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ОТДЕЛКА ХЛОПЧАТОБУМАЖНЫХ И ПОЛИЭФИРНЫХ ТКАНЕЙ С ИСПОЛЬЗОВАНИЕМ ХИТОЗАНСОДЕРЖАЩИХ КОМПОЗИЦИЙ

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АННОТАЦИЯ

С увеличением напряженности повседневной жизни людей выделение пота человеческим телом неуклонно повышается. В связи с этим специалисты текстильной промышленности постоянно разрабатывают новые виды материалов для удовлетворения потребностей потребителей. На сегодняшний день хлопчатобумажные и полиэфирные ткани преобладают среди всех текстильных материалов, которые люди чаще всего используют в повседневной жизни. Текстильные изделия, особенно изготовленные из целлюлозных волокон, таких как хлопок, могут способствовать росту микроорганизмов из-за большой площади контакта с телом человека и высокой гигроскопичности. В отличие от целлюлозных материалов полиэфирные волокна не содержат химически функциональных или гидрофильных групп. При этом использование, как хлопчатобумажных, так и полиэфирных тканей может приводить к появлению нежелательных запахов из-за разложения пота микроорганизмами. Нанесение хитозана на текстильные полотна является перспективным подходом для функционализации текстиля. Известно, что хитозан является популярным отделочным средством благодаря его внутренним свойствам, таким как биосовместимость, биоразлагаемость, нетоксичность, распространенность в природе, антимикробная и антистатическая способность и т. д. В этом исследовании для отделки хлопчатобумажных и полиэфирных тканей был применен раствор хитозана с использованием традиционной технологии «пропитка – отжим – сушка». Исследования тканей осуществлялось с использованием дроп-теста, сканирующей электронной микроскопии и цветовых измерений. В данном исследовании представлен анализ результатов отделки хлопчатобумажных и полиэфирных тканей хитозансодержащими аппретирующими композициями.

Ключевые слова: *хитозан; плюсование; крашение; сканирующая электронная микроскопия; СЭМ; дроп-тест.*

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FINISHING OF COTTON AND POLYESTER FABRICS USING CHITOSAN-CONTAINING RECIPES

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ABSTRACT

With the increased stress in people's daily lives, the secretion of sweat from the human body has steadily increased. Therefore, textile industries continue to introduce various products to meet consumers' demands. Thus far, people use more cotton and polyester fabrics among other textile fabrics in their daily usage or total living period. Textile products, especially those made from cellulose fibers such as cotton, can promote the growth of microorganisms due to their high surface area and moisture retention. In contrast to cellulosic materials, polyester contains no chemically functional or hydrophilic groups. Therefore, it is necessary to ensure wearers' protection as both cotton and polyester can create unwanted odors due to the decomposition of sweat by microorganisms. The application of chitosan on textile substrates is a useful approach for textile functionalization. Chitosan has been reported as a popular finishing agent due to its intrinsic properties, such as biocompatibility, biodegradability,

non-toxicity, abundance in nature, antimicrobial, and antistatic ability, etc. In this study, the solution of chitosan was applied to 100 % cotton and polyester fabrics using a common pad-dry-cure technique. The resulting fabrics were characterized by drop-test, scanning electron microscopy (SEM), and color measurement. Thus, this study presents a small overview of the finishing using chitosan-containing recipes on both cotton and polyester fabrics.

Keywords: *chitosan; padding; dyeing; scanning electron microscopy; SEM; drop test.*

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INTRODUCTION

Cotton and polyester fibers play a dominant role in the textile industry. Due to their properties and price, they are the most popular fibers in apparel, home textiles, and industrial textiles [1–4]. In our daily life, our bodies always secrete sweat, enhancing the bacterial growth within the fabric, which can cause unexpected odor and harm human health. It is important to protect the wearers against the escalation of bacteria and diseases [5]. With the increasing awareness of wearers' protection, numerous techniques for the surface modification of cotton and polyester fabrics have been performed to give additional functionalities [6]. Chitin is regarded as the second most abundant polysaccharide resource after cellulose [7]. Chitosan is gained from chitin through the deacetylation process. Figure 1 shows the chemical resemblance between cellulose, chitin, and chitosan with a 100 % degree of deacetylation. Chitosan contains different amounts of β-(1 → 4)-linked 2-amino-2-deoxy-β-D-glucopyranose and 2-acetamido-2-deoxy-β-D-glucopyranose residues [8, 9, 10, 11]. Chitosan is nontoxic, biodegradable, and biopolymer which offers antimicrobial function [12, 13, 14, 15, 16].

It has been reported that chitosan possesses excellent deodorizing, moisturizing, biocompatibility, and other attractive properties [17]. The presence of the amino groups in the structure make chitosan soluble at acidic pH. Further, a lower pH and degree of acetylation favors the antimicrobial function of chitosan [18–20]. The aim of this study is to evaluate

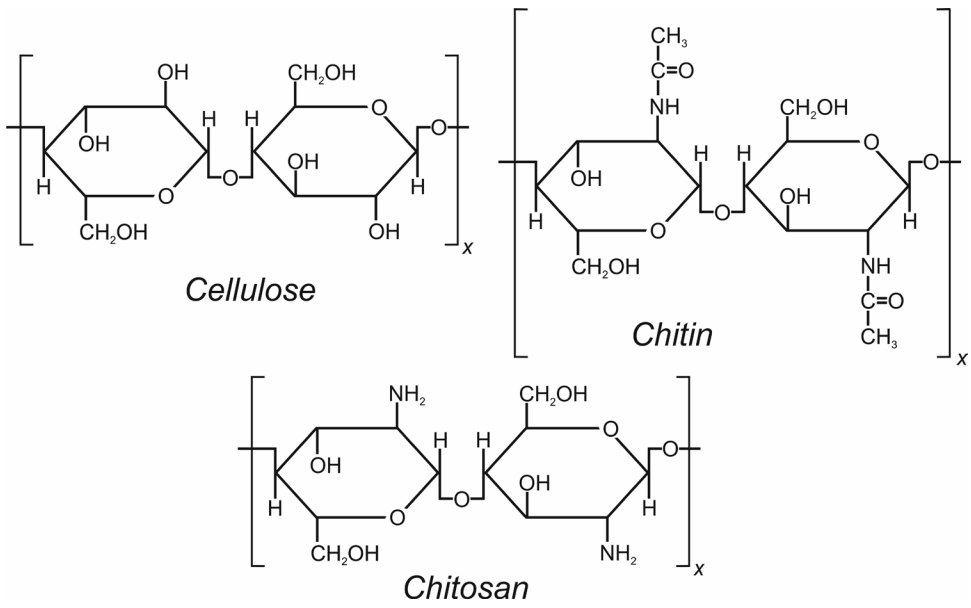

Figure 1 – Comparison of chemical structures of cellulose, chitin, and chitosan

characteristics after finish of cotton and polyester fabrics utilizing chitosan-containing recipes.

MATERIALS AND METHODS

Materials

In this research, different woven cotton and polyester fabrics from the company Technotex GmbH (Lauterbach, Germany) are used. Table 1 shows the description of the woven fabrics used for the experiments. Following chemicals were used: Chitosan with a deacetylation degree of 90 % was purchased from Biolog Heppe® GmbH (Landsberg, Germany), acetic acid from Bernd Kraft GmbH (Duisburg, Germany), and a dispersing agent Dispergator XHT-S from CHT Germany GmbH (Tübingen, Germany).

The padding is performed on a universal padding machine, DL-2500 HV from Feyen Maschinen GmbH (Krefeld, Germany), drying is done using Werner Mathis AG (Zurich, Switzerland) dryer and a quick dyeing treatment is carried out on a Datacolor Ahiba Pro IR (Marl, Germany) device.

Treatment procedure

Chitosan solutions in 0.5 % concentration were prepared using 250 mL of soft water with 10 mL (w/v) of acetic acid (50 %). The pH value of the acidic solution without chitosan was 1.95. Chitosan powder of 1.30 g was carefully added into the acetic acid solution and stirred until complete dissolution. The pH of the chitosan-containing solution (w/v) was checked before applying between the padding rollers for finishing treatment, which is 2.23. During chitosan treatment on polyester fabrics, similar chitosan concentration was maintained but additionally 10 ml (w/v) of dispersing agent was mixed into the liquor bath. Both cotton and polyester fabrics were cut in size 21.5 cm × 30 cm and weighed to assess the weight gain (%) for before and after treatment.

Table 1 – Fabric description of woven fabrics used for current investigations

Fabric	No. of warp threads/cm	No. of weft threads/cm	Weight per area (g/m^2)
Cotton	18	13	200
Polyester	16.5	14.5	150

Figure 2 – Photographs of used devices – padding, drying, dyeing (from left to right)

Each sample was run through the rollers four times. The padding procedure was done at room temperature and after padding the fabrics were dried at 90 ^{0}C for 5 minutes.

For dyeing, a reactive dye, Remazol Brilliant Red F3B (2 %) from DyStar (Raunheim, Germany) was selected for both cotton and polyester samples including a surface active agent TritonX from Carl Roth GmbH + Co. KG (Karlsruhe, Germany). Treated and untreated samples were cut in size 7 cm × 15 cm and placed in the dye pots with solution of the dyeing machine (Figure 2), where the temperature was set to 40 ^{0}C for 5 minutes at 30 revolutions per minute. No extra wash cycle was performed after dyeing, but the dyed samples were rinsed with soft water.

Analytical methods

The fabric surface morphology is observed using a scanning electron microscope (SEM) (Tabletop Microscope TM4000, Hitachi, Japan). The hydrophilic properties of treated and untreated woven fabrics are determined by using TEGEWA-dropt-test with the Patent Blue V solution (0.2 %). On each fabric, three droplets of the dye solution were applied. For the detection of chitosan presence on the treated-dyed and untreated-dyed fabrics, color measurements are evaluated using a Datacolor 400 spectrophotometer from Datacolor Europe GmbH.

RESULTS AND DISCUSSION

In this study, same chitosan concentration (0.5 %) was implemented for both cotton and polyester fabrics by a universal padding machine. It is a simple process, but uneven distribution of the solution will always be a big issue as the samples are handled and run through the rollers completely manually. It is not easy to maintain the 100% precision of handwork and similarly liquor between the rollers stays in nonequilibrium state, as fluidity seemed not same for the left, right, and middle. However, the drop-test, color measurement will give small overview of chitosan presence on the fabric surface.

Wet gain assessment

The wet pick-up is determined to support information about the wetting properties of treated fabrics and is calculated using the following equation:

$$Wet\ pick\text{-}up\ (\%) = \frac{w - w_0}{w_0} \times 100, \quad (1)$$

here, w is the weight of treated sample and w_0 is the weight of original (untreated) sample.

Table 2 shows the wet pick-up (%) for cotton and polyester fabrics after chitosan-finishing. It is obvious to observe more weight gain for the treated samples and the wet pick-up rate is quite different between cotton and polyester as undoubtedly cotton can absorb and hold more liquid within it.

Surface Analysis

Figure 3 shows scanning electron microscopic images of cotton and polyester fabrics both untreated and treated with 0.5 % chitosan. The SEM images of polyester fibers/filaments exhibit flat and shiny appearance compared to cotton fibers as cotton contains many foreign particles within the structure. However, it is not relevant from sample topography with naked eyes to justify the presence of chitosan on the fabric surface.

Table 2 – Wet pick-up in the percentage of treated cotton and polyester fabrics

Fabric	Weight before treatment (g)	Weight after treatment (g)	Wet pick-up (%)
Cotton	19.5	34.68	77.48
	416.81	29.65	76.38
Polyester	14.14	22.26	57.42
	14.21	22.39	57.56

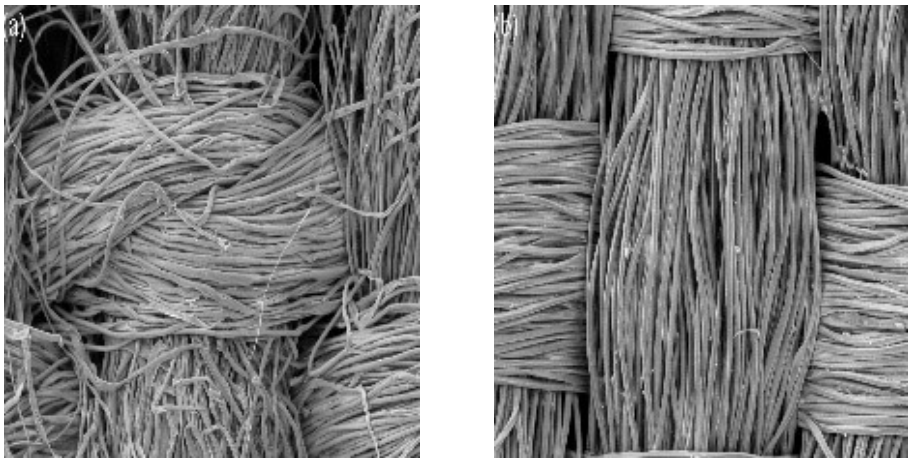

Figure 3 – SEM images of cotton (left) and polyester (right) fabric after treatment with chitosan recipe

Drop-test

The drop-test is performed with a Tegewa Patentblau V (0.2 %) solution for both the treated and untreated cotton and polyester fabrics. The samples are mounted on a circular board and adjusted properly to apply the drops of blue solution by means of a dripper. Hence, the absorption time of the droplets are recorded as shown in Table 3. There is no great change of color for 0.5 % chitosan implementation. Although cotton shows good absorption, still noticeable differences in penetration time between treated and untreated samples (see Table 3). Chitosan has made the cotton structure to open up to penetrate the droplets easily and quicker. Unfortunately, the blue dyed yarns are considered to be mercerized in the previous stages before weaving, which shows remarkable deviation. On the contrast, due to surface adhesion and bipolar attraction between chitosan and other chemical additives has made the droplets to penetrate not in lesser time as for the untreated polyester.

Color measurement

Color change was measured by a Datacolor 400 spectrophotometer device taking three readings from each sample and illustrated difference in reflectance curves from the mean value. It is obvious from the graphic images (Figure 5) that finished samples show greater deviation as chitosan present on the fabric surface absorb the color particles and try to block them for a certain limit, thus reflects less than for the untreated samples. However, for polyester fabrics no noticeable change in color is determined. This is why, a quick dyeing step was followed to

Table 3 – Results of drop-test

Fabric	Vertical drop size (cm)	Horizontal drop size (cm)	Sink-in time (secs.)
Cotton (reference)	4.9 (4.8)	1 (0.6)	131.9 (1127.3)
	4.5	1.8	237.9
	4.8	1.7	284.9
Polyester (reference)	2.3 (7.6)	3.2 (4.5)	3.2 (0.5)
	3	2.7	3.9
	3	2.7	3.3

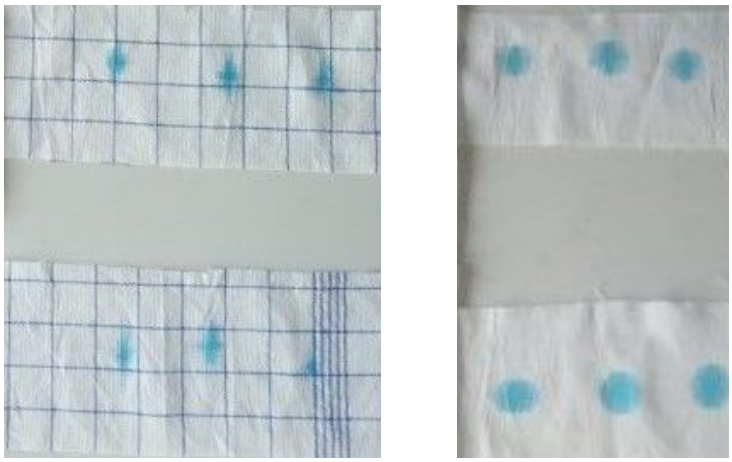

Figure 4 – Images after drop-test with Tegewa blue (0.2 %) solution. Cotton (left), Polyester (right)

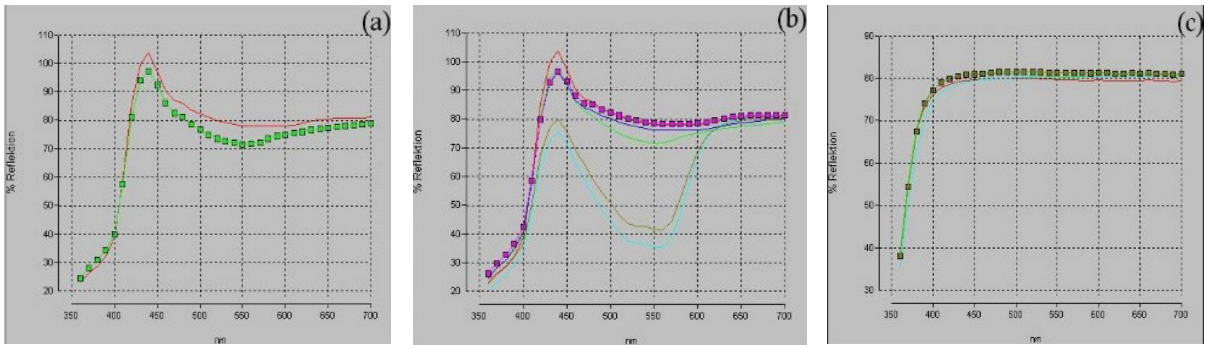

Figure 5 – Reflectance curves according to datacolor 400 for cotton and polyester fabrics. (a) Untreated cotton (red) and dyed cotton (green), (b) raw cotton-finished cotton (red to green from top) and finished-dyed cotton (green beige to blue bottom) with maximum change, (c) dyed polyester (red) and finished-dyed polyester (others) with minimal change

confirm the presence of chitosan utilizing color measurement process.

CONCLUSIONS

Low concentrated chitosan-based recipes for cotton and polyester fabrics are presented. This study shows a simple cold-pad technique to apply chitosan on cotton and polyester according to laboratory standard. However, it is clear that a certain amount of chitosan stays on both cotton and polyester fabrics from the drop-test, even for the dyed samples after rinsing from color measurement graphics. In this experiment, no additional fixing agent is used and no extra wash cycle is performed. Therefore, to achieve the antimicrobial action of chitosan for long-term, fixation should be done to advise particular washing parameters with several wash cycles.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest in the authorship or publication of this paper.

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