FIBROUS STRUCTURES BASED OF NATURAL POLYMERS FOR TISSUE ENGINEERING APPLICATIONS

EWA-STODOLAK ZYCH[1], ANNA ŚCISŁOWSKA-CZARNECKA[2], BEATA KOLESINSKA[3], MAŁGORZATA CIEŚLAK[4], DOROTA PUCHOWICZ[4], IRENA KAMINSKA[4], MACIEJ BOGUN[4*]

[1] DEPARTMENT OF BIOMATERIALS AND COMPOSITES, AGH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KRAKOW, POLAND
[2] FACULTY OF MOTOR REHABILITATION, UNIVERSITY OF PHYSICAL EDUCATION IN KRAKOW, POLAND
[3] INSTITUTE OF ORGANIC CHEMISTRY, LODZ UNIVERSITY OF TECHNOLOGY, POLAND
[4] TEXTILE RESEARCH INSTITUTE, LODZ, POLAND
*E-MAIL: MBOGUN@IW.LODZ.PL

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Introduction

One of the directions of tissue engineering is the search for new materials based on natural origin polymers. Nowadays, derivatives of chitin and hyaluronic acid, collagen, proteins or alginates are of great importance in the preparation of materials for various types of scaffolds [1-2]. The use of these polymers to obtain hybrid materials based on both biopolymers and other bioactive substances creates opportunities for faster tissue regeneration and thus increases the effectiveness of the therapy undertaken. For this type of materials, it is important to use biocompatible substances, also of appropriate structure, or even a personalized, hierarchical model that will allow the proper interaction of the biomaterial with natural tissues. The aim of this work is to present examples of the use of fibrous structures for the production of hybrid materials for regeneration of bone tissue.

Materials and Methods

In the work fibres made at the Lodz University of Technology (LUT) were used. The developed layered systems (mass per unit area of ca.100g/m^2, FIG. 1) consist of one inner layer of two kind of modified calcium alginate (CA) fibres (with nanoparticles of hydroxyapatite, (HAp) and Fe_3O_4 introduced into their structure, CA+HAp/CA+Fe_3O_4) and two outer layers of poly(lactic-co-glycolic acid (PGLA) nanofibres. The inner layer was produced using the needled nonwoven method and different proportions of both modified fibres. The nanofibres forming the outer layers were applied by electrospinning method. For selected versions of the systems a physical modification with the RGD peptide has been undertaken. Such solution supports cell regeneration and increases cell adhesion by integrin activation.
The materials were examined using scanning electron microscopy (SEM) and Raman spectroscopy techniques.
The stability of these hybrid fibrous materials was tested (*in vitro*) by incubation in two media: phosphate buffer (PBS) and water (temperature 37°C, 5% CO_2). Degradation tests were carried out for 36 days.

Results and Discussion

The chemical structure of the modified fibres containing bioactive additives was confirmed using Raman spectroscopy. The spectral analysis results in the presence of characteristic peaks coming from the vibrational band of carboxylane group, M and G blocks of alginate. The resulting differences between the spectra are mainly related to the presence of modifying compounds. Obtained layered materials are characterized by the anisotropy of the distribution of elementary fibres in the material structure. This effect is extremely important from the point of view of the application of this type of material. In the case of material degradation studies, the applied test procedure allowed to establish a certain tendency regarding the durability of nanocomposite nonwovens based on calcium alginate; the more complex multi-electrolyte fluid (such as a phosphate buffer) the shorter the degradation time. In the case of PBS the inner hybrid nonwoven was disintegrated after 36 days. The medium after the degradation test contains a deposit composed mainly of nanocomposite CA fibres and a thin fibrous layer from outer PGLA nonwovens.

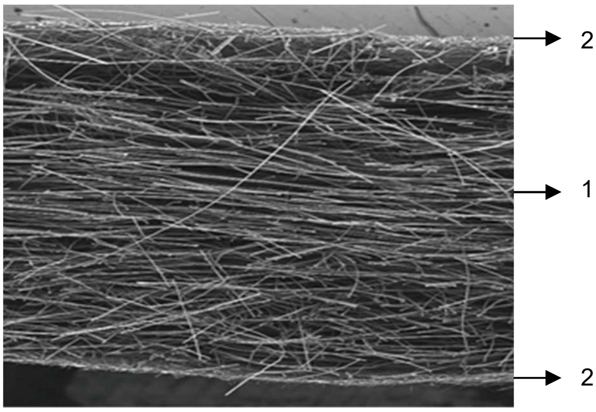

FIG. 1. SEM image of the layered system sample; 1 – inner layer of CA+HAp/CA+Fe_3O_4, 2 – outer layers of PGLA.

Conclusions

The SEM and Raman spectroscopy studies confirmed the layering formation of the fibrous systems as well as their chemical structures and various content of the used modified fibres. Degradation studies in the immersion media have shown different degradation effect of developed layered systems over time. This creates the possibility of modelling fibrous structures with a controlled degradation process.

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References

[1] J.Fraczyk, W.Lipinski, A.Chaberska, J.Wasko, K.Rozniakowski, Z.J.Kaminski, M.Bogun, Z.Draczynski, E.Menaszek, E.Stodolak-Zych, M.Kaminska, B.Kolesinska: "Search for fibrous aggregates useful in regenerative medicine formed under physiological conditions by self-assembling short peptides containing two identical aromatic amino acid residues", Molecules, 23(3), (2018),568
[2] M.Boguń: "Nanokompozytowe włókna alginianowe i kompozyty z ich udziałem do zastosowań w inżynierii biomateriałowej", Zeszyty Naukowe PŁ nr 1062, Rozprawy naukowe Z. 389, Łódź, 2010.