FABRICATION AND CHARACTERIZATION OF FIBER-REINFORCED HYDROGELS FOR TISSUE ENGINEERING APPLICATIONS

Jan Drexler[1], Gesine Hentschel[1], Andre L.C. Conceição[2], Rainer Detsch[3], Aldo R. Boccaccini[3], Birgit Glasmacher[1]

1. *Institute for Multiphase Processes, Leibniz University Hannover, Germany*
2. *German Electron Synchrotron DESY, Germany*
3. *Institute of Biomaterials, University of Erlangen-Nuremberg, Germany*

Introduction

The application of hydrogels in tissue engineering is limited due to their low mechanical properties. They can be tuned by incorporating electrospun fibers [1,2]. In addition, the fiber-like morphology of the natural extracellular matrix can be simulated in order to improve cell adhesion. The combination of electrospun fibers and hydrogels may create a biomimetic environment which replicates the water-swollen, fibrous characteristics of natural tissues [1,3]. Here, we present methods for the fabrication and characterization of fiber-reinforced poly(sodium acrylate-co-acrylamide) (PSAAm)-hydrogels. Both layered structures and hydrogels with dispersed short fibers are considered.

Methods

Fiber mats for the layered structures were produced by solution-based electrospinning (SE) and melt electrospinning (ME) of polycaprolactone (PCL). Solutions for SE were prepared by dissolving 24%w/w PCL (14kDa, Sigma Aldrich) and 6%w/w PCL (80kDa, Sigma Aldrich) in trifluoroethanol (abcr). SE was performed in a uniaxial vertical setup with a rotating drum collector. For ME, PCL (45kDa) was melted at 80°C and subsequently processed into fibers. Short fibers were made from PCL in SE and fatty acid-terminated poly-L-lactide (PLLA) in ME. PLLA fibers were mechanically comminuted using a mortar. Electrospun PCL fiber mats were fabricated according to the procedure for layered structures. The fiber mats were then exposed to UV light (Osram HNS S/E, 11W, 4h) and crushed into short fibers by ultrasonication in isopropanol (Hielscher Electronics UP200S) in an ice bath to prevent melting of the PCL fibers. For the production of layered structures, PSAAm hydrogel precursor and fiber mats were alternately placed in a mold. The short fibers were added to the hydrogel precursor and then dispersed in a water bath for 15min before the reaction starter was added. The morphology of the produced fibers was evaluated by SEM (Hitachi S3400-N). The interface between fiber mat and hydrogel was observed in a sliced cross-section using SEM (Jeol JSM-IT510LA) with a cryostage. Hydrogels with dispersed fibers were measured with SAXS tensor tomography at DESY beamline p62 to investigate crystallinity and molecular orientation.

Results

PCL fiber mats produced for layered structures had fiber diameters of 1±0.6µm (SE) and 87.4±3.7µm (ME). Cryo-SEM of the layered structures showed infiltration of hydrogel into the pores of electrospun fiber mats for ME, but not for SE. Short PCL fibers were 2.2±1.5µm in diameter and 10±6.7µm in length whereas short PLLA fibers were 161.4±21.8µm in diameter and 551±229.3µm in length. SAXS tensor tomography at DESY proved to be capable of volumetric visualization of crystallinity and orientation in hydrogels.

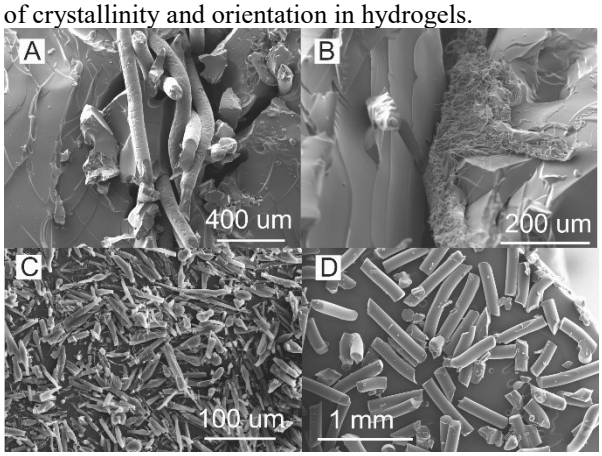

Figure 1: Cross-section of layered structures with PLLA (A) and PCL (B) fiber mats. Short fibers for the incorporation into hydrogels produced from PCL in SE (C) and PLLA in ME (D).

Discussion

Layered structures and hydrogels with dispersed fibers were successfully prepared. Hydrophilization of the SE-PCL mats could improve the infiltration of the hydrogel into the pores. Further work will focus on the mechanical characterization of the reinforced hydrogels and their swelling behavior. The combination of fibers and alginate-based hydrogels is planned in cooperation with the University of Erlangen-Nuremberg.

References

1. Yongcong et al., J Biomed Mater Res, 107A:2694-2705, 2019.
2. Szentivanyi et al., Adv Drug Deliv Rev, 63:209-220, 2011.
3. Grewal and Highley, Biomater Sci, 9(12):4228-4245, 2021.