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Effect of Ultrasonic Mercerization on the Cotton / Polyester Blend Fabric.

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ABSTRACT

Mercerization is a famous treatment of cotton fabric to improve physical properties and the fabrics appearance. In this study we used 3 groups of plan fabric, cotton and cotton/polyester blended under same position. Fabrics mercerized for 4 min at same temperature 60 °C with constant caustic soda under relax fabric (without tension). It was observed that mercerization treatment with ultrasonic cause increase tenacity on the cotton fabric and weight loss in cotton/polyester blend fabric. Also in the ultrasonic system we chose two frequency 30 kHz and 60 kHz. Results show that by increasing frequency, tenacity of the cotton and cotton/polyester fabric increased. And also by increasing the ultrasonic frequency number of small pills decreases by decreasing the ultrasonic frequency (e.g. frequency 30 KHz) fabric surface fibrillation disappear and fibrillation effect lower than other samples.

Keywords: ultrasonic mercerization, pilling, cotton/polyester blend fabrics, frequency effect, tenacity of fabrics.

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INTRODUCTION

Sound waves have been classified into infra-sound (up to 16Hz), audible sound (16 Hz –16000 Hz) and ultrasound which include sound waves higher than audible sound with a frequency above approximately 16 kHz up to 106 kHz. Unlike gases and liquid, in solids both longitudinal and transverse waves are transmitted. The effects of ultrasonic actually arise from the way in which sound is propagated through the medium. In liquids, longitudinal vibrations of molecules generate compressions and rare factions, *i.e.,* areas of high and low local pressure. The latter results in the formation of cavities, *i.e.,* very small vapor bubbles of 500nm in size, which can collapse and cause shock waves through out the medium. The formation of cavitations depends on the frequency and intensity of waves, temperature and vapor pressure of the liquid [1].

Cavitations are the principal physical phenomenon behind all the effects of ultrasound in most of the treatments. Cavitations refer to the formation, growth and collapse of vapor or gas bubbles under the influence of ultrasound. If the bubbles collapse in the vicinity of a solid surface such as a textile material, it results in the formation of a high velocity micro jet with the velocities as high as 100 m/s –150 m/s directed towards the solid surface. These micro jets can give rise to intra yarn flow, increase in the rate of the mass transfer between the intra-yarn and inter yarn pores. On the other hand, they may be carried along with the sound waves if they do not collapse immediately. This, in turn, pushes water along with the bubbles producing a flow of water called streaming away from the sound source. The two phenomena attributed to ultrasound are the rapid movement of liquids caused by variation of sonic pressure which subjects the solvent to compression and rarefaction and micro streaming. Simultaneous formation and collapsing of tiny air bubbles result in a large increase in pressure and temperature at microscopic level. Heat induced by the ultrasonic process is adequate for dyeing process and thus eliminates the need for external heating in many cases. Advantages of ultrasonic's in textile wet processing include energy saving by reduced processing temperature, time, and lower consumptions of auxiliary chemicals and further processing enhancement by overall cost control[2]. Ultrasonic method has been effectively utilized in various fabric preparation processes including desizing, scouring, bleaching, mercerization and auxiliary processes, like washing and laundering. Desizing of cotton and nylon fabrics under ultrasonic treatment results complete removal of oils used in the size recipe while the treatment without ultrasound shows residual oil stains [3].other researchers stress that alkalization increases the relative cellulose content and causes greater crystallinity wheat straw fiber[4]. However, the most important aspect of the alkali treatment of native cellulose is that it results in the phase transformation of cellulose 1 to cellulose 2, improving the mechanical properties of natural lignocelluloses materials [4, 5].

MATERIALS AND METHODS

We used 3 sample fabrics , cotton 100%, cotton polyester 65/35 and cotton polyester 70/30 that the linear densities of warp and weft are 30/1 Ne and the warp and weft density of these fabrics are 35 picks/centimeter. Fabrics woven with plain weave. After weaving, the woven fabrics (e.g. three samples) were washed in the presence of a non-ionic leveling agent (2g/l) at 60 °C for 35 min. Single stage preparatory process using hydrogen peroxide has been developed successfully in such processes, caustic soda provides required alkalinity for scouring and activation of hydrogen peroxide and when activated, hydrogen peroxide degrades the sizing materials at 60 °C temperature, bleaching occur along with completion of desizing. A self-emulsifiable solvent system of bleaching has been developed to combine the two different frequency processes involved in the preparatory process. The system uses a high proportion of water, very low levels of solvents and hydrogen peroxide. Various free radicals created during the treatment resulted in disintegration and destruction of foreign matters present in the cotton. The bleaching effect is more distinct with peroxide than sodium chlorite, even at the higher concentrations. Presence of co-oxidants impedes the decomposition of each other, especially at their lower concentrations. The reactions under alkaline medium are initiated as chain reaction by the production of different free radical in different steps. The different step of the reaction is shown

Formula 1:

$$HO_2H \longrightarrow H^+ + HO_2^-$$

$$HO_2^- + HO_2H \longrightarrow HO_2^{\cdot} + HO^{\cdot} + HO^-$$

$$HO^{\cdot} + H_2O_2 \longrightarrow HO_2^{\cdot} + H_2O$$

Measurement of tensile and pilling properties

Fabrics strength was measured on Tensometric testing machine using 250mm test length and 100 mm/min extension rate. The tests were performed in the standard atmosphere of 60 ±5% r.h. and 20 ± 2 **°C** temperature. For each sample 5 observations records. The average values of tenacity in the fabrics were compared. Pilling of fabrics was measured on Sherly pilling box tester and fabric samples were performed on an ICI pilling tester. The ICI pilling-box is designed to a random rubbing motion with mildly abrasive material. Therefore, the tests were conducted in accordance with standards, which are used in the factory, commonly used and accepted by industry. The numbers of rotation were varied from 20,000 turns to 40,000 turns. The pilling properties of the samples were evaluated by comparing their visual appearance with standard photographs. For this purpose, we used CCD camera and processed the results by Photoshop and visual basic softwares. The experimental results of tenacity and pilling tests for all samples were analyzed at 95% level significant by using ANOVA and Duncan test [6]. To recognize the difference among means, we used the Duncan test for obtained results. Also in the ultrasonic system we chose two frequency 30 kHz and 60 kHz.

RESULTS AND DISCUSSIONS

To recognize the effect of ultrasonic effect on tenacity in this research, at first, fabrics used was tested. The results of tensile test performed on fabrics are presented in Table 1. As it can be seen, some properties of fabrics are compared. Results show that the Tenacity of cotton/polyester (60/40) at high frequency is more than of the other samples. Also Duncan test on the experimental results of tensile test on samples showed significant difference among the means in Table 2.

Table 1: Comparison of some properties of cotton and cotton/polyester fabrics.

Type of fabrics	Tenacity(cN/Tex) at frequency 30 kHz	Tenacity(cN/Tex) at frequency 60 kHz	Elongation % at frequency 30 kHz	Elongation % at frequency 60 kHz
Cotton	11.85	13.23	37.3	33.4
Co/Po (60/40)	14.59	16.70	43.2	37.8
Co/Po(70/30)	13.59	15.21	49.3	39.4

Trend to increases the ultrasonic frequency the tenacity of fabrics were increased. Also at frequency 60 KHz three samples same manner and best results of tenacity. These manner causes of effect ultrasonic sounds on the surface of fabric and influence of cellulose was increase that reactions under alkaline medium are initiated as chain reaction by the production of different free radical in different steps. Therefore, fabrics tenacity at high ultrasonic frequency was increased.

Table 2: Duncan test on the effect of ultrasonic wave on Tenacity of blended fabrics.
Tenacity (cN/Tex) Duncan

Type	N	Subset for alpha = .05				
		1	2	3	4	5
Cotton at frequency 30 kHz	5	11.85200				
Cotton at frequency 60 kHz	5		13.23600			
Co/Po 70/30 at frequency 30 kHz	5		13.59200			
Co/Po 60/40 at frequency 30 kHz	5			14.59800		
Co/Po 70/30 at frequency 60 kHz	5				15.21400	
Co/Po 60/40 at frequency 60 kHz	5					16.70000
Sig.		1.000	.094	1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed. a Uses Harmonic Mean Sample Size = 5.000.

The pilling test results of fabrics on the ICI pilling-box tester are shown in figure 1.

Based on the size of pills, we divided the pills into three types in terms of diameter of occupied area by pills as below:

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Small pill: D<=1 mm; medium pill: 1<D<2 mm; large pill: D>2 mm.

Then, the number of each type was counted on surface of fabrics at difference rotations. As it can be seen in figure 1, by increasing the ultrasonic frequency number of small pills decreases, but in Cotton 100% case, intensity is higher than the other samples.

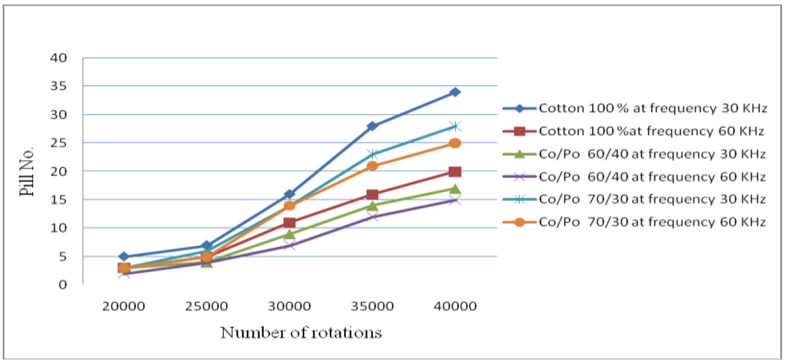
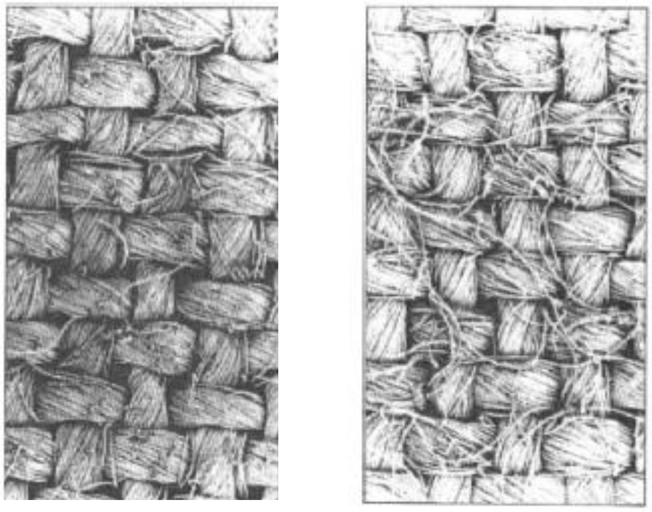


Figure 1: Number of small pills at 20,000 -40,000 of ICI rotation.

Best results of pilling Concern to Co/Po 60/40 at frequency 60 KHz and high pilling of fabrics concern to cotton 100% at frequency 30 KHz. Also we observed surface of fabrics with SEM. Figure 2 shows cotton polyester fabric mercerize treatment with ultrasonic at low frequency without fibrillation effect and cotton polyester fabric mercerize treatment with ultrasonic at high frequency with fibrillation effect, by decreasing the ultrasonic frequency(e.g. frequency 30 KHz) fabric surface fibrillation disappear and fibrillation effect lower than other samples.

a



b

Figure 2: (a) cotton polyester fabric mercerize treatment with ultrasonic at 30 KHZ without fibrillation effect (b) cotton polyester fabric mercerize treatment with ultrasonic at 60 kHz with fibrillation effect.

CONCLUSIONS

The obtained results in this article indicated that trend to increases the ultrasonic frequency the tenacity of fabrics were increased. Also at frequency 60 KHz three samples same manner and best results of tenacity. Pilling test results of plan fabrics shows that by increasing the ultrasonic frequency number of small pills decreases, but in Cotton 100% case, intensity is higher than the other samples. cotton polyester fabric mercerize treatment with ultrasonic at low frequency without fibrillation effect and cotton polyester fabric mercerize treatment with ultrasonic at high frequency with fibrillation effect, by decreasing the ultrasonic frequency(e.g. frequency 30 KHz) fabric surface fibrillation disappear and fibrillation effect lower than other samples.

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