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Methods for Estimating Biocide Efficiency Fiber Materials Processing

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ABSTRACT: The article analyzes comparative studies of the possibility of assessing the effectiveness of biocidal treatment of fibrous materials with migratory and non-migratory drugs. Several methods are used to control the effectiveness of bioprocessing on any specific material, depending on the substrate itself, the type of biocidal preparation, the type of microorganisms and the final requirements for the product for biocidal protection. Tests for antimicrobial and antifungal activity are divided into three main groups: diffusion, quantitative and counting. The assessment of the quality of processing materials with biocidal preparations is carried out by a microbiological laboratory that has a sanitary and epidemiological conclusion for the right to work with pathogens of infectious diseases.

KEY WORDS:fibrous materials, antimicrobial properties, bacteria, quality assessment, processing efficiency, diffusion tests.

I. INTRODUCTION

Throughout the world, the prevention of skin diseases is gaining importance, especially in military units and professional teams. It is here that there are factors contributing to the occurrence of pyoderma (skin contamination with fuels and lubricants, microtraumatism, prolonged wearing of professional clothing and footwear; increased sweating due to physical exertion, exercises, rescue operations, professional sports, etc.), in conditions under which it is difficult , and sometimes it is impossible to maintain proper personal hygiene. Skin disease is usually a sluggish process and, in addition to physical suffering, cause the patient moral inconvenience, since, unlike other diseases, they have external manifestations that are noticeable to others. It is well known that it is easier to prevent a disease than to cure it.

The problem of damage by microorganisms to materials for the manufacture of clothes and shoes is very relevant: the process of biological damage can lead to premature destruction of clothing and shoes, and in many cases to a deterioration in the health of a person who wears these clothes and shoes: infection of the human body with opportunistic microorganisms, the appearance of allergies from saprophytic molds, etc.

Antibactericidal (antimicrobial, antifungal, repellent, anti-putrefactive) processing of materials, developed half a century ago and is widely used at present in many countries of Europe, America, Southeast Asia. The leader in the production of biocides is North America, a significant demand for them in China and India.

Despite the improvement of the quality of life, hygienic education, compliance with the rules of personal hygiene, the incidence of human skin remains high, with no apparent tendency to decrease, especially in organized groups. One of the additional factors in reducing skin morbidity, along with specific treatment, is the prophylactic wearing of underwear, socks, shoes, the use of bedding with antimicrobial treatment [1].

Undoubtedly, interest in antimicrobial fibrous materials (tissues, skin, non-woven materials) has increased significantly. They do not allow bacteria to settle in clothes and shoes, on the basis of which, infection prevention can be carried out.

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But antibacterial clothing can also be used against a more commonplace problem - an unpleasant odor, since only bacteria give it sweat. The so-called “anti-odor” effect (“AntiSmell”) of antibacterial clothes and shoes kills bacteria and stops the process of their spread [2]. Fabrics made from fibers with bactericidal properties are not harmful to the skin: they do not affect the natural flora of the skin even with prolonged wear. This result came from a study at the Hohenstein Institute. Scientists have come to the conclusion that the hygienic properties of antibacterial materials are not in doubt [3].

II. ANALYTICAL RESEARCH.

Giving biocidal materials antimicrobial properties has two main objectives: protection from the action of microorganisms and protection against the action of pathogenic microflora of objects in contact with materials. Natural textile and leather fibers are easy prey for microbes because they easily retain water and microbial enzymes that can easily hydrolyze their polymer bonds. As you know, cotton, wool, jute and linen are the most susceptible to the effects of microbes. In natural fibers, the period of conservation of microbes is also diverse [4].

Modification of textile lining materials in order to give them antibacterial properties can be carried out at the stage of processing fiber-forming polymer into textile fiber, as well as at the stage of processing the finished textile fiber, web or product.

Giving antibacterial properties to textile materials is possible at the stage of synthesis and formation of fiber-forming polymer. Often, not one, but several antibacterial substances are introduced into the fiber. Such materials are more effective, and the introduction of an antibacterial agent directly into the fiber allows the antibacterial textile materials obtained by this method to withstand up to 250 washing cycles.

Giving antibacterial properties to textile materials is also possible at the finishing stage, namely by applying an antibacterial substance to the material during dyeing, that is, at the last stage of finishing the textile. This method is most economically feasible, since it requires the restructuring of the process only at the last stage. But a significant drawback of applying antibacterial substances at the stage of finishing is the problem of obtaining stable antibacterial coatings. This is due to the low adhesion of the antibacterial substance to textile fibers and leaching of the biocide from the surface of textile materials during the operation of products. [5].

The antibacterial properties of the materials are given by various methods and to evaluate the quality of the antimicrobial (biocidal) treatment of materials in contact with human skin, requires the choice of methods for checking such processing.

In practice, several methods are used to control the effectiveness of processing on a particular material, depending on the substrate itself, the type of biocidal preparation, the type of microorganism, and the final requirements for the biocidal protection product. There are norms and standards for the qualitative and quantitative assessment of the effectiveness of antimicrobial treatment [6].

Tests for antimicrobial and antifungal action are divided into three main groups:
- diffusion or quality (using agar) - only for migrating biocidal preparations;
- quantitative (using liquid nutrient media and dilutions of the drug);
- count (count test) - mainly for covalently fixed biocidal drugs.

Diffusion (qualitative) tests carried out in an agar layer give an idea of the quality of processing materials with antimicrobial or antifungal effects. The degree of growth inhibition of the tested microorganisms (bacteria or fungi) is investigated. Samples of the test material (pieces of tissue 2 × 2 cm in size) are laid out in Petri dishes with nutrient agar contaminated with a test microorganism (108 m.k. / ml). plates with agar are cultured in a thermostat at 37 ° C for 24–48 hours. Tissue samples containing no antimicrobial components are used as controls. Evaluation of the quality of antimicrobial treatment of the test material is carried out according to the degree of inhibition of bacterial or fungal growth on nutrient agar, measured from the edge of the sample to the microorganism growth boundary, expressed in millimeters. The efficiency indicator is estimated by the zone of growth inhibition, the value of which should be at least 4 mm. The zone of growth inhibition of microorganisms around the samples depends on the degree of diffusion of antimicrobial agents into the nutrient agar layer. Therefore, this technique is applicable only for migrating preparations

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that are not fixed to the fiber by covalent bonds [7]. Thus, classical diffusion methods are unacceptable for evaluating the effectiveness of non-migratory drugs.

A quantitative method for assessing the effectiveness of processing materials with migratory preparations is based on the study of their effect (to one degree or another dilution) on strains of control microorganisms. For this purpose, a series of dilutions of the test drug is prepared, and then 2 infected test objects for each exposure are added to each cork (vial) diluted. Exposure can be from 5 minutes to 1 hour (depending on the drug and its concentration). After the expiration of the exposure time, 2 test objects are removed with sterile forceps and immersed in a solution of a neutralizer or sterile tap water.

As neutralizers use:
- for oxidizing agents (chlorine, iodine, peroxide, ozone) - 0.5 ÷ 1.0% sodium thiosulfate solutions;
- for aldehyde-containing and phenol-containing agents - water;
- forsurfactants - 0.1 ÷ 1.0% sulfonolsolutions;
- for composite products - a universal neutralizer containing tween-80 - 3%, histidine - 0.1%, saponin - 3% and cysteine - 0.1%.

After 5 minutes, the test objects are transferred to a second test tube (bottle) with sterile tap water. Then after 5 minutes each test object is placed in a test tube with a liquid nutrient medium (meat and peptone broth, nutrient broth, sugar broth). The control are 2 test objects not exposed to the disinfectant. The crops are thermostated at a temperature of 37 ° C for 24 hours. The results are taken into account by the absence of growth of microorganisms in test tubes with a liquid nutrient medium. The concentration of the drug, which has a biocidal effect, is determined by the last test tube (bottle), in which there is no growth of microorganisms [8].

Counting tests make it possible to evaluate the effectiveness of antimicrobial treatment of materials with non-migratory drugs. These tests are used to determine the growth retardation of microorganisms on a specific material. The number of microorganisms is counted after 6 ÷ 24 hours of cultivation and compared with the number of microorganisms at the beginning of the test. To count the number of colonies of microorganisms create a series of dilutions. Given that this test is rather time-consuming, it is used only in cases where the diffusion test is not applicable.

As an example of the count test method for controlling antimicrobial activity, the Japanese method with shaking DuPont FSTM E 21-49 is presented.

The crushed samples of the test object (material treated with a non-migrating preparation) and the control test object (raw material) weighing 2 g are placed in test tubes with nutrient broth containing a certain number of microorganisms Staphylococcus aureus (Staphylococcus aureus) and Escherichia coli (Escherichia coli) in the form suspensions with different initial concentrations: 109, 107, 105. Tests are carried out with continuous shaking (using a shattel or shaker) of a sealed tube at room temperature for 24 hours. wish to set up to break the covalent bond with the material of the drug. After 24 hours, 1 ml of suspension is taken and serial dilutions of 100, 1000, 10 thousand and 100 thousand times are carried out until the number of colonies is available for counting. Then, crops on solid nutrient media are carried out and thermostated at a temperature of 37 ° C for 48 hours [8].

After 48 hours, colony counts are performed in CFU / ml (CFU - colony forming unit). The resulting value is multiplied by the degree of dilution and compared with the original number of microorganisms. The decrease in microbial seeding of nutrient broth is estimated as a percentage of the initial microbial load in suspension and is compared with the same indicator of the control test object. Evaluation of test results is carried out in points.

The suspension method allows you to determine the dependence of the antimicrobial activity of tissues on the microbial load.

A test object of the test material is placed in a test tube with 1 ml of meat-peptone broth (pH 7.2-7.4) containing a 10-fold decreasing number of cells (109 ÷ 103 mk / ml) of test cultures (Staphylococcus aureus, Escherichia coli) 1 cm2 in size. The results are taken into account after 24 h of incubation of crops in an incubator at 37 ° C, stating the absence of growth in test tubes with the maximum number of introduced test culture cells.

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Determining the effectiveness of antimicrobial treatment of materials by the suspension method is carried out by the growth of microorganisms in a test tube with samples of experimental materials, the microbial load of which is not lower than 105 mk / ml. [9]

Before starting the research, microbiologists must find out the type of drug with which the material was processed (migratory or non-migratory). The choice of research method depends on this. Migrating drugs - drugs that are not fixed by covalent bonds with the processed material, freely moving from the material to the environment. Non-migratory preparations - preparations fixed by covalent bonds with the processed material, capable of being retained on this material for a long time.

To assess the effectiveness of biocidal processing of materials, the following international standards have been developed and are in force:
- antifungal effectiveness standards SAN BIO 12/94, AATT 30, ASTM G 21-96, EN ISO 11721-1;
- antimicrobial action standards SN 195920, AATCC 147, JIS L 1902, ASTM E 21-49;
- antibacterial efficacy standard ISO 16187: 2013. Shoes and shoe parts. Test methods for assessing antibacterial activity [10]

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III. CONCLUSIONS

1. Tests for antimicrobial and antifungal activity are divided into three main groups: diffusion, quantitative and counting. The quality assessment of materials processing with biocidal preparations is carried out by a microbiological laboratory, which has a sanitary and epidemiological certificate for the right to work with pathogens of infectious diseases.

2. The quality of the processing of materials with biocidal preparations can be assessed by a microbiological laboratory that has a sanitary-epidemiological opinion on the right to work with pathogens of infectious diseases of the III – IV pathogenicity group and accredited for this type of activity. Certification studies may be carried out by laboratories specially accredited for certification testing.
- In the case of using migratory preparations, classical qualitative diffusion research methods and quantitative dilution methods are acceptable.
- In the case of the use of non-migratory preparations, counting methods are applied with mandatory shuttling (shaking) for 24 hours.

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