STUDY OF MOISTURE MANAGEMENT IN KNITTED FABRICS USED IN SPORTSWEAR

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REZUMAT. Unul dintre criteriile cheie de performanță pentru îmbrăcămintea sport este gestionarea umidității, adică abilitatea de a transporta umezeala rezultată prin transpiraţie departe de piele. In lucrare este prezentat un studiu privind managementul umidităţii prin materiale textile tricotate, realizate din fibre de poliester (CoolMax), fibre special realizate în acest scop.

Cuvinte cheie: gestionarea umidităţii, îmbrăcăminte sport, fibre CoolMax.

ABSTRACT. One of the key performance criteria for sportswear is moisture management, i.e. the ability to transport moisture resulting from sweating away from the skin. The paper presents a study on moisture management through knitted textile materials made of polyester fibers (CoolMax), fibers specially designed for this purpose.

Keywords: moisture management, sportswear, CoolMax fibres.

1. INTRODUCTION

One of the key performance criteria in modern sportswear and outdoor wear is moisture management - the ability of a garment to transport moisture away from the skin to the garment outer surface. It has been shown that fabrics which wick moisture rapidly through the fabric while absorbing little water help to regulate body temperature, improve muscle performance and delay exhaustion [6].

Moisture management properties refers to such characteristics of a fabric as wicking rate, moisture transport rate, and drying (or release) rate. "Wicking" refers to capillary action in a fabric whereby moisture or liquid is dispersed or spread through a given area. "Moisture transport rate" means the distance traveled along the length of a fiber or filament within a prescribed time limit. "Drying rate" or "release rate" refer to the volume of water evaporated from a fabric within a prescribed time limit [7].

Moisture handling properties of textiles during intense physical activities have been regarded as major factor in the comfort performance. Actually, the comfort perceptions of clothing are influenced by the wetness or dryness of the fabric and thermal feelings resulting from the interactions of fabric moisture and heat transfer related properties [8]. The garment that is worn next to skin should have:

a) good sweat absorption and sweat releasing property to the atmosphere

b) fast drying property for getting more tactile comfort.

2. FACTORS AFFECTING MOISTURE MANAGEMENT

There are several factors that affect moisture management in a textile fabric. The most important of them are presented in the figure 1:

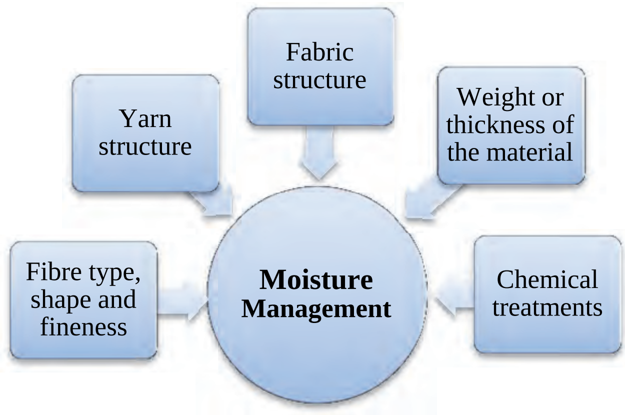

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Fig. 1. Factors affecting moisture management in a fabric structure

Natural fibres such as cotton and wool are hygroscopic and are characterised by high absorbtion levels, but the absorbed moisture is bound in strongly and is released very slowly. This result in a low moisture transport rate for the textiles made of these fibres. On the other hand synthetics fibres, such as polyester, are not hygroscopic and therefore absorb comparatively small amounts of moisture, but because of the hydrophilic fibre surface these fibres have a high moisture transfer rate [1].

Synthetic fabrics are generally considered to be the best choice for garments worn as a base layer, because they are able to provide a good combination of moisture management, softness and insulation [2].

The mechanism by which moisture is transported in textiles is similar to the wicking of a liquid in capillaries, which is governed by the Laplace equation [3].

The height *h* (m) of a liquid column is given by the equation (1):

$$h=\frac{2\gamma\cos\theta}{\rho g R} \quad (1)$$

where:

γ is the liquid-air surface tension, J/m²

θ is the contact angle, °

ρ is the density of liquid (mass/volume), kg/m^3

g is acceleration due to gravity, m/s²

R is radius of tube (length), m

Thus, the capillary action is determined by two fundamental properties of the capillary:

- the diameter;
- the surface energy of its inside face.

The smaller the diameter or the greater the surface energy, the greater the tendency of a liquid to move up the capillary. In textile structures, the spaces between the fibres effectively form capillaries. Hence, the narrower the spaces between these fibres, the greater the ability of the textile to wick moisture. Fabric constructions, which effectively form narrow capillaries, pick up moisture easily [2].

3. MATERIALS

CoolMax is a Dacron Polyester fiber that is renown for its moisture management wicking and drying capabilities. This fiber has a unique structure that provides 20% more surface area than ordinary fibers. The secret of CooMax originates from its multi-channel cross section (Fig. 2 and Fig. 3). It applies the capillary theory to textile development, and can make it rapidly absorb sweat and moisture from the skin surface, transport it to the fabric surface, and then evaporate it. At the same time, due to its profiled fiber cross section (Fig. 4) and loose yarn structure, the air permeability is largely increaset. It can maintain the dry and cool condition between textile products and skin so as to reach its goal of quick moisture-absorption, sweat-ventilation and comfort [9, 10]. Moisture management of the textile product is achieved starting with the fibre, where engineered tertachanel shaped fibre have 4 water-directing channels to quickly wick away sweat.

The fibre cross-section has also a considerable effect on visual properties (e.g. lustre, colour, transparency, cleanability) and physiological properties (e.g. moisture conductivity/transfer, heat insulation) [9, 10].

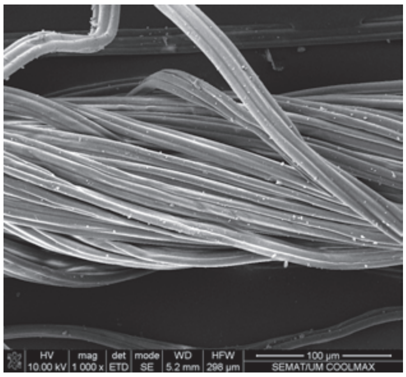

Fig. 2. SEM image of the yarn

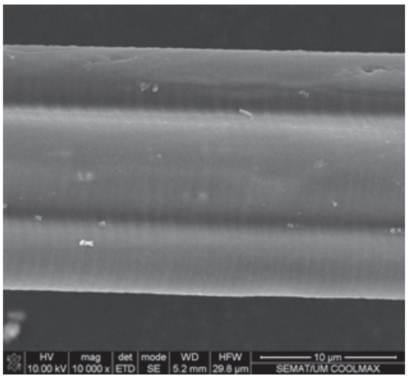

Fig. 3. SEM image of the fibre

The special sectional structure also reduces the fibre contact with the skin, making the fabric feel drier to the touch [10].

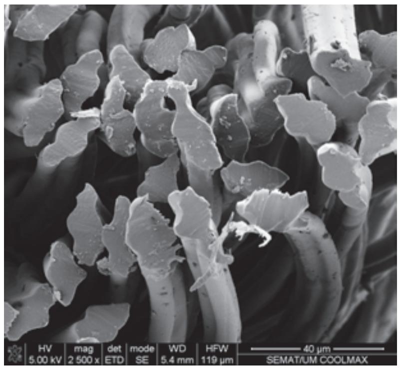

Fig. 4. Cross section of the CoolMax fibre

In this study a Single Jersey knitted fabric made of Dacron 702 WSD 1,7/38 T_{tex} 14 and Lycra 70D was obtained on the 8-feed Single-Jersey Circular Knitting Machine MERZ – MBS. The details of machine:

gauge – 28 E, diameter – 13”, speed – 50 rpm, number of needles – 1152. The loop length was 2.50 mm.

For comparison a knitted fabric made of 20% SeaCell® pure/10% SeaCell® active/70% Combed Cotton, T_{tex}12 and Lycra 70D was used. This knitted fabric was obtained in the same conditions, with the same loop length.

Table 1. **The properties of the fabrics**

	CoolMax/Lycra	SeaCell/Lycra
Thickness, mm	1.246	1.193
Fabric weight, g/m^2	297.08	294.90
Fabric density, g/cm^3	0.238	0.247

4. EXPERIMENTS AND DISCUSSION

4.1. DIFFUSION CAPACITY

The samples fabrics were placed flat on a hydrophobic board with the outer surface facing down. The area (mm^2) was measured with water allowed to diffuse at 30 second after dripping 0.2 ml of water using a precise dropper whose tip was 10 mm above the fabric surface. The measurement was repeated at five different points and the average of the diffusion area (mm^2) was taken to indicate the diffusion capacity of the fabrics.

The CoolMax/Lycra fabric shows the largest area diffused with water. The water have been absorbed in about 1 second, the diffusion area being 700.98 mm^2, 1075.21 mm^2 after 15 seconds and respectively 1256.63 mm^2 after 30 seconds. The Seacell/Lycra fabric indicates a comparatively lower diffusion rate. For this fabric the water have been absorbed in 15 seconds, the diffusion area being 293.56 mm^2 and 490.87 mm^2 after 30 seconds. This can be attributed to the hydrophilic nature of cotton fibers, which tends to absorb the water dropped onto the fabric surface. When wet with water, the cotton fibers expand, thus slowing down the diffusion rate.

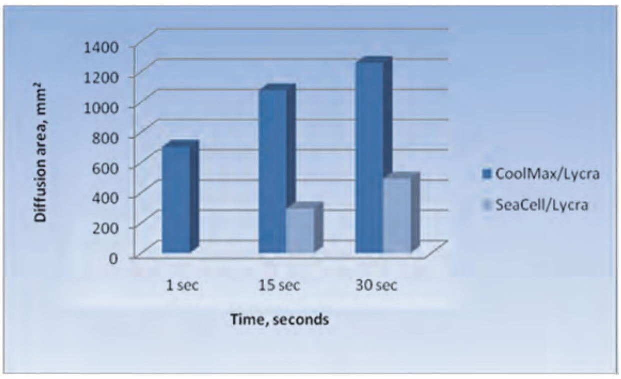

Fig. 5. Diffusion rate

Although polyester is conventionally hydrophobic, the channels formed in the fibres of these yarn have been found to be highly effective pathways for the movement of moisture.

4.2. DRYING RATE

In order to determin the drying rate, the fabrics have been cut into circular samples of 54 cm^2 and recorded its dry weight (W_f). 0.2 ml of water was dropped onto it using a precise dropper whose tip was 10 mm above the fabric surface and recorded its wet weight (W_0) at the initial stage. The change in weight (W_i) was measured at 10-minute intervals. The remaining water ratio (%) was calculated at each interval using the following equation:

$$RWR = (W_i - W_f)/(W_0 - W_f) \times 100\ \% \qquad (2)$$

The remaining water ratios within 1 hour and 30 minutes experimental duration have been determined and used to express the drying rate of the fabrics.

Figure 6 shows the drying rate of the knitted fabrics obtained with CoolMax/Lycra yarn and Seacell/Lycra yarn in the same conditions.

As can be seen, the CoolMax fabric has the lowest remaining water ratio, implying the fastest drying rate. This can be attributed to the difference in remaining water ratio between polyester and cotton fibers. Polyester fibers have a low remaining water ratio of 0.4% while that of cotton fibers is as high as 8.5%.

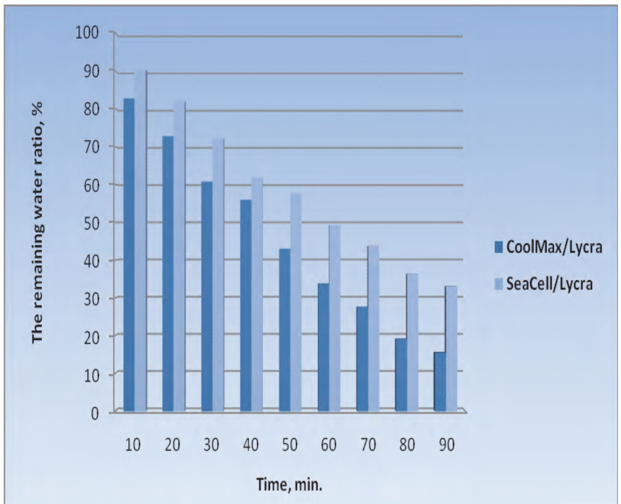

Fig. 6. Drying rate

4.3. WICKING - ‘DROP’ TEST

In this test, conducted according to International AATCC 79 – 2007- absorbency of Textiles - test standard, a certain amount of distilled water (approximately a drop) is placed on the fabric from a height of approximately 6 mm, and the amount of time for the fabric to absorb the water is measured in seconds [4]. As can be seen from figure 7, CoolMax fabric has excellent absorption properties and absorb water faster than SeaCell fabric.

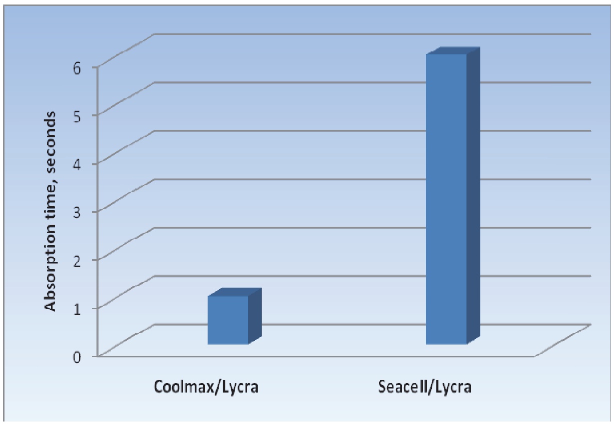

Fig.7. Wicking properties

4.4. WICKING – „TRANSVERSE PLATE" TEST

The apparatus used to determine the transverse wicking consists of a horizontal glass plate fed from below with water through a capillary tube from a reservoir placed on an electronic balance. The sample (19 cm x 19 cm) is placed on the glass plate and is held in contact with it (and with water) applying another glass plate on top of it. The changing weight of the reservoir is measured by an electronic balance to determine the rate of liquid uptake by the textile material in the sample. Similarly aparatus have been used by Buras, Hussain & Tremblay-Lutter and McConnell [4].

As can be seen from Figure 8, the CoolMax/Lycra fabric has a higher rate of water absorption compared with SeaCell/Lycra fabric.

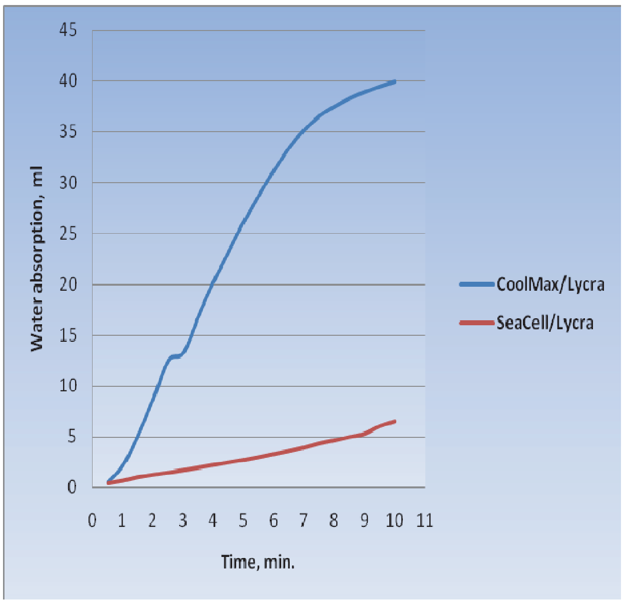

Fig. 8. Wicking properties

4.5. WATER VAPOUR PERMEABILITY

The water vapour permeability was determined on SDL Shirley Water Vapour Permeability Tester M – 261, according the standard BS 7209-1990. The cup method is a very common method for testing the moisture transfer ability of fabrics. It is used to measure the rate of water vapour transmission perpendicularly through a known area of a fabric to a controlled atmosphere [5].

The water vapour transmission rate (WVTR) in grams per hour and per square metre was calculated by the following equation:

$$WVTR=\frac{G}{tA} \quad (g/m^2/h) \qquad (3)$$

where:

G is weight change of the cup with fabric sample, in grams

t is the time during which G occurred, in hours

A is the testing area in square metres.

The index of water vapour transmission rate was calculated by the following equation:

$$I=\frac{WVRT}{WVRT_r}\cdot 100\ (\%) \qquad (4)$$

where $WVTR_r$ is the water vapor transmission rate of the reference fabric.

The index of water vapour transmission rate of CoolMax/Lycra fabric is higher than that of SeaCell/Lycra structure (Fig. 9).

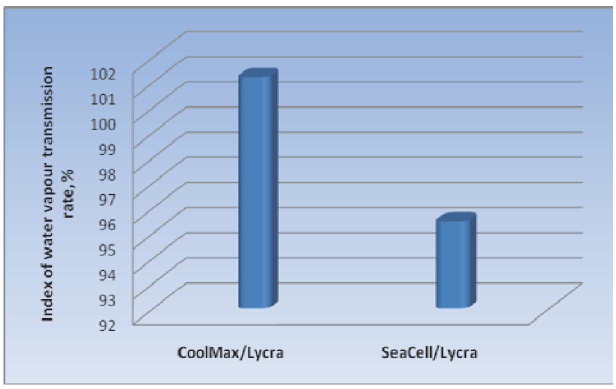

Fig. 9. Water vapour transmission

5. CONCLUSIONS

Good moisture absorption and release can be found in fibers with greater specific surface area.

Fabrics with good moisture absorption and release can be developed using profiled polyester fibers.

Polyester fabrics are the best choice for active sportswear because they are able to provide a good moisture management.

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