International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Effect of Plasma Treatment on the Comfort Properties of Linen Fabric

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DOI: https://doi.org/10.55248/gengpi.2022.3.10.70

ABSTRACT:

In this study, atmospheric air pressure plasma is treated with plain linen fabric. The important part of doing this surface modification is to study the comfort properties of the effect made by plasma on plain linen fabric. More attention was given to evaluating the air permeability, water vapour permeability, and wickability of the surface modified fabric. The results show that the plasma treated fabric outperforms the untreated fabrics in terms of air permeability and wickability in the warp and weft directions with a 5 minute interval time. But in plasma treated fabric, water vapour characteristics reveal the better characteristics compared to the untreated. Thus, this research work helps in understanding the comfort properties of surface modified linen fabric.

Key Words: Linen Fabric, Plasma Treatment, Air Permeability, Wickability

INTRODUCTION:

One of the main current concerns of textile and garment manufacturers is the comfort of clothing. The human sensory response to clothing materials serves as the foundation for comfort, which is influenced by a number of thermal, physiological, and mechanical factors. Textiles have many comfort features that make clothing comfortable, including heat transfer, thermal protection, air permeability, moisture permeability, water absorption, water repellency, size and fit. In order to meet unique requirements for a variety of applications, the surface of textiles provides an important platform for functional modifications. The surface of textiles can be altered using a variety of methods, from conventional solution treatment to biological methods. Here, linen fabric has been treated plasma with atmospheric air and untreated plain fabric to meet the variety of applications along with comfort properties such as air permeability, water vapour permeability, and wickability. 100 per cent raw linen fabric, plain-weave, with a fabric weight per unit area of 250 g m-2 was selected for the experiments. The fabric samples were conditioned at 65% relative humidity. It is very hygienic and imparts an air of satisfaction and style to the wearer. The quality of linen produced is considerably influenced by the weather conditions during its growth.With the trend of fashion towards natural, comfortable yet elegant fabrics, linen and linen-blended fabrics have gained prestige and increased in reputation. It is therefore necessary to raise awareness among users of the unmatched qualities of linen and its blends, to promote its production as well as its usage. In this context, the handle and comfort behaviour of linen and linen blended fabrics have been studied. The atmospheric air plasma was done on the fabric with system frequency of 60KHZ in aluminium electrode with the electrode gap of 7.5 cm at room temperaturIn this paper we are going to discuss whether the comfort qualities of linen fabric have been impacted by surface modifications.

LITERATURE REVIEW:

Cellulose, which is largely found in secondary cell walls, makes up the majority of linen. In raw linen, the non-cellulosic components such hemicelluloses, pectin, lignin, and certain fats and waxes make up about 30% of the total fibre weight. They are mostly detectable in the major wall and middle lamella. The fibres' waxy exterior layer renders them hydrophobic, and some non-cellulosic elements, particularly pectic ones, serve as cement for the numerous final cells. Plasma has the ability to partially dissolve and remove the fiber's thin outer covering of wax. In ambient air, non-thermal plasma therapy was carried out using a diffuse coplanar surface barrier discharge. 300 W of power was used to treat the fabrics on both sides and treatment times of 30, 60, 120, 180 s.[1]

The fabric's ability to bend is measured by its bending rigidity (B). The bending stiffness of a fabric mostly depends on the bending rigidity of the constituent fibre yarns used to make the fabric, the fabric's construction, and—most importantly—the type of chemical treatment the fabric has received. The amount of pectin, the crystallinity of the cellulose, and the fiber's differing cross-sectional shape from cotton fibre all have an impact on how stiff the linen fabric is when bent.Because friction between and within yarns affects how a material bends, the sort of chemical treatment used to the material largely determines how much friction there is. Because low stress bending has a stronger connection to and higher correlation with cloth handle, it is more significant. The fabric handle will be lower the higher the stiffness. [2]

The hydrophilic characteristics of treated substrates significantly enhance after plasma treatment thanks to the formation of new functional groups and a discernible rise in their attraction for future H_2O_2 bleaching. The plasma gas, namely oxygen > air > nitrogen > none, and the discharge power, namely the higher the power supply, the shorter and greater was the modification extent, govern the amount of improvement in wettability as well as following bleachability. An environmentally friendly alternative to traditional scouring of linen-based textiles, oxygen or air plasma treatment greatly improves the hydrophilicity, improves the subsequent bleachability, saves time, water, and energy, as well as prevents or minimises pollution at the source. [4]

The same warp (100 percent cotton) and several weft yarns were used to create 10 different fabric kinds. Comparisons were made between 100% cotton and 100% linen fabrics that had been woven with two different ratios of cotton/linen, viscose/linen, and lyocell/linen blended weft yarn. The linen weft fabric has thermal properties that were comparable to those of other fabrics. Additionally, the usage of linen and man-made cellulosic fibre blend fabrics increased air permeability, bending, and shear ability but did not significantly change thermal absorptivity. In comparison to 100% cotton fabrics, the 80% lyocell/20% linen weft fabric displayed the highest values for heat and vapour passage, formability, and elongation qualities. [3]

We present the wetting and wicking behaviour of linen that has been exposed to low-temperature oxygen and argon plasma. Utilizing contact angles and both upward and downward water wicking techniques, the wetting and wicking capabilities of plasma-treated linen are studied. For clearly differentiating the effects of plasma treatment under diverse circumstances, the downward wicking method is preferable. [5]

Using the KES-F7 system, the thermal characteristics of commercially available pure linen fabrics and linen-blend woven fabrics were assessed at moisture contents of 0%, 20%, 40%, and 60%. (Thermo Iabo II type). The rate of water absorbent was used to statistically examine the experimental properties. The following were the key findings: The thickness of pure glass and the thermal insulation value (TIV) have a positive link by absorbing water, linen fabrics and linen-blend woven fabrics are created. The TIV and cover factor, however, are negatively correlated. The heat conductivity (k), thickness, and weight of woven fabrics made entirely of linen and of linen and cotton are highly positively correlated. There is a strong negative relationship between the k and the permeability of the air (Ap). By absorbing water, pure linen and linen-blend woven fabrics' bulk density and perceived warmth/coldness are highly positively correlated. There is a strong inverse relationship between porosity and how warm or chilly you feel. At a 60% rate of water absorbent, water absorption reaches its maximum value. The TIV declines with water absorption and is positive at zero percent, negative at twenty percent, forty percent, and sixty percent, and negative at sixty percent. [6]

Plasma Treatments:

As an alternative to wet chemical fabric treatment and pretreatment techniques, such as shrink resistant or water repellent finishing, which tend to affect fabric mechanical properties and are environmentally dangerous, plasma treatment of textile fabrics and yarns is being researched. The application of study findings to technology would create operating circumstances that are non-polluting and extremely promising. Two basic approaches can be taken into consideration for chemical finishing using plasma: grafting a material onto the fibre or surface modification using discharges. Plasma treatment alters the surface's topmost atomic layers while having no effect on the material's bulk properties. This process for treating textiles could lead to the desired surface alterations of surface etching, surface activation, cross-linking, chain scission, decrystallization, and oxidation, among others. The choice of working gas, as well as plasma density and energy, affect the course of treatment. As a plasma medium, one may utilise air, oxygen, argon, fluorine, helium, carbon dioxide, or mixes thereof. The type of gas used has an impact on the process outcome. Even though the gas is the same, a different fibre type will produce a different result. Textiles can be treated at the plasma region or in the space between two electrodes (really in the plasma). A schematic of a plasma device with several reactive species is shown. Plasma-chemical conversion of the feed gas yields chemically active particles that, when they come into contact with textile surface molecules, can alter those molecules via chemical reactions. It is necessary to provide the radicals produced inside the plasma zone a chance to migrate to the reaction site on the surface of the textile fibre. As a result, on the one hand, the path of radicals between the sites of generation and reaction is constrained. Distance between individual fibres and, on the other hand, by the gas density, or by the typical separation of gas molecules. Assuming there is a correlation between penetration and reactivity of radicals following several collisions with gas particles and at surface spots on fibres depth of the plasma effect inside the textile structure and process pressure as well as the textile structure itself.

METHODOLOGY

Air Permeability:

To test air permeability, an air tronic tester with the model number 3240A and ASTM D737 is utilised. It has a volumetric counter with a 50-liter hourly minimum capacity and a 5800-liter hourly maximum capacity. Additionally, it comes in several testing areas of 20, 20, 10, 5, 2, and 20 cm2. I used a test area of 10 cm2 with a pressure drop of 100 Pa and a measurement volume of 10 litres per minute to compare plasma-treated and untreated linen fabrics, and I documented the results.

Water vapour permeability:

The Water Vapour Permeability Tester Model M261 with ASTME 96 specifications is used with 46ml of water at 20 °C2 °C in each open dish, which is predetermined from the dish's dimensions to give an air layer that is 10 mm deep between the surface of the water and the underside of the supported specimens. The specimens were positioned over the turntable, and measurements of the water vapour permeability of various fabrics were made.

Wickability:

A manual test was used to determine wickability. An exposed lower edge of a strip of fabric held vertically in distilled water is used for this test. The leading edge of the water is then tested at various intervals for rate of rise. The height of the rise that is noticed over time is a clear indicator of the test fabric's ability to wick moisture. Weighing the fabric after the test to see how much water it has absorbed is one technique to account for this. A percentage of the mass of the length of dry cloth could then be expressed as a result of the evaluation of the readings, which produced the mass that is equivalent to the height of water rise that was measured.

PHYSICAL PROPERTIES OF LINEN FABRIC:

Table -1: Physical Properties Of Plain Linen Fabric

Properties / fabric	Plain linen fabric
Thickness (mm)	18
Fabric GSM (g/m2)	150
Fabric weave type	Tabby weave

RESULTS AND DISCUSSION

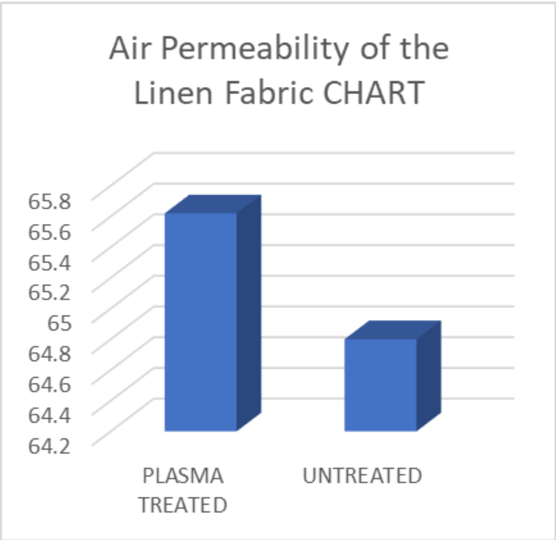
Air Permeability

The air permeability of the fabric samples was tested and the results are given in table no 2. The result shows that plasma treated linen fabric has slightly higher air permeability characteristics when compared to the untreated linen fabric.

Table -2: Air Permeability of the Linen Fabric samples

Fabric type linen (plain woven fabric)	Air permeability (lit/min)
Plasma treated fabric	65.62
untreated fabric	64.8

Chart1: Air permeability of the fabric



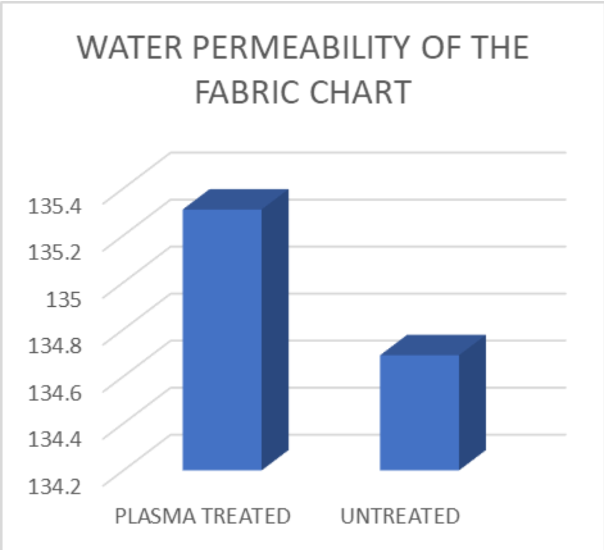
Water Vapour Permeability

The water vapour permeability of the linen fabric samples were tested and results were given in table no 3. The result shows that plasma treated linen fabric has the slightly higher water vapour permeability when compared to the untreated linen fabric.

TABLE NO :3 WATER PERMEABILITY OF THE FABRIC SAMPLE:

Fabric type linen (plain woven fabric)	Water vapour permeability (g/m2/24 hr)
Plasma treated fabric	135.31
Untreated fabric	134.69

Chart2 : water permeability of the fabric sample



Wickability

The wickability of the fabric samples was tested, and the results are given in table no 4 and 5. The result shows that plasma treated linen fabric has a higher wickability property when compared to untreated linen fabric.

TABLE NO: 4 WICKABILITY OF THE FABRIC SAMPLE WARP DIRECTION:

Time in minutes	Wickability of Plasma treated linen fabric (cms)	Wickability in untreated linen fabric (cms)
1 MIN	4.2	3.28
3MIN	6.5	4.9
5MIN	7.9	5.88

Chart 3: wickability sample warp direction

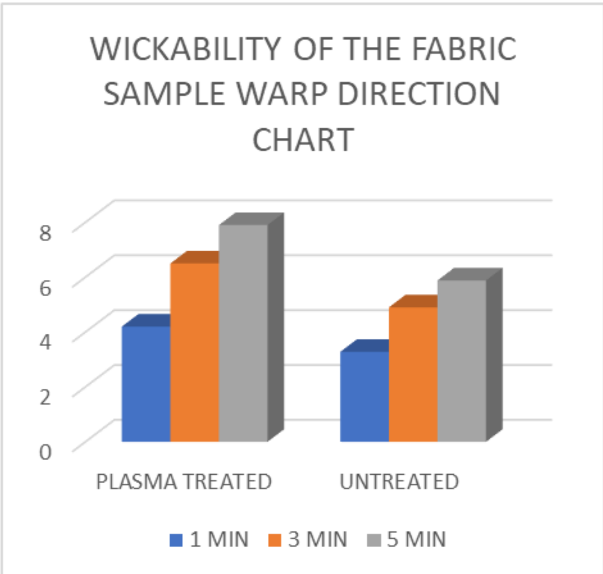
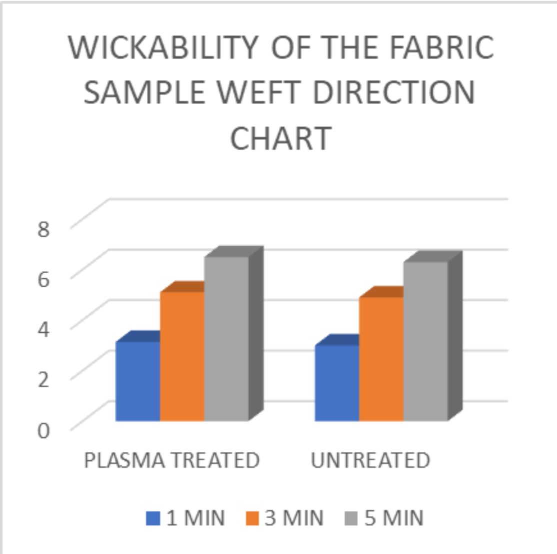


TABLE NO: 5 WICKABILITY OF THE FABRIC SAMPLE WEFT DIRECTION:

Time in minutes	Wickability of Plasma treated linen fabric (cms)	Wickability in untreated linen fabric (cms)
1 MIN	3.14	3.3
3MIN	5.1	4.9
5MIN	6.5	6.3

Chart 4: wickability of the sample weft direction



CONCLUSION:

From the analysis of the results, it is found that the plasma treated lenin fabric has a higher air permeability property. In the water vapour permeability test, plasma fabric performed the best of the untreated, and at least in the wickability test, the warp direction and weft direction of the plasma treated fabric had the higher wicking property. Thus, this study demonstrates that there are slight changes that occur in the comfort properties of surface modified fabrics, and each surface modified fabric performs differently in each comfort property such as air permeability, water vapour permeability and wickability

ACKNOWLEDGEMENT

We thank the management of Kumaraguru College of Technology for providing the necessary support in submitting this paper.

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