Available online at www.sciencedirect.com
ScienceDirect
Surface & Coatings Technology 201 (2007) 4926–4930
SURFACE & COATINGS TECHNOLOGY
www.elsevier.com/locate/surfcoat

Comparison between decolorization of denim fabrics with Oxygen and Argon glow discharge

M. Ghoranneviss [a], S. Shahidi [a,*], B. Moazzenchi [a], A. Anvari [b], A. Rashidi [a], H. Hosseini [a]

[a] Plasma Physics Research Center, Science and Research Campus, Islamic Azad University, Tehran, P.O.Box: 14665-678, Iran
[b] Physics Department, Sharif University of Technology, Tehran, Iran'

Available online 23 August 2006

Abstract

In this study, we have used a low temperature plasma, produced by a DC magnetron sputtering device, for decolorizing of denim fabrics, and the effect of using different gases such as Argon and Oxygen as the discharge medium have been investigated. The results obtained under equal periods of time have been compared and the effect of washing on the treated denims has been reported.

PACS: 82.33.Xj; 81.05.Lg; 42.81.Cn; 52.77.-j
Keywords: Cold plasma; DC discharge; Decolorization; Denim; Fabrics

1. Introduction

Denim jeans have consistently been fashionable in the world. This fabric inspires strong opinions from historians, teenagers, and movie stars, and has acquired different styles throughout the years. It was traditionally colored blue with indigo dyes to make blue jeans. Most jeans today are stonewashed, to achieve a soft handle as well as desirable worn look. However, at present the aged look is obtained by non-homogeneous removal of the indigo dye trapped inside by the cooperative action of the enzymes and mechanical factors such as beating and friction [1–3].

The use of natural pumice stones in denim garment washing has some disadvantages. The difficulty of removing residual pumice from processed clothing items, the damage to the equipment by the overload of tumbling stones and pumice stones and particulate material, clogging of the machine drainage passages and the drains and sewer lines at the machine site are some of the problems that may arise [1,4,5].

Recently, in addition to pumice stones, cellolytic enzymes are used on the cotton fabrics and create stonewashed look, but the average duration of the process is 90 min.

The production of discolored jeans through conventional technology contaminates large quantities of water with chemical products used in the process [6].

Recently, dry modification processes that generate no waste have been introduced, such as, sputtering and chemical etching cold plasma techniques [7,8]. The Low Temperature Plasma (LTP) Technique is used widely to modify polymer and textile materials. LTP contains radicals, ions, photons and other excited species. By controlling the plasma variables, such as nature of gas, the discharge power, the pressure and exposure time, a great variety of surface effects can be generated [9,10].

Both non-polymerizing and polymerizing gases can be used in LTP treatment. However, the final results of LTP will depend largely on the nature of the gases utilized [11].

In this study, we have compared the effect of low temperature plasma of Argon with LTP of Oxygen on decolorization of denim fabrics.

2. Experimental

In this experiment a sputtering device was employed for decolorizing of the samples. The apparatus consists of two coaxial cylinders as shown in Fig. 1, in which a low current DC glow discharge (under 1200 V and 100 mA) could be produced radially between anode and cathode. The system was evacuated using a

* Corresponding author. Tel.: +98 21 44815921; fax: +98 21 44817165.
E-mail address: shahidish@yahoo.com (S. Shahidi).

0257-8972/$ - see front matter © 2006 Elsevier B.V. All rights reserved.
doi:10.1016/j.surfcoat.2006.07.162

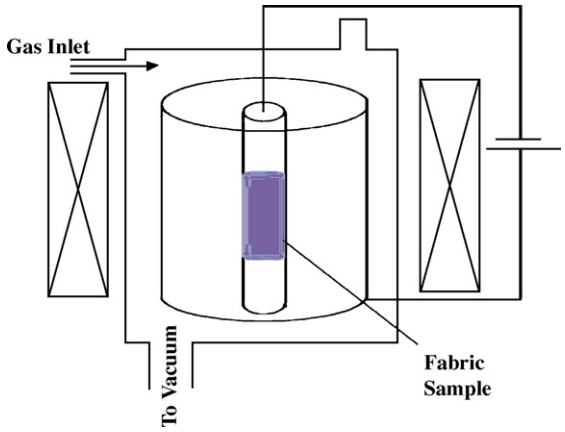

Fig. 1. Experimental setup.

rotary pump, and then filled with oxygen or argon gas to the pressure of 10^{-2} Torr.

Denim fabrics (from Pars Takmill, Ghom,Iran, and 100% cotton) were placed on the cathode and exposed to the plasma for different period of times e.g. 5, 10 and 15 min. The fabrics were first washed with 1% nonionic detergent solution in 70 °C water for 15 min and then rinsed with water for another 15 min before LTP treatment, in order to minimize the change of contamination. After LTP treatment some pieces of samples were washed again to remove any dyes left on their surfaces. The morphology of the samples was observed using a Scanning Electron Microscopy (SEM) (LEO 440I), while the surface reflection (R) and the amount of color strength (K/S) were measured by a (Carry 500 UV–VIS NIR) reflective spectrophotometer.

Also the percentage of crystalinity of the samples was determined by SEIFERT (PST-3003) X-Ray Diffractometer and the load and elongation at break value, (tensile strength) was measured by an INSTRON 4302 Tensile-Tester at a cross head speed of 50 mm/min.

3. Result and discussion

In this research instead of using stonewash technique for decolorization of denim fabrics, we have examined the sputter technique. This technique does not need any pumice stone or related enzymes which are usually expensive and tend to reduce the strength of the materials.

In this study, the decolorization of denim fabrics by two non polymerizing gases such as Ar and O_2 have been investigated and the results have been compared. In sputtering treatment, attacking of active particles (ions, radicals, electrons, etc.) to the surface of fabric placed on the cathode, would sputter the surface dyes from the fabrics. In Ar LTP the dyestuff are removed from the denim, leaving a very smooth and varnish surface on the fabrics. As Argon is not a reactive gas, no reaction appears between fabrics and this gas, while in Oxygen sputtering, in addition to sputtering of the surface dyes, the Oxygen active radicals can create functional groups on the surface of denim fabrics [7,12–15], so, some dyes that remained on the surface of fabrics would be oxided. However after washing the treated samples, the varnish of the oxygen treated sample looks better than the argon treated one (Fig. 2). This is because that, in water environment, the affinity of oxided dyes to water is more than that of fibers, so the oxided dyes would be removed by washing.

3.1. Scanning electron microscopy (SEM)

We used SEM technique to investigate the morphology of the surfaces both before and after plasma treating. A view of untreated denim is shown in Fig. 3 (a) and the results of 15 minutes treating, using Ar and O_2 as the discharge medium, are shown in Fig. 3 (b) and (c) respectively. As shown the porous areas of both treated samples have been partially removed and the surface of these samples is smoother than untreated sample. However after washing the treated samples Fig. 3 (d) and (e) as the oxided dyes produced by oxygen have more affinity to the water than to the fabric, the results allocate better properties to the O_2 treated samples than those treated by Argon.

3.2. Reflective spectrophotometery

Color intensity of the samples was measured by a reflective spectrophotometer (500 UV VIS–NIR), over the range of 300–500 nm, and the reflection factors (R) were obtained, (the

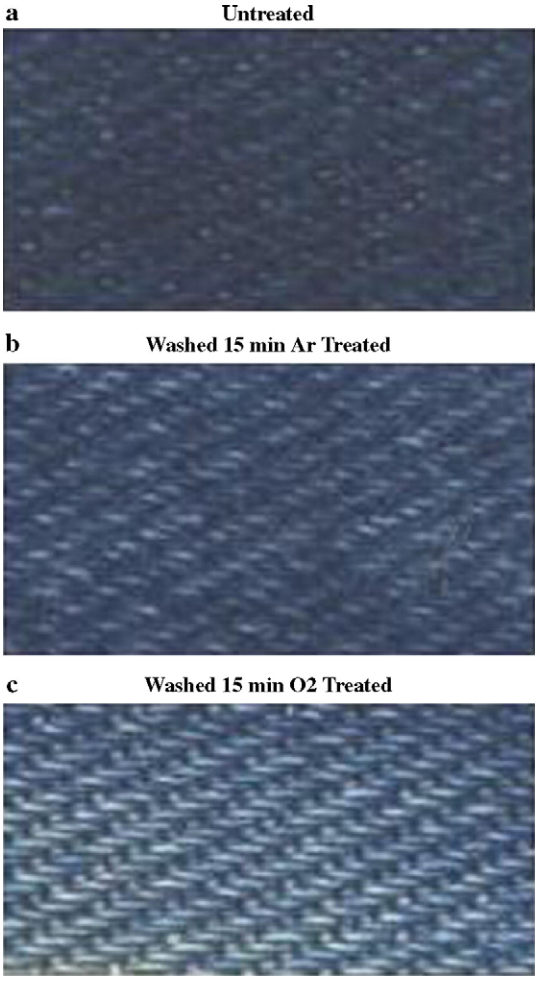

Fig. 2. Photographs of untreated (a) washed 15 min O_2 LTP treated sample. (b) Washed 15 min Ar LTP treated sample (c).