Література

1. EN ISO 13688:2013. Protective clothing – General requirements. Brussels: European Committee for Standardization, 2013. 30 p.
2. REGULATION (EU) 2016/425 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 9 March 2016 on personal protective equipment and repealing Council Directive 89/686/EEC. Брюссель: Європейський Парламент та Рада, 2016. (Доступний на: EUR-Lex).
3. Design considerations for low-level risk personal protective clothing URL: https://pmc.ncbi.nlm.nih.gov/articles/PMC6546585/ (дата звернення: 07.10.2025).
4. FLAXPOL. Про підприємство FLAXPOL URL: https://www.flaxpol.pl/clothing/info-list-category/32-oferty-pracy.html (дата звернення: 07.10.2025).

UDC
685.34.073.33

OLHA, HARANINA, YANA, REDKO, ANNA, VARDANIAN, TARAS, SHOKOT
Kyiv National University of Technologies and Design, Ukraine

ANTIMICROBIAL TREATMENT OF TEXTILE MATERIALS FOR FOOTWEAR

Purpose. *Establishing the effectiveness of antimicrobial treatment of polyester-cotton textile materials for the footwear industry. Determining the impact of antimicrobial treatment on the complex of hygienic characteristics of textile materials in order to increase the comfort and safety of footwear during exploitation.*

Keywords*: antimicrobial treatment, textile materials, footwear elements, material testing, hygiene*

Objectives. The use of traditional methods to improve the hygienic characteristics of footwear (perforation, ventilation systems, the use of materials with increased vapour and air permeability) does not currently provide high level of comfort for the consumer and zonal protection against the growth of pathogenic microflora. This causes a high risk of dermatological diseases, which are directly related to extreme moisture and microbiological contamination inside the shoes [1-2]. The decisive factor for comfort is the hygiene of footwear. There is a need of implementation the innovative approaches to creating new-generation materials for safety and prevention of skin pathologies. Such textile materials must conform to quality standards, combining sufficient values of air permeability, vapour permeability and long-lasting antimicrobial action [3]. The application of antibacterial agents to obtain antimicrobial textile materials with a long-

lasting protective effect without worsening characteristics is an important and one of the most promising areas of research [4]. The study aimed at developing a technology for obtaining antimicrobial textile materials with improved hygienic characteristics, which are capable of application in the production of footwear for various functional purposes, in special and everyday footwear, is becoming highly relevant.

Methodology. Samples of textile materials made of a cotton-polyester blend were given to antimicrobial treatment with a 40% alcohol solution of a broad-spectrum phenyl-phenolic antibacterial agent. Material tests were conducted to determine hygienic indicators: hygroscopicity, vapour and air permeability. The antimicrobial activity of the obtained samples was studied by determining the growth inhibition zones during 24 and 48 hours.

Research results. The antimicrobial treatment of textile materials was carried out in accordance with [5]. The values of hygroscopicity, vapour permeability and air permeability of textile materials are given in Table 1.

Table 1 – **Hygienic characteristics of textile materials after antimicrobial treatment**

Sample	Hygroscopicity, %	Vapour permeability, mg/cm²·h	Air permeability, dm³/m²·s
Control	9	14	41
1	4	13	38
2	5	15	36
3	9	13	63

Samples 1 and 2 showed a decrease in moisture capacity compared to the control sample, indicating a decrease in the hydrophilicity of the material as a result of treatment. In contrast, sample 3, which contains the maximum concentration of phenyl-phenolic compounds, is characterised by increased hygroscopicity (8,92 %), exceeding the control values. All modified samples showed increased vapour permeability, with the highest level recorded in sample 1 (15,7 mg/cm²•hour), which can be considered a positive factor for increasing comfort during footwear exploitation due to more intensive moisture removal in the form of vapour. At the same time, samples 1 and 2 showed a slight decrease in vapour permeability, probably due to partial blockage of the pores in the textile structure after treatment. Sample 3 showed an increase in air permeability (63,2 dm³/m²•s), which may indicate the modifying effect of the active substance on the microporous structure of the material. The effectiveness of antimicrobial treatment of textile materials was studied at the O.M. Marzieiev Institute of

Public Health of the National Academy of Medical Sciences of Ukraine in accordance with current standards. The tests were carried out using test cultures of Candida albicans (ATCC 10231), Aspergillus brasiliensis (ATCC 16404) fungi and Staphylococcus aureus (ATCC 6538), Escherichia coli (ATCC 8739), Pseudomonas aeruginosa (ATCC 9027) bacteria. All treated samples showed confirmed bactericidal and fungicidal activity (growth inhibition zones >4 mm), as shown in Fig. 1

.Based on the results of determining growth inhibition zones (24–48 hours), it was established that all samples exhibit pronounced antimicrobial activity (>4 mm), which meets international standards. The highest sensitivity of Staphylococcus aureus was recorded in sample 2 (3 g/l) – 20,25 mm, while sample 3 (4 g/l) showed the maximum antimycotic effect against Candida albicans (10,25 mm) and Aspergillus brasiliensis (6,00 mm). Stable activity against Pseudomonas aeruginosa increased from 2–3 mm (24 hours) to 7 mm (48 hours), indicating a gradual increase in effect. Samples 2 and 3 proved to be the most effective overall and can be recommended for use in the footwear industry to provide long-term bioprotection.

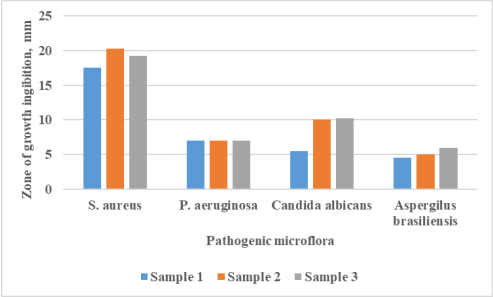

Fig. 1. **Antimicrobial activity of textile materials**

Conclusion. The studies confirmed the effectiveness of antimicrobial treatment of polyester-cotton textile materials for the footwear industry. All treated samples demonstrated sustained bactericidal and fungicidal activity against a wide range of microorganisms, indicating a high level of protective properties. Antimicrobial treatment did not cause a significant deterioration in the hygienic characteristics of the materials: satisfactory indicators of hygroscopicity, vapour permeability and air permeability were maintained. Sample №3 is particularly noteworthy, combining high air permeability with a pronounced antimicrobial effect. In summary, antimicrobial textiles are a promising solution for footwear, enhancing comfort, safety, and skin health in both specialized and everyday use.

References

1. Footwear microclimate and its effects on the microbial community of the plantar skin / T. Miao et al. *Scientific reports*. 2021. Vol. 11, no. 1. P. 1–13. URL: https://doi.org/10.1038/s41598-021-99865-x.
2. Footwear innovation to improve the comfort of use / I. Masłowska-Lipowicz et al. *The importance of social innovations in the knowledge-based economy in the context of footwear sector solutions*. 2024. P. 51–120. URL: https://doi.org/10.18778/8331-401-3.03.
3. Stetsyk Y., Popovych N., Martosenko M. Quality management for footwear used in outdoor activities. *Economics and region*. 2023. No. 4(87). P. 216–224. URL: https://doi.org/10.26906/eir.2022.4(87).2802.
4. Варданян А., Редько Я. Антибактеріальні агенти для створення текстильних матеріалів – сучасний стан та тенденції розвитку. *Herald of Khmelnytskyi National University. Technical sciences*. 2024. Т. 333, № 2. С. 112–119. URL: https://doi.org/10.31891/2307-5732-2024-333-2-17.
5. Гараніна О., Варданян А., Романюк Є., Редько Я., Шокот Т. Вплив антимікробної обробки на гігієнічні та експлуатаційні властивості текстильних матеріалів для взуттєвої промисловості / *Herald of Khmelnytskyi national university*. 2025. Т. 353, № 3.2. С. 91–97. URL: https://doi.org/10.31891/2307-5732-2025-353-10.

УДК 687.8: 677.024.53/ .54:[677.07 5.027.6

ДЕНИС ДЕВОГУЦ, ЛЮДМИЛА ГАЛАВСЬКА
Київський національний університет технології та дизайну, Україна

АНАЛІЗ ВИРОБНИКІВ ФЛІСОВИХ ТЕКСТИЛЬНИХ МАТЕРІАЛІВ ТА ДОСЛІДЖЕНЬ ЩОДО ПОЛІПШЕННЯ ЇХНІХ ВЛАСТИВОСТЕЙ

Мета. *Аналіз виробників флісових текстильних матеріалів типу polar fleece, з акцентом на технологіях виготовлення. Приділити увагу науковим дослідженням функціональних властивостей флісових текстильних матеріалів та сферам застосування.*

Ключові слова: *фліс, Polartec, виробництво флісу, polar fleece, теплоізоляція, властивості.*

Постановка завдання. Флісові текстильні матеріали, так звані polar fleece займають важливе місце у виробництві спортивного одягу та бойового екіпірування військовослужбовців та інших формувань спеціального призначення. Класична технологія включає виготовлення трикотажної основи з використанням спеціальних видів синтетичних ниток, поверхня якої у ході подальшого запатентованого опорядження