Innovative biopolymer membrane for periodontal ligament regeneration

CANOE - CB3S



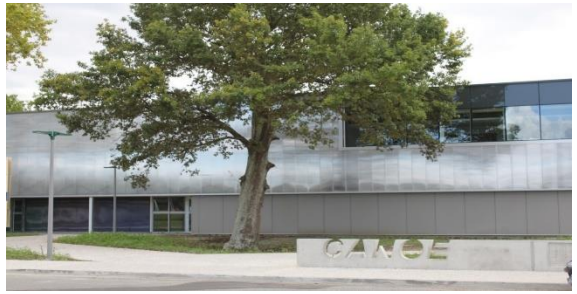
With the support of:

CANOE PRESENTATION

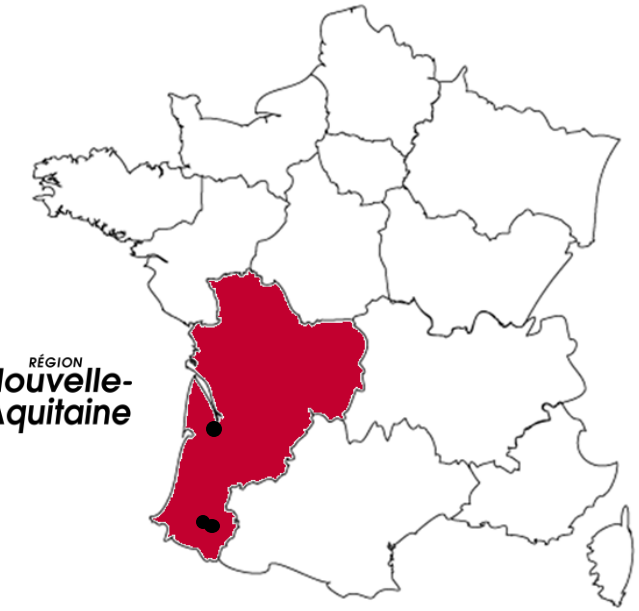
- NAME : CENTRE TECHNOLOGIQUE NOUVELLE-AQUITAINE COMPOSITES & MATÉRIAUX AVANCÉS
- LEGAL STATUS: NON-PROFIT RESEARCH AND TRANSFER ORGANISATION
- MISSION : TO PROVIDE R&D SERVICE TO COMPANIES FOR DEVELOPING PRODUCTS AND PROCESSES IN THE FIELD OF FIBER, PLASTURGY AND COMPOSITE MATERIALS

3 LOCATIONS IN SOUTH-WEST OF FRANCE







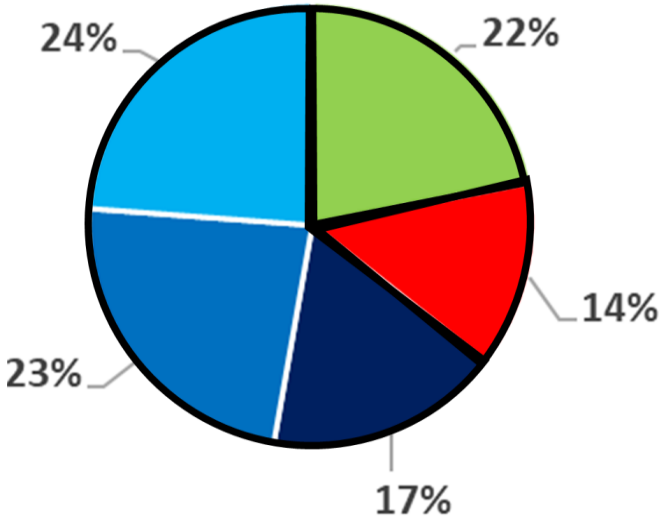


RÉGION Nouvelle-Aquitaine

FLOOR AREA : 5 500 M²

MANPOWER 2025 : 48 PHDs/ENG/TECH

INCOME BREAKDOWN



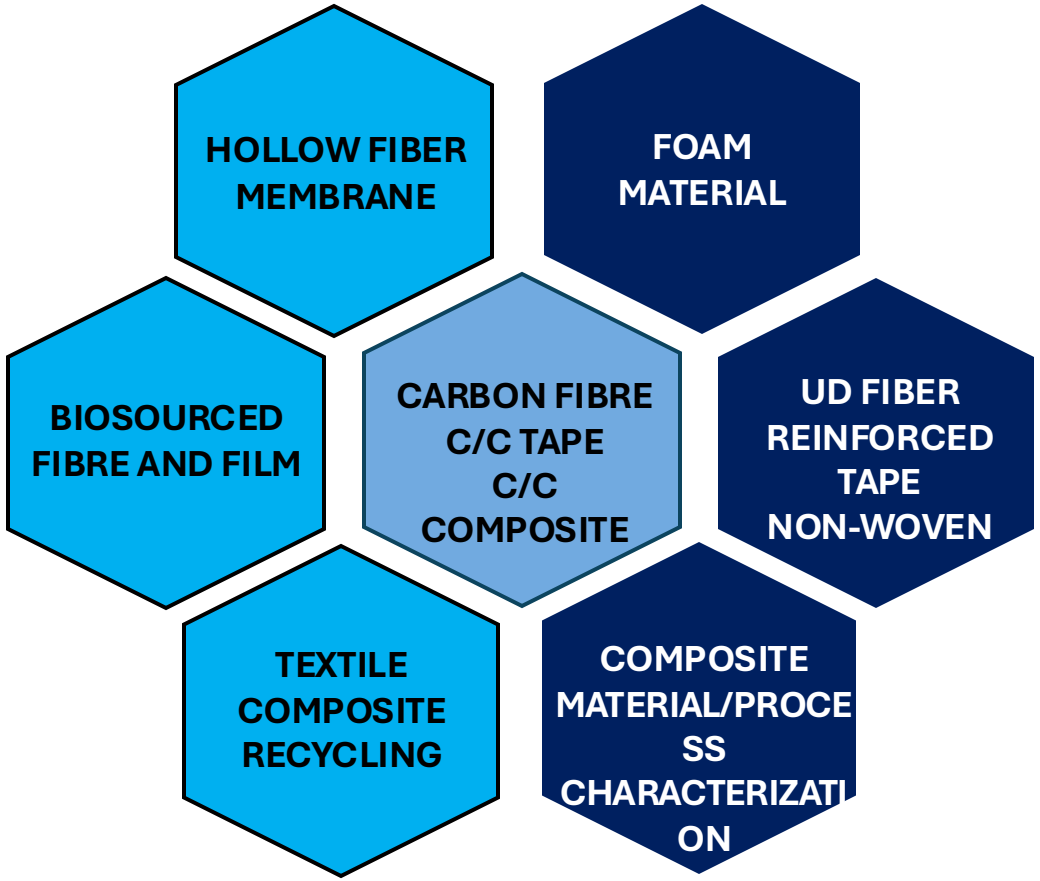
EXTERNAL R&D CONTRACT ACTIVITY

COOPERATIVE R&D ACTIVITY

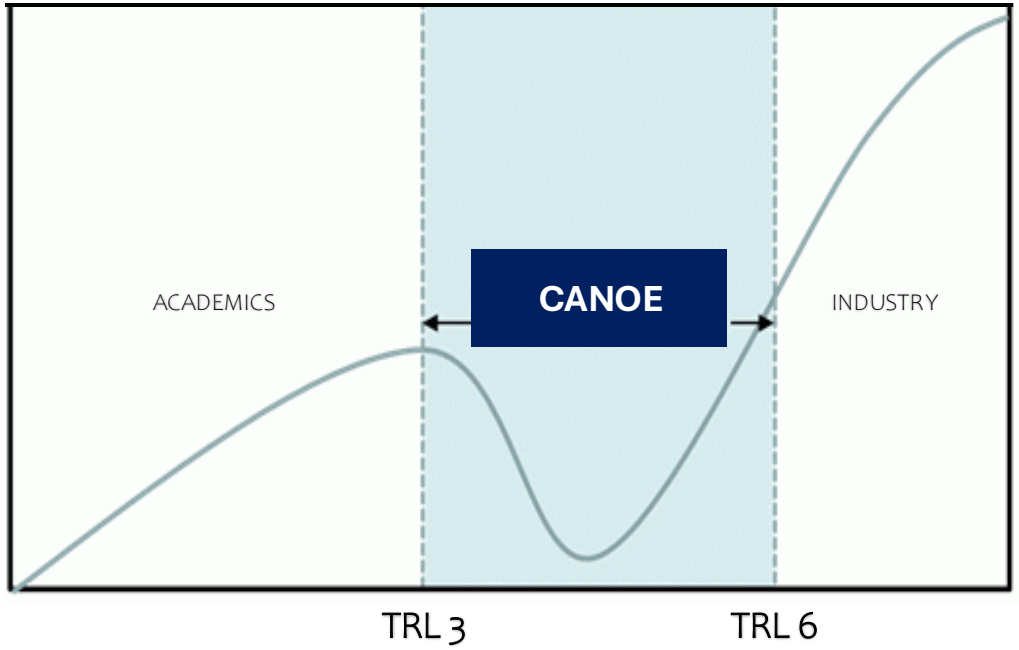
INTERNAL R&D ACTIVITY

CANOE PRESENTATION

CORE EXPERTISE



TECHNOLOGY READINESS LEVEL



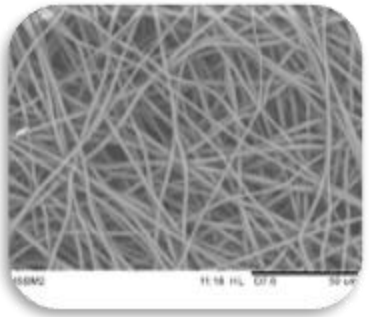
LAB PRESENTATION

Biomaterials Engineering and Surface Treatment (BEST) team had two expertises in biomaterials

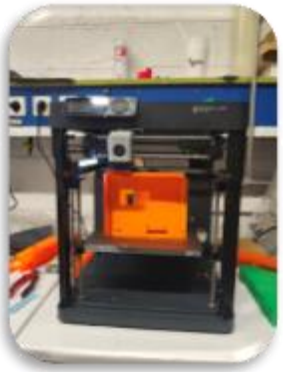
Expertise 1: Elaboration

ELECTROSPINNING





3D PRINTING AND BIOPRINTING

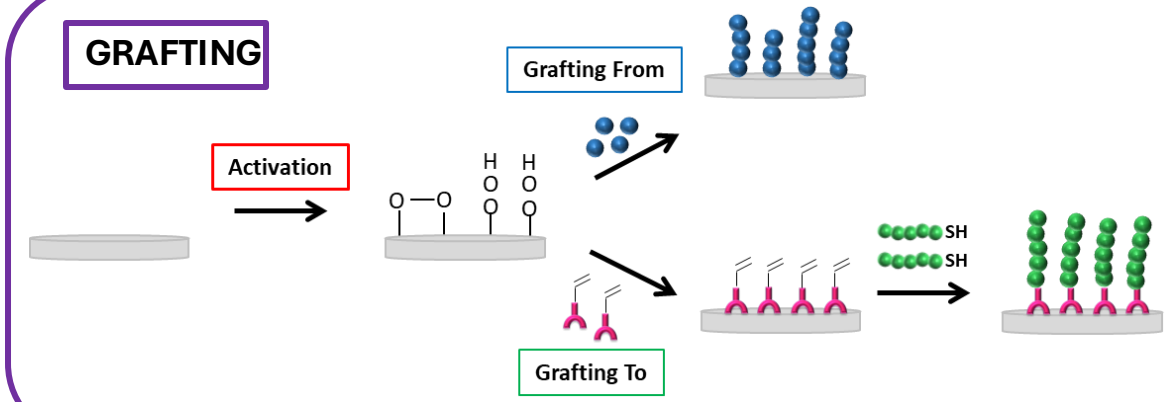






Expertise 2 : Functionalization

GRAFTING

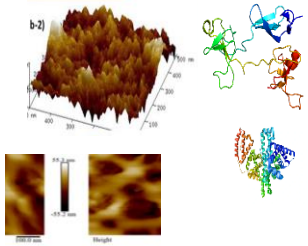


BIOLOGICAL RESPONSE

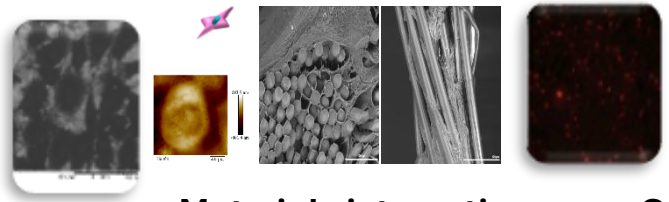


❖ **Bacteria :**

❖ **Proteins :**



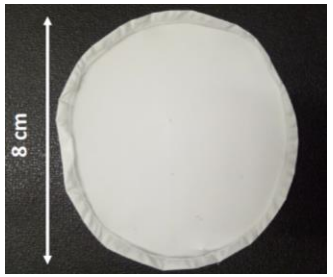
❖ **Cells :**



Materials interactions <--> Cells <--> Bacteria <--> Proteins

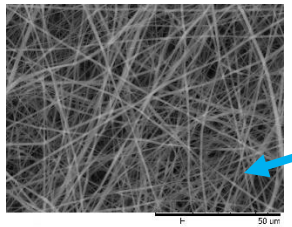
BEST Team: Proven Expertise in Electrospun PCL Membranes

Periodontal regeneration

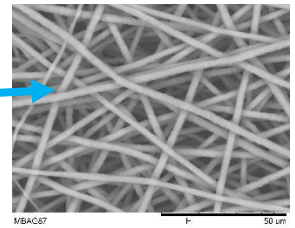


Selective occlusive barrier for epithelial and connective tissue cells

First test of Bi-layer PCL-PCL patch



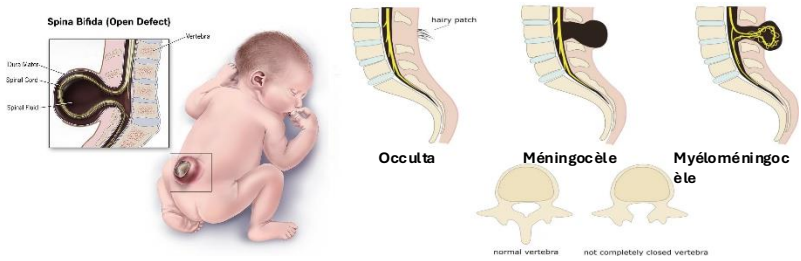
nano-fibers Membrane
Gingival side



µ-fibers Membrane
Bone side

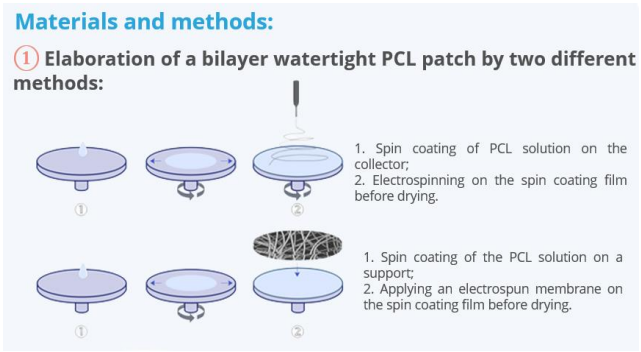
Enhance cell proliferation and infiltration within the fibrillar network

Spina bifida Treatment



Bilayer patch

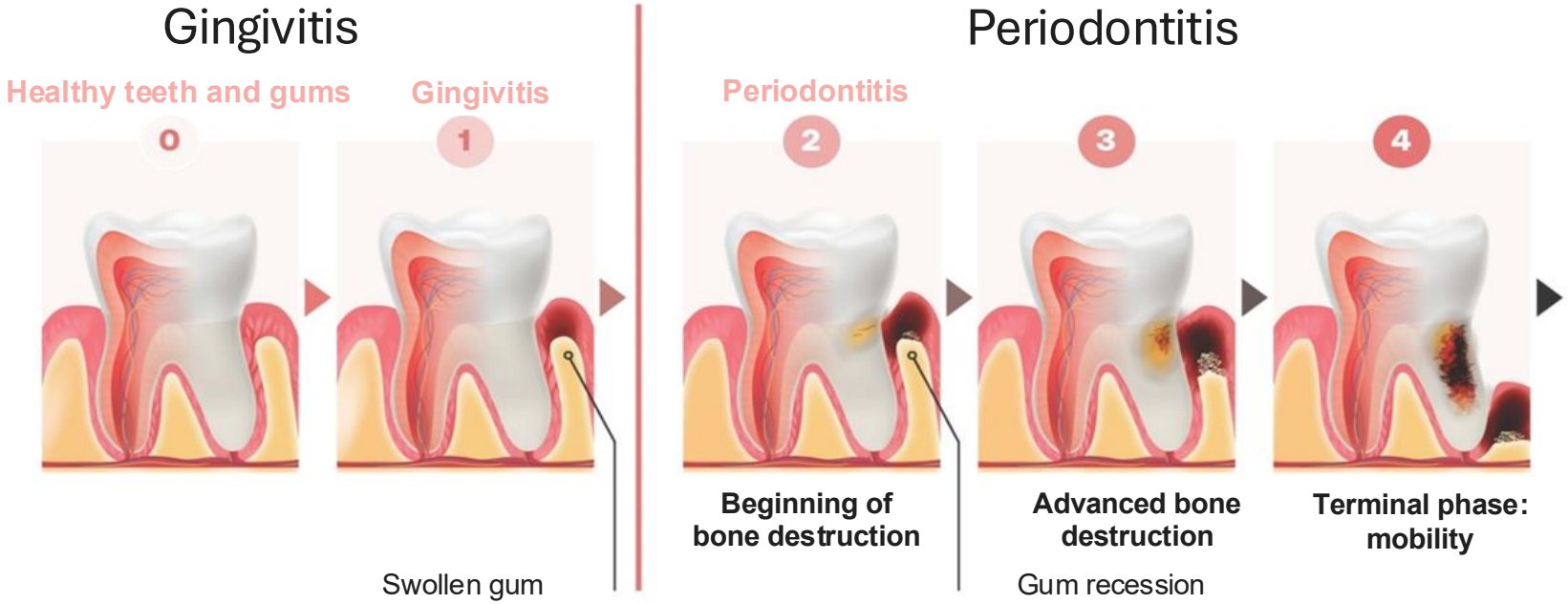




Amokrane, G.; Humblot, V.; Jubeli, E.; Yagoubi, N.; Ramtani, S.; Migonney, V.; Falentin-Daudré, C.. *ACS Omega* **2019**, *4* (17), 17194–17208.
Baumann, J. S.; Falentin-daudre, C.; Stirnemann, J. Materialia 2023, 28, 101780.
Botto, L. D.; Moore, C. A.; Khoury, M. J.; Erickson, J. D. *New England Journal of Medicine* **1999**, *341* (20), 1509–1519.
Benabdherrhammane K., Stirnemann J., Ramtani S., Falentin-daudré C. *Wound Regeneration and Repair,* 2023,
Benabdderrahmane, K.; Stirnemann, J.; Ramtani, S.; Falentin-daudré, C.; *J.Biomater. Appl.* 2025; 39, 1097-1114,

CONTEXT OF THE STUDY

Periodontal diseases :



Problem: Recreating functional tissue capable of stabilizing the tooth

Existing solutions:

- Periodontal surgery
- Guided tissue regeneration (GTR)
- Tissue engineering

DESIGN RATIONALE OF THE BILAYER PATCH

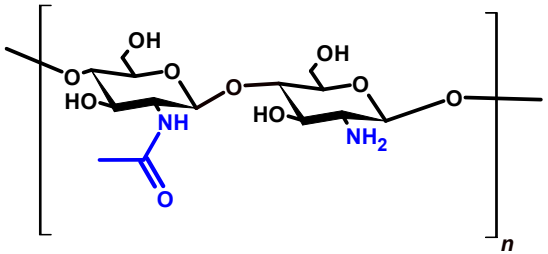
Chitosan Advantages:
- ✓ Antibacterial properties
- ✓ Promotes wound healing
- ✓ Hydrophilic surface

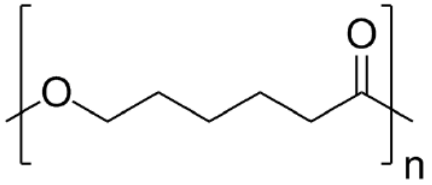
Chitosan Drawback:
- ✖ Lack of mechanical resistance

Polycaprolactone (PCL) Advantages:
- ✓ FDA-approved polymer
- ✓ Slow degradation
- ✓ High mechanical strength

Polycaprolactone Drawback:
- ✖ Hydrophobicity







Synergistic effect for ligament application
- Bioactivity (chitosan) + structural stability (PCL)
- Optimized micro-environment for periodontal regeneration

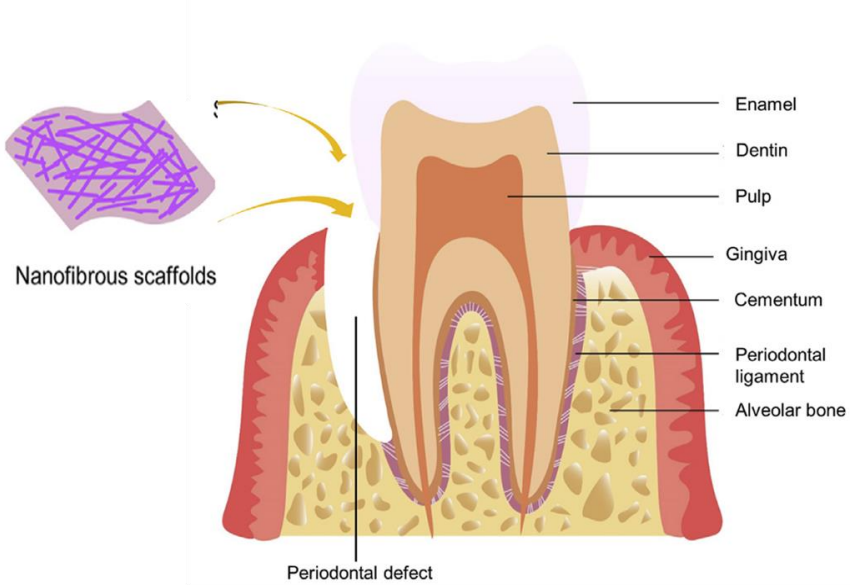


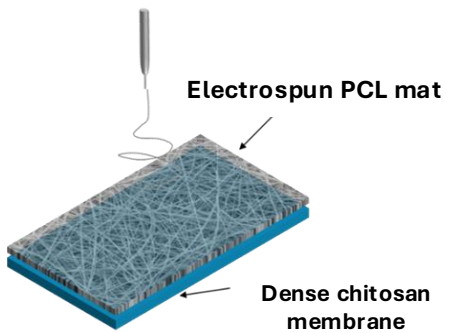
Wahba, M. I. Enhancement of the Mechanical Properties of Chitosan. *J. Biomater. Sci. Polym. Ed. 2020*, 31 (3), 350–375.
Aranaz, I.; Alcántara, A. R.; Civera, M. C.; Arias, C.; Elorza, B.; Heras Caballero, A.; Acosta, N.. *Polymers* **2021**, *13* (19), 3256.

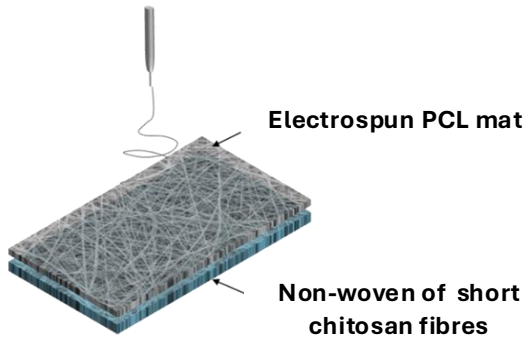
TECHNICAL CONTENT

The aim of the project is to develop a double-layer membrane composed of:

- A chitosan layer (membrane or non-woven fiber) for contact with the connective tissue : CANOE's work
- An electrospun PCL layer for contact with for contact with the alveolar bone : CB3S's work







Target total thickness : 500µm

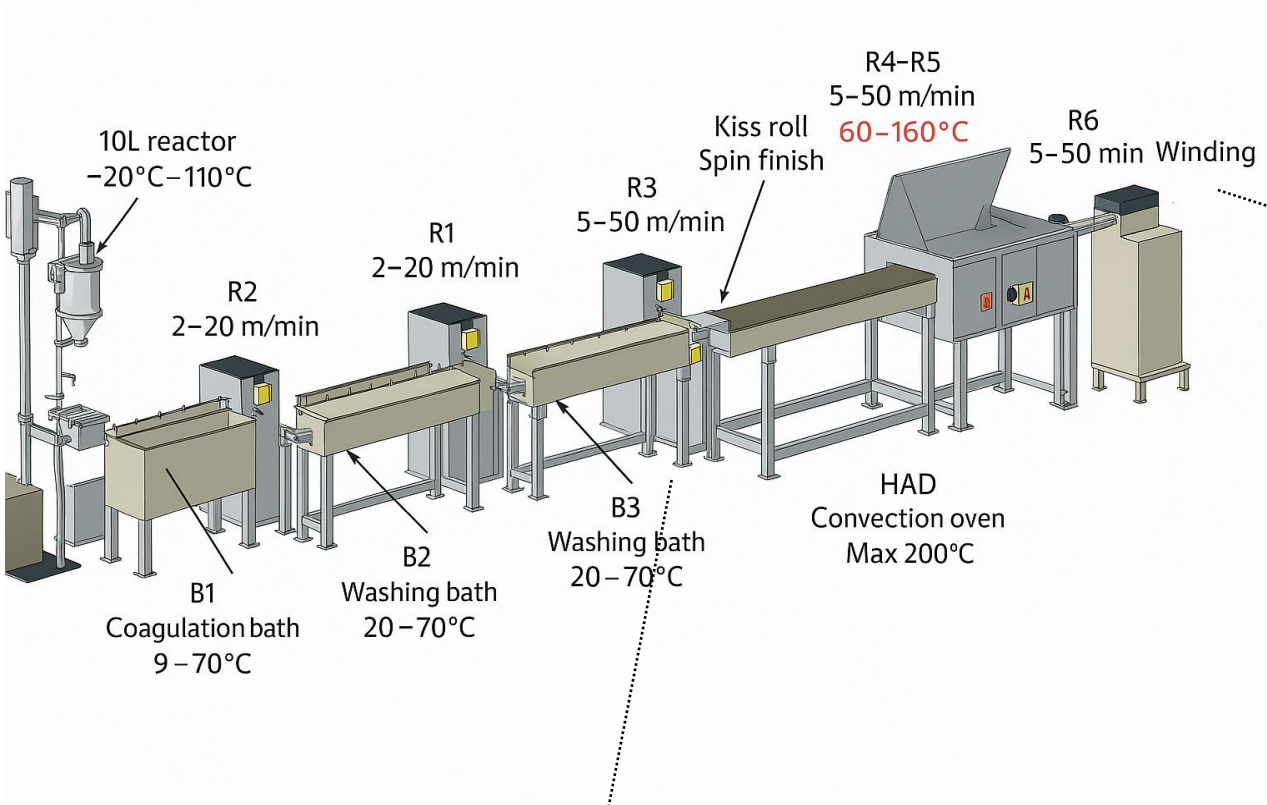
« Fabrication and Characteristics of Chitosan Non-woven Fabric developed using only water as plasticizer -The Korean Fashion and Textile Research Journal | Korea Science ».

CHITOSAN FIBRE PRODUCTION





Spinneret
500 holes * 100µm

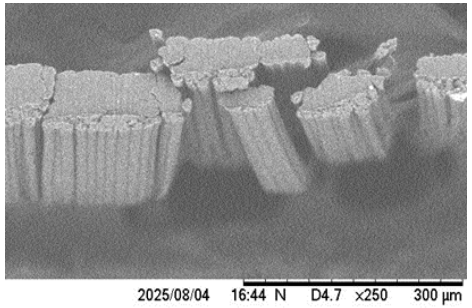


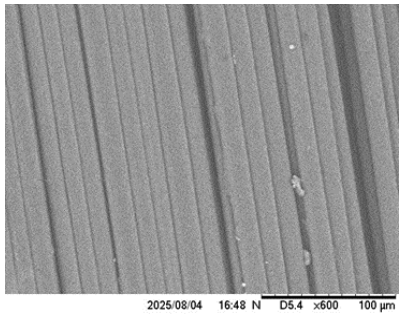


Dry fibers



Wet fibers





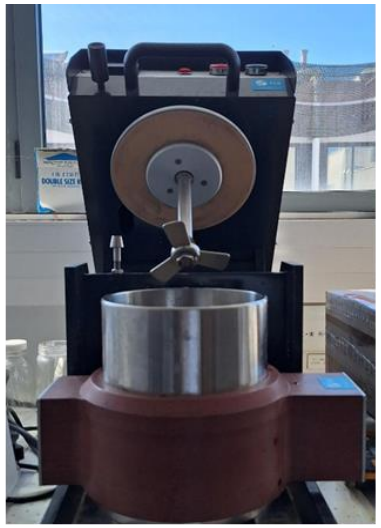
14 - 16µm/filament

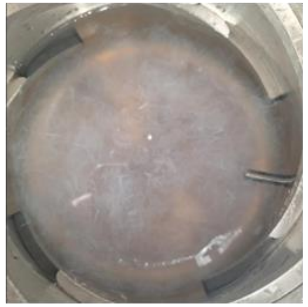
CHITOSAN NON-WOVEN PRODUCTION



5-10 mm cut fiber

Fiber dispersion (pulper)



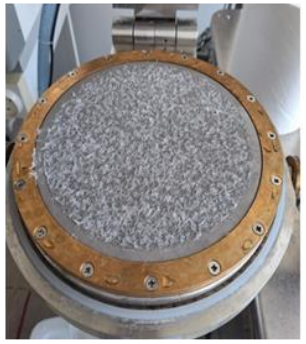


Addition of a binding agent (optional)

Fiber dispersion into the sheet former machine



Pre-drying



Drying





Ø 20 cm disk

Consolidation (optional)

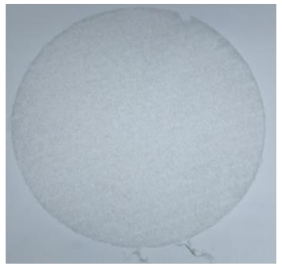


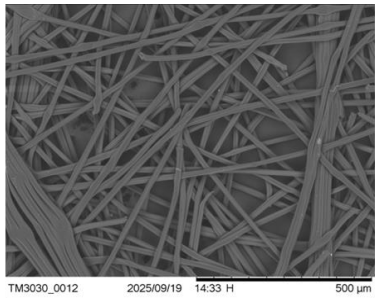
NON-WOVEN ASPECT AND PROPERTIES

LE CENTRE TECHNOLOGIQUE NOUVELLE AQUITAINE COMPOSITES & MATÉRIAUX AVANCÉS

Non-woven made from dry fibers, without binding agent

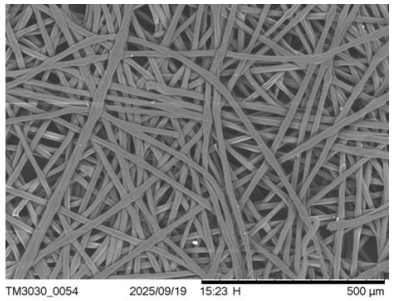
30 gsm (g/m^2)

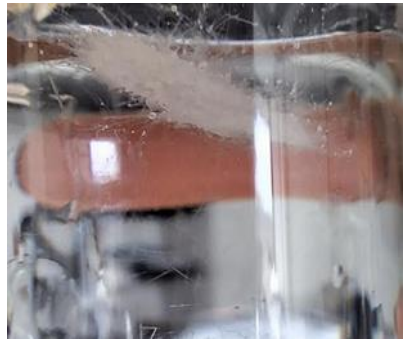




50 gsm (g/m^2)



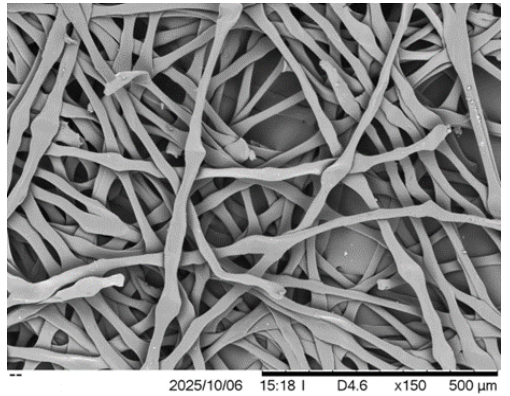




Disheveled after water immersion
Not selected for electrospinning trials

Non-woven made from wet fibers, without binding agent

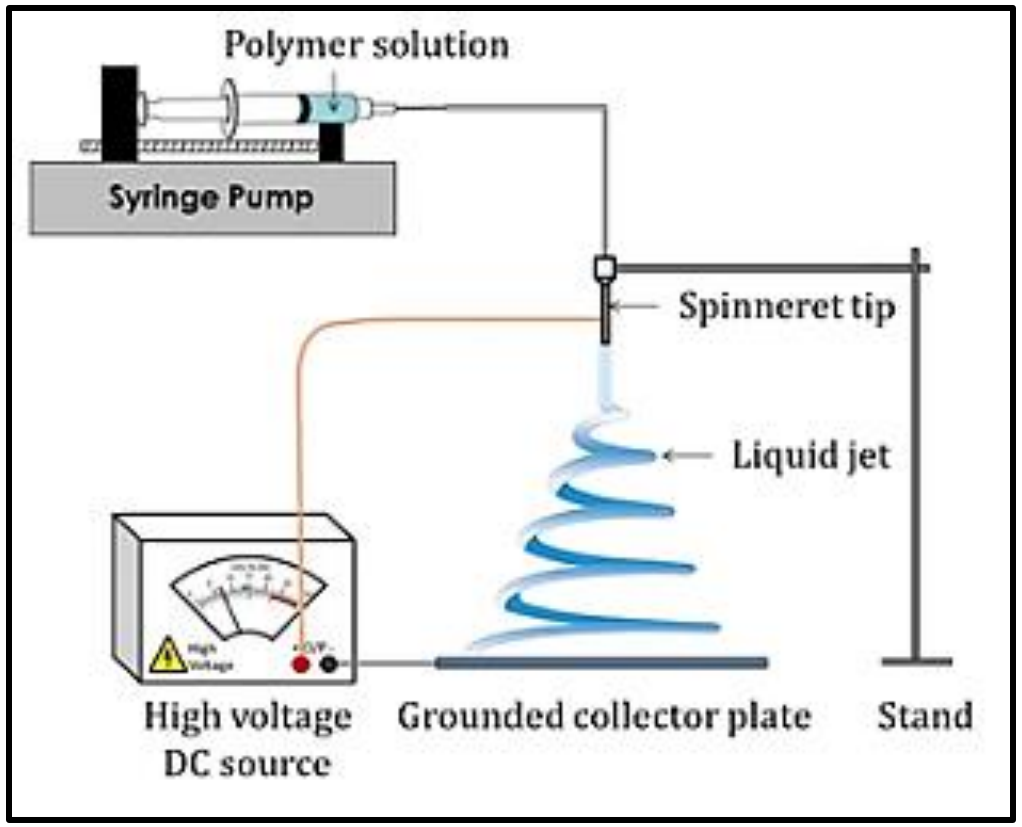






Excellent integrity in water (24-hour immersion)
Selected for electrospinning trials

ELECTROSPINNING DEVICE AND PARAMETERS



Schematic representation of the electrospinning process

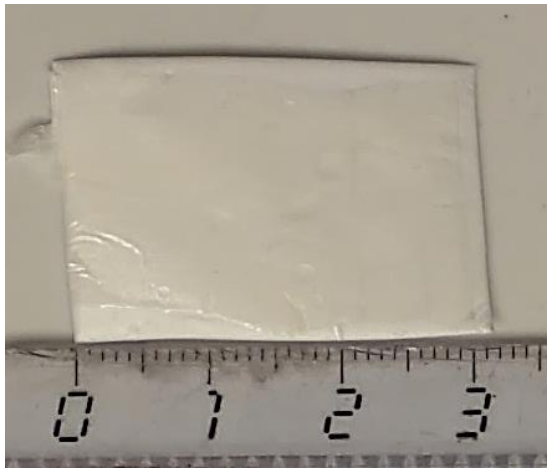
- U = 9,5kV
- d = 15cm
- Time = 2h
- Flow = 2mL/h
- [PCL] = 25% Weight in acetic acid
- Temperature = 30°C

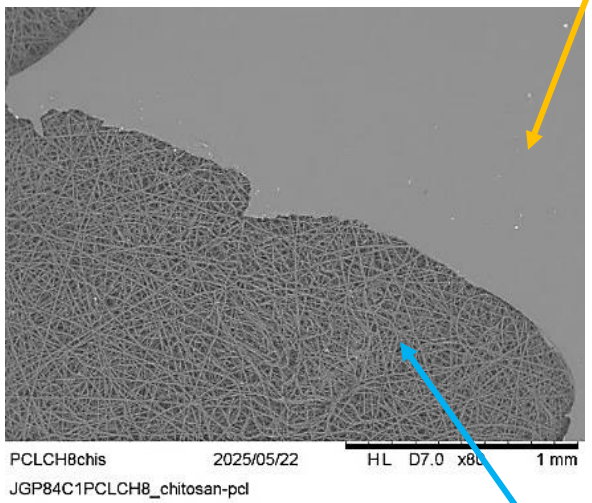


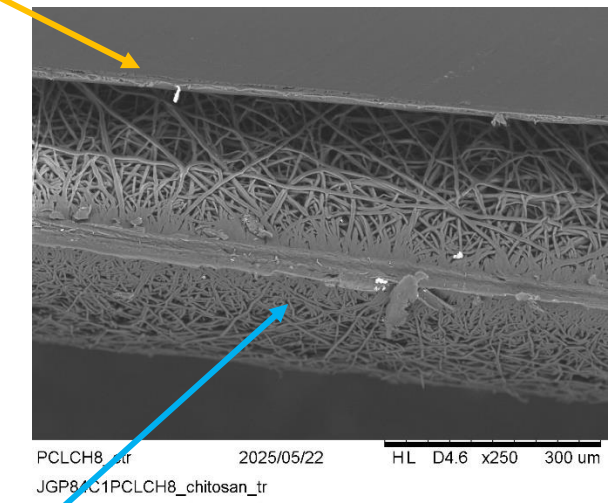
G. Amokrane, V. Humblot, E. Jubeli, N. Yagoubi, S. Ramtani, V. Migonney, C. Falentin-Daudré, *ACS Omega*, 4, (2019), 17194–17208.
K. Benabdderrahmane, Ph.D Thesis

First results electrospinning on chitosan

Dense Chitosan membrane



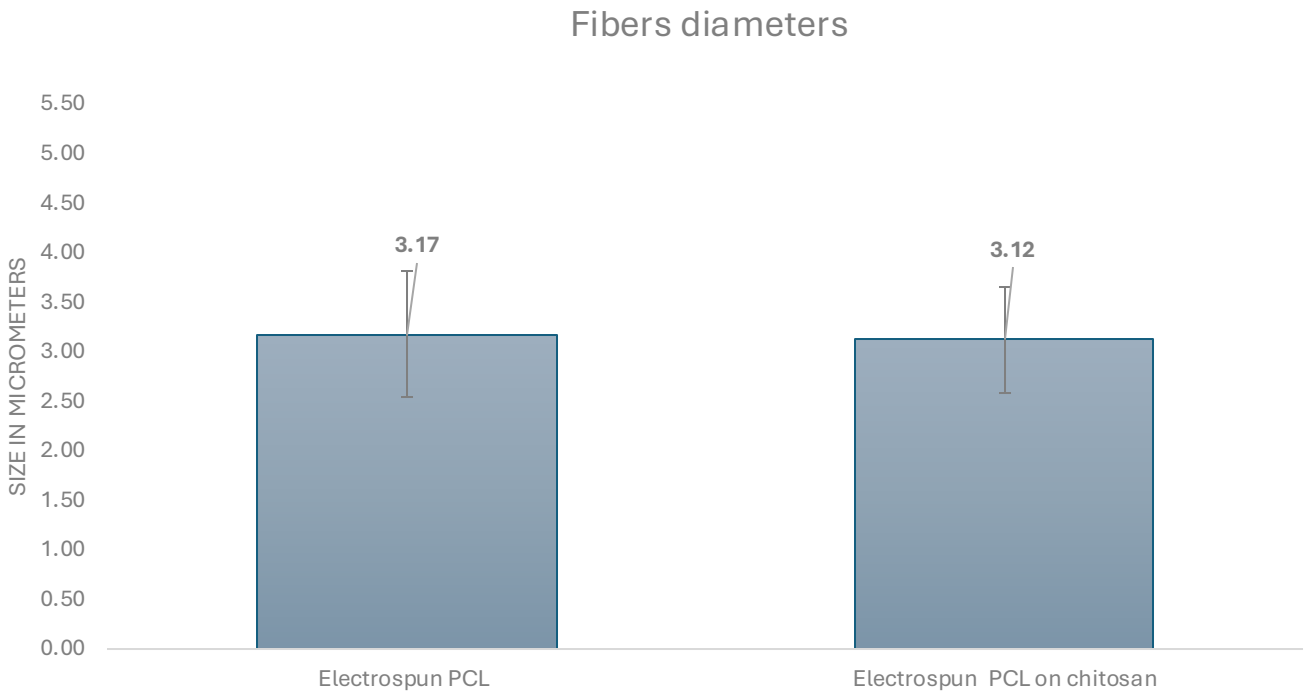




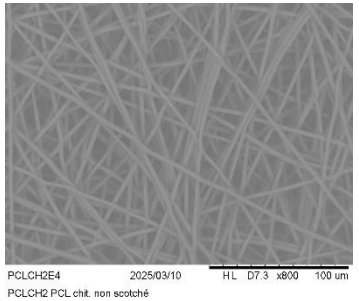
Electrospun
PCL

Electrospinning of PCL onto chitosan is achievable, and the resulting electrospun membrane exhibits good adhesion to the chitosan substrate

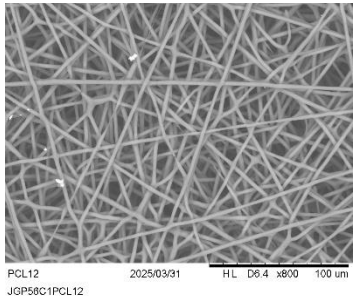
First results electrospinning on chitosan



For each membrane
100 fibers was measured



Electrospun PCL
on Chitosan

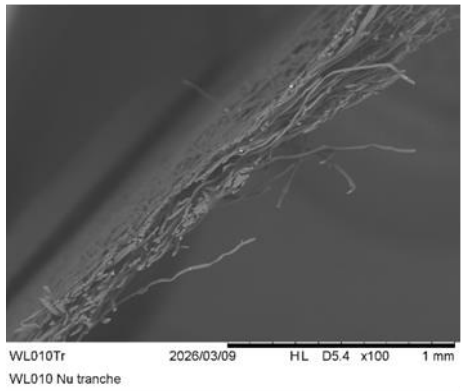


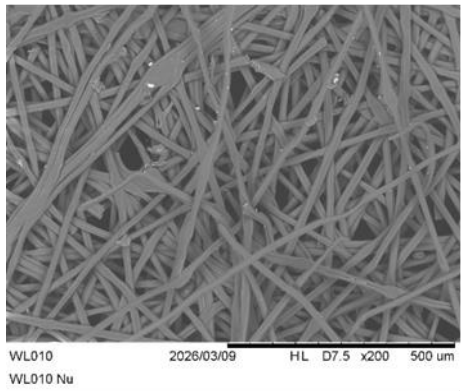
Electropun PCL

Electrospinning of PCL onto chitosan does not significantly affect the fiber diameter

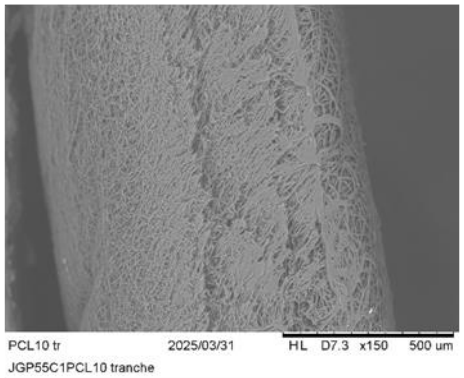
First results electrospinning on chitosan fibers

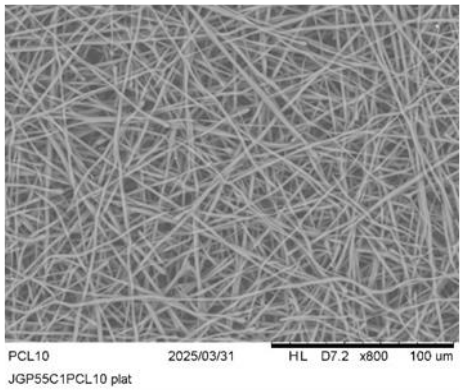
Chitosan fibers



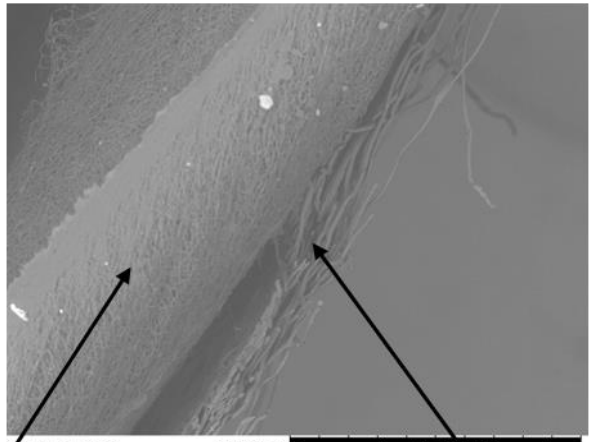


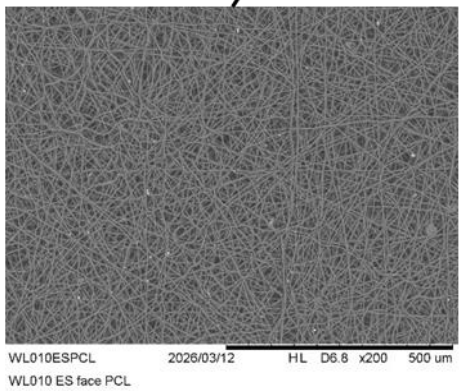
Electrospun PCL

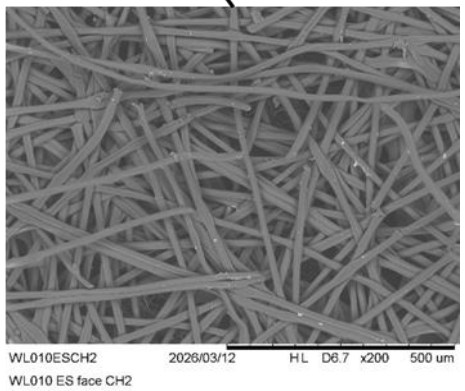




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Face 1:
Electrospun PCL

Face 2:
Chitosan fibers

Conclusions and perspectives

Conclusions :

- PCL can be successfully electrospun onto a chitosan substrate
- The presence of chitosan does not affect fiber morphology or diameter during the electrospinning process
- The electrospun membrane exhibits good adhesion to the chitosan substrate

Perspectives

- Future work will focus on non-woven chitosan membranes
- Cytotoxicity evaluation and cell morphology analysis will be performed on the developed bilayer patches
- Based on the results obtained, optimizations can be made to the chitosan nonwoven fabric :
  ➔Adjustment of pore size : fibres diameter and basis weight (actual porosity between 40% and 80%)