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Defining the warp length required for weaving process

JOVAN STEPANOVIĆ
NENAD ĆIRKOVIĆ
DRAGAN RADIVOJEVIĆ
MIRJANA RELJIĆ

REZUMAT – ABSTRACT

Determinarea lungimii urzelii în procesul de țesere

Calculul lungimii urzelii în procesul de realizare a țesăturilor cu lungimi prestabilite reprezintă o problemă de actualitate în țesătorie. Scopul acestei lucrări îl constituie elaborarea unei metode de calcul corect al lungimii urzelii în realizarea unei țesături cu o lungime prestabilită. Proiectarea lungimii urzelii este strâns legată de ondularea capetelor de urzeală, care este determinată de anumiți parametri. Cei mai importanți dintre aceştia sunt: caracteristicile firelor utilizate, tipul de legătură, desimea şi gradul de tensionare a firelor. Pe baza rezultatelor cercetărilor teoretice şi experimentale au fost definite relațiile ce pot fi folosite în proiectarea lungimii urzelii pentru a formula diferite soluții structurale şi constructive.

Cuvinte-cheie: proces de țesere, lungimea urzelii, lungimea țesăturii, capete de urzeală, caracteristicile firelor

Defining the warp length required for weaving process

Determination of warp length for weaving of required length of fabric is always a current problem of weaving production. Thus, the aim of this paper is to contribute to the development of a method for the correct definition of required warp length for a given fabric length. Designing the warp length is closely related to the determination of warp ends crimp. The crimp of warp ends in fabric is defined by a number of parameters. The most important among them are characteristics of yarns used, fabric weave, density and tension of threads. Analyzing theoretical assumptions and experimental results defined are relationships that can be used in designing warp lengths to form various structural and construction solutions.

Key-worlds: weaving process, warp length, fabric length, warp ends, characteristics of yarns

In the fabric forming process on the loom, deformations of warp ends and weft threads appear as a result of mutual crossings. Small arcs appear on spots where ends touch and press each other. Therefore, the woven fabric length is shorter than the warp length applied. The same applies to fabric width that narrows compared to the length of weft used. This difference represents ends crimp and shrinkage. The amount of crimp and shrinkage is a very important parameter as required yarn quantity for a given fabric is determined based on this parameter.

Considering that the warp is longer than the fabric it is possible to express the warp share in the fabric by warp crimp coefficient (1):

$$c_{wa,c} = \frac{l_{wa}}{l_f} \tag{1}$$

where:

l_{wa} is warp length for a given fabric length, m;

l_f – fabric length, m;

$c_{wa,c}$ – warp crimp coefficient,

or as a crimp percentage of warp ends (2):

$$w_{wa,c} = \left(1 - \frac{1}{c_{wa,c}}\right) \cdot 100 \quad [\%] \tag{2}$$

where:

$w_{wa,c}$ is warp crimp and shrinkage, %.

In this way it is possible to design accurately the length of warp, l_{wa}, necessary to be warped for weaving the given fabric length, l_f, by using the following equation (3):

$$l_{wa} = l_f \cdot c_{wa,c} \quad [\text{m}] \tag{3}$$

The correct determination of warp crimp and shrinkage has high practical importance for weaving because it reflects primarily on material “consumption coefficient”. By crimp and shrinkage given is the actual consumption of warp and weft for producing the fabric surface unit. Moreover, incorrect determination of crimp and shrinkage leads to mistakes in defining the real waste in weaving.

MATERIALS AND METHODS

The mistakes in defining required warp length arise from incorrect determination of warp ends crimp and shrinkage.

In the forming process of analyzed fabrics, on modern looms, optimum tensioning of warp ends was used, which was conditioned by physical-mechanical characteristics of applied yarns. Tension force of warp ends was controlled by computerized tensiometer type DTFX-200.

There were analyzed 72 fabrics with different structural and constructive solutions. The fabrics were made in plain weave, three ends twill, four ends twill, five ends satin, five threads mixed panama and five threads reinforced twill. The fabrics were made from cotton type yarns (cotton or blends of cotton and polyester fibers). Yarns used for warp were 16 tex, 20 tex, 16.7 × 2 tex, 20 × 2 tex, 25 × 2 tex, and 30 × × 2 tex and for weft were 20 tex, 21 tex, 25 tex, 50 tex, 16.7 × 2 tex, 20 × 2 tex, 21 × 2 tex, 25 × 2 tex, and 30 × 2 tex. Density of warp ends was in the range of 23 cm^{-1} – 45 cm^{-1}, and that of weft threads was in the range of 14 cm^{-1} – 32 cm^{-1}.

In regard to differences in crimp and shrinkage of the same fabric, tests were done on sectors on fabric surface. For that, each fabric was divided in six sectors (250 × 250 mm) and 20 measurements of extracted warp ends were made on each sector. Based on measurement results (120 measurements of ends system for each fabric), crimp coefficients of warp ends for each fabric were determined. Length measurement of decomposed ends were made using load of 0.5 cN × tex^{-1}.

RESULTS AND DISCUSSIONS

Defining the warp length required for a given fabric length is conditioned by precise determination of warp ends crimp. It is known that a number of parameters affect the warp ends crimp (%) in fabric. The most significant among them are characteristics of yarns used, fabric weave, density and tension of threads [1, 2]. Therefore, the experiments were focused on analyzing the effects of parameters mentioned above, on threads crimp.

In analysis of the effect of used weave on warp crimp, especially significant parameter is the number of changes of warp and weft floats in weave draft sequence.

The results show that plain weave fabrics have higher warp crimp values compared to three threads *Z* twill with weft float, other parameters remaining unchanged. That is an expected result, knowing that plain weave fabrics have higher float changes per unit length in both directions, compared to analyzed twill weave (figures 2, 3 and figure 8).

The results of testing the weft threads density effects show that changing the weft density in fabric leads to changes of warp ends crimp. Decreasing the weft density in fabric reduces the warp ends crimp. The change of weft threads density leads to significant changes of warp crimp because of decreasing or increasing warp floats per fabric unit length (fig. 8).

When in weaving process the weft with lower length mass is replaced by higher length mass weft, the warp crimp is increased. This increase of warp crimp by using higher length mass weft is the result of higher actual diameter of weft threads which is directly proportional to weft length mass square root.

The weaves derived from plain weave, having threads with the same interlocking in sequence direction, present a special problem. For example, cross rib weave contains adjacent weft threads having the same interlocking (binding points) in the repetition pattern unit, longitudinal rib contains adjacent warp ends with the same interlocking and in panama weave there are adjacent threads in both directions, having the same interlocking. Therefore, analyzed were thread crimp values in fabrics with five threads mixed panama and with five threads reinforced twill (figures 6, 7). By analyzing these fabrics, the same repetitions and the same number of thread floats are observed in both directions of weave repetition. However, those fabrics have a different thread crimp value, which is explained by different positions occupied by warp and weft threads in the analyzed weaves. Namely, in repetition unit of five thread twill with weft floats, all threads have different binding points, while in fabrics with five thread mixed panama weave, groups of two and three threads have the same interlocking (binding). Thereby, the middle thread, in a group of three with the same binding, undergoes both side deformations, while the other four threads undergo one side deformation, which reflects on structural characteristics of these fabrics.

By using experimental results and theoretical knowledge [4], the following equation (4) is derived by which the required warp length for a given fabric length can be determined, and which is defined depending on the weave used:

$$l_{wa} = l_f \cdot c_{wa,c} = l_f \cdot (k \cdot f_{wa,c} + 1) \quad [m]$$
$$f_{wa,c} = (0{,}5 + p_{wa}) \cdot c_{f,wa} \cdot d_{rel,we}^{2} \qquad (4)$$

where:

$f_{wa,c}$ is warp crimp factor;

$d_{rel,we}$ – relative density of weft threads;

$c_{f,wa}$ – flexibility coefficient of warp ends;

p_{wa} – warp ends position in fabric;

k – coefficient.

Relative densities of warp and weft threads [1, 4] are determined by using the following equations (5), (6), (7) and (8):

$$d_{rel,wa} = \frac{d_{wa}}{280.25}\left[\frac{a_{we}(2.6 - 0.6z_{we})}{c_{f,we}R_{wa}} \cdot \left(\sqrt{\upsilon_{wa}^2 + 2\upsilon_{wa}\upsilon_{we}} - \upsilon_{wa}\right) + \upsilon_{wa}\right] \qquad (5)$$

$$d_{rel,we} = \frac{d_{we}}{280.25}\left[\frac{a_{wa}(2.6 - 0.6z_{wa})}{c_{f,wa}R_{we}} \cdot \left(\sqrt{\upsilon_{we}^2 + 2\upsilon_{wa}\upsilon_{we}} - \upsilon_{we}\right) + \upsilon_{we}\right] \qquad (6)$$

$$\upsilon_{wa} = \sqrt{\frac{T_{t,wa}}{\rho_{wa} \cdot p_{wa}}} \qquad (7)$$

$$\upsilon_{we} = \sqrt{\frac{T_{t,we}}{\rho_{we} \cdot p_{we}}} \qquad (8)$$

where:

d_{wa}, d_{we} are warp and weft density, cm^{-1};

R_{wa}, R_{we} – repetition unit of thread system analyzed;

a_{wa}, a_{we} – number of float changes;
ρ_{wa}, ρ_{we} – fiber volume mass, g/cm^{-3};
p_{wa}, p_{we} – fiber packing coefficient (factor) in yarn;
z_{wa}, z_{we} – position of binding points in repetition unit;
$c_{f,wa}$, $c_{f,we}$ – yarn flexibility coefficient;
$T_{t,wa}$, $T_{t,we}$ – warp and weft yarn count, tex.

Thread positions in fabrics are conditioned by relative densities of both thread systems. Using approximation, dependency of warp and weft thread positions on relative densities ratio ($d_{rel,wa}/d_{rel,we}$) was determined and shown in figure 1.
Correlation between warp and weft thread positions (based on warp thread diameter) and relative density ratio can be presented as:

$$p_{wa,we} = ax^3 + bx^2 + cx + d \qquad (9)$$

where:
a, b, c, d are coefficients of third degree polynomial;
x – ratio of relative warp and weft densities ($d_{rel,wa}/d_{rel,we}$).

Values of polynomial coefficients, describing given correlations, are shown in table 1. Figures 2–7 show correlation plots of warp crimp factors and crimp coefficients for fabrics with plain weave, three thread and four thread twill, five thread satin, five thread mixed panama and five thread reinforced twill weaves.
Based on experimental results (figures 2–8) coefficient values of k (4) were defined and shown in table 2 depending on weave type.

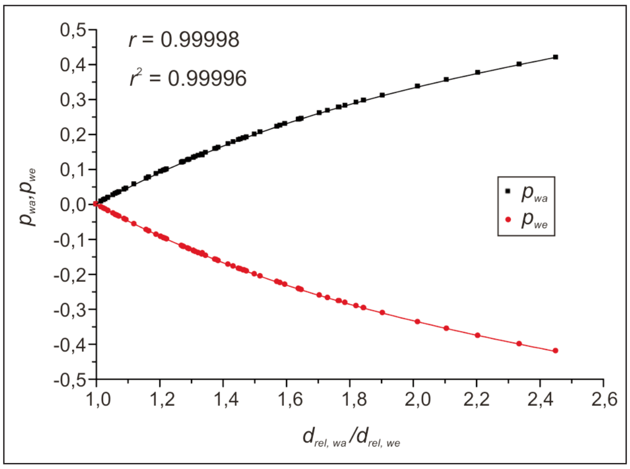

Fig. 1. Dependency of thread position on the ratio of relative densities

Table 1

VALUES OF POLYNOMIAL COEFFICIENTS				
Thread positions in fabrics	**Coefficient values for determination of threads positions**			
	a	***b***	***c***	***d***
p_{wa}	0.0421282	–0.32324	1.00694	–0.72513
p_{we}	–0.0421282	0.32324	–1.00694	0.72513

Table 2

VALUES OF k COEFFICIENT FOR VARIOUS WEAVES	
Weave	k
Plain weave	0,510323
Three thread twill weave	0,485665
Four thread twill weave	0,438242
Five thread satin weave	0,266729
Five thread mixed panama weave	0,304210
Five thread reinforced twill weave	0,362913

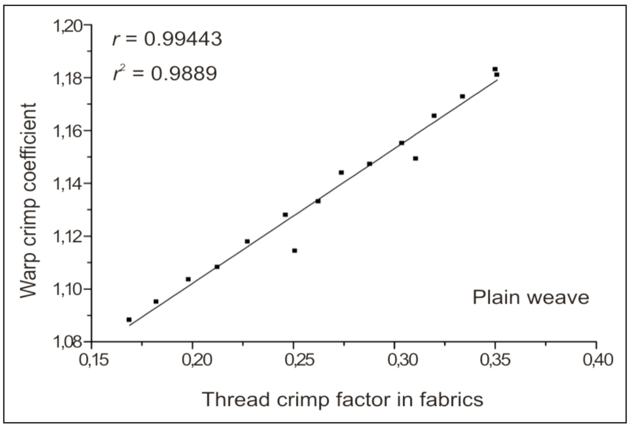

Fig. 2. Correlation plot of warp crimp coefficient and thread crimp factor in fabrics 1 to 16

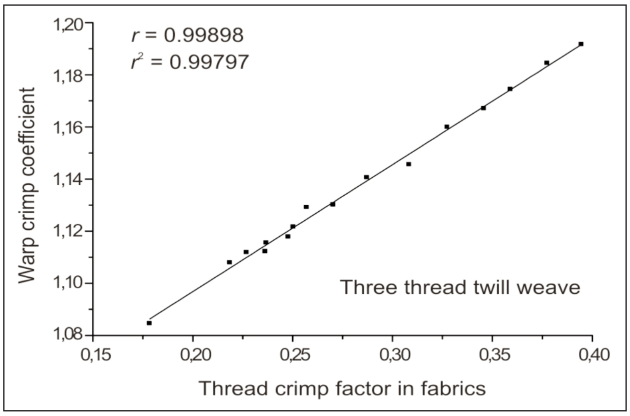

Fig. 3. Correlation plot of warp crimp coefficient and thread crimp factor in fabrics 17 to 32

Besides, analyzing fabric structure and construction parameters, correlation defining warp length for a given fabric length was derived. This correlation can be applied for projecting warp length for raw fabrics having various structural and constructive solutions.

$$l_{wa} = l_f \cdot c_{wa,c} = l_f \cdot \left(\frac{0.1298 \cdot a_{wa}^3 (2.6 - 0.6z_{wa})^3}{R_{we}^3} \cdot d_{rel,we}^6 - \frac{0.4608 \cdot a_{wa}^2 (2.6 - 0.6z_{wa})^2}{R_{we}^2} \cdot d_{rel,we}^4 + \frac{0.5062 \cdot a_{wa} (2.6 - 0.6z_{wa})}{R_{we}} \cdot d_{rel,we}^2 + 1 \right) \text{ [m]} \qquad (10)$$

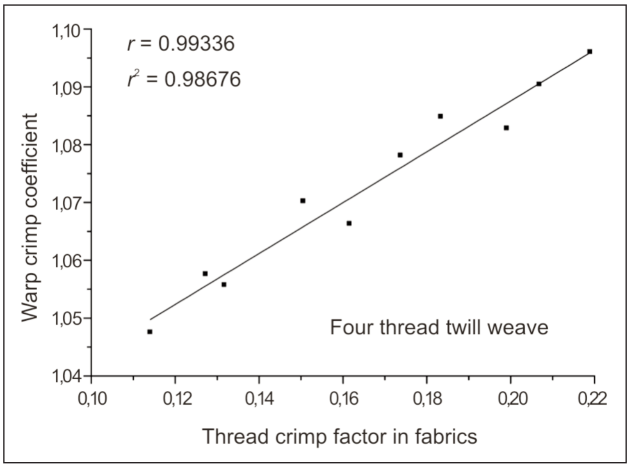

Fig. 4. Correlation plot of warp crimp coefficient and thread crimp factor in fabrics 33 to 42

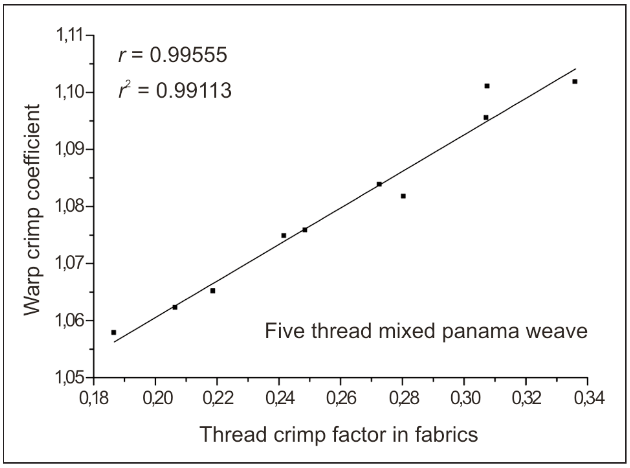

Fig. 6. Correlation plot of warp crimp coefficient and thread crimp factor in fabrics 53 to 62

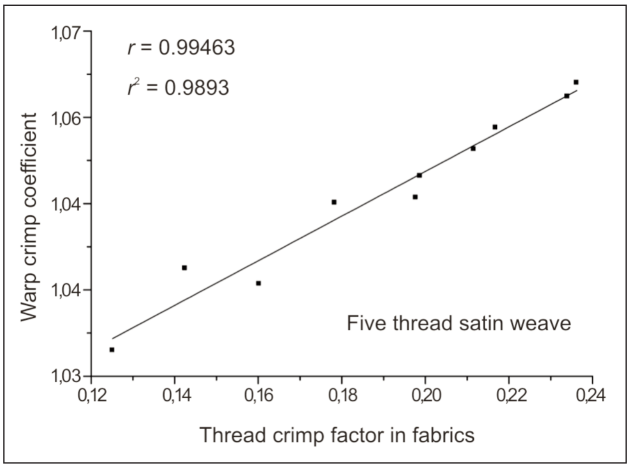

Fig. 5. Correlation plot of warp crimp coefficient and thread crimp factor in fabrics 43 to 52

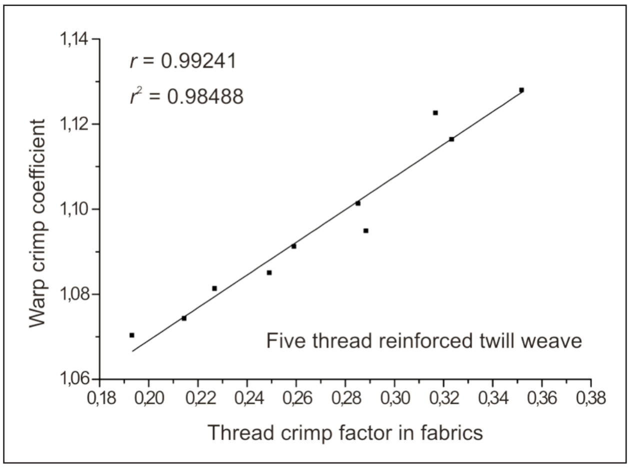

Fig. 7. Correlation plot of warp crimp coefficient and thread crimp factor in fabrics 63 to 72

Some results deviation is possible with some special fabrics, where relative weft density value exceeds top limit, i.e. $d_{rel,we} > 1$. Under these conditions, warp threads occupy forced positions in the fabric [5, 6], which highly affects crimp coefficient values in fabrics.

CONCLUSIONS

During determination of the required warp length, the majority of errors appeared as a result of incorrect projecting of warp ends crimp. Specific problem in projecting warp crimp is a relatively high number of defining parameters. Because the weave used has an important effect on thread crimp, equations for predicting warp length for a given fabric length are suggested depending on the weave used. Moreover, by applying theoretical and experimental results, an equation is suggested by which the required warp length for fabrics having repetition units of two to five threads can be projected.

However, though the modern projecting methods consider all more significant structural and construction fabric parameters, it is possible to get results that deviate from real values. This is primarily the consequence of incorrect adjustment and control of tension forces of warp ends during weaving process. By using optimum tensioning of warp ends in the process of fabric forming on looms, a minimum end breaks are achieved and structural and physic-mechanical characteristics of used yarns are being maintained.

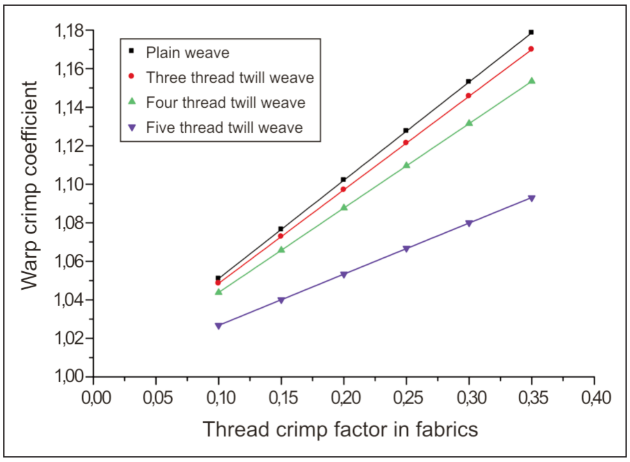

Fig. 8. Correlation plot of warp crimp coefficient and thread crimp factor in fabrics

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Authors:

RJOVAN STEPANOVIĆ
NENAD ĆIRKOVIĆ
University of Niš
Faculty of technology
Leskovac, Serbia
e-mail: jovan64@yahoo.com

DRAGAN RADIVOJEVIĆ
High Technical School of Textile
Leskovac, Serbia

MIRJANA RELJIĆ
C.I.S. Institut
Beograd, Serbia

DOCUMENTARE

Materii prime

MATERIALE TEXTILE INTELIGENTE PENTRU ÎNDEPĂRTAREA IMPURITĂȚILOR

Compania japoneză ***Kuraray*** a elaborat un nou material textil nețesut, care poate îndepărta impuritățile din lichide sub formă de ioni metalici.
Noul material nețesut, care absoarbe în mod selectiv şi separă ionii metalici din lichide, este utilizat în procesele de filtrare, pentru îndepărtarea impurităților sub formă de ioni metalici din apa de mare sau din apele uzate.
Noul material a fost prezentat, de ***Kuraray Kuraflex,*** la cea de-a 11-a *Conferință Nanotech*, desfăşurată recent la Tokyo. Elaborarea acestui material este o consecință a cercetărilor efectuate la ***Universitatea Fukui,*** din Japonia, unde o echipă din cadrul departamentului Fibre Amenity Engineering Course, condusă de profesorul Teruo Hori, a studiat aplicarea unei tehnologii avansate de prelucrare a fibrelor, în scopul îmbunătățirii colectării ionilor de metale rare.
Noul material nețesut *Felibendy,* dezvoltat de Kuraray pe baza unei tehnologii proprii cu jet de abur, este utilizat în aplicațiile de filtrare a apei. El este realizat din fibre *Sophista*, care au un înveliş dintr-o răşină polimerică de etilenvinilalcool şi un miez de poliester. Fibrele Sophista au o structură complexă şi poroasă, care măreşte suprafața ce intră în contact cu soluția. În plus, structura permite o curgere uniformă a soluției prin material, acest lucru fiind facilitat de proprietățile hidrofile ale EVAL.
Felibendy reacționează rapid la procesul de polimerizare grefată indusă cu fascicul de electroni, care măreşte suprafața materialului atunci când acesta vine în contact cu soluția, permițându-i să fie procesat la viteze mari. De asemenea, procesul modifică structura fibrei, astfel încât aceasta absoarbe cu uşurință ionii metalici.
În urma tratamentului aplicat, creşte eficiența fibrelor în colectarea ionilor de metal, atunci când acestea sunt imersate în apa de mare sau în apele industriale uzate. Ionii de metal pot fi eliberați separat din materialul textil, prin schimbarea *p*H-ului apei.
În iulie 2011, cele două părți implicate în realizarea acestui material au lansat un proiect comun, la scară completă, şi au solicitat un brevet de invenție comun. De asemenea, părțile au pus bazele unei noi afaceri, pe care speră să o lanseze, în Japonia, sub forma unui proiect de colaborare între industrie şi universitățile de profil.

Smarttextiles and nanotechnology, iulie 2012, p. 9

Characterization of polyester fabric covered with copper film by radio frequency magnetron sputtering

LINGLING MENG

QUFU WEI

XINMIN HUANG

REZUMAT – ABSTRACT

Caracterizarea țesăturilor din poliester acoperite cu peliculă de cupru, prin pulverizare magnetron în regim de radiofrecvență

Peliculele nanostructurate de cupru (Cu) au fost depuse pe suprafața unei țesături simple din poliester, prin pulverizare magnetron în regim de radiofrecvență (FR), la temperatura camerei. Modificarea morfologiei suprafeței fibrelor de poliester cu depunere de Cu a fost observată prin microscopia de forță atomică (AFM), care a evidențiat formarea unor conglomerate de cupru pe suprafața fibrei. Legăturile interfaciale dintre peliculele de cupru şi fibre au fost analizate cu ajutorul microscopiei electronice de baleiaj SEM şi a testelor de exfoliere. De asemenea, au fost analizate proprietățile de transmitanță a luminii, de tracțiune şi rezistivitate de suprafață a țesăturii din poliester acoperită cu peliculă de cupru. S-a constatat că țesăturile cu pelicule de Cu posedă o mai bună absorbție a razelor ultraviolete, iar conductivitatea de suprafață a materialelor este îmbunătățită semnificativ odată cu creşterea timpului de pulverizare. De asemenea, rezistența la tracțiune a firelor de urzeală şi bătătură este uşor îmbunătățită. O modificare similară s-a constatat şi în cazul alungirii la rupere a firelor de bătătură, în comparație cu firele de urzeală, pe măsură ce timpul de pulverizare a crescut.

Cuvinte-cheie: peliculă de cupru, pulverizare magnetron RF, AFM, SEM, conductivitate de suprafață, proprietăți de tracțiune

Characterization of polyester fabrics covered with copper film by radio frequency magnetron sputtering

The nanostructured copper (Cu) films were deposited on the surface of polyester plain fabric by RF (radio frequency) magnetron sputtering at room temperature. The change of the surface morphology of Cu-deposited polyester fibers was observed by atomic force microscopy (AFM), which revealed the formation of copper clusters on the fiber surface. The interfacial bonding between the copper films and the fibers was also examined by SEM and peel-off test. The light transmittance, surface sheet resistance and tensile properties of Cu-deposited polyester fabric were also measured. It turned out that Cu-deposited fabrics showed better ultra-violet absorption and the surface electricity of the materials was significantly improved with the increase of sputtering time. Tensile strength of warp and weft yarns was slightly improved. The break elongation of weft yarns showed a similar change compared to warp yarns as the sputtering time increased.

Key-worlds: copper film, RF magnetron sputtering, AFM, SEM, surface conductivity, tensile property

Copper and copper thin films have been extensively used in the field of electronics and optoelectronics because of good electrical, optical and mechanical properties [1–5]. Nanoscale copper thin film is an ideal functional material with high conductivity and good resistance to electromigration, which can be used in advanced electronic devices. Nanostructured copper thin film on the substrate of textile materials also can be used to develop antistatic, electromagnetic shielding and antibacterial materials. In recent years, various methods have been tried to prepare nanoscale copper films, such as chemical vapor deposition (CVD), physical vapor deposition (PVD), pulsed laser deposition and magnetron sputtering deposition. Magnetron sputtering is considered a better technique for preparing functional nanofilms under vacuum conditions and the process is exclusively sputtering, which results in better adhesion between substrate and thin films [6–9]. In this study, nanostructured copper films were deposited onto the surface of polyester plain fabric by the radio frequency (RF) magnetron sputtering at room temperature. The influence of sputter coating time on the morphology was characterized by atomic force microscopy (AFM) and scanning electron microscopy (SEM). The electrical conductivity, light transmittance and tensile properties of materials were further investigated.

EXPERIMENTAL PART

Materials preparation

The substrate used in this study was polyester plain fabric with warp and weft density of 306 root/10 cm × × 188 root/10 cm, warp and weft yarn density of 16 tex × 16 tex. First of all, the fabric samples were immersed in acetone solution for 30 minutes with ultrasonic washer to remove the organic solvents and dust on the fabric surface. Then they were washed twice in de-ionized water and dried in an oven at

50°C. The dried samples were cut into a size of 20 × 20 cm^2 for sputter coating.

Copper deposition

A lab radio frequency (RF) magnetron sputter coating system JZCK-420B (Shenyang, China) was used to deposit copper thin films. A high purity copper (Cu) target (99.999%) with a diameter of 10 cm was mounted on the cathode, and the fabric sample was placed on an anode with one side facing the target. The distance between the target and the fabric sample was 60 mm. Argon (99.99%) was used as the bombardment gas. Prior to the deposition, the target was discharged in argon gas for about 5 minutes to remove impurities on its surface and sputtering chamber was pumped to achieve a base pressure of 5.0×10^{-4} Pa. To avoid the deformation of the fabric sample caused by high temperature, water-cooling was used to control the temperature of the fabric sample during the sputtering process. Meanwhile, the sample holder was rotating at a speed of 100 rpm to ensure copper particles uniformly deposited on the fabric sample. According to previous experimental analysis, the sputtering pressure was set at 0.2 Pa with the power of 120 W. The coating time was set at 5 minutes, 10 minutes and, respectively, 15 minutes in this study.

Characterization of samples

Surface morphology

The surface morphology and grain size of nanostructured copper films after sputtering were examined by atomic force microscopy (AFM). The AFM used in this study was CSPM 4000 provided by Benyuan Co., Ltd (Guangzhou, China). Scanning was carried out in contact mode by a silicon cantilever and all samples were scanned at room temperature. The scanning scope was set at a size of 5.0 × 5.0 μm^2, and the frequency was adjusted to 1.2 Hz.

Interfacial bonding

The observation of interfacial bonding between copper films and the polyester fibers was performed on the cross-section of the fibers by the SEM (FEI Quanta-200, Holland). The influence of coating time on the adhesion of the copper coatings to the fabric sample was analyzed by SEM images.

The peel-off test was conducted by a universal materials testing machine (Zwick BZ2.5/TNIS, Germany) to examine the interfacial adhesion of the coated layer to the fabric. The test speed was set at 200 mm/minutes in this study. The initial distance was 10 mm and 3M600 test adhesive tape was used. The test samples were cut into 7 × 2.5 cm^2 for the peel-off test. The samples were pressed with a load of 400 g for 12 hours before the peel-off test. All the tests were performed at 20 ± 2°C and 65 ± 2% RH (relative humidity). Each test was carried out three times and the average values were used.

Optical properties

The optical properties of the fabric samples deposited with copper thin films were analyzed by measuring the transmittance of Ultra-violet (UV) and visible (Vis) light. The UV–Vis spectroscopy (SP-1700, Shanghai) with a deuterium lamp was used to scan the transmittance of samples in the wavelength ranging from 300 nm to 600 nm.

Electrical properties

The electrical properties of samples were characterized by resistivity analysis, which was measured by SX1934 four-point probe tester made by Baishen Technology Co., Ltd (Suzhou, China). In order to minimize the deviations caused by the unevenness of the fabric sample surface, the resistivity of each sample was measured ten times and then the average values were obtained.

Tensile properties

The effect of the Cu sputter coating on the mechanical properties of the fabrics was investigated by means of measuring the tensile properties of warp and weft yarns because the diameter of coating area was only about 10 cm on the fabric samples.

The yarns' tensile properties were measured on a HD 021C type electron single yarn tester (Hong-da Textile Instrument, Nantong, China) in conformity with the ISO2062. The size of samples fixed in a holder with the distance of 90 mm was 20 × 20 cm^2, and the speed of stretching tension was set at 100 mm/minutes. The samples of warp and weft yarns were measured five times respectively, and the average values were used. The tensile strength and break elongation were measured and compared.

RESULTS AND DISCUSSIONS

Surface morphology

The AFM image of 5.0 × 5.0 μm^2 reveals that the original polyester fiber was relatively smooth with some spots, as presented in figure 1 *a*. The spots may be formed during the process of fiber manufacturing. The copper sputter coating apparently modified the surface characteristics of the polyester fibers as illustrated in figure 1 *b, c, d*. The copper nanoparticles formed the thin film on the original fiber surface when coating time was 5 minutes. The average size of copper clusters was about 44.7 nm and the surface roughness was about 2.24 nm as analyzed by AFM software. It is found that more copper nanoclusters uniformly deposited on the fiber surface as the sputtering time was increased to 10 minutes, as presented in figure 1 *c*. The average size of the sputtered Cu clusters was increased to about 60.6 nm and the roughness of the fiber surface was also further increased to 5.13 nm. The increase in sputtering time led to the formation of large copper aggregates on the fiber surface due to the collision of the sputtered copper particles. The AFM image in figure 1 *d* reveals that more compact and continuous copper clusters covered up the fiber surface. The average size was further increased to 84.1 nm and the surface roughness was increased to 7.41 nm, indicating the growth of the deposited copper clusters (fig. 1 *a, b, c, d*).

Interfacial bonding

The SEM observations reveal the interfacial bonding between the copper coating and the fabric substrate, as indicated in figure 2. The adhesion of the sputtered Cu nanoclusters to the polyester plain fabric was also examined by peel-off test. The results of the test are listed in table 1.

It can be seen from figure 2 *a* that more cracks of the deposited copper film were formed on the fiber surface

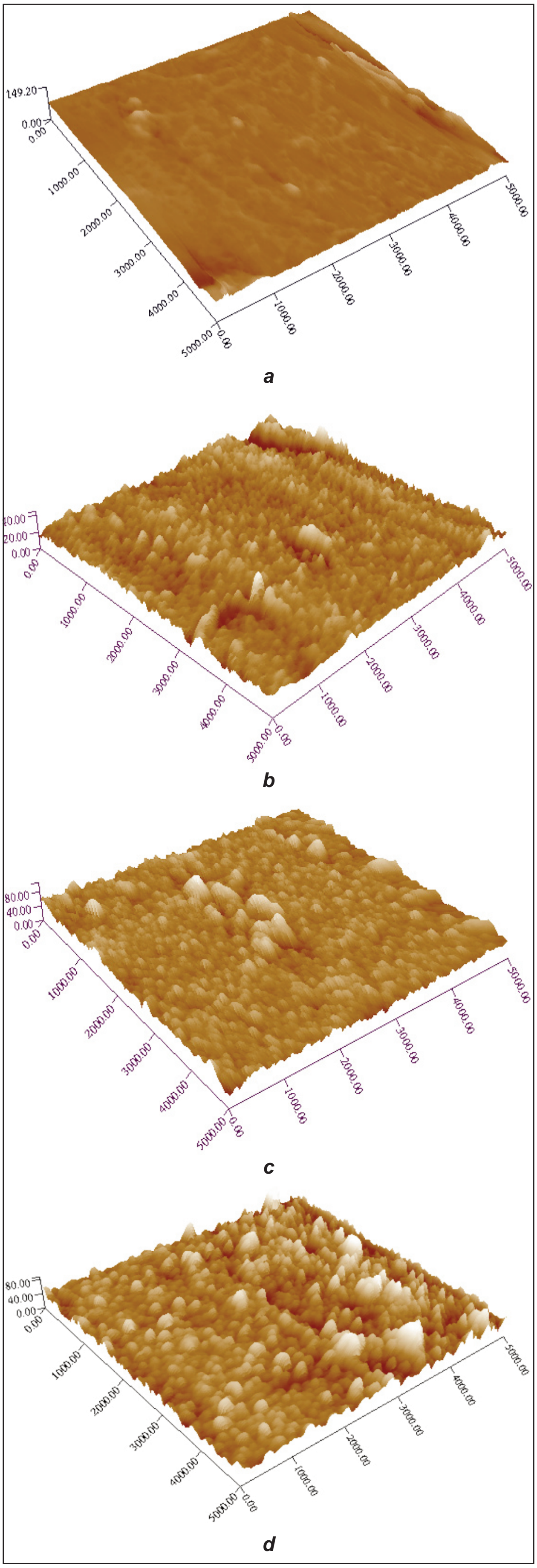

Fig. 1. Surface morphology at different coating times (5.0 × 5.0 μm^2):
a – original sample; ***b*** – after 5 minutes coating; ***c*** – after 10 minutes coating; ***d*** – after 15 minutes coating

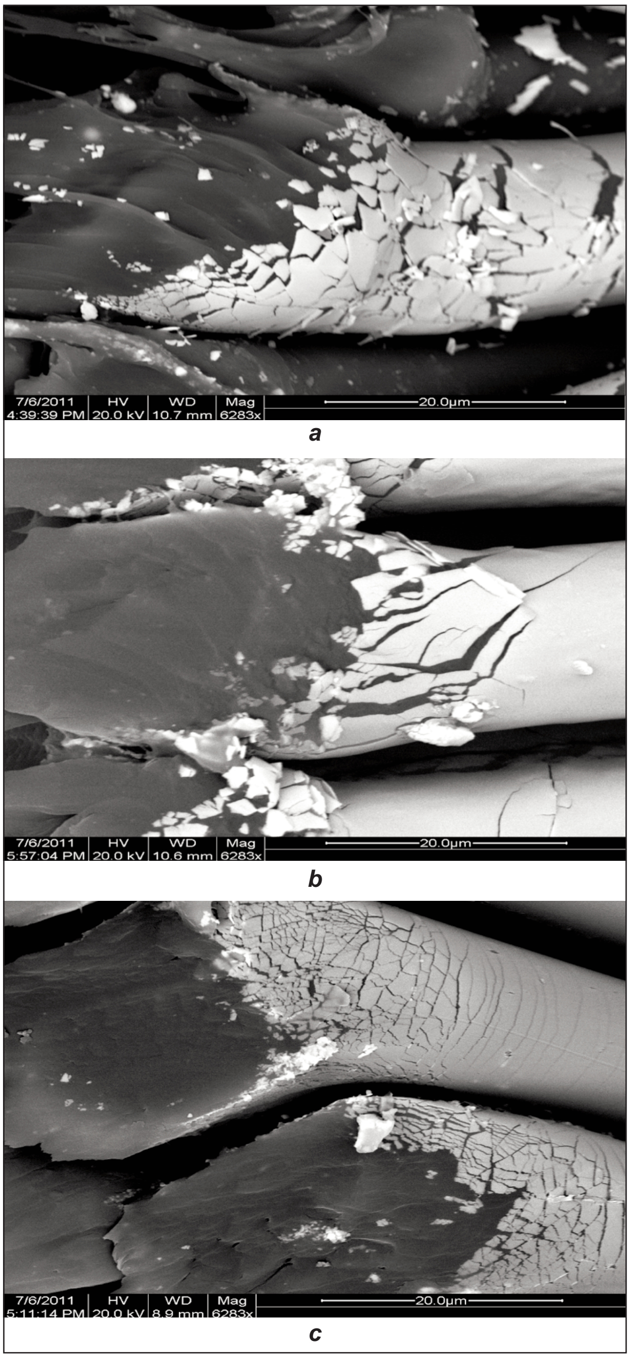

Fig. 2. Interfacial bonding observed in SEM:
a – after 5 minutes sputtering; ***b*** – after 10 minutes sputtering; ***c*** – after 15 minutes sputtering

after the fabric sample was cut, which was sputter coated with copper film for only 5 minutes. The cracks indicated the poor adhesion of the copper coatings to the fibers. Besides this, the image reveals the separation of the coating layer from the fibers, which lies in that the sputtered copper particles did not have sufficient energy to penetrate into the fiber [10]. It can be seen from table 1 that the average peel-off strength of the sputtered Cu nanoclusters from the polyester plain fabric was about 2.1 N when the sputtering time was only 5 minutes. When the sputtering time was increased to 10 minutes, fewer cracks were formed on the fiber surface, indicating improvement in the bonding of the copper layer to the fibers, as shown in figure 2 *b*. Meanwhile, the peel-off strength was increased to about 3.2 N, due to the growth of the sputtered Cu particles and better coverage of the copper layer on the fabric. The bonding was further improved as the sputtering time added up to 15 minutes. Figure 2 *c* shows that dense coating with fine cracks was around the cutting edge, and the peel-off strength was further increased to 3.8 N. The improvement in interfacial bonding as the coating time increases was attributed to the increased energy provided for the sputtered Cu particles to hit the fiber surfaces [10] (fig. 2 *a, b, c* and table 1).

Table 1

RESULTS OF PEEL-OFF TEST	
Sample	**Peel-off strength,** N/cm
5 minutes coating	2.1
10 minutes coating	3.2
15 minutes coating	3.8

Optical properties

The UV-Vis spectra reveal the effect of sputtering time on the optical properties of the copper-deposited polyester fabric as presented in figure 3. It shows that the original sample had a transmittance of below 30% in the wavelength ranging from 400 nm to 600 nm, indicating a good transmittance of visible light through the fabric. The transmittance was reduced to about 5% in the range between 400 nm and 300 nm, indicating less transmittance of the ultraviolet light (UV) through the fabric sample. The UV-Vis spectra also reveal that the optical transmittance was gradually enhanced as the wavelength increased. The copper sputter coating significantly altered the optical properties of samples. The transmittance of copper-deposited polyester plain fabrics was lower than that of uncoated polyester plain fabric in the wavelength range between 300 nm and 600 nm. The increase in sputtering time led to a remarkable decrease in transmittance. In addition, it is found Cu coating improved light shielding effect and it is obvious that the coating thickness had some effect on the light transmittance (fig. 3).

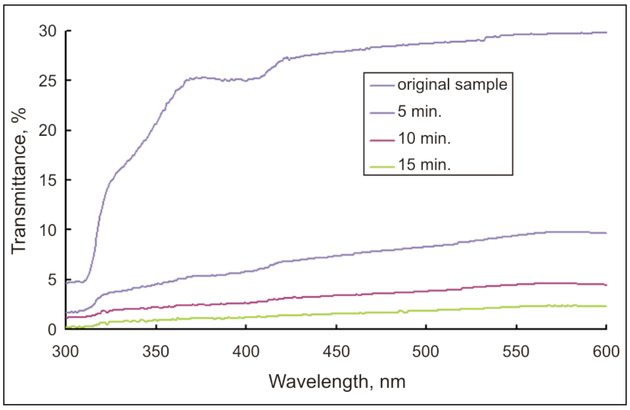

Fig. 3. Transmittance spectra of polyester plain fabric samples

Electrical properties

The results of surface resistance of the copper-coated samples are listed in table 2. It can be observed that the surface resistance of the polyester plain fabric before the copper sputter coating was over 10^6 Ωcm, indicating an electrical isolation property. The surface resistance dropped from over 10^6 to about 25.3 Ωcm after it was coated for 5 minutes, which demonstrated that the surface electrical properties of the sample were significantly improved. It is noted that the sheet resistance decreased with an increase of coating time, as presented in table 2. It is obvious that the surface resistance was further lowered from about 13.9 to 7.7 Ωcm as the sputtering time rose from 10 minutes to 15 minutes, which was attributed to the growth of the sputtered Cu clusters and more compact and continuous copper clusters covering up the polyester fiber surface (fig. 1 and table 2).

Table 2

SURFACE RESISTANCE	
Sample	**Average sheet resistance,** Ωcm
original	out of range (over 10^6)
5 minutes coating	25.3
10 minutes coating	13.9
15 minutes coating	7.7

Tensile properties

The tensile strength of warp and weft yarns before and after the sputter coatings are presented in table 3. The tensile strength of warp yarns was gradually increased from 32.4 cN/tex to 33.7 cN/tex, 34.5 and 35.3 cN/tex after the fabric was sputter coated with copper for 5, 10 and 15 minutes, respectively. The tensile strength was increased by 4.01% for 5 minutes coating and 8.95% for 15 minutes coating. The tensile strength of weft yarns was enhanced to 36.6 cN/tex from 33.1 cN/tex. It indicated tensile strength of warp and weft yarns was slightly increased

Table 3

TENSILE STRENGTH OF WARP AND WEFT YARNS		
Sample	**Warp yarn**	**Weft yarn**
original	32.4 cN/tex	33.1 cN/tex
5 minutes coating	33.7 cN/tex	34.7 cN/tex
10 minutes coating	34.5 cN/tex	35.1 cN/tex
15 minutes coating	35.3 cN/tex	36.6 cN/tex

as sputtering time extended. The increase in tensile strength was attributed to stiffness of copper film deposited on the fabric, which enhanced the tensile strength of the sputter coated yarns (fig. 3 and table 3). The effect of sputtering time on the break elongation of warp and weft yarns is illustrated in figure 4. The break elongation of warp yarns dropped from 26.58% to 23.12% with 5-minutes coating, and then greatly rose to 30.06% as sputtering time was increased to 10 minutes, and then dropped to 25.69%. The reason for this phenomenon is that the elasticity of polyester yarns adhered to copper particles at the beginning of deposition, and therefore the break elongation of coated warp yarns became lower when the coating time was 5 minutes. At the same time, the copper particles attached to the fiber surface carried the energy generated by the sputtering, which was gradually transferred to the polyester fiber. The energy transfer caused the temperature of polyester fiber to rise, which facilitated the penetration of the sputtered particles into the fibers, and thus break elongation of the coated warp thread was gradually enhanced along with the reduced internal stress of fibers and the elasticity of yarns was improved when sputtering time was increased from 5 minutes to 10 minutes. There was not enough energy for the later deposited particles to penetrate into the fibers because the temperature was controlled by water cooling in the sputtering chamber during the sputtering process. For this very reason, the breaking elongation of warp yarns deposited with copper for 15 minutes decreased. It can also be seen from figure 4 that the break elongation of weft yarns had the similar change to warp yarns as sputtering time increased. The break elongation of weft yarns dropped from 30.25% to 26.45% with 5-minutes coating and sharply rises to 31.32% as sputtering time was increased to 10 minutes, and then reduces to 25.21%.

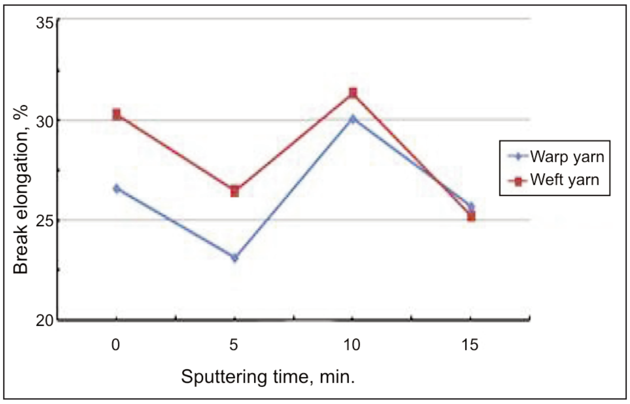

Fig. 4. The break elongation of warp and weft yarns

CONCLUSIONS

In this study, radio frequency *RF* magnetron sputtering was used to deposit Cu thin films onto the surface of polyester plain woven fabric. The effects of sputtering time on the structural, optical, electrical and tensile properties of samples were investigated. It was found that the sputter coating with copper could significantly change the surface morphology of the fabric. The light transmittance, surface sheet resistance and tensile properties of the fabric were also altered by the sputter coating with copper.

Acknowledgements

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Autori:

LINGLING MENG
Key Laboratory of Eco-Textiles
Ministry of Education
Jiangnan University
Wuxi, China

College of Textile & Clothing,
Yancheng Institute of Technology
Yancheng, China

QUFU WEI
Key Laboratory of Eco-Textiles
Ministry of Education
Jiangnan University
Wuxi, China

XINMIN HUANG
College of Textile & Clothing
Yancheng Institute of Technology
Yancheng, China

Corresponding author:
QUFU WEI
e-mail: qfwei@jiangnan.edu.cn

DOCUMENTARE

Materii prime

O NOUĂ ȚESĂTURĂ DIN FIBRE SUPERABSORBANTE

Compania ***Bluestar Group***, cu sediul în China, lider în domeniul produselor chimice, este una dintre companiile cu cea mai rapidă creştere economică.

Filiala ***Technical Absorbents Ltd***, din Grimsby, Marea Britanie, este producătoarea fibrelor superabsorbante *SAF*, destinate producerii țesăturii *Koolsorb,* lansată la *Emergency Services Show* – Coventry, Marea Britanie, 21 – 22 noiembrie 2012. Această țesătură este utilizată pentru confecționarea lenjeriei de corp (fig. 1), ce urmează a fi purtată sub îmbrăcămintea exterioară de protecție pentru condiții grele de lucru, în vederea menținerii unei temperaturi constante şi a unui confort plăcut. Ea este astfel concepută încât să absoarbă rapid şi apoi să rețină transpirația, conferind celor ce poartă echipamente individuale de protecție o senzație de răcoare, de uscăciune şi confort.

Țesătura Koolsorb poate fi utilizată pentru confecționarea unei game largi de articole de îmbrăcăminte, destinate a fi purtate direct pe piele, sub o îmbrăcăminte de protecție grea. Ea stimulează disiparea căldurii şi a umidității, prin absorbția rapidă şi reținerea transpirației corpului. O caracteristică foarte importantă o reprezintă faptul că efectul de răcire nu se bazează pe evaporare. În aceast sens, directorul pentru Dezvoltarea Afacerilor, Dave Hills, afirma: *„Materialul aflat în contact cu pielea rămâne relativ uscat şi îndepărtează prin conducție căldura din zonele fierbinți ale corpului. Aceasta are drept rezultat un efect de răcire, cu până la 6°C, pentru cel care poartă respectiva îmbrăcăminte, reducând direct riscul solicitării termice. Articolele de îmbrăcăminte confecționate cu ajutorul acestei tehnologii pot fi spălate de mai multe ori, fără a-şi pierde caracteristicile, ceea ce reprezintă un factor important“.* Conform afirmațiilor lui Hills, compania se află în faza producției finale a țesăturii şi, pentru a demonstra eficiența acesteia, plănuieşte să lanseze o gamă de prototipuri de îmbrăcăminte, cum ar fi articole de lenjerie de corp pentru trunchi şi cap, care pot fi purtate sub echipamentele individuale de protecție exterioară.

Fig. 1

Lincolnshire Fire & Rescue, unul dintre serviciile de pompieri din Marea Britanie, a pus deja la dispoziția instructorilor tunici prototip, concepute a fi purtate sub îmbrăcămintea de protecție, pentru efectuarea unor teste inițiale privind confortul şi reducerea oboselii celor care le poartă.

Pentru țesătura Koolsorb a fost depusă o cerere de brevet cu numărul GBI 105993.8. Ea va fi comercializată sub marca *Technical Absorbents' KoolSAF*.

Technical Textiles International, septembrie 2012, p. 2

Body shape characteristics on children aged 7-10, using statistical indicators calculated with univariate analysis

ANA VÎRCAN
MANUELA AVĂDANEI

IONUȚ DULGHERIU
MITU STAN

REZUMAT – ABSTRACT

Caracteristici antropometrice ale copiilor cu vârsta cuprinsă între 7 şi 10 ani, folosind analiza univariată de calcul al indicatorilor statistici

Creşterea şi dezvoltarea fizică şi psihică a copiilor este influențată de factorii genetici, sociali, geografici, nutriționali, dar şi de nivelul de cultură, educație, civilizație etc. În consecință, este un proces extrem de dinamic şi neuniform în timp. Lucrarea tratează creşterea şi dezvoltarea copiilor cu vârsta cuprinsă între 7 ani şi 9 ani şi 11 luni, în scopul obținerii informațiilor necesare construcției de tipare, în concordanță cu dimensiunile grupei de vârstă studiate. În fiecare perioadă a copilăriei, corpul copilului evoluează în mod diferit, de aceea produsele destinate acestora – îmbrăcăminte, încălțăminte, jucării, produse pentru confortul personal etc., trebuie proiectate şi realizate în corelație cu particularitățile grupei de vârstă. Lucrarea are drept scop caracterizarea grupei de vârstă 7–9 ani şi 11 luni, pe baza analizei şirului variațional al dimensiunilor principale ale corpului copilului. Datele experimentale necesare efectuării studiului au fost obținute prin metoda directă de măsurare, asupra unei selecții de copii – 194 de fete şi 199 de băieți. Valorile particulare ale dimensiunilor corporale au fost prelucrate prin analiza univariată, în scopul identificării tipurilor morfologice specifice acestei grupe de purtători şi a frecvenței de apariție a acestora.

Cuvinte-cheie: antropometrie, creştere, tipuri morfologice, frecvența apariției

Body shape characteristics of children aged 7–10, using statistical indicators calculated with univariate analysis

The growth and the physical and psychical development of children is being influenced by genetic, social, geographical, nutritional factors and also cultural, educational, civilization ones. Therefore it is an extremely dynamic and non-uniform process over time. The present paper analyzes the growth and development of children aged between 7–9 years and 11 months as to obtain the necessary information for pattern construction according to the studied age group dimensions. In each childhood period the body of children develops differently, therefore the products intended for them (clothing, footwear, toys, and personal comfort items) must be designed by correlating age group particularities. The purpose of the present paper is to analyze the characteristics of the age group between 7–9 years and 11 months based on the variational calculus of the main body dimensions on children. The experimental data necessary for this study has been obtained through the direct method of measurement on a target group of children (194 girls and 199 boys). Particular values of body dimensions were reviewed by univariate analysis with the purpose of identifying morphological types specific to this target group and the frequency of appearance.

Key-words: anthropometry, growth, morphological types, frequency of appearance

The serial production of different products must be oriented towards customer satisfaction. Within these conditions, the production of clothing for children must be based on identifying the main morphological types within the population and their appearance frequency.

The growth and development of the body of children is a dynamic process and non-uniform over time, with coherent and successive phases that impose specific traits for each childhood period. This process can be described through a set of psycho-physical characteristics with a certain stability that allow the identification of particularities through which the subjects of the same age are seen to be alike or within the same age interval, therefore it is desirable and correct the direction towards analyzing this growth and development process on periods.

Researchers have demonstrated the existence of a secular growth in the particular values from body dimensions; therefore it is necessary the update of the database used in the industrial production of children items providing personal comfort (Brumariu, A. *Proiectarea îmbrăcămintei.* Note de curs,1990). The update of the data is made upon anthropometric investigations on target groups of children, with a specific age group [1–3].

The purpose of the paper is to identify and characterize the morphological types specific to age group between 7–9 years and 11 months using the data from anthropometric investigations on 391 children (194 girls and 199 boys) from Oltenia. The necessary information for the study was obtained through direct method of body measurement, following the protocol in the ongoing anthropometric investigation, according to STAS 5279-87, respectively SR ISO 3635/98.

RESULTS AND DISCUSSIONS

The specific values of body size obtained through direct method of measurement of body dimensions (body height – I_c, chest perimeter – P_b, waist perimeter – P_t and hips perimeter – P_s) were processed through unidimensional statistics with the purpose of characterizing their variability and identification of morphological types for group age 7–10 years.

The variability study on specific values was created by applying the statistical analysis. In this respect, were calculated statistical parameters based on the formulas from table 1, following the work methodology described in lecture notes (Note de curs – *Statistică psihologică şi prelucrarea informatizată a datelor* – Gheorghiu D. and Răulea, C., 2005 and, respectively, 2010) and in specialized literature [1, 3, 5–8].

The values of the statistical parameters for the two target groups (girls and boys) described in table 1 are presented in table 2.

Table 1

STATISTICAL PARAMETERS OF TENDENCY AND DISPERSION INDEXES		
Notions used for interpretation	**Symbol**	**Calculation relationship**
Individual value	x_i	Values obtained experimentally
Selection volume	n	The number of measurements, established according to the purpose
Arithmetic average	$\bar{x}$	$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$
Dispersion	σ^2	$\sigma^2 = \frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})^2$
Standard deviation (square average deviation)	σ	$\sigma = \sqrt{\sigma^2} = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})^2}$
Real standard deviation	s_x	$s_x = \frac{s}{\sqrt{n}}$
Variation coefficient	C_V	$C_V = \frac{\sigma}{x} \times 100$
Selection amplitude	A	$A = x_{max} - x_{min}$
Class size (class interval size)	c	$c = \frac{A}{k}$
Class number	k	$k = 1 + 3.332 * \log n$
Class number for gathering measured values	m	$m = \frac{x_j - \bar{x}_a}{c}$
Absolute frequency	f_m	-
Cumulated absolute frequency	f_{mc}	-
Relative frequency	f_r	-
Cumulated relative frequency	f_{rc}	-
Variables used to calculate sweetness and kurtosis coefficients	mf_m, $m^2 f_m$	-
Approximate arithmetic average value	$\bar{x}_a$	It is chosen as calculation base
The size of the trust level of medium value corresponding to the level of precision or statistical safety imposed	q	$q = t \times s_x = t \times \frac{\sigma}{\sqrt{n}}$
Student test	t	Value taken from the statistic-mathematical tables according to selection volume and trust level imposed
Selection average test	$t_{\bar{x}}$	$t_{\bar{x}} = \frac{\bar{x}}{\sigma}$
Selection average error	e_M	
Student test	t	Value taken from the statistic-mathematical tables according to selection volume and trust level imposed

Table 2

VALUES OF THE TENDENCY AND DISPERSION INDICATORS ON THE 2 TARGET GROUPS						
Statistical indicators types/ Values	**Anthropometrical sizes**					
	Girls			***Boys***		
	I_c	P_b	P_s	I_c	P_b	P_t
Number of classes, *k*	9	9	9	9	9	9
Class size	3.96 ≈ 4	3.11 ≈ 3	3.75 ≈ 4	4.03 ≈ 4	2.82 ≈ 3	3.48 ≈ 4
Standard deviation, σ	9.11	6.2	7.06	7.63	5.12	6.06
Selection arithmetic average $\bar{x}$, cm	131.68	63.25	69.29	131.69	63.00	58.04
Dispersion, σ^2	83.02	38.47	34.75	58.27	26.18	36.76
Amplitude, *A*	35.70	28.00	33.80	36.30	25.40	31.40
Selection average error, e_M	0.65	0.45	0.51	0.54	0.36	0.43
Selection average test, $t_{\bar{x}}$	14.45	10.20	9.81	17.25	12.31	9.57
Student test, *t*	1.97	1.97	1.97	1.97	1.97	1.97
Variation coefficient, C_V	6.92	9.81	10.19	5.8	8.12	10.45
Trust domain, *q*	± 1.28	± 0.87	± 0.99	± 1.06	± 0.71	± 0.84

From the analysis of the values presented in table 2 rise the following conclusions:

- the number of classes obtained from dividing the experimental data is the same for the 2 target groups, because they were almost equal as a volume;
- the experimental data was analyzed for the identification of values considered "aberrant", for eliminating them and modifying the selection volume towards a determination of some real values for statistical parameters that could state as better possible the facts. In the specific values were not identified "aberrant" ones;
- the calculated arithmetic average are consistent under statistical report, because the selection average test $t_{\bar{x}} > t_{p,f}$, where ($t_{p,f}$ = 1.972). In this case, the selection average can be used for calculating the interval where is to be found the average for the entire population;
- the representativeness of the selection average is justified by the perimeter value e_M; the values of this statistic perimeter are < 5%,so the selection average states a real phenomenon and can be used in calculating the interval for the average for the entire population;
- the selection homogeneity is high, the specific values of the analyzed sizes are close together and with the selection average (C_V < 10%). A higher homogeneity is found for the height of the body and smaller for the 2 perimeters of the body (chest and hips perimeter), therefore in this period because of the nutrition diet, social life and sportive life, the development in body mass and adipose tissue is different from child to child;
- the amplitude of the experimental data is not big, so the specific values are close together and within the selection average.

The experimental data for the analyzed body sizes are divided into classes, and the obtained results are centralized in tables 3–8.

Table 3

VARIATIONAL DATA FOR BODY HEIGHT ON GIRLS								
Classes	x_j	m	f_m	f_{mc}	$f_r = f_m/n$	f_{rc}	mf_m	m^2f_m
118 – 121.9	120	–3	14	14	0.07	0.07	–42.00	126
122 – 125.9	124	–2	24	38	0.12	0.20	–48.00	96
126 – 129.9	128	–1	35	73	0.18	0.38	–35.00	35
130 – 133.9	132	0	35	108	0.18	0.56	0.00	0
134 – 137.9	136	1	31	139	0.16	0.72	31.00	31
138 – 141.9	140	2	28	167	0.14	0.86	56.00	112
142 – 145.9	144	3	12	179	0.06	0.92	36.00	108
146 – 149.9	148	4	10	189	0.05	0.97	40.00	160
150 – 154	152	5	5	194	0.03	1	25.00	125
c = 4	-	-	194	-	-	-	$\frac{-125}{188} = -0.66$	793

Table 4

VARIATIONAL DATA FOR BODY HEIGHT ON BOYS								
Classes	x_j	m	f_m	f_{mc}	$f_r = f_m/n$	f_{rc}	mf_m	m^2f_m
118.1 – 122	120	–3	18	18	0.09	0.09	–54.00	162
122.1 – 126	124	–2	26	44	0.13	0.22	–52.00	104
126.1 – 130	128	–1	35	79	0.18	0.40	–35.00	35
130.1 – 134	132	0	42	121	0.21	0.61	0.00	0
134.1 – 138	136	1	31	152	0.16	0.76	31.00	31
138.1 – 142	140	2	29	181	0.15	0.91	58.00	116
142.1 – 146	144	3	9	190	0.05	0.95	27.00	81
146.1 – 150	148	4	6	196	0.03	0.98	24.00	96
150.1 – 154.4	152	5	3	199	0.02	1.00	15.00	75
$c = 4$	-	-	199	-	-	-	$\frac{-141}{155} = -0.9$	700.00

Table 5

VARIATIONAL DATA FOR CHEST PERIMETER ON GIRLS								
Classes	x_j	m	f_m	f_{mc}	$f_r = f_m/n$	f_{rc}	mf_m	m^2f_m
53 – 55.9	54.5	–3	15	15	0.077	0.077	–45.00	135
56 – 58.9	57.5	–2	30	45	0.155	0.232	–60.00	120
59 – 61.9	60.5	–1	46	91	0.237	0.469	–46.00	46
62 – 64.9	63.5	0	40	131	0.206	0.675	0.00	0
65 – 67.9	66.5	1	21	152	0.108	0.784	21.00	21
68 – 70.9	69.5	2	20	172	0.103	0.887	40.00	80
71 – 73.9	72.5	3	7	179	0.036	0.923	21.00	63
74 – 76.9	75.5	4	6	185	0.031	0.954	24.00	96
77 – 80	78.5	5	9	194	0.046	1.000	45.00	225
$c = 3$	-	-	194	-	-	-	$\frac{-151}{151} = -1$	786

Table 6

VARIATIONAL DATA FOR CHEST PERIMETER ON BOYS								
Classes	x_j	m	f_m	f_{mc}	$f_r = f_m/n$	f_{rc}	mf_m	m^2f_m
53 – 55.9	54.5	–3	5	5	0.03	0.03	–15.00	45
56 – 58.9	57.5	–2	18	23	0.09	0.12	–36.00	72
59 – 61.9	60.5	–1	41	64	0.21	0.33	–41.00	41
62 – 64.9	63.5	0	68	132	0.34	0.67	0.00	0
65 – 67.9	66.5	1	38	170	0.19	0.86	38.00	38
68 – 70.9	69.5	2	12	182	0.06	0.92	24.00	48
71–73.9	72.5	3	9	191	0.05	0.96	27.00	81
74 – 76.9	75.5	4	5	196	0.03	0.99	20.00	80
77 – 80	78.5	5	3	199	0.02	1.00	15.00	75
$c = 3$	-	-	199	-	-	-	$\frac{-92}{124} = -0.74$	480.00

Based on the results centralized in tables 3–8 is made up the polygon of absolute frequencies and the histograms of absolute frequencies cumulated (fig. 1, 2). Analyzing the graphical representations from figures 1 and 2 it can be noticed the fact that the shape of growth curves corresponds to relations of continuous type, to which the values are infinitely close together, representing a limit of the polygon and frequency histograms.

The specific values of body sizes is verified to check if whether they are close as shape to the distribution curves Gauss-Laplace. If it follows this distribution then the number of specific values (expressed in normed deviations) is distributed symmetrically in

Table 7

VARIATIONAL DATA FOR HIPS PERIMETER ON GIRLS								
Classes	x_j	m	f_m	f_{mc}	$f_r = f_m/n$	f_{rc}	mf_m	m^2f_m
54.5 – 58.4	56.5	–3	8	8	0.041	0.041	–24.00	72.00
58.5 – 62.4	60.5	–2	24	32	0.124	0.165	–48.00	96.00
62.5 – 66.4	64.5	–1	37	69	0.191	0.356	–37.00	37.00
66.5 – 70.4	68.5	0	48	117	0.247	0.603	0.00	0.00
70.5 – 74.4	72.5	1	33	150	0.170	0.773	33.00	33.00
74.5 – 78.4	76.5	2	27	177	0.139	0.912	54.00	108.00
78.5 – 82.4	80.5	3	8	185	0.041	0.954	24.00	72.00
82.5 – 86.4	84.5	4	4	189	0.021	0.974	16.00	64.00
86.5 – 90.4	88.5	5	5	194	0.026	1.000	25.00	125.00
c = 4	-	-	194	-	-	-	$\frac{-109}{152} = -0.71$	607.00

Table 8

VARIATIONAL DATA FOR WAIST PERIMETER ON BOYS								
Classes	x_j	m	f_m	f_{mc}	$f_r = f_m/n$	f_{rc}	mf_m	m^2f_m
47.8 – 51.2	49.50	–2	13	13	0.07	0.07	–26	52
51.3 – 54.7	53.00	–1	44	57	0.23	0.3	–44	44
54.8 – 58.2	56.50	0	63	120	0.32	0.62	0	0
58.3 – 61.7	60.00	1	49	169	0.25	0.87	49	49
61.8 – 65.2	63.50	2	16	185	0.08	0.95	32	64
65.3 – 68.7	67.00	3	11	196	0.06	0.98	33	99
68.8 – 72.2	70.50	4	0	196	0	0.98	0	0
72.3 – 75.7	74.00	5	0	196	0	0.98	0	0
75.8 – 79.2	77.50	6	3	199	0.02	1	18	108
c = 4	-	-	199	-	-	-	$\frac{-70}{132} = -0.71$	416.00

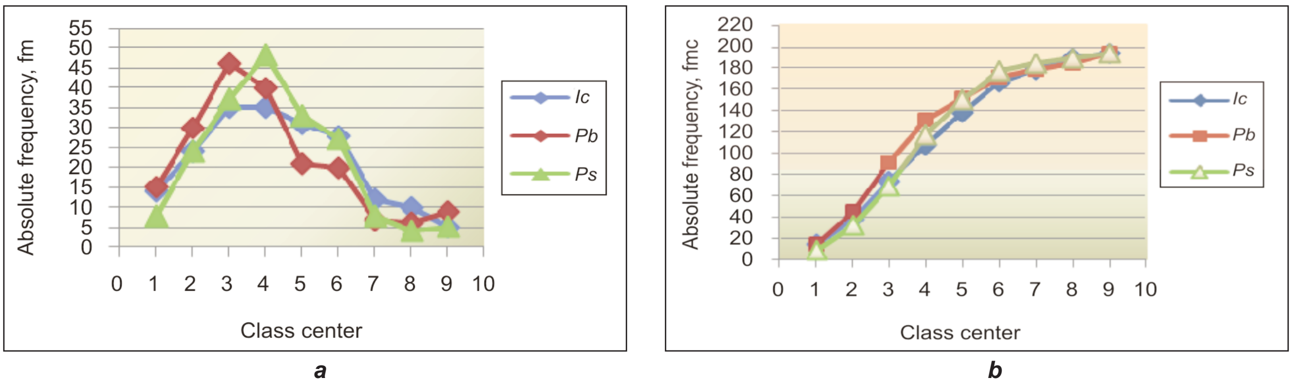

Fig. 1. The polygon and the absolute frequency histogram for girl selection

relation with the average value, leading to important information for orienting the distribution of a volume of products designed for children (a bigger number of products will be distributed for the average value, and after that will decrease symmetrically to the interval extremity).

The verification of the regularity of distribution curves on experimental values is made using the relation (1):

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} \times e^{-\frac{(x_j - \bar{x})^2}{2\sigma^2}} \quad (1)$$

where:

$f(x)$ is probability density for results distribution, considerate as random variables for $-\infty < x_j < +\infty$.

The value of function $f(x)$ is determined based on the data from tables 9 and 10 and the calculation of the theoretical number of subjects n_t, with relation (2):

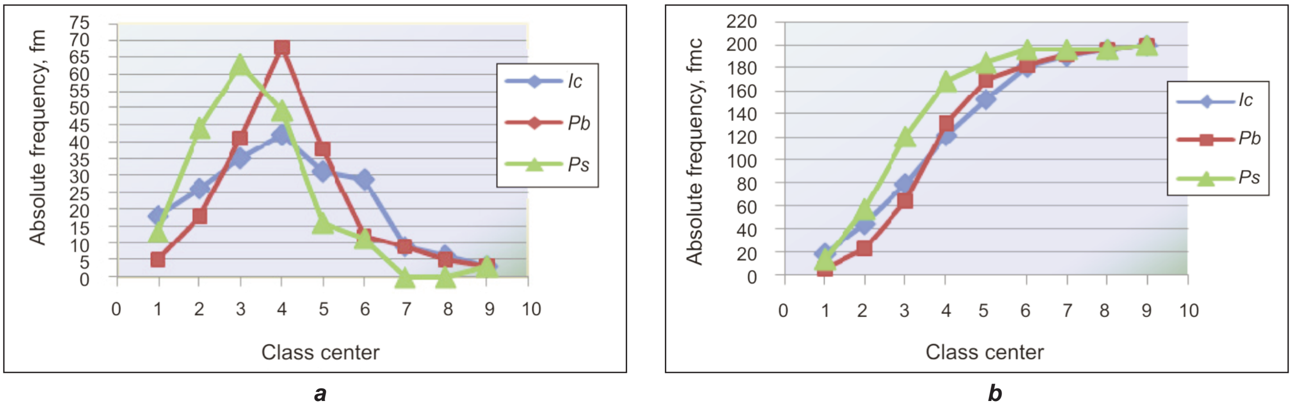

Fig. 2. The polygon and the absolute frequency histogram for boys selection

Table 9

DETERMINING THE NORMAL DISTRIBUTION CURVES FOR $\hat{I}_c$ ON GIRLS						
Classes	**Class average,** x_j, cm	**Real number of subjects**	$x_j - \bar{x}_c$	**Normed deviation,** $\frac{x_j - \bar{x}_c}{\sigma}$	**Regular curve ordered,** $f(x_j)$	**Theoretical number of subjects,** n_t
118 – 121.9	120	14	–12	–1.32	0.17	16
122 – 125.9	124	24	–8	–0.88	0.27	25
126 – 129.9	128	35	–4	–0.44	0.36	32
130 – 133.9	132	35	0	0.00	0.40	36
134 – 137.9	136	31	+4	0.44	0.36	32
138 – 141.9	140	28	+8	0.88	0.27	25
142 – 145.9	144	12	+12	1.32	0.17	16
146 – 149.9	148	10	+16	1.76	0.08	8
150 – 154	152	5	+20	2.20	0.04	4
-	-	194	-	-	-	194

Table 10

DETERMINING THE NORMAL DISTRIBUTION CURVE FOR $\hat{I}_c$ ON BOYS						
Classes	**Class average,** x_j, cm	**Real number of subjects**	$x_j - \bar{x}_c$	**Normed deviation,** $\frac{x_j - \bar{x}_c}{\sigma}$	**Regular curve ordered,** $f(x_j)$	**Theoretical number of subjects,** n_t
118.1 – 122	120	18	–12	–1.57	0.12	13
122.1 – 126	124	26	–8	–1.05	0.23	25
126.1 – 130	128	35	–4	–0.52	0.35	37
130.1 – 134	132	42	0	0.00	0.40	42
134.1 – 138	136	31	4	0.52	0.35	37
138.1 – 142	140	29	8	1.05	0.23	25
142.1 – 146	144	9	12	1.57	0.12	13
146.1 – 150	148	6	16	2.10	0.04	5
150.1 – 154.4	152	3	20	2.62	0.01	2
-	-	199	-	-	-	199

$$n_t = f(x_j) \times \frac{n_r \times c}{\sigma} \qquad (2)$$

Based on the data centralized in tables 9 and 10 are made up the graphics for regular distribution curves, type Gauss-Laplace, for each anthropometric size analyzed, for the 2 target groups (girls and boys).

The representation of the distribution curves for main parameters for the selection of girls and boys, are the base for calculating the regular distribution function obtained as $\hat{I}_c$ indicator.

Based on the data from the graphics 3–5 are obtained the results from table 11 (distribution of values number

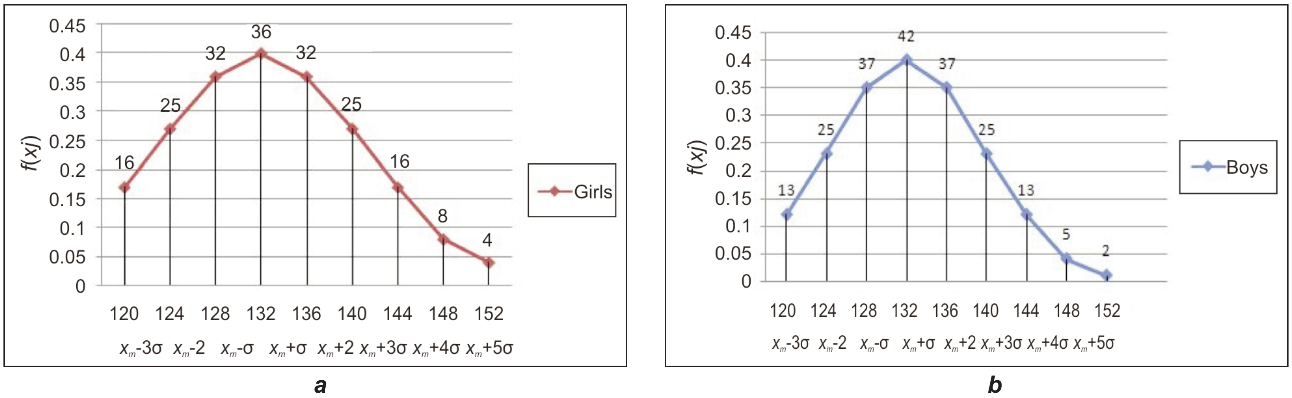

Fig. 3. The graphic of the regular distribution curve for $\hat{I}_c$

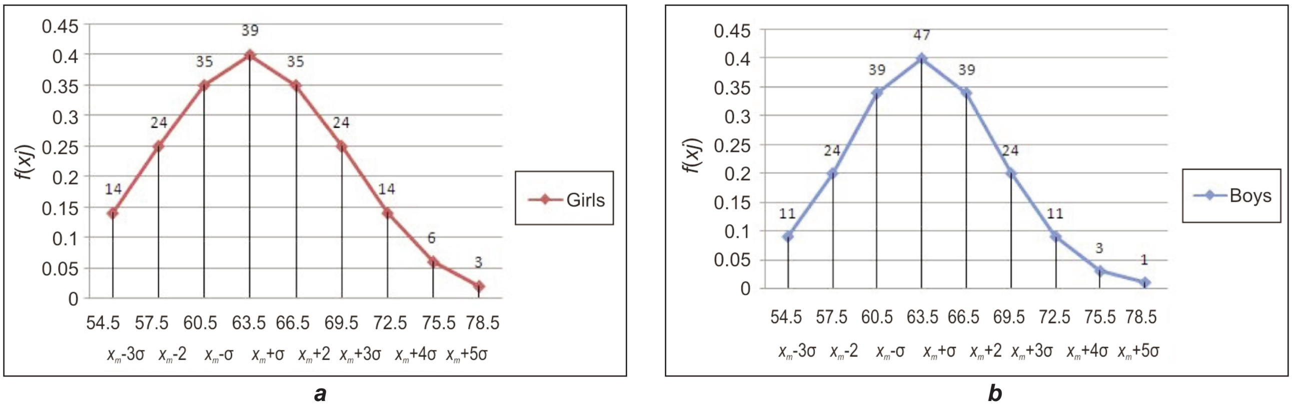

Fig. 4. The graphic of the regular distribution function for P_b

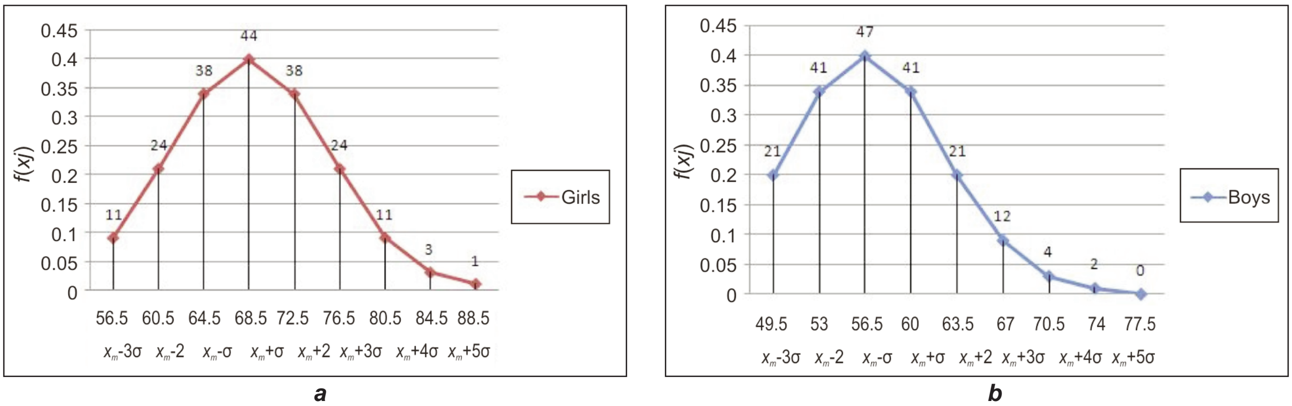

Fig. 5. The graphic of the regular distribution function for P_s on girls and P_t on boys

expressed in normed deviations with relation to the average value).

From the analysis of figures 3–5 with distribution curves and the data from table 9 are raised the following conclusions:

- the experimental values for $\hat{I}_c$ and P_b follow the regular distribution curve Gauss-Laplace; the interval $\bar{x}$ – 3σ and $\bar{x}$ + 3σ has over 93% from the population; the rest of the values are particular cases, they do not represent a consistent percentage among the population for which should be created serial production items;
- the distribution curve for P_t differs from the regular distribution curve type Gauss-Laplace. In this case,

Table 11

DPERCENTAGE OF REPARTITION FREQUENCY ON THE NUMBER OF SUBJECTS

	Dimensions	$\bar{x} \pm \sigma$	$\bar{x} \pm 2\sigma$	$\bar{x} \pm 3\sigma$
Girls	I_c	51.54%	77.31%	93.81%
	P_b	56.18%	80.92%	95.36%
	P_s	61.85%	86.59%	97.93%
Boys	I_c	58.29%	83.41%	96.48%
	P_b	62.81%	86.93%	97.98%
	P_t	68.82%	90.95%	96.98%

in the interval $\bar{x} - 2\sigma$ and $\bar{x} + 2\sigma$ is found a big percentage from the population, and after that the symmetry is not followed. Therefore children with P_t values above the superior part cannot find items from serial productions, because this percentage is not consistent from a statistical point of view and serial production is not profitable for this consumer segment.

CONCLUSIONS

Analyzing the results obtained from the research on statistical perimeters for anthropometric sizes taken into consideration, we have reached the following conclusions for the proceeding researches:

- the morphological types representative for the age group analyzed are found in a high percentage in the interval $\bar{x} - 2\sigma$ and $\bar{x} + 2\sigma$. In this case the items made on numeric distribution according to figures 3–5 provide the degree of requirements from the consumers, from a dimensional point of view;
- the variability of the analyzed sizes is small, the homogeneity is big, so in this interval there are not consistent differences of the growth and development process from one child to another;
- the anthropometric sizes of which experimental data present a consistent deviation from the regular distribution law, type Gauss-Laplace, and need a statistical processing through the method of logarithmic transformation as to obtain a regularity in unidimensional distribution;
- the representative morphological types for the 2 target groups are close as level, so in this period sexual differentiation is not yet accentuated;
- the representativeness of the selection average provides consistent results for the entire population from which was selected the target group, therefore all the conclusions and characteristics of the 2 groups can be extended to all.

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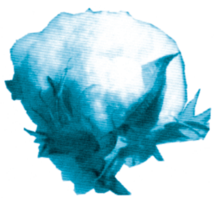
Authors:

PhD student eng. ANA VÎRCAN
Lecturer dr. eng. MANUELA AVĂDANEI
Dr. eng. IONUȚ DULGHERIU
Prof. dr. eng. MITU STAN

Technical University Gheorghe Asachi
Faculty for Textile-Leather and Industrial Management
53 D. Mangeron, 700050 Iasi
e-mail: avircan@tex.tuiasi.ro



The soil removal and disinfection efficiency of chemo-thermal and LCO_2 treatment for hospital textiles

BRANKO NERAL

SONJA ŠOSTAR-TURK

SABINA FIJAN

REZUMAT – ABSTRACT

Îndepărtarea murdăriei şi eficiența dezinfecției prin tratamente chimico-termice şi LCO_2, la textilele medicale

În cadrul acestui studiu au fost efectuate două procese diferite de spălare a textilelor medicale. Prima metodă investigată a fost cea de spălare clasică, chimico-termică, într-o singură baie, la 60ºC, folosind o maşină de spălat cu tambur, în mediu apos. Cea de-a doua metodă investigată a fost cea de curățare chimică într-o singură baie, utilizând LCO_2. Îndepărtarea murdăriei şi eficiența dezinfecției au fost evaluate pentru următorii bioindicatori textili: Enterococcus faecium, Enterobacter aerogenes şi Candida albicans, împreună cu o soluție de transpirație acidă, sânge sau ciocolată cu lapte. În urma rezultatelor obținute s-a ajuns la concluzia că toate procedurile de spălare efectuate au dovedit o creştere a eficienței dezinfecției, pe măsură ce valorile RED au depăşit şase unități logaritmice. S-a descoperit că eficiența îndepărtării murdăriei, în cazul ambelor tratamente, a fost maximă în cazul transpirației acide. Pentru sânge şi ciocolata cu lapte, eficiența îndepărtării murdăriei a fost destul de mare în cazul procedurii de spălare chimico-termică.

Cuvinte-cheie: textile medicale, spălare chimico-termică, tratament LCO_2, îndepărtarea murdăriei, dezinfecție

The soil removal and disinfection efficiency of chemo-thermal and LCO_2 treatment for hospital textiles

In the research two different laundering procedures of hospital textiles were prepared and executed. The first procedure investigated was a classical type of one bath chemo-thermal laundering procedure at 60ºC which was performed in a drum washing machine with water as the medium. A one-bath dry-cleaning procedure using LCO_2 was the subject of the second investigated procedure. The soil removal and disinfection efficiency were evaluated using the following textile biondicators Enterococcus faecium, Enterobacter aerogenes, and Candida albicans, soiled with a solution of acid perspiration, blood or chocolate milk. From the results it can be concluded that all performed laundering procedures proved efficient disinfection efficiency as the RED values were above 6 log steps. It was found that the most efficient removal for both treatments was noted for acid perspiration, meanwhile for blood and chocolate milk the soil removal efficiency was noticeably high for the chemo-thermal laundering procedure.

Key-words: hospital textiles, chemo-thermal laundering, LCO_2 treatment, soil removal, disinfection

Textiles which enable adhesion, colonisation and penetration of microorganisms, represent a potential source of infection for its users or staff (health care workers or other workers who interact directly with the textiles). Appropriate temperatures, sufficient humidity level and nourishments, such as blood, body fluids, present in hospital textiles influence the survival of microorganisms [1, 2, 3]. The main purpose of disinfection is the reduction of pathogenic microorganisms and the destruction of vegetative pathogens [4]. The phenomenon of chemotherapeutic-resistant microorganisms (antimicrobial resistance) and growth of mutants challenges the laundering procedures of hospital textiles. The laundering procedures should clean textiles of all impurities and simultaneously assure adequate hygiene level during the procedure.

It is known that the laundering procedure of hospital textiles is composed of two phases [5]. The first phase is cleaning of impurities (soils, stains etc.), which is followed by the disinfection phase. If all impurities have not been cleaned of then the disinfection phase may not be effective because microorganisms trapped between fibres or inside textile may survive. For sterilization of medical devices physical (heat, radiation, gaseous, filtration), chemical or physiochemical methods are available [4, 6] but they are not all suitable for textiles. The problem concerning disinfection of medical textiles lies in physiochemical characteristics of fabrics, nonwovens or laminates as concerning heat sensitivity, fibre or surface structure, change of functionality or capabilities, reduction of lifetime [6].

Nowadays, the cleaning of textiles from hospitals, health centres, retirement homes and food industry, is performed in drum or tunnel washers using large amounts of water. The synergy of the laundering temperature, bath ratio, duration, laundering/ disinfection/ auxiliary agents supplements, and intensity of mechanical treatment effect the removal of bacteria, fungus and viruses form textiles during the laundering procedure [7, 8]. Characteristics of chemical and mechanical laundering procedures are: high energy, fresh water and detergents consumption, huge amounts of laundry wastewaters, high velocity of kinetics process, which has a critical impact on shortening the textiles lifespan, mechanical parts of washing equipment and operating costs.

One of the new cleaner methods for sustainable textile laundering is carbon dioxide (CO_2). The main reasons are that CO_2 is non-toxic, non-flammable, chemically inert, available on the large scale and inexpensive. The supercritical carbon dioxide ($scCO_2$) is well known and has been efficiently used in pharmaceutical and food industry for a long period [9–12]. $ScCO_2$ has replaced water as a solvent in dyeing of synthetic and some natural textile fibres [13–16] In another report [6], where the focus of the investigation were medical textiles and $scCO_2$ and LCO_2 treatment, results showed that the inactivation of vegetative microorganisms was attainable with a low-temperature process and pressure of 50 bar.

The LCO_2 cleaning method is still a relatively new process. It is obvious that carbon dioxide based cleaning technology needs further verification, research and development of the cleaning performance, as well as the hygiene/disinfection/sterilisation efficiency.

In our research we focused on evaluation of the effectiveness between the classical chemo-thermal and the newly developed LCO_2 dry-cleaning method. Two different laundering procedures of hospital textiles were prepared and executed. The first investigated procedure was a classical type of chemo-thermal laundering procedure, a one bath laundering procedure with water as the medium. A one-bath dry-cleaning procedure using LCO_2 was subject of the second investigation. For all performed laundry processes the disinfection and spot removal efficiency were evaluated.

EXPERIMENTAL PART

Textile substrates

The experiments were performed on 100% cotton fabrics, which were desized, scoured, bleached and mercerised. Textile substrates characteristics which were used for preparation of textile bioindicators or as ballast in disinfection laundry procedures are presented in table 1.

Bioindicators

For testing the disinfection efficiency of laundering procedures for hospital textiles in laundries, clinically relevant bioindicators (pathogenic bacteria such as: *Enterococcus faecium* ATCC 6057, *Enterobacter aerogenes* ATCC 13048, and fungi, namely *Candida albicans* ATCC 2091) were used. Preparation of textile bioindicators has been briefly described previously [17].

Artificial soils

Textile bioindicators were soiled with solution of acid perspiration, blood or chocolate milk. Acid perspiration solution was prepared in accordance with [18]. Defibrinated sheep blood was used for blood soils. Bags with blood for experiments were obtained from Microbiol diagnostics (I). The blood was taken from selected healthy animals which were not treated with antibiotics. For soiling bioindicators with chocolate milk a commercial chocolate Monte drink from Zott GmbH (D) was used. According to the declaration the main ingredients were: milk (0.9% milk fat), sugar, powdered milk, powdered chocolate (2%), milk, starch, carrageenan, aroma. Solutions of soils (2 mL) were applied on the textile bioindicators. The bioindicators were then dried in the incubator for 24 hours at 37°C.

Chemo-thermal treatment

The laundering procedures were conducted in the laboratory washing machine, Wascator Nyborg W365H MP (Electrolux Laundry Systems, S), with a

Table 1

CHARACTERISTICS OF TEXTILE SUBSTRATES USED

Parameter	Bioindicator fabric	Ballast fabric
Producer	WFK GmbH (D)	MTT Maribor (SLO)
Product	ISO 2267:1986 cotton control fabric	Multipurpose fabric
Fibre composition	100% cotton	100% cotton
Density	Warp – 27 threads/cm, 295 dtex Weft – 27 threads/cm, 295 dtex	Warp – 28 threads/cm, 200 dtex Weft – 26 threads/cm, 200 dtex
Mass	170 g/m^2	120 g/m^2
Weave	Plain	Plain
Colour characteristics (CIE D65/10)	L^*= 93.03 C^* = 0.99 h = 124.05	L^*= 86.58 C^* = 11.81 h = 72.38
Whiteness degree	WI_{CIE} = 79.25	WI_{CIE} = 70.57

capacity of 6.5 kg, a drum volume of 65 L, an extraction with 1,100 rpm, G-factor of 350, and with the possibility of programming the exact temperature, mechanical action, duration, bath ration, and dosing. The Ecobrite LLD-205 automatic dosing device (Henkel Ecolab, A) and the WAK 10-KMN-1 cationic water softening device (Hidrotehnični biro, SLO) were used to ensure the exact dosages of washing/disinfecting/neutralising agents.

The washing procedure simulated a typical program for washing hospital textiles. The procedure began with loading the washing machine with bioindicators and ballast textile followed by automatic dosing of softened water (bath ration 1:5) and laundering agent (1,20 g/L). The bath was then heated to the determined temperature (60°C) followed by dosing of disinfecting agent (0,79 g/L) and washing. Main washing was followed by two rinsing phases (30°C) and a neutralisation phase with the addition of a neutralising agent (1 mL/kg). The last step was water extraction by centrifuge. In investigated chemo-thermal laundering procedure the industrial laundering detergent (highly concentrated, strongly alkaline liquid with addition of optical brightener, composed of: sodium hydroxide, potassium hydroxide, glycolic acid, nonionic surfactants, phosphonates), bleaching and disinfection agent (colourless liquid, highly concentrated, strongly acid, composed of solutions: hydrogen peroxide, peracetic acid, acetic acid), and neutralizing agent (solution of acetic acid) were used.

LCO_2 treatment

During the research a UHDE (HP Technologies GmbH Hagen, D) high pressure extraction device was used where main characteristics are: maximum working pressure 500 bar, maximum working temperature 120°C, two cleaning vessels (500 mL and 5,000 mL) and a flow rate of CO_2 between 5 and 33 kg/h [10]. UHDE device is a closed system where the contaminated CO_2 is distilled, recycled and used again.

In the research a dry-cleaning detergent, specially developed for use with LCO_2 was used. The dry-cleaning detergent is a clear and colourless liquid, with *p*H 8–9, density of 0,93 g/mL at 20°C, and a viscosity less than 100 mPa s at 20°C. In experiments the dosage of dry-cleaning detergent was 4 mL/L LCO_2.

Determination of disinfection efficiency

The concentration of micro-organisms on the cotton swatches during the incubation process, and after chemo-thermal or LCO_2 treatment, were calculated using the equation (1):

$$CFU = N \cdot f \qquad (1)$$

where:

CFU is number of colonies on cotton swatch;

N – number of micro-organisms on agar plate;

f – dilution factor 1:10, 1:100 or 1:1,000 (mL^{-1}).

After laundering treatment each bioindicator was placed into saline solution to release the micro-organisms from the cotton swatches. The colony forming unit (*CFU*) was assessed by serial tenfold dilutions and plating on selective agars. The average *CFU* after the incubation periods was used to determine the reduction efficiency using equations (2):

$$RED = \log\,(CFU_b \,/\, CFU_a) \qquad (2)$$

where:

RED is colony reduction efficiency;

CFU_a – *CFU* on cotton swatches after chemo-thermal or LCO_2 treatment;

CFU_b – *CFU* on cotton swatches before chemo-thermal or LCO_2 treatment.

Determination of soil removal efficiency

Efficiency of soil removal was evaluated based upon measurements of reflection and calculation of stain removal index (*SRI*).

Reflectance measurements of soiled and laundry treated samples were determined with a spectrophotometer Datacolor Spectra Flash SF 600 (d/8 measurement geometry, measurement wavelength range from 400 nm to 700 nm, measurement area of 12 mm in diameter and SIN-specular included measurement mode). *XYZ*, CIE *L*a*b*, C*, h* CIELAB 1976 and colour difference ($dE^*_{D65/10}$) were calculated with Datacolor Datamaster software (CH).

The *SRI* was calculated in accordance with [19] by equation (3):

$$SRI = 100 - ((L^*_U - L^*_w)^2 + (a^*_U - a^*_w)^2 + (b^*_U - b^*_w)^2)^{1/2} \qquad (3)$$

where:

SRI is cleaning performance index, %;

L^* – CIELAB L* coordinate (lightness);

a^* – CIELAB a* coordinate (red-green axis);

b^* – CIELAB b* coordinate (yellow-blues axis);

u – unstained fabric, washed in the treatment conditions;

w – stained fabric, washed in the treatment conditions.

RESULTS AND DISCUSSIONS

The antimicrobial effect and the soil removal efficiency from textile swatches were determined in the chosen laboratory laundering procedures. Soils of acid perspiration, blood and chocolate milk were applied on the textile bioindicators and then dried in the laminar flow. The bioindicators were then chemo-thermal or LCO_2 treated with added detergent/disinfecting agent/neutralising agent or dry-cleaning detergent, and *CFU*, and *RED* evaluated. All experiments were repeated three times. The disinfection efficiency is noted in table 2, whilst the soil removal efficiency is noted in table 3.

Table 2

MICRO-ORGANISMS REDUCTION OF CHEMO-THERMAL AND LCO_2 LAUNDERING PROCEDURES					
Bioindicator	**Treatment**				
	Chemo-thermal			**LCO_2**	
	CFU_B, $mL^{-1} \cdot 10^7$	*CFU_A*, $mL^{-1} \cdot 10^7$	*RED*	*CFU_A*, $mL^{-1} \cdot 10^7$	*RED*
E. faecium	7.00	0.00	> 7.85	0.00	> 7.85
E. aerogenes	11.00	0.00	> 8.04	0.00	> 8.04
C. albicans	2.00	0.00	> 7.30	0.00	> 6.30

Table 3

COLOUR DIFFERENCE *dE** (D65/10) AND SOIL REMOVAL EFFICIENCY *SRI* OF SOILED COTTON SWATCHES AFTER CHEMO-THERMAL OR LCO_2 LAUNDERING TREATMENT					
Soil	**No. laundering**	**Treatment**			
		Chemo-thermal		**LCO_2**	
		*dE**	*SRI*, %	*dE**	*SRI*, %
Unsoiled fabric	*1*	0.77	-	0.79	-
	2	2.19	-	0.82	-
	3	2.88	-	0.85	-
Acid perspiration	*1*	2.24	96.94	1.67	98.97
	2	3.16	97.85	0.75	97.77
	3	5.65	98.63	1.77	98.45
Blood	*1*	60.83	92.95	43.85	78.66
	2	60.90	93.80	40.75	74.56
	3	63.82	99.47	52.37	85.35
Chocolate milk	*1*	44.11	96.59	19.55	74.40
	2	47.41	98.05	19.42	74.23
	3	46.99	98.89	18.06	72.73

Note: dE is colour difference between soiled untreated and treated sample*

The chosen chemo-thermal laundering procedure as well as the dry-cleaning LCO_2 treatment proved to have a disinfection effect since no bioindicators survived the process. From the results in table 2 it can be concluded that all performed laundering procedures proved sufficient disinfection efficiency as the *RED* values were above 6 log steps. In the series of previous LCO_2 experiments the temperature was varied from 40°C to 60°C, while the other treatment conditions were all the time unchanged: 25 minutes of LCO_2 treatment at 50 bar, with the addition of dry-cleaning detergent, and 15 minutes of decompression from working to surrounding pressure. We found that 40°C was efficient for *Enterobacter aerogenes* and Candida albicans and 50°C was efficient for all chosen microorganisms namely: *Enterococcus faecium*, *Enterobacter aerogenes*, *Candida albicans*. Unlike the chemo-thermal disinfection laundry process, which is based on a water bath, LCO_2 treatment was carried out without the presence of water. In the early stages of the research we had conducted a series of tests where we followed the effect of water disinfection and LCO_2, and a combination of water, water detergent and LCO_2. The results (data not shown) revealed no disinfecting effect of laundering baths; therefore the water was eliminated from the LCO_2 treatment of bioindicators. It is important to expose that our preliminary results where disinfection effectiveness using the combination of water and LCO_2 was investigated did not match with the results of Schmidt [20].

From the results of total colour differences between unwashed and washed samples with soils of acid perspiration, defibrinated sheep blood and chocolate milk and the *SRI* (table 3) we can conclude the general ascertainment that after one washing cycle only partial stain removal was noted. It was found that the most efficient removal for both treatments was noted for acid perspiration, meanwhile for blood and chocolate milk the soil removal efficiency was noticeably high in the chemo-thermal laundering procedure.

The most efficient removal after the first chemo-thermal washing cycle (table 3) was noted for acid perspiration (*SRI* equals 96.94%) and somewhat lower for chocolate milk (*SRI* equals 96.59%) and lowest for blood soils (*SRI* equals 92.95%). An almost complete removal was reached after the third washing since the *SRI* values were much higher. In case of LCO_2 treatment of soiled textile bioindicators the *SRI* values were comparable with chemo-thermal only for acid perspiration (*SRI* equals 98.97%), meanwhile for blood (*SRI* equals 78.66%) and chocolate milk (*SRI* equals 74.40%) they were much lower.
The assessment of *dE** values for the unsoiled test fabrics (table 3) that were chemo-thermally washed shows that the values rise with the rising number of washes. This could be attributed to redeposition of soils and low dispergation characteristics of the used chemo-thermal laundering detergent.

CONCLUSIONS

Our research showed that LCO_2 treatment can successfully be used for textile disinfection. However, the limitations of the LCO_2 technology are: the soil removal efficiency is lower than with the chemo-thermal laundering procedure as the detergents and additives have not be sufficiently improved or modified, the process is not yet robust enough to run for long periods without repairs, and the investment costs are twice as high as those of solvent based laundering units. However, the development of new dry-cleaning detergents and additives to improve the cleaning efficiency will be the scope for further investigations.

Acknowledgments

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Authors:

Assist. prof. BRANKO NERAL
University of Maribor
Faculty of Mechanical Engineering
Institute for Engineering Materials and Design
Smetanova ulica 17, SI-2000 Maribor, Slovenia

PhD Assist. prof. SABINA FIJAN
University of Maribor
Faculty of Mechanical Engineering
Institute for Engineering Materials and Design
Smetanova ulica 17, SI-2000 Maribor, Slovenia

PhD Prof. SONJA ŠOSTAR-TURK
University of Maribor
Faculty of Health Sciences
Žitna ulica 15, SI-2000 Maribor, Slovenia

Correspondence author:
BRANKO NERAL
e-mail: branko.neral@uni-mb.si

DOCUMENTARE

Noi tehnologii

UN BUN CONTROL AL UMIDITĂȚII CU FIBRELE TREVIRA

Catastrofele legate de climă au cauzat neajunsuri în furnizarea fibrelor naturale, mai ales pe piața lânii. Aceşti factori au readus în prim-plan fibrele artificiale şi, în special, cele din poliester.
Producătorul de fibre ***Trevira*** satisface această tendință cu ajutorul unei fibre noi, *Trevira Moisture Control,* care poate fi utilizată în producerea țesăturilor destinate confecționării articolelor de îmbrăcăminte de înaltă calitate.
Materialele realizate din fibre Trevira Moisture Control posedă aceleaşi caracteristici ca şi cele din fibre Trevira, inclusiv proprietăți antipiling foarte bune, rezistență excelentă la vopsire, reziliență şi întreținere uşoară. În plus, acestea au un aspect semimat îmbunătățit, un tuşeu moale şi un bun control al umidității.
Cercetările efectuate la ***Institutul Hohenstein*** au demonstrat că, în ceea ce priveşte aspectul şi confortul, materialele realizate din fibre Trevira Moisture Control sunt compatibile, din toate punctele de vedere, cu cele clasice, din lână 100%. În plus, testele de uzură efectuate pe materiale destinate uniformelor utilizate în domeniul aerospațial au demonstrat că ele asigură atât un confort excelent, cât şi standarde ridicate de reziliență.
Profilul fibrelor are un sistem special cu două canale, care accelerează transportul moleculelor de condensare eliminate de piele, dinspre interior spre stratul exterior. Umiditatea de pe suprafața materialului textil este dispersată şi evaporată rapid. Astfel, partea interioară a suprafeței textile, care intră în contact cu pielea, rămâne uscată, prevenind apariția unui efect de răcoare neplăcut.
Textilele care conțin noile fibre sunt ideale pentru a fi utilizate la confecționarea îmbrăcămintei personalizate, îmbrăcămintei de serviciu sau a celei sport, datorită proprietăților-cheie ale acestora: management foarte bun al umidității, dispersie şi evaporare rapidă a umidității, uscare rapidă, caracteristici bune antipiling, întreținere uşoară, capacitate de spălare cu standarde de rezistență ridicate, tuşeu plăcut, proprietăți electrostatice bune, rezistență la razele UV şi la clor.

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Comfort evaluations in interference with an anti-allergic fabric

MIHAELA HRIȚCU - ŞALARIU
DORU RADU

ADA FERRI
AURELIA GRIGORIU

REZUMAT – ABSTRACT

Evaluarea proprietăților de confort la contactul cu un material textil antialergic

Lucrarea este axată pe evaluări ale nivelului de confort al pielii în contact cu materiale textile tricotate antialergice, în comparație cu o probă-martor. Pentru a trata o afecțiune alergică cutanată sunt necesare anumite condiții, şi anume un medicament eficient şi un confort adecvat pentru o piele sensibilă. S-au investigat unele proprietăți de confort, precum permeabilitatea la vaporii de apă, permeabilitatea relativă la vaporii de apă, rezistența termică, permeabilitatea la aer, hidrofilia, transferul şi profilul umidității, în scopul evaluării capacității materialelor textile destinate pacienților cu afecțiuni cutanate de a oferi un confort avansat şi o protecție eficientă pentru piele. Condițiile experimentale au oferit posibilitatea de a obține materiale textile tricotate cu un nivel ridicat de confort în contact cu pielea deteriorată a pacienților cu boli alergice. Utilizarea sistemului de eliberare controlată a medicamentului, prin intermediul unei ciclodextrine, nu afectează proprietățile de confort.

Cuvinte-cheie: materiale textile tricotate, proprietăți antialergice, proprietăți de confort, MCT-β-CD, principii active

Comfort evaluations in interference with an anti-allergic fabric

The paper focuses on evaluations of anti-allergic knitted fabrics in terms of dermic comfort by comparison with a witness. To resolve an allergic cutaneous affection, some conditions are necessary: an efficient medicine and an adequate comfort for a sensitive skin. Some comfort properties (water vapour permeability, relative water vapour permeability, thermal resistance, air permeability, wettability, conduction and humidity profile) have been investigated, in order to assess if fabrics intended for cutaneous diseases are able to offer a higher comfort, protection and efficiency for skin. Experimental conditions permitted to obtain knitted fabrics with a high comfort status in interference with damaged skin of patients with allergic disorders. The use of controlled release system for medicine by means of a cyclodextrin does not affect comfort properties.

Key-words: knitted fabrics, anti-allergic properties, comfort properties, MCT-β-CD, active principles

The prevalence of allergic diseases from nowadays, which has increased significantly in last years, imposes a challenge for achieving functionalized textile materials with anti-allergic properties. In this connection, as a therapeutic perspective it is trying to provide on textile surface temporarily reservoirs with some natural products which can be released under control to prevent or even to stop an allergic episode. By direct contact on the skin level, the functionalized textile materials can improve the barrier function of the skin damaged by allergic skin diseases.

It has been estimated that one quarter of the world population suffers some type of allergy in their lifetime. More than 500 million people suffer from allergy. For instance, in Germany there are 25 million allergic people and in France more than 12 million [1, 2].

In the dynamics of allergy prevalence are involved: the genetic inheritance, the stress, the environmental pollution, the modern life conditions and complexity of technical, pharmaceutical and food technologies [2–4].

Allergic diseases are common complex diseases that frequently follow a chronic relapsing course and affect the quality of patient and family life in a significant manner. The present research focuses on skin diseases such as atopic and contact dermatitis.

Atopic dermatits is a chronic inflammatory pruritic disease, particularly pruritic (with typical distribution and morphology) with an important genetic inheritance component that affects a large number of children and adults in all countries (especially industrialized countries). The eruption of disease is characterized by dry erythematous papule, excoriations and the formation of large lichenified plaques [5, 6].

Contact dermatitis is characterized by redness, itching, vesiculation and in more chronic form, scaly desquamation, resulting from exposure to environmental substances. Clinically, there are two types of contact dermatitis: irritant contact dermatitis and allergic contact dermatitis. Irritant contact dermatitis arises from local inflammatory reactions due to a single exposure or to a few skin contacts with toxic and irritating products that lead to local inflammation. In this case, immunological processes are not involved. Allergic contact dermatitis is produces by a delayed hypersensitivity reaction and is initiated by an innate inflammatory immune response to skin contact with low molecular weight chemicals. Contact allergens form a group of low molecular weight (< 500 Dalton). Other examples are metal ions (nickel, cobalt, chrome, and mercury), resins, rubber, fragrance, and dye staffs from textiles, some topical antibiotics or some types of textile materials. Allergic contact dermatitis is one of the most prevalent occupational skin diseases and causes severe and long-lasting health problems. Irritant contact dermatitis evolves as a consequence of direct toxic effects of physical or chemical agents resulting in keratinocyte damage and local inflammation, while allergic contact dermatitis critically depends on adaptive immunity [6, 7].

The immunologic mechanism reaction which determines the cutaneous inflammations of atopic and contact dermatitis is complex and differs from one individual to another. Nevertheless, in all cases, the mediators are involved: allergens (which generate an allergic reaction), immunoglobulin E, antigen, basophiles (represent < 1% of peripheral blood leukocytes), mast cell and histamine [8].

The treatment of an installed allergy is equivalent to the blockage of the mediator release responsible for the occurrence of the disease or the improvement of the symptomatology. At this stage one can interfere by using an anti-allergic textile support, which could block the release of the mediator [9].

The paper highlights analyses and results obtained on functionalized knitted textiles treated with natural active principles in terms of comfort. It is well known that comfort is a key factor to be considered for medical textiles. Thus, a special condition for functional clothings intended in medical field should be able to offer higher comfort properties together with protection and efficiency. In these circumstances, the aspects of some comfort properties of untreated and functionalized knitted fabrics have been evaluated. Details on obtaining an anti-allergic functionalized fabric involves a careful selection of the type of material, able to offer in finishing stage the necessary conditions to develop temporary reservoirs with anti-allergic drugs (active principles) on the surface of textile support.

In most of the care therapies of contact and atopic dermatitis, one recommends to use cotton textiles worn directly on skin. Generally, due to their hygienic properties, good handle, as well as water vapour and air permeability, the natural fibres are appropriate tools for these disorders, as mentioned by Oglakcioglu et. al. [10]. Therefore, the specialty literature mentions various uses of special textile articles, intended for patients who suffer from certain skin diseases [11–14]. Through a direct contact with the skin, the anti-allergic textile need to maintain a wellness and healthy condition so that not to make worse the already damaged skin. With this in view, the comfort condition between textile material - skin - environment has an important role. Among all the comfort factors, thermal comfort is the primary one and medical textiles must guarantee a feeling of thermal comfort as a prerequisite [15].

The textile material used for cutaneous lesions should be soft, sterile, nontoxic, have a good capacity of the moisture and perspiration sorption, high permeability for water vapours from the textile material to the environment. Another recommendation for designing the anti-allergic textiles implies the relationship between mechanical and surface properties of materials and the sensations manifested by skin contact. Furthermore, it is necessary that the textile fabric do not contain different products or substances which have an allergic potential or can aggravate the lesion condition.

EXPERIMENTAL PART

Materials used

Textile support and preparation treatment

The utilized textile support represents a knitted fabric with an interlock structure (performed on a circular knitting machine within the Department of Textile Leather and Industrial Management from Iasi, Romania) made of 100% cotton (Egyptian origin) from yarns with fineness of *Nm* = 60/1. Knitted fabric subsequently supports a treatment of alkaline boiling for removal of natural and accidental impurities, and sterilization through a bleaching treatment with hydrogen peroxide, to obtain a soft handle and a hydrophilic surface without pathogen agents (hydrogen peroxide is as well used as sterilization reagent).

Alkaline boiling treatment was carried out at a liquor ratio of 1:20 with NaOH, Na_2CO_3, $Na_2S_2O_3$, surfactant Lavotan DSU (Bezema) and levelling agent Sirrix 2UD (Clariant) followed by repeated hot and cold washing.

Bleaching treatment was carried out at a liquor ratio of 1:20 with H_2O_2, Na_2CO_3, Na_2SiO_3 followed by repeated hot and cold washing and drying at temperature room (22°C) for 72 hours.

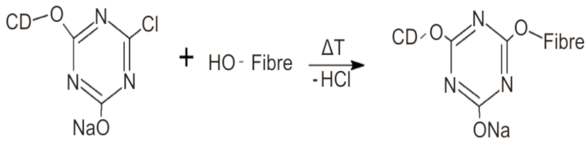
Host and guests compounds

To form temporary reservoirs of natural products (active principles), a reactive cyclodextrin derivative called monochlorotriazinyl-beta-cyclodextrin (MCT-β-CD, supplied by Wacker Chemie) has been used as a host compound. The functionalization of fabrics with MCT-β-CD provides hosting cavities that can include a large variety of chemicals [16] for specific textile finishing.

The grafting treatment was carried out at a liquor ratio of 1:10 with MCT-β-CD and Na_2CO_3. The treatment consisted in the following phases:

- impregnating of knitted fabric in MCT-β-CD and Na_2CO_3 solution for 2 minute followed by padding stage (on Benz foulard) at squeezing ratio 135%;
- drying for 10 minutes at 80°C (on Mesdan Lab Dryer);
- curing (using Mesdan Lab Dryer) at 160°C for 7 minutes;
- repeated hot (90°C) and cold washing up to *p*H = 6.5–7 to remove the reaction products;
- drying at temperature room (22°C) for 72 hours.

MCT-β-CD is fixed to cotton fibre by a nucleophilic substitution reaction induced by elevated temperature [16], as is shown in reaction (1):



(1)

Three different natural active principles which were included in cavity of the cyclodextrin derivative (grafted on surface fabric) were used in this study as a guest compounds. The active principles with anti-allergic activity are illustrated in table 1.
To assess the possibility of penetrating into the hydrophobic cavity of the cyclodextrin product, we have determined and measured the specific conformation and dimensions of menthol and some classes of compounds from Viola tricoloris herba and propolis. Because Viola tricoloris herba and propolis are not pure compounds (they include many components such as flavonoids, terpens, esters and others components), we have performed a characterization of ferulic acid, flavonoids, solanine and antocians compounds which are responsible for anti-allergic action. The data have been published by Radu et al. [14]. All compounds can penetrate and establish sorption interactions within the inclusion compound. An example for a compound included in the cyclodextrin cavity is illustrated in figure 1.
One can notice that, due to the characteristic dimensions of menthol (length = 6.94 Å and width = 2.54 Å) it can easily penetrates inside of β-cyclodextrin cavity which has 6.2 Å inner diameter and 7.8 Å cavity height [17].
Once included in the cyclodextrin cavity, the active principles can be released in a controlled manner (fig. 2), in our case under the action of dermal stimuli (sweat, temperature, friction). Thus, active principles complexed by fixed cyclodextrin are set free by wearing and can easily penetrate into the skin [17].

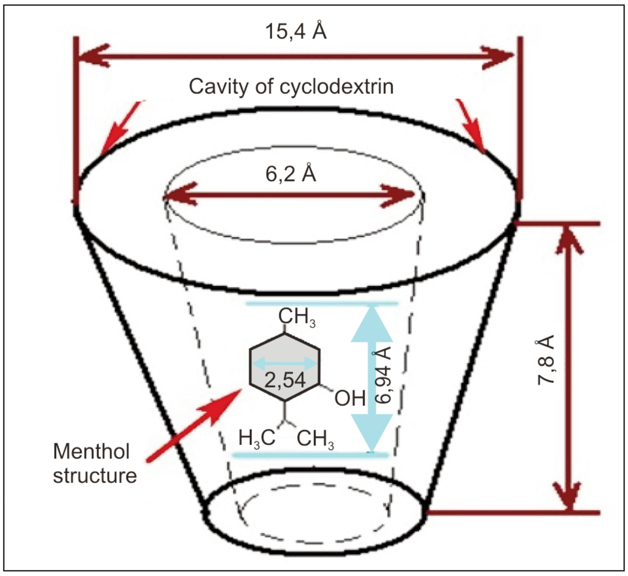


Fig. 1. Active molecule of menthol included in cyclodextrin cavity and characteristic dimensions (Å)

Technique of anti-allergic substance application on grafted fabrics

The anti-allergic substances have been applied on the grafted textile surface by a spraying technique in working conditions at temperature room (22°C), followed by a heat treatment at 50°C (in Venticell 22 drying chamber) for 4 hours. The optimal amount of active principles which was applied on fabrics surface was determined through *in vivo* tests. The procedure and data obtained one presented in works by Radu et al. [3, 19].

Table 1

PRESENTATION OF NATURAL ACTIVE PRINCIPLES		
Natural active principles	**Properties and action**	**Native solution used in experimental work**
Viola tricoloris herba	– a spontaneous plant collected from Romania which is received as gift (from Faculty of Pharmacy, Cluj-Napoca, Romania by courtesy of pharmacist Toiu A.M; – has a strong anti-allergic action and behaves as a skin regenerator according with recommendations for dermatological disorders.	Used as a 25% aqueous extract
Menthol	– synthetic product supplied by Sigma Aldrich (99% purity); – has anti-allergic, anti-itching properties, mostly used against local irritation and contact rashes.	Prepared as a solution of ethanol 30% (w/v)
Propolis	– solid product, collected in 2010 from families of bees in Danesti area (the eastern part of Romania); – has antiseptic, antimycotic, bacteriostatic, astringent, choleric, spasmolytic, anti-inflammatory, anesthetic and antioxidant properties.	The solid product was dissolved by stirring in ethanol (96%) for 48 hours at 30°C. The solution was filtered twice on a filter paper. The filtrate was concentrated by vacuum evaporation. The solid filtrate was conditioned and weights and then dissolved again in ethanol (96%) at 30°C forming a solution of 30% (w/v).

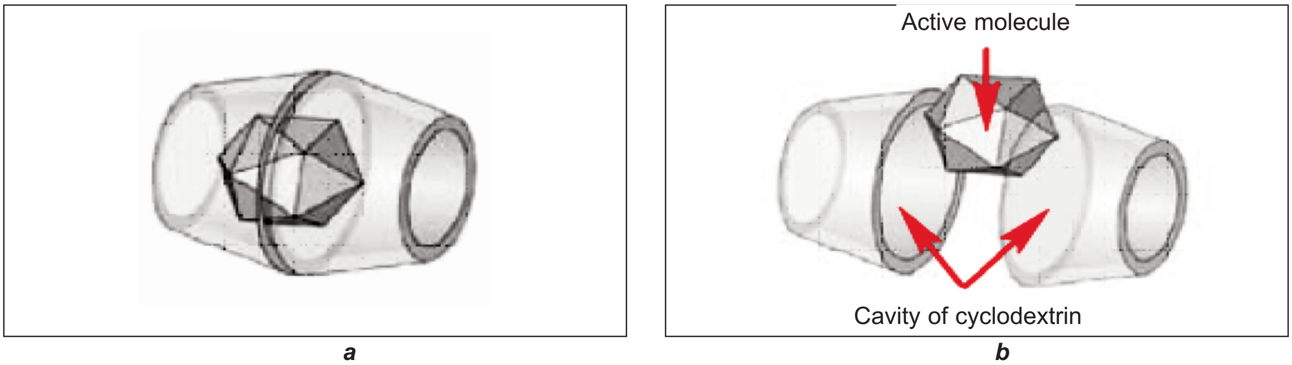


Fig. 2. The mechanism of cyclodextrin cavity for controlled release of various active molecules:
a – the incorporation of active principle in cavity of cyclodextrin;
b – the release of active principle under various stimuli (according to Andreaus et al. [17])

Knitted fabric used in experimental tests

Six different untreated and functionalized knitted fabrics were investigated in study. Table 2 illustrates tested fabrics processing variants.

Methods used

Comfort tests methods

The paper presents comfort measurements of knitted fabrics presented in table 2. The aim consists in the evaluation of anti-allergic fabrics response in terms of dermic comfort (water vapour permeability, relative water vapour permeability, thermal resistance, air permeability, wettability, humidity profile and conduction, all named moisture management properties) by comparison with a witness fabric.

The experimental tests were carried out in the Laboratory of Advanced Textile Technology (LATT, Biella) from Department of Materials Science and Chemical Engineering, Polytechnic University of Turin, Italy. The knitted fabrics were conditioned for 48 hours in standard atmospheric conditions of temperature 20 ± 2ºC and 65 ± 2% RH (relative humidity) before starting testing.

Water vapour permeability, relative water vapour permeability and thermal resistance were evaluated on Permetest instrument (Czech Republic) according to ISO 11092:1993 Standard. The ability of a garment to transfer moisture is related to the water vapour resistance of the fabric. According to ISO 11092, the vapour resistance under steady state conditions is measured via the skin model (Permetest) [20]. Water vapour permeability and relative water vapour permeability measurements were conducted in a climatic chamber under controlled conditions at 35ºC and 40% RH (different from standard conditions) and thermal resistance was determined under controlled standard conditions. The obtained data represent an average of 6 tests evaluated on Permetest.

The air permeability was investigated on Branca IdealAir (Italy) instrument with an applied pressure of 100 Pa, according to EN ISO 9237:1995 Standard. The air permeability of textile fabrics is determined by the air flow passing perpendicularly through a given area of fabric (in our case the tested area was 2 cm^2) by measuring the pressure loss over a given time period. The obtained data are the average of 10 tests determined on Branca IdealAir.

The tests on fabric wettability have been conducted on Tensiometer KRÜSS K100SF (Germany) device under standard atmospheric conditions 20°C and 65% RH. A capillary rise method was applied to evaluate the liquid sorption of fabrics. The quantitative wetting of fabrics was determined by surface tension and contact angle. The instrument measured the weight of liquid wicking into vertical strips of knitted fabrics, when the fabric is wetted by capillary rise. During the measurements, the hanging strips of fabric were put into contact with the surface of the liquid without being immersed. The wettability measurements were performed on each direction of knitted fabrics (wale and course). The data obtained repre-

Table 2

THE VARIANTS OF KNITTED FABRICS USED IN EXPERIMENTAL TESTS		
Code	**Knitted fabric variants**	**Indication of functionalized fabric variant**
I	Witness fabric	Alkaline boiling and bleaching treatments
II	Grafted fabric	Grafting with MCT-β-CD
III	Knitted fabric functionalized with Viola tricoloris herba	Treatment with Viola tricoloris herba
IV	Knitted fabric functionalized with menthol	Treatment with menthol
V	Knitted fabric functionalized with propolis	Treatment with propolis
VI	Knitted fabric functionalized with menthol + propolis	Treatment with menthol and propolis

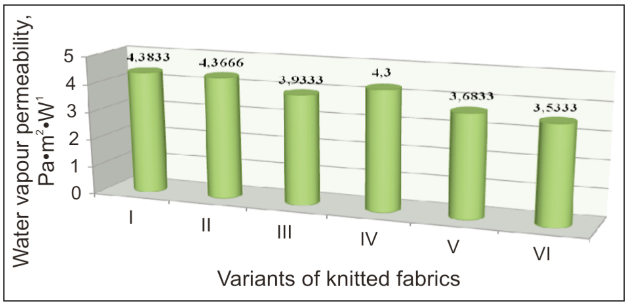


Fig. 3. Values of water vapour permeability for witness and functionalized fabrics

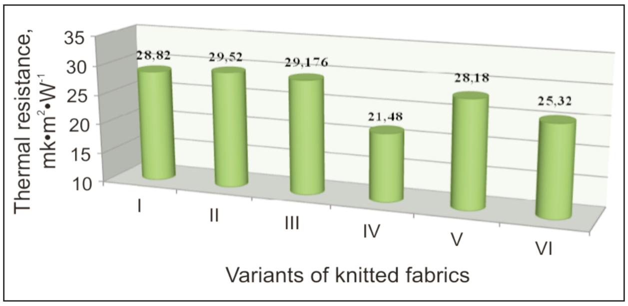


Fig. 5. Values of thermal resistance for witness and functionalized fabric

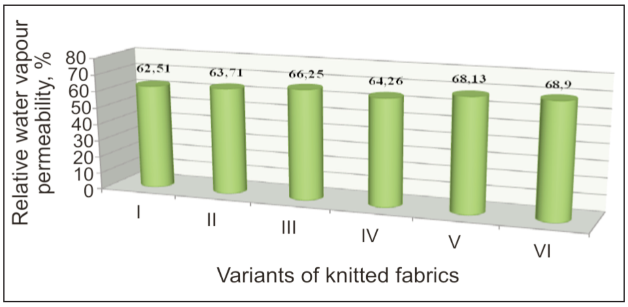


Fig. 4. Values of relative water vapour permeability for witness and functionalized fabrics

sent an average of 3 tests evaluated on KRÜSS tensiometer.

The tests on humidity profile and conduction (moisture management properties) were carried out on Moisture Management Tester M290 SDL (MMT) Atlas (England) instrument under standard atmospheric conditions (65% RH and 20°C). The experiments have been made according to AATCC Test Method 195: 2009. The moisture management properties were determined through the utilization of a test solution (prepared with distilled water and sodium chloride). The test solution was transferred onto the fabric surface in three directions such as mentioned in Test Method 195. The obtained data represent an average of 2 tests realized on MMT instrument.

RESULTS AND DISCUSSIONS

It is well known that the finishing treatments, thickness and texture of textile samples or yarn fineness represent parameters with significant implications for comfort properties. Figures 3–9 present the results of comfort measurements evaluated in the study.

Water vapour permeability

Yao et. al. [21] communicated that the high water vapour permeability of cotton fabric indicates higher vapour evaporation from the skin, which provides breathable cloth, as compared to a polyester fabric. According to figure 3, ungrafted witness fabric (sample I), grafted fabric (sample II) and fabric functionalized with menthol (sample IV) present the greatest water vapour permeability values (approximate 4.3 Pa·m^2·W^{-1}) as compared to knitted fabric functionalized with menthol + propolis (sample VI), where water vapour permeability value is smaller (3.5333 Pa·m^2·W^{-1}). As one can see from the presented results, the knitted fabrics functionalized with anti-allergic substances have the smallest values of water vapour permeability, except for the fabric treated with menthol, which has more or less the same value as previously noted. A possible explanation may be the presence of hydrophobic principles, such as Viola tricoloris herba and propolis, which avoid the adsorption of vapour molecules on cotton fibre. In case of fabric treated with menthol, which presents OH^- hydroxil group available for water vapour adsorption, water vapour permeability does not significantly change.

Relative water vapour permeability

The high values of the relative water vapour permeability show that all the fabrics are strongly transpiring [20]. Under the conditions of the study (fig. 4) knitted fabrics functionalized with menthol and propolis (samples V and VI) have high value of relative water vapour permeability (approximate 68.9%), followed by knitted fabric functionalized with Viola tricoloris herba (66.25%) in comparison with witness fabric (62.5166%). It has been noticed that the value for the witness sample is not so different as compared to the values of functionalized samples.

Thermal resistance

Thermal resistance represents the property of a textile material to keep the heat inside. Gun [22] reported that the higher the thermal resistance, the lower the heat loss. Also, Oğlakcioğlu and Marmarali [23] confirmed in their work that if the thermal resistance of fabric is small, the heat energy will gradually diminish in the sense of cooling. From figure 5 one can notice that knitted fabric functionalized with menthol (sample IV) presents the lowest value of thermal resistance (21.48 mk·m^2·W^{-1}). The effect is due to the cooling effect assigned to menthol. The results also indicate that the thermal resistance increases for knitted fabrics functionalized with menthol + propolis (sample VI = 25.32 mk·m^2·W^{-1}).

Air permeability

The values of knitted fabrics air permeability are presented in figure 6. One can remark that the fabric grafted with MCT-β-CD (sample II) and fabrics grafted and functionalized with active principles (samples

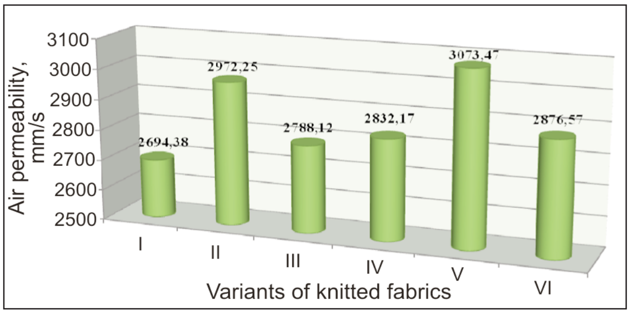


Fig. 6. Values of air permeability for witness and functionalized fabrics

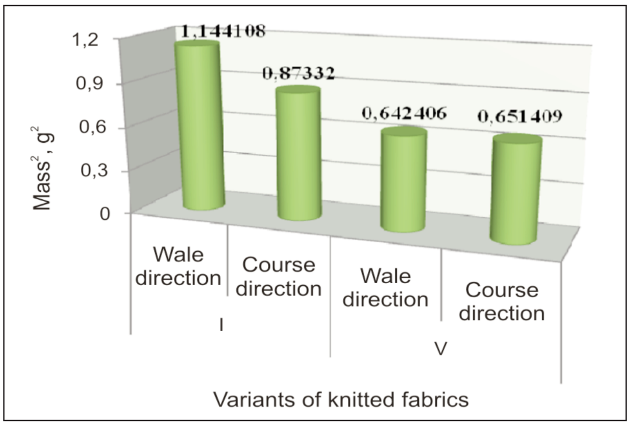


Fig. 7. Mass of liquid absorbed for witness and fabric functionalized with propolis

III, IV, V and VI) have the highest values of air permeability as compared to the witness sample (I). It has been expected that the addition of cyclodextrin product and active principles reduce the fabric porosity and decrease rather than increase air permeability. A possible cause of the slight increase of air permeability value can be the changing surface structure of knitting fabrics suffered in the padding processing specific for grafting treatment. The knitted fabrics under investigation are quite deformable and a light stretch in the padding stage may have changed the structure, thus affecting air permeability.

Textile wettability

As has been mentioned before, the wettability measurements were performed on wale and course directions of the witness fabric (sample I) and knitted fabric functionalized only with propolis (sample V). The liquid weight gain with time (120 s) for knitted fabrics have been taken in account. In figure 7 the square of the amount of liquid absorbed (the mean of weight gain in g^2) for investigated fabrics coded with I and V is illustrated. The amount of liquid depends on determination direction (wale/course) and fabric treatment. For example, for witness fabric the amount of liquid absorbed in course direction (1.144108 g^2/120 s) differs from wale direction (0.87332 g^2/120 s), while no appreciable difference was observed in the two directions for the treated fabric. In particular, the amount of liquid absorbed (approximate 0.65 g^2/120 s) for knitted fabric treated with propolis on wale and course directions is smaller than for the untreated fabric. This situation may be due to the presence of propolis that covers the surface of the fabric, making it more hydrophobic.

Moisture management properties

The data of moisture management properties (overall liquid moisture management capability and one-way transport capacity) of knitted fabrics are summarised in figures 8 and 9.

One-way transport capacity shows the difference between the areas of the liquid content of fabric versus time (120 seconds). Overall liquid moisture management capability represents an index of the overall capability of fabrics to transport moisture.

The highest one-way transport capacity (%) and highest overall liquid moisture management capability values show that liquid/sweat can be easily and quickly transferred from the skin to the outer surface [24]. The diagrams from figures 8 and 9 reveal that fabric grafted with MCT-β-CD and treated with propolis (sample V) has the highest one-way transport capacity (2220.0371%), and fabric treated with menthol presents the highest overall liquid moisture management capability (IV = 0.911). This value is quite closed to overall liquid moisture management capability value of the fabric treated with propolis (sample V = 0.8934). It means that the fabrics treated with propolis and menthol present good properties of liquid transport from cutaneous level to environment. Hes and Williams [26] accentuated that the movement of liquid sweat away from the skin plays an important role in comfort, so that the presence of

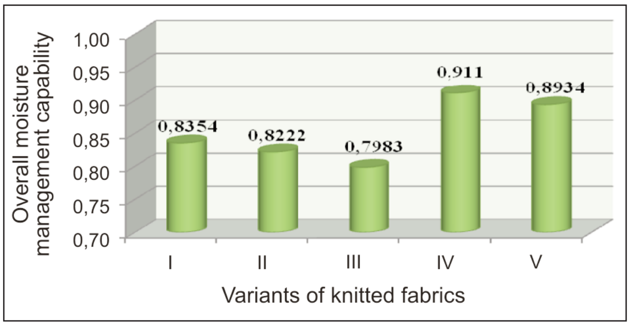


Fig. 8. Values of overal capability for witness and functionalized fabrics

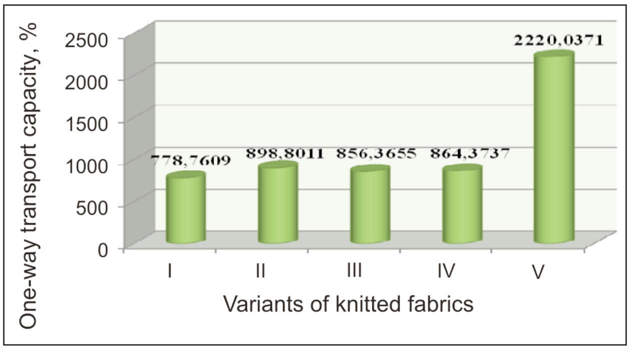


Fig. 9. Difference values between areas of liquid content for witness and functionalized fabrics

liquid sweat on the surface of the skin often gives rise to a feeling of discomfort. In treatment of skin diseases this can become an advantage because at the direct contact of the textile material with the skin, the presence of small amounts of water on the skin surface is essential for the release of the active principles from cyclodextrin cavity grafted on textile support [17]. One can say that knitted fabric treated with menthol and knitted fabric treated with propolis can give the most outstanding feeling of comfort next to the skin contact.

The values of moisture management properties are consistent with the wettability measurements. Thereby, according to moisture management measurements presented in another paper [26], the wetting time (in seconds) and absorption rate (%/seconds) for fabric side functionalized with propolis that comes in direct contact with the skin are very slow. This denotes the hydrophobic character of propolis which diminishes the liquid sorption capacity of the textile material.

CONCLUSIONS

Comfort properties of knitted fabrics functionalized with Viola tricoloris herba, menthol and propolis are not affected, as compared to the comfort properties of witness sample. Propolis application on fabric surface diminishes the liquid sorption capacity of the tested fabrics.

According to the experimental conditions, functionalized knitted fabrics offer a high comfort status in interference with damaged skin of patients with skin allergic diseases.

Acknowledgments

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Authors:

Ph.D. student MIHAELA HRIȚCU - ŞALARIU
Assoc. prof. DORU RADU
Prof. dr. eng. AURELIA GRIGORIU
Technical University Gheorghe Asachi
Faculty for Textile-Leather and Industrial Management
53-55 D. Mangeron, 700050 Iasi

Assoc. prof. ADA FERRI
Polytechnic University of Turin
Department of Materials Science and Chemical Engineering
10129 Turin, Italy

Corresponding author:
MIHAELA HRIȚCU - ŞALARIU
e-mail: miha.hritcu@yahoo.com

INDUSTRIA TEXTILĂ ÎN LUME

CERERE CRESCUTĂ DE FIBRE INTELIGENTE

AGY a mărit cu 20% producția de armături din fibră de sticlă *S-2*, existând posibilitatea extinderii în continuare, în funcție de cerințele pieței.

Fibrele de sticlă S-2 sunt produse în exclusivitate de AGY şi sunt furnizate pe o mare varietate de piețe. În industria aerospațială, fibrele de sticlă S-2 oferă proprietăți de ranforsare unice, foarte importante pentru aplicațiile aerospațiale de înaltă performanță, cum sunt paletele elicei de elicopter, podeaua, interiorul şi părțile structurale ale aparatelor de zbor.

AGY oferă produse din fibră de sticlă astfel proiectate, încât să fie compatibile cu răşinile fenolice, epoxidice, poliesterii, esterii vinilici şi cauciucul, precum şi cu multe răşini termoplastice.

Sticla S-2 are o rezistență la întindere mai mare decât cea a fibrei de carbon cu modul standard şi decât cea a majorității fibrelor aramidice.

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Treatment of cotton fabric with SnO_2 nanoparticle and chitosan

ZHANG HUI LINLIN ZHU

REZUMAT – ABSTRACT

Tratamentul țesăturilor de bumbac cu nanoparticule de SnO_2 şi chitosan

Pentru creşterea rezistenței vopsirii țesăturilor de bumbac la radiațiile ultraviolete, nanoparticulele de SnO_2 au fost mai întâi modificate cu agentul de cuplare silan KH560 şi apoi au fost introduse în lichidul de finisare cu chitosan, cu o masă moleculară mai mică de 5 000 şi un grad de deacetilare 0.86, iar apoi au fost vopsite cu Reactive Navy Blue R-X. Au fost investigate caracteristicile structurale ale fibrei de bumbac, folosind microscopia cu scanare electronică, spectroscopia în infraroşu cu transformata Fourier, metode termogravimetrice şi calorimetrice cu scanare diferențială. Au fost analizate unele proprietăți precum spectrul de reflectanță, rezistența la încovoiere şi tracțiune, randamentul tinctorial şi rezistența la vopsire a țesăturii de bumbac, înainte şi după tratare. Rezultatele arată că, în comparație cu țesătura inițială de bumbac, performanțele termice ale țesăturii tratate cu SnO_2/chitosan au fost mai bune. A crescut capacitatea țesăturii de bumbac de a reflecta radiațiile ultraviolete. De asemenea, au crescut rigiditatea la încovoiere şi rezistența la tracțiune, însă sarcina de rupere a scăzut. Totodată, s-a micşorat rezistența vopsirii la frecare şi la curățare umedă, însă rezistența la lumină s-a îmbunătățit.

Cuvinte-cheie: țesătură de bumbac, nanoparticule de SnO_2, chitosan, tratare

Treatment of cotton fabric with SnO_2 nanoparticle and chitosan

In order to improve the color resistance to ultraviolet radiation, SnO_2 nanoparticles were first modified with silane coupling agent KH560, and then were added to the finishing liquid of chitosan of molecular weight less than 5 000 and degree of deacetyaltion 0.86 to treat cotton fabric, followed by dyeing with Reactive Navy Blue R-X. The structural features in cotton fibre were investigated by means of scanning electron microscope, Fourier transform Infrared spectroscopy, thermogravimetric and differential scanning calorimetry techniques. The properties including reflectance spectrum, bending, tensile, color yield and color fastness of cotton fabric before and after treatments were measured. Results indicated that as compared with the original cotton fabric, the thermal performance of the SnO_2/chitosan treated fabric behaved better. The ability of cotton fabric to block ultraviolet light was enhanced. The bending rigidity and tensile strain increased, but the breaking load decreased. The color fastnesses to rubbing and wet scrubbing decreased, however the color fastness to light was improved.

Key-words: cotton fabric, SnO_2 nanoparticle, chitosan, treatment

Chitosan, a functional biopolymer, has received much attention because of its many unique properties e.g. biocompatibility, biodegradability, biological activity, nontoxicity, cationic nature, and solubility in available aqueous solvents [1]. The molecular unit of chitosan contains one amino- and two hydroxyl groups potentially capable of reacting with aliphatic and aromatic anhydrides. In acid medium, chitosan reacts at the amino group [2]. In the textile industry, chitosan has been widely studied for effects such as shrink resistance [3–5], improved dye uptake [6, 7], durable antimicrobial activity even after repeated launderings [8, 9], and as auxiliary or anti-static agents [10], and etc. It was reported that cotton fabric treated with chitosan was then dyed with reactive and direct dyes without the addition of salt. The color yield *K/S* value and wash fastness showed better than the untreated cotton fabric, but the light fastness was inferior to that on untreated one. The antimicrobial activity of treated cotton fabric was lower considerably after dyeing, probably due to the antimicrobial effect of the cationic group on chitosan being blocked by its combination with the anionic dye [11, 12].

The ultraviolet radiation can damage cotton fabric, especially the degradation of the color, if it is exposed to excessive amounts [13]. Stannic oxide (SnO_2) can be used as a solid state gas sensor material, oxidation catalyst, and transparent conductor. The dual valence of Sn facilitates a reversible transformation of the surface composition from stoichiometric surfaces with Sn^{4+} surface cations into a reduced surface with Sn^{2+} surface cations depending on the oxygen chemical potential of the system. Critical for triggering a gas response are not the lattice oxygen concentration but chemisorbed oxygen and other molecules with a net electric charge [14]. The sensing mechanism of SnO_2 is usually based on the change of the resistance of the sensor in different gas environment. In air, the surface-adsorbed oxygen species on the surface of SnO_2 act as surface acceptors of electrons, hence diminishing the conductivity of SnO_2 [15]. However, there have been few investigations involving SnO_2 nanoparticles applied to cotton fabric. In order to impart effective protection against ultraviolet radiation, we employed the chitosan processing solution mixed with SnO_2 nanoparticle to deal with cotton fabric with the help of citric acid as the crosslinking agent, followed by dyeing using Reactive Navy Blue R-X. The morphology, structure, thermal stability and optical properties of cotton fabric before and after treatments were characterized by scanning electron microscope (SEM), Fourier transform infrared spectroscopy (FT-IR), thermal gravimetric (TG), differential scanning calorimetry (DSC) and reflectance spectrum. The bending, tensile, color yield and color fastness to rubbing and wet scrubbing of cotton fabric were also investigated.

EXPERIMENTAL PART

Materials used

The bleached cotton fabric (plain weave, number of ends, and picks are 50 and 32 per centimeter, the linear densities of ends and picks are 20 tex and 14.5 tex) was purchased from Shaanxi Tanghua no. 4 Textile Co., Ltd. The chemical used in the present investigation are in analytical reagent grade, and include anhydrous ethanol (C_2H_5OH), acetone (CH_3COCH_3), acetic acid (CH_3COOH), 36% hydrogen peroxide (H_2O_2), sodium hydroxide (NaOH), citric acid ($C_6H_8O_7$), sodium hypophosphite monohydrate ($NaH_2PO_2 \cdot H_2O$), triethanolamine ($C_6H_{15}NO_3$), sodium chloride (NaCl), and sodium carbonate (Na_2CO_3). SnO_2 nanoparticles were provided by Xi'an Jiaotong University in China. The silane coupling agent KH560 ($CH_2CHCH_2O(CH_2)_3Si(OCH_3)_3$) was supplied by Nanjing Daoning Chemical Co., Ltd. Chitosan of molecular weight 250000 and degree of deacetyaltion 0.86 was supplied by Qingdao Heppe Biotechnology Co., Ltd. The Reactive Navy Blue R-X (C. I. Blue 59) was used for dyeing cotton fabric in this experiment.

Modification of SnO2 nanoparticle

First, required amount of SnO_2 nanoparticles (0.2 g) was weighted accurately, and then immersed in the ethanol solution (30 ml) for 10 minutes, and subsequently ultrasonically oscillated in the frequency of 50 KHz for 15 minutes, using a SY2200-T sonicator (Shanghai Shengyuan Supersonic Instrument Equipment Co., Ltd.) at an energy level of 100 W at 40°C. The SnO_2 nanoparticle suspension was centrifuged using a LDZ4-1.8 centrifugal machine (Beijing Jingli Centrifugal Machine Co., Ltd.). The remainder was dried at 80°C for 10 hours in a DZ-2BC vacuum drying oven (Tianjin Taisite Instrument Co., Ltd.). Second, 4 ml of silane coupling agent KH560 was added to 100 ml of ethanol solution (the volume ratio of ethanol to water was 1:1) by dropping under stirring, and the mixture was sonicated for 10 min at room temperature and adjusted *p*H value as 3.5 with acetic acid. Third, the pretreated SnO_2 nanoparticle was mixed with the KH560/ethanol solution and sonicated for 10 minutes at room temperature. After reacting in 60°C constant temperature water bath for 3 hours under stirring, SnO_2 nanoparticle was filtrated using a SHB-3 vacuum pump (Zhengzhou Dufu Instrument Co., Ltd.). They were collected and washed with acetone for 3 times and distilled water until neutral then dried at 40°C for 10 hours.

Treatment of cotton fabric

Firstly, 5.0 g of chitosan was dissolved in 5% acetic acid and 6% hydrogen peroxide, and then ultrasonically degraded for 1.5 h using a SY2200-T sonicator at an energy level of 100 W at 60°C. The degraded solutions were neutralized with 10 g/l sodium hydroxide to precipitate the degraded chitosans. They were collected and washed with distilled water until neutral then dried at 40°C in the vacuum drying oven thereby yielding chitosan with molecular weight of less than 5000. Secondly, 1.2% of degraded chitosan was dissolved in 6% of citric acid solution at room temperature, followed by the addition of 5% of sodium hypophosphite monohydrate, 3% of triethanolamine, 0.2% of penetrating agent JFC and 1% of prepared SnO_2 nanoparticles under stirring, which was mixed to make the chitosan processing solution. The mixture was sonicated for 15 minutes at room temperature. Thirdly, cotton fabric was impregnated in the SnO_2/chitosan finishing liquid at 80°C for 30 minutes at a liquor ratio of 30:1, and padded twice to a wet pickup of 100%. The padded fabric was then dried at 90°C for 150 seconds and cured at 160°C for 90 seconds. Finally, the sample was washed at 80°C for 15 minutes, neutralized with a sodium hydroxide concentration of 0.1 M, again cold washed and dried in air.

Dyeing of cotton fabric

The fabric samples of untreated and SnO_2/chitosan treated were dyed using Reactive Navy Blue R-X dye in the lab. The dyes were applied at 2% owf at a liquor-to-goods ratio of 50:1. 40 g/l of sodium chloride and 10 g/l of sodium carbonate were added. The samples were dipped into the dye bath and kept for 10 min with continuous stirring at 50°C. After this treatment, 20 g/l of sodium chloride was added in the same bath every 10 minutes and kept for 10 minutes under the same condition. The liquor was heated to 90°C at a speed of 2°C/minute, followed by adding 10 g/l of sodium carbonate. The samples were kept for 30 minutes, and then washed in an aqueous solution containing soap 2 g/l and sodium carbonate 2 g/l at boil at a liquor-to-goods ratio of 30:1 for 10 minutes. Finally, the samples were washed with cold water and dried under ambient conditions. The samples were preconditioned before testing in a standard environment according to GB/T 6529-2008.

TESTING METHODS

Size distribution measurement

The size distributions of SnO_2 nanoparticles before and after treatments were determined by using a Mastersizer S laser particle size analyzer (Malvern Instruments Ltd.). The scanning range was from 0.05 μm to 3 500 μm.

Scanning electron microscopy

The surface structures of the fabric samples before and after treatments were mounted on SEM stubs and sputter coated with platinum before examination in a JSM-6700F field scanning electron microscope (JEOL Ltd.). Photographs of the samples with surface characteristics were taken randomly.

Fourier transform infrared spectroscopy

The cotton fibre samples were examined in KBr pellets obtained by pressing the pulverized materials at 1% concentration. The FT-IR spectrophotometer was a TENSOR 27 model (Bruker Corporation), and the spectra were collected with the aid of OMNIC software. The wavenumbers was in the range of 400 cm^{-1} – 4 000 cm^{-1}.

Thermogravimetric and differential scanning calorimetry analyses

Thermogrametric analyses were determined on the samples using a TGA/SDTA851e thermogravimetric/differential thermal analyzer (TG-DTA) instrument (Mettler-Toledo) according to GB/T 13464-2008. Percentage weight change versus temperature was evaluated at a heating rate of 10°C/minutes with a nitrogen flush rate of 30 ml/minutes over the range of 35–550°C. Differential scanning calorimetry (DSC) analyses were performed in a Sapphire apparatus equipped with a DSC 20 cell purged with nitrogen of 30 ml/minutes. The temperature program was set in the range from 35°C to 550°C at a heating rate of 10°C/minute.

Reflectance spectrum testing

The diffuse reflectance profiles of untreated and SnO_2/chitosan treated samples in the 200-800 nm wavebands were measured using a U-3010 UV-visible spectrophotometer (Hitachi Ltd. Scanning speed: 120 nm/minute. Detector: Photomultiplier. Inner face coated with $BaSO_4$. Incident angle on reflective sample was 10° on both standard and reference sides) with an integrating sphere (ø150 mm). The tested sample was overlapped so that the light could not transmit through fabric.

Fabric bending testing

The flexural rigidities of cotton fabric before and after treatments were evaluated using the LLY-01B electrical fabric stiffness tester (Wenzhou Darong Textile Instrument Co., Ltd.) according to GB/T 7689.4-2001. The length of the sample was 15 cm and the width was 2 cm. The bending angle was set on 45°. Values reported were averages of ten measurements.

Fabric tensile testing

Tensile properties of the fabric samples were measured using an YG(B)026D-500 electronic fabric strength tester (Nantong Hongda Experiment Instrument Co., Ltd.) according to GB/T 3923.1-1997. The initial gauge length was 20 cm and the width was 5 cm. The testing rate was 50 mm/minute and the pre-tension was 2 N. Ten samples per treatment set were tested and the breaking load and tensile strain averaged.

Color yield measurement

The color yield *K/S* values of dyed samples at the maximum light absorption wavelength 594 nm were measured under D65/10° illuminant by using a SF300 Plus colorimeter (Datacolor company) using a measuring area with a diameter of 9 mm. The colorimeter was calibrated before testing against a standard white board. Samples were measured three times in each of five sites, and the average of the measurements was recorded as the *K/S* value.

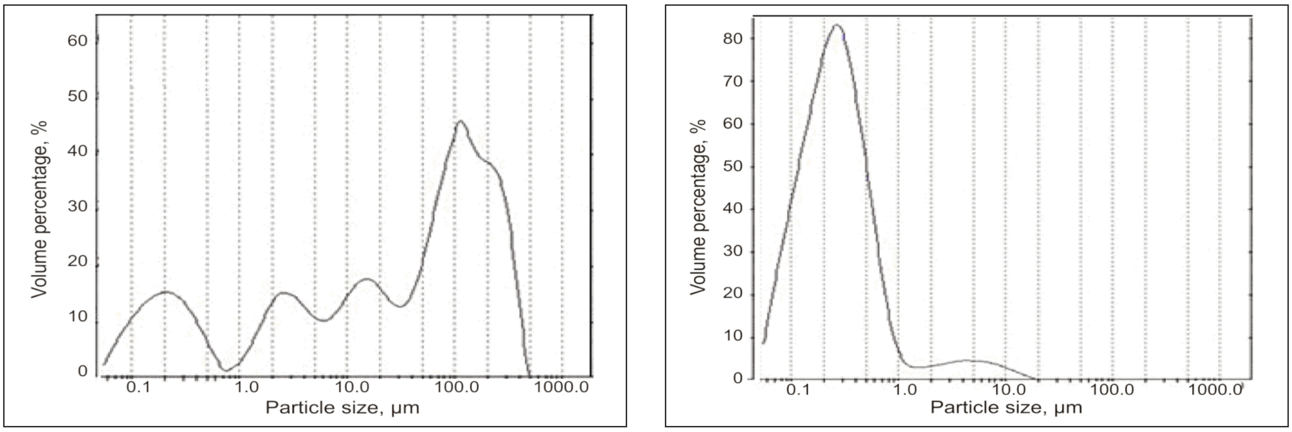
Color fastness measurement

The fastnesses to rubbing, wet scrubbing and light of untreated and SnO_2/chitosan treated samples were evaluated using the YG571 color fastness tester and YG611 color fastness tester (Wenzhou Darong Textile Instrument Co., Ltd.) to assess the color fastness to rubbing, wet scrubbing and light according to GB/T 3920-2008, GB/T 420-2009 and Blue Wool reference, respectively. The color fastnesses to rubbing and wet scrubbing were assessed and sorted into five grades, marked 1, 2, 3, 4, 5, according to ISO/BS standard gray card. The color fastness to light was assessed and sorted into eight grades, marked 1, 2, 3, 4, 5, 6, 7, 8, according to GB/T8427-1998. The smaller the grade, the more obvious were the color changes. All experiments were carried out at least in triplicate.

RESULTS AND DISCUSSIONS

Analysis of particle size distribution

The Debrouckere average diameters (volume moment average values) *D* [4, 3] of SnO_2 nanoparticles were 85.23 μm before treatment (concentration 0.0002% vol.) and 0.58 μm after treatment (concentration 0.0013% vol.), respectively. The corresponding volume middle value diameters *D*(*v*, 0.5) were 45.54 μm and 0.25 μm, and the sauter average values (surface moment average values) *D* [3,2] were 0.87 μm and 0.20 μm. The volume percentages of SnO_2 nanoparticles versus particle size before and after treatments were given in figure 1. It was evident that the particle size distribution of SnO_2 nanoparticles before treatment was between 0.05 and 800 μm with heavy agglomeration (fig. 1 *a*). After being treated with KH560, the particle size distribution was significantly reduced



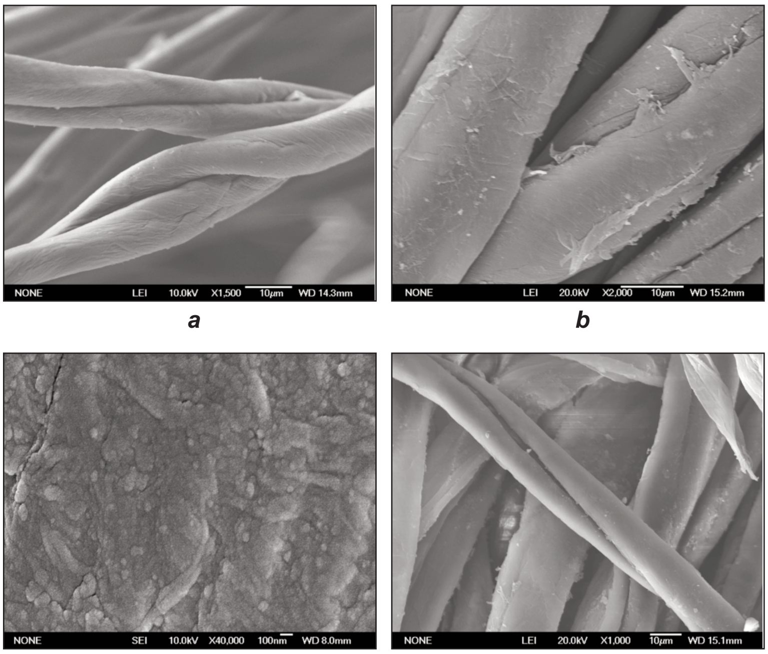
a ***b***

Fig. 1. Particle size distribution of SnO_2 nanoparticles:
a – before treatments; ***b*** – after treatments

and the agglomeration problem was solved, which resulted from a narrow size distribution (fig. 1 *b*). The methoxy groups of KH560 was first hydrolyzed to produce active silanol groups to form polysiloxanes. The polysiloxanes then hydrogened bond with OH groups of SnO_2 nanoparticle. Finally, the covalent linkage was formed with SnO_2 after drying [16].

SEM analysis

The SEM pictures of cotton fabric before and after treatments were showed in figure 2. It was obvious that the surface of untreated cotton fibre was smooth and clean (fig. 2 *a*). When cotton fabric was treated with SnO_2 nanoparticle and chitosan, a layer of transparent substances was coated on the surface of cotton fibre, and some small particles could be seen (fig. 2 *b*), which it might be the mixture of chitosan and SnO_2 nanoparticles adhered on the fibre surface. SnO_2 nanoparticles were homogeneous dispersed in the fibre surface from high magnified image (fig. 2 *c*). After being dyed with Reactive Navy Blue R-X, the fibre surface had a thin layer of matter. A few tiny particles were homogeneously distributed on the fibre surface (fig. 2 *d*).



a ***b*** ***c*** ***d***

Fig. 2. SEM pictures of cotton fibre:
a – 1 500x untreated; ***b*** – 2 000x; ***c*** – 40 000x SnO_2/chitosan treated; ***d*** – 1 000x dyed with Reactive Navy Blue

FT-IR analysis

The spectra of cotton fabric before and after treatments were compared in figure 3. It could be seen that compared with the spectrum of the untreated cotton fabric, the peaks at 3 414 cm^{-1} (OH stretching) and 1 637 cm^{-1} (H_2O group) shifted to 3 350 cm^{-1} and 1 642 cm^{-1}, respectively. The spectrum of the SnO_2/chitosan treated fabric was totally dominated by the spectrum of the original one. The contribution of the KH560 and SnO_2 nanoparticle were negligible. At the same time, the characteristic absorption groups in the range 1 200–1 000 cm^{-1} of chitosan were not detected because of the overlapping. So it was hard to judge whether the chemical modification induced in cotton fibres by SnO_2/chitosan treatment was confirmed. It seemed that the chitosan (Chitosan-NH_2) reacted with citric acid (R-COOH) forming amide bond. The ester linkage was formed between the chitosan and citric acid with NaH_2PO_4 as catalyst during the drying and curing process. The reaction between citric acid and cotton fibre (Cellulose-OH) occurred to form the ester bond. So chitosan was grafted onto cotton fibre using citric acid as polycarboxylic cross-linker [17]. The acetylamino group of chitosan might be considered to form hydrogen bonds with the ring-opening polymerization of epoxy group of KH560.

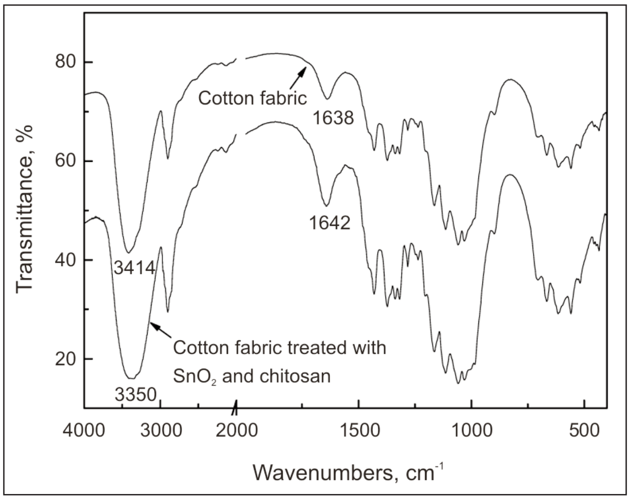


Fig. 3. FT-IR spectra of cotton fabric before and after treatments

endothermal peaks at 35.9°C for the untreated fabric and 68.9°C for the SnO_2/chitosan treated fabric were attributed to the dehydration of absorbed water. The major endothermic peak decreased from 378.1°C to 338.0°C, which was ascribed to the decomposition of cotton fibre.

Reflectance spectra analysis

The diffuse reflectance spectra of the untreated, SnO_2/chitosan treated and washed (30 times) cotton fabrics were presented in figure 5. Compared with the untreated fabric, it could be seen that the average reflectances of SnO_2/chitosan treated fabric were reduced to 34.3%, 40.3% and 22.9% in the ranges of 200–280 nm, 280–315 nm and 315–400 nm, respectively. This was due to the high absorption ability of SnO_2 nanoparticles to ultraviolet rays [18]. We also

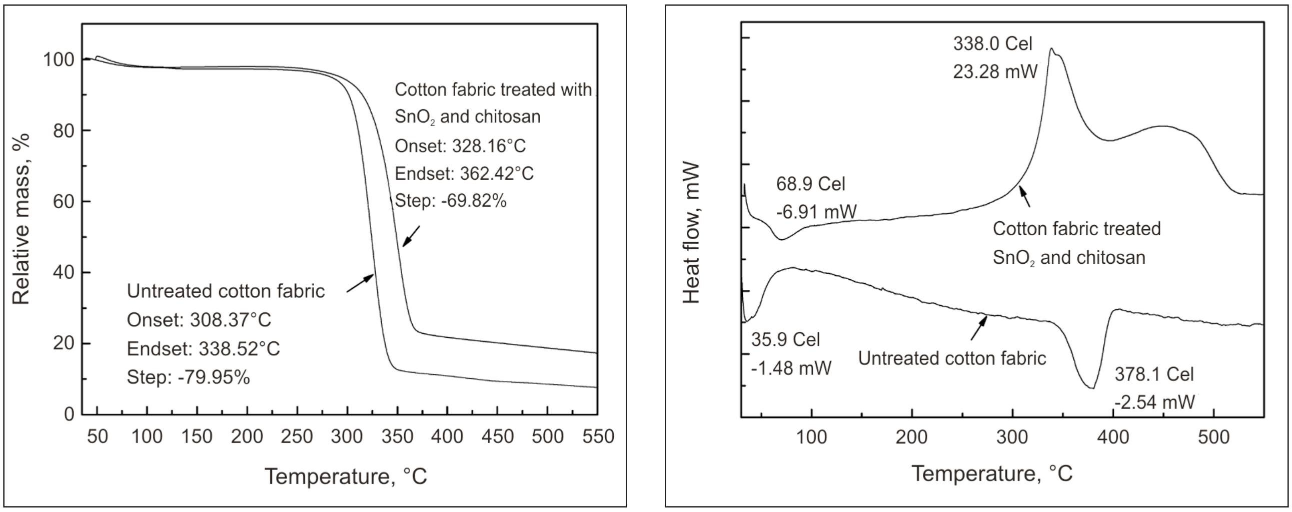


Fig. 4. TG and DSC curves of cotton fabric before and after treatments

$$R - COOH + H_2N - Chitosan \rightarrow$$
$$\rightarrow R - COO \cdot NH_3^+ - Chitosan \quad (1)$$

$$R - COOH + HO - Chitosan \rightarrow$$
$$\rightarrow R - CO \cdot O - Chitosan \quad (2)$$

$$R - COOH + HO - Cellulose \rightarrow$$
$$\rightarrow R - CO \cdot O - Cellulose \quad (3)$$

TG and DSC analyses

The thermograms of cotton fabric before and after treatments were exhibited in figure 4. It was clear from TG curves (fig. 4 *a*) that 20.05% residual weight occurred in the 278.6–359.3°C range for the original fabric. On treating with SnO_2 nanoparticles and chitosan onto cotton fibre, 30.18% residual weight occurred in the range of temperature 290.5–378.4°C. As compared with the untreated fabric, the onset decomposition temperature of SnO_2/chitosan treated fabric increased from 308.37°C to 328.16°C. It was obvious from DSC curves (fig. 4 *b*) that the small

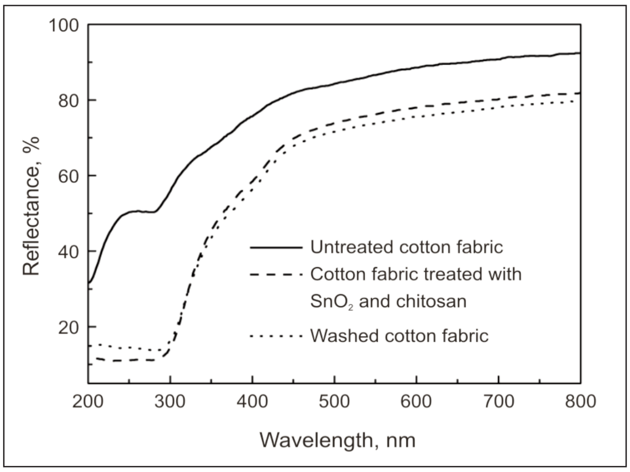


Fig. 5. Reflectance spectra of cotton fabrics

carried out a washing test with IWS TM31 programme of standard. As the number of washing increased, the reflectance had a little increase, but not distinct less than 30 times.

Table 1

STIFFNESS RESULTS OF COTTON FABRIC				
Cotton fabric	**Bending length/cm**		**Bending rigidity/mgf·cm**	
	warp	**weft**	**warp**	**weft**
Untreated	2.33	1.82	189.7	90.4
Treated with SnO_2/chitosan	3.04	2.16	421.4	151.2

Table 2

TENSILE RESULTS OF COTTON FABRIC				
Test targets	**Untreated**		**SnO_2/chitosan treated**	
	warp	**weft**	**warp**	**weft**
Breaking load/N	306	199	30.2	8.4
Tensile strain/%	279	172	34.4	9.8

Bending properties analysis

Table 1 showed the changes in bending length and bending rigidity, which related to the softness of cotton fabric. It was clear that compared with the untreated fabric, the bending rigidities of the SnO_2/chitosan treated fabric increased 122.2% and 67.3% in warp and weft directions, respectively. This was mainly due to the chitosan film coated onto cotton fibre, which resulted in the increase of the resistance to bending.

Tensile properties analysis

Table 2 showed the changes in breaking load and tensile strain, which related to the tensile properties of cotton fabric. It was evident that the breaking load decreased but the tensile strain increased to some extent when cotton fabric was treated with SnO_2/chitosan. Citric acid presented in chitosan processing liquor itself acted as the hydrolyzation catalyst, which could catalyze the hydrolyzation of cellulose and chitosan. The chemical crosslinkage mostly occurred in the amorphous region or in the surface of crystal region. The interfacial forces between the crystal region and the amorphous region were changed. Under the non-homogeneous grafting condition, the distribution of branched chains was nonuniform, and the lengths of the chains were different. Therefore, the movements of the macromolecular chains were restricted, which resulted in the stress concentration phenomenon. So the breaking load decreased and the tensile strain increased for the treated cotton fabric.

Color fastness analysis

The *K/S* value increased from 3.37 to 4.54 when cotton fabric was treated with SnO_2/chitosan. Because cotton fibre developed anionic surface charge (zeta potential) in water, reactive dye (anionic dye) had a low affinity to the cotton fiber. The charge repulsion between dye and cotton fiber could be overcome by adding chitosan. Cotton fibre was cationized through chemical modifications with chitosan containing cationic group [2]. So these cationic groups could absorb the reactive anionic dyes by electrostatic attraction. After treating with SnO_2/chitosan, the color fastnesses to dry and wet rubbing and wet scrubbing were reduced from grade 5, 4 and 5 to grade 4, 3 and 4.5, respectively. The color yield of the dyed cotton fabric mainly depended on the severity of the degree of reaction between dye molecules and the hydroxyl groups of cotton cellulose. The immobilized SnO_2 nanoparticles could impede the dye absorption during the dyeing process. The unfixed dye molecules were removed from the fabric after being rubbed or scrubbed.

However, the color fastness to light was improved from grade 3 to grade 5, which was attributed to the optical transition of SnO_2 nanoparticles [19].

CONCLUSIONS

In the present work, cotton fabric was first treated with chitosan and SnO_2 nanoparticle modified with KH560, and then dyed using Reactive Navy Blue R-X. The correlation between the structure and properties of cotton fabric before and after treatments was investigated. The treatment affected the surface configuration, the thermal stability of cotton fibre. The properties of reflectance spectrum, bending, tensile, dyeing and color fastness were changed. The particle size distribution showed that the agglomeration of SnO_2 nanoparticle was prevented effectively after being modified with KH560. SEM and FT-IR showed that the cotton fibre was coated with a layer of chitosan film mixed with SnO_2 nanoparticles, and SnO_2 nanoparticles were closely anchored on fibre surface by the synergistic effect of chitosan and citric acid. TG and DSC showed that the thermal stability and percent residual weight increased. The flexural rigidity increased but the tensile properties decreased. The color yield and color fastness to light were improved. The color fastnesses to rubbing and wet scrubbing became worse.

Acknowledgement

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Authors:

ZHANG HUI
LINLIN ZHU
School of Textile and Materials
Xi'an Polytechnic University
19 South Jinhua Road, Beilin District
Xi'an 710048, Shaanxi Province, P. R. China
e-mail: hzhangw532@xpu.edu.cn

Strategic entrepreneurial management – necessity and opportunity

DOINA I. POPESCU MIRCEA STELIAN DRĂGHICI

REZUMAT – ABSTRACT

Managementul strategic antreprenorial – necesitate şi oportunitate

Lucrarea prezintă conceptul de management strategic ca un demers decizional complex, interactiv, global şi deschis, dinamic şi prospectiv, precum şi factorii care concură la relansarea spiritului antreprenorial, subliniind necesitatea identificării criteriilor determinante pentru succesul pe termen lung al întreprinderii, ca opţiune determinantă în managementul strategic. Astfel, schimbarea factorilor de pe piaţă şi mutaţia valorilor sociale conduc inerent la schimbarea strategiei. În acest context, implementarea strategiei inovării constituie un răspuns la schimbările factorilor exogeni şi/sau endogeni de mediu. De asemenea, sunt prezentate atât strategiile integratoare ale calităţii şi rolul lor în supravieţuirea întreprinderii, cât şi rezultatele unui sondaj pe bază de chestionar cu privire la strategiile folosite de firmele din industria de confecţii îmbrăcăminte din România, industrie reprezentativă pentru strategiile antreprenoriale folosite.

Cuvinte-cheie: management strategic, analiză strategică, decizii operaţionale, decizii de pilotaj, decizii strategice, management strategic antreprenorial, cultură inovativă, strategii integratoare ale calităţii, industria de confecţii îmbrăcăminte

Strategic entrepreneurial management – necessity and opportunity

This paper presents the concept of strategic management as a complex, interactive, global, open, dynamic and prospective decision-making approach, as well as the factors that contribute to the entrepreneurial spirit recovery, stressing the need to identify the dominant criteria for long-term success of the enterprise as a crucial option in the strategic management. Thus, the change of market factors and movement of social values inherently lead to the strategy change. In this context, implementation of innovation strategy is a response to the changes of exogenous and/or endogenous environment factors. The integrated quality strategies and their role in the company's survival as well as survey results on strategies used by companies in the textile-clothing industry in Romania, a representative industry for the entrepreneurial strategies used are also presented.

Key-words: strategic management, strategic analysis, operational decisions, pilot decisions, strategic management, entrepreneurial strategic management, innovative culture, integrative quality strategies, textile and clothing industry

ACTION FIELDS FOR STRATEGIC MANAGEMENT

Strategic management is a dynamic process, in which, via strategic decisions, company managers foresee and ensure future company changes, under the impact of environmental endogenic and exogenic constraints.

The concept of strategic management is opposing the company's short term operational administration, integrated into a triple logic [1]:

- a company's global approach, the former one being considered a system built of sub-systems (e.g. functional) that are in permanent interaction with each other, and is, especially, a system open to its environment with which is found in constant interdependency;
- a voluntarist, anticipative and proactive attitude, implying choices and decisions for the future, in uncertain and unknown universes, opposing a simple extrapolation in time of the company's present situation;
- an approach connected to time and duration, the strategic decision implying harmonious company organization in the future, maintaining a certain permanency in the effort for reaching the established objectives.

Every company (firm), in order to define itself as a global entity, open to its environment, like every system, includes three components:

- inputs, that is, the resources it needs, regrouped into four great categories:
  - physical resources, largely including primarily raw materials and equipments;
  - financial resources available for the company on the short and long run;
  - human resources that bring ideas, know-how and organizing;
  - information, the company being considered as a machine for transforming internal and external information, essential to its functioning and even survival;
- the transformation process of the various resources (the "black box");
- outputs of the company as a system, taking the form of:
  - products and/or services that the company is taking out on the market;
  - financial results, as positive as possible;

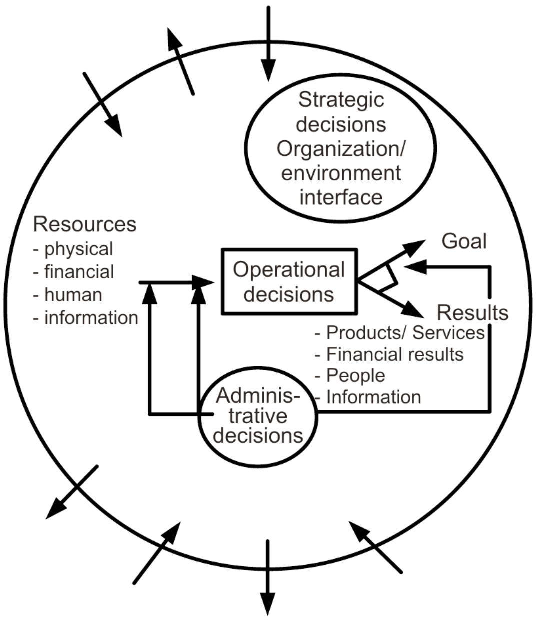

Fig. 1. Types of decisions inside an organization
Sourse: Oreal, S. Management strategique de l'entreprise, 1993, p. 21

– people, in the generic sense of the term, very different, to the extent to which their integration in the company's organized system causes them multiple transformations, negative (fatigue, stress, conflicts etc.), or positive (the work itself and the interest which it triggers, promotions, accumulated experience, complementary training etc.);
– information, often internal, different from the one found in the system's input, but complementary.

Based on the above, company`s management is able to take decisions which may be: operational decisions, administrative decisions and strategic decisions. Figure 1 offers a schematic representation for organizational decision types.

Operational decisions

Operational decisions constituting the central part of the company's system, regard the quasi daily life of the various services/departments: production, commercial, supervision, human resources. They have but short term effects. These decisions are taken on the grounds of a relatively limited number of decisional variables, almost always the same, in the context of limited levels of risk and uncertainty.

Administrative decisions

Administrative decisions are connected to the necessity of identifying the emerging gaps between the pre-established goals and forecasts, on one side, and the results, that is, the real outputs of the company's system, on the other side. These decisions also regard the analysis of the sources and causes that have generated the mentioned gaps, and also taking the necessary corrective measures. These decisions take into consideration the company's strategy very rarely, focusing on the 'navigation' function, that is, on a better administration of the company, inside a strategic axis, voluntaristic predefined, and on taking the corrective actions in order to bring the company back to its strategy's coordinates.

Strategic decisions

Strategic decisions are situated in the interface area between the company's system and its environment, and focus on the administration of the one-to-one interrelations, knowing that the various environments of the company are more and more unstable and contain numerous actors that look for their own strategies. Being connected to the long-term administration of the company, the strategic decision represents the most important part of the company's coordination function.

Decisions making

Decisions making or the strategic approach is based on the iterative logic, according to a classic decisional model, having four essential phases:
- problem situation diagnosis and analysis (the traditional internal and external analyses);
- decision taking, based on solution selection according to goals, from more alternatives and taking into consideration the pre-established criteria;
- action, that is, to put into practice the taken decision;
- control, meaning to verify if the pre-defined goals have been reached.

Consequently, the concept of strategic management – a concept much broader than the notions of strategy and general policy, which are included in it – relies on a decisional approach (S. Oréal, 1993, p. 28). Thus, the decisional approach is:
- complex – the number of variables that can influence the decision is considerable;
- interactive, more than sequential – even if the different stages can be exactly identified by the company, they cannot be separated – but in rare cases – and they permanently overlap;
- global and open – the company cannot survive in a closed container;
- dynamic and prospective – it is about preparing the company's future and not about explaining its present situation.

TOWARDS AN ENTREPRENEURIAL STRATEGIC MANAGEMENT

The last decade of the 20^{th} century has been characterized by a real revolution in the economic system of the developed countries, revolution that has extended to the ex-socialist countries that opted for the transition to a free-market economy. We are talking about the conversion from a managerial economy to an entrepreneurial one, under the pressure of a complex of interdependent factors [2, 3], among which can be mentioned:
- the level of "current consumption goods' demand saturation, that has as an effect the emergence of

the hyper-segmentation phenomena, in the context of the transition from standardization preeminence to that of client satisfaction, especially from the perspective of the complementary services" (utilities) quality, incorporated in the attributes package that defines, in the modern acceptance, the concept of a total product. Thus, the company is pressed to adopt more profound segmentation strategies, offering for each consumer segment the most suitable products to their needs. Real "packages" of complementary goods and services are being proposed, which bring a global solution (and a personalized one, if possible) to clients' consumption problems. For instance, the automotive builders, having the status of vehicle suppliers, have become "mobility architects", designing complete "packages" that include offering a vehicle, an insurance contract, a maintenance service package [4];

- the mega-company, which often offers privileges to internal transactions, "reconfigures" itself on open markets and the "key-theories" of the managerial society, essential in the "classic" strategic marketing, become inoperative. Consequently, under the double pressure of the clients and competitors, the company (organization) is forced to an increased reaction capacity, that becomes an advantage for small companies;
- economies of scale (that have proven their efficiency only in several processing industries) become "uneconomies" of scale. Therefore, when the necessity to offer services predominates (for example, the geographical or transactional proximity with the client), the large size of the company represents an impediment;
- economies of experience and apprenticeship (professional training) become more like disabilities in a strategy focused on rapid and sometimes drastic changes. The strategic change is hindered by the switching costs, established by the non-recoverable expenses and the social costs of market exiting;
- economies of scope become a disability to the extent to which the change is hindered by the strong complementarity of products, brands, distribution circuits etc. Abandoning certain products or activities becomes expensive.
- outsourcing and specialization come to offer new alternatives to hyper-companies (specific to integrated economies), the latter ones looking, as an answer, to diminish their size or to reconfigure their structures via – refocusing on basic activities and resort to outsourcing; and constituting matrix autonomic units.

On the background of the mutations generated by all these factors, we are witnessing nowadays at the reinitiating of the entrepreneurial spirit inside the bureaucratic managerial companies. Such an entrepreneurial spirit manifests itself in three directions:

- finding some solutions in order to face the financial risk of its own capital resources;
- accepting uncertainty: the increasing autonomy in the new organizational structures forced by the aforementioned market pressures increases the level of uncertainty;
- permanent search for innovation: in order to win the new battles in these new environmental conditions, the company will have to build two competitiveness axes:
  a. supply stimulation via innovation;
  b. demand stimulation via marketing actions.

The explosion of small businesses (sometimes strongly connected to the outsourcing tendency of several activities in hyper-companies) brings into discussion the foundations of classic strategic marketing and reference strategic models, respectively. There is one question rising: if these models are of pragmatic value to the small company or not. Consequently, already becoming evidence, the majority of the professional papers on strategic analysis, from the North-American area, the case studies taken into consideration in order to sustain the choice of certain strategic alternatives, have large companies as reference subjects. Thus, for instance, M. Porter permanently mentions the strategic groups to which he offers consultancy services: Kodak, 3M, Rank Xerox, General Electric etc.

Nowadays, the systemic approach has to become the strategic management rule. The following need emerges: to fundamentally "rethink and redesign the business processes to generate dramatic improvements in critical performance measures – such as cost, quality, service and speed" [5]. This requirement is the definition given to the concept of reengineering by the American authors M. Hammer and J. Champy (1996), in their work *Reengineering the corporation.*

Faced with this requirement, the corporation has two options [6]:

- the deterministic view, implying an adaptation of the company to its environment and markets;
- the constructive view, requiring the company to build a voluntarist approach, thus allowing it to create a supply that generates its own growth terms.

In fact, the deterministic view constitutes the reflection axis of the modern strategic analysis, allowing the comprehension of at least two problem categories:

- a dynamic formation process, a problem of successive adaptation, which capitalizes the importance of the modern approach to the strategic analysis, as an opposing alternative to the deliberate and permanently planning managerial vision;
- a cognitive plan, based on the role of managerial representations, concepts and perceptions; in this type of process, the intuition has its predominant part, too [7].

Through the publication of Michael Porter's works – *Competitive strategy: techniques for analyzing industries and competitors* (1980) and *Competitive advantage: creating and sustaining superior performance*

(1985) – new elements have been added to the concept of strategic analysis. Therefore, on one side, three major strategy types are identified, known in the specialized literature under the name of generic strategies that a company is able to adopt in a given activity segment – cost leadership, differentiation and focus strategies – and, on the other side, a pertinent analysis scheme is suggested in order to study an activity sector. Moreover, M. Porter develops a new concept, that of the value chain, concept that is aimed at identifying a company's added value, the former one being analyzed via a functional view, offering the possibility to identify the activity sectors in which there is a possibility to take actions in order to obtain precise and sustainable competitive advantages. On this kind of theoretic frame, the definition given by M. Porter to the company's strategy is memorable: "striving for competitive advantages".

Every manager has to ask himself questions regarding the advantages that allowed his success in the past and those that sustain his business in the present, because this way he is able to judge the advantages that will ensure his future success.

Being considered a competitive strategy, quality strategy implies that product quality level represents an essential strategic element, and every competitive strategy is weighed against the product-market-technology triad, to which, via an entrepreneurial approach, the environmental variable is added.

Moreover, quality integrated strategies are considered, starting with the '80s, to have a central role in competitive strategies. "Total quality management" (an orientation towards exceeding customer expectations), "excellence" (quality, efficiency and time saving), "kaizen" (continuous improvement, the "umbrella" concept where the process oriented approach dominates) represent examples of such kind of quality integrated strategies. Their implementation is possible with the remark that in some cases, an organizational cultural change is required.

The so-called "quality-appeal" is constantly enhancing its importance, over the years, proving Deming right, who, in his book *Out of crisis*, underlines quality evolution becoming a chain reaction element, along with productivity, downsized costs and market winning.

In a world of competition and sophisticated demand, quality represents the way towards company survival. Quality can be obtained only via continuous improvement of the company's performance and an adequate training for workers, who see quality as an innovative culture, more importantly with every worker of the company contributing to quality (fact that is enhanced in the 4Q contribution model: design quality, production quality, distribution quality and rational quality) [8].

Thus, the entrepreneur's vision (the change initiator), transformed into strategy terms and objectives, relies on the implementation of an innovation culture, where the innovation process becomes part of the daily routine. Focusing on innovation means change in the held portfolio. Therefore, a more profound categorization may benefit more efficiently from the attention and the resources allocated in order to create an innovative culture. The final goal is to create a social system inside the company, able to maximize personnel's abilities and creativity, orientating it towards the consumer [9].

Innovation has to be open via using employees' abilities and taking into consideration their interests, and also via opening partnerships with other companies.

Integrated innovation relies on product refining during all its stages: idea, prototype, development, qualification, marketing to be incorporated in the general company innovation process. This sequential practice rigorously analyzed needs active leaders and the existence of a strong innovation culture.

Given that consumers are becoming increasingly more aware of advantages, convenience, service, choice, in the context of crisis, value creation begins by evaluating the price that the consumer is willing to pay, which includes remodeling the company, product, service, and distribution reinvention, overcoming traditional thinking schemes.

For distributors, the basic current concepts in such a framework are: reinventing value, new marketing and proximity to the consumer, thanks to the best information and a thorough knowledge. Gary Hamel, professor of strategic management at London Business School, launched the phrase "triple challenge" to the company that wishes to become competitive (redefining the concept of product, redefining market borders, reshaping the sector structure), understanding and evaluation of consumer needs being the starting point of the revolutionary approach of the sector [10].

Initiated in the U.S., by the Food Marketing Institute (Washington DC) and based on the experience of Wall-Mart/Procter & Gamble, ECR (efficient consumer response) is a producers-distributors-consumers partnership strategy. ECR allows the realization of the common objective of minimizing costs, stocks and time response to a request from the point of sale.

In the late 90^{s} some European retail traders developed the idea of tailoring a shop towards a lifestyle theme, in the form of "concept stores" which specialized in cross-selling without using separate departments. One of the first concept stores was 10 Corso Como in Milan, Italy (which includes a café and a library) followed by Colette in Paris (which includes an art gallery and a nightclub), and Quartier 206 in Berlin.

Stephen Ogden-Barnes, of Monash University's Centre for Retail Studies, conducted studies on concept stores in North America, Europe and Australia. Thus, he believes that concept stores are sweeping the world and retailers everywhere are experimenting with ways of keeping the customers inside the shop for longer [11].

Concept stores are retail models where the buying process has a different meaning and involves philosophical meaning.

The customer has opportunity not only to buy physical products but also is provided with a full emotional

Table 1

DISTRIBUTION OF THE SAMPLE BY DEVELOPMENT REGIONS AND CORRELATION WITH THE DISTRIBUTION OF SMES IN THE CLOTHING INDUSTRY			
Development region	**Questionnaire respondents** (absolute value)	**Questionnaire respondents** (% of total)	**Distribution of clothing SMEs** (% of total)*
North-West	14	12,50	13,43
North-East	34	30,11	15.01
West	7	6,50	10,02
Center	17	14,65	14,86
South-West	5	4,54	8,88
South-East	16	14,53	13,95
South	13	11,40	13,65
Bucharest- Ilfov	6	5,77	10,20
Total	112	100	100

* Source: National Statistics Institute, 2011 - National Forecasting Commission, 2011

and sensory experience. In practice, those shops offer mix of items of different designers and brands addressed to the particular groups for example ecologically friendly, luxurious or street wear oriented customers.

The variety of products usually includes clothes, shoes, accessories, books, cosmetics, food and gadgets. It is important that all items must be united around the concept store's philosophy which is expressed in unusual layout of the store to underline extraordinary character of products that are sold there.

In addition, concept stores predestination is to be trend follower. The assumption is that after all the touching and feeling, customers will be willing to spend more money.

The experience will be associated with the store's identity and the customer will come back in the future. This kind of retail venture has become a part of many cities' cultural environment by offering access to art news, fashionable products, food, music and technological solutions.

The decision to maximally concentrate on the innovation process has a direct influence on company's performances, in terms of turn-over, profit, market position.

In this context, the significant amplitude that the SMEs sectors have taken, starting with the eighth decade of the 20th century is justified through important advantages that these present such as:

– high levels of adaptability to market demands;
– realizing products and services for a differentiated demand;
– great innovation capacity;
– creativity climate;
– a better human resource management.

The clothing industry in Romania is a branch with a long tradition in export of a diversified product mix, ranks third in exports of Romania, fourth in the EU clothing exports, focuses the largest number of SMEs in the industry, is an industry representative to identify business strategies used and these are reasons for considering that a study in this sector is timely

SURVEY REGARDING ON ENTREPRENEURIAL STRATEGIES USED BY COMPANIES FROM CLOTHING INDUSTRY IN ROMANIA IN THE CONTEXT OF WORLD ECONOMIC CRISIS

The present research follows four major objectives:

Objective 1: Identification of the features of production and according to this analysis of problems facing Romanian companies in addressing external and internal market in the world economic crisis;

Objective 2: Identification of the currently used strategies by companies in the clothing industry in Romania;

Objective 3: Identification of the currently used distribution channels in the analyzed companies, for the marketing of their own brands;

Objective 4: Substantiating future directions of action for revival of the companies from Romanian clothing industry.

Survey based on a questionnaire (Appendix) included questions which were structured into three sections:

I. General information about the analyzed companies. This section contains general questions of identification, address, development area which the company belongs to, the classification of them by nature of capital, by the destination of the products.

The study was conducted on a number of 122 clothing companies (men and women clothing), from all development regions in Romania and it refers to the year 2011.

In table 1 is presented the geographic distribution of survey' respondents (top managers and middle managers of clothing firms) according to the 8 national development regions and SMEs split of clothing industry nationwide. It is noted a balance between geographical structure of survey respondents and structure of the SMEs in the clothing industry in Romania.

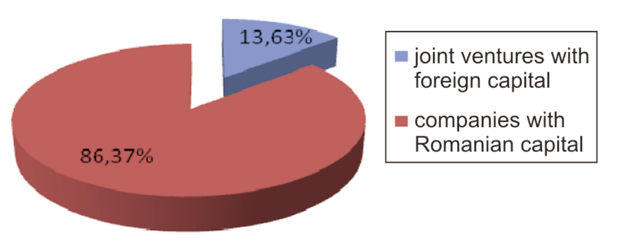

Fig. 2. Structure of the sample by capital type

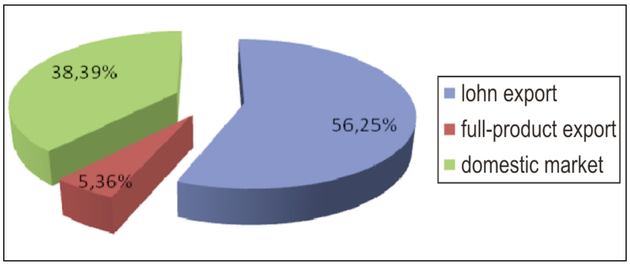

Fig. 3. Product destination

Most respondents are from the North-East Region, which is justified by number and potential of the clothing companies in the region. At the opposite pole, stands, the South-West, Bucharest-Ilfov, and West Regions which containing a smaller number of clothing companies.
By the capital type, of the 112 firms, 15 are joint ventures with foreign capital, and 97 are local capital ventures (fig. 2).
Knowing that in Romania, the clothing firms produce over 60% for export (57% lohn and 3% own brand) and below 40% for the domestic market, the study revealed that by product destination, of the 112 companies, 69 export, the other 43 are addressing to the local market with their own brands. Of the 69 export companies, 63 companies export their entire production in lohn system, 6 companies export full-product, but also primarily support full-product export by processing in lohn system as well (fig. 3).
II. Information about currently used strategies by companies in the clothing industry in Romania in the context of world economic crisis. The set of questions used in this section serves the direct purpose of research, the questions are aimed to identify the currently used strategies by companies in the clothing industry in Romania, to identify the problems facing Romanian companies in addressing external and internal market, the links between the processing form and the used strategies, and, also, the distribution channel used, and their correlation with the development area which it belongs to, with nature of capital, aspects reffering to customer focus.
Following the survey based on questionnaire resulted the following issues: 49 companies managers of the 112 firms have developed and implemented a strategy to reduce lohn production. The 49 managers can realize their own brands through processing in the same time in lohn system. Of the 49 companies, only 6 export production under its own brand through develop niche business, namely: 2 sports clothing (one of them clothing for a certain segment of sports – paragliding and hang gliding, and the other ski suits and motorcycle suits from waterproof and insulating materials), 2 lingerie and swimwear, 1 ecological clothing, 1 Gore-Tex military uniforms, other 43 addressing to the internal market. The two companies which exploiting sport market niche are from Center development region. One of the lingerie and swimwear firms is of the Bucharest – Ilfov region and the other from the North West region. The company that produces organic clothing is in the NW region. Company that manufactures military uniforms Gore-Tex is from NE region. Of the six companies exporting under its own brand, the company that manufactures ecological clothing, and the company that produces Gore-Tex military uniforms are joint ventures with foreign capital, the other four are companies with Romanian capital.
Managers of the other 63 companies have said that lohn processing is the only viable solution. In support of this claim, have identified the following causes for which can not produced its own brand and can not be realized full products, and in the same time and favoring factors:

- financial difficulty to acquire quality raw materials;
- impossibility of recourse to bank credit for investment (huge level of banks' interest);
- impossible penetration foreign channels (all managers interviewed felt that foreign partners have highly well organized their distribution channels, making it virtually impossible to penetrate with their products);
- shortage of skilled labor due to both labor migration and plummeting demand for high schools and higher education institutions of profile. The fact that young people are moving increasingly toward specialization from services for example, to the detriment of specific ones from clothing industry is a global phenomenon and not just one specific for Romania. All managers have said that young people in Romania no longer going to work in clothing industry, on the one hand, due the decrease in the number of companies and the reduce the production capacities and on the other due to low wages. Managers said they can not increase salaries given that the need to remain competitive in an increasingly difficult market. Also, four managers have justified that the lack of real financial incentives for businesses when involved in conducting the practical training labor insertion led to major reductions in school-companies cooperation agreements since 2009;
- the reduction of production capacities of Romanian clothing firms that favor execution of lohn orders, small majority, tailored to fashion trends launched on average every two months;
- redirecting lohn orders from countries of North Africa to Romania in conditions of political instability in this area.

Finally, another reason why these companies do not work for domestic, nor do they want to develop a strategy in this respect is represented by low purchasing power from Romania:

– all the 63 managers of companies with lohn production consider that production under own brand is the most dangerous kind of business in this industry, in the current market conditions. Only one manager which making lohn believes that the only alternative, but very expensive in his opinion, is the creation of own brands, but which not necessarily be produced in Romania;
– to the question if they fear that they will lose markets, partners (with which carrying out CMT) in favor of countries like Ukraine, Moldova, Bulgaria, the Asian countries which levy lower labor costs, 84 managers consider that in all these countries the quality of products is lower than the quality of Romanian products. On the other hand, 16 managers consider that people buy what is fashionable, even neglecting the quality of product. Four of the 16 said that for a few cents, customers which offering lohn orders, are able to change the continent, not just the country;
– all managers have said that to meet the new concept from the market, that is fast fashion (5–6 collections per year are presented instead of two, are produced in small series and limited in order to give consumer the feeling of exclusivity, uniqueness, to satisfy his desire to break patterns of ordinary mass-market), firms have flexibility in organizing their production process. Thus, 43 managers of companies that have developed and implemented a strategy to reduce lohn production, of the others 49, consider that it is time for middle brands, having the advantage that their names are associated with certain standards of quality and creativity. Evolving between luxury and low prices, these brands are more autonomous, more flexible, and have a stronger identity, as an alternative to standardization;
– the six firms that produce for export under its own brand with lohn production in the same time attend international trade fairs;
– managers of 106 companies which not participating to international fairs argue that processing in lohn system, means that design belongs to the foreign partner, this ask only quality of execution, quality finishing, compliance deadlines. Of these 106 firms, those 43 which produce and own brand for domestic market say that the identification of market trends are realized through market researches done by themselves;
– managers of the 6 companies which realize own brand exports (full business) buy their raw materials from abroad and accessories from importers and/or Romanian producers. Companies that perform textile exports sportswear use “smart materials” with aerodynamic properties, microporous polyurethane film fabrics that allow its breath and determine the impermeability. The company that performs exports of ecological clothing uses organic hemp, also dyes used are environmentally friendly, being derived from plants. The companies that perform exports of lingerie and swimwear use materials embellished with Swarovski crystals, pointing out the originality and creativity. Company that makes Gore-Tex military uniform has the certificate of excellence GOLD Gore-Tex, incorporating the latest technology generation (fabric high-tech, aramid fiber type with flame retardant properties that meet quality standards, having in the same, time and a special design). Thus, these firms use innovation strategy in order to gain and protect market share, while giving great deal to quality. For these companies, the strategies used are ways to react in order to identify unmet needs, whereby developing a new product. This involves switching from ensuring consumer satisfaction in ensuring its loyalty, and the insurance of consumer enthusiasm (surprised consumers by anticipating or even creating needs and desires which are not expressed – unmet needs). Enthusing the consumer is considered to be the new frontier that allows the differentiation of supply over the competition [12]. Customers of companies which perform sportswear products exports are instructed upon the way of use and maintenance of products, they get a few years warranty on the product and, also service if necessary. The company which performs ecological products exports is consistent with the ethical fashion concept, and acting on eco niche. Manager of this company considers that the company's products is addresses some consumers who believe in a world without artificial colors with traditional culture and decent working conditions for employees in the clothing and not only. Thus, the manager of this company believes that the success of his company's products is because it meets the requirements of consumers who are interested of moral side in clothing production, but also those related to functionality and especially of those related to design. He also believes that managed to attract a significant share of customers, fashion' enthusiasts, by manufacturing of “green products” which emphasis on design and quality and, they are attractive in the same time. The products of this company have labels containing information on the benefits of organic hemp and information on the use and maintenance of their. It is clear that, in order to increase their sales volume, in the context of global economic crisis, managers and owners (shareholders) should be aware of the need to exploit market opportunities by applying innovation strategy. The extent to which they expressed agreement with the understanding that “adoption of innovation is one of the factors that ensures success of the company” is given in figure 4. The results reveal the following (fig. 4):

- 31,25% of respondents agree with the above statement, in more or less clear categorical terms (total or partial agreement);

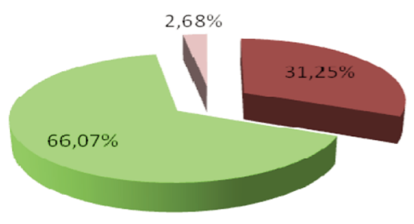

Fig. 4. Level of innovation acceptance

- 66,07% disagree with the statement made (strongly disagree or in part);
- 2,68% do not express an opinion.

From the replies we observe that most of the investigated managers do not appreciate the role and importance of the adoption innovation for their organizations. In table 2 is presented correlative analysis of the awareness of the need to adopt innovation and product destination of the analyzed companies.

The need for knowing the advantages of adoption of innovation in order to protect long-term market share is clearly being distinguished:

– three of the managers of surveyed firms with lohn system are associated in ASTRICO North-East cluster, organized around of these producers, plus the Regional Development Agency North-East and "Ghe. Asachi" Technical University of Iasi. Thus, given the large reduction in lohn orders (large orders with delivery within more than six weeks for which is preferred China), Romanian clothing firms have substantially reduced production capacity to accommodate to smaller orders that are majority placed further in Romania. This cluster has been created to strengthen cooperation between these producers in order to meet large orders which still exist (about 3–4 months/year), but with delivery times of up to six weeks. Thus, one single manufacturer has not capacity to execute such orders and respecting these terms. Also, another major advantage of the cluster is that one of the firms of cluster is the one that providing raw materials for others. In addition, for cluster formations are specific lines of financing, the financial part of the grant is over 50% as minimum, and almost 98% for structural funds SOP HRD;

– at the question to what extent the global economic crisis has affected the sales and hence, the production, all the managers claimed that its effects are reflected in lower production due to decreased consumption. Managers of the six companies that export under its own brand argue that the crisis effects are felt mainly in domestic sales, foreign market being still interesting (excellent services, very good relation between price-quality which have created a special relationship between producer-customer). Also, managers of these companies consider that in a small business niche is so unlikely to get "hit" by the onslaught of Chinese products on the European market, because the segment is too small and uninteresting to those who make huge amounts of cheap products;

Table 2

CORRELATIVE ANALYSIS OF THE AWARENESS OF THE NEED TO ADOPT INNOVATION AND PRODUCT DESTINATION OF THE ANALYZED COMPANIES			
Surveyed companies	**Full export 6**	**Lohn export 63**	**Internal market 43**
Of which:			
Total agreement	5	-	16
Partial agreement	1	2	11
I do not know/I am not sure	-	2	1
Partial disagreement	-	35	10
Total disagreement	-	24	5

– to the question about measures adopted to counter the effects of the crisis, all managers replied that in this period the aim is to resist the market by lowering costs, increasing productivity, flawless execution, and compliance deadlines;

– the 43 managers which chose the domestic market, with sustaining their own brands through lohn processing argued their choice as follows:
  - relocation of labor market and its costs, as the positive effect of economic crisis, meaning raw materials' prices decline, the benefit of producers and final customer;
  - transmission of financial and economic problems from the markets of potential lohn partners to Romanian partner which has not its own brand;

– managers of companies that address the internal market, to develop brand/brands, buy the raw materials and accessories especially from countries with tradition. 31 companies are direct importers;

– 12 managers have diversified offer and for this reason they bought production capacity to manufacture and of accessories.

With respect to the distribution channels used by the surveyed companies which export full-product, of the 6 firms, the two sportswear firms have traditional clients in Italy, France and Germany who delivers products on demand, the two companies of lingerie and swimwear have stores in Italy, France, England, Germany and Hungary, the firm which acting on eco niche have traditional clients in the U.S., E.U, Japan, Australia, South Africa, and the firm which produces uniforms delivers products on demand in Italy, Spain and France.

With respect to the distribution channels used by the companies analyzed, which address to the internal market, of the 43 firms, 27 use their own distribution (the manufacturer is at the same time the sales agent), 5 companies use authorized dealers for Romania, 2 sell their products at fairs in the country, 4 companies have their own stores, 3 companies sell in hypermarkets, and 2 firms sell online (fig. 5).

Of the 4 companies that have their own shops and are addressing the national market, 2 companies have their store in the same city in which they are based, 2 companies have it in other cities in Romania. Two of the companies that have stores both in the city where they are based, and in other cities in Romania, sell its products in concept store type shops. These are companies with successful brands, companies with financial strength. The two companies are present in concept.store Cocor, one of them is selling lingerie and is located in the North-West development area, and the other are selling clothing for women and is located in the Bucharest – Ilfov development area. By the capital type they are companies with Romanian capital.

Managers of companies that have stores in the same city in which they are based. emphasized that people are very receptive to signaling of promotion in the window, and sometimes many of them want to look like mannequin from the window. For these reasons, they practice promotional prices and arranged their sales surfaces, the window also differently from one season to another, presenting a range of products grouped according to consumer universes.

The manager of a firm says that the role of the window is "to tell a story". Thus, in its company store besides clothes are accessories, books, furniture, everything in order to transmit properly the brand philosophy. All managers which address to the internal market have identified an important change in the behavior of Romanian customers which have reduced or waived on the purchase of Chinese products. Thus, all managers are aware of the need to adapt their offer to increasingly sophisticated requirements of Romanian consumers seeking quality goods at relatively low prices. Also, the consumer seeks products authentic and personalized, buy perhaps less, but more careful in terms of quality and concept. All managers of firms which producing for domestic market argue that their designers dealing also with costs, marketing, sales tracking. Thus, the designer has knowledge so vast that it will not propose unfeasible things or which could get out of the budget. Throughout the process creation and production of collection, the designer liaises with all departments, including the commercial department and with salesmen. Thus, all these managers have revealed that one of the most important steps, in coordinating and designing of a collection, is information. As long as buyers are more advised, it is equally important to provide an updated product. In this context, their designers are always in touch with trends in fabrics, accessories and new technology, with studies on contemporary cultural influences.

As a result of the study conducted on the sample of clothing companies resulted that managers of 63 of the 112 companies, consider that lohn system is the only viable solution for Romania in the current market conditions. In this context, most managers have not invested to implement a strategy to full export, with everything that it implies.

The fact that only at 43 of the 112 companies given due importance for marketing activities, that only

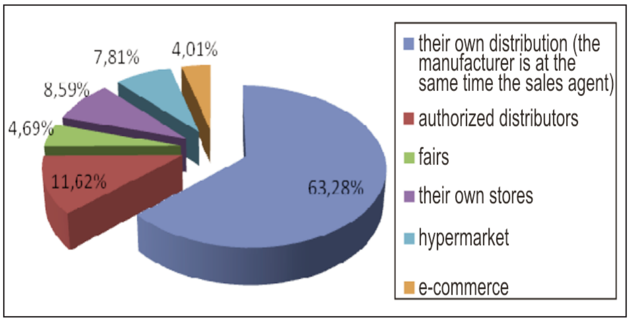

Fig. 5. Channels of distribution used by companies that address the internal markete

6 companies participate to international fairs, shows the orientation of the majority of companies, for processing in lohn system. The 6 companies which perform full export (supported by lohn) are those which invested in the imposition of a mark, with all that this implies (R & D, commercial – with three components namely: marketing, purchasing, sales – manufacturing, financial-accounting, and human resources), instead of exercising easy management.

The companies with full exports are those which participating at international fairs. Also, these companies are those that have developed niche business through valuing market opportunities on a segment of sports clothing, ecological clothing, lingerie and swimwear, respectively military uniforms. Applying innovation strategy, the accent on quality, the very good price-quality report, providing excellent services, all of these make that the business grow and under crisis conditions.

The companies which perform full exports are those that investing in quality raw materials, in product design and marketing activities, two of them having stores abroad.

Furthermore, all managers identify as a major problem the impossibility of penetration the distribution channels.

The companies which addressing the internal market were aligned to fast fashion concept and to the concept related of designer which must be specialized in marketing costs and tracking sales.

Only two of the companies' managers that have own store are concerned about concept store type of retail, designed in order to rethink the store according to customer behavior in their purchasing process, and only one gives consideration to arranging its own sales area.

In 2012, clothing companies' managers consider that must take into account that the price increase equals with losing the market. In this period, the main problem is maintaining market and in terms of consumer behavior it can not longer speak of the concept of irrational consumer or impulsive buying.

III. Future directions of action for revival of the companies from Romanian clothing industry.

This section is very important because it shows the main future ways to increase the competitiveness of the clothing companies in the context of world economic crisis. The study also contains, and information gathered from informal interviews, especially for companies exploiting market niches, those which adopt new forms of retail, and those which are associated to the North East ASTRICO cluster. The future directions of action for revival of the companies from Romanian clothing industry are:

- increasing the competitiveness of companies by reducing production costs, by applying innovation strategy, by applying integrating quality strategies;
- development and implementation of strategy to reduce lohn production and increasing the number of companies which produce under own brand;
- increasing focus on operational package of ASTRICO North/East cluster on the four main directions: innovation, technology; marketing, promotion, internationalization; training, education and management, not only on cooperation in order to realize the large orders;
- increasing the promotion activities;
- knowledge and awareness of the benefits of marketing the products in the new retail forms.

CONCLUSIONS

This paper presents the importance of implementing proper strategies according to changes in exogenous factors and/or endogenous of the environment. Thus, the implementation of innovation strategy (a consumer unmet need in the current market offer for example) may have strategic importance in that it can represent opportunities for those seeking to gain market positions.

In the paper is also highlighted the role of integrative quality strategies for survival of firm and the necessity of transition from the piecemeal execution to the full product strategy. In this respect, it was elected a representative economic sector in Romania in terms of entrepreneurship revival, namely clothing industry.

In the context of global economic crisis, knowledge of the main trends in clothing production and clothing sales by garment companies in Romania is of strategic importance. Amid global economic crisis with its effects on consumption and production, shows that most companies consider lohn processing system as the only one viable. This is a strategy of maintaining market.

On the other hand, very few companies have managed to impose their own brands and an even smaller number of companies manage to export their own brand using the innovation strategy and identifying the opportunities for long-term success of the company. Thus, in accordance with the general trends of globalization of markets and in context of the global economic crisis, shift is needed from ensure customer satisfaction and loyalty to ensure his enthusiasm, as crucial option in strategic management. For this purpose it is necessary to create an innovative culture in the Romanian clothing firms.

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Authors:

PhD senior lecturer DOINA I. POPESCU
PhD student MIRCEA STELIAN DRĂGHICI

The Bucharest University of Economic Studies
P-ta Romana 6
010374 Bucharest
e-mail: doinaipopescu@yahoo.com
e-mail: mircea.draghici@dentirad.ro

SISTEM MECATRONIC CU SENZOR OPTOELECTRONIC PENTRU DETECȚIA ÎNTRERUPERII FIRULUI ÎN PROCESELE TEHNOLOGICE TEXTILE

Sistemul mecatronic cu senzor optoelectronic pentru detecția întreruperii firului în procesele tehnologice textile este destinat să completeze sau să înlocuiască actualele sisteme electromecanice bazate pe contacte electrice.

Majoritatea sistemelor actuale sunt bazate pe contacte electrice, acționate de o pârghie care oscilează în jurul unui punct fix. Pârghia este antrenată de un fir textil, care trece printr-un inel încastrat în aceasta. Atunci când firul este întins, pârghia ocupă o poziție ce nu permite închiderea contactului electric, iar când firul se rupe pârghia ocupă o altă poziție, sub acțiunea câmpului gravitațional sau a unui arc. Astfel, contactul electric se închide, permițând aprinderea becului de semnalizare şi oprirea automată a utilajului.

Dezavantajul acestui sistem constă în ratarea detectării ruperii firului şi, implicit, nesemnalizarea şi oprirea la timp a utilajului, din cauza oxidării inerente a contactelor electrice, sau a depunerii de particule de praf şi vapori de apă pe suprafața acestora, împiedicând realizarea contactului electric. Consecințele acestei situații sunt greu de estimat, atât prin afectarea calității produsului obținut, cât şi prin continuarea procesului tehnologic cu unul sau mai multe fire rupte, care pot fi antrenate necontrolat de celelalte fire.

Sistemul mecatronic cu senzor optoelectronic pentru detectarea întreruperii firului, în timpul proceselor tehnologice textile, se bazează pe folosirea unei bariere optice, formată dintr-un emițător şi un receptor în spectru de radiații vizibile, infraroşu sau radiații laser.

În figura 1 este prezentat un sistem optoelectronic cu barieră optică, formată dintr-un emițător (LED), un receptor (fotodiodă sau fototranzistor) şi un obstacol (fir textil, pârghie sau alte elemente care pot modifica intensitatea radiației generată de emițător şi sesizată de receptor). Dioda luminiscentă, LED-ul (light emitting diode), conține o joncțiune de tip *pn* polarizată direct, în care se încorporează – în zonele neutre ale dispozitivului – purtători minoritari de sarcină, care – prin recombinare – emit fotoni.

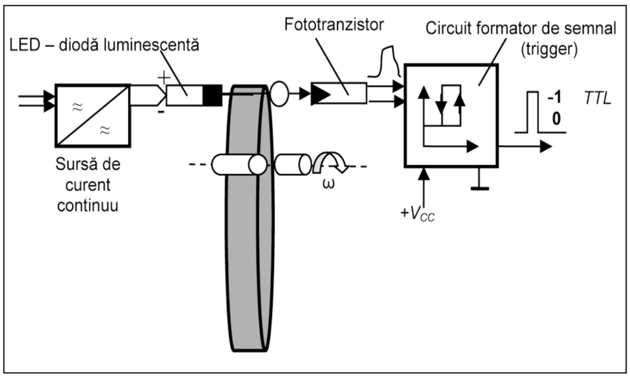

Fig. 1. Sistem optoelectronic pentru detectarea unor discontinuități

Pentru alte zone spectrale, se folosesc LED-uri cu GaAs (arseniură de galiu), mai ales pentru domeniile infraroşu şi roşu, galben sau verde. Traductoarele detectoare de radiații luminoase, cu elemente semiconductoare (fotodiode şi fototranzistoare), au înlocuit aproape total fotomultiplicatoarele şi fotocelulele electronice, din cauza gabaritelor specifice, consumului energetic şi particularităților impuse surselor de alimentare.

În drumul ei spre receptor, radiația generată de emițător este atenuată de un obstacol, care poate fi chiar firul controlat sau o pârghie ce oscilează în jurul unui punct, această pârghie fiind, la rândul ei, antrenată de firul controlat.

Pentru funcționarea optimă a barierei optice se stabilesc mai multe elemente:

- căile de transmisie a radiației de la emițător la receptor (transmisie directă, prin reflexie sau prin refracție);
- lungimea de undă a radiației (ultraviolet, vizibil sau infraroşu);
- modul de urmărire a firului (urmărire directă sau indirectă – prin intermediul unei pârghii).

La întreruperea firului controlat, receptorul generează un semnal, pe care-l transmite unui automat programabil *PLC* (programmable logic controller), având ca funcții analiza stării semnalelor de intrare, luarea deciziei în vederea opririi utilajului, calculul numărului de întreruperi şi stabilirea fiabilității utilajului.

Fiind dotat cu programare automată, acesta transmite mesaje unui bloc de afişare/display tactil, pentru a informa operatorul în privința stării reale de desfăşurare a procesului, precum şi semnale de comandă unui bloc electric ce conține un actuator al instalației tehnologice, în vederea opririi automate la detecția întreruperii unui fir (fig. 2).

Pentru a deosebi lumina emițătorului de cea naturală, bariera optică conține un oscilator de impulsuri modulate în frecvență, care, ulterior, sunt amplificate

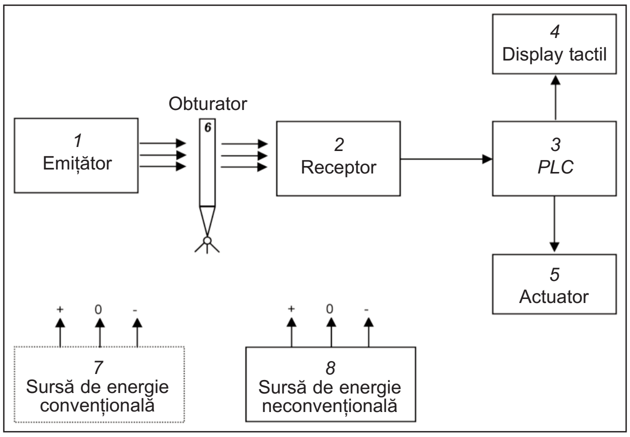

Fig. 2. Schema blocului electric

de un amplificator corespunzător şi transformate într-un mănunchi de raze de lumină cu ajutorul unui LED şi a unui receptor ce transformă radiaţia luminoasă în semnal electric. Toate blocurile electronice pot fi alimentate de la o sursă de energie clasică sau de la o sursă electrică neconvenţională.

Pentru completarea sistemelor actuale de detecţie a întreruperii firului, se foloseşte ca obstacol în calea radiaţiei generată de emiţător – ce trebuie să ajungă la receptor, chiar corpul pârghiei antrenată de firul controlat în procesul tehnologic textil. În acest caz, este garantată detecţia întreruperii firului cu o investiţie minimă şi un rezultat surprinzător.

O altă variantă de implementare a sistemului mecatronic integrat cu senzor optoelectronic pentru detecţia prezenţei firului textil în diferite procese tehnologice textile o reprezintă realizarea unei bariere având ca obstacol firul propriu-zis. În această situaţie, se analizează proprietăţile firului textil, ţinându-se cont de coeficientul de absorbţie a radiaţiei emise de LED, în funcţie de tipul firului. Se foloseşte o barieră optică a cărei radiaţie este puternic absorbită de firul controlat. Secţiunea spotului luminos de radiaţie este comparabilă cu secţiunea firului controlat, pentru a garanta detectarea firului rupt.

O altă aplicaţie a sistemului mecatronic integrat (fig. 3) cu senzor optoelectronic pentru detecţia prezenţei firului textil în diferite procese tehnologice textile poate fi extinsă la urmărirea şi depistarea variaţiei secţiunii firului, într-un anumit proces tehnologic. Pentru aceasta, cu ajutorul unui display tactil se setează secţiunea firului textil controlat. În acelaşi timp, se setează şi limitele de toleranţă ale variaţiei secţiunii. La acest sistem se poate ataşa o rolă de ghidare a firului, eventual în locul elementului de ghidare existent, cu scopul de a măsura lungimea firului controlat, aceasta permiţând bobinarea firelor cu lungimi determinate.

PLC-ul, în baza unui program adecvat, poate face o statistică a variaţiei secţiunii firului, iar în cazul depăşirii limitelor prescrise, avertizează operatorul şi opreşte utilajul.

Fig. 3

Mai multe sisteme mecatronice integrate cu senzor optoelectronic pentru detecţia prezenţei firului textil în diferite procese tehnologice pot fi cuplate în reţea pentru a transmite toate informaţiile unui calculator central, cu rol decizional şi de control.

Prin introducerea unui PLC şi a unui ecran tactil, sistemul mecatronic cu senzor optoelectronic pentru detecţia întreruperii firului în procese tehnologice textile beneficiază de prezenţa ultimelor trenduri şi tehnologii în domeniul automatizărilor industriale. Astfel, detecţia întreruperii firului textil se realizează în timp real, rata de succes fiind de 100%. Capacitatea mare de memorare şi procesare a PLC-ului facilitează extinderea aplicaţiei curente, prin adăugarea de noi cerinţe, fără a afecta realizarea celor deja implementate. Ecranul tactil beneficiază de o rezoluţie nativă de 240 x 400 pixeli şi 256 de culori, ceea ce îl transformă într-un dispozitiv de afişare puternic şi intuitiv, printr-o manieră de utilizare simplă, dar eficientă.

Ing. ***Radu Rădulescu***
I.N.C.D.T.P. – Bucureşti

DOCUMENTARE

Materii prime

FIBRE MULTIFILAMENTARE DIN FLUOROPOLIMERI

Colaborarea a două companii – compania de produse chimice ***Arkema*** – din Colombes, Franţa, şi compania furnizoare de filamente şi fibre din fluoropolimeri ***Lenzing Plastics GmbH,*** cu sediul în Austria, s-a concretizat într-un homopolimer de polifluorură de viniliden (PVdF), care poate fi extrudat în formă multifilamentară, pentru a conferi fibrelor o mai mare tenacitate, astfel încât să reziste la abraziune şi la contactul cu produse chimice agresive, chiar la temperaturi înalte. Cele două companii au colaborat pentru realizarea răşinii *Kynar 705*. Fibrele obţinute au un grad ridicat de alb, un conţinut general scăzut de gel şi o tenacitate care poate depăşi 27 $cN.tex^{-1}$. Această răşină este adecvată pentru extrudarea fibrelor monofilamentare şi a neţesutelor consolidate.

Potenţialele aplicaţii ale fibrelor obţinute din răşina Kynar 705 se referă la domenii precum: filtrarea produselor chimice şi a gazelor, separatoare pentru baterii şi arhitectură.

Frecarea redusă şi tensiunea de suprafaţă scăzută a ţesăturilor permit ca filtrele realizate din aceste materiale să fie menţinute curate cu uşurinţă, iar caracteristicile mecanice ale acestora conferă mediilor filtrante un timp de viaţă cu până la 10 ori mai mare decât cel al produselor convenţionale, care nu sunt obţinute din fluoropolimeri.

Răşina Kynar 705 oferă rezistenţă la radiaţiile ultraviolete şi la expunerea la vânt, făcând ca materialele realizate din aceasta să fie adecvate utilizării în aer liber.
Cele două companii continuă să conlucreze pentru a descoperi şi a promova noi aplicaţii ale fibrelor multifilamentare.

Technical Textiles International,
septembrie 2012, p. 4

NOI MATERIALE COMPOZITE MARCA *TIXPREF*

Pentru a contribui la reducerea duratei ciclului de fabricaţie a compozitelor, companiile ***Victrex Polymer Solutions*** şi ***Tissa Glasweberei AG*** au dezvoltat în colaborare noi ţesături compozite, care urmează să fie comercializate sub marca *Tixpref* şi *Tissa.*
Ţesăturile din benzi unidirecţionale sunt realizate din fibre de sticlă *AGY S-2* sau din fibre de carbon impregnate cu polimeri de înaltă performanţă, *Victrex Peek.* Prin elaborarea noilor compozite Tixpref se obţine o reducere a timpului necesar formării prin presare a materialelor din straturi compozite cu până la 50%, şi chiar mai mult – la componentele cu pereţi subţiri.
Ţesăturile Tixpref oferă numeroase avantaje, printre care proprietăţi mecanice excelente, datorită conţinutului ridicat de fibre (circa 65%), şi rezistenţă mare împotriva deteriorării. Fiind termoplastice, aceste ţesături posedă, în comparaţie cu cele termofixate, bune caracteristici de rezistenţă şi rigiditate, precum şi o excelentă dispunere a fibrei în matrice, rezultând o durată de viaţă mai mare pentru partea de compozit, dar şi o reducere a greutăţii acestora. Ţesăturile sunt uşor şi sigur de manevrat, fiind adecvate proceselor automatizate şi metodelor de fabricaţie în exteriorul autoclavei.
În prezent, ***Tissa*** a dezvoltat noi ţesături cu caracteristici de antişifonare, utilizând polimerul Victrex Peek, realizate din două straturi de fibre, pentru a împiedica deplasarea.

***Smart**textiles and nanotechnology,*
august 2012, p. 10

Nanotehnologii

TRATAMENT ANTIMICROBIAN CU NANOPARTICULE

Compania ***NanoHorizons***, cu sediul în Bellefonte, Philadelphia, a brevetat un substrat textil antimicrobian şi antifungic, cu eficacitate şi rezistenţă la spălare excepţionale. Acesta este realizat printr-o tehnologie bazată pe nanoparticule de argint, ce asigură o protecţie antimicrobiană de durată, ţesăturilor şi produselor din diverse domenii de aplicaţie.
În acest sens, vicepreşedintele James Delattre afirma: *„US Patent 8 183 167BI nu este doar o completare a portofoliului nostru, tot mai mare, de proprietate intelectuală, ci aduce pe piaţă o soluţie nouă pentru creşterea rezistenţei la spălare şi a performanţei, pe care actualele tehnologii antimicrobiene nu le au. Deşi brevetul este specific ţesăturilor şi fibrelor din polimeri sintetici, aditivii antimicrobieni folosiţi pot fi integraţi rapid în fire şi ţesături naturale, pelicule, spume şi polimeri, pentru a controla dezvoltarea bacteriilor, fungilor şi mucegaiului în dispozitive, materiale textile şi suprafeţe de contact".*
În prezent, ***Nanohorizons*** dezvoltă, produce şi comercializează aditivi de argint la scară nano, marca *SmartSilver*, care sporesc semnificativ capacitatea argintului de a controla dezvoltarea microbiană.
Produsele *SmartSilver* nu se degradează termic şi furnizează o protecţie antimicrobiană remarcabilă, o perioadă lungă de timp, fără a fi nevoie de cantităţi mari de aditivi.
Aditivii antimicrobieni nu impun compromisuri în procesul de fabricaţie sau în performanţele produsului, iar articolele de îmbrăcăminte şi încălţăminte astfel tratate îşi păstrează prospeţimea şi nu dezvoltă mirosuri neplăcute. Produsele din spumă şi laminatele protejate cu SmartSilver rezistă la dezvoltarea populaţiilor microbiene care, în timp, provoacă degradarea acestora. Peliculele şi materialele plasticele obţinute pe baza tehnologiei SmartSilver previn dezvoltarea mucegaiurilor şi acumularea mirosurilor. Ingredientul activ din produsele SmartSilver este înregistrat EPA, în categoria FIFRA, şi certificat Oeko-Tex ca neconţinând niveluri dăunătoare de substanţe periculoase.

***Smart**textiles and nanotechnology,*
iulie 2012, p. 5

NANOCOMPOZITE CU CAPACITATE DE AUTOREPARARE

Qipeng Guo de la ***Universitatea Deakin***, din Australia, a brevetat o nouă invenţie referitoare la nanocompozitele polimerice cu proprietăţi de autoreparare şi procedeu de realizare a acestora.
Nanocompozitele sunt obţinute prin dispersia unui material format din particule cu dimensiuni nanometrice într-o matrice polimerică. Ele posedă proprietăţi chimice şi/sau fizice superioare comparativ cu compozitele polimerice convenţionale sau cu polimerul de bază, în absenţa oricăror particule de ranforsare, de aceea prezintă interes pentru diverşi utilizatori, printre care industria aerospaţială şi cea a ambalajelor.
Trebuie menţionat, însă, că diferiţi factori externi pot provoca deteriorări ale nanocompozitelor. Comportarea fizică sau chimică a unui nanocompozit se poate modifica, de exemplu, sub influenţa temperaturii ridicate, a presiunii, a stresului sau impactului mecanic, a degradării chimice sau a altor factori externi. Astfel de schimbări în comportamentul fizic sau chimic pot

determina apariția fisurilor în materialele nanocompozite, ceea ce face ca acestea să nu mai poată avea performanțele cerute. Aceste deteriorări creează probleme mai ales atunci când nanocompozitele sunt folosite pentru realizarea unor subansambluri de mare performanță, cum ar fi componentele aerospațiale. Din acest motiv, subansamblurile trebuie verificate periodic şi, în multe situații, este necesară repararea sau înlocuirea acestora, ceea ce implică costuri crescute.
Materialele polimerice cu capacitate de autoreparare, ca reacție la diverse deteriorări, prezintă un interes din ce în ce mai mare. Materialul compozit cu capacitate de autoreparare este format din microcapsule ce conțin agenți promotori ai reparării, încorporați într-o matrice polimerică compozită şi un catalizator înglobat, la rândul lui, în matrice. Atunci când materialul suferă o deteriorare, agenții de reparare sunt eliberați în prezența unui catalizator, favorizând reacția de polimerizare, care generează un polimer pentru umplerea ariei afectate. Această umplere stopează diseminarea fisurii şi reduce deteriorarea materialului. Un dezavantaj al acestui material îl constituie faptul că, chiar în condiții de stres obişnuit şi utilizare normală, microcapsulele se pot deschide, iar agentul de reparare şi catalizatorul pot interacționa. Un alt dezavantaj este acela că materialul nu se poate autorepara rapid, dacă deteriorarea reapare în aceeaşi zonă.
Un nou tip de nanocompozit cu capacitate de autoreparare, care elimină aceste dezavantaje, este prezentat în brevetul WO/2012/065213. Soluția conține o macromoleculă, un agent de reticulare pentru legătura necovalentă cu macromolecula şi o nanosubstanță de umplere. Ca agent de reticulare este folosită ureea, iar macromolecula de condensare este formată dintr-un polimer de tipul poliamidei.

Smarttextiles and nanotechnology, iulie 2012, p. 3

Noi tehnologii

CAMUFLAJ NATURAL CU MUŞCHI ARTIFICIALI

Cercetătorii de la ***Universitatea din Bristol***, Marea Britanie, au dezvoltat un sistem de muşchi artificiali care, prin simpla apăsare a unui comutator, pot imita capacitatea de camuflare a unor organisme, cum ar fi calamarul şi peştele-zebră.
Cele două sisteme individuale ar putea fi încorporate în îmbrăcămintea inteligentă, pentru a imita trucuri de camuflare similare cu cele observate în natură. În acest sens, Jonathan Rossiter, autorul principal al studiului, a declarat: *„Ne-am inspirat din modelele existente în natură şi am folosit aceleaşi metode de transformare a muşchilor artificiali în efecte vizuale uimitoare“.*
Muşchii artificiali, moi şi elastici, se bazează pe cromatofori, nişte celule speciale care se regăsesc la amfibieni, peşti, reptile şi cefalopode şi care conțin pigmenți de culori responsabili cu efectele de schimbare a culorii. În natura înconjurătoare, schimbarea culorii viețuitoarelor poate fi declanşată de diversele modificări ale stării de spirit, ale temperaturii, de stres sau de alte elemente din mediu şi este utilizată pentru camuflaj sau pentru atragerea unui partener.
În cadrul acestui studiu, au fost create două tipuri de cromatofori artificiali: primul tip este bazat pe un mecanism de schimbare a culorii similar celui întâlnit la calamari, iar cel de-al doilea tip se bazează pe un mecanism similar celui întâlnit la peştele-zebră.
La calamar, există o celulă tipică de schimbare a culorii, aflată într-un sac central, care conține granule de pigment. Sacul este înconjurat de o serie de muşchi şi atunci când celula este pregătită pentru a schimba culoarea, creierul trimite un semnal către muşchi, iar aceştia se contractă. Muşchii contractați fac ca sacii centrali să se extindă, generând un efect optic de schimbare a culorii calamarului.
În cadrul studiului, contracția rapidă a acestor muşchi a fost imitată cu ajutorul elastomerilor dielectrici (DEs) – obținuți din materiale inteligente, de obicei polimerice, conectate la un circuit electric. Aceşti muşchi se contractă atunci când este aplicată o tensiune şi revin la forma lor inițială atunci când sunt scurtcircuitați.
Spre deosebire de calamar, peştele-zebră conține celule ce posedă un mic rezervor cu pigment negru, care, atunci când este activat, ajunge la suprafața pielii şi se răspândeşte în exterior într-un mod similar acțiunii de vărsare a cernelii negre. Petele naturale întunecate de pe suprafața peştelui-zebră par, prin urmare, mai mari, iar efectul optic dorit este realizat. De obicei, modificările sunt produse de hormoni.
În cadrul aceluiaşi studiu, celulele peştelui-zebră au fost imitate, la microscop, cu ajutorul a două lamele de sticlă, intercalând între ele un strat de silicon. Pe ambele părți ale lamelei au fost poziționate două pompe, realizate dintr-un DEs flexibil, care au fost conectate la sistemul central cu ajutorul a două tuburi de silicon: unul dintre tuburi pompează o soluție de alcool alb-opac, iar celălalt tub un amestec de cerneală neagră şi apă.
„Cromatoforii artificiali sunt scalabili şi adaptabili. Ei pot fi încorporați într-o piele artificială compatibilă, care, chiar dacă se va întinde sau deforma, va putea funcționa în continuare în mod eficient“ – afirma Jonathan Rossiter.
Acest lucru înseamnă că aceşti cromatofori pot fi utilizați în diverse medii, chiar şi acolo unde tehnologiile tradiționale „greoaie“ sunt periculoase, de exemplu în cazul îmbrăcămintei inteligente, la interfața fizică cu corpul uman.

Smarttextiles and nanotechnology, septembrie 2012, p. 3