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REPLACEMENT OF THE VISUAL METHOD FOR ASSESSING THE STABILITY OF THE COLORING OF FABRICS WITH THE INSTRUMENTAL

Abstract. The article considers the improvement of methods for testing the color fastness of textile materials with the replacement of the visual method with an objective colorimetric evaluation method. A new method for testing the color fastness of textile materials is proposed.The analysis of domestic and foreign standards that establish the calculation and establishment of color fastness standards for cotton fabrics and their comparison with the norms of international and domestic standards was carried out. It is shown that the development of methods for instrumental determination of color fastness to friction, which is an alternative to the method of visual assessment of the color fastness of any textile material on a gray scale, is currently an urgent and promising scientific and technical task.A new method for testing the color fastness of textile materials is proposed. The overall color difference (ΔE) between the test sample of the color fastness test material and the original sample was measured. For both samples, the overall color difference was determined in the CIEL*a*b* system, the values of which are converted into equivalent points on a gray scale. The score in terms of the value of ΔE was calculated on a computer using the Ecsel environment and displaying the calculation results on the display screen.
Keywords: standard, color, stability, friction, general color difference.

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Introduction. The analysis of domestic and foreign standards shows that they establish the calculation and normsof color fastness of cotton fabrics, their comparison with the norms of international and domestic standards. In the ECO-TEX 100 standard and in Russian standards, color fastness to water, sweat, friction is established. In domestic standards, the norms depend on the purpose of the textile material. Color fastness is evaluated after exposure to dry and wet friction in accordance with the test methods regulated by state standard 9733-83.

According to the existing method for determining the resistance of color to friction, the final result in points is evaluated visually on a scale of gray standards.

This may introduce into the final result of the assessment some errors related to the health and general emotional state of the observer. These shortcomings can be eliminated through the instrumental method of evaluating the final result. The development of a method for instrumental determination of the friction resistance of oraska makes it possible to replace the organoleptic evaluation of the color strength to mechanical stress during friction on a scale of gray standards, which is an urgent and promising scientific and technical task.

The purpose of the study is to develop an instrumental method for determining the color strength of a textile material to friction instead of a visual method on a scale of gray standards.

Research methods and conditions. Measurement of chromaticity coordinates of non-luminescent transparent and reflective samples in the XYZ system. It is established by the International Commission on Illumination (ICI) for a standard observer, with a light source with state standard 7721-76 in the spectral range of 380-720 nm with a number of spectral information sampling points of at least 24. The measurements were carried out using the «Spectroton» instrument. This instrument can also be used to measure spectral transmittances and spectral aperture reflectances. With its help, you can determine the coordinates of color and chromaticity with light sources A, C, D65 state standard 7721-76 in the XYZ system. In addition, it allows you to measure such color indicators as color difference, saturation, lightness, color tone. Color differences in lightness and tone can be additionally measured. In addition to color indicators, you can measure the metamerism index, the degree of whiteness of the sample in the CIEL*a*b* system.

Literature review. Evaluation of the quality of coloring of textile materials in terms of color fastness to washing, dry and wet friction is carried out in almost all works related to coloring and special types of finishes.

Much attention is paid to the coloristic quality of the printed pattern in terms of color and color fastness [1]. The paper describes the quality of eco-printing of silk fabrics with various natural dyes in terms of the aesthetics of the pattern, color, and resistance to washing and abrasion. Evaluation of color fastness on silk fabrics to washing with soap showed good results. Color fastness was 4 points in the "good" category. The value of resistance to wet friction on silk fabrics ecoprint as a whole gives a score of 4-5 points

The evaluation of the quality of the coloring and its influence on the physical and dimensional properties of the canvases is also carried out in the process of their production [2]. Among the physical properties, the color fastness to washing and friction was evaluated. Internationally approved ISO methods for washing fastness testing are used. Small differences were found in the color fastness to friction.

Evaluation of color fastness is also carried out in works aimed at reducing pollution caused by textile printing, solving the problems of using synthetic dyes, thickeners for environmental balance and human health [3]. When printing on natural fabrics with natural dyes, chitosan and chitosan nanoparticles were used. It has been established that fabrics treated with chitosan nanoparticles have high values of resistance to washing, sweat and friction.

Evaluation of color fastness to washing and wet friction makes it possible to compare the results of dyeing wool and woolen fabrics in magnetically treated and untreated water [4]. Tests of fabrics dyed in this way have shown that they have increased dye absorption and significantly improve wash and wet abrasion fastness.

The properties of color fastness of silk fabrics of silkworm and tussus in mixtures with cellulose fibers were compared [5]. In this study, the color fastness properties of wild tussah silk fibers were studied in comparison with mulberry silk fibers. Color fastness tests were carried out to evaluate the performance. The results show that both types of silk fibers are suitable for spinning and weaving processes, and the fastness results show that mulberry fibers have better color fastness properties compared to tussah silk fibers.

The paper [6] explores the use of reactive and acid dyes in the dyeing of polyester after chemical modification. Modification of the polymer at 130° C. for 60 minutes prior to dispersion dyeing provided greater color depth than conventional high temperature dispersion dyeing of polyester. The color fastness of modified and reactive dyed fabrics to washing and perspiration has reached a level of good to excellent (4/5).

The study [7] is devoted to the extraction of the dye from teak leaves and the dyeing of natural fabrics using various aqueous media. At the same time, the color and strength properties of the colored samples were assessed in terms of resistance to washing, friction, light and sweat. The extracted dye exhibited moderate to good fastness properties in terms of lightfastness, washability, abrasion and perspiration on wool and silk, and excellent properties on nylon. The use of color fastness evaluation methods allows teak leaf dyeing to be shown as a step towards sustainable development and efficient waste management with promising potential for application on natural and synthetic fabrics.

Determination of various tissue parameters is one of the important methods for assessing tissue quality [8]. Intelligent control is a popular development trend today. In recent years, computer control technology has been widely used in the field of fabric density measurement, color analysis and weave pattern recognition. The shortcomings of current research and possible directions of research in the future are analyzed. Computer control technology not only has an objective evaluation, but also has the advantages of accuracy and efficiency, and has good development prospects in the field of textiles.

The article [9] presents a comprehensive review of automatic recognition of tissue structural parameters in recent years. The structural parameters of the fabric mainly include the density of the fabric, weave pattern, color pattern, etc., which must be pre-set before production and carefully checked duringю. The analysis of these parameters is considered the most critical step in the textile industry. Commonly used manual operations based on human sight and experience require a lot of time and labor. Methods based on computer control or other automatic methods have the advantages of fast response, objective evaluation and high stability. The presented material can help researchers in understanding and using automated methods for recognition of structural parameters of fabric, provides some new ideas for other recognition tasks in the textile industry.

In [10], the color fastness and strength properties of fabrics dyed with extracted dyes were evaluated and compared using infrared Fourier spectroscopy.

In [11], a certain method for assessing color fastness is used. The evaluation of the quality of coloring was carried out according to the level of fixation of dyes in the work. To achieve almost 100% dye fixation, macromolecular cross-linking reactive dyes have been developed, and the mechanism of their staining and fixation has been discussed. The work also actively uses a certain method for assessing color fastness.

The authors of [12] showed that reactive dyes have good color fastness to washing and abrasion. The use of methods for evaluating color fastness showed that the application of a formaldehyde-free fixer to dyed products increased the color fastness to washing and abrasion, especially for blended yarns.

[13] presented a detailed description of the test apparatus with an overview of the lightfastness results and the resulting dataset when more than 100 synthetic dyes were tested for lightfastness. Comparisons are given with lightfastness data and ISO values available in the color index. The authors suggest that the data set will serve as a basis for expanding interest in additional materials and test methods.

The use of nutshell dyes [14] can provide a pure and stable source of dyes that can be used to replace synthetic counterparts. When using methods for assessing color fastness, it was shown that good resistance to washing (4-5), light (3-8) was achieved even without the use of mordant.

From the experience of the conducted studies, it can be seen that in the process of testing the color for friction strength, the initial color of the test sample changes. These changes can be assessed by changing the saturation of the color, its lightness and tone. These indicators after friction can change at the same time, but with different combinations. No matter how the nature of these changes changes, the difference in color of the original sample and the sample after friction that is visible to the eye is taken into account. This difference is compared with the gray scale data. In this regard, the development of a method for instrumental determination of color fastness to physical and chemical influences, which makes it possible to replace the method for assessing the color strength to friction on a scale of gray standards, is an urgent and promising scientific and technical task.

Research results and discussions. Some indicators of color strength in points and the conditions under which they are determined are presented in Table 1.

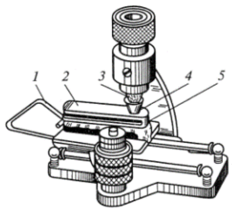
Table 1

Color strength to friction in points*

Color fastness indicators		Norm according to state standard 7779-75			Norm according to the ECO-TEX 100 standard
		OK	PK	OPK	
Friction	dry	3	3-4	3-4	4
	wet	-	-	-	2-3

**Note. OK – ordinary color fastness; PK – strong color fastness; OPK – extra strong*

According to the method of the ECO-TEX 200 standard, the color fastness of textile materials is assessed only by shading the white material. According to state standard 9733.0-83, color stability is also assessed by changing the color of the original sample using the PT-4 device (Fig.1)



1 - handle; 2 - table; 3 - rubber stopper; 4 - spring ring; 5 - ring

Figure 1. Device PT-4 for testing the color strength to mechanical stress

The color indicators of the coloring of the dyed and printed fabric were carried out on the «Spectroton» color measuring equipment. At the same time, color ΔE values were measured to compare the differences between the initial colored sample and the sample that passed the friction test. The general color difference characterizes the change in color indicators in terms of its lightness, saturation and color tone. For the original sample and the sample after friction, ΔE was measured in the CIEL*a*b* system.

Then, in order to show the final values of the color fastness in points corresponding to the scale of gray standards, the values of ΔE were recalculated.

The design of the device "Spectroton" provides:

1) the possibility of taking into account or excluding the specular component of the reflection;

2) measurement geometry of reflective samples (diffuse illumination, observation at an angle, etc.).

Two principles are used in the operation of the “Spectroton” color measuring device (Fig. 2). The first is the measurement of reflection coefficients. The second is the measurement of the transmittances of the sample. The measurements are based on 24 fixed wavelengths in the visible region of the spectrum. Moreover, these measurements are carried out at the moment of flashing the flash lamp. This is followed by mathematical processing of the measurement results. For this processing, an integrated programmable universal controller is used.

Figure 2. Colorimeter "Spectroton"

Test samples were prepared according to the following scheme. After testing the sample for friction, a part of a certain size was cut out of it. The dimensions of the cut out part are determined by the dimensions of that part of the “Spectroton” device where the sample is fixed to measure color differences. The test sample must be free from foreign defects. The sample is placed on a white substrate that is not transparent to light. Since ΔE is measured, the original sample before friction and the test sample after friction should be prepared for measurement in the same way. Thus, first measured color indicators on the original sample. Then the same parameters were measured on the sample after friction. By comparing them with each other, the device shows the value of ΔE, i.e. the difference between samples in lightness, saturation, and hue. After measuring ΔE in the CIEL*a*b* system, a recalculation was carried out according to formula (1) to convert the ΔE value into points displayed on the scale of gray standards.

$$\Delta E = 0{,}125\left(2\,\frac{n+1}{2} - 1\right) \qquad (1)$$

n = 10 - 2N.

where N is the value of color fastness to light in points.

The color fastness in points was expressed numerically with rounding up to 0.5 points.

$$N = 5{,}5 - \log(\Delta E + 1) / \log 2 \quad (2)$$

Table 2

Limits of change in the value of ΔE and gradation of color change in points

ΔE value	Equivalent gray scale color fastness score
Less than 0,40	5
$0{,}40 \leq \Delta E < 1{,}25$	4.5
$1{,}25 \leq \Delta E < 2{,}10$	4
$2{,}10 \leq \Delta E < 2{,}95$	3.5
$2{,}95 \leq \Delta E < 4{,}10$	3
$4{,}10 \leq \Delta E < 5{,}80$	2.5
$5{,}80 \leq \Delta E < 8{,}20$	2
$8{,}20 \leq \Delta E < 11{,}60$	1.5
Over 11.60	1

The ΔE score was calculated on a computer using the Excel environment. After entering the ΔE value, the color fastness score is displayed on the computer display screen. Figure 1 on the left shows a picture of entering the value of ΔE, i.e. the computer asks for the value of ΔE, which must be entered in the upper field. Then the "calculate" key is pressed and the result of the calculation appears. For example, after entering the value ΔE=15, the color fastness in points is equal to 1 (Fig. 3, the right one).

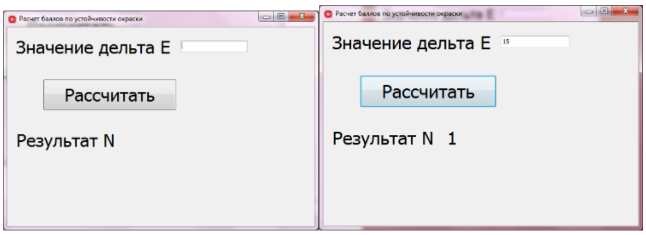


Figure 3. Displaying on the computer screen the result of stability in points by the value of ΔE

Conclusion. A new method is proposed for determining the strength of the color fastness of textile materials to friction and compliance with the requirements of the standards is confirmed. Improving the methods for assessing the friction strength of textile materials for dyeing allows not only to effectively and in the shortest possible time to identify the quality of the textile material, but also to simplify the testing procedure itself and at the same time reduce the time and overall costs of testing.

References

1. Wahyuningsih S.E., Kusumastuti A., Krisnawati M., Yuniar M., Furi M.R. Quality of motif, colors and fastness of Sekar Ayu ecoprint products in terms of mordant type, natural dyes, and types of leaves on silk fabrics // IOP Conference Series: Earth and Environmental Science, 2022. Vol. 969, No.1. 012043.

2. Rahman M.M., Sultana J., Hossain M.S., Adeel M. Effect of Manufacturing Parameters on the Physical and Dimensional Properties of Single Jersey and Lycra Single Jersey Fabric // Materials Science Forum, 2022. MSF 1054. P. 135-142
3. Abdelslam S.H., Mashaly H.M., Abd El-Thalouth J.I., Saad M.O., Abdel-Aziz M.S. An environmental friendly approach in printing of natural fabrics on using chitosan and chitosan nanoparticles // Egyptian Journal of Chemistry, 2021. Vol. 64, No.8. P. 4283-4299
4. Czaplicki Z., Matyjas-Zgondek E., Strzelecki S. Dyeing of Wool and Woolen Fabrics in Magnetically Treated Water // Journal of Natural Fibers, 2021. Vol.18, No.12. P. 2055-2062
5. Uzumcu M.B., Celik P., Gulumser T., Kadoglu H. A Comparison of Color Fastness Properties of Mulberry Silk and Tussah Silk Fabrics in Blends with Cellulosic Fibers // Journal of Natural Fibers, 2021. Vol.18, No.11. P. 1834-1843
6. Toprak T., Anis P. Dyeing properties of orgonobase-induced poly(ethylene terephthalate) fabric // Textile Research Journal, 2020. Vol.90, No.23-24. P. 2658-2673
7. Agrawal A., Chopra S. Sustainable dyeing of selected natural and synthetic fabrics using waste teak leaves (Tectona Grandis L.) // Research Journal of Textile and Apparel, 2020. Vol.24, No.4. P. 357-374
8. Fan M., Xin B., Zhu R., Deng N. Review of Computer Vision Applications in Fabric Recognition and Color Analysis // Journal of Donghua University (English Edition), 2022. Vol.39, No.6.P p. 581-589
9. Meng S., Pan R., Gao W., Yan B., Peng Y. Automatic recognition of woven fabric structural parameters: a review // Artificial Intelligence Review, 2022. Vol. 55, No.8. P. 6345-6387
10. Sultana S., Akter K., Sarker M.K.U., Haque M.M., Islam M.R. Color Fastness and Tensile Properties of Cotton Fabric Dyed with Extract from Albizia Procera Sawdust // Fibers and Polymers, 2022. Vol.23, No.10.P. 2820-2827
11. Zhang S., Ma W., Tang B., Shan B. Innovation and application of dyes with high fixation // Chinese Journal of Chemical Engineering, 2022. Vol.51. P. 146-152
12. Liu J., Jiang W., Lv C. Dyeing of soybean protein/flax blended yarns with reactive dyes and subsequent dye-fixation // Scientific Reports, 2022. Vol. 12, No.1. P.1506
13. Hagan E., Castro-Soto I., Breault M., Poulin J. The lightfastness of early synthetic organic dyes // Heritage Science, 2022. Vol.10, No.1. P.50
14. Dulo B., De Somer T., Phan K., Raes K., De Meester S. Evaluating the potential of natural dyes from nutshell wastes: Sustainable colouration and functional finishing of wool fabric // Sustainable Materials and Technologies, 2022.Vol. 34, e00518.

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МАТАЛАРДЫ БОЯУ ТҮСІНІҢ ТҰРАҚТЫЛЫҒЫН БАҒАЛАУДЫҢ КӨРНЕКІ ӘДІСІН ҚҰРАЛДЫҚ БАҒАЛАУҒА АУЫСТЫРУ

Аңдатпа. Мақалада визуалды әдісті объективті колориметриялық бағалау әдісімен ауыстыру арқылы текстиль материалдарының түс беріктігін тексеру әдістерін жетілдіру қарастырылады. Текстиль материалдарының түс тұрақтылығын тексерудің жаңа әдісі ұсынылды. Мақта маталарының түс тұрақтылығы нормаларын есептеу мен белгілеуді белгілейтін отандық және шетелдік стандарттарға талдау және оларды халықаралық және отандық стандарттардың нормаларымен салыстыру жүргізілді. Кез келген текстиль материалының түс тұрақтылығын сұр шкала бойынша визуалды бағалау әдісіне балама болып табылатын үйкеліске түс тұрақтылығын аспаптық анықтау әдістерін әзірлеу қазіргі уақытта өзекті және перспективалы ғылыми-техникалық міндет болып табылатыны көрсетілген. Текстиль материалдарының түс тұрақтылығын тексерудің жаңа әдісі ұсынылды. Түс тұрақтылығы сынақ материалының сынақ үлгісі мен бастапқы үлгі арасындағы жалпы түс айырмашылығы (ΔE) өлшенді. Екі үлгі үшін де жалпы түс айырмашылығы CIEL*a*b* жүйесінде анықталды, оның мәндері сұр шкаладағы баламалы нүктелерге түрленеді. ΔE мәні бойынша балл компьютерде Excel ортасын пайдаланып және дисплей экранында есептеу нәтижелерін көрсету арқылы есептелді.

Тірек сөздер: стандарт, түс, тұрақтылық, үйкеліс, жалпы түс айырмашылығы.

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ЗАМЕНА ВИЗУАЛЬНОГО МЕТОДА ОЦЕНКИ УСТОЙЧИВОСТИ ОКРАСКИ ТКАНЕЙ НА ИНСТРУМЕНТАЛЬНЫЙ

Аннотация. В статье рассмотрено совершенствование методов испытания устойчивости окрасок текстильных материалов с заменой визуального метода на объективный колориметрический метод оценки. Предложен новый метод испытания устойчивости окраски текстильных материалов.Проведен анализ отечественных и зарубежных стандартов, устанавливающих расчет и установление норм устойчивости окраски х/б тканей и сравнение их с нормами международных и отечественных стандартов. Показано, что разработка методов инструментального определения устойчивости окраски к трению и являющийся альтернативным по отношению к методу визуальной оценки устойчивости окраски любого текстильного материала по серой шкале, является в настоящее время актуальной и перспективной научно-технической задачей. Предложен новый способ оценки прочности окраски материалов текстильных. После проведения механических воздействий на испытуемую окраску проводили оценивание колористических показателей окраски по общему цветовому различию (ΔE), которое измеряли на испытуемой пробе и пробе после механических воздействий. Для обеих проб определяли общее цветовое различие в системе CIEL*a*b*, значения которых пересчитывают в эквивалентные баллы по серой шкале. Оценку в баллах по значению ΔE рассчитывали на компьютере с использованием среды Excel и выводом результатов расчетов на экран дисплея.

Ключевые слова: стандарт, окраска, устойчивость, трение, общее цветовое различие.