Preparation and characterization of polysaccharides/PVA blend nanofibrous membranes prepared by Electrospinning

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Introduction

Electrospinning allows the production of polymer fibres with diameters in the sub-micron size range, through the application of an external electric field, keeping intact the bulk properties of the polymers (fig.1). Electrospun membranes possess some unique structural features, such as a high surface to volume ratio and very good mechanical performance, properties that are determinant to their use in several applications such as air and liquid filtration, tissue engineering, optical and chemical sensors [1].

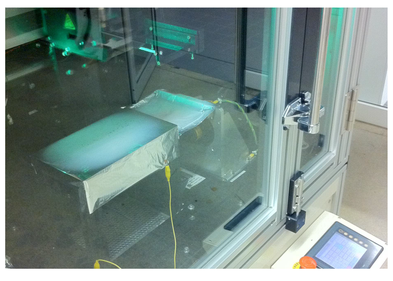


fig.1 - electrospinning equipment

Main Goal

Electrospinning of a blend containing biopolysaccharides (chitosan and exopolysaccharides) and polyvinyl alcohol (PVA) into a polyvinylidene difluoride (PVDF) basal microfiltration membrane, with the ultimate aim of developing a mid-layer nanofibrous porous support for exploitable thin-film composite (TFC) membranes for water filtration.

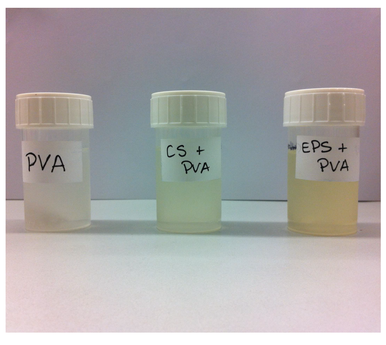
The electrospun blended nanofibrous membranes were fully characterized in order to investigate their morphology, diameter, structure, mechanical and thermal properties. The results showed that these membranes have great potential for filtration purposes [2].

Experimental

Preparation of electrospun blend nanofibrous membranes > Characterization of electrospun PVA/polysaccharides blend membranes: AFM, SEM, EDS, DMA.

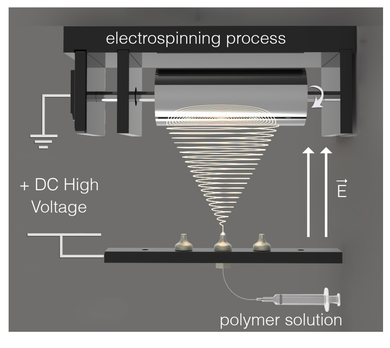
PVDF - basal filter

5 cm Ø | 0.2 µm



Polymer solutions

a) PVA 12%wt (in H2O) | b) PVA 12%wt + Chitosan (CS) 0.5%wt (in 1% Acetic acid aq. solution) | c) PVA 12%wt + cyanobacterial extracellular polymeric substances (EPS) 0.5%wt (50/50 DMSO:H_2O)



Electrospinning

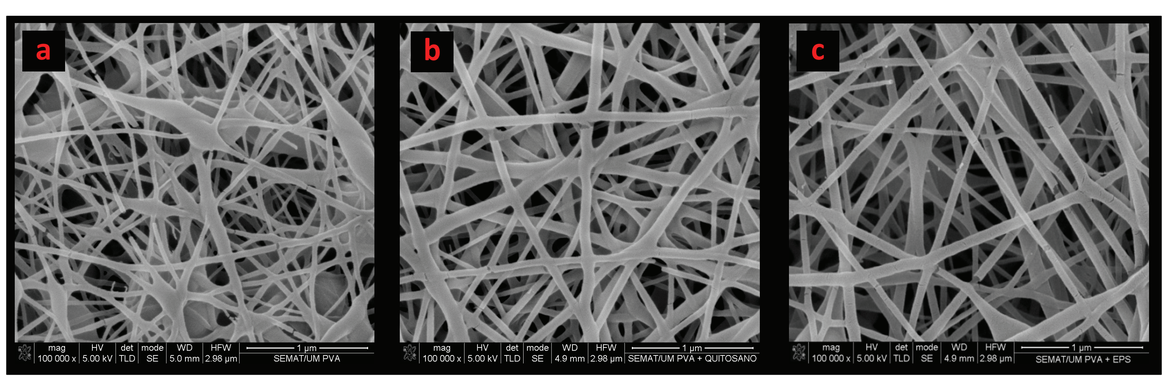
Conditions
Room temperature | 10mL syringe with needles of 0.5mm of inner diameter | Electric field: 20 to 23k | Feed rate: 0.2mL/h

Viscosity and conductivity of the polymer solutions

Polymer blend (%wt)	Conductivity (µS cm^{-1})	Viscosity (cP)
12% PVA	874±9	96±3
12% PVA ± 0.5% EPS	1149±26	563±3
12% PVA ± 0.5% CS	1274±20	442±12

Results

SEM



AFM (analysis area - 5x5 µm)

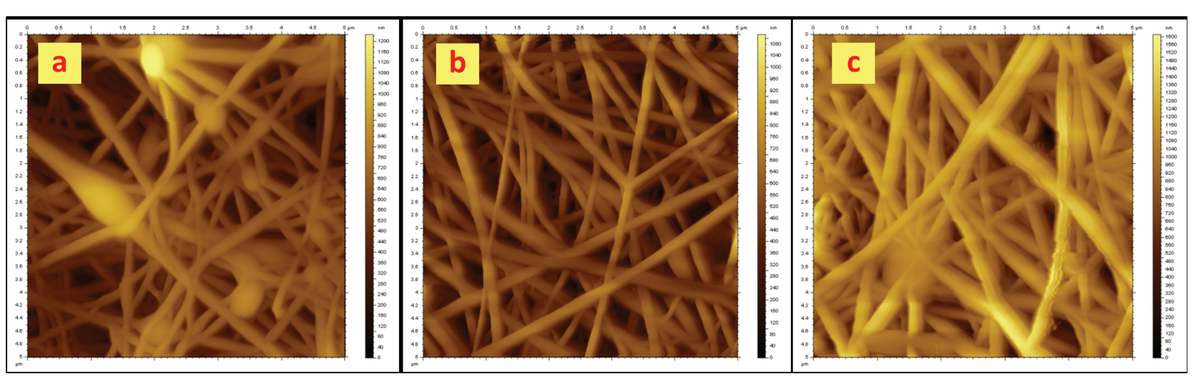


fig.2 - SEM and AFM images of PVA/polysaccharide blended electrospun fibres using (a) 12%wt PVA, (b) 12%PVA and 0.5%CS, and (c), 12%PVA and 0.5%EPS solutions.

	PVA		PVA/CS		PVA/EPS	
Element	Wt %	At %	Wt %	At %	Wt %	At %
C	44.30	51.44	42.27	49.26	37.32	44.25
O	55.70	48.56	55.84	48.85	61.97	55.40
N	-	-	1.89	1.89	-	-
S	-	-	-	-	0.71	0.35
Total	100.00	100.00	100.00	100.00	100.00	100.00

table 1 - Variation of weight and atomic percentages of the atoms C, O, N and S in the electrospun nanofibres

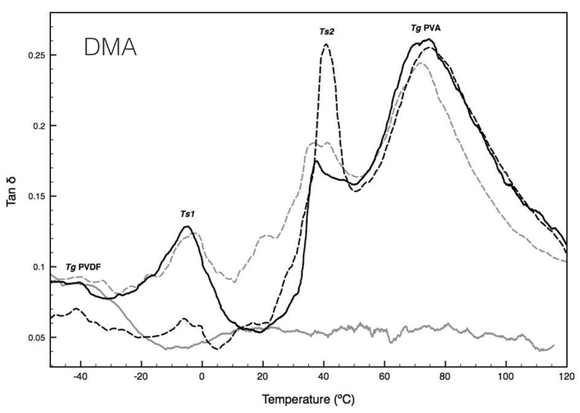


fig.3 - Tan δ curves versus temperature of the membranes. PVDF (solid grey line), PVDF coated with PVA nanofibres (dashed grey line), PVDF coated with PVA/CS nanofibres (dashed black line), and PVDF coated with PVA/EPS nanofibres (solid black line).

Conclusions

- Electrospun PVA/CS and PVA/EPS blend nanofibrous membranes were successfully prepared, with an uniform and smooth morphology, and narrow diameter distribution from ≈50 to 130nm.
- Thermal and mechanical analysis demonstrated the presence of intermolecular hydrogen bonds between the polysaccharides and PVA.
- The electrospun PVA/polysaccharides blended membranes showed better tensile mechanical properties when compared with PVA alone, and resisted more against disintegration in the temperature range between 10 and 50 °C.
- These membranes were afterwards further coated with an ultra-thin selective top layer.

References

[1] Liu, Y., Wang, R., Ma, H. Y., Hsiao, B. S., Chu, B. (2013) High-flux microfiltration filters based on electrospun polyvinylalcohol nanofibrous membranes. Polymer, 54, 548-556. | [2] Santos, C., Silva, C. J., Büttel, Z., Guimarães, R., Pereira, S. B., Tamagnini, P., Zille, A. (2014) Preparation and characterization of polysaccharides/PVA blend nanofibrous membranes by electrospinning method. Carbohydrate Polymers, 99, 584-592

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