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INVESTIGATION OF THE ANTIMICROBIAL ACTIVITY OF FUNCTIONAL KNITTED MATERIALS

Purpose. *Justification and experimental assessment of the antimicrobial activity of tubular compression knit fabric modified with various antimicrobial agents. The stability of the antibacterial effect after multiple washing cycles was evaluated, and the possibilities for using the material in clinical practice were determined.*

Keywords: *compression knitted fabric, surface modification, antimicrobial activity, phenyl-phenolic series intensifier, wash resistance, Escherichia coli, Staphylococcus aureus, disinfectants, medical textiles, military medicine.*

Objectives. Compression knitwear is given antibacterial properties through the use of special raw materials or final finishing. It is important to preserve the effect after repeated washing, which is especially relevant when creating functional stump covers that contribute to the successful rehabilitation of amputees [1].

Cotton fibres have high hygienic properties, but due to their hydrophilicity, they create a conducive environment for the growth of microorganisms. This has prompted the active application of functional textile materials with antimicrobial properties [2,3]. Most often, antibacterial properties are imparted during finishing using metals (silver, copper and zinc oxides), chitosan or triclosan. Silver remains one of the most effective agents due to its broad spectrum of action, while triclosan is known for its ability to block fatty acid synthesis enzymes [4].

Researches show that the antimicrobial activity of knitwear depends not only on the composition of fibres, but also on the structural characteristics of yarn and the structure of the fabric [5]. The key quality criterion is the stability of antimicrobial activity after repeated washing.

Medical textiles play an important role in the postoperative care and rehabilitation of patients with amputated limbs, providing compression therapy and preparing the stump for prosthetics. Since textile materials that are in prolonged contact with the skin can be a breeding ground for bacteria and fungi, research into combining compression properties with antimicrobial protection to reduce the risk of infectious complications is relevant.

Methodology. Tubular compression knitwear with elastomeric thread (1×1 and 3×1 repeat) was developed, and samples with compression level I (18–21 mm Hg) were selected. After technological washing, the stability of linear dimensions was established. Antimicrobial properties were ensured by treating with triclosan in the dye bath and applying a 25% alcohol-free disinfectant. Activity against *E. coli* and *S. aureus* was evaluated by the diffusion method (EN ISO 20645:2004).

Research results. For surface modification, tubular knitwear was developed with the introduction of elastomeric thread into the ground in the form of press-knitted loops and drawstrings with a 1×1 and 3×1 repeat. The samples were made on a class 13 circular knitting machine (cylinder diameter 3.75") using a smooth plated weave. Cotton yarn 20 tex was used as the plating thread, and textured polyamide thread 4.4 tex with an elastane core 2.2 tex was used as the ground thread. During knitting, the vertical density (9, 10, 11 cm⁻¹) and the feed rate of the elastomeric thread (50–110 min⁻¹) were varied. For the study, samples with a compression level of 18–21 mm Hg were selected, obtained at 110 min⁻¹ and reports of 1×1 and 3×1. The wheel rotation frequency (n, min⁻¹) was 110. The main structural parameters are given in Table 1.

Table 1 – **Structural and physical-mechanical indicators of knitted fabric samples**

Rapport of elastomeric yarn laying	Sample code	Number of wale columns (100 mm)	Number of course rows (100 mm)	Surface density, ms (g/m ²)	Loop length of plating yarn (mm)	Loop length of ground yarn (mm)
1×1	1	85	110	402,4	5,6	5,2
	2		100	397,6	6,2	5,8
	3		90	400,8	6,8	6,4
3×1	4	90	110	450,0	6,1	5,5
	5		100	456,8	6,7	6,1
	6		90	417,6	7,3	6,7

To ensure technological shrinkage, the knitted fabric samples were washed with detergent at 40 °C. According to DSTU ISO 5077:2001, the change in linear dimensions was determined: due to the use of polyamide thread with an elastane core, shrinkage was observed along the loop row and column, after subsequent washings the dimensions remained stable. Textiles with antibacterial properties were prepared by pretreatment with triclosan emulsion (CAS: 3380-34-5) with DTS dispersant (2 g/l, modulus 10, concentration 0,5–3 g/l, 1 hour, 100 °C). The knitted fabric samples were dyed using a two-bath method [5].

The samples were coded according to the treatment modes: samples 1–6 were treated with a phenyl-phenolic intensifier (0,5–3 g/l in increments of 0,5), sample 7 was treated with a 25% solution of a new-generation disinfectant using a spray method. The results of antimicrobial activity and

inhibition zones are shown in Table 2 and illustrated in Figure 1.

Table 2 – Antimicrobial activity of the investigated knitted fabrics

Sample code	Finishing	S. aureus / E. Coli, (zone of growth inhibition, mm)			
		Перед пранням	Після 1 прання	Після 2 прання	Після 5 прань
1	Phenyl-phenolic series intensifier	30,2 / 16,9	29,7 / 16,2	20,7 / 15,5	19,2 / 12,2
2		31,2 / 15,8	31,0 / 15,2	23,8 / 14,8	19,7 / 13,3
3		31,8 / 16,7	28,2 / 16,5	20,7 / 14,8	20,0 / 13,7
4		28,7 / 16,0	26,2 / 15,2	16,3 / 13,8	16,2 / 13,0
5		29,2 / 15,3	27,0 / 15,2	17,2 / 15,2	16,5 / 14,2
6		28,8 / 16,2	27,0 / 15,3	17,5 / 15,0	17,2 / 12,3
7	Disinfectant of the new generation (25%)	6,3 / 4,3	0,8 / 0	0 / 0	0 / 0

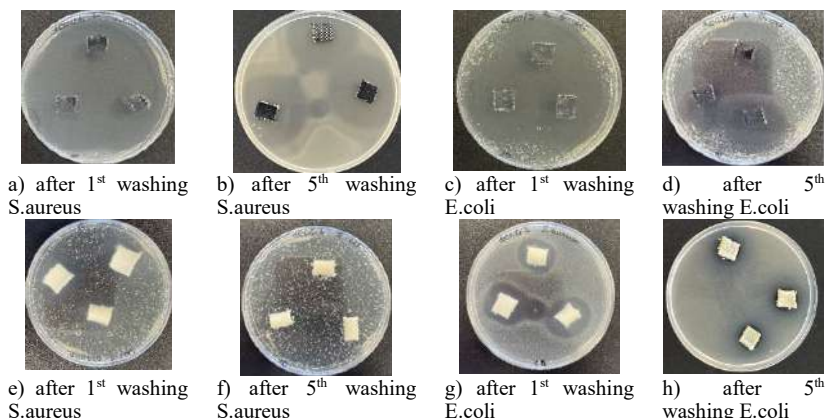


Fig. 1. Antibacterial activity of treated samples against *S. aureus* and *E. coli* after 1st and 5th washing cycles: a-d treated by phenyl-phenolic series intensifier; e-h treated by disinfectant of the new generation (25%)

Studies of the antimicrobial activity of knitted fabrics showed significant differences depending on the treatment method used. Samples modified with a phenyl-phenolic series intensifier (№ 1–6) demonstrated a high level of inhibition of *Staphylococcus aureus* growth (28,7–31,8 mm) and moderate activity against *Escherichia coli* (15,3–16,9 mm) before washing. After the first wash cycle, the inhibition zones remained virtually unchanged, indicating sufficient stability of the antimicrobial effect. Further washing led to a gradual decrease in activity, but even after five cycles, the samples retained a pronounced inhibitory effect (16–20 mm for *S. aureus*, 12–14 mm for *E. coli*). This proves the feasibility of using this intensifier to form long-lasting antimicrobial properties in knitted fabrics.

In contrast, the sample treated with a new-generation disinfectant (№

7) showed significantly lower initial antimicrobial activity (6,3 mm for *S. aureus* and 4,3 mm for *E. coli*), and after the first wash, the effect practically disappeared, making this treatment method unstable during use.

The loop structure of knitted fabric can affect its antibacterial activity. Research shows that when laying an elastomeric thread with a 3×1 repeat, the antibacterial properties of knitted fabrics are slightly lower. This is due to the formation of a more relief and smaller surface area that directly contacts pathogenic microflora.

Conclusion. Therefore, treatment with a phenyl-phenolic intensifier provides higher and more stable antimicrobial activity of knitted materials compared to disinfection treatment, which confirms the promise of this approach for the creation of functional textile products.

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