POSSIBILITIES OF INVESTIGATIONS FOR MICROSTRUCTURED TEXTILE SUPPORTS

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Abstract

Testing and control of textiles represents a quality warranty and, in the same time, a way to assure a motivation of research activity in the laboratory. The paper is focused towards different alternatives of testing for microstructured/functionalized textile surfaces by laser irradiation. The optic investigations used are relevant for the changes obtained by the irradiation surface treatments of textiles. The study and characterization of microstructured surfaces were achieved through microscopic techniques, as well as contact angle measurement. The comparative study possibilities of tests on textiles, as well as the obtained results may lead to a complete and safe characterization of the induced modifications with positive effects onto textile goods comfort properties.

Key words:

Textile surface modification, stereomicroscopy, AFM, SEM, contact angle measurement.

1 INTRODUCTION

In textile processing, the surface properties of a fiber or a fabric are extremely important. These characteristics may be affected by the UV-laser induced surface modification.

There is a strong need to modify the polymer surface with keeping their desired unchanged bulk properties, with application in many industrial fields. Chemical

activation of the surfaces is the most often used method; however the ecological requirements force the industry to search alternative environmental safety methods. Laser irradiation induces microstructured of polymers meaning a roughness alteration, achieving to a ripple like microstructure.
The aim of the present work was to summarise the investigations already made on previous studies of the authors, on some fabrics surfaces, by means of laser treatment, in order to improve their hydrophilic properties [1,2].
Many laser applications in the surface modification field were made at reduced fluencies [3]. Significant increase in the hydrophilicity of laser treated materials was observed but the application in industry has many disadvantages, mainly problems with a long processing times and high energy consumption.

2 EXPERIMENTAL

2.1 Materials

In this study the laser activation of fabrics made by 100% viscose, polyamide and polyester was investigated.

2.2 Procedures

White plain weaves samples were conditioned at 20 ± 2 °C and 65 ± 2% relative humidity before the preparation stage technology.
Irradiation was performed using a femtosecond (fs) LPX 200 Excimer 248 nm KrF.
The samples were irradiated directly from the laser beam without using either special photo mask or focusing lens. The parameters of the treatment are: constant energy (170 mJ) fluence (29 – 43 mJ/cm^2) and number of pulses (1 – 4) vary from experiments in order to study their effects upon samples. The pulse repetition was kept constant at 1 Hz to avoid any possible heat accumulation.

2.3 Testing methods

The microstructure of surface samples has been characterized by means of some co assisted testing methods. The surface properties of treated and untreated samples were characterized by means of the contact angle measurement and the water permeability measurement.
The morphology of samples was investigated by Stereomicroscopy, Scanning Electron Microscopy (SEM) and Atomic Force Microscopy (AFM)
The measurement of water contact angle was performed using a Sigma 700 computer-controlled research tensiometer. Water permeability of samples before and after laser treatment was determined measuring the time necessary for the penetration of 5 ml of the testing liquid across the sample. The absorption properties of sample were measured as a difference of the weights of the sample before and after the dipping in the testing liquid. The contact angle was measured directly from the observation of the solid-liquid meniscus.
Stereomicroscopy was performed using a LEICA DM-RM Stereomicroscope (Germany) with magnitude of 20".
Scanning Electron Microscopy (SEM) (TESCAN). All samples were gold coated prior to SEM examination.

Atomic Force Microscopy (AFM). AFM is the one of the effective tools to examine the microstructures of fibres. It is able to scan materials without any special preparation at normal temperature and pressure. The AFM used in this study was CSPM3300 produced by Benyuan Company. The vertical resolution of the machine is 0.1 nm, while the horizontal solution is 0.2 nm. The scanning mode used was contact mode in this study, and the scanning range was set at a size of 5.0 umX5.0 um. In this study, the scanning mode used was contact mode. The force-distance plot measurement and scan image were obtained in water.

3 RESULTS AND DISCUSSIONS

There is a closed relationship between contact angle of liquid on solid and surface free energy. The dependence of the water contact angle and the water permeability on the laser treatment number of pulses is shown in Fig. 1. First, the permeability increased during the first 2 pulses, followed by a slow increase with increasing the number of pulses. However, the water contact angle linearly decreases with increasing of pulses.
Strong influence of the fluence to hydrophilic properties of viscose textiles was observed. The permeability exponentially increases with increasing fluence, however the water contact angle decreases linearly. The contact angle decreased linearly with increasing laser treatment time. The laser irradiation treatment longer than 4 pulses can cause the hydrophilisation of surface of textile[1]. Due to this result, the optimal laser treatment time at this condition is 4 pulses.

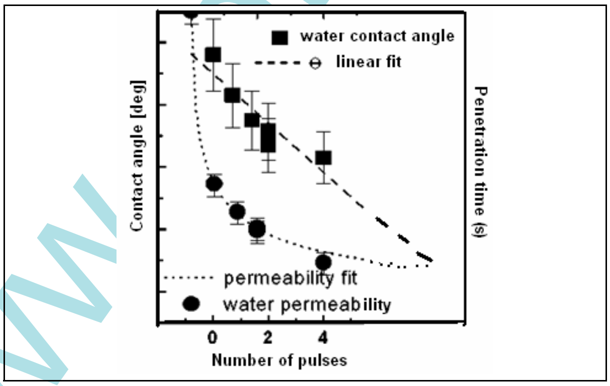

Figure 1 - Dependence of contact angle and water permeability as a function of surface treatment number of pulses

SEM micrographs of untreated and laser treated PES samples are presented in Fig. 2, 3 and 4. Before the treatment the sample had a smooth surface. After the laser treatment the surface developed a certain roughness or periodic roll, the so called ripple like or rolls like structure, as shown in Fig. 4. The orientation of this type of structure is perpendicular to the orientation of the fibres.

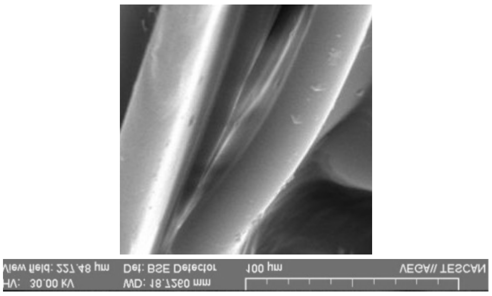

Figure 2 - Scanning electron micrograph (x 500 BSE) of control (no treatment) PES fabric sample

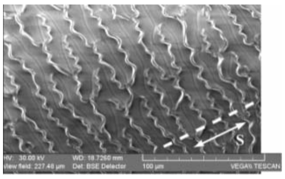

Figure 3 - Scanning electron photo (x 1000 BSE) of laser treated polyester fabric: 248 nm, 2 pulses, 37 mJ/cm^2

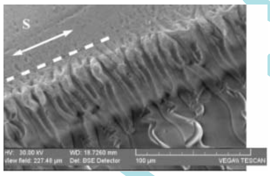

Figure 4 - Scanning electron photo (x 2000 BSE) of laser treated polyester fabric: 248 nm, 2 pulses, 37 mJ/cm^2

The stereomicroscopic photos revealed the viscose and PES samples surface modification, showing small sections of fibres and lustre conferred. Relevant changes have been noticed in the images above (Fig. 5, 6, 7 and 8):

Figure 5 - Stereomicroscope image of control viscose fabric sample

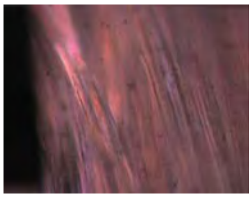

Figure 6 - Stereomicroscope image of laser treated viscose fabric sample

Figure 7 - Stereomicroscope image of reference PES fabric sample

Figure 8 - Stereomicrospe image of laser treated PES fabric sample

Despite the fact that PES fibres without laser treatment appear to be smooth, AFM images exhibit lines and roughness of the irradiated surface.

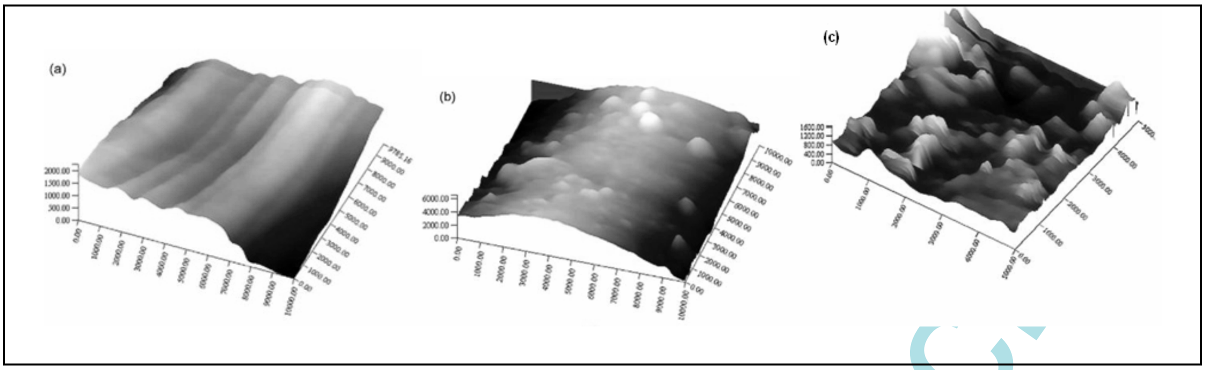

Figure 9 - AFM micrographs of PES fibres (a) untreated; (b) laser treated for 1 pulses, 248 nm, 37 mJ/cm^2; (c) laser treated for 4 pulses, 248 nm, 37 mJ/cm^2.

The surface topography has changed from an original smoothness to a fibrous one characterized by hills and groves[2]. The height of the lines ranges from 30 to 353 nm (Fig. 9a). Laser treatment with 37 mJ/cm^2 and one laser pulse, etches the surface of PES fibres, forming aggregates on the surface as illustrated in 9(b). The AFM image also reveals the size of aggregates in the range between 10 and 314 nm. The longer exposure to the laser, the rougher the surface becomes Fig. 9(c).
The surface roughness computed from AFM images are summarized in Fig. 10 and 11. Both R_a and ripple spacing show almost linearity (linear relation) with laser number of pulses. R_a and ripple spacing increase with the number of laser pulses. For the roughness (R_a), the value increased dramatically after the second pulse. An increase in R_a represents an increase in ripple size.

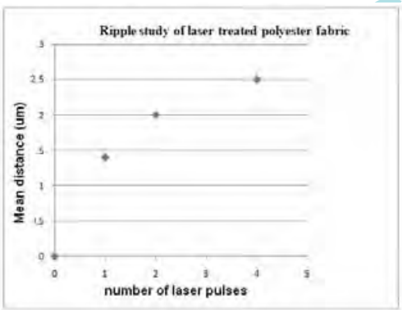

Figure 10 - Ripple modification of laser treated PES fabric

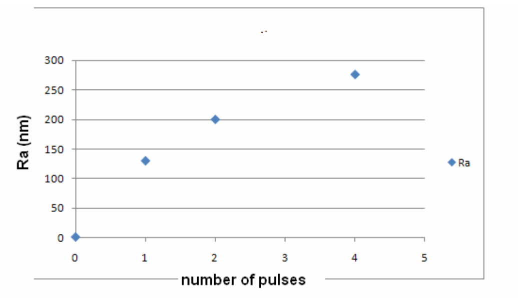

Figure 11 - Roughness evaluation of laser treated PES fabric

In case of polyamide textiles, increasing the hydrophilicity of textile surface requires only a short treatment with the laser.
Laser treatment did not change the surface morphology of the polyamide sample. The surface roughness is approximately the same within the experimental range (number of laser pulses) (Fig. 12).

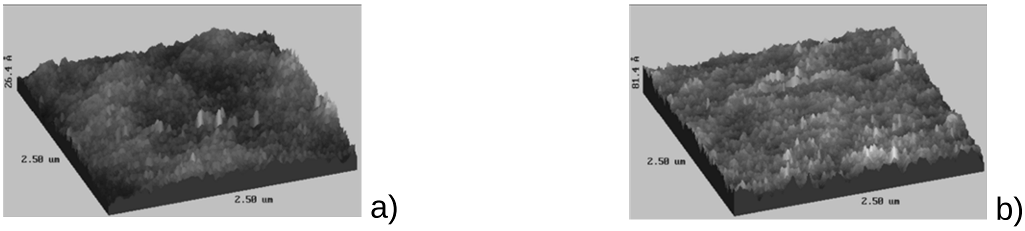

Figure 12 - AFM micrographs (topographic images) of fibres (a) untreated polyamide textile surface; (b) laser treated polyamide textile surface, for 4 pulses, 248 nm, 43 mJ/cm^2

In Fig. 13, the plots of force (nN) against distance (nm) show the most relevant difference between the reference sample surface and the laser-treated one. In case of reference sample, a significantly large adhesion force between the surface and the AFM tip was detected. On the contrary, the laser-treated sample did not exhibit any adhesion to the AFM tip. A good agreement with the well-known surface hydrophilicity can be noticed. The water molecules are strongly bound on the hydrophilic surface. They cannot be removed by simply pressing with solid surfaces. On hydrophobic surfaces, the water molecules are easily squeezed out, allowing intimate contact between the hydrophobic surfaces [3].

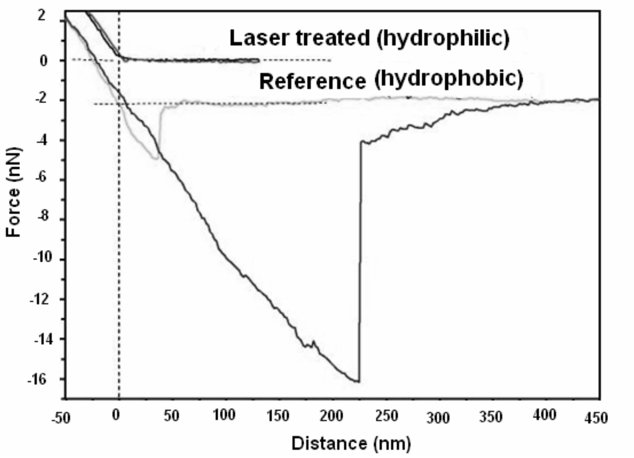

Figure 13 - Force-distance plots measured for surfaces belonging both to reference sample (hydrophobic) and laser-treated sample (hydrophilic) of polyamide fabrics.

4 CONCLUSIONS

- The excimer laser modification process has a high industrial potential, as it is an environmentally friendly dry process not involving any of the solvents required for a wet chemical treatment. Changes in morphology of the irradiated surfaces were examined by microscopic techniques and may also be one of the reasons for enhancement of the properties of textile fibers such as: wetting, adhesion and dyeability.

- After the laser treatment, investigations like: stereomicroscopy, SEM, AFM, water contact angle, permeability analyses, have been proven to be powerful tools in examination of surface microstructuring and the hydrophilicity of the textile materials.
- It is therefore suggested that the correct selection of laser irradiation parameters, without significant damage of the textile surface evaluated by relevant laboratory investigations, means the achieving of considerably changes of comfort properties.

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