

Functional Dyeing of Cotton and Co/PES blends for health-care sector

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An innovative photoactive phthalocyanine based antimicrobial system used for textile barrier finishing was studied and optimized as a new tool for photo-initiated antimicrobial functionality of textiles. Photoactivity of Zn, Al-PTCs is based on production of singlet oxygen 1O_2 when exposed to light. This highly reactive form of oxygen is able to kill majority of microorganisms and to destroy some pollutants. The lifetime of the singlet oxygen is only several microseconds and therefore its effect is limited to max 200 nm distance from the dyed fabric surface.

- Durable freshness
- Anti-odour
- Comfort

Singlet oxygen production



No additional antimicrobial finishing needed

- ✓ Clothing for health care staff
- ✓ Bed linen
- ✓ Face masks



Reactive or vat/reactive dyeing of different shades



The synthesis and of the best photoactive phthalocyanine dye has been optimized in pilot-plant scale. Its application for dyeing of mercerized cotton 120 g/m² and 50/50 cotton/PES blend 140 g/m² (plain weave shirting and bedlinen textiles) was verified in lab and pilot-plant scale. For improvement of colour-fastnesses and different colour-shades at reduced costs, combination of the photoactive phthalocyanine dyeing with vat dyeing (two-steps dyeing) or with reactive dyeing (one-bath) has been optimized in industrial scale (jigger dyeing).

- Effect stable in repeated washing (60°C + chemo-thermodisinfection)

- Compatible with washpermanent FR, DWOR and 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

100% Cotton shirting - Colourfastness			Singlet oxygen production $k_{\text{rel}} \cdot 10^{-2} [\text{min}^{-1} / \text{J}^{-1}]$	Shade
water	EN ISO 105-E01	4/4/4	0,1128	Antimicrobial effect
washing 60°C C15	EN ISO 105-C06	3-4/4/4-5		
persp. alkaline	EN ISO 105-E04	4/4/4		
persp. acid	EN ISO 105-E04	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	E. coli inhibition: 99,8%	
act. chlorine	EN ISO 105-E03	3		

Testing of photoactivity (velocity of the singlet oxygen production) of the finished textiles was conducted by means of an iodide method. Antimicrobial activity of the finished textiles was evaluated according to the modified standard EN ISO 20743 (proper illumination needed) after dyeing and repeated maintenance cycles prescribed for health care sector: washing at 60 °C + chemo-thermo-disinfection. The antimicrobial activity of the dyed fabric is stable min in 50 maintenance cycles. According to EN ISO 10933-10 the dyed textiles have no skin sensitizing or irritation potential. Good mechanical-physical and physiological parameters (moisture management).

Combination of PTC with vat dyeing: influence on shade, colourfastnesses and AMB effect

100% Cotton	vat dyeing	combination of vat + PTC dyeing
		PTC 0.5% (phthalocyanine only)
		washing 60°C: 4/4-5/4-5 hypochlorite: 1-2 lightfastness: 2 E. coli inhibition: 99%
	vat 0.225%	vat 0.225% + PTC 0.5%
	washing 60°C: 4-5/4-5/4-5 hypochlorite: 4-5 lightfastness: 6	washing 60°C: 4/4-5/4-5 hypochlorite: 3-4 lightfastness: 3-4 E. coli inhibition: 100%
	vat 0.440%	vat 0.440% + PTC 0.5%
	washing 60°C: 4-5/4-5/4-5 hypochlorite: 4-5 lightfastness: 6-7	washing 60°C: 4/4-5/4-5 hypochlorite: 3-4 lightfastness: 5 E. coli inhibition: 99,9%
	vat 0.660%	vat 0.660% + PTC 0.5%
	washing 60°C: 4-5/4-5/4-5 hypochlorite: 4-5 lightfastness: 6-7	washing 60°C: 4-5/4-5/4-5 hypochlorite: 3-4 lightfastness: 5-6 E. coli inhibition: 85%
	vat 0.880%	vat 0.880% + PTC 0.5%
	washing 60°C: 4-5/4-5/4-5 hypochlorite: 4-5 lightfastness: 6-7	washing 60°C: 4/4-5/4-5 hypochlorite: 4 lightfastness: 5-6 E. coli inhibition: 96%

One-bath combination of Re-PTC with commercial reactive dye (Sumifix Turquoise Blue G)

100% Cotton	PTC 0.5% (phthalocyanine only)
	Colourfastness
	washing 60°C: 3-4/4-5/4-5 hypochlorite: 2-3 lightfastness: 2-3 E. coli inhibition: 99%
	PTC 0.5% + STB G 0.1%
	Colourfastness
	washing 60°C: 4/4-5/4-5 hypochlorite: 1-2 lightfastness: 2-3 E. coli inhibition: 99%
	PTC 0.5% + STB G 0.2%
	Colourfastness
	washing 60°C: 4/4-5/4-5 hypochlorite: 1-2 lightfastness: 3 E. coli inhibition: 92%
	PTC 0.5% + STB G 0.3%
	Colourfastness
	washing 60°C: 4/4-5/4-5 hypochlorite: 2 lightfastness: 3-4 E. coli inhibition: 92%

Combination of vat and Re-PTC dyeing – influence of maintenance cycles on shade, singlet oxygen production and antimicrobial properties

No. of cycles	Relat. depth of shade (%)	Singlet oxygen production $k_{\text{rel}} \cdot 10^{-2} [\text{min}^{-1} / \text{J}^{-1}]$	E. coli inhibition (%)	Dyeing shade
0	100	10,77	100	
1	86,07	8,78	100	
5	75,67	8,09	97	
10	67,00	7,48	98	
25	64,45	7,21	97	
50	63,83	7,81	95	

Dependence of photocatalytic properties in dependence on Re-PTC concentration (100% cotton)

Singlet oxygen production $k_{\text{rel}} \cdot 10^{-2} [\text{min}^{-1} / \text{J}^{-1}]$	PTC concentration [% a.m.]	Colour shade
0,1804	0,5%	
E. coli inh: 100%		
0,1820	1%	
E. coli inh: 100%		
0,1380	2%	
E. coli inh: 99%		
0,1718	3%	
E. coli inh: 100%		
0,1305	4%	
E. coli inh: 100%		
0,1322	5%	
E. coli inh: 100%		
0,1479	6%	
E. coli inh: 100%		

Colourfastness testing: washing 60°C: EN ISO 105-C06 (C15); hypochlorite: ISO 105-E01; lightfastness: Q-SUN

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