POTENTIAL OF ELECTRO-SPINNING TECHNIQUE TO DRUG DELIVERY SYSTEM

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Introduction

Electrospinning is technique used to manufacturing nano- and submicrofibers base on synthetic or natural polymers. The size and microstructure of fibrous scaffold are suitable to cells adhesion and proliferation. Microstructure of fibrous scaffold mimicking natural extracellular matrix (ECM) [1]. Additionally, biomaterials used to electrospinning procedure can be modified by bioactive compound, peptides or growth factors (FIG. 1.). The non-woven materials characterized by high porosity and high surface area to volume, which allow for efficient loading of the material with drug. It is also a possibility to obtain a porosity of the single fiber. That can further enhance the surface area to volume ratio and increase the functionality of the fibres [2].

This work was based on achievement a porous fibrous membrane with antibacterial properties. For this purpose we obtained three different fibrous membranes by electrospinning using polylactide (PLA) and three sets of solvents. The main goal was to achieve porosity of single fiber to get better antibacterial properties in the next step. We solved this issue using high humidity during electrospinning process and introducing gentamicin into the spinning solution. The obtained porosity can be studied using temporometry based on changes in heat of fusion.

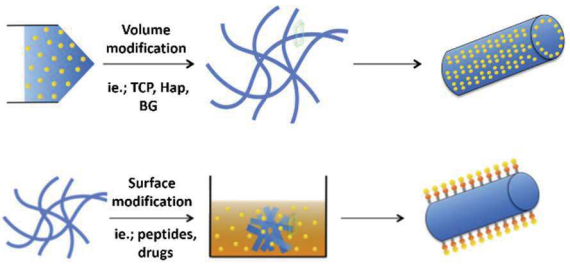

FIG. 1. Electrospinning fibers modification: on the surface and in the bulk.

Materials and Methods

The PLA 3251D polylactide from Nature Works was used in the research as base material for electrospinning. Analytically pure reagents provided by Avantor SA: dichloromethane (DCM), dimethylformamide (DMF), chloroform (CHL) and dimethyl sulfoxide (DMSO) were used as solvents for the preparation of spinning solutions. Porous polymer fibers were modified with 5% w/v of gentamicin (Polfa SA), in the form of gentamicin sulfate. The electrospinning process was carried out under experimentally determined conditions, namely: humidity (30-70%), temperature (25°C) and voltage (12-15 kV). Both the measurement of diameters and the microtexture observations of PLA submicrofibers were made using the scanning electron microscope Merlin Gemini II (Zeiss). Surface wettability of the tested materials was determined by means of direct measurements (DSA 10, Kruss) at room temperature using high purity water (UHQ, PURE Lab, Vivendi water) as a measuring liquid. The free surface energy was determined by the Owens-Wendt method using diiodomethane as a non-polar liquid.

Experiments on controlled drug release were performed using small pieces of electrospun membrane (10 mg) that were incubated in 50 ml of phosphate buffer saline (PBS) medium into polypropylene tubes at 37°C for 7 days. The concentration of drug in the immersion medium was measured by plasma inducted spectroscopy (ICP-ASA, Hewlett-Packard ICP 4500 spectrometer).

Results and Discussion

The results of the conducted research indicate that porous and non-porous PLA fibers can be successfully modified with gentamicin. The different size (diameter) of the fibers influenced the pore size (FIG. 2). Indirect proof for the presence of gentamicin are results of wettability tests (CA). Non-woven materials with gentamicin characterized low wettability in comparison to porous fibers but without antibiotic. The homogeneous pore size distribution in membrane with porous fibers well corresponds to the shape of the drug release profile. The release profile has a much milder course, when the fibers size and the pores diameter were larger (with larger surface pores). Slower kinetic of drug release was observed when the diameter of fibers and pores had nanometric diameter.

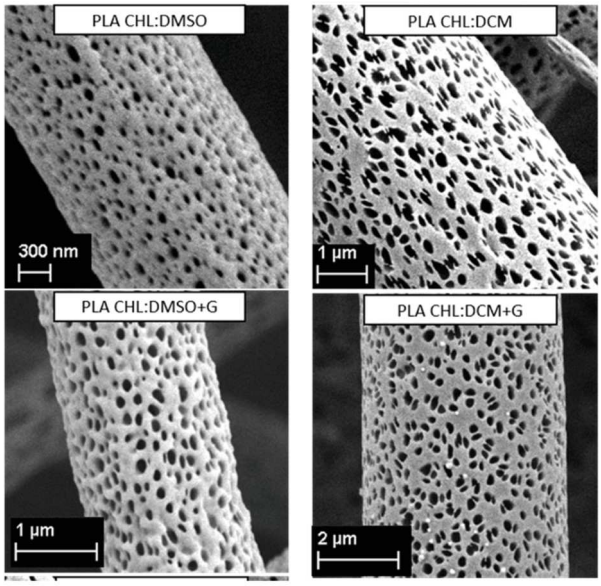

FIG. 2. Morphology of porous fibers with and without gentamicin.

Conclusions

The preliminary results show, that it is possible to propose several solutions of materials with optimal properties, designed on the basis of a correct combination of porous and solid fibers, which will ensure an prolonged release time of the drug.

Acknowledgments

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References

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[2] P. Kamble, B. Sadarani, S. Bhullar, Nanofiber based drug delivery systems for skin: A promising therapeutic approach", J. Drug Deliv. Sci. Technol. 41 (2017) 124–133.