Preparation and Study of Conductive Fabric

Xiaojun Yang [a], Wei Hong[b *], Xiuhong Zhao[c], Fei Mi [d], Jielin Wang [e], Heng Zhang[f], Jianwen Gao[g]

Qinghuangdao Entry-exit Inspection & Quarantine Bureau Coal Inspection Technique Center, Qinhuangdao Hebei P. R. China

[a] qhdyangxj@sina.com, [b] weih@ysu.edu.cn, [c] 709959372@qq.com, [d] 33132769@qq.com, [e] mjzxwangjl@sina.com, [f] 13780357728@163.com, [g] 1459035567@qq.com

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Abstract. In this paper, conductive polyester fabric be prepared by site adsorption polymerization. The effects on the electrical properties of fiber by the alkali treatment, aniline monomer concentration, oxidant concentration, the dopant concentration, further doping and other factors. Optimize experimental parameters, determine the optimum conditions. The fibers were characterized by Using FTIR, DSC, XRD, SEM.

Introduction

Polyaniline with cheap raw materials, stable, good conductivity performance advantages, is considered to be the most promising polymers. Because of the rigid polyaniline chain, polar, poorly soluble, does not melt, processability and spinnability is poor, limiting its widespread application [1-7]. Site adsorption polymerization of the fiber is placed in the aniline monomer, make the fiber surface adsorption amount of aniline, then slowly droppe d oxidant, synthetic conductive polyaniline on fiber's surface. This approach not only retains the original mechanical properties of the fibers and the fibers have excellent electrical properties [8].

Experiment

Weigh a certain amount of polyester fiber, placed 10 g / L NaOH solution and stirred at 40 ℃ condition 2 h, followed by several pickling, drying.

Pretreated polyester fibers are placed aniline monomer solution mixed with hydrochloric acid, and soak 30 min. Ammonium persulfate (APS) solution was then added slowly, stir, so that in-situ polymerization of aniline monomer deposited on the fiber surface. Fibers removed after 120 min reaction with hydrochloric acid, acetone, washed several times with deionized water, respectively, dried to constant weight.

Results and discussion

Re – doping. Polyester fabric compact structure, polarity is not strong, poor absorption of aniline. The polyester fabric is treated by NaOH hydrolysis reaction occurred on the fiber surface can be improved polyester fiber adsorption of aniline.

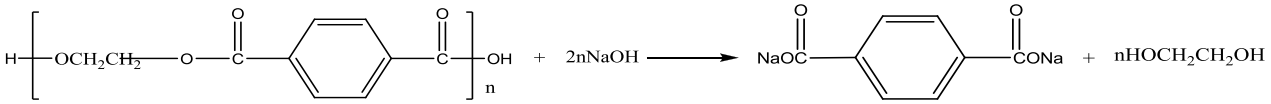

Fig. 1 polyester hydrolysis

After the fiber after alkali etching on the surface of the formation of many small irregular trench holes, and remove the fiber surface residual slurry. Thus on the one hand to enhance the adsorption capacity of polyester fiber, polyaniline is deposited in the hole on the other hand, it can be firmly attached to the surface of the fiber, reinforced polyester fiber conductivity and stability. Table 1 shows that, after the alkali pretreatment of the fabric as compared to non-pretreated fabric, the fabric after polymerization into a light green color from dark green, to increase the conductivity of the fabric. This is because the effective absorption capacity of the fabric after alkali treatment more polyaniline, polyaniline can penetrate into the interior of the fiber.

Table 1 conductive properties of the fabric before and after the alkali treatment

Item	Pretreatment	Unpretreated
Surface resistivity $R_0(\Omega/cm^3)$	3.73×10^3	5.46×10^4
Color	Dark green	Light green
Conductivity σ(s/cm)	0.06	0.02

Effect of aniline monomer concentration on the conductive properties of polyester fabric

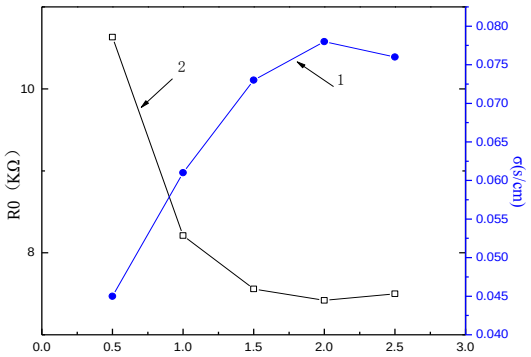

Fig. 2 Effect of aniline monomer concentration on the conductive properties of polyester fabric (1- conductivity; 2- surface resistance, treatment conditions: oxidizer concentration: 0.15 mol / L dopant concentration: 1.5 mol / L, reaction time: 2 h, reaction temperature: 20 ℃, stirring rate: 120 rpm.)

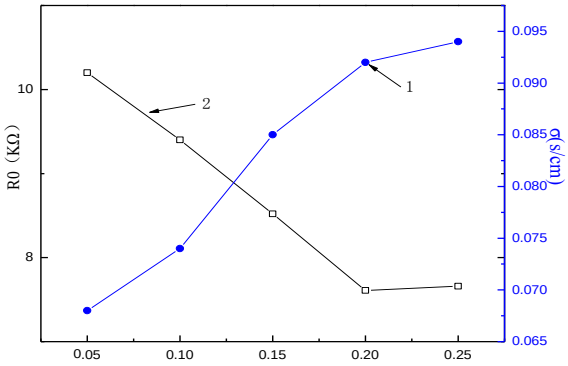

Fig. 3 Effect of oxidant concentration on fabric conductive properties (1 conductivity; 2 - the surface resistance; 3-treatment conditions: aniline concentration: 0.15 mol / L, the concentration of hydrochloric acid 1.5 mol / L, reaction time: 2 h, reaction temperature: 20 ℃, stirring speed: 120 rpm.)

Fig. 2 shows: when aniline concentration within 0.5-2.0 mol / L range, the conductivity increases with fabric aniline concentration increases. When aniline concentration of 2.0 mol / L, the polyester fabric for maximum conductivity, and then continue to increase the concentration of aniline, it has little effect on the fabric conductivity stabilized. Surface resistance is increased with the aniline monomer concentration decreases, and finally tends to a constant value. This is because when aniline concentration is too low, is not conducive to the growth of polyaniline chain reaction, cannot produce a higher molecular weight polyaniline, while lower concentrations of aniline is not conducive to deposition on the fiber surface and thus poor conductivity. For certain reaction system, not the aniline monomer concentration, the higher the fabric conductivity, because the chain reaction also depends on the amount of oxidant, when a certain amount of oxidant, the polyaniline molecular chain to grow to a certain extent it will stop growth, the fabric will not continue to enhance

conductivity, electrical conductivity stabilized. Also according to quantum theory, the longer the molecular chain conjugated electronic activation energy lower, the better carrier mobility, concentration of aniline is too large, prone to side effects, is not conducive to the generation of highly conductive polyaniline.

Effect of oxidant concentration on fabric conductive properties. Fig. 3 shows that, when the oxidant concentration is less than 0.2 mol / L, oxidation ability, low conductivity of the fabric. With the gradual increase in the oxidant concentration, the conductivity increases, when the oxidant concentration of 0.2 mol / L, the adsorption of aniline monomer in the fiber surface can be completely oxidized to form doped polyaniline, evenly distributed in the fiber surface conductive path. At this rate of polymerization appropriate, both to ensure the effective absorption of aniline fiber, but also enable the polymerization reaction normally, so the higher the conductivity of the fabric. The concentration of the oxidizing agent is too large, the polymerization of aniline monomers too quickly, cannot be formed in the structured surface of the fiber, conductive coating uniformly distributed, resulting in decreased conductivity. At the same time the excess oxidant can be further oxidized polyaniline, macromolecular chains cracked into low molecular weight compounds, resulting in fiber conductivity performance. The concentration of the oxidizing agent is too large, the solution quickly black color, the fabric surface deposition of a large number of black precipitate, the color becomes black. This is due to the high concentration of the oxidizing agent to the good performance of semi-conductive polyaniline oxidation of the redox-type non-conductive polyaniline full oxidation of the formula to reduce the conjugation of macromolecular chains, reducing the electron delocalization, and therefore conductivity decline.

Effect of dopant concentration on the conductive properties of the conductive fabric. Doping acid plays an important role in the process of conducting polyaniline synthesis. First acidic conditions favor aniline coupling manner by 1,4 polymerization, secondly to provide the required proton conductivity, electrical conductivity imparting certain polyaniline. Fig. 3-4 shows that, with the increasing concentration of the dopant acid, fabric conductivity gradually increased, and finally tends to a constant value. This is because the doping low acid concentrations, is not conducive to the generation of high molecular weight polyaniline and dopant acid in the reaction also play a catalytic role. At low acid concentration, the polymerization rate is low, slow response, aniline low yields

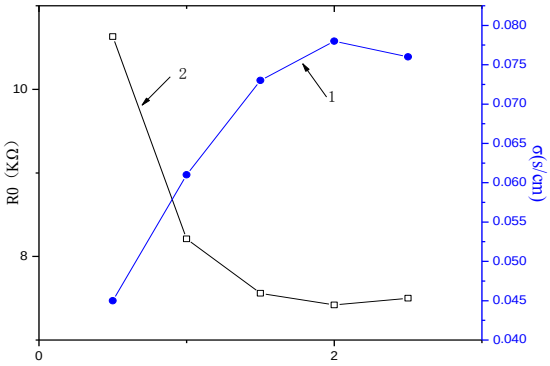

Fig. 4 Effect of dopant concentration on the fabric (1 - conductivity; 2 - the surface resistance; 3 - treatment conditions: aniline concentration: 0.15 mol / L, oxidant concentration 0.2 mol / L, reaction time: 2 h, reaction temperature: 20 ℃, the oscillator speed: 120 rpm / min.)

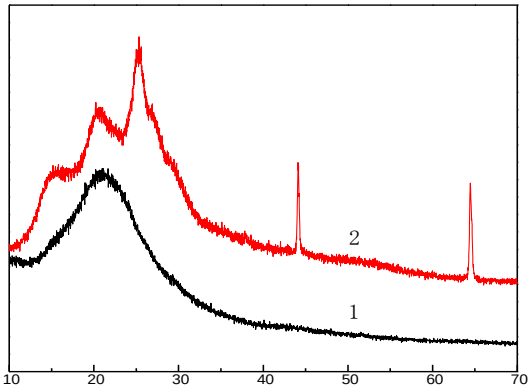

Fig. 5 X-ray images of before and after the doping doped polyaniline (1 - polyaniline; 2 - doped polyaniline)

obtained. When the acid concentration of 1.5 mol / L, will cause significant changes in morphology of aniline in the fabric surface to form a conductive network chain, a significant increase in the conductivity and tends to a constant value. When the reaction system doping acid concentration is too high, deep oxidation of aniline, aniline generate most radical cation, aniline cannot generate macromolecular conjugated polyaniline, high acid concentration in the system, limits the growth of polyaniline chain, generating large number of small molecular weight products, resulting in decreased conductivity.

Effect on the fabric conductive properties of Re – doping. As shown in Table 2, the redoped fabric conductivity increased. This may be because the dedoping and doping re failed to affect the molecular chain conformation polyaniline, aniline connection mode is not changed, but the main chain of the π-conjugated increased extent, while the H+ from the more localized state into delocalized state, formed more carriers; followed further on the surface of the fabric holes, pores and the like inside the fibers recess further doping to enhance the conductivity of the fabric. By Re - doping can improve the conductivity of the fabric of life and frequency of use.

Table 2 Effect of conductance properties of the fabric of the Re - doping

Performance / Sample	Surface resistivity $R_0(\Omega)$	Conductivity σ(s/cm)
Once doping	4.83×10^{4}	5.43×10^{-3}
Secondary doping	3.62×10^{3}	2.88×10^{-2}

XRD analysis. Line 1 is polyaniline WARD spectrum (Fig. 5). The emergence of a large scattering peak at 2θ = 20 ° at the instructions presented amorphous polyaniline. After hydrochloric acid doped polyaniline (line 2) in 2θ = 15.4 °, 20.6 ° and appears diffraction peaks at 25.0 °, which are attributed to PANI layered ordered structure, vertical structure of polyaniline backbone periodically and parallel structure, description of hydrochloric acid doped with a certain degree of crystallinity, but relatively weak peak intensity, larger width explain its crystallinity is not strong, small crystal size. Crystalline regions due to molecular chains arranged neat, smooth conductive pathways [9].

Fourier transform infrared spectroscopy.

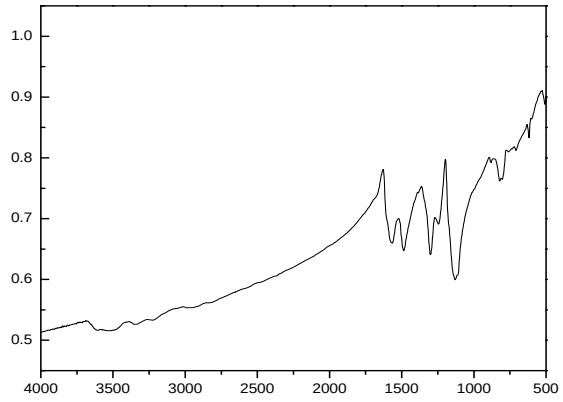

Fig. 6 Doped polyaniline FTIR Figure

Eigenstate PANI in the infrared spectra at 832 cm-1 outer benzene ring para disubstituted benzene CH-plane bending vibration characteristic absorption peak, 1165 cm-1 the benzene ring stretching vibration and C = C CN stretching vibration absorption peak, 1307 cm-1 benzene ring is characteristic vibration absorption peak, 1590 cm-1 the benzene ring stretching vibration absorption

peak of C = C, 3388 cm-1 the NH stretching vibration absorption peak . Fig. 6 is a hydrochloric acid doped PANI emulsion of the FT-IR spectra. Hydrochloric acid doped polyaniline spectrum eigenstate polyaniline contrast, in 1165 cm-1,1590 cm-1 represents the absorption peaks in the polymer chain quinone imine structural units were moved to 1120 cm-1 and 1571 cm-1, after doped polyaniline, imino nitrogen into positive ions, the charge can be delocalized to the amino nitrogen or benzene ring, the molecule chains charge delocalization degree of enhancement, so quinone and benzene formula structure of the electron cloud density decreased, reducing interatomic gravity, resulting in inducing effect, therefore, the absorption peak shifted to low-doped wave direction. 1300 cm-1 quinone structure in CN bond stretching vibration absorption, the absorption peak at 822 cm-1 at the outer surface of the polymer structure unit aniline substituted benzene ring bending vibration of CH bond deformation cause. Quinone absorption peak is larger, the higher the degree of oxidation of polyaniline. The product described above has doped polyaniline structure [10].

The fiber morphology. Fig. 8 (a) is alkali treated fibers without electron microscope images, the fiber surface is not rough and smooth, there is more granular projections, which is in the preparation process of polyester remaining sizing agent. Fig. 8 (b) is by alkaline treatment for 1 h electron microscope image, the fiber surface is smooth, some regions have grooves, no obvious cracks, indicating the fiber surface sizing agent has been completely removed, and the fiber has a slight corrosion action, not destroy the fiber structure. Fig. 8 (c) is adsorbed by the polymeric fiber field electron micrograph, the figure fiber surface smooth, seamless, polyaniline in its uniform surface adsorption.

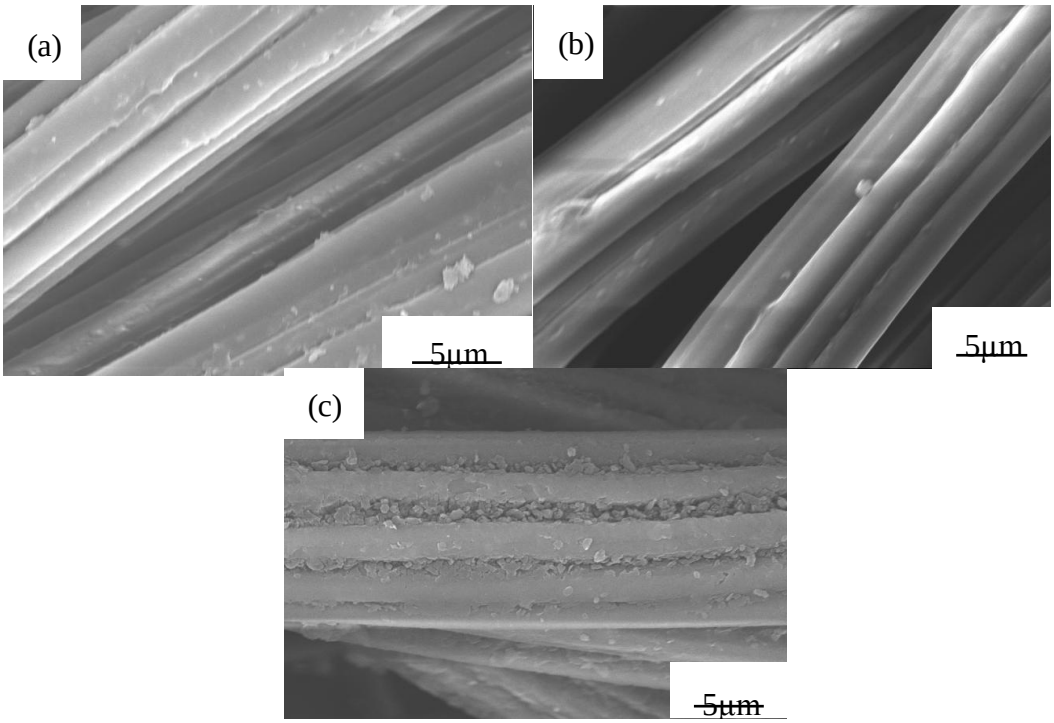

Fig. 8 The field before and after the alkali treatment and scanning electron microscopy image after adsorption polymeric fibers

(a: SEM image without fiber lye treatment; b: after 1 h after alkaline treatment electron microscope image fiber; c: adsorption site polymeric fibers electron micrograph)

Result

The study showed that after hydrochloric acid doped product having doped polyaniline structure, has a crystallinity, the crystallinity is not strong, small crystal size, fiber surface smooth, uniform polyaniline adsorbed on the surface. With increasing concentrations of aniline, fabric conductivity starts to increase, when the aniline concentration 0.3 mol / L, fabric conductivity maximum, then continue to increase the concentration of aniline, has little effect on the fabric conductivity stabilized. The optimum conditions for producing the conductive fibers are: aniline concentration: 0.3 mol / L, oxidant concentration: 0.2 mol / L. Dopant concentration: 1.0 mol / L, reaction time: 2 h, reaction temperature: 20 ℃, stirrers speed: 120 rpm.

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