THE INFLUENCE OF MICROSTRUCTURE OF FIBROUS PLA/PVA MEMBRANES ON PHYSICOCHEMICAL AND BIOLOGICAL PROPERTIES

EWA DZIERZKOWSKA[1]*, PRZEMYSŁAW ŻMUDA[2], ANNA ŚCISŁOWSKA-CZARNECKA[3], KAMIL KORNAUS[4], EWA STODOLAK-ZYCH[1]

[1] DEPARTMENT OF BIOMATERIALS AND COMPOSITES, AGH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KRAKOW, POLAND
[2] DEPARTMENT OF BIOCYBERNETICS AND BIOMEDICAL ENGINEERING, AGH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KRAKOW, POLAND
[3] DEPARTMENT OF COSMETOLOGY, ACADEMY OF PHYSICAL EDUCATION, KRAKOW, POLAND
[4] DEPARTMENT OF CERAMICS AND REFRACTORIES, AGH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KRAKOW, POLAND
*E-MAIL: DZIERZKOWSKA@AGH.EDU.PL

[ENGINEERING OF BIOMATERIALS 158 (2020) 52]

Introduction

Nano- and sub-micron scale of fibrous materials produced by electrospinning method draw the attention of many researchers. Versatility, affordability and fiber architecture comparable to natural extracellular matrix is the greatest asset of this technique. This fiber support cell adhesion, proliferation and differentiation of every tissue. However, mimicking the three-dimensional network of the native ECM is still challenging [1]. Dense packing of the fibers and small pores diameter limit cell infiltration to inner side of the scaffold. Fortunately, highly versatile electrospinning method led to the formation fibrous scaffold with enhanced pore size. One of the approach to increasing pore size is use of sacrificial fibers in two-syringe system electrospinning [2]. Scaffold composed of soluble as well as insoluble polymer fibers and in the sequel selective removal of the soluble elements enhance the pore size [3]. This two-syringe system could deposit fibers layer by layer and due to the time lag tailored the gap between insoluble fibers. Alternatively, bi-modal scaffold could be also fabricated by concurrently electrospinning. Typically, the sacrificial element is removed but also it might well form a part of drug carrier. Based on the fiber diameters, the size of the gap could be successfully controlled. As a result of sequential or concurrent electrospinning, electrified polylactide and polyvinyl alcohol fibers can be obtained. The fibers diameter was tailored by several process parameters e.g. molar mass or distance between the tip of the needle and collector [4].

Materials and Methods

PLA (3251D and 3001D, Nature Works) was dissolved in dichloromethane (DCM, Avantor) and dimethylformamide (DMF, Avantor). Distilled water and ethanol (EtOH, 98%) were the solvents for PVA (M.W. 500-5000 and 115000 Alfa Aesar). Morphology was characterized used the scanning electron microscope (NOVA NANO SEM 200). Physicochemical properties of the surface: wettability, surface energy was tested using a goniometer (DSA 25 Kruss). The presence of two different polymer fibers was confirmed by Fourier transformation infrared spectra (FTIR, FT 3000 Excalibur). The porosity of the manufactured membranes was determined by mercury perimetry (PoreMaster 60, Quantachrome). In vitro cell response was performed by seeding fibroblast on the fibrous membrane.

Results and Discussion

Expected results differences in fibers diameter and the porosity of the non-woven mats depending on different work distance and molecular mass which affect on inner pore size. Altering distance between tip of needle and collector, fiber diameters can be varied by 400nm and 40nm for PLA and PVA, respectively (FIG. 1). That parameters correlate with porosity. Depending on polymer and type of bi-modal electrospinning the value of the water contact angle is in the range from 70 to 130° (TABLE 1, FIG. 1). FTIR spectra confirming the presence of both polymer fibers in the membrane (FIG. 2). The absorption bands from -OH and C-H groups confirms the presence of PVA fibers in the bi-modal membrane. Characteristic C=O, C-O and O-C-O groups for PLA are also present.

TABLE 1. The values of contact angles [°].

Type of two-syringe electrospinning		Contact angle [°]
Sequential	1	131,11°± 6,77
	2	73,01°±5,24

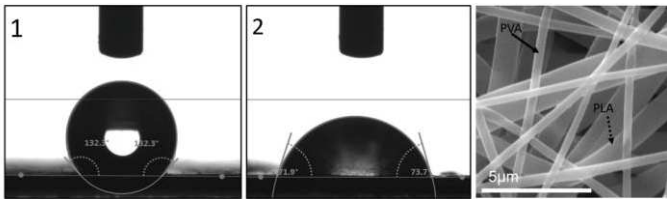

FIG. 1 The picture of water droplet sits on bi-modal scaffold consist of: 1 – PLA/PVA/PLA and 2 – PVA/PLA/PVA. SEM microphotography of PVA and PLA fibers obtained by sequential electrospinning (PVA/PLA/PVA).

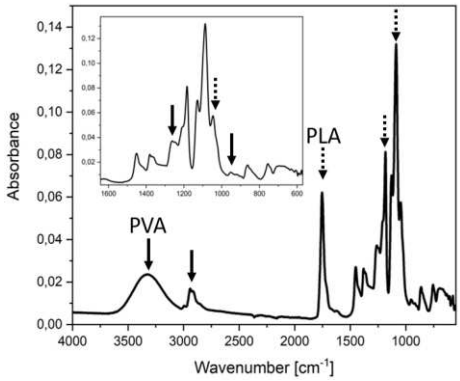

FIG. 2. FTIR spectra of PVA/PLA/PVA bi-modal scaffold.

Conclusions

Electrospun membrane with enhanced porosity can be tailored to provide sufficient scaffold for dermal tissue engineering. Two approaches of sequential and concurrent bi-modal membrane have different interaction with dermal fibroblasts and it have different physical properties.

Acknowledgments

This study was performed within the framework of funding for statutory activities of AGH University of Science and Technology, Faculty of Materials Science and Ceramics (11.11.160.182).

References

[1] E. Stodolak-Zych *et al.*, J. Mol. Struct., 1211 (2020) 128061.
[2] Z. Tan *et al.*, Mater. Sci. Eng. C, 67 (2016) 369-377.
[3] J. Ameer *et al.*, J. Funct. Biomater., 10 (2019) 30.
[4] J. Rnjak-Kovacina *et al.*, Biomaterials, 32 (2011) 6729-6736.