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MULTIFUNCTIONAL NANOCOATING ON SYNTHETIC FIBRES DEPOSITED BY PULSED MAGNETRON SPUTTERING

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ABSTRACT

The using of new techniques applied to the development of new materials, devices or systems in nanometrics scale is increasing in the recent years. Those new materials are receiving higher attention because due of their potentials applications in medicine, biology, microelectronics, magnetic devices, powder metallurgy, renewable energies, and textile. Textile industries are using a new technology nanocoating, which is the application of a thin film of a material polymeric or not in a textile material. Researchers are inspired to mimic nature in order to create textile materials with higher levels of functions and smartness. Applied nanocoatings on textiles fibers have the objective to develop materials with multifunctional properties as: antimicrobial, UV protection, water repellence, soil resistance, anti-static, anti-infrared, flame-retardant properties, colour fastness and strength of textile (Carneiro, 2010).
In the present work, low temperature pulsed DC magnetron sputtering method (PMS) (Figure 1) was used to create multifunctional nanocoatings on poly (lactic acid) (PLA) textile fibres surfaces. In this study, the principal objectives are :
-The application of TiO_2 nanocoating on PLA fibres to obtain a textile material with UV protection, photocatalytic and antibactetial properties;
-PTFE nanocoatings and thermochomic micro/nanocapsules was used on PLA fibres to obtain a thernochromic super water-repellent textile material.
The nanocoatings were characterized by SEM (scanning electron microscopy), AFM (atomic force microscopy) and TEM (transmission electron microscopy).
Photocatalytic efficacy was tested by degradation of MB dye (1 ppm). And the reaction kinetics can be described by a modified Langmuir-Hinshelwood model in agreement with a surface reaction, as discussed, e.g. by Fonzo et al (2009).

$$\ln\frac{C_0}{C} + k(C_0 - C) = k_r K t \qquad (1)$$

Where C is the methylene blue concentration at time t, C_0 the initial value, K is the adsorption coefficient of the methylene blue and k_r the reaction rate constant.
The ultraviolet protection factor (UPF) values were calculated according to the Standard AS/NZS 4399:1996. Measurements were performed in a UV-visible spectrophotometer system SDL, model M284, from 295 nm at an interval of 1 nm. The percentage blockings of UV-A (315nm – 400 nm) and UV-B (295 nm – 315 nm) were calculated from the transmittance data. The UV protection factor (UPF) was calculated using the following equation (Kathirvelu et al. 2009).

$$UPF = \frac{\sum_{\lambda_1}^{\lambda_2} E_\lambda \times S_\lambda \times \Delta\lambda}{\sum_{\lambda_1}^{\lambda_2} E_\lambda \times S_\lambda \times T_\lambda \times \Delta\lambda} \qquad (2)$$

where E_λ is the relative erythemal spectral effectiveness, S_λ is the solar spectral irradiance (in $W/m^2.nm^{-1}$), T_λ is the spectral transmission of the specimen, and $\Delta\lambda$ is the measured wavelength interval (nm).
Antimicrobial property of the textile fabric nanocoated was evaluated according to AATCC: 100-2004 and 147-2004 (qualitative and quantitative values), using *Staphylococcus aureus*.

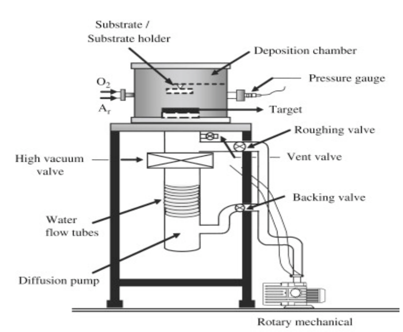

Figure 1. Schematics of DC pulsed magnetron sputtering system for nanocoating deposition.

The super hydrophobic properties of the thermochomic PLA were evaluated by Contact angle measurements carried out in OCA 20 using distilled water (5 µL) where the drop image was captured by Dynamic Contac Angle (DCA) measurement. The contact angle for the WDCA measurements was determined mathematically through the fitting of a Young–Laplace curve around the drop by the equation:

$$\cos(\theta) = \frac{\gamma SV - \gamma SL}{\gamma LV} \qquad (3)$$

where γSV, γSL, and γLV are surface energies (solid/vapor, solid/liquid, and liquid/vapor, respectively) and θ is the contact angle between the liquid and the solid surface.

The results showed that pulsed DC magnetron sputtering method is efficient for the application of the nanocoating ultra thin film on this textile fibre (Figure 2). The photocatalytic property of nanocoated PLA is showed in Figure 3. The degradation of colour was efficient (93%) after 4 hours.

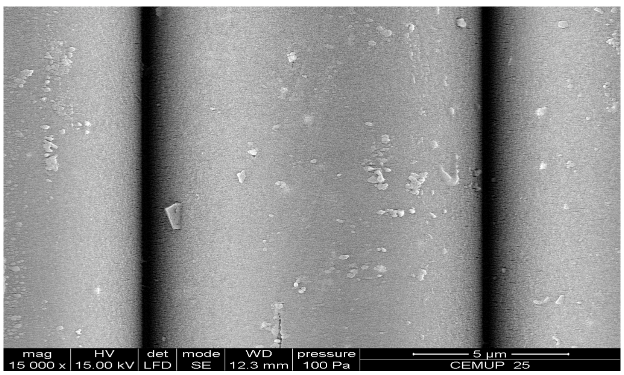

Figure 2 – The SEM image of TiO_2 thin films deposited on PLA.

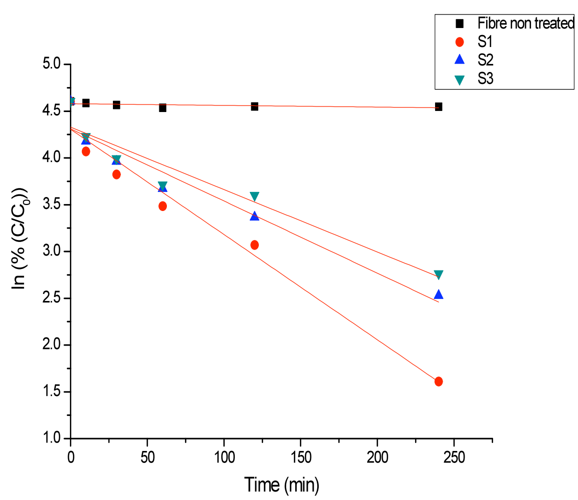

Figure 3 - Photocatalytic degradation of Methylene blue dye (1 ppm, pH=7) with 93% efficiency after 4 hours .

The Figures 4 show the thermochomic PLA nanocoated with PTFE in nanometer scale. The fabric showed superhydrophobicity of about 168º. The results also showed that the nanofinishing also enhanced the super water repellent properties on textile fabrics.

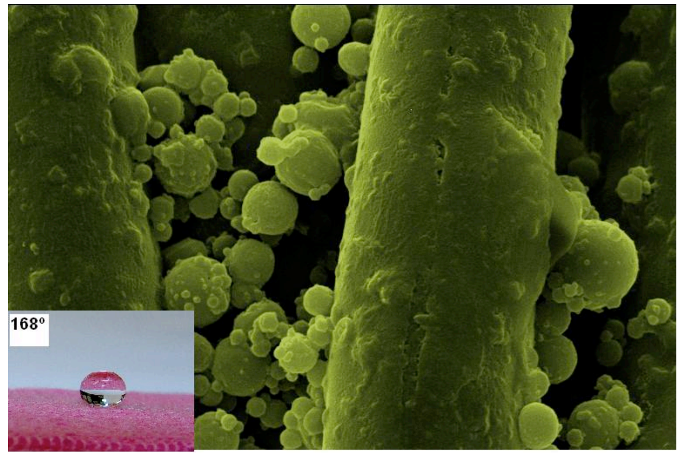

Figure 4 – The SEM image of nanocoating deposited on super water-repellent PLA with thermochromic micro and nanocapsules.

Unquestionably, we believe that techniques applied to the development of new materials in nanoscale (nanotechnology), holds a strong promising future for textile industry and for the consumers.

REFERENCES

Fonzo, F. Di; Casari, C. S., V. Russo, Brunella, M. F., Bassi, C. A. Li, Bottani, E. Hierarchically organized nanostructured TiO2 for photocatalysis applications. *Nanotechnology*. 20 015604(2009).

Kathirvelu, S., D'Souza, L., Dhurai, B. A Study on Functional Finishing of Cotton Fabrics Using Nano-particles of Zinc Oxide. *Materials Science*. 15, 1392 (2009).

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