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
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  Tencel ®  OP Laminate
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
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)
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

\[
y = -4.8696x^2 + 26.53x + 177.85 \\
R^2 = 0.8774
\]

\[
y = 1.4089x^2 - 29.994x + 258.51 \\
R^2 = 0.9629
\]
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

3 In dry conditions of extreme contamination

4 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

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
3 x 30 pcs

10W+S
3 x 30 pcs

20W+S
3 x 30 pcs

30W+S
3 x 30 pcs

50W+S
3 x 30 pcs

Σ 360 pcs

Storage 1, 2 and 3 months
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

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

PERMEABILITY OF MICROORGANISMS

FRONT

PES/cotton

BACK
RESULTS

PERMEABILITY OF MICROORGANISMS

FRONT

BACK

Tencel®
RESULTS

PERMEABILITY OF MICROORGANISMS

Three-layer textile laminate
PES/PU/PES

FRONT

BACK
# RESULTS

## PERMEABILITY OF MICROORGANISMS

<table>
<thead>
<tr>
<th>Samples</th>
<th>No. of washing and sterilization processes</th>
<th>CFU on the front of the textile</th>
<th>CFU on the back of the textile</th>
<th>Front - back ration CFU</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Samples I</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PES/cotton 50%/50%</td>
<td>1 W + S</td>
<td>356</td>
<td>11</td>
<td>32:1</td>
</tr>
<tr>
<td></td>
<td>10 W + S</td>
<td>275</td>
<td>14</td>
<td>20:1</td>
</tr>
<tr>
<td></td>
<td>20 W + S</td>
<td>318</td>
<td>9</td>
<td>35:1</td>
</tr>
<tr>
<td></td>
<td>30 W + S</td>
<td>286</td>
<td>7</td>
<td>41:1</td>
</tr>
<tr>
<td></td>
<td>50 W + S</td>
<td>396</td>
<td>2</td>
<td>198:1</td>
</tr>
<tr>
<td><strong>Samples II</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100% Tencel®</td>
<td>1 W + S</td>
<td>419</td>
<td>7</td>
<td>60:1</td>
</tr>
<tr>
<td></td>
<td>10 W + S</td>
<td>359</td>
<td>8</td>
<td>45:1</td>
</tr>
<tr>
<td></td>
<td>20 W + S</td>
<td>294</td>
<td>2</td>
<td>147:1</td>
</tr>
<tr>
<td></td>
<td>30 W + S</td>
<td>182</td>
<td>3</td>
<td>60:1</td>
</tr>
<tr>
<td></td>
<td>50 W + S</td>
<td>341</td>
<td>2</td>
<td>170:1</td>
</tr>
<tr>
<td><strong>Samples III</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Three-layer textile laminate PES/PU/PES</td>
<td>1 W + S</td>
<td>155</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>10 W + S</td>
<td>167</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>20 W + S</td>
<td>175</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>30 W + S</td>
<td>132</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>50 W + S</td>
<td>464</td>
<td>0</td>
<td>-</td>
</tr>
</tbody>
</table>
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 1cm²
PERMEABILITY OF MICROORGANISMS IN CONTROLLED STORAGE CONDITIONS

0,5 ml Brain-Heart liquid broth

INCUBATION 48 h + 35°C Absorbing paper 1cm²

COUNTING OF BACTERIAL COLONIES BLOOD AGAR
## RESULTS

### PERMEABILITY OF MICROORGANISMS IN CONTROLLED STORAGE CONDITIONS

<table>
<thead>
<tr>
<th>Samples</th>
<th>Number of washing and sterilization procedures</th>
<th>Storage time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1 month</td>
</tr>
<tr>
<td><strong>Samples I</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>PES/cotton 50%/50%</strong></td>
<td>10 washings &amp; sterilizations</td>
<td>NMG</td>
</tr>
<tr>
<td></td>
<td>20 washings &amp; sterilizations</td>
<td>NMG</td>
</tr>
<tr>
<td></td>
<td>30 washings &amp; sterilizations</td>
<td>NMG</td>
</tr>
<tr>
<td></td>
<td>50 washings &amp; sterilizations</td>
<td>NMG</td>
</tr>
<tr>
<td><strong>Samples II</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>100% Tencel®</strong></td>
<td>10 washings &amp; sterilizations</td>
<td>NMG</td>
</tr>
<tr>
<td></td>
<td>20 washings &amp; sterilizations</td>
<td>NMG</td>
</tr>
<tr>
<td></td>
<td>30 washings &amp; sterilizations</td>
<td>NMG</td>
</tr>
<tr>
<td></td>
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<td>NMG</td>
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<tr>
<td><strong>Samples III</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Three-layer textile laminate PES/PU/PES</strong></td>
<td>10 washings &amp; sterilizations</td>
<td>NMG</td>
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<td>NMG</td>
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<tr>
<td></td>
<td>50 washings &amp; sterilizations</td>
<td>NMG</td>
</tr>
</tbody>
</table>
# 3 TYPES OF TEXTILES (cotton/PES, Tencel®, PES/PU/PES)

<table>
<thead>
<tr>
<th></th>
<th>Strength</th>
<th>Elongation</th>
<th>Air permeability</th>
<th>Permeability for microorganisms</th>
<th>Permeability for microorganisms after storage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Tencel®</td>
<td>PES/PU/PES</td>
<td>Cotton/PES</td>
<td>Cotton/PES</td>
<td>PES/PU/PES</td>
</tr>
<tr>
<td>2</td>
<td>Tencel®</td>
<td>PES/PU/PES</td>
<td>PES/PU/PES</td>
<td>PES/PU/PES</td>
<td>PES/PU/PES</td>
</tr>
<tr>
<td>3</td>
<td>Cotton/PES</td>
<td>PES/PU/PES</td>
<td>PES/PU/PES</td>
<td>PES/PU/PES</td>
<td>PES/PU/PES</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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.
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