

Текстильні вироби є невід'ємною частиною щоденного життя людей. В процесі експлуатації текстильних виробів організм людини має безпосередній контакт з текстильними матеріалами протягом всього життя, тому питання їх безпечності на сьогодні є особливо важливим у виробництві текстильних матеріалів і одягу.

Створення інноваційних формул мийних композицій дозволяє поєднати високу ефективність мийного процесу з наданням текстильним матеріалам спеціальних видів опорядження. Дослідження, спрямовані на розробку ефективних композицій з поліфункціональною дією на основі біоПАР (поверхнево-активних речовин, які піддаються біодеградації) із застосуванням протимікробних препаратів, є актуальними і перспективними. Вони також сприяють розвитку ринку хімічної продукції, зниженню матеріалоемності технології і собівартості послуги, підвищують екологічну безпеку процесу.

Проведено комплексну оцінку змін експлуатаційних властивостей текстильних матеріалів після обробки композиціями екологічно-безпечних речовин. Результати дослідження сприятимуть зменшенню екологічного навантаження на навколишнє середовище, здоров'я людей. Крім того, забезпечується збереження споживчих властивостей текстильних виробів в процесі експлуатації.

Представлено комплексне дослідження впливу композицій екологічно-безпечних речовин на гігієнічні властивості текстильних виробів. Проведено аналіз ефективності дії композицій на технологічні параметри (мийна здатність, антіресорбційна здатність, концентрація композиції, тривалість обробки) процесу видалення забруднень з текстильних виробів з бавовни, полієфіру та їх сумішей. Визначено кількісні показники капілярності тканин, а саме висоту підняття розчину композиції (h , мм), яка характеризує якість очищення пор текстильних матеріалів. Експериментальні дані свідчать про те, що обробка тканин з бавовни і полієфіру та їх сумішей композиціями сприяє підвищенню їх гідрофільності, що виражається у покращенні їх змочувальності водними розчинами і збільшенню капілярності від 131 мм до 152 мм за рахунок присутності на матеріалах адсорбованих біоПАР.

Досліджено вплив композицій екологічно-безпечних речовин на представника нормальної мікрофлори тіла людини *P. freudenreichii*. Виявлено, відновлення культури до 104–105 клітин/мл через 48 год експозиції зразка тканини та в середовищі контролю стерильності *P. freudenreichii*.

Встановлено, що обробка текстильних виробів при концентрації композицій екологічно-безпечних речовин 2,5 г/л є технологічно та екологічно доцільною. Оскільки досягається висока якість очищення виробів (від 80 % до 88 %), підвищується капілярність текстильних матеріалів, зберігається здорова мікрофлора шкіри людини. Одержані дані дослідження дозволяють рекомендувати застосування композицій екологічно-безпечних речовин, як для обробки текстильних виробів спеціального призначення (для військових, спортсменів і т. д.), так і для домашнього текстилю.

Ключові слова: екологічно-безпечні речовини, бінарні композиції, текстильні вироби, гігієнічні властивості, аквачищення, протимікробна обробка

RESEARCH ON THE EFFECT OF COMPOSITIONS OF ECOLOGICALLY SAFE SUBSTANCES ON THE HYGIENIC PROPERTIES OF TEXTILE PRODUCTS

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1. Introduction

The textile and light industry market is dynamic and constantly expanding due to the replenishment of the range of new textile materials based on a combination of natural, artificial and synthetic fibers using textile effects and special types of finishing. Modern textile materials and products in terms of their impact on human health are a source of potential effects of a complex of factors: the nature of materials, the peculiarities of technological processes of their production, and finishing preparations. Technological processes of treatment of raw materials, production of fabrics provides for

the use of apprêt, textile auxiliary substances (auxiliaries), which allow the increase in the efficiency of production, improve the appearance of materials and provide special coating properties for the products.

To ensure the profitability of textile products and their range, today ecologically safe technologies are characterized by [1, 2]: a combination of technological operations and processes; reduced time of manufacturing; reduction of water and chemical reagents consumption due to spraying of solutions and application of foam compositions; water reusing; using safe surface-active substances (surfactants) and auxiliaries. Washing, wet cleaning and finishing means should

meet the following hygienic requirements: they should not cause irritating and allergenic reactions to the human body while respecting the mode of their use; they should not have teratogenic, carcinogenic, embryotoxic, mutagenic and other negative effects on the human body; the formulation of the equipment for finishing should include ingredients manufactured according to the normative documentation agreed with the respective controlling bodies of Ukraine; they should not contain chemicals of I and II classes of hazard; the aggregate states of the compositions should prevent the passage into the respiratory tract, the digestive tract, and the mucous membranes of a human when used; synthetic compositions should not change the physical and chemical properties of the treated materials and worsen their hygienic properties; when developing new formulas of compositions it is necessary to use high-biodegradation surfactants (bio-surfactants).

Bio-surfactants, unlike synthetic ones, are biodegradable and ecologically safe. Specific properties of biogenic surfactants determine the prospects for their use to create new and modify existing means [3]. The practical application of bio-surfactants is subject to their ability to significantly reduce the surface and interphase tension of aqueous solutions, emulsify hydrophobic substances, regulate the wetting of surfaces and the rheology of solutions. Bio-surfactants have high efficiency and increase the activity of enzymes. In this regard, bioparticles are promising as independent reagents, as well as for the preparation of complex solutions.

In the process of exploiting of textile products, the human body has direct contact with textile materials throughout life, so the issue of their safety today is especially important in the production of textile materials and clothing. During the use of clothing, textile products are contaminated in contact with human skin due to metabolic processes and a favorable environment for the development of bacteria is created. Manifestations of their excessive growth in textile products are diverse and highly undesirable: along with the appearance of smell, formation of moldy spots and a change in color, they can lead to the loss of functional properties of the material. Parasitic bacteria in the human body provoke the development of various diseases.

It is possible to obtain textile materials with special properties using polyelectrolytes, dispersions of polymers, minerals, nanoparticles, active additives and synergistic compositions based on them. After treatment with auxiliaries of complex action, textile materials are provided with anti-adhesive, water-repellent, capillary, antistatic, hygienic, antimicrobial properties depending on their particular purpose and application.

Creation of innovative formulae of washing compositions, intensifiers, activators of wet cleaning and washing will allow the combination of high efficiency in the washing process with the provision of special types of finishing for textile materials. The use of surfactants in the treatment of textile materials will reduce the ecological burden on the environment and human health and ensure the protection of textile products during their use.

2. Literature review and problem statement

In recent years, there has been a tendency towards the production of textile materials with additional properties [2]. Characteristics such as “Bio” or “100 % natural” in most

cases are considered as the main arguments in favor of the purchase of textile products with additional properties.

The work [4] states the main directions of increase in ecological safety in textile finishing technologies. It shows that due to the combination of technological operations in the process, it is possible to achieve high quality of product processing, however, recommendations for the specific application of compositions and treatment parameters are not given.

Technologies for providing products with antimicrobial properties are investigated in the work [5]. However, the authors do not give a study of the effects of the applied preparations on the human microflora, and the proposed technologies cannot be used in living conditions and services. This, in its turn, limits the effectiveness of the use of antimicrobial preparations for household products. The process of exploitation of fabrics and products from them is accompanied with complicated processes of dirt deposition on a fiber, penetration of pollutants deep into the fiber and fixing them on the material.

The work [6] gives the results of the contamination of products: decrease in brightness and purity of color, decrease of strength, deterioration of hygienic properties, appearance of bad smell, creation of environment for the development of pathogens. That is, there is a deterioration in the consumer properties of textile products. The proposed methods do not allow a comprehensive evaluation of the changes in the properties of contaminated materials, which worsens the quality of product cleaning. To solve this problem, the authors [7] developed an algorithm for studying the contamination of textile materials. The method allows determining quickly and qualitatively the degree of contamination of products and choosing the appropriate parameters for cleaning materials.

The study [8] has shown; that human skin is constantly in direct contact with the external environment, including exogenous microflora. It is a powerful physical and environmental barrier which prevents the penetration of toxic substances and infectious agents into the body's internal environment. However, the skin is abundantly inhabited by microorganisms.

The research [9] suggests that representatives of the skin microflora are often various types of genera *Corynebacterium*, *Staphylococcus*, *Micrococcus* and *Propionibacterium*. All representatives of normal human microflora perform one of the most important functions in nonspecific immune protection. They colonize the biotope and protect this area from being inhabited by pathogenic microorganisms. Although sometimes representatives of normal microflora can also be dangerous for an immunosuppressive organism or against quantitative and qualitative disorders in microbiocenosis, becoming pathogens. Therefore, the representative of human normal flora *Propionibacterium* (*P. freudenreichii*) can have a pathogenicity with excessive colonization against the background of microbial skin disorders. Therefore, it is necessary to use safe compositions for the treatment of textile products that do not have an allergic effect on the human body and protect the healthy microflora of the skin [10].

According to the European Biocidal Products Directive 98/8/EC, antimicrobial, antifungal, repellent solutions are biocidal agents and therefore subject to ecological, toxicological control and normalization [11]. The means used in the textile industry are of type 9: “Biocides for fibrous materials, leather, rubber and polymer materials”. The Annex to this

Directive contains a list of all active substances authorized for use in the EU countries. All the products of leading companies, such as Sanitized AG®, are strictly in accordance with this list.

Based on the literature review, it was shown that the open areas of the human skin have a non-permanent microflora, and the closed ones are dependent on the textiles and the conditions of their use. The issue of the safe influence of modern compositions on the consumer properties of products and human health remains urgent.

In order to solve the existing problems with the care of textile products, the authors recommend using compositions that will remove dirt from material and protect the body from harmful effects of microorganisms.

The authors' use of the systematic approach to the analysis of chemical and technological processes of treatment of materials, the study of the indicators of the efficiency of the washing ability of the compositions for the processes of washing and aqueous cleaning allow expanding the possibilities of their use in the treatment of products from the standpoint of functionality and finishing effect.

Thus, it can be stated that a comprehensive study of the effects of compositions of ecologically safe substances on the hygienic properties of textile products is appropriate and represents scientific and practical interest.

3. The aim and objectives of the study

The aim of the study is to research the effects of compositions of ecologically safe substances on the hygienic properties of textile products based on a comprehensive definition of their physico-chemical and technological characteristics. This will solve the actual problem of increasing the ecological safety of product treatment processes with the use of surfactants, reducing the cost of compositions, combining technological operations, improving the hygienic properties of products.

With the view to achieving this aim, the following was offered:

- to study the influence of compositions of ecologically safe substances on qualitative indicators of product cleaning: washing and anti-resorption capacity and capillarity;

- to analyze the antimicrobial properties of compositions of ecologically safe substances at different microbial loading taking into account the restoration of the *P. freudenreichii* culture;

- to substantiate the effectiveness of the use of compositions of ecologically safe substances in specific technological processes of product treatment (washing, wet cleaning, finishing).

4. Technological parameters of treatment and characteristics of methods of the study of the influence of compositions of ecologically safe substances on the hygienic and antimicrobial properties of textile products

The study of the influence of compositions of ecologically safe substances on the hygienic properties of textile products was carried out on samples of cotton, polyester fabrics and their mixtures that were presented on Ukrainian market in accordance with ISO 105 standards. ISO 5077 EN 340: 2004 PN-P-84525, ISO 14184-1. Characteristics of the fabrics are given in Table 1.

Table 1

Characteristics of the investigated fabrics

Name of fabric	Width, cm	Binding	Surface density, g/m ²
Fabric made of cotton	150	linen	180
Fabric containing 80 % cotton and 20 % polyester	150	linen	220
Fabric containing 65 % cotton and 35 % polyester	150	linen	220
Fabric made of polyester	150	linen	220

The fabrics used in the studies were in the prepared form – boiled and bleached.

To assess the hygienic properties of the studied samples of textile materials, the degree of removal of contaminants, anti-resorption capacity, capillarity and antimicrobial characteristics were determined.

For the preparation of contaminated samples of textile materials, fabric samples were treated with a complex contaminant containing soot and fatty substances. The period of treatment of samples was 10 minutes with stirring. Subsequently, the treated samples were pressed between layers of filter paper, dried at room temperature, and then placed in a drying cabinet for 1 hour at a temperature of 60 °C. Contaminated samples were used to determine the degree of contamination for textile materials.

Washing and finishing of the samples were carried out in aqueous solutions of a composition of ecologically safe substances (at a concentration of 2.5 g/l, 5 g/l) containing: Cocamide DEA and N,N'-bis(4-chlorophenyl)-3,12-diimino-2,4,11,13-tetraazatetradecanediimidamide [12, 13].

The composition is prepared by mechanical mixing of the estimated amount of the initial components. The characteristics of wet cleaning for each type of textile sample are given in Table 2.

After treatment, the samples were dried at room temperature, then kept in a drying cabinet at 50 °C for 30 min.

Table 2

Parameters of treatment of cotton, polyester and mixed fabrics with solutions of the composition

Operation name	Temperature, °C	Movement/pause, s	Speed of rotation, r/min	Treatment time, min
First cleaning	30 °C	10/10	30	5
Second cleaning	40 °C	8/4	30	5
First rinsing	–	13/4	40	4
Second rinsing	–	13/4	40	4

Determination of the washing ability of the composition was carried out by an optical method based on measuring the reflection coefficients from the source, contaminated and treated fabric samples. For measurements of reflection coefficients, the FOU-42 (Belarus) device was used. By the Kubelka-Munch equation, the washing ability (WA, %) of the composition was determined [10, 14].

The anti-resorption ability (AR, %) – the ability of detergents to prevent the precipitation of contaminations on

the fabric after washing. It was determined by measuring the intensity of the reflected light from pure fabric and from the sample of the fabric after washing in the composition [10].

The hygienic properties of the products, after treatment with the compositions, were determined by the hygroscopicity of the textile materials, in accordance with the requirements of DSTU GOST 3816:2009 (ISO 811-81). For the research, samples of cotton, polyester and their mixtures of 5×30 cm were cut out and subjected to treatment in aqueous solutions of the composition. After that, the height (h, mm) of the solution ascend on the fabric was measured at certain intervals of time (t, min) for an hour (Fig. 3).

Investigation of the antimicrobial properties of the composition of ecologically safe substances characterized the effect on the representative of the normal microflora of the human body *P. freudenreichii*. The study is divided into two stages: the first one is aimed at determining the effect of the composition on the number and activity of *P. freudenreichii*, the second – on determining the ability of the *P. freudenreichii* culture to recover after changing the nutrient medium. *P. freudenreichii* reference strain of the microorganism is a representative of the family of propionic acid bacteria. SCE was used for its cultivation (sterile control environment – thioglycolic).

At first, the 24-hour culture of *P. freudenreichii* was prepared, then, based on the McFarland standard [12], a working suspension of bacteria was prepared in two microbial loads (10^7 CFU/ml and 10^8 CFU/ml). Then, the sample of fabric treated with a solution of the composition was placed in a test tube with the *P. freudenreichii* culture and cultured for 24 hours at a temperature of 37 °C. The influence of the composition of ecologically safe substances on the number and activity of *P. freudenreichii* was carried out based on the determination of optical density, proportional to the concentration of the culture relative to the McFarland's standard.

To determine the ability of the *P. freudenreichii* culture to recover after changing the nutrient medium, the fabric sample was placed in the second SCE to provide optimum nutrition of the reference strain. Cultivations were carried out for 48 hours at a temperature of 37 °C. The ability of *P. freudenreichii* for restoration was established by the results of determining the optical density, proportionally calculating the concentration of the culture relative to the McFarland standard.

5. Determination of qualitative and quantitative indicators of hygienic properties of textile products after treatment with compositions of ecologically safe substances

To assess the effect of the compositions of environmentally safe substances on the quality of removal of contaminations from textile products, washing (WA, %) and anti-resorption ability (AR, %) were determined by the photometric method for whiteness of fabrics. The results of the study are presented in Table 3.

Experimental studies have shown that for textile materials, the highest rates of washing capacity are achieved at a concentration of composition of 2.5 g/l and make up 83.62 % for cotton fabrics; 81.59 % for fabric containing 80 % cotton and 20 % polyester; 80.10 % for fabric containing 65 % cotton and 35 % polyester; 77.79 % for polyester fabric. This ensures the prevention of re-precipitation of dirt on textile

fibers during processing, which corresponds to the following indicators of anti-resorption capacity: 13.27 % for cotton fabric; 15.53 % for fabric containing 80 % cotton and 20 % polyester; 14.21 % for fabric containing 65 % cotton and 35 % polyester; 17.66 % for polyester fabric.

Table 3

Influence of the composition of ecologically safe substances on the quality of removal of contaminants

Composition	Cotton Fabric		Fabric Containing 80 % Cotton, 20 % Polyester		Fabric Containing 65 % Cotton, 35 % Polyester		Polyester Fabric	
	WA, %	AR, %	WA, %	AR, %	WA, %	AR, %	WA, %	AR, %
Composition, C=2.5 g/l	83.62	13.27	81.59	15.53	80.10	14.21	77.79	17.66
Composition, C=5 g/l	82.27	16.61	81.39	17.72	81.16	15.07	74.84	19.68

Fig. 1, 2 show the dependence of the washing and anti-absorption capacity on the composition concentration for cotton, polyester and mixed fabrics.

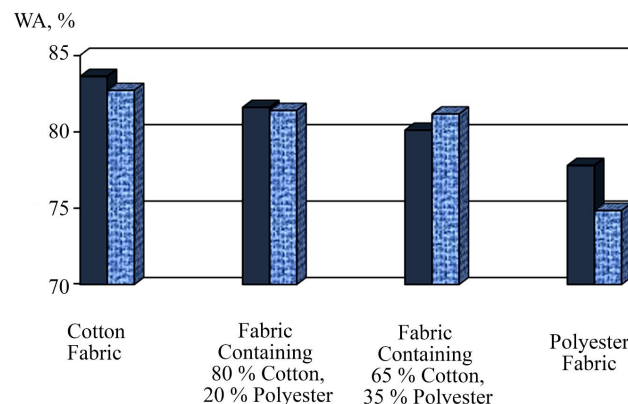


Fig. 1. Effect of concentration of compositions on the washing ability of solutions:

■ – C_{com}=2.5 g/l, ■ – C_{com}=5 g/l

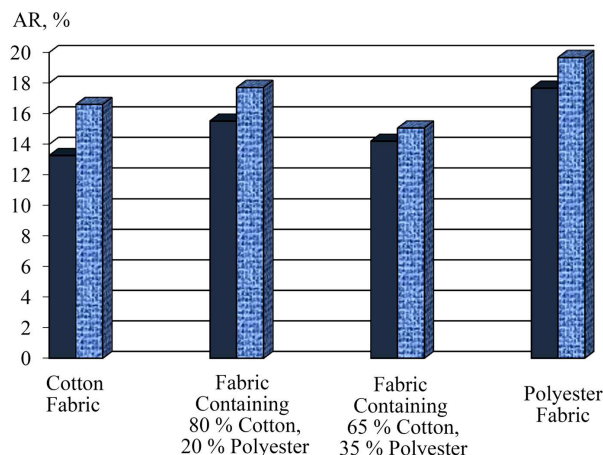


Fig. 2. Influence of concentration of compositions on the anti-resorption capacity of solutions:

■ – C_{com}=2.5 g/l, ■ – C_{com}=5 g/l

Comparative studies of the washing and anti-resorption properties of the composition have shown that when textiles are treated with the solution of the composition with the concentration of 2.5 g/l, better indicators of removal of contamination from fabric are achieved than with the concentration of 5 g/l, therefore it is expedient and justified to use the working concentrations of solutions of composition of 2.5 g/l for washing and wet cleaning of products.

The indicators of hygroscopicity of fabrics determined the hygienic properties of textile materials after treatment with compositions of ecologically safe substances [9, 12]. Fig. 3 shows the results of studies of products capillarity (*h*, mm), which determines the quality of cleaning of pores of textile materials and, accordingly, hygroscopicity of products.

The study of the influence of compositions of ecologically safe substances on the representative of the normal microflora of the human body *P. freudenreichii* is shown in Table 4.

Under the influence of untreated fabric samples on the *P. freudenreichii* culture (10^7 CFU/ml), the number of bacteria did not decrease, but, on the contrary, increased by an order of magnitude up to 4.7×10^8 CFU/ml, 3.6×10^8 CFU/ml, 4.1×10^8 CFU/ml and 5.3×10^8 CFU/ml, respectively. That testifies to the absence of influence of untreated samples on the growth and reproduction of the culture. Moreover, due to the high density of the *P. freudenreichii* culture, most likely the number grows only by an order of magnitude. The study on the restoration of the culture confirmed the previous assumptions, so, the reference microorganism increased its number to 10^8 – 10^9 cells/ml. Consequently, the number of *P. freudenreichii* (10^8 CFU/ml) bacteria did not decrease, but on the contrary increased to 1.83×10^9 CFU/ml, 1.65×10^9 CFU/ml, 2.4×10^9 CFU/ml and 2.22×10^9 CFU/ml, respectively. The restoration of the culture testifies the absence of influence of untreated samples on the activity of the representative of the human microflora *P. freudenreichii*.

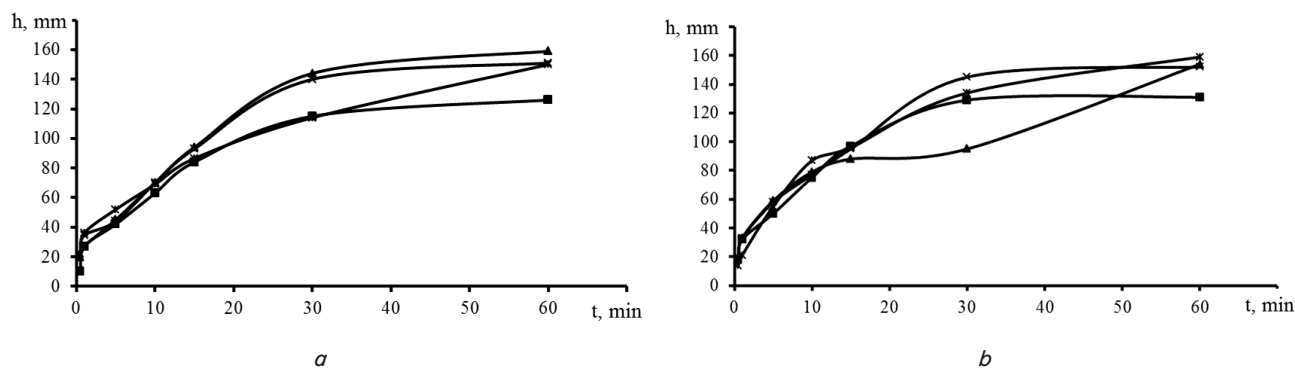


Fig. 3. Effect of compositions of ecologically safe substances on the hygroscopicity of the samples under study: a – $C_{com}=2.5$ g/l; b – $C_{com}=5$ g/l: \blacksquare – cotton fabric; \blacktriangle – fabric containing 65 % cotton and 35 % polyester; \bullet – fabric containing 80 % cotton and 20 % polyester; \blacklozenge – polyester fabric

Table 4

Results of the study of the influence of compositions of ecologically safe substances on *P. freudenreichii* at different microbial loading

Fabric samples	Microbial load – 10^7		Microbial load – 10^8	
	Amount of CFU/ml after 24 hour incubation	Restoration of the culture / fabric sample exposure 48 hours	Amount of CFU/ml after 24 hour incubation	Restoration of the culture / fabric sample exposure 48 hours
Output samples of fabric (untreated)				
Cotton fabric	4.7×10^8	+++++	1.83×10^9	+++++
Fabric containing 80 % cotton and 20 % polyester	3.6×10^8	+++++	1.65×10^9	+++++
Fabric containing 65 % cotton and 35 % polyester	4.1×10^8	+++++	2.4×10^9	+++++
Polyester fabric	5.3×10^8	+++++	2.22×10^9	+++++
Samples of treated with a composition of ecologically safe substances, $C_{com}=2.5$ g/l				
Cotton fabric	2.4×10^4	+++	1.83×10^5	+++
Fabric containing 80 % cotton and 20 % polyester	1.3×10^3	++	7.2×10^4	+++
Fabric containing 65 % cotton and 35 % polyester	4.4×10^2	++	3.9×10^3	++
Polyester fabric	2.9×10^5	+++	1.47×10^6	++++

Note: CFU – colony-forming units; “+” – restoration of the ability of the culture to colonize the nutrient medium (calculations were carried out according to the McFarland standard): + – concentration of bacterial suspension 1–10 cells/ml; ++ – concentration of bacterial suspension 10^2 – 10^3 cells/ml; +++ – concentration of bacterial suspension 10^4 – 10^5 cells/ml; ++++ – concentration of bacterial suspension 10^6 – 10^7 cells/ml; +++++ – concentration of bacterial suspension 10^8 – 10^9 cells/ml

6. Discussion of the results of the study of the ecologically safe substances' impact on products hygienic properties

Studies have shown that the compositions of environmentally safe substances remove contaminants and other substances that remain on the fabric in the process of its production, that is, there is the cleaning of pores on the surface of textile materials, which in turn increases the capillarity of textile materials. Experimental data show that the treatment of fabrics made of cotton, polyester, and their mixtures with compositions of safe substances contributes to increasing their hydrophilicity, which is expressed in improving their wettability by water solutions and increasing capillarity due to the presence of adsorbed biosurfactants.

Determination of the effect of the studied composition of ecologically safe substances on the sample of fabric, after treatment with $C_{com}=2.5$ g/l on the representative of normal human body *P. freudenreichii* demonstrated the following results. In relation to the culture of the reference bacterium with a microbial load of 10^7 CFU/ml, the treated sample of cotton fabric reduced their number for 24-hour incubation to 2.4×10^4 CFU/ml. Regarding the restoration of the culture, after 48 hours of exposure of the fabric sample and in the sterility control environment, *P. freudenreichii* was able to recover to 10^4 – 10^5 cells/ml. With an increase in the microbial load by an order, the following result can be observed, after 24 hours of interaction of the treated cotton sample with the *P. freudenreichii* culture, the number of viable microorganisms decreased to 1.83×10^5 CFU/ml. Restoration of the culture in this case was observed in the range of 10^4 – 10^5 cells/ml.

The sample of treated polyester fabric decreased the number from 10^7 CFU/ml to 2.9×10^5 CFU/ml, and from 10^8 CFU/ml to 1.47×10^6 CFU/ml, that is, two orders of magnitude in each experiment, respectively. Recovery of the culture after 48 hours of exposure of this sample in the sterility control environment has demonstrated synchrony and dependence on the primary microbial load. Thus, the *P. freudenreichii* culture with a microbial load of 10^7 CFU/ml recovered only to 10^4 – 10^5 cells/ml, and from 10^8 CFU/ml to 10^6 – 10^7 cells/ml.

The study of the effect of the treated fabric sample containing 80 % cotton and 20 % polyester on *P. freudenreichii* showed the following results. After 24 hours of incubation of the sample in the *P. freudenreichii* culture with a microbial load of 10^7 CFU/ml, the number of viable microorganisms decreased to 1.3×10^3 CFU/ml, and at 10^8 CFU/ml – to 7.2×10^4 CFU/ml. Recovering the reference culture under the influence of the treated fabric sample containing 80 % cotton and 20 % polyester was carried out according to the previous microbial loading, after 48-hour incubation the culture with a microbial load of 10^7 CFU/ml was restored to 10^2 – 10^3 cells/ml, indicating that irreversible changes in the microorganism activity, and the culture with 10^8 CFU/ml – up to 10^4 – 10^5 cells/ml.

The treated sample of fabric containing 65 % cotton and 35 % polyester was one of the most effective against the antimicrobial effect on the *P. freudenreichii* culture among the studied samples. After 24 hours of culture incubation with a microbial load of 10^7 CFU/ml with the sample, the number of microbial cells decreased to 4.4×10^2 CFU/ml and viability in this case, after 48 hours, in another sterility control environment significantly decreased to 10^2 – 10^3 cells/ml.

The experiment with microbial loading *P. freudenreichii* 10^8 CFU/ml demonstrated the following results. Under the influence of the sample of treated fabric containing 65 % cotton and 35 % polyester in 24 hours, the number of bacteria decreased to 3.9×10^3 CFU/ml.

Consequently, the results of the study confirmed the complex effectiveness of the composition of environmentally safe substances in relation to the efficient treatment of products with the preservation of healthy microflora of human skin. Methods used in the work can be applied to determine the hygienic properties of textile materials of different fibrous compositions.

The benefits of this study are the simplicity and availability of conducting the experiments. It is possible to obtain correct and reliable results of measurements with high accuracy, using the Kubelka-Munch method, in comparison with the Mengh-Kaufman methods. However, the empirical determination of quantitative indicators of hygienic properties is associated with certain difficulties, primarily with the nature and composition of contaminants, the way of their application and fixation. It should also be taken into account that this technique can be used for non-dyed textile materials.

Systematic analysis of technological processes of product purification, fast and efficient processing of experimental data allows expanding the possibilities of using the compositions of environmentally safe substances in the processes of washing or wet cleaning in terms of the finishing effect.

Prospects for the development of this study are the determination of the effect of the composition on other representatives of the skin microflora, as well as on the physical and mechanical properties of fabrics.

When studying the effect of the compositions on the physical and mechanical properties of products, the structure of materials should be taken into account. For example, woolen fabrics with a hairy surface are more polluted than polyester with a smooth surface. The structure of the material itself, the order of the individual fibers, the interweaving, characteristics of its surface have a significant impact on the quality of product cleaning.

To obtain the coordinated values, it is necessary to choose textile materials of such fibrous composition and assortment.

7. Conclusions

1. The quantitative indicators of efficient treatment of products that ensure high hygiene and preservation of consumer properties of products were determined. The study shows that for textile materials the highest indicators of the quality of removal of contaminants are achieved at a concentration of composition of 2.5 g/l and constitute 83.62 % for cotton fabrics; 81.59 % for fabric containing 80 % cotton and 20 % polyester; 80.10 % for fabric containing 65 % cotton and 35 % polyester; 77.79 % for polyester fabric. In this case, prevention of re-precipitation of dirt on textile fibers during treatment, which corresponds to the following indicators of anti-resorption capacity: 13.27 % for cotton fabric; 15.53 % for fabric containing 80 % cotton and 20 % polyester; 14.21 % for fabric containing 65 % cotton and 35 % polyester; 17.66 % for polyester fabric.

2. Based on the complex study of capillarity and antimicrobial properties of the composition of ecologically safe

substances, the technological feasibility of using the composition at a concentration of $C_{com}=2.5$ g/l to provide textile products with antimicrobial properties during washing and wet cleaning was confirmed, the composition is added directly to the bath.

3. It was found that the use of a composition of ecologically safe substances during washing, wet cleaning and finishing of special purpose products (for military,

athletes, etc.) and home textiles improves the capillarity of the fabric from 131 mm to 152 mm, restores the microflora of the skin (*P. freudenreichii* culture) to 10^4 – 10^5 cells/ml after 48 hours of fabric sample exposure and in the sterility control environment, enhances the ecological safety of the processes of product treatment, promotes the development of the textile, pharmaceutical and chemical industries.

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