A multifunctional cotton fabric using TiO_2 and PCMs: introducing thermal comfort and self-cleaning properties

F A P Scacchetti[1,2], E Pinto[3,4] and G Soares[1]
[1]University of Minho, Centre for Textile Science and Technology, Guimarães, Portugal
[2]Federal University of Technology – Paraná, Textile Engineering Department, Apucarana, Brazil
[3]Laboratory of Microbiology, Biological Sciences Department, Faculty of Pharmacy of University of Porto, Porto, Portugal
[4]Interdisciplinary Centre of Marine and Environmental Research (CIIMAR/CIMAR), University of Porto, Matosinhos, Portugal
E-mail: fabioscacchetti@utfpr.edu.br

The development of materials with multiple functionalities is a market imperative that places new challenges on textile processing. Whatever the application, the goal is always to achieve the best performance with the simplest and most economically attractive process, without forgetting the sustainability issues. The purpose of this study is to establish the conditions to obtain by a simple method a cotton material with comfort, self-cleaning properties and antimicrobial activity. For that, microcapsules of phase change materials (PCMs) and TiO_2 nanoparticles (NP) were applied conjugated and resulting fabrics were characterized by infrared spectroscopy (FTIR), differential scanning calorimetry (DSC), contact angle and scanning electron microscopy with X-ray microanalysis (SEM/EDS). The self-cleaning properties of treated fabrics were also analyzed based on the photocatalytic ability of coated fabrics capability to decomposition of methyl orange (MO) under solar simulator irradiation [1] [1]and assessment of degradation of coffee, red wine and curry stains [2]. The comfort properties were assessed according DSC and Alambeta analysis. Moreover, incorporating TiO_2 NP in the finishing formulation also was assessment the bacterial inhibition on the treated fabrics.
Keywords: cotton, self-cleaning, PCMs, antibacterial

Materials and Methods

The samples used were bleached taffeta plain-weave fabrics 100% cotton, 585 g/m2, supplied from Têxtil Belém (Brasil). The TiO_2 NP (Aeroxide, P25) were purchased from Quimidroga (Spain), melamine-formaldehyde (MF) microcapsules of PCMs were supplied by Micrópolis Devan (Portugal). All other reagents were purchased from Sigma-Aldrich (Portugal).
The TiO_2 NP (6%) and PCMs (300 g/L) were applied by conventional pad-dry-cure process, alone or combined in same bath. The samples were dried at 100ºC during 2 minutes and cured at 140ºC during 2 minutes. Finally, they were rinsed thoroughly with tap water and air dried. The samples were characterized and evaluated according to the techniques described previously**.**

Some Results

The materials were characterized by ATR-FTIR. All the bands corresponding to the elongation and vibration of OH, C-H, carbonyl group, N-H, C-N and symmetrical deformation vibrations of CH_3 in

the Si-CH_3 groups were identified. The results are in agreement with those described by Wu et al. with respect to the characterization of materials functionalized with TiO_2 [1].
The DSC thermograms and Alambeta results concerning the thermal storage energy, melting crystallization transition points and thermal conductivity revealed that the finished materials with combination of TiO_2 and PCMs had thermoregulation properties.
The efficiency of self-cleaning finish process, using a single-step or two-steps approach, was analyzed by comparing the photocatalytic capacity of the fabrics produced to decompose MO. The obtained results can be observed in Figure 1.

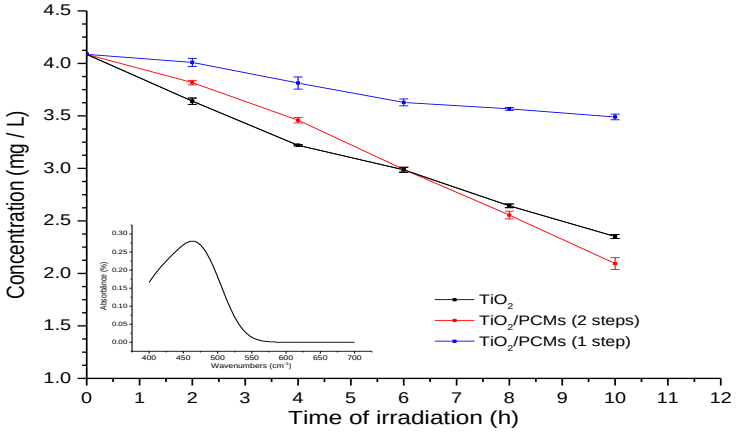

Figure 1. Photocatalytic activity of TiO_2/PCM-coated cotton.

The results showed that the material functionalized with PCMs and TiO_2 by 2 steps process had similar behavior to the material with TiO_2 applied alone in terms of MO degradation. In the self-cleaning tests these samples also presented similar results.
The antibacterial properties of treated materials were evaluated against *S. aureus* and *E. coli*. The samples containing TiO_2, combined or not with PCMs, under UV irradiation showed a slight delay in the microorganisms' growth, on assay conditions. The effect seems to be improved by the PCMs presence.

Conclusions

In this study, the functional properties of cotton fabric were improved using the combination of TiO_2 NP and PCM. Thermal regulation properties are enhanced by the presence of PCM. On the other hand, the incorporation of TiO_2 particles into the cotton fabric promoted self-cleaning and antibacterial characteristics, but the presence of PCM combined with TiO_2 increases the bioactivity of materials.

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The corresponding author data must be written at the end of the abstract

Corresponding author:
Fabio A P SCACCHETTI
University/Company, Faculty, Department/Laboratory
Federal University of Technology – Paraná, Textile Engineering Department, Apucarana, Brazil
E-mail: fabioscacchetti@utfpr.edu.br

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