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ANALYSIS OF THE EFFECTS OF MERCERIZATION TREATMENT ON COTTON WOVEN FABRICS

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Abstract*- In this experiment* m*ercerization was done as a finishing process for cotton woven fabrics and observed its impact on brightness, moisture absorbency, and strength and color fastness of the fabric. There are several factors are involved in mercerization which control the ultimate results of mercerization. The experiment was carried without tension at constant temperature by varying alkali concentration, which affects different properties of the fabric. Then the fabric was dyed with reactive dye to investigate the color fastness effects. Finally the results were evaluated in context to the variables and some significant results were obtained. From the experiment it was observed that moisture regain increase with the increase of alkali concentration compared to un-mercerized sample. Same result was obtained in case of tensile strength in both warp and weft direction. Brightness values also show upward trend. Color fastness property of the fabric varies a little bit compared to un-mercerized sample.*

Keywords: Mercerization, Alkali, Moisture, Tensile Strength, Fastness.

1. INTRODUCTION

Textile finishing stage plays a fundamental role in the commercial results of textiles, which strictly depend on market requirements that are becoming increasingly stringent and unpredictable, permitting very short response times for textile manufacturers. The behavior of fabrics in end products is decisively influenced by their performance characteristics. These characteristics can be optimally adapted to the quality requirements by varying physical and technological parameters of the finishing process. Nowadays, the modern finishing process those are applied on textile products, it is possible to provide cotton fiber with a structure of similar to the superior properties of synthetic fibers. Mercerization is one of the finishing operations that change the physical and characteristic properties of cotton fiber and improves the processing quality of yarns and the quality of the products produced from them [1]. Mercerization is introduced in the surface of cotton goods either as pretreatment process for dyed materials or as finishing process for white goods. Cotton fabric is generally mercerized to improve dyeing property [2-3]; whereas it has been pointed out the treatment causes a stiff hand of the fabric. Mercerization has great impact on luster, moisture regain, chemical reactivity, dimensional stability, tensile strength and smoothness of cotton goods [4-10]. Mercerization can be applied on yarn or on the fabric itself either in the slack state or under tension [11]. Mercerization treatment results in the changes in microstructure, morphology and conformation of the cellulose chains. The extent of the changes that occur depends on the processing time, caustic concentration, temperature, and degree of polymerization and source of cellulose, slack or tension treatment and physical state of cellulose [5, 12-13]. Caustic soda solution is the best way among various alkali systems for effective mercerization process [from 4204]. It is well known that mercerization between cotton fiber and sodium hydroxide is an exothermic reaction, and the natural cellulose crystallite, cellulose I transfers to cellulose II by the treatment. Since concentrated sodium hydroxide flotte (operational solution that includes chemicals) is used in mercerization process, the reactions that take place with the cellulose fibers are intra-micellar reactions. That is, the sodium hydroxide flotte that is concentrated this much, penetrates inside the micelles (crystallites) and a structure called hydrate cellulose emerges [14]. Sodium hydroxide reacts with the hydroxyl groups inside the macromolecule in such a way that it either produces sodium cellulosate or it links to the molecules through the pulling forces. In this experimental work, mercerization was done as a finishing process for white cotton woven fabrics. There are several factors are involved in mercerization which control the ultimate results of mercerization. During this experiment, mercerization parameters like alkali concentration and tension were varied, which play the vital role during mercerization. After mercerization, the brightness, strength and moisture absorbency of the samples were measured and the results were evaluated in context to the variables.

2. MATERIALS AND METHODS

2.1 Materials

The experimental procedure was carried out on plain woven fabrics of specification 40×40/110×70 prepared from cotton yarn of 40 Ne. The woven fabric of GSM 110 was then used for mercerization after scouring and bleaching. Sodium hydroxide of 98% purity in solid flakes form was used as mercerizing chemicals and anionic sulplhated alcohol (NANOWET MRO, stable to concentrated alkali up to 320º Be) was used as mercerizing oil. Hot reactive dye was used for dyeing mercerized and un-mercerized fabric samples.

2.2 Methods

2.2.1 Scouring and Bleaching

Grey fabric was scoured and bleached in the same bath for removing wax, fat oily substance and natural coloring matter to get good reflectance. Chemicals and auxiliary used in this process are caustic soda-3 g/l, wetting agent- 1 g/l, detergent- 2 g/l, hydrogen per oxide (35%)- 4 g/l, peroxide stabilizer- 1 g/l. Materials and liquor ratio is maintained by 1:10. The scouring and bleaching process temperature is maintained 98ºC and experiment last for 60 min. The pH of the solution is kept 11.

2.2.2 Mercerization

The sample was prepared from the bulk material using scissor and scale by 12 × 12 inch. The mercerization liquor was prepared with different concentration of caustic as 13%, 21% and 27%. Mercerizing oil 2 g/l is used with 500 ml water for 1 min. The experiment was carried out at 20ºC temperature without tension in padder. Then fabrics were rinsed with cold water to remove traces of alkali completely. Any remaining alkali was neutralized with dilute acetic acid solution, followed by washing with cold water. Then fabrics were dried in dryer at 95oC for 16 min.

2.2.3 Dyeing

After mercerization, both the mercerized and un-mercerized samples were dyed with reactive dye in the same bath with 1.5, 3 and 4.5 percentage shade.

2.2.4 Determination of moisture regain% (MR %)

Both mercerized and un-mercerized cut sample fabrics of same size are weighted by electric balance. Then oven dry weights of these samples are measured by electric balance. Moisture regain percentage of the samples are calculated by the following formula (1)

$$R = \frac{W}{D} \times 100\% \qquad (1)$$

Here, Oven dry weight = D, Weight of water = W and Moisture regain = R

2.2.5 Determination of brightness values (K/S)

Samples are prepared in four fold and set it in the measuring port of spectrophotometer. Then brightness values (K/S) of samples were evaluated by using Data Color software.

2.2.6 Measurement of tensile strength (TS)

A rectangular sample size of 7 inch × 2 inch was taken to determine the tensile strength both in warp and weft direction by strip method (ASTM D5035).

2.2.7 Color fastness to Wash

A sample size 4 inch × 1.5 inch sew it along with 10 cm × 4 cm multi-fiber fabric and wash with 5 g/l standard soap and 2 g/l soda at material to liquor ratio 1:50. The washing process is continued for 30 min at 60ºC temperature and result is recorded according to ISO 105-C 06: 2010.

2.2.8 Color fastness to rubbing (Dry and Wet rubbing)

Test specimen 5.5 inch × 2 inch is locked onto the base of the crock meter. Using the spinal clip a 2 inch × 2 inch square of the white rubbing test cloth is set to the finger of the crock meter. Finger is lowered onto the test sample. Hand crank is turned and ten complete turns of the crank is made. After removing the white rubbing test cloth from the finger, color transfer is determined using grey scale for staining according to AATCC 8-2007. For wet rubbing test the procedure is repeated with cotton test cloth wetted in distilled water.

2.2.9 Color fastness to light

This test measures the resistance to fading of dyed textiles when exposed to daylight according to AATCC 16. Tested specimen is exposed for a time of 72 hours under the light source Daylight B01 and compared the changes with original unexposed specimen and evaluates color fading using blue wool reference (blue light fastness scale).

3. RESULT AND DISCUSSION

Effects of alkali concentration percentage on different parameters are shown in the Table 1.

Table 1: Effects of alkali concentration percentage on different parameters

Conc. Of NaOH %	Moisture Regain %	TS-lbs (Warp)	TS-lbs (Weft)	K/S
0*	6.66	45	37	63.65
13	7.02	49	40	67.00
21	7.46	53	44	68.25
27	8.47	42	34	69.20

*Un-mercerized

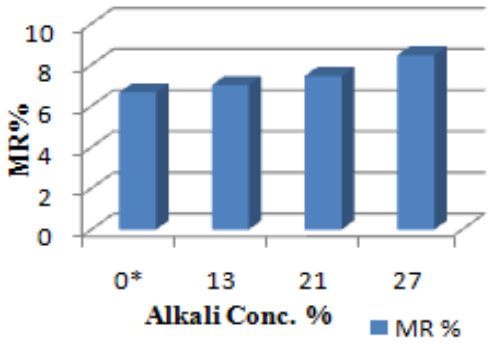

Fig. 1: Effect of alkali conc. on MR%

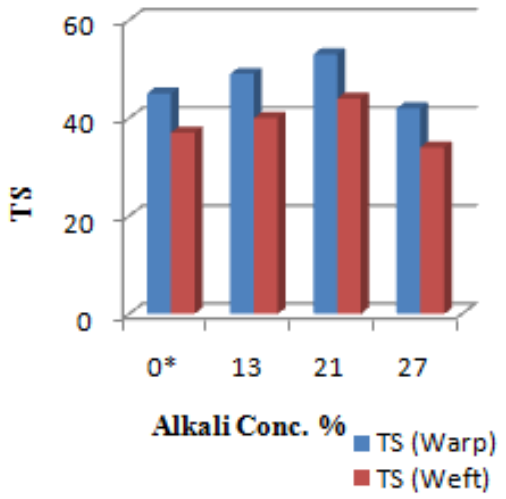

Fig. 2: Effect of alkali conc. on TS

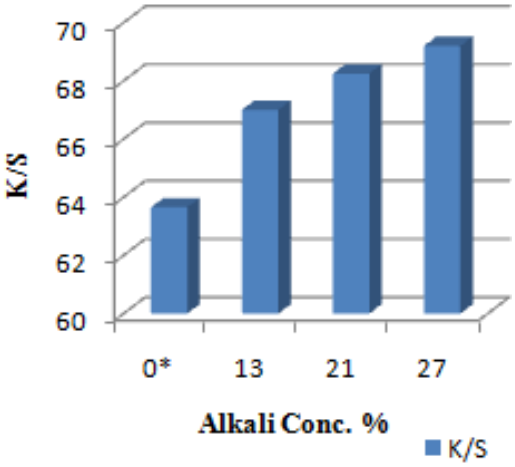

Fig. 3: Effect of alkali conc. on K/S

As the concentration of alkali increases, the amorphousness of the fibers also increases and the canals or spaces within the cellulose structure become more uniform which causes more moisture absorption.

The tensile strength increases at both warp and weft direction with the increase of concentration of NaOH within same temperature 20 C with the exception at concentration 27% as shown in the Fig 2. As the concentration of alkali increases, more swelling takes place which results molecular alignment in more regular way leading to an increase in hydrogen bond formation. So tensile strength increases with the alkali concentration. In case of highest alkali concentration, moisture regain reaches to maximum level which de-crystallize the fiber structure more, as a result strength of the material deteriorate.

From the Fig 3, it is clearly seen that brightness value shows an upward trend. When the concentration of alkali increases, more swelling takes place in the fiber. As a result the cross section becomes more circular and the surface structure becomes more smooth and regular enabling it to reflect incident light more evenly as a result brightness value is increased.

Color fastness test results of the sample are shown in the Table 2. From the Table 3 it is observed that wash fastness, rubbing fastness and light fastness properties of the sample are within acceptable range. No significant effect of mercerization on color fastness is found in the experiment. Most of the sample shows the same grade of fastness before and after mercerization. For 4.5% shade slight improvement is observed. This is may be due to absorption of more dye in the surface of the fabric. Salt concentration, pH, and temperature plays vital role along with alkali concentration in color fastness properties of the fabric. Warner reported that pH and temperature affect the degree of color change [15].

Table 2: Various color fastness test results

Alkali conc.	Dye shade %	Wash fastness		Rubbing fastness		Light fastness	
		Mercerized	Un-mercerized	Mercerized	Un-mercerized	Mercerized	Un-mercerized
13%	1.5	3 - 4	3 - 4	3 - 4	3	3 - 4	3
	3%	4	3	3 -4	3	3 -4	3
	4.5%	3-4	3-4	3 - 4	3	3 - 4	3
21%	1.5%	3-4	3-4	4	3 - 4	4	3 - 4
	3%	3	4	4	3 - 4	4	3 - 4
	4.5%	3-4	3	4	3 - 4	4	3 - 4
27%	1.5	3 – 4	3 - 4	3-4	3	3-4	3
	3%	3 - 4	3 - 4	3 - 4	3	3 - 4	3
	4.5%	4	4	3—4	3	3 -4	3

4. CONCLUSION

From this experiment it is clearly noticed that alkali concentration percentage play crucial role on moisture regain percentage, tensile strength both warp and weft wise and brightness of the fabric. The more the alkali concentration the more the moisture regain and brightness of the sample. Tensile strength is increased up to alkali concentration of 21 percentages. Color fastness properties of the fabric increased a little by mercerization treatment process.

5. REFERENCES

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6. NOMENCLATURE

Symbol	Meaning	Unit
Ne	Yarn Linear Density- Number of 840 yards in one lb	
GSM	Fabric weight in gram per square meter	
°Be	Concentration of NaOH	
g/l	Gram per liter	
MR%	Moisture Regain Percentage	
K/S	Kubelka - Munk function for brightness. where K is an absorption coefcient and S is a scattering coefcient	
TS	Tensile Strength	
NaOH	Sodium Hydroxide/Caustic Soda	