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Comparative Study of the Contact Angle in Fabrics Treated with Plasma

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***Abstract*— Among the techniques of modifying the properties of the surfaces applied in the industry, plasma treatment is widely used. Several studies have been conducted, especially in the last decade, analyzing textile articles of different fibers regarding the improvement of functionalities. This work evaluated the effect of plasma (corona discharge) treatment on polyamide 6.6 fabrics with elastane, establishing a comparison of the contact angle between treated and untreated samples. A significant reduction in the contact angle value of the treated samples was observed, increasing the absorption capacity of the fabric.*

I. INTRODUCTION

Studying the characteristics of fibers (physical and chemical properties) is fundamental to establish a relationship with the comfort properties of the finished product. The modification of surface properties creates unlimited possibilities for the development of new products for the textile industry, improving the comfort and functionality of the fabric. In physics and chemistry, plasma is considered a partially ionized gas containing electrons, positive and negative ions, radicals, atoms, and molecules. Ionization is caused by the introduction of energy in all gas through direct electric current, radiofrequency, or microwave energy sources (INAGAKI et al., 1997; INAGAKI et al., 1999). Concerning the thermal state of the gas, there are two types of plasma: hot and cold. Hot plasmas, characterized by an average temperature between 1500 and 3500ºC, are used in the surface treatment of metallic materials to increase the hardness of metal alloys. Cold plasmas with a temperature below 100ºC are most often used in the treatment of materials with a low melting point. In polymeric materials, cold plasma is used to improve surface properties, such as wettability and adwe, through the interaction of reactive species with the surface (CAIAZZO, 1996). The effect of plasma treatment on a given material is characterized by the type of chemical reaction between its surface and the gases present in the plasma and the changes that occur on the surface depend on the chemical composition of the polymer and gases used (D'AGOSTINO, 1999). In general, the treatment of a polymer with plasma produces significant changes in wettability and adwe, due to changes in chemical composition, contact angle, molecular weight, and morphology of the surface layer. The effects of plasma treatment, even if the intensity of the activity of reactive species on the surface is high, affect only one surface layer (approximately between 50 Å and 10 µm thick) (COOPES et. al, 1982). There are two processes of interest in plasma study, low pressure (approximately 1 torr) and atmospheric pressure. Plasma at atmospheric pressure has a typical example, the treatment by Corona Discharge (COOPES et. al, 1982). Corona Discharge in Atmospheric Air consists of positively charged ions, electrons, excited or metal-oxygen, and nitrogen species. The energies of the particles (1-20 eV) are sufficient to break C-C and C-H bonds (2.54 eV and 3.79 eV, respectively) and generate free radicals on the polymer surface, which can react with oxygen atoms and form polar groups, mainly CO, C=0, C-O (FRALEY and MEKA, 1994). In the present work, the samples were treated with corona discharge in atmospheric air. The contact angle represents an important factor in the absorption process, studying their behavior in mesh tissues after treatment with plásmatic discharge, possibly a better understanding of changes in surface properties.

II. MATERIALS

2.1 Circular knitting data

Table 1 shows the circular knitting data.

Table 1. Fabric sample data

Knitting	Single jersey
Composition	92% PA/8% Spandex
Machine (needles/inch)	38
Weight (g/m²)	180

III. METHODS

3.1 Equipment for measuring the dynamic contact angle. The device used to measure the dynamic contact angle was the FTA 1000 model.

3.2 Plasma equipment

The equipment used for the treatment of knitted fabrics was Plasma Labo, from the textile machine manufacturer Arioli (Figure 1).

Fig.1: Laboratory plasma equipment

Table 2 shows the general specifications of the equipment:

Table 2. Equipment specifications

Work speed (m/min)	5 to 30
Power (Kw)	1.5
Time cycle (ms)	50 to 2000
Frequency (Khz)	30 to 80

The fabric sample was treated with 1.5 kW. The area of the treated knitting was 25x60 cm².

IV. RESULTS

The following graphs show the values of the contact angle (°) of the drop deposited on the textile surface as a function of time (dynamic contact angle). The value of the table of the deposited drop represents the initial value of the contact angle.

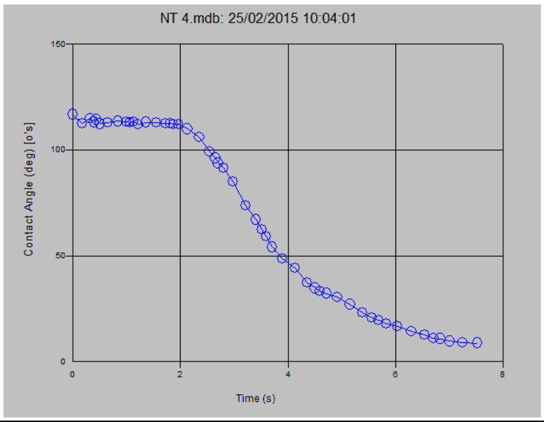

Fig.2: The contact angle of the untreated sample.

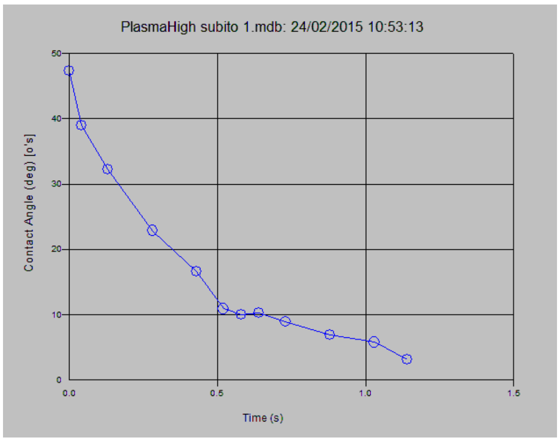

Fig.3: Dynamic contact angle measured right after treatment.

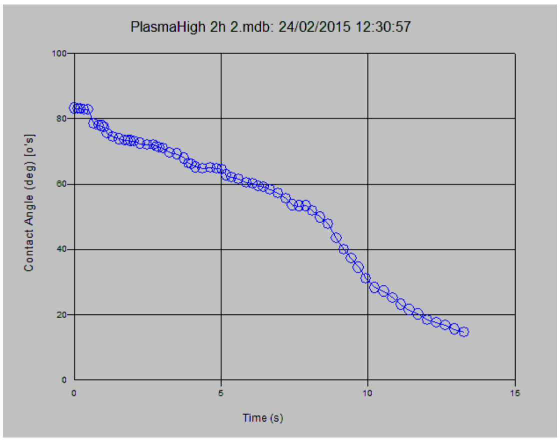

Fig.4: Dynamic contact angle measured two hours after treatment.

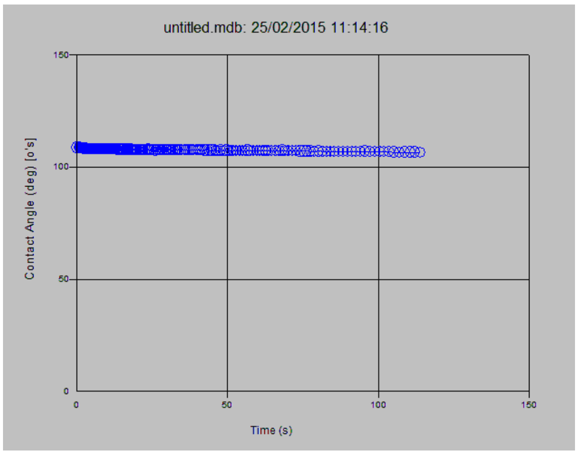

Fig.5: The contact angle of the sample was measured twenty-four hours after treatment.

V. CONCLUSION

The plasma-treated sample shows a significant reduction in the contact angle; both static and dynamic. After twenty-four hours, there is no difference in the value of the initial contact angle between the treated and untreated samples.

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