22nd IFATCC
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Multifunctional multilayer textiles
for health care sector

with protective barrier properties and enhanced wearing comfort
using enzymes for PET modification
for improved breathability and final treatment

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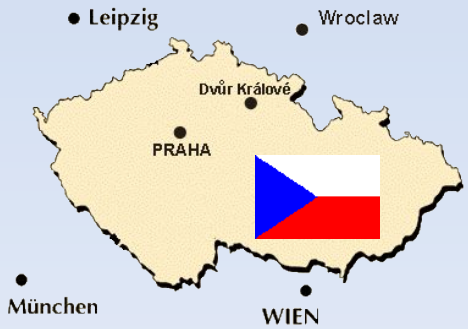

innovation from the source ...

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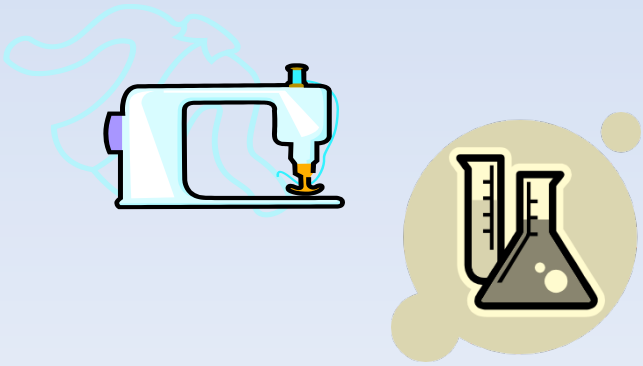
Multifunctional textile surfaces as carriers of permanent protective barrier effects, mechanical and physiological parameters (wearing comfort)

Basic trend of sustainability

for

- Protective clothing (PPE)
- Functional outer garment
- **Health care sector**
- Cleanroom application



- **Textile substrates selection**
  natural, synthetic polymers, mass modification,..
- **Functional fibers / yarns incorporation**
- **Fabric construction**
  weight, sett, weave, multilayer structures,..
- **Textile surfaces activation** /active centers creation
  enzymes, plasma,..
- **Final treatment**
  functional chemicals, mechanical surface treatment

Multifunctional textile surfaces as carriers of permanent protective barrier effects, mechanical and physiological parameters (wearing comfort)

Healthcare sector

Effects reliable

- simultaneously
- permanent in maintenance

(washing 64°C, thermosterilizing 134°C, 10min)

Required properties and effects :

- hydrophobicity / hydrostatic head EN 20811
- antistatic EN 1149-1, 2, 3
- low linting ISO/DIS 9073-10
- antibacterial properties (EN ISO 20743)
- resistance to microbial penetration

  EN ISO 22610 –wet, EN ISO 22612 – dry
- mechanical parameters

  EN ISO 13934-1, 13938-1, 29073-3
- wearing comfort (MMT)
- breathability (MVTR) EN ISO 15496
- specific : electromagnetic shielding

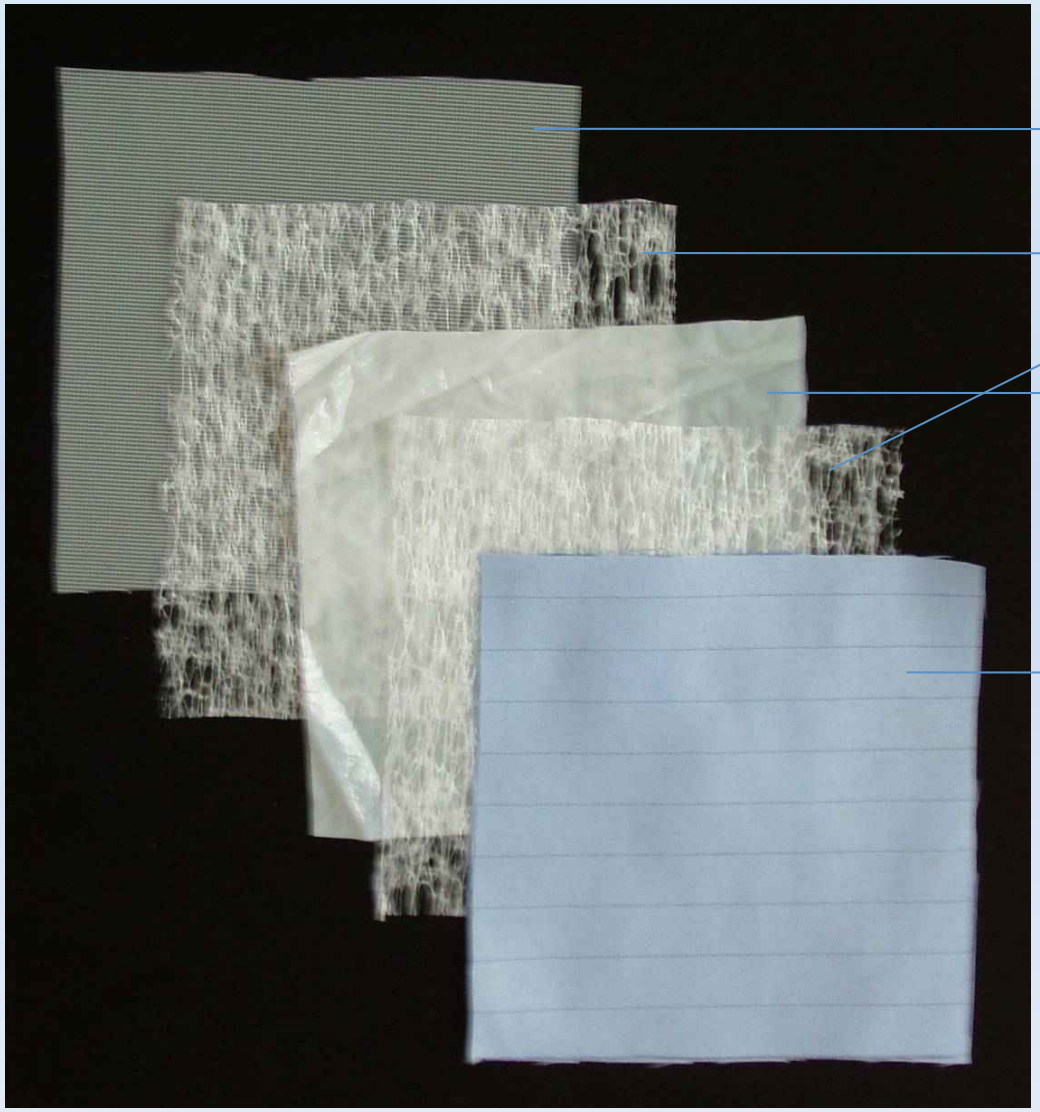
  MIL-STD 285, FR - EN ISO 15025,..

EN 13795 Part 3: Surgical drapes, gowns and clean air suits, used as medical devices for patients, clinical staff and equipment –

Performance requirements and performance levels

Characteristic	Standard	Unit	Requirements			
			Standard performance		High performance	
			Critical product area	Less critical product area	Critical product area	Less critical product area
Resistance to microbial penetration - Dry	EN ISO 22612: 2005-05	$\log_{10}$ (CFU)	not required	≤ 2	not required	≤ 2
Resistance to microbial penetration - Wet	EN ISO 22610: 2006-10	I_B	≥ 2,8	not required	6.0	not required
Cleanless - microbial	EN 1174 (1-3)	$\log_{10}$ (CFU/dm²)	≤ 2	≤ 2	≤ 2	≤ 2
Cleanless – Particulate matter	EN ISO 9073-10: 2005-03	IPM	≤ 3,5	≤ 3,5	≤ 3,5	≤ 3,5
Linting	EN ISO 9073-10: 2005-03	$\log_{10}$	≤ 4,0	≤ 4,0	≤ 4,0	≤ 4,0
Resistance to liquid penetration	EN 20811: 1992-08	cm H_2O	≥ 20	≥ 10	≥ 100	≥ 10
Bursting strength – Dry	EN ISO 29073-3: 1992-08	kPa	≥ 40	≥ 40	≥ 40	≥ 40
Bursting Strength - Wet	EN ISO 29073-3: 1992-08	kPa	≥ 40	not required	≥ 40	not required
Tensile strength – Dry	EN ISO 13938-1: 1999-10	N	≥ 20	≥ 20	≥ 20	≥ 20
Tensile Strength - Wet	EN ISO 13938-1: 1999-10	N	≥ 20	not required	≥ 20	not required

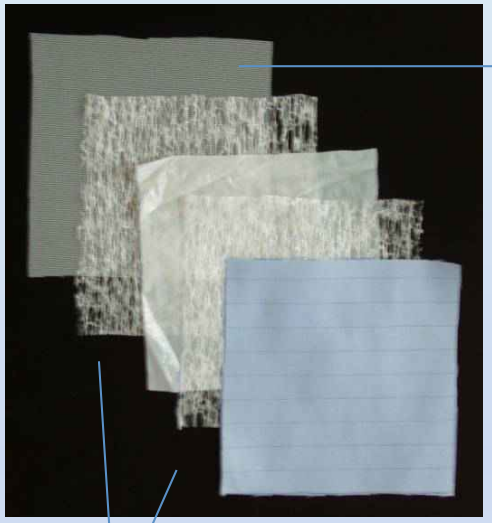
Multilayer (bio)functionalized laminated sandwich structures



- supporting separative PET inner layer
- thermoadhesive copolymer net (E.V.A. – PET)
- enzyme treated PBT non-porous membrane
- outer (functionalized) PET layer

THERMOCALLENDER LAMINATION

Multilayer textile structures: Added value enhancement by enzymes



separative inner layer

100% PET, air permeable, light, soft

THERMOCALLENDER LAMINATION

non-porous hydrophilic PBT membrane

- 20g/m²
- permanent waterproof (>100cm)
- breathable (MVTR)
- non-atrpermeable
- resistant to microbial penetration
- thermoinsulative

Treatment with PET-enzymes
for :
- breathability enhancement

thermoadhesive net

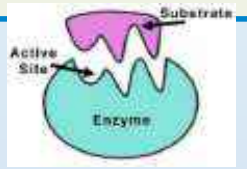
ultralight copolymer webs
- optimized melting point
- from 14g/m²
- air-permeable
- moisture transport
- bonding strength and durability
- thermocallender application

outer PET layer

breathable, low linting,
functionalization possibilities:
- electroconductive fiber / polymer
- antimicrobial
  (AB polyester-micro or finishing)
- FR (Trevira CS or finishing)

Treatment with PET-enzymes
for :
- binding of antimicrobial agent
- enhancement of FR (wet pick-up)
- antistatic properties support
- moisture transport improvement

ENZYMATIC MODIFICATION OF POLYESTER SUBSTRATES



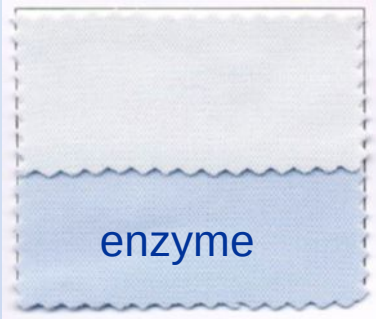
TEXAZYM PES: 30-35°C, 30-60min, pH=4,5
TEXAZYM CP: 50°C-55°C, 30-60min, pH= 6-7,5

Limited ester bond breaking:

R-COOR´ ⟶ R-COOH + HO – R´

- **New reactive groups forming**
- **Improvement of end-use properties**
  - Hydrophilicity improvement
  - Breathability increase
  - Antistatic properties support

    = *Physiological parameters improvement (MMT)*
  - Possibilities of next functionalization (binding of antimicrobial agent)
- **Without weight and tensile strength loss**
- **Mild application conditions**



verification by dyeability with reactive dye: C.I. Reactive Blue 11

Colourfastness

water	:	4D / 4-5 / 4-5
washing 40°C	:	4-5D / 4-5 / 4-5
alk. perspiration	:	2-3D / 4-5 / 4-5
wet rubbing	:	4-5
dry rubbing	:	4-5

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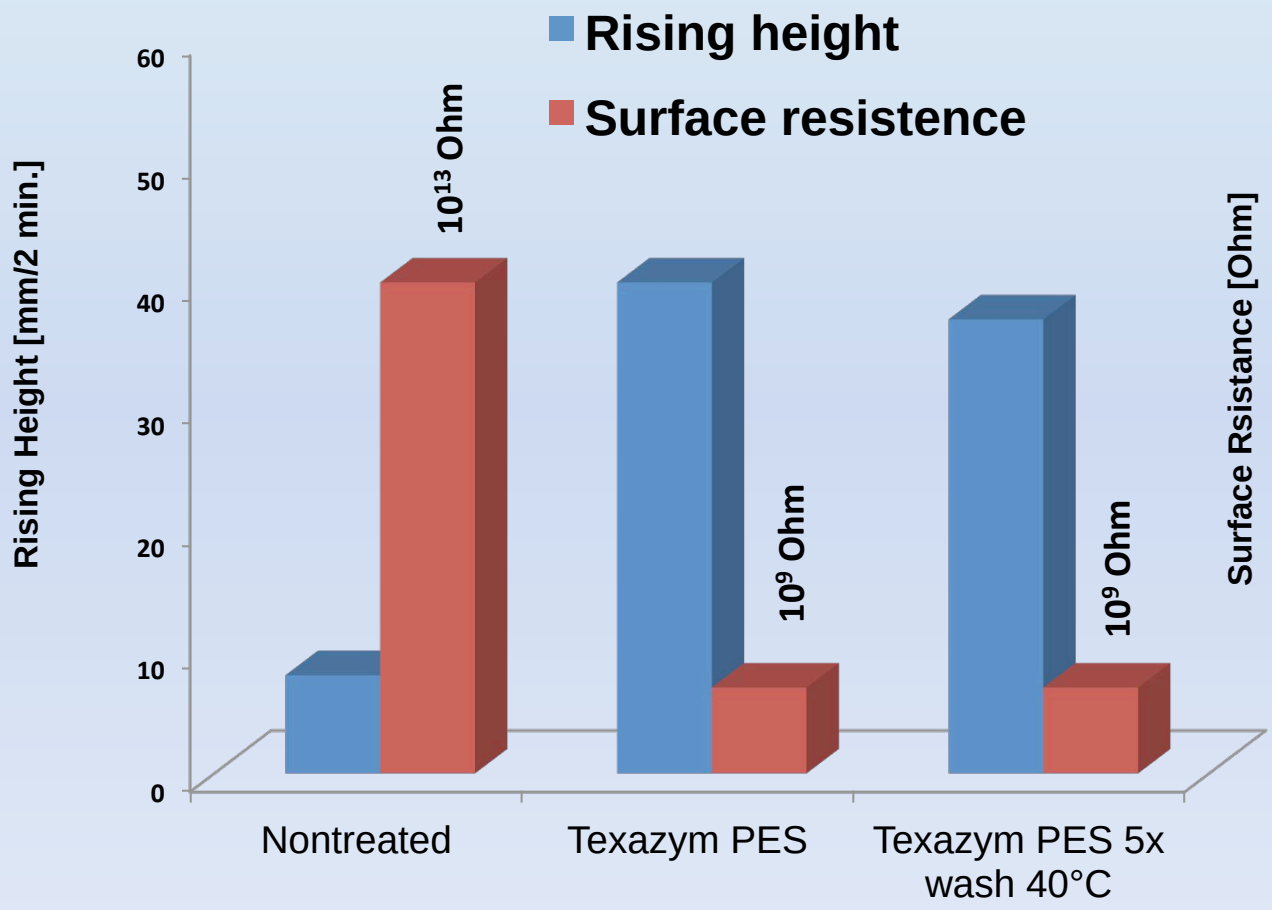
Enzymatic modification of PES – Experience

Antistatic effect, improved hydrophilicity, durability in repeated laundry



- Also FR polyester (Trevira CS) and blended constructions parameters improvement

Enzymatic modification of PES – Experience
Liquid transport improvement

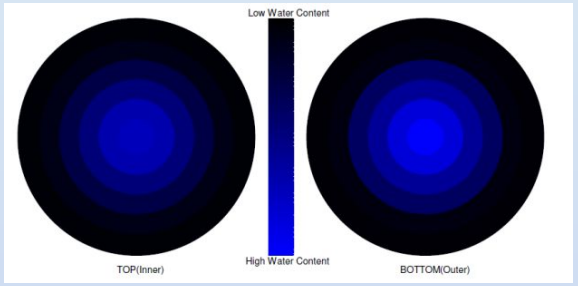
MMT

spreading speed / mm/s/

PET

PET micro

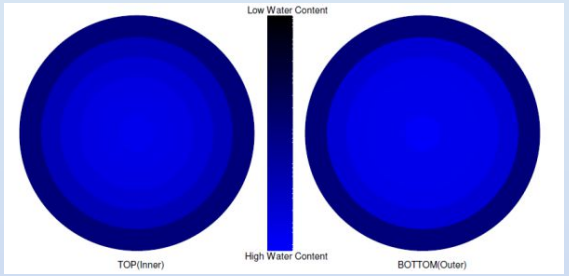
0,3



0,4

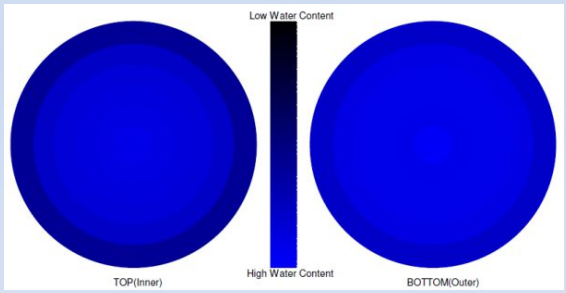
Untreated

1,7



1,6

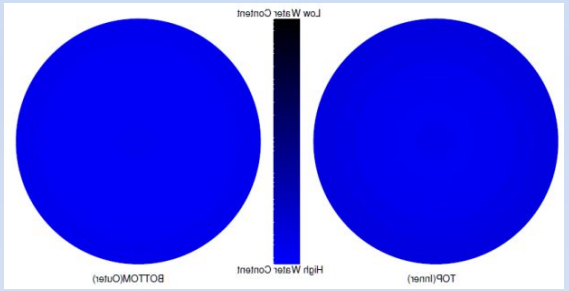
3,1



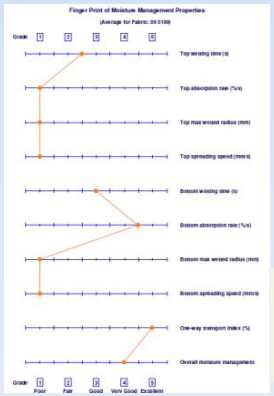
3,8

TEXAZYM PES

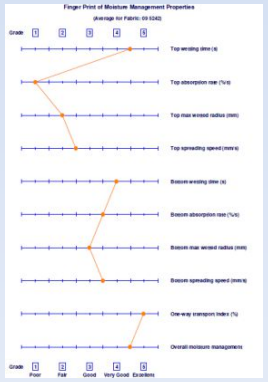
4,6



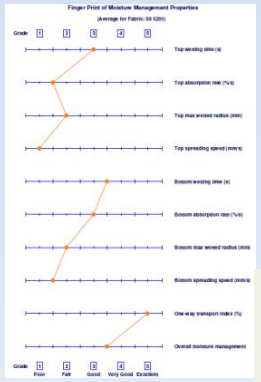
4,8



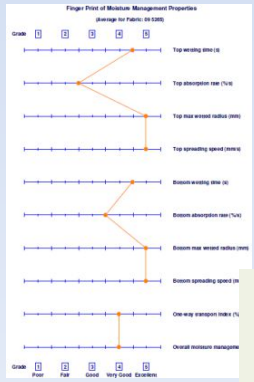
OMM 3,5



OMM 4,0

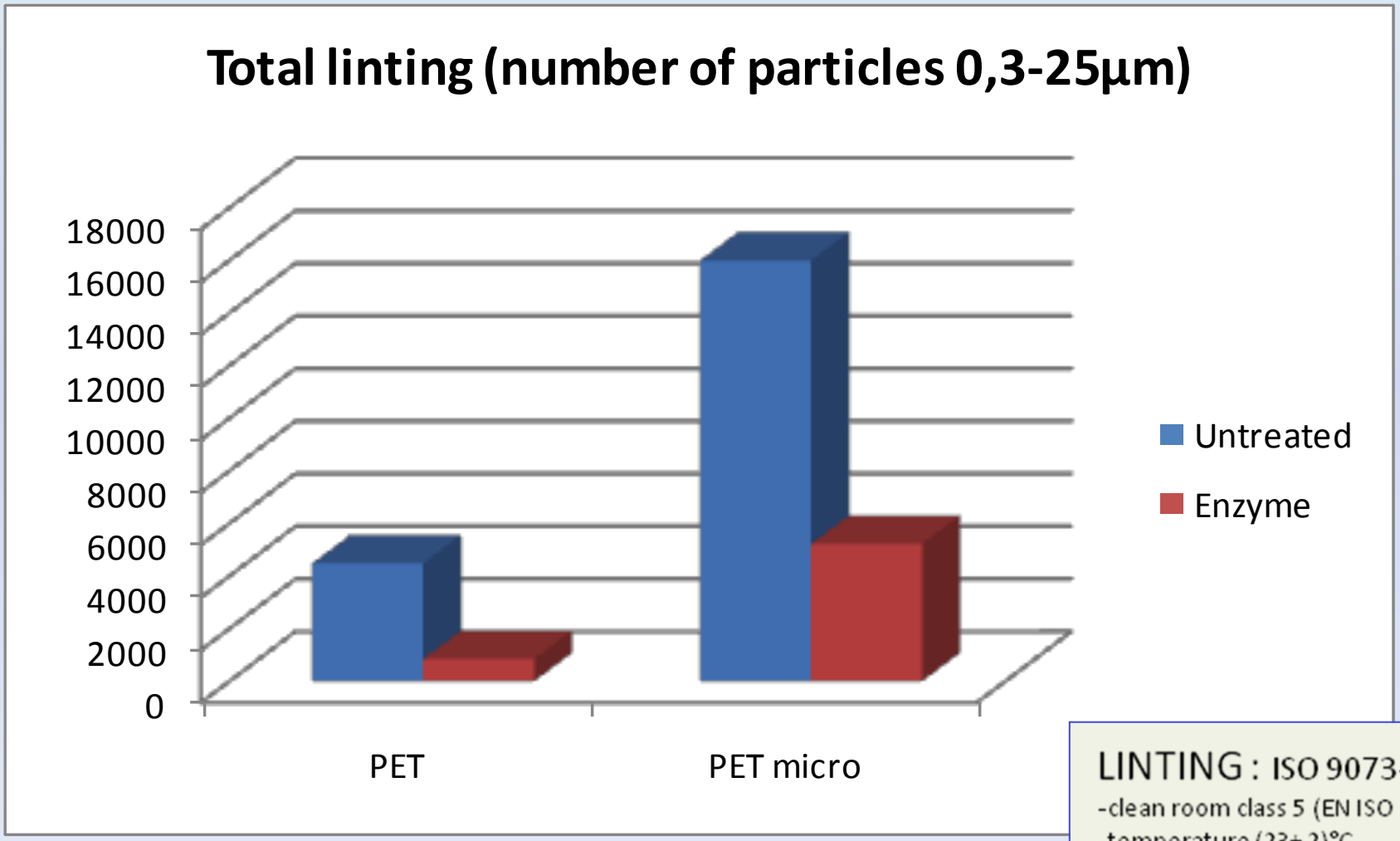


OMM 3,0



OMM 3,5

Enzymatic modification of PES – Experience
Reduction of number of released particles (LINTING)



LINTING : ISO 9073-10
-clean room class 5 (EN ISO 14644-1)
-temperature (23± 2)°C
-RH (50± 5)°C

Enzymatic treatment of PBT membrane – breathability improvement

TEXAZYM PES – lipolase: 1:10; 2%owf; 35°C, pH= 4,5; 60min, rinsing water

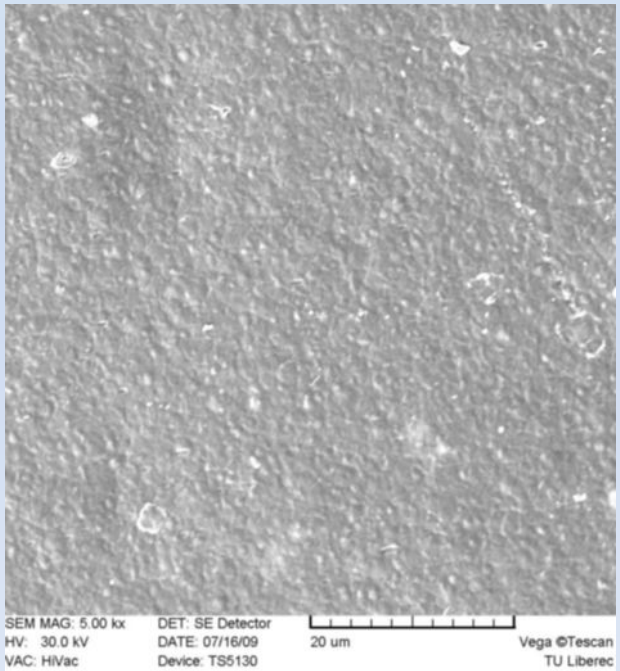
TEXAZYM CP – cutinase: 1:10; 2% owf; 50°C, pH=6,0; 60min, rinsing water

PBT membrane	hydrophobicity EN 20811 (cm)	breathability MVTR EN ISO 15496 ($g/m^2.Pa$)	dimensional change EN ISO 1077 (%)
untreated	>100	0,11	-
5x washing 64°C	>100	0,10	0
5x washing 64°C, thermosterilization 134°C/10min.	>100	0,09	+0,1
TEXAZYM PES	>100	0,18	0
5x washing 64°C	>100	0,18	+0,05
5x washing 64°C, thermosterilization 134°C/10 min.	>100	0,21	+0,02
TEXAZYM CP	>100	0,22	-0,01
5x washing 64°C	>100	0,21	+0,02
5x washing 64°C, thermosterilization 134°C/10min.	>100	0,24	+0,03

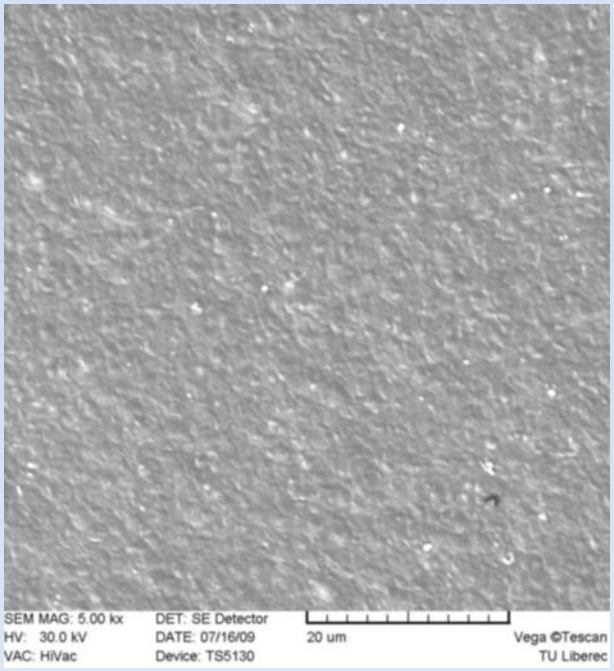
Enzymatic treatment of PBT membrane

Effects need to be durable (membrane resistivity)
in repeated washing 64°C + thermosterilization 134°C 10min (steaming)

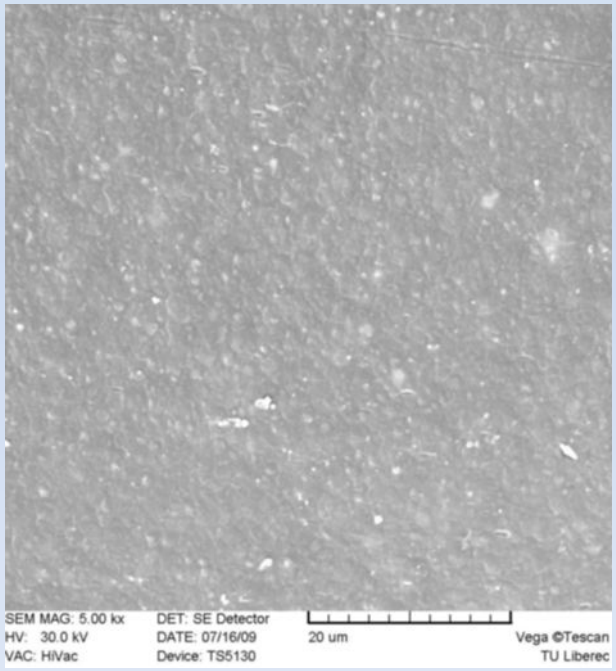
PBT membrane 300x magnified



original



5x washed 64°C



5x steamed 134°C 10min

Enzymatic treatment of PET fabric outer layer

binding of antimicrobial agent: improved permanency

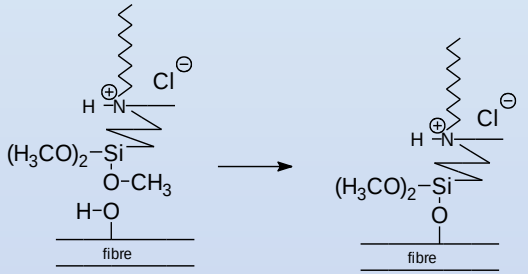
Chemical bond between new –COOH and –OH groups and quat based antibacterial system

„Dimethyltetradecyl (3-(trimethoxysilyl)propyl)ammonium chloride“

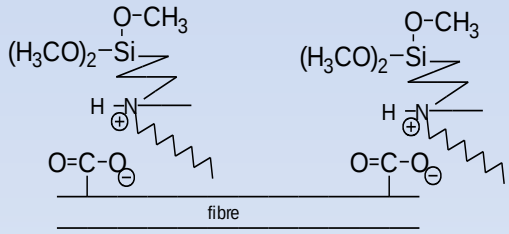
Staphylococcus aureus (AATCC 100)

	Reduction of colonies /%/		
	without washing	5 x washing 40°C	15 x washing 40°C
PES + antibacterial agent	90%	exceed	exceed
PES + TEXAZYM PES + antibacterial agent	85%	96%	92%

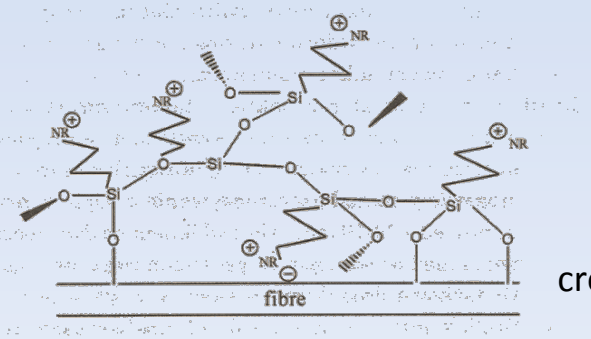
G+ and G- effective



covalent bond



ionic bond



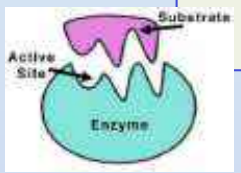
crosslinking

Enzymatic treatment of PET fabric outer layer
enhancement of FR & antistatic properties support

synergical effect

1.st step

enzymatic modification
TEXAZYM PES, CP



+

2.nd step

permanent FR treatment
TEXAFLAM PE Conc.

thermosol application

enzyme treatment supports final effects :

- hydrophilicity increase
  higher wet pick-up
  = higher phosphorus content
- surface resistivity decrease
  = antistatic properties

- FR effect (P content)*
- inherent antistatic properties of FR product
  substantial surface resistance decrease

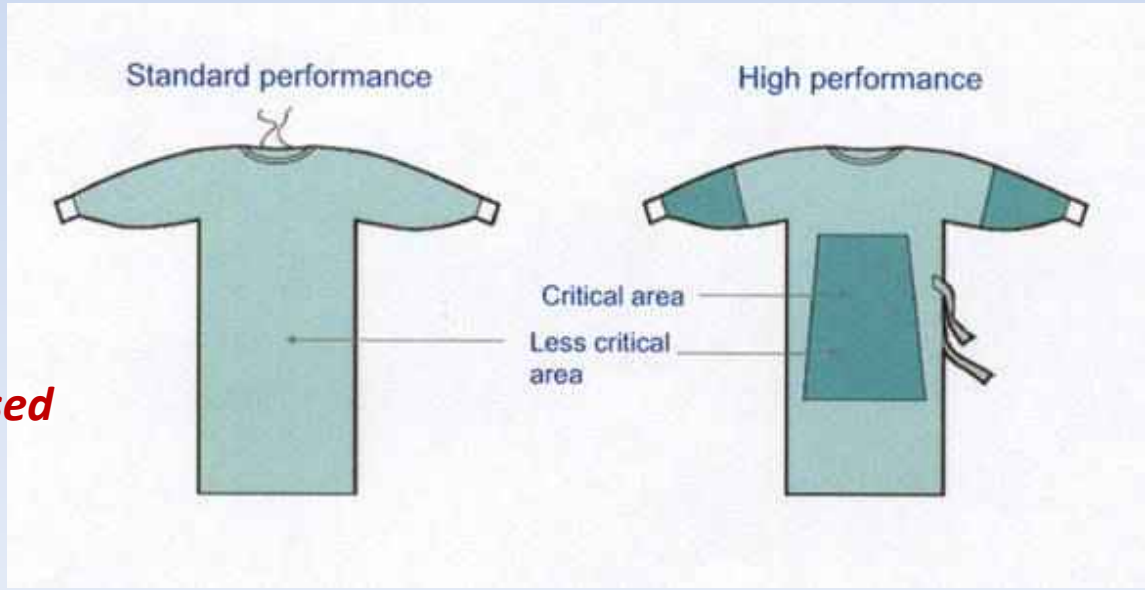
P content increase by 25%

FR treated only outer layer (= 2/3 owf.) **P content necessary to be increased**:
a) product concentration & b) higher wet pick-up (enzymes)

Resulting multilayer textile structure properties

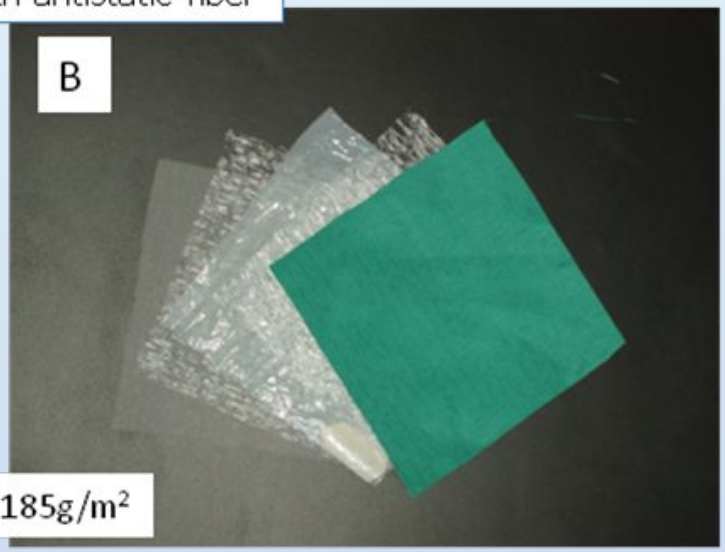
Parameter	Standard	Result
Resistance to water penetration	EN 20811	>100cm
Breathability (MVTR)	EN ISO 20811	0,2g/m^2.Pa
Air permeability	EN ISO 9237	0mm/s
Resistance to microbial penetration - Wet	EN ISO 22610	< 2
Resistance to microbial penetration - Dry	EN ISO 22612	< 2
Surface resistivity	EN 1149-1	10^5 Ω (64% r.h.) 10^7 Ω (25% r.h.)
Tensile strength	EN ISO 13934-1	1358N (weft) 1991N (warp)
Square weight	EN 12127	215g/m^2

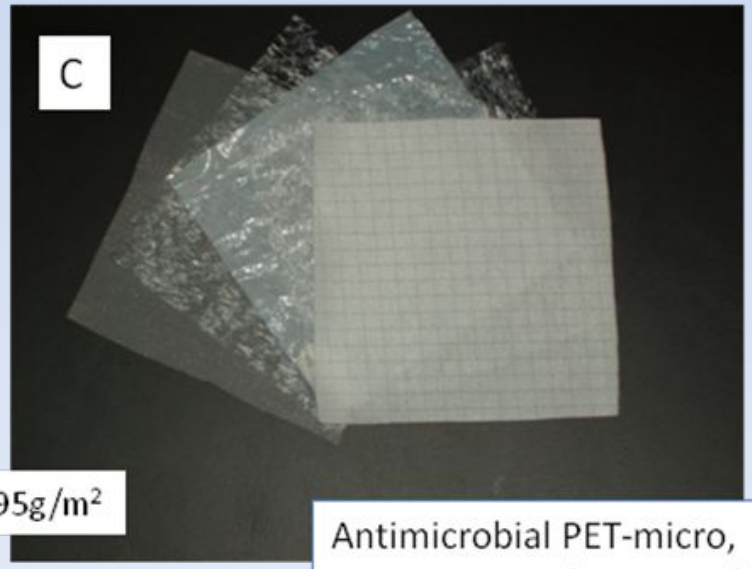
Effects durable
in repeated washing 64°C
+ thermosterilization 134°C 10min



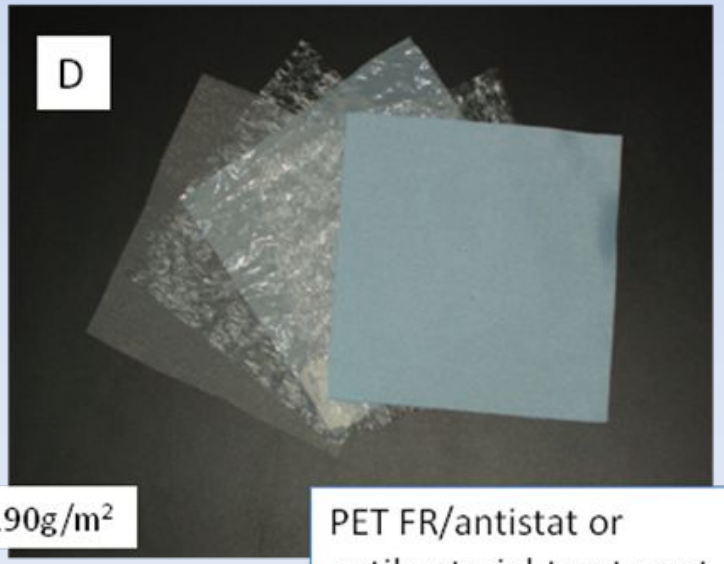
Multilayer structure possible to be used only for critical areas of garment :

examples of structures with antistatic fiber





Antimicrobial PET-micro, antistatic grid (AMANDA)



PET FR/antistat or antibacterial treatment

CONCLUSIONS

- **Multilayer textile structures using functional PBT membrane have extra high and durable barrier effects**
  - **waterproof**
  - **resistivity to microbial penetration**
  - **antistatic**
  - **antimicrobial, FR effects support, ...**
- **Enzymatic modification of non-porous PET membrane can double its breathability without negative influence on membrane properties (decisive layer)**
- **Enzymatic modification of outer surface PET layer improves effects of its functionalization (antibacterial, FR) and moisture managemet parameters (MMT)**
- **Ecofriendly enzyme biotechnologies as a part of complex processing and functionalization of textiles**

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THANKS FOR YOUR ATTENTION

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