HYDROGELS BASED ON NATURAL POLYMERS FOR CARTILAGE TISSUE REGENERATION

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Introduction

Cartilage tissue is composed of chondrocytes and protein fibers. It is a delicate tissue susceptible to deformation, and it has rather little possibility of regeneration. Due to insufficient methods of treatment of damaged cartilage tissue, new solutions are being sought for this problem including application of polymeric hydrogels. In our work we present hydrogels based on sodium alginate modified with both graphene oxide and hydroxyapatite for cartilage tissue regeneration. Sodium alginate shows low toxicity and biocompatibility. Moreover, its properties can be modified through crosslinking and/or incorporation of additives. HAp was added to the alginate matrix, due to its good biocompatibility and ability to stimulate bone regeneration in small bone defects. Another used additive was graphene oxide, which is characterized by exceptional mechanical properties and a large specific surface area. Graphene oxide presence has also a positive effect on cell adhesion.

Materials and Methods

Hydrogels have been obtained using sodium alginate (Acros ORGANICS), anhydrous calcium chloride (POCH), distilled water, graphene oxide (GO) in the form of a paste (ITME) and hydroxyapatite (HAp) from MKNano. The concentration of GO and HAp in hydrogels is presented in Tab. 1.

Sample	1	2	3	4	5	6	7
HAp [%]	30.0	15.0	10.0	5.0	2.0	1.0	0
GO [%]	0	0.1	0.2	0.5	1.0	1.5	3.0

The obtained hydrogels were subjected to a compressive strength test. FTIR and DSC analyses were performed, as well as the preliminary bioactivity and in vitro chemical stability were also investigated.

Results and Discussion

Mechanical tests of unmodified alginate hydrogels show that the best mechanical properties exhibited hydrogel obtained from 3% water solution of sodium alginate crosslinked with 0.075M $CaCl_2$ solution.

The FTIR analysis showed a shift of bands towards higher wave numbers for the C=O group. This may indicate that the polymer chains become looser and the hydrogen bonds get weaker.

DSC studies showed water melting in the hydrogel samples and next water evaporation. The highest heat of melting was observed for the sample containing 0% HAp + 3% GO, the smallest for 2% HAp + 1% GO material. The greatest heat of evaporation was found for hydrogel containing 2% HAp + 1% GO and the smallest 30% HAp + 0% GO.

The bioactivity study showed that only samples containing 5% HAp + 0.5GO and 10% HAp + 0.2% GO were observed to have small amounts of apatite under the chloride layer – FIG. 1. For the chemical stability study, changes in pH were recorded during the incubation of samples in PBS. The mass of samples in PBS fluid increased by approximately 30% after 4 days and remained at this level until the end of incubation. In case of incubation in Ringer's fluid, the pH of the samples increased slightly. Similarly to the incubation in PBS, the mass of samples increased by about 35%.

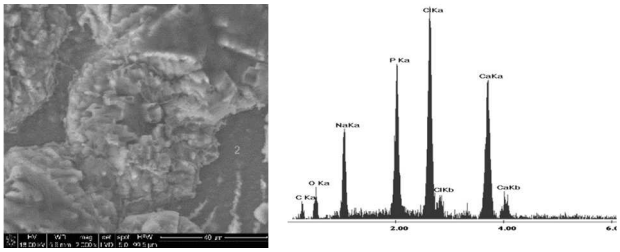

FIG. 1. SEM microphotographs and EDS results of hydrogel modified with 10% HAp and 0,2%GO after incubation in SBF

Conclusions

Among the materials tested, the most promising results were obtained for the hydrogel modified with 10% HAp + 0.2% GO. The resulting composites exhibit mechanical properties similar to those of natural cartilage as well as a significant improvement in thermal properties (compared to sodium alginate) and a small change in pH during incubation in PBS and Ringer fluid.

Based on the obtained results it can be concluded that the hydrogels modified with GO and HAp possess some promising potential for the regeneration of cartilage tissue.

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