Mechanical properties of aligned PCL nanofibers made by electrospinning

Reyda Akdemir[1], Havvagul Ermis[1], Silvia de la Flor Lopez [2], Joan Rosell Llompart[1,3]

[1] Department of Chemical Engineering, Universitat Rovira i Virgili, E-43007 Tarragona, Spain
[2] Department of Mechanical Engineering, Universitat Rovira i Virgili, E-47007 Tarragona, Spain
[3]Catalan Institution for Research and Advanced Studies - ICREA, E-08010 Barcelona, Spain

reyda.akdemir@urv.cat

Abstract

The importance of mechanical properties of artificial scaffolds for cell growth is particularly obvious in tissues such as for bone, cartilage, blood vessels, tendons and muscles. Polycaprolactone (PCL) is a very convenient polymer for such purpose due to its low degradation rate and good mechanical properties.[1] Here we report on the preparation and mechanical characterization of aligned PCL nanofibers produced by electrospinning stabilized with a co-flow jacket of solvent vapor.[2] The electrospinning setup is shown in Figure 1. By using aligned nanofibers,[3] mechanical properties of a single fiber were computed. The dissolution of PCL was done in a chloroform-methanol (3:1,v/v) mixture.[4] The average diameter of the PCL nanofibers was determined from their sizing in Scanning Electron Microscopy (SEM) images. Dynamic Mechanical Analysis (DMA) was carried out on samples containing thousands of identical nanofibers. As the fibers are aligned and identical, the mechanical tests performed on each sample can be used for computing single fiber average properties. The aligned fibers and the methodology which was followed are shown in Figures 2 and 3. The elastic modulus was obtained by computing the stress for a single PCL fiber. The average tensile elastic modulus and ultimate tensile strength for our neat-PCL nanofibers (Figure 4) was determined as 139 and 41 MPa, respectively. This elastic modulus value lies between that for bulk PCL (343.9 to 363.4 MPa) and the value previously reported for electrospun PCL nanofibers (27.3±3.1 MPa).[1],[5]
Given the broad material versatility of electrospinning, the proposed method can be extended to many other nanofiber compositions.

Acknowledgements

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No. 713679, from the Catalan Government (2017SGR1516), and from the Universitat Rovira i Virgili (URV).

References

[1] Kim, G. H. (2008). Electrospun PCL nanofibers with anisotropic mechanical properties as a biomedical scaffold. Biomedical Materials, 3(2), 25010.

[2] Larsen, G., Spretz, R., & Velarde-Ortiz, R. (2004). Use of coaxial gas jackets to stabilize Taylor cones of volatile solutions and to induce particle-to-fiber transitions. Advanced Materials, 16(2), 166169.

[3] Kiselev, P., & Rosell-Llompart, J. (2012). Highly aligned electrospun nanofibers by elimination of the whipping motion. Journal of Applied Polymer Science, 125(3), 2433–2441.

[4] Thomas, V., Jose, M., Chowdhury, S., Sullivan, J., Dean, D. & Vohra, Y. (2006). Mechano-morphological studies of aligned nanofibrous scaffolds of polycaprolactone fabricated by electrospinning. Journal of Biomaterials Science, Polymer Edition, 17(9), 969-984.

[5] Santosh, M., Karuppudaiyan, V. S., Eshraghi, S., Das, S., Ilankeeran, P. K., Washburn, N. R. (2011). Mechanical & Microstructural Properties of PCL Scaffolds with 1-D, 2-D & 3-D Orthogonally Oriented Porous Architectures Produced by Selective Laser Sintering. Acta Biomater., 6(7), 2467–2476.

Figures

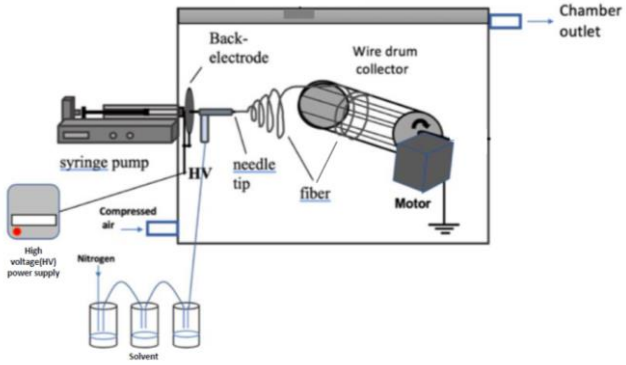

Figure 1. Electrospinning setup

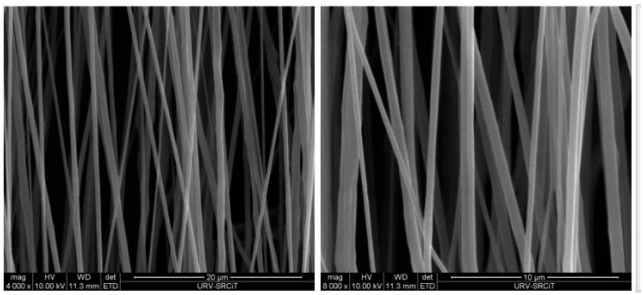

Figure 2. SEM images of aligned PCL nanofibers.

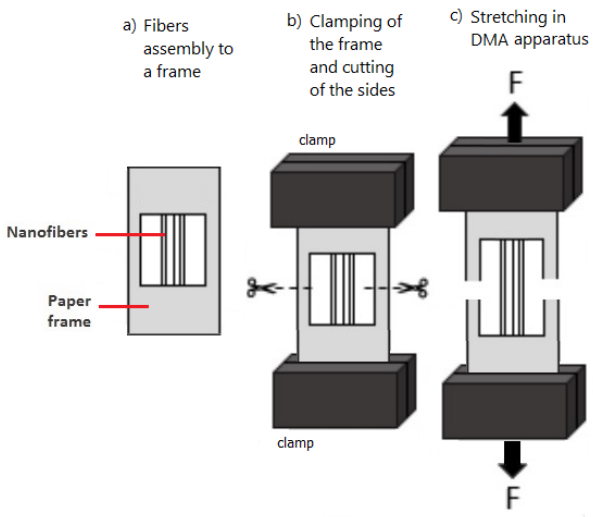

Figure 3. Mechanical testing of the aligned nanofibers. Assembly on DMA clamps (a) and (b) ; DMA test (c).

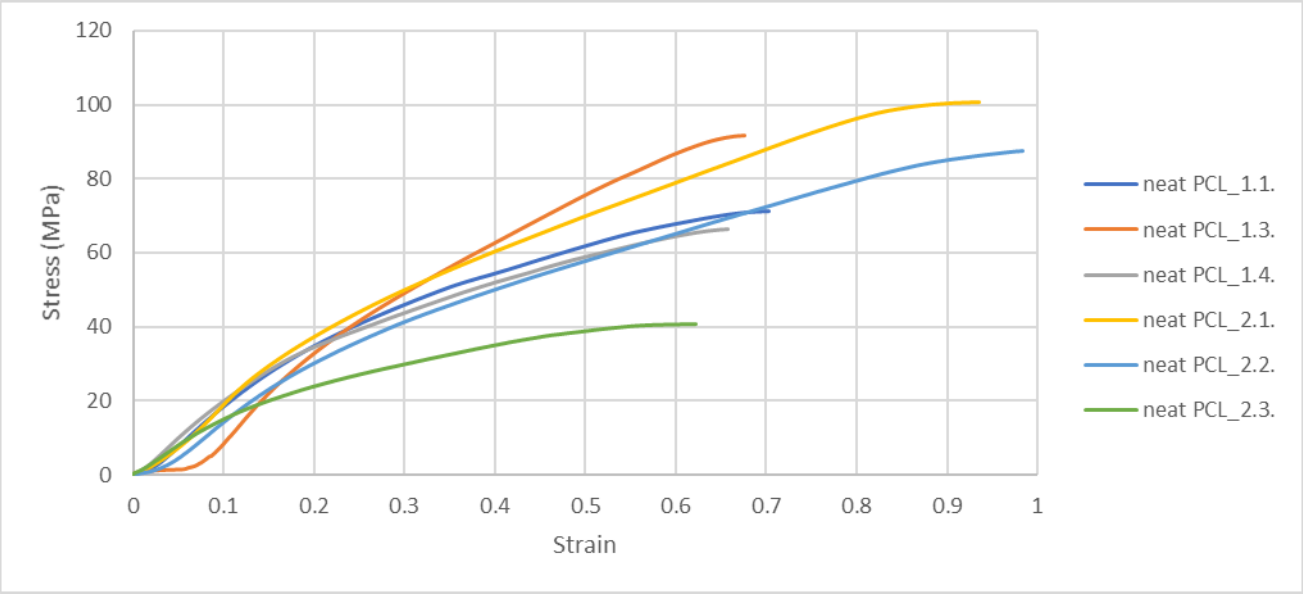

Figure 4. Tensile Test Curves of aligned PCL fiber mats.