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FUNCTIONALIZATION OF ELASTIC BANDAGES FOR BIOMEDICAL APPLICATIONS

Purpose. *Justification of the choice of elastic bandages and determination of their suitability for functionalization with nanoparticles of magnetite with the aim of forming new properties – magnetosensitivity, biocompatibility and sensory capabilities that expand the range of medical applications.*

Keywords: *nanotechnology, elastic bandages, functionalization, materials science, medicine*

Objectives. Elastic medical bandages are one of the most common dressing materials in modern medicine, used for compression therapy, postoperative rehabilitation and orthopedic support. In the context of the development of nanotechnology, it is relevant to provide such materials with additional functions, in particular, sensitivity to a magnetic field. This opens up prospects for application in the field of passive monitoring of motor activity, wound healing, and local magnetotherapy.

Methodology. The justification for the choice of elastic bandages for functionalization is based on the basic principles of materials science for light industry products for further comprehensive assessment of the quality of materials, taking into account operating conditions. The objects of the study were selected samples of elastic bandages presented by various manufacturers, the characteristics and raw material composition of which are given in Table 1.

Research results. During the analysis of elastic bandage samples, a nomenclature of consumer properties and factors of their formation was developed. A comparative analysis of the extensibility, structural stability and biocompatibility of elastic bandages of different raw material composition was carried out.

According to the results of the study, it was found that sample 1 is characterized by high extensibility and a significant proportion of natural fibers, which ensures good biocompatibility and suitability for compression

therapy. However, excessive elasticity and hygroscopicity of cotton can complicate the uniformity of nanoparticle fixation and long-term stability of the magnetite nanocoating. Sample 2, which does not contain elastane, has an optimal combination of properties: sufficient elasticity for medical purposes, potential mechanical stability during cyclic loads, as well as a more uniform fiber surface due to polyamide (PA), which ensures reliable adhesion of nanoparticles, but demonstrates lower extensibility, therefore it is recommended as a control material for assessing the influence of elastomeric components. Sample 3 with the dominance of viscose has sufficient hygroscopicity and softness, has satisfactory indicators of extensibility and adhesion between layers, however, under wet conditions, deterioration of nanocoating adhesion is possible and in the context of long-term stability and uniformity of functionalization it is inferior to other samples. Sample 4 demonstrates a successful ratio of extensibility, strength and stability of the structure, combining the optimal properties of synthetic and natural fibers. Such a structure will provide: uniform distribution of nanoparticles due to the combination of hydrophilic (cotton) and hydrophobic (polyester (PE)) components; sufficient elasticity and stability of the magnetic response, as well as activation of polyester fiber during the formation of magnetite nanoparticles [1].

Table 1 – Samples of elastic bandages and their characteristics

Test samples	Raw material composition, %	Characteristics of samples
Sample 1	Cotton ~ 89, PA - 8, elastane - 3	Surface density – 220 g/m ² , thickness 0.8 mm, stretchability ≈ 170%
Sample 2	Cotton ~ 40, PA - 60, elastane - 0	Surface density – 200 g/m ² , thickness 0.75 mm, stretchability ≈ 110%
Sample 3	Viscose ~ 91 PA -7, elastane -2	Surface density – 180 g/m ² , thickness 0.65 mm, stretchability ≈ 130%
Sample 4	Cotton ~74, PE - 24, elastane - 2	Surface density – 190 g/m ² , thickness 0.7 mm, stretchability ≈ 150%

Thus, the most promising and effective for functionalization with magnetite nanoparticles was determined to be sample 4, which will provide a balance between biocompatibility, mechanical stability and uniformity of nanocoating application.

Prospects for expanding research lie in combined bio-functionalization with the participation of gel compositions with antibacterial or healing additives, which will allow increasing the efficiency of wound healing, use in local magnetotherapy and sensor systems for medical purposes [2].

As a result of the analysis of elastic bandage samples during the manufacturing process, their consumer properties were determined, a nomenclature of quality indicators was developed, which takes into account the operating conditions after treatment with nanomagnetite, and a number of criteria (requirements) were formulated, which are given in Table 2. The main criteria were: physical and mechanical indicators, structural indicators, hygienic properties, medical and biological criteria and functional properties after modification. Functionalization with nanoparticles can provide: passive magnetic tracking of movements in rehabilitation; improved healing due to local magnetic effects; creation of sensory textile systems for patient monitoring.

Table 2 – Nomenclature of quality indicators

Indicator group	Specific parameters	Performance criteria after functionalization
Physico-mechanical	Breaking force, elongation at break (ISO 13934-1:2013) [3]	Retention of elasticity after loading (stretchability) $\geq 80\%$
Structural	Distribution of nanoparticles in fibers (SEM, EDX)	Uniformity of distribution and fixation of nanoparticles
Hygienic	Hygroscopicity, air permeability (ISO 9237:2003)	Compliance with GOST 3816-2009, IDT
Biomedical	Antibacterial properties (ISO 20743:2021)	Activity against <i>S. aureus</i> and <i>E. coli</i> , not less than 4 mm
Functional	Residual magnetization, response to magnetic field (VSM, Hall sensor)	Stable magnetic response after $\geq 1-5$ washes, DSTU ISO 105-C06:2009

Conclusion. Samples of elastic bandages with different raw material composition were analyzed. It was determined that the most effective for functionalization is a sample based on polyester and cotton, and a promising direction for the development of nanotechnologies for textile functionalization is the combination of magnetosensitive properties with biopolymer and hydrogel compositions to expand the scope of medical application. The proposed nomenclature of indicators can serve as a basis for further development of a new generation of magnetosensitive dressing materials with increased efficiency.

References

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