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EFFECT OF ROUGHNESS AND FRACTAL DIMENSION DETERMINED BY AFM ON THE SUPERHYDROPHOBIC SURFACE OF PLA FIBRE NANOCOATED BY PMSD

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KEYWORDS

Fractal dimension, Textile superhydrophobic, Nanocoating, Magnetron sputtering

ABSTRACT

In this work, PLA fibers were nano coated by an physical method innovative in order to obtain superhydrophobic surface. This study showed that both the roughness when the fractal dimension were responsible for obtaining this material with excellent water repellency.

INTRODUCTION

The behavior and nanostructure of materials and systems can be characterized quantitatively using the ideas of roughness and fractal aggregates. According to fractal concept, which is due to Mandelbrot, an object is self-similar if, when magnified several times, reproduces the same image geometry to a greater or lesser extent. If a surface has a behavior of self-similarity is a repetition of a pattern, which defines the fractal dimension. The expansion of the contact surface is self- similar with the contact surface to a smaller scale.

Today, the relationship between roughness and fractal dimension of nanomaterials can be proven by analysis of AFM and improvements this technology allow for high resolution imaging in different purposes. This technique has proved a powerful tool in the development process of biosensors, biomimetic and superhydrophobic surfaces.

According to Onda *et al*, the results of superhydrophobic are due to the presence of fractal structures and high surface roughness, which leads in this case, a thermodynamic equilibrium at the material surface. To prove this theory, this research work AFM analysis was performed on PLA fibres without and PTFE nanocoated. A specific software for the analysis of nanostructured surface was used to obtain from AFM images, roughness and fractal dimension values. As well as these two parameters relate to the formation of a superhydrophobic surface.

MATERIALS AND METHODS

A pulsed DC magnetron sputtering deposition (PMSD) at low temperature was used to create superhydrophobic poly (lactic acid) textile fibres and argon was used as gas work. 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 nanocoatingswere characterized by SEM (scanning electron microscopy) STEM (scanning transmission electron microscopy) and AFM (atomic force microscopy). The surface chemistry was characterized by XPS analysis. The model proposed by Cassie and Baxter was used to characterize the superhydrophobic surface using the equation:

$$cos_{CB} = f_{ls}\left(R_f \, cos\theta_{ls} + 1\right) - 1$$

where θ_{CB} is the contact angle observed on a rough surface R_f, f_{ls} is the fraction of the liquid in contact with the solid, θ_{ls} is the angle formed between the liquid and solid surface. The fractal dimension was determined by the AFM images and software SPIP. For evaluating the average fractal dimension (MDF) by analyzing the Fourier amplitude spectrum.

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RESULTS AND CONCLUSION

By PMSD was observed the formation of a nanocoating on PLA fiber with average particle size of approximately 125 nm, with a wide range of particle size estimated from 10 nm to 240 nm due to formation of numerous clusters caused by nanoparticles that go beyond the barrier of the kinetic energy of activation, which makes the nanorevestimento more heterogeneous, more wrinkled and the presence of cavities with depths in the order of ± 60 nm (Figure 2(b)). These are the morphological properties and nanostructured essential to obtain a surface biomimetic or "*Lotus Effect*.

The sample of untreated PLA has low value fractal dimension value (2.01), characteristic of a smooth surface and samples A and B show respectively an average fractal dimension of 2.17 and 2.19, which can be explained by the low roughness nanocoating. The sample C showed higher MFD (2.37) due to its greater roughness, presence of pores or "valleys " and a greater formation of fractal aggregates (clusters).

These results prove the direct relationship previously proposed in studies Hazllet and Onda et al between the roughness, the energy balance of the fractal dimension of textiles surfaces nanocoated. The higher roughness and a low S_{tdi} and S_{tr37}, less uniform will be the texture of the PLA nanocoated, raising its fractal dimension, and therefore more likely to have a PLA fiber superhydrophobic with " L*otus Effect"* (Figure 1).

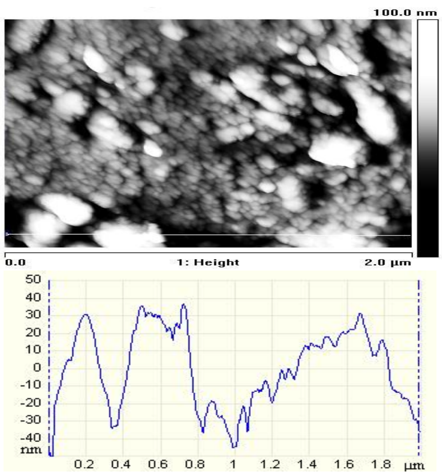

Figure 1 - AFM images (2µm x2µm) (a) and roughness (b) of PLA fiber nanocoated by PMSD

Table - Parameter Space of the samples

Samples	**Fractal Dimension**	**$^*S_{tdi}$**	**$^{**}S_{tr37}$**	**Roughness**
Pristine	2.01	0.9	0.87	1.15
A	2.17	0.82	0.78	3.46
B	2.19	0.77	0.70	6.48
C	2.37	0.64	0.68	42.6

***Index of the texture direction, **radius of the appearance of texture parameters**

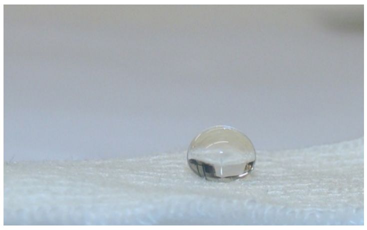

Figure 3 – Water drop on the sample PLA fabric nanocoating with superhydrophobic properties, *" Lotus effect "*

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