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# A facile fabrication of multifunctional knit polyester fabric based on chitosan and polyaniline polymer nanocomposite

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ABSTRACT

Knit polyester fabric was successively modified and decorated with chitosan layer and polyaniline polymer nanocomposite layer in this paper. The fabric was firstly treated with chitosan to form a stable layer through the pad-dry-cure process, and then the polyaniline polymer nanocomposite layer was established on the outer layer by in situ chemical polymerization method using ammonium persulfate as oxidant and chlorhydric acid as dopant. The surface morphology of coated fabric was characterized by scanning electron microscopy (SEM), and the co-existence of chitosan layer and granular polyaniline polymer nanocomposite was confirmed and well dispersed on the fabric surface. The resultant fabric was endowed with remarkable electrical conductivity properties and efficient water-repellent capability, which also have been found stable after water laundering. In addition, the photocatalytic decomposition activity for reactive red dye was observed when the multifunctional knit polyester fabric was exposed to the illumination of ultraviolet lamp. These results indicated that chitosan and polyaniline polymer nanocomposite could form ideal multifunctional coatings on the surface of knit polyester fabric.



## 1. Introduction

The development of textile industry has increased the demand for multifunctional fabric, a great deal of investigations attempted to impart multifunctional properties on fabric in recent years [1–4]. Especially, the application of polymer nanocomposite in the multifunctional finishing of textiles has emerged in the last decades, which can improve bonding properties and impart desired conductivity, UV protection, antimicrobial and wettability properties, etc. [5–9]. In the present work, we mainly focused on the application of polymer nanocomposite to knit polyester textile for achieving desired electrical conductivity, hydrophobic properties, and photocatalytic activities.

Many great investigations and new techniques have been carried out to endow some special functions on textiles, such as the improvement in wetting, antistatic, electrical conduction, water-repellent and adhesion behavior, photocatalytic activity, etc. [10–15]. Several approaches such as enzymatic modification, grafting of different monomers, sol–gel method, γ-ray radiation method, application of supercritical carbon dioxide and molecular layer-by-layer self-assembly techniques has been devoted on the surface modification of polyester textiles [16–19]. For instance, Shyr et al. [13] has explored the possibility for antistatic and water-repellent properties to coexist on a single sample of polyester fabric with the application nano-silver antistatic finish and fluorine water-repellent finish. Textor et al. [20] utilized sol–gel method to modify the fabric surface based on finishing agent consist of alkoxysilanes modified with alkyl chains and amino-functionalized alkoxysilanes. Furthermore, Molina et al. [16] prepared the polyester fabric with excellent electrical conductive properties by chemical reduction of graphene oxide, also samples with a different number of coatings layers were accessed. Romero et al. [21] employed a polyoxometallate ($PW_{12}O^{3-}{}_{40}$) as a counter ion to produce polypyrrole-coated conductive fabrics with in situ chemical polymerization method. Atmospheric pressure plasma also was taken by Davis and his co-workers to fabricate the fabric with durable water-repellent functionality and good antimicrobial functionality [22].

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With the development of solar energy or rays from artificial sources utilization, visible-light driven photocatalyst has attracted much attention recently. Photocatalytic activity of dyes on fabrics has attracted much attention. For example, Zohoori et al. [23] investigated the influence of $SrTiO_3$ along with $TiO_2$ on cotton fabric to improve the photocatalytic self-cleaning property. Rehan et al. [24] developed the poly(ethylene terephthalate) fabrics with enhancement of photocatalytic activity synthesis of $TiO_2$ nanocomposite particles. Ameen et al. [25] prepared polyaniline/graphene nanocomposites by the polymerization of aniline monomer with graphene and evaluated the photocatalytic activity toward the degradation of rose Bengal dye. Therefore, it is an interesting subject and potential trend to study the multifunctional fabric with photocatalytic activity.

All these above-mentioned modification approaches were relatively effective, but, some expensive equipment, complex treatment process and rigor operations should also be considered. In our paper, multifunctional knit polyester fabric was successfully fabricated with a facile combination technique of simple pad-dry-cure process and in situ chemical polymerization method. Such route expressed facile, simple, low-cost and effective properties.

Chitosan, extracted by a deacetylation procedure from chitin, has been attracted numerous attention due to the outstanding properties, such as nontoxic, biocompatibility, biodegradable and antibacterial activity [26–28]. Polyaniline is one of the most promising conductive polymers because of its environmental stability, controllable electrical conductivity, and interesting redox properties [29–31].

In this paper, chitosan and polyaniline polymer nanocomposite were used as multifunctional finishing agent to finish the knit polyester fabric by conventional pad-dry-cure process and soft in situ chemical polymerization route. The properties of electrical conductivity, water-repellent and photocatalytic activities were also further investigated, then the durability of the above-mentioned properties were evaluated as well.

## 2. Experimental

### 2.1. Materials

The knit polyester fabrics were supplied by Qingdao Jifa Group Co., Ltd, in this study. Chitosan, with a deacetylation degree of 90% and average molecular weight of 125,000 g/mol, was purchased from National Medicine Group, Shanghai, China. Aniline was purchased from Tianjin Fine Chemical Research Institute. All other reagents used in this study were analytical grade, obtained from Laboratory of New Fiber Materials and Modern Textiles, the Growing Base for State Key Laboratory, Qingdao University, and distilled or double distilled water was used in the preparation of all solutions.

### 2.2. Preparation of multifunctional knit polyester fabric

In initial experimentation, sodium hydroxide was taken as the preferred alkali for alkaline treatment, which was deemed as an effective method to increase aniline deposition and polymerization on fabric, and also the weight loss affected negligibly. In detail, the samples of knit polyester fabric were treated with sodium hydroxide solution of 2% (w/v) at the temperature of 90 °C for 100 min in liquor ration of 1:40. The pretreatment knit polyester fabrics were padded in chitosan solutions containing the concentrations of 2% (w/v) in the acetic acid solution of 2% (v/v). The application was carried out using pad-dry-cure process as follows: padding nip pressure was set to obtain 100% wet pick up. Then drying followed by curing in the vacuum oven at 70 °C for 10 min and 120 °C for 5 min.

The pretreatment samples coated with chitosan without crease were immersed in a bottle containing 10 mL aniline monomer and 40 mL anhydrous ethyl alcohol for 1 h. Afterwards, a homogeneous padder was used to control the weight of fabric with aniline and anhydrous ethyl alcohol accurately. Then the required amounts of ammonium persulfate (APS) at 1:1 molar ratio with aniline, chlorhydric acid (HCl) at 1:0.5 molar ratio with aniline were added into aqueous solutions. The polymerization procedure in the aqueous solutions at room temperature for another 2 h with continuous stirring, thus the knit polyester fabric coated with chitosan and polyaniline nanocomposite polymer was obtained.

### 2.3. Characterization

The morphological structures of knit polyester fabric coated with chitosan and polyaniline nanocomposite were studied with scanning electron microscopy (SEM, JSM-5600LV, operating at 15 kV), and a small amount of gold was painted onto the surface of all samples to get clear photograph.

The surface electrical resistance of the nanocomposite coated fabric was carried on according to the AATCC (American Association of Textile Chemists and Colorists) Test Method 76-2005 by two point-probe technique in this study. Each test specimen was taken from a different part of the fabric five times on each side and the average values were taken. The environmental temperature and relative humidity were kept at 20 °C and 65%, respectively.

The water contact angle measurement of nanocomposite coated fabric samples were used to characterize the hydrophobic properties, which was determined by a method of drop on a filament. The wetting of the nanocomposite coated fabric samples was studied by the sessile drop contact angle measurement according to the set up described in literatures [26,32–35]. Briefly, the image of the deionized water sessile drop was registered with digital camera, then the statistical mean and standard deviation of the characterization data were calculated for presentation. The initial advancing angle obtained 2 s after the drop deposition of each sample was characterized.

The photocatalytic activity of fabric samples was assessed by degradation of red dye. The fabric samples (control, chitosan treated, and nanocomposite treated) with the same size 10 × 10 cm were immersed in 100 mL of active red dye solution (100 mg/L, PH 5.5) and illuminated by 300 W ultraviolet lamp for 15, 30, 45, 60, 120, 150 and 180 min under the condition of 65% humidity and 25 °C. Then, the red dye concentration of each sample was determined by UV–Vis spectroscopy (UV–Vis Spectrophotometer, 2550 Shimadzu, Japan) at $\lambda_{max}$ 517 nm.

The relative concentration ($C_0/C$) of active red dye solution could be calculated by $C_0$ (the initial concentration of active red dye) and $C_t$ (the concentration of active red dye at different irradiation times), meanwhile, the dye removal percentage $Q$ (%) at time $t$ can be determined as follows:

$$Q = \frac{C_0 - C_t}{C_0} \times 100\%$$

Laundering was carried out by subjecting surface-treated fabrics to the AATCC Test Method 61-2006. The test was performed using a standard color-fastness to washing laundering machine (Model SW-12AII, Wenzhou Darong Textile Instrument Co., Ltd., China) equipped with 500 mL (75 mm × 125 mm) stainless-steel lever-lock canisters. The fabric was laundered in a rotating closed canister containing 200 mL aqueous solution of an AATCC standard WOB detergent (0.37%, w/w) and 10 stainless steel balls, the sizes of the fabric samples were 50 mm × 100 mm (2.0 in. × 4.0 in.) for the experimental test.