ALTERBIO - ENVIRONMENT FRIENDLY FUNCTIONAL BARRIER TEXTILES BASED ON PHOTOACTIVE PHTHALOCYANINE DYEINGS

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Abstract/Extended abstract

Innovative photoactive phthalocyanines (PTCs) based antimicrobial system used for textile barrier finishing was studied and optimized as a new tool of photo-initiated antimicrobial functionality of textiles. Photoactivity of PTC compounds containing certain metals as a central atom 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 the field of its effect is 20 nm from a surface modified by chosen PTC derivatives. These unique properties of photoactive PTCs systems were used for preparation of antimicrobial/self-cleaning textile materials with long-lasting wash-permanent barrier effect as an effective, safe and less environmentally risky alternative of conventional antimicrobial systems [1,2].

A range of photosensitive PTCs containing Zn or Al with a structure suitable for wash-permanent functional textile finishing was synthesized in Centre for Organic Chemistry (COC). PTCs with reactive groups creating a covalent bond with cellulosic fibres as reactive dyes and PTC dispersions with a long hydrophobic chain applicable on polyester fibres as direct dyes were prepared and evaluated.

Application of the newly synthesized PTCs derivatives on textile materials was studied and evaluated in INOTEX. The 3 - 6% dyeings of cotton and polyester textiles were conducted using conventional exhaustion processes: reactive dyeing of cotton at 60° C, HT dyeing of polyester at 130° C, L. R.: 1:12, Labomat. The dyeing step was followed by a proper after-treatment for unfixed parts removal. Resulting dyeings were evaluated in terms of the dyeing shade and colour-fastness in washing, perspiration, light and rubbing (dry and wet) according to relevant standards.

Testing of the photoactivity of the finished textiles is based on evaluation of their capability to produce singlet oxygen. These testing were performed in COC using an iodide method determining a rate of triodide production at the presence of singlet oxygen (Eq.1). The triodide content growth can be observed spectrophotometrically (absorption at λ=351 nm). The photocatalytic effect of the fabrics was initiated by a LED light source emitting a red radiation suitable for excitation of PTCs under defined conditions (Fig.1).

$$^1O_2 + 2I^- \xrightarrow{H^+} I_2$$

$$I_2 + I^- \longrightarrow I_3^-$$

Equation 1

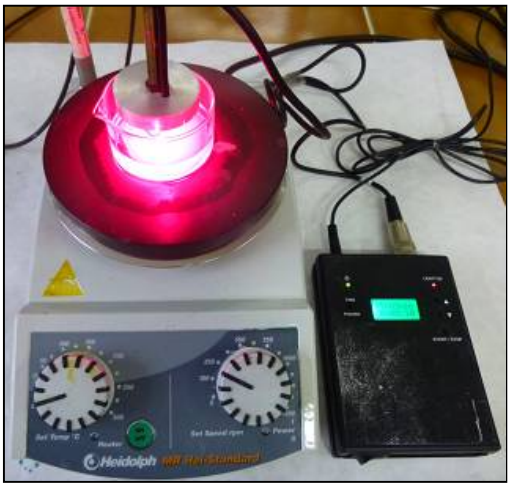

Figure 1: Testing of photocatalytic effect of fabrics

These tests were used for testing and comparison of photoactivity of textiles finished by different types of PTCs after the finishing/dyeing process and also after the repeated washing cycles (5x, 10x washing at 60° C). According to the results, the best PTCs providing textiles with the highest $^1O_2$ production capability and with a proved stability of the effect in repeated washing were selected.

Textiles finished with the PTC derivatives (1146/75, 1134/231) with the best colour properties (shade, colour-fastnesses) and the highest and wash-stable photoactivity proceeded to microbiological testing in the National Institute of Public Health, Prague. The antimicrobial effect and its permanency in repeated washing cycles (5x, 10x 60° C) were evaluated according to the modified quantitative standard EN ISO 20743 (Bacteria strains used: G-negative *Escherichia coli* CCM 4517, G-positive *Staphylococcus aureus* CCM 4516). For these microbiological tests two different artificial light-sources necessary for the photoactive effect initiation were selected: a lamp with a wavelength simulating light conditions in building interiors with a limited daylight access, and a lamp-tube simulating outdoor daylight environment. UV parts of spectra were eliminated in both lamps. The experiments were conducted under intensity of light radiation 2,1 and 5 J x cm^{-2}. The tests according to the standard EN ISO 20743 were performed using the Absorption method (an evaluation method in which the test bacterial suspension is inoculated directly onto samples) in Petri dishes (contact time 18 – 24 h, temperature 37° C). Antibacterial activity (A) was calculated according to Eq. 2:

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

Equation 2

where $F = C_t - C_0$ = Growth value on the control sample (untreated)
$G = T_t - T_0$ = Growth value on the antibacterial sample (PTC finished)

Results of antibacterial activity of cotton dyed with PTC 1146/75 (3% dyeing) after finishing and repeated washing are summarized in Tab.1:

Table 1: Antibacterial activity of PTC dyed cotton fabric after finishing and repeated washing

Antibacterial activity – A (log)					
	Cotton fabric dyed with PTC 1146/75 (3% dyeing)	**Light source**	**Light exposition /J x cm^{-2}/**	***S. aureus***	***E. coli***
1)	Unwashed	daylight indoor conditions	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	5,0	4,6	5,1
			2,1	4,7	3,8
	5 x washed at 60°C		5,0	4,7	5,0
			2,0	4,6	3,8
	10x washed at 60°C		5,0	4,6	5,0
			2,1	4,8	3,7

Summary:
From the results of antibacterial activity it can be concluded that cotton fabric dyed with a photosensitive PTC derivative has a high antimicrobial effect against both G+ and G- bacteria strains. This effect is stable in repeated washings at 60° C. Moreover the stability of the effect in repeated washing followed by a chemo-thermo-disinfection used in health care sector has been proved This type of barrier finishing/dyeing represents an effective non-toxic and eco-friendly alternative of antimicrobial finishing systems and is suitable for apparel textiles and bed-linens.

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References:

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