THE DEPENDENCE OF MECHANICAL PROPERTIES ON TiO_2 NANOPARTICLES CONCENTRATION IN HYBRID HYDROGEL MATERIALS WITH POTENTIAL USE AS BONES SCAFFOLDS

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Introduction

Introduction of TiO_2 to polymer matrices induces the formation of apatites on the surface of the materials, which demonstrates the biological activity of the synthetized hybrids. Such materials can be used as scaffolds for the bone tissue grow. Polymer gelation takes place at about 37°C, which enables the material to be injected into a specific bone defect site and to form the scaffold at the target site.

Materials and Methods

The microstructure of prepared hybrids after mineralization was observed with use of a field emission gun (FEG) scanning electron microscope FEI Europe Company − NOVA NANO SEM 200 equipped with an EDAX energy dispersion spectrometer. The mechanical properties of the tested hydrogels were studied with a Physica MCR-301 (Anton Paar) rheometer equipped with a parallel-plate PP 50 made of stainless steel with a 25 mm diameter. Rheoplus/32 v3.40 software was used. To determine the value of the storage modulus (G') measurements were conducted in oscillation mode using a frequency of 1 Hz and strain of 0.3%, the measuring gap was set at a distance of 0.3 mm. All measurements were performed at 37°C. After cytotoxicity testing the absorbance of the solutions was measured at 450 nm using a microplate reader TECAN Infinite M200.

Results and Discussion

The activity is oriented on optimization of selected TiO_2 nanopowder concentration in the polymeric hybrid materials based on natural polymers (collagen, chitosan) crosslinked with genipine. The introduction of TiO_2 into hydrogel matrices aims to improve mechanical properties and improve the biological activity of materials. The research concerns the development of a material with the highest possible mechanical strength while preserving its biological activity. An anatase TiO_2 nanoparticle with a specific surface area of about 100 m^2/g was used to prepare sample series. Based on previous research, it was found that the addition of TiO_2 to the polymer matrix at 1.9 mg/ml resulted in a deterioration in mechanical properties. Within the project studies with materials with lower TiO_2 concentration were performed as well as cytotoxicity on human osteoblastic bone cells (MG-63) with XTT method and defining the rheological properties of the hybrids (G', G ", viscosity) were carried out. As we already showed in previous publication the addition of TiO_2 to polymer hybrids induces the deposition of apatites on the surface of the materials [1]. This effect was not found for polymer matrices that did not contain TiO_2. There was no significant effect of the polymorphic TiO_2 variation on the properties of the tested systems. Literature reports on other polymer materials with TiO_2 nanoparticles indicate that the addition of oxide, depending on concentration, can affect the mechanical properties by either improving or deteriorating it. This is the reason why it was so important to determine the optimal concentration of TiO_2 that will keep the biological activity without impairing the mechanical properties and may even improve them. The early results suggest that the optimal TiO_2 concentration is within the range of 0.2-0.5 mg/ml

Conclusions

The gained results of the research are the first and fundamental step to solve the scientific problem of obtaining hydrogel hybrid materials with TiO_2 nanoparticles that can be used as bones scaffolds. It was also found that the properties of hybrid materials depend on TiO_2 concentration. The optimal nanoparticle concentration seems to be about six times lower than the one we used in our preliminary research [1] resulting in storage modulus improvement.

References

[1] K. Zazakowny, J. Lewandowska-Łańcucka, J. Mastalska-Popławska, K. Kamiński, A. Kusior, M. Radecka, M. Nowakowska: Biopolymeric hydrogels − nanostructured TiO_2 hybrid materials as potential injectable scaffolds for bone regeneration, Colloids and Surfaces B: Biointerfaces, 148 (2016) 607–614.