Environmentally Friendly Pretreatment for Enhanced Coating of TiO_2 Nanoparticles on PET/Wool Fabric

Aminoddin Haji[1], Ahmad Mousavi Shoushtari[2], Firoozmehr Mazaheri[2], Sayyedeh Ensieh Tabatabaeyan[2]

***Abstract*—** In this study, plasma treatment as an environmentally friendly process, was used to prepare Wool/PET fabric for enhanced deposition of titanium dioxide nanoparticles. TiO_2 nanoparticles were stabilized on the fabric using citric acid as crosslinking agent in the presence of sodium hypophosphite by a pad-dry-cure process. SEM images confirmed the improved deposition of nanoparticles after plasma treatment. To investigate the self-cleaning property of the coated fabric, methylene blue staining test was employed. The changes in color differences of samples showed that an appropriate discoloration was achieved on the fabric samples treated with TiO2 after UV radiation.

***Keywords*—** Coating, Environment, Plasma, Polyester, Wool.

I. Introduction

TiO_2 nanoparticle coatings are widely used in water purification, indoor air purification/deodorization, antibacterial effect, antifogging and self-cleaning glasses. Recently, several studies have reported deposition of nanocrystalline TiO_2 layers on textiles to obtain self-cleaning properties [1]. When TiO_2 is exposed to photon radiations with an energy higher than or equal to the band gap, electron-hole pairs can induce the formation of reactive oxygen species, which oxidize and degrade pollutants and bacteria [2].

Wool/PET fabric is one of the very commonly used blend fabrics in the textile industry. Self-cleaning finishing of this fabric has been studied by Montazer et al. They have used pretreatments with enzyme (Lipase) and oxidizing agent ($KMnO_4$) to enhance the loading of titanium dioxide nanoparticles [3, 4].

Oxygen plasma treatment can introduce oxygen containing functional groups to the surface of wool and polyester fibers and eliminate the hydrophobic scales of wool to increase the adsorption of titanium dioxide nanoparticles on the fibers without yellowing and affecting the physical properties of the fabric. In this study the wool/PET fabric was functionalized with oxygen plasma and coated with TiO_2 nanoparticle and the self-cleaning property of the finished fabric was evaluated.

II. Experimental

A. Materials

Wool/PET (45/55 %) with twill weave and area density of 240 g/m^2 was obtained from Motahary textiles Co., Qazvin, Iran. Nano titanium dioxide powder with average particle size about 10-15 nm was bought from the Tecnon Company (Spain). Methylene blue (MB), citric acid (CA), and sodium hypophosphite (SHP) were of analytical grade and purchased from the Merck (Germany).

B. Plasma Treatment

The samples were pretreated using radio frequency (13.56 MHz) low pressure plasma equipment (model: Junior plasma, Europlasma, Belgium) with oxygen gas (Chamber pressure: 100 mTor, Oxygen flow rate: 20 sccm, Power: 100 W, Time: 3 min).

C. Coating process

The dispersions are prepared with 10 g/L TiO_2, 5 g/L CA 2.5 g/L SHP in distilled water by sonicated for 10 min. The untreated and plasma treated samples were soaked in the dispersion of nano TiO_2 for 2 min and padded with pick up of 100 %. Then the samples were dried at 70 ºC and cured at 160 ºC for 3 min. Finally the samples were sonicated for 5 min to remove the unattached TiO_2 particles from the fabric surface.

Aminoddin Haji[1] is with the Textile Engineering Department, Birjand Branch, Islamic Azad University, Birjand, Iran (corresponding author's phone:+989151634958; e-mail:Ahaji@iaubir.ac.ir).

Ahmad Mousavu Shoushtari[2], is with Textile Engineering Department, Amirkabir University of Technology, Tehran, Iran (e-mail: Amousavi@aut.ac.ir).

Firoozmehr Mazaheri[2], is with Textile Engineering Department, Amirkabir University of Technology, Tehran, Iran (e-mail: F.mehr@techrese.com).

Sayyedeh Ensieh Tabatabaeyan [2], was with Textile Engineering Department, Amirkabir University of Technology, Tehran, Iran (e-mail: Elika_tabatabayi@yahoo.com).

D. Self-cleaning property

The samples were stained with one drop (0.04 mL) of methylene blue solution and irradiated with a 400 UV-C lamp from 10 cm distant for 5 h. the color difference between the non-radiated and radiated stained samples was evaluated using grey scale.

E. Scanning electron microscopy

SEM images were taken on a SIGMA VP field emission scanning electron microscope (FESEM) (ZEISS, Germany) to study the surface morphology of raw and TiO_2 coated samples.

III. Results and Discussion

Two wool/PET fabric samples (one raw (washed) sample and one plasma treated sample) were coated with titanium dioxide nanoparticles as mentioned above. Figure 1 shows the FESEM images of the samples.

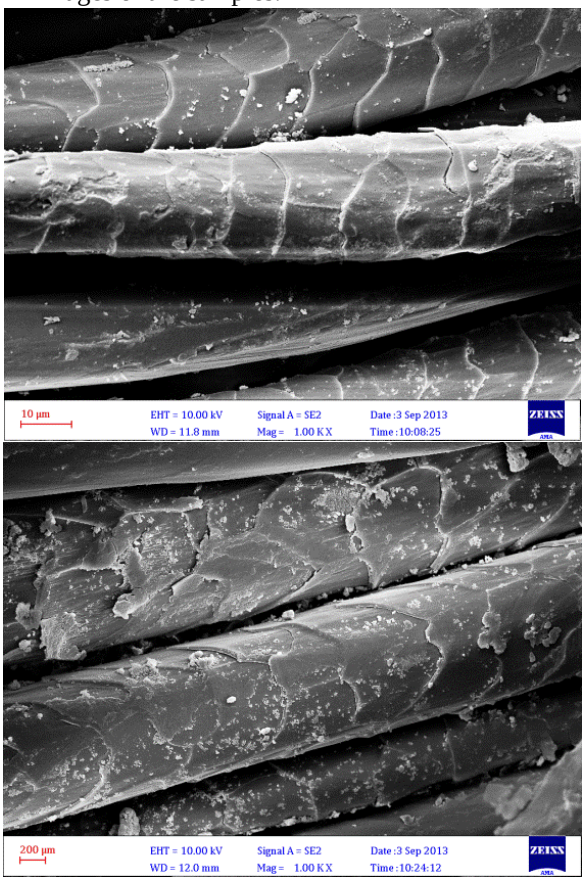

Fig. 1 FESEM images of raw (up) and plasma treated (down) samples after coating

It can be seen obviously that plasma treatment has increased the loading of TiO_2 nanoparticles on the surfaces of the wool and polyester fibers.

The FESEM apparatus was equipped with EDS. Figure 2 shows the EDS spectra of raw wool sample and raw and plasma treated wool samples after coating with TiO_2 nanoparticles. Higher amount of Ti detected on the plasma treated sample confirms the improvement of loading due to introduction of functional groups after oxygen plasma treatment to the surface of the sample.

Figure 3 shows the self-cleaning properties of raw wool (untreated with TiO_2), and the two samples shown in figure 1 after staining with MB and UV irradiation. It is evident that the plasma treated sample showed the highest degree of discoloration after irradiation which confirms the higher amount of loading of the TiO_2 nanoparticles on the plasma treated sample.

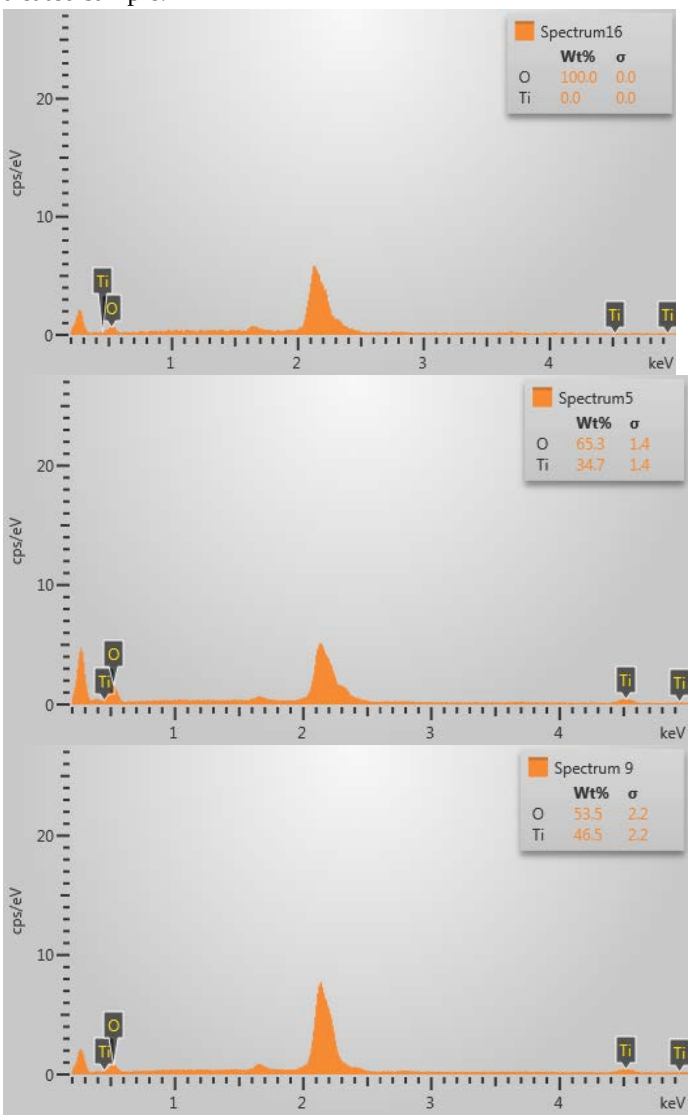

Fig. 2 EDS spectra of raw wool sample and raw and plasma treated wool samples after coating with TiO_2 nanoparticles respectively.

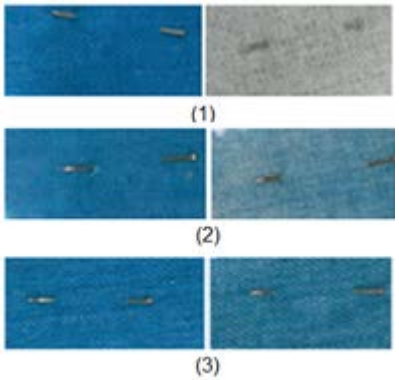

Fig. 3 Non radiated (left) and UV radiated (right) samples (1: plasma treated-coated, 2: raw-coated, 3: raw)

IV. CONCLUSION

Wool/PET fabric was treated with oxygen plasma prior to coating with TiO_2 nanoparticles. Plasma treatment enhanced the amount of nanoparticle loading on the fabric. The plasma treated and coated sample showed better self-cleaning property compared to non-coated and raw-coated samples. Plasma treatment can replace processes such as oxidizing and enzyme pretreatments without consumption of water and chemicals and preserving the physical properties of the fibers.

REFERENCES

[1] Qi, K., Xin, J.H., Daoud, W.A., and Mak, C.L., 'Functionalizing Polyester Fiber with a Self-Cleaning Property Using Anatase Tio2 and Low-Temperature Plasma Treatment', Int J Appl Ceramic Technol, Vol. 4, No. 6, 2007, pp. 554-563.

[2] Mirjalili, M., Karimi, L., and Barari-tari, A., 'Investigating the Effect of Corona Treatment on Self-Cleaning Property of Finished Cotton Fabric with Nano Titanium Dioxide', J Text Inst, In press, DOI: 10.1080/00405000.2014.932058

[3] Montazer, M. and Seifollahzadeh, S., 'Pretreatment of Wool/Polyester Blended Fabrics to Enhance Titanium Dioxide Nanoparticle Adsorption and Self-Cleaning Properties', Color Technol, Vol. 127, No. 5, 2011, pp. 322-327.

[4] Seifolahzadeh, S. and Montazer, M., 'Self-Cleaning of Methylene Blue and Acid Blue 113 on Wool/Polyester Fabric Treated with Nano Titanium Oxide under Uv Irradiation without Yellowing', J color sci technol, Vol 4, No. 1, 2010, pp. 115-123.