ODOR REDUCTION THANKS TO TEXTILE MATERIALS

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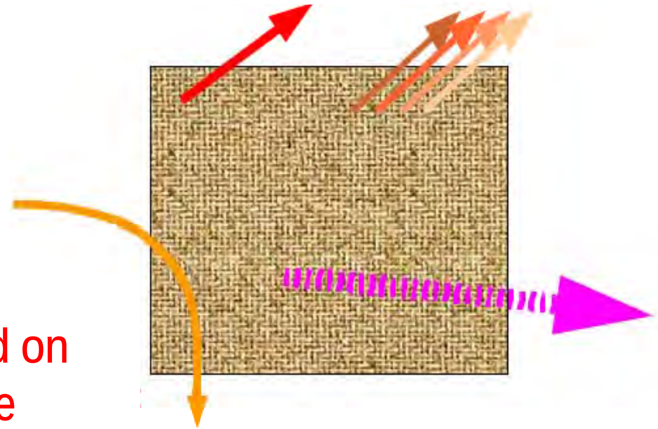
Origin of odours from Textiles

Vapour Pressure

Emitted compounds function of the product



Substances Adsorbed on the product surface

Emission of impurities and contaminants from the transport, storage and handling of the products (new material) OR after contact with the skin (using conditions)

Substances contained in the product

Emission of auxillary compounds impurities and contaminants from the process

Textile and skin interactions

- SKIN = not sterile surface : Ecosystem which plays an important role in the body balance

- Resident micro-organisms : various bacteria adapted to the physiological skin conditions : surface temperature between 30°C and 35°C, pH from 5 to 6,5, various nutritive substances (perspiration, sebum from the sebaceous glands, cellular fragments)

- Major skin microflora strains : Staphylococcus (*Staphylococcus aureus* and *epidermidis* – Gram-positive), micrococcus, aerobic and anaerobic corynebacteria, propionobacteria and, in case of lack of hygiene : Gram-negative bacteria

- Transient micro-organisms (Temporary colonization) : constituted of many micro-organisms from endogenous (from the body) or exogenous (environnement) sources.

Textile and Bacteria interactions

- Role of the textile in odour generation : Act as a barrier which block the water evaporation and increase its condensation. The consequent moisture combined with the presence of nutrients at the interface between the skin and the textile induce the growth of micro-organisms and the potential to generate malodour.

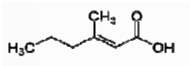
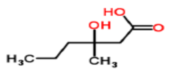
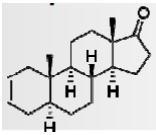
- Reinforced by the high specific surface of the textile products

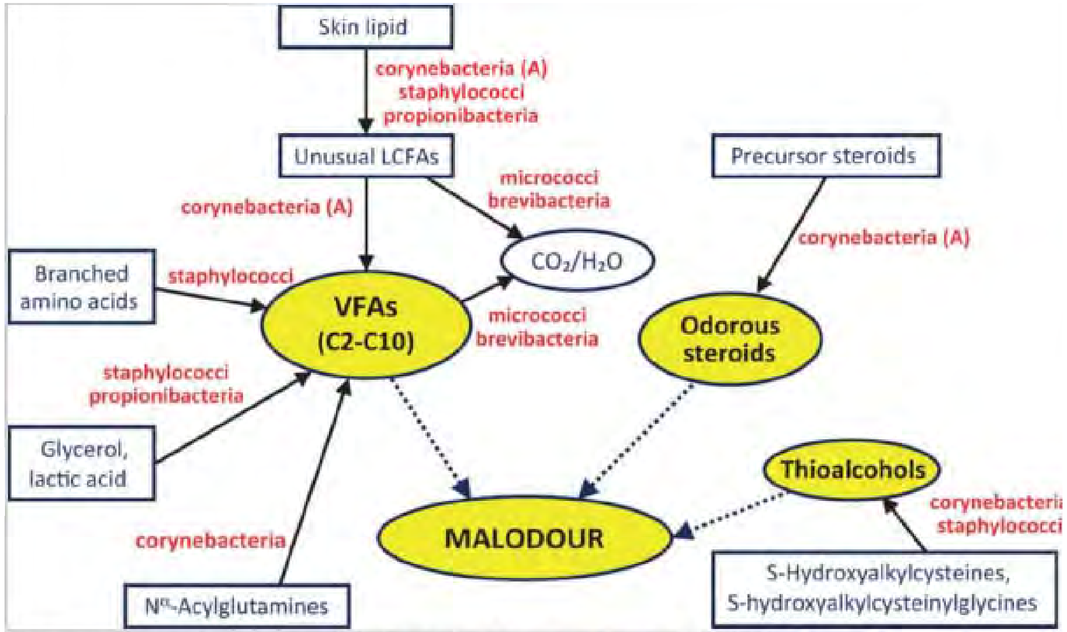
- After 8H of « normal » wearing, the bacteria population reach 10^4 / cm²

- The body odour intensity is considered as a malodour from 10^7 germs/cm². As the number of bacteria can double about every 30 minutes, a malodour can be perceptible after 12 hours of a « normal » wearing.

Interaction Textile / Odorous substances

- Relation between malodour and number of total specific bacteria **Coryneforms** (*James et al. 2004*)
- Other bacteria participate to the gobal sweat odour : **Staphylococci** and **Micrococci**

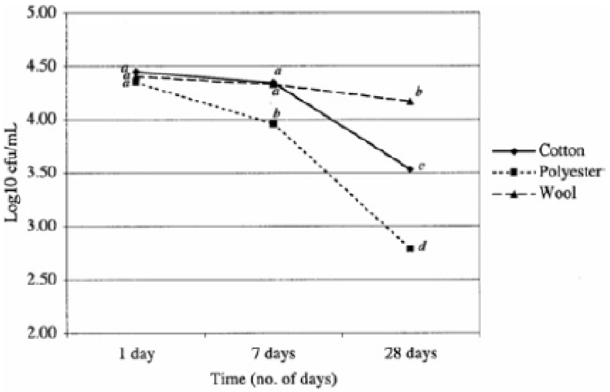
- Odorous compounds issued from the bacteria degradations :
  - ✓ 3-Methyl-2-hexenoic acid (axillary) 
  - ✓ Isovaleric acid (feet)
  - ✓ 3-hydroxy-3-methylhexanoic acid 
  - ✓ Thioalcohol
  - ✓ Androstenone 
  - ✓ …

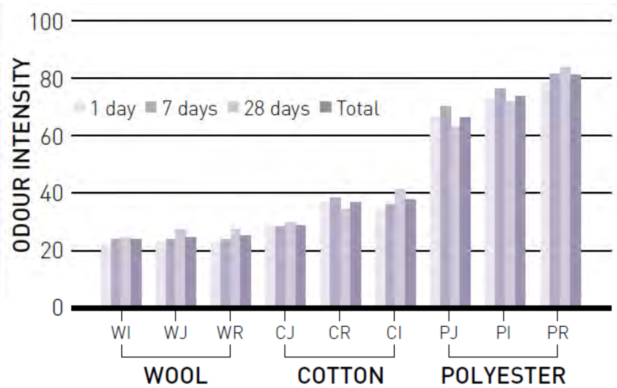


Source: James, AG et al., 2013, FEMS Microbiol Ecol, 83, 527-540.

Textile – Bacteria interactions in the odour release

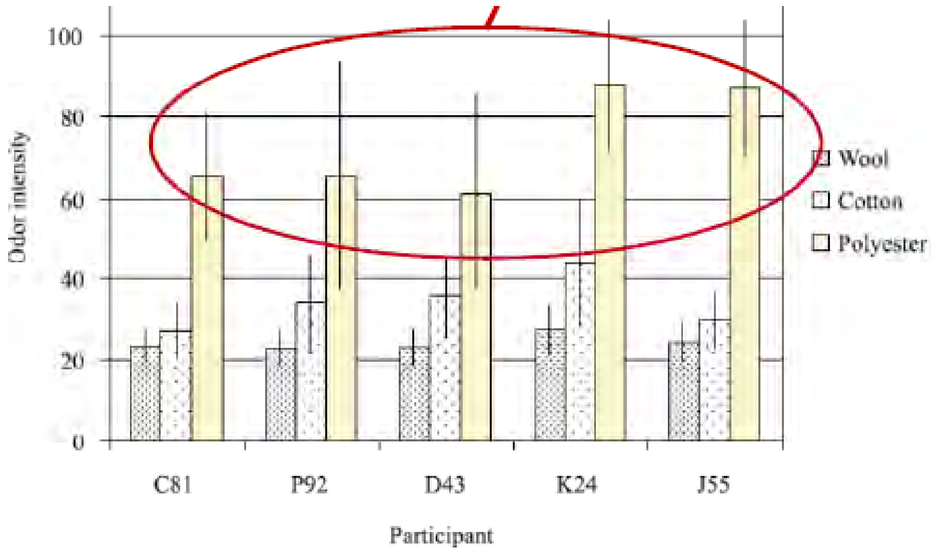
- First Observations :
  - ✓ Higher adhesion of bacteria on hydrophobic, non polar surfaces : Polyester vs. Cotton (*Fletcher, M., 1996. Bacterial adhesion*)
  - ✓ Lower growth of Staphylococcus on hydrophilic compared to hydrophobic fibers (*Teufel and Redl, 2006*)
- Complementary Studies :
  - ✓ Comparable microbial numbers on wool, cotton and polyester after 1 day use (*Teufel and Redl, 2006*)
  - ✓ Higher <u>survival rate</u> of bacteria on wool than on polyester or cotton
  - ✓ BUT : odour intensity is lower on wool





Source : Mc. Queen et al. (2007). Odour Intensity on apparel fabrics and the link with bacterial populations. Textile Research Journal, 77, 449-456

Odour retention on fabrics – Axillary odours



- The odour intensity is higher for hydrophobic fibers regardless of sweat composition (Polyester >> Cotton and Wool)

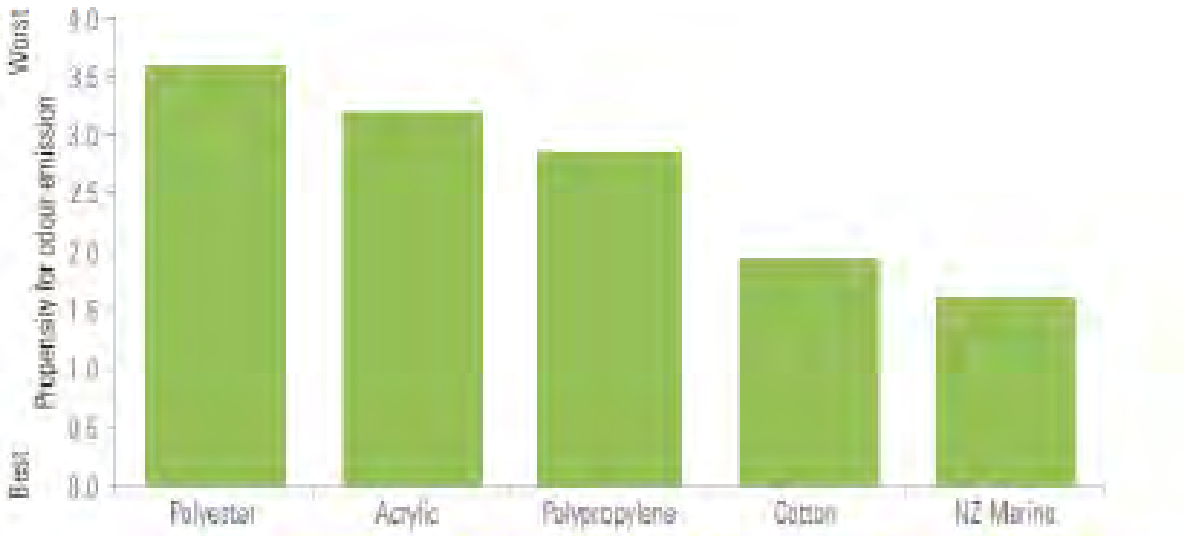
- Significant results were obtained in particular for Wool fabrics which are less odorous after wear than polyester (panel of 13 assessors)

- Short-chain carboxylic acids were detected as responsible of the polyester odour after wear (Otago University)

- An other study (New Zealand) found that wool fabrics retained about 66% less body odour intensity than polyester fabrics and 28% less than cotton fabrics (olfactory measurement)

Odour retention on fabrics – Feet odours

- Sensory Study on odours emissions from socks made with different fabrics
- From The Wool Research Organisation New Zealand Inc. (WRONZ), become Canesis Network Ltd and then AgResearch Ltd.



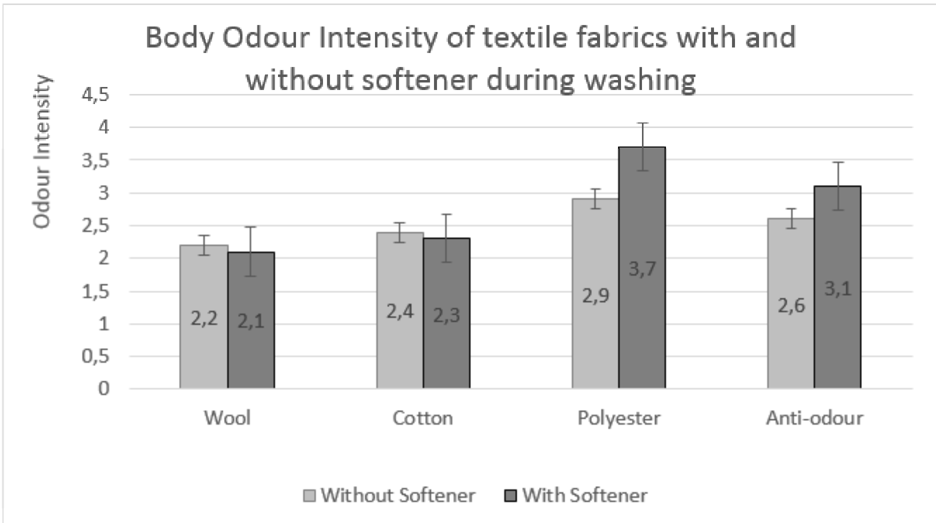
- Confirm previous studies (Wool, far less odours compared to Polyester or Acrylic)

Synthesis : Influence of the type of fiber on bacteria and odour

	Polyester	Cotton	Viscose	Acrylic	Polyamide	Wool
Odour	+++ (fatty acids, Ketones and aromatic comp.)	+ (Aldehydes)	+	+ +	+ +	- / + (Aldehydes / Ketones)
Bacteria initial development	+ +	+	+	+	+	+
Bacteria persistancy	+ + (2, 4, 5)	+ (1, 2, 5)	- - (1, 3, 4)	- (1, 2, 3, 4)	+ / - (1, 5) (2, 3)	+ + (1, 2, 4, 5)
Origin	Develop. of specific odour releasing strains					

Impact of washing on textile odours

- Fabric softeners seems to enhance the bad odour on Polyester (*Laitala et al. 2012*)
- Lipase in detergents may have an impact on odour formation (Munk et al. 2000)
- Volatile substances like carboxylic acids are faster removed in a washing process than micro-organisms (Chung and Seok, 2012)
- Volatils substances are easier removed on Cotton than on Polyester (McQueen et al., 2013)
- Volatiles from washing machine contribute to laundry malodour (Stapleton et al., 2013)



Source : Laitala et al. (2012). Troubles with the Solution : Fabric Softeners and Odour Properties. Tenside Surf. Det., 49 (5), 362-368.

Potentially odorant substances at the interface of human skin and textile

Odour

S

H_2S Mercaptans*
Sulfides*
Thiazoles
Thiophenes

N

Amines*
Pyrazines*
Pyrridines
Nitriles
Pyrroles
Indole

Odour

O

Alcohols*
Aldehydes*
Ketones / Esters*
Acids*
Furanes
Acetals

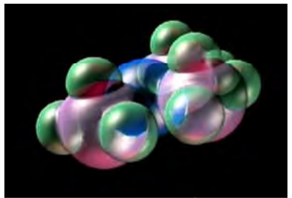
Odour

* Typical Sweat Odours

Odour

Hydrocarbons

Alkenes
Terpenes
Some Alkanes



Aromatics

BTEXS / BHT

Odour

Testing

➡ <u>Olfactory Evaluation</u> :

- External parameters control (French norms (sensory analysis) AFNOR V09 105, SSHA).

- Samples management

- Measurement of Detection, Intensity, type of Odours (+ deodorization efficiency, following ISO 17 299)

- Repeatability and reproducibility of the measurement

➡ <u>Microbiological testing</u> :

- ISO 20743, ASTM2149, JIS L 1902 & AATCC100

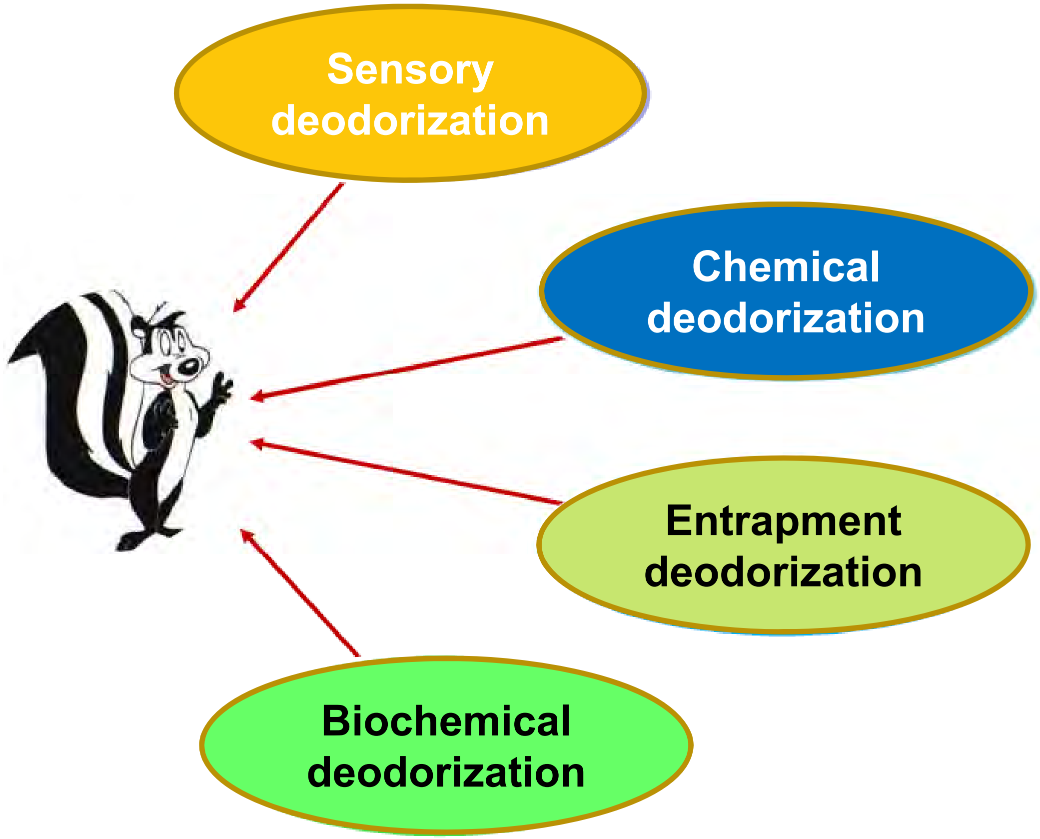
➡ <u>Other Tests</u> :

- Durability (Wash, Abrasion)

- VOC (GC/MS and HPLC/MS)

- Air or water permeability

Odour elimination in textiles



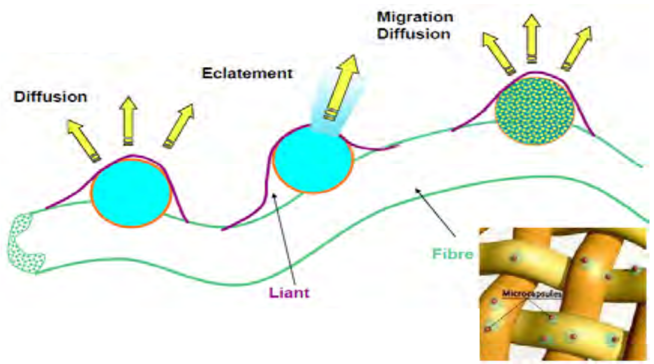
Odour elimination in textiles

- Sensory deodorization :

Textile : controled release (microcapsules, resines)

  - Masking Agents (biology / biochemistry) : Hiding bad odours (essential oil) : Competitive chemical bonding with the olfactory receptor (« fragrance finishing ») : masquodor® (Protex)
  - Neutralizing Agents (chemitry) : Based on a chemical reaction directly with the malodourous substance (air or liquid phase) : Decrease of the « bad » odour intensity or modification of the chemical structure (odour modificaiton)

- Processes : Impregnation (crosslinking agent), Spraying, Coating, Incorporation in the fibre.
- Stage : Impregnation : thermal fixation (=at 130 to 170°C (drying and curing step)
- Release : Physical (dialytic : wall insoluble and product soluble in water and body fluids) / Biochemical (enzymatic degradation) / Chemical (dissolution by specific reactions)



Microencapsulation

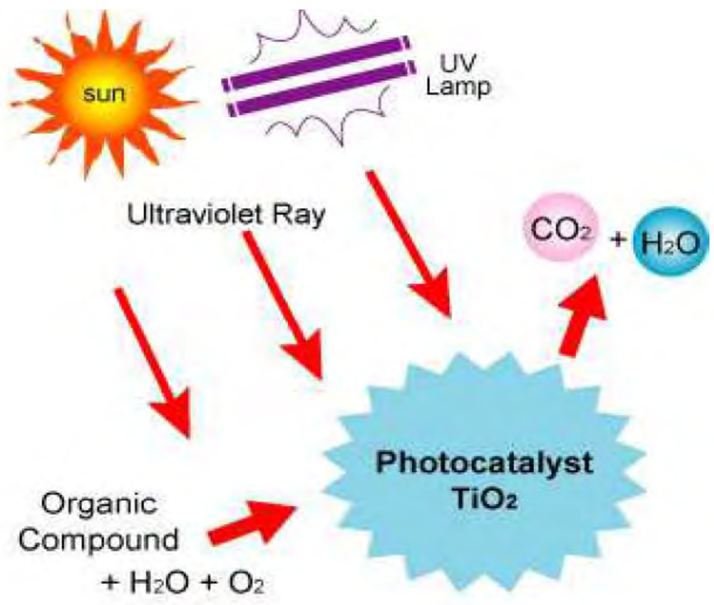
- Advantages : many manufacturing processes / Several types of textiles
- Disadvantages : Curing temperature decreased aroma retained inside the microcapsule / washing durability (< 25 home launderings) / Biocidal products regulation (BPR) 528/2012

Odour elimination in textiles

- Chemical deodorization :

Textile : Addition of chemically active products to degrade odorous substances (ex : TiO2 for photocatalysis)

- Chemical reaction to transform substances with a bad odour in other substances without odour or with a better odour
    - Redox réactions (organic compounds),
    - Acido-basic (nitrogenous compounds with acidic reagent or sulfur compounds with basic reagent)
    - Ionic exchange (ammoniac or sulfure compounds neutralization by ferric salts or acétaldéhyde, H2S and amines by polyoxometalates)
    - Photocatalysis (Reaction between radical species from O2 and H20 and organic compounds)

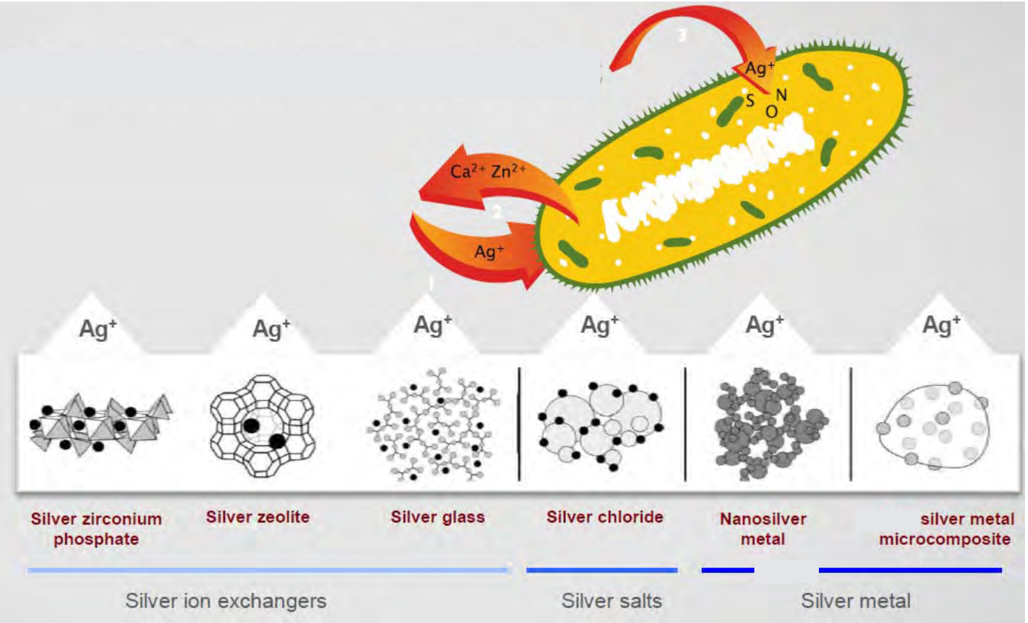


Photocatalysis

Odour elimination in textiles

- Biochemical deodorization:

Textile : biocides



- Bactériostatic : Hinder proliferation of bacteria (without changing bacteria's skin flora).
- Bactericide : Eliminate micro-organisms (lethal action)

Odour elimination in textiles

- Biochemical deodorization:

Textile : biocides

- Regulations (biocide directive N°98/8/CE : Biocide market regulation)
- Selection of the technology depending on the objective (fabric protection or deodorization) and on the manufacturing process (melting process : dissolution in the melting polymere (PES, PA et PP), Dry or Solvent process : dissolution in the solvent (cellulosic acetate, acrylic and chlorofibers) or wet process: dissolution in water (viscose)

Biocide	Ratio (%)	Price ($/kg)
Silver	32,5	70* - 130
Silane Quats	13	30 - 50
Quats	4,5	50

Source : Report Biocides in Textiles, 2017

And… Triclosan, Zinc Pyrithione, Izothiazolinones (BIT, MIT, CMIT), formaldehyde releasers, phenolic derivates, paraben, copper, organic acids, alcohols

Odour elimination in textiles

- **Biochemical deodorization**: formulation and application processes

  - Biocide coated finishes (90% production in volume of pure product)
    - Aegis, Aglon, Purista (Lonza), Irguard (BASF), Foamfresh (Piedmont), Sanitized, Ultrafresh (Thomson), Silvadur (Dow), Pure TF (HeiQ)
    - Processes : Exhaustion, Padding, Spraying
    - Stage : Pre-spinning (on thread), Finishing (on raw textile), Spraying

  - Biocide Inherent fibres (10% production)
    - Allerban (Advansa), Coolmax (Asota), Saniguard (Miroglio), Rhovyl, Bactershield (Sinterama), Mushon (Toray), Bioactive (Trevira), Radilon (Radici), XT2 and X-static Fibers (Silverescent products, Noble), Newlife (Polygiene / Sinterama)
    - Processes : Synthetic fibre production
    - Stage : Spinning solution, mixed at the melt polymer

Limits :

- Some studies did not prove the efficiency of antibacterial treatments on odour reduction (*Mc Queen et al. (2013), Journal of the textile institute, 104 (1), p. 108*) and the durability is still called into question (Swedish Chemicals Agency, KEMI, PM 8/15, 2015)
- High cost of treatment

Source : Report Biocides in Textiles, 2017

Odour elimination in textiles

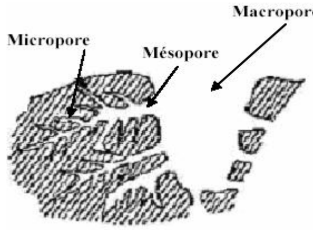
- Entrapment deodorization :

*Textile : Trapping charges (physical and chemical interactions : cyclodextrines, **activated carbons**, silica gel, argiles, zeolites)*

ACTIVATED CARBON

- Odorous substances are chemically or physically fixed on active sites at the surface of the material Hydrogen, Van der Waals or ionic bonds (+ chemical functionalisation to increase reactivity)
- Chemical selectivity depending on :
  - ✓ The pore size (macropores : from 50 to 2000 nm, mesopores : from 2 to 50 nm, micropores : < 2 nm)
  - ✓ The polarity (hydrophilic characteristics)

Activated Carbon



CAG

NEW DEVELOPMENTS

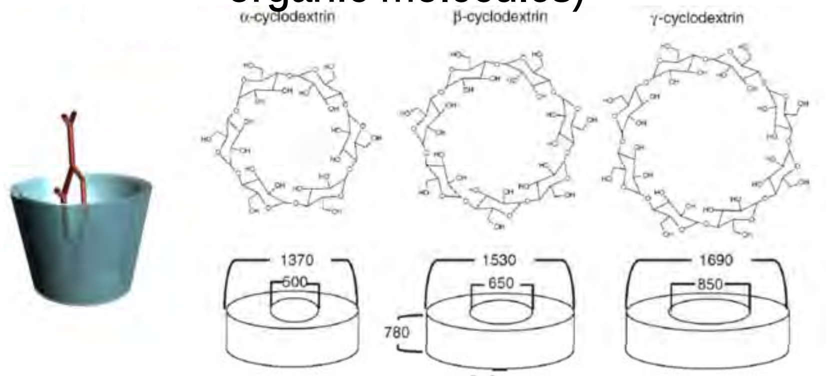
- Activated carbon fibers (in comparion with standard activated carbon functionalisation : larger specific surface, better adsorption capacity, better accessibility to micropores, faster adsorption kinetics)
- Porous polymers: Control of the specific surface and hydrophilic parameters, purity

Products : HeiQ Fresh NKU (zeolithes),
Scentry (Microban, activated carbons),

Odour elimination in textiles

- Entrapment deodorization - CYCLODEXTRINES

Torus-shaped molecules with hydrophobic cavities between 0,5 and 0,85 nm (trapping of organic molecules)



Cyclodextrines

Advantage :

- Do not interact with dying products (colour and odour efficiency)
- Efficiency proved on real samples (cigarette smoke: *Setthayanond, J et al. (2017). Cellulose, vol.24, issue 11, pp.5233-5250*)

Table 1. Feasible interactions between β-CD and some textile fibres [14].

Parameter	Cotton	Wool	PES	PA	PAN	PP
Ionic interactions	-	+	-	+	+	-
Covalent bonds	+	+	-	+	-	-
Van der Waal forces	-	-	+	+	+	-
Crosslinking agents	+	+	+	-	-	-
Graft polymerisation	+	+	+	+	+	+

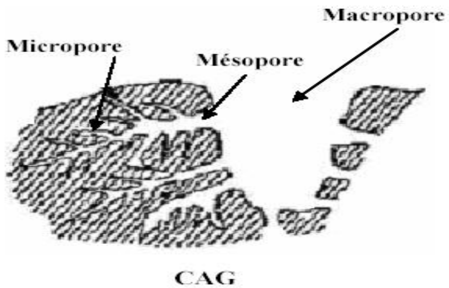
+=possible,-=not possible, PES-polyester, PA-polyamide, PAN-polyacrylonitrile, PP-polypropylene.

AOBCI. AUTEX Research Journal, vol.11, N°4; Dec 2011

Anti-odour fabrics – Market Study

➢ Entrapment technology

- Carbon based (Activated carbon, activated carbon fibers…)
  - Zorflex (Calgon)
  - Cocona (replaced by 37,5)
  - Scafé
  - Bamboo charcoal (Acelon Chemical)
  - Saratech (Blücher)
- Minerals (zeolites, clays, nanomaterials…)
  - LAVA XL (Sciessent)
- Polyméric (Synthetics polymers…)
- Molecular (Cyclodextrines)



Selectivity
Efficiency

Anti-odour fabrics

- Activated Carbon Fibers

Blücher

Chemviron

Kureha

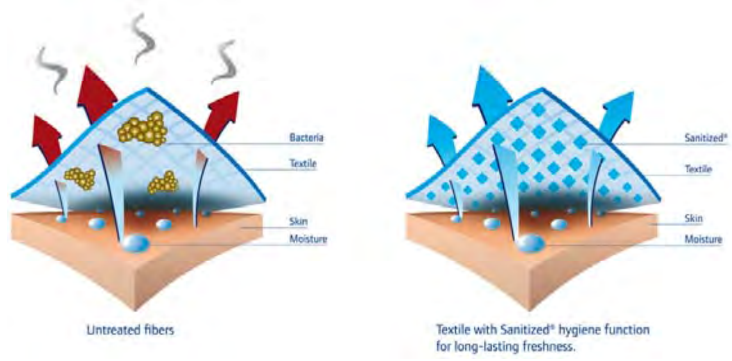
Standard Claims
Ammonia, Trimethylamine
Methylmercaptan, Hydrogensulfide, Methyldisulfide
Carboxylic acids (C2 to C4), Aromatic compounds, Acetic ether, Methyl isobutyl Ketone, i-butanol
Aldehydes (C3 to C5)

Anti-odour fabrics

- Cyclodextrine solutions

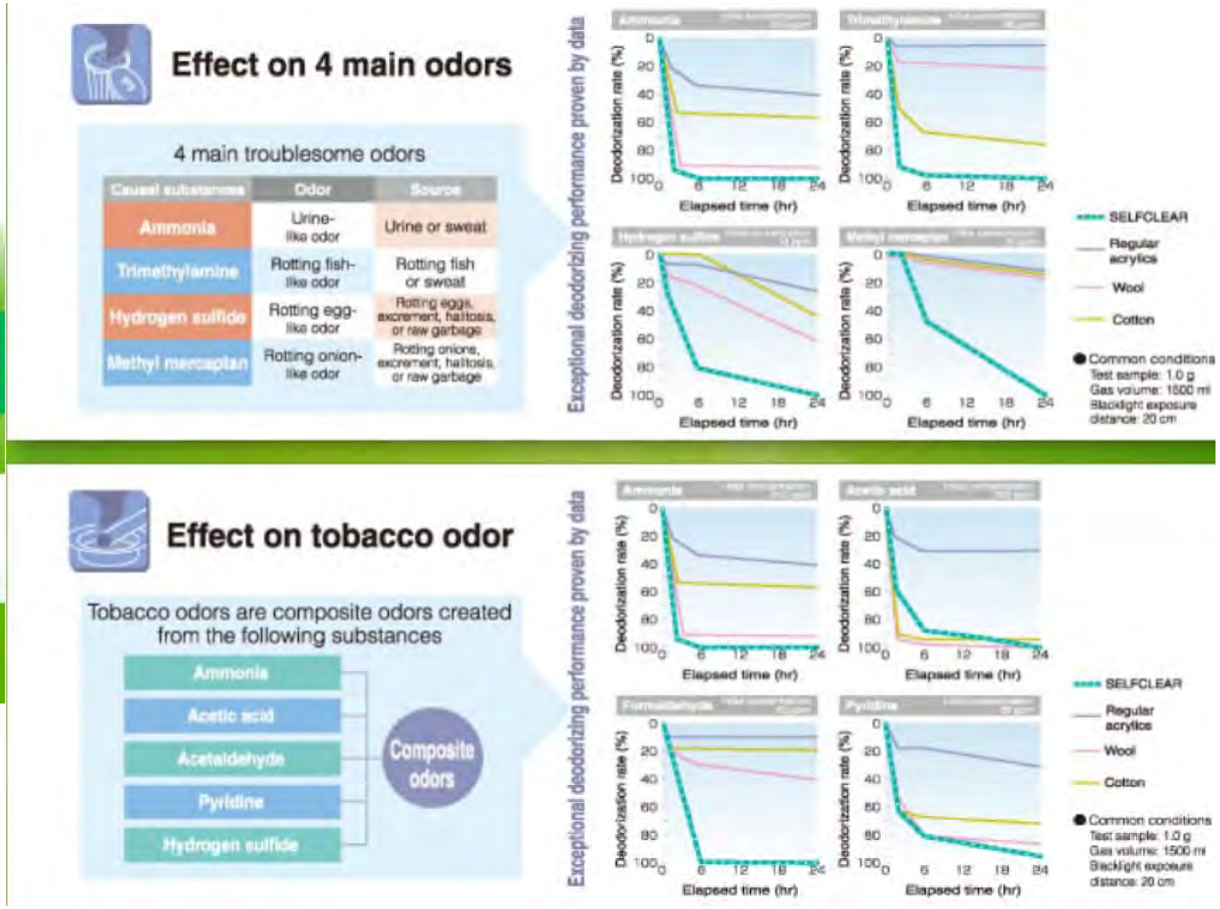
- Pulcra Chemicals GmbH : Anti-odour treatment Cyclofresh® (+ silver : cyclofresh plus®)
  - Liquid application
  - Body odours absorption + Fragrance release
  - Suit with many types of fabrics
  - Regenerated by washing or spraying

- Sanitized AG : Traitement ACTIFRESH®
  - Liquid / Solid applications (liquid, paste, masterbatch, powder), for extrusion, padding, extraction, spray, coatings



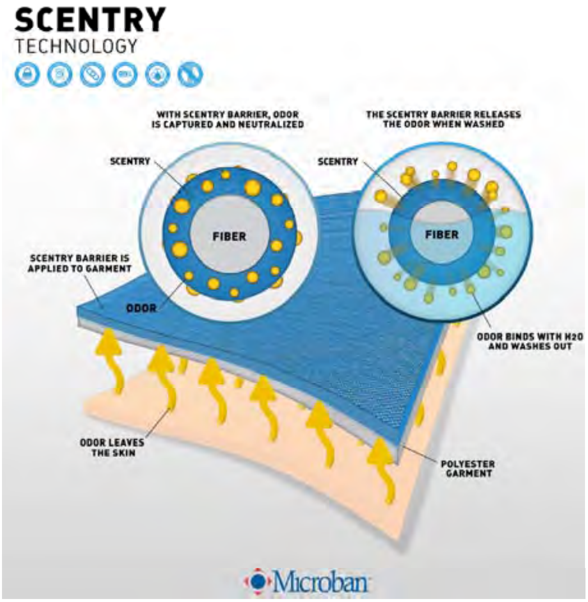
Anti-odour fabrics

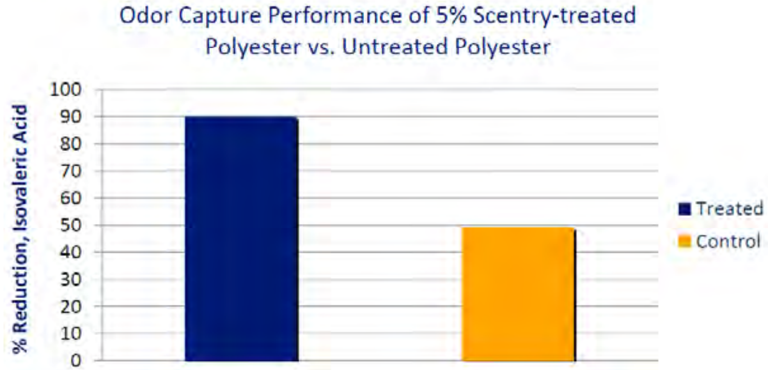
- Photocatalytic Fibers

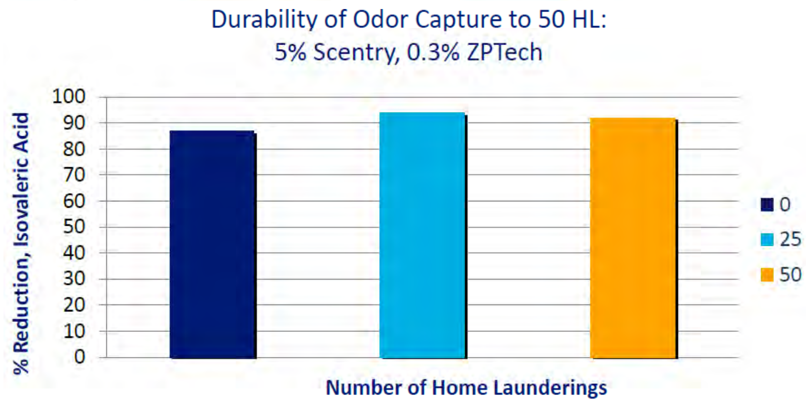


Anti-odour fabrics

- Antibacterial agent
  - ✓ Liquid-based coating, applied after dying (during finishing process)







Source : Welch, K.T.; Lan, T. & Aylward, B. Scentry (2016). Scentry® and ZPTech® : A bifunctional, Effective, and Durable Odor Solution for Polyester Activewear

RESET

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Thank you!