RESEARCH ON LIGHT RESISTANCE OF THE CHENILLE COTTON FABRICS' COLORING

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ABSTRACT

Colour fastness is one of the important characteristics, which depends on the further effective and rational use of the potential fabric resource, durability, wear resistance, and the level of competitiveness in the market. Therefore, evaluating the light fastness of colours of cotton fabrics, in the wear of which sunlight plays a major role, is an urgent scientific task. Chenille cotton fabric, which is currently in demand by textile decorators and modern interior decoration, was chosen for the research. The research was carried out using methods of visual and instrumental colorimetry. The conducted research is valuable for providing information to the market and for further analysis and implementation of the process of developing a system technology for designing chenille cotton fabrics.

KEYWORDS

Colour fastness; Chenille cotton fabrics; Consumer characteristics; Colorimetry.

INTRODUCTION

As is well known, the light fastness of the colour of interior cotton fabrics is one of the main characteristics of their quality. It is the light fastness of the colour that depends on the provision of aesthetic properties in the process of wear of products made of these fabrics used in modern interiors, the effective and rational use of the potential resource of their fibrous base, the provision of the necessary durability of the finished products, as well as the level of their environmental safety and, in general, the level competitiveness in the market. The light fastness of colouring is determined by many factors, in particular, the lightfastness of dyes, fibres, and finishes, the appropriate selection of individual parameters of fabric characteristics, and the methods of their final and special decoration [1,2]. The light fastness of the colour of chenille cotton fabrics provides functional and technological properties, affects the quality indicators of textile products, and plays a significant role in the formation of modern interior design [3].

The high level of quality of the modern residential and public interior, and the comfort of its internal environment, is an indicator of the successful development of the state. There is a significant amount of research on the properties of fabrics and their use in modern interiors.

In the 21st century, the inner filling of the modern interior acquires a new meaning, new properties, and features, new requirements are placed on fabrics and textiles that participate in the formation of the interior space. On the one hand, the filling of the modern interior continues to preserve the connection with the traditions of folk art of the past, taking into account history, archaeology, and ethnography, which is reflected in publications [4]. This is evidenced by the use of artistic and decorative textiles in the interiors of public buildings, as well as the use of applied arts, which vividly reflect Ukrainian folk traditions. Decorative fabrics in a modern interior can act as an active artistic accent, allowing to achieve an individual solution, both for large halls, various institutions, and individual rooms. In this regard, various studies were conducted on the artistic properties of textile products in the formation of the interior design of household service establishments and the identification of the peculiarities of their use [5].

On the other hand, the filling of a modern interior puts forward new requirements for the quality characteristics of fabrics and textiles, which are associated with new materials and technologies, the emergence of new styles, and directions of fashion trends. The analysis of modern trends in determining the colour fastness of natural dyes on cotton fabrics by instrumental methods using a spectrophotometer is reflected in the publication [6]. The publication [7] is dedicated to the study of air permeability, vapor

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Received November 28, 2022; accepted July 19, 2023

permeability, and individual structural parameters of the fabric. The physical properties of cotton fabric after five washing-drying cycles were studied, as well as the effect of drying on the smoothness and shrinkage of the fabric [8]. Tests related to the process of fixing the natural colours of natural dyes on cotton and silk fabrics using the bone ash test are presented in the scientific paper [9]. Research is aimed at studying the effect of styrene-acrylic and urethane-polymer films filled with titanium dioxide nanoparticles on the change in thermophysical properties of the surface of cotton fabric [10]. Experimental studies of the effect of washing and moisture on changes in the breathability of cotton fabrics and the effect of different types of seams on breathability were conducted, and the results of these studies are presented in the scientific paper [11]. The scientific paper is devoted to the study of the behaviour of woollen fabrics during friction (experimental research), to the study of their frictional characteristics. The possibility of increasing the dyeability of viscose fabric by modifying the surface with silk fibroin is considered in the scientific paper [12].

Therefore, various aspects of the study of the properties of textile fabrics for the interior design of civil buildings and structures are considered in the works of many authors, however, the internal environment of the modern interior has its specifics of their use and requires additional research. This concerns the use of chenille cotton fabrics, and their properties for choosing the area of their application as curtains, pillowcases, tablecloths, upholstered furniture, etc. In fact, it is not possible to cover the work of all the studies that were conducted, there were a lot of them, however, after analysing this issue, we found that there are currently no studies related to the use of chenille cotton fabrics in modern interiors. These fabrics won the favour of the consumer, thanks to their attractive appearance and pleasant tactile sensations. It is the chenille thread that gives the fabric additional velvetiness, uniqueness, and special softness. Chenille cotton fabric with the content of natural components - cotton - is especially popular among consumers. As a rule, it has in its composition, in addition to natural cotton fibres, synthetic components: acrylic, polyester, polyester, viscose, etc. The combination of natural and synthetic fibres in the fabric provides, in turn, high characteristics of environmental friendliness, wear resistance, and practicality.

There are known studies that show that chenille fabric is most often used for upholstering upholstered furniture. As a rule, for the upholstery of seating furniture made in a classic style, in particular, this applies to chairs and armchairs, chenille cotton fabric in a stripe or with a small pattern is chosen. Furniture made in the Art Nouveau style prefers monophonic chenille cotton fabrics for upholstery. A type of chenille cotton fabric is jacquard chenille, which is a type of jacquard fabric with a complex weaving pattern and an exquisite appearance. Chenille, which belongs to the group of jacquard fabrics, has several chenille threads in its structure. The fluffiness of the chenille thread gives the fabric additional volume, unique texture, and special softness. In terms of environmental characteristics, such chenille is close to tapestry, as it contains natural components; however, such chenille is cheaper in price than tapestry, as it uses a smaller range of threads [13].

Manufacturers of chenille cotton fabrics began to impregnate them with various chemical means in order to extend the term of their use and increase strength, wear resistance, and practicality; such additional interventions in the fabric base make fabrics more resistant to scratches, moisture absorption, abrasion, peeling, high-temperature effects, etc.

In turn, expanding the range of chenille cotton fabrics requires research into their quality characteristics. The need for different production methods, hygienic, aesthetic, practical chenille cotton fabrics, significant expansion and optimization of the assortment, poses the task of providing consumers with information. In particular, it is necessary to investigate the consumer characteristics of chenille cotton fabrics for the further process of developing a system technology for their design. This, first of all, concerns light resistance - one of the main factors of their wear and deterioration of the aesthetic appearance. At the same time, in our opinion, insufficient attention is paid to the issue of evaluating the light fastness of chenille cotton fabrics in domestic periodicals and monographic publications. Therefore, evaluating the light fastness of the colours of chenille cotton fabrics, in the wear of which sunlight and artificial light play a major role, is an actual scientific task.

The purpose of the work is to study the light fastness of chenille cotton fabrics for interior use depending on the duration of artificial lighting with the aim of developing recommendations for the scope of their application.

MATERIALS AND METHODS

The study of the light resistance of chenille cotton fabrics depending on the duration of artificial lighting was carried out visually and instrumentally.

The object of research in this work was chenille cotton fabric of Turkish production Divotex, the characteristics of which are given in Table 1.

Laboratory studies were conducted in accordance with the methodology of the international standard EN 20105 – B02:1996 [16]. An air-cooled laboratory unit was used. Six samples of chenille cotton fabric were prepared for the study, the size of the samples was 100*70 mm. Fabric samples had the same raw material composition and physical and mechanical properties (Table 1) but were decorated in different shades of the same color scheme (from light to dark).

Table 1. Characteristics of the investigated fabric.

Fabric	Fibre composition	Fabric dye	Thickness, [mm]	Weigh (GSM), [g/m^2]	Density [threads/cm]	Type of decoration	Weave
Chenille decor volvo duz	acrylic 46%, polyester 34%, cotton 20%	Reactive Red H8B	0.92	260	warp: 33 weft: 25	dyed in one color	plain

The tissue samples prepared by us, together with the reference samples, were placed in a laboratory installation, which contained:

1) Light source – xenon arc lamp with a corresponding color temperature from 5500 to 6500 K;

2) A light filter was placed between the light source, samples, and standards in such a way that the ultraviolet spectrum was constantly reduced. According to the methodology [16], the transmittance of the glass used should be 90% between 380 and 750nm, decreasing to 0% between 310 and 320nm;

3) Thermal filter, the spectrum of the xenon arc contains a significant amount of infrared radiation, which must be minimised by thermal filters. At the same time, the light source is in a well-ventilated exposure chamber.

In the laboratory setup, indicators of lighting, temperature, and humidity were maintained according to the methodology. According to the method, a special opaque cover was placed on one-third of the fabric sample and reference samples. The fabric sample, together with the standards, was secured with sample holders on the sample rack of the laboratory setup so that the holders were supported both above and below and in the proper vertical center. All remaining spaces in the sample rack were completely filled with white cardboard holders. In the laboratory setup, all six tissue samples were located at the same distance from the light source – a xenon arc lamp. Six fabric samples and six reference samples were simultaneously exposed. After every 24 hours of insolation, 6 samples of chenille cotton fabric were removed to evaluate the light fastness of the color. The total duration of exposure was 288 hours. At the same time, changes in the light fastness of dyed samples of chenille cotton fabrics were assessed visually and instrumentally.

Visual studies of tissue samples were performed according to the scale of blue standards.

Light fastness was evaluated by indicators of the color difference *ΔE* between dyed tissue samples after 24 and 288 hours of irradiation, respectively. In turn, the color difference *ΔE* was determined using the spectrophotometer "Datacolor-9600" according to the calculation formulas of the system CIELAB MKO [4,14].

This system also determined the purity of shade *L*, color saturation *S*, and color tone *T*. The determined color characteristics calculated in the CIELAB MKO system are presented in Table 2. The results of the studies, which were obtained when compared with known methods, are presented in Table 3. About the change the lightfastness of the color of the studied samples of chenille cotton fabrics after the corresponding periods of their insolation was judged by the indicators of color difference *ΔE*, the results of the studies are presented in Table 4 and Figure 1.

RESULTS AND THEIR DISCUSSION

The main characteristics of colour fastness are purity of shade *L* (lightness), colour saturation S, colour tone *T*, and indicators of general color difference ΔE [4,14]. The purity of the shade *L* % is a value that characterizes the brightness of the light stream reflected or transmitted by the colour body in relation to the incident light stream:

$$L = \frac{\int_{380}^{780} \phi(\lambda)\rho(\lambda)d(\lambda)}{\int_{380}^{780} \phi(\lambda)\varphi(\lambda)d(\lambda)}, \qquad (1)$$

where: (λ) - the intensity of monochromatic radiation of the incident light stream; $\rho(\lambda)$ - reflection coefficient of monochromatic rays; $\phi(\lambda)$ - function of the spectral sensitivity of the eye.

Colour saturation *S* - determines the degree of manifestation of the colour tone. Colour saturation is defined as the ratio of the brightness of monochromatic radiation to the total brightness of the colour:

$$C = \frac{B_\lambda}{B_\lambda + B_\varpi} 100 \qquad (2)$$

where: B_λ - brightness of monochromatic radiation; B_ϖ - the brightness of white colour.

The colour tone *T* of a chromatic colour is the wavelength of such a monochromatic colour, the mixing of which in a certain proportion with white when projecting on an achromatic screen ensures that a given chromatic colour is obtained.

The Δ*E* value characterizes the color difference (both in terms of chrominance and lightness) of two compared samples and is proportional to the visually reproduced color difference for these samples. The International Organization for Standardization, responsible for measuring colour in the textile industry, recommends the following formula for calculating color difference in the CIELAB MKO system:

Table 2. Colorimetric characteristics of researched chenille cotton fabrics

Fabric samples that have been investigated	PANTONE Color system (American system)	The visual appearance of fabrics that were investigated	Colour differences in the CIELAB MKO system		
			Colour tone *T*	Colour saturation *S*	Purity of shade *L*
Fabric 1	15 -5217	The darkest (saturated) color	86.4	26.6	43.2
Fabric 2	15 - 5219	The brightest (juiciest) color	84.4	25.2	43.3
Fabric 3	15 - 5220	Bright color	83.8	24.7	43.8
Fabric 4	15 - 5223	Muted colour	82.6	23.7	45.4
Fabric 5	15 - 5225	The most muted	81.5	22.7	47.8
Fabric 6	15 - 5227	The lightest colour	81.32	15.2	51.53

$$\Delta E = [(\Delta a)^2 + (\Delta B)^2 + (\Delta L)^2]^{1/2}, \quad (3)$$

where: ΔE – colour difference the two test samples;

L – purity of shade;

a,B – colour coefficients.

The color characteristics of the samples were evaluated according to the PANTONE Colour system [4], the SIELAB system of the MKO, and the scale of blue standards [4, 14] are presented in Table 2. The main characteristics of light resistance were defined and presented in Table 2.

It can be seen from Table 2 that the greatest saturation of color *S* and colour tone *T* is observed in the darkest and brightest fabric samples, and the purity indicators of shade L in these samples are the lowest. As a result of research, it was found that artificial lighting has the greatest effect on the purity of the shade, at the same time, it was found that with the maximum decrease in color saturation, the color tone decreases.

The overall color difference ΔE was determined according to the method, it is the most important indicator of the light fastness of the colour.

The next stage of the study was a comparison of the results of the overall color difference ΔE of the tissue samples, which were determined by the instrumental method using the spectrophotometer «Datacolor-9600» with the results of the study, which were determined by the visual method according to the methods of ISO 105 BO1: 2014 [4,14] and AATCC 16.3 [15]. The results of the study are presented in Table 3.

Table 3 presents indicators of the total color difference ΔE of the studied samples of chenille cotton fabrics for the entire period of their insolation. The results show that the highest indicator is observed in fabric samples that have the darkest and most striking colour. According to the international standard ISO 105- B02: 2014 (E) the smallest number of points is observed in fabric 6, which is the most striking. According to the methodology of the american standard AATCC 16.3 of fabric 2, according to the scale of blue standards, corresponds to the indicator L8, which is the highest.

According to the data in Table 3, it can be concluded that the results of the study of the resistance of the fabric to artificial light by the instrumental method do not differ significantly in comparison with the results of the study by visual methods, namely by the methodology of the international standard ISO 105-B02: 2014 (E) and the methodology of the American standard AA TCC 16.3.

The light fastness of the color of fabric samples was determined by the visual method according to standard EN 20105 – B02:1996 [16]. This standard is based on the assessment of the degree of change in the original color of the examined fabric sample, which is established visually by comparison with special standards. The scale of "blue standards" is used to determine the degree of change of the primary color of the fabric due to artificial light.

Table 3. The results of the study of the general color difference ΔE.

Fabric samples that have been investigated	Color difference in tissue samples, Δ*E* (instrumental method)		International standard ISO 105- B02: 2014 (E) (visual method)		American standard AA TCC 16.3 (visual method)
	In 24 hours	In 288 hours	According to the classification	By rating, in points	On a scale of blue standards, from L2 to L9
Fabric 1	8,2	12,0 (3.8)	High light fastness	8	L7
Fabric 2	7,2	11,8 (4.6)	The highest light fastness	8	L8
Fabric 3	6,4	10,1 (3.7)	High light fastness	7	L5
Fabric 4	6,2	9,8 (3,6)	Good light fastness	6	L4
Fabric 5	2,0	5,4 (3,4)	Good light fastness	5	L3
Fabric 6	3,8	5,7 (1,9)	Satisfactory light fastness	4	L2

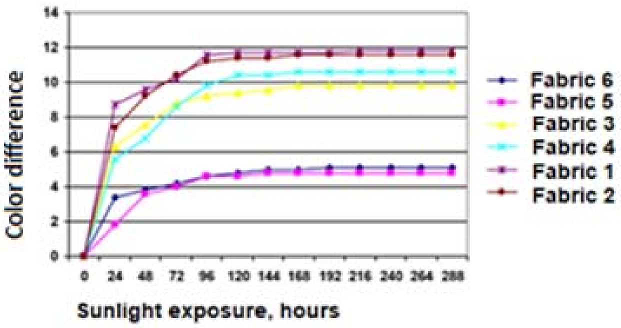


Figure 1. Influence of insulation on the light resistance of the chenille cotton fabrics' color.

The light fastness of the color of fabric samples is estimated from 2 to 9 points according to this scale. A score of 5 and above is considered high. Below 3 points are low-quality fabrics.

The results of the study of the change in the value of the total color difference Δ*E* of six investigated samples of chenille cotton fabrics depending on the duration of insolation, which according to the method was 288 hours, are illustrated in Fig. 1.

It can be seen from the graph that during the first 24 hours of the study, a sharp change in the color difference Δ*E* is observed in all six samples. During the next three days of the study, when the total duration of insolation was 96 hours, in samples 1, 2, 3 and 4, a sharp change in the color difference ΔE is observed, after which the stabilization of the change in Δ*E* occurs until the end of insolation. Fabric samples 5 and 6 undergo sharp changes in color difference only in the first 24 hours, and more gradual changes are observed during other periods of insolation.

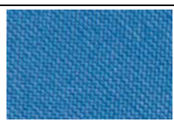
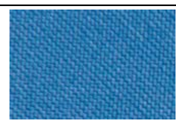
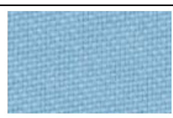
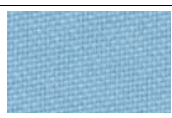
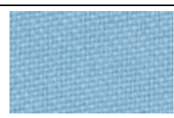
The visual method of research is best seen in the macro photos in Table 4. Throughout the research, macro photography of the samples was carried out. For macro shots, we chose sample 2 and sample 6. It is these samples that most convincingly demonstrate changes in the color difference (Table 3), starting from the highest light resistance to the lowest. The colour change (Table 4) is followed after 24, 96, 192, and 288 hours of insolation according to the conducted research.

Therefore, the lightfastness of the color of samples of cotton chenille fabrics depends not only on the structural characteristics of the fabric (Table 1), but also to a large extent on the saturation of color S, color tone *T*, purity of shade *L*, color difference Δ*E*, as well as on the duration of insolation. It was found that as a result of insolation of fabric samples, higher light fastness of colors is observed in samples of the darkest saturated and brightest colors. Studies have shown that the highest color difference Δ*E* is observed in sample 2. The color difference Δ*E* for fabric 1 and fabric 2, which have the darkest and brightest colors, are insignificant.

This indicates that such samples have good resistance to artificial light and do not lose their color under the influence of prolonged insolation. Therefore, you can sew curtains and curtains from such fabrics, they will keep their color for a long time and look good. This indicates that such samples have good resistance to artificial light and do not lose their color under the influence of prolonged insolation. Therefore, you can sew curtains and curtains from such fabrics, they will keep their color for a long time and look good.

At the same time, when comparing the data of the research results, it should be borne in mind that the color difference Δ*E* for fabric 1 and fabric 2, established by the spectrophotometric method, which occurs as a result of color fading under prolonged exposure to artificial light, corresponds to the contrast, which is evaluated by 8 points, according to the scale blue standards. This indicator is considered the limit of light aging of the color of samples of cotton fabrics and is widely used in the practice of materials science and commodity research as an objective criterion for evaluating the stability of the color of samples of cotton fabrics during their operation. Therefore, using this criterion to evaluate the change in light fastness of colour on the examined samples of chenille cotton fabrics, all six samples we took can be considered lightfast to artificial light. This makes it possible to recommend samples of chenille cotton fabrics of certain characteristics for use in textile design, and in furnishing a modern interior on the consumer market.

Table 4. The results of the study of image stability during insulation.

Fabric №	Reference images	Photographs of the sample after insulation			
		24 hours	96 hours	192 hours	288 hours
Fabric 1					
Fabric 6					

CONCLUSION

So, it was established that the color indicators of samples of chenille cotton fabrics of different shades of the same colour scheme, which are calculated in the CIELAB MKO system, which corresponds to the color codes according to the PANTONE Colors catalogue, have acceptable indicators for use.

The comparison of the methods for determining the light fastness of chenille cotton fabrics made it possible to verify the minor deviations in the results, which in turn indicates the feasibility of using these methods for research in practice.

The change in the overall color difference ΔE in tissue samples during 288 hours of insolation in laboratory conditions was studied. This opens up the further possibility of fabric design, in which by appropriate selection of color saturation S, color tone T, and purity of shade L, it will be possible to purposefully form the given light resistance of the color of chenille cotton fabrics, depending on the specific conditions of their use. The conducted research made it possible to make sure that such chenille cotton fabrics, which will have light and calm shades, will have the greatest use in the consumer market.

The conducted research is valuable, first of all, for a person who uses chenille cotton fabrics for furnishing a modern interior. Using the colour code from the PANTONE Colour, a person must understand which fabrics can be used for sewing curtains, and which for sewing pillows, tablecloths, furniture upholstery, etc. Research of this kind should bring practical benefit to a person, and bring them moral and aesthetic satisfaction from the use of such a fabric in the interior. Research of this kind should also be carried out for the further implementation of the process of developing a system technology for the design of new chenille cotton fabrics, taking into account the peculiarities of the raw material composition, the type of dye, the technologies of the final treatment of the fabric, etc.

The prospect for further research is the search for more perfect and ecologically safe ways of light stabilization of dyeing since the dominant factor in the wear of chenille cotton fabrics in operating conditions is the long-term effect of light weather on them.

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