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Plasma Technology Applied in Textile Industry

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Plasma technology applied to textiles is a dry, environmentally and worker friendly method to achieve surface alteration without modifying the bulk properties of different materials. In particular, atmospheric non-thermal plasmas are appropriate because most textile materials are heat sensitive polymers and applicable in a continuous processes. In the last years plasma technology has become a very active, high growth research field, assuming a great importance among all available material surface modifications in textile industry. The main objective of this work is to present an update on the current state of art relating plasma technologies applied to textile industry. The main effects obtained by the application of plasma discharge and all the textile production chain such as: desizing, mercerization, dyeing, printing, composite and finishing will be superficially discussed.

Keywords: Plasma, Textile Industry, Dyeing, Printing, Composites

Nowadays, due to the increasing growth competition, textile materials cannot be restricted to clothes, linen, tablecloth and curtains, but they also have to be regarded also as high-tech products that, in addition to the traditional clothing industry, find application in many technological fields, like construction, agriculture, automotive, aerospace and medicine. In this context, plasma technology has assumed a great importance among all available textile surface modifications processes.[1] It is a dry, environmentally- and worker-friendly method to achieve surface alteration without modifying the bulk properties of different materials.[2] Despite the high potential advantages, environmentally friendly approach and application possibilities of plasma technology its use in textile industry is still limited. Some responsibility can be attributed to the traditional and rigid management structure of the textile industry, but probably the real causes are intrinsically related to the properties of textile materials. Three main drawbacks may be reported: (i) *Surface cleanliness*. Since plasma treatment only influences the top layer, contaminations or different surface conditions (e.g. weft and warp direction) of the textile could have significant negative effects. (ii) *Three-dimensional structure of textiles*. Textiles are porous three-dimensional structure and plasma species could not penetrate deep enough into fabric structure to ensure proper treatment as the wet processes do. (iii) *Large surface area*. Textile materials whereas composed of individual fibres, are characterized by a large surface area, usually one order of magnitude larger than flat films.[3] In spite of that limitation, in the last years, due to constant technological improvements and scientific research efforts, plasma technology is already used for several niche applications in the textile industry and its use in new and improved methods for wider application is close to breakthrough.

Desizing: The application of sizing agents to warp yarns plays an important role in high weaving efficiency by increasing yarn strength and reducing yarn hairiness. Sizing

agents must be completely removed by desizing prior to dyeing and finishing fabrics with many disadvantages, such as, high energy and water consumption.[4] Plasma can effectively aid desizing since it does not involve such large quantities of chemicals and water as the conventional desizing does. However, an efficient fibrous surface cleaning needs a careful selection of the plasma treatment type in order to avoid fibre damage.
Dyeing: In general, conventional dyeing processes have a low yield, and the percentage of dye lost in the effluents can reach up to 50%. Besides the obvious aesthetic problem, dye wastewaters without an appropriate treatment can persist in the environment for extensive periods of time and are deleterious not only for the photosynthetic processes of the aquatic plants but also for all the living organisms. In this context, plasma technology inducing significant surface modifications and removing the natural or synthetic occurring grease and wax in textile fibres, has proved to increase dyeing rates of textile polymers, to improve the diffusion of dye molecules into the fibres, to enhance colour intensities and washing fastness of several fabrics such as cotton, polyamide, polyester, silk and wool.[5] The higher dye exhaustion provided by plasma application improves dyeing uniformity achieving high levels of strength and decreasing the amount of dyestuff and water necessary for a desired shade.
Printing: Inkjet printing is becoming increasingly widespread for the printing of textiles. However, without any pre-processing, some textiles have a lower capacity to retain water, inks, finish and embossing agents mainly due to the morphologies or chemical properties of the fibres providing low yield and low strength of the print. Nowadays, atmospheric plasmas offer an attractive pre-treatment method for pigment inkjet printing of textile, providing the necessary requisites for continuous and open process.[6].
Composites: The main purpose of plasma surface treatment of textiles used as reinforcements in composite materials is to modify the chemical and physical structures of their surface layer, tailoring fibre-matrix bonding strength or toughen, control interfacial bonding and adhesion, but without influencing their bulk mechanical properties.[7] Plasma treatment improves the fibre-matrix adhesion by introducing polar groups, by deposition of a new layer of the same polymer or by changing the surface roughness of the substrate. These characteristics may favour the formation of strong bonds between the fibre and polymeric matrix.[8]
With this study we concluded that plasma technology can be applied in almost all steps of the textile industry and the choice of the best plasma process to be used between atmospheric and low-pressure technologies depends on the processing type, speed, sample size and extent of the intended modification.

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