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INTERNATIONAL JOURNAL
OF CURRENT RESEARCH

International Journal of Current Research
Vol.9, pp.005-009, October, 2010

ISSN: 0975-833X

RESEARCH ARTICLE

INVESTIGATION OF WETTING AND WICKING BEHAVIOR OF TRILOGICAL TREATED COTTON FABRIC BY VERTICAL WICKING PRINCIPLE

Yuvarani, M[1], Ramesh Chandra Nayar[2], Prakash, C*[1] and Koushik, C.V[1]

[1]Department of Fashion Technology, Sona College of Technology, Salem - 636005, Tamilnadu, India
[2]Department of Textile Technology, Alagappa Chettiar College of Technology, Anna University, Chennai – 600025, Tamilnadu, India

ARTICLE INFO

Article History:
Received 18th August, 2010
Received in revised form
19th September, 2010
Accepted 23rd September, 2010
Published online 1st October, 2010

Key words:
Wicking, Wetting,
Desizing, Wicking Principle,
Woven fabric.

ABSTRACT

The wetting and wicking behavior of grey cotton fabrics treated with three (trilogical) different methods of desizing (water, acid, enzymatic desizing), and one combined scouring process is presented. Wetting and wicking abilities of scoured cotton fabrics are investigated using capillary action, contact angles and water wicking test methods. The experimental setup can be used to determine the distance of water travels along the fabric as a function of time. All these measurements were made under standard atmospheric conditions. The comparison t- test was used to determine any statistically significant difference with treated sample at confidence limit of 95%.

INTRODUCTION

Moisture/liquid transport in textile fabrics is one of the critical factors affecting physiological comfort. Fabrics that rapidly transport moisture/liquid away from the surface of the skin make wearers feel more comfortable by keeping the skin dry (Sofien Benltoufa *et al.,* 2008; Benisek at al., 1987; Silva, 2000 and Holme, 2002). The behavior of liquid moisture transfer in the clothing significantly influences the wearer's perception of moisture sensation and comfort sensation. Some standards and test methods can be employed to evaluate the fabric's simple absorbency and wicking properties (AATCC (2000), and the liquid strike-through time of non-woven also can be tested according to ISO90730-8.

Wetting is an important property of textile material for textile processing and performance. The comfort of clothing made from cellulosic fibers is closely associated with moisture absorbency.

***Corresponding author:** *dearcprakash@rediffmail.com*

The hydrophilic properties of cellulosic fibers also have great industrial importance for many processes (e.g.) scouring, dyeing and finishing. Wettability can be valuable for characterizing fiber surfaces liquid transport, interaction of fibers with liquid and surfactants and adhesion with polymer. Various wetting tests have been devised to obtain information on wettability absorbency and moisture transport (Ghali *et al.,* 1994). Wetting and wicking are related processes. A liquid that does not wet fibers, cannot wick into a fabric and wicking can only occur when fibers assembled with capillary spaces between them are wetted by liquid. The resultant capillary force drives the liquid into the capillary spaces. To reflect this wide range of conditions, textile researchers sometimes attempt to distinguish between two phenomena related to liquid transport in fabrics–wettability and wickability. For example, Harnet and Mehta stated that wickability is the ability to sustain capillary flow, whereas wetability describes the initial behavior of a fabric, yarn on fiber when brought into contact with water (Harnett and Mehta, 1985). The interaction of fiber assemblies (yarn or fabrics) with liquid depends on the chemical nature of the fibre surface and the geometry of fiber assemblies. Including pore size distribution, fibre diameter and surface roughness and liquid properties such as surface tension viscosity and density(Junyan *et al.,* 2005; Mohan Ram, 2007). Changing the fibre chemical composition in a fibrous material can alter it's over all surfaces wetting behavior. In any fibrous material structure of woven, non woven and knitted fabrics, a distribution of pore size along any planer direction is expected. Wicking rate and liquid transported in a fabric depend on these pore sizes and their distribution. Wicking process can be divided into two groups, wicking from an infinite liquid reservoir (immersion Tran planer wicking and longitudinal wicking) and wicking from a finite (limited) liquid reservoir (a single drop wicking in to a fabric (Junyan *et al.,* 2005; Mohan Ram, 2007;Norman Hollies, 1956; Wong *et al.,* 2001; You-Lo Hsieh and Bangling Yu, 1992;You-Lo Hsieh, 1992). In this paper, we report a new test method for characterizing the wicking properties of textiles.

MATERIAL AND METHODS

Materials

Wicking properties are significantly affected by fiber, yarn and fabric properties. The work was carryout using 100% grey cotton fabrics at different GSM, such as (high, medium and low). These fabric particulars are shown in following Table 1.

Table 1. Fabrics Particulars

S.No.	*Type of weave*	*Warp Count*	*Weft Count*	*EPI*	*PPI*	*GSM*
1	Plain	20^s	20^s	92	88	208
2	Plain	40^s	40^s	92	88	181
3	Plain	80^s	80^s	92	88	100

Method of Desizing treatments

There are three different variety of GSM of fabric (high, medium & low) is taken to follow three methods of desizing (water, acid, enzymatic) in the open bath with the following recipes

Normal desizing

M: L: R = 1:20
Water = owg
Time = 24hr

Acid desizing

M: L: R = 1:20
HCL = 2cc/ liter
Temperature = 50-60 °C
Time = 1 hr

Enzyme desizing

M: L: R = 1: 20
Amylase enzyme = 0.5 – 1.0 % owg
Temperature = 60 - 105 °C
PH = 6.5 - 8.0
Time = 1hr
Nonionic wetting agent = 0.75 - 1.0 gpl
NaCl or $CaCO_3$ = 1.0 - 2.0 gpl

After desizing the materials are washed and squeezed well.

Scouring treatment

All methods of desized samples are scoured to remove the fatty oils, waxes and also to improve the wet ability of fabrics with the following recipe used,

M: L: R = 1: 20
NaOH = 2 gpl
Na_2CO_3 = 1 gpl
Soap solution = 2 gpl
Temperature = 40 – 90º C
Time = 1 hr

Finally the scoured samples are thoroughly washed and squeezed well.

Process

The three different GSM (low, medium and high) of 100% cotton woven dry fabrics is treated with the above mentioned recipe, followed by conditioning (Holme, 2002; Ghali *et al.,* 1994) at standard atmospheric condition. The vertical wicking test was taken on both grey and treated fabrics using experimental setup at standard room temperature of 20°C with relative humidity of 65%.

Contact Angle

For wicking to take place the fibers has to be wetted first by the liquid. It is the balance of forces involved in wetting the fiber surface that drives the wicking process. When fibers are wetted by liquid, the existing fibers –air interfaces is displaced by a new fiber – liquid interfaces. The forces involved in the equilibrium that exists when a liquid is in contact with a solid and vapor at the same time are given by the following equation,

$$\Gamma SV - \Gamma SL = \Gamma SV \cos\theta$$

Where, Γ represents the interfacial tensions that exist between the various combinations of solid, liquid and vapor.

θ - Equilibrium contact angle
ΓLV - surface tension of liquid

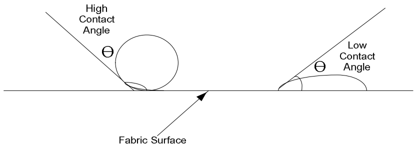

Fig 1. Contact angle

The angle between the fabric surface and the water molecule decides the wicking behavior of the wetted fabric. The contact angle is less in case of a fabric (Harnett and Mehta, 1985;Mohan Ram, 2007;Norman Hollies, 1956), which has higher wicking behavior and the water contact angle is higher for water repellent fabrics.

Water Uptake Measurements

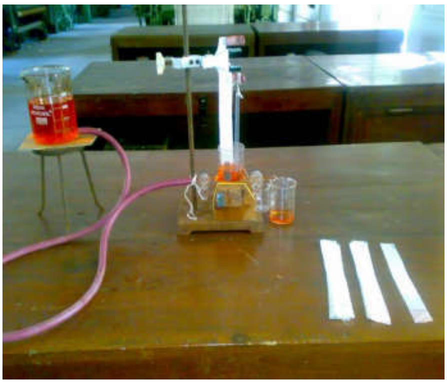

Fig 2. Model of water wickability tester

over the fabric stand. Then the sample is immersed into 1 inch depth and the capillary rise is measured on the scale after 30 seconds. These test carried out in standard room temperature of 20°C with (3) relative humidity of 65%. The tested results for different treated fabrics are statistically analyzed with t-test are tabulated in Table I and II.

RESULTS AND DISCUSSION

The results of the vertical wicking test on different methods of desized fabrics using (water, acid and enzyme) after that fabrics scouring is presented. Desized and scoured fabrics are used to carry out the wicking test for using wick ability tester. The size of the tested fabric is 1 inch width and 8 inch length with its lower end immersed in a reservoir of distilled water. After 30 seconds has elapsed, the height reached by the water in the fabric above the water level in the reservoir is measured using scale. The measured height of rise is taken as a direct indication of the wick ability of the test fabric. The measurement results are summarized in Table – I. Statistical analysis helped to identify the significance of the difference between the desized and scoured fabrics. Table –1indicates the results of the wick ability test values for three different methods off desized & scoured fabrics.

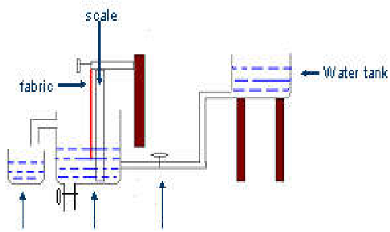

Table 1. Results of the Wick ability test values for Desized & Scoured fabrics (Capillary absorption in cm/sec)

S. NO	*Description of fabrics*	*Grey fabric*					*Normal Desized & Scoured fabric*					*Acid Desized & Scoured fabric*					*Enzyme Desized & Scoured fabric*				
1	High GSM (20^S)	0.1	0.1	0.2	0.1	0.1	2.7	2.9	3.2	2.8	2.6	2.2	2.5	2.4	2.5	2.2	3.4	3.6	3.2	3.5	3.1
2	Medium GSM (40^S)	0.2	0.1	0.2	0.2	0.1	2.5	2.0	2.3	2.4	2.2	2.5	2.2	2.4	2.6	2.8	3.5	3.9	3.4	3.6	3.3
3	Low GSM (80^S)	0.1	0.2	0.2	0.2	0.1	1.5	1.6	1.8	1.7	1.9	2.3	3.0	2.8	2.9	2.5	2.3	2.8	2.5	2.9	2.7

Table 2. Results of the t- test values for Wick ability

S.NO.	*Description of fabrics*	*t-test values Grey Vs. Treated*			*t-test values (between treatments)*		
		Grey Vs. normal	**Grey Vs. acid**	**Grey Vs. enzyme**	**Normal Vs. acid**	**Normal Vs. enzyme**	**Acid Vs. enzyme**
1	High GSM(20^s)	5.96278E-06	5.01216E-06	6.07666E-06	0.05058	0.018563	0.000145
2	Medium GSM (40^s)	5.71326E-06	2.21981E-05	7.01765E-06	0.097185	0.01512	0.005557
3	Low GSM(80^s)	3.29336E-05	1.91666E-05	1.38736E-05	0.002111	0.000949	0.0529133

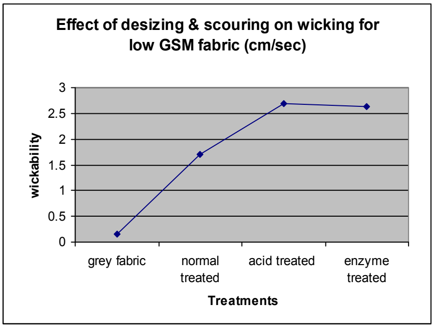

Fig. 3. Effect of desizing and scouring on wicking for High GSM fabric

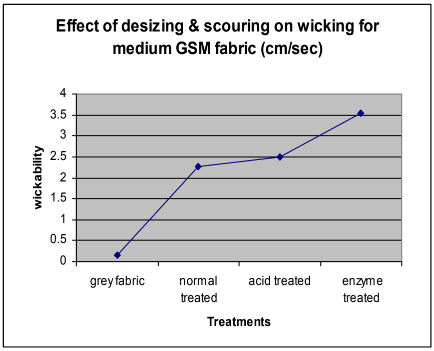

Fig. 4. Effect of Desizing and Scouring on wicking for Medium GSM fabric

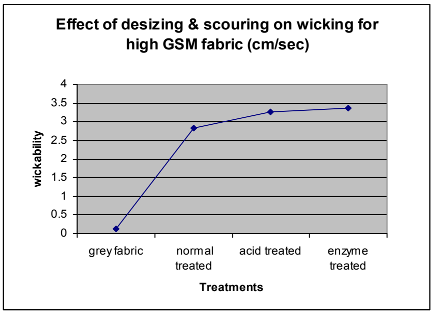

Fig. 5. Effect of Desizing and Scouring on wicking for Low GSM fabric

Comparison of Grey Fabric vs Treated Fabrics

In this comparison tests the wicking behavior of the grey fabric is very low compared to treated fabrics. During desizing and scouring treatment the wetting of fabric will be increased, but in grey fabric starch is presented it will resist the absorbency of water in fabrics. In the wicking test values are statistically analyzed and interpreted the results were come highly significant to each other. After that to compare the t-test values for between treatments are come significant to each other.

Effect of desizing and scouring on wicking for High GSM fabric

The 100% grey cotton high GSM fabric wick ability is very poor. The fabric is desized by using (water, acid, and enzyme) and scoured gradually increase the wick ability of fabric. In the normal desized and scoured high GSM fabric wicking is initially increased. From an acid treated fabric, wicking behavior curve is further raised continuously to compare the normal treated fabric. Finally in this graph explain to compare all the treatments the enzyme desized and scoured fabric having high wicking behavior at 30 seconds duration.

Effect of Desizing and Scouring on wicking for Medium GSM fabric

In the medium GSM fabric at grey stage has low wicking behavior. After desizing using different chemicals (water, acid and enzyme). In the water desized & scoured fabric wicking behavior curve is initially raised at a faster rate , an acid treated fabrics curves further increased up to one stage and reduced slightly . Enzyme treated fabric having high wicking behavior compare to other treated fabrics the curve reached peak point at 30 seconds duration.

Effect of Desizing and Scouring on wicking for Low GSM fabric

Grey stage fabric having poor wicking behavior. After that fabric was desized & scoured to improve the wicking behavior of fabrics by each step of the process. Particularly this low GSM fabric acid desized & scoured fabric having more wicking behavior compared to other. Comparing the various test methods for wicking on fabrics before and after desized & scoured fabric, the results are come highly significant to each other. All these treated fabrics particularly the enzyme desized & scoured fabrics having best wicking behavior.

Conclusions

These experiments have confirmed that the wicking properties commonly associated with cotton fabrics are not necessarily inherent to the fiber, but are often due to the presence of oil, waxes and surfactants. These can be removed by desizing and scouring, with consequent drastic reduction of wick ability of fabric. The strip test does not seem an appropriate method for measuring wicking properties that might be of relevance to clothing comfort studies. Results obtained using distilled water at 20°C as the wicked liquid appear to be accurately indicative of wicking behavior using human perspiration at normal skin temperature . So the enzyme desized and scoured fabrics having best wicking behavior compare to other treated fabrics, any way the former may be regarded as an acceptable substitute in studies of the perspiration transport properties of fabrics.

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