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PHYSICAL PROPERTIES OF ANTIBACTERIAL TREATED COTTON FABRICS AND EFFECT OF LAUNDRY CYCLE

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Abstract: *During daily usage of textiles, humidity and warmth conditions provide appropriate living conditions for bacteria and microorganisms in textile products. Bacteria growth, infection and cross infection by pathogens might develop due to usage of textile products. Especially since World War II, antibacterial textile products have developed as a result of the hygiene demand of the society.*
In this study, triclosan (sample A), quaternary ammonium plus triclosan (sample B), dichloro phenol (sample C), silver (sample D), quaternary ammonium (sample E) and chitosan (sample F) based six different antibacterial additives were applied on 100% cotton fabrics for antibacterial treatment. All six treated fabrics and the untreated fabric (control sample) were washed for 40 cycles; the antibacterial efficacies were tested; changes in tear strength and Berger whiteness values of the samples were recorded prior to washing and after 1st, 5th, 10th, 20th and 40th washing cycles.
Regarding all washing cycles, a decrease in tear strength results is observed between unwashed and 40 cycle washed samples. Textile materials such as bedlinen, pillow cases, surgeon gowns for which tear strength values are important and that have antibacterial treatments should be tested for tear strength values for different washing cycles to see if they meet minimum tear strength requirements. The change in tear strength and Berger whiteness of samples shows differences according to the antibacterial agent treated and washing cycle applied. Generally, slight decreases in tear strength values are observed. And slight decreases in whiteness, except for sample F which is treated with chitosan, are observed as well. Textile materials having antibacterial treatments should be tested for the special antibacterial agent they are treated and for the number of washing cycles that is required for their product life.

Keywords: *antibacterial treatment, tear strength, Berger whiteness, antibacterial efficacy, cotton fabric*

1. INTRODUCTION

Antibacterial textiles were developed in the World War II especially to overcome the problem of decomposing tents caused by microorganism reproduction due to moisture and heat conditions in tent fabrics [1]. Antibacterial textiles are used to prevent infections from microorganisms, to control infections, to prevent odor caused by microorganisms, to prevent staining, color change and quality loss in textiles caused by microorganisms [2].

In the literature there are numerous studies focusing on the antibacterial properties of textile materials having various antibacterial substances ranging from synthesized materials such as triclosan nanosilver to natural antibacterial substances such as chitin, chitosan and silver [3–9].

Zhang et al (2003) tested the antibacterial efficacy of chitosan treated cotton fabrics and obtained high values; they obtained efficacy for longer times when they added glutaric dialdehyde into the impregnation solution [3].

Aly et al (2004) evaluated the crease resistance and antimicrobial efficiency values of chitosan citrate treated cotton fabrics. Strength values, washing fastness values and Berger whiteness values of samples were measured as well. They observed that after heat treatment all values of the samples showed good results [4]. Balci and Babaarslan (2005) observed different strength results depending on the concentration of the antibacterial agent applied [5]. Mihaiilovic et al (2007) obtained higher tensile strength results when they treated the fabrics with antibacterial agent [6].

Orhan et al (2007) checked the antibacterial efficacy of triclosan treated cotton fabrics; they observed that washing cycle decreased the efficacy of the samples [7]. Jeong et al (2002) observed a decrease in the tensile strength values of chitosan treated wool fabrics [8].

Palamutcu et al (2007) concluded that the application of the antimicrobial treatments changes the tensile strength of the woven fabric. These treatments lead to a positive change in the tensile strength and crease recovery of angle of (weft direction) the treated fabrics. As result of the two antimicrobial test methods (AATCC100 and AATCC147), they observed that antimicrobial efficiency of each antimicrobial agent differ from each other and their efficiency is affected by the number of washing cycle [9].

2. EXPERIMENTAL APPROACH

In this study, triclosan (sample A), quaternary ammonium plus triclosan (sample B), dichloro phenol (sample C), silver (sample D), quaternary ammonium (sample E) and chitosan (sample F) based six different antibacterial additives were applied on 100% cotton fabrics for antibacterial treatment.

The antimicrobial bioactivity of samples against three microorganisms: Staphylococcus Aureus, Escherichia Coli and Candida Albicans, was evaluated in microbiology laboratory. All six treated fabrics and the untreated fabric (control sample) were washed for 40 cycles; the antibacterial efficacies were tested, the results of the antimicrobial tests were published elsewhere previously [20]. Changes in tear strength and Berger whiteness values of the samples were recorded prior to washing and after 1st, 5th, 10th, 20th and 40th washing cycles.

2.1 Materials and Method

In this work one natural (chitosan) and five different brands of synthetic antibacterial additives have been used for the treatment of 100% percent 153 g/m2 cotton woven fabric and evaluated at 0, 1, 5, 10, 20 and 40 washing cycles.

The tear strength of the samples were evaluated both in the warp and weft directions according to standard test method ISO 13937:2000. The mean value of at least ten samples is given as the tear strength value. The tear strength results in the warp and weft directions are given in Table 1 and Table 2, respectively. The Berger whiteness of the samples was measured with a spectrophotometer, Datacolor 600. The whiteness values of samples are given as the mean value of at least five samples in Table 3.

2.2 Results

The tear strength values in the warp direction, the tear strength values in the weft direction and the Berger whiteness values of the samples are given in Table 1, Table 2 and Table 3, respectively.

Table 1: *Tear strength values (Newton) in the warp direction*

Sample (warp direction)	unwashed	After 1st wash	After 5th wash	After 10th wash	After 20th wash	After 40th wash
control	4,76	4,48	4,00	3,75	3,51	3,71
A	4,47	4,65	3,94	3,83	3,75	4,00
B	4,33	4,52	3,65	3,73	3,43	3,48
C	4,55	4,02	3,73	3,88	3,68	3,39
D	4,44	4,15	3,60	3,66	3,65	3,71
E	4,34	4,24	3,72	3,71	2,50	3,00
F	4,15	4,08	3,00	3,66	3,98	4,00

Table 2: *Tear strength values (Newton) in the weft direction*

Sample (weft direction)	unwashed	After 1st wash	After 5th wash	After 10th wash	After 20th wash	After 40th wash
control	3,70	3,98	3,50	3,04	2,77	3,03
A	3,48	3,91	3,31	3,37	3,21	3,00
B	3,91	3,98	3,49	3,25	3,10	2,95
C	3,71	3,25	3,18	3,24	3,18	3,02
D	3,77	3,30	3,17	3,16	3,04	2,79

E	3,65	3,55	3,11	3,35	4,00	3,50
F	3,31	3,38	3,69	3,06	2,69	2,50

Table 3: *Berger whiteness values of samples*

Sample code	unwashed	After 1st wash	After 5th wash	After 10th wash	After 20th wash	After 40th wash
control	147,10	149,69	149,72	149,74	151,75	146,74
A	140,82	142,15	149,01	148,78	150,17	146,95
B	144,03	142,41	148,97	148,18	151,07	146,06
C	145,54	146,76	151,58	151,79	153,73	147,82
D	143,81	146,03	145,91	148,00	150,70	147,05
E	142,38	143,05	150,04	150,73	150,85	148,64
F	129,80	139,38	144,37	144,81	146,45	146,89

3. CONCLUSIONS

The tear strength values obtained in the warp direction are higher than the tear strength values obtained in the weft direction of the samples. This fact is a result of warp yarns being stronger than weft yarns in the fabric structure. After the first washing cycle all samples, either in the warp or weft direction, showed increases in tear strength values. This might be due to the shrinkage of the fabrics after the first washing cycle. Although small increases were observed between some washing cycles such as between the 20th and 40 th washing cycles, for both directions the samples showed slight decreases in tear strength test results. Regarding all washing cycles, a decrease in tear strength results is observed between unwashed and 40 cycle washed samples. Cotton fabrics are wear out as results of the mechanical enforcement during the repeated machine washing. Mechanical enforcement causes surfacial wear out effect on the yarns. Weakened yarns can be broke down with less mechanical enforcement, resulting lower tear strength value. The small increase observed between some washing cycles might be due to the accumulation of detergent on the textile material which causing a reinforcing effect against tearing motion on the warp or weft yarns of the fabric. Accumulated residual detergents or any other residuals may also effects the slippage movement of the warp or weft yarns over each other. When the warp or weft yarns slip easily over each other required fabric tearing force increases. And when the slippage of warp and weft yarns is not easily occurs yarns break down one by one and required tearing force of the fabric decreases. There are different behaviours reported about the tear strenght of the fabric in the literature where most of them are related to above explained residue accumulation [4-9].

Textile materials such as bedlinen, pillow cases, surgeon gowns for which tear strength values are important and that have antibacterial treatments should be tested for tear strength values for different washing cycles to see if they meet minimum tear strength requirements.

The Berger whiteness values of the samples did not show a siginificant decrease for none of the samples. The control sample showed an increase until the 20th washing cycle, and a slight decrease after the 20th washing cycle. This sligt decrease might be due to the accumulated detergent and debris in the fabric structure. Compared to the control sample, all samples showed lower Berger whiteness values, which proves that the antibacterial agents caused a change in the whiteness of the fabric. However, the overall change in whiteness after even the 40th washing cycle shows a slight decrease. For chitosan treated sample F, the whiteness indexes are showing a decrease as washind cycles are increased. Chitosan has a yellowish color, and as the number of washing is increased, the whiteness of the fabric increases. The increase of whiteness degree for chitosan treated sample F might be due to the removal of chitosan molecules as more washing cycles are applied. For all samples including the control sample, the overall change in whiteness is a slight change; and this slight change should be considered in textile materials where a certain whiteness is expected such as bedlinens especially for chitosan treatment.

The change in tear strength and Berger whiteness of samples shows differences according to the antibacterial agent treated and washing cycle applied. Generally, slight and tolerable decreases in tear strength values are observed. And slight decreases in whiteness, except for sample F which is treated with chitosan, are observed as well. Textile materials having antibacterial treatments should be tested for the special antibacterial agent they are treated and for the number of washing cycles that is required for their product life.

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