BOOSTING ELECTRICAL CONDUCTIVITY OF TEXTILES VIA FABRICATION OF SILVER NANO-RIBBONS USING THE FIBER TEMPLATES

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ABSTRACT

This research has accomplished an exceptional achievement to synthesize metallic nano-ribbons. A simple and fast spray method has been used to fabrication the metallic ribbon-shape nanostructures on the cotton fabrics. In fact cotton fabrics can act as a good template directing the shape of nanostructures. The method to achieve this end has been reported and discussed. The SEM micrographs demonstrated the nano-ribbon fabrication. Evaluation the electrical conductivity disclosed that electrical resistance of fabrics containing the silver nano-ribbons has been decrease about 7640 times as compared to untreated one. In fact electrical resistance has been declined from 6.53×109 $\Omega.cm^{-1}$ on treated fabrics to 8.55 ×105 $\Omega.cm^{-1}$ on untreated fabrics. Consequently, applying this technique decreases the electrical resistance by four orders of magnitude.

Key words: Electrical conductivity; Nano-ribbons; Metallic; fiber template.

INTRODUCTION

Electrically conductive polymers such as polypyrrole and and polyaniline has been used in order to increase textile conductivity [1]. Many potential applications of electrically conductive textiles, such as sensors, static charge dissipation, filters, electro-magnetic interference shield, and special purpose clothing acting as protection or dust and germ free purpose have been driven num-bers of researches to improve textile conductivity [2]. By developing electrically conductive nanostructures, promotion electrical conductivity of textiles using conductive nanostructures like nano-metal, nano-carbon black, carbon nanotubes (CNT) [2], etc. has been highlighted as the subject of renewed interest. Among the various conductive materials such as gold, palladium, silver, nickel, copper, graphite and carbon fiber, silver can present the best properties due to the excellent conductivity and chemical durability[3]. On the other hand, producing different shapes of nanostructures as well as modifying substrates on their basis is a high topic of interest [4-7]. This research has achieved an excellent success to synthesize metallic nano-ribbons with the feature of increasing conductivity of cotton fabrics.

METHODS OF SAMPLE MANUFACTURING AND ANALYSIS

Materials: Poly(vinyl pyrrolidone) (PVP, Mw 10,000) was purchased from

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Aldrich Chemical Company. Silver nitrate (AgNO3) with 99% purity and ethylene-glycol were purchased from Merck Chemical Company. A solution of PVP and AgNO3 in ethylene-glycol (EG) have been prepared and applied on the prewashed 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 applied immediately for fabric treatments by spray method. Spraying technique is one method for treatment of almost any surface. On the base of this method, the solutions were sprayed onto the fabric surface using a Paasche airbrush. In detailed explanation, samples were sprayed by the prepared solution containing 1.5 mM silver salt (AgNO3) and 8gr per100ml ethylene-glycol (EG) and dried at 160±5°C for 8 min. Fabrications of the nano-ribbons on the fiber surfaces and their morphologies have been investigated by means of a Vega ©Ts 5136 MM Tescan scanning electron microscopy applying 30 KeV. and magnification of about 50000. The electrical conductivity of each sample has been evaluated according to the DIN 54345 by means an eltex tera-ohm-meter 6206.

RESULTS AND DISCUSSION

This research aimed to synthesize of metallic nano-ribbons by controlling evaporation velocity of ethylene-glycol on the fabric structure as a template which leads to the controlling the shape of nanostructures. Ethylene-glycol (EG) acts as a reducing agent to reduce Ag+ to nano-particles [8]. In this research, poly(N-vinylpirrolidone) (PVP) was used as the best protective agent to prevent from agglomeration of particles. PVP can encircle the formed particles without any limitation for crystal growth [8]. Silver nanoparticles are crystalline structured materials. Therefore two known factors including nucleation and crystal growth direct the formation of the crystals [9]. In fact, using complete solubility of silver nitrate in ethylene-glycol desired concentration of $AgNO_3$ in EG can be prepared.

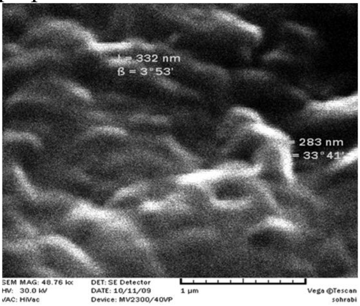

Fig. 1 – Nano-ribbons fabricated on the faber surfaces [10]

By gradually evaporation of ethylene-glycol as well as developing reaction, Ag ion concentration increases to the saturation point and thus the nucleation occurs. Then crystal growth can be pursued. Consequently, treating surface with pre-solutions having concentrations lower than saturation point and then controlling the evaporation rate of the solution on the fabric templates is the aim of the control of crystal geometry via controlling the concentration of Ag ion, reducing agent, and stabilizer simultaneously. Consequently proposed technique can provide a geometry controlled method to in-situ synthesize nano-ribbons on the fabric templates [10].

SEM micrographs verify the formation of silver nano-ribbons. *Figure 1* shows the treated samples. Lack of nano-ribbons on the sample treated with maximum concentration of AgNO3 (*Fig. 2*) alone as well as the untreated sample (*Fig. 3*) confirmed that reduction of Ag ions to Ag nano-particles cannot be achieved without any reducing agent like ethylene-glycol [10].

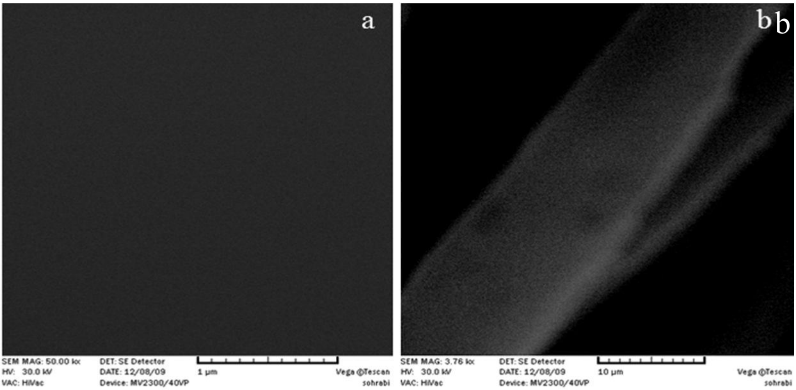

Fig. 2 – a) Lack of nano-rods on the sample treated with the same concentration of AgNO3 alone, b) “a” with lower magnification

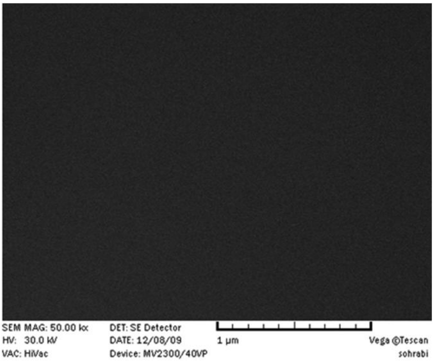

Fig. 3– Lack of nano-rods on the untreated sample

On the basis of Sun et al. finding [11], the high temperature is a key factor for the shape controlled synthesizing nano-rods in the solution. However, present research disclosed that silver nano-ribbons can be formed on the fabric template at high temperature. It fact, the nano-porous structure of cotton can act as a nano-reactor and hence a good template to control the shape of nanostructuers. Evaluation of the electrical conductivity disclosed that electrical resistance of fabrics containing the silver nano-ribbons has been decrease about 7640 times as compared to untreated one. In fact electrical resistance has been declined from 6.53×10^{9} $\Omega\cdot cm^{-1}$ on treated fabrics to 8.55×10^{5} $\Omega\cdot cm^{-1}$ on untreated fabrics. Consequently, applying this technique decreases the electrical resistance by four orders of magnitude.

CONCLUSIONS

This paper deals the electrical conductivity of fabrics containing silver nano-ribbons. The cotton fabric substrate has been used as a template to control of the nanostructure shapes. A ribbon shape silver nanostructures has been formed via a simple and fast spray method. Formation nano-ribbons was proven by SEM micrographs. It is interesting that the electrical resistance has been decreased from 6.53×10^{9} $\Omega\cdot cm^{-1}$ on treated fabrics to 8.55×10^{5} $\Omega\cdot cm^{-1}$ on untreated fabrics. Consequently, about four orders of magnitude decrease in the electrical resistance has been obtained using this technique.

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