Załącznik nr 3

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ABSTRACT OF THE DISSERTATION

„ Developing a manufacturing process for prototype multifunctional composite materials for bone tissue regeneration using 3D printing techniques"

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This dissertation, consisting of a series of five thematically consistent peer-reviewed scientific publications, concerns developing and applying a simple technique for obtaining synthetic biomaterials in the form of polymer and polymer-ceramic filaments and the production of scaffolds for bone cell culture using 3D printing. Such materials can be used as a substrate for cell growth and repairing bone tissue defects, e.g., after bone tumor resection or resulting from complicated fractures. Particular emphasis was placed on presenting the development of a simple method for producing a short series of filaments with a specified composition, which would allow for the overview of 3D printing of a range of scaffolds and the assessment of their physical and biological properties.

The first part of the dissertation presents the research topic and the issue related to bone structure and bone tissue regeneration. The topics of tissue engineering and the requirements for biomaterials used in the production of implants were also described. Then, the techniques for producing bone implants were presented, including 3D printing and their possible application in obtaining three-dimensional scaffolds for bone tissue regeneration. A need for continued development of technologies to produce implants for bone tissue regeneration was identified, with particular emphasis on the technological and developmental possibilities of simple 3D printing techniques. At the same time, based on the literature, it was recognized that there is a gap that can be filled by a simple filament manufacturing device that allows the receiving of a series of filaments with low material consumption.

The second part of the dissertation presents the design and construction of the device for pneumatic extrusion of materials as polymer and polymer-ceramic filaments. The designed and built device for pneumatic extrusion of materials in the form of polymer and polymer-ceramic filaments. The developed technique was applied to the production of filaments made of biodegradable polymers: poly(lactic acid) (PLA) and polycaprolactone (PCL), and with the addition of calcium β-triphosphate (β-TCP) as a model mineral element used in the manufacture of bone implants. The produced filaments were used to manufacture bone scaffolds by fused filament fabrication 3D printer. The 3D-printed scaffolds were evaluated for properties crucial for bone implants, such as physical parameters and mechanical properties, and in vitro tests were conducted to determine cytotoxicity and effects on the cell behavior of

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selected cell lines. Based on the results from the second part of the work, it was shown that polymer and polymer-ceramic filaments can be obtained by using pneumatic extrusion.

The third part of the dissertation demonstrates the results of bone tissue scaffolds obtained by using the developed pneumatic extrusion method to produce a range of new materials in the form of filaments, and then 3D printing the scaffolds. The first example shows the production of PLA scaffolds to test a technique for coating bone scaffolds with a polyvinylpyrrolidone-based hydrogel coating. The second example shows the use of the addition of modified hydroxyapatite nanoparticles to improve the integration of the polymer with hydroxyapatite. The third example demonstrates the use of poly(ethyl glycol) as a porogen to obtain PCL- and β-TCP-based scaffolds with a developed porous structure. The fourth example shows the possibility of adding, at the stage of filament production, adenosine as a potentially bioactive substance to improve bone regeneration. In all of the presented examples, key properties of obtained scaffolds were examined and evaluated, such as physical and mechanical properties, or effects on cell behavior and cytotoxicity of selected cell lines by in vitro experiments. Based on the results from the third part of the dissertation, it was proved that the method of pneumatic extrusion of filaments makes it possible to extensively study the diverse compositions of printed scaffolds with properties beneficial to bone tissue regeneration.

This dissertation concludes with a summary of the results and a discussion about fulfilling all research theses.

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