(REFEREED RESEARCH)

PRODUCTION OF POLYESTER/POLYANILINE, COTTON/POLYANILINE COMPOSITE FABRICS AND EXAMINING ELECTRICAL CHARACTERISTICS

POLYESTER/POLİANİLİN, PAMUK/POLİANİLİN KOMPOZİT KUMAŞLARININ ÜRETİLMESİ VE ELEKTRİKSEL ÖZELLİKLERİNİN İNCELENMESİ

Ayşe Selcen ALTINOK[1], İbrahim ÜÇGÜL[2], Ayşegül UYGUN ÖKSÜZ[3]

[1]*Çukurova University, Department of Textile Engineering, Adana, Turkey*
[2]*Süleyman Demirel University, Department of Textile Engineering, Isparta, Turkey*
[3]*Süleyman Demirel University, Department of Chemistry, Isparta,Turkey*

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ABSTRACT

In this study, conductive cotton and polyester composite fabrics were produced by chemical polimerization of aniline on fabrics. Variation of rates of conductivities were examined at the different rates of aniline and stable temperature, humidity. Fulard Machine was used for coating fabrics with conductive polymers. Four tests were tried using four different concentrations of aniline in production of composite fabrics coated conductive polymers. In these tests, aniline as monomer, $(NH4)_2S_2O_8$ as oxidant, Kieralon ED-B as surfactant, HCl as acid were used. Also $AgNO_3$ was added in aniline solution for increasing conductivity. Finally, electrical properties of produced composite fabrics were measured and images of SEM of them were examined to observe polyaniline ratio of holded onto fabrics and the polyaniline distribution of the fabric surfaces.

Key Words: Polyaniline, Electrical conductivity, Chemical polimerization, Cotton, Polyester.

ÖZET

Bu çalışmada, pamuk ve poliester ipliklerden üretilmiş dokuma kumaşlar üzerinde anilinin kimyasal polimerizasyonu ile oluşan polianilin ile pamuk ve poliester dokuma kumaşlar kaplanarak iletken kompozit kumaşlar üretilmiştir. Sıcaklık ve nem sabit tutulup, kullanılan anilin oranları değiştirilerek iletkenlik oranlarındaki değişimler gözlenmiştir. Ayrıca çözeltiye gümüş nitrat ilave edilerek iletkenliğe olan etkisi incelendi. İletken polimer ile kumaşı kaplamak için fulard makinesi kullanılmıştır. İletken polimer kaplı tekstil kompozitleri üretmek için farklı deneyler yapılmıştır. Bu deneylerde monomer olarak anilin, oksidant olarak $(NH4)_2S_2O_8$, yüzey aktif madde olarak Kieralon ED-B, asit olarak ise HCl kullanılmıştır. Ayrıca iletkenliği arttırmak için anilin çözeltisine $AgNO_3$ eklenmiştir. Bütün proseslerin sonunda; Üretilen kompozit kumaşların elekriksel özellikleri ölçülmüştür ve SEM görüntüleri incelenerek polianilinin kumaş yüzeyine ne kadar tutunduğu ve dağılımı gözlenmiştir.

Anahtar Kelimeler: Polianilin, Elektriksel iletkenlik, Kimyasal polimerizasyon, Pamuk, Poliester.

Corresponding Author: A. Selcen Altınok, selcenadamhasan@gmail.com, Tel: +90 322 611 36 00

1. INTRODUCTION

Electrically conductive and antistatic fabrics are produced adding metal particles, metal salts or carbon particles in production phase of yarn, as well as conductive fabrics are produced using copper wires during process of woven. Used copper wire tends to worsen the mechanical properties of yarn and comfort properties of garments made from fabrics produced by this method is also poor. Also conductive polymers and carbon powders are used as a further alternative in production of antistatic fabric. Generally, textile fibres are non-conductive electrically and electrostatic charge of fibers is cause serious problems during production processes.

After Poliasetilen (PA), Polipirol (PPy), Polianilin (PANI) conductive polymers are discovered, It has been noticed that production of conductive fabrics are possible without loss of mechanical properties. In recent years, researchers are focused on synthesis, properties, stability and workability of conductive polymers. Conductive polymers are widely used in scientific studies, conductive coatings, sensor productions, diode, transistor and micro-electronic devices, anti-static material (1).

Polyaniline are investigated extensively due to the properties of redox, environmental stability, high conductivity depending on doping level, easy synthesis and low price. Despite all of desirable characteristics, low resolution, workability hard with traditional methods and low mechanical strength are limited the studies done on it. In textile, Conductive polymers are used in production of electrically conductive fabric or yarn. In production of conductive fabric, aniline monomers can be polymerized from aqueous solution or vapor phase on the fabric using appropriate oxidant. In production of conductive yarn; liquid polymer is turn into yarn using methods of synthetic yarn production. Previous studies have examined; conductive fibres had obtained coating polyaniline on polyester fibres (2). Tae Su Kang and friends produced electrically conductive polypyrol fibres using electrospinning method (3). Also conductive yarns and fabrics were produced impregnating with copper and silver ions. Today, anti-static products occupy a very large place in industry. These fields are as follows: materials commonly used in electronic equipment, antistatic conductive bags, packing foams, table cloths/coating, anti-static wristbands, antistatic chairs, antistatic heel straps, antistatic aprons, etc. In this study, conductive cotton and polyester composite fabrics were produced by chemical polimerization of aniline on fabrics.

2. MATERIAL AND METHOD

Foulard machine used to coat the fabric with conductive polymer. The coating process is realized dipping all fabrics completely into 2 liter foulard bath.

Figure 1. Coating Process

Four different experiments were done to produce conductive polymer coated textile composites. In these studies aniline as monomer, $(NH_4)_2S_2O_8$ as oxidant, Kieralon ED-B as a surfactant, HCl as acid was used.

Kieralon ED-B is mixture of nonionic and anionic surfactants, low-foaming washing-off agent for prints, dyeings, and coloured woven qualities. Same surfactants (Kieralon ED-B) are used for both cotton and polyester.

Surface electrical resistance of composite fabrics was measured with Multimeter device.

Surface structures of obtained composite fabrics were examined with SCANNING MICROSCOPE JEOL JSM-6300 (SEM) at the appropriate voltage magnification.

Tablo 1. Technical informations of used raw fabrics

Properties of fabrics	
The raw material of fabrics	**100% cotton and 100% polyester**
Structure of fabrics	**Raw fabric**
Type of woven	**Twill 2/1 S**
Weft	**23 weft/cm**
Warp	**36 warp/cm**

2.1. Production of PES/PANI and Co/PANI composite fabrics containing different percentages of PANI

PES/PANI and Co/PANI composite fabrics containing different percentages of PANI were produced using surfactant.

All processes were done at room temperature and 65% relative humidity rate.

After polymerization processes, obtained composite fabrics was washed twice with distilled water. All fabrics were dried in room temperature and 65% relative humidity during 24 hours.

Amount of polyaniline absorbed on all fabrics was calculated using fabric weights before and after polymerization processes.

2.1.1. Synthesis of PES/PANI and Co/PANI composite fabrics using 1 mol/l aniline

A foulard bath was prepared adding 5 g Kieralon ED-B to 1 mol/L aniline solution. Then Raw fabrics were passed from this foulard bath. After This bath, fabrics were passed from polymerization bath prepared to dissolve 228 g $(NH_4)_2S_2O_8$ in 88 ml/1L HCl. Fabrics were waited in polimerization bath until they would be black and green.

Percentages of Polyaniline absorbed on PES/PANI and Co/PANI fabrics are respectively 42,26 and 118,43.

2.1.2. Synthesis of PES/PANI and Co/PANI composite fabrics using 0.1 mol/L aniline

In this experiment, 5 g Kieralon ED-B as a surfactant was added to 0.1 mol/L aniline solution and distilled water was used to complete the solution to 1 liter. For polymerization bath, $(NH4)_2S_2O_8$ and HCl were used in same proportions and at same laboratory conditions.

Percentages of Polyaniline absorbed on PES/PANI and Co/PANI fabrics are respectively 35.6 and 94.

2.1.3. Synthesis of PES/PANI and Co/PANI Composite Fabrics Using 0.5 mol/L Aniline

2 L volume of foulard machine was used to coat the fabrics with conductive polymer. Cotton and polyester fabrics were attached to each other by seaming for being passed from foulard bath. 2L volume of Foulard bath was prepared with 0.5 mol aniline, 2.5 g/L Kieralon ED-B and H_2O. Then Fabrics were passed from this foulard bath. Shortly after this

foulard bath, Fabrics were passed from polymerization bath prepared with dissolved 58 g $(NH_4)_2S_2O_8$ 0.2 mol/1L in (20ml) HCl.

Percentages of Polyaniline absorbed on PES/PANI and Co/PANI fabrics are respectively 36.02 and 93.24.

2.1.4. Synthesis of Co/Aniline composite fabrics adding $AgNO_3$

The purpose of this process; Electrical conductivity of obtained composite fabrics were increased. So nitrate of silver ($AgNO_3$) was added to prepared aniline solution. Firstly, A solution including 1 mol aniline/L (93g), (15%) HNO_3 (30 ml), 5 g/L Emulsionante as a surfactant, 50g/L $AgNO_3$ was prepared for foulard bath and cotton fabrics were passed from this foulard bath three times.

Then, Cotton fabrics were waited 15 minutes in 1 L of polymerization bath including 58 g/L $(NH_4)_2S_2O_8$ and 30 ml HNO_3.

2.2. Measurement of electrical conductivity

In this study, two terminal technique was used for measurement of electrical conductivity. Dimensions of electrodes and samples are really important for this technique. For example; the relationship between resistance and conductivity of sample are given the following equation.

$Rs = Rx\, l / A$ $\qquad$ $S = l / Q$

R_s = Specific resistivity of sample (ohm/cm),

l = The distance between the two electrodes on the sample

A = Thickness of the sample,

S = electrical conductivity of sample ($ohm^{-1}cm^{-1}$)

Figure 2. Measurement of electrical conductivity with two terminal technique

3. RESULTS AND DISCUSSION

Figure 2 is showed variation of the percentages of stored aniline solution on cotton and polyester composite fabrics when the molar ratio of aniline in solutions are increased.

It is seen clearly that the ratio of stored aniline on the composite fabrics maximized when the molar ratio of aniline in the solutions were increased and the maximum level of surfactant was used.

Also it is identified that the aniline absorption ratios of cotton fabrics were better than polyester fabrics due to chemical structures of them. But it is seen that upward trends of stored aniline ratios in both fabrics were paralel.

Certainly, it is observed that usage of the surfactant effected the absorption ratio of aniline solution. When the surfactant was used in solution including 1 mol of aniline, the percentage of stored aniline ratio of the cotton fabric increased from 99.39% to 118.43 %, the polyester fabric increased from 39.02 % to 42.26 %.

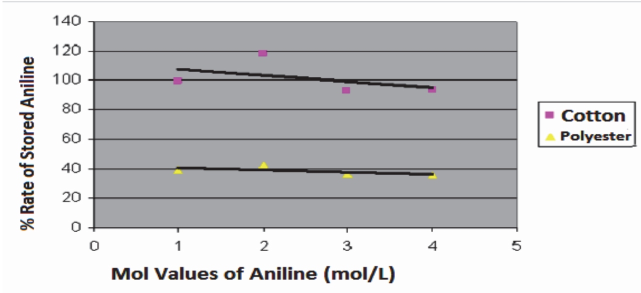

Figure 3. Variations of the percentages of stored aniline rate on cotton and polyester fabrics when aniline rates were increased in solutions

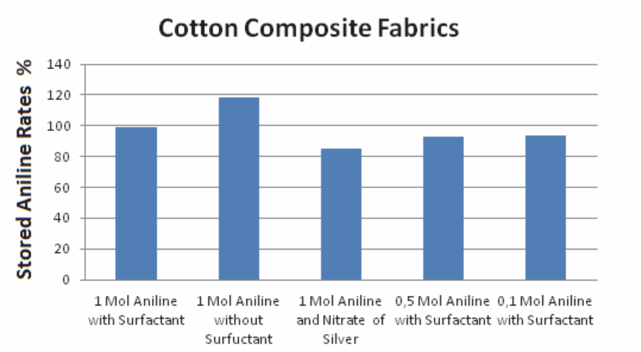

Figure 4. The absorption rates of aniline solutions on cotton fabrics

Figure 3 is shown that stored aniline rate has remained stable at a certain point aniline rate is increased up to be increased. Stored aniline rates on all fabrics were calculated using fabric weights before and after polymerization processes.

Also strored aniline solution rate increases, the conductivity of the fabric increases so (Figure 4).

It was seen clearly that Aniline/$AgNO_3$/Cotton composite fabric has higher electrical resistance and stored lower solution rate due to low solubility of $AgNO_3$ in aniline and HNO_3 solution.

Tablo 2. Electrical resistances and percentages of stored aniline solutions of PANI/AgNO3/Co ve PANI/Co composite fabrics

Composite Fabrics	Mole Ratio	Stored Aniline Solution Rates (%)	Electrical Resistivities (ohm/cm)
PANI/AgNO3/Co	1 mol	85.53	$15x10^5$
PANI/Co	1 mol	118.43	$15x10^3$

It will be seen that Aniline particules just attach non-uniformed on cotton fabrics If SEM images are examined detailed.

It was found that most of the samples had very high values to be more than the maximum limit value of 20 megaohms when electrical resistances of the fabric samples had been measured.

Aniline/$AgNO_3$/Cotton and Aniline/Cotton composite fabrics had highest electrical conductivity between other fabrics.

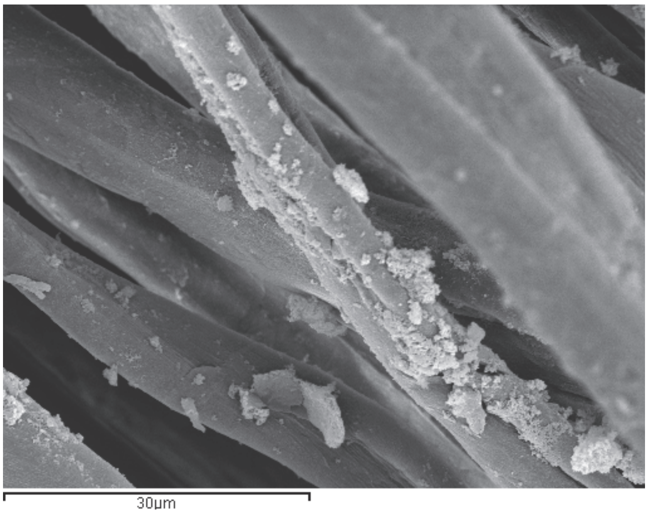

Figure 5. SEM image of PANI/Co composite fabric, 2000x

Before and after washing process, When the SEM images of composite fabrics examined, It is found more aniline particles on cotton composite fabrics than polyester fabrics. However, cause of higher electrical resistivity of cotton composite fabrics is quite irregular and scattered settlement of aniline particles on fabric surface.

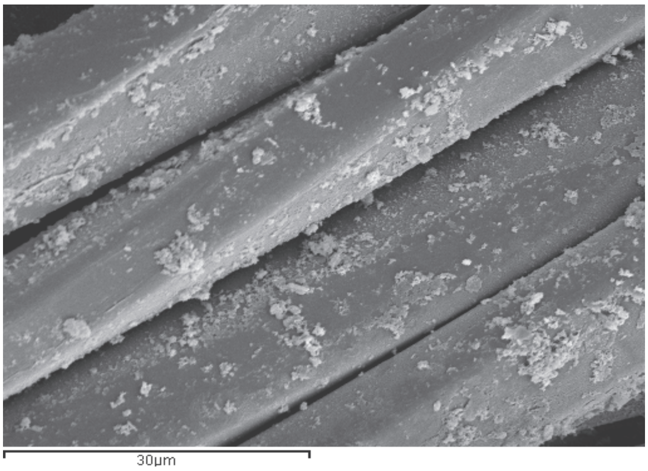

Figure 6. SEM images PANI/PES composite fabric, 2000x

On the contrary of the cotton fabric, settlement of aniline particules on polyester fabric is quite uniform and smooth. But also, electrical conductivities of the polyester fabrics are very low, This is because the aniline particles that are not continuous as on cotton, are the point.

As a result of the experiments; electrically conductive cotton composite fabric has been achieved. Electrical resistance of Polianiline/AgNO3/Cotton composite fabric is 15 x 10^5 ohm/cm and electrical resistance of Polianiline/Cotton composite fabric is 15 x 10^3 ohm/cm. These composite fabrics can be used in the production of antistatic and conductive fabric used for protective clothing.

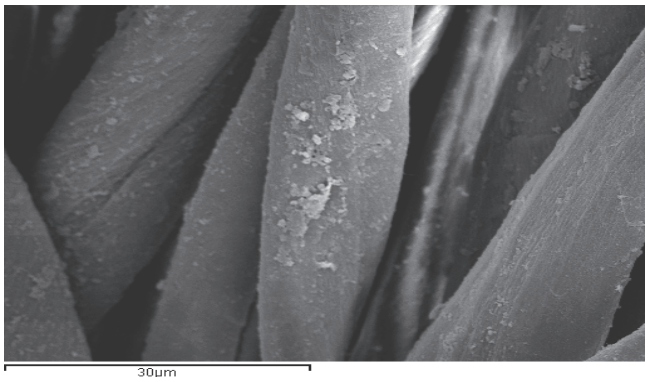

Figure 7. SEM images of $AgNO_3$/PANI/Co composite fabrics, 2000x

4. CONCLUSIONS

In this study; Coating process of Polyaniline onto cotton and polyester fabrics was made using chemical polymerization method. In the textile industry, using foulard machine in coating process of polyaniline has made possible the production of conductive fabric in a practical way. Also differently, It was examined the effects of electrically conductivity of $AgNO_3$ on cotton composite fabric.

Increase of conductivity of the composite fabric depends on increase of aniline rate in solutions and rate of absorbed solution on the fabric. Rate of Stored PANI on cotton fabric went up to 118.43% value. Electrical resistance of Polianiline/AgNO3/Cotton composite fabric is 15 x 10^5 ohm/cm and electrical resistance of Polianiline/Cotton composite fabric is 15 x 10^3 ohm/cm. Obtained these values are quite good level for production of conductive composite fabric using polymerization method.

It was revealed that before and after washing process, concentrations of used HCl, $AgNO_3$, $FeCl_3$ chemicals had been effected electrical resistance of the surface and percentage of absorbed solution.

It was seen that Aniline/$AgNO_3$/Cotton composite fabric had lower solution ratio and higher electrical resistance due to low solubility of $AgNO_3$ in aniline and HNO_3 solution. However, It was found that $AgNO_3$ had positive effects on PANI/Cotton composite fabric.

It was found that most of the samples had higher values than the maximum limit value of 20 megaohms when electrical resistances of the fabric samples had been measured. But given the values found so far; Electrical conductivities of PANI/cotton and PANI/$AgNO_3$/ Cotton composite fabrics are quite good level.

After the washing process; It was found that polyaniline didn't make a chemical bond with cotton and polyester and just attached physically on these fabrics when electrical conductivities results had been controlled. So it is tought that obtained composite fabrics can be used for disposable antistatic technical textile products.

Results obtained were showed that electrically conductive PANI/Cotton composite fabrics were produced by chemical polymerization method. It is considered that combination of electrical conductivity of PANI and physical, chemical and mechanical properties of cotton will be very important for production of antistatic composite fabric.

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