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Potencialities of electrospun mats based on PVA/CA for applications as chronic wound dressings

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Introduction

Chronic wounds are unable to follow the normal healing steps, taking more than 12 weeks to heal. They are characterized by a defective matrix and cell debris impair healing, prolonged inflammation, moisture imbalance and high bacteria amounts. Bacterial infections are the main cause behind complications with the healing of chronic wounds.

Biodegradable polymeric wound dressings were engineered by electrospinning with a porous fibrous nanostruture resembling the extracellular matrix. The goal was to generate dressings with thin fiber diameters that, in the future, will be functionalized with antimicrobial peptides (AMPs) with immunoregulatory properties, to prevent bacterial colonization and fight infection.

Electrospun Polymeric Wound Dressings

Electrospinning is a versatile technique to produce non-woven fibers. By increasing some of these parameters such as electrical conductivity, distance between the spinneret and collector, humidity and temperature is possible to decrease the fibers' diameter and control the morphology of the mats. Hence, it is possible to attain dressings with a structure similar to the extracellular matrix, with high porosity and large surface area, that accelerate the healing while allowing:

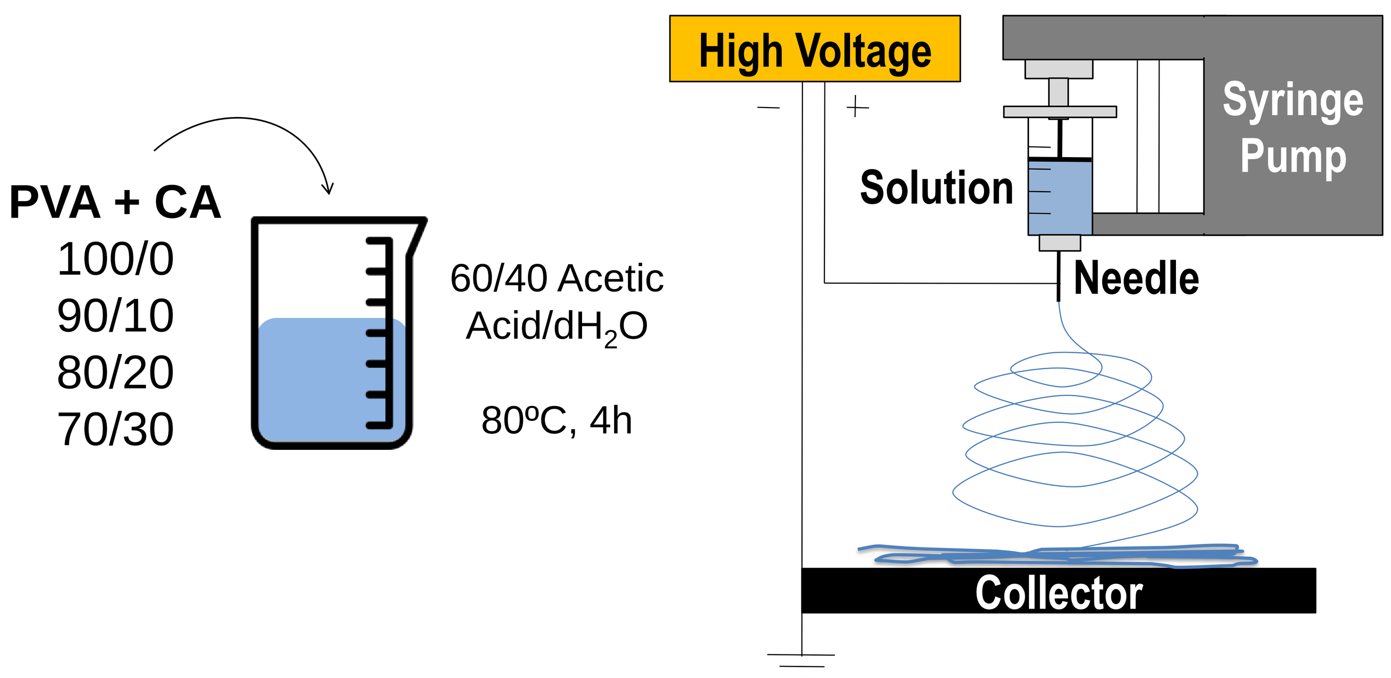
- Oxygen exchange;
- Nutrient supply;
- Control of fluid loss and exudates absorbency;
- Stimulate proliferation, migration and differentiation of fibroblasts and keratinocytes…

Synthetic biodegradable polymeric matrixes have been widely applied due to their versatile physical and mechanical properties and demonstrated wound-healing abilities, being processed either from single- or multi-polymer combinations.

Materials and Methods

Poly(vinyl alcohol) (PVA) with Mw 78,000 and 88% hydrolyzed was purchased from Polysciences, Warrington, USA. **Cellulose acetate (CA)** with Mw 30,000 was purchased from Sigma Aldrich, USA. The acetic acid (glacial) 100% was purchased from Merck, Germany.

Polymeric solutions of **PVA/CA** were prepared at 11% and 9% (w/v) concentrations in acetic acid/distilled water at 60/40 v/v. PVA and CA were combined at varying ratios: 100/0 (or 100 PVA), 90/10, 80/20 and 70/30 (v/v). These solutions were continuously stirred at 80 ºC for 3 h and were electrospun at specified processing conditions of applied voltage, feed rate, collection distance and needle inner diameter, which was established at 18G. After the electrospinning process, the samples were placed in a drying oven for 12 h at 40 ºC.

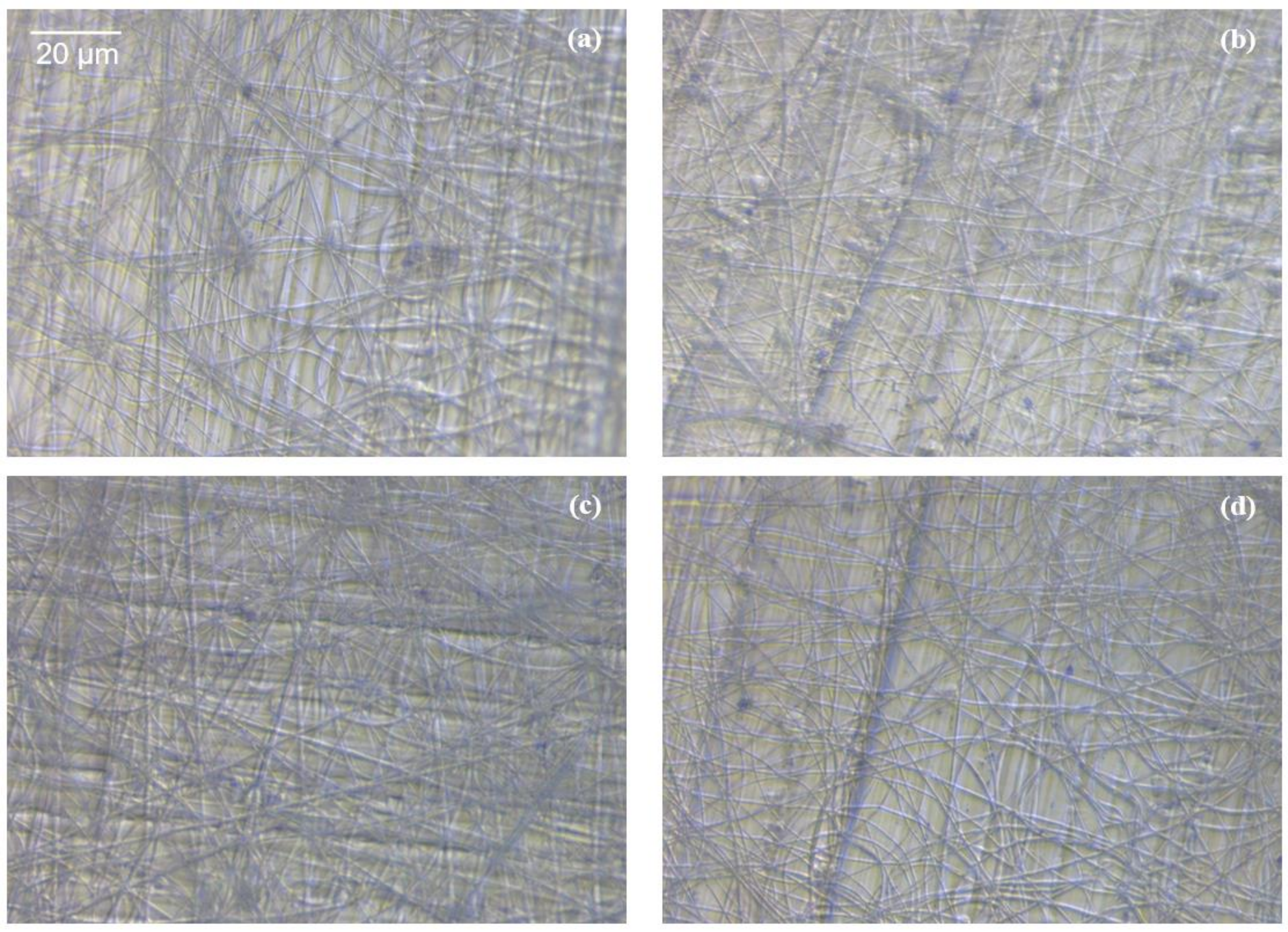


Results

Electrospun processing parameters, particularly voltages and feeding rates, which were found the most influential in the fibers diameter of PVA/CA, were selected and altered as the mats were being formed and the resulting nanofibers observed.

PVA/CA Meshes	Processing Parameters: Electric Potential (kV)	Feed Rate (mL/h)	Distance (cm)	Fiber Diameter ± SD (nm)
11 % (w/v)				
100/0	28.0	1.2	17.0	705 ± 179
	29.0	0.8	17.0	851 ± 229
9 % (w/v)				
100/0	20.0	0.7	18.0	838 ± 246
	22.0	1.3	14.0	921 ± 155
	24.0	1.3	15.5	790 ± 188
	25.0	0.7	18.0	781 ± 190
	29.0	0.8	17.0	**665 ± 151**
	29.0	1.3	17.0	877 ± 227
	29.0	1.5	15.5	682 ± 188
	29.0	1.7	15.6	795 ± 170
90/10	20.0	0.8	17.0	788 ± 216
	22.0	0.8	17.0	772 ± 164
	29.0	0.8	17.0	**632 ± 117**
80/20	20.0	1.2	17.0	626 ± 149
	25.0	1.2	17.0	516 ± 128
	25.0	0.8	17.0	742 ± 181
	29.0	0.8	17.0	**665 ± 177**
70/30	29.0	0.8	17.0	**731 ± 156**

Optic micrographs (bright field) of (a) 100/0, (b) 90/10, (c) 80/20 and (d) 70/30 PVA/CA nanofibrous electrospun meshes, processed at 29 kV, 0.8 mL/h and 17 cm distance. All images were collected with the objective magnification of 100x and ocular magnification of 10x (scale bar of 20 µm).



Conclusions

Polymeric mats of PVA/CA were produced with the minimal diameter possible using the most environmentally friendly and sustainable processes and materials. The electrospinning processing conditions were established at **29 kV, 0.8 mL/h and 17 cm**. These were the most successful in giving rise to continuous, beadles, small diameter nanofibers for all polymeric combinations. In the future, AMPs will be introduced in these mats to fight chronic wounds infections.

References

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