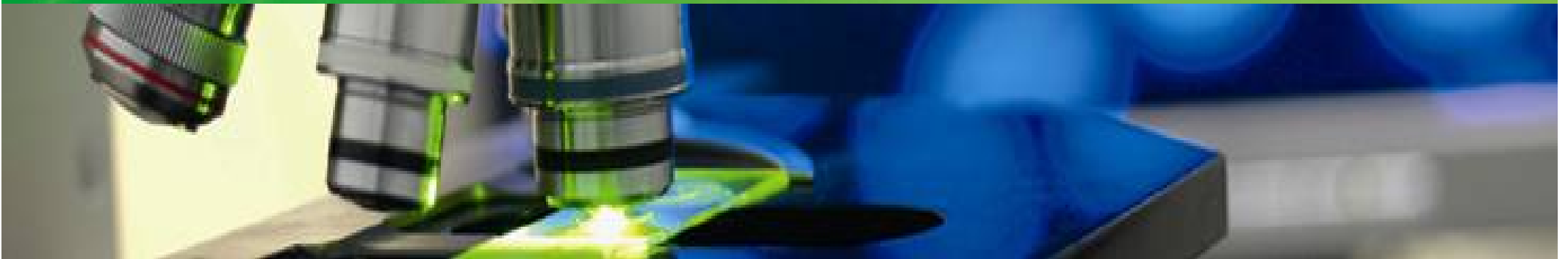


# Antimicrobial Textiles in Sports Activities – Application, Assessment and Safety Aspects

Dr. Anja Gerhardts – Hohenstein Institute  
09.05.2012 – Performance Days



# General requirements for a reasonable use of antimicrobial textiles

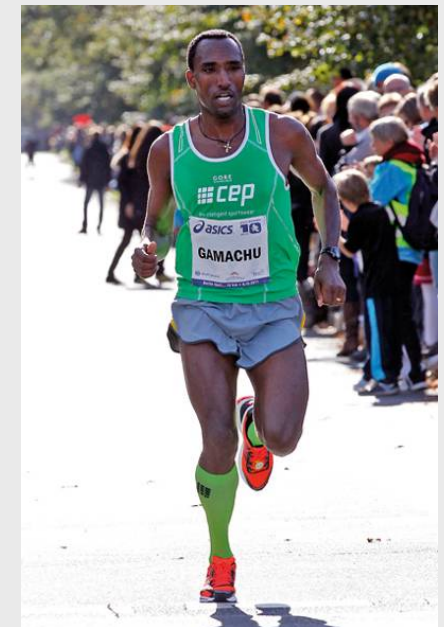
**Efficacy**

**and**

**Safety**

This means

- proof of an application-oriented effectiveness
- exclusion of harmful effects to people or environment due to biocide usage



# Antimicrobial textiles: active substances and fields of application

## Active substances

- Silver (metal salts)
- Quaternary Ammonium compounds (Quats)
- Polyhexamide PHMB
- Copper
- Chitosan
- Regenerable N-halamine polymeric biocides
- Triclosan
- Dyes (biocide spacer dye)

## Fields of application

### Protection

- Fibre protection - *microbial corrosion*
- Prevention of infections - *reduction of pathogens, e.g. in medical facilities & nursing homes*

### Odour

- Odour reduction and control

### Therapy

- Support of therapies in *wound infection*
- Atopic dermatitis - *effect on microflora disorders*

# Antimicrobial textiles: product specifications depend on the fields of application

## Fields of application

- Fibre protection
- Prevention of infections
- Odour reduction (sports)
- Wound management

## Product specifications

- Active principle
- Active substance
- Level of effectiveness
- Specificity of effectiveness
- Duration of effectiveness (onset and durability)
- Safety (e.g. effects on skin and microflora)

# Requirements for antibacterial sportswear

Efficacy against bacteria on the textile surface  
Duration of efficacy (fast onset of action / duration of sporting activity)

Hygiene

***Challenge Test according to ISO 20743 and modifications***

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Exclusion of skin reactions (allergy, irritation) or negative influence on skin microflora

Safety

***Basic tests: cytotoxicity test, sensitization test***

***Wearing trials: skin microflora and local skin parameters***

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- a) Sweat odour reduction – subjective assessment
- b) Sweat odour reduction – objective assessment

Odour

***Test methods in vitro and in vivo***

## Tests for antimicrobial efficacy

### Standard methods

- **ISO 20743 (JIS L 1902)**  
Absorption method, quantitative test  
(*bacteria and virus*)
- **ISO 22196 (JIS Z 2801)**  
Film contact method, quantitative test  
(*bacteria and virus*)
- **EN 14119**  
Agar diffusion test, qualitative test  
(*mould fungi*)

# Tests for antimicrobial efficacy

## Assessment criteria

defined by Hohenstein Laboratories  
*currently accepted worldwide*

Antibacterial activity*	Growth reduction [log <sub>10</sub> CFU]
No	< 0.5
Slight	0.5 to < 1
Significant	≥ 1 to < 3
Strong	≥ 3

\*against test strains

*Staphylococcus aureus* ATCC 6538 and *Klebsiella pneumoniae* ATCC 4352

## Marketing instruments



## Modified tests for antimicrobial efficacy

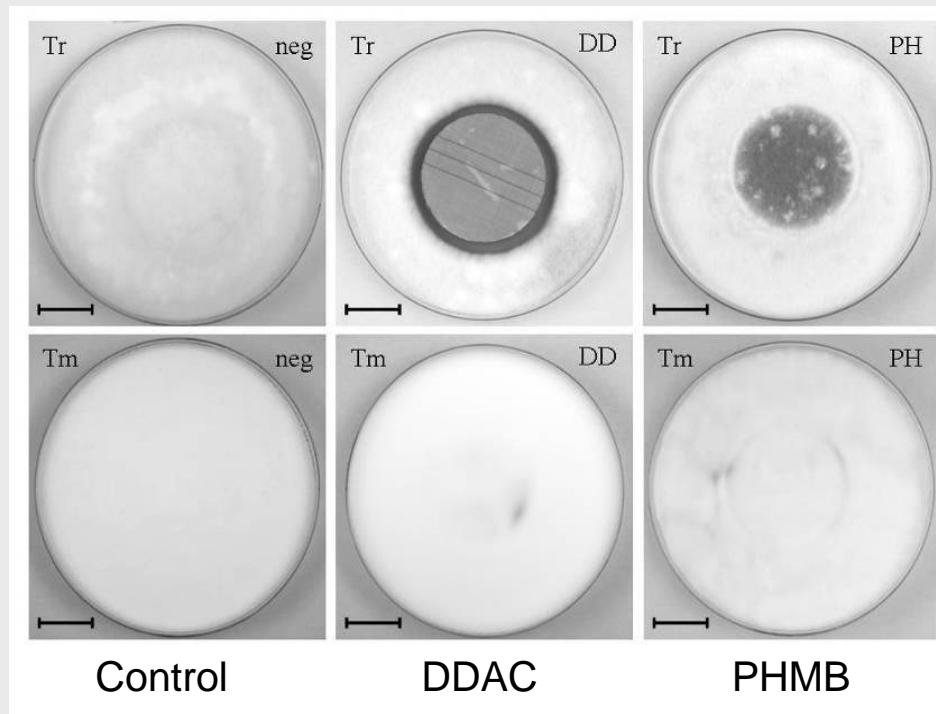
### Application-oriented modifications of standard methods

- Variation of test strains
  - odour causing germs (e.g. skin microflora)
  - hygiene-relevant germs (e.g. germs of the oral cavity, dermatophytes and others)
  - decomposers (*Aspergillus niger*, *Penecillium spec.*, etc.)
  - wound or nosocomial germs (e.g. MRSA, enterococci incl. VRE, *Candida albicans*, norovirus, etc.)
- Kinetics of antimicrobial activity (e.g. shorter contact time)

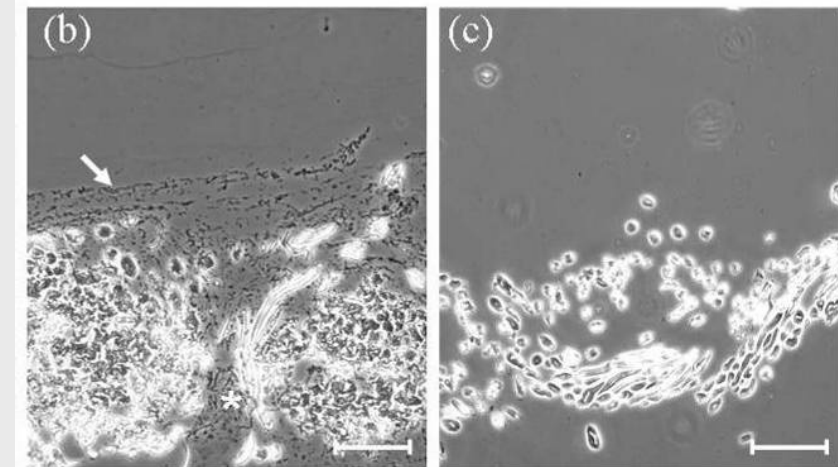
## Modified tests for antimicrobial efficacy

### Modification of test strain for efficacy against athlete's foot

Example: Dermatophytes differ in susceptibility to biocides



Tr = *Trichophyton rubrum*, Tm = *Trichophyton mentagrophytes*



mycoses

Diagnosis, Therapy and Prophylaxis of Fungal Diseases

Original article

Dermatophyte susceptibility varies towards antimicrobial textiles

Timo R. Hammer, Helmut Mucha and Dirk Hofer

Institute for Hygiene and Biotechnology, Hohenstein Institutes, Schloss Hohenstein, Boennigheim, Germany

# Sportswear / efficacy against bacteria

Suspension test according to DIN EN ISO 20743



## Functional fiber 1

Integrated silver

Specificity:

- *S. aureus*
- germs of microflora

Log reduction: 2-3



## Functional fiber 2

Silver coating

Specificity:

- *S. aureus*
- germs of microflora

Log reduction: 4-5



## Functional fiber 3

Fiber finished with silver

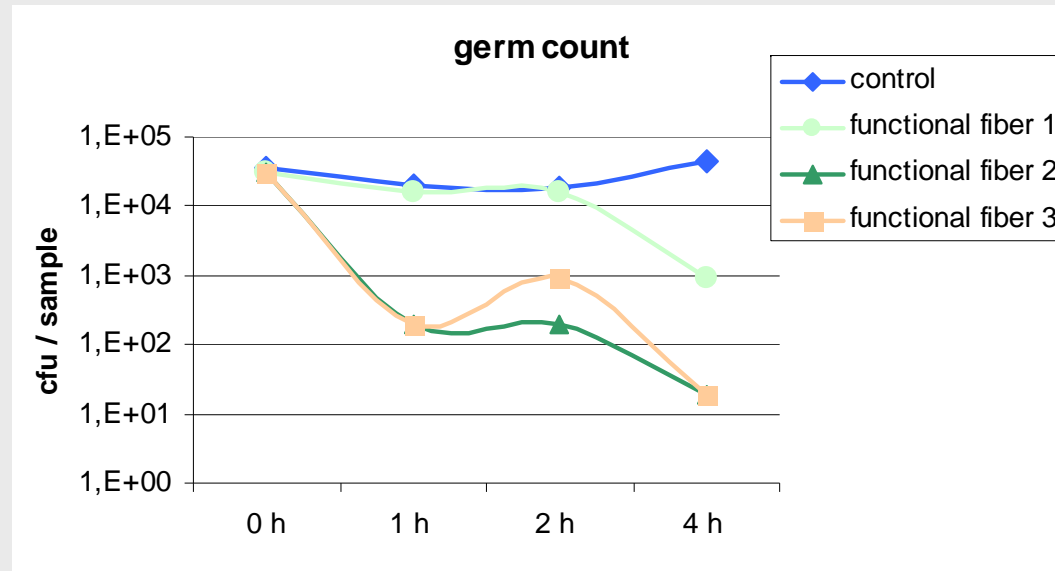
Specificity:

- *S. aureus*
- germs of microflora

Log reduction: 3.5-4

## Sportswear / onset of efficacy against bacteria

Modified suspension test following DIN EN ISO 20743



~ 1h

Source: wikipedia



~ 6h

Source: wikipedia

## Suspicion of risks silver/skin and silver/microflora

### Silver / Skin

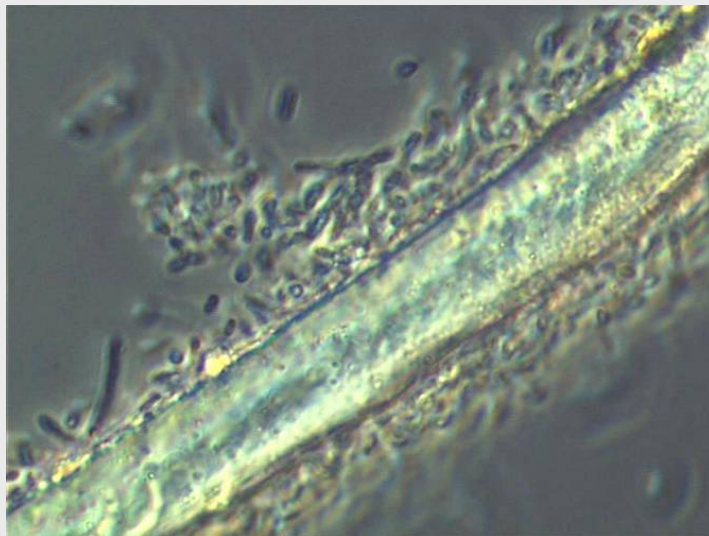
Human toxicity ??

- Toxicity for human cells
- Mutagenicity
- Sensitizing potential



### Silver / Skin microflora

- Binding to negatively charged bacterial cell walls
- Disruption of metabolism and cellular respiration of bacteria



# Tests on biological safety / human toxicity

## Biological Assessment

ISO 10993-5:2009 Test for *in vitro* cytotoxicity

ISO 10993-3:2003 Tests for genotoxicity, carcinogenicity and reproductive toxicity

ISO 10993-10:2010 Tests for irritation and skin sensitization

## Marketing instruments



## Tests on biological safety / human toxicity

Cytotoxicity

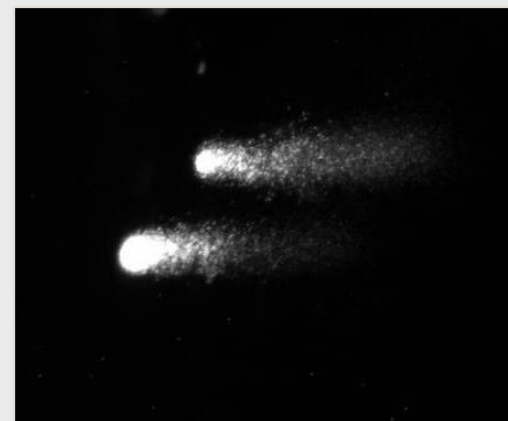
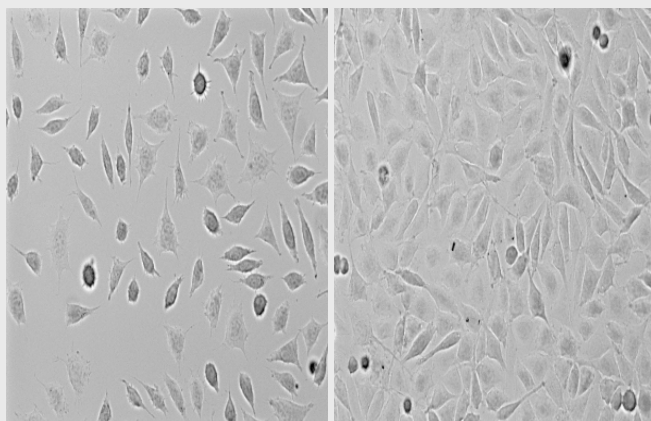
Genotoxicity



Cytotoxicity Test (ISO 10993-5)

Ames Test

Comet Assay



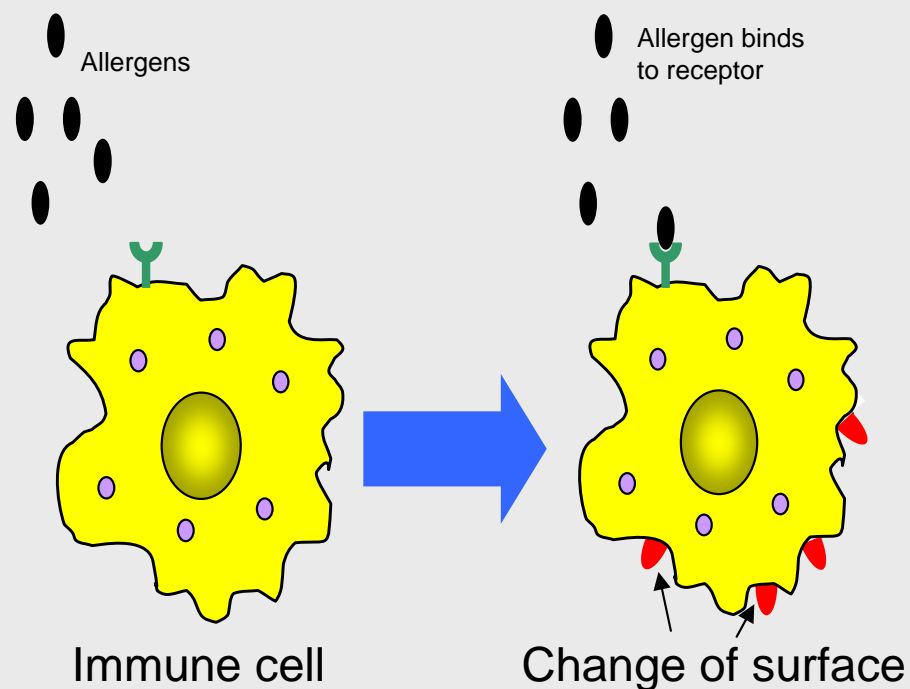
*In vitro* tests for the assessment of biological risks

## Tests on biological safety / human toxicity

Epicutaneous test (ISO 10993-10)



*In vitro* sensitization test (THP-1 test)



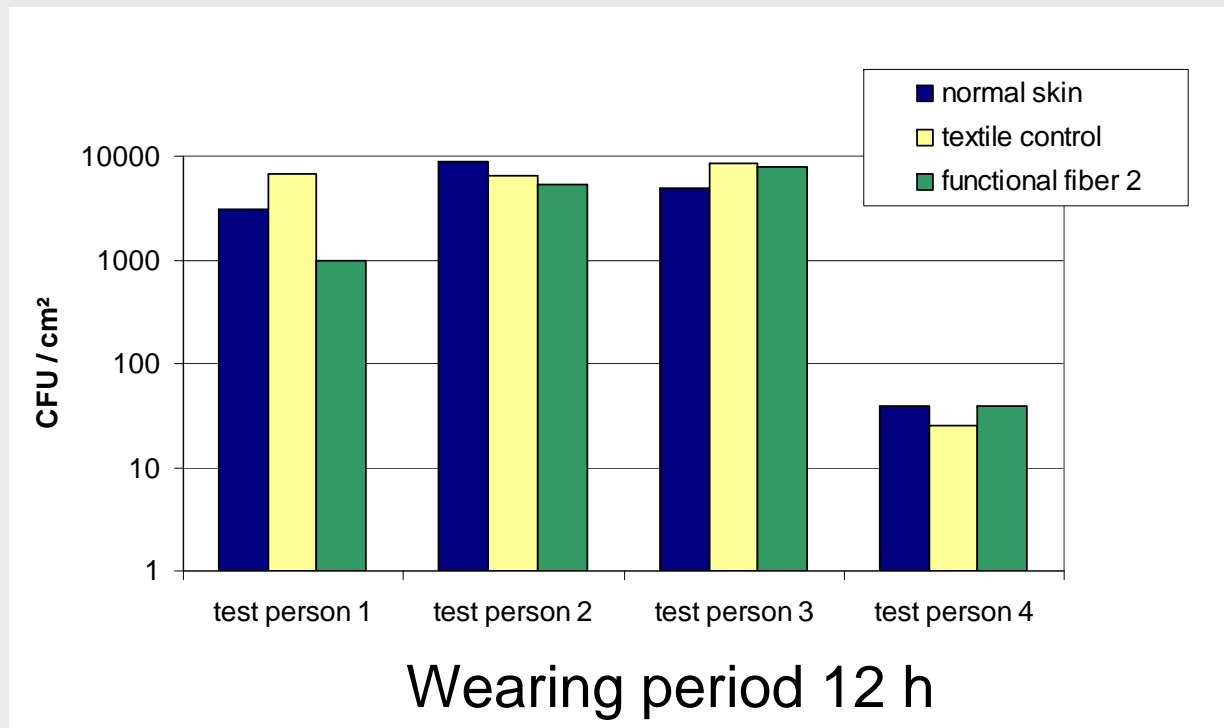
Wearing trials & cell test for the assessment of biological risks

## Silver and the human skin microflora

Patch test on the forehead



Functional fiber 2



➔ No effects on human skin microflora by normal use of textiles

## Silver and the human skin microflora

- Field study with 60 subjects (21 – 65 years)
- Microbiological and dermatological supervision
- Halved shirts (verum/placebo) were worn
- Wearing for 8 h/d over a period of 5 weeks



International Scholarly Research Network  
ISRN Dermatology  
Volume 2011, Article ID 369603, 8 pages  
doi:10.5402/2011/369603

### *Research Article*

## **Antimicrobial Active Clothes Display No Adverse Effects on the Ecological Balance of the Healthy Human Skin Microflora**

**Dirk Hoefler and Timo R. Hammer**

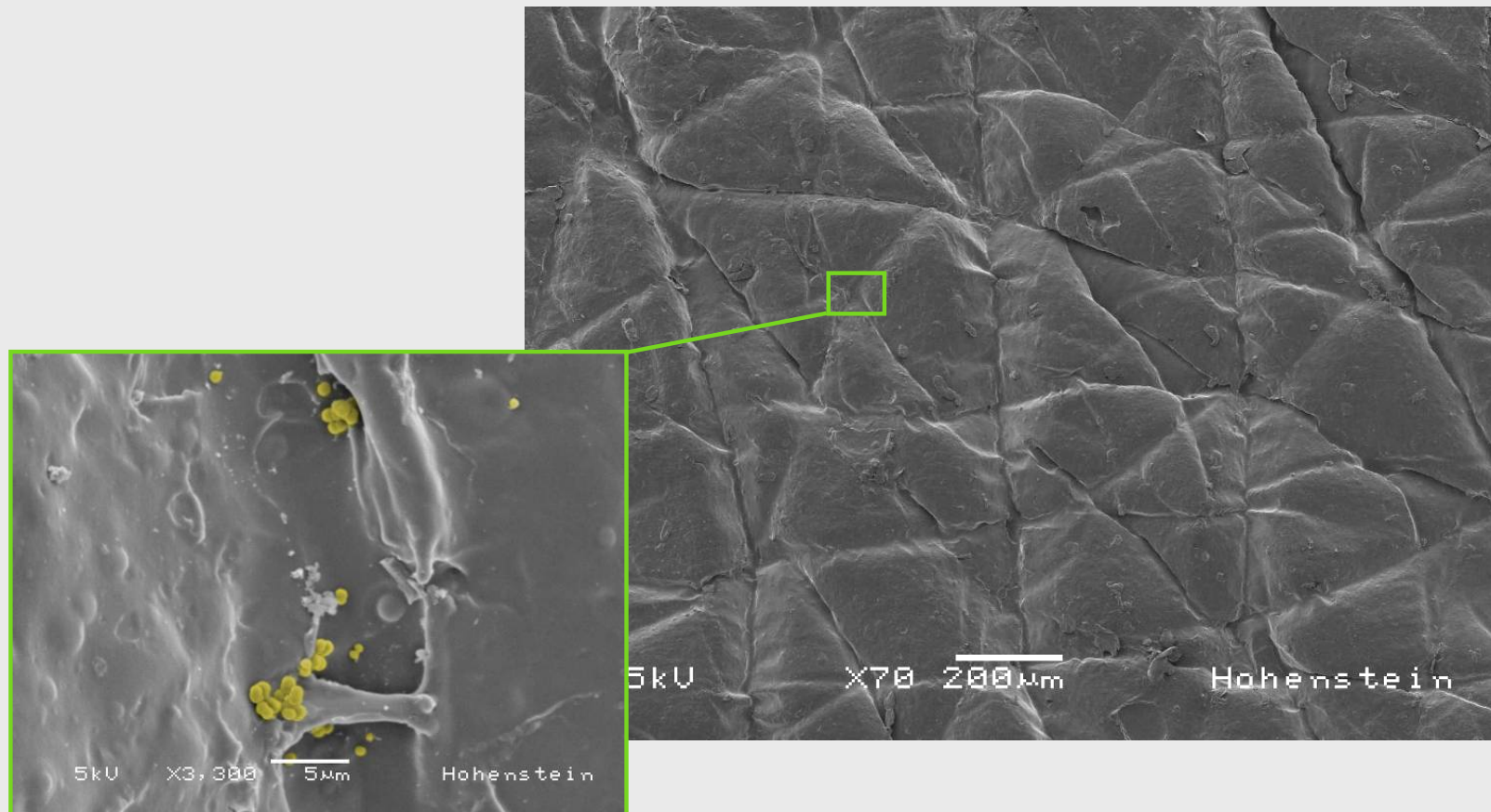
*Institute for Hygiene and Biotechnology, Hohenstein Institutes, Schloss Hohenstein, 74357 Boennigheim, Germany*

Correspondence should be addressed to Dirk Hoefler, d.hoefler@hohenstein.de

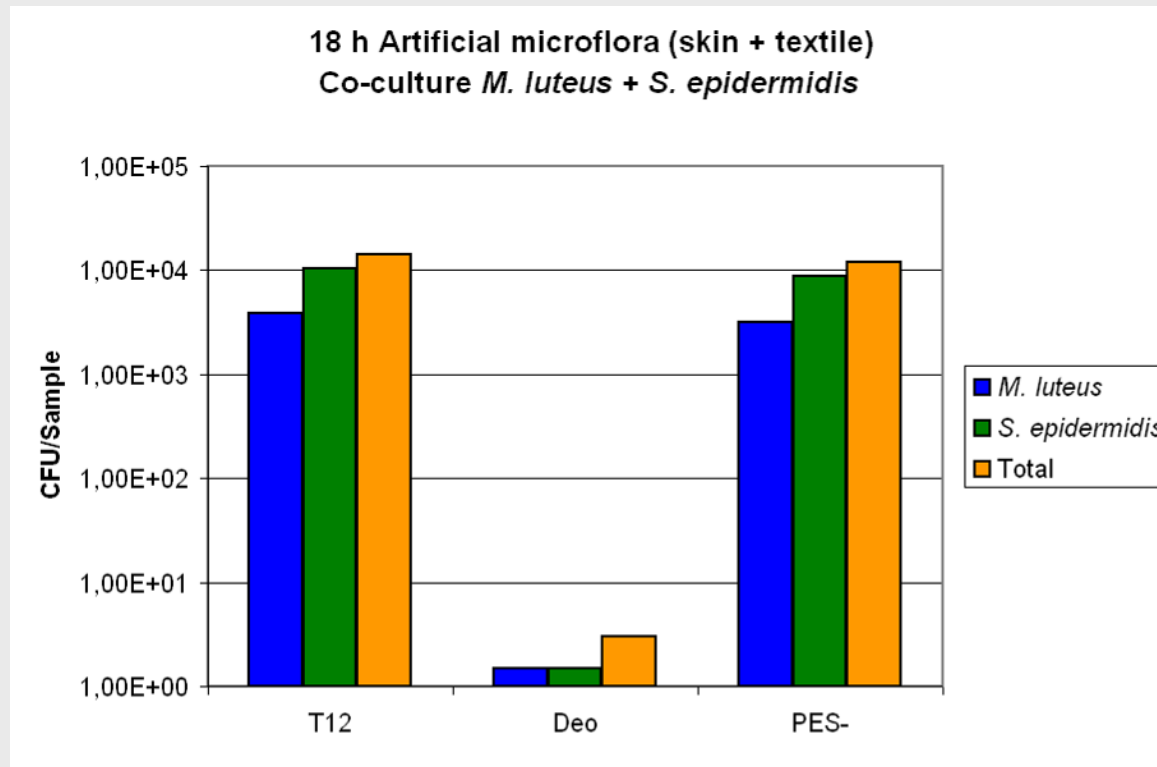
Received 13 January 2011; Accepted 27 February 2011

## Hohenstein BioSkin and artificial skin microflora

Hohenstein developed an artificial skin and its colonization with bacteria of the human microflora



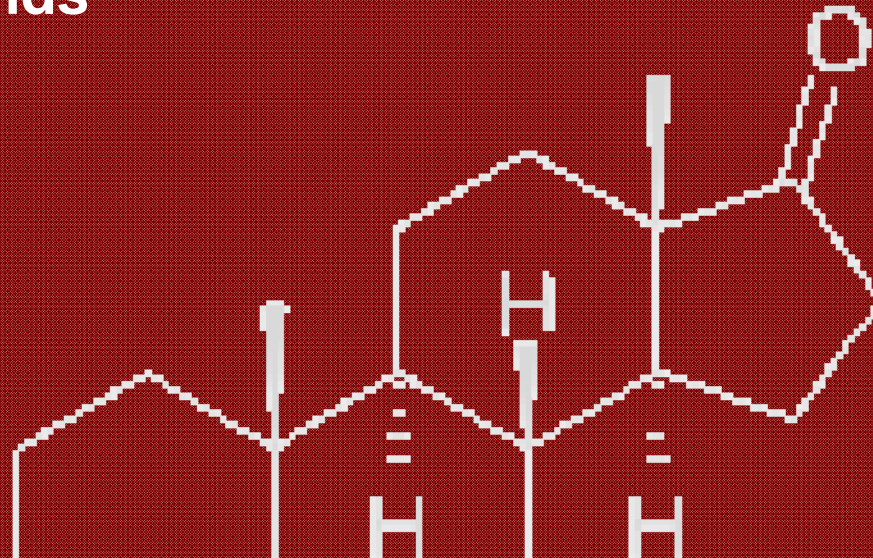
## Hohenstein BioSkin and artificial skin microflora



- ➔ Wearing simulation of antibacterial textile on the artificial skin
- ➔ No negative effect on bacteria of the human microflora

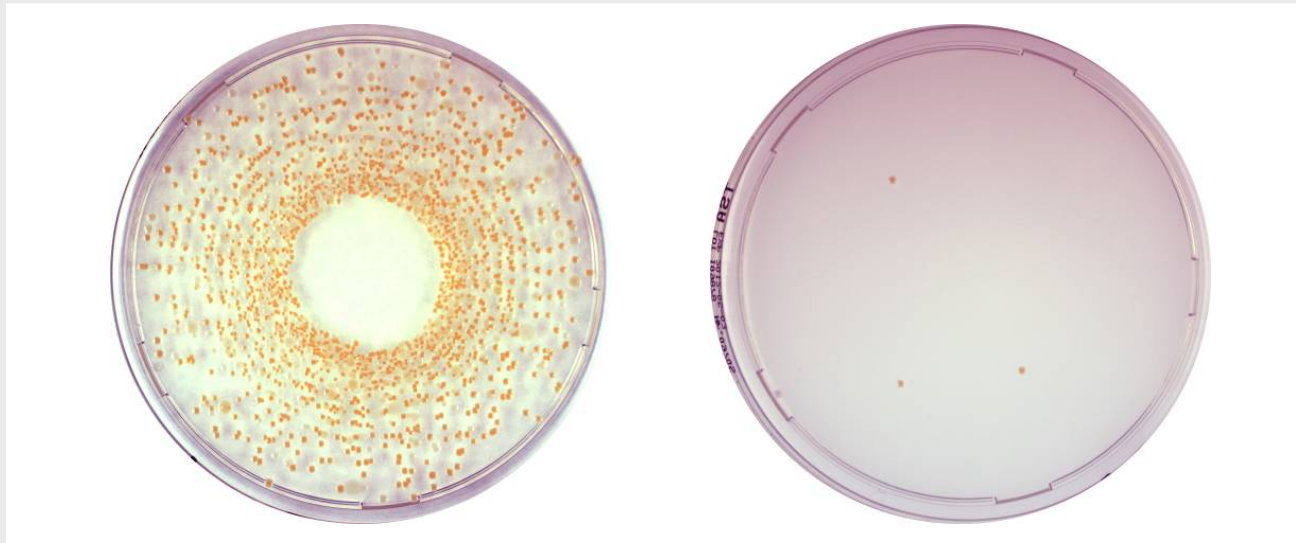
## Substances responsible for sweat odour

- Volatile Sulfur Compounds
- Short Chain Fatty Acids
- Carboic Acids
- Steroids
- ....



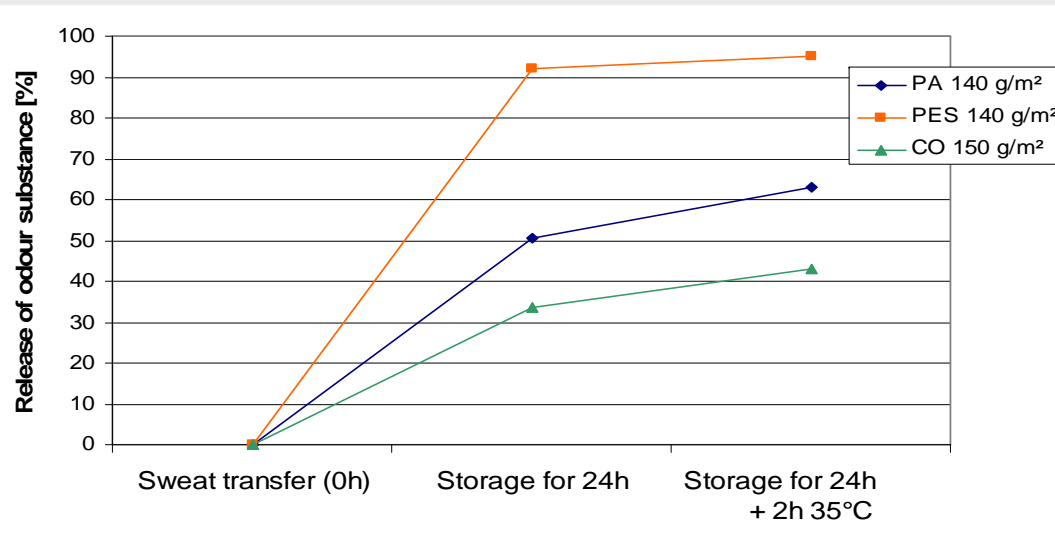
## Hohenstein *in vitro* test systems for odour reduction

- **Agar test** for antimicrobial activity against odour causing germs of the skin (e.g. *Staphylococcus epidermidis*, *Corynebacterium jeikeium*, *Micrococcus luteus*, *Saccharomyces cerevisiae*)



## Hohenstein *in vitro* test systems for odour reduction

- **Binding and release studies** using radioactive labelled sweat odour molecules
- Quantification of odour molecules on the textile



## Hohenstein *in vivo* test system for odour reduction

- **Artificial sweat studies** (mixture of key sweat odour molecules)
- Sniffing test (olfactometry) with odour panellists
- Used for
  - material comparison
  - efficacy testing of laundry processes



## Hohenstein field test system for odour reduction

- **Wearing trials** with test persons (antibacterial sportswear vs. control)
- Sniffing test with odour panellists



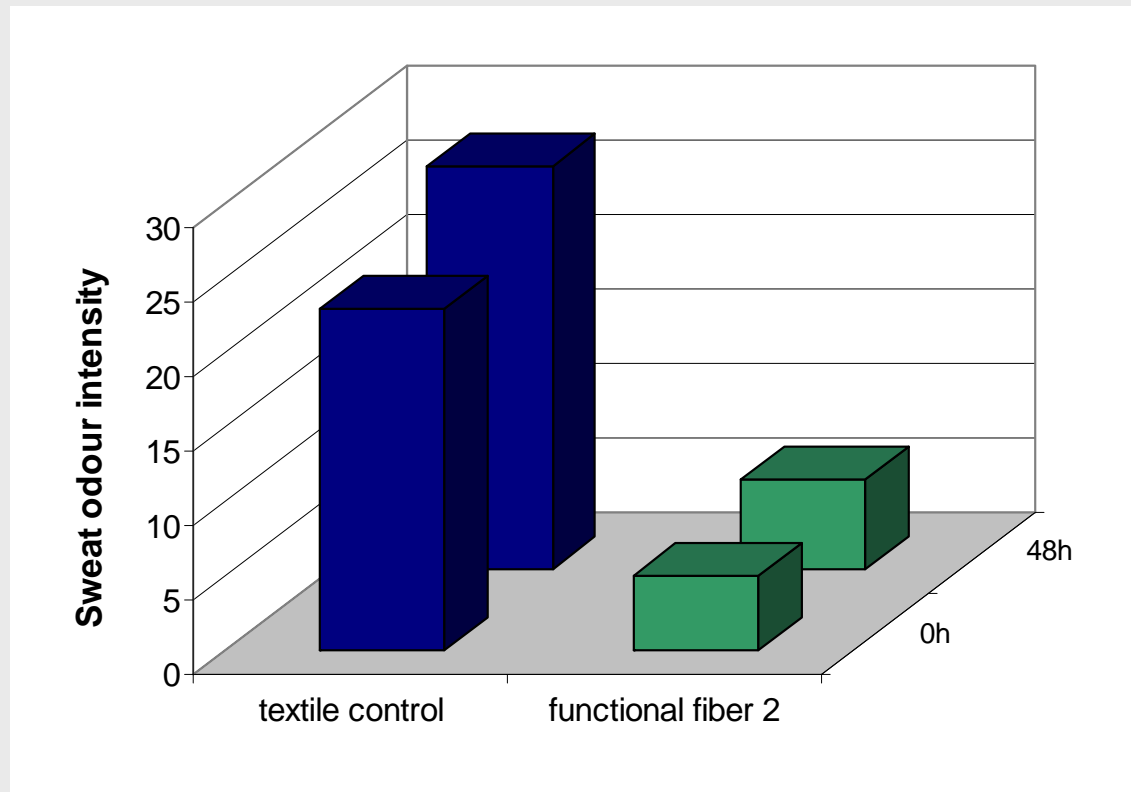
Sporting activity > 1 hour

Sweat odour  
→



Olfactometry

## Hohenstein field test system for odour reduction



- ➔ Significant differences in the assessment of odour intensity
- ➔ Strong and fast odour reducing efficacy of the antibacterial textile

# Testing and assessment of antimicrobial textiles in sport activities

- Antimicrobial textiles are a plus at the point of sale
- Antimicrobial activity has to be adapted to the specific sport activity (onset, duration)
- Keep safety aspects in mind (biocides)
- The performance of „all day fresh“ can be evaluated



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**Thank you very much for your interest !**

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