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ANNALS OF THE UNIVERSITY OF ORADEA
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EXPERIMENTAL PLAN BASED ON THE RANDOMIZED COMPLETE BLOCK METHOD FOR THE DEVELOPMENT OF FLEXIBLE MATERIALS FOR ELECTROMAGNETIC ATTENUATION

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Abstract: *The negative effects of continuous exposure to electromagnetic waves know a continuous growth on the last years because of new developments in electronics and mobile communication applications in different fields (medical, smart devices for IoT applications). There are some researches concluding that exposure to electromagnetic fields could affect the cells (PMBCs, T lymphocytes, B lymphocytes, NK cells and macrophages) of the immune system including cell proportion, cell cycle, apoptosis, destruction activity and cytokine content. Considering the negative effect of electromagnetic inference, it is necessary to develop advanced materials to attenuate electromagnetic waves to protect electronic equipment and humans.*
In this context, this paper presents an experimental plan based on completely randomized blocks (RCBD) for obtaining adequate textile coating for electromagnetic shielding applications taking into account the design of electromagnetic shielding devices should include the modelling of the attenuation phenomenon of electromagnetic waves using Schelkunoff and Calculation theories.
The proposed experimental plan consists of experiments distributed in blocks, each block corresponding to the technology used. For each experimental block, the factors specific to the technology used (independent variables such as the metals used (Ni, Cu, graphite, Fe_3O_4, Ag, Zn), mass (M), air permeability (Pa), thickness (δ)) that could influence the response variable (electrical resistance (Rs)) have been taken into consideration

Key words: *textile, EM shielding, electromagnetic wave,*

1. INTRODUCTION

Concern about possible health hazards from exposure to electromagnetic waves has increased in recent decades with their widespread application in many fields. The immune system plays a crucial role in maintaining body homeostasis. It is important to note that the immune system is also a sensitive target for electromagnetic fields. In recent years, the biological effects of electromagnetic fields on immune cells have attracted more and more attention. Accumulated data suggest that exposure to electromagnetism could affect the cells of the immune system to a certain extent, including cell proportion, cell cycle, apoptosis, destruction activity, cytokine content, and so on. The research subjects mainly covered all types of immune cells, especially PMBCs, T lymphocytes, B lymphocytes, NK cells and macrophages [1].

Electromagnetic Interference (EMI): EMI is the phenomenon by which electromagnetic waves interfere with other electronic/electromagnetic systems, causing interference in communications or damage to electronic components.

Biological rhythms, physical well-being and mental states depend on the electrical system of brain waves interacting with the extremely weak electromagnetic fields generated by the Earth's telluric and cosmic radiation. We are exposed to a wide range of strong electromagnetic radiation, artificially generated, which negatively affects the subtle balance in the energy fields of nature and has become the source of the so-called "diseases of civilization". This also includes sensitivity to electromagnetism. In general, there is a lack of awareness and understanding of electromagnetic fields' impact on health and well-being [2].

Mobile wireless communication networks have become an important aspect of human life. Electronic products make people's lives easier and more systematic. However, a variety of harmful radiation is produced by this equipment. This electromagnetic radiation (EMR) affects human health, flora, and fauna. Without considering the health effects caused by electromagnetic radiation, considerable investments are made to develop these services. Numerous studies have been conducted to demonstrate the harmful effects of EMR on environmental sustainability and the effects caused by these radiations have been proven [1, 3]. Considering these aspects, it is necessary to develop materials for electromagnetic shielding and electromagnetic wave attenuation for equipment and human protection.

Electromagnetic shielding is based on two fundamental processes - reflection and absorption of electromagnetic waves. The material parameters involved in shielding are electrical resistance, electrical conductivity σ, electrical permittivity ε and magnetic permeability μ. The absorption of electromagnetic waves can be due to conductive, dielectric or magnetic losses, depending on the material parameters important in the interaction of the waves with the electromagnetic shield in question. The appropriate selection of materials, their structure and the geometric configurations in which they are used ensures the design of electromagnetic screens with optimized properties for the fields of application [1-3].

2. THEORETHICAL MODELING

The design of electromagnetic shielding devices involves the theoretical modelling of the attenuation phenomenon of electromagnetic waves. This can be achieved using two theories − Schelkunoff theory and Calculation theory [4, 5, 6, 7] both aiming to quantify the shielding effect using the shielding effectiveness parameter (SE) measured in decibels (dB) and defined according to the logarithmic relationship (1).

$$SE[dB] = 10 \cdot lg\left(\frac{P_i}{P_t}\right) \quad \textbf{(1)}$$

Where: P_i and P_t are the incident and transmitted electromagnetic wave power.

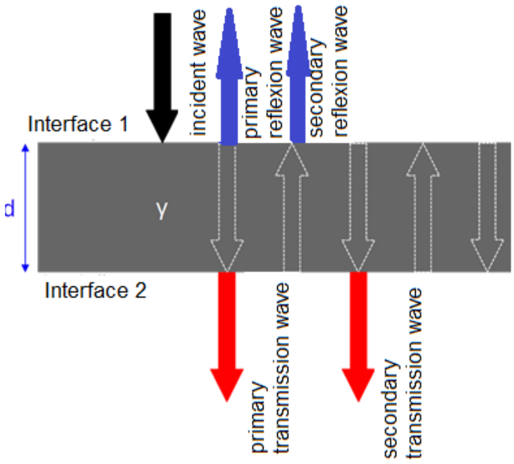
The electromagnetic wave is composed of two coexisting and interdependent wave types (electrical and magnetic) that can interact predominantly electrically or magnetically with matter. Considering this aspect, the electromagnetic wave can be considered to be, as the case may be, an electric or magnetic wave. Thus, the SE parameter can be expressed as a function of the intensity of the type of field (electric or magnetic) underlying the electric or magnetic wave, incident and transmitted [4, 5, 6, 7], according to relation (2):

$$SE[dB] = 20 \cdot lg\left|\frac{E_i}{E_t}\right| = 20 \cdot lg\left|\frac{H_i}{H_t}\right| \quad \textbf{(2)}$$

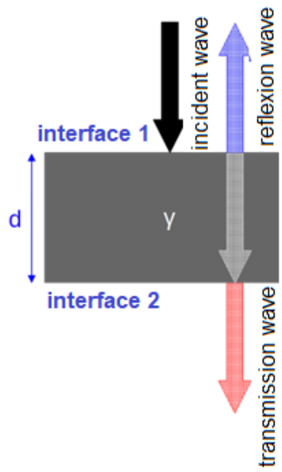
Where E_i and E_t are the electric field intensity of the incident and transmitted electric wave, and H_i and H_t are the magnetic field intensity of the incident and transmitted magnetic wave [4, 5, 6, 7].

According to the "Schelkunoff theory" (figure 1.a), the incident waves are partially reflected by the separating interface between the external environment and the screen material (interface 1), resulting in primary reflection waves. Thus, the non-reflected waves are transmitted through the screen and partially/totally absorbed by it, after which the non-absorbed waves are partially reflected inside the screen at the interface screen - external medium (interface 2). Thus, the waves not reflected by this interface pass through the shielding material in the external environment, resulting in primary transmission waves. The waves partially reflected inside the screen (mentioned before) are transmitted from the interface 2 to 1 and partially absorbed by the material, with a new internal reflection taking place simultaneously with the passage from the screen to the external medium of origin (resulting in secondary reflection waves) [4, 5, 6, 7].

According to "Calculation theory" (figure 1.b), the incident waves are partially reflected by the separating interface between the external environment and the screen material (interface 1), resulting in reflection waves. Unreflected waves are transmitted through the screen and partially/totally absorbed by it, after which they exit the shielding material into the external environment, resulting in transmission waves. The theory does not consider the phenomenon of multiple reflections separately but includes it in a global reflection and absorption [4, 5, 6, 7].



a. Schelkunoff theory



b. calculation theory

Fig.1: *Schematic representation of the electromagnetic shielding phenomenon [4, 6]*

Each of the two theories uses one effectiveness term related to reflection and one related to absorption, but without being identical because, unlike the second theory, the first theory considers multiple internal reflections in the calculations. Schelkunoff's theory is suitable for monolayer electromagnetic shields with homogeneous and isotropic properties due to the importance given to multiple reflections, which in the model are considered to occur only between two separation interfaces between different media. Instead, the calculation theory lends itself to single-layer screens as well as multilayer ones, presenting at the same time the additional advantage of a more straightforward calculation than in the case of the other theory, a better correspondence of the physical meaning of the quantities $SE\rho$ and $SE\alpha$ with the notions of attenuation by reflection and absorption [4, 5, 6, 7].

3. EXPERIMENTAL PLAN BASED RANDOMISED BLOCKS

The experimental plan with completely randomized blocks (RCBD) [8], was obtained by the distribution of experiments in blocks was used, each block corresponding to the technology used (ultrasound, screen printing, lamination or magnetron spraying). For each experimental block, the factors specific to the technology used were taken into account (independent variables (table 1) such as the metals used (Ni, Cu, graphite, Fe_3O_4, Ag, Zn), mass (M), air permeability (Pa), thickness (δ)) that can influence the response variable (electrical resistance (Rs)). The experimental plan, based on completely randomized blocks (RCBD), was achieved using the design of blocks with 2 factors with replication (table 2) was used. Table 3 presents the analysis of variance for completely randomized blocks with replication.

Table 1. *Parameters used for the RCBD experimental plan*

Metal	**Mass (M)**	**Thickness (δ)**	**Air permeability (Pa)**	**Surface resistance (Rs)**
Ni	1159	2.13	9.29	1000
Cu	1587	4.48	33.9	1E+07
Cu	1431	3.34	31.7	1.1E+07
Grafit	709	0.915	45.46	1E+11
Fe3O4	515	1.011	5.755	1E+07
Ni	556	4.385	16.8	1000
Cu	650	1.527	8.876	1E+07
Cu	658	1.847	6.123	1000
Ag	476	1.304	4.27	1E+08
Cu	760	2.25	9.52	1000
Cu	776	1.77	33.16	1000
Cu	702	3.52	31.92	1000
Cu	780	5.38	264.8	1000
Ni	828	4.42	109.1	1000
Ni	950.4	3.9	10.148	1000
Ag	1020.4	3.248	3.248	1000
Cu	1125.2	4.106	90.3	1E+10
Ni	966.4	4	90.383	1000
Ag	1002.8	4.762	141	1000
Ni	590.8	1.5	113.4	1000
Ni	623.2	1.424	109.4	1E+07
Cu	623.6	1.42	121.8	1E+10
Fe3O4	602.8	2.408	55.73	1E+08
Ag	769.6	3.878	143	1000
Ni	577.2	1.25	88.14	100000
Zn	559.2	1.684	16.2	100000

Table 2. *Experimental design - completely randomized blocks with replication*

SUMMARY	M	δ	Pa	Rs	Total
Ni					
Count	45	45	45	45	180
Sum	37290.4	123.113	1975.577	5.45E+12	5.45E+12
Average	828.6756	2.735844	43.90171	1.21E+11	3.03E+10
Variance	55463.26	1.504862	2862.662	9.95E+22	2.72E+22
Total					
Count	45	45	45	45	
Sum	37290.4	123.113	1975.577	5.45E+12	
Average	828.6756	2.735844	43.90171	1.21E+11	
Variance	55463.26	1.504862	2862.662	9.95E+22	

Tabel 3. *Analysis of variance - completely randomized blocks with replication*

Source of Variation	SS	df	MS	F	P-value	F crit
Sample	0	0	65535	65535		
Columns	4.96E+23	3	1.65E+23	6.639405	0.000284	2.655938877
Interaction	0	0	65535	65535		
Within	4.38E+24	176	2.49E+22			
Total	4.88E+24	179				

Where: SS-experimental error; p-value represents the statistical significance of the test and shows the probability of an error observed by chance; Df represents the number of degrees of freedom; Fcrit represents the critical value, MS represents the square mean and is the expression of the dispersion of the analyzed sample.

Analyzing the obtained data, it is observed that between F and F_{crit} there is the following relationship (3):

$$F_{crit} > F \quad \textbf{(3)}$$

Where:

$$F_{crit} = F_{\alpha, df_m, df_e} \quad \textbf{(4)}$$

In the randomized block analysis, the following assumptions were used:

- The significance level is 0.05;
- The population of experimental parameters is divided into a number of 4 homogeneous subpopulations (blocks);
- Variation within blocks can be minimized by reducing experimental error (MSE).
- Treatments based on different metal microparticles are randomly assigned to the experimental parameters on each block. Because a randomization was used for each block.

Analyzing the randomized blocks, it is observed that using the RCBD method without replication, the P value is equal to 0.000328 (p<0.001) and it follows that the null hypothesis is eliminated. Thus, depending on the metal used, the electrical resistance of the screen can be defined by the following regression equations (5-10) presented in Table 4.

Table 4. *Regression equations (Rs = f (metal, M, δ, Pa))*

Metal	The relationship between the response variable Rs and the independent parameters	
Ag	X = 41258168986 + 179372247 * Y - 54617856694 * Z - 356077211 * W	**(5)**
Cu	X = 171796334327 + 179372247 * Y - 54617856694 * Z - 356077211 * W	**(6)**
Fe_3O_4	X = 4119780818 + 179372247 * Y - 54617856694 * Z - 356077211 * W	**(7)**
Grafit	X = 38987685750 + 179372247 * Y - 54617856694 * Z - 356077211 * W	**(8)**
Ni	X = 41263747348 + 179372247 * Y - 54617856694 * Z - 356077211 * W	**(9)**
Zn	X = 484992709600 + 179372247 * Y - 54617856694 * Z - 356077211 * W	**(10)**

Where: x represents electrical resistance, y represents mass, z represents thickness and w represents air permeability.

5. CONCLUSIONS

In conclusion, to reduce the consumption of raw materials (textiles, chemicals), an experimental design based on randomized blocks will be used, which will allow the selection of appropriate experiments based on the parameters or materials used to reduce experiments with the null hypothesis. In both analyzed cases, the inequality $0.0002 < $ p-values <0.05 means that the results will only contain the null hypothesis for a percentage less than 5% (unfavourable hypothesis for electrical resistance values (Rs) > 10^5 Ω).

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ADVANCED SHADING TECHNIQUES IN ARAHWEAVE

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Abstract: *In the dynamic world of textile design, where digital tools have revolutionized the process of creating patterns, ARAHNE software programs, ArahPaint, ArahWeave, ArahDrape and ArahView 3D, are recognized as leading CAD/CAM software tailored for professionals. ArahPaint is a software designed for instant drawing in seamless repeats, enabling users to easily view and generate repetitions of their pattern. Specifically optimized for designing and weaving Dobby and Jacquard woven fabrics, ArahWeave software exemplifies how digital technology is reshaping the creative process in the textile industry. The advanced simulation tools of ArahWeave facilitate a highly realistic preview of how seamless pattern will appear when woven into fabric. Users can adjust structural parameters including thread patterns, yarn characteristics, colour schemes, fabric density, and weaves to achieve their desired aesthetic and structural appearance in woven fabric and present a 3D model simulation of their fabric in ArahView 3D. ArahDrape is a texture mapping software designed to help weavers, designers, and retailers enhance the presentation of their fabrics. Like mastering any other skill, using ARAHNE software programs requires dedicating time to learn and practice creating various textile patterns suitable for a range of textile applications. Additionally, users' artistic skills empower them to enhance both the quality and uniqueness of their textile designs.*
This paper explores the advanced shading techniques of Jacquard woven fabrics, simulated in ArahWeave software. The aim is specifically focusing on the process from inspiration to creating seamless patterns suitable for various Jacquard fabric types, providing solutions to users who wish to transcend the confines of traditional textile design.

Key words: *seamless repeat, textile pattern, Jacquard woven fabric, ARAHNE, digital technology*

1. INTRODUCTION

The Jacquard weaving in textile design is more than just a weaving technique; it represents a convergence of artistic expression and technological innovation, which facilitates the creation of complex patterns ranging from basic geometric shapes to elaborate motifs and images. It is a technique that enables customization for various design applications in industries such as fashion and interior design (home decore, upholstery, etc.). Named after its inventor Joseph Marie Jacquard, Jacquard weaving emerged in the early 19th century as a groundbreaking innovation in textile production. Prior to its development, obtaining intricate seamless patterns through weaving required laborious manual processes. The Jacquard loom introduced a revolutionary mechanism controlled by punched cards, opening up new possibilities for textile pattern design.

In the present, textile patterns can be created with remarkable details thanks to advancements in electronic Jacquard technique. This technology has been further complemented by digital tools, which have revolutionized the process of creating seamless repeats.

One notable software in this realm is ARAHNE, recognized as a leading CAD/CAM software optimized for designing and weaving Dobby and Jacquard woven fabrics. With its user-friendly interface and powerful software programs such as ArahPaint, ArahWeave, ArahDrape and ArahView 3D, ARAHNE provides sophisticated features specifically designed for electronic weaving methods.

ArahPaint is a free software that facilitates the easy application of design elements and principles. It is a powerful software designed to generate intricate motifs and seamless repeats using drawing tools, color management, shading algorithms, filters, resolution considerations, and many others. With seamless integration with structural parameters, users can refine patterns to ensure a smooth transition to the final woven fabric.

The advanced simulation tools of ArahWeave facilitate an ultra-realistic preview of how the seamless pattern will appear when woven into fabric. Users can adjust all structural parameters, including thread patterns, yarn characteristics, color schemes, fabric density, and weaves, to achieve their desired structure and appearance characteristics, and present a 3D model simulation of their fabric in ArahView 3D.

ArahDrape is a texture mapping software designed to help weavers, designers, and retailers enhance the presentation of their fabrics. With its 3D Grid and Shading tools, users can realistically apply the textures designed in ArahWeave to a final product that has been vectorized within a photographed image. Undoubtedly, all these tools of the programs cannot substitute for the skills, knowledge, and experience of a professional woven fabric designer.

2. FROM INSPIRATION TO SEAMLESS REPEATS

Creating your own seamless repeat can be a rewarding process that begins with discovering a source of inspiration with which you identify and has the potential to be translated into an original design. In this paper, I drew inspiration from a photographic image by Violeta Radu, a renowned visual artist known for exploring various themes, including the cross sign (Fig. 1).

This symbol exists in every construction, in every object; it serves as a durable source for splicing, weaving, and braiding. The photographic image displays a church tower cross visible in the background through a crack in a wooden fence [1].

This shape, resembling the cross sign, captured the essence of my inspiration. I translated it into vector graphics using Adobe Illustrator, creating two seamless repeats, which I named “The Cross Man” (Fig. 2) and “The Pair of the Cross Man” (Fig. 3).

These seamless repeats reflect my unique artistic vision, expressed through the language of design, and demonstrate their adaptability for diverse applications such as woven or printed fabrics, wallpapers, or digital artworks [2], [3].

***Fig. 1**: Source of inspiration*

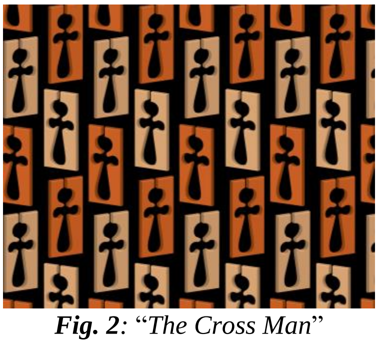


***Fig. 2**: “The Cross Man”*

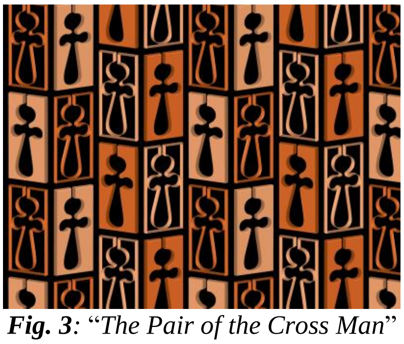
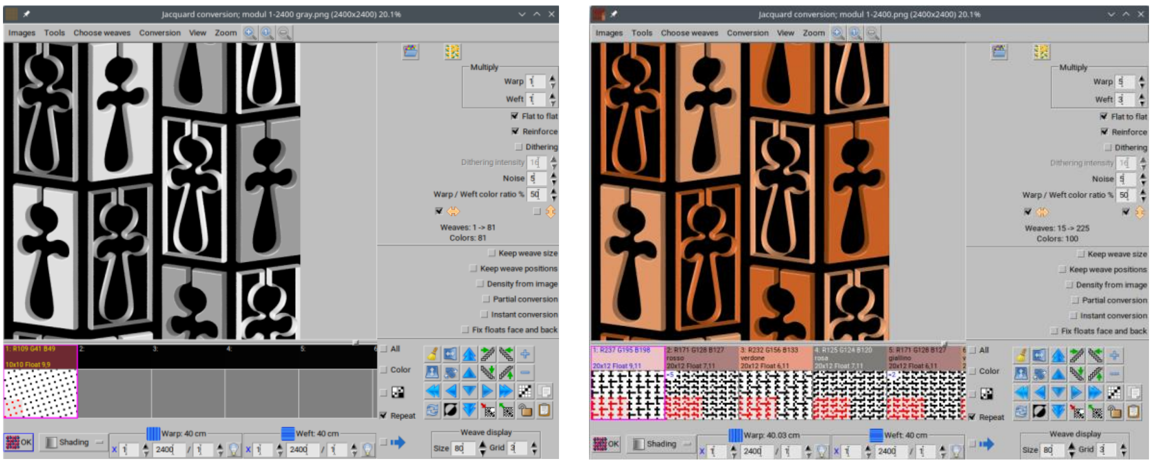


***Fig. 3**: “The Pair of the Cross Man”*

3. EXPLORING SHADING TECHNIQUES IN ARAHWEAVE

The term “shading effects” refers to techniques used in visual arts to create the illusion of depth, volume, and texture through variations between light and dark areas. The term itself can also be applied in weaving. It refers to the transition unidirectional or bidirectional of weave effects from warp to weft, changes in the density and fineness of thread systems, non-uniform denting, and the utilization of gradient thread colors. The Jacquard shading technique provided by ArahWeave software enhances the structure and appearance characteristics of woven fabrics, making them highly desirable for both aesthetic and functional purposes. The advancements in digital technology have allowed for even more complex and detailed Jacquard patterns, further expanding the creative possibilities for textile designers and manufacturers. ArahWeave software has its “limitations”, which are driven by deeper technical aspects of weaving. It is known that the number of warp threads in Jacquard weave size is determined by the number of hooks. For example, the Stäubli electronic Jacquard machine, LXL V model, offers a configuration up to 14,336 hooks, and the maximum weave size is 65,520 by 65,520 threads for ArahWeave Pro and 262,080 by 262,080 threads for ArahWeave Pro XL, much more than what is possible to achieve in practice [4].

Once an image or seamless repeat is loaded into the Jacquard conversion window, the user can choose the desired Jacquard conversion method. In addition to the Normal type of Jacquard conversion, where the user manually selects a weave for each color, ArahWeave software provides alternative types of Jacquard conversion such as Shading [5], Extra wefts [6], Fil coupé, and Blanket. Using the same seamless repeat in Shading mode, two Jacquard weaves were simulated: one as a simple Jacquard weave with a warp thread system and a weft thread system (Fig. 4a), and the other a compound Jacquard weave simulated with five warp thread systems and three weft thread systems (Fig. 4b). In simulating Jacquard woven fabrics, warp and weft threads with identical structural characteristics were used, along with the same 40 by 40 cm repeat dimensions and an equal number of threads in both warp and weft directions, totaling 2400 by 2400.



a *b*

Fig. 4*: ArahWeave - Jacquard conversion window*

In the Fabric menu, users can select thread patterns, colors (Fig. 5), and yarns (Fig. 6), and adjust the thread density in both the warp and weft directions to simulate various types of fabrics with different characteristics and appearances. The Consumption window from the Fabric menu provides users easy access to all technical data and facilitates the calculation of the fabric production parameters

(Fig. 7). This helps to optimize woven fabric simulation and production planning by providing necessary information about the yarn consumption and the finished price.

Fig. 5*: ArahWeave - Edit colors*

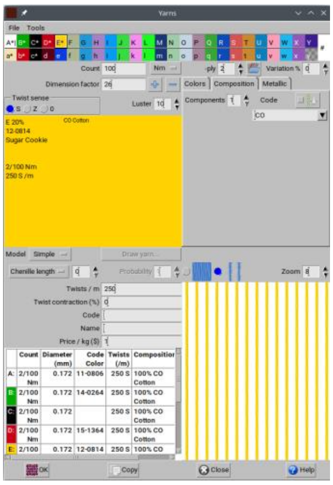


Fig. 6*: ArahWeave - Yarns*

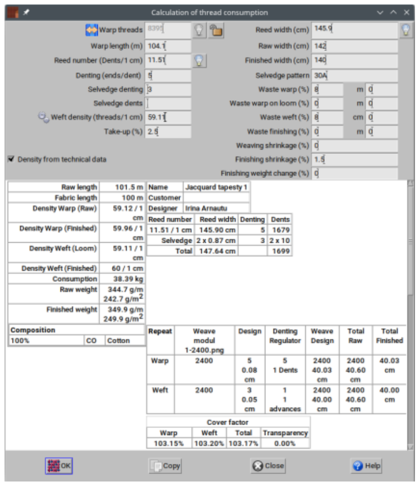


Fig. 7*: ArahWeave - Consumption*

The zoom level of woven simulation ranges from a minimum of 5% (twenty times smaller) to a maximum of 2000% (twenty times bigger), allowing the user to observe and analyze all structural details with more precision. ArahWeave software offers four possible view modes, available from the View menu: Weave, Integer, Shaded Integer, and Simulation. Simulation mode offers various quality levels ranging from 1 to 9, where higher numbers signify a more accurate and higher quality of simulation. In figure 8 is presented the simulation of “The Pair of the Cross Man” seamless repeat as a simple Jacquard weave, and in figure 9 as a compound Jacquard weave. If in the case of simple Jacquard weave, the reverse is its inverted face, in the compound Jacquard weave, the difference between face and reverse is more pronounced. The selection of warp and weft thread colors aimed to closely match the chromatics of the seamless repeat and accentuate its shading effects. While the shading is more accurate in simple Jacquard weave, it's restricted to colored gray tones. Achieving a closer match to the chromatics of the seamless repeat requires the optical blending of various thread colors, an appearance characteristic of compound Jacquard weave.

Fig. 8*: ArahWeave - simple Jacquard woven fabric, simulation 8, 25% zoom level, face and reverse*

Fig. 9*: ArahWeave - compound Jacquard woven fabric, simulation 8, 25% zoom level, face and reverse*

Figure 10 shows the 3D simulation of compound Jacquard woven fabric on different final products in actual 1:1 size, using ArahDrape software. The 3D simulation assists designers in determining the structural and appearance characteristics of woven fabric, and enabling customers to express their approval or disapproval of the textile pattern design.

Fig. 10: *ArahDrape - 3D simulation of texture on final products, in real 1:1 size*

5. CONCLUSIONS

Jacquard weaving represents a fusion of artistry and technology, fueled by innovation and experimentation. The creative process begins with a source of inspiration and moves towards its conceptualization. ArahWeave software serves as a versatile "canvas" for translating the concepts into simulations and, ultimately, into practical weaving applications.

The possibilities for creating shading effects within Jacquard woven fabrics are limitless. The advanced tools provided by ArahWeave software enable the exploration of shading techniques in a virtual environment, far surpassing the boundaries of traditional textile design.

Through iterative refinement and visualization, the users can preview the effects of shading in Jacquard woven fabrics before actual weaving, simulating their application on final products in ArahView 3D and ArahDrape software.

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

POTENTIAL USE OF BIO-DYES FOR GREEN COLORING OF MEDICAL TEXTILES

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Abstract: *Cotton is a textile material frequently used in the medical system. The possibility of using natural extracts for coloring biotextiles is a current way of giving sustainability attributes to articles used in medicine. The influence of five different classical mordants and biomordants (citric acid, tannic acid, ferrous sulfate II, copper sulfate and ferrous sulfate with oxalic acid), by meta-mordanting and dyeing by exhaustion and sonication methods with Rhus typhina L. fruit extract, was evaluated. The investigation was carried out by measuring the chromatic coordinates, water and dry rubbing resistance, as well as measuring the FT-IR absorption spectra. The mixture between ferrous sulfate and 4% oxalic acid produced, according to the ATR-FTIR analysis, the greatest changes in the cotton structure, but significantly reduces the color changes resulting from the simple use of sulfate. The promising obtained results such as low color changes when using biomordants, good resistance to water and friction, encourage to continue the research regarding the application of this extract in the friendly technology of cotton dyeing.*

Key words: *cotton fabrics, Rhus typhina L., biomordant, exhaustation, ultrasonication, ATR-FTIR*

1. INTRODUCTION

In recent years there has been an increasing interest in textile dyes obtained from natural resources, which present a significantly lower risk for human health and the environment than synthetic dyes [1].

In 2023, Karadag [1] proposed the introduction of a new standard named the Natural Organic Dye Standard (NODS) for naturally dyed textiles, which also comprised a list of dye plants among which the woody species *Rhus typhina* L. was included. *R. typhina* or staghorn-sumac is an alien species found in the flora of Romania, which was introduced as an ornamental species [2]. Its bright red fruits are rich in antioxidant and antimicrobial compounds such as vitamin C [3], flavonoids, phenols and anthocyanins [4]. The fruits of different sumac species were previously used in a mixture with other tinctorial plants to obtain a red dye [5], but the staghorn-sumac fruit itself would produce a crimson dye [6]. Moreover, tannins identified in the leaves make them a good alternative for fixing pigments in dyed fabrics [7].

In order to eliminate the release from textile supports of some toxic compounds on the skin with exposure to allergies or other dermatological conditions, attemps are made to use natural dyes for medical articles as well. The scientific world has become more and more captivated by the use of plant extracts to obtain textile materials with antimicrobial properties [8]. According to the study of Secareanu et al. [9], cotton could represent an important functionalized material for medicine, with the potential to limit the spread of acne-causing bacteria [9], or much stronger infections, such as those caused by *Klebsiella pneumoniae* and *Staphyloccocus aureus* [10], this being a material frequently found in hospitals, in medical suits and bed sheets [11].

Plant-based dyeing represent a complex process defined by the characteristics of textile material, how the fabric is treated with different mordants, how the vegetable substrate is collected, processed and then extracted, but also what values are selected for the actual dyeing parameters [12, 13]. Many researches have been conducted using the eco-dyeing solution with polar solvents such as distilled water [13], ethanol [13,14] and methanol [15]. Moreover, a plant extract used as a natural dye was presented as being more valuable when it has the lowest possible content of heavy metals and a wide palette of shades obtained by varying the mordant [14]. In different studies, natural dyeing improved cotton characteristics such as the ultraviolet protection factor and the tensile strength [16].

The aim of the present study was the evaluation of two different dyeing techniques of a cotton fabric with extracts of *R. typhina* fruits, using standard mordants and biomordants, in order to identify the most effective conditions that provide a good color and resistance quality, but also of the painting during the use of the product/fabric.

EXPERIMENTAL RESEARCH

2. MATERIALS AND METHODS

2.1. Plant material and extract preparation

R. typhina fruits were collected from Popești, Vâlcea county, in November 2022. These were dried at room temperature, in the shadow, until a moisture content below 6%, then were ground and sieved through a 0.71 mm mesh sieve. Distilled water brought at 40°C was used as a solvent to obtain the coloring extract. The maceration took place at room temperature for 24 h with occasional stirring, followed by centrifugation at 8000 rpm, at 4°C (Universal 320, Hettich, Germany), for 10 min.

2.2. Analysis of anthocyanin content

The anthocyanin content of the extract was evaluated using the method of Giusti and Rodriguez-Saona (1999) [17] usig the spectrophotometer (Analytik Jena, Specord 200 Plus UV-Vis, Germany). The results were expressed as „mean ± SD", in mg/100 g cyanidin-3-O-glucoside.

2.3. Material used and dyeing of the textile support

The textile material is constituted by 100% cotton, fabric weighing 120 g/m^2, with a canvas binding, and a warp and weft density of 20 yarns/cm. The chemicals used come from the company

Scharlau S.L. and were of analytical grade, with purities over 98%. Dyeings by exhaustation and ultrasonication were done on samples of cotton fabrics, in presence and absence of biomordants (citric and tannic acids), and standard mordants (copper sulfate and iron sulfate).

For each dyeing experiment, two concentrations of mordants were used: 3% and 5%, and in addition to the mentioned solutions, a mixture of iron sulfate with oxalic acid 4% was used, related to the amount of textile material.

The exhaustation dyeing method (80°C) and sonication procedure (40°C) using the Elmasonic E Ultrasonic bath, were applied as coloring methods, each being performed for 15 min to 25:1 liquid ratio.

2.4. Chromatic characterization in CIELAB system of dyed cotton and fastness properties

The CIELAB analysis of cotton samples dyed with *Rhus typhina* L. fruit extract was realised spectrophotometrically (Datacolor 110 LAV reflection spectrophotometer) by using the Tools II Plus software, under the D65 /10^0 illumination/observer conditions, in order to evaluate the chromatic parameters: L* (luminosity), a* (redness), b* (yellowness), C* (chroma) and h (hue/tone) and calculate by their differences compared to the reference sample, also the total colour change (ΔE*).

The experimental evaluation of the color was done by comparing it with the samples dyed without mordant.

As medical articles are generally disposable, we consider their characterization by resistance of paints to water and friction. Color fastness to water and dry rubbing were performed based on specific standards [18,19], for the latter using Crockmaster equipment. The color resistance of samples was analyzed before and after meta-mordanting treatment.

2.5. ATR-FTIR analysis

The changes in the chemical structures of colored cotton were studied by attenuated total reflection-FTIR analysis, operated at a resolution of 4 cm^{-1}, performed with an ATR-FTIR spectrometer (Bruker, Germany), with the combined ZnSe ATR and QuickSnapTM modules.

3. RESULTS AND DISCUSSIONS

The total content of anthocyanins extracted from *R. typhina* fruits was 18.29±1.35 mg/100g DW.

Cotton is a textile material that is difficult to undergo natural coloring without the use of a mordant, compared to other textile materials such as silk, ferrous sulfate and copper sulfate being often used in its dyeing, while tannic acid is more considered a pretreatment mordant that increases the affinity of the material for mordants [20].

3.1 Chromatic characterization and resistance testing of dyed cellulosic support

The evaluation of color changes is carried out to appreciate the influence of the mordants used and then anticipating the various treatments to which the colored materials are subjected. The results are presented in table 1.

Figures 1-2 are suggestive for the interpretation of changes in color, brightness, hue and saturation, as well as the variation of the most common colorfastness.

Table 1: *Colour measurements and colour fastness values for exhaustion dyed cotton samples with Rhus typhina L. extract*

No.	Dyeing procedure / Mordant used	ΔL*	Δa*	Δb*	ΔC*	ΔH*	ΔE*	Water fastness	Rubbing fastness
	EXHAUSTION METHOD								
1.	Reference sample (REH)	75.86	21.46	2.31	21.59	6.14	-	2-3	3
2.	3% Citric acid (CA3)	-1.28	1.09	2.33	1.44	2.13	2.87	3-4	3-4
3.	5% Citric acid (CA5)	-1.02	0.31	1.92	0.59	1.85	2.19	4-5	4
4.	3% Tannic acid (TA3)	-0.64	-0.23	1.60	0.01	1.62	1.74	3-4	4
5.	5% Tannic acid (TA5)	-0.33	-1.96	1.15	-1.78	1.41	2.29	4	4-5
6.	3% $FeSO_4$ (iron sulfate) (IS3)	-18.52	-14.68	-6.88	-13.41	-9.11	24.61	4	4
7.	5% $FeSO_4$ (iron sulfate) (IS5)	-25.57	-16.50	`-7.94	-14.07	-11.71	31.45	4-5	5
8.	3% $CuSO_4$ (copper sulfate) (CS3)	-1.35	-2.92	3.05	-2.29	3.55	4.44	5	4-5
9.	5% $CuSO_4$ (copper sulfate) (CS5)	-1.40	-4.08	5.47	-2.55	6.33	6.97	5	4-5
10.	3% $FeSO_4$ + 4% Oxalic acid (IO3)	-1.59	-3.13	4.12	-2.16	4.71	5.42	4-5	4-5
11.	5% $FeSO_4$ + 4% Oxalic acid (IO5)	-1.02	-4.77	2.62	-4.19	3.48	5.54	4-5	4-5
ULTRASONICATION METHOD									
1.	Reference sample (RUS)	75.56	22.00	1.36	22.05	3.53	-	2-3	3
2.	3% Citric acid (CA3)	-1.04	1.54	1.37	1.65	1.23	2.31	4	3-4
3.	5% Citric acid (CA5)	-0.34	0.68	0.59	0.72	0.54	0.96	5	4
4.	3% Tannic acid (TA3)	-0.12	0.21	1.41	0.34	1.38	1.43	4-5	4
5.	5% Tannic acid (TA5)	-1.34	-1.96	0.90	-1.87	1.06	2.53	4-5	4-5
6.	3% $FeSO_4$ (iron sulfate) (IS3)	-14.18	-13.82	-4.82	-13.16	-6.41	20.38	4	4-5
7.	5% $FeSO_4$ (iron sulfate) (IS5)	-19.64	-15.77	-6.33	-14.07	-9.53	25.97	4-5	5
8.	3% $CuSO_4$ (copper sulfate) (CS3)	-1.46	-1.31	2.99	-0.90	3.13	3.57	5	4-5
9.	5% $CuSO_4$ (copper sulfate) (CS5)	-1.84	-1.77	4.09	-1.10	4.32	4.83	5	4-5
10.	3% $FeSO_4$ + 4% Oxalic acid (IO3)	-1.79	0.44	3.52	0.92	3.43	3.98	4-5	5
11.	5% $FeSO_4$ + 4% Oxalic acid (IO5)	-4.76	-7.55	-0.76	-7.58	-0.36	8.95	5	5

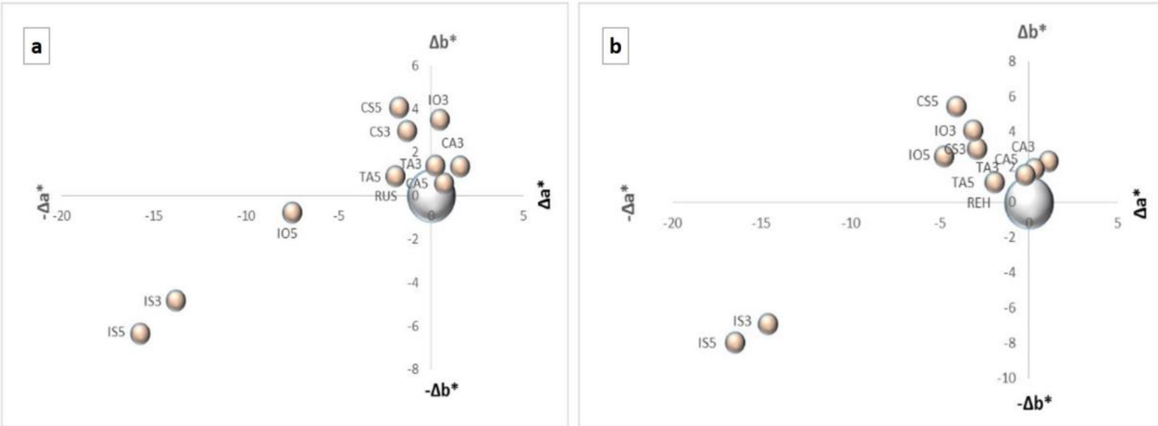

***Fig. 1**: Distribution of colour attributes of simultaneously mordanted and dyed samples, through the exhaustion procedure (a) and sonication procedure (b).*

Cotton fabrics dyed with extract changed slightly from pinkish-slightly purple by adding classic mordants or biomordants. Some differences were easily perceptible, others more sensitive, >3 units being evaluated negatively. High differences > 6 units were observed in samples treated with iron sulfate 3 and 5% and those with copper sulfate 5%. The samples treated with citric acid kept the pink-violet color with positive a* (redness) and b* (yellowness) coordinates, when dyeing by exhaustion, and even the use of tannic acid changed the hue relatively little towards pink-yellow, except for the samples colored in greenish-blue where iron sulfate was used and the samples with copper sulfate, iron sulfate and oxalic acid colored pinkish-yellow-light greenish.

***Fig. 2**: Graphical representation of the difference in luminosity, colour and fastness values of samples dyed by the exhaustion method (a) and ultrasonication method (b).*

Compared to untreated samples, the brightness differences are reduced in case of using tannic acid, citric acid and iron sulfate+oxalic acid, at 3 and 5%, for both applied dyeing methods. From table 1 and figure 2(a) it can be seen that the water fastness of the cotton mordanted with citric and tannic acid was slightly (1/2 unit) lower than the resistance of the samples dyed and mordanted with copper and iron sulfate, while the rubbing fastness is comparable to these mordants.

Through ultrasonication dyeing, color differences were low, suggesting that a temperature of around 40^{0}C does not significantly change the shade of the paints. Samples treated with iron sulfate 3-5%, but also iron sulfate with oxalic acid 5%, were negative. The color of the samples is somewhat stable for dyeing assisted by biomordants for both 3 and 5% concentrations, close to the shade of the untreated sample, in pink-slightly orange tones, but for the classic $FeSO_4$ mordant it changes to greenish-blue.

An increase in water and rubbing resistance for the samples dyed using ultrasounds in the presence of 5% tannic acid, but also iron sulfate with oxalic acid, with the exception of citric acid at low concentration, was noticed.

3.2. ATR-FTIR analysis of dyed cotton samples

The results of the ATR-FTIR analysis for control and cellulosic samples dyed by exhaustation and ultrasound method are reported in Figure 3 and Figure 4.

The assignment of absorption peaks in the ATR FT-IR spectra was done based on the literature [21,22,23,24,25,26,27,28,29]. The absorption peaks at 3271.06 cm^{-1} (E) and 3270.06 cm^{-1} (US) are due to the alcoholic/ phenolic − OH stretching hydroxyl group of cellulose and tannins present in natural extract The sharp peaks in this region can also be associated with a NH stretching [23]. The peaks at 2849.85 and 2897.89 cm^{-1} (E) and at 2849.19 and 2894.74 cm^{-1} (US) are assigned to the asymmetric and symmetric stretching vibrations of CH_2. The peak at 1646.23 cm^{-1} are attributed to carbonyl group (C=O) stretching vibration. The peaks at 1453.64 cm^{-1} for exhaustation (E) and 1450.17 cm^{-1} for ultrasonication (US) indicates the presence of methylene groups (CH_2). The peaks at 1203 cm^{-1} may be attributed to C-O-C-functions of ethers and esters. The peak at 1028 cm^{-1} was associated with C–O–C pyranose ring skeletal vibration of cellulose. The range below 1000 cm^{-1} is considered the fingerprint area, providing information about the substitution of aromatic rings. The peak at 897 is specific for β-glycosydic bonds of cellulose.

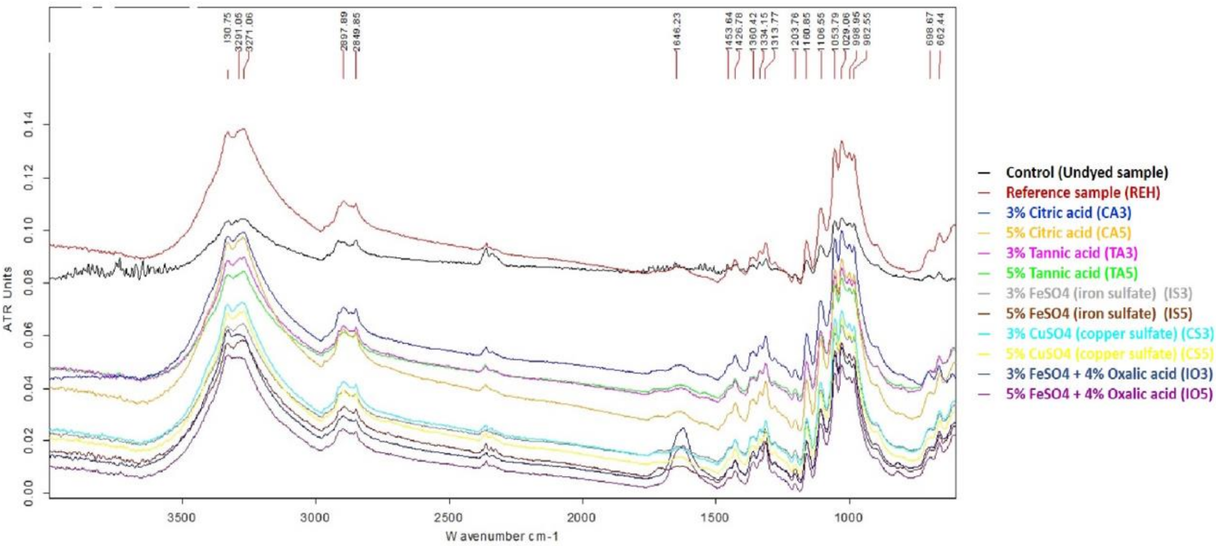

Fig. 3: *ATR-FTIR spectra of investigated cotton samples, dyed by exhaustation with R. typhina extract in the presence and absence of mordants.*

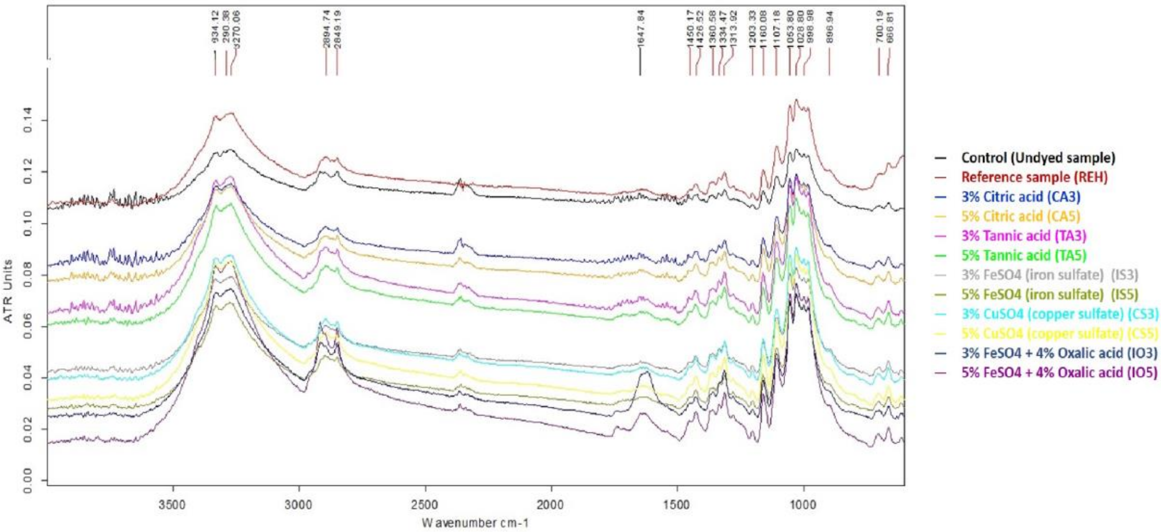

Fig. 4*: ATR-FTIR spectra of investigated cotton samples, dyed by ultrasonication with R. typhina extract in the presence and absence of mordants.*

The use of mordants, did not significantly change the structure of the cellulosic fibres support and did not bring differences compared to the structure of the sample dyed without mordant, respectively REH and RUS. Decrease of intensities of several absorption peaks were observed in samples dyed by both methods compared to the undyed cotton fabric, except for the ones dyed by ultrasonication technique using TA3 and CA3. In the study by Rosu et al. (2021) [24], after the dyeing of cotton with triphenodioxazine dye, the absorption bands of the FTIR spectra specific to the groups present in its structure decreased in intensity, a fact that was less visible in case of dyeing with staghorn sumac extract. On the contrary, some absorption peaks, at ≈3270 $cm^{-}1$, were intensified. The main difference was that US dyeing preserved a structure similar to that of the control than in the case of the E method. The mixture between ferrous sulfate and 4% oxalic acid produced the greatest changes in the cotton structure support.

5. CONCLUSIONS

The present study highlights the potential of the *R. typhina* extract to provide pleasant shades of pink-purple when applied on cellulosic support by conventional and modern dyeing methods.

The most efficient treatment with a biomordant (citric or tannic acid) simultaneously with dyeing, in addition to the relatively small color changes, can also lead to acceptable resistance to water and rubbing. The use of biomordants best preserved the cotton structure after dyeing, especially by ultrasonication. Based on the obtained results, iron sulfate is not recommended as a standard mordant for dyeing cotton with the *R. typhina* fruit extract, as it considerably changed the color of the materials and affected their resistance by combining with oxalic acid. However, the addition of oxalic acid keeps the color of the textile dyes close.

The ecodyeing with the *Rhus typhina* L. extract and assisted by citric acid gives the cellulosic support stability of the color shade and the possibility of use for health products.

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FASCICLE OF TEXTILES, LEATHERWORK

DYNAMIC ASSESSMENT OF WATER VAPOR RESISTANCE OF FABRICS CONTAINING HYDROPHILIC NATURAL FIBERS

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Abstract: *The transfer of water vapor through a textile is a crucial factor for ensuring comfort and performance in various applications that involve exposure to moisture or sweating, including military, firefighting, and outdoor sports activities. This work proposes a new experimental setup to measure the water vapor resistance of fabrics under different temperature and humidity conditions, providing more realistic values compared to conventional steady-state methods. Two different fabrics were analyzed. The first one is a common blend of fibers that mainly contains cotton (95 %) and elastane (5 %), and the second one contains modacrylic fibers (MAC Protex® 60 %) in combination with cotton (40 %). The results showed that the predominance of cotton in the composition of the fabric can lead to an increase of up to 13 % in the resistance to vapor transfer, attributed to the swelling effect of the fibers due to the increase in relative humidity. Blending cotton and PROTEX fibers in such fabrics provides improved moisture management properties in the sense of maintaining constant water vapor resistance even as relative humidity increases, contributing to wearer dryness and comfort.*

Keywords: *moisture transfer, cotton fibers, breathability, relative humidity, temperature.*

1. INTRODUCTION

The garment's primary function is to establish a stable microclimate in proximity to the skin, facilitating the body's thermoregulatory system regardless of environmental conditions or physical exertion. Breathability, defined as a textile's capacity to allow the transmission of moisture vapor through the material, plays a crucial role in sustaining the wearer's thermophysical comfort [1]. Therefore, many studies related to the breathability of various fabrics have been carried out [2], [3], [4], [5], [6]. However, most studies examined breathability characteristics according to two standards: the evaporative dish method (BS 7209) and the Hohenstein measuring method (ISO 11092). The first method involves quantifying the water vapor transmission rate (WVTR) and is a simple and cost-effective method used for quality control under standard conditions. In contrast, the second method, known also as the skin model, involves measuring the moisture vapor resistance (R_{et}) by the evaporative heat loss technique and is a method known for its accuracy and is mainly used in research and product design applications. Although a correlation has already been established between the properties determined by the two methods, WVTR and R_{et} respectively [7], [8], for hydrophilic materials this relationship is not valid.

The objective of this study is to assess the moisture vapor transfer resistance of hydrophilic textile materials under diverse humidity and temperature conditions and to establish a correlation with their moisture content.

2. MATERIALS AND METHOD

Two different textile fabrics were analyzed (Table 1). The first one (Sample A) is a common blend of fibers that mainly contains cotton (95 %) and elastane (5 %), and the second one (Sample B) contains modacrylic fibers (MAC Protex® 60 %) in combination with cotton (40 %). These materials are knitted fabrics used for the manufacture of underwear for protective clothing. Samples were selected to exhibit different characteristics concerning fiber moisture regain.

Table 1: *Characteristics of the fabrics*

Code	Composition	Structure	Weight ($g·m^{-2}$)	Thickness (mm)	R_{et} ($m^2·Pa·W^{-1}$)	I_{mt}	Moisture regain (%)
A	95% Cotton/ 5% Elastane	piqué	253 ± 5	1.16 ± 0.01	2.83 ± 0.10	0.48	6.50 ± 0.2
B	60% Modacrylic/ 40% Cotton	piqué	234 ± 3	0.83 ± 0.01	3.35 ± 0.05	0.41	3.53 ± 0.1

The characteristics of the fabrics listed in Table 1 were evaluated in accordance with established standards. Fabric weights were determined following the ASTMD 3776/D 3776M - 09a procedure, while the thickness of knitted fabrics was measured using the SDL – Digital Thickness Gauge M034A as per NP EN ISO 5084-2013. Thermal and water-vapor resistance were assessed using the sweating-guarded hotplate method ("skin model"), in compliance with ISO 11092:2016. A controlled climatic chamber was utilized to ensure specific environmental testing conditions. Moisture regaining from the textiles was determined through the drying method outlined in ISO 287:2008.

A Sweating Guarded Hotplate tester was employed to assess the water vapor transfer properties of the two types of fabrics (Fig. 1).

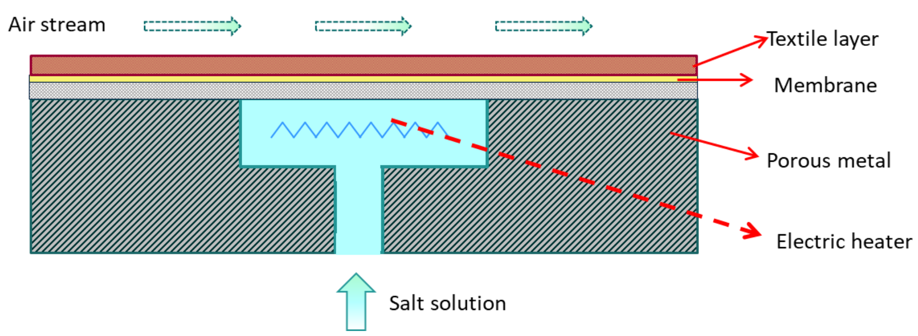

Fig. 1*: Skin Model experimental setup*

The device comprises a porous square metal plate fixed on a thermally conductive block, heated with an electric thermal heater. Sensors monitor the temperature of the thermal protection, water and porous metal plate, ensuring constancy within ±0.1 K. To compensate for the heat absorbed during water evaporation, a heating power H is provided by a suitable device, monitored with a precision of ±2 % throughout the operation. For R_{et} determination, the porous hot plate is protected by a breathable membrane impermeable to liquid water. The test sample is positioned above the membrane, and a conditioned air current (1 ±0.05 ms^{-1}) is flowing over and parallel to its top surface. Four humidity sensors (KFS 140-M SMD) measure the average humidity of the textile material.

To obtain the R_{et} values for different humidity and temperature values, the conditions from ISO 11092:2016 have been modified. The distilled water has been replaced with saturated salt solutions which provide different accurate values of the water vapor saturation pressure at four constant temperatures: 25 °C, 35 °C, 45 °C, and 55 °C. For each sample, choosing the right salt solution and adjusting the humidity of the air, conditions inside of the Skin Model were made so that the average humidity RH % of the textile, measured by sensors, was between 10 % and 90 %, with adjustments steps by steps of 10 %. The moisture content in the samples at the same partial pressure targets was determined by using a gravimetric method that measures uptake and loss of moisture. For that, initially, the samples underwent conditioning under a continuous flow of dry air for approximately 10 hours. Subsequently, they were exposed to the partial pressure of water vapor (pa), ranging from 10 % to 90 % of saturated pressure (ps), with increments of 10 %. The equilibrium criterion was defined by selecting a minimal value (0.005 % per min.) for the mass variation over time variation (dm/dt). This setup enables the software to automatically ascertain the time needed for the sample to achieve its equilibrium moisture content before progressing to the subsequent step (pa/ps). Moreover, this arrangement was employed to determine the minimum time required for R_{et} estimation using the Skin Model test at different relative humidities (RH %).

3. RESULTS AND DISCUSSION

Three determinations were made for each sample. A deviation of less than ±3 % from the average values was found. Figure 2 shows the average values and errors obtained for R_{et} at 25 ^{o}C, for different relative humidity values.

Experiments carried out in the relative humidity range between 10 % and 90 % show that the water vapor resistance increases relatively linearly with the moisture content at constant temperature for sample A containing mainly cotton, and remains almost constant in the case of cotton and synthetic fiber sample B (Fig. 2). R_{et} determined according to the ISO 11092:2016 standard (static conditions) was 2.83 $m^2 \cdot Pa \cdot W^{-1}$ for sample A, and 3.35 $m^2 \cdot Pa \cdot W^{-1}$ for sample B (Table 1). Since the structural characteristics of the two samples are different (thickness, mass), it is not the value itself of the R_{et} that interests us in this study, but the variation depending on the relative humidity and temperature. When the composition of fabrics is mostly cotton, the resistance to vapor transfer can increase up to 13 % due to the swelling effect of the fibers that affects the inner structure of the system. Through the integration of PROTEX fibers, the resultant textiles can enhance moisture control by maintaining constant water vapor resistance, even with an escalation in relative humidity. This contributes to keeping the individual dry and comfortable.

Figures 3 and 4 illustrate two-dimensional representations of R_{et}, which demonstrate how the water vapor resistance of a textile layer is impacted by variations in both temperature and mean relative humidity. The study showed that increasing temperature can have a noticeable effect on vapor transfer properties, but this effect is primarily caused by vapor diffusion (properties of air that fill the voids in textile porous media) rather than any intrinsic changes to the textile fibers themselves [9]. The experimental results show a decrease in water vapor resistance when the temperature increases.

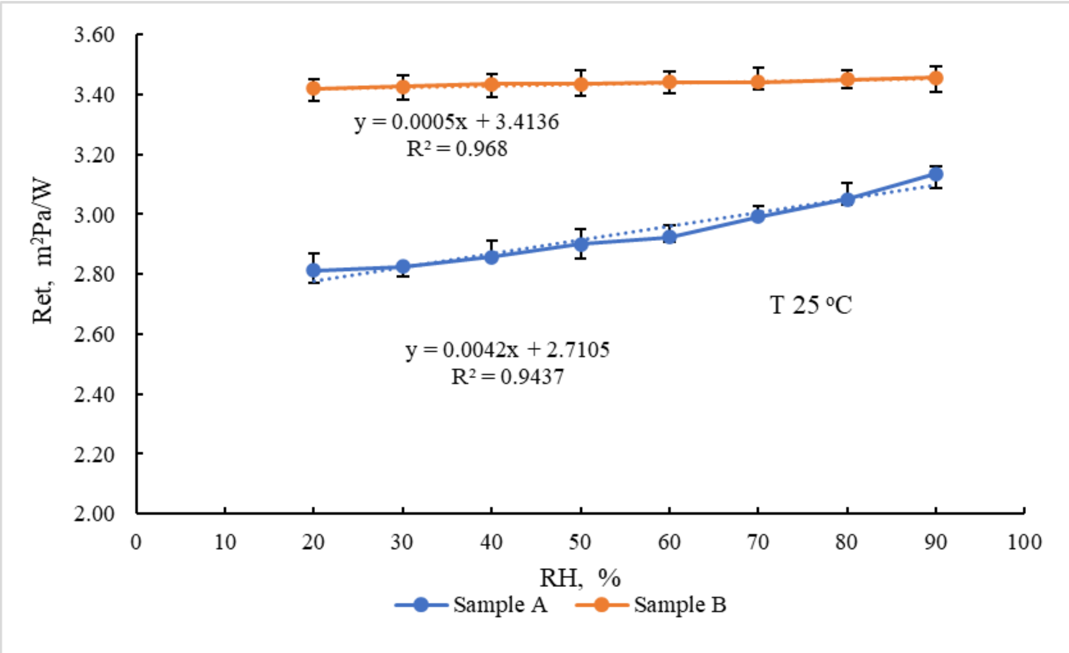

***Fig. 2**: R_{et} at 25 °C as a function of relative humidity*

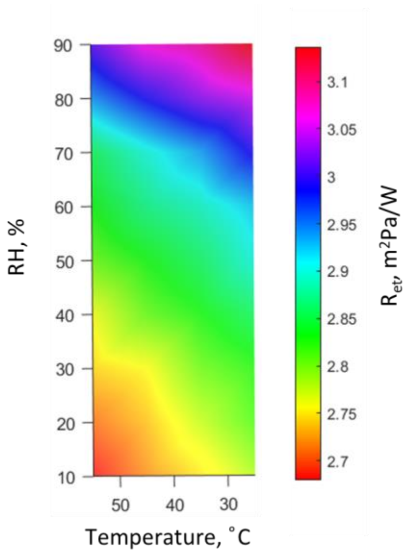

***Fig. 3**: R_{et} of Sample A, at different relative humidity and temperature*

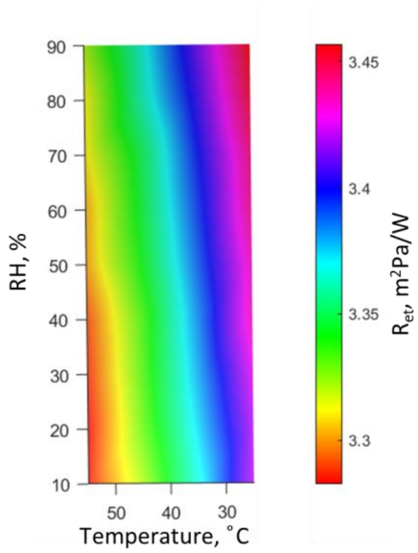

***Fig. 4**: R_{et} of Sample B, at different relative humidity and temperature*

So far, in the specialty literature, no other studies are known that refer to a correlation between the evaporative resistance of textiles and ambient humidity. However, many authors have studied the influence of environmental conditions on other parameters closely related to R_{et}, such as air permeability. Miguel [10] found that air humidity can significantly influence the performance of nonwoven filters concurrently with changes in air permeability. Adámek *et al.* [11] observed a linear dependence between Air Permeability and R_{et} determined under standard conditions for various types of textile materials. Hess *et al.* [12] measured air permeability for different fabrics at various humidity and temperature values. The experiments revealed that, in all cases, air permeability decreased with increasing air humidity and temperature. They observed that the effect of humidity was the lowest on the hydrophobic polypropylene fabrics. This can be explained by the lowest swelling of these fibers, contrary to the highest swelling of the hydrophilic cotton fibers.

4. CONCLUSIONS

This paper presents a new method for determining the water vapor resistance of textile materials. The method allows the determination of water vapor resistance under dynamic conditions, a fact with major significance especially in the case of hydrophilic materials. The water vapor resistance of hydrophilic textiles under varying humidity and temperature conditions differs from the values obtained through standard methods for assessing this property. This variation is particularly crucial in the selection of clothing layers in activities like firefighting, military operations, or active sports. While natural fibers offer comfort, their moisture content can adversely affect water vapor transfer properties. In this situation, blending specific synthetic fibers with natural ones can mitigate the swelling effect of natural fibers, thereby minimizing its impact on vapor transfer. Consequently, the dynamic assessment of vapor resistance in textile fabrics proves beneficial for optimizing thermophysiological comfort.

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ANNALS OF THE UNIVERSITY OF ORADEA
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USE OF FABRIC OFFCUTS TO MAKE A DRESS

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Abstract: *In this paper, we aim to demonstrate that sustainability will be a must-have in the coming years. We will explore methods of reusing textile waste and reducing it. Sustainability starts with a global shift in perception, where designers need to change how they view clothes and their functionality. Beyond beauty, we are talking about finite resources, massive consumption, and a significant amount of waste. When we reuse, worn materials can be transformed into new products, reducing the need to consume natural resources for their production. By reusing waste from production or extracting pieces from other used items, we can preserve materials that hold sentimental value for us and utilize waste that would otherwise increase production costs through energy consumption. It is essential to change our habits related to how we "consume" clothes and to start thinking about the impact we have on the environment. It is important to realize that we can have a significant impact on the environment through the choices we make about the clothes we buy and how we manage them after we stop using them. It is our responsibility to change the way we consume and to act to protect the environment for future generations. This paper provides practical information on the process of textile waste recovery.*

Key words: *recycling, waste materials, reuse, textile waste.*

1. INTRODUCTION

The textile production process, both in factories with large production lines and in small workshops, results in textile waste [1] of different sizes, shapes, colors and textures, which can be reused in the manufacturing of other products, as useful as those made in the first stage. [2]. This textile waste can be transformed into new products through various recycling or reuse methods, such as transformation into new materials [3]. Some companies active in the field of sustainable fashion have already adopted practices of reusing textile waste, thus helping to reduce the negative impact on the environment [4]. By recycling textile waste, the amount of new materials used in production can be reduced, as well as the amount of waste sent to landfill [5]. Thus, the reuse of textile waste can be an effective solution for reducing the negative impact of the textile industry on the environment [6]. It is important for both producers and consumers to be aware of the importance of textile recycling and to support initiatives that promote a more responsible approach to the use of natural resources [6]. To reuse this waste in the production of another dress, the fabric scraps can be used to create decorative details on the new dress, such as appliquéd ruffles, or to create interesting design elements such as pockets, buttons or trims. Leftover sewing thread can be reused for sewing the new dress or for other projects. Pieces of cardboard or paper can be used to make new templates or patterns for the new dress. Through these methods of recycling and reusing the waste resulting from the production of a dress, the impact on the environment can be reduced and unique and creative products can be created with a minimum of consumed resources [6].

2. MATERIALS AND METHODS

Creating a dress involves technical skills, creativity and passion for design and fashion. From the initial concept to the final realization, designers and tailors work together to bring a unique and exclusive piece of clothing to life. Every detail is important, from choosing the right material to correctly tailoring and assembling the parts. The creative process can take weeks or months, but the end result rewards the effort. A well-made dress is not just a piece of clothing, it ultimately is an expression of a woman's personality and style, bringing her confidence and joy while wearing it. This dress, presented in this work, has a simple cut, with a medium length, perfect to be worn on summer days. The amount of waste generated by making a dress can vary depending on the design, size and complexity of the dress. However, on average, about 15-20% of the fabric becomes waste during the production process. This means that for every five to eight dresses made, I would be able to collect enough scraps to create a whole new dress from the scrap material. By paying attention to the waste generated during the production process and finding creative ways to reuse these scraps, it is possible not only to reduce the impact on the environment, but also to create unique and sustainable fashion pieces. In addition, incorporating zero-waste designs and techniques into dressmaking can further reduce the amount of waste generated, making the fashion industry more sustainable and greener. It is made of a light and pleasant material that allows the skin to breathe and it feels comfortable throughout the day. The design of the dress is simple yet elegant, with a clean body line that fits perfectly on the female silhouette. It is suitable for various occasions and can be accessorized in different ways to create versatile and modern looks. After selecting materials based on color and texture, as shown in fig.1, we visualize the images in our minds and sketch a model shown in fig.4, to obtain the desired shape. Then, with the help of GeminiCAD, the pattern of the dress is made, as shown in fig.5. Raw materials, pieces of fabric resulting from cutting, pieces recovered from non-conforming products (defects) and coupons of fabric with defects that had to be removed during the cutting operation were used. Fabric scraps were saved for future projects or incorporated into other garments as design elements. The scraps resulting from the cutting process, taking into account the direction of the thread, were assembled together to make other panels, for the landmarks of other products. The defective fabric coupons that had to be removed during cutting were used for smaller projects that required less fabric, such as various decorative accessories, as shown in fig.6. These parts are subjected to a preparation process, as shown in fig.2, to be later assembled into a panel.

***Fig. 1**: Selected wastes*

***Fig. 2**: Waste preparation*

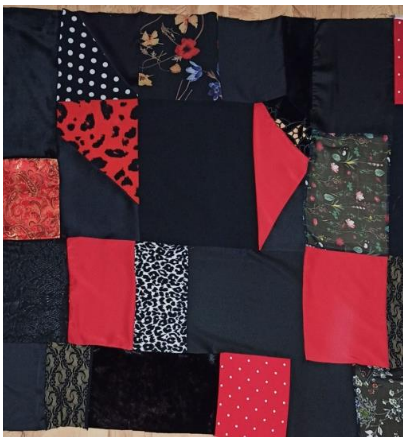

***Fig. 3**: Prepared panel from textile waste*

***Fig. 4**: Model sketch*

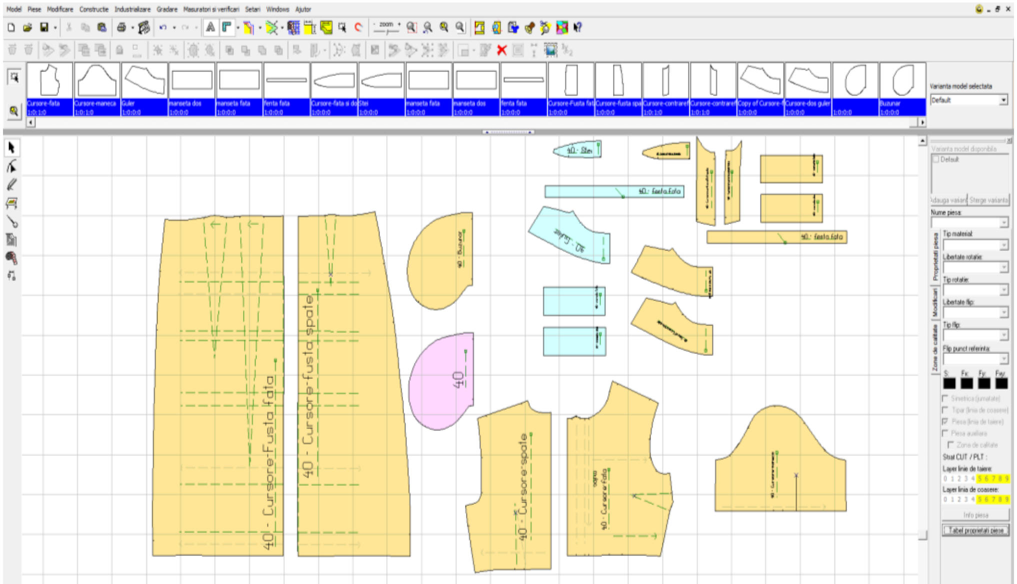

***Fig. 5**: Dress printing made using Gemini CAD program*

***Fig. 6**: Accessory*

***Fig. 7**: Final product*

Needless to say, for small producers and creative workshops, the use of textile waste can bring significant benefits, both economically and in terms of sustainability and social responsibility. In addition, the use of textile waste can bring an element of originality and innovation to the final products, giving them a unique and personalized look. Accessories made from textile scraps can add aesthetic value and creativity, so they can be appreciated by consumers as products with a positive impact on the environment.

5. CONCLUSIONS

In conclusion, this paper highlights the importance of adopting sustainable and innovative practices in the textile industry to reduce resource consumption.

At the same time, we have identified and implemented textile recycling solutions. On one hand we have transforming textile waste into new materials, such as yarn or fabric, or on the other hand using recycled textiles in the production of new textile items. We have also promoted practices to reduce the consumption of textiles (waste), textiles from tailoring or even the reuse of pieces of an preexisting article.

Going through all the steps in the making of the product, I have discovered that you can create a lot of items from clothing. We can easily improve the appearance of already made pieces because the qualities of the textile material give you the possibility of achieving novelty in clothing creation. Both clothing and accessories can contribute to personal comfort, if they are in close harmony with the wearer's character. They can attract pleasant attention, through line and color, ensuring aesthetic comfort, so important in human life.

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ANNALS OF THE UNIVERSITY OF ORADEA
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SPUTTERING METHOD FOR CONDUCTIVE TEXTILES

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Abstract: *PVD Sputtering is a very popular, and versatile coating method to create multi-functionalities on various kinds of substrates including textile surfaces. The paper presents the obtaining of the two conductive textile structures via the hybrid PVD by DC sputtering method with copper target and analysis of them from the structural and electrical properties point of view. The two textile substrates are woven, made of 100% cotton yarns, with a specific mass of 207 g/m^2 that was preliminary prepared by chemical finishing (padding) with two different substances: ITOBINDER-Acrilat (TA1) si PERMUTEX-EX-RU-Urethan (TA2). After the sputtering process a Cu thin layer with a specific mass of about 5 mg/cm^{2}were obtained. The SEM analyses revealed a fibrous structure, on the surface of which a thin coating has been deposited. It is found that the coating has a columnar appearance and is uniform and continuous on the surface of the sample. The electric measurements were made with BX PRECISION 889B Bench LRC/ESR METER. on 1 inch and 10 cm show that the electrical conductivity values are up to 83% higher for the textile samples preliminary finished with TA1 than those with TA2 and decrease with increasing distance between electrodes.*

Keywords: *Hybrid PVD, DC magnetron sputtering, woven substrate, conductive, copper layer*

1. INTRODUCTION

New generations of functionalized textiles will serve new types of performance requirements in military, biomedical/healthcare, industrial, environmental protection, etc., under sustainable conditions [1]. Advances in the areas of manufacturing and increasing the service life of structural elements and tools applicable to many areas of life are made possible by the frequent use of coating techniques. The extensive selection of currently available coating types and their application technology are the result of the increased demand in the field of innovative methods for functionalization and surface protection of materials, including textiles, in recent years [2].

As a physical vapor deposition (PVD) method, sputtering deposition is a dominant technique to grow thin films onto various kinds of substrates that enhance specific properties like scratch resistance, conductivity, and durability [3]. The sputtering phenomenon occurs when energetic particles of a gas or plasma (incident ions) bombard a material, also known as the target. One of the most used sources for the incident ions is plasma. Magnetron sputtering, even with direct current (DC) or radio-frequency (RF) uses a magnetic field and an electric field to confine particles near the surface of the target, leading to the growth of the ion density and generating a high rate of sputtering. Magnetron Sputtering is a remarkable environment-friendly process that can be used to prepare various kinds of materials: conductive semiconductive and insulator materials [4]. More, this technique has many advantages such as simple and low-cost handling and control of the equipment, large and high-density coating area with high-purity thin film, strong adhesion onto the surface, low operation temperature, etc. The sputtering deposition technique, although not new, can also be used for the deposition of conductive particles on textile surfaces. Multifunctional textiles can be fabricated by deposition of metal, which induces multifunction simultaneously (e.g. antibacterial, hydrophobic, and conductive flexible surface) [5]. Sputtered thin films have excellent uniformity, density, and adhesion making them ideal for multiple applications (UV protection, antistatic, self-cleaning, RF interference shielding materials for industrial, space, military, and medical fields, etc.) [6]. The textile substrates for sputtering can contain both natural and synthetic fibers such as cotton, silk, nylon, and polyester. The quality/uniformity/morphology of the sputtered coating is highly influenced by the structure parameters of the textile substrate (weave pattern, yarn thickness, and density, obtaining technology of the yarn (e.g. carded, combed), degree of compactness of the yarns, free fibers content, etc.) [7]. Moreover, the sputtering technology and structure of the textile substrate and preliminary treatments/finishings of the textile substrate influence the electroconductive properties of the textile.

This article presents the obtaining of the two conductive textile structures via the hybrid PVD by DC/RF sputtering method with copper target and analysis of them from the structural and electrical properties point of view.

2. METHODOLOGY

2.1 Materials

For experimental, a woven textile substrate made of 100% cotton, with a density of 610 yarns/10cm (warp) and 360 yarns/10 cm (weft) and a mass of 207 g/m^2 has been prepared by chemical finishing (padding) with tho different substances: ITOBINDER-Acrilat si PERMUTEX-EX-RU-Uretan. Previous research has revealed the tendency of metal ions to penetrate between the fibers of the textile substrate so that their deposition does not form a continuous film. So finishing with the two chemical auxiliaries results in the deposition of metal ions in a film with continuity in terms of electrical properties.

The 2 samples of 100 x 100 mm each, cut from the finished textile structures have been used as substrates in the process of DC sputtering. The textile fabrics used as substrate were fixed to the support of the deposition installation. Thin film deposition was performed on a hybrid PVD (Physical Vapor Deposition) system (fig. 2.9) with a DC/RF Magnetron Sputtering module. The equipment is manufactured by Kurt J. Lesker and consists of a 2-inch diameter TORUS magnetron sputtering cannon/circular box, a PD500x DC source with a maximum power of 1500W, and an R301 RF source with a maximum power of 300W. A commercial Cu target (99.999%) with a diameter of 2 inches and a thickness of 3 mm was used for deposition, was mounted on the magnetron sputtering cathode.

3. EXPERIMENTAL

The magnetron sputtering deposition technology flow for Cu coating on textile substrate comprises the following steps:

1. ***Substrate preparation step (a.*** cleaning and degreasing of the textile surface; ***b.*** loading the substrate and deposition materials into the vacuum chamber.)
2. ***Setting evaporation parameters for the copper target c.*** vacuuming of the enclosure (high vacuum up to 10^{-7} Torr); ***d.*** introduction of Argon (Ar) into the enclosure to a partial vacuum of 10^{-3} Torr; ***e.*** ignition of the plasma and sputtering of the Cu target; ***f.*** deposition itself.
   The experimental matrix is shown in Table 1.

Table 1: *Experimental matrix*

Charge no.	*Substrate*	*Substrate dimensions*	*Material deposited*	*Operating parameters*
1	Impregnated textile material (ITOBINDER-AG-Acrylate) – Textile auxiliary 1 – TA1	100 x 100 mm	2-inch Cu target of 99.999% purity	Starting vacuum: $9*10\ e^{-6}$ mbar working vacuum: $1.9*10^{e-3}$ mbar Flow Ar: 50 ml/min Power source: DC: 100 W Deposition time: 120 min
2	Impregnated textile material (PERMUTEX-EX-RU-Urethane) - Textile auxiliary 2 – TA2			


Fig. 1*: Textile samples with Cu deposition by DC/RF Magnetron Sputtering*
Impregnated with ITOBINDER-AG-Acrylate *Impregnated with PERMUTEX-EX-RU-Urethane*

The specific mass of the layer deposited on the samples is about 5 µg/cm^2

4. RESULTS AND DISCUSSIONS

4.1 Scanning Electron Microscopy – SEM

The sputtered textile samples were analyzed on the surface and in cross-section by scanning electron microscopy in Low Vacuum mode, using the secondary electron backscatter detector (ABS) and the energy dispersive spectroscopy (EDS) detector.

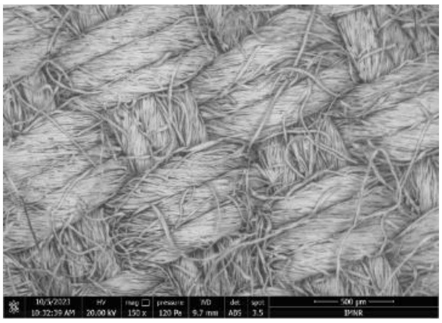
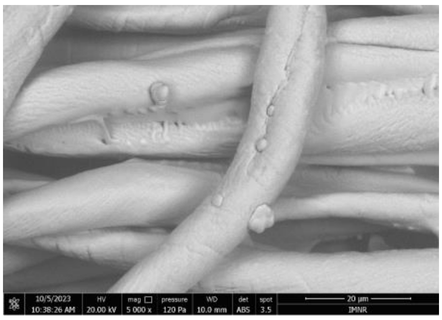

a)

b)

Fig. 2: *SEM with the surface of the analyzed sample (a. Overview- this image was analyzed at 150X magnification and 500 µm scale., b. Detail- this image was analyzed at 5000X magnification and 20 µm scale.)*

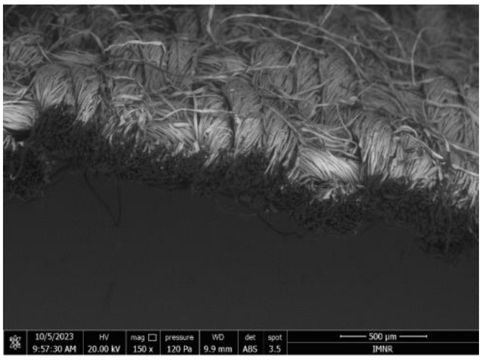
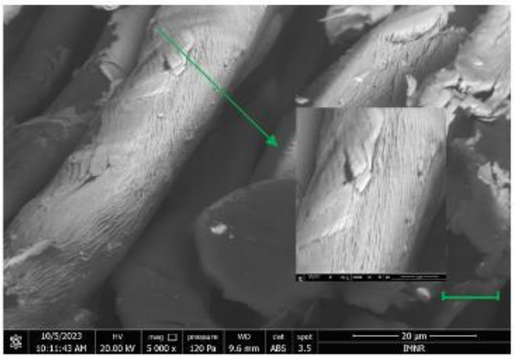
 a)  b)

Fig. 3: *SEM with a cross-section of the analyzed sample (a. Overview- this image was analyzed at 150X magnification and 500 µm scale., b. Detail- this image was analyzed at 5000X magnification and 20 µm scale)*

The study of the samples revealed a fibrous structure, on the surface of which a thin coating has been deposited (Fig. 2a, b and 3a, b) It is found that the coating has a columnar appearance and is uniform and continuous on the surface of the sample. Semi-quantitative EDS chemical spot analysis revealed the presence of the main element of interest (Cu) (fig. 4)

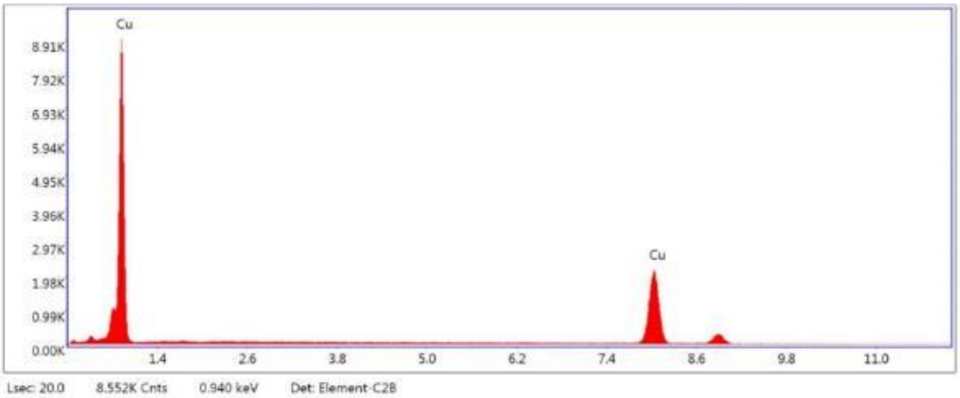


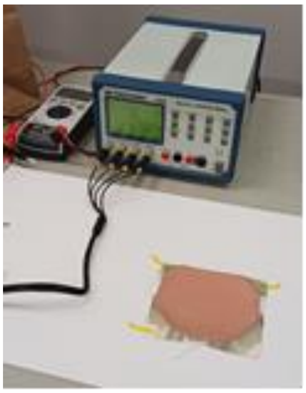
Fig. 4. *ESD analysis with identification of the main target element Cu*

4.2. Electrical characteristics of the sputtered textile structures

The electrical characteristics of textile structures obtained by the sputtering method were determined using the BX PRECISION 889B Bench LRC/ESR METER. The 2 measuring electrodes of the device were placed at a distance of 1 Inch and 10 cm. The calculation formula for electrical conductivity is expressed by relation 1.

$$\rho = \frac{U}{I} \cdot \frac{D \cdot g}{L} = R \cdot \frac{D \cdot g}{L} \quad \textbf{(1)}$$

Where:
D - Electrode width (0.01 m); distance between electrodes (L1 - 0.025 m and L2 - 0.1 m);
g -thickness of textile material (0.62 mm)


a)


b)

***Fig. 5:** Linear electrical resistance measurement*

Table 2 presents the values obtained for the electrical resistivity of structures treated with TA1 and TA2 coated with Cu by the sputtering method (Fig. 5a. measurement equipment, Fig. 5b. actual measurement).

***Table 2:** Coated fabrics properties*

values	***ITOBINDER AG-Acrilate***		***PERMUTEX***	
	1 INCH	10 CM	1 INCH	10 CM
Average, OHM	0.12	0.19	0.66	2.05
Thickness, mm	0.64	0.64	0.7	0.7
Thickness, m	0.00064	0.00064	0.0007	0.0007
Resistivity, OHM*m	7.616E-05	3.12E-05	0.000464	0.000365
Conductivity, S/m	13130.25	32039.45	2154.71	2742.07

The average values of resistivity (ohm/m) and electrical conductivity (siemens/m) show that there is continuity over the entire textile-coated surface, with higher values for textile samples pretreated with TA1. It is thus found that treatment with this chemical auxiliary causes a decrease in the permeability and porosity of the textile surface, higher than in the case of using TA2, with a more pronounced effect on the uniformity of the Cu layer deposited by the sputtering method.
The electrical conductivity values are thus up to 83% higher for the textile samples preliminary finished with TA1 (32039 S/m) than those with TA2 (2742.07 S/m) and decrease with increasing distance between electrodes.

5. CONCLUSIONS

Thin film deposition was performed on a hybrid PVD (Physical Vapor Deposition) - DC/RF Magnetron Sputtering module, using a commercial Cu target (99.999%). The Cu target was mounted on the magnetron sputtering cathode. SEM analyses revealed the surface morphology of textile structures on whose surface a thin coating of 5μg/cm^2 was deposited. The coatings have a columnar appearance and are uniform and continuous on their surface. Determination of the electrical characteristics of the textile structures reveals that the best values of electrical conductivity were obtained for textile structures pre-treated with ITOBINDER AG-Acrylate. The values obtained are almost the same as those achieved in the first phase of the project, in which the tubular knitted structures with conductive textile yarn content recorded maximum values of ~ 32.808 S/m - a tubular structure made of 100% AgSIS Lib40.

ACKNOWLEDGEMENTS

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

ENHANCING INDEPENDENCE: A STUDY ON INNOVATIVE ADAPTIVE CLOTHING FOR DISABILITIES

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Abstract: *The global issue of improving the quality of life for individuals with special needs calls for the fashion industry's dedication to offering equal opportunities, preventing discrimination, and raising their living standards as active members of society. The field of adaptive clothing has evolved over the years, showcasing a big progress from the early 20th century's practical solutions to the innovative technology of today. Adaptive clothing is designed to assist people with various physical limitations by incorporating features that make dressing and undressing easier, often without requiring assistance. This research delves into the critical need to enhance the quality of life for individuals with disabilities, particularly through the development of adaptive clothing tailored to the needs of wheelchair users. By thoroughly examining disability classifications and clothing requirements, it underscores the importance of tailored solutions to address comfort and functionality challenges. The study emphasizes the pivotal role of adaptive clothing in fostering independence and reducing reliance on assistance for those with physical disabilities. Through a focused case study, a garment specifically designed for wheelchair users is developed, featuring innovative design modifications aimed at optimizing both comfort and functionality. With a strong emphasis on functionality and comfort, the research prioritizes meeting both consumer preferences and physiological needs. Ultimately, the goal of this research is to raise the standard of adaptive clothing, promoting inclusivity and enhancing the overall well-being of individuals with disabilities.*

Key words: *Adaptive clothing, Disabilities, Quality of life, Inclusivity functionality, innovation.*

1. INTRODUCTION

The quest to improve the quality of life for people with disabilities has long been a significant concern, prompting innovative solutions to address their diverse needs. In contemporary society, people with disabilities represent the largest minority cohort worldwide, yet remain quite underserved and inadequately represented. Today's problem of the fashion industry is the failure to prioritize accessibility in design. As a result, this communicates to a significant portion of the population, approximately one in every four individuals, that their inclusion and participation are not valued or desired. [1,8]

Adaptive clothing, particularly tailored for wheelchair users, emerges as a vital aspect of this endeavor. The development of such clothes represents a crucial step in promoting independence and autonomy among individuals with disabilities, lessening their reliance on external assistance for daily tasks. By focusing on functionality, comfort, and inclusivity, this research seeks to elevate the standard of adaptive clothing.

Through collaborative efforts and a commitment to inclusivity, the fashion industry can play a pivotal role in fostering a more accessible and equitable society for all. [1,8]

2. GENERAL INFORMATION

The term disability is defined as any type of limitation or inability to perform a certain activity that falls within an interval considered "normal" for a person. It is also characterised by deficiencies or excesses in activities or behaviours normally expected of a person. The disability can be temporary or permanent, reversible or irreversible, progressive or regressive. [5,10].

Improving the quality of life is an issue of national and international concern. It is a responsibility for us, people from the fashion industry to create equal opportunities for persons with disabilities, to prevent any intentional or unintentional discrimination they face and to improve their standard of living and ensure that they have an equal share in social development as productive members of society [4,10,11].

The majority of adaptive clothing currently available in the market is primarily designed to aid caregivers in reducing physical strain while dressing individuals with disabilities. It has been observed that individuals with physical disabilities encounter challenges in finding clothing that not only fits well but also aligns with their personal style. This issue stems from several factors: [6,9]

1. Most garments are tailored for individuals in a standing position, which does not cater adequately to the needs of individuals with disabilities.
2. A significant portion of individuals with disabilities does not conform to the standard size categories, indicating a misalignment between their body dimensions and the current sizing system.

According to the data sourced from [2], it is projected that approximately 5% of Romania's population, equivalent to nearly 900,000 individuals, possesses a disability certificate as of June 2023. Remarkably, women exhibit a higher prevalence among individuals with disabilities in Romania.

In a broader European context, based on ***Fig 1***, as of 2022, Eurostat estimates indicate that 27% of the European Union population aged 16 and above reported having some form of disability. This corresponds to approximately 101 million people, constituting one in every four adults in the EU. [3]

Fig. 1*: The map of percentage of people with a disability by country in EU for 2022* [3]

In 2022, across all member states of the EU, the proportion of women with disabilities exceeded that of men. As shown in ***Fig. 2***, on average, 29.5% of the total female population in the EU was reported to have a disability, in contrast to 24.4% of the total male population. [3]

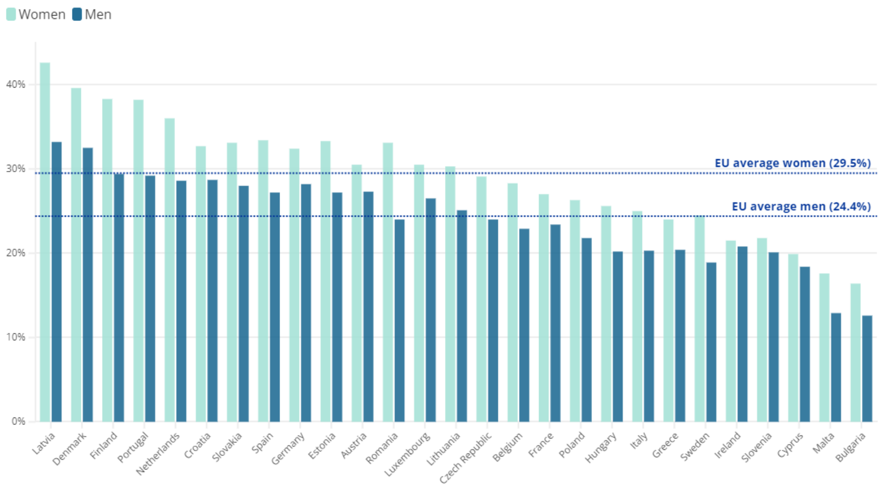


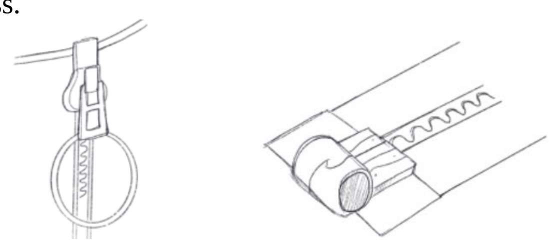
Fig. 2*: The proportion of people with a disability by country in EU for 2022* [3]

3. PRACTICAL ASPECTS

3.1. Recomandations

Various disabilities, including cerebral palsy, arthritis, muscular dystrophy, multiple sclerosis, and paralysis, manifest in diverse ways, impacting movement, muscle control, and posture. Individuals affected by these conditions often experience difficulties such as stiff muscles, heightened reflexes, impaired balance, and involuntary movements. These physical challenges can progressively affect fine motor skills, particularly in the wrists, hands, fingers, feet, and toes, making tasks like manipulating zippers or buttons challenging. [6,10,11]

Drawing from this understanding, this research endeavors to explore the intricacies of adaptive clothing design, particularly focusing on addressing the complex needs of individuals reliant on wheelchairs. By examining specific clothing requirements for those leading sedentary lifestyles due to wheelchair use, the study aims to propose innovative solutions that enhance comfort, functionality, and overall quality of life. ***Fig. 3*** illustrates one such solution, demonstrating how attaching a ring to the zipper slider and utilizing magnetic closure can significantly ease the dressing and undressing process.



a) b)

Fig. 3*: Recomandation for details of adaptive clothes:* [7]
a) ring attached to a zipper slider; b) magnetic zipper;

In line with this objective, the research proposes to adapt a vest using CLO3D software for simulating and fitting virtual garments. This approach allows for a systematic exploration of garment design adjustments tailored to the unique needs of wheelchair users, paving the way for improved accessibility and inclusivity in clothing design.

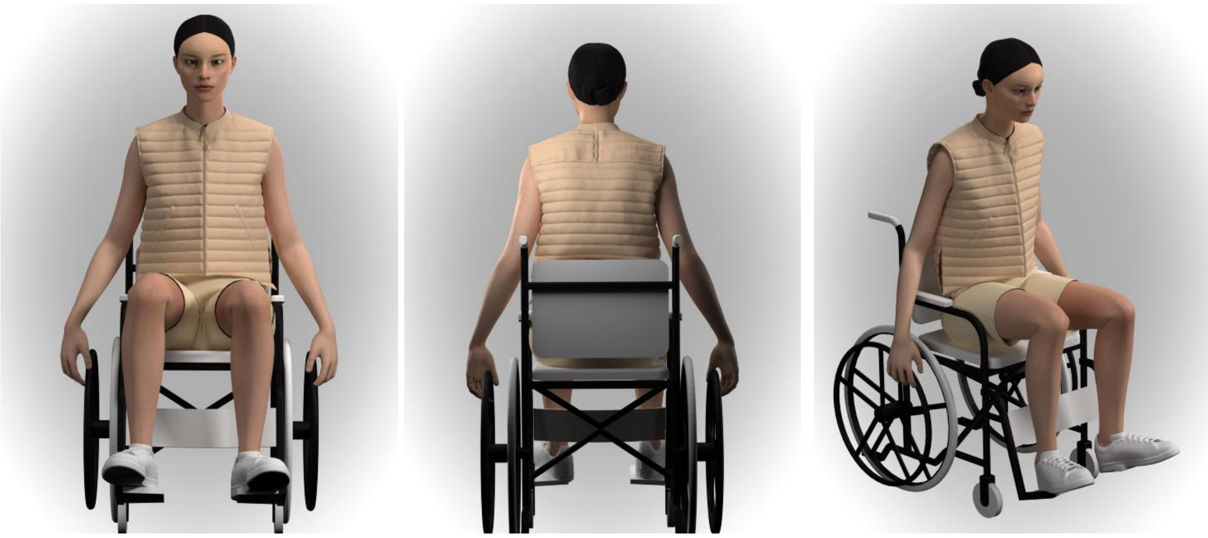
3.2. Case Study

In the proposed case study, the individual demonstrates functionality in the upper body, including functional upper limbs with slight tremors and weakness in the hands, while experiencing impairment in the lower limbs. Additionally, a third-party helper is present.

Given these circumstances, our proposal revolves around designing a sleeveless vest, ***Fig. 4,*** meticulously tailored to meet the specific needs of this individual. The vest design incorporates several key features to enhance usability and comfort. A full-front zipper with a magnetic closure at one end, coupled with a slider attached to a textile ring, facilitates easier manipulation, especially for individuals with hand weakness or tremors. The collar, designed with short, rounded corners, prioritizes comfort during wear.

Furthermore, the back part of the vest is divided into three sections, incorporating Velcro bands to streamline the dressing and undressing process, thereby ensuring accessibility and convenience for both the wearer and the assisting caregiver.

An additional functional and design element is the inclusion of side slits, offering flexibility and comfort in case of weight fluctuations due to medical treatments, as well as catering to individuals whose disabilities may not be visually apparent but still benefit from adapted clothing.



a) *b)* *c)*

Fig. 4*: The sleeveless vest view from the: a) front; b) back; c) side.*

The vest (***Fig. 5)*** is crafted in a neutral, warm beige color to promote psychological comfort for the wearer and maximize its versatility. Moreover, angled pockets are strategically positioned to offer both comfort and functionality, catering to the wearer's needs and preferences. This thoughtful design approach aims to optimize functionality and comfort while addressing the unique challenges presented by the individual's condition.

***Fig. 5**: The sleeveless vest details: a) pockets; b) zipper and slider; c) back; d) split.*

5. CONCLUSIONS

The prevalence of disabilities underscores the urgency for inclusive solutions in fashion design. By prioritizing accessibility and addressing the diverse needs of individuals with disabilities, adaptive clothing represents a vital step towards fostering inclusivity and enhancing quality of life.

Through meticulous design considerations and innovative features such as magnetic closures, adjustable collars, and segmented back sections, tailored solutions can effectively cater to the unique challenges faced by individuals reliant on wheelchairs. The proposed vest design, featuring side slits and angled pockets, exemplifies a holistic approach to adaptive clothing, balancing functionality with comfort and aesthetics.

Moving forward, continued research and collaboration within the fashion industry are essential to ensure that adaptive clothing remains responsive to the evolving needs of individuals with disabilities, thereby promoting dignity, independence, and social inclusion.

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ANNALS OF THE UNIVERSITY OF ORADEA
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BENDING LENGTH, WICKING AND WATER ABSORBENCY PROPERTIES OF SODIUM CHLORIDE (NACL) SALT IMPREGNATED GAUZES

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Abstract: *In this study, sodium chloride (NaCl) solutions with different weight pecentages (1, 3, 5 and 10 wt %) were prepared. Gauzes were impregnated with different salt loadings and samples were padded at around 100 % pick-up ratios. The samples were let dry in 130 Cº for three hours and desiccated for 8 hours prior to testing. Absorption tests, wicking length tests, and Cantilever bending strength tests were evaluated. Absorption tests were evaluated according to droplet testing measurements. Wicking tests are good indicators of moisture transport in fibrous structures. Wicking length tests were only conducted in warp direction as the gauzes used as samples were narrow width woven structures. Gauzes need good absorption, good moisture transport and good pliability properties. Bending length results of impregnated gauzes were obtained from Cantilever method. The bending strength test shows flexibility with decreased bending lengths and stiffness with increased bending length values. Wicking heights increase as salt solutions have higher percentages, this might show that the samples have good moisture transport which is a necessary property in gauzes. Bending length increases with saline loading on impregnated samples and the flexibility properties of gauzes decrease as salt loading is increased. Flexibility is related to pliability and the increase in bending length is a challenge that have to be taken into account when using saline loaded bandages in wound healing as they will be stiffer.*
.

Key words: *Gauze, medical textile, cotton, narrow width open structure, droplet testing, pliability.*

1. INTRODUCTION

Textiles are materials that not only find traditional applications but also technical applications including medical usages. Medical textiles or “biotextiles” are technical textiles that have medical or hygiene purposes. There are many ways to classify medical textiles as there is a wide range of medical textile products. One major classification of medical textiles has three main subclasses: surgical medical textiles (implantable medical textiles, non-implantable medical textiles), extracorporeal medical textiles, and healthcare-hygiene medical textiles [1].

Gauzes are among non-implantable medical textiles. Gauzes are used not only as absorbents but also as dressings in the medical sector [2]. Gauze is an open-weave structured, lightweight technical textile. Gauze fabric might be manufactured in woven or non-woven form, the fiber type of gauzes might be cotton or viscose [3]. As a result there are many types of gauzes in the medical market such as plain gauzes, paraffin-coated gauzes, saline-impregnated gauzes, and combat gauzes.

Absorbency is the ability of textiles to take fluid in their structures [4]. Beside of absorbency, good moisture transport is an important feature depending on the usage purpose of the gauze. Moisture transport determination is important as wounds are subjected to gauzes in multiple plied structures that still need a certain amount of moisture transport. Wicking test is a method that indicates moisture transport of textile materials [5].

The Cantilever bending length and bending strength measurement method is a commonly used testing method to have idea about the flexibility and stiffness of technical textile materials including medical textiles. A gauze needs to be pliable; and as the material gets more flexible and so "less stiff", plying the gauze will get easier. The flexural rigidity of a fabric is its resistance to bending. A greater resistance to bending feels stiffer [3].

M. Mumtaz et al (2023) investigated the efficacy of a kaolin-impregnated gauze in cardiac surgery and concluded that the kaolin-impregnated gauze performed well for mild (grade 1) to moderate bleeding (grade 2) in cardiac surgery compared to a control gauze as the procoagulating kaolin quickened the clotting process [6].

A.L. Strong et al (2018) studied the antibacterial efficacy of quaternary ammonium salt (QAS) impregnated gauze. Gauze samples were soaked in QAS solutions and let to dry within 24 hours and QAS impregnated gauzes were applied over the patient drains and observed with daily drain washing procedure and impregnated gauze change intervals for six days. Regular showering, drain washing with saline solutions and applying nonimpregnated gauzes daily to control group was also carried out for result comparison. The study proved that QAS impregnated gauze reduced bacterial colonization in cardiac patients for the short term study [7].

S. Kittinaovarat and W. Pinduang (2019) coated modified and unmodified cotton gauzes with silver chloride (AgCl), they modified cotton with carbocymethylation and applied ultraviolet irradiation to fix the coating process of the silver chloride onto cotton gauzes. Silver chloride coated gauzes, both modified and unmodified ones, performed good antibacterial efficacy against Staphylococcus Aureus and Eschericia Coli bacteria [8].

M. Alavi et al (2014) studied the wound healing and coagulation efficacy of bentonite and halloysite mineral impregnated gauzes. The researchers impregnated sterile gauzes into bentonite-halloysite-petroleum jelly (Vaseline) mixtures to obtain impregnated gauzes and sterilized them at 160 degree Celsius for two hours. Researchers concluded that wound healing was around 10 to 12 days and clotting time shortened with bentonite-halloysite impregnated gauzes [9].

W. Zheng et al (2021) produced a natural-materials based wound dressing using a simple layer-by-layer method to obtain coating of carboxymethyl chitosan-gelation-alginate on cotton gauze and concluded that this coated gauze was a possible candidate for wound dressing [11].

V.G. Reddy et al (2022) studied the effectiveness of normal saline and honey gauze dressing by wetting gauze dressings in normal saline solutions and commercially available tubed honey. Researchers concluded that normal saline is a better wound dressing material compared to honey as saline is a natural and cost-effective material for gauze dressings [12].

Natural sourced candidates for gauze impregnation such as kaolin, honey and natural extracts of pomegranate peels and olive leaves extract, chitosan, alginate and gelatin are being studied as antibacterial and wound healing natural materials [6, 9-12].

In this study, the aim is to assess water absorbency properties and bending length values of NaCl salt impregnated gauzes.

2. EXPERIMENTAL APPROACH

2.1 Materials and Method

Cotton gauzes at narrow width woven form having 10 wefts/cm and 10 warps/cm were used as received. NaCl was pure from Company Riedel-de Haen. Distilled water was used to form, sodium chloride (NaCl) solutions with different weight pecentages (1, 3, 5 and 10 wt %) were prepared. Gauzes were impregnated with different salt loadings and samples were padded at around 100 % pick-up ratios. The samples were let dry in 130 Cº for three hours and desiccated for 8 hours prior to testing. Absorption tests, wicking length tests, and Cantilever bending strength tests were evaluated. Absorption tests were evaluated according to droplet testing measurements.

The Cantilever bending test method, devised by Pierce, is testing a 20 x 2.5 cm sized fabric sample on a smooth low-friction surface of the cantilever platform (Figure 1). The fabric sample is advanced by the ruler and the length on the ruler "L" is the length when the sample touches the angled surfaces mirror lines. Bending length "C" is calculated as L/2 according to the method devised by Pierce.

Fig. 1. The Cantilever platform for bending length tests

The cotton gauzes were impregnated in saline solutions and padded at padded at around 100 % pickup ratios at a laboratory type pad batch equipment, brand Kucuker Company. Samples and their codes are shown in Table 1.

Table 1 samples and codes

Sample code	**Salt solution weight %**	**Salt (g) in solution**	**Deionized water (g) in solution**
G_control	_	_	100
G_s1	1 wt%	1	99
G_s3	3 wt %	3	97
G_s5	5 wt %	5	95
G_s10	10 wt %	10	90

2.2. Method

A gauze needs to be soft, pliable and absorbent [2]. Absorbency is a textile material's ability to take a fluid in its structure similar to a sponge's fluid intake [4]. Absorbency testing is a biased subject as the fluid amount and the absorbency time depends upon needs of the application usage. Absorbency testing methods include droplet test methods and sinking time methods.

For water absorption tests, droplet test time test was carried out for one layer gauzes as well the absorbed area is measured on width and length of elliptic shapes formed by the droplet on gauzes. The droplet test time and test method are valid for various applications for absorption. Droplet test method for hydrophility ranking was carried out according to the Turkish Standard TS

866. According to the sinking time test method, the textile material is released from 10 mm height onto the water reservoir surface, the time is watched and recorded for the accurate time needed for the fibrous material to be wetted and completely immersed. At least three measurements are required. Ratings are as: 0 to 50 seconds to immerse is very good, 50 sec to 100 sec is average and 100 sec and more is regarded as low hydrophility rate according to TS 866. Table 2 shows results for droplet testing for absorbency in terms of hydrophility.

Table 2. Droplet time test results of samples

Sample code	Absorbing time (sec)	Absorbed elliptic area (cm x cm)
G_control	41.08 ± 06.32	5.66 ± 0.51 x 3.30 ± 0,27 cm
G_s1	44.29 ± 13.57	5.17 ± 0.42 x 3.13 ± 0,21 cm
G_s3	47.12 ± 07.53	4.86 ± 0.37 x 3.55 ± 0,23 cm
G_s5	49.12 ± 08.24	4.61 ± 0.24 x 2.88 ± 0,12 cm
G_s10	55.38 ± 12.32	4.40 ± 0.42 x 3.42 ± 0,13 cm

As wicking tests are a sign of good moisture transport, wicking tests were conducted with wicking height on the warp direction of narrow-width woven gauzes using 1wt% potassium chromate deionized water solutions. The wicking heights according to time intervals are listed in Table 3.

Table 3. Warp direction wicking heights according to time intervals

Sample code	Wicking heights (mm)			
	10 sec	30 sec	60 sec	300 sec
G_control	4.5 ± 0.71	11.5 ± 2.12	17 ± 1.41	38 ± 4.24
G_s1	5.3 ± 0.49	13.7 ± 1.98	21 ± 2.27	43 ± 3.86
G_s3	5,6 ± 0.61	13.8 ± 2.14	34 ± 2.48	57 ± 2.73
G_s5	6.1 ± 0.56	15 ± 1.74	49 ± 2.06	69 ± 2.91
G_s10	7.5 ± 0.72	18 ± 2.83	58 ± 2.82	77 ± 3.53

Bending length gives idea about the pliability of textile materials. Bending length is tested for gauzes. Results of the Cantilever bending length “C” are given in Table 4. There is a slight increase in sample stiffness due to saline solution impregnation process. Stiffness increase means there is a decrease in flexibility with saline loading. The saline loading is a drawback as the necessary pliability is adversely affected by saline loading.

Table 4 results for bending length of gauze samples

Sample code	**"C" bending length (cm)**
G_control	1.46 ± 0.06
G_s1	1.56 ± 0.16
G_s3	1.63 ± 0.47
G_s5	1.68 ± 0.24
G_s10	1.75 ± 0.12

2.3. Results

Droplet testing results show an increase in absorbing time and a slight decrease in absorbed area by the droplet with saline solution wt % increase. Table 3 gives the wicking heights of samples, only in warp direction. Wicking heights increase as salt solutions have higher percentages, this might show that the samples have good moisture transport which is a necessary property in gauzes. Bending length increases with saline loading on impregnated samples and the flexibility properties of gauzes decrease as salt loading is increased. Flexibility is related to pliability and the increase in bending length is a challenge that have to be taken into account when using saline loaded bandages in wound healing as they will be stiffer.

3. CONCLUSION

Wound healing and absorption of gauzes depends on patient to patient as the amount and type of fluid exudates show a wide variety depending on acuteness of the wound. Specific saline loadings might be preferred for different wounds. Further investigation is aimed for antibacterial and antiviral efficacy of saline loaded gauzes.

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

TEXTILE AND FASHION DESIGN WITH THE INTEGRATION OF SACRED SYMBOLS

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Abstract: *The textile and fashion industries face challenges in pattern diversity, innovation, and the integration of mathematical and symbolic design methods. This study aims to address these issues by improving the diversity, complexity, and adaptability of models while integrating mathematical principles and symbol-based techniques. Basically, research shows that using different mathematical models, like Hamiltonian or fractals, can make our models more diverse and effective. Improving the mathematical skills of designers is essential to overcome the complexities associated with mathematical design methods. The advancement of symbol-based design methodologies promotes cross-cultural adaptability and mitigates limitations in methodology dependency. A holistic approach involving research, education, and technological advancement is vital to driving innovation in textile and fashion design. Algorithms for sacred geometry figures offer new avenues for creating visually appealing designs with spiritual meaning. The fusion of mathematical precision and artistic expression in gold geometric ornaments embody harmony and beauty, tailored to contemporary aesthetics. Integrating sacred figures into clothing and home goods allows designers to offer unique, personalized products while embracing sustainability trends.*

Keywords: *Textile, Fashion, Mathematical integration, Symbolic design, Innovation, Pattern diversity*

1. INTRODUCTION

Sacred geometry offers a wealth of inspiration for fashion designers, allowing them to imbue garments with deeper meaning and aesthetic appeal. By incorporating sacred geometric patterns, shapes, and symbolism, designers can create visually stunning designs that resonate with spiritual and cultural meaning. This can be achieved through pattern design, silhouette and structural elements, embroidery and embellishments, accessories and jewelry, color symbolism, and cultural and spiritual references. By using sacred geometry in fashion design, designers can create garments that not only look beautiful but also carry deep messages and connections to the divine or the universe.

Liu [1] reviewed the advantages of quasi-regular patterns generated by the Hamiltonian for textile fabrics, highlighting their unique balanced symmetry. However, it acknowledges the limitations of a limited number of models. To address this, the paper introduces 110 functions derived from the Hamiltonian, improving the variety and quantity of models. These functions, implemented using Visual Basics, allow individual selection and modification of patterns and color conditions, effectively achieving the desired results.

Lu et al. [2] explored the benefits of incorporating fractal patterns into knitted fabric design, highlighting its unique and versatile characteristics. Fractal patterns offer complexity and irregularity, inspiring innovative designs. The study uses C++ programming to generate fractal models based on single pictures and time-avoidance algorithms. These patterns are then processed using computerized knitting software and applied to jacquard fabrics. The results demonstrate the adaptability of fractal patterns in knitted fabric design, demonstrating their potential to create complex and visually engaging textiles. However, the paper acknowledges that current knitted fabric patterns are mostly traditional, highlighting the need for further research and the integration of fractal designs into the textile industry.

According to Rani et al. [3], mathematics in fashion design ensures precision, efficiency, cost-effectiveness, and creativity. On the other hand, fashion designers depend heavily on mathematical principles, which can be complex and error-prone without sufficient skills or resources.

Jalalimanesh et al. [4] point out that mathematical ratios and sequences bring precision and innovation to textile design, improving usability and feasibility, as indicated by positive feedback from experts. The complexity of implementing precise mathematical models, the limited application outside of Fibonacci sequences and traditional motifs, and the technical dependence on programming skills can present challenges for designers.

The fashion model design method proposed by Cui et al. [5] is symbol-based and offers adaptability for cross-cultural design, innovation in pattern creativity, and potential for systematic application in fashion design. There is a dependence on Pierce's semiotic methodology [6], focusing primarily on geometric models, and a need for further refinement and development to expand its applicability.

The review of the available literature shows that the textile and fashion industry faces challenges related to pattern diversity, innovation, and the integration of mathematical and symbolic design methods. Specifically, there is a need to address limitations in model diversity, complexity, and the integration of mathematical and symbolic design techniques.

The purpose of this research is to address various challenges and constraints in textile and fashion design, including pattern diversity, innovation, and the integration of mathematical and symbolic design methods. There is a need to improve model diversity, complexity, and adaptability for cross-cultural design while advancing the integration of mathematical principles and symbol-based design methodologies. This will promote creativity, precision, efficiency, and cost-effectiveness in textile and fashion design processes.

2. MATERIAL AND METHODS

Six algorithms have been developed that realize sacred geometry figures. These algorithms are presented in Appendix A. Some of the algorithms use the “circles” function available in the Matlab help page.

Figure 1 shows the results of the implementation of the proposed algorithms.

The “Egg of Life” algorithm draws two types of circles in different colors. The first circle is centered at coordinates (200, 200) with a radius of 60 and is colored red, while the second set of circles is offset relative to the first and is colored green. Positioning angles for circles are calculated in radians.

The algorithm "Flower of Life" draws a central circle and surrounds it with additional circles based on sacred geometry. It defines parameters such as the radius of the circles and their number. It then creates a shape, draws the center circle, and goes through drawing additional circles based on certain angles.

The “Fruit of Life” algorithm draws circles arranged in a specific geometric pattern. First, define parameters for the center circle and surrounding circles. It then draws three sets of circles with different radii and colors.

The "Merkaba" algorithm generates a basic representation of the Merkabah, also known as the star tetrahedron, by defining the vertices and edges of two tetrahedra. The first tetrahedron is shown in blue, and the second in red. The graphics are three-dimensional. The Merkaba is a sacred geometric shape believed to have spiritual significance in various mystical traditions.

The Tree of Life algorithm draws circles and lines connecting in a certain pattern. Parameters such as the radius of the circles, the number of circles, and the number of lines are defined. The circles are located at right angles around a central point, and lines are drawn to connect them.

The algorithm "Vesica Piscis" generates an image with four circles by drawing them in different sizes and positions. The preceding shapes are calculated, parameters such as radii for the circles are defined, and a shape is created. A large circle is then drawn in blue and smaller circles in red, with the two positioned above and below the larger circle.

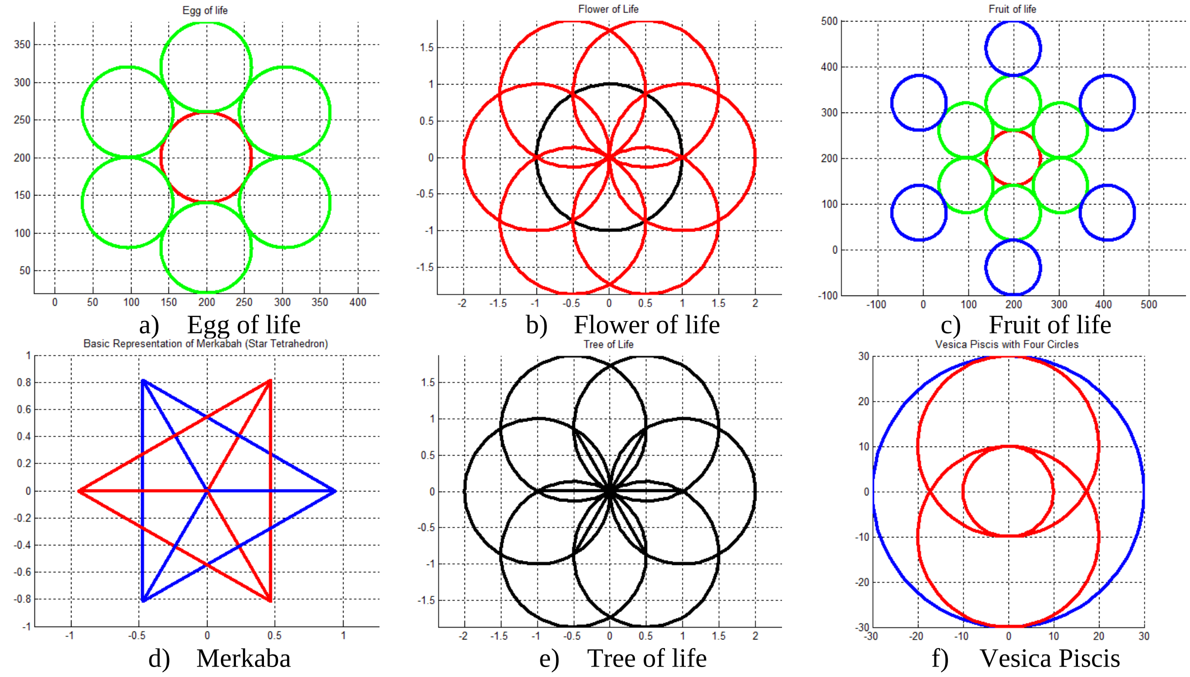


***Fig. 1.** Figures generated by the proposed algorithms*

A color range borrowed from the latest color trends for the years 2023–24 has been used to shape the designs. The color of the year 2024 can be described as gentle, warm, and cozy (PANTONE 13-1023 Peach Fuzz). This can be reflected in warm shades as well as pastel soft tones. These colors create a sense of calm and comfort, which can be important for the harmony and well-being of people in 2024.

3. RESULTS

Golden geometry ornaments are extremely suitable for use in textile design due to their elegance and sophistication. These ornaments are characterized by their precise and symmetrical shapes that complement each other in harmony and balance.

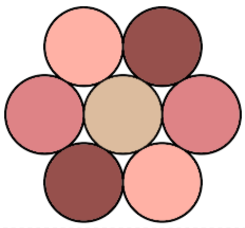
In textile design, golden geometry ornaments can be used for fabric decoration, embroidery design, stamps, and prints. They can also be incorporated into various types of textile accessories, such as cushions, curtains, tablecloths, etc.

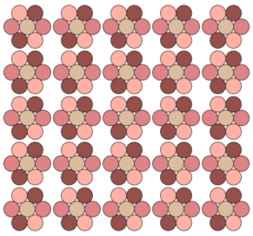
Golden geometry is based on the principles of the golden ratio and Fibonacci numbers, which are considered the basis of harmony and beauty in nature. These mathematical proportions are used to create a variety of geometric ornaments that give a unique and sophisticated look to the textile design.

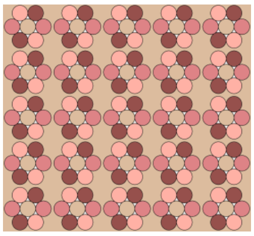
In the present work, various patterns are formed using ornaments obtained on the basis of golden geometry in combination with colors relevant for the last few seasons. Various clothes, accessories, and household goods are customized on their basis, which shows the many possibilities for creativity in line with the current sustainability trends.

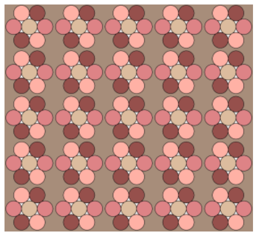
The sacral figures that were generated with the proposed algorithms were used.

Figure 2 features a variety of designs and accessories, including bags, throw pillows, and curtains. These designs include patterns derived from four colors and are adaptable to be placed on a white or colored background. Specific items listed include women's handbags, including a sack and large handbag, as well as women's shoes, decorative pillows, paper bags, and curtains.


Ornament 1 obtained from 4 colors


Pattern in white background


Pattern in colored background


Pattern in colored background


Handbag


Sack


A paper bag


Decorative pillow


A voluminous handbag


Women's shoes


Decorative pillow

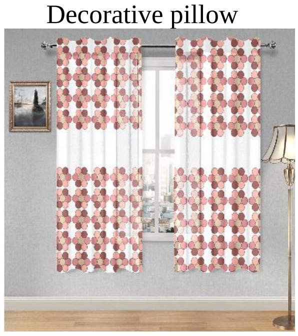

Curtains

***Fig. 2.** Ornamental designs and accessories*

Figure 3 shows objects that consist of a colored ornament obtained from three colors, which can be positioned on a white or colored background. These decorative designs are complemented by a variety of women's clothing, including handbags, sneakers, t-shirts, dresses, tunics and sleeveless dresses. The collection also includes household items such as wall and wrist clocks.

Fig. 3. *Objects of floral ornament obtained from three colors*

4. DISCUSSION

From the analyses made and the results obtained, it can be summarized that increasing the variety of models should include the development and application of methods, such as the introduction of additional functions derived from mathematical principles such as Hamiltonian [2] or fractal models [1], to improve the variety and quantity of designs.

There is a need to improve pattern complexity and innovation by exploring and integrating fractal patterns into fabric design processes using programming languages such as C++, Matlab, etc. to generate complex and visually engaging designs.

The integration of mathematical principles consists of improving the mathematical skills and resources of designers to overcome the complexities and errors associated with mathematical design methods [4, 6].

Extending symbol-based design approaches by further developing and refining symbol-based design methodologies to promote adaptability for cross-cultural design while addressing limitations in methodology dependency and the scope of designs being developed.

The integration of mathematical principles and sacred symbols in textile and fashion design holds promise for stimulating innovation, improving product diversity, and increasing market competitiveness [8].

It can be summarized that a comprehensive approach involving research, education, and technological advancement is needed to address these challenges and drive innovation in textile and fashion design.

5. CONCLUSION

The development of algorithms for realizing sacred geometry figures offers a new approach to creating complex and aesthetically pleasing designs. Applying these algorithms produces visually stunning results.

Each algorithm, from the Egg of Life to the Vesica Piscis, offers a unique method for generating sacred geometric shapes ranging from simple arrangements of circles to complex three-dimensional images. These shapes have spiritual significance in various traditions and add depth and meaning to the design.

The use of gold geometric ornaments in textile design represents a fusion of mathematical precision and artistic expression. By incorporating the principles of the golden ratio and Fibonacci numbers, these designs embody harmony and beauty, resonating with the elegance and sophistication sought in contemporary textile aesthetics. The adaptability of these designs to a variety of textile applications, including fabric decoration, embroidery, stamps, and prints, highlights their versatility and potential for creative expression. By integrating these sacred figures into clothing, accessories, and home goods, designers can tap into current sustainability trends while offering consumers unique and personalized products.

APPENDIX A

Listings of algorithms used in this study

```
clc, clear all, close all
fi1=30:360/6:380
a=200; b=200
r=60
circles(a,b,r,'facecolor','none','edgecolor','r','linewidth',3)
t=pi/180
x1=a+2*r*cos(fi1*t)
y1=b+2*r*sin(fi1*t)
circles(x1,y1,r,'facecolor','none','edgecolor','g','linewidth',3)
title('Egg of life');
grid on
axis equal
```

```
clc, clear all, close all
% Define parameters
radius = 1;        % Radius of the circles
numCircles = 6;    % Number of circles in the Flower of Life
% Create a figure
figure;
hold on;
axis equal;
% Draw the central circle
theta = linspace(0, 2*pi, 100);
xc = radius * cos(theta);
yc = radius * sin(theta);
plot(xc, yc, 'k','linewidth',3);
% Draw additional circles based on sacred geometry
for i = 1:numCircles
   angle = (i-1) * 60; % Angle between circles
   x = radius * cosd(angle);
   y = radius * sind(angle);
   xc = x + radius * cos(theta);
   yc = y + radius * sin(theta);
   plot(xc, yc, 'r','linewidth',3);
end
grid on
```

```
% Display the result
title('Flower of Life');
hold off;
```

```
clc, clear all, close all
fi1=30:360/6:380
a=200; b=200
r=60
circles(a,b,r,'facecolor','none','edgecolor','r','linewidth',3)
t=pi/180
x1=a+2*r*cos(fi1*t)
y1=b+2*r*sin(fi1*t)
circles(x1,y1,r,'facecolor','none','edgecolor','g','linewidth',3)
x2=a+4*r*cos(fi1*t)
y2=b+4*r*sin(fi1*t)
circles(x2,y2,r,'facecolor','none','edgecolor','b','linewidth',3)
title('Fruit of life');
grid on
axis equal
```

```
clc, clear all, close all
% MATLAB Code to plot a basic representation of Merkabah
(Star Tetrahedron)
% Define the vertices of the tetrahedrons
vertices_up = [
   sqrt(8/9), 0, -1/3;
   -sqrt(2/9), sqrt(2/3), -1/3;
   -sqrt(2/9), -sqrt(2/3), -1/3;
   0, 0, 1
];
vertices_down = -vertices_up;
% Define the edges of the tetrahedrons
edges = [
   1 2;
   2 3;
   3 1;
   1 4;
   2 4;
   3 4;
];
% Plot the first tetrahedron
figure;
hold on;
for i = 1:size(edges, 1)
plot3(vertices_up(edges(i,:), 1), vertices_up(edges(i,:), 2),
vertices_up(edges(i,:), 3), 'b','linewidth',3);
end
% Plot the second tetrahedron
for i = 1:size(edges, 1)  plot3(vertices_down(edges(i,:), 1),
vertices_down(edges(i,:), 2), vertices_down(edges(i,:), 3),
'r','linewidth',3);
end
axis equal;
grid on;
xlabel('X');
ylabel('Y');
zlabel('Z');
title('Basic Representation of Merkabah (Star Tetrahedron)');
hold off;
```

```
clc, clear all, close all
% Define parameters
radius = 1;         % Radius of the circles
numCircles = 7;     % Number of circles
numLines = 6;       % Number of lines
% Create a figure
figure;
hold on;
axis equal;
% Draw circles
for i = 1:numCircles
   angle = (i-1) * 60; % Angle between circles
   x = radius * cosd(angle);
   y = radius * sind(angle);
   theta = linspace(0, 2*pi, 100);
   xc = x + radius * cos(theta);
   yc = y + radius * sin(theta);
   plot(xc, yc, 'k','linewidth',3);
end
% Draw lines connecting circles
for i = 1:numLines
   angle = (i-1) * 60; % Angle between lines
   x1 = radius * cosd(angle);
   y1 = radius * sind(angle);
```

```
clc, clear all, close all
% Clear previous figure
clf;
% Define parameters
r = 10;
radius_big = 3 * r;
radius_small = r;
radius_small_2 = 2 * r;
% Create figure
hold on;
% Draw big circle
theta_big = linspace(0, 2*pi, 100);
x_big = radius_big * cos(theta_big);
y_big = radius_big * sin(theta_big);
plot(x_big, y_big, 'b','linewidth',3);
% Draw smallest circle
theta_small = linspace(0, 2*pi, 100); % Full circle
x_small = radius_small * cos(theta_small);
y_small = radius_small * sin(theta_small);
plot(x_small, y_small, 'r','linewidth',3);
% Calculate centers of the other two circles
center_top = [0, radius_small];
center_bottom = [0, -radius_small];
% Draw the other two circles
```

x2 = radius * cosd(angle+180);
y2 = radius * sind(angle+180);
line([x1 x2], [y1 y2], 'Color', 'k','linewidth',3);
end
% Display the result
title('Tree of Life');
grid on
hold off;
	theta_other = linspace(0, 2*pi, 100);
	x_top = center_top(1) + radius_small_2 * cos(theta_other);
	y_top = center_top(2) + radius_small_2 * sin(theta_other);
	plot(x_top, y_top, 'r','linewidth',3);
	x_bottom = center_bottom(1) + radius_small_2 * cos(theta_other);
	y_bottom = center_bottom(2) + radius_small_2 * sin(theta_other);
	plot(x_bottom, y_bottom, 'r','linewidth',3);
	% Set axis limits
	axis equal;
	xlim([-radius_big, radius_big]);
	ylim([-radius_big, radius_big]);
	title('Vesica Piscis with Four Circles');
	% Show grid
	grid on;
	hold off;

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ANNALS OF THE UNIVERSITY OF ORADEA
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CHROMATIC BEHAVIOR OF WOOL TEXTILES TREATED WITH GREEN SILVER NANOPARTICLE DISPERSIONS SUBJECTED TO ACCELERATED AGING

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Abstract: *The present work aimed to study the chromatic impact of the green synthesized silver nanoparticles (AgNPs) applied on wool-based fabrics. The need to evaluate the behavior of the AgNPs-based treatment applied on textiles arises from the research of this type of treatment in the conservation of heritage objects, due to its remarkable antimicrobial properties. Therefore, it is essential to ensure that the conservation treatment does not alter the aesthetic aspect of the materials. Thus, in this research, wool textile materials treated with green AgNPs dispersions were exposed to an accelerated aging process (UV radiation, temperature, and humidity). The dispersions used were obtained by phytosynthetesis, using two type of plant extracts. For fifteen days, the samples were collected after every three days and colors measured. The total color change was calculated and compared to the unexposed samples. It was found that the value of the brightness was not affected by the presence of the treatment. While the variation of the a* parameter was also not affected by the treatment, b* appeared to change more gradually in the case of the untreated fabric. Comparing the total color shift, the modification of the visual aspect of the samples was minimum. These results support the beneficial effect of AgNPs treatment for cultural heritage conservation.*

Key words: *silver nanoparticles, wool, heritage, chromatics*

1. INTRODUCTION

It is important to have knowledge about the chromatic effect of the treatment used in the conservation-restoration of heritage objects, as it is necessary that it does not change the color of the artifacts or, in the case of restoration, slightly intensifies the color tones, for objects that have faded over time [1]. Combating textile degradation using silver nanoparticles (AgNPs) is a topic of great interest for researchers [2-4]. The green synthesis and the effect against the contamination with microorganisms represented the object of many studies around AgNPs fabrication [5, 6]. For this work, two types of AgNPs dispersions were phythosynthesized, by using plant extracts of *Primula officinalis* and *Stellaria media*, respectively. Afterwards, they were applied on textile fabrics and the samples were exposed to artificial degradation, in order to determine the behavior of such treatments to accelerated weathering conditions. Accelerated aging tests are commonly conducted to evaluate the weatherability and service life of polymeric materials and involve the simulation of the environment conditions [7]. A special chamber equipped with UV lamps with controlled temperature and humidity is used for this purpose. The support textile selected for the experiments consisted of wool fabrics, since it is a common material used in traditional garment manufacturing and it was reported to suffer significant modification when exposed to UV light [8, 9].

2. EXPERIMENTAL

2.1 Materials and methods

Five wool samples measuring 11×9 cm were exposed to accelerated aging conditions, in a UV chamber (QUV accelerated weathering tester device), following a working cycle reported in our previous study [9]. The equipment was provided with fluorescent UV-B lamps (UVB-313), having nearly all the energy concentrated in the range 280-360 nm, with a wavelength peak at 313 nm. The working cycle involved UV light for 8 hours at, 70ºC, followed by 4 hours of humidity (60%), at 50ºC. Samples of the exposed fabrics were collected every three days, and they constituted the control samples. In parallel, wool fabrics treated with AgNPs dispersions were subjected to the same process. The AgNPs dispersions were synthesized and applied according to the following reports [10, 11].

2.2 Characterization technique

The chromatic effect of the textile samples was evaluated using a Datacolor (D65/10 lamp) instrument (Datacolor, Inc., Lucerne, Switzerland). The chromatic parameters were expressed in the CIE L*a*b* color system (figure 1).

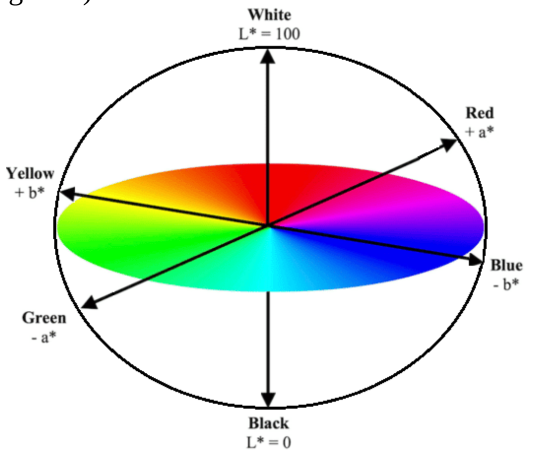

Fig. 1. *The CIE L*a*b* chromatic space.*

The CIE L*a*b* parameters are L* which quantifies the brightness of the sample, and a* and b*, which refer to the color of the sample. The values of a* and b* are situated in the range −100 and +100. When a* and b* are both positive, the color of the sample is in the range of red-orange-yellow. When a* is negative and b* is positive, the color of the sample is in the yellow-greenish-green range. When a* and b* are negative, the color of the sample is in the range green-turquoise-blue. When a* positive and b* negative, the color of the sample is in the range of blue-purple-red. The total color changed (ΔE*) can be calculated according to the formula:

$$\Delta E^* = [(\Delta L^*)2 + (\Delta a^*)2 + (\Delta b^*)2]1/2 \ [12]. \quad (1)$$

3. RESULTS AND DISCUSSIONS

The chromatic parameters of the untreated sample revealed a total color shift of 26.92 (table 1). The most affected parameter was the b* parameter, which increased gradually from 9.77 (before exposure) to 33.06 (after 15 days of exposure). The luminosity was also affected (from 84.21 to 71.07). The visual effect consisted of acquiring a yellow tint. This behavior correlates with previous reports related to wool exposure to accelerated weathering conditions [9, 13] and it is attributed to the wool content of photoactive protein residues, such as cystine, tryptophan, phenylalanine, and tyrosine. These components absorb UV radiation, producing chromophores, which are responsible for the visual effect of a color [14]. The values of the chromatic parameters obtained by measuring the samples treated with AgNPs dispersions are listed in table 2 and 3, corresponding to the treatments produced with *Primula officinalis* extract and *Stellaria media*, respectively. The exposed samples were compared to the treated samples. The total color shift was 26.46 for samples treated with *Primula officinalis*-based treatment and 27.98 for *Stellaria media*-based treatment. While in both cases the b* parameter varied almost identically, the brightness difference was slightly higher in the case of *Stellaria media*-based treatment. However, the total color shift was very close to the value obtained for the untreated sample, for both treatments, suggesting that the visual impact is minimal. The increase of ΔE* of only 0.5 and 1, respectively, is not generally discernible.

***Table 1**. Chromatic measurements of the **untreated** wool sample exposed to accelerated degradation conditions.*

Exposure time	L*	a*	b*	ΔL*	Δa*	Δb*	ΔE*
Before exposure	84.21	0.03	9.77	-	-	-	-
After 3 days	77.69	-0.75	18.92	-6.52	-0.78	9.15	11.26
After 6 days	75.62	-0.3	25.11	-8.59	-0.33	15.34	17.58
After 9 days	73.43	1.27	30.67	-10.78	1.24	20.9	23.55
After 12 days	71.89	2.62	32.38	-12.32	2.59	22.61	25.88
After 15 days	71.07	3.16	33.06	-13.14	3.13	23.29	**26.92**

***Table 2.** Chromatic measurements of the wool sample **treated** with AgNPs dispersions based on Primula officinalis extract, exposed to accelerated degradation conditions.*

Exposure time	L*	a*	b*	ΔL*	Δa*	Δb*	ΔE*
Before exposure	77.54	1.16	9.12	-	-	-	-
After 3 days	75.24	-0.09	22.37	-2.3	-1.25	13.25	13.51
After 6 days	72.93	0.91	28.12	-4.61	-0.25	19	19.55
After 9 days	70.87	2.18	31.43	-6.67	1.02	22.31	23.31
After 12 days	70.75	2.69	30.69	-6.79	1.53	21.57	22.67
After 15 days	68.51	4.29	33.79	-9.03	3.13	24.67	**26.46**

***Table 3.** Chromatic measurements of the wool sample **treated** with AgNPs dispersions based on Stellaria media extract, exposed to accelerated degradation conditions.*

Exposure time	L*	a*	b*	ΔL*	Δa*	Δb*	ΔE*
Before exposure	77.91	0.84	8.01	-	-	-	-
After 3 days	73.54	0.47	23.49	-4.37	-0.37	15.48	16.09
After 6 days	70.72	1.65	29.49	-7.19	0.81	21.48	22.67
After 9 days	68.15	2.7	30.03	-9.76	1.86	22.02	24.16
After 12 days	67.93	3.94	33.18	-9.98	3.1	25.17	27.25
After 15 days	65.15	4.58	32.63	-12.76	3.74	24.62	**27.98**

The chromatic diagrams (figures 2-5) illustrate the color variation during the exposure.

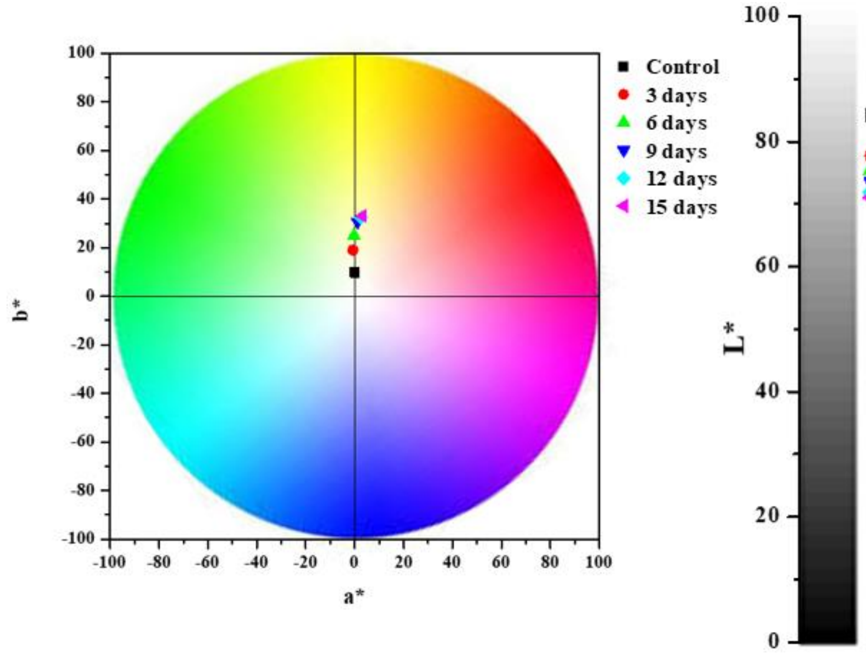

Fig. 2. *Chromatic diagrams of the untreated wool samples exposed to accelerated degradation conditions.*

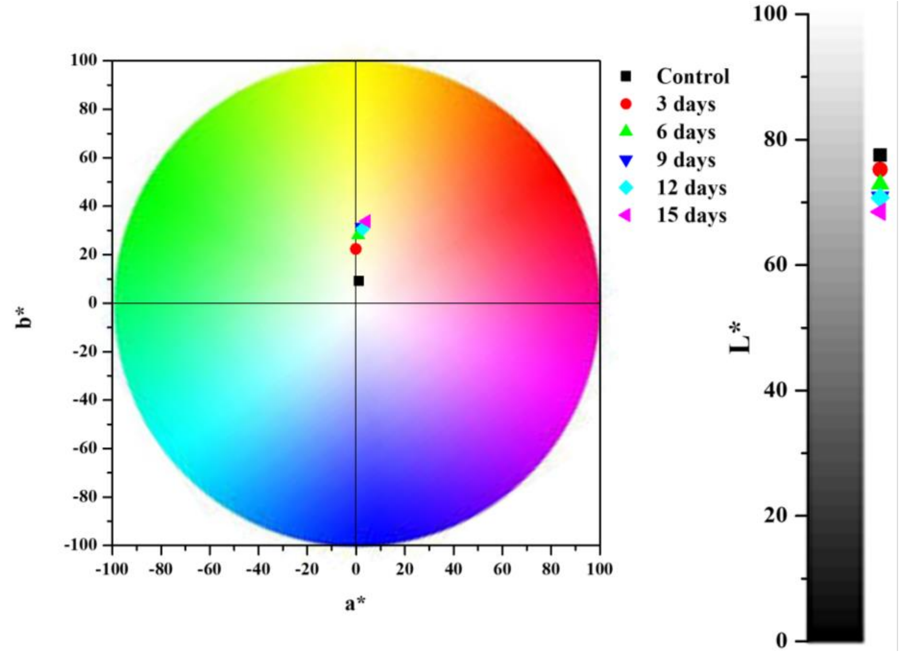

Fig. 3. *Chromatic diagram of the wool samples treated with AgNPs dispersions based on Primula officinalis extract, exposed to accelerated degradation conditions.*

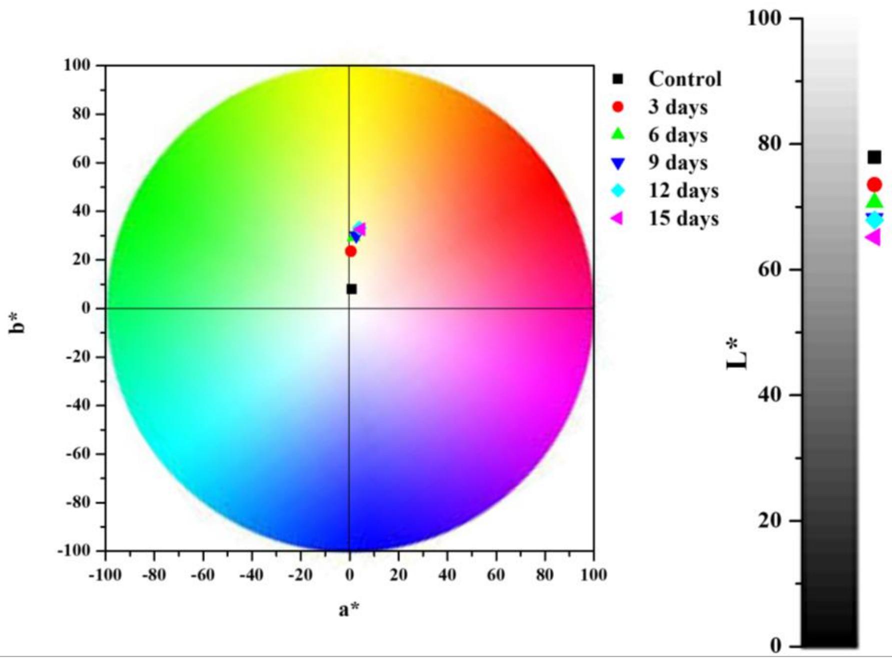

Fig. 4. *Chromatic diagram of the wool samples treated with AgNPs dispersions based on Stellaria media extract, exposed to accelerated degradation conditions.*

The observations regarding the brightness decrease revealed that minimum value was not influenced by the presence of the AgNPs treatment, even though this parameter was lower before the exposure, compared to the untreated sample. In the case of the a* parameter, the slight shift at the end of the process is more visible in the case of the treated exposed samples. Also, the b* parameter variation occurs more gradually in the case of the untreated sample.

4. CONCLUSIONS

The chromatic behavior of wool fabrics treated with phytosynthesized AgNPs dispersion subjected to accelerated weathering conditions was analyzed. The minimum value of the brightness was not affected by the presence of the treatment. While the variation of the a* parameter was not affected by the treatment, b* appeared to change more gradually in the case of the untreated fabric. Following the total color shift, the alteration of the visual aspect was minimum in both cases. The slightly higher value obtained in the case of the *Stellaria media*-based treatment was attributed to the phytocomponents of the extract. These results support the promoting effect of AgNPs treatment for cultural heritage conservation.

ACKNOWLEDGEMENTS

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“Advanced functional textile materials for protection and improving the quality of life – TEX4AGE”.

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

PREPARATION AND CHARACTERIZATION OF SELENIUM NANOPARTICLES ON TREATED TEXTILE FABRIC

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Abstract: *Infectious diseases are a serious threat to global health. In today's tightly connected world, a disease can be transported from any remote village to any major city on any continent very rapidly. By accumulating contaminants from air, clothes can become a transport vector and source of 'secondary exposure'. Thus, the development of new and efficient antimicrobial textiles to kill or slow the spread of microorganism is a focus point in textile research and gained much interest in recent years. These antimicrobial textiles are used in various applications ranging from households to commercial, including air filters, food packaging, health care, hygiene, medical, sportswear, storage, ventilation and water purification systems. There is a considerable interest for incorporating metal nanoparticles in textiles in order to obtain functional properties. Selenium nanoparticles are emerging as an effective antimicrobial agent for textiles. In this study, we investigated the properties of SeNPs prepared by a green method of synthesis. Formation and size distribution of SeNPs was confirmed by dynamic light scattering (DLS) analysis and scanning electron microscopy (SEM). Chemically stabilized SeNPs dispersions were subsequently used to treat cotton fabrics by padding. DLS analysis and Zeta potential measurements confirmed the synthesis of spherical, well-dispersed SeNPs and SEM analysis showed the successful deposition of SeNPs on cotton fabrics.*

Key words: *selenium, antimicrobial, textiles, nanoparticles, SEM microscopy*

1. INTRODUCTION

Textiles are indispensable objects and shape our daily life. In the last 30 years, textile industrial companies in Europe have been producing textiles that are used in many fields of application: in the field of agriculture, they are nets to protect crops against insects or climatic aggressions, textile screens for thermal insulation and solar filtration; in furnishing/decoration field: cover sofas, household linen (sheets, blankets, bedding protection), bathroom linen, furniture, curtains, and many others; in the building and construction sector, there are textiles and fabrics for solar protection, facade cladding, stretch roofs for football stadiums, interior and exterior blinds, etc.; in the industrial sector, textiles are used as fiberglass, used for electrical insulation and hot air filtration, truck covers, etc.; in the medical/health sector, textiles are used for implants, dressings, medical devices and masks; in transport, seats, airbags are made of textile, as well as helicopter blade tips, aircraft, and rocket nose sections for the aerospace industry [1,2].

Textile structures possess the ability to retain moisture, enabling bacteria spreading, which causes a range of unwanted effects, not only on the textile itself, but also on the user. Over the last few years, coronavirus pandemic generated an increase of public health awareness of the pathogenic effects regarding personal hygiene and associated health risks, thus intenstive research has been performed in order to minimize microbes'growth (bacteria, viruses and fungi) on textiles [3].

In the last decades there was a tremendous progress in textile functionalization by chemical or physical modifications, providing functions as antimicrobial [4], insect-repellent [5], water-repellent [6], odour-control [7], flame-retardant [8], etc. Nanotechnology can enhance fabrics properties. Among the nanomaterials used, metal nanoparticles are the most popular and versatile. Inorganic nanoparticles such as SeO_2, TiO_2, Cu_2O, CuO, ZnO, SiO_2 and Al_2O_3 are most commonly used because they are thermo-stable at high temperatures. Silver nanoparticles have become one of the most explored nanotechnology-derived nanostructures and have been intensively investigated for their unique physicochemical properties in terms of toxicity, surface plasmon resonance and electrical resistance [9]. The same unique properties that led to their widespread applications raise questions about potential environmental and health effects of exposure during the manufacture and usage. Thus, exposure to silver nanoparticles by inhalation, skin and parenteral exposure can led to oxidative stress, DNA damage, and inflammation [10]. Selenium is a naturally occurring metalloid, essential to human health and plays a substantial role in the functioning of the human organism. It is incorporated into selenoproteins, thus supporting antioxidant defense systems [11]. Several chemical and physical procedures for selenium nanoparticles formation have been discovered, however, the employment of different chemical compounds and physical approaches can result in hazardous agents that restrict the therapeutic potential of selenium nanoparticles in industry. As a result, significant efforts and research have been dedicated towards the green synthesis of selenium nanoparticles, which is eco-friendly and non-toxic [12,13].

In this research, selenium nanoparticles were synthetized by a green method, different types of nanoparticles dispersions were formulated and applied on cotton fabrics. Dynamic light scattering (DLS) analysis was used to confirm the formation of nanoparticles, and characterization of treated fabrics was performed by scanning electron microscopy (SEM).

2. EXPERIMENT

2.1 Materials

The fabrics used in this research were 100% cotton (shirt fabric). Sodium biselenite ($NaHSeO_3$), ascorbic acid, polyvinylpyrrolidone (PVP) and polyvinyl alcohol (PVA) were purchased from Sigma-Aldrich and are of analytical grade. Itobinder AG, polyacrylic binder was purchased from LJ Specialities, UK.

2.2 Methods

Selenium nanoparticles (SeNPs) were synthesized from sodium biselenite as a precursor (in various concentration of 50 and 100 mM) by a green method [12]. Reducing agent of sodium biselenite to selenium nanoparticles was ascorbic acid, prepared in various concentration of 100 mM and 200 mM and added to dispersions at the same molar ratio of 2:1 for both dispersions (acid ascorbic: sodium biselenite). We used stabilizing agent PVP and PVA in concentration of 60 g/L for 50 mM sodium biselenite solution (Table 1).

Table 1. *Recipes of the nanoparticle dispersions*

Dispersion number	$NaHSeO_3$ (mM)	Ascorbic acid (mM)	Concentration of stabilizing agent (g/L)	Stabilizing agent
1	50	100	60	**PVP**
2	100	200	120	**PVA**

Treatment of textile materials with nanoparticles dispersions was performed by padding on laboratory dyeing machine RedKrome REDP – Ugolini, as following: 50 mL NPs dispersion + 30 g/L Itobinder, drying at 100ºC for 2 minutes and condensing at 150ºC for 1 minute.

The surface morphology of the selenium nanoparticles coated fabric was investigated by scanning electron microscope (SEM Quanta 200, FEI, Holland) equipped with energy-dispersive X-ray analysis (EDX) system.

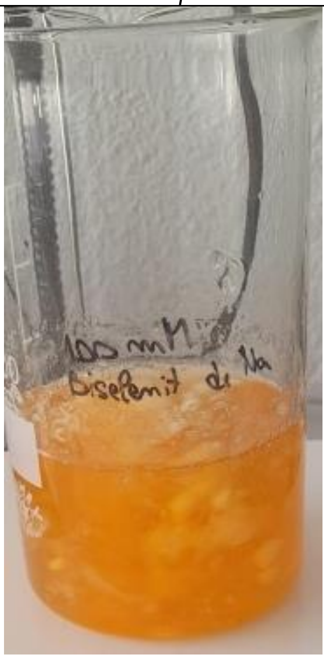
Particle size was determined by dynamic light scattering technique (DLS) by measuring the random changes in the intensity of light scattered from dispersions. The samples were analysed using Zetasizer Nano ZS equipment (Malvern).

2.3. Reduction of selenium precursor to selenium nanoparticles

The formation of selenium nanoparticles was observed by changing the color of biselenite precursor solution from colorless to orange and to dark orange when adding ascorbic acid (Table 2).

As a reductive agent, ascorbic acid acts as an electron donor and provides the reduction of orange colored precursor sodium biselenite to dark orange color selenium nanoparticles.

Table 2*. Reduction of sodium biselenite to selenium nanoparticles by ascorbic acid*

	
Sodium biselenite and PVA on magnetic stirring	Sodium biselenite, PVA and ascorbic acid as a reductant

2.4. Dynamic light scattering (DLS) analysis and Zeta potential measurements.

Dynamic light scattering is a suitable technique for the determination of the size distribution profile of particles in a dispersion. DLS was performed to confirm the formation of selenium nanoparticles and revealed a gaussian size distribution of nanoparticles for both dispersions.

All the samples were measured 3 times, without further preparation at 25°C, using disposable folded capillary cells (DTS 1070).

Pdl represents the polydispersity of the sample and values <0.2 are preferred. Pdl values obtained are below 0.2 for both dispersions, suggesting that the samples are quite polydisperse. The Zeta potential is an indicator of sample stability.

Dispersion 2 was stabilized with polyvinylic alcohol and revealed promising results, with an average size of the nanoparticles determined by DLS of around 170 nm, and a zeta potential of -0.382 mV, compared with dispersion 1, stabilized with polyvinylpyrrolidone that determined the agglomeration of particles, revealing an particles average size of approximately 5000 nm and a zeta potential of 0.402 mV (Figure 1 and 2)

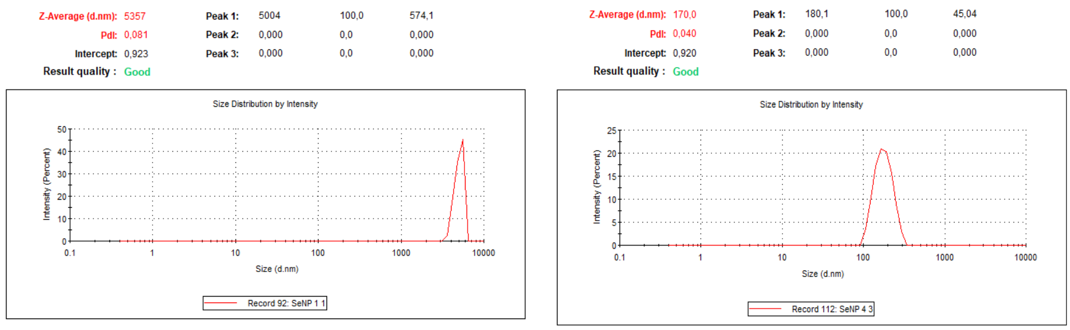


Figure 1. *Size distribution by Intensity of dispersion 1 (left) and dispersion 2 (right)*

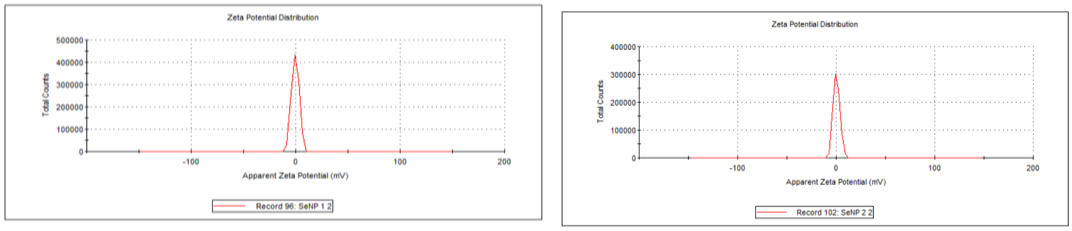
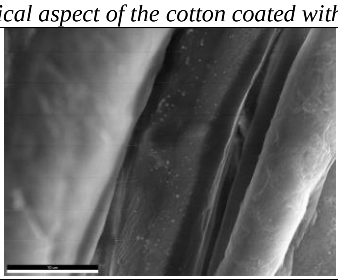
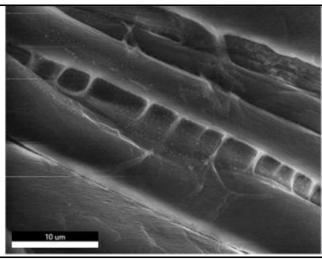


Figure 2. *Zeta Potential distribution of dispersion 1 (left) and dispersion 2 (right)*

2.5. SEM/EDX analysis of the fabric coated with SeNPs dispersions

Table 3: *Morphological aspect of the cotton coated with SeNPs*

		
Untreated fabric	**Fabric treated with dispersion 1**	**Fabric treated with dispersion 2**

The cotton fabric treated with selenium nanoparticles is covered with relatively uniform dispersed nanoparticles (Table 3), the smallest ones ranging from 118.2nm to 181.5nm. Itobinder AG is a self cross linking aqueous acrylic emulsion. It was used to increase the adherence of nanoparticles dispersions on the cotton surface. It is possible that some of the carboxyl groups of the binder interact with selenium particles and other functional groups existing in dispersion. Also, during drying, the binder forms a network which immobilizes the nanoparticles, assuring a stronger fixation of the nanoparticles on the fabric.

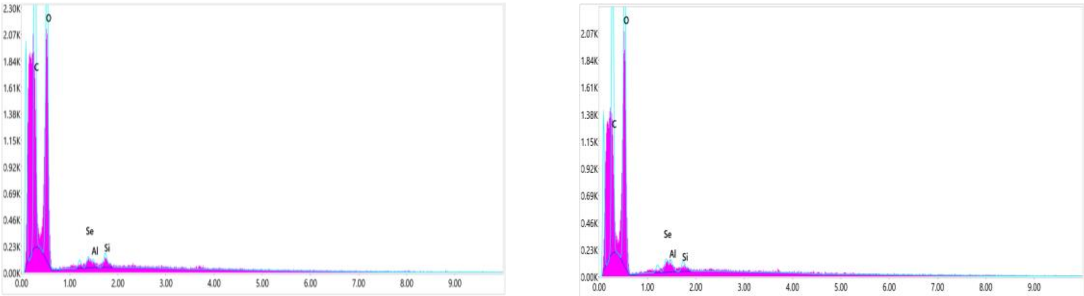


Fig. 3. *EDX spectra of the fabrics coated with SeNPs dispersion 1 (left) and dispersion 2 (right)*

Table 4: *EDX quantification of the Se% wt on the cotton fabrics*

Dispersion 1				Dispersion 2			
Element	**Weight %**	**Atomic %**	**Error %**	**Element**	**Weight %**	**Atomic %**	**Error %**
C K	50.53	58.21	9.5	C K	45.89	53.78	9.76
O K	47.51	41.09	10.28	O K	51.52	45.31	10.13
AlK	0.37	0.19	19.61	AlK	0.69	0.36	13.73
iK	0.72	0.36	9.55	SiK	0.66	0.33	11.35
SeL	0.87	0.15	13.18	SeL	1.24	0.22	12.35

A greater amount of selenium nanoparticles (1.24%) is evidentiated by EDX quantification equipped with Smart Quant software on dispersion 2 (Figure 3 and Table 4), due to a better stabilization capability of PVA compared to PVP, and a better fixation of selenium nanoparticles on fabrics.

4. CONCLUSIONS

Cotton fabrics were treated with dispersions of selenium nanoparticles, synthesized by a green chemistry route. The size and morphology of selenium particles investigated by DLS demonstrated that PVA assures a better stabilization of the dispersion showing that majority of the particles were approximately 170 nm compared to PVP, that determined the agglomeration of particles. SEM-EDX analysis confirmed the presence of selenium nanoparticles on cotton fabrics, in a greater amount on fabric stabilized with PVA. Research will continue with investigation of antimicrobial properties of treated fabrics.

ACKNOWLEDGEMENTS

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

INNOVATIONS IN BIOMATERIAL INDUSTRY-PROPOLIS AS AN COMPLEMENTARY ELEMENT

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Abstract: *This work highlights the importance of biomaterials in the fashion industry, outlining the recent progress and innovations in this field. The actuality of the topic is determined by the necessity of the fashion industry to adopt sustainable and ecological materials with the purpose of reducing the negative impact of textiles on the environment. Biomaterials, which are presented in the first stage of research and development, represent biopolymers which offer new perspectives on the production of traditional textiles. The main purpose of the work is to create new recipes for biomaterials with the addition of propolis. The general objective is to obtain a biomaterial with similar aesthetic properties as natural leather, at the same time having therapeutic functions. There are examples presented to illustrate the diversity and potential of biomaterials. The experimental part presents the fabrication process of biomaterials, including their creation and analysis, with the aim of evaluating their proprieties and quality. It is proposed to use propolis for conferring additional properties such as antimicrobial, antioxidant, anti-inflammatory, and air fresheners. The coat made from samples of biomaterials presents an example of a wearable, functional, and sustainable product whose functionality is determined by the proprieties of the propolis powder in the biomaterial's recipe. As further directions of development is mentioned the wearing in real conditions of the prototype made in order to evaluate the antibacterial, odorizing, anti-inflammatory properties.*

Key words: *sustainable, materials, recipe, agar-agar, gelatin.*

1. INTRODUCTION

In the context of promoting a sustainable fashion industry, designers have the role of finding nature-friendly solutions. An example of this is replacing traditional materials with bio-based materials. Bio-based materials are becoming significant for the fashion industry due to the benefits they bring to the environment, as well as the functionalities that can be attributed to them through the use of consumer-friendly components. Currently, biomaterials are presented as prototypes or in their early stages of research and development, having a promising result in the near future. They represent biopolymers, which offer new ways to conceptualize traditional textile production. [1-8]

In this work it is proposed way of obtaining biomaterials for fashion industry, materials that will be the basis for creating models of clothing products that will meet the needs of today's society – functional and sustainable clothing products.

2. EXAMPLES OF BIOMATERIALS IN FASHION INDUSTRY

Biomaterials for the garment industry must possess similar proprieties as the traditional materials: physical properties (width and length, specific mass, thickness), mechanical properties (tensile strength and elongation, wear resistance), hygienic-functional properties (thermal insulation capacity, air permeability, hydrophilia, hygroscopicity, water permeability), visual properties (dimensional stability, wrinkling ability to return, draping, flexibility, transparency) [10, 11].

As mentioned in the studied sources [10, 11], the methods of obtaining biomaterials for fashion industry are the following: manufacturing (bio-plastic, skins, yarns); growth (skins based on mycelium, skins based on microbes, silk from spider threads); extraction (examples: pinatex, bamboo, coconut, banana).

Mostly, existing biomaterials come as a substitute for traditional textiles. A first example of innovative biomaterial is jacquard textile from banana's plant. This can be obtaining from a species of banana cultivated in Filipine. The material is lightweight, highly resistant, air-permeable, has antibacterial properties and is biodegradable. [1]

Carmen Hijosa is the designer that created Pinatex- a trademarked fabric obtained from pineapple leaf waste. [2] Vegea is a product obtained from the recovery of waste from the Italian wine industry and biomass. [3]

Fig. 1: *Pinatex – biomaterials obtained from pineapple leaves' waste [2]*

Fig. 2: *Vegea - vegan alternative from grape for animal leather [3]*

Adriano di Marti's Company, Mexic, after two years of researches, produce Desserto bioleather in 2019. This is obtaining from Nopal cactus, the leaves of which are picked twice a season, without harm to the plant. [4] Engineers from Bolt Treads produce leather from mycelium – fibres derived from mushroom root structures. In 2022, it was created the first luxury bag from mycelium- Mylo bag. [5]

Fig. 3: *Desserto Bioleather [4]*

Fig. 4: *Luxury bag from mushroom leather [5]*

In 2023, Stella McCartney collaborates with startup Radiant Matter and creates biodegradable sequins. [6] Vegan leather is the hallmark of the Hungarian brand Nanushka. Although the brand was founded a decade ago, it has made known by the growing interest in sustainable fashion. [1,8]

Fig. 5: *Delevingne model in Biosequins-covered jumpsuit on the April cover of Vogue [6]*

Fig. 6: *Jacket from vegan leather Nanushka [7]*

Another example in this field are the projects of the participants of the intensive multidisciplinary program Fabricademy. Within the Biofabric Materials course, under the guidance of Cecilia Raspanti [10], they learnt how to create biomaterials. The recipes underlying the study presented in this work, recipes for biofoils, bioplastics and bioskin, are described in the specialised publications studied [11, 12].

Fig. 7: *The final projects from Fabricademy program- concepts based on biomaterials uses [10]*

Based on the studied information, we can say that the field of biomaterials, although it is at its beginnings, it represents the interes of designers who promote nature-friendly fashion.

3. EXPERIMENTAL RESEARCH

3.1. Material and method

The process of obtaining biomaterials can vary depending on the specific type of biomaterial and the biological resource used. However, there are some general steps that most biomaterials go through in their production process: raw material preparation, biomaterials processing, product finishing, testing and evaluation, integration into finished products.

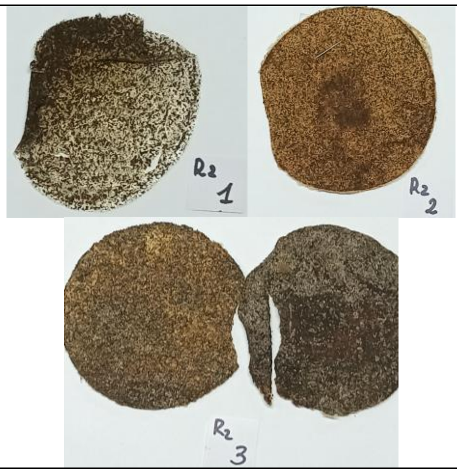
Initial experimental studies included the creation of biofoil and bioplastic samples. In both cases, propolis powder was added.

Studied recipes has 3 main components: bio-polymer – gelatin or agar-agar plasticiser– glicerin; solvent – water.

Propolis powder will be used in the composition of bio materials, in order to confer antimicrobial, antioxidant, anti-inflammatory and odorizing properties, properties that propolis powder possesses.

Following are described the experiments done initially (table 1).

Table 1: *Biomaterials samples with addition of propolis*

Recipe	Biomaterial's samples obtained initially
First recipe - biofoils	
Ingredients: agar-agar, glicerin, gelatin, propolis powder. Raport: 1:5:6,6. Water – 400 ml. The total quantity of propolis represent 10% of the solution quantity after evaporation. We mixed the ingredients in cold water and put them in the pot on low heat. We flutter ocassionaly the mixture and collect the formed foam. The boiling time is about 40- 50 minutes. The biomaterial is poured into a lined form with waterproof material. The optimal drying time of the biomaterial is about seven days, at room temperature, without strong drafts. At the same time, the room should be well-ventilated.	
Second recipe - bioplastic	
Ingredients: agar-agar, glicerin, propolis powder. Raport: 2:1. Water – 400 ml. The total quantity of propolis represent 10% of the solution quantity after evaporation. We mixed the ingredients in cold water and put them in the pot on low heat. We flutter ocassionaly the mixture and collect the formed foam. The boiling time is about 40- 50 minutes. The biomaterial is poured into a lined form with waterproof material. The optimal drying time of the biomaterial is about seven days, at room temperature, without strong drafts. At the same time, the room should be well-ventilated.	

The initial sample obtained were analysed visually and tactilely. Properties similar to those of natural leather were observed in the case of samples obtained based on recipe 1.

Further experiments were carried out to obtain perfect samples of larger sizes which will later be used to make a real product – a coat for people suffering from various diseases that could be improved using propolis.

For some casting surfaces appeared difficulties like: determining the optimal boiling time, the drying period until the extraction of the biomaterial from the form in which it was poured, the correct determination of the amount of ingredients raorted to the casting surface. The optimal final recipe is: ingredients – water 450 ml; raport – 1 (agar-agar): 5 (glicerin): 6,6 (gelatin); boiling time:50 min. The surface were the biomatersial was poured has the following dimensions: 410/300 mm. By experimental method – on a wooden stick the initial level of cold liquid was marked, occasionally the level of it being measured with the same stick. When the liquid dropped more than 50% and corresponded to the boiling time, it was added the propolis powder, which boiled in the composition for up to 5 minutes.

Some samples obtained at this stage where presented in figure 2. The eighth sample from the figure 2 was obtained by applying the final recipe described above.

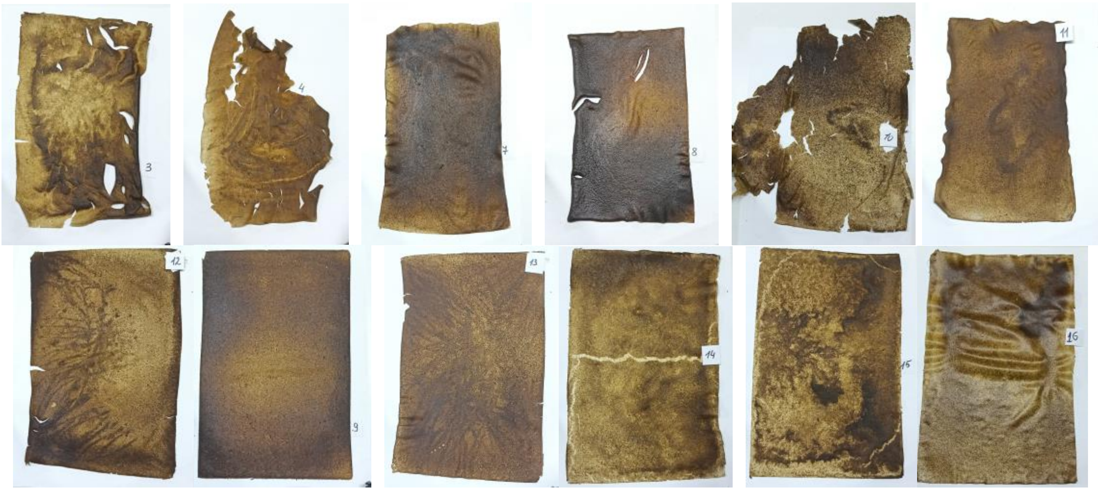


Fig. 2: *Biomaterial samples obtained in the second stage of experimentation*.

3.2. Results and discussion

The experimentation period for obtaining biomaterial samples was quite long as there were many variables that determined the appearance, quality, elasticity, durability of the material. These include: boiling time, boiling temperature, proportions used, casting surface, quality of raw material, temperature of the room where samples were left for drying.

Recommendations: for 200 ml of water take 1.5 gr. of agar-agar, 7.5 ml of glycerin and 15 gr. of gelatin. The amount of ingredients is calculated depending on the area of the form into which the biomaterial is poured. The flame of the stove is set to the minimum. It is worked quickly, because the biomaterial as soon as it begins to become cold, solidifies.

Following the experiments described above, the obtained samples were used to make the prototype of the coat for people with various diseases that can be improved with the help of propolis (figure 3). It is presumed that the antimicrobial and anti-inflammatory properties of propolis powder integrated in the biomaterial samples obtained have been retain. Regarding to the odorizing properties, by interacting with the heat production of the wearer's body, they were intensified when the jacket was wore for a short time.

Fig. 3: *The coat prototype realised by using biomaterial with propolis addition*

4. CONCLUSIONS

It is important to note that manufacturing processes and exact formulas of recipes may been vary depending on the specific goals of the designers. The materials obtained can have varied textures and properties, and their usage can contribute to the development of more sustainable and environmentally friendly options. Recent research and developments in the field of biomaterials point a promising direction for the future of textile industry and other related fields. Although there are still challenges in the production, implementation and experimental research of biomaterials such as that described in this work, there are important contributions in understanding and improve these materials. Recommendations for optimising the production process, such as the biomaterial coat with added propolis presented in this study, represent important steps towards the wide use of biomaterials in various practical applications. As further research directions, it is planned the wearing of the created prototype in real time in order to subjectively and objectively assess of the antibacterial, odorizing, anti-inflammatory and antifungal properties of propolis.

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

ADVANCES IN THE DEVELOPMENT OF TEXTILE SUPERCAPACITORS: MATERIALS, TECHNOLOGIES AND PRINCIPLES

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Abstract: *The current context is marked by an increased demand for efficient and flexible energy storage solutions. Due to the increased interest in this field, researchers are focusing on developing supercapacitors integrated into textile materials. This innovation promises to revolutionize areas such as smart clothing and wearable electronics, combining the advantages of textile materials that exhibit high-performance supercapacitors in terms of the rapidity of the charging and discharging process. The choice of electrode materials, such as carbon, conductive polymers, and metal oxides, is necessary for optimizing the capacity, energy density, and cyclic stability of the supercapacitors integrated into textiles. By integrating supercapacitors into textile materials, new perspectives are opened for efficient energy management in the digital era, offering innovative solutions in powering wearable devices and improving the quality of life through sustainable technologies at a reduced cost. This research direction highlights the importance of continuously developing materials and manufacturing technologies to precisely meet the increasing energy requirements.*

Key words: *supercapacitors, textiles, methods, functionalization, conductive materials.*

1. INTRODUCTION

Developing improved energy storage devices is one of the keys to successful global energy management for a greener and more energy balanced environment. In particular, one of the challenges is to improve energy transportability: lighter, more compact and mechanically flexible energy storage devices are needed for a significant number of applications, from wearable energy that could be incorporated into clothing, to space applications where the cost per weight and volume is enormous.

A number of recent studies, initiatives and products have been reported and proposed for the development of flexible energy devices based on various types such as $Zn\text{-}MnO_2$ (non-rechargeable) primary batteries, Li-MnO2 primary batteries as well as secondary batteries (rechargeable) such as lithium batteries, supercapacitors or systems based on radical polymers [1].

The increasing demand for energy and, at the same time, the depletion of natural resources are factors of a sustainable form of energy and storage since the second half of the 20th century. Harvesting renewable forms of energy, such as solar energy, wind energy, tidal energy, etc. are some examples that are being researched for indoor/outdoor applications from wearables to robots and grid power. One of the challenges for renewables is that they provide intermittent power, and as a result, environmentally friendly energy storage devices such as batteries and supercapacitors (SCs) are required. The launch of lithium-ion batteries in portable devices by Sony Corporation in the early 1990s was a major shift in technological advancements in electronic gadgets such as mobile phones, wearables, robots and autonomous devices, electric vehicles, etc. Supercapacitors or ultracapacitors are considered among the most efficient electrochemical energy storage devices because they offer high capacity, excellent energy density and specific power, high stability at charge-discharge rates, longer lifetime, and another aspect is represented by the fact that they can be light, flexible and portable. Compared to battery devices, supercapacitors offer higher energy density, longer cycling stability and faster charge-discharge process [2].

2. HISTORY OF SUPERCAPACITORS

There are many types of methods and elements that can be used for energy storage, where capacitors are one of the fundamental electrical circuit elements. From the simplest electrostatic capacitors to electrolytic capacitors, and then to supercapacitors, capacitance has been increased from milli-farads (mf) to hundreds or even thousands of farads (f), and the efficiency and effectiveness of capacitors have also been improved.

The first supercapacitor was the leyden jar. In 1746, Pieter Van Musschenbroek made a double-layer supercapacitor in Leyden in the Netherlands. It was found that electric charges could be stored on plates in the configuration, and the so-called capacitor was connected with a capacitor in the electrostatic mechanism. However, the first patent was not registered until 1957, when a carbon-based capacitor with a large surface area was illustrated. The electrolytic capacitor was then developed and commercialised as a polarised capacitor in which the conductive salts of the electrolyte interact with the metal electrodes. Basically, two metal sheets coated with a layer of insulating oxide were placed with a paper separator soaked with electrolyte. The thin oxide layers on the electrodes acted as dielectric elements, giving a higher capacitance per unit volume compared to electrostatic capacitors. Aluminium, tantalum, niobium and niobium oxides were commonly used to make electrolytic capacitors, with relative permittivity ranging from 9.6 to 41, and capacitivity ranging from a few μf to tens of mf, or even in some extreme cases, hundreds of mf [1,3]. Compared to traditional electrostatic and electrolytic capacitors, supercapacitors offer tens to hundreds of times more specific energy. In addition, supercapacitors can deliver higher specific power than many types of batteries, while the specific energy of supercapacitors is relatively lower than that of batteries.

Supercapacitors are the key to closing the gap between the two energy storage devices, batteries and capacitors, and establishing energy storage devices that charge fast and provide intermediate specific energy. Because their charge storage process is highly reversible, supercapacitors have relatively longer life cycles and can exhibit fast responses in both charging and discharging. This has led to considerable interest in their applications in various consumer electronic devices, industrial energy management systems and hybrid electric and fossil fuel vehicles [2,3].

2.1 Fundamental principles

Supercapacitors, also known as ultracapacitors or electrochemical capacitors [4,11], stand out in the energy storage landscape because of their unique mechanism for storing electrical energy. Unlike batteries, which rely on chemical reactions to store and release energy [5], supercapacitors store energy by physically separating charge in an electric double layer (EDL).This fundamental difference gives supercapacitors fast charge and discharge capabilities, exceptional power density and a lifetime that far exceeds that of conventional batteries [6]. Energy storage in supercapacitors is facilitated primarily by two mechanisms: electrical double layer capacitance (EDLC) and Pseudocapacitance. EDLC occurs at the interface between the electrode surface and the electrolyte, where a charge separation is formed with no real electron transfer across the interface, similar to a parallel plate capacitor [7,13]. This phenomenon is predominantly observed in carbon-based electrodes, where the large surface area and porous structure provide an extended interface for charge accumulation [8]. The performance of supercapacitors is governed by several key parameters, with capacitance, energy density, power density and cyclic stability emerging as critical factors. Capacitance, measured in farads (F), indicates the amount of charge a supercapacitor can store at a given voltage. It is intrinsically related to the electrode surface area and the distance between the electrode and the electrolyte ions. The choice of electrode material and its nanostructure is essential in defining the characteristics of the supercapacitor. Materials with large surface areas, such as activated carbon, graphene and carbon nanotubes, are preferred for EDLC supercapacitors [9]. For pseudocapacitive supercapacitors, materials that undergo redox reactions, such as certain metal oxides (e.g. RuO_2, MnO_2) and conductive polymers (e.g. polyaniline, polypyrrole) are chosen [8]. Figure 1 shows types of flexible supercapacitors and their typical configurations.

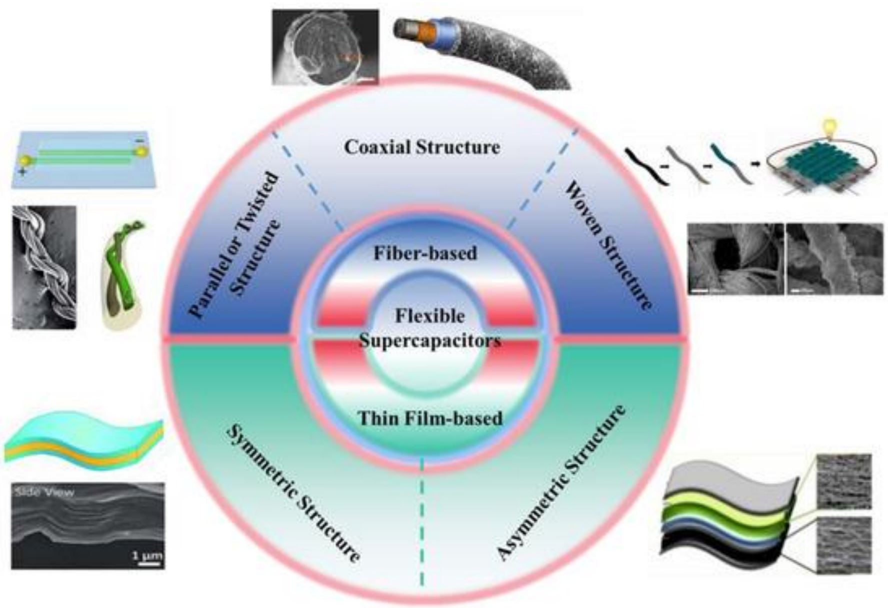

Fig. 1. *Flexible supercapacitors and their typical configurations [10].*

2.2 Classification of supercapacitors

Supercapacitors are divided into three different categories, as shown in Figure 2, where they are classified according to their charging mechanisms: (a) double-layer capacitors; (b) pseudocapacitors; and (c) hybrid capacitors.

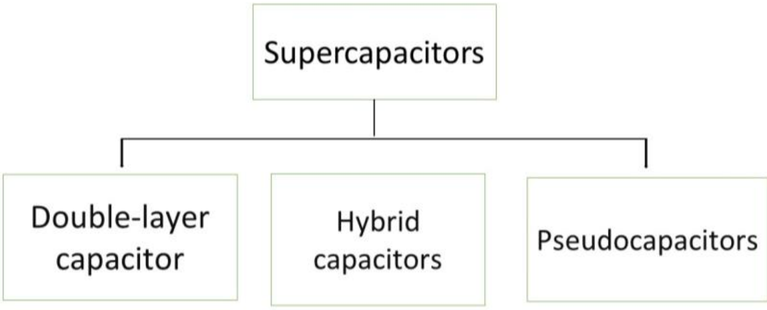

***Fig.2.** Classification of Supercapacitors [13]*

In the case of double-layer capacitors, an energy storage system is formed containing two layers of polarising electrodes, placed between a separator and charged with electrolytes. Energy can be stored as an electrostatic mechanism.

Pseudocapacitors energy is stored via the reduction-oxidation (redox) material in the context of redox reactions, where the fast chemical reaction serves as a capacitance.

For hybrid supercapacitors, substances such as activated carbon, conducting polymers or even transition metal oxides are doped or added to the electrodes so that supercapacitors can exhibit both electrostatic responses and reversible Faradaic charge transfer, where the lithium ion supercapacitor is a typical example in this category [1].

2.3 Energy storage mechanism in supercapacitors

In general, two different operating principles are applied for energy storage in supercapacitors: (1) double-layered capacitance, or so-called electrical/electrochemical double-layered capacitance (EDLC), and (2) pseudocapacitance [1].

Electrical double layer capacitance (EDLC)

In double-layered capacitance, energy is stored in a manner similar to that of a traditional parallel capacitor by separating charges. However, it can retain a much larger amount of energy than a conventional capacitor. Since charge separation occurs over a relatively small distance in the case of an electric double layer, the interface can be established between a particular electrode and its adjacent electrolyte [1,2].

Pseudo-capacity

In pseudocapacitance, a relatively large capacitance is found under a non-electrostatic base, which is due to a reversible Faradaic charge transfer. In addition, with a limited amount of active material or effective surface area, a capacitance related to an electrochemical charge transfer process is produced. Recently, pseudocapacitive materials investigated are transition metal oxides such as manganese(II) oxide (MnO_2), and conducting polymers such as polypyrroles (Ppy), polyaniline (PAni) or polythiophene (PTh) derivatives (e.g. poly(3,4-ethylenedioxythiophene), PEDOT)[1].

3. ELECTRODE MATERIALS

Supercapacitors can be made from a wide range of materials, such as carbon materials, conducting polymers and metal oxides, with the selection of the material used depending on the type of capacitance, specifically the storage mechanism to be used. For double-layered capacitance, carbonaceous materials are generally used, and for pseudocapacitance, metal oxides and conductive polymers are commonly applied. Therefore, for capacitors exhibiting both types of capacitance, either carbon composite materials with metal oxides or conductive polymers are used [1].

4. SUPERCAPACITORS BASED ON COATED TEXTILES

Since many textiles or fabrics are not conductive (e.g. cotton, wool, nylon, polyester), before applying these substrates to prepare flexible textile-based supercapacitors, their electrical conductivity must be improved. To facilitate better electrical conduction on various non-conductive fabric surfaces, a layer of conductive material is usually applied to the surfaces of yarns or fibres. This conductive layer can be prepared by physical vapour deposition (PVD), chemical vapour deposition (CVD), electrostatic spraying, electroless deposition, solution casting, dip coating or simply screen printing.

Various types of textile materials, including cotton, polyester, polyamide, spandex and carbon fabrics, are widely used to produce supercapacitors, and research results have been reported.
Researchers have developed flexible electrodes with a PANI-CNT-Cotton combination with a specific capacitance of 410 Fg^{-1}. After 3000 cycles, it degraded to 61% of its original value[7]. Then, other researchers further developed this idea and developed another flexible PANI-CNT-Cotton/Polyester electrode with a specific capacitance and areal capacitance of 11.1 Fg-1. After cycling this test device more than 15,000 times, 95% of the original capacitance could be maintained[8]. In another paper, it was reported how a stretchable textile was fabricated by direct immersion of a Spandex fabric substrate in an aqueous PEDOT-PSS dispersion. An average conductivity of 0.1 $S/cm\text{-}^{1}$ was measured from this conductive fabric, and by repeating the immersion step, the conductivity of the fabric increased to 2.0 S/cm^{-1} and gave a 33% faster switching speed[1]. In another study, polypyrrole/lignosulphonate (PPy/LGS) was deposited on cotton fabrics by *in situ* chemical oxidative polymerization of pyrrole in the presence of lignosulphonate, which functioned as both a template and a dopant. The electrical conductivity of the fabric increased to 3.03 S/cm^{-1} [9].

5. CONCLUSIONS

Sustainability and energy self-sufficiency are important aspects of the green economy. In this regard, this review article summarizes recent advances and various synthetic procedures used for the development of various flexible electrodes. Innovative materials such as metal oxides, conductive polymers and carbonaceous materials, together with advanced fabrication methods, suport the development of textile supercapacitors with improved conductivity capabilities, offering a promising approach to meeting energy requirements.

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

THERMOGRAPHIC STUDY ON TEXTILE TREATMENT EQUIPMENT

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Abstract: *The thermal analysis of the equipment in this work paper, has an important role (for planning maintenance activities), because this machine ensures optimal loading with different material treatment solutions, intended for mattresses, according to customer requirements. In the present paper the authors conducted a research on the whole technological flow in order to plan predictive maintenance activities using online monitoring methods. The monitoring of machine conditions is very important from the viewpoints of productivity, economic benefits, and maintenance. With one motor not functioning, the ventilation system may not be able to circulate enough air to properly cool the treated material. This can lead to overheating and potential damage to the material. Without all motors working together, the airflow and temperature within the treatment equipment may become uneven. The increased heat caused by a lack of proper ventilation can also harm the equipment itself, potentially causing mechanical failures or other issues. The failure of one ventilation motor can have significant negative impacts on the overall performance and effectiveness of the treatment process. It is important to promptly address and repair any malfunctioning motors to ensure the continued operation of the equipment and maintain the quality of the treated material. This paper presents only a part of the research carried out and in a future paper the rest of the analyses performed on the Squeezing Pader Machine will be presented.*

Key words: *thermal imaging, FLIR SC 640, FLIR RESEARCH IR MAX 4.40 software.*

1. INTRODUCTION

Early detection and diagnosis of incipient faults is desirable for online condition assessment, product quality assurance, and improved operational efficiency of induction motors [1].

Motors are critical for many industrial processes because they are cost effective and robust in the sense of performance [1]. They are also critical components in many commercially available equipment and industrial processes. Because of the potential savings offered by fault diagnosis systems, a lot of research has been carried out for the study and development of fault detection and diagnosis [2] methods for electric machines. Research on monitoring the condition of industrial machinery is a very important area aimed at avoiding unexpected situations such as: malfunctions, breakdowns, failures, shutdowns and not least economic losses [1], [2]. The state of the textile machines can be evaluated by monitoring different parameters, such as vibration and temperature [3, 4, 5, 6], so their maintenance can be performed a short time before the failure [7].

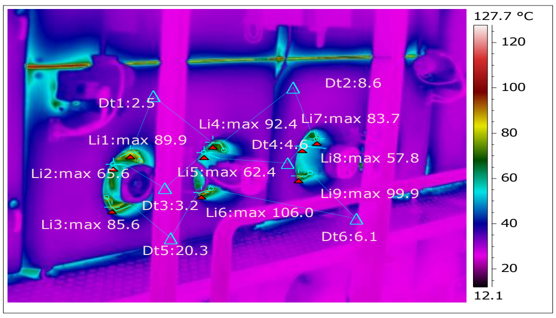
Thermography measurements were performed at the Lava Knitting in Oradea [8]. The Flir SC 640 thermal imaging camera was used, which is a portable thermographic scanning equipment, ”without cooling”, which has the strongest existing IR detector, with a resolution of 640 × 480 pixels and with a thermal sensitivity encountered so far only by cameras with cooling systems (<0.04°C) [5].

2. MATERIALS AND METHODS

Thermographic measurements were performed on the Squeezing Pader Machine, which is a machine for treating textile materials (mattress covers), as shown in Fig. 1. As it can be seen from Fig. 3 the maximum temperature along line Li1, which is positioned on motor 1, is 89.9°C, and the minimum temperature is 77.6°C. The temperature variation along line Li1 is 12.3°C, and the emissivity is 0.85 along line Li1, positioned on motor 1. The maximum temperature along line Li2, which is positioned on motor 1, is of 65.6°C, and the minimum temperature is 59.0°C. The temperature variation along the Li2 line is 6.5°C, and the emissivity is 0.85 along the Li2 line, positioned on motor 1. The maximum temperature along line Li3, which is positioned on motor 1, is 85.6°C and the minimum temperature is 65.1°C. The temperature variation along line Li3 is 20.5°C, and the emissivity is 0.85 along line Li3, positioned on motor 1.

***Fig. 1**: Equipment for the treatment of textile materials [8]*

***Fig. 2**: FLIR SC 640 thermal imaging camera components [9]*



a)

b)

Image Camera Type	FLIR SC640
Li1 Max. Temperature	89.9 °C
Li1 Min. Temperature	77.6 °C
Li1 Max - Min Temperature	12.3 °C
Li1 Emissivity	0.85
Li1 Object Distance	2.0 m
Li1 Reflected Temperature	22.5 °C
Li2 Max. Temperature	65.6 °C
Li2 Min. Temperature	59.0 °C
Li2 Max - Min Temperature	6.5 °C
Li2 Object Distance	2.0 m
Li2 Emissivity	0.85
Li2 Reflected Temperature	22.5 °C
Li3 Max. Temperature	85.6 °C
Li3 Min. Temperature	65.1 °C
Li3 Max - Min Temperature	20.5 °C
Li3 Emissivity	0.85
Li3 Object Distance	2.0 m
Li3 Reflected Temperature	22.5 °C
Li4 Max. Temperature	92.4 °C
Li4 Min. Temperature	66.3 °C
Li4 Max - Min Temperature	26.1 °C
Li4 Emissivity	0.85
Li4 Object Distance	2.0 m
Li4 Reflected Temperature	22.5 °C
Li5 Max. Temperature	62.4 °C
Li5 Min. Temperature	50.6 °C
Li5 Max - Min Temperature	11.8 °C

Li5 Emissivity	0.85
Li5 Object Distance	2.0 m
Li5 Reflected Temperature	22.5 °C
Li6 Max. Temperature	106.0 °C
Li6 Min. Temperature	67.3 °C
Li6 Max - Min Temperature	38.7 °C
Li6 Emissivity	0.85
Li6 Object Distance	2.0 m
Li6 Reflected Temperature	22.5 °C
Li7 Max. Temperature	83.7 °C
Li7 Min. Temperature	58.3 °C
Li7 Max - Min Temperature	25.4 °C
Li7 Emissivity	0.85
Li7 Object Distance	2.0 m
Li7 Reflected Temperature	22.5 °C
Li8 Max. Temperature	57.8 °C
Li8 Min. Temperature	43.4 °C
Li8 Max - Min Temperature	14.5 °C
Li8 Emissivity	0.85
Li8 Object Distance	2.0 m
Li8 Reflected Temperature	22.5 °C
Li9 Max. Temperature	99.9 °C
Li9 Min. Temperature	71.2 °C
Li9 Max - Min Temperature	28.7 °C
Li9 Emissivity	0.85
Li9 Object Distance	2.0 m
Li9 Reflected Temperature	22.5 °C

Fig. 3:*IR and real spectrum image of motor 1, motor 2, motor 3 and temperatures along the measured lines: (a) infrared image, (b) real image.*

As can be seen from Fig. 3 the maximum temperature along line Li4, which is positioned on motor 2, is 92.4°C, and the minimum temperature is 66.3°C. The temperature variation along the Li4 line is 26.1°C, and the emissivity is 0.85 along the Li4 line, positioned on motor 2. The maximum temperature along line Li5, which is positioned on motor 2, is 62.4°C and the minimum temperature is 50.4°C. The temperature variation along line Li5 is 11.8°C, and the emissivity is 0.85 along line Li5, positioned on motor 2. The maximum temperature along line Li6, which is positioned on motor 2, is of 106.0°C, and the minimum temperature is 67.3°C. The temperature variation along line Li6 is 38.7°C, and the emissivity is 0.85 along line Li6, positioned on motor 2. As can be seen from Fig. 3 the maximum temperature along line Li7, which is positioned on motor 3, is 83.7°C, and the minimum temperature is 58.3°C.

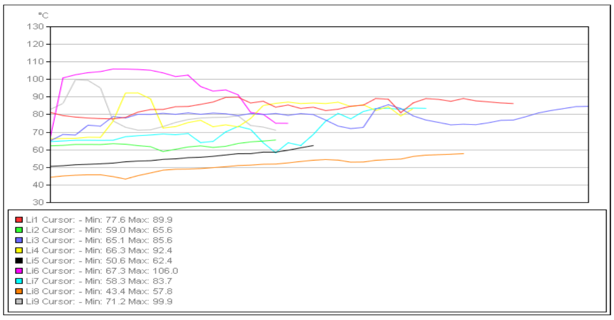
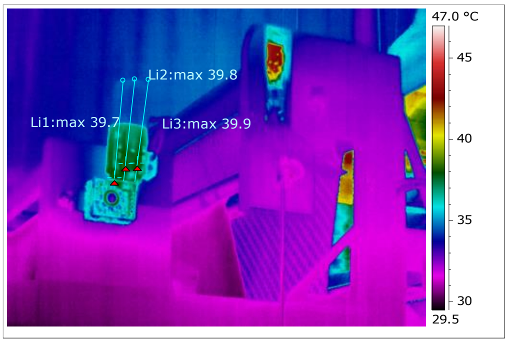


Fig. 4: *Temperature variation along the lines positioned on motor 1, motor 2 and motor 3*

The temperature variation along the Li7 line is 25.4°C, and the emissivity is 0.85 along the Li7 line, positioned on motor 3. The maximum temperature along line Li8, which is positioned on motor 3, is 57.8°C and the minimum temperature is 43.4°C. The temperature variation along line Li8 is 14.5°C, and the emissivity is 0.85 along line Li8, positioned on motor 3. The maximum temperature along line Li9, which is positioned on motor 3, is of 99.9°C, and the minimum temperature is 71.2°C. The temperature variation along line Li9 is 28.7°C, and the emissivity is 0.85 along line Li9, positioned on motor 3.

Fig. 4 shows the temperature variation along the lines positioned on motor 1, motor 2 and motor 3.



a)

b)

Image Camera Type	FLIR SC640
Li1 Max. Temperature	39.7 °C
Li1 Min. Temperature	35.5 °C
Li1 Max - Min Temperature	4.2 °C
Li1 Emissivity	0.85
Li1 Object Distance	2.0 m
Li1 Reflected Temperature	22.5 °C
Li2 Max. Temperature	39.8 °C
Li2 Min. Temperature	35.3 °C
Li2 Max - Min Temperature	4.5 °C

Li2 Emissivity	0.85
Li2 Object Distance	2.0 m
Li2 Reflected Temperature	22.5 °C
Li3 Max. Temperature	39.9 °C
Li3 Min. Temperature	35.5 °C
Li3 Max - Min Temperature	4.4 °C
Li3 Emissivity	0.85
Li3 Object Distance	2.0 m
Li3 Reflected Temperature	22.5 °C

Fig. 5*:IR and real spectrum image of motor 4 and temperatures along the measured lines: (a) infrared image, (b) real image.*

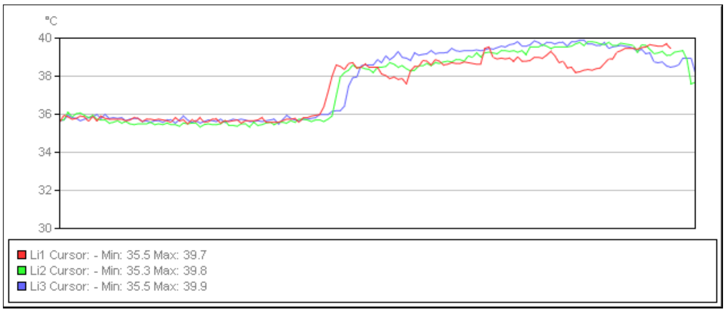
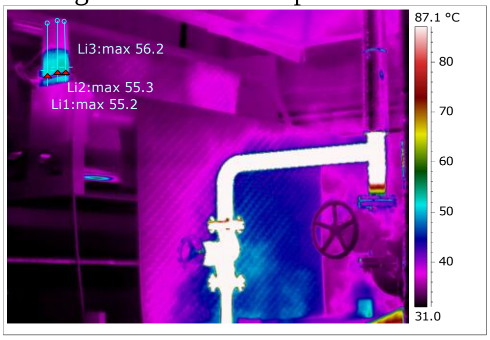


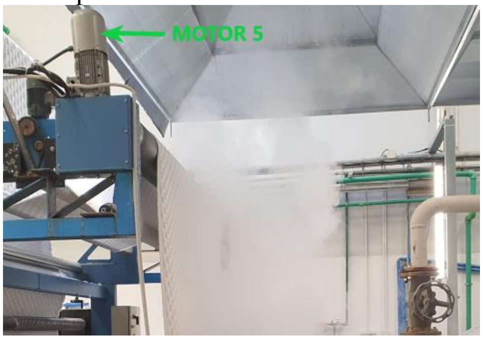
Fig. 6*: Temperature variation along the lines positioned on motor 4*

As it can be seen from Fig. 5 the maximum temperature along line Li1, which is positioned on motor 4, is 39.7°C, and the minimum temperature is 35.5°C. The temperature variation along line Li1 is 4.2°C, and the emissivity is 0.85 along line Li1, positioned on motor 4. The maximum temperature along line Li2, which is positioned on motor 4, is of 39.8°C, and the minimum temperature is 35.3°C. The temperature variation along the Li2 line is 4.5°C, and the emissivity is 0.85 along the Li2 line, positioned on motor 4. The maximum temperature along line Li3, which is positioned on motor 4, is 39.9°C and the minimum temperature is 35.5°C. The temperature variation along line Li3 is 4.4°C, and the emissivity is 0.85 along line Li3, positioned on motor 4.

Fig. 6 shows the temperature variation along the lines positioned on motor 4.



a)



b)

Image Camera Type	FLIR SC640
Li1 Max. Temperature	55.2 °C
Li1 Min. Temperature	36.5 °C
Li1 Max - Min Temperature	18.7 °C
Li1 Emissivity	0.85
Li1 Object Distance	2.0 m
Li1 Reflected Temperature	22.5 °C
Li2 Max. Temperature	55.3 °C
Li2 Min. Temperature	37.6 °C
Li2 Max - Min Temperature	17.8 °C

Li2 Emissivity	0.85
Li2 Object Distance	2.0 m
Li2 Reflected Temperature	22.5 °C
Li3 Max. Temperature	56.2 °C
Li3 Min. Temperature	37.8 °C
Li3 Emissivity	0.85
Li3 Max - Min Temperature	18.4 °C
Li3 Object Distance	2.0 m
Li3 Reflected Temperature	22.5 °C

Fig. 7*:IR and real spectrum image of motor 5 and temperatures along the measured lines: (a) infrared image, (b) real image.*

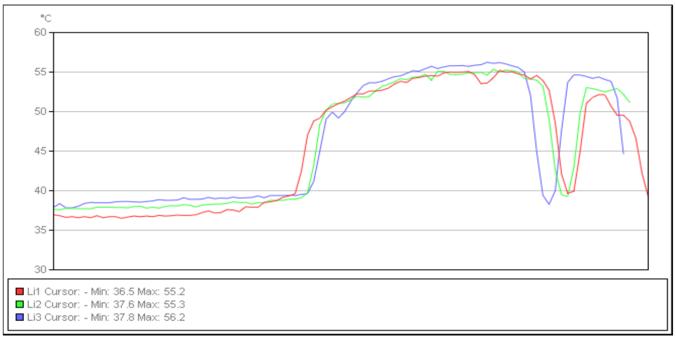


Fig. 8*: Temperature variation along the lines positioned on motor 5*

As it can be seen from Fig. 7 the maximum temperature along line Li1, which is positioned on motor 5, is 55.2°C, and the minimum temperature is 36.5°C. The temperature variation along line Li1 is 18.7°C, and the emissivity is 0.85 along line Li1, positioned on motor 5. The maximum temperature along line Li2, which is positioned on motor 5, is of 55.3°C, and the minimum temperature is 37.6°C. The temperature variation along the Li2 line is 17.8°C, and the emissivity is 0.85 along the Li2 line, positioned on motor 5. The maximum temperature along line Li3, which is positioned on motor 5, is 56.2°C and the minimum temperature is 37.8°C. The temperature variation along line Li3 is 18.4°C, and the emissivity is 0.85 along line Li3, positioned on motor 5.

Fig. 8 shows the temperature variation along the lines positioned on motor 5.

5. CONCLUSIONS

The failure of one ventilation motor can have significant negative impacts on the overall performance and effectiveness of the treatment process. It is important to promptly address and repair any malfunctioning motors to ensure the continued operation of the equipment and maintain the quality of the treated material.

Overall, by implementing a predictive maintenance strategy and regularly monitoring key parameters, textile manufacturers can prolong the lifespan of their machines, improve operational efficiency, and reduce maintenance costs.

A malfunctioning motor can decrease the overall efficiency of the ventilation system, potentially leading to longer processing times and higher energy consumption.

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STRUCTURAL CHARACTERISTICS OF TEXTILES COLLECTED FOR REUSE AND RECYCLING

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Abstract: *The circular economy is a new economic model for addressing human needs and fairly distributing resources without undermining the functioning of the biosphere or crossing any planetary boundaries. The research project carried out under the EU contract presents an analysis of 8720 pieces (1500 kg) of used clothing collected from the population for reuse and recycling, in terms of quantification and composition. A Near Infrared (NIR) scanner for the determination of textile fibre composition was used; other characteristics of the garment like product type, age group, colour and presence of disruptors were captured in the app on the electronic device through a short predefined multiple-choice survey, using an application designed by Matoha Instrumentation Ltd. Destination function four groups were selected: disposal (19%), re-wearable non-EU (32%), re-wearable EU(25%), and recycling (24%). The structure of used clothing for adults highlights the preference of consumers for pieces intended for the upper part of the body (42.0%) with a faster change dynamic. The fraction for the lower part of the body (skirts, pants, etc.) follows with 19.9% and underwear with 1.4%, which is characterized by a longer duration of use. The degree of wear and tear of used clothing items correlates with the fractions intended for export (57%), highlighting the main characteristic of the fast fashion phenomenon, namely the shortening of the duration of use of products. The high share of the recycling fraction (19%) highlights the potential of this type of waste for recycling through mechanical or chemical technologies. 14.7% of the pieces of clothing had a blue colour which expresses calm, and responsibility and 12.7% had a white colour which expresses purity, cleanliness and virtue. The predominant composition of the textile materials in used clothes is cotton 34.2% and the basic structure is specific to knitted items (55%).*

Keywords: *used textiles, sorting, reuse, analysis, recycling***.**

1. INTRODUCTION

The textile ecosystem, comprised of textile fabrics, clothing, leather, and footwear (TCLF), is one of the largest industries in the world, with one of the most globalized value chains that exist today [1]. The European textile ecosystem with more than 2.2 million workers faces strong international competition, being the world's second exporter of Textiles & Clothing after China [2].

In this context, the number of textiles & clothing (T&C) produced increased year by year, but the trend of "fast fashion", identified in the market determines the rapid obsolescence of these. As a consequence, T&Cs are discarded for a variety of reasons – a garment may still be wearable but no longer attractive to the consumer [3]. While the production of T&Cs contributes to the raw material deprivation, globally, around 87% of discarded textiles (about 92 million tons, globally) end up in landfills, while more than 90% of these are potentially reusable and recyclable. The environmental impact caused by discarded textiles is huge impacting soil, water, and air [4]. The textile industry is the second most polluting industry, after the oil industry, and is responsible for 20% of the world's wastewater.

The year 2025 is a milestone for EU-27 countries to collect separately the textiles. The goal is to ensure that used textiles are sorted for reuse and that non-reusable textiles are prioritized for recycling. Even, more and more clothes may be passed on for further use via the second-hand market, having the African and Asian continents as the last destination (about 46% of the Europeans used textiles goes to Africa and about 41% goes to Asia), and finally, most of them end up in open landfills and informal waste streams [5]. Among all European countries, Romania recycles only 3% of the entire volume of waste it produces, the rest being thrown into the landfill.

The limitation of the textile waste flow is possible by applying a strategy in the context of the Circular Economy. The circular economy is a new economic model for addressing human needs and fairly distributing resources without undermining the functioning of the biosphere or crossing any planetary boundaries [6]. Implementing this will have a great impact on the research sector (promoting innovative technologies for sustainable textiles) and on new businesses involved in the collection and treatment of textiles (with opportunities and a larger market for used textiles for social enterprises).

2. MATERIALS AND METHODS

Several factors influence the amount, the structure, and the degree of wear and tear of the waste collected from a certain area. We took into account two main factors:

- Socio-economic conditions: The level of income highly determines the quality of textiles consumed, hence affects the potential destinations of collected textiles. Besides, neighbourhoods with citizens with high levels of environmental awareness tend to have higher collection rates than others.
- Demographic conditions: Consumption and disposal patterns can differ depending on the degree of urbanization and average population age.

For the research, we employ a quantity of 1500 kg of used textiles, respectively 8720 used garment pieces, that were classified and analysed in a specialized deposit from Romania, that are intended for reuse and recycling. The collection was carried out with the support of governmental organizations for social protection.

2.1 Method

The study took place in a city with approximately 4 million inhabitants, characterized by a high degree of pollution, a continental climate, a very dynamic lifestyle and an average annual income of approx. 13,850 euros/inhabitant, which is 86% higher compared to the residents of other areas of the country and 8% below the European average. The average age of the inhabitants is 42.3 years. The capture of garment characteristics was made in two steps:

- the garment was scanned by a volunteer using the NIR handheld device, to assess its composition;
- other characteristics of the garment like product type, age group, colour and presence of disruptors were captured in the app on the electronic device through a short predefined multiple-choice survey, using an application designed by Matoha Instrumentation Ltd.

Destination function four groups were selected: disposal, re-wearable non-EU, re-wearable EU, and recycling.

3. RESULTS

3.1 Garment type

The analysis of the batch of used clothes highlighted the results presented below.

- Garment type according to users (Fig.1): 22.9% garments for children, 67% garments for adults, 8.29% other textile products, 1.2% blank, accessories such as hats, gloves, medium and small accessories 4.7%.

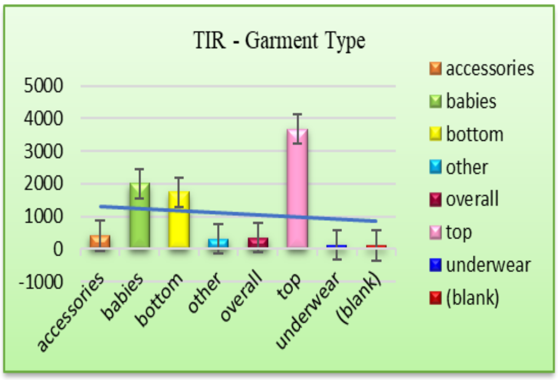

Fig. 1: *Fractions of the batch*

The structure of garments for adults highlights the consumers' preference for pieces intended for the upper part of the body (42.0%) with a faster change dynamic. Next, the fraction for the lower part of the body (skirts, pants, etc.) with 19.9% and underwear, with 1.4%, which is characterized by a longer duration of use. Other types of garments mean 36.7%.

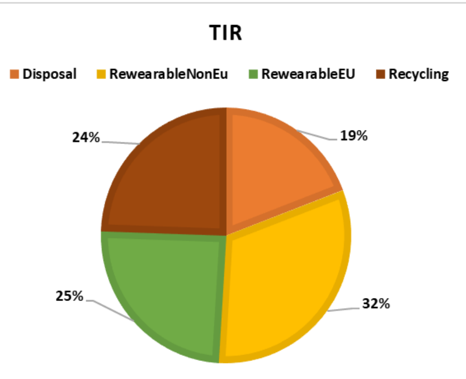

Fig. 2: *Garment type per batch*

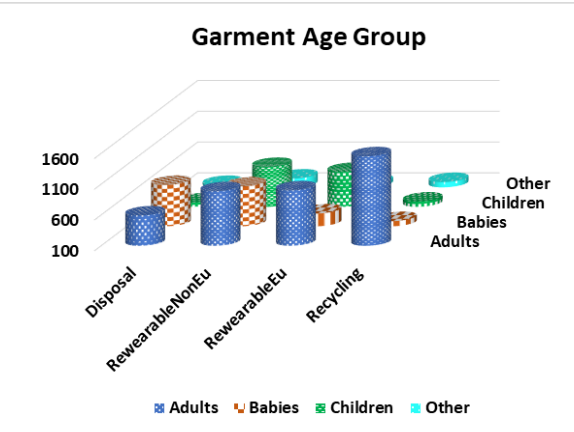

Fig. 3: *Fraction per garment type*

Fig. 2-3 present the share of each type of garment by destination group after collection. From the whole batch, 19% represents the disposal fraction, 24% the recycling fraction, 32% the fraction intended for export to non-EU countries and 25% the fraction intended for export to EU countries. It is noted that the largest share of the recycling fraction is from used clothing for adults. This orientation is correlated with the degree of wear (Fig.4 and 5), respectively: degree 1: pieces with multiple stains and holes, missing buttons and /or broken, zippers, including clothes impossible to identify; degree 2: pieces with multiple stains and holes, missing buttons and/or zippers but the garment possible to identify; degree 3: pieces with few and small stains or holes and/or some discolouration and pilled or thinned to a major extent; degree 4: the item is visibly worn with minor hole(s) or stain(s) or fabric being to a minor extent thinned or pilled (not all of these factors together); degree 5: new items with tags, without tags or like new, no visible damage.

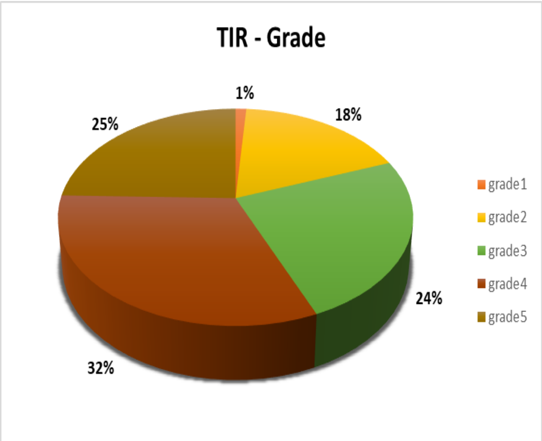

Fig. 4: *Degree of wear per batch*

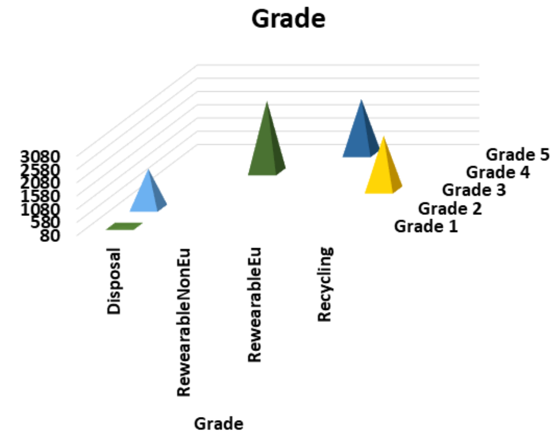

Fig. 5: *Degree of wear per fraction*

More than 32% of used clothing pieces have grade 5 of wear, being almost new and 25% grade 4. These percentages highlight the phenomenon of fast fashion that has led to the shortening of the use of products.

3.2 Composition

People are becoming increasingly aware of the importance of the composition of the clothing they wear. Apart from the key aspects related to environmental protection and moving towards a more eco-friendly life, it is essential to remember how important the fabric composition is for skin and comfort of use. The composition is a classification of materials, fabrics and knitted fabrics by what type of fibre they are made of. Every fabric or knitted fabric of a given composition has its uses. There are no bad ones or good ones – the important thing is to apply them appropriately to our needs. In addition, it is essential knowledge to properly care for the item so that it can serve for years. Therefore, it is useful to know the specifics of different materials, and then make an informed choice when shopping. In the spirit of environmental protection, we are keen to bet primarily on materials made of natural fibres, if only because synthetic ones such as polyester take a long time to decompose.

In our study:

✓ 34.2% of the garments are made from cotton (Fig. 6-7). Its characteristics are that it absorbs moisture very well retains heat, is breathable and does not crease. Another very positive property is that it is non-sensitizing– which is great news for allergy sufferers.

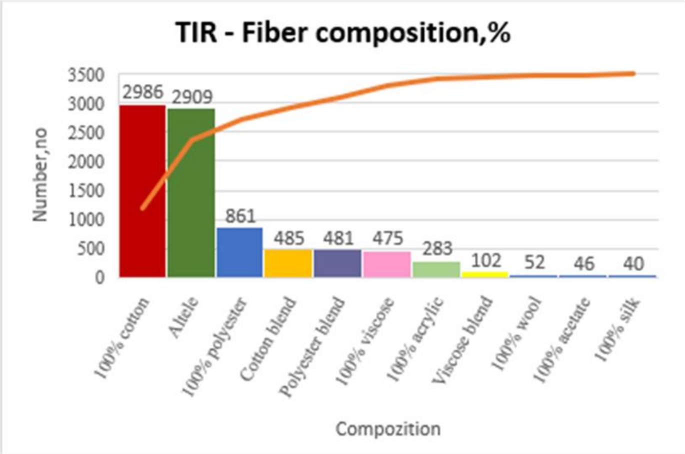

Fig. 6: *Composition per batch*

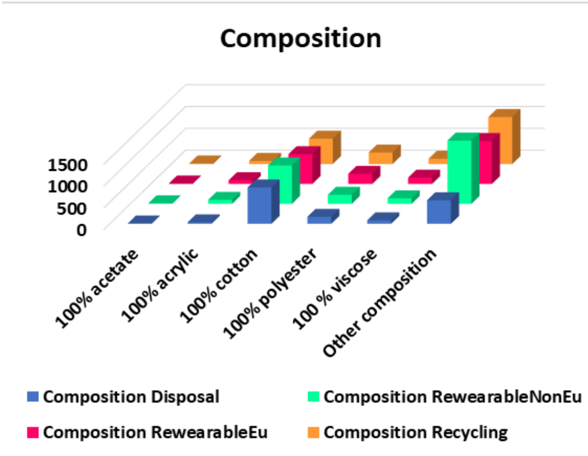

Fig. 7: *Composition per fractions*

✓ 9.8% of the garments are made from polyester. Polyester is noted for its exceptional durability and resistance to wrinkling, shrinkage and stretching. It withstands regular wear and tear, making it suitable for durable garments. Initially, consumers were enthusiastic about the improved durability profile of polyester compared to natural fibres, and these benefits are still valid today. In recent decades, however, the harmful environmental impact of this synthetic fibre has come to light in great detail, and the consumer stance on polyester has changed significantly.

✓ 5.45 of the garments are made from viscose: Viscose is an artificial fibre that is made from naturally occurring raw materials, such as wood cellulose. It has properties similar to cotton, it is a pleasant and soft material. Unfortunately, it is also characterized by low durability and the fact that it creases a lot.

In general, mixtures of 2 or more fibres aim to capitalize on the positive comfort and durability characteristics of each fibre. The most well-known are those made of cotton/polyester.

In our study:

✓ 10.8 % of the garments are made from cotton/polyester blend - because polyester fibres are so tough, unlike cotton and other natural fabrics, they do not easily rip, stretch, or pill. When blended with cotton, polyester improves the shrinkage, durability, and wrinkling profile of this widely-produced natural fibre. Because of its durability, polyester clothing doesn't need special maintenance and can easily withstand damage from machine washing. Polyester fabric is particularly well-liked for outdoor apparel due to its resilience;

- ✓ 39.75% of the garments are made from the other fibrous mixtures.

One major limitation of the use of NIR is its limited ability to recognise the presence of elastane. Elastane is often added to cotton garments to optimise comfort and fit. Pure cotton may contain small amounts of elastane.

3.3 Colour

Few things in design are more subjective, or more important than the use of colour. A colour that can evoke one reaction in one person may evoke the opposite reaction in another, due to culture, prior association, or even just personal preference. In our study: the colour of used garments was considered the solid or dominant colour. If it wasn't possible to define the same dominant colour, the article was considered multicoloured.

Based on this were obtained:

- ✓ 14.7% of the pieces of clothing had a blue colour that expresses calm, responsibility and sadness. Blue is a primary colour across all models of colour space. It is the colour of the ocean and the sky; it often symbolises serenity, stability, inspiration, or wisdom (Fig.8).
- ✓ 12.7% of the pieces of clothing had a white colour that expresses purity, cleanliness and virtue. White is often associated with purity, perfection, honesty, cleanliness, and beginnings. Surveys in Europe and the United States repeatedly link the colour white to forms of purity.
- ✓ 10.6% of the pieces of clothing had grey colour express grey moody, conservative and formal. In Europe and North America, surveys show that grey is the colour most commonly associated with neutrality, conformity, boredom, uncertainty, old age, indifference, and modesty.
- ✓ 10.2% of the pieces of clothing had a black colour that expresses mystery, elegance and evil. It can be linked with death, mourning, evil magic, and darkness, but it can also symbolize elegance, wealth, restraint, and power. As the first pigment used by artists in prehistory and the first ink used by book printers, black played an important role in the development of art and literature.

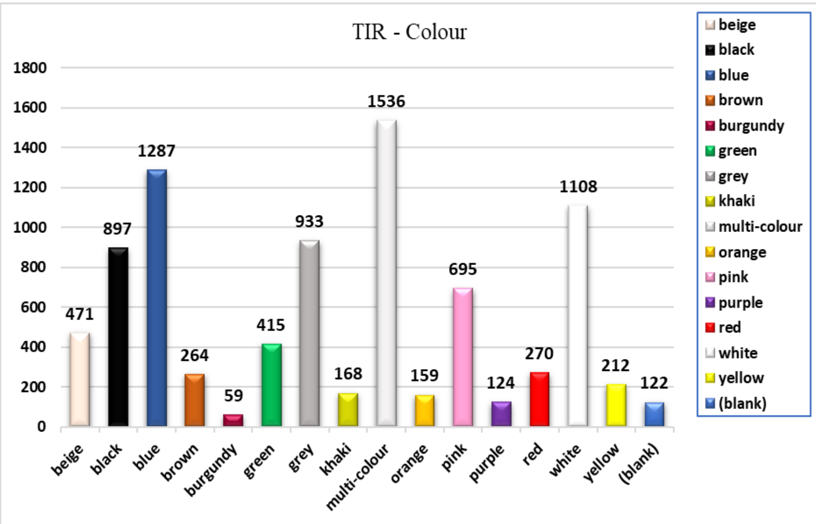

Fig.8: *Colours per batch*

Fig.9 shows that the share of colours on the fractions is similar to that identified on the whole batch of used clothes.

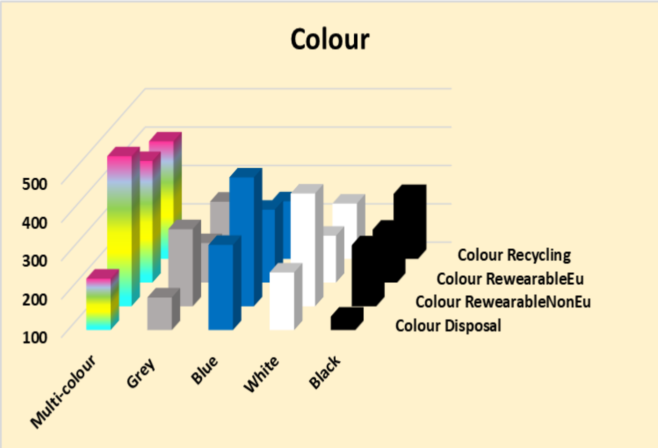

Fig. 9: *Colours per fractions*

In our study, 17.6% of the pieces of clothing had a combination of colours (Fig. 8-9) that was nominated as multicolour. The other colours mean 34.2%.

Structure of the raw material

Fabric structure is most relevant to assess the potential use of textiles as feedstock for mechanical recycling. Specific characteristics make a difference between them. The knit fabric is looped together. The woven fabric is interlaced at right angles. Woven fabric does not stretch across the width but along the length. Knitted fabrics stretch easily across the width and slightly lengthwise. Knitted fabrics keep their shape when pressed, while woven fabrics show folds on the surface when pressed. Examples of knit are single jersey, interlock, pique, rib and ponte roma and woven fabrics are twill, chiffon, denim and poplin. Out of 8720 pieces of clothing analysed, 55% are made of textile materials obtained by knitting technology, 44% of textile materials are made by woven technology and 1% are unidentified (fig. 10-11).

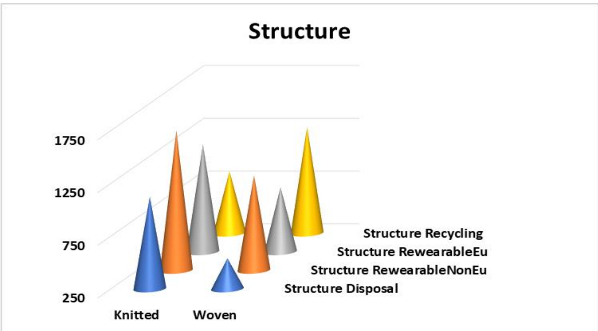

Fig. 10: The structure of raw material per batch

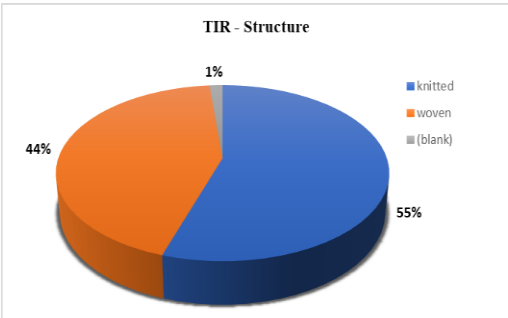

Fig. 11: The structure of raw material per fractions

5. CONCLUSIONS

- A batch of 8720 pieces of used clothing collected from the population in 4 fractions, weighing approx. 1500 kg, was analyzed.
- The share of wear grades 4 and 5 correlates with the fractions intended for export (57%), highlighting the main characteristic of the fast fashion phenomenon, namely the shortening of the

product lifespan. The high share of the recycling fraction (19%) highlights the potential of this type of waste for recycling through mechanical or chemical technologies.

- The predominant colours of the pieces of clothing are blue colour (14.7%) which expresses calm, responsibility, and sadness and white colour (12.7%) which expresses purity, cleanliness and virtue.
- The predominant composition of textile materials in used clothes is cotton (34.2%) and the basic structure is specific to knitted items (55%).

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