POLYMERIC HYDROGELS FOR CARTILAGE TISSUE REGENERATION

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[ENGINEERING OF BIOMATERIALS 148 (2018) 78]

Introduction

Trauma, arthritis and sports-related injuries can damage cartilage and subchondral bone tissues. It has been reported in literature that almost 60% of patients examined by knee arthroscopy show cartilage damage, and ca. 15% of people over 60 years of age have some clinical symptoms of cartilage damage [1,2]. Cartilage tissue has limited capacity for intrinsic repair due to lack of vascularization, innervation, lymphatic networks, and progenitor cells [3]. Current strategies to cartilage tissue defects have evolved from surgery (e.g. microfracture), through osteochondral transplantation, and recently to cell-based repair techniques [4]. To enhance the reconstruction process of the damaged cartilage and bone tissues, it is important to obtain scaffolds able to mimic the features of the tissues and to transport efficiently cells and growth factors. Ideal scaffolds of cartilage tissue should be porous, biocompatible, and capable of promoting cell differentiation and new tissue formation. Very important are mechanical properties that should be stable during degradation of scaffold in response to the formation of new tissue [3]. Hydrogels are promising materials for the delivery of cells and bioactive molecules due to their viscoelastic properties and water-swollen structure [5]. Sodium alginate (SA), a well-known natural polysaccharide composed of α-l-guluronate (G) and β-d-mannuronate (M) residues, is widely used in different biomedical applications, e.g. as scaffolds that can deliver cells and bioactive molecules. One of the advantages is the possibility of hydrogels formation with divalent cations such as calcium or magnesium ions [6]. In our work alginate hydrogels reinforced with graphene oxide (GO) or/and hydroxyapatite (HAp) were investigated as potential biomaterials for cartilage tissue regeneration.

Materials and Methods

For preparation of hydrogels, sodium alginate from *Acros ORGANICS*, calcium chloride from *POCh Avantor*, graphene oxide (GO) in the form of paste from ITME and hydroxyapatite (HAp) from *mkNano* have been used.
Three series of samples (with GO, HAp and both GO and HAp) have been prepared using 3% aqueous solution of sodium alginate cured with 0,075M solution of calcium chloride. GO of concentration was 0.1-3% and 1-30% of HAp. Modifiers were added to sodium alginate solution before curing. The ball shape samples were left for a week in $CaCl_2$ solution in order to obtain fully crosslinked hydrogels.
The obtained hydrogels were investigated using spectroscopic, microscopic and thermal analysis methods. Moreover, investigations of mechanical properties, wettability, tribology, *in vitro* chemical stability *(in PBS and Ringer solution)* and preliminary assessment of bioactivity were performed.

Results and Discussion

SEM observation showed no agglomeration of GO, whereby different result was obtained in case of HAp - this modifier was easily seen on the surface of alginate hydrogel. Noteworthy, it can be helpful in case of reaction with the bone situated underneath the articular cartilage.
The FTIR data confirmed that an addition of GO and HAp influence the alginate matrix; both GO and HAp nanoparticles weakened hydrogen bonds which can be the result of increasing the distance between alginate macrochains. TG and DSC analyses results showed that even a small amount of modifier changes the thermal properties of hydrogels - FIG. 1.

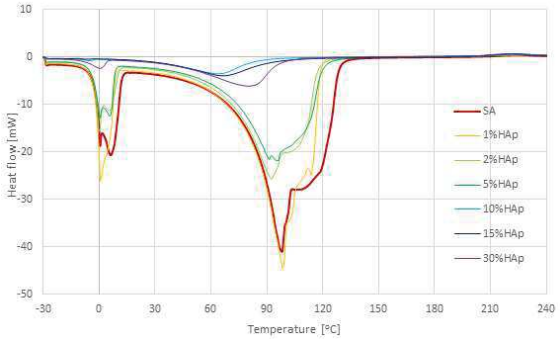

FIG. 1. DSC curves of alginate hydrogels modified with HAp.

TG analysis showed low tolerance to temperature and confirmed high water contents in hydrogels. The wettability test made on alginate films with various alginate content revealed high hydrophilicity of the material as the drop situated on the surface spilled immediately. The contact angle was estimated at around 10°. Moreover, it was observed that the applied modifications strongly influence mechanical properties of alginate hydrogels.

Conclusions

Based on the obtained results it can be concluded that addition of GO or/and HAp considerably change the properties of alginate hydrogels. The obtained hydrogels can be considered as promising materials in modern cartilage tissue engineering.

Acknowledgments

This study was funded by The National Centre for Research and Development (NCBR) in the program STRATEGMED III (project no. STRATEGMED3/ 303570/7/NCBR/2017). Joanna Jagiełło and Dr. Ludwika Lipińska from the Institute of Electronics Materials Technology (ITME) in Warsaw are gratefully acknowledged for providing graphene oxide. We are grateful to Patrycja Domalik-Pyzik (AGH-UST) for rheology and tribology measurements.

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