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Development of Plasma Treated Cotton and Cotton/ Nylon Interwoven Fabrics

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Abstract: *Plasma technology is an emerging field to modify the surface molecule structure of the fabrics. In this work, optimization of plasma process parameters for the development of plasma treated cotton and cotton/nylon interwoven fabrics have been done. The effect of pretreatment on the fabrics was assessed by absorbency properties studies. Characterizations of plasma treated fabrics have been analyzed using Fourier Transform Infra Red (FTIR) Spectroscopic has been also discussed in this chapter. The optimized plasma process parameters were treatment time of 60 sec, pressure of 0.5 mbar, electrode distance was 0.2 cm and the reactor gas was air. Plasma treated cotton woven fabric absorbency time reduced to 2.3 seconds and cotton/ nylon interwoven fabric absorbency time reduced to 5.3 seconds. The reduction in the time of absorbency represents the improvement in the functional polar groups of the plasma treated fabrics. It is confirmed by FTIR spectroscopic analysis.*

Keywords: *Cotton, plasma, cotton/nylon interwoven fabric, absorbency*

1. INTRODUCTION

Plasma is a substance called as the fourth state of matter whose atoms has detached electrons and, therefore, become ionized. Due to detachment of electron in the gas by ionization process which remains the plasma as electrically neutral. Hence plasma, ionized gas, has nearly equal number of positive ions and negative ions. Generally, the plasma can be generated by laser light irradiance or high temperature heating which create speedy electrons. These electrons can induce the ionization of gas molecules that result large concentrations of energy in the plasma. Many industries utilize plasma process as a non-conventional technique in efficient way. Plasma technology offers an eco-friendly method for textile processing. As Plasma Technology offers many aforementioned advantages, the same was adopted in this work for the surface modification of textile substrates. (Shiskoo et al. 2007)

Three types of plasma processes have been referred for general purpose. Modification of surface structure of the material is generally carried out with glow discharge plasma which involves noble gases such as oxygen or air. Second application is plasma grafting or polymerization on the surface Third application is plasma cleaning which remove topical substances from the substrate surface by means of plasma treatment. (Hegemann, 2006).

Increasing of functional polar groups or changing non-polar groups into polar groups in the surfaces will be made by plasma treatment to improve water absorbency. Functional groups can be made more polar groups to improve wettability and hence dye absorbency of textile material which is unutilized area in plasma application. Plasma treatment on textiles leads to much modification in textile material which can enhance its functional performance. (Guimond et al 2010). Based on end uses of the textile products, various types of gases have chosen for the surface modification of textile materials. Argon, nitrogen, oxygen, air, inert gases i.e. helium and mixture of these gases are also used to achieve enhanced process performance and flexibility in the processing methods (Kutlu and Cireli 2004).

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Enhancement of properties of textile material is mainly depending on the reaction between surface molecule and plasma. Therefore, it becomes essential to optimize the process parameters so as to obtain better quality in plasma treatment. Response Surface Method and Taguchi Method are generally adopted in design of experiments to optimize the required output parameters. In this study, Taguchi method, a robust mathematical tool, is used to optimize the plasma process parameters.

2. Materials and Methods

The grey cotton fabric for dyeing having the specification of 140 g/ m^2, warp 34 threads/cm, Yarn count 40/1, weft 33 threads/cm was used. A 50/50% cotton/nylon interwoven fabric with an aerial density of 150 gsm was selected.

2.1 Selection of Plasma Process Parameters

These dissociated ions and the free electrons in the excited state, etched the topical surface of the textile substrate kept between the electrodes. Such bombardment of electrons in the excited state resulted in the formation of polar groups which thereby resulted in the development of plasma which is utilized for the surface modification of fabrics. These polar functional groups formed, were responsible for enhancement of carboxyl and aldehyde groups in the case of in cellulose substrate

The effectiveness of plasma treatment is influenced namely by three process parameters such as the distance between the electrodes, duration of plasma treatment and pressure inside the plasma chamber. A way in this research work, statistical technique has been adopted for optimization plasma process among above said three parameters. In this study, Taguchi method, a statistical tool, has been used to select these essential three plasma process parameters.

Table 1 Process Parameters and their Levels

Process parameters	Level 1	Level 2	Level 3
Treatment Time (Sec)	30	60	90
Pressure (mbar)	0.25	0.5	0.75
Electrode Distance (cm)	0.1	0.2	0.3

Based on literature survey, the three levels of design parameters have been formulated. The three levels of treatment parameters of 30 seconds, 60 Seconds and 90 Seconds for treatment time, three levels such as 0.25 mbar, 0.5 mbar and 0.75 mbar for pressure and the three levels of 0.1cm, 0.2 cm and 0.3 cm for electrode distance that have been selected .

2.2 Designing of Taguchi's Orthogonal Array

Orthogonal arrays are particular experimental design developed by Taguchi that involve minimum number of experimental trials that help to identify the critical factors. These arrays were used to study the influences of plasma parameters which would have high influence on the process of characteristic of textile material. The Taguchi's method recommended typical design of orthogonal array which used to optimize the process parameters.

2.3 Absorbency Characteristics of Plasma Treated Cotton Fabrics

Based on the orthogonal array of experimental design nine different plasma treated cotton samples were produced and their absorbency characteristics of the same have been studied as per AATCC 97 test method and their absorbency on the nine sample has been tabulated in 4.3. From the fabric absorbency value, optimization of plasma process parameters carried out using Taguchi's statistical tool.

Table. 3 Effect of Process Parameters in terms of absorbency value for cotton woven fabrics

Expt. No	Treatment Time (Sec)	Pressure (mbar)	Electrode Distance	Absorbency value (Sec)
1	30	0.25	0.1	3.4
2	60	0.5	0.2	3.0
3	90	0.75	0.3	3.7
4	30	0.25	0.2	2.5
5	60	0.5	0.3	2.2
6	90	0.75	0.1	3.2
7	30	0.25	0.3	4.2
8	60	0.5	0.1	3.2
9	90	0.75	0.2	3.9

2.4 Absorbency Characteristics of Plasma Treated Cotton/Nylon Interwoven Fabrics

Based on the orthogonal array of experimental design nine different plasma treated cotton/nylon interwoven samples were produced and their absorbency characteristics of the same have been studied as per AATCC 97 test method and their absorbency on the nine sample has been tabulated in 4.4. From the fabric absorbency value, optimization of plasma process parameters carried out using Taguchi's statistical tool.

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Table 4.4 Effect of Process Parameters in terms of absorbency value for cotton/nylon interwoven fabrics

Expt. No	Treatment Time (Sec)	Pressure (mbar)	Electrode Distance	Signal/Noise Ratio of Absorbency
1	30	0.25	0.1	5.6
2	60	0.5	0.2	5.3
3	90	0.75	0.3	6.9
4	30	0.25	0.2	4.7
5	60	0.5	0.3	3.9
6	90	0.75	0.1	5.5
7	30	0.25	0.3	6.0
8	60	0.5	0.1	5.4
9	90	0.75	0.2	5.7

2.5 Characterization of Plasma Treated Fabrics by FTIR Analysis

Fourier Transform Infrared spectroscopy was performed for the untreated, plasma treated cotton and cotton/nylon interwoven fabrics to analyze the changes in the chemical structure. The Fourier Transform Infra Red Spectrogram of the untreated woven cotton fabric can be seen in the form of graph in Figure 1. The peaks were found at different wavelengths of 1052.70 cm^{-1}, 1428.03 cm^{-1}, 1629.28 cm^{-1}, 2897.28 $cm^{-1}$and 3335.76cm^{-1}. The peak at the wave length of 1052.70 cm^{-1} represents the O-H bend which indicates the presence of carboxylic acid. The increasing of a peak at the wave length 3335.76 cm^{-1} indicates the introduction of the presence of O-H stretch which in turn represents the increasing of carboxylic acids.

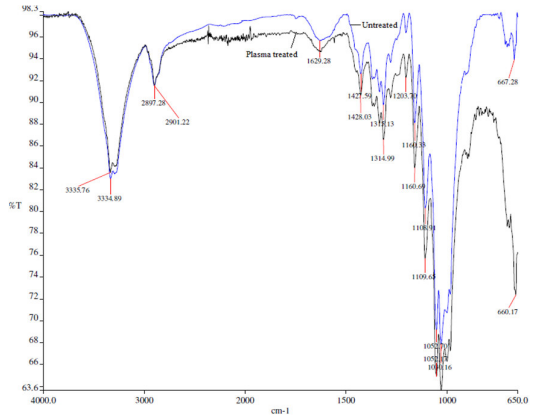

Figure 1 FTIR spectra of untreated and plasma treated cotton fabrics

3. Conclusion

The pretreatment process of cotton and cotton/nylon interwoven fabrics were carried out with air plasma. Optimization of plasma parameters was carried out using Taguchi method. The optimized plasma process parameters were treatment time of 60 sec, pressure of 0.5 mbar, electrode distance was 0.2 cm and the reactor gas was air. The effect of plasma pre-treatment on the fabrics was evaluated by absorbency characteristics studies. Plasma treated cotton woven fabric absorbency time reduced to 2.3 seconds and cotton/ nylon interwoven fabric absorbency time reduced to 5.3 seconds. The reduction in the time of absorbency represents the improvement in the functional polar groups of the plasma treated fabrics. It is confirmed by FTIR spectroscopic analysis.

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