INTRODUCTION

Wickability of fabrics has become an important test as it discloses information on comfort, dyeability and usefulness as a sportswear. A number of papers on the wickability of yarns and fabrics have been published and reviews have appeared [1]. The role of water in transporting moisture has been appreciated for a very long time. A considerable amount of work has been carried out on the application of sericin to polyester and cotton fabrics [2–4]. From the papers published it is found that wickability test, although was performed on the fabrics, has not been studied in detail.

Wicking is the spontaneous transport of a liquid driven into a porous system by a capillary force [5]. Wicking height is proportional to root of time. Lucas-Washburn equation, which is a very popular one, includes properties such as surface tension, radius of the capillary, contact angle and viscosity of the liquid which has been used to study wickability. It is reported that the weft density pore size and the arrangement of void spaces in fabric have a significant effect on the wicking performance [6]. It is also reported that the motion of liquid in the void spaces between fibers in a yarn impacts the mechanism of fabric wicking critically [7]. It is found that the rate of movement of liquid is governed by the fibre arrangement in yarn which control the capillary size and continuity [8].

Validity of Washburn’s equation can be checked by two models, namely

\[ h^2 = c^2 t \] \hspace{1cm} \text{(1)}

\[ h = c't^k \] \hspace{1cm} \text{(2)}

Where \( h \) is wicking height, \( t \) – time and \( k \) – time exponent, \( c \) and \( c' \) are constants.

In this communication, the wickability of sericin treated polyester fabrics is dealt with. Although some data on wickability have been provided, they were not examined in detail. The applicability of Washburn’s equation is discussed for a series of polyester fabrics that have been treated with sericin.

MATERIALS AND METHODS

Sericin was obtained from CSTRI Bangalore. Polyester fabric with plain weave having the specification of 133 g/m² weight with 55 ends per cm and 33 picks per cm was used for the study.
Modification of polyester fabric
Polyester fabric sample was scoured to remove any impurities and it was pretreated with alkali 1M (40 g/l) NaOHH at 80°C for 45 min with 1:100 material to liquor ratio to create functional groups on its surface, before applying sericin to the fabrics.

Application of sericin
Sericin was applied on modified polyester fabric with and without the use of a crosslinking agent. 20 g/l of sericin solution was used. Alkali treated fabric were padded with the sericin solution in a laboratory padding mangle by a 2 dip 2 nip process. The padded fabric was dried at 80°C for 3 min and cured at 130°C for 2 min. Cured samples were then washed and dried. Glutaraldehyde was used as a crosslinking agent to attach sericin to alkali modified polyester.

Plasma treated with DMDHEU
The polyester fabric was prepared in the required dimension of 54x54 cm and weighed. This fabric was clamped to the frame and inserted in the plasma chamber between the two plates and pressure in the chamber was brought to 0 bar then the oxygen gas was passed to the chamber with the flow rate of 2 bar pressure. Initially the top side of the fabric was exposed to the plasma current 1.06 amp, plasma voltage 350 volt at temperature 29°C this was continued for 5 min. Then the bottom side of the fabric was exposed to the plasma current 1.53 amps, plasma voltage 300 volt at a temperature of 29°C for 5 min. After the process, the fabric was weighed again to determine the weight loss percentage.

Plasma treatment changes the surface properties of the fabric [9].

Plasma treated with Glutaraldehyde (GA)
The required dimension of the plasma treated fabric was weighed and the fabric was wetted in water along with wetting agent (TRO) and then treated with the solution of Sericin 25% (owf), GA 20 g/l, magnesium chloride 10 g/l and acetic acid 1.0 ml/l using material-to-liquor ratio of 1:9. The above procedure was followed for both padding and curing.

Alkali treatment with DMDHEU and Glutaraldehyde
The same untreated polyester fabric was treated with 15% NaOH (owf) with the material-to-liquor ratio kept at 1:40, at 60°C for 30 min. This alkaline treated polyester fabric was then treated with sericin, Glutaraldehyde, magnesium chloride and acetic acid and sericin, DMDHEU, polyethylene emulsion combination as in the same manner above and then padded and then cured.

Untreated polyester with DMDHEU and Glutaraldehyde
Untreated polyester fabric was directly treated with DMDHEU with other chemicals and Glutaraldehyde with the above mentioned chemicals. Drying and curing were carried out at 140°C for 3 min.

Experimental
In this study, seven samples of polyester fabric such as polyester fabric treated with alkali (PA), untreated polyester treated with sericin and Glutaraldehyde (USG), polyester fabric with sericin and DMDHEU (USD), Polyester fabric treated with alkali followed with Sericin and Glutaraldehyde (ASG), polyester fabric treated with alkaline followed with sericin and DMDHEU (ASD), Polyester fabric treated with plasma followed with sericin and Glutaraldehyde (PSG), Polyester fabric treated with plasma followed with sericin and DMDHEU (PSD). Details of the polyester fabrics used are given in table 1.

| S.No. | Particulars                                      | Ends/cm | Picks/cm | GSM | Thickness (mm) |
|-------|-------------------------------------------------|---------|----------|-----|----------------|
| 1     | Polyester fabric treated with alkali (PA)       | 55      | 33       | 133 | 0.32           |
| 2     | Untreated Polyester fabric with sericin and DMDHEU (USD) | 54 | 32 | 134 | 0.31 |
| 3     | Untreated polyester fabric with sericin and glutaraldehyde (USG) | 55 | 34 | 135 | 0.32 |
| 4     | Alkali treated polyester fabric with sericin and DMDHEU (ASD) | 54 | 33 | 137 | 0.33 |
| 5     | Alkali treated polyester fabric with sericin and glutaraldehyde (ASG) | 55 | 34 | 138 | 0.32 |
| 6     | Plasma treated polyester fabric with sericin and DMDHEU (PSD) | 54 | 33 | 131 | 0.32 |
| 7     | Plasma treated polyester fabric with sericin and glutaraldehyde (PSG) | 54 | 33 | 133 | 0.32 |
Determination of Wickability of treated and untreated fabrics

Wickability was studied by using vertical wicking method (DIN 53924 standard) as shown in figure 1.

RESULTS AND DISCUSSION

By plotting $h^2$ against $t$ and using regression model passing through origin it will be possible to obtain values of $k$ and check the applicability of Washburn’s equation.

The evaluation of the $h^2$ as a function of time is determined for given times in the region of 0–600 s and the slopes are given in table 2. The curve obtained is linear and the experimental values lead to a linear regression coefficient of $R^2$ exceeding 0.99. It is necessary to get a correlation coefficient of more than 0.99, as only then will the Lucas Washburn’s equation is followed.

The results of the wicking test are shown in tables 2 and 3.

Model A

Plotting height in cm$^2$ against the time sec gives the following values which are given in table 2. Regression analysis has been done to get slope and intercept.

Model B

Values of slopes and intercepts are given in table 3, following model $h = c^t k$.

There are two models which are used to find out the validity of Washburn’s equation. The first model is

$$h^2 = c^2 t \quad \text{or} \quad h = c^{\sqrt{t}} \quad (3)$$

$$h = c^t k \quad (4)$$

Where $h$ is wicking height in cm and $t$ – time in second. By plotting $h^2$ against $t$ and using regression model passing through origin it will be possible to obtain values of $k$ and check applicability of Washburn’s equation. Values are shown in table 2.

The second model B is $h = c^t k$. This was proposed by Laughlin et al. [10] who suggested the following equation and Deboer [11] has also used this equation. It is interesting to note that Deboer [11] has not referred to Laughlin et al’s [10] paper in his study.

By taking logarithm on both sides

$$\ln(h) = k \ln(t) + \ln(c') \quad (5)$$

This model has been used by Nyoni [12] and Zhuang et al. [13] in their studies.

Table 3 gives the results, in this equation, there are strange units $\ln(c')$ of $k$ and $c$ parameters. $c'$ is not intercept but equal to value of $\ln(h)$ for time $t = 1$.

When $h = 0$, $t = 0$ and this leads to difficulties because $\ln(0)$ is minus infinity. Hence, while in X-axis the curve starts from zero, in Y-axis a finite value is

Table 2

| Time (sec) | UT (cm) | USD (cm) | USG (cm) | ASD (cm) | ASG (cm) | PSD (cm) | PSG (cm) |
|-----------|---------|----------|----------|----------|----------|----------|----------|
| Slope (cm$^2$/s) | 0.02 | 0.06 | 0.05 | 0.05 | 0.06 | 0.04 | 0.06 |
| Intercept | $-1.15$ | $1.03$ | $-0.20$ | $1.48$ | $0.44$ | $0.95$ | $0.13$ |
| $R^2$ | 0.99 | 0.98 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 |

Table 3

| Time (Sec) | PA (cm) | USD (cm) | USG (cm) | ASD (cm) | ASG (cm) | PSD (cm) | PSG (cm) |
|-----------|---------|----------|----------|----------|----------|----------|----------|
| Slope (cm/min) | 0.83 | 0.53 | 0.52 | 0.43 | 0.48 | 0.47 | 0.49 |
| Intercept | $-3.93$ | $-1.57$ | $-1.61$ | $-1.05$ | $-1.27$ | $-1.37$ | $-1.38$ |
| $R^2$ | 0.98 | 0.98 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 |
obtained by taking logarithm of wicking height values. Thus at 0 time, there is wicking which looks absurd. Another problem with regard to this model is that when wicking height and time have values less than 1, negative values are obtained. In this model when \( K = 0.5 \), it is taken that Washburn’s equation is valid. Alternatively, the model \( h^2 = c^2 t \) is sound as for 0 time, 0 is the wicking [14–16]. This model is devoid of the deficiency as mentioned above.

CONCLUSION

Using the model \( h^2 = c^2 t \) the experimental results have shown that the wicking height square had a positive and high correlation with time in the warp direction (\( R^2 = 0.99 \)) indicating that the Lucas – Washburn’s equation was suitable for evaluating the wicking property of sericin treated polyester fabrics. This other model namely, \( h = c^t k \) is not sound as there are strange units.

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Authors:

DASARATHAN KAMALRAJ¹, VENKATRAMAN SUBRAMANIAM²

¹ Anna University, Textile Technology, Department of Handloom &Textile Technology, Indian Institute of Handloom Technology, Foulke’s Compound, Thillai Nagar, Tamilnadu, Salem – 636001, India
² Anna University, Textile Technology, Department of Textile Technology, Jaya Engineering College, CTH Road, Thiruninravur, Chennai – 602024, Tamilnadu, India

e-mail: kamalraj3448@gmail.com; vsubram@hotmail.com

Corresponding author:

DASARATHAN KAMALRAJ

e-mail: kamalraj3448@gmail.com