SMART TEXTILES FOR LIVING BACTERIA DETECTION BASED ON ELECTROCHROMIC MATERIALS

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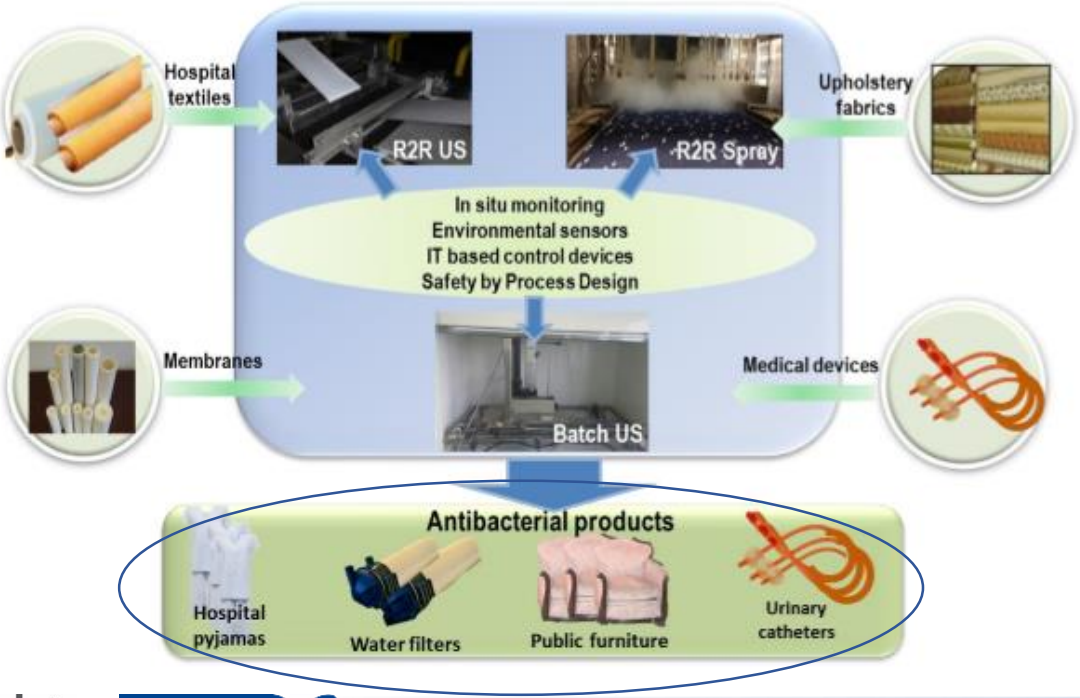
PROTECT PROJECT

Pre-commercial lines for production of surface nanostructured antimicrobial and anti-biofilm textiles, medical devices and water treatment membranes

Up to 60% of the textiles used in hospitals are contaminated with potentially dangerous bacteria

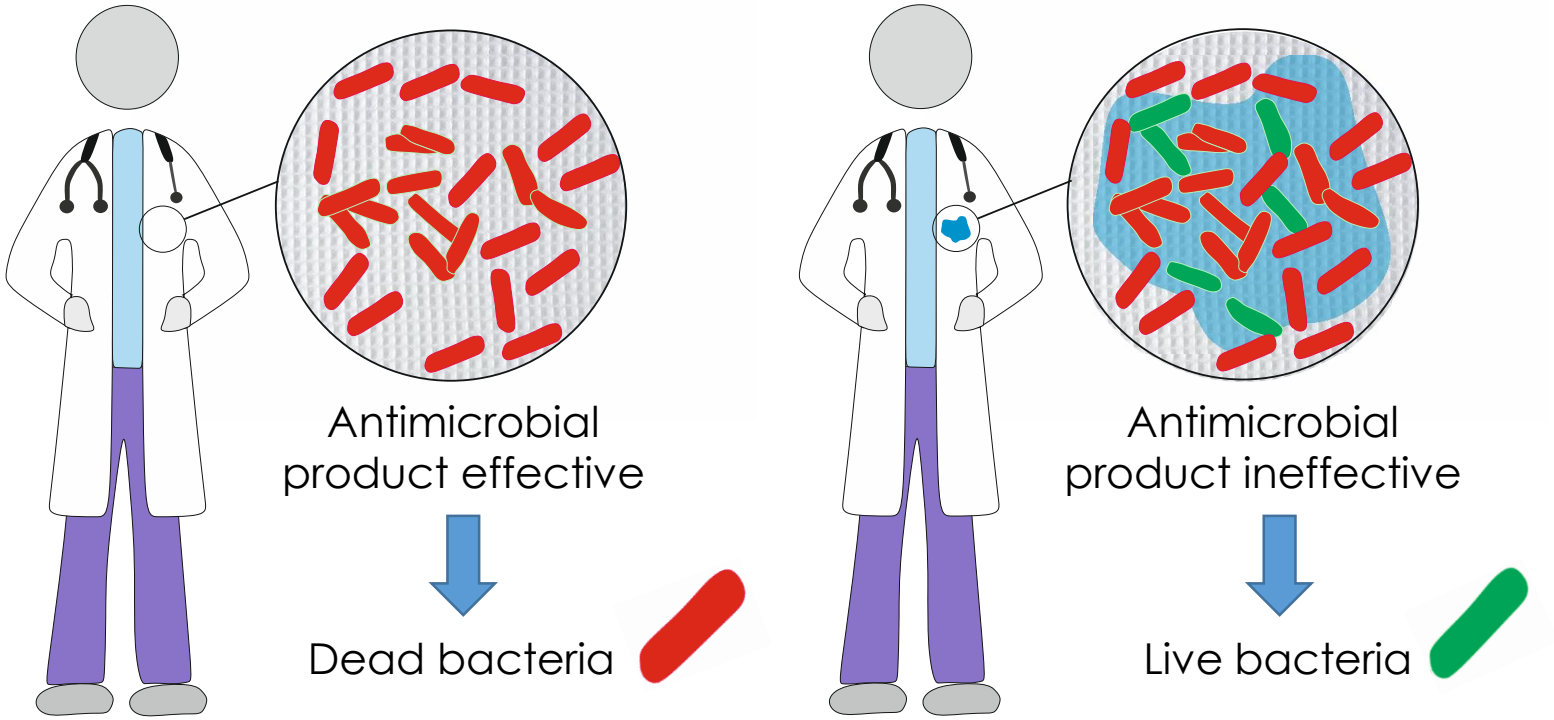
American Journal of Infection Control



Hospital-acquired infections (HAI)

PROTECT PROJECT

Pre-commercial lines for production of surface nanostructured antimicrobial and anti-biofilm textiles, medical devices and water treatment membranes



Smart sensors for live bacteria detection

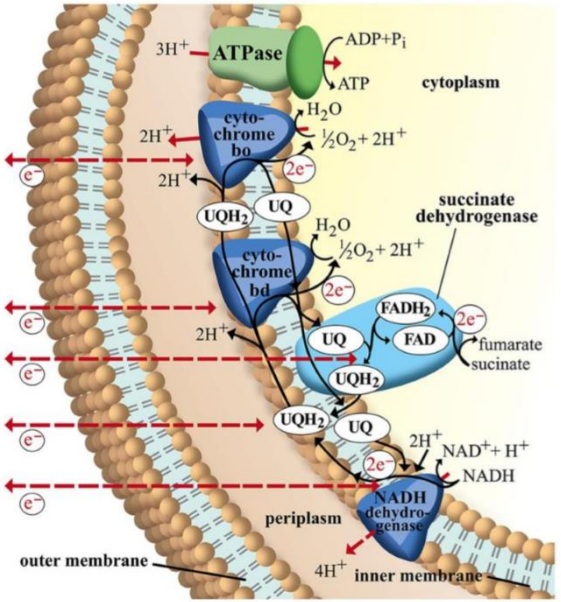
BIOELECTROCHROMIC MOLECULES AS SENSING PROBES

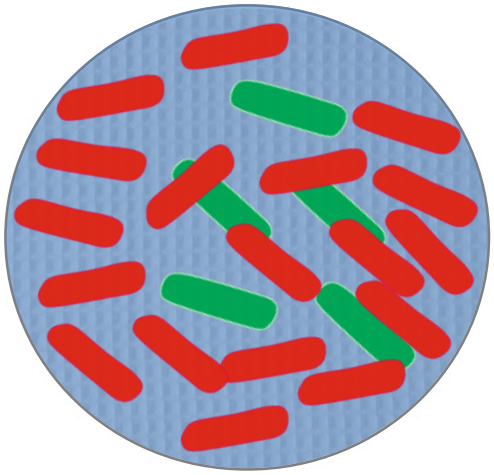
Final electron aceptors of the bacterial electron transport chain.

Redox change → Color change

Bioelectrochromic (Oxidized state)

Bioelectrochromic (Reduced state)



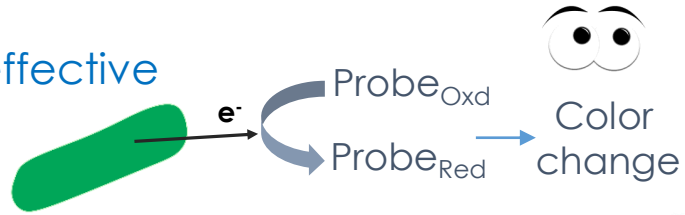


Antimicrobial product effective

Dead bacteria

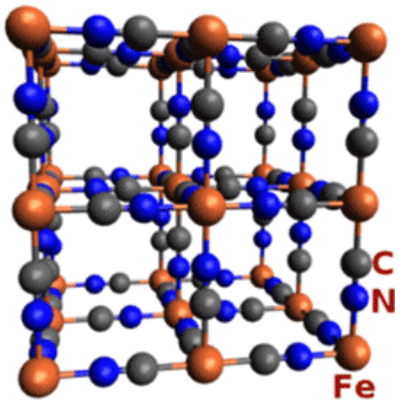
Antimicrobial product ineffective

Live bacteria

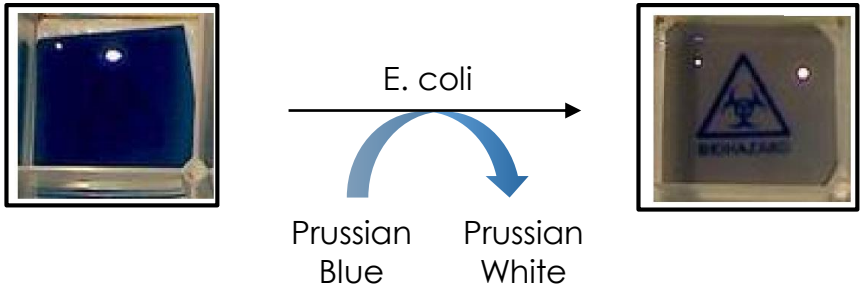


BIOELECTROCHROMIC MOLECULES AS SENSING PROBES

Prussian Blue



Water filter modified with PB



Blue → Colourless

Why??

- Preliminary results support the use of PB as metabolic indicator.
- PB is a popular pigment previously used as a textile dye.
- PB low toxicity and easy synthesis.
- PB applications in biomedicine and biosensing.
- Clear color change.

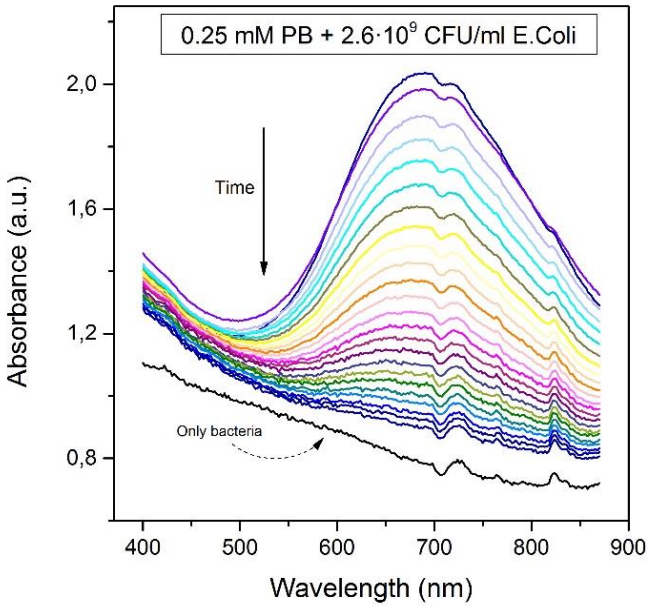
BIOELECTROCHROMIC MOLECULES AS SENSING PROBES

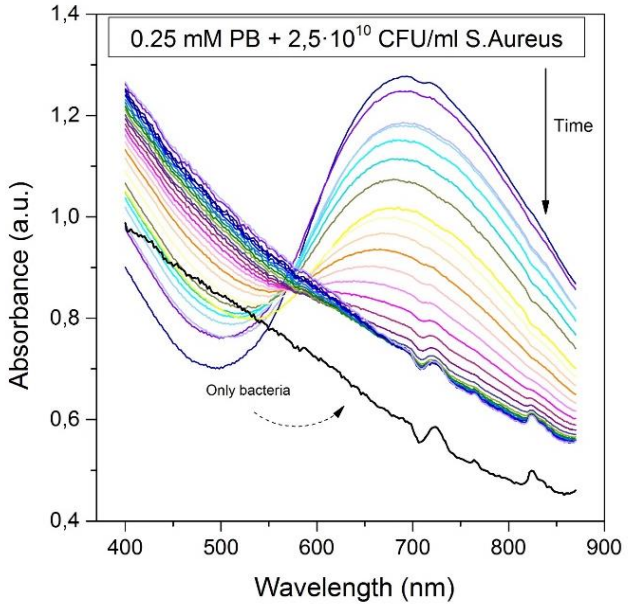
Prussian Blue

Bacterial assays
(in solution)

PB soluble

PB ~~insoluble~~





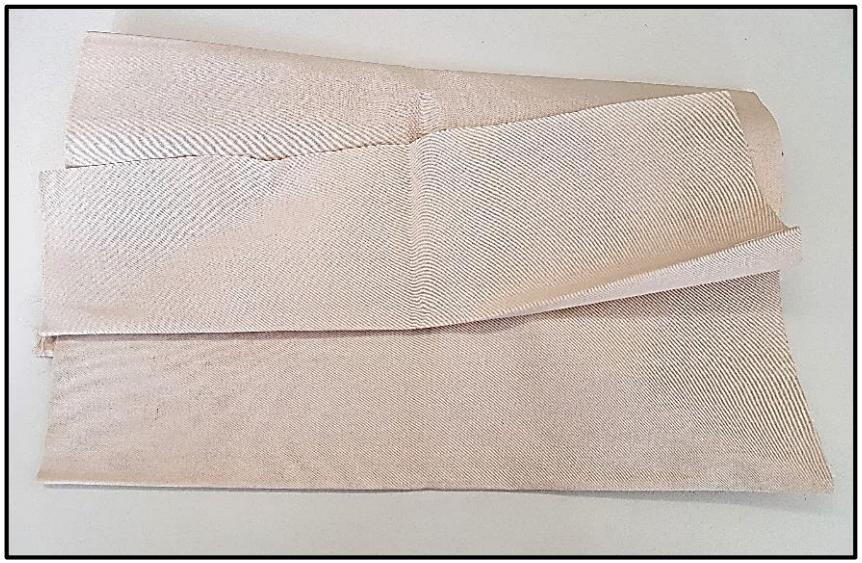
0.25 mM PB soluble in solution + bacteria

BIOELECTROCHROMIC MOLECULES AS SENSING PROBES

Polyester Cotton Fabrics

Unmodified textile

Modified textile with antibacterial NPs



CuO NPs
Modification Speed of 5 m/min

BIOELECTROCHROMIC MOLECULES AS SENSING PROBES

Prussian Blue deposition processes into the textile

- Ultrasound coating
- Cyanotype Process

BIOELECTROCHROMIC MOLECULES AS SENSING PROBES

Prussian Blue deposition processes into the textile

Ultrasound coating

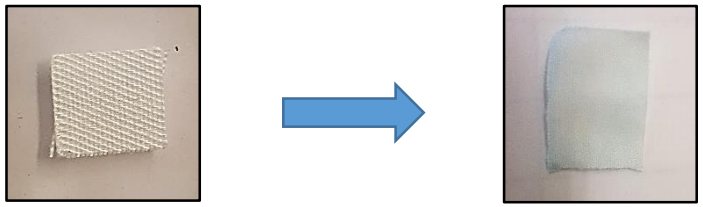
Sonication time

Concentration

Cyanotype Process

- **Prussian Blue soluble**

$$FeCl_2 + K_3[Fe_2(CN)_6] \rightarrow K[Fe_2(CN)_6]$$



- **Prussian Blue insoluble:**

$$K_3[Fe_2(CN)_6] + FeCl_{2(exc)} \rightarrow Fe_4[Fe(CN)_6]_3$$

BIOELECTROCHROMIC MOLECULES AS SENSING PROBES

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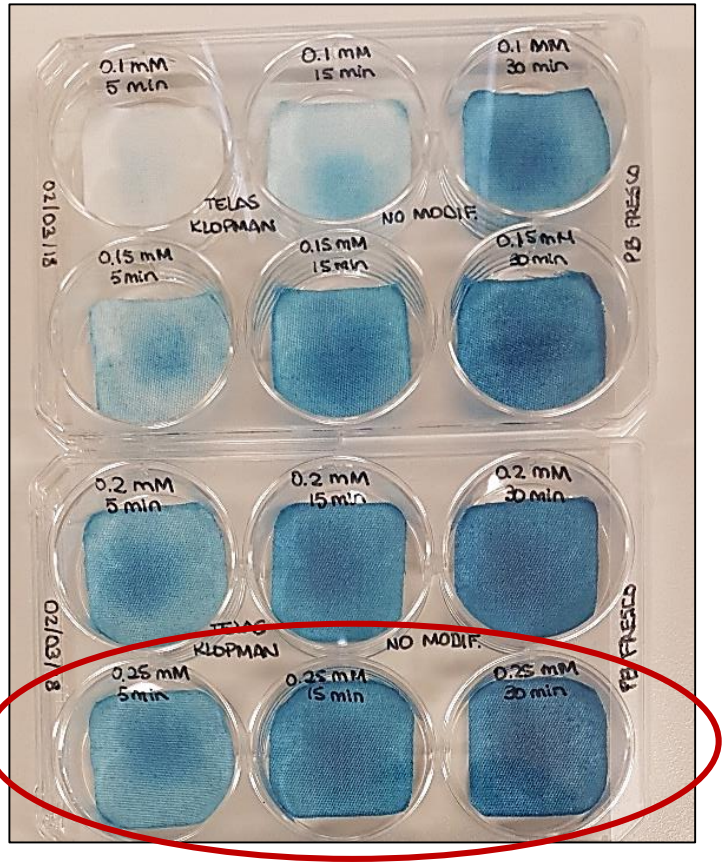
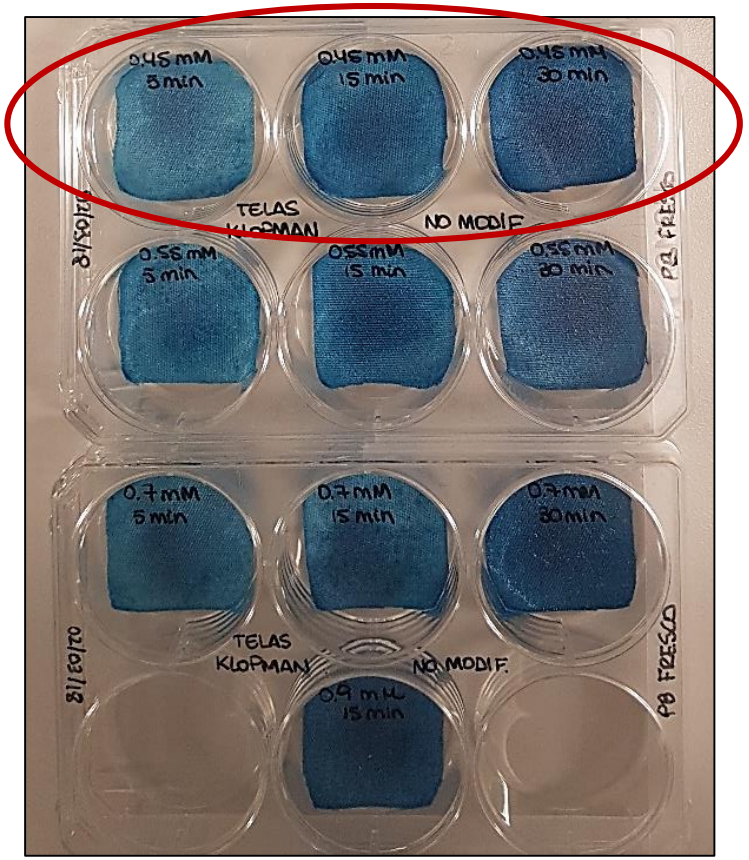
CuO NPs
Modification Speed of 5 m/min

BIOELECTROCHROMIC MOLECULES AS SENSING PROBES

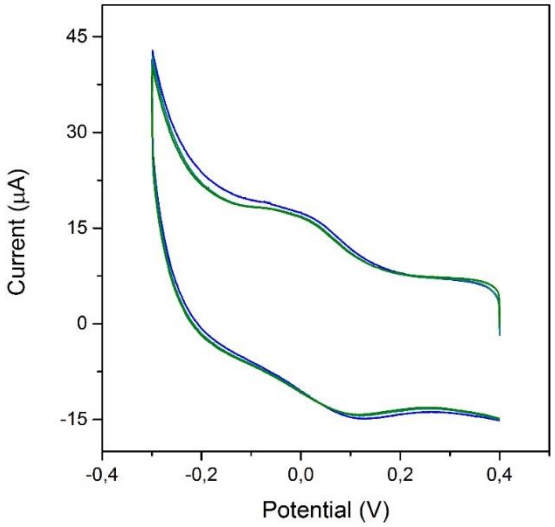
Ultrasound Coating: Unmodified Textiles





BIOELECTROCHROMIC MOLECULES AS SENSING PROBES

Ultrasound Coating: Unmodified Textiles



PB redox reactions

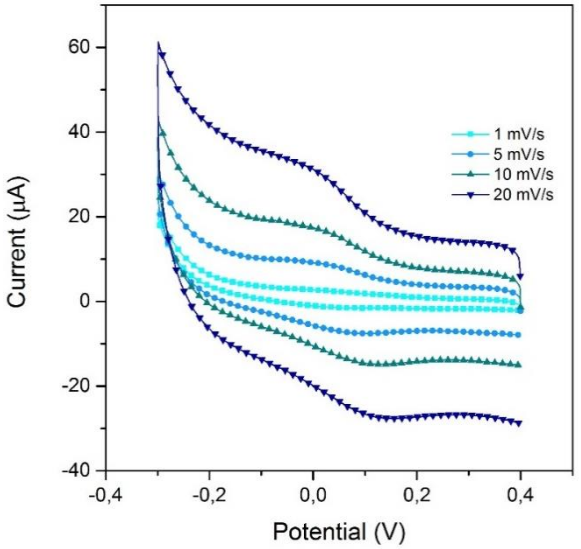
$$\mathbf{KFe^{III}Fe^{II}(CN)_6 + K^+ + e^- \leftrightarrow K_2Fe^{II}Fe^{II}(CN)_6}$$

"soluble PB" — Prussian White-PW (Everitt Salt)

$$\mathbf{Fe_4^{III}[Fe^{II}(CN)_6]_3 + 4K^+ + 4e^- \leftrightarrow K_4Fe_4^{II}[Fe^{II}(CN)_6]_3}$$

"insoluble PB" — Prussian White-PW (Everitt Salt)

UAB Universitat Autònoma de Barcelona



Electrochemical Measurements

RE: Saturated Calomel Electrode (SCE)
CE: Platinum
WE: Glassy Carbon glass

2-hydroxyethyl cellulose

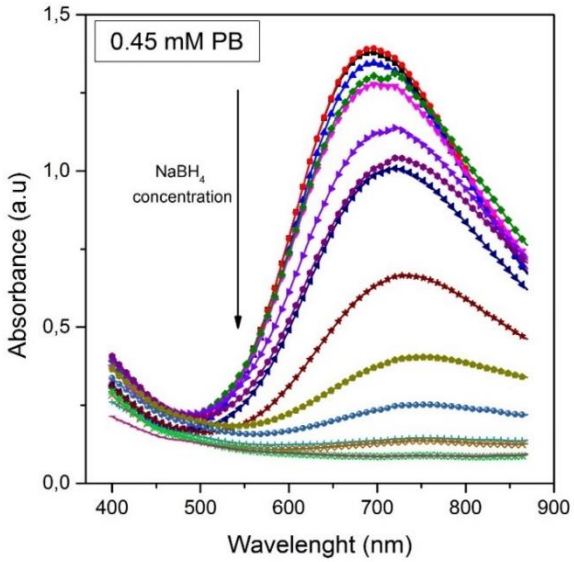
gtq

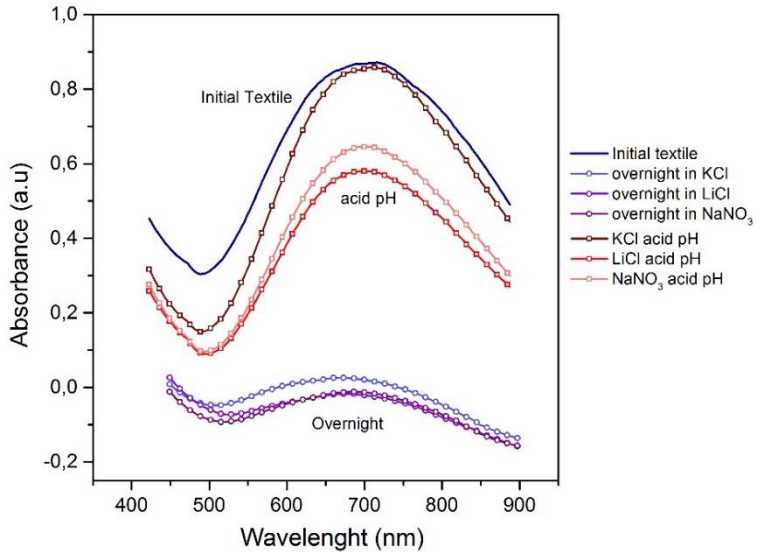
cnm Centre Nacional de Microelectrònica IMB

BIOELECTROCHROMIC MOLECULES AS SENSING PROBES

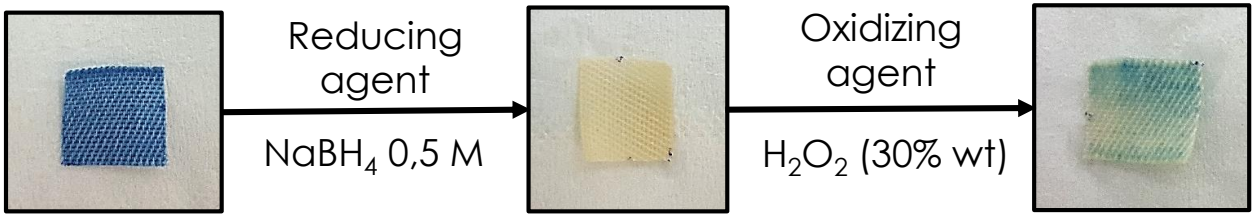
Ultrasound Coating: Unmodified Textiles

- Reversibility assays





Textiles with 0.25 mM PB (15 min)



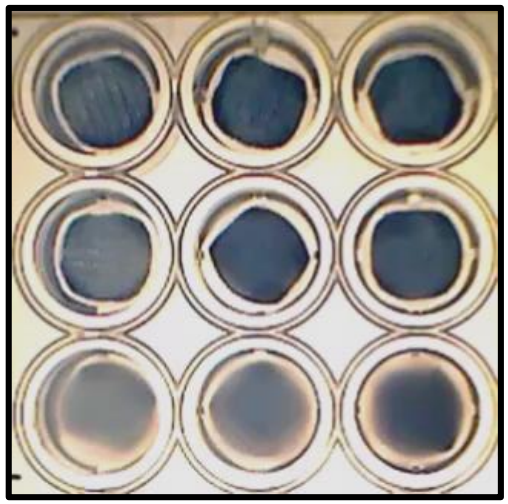
BIOELECTROCHROMIC MOLECULES AS SENSING PROBES

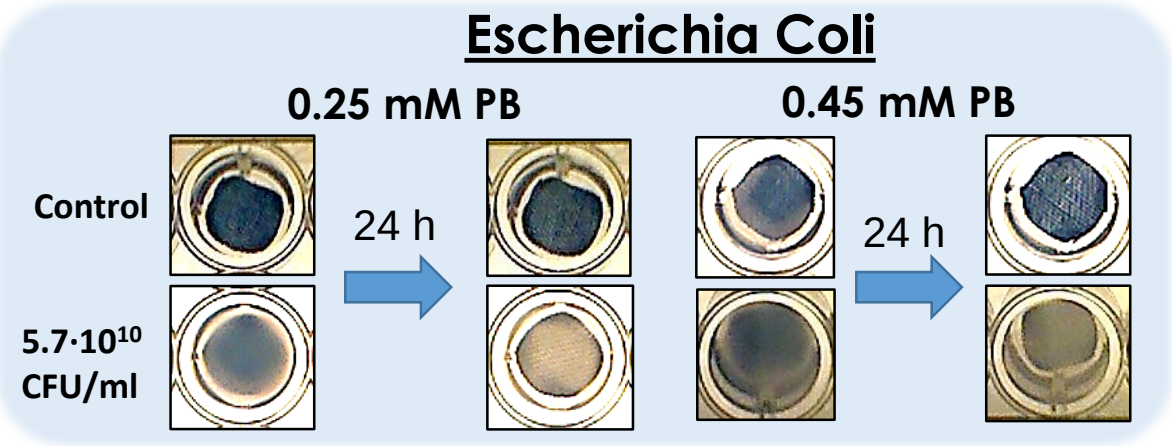
Ultrasound Coating: Unmodified Textiles

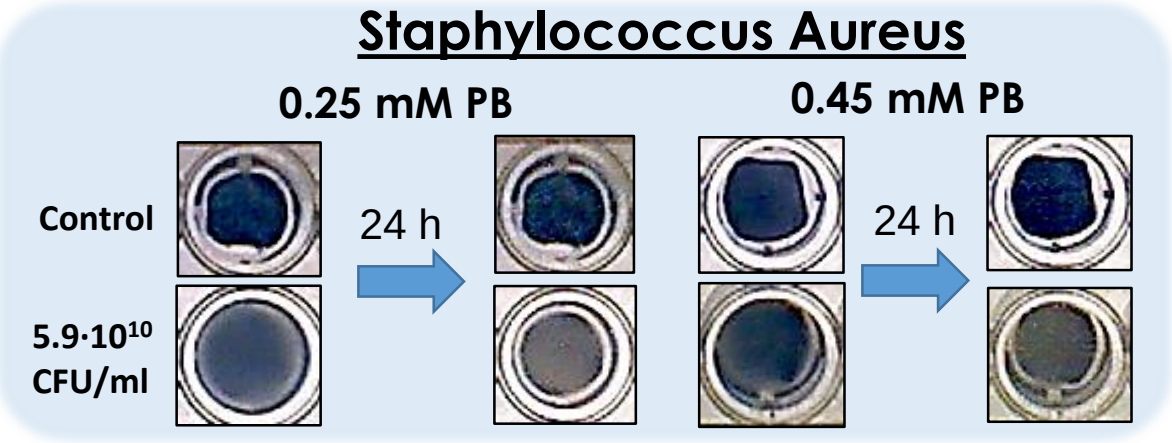
- Bacterial assays

15 minutes of sonication

0,25 mM PB







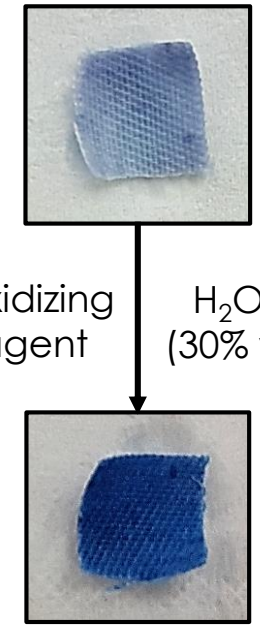
BIOELECTROCHROMIC MOLECULES AS SENSING PROBES

Ultrasound Coating: Unmodified Textiles

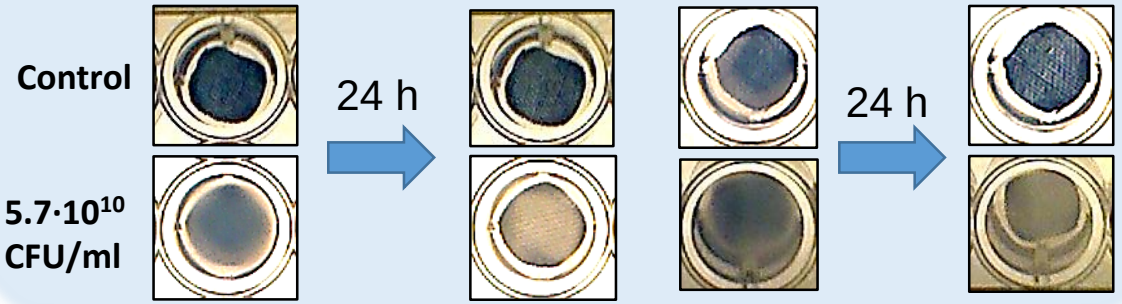
- Bacterial assays

Reversibility

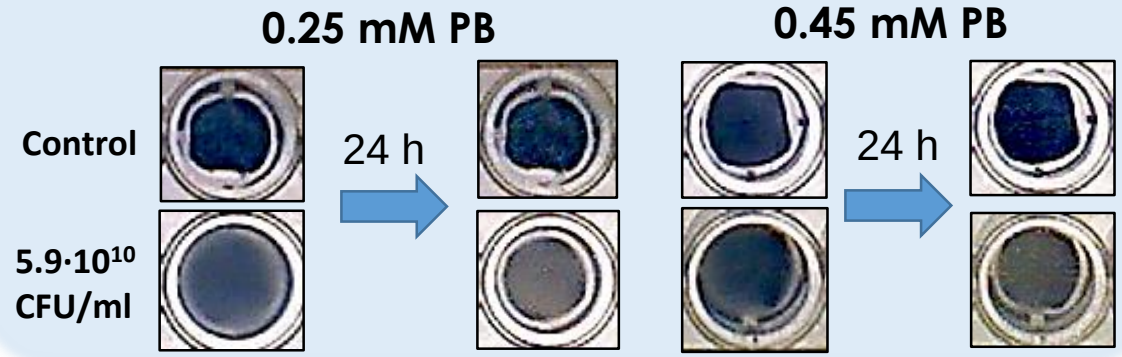
Textiles with 0.25 mM PB (15 min) + S.Aureus



Escherichia Coli



Staphylococcus Aureus



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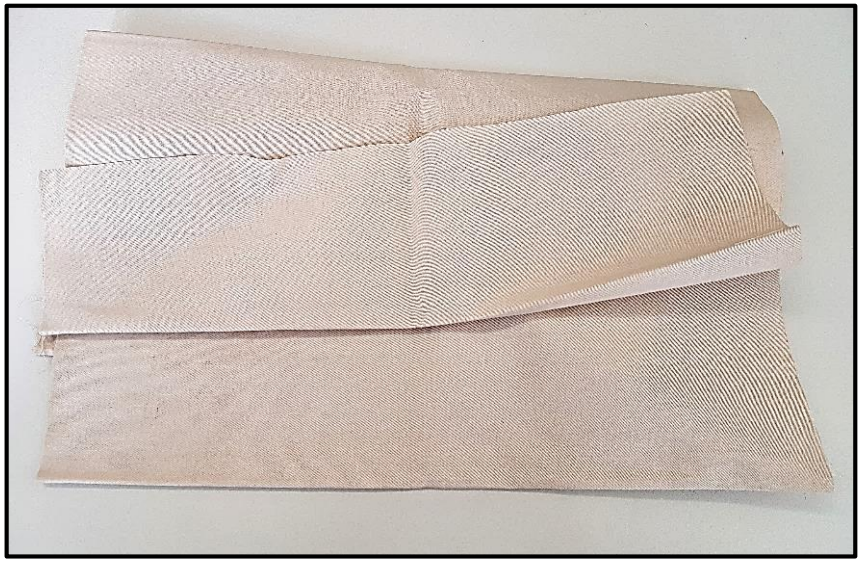
Polyester Cotton Fabrics

Unmodified textile

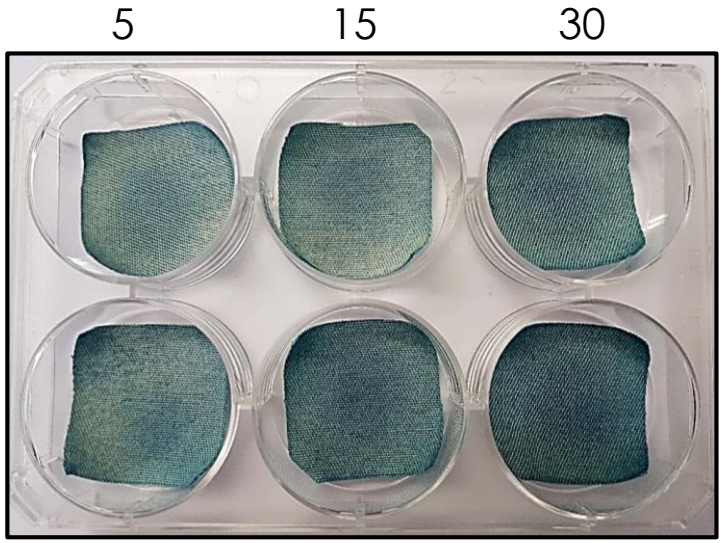
Modified textile with antibacterial NPs



CuO NPs
Modification Speed of 5 m/min

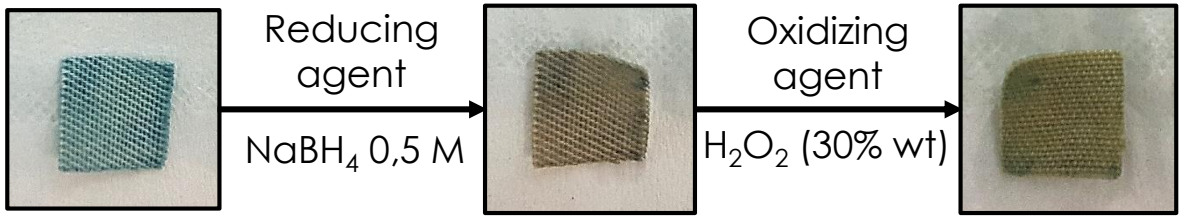
BIOELECTROCHROMIC MOLECULES AS SENSING PROBES

Ultrasound Coating: Modified Textiles (CuO NPs)



- Reversibility assays

Textiles with 0.25 mM PB (15 min)



BIOELECTROCHROMIC MOLECULES AS SENSING PROBES

Ultrasound Coating: Modified Textiles (CuO NPs)

- Bacterial assays

Reversibility

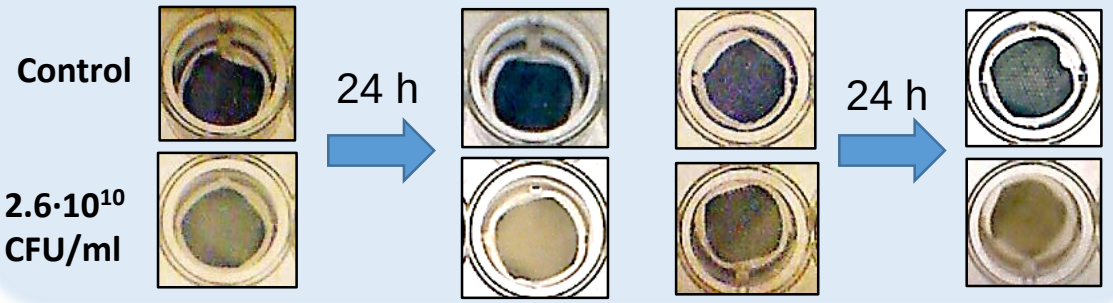
15 minutes of sonication

Textiles with 0.25 mM PB (15 min) and 0.45 mM PB

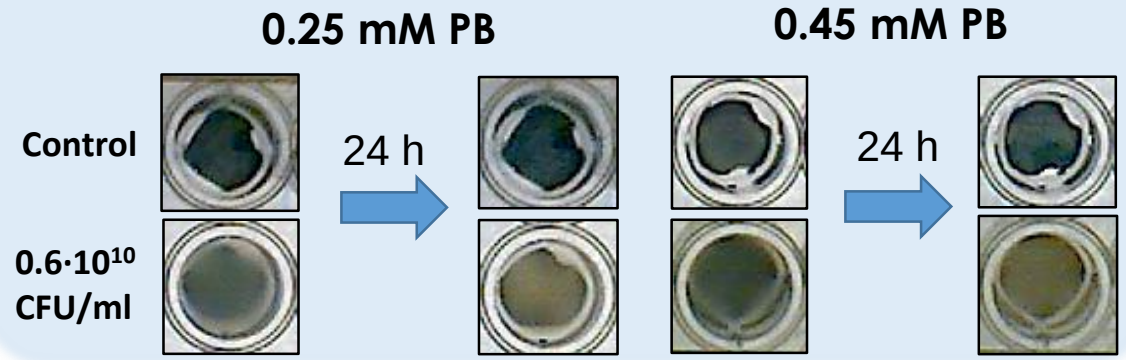
Oxidizing agent

H_2O_2 (30% wt)

Escherichia Coli



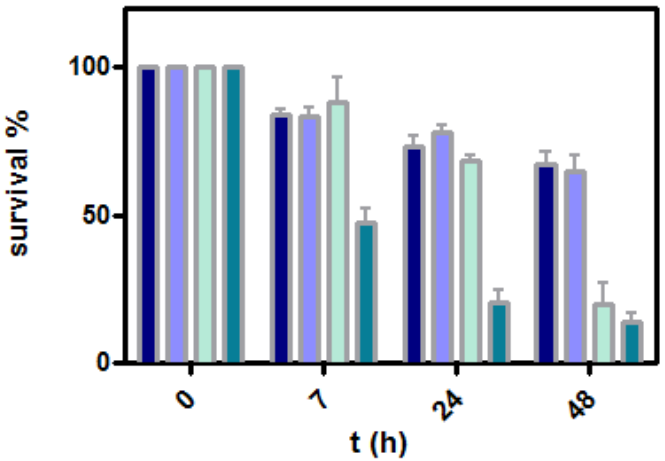
Staphylococcus Aureus

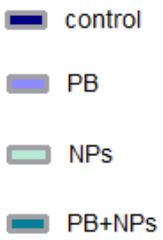


BIOELECTROCHROMIC MOLECULES AS SENSING PROBES

Ultrasound Coating: Modified Textiles (CuO NPs)

- Bacterial assays

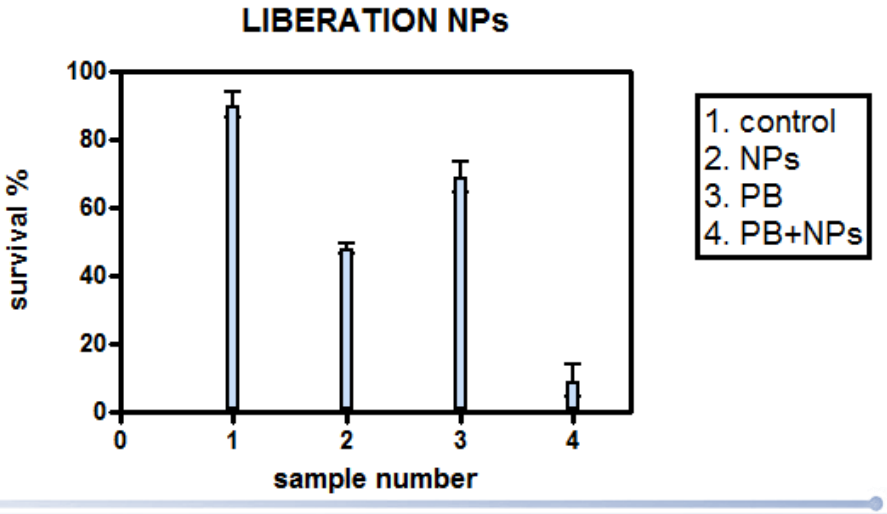




PB do not affect the antibacterial activity

Textiles with PB and CuO NPs increase the bactericidal capacity

Liberation of NPs to the medium in the textiles with CuO NPs



WORK IN PROGRESS

Optimization of PB direct sensing strategy on polyester cotton textiles.

- Optimization of polyester cotton modification with PB.
- Full characterization of PB modified cotton samples.

Stable modification of modified and unmodified textiles with the electrochromic compounds.

- Washability and longevity.
- Consumer and manufacturing safety.

Study with cyanotype Process.

FUTURE WORK

Self-life determination of antimicrobial compounds.

Full control of the electrochemical behavior of the textiles.

Fast and sensitive response to bacteria.

New electrochromic sensing materials for visual detection.

- Colorless to colored change.

THANK YOU FOR YOUR ATTENTION

Acknowledgements

This work was supported the European Commission through the project PROTECT (H2020-NMBP-PILOT-720851).