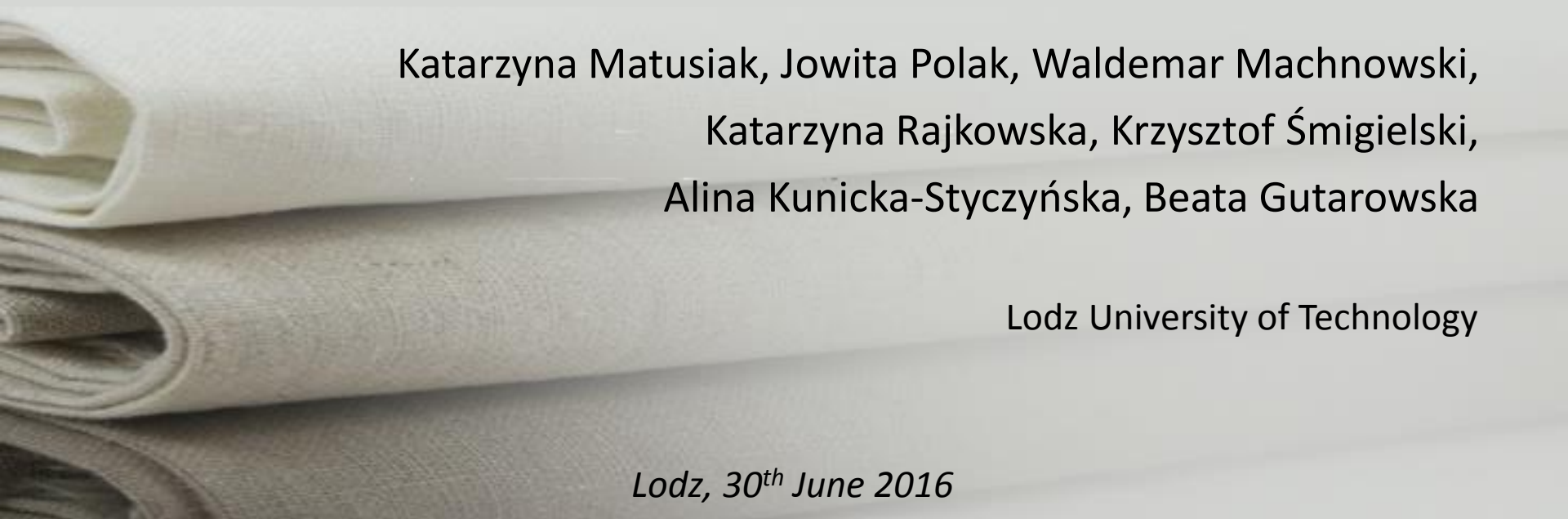




Essential oils – an alternative method of textiles disinfection



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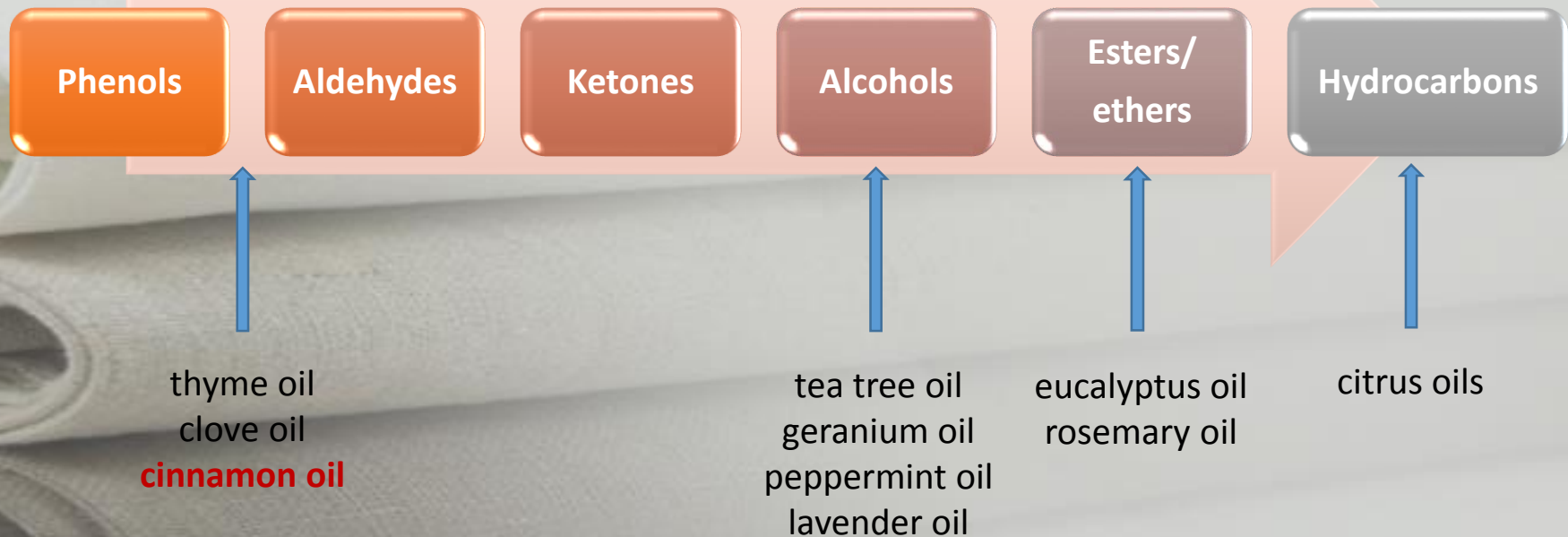
Lodz University of Technology

Lodz, 30th June 2016

Why essential oils?

- Alternative to toxic chemicals - **use of biocidal or biostatic natural substances**
- Broad-spectrum of antimicrobial activity
- Vapours of compounds penetrate into the material
- Chemical compounds of high volatility

Biocidal activity of chemical compounds in essential oils



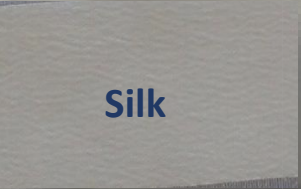


Aim and scope

Evaluation of antimicrobial properties of cinnamon oil vapours and its influence on historical textiles

- composition of the cinnamon essential oil (CEO) in the gaseous phase
- content of CEO in textiles after disinfection
- gaseous minimal inhibitory concentration (MIC) of cinnamon essential oil against the tested strains of microorganisms
- optimal parameters of textiles disinfection with essential oils
- the influence of essential oils disinfection on mechanical and optical parameters of textiles
- disinfection of historical textiles

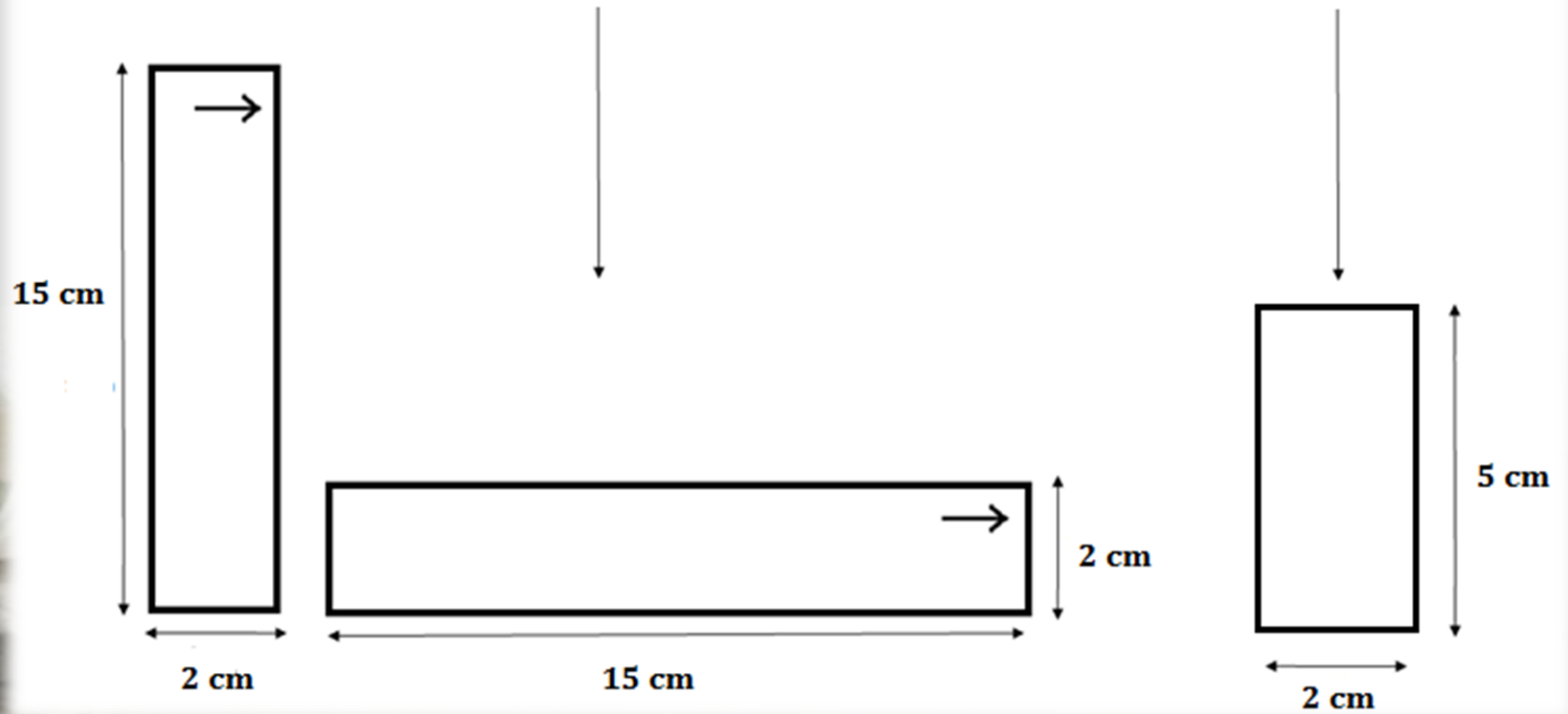
Textiles

Fiber	Mass per unit area (g/m ²)	Thickness (mm)	Porosity (%)	Finishing	Manufacturer
 Cotton	278	0.76	76	Unbleached	Andropol S.A. (Poland)
 Linen	285	0.70	73	Natural colour	Świat Lnu (Poland)
 Silk	52	0.12	67	Natural colour Degummed	Fei-Long Inc. (China)

Textiles

The influence of CEO disinfection on mechanical and optical parameters of textiles

Microbiological analysis



Historical textiles



embroidered pillowcase 1950 (cotton)



ribbon 1980 (polyester)



starched coif 1918 (silk)



trousers 1940 (cotton)

Microorganisms

	Microorganisms	Source	Textiles	Choice criteria
Bacteria	<i>Bacillus megaterium</i>	ŁOCK 105	Silk	<ul style="list-style-type: none"> the frequency of fabric contamination and the ability to degrade the natural fibers most commonly used as reference microorganisms for disinfection effectiveness studies
	<i>Pseudomonas fluorescens</i>	ŁOCK POM2123		
	<i>Streptomyces</i> sp.	ŁOCK 0894		
Mould	<i>Aspergillus niger</i>	ATCC 16404	Cotton Linen	
	<i>Penicillium funiculosum</i>	ŁOCK 0587		
	<i>Trichoderma viride</i>	ŁOCK E153		

ATCC – American Type Culture Collection; ŁOCK – Łódź Pure Culture Collection

Media:

- Mould - MEA (Merck, Germany)
- Bacteria – TSA (Merck, Germany)

Incubation conditions:

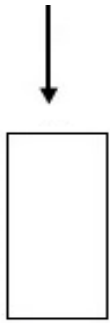
- Mould – 27 °C, 7 days
- Bacteria – 30 °C, 24 h

Methods

Test	Standard	Studied parameters	Equipment
CEO composition	SPME	Components concentration (mg/m ³)	TRACE GC Ultra (Thermo Electron Corporation, USA)
Antimicrobial effectiveness	AATCC 100:2012	Reduction (%)	Climatic chamber KBF720 (Binder GmbH, Germany)
Mechanical properties	ISO 13934–1:2002	Elongation at break (%) Breaking strength (N)	INSTRON Model 4204 (Instron, USA)
Optical parameters	ISO 105-J01:2002	CIEL*a*b*	V–670 UV–Vis–NIR Spectrophotometer (JASCO, USA)
Thermal ageing	Feller (1994)	140°C, 26h (70 years)	Thermal Ageing Oven UTS-1 (Uni-Tech sales, India)

Disinfection chamber

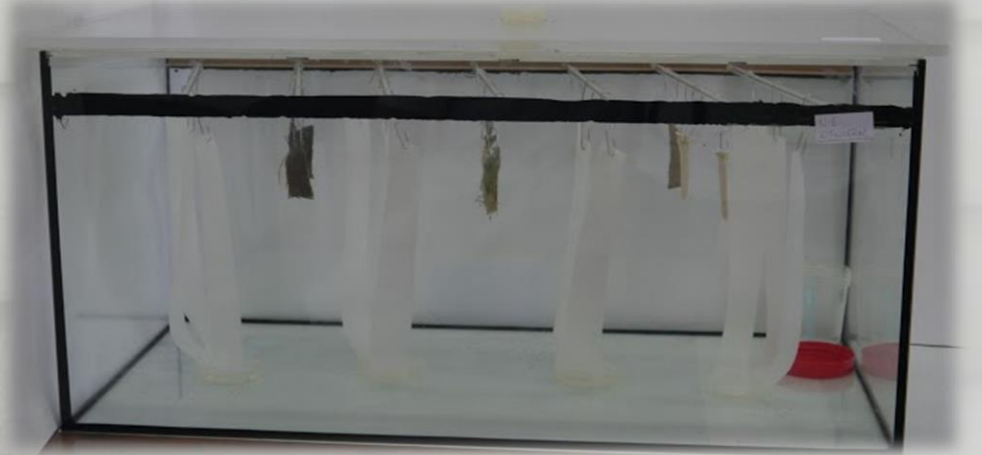
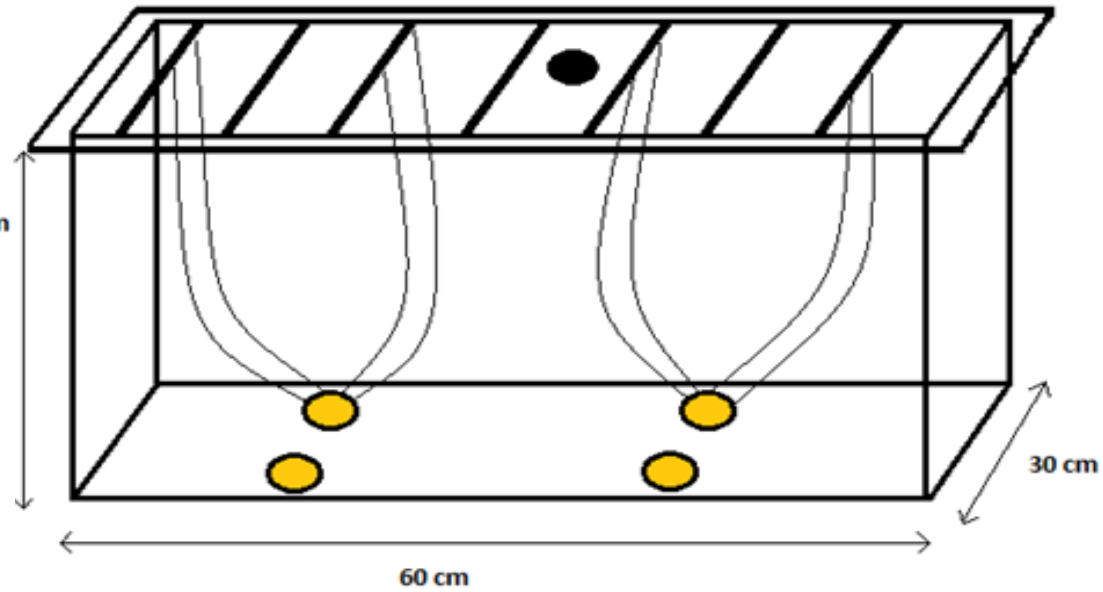
Textiles inoculation (250 μ l)



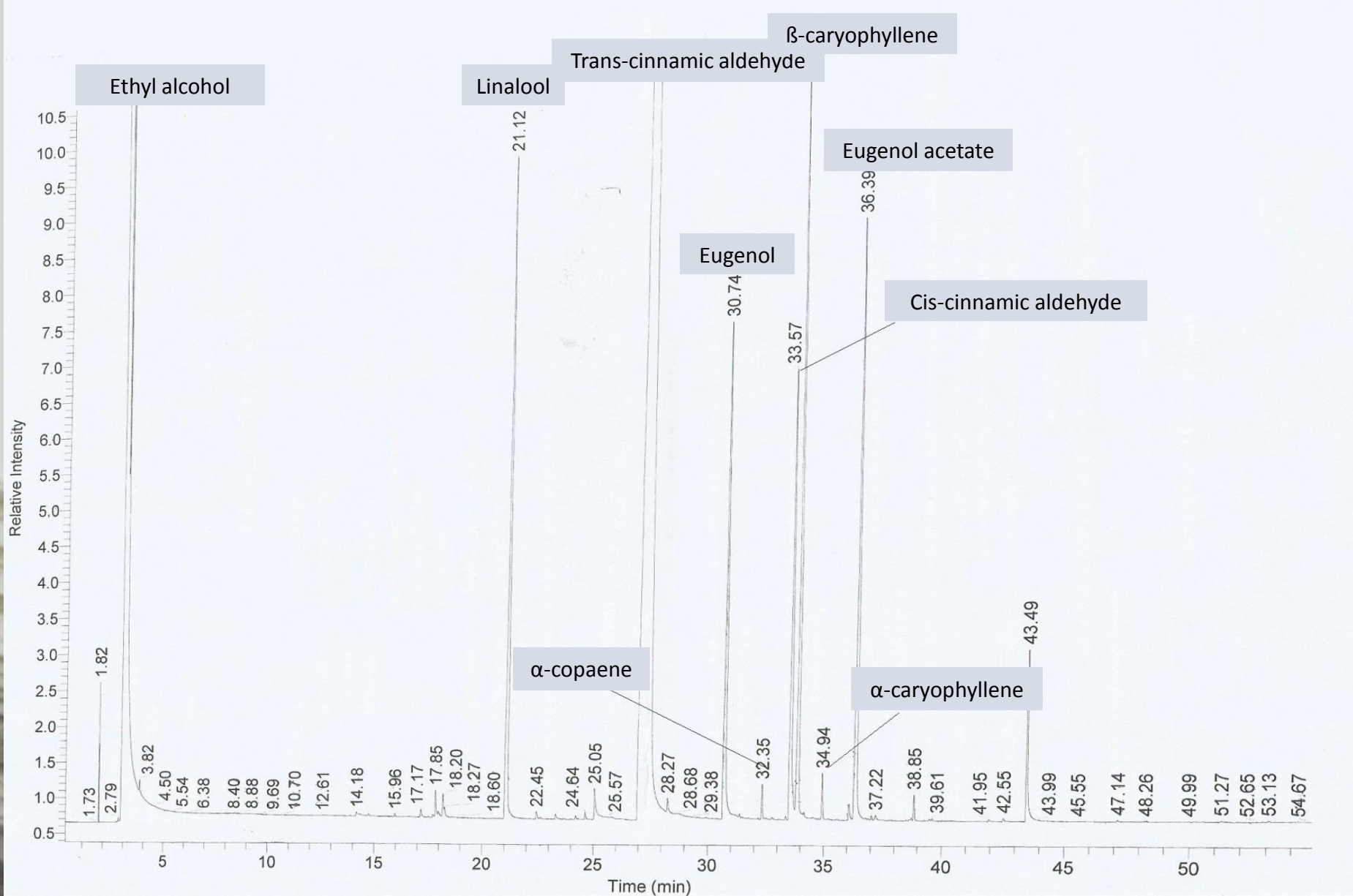
Textiles incubation
(21 days; 28°C; RH 80%)



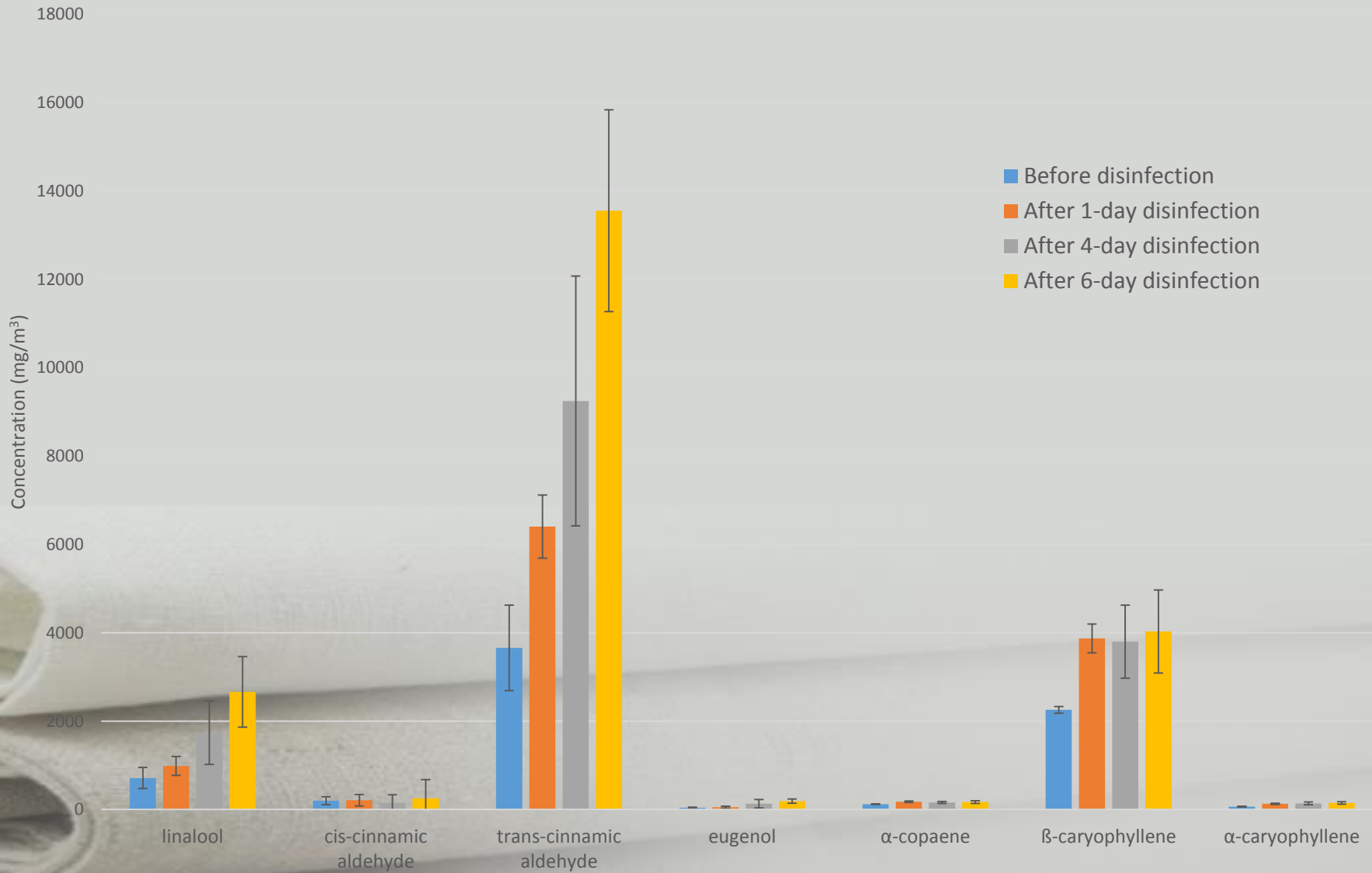
Textiles disinfection



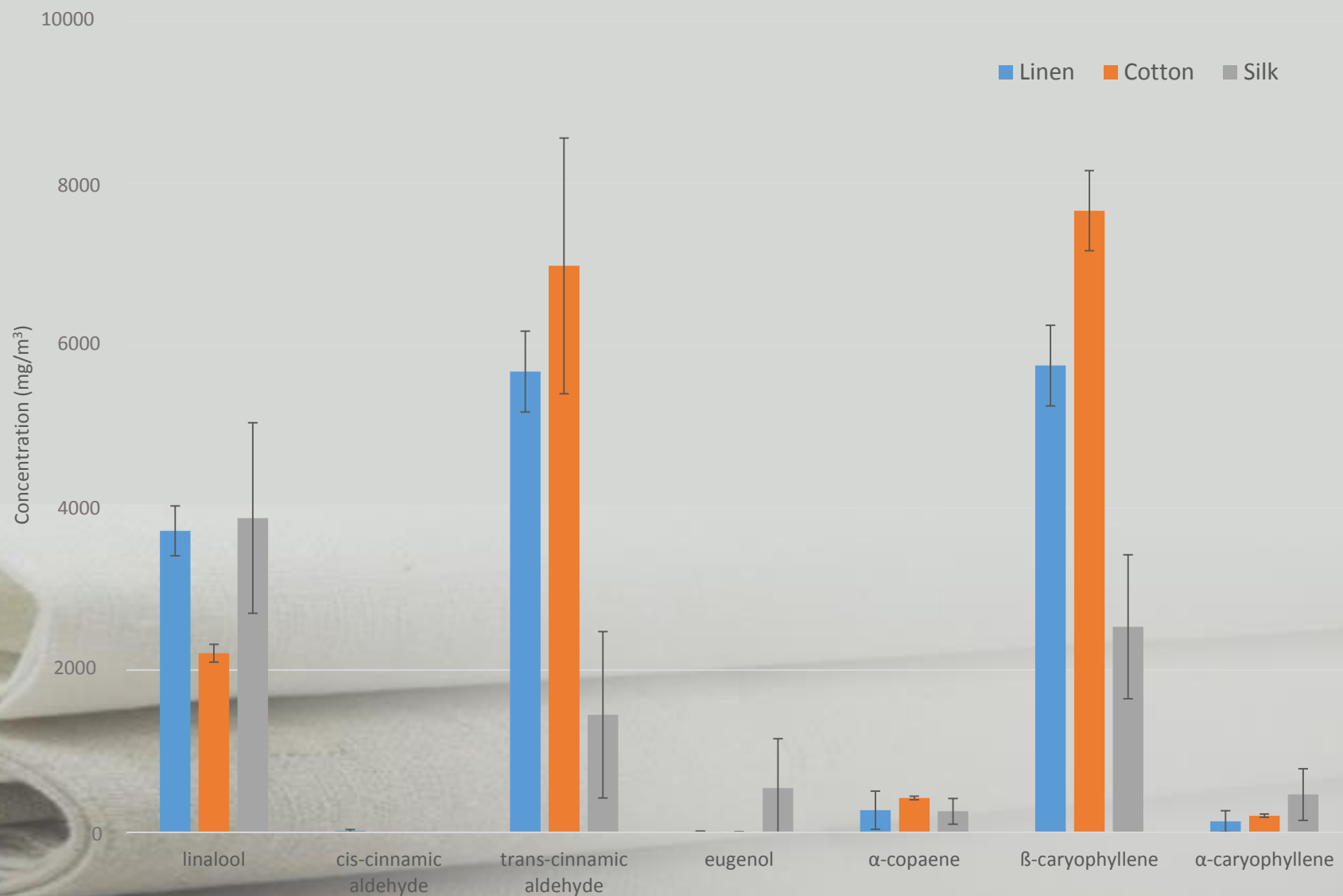
Composition of CEO in gaseous phase



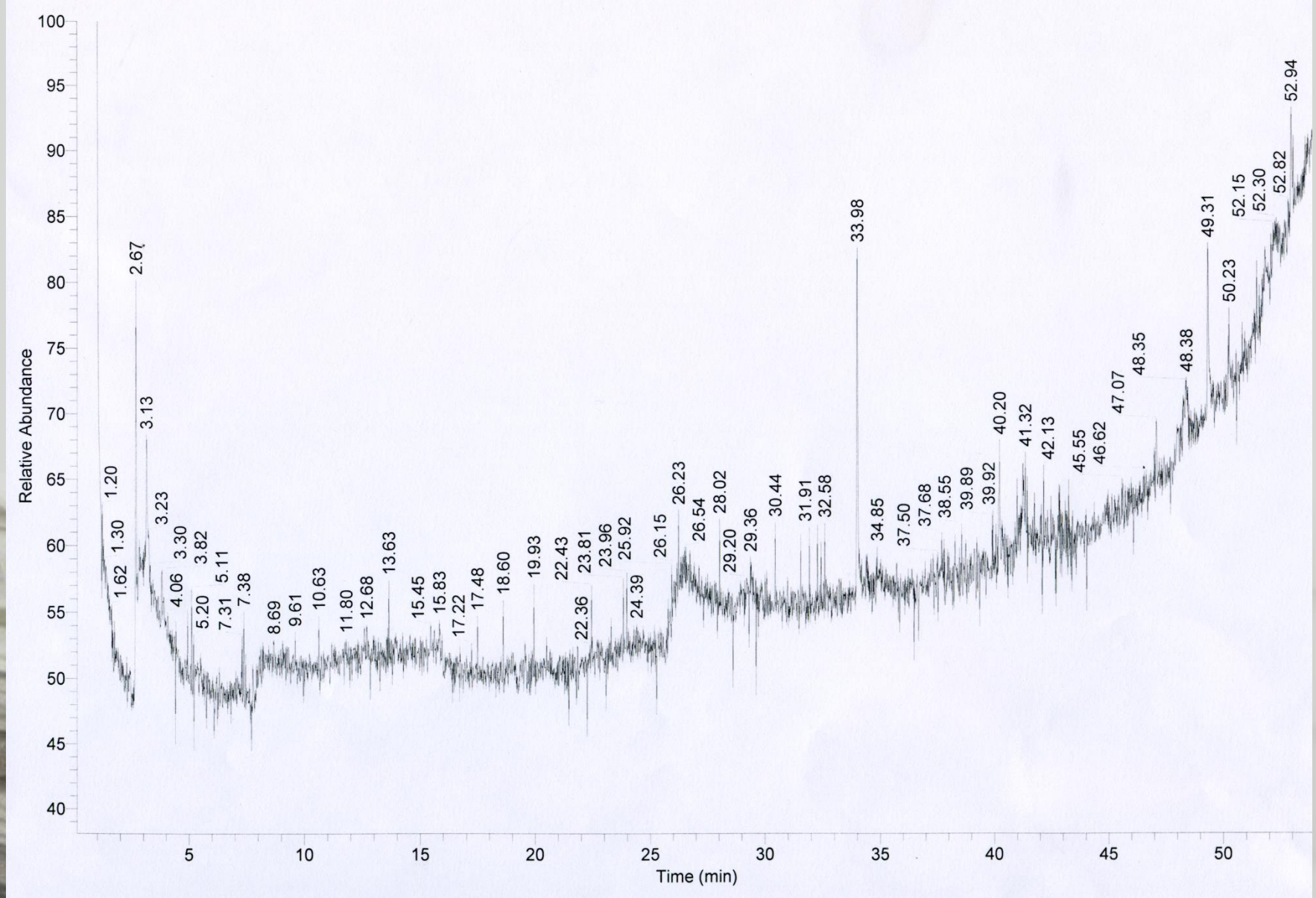
Composition of CEO in gaseous phase



Content of CEO in textiles after disinfection



Content of CEO in textiles after disinfection (4 weeks)



Gaseous MIC of cinnamon essential oil

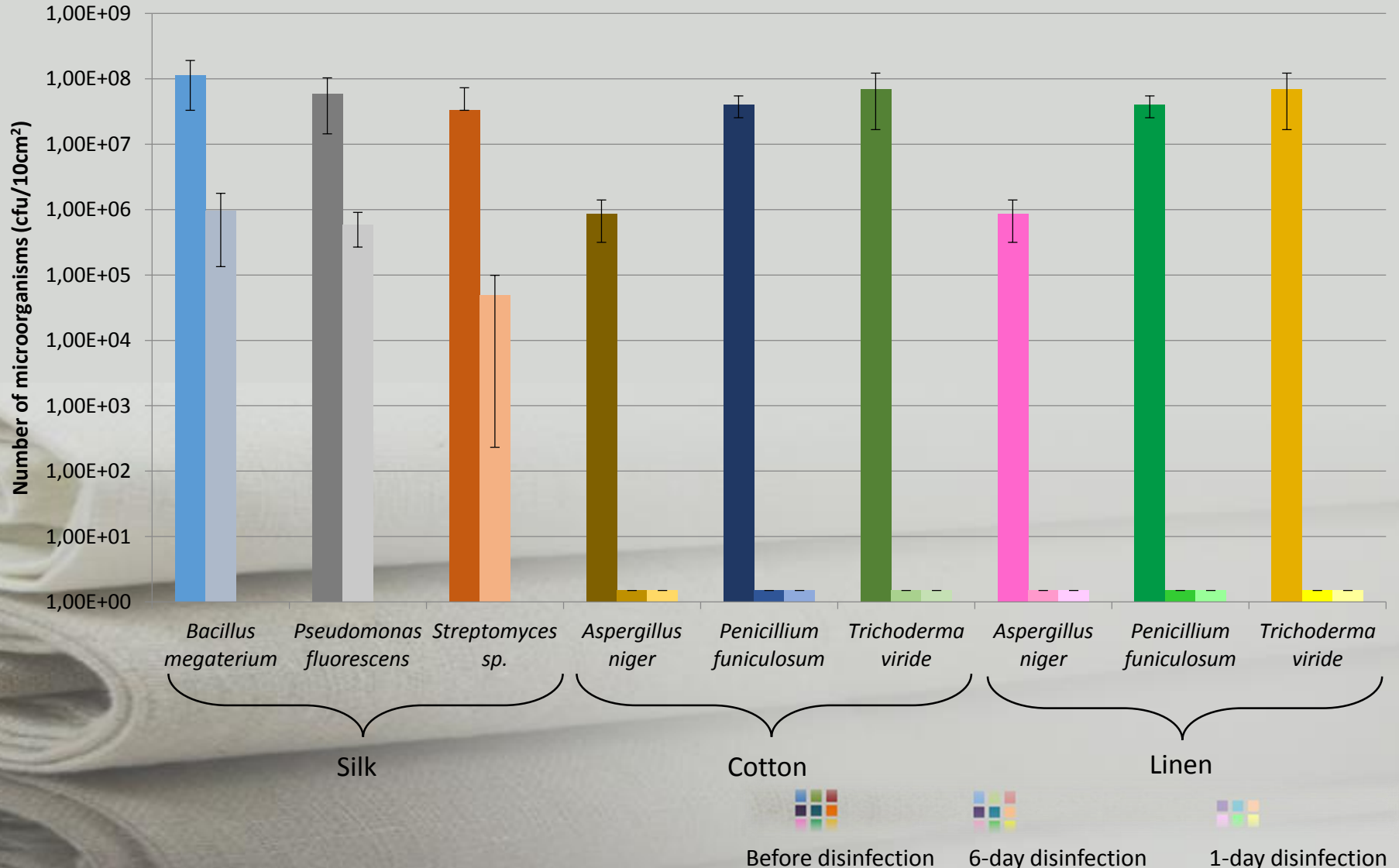
Microorganisms	CEO MIC (%)
<i>Bacillus megaterium</i>	6.25
<i>Pseudomonas fluorescens</i>	6.25
<i>Streptomyces</i> sp.	12.50
<i>Aspergillus niger</i>	3.125
<i>Penicillium funiculosum</i>	3.125
<i>Trichoderma viride</i>	6.25

MIC - minimal inhibitory concentration



Optimal parameters for CEO disinfection of textiles - time

12.5% - cinnamon essential oil concentration

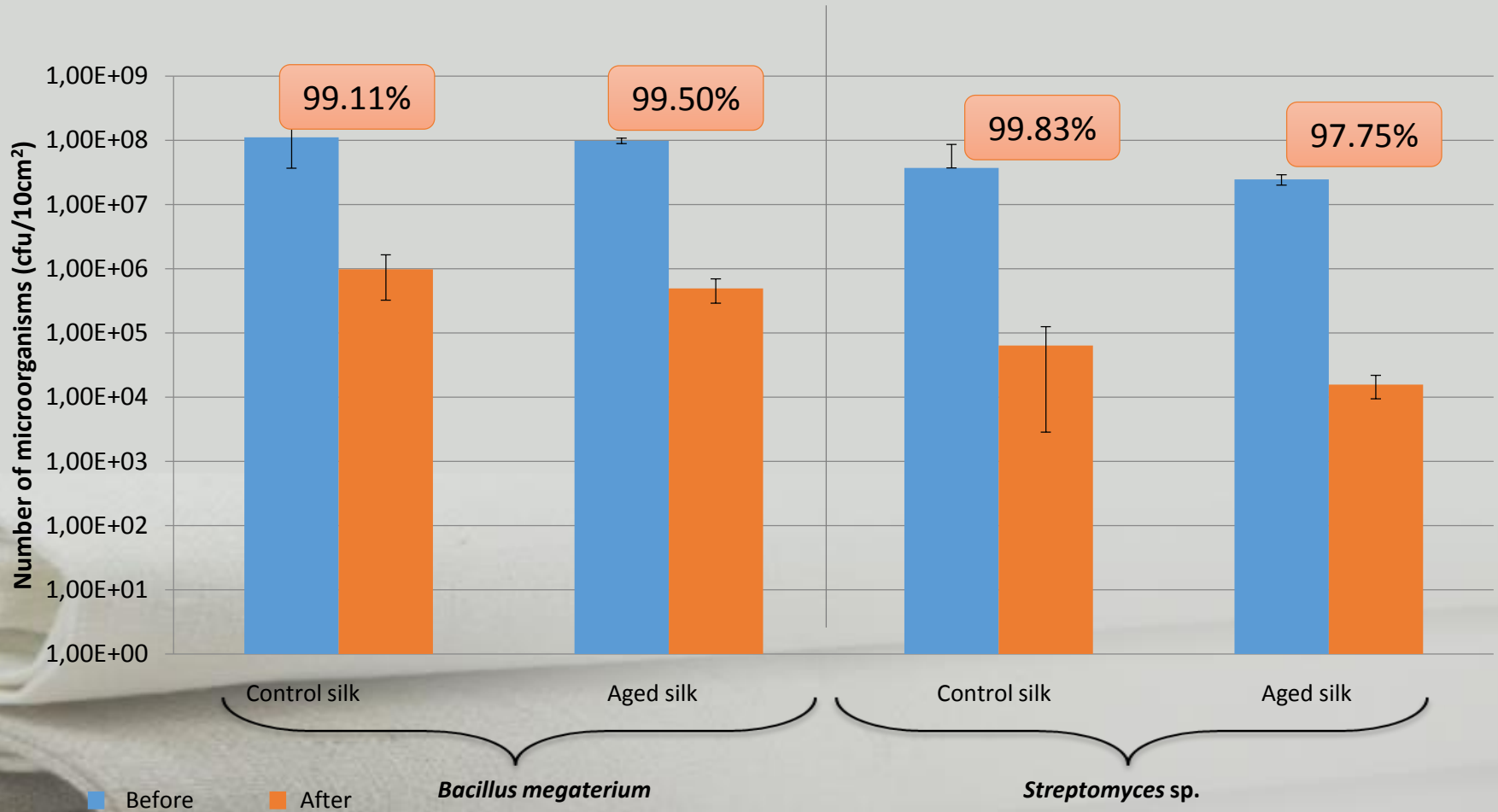


Optimal parameters of textiles disinfection – CEO concentration

Microorganisms	Textiles	Reduction (%)			
		6-day disinfection	1-day disinfection		
			Concentration of CEO		
		12.5%	12.5%	6.25%	3.125%
<i>Bacillus megaterium</i>	Silk	99.11	nt	nt	nt
<i>Pseudomonas fluorescens</i>		98.77	nt	nt	nt
<i>Streptomyces sp.</i>		99.83	nt	nt	nt
<i>Aspergillus niger</i>	Cotton	100	100	100	100
	Linen	100	100	100	100
<i>Penicillium funiculosum</i>	Cotton	100	100	100	100
	Linen	100	100	100	100
<i>Trichoderma viride</i>	Cotton	100	100	100	100
	Linen	100	100	100	100

nt- not tested

Optimal parameters for CEO disinfection – age of textile



6-day disinfection; 12.5% - cinnamon essential oil concentration; textile - silk

The influence of CEO disinfection on mechanical and optical parameters of textiles

Parameter	Cotton		Linen		Silk	
	Before	After	Before	After	Before	After
Breaking strength (N)	278.67±13.41	265.33±5.86	381.90±35.48	368.63±31.66	80.67±1.83	66.20±1.61
Elongation at break (%)	13.63±0,42	13.47±0.31	11.7±0.36	10.43±0.21	13.47±0.31	18.60±0.44
L*	75.21	76.62	53.67	51.76	98.13	96.98
a*	2.42	2.09	1.73	2.00	-0.03	-1.16
b*	9.47	10.47	9.30	10.00	2.17	4.81
Δ E	1.76		2.05		3.09	

L* - lightness (black/white); a* color in the green/red field; b* color in the blue/yellow field; ΔE - difference in color

0 < ΔE < 1 - observer does not notice the difference

1 < ΔE < 2 - only experienced observer can notice the difference

2 < ΔE < 3.5 - unexperienced observer also notices the difference

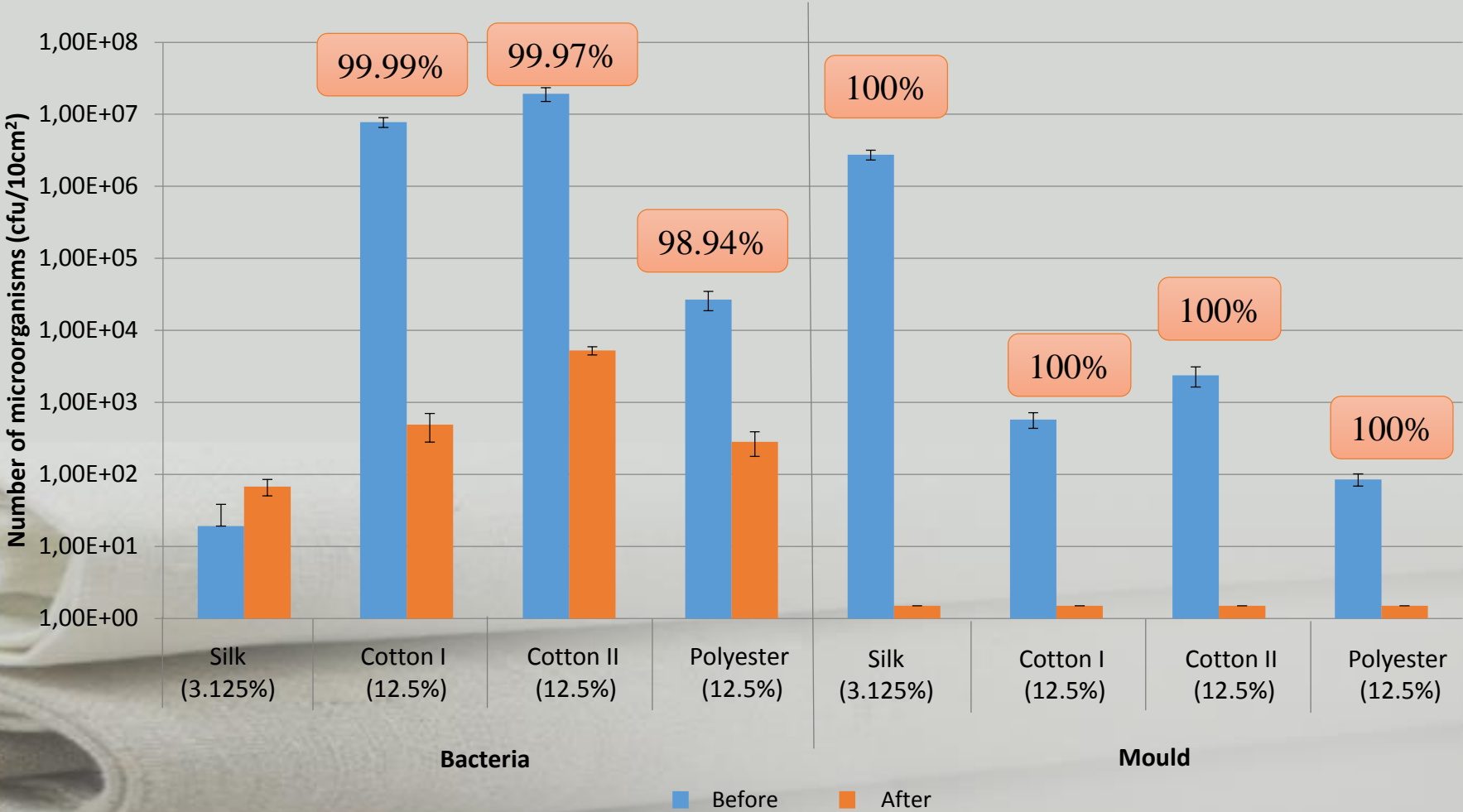
3.5 < ΔE < 5 - clear difference in color is noticed

5 < ΔE - observer notices two different colors

$$\Delta E = \sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2}$$

1-day disinfection; 12.5% - cinnamon essential oil concentration

Disinfection of historical textiles in MIC concentration



1-day disinfection; 12.5% and 3.125% - cinnamon essential oil concentration

Summary



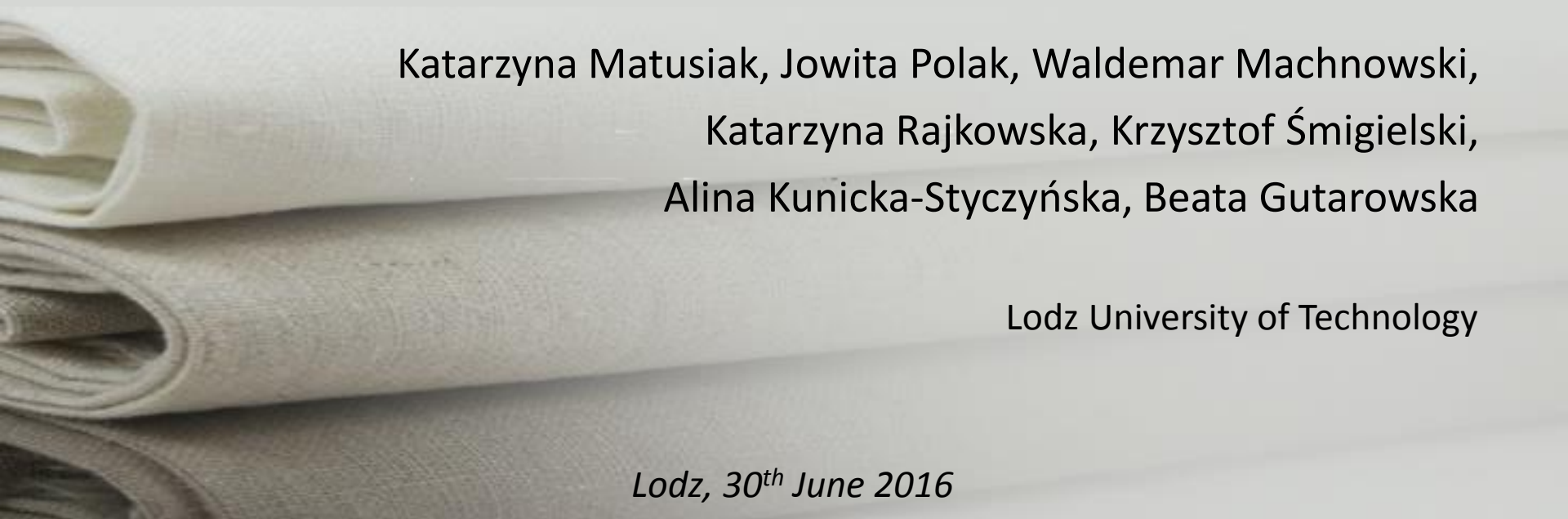
1. Optimal parameters for CEO textiles disinfection are: **1 day**, and CEO concentration depending on microflora - **3.125%** and **12.5%**
2. Cinnamon oil vapours used in the disinfection are **safe for cellulose textiles** (do not cause significant changes in optical and mechanical parameters)
3. **Microbiological analysis** of contaminated textiles should be done before CEO disinfection
4. CEO disinfection is an effective method for **historical textiles** decontamination

Cinnamon essential oil vapour is an **effective, sustainable** and **safe** method of historical textiles disinfection





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Lodz, 30th June 2016