



A Recent Uses of Plasma in the Textile Printing

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PLASMA treatment for almost all synthetic and cellulosic textiles is considered to be one of these physical technologies. Plasma treatment does not involve the treatment of hazardous chemicals and thus, compared to chemical treatment, there are no problems with effluents. The study demonstrated that most types of materials (natural synthetics and blends) with natural dye using pigment printing techniques can be printed using high-quality plasma radiation. It is an environmentally friendly process, fast-growing, and finds certain potential applications. The study claims that polyester plasma therapy and surface modifications can alleviate difficulties with printing. The study investigates the treatment of a PET fabric with an efficient plasma approach to activate the surface before cationization treatment.

Keywords: Plasma, Polyester, Cotton, Wool, Blend.

Introduction

Cellulosic textiles were early employed as a chemical alteration to convey their new characteristics and to increase their effective use for various purposes. Some of these chemical alterations can be replaced with ecologically benign techniques via physical technology. One physical technology used to almost any synthetic and cellulosic textile fabric is termed plasma therapy. It alters the surface of the fiber and does not impact the bulk features. This subject is rapidly evolving and finds certain potential uses as an ecologically friendly procedure. Plasma therapy does not entail the handling of dangerous chemicals, and so, compared to chemical treatment, there are no difficulties with effluents [1-33].

Plasma is an ionized gas. When a solid is heated enough to break the crystal grid structure away from the thermal motion of the atoms, a liquid normally is produced. When a liquid is sufficiently heated to spray atoms faster than re-

condense from the surface, gas is created. If a gas is heated sufficiently to collide and knock off its electrons, a plasma is formed, the so-called fourth state of matter [1, 34].

Plasma Treatment in Textile Cycle

Plasma treatment as a Step

The present wet processing step can be replaced with a plasma treatment, e.g., wetting and adhesion treatments, such as for dyeing, coating, and forming composites, are beneficial. Saving costs relating to the environment is a priority[35]. The final stage in building a newly developed textile may be plasma treatment. Textiles having characteristics that cannot be induced by wet processing are manufactured here. A priority is the added value[36].

Plasma Treatment to Save Water, Materials, and Energy

This is perhaps the most exposed environmental component of plasma technology. It was important because of the growing expenditures associated with the environment. Its importance,

however, relies on the above instances. When a plasma treatment fully replaces a wet method, the biggest benefits will be experienced. Although these circumstances are not frequent, plasma technology is generally cost-efficient every day because of a constant rise in water extraction and waste disposal costs[35].

The cost savers connected are,

- Lowered quantity of chemicals required in wet treatment following plasma treatment. Bath chemical depletion. BOD/COD reduced for wastewater treatment.
- Wet processing time shortening; this is compensating for the potential additional treatment time.
- Decrease the required temperature of the wet processing; save energy from heating. This adds to the plasma treatment's efficient energy.

Additional benefits include better performance and rapidity, which adds value, for finished textiles[1, 35].

Plasma Treatment for Unique Textile Properties

Although this sort of high-performance text is now not particularly significant in quantities (square meters), economic significance is undoubtedly increasing. Even tiny textile batches may provide large profits, due to their high added value, however flawless process control is essential[35]. Textiles are generally projected to rise in relevance for medicinal applications in the biotechnology sector. Specific applications include selective biocompatibility, organic tissue cultivation, etc. [1, 36].

Application of Plasma onto textile materials

Treatment of Cotton, cotton/polyester fabrics

Cotton Fabric Treatment using a dielectric barrier (DBD) plasma and cochineal natural coloration printing[1].

In this investigation, plasma was employed to activate the cotton surfaces and its combination with the application of dielectric block discharge polyester (DBD). The objective of this effort is for the active textiles to include new qualities into surfaces to be printed using natural colors taken from the crude dried and crushed cochineal insect bodies[37].

Two approaches, conventional or ultrasonic, are applied to remove the dye. There are differences in weight, tensile strength, and impressiveness of cotton and polyester/cotton. The Electron

Scanning Microscope (SEM) distinguishes the surface morphology of the treated materials. The nuclear microscope is used to characterize chemical groups formed on the surfaces of active materials by plasma therapy (AFM) [38].

Three aspects influence color extraction, 1. temperature, 2. time extraction, 3. method extraction. Extractability rises with temperature and absorption by utilizing (United States) technology amounts to 1.98 mg g⁻¹, but utilizing (CH) technique at the same temperature it amounts to 1.63 mg g⁻¹. Using the US approach at a power of 500 W and 60 minutes the maximum detection was obtained[38]. The treatment with O₂-plasma enhances cotton and PE/cotton color strength compared to the intensity of the two air-plasma-treated materials. Increased plasma exposure times from 3 to 10 minutes and the power to be released from 3 to 15W reduce the wetting period of the processed tissues, resulting in increased weather resistance. In comparison to the air plasma and oxygen plasma-treated samples, the SEM images indicated a smoother surface for untreated cotton and polyester/cotton samples[37].

The treatment increased the weight, impressiveness, and quickness of cotton and polyester/cotton textiles treated with natural cochineal coloring[1].

The use of ecologically safe materials is a contemporary trend for textile coloring, with natural colors, owing to their many attributes including biodegradability and ecologically friendly characteristics, the most essential[39].

Natural thinner teats also include certain functional groups that provide additional characteristics, such as antibacterial and UV protection. Although synthetic dyes are cheaper than natural dyes, for the reasons outlined above, small dyers and textiles exporters prefer natural dyes[40].

Cochineal is a natural dye that is regarded as the most significant insect teeth and comes from women's Dactylopius insects Although the natural color is a key use since ancient times for coloring natural materials, cochineal is not one of them; it is an acidic coloration which can only print wool, nylon materials, and mixtures. Pretreatment of cotton must thus be done before printing, to improve the printability of cotton teeth [38].

The plasma technique is gaining favor in

the textile sector by avoiding waste creation in wet chemical processes, among other surface modification technologies. On the other hand, it has been found that plasma is a healthy technique that does not cause any toxic materials and is used for modifying the finest layer of fabric surface and improves weather, water repellency, printing, and film deposits on material surfaces[1]. In the environmental regulations, it is a healthy technique. The DBD is frequently utilized for chemical, industrial and biological applications. Industrial applications include polymer, textile, and food surface treatment [40].

Natural dyes via plasma irradiation to enhanced printing fabrics performance

Natural dyes have been recognized as key areas of application since ancient times for their usage in coloring materials like wool, silk, cotton, and flax. They can be of varied hues, including root, bark, leaves, flowers, and fruit, from different sections of the plant [41].

The application of natural colors with poor to moderate washing and light fastness has dropped to a significant amount due to the emergence of widely accessible and cheaper synthetic color-proof teats[42]. However, the use of natural dyes on natural textiles in recent years has been reviving and increasingly interested in contributing to global environmental consciousness. Several dyers and small export facilities for textiles have begun to explore the prospects of utilizing natural dyes to regularly dye and print fabrics to counteract the pollution produced by synthetic colors. Natural dyes offer several significant benefits, including the absence of health hazards, their easy harmonization with nature, their low chemical reactivity, and no severe environmental impacts [41].

Pigment printing is, as far as the simple application is concerned, not only the oldest but also the easiest printing technology. It provides advantages such as the convenience of practically final printing in its printing stage, print quality and adaptability to practically all types of fabric or mixture as well as the ability to avoid washing after fixing[43]. Fine spreading thicknesses that have little appeal to any fabric[43].

The process of plasma is extremely simple to handle and only requires a brief treatment period; the surface alteration depths of plasma material vary from 100 to several micrometers; the bulk of the polymer remains intact; and the original

material retains mechanical, physiochemical, and electro-physical properties[43]. Plasma is a complete gaseous ion, electron, metastable, neutral, radical, and photonic combination. The fiber surface produces fractures and grooves by large concentrations in oxygen plasma neutral species [42]. Free oxygen radicals promote surface polarity, either during treatment or immediately following plasma treatment, by exposing the new Polar Carboxylic and Hydroxylic derivatives to the environment[42].

This article analyzes the capacity of the pigment-printing process to print diverse textile materials (natural, synthetic, and mixes) with natural dyes (which have no affinity for some of the fibers) (which have no affinity for some of the fibers). [43]

Two different techniques can be applied i) Treatment with plasma then printing and ii) Printing then plasma treatment

i) Plasma treatment è printing process è fixation è washing è air-drying.

ii) Printing process è fixation by plasma è washing è air-drying.

For the first technique, the samples were placed at a temperature of 180°C for 3 minutes, and for the second way, the plasma was used as a fixing technique. The samples are all washed twice, once in cold water and once in hot water, and then in dry air [41].

Treatment with plasma

Various fabrics (cotton, wool, polyester, polyamide, cotton/polyester (60/40), and wool / polyester (80/20)) are subjected to atmospheric plasma at low temperatures. Different plasma discharge conditions have been used (12.5, 24.5, and 41.5 W) and exposure times (3, 5, 7, and 10 minutes).

Printing of fabric

The printing paste had been produced as follows, [44-46]

Synthetic thickener	2 g
Binder	5–20 g
Urea	4 g
Dyes	3 g
Water	x g
	100 g

Atmospheric plasma effects on the printability of wool textiles

Wool Fiber is morphologically composed of cuticle and cortical cells joined by the complex of the cell membrane (CMC) [47]. The cuticle cells are placed in a layer of flat scales that overlap one another on the outside end of the fiber which surrounds the cortical cells[48].

Indeed, it is vitally vital to the pre-treat wool fabric before printing to get full color, elevation, and brightness. However, a lot of pollutants can come from this sort of method (acidic or alkaline wastewaters and high content of AOX, etc.)[49]. With ecological and economic restraints on the textile sector increasingly essential, it was vital to create environmental and economic procedures. Plasma treatment is a solution for the textile industry as an alternate option[50].

Plasma therapy is physical since it impacts both the physical and chemical surface formed when gas is subjected to an electromagnetic field at low or atmospheric pressure and near ambient temperatures[47]. Plasma chemistry occurs in unbalanced situations. The plasma temperature is quite small, such that the active species in plasma can swiftly lose their energy once the polymer material has reacted[48]. The plasma insertion into the polymer materials occurs on the surface, which only marginally affects the inside of the substance. Plasma treatment may be utilized as an effective way to affect the surface characteristics of wool fabric without changing the inside part of the fiber since only around 1000 Å° can penetrate the plasma species[49].

The wool processing plasma only alters the cuticular surface of the fibers without changing the qualities of the material in bulk. As a result of hydrocarbon chain oxidation, new hydrophilic groups like $-OH$, $-C=O$, and $-COOH$ develop on the surface[49]. In addition to these benefits, the chain length of fatty acid is shortened, improving surround weight resistance, dyeing capacity, fiber cohesiveness, and shrinking resistance. The process of oxidation also boosts cysteine oxidation in the exocuticle, transforms it into cystic acid, and reduces the amount of fiber board cross-linkages. Plasma therapy thus modifies the cell membrane complex and endocuticles, eliminates the covalently linked fatty acid layer, and partially destroys the epicuticle. In this work, knitted wool textiles have been treated with ambient air and argon and printed with two distinct receipts[47]. The color rates, the color speed values, and the topography of the surface were examined[50].

Printing

A flat-screen printing process using a Johannes Zimmer MDK workstation was used to print wool textiles. Drying took place at 100°C for 2 minutes at the Rapid Laboratory Type Dryer. Steaming in a high-temperature vapor was done at 102°C at varied intervals like 20, 25, and 30 minutes (Mathis, Switzerland)[50]. To remove thickening and any unfixed color, the printed textiles were washed as follows,[47] Coldwater for 5 minutes, soap solution at 30°C for 3 minutes, soap solution for 5 minutes, soap solution at 50°C for 5 min., soap solution for 5 minutes, soap solution for 5 minutes. Then at room temperature, the textile was strained and dried[48].

Effect of plasma atmospheric pressure glow on surface modification and printing of wool/polyamide blends

This work has been utilized to change the surface characteristics of wool/polyamide fabric by using plasma atmospheric pressure glow discharge. There was also discussion on the effect of air plasma treatment on wool/polyamide mixture printing[51]. Three dyes, namely acid, basic and reactive dyes were utilized. A variety of times and the current of discharge in the treatment of air plasma were explored to transmit changes in wool/polyamide characteristics, such as whiteness[52]. FTIR and SEM were used for surface characterization. The plasma treatments improve Wool-Polyamide mixture color strength with acid, basic, reactive dyestuff, and speed characteristics and are a method for printing the combination with one single color [53].

Wool/polyamide is a common mixed fabric. In terms of hollow recovery, durability, abrasion resistance, rapid drying, and dimensional stability, it may demonstrate the complementing features compared with polyamide-pure or wool fibers. Wool/polyamide blends printed with another class of teeth may result in scattered teeth, but background stains and low rapidity are common[52].

The employment of blends of several color types can create issues in color coordination, especially in the case of diverse blending characteristics. Acid, complex metal, reactive and fundamental teeth[51]. Theoretically, these dyes are designed to print mixtures of wool/polyamide. The use of acid and metal complex dyes is restricted in particular. In addition to the appropriate brilliance of color, the acid dyes

should be selected to achieve appropriate light and wet speed for each end application[52]. A series of research examined and employed plasma pressures in wool and polyamide, but only a few focused on wool/polyamide mixing[53].

plasm is used to discharge atmospheric pressure glow on wool/polyamide mixtures to improve their physical properties and impressiveness with acidic, reactive, and basic colorants to ensure the maximum color and dye fastening[52, 53].

Using plasma for surface change of polyester fabric at low temperatures for improving printability

Many studies have been conducted to evaluate the use of plasma as green and fast textile surface technology. In this experiment, the polyester fabric was treated with cold plasma for different times between 1 and 5 min. Untreated and treated fabrics were bleached and colored using inkjet and silkscreen techniques[54, 55].

Although the polyester fabric treated with plasma diminishes the whiteness of the textile, it has been shown, in comparison with untreated tissue, that the plasma tissue has more blackening. The results also show that plasma treatment improves color absorption by continuous and non-permanent dyeing methods[56]. It is also worth noticing that with continuous technology the increase in color absorption is substantially more than in non-continuous technology. Plasma processing also increases the color absorption of polyester printing[54]. Color uptake by extending the plasma treatment duration. In the same printed circumstances, the penetration and spread of colors in plasma-treated materials is less than in the untreated material[55].

Two distinct procedures were used to print untreated and plasma-treated samples. The FH6100 inkjet printer was utilized in the first procedure. Each specimen was printed with a scattered dye, fixed at 190C, and washed and dried with kaveron Black SRD 300. The examples were produced manually using silkscreen printing in the second approach[55]. It had 50 poise viscosity and comprised 25 g/kg SRD 300, 20 g/l urea, water, and synthetic condensers of cavernous black[56]. The reflecting of the back and front of the samples in 16 different wavelengths was measured using the X-Rite reflective sample Sp60, to investigate the quantity of absorbed color in the samples, and to examine the quantity of color penetrating in and behind the samples using two of

the above-mentioned methods Photographs were shot with a micro view (10-800 amplification ratio) USB digital microscope[54].

It is challenging to print the smooth surface, the hydrophobicity, and the high permeability of polyester fiber. High penetration of the paint paste from a printed surface to both the inside and beyond the textile causes issues with inkjet printing, which decreases color depth on the imprinted surface. The issue is possible if the polyester fiber increases its hydrophilicity and the fiber produces a rough surface. Plasma therapy and surface change of polyester can thereby alleviate the issues associated with printing. Polyester textiles were treated with plasma for 1, 3, and 5 minutes in this investigation[54]. The sample was then colored and printed using several processes, without being treated and plasma treated. The results reveal that polyester materials are absorbed more colorfully by plasma therapy[56]. The increase in color absorption depends on the time of the plasma processing. The penetration of the tissues into the plasma-treated samples during the printing process is smaller than the penetration of untreated tissue[55].

Highly efficient alteration of surfaces employing plasma technologies to green polyester fabric coloring

The study is based on the application of an environment-friendly and cationizing effective plasma technology to enhance the hydrophobic nature of polyester (PET) by integrating hydrophilic functions on the PET surface[57]. The results of the study Before cationization with a quaternary ammonium salt, the PET surface was treated firstly with three distinct plasma gases (Quat 188)[58]. In both dyeing and printing operations, madder roots were employed for natural dyes for the green color of PET materials. To evaluate the effect of both plasma gases and cationization treatment on colorizing PET fabric, color strength (K/S) was assessed[59].

Before the treatment of cationization, exposure to plasma nitrogen was successful ineffective PET coloring, which resulted in nitrogen being selected as a working gas with a flow rate of 3 liters/min[58]. The results also indicated that PET fabric with a very effective surface was achieved by combining the nitrogen plasma and cationization process, leading to better color, weight resilience, traction strength, and ruggedness[57].

Polyester (PET) is one of the most polyester synthetic fibers used today in several textile goods[59]. PET is distinguished by superior mechanical strength, organic solvent resistance and many other chemicals, wrinkle resistance, and environmental resistance, including UV radiation[60].

Several approaches have been used in recent years to modify the material surface. These techniques aim at altering polymeric materials' surface characteristics without changing their mass characteristics[61]. Plasma therapy is a technology used in the textile market because it may prevent the waste generated by the wet treatment of textiles[58]. The hydrophobic character of PET can be modified by environmentally friendly plasma treatment through the creation of hydrophilic functional groups on its surface. The processing of plasma produces free reactive radicals, photons, atoms, and ions capable of grazing surfaces and entering such functional groups[60]. Therefore, enhanced physical interactions result from the enhanced adhesion of chemicals and polymers[59].

Polyester fabric surface modification

Pretreatment of plasma

PET textiles have been treated using atmospheric pressure low-temperature plasma discharge dielectric barrier (DBD). A 25 kV/30 mA AC power supply at 50 Hz was produced for plasma discharges. Both electrodes were linked to the power supply of the high voltage AC[61]. PET samples (25 to 25 cm) were located at atmospheric pressure between two electrodes. They were subjected to various plasma gasses (nitrogen) [NPg], air [APg], and oxygen [OPg]. In this experiment, plasma discharges were applied at varying power levels for 3-15 minutes[59].

Polyester materials with Quat 188 Modification

PET textiles and plasma-treated PET (NPg, APg, OPg) textiles were treated using a newly made solution comprising a Quat 188 mixture at a variety of concentrations (0–150g/l) and 50 percent sodium hydroxide ratio (0–80g/l). The textiles were submerged at a liquor ratio of 50,1 in a quat-188 solution, 75°C at varying intervals (0–120 minutes). All cationic materials were rinsed with water several times and neutralized with a solution of 1 g/l of acetate acid. Finally, the materials were fully rinsed with water and soaped at 100° for 30 minutes with Triton X-100 (3 g/l)

then washed with water and dried in the air[59, 60].

Conclusion

Air and oxygen were utilized for LTP surface treatment of cotton and polyester/cotton textiles. O₂-plasma treatment has more influence than air plasma treatment on both cotton and polyester/cotton materials. DBD plasma improved printability and boosted the color strength of all processed textiles almost to quadruple compared to the control.

Plasma therapy was an excellent method for improving weather resistance, whiteness of printed wool/polyamide fabric, and color strength. The etching and redness impact on the surface were noticed, and scales were partially removed from the wool in the mixture. The FTIR spectrum shows the existence of functional groups comprising oxygen and secondary aliphatic amine groups that promote the interactions of the dyed fiber.

The high push of painted paste from within and below the printed surface lowers the depth of color. The problem can be solved if the Polyester fiber is increased in hydrophilicity and a rough surface in the fiber is created. The study claims that polyester plasma therapy and surface modifications can alleviate difficulties with printing. The study investigates the treatment of a PET fabric with an efficient plasma approach to activate the surface before cationization treatment.

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استخدامات حديثة للبلازما في طباعة المنسوجات

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تعتبر معالجة البلازما لجميع المنسوجات الاصطناعية والسليولوزية واحدة من هذه التقنيات الفيزيائية. لا تتضمن معالجة البلازما معالجة المواد الكيميائية الخطرة ، وبالتالي ، مقارنة بالمعالجة الكيميائية ، لا توجد مشاكل مع النفايات السائلة. أظهرت الدراسة أن معظم أنواع المواد (التركيبية الطبيعية والمزيج) مع الصبغة الطبيعية باستخدام تقنيات الطباعة الصبغية يمكن طباعتها باستخدام إشعاع البلازما عالي الجودة. إنها عملية صديقة للبيئة وسريعة النمو وتجد تطبيقات محتملة معينة. تدعي الدراسة أن علاج بلازما البوليستر وتعديلات السطح يمكن أن تخفف من صعوبات الطباعة. تبحث الدراسة في معالجة نسيج *PET* باستخدام نهج بلازما فعال لتنشيط السطح قبل المعالجة الكاتيونية.