DEPOSITION OF IRON ON CARBON NONWOVENS BY MAGNETRON SPUTTERING

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[ENGINEERING OF BIOMATERIALS 163 (2021) 69]

Introduction

Cavities in cartilage and bone tissue are outcome of diverse diseases, accidents or tumors. Larger defects must be adequately supplemented by transplantation method using a wide variety of implants including synthetic or natural allo-, auto- and xeno- geneic materials. One of the different approach to treatment is usage of materials forming a tissue scaffold. The ideal scaffold has some particular requirements such as biocompatibility in both primary and degraded form along with uniform porosity that allow access of nutrients to the treated tissue. Ideally, the outer layer of such material should exhibit structural and surface compatibility with processes of bone tissue cell adhesion and proliferation [1]. A modern approach in biomaterials engineering is utilization of carbon fibers, using polyacrylonitrile (PAN) fibers as a precursor, as a tissue scaffold. For this reason, proper selection of precursor fibers is crucial, since strength and porosity of the carbon fibers depend as well as on the type of precursor. The aim of the study was to investigate the possibility of obtaining carbon nonwovens from needle punched, precursor PAN nonwovens. Prepared in such way nonwovens may become a scaffold for bone tissue regeneration.

Materials and Methods

The study was conducted on PAN needle punched nonwovens, prepared from fibers 60mm in length, previously oxidized. Several variants of nonwovens were produced, with different surface mass, i.e. 80 g/m^2 (PAN1), 120 g/m^2 (PAN2), 190 g/m^2 (PAN3), 330 g/m^2 (PAN4), 600 g/m^2 (PAN5). Determination of parameters such as: tensile strength (PN-EN 29073-3:1994), thickness (PN-EN ISO 9073-2:2002), swelling and absorbency at free soaking in NaCl and PBS, the presence of chloride ions and heavy metals have been conducted. Precursor nonwovens were subjected to carbonization process, using a two-stage thermal treatment process. Iron was deposited in the obtained carbon nonwovens using the magnetron sputtering method on a DC magnetron manufactured by P.P.H. Jolex s.c. (Częstochowa). The modification was carried out in argon atmosphere (4%) for 10 min, at effective power 1 kW and working pressure 2.9x10^{-3} mbar.
After iron deposition, the morphology of the fibers surface was examined the use of Tescan Vega 3 scanning electron microscope (Tescan Analytics, Brno, Czech Republic) equipped with the EDS (Oxford Instruments, Abingdon, UK) X-ray micro analyser.

Results and Discussion

Results analysis as well as preliminary carbonization tests revealed that the most optimal structure and properties (based on the declared and intended use of such material) have been observed for samples with lower surface mass. Such nonwovens were characterized with the highest air permeability parameter, which may be beneficial. For samples with higher surface mass, the inefficient flow of thermal energy to inside of the nonwoven was observed, what very likely disturb natural body thermoregulation. Therefore, for further tests sample PAN2 (120 g/m^2) has been selected.
Analysis of the swelling results - fluid handling capacity and dehydration rate demonstrated that the PAN2 nonwoven showed no significant swelling ability in both fluids, NaCl and PBS. Fluid handling capacity and absorbency tests presented similar characteristics for both fluids. SEM+EDS analysis indicated the regular distribution of iron on the fiber surface (FIG. 1).

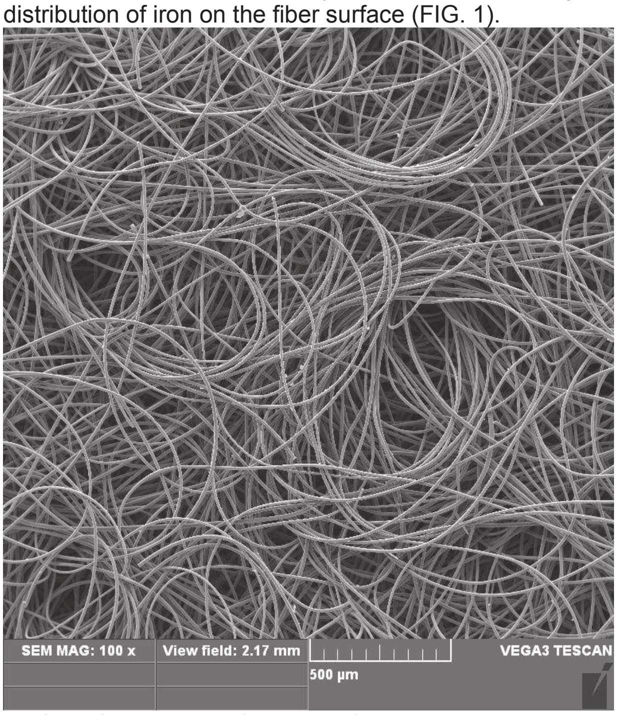

FIG. 1. SEM image of iron modified carbon nonwovens.

Conclusions

The analysis of the research showed that the PAN2 nonwoven is characterized by the most optimal structure and properties, based on declared and intended use of such material. Nonwovens obtained as shown ensure homogeneous supply of thermal energy to the entire volume of the material. Additionally, regular distribution of iron and uniform metallic surface into a polymer nonwoven material exhibits a potential for its imaging after implantation, e.g. using magnetic resonance.

Acknowledgments

This research was funded by the National Science Centre, Poland, grant number UMO-2018/31/B/ST8/02418.

References

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