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A study on the properties of polypyrrole coated polyester fiber

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Abstract. Polyester fibers are used in a great many textile and industrial materials, their undesirable electrical advantage bring about disadvantages. Direct polymerization of pyrrole on polyester fibers may provide useful tools for producing new conducting materials. Polyester/polypyrrole composite fiber was prepared by in situ oxidative polymerization from liquid phase pyrrole at room temperature. The result showed that deposition of pyrrole is an effective way to impart conductivity to polyester fiber. The Tg of coated polyester fiber decreased and the surface of Ppy coated polyester fiber displayed an evident granular structure. In addition, the Ppy coatings have good stability under washing and heating treatment, which demonstrate that polypyrrole has good affinity to polyester fiber.

Introduction

Conducting polymers, such as polypyrole, polyaniline, and polythiophene have attracted much attention due to their unusual electronic, metallic behaviour, and optical properties with several potential applications in sensor, electronic devices and artificial muscles[1-4]. In particular, doped polypyrrole exhibits high conductivity and good environmental stability, thus it is the object of much research and applications. Polypyrrole cannot be directly processed, due to its intrinsically poor mechanical properties, therefore it generally used for coating other materials[5-7].

Polyester fibers are widely used both in the textile industry and outside the classical textile fields. However, fabrics composed of polyester fibers are easy to accumulate static electricity because of its low conductivity [8,9]. Therefore, how to impart the conductivity to polyester fiber has attracted attentions. Deposition of conducting polymers is a relatively simple operation. Direct polymerization of conductive conjugated polymers on polyester fibers may provide useful tools for producing new conducting materials which allow to forming a conductive layer on the fiber substrate[1-7]. And polypyrrole has already demonstrated good affinity to protein and cellulose fibers. A great deal of work has been carried out on viscose,
Lyocell, wool and silk fibers [3,10,11]. As far as polyester fibers are used in a great many textile and industrial materials, their undesirable electrical advantage bring about disadvantages. Therefore, how to impart conductive property to polyester fiber is still an important work.

In this work, Ppy coated polyester fiber were prepared by liquid deposition at room temperature. Ppy-coated polyester fibers were characterized by morphological, DMA, and electrical conducting analyses. The effect of deposition technique on the electrical and mechanical properties of Ppy coated polyester fibers was discussed. sina.com

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Experimental detail

Materials

Polyester fibers are provided by Rongsheng Co., Ltd, Zhejiang, China. Analytical grade pyrrole was purchased from Aldrich. Iron (III) chloride hexahydrate and cetyltrimethylammonium bromide were purchased form Tianjin Chemical Reagent Institute without any further purification.

Preparation of Ppy coated polyester fibers

2 mol/L aqueous solution of iron (III) chloride hexahydrate (catalyst) was preparted firstly, then polyester fibers were soaked in these catalyst solution contain various concentration of cetyltrimethylammonium bromide (dopant) for 30 min. After that, these socked polyester fibers were put into reaction tank filled with liquid phase pyrrole monomer. The polymerization was carried out at room temperature. After deposition on the polyester fiber, the fiber became black and these samples were thoroughly washed with water to remove the chloride hexahydrate and pyrrole which may excess on the fiber surface.

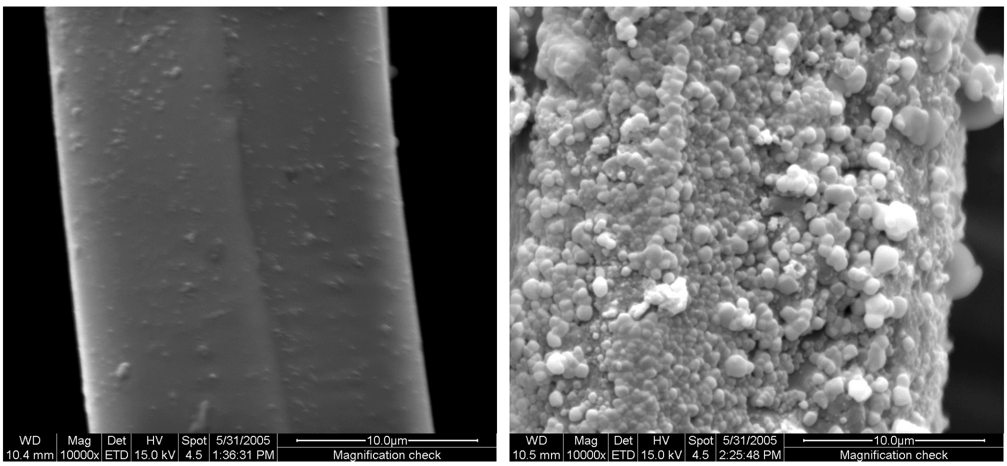
Test and analysis

Electrical resistance, R, (Ω) of fiber was measured with a two-lead system at room temperature. Coated fibers were washed in a commercial washing machine with a commercial washing powder under the same condition. The numbers of washing cycles were varied and each washing cycle was 5min. Then the resistance of fibers with different washing cycles was measured. The surfaces of fiber were observed by SEM (FEI Quanta 200). DMA measurement was performed using NETZSCHDMA-242. The heating rate and frequency were fixed at 10 ° C/min and 1 Hz.

Results and discussion

SEM of Ppy coated polyester fiber

The morphological characteristics of the polyester and polypyrrole coated polyester fiber are shown in Fig. 1. An image of polyester fiber before polymerization is shown in Fig. 1(a) and the surface of polyester fiber is smooth. After pyrrole polymerization, fibers appeared homogeneously coated with a film of Ppy (shown in Fig.1(b)). The Ppy coatings displayed a much rougher and evident granular structure.



(a) (b)

Fig.1 SEM picture of (a) as received polyester fiber, (b) Ppy coated polyester

DMA analysis

The DMA curve of polyester fibers as received and liquid deposition polyester fiber are shown in Fig.2. The maximum value of tan δ is the value of Tg , which is related to molecular packing and the chain rigidity and linearity. Compared with the polyester fiber as received, the Tg of Ppy coated polyester fibers are decreased from 118.5°C to 86.6°C and the shape of peak become broadening. The order of macromolecule in the amorphous region of polyester fiber reduced after treating by the oxidizing agent and dopant, which results in the peak of tan δ move to lower temperature obviously. In addition, the action between polyester macromolecule and oxidizing is not homogeneity, which result in the shape of peak has the characters of dispersion and broadening.

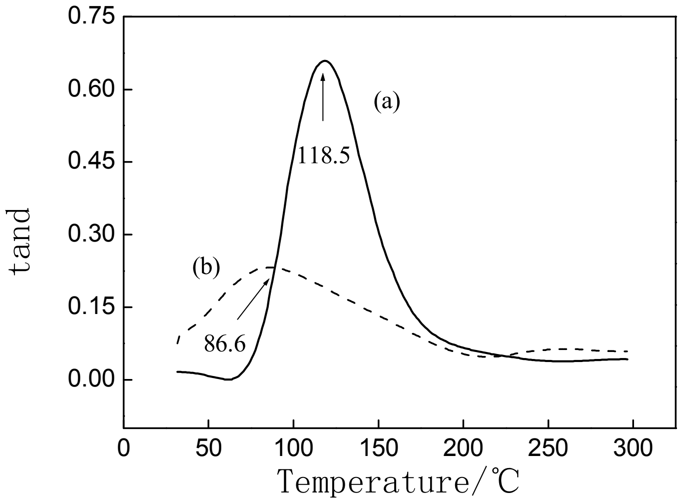


Fig. 2 DMA curve of (a) as received polyester fiber, (b) Ppy coated polyester

Stability of Ppy coatings

The stability of polypyrrole coatings under different washing cycles and storage time are discussed and the results are shown in Fig. 3 and Fig.4, respectively. The results show that the resistance of prepared conductive fiber has a litter increasing with the increasing of washing cycles and storage time. The Ppy coatings on the polyester fiber surface are stable under the experimental conditions. In addition, the The results of Fig. 3 and Fig.4 show that the concentration of dopant has strong effect on the resistance of Ppy coated polyester fiber. From the results of Fig.3 and Fig.4, we can see that the resistance decreased obviously with the increasing of dopant concentration from 0mol/l to 0.001mol/L and the resistance changed little when the dopant concentration increasing to 0.002mol/L.

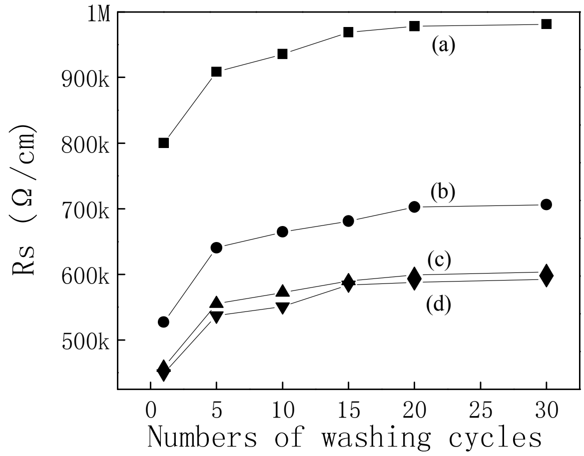


Fig. 3 Effect of washing cycles on the resistance with various concentration dopant
(a) 0;(b)0.0005mol/L;(c)0.001mol/L;(d)0.002 mol/L

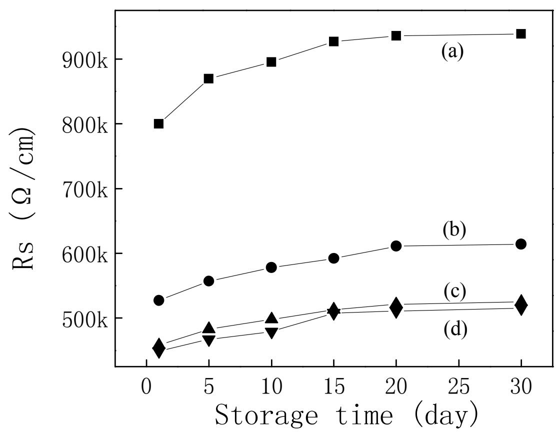


Fig. 4 Effect of storage time on the resistance with various concentration dopant
(a) 0;(b)0.0005mol/L;(c)0.001mol/L;(d)0.002 mol/L

The Ppy coating durability was also tested through heating experiment. Fig. 5 (heat treatment for 15min) and Fig.6 (heat treatment for 60min) shows the effect of heating on the resistance of Ppy coated polyester fiber at 50°C,80°C and 110°C, respectively. When the concentration of dopant is same, the resistance of fiber is increasing with the increasing heat treating temperature and treating time, which is maybe associated with the evaporation of dopant at higher temperature. To approve it, these heated doping fibers were re-doping with HCl and the result is showed in Table 1. We can see that the resistance of re-doped Ppy coated polyester fibers were decreased which showed that the increasing of resistance at heating condition is connected with de-doping of the dopant and Ppy coatings are thermal stable at the experimental condition.

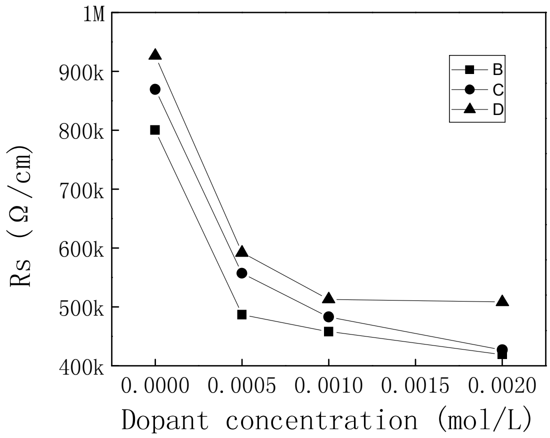


Fig. 5 Effect of heat temperature on the resistance with various treating temperature

-■- 110° C; (b) -●- 80° C;(c) -▲- 50° C

(heat treating time is constant at 15min)

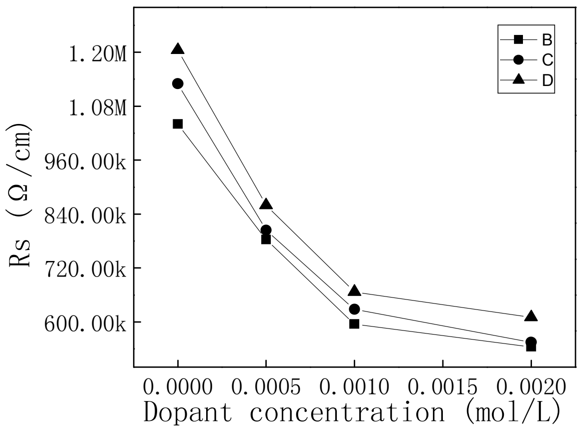


Fig. 5 Effect of heat temperature on the resistance with various treating temperature

-■- 110° C; (b) -●- 80° C;(c) -▲- 50° C

(heat treating time is constant at 60min)

Table 2 Resistance of Ppy coated polyester fiber after treated at 110° C and doping again with HCl (the concentration of dopant is 0.0005mol/L)

Resistance (Ω/cm)	Treated at 110° C	After re-dopoing
Fiber being heated treating for 15min	4.87×10^5	8.23×10^4
Fiber being heated treating for 60min	7.83×10^5	2.21×10^5

Summary

Polyester/polypyrrole composite fibers were prepared by in situ oxidative polymerization from liquid phase pyrrole at room temperature, by using $FeCl_3$ as catalyst. The structure, morphological and electrical properties, stability of coated fibers was investigated, respectively. The experimental results show that deposition pyrrole is an effective way to impart conductivity to polyester fiber and

the polyester fiber has lower resistance after pyrrole deposition on the fiber surface. The Tg of coated polyester fiber decreased and the surface of Ppy coated polyester fiber displayed a much rougher, evident granular structure. In addition, the Ppy coatings have good stability under washing and heating treatment, which demonstrate that Polypyrrole has good affinity to polyester fiber.

References

[1] M.Khalid, F.Mohammad: Synthetic Metals, Vol. 159(2009),p.119

[2] C.F.Xiao, X.M.Tao, S.M.Leung: Polm. Int., Vol. 55 (2006),p.101

[3] I.Cucchi, A.Boschi, C.Arosio, F.Bertini: Synthetic Metals, Vol.159(2009), p.246

[4] X.Jin, C.F.Xiao, Synthetic Metals, Vol.160(2010),p.368

[5] V.Georgakilas, P.Dallas, D.Niarchos, Synthetic Metals, Vol.159(2009),p.632

[6] A.Varesano, A.Aluigi, C.Tonin, fibers and polymers, Vol.7(2006),p.105

[7] B.Qu， Y.T.Xu, Synthetic metals, Vol.160(2010),p.732

[8] X.Jin, C.F.Xiao, Journal of Applied Polymer Science, Vol.102(2006),p.4144

[9] X.Jin, C.F.Xiao, Journal of Applied Polymer Science, Vol.102(2006),p.2685

[10] A.Varesano, L.D.Acqua, C.Tonin: Polymer Degradation and Stability, Vol.89(2005),p.125

[11] A.Varesano, A.Aluigi, C.Tonin: Fibers and Polymers, Vol.7 (2006),p.105