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NEW ENVIRONMENTALLY FRIENDLY COMPLEX FLAME RETARDANT AND ANTIMICROBIAL FINISHING FOR TEXTILE MATERIALS

I.V. HOROKHOV, I.M. KULISH, T.S. ASAULYUK
Kherson National Technical University

Taking into account the potential impact of textile finishing on the environment and human health, recent publications have emphasized the development of halogen-free and formaldehyde-free compositions. In this regard, biosourced flame retardant and antimicrobial agents combine high flame retardant and antimicrobial properties with low environmental impact. In this work, phytic acid is studied as a biologically based fire retardant due to the presence of a high phosphorus content in it, while at the same time exhibiting antimicrobial properties. Polyhexamethylene guanidine phosphate, in turn, is an effective and environmentally friendly antimicrobial agent, and the presence of the nitrogen element contributes to the creation of phosphorus-nitrogen synergism necessary to increase the fire resistance of fabrics.

Therefore, the goal of this work is to improve the antimicrobial and flame retardant properties of textile material based on the principles of "green technologies" using environmentally friendly substances that can provide the flame retardant function of textile material due to phosphorus-nitrogen synergism, as well as increase its antimicrobial properties.

Phytic acid (PhA) and polyhexamethylene guanidine phosphate (PHMG-p) have been investigated as functional substances capable of providing a complex finish to fabrics and imparting both antimicrobial and flame retardant properties. Blended cotton-polyester fabric was treated with an aqueous solution with the addition of citric acid (CA), which improves the solubility of PhA in water and increases the carbon residue during the combustion of the fabric. The tricarboxylic acid addition also provides cross-linking with the –OH groups of the cellulose component of the fabric. After impregnation with the finishing composition, the textile materials were pressed on a laboratory padder, dried at a temperature of 80°C, followed by heat setting at a temperature of 120°C for 5 minutes.

The fire resistance test of the fabric sample treated with the studied composition showed that the charring height after exposure to a flame for 15 seconds was 6.5 cm. At the same time, treated sample is characterized by the intumescent nature of the fabric behaviour during combustion. There was no residual burning of the fabric after removal from the fire. The absence of drop formation of the polyester component of the fabric was also noted.

Phosphorus-containing compounds, which include the biomacromolecule of PhA, are thermally decomposed to PO•, which can block combustion, although H• and HO• are formed when the matrix combustion is extinguished. On the other hand, phosphorus-containing compounds can catalyse dehydration and carbonization reactions containing –OH groups [1]. The condensed phase mechanism based on the use of PhA is further enhanced by the inclusion of PHMG-p containing nitrogen.

When the system is functionalized with nitrogen-containing compounds, mechanisms of gas-phase and intumescent action are observed through the release of NH3 during combustion. During the decomposition of the nitrogen-containing agent, a gas barrier of ammonia is formed above the surface of the substrate, which impedes the access of oxygen and inhibits the oxidation of carbon in the gas phase. Phosphorylation of cellulose is catalysed by nitrogen-containing molecules through the intermediates PN, CO_2, NH_3. It was shown in [2] that the formed carbon layer and the formed dense framework in this case may contain POP, POC, PNC bonds.

The results of thermal analysis it was found that the mass fraction of residue of the textile material treated with composition containing PhA and CA is 4.82% and 5.07% in the case of the addition of PHMG-p. The coke residue of the initial cotton-polyester fabric at a temperature of 700°C was 1.7%.

Given that textile materials are used in everyday life, transport and other public places, determining the effectiveness of antimicrobial treatment to inhibit bacterial pollution of air microflora is of great importance. This method is one of the simplest and fastest methods for studying air microflora and is used for comparative analysis of bacterial environmental pollution. For inoculation of microorganisms from the microflora of the environment, Petri dishes with solidified agar were left in an open space in a room for 15 min. Fabric samples in the form of a round disk were placed in a Petri dish on the surface of air-inoculated agar, covered, placed in a thermostat for incubation for 72 hours at a temperature of 38°C. The antimicrobial properties of textile materials were determined by analysing the diffusion of a fabric disk. The results of the study showed that the initial fabric is characterized by high bacterial contamination, the absence of an inhibition zone around it, and the development of various microflora inoculated from the air. Composite treatment shows a significant zone of growth inhibition of pathogenic microflora, that is observed even after the first washing. After the fifth washing, the quality of the antimicrobial treatment decreases, but still, at a distance of 1 – 2 mm around the sample, the maximum amount of microflora is suppressed. The zone of inhibition formed around textile samples treated with PHMG-p and biological PhA confirms the effectiveness of the antimicrobial treatment against a variety of airborne bacteria.

Thus, as a result of the study, it was proven that the composition containing phytic acid and polyhexamethylene guanidine phosphate, due to the high content of phosphorus and nitrogen, gives the cotton-polyester fabric flame retardant and antimicrobial properties.

References

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