The water absorption by a crosslinked material strongly depends on the crosslinking density. For the comparison, all kinds of the obtained alginate beads were investigated for water absorption by immersing them in distilled water for 24h and 48h. Water intake was determined by weight raise in relation to initial mass of a dry product. For the lower calcium chloride solution concentrations the water absorption was decreasing with icreasing the $CaCl_2$ concentration, but for the concentrations higher than 0,3 M the water absorption was stabilized at similar level. This effect could be observed in both ionically and covalently crosslinked beads and both after 24h and 48h. The water was fastest absorbed at the beginning and then the process rate was decreasing until the saturation of the material. The water absorption is strictly connected to the density of crosslinking. The higher $CaCl_2$ concentration the higher density of crosslinking and the lower water absorption. For cellulose reinforced alginate beads the water absorption was decreasing with increasing the amount of the additive. The relation between the time and the mass of absorbed water was similar as for the materials not containing cellulose. In case of ionically and covalently crosslinked alginate beads a change in the highest range of the concentration did not affect the yield of the process so it was occurring only to some maximal degree.

Morphology of the surface of all alginate beads independently on the crosslinking density was very similar. The surface of the beads has high roughness. The flatness is a result of contiguousness of the beads to each other or to the substrate during drying. Reinforcment of the beads with cellulose allowed to obtain the spheres of undisturbed shape. Qualitative elemental analysis was obtained with the energy dispersive spectroscopy. The ionically crosslinked product still containes certain amount of sodium and chloride ions, while after covalent crosslinking the contents of these elements were significantly lower, however calcium content decrease can be also seen. It means that the cations are eliminated during the reaction of epichlorohydrin with alginate molecules, and as a consequence it means that carboxyl groups are involved in the reaction. The in vitro biodegradation process was examined by incubating 200mg a sample in 20ml of PBS buffer for 14 days at the temperature of 37^{o}C. The pH value change is directly connected with the degree of the biodegradation. The most intense biodegradation occurred during the first day of the incubation. Then the pH change were insignificant. For all of the products the observations were very similar.

Conclusions

The beads possessing various hardness corresponding to the degree of the crosslinking were fabricated. Crosslinking was conducted by two ways - ionically and covalently. The alginate beads were additionally reinforced by addition of cellulose fibers. The water absorption in the products was investigated. It strongly depends on the density of crosslinking. For samples obtained in the CaCl2 solution of the lowest concentration (0,1 M) the water absorption was almost twice of the dry alginate mass while in the samples obtained in the solutions of 0,3 M and higher concentration it was three times lower. Analogically, the water uptake in ionically bonded alginates was visibly higher than in this additionally crosslinked by covalent intermolecular bonding. The samples were characterized with scanning electron microscopy and energy dispersive spectroscopy.

Acknowledgements

The authors gratefully acknowledge the National Science Center (Poland) for financial support (grant no. 2011/01/B/STB8/07795).

References

[1] Jejurikar A., Lawrie G., Martin D, Grøndahl L.: A novel strategy for preparing mechanically robust ionically cross-linked alginate hydrogels. Biomedical Materials 6(2) (2011) 025010
[2] Pal K., Banthia A.K. , Majumdar D.K.: Polymeric Hydrogels: Characterization and Biomedical Applications - A mini review. Designed Monomers and Polymers 12 (2009) 197-220
[3] Grasselli M., Diaz E.L., Cascone O.: Beaded matrices from cross-linked alginate for affinity and ion exchange chromatography of proteins. Biotechnology Techniques 7(10) (1993) 707-712

PRELIMINARY STUDY ON THE ELECTROSPUN PLA–BASED NANOFIBRES AS BIOMATERIALS FOR THE TREATMENT OF CARTILAGE

Anna Magiera[1], Jarosław Markowski[2], Marta Lesiuk[3], Aleksander L. Sieron[3], Jan Pilch[2], Stanisław Błażewicz[1]*

[1] AGH University of Science and Technology,
Faculty of Materials Science and Ceramics,
Department of Biomaterials,
al. A. Mickiewicza 30, 30-059 Krakow, Poland
[2] Medical University of Silesia,
Department of Laryngology,
ul. Francuska 20, 40-752 Katowice, Poland
[3] Medical University of Silesia,
Department of General, Molecular Biology and Genetics,
ul. Medyków 18, 40-752 Katowice, Poland
* e-mail: blazew@agh.edu.pl

Abstract

Electrospinning is a simple and universal way to produce fibres from a variety of materials having diameters ranging from submicrometers to nanometers. Such fibres can be formed from resorbable and non-resorbable polymers, ceramics and their different combinations containing nanoparticles. Such a method has gained a great interest in medicine due to its ability to form a fibrous space architecture, similar to the natural extracellular matrix [1,2]. On the other hand, due to a wide range of technical facilities of electrospun fibers the method allows to create directionally-dependent space architecture of nanofibres which mimic natural tissues [3]. Considering the similarities between the microstructure created by nanofibres and the extracellular matrix, nanofibrous materials made by ES technique seem to be promising scaffolds to regenerate cartilage [4] and neural tissue [5]. A material which is used for cartilage scaffolds should mimic native cartilage, which is known to have an oriented structure associated with its mechanical and physiological functions [5]. Scaffold with a biomimetic-oriented architecture is an important requirement for tissue-engineered cartilage.

In this study, PLA oriented and non-oriented fibrous scaffolds were manufactured. Selected properties of the materials were analysed and dissussed in view of the manufacture of optimal structure for cartilage tissue engineering.

Keywords: *electrospinning, nanofibrous scaffold, cartilage*

[Engineering of Biomaterials, 128-129, (2014), 110-111]

Acknowledgments

This work was supported by the National Science Centre, PRELUDIUM 6 research program and project no. 2013/11/N/ST8/01169.

References

[1] Spaddacio C., Rainer A., Trombetta M., Vadala G., Chello M., Covino E., Denaro V., Toyoda Y., Genovese J.A.: Poly-L-lactic acid/hydroxyapatite electrospun nanocomposites induce chondrogenic differentiation of human MSC. Annals of Biomedical Engineering 37 (2009) 1376-89

[2] Xin X., Hussain M., Mao J.: Continuing differentiation of human mesenchymal stem cells and induced chondrogenic and osteogenic lineages in electrospun PLGA nanofiber scaffold. Biomaterials 28 (2007) 316-25

[3] Jia S., Liu L., Pan W., Meng G., Duan C., Zhang L.: Oriented cartilage extracellular matrix-derived scaffold for cartilage tissue engineering. Journal of Bioscience and Bioengineering 113 (2012) 647-653

[4] Lia W.J., Tulia R., Okafora C., Derfoula A., Danielsonb K.G., Halla D.J., Tuan R.S.: A three-dimensional nanofibrous scaffold for cartilage tissue engineering using human mesenchymal stem cells. Biomaterials 26 (2005) 599-609

[5] Yang F., Qu X., Cui W., Bei J., Yu F., Lu S., Wang S.: Manufacturing and morphology structure of polylactide-type microtubules orientation-structured scaffolds. Biomaterials 27 (2006) 4923-4933

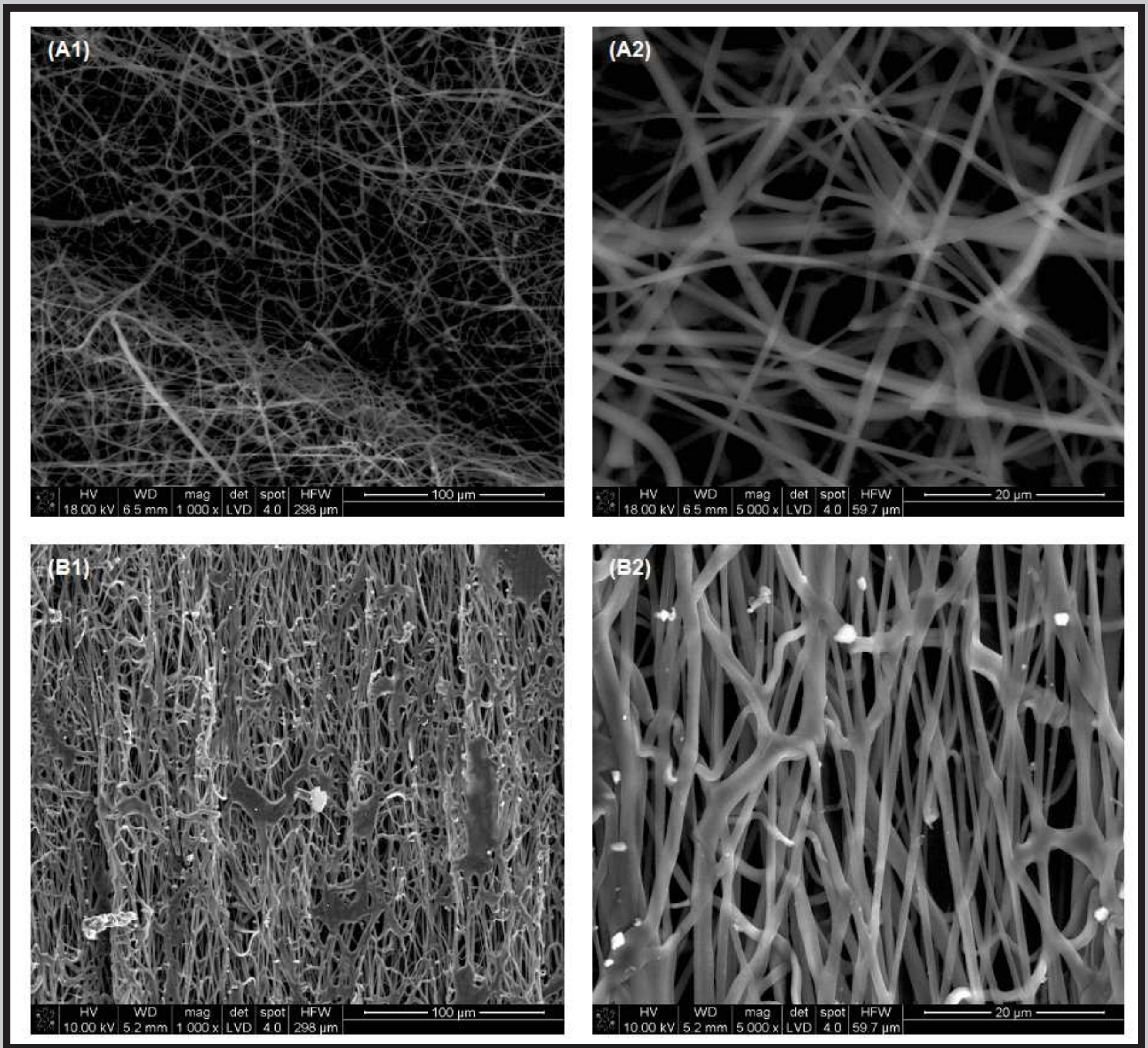

FIG. 1. SEM images of fibrous scaffolds: (A) non-oriented PLA, (B) oriented PLA. (Scale bars: (1) 100 µm, (2) 20 µm).