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Air versus Helium atmospheric-pressure plasma for enhanced adhesion of woven textiles

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Atmospheric-pressure plasma treatment is used to improve the dyeing quality of woven structures. A comparison is carried out between inert gas and air atmospheric-pressure plasma, attempting to separate and analyze the physical and chemical plasma effects on the woven, under conditions where oxidation, hence chemical processes, likely superposes on the physical effect. This approach is useful in a context where the separation between combined cleaning – chemistry – roughness modification and their respective roles on the efficiency of the fabric dyeing procedure is more difficult. The results show that air–plasma treatment probably brings a supplementary component to the treatment outcomes, compared to He–plasma, although both treatments are conducting to improved adhesion properties of the woven, resulting in better quality of dyed fibers.

1. Introduction

Plasma treatment has developed markedly due to its potential environmental and efficient energy use benefits, in developing high-performance fiber-based materials.

Taking this into account, we studied the surface modification of synthetic woven textiles, using atmospheric-pressure plasma, for controlled adhesion, targeting improved dyeability, since dyeing is compulsory step for most textiles finishing, also aiming to explore the plasma capability to modulate the permeability of fabrics and the relation between the process parameters and the 3D weaving parameters of the fabrics.

2. Experimental

The reactor consists of a dielectric barrier discharge (DBD), in asymmetrical electrode arrangement. The treated fabrics are six types of commercial polyester woven, presented as raw materials, with different weaving parameters.

Processing is carried out for 30 s. Then, fabric dyeing is performed under industrial conditions, on untreated and plasma-treated samples. Moreover, two different dyeing temperatures are tested.

The materials are then analyzed by the usual wettability/wickability measurement, SEM and XPS, also by evaluation of color changes in the CIELAB color space.

The influence of the plasma treatment on the mechanisms at the interface between the material and a dye solution is established by a diffusion method. The measurement is carried out with the woven placed between two cells and the absorbance measurement is performed until equilibrium is reached in both cells.

3. Results and discussion

The enhanced adhesion properties of the plasma-treated samples are demonstrated by color analysis, with increased color intensity on plasma-treated samples, compared to untreated ones. Also, the air-plasma has demonstrably more pronounced effect on the color intensity, compared to the He-plasma.

The diffusion test is demonstrating the accelerated flow of the dye solution through the textured sample, for air-treated, compared to He-treated samples. The fluid is flowing at higher rate and the saturation of the flow, due to physical obstruction of the woven pores, is visibly limited for air-treated samples. This could suggest that a chemical effect is superposing on the physical cleaning effect of the He-plasma, conducting to better quality of the capillary channels. The plasma effect on loosely weaved structure is more limited, compared to denser structures.

Then, the process rates were evaluated, confirming that in case of the He-plasma treatment, the effect would be dominantly the physical one, whereas the strong modification of both rates for air-treated samples would imply that a chemical effect superposes on the physical one.

4. Conclusion

The results will be further exploited in developing large-scale set-up for air plasma operation, which obviously represents lower cost technological solution.

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