Investigation of the Inhibitory Effect of Biocidal Products (Based on Guanidine) on the Activity of Building Materials Destructors

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Abstract. The article presents the classification and specificity of effective methods of protection from bio-damage. Settling on the surface of building materials and structures, microorganisms, along with the destructive effect, worsen the environmental situation in buildings and structures.

Studying the works of Russian and foreign authors in the field of biotechnology made it possible to generalize the basic methods of combating biological damage to KSM (carbamide resin), which are divided into physical, biological and chemical.

One of the most effective and long—lasting ways to protect building materials and structures from damage by microorganisms is the use of biocidal compounds. The latter are introduced into the composition of the material during its manufacture or by the method of impregnation. Fungicides also inhibit the development of microorganisms by reducing the intake of nutrients from the environment to the cells of the fungus.

In world practice, promising biocidal compounds are considered to be preparations based on guanidine, which are effectively used in medicine, the textile industry, in chemical technologies for the synthesis of surfactants, etc. In this article, the inhibitory effect of the preparation “Teflex” (base – polyethylene guanidine) on the activity of exoxidoreductases of fungi destructors of construction composites (Aspergillus fumigatus, Stemphylium verruculosum, Trichoderma koningii and Paecilomyces carneus) at the maximum of enzymatic activity was evaluated. Biocides were introduced into the fungi culture medium on day 3 (in vitro).

It was found that “Teflex” fungicides inhibit phenolosidotes, cotoloses and peroxidoses: phenol oxidases of the fungus Aspergillus fumigatus - 1.4 times, Paecilomyces carneus - 1.6 times, Trichoderma koningii - 2.0 times, Stemphylium verruculosum - 4.2 times (Figure 7.1 A); catalases of the fungus Paecilomyces carneus - 1.8 times, Trichoderma koningii - 2.2 times, Stemphylium verruculosum - 9.3 times, Aspergillus fumigatus - 23.9 times (Figure 7.1 b); peroxidases of the fungus Aspergillus fumigatus - 3.4 times, Trichoderma koningii-4.6 times, Paecilomyces carneus-9.9 times, Stemphylium verruculosum - 43.7 times. The fungicidal
effect of the preparation "Teflex" may be associated with its destabilizing effect on the native structure of enzymes. It leads to a violation of the tertiary structure of the enzyme, causes protein denaturation and disorganization of the cell membrane.

1. Introduction
Currently, the problem of increasing the durability of building materials, products and structures is gaining strong interest. This is due to the fact that buildings and structures are affected by an increasing number of different aggressive environments, one of which is biological [1,2]. In recent years, there has been an increase in the diversity and number of microorganisms involved in the processes of bio-damage of various types of materials [2-12].

2. Relevance and scientific significance of the problem
Settling on the surface of building materials and structures, microorganisms, along with the destructive effect, worsen the environmental situation in buildings and structures (lead to the appearance of mold smell in the premises and emit toxic products, allergens) [13, 14]. Fungi, developing on materials, emit a lot of spores and various life products that can cause a number of serious human diseases. First of all, these are mycoses-lesions of a fungal infection (for example, aspergillosis—a disease caused by Aspergillus fungi), which are very difficult to diagnose and even more difficult to treat. It is also known that 50% of bronchial asthma diseases are associated with the defeat of micromycetes. They also cause penicillosis, often accompanied by inflammation of the joints and bones. Therefore, the growth of fungal colonies causes harm not only to construction and industrial materials, but also to people who are in contact with them, and the health of not only these people, but also their relatives, to whom the spores of fungi get through clothing, is at risk [15].

In livestock buildings, construction structures and products that are infected with pathogenic microorganisms, growth is decreasing, animal deaths are increasing, and medical centers infected with staphylococci become suitable for use only after repair work that includes replacing the infected layer of plaster with a new one [16].

When engineering structures are damaged the problems of food conservation become more acute: typical are the huge losses of grain and flour in flour mills, meat and other products in the food and processing industry.

It follows from the above that the risk of occurrence and development of bio-damage should be excluded at the earliest stage, i.e. already in the design of building products and structures [17].

3. Theoretical part
The study of the works Russian and foreign authors in the field of biotechnology allowed us to generalize the main methods of combating bio-damage of composite construction materials [17-19]. They can be temporary and long-term (Fig. 1).

In order to apply certain methods of protecting materials and structures correctly and efficiently it is necessary to know the species composition of specific pathogens of biodeterioration in various operating conditions. There are various methods for detecting and isolating microorganisms in damaged material (Fig. 2), which are summarized in the studies [20, 21, 22].
Methods of protection against biodeterioration

Temporary
- Preventive
- Physical
- Biological

Long lasting
- Constructive
- Preventive
- Chemical

**Figure 1.** Classification of protection methods.

Detection methods

- Fingerprinting with sticky cellulose tape
- Filtration of liquid material through a membrane filter
- Homogenization of viscous material
- Flushing (scraping) from the surface of a solid material

Microscopy

Sowing or placing the sample on a solid or nutrient medium to establish species

- Wort - agar or agar medium
- Chapek - Dox with sucrose for the detection of mushrooms
- Meat peptone broth and must for the isolation of bacteria of the genus Pseudomonas
- Meat peptone broth and must for the isolation of the genera Arthrobacter and Micobacterium
- Mineral media with ammonium to isolate nitrifying bacteria
- Special media with sulfates for the release of CRP

**Figure 2.** Methods for detecting microorganisms in damaged material.
One of the most effective and long-lasting ways to protect building materials and structures from damage by microorganisms is the use of biocidal compounds. The latter are introduced into the composition of the material during its manufacture or by the method of impregnation. In addition, biocidal paint and adhesive coatings are applied to the surface of materials and products subject to microbial damage [23-31].

Biocides used for the destruction of microorganisms can be divided into two groups: fungicides – to protect materials and products from damage by fungi (mainly mold); bactericides – to protect against putrefactive, mucus-forming, acid-forming and other bacteria.

The toxic effect of biocidal additives is based on their ability to inhibit the activity of enzymes and certain metabolic reactions of fungi, to inhibit respiration, and to disrupt their cellular structures. The fungicide, in contact with the cell wall of the fungus, penetrates the cell and interacts with its components, suppressing biosynthesis [19, 32, 33, 34].

Many classes of fungicides cause disorganization of cell membranes, which leads to an increase in the permeability of the latter, the exit of proteins and endogenous enzymes from the mycelium cells into the culture fluid. Fungicides also inhibit the development of microorganisms by reducing the intake of nutrients from the external environment into the cells of the fungus [2].

In world practice, promising biocidal compounds are considered to be preparations based on guanidine, which are effectively used in medicine, the textile industry, in chemical technologies for the synthesis of surfactants, construction, etc.

The inhibitory effect of the preparation “Teflex” (base – polyethylene guanidine) on the activity of exoxidoreductases of fungi destructors of construction composites Aspergillus fumigatus, Stemphylium verruculosum, Trichoderma koningii and Paecilomyces carneus at the maximum of enzymatic activity was evaluated below. Biocides were introduced into the fungi culture medium on day 3 (in vivo).

4. Purpose, objectives and methods of research
The purpose of the research was to evaluate the effect of the preparation "Teflex" on the activity of exoxidorectases of mycelial fungi.

Research objectives:
1. Investigation of the inhibitory effect of the preparation "Teflex" on the activity of exoxidorectases of mycelial fungi;
2. Investigation of the effect of the preparation on the phenol oxidase activity of fungi;
3. Investigation of the effect of a biocidal preparation on catalase activity.

5. Method of research
The inhibitory effect of the preparation "Teflex" on the activity of exoxoxidorectuases was performed in fungi Aspergillus fumigatus, Stemphylium verruculosum, Trichoderma koningii and Paecilomyces carneus at the maximum of enzymatic activity. Biocides were introduced into the fungi culture medium on day 3 (in vivo).

Studies of the effect of the preparation “Teflex” on phenol oxidase activity were carried out on the 7th day at the optimal pH value(7.4) for all four types of fungi, on peroxidase activity at pH=4.6 in Aspergillus fumigatus on the 19th, Stemphylium verruculosum, Paecilomyces carneus, Trichoderma koningii at pH=5.4, on the 7th day of cultivation. The effect of the fungicide on catalase activity was evaluated for the fungus Aspergillus fumigatus on day 19 at pH=7.4, for Stemphylium verruculosum and Trichoderma koningii on day 19 at pH=8.0, for Paecilomyces carneus on day 16 at pH=6.8.

6. The results obtained and their discussion
The research results of this series of experiments (Fig. 3) showed that preparation “Teflex” indeed showed an inhibitory effect on catalase, phenol oxidase, and fungal peroxidase. The “Teflex” fungicide inhibited:
1. phenol oxidase of the fungus Aspergillus fumigatus - 1.4 times, Paecilomyces carneus - 1.6 times, Trichoderma koningii - 2.0 times, Stemphylium verruculosum - 4.2 times (Figure 3 A);

2. catalase of the fungus Paecilomyces carneus - 1.8 times, Trichoderma koningii - 2.2 times, Stemphylium verruculosum - 9.3 times, Aspergillus fumigatus - 23.9 times (Figure 7.1 B);

3. peroxidase fungus Aspergillus fumigatus - 3.4 times, Trichoderma koningii - 4.6 times, Paecilomyces carneus - 9.9 times, Stemphylium verruculosum - 43.7 times (Figure 5.1 C).

The fungicidal effect of preparation “Teflex” may be associated with its destabilizing effect on the native structure of enzymes. It leads to disruption of the tertiary structure of the enzyme, causes protein denaturation and disorganization of the cell membrane. As a result of the action of this preparation on the mycelium of the fungus, the integrity of cells is violated, which leads to a decrease in the adaptive capabilities of the body, the ability to respond adequately to the impact of a stress factor.
Figure 3. Effect of the "Teflex" preparation on Exo-oxidoreductases of fungi - destructors of construction composites.

Thus the preparation "Teflex" has shown an inhibitory effect on catalase, phenol oxidase, and peroxidase of fungi Aspergillus fumigatus, Stemphylium verruculosum, Trichoderma koningii, Paecilomyces carneus. Therefore, this preparation can really be recommended as an effective means of protecting construction composites.

7. Conclusions
1. The article provides a classification and specificity of effective methods of protection against biological damage and studies of materials with biocides "Teflex".

2. It is shown that, settling on the surface of construction materials and structures, microorganisms break down the design and worsen the ecological situation in the buildings. In this regard, the risk of occurrence and development of biological damage should be excluded already when designing construction products and structures.

3. The study of the works of Russian and foreign authors in the field of biotechnology has allowed us to generalize the main methods of combating bio-damage of composite construction materials which are divided into physical, biological and chemical.

4. One of the most effective ways to protect building materials and structures from damage by microorganisms is the use of biocidal drugs that are introduced into the material during its manufacture or by impregnation. Fungicides cause disorganization of cell membranes, which leads to an increase in the permeability of the latter, the exit of proteins and endogenous enzymes from mycelium cells into the culture liquid, and also inhibit the development of microorganisms by reducing the intake of nutrients from the external environment to the cells of the fungus.

5. It was found that the fungicides "Teflex" inhibit phenolosidotoses, cotoloses and peroxidoses: phenolosidases of the fungus Aspergillus fumigatus - 1.4 times, Paecilomyces carneus - 1.6 times, Trichoderma koningii - 2.0 times, Stemphylium verruculosum - 4.2 times; catalasases of the fungus Paecilomyces carneus - 1.8 times, Trichoderma koningii - 2.2 times, Stemphylium verruculosum - 9.3 times, Aspergillus fumigatus - 23.9 times; the peroxidases of the fungus Aspergillus fumigatus - 3.4 times, Trichoderma koningii-4.6 times, Paecilomyces carneus-9.9 times, Stemphylium verruculosum - 43.7 times;
6. The fungicidal effect of the preparation "Teflex" may be associated with its destabilizing effect on the native structure of enzymes. It leads to a violation of the tertiary structure of the enzyme, causes protein denaturation and disorganization of the cell membrane.

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