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Effect of In Situ Green Synthesis of Nano Silver and Starching on Textile Properties of Wool Yarn.

Mohsen Hosseinkhani*, and Ali Akbar Zolriasatein

Department of Textile Engineering, Shahr-E-Rey Branch, Islamic Azad University, Tehran, Iran.

ABSTRACT

One of the environmentally friendly processes in textile engineering is the green synthesis of nano particle. In this study, nano-silver was green synthesized by using maltose and simultaneously applied on wool yarn by mechanical stretching. Through this method, the tensile strength was improved but the color difference and dye strength were decreased in contrast to silver free samples. Experimental condition affected by the size and form of nano-silver. The results show an increase in antibacterial properties of treated fibers which is attributed to the presence of silver onto wool fibers. SEM micrographs show lots of Nano-silver particles onto treated wool fibers.

Keywords: green synthesis, nano silver, wool yarn, textile

Corresponding author

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INTRODUCTION

Nowadays, fine wool fibers are extremely desirable in wool textile industry because of their soft hand, silk-like appearance, high tensile strength and light weight. It can be produced via some different processes such as chemical, bio chemical and mechanical methods [1-5]. Both enzymatic and chemical treatments can lead to generate finer and lighter fibers nevertheless, strength loss due during the process is unavoidable. It mainly can attribute to wool fiber damage. In this way, mechanical stretching may prohibit fiber damage and generate light-weight woolen goods. Also, this process is an environmentally friendly method [1].

Mechanical stretching is called slenderizing. It can create a novel wool fiber. The changes in wool properties can be attributed to secondary structure transformation of the fiber [6-9].

After stretching process, the super molecular structure of wool fiber is transformed from alpha helix to beta pleated form. In this study, stretching process was combined with pre-reduction treatment [9].

MATERIAL AND METHODS

Materials

Iranian sheep wool (sanjabi breed) yarn was used in this study (i.e. yarn count 2.38 Nm, finesse 59.9 µ and tensile strength 0.568 g/dTex). Non-ionic detergent (Diadavin UN) supplied by Bayer company. Silver nitrate ($AgNO_3$), sodium carbonate (Na_2CO_3), ammonia, glucose and maltose were purchased from Merck Company, Germany.

Preparation methods

Pre-treatment of wool yarns (removal of natural impurities) were performed under following conditions (Table 1). Nano silver synthesis and dyeing of wool yarn were performed at the same time in a one bath under following conditions (Table 2).

Table 1: Pre-treatment conditions and chemicals

Materials and conditions	Amount
Detergent	2 g/l
Sodium carbonate	1 g/l
L/G	30/1
Temp	70 °C
Time	30 min

Tensile strength

Tensile strength of wool yarns were measured by Testometric M500-25CT. It was performed under ASTM D 2256-97 standard. These measurements were taken place by CRE system, with a clamped distance of 250 mm and a test speed of 300 mm/min.

Table 2: Synthesis and applying of Nano-silver onto wool yarn simultaneous with dyeing

Materials and conditions	Amount						
Acid dye (%)	1	1	1	1	1	1	1
CH_3COOH (%)	0.5	0.5	0.5	0.5	0.5	0.5	-
$AgNO_3$ (%)	-	-	-	0.1	0.1	0.1	0.1
Glucose (%)	-	0.5	-	0.5	-	0.5	0.5
Maltose (%)	-	-	0.5	-	0.5	0.5	-
L/G	30/1	30/1	30/1	30/1	30/1	30/1	30/1
Temp (°c)	70	70	70	70	70	70	70
Time (min)	60	60	60	60	60	60	60
Sample code	N	O	P	Q	R	S	T

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Color spectroscopy analysis

A reflectance spectrophotometer (Color-eye 7000) was used for measurement of color differences between samples. Yellowness index of wool samples was calculated according to ASTM D 1925 standard method. Whiteness index of wool samples was computed under CIE Canz 82 standard method.

Surface morphology of wool fibers

The surface morphology of wool fibers were examined by a scanning electron microscope (Philips XL 30). Samples were coated by gold which lasted 60 seconds.

RESULTS AND DISCUSSION

Tensile strength

Table 3 and Figure 1 show that synthesis of Nano-silver simultaneous with dyeing, results in increase in tensile strength. It can be concluded by comparison T sample with N sample. Absence of acid during the dying leads to prevent decreasing in tensile strength. On the other hand, the tensile strength can be affected by type of carbohydrate. It is obvious by comparison T sample with N sample. It seems that bigger sized carbohydrates result in higher tensile strength. It seems that bigger sized carbohydrates are more resistant to acids. By comparison S sample with R sample it can be concluded that using of two different carbohydrates can be more effective and results in higher tensile strength.

Table 3: Results of appearance and tensile strength of wool samples

Code / Sample	Tensile strength (g/dTex)	Appearance Properties of samples					
		L*	%Reflectance	K/S	ΔE	Yellowness	Whiteness
N	0.826	50.963	1.677	28.82	شاهد	160.258	-291.396
O	0.871	51.400	1.754	27.51	0.51	159.098	-290.632
P	0.807	50.345	1.654	29.24	0.926	161.814	-290.762
Q	0.787	48.121	1.785	27.02	7.03	155.425	-287.487
R	0.857	47.749	1.918	25.07	4.58	156.157	-286.259
S	0.842	50.803	2.106	22.75	5.96	151.523	-282.509
T	0.874	50.281	3.000	15.68	4.1	153.376	-285.325

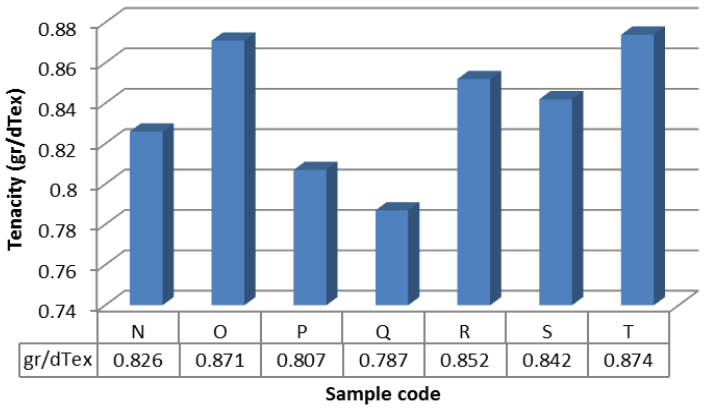

Figure 1: Changes in tensile strength based on different pre-treatment

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Analysis of color difference and dye strength

Table 3 and Figure 2 illustrate that synthesis of Nano-silver simultaneous with dyeing results in increase in color difference of Nano-silver treated wool yarns. It is obvious by comparison blank sample (N) with T, Q, R and S samples.

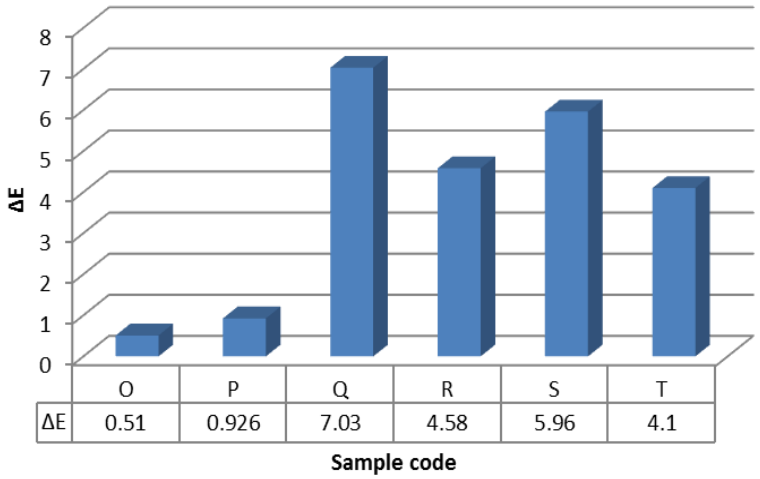

Figure 2: Color difference of untreated and Nano- silver treated wool yarns

Figure 3 depicts that synthesis of Nano-silver simultaneous with dyeing can lead to descend dye strength of Nano-silver treated yarns. After Nano-silver treatment, dye strength decreased from 28.82 to 15.68. This sharp decline can affect appearance of Nano-silver treated wool yarns.

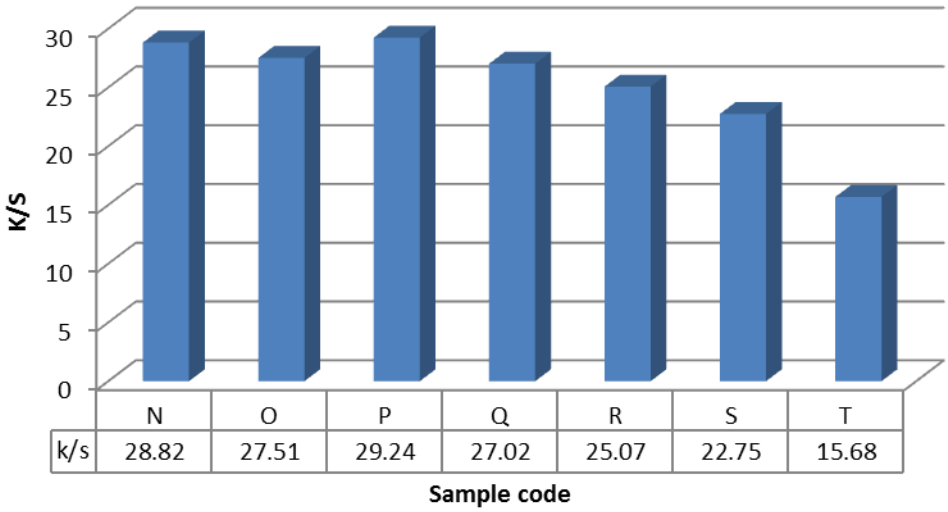

Figure 3: Dye strength of untreated and Nano- silver treated wool yarns

Antimicrobial properties

Staphylococcus aureus and Escherichia Coli were used for evaluating of antibacterial properties. It was conducted by AATCC 100-1993 method. Decrease in number of bacteria was calculated by the following formula.

$$R\ (\%) = [(A-B)/A] \times 100$$

A: Number of bacterial colony onto untreated sample
B: Number of bacterial colony onto nano-silver treated sample
R: Decrease rate of bacterial colony

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The results were obtained from five repetitions. It was summarized in table 4. Since Staphylococcus aureus and Escherichia Coli have different structures, they can lead to different effects on wool samples. Hence, N and S samples showed different results. It can be concluded that synthesized nano-silver have an antibacterial effects.

Table 4: Antibacterial properties of samples

Sample code	*Escherichia coli* (R %)	*Staphylococcus aureus* (R %)
N	56	87
S	32.2	51.1

Whiteness and yellowness indices

Whiteness and yellowness indices of untreated (blank) and Nano-silver treated yarns were shown in Table 3. It seems that Nano-silver treatment leads to decrease in yellowness index.

Analysis of FT-IR

Figure 4-10 and Table 5 show the FT-IR spectrum of protein molecular structure. At 3710-3770 cm^{-1}, there is a peak which is attributed to OH group or presence of water. Investigation of peptide group (-CONH-) can be examined by Amid I, Amid II and Amid III absorption peaks.

The absorption peak in the range of 1640-1700 cm^{-1} can be attributed to – CO group. The absorption peak in the range of 1510-1530 cm^{-1} can be considered as a transformation of (-C-N-H) which reveals both stretching C-N band and bending N-H band together. At 1020-1120 cm^{-1}, there is a peak which indicates oxidation of -S-S- to -S-O group.

Table 5: Position of peaks and their characteristics for wool samples

Sample	Position (cm^{-1})	Peak characteristic	Range (cm^{-1})
O	1624 1517	-CO C–N–H	1600-1700 1500-1600
P	1628 1515	-CO C–N–H	1600-1700 1500-1600
Q	1638 1514	-CO C–N–H	1600-1700 1500-1600
R	1622 1513	-CO C–N–H	1600-1700 1500-1600
S	1622 1521	-CO C–N–H	1600-1700 1500-1600
T	1620 1520	-CO C–N–H	1600-1700 1500-1600

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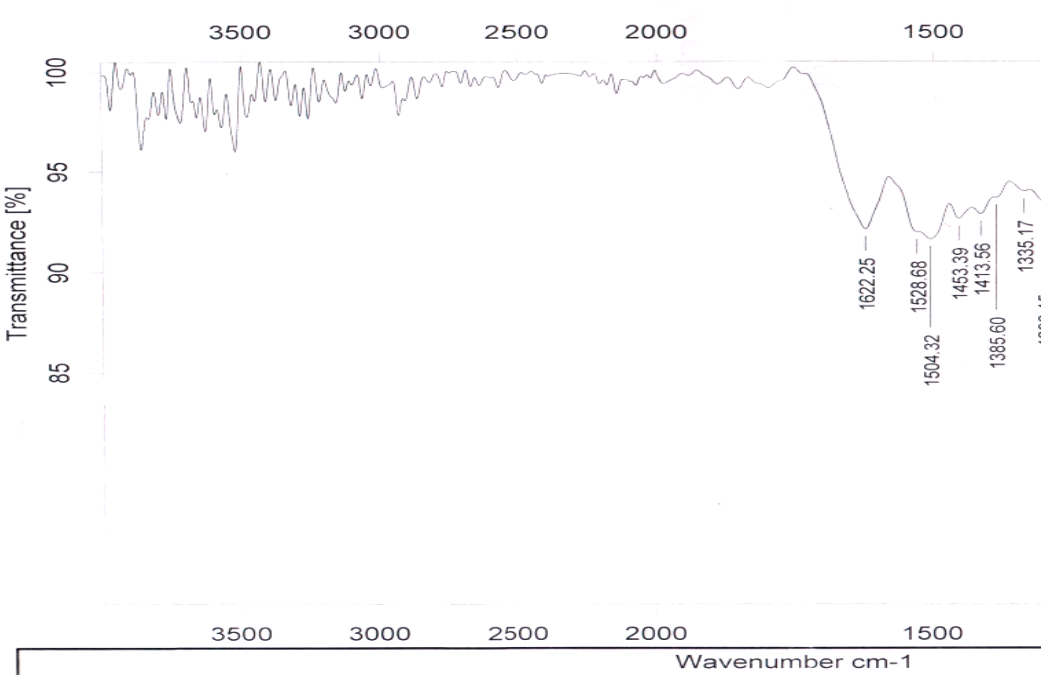

Figure 4: FT-IR spectrum of N sample (blank)

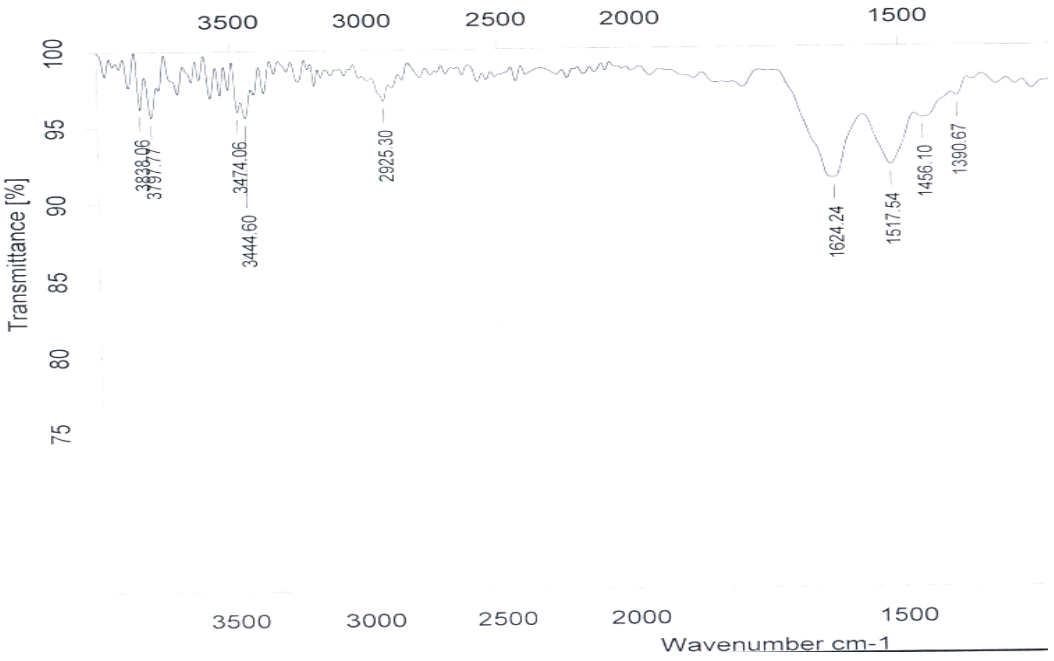

Figure 5: FT-IR spectrum of O sample

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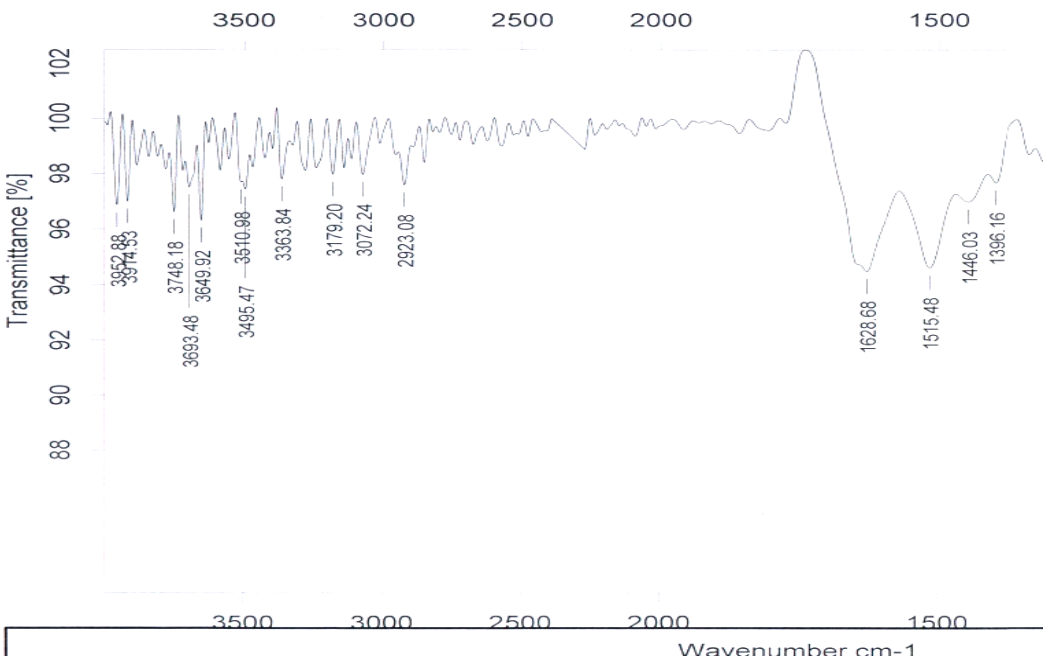

Figure 6: FT-IR spectrum of P sample

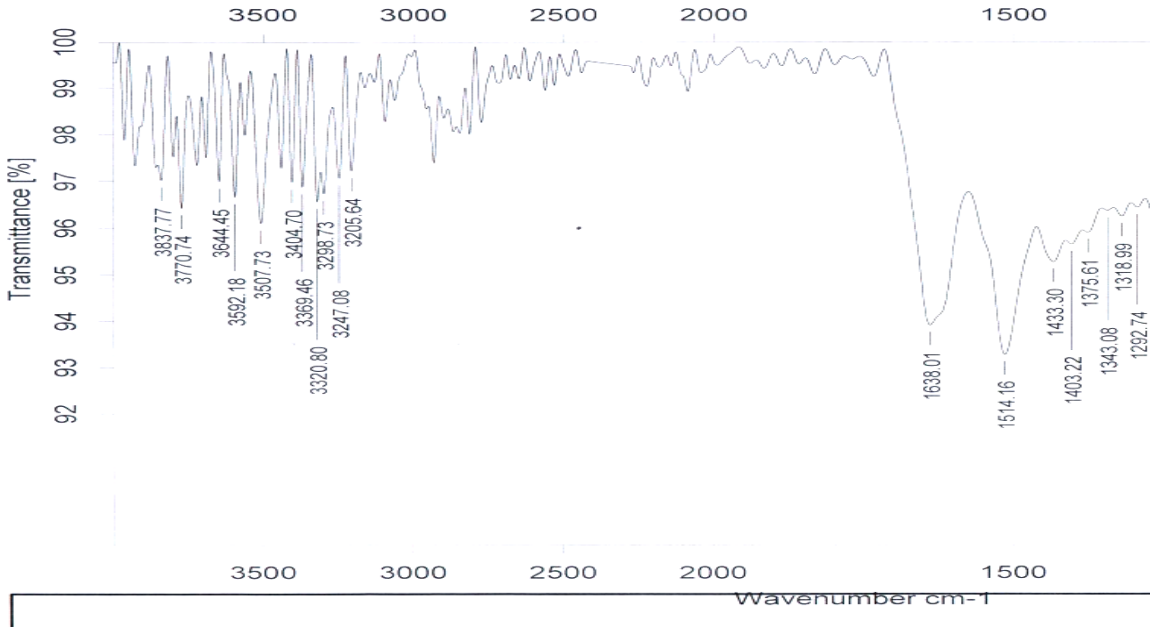

Figure 7: FT-IR spectrum of Q sample

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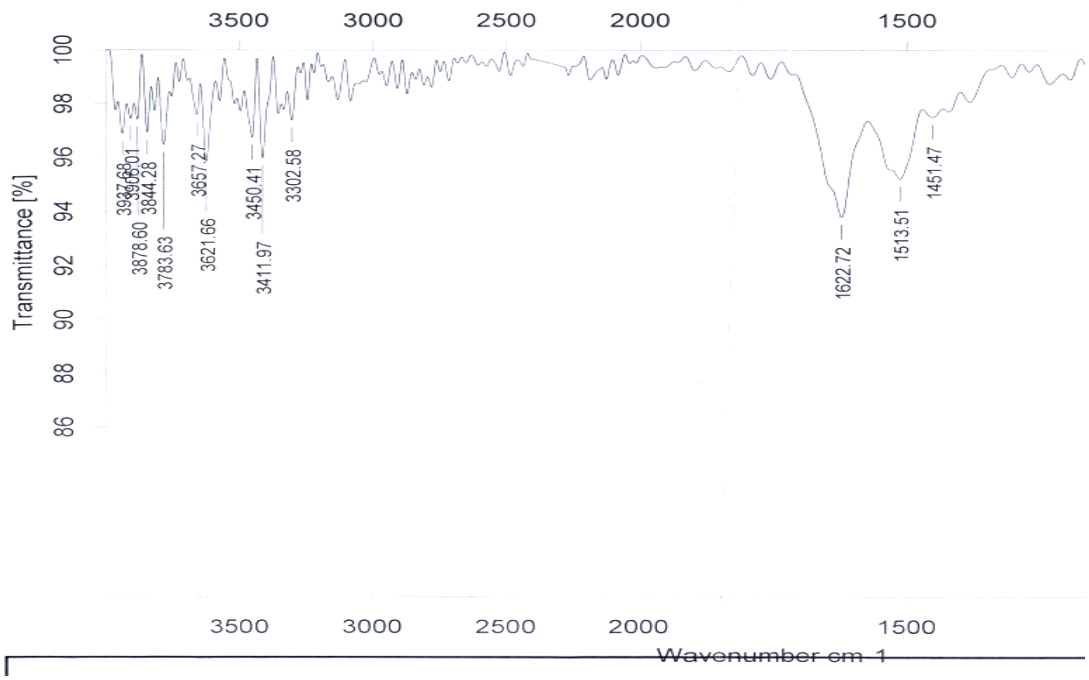

Figure 8: FT-IR spectrum of R sample

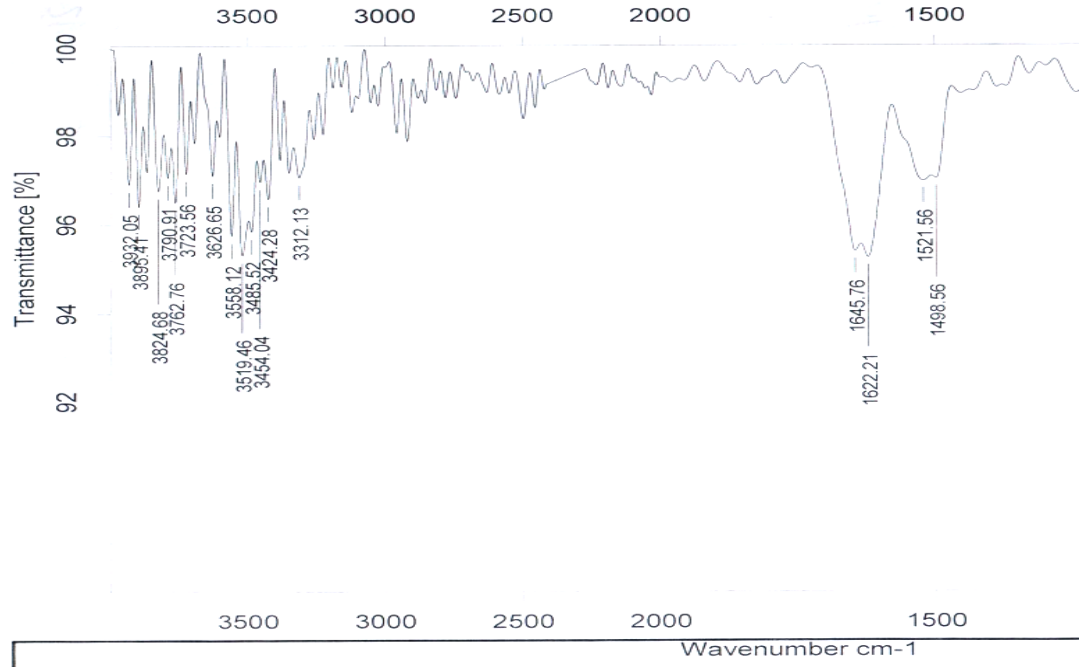

Figure 9: FT-IR spectrum of S sample

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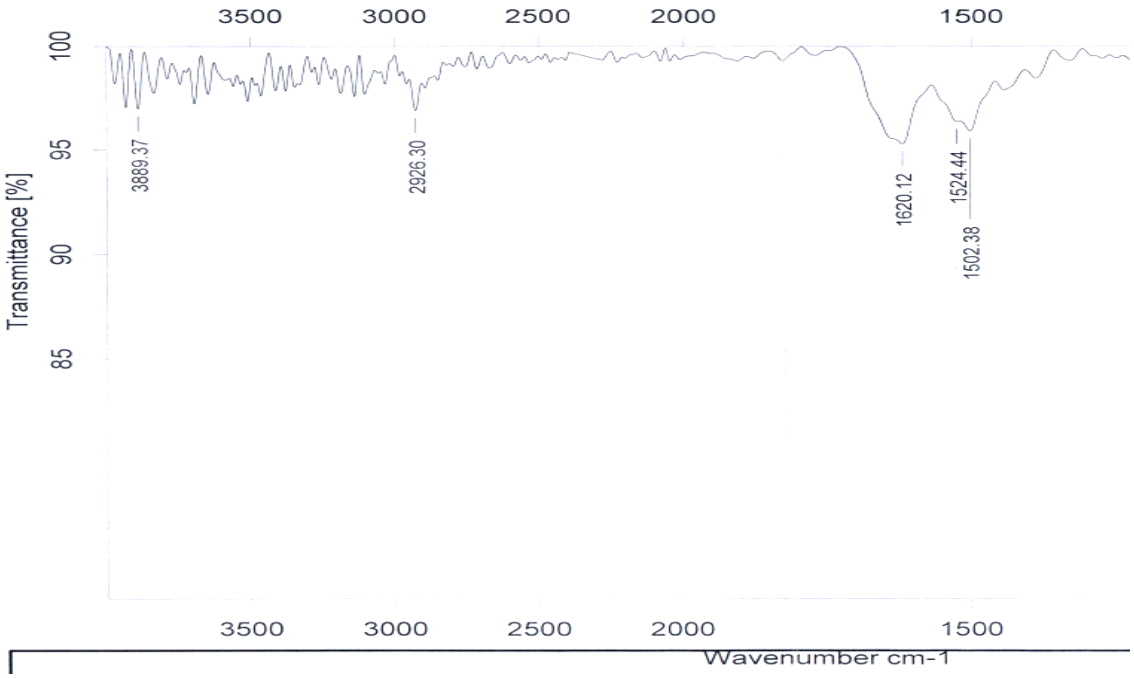

Figure 10: FT-IR spectrum of T sample

Figure 4-10 show that carbonyl group (from 1504 to 1622 cm^{-1}) can shift to other wavelengths which is attributed to presence of silver between polymeric chains. Changes in position of absorption peaks are function of experimental conditions.

Analysis of surface morphology of wool fibers (SEM)

Figure 11-12 illustrates the gold coated surface of wool fibers. Using of stronger reducing agent can lead to decrease in synthesized nano silver dimensions. Hence, changes in both silver nitrate and reducing agent concentrations can affect the dimensions of synthesized nano silver.

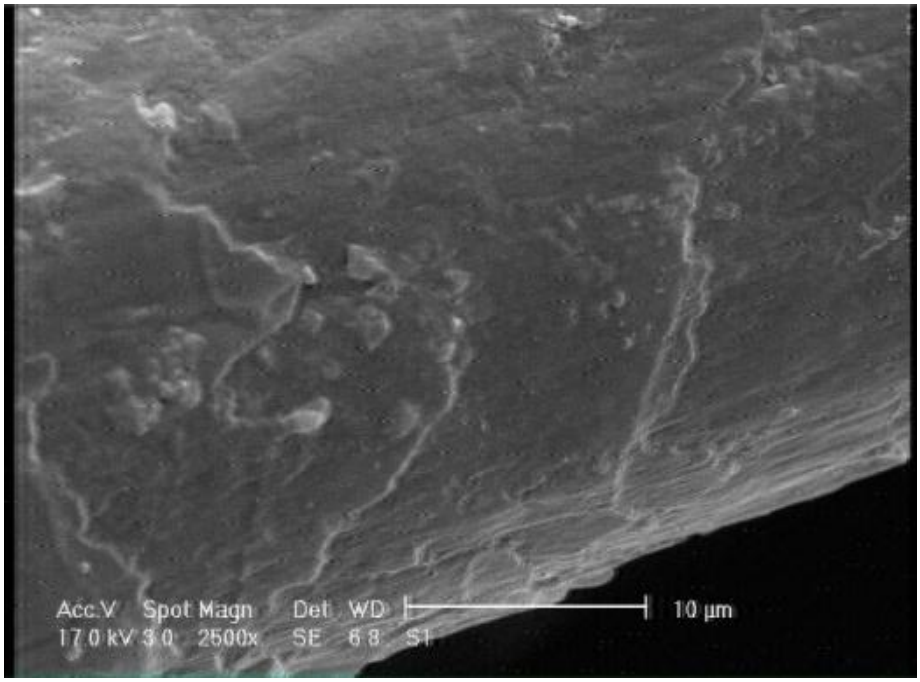

Figure 11: SEM micrograph of N sample (blank)

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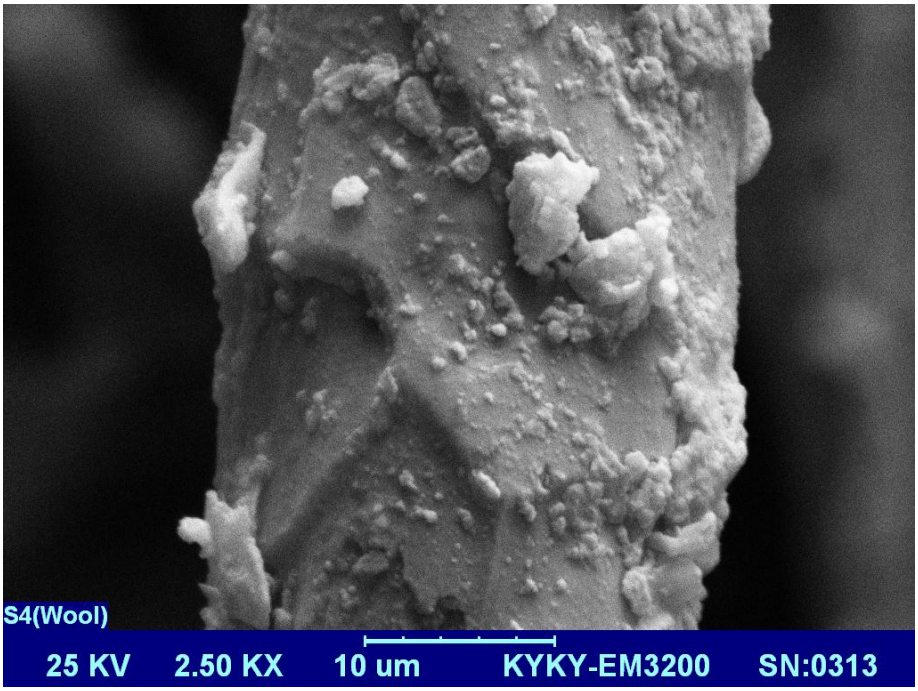

Figure 12: SEM micrograph of Q sample (Nano-silver treated)

By comparison Figure 11 with Figure 12, it is obvious that silver could be deposited onto wool fiber by this new procedure. To obtain the uniform distribution of Nano-silver onto wool fibers, condition of this process (e.g. concentration of silver nitrate and reducing agent) should be controlled. It seems that by using different reducing agent and different thermal conditions the size of Nano-silver can be altered.

CONCLUSION

High molecular carbohydrates such as maltose can contribute to synthesize of Nano-silver which leads to improve the tensile strength. Presence of Nano-silver can decrease the color difference and dye strength of dyed samples in contrast to silver free samples. In FT-IR spectrum, some absorption peaks shifted to other positions which can be attributed to synthesize of Nano-silver. Displacement of the absorption peaks of some functional groups shows that condition of experiment can affect size and form of Nano-silver. Hence, condition of experiment such as concentration of silver nitrate and reducing agent should be controlled. The results show an increase in antibacterial properties of treated fibers which confirms the presence of silver onto wool fibers. SEM micrographs show lots of Nano-silver particles onto treated wool fibers.

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