Hybrid fibrous materials for advanced tissue engineering

B. Hermenegildo[1]
R.M. Meira[2], D. Correia[2,3], Leyre Pérez-Álvarez[1,4], José L. Vilas[1,4], Senentxu Lanceros-Méndez[1,5]
[1] BCMaterials, Basque Center for Materials, Applications and Nanostructures, UPV/EHU Science Park, 48940 Leioa, Spain.
[2] Centro/Departamento de Física, Universidade do Minho, 4710-057 Braga, Portugal
[3] Department of Chemistry and CQ-VR, Universidade de Trás-os-Montes e Alto Douro, 5000-801 Vila Real, Portugal
[4] Macromolecular Chemistry Research Group, Department of Physical Chemistry, Faculty of Science and Technology, UPV/EHU, Leioa, Spain
[5] IKERBASQUE, Basque Foundation for Science, 48013 Bilbao, Spain
bruno.hermenegildo@bcmaterials.net

To mimic the natural environment of tissues, support structures are necessary in order to allow for healthy cell and tissue development. Hydrogels have become interesting materials to develop these support structures. However, hydrogels alone cannot provide all the necessary stimuli and microenvironment for cell development and, therefore, hybrid materials are currently being developed. Cells and tissues also require more than a suitable biochemical environment [1], as electrical and mechanical stimuli are extremely important for their healthy development [2]. Scaffolds can be functionalized with nanomaterials, so these stimuli can be applied to the forming tissue [3].
Muscle is an electromechanical material, highly responsive to these stimuli [4], and the directional growth of the myoblast cells can be achieved by using aligned fibers [5].
Therefore, introducing electroactive polymers in a hydrogel scaffold, allowing for external stimulation, results in improved in-vitro mimicry of natural conditions for muscle cell growth and differentiation [6]. In this context, the present work presents the development of electrospun electroactive polymer fibers [7], to fabricate functionalized hybrid hydrogel scaffolds for muscle tissue engineering.
Oriented and non-oriented fibers, based on electroactive, biocompatible, biodegradable and biostable polymers, have been processed and characterized. They were further modified with ionic liquids and magnetic particles to allow electro and mechanotransduction to be applied to the cells.
This resulted in fibers with diameters between 0.5-3 µm, crystallinity between 45-60%, electroactive phase content around 90%, with the thermal stability of the polymer being unaffected by the inclusion of these materials. The results confirm the suitability of the materials for biomedical applications.

Funding by Spanish State Research Agency (AEI) and the European Regional Development Fund (ERFD) through the project PID2019-106099RB-C43/AEI/10.13039/501100011033. Financial support from the Basque Government under the ELKARTEK, HAZITEK and PIBA (PIBA-2018-06) programs is also acknowledged.

REFERENCES

1. Gajendiran, M., et al., *Conductive biomaterials for tissue engineering applications.* Journal of Industrial and Engineering Chemistry, 2017. **51**: p. 12-26. DOI: 10.1016/j.jiec.2017.02.031
2. Meira, R.M., et al., *Ionic-Liquid-Based Electroactive Polymer Composites for Muscle Tissue Engineering.* ACS Applied Polymer Materials, 2019. **1**(10): p. 2649-2658. DOI: 10.1021/acsapm.9b00566
3. Li, J., et al., *Strain-based scanning probe microscopies for functional materials, biological structures, and electrochemical systems.* Journal of Materiomics, 2015. **1**(1): p. 3-21. DOI: 10.1016/j.jmat.2015.03.001
4. Fukada, E. and H. Ueda, *Piezoelectric Effect in Muscle.* Japanese Journal of Applied Physics, 1970. **9**(7): p. 844-845. DOI: 10.1143/jjap.9.844
5. Ribeiro, C., et al., *Piezoelectric polymers as biomaterials for tissue engineering applications.* Colloids and Surfaces B: Biointerfaces, 2015. **136**: p. 46-55. DOI: 10.1016/j.colsurfb.2015.08.043
6. Palza, H., P. Zapata, and C. Angulo-Pineda, *Electroactive Smart Polymers for Biomedical Applications.* Materials, 2019. **12**(2): p. 277. DOI: 10.3390/ma12020277
7. Ribeiro, C., et al., *Electroactive poly(vinylidene fluoride)-based structures for advanced applications.* Nat Protoc, 2018. **13**(4): p. 681-704. DOI: 10.1038/nprot.2017.157