DEVELOPMENT OF FUNCTIONAL HYDROGELS FOR CONTROLLED ION RELEASE

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Introduction

Tissue engineering seeks to mimic the natural extracellular matrix (ECM) using materials and bioactive factors to control cellular responses. The typical components used in tissue engineering are cells, biomaterials and biomolecules/bioactive factors [1].
Recently, hydrogels have gained popularity among biomaterials used as 3D scaffolds for tissue regeneration. The combination of their unique properties like biocompatibility, high water content, permeability, hydrophilicity, physical properties and chemical structure made them ideal candidates for different biomedical applications in tissue regeneration [2].
There is a broad variety of biomolecules/bioactive factors employed for Tissue Engineering applications such as growth factors, hormones, peptides, components of the extracellular matrix, vitamins or ions, all of them possibly promoting cell proliferation and/or differentiation [1].
Boron is a trace microelement essential in the metabolism of living organisms. Yet, its exact role in mammalian cells and the precise mode of action at the molecular level had not been well defined. Recent scientific achievements have described a novel activity of boron related to myogenic differentiation [3] and vascularisation [4]. This work aims to optimise the engineering of hydrogel-based material systems capable of sustained boron-release for Tissue Engineering applications.

Materials and Methods

Two different types of hydrogels have been tested. The hydrogel-based material were composed of alginate and polyethylenglycol (PEG), and they were loaded with two different concentrations of boron 0.59 mM (Boron low) and 1.47 mM (Boron high). Additionally, three types of PEG hydrogels were designed: PEG 3% (30 mg/ml), PEG 5% (50 mg/ml) and PEG 10% (100 mg/ml).
The long-term release assay was conducted to assess the boron delivery from hydrogel systems. The aim of the experimental design was to analyze the relation between the hydrogel composition and the boron-delivery. Additionally, hydrogel characterisation and optimisation of hydrogel production. Boron liberated from hydrogels was assessed by colorimetric techniques, measuring absorbance using azomethine reaction that occurs specifically with boron. Mechanical (TMA) and thermogravimetric analysis (TGA) was used to investigate the effects of boron on the mechanical and thermal properties of the hydrogels.

Results and Discussion

The boron concentration measurements, TGA and TMA studies confirm that boron interacted with both hydrogels (alginate and PEG). As the quantity of boron inside the PEG hydrogel polymer chain is quite high. It creates a possibility to release the ions during sample degradation. Boron remains cross-linked in the PEG polymer chain independently from the concentration of PEG and its cross-linker. The majority of boron ions are liberated after one day of immersion. Boron-loaded alginate hydrogels release similar boron concentrations. However, TGA results indicated that with the increase in the amount of boron, the percentage of residual mass increases. Taking into consideration all performed tests it can be suspected that boron is covalently cross-linked with polymer chains.

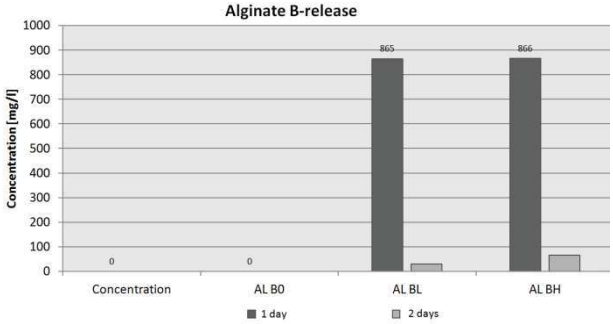

FIG. 1. Boron-release from alginate hydrogels.

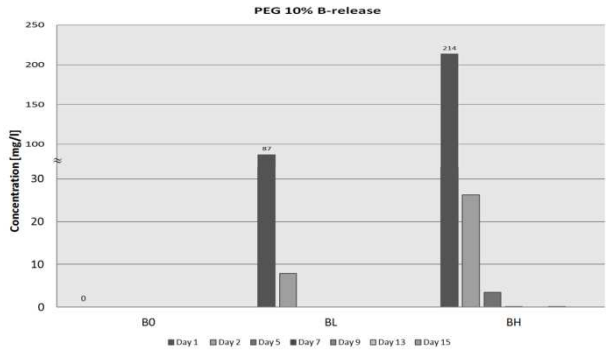

FIG. 2. Boron-release from PEG 10% hydrogels.

Conclusions

Controlled boron ions release hydrogels could be a promising tool for future *in vivo* applications. Even after one month they could be applied by an injection. This work should be treated as the first step of development and optimisation of functionalised hydrogels.

References

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