

# **NEW, MODERN TEXTILES AS WRAPPING MATERIAL FOR STERILIZATION**



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This scientific research was conducted for the dissertation of candidate **Beti Rogina – Car** in cooperation with:

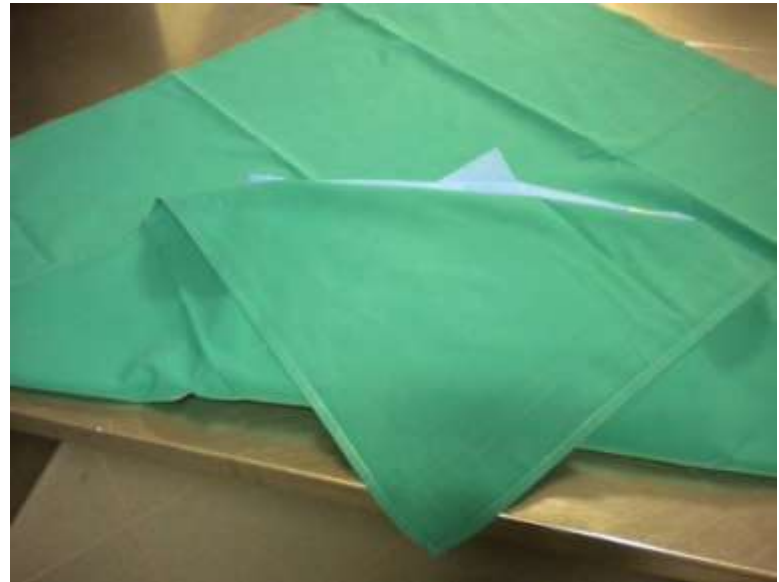
- ***Faculty of Textile Technology Zagreb***
- ***University Clinical Hospital Centre Zagreb, Croatia***

# THE USE OF TEXTILES IN MEDICINE





## **THE USE OF TEXTILES IN STERILIZATION**



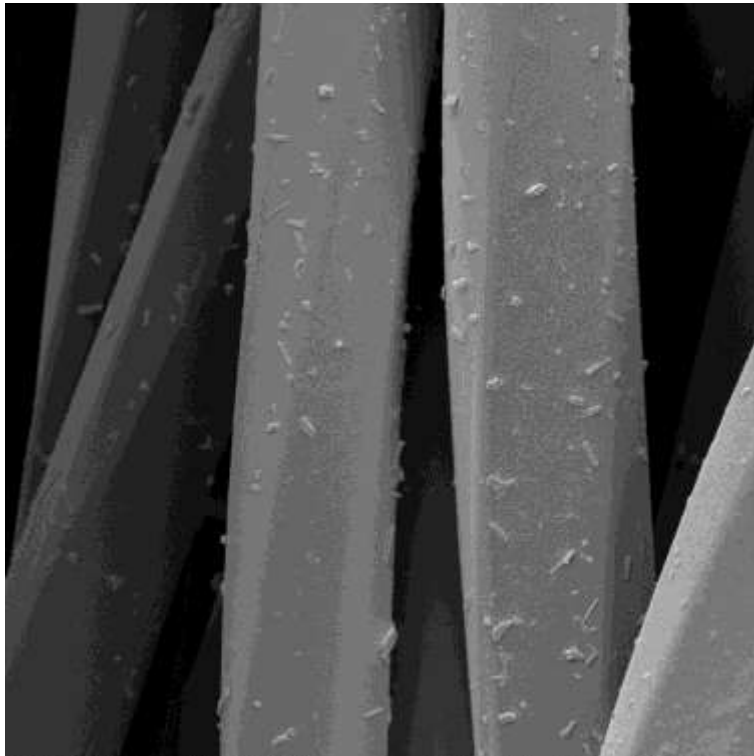
## **COTTON**

- undeclared quality
- microbial barrier - questionable



No data about a range of other characteristics of cotton fabrics required for ensuring microbial barrier

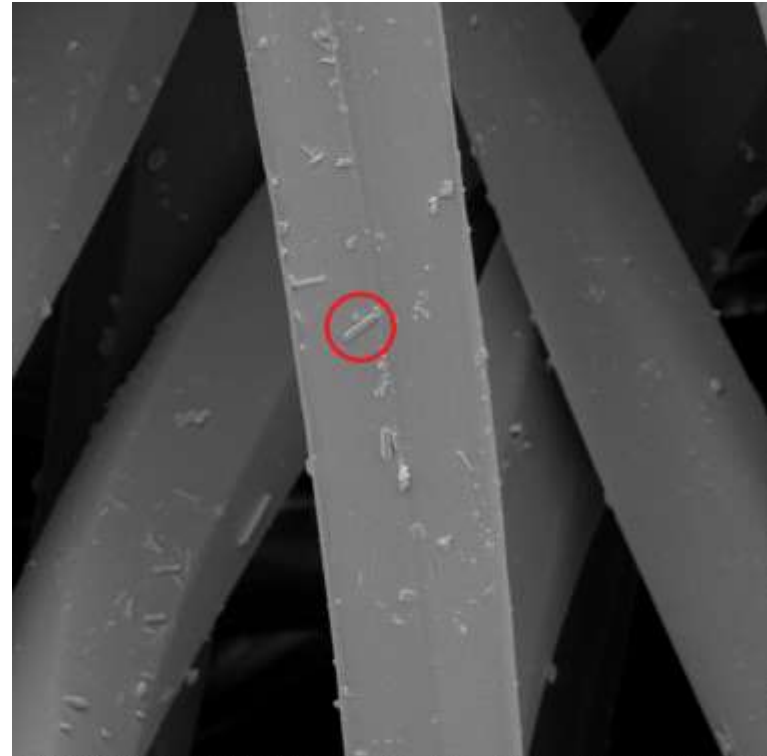
# UNDER APPROPRIATE CONDITIONS OF HUMIDITY AND TEMPERATURE, MOST MEDICAL TEXTILES MADE OF NATURAL FIBERS PRESENT AN EXCELLENT BASIS FOR BACTERIAL AND FUNGAL GROWTH



SEM HV: 10.00 kV WD: 31.14 mm  
SEM MAG: 3.00 kx Det: SE  
Name: L\_L\_1B\_13

20 μm

MIRA\\ TESCAN  
Performance in nanospace



SEM HV: 10.00 kV WD: 31.11 mm  
SEM MAG: 3.00 kx Det: SE  
Name: L\_L\_1B\_15

20 μm

MIRA\\ TESCAN  
Performance in nanospace



# NEW MEDICAL TEXTILES

Three types of textiles were selected for testing:

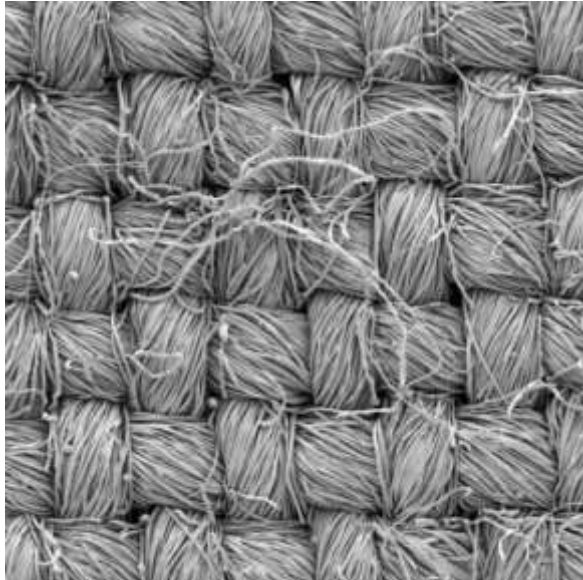
- Cotton/PES 50%/50%
- Tencel ® 100% (lyocell fibres with trade name)
- Three-layer textile laminate PES/PU/PES  
(known as operating, OP laminate )

**All of declared and standardized quality**



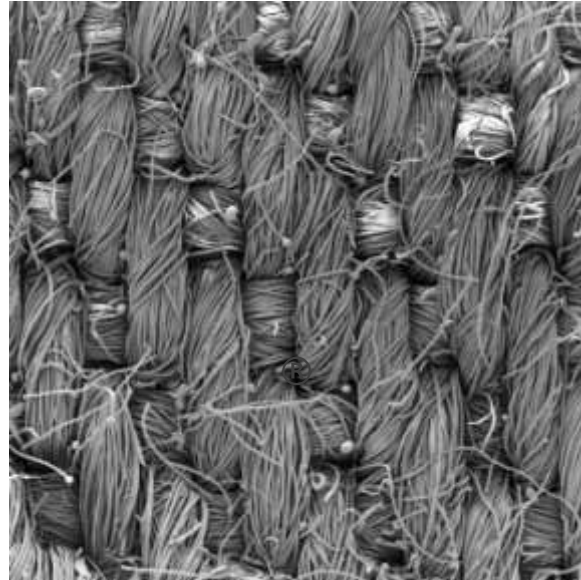
# DIFFERENCES IN THE STRUCTURE AND FORM

## Cotton/PES



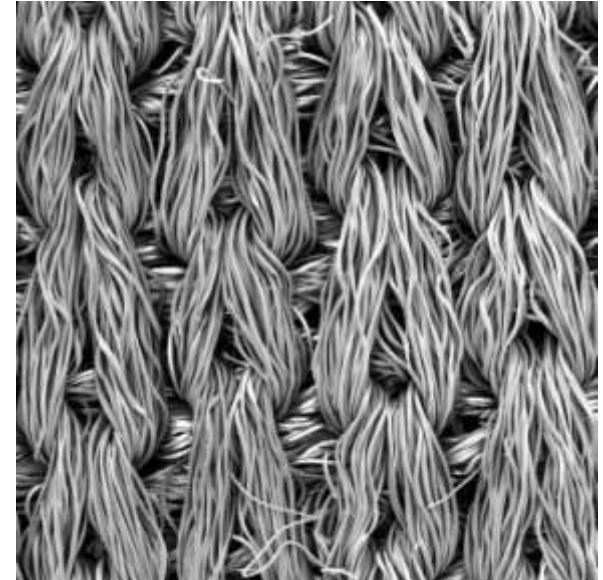
SEM HV: 10.00 kV WD: 31.19 mm MIRA3 TESCAN  
SEM MAG: 100 x Det: SE 500 µm  
Name: PP\_10L\_1 Performance in nanospace

## Tencel®



SEM HV: 10.00 kV WD: 31.43 mm MIRA3 TESCAN  
SEM MAG: 100 x Det: SE 500 µm  
Name: T\_10L\_1 Performance in nanospace

## OP Laminate



SEM HV: 10.00 kV WD: 31.09 mm MIRA3 TESCAN  
SEM MAG: 100 x Det: SE 500 µm  
Name: L\_10L\_1 Performance in nanospace



All samples were tested after multiple washing and sterilization:



1 For mechanical influences (strength and elongation)



2 For air permeability



3 For permeability of microorganisms in dry conditions of extreme contamination



4 For permeability of microorganisms after storage in controlled storage conditions

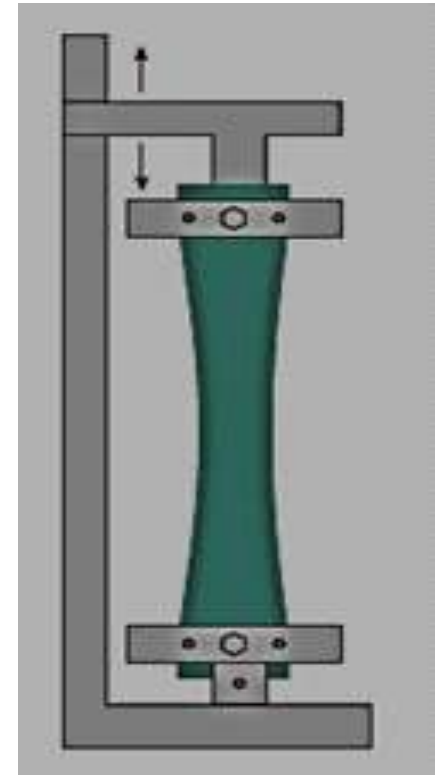


## STRENGTH AND ELONGATION

Each sample was tested on a dynamometer for strength and elongation

**before washing  
and sterilization**

**after the 1<sup>th</sup>, 10<sup>th</sup>, 20<sup>th</sup>,  
30<sup>th</sup> and 50<sup>th</sup> washing  
and sterilization**

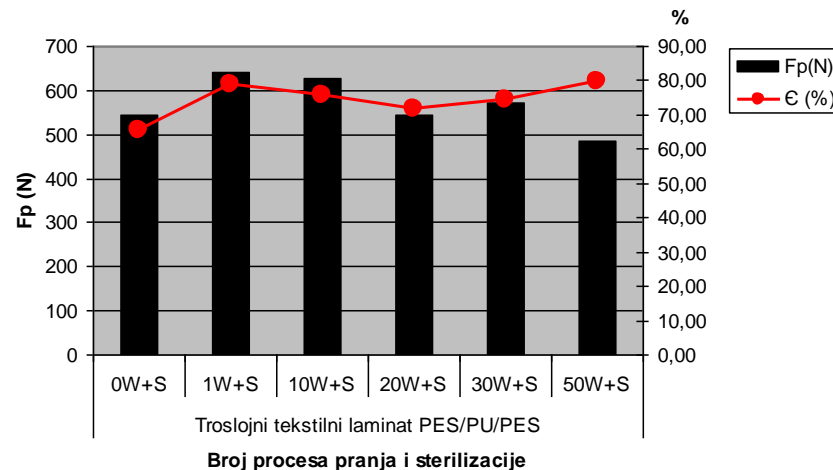
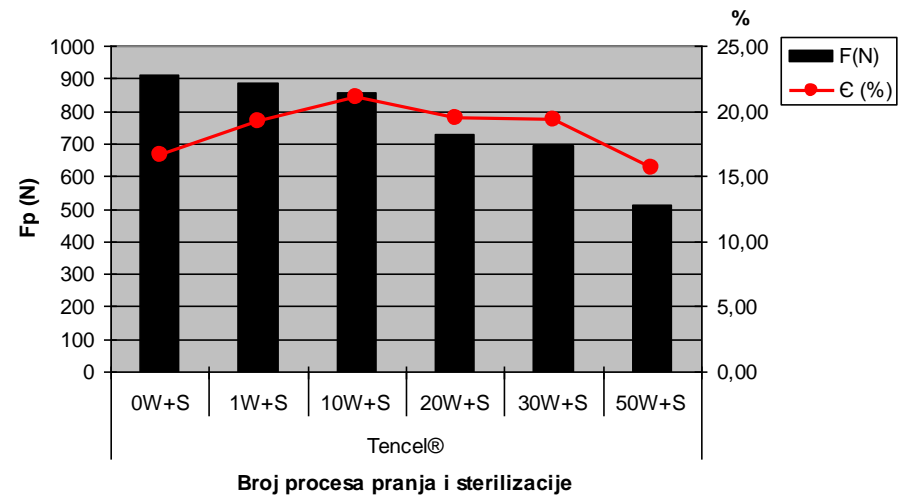
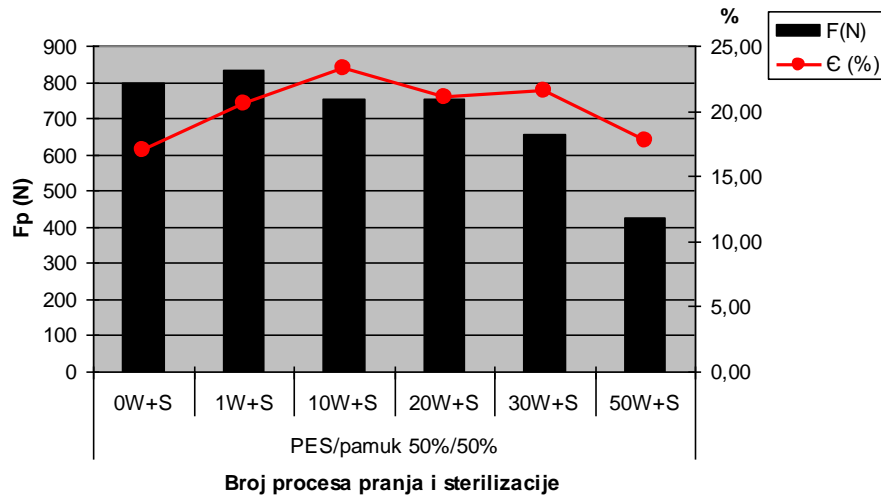


# RESULTS

# 1 ,10, 20, 30, 50 W & S



## Mechanical influences (strength and elongation)



# AIR AND MICROORGANISMS PERMEABILITY

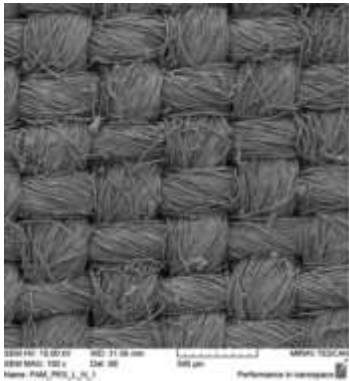
Textile material shrinks during washing and sterilization which results that the density of the fabric increases while the penetration of air and microorganisms decreases



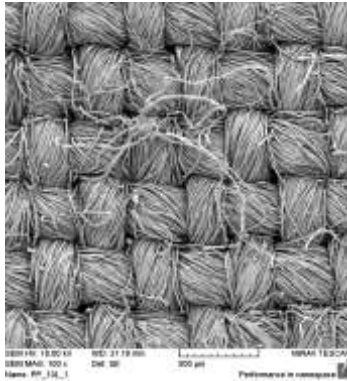
# RESULTS



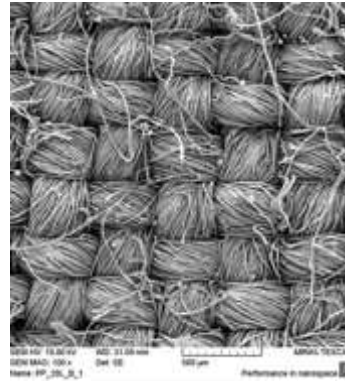
Changes in density of PES/cotton



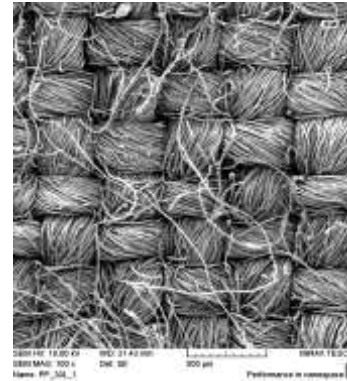
0W+S



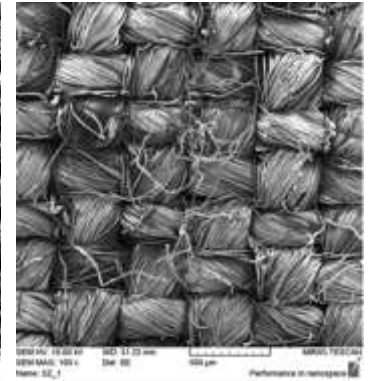
10W+S



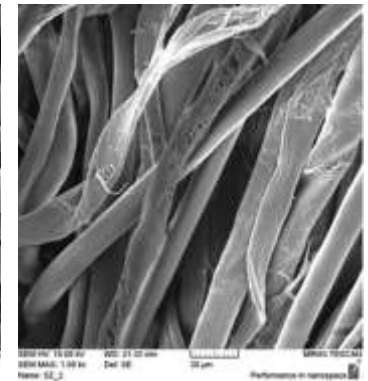
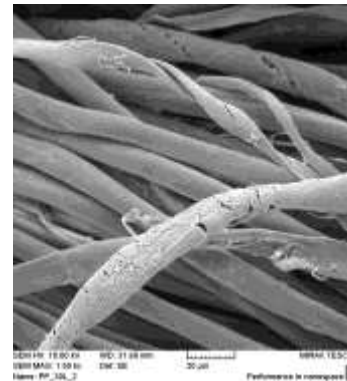
20W+S



30W+S



50W+S



# RESULTS



Changes in density of Tencel®



0W+S



10W+S



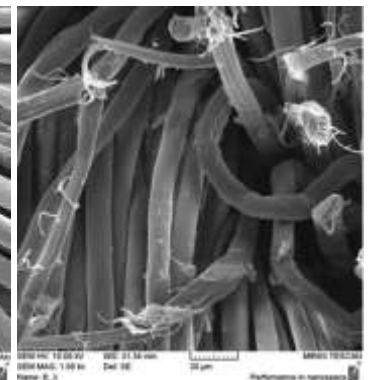
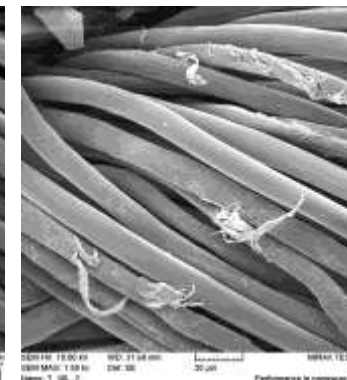
20W+S



30W+S



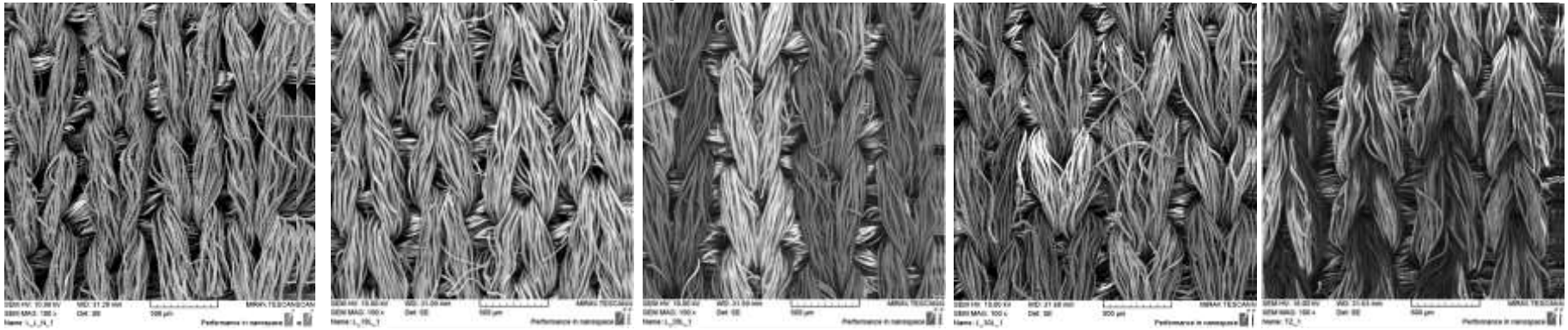
50W+S



# RESULTS



Changes in density of three-layer textile laminate  
PES/PU/PES



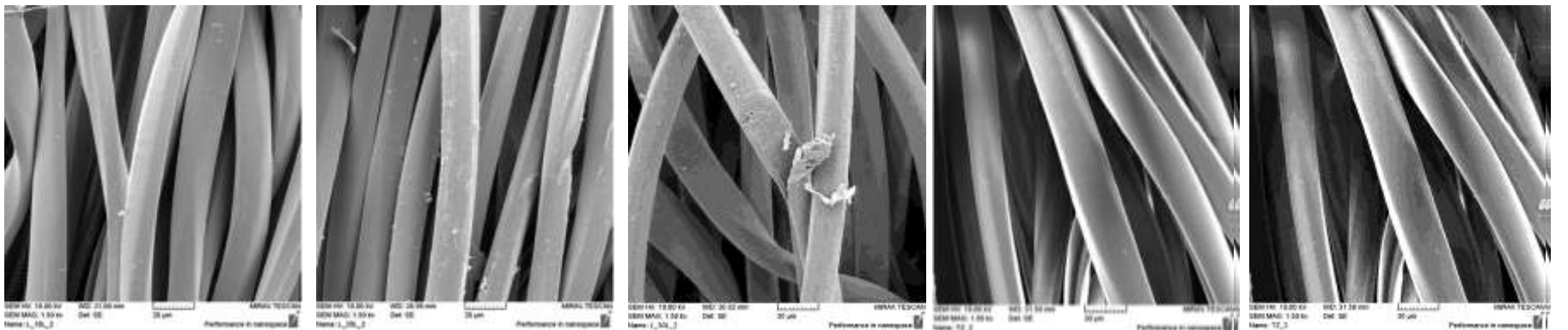
0W+S

10W+S

20W+S

30W+S

50W+S

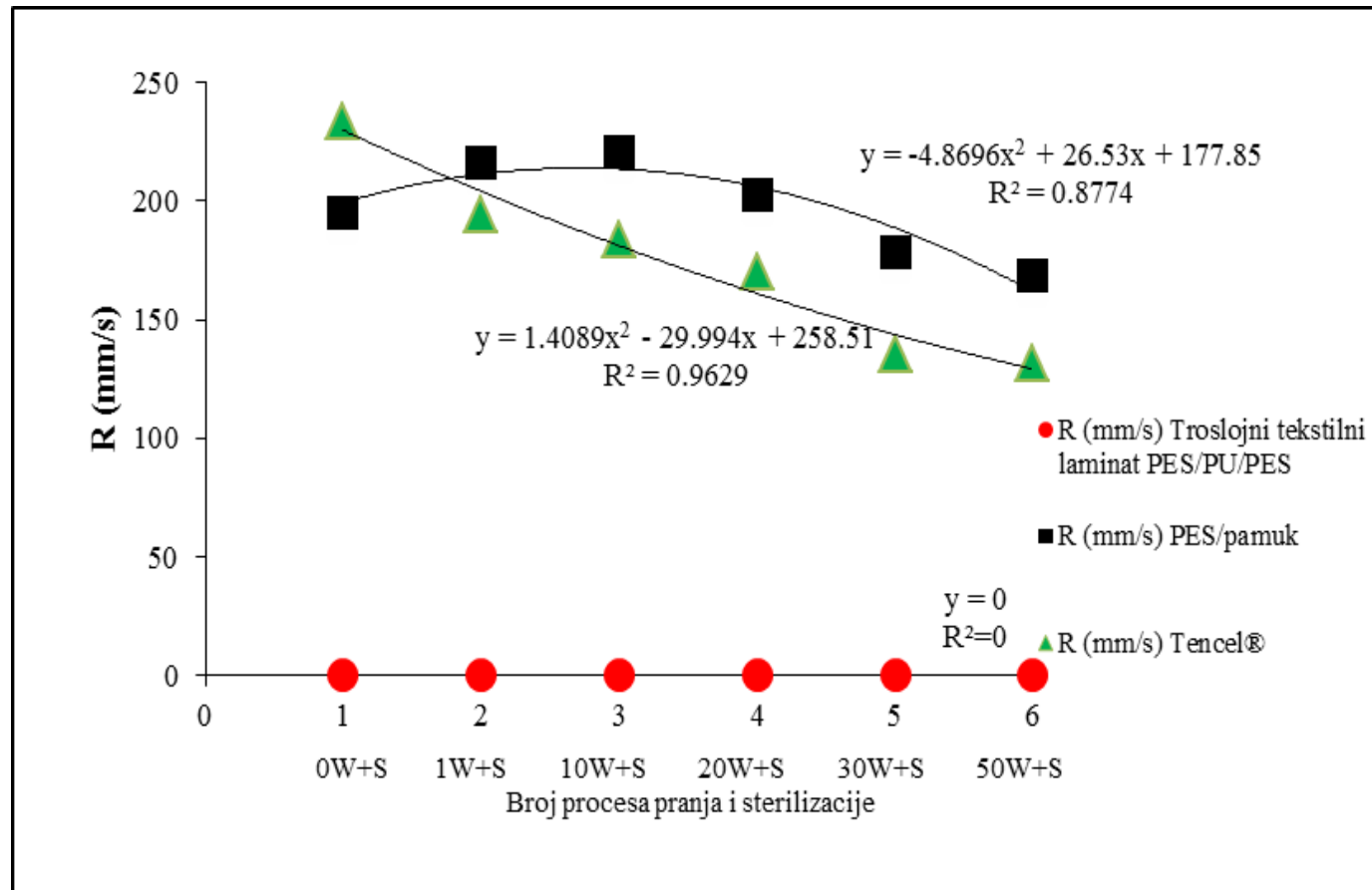




# RESULTS



## AIR PERMEABILITY





## RESULTS

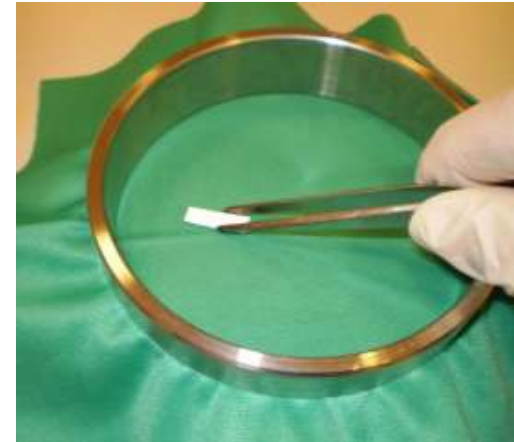
### AIR PERMEABILITY

- Three-layer textile laminate is completely air impermeable due to its polyurethane membrane. However, it should be noted it is permeable to a sterilization medium which gives it a basic criteria for sterilization
- In the PES/cotton and Tencel® blend, it is visible that air permeability continuously decreases after washing and sterilization which can be explained with the fact that the textile shrinks during washing and sterilization

# PERMEABILITY OF MICROORGANISMS



In dry conditions of extreme contamination



After storage in controlled storage conditions



# RESEARCH PLAN

PES/Coton  
50%/50%

Tencel®

Three-layer textile laminate  
PES/PU/PES

Process of washing and  
sterilization

Storage  
1, 2 and 3 months

Permeability  
test



← 3 x 6 pcs

← 3 x 6 pcs

← 3 x 6 pcs

← 3 x 6 pcs

← 3 x 6 pcs

**Σ 90 pcs**



1W+S  
10W+S  
20W+S  
30W+S  
50W+S

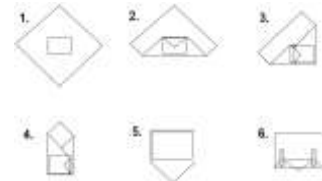
→ 3 x 30 pcs

→ 3 x 30 pcs

→ 3 x 30 pcs

→ 3 x 30 pcs

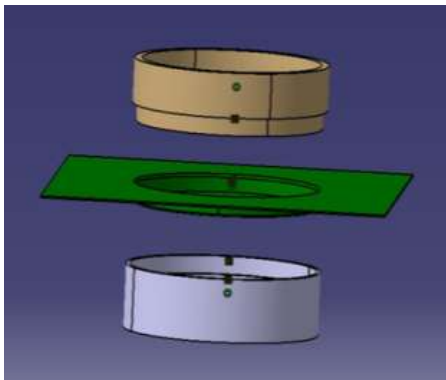
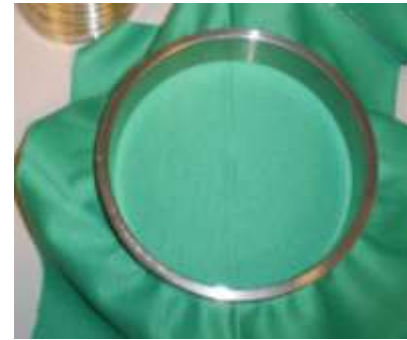
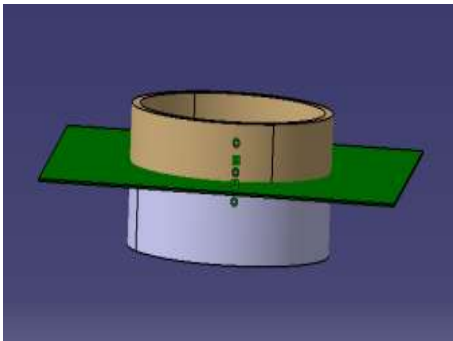
**Σ 360 pcs**





## PERMEABILITY OF MICROORGANISMS

Constructed and executed device  
for testing microbial barrier efficiency of medical textiles





# STERILIZATION

134 °C/5 min





## PERMEABILITY OF MICROORGANISMS IN DRY CONDITIONS OF EXTREME CONTAMINATION

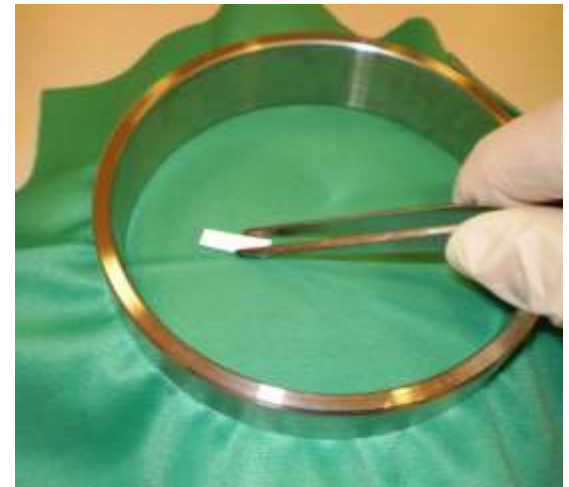


Bacterial endospores

*Geobacillus Stearotermophilus*  $10^5$

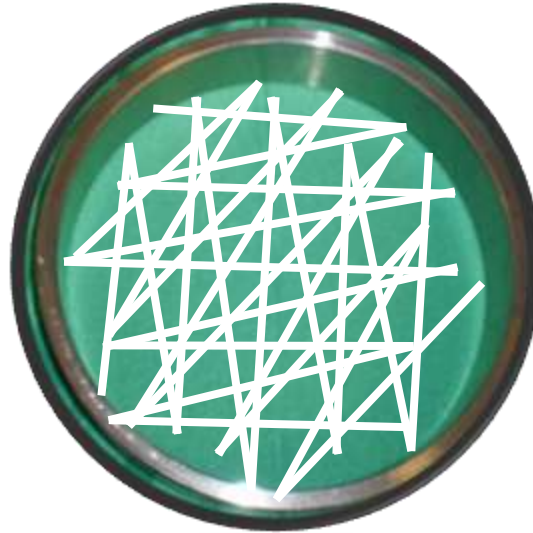
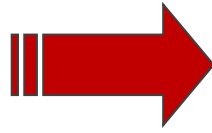
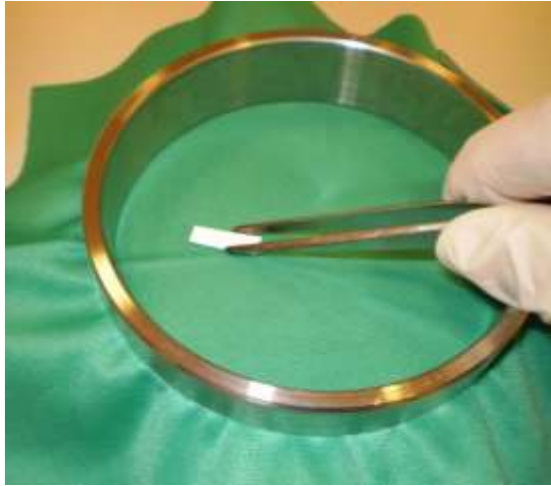
and

*Bacillus Atrophaeus*  $10^6$  were used

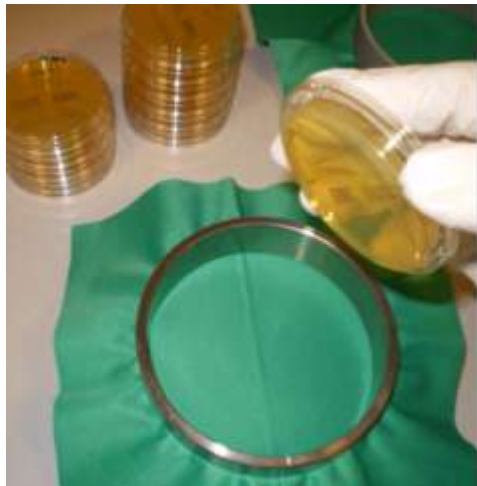




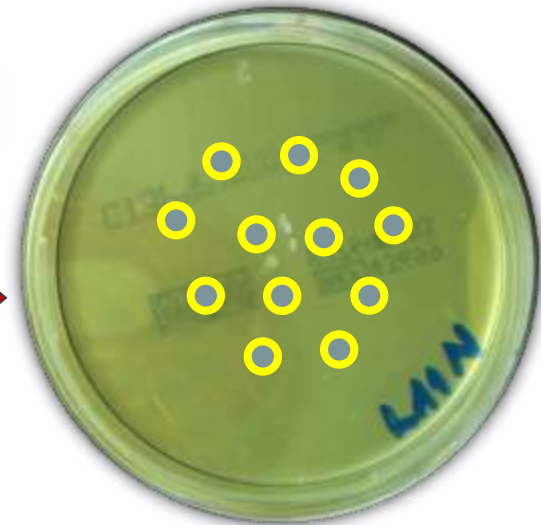
# PERMEABILITY OF MICROORGANISMS



INCUBATION 24 h



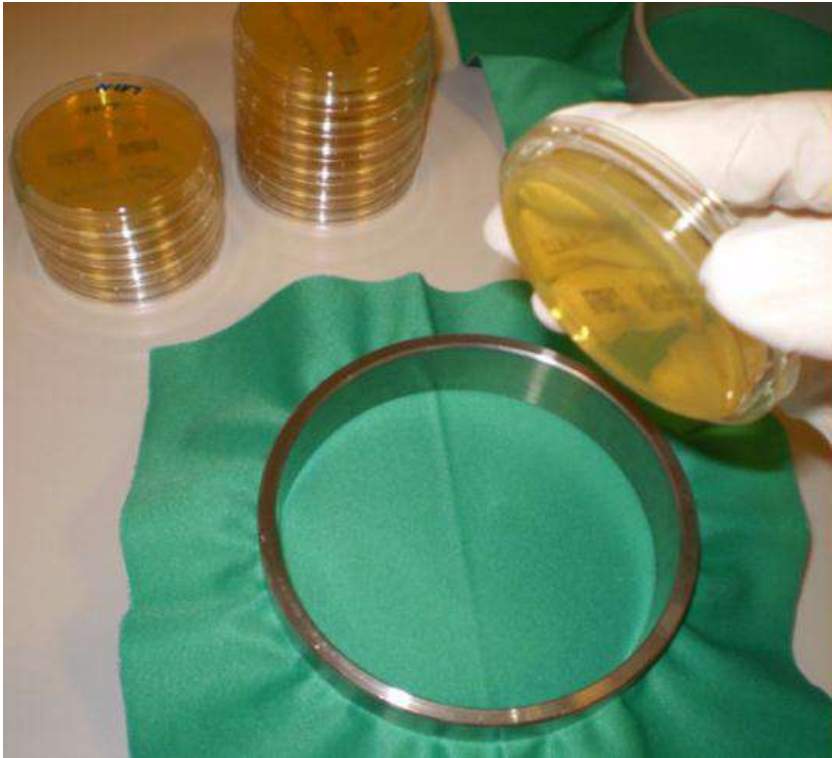
INCUBATION  
48 h + 35 C







## PERMEABILITY OF MICROORGANISMS



Lower side



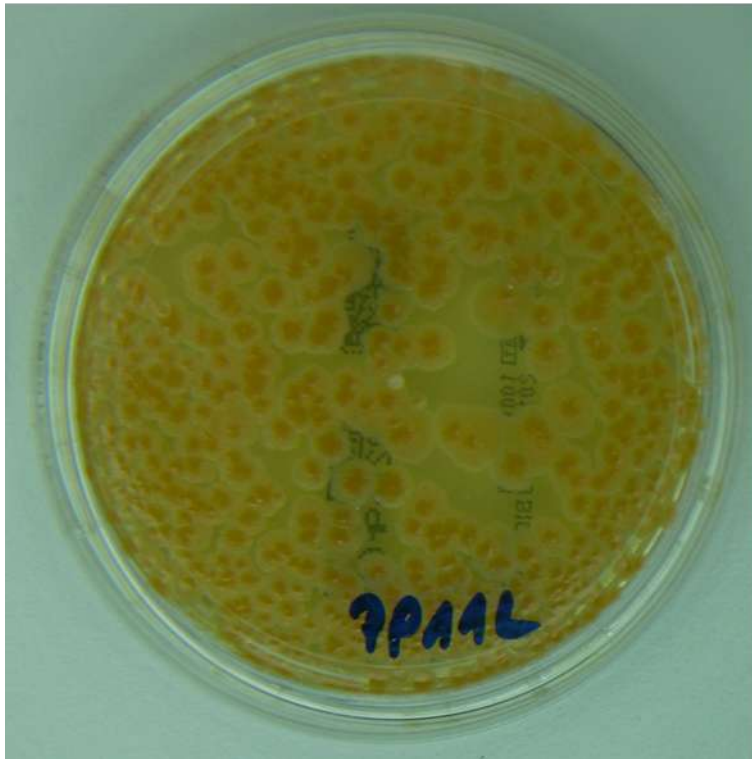
Upper side

Process of collecting prints from the test samples, using CT3P agar plates

# RESULTS



## PERMEABILITY OF MICROORGANISMS



FRONT



BACK

PES/cotton

# RESULTS



## PERMEABILITY OF MICROORGANISMS



FRONT



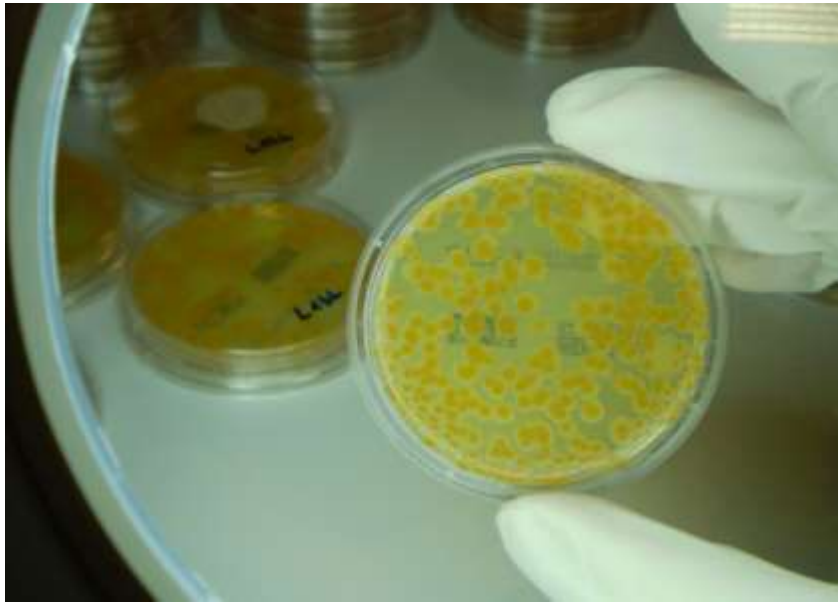
BACK

Tencel®

# RESULTS



## PERMEABILITY OF MICROORGANISMS



FRONT



BACK

Three-layer textile laminate  
**PES/PU/PES**

# RESULTS



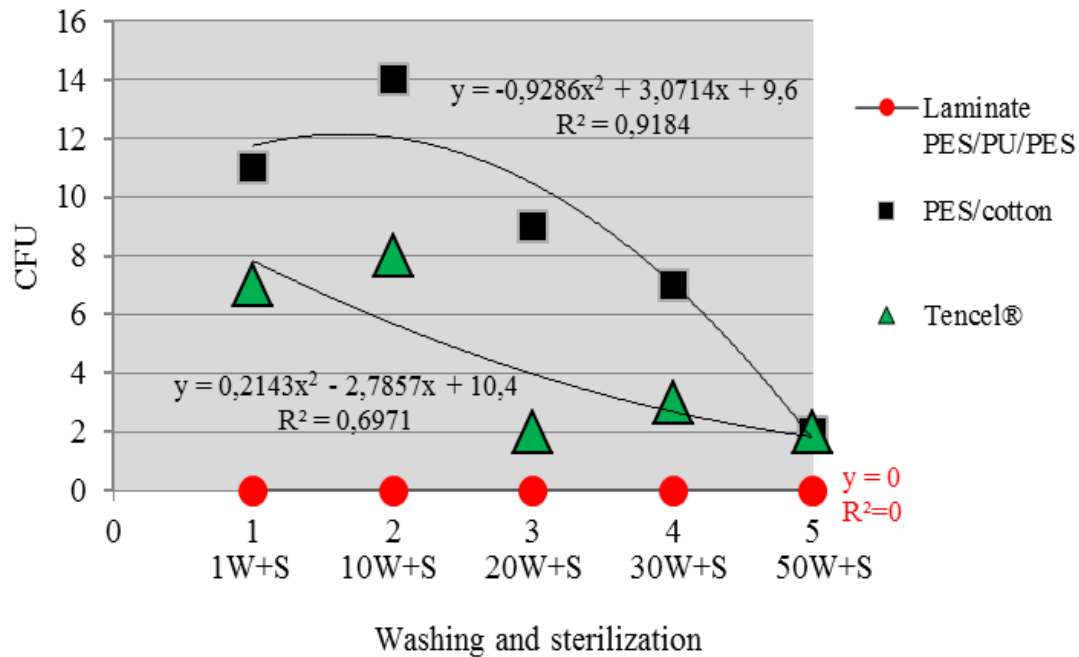
## PERMEABILITY OF MICROORGANISMS

Samples	No. of washing and sterilization processes	CFU on the front of the textile	CFU on the back of the textile	Front - back ration CFU
<b>Samples I</b> <b>PES/cotton</b> <b>50%/50%</b>	1 W + S	356	11	32:1
	10 W + S	275	14	20:1
	20 W + S	318	9	35:1
	30 W + S	286	7	41:1
	50 W 'S	396	2	198:1
<b>Samples II</b> <b>100% Tencel®</b>	1 W + S	419	7	60:1
	10 W + S	359	8	45:1
	20 W + S	294	2	147:1
	30 W + S	182	3	60:1
	50 W + S	341	2	170:1
<b>Samples III</b> <b>Three-layer textile</b> <b>laminate</b> <b>PES/PU/PES</b>	1 W + S	155	0	-
	10 W + S	167	0	-
	20 W + S	175	0	-
	30 W + S	132	0	-
	50 W + S	464	0	-

# RESULTS



## PERMEABILITY OF MICROORGANISMS



Regression analysis of how washing and sterilization affects microbial barrier permeability in medical textiles



## PERMEABILITY OF MICROORGANISMS IN CONTROLLED STORAGE CONDITIONS





## PERMEABILITY OF MICROORGANISMS IN CONTROLLED STORAGE CONDITIONS



### Microclimate conditions

Temperature: 15 – 30 °C

Relative humidity : 30 – 60%



The material to be stored on shelves  
must be located:

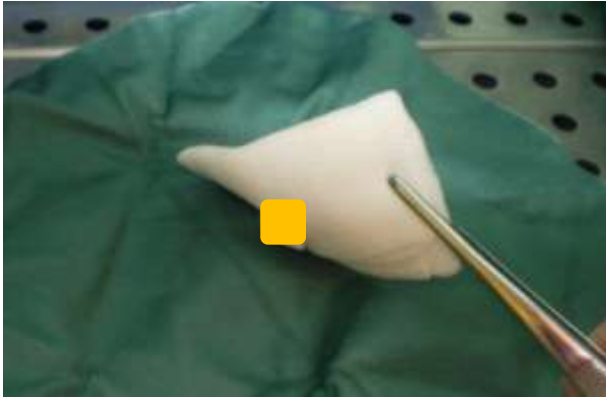
25 cm from the floor,  
45 cm from the ceiling  
5 cm from the walls







# PERMEABILITY OF MICROORGANISMS IN CONTROLLED STORAGE CONDITIONS



INCUBATION  
48 h + 35°C



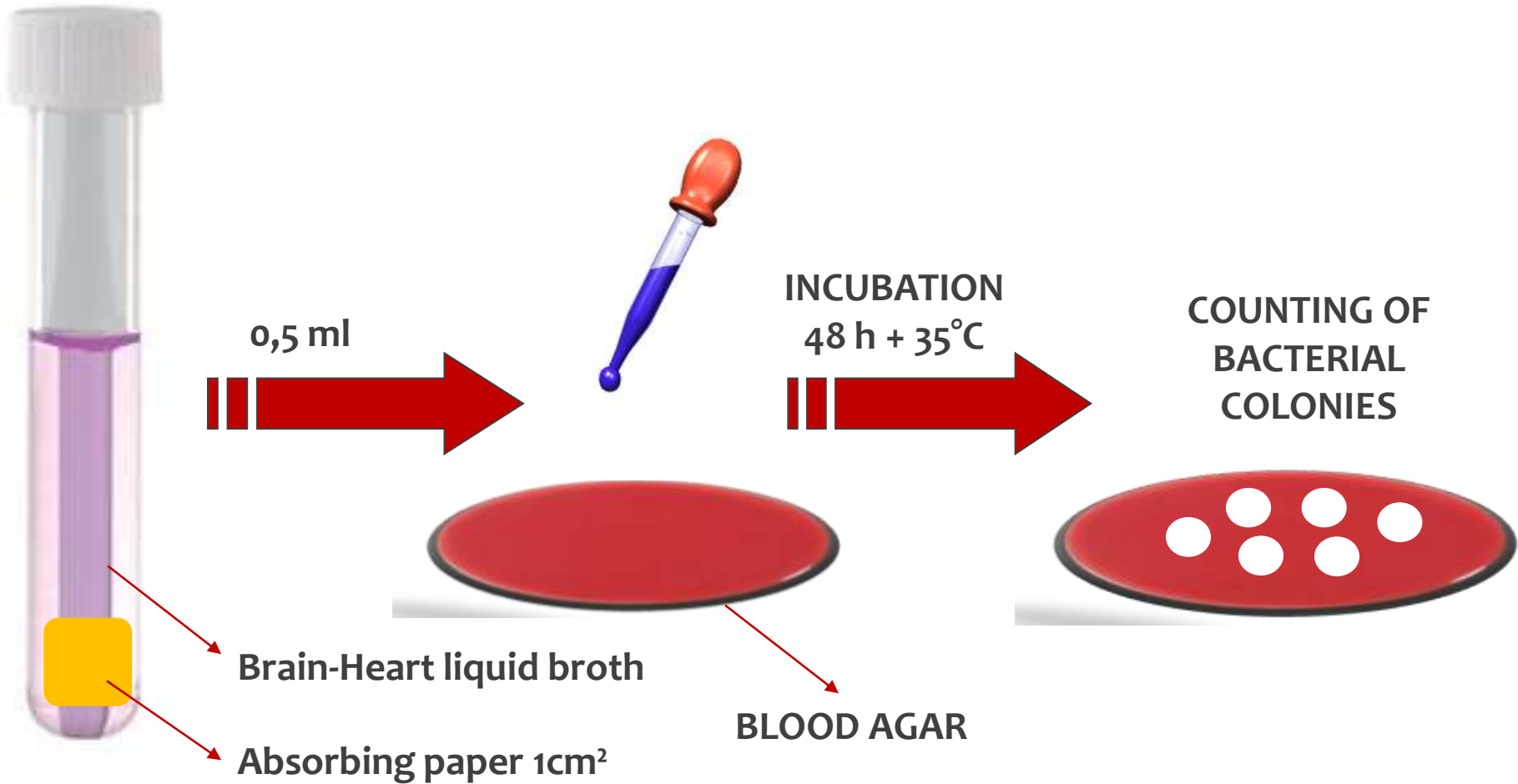
CLARITY OF  
THE BROTH

Brain-Heart liquid broth

Absorbing paper 1cm<sup>2</sup>



# PERMEABILITY OF MICROORGANISMS IN CONTROLLED STORAGE CONDITIONS



# RESULTS







## PERMEABILITY OF MICROORGANISMS IN CONTROLLED STORAGE CONDITIONS

Samples	Number of washing and sterilization procedures	Storage time		
		1 month	2 months	3 months
<b>Samples I</b>  <b>PES/cotton</b> <b>50%/50%</b>	10 washings & sterilizations	NMG	NMG	NGM
	20 washings & sterilizations	NMG	NMG	NMG
	30 washings & sterilizations	NMG	NMG	NMG
	50 washings & sterilizations	NMG	NMG	NMG
<b>Samples II</b>  <b>100% Tencel®</b>	10 washings & sterilizations	NMG	NMG	NMG
	20 washings & sterilizations	NMG	NMG	NMG
	30 washings & sterilizations	NMG	NMG	NMG
	50 washings & sterilizations	NMG	NMG	NMG
<b>Samples III</b>  <b>Three-layer textile laminate</b> <b>PES/PU/PES</b>	10 washings & sterilizations	NMG	NMG	NMG
	20 washings & sterilizations	NMG	NMG	NMG
	30 washings & sterilizations	NMG	NMG	NMG
	50 washings & sterilizations	NMG	NMG	NMG



### 3 TYPES OF TEXTILES (cotton/PES, Tencel®, PES/PU/PES)

	Strenght	Tencel ®	↑	Cotton/PES	↓
	Elongation	PES/PU/PES	↑	Tencel ®	↓
	Air permeability	Tencel ®	↑	PES/PU/PES	0
	Permeability for microorganisms	Cotton/PES	↑	PES/PU/PES	0
	Permeability for microorganisms after storage				0

# BETORE THE CONCLUSION



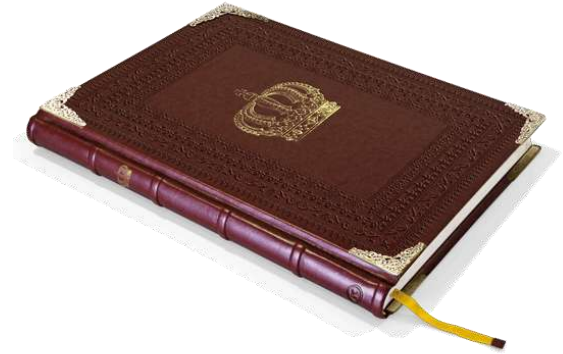
It is evident that Tencel is the most resistant one to tearing, while OP laminate recorded the highest level of elongation.

The most permeable to air is Tencel, while the three-layer laminate is completely impermeable to air and microorganisms. The worst characteristics showed a cotton / PES.

Nevertheless, none of the tested textile material is not permeable for microorganisms after storage of three months.

Electronic microscope recorded damages on membranes of the OP laminate after 50 washings and sterilization, which were not present after 30 procedures.

# CONCLUSION



The tested cellulosic textiles and three-layer textile laminate, even in one layer can be used as wrapping material for sterilization under conditions described in the research and provide a microbial barrier after sterilization.

Microbial barrier is safe against contamination during the test period of 3 months and after 50 washing and 50 sterilization procedures.

Thank you for your attention



Have a nice rest of the day