



Workshop: **Next-Generation Antimicrobial Nano-coatings for High-Traffic Surfaces**



***S**ustainable nano**Pa**Rticles **E**nabled anti**M**icrobial surfac**E** coating*

Topic:

Antimicrobial surface solution for demanding sectors



Speaker:

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Next Technology Tecnotessile

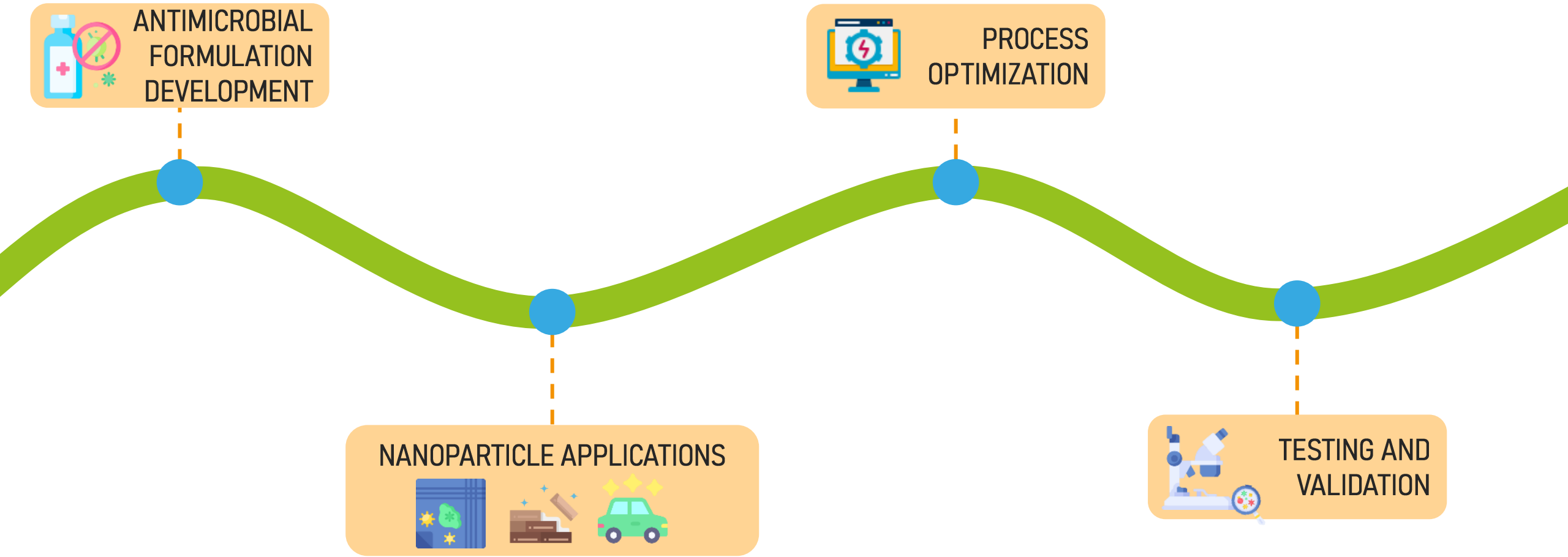


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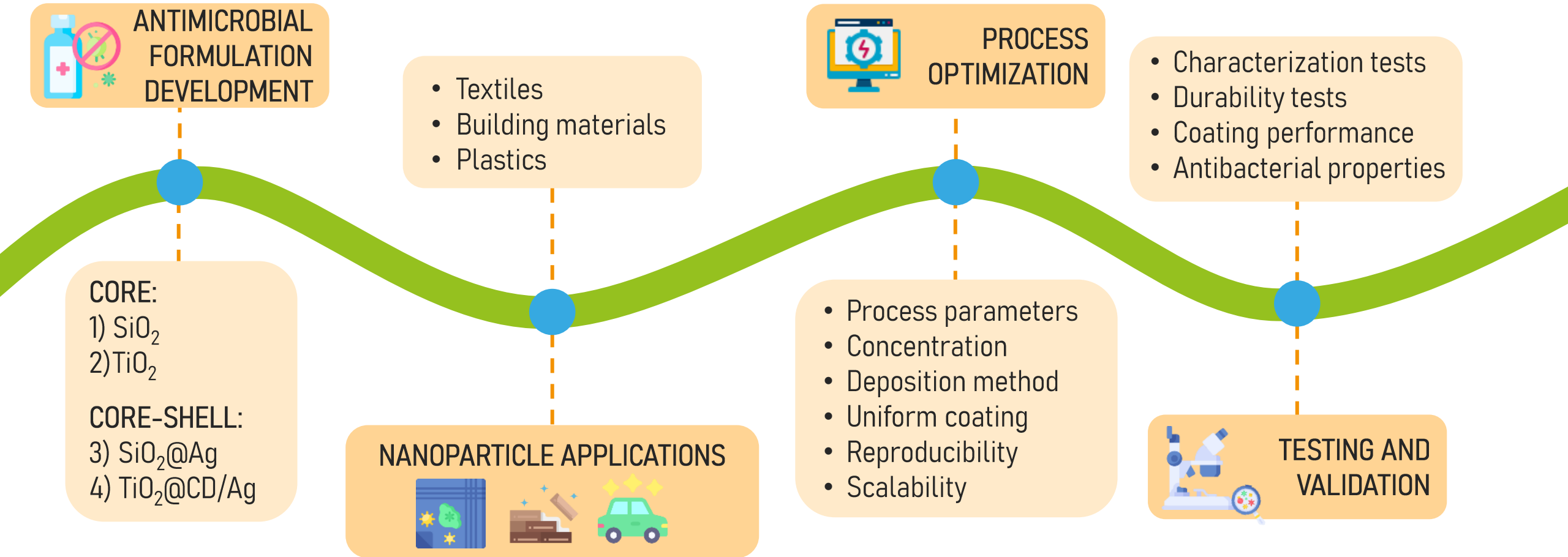
Antimicrobial surface solution for demanding sectors

(Work Package 6 - Implementation and validation)



Antimicrobial surface solution for demanding sectors

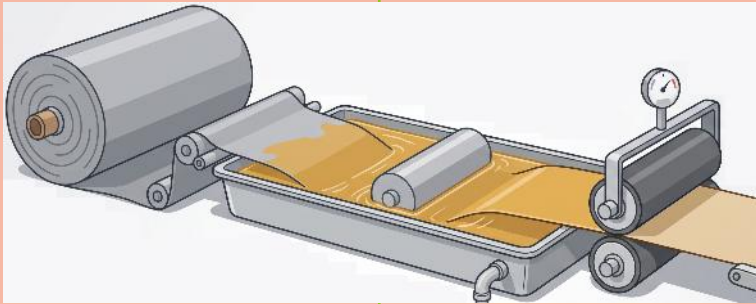
(Work Package 6 - Implementation and validation)



Antimicrobial surface solution for demanding sectors

(Work Package 6 - Implementation and validation)

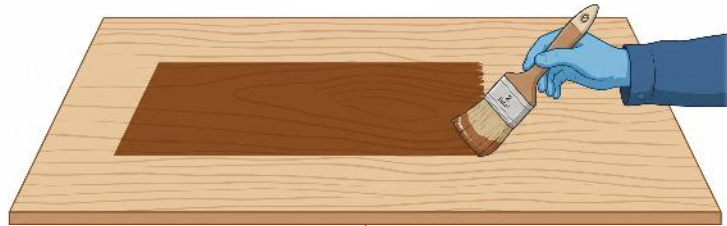
NANOPARTICLE APPLICATIONS



DIP-COATING



BUILDING MATERIALS



BRUSHING



PLASTIC MATERIALS



SPRAYING

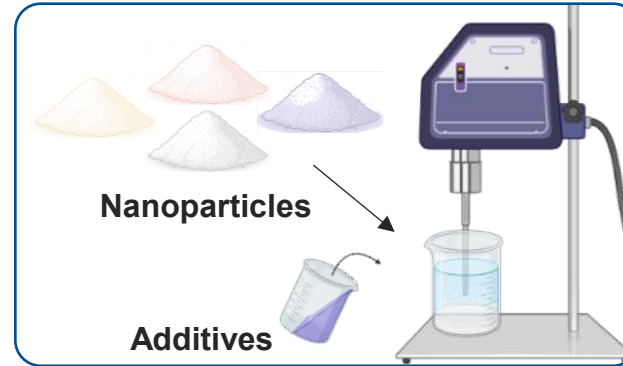


TEXTILES - Antimicrobial formulation development

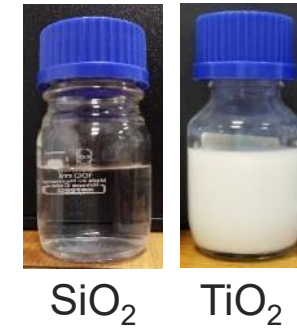
Laboratory scale - Dispersion of NPs

Preparation of water-based NP dispersion:

- Sonication
- NPs (SiO_2 , $\text{SiO}_2@\text{Ag}$, TiO_2 , $\text{TiO}_2@\text{CD}/\text{Ag}$)
- Additives (wetting agent, dispersing agent)



Core NP suspension



Core-shell NP suspension



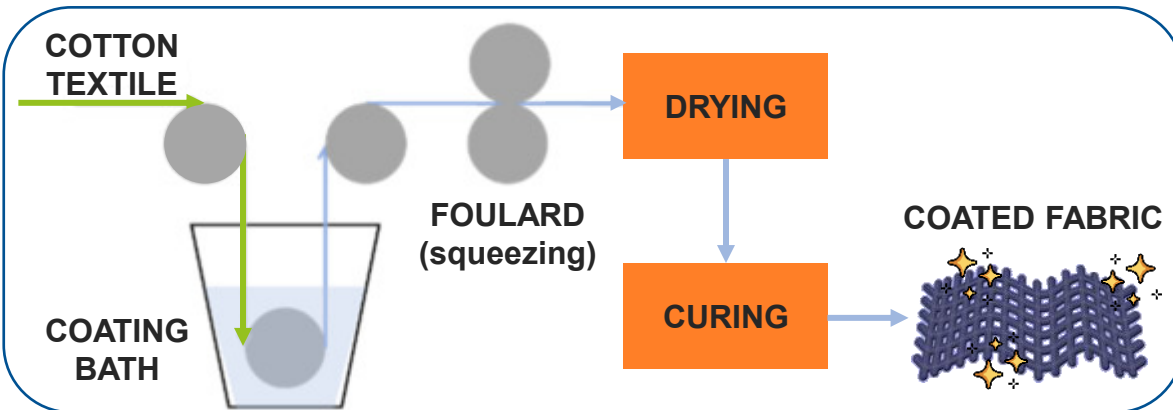
Industrial scale application – Dip-coating

Industrial scale process was reproduced at laboratory scale:

- Core / core-shell NP suspensions
- Fixing agent (acrylic-based (AC) or polyurethane-based (PU) resin)

First trials

Optimization phase



Coated cotton textiles



Characterization analyses



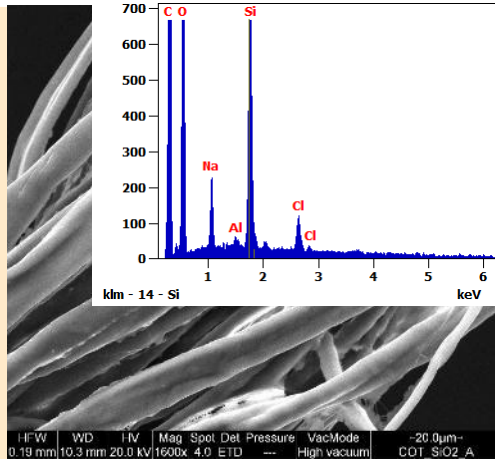
TEXTILES - Coated textile samples with AC-based resin vs PU-based resin

Characterization analyses – SEM-EDX analyses

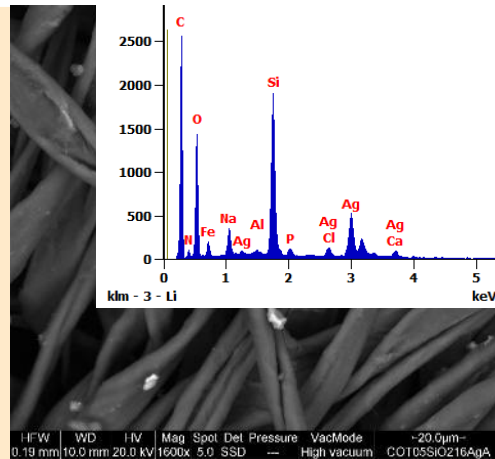
- Polyurethane-based resin improved the particles dispersion on the cotton textile

Acrylic-based resin

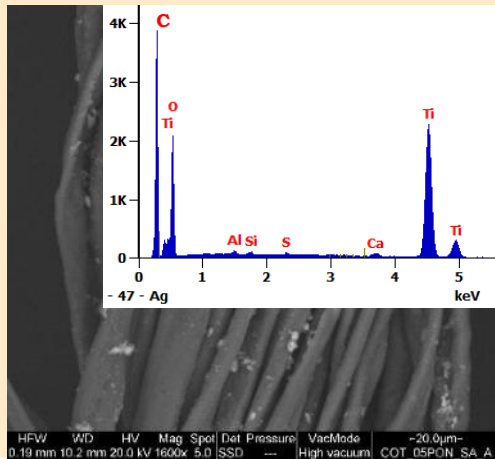
Sample with SiO₂



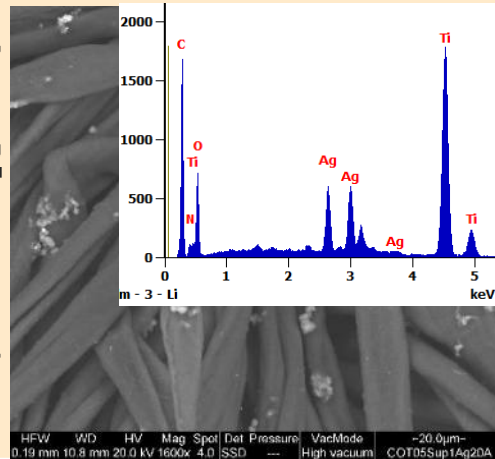
Sample with SiO₂@Ag



Sample with TiO₂

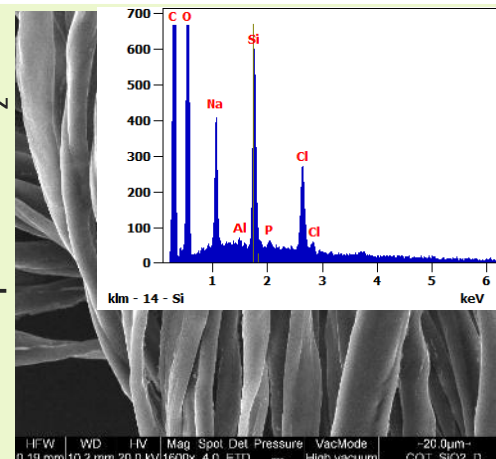


Sample with TiO₂@CD/Ag

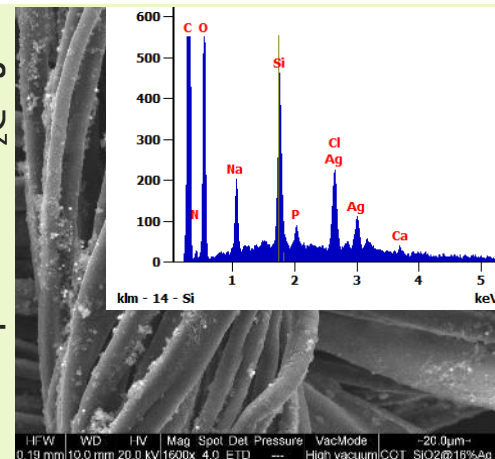


Polyurethane-based resin

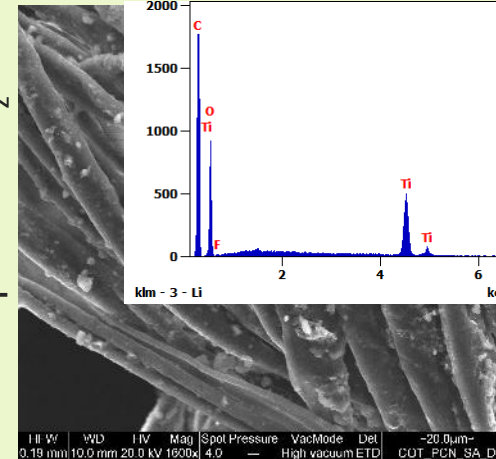
Sample with SiO₂



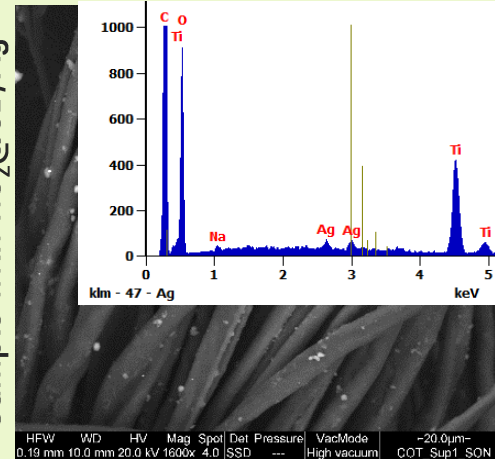
Sample with SiO₂@Ag

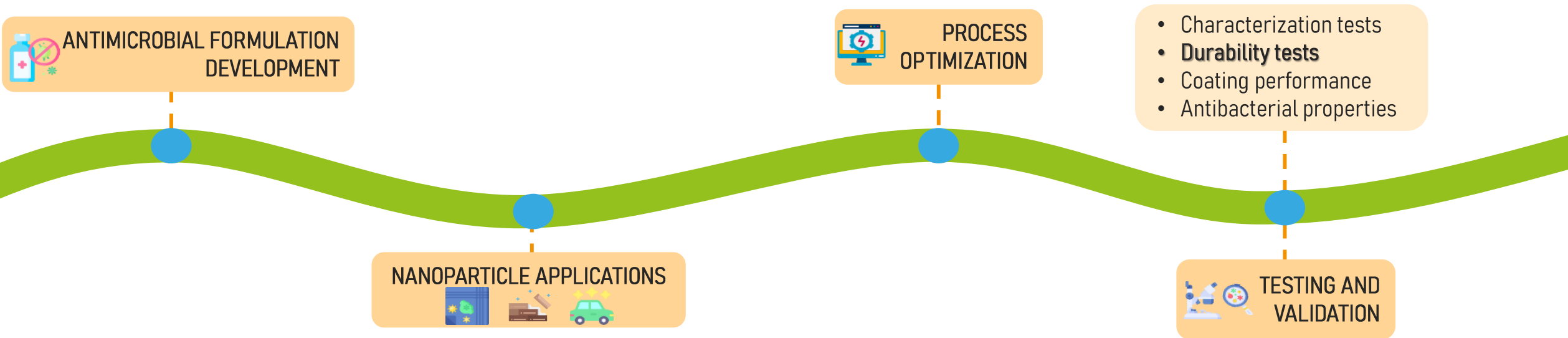


Sample with TiO₂



Sample with TiO₂@CD/Ag





- ## Durability tests
- Abrasion resistance
 - Rubbing resistance
 - Washing resistance
 - Dimensional stability to washing

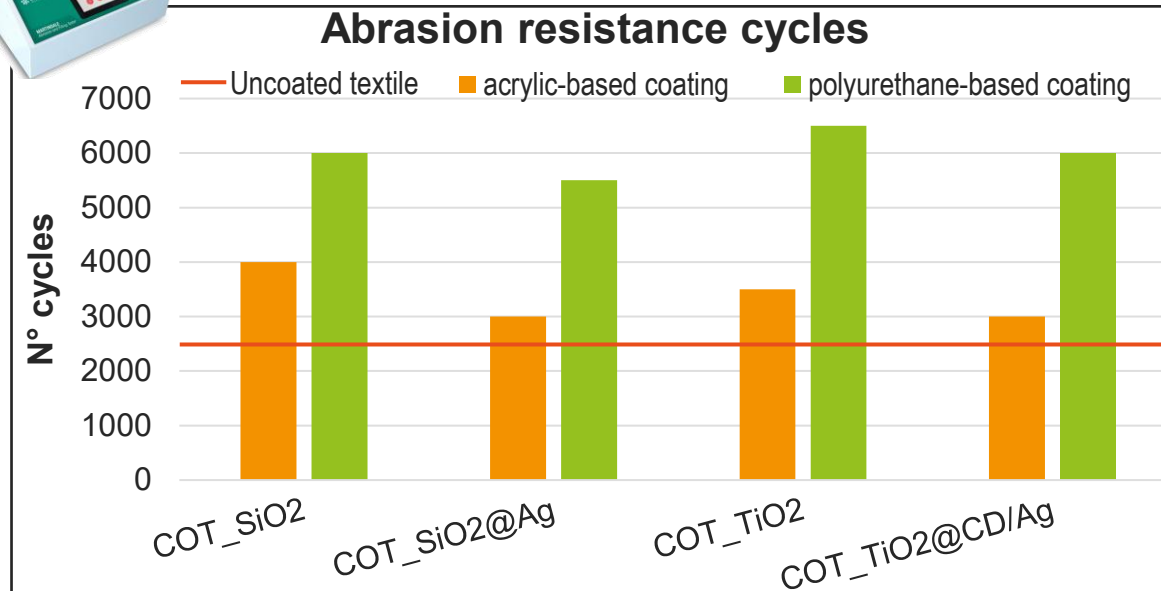




TEXTILES - Coated textile samples with AC-based resin vs PU-based resin

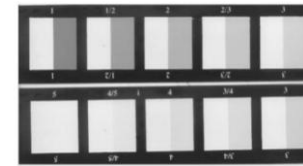
Durability tests – Abrasion resistance

- Textile Standard: EN ISO 12947 – Determination of the abrasion resistance of fabrics by the Martindale method (Martindale method)
- Polyurethane-based resin improved the abrasion resistance:
 - ✓ **Reduced pilling formation**
 - ✓ **Reduced discoloration phenomena**



Durability tests – Rubbing resistance

- Textile Standard: EN ISO 105-X12 – Tests for colour fastness: Colour fastness to rubbing (Crockmeter method)



Grey Scale assessment for colour staining

Grey Scale rating: 1 – 5, where 5 represents the best fastness performance

- Polyurethane-based resin improved the rubbing resistance:
 - ✓ **slight colour staining**

Cotton fabric sample	Resin	NP	Grey scale rating
COT_SiO ₂ _AR	Acrylic-based	SiO ₂	n.a.
COT_SiO ₂ @Ag_AR		SiO ₂ @Ag	3
COT_TiO ₂ _AR		TiO ₂	n.a.
COT_TiO ₂ @CD/Ag_AR		TiO ₂ @CD/Ag	3
COT_SiO ₂ _NR	Polyurethane-based	SiO ₂	n.a.
COT_SiO ₂ @Ag_NR		SiO ₂ @Ag	5
COT_TiO ₂ _NR		TiO ₂	n.a.
COT_TiO ₂ @CD/Ag_NR		TiO ₂ @CD/Ag	4/5



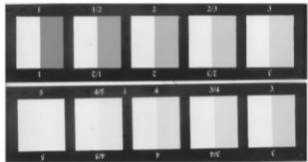
TEXTILES - Coated textile samples with AC-based resin vs PU-based resin

Durability tests – Washing resistance



Dimensional stability to washing

- Textile Standard: EN ISO 105-C10 – Tests for colour fastness: Colour fastness to washing with soap
→ *Washing temperature*: 40°C
→ *Washing time*: 30 minutes



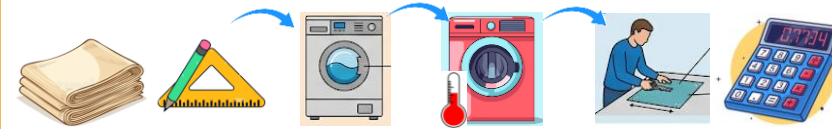
Grey Scale assessment for colour staining

Grey Scale rating: 1 – 5, where 5 represents the best fastness performance

- Polyurethane-based resin improved the washing resistance:
✓ **slight colour change**

Sample	Resin	NP	Grey scale rating
COT_SiO ₂ _AR	Acrylic -based	SiO ₂	4
COT_SiO ₂ @Ag_AR		SiO ₂ @Ag	3
COT_TiO ₂ _AR		TiO ₂	4
COT_TiO ₂ @CD/Ag_AR		TiO ₂ @CD/Ag	3
COT_SiO ₂ _NR	Polyurethane -based	SiO ₂	4
COT_SiO ₂ @Ag_NR		SiO ₂ @Ag	5
COT_TiO ₂ _NR		TiO ₂	4/5
COT_TiO ₂ @CD/Ag_NR		TiO ₂ @CD/Ag	4/5

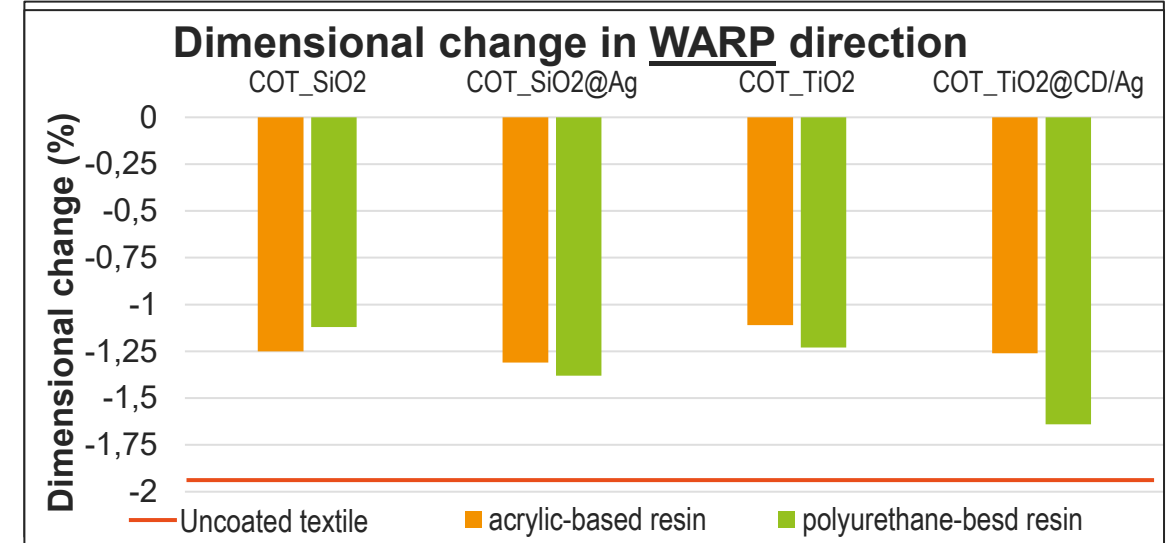
- Textile Standard: EN ISO 5077 – Determination of dimensional change in washing and drying
→ *Drying method*: tumble dryer
→ *Evaluation*: percentage dimensional change after washing and drying

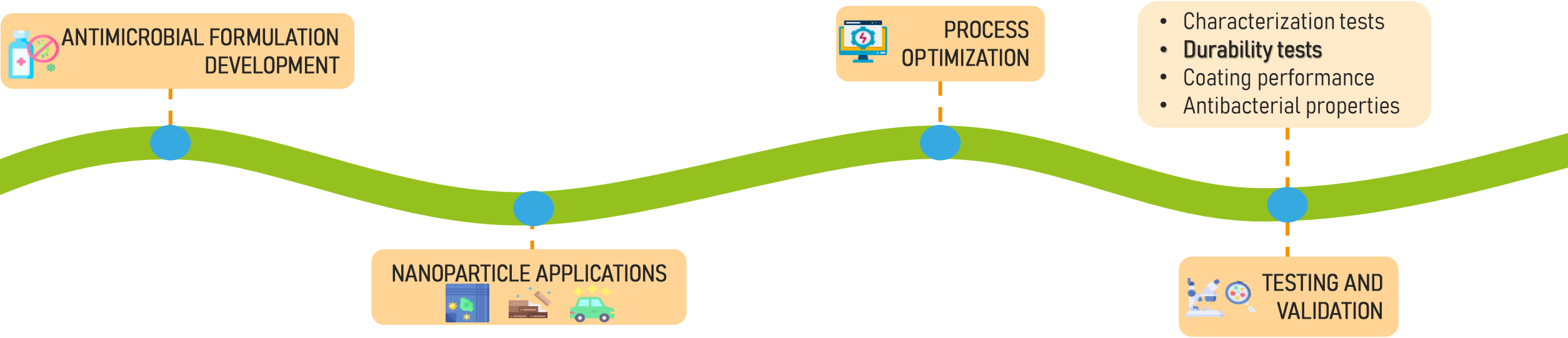


$$x\% = \frac{x_t - x_0}{x_0} \times 100$$

x_0 : original dimension
 x_t : dimension measured after treatment

- Both acrylic and polyurethane-based resin reduced the shrinkage:
✓ **Coatings reduced the shrinkage of the coated cotton textiles**



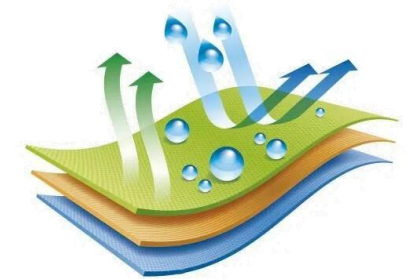


Coating performance

- Vertical Wicking
- Thermal and water vapour resistance



Coated textile samples with PU-based resin



Coating performance - Vertical Wicking

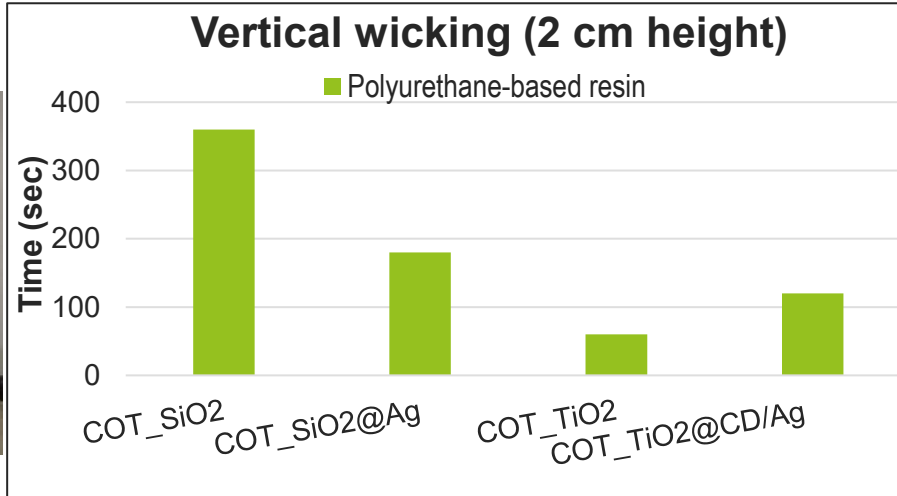
- Textile Standard: AATCC TM197 – Vertical Wicking Rate of Textiles: to Specified Distances
 → *Evaluation*: Recording of the time required for the water front to reach a 2 cm height

Example:

Uncoated cotton textile



Time >30 min

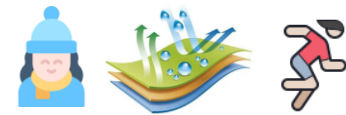


- Uncoated cotton fabric reached the 2 cm height after ~ 30 min.
- Coated fabric reached the 2 cm height faster than the uncoated fabric.
- Initial capillary transport was rapid.
- Wicking rate decreased beyond 2 cm (>30 min to reach 4 cm).

Coating performance – Thermal and water vapour resistance

- Textile Standard: EN ISO 11092 - Measurement of thermal and water-vapour resistance under steady-state conditions (sweating guarded-hotplate test)
 → *Parameters (R_{ct})*: 20°C, 65% RH
 → *Parameters (R_{et})*: 35°C, 40% RH

Sample	R _{ct} (m ² K/W)*	R _{et} (m ² Pa/W)*
Uncoated cotton fabric	0,031	1,50
COT_SiO ₂ _NR	0,022	1,10
COT_SiO ₂ @Ag_NR	0,026	1,10
COT_TiO ₂ _NR	0,039	1,76
COT_TiO ₂ @CD/Ag_NR	0,038	1,77
Pile or Wool jumper	~0,080	10,00 – 15,00
T-shirt for running	~0,020	3,00 – 5,00



Example of comfortable garments

* Hohenstein Institute reference values:

R_{ct} = 0,155 m² K/W amount of insulation that allows a person at rest to maintain thermal equilibrium in an environment at 21°C in a normally ventilated room (0,1 m/s air speed).

R_{et} < 6 m² Pa/W correspond to very high level of breathability; R_{et} < 20 m² Pa/W correspond to medium level of breathability; R_{et} > 30 m² Pa/W correspond to very low level of breathability.

- Uncoated and coated samples showed low thermal insulation and high breathability
- Coatings does not affect the thermal and water vapor resistance of the cotton fabric.

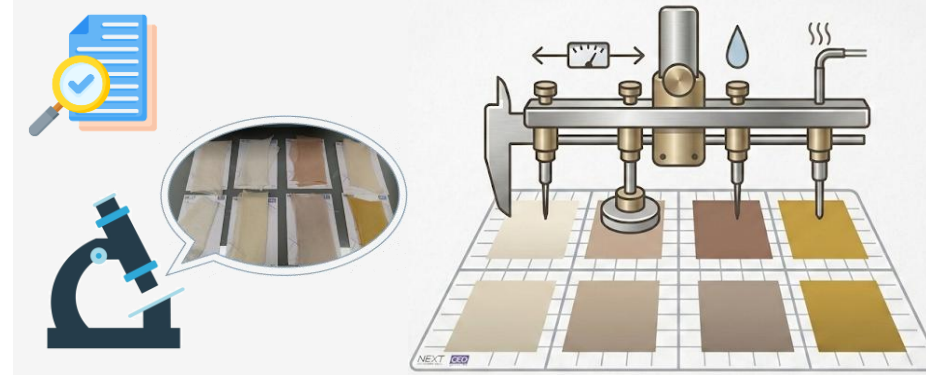
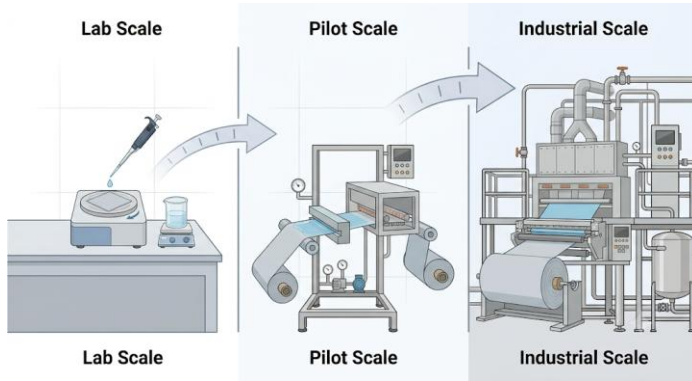


Conclusions on the activities performed on textile substrates





Conclusions on the activities performed on textile substrates



Cotton textile coated with the SUPREME's antimicrobial coatings

- ✓ Formulation developed and applied at laboratory-scale;
- ✓ Process compatible with industrial-scale textile finishing.

- ✓ The coated fabrics with polyurethane-based resin demonstrated improved performance compared to the coated fabrics with acrylic-based resin;
- ✓ Homogeneous nanoparticle distribution;
- ✓ Superior durability and washing resistance;
- ✓ The coated fabrics showed low thermal insulation and high breathability.



Thank you.



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