BIOACTIVE PHOTOCROSS-LINKABLE HYBRID MATERIALS FOR TISSUE ENGINEERING APPLICATIONS

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[ENGINEERING OF BIOMATERIALS 138 (2016) 30]

Synthetized by Stöber method silica nanoparticles of two sizes were dispersed in three types of polymeric sols namely: the gelatin, alginate and gelatin/alginate, which were subsequently photo-crosslinked and purified by lyophilisation. The swelling ratio, gel fraction and mechanical properties of the materials developed were examined and compared to these determined for plain hydrogel matrices. The mineralization process was conducted in *in vitro* environment in the presence of 1.5 SBF. The materials obtained were exposed to simulated body fluid solution for 7 days and then the morphology and chemical composition of the minerals formed were studied by means of SEM and EDS measurements. The hybrids were synthesised in order to prepare the novel scaffolds, which after swelling can fill up bone defects and provide the conditions essential for the bone tissue regeneration. Considering that application, the biological tests were also performed. The cytocompatibility of the resulted hybrids was evaluated using XTT test against two different cells lines.

It was confirmed that addition of silica nanoparticles to the systems has beneficial effect on the mechanical properties. The storage modulus reached the highest values in the case of gelatin-based hybrids and had the lowest values for alginate-based materials. The *in vitro* cell culture study has shown that the surface of prepared hybrid materials ensures suitable biocompatibility as they can support both MEFs as well as MG-63 mitochondrial activity. Based on XTT test it was demonstrated that addition of SiO_2-nanostructures to the hydrogels does not compromise cytocompatibility of resulted hybrids with respect to plain hydrogels. Finally *in vitro* experiments performed under simulated body fluid (SBF) condition have revealed that due to inclusion of SiO_2 nanostructures into the biopolymeric hydrogel matrices the mineralization is successfully induced. By means of scanning electron microscopy (SEM) and energy dispersive X-ray spectroscopy (EDS) measurements the formation of apatite-like structures in hybrid materials were confirmed. These results clearly illustrate that inclusion of SiO_2 nanoparticles into the hydrogels is beneficial because plain hydrogels (except gelatin) have not induced mineralization under the applied experimental conditions.

Introduction

Development of the novel biomaterials designed to serve for bone tissue engineering still represents a significant challenge for current regenerative medical research [1]. Scaffolds for tissue reconstruction have been especially extensively studied since there is a need for materials offering new therapeutic opportunities for the repair of bones damaged by trauma, diseases, as well as, due to the aging process [2]. Preparation of the scaffold that would meet all rigorous criteria for maintaining cell growth is very challenging. The scaffold has to serve as a temporary extracellular matrix (ECM), mimic matrix architecture, guide cells, facilitate their growth and provide mechanical support. It is also expected that scaffolds, especially those dedicated for bone reconstruction, will not only mimic the natural extracellular matrix but they will be also bioactive ensuring their interactions with tissue and providing the natural environment and support for bone regeneration [3,4]. Alginate - a linear unbranched polysaccharide is one of the most versatile natural materials known to form hydrogels. This naturally derived polymer is structurally similar to the natural ECM and exhibits low toxicity after purification. Alginate hydrogels are currently being used and explored for a broad range of medical applications including cell encapsulation, drug delivery, as well as, tissue engineering [5]. Gelatin is the basic building block of collagen, a major component of the extracellular matrix and one of the most commonly used protein for creating cellular scaffolds [6]. Silica is a component improving the bioactivity of the polymeric materials.

Materials and Methods

The mechanical properties of the materials developed were studied with a Physica MCR-301 (Anton Paar) rheometer. The mineralization process was controlled using scanning electron microscopy (SEM) and energy dispersive X-ray spectroscopy (EDS). The cytotoxicity of the materials was controlled using the colorimetric assay XTT with two different cell lines: osteoblasts-like culture (MG-63) and mouse embryonic fibroblasts (MEFs). Statistical significance was calculated using Student's t-test with statistical significance level set at $P<0.05$.

Results and Discussion

This paper presents the results of our studies on physicochemical, mechanical and biological properties of the novel materials fabricated from photocross-linked gelatine/alginate based hydrogels and silica nanoparticles that can serve for bone tissue regeneration. Both gelatin and alginate were functionalized with methacrylate groups allowing their photocrosslinking.

Conclusions

Taking into account all data obtained one can conclude that hybrids developed within these studies are promising candidates for bioactive scaffolds in tissue engineering.

Acknowledgments

JL-Ł acknowledges the financial support of Ministry of Science and Higher Education for Young Researchers administered by the Faculty of Chemistry, Jagiellonian University (nr PSP K/DSC/003796). M.N. acknowledges the financial support of Foundation for Polish Science (TEAM grant PolyMed, TEAM/2008-2/6

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