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Electrospun borosilicate-based membranes with enhanced angiogenic response for tissue regeneration

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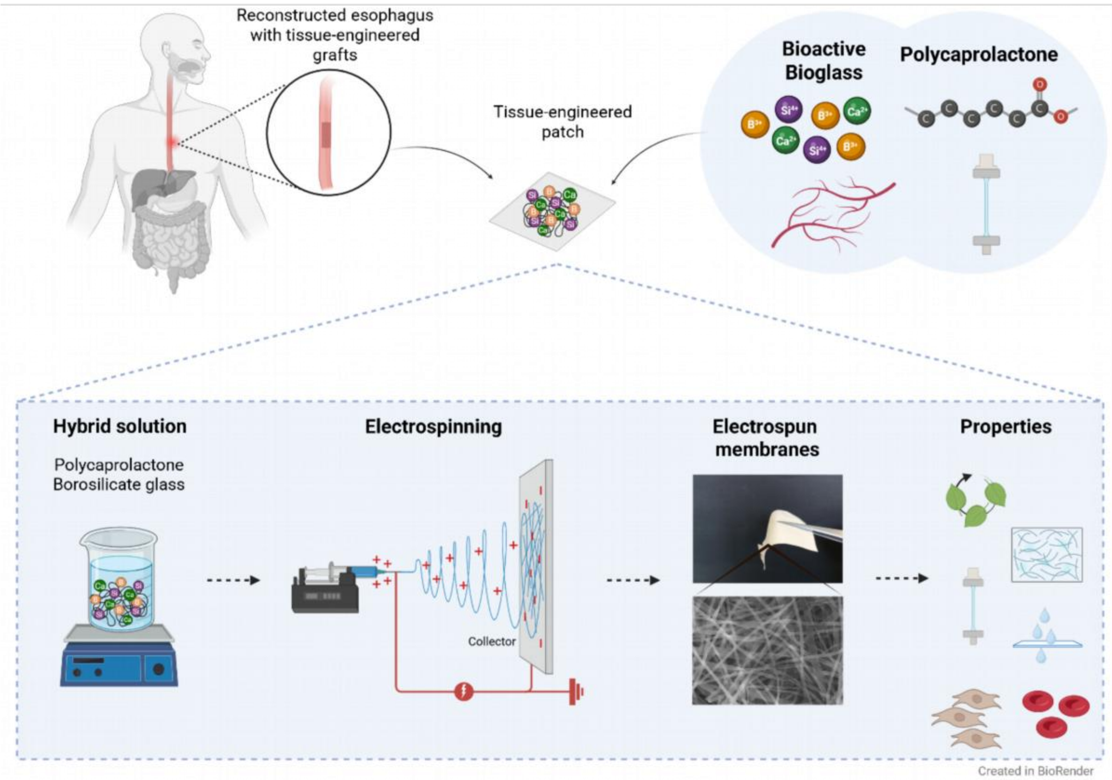
Project. Multicomponent fibrous membranes for esophageal tissue engineering (https://doi.org/10.54499/2021.05864.BD)

Abstract.



Boron (B) has been found to be a key element in cell and bone metabolism. It plays an important role in calcium regulation, bone remodelling, and, especially, in angiogenesis promotion. *In vitro* studies have shown that boron can stimulate osteogenesis by inducing mineralization in osteoblasts, and vascularization through the expression of pro-angiogenic growth factors. Due to these effects, boron-containing biomaterials are gaining more attention in the field of regenerative medicine. One of the most promising approaches has been the incorporation of boron into bioactive glass formulations to improve their physical-chemical properties and biological performance. Among these, borosilicate glasses, which combine silicon and boron, stand out due to their slower degradation rates and sustained release of bioactive ions. These features make them more biocompatible and more effective in promoting angiogenesis compared to borate glasses. Sol-gel process can be a sustainable method to integrate this inorganic phase into an organic network, such a biocompatible polymer as polycaprolactone (PCL), to form an organic-inorganic hybrid material. PCL will offer flexibility and biodegradability, while the inorganic network will provide bioactivity. As a result, a hybrid material with adequate mechanical strength and biologic functionality can be created, suitable for soft tissue applications.

In this study, electrospun hybrid membranes composed of PCL and borosilicate-calcium glass compositions were developed, synthesized via sol-gel route, and electrospinning process. Membranes were fabricated using different boron concentrations in order to evaluate their effect on fiber morphology, structure, mechanical performance, and biological response. The membranes were characterized in terms of surface topology; mechanical behaviour and their biocompatibility was assessed *in vitro* using fibroblasts and human umbilical vein endothelial cells (HUVECs). Special attention was given to the angiogenic response, through the analysis of HUVECs ability to adhere and proliferate on the membrane surfaces. Among the tested compositions, the formulation with 20% boron (molar ratio) showed the most promising results, exhibiting good mechanical strength (with high elastic modulus and relative ultimate strain) and enhanced cellular performance. This work demonstrates that combining organic and inorganic components via the sol-gel method, followed by electrospinning process, is a viable approach to create flexible, bioactive membranes with tuneable boron content. The resulting materials show strong potential for regenerative therapies where vascularization is critical, such as oesophageal tissue engineering.