NANOWIRE FABRICATION ON COTTON SURFACES: EFFECT OF THE PRETREATMENT

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ABSTRACT

Anisotropic nanostructures such as nano-wires, nano-tubes, nano-rods, nano-ribbons, nano-layers, etc. are extremely attracted due to their larger surface area as compared to nano-particles. This research has targeted at fabrication of the metallic nano-wires through a simple one-step pad-dry method. The effects of mercerizing as one of the most common and important finishing treatments on cotton fabrics have been investigated. Mercerized and un-mercerized fabrics with the same structures have been treated and compared. SEM micrographs confirmed fabrication of the nano-wires with a high aspect ratio on the fiber surfaces oriented parallel with fiber axes. An enhanced potentiality for growing nano-wires with higher level of orientation has been observed for mercerized fabrics compared to un-mercerized ones. As it is well known, mercerizing can cause some structural changes in cotton fibers. Reduction of crystallinity as a result of this process (mercerizing) leads to increasing the amorphous regions which have a good potentiality for growing nano-structured materials. The higher moisture regains, absorbency, smoother morphology, etc. caused by mercerizing can direct the better growth of nano-structures on mercerized fabrics.

Key words: nanowire, Mercerizing, cotton; Pretreatment.

INTRODUCTION

Since the efficiency of nanostructures depends to their surface area, achieving a technique to synthesize nanowire as one of the most attractive anisotropic nanostructures is a very important accomplishment [1]. For example to develop electrically conductive surfaces conductivity could be obtained in systems even where the particles were not necessarily in contact because of a carrier tunneling mechanism. However, for tunneling to work, the distance between particles had to be less than 10 nm [2]. Therefore anisotropic conductive nanostructures are more attractive for this demand.

On the other hand, there are some difficulties in the case of applying nano-sized colloidal particles on textiles. In fact, various methods to produce silver nano-particles have been presented. One of the most applicable and economical methods is the reduction of Ag ions, from silver salt solutions, to nano-particles [1]. However, the stability of nano-particle dispersions is almost lim-

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ited to several hours or days. Then they are not suitable for long-time storage. Overlooking this problem, carrying of the produced dispersions is very difficult and costly because they cannot be presented in high concentration even by using different stabilizers. This limitation has been caused by their high agglomeration potential increasing by the concentration. Therefore, the delivery of the produced nanoparticles in powder form is preferred. However, most of the textile finishing process should be performed in aqueous area. Therefore, for applying nano-powder making a new stable dispersion of them is necessary. However, providing this dispersion is very difficult, costly, energy and time-consuming especially for anisotropic nanostructures like nano-wires and so on. To overcome aforementioned troubles, this paper focuses on presenting a novel in-situ synthesizing of silver nano-wires.

METHODS OF SAMPLE MANUFACTURING AND ANALYSIS

A solution of poly(vinyl pyrrolidone) (PVP, Mw 10,000) purchased from Aldrich Chemical Company and silver nitrate ($AgNO_3$) purchased from Merck Chemical Company in ethylene-glycol (EG) purchased from Merck Chemical Company have been prepared and applied on the pre-washed cotton fabric samples. In fact, regarding complete solubility of silver nitrate and PVP in EG, the appropriate solutions of these two compounds have been provided under ultra-sound and then with respect to the miscibility of these solutions, the desired mixtures of these three chemicals have been prepared and used through a one-step pad process. In detailed explanation, samples were immersed in the prepared baths containing 1.5 mM silver salt ($AgNO_3$) and 8gr per100ml ethylene-glycol (EG) for 1 min. and squeezed by pad to 100% wet pick-up. Samples were dried at the ambient temperature. Fabrications of the nano-wires on the fiber surfaces, their morphologies, and orientations have been investigated by means of a Vega ©Ts 5136 MM Tescan scanning electron microscopy applying 30 KeV. acceleration voltage. The Philips XL30 was also employed for Scanning Electron Microscopy (SEM) and energy dispersive X-ray (EDX) analysis of some samples.

RESULTS AND DISCUSSION

In present research, a new method for conducting a size controlled reaction has been presented [3]. SEM micrographs verify the formation of the slender and continue nano-wires on the surfaces of fibers. *Figure 1* shows mercerized treated sample. As shown in this figure (*Fig. 1*) the observed nano-wires have a high aspect ratio. It is highly interesting that nano-wires are oriented parallel with fiber axes on the fiber surface. As shown in these figures, the wire ends have not been detected which confirmed achieving a high aspect ratio. Mercerizing is one of the most common and important finishing treatments on cotton fabrics.

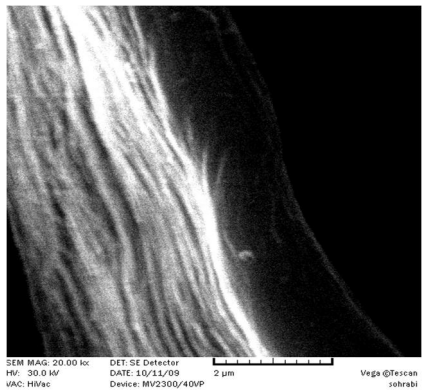

Fig. 1 – Formation of the slender and continues nano-wires and their orientation parallel with fiber axes with a high aspect ratio[3]

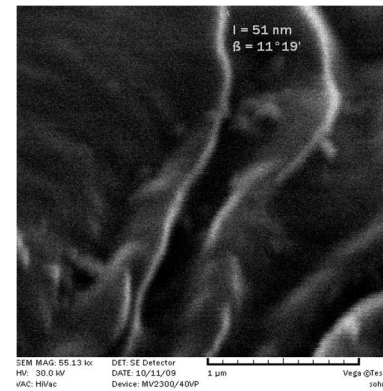

Fig. 2 – Un- mercerized fabrics with the same treatment as fabrics demonstrated in Fig. 1[3]

The main goal of mercerizing is increasing the luster. In addition, it has several advantages such as increasing fabric hygroscopicity, strength, dye affinity, etc. Therefore, considering the effect of mercerizing on the suggested finishing treatment on cotton is worthwhile. Because of the considerable increase of the fibrous porosity of the mercerized fabrics, it is expected that this process increases the efficiency of the reaction.

Fig. 2 illustrates the surface of un-mercerized fabric treated in the similar condition. As can be concluded, growth and orientation of nano-wires on the fabric surfaces are noticeably affected by this common pre-treatment.

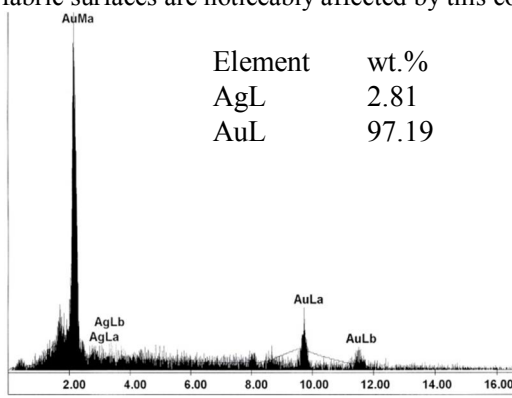

Fig. 3 – EDX patterns of mercerized fabrics treated via pad process [3]

Comparing *Fig.1* and *Fig.2* reveals that mercerizing can promote the reaction efficiency and improve orientation of nano-wires on the fabric surfaces. Concequently, cotton nanoporous structures on mercerized samples can act as the perfect nano-reactores to promote this reaction. The EDX pattern (*Fig. 3*) confirms the fabrication of silver on the sample.

According to Sun et al. finding [4], the high temperature is a key factor to control the shape during synthesizing nano-wires in the solution. However, this research disclosed that

nano-wires can be formed even at the ambient temperature when they are forming on the mercerized cotton fibers. It has been confirmed that nano-porous structure of cotton can act as a nano-reactor.

CONCLUSIONS

In this research the effect of the mercerizing as a pretreatment on the potentiality of cellulose fibers to grow nano-wires has been investigated. A simple one-step pad-dry method has been applied to synthesize nanowire on the cellulose fibers. Mercerizing has several advantages such as increasing fabric hygroscopicity, strength, dye affinity, luster, etc. Therefore, considering the effect of mercerizing on the suggested finishing treatment on cotton is worthwhile. Because of the considerable increase of the fibrous porosity of the mercerized fabrics, it is expected that this process increases the efficiency of the reaction. The results revealed the promotion effect of mercerizing on reaction efficiency and orientation of nano-wires on the fabric surfaces. Formation of the slender and continuous nano-wires with a high aspect ratio on the surfaces of fabrics was proven by SEM micrographs. The higher moisture regain, absorbency, smoother morphology, can also provide the better condition for the growth of the nano-structures on mercerized fabrics.

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