Avec le soutien de la Wallonie

Provincie Oost-Vlaanderen Voor ieder van ons

Région Hauts-de-France

PROGRAMME DE COOPÉRATION TRANSFRONTALIÈRE
GRENSOVERSCHRIJDEND SAMENWERKINGSPROGRAMMA

Interreg France-Wallonie-Vlaanderen
UNION EUROPÉENNE
EUROPESE UNIE

PHOTONITEX

Closing Event : project PHOTONITEX

Tourcoing, 29th September 2022

MATERIA NOVA Materials R&D Center

CETI CENTRE EUROPÉEN DES TEXTILES INNOVANTS

EuraMaterials

ensait ROUBAIX ECOLE D'INGENIEURS TEXTILE

JUNIA HEI

UMONS Université de Mons

Université de Lille

GHENT UNIVERSITY

AVEC LE SOUTIEN DU FONDS EUROPÉEN DE DÉVELOPPEMENT RÉGIONAL
MET STEUN VAN HET EUROPEES FONDS VOOR REGIONALE ONTWIKKELING

Interreg France-Wallonie-Vlaanderen

UNION EUROPÉENNE EUROPESE UNIE

PHOTONITEX

Work Package 3 : Static and dynamic structuring of membrane

- **Mohamed Boutghatin, IEMN Lille**
- **Eric Khousakoun, Materia Nova Mons**

Work Package 3 and 4 : Static and dynamic structuring of membrane and filaments

- **Marjorie Garzon Altamirano, Umons ENSAIT Mons-Roubaix**
- **Jozefien Geltmeyer, Ugent Gent**
- **Muluneh G. Abebe, UMons Mons**

Work Package 4 : Static and dynamic structuring of filaments

- **Hafiz Muhammad Kaleem Ullah, CETI Tourcoing**

Work Package 3 : Static and dynamic structuring of membrane

Etude de membranes photoniques dans le MIR pour le confort thermique individuel

Mohamed Boutghatin, IEMN Lille

Université de Lille

Interreg
France-Wallonie-Vlaanderen
UNION EUROPÉENNE
EUROPESE UNIE
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470 persons

- 170 teacher-researchers
- 140 PhD students
- 90 engineers and technicians

IEMN

- 1600 m^2 of clean rooms
- 1400 m^2 of laboratories

Université de Lille

Interreg France-Wallonie-Vlaanderen

UNION EUROPÉENNE EUROPESE UNIE

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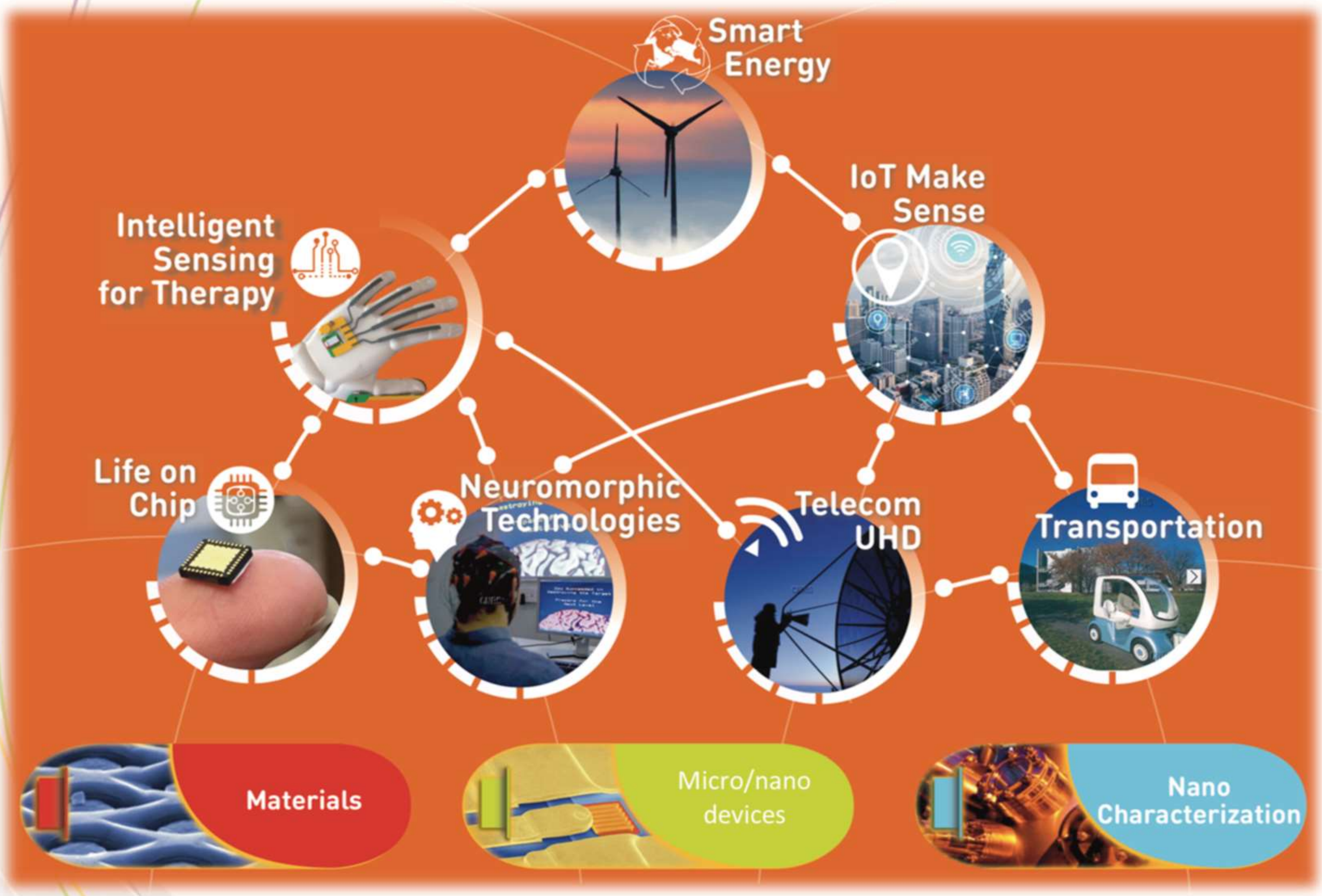
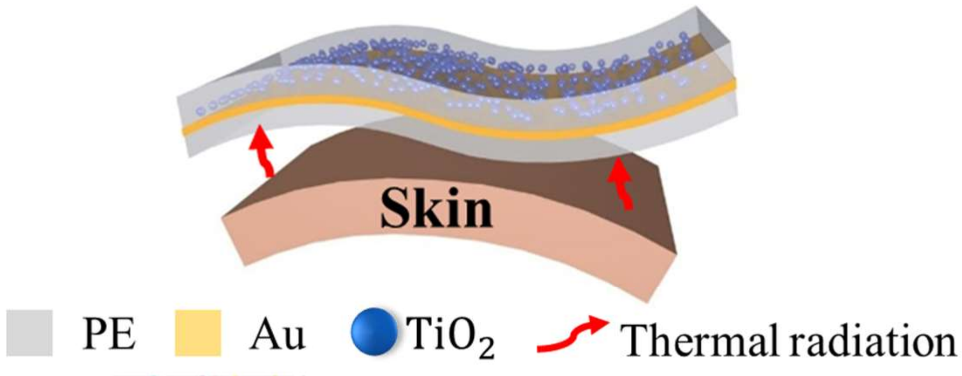
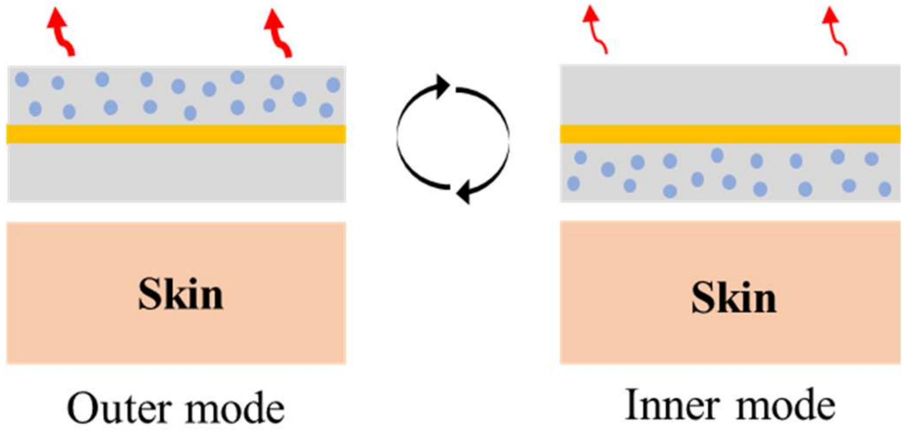


Multilayer membrane

Concept



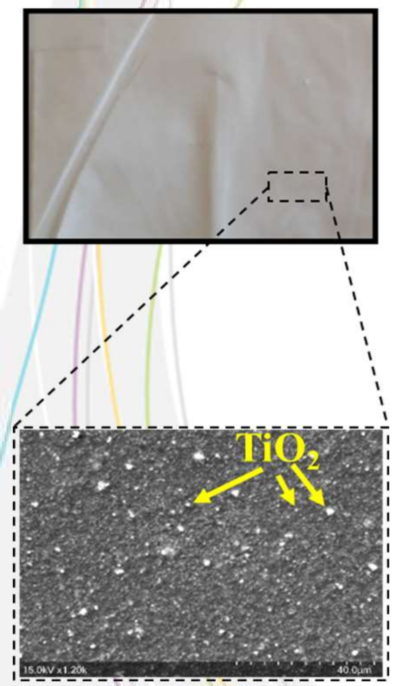


❖ Flip the structure: modulation of the emissivity towards the environment

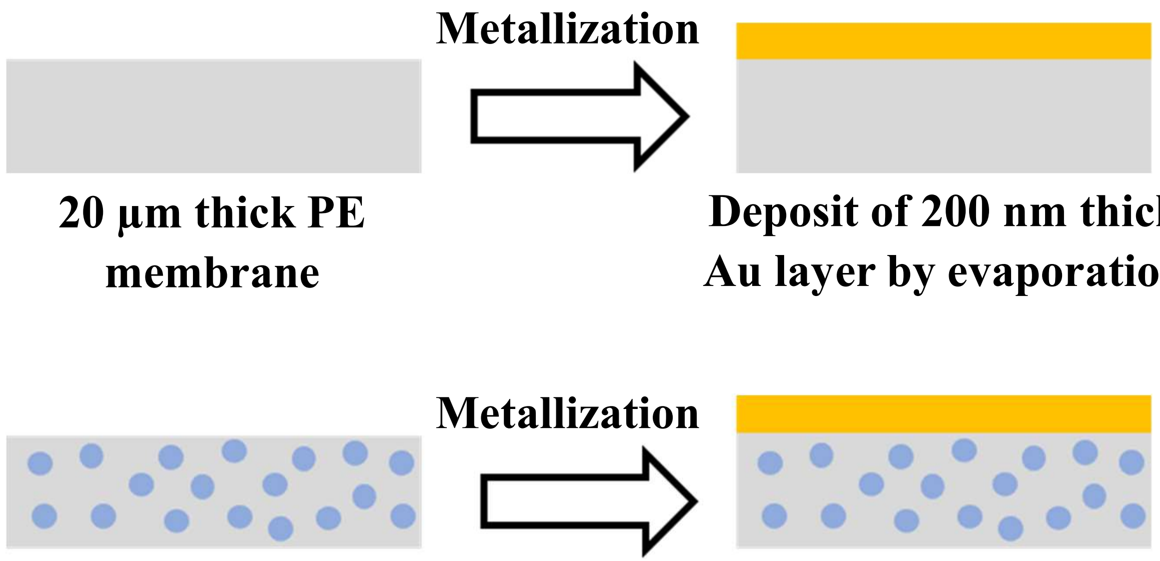
Multilayer membrane

Morphology and fabrication

PE membrane (thickness = 20 µm; 5 % by voulume of TiO_2)



SEM image



20 µm thick PE membrane

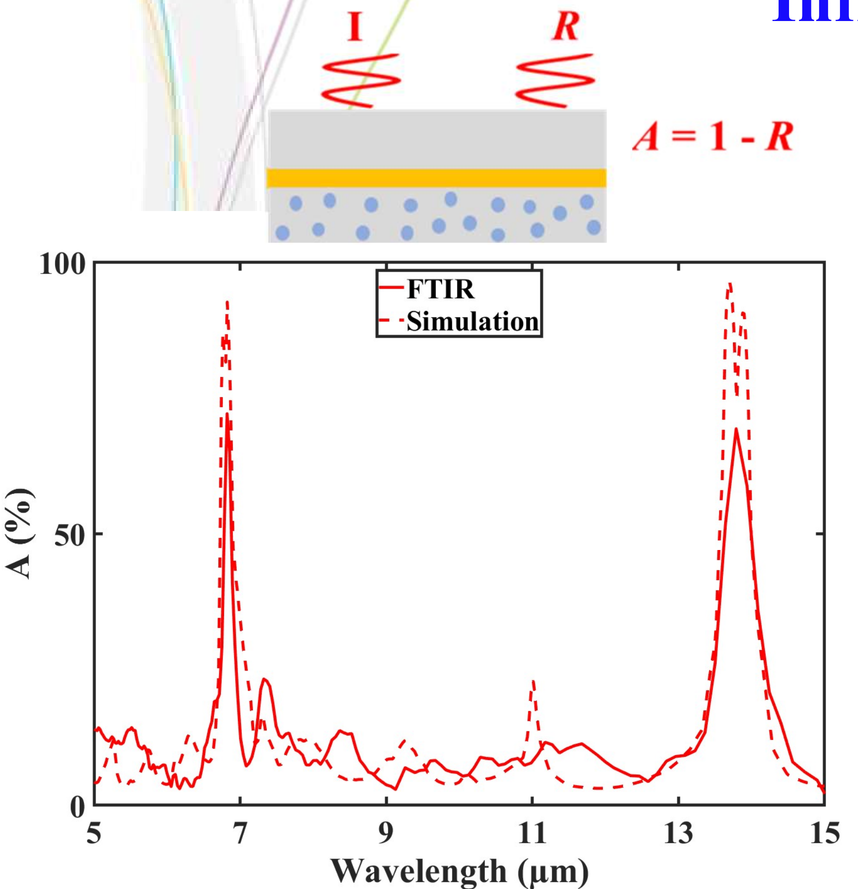
Deposit of 200 nm thick Au layer by evaporation

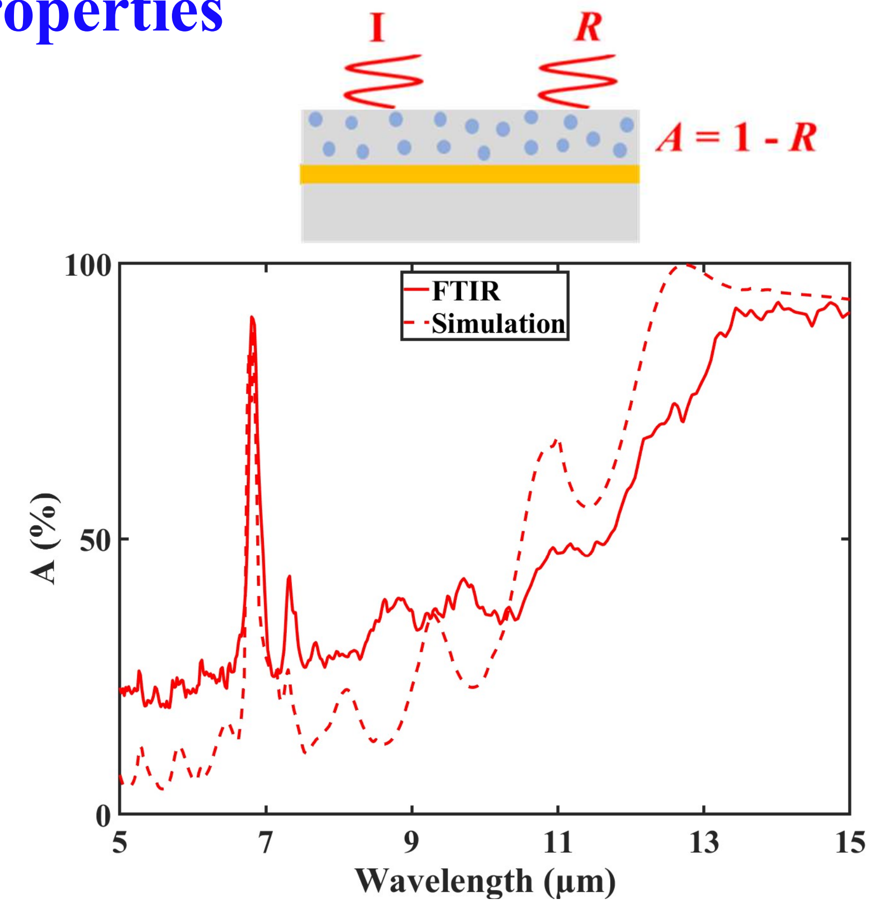
20 µm thick PE- TiO_2 membrane

Deposit of 200 nm thick Au layer by evaporation

Multilayer membrane

Infrared properties





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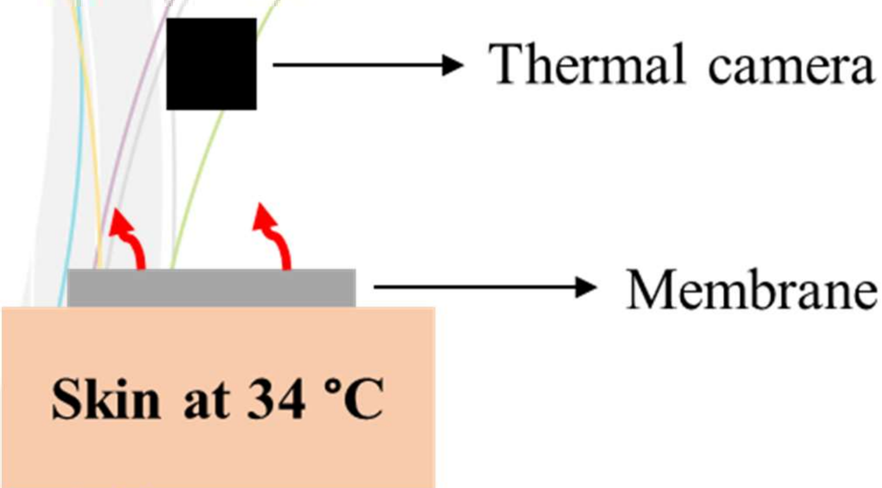
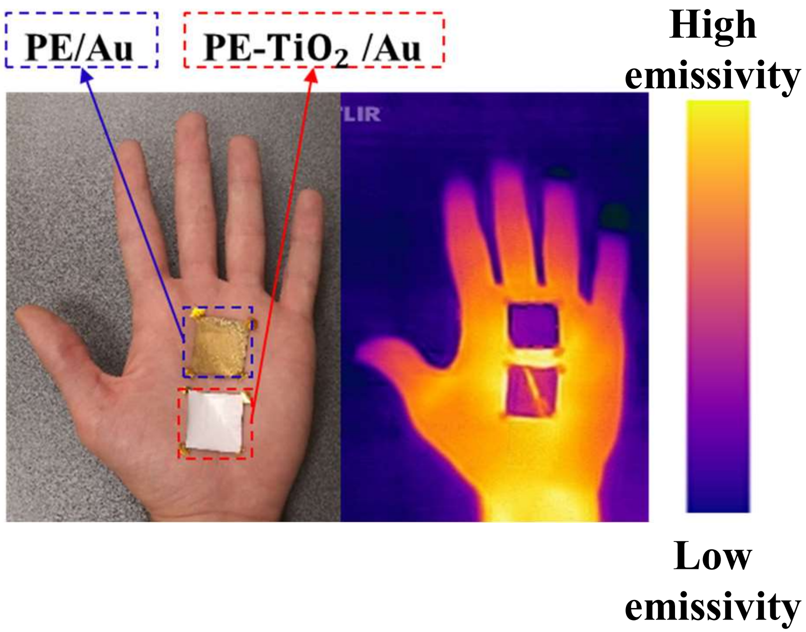
PHOTONITEX

Multilayer membrane

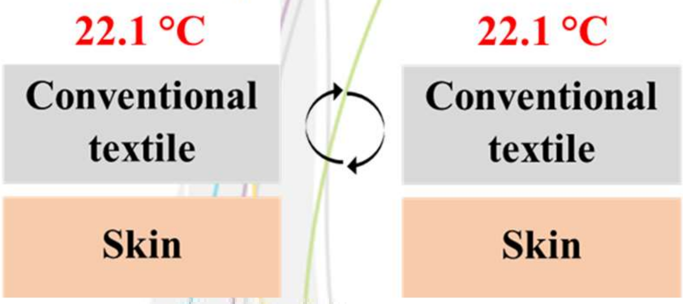
Emissivity



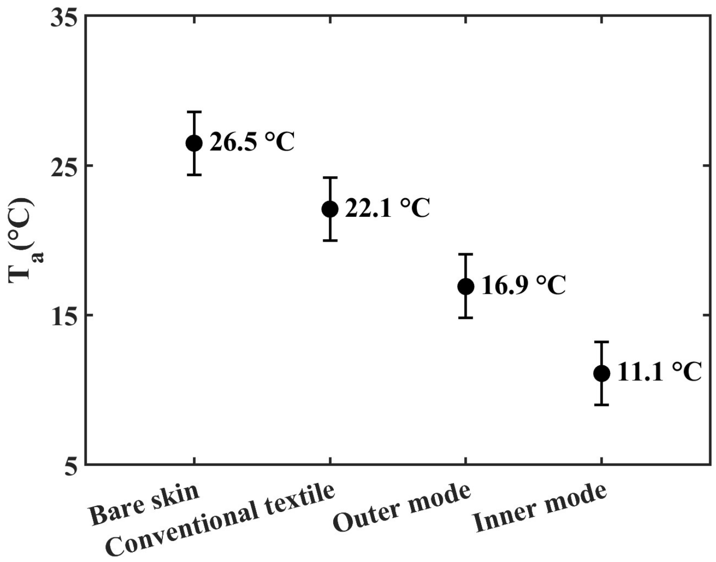


Multilayer membrane

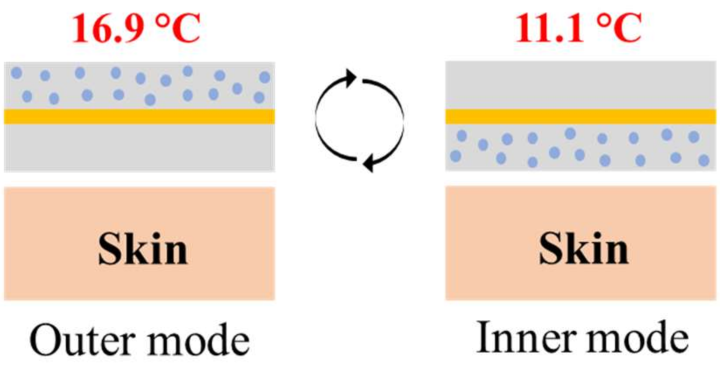
Thermal performances



One working mode



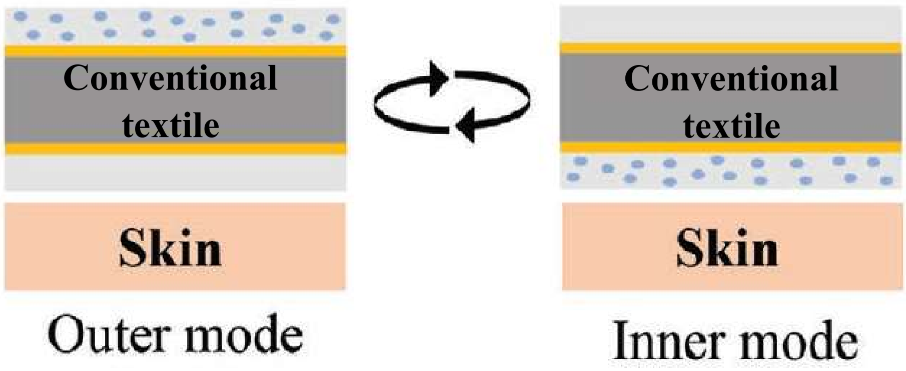
Thermal comfort zone

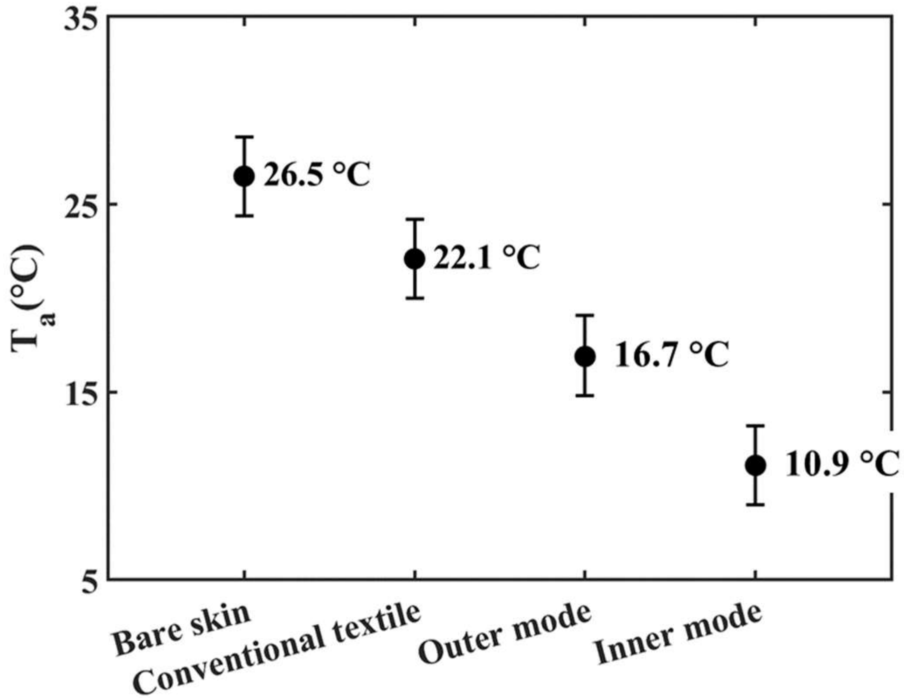


Two working modes

Multilayer membrane

Transfer on a conventional textile





Multilayer membrane

Conclusion

Multilayer membrane :

- ❑ **Flexible**
- ❑ **Easy to manufacture**
- ❑ **Able to maintain the thermal comfort in the range [11,1-16,9] °C**

Continuation of the work with ANR-PRCE-POCOMA project (2022-2025)

Work Package 3 : Static and dynamic structuring of membrane

1. Materia Nova in few words

2. Surface structuring
    a. Infrared domain interest
    b. Sol-gel process interest

3. Sol-gel process

4. Results from Photonitex project
    a. Static structuring
    b. Dynamic structuring

Eric Khousakoun, Materia Nova Mons

Materia Nova : in few words

PHOTONITEX

20 years

8 Millions €

86 Experts
(With UMONS -285 Experts)

Advanced equipments

Strong network

200 Project

THE TECHNOLOGICAL ACCELERATOR OF RESPONSIBLE INNOVATION IN MATERIALS AND PROCESSES

Materia Nova : in few words

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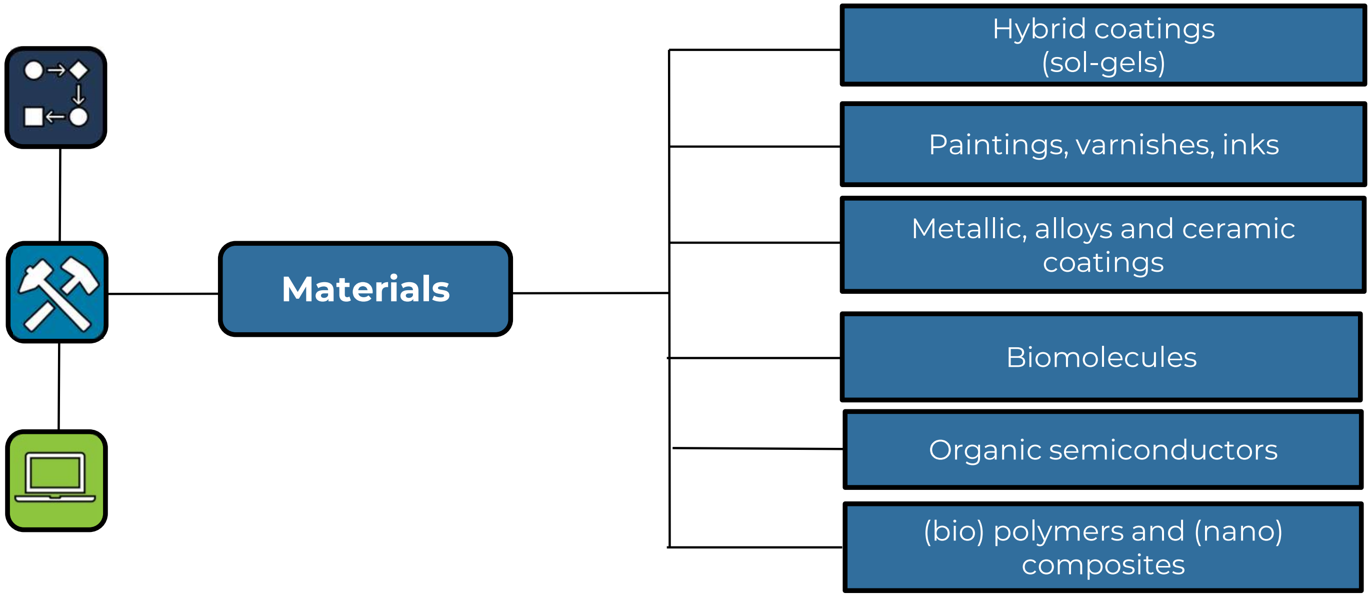
Our Technologies

CREATE NEW MATERIALS



THE TECHNOLOGICAL ACCELERATOR OF RESPONSIBLE INNOVATION IN MATERIALS AND PROCESSES

Surface structuring : interest in infrared domain

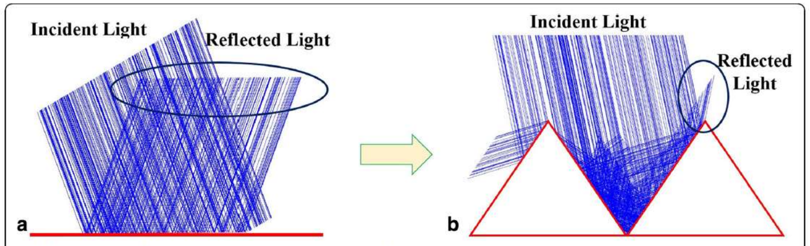
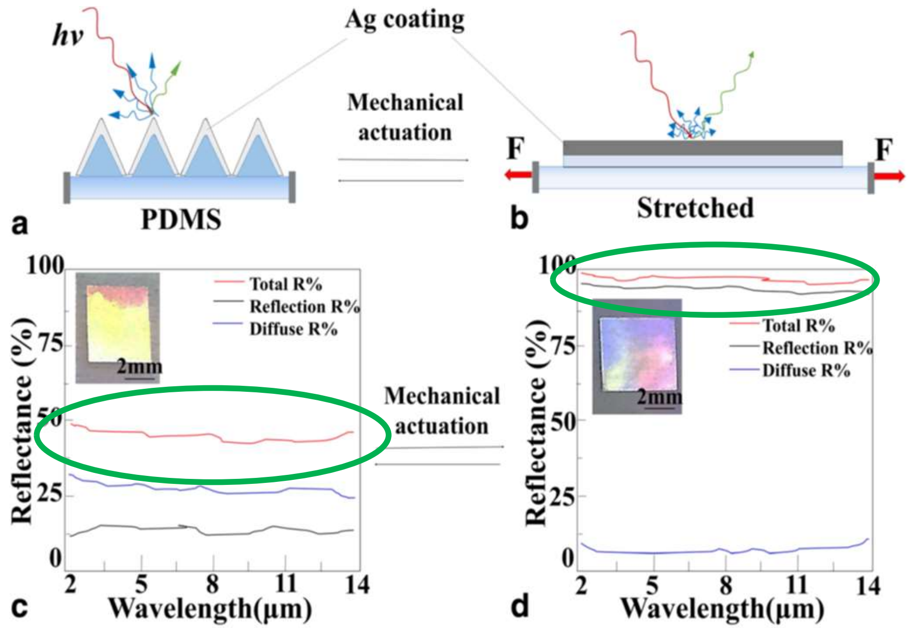


Fig. 1 Model of infrared mechanism. **a** Light was incident on the flat film; **b** on the triangular structures

Wang et al. Nanoscale Research Letters (2018) 13:361 https://doi.org/10.1186/s11671-018-2783-z



Surface structuring : interest of sol-gel process

Cross-linking under vacuum

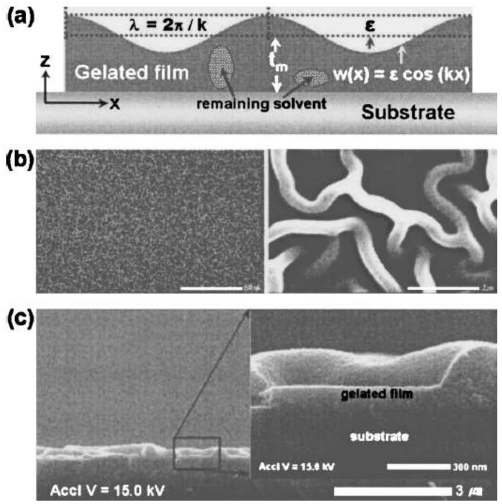


FIG. 1. (a) The geometry of the deformed sol-gel-derived film on a substrate. (b) Plane SEM images showing representative wrinkle patterns in the form of skeletal branches for the ZnO film (film thickness=85 nm) annealed at 150 °C for 18 h (scale bars are from left: 50 and 2 μm, respectively). (c) A cross-sectional FESEM image of the wrinkle patterns of the film. The inset is a magnified FESEM image of the wrinkled region.

Kwon, S. J. et al., Physical Review E, 2005, 71(1).
DOI: 10.1103/PhysRevE.71.011604

Cross-linking under temperature gradient

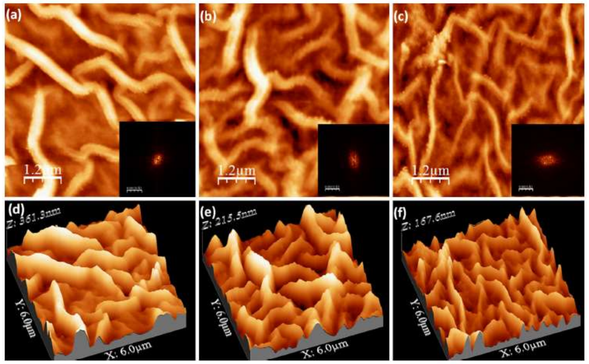


Fig. 3 Two-dimensional and three-dimensional AFM images (6 μm × 6 μm) of a, d ZnO-A, b, e ZnO-B, and c, f ZnO-C thin films preheated with different rates. *Inset* shows the corresponding FFT image

Navin, K. et al. Applied Physics A, 2015, 121(3), 1155–1161
DOI 10.1007/s00339-015-9481-9

Cross-linking under UV

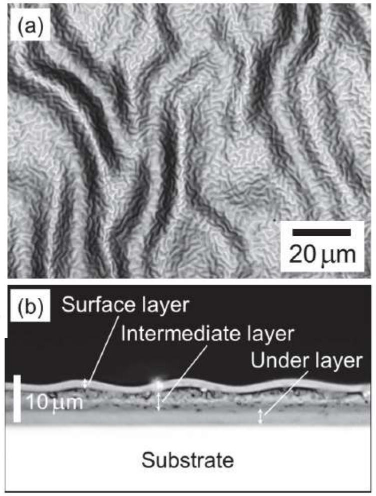


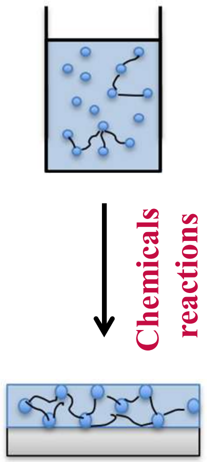
FIGURE 1. Microscopic images of the obtained films. (a) Surface image of nested wrinkles by confocal laser microscopy (LSCM) and (b) cross sectional image of nested wrinkles by optical microscopy.

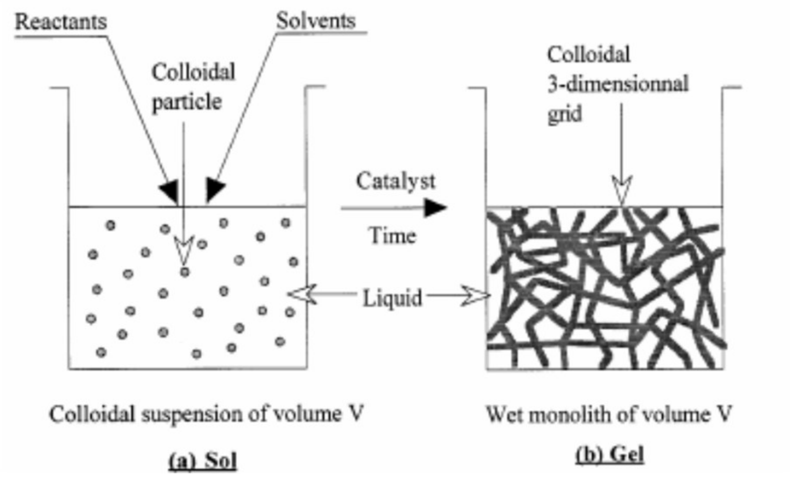
Suzuki et al. AIP Conf. Proc. , 2014, 1624, 141-146
DOI 10.1063/1.4900470

Sol-gel process : principle

Sol
=
Solution with precursors/solvent/ catalyst

Gel
=
Network cross-linking
Ex: siloxane network





The sol-gel chemistry involves two distinct phases: solution and gelation: a sol is a colloidal suspension of solid particles, whereas a gel is an interconnected network of solid phase particles that form a continuous entity throughout a secondary, usually liquid, phase.

Sol-gel process : steps of synthesis

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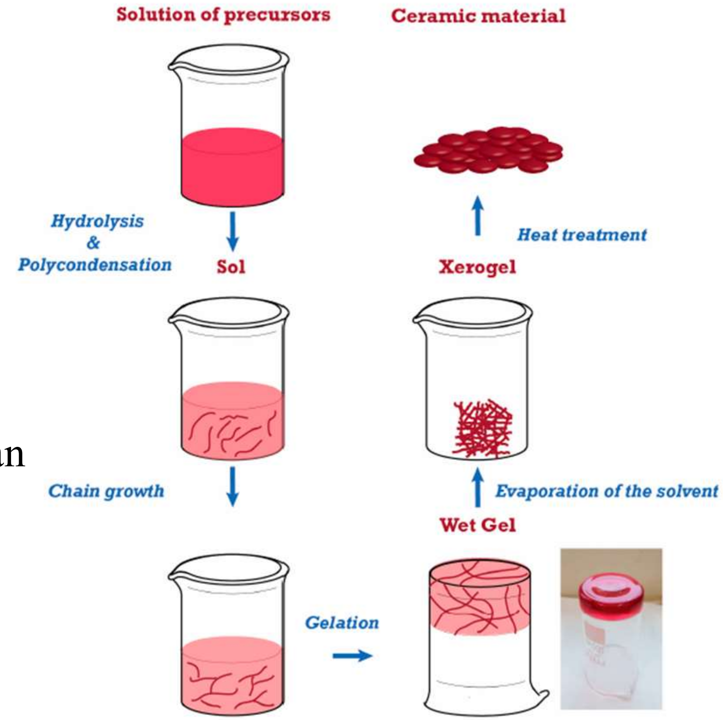
1. Preparation of the solution of precursors.

2. Hydrolysis and partial condensation of alkoxides to form a “sol”.

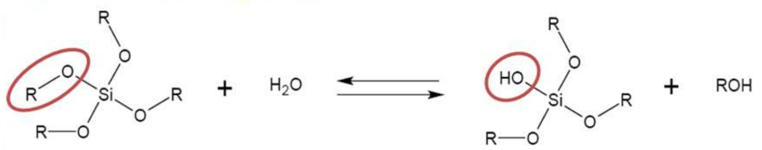
3. Formation of the gel via polycondensation of hydrolyzed precursors.

4. Drying. The gel forms a dense “xerogel” via collapse of the porous network caused by the evaporation of the solvent (or an aerogel for example through supercritical drying).

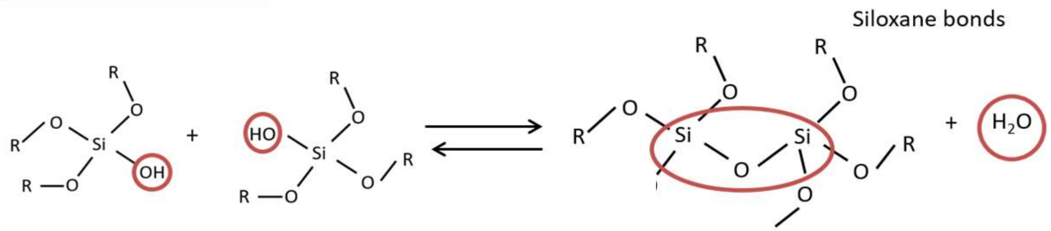
5. Calcination to obtain mechanically stable materials.



Hydrolysis



Condensation



Sol-gel process : deposition methods

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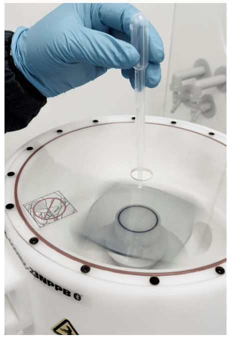
Synthesis

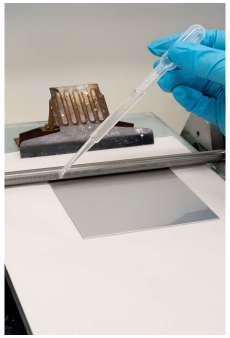
Deposition

Spin coating

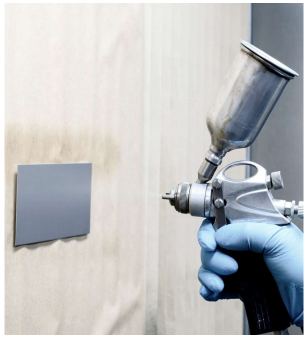


Dip coating

Roll coating



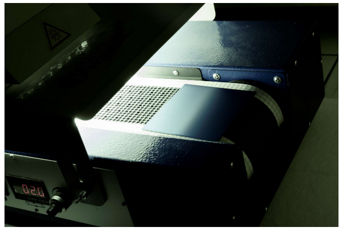
Spray coating



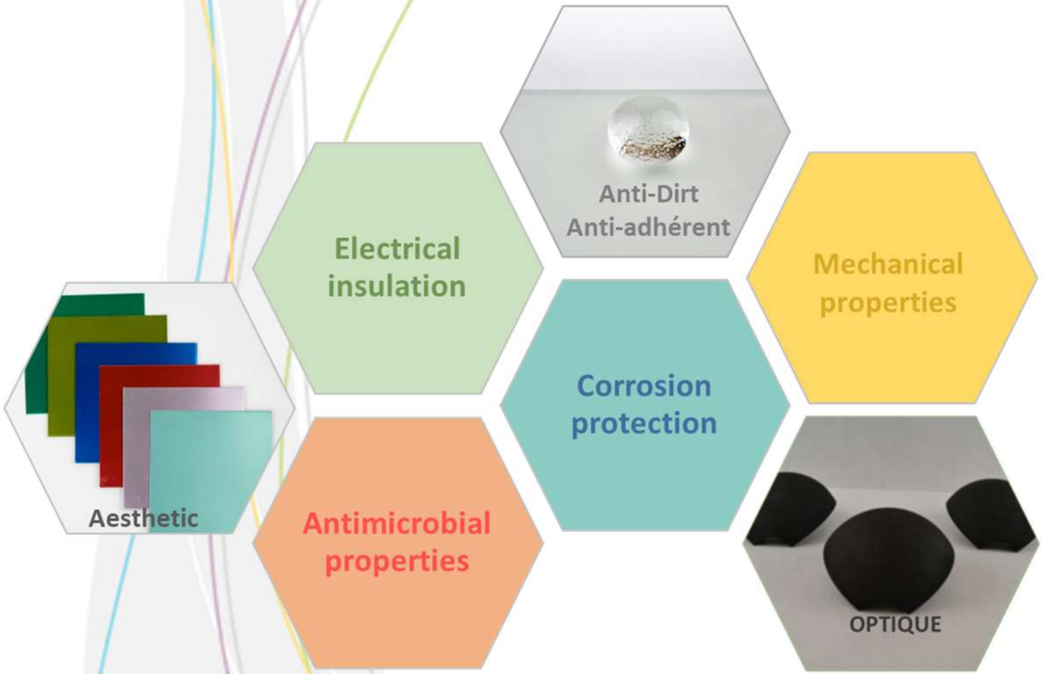
Cross linking

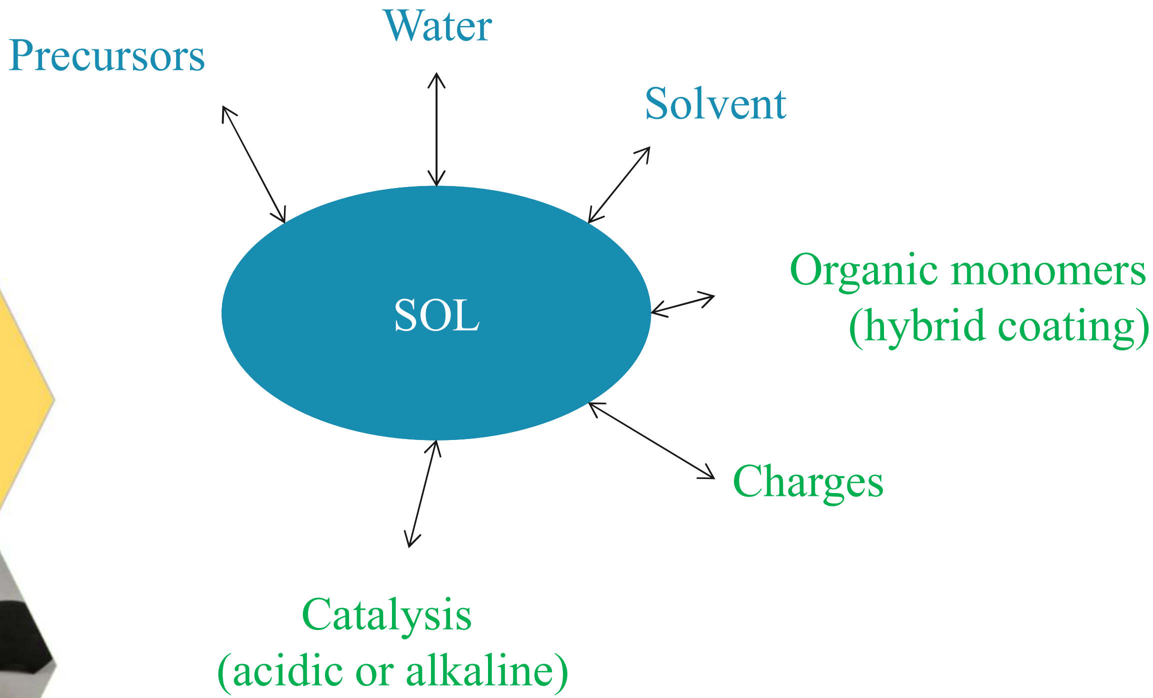
Thermal – UV – ambient

Example : UV exposition



Sol-gel process : property modulation

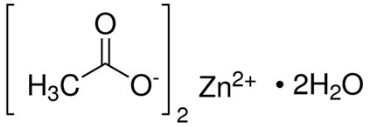


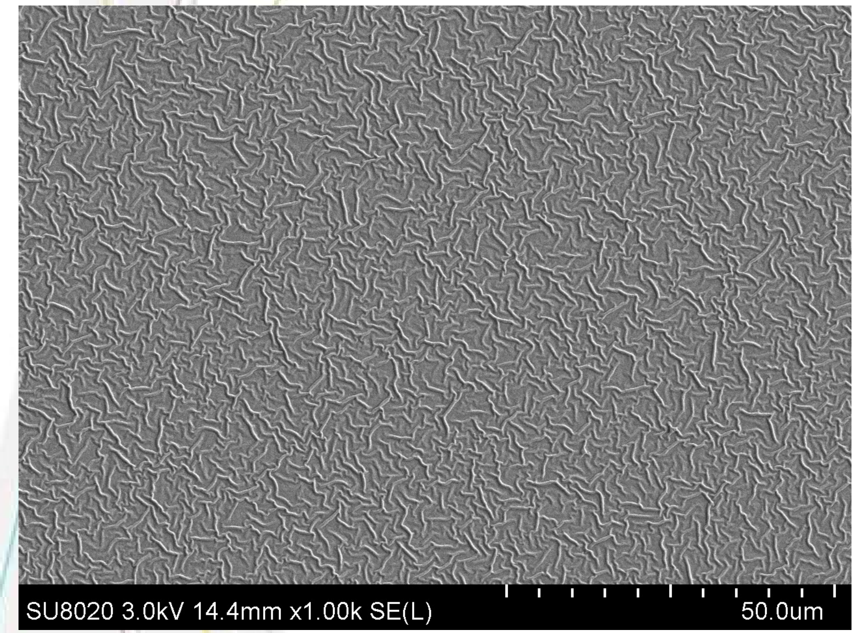


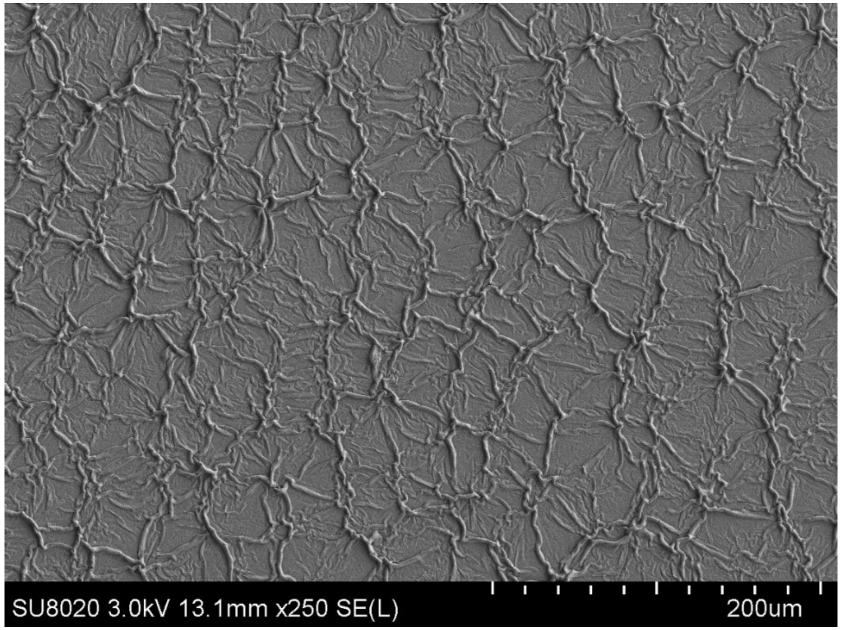
Static structuring of membrane: from synthesis to characterization of the film

PHOTONITEX

Zinc acetate precursors







Pictures obtained by SEM at the surface of the film (left by spin-coating and right par spray-coating)

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Static structuring of membrane: results

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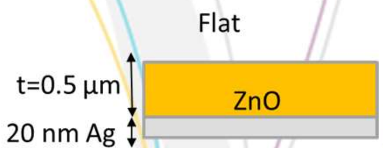
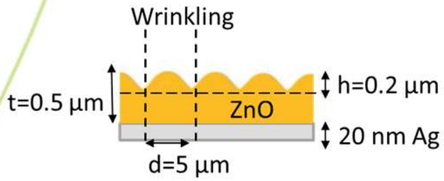
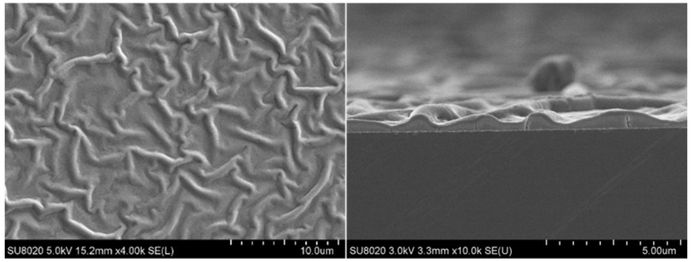
PHOTONITEX





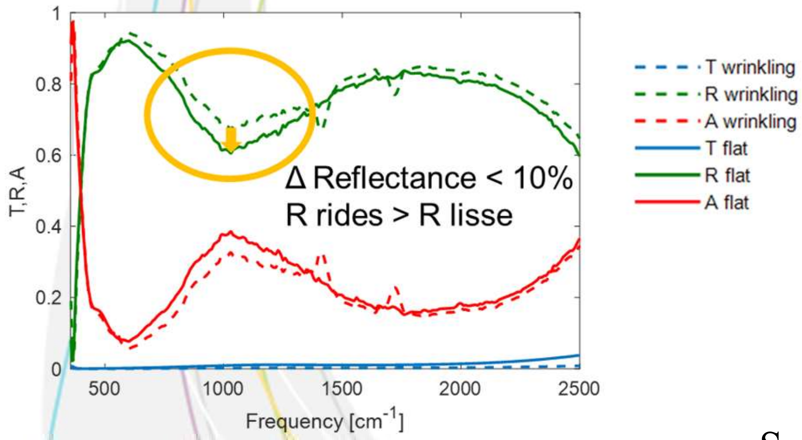


JUNIA HEI · ISEN · ISA

UMONS Université de Mons

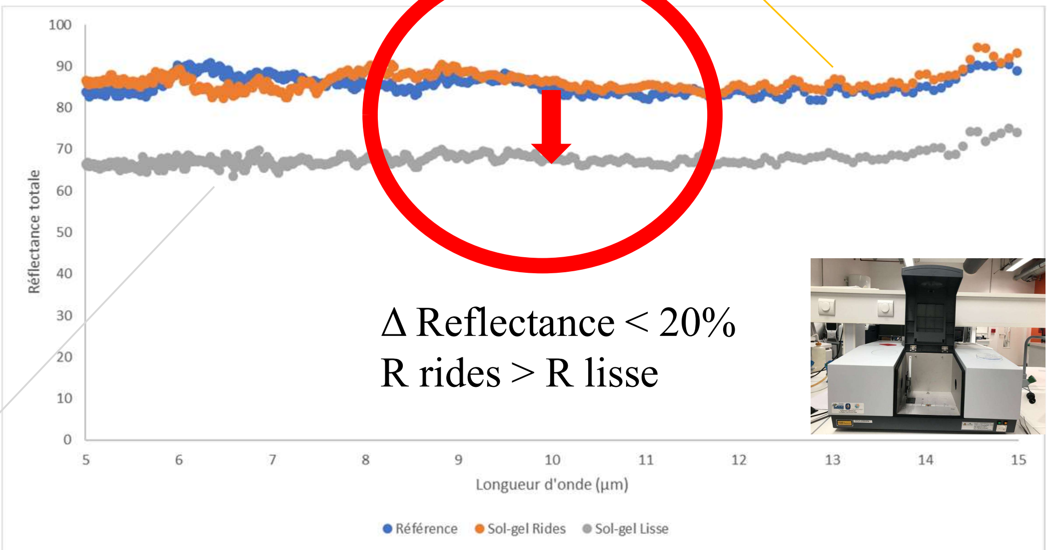
Formulation for lower amplitude wrinkles

Mathematical simulation of wrinkling structures



Experimental part

Wrinlking structures



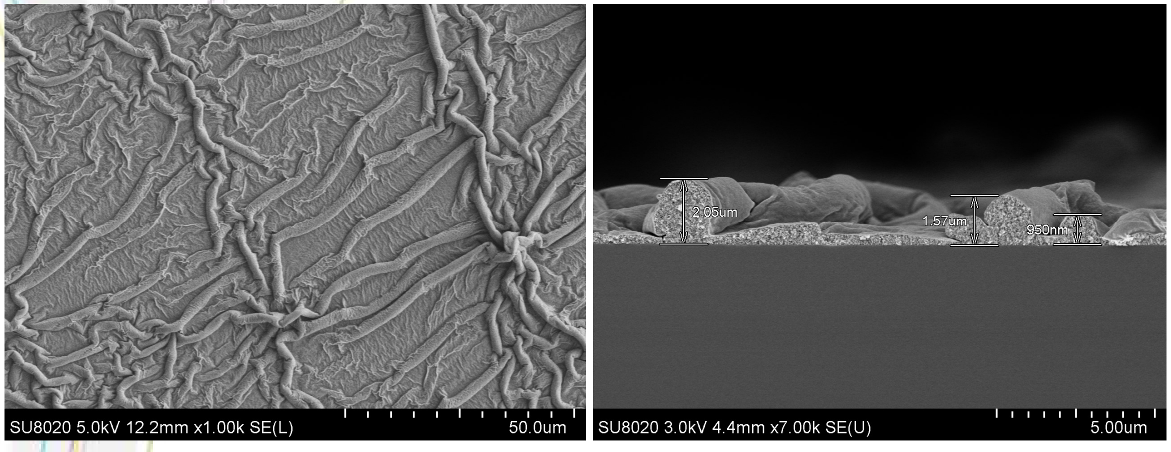
Δ Reflectance < 20%
R rides > R lisse

HEI

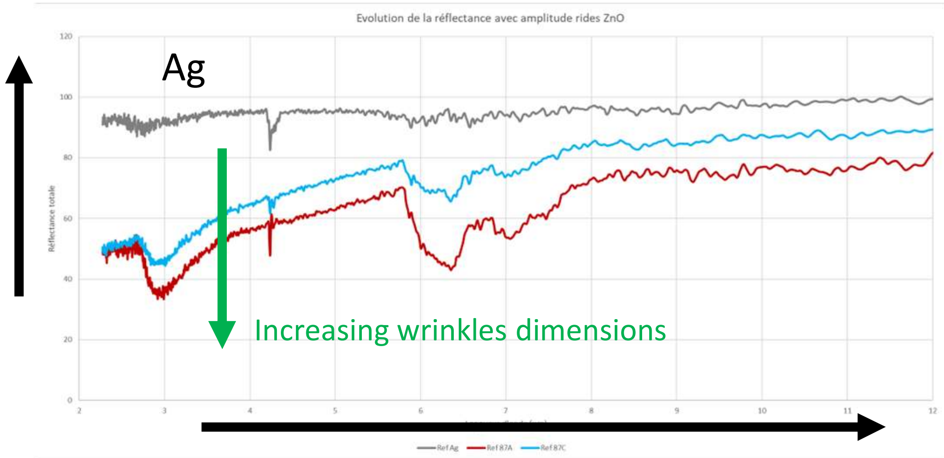
Smooth structure

Static structuring of membrane: results

PHOTONITEX

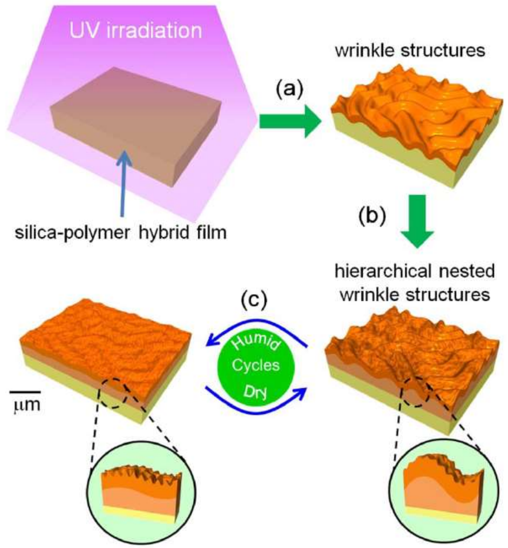


Formulation for higher amplitude wrinkles



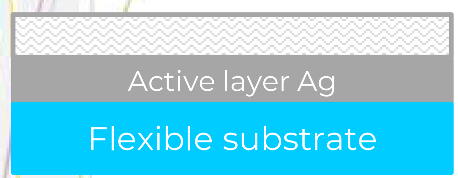
Dynamic structuring of membrane: synthesis

Formulation of hybrid sol-gel based on thermosensible polymer



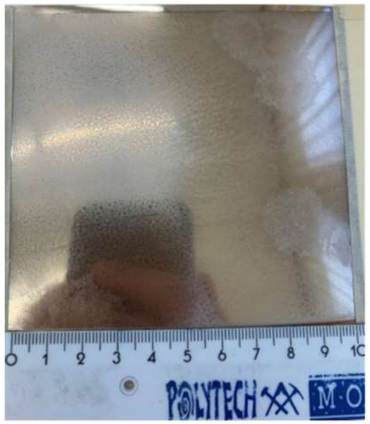
Tokudome, Y., Suzuki, K., Kitanaga, T. & Takahashi, M. Sci. Rep. 2, 683; DOI:10.1038/srep00683 (2012)

Deposition of the hybrid sol-gel layer



Flexible sample A4 format covered with a thin layer of Ag (20 nm)

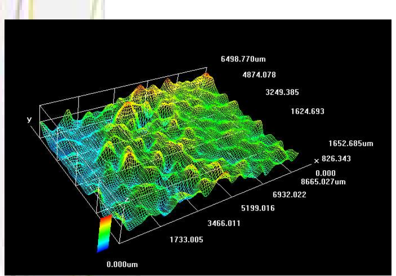
10*10 cm^2 cutted for optical characterization



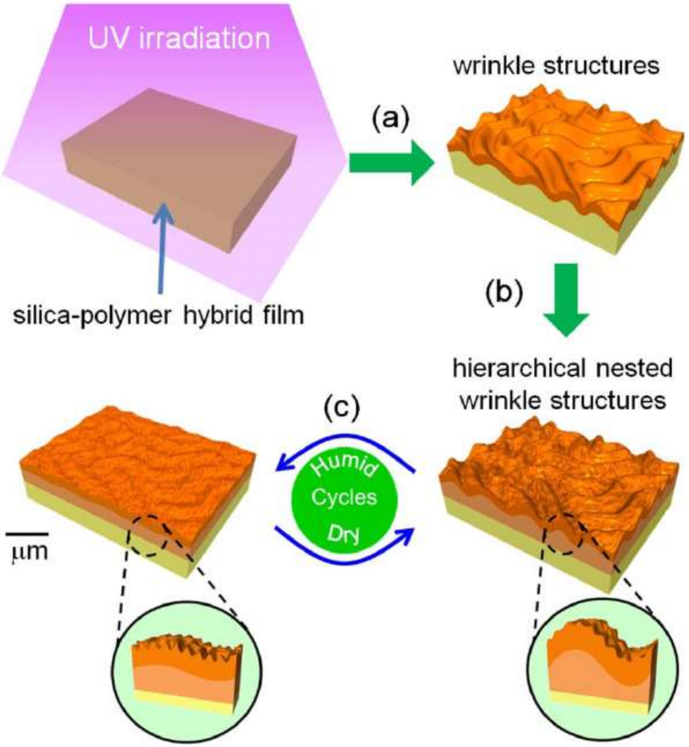
Dynamic structuring of membrane: characterization

Characterization by 3D microscopy

T = 20°C, HR 70%



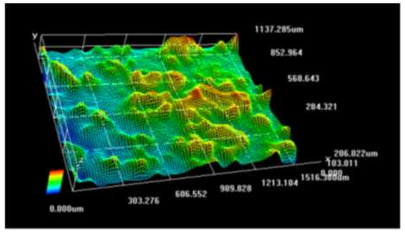
Ra = 0.4 ± 0.1 µm
Rz = 0.8 ± 0.2 µm



Rz (µm) (maximum height of the profile)

Ra (µm) (average height of the profile)

T = 45°C, HR 0%



Ra = 2.3 ± 0.5 µm
Rz = 5.3 ± 0.3 µm

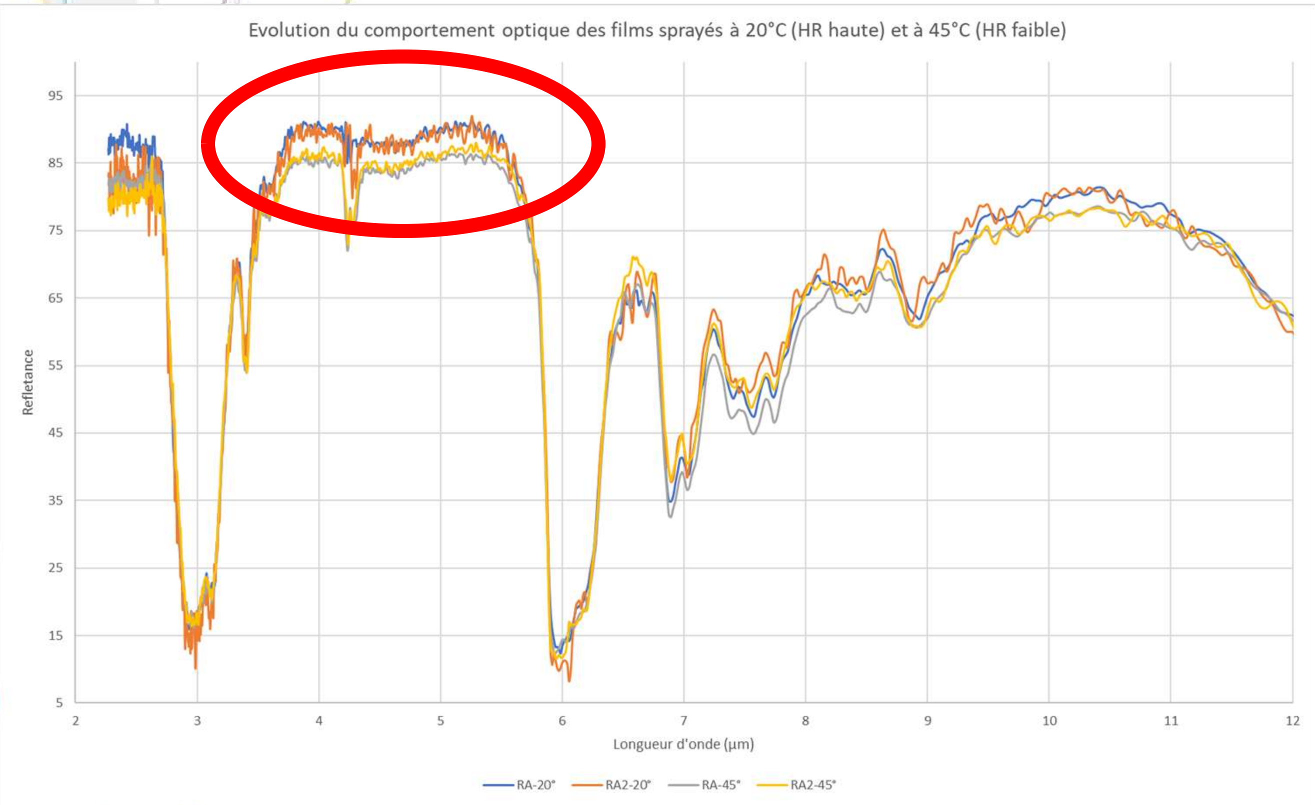
=> Study of optical properties with surface modifications

Dynamic structuring of membrane: optical properties in infrared region

INTERREG France-Wallonie-Vlaanderen — UNION EUROPÉENNE EUROPESE UNIE

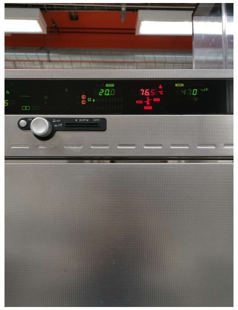
PHOTONITEX

On both sides of LCST, 25°C (RH high) and at 45°C (RH low)



Hybrid sol gel formulation

Conditioning at climatic



Characterization with FTIR

Between 3.5 µm and 5.5 µm (IR regions), different of optical response between « smooth » structures and « rough » structures => dependance of the dimensions of wrinklings structures

Conclusions & Perspectives

PHOTONITEX

❑ **Static wrinkling structures by sol-gel process on membrane**:
- Nanometric and micrometic wrinklings structures could be obtained by solgel process by spray or spin deposition
- **Proof of concept** that the wrinklings (# smooth structures) structures have an impact on optical response in infrared region
- Experimental part could be fitted by modelisation

❑ **Dynamic wrinkling structures by sol-gel process on membrane:**
- Hybrid solgel containing a organic thermosensible part could be synthesized
- Spray deposition could be achieved on **A4** flexible substrate (PI covered by Ag)
- Surface structure evolved with T and RH (Ra, Rz)
- Optical response (Reflectance) in infrared region evolved with T and RH

➢ **Others properties of sol-gel in membrane needed to be evaluated**

➢ **Applications on fibers**

Work Package 3 and 4 : Static and dynamic structuring of membrane and filaments

Design of dynamic hydrogel-based materials for near-IR thermal management fabrics

Laboratory Of Polymeric And Composite Materials

Gemtex
Textile Research Laboratory

Marjorie Garzon Altamirano, PhD student

September 29, 2022 – Closing event

Interreg France-Wallonie-Vlaanderen
PHOTONITEX

Laboratory Of Polymeric And Composite Materials

UMONS Université de Mons

MATERIA NOVA Materials R&D Center

Research

- Natural, reborn and eco-friendly polymers
- Sustainable Polymer materials & related (Nano)composites
- Macromolecular Engineering
- Reactive extrusion and Eco-friendly processes
- Adaptive Polymeric Materials & Additive Manufacturing

Projects

Interreg France-Wallonie-Vlaanderen GoToS3 BIOCOMPAL

NIPU NON-ISOCYANATE POLYURETHANES

Interreg France-Wallonie-Vlaanderen TEXTOS

Biodest

3D4MED

STELLAR

Gemtex: Textile Research Laboratory

ensait
ROUBAIX
ECOLE D'INGENIEURS TEXTILE

Research

1. **Multifunctional Textiles ans Processes**
   - Nanostructuration of textile materials
   - Surface treatments of textile structures
2. **Mechanics Textile Composites**
   - Ballistics
   - Textiles reinforced composites
3. **Human Centered Design**
   - Sensory design into design processes
   - Smart and multifunctional textiles

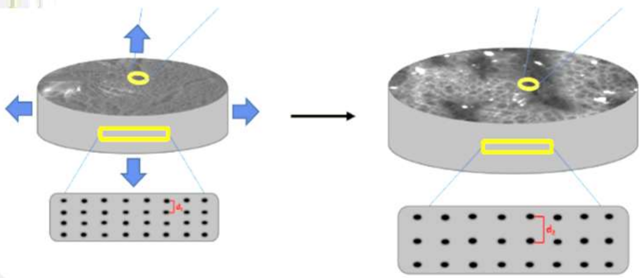
Projects

Digital Fashion Project
Collaborative Online International Learning in Digital Fashion

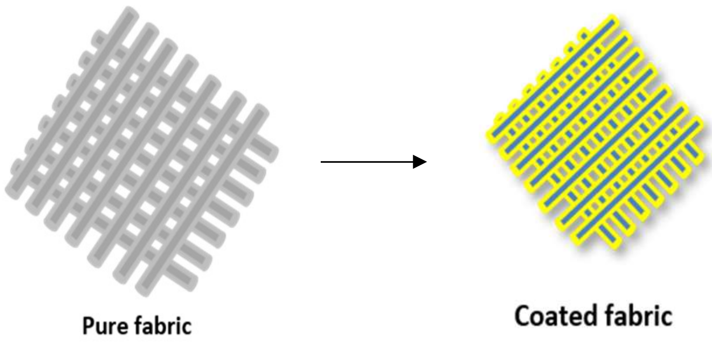
Interreg
CLEANTEX

Design of dynamic hydrogel-based materials for near-IR thermal management fabrics

Photonic dynamic structures



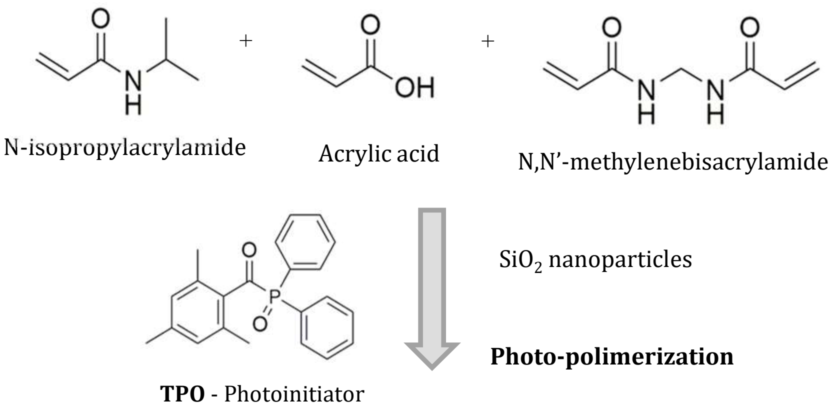
Design of thermoregulating textiles

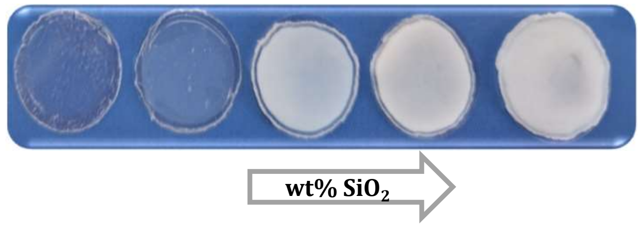


Design and demonstration of dynamic self-structuring membranes in the modulation of infrared radiation reflection

Design of hydrogels composite:
P(nipam-AA)/SiO_2

Free radical photo-polymerization





UMONS Université de Mons SMPC ensait ROUBAIX ECOLE D'INGENIEURS TEXTILE gemtex ROUBAIX LABORATOIRE DE RECHERCHE TEXTILE

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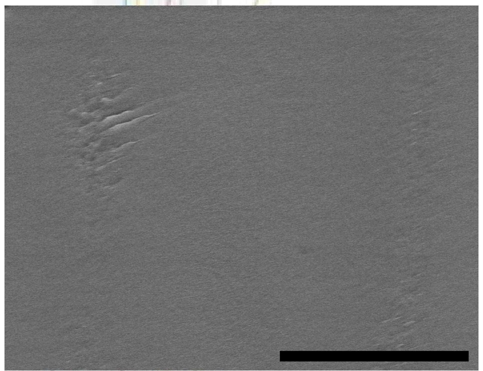
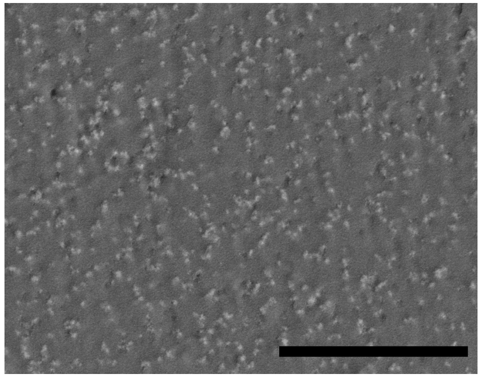
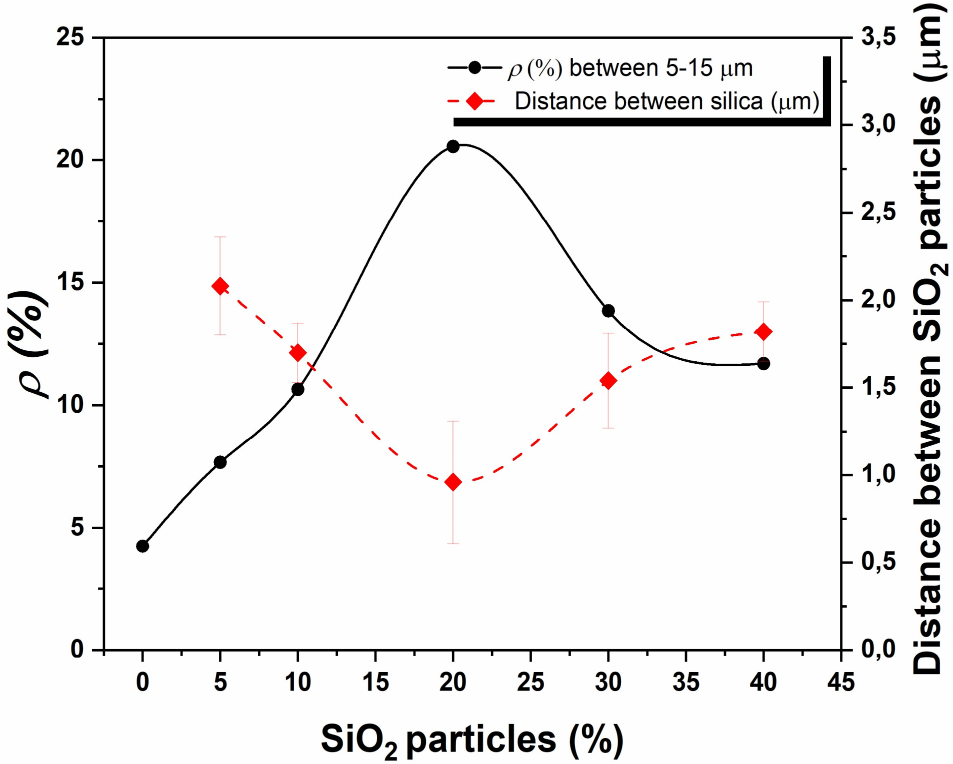
PHOTONITEX

Design and demonstration of dynamic self-structuring membranes in the modulation of infrared radiation reflection

Infrared responsive: SiO_2 effect

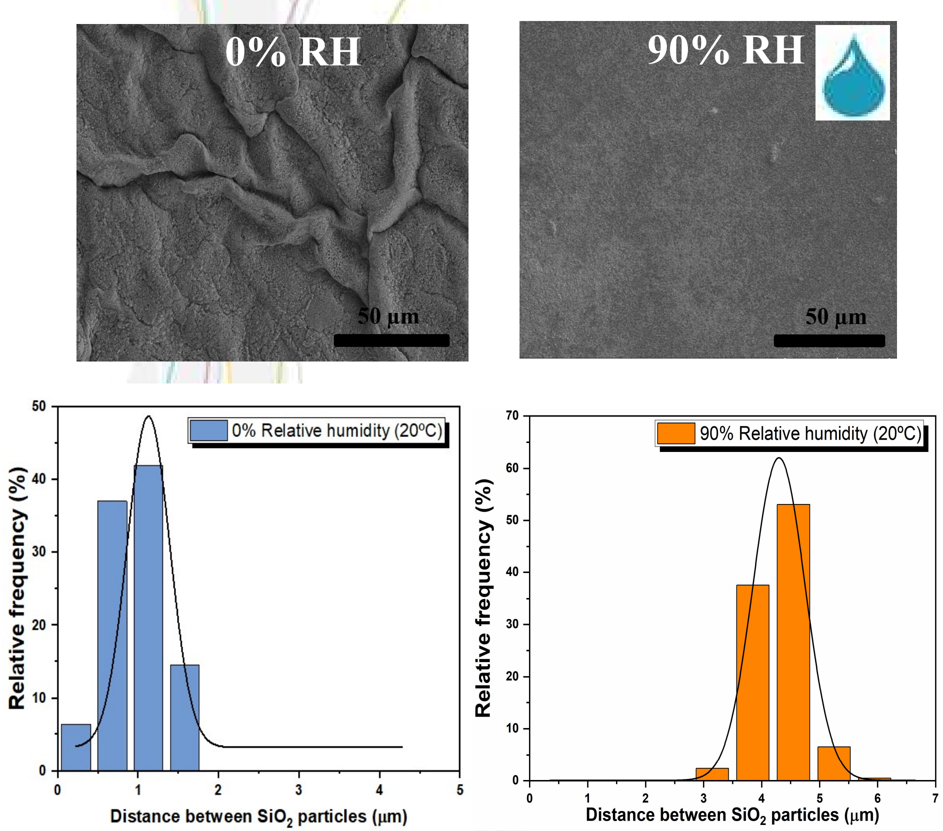


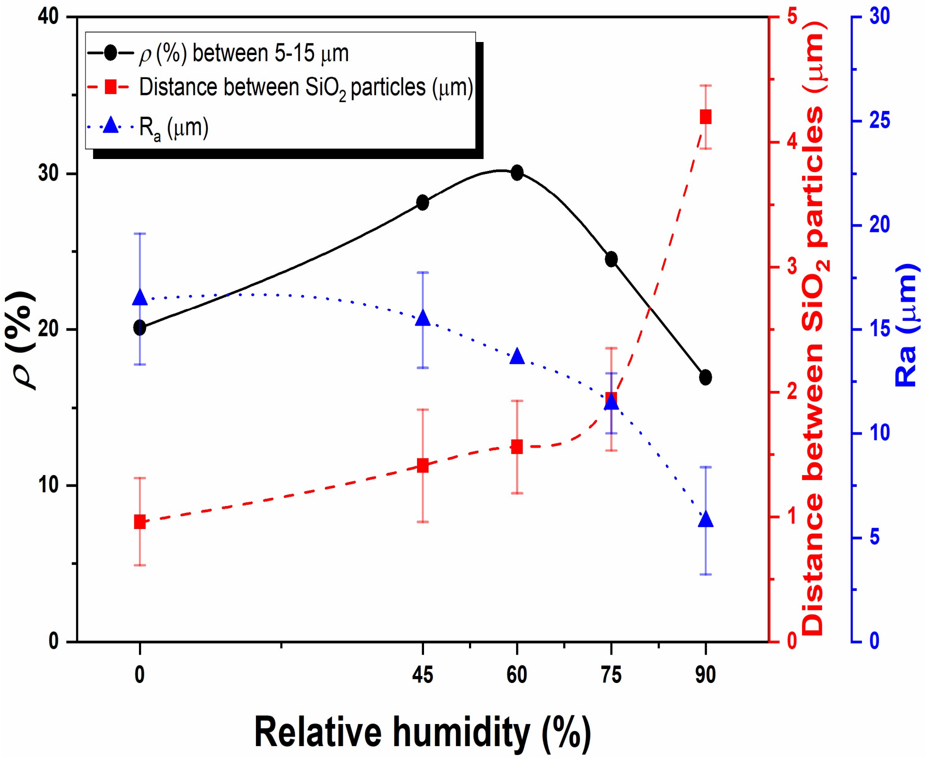




Design and demonstration of dynamic self-structuring membranes in the modulation of infrared radiation reflection

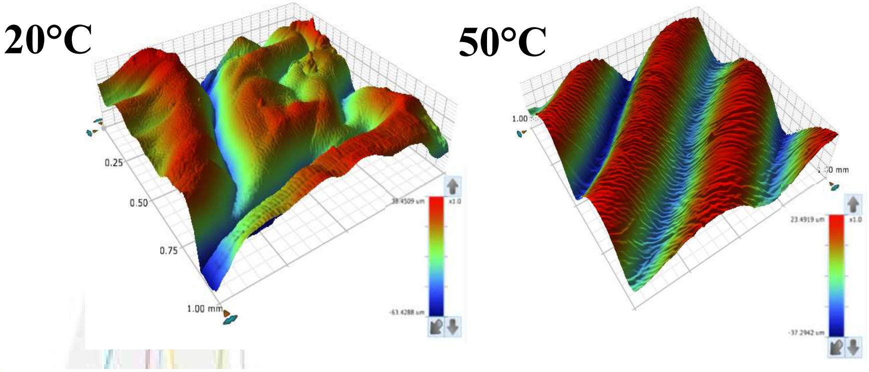
Infrared responsive: Relative humidity effect

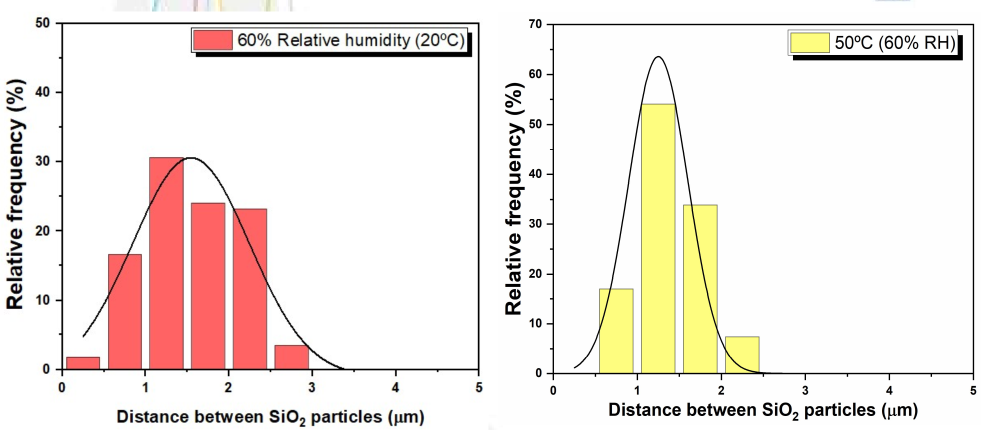


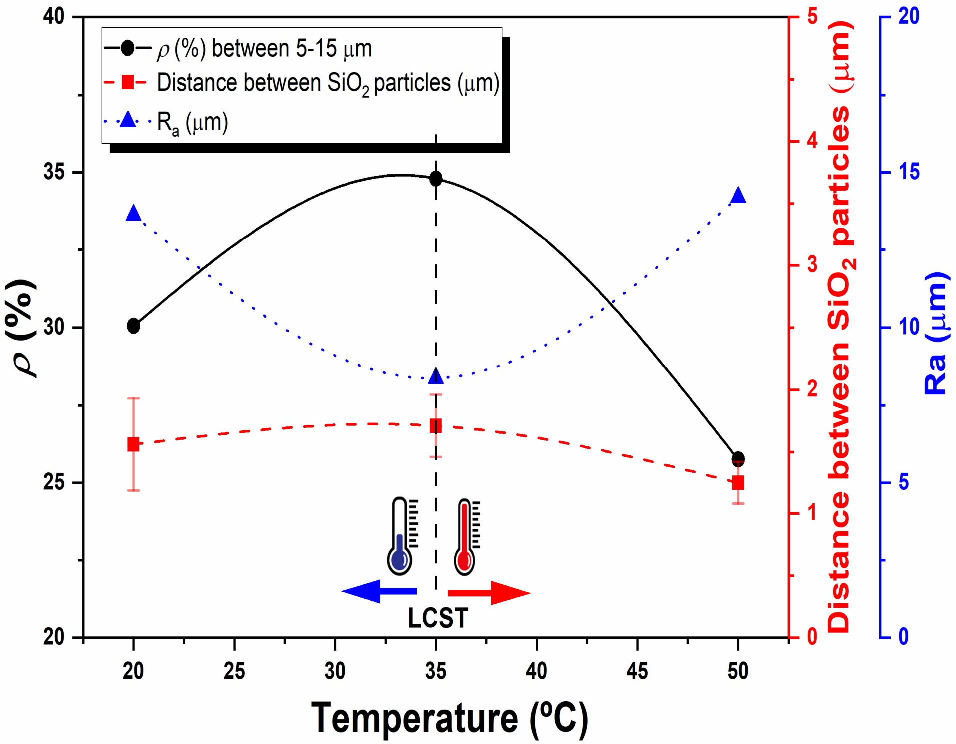


Design and demonstration of dynamic self-structuring membranes in the modulation of infrared radiation reflection

Infrared responsive: Temperature effect

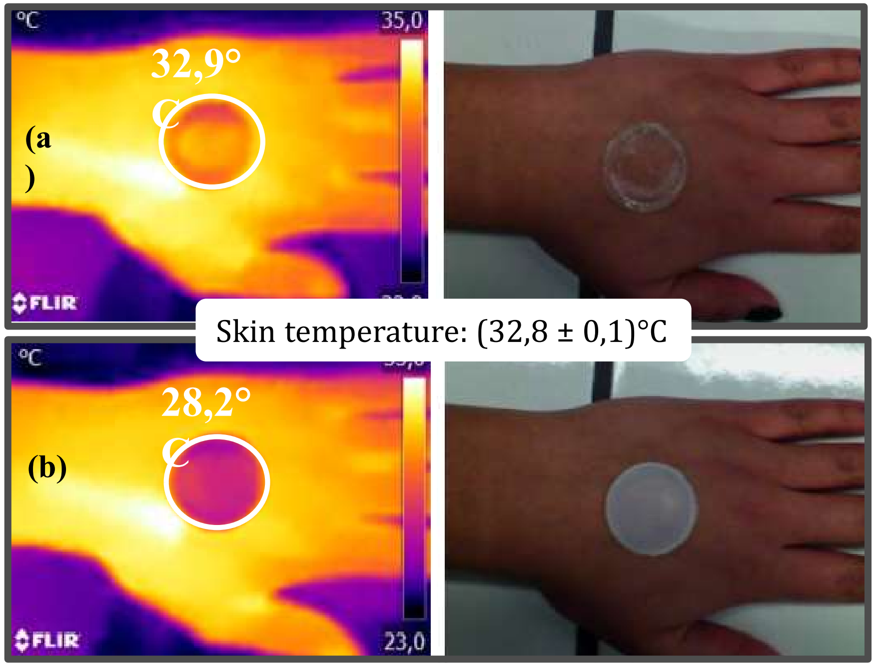






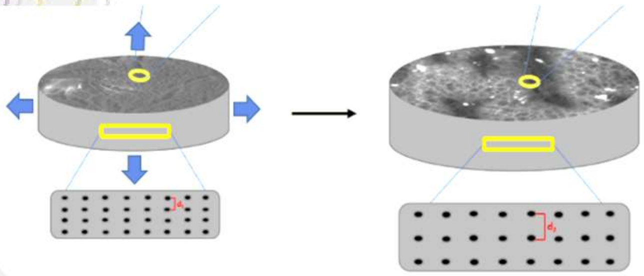
Design and demonstration of dynamic self-structuring membranes in the modulation of infrared radiation reflection

Thermal behavior:

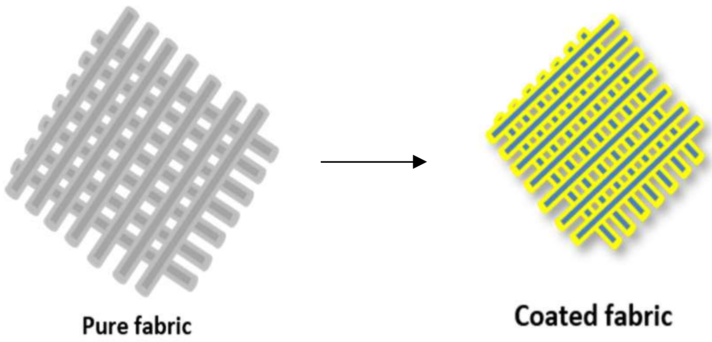


Design of dynamic hydrogel-based materials for near-IR thermal management fabrics

Photonic dynamic structures

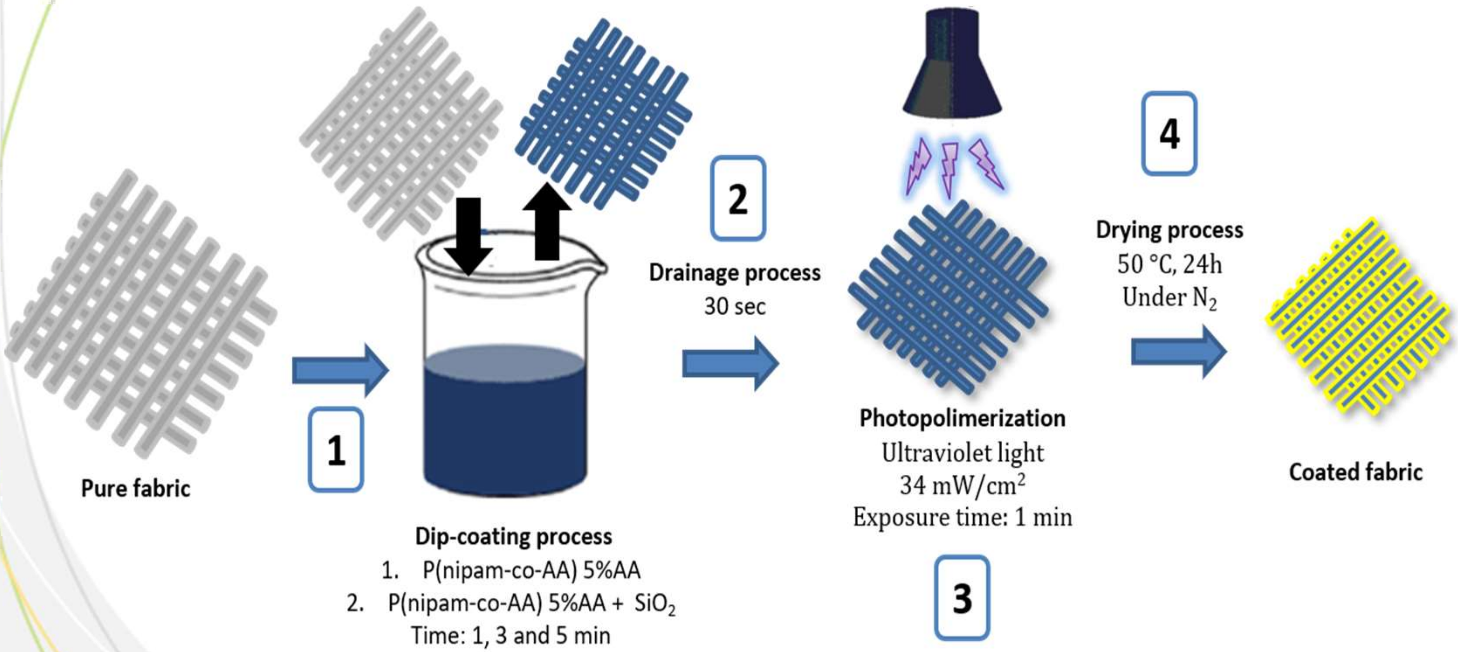


Design of thermoregulating textiles



Application of dynamic systems based on SiO_2 with infrared response in commercial fabrics

Dip-coating process



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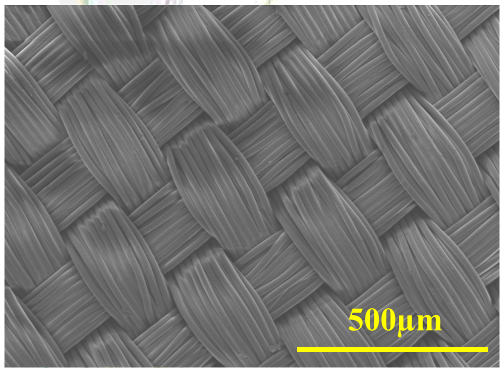
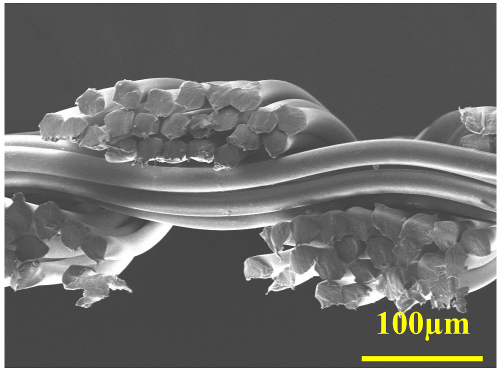
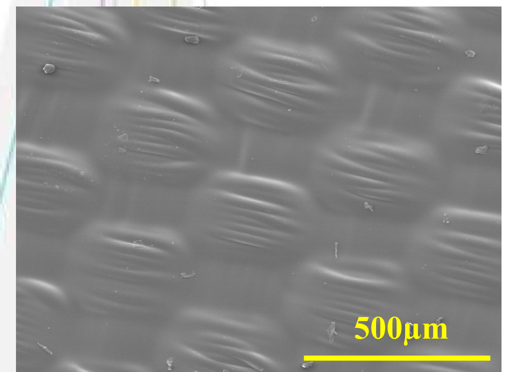
Application of dynamic systems based on SiO_2 with infrared response in commercial fabrics

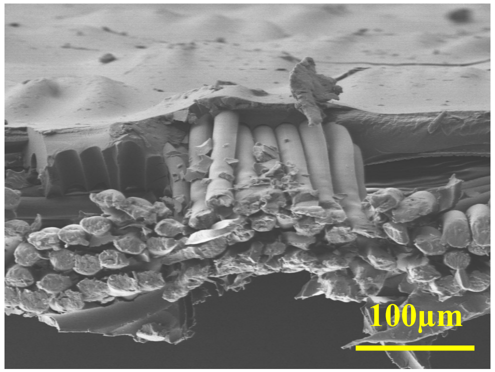
PA 6-6 pure fabric





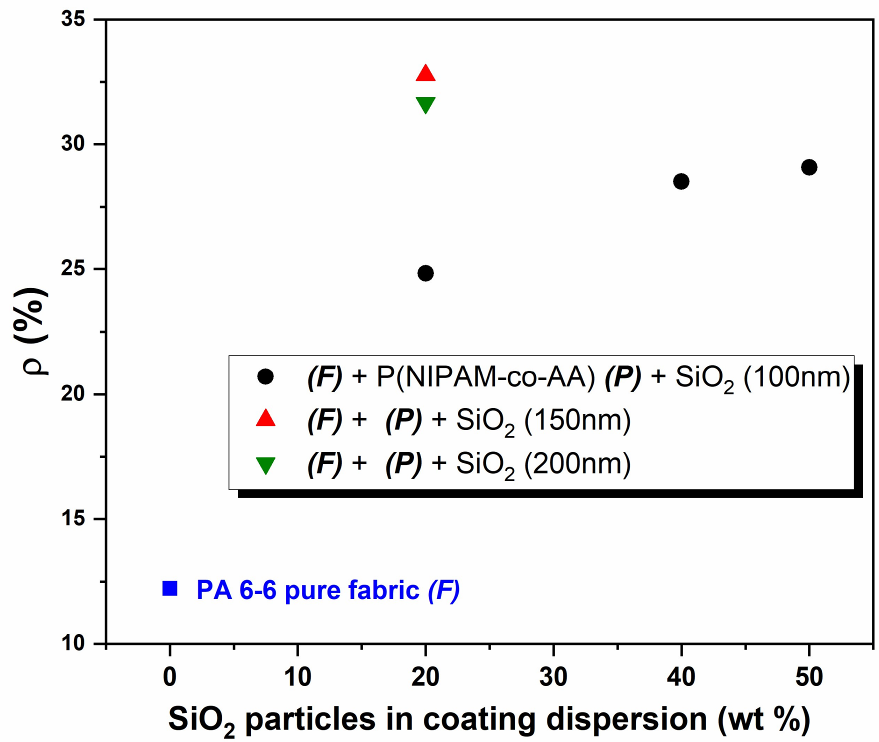
Coated fabric





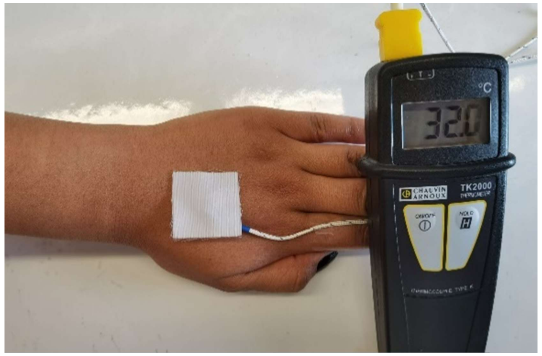
Infrared responsive:

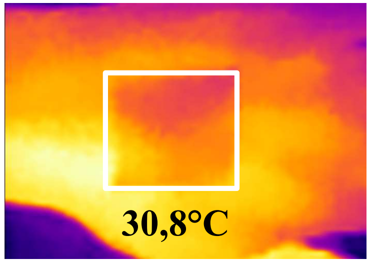
Size and wt% SiO_2 effect



Application of dynamic systems based on SiO_2 with infrared response in commercial fabrics

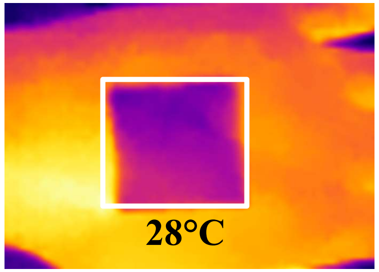
Thermal behavior:





PA 6-6 pure fabric

Sample	Temperature between skin and fabric(°C)
PA 6-6 pure fabric	31,1
Coated fabric	33,3



Coated fabric

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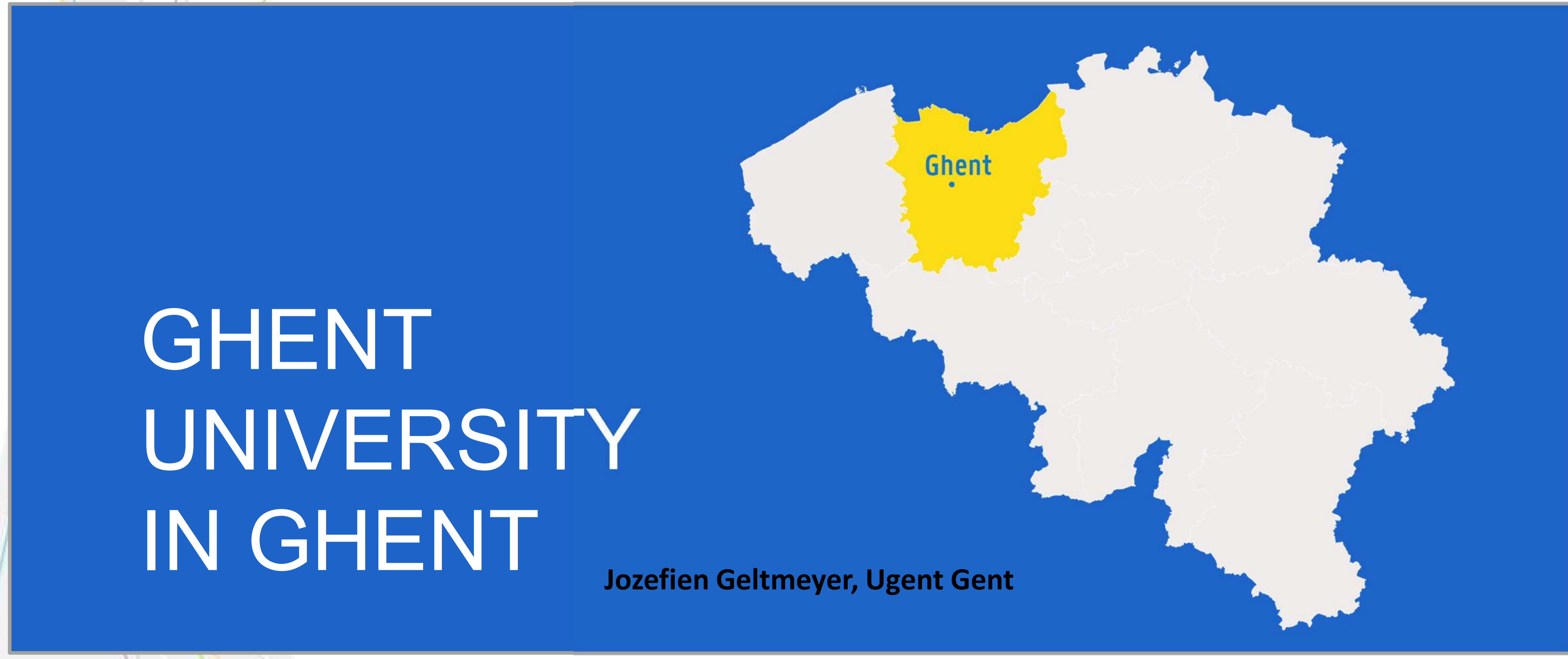
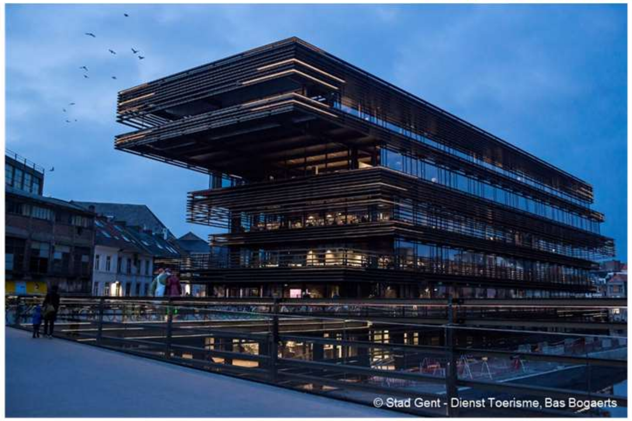
Work Package 3 and 4 : Static and dynamic structuring of membrane and filaments



Jozefien Geltmeyer, Ugent Gent



Ghent: Medieval city

263.600 inhabitants

76.500 students

167 nationalities

1.400 restaurants & cafés

3.600 startups per year

Bron: gent.buurtmonitor.be/dashboard

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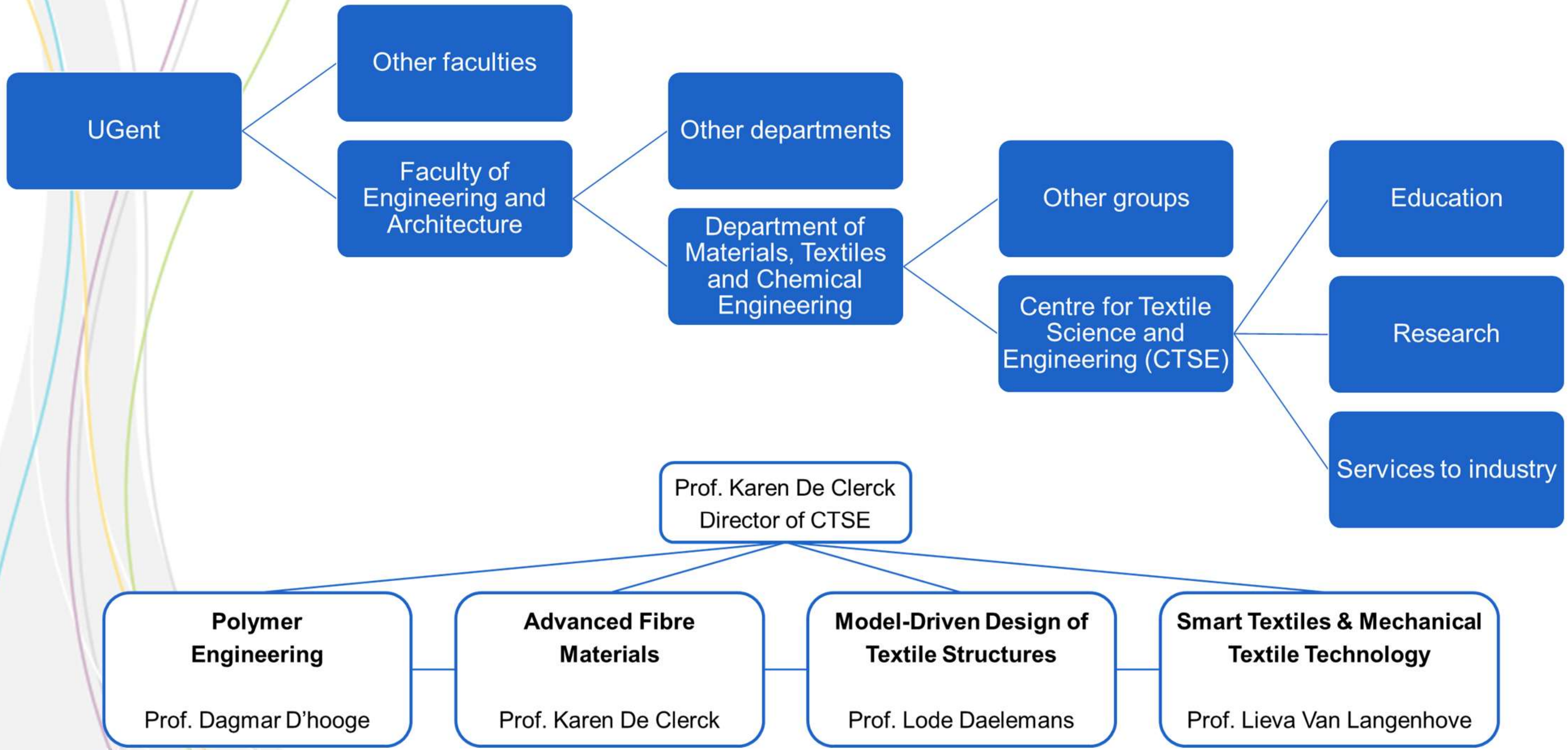
CTSE WITHIN UGENT



GHENT UNIVERSITY

AT CTSE WE STUDY ALL TYPES OF TEXTILE MATERIALS

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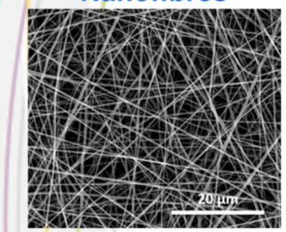
Chemicals

Processing

Fibers

Textile materials

Nanofibres



Bio-based fibres

Carpets

Fibre and filament extrusion

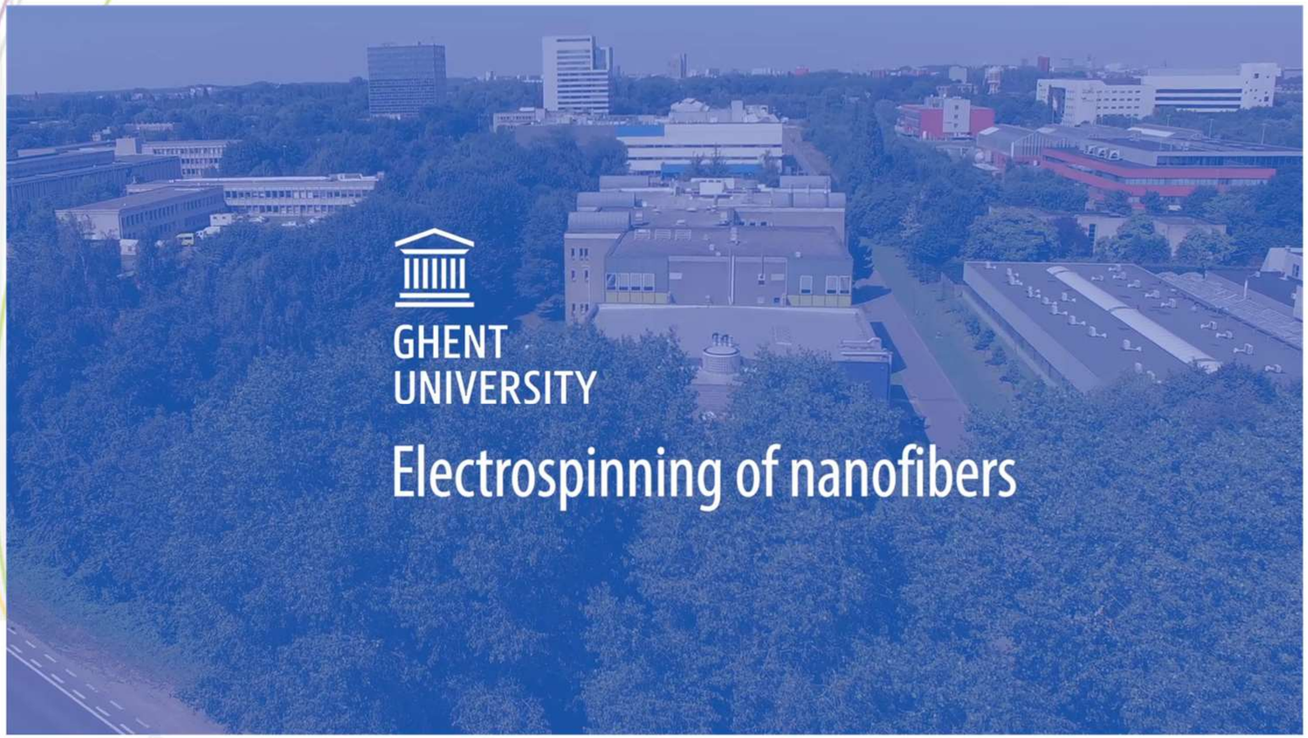
Technical textiles

Artificial turf

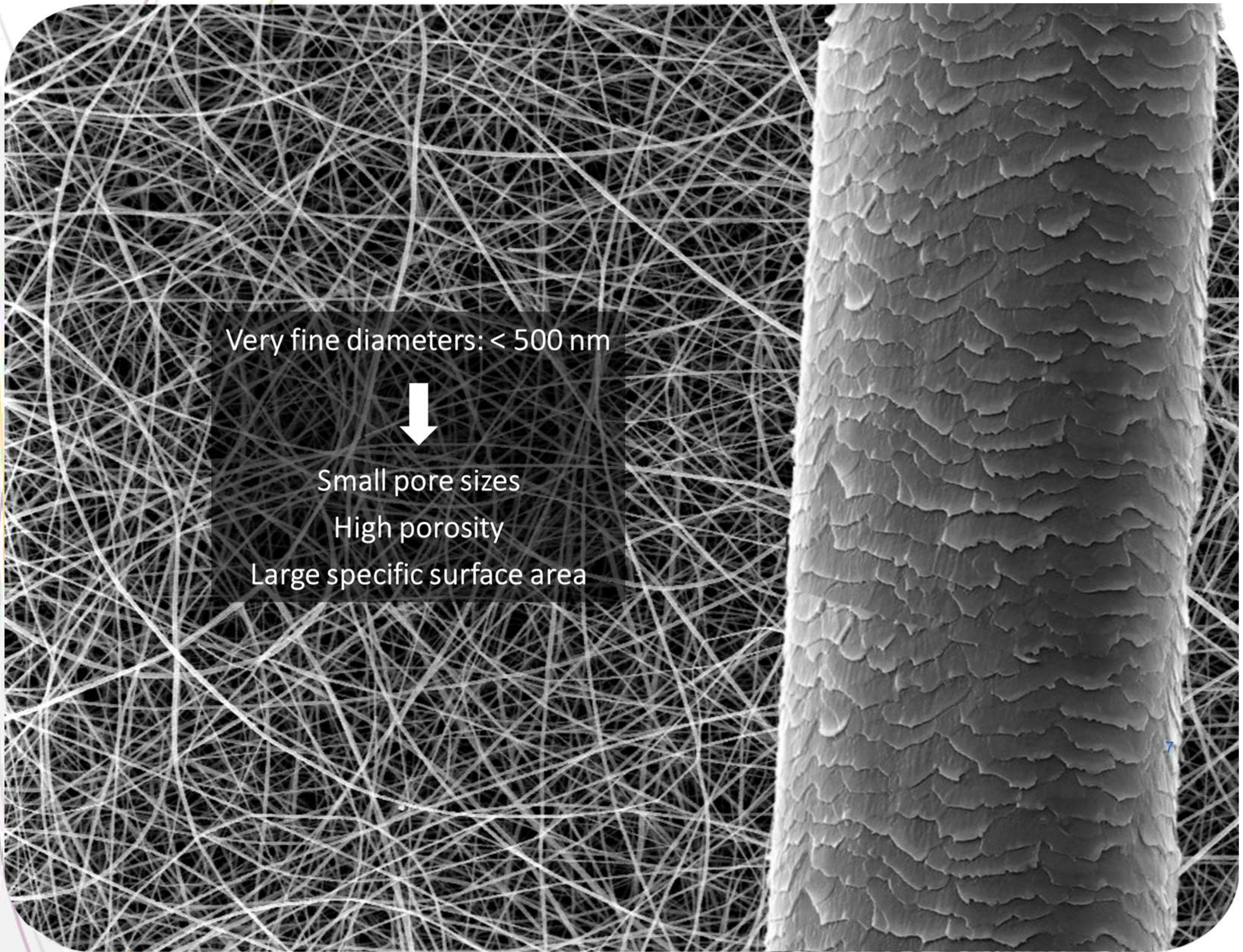
Smart textiles

Yarns, fabrics and non-wovens

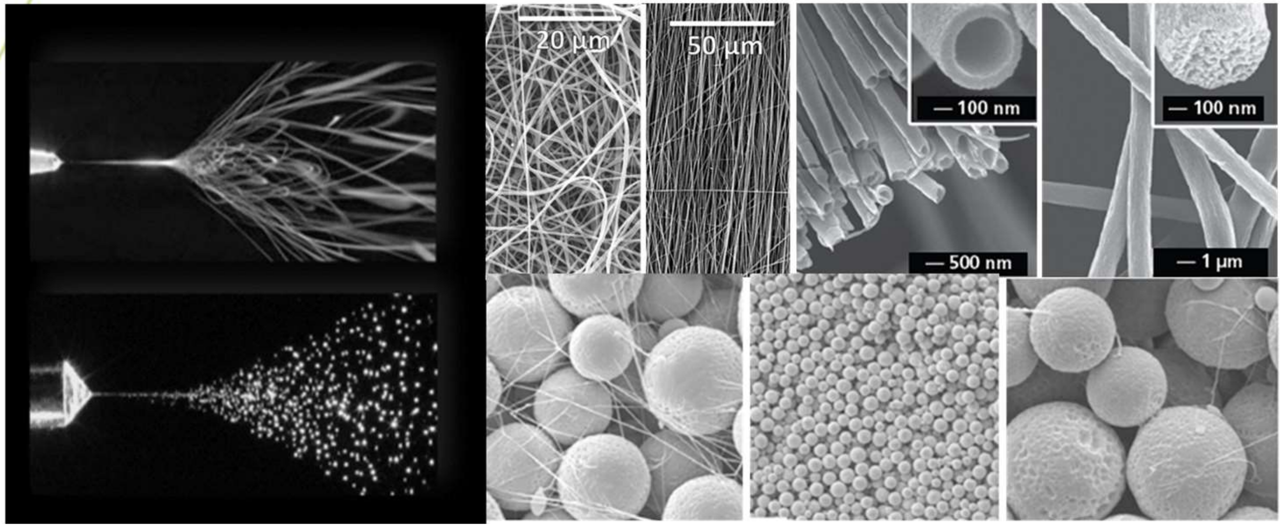
ELECTROSPINNING OF NANOFIBERS AT GHENT UNIVERSITY FOR VARIOUS NOVEL APPLICATIONS



https://www.youtube.com/watch?v=K_Nf3MAUyzk


Very fine diameters: < 500 nm
Small pore sizes
High porosity
Large specific surface area

VARIOUS MATERIAL MORPHOLOGIES CAN BE OBTAINED BY ELECTROSPINNING

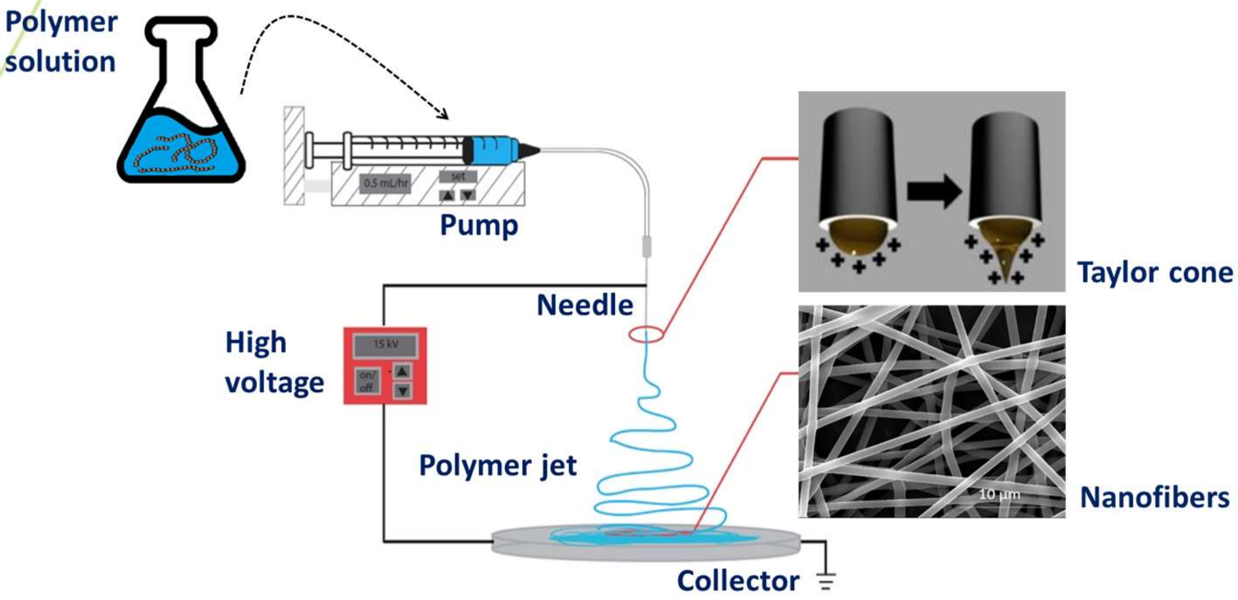


From **nanofibers** over **nanobeads**

From **random** to **oriented** structures

From **solid** to **porous** to **hollow** structures

THE BASICS OF ELECTROSPINNING



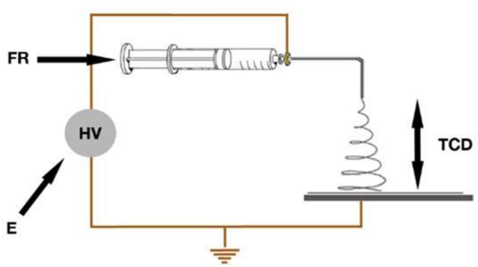
Process parameters	Solution parameters	Ambient parameters
Flow rate	Molar mass polymer	Humidity
Tip to collector distance	Conductivity polymer solution	Temperature
Strength electrical field	Surface tension polymer solution	
Collector type	Polymer concentration	
	Polymer solution viscosity	

ELECTROSPINNING SYSTEMS AVAILABLE AT CTSE

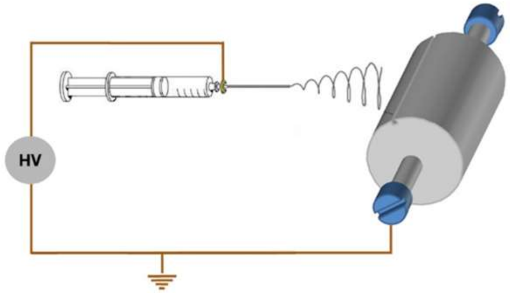
PHOTONITEX

From lab-scale mononozzle to semi-industrial continuous production

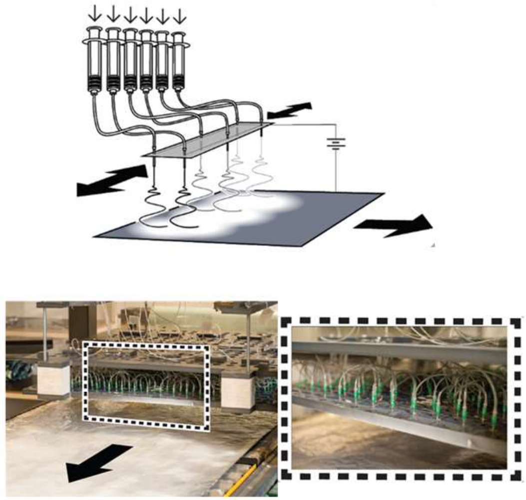
Lab-scale mononozzle



Rotating drum setup



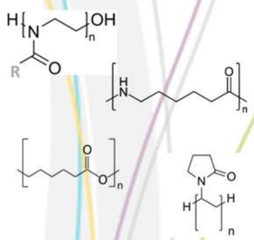
Semi-industrial multinozzle

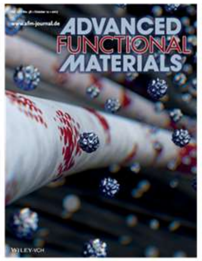


Production of nanofiber based media
- As rolled goods with or without substrate
- With grammage between 0.05 - 100 g m^{-2}

ELECTROSPINNING EXPERTISE AT CTSE

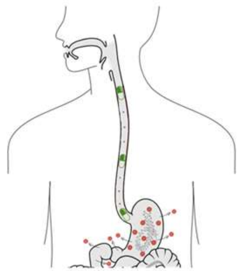
Electrospinning of organic nanofibers





Sensors

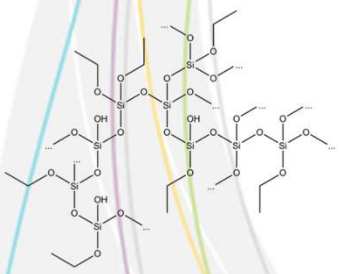
'Green electrospinning' & electrospinning of biopolymers

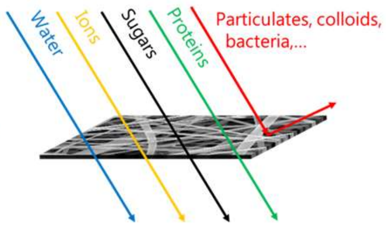


Drug delivery

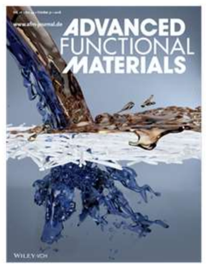
Wound dressing

Electrospinning of inorganic/ceramic nanofibers

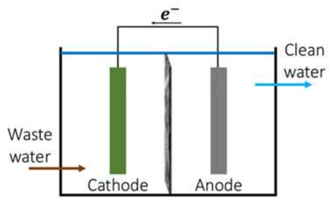




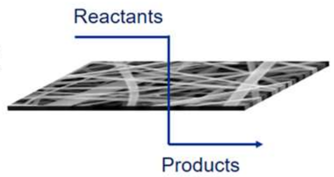
Filtration



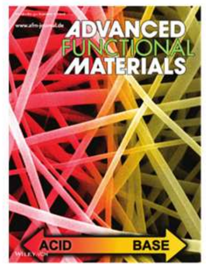
Separation of heteregenous azeotropes



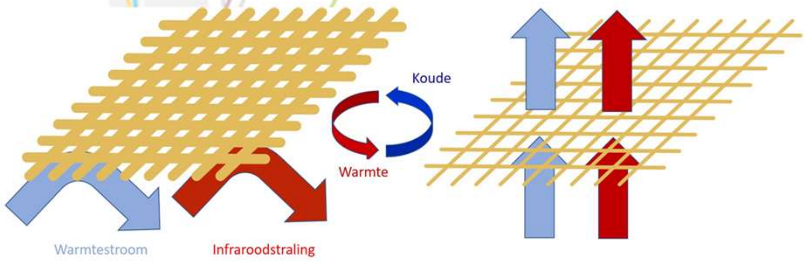
Electrochemical separation



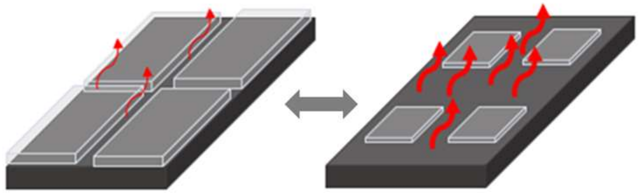
Catalysis



PHOTONITEX - SELF-STRUCTURING MEMBRANE VIA ELECTROSPINNING



Design: Metal island fabric



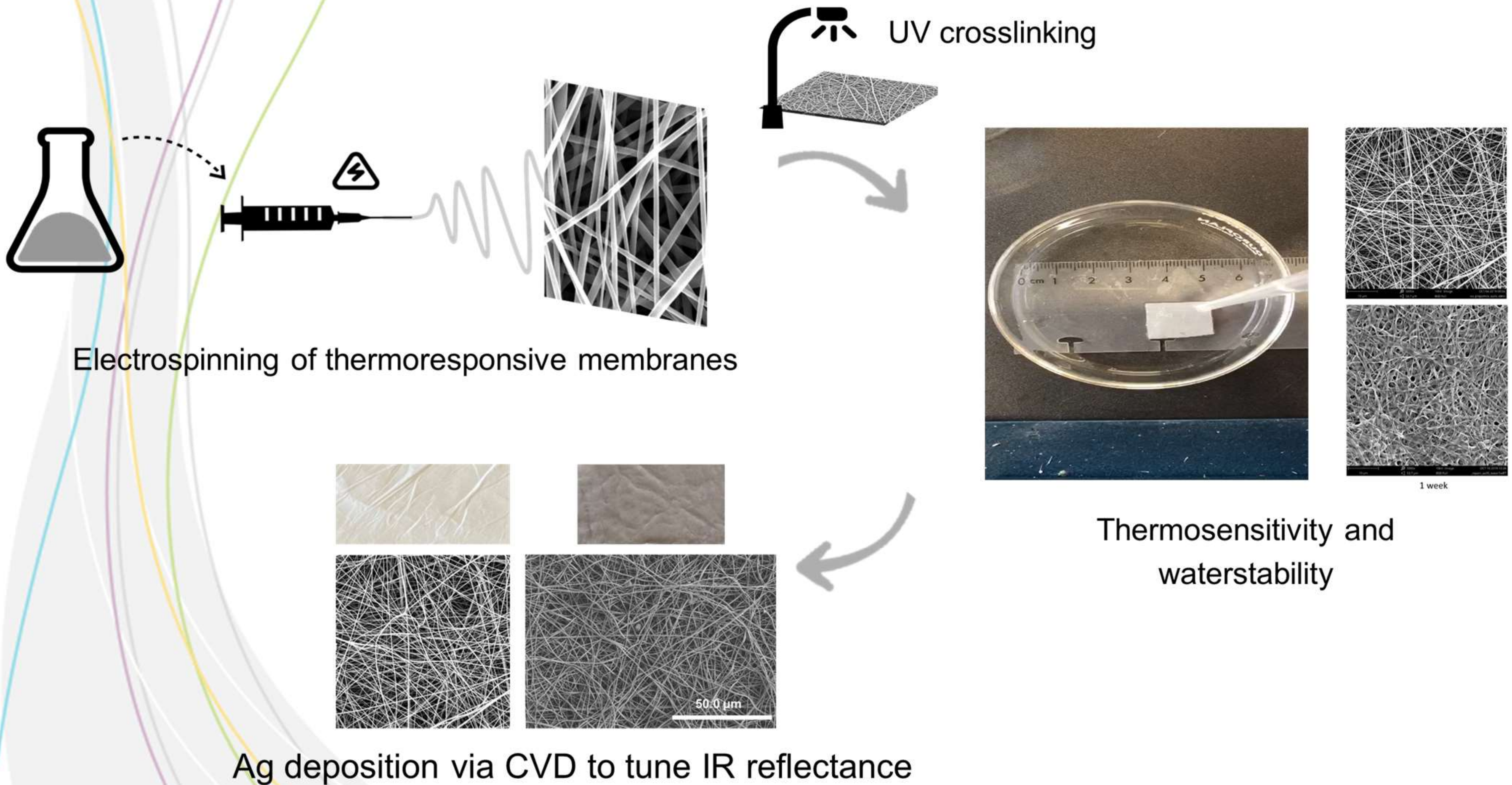
Heating Cooling

Top layer: thermoresponive membrane

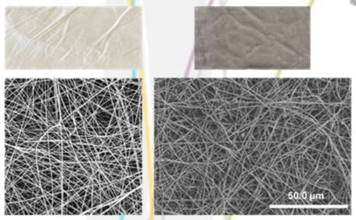
Bottom layer with high emissivity

Thermoresponive membrane produced via electrospinning of thermoresponsive polymer

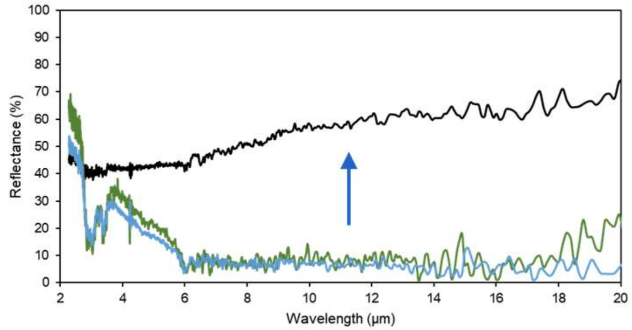
PHOTONITEX - SELF-STRUCTURING MEMBRANE VIA ELECTROSPINNING

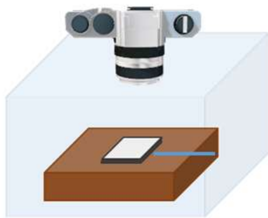


PHOTONITEX - SELF-STRUCTURING MEMBRANE VIA ELECTROSPINNING



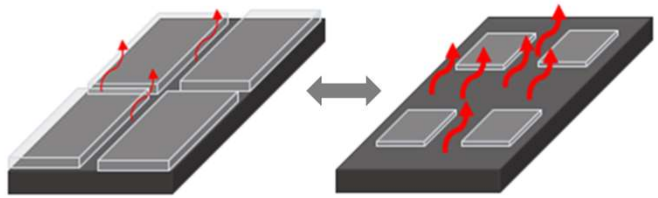
Ag deposition via CVD to tune IR reflectance





Experimental validation

Design: Metal island fabric



Heating **Cooling**

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Work Package 3 and 4 : Static and dynamic structuring of membrane and filaments

Dual-mode thermoregulation with passive photonic textiles

Muluneh G. Abebe, UMons Mons

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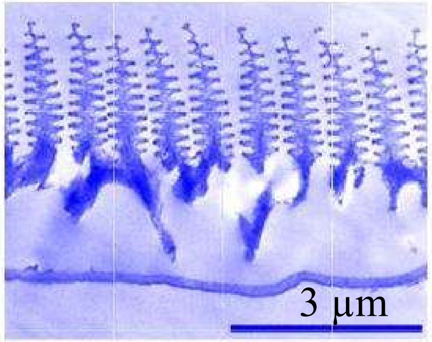
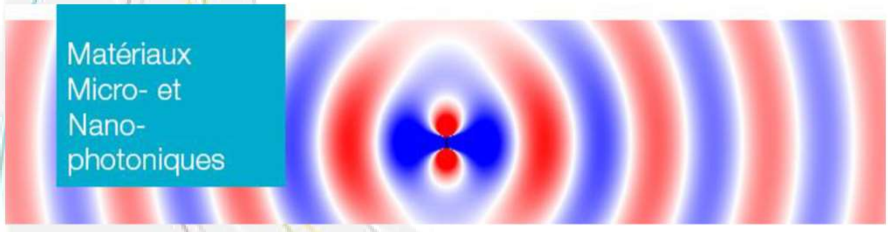
Micro- and Nanophotonic Materials Group

New physics if wavelength ~ size of structures

2 research directions → Fundamental photonics
→ Applied photonics



Bjorn.Maes@umons.ac.be
www.umons.ac.be/nanophot



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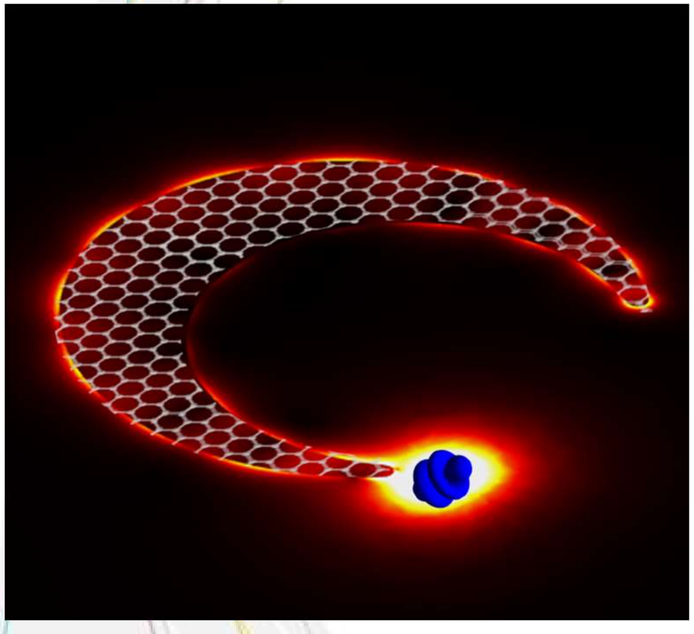
Fundamental example:
Higher-order interactions

'Forbidden' transitions possible!



New simulation methods needed...

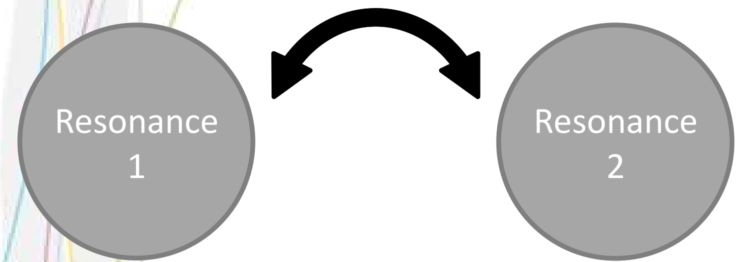
Applied example:
Adaptive textiles

Always comfortable

Modeling approaches

Analytical

Coupled-mode theory



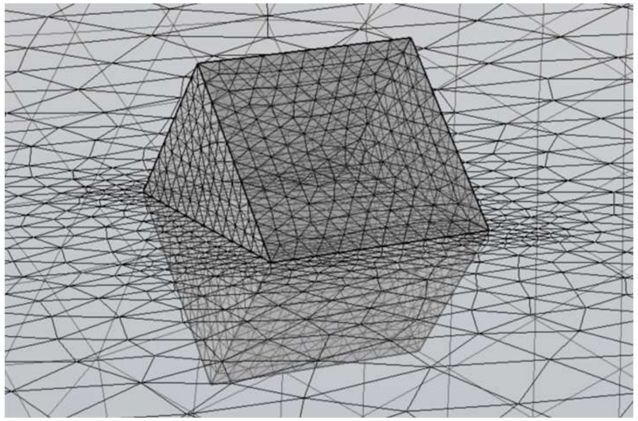
Floquet-theory

Fluctuational electrodynamics

Etc.

Simulations

Electromagnetism (Maxwell)



Macroscopic QED

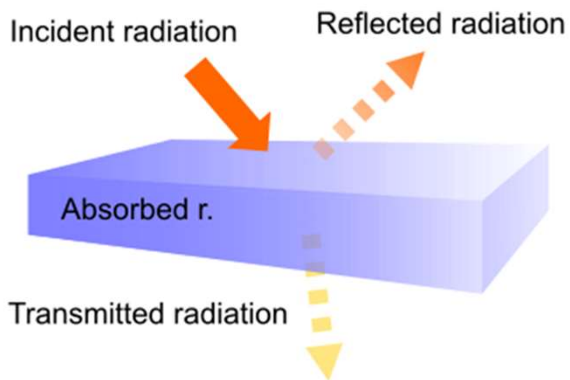
Monte-Carlo

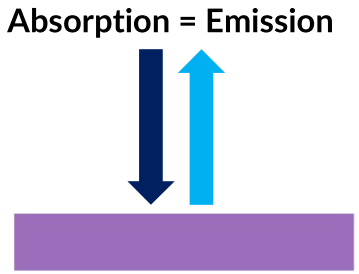
Etc.

Bjorn.Maes@umons.ac.be
www.umons.ac.be/nanophot

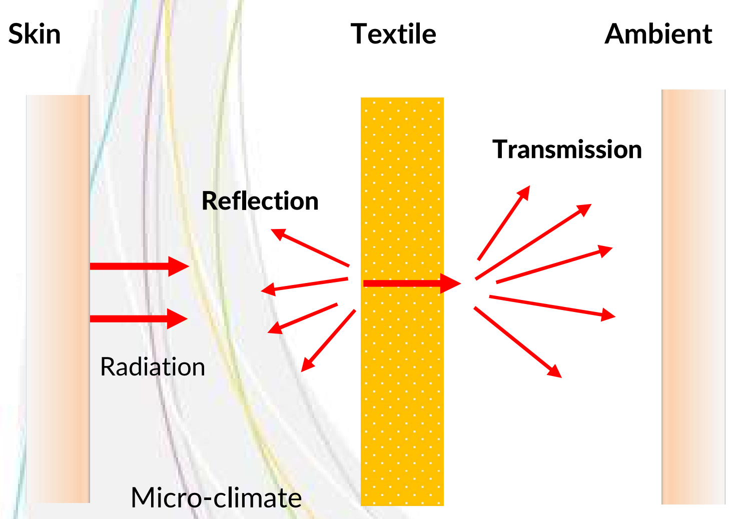
Design directions

PHOTONITEX

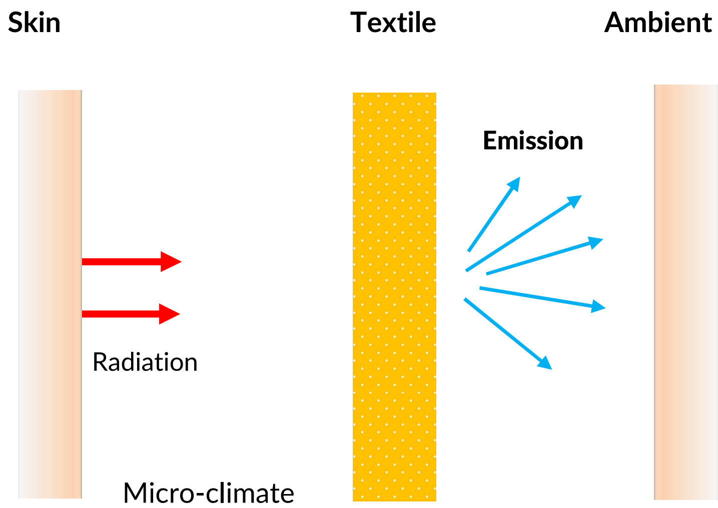




Transmission/Reflection modulation

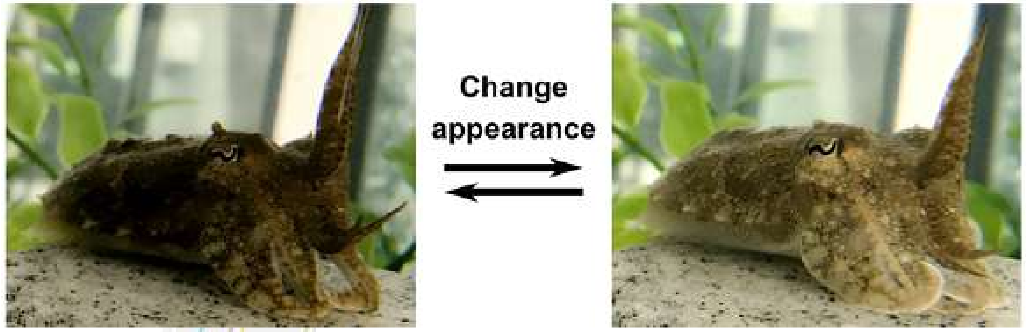


Emission modulation

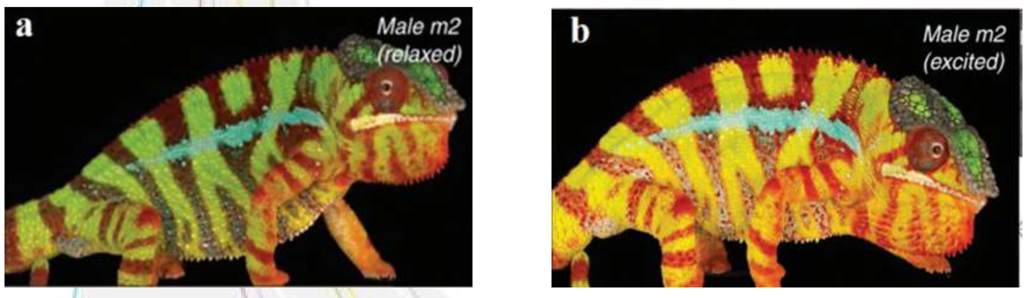


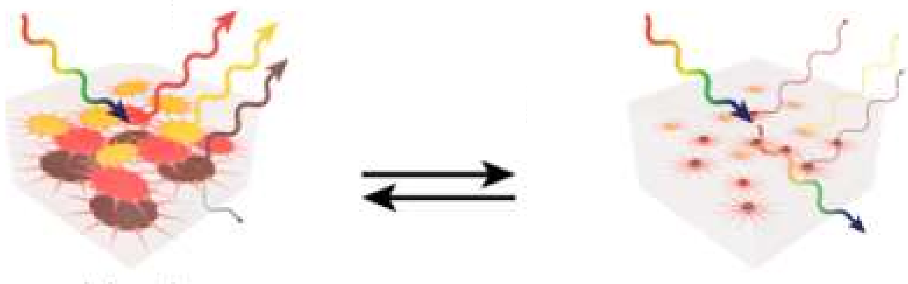
Looking at nature closely

Transmission/reflection/emission modulation



Pelagic octopus





Transmission modulation

- **Metallic micro-wires**
- Metallic micro-particles

Emission modulation

- Janus-yarn
- Metal islands using electrospun layers
- Surface wrinkling structures

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Metallic micro-wires

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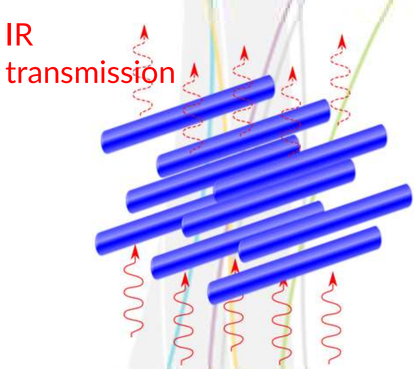
Traditional textile (static)

A single mode

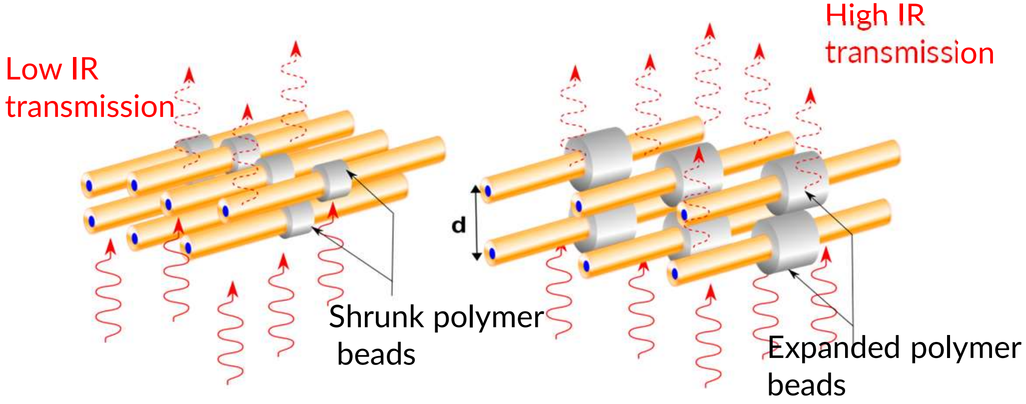


- Limited heating or cooling.

Thermoregulating textile (dynamic)

Heating Mode
Cold ambient

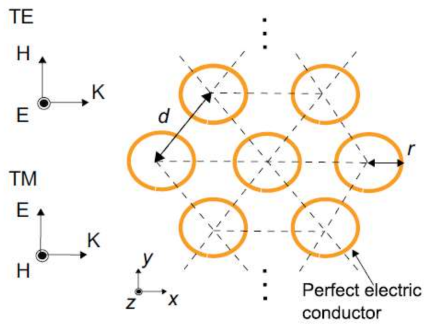
Cooling Mode
Hot ambient

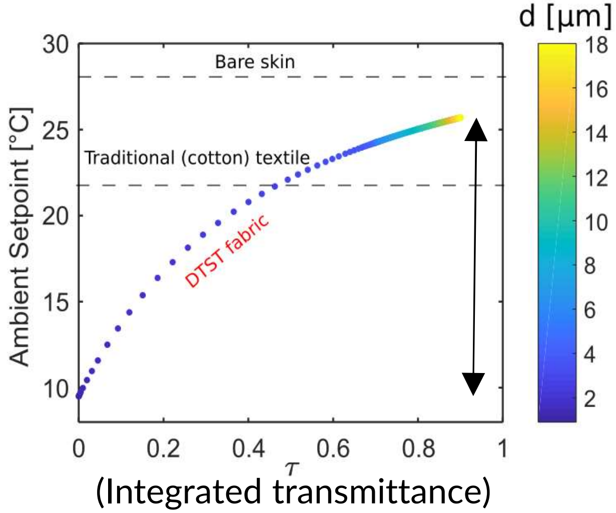


- Polymer beads shrink
- Low IR transmittance

- Polymer beads expand
- High IR transmittance

Simulated geometry





Abebe et al. Phy. Rev. Appl. 14, 044030 (2020).

- A wide setpoint temperature window of 16 °C is achieved.
- The textile user is comfortable between 9.5 °C and 25.7 °C

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PHOTONITEX

Transmission modulation

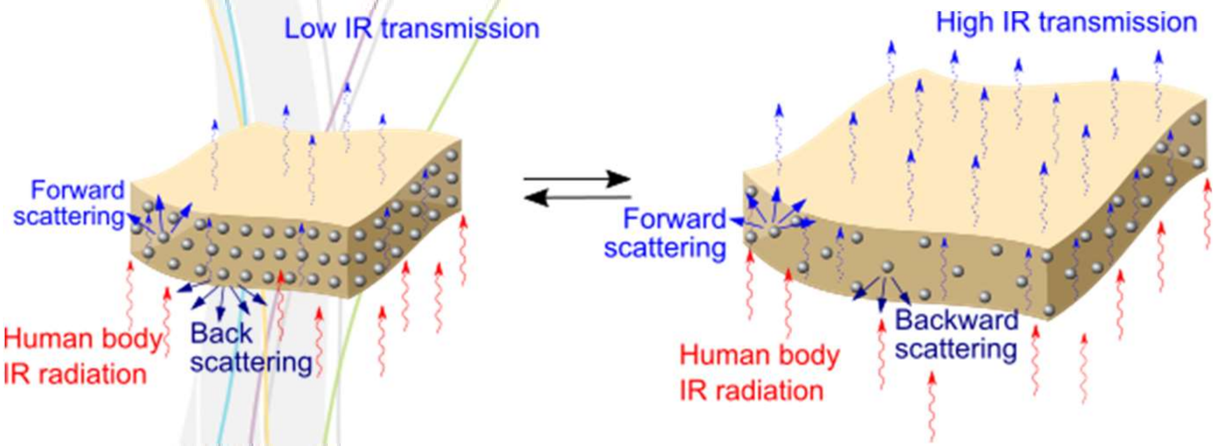
- Metallic micro-wires
- **Metallic micro-particles**

Emission modulation

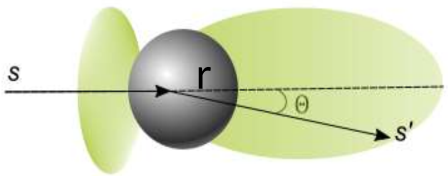
- Janus-yarn
- Metal islands using electrospun layers
- Surface wrinkling structures

Metallic micro-particles

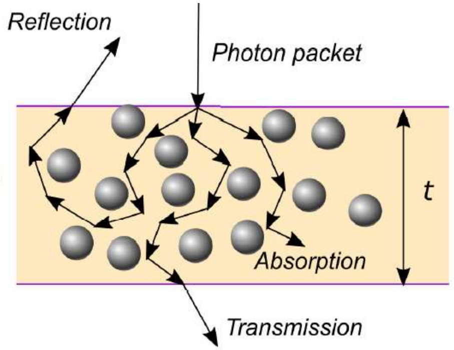
Heating mode (Cold ambient) **Cooling mode (Hot ambient)**



Single particle



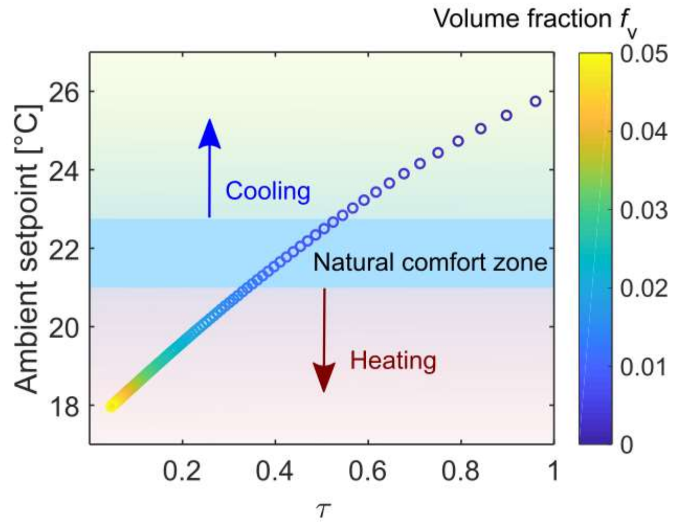
Particle cloud



- Polymer shrinks.
- Particle volume fraction increases.
- <u>High IR reflection.</u>

- Polymer expands.
- Particle volume fraction decreases.
- <u>High IR transmittance.</u>

- Particle density (volume fraction f_v) determines the radiative heat transfer.
- Setpoint window of 7°C (from 18°C to 25°C).



Abebe et al. Nanoscale 14, 1421-1431 (2022).

Transmission modulation

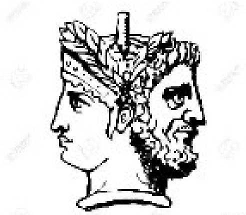
- Metallic micro-wires
- Metallic micro-particles

Emission modulation

- **Janus-yarn**
- Metal islands using electrospun layers
- Surface wrinkling structures

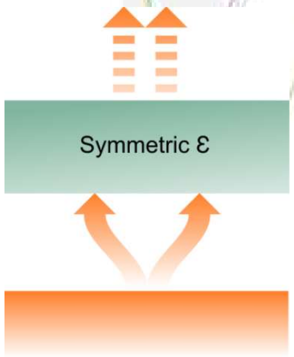
Janus-yarn for passive dual-mode textile

PHOTONITEX



Traditional textile

Heating or Cooling



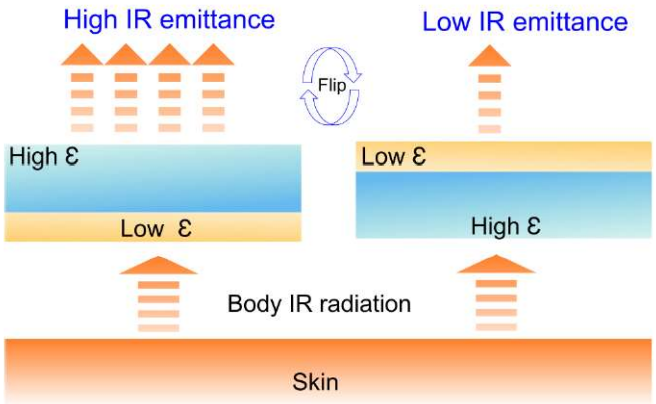
One Mode

- Heating or cooling.
- Mainly controls thermal conduction.

Janus-yarn textile

Cooling mode

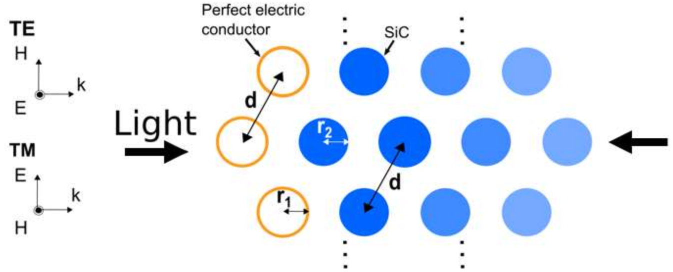
Heating mode

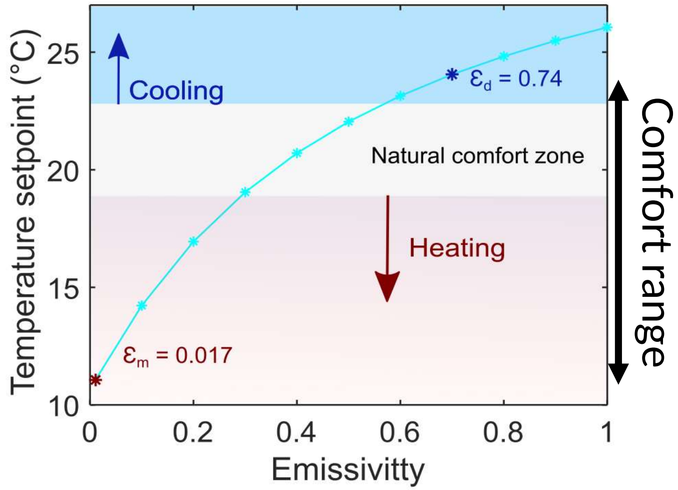


- Dielectric fibers face the outside
- High IR emissivity.

- Metallic fibers face the outside.
- Low IR emissivity.

Simulated geometry





- The textile user is comfortable between 11 °C and 24 °C.

Abebe et al. Phys. Rev. Appl. 16, 054013 (2021).

Transmission modulation

- Metallic micro-wires
- Metallic micro-particles

Emission modulation

- Janus-yarn
- **Metal islands using electrospun layers**
- Surface wrinkling structures

Metal islands using electrospun layers

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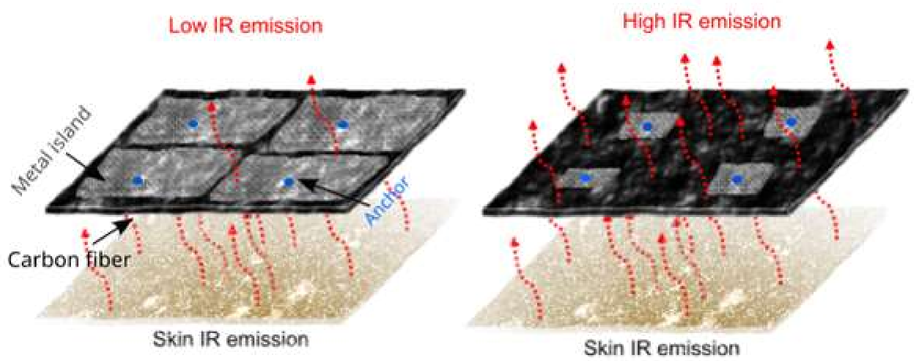
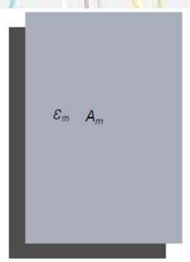
Heating mode **Cooling mode**



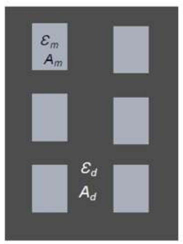
- Large surface area
- Low effective emissivity

- Small surface area
- High effective emissivity

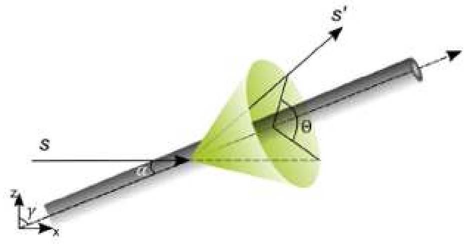
Heating mode



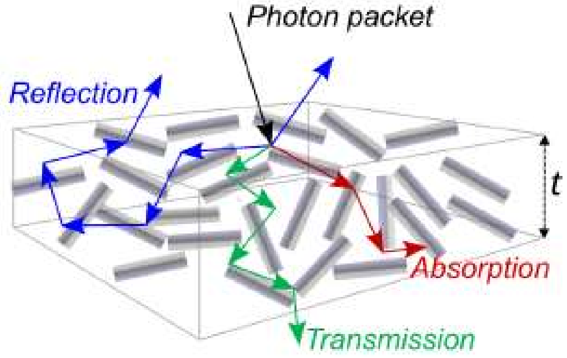
Cooling mode



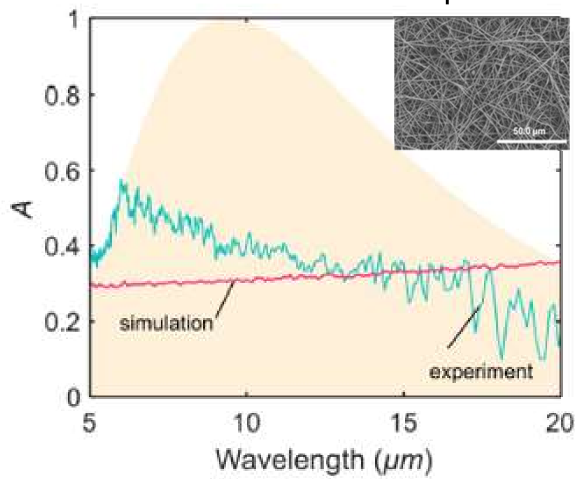
Single nanowire

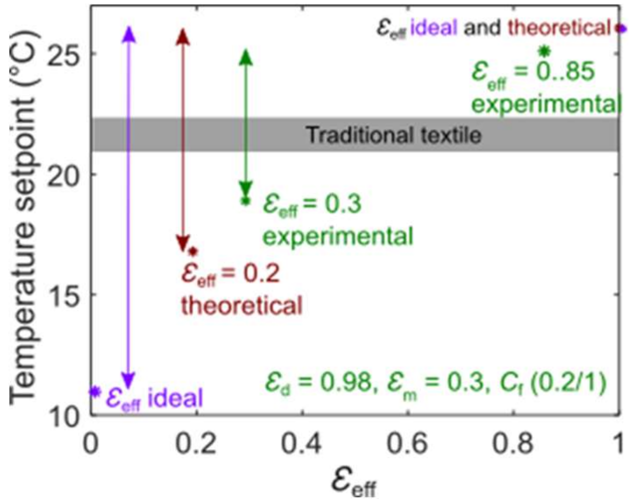


Nanowire cloud



Experiment





Setpoint window of 6°C (from 19°C to 25°C).

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PHOTONITEX

Transmission modulation

- Metallic micro-wires
- Metallic micro-particles

Emission modulation

- Janus-yarn
- Metal islands using electrospun layers
- **Surface wrinkling structures**

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Surface wrinkling structures

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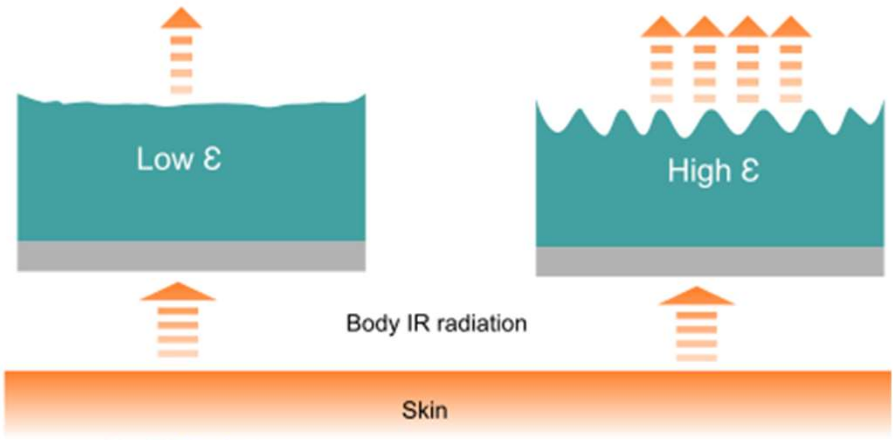
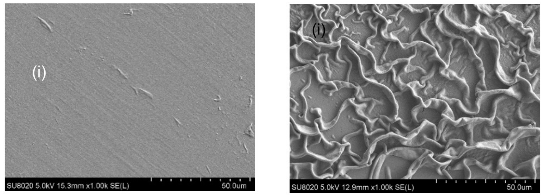
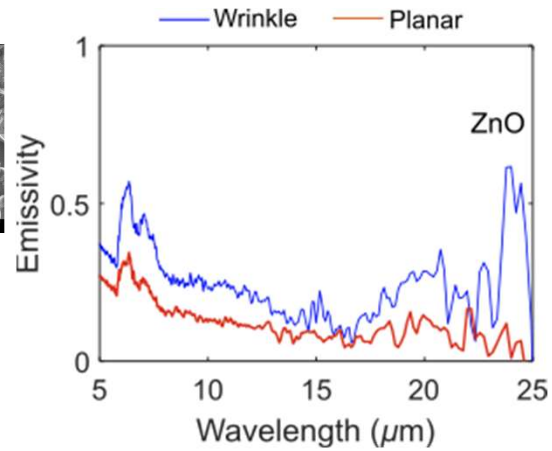
Design working principle

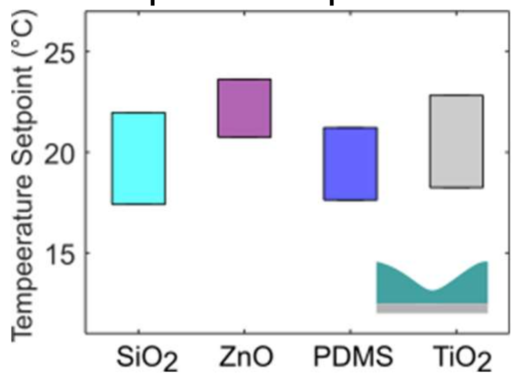


Experiment





Setpoint temperature



Heating mode (Cold)

- Flat surface (less wrinkling)
- Low IR emissivitty

Cooling mode (hot)

- Wrinkled surface (more wrinkling)
- High IR emissivity

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Work Package 4 : Static and dynamic structuring of filaments

Development of a Smart Textile to Improve Thermal Comfort

Hafiz Muhammad Kaleem Ullah, PhD student

Center of European for Innovative Textiles

A unique collaborative place of **60 000 sq.ft dedicated to creativity, engineering and prototyping**,

Innovating under confidentiality for 10 years **with leading brands** of technical textiles, professional equipments, sports, fashion and luxury,

Helping **to accelerate the digital and sustainable transformation of textile industry**.

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Seven pilot platforms for R&D, prototyping & industrialization

ON DEMAND DESIGN & PRODUCTION	FILAMENTS & FIBRES	YARNS & FABRICS	SPUNBOND & MELTBLOWN NONWOVEN	DRY PROCESS NONWOVEN	TEXTILE TO TEXTILE RECYCLING	SORTING AND DISMANTLING

CETIA
FROM GOODS TO MATERIALS

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Coverage – World class network

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CIRFS

EUROPEAN MAN-MADE FIBRES ASSOCIATION

edana

IVGT

UNIDO

EuraMaterials

techtera

EREMA PLASTIC RECYCLING SYSTEMS

coperion

Manufacture

ANDRITZ

HILLS INC.

LECTRA

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ENSAIT,

French Grande Ecole, one of the leading textile schools in Europe

The staff

- 40 Teachers
- 22 Engineers and technicians
- 33 Administrative staff

The students

- 426 Engineering students
- 367 in initial training
- 59 in apprenticeship
- 57 PhD students

Library 2018/2019

GEMTEX Laboratory

www.gemtex.fr

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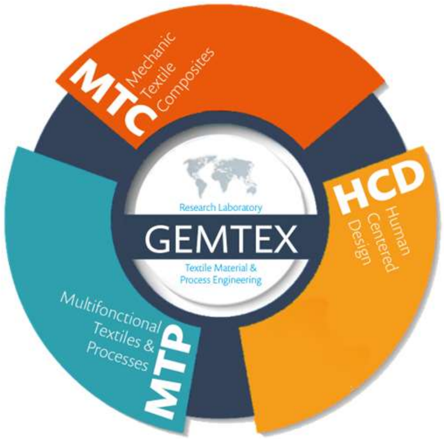
Professors **12**

Assistant Professors **18**

Technicians & engineers **10**

Temporary Teacher Researchers **4**



Created in **1992**

Director

Pr. Xianyi ZENG

57 2019 PhD students

55 RDI Programs since 2013

12 Patents since 2013

1 Erasmus Mundus Program

Fields of application:

aeronautics, transport, medical, wellness, sport & leisure, construction, clothing, ….

gemtex ROUBAIX
LABORATOIRE DE RECHERCHE TEXTILE

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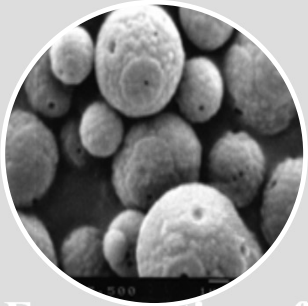
The skills of the MTP group

Complex systems with functional properties



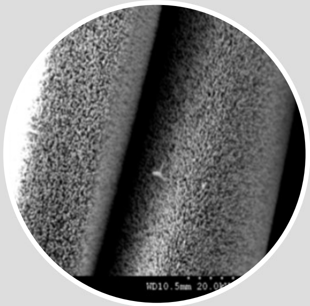
Formulation of complex systems

In a melted process:
- polymer blend
- nanocomposites

In solution (finishing, diffusion):
- addition of molecules
- enzyme additions

Synthesis of microcapsules

Characterization

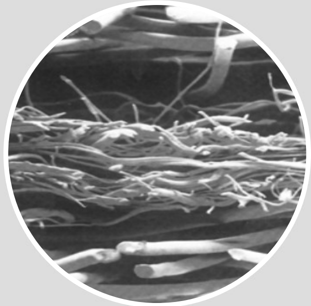


Methods of implementing complex systems

Mass functionalization:
Melt spinning, 3D printing, sheathing, diffusion

Surface functionalization :
Electrospraying, padding, grafting, coating

Characterization



Advanced Textile Processes and Structures

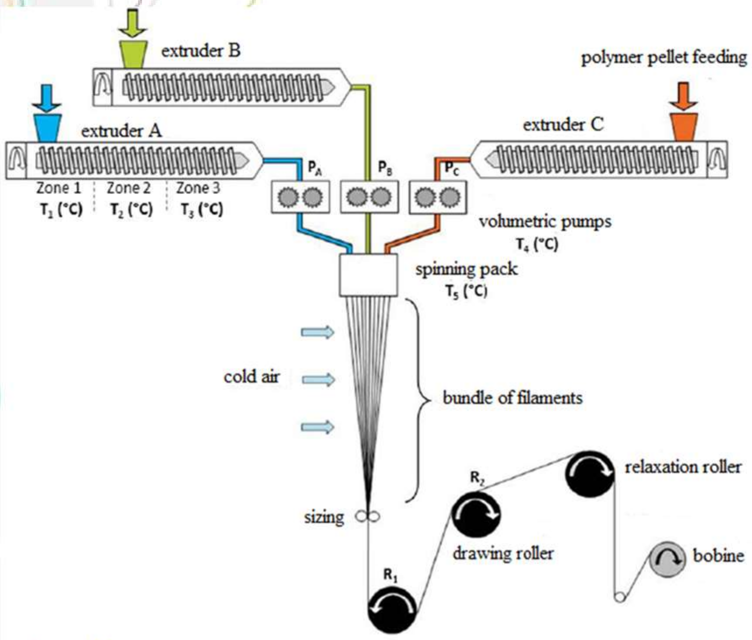
Spinning
Nonwovens
Knitting
Weaving
Braiding
Characterization

Sustainable development

PHOTONITEX

What is Multi-component Fiber

- Multi-component fiber is made of two or more materials



Why multi-component Fibers?

- Exploit capabilities not existing in either polymer alone
- Bring multi functional properties in a single fiber
- Expand the range of possible applications
- Improve the materials performance for specific needs

Dasdemir, M., Maze, B., Anantharamaiah, N. et al J Mater Sci 47, 5955–5969 (2012). https://doi.org/10.1007/s10853-012-6499-7, Polyester/Nylon Composite Microfiber Yarn DTY - Guangzhou BaoJia Synthetic Fiber Co,Ltd (ecplaza.net), Ayad (2016, L'UNIVERSITE DES SCIENCES ET TECHNOLOGIES DE LILLE École doctorale des Sciences Pour l'Ingénieur

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Introduction to Materials

- **Polymer A*/B***
  - Commonly used in textiles

Immiscible to each other

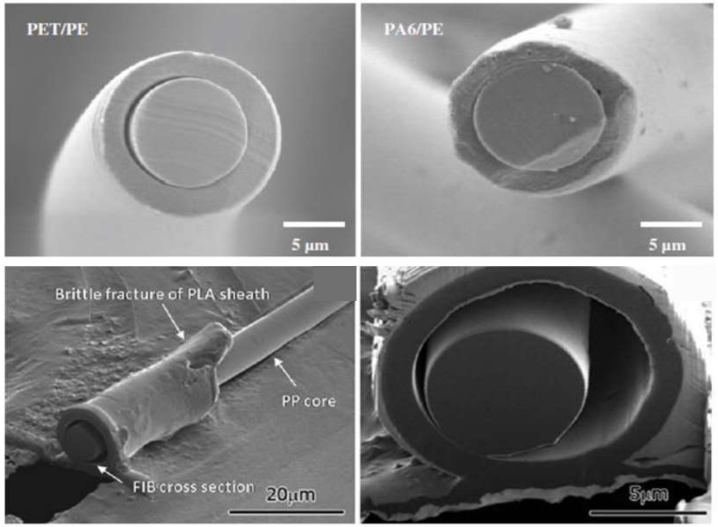
poor interfacial adhesion

Poor performance
Fiber splitting

Addition of **C***

Improved adhesion between polymer A and B

Material Development → ***Fiber Development***

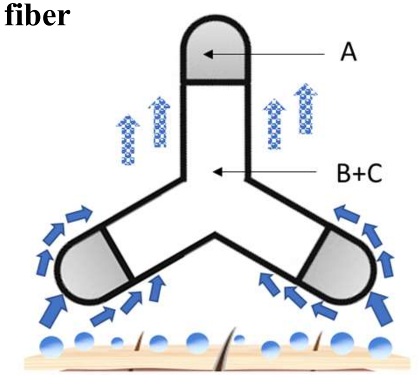


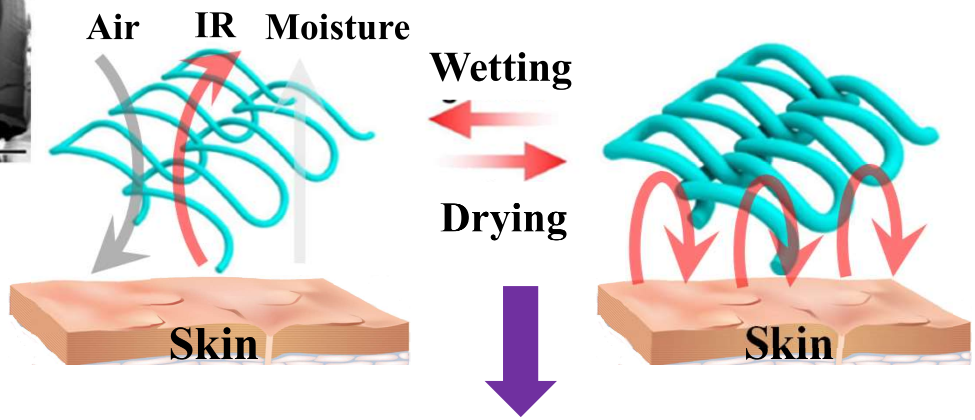
Tipped Trilobal bicomponent fiber

Complex geometry

involves

Complex rheology





A = Polyester
B = Nylon
C = Adhesion promoter

Dynamic Thermal Comfort

Dasdemir, M., Maze, B., Anantharamaiah, N. et al J Mater Sci 47, 5955–5969 (2012). https://doi.org/10.1007/s10853-012-6499-7, Polyester/Nylon Composite Microfiber Yarn DTY - Guangzhou BaoJia Synthetic Fiber Co,Ltd (ecplaza.net), Ayad (2016, L'UNIVERSITE DES SCIENCES ET TECHNOLOGIES DE LILLE École doctorale des Sciences Pour l'Ingénieur

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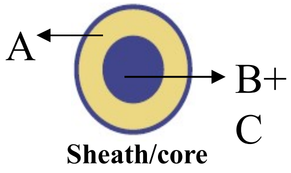
Steps Towards Innovation



Materials Development
- Compounding

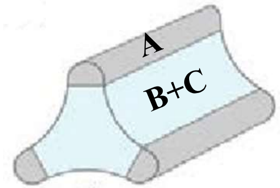
Material Testing
- Rheology via capillary Rheometer

Fiber production
- Multi-component melt spinning

Fiber Testing
- Mechanical Analysis
- Thermal Analysis
- Morphological Analysis

Final Fiber production
- Final bico fiber via multi component melt spinning

Fabric Construction
- Knitting Fabric Construction



Materials Development

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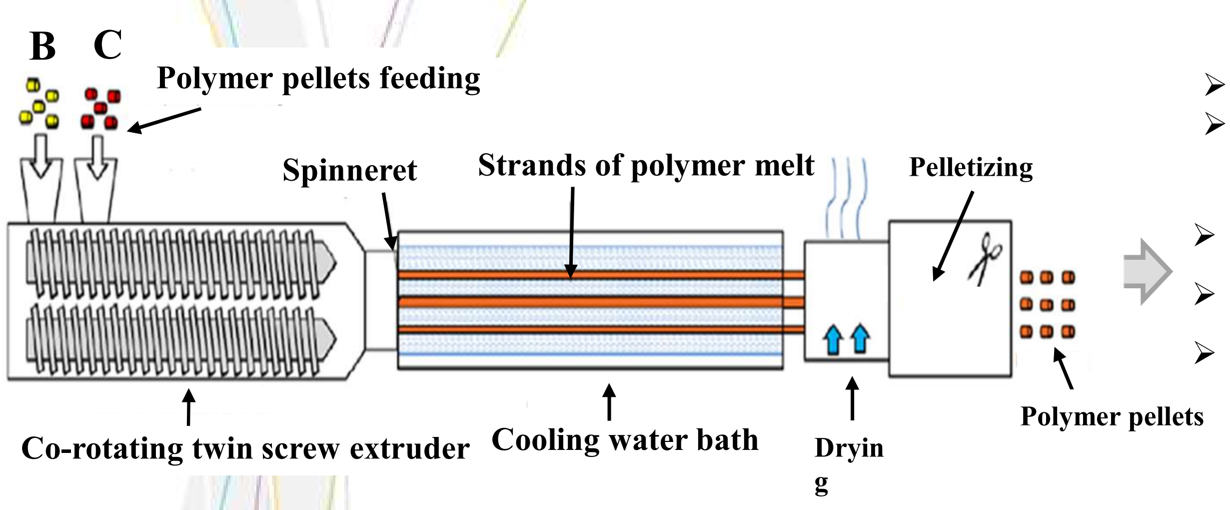
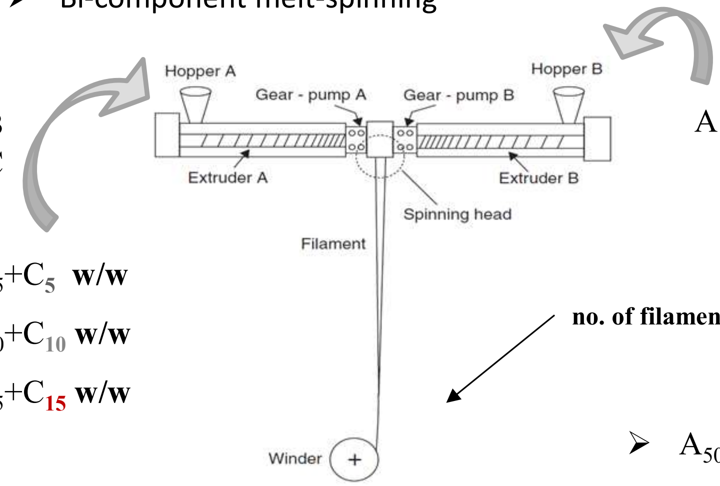
Material Development

- Polymer Extrusion
  - Polymer mixing



- Bi-component melt-spinning

- B
- C

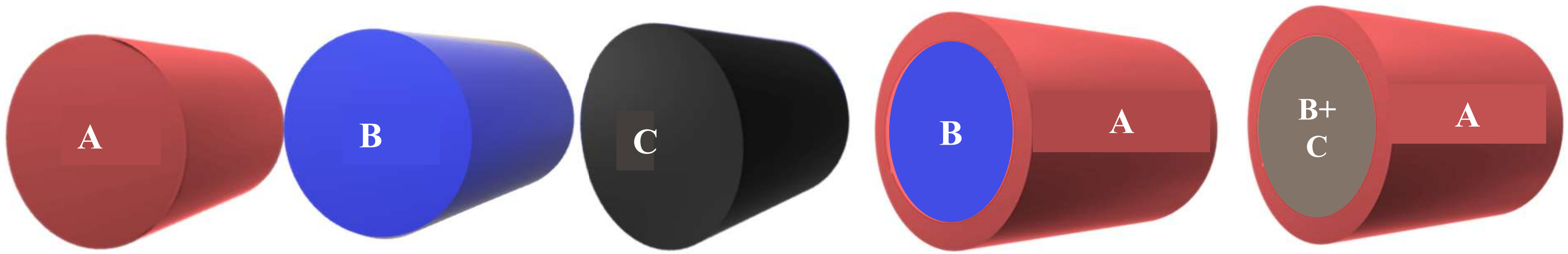


- $B_{95}+C_{5}$ **w/w**
- $B_{90}+C_{10}$ **w/w**
- $B_{85}+C_{15}$ **w/w**

no. of filaments in yarn = 36

- A_{50}/B_{50}
- $A_{50}/(B+C_{5\%})_{50}$
- $A_{50}/(B+C_{10\%})_{50}$
- $A_{50}/(B+C_{15\%})_{50}$

A = Polyester
B = Nylon
C = Adhesion promoter



Fakirov S, Stribeck N, Apostolov AA, Denchev Z, Krasteva B, Evstatiev M, et al. J Macromol Sci - Phys. 2001;40 B(5):935–57

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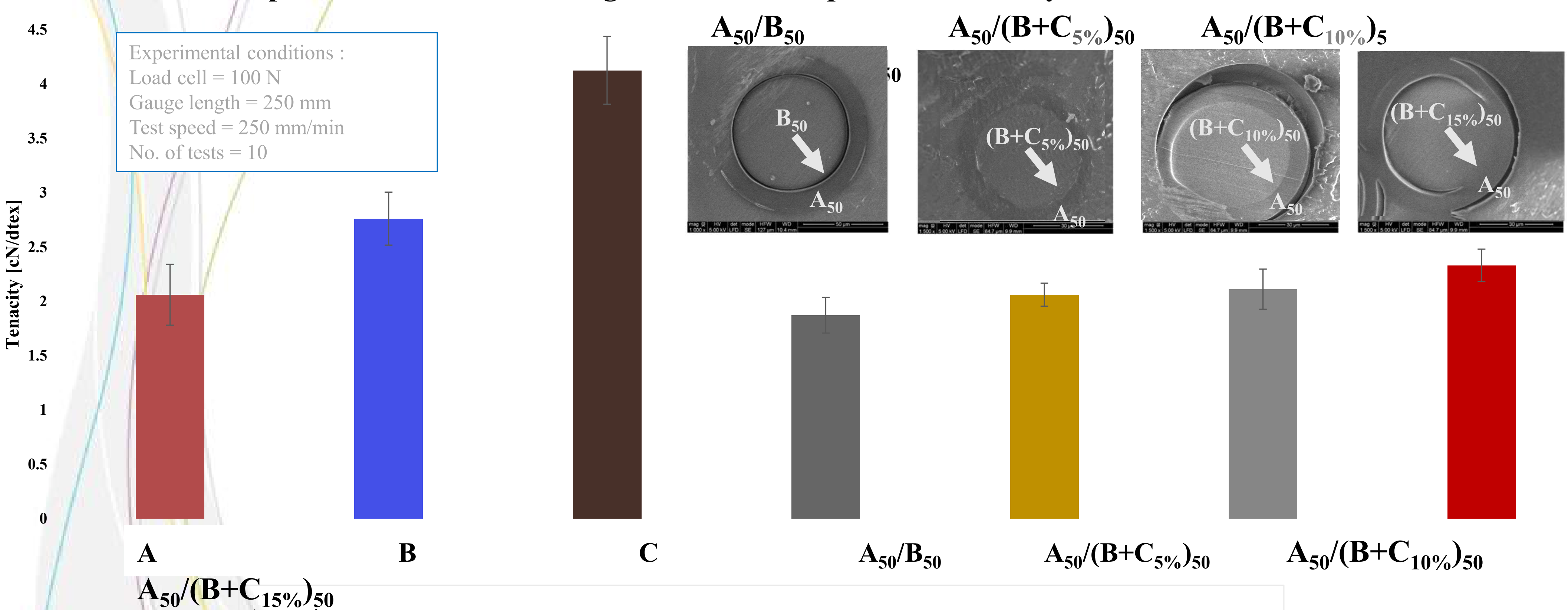
Tensile Testing

Influence of Adhesion promoter on tensile strength of A/B bicomponent filament yarn



- A/B : Tenacity decreases due to poor interfacial adhesion
- A/B+C : Tenacity tends to increase as C ratio increases= improved interfacial adhesion

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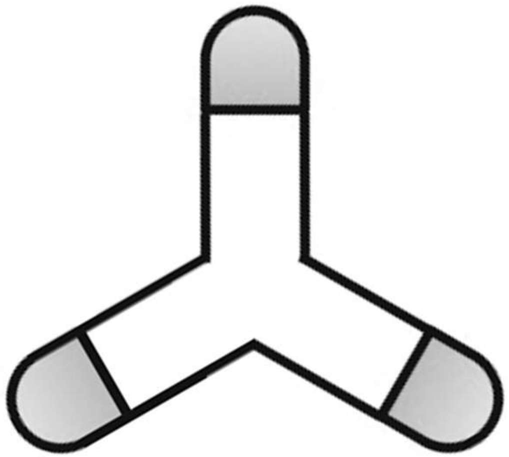
Fiber Development for Thermal Comfort Textiles



September 29, 2022 – Closing event

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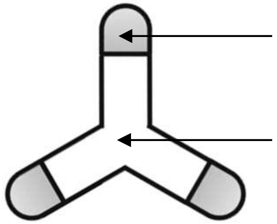
- **Polymer A/B**
  - Commonly used in textiles

CETI Multicomponent melt spinning

HILLS INC.



Involved parameters

Nature and grade of polymers

Flow rate ratios of polymers

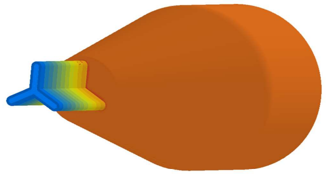
Viscosity ratios

Extrusion and spinning temperatures of polymers

Adhesion of polymers together

Experimental time and energy consuming process

compuplast



Virtual Extrusion Laboratory™

3D FEM simulation

Process optimization

Fiber development

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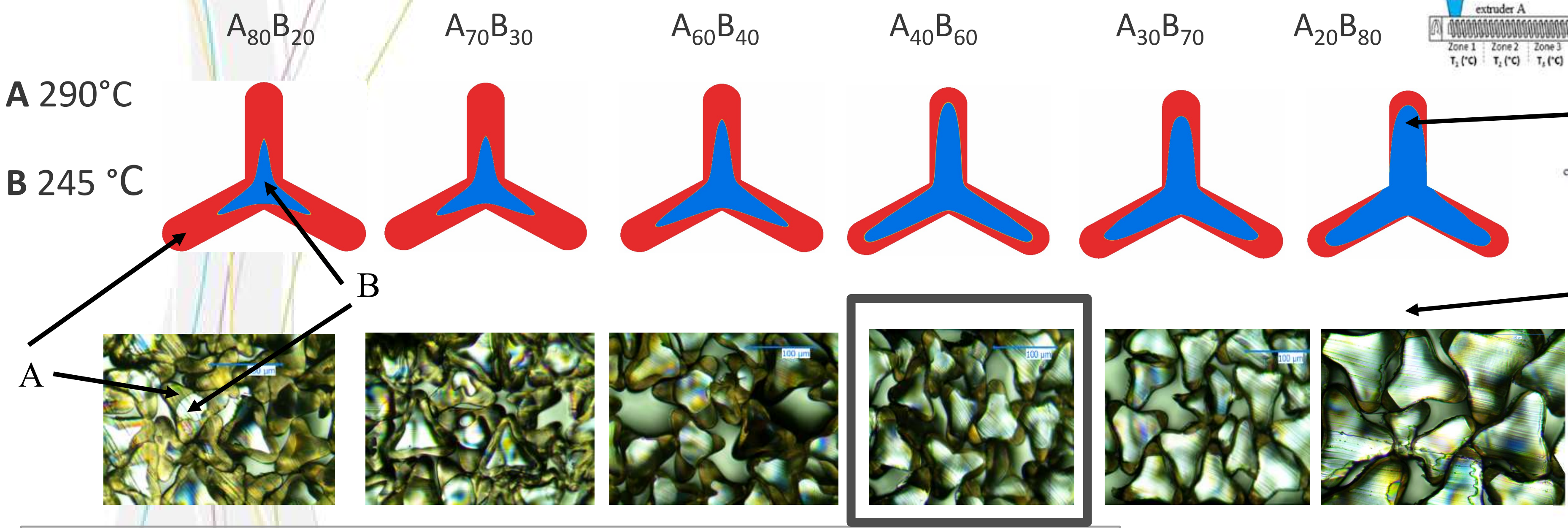
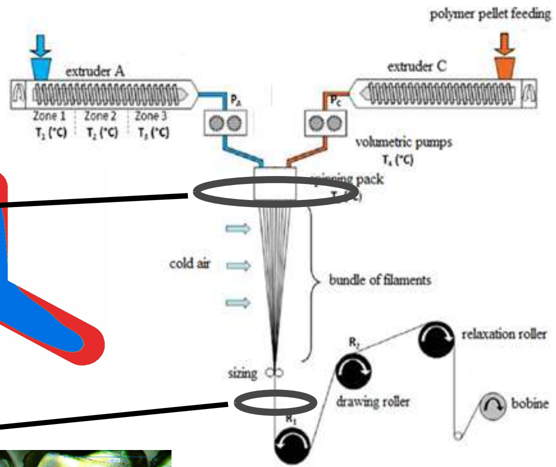
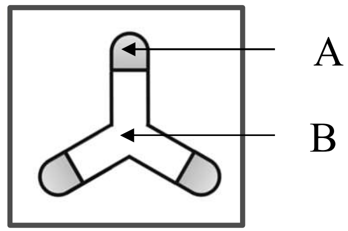
Simulations Vs Experimental results

Influence of polymer ratio







Simulation predicts more encapsulation

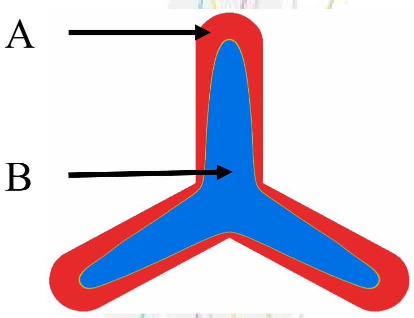
The spinneret exit shape of cross section is not observable

↑ ratio of B ↑ B quantity at exit

↑ encapsulation of B

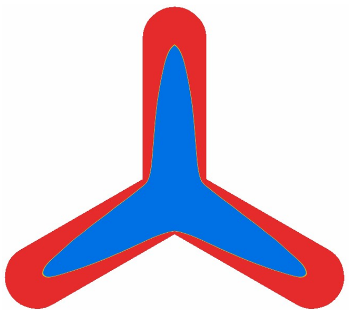
Simulations results

- Influence of increasing A temperatures
- $A_{40}B_{60}$



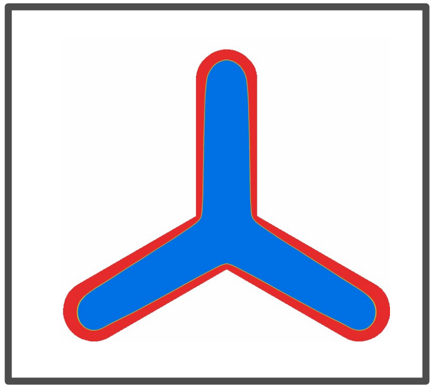
A 290°C

B 245 °C



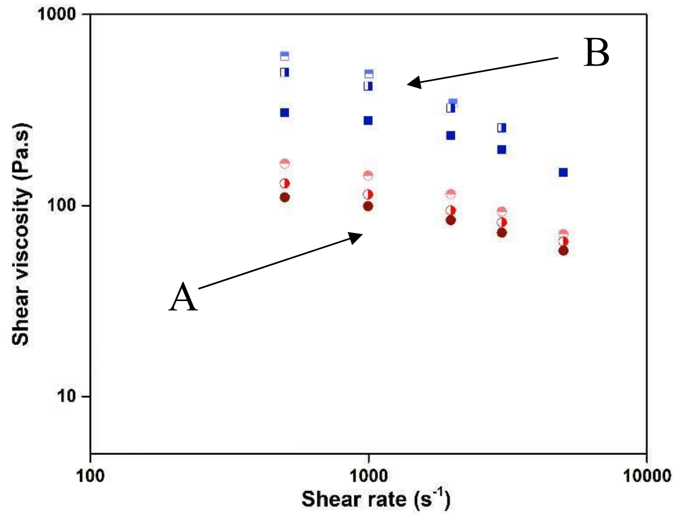
A 295°C

B 245 °C



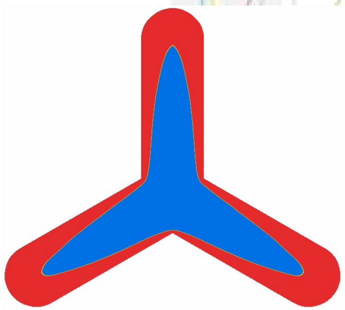
A 310°C

B 245 °C



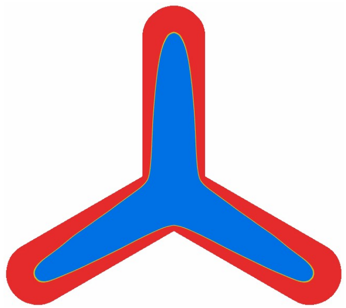
Simulations results

- Influence of increasing B temperatures
- $A_{40}B_{60}$



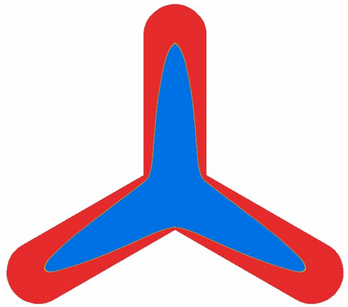
A 290°C

B 240 °C



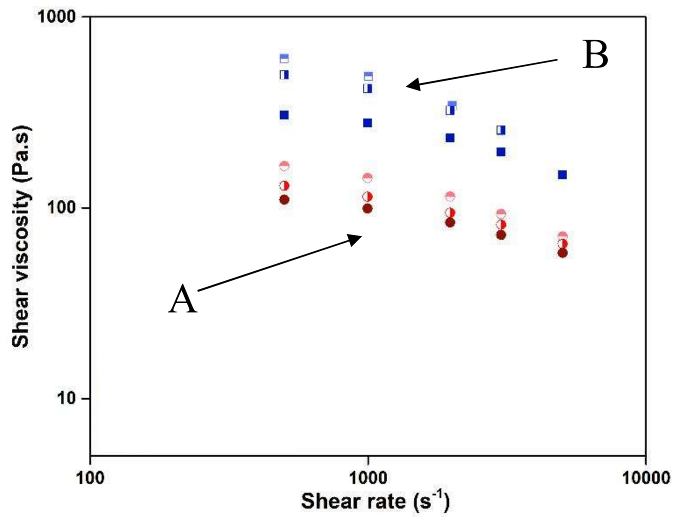
A 290°C

B 245 °C



A 290°C

B 250 °C



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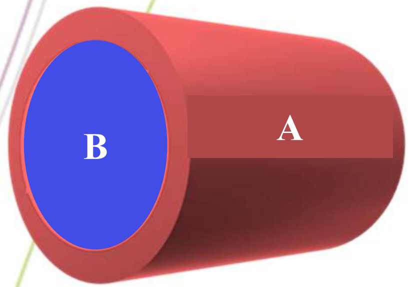
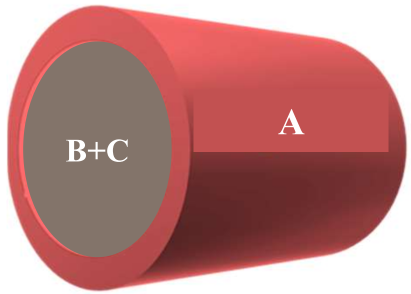
Material Development

Fiber Development



Vs



- Immiscible
- Poor interfacial molecular interaction
- Low mechanical properties

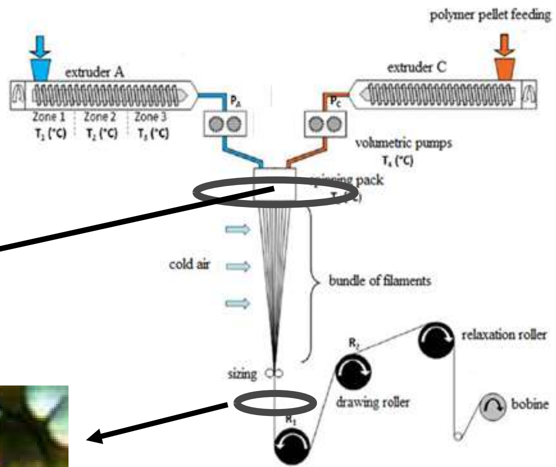
- Increased cohesion
- BETTER interfacial molecular interaction
- Improved mechanical properties

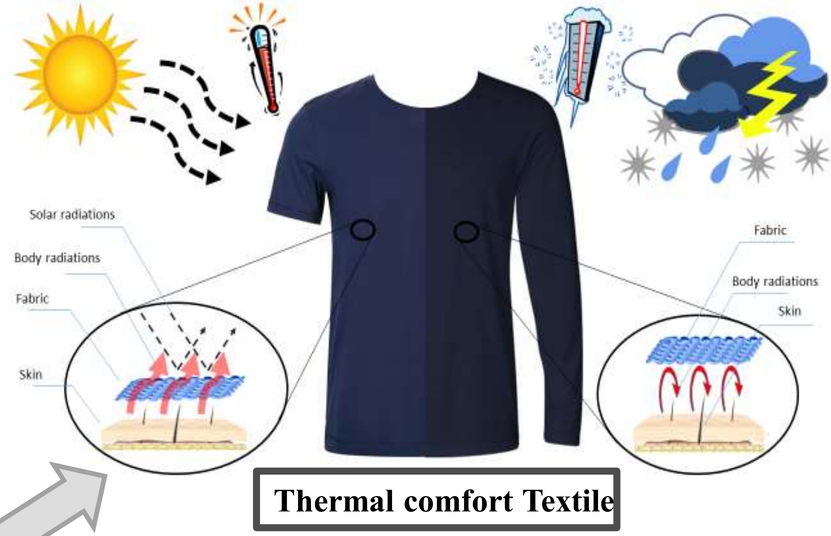
Prospects

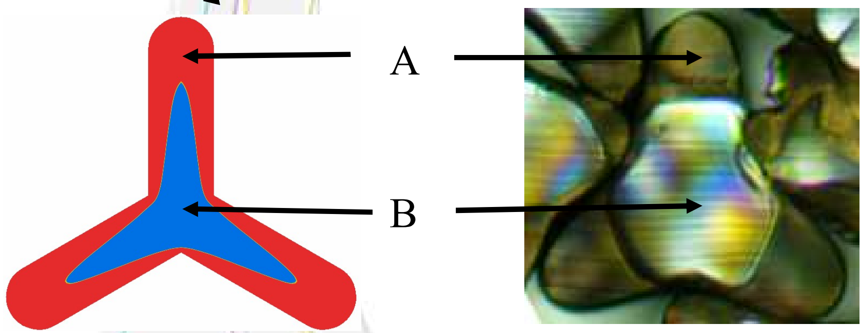
- Bring multi functional properties in a single fiber
- Expand the range of possible applications
- To improve the materials performance for specific needs

Material Development → ***Fiber Development*** → ***Fabric Development***

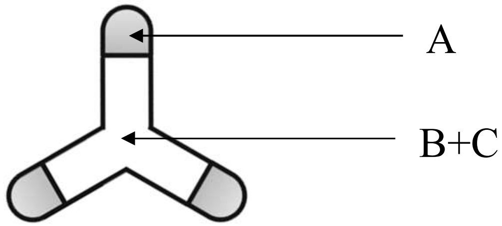
$A_{40}B_{60}$







Inside the die Vs Extrudate



Post extrusion simulation in progress

Under development

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Thank you for your attention