Sustainable polyethylene fabrics with engineered moisture and heat transport

Candidature for the Elsa Piana Award

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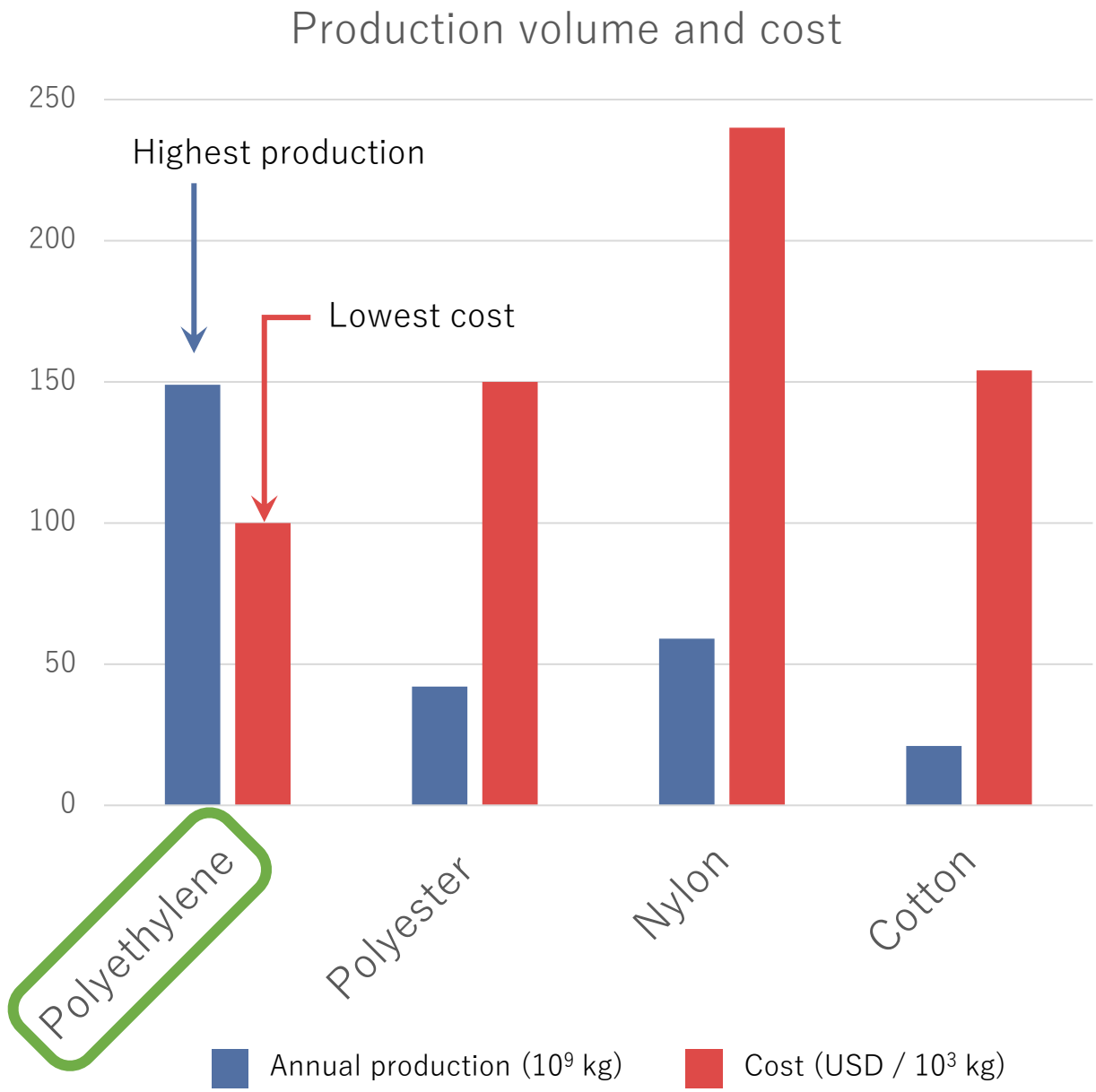
[3]*Istituto Nazionale di Ricerca Metrologica (Italy)*

Massachusetts Institute of Technology

POLITECNICO DI TORINO

Why polyethylene?

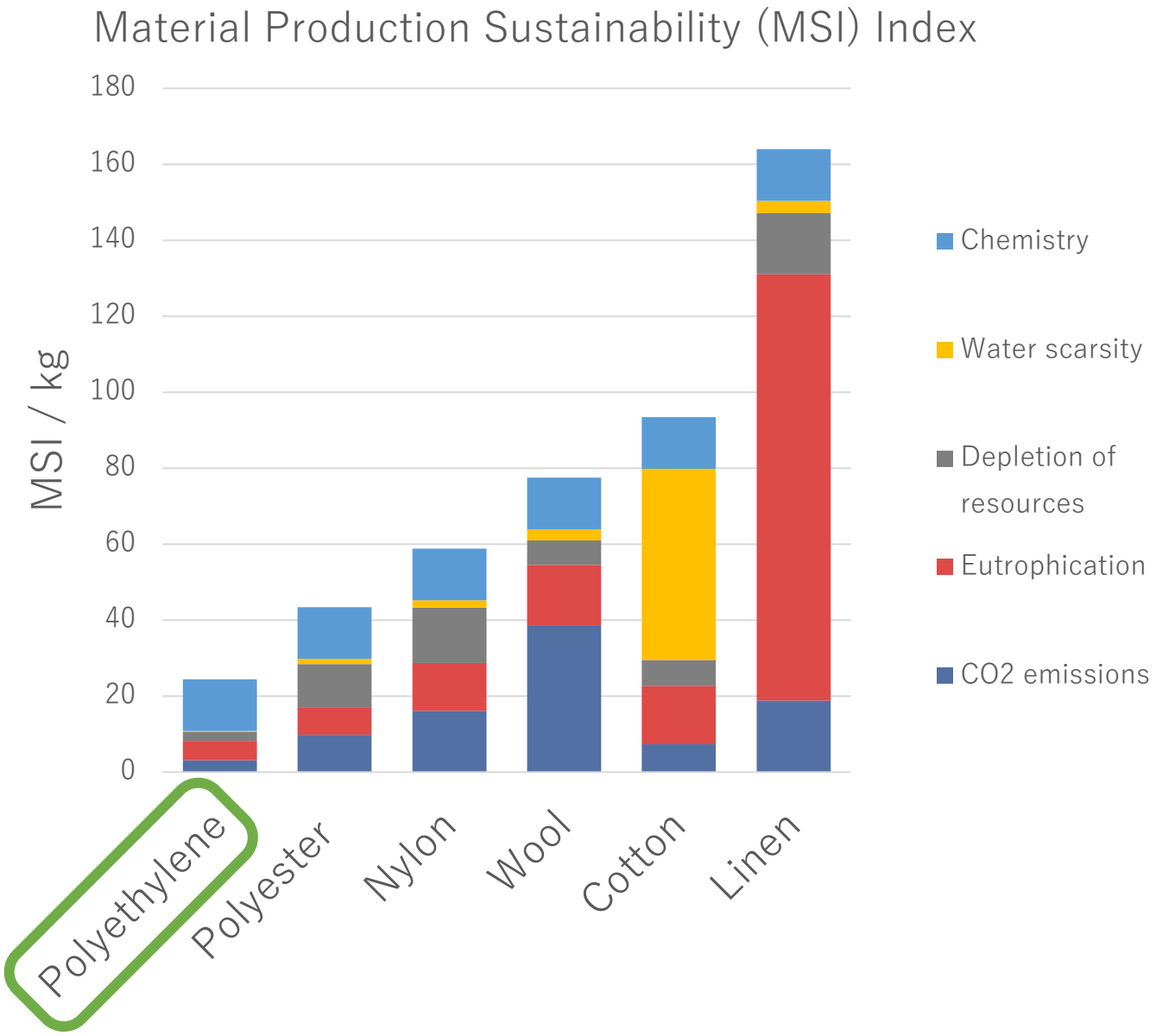
- 149 million ton produced / year [1-2]
- Cheap [1-2]



[1] Qin, Y. (Michelle). *Global Fibres Overview*. (2014).
[2] Geyer, R., Jambeck, J. R. & Law, K. L. Production, use, and fate of all plastics ever made. *Sci. Adv.* **3**, e1700782 (2017)

Why polyethylene?

- Low environmental impact [3]
- Corrosion-resistant
- Easy to recycle [4]

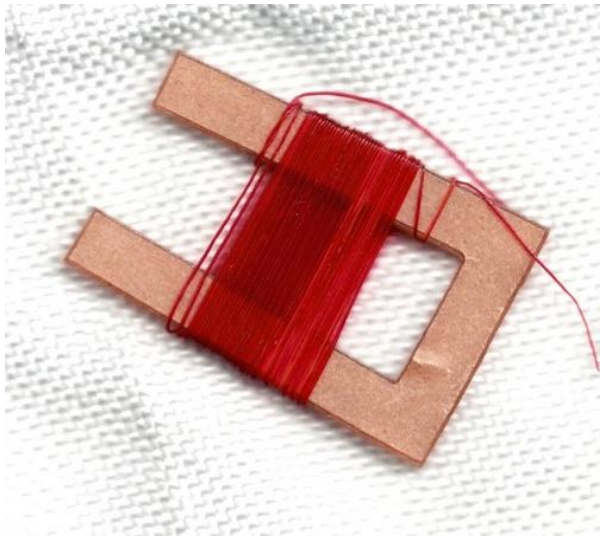


[3] Higg Materials Sustainability Index - https://msi.higg.org/

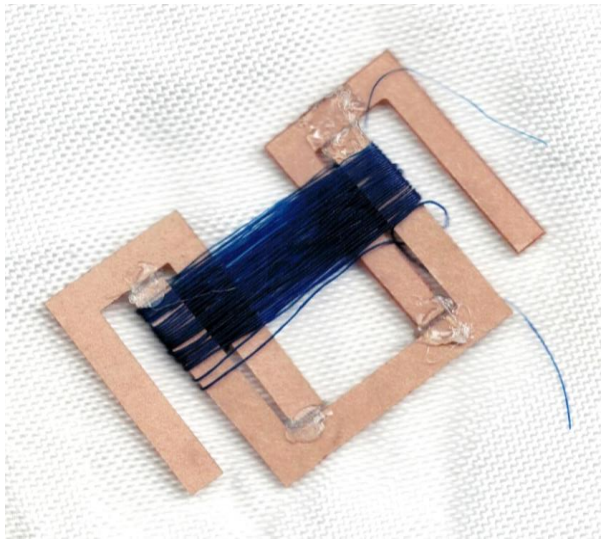
[4] Muthu, S. S., Li, Y., Hu, J. Y. & Mok, P. Y. Recyclability Potential Index (RPI): The concept and quantification of RPI for textile fibres. *Ecol. Indic.* **18**, 58–62 (2012)

Why PE fabrics?

Red-dyed
polyethylene fibers



Blue-dyed
polyethylene fibers

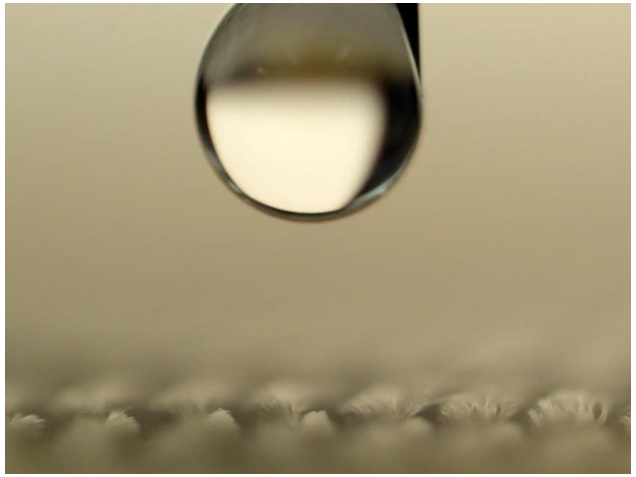


- Dry coloring (no water needed)

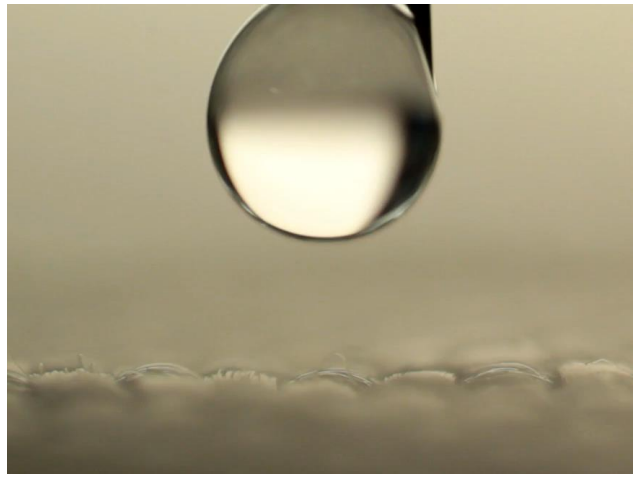
Saving 200L/ kg of material produced

- Tunable surface chemistry
(**play the videos!**)

Hydrophobic textile



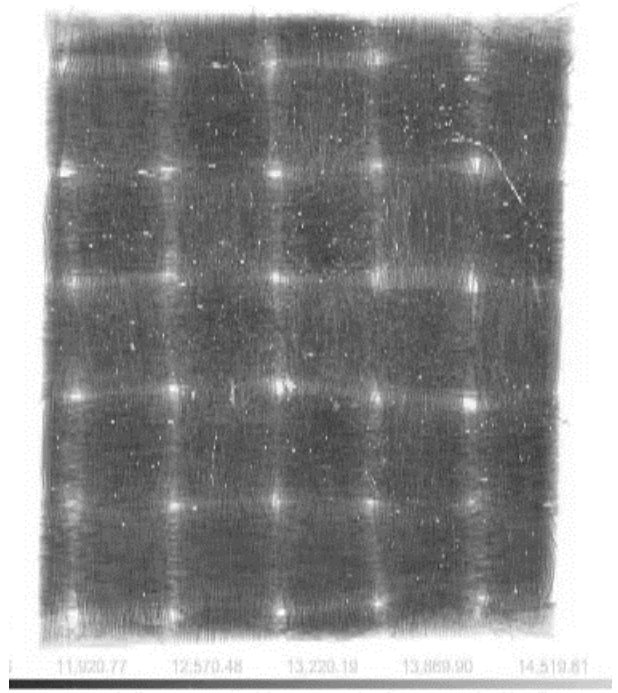
Hydrophilic textile



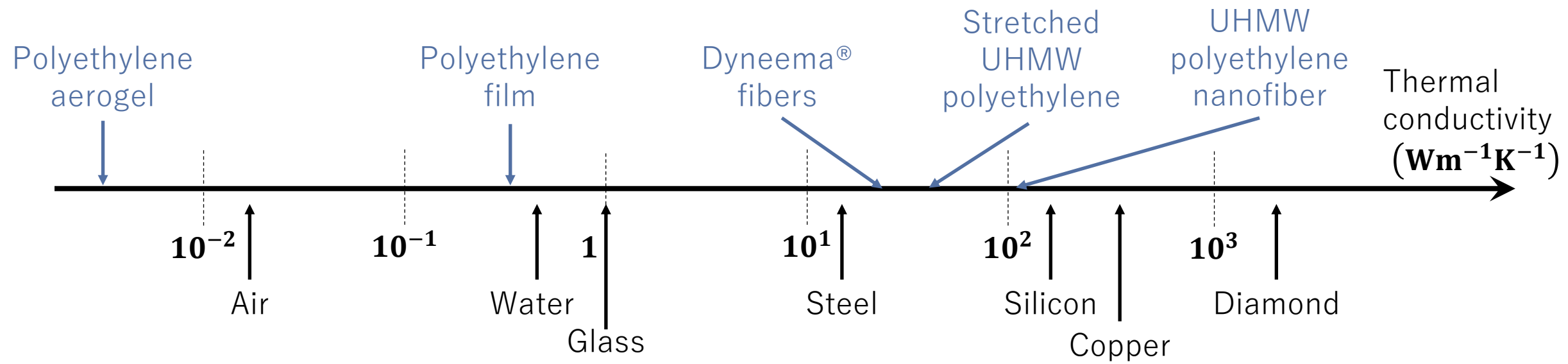
Why PE fabrics?

- Outstanding control of micro/macro-structure

(**play the video!**)



- Tunable thermal and mechanical properties



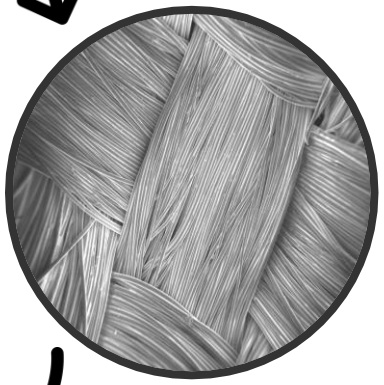
The process

We envision a **closed-loop** process creating **high-value** products from **plastic waste**

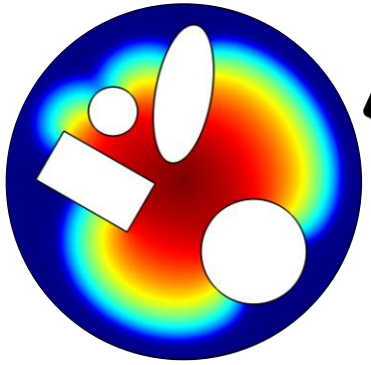
STEP 1:
PE waste

STEP 2:
Recycling

STEP 3:
Micro-structure
design and characterization



STEP 4:
Component-wise
design and optimization

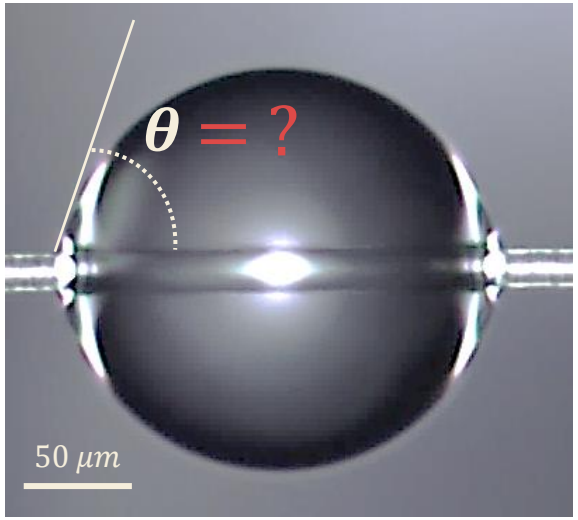


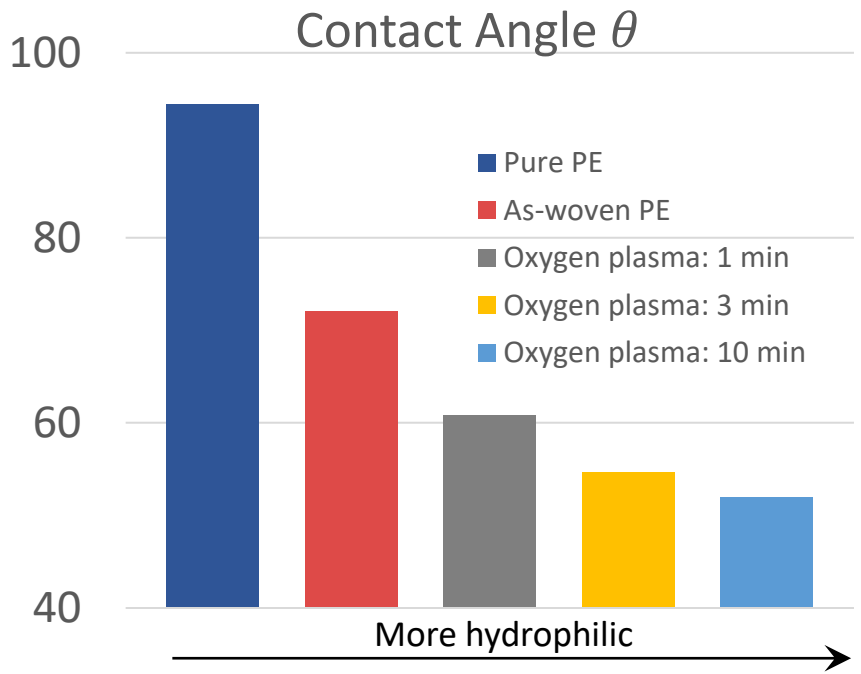
STEP 5:
Fabrication and
implementation

Characterization & Modelling – Microstructure

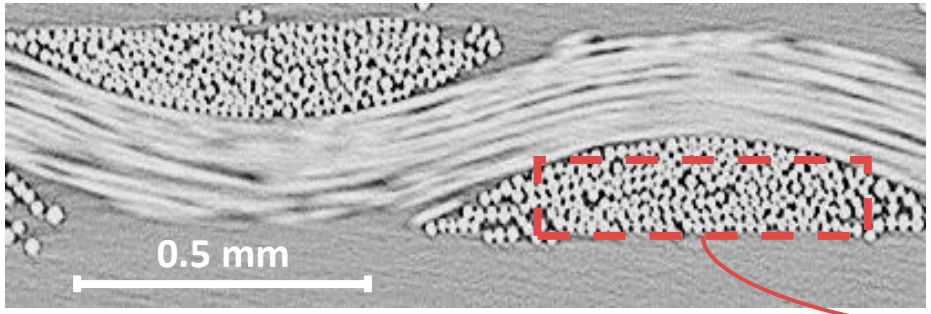
Wettability:

- Crucial to determine wicking and evaporation
- Depends on the surface chemistry
- Can be easily tuned

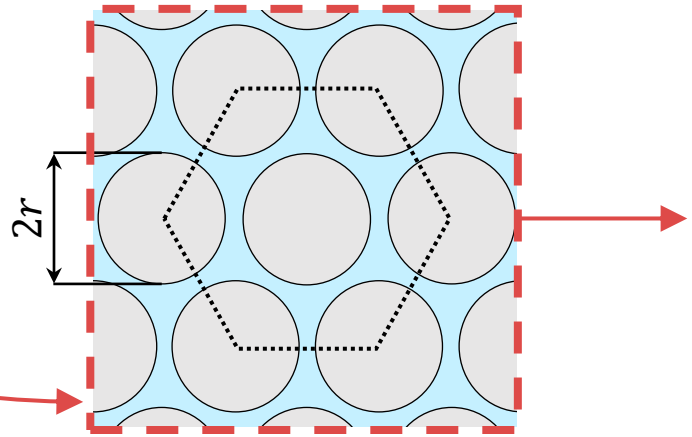




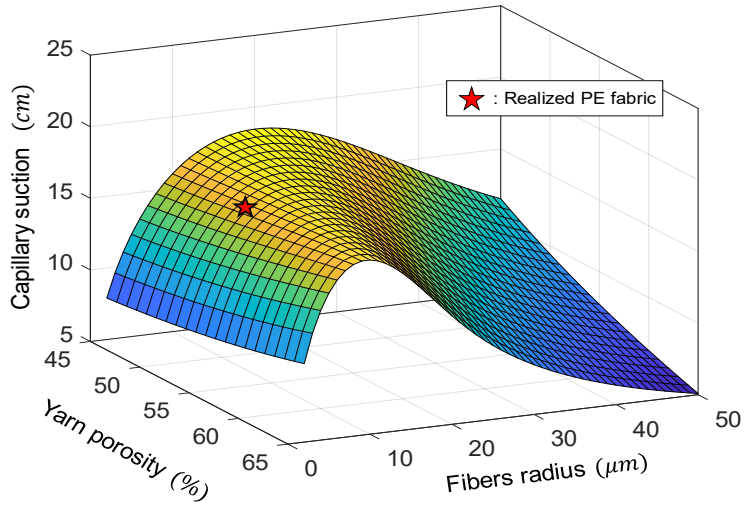
Fibers arrangement



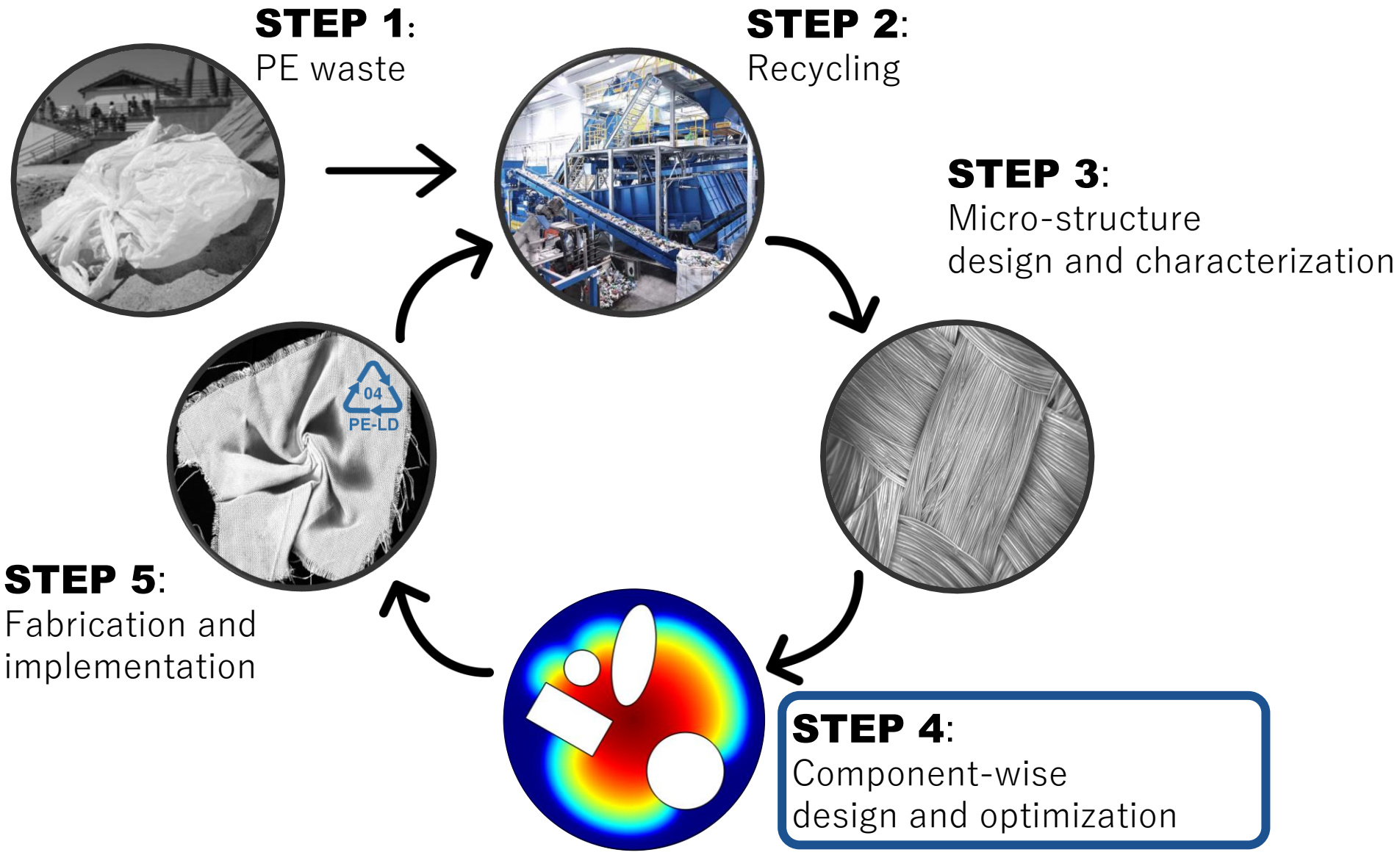
Modelling



Optimize the fabric microstructure



The process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04
PE-LD

Characterization & Modelling – Macrostructure

Heat and mass transfer phenomena involved

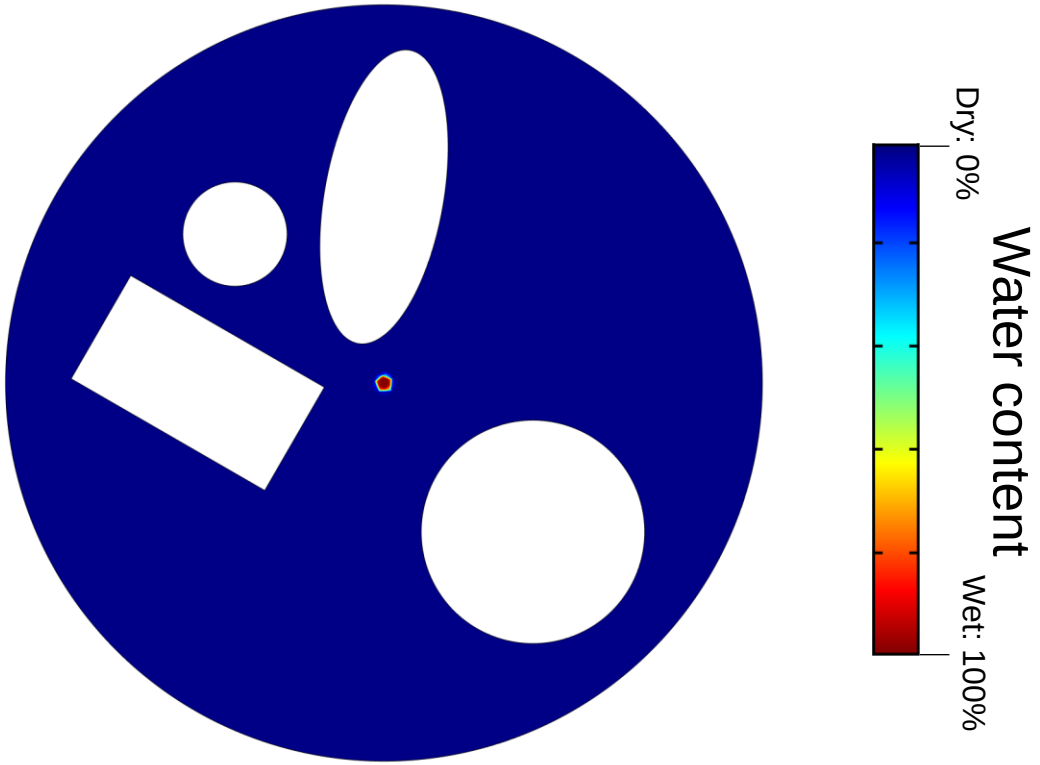
- Micro-structure
- Thermophysical properties of the fluids
- Evaporation
- Conduction and convection
- Radiation

Finite-elements implementation to investigate the coupled heat and mass transfer

Component design

Wetting of complex 2D and 3D geometries

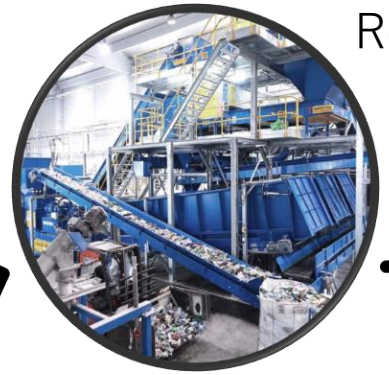
(play the video!)



The process

STEP 1:
PE waste

STEP 2:
Recycling



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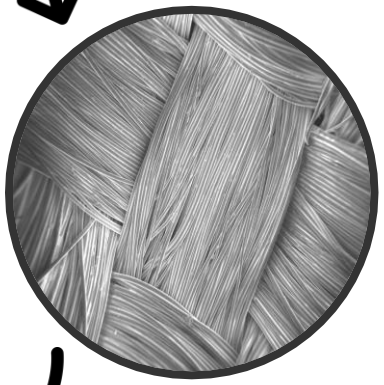
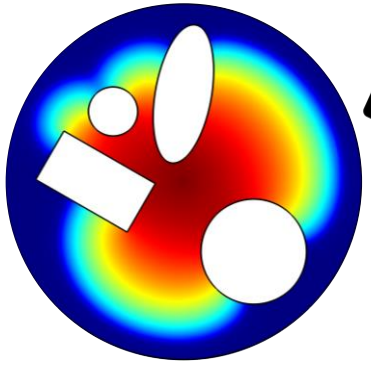
Micro-structure
design and characterization



STEP 4:
Component-wise
design and optimization



STEP 5:
Fabrication and
implementation

Weaving

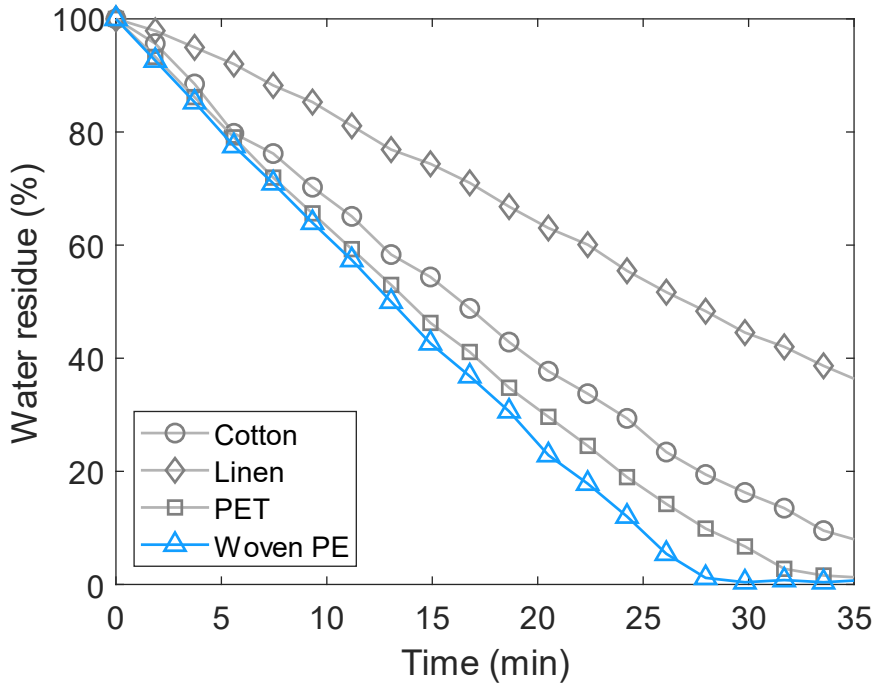
Our fibers can be knitted or woven on **standard industrial equipment**, obtaining various white or colored patterns.

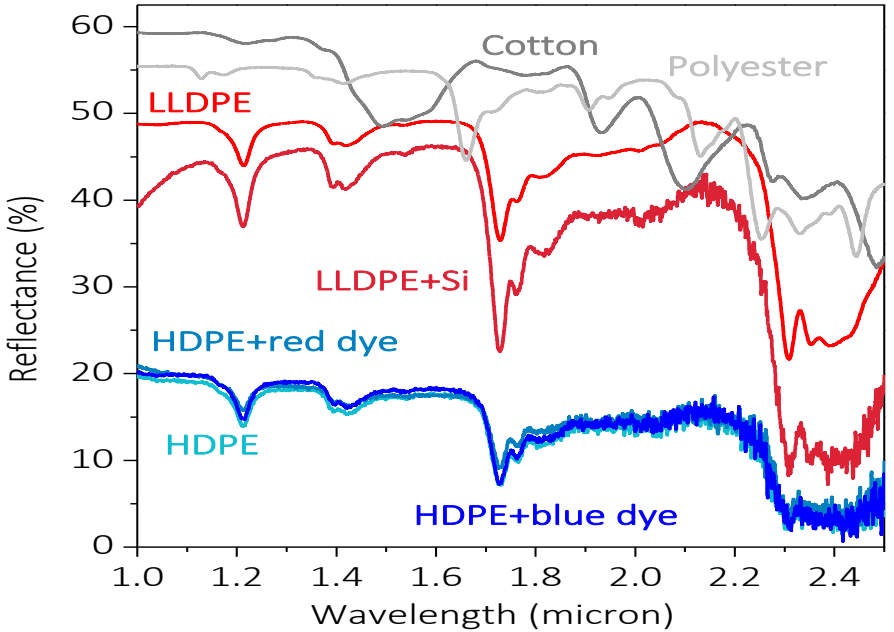
Single-material products are **easier to recycle**: the versatile properties of PE make it suitable to craft **all the components** of garments, from the textile to the buttons and to the label.

Performance

Faster drying rates

Our fabrics **dries faster** than conventional materials, translating into **energy savings** where frequent washing of large quantities of fabrics is required (i.e., **childcare** and **hospitals**)



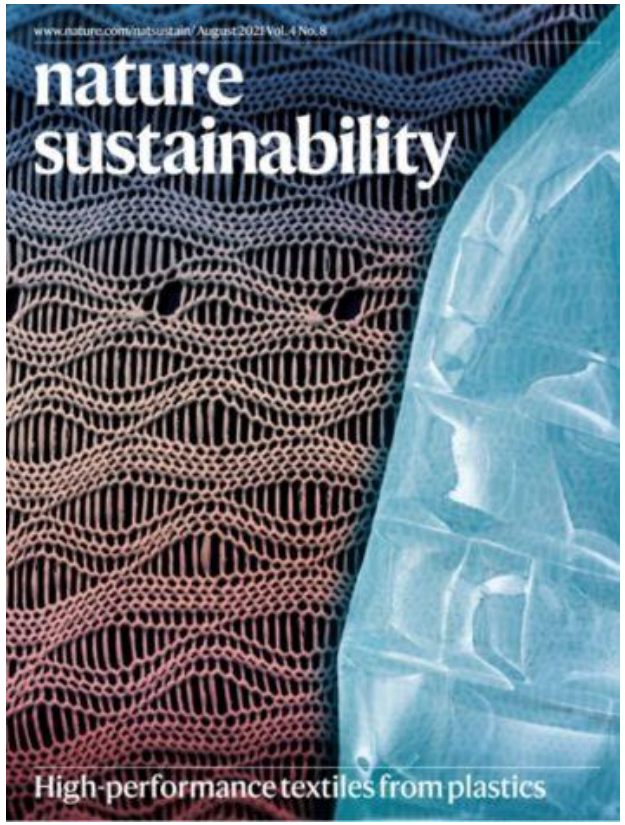


Easy to recycle

Even when dry-colored, our PE fabrics maintain the same **infrared footprint**, easing their sorting and **recycling** process with conventional equipment

Dissemination & Impact

Our work got the cover on Nature Sustainability



The research was presented in the Italian tv program RAI TG Leonardo

An academic spin-off company was recently launched.

The research has been highlighted by the international edition of BBC.