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Electroless silver nitrate plated yarn

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ABSTRACT

A study on electro less plated yarn charactertics through Box Behnken Design by various the sliver nitrate amount, temperature and time has been reported. The cotton and polyester yarns were plated with sliver nitrate by electroless plating at various concentration, temperature and time. The surface morphology, antimicrobial activity, electrical conductivity, strength and elongation have been measured for cotton and polyester silver plated yarn. It is observed from SEM image that deposition and firm attachment of sliver particle over the surface of yarn structure. It is also observed that the sliver plated yarns have better antimicrobial activity, electrical conductivity and strength than normal yarn.

Introduction

Plated yarn in particular has an identity and a quality of brightness that can create beautifully reflected and lustrous images. The reflective surfaces can offer a unique appearance as a result of this technical process and plated yarns are very popular in both the contemporary consumer market and in technical applications. Plated yarn has been produced by a laminating process between metal powder or foil and yarn with binder. Vacuum deposition and sputtering coating processes have been applied to polyester yarn with aluminium, titanium and stainless steel and a silver-plated product was usually produced by electro-plating on the surface of conductive materials. Some researchers have suggested a process to achieve the results obtained with conductive yarn by using chemical silver plating, which is a method used for precision work in manufacture. Although chemical silver plating has been employed for more than 50 years, it is still primarily used in the manufacture of reflective mirror surfaces and in the pre-treatment of electroplating on non-conductive materials such as acrylonitrile butadiene styrene, ceramic, glass, etc. Unlike electroplating, in which externally supplied electrons act as the reducing agent in autocatalytic deposition, silver coatings are formed as a result of a chemical reaction between the reducing agent and metal ions present in solution. Chemical silver plating could be a unique process providing good potential for creation of yarns with a metallic appearance and good handling characteristics. Over the past few years, very limited yarn design with deep creation was performed to demonstrate the effects of chemical treatments on two yarns that included cotton and polyester. It is hoped that this recently developed treatment process for yarn can enhance its tactile qualities and aesthetic appearance, which were both evaluated thoroughly in this study.

The techniques include electroplating, electroless plating, conductive paints, thermal evaporation, sputtering method, metal fillers injected during the molding stage, and other metallization process. Among them electroless metal plating is probably a preferred way to produce metallization of polymer subtracts. The most widely used the metals are copper, silver and nickel. As electroless method has advantages in terms of coherent metal deposition [1-4], excellent conductivity, EMI shielding effectiveness and applicability to complicated shaped substrates, etc.The important application of electroless plating is made possible by rending the nonconductive surfaces catalytically active ,so as to initiate electroless metal deposition [5-16]

Electroless plating is a chemical reduction process which depends upon the catalytic reduction of a metallic ion in an aqueous solution containing a reducing agent, and the subsequent deposition of the metal without the use of electrical energy. The metals capable of being deposited by electroless plating include nickel, cobalt, copper, gold, palladium and silver [17-20]. In this chemical plating method, the metallic ions are reduced to metal only on a specific surface in the presence of catalysts prior to reaction.

Materials And Methods

The polyester and cotton yarns (count- 40^{S}) are selected for electroless silver nitrate plating with the yarn parameters. The polyester materials and cotton materials were plated with silver nitrate by Electroless Plating Method at various concentrations, various temperature and time by using Box Behnken Design as shown in Table 1. Electroless silver plating was carried out by multi-step processes including pre-treatment, sensitisation, electroless silver plating, post treatment for stopping silver reduction, rinsing and drying. After electroless silver plating, the samples were rinsed in deionised water directly, cured at 150 for 1 minute, and then conditioned according to the ASTM D1776-04 before measurement. In order to locate the silver deposition on a selected area of the yarn, it is necessary to make the yarn surface act as a catalyst. The activation energy of the catalytic route is lower than the homogeneous reaction in solution. A smooth deposition is obtained if the metal deposited by autocatalysis acts as a catalyst. Based on the method of chemical silver-plating for a nonmetal substrate, three main steps, namely pre-treatment, the plating process and post-treatment were employed in the experiment.

Results and discussions

Effect of electroless silver nitrate plated yarn on antimicrobial activity

Sliver nitrate plated yarn and excellent antibacterial effects are all snecimens agents grant-positive and figure and grams-negative bacteria. Table 2 shows the antimicrobial activity effects of sliver nitrate plated yarn. It is found that the bacterial reductions of all samples were excellent aginst E-coil. In this

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study the application of sliver particles were investigate by growing E-coil on agar plates. When sliver particles were present an ager plater, they could completely inhibit the bacterial growth. However, inhibiter depends upon concentration of sliver particles. The yarn padded with 6 gms sliver nitrate had better bacterial activity than the samples treated with 4gms and 2 gms as shown in the table 2 results obtained in the antimicrobial best shows that, sliver at 6gms and temperature at 44°c the antimicrobial activity increase with increase in curing time. The higher bacterial inhibiter was obtained at 6gms and 44°c with curing time 6min

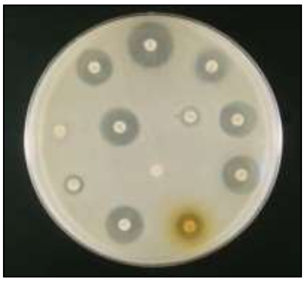

Figure 1 Antimicrobial activity

Electrical resistance and conductivity measurement

From the Table.3, It is observed that the sample with 6gm sliver plated yarn has good conductivity and low resistivity than other sample with 4 gms and 2 gms plated yarn due to sliver particle present in the surface of yarn structure which enable to increase the conductivity of sliver plated yarns. It is also found that curing time and temperature also influences the conductivity and resistivity of plated yarn

Surface Morphology of Silver Plated Particles By Sem

Magnification at lower level to higher level (X600, X1500,X3500, X7500, X15000, X33000), for the sample treated with low and high concentration levels of silver particles revealed the surface deposit of that were mainly aggregated to an extend of 124 nm to 160 nm as shown in figure 2-5. Also the deposits were found to be high near the asperities, surface cracks and cross-over points, between the fibres, which could exercise additional holding by trapping the silver particles compare to the smooth surface of the yarns. The significant amount of silver particles that appear to be present throughout the fibre surface, are expected to be considerable influence on the electromagnetic shielding properties of yarns. When such depositions are present in the yarn samples, more attenuation can be expected from those samples.

The SEM from figure 2 to 5 showed clear image of fibre with the surface cracks associated with them, in the middle of fibres and incurrent convolution of the fibres. The treatment with silver plated resulted in deposition and foam attachment of silver particles for the surface of the yarns. However such a deposits appeared to be concentrated in certain places, which obviously could result in agglomerate of the particles such a silver deposits over the yarn surface can be expected to scatter the electro magnetic waves. It is observed that from figure 2 to 5 that the samples treated with higher concentration level of silver plated particles showed higher silver deposits on to the surface of the fibres than the samples treated with low concentration level of silver materials. The differences in concentration level are expected to have different level of influence on the electro magnetic shielding effectiveness against electro magnetic interference.

It is observed that cotton material has observed more sliver particles than polyester material. It may be due the hydroxyl group present it cotton

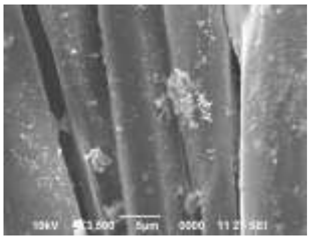

Figure 2 Surface Morphological Structure of silver plated yarn by SEM (X3500)

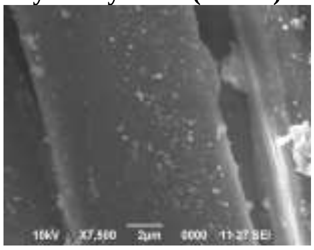

Figure Surface Morphological Structure of silver plated yarn by SEM (X7500)

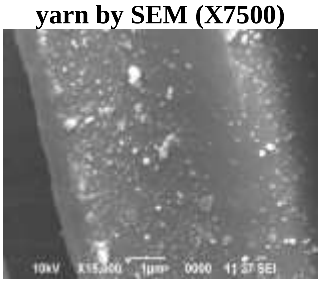

Figure 3 Surface Morphological Structure of silver plated yarn by SEM (X15000)

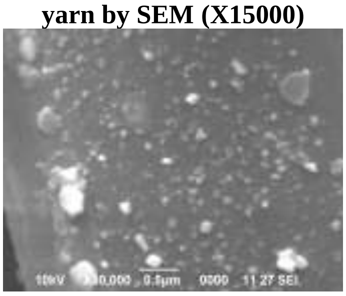

Figure 4 Surface Morphological Structure of silver plated yarn by SEM (X30000)

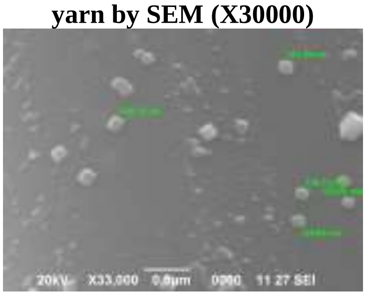

Figure 5 Surface Morphological Structure of silver plated yarn by SEM (X33000)

Single yarn tenacity and elongation

The grey yarn and electroless plated yarn were tested as per uster standard method ASTM D 2256-02. It is observed from Table 4 that the electro plated yarn have better strength then gray yarn and % elongation, and CV % of strenth and CV % of elongation of yarn were reduced due to depositing thin uniform layers of bright sliver particule.

Conclusion

The following conclusions have been made in this study.

- Sliver nitrate concentration and temperature have a significant influence on Electrical resistance and conductance measurement.

- The yarn sample treated with high concentrated sliver nitrate have better Antimicrobial activity and electrical conductivity than the yarn treated with lower level concentration of sliver nitrate. The antimicrobial property is achieved due to presence of water soluble salt of silver.
- SEM images show the deposition of silver nitrate particles on the surface of yarn. Here silver nitrate particle forms ionic bond with cotton molecule

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Table 1 Experimental design of box-behnken

S.No	Silver nitrate amount (g)	Temperature(°c)	Time (min)
1	2	23	6
2	6	23	6
3	2	44	6
4	6	44	6
5	2	34	3
6	6	34	3
7	2	34	9
8	6	34	9
9	4	23	3
10	4	44	3
11	4	23	9
12	4	44	9
13	4	34	6
14	4	34	6
15	4	34	6

Table 2 Box-behnken design for Antimicrobial Activity

S.No	Silver nitrate amount (g)	Temperature (°c)	Time (min)	Antimicrobial Area (mm)
1	2	23	6	8
2	6	23	6	20
3	2	44	6	12
4	6	44	6	30
5	2	34	3	13
6	6	34	3	24
7	2	34	9	14
8	6	34	9	26
9	4	23	3	10
10	4	44	3	16
11	4	23	9	18
12	4	44	9	23
13	4	34	6	16
14	4	34	6	15
15	4	34	6	17

Table 3 Box-behnken design for Electrical resistance value

S.No	Silver nitrate amount (g)	Temperature(°c)	Time (min)	Resistance value (mega ohms)
1	2	23	6	1652
2	6	23	6	1002
3	2	44	6	1363
4	6	44	6	902
5	2	34	3	1453
6	6	34	3	954
7	2	34	9	1302
8	6	34	9	927
9	4	23	3	1541
10	4	44	3	1227
11	4	23	9	1033
12	4	44	9	985
13	4	34	6	1345
14	4	34	6	1341
15	4	34	6	1352

Table -4 Single Yarn Tenacity And Elongation

S.N	DETAILS	GREY YARN	ELECTROLESS PLATED YARN
1	Actual Strength(g)	233.1	256.6
2	CV% of Strength	11.33	10.33
3	%Elongation	5.55	6.09
4	CV% of Elongation	13.32	11.03
5	RKm(g/Tex)	11.84	13.03