

Atmospheric Pressure Plasma Surface Treatment of Rayon Fabrics

S. Nithya, K.R. Aranganayagam, C. Nithesh

Abstract: The low temperature plasma is used to enhance the surface properties of rayon fabrics. The bulk properties of rayon fabrics are not affected by plasma treatment which is confirmed by XRD and FTIR studies. The investigation on the wettability of the rayon fabrics is the prime purpose of the study. The study includes the outcome of the investigational parameters of the glow discharge such as the pressure of gas, the time taken for the treatment and discharge voltage on the samples wettability.

Keywords: XRD, Plasma, Wettability, Rayon

I. INTRODUCTION

Rayon fibres are the oldest commercial manmade fibre made from regenerated cellulose. Since they are more shiny, comparatively soft than cotton and drapable; they are often used in summertime garments. The normal progress rates in the production of rayon fabrics in Asia [1] are relatively higher when compared to the fabrics other than of rayon. Regular rayon, particularly when it is wet, has the low rate of appearance maintenance and durability. It also possesses the minimum elastic recovery of fibre. To alter the properties of the rayon fabrics, investigations were done with the use of plasma treatment on it. Plasma technology has occupied a unique position as an alternate to the traditional and the old processing technique; this is made possible by the modification done on the materials without affecting the primary properties of the textiles. [2-7]. Figure 1 shows how the plasma treatment involves the bombardment of ions, electrons, neutral and radicals, on the surface of fabrics. Chemical bonds are dissociated by some of these active species thereby initiating reactions on the surface of fibre. The difficulty of the polymer composition and the gas phase finds it difficult to separate and analyse the particular responsibilities of the component in each plasma [8]. The reality of the substrate and the operating conditions during the treatment shall affect the efficiency in plasma treatment. Surface modification on rayon fabrics are carried out in order to enhance its durability [9]. With the aid of plasma treatment, the wettability properties in the textile materials could be modified. Many studies on plasma surface modification which enhances the wettability have been reported [10-16]. Also plasma treatment improved the water vapor permeability of bamboo fabric [17]. There is proportion increase in water vapour permeability and air permeability with bamboo fibre [18-19]. In this paper, rayon fabrics are processed with low temperature plasma treatment and its wettability measurements are studied.

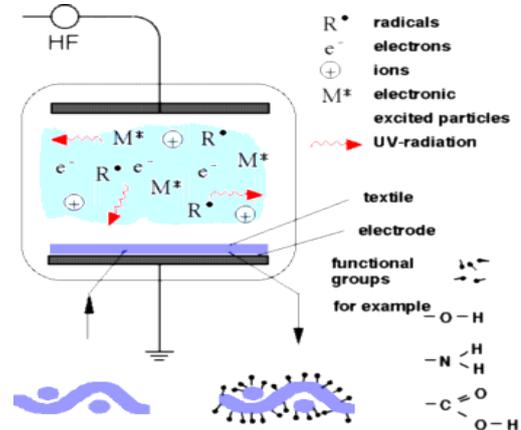


Fig. 1 Principle of Plasma Treatment

II. EXPERIMENTAL

Undyed rayon fabrics, dispersed dyes and doubly distilled water are used in this study.

A. Treatment of plasma

The surface processing of rayon fabric was done in atmospheric plasma equipment. Figure 2 clearly shows the total setup of the experimental structure. Plasma chamber, power supplies, electrodes, substrate holders and vacuum system are the major components of the experimental structure. The plasma chamber is initially made clean using water and later with the distilled water. Further it is dried and using the acetone, it is cleaned again. The vacuum system contains of a double stage rotary pump. All experiments are carried out in the dry air. Rectangular rayon samples are implanted into the plasma reactor and exposed to plasma. The plasma treatment time is 5 minutes for a potential of 350 V maintained at a pressure of 0.08 mbar.

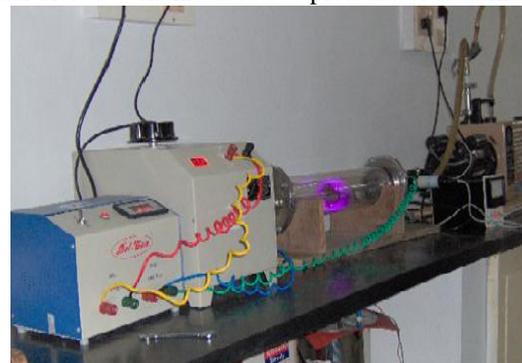


Fig.2. Plasma chamber

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S. Nithya, Department of Science & Humanities, Kumaraguru College of Technology, Coimbatore, Tamilnadu, india

K.R. Aranganayagam, Physics Division, Kumaraguru College of Technology, Coimbatore, Tamilnadu, india

C. Nithesh, Department of Science & Humanities, Chemistry Division, Kumaraguru College of Technology, Coimbatore, Tamilnadu, india

B. Characterization

Using the $Cu\alpha$ radiation at a rate of 0.3 sec, the samples are scanned and analysed in the 20° - 30° (2θ) scale angle range. Using the Bruker AXS D8 automated X-ray diffractometer, the samples are analysed. In order to find any sort of modifications in the chemical structure on surface of the fabric that is untreated as well as plasma treated rayon samples, usual settings with a Germanium-coated KBR plate and (FTIR-8400s SHIMADZU) Fourier transform infrared spectrometer are used. Further to the plasma treatment, capillary rise method is used to identify the wettability on the rayon fabrics.

III. RESULTS AND DISCUSSION

A. X-Ray Diffraction

XRD is used to examine the nature of crystalline of rayon fabrics. The XRD patterns of treated and untreated rayon fabrics are shown in Figures 3a & 3b. Cellulose II crystal structure is possessed by Rayon fibres. 3 peaks are observed in untreated rayon fabrics at $2\theta = 12.5^{\circ}$, 21.3° , and 22.3° corresponding to the (101), (101), and (002) lattice planes, respectively, of cellulose II. XRD results revealed that the amount of intensity of diffracted XRD by plasma treated rayon fabrics was reduced. No significant change was observed in rayon fabrics after plasma treatment thereby indicating that the treatment does not give bulk effect.

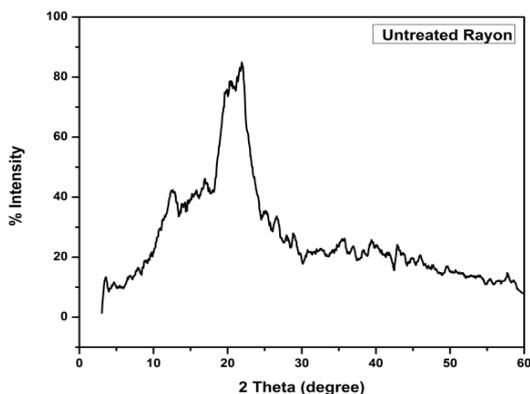


Fig.3a: XRD pattern of untreated rayon fabric

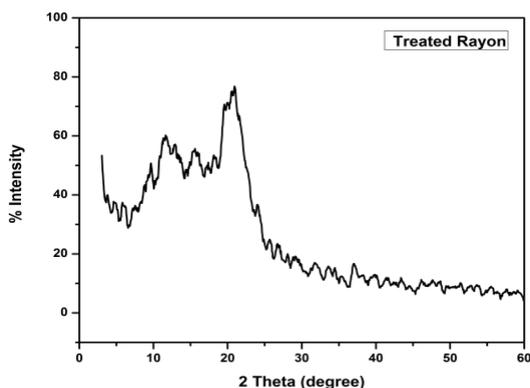


Fig. 3b: XRD pattern of treated rayon fabric

B. FTIR Analysis

To confirm the earlier conclusion on the basis of X-ray diffraction studies which states that the plasma etching is only a surface phenomenon, the infrared studies were carried out for rayon fabrics. To deduct the various types of vibrations present in any compound, the FT-IR spectroscopy is recognized as one best mechanism which is possible. In FT-IR spectra, plots are drawn between frequency or Wave number and intensity of absorption. Figure 4a and 4b shows the FTIR spectra of treated and untreated rayon fabric. In plasma treated rayon fabric, the bands around 3473, 3305 and 3232 cm^{-1} corresponds to alcoholic OH stretching. The bands around 2904 cm^{-1} and in the region 1442 cm^{-1} are because of C-H stretching and C-H bending. Carboxyl groups were noticed in the plasma treated rayon fabric with bands at 1797 cm^{-1} corresponding to C=O stretching. Bands near 1200–1400 cm^{-1} correspond to O–H bending bands. The O-H groups will enhance the wettability and dyeability of the plasma treated rayon fabric.

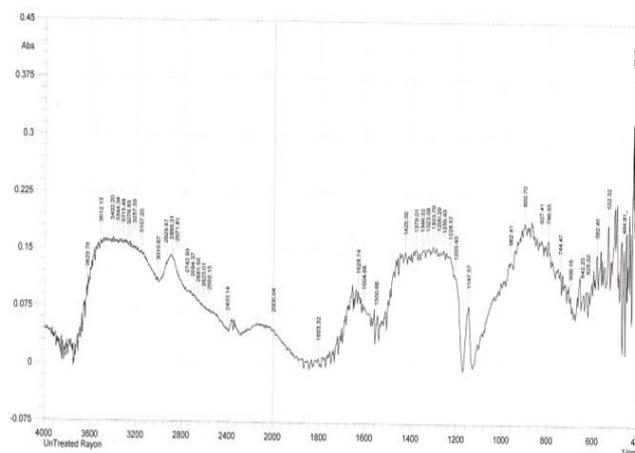


Fig. 4a FTIR spectra of untreated rayon fabric

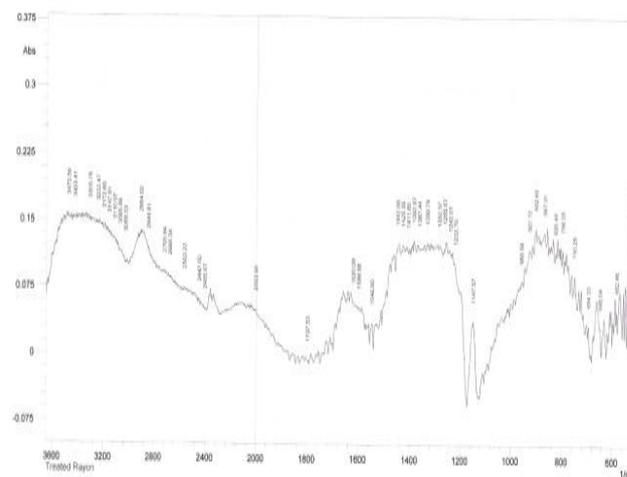


Fig. 4b FTIR spectra of plasma treated rayon fabric

C. Wettability Measurements

Immediately next to the plasma treatment, wettability test is carried out in rayon fabrics. This process paved a better way for the spontaneous wicking. The readings of absorption height were taken consequently as a result of the capillary forces. The surface of the untreated rayon fiber is rougher and chemically more heterogeneous than that of the treated fiber. The absorption height of plasma treated rayon fabrics was increased by increasing the treatment time, the gas pressure and the discharge voltage. Figure 5a, 5b and 5c represents the dye uptake data of plasma treated rayon fabrics against gas pressure, discharge voltage and treatment time. From the results of the graph, samples that are treated with the plasma has shown a prominent and considerable improvement in dye uptake. this can be compared with the ones that are not treated. This shows that the dye uptake of rayon fabrics was increased by plasma treatment, gas pressure and voltage.

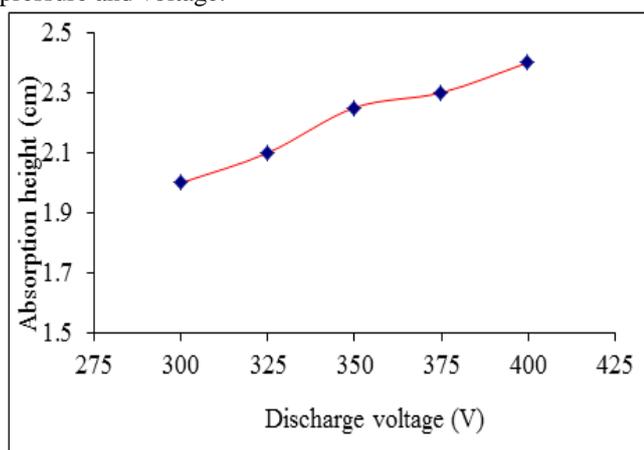


Fig.5a Effect of discharge voltage on wettability of rayon fabrics

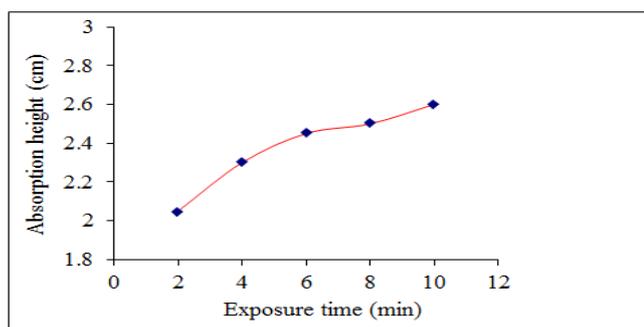


Fig.5b Result of time taken for treatment on wettability of rayon fabrics

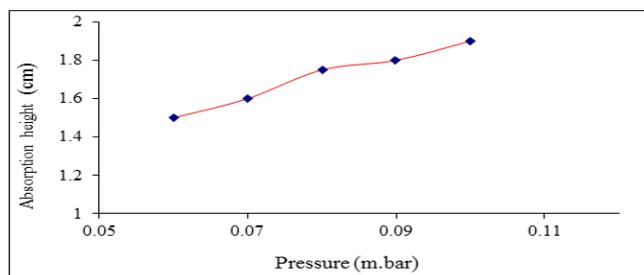


Fig.5c Effect of pressure on wettability of rayon fabrics

IV. CONCLUSION

The results of low temperature plasma treatment on rayon fabrics are investigated. Plasma treatment does not disturb the bulk property of rayon fabrics which are confirmed by XRD and FTIR studies. The wettability of the rayon fabric had been remarkably enhanced by plasma treatment by varying gas pressure, discharge voltage and treatment time.

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