Rheological Study on Chitosan-Based Self-Healing Polymer Composite for Biomedical Applications

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Introduction: The design of thermo-responsive self-healing polymers is drawing lots of attention due to their applications in biomedical engineering such as suture-less surgery, drug delivery and wound dressings. Chitosan is well-known as a biocompatible biopolymer [1]. In this study, a chitosan-based polymer composite with self-healing and thermo-responsive properties has been designed. The self-healing property, cell cytotoxicity and thermo-sensitivity of the hydrogels are being evaluated. Graphene oxide was added to improve the self-healing property of the hydrogels. Self-healing properties were characterized by two techniques: visual evidence and a rheological study, while the thermo-responsive property of the prepared composite was characterized by a rheological study. A live/dead assay was done to show non-toxicity of the structure.

Keywords: self-healing, chitosan, graphene oxide, thermo-responsive polymer.

Material and Method: The following materials were used: chitosan with 95% degree of deacetylation and Mw 500 Cp (Heppe, Germany), lactic acid 85% (Sigma Aldrich), graphene oxide (GO) (ACS, single layer, H method), beta glycerol phosphate (BG) (Sigma Aldrich), 3,4-dihydroxyhydrocinnamic acid 98% (Sigma Aldrich).

Chitosan/Graphene oxide preparation (CS/GO)

The desired weight of GO was dispersed in 10 ml DI water by sonication for 30 mins. 1 ml of GO solution was dissolved in 5 ml water and 0.1 g chitosan added to this solution. Then 0.037 ml lactic acid was added to protonate the chitosan and dissolve it in the GO-water solution, which was stirred for 8 hrs.

Chitosan/Graphene oxide/Beta glycerol phosphate/di-hydrocaffeic acid preparation (CS/GO/BG/HCA)

A 66% w/v beta-glycerol phosphate solution was prepared in 9 ml water and filtered to remove any impurities and unsolved particles. Then 1.5 ml of BG solution was added to the CS/GO at 4°C and stirred for 5 minutes to reach a pH 6.8-7.0. Lastly the appropriate amount of HCA was added to the solution and mixed for 5 minutes. Four different chitosan/HCA ratios, GO concentrations (CH: HCA GO) were prepared.

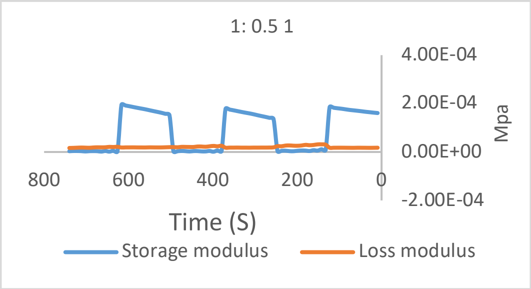

Figure 1. Results of rheological study to record the self-healing property of a 1:0.5, Chitosan: HCA ratio, and 1 % w/v GO concentration

Results:

Three of the chitosan-based polymer composites had an appropriate self-healing and biocompatible performance making them good candidates for biomedical applications. With the addition of GO, the density and thickness of crosslinked structure and the self-healing properties improved. Due to the repulsive interaction between chitosan and HCA, the addition of HCA increased the gelation time and decreased the self-healing properties. Three of the CS: HCA GO samples were found to be biocompatible.

Conclusions:

Chitosan is one of the most widely used materials for making hydrogels for biomedical applications. Chitosan has excellent biocompatibility, low toxicity, and stimulates an immune response. However, it does not have good mechanical properties. In this study, we took the advantage of GO to improve its mechanical performance as well as the self-healing properties. BG as a gelling agent was added to the chitosan solution to provide its thermo-responsive property, while the addition of HCA decreased its self-healing properties. In summary, our study showed that an optimum combination of chitosan/HCA/GO can provide appropriate self-healing properties with minimal cytotoxicity.

Reference:

[1] H. Hamedi, S. Moradi, S. M. Hudson, A. E. Tonelli, "Chitosan based hydrogels and their applications for drug delivery in wounddressings: A review," *Carbohydrate Polymers,* vol. 199, pp. 445-460, 2018.