INFLUENCE OF DUAL CROSS-LINKING ON THE SWELLING ABILITY OF GELATIN-ALGINATE HYDROGELS

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Introduction

Hydrogels are three-dimensional materials capable of absorbing large amounts of water while maintaining their structure [1]. The swelling capacity is due to the high thermodynamic affinity of this class of materials to the solvent. Gelatin is a biopolymer, obtained by denaturation of collagen. As a polar biopolymer, gelatin dissolves quickly in water. However, when cross-linked, it gains better mechanical properties and reduction of degradation degree [2]. Alginates are naturally occurring anionic polymers commonly obtained from brown seaweed. The soluble alginate sodium salts are converted into insoluble gels by cross-linking with divalent ions [3]. Calcium chloride is one of the most widely used agents for the ionic cross-linking of alginate.

Materials and Methods

Gelatin and sodium alginate were dissolved in water and then mixed to finally obtain a solution of 6% gelatin and 2% sodium alginate in one mixture. Meanwhile, two different crosslinkers were prepared: squaric acid (SQ) in 2% and dialdehyde starch (DAS) in 1% and 2% weight percent based on the dry weight of the protein. Finally, the hydrogels were immersed in 1% or 2,5% and 5% calcium chloride solution to cross-link sodium alginate.
The swelling ability was tested using the conventional gravimetric method. Dried samples were weighed and placed in PBS solution at room temperature. The incubation process was held for 1, 2, 4, 6, 24, and 48 h.

Results and Discussion

The examined gelatin-alginate gels exposed high swelling ability. The swelling ratio observed after 24 h hydrogel incubation in PBS solution (FIG. 1) is presented below.

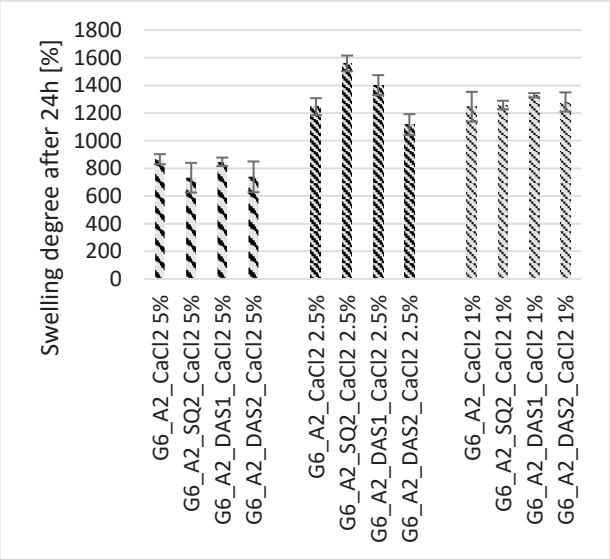

FIG. 1. The swelling ratio after 24 h hydrogel incubation in PBS solution.

Base materials G6_A2_$CaCl_2$ 1% and G6_A2_$CaCl_2$ 2.5% showed similar swelling ability after 24h incubation in PBS. However, the cross-linking by 5% $CaCl_2$ solution caused a reduction of swelling degree. After the 24 h incubation, the highest increase in the swelling ratio for G6_A2_SQ2_$CaCl_2$ 2.5% and G6_A2_DAS1_$CaCl_2$ 2.5%, was observed. The smallest increase in the swelling ratio was observed in all gels ionically cross-linked by 5% calcium chloride solution indicating an effective gelatin-alginate cross-linking process. These results show the greater effect of concentration $CaCl_2$ solution applied for cross-linking than the use of chemical cross-linkers DAS and SQ on the swelling degree. On the other hand, the hydrophilic nature of DAS and the polar structure of SQ could affect the increased water absorption capacity of the material.

Conclusions

The swelling ability test confirmed the integrity and stability of materials achieved by dual cross-linking of sodium alginate and gelatin. The swelling ratio significantly decreased after the addition of 5% of $CaCl_2$ solution. This result might be caused by the competitive interactions between Ca^{2+} ions and DAS and SQ, especially in higher concentrations. Also, the $CaCl_2$ solution concentration presented as more important than the addition of cross-linking agents.

Acknowledgments

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