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Effect of Plasma Treatment on Mechanical Properties of Handloom Cotton Fabrics

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Abstract: *The surface engineering sector is growing in the last few decades. Primarily surface treatments are for providing enhanced functionality to the near surface regions. The plasma treatment has the potential to change the functional characteristics in the range of physical and topographical properties which are measured by field emission scanning electron microscopy (FESEM) for analytical microscopy study. The surface investigation conducted by FESEM provided distinctive features of Plasma treated and untreated hand loom cotton fabric samples. The plasma treated handloom cotton fabrics were dyed using natural colourant Curcuma longa (Turmeric) using mordants such as Alum and Myrobolan. The test result shows that a significant variation in mechanical properties such as tensile strength, elongation, stiffness and thickness of plasma treated dyed fabric when compare to parent fabric. Due to this attempt, the value addition of handloom cotton fabrics tends to enhance the socioeconomic conditions of handloom cotton weavers.*

Keywords: *Woven fabrics, Plasma treatment, FESEM, Natural dyes, Handloom cotton fabrics, mechanical properties, socioeconomic conditions, SEM images, Curcuma longa (Turmeric), Characterization*

1. INTRODUCTION

The value addition of conventional handloom cotton fabrics can be done by imparting special effects such as surface modification and finishing to meet the specific end uses. It is well known fact that wet based & heat based processing is costly, environmentally burdensome, consuming as well as wasting high quantities of chemicals, raw materials and huge amount of energy & water. An economically and environmentally reduction in water consumption is becoming necessery because of the increasing costs of water and effluents cleaning, which incurred high energy costs for after-treatment drying process.

A surface modification technology on traditional textile materials is a novel process, which can be added in textile materials to gain comfort, safety, aesthetics and functional performance. The main advantage of modifying surface layer of the handloom material is to increase the mechanical strength, flexibility, comfort properties and etc. In this study surface modification with help of Plasma treatment on handloom cotton fabric is carried out.

Plasma is fourth state of matter, next to solids, liquids and gases. A gas consists of freely moving atoms and or molecules. Free electrons present in the plasma treated fabric helps for surface modification and influencing on the top layer without changing the bulk characters. It is an environmentally friendly alternative to the conventional wet processing available form improving the surface properties and convert low energy surfaces to higher energy surfaces by attaching oxygen or organ gas plasma containing species to the surface. Characterising of plasma treated surface involve determining surface topography, mechanical strength and so on.

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2. Materials and Methods

A commonly available handloom cotton fabric has been selected for this study. Plasma treatment on handloom cotton fabric was done with Oxygen and Organ gases. The dyeing has been done using natural dye namely *Curcuma longa* (Turmeric) and mechanical properties have been critically analysed.

2.1 Materials

A handloom cotton plain weave fabric was selected for this study with the construction details are given below in table 1. The natural dye namely *Curcuma longa* (Turmeric) has been used to dye the fabric.

Table 1 handloom cotton woven fabric parameters

Sl no	Description	Values
1	Warp count	2/34^{s}Ne
2	Weft count	17^s Ne
3	Ends per cm	18
4	Picks per cm	23
5	Weight per square meter	159 grams
6	Cover Factor	19.90

2.2 Methods

A handloom cotton plain fabric was selected for this study as per construction details given in table 1. The natural dye namely *Curcuma longa* (Turmeric) has been used to dye the handloom cotton fabric. The field emission scanning electron microscope (FESEM) model ZEISS was used to study the changes in the surface morphology of plasma treated and untreated handloom cotton fabric samples. The assessments of topographical study to identify the changes in surface structure with help of field emission scanning electron microscope as well as analysis of mechanical properties are done on handloom cotton fabrics. The following mechanical properties characteristic have been studied by using the following standards:

Table 2 Mechanical Properties Testing Standards

Sl no	Properties	Standards	units
1	Tensile Strength	ASTM D 5035-11	kg
2	Elongation	ASTM D 5035-11	%
3	Stiffness	ASTM D 1388 -14	cm
4	Thickness	ASTM D 1777 -96	mm

3. Result & Discussion

The test was conducted on handloom cotton fabrics of plasma untreated, plasma treated natural dyed using *Curcuma longa* (Turmeric) with double mordants Alum and Myrobolan with the following mechanical properties testing tensile strength, elongation, stiffness and thickness and results have been shown in figure 1,2,3 and 4 which are then critically analysed. Accordingly, figures 5,6,7 SEM images of untreated handloom cotton fabric shows the differences in the corresponding SEM images of the Plasma treated and natural using *Curcuma longa* (Turmeric) with double mordants Alum and Myrobolan .

3.1 Mechanical Properties

The following mechanical characteristics like tensile strength, elongation, stiffness, thickness for the handloom cotton grey fabric, Plasma treated grey fabric, Plasma treated natural dyed fabrics have been tested and the results were given in graph form.

3.1.1) Tensile Strength Characteristic

The tensile strengthen characteristic for the handloom cotton grey fabric, Plasma treated grey fabric, Plasma treated natural dyed fabrics have been tested and the results were shown below:

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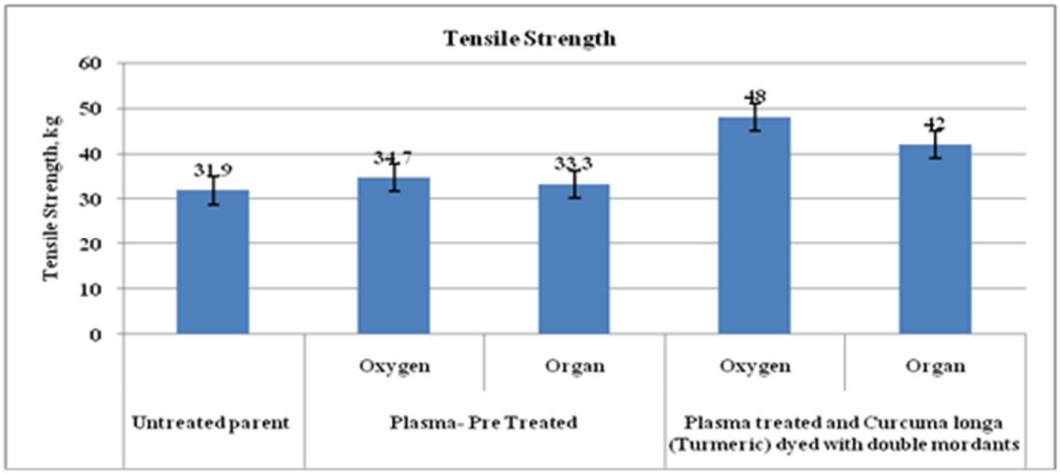

Figure 1 Comparison of tensile strength property of Plasma treated and untreated with natural dye *Curcuma longa* (Turmeric) dyed handloom cotton fabric

From the figure 1, it is observed that the maximum tensile strength of 48 kgs has been noticed in the Oxygen gas plasma treated natural dyed *Curcuma longa* (Turmeric) using double mordants. The lowest tensile strength of 31.9kgs has been noticed for the parent untreated grey fabric sample .

The tensile strength value has been slightly incresed to 33.3 – 34.7 kgs after Organ and Oxygen gas plasma treated grey handloom cotton fabric respectively and further increased to 42 - 48 kgs for Organ and Oxygen gas plasma treated natural dyed *Curcuma longa* (Turmeric) using double mordants respectively.

3.1.2) Elongation Characteristic

The elongation characteristic for the handloom cotton grey fabric, Plasma treated grey fabric, Plasma treated natural dyed fabrics have been tested and the results were shown below:

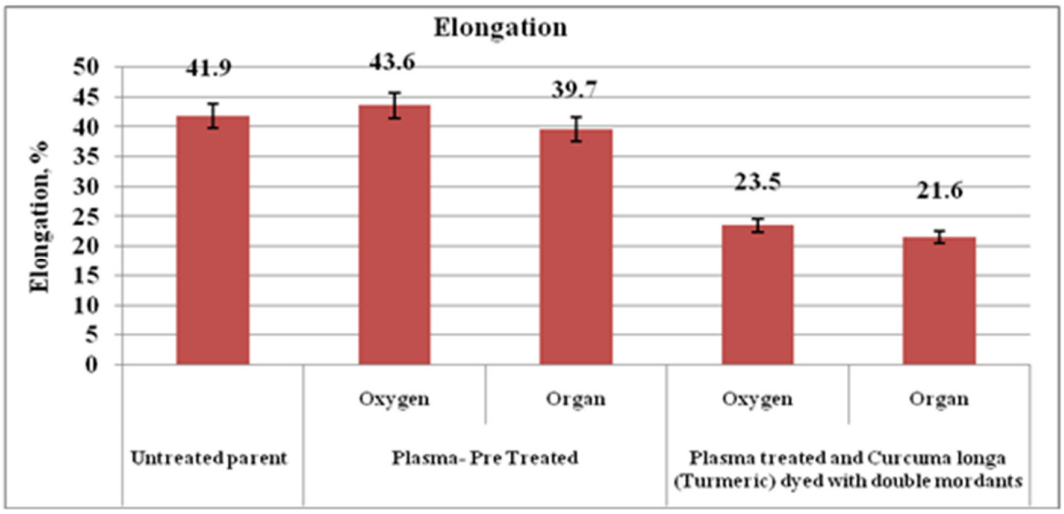

Figure 2 Comparison of elongation property of Plasma treated and untreated with natural dye *Curcuma longa* (Turmeric) dyed handloom cotton fabric.

From the figure 2, it is observed that the maximum elongation of 43.6% has been noticed in the Oxygen gas plasma pretreated grey fabric and slightly reduced value of 39.7% for Organ Plasma pretreated grey fabric.

The elongation value has been further reduced to 21.6 – 23.5 % after Organ and Oxygen gas plasma treated and dyed with *Curcuma longa* (Turmeric) using double mordants Alum and Myrobolan respectively.

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3.1.3) Stiffness Characteristic

The stiffness characteristic for the handloom cotton grey fabric, Plasma treated grey fabric, Plasma treated natural dyed fabrics have been tested and the results were critically analysed:

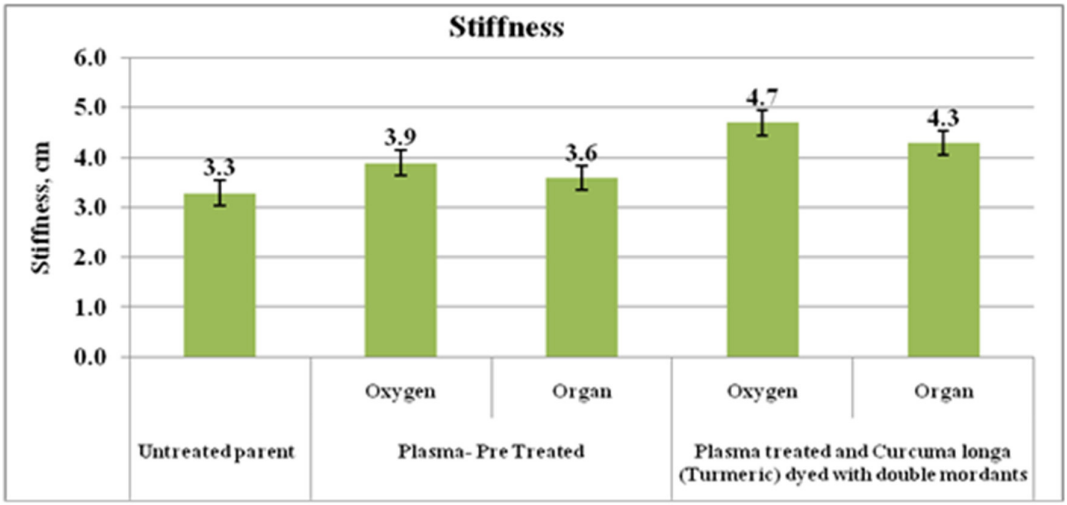

Figure 3 Comparison stiffness property of Plasma treated and untreated with natural dye *Curcuma longa* (Turmeric) dyed handloom cotton fabric.

From the figure 3, it is observed that the maximum stiffness value of 4.7 cms have been noticed in the Oxygen gas plasma treated *Curcuma longa* (Turmeric) natural dye using double mordants. The stiffness value is slightly reduced to 4.3 cms for Organ gas plasma treated *Curcuma longa* (Turmeric) natural dye using double mordants.

The stiffness value is low 3.6 – 3.9 cms for Organ & Oxygen gas plasma pretreated grey fabric sample but furher low value of 3.3cms is noticed in case of parent grey fabric sample.

3.1.4) Thickness Characteristic

The thickness characteristic for the handloom cotton grey fabric, Plasma treated grey fabric, Plasma treated natural dyed fabrics have been tested and the results were critically analysed.

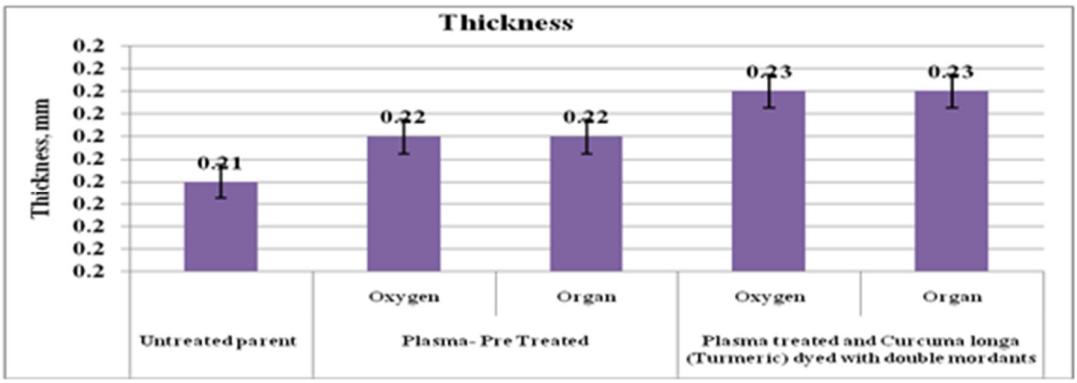

Figure 4 Comparison thickness property of Plasma treated and untreated with natural dye *Curcuma longa* (Turmeric) dyed handloom cotton fabric.

From the figure 4, it is observed that the maximum thickness value of 0.23mm was noticed for Oxygen and Organ gas plasma treated *Curcuma longa* (Turmeric) natural dye using double mordants.

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The slightly reduced thickness value of 0.22mm wase noticed in Oxygen and Organ Plasma treated pretreated grey fabrics and where as the thichness value 0.21mm is noticed for grey handloom cotton fabric.

3.2. Morphological Analysis

The morphology of plasma treated and untreated handloom cotton fabrics were investigated using field emission scanning electron microscopy (FESEM). SEM images were given in figures 5, 6 and 7 confirmed a noticeable difference in surface morphology of the fabric after plasma treatment. Deposition on the surface of fabric samples with plasma treated natural dye using *Curcuma longa* (Turmeric) with double mordants was observed. The test results of handloom cotton fabrics of plasma untreated and plasma treated and dyed were discussed below:

3.2 Characterisations by SEM

The possible change of surface morphology before and after plasma treatment has been evaluated by scanning electron microscope. Comparing the SEM images, the morphological changes are obvious between plasma treated and untreated handloom cotton fabric as shown below:

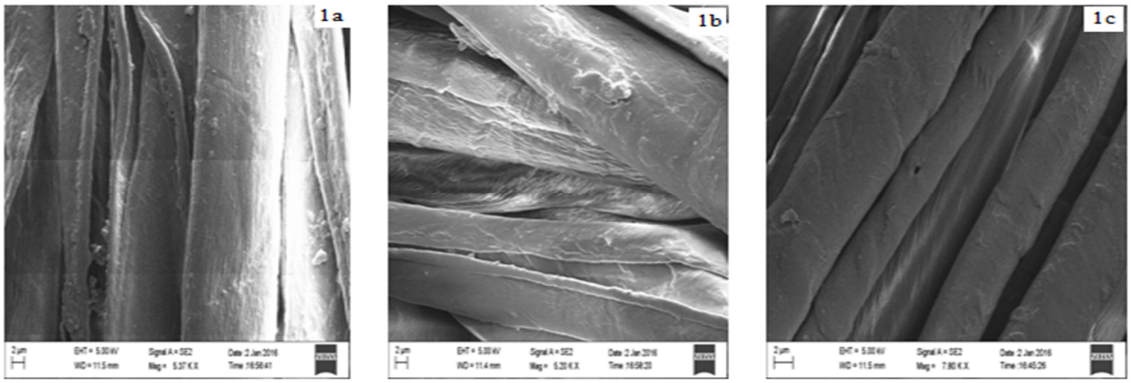

Figure 5.SEM micrograph image comparision of grey handloom cotton fabric (1b) with Oxygen and Organ gases Plasma treated grey handloom cotton fabric (1a,1c) respectively.

From figure 5, the SEM micrograph images of grey handloom cotton fabric (figure 1b) is compared with Oxygen plasma treated grey (figure 1a) handloom cotton fabric and Organ plasma treated grey (figure 1c) grey handloom cotton fabric.

According to figure 5, the SEM micrograph image of Oxygen plasma treated grey handloom cotton fabric (figure 1a) and Organ plasma treated grey handloom cotton fabric (figure 1c) have visible smooth surface differences noticed from the corresponding parent grey handloom cotton fabric (figure 1b) because of plasma treatment surface modifications.

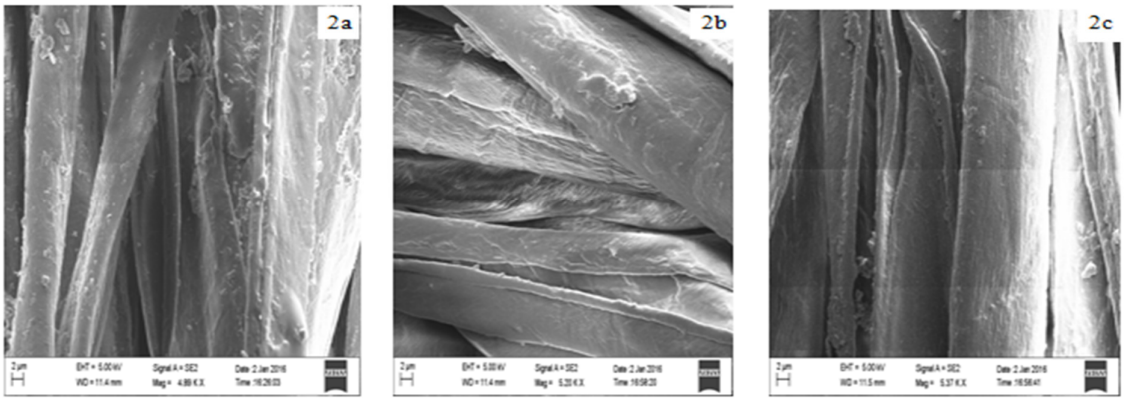

Figure 6.SEM micrograph image comparision of parent handloom cotton fabric (2b) with Oxygen Plasma treated grey handloom cotton fabric (2c) and Oxygen Plasma treated natural dyed *Curcuma longa* (Turmeric) with double mordant handloom cotton fabric (2a)

From figure 6, the SEM micrograph images of handloom cotton grey (figure 2b) is compared with Oxygen plasma treated grey handloom cotton fabric (figure 2c) with Oxygen Plasma treated natural dyed *Curcuma longa* (Turmeric) with double mordant handloom cotton fabric (figure 2a).

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It is observed from figure 6, the SEM micrograph image of Oxygen plasma treated natural dyed *Curcuma longa* (Turmeric) using double mordant handloom cotton fabric (figure 2a) shows dye deposit particles and which is clearly visible from corresponding grey handloom cotton fabric (figure 2b) and Oxygen plasma treated un-dyed grey handloom cotton fabric (figure 2c).

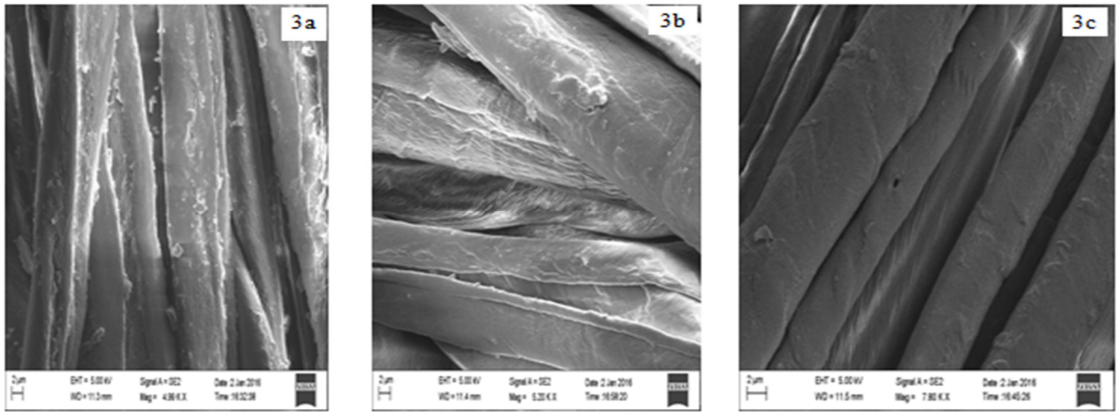

Figure 7.SEM micrograph image comparision of parent handloom cotton fabric (3b) with Organ Plasma treated grey handloom cotton fabric (3c) and Organ Plasma treated natural dyed *Curcuma longa* (Turmeric) with double mordant handloom cotton fabric (3a)

From figure 7, the SEM micrograph images of parent handloom cotton (figure 3b) is compared with Organ plasma treated grey (figure 3c) handloom cotton fabric with Organ Plasma treated natural dyed *Curcuma longa* (Turmeric) with double mordant handloom cotton fabric (figure 3a).

It is observed from figure 7, the SEM micrograph image of Organ plasma treated natural dyed *Curcuma longa* (Turmeric) using double mordant handloom cotton fabric (figure 3a) shows dye deposit particles and which is comparably visible from corresponding grey handloom cotton fabric (figure 3b) and Oxygen plasma treated un-dyed grey handloom cotton fabric (figure 3c).

4. Conclusion

The effect of plasma treatment on mechanical properties and surface modifications of handloom cotton fabric were investigated. The FESEM results of plasma treated handloom cotton fabric shows the clear change in surface. The result confirms the plasma treatment shall change the surface of the handloom cotton fabric. Examination of surface morphology revealed that plasma treated handloom cotton fabric have significantly smoother surface than that of untreated handloom cotton fabrics and mechanical properties test results also confirms the changes in handloom cotton fabric sample after plasma treatment.

5. References

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