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BIOPRODUCTS ENGINEERING

Development of Bioglass/Collagen Dressings via Tape Casting for Potential Use in Tissue Engineering

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ABSTRACT

Tissue engineering has emerged as a promising approach for the regeneration of bone injuries and diseases. In this context, the present study aims to develop tapes by the tape casting technique, using bioglass, collagen, water, and carboxymethylcellulose. These tapes can function as dressings in applications such as bone tissue regeneration. The tape casting technique, widely used in the production of electronic substrates, multilayer capacitors, and fuel cells, is used in this research to manufacture the bandages. The combination of ceramic materials such as bioglass with natural polymers such as collagen offer biocompatibility and biodegradability to the tapes, making them bioactive materials. Physical, chemical, thermal, and mechanical analyses were conducted to characterize the material. It was concluded that the bioactive glass-based dressings developed in this research have potential for application in tissue engineering. The tape bonding process is a quick and effective method for obtaining the dressings. As a suggestion for future work, cytotoxicity analyses of the dressings will be conducted to confirm their application in tissue regeneration.

Keywords: Bioglass. Collagen. Tape Casting. Tissue Engineering.

1 INTRODUCTION

The global population is increasing in both size and proportion of elderly individuals. Consequently, there is a noticeable rise in age-related diseases, leading to bone and cartilage deterioration, along with an increased risk of fractures due to falls and the challenges associated with performing numerous surgical procedures on elderly patients. Tissue engineering emerges as an alternative to enhance quality of life and aims to develop solutions for treating injuries, fractures, and degenerative diseases[1,2].

Through the tape casting technique, it is possible to develop tapes that simultaneously incorporate natural polymers such as collagen, carboxymethylcellulose (CMC), and ceramic biomaterials such as bioglass. These materials confer bioactive and biodegradable properties to the tapes, making them even more attractive for bone tissue engineering applications as a dressing. Bioglass is a ceramic biomaterial suitable for bone tissue engineering due to its composition similar to bones and natural polymers, which can be resorbed by the body[3].

The ceramic materials selected to compose the dressings are traditionally known for their physical-chemical, mechanical, and biological properties necessary for this application. The incorporation of natural polymers, such as collagen, provides additional advantages, including the potential for resorption by the body. Moreover, the use of water and natural additives in the formulation of the dressings reduces dependence on organic solvents, making the process more environmentally friendly and less toxic. This feature is particularly relevant in the pursuit of sustainable approaches to the production of biomaterials for biomedical applications. Therefore, the results obtained from this research can contribute to the advancement of the field of tissue engineering, benefiting patients and enhancing the therapeutic options available for the elderly.

2 MATERIAL & METHODS

Preliminary tests allowed defining the methodology and processing parameters used in this study. Bioglass was used as a ceramic filler, while type I bovine collagen were used as the polymer matrix. Carboxymethylcellulose (CMC) was used as a binder and stabilizer in the suspension preparation, and water was used as a solvent.

The suspensions were prepared by dissolving natural polymers in deionized water under magnetic stirring at 55 °C at room temperature. After forming the polymer solution, the binder was added at the same temperature. Then, the ceramic filler was added for homogenization. The pH of each formulation was evaluated at the end of the stirring process. The resulting mixture was then transferred to the tape caster. Rheological properties were measured using a plate-plate rheometer. The paste behavior in the dynamic regime was evaluated by measuring viscosity and shear stress, varying the shear rate to study the rheological profile of the developed paste.

The pastes were shaped in a tape caster on a flexible Mylar® film. The drying period was performed at room temperature inside the equipment until complete evaporation of the deionized water. The samples were characterized in the green state after drying to understand the effect of composition on the properties of the tapes. Morphological characterizations (SEM) were performed to evaluate the incorporation of ceramic particles into the polymer matrix and porosity, mineralogical (XRD) to identify crystalline and

non-crystalline phases, chemical (FTIR) to identify functional groups, and wettability (contact angle) to assess the hydrophilicity of the sample.

3 RESULTS & DISCUSSION

A considerable change in rheological properties (Figure 1) was also observed according to the concentration of natural polymer used. As the concentration of collagen increases, the viscosity and shear rate of the suspensions also increases.

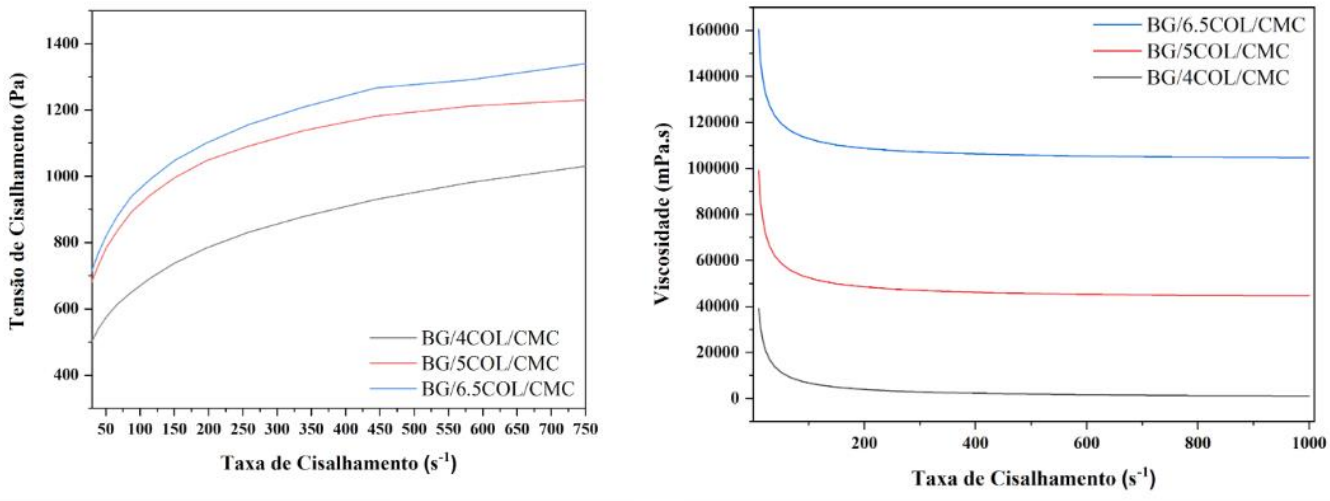

Figure 1 Rheological behavior of Bioglass/Collagen Dressings. Source: elaborated by the author.

The dressings exhibited the morphological (Figure 2) and mineralogical characteristics of their constituents (Figure 3). Collagen-based dressings showed contact angle = 0°, which means that the samples present hydrophilicity.

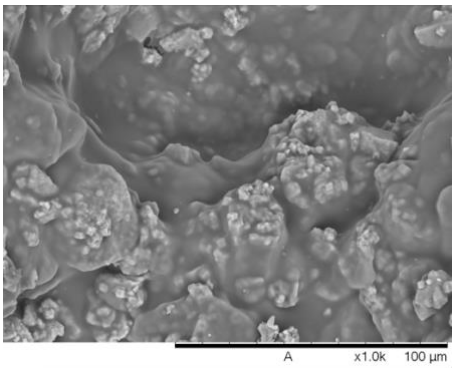

Figure 2 SEM of Bioglass/Collagen Dressings. Ampliation 1000x. Source: elaborated by the author.

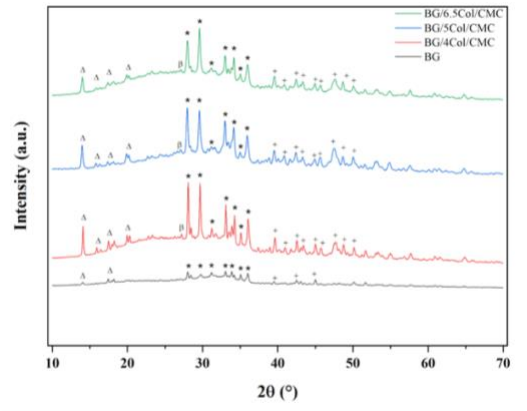

Figure 3 XRD of Bioglass/Collagen Dressings. Source: elaborated by the author.

4 CONCLUSION

The materials used in the compositions of the bandages have proven to be an effective alternative to slurries. This study allows for the evaluation of the efficiency of the proposed synthesis methodology for obtaining Bioglass/Collagen Dressings.

The concentration of collagen used significantly impacted the processing of the samples. The developed pastes maintained chemical stability throughout the synthesis and tape-casting processes. All formulations exhibited viscosity values adequate for tape casting. Despite having the same chemical composition, the concentration of collagen affected the rheological behavior of the suspensions differently. Optimizing temperature, casting velocity, and the fixed doctor blade gap enabled the development of a continuous tape with consistent thickness, ensuring reproducibility and process control in the production of the dressings. Variations in polymer concentration within the formulations do not affect the crystallinity, morphology or chemical groups.

In conclusion, Bioglass/Collagen Dressings produced via tape casting offer a rapid and efficient means of manufacturing dressings with uniform dimensions.

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