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Electrodynamic tailoring of self-assembled three-dimensional electrospun constructs

Tiago C. Reis,[a] Ilídio J. Correia[b] and Ana Aguiar-Ricardo[a,*]

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[a] *REQUIMTE, Departamento de Química, Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, Campus de Caparica, 2829-516 Caparica, Portugal; E-mail: air@fct.unl.pt*
b CICS–UBI Health Sciences Research Center, University of Beira Interior, Avenida Infante D. Henrique, 6200-506 Covilhã, Portugal; E-mail: icorreia@ubi.pt

Supplementary Information

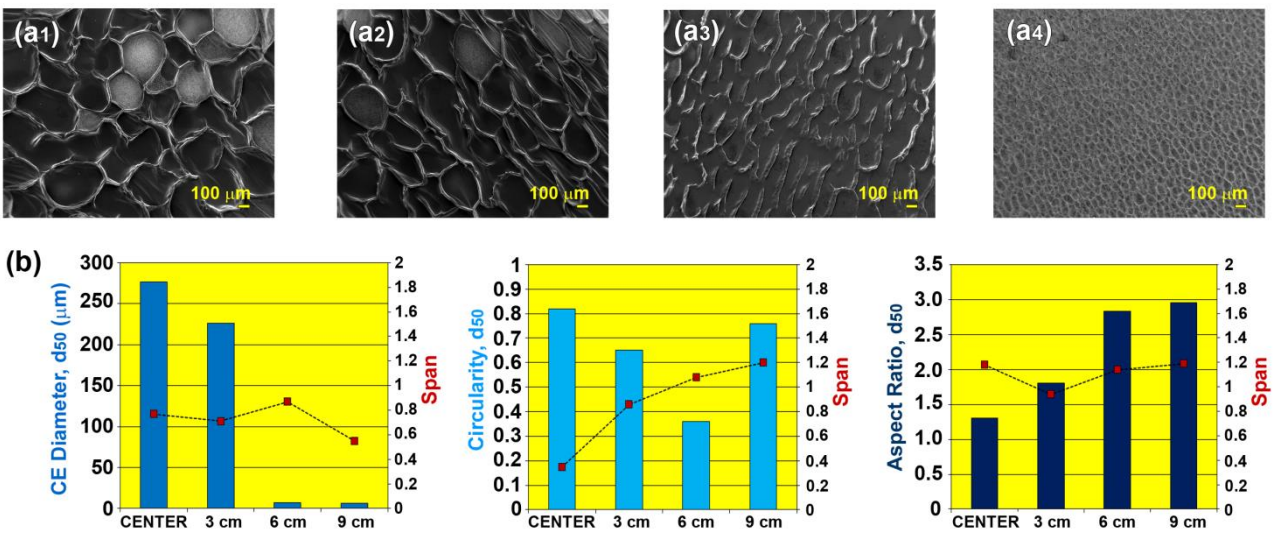

Fig. S1 Surface roughness and morphology comparison of different localized portions of the same electrospun membrane (35wt% PCL in 40AA/60FA at 1.5 kV.cm^{-1} with a flow rate of 0.07 mL.h^{-1}). The surrounding environment was set for 20 ºC and a humidity level of 31 ± 1%. SEM micrographs (a1) center, (a2) distance from the center of 3 cm, (a3) distance from the center of 6 cm and (a4) distance from the center of 9 cm. Shape analysis and comparison (b).

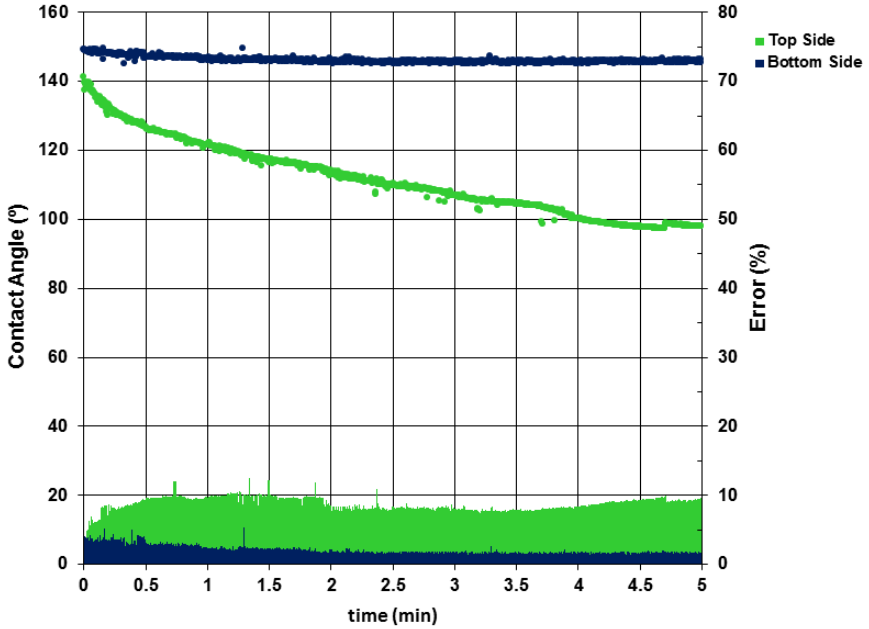

Fig. S2 Static contact angles assessment. The static contact angles were measured at room temperature by a KSV Goniometer (model CAM 100) by applying the sessile drop method. The used liquid was glycerol (≥99.0%, Sigma-Aldrich) whereas each droplet had a volume of 100 µL, while the acquisition time was extended up to 5 minutes with a frame interval of 300 ms. At least four measurements were carried out per sample and the shown data are averaged values. The error(%) was defined as: (standard deviation$(n\geq4)_t$ *100)/average$(n\geq4)_t$.

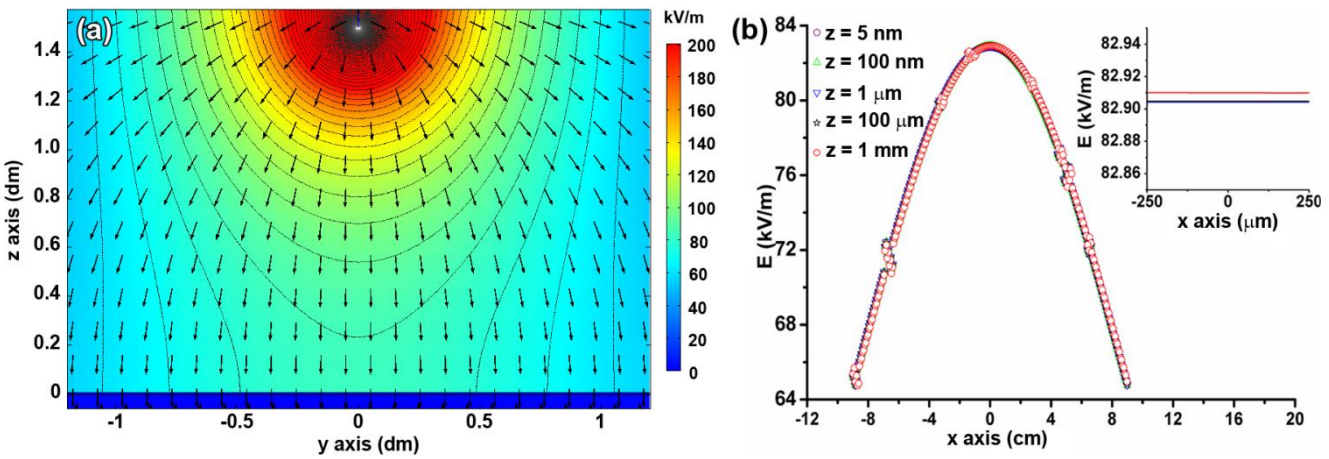

Fig. S3 Electric field simulation before the fibers deposition. The electric field configuration and intensity was simulated in COMSOL Mutiphysics 4.0. The geometry relies in a box full of air (length=50 cm; depth=50 cm; height=26 cm), whereas within was placed a grounded aluminum collector (length=25 cm; depth=25 cm; height=0.1 cm) and a steel tubular nozzle (external diameter= 0.1 cm; internal diameter=0.07 cm; height=4 cm). The nozzle-to-collector distance was set at 15 cm and the applied voltage in the nozzle was set at 24 kV. Preference was given to the software material library: Air (Air), Aluminum (UNS A91050) and steel (UNS S31600). (a) Electric field configuration and intensity coupled with isolines. (b) Electric field intensity assessment across de collector x axis between - 9 to + 9 cm, where z states the distance from the collector's plan towards the tip of the nozzle.

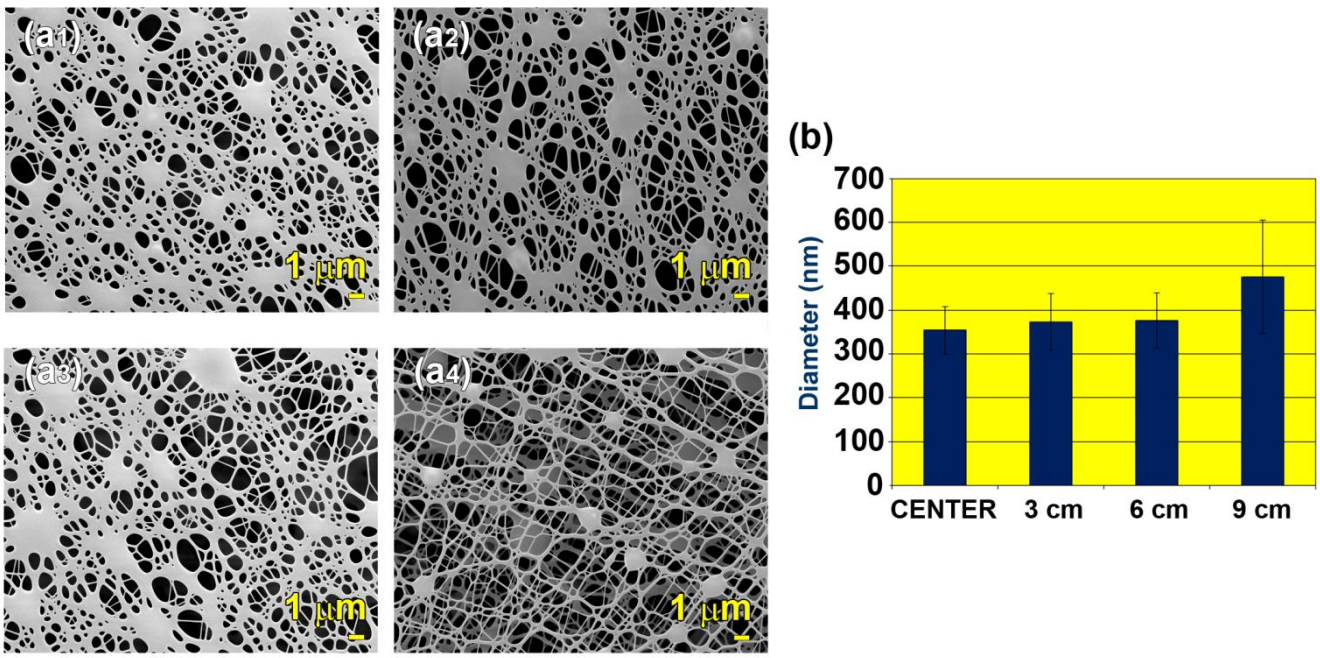

Fig. S4 Pore size cumulative distribution of different localized portions of the same electrospun membrane (35wt% PCL in 40AA/60FA at 1.5 kV.cm^{-1} with a flow rate of 0.07 mL.h^{-1}). The surrounding environment was set for 20 ºC and a humidity level of 31 ± 1%. SEM micrographs (a1) center, (a2) distance from the center of 3 cm, (a3) distance from the center of 6 cm and (a4) distance from the center of 9 cm. (b) Mean diameter comparison.

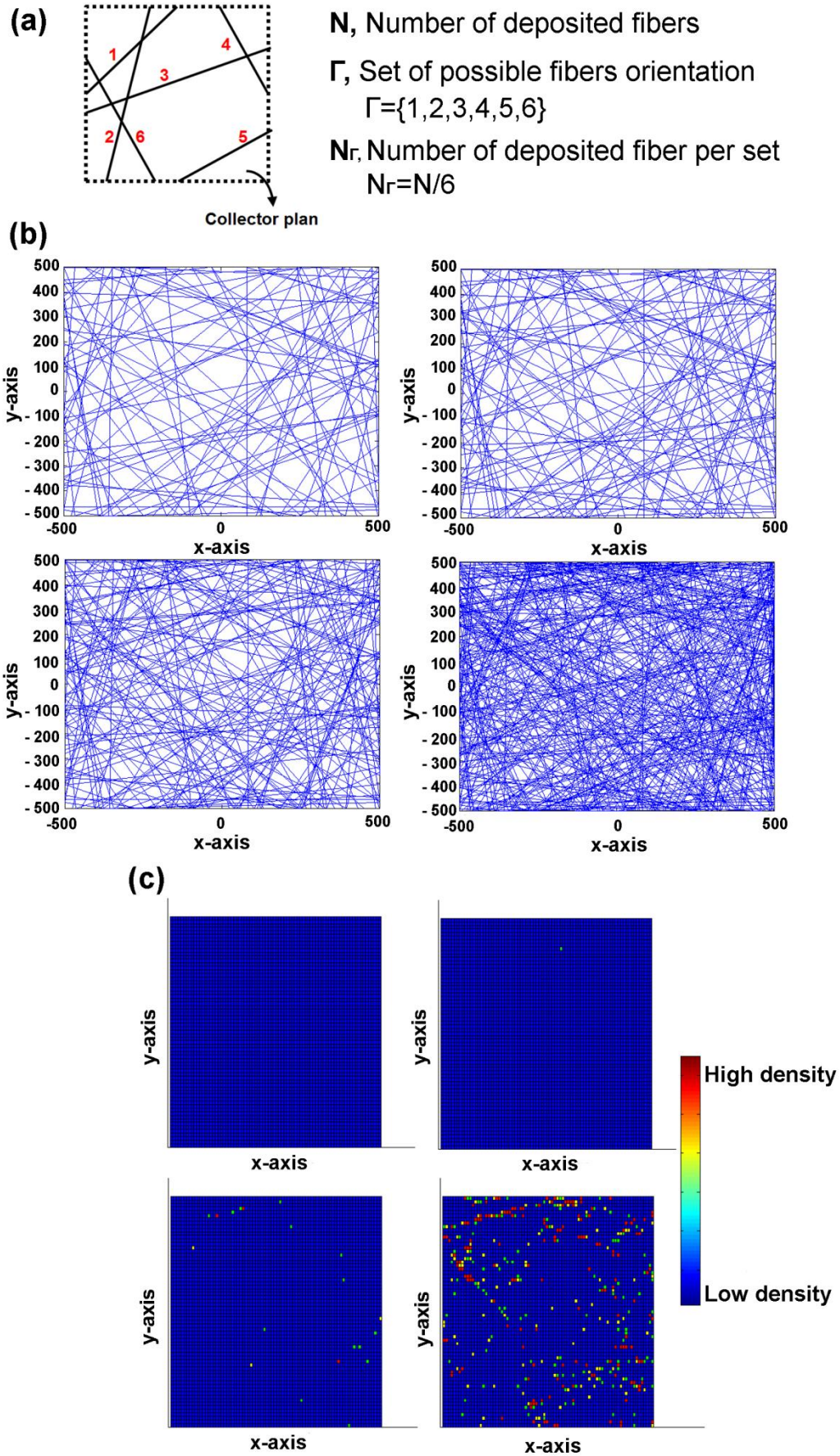
(a)
1
2
3
4
5
6
Collector plan
N, Number of deposited fibers
Γ, Set of possible fibers orientation
Γ={1,2,3,4,5,6}
Nr, Number of deposited fiber per set
Nr=N/6
(b)
y-axis
x-axis
500
400
300
200
100
0
- 100
- 200
- 300
- 400
- 500
-500
0
500
(c)
y-axis
x-axis
High density
Low density

Fig. S5 Arbitrary fiber deposition in the collector's center. (a) The random fiber model was developed in Matlab R2011b, generating six sets of possible fibers (Total number of fibers, N=400). The output scenarios were then transferred into the COMSOL Mutiphysics simulation for further studies. (b) Random fiber deposition, whereas the incremental number of fiber deposited (N) was taken in consideration as a time-driven parameter. (c) Fiber density representation.

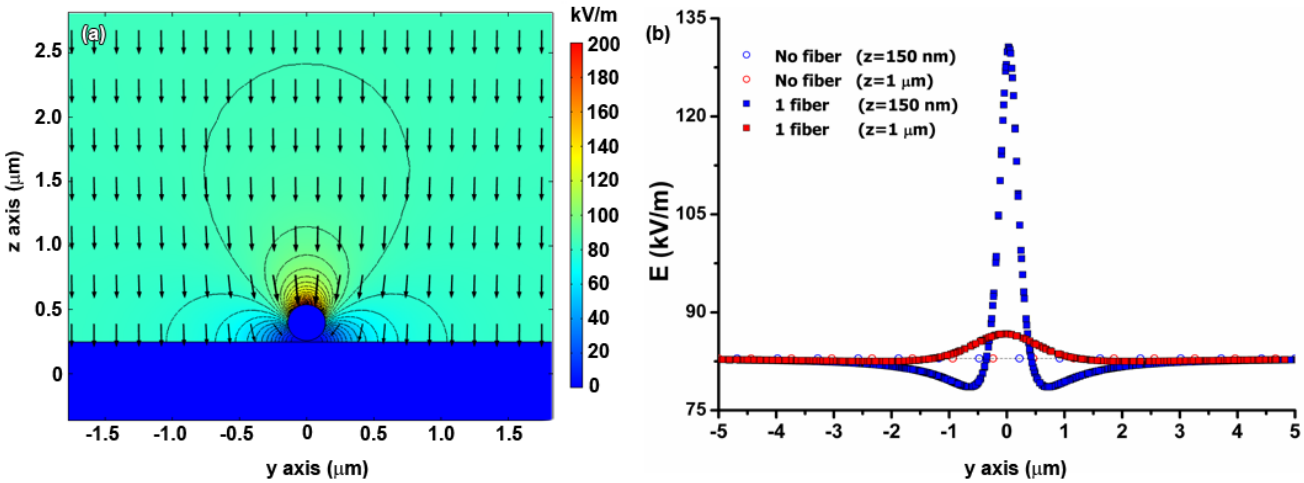

Fig. S6 Electric field in the presence of one nanofiber: (a) orientation and contour lines, (b) field intensity in x=0 plane. We simulated the polarization of one nanofiber under an intense electric field. We could see that a nanofiber can be polarized, and can cause a slight distortion of the electric field due to the surface charge accumulation at its surface. Despite the electric field becomes stronger near to the fiber surface, one single fiber does not have a significant impact at higher heights.

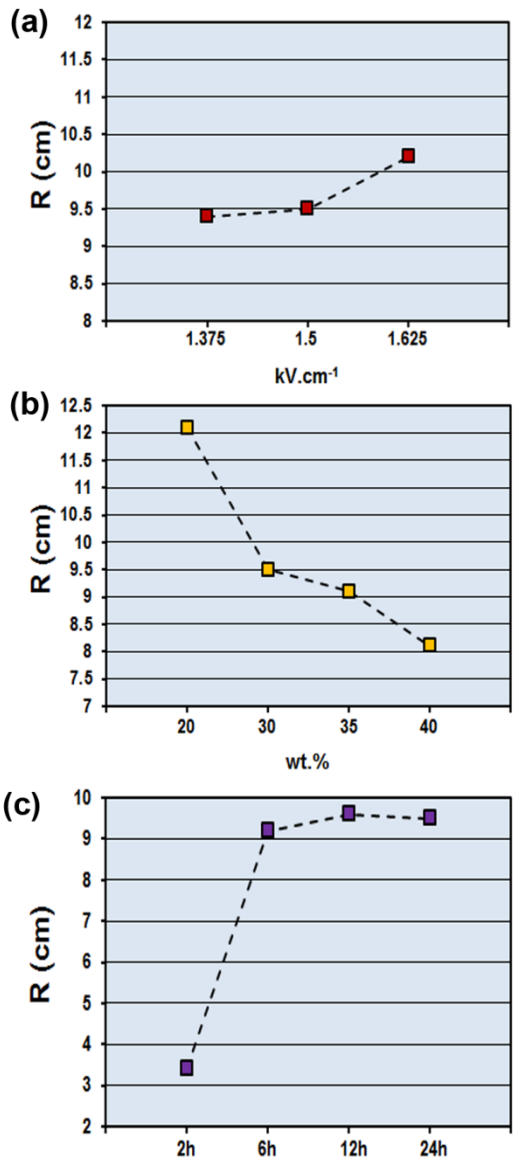

Fig. S7 Variation of Rmax according to the (a) electric field intensity (35wt% PCL in 40AA/60FA with a flow rate of 0.07 mL.h^{-1} during 24 h, the surrounding environment was set for 21 ºC and a humidity level of 31 ± 1%), (b) polymer concentration (PCL in 40AA/60FA processed at 1.5 kV.cm^{-1} with a flow rate of 0.07 mL.h^{-1} during 24 h, the surrounding environment was set for 21 ºC and a humidity level of 32 ± 1%) and (c) production time (35wt% PCL in 40AA/60FA at 1.5 kV.cm^{-1} with a flow rate of 0.07 mL.h^{-1}, the surrounding environment was set for 20 ºC and a humidity level of 31 ± 1%).

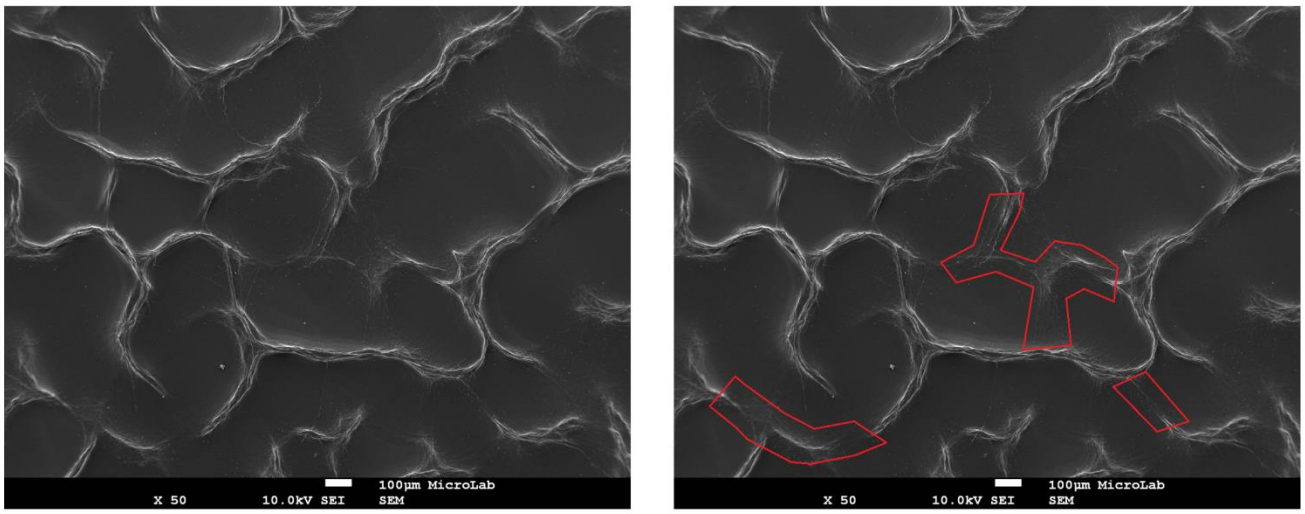

Fig. S8 Evidence of the need to extend the production time of the electrospun material (35 wt.% PCL in 40AA/60FA processed at 1.375 kV.cm^{-1} with a flow rate of 0.07 mL.h^{-1} during 24 h, the surrounding environment was set for 20 ºC and a humidity level of 31 ± 1%) for the sake of obtaining closed cells. On the right it is highlighted the smooth appearance of new MAFs.

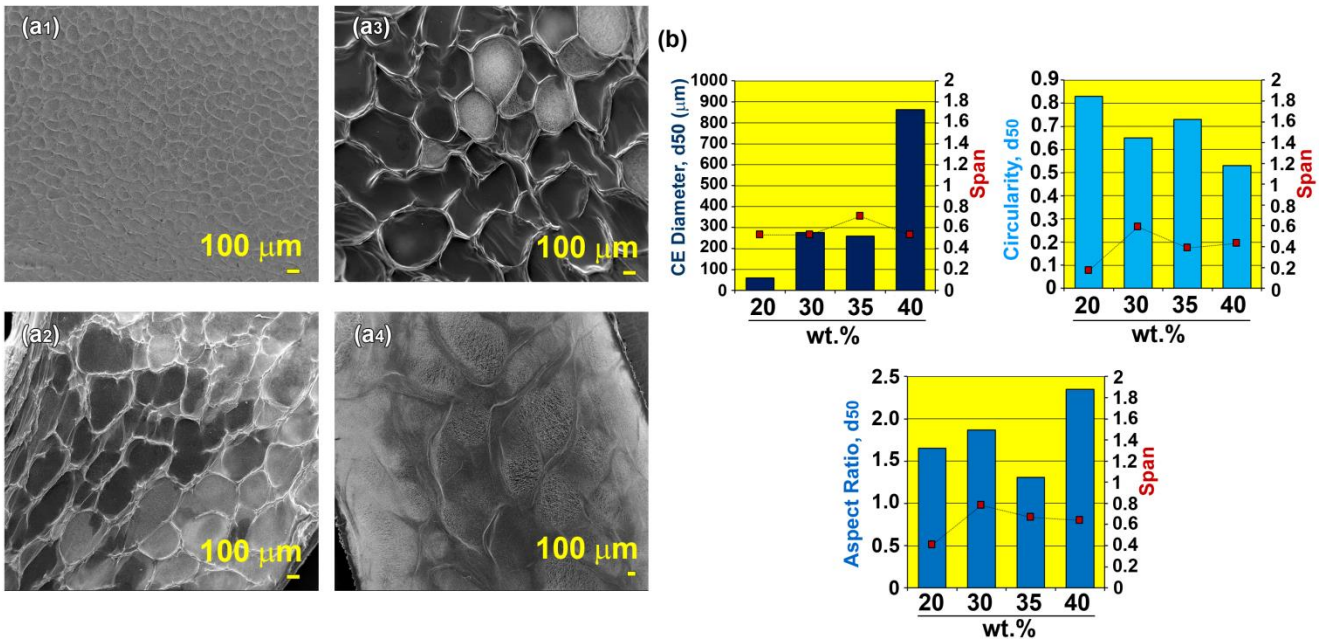

Fig. S9 Morphology comparison of electrospun membranes processed from parental polymer solutions with different concentration under the same processing conditions (PCL in 40AA/60FA at 1.5 kV.cm^{-1} during 24 h with a flow rate of 0.07 mL.h^{-1}, the surrounding environment was set for 21 ºC and a humidity level of 32 ± 1%). SEM micrographs (a1) 20wt.%, (a2) 30wt.%, (a3) 35wt.%, and (a4) 40 wt.%. Shape analysis and comparison (b).

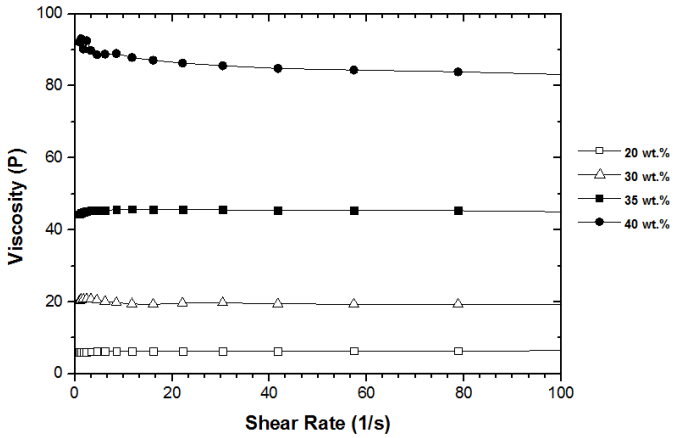

Fig. S10 Flow curves of PCL polymer solutions in 40AA/60FA at different concentrations.