and the surface tension was measured. In addition, the rheological behavior of the solutions was evaluated using rheometric measurements. Finally, scanning electron microscopy (SEM) was used to study the morphology of the membranes and estimate the average fiber diameter. The obtained results showed that increasing titania nanoparticles at a constant SiO2 content has decreased the average diameter from 959 to 712 nm, which can be attributed to the higher conductivity and lower surface tension of solutions with a higher TiO2 amount leading to facilitated fiber stretching during electrospinning. On the other hand, introducing silica nanoparticles to a certain extent can decrease the fiber diameter due to the predominant effect of improved conductivity. However, beyond this extent, the significant increase in the solution viscosity at 1wt.% caused the formation of thicker fibers with an average diameter of about 1160 nm. These findings emphasize the importance of solution properties for designing an efficient water membrane by controlling its fiber diameter and specific surface area.

OBJECTIVES

Diameter is a critical issue in fibers that is directly affected by electrospinning parameters. By altering the diameter of a fibrous membrane, many properties can be properly controlled. In this paper, PSU/TiO2/SiO2 nanocomposites were fabricated via electrospinning, and the effects of titania and silica nanoparticles on the electrospun fiber diameters have been investigated. To understand the underlying mechanisms for changes in the fiber diameter, solution parameters including conductivity, surface tension, and viscosity of solutions have been measured.

MATERIALS & METODS



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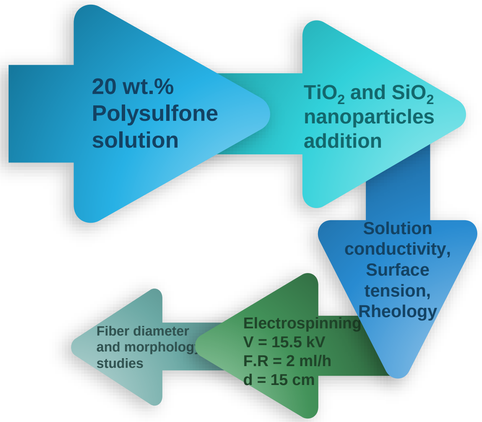
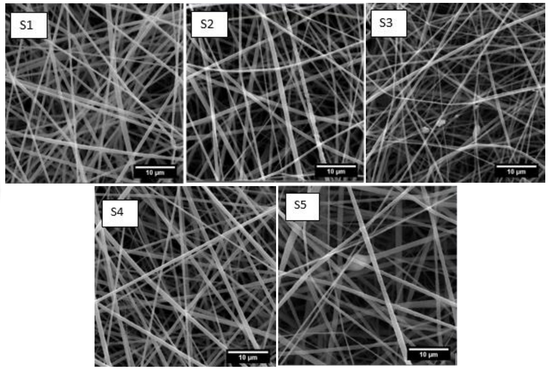


Sample code	Silica NPs (wt.%)	Titania NPs (wt.%)
S1	0.5	0
S2	0.5	0.5
S3	0.5	1
S4	0	0.5
S5	1	0.5

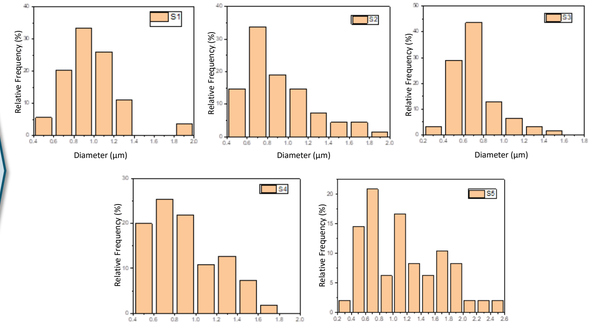
RESULTS

SEM images of electrospun fibers.

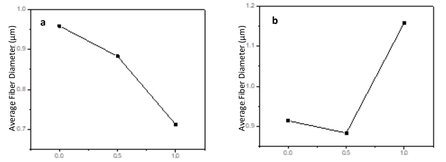


RESULTS

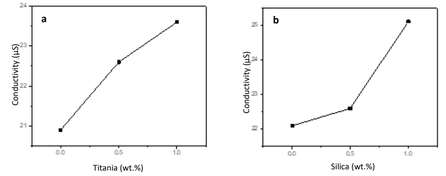
The fiber diameter distribution of fibrous mats.



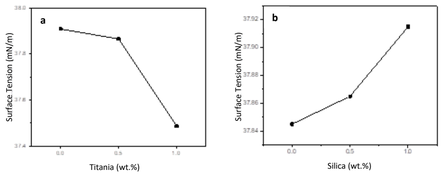
Average fiber diameter of electrospun fibers at constant amount (0.5 wt.%) of a) silica and b) titania.



Conductivity of composite polymer solutions at constant amount (0.5 wt.%) of a) silica and b) titania.

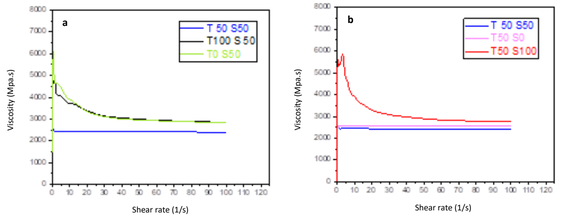


Surface tension of composite polymer solutions at constant amount (0.5 wt.%) of a) silica and b) titania.



RESULTS

Viscosity of composite polymer solutions at constant amount (0.5 wt.%) of a) silica and b) titania



CONCLUSIONS

In the present study, the effects of titania and silica nanoparticles on the average fiber diameters in electrospun PSU-based composite membranes at constant voltage, feed rate, and polymer concentration were investigated. The results indicated that titania had decreased the average fiber diameter at a certain amount of silica (0.5 wt.%). However, increasing silica created an optimum in the average fiber diameter variations at a constant amount of titania (0.5 wt.%). The obtained results on the solution properties, including conductivity, surface tension, and viscosity, showed that thinner fibers are produced at higher solution conductivity, smaller surface tension, and lower viscosity values. The present findings emphasize the importance of in-depth knowledge of the solution properties to determine the physical feature, hence the performance of PSU membranes.

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