SURFACE MODIFICATION OF COTTON/POLYESTER MIXED FABRIC WITH CHITOSAN *APIS MELLIFERA*

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Abstract: Surface modification of cotton/polyester mixed fabric was done with chitosan to analyze how capillarity, k/s value, dye uptake % and wash fastness property vary of the dyed fabric. In this investigation scoured and bleached cotton/polyester blended fabric was treated with 0.5%, 1,0 %, 1.5 %, 2,0 % chitosan. The infrared spectrum of cotton/polyester specimens were analyzed by Fourier Transform Infrared Spectrometer (FTIR). After dyeing k/s value of untreated and treated cotton/polyester specimens were measured. There was a remarkable variation of k/s value on different treatment process. Dye uptake % of untreated and treated cotton/polyester specimens were determined by using UV Visible Spectrophotometer in terms of absorbency. Color fastness to wash was measured using ISO standard.

Keywords: cotton/polyester mixed fabric (C/PE), chitosan *Apis mellifera*, capillarity, dye uptake, k/s value, FTIR Spectrum.

Annotatsiya: paxta/poliefir tolali aralash mato yuzasi xitozan bilan midifikatsiya qilinda va uning kapillyarlik, rang intensivlik k/s, bo'yoqni o'zlashtirish darajasi %, yuvishga chidamlilik xossalari tahlil qilindi. Tahlilda oqartirilgan paxta/poliefir aralash mato xitozanning 0.5%, 1,0 %, 1.5 %, 2,0 %li eritmalari bilan ishlov berildi. Ishlov berilgan paxta/poliefir mato namunalarining IQ spektrlari olindi. Ishlov berilgan va ishlov berilmagan matolar turli bo'yash usullarida bo'yaldi va bo'yalgandan keyin rang intensivliklari k/s qiymati aniqlandi. UV spektrofotometr yordamida namunalarning bo'yoqni o'zlashtirish darajasi tahlil qilindi. ISO standart tahlil usullari bilan yuvishga chidamlilik ko'rsatkichlari aniqlandi.

Kalit so'zlar: paxta/poliefir tolali aralash mato (P/PE), *Apis mellifera* xitozani, kapillyarlik, bo'yoqni o'zlashtirish darajasi, rang intensivlik k/s, IQ spektr.

Аннотация: Поверхностная модификация хлопкополиэфирной смешанной ткани была проведена с использованием хитозана для анализа того, как изменяются капиллярность, значение k/s, процент поглощения красителя и устойчивость окраски к стирке. В данном исследовании отбеленная и промытая хлопкополиэфирная смешанная ткань обрабатывалась хитозаном в

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концентрации 0,5 %, 1,0 %, 1,5 % и 2,0 %. Инфракрасный спектр образцов хлопкополиэфирной ткани был проанализирован с помощью инфракрасного спектрометра Фурье (FTIR). После окрашивания было измерено значение k/s для необработанных и обработанных образцов хлопкополиэфирной ткани. Была выявлена значительная вариация значений k/s при различных режимах обработки. Процент поглощения красителя для необработанных и обработанных образцов хлопкополиэфирной ткани определялся с использованием УФ-видимого спектрофотометра по показателю поглощения. Устойчивость окраски к стирке измерялась по стандарту ISO.

Ключевые слова: хлопкополиэфирная смешанная ткань (Х/ПЭ), хитозан *Apis mellifera,* капиллярность, поглащение красителя, значение k/s, FTIR-спектр.

Introduction

Modification is generally used to designate a deliberate change in composition or structure leading to an improvement in different type of fiber properties. Surface modification of the polymeric fibers without changing the mass properties has been a classical research topic for many years which is now widespread studies as new applications of polymeric materials develop, particularly in the fields of biotechnology, bio-engineering, and recently in nanotechnology [1]. Surface modification is the unite insertion of physics and chemistry together to modify material to promote surface properties [2]. Polyester is a synthetic fabric that's usually derived from petroleum. This fabric is one of the world's most popular textiles. Polyester is hydrophobic (water-repellent) because of the nonpolar aromatic and ester groups in its structure. It has low moisture absorption (~0.4%), which reduces dyeability with hydrophilic dyes. This is why carriers or surface modifications (like alkaline hydrolysis, plasma, or chitosan treatment) are used to improve dye uptake. In some applications, polyester may be the sole constituent of apparel products, but it's more common for polyester to be mixed with cotton or another natural fiber [3].

Chitosan is a nontoxic and biodegradable biopolymer sufficiently found in natural source, particularly in the exoskeletons of shell arthropods and mollusks as well as the cell wall of certain fungi in the form of chitin [4, 5]. Chitin deacetylates in alkaline solution to obtain chitosan. The organic name of chitosan is β-(1-4)-2-amino-2-deoxy- D-glucopyranose [6,7]. Chitosan is composed two main functional groups, namely hydroxyl and amino groups as well as ether linkages. Chitosan and cellulose have analogous structure with the same β-glucoside linkages and the main discrepancy is the presence of primary amino groups at the greater part of the C-2 position in chitosan, in place of the hydroxyl groups in cellulose [8, 9]. Chitosan

ISSN 3030-3907

has primary amino groups in its structure and the number of these amino groups is related to the rate of antimicrobial activity. The acquaintance of asparagine to chitosan oligosaccharide significantly enhanced the bactericidal activity and least inhibitory concentration. This is the probable indication of the higher the number of amino groups, the higher the antimicrobial activity [10]. The possibility to modify textile fibers (natural or man-made) with chitosan by means of impregnation improves the mechanical properties of such treated textiles; their staining behavior, water resistance, electro conductivity, and adds bioactive, as well as bacteriostatic behavior [11,12]. Chitosan treated cotton/polyester showed a better dye ability [13,14]. Pretreatment of cotton/polyester fabric with alkaline peroxide enhance the adsorption of chitosan. This adsorbed chitosan improve dyeing rate, k/s value, fastness properties of C/PE [15]. Chitosan present on C/PE surface can easily attract and interacts with the dyestuff, so that it improves the dyeing rate reducing dyeing time. So it is considered as a dominating dyeing site on C/PE fiber surface [16,17].

Materials and Methods

80/20 C/PE mixed fabric was collected from "Parvoz Humo Ravnak Trans" LLC. Stabilizer, detergent, active/disperse dye and sequestering agent were used as a auxillary chemicals. Chitosan obtaining from *Apis mellifera* dead honey bees, was used as cationizing agent. To dissolve this chitosan acetic acid was applied.

The mixed fabric was cut into some specimens of two different sizes. Half of the total no. of specimens was of 5x5cm while the rest half were of 10x10 cm. Treatment of C/PE with chitosan - bleached C/PE mixed fabrics were treated with 0,5 %; 1,0 %; 1,5% and 2,0 % chitosan solution 20 - 30 minutes. These chitosan of different concentrations solutions were prepared using 1-2 % acetic acid and was stirred for 2-4 hour to ensure chitosan was dissolved thoroughly.

Capillarity properties of treated and untreated C/PE was detected ISO standard.

FTIR (Fourier Transform Infrared Spectrometer) analysis modification of C/PE was estimated by using FTIR spectrophotometer. The infrared spectrum of untreated, 0.5%; 1,0 %; 1,5% chitosan treated specimens were measured using FTIR spectrophotometer in spectra range 4000-500 cm^{-1} using KBr disc technique.

Determination of Color Strength - the reflectance value of each dyed specimen for the wavelength range of 400-700nm (with 10nm intervals) was found using spectrophotometer. By using this reflectance value in the Kubelka Munk's equation the value of color strength (k/s) was calculated:

$$(k/s) = \frac{(1-R) \times 2}{2R}$$

Here, R- Reflectance

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Determination of Dye Uptake % - absorbency of original dyeing solution, treated and untreated C/PE specimens dyeing effluent solution were measured by UV Visible Spectrophotometer. Dye uptake % of untreated and treated C/PE was calculated using following formula:

$$\text{Dye uptake \%} = \frac{(A_0 - A_1}{A_0} \times 100\%$$

Here, A_0 - maximum absorbency of dye liquor before dyeing

A_1 - maximum absorbency of dye liquor after dyeing.

To determine color fastness to wash ISO 105 C04 method was followed.

Result and discussion

The capillarity properties of treated and untreated C/PE fabrics were analysed (Fig.1).

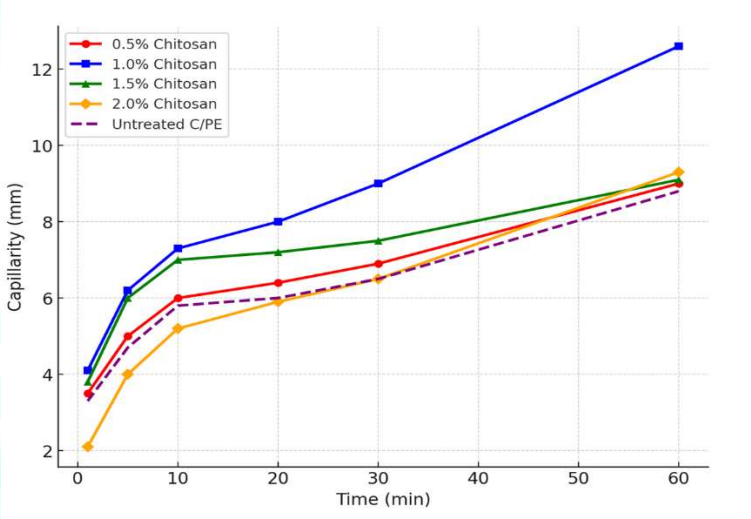


Figure 1. Capillarity analysis treated and untreated C/PE fabrics

The most pronounced enhancement in capillarity was achieved at a chitosan concentration of 1,0% indicating the optimum treatment condition. This outcome substantiates that precisely controlled chitosan deposition is capable of significantly improving the moisture management performance of C/PE fabrics through favorable surface chemical modification while simultaneously preserving the intrinsic pore architecture of the fibrous substrate.

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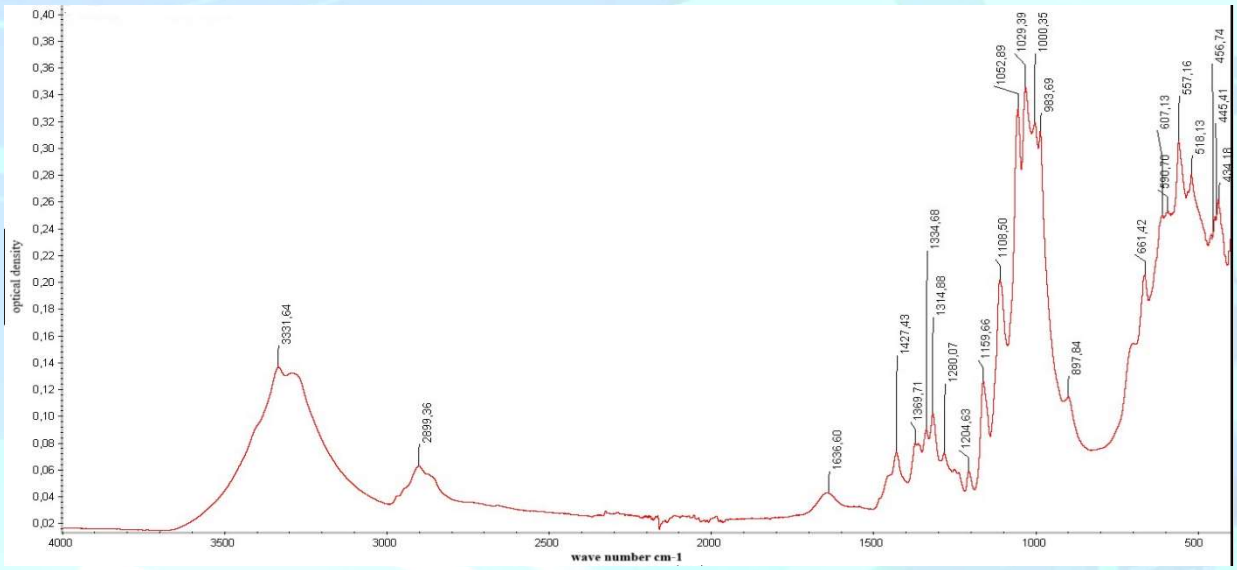


Figure 2. FTIR spectrum of untread C/PE fabric

FTIR had been utilized to determine the impact of the different treatment process on the properties of the diverse capacity bunches. Also determine the diverse amino acids present in C/PE. An infrared spectrometer decides the positions and relative sizes of the considerable number of ingestions or tops in the infrared area and plots them on a bit of paper. This plot of retention power (transmittance) versus wave number is alluded to as the infrared range of the compound. The infrared spectrum of untreated, 0.5%; 1,0 %; 1,5% chitosan treated are studied here from figures 2 to 5.

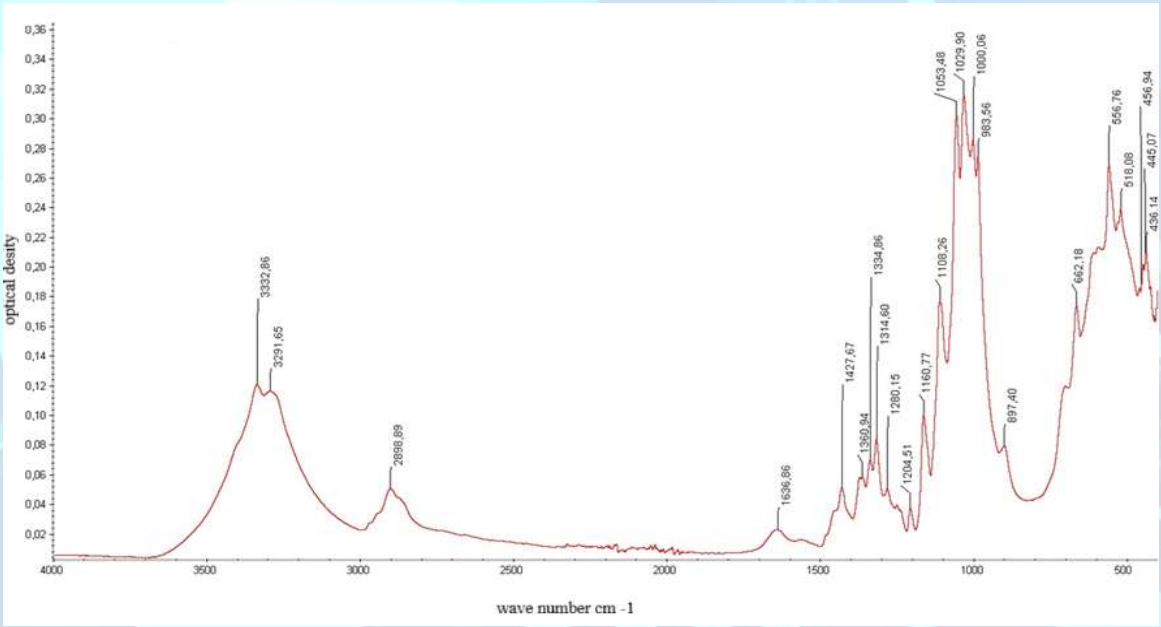


Figure 3. FTIR spectrum of 0,5 % chitosan tread C/PE fabric

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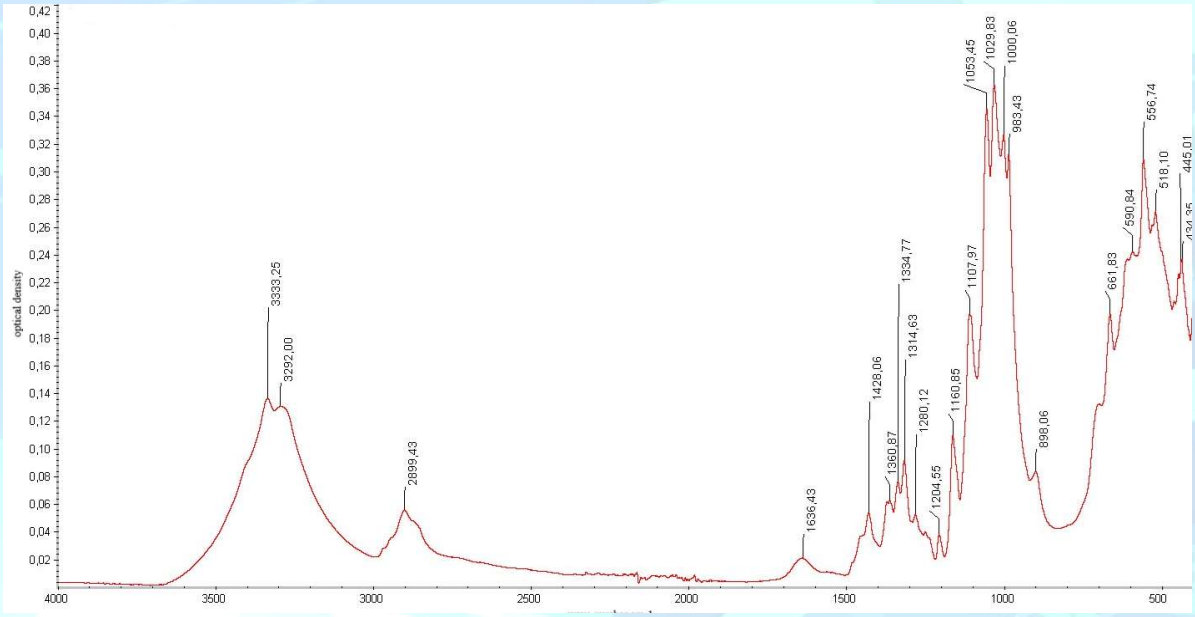


Figure 4. FTIR spectrum of 1,0 % chitosan tread C/PE fabric

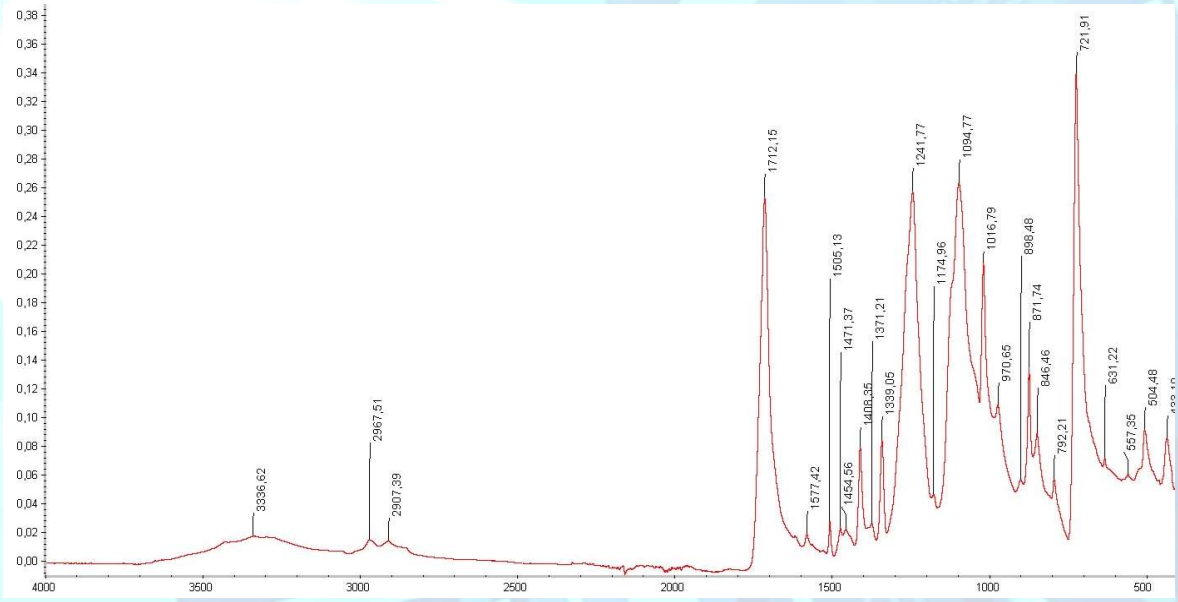


Figure 5. FTIR spectrum of 1,5 % chitosan tread C/PE fabric

FTIR analysis revealed that at 0,5% chitosan only minor chemical interactions occurred, indicating weak surface modification. At 1,5% strong and sharp peaks confirmed deep penetration of chitosan into the fabric, though this may negatively affect mechanical properties. The 1,0% concentration demonstrated the most balanced performance, with stable chemical bonding that enhanced functionality while maintaining structural integrity.

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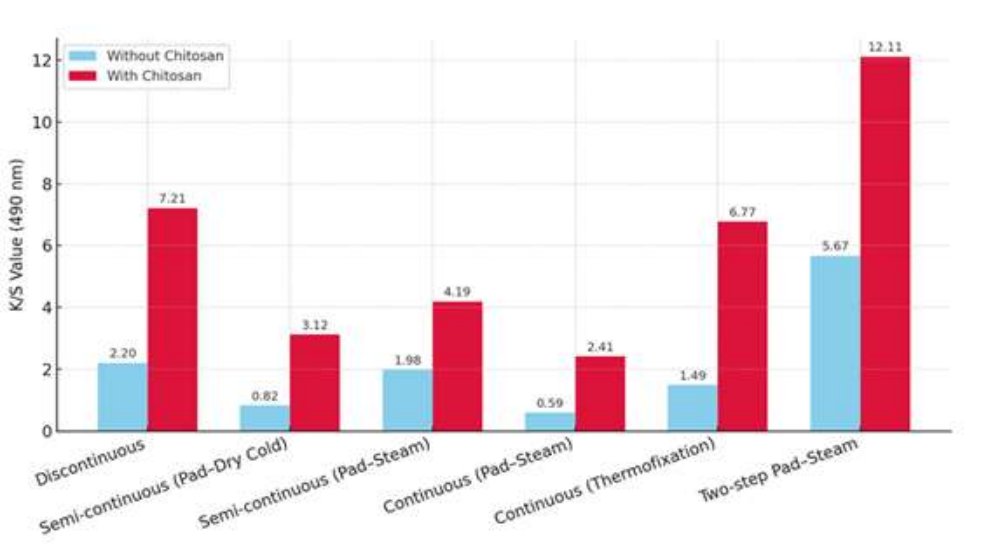


Figure 6. Color intensity of C/PE fabrics by dyeing methods

The K/S value increased significantly in the 1,0 % chitosan treated specimens, reaching its maximum at this concentration. However, beyond 1,0 % a gradual reduction in K/S value was observed with further increases in chitosan concentration. From Figure 6, it is evident that while moderate chitosan loading enhances dye uptake, excessive deposition reduces the K/S value most likely due to pore blockage within the fabric structure. Color fastness to wash of all the treated and untreated specimens are shown in Table.

Table.

Color fastness to wash of all the treated and untreated C/PE speciments

№	Dyeing methods	Abrasion resistance				Soap resistence at 40°C		Sweat resistance	
		Dry		wet					
		untreat	Chit. treated	untreat	Chit. treated	untreat	Chit. treated	untreat	Chit. treated
1.	Discontinuous	5/4	5/5	4/4	4/5	4/5/4	5/5/5	5/5/4	5/5/5
2.	Semi-continuous Pad-dry cold	5/4	5/5	4/4	5/4	4/5/4	5/5/4	4/5/4	5/5/4
3.	Semi-continuous Pad-steam	5/4	5/5	4/4	5/4	4/5/4	5/5/4	4/5/4	5/5/4
4.	Continuous Pad-steam	5/4	5/5	4/4	5/4	4/5/4	5/5/4	4/5/4	5/5/4

ISSN 3030-3907

5.	Continuous Thermofixation	5/4	5/5	4/4	5/4	4/5/4	5/5/4	4/5/4	5/5/4
6.	Two step Pad steam	5/4	5/5	4/4	4/5	4/5/4	5/5/5	5/5/4	5/5/5

The application of chitosan treatment resulted in enhanced physicomechanical properties of fabrics relative to untreated samples.

Conclusion

The chitosan treated specimens comparatively had higher capillarity. Chitosan treated cotton/polyester fabrics had satisfactory results on k/s value of dyed sample. FTIR analysis shows the effectiveness of different treatment techniques. There was noticeable variation of wash fastness property of treated and untreated C/PE specimens.

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