INTRODUCTION OF GRAPHENE OXIDE, REDUCED GRAPHENE OXIDE AND HYDROXYAPATITE INTO CHITOSAN HYDROGEL MATRIX – CHANGES IN MECHANICAL BEHAVIOUR

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Introduction

Since 1960, when they were firstly used and described as a material for contact lenses production, hydrogels have been continuously developed. Recent years shown that the interest in these materials has increased, especially in medical, dental and pharmaceutical applications e.g. drug carriers, wound treatments, capsules matrices and coatings. Modification of hydrogel allow to change and control various properties e.g. level of active compound release, water absorption/dehydration rate, electrical and magnetic response, etc.

One of the most interesting and promising modifiers that can be introduced into hydrogel matrix is graphene and graphene oxide. Considerable progress in reducing costs of production increased accessibility of these materials. Due to their low density, unique electrical, thermal and optical properties, they seem to be an excellent modifying phase in composites. Moreover, high solubility of graphene oxide in water imparts its feasibility as new filler for reinforcement hydrophilic biopolymers.

Chitosan is a natural polymer that has been studied extensively over several decades. It possesses a number of interesting properties including biocompatibility, biodegradability, and affinity to water. It is used in separation membranes, artificial skin, bone substitutes, tissue engineering, coatings and water treatment. Unfortunately its mechanical properties are rather poor thus a wider range of application, especially in a medical field is limited. By combining the advantages of graphene oxide, chitosan and naturally present in bones inorganic phase eg. hydroxyapatite, different types of promising materials for medical applications can be obtained.

Materials and Methods

In this study a natural polymer matrix – hydrogel based chitosan (CS) – was reinforced with three types of particles: graphene oxide (GO) (ITME, Poland), reduced graphene oxide (rGO) (ITME, Poland) and hydroxyapatite (HAp) (mkNano, Canada). Several variations of composite foils were obtained by solution-evaporation casting method with certain percentage of compositions. Into hydrogel based chitosan matrix following modifiers were introduced: CS/GO, CS/rGO, CS/HAp, CS/GO/HAp, CS/rGO/HAp. To examine their mechanical properties static uniaxial tensile tests and analyses of strain-stress curve were performed (Zwick 1435). Tensile strength R_m, Young's Modulus E and Maximal deformation ε_{Fmax} were characterised. Due to the nature and geometry of samples tests were difficult to conduct. Thin hydrogel based composite foils are very sensitive to an air humidity. When they were drying out they became to shrink and to coil up.

Results and Discussion

Based on the results it can be concluded that the introduction of the graphene family nanofillers into hydrogel based polymer matrices effects on their mechanical parameters. The largest strengthening effect was obtained by adding a nanofiller to the hydrogel matrix in the form of reduced graphene oxide.

The addition of the ceramic microphase (HAp) to the chitozan/graphene and chitozan/grapheme-oxide matrix significantly decreased the Young's modulus and the tensile strength. It is supposed that HAp particles impede structural integrity thus mechanical parameters of the composite drop.

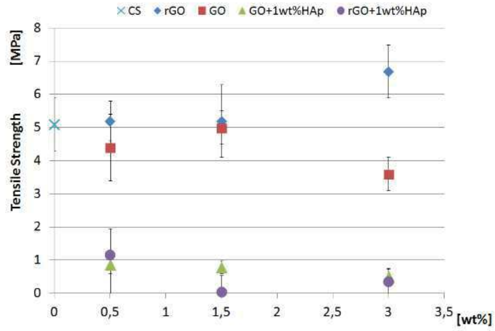

FIG. 1. Tensile strength of different hydrogel composites.

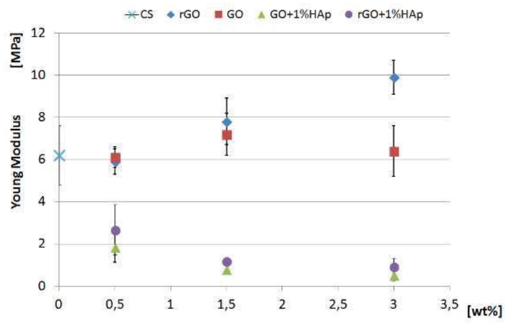

FIG. 2. Young modulus different hydrogel composites.

Conclusions

The hydrogel/graphene oxide and hydrogel/graphene oxide/hydroxyapatite composites were successfully obtained by using solution-evaporation casting method. Addition of different content of nano- and microfillers allows to control and modify mechanical properties of the composites. This approach can be exploit for fabrication of a new, multifunctional material for biomedical applications. Tailored properties of such implant should improve bone or cartilage tissue regeneration.

Acknowledgments

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