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Magdalena Żukowska, MSc. Eng. – 1st Prize of the XI Ed. PTIB Competition (2017)

RAPID MANUFACTURING AND VIRTUAL PROTOTYPING OF PRE-SURGERY AIDS

Abstract: Progressive development of rapid manufacturing and virtual proto-typing have a significant influence not only in the industry and transport, but also in the medicine. Presurgical support and preparation of a surgeon with use of these technologies, especially in complex cases, can help prepare more pre-cise plan of surgery and perform a simulated operation. The aim of these studies was to develop a methodology and manufacture an anatomical model of a kid-ney with a tumour, using rapid manufacturing technologies and virtual proto-typing techniques. The model was a part of a presurgical support, allowing a doctor to become acquainted with an organ and a tumour and was also used for a simulative operation of partial nephrectomy. Due to the fact that model has two functions (preoperative planning and simulative operation), an important part during the production process was to consult procedures like cutting or su-turing. Combination between technology of 3D printing and vacuum casting and silicon usage allowed to create a model, which imitates living tissues, espe-cially the renal cortex and tumour. Transparency, which is a property of both models – physical and virtual – also plays a relevant role. Transparency helps surgeons in precise planning before operation. Doctors can familiarize them-selves with arrangement of internal structures and pathologically altered areas. The collected information and tests performed with a cooperating hospital helped evaluation of created models, their usefulness and future implementation possibilities.

Michał Pielka, MSc. Eng. – 3rd Prize of the XI Ed. PTIB Competition (2017)

MOTION MAPPING METHODS FOR A VIRTUAL ENVIRONMENT RADIO INTERFACE

Abstract: The aim of the study was to implement the prototype of an inertial motion capture system [1,2] (MoCap) and create an associated virtual environment. Therefore, research was carried out on both software and functionality of the controller built using reduced architecture[3]. The developed sensor modules are ones of the smallest on the market, so they can be used in, for example, motor rehabilitation.

The commonly used methods of processing data from MEMS sensors as well as algorithms implemented in these sensors by manufacturers have been verified [4]. In addition, the accuracy of rotation mapping by the developed radio sensors in a virtual environment with different data representations has been estimated. To reach the assumed objective, it was necessary to create software for three different platforms: I - embedded software for microcontrollers of each of the MoCap system modules, II - virtual environment for PCs, and III - virtual environment for mobile devices - a smartphone placed in VR goggles. The created multiplatform software has been integrated into one virtual system and augmented reality.

The concept of reduced architecture verified in the study can be successfully implemented in other bioengineering systems [5], which will allow to minimize the size of electronic circuits and reduce the costs of their production.

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Ewa Dzierzkowska, MSc. Eng. – 1st Prize of the XII Ed. PTIB Competition (2018)

FIBROUS POLYMER MEMBRANE AS DRUG DELIVERY SYSTEM

Abstract: The fibers obtained using electrospinning technique can be use as drug carriers. Surface modification and changes in morphologies, for example porous fibres may have the potential for improved performance in drug delivery applications [1-3]. The aim of this study was to obtain a fibrous membranes for medical applications, possessing antibacterial properties, being simultaneously a scaffold for growing cells and releasing the pharmacologically active substance at different speeds. Differences in the release profile resulted from the use of various solvents and the preparation conditions. For this purpose, solid and porous nonwovens based on polylactic acid (PLA) and 3 pair of different solvent - dichloromethane (DCM) with N, N-dimethylformamide (DMF), chloroform (CHL) with dimethyl sulfonoxide (DMSO) and chloroform (CHL) dichloromethane (DCM) were produced. Each nonwovens was modified with a pharmacological substance - gentamicin (G) by volume (V) and by surface (S). The evaluation of materials was carried out using scanning electron microscopy with microanalysis (SEM / EDS), wettability tests with surface energy determination, roughness test, Fourier transform infrared spectroscopy (FTIR), differential scanning calorimetry (DSC). The effectiveness of drug release was checked by antybacterial activity test and spectroscopy with inductively coupled plasma (ICP). The results of tests have shown that depending on the type of solvents used at the electrospinning stage, porous fibers can be obtained from polylactide (Fig. 1). The addition of gentamicin affected antibacterial properties, and the pore size determined the rate of drug release monitored by the ion coupled plasma method (ICP).

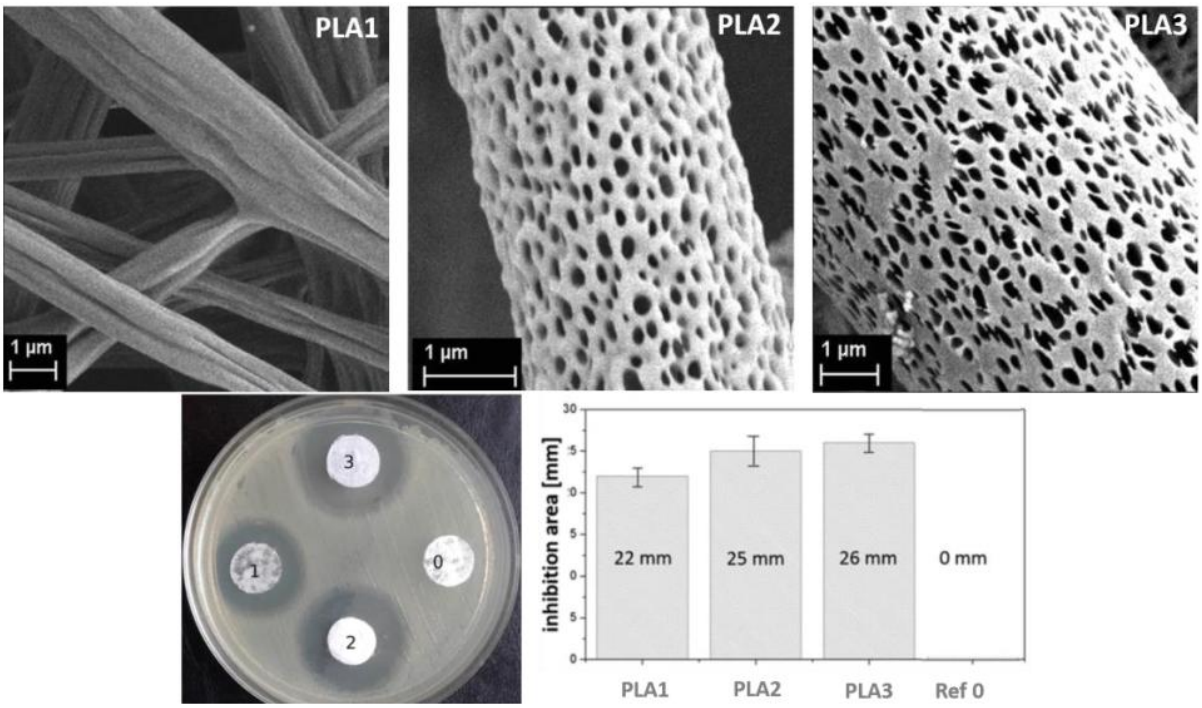

Fig. 1 PLA fibers with diffrent morfologies and the inhibition zone for bacteria of membrane with gentamicine.

Obtained results of widely conducted research, although they are preliminary, show that the produced fibrous membranes can be an innovative solution in the field of drug delivery systems.

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Magdalena Kocot, MSc. Eng. – 3rd Prize of the XII Ed. PTIB Competition (2018)

COMPOSITE BIOMATERIALS FOR TISSUE REGENERATION

Abstract: One of the biggest challenges in tissue engineering is to obtain scaffold that would promote bone regeneration and provide support to newly formed bone tissue until it matures. Among all investigated biomaterials, hydrogels play an important role in bone regeneration, because of their unique properties. These highly hydrated three-dimensional polymer networks are biocompatible, have tuneable biodegradability and porous structure. What is more, it is possible to enhance and modify properties of hydrogels by developing hydrogel-inorganic composites and thus improve their bioactivity, mechanical properties and develop composites that can mimic the structure of natural bone tissue. One of the approaches to obtain hydrogel-inorganic composites is hydrogels mineralization. In this study three strategies of whey protein isolate (WPI) hydrogels mineralization was performed and investigated. WPI is a by-product from the production of cheese and Greek yoghurt thus its usage is advantageous for environmental and financial reasons. The first method of WPI hydrogel mineralization concerned enzymatic mineralization with ALP, which leads to calcium phosphate formation. Moreover, optimization of the process by adding bioactive molecules and influence of freeze-drying on hydrogel properties was studied. Mineral formation and composite properties were evaluated by dry mass percentage, swelling studies, degradation (BCA assay), morphology (SEM), structure (FTIR), calcium and phosphorous concentration (ICP-OES). The second method aimed to induce enzymatic mineralization by incorporation of urease, which leads to calcium carbonate formation. The effect of different temperature, urease concentration and mineralization media was evaluated by rheological studies, dry mass percentage, morphology (SEM), structure (FTIR, Raman spectroscopy), phase identification (XRD), calcium and magnesium concentration (ICP-OES) and biological properties (cytotoxicity tests). The third method of WPI hydrogels mineralization included incorporation of preformed aragonite particles and investigation of composite properties by swelling studies, degradation (BCA assay), morphology (SEM), structure (FTIR, Raman spectroscopy), mechanical properties (compressive strength), particle distribution (Micro-CT imaging) and biological studies.

Katarzyna Charuza, MSc. Eng. – Distinction of the XII Ed. PTIB Competition (2018)

MODIFICATIONS OF WPI-BASED HYDROGELS FOR BONE TISSUE REGENERATION

Abstract: This study deals with the design of novel hydrogels based on whey protein isolate (WPI) for tissue regeneration and improvement of their properties by addition of (a) gelatin, (b) bioactive glass particles and (c) a combination of both. Hydrogels have shown a huge potential in tissue engineering so far, but they still need improvements to fulfill a number of requirements regarding mechanical, physicochemical and biological aspects. Therefore three strategies of WPI modification were chosen. In order to improve cell adhesion and proliferation as well as mechanical strength, gelatin type A and B have been added to the WPI hydrogels. In the second experiment hydrogel was combined with bioactive glass particles (A2 type of two sizes) to assure material bioactivity and allow mineralization process in physiological environment. The final stage of research was to check whether combination of these two approaches results in synergic effect regarding material properties. Obtained results show that it is possible to enhance mechanical strength of WPI hydrogels by addition of certain concentrations of gelatin and also by electron irradiation, but this modification does not influence strongly cell behaviour in contact with the materials.
Experiments with bioactive glasses confirm that the obtained composites have the capacity to mineralise further in physiological fluids. Manufactured composites had promising properties and after further studies they could be used in bone tissue regeneration.

Karolina Paszkowska, MSc. Eng. – Distinction of the XII Ed. PTIB Competition (2018)

PRODUCTION AND INVESTIGATION OF BIOACTIVE PEPTIDE COATINGS

Abstract: Patients from all over the world are waiting for new solutions for a problem of occlusion of small diameter blood vessels. Ideal future therapy for such disease could be an implantation of the artificial blood vessel, fully colonized by patient's own cells. It would allow for realization of the overarching goal of regenerative medicine - complete restoration of the damaged fragment of the body and return to its full functionality. Use of specific polymers as scaffolds for cell culture allows to obtain structures in any shape or size. These structures are additionally characterized by very good biocompatibility, adequate surface porosity and relatively low production cost. Surface modification of polymeric materials makes them biologically active, what results in increase of cell adhesion and growth. In presented work, cylindrical structures with small diameter ((Ø = 2 mm) were made with the use of polyurethane. The technique used for structures production was phase inversion, which allows for obtaining materials in a simple, fast and cheap way, with the possibility of further modification. Obtained cylinders were then modified by connecting specific peptide sequence REDV to the surface. This peptide sequence is known to increase the adsorption of endothelial cells on synthetic material. On the obtained bioactive surface, HUVEC (Human Umbilical Vein Endothelial Cells) cells were cultured. Polymer cylinders have been tested and characterized for the effectiveness of each reaction step using colorimetric tests. The results indicate effective joining of selected groups (NH2, COOH) to the polyurethane. HUVEC cells adhered on the inner surface of the tube and stayed alive during the time of the experiment, which shows that the connection of peptide was performed correctly. The results of present work may provide a starting point for further research on the potential vascular prostheses, made by the phase inversion method.

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