FIBROUS CARBON SCAFFOLD MODIFIED BY POLYSACCHARIDES WITH POTENTIAL BIOLOGICAL ACTIVITY

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Introduction

In medicine carbon fibers are mainly known as a component of complex, multi-phase composites. At the same time, carbon fibers themselves in the form of nonwovens or mats can be attractive scaffolds facilitating cell adhesion, proliferation and differentiation. Thus, fibrous materials of different fibres distribution i.e.: unidirectional (1D), bidirectional (2D) or multidirectional (MD) may constitute scaffolds for the cells of many tissues [1]. Due to high biocompatibility of amorphous carbon fibres, these substrates are an interesting biomaterial, which can be used independently or additionally modified to enhance and direct the biocompatibility effect towards a specific cell group [2-3].
The potential of carbon fibres to regenerate bone tissue can be regulated by their modification with biopolymers. Chitosan (CS), alginate (CA) or gelatin (G) are known for their ability to support repair processes in damaged cartilage. It seems that the combination of carbon fibres and polysaccharides will facilitate the stimulation of cartilaginous growth, especially in areas where there is a contact between two tissues: cartilage and bone, e.g. in cartilaginous dysplasia.
The aim of this study was to obtain and characterize low-module carbon nonwovens, which were references for fibrous constructions being a combination of carbon nonwoven fabric and one of the selected polysaccharides: chitosan (CF/CS) or alginate (CF/CA).

Materials and Methods

Controlled thermal conversion of polymeric nonwoven fabric obtained from polyacrylonitrile by the wet spinning method (Lukasiewicz Research Network - The Textile Research Institute) to carbon fibers in two-stage process: oxidation (250°C/air) and low-temperature carbonization (970°C/nitrogen) was conducted. Fiber morphology was observed using scanning electron microscope (Nova NanoSEM, FEI). A change in the wettability of materials related to the method of thermal treatment was shown; the longer the oxidation stage, the higher the hydrophilicity of materials (up to 65°, Kruss goniometer 25E) and the more numerous oxygen functional groups (carboxylic, carbonylic groups, FTIR-ATR, Bruker BioRAD).

Results and Discussion

During thermal conversion process material were shrinkage (about 12% of total shrinkage of nonwoven fabric, about 6% shrinkage of a single fiber) was recorded. A change in the wettability of materials related to the method of thermal treatment was shown; the longer the oxidation stage (with low temperature ie. 180°C), the higher the hydrophilicity of materials (up to 65°) and the more numerous oxygen functional groups (carboxylic, carbonylic groups). Shorter oxidation stage at higher temperature (260°C/30min) reduces the hydrophilicity of the material but allows to obtain a less brittle non-woven fabric, which makes further processing easier (carbonization, 970°C).
Carbon nonwovens have a wettability of 70-80°, which makes them easy to contact with biopolymer solutions. Soaking the non-woven fabric in polymer solution and its lyophilization leads to maintaining the fibrous form of the structure and allows easier contact of the materials with the culture medium. The biopolymer layer present on the fibres does not exceed a few micrometers (1-3 μm) and depends on the concentration of the biopolymer with which the nonwoven is soaked.
The wettability of the carbon fibric - biopolymer system changes in relation to the unmodified nonwoven; the substrate becomes more hydrophobic (about 90°). The biopolymer layer limits material crumbling and facilitates its portability during manipulations connected with preparation of material for biological tests in in vitro condition (sterilization, microscopic observations).

Conclusions

The complex two-component systems: carbon fiber - biopolymer (alginate, chitosan) allow to obtain structures with increased stiffness of CF/CA and CF/CS, which facilitates their manipulation during biological tests and clinical applications. Further work on these materials is necessary to determine their medical suitability.

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