Development of bioactive patch for wound healing

J. Panitz[1], I. Lang-Olip[2], D. Brislinger[2], B. Glasmacher[1], M. Mueller[1], S. Leal-Marin[1]
[1] Institute of Multiphase Processes, Leibniz University Hanover, Germany
[2] Division of Cell Biology, Histology and Embryology, Gottfried Schatz Research Center, Medical University of Graz, Austria

1 Motivation

The failure of traditional dressings to manage multifactorial challenges such as exudate and infection necessitated the development of bioactive dressings.

This study aimed to develop a multilayer bioactive patch for wound dressing.

2 Scaffold Fabrication

Development of a polyvinyl fluoride and graphene (PVDF-GnP) base layer via Non-solvent Induced Phase Separation (NIPS) to establish controlled porosity and structural support using 2 different concentrations 1.5 and 2% (w/v).

Subsequent integration of a bioactive 10% (w/v) polycaprolactone- 4% (w/v) collagen (PCL-collagen) top layer onto the pre-cast NIPS-derived PVDF-GnP substrate via electrospinning to form the multilayer scaffold.

3 Results

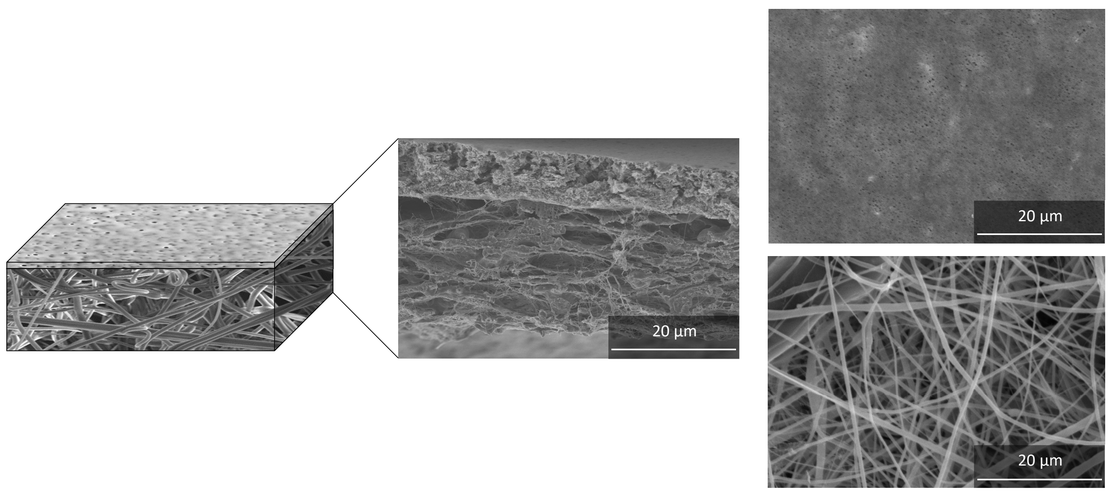


Fig 1. SEM images multilayer patch

The schematic (left) illustrates the layered design: an upper, dense PVDF-GnP cover membrane (top right, obtained by the NIPS process) protects the underlying, porous PCL-collagen nanofibrous structure (bottom right, obtained by electrospinning), and the cross-section (middle).

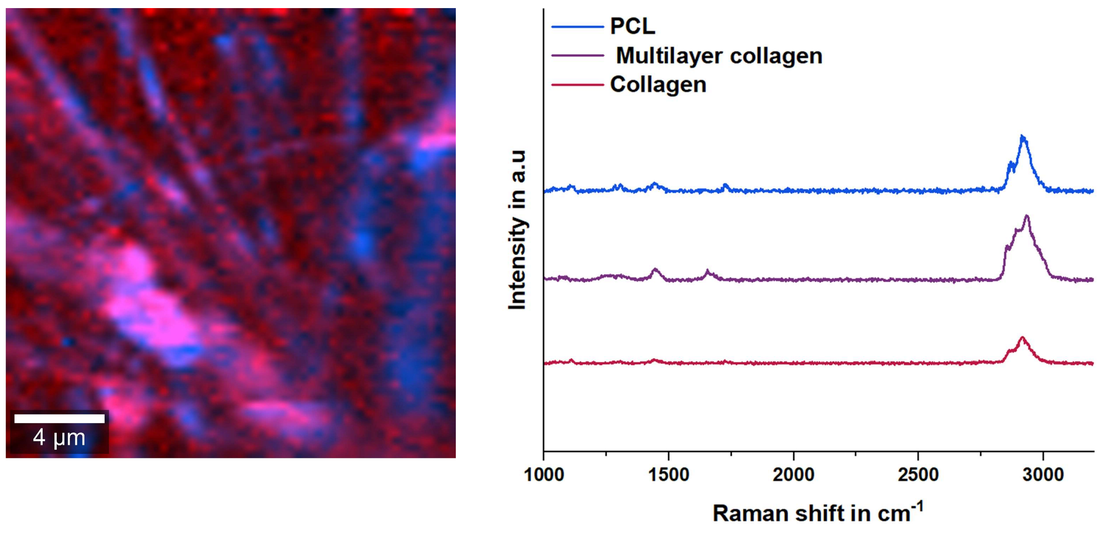


Fig. 2. Raman spectroscopic analysis of component distribution

Average Raman spectra (right) of the analyzed region are shown together with a compositional Raman map (right) of the electrospun membrane (4% collagen). The map visualizes the spatial distribution of polycaprolactone (PCL, blue), collagen (red), and mixed regions where both components are present (purple).

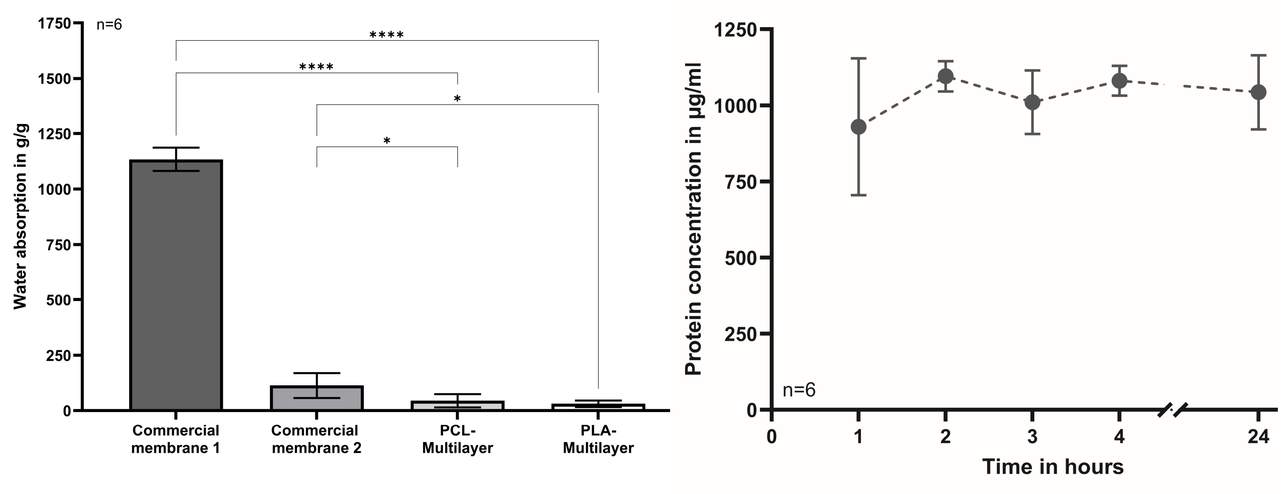


Fig. 3. Water absorption and protein release performance of membranes

Water absorption capacity (left) of different membranes and dressing materials, expressed as the ratio of absorbed water weight to dry weight. Commercial membrane 1, silicone-based, exhibits high absorption performance, while multilayer scaffolds show a comparatively lower capacity, similar to commercial membrane 2. In addition, the protein released profile (right) showed a concentration over 24 hours. The release increases rapidly and stabilizes after approximately 2 hours, maintaining a steady profile afterwards.

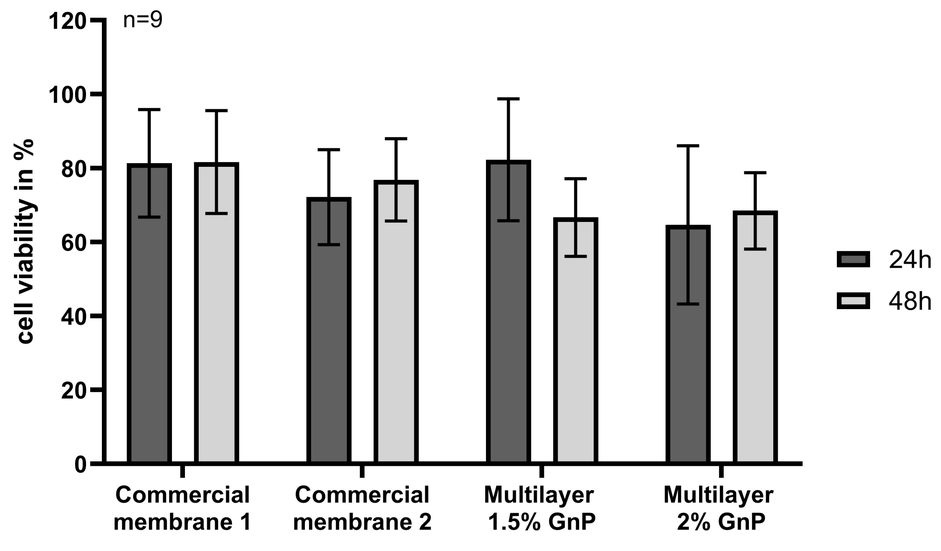


Fig. 4. Cell viability of adipose-derived mesenchymal stem cells (AD-MSCs)

Cell viability of AD-MSCs following incubation with different patch materials is presented. The graph compares viability at 24 h and 48 h for experimental multilayer patches containing 1.5% and 2% GnP, alongside commercial reference materials.

4 Conclusions and Outlook

By integrating efficient water absorption with a sustained and controlled release of collagen, the system promotes a balanced wound environment that could facilitate cell activity, tissue regeneration, and improved healing outcomes.

The demonstrated biocompatibility highlights the patch as a promising candidate for wound healing applications, indicating its potential for safe and effective integration within biological systems.

Future work will involve comprehensive in vivo evaluation using the chorioallantoic membrane (CAM) model to investigate vascularization processes and further assess the regenerative potential of the system for wound healing applications.

Further validation of biocompatibility will be carried out using Human Dermal Fibroblasts (HDFa) to provide a more application-relevant and physiologically meaningful assessment of cell–material interactions.

Contact:
Julia Panitz, M.Sc.
Institute for Multiphase Processes
Leibniz University Hannover
An der Universität 1 | D-30823 Garbsen | Germany
Email: panitz@imp.uni-hannover.de
Web: http://www.imp.uni-hannover.de



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