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Electrospun wool keratin-based scaffolds undergoing gold deposition as promising biomaterials for bone tissue applications

N. Bio-based high-performance textile coatings

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Abstract

Research on novel systems for treating bone defects remains an ongoing challenge in the biomedical field. At the state of the art, the therapeutic approach applied until now has focused on bone grafts. They can be classified into autografts, allografts and xenografts, depending on the origin of the transplanted tissue. However, these techniques are hampered by significant shortcomings: limited graft availability, risk of pathogen transmission and possible bleeding after the bone implantation.

An alternative method is to consider bio-based structures that mimic the extracellular matrix of tissue to reproduce the complex anatomy of bone. The literature explores various types of polymers for this application area: natural, synthetic, or sometimes blended formulations. In this scenario, keratin, a fibrous protein extracted from different sources, including waste materials such as wool fibers, meets essential requirements for biomedical device applications: a biodegradable nature, cellular compatibility, cost-effectiveness and low immunogenicity.

The present work aims to fabricate scaffolds composed of wool keratin via electrospinning, a simple and robust technique that produces nanofibers with diameters around 100 nanometers from a polymeric solution, resulting in a high surface-to-volume ratio.

Wool keratin nanofibers are deposited using cellulose fiber sheets as a biodegradable, easy-to-handle nanofiber collector. Subsequently, the specimen's nanofibers are stabilized by thermal treatment to make them water-insoluble.

The resulting nanofiber mats were then subjected to gold deposition to impart antibacterial properties. To achieve these goals, the combination of two techniques has been employed: sputtering for 5 seconds followed by wet-chemical synthesis, at different $HAuCl_4$ concentrations. Sputtering produces nucleation sites for wet-chemical synthesis.

The prepared scaffolds have been characterized using a range of techniques: scanning electron microscopy (SEM), spectroscopy, wettability and antibacterial tests. A correlation between the amount of keratin nanofibers deposited onto the support and the presence of gold in terms of antibacterial activity was assessed.

The findings suggest that increased nanofiber coverage on the cellulose sheet was associated with enhanced antibacterial activity, driven by greater gold deposition along the nanofibers. Conversely, lower initial gold concentrations on the specimens were associated with reduced bacterial reduction.

Overall, these preliminary outcomes evidenced the potential of combining electrospinning, wool keratin and gold deposition to create nanofiber membranes that could play a relevant role in bone tissue repair. Future challenges will regard the implementation of hydroxyapatite in the electrospinning solution, followed by cytocompatibility evaluations.