

Functional self-clean dyeing for clothing, face –masks and bed-linen

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FreshDye

Functional dyeing of cellulosic fibres and their blends with PES
with a self-cleaning effect stable min in 50 washing cycles

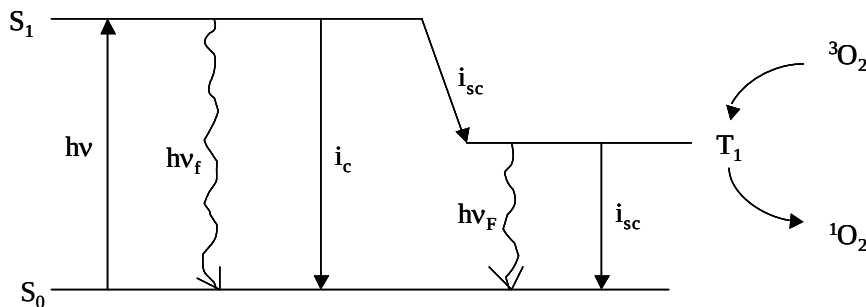
- Maedical staff clothing
- Face masks
- Bed linen
- Filters
- Interior textiles



FreshDye Self-cleaning effect based on $^1\text{O}_2$: singlet oxygen generation by a photoactive dyestuff

- Pollutants degradation
- Prevention of microorganisms survival
- Anti-odour effect

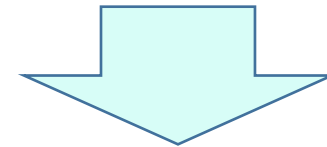
$^1\text{O}_2$ singlet oxygen produced by excited photoactivator under daylight (D65) or interior illumination
 $\lambda_{\text{max}} = 600 - 700 \text{ nm}$



Mechanisms of singlet oxygen production
Jablonski diagram

$^1\text{O}_2$ singlet oxygen:

- highly reactive, short life time (μs)
- effect limited on a fabric surface (200 nm)
- photoactive dye fixed on the fibre by a covalent bond

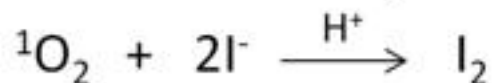


- Effect stable in repeated washings
- No leaching into the environment
- No additional AMB finishing needed

FreshDye Self-cleaning effect based on $^1\text{O}_2$: singlet oxygen generation by a photoactive dyestuff

Photoactivity of dyed textiles evaluation (COC)

Iodide method for $^1\text{O}_2$ production speed assessment



Spectrophotometric determination of I_3^- (triiodide) content growth ($\lambda = 351 \text{ nm}$)

- Textile fabric immersed in I^- solution illuminated by LED red-light corresponding with the absorption spectrum of the dyestuff
- I_3^- linear growth slope: k_{obs}



FreshDye Self-cleaning effect based on $^1\text{O}_2$: singlet oxygen generation by a photoactive dyestuff

Functional dyeing - Utility sample CZ31976 – Textile fabric dyed with the photoactive dyestuff with self-cleaning properties for medical and hygienic purposes



Result of the development of the optimized dyeing technology



laboratory → pilot plant → industrial

- Woven fabric, knits, nonwovens
- Cotton, Co/PES, VS
- Combination with reactive and vat dyeing (colour shades)



100% Cotton shirting - Colourfastness			Singlet oxygen production $k_{\text{O}_2} \cdot 10^2 \text{ [min}^{-1} \text{] / [r}^{-1} \text{]}$	Shade
water	EN ISO 105-E01	4/4/4	0,1128	
washing 60°C C15	EN ISO 105-C06	3-4/4/4-5		
persp. alkaline	EN ISO 105-F04	4/4/4		
persp. acid	EN ISO 105-E01	4/4-5/4-5		
rubbing dry	EN ISO 105-X12	4		
rubbing wet	EN ISO 105-X12	4		
light Q-SUN	EN ISO 105-B02	4K		
act. chlorine	EN ISO 105-E03	3		
			Antimicrobial effect	
			E. coli inhibition: 99,8%	

FreshDye Self-cleaning effect based on $^1\text{O}_2$: singlet oxygen generation by a photoactive dyestuff

Verified technology

Optimized dyeing technology

Short-run production

Combination with functional / top finishing



EN ISO 20743:2014: Antibacterial activity - A

	100% Cotton	50/50 Co/PES
<i>E. coli</i>	3,5	4,1
<i>Ent. faecalis</i>	4,3	2,6



Antimicrobial activity of Al/VS and Zn/VS PTC dyed cotton fabric

$$A = (\log C_t - \log C_0) - (\log T_t - \log T_0) = F - G$$

Antibacterial activity – A (log)					
Zn/VS PTC 1146/75 (3% dyeing)		Light source	Light exposition (J/cm ²)	<i>S. aureus</i>	<i>E. coli</i>
1)	Unwashed	daylight indoor conditions SPIRAX	2,1	5,1	6,5
	5 x washed at 60°C			1,9	2,9
	10x washed at 60°C			1,2	2,3
2)	Unwashed	daylight outdoor conditions NARVA	5,0	4,6	5,1
			2,1	4,7	3,8
	5 x washed at 60°C		5,0	4,7	5,0
			2,1	4,6	3,8
	10x washed at 60°C		5,0	4,6	5,0
			2,1	4,8	3,7



EN ISO 20743

$$F = C_t - C_0$$

Growth value on the control
sample (untreated)

$$G = T_t - T_0$$

Growth value
on the antibacterial sample
(PTC finished)

Antibacterial activity – A (log) SPIRAX – daylight indoor 5 J/cm ²			
Al /VS PTC 1134/231 (3% dyeing)		Maintenance type	
Washing	Unwashed	<i>S. aureus</i>	5,5
	5 x washed at 60°C	<i>E. coli</i>	4,9
	10x washed at 60°C	<i>S. aureus</i>	5,6
Washing + CHT (Persteril) (chemo-thermo-disinfection)	Unwashed	<i>E. coli</i>	4,1
	5 x washed at 60°C + CHT	<i>S. aureus</i>	3,0
	10x washed at 60°C + CHT	<i>E. coli</i>	3,5
Washing + CHT (Persteril) (chemo-thermo-disinfection)	Unwashed	<i>S. aureus</i>	5,0
	5 x washed at 60°C + CHT	<i>E. coli</i>	6,0
	10x washed at 60°C + CHT	<i>S. aureus</i>	5,0
Washing + CHT (Persteril) (chemo-thermo-disinfection)	Unwashed	<i>E. coli</i>	5,5
	5 x washed at 60°C + CHT	<i>S. aureus</i>	5,0
	10x washed at 60°C + CHT	<i>E. coli</i>	5,4

• **Reliable AMB effect**
against both **G+** and **G-**
microorganism strains.

• The AMB effect **stable**
in repeated washing
(60°C) + CHT disinfection
cycles
(health care sector).

FreshDye Self-cleaning effect based on $^1\text{O}_2$: singlet oxygen generation by a photoactive dyestuff

Výbarvení	Stálobarevnost	produkce singletního kyslíku $k_{\text{pss}} \cdot 10^{-2} [\text{min}^{-1}] / [\text{J}^{-1}]$	Odstín
0,5%	ve vodě praní 60°C C15 pot alkalický pot kyselý suchý otěr mokry otěr na světle Q-SUN	4-5/4-5/4 3-4/4/4-5 4-5/4/4-5 4-5/4-5/4-5 4-5 4-5 1-2	0,1604 Inh.E.Coli: 100%
1%	ve vodě praní 60°C C15 pot alkalický pot kyselý suchý otěr mokry otěr na světle Q-SUN	4-5/4-5/4 3-4/4/4-5 4/4/4-5 4-5/4-5/4-5 4-5 4-5 2-3	0,1620 Inh.E.Coli: 99%
2%	ve vodě praní 60°C C15 pot alkalický pot kyselý suchý otěr mokry otěr na světle Q-SUN	4-5/3-4/3-4 3-4/3-4/4-5 4-5/3-4/4 4-5/4/4-5 4-5 4-5 3K	0,1380 Inh.E.Coli: 100%
3%	ve vodě praní 60°C C15 pot alkalický pot kyselý suchý otěr mokry otěr na světle Q-SUN	4-5/3-4/3-4 3-4/3-4/4-5 4-5/3-4/4 4/4/4 4-5 4-5 3K	0,1718 Inh.E.Coli: 100%
4%	ve vodě praní 60°C C15 pot alkalický pot kyselý suchý otěr mokry otěr na světle Q-SUN	4-5/3-4/3-4 3-4/3-4/4-5 4/3-4/4 4/4/4-5 4-5 4-5 3K	0,1305 Inh.E.Coli: 100%
5%	ve vodě praní 60°C C15 pot alkalický pot kyselý suchý otěr mokry otěr na světle Q-SUN	4-5/3-4/3-4 3-4/3-4/4-5 4-5/3/4 4-5/4/4-5 4-5 4 3K	0,1322 Inh.E.Coli: 100%
6%	ve vodě praní 60°C C15 pot alkalický pot kyselý suchý otěr mokry otěr na světle Q-SUN	4-5/3-4/3-4 3-4/3-4/4-5 4-5/3-4/4 4-5/4/4 4-5 3-4 3K	0,1479 Inh.E.Coli: 100%

Lab dyeing

- Influence of the dyestuff concentration on $^1\text{O}_2$ production, AMB effect
- Combination with Re / vat dyes (example)

	Stálobarevnost	Odstín	k (min ⁻¹)
0,2% TYRKYS BLUE G + 0,5% FTC 1140/170 (dohromady)	Ve vodě 4/4-5/4-5 Praní 60°C C15 3-4/3-5/4-5 Pot alkalický 4/4-5/4-5 Pot kyselý 4/4-5/4-5 Suchý otěr 4-5 Mokry otěr 4-5 Akt. chlór 1 Na světle 3-4K		0,0670 inhibice: 98%
0,2% TYRKYS BLUE BGF + 0,5% FTC 1140/170 (dohromady)	Ve vodě 4/4-5/4-5 Praní 60°C C15 3-4/4-5/4-5 Pot alkalický 4/4-5/4-5 Pot kyselý 4/4-5/4-5 Suchý otěr 4-5 Mokry otěr 4-5 Akt. chlór 1 Na světle 3-4K		0,1062 inhibice: 100%
0,2% BRILLANT BLUE R + 0,5% FTC 1140/170 (dohromady)	Ve vodě 4/4-5/4-5 Praní 60°C C15 3-4/3-5/4-5 Pot alkalický 3-4/4-5/4-5 Pot kyselý 4/4-5/4-5 Suchý otěr 4-5 Mokry otěr 4-5 Akt. chlór 1 Na světle 3-4Č		0,1149 inhibice: 96%

Repeated washing (min 50x60°C) + chemothermo-disinfection

COTTON

Colour strength, $^1\text{O}_2$ production, AMB (E-coli)

Co/PES

Barvení 100% bavlněné textilie kombinací kypového barvení a barvení reaktivním ftalocyaninem FTC 1140/170				
Počet cyklů praní 60°C + CHT	Odstín relat. síla /%/	produkce singlet. kyslíku k_{pov} $10^{-3} [\text{min}^{-1}] / [\text{J}^{-1}]$	inhibice E. coli /%/	Odstín
0	100	10,77	100	
1	86,07	8,78	100	
5	75,67	8,09	97	
10	67,0	7,48	98	
25	64,45	7,21	97	
50	63,83	7,81	95	

Barvení 50/50 ba/PES textilie kombinací kypového barvení a barvení reaktivním ftalocyaninem FTC 1140/170				
Počet cyklů praní 60°C + CHT	Odstín relat. síla /%/	produkce singlet. kyslíku k_{pov} $10^{-3} [\text{min}^{-1}] / [\text{J}^{-1}]$	inhibice E. coli /%/	Odstín
0	100	8,54	100	
1	87,73	6,99	100	
5	81,60	5,33	99	
10	75,75	6,27	98	
25	73,07	6,06	97	
50	66,98	5,49	98	

FreshDye Self-cleaning effect based on $^1\text{O}_2$: singlet oxygen generation by a photoactive dyestuff

Physiological properties, moisture management of dyed fabrics

	100% Cotton	50/50 Co/PES
Absorptivity ČSN 80 0831 /%/	92,4	106
Air permeability ČSN EN ISO 9237 /mm/s/	915	539
Breathability ČSN EN ISO 15496 /g/m ² .Pa.h/	0,861	0,627
Liquid transport AATCC TM 195 SDL ATLAS		

FreshDye – combination with functional finishings

+ F-free DWR/anti-soil

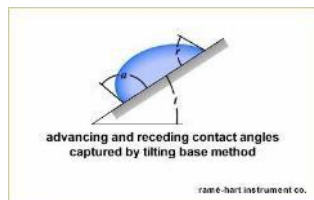
ECO – DWOR

ARKICL-1 – encapsulated paraffin



Double barrier effect:

- AMB effect
EN ISO 20 743 / JIS Z 2801: *Ent. Faecalis*
- +
- DWR/anti-soil:
EN ISO 4920: spraytest 4



Roll-test 9-11
VÚCHV Žilina

Reduction of colonies:

99,61% (illuminated)

97,58% (at dark)



Textilní zkušební ústav, s.p.

AZL 20/ 0288
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100 % cotton FTC 3% 5x40 <i>Enterococcus faecalis</i> CCM 4224			
sample identification	time 0 h (CFU)	time 18 h (CFU)	Antibacterial activity value A
reference sample (illuminated)	1.97×10^5	1.19×10^6	-
reference sample (lightless)	1.97×10^5	3.22×10^6	-
antibacterial treated sample (illuminated)	-	< 10	> 5.12
antibacterial treated sample (lightless)	-	3.22×10^5	1.00

100% cotton FTC 3% ARK/ICL-1 <i>Enterococcus faecalis</i> CCM 4224			
sample identification	time 0 h (CFU)	time 18 h (CFU)	Antibacterial activity value A
reference sample (illuminated)	1.97×10^5	1.19×10^6	-
reference sample (lightless)	1.97×10^5	3.22×10^6	-
antibacterial treated sample (illuminated)	-	< 10	> 5.12
antibacterial treated sample (lightless)	-	5.24×10^4	1.79

Washable / reusable self-cleaning face masks



INOTEX spol. s r. o.

FreshDye – FUNCTIONAL DYEING OF COTTON AND Co/PES FOR REUSABLE **FACE MASKS, CLOTHING, BEDLINEN, FILTERS** WITH **WASHSTABLE SELF-CLEANING EFFECT**

Special reusable face-masks form cotton or Co/PES with self-cleaning effect based on photoactive dyeing with singlet oxygen generation under illumination with daylight or common artificial light. Short living oxygen form decomposes pollutants and microorganisms.

Testing of the material safety have been performed in the National Institute of Public Health (Prague) and Textile testing Institute (Brno) according to EN ISO 20 743 and JIS Z 2801. The self-cleaning effect is stable mini. in 50 washings at 60°C.

Suitable for health care sector: face masks, (medical stall clothing, bed linen, face masks, filters as a nosocomial infections prevention.

FreshDye technology of functional dyeing transferred into industrial production.



Summary

FreshDye – technology of functional dyeing with longterm wash-stable self-cleaning effect (min 50 cycles 60°C + chemothermo-disinfection)

Materials: Cotton, Co/PES, VS – woven fabrics, knits, NWs

- face masks
- protective clothing
- bedlinen and interior textiles
- filters



- Degradation of pollutants under daylight or artificial light illumination
- Compatible with functional finishing (flameproof, hydrophobic, easy-care)
- No additional AMB finishing needed, AMB effect acc EN ISO 20743 / JIS Z 2801
- Assessed acc ISO 10993-10:2010 Biological evaluation of medical devices — Part 10: Tests for irritation and skin sensitization
- At present under testing acc BS ISO 18184:2019: Textiles – Determination of antiviral activity of textile products (SZÚ OVA)

Industrial dyeing – INOTEX spol s.r.o.

inoTEX®

Thanks for your attention

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