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# IMPROVEMENT OF POLYACRYLONITRILE FIBER TO REDUCE FLAMMABILITY USING FIRE PROTECTION SYSTEMS

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**Abstract:** Today, synthetic fabrics and fabrics made of both natural and artificial fibres compete successfully in the textile and clothing industry. Chemical fibres have several specific properties that surpass the properties of natural fibres (heat resistance, abrasion resistance, durability, elasticity, etc.), which makes them indispensable in many industries. This article discusses the issues of improving polyacrylonitrile fibre to reduce flammability using fire protection systems

**Keywords**: fibre, natural and artificial fibres, heat resistance, abrasion resistance, durability, elasticity.

## Introduction

Today, the need for modern textile materials used in production is very high, and several special requirements are imposed on them in connection with their use in severe, sometimes extreme conditions. These types of materials must have fire resistance, oil-oil-water resistance, biocide, etc., and often a combination of properties. The problem of creating fire-resistant technical fabrics and non-woven materials of various natures and purposes is particularly relevant. This is because textile materials are a serious source of danger during a fire: they ignite easily, promote the spread of flames, and emit large amounts of smoke and gases when burned [1,2].

## The main part

Thus, in 2000, 24,860 fires occurred in Russia due to the burning of textile materials, of which 5,934 people died [3,4,5].

To reduce this risk, several states have passed regulations and laws prohibiting the use of products made from flammable fabrics. First of all, this applies to overalls, decorative, covering materials, curtain fabrics, and non-woven materials. For example, in the USA, and Germany, the use of only fire-resistant fabrics and coatings in public buildings has been legally approved for a long time. Even clothes for children and pensioners are made from such materials [6,7,8,9]. In Russia, fire-resistant materials are widely used for the production of overalls, and

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they are mainly obtained using imported preparations. These drugs and their dosage forms are very expensive, and fabrics treated with them cannot always ensure compliance with all special and hygienic requirements, in particular, formaldehyde content [10-15]. The essence of the complex phenomenon of the combustion process is manifested in the interaction of chemical and physical processes. Knowledge of the mechanism and kinetics of the chemical transformation of polymers into final combustion products allows for predicting their behaviour in fire-hazardous situations, controlling the combustion process, and creating fire-resistant materials. Despite a large number of studies, information on these issues in the field of chemical fibres and composite materials based on them is limited, and methods of directed control of their combustion processes have not been fully developed. Solving this important scientific and economic problem is based on the study of the laws of action of flame retardants (FR) of a certain composition and structure, composition of compositions, methods and parameters of thermal-oxidative decomposition and modification. Combustion of PM makes it possible to create the scientific basis of the modification technology that ensures the production of polymer materials with low fire resistance, which has dangerous and demanding operational characteristics and is an actual direction of research [16-22].
The purpose of this work is to develop the technology of modification of PAN fibres with hybrid systems that ensure the production of polyacrylonitrile fibres with reduced flammability for textile and technical purposes.

**Results**

To achieve this goal, the following tasks were solved:

1. Selection of fire protection systems and modification parameters for finished and freshly spun PAN fibres.
2. To study the effect of flame retardant concentration, and bath temperature on the sorption kinetics of PAN fibres and to determine the efficiency of fibre interaction with flame retardant (Figure 1).

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Interaction efficiency of flame retardants with PAN fiber

| Modifying Bath Composition | Concentration-ZG (T2 + PF) in the bath, % | Sorption time, min. | | | | | |
|---|---|---|---|---|---|---|---|
| | | 0,5 | 1 | 5 | 10 | 20 | 30 |
| | | Efficiency of interaction between CG and fiber, % | | | | | |
| T-2:PF: MTZ 1:1:0.1 | 10 | 54 | 63 | 63 | 61 | 64 | 59 |
| | 20 | 63 | 66 | 71 | 68 | 60 | 55 |
| | 30 | 45 | 59 | 53 | 45 | 52 | 53 |
| | 40 | 49 | 51 | 54 | 54 | 52 | 57 |
| T-2:PF: MTZ:FK 1:1:0,1:0,01 | 10 | 51 | 59 | 65 | 64 | 63 | 67 |
| | 20 | 65 | 68 | 70 | 67 | 51 | 59 |
| | 30 | 52 | 51 | 52 | 44 | 46 | 48 |
| | 40 | 46 | 52 | 56 | 53 | 55 | 49 |

**Figure 1. The effectiveness of the interaction of fibres with fire retardant**

3. Study of the effect of fire-resistant systems on the structure and properties of PAN fibres, pyrolysis and combustion indicators.
4. Determination of the possibility of using modified fibres in the production of carbon fibres.
5. It has been proven that there is a chemical interaction of flame retardants with PAN fibre. In the spectra of modified fibres, the characteristic vibration bands of the C=0 bond are significantly reduced and the vibration bands of the COC group appear; -MH2. The band of the free unbound (unassociated) hydroxyl group -OH expands and manifests itself at low vibrational frequencies of the bound -OH group formed as a result of the chemical interaction of the flame retardant (FG) with the fibre.
6. The effect of refractory substances on physicochemical processes during pyrolysis and combustion was determined. Refractories start cyclization processes, which is confirmed by a decrease in the temperature of the initiation of cyclization, a decrease in exothermicity, and a decrease in the activation energy of cyclization.
7. A high efficiency of the CG effect introduced into the newly spun fibre was found. This is due to differences in the structure and fixation mechanism of CG in the fibre. Modified fibres CI: finished 34%, freshly formed 40.5% vol.
8. CG has been proven to have a significant effect on the fibre structure, which leads to an increase in the degree of crystallinity from 40 to 58%, an increase in the size of crystallites

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from 0.015 to 0.020 μm, devitrification of amorphous regions and relaxation of stresses in fibres. amorphous phase of the polymer.

9. The advantages of processing modified fibres into carbon fibre have been revealed, which leads to an increase in carbon fibre yield due to the initiation of cyclization processes during thermal oxidation and a decrease in the rate of decomposition of modified PAN fibre.

The following basic rules for research are put forward:

1. Modification parameters for finished and freshly spun PAN fibres.
2. Mechanisms of interaction of flame retardants with PAN fibre.
3. Comprehensive studies on the composition of the modifying baths of ready and newly spun PAN fibres, the ratio of components, the effect of modification parameters on the structure, deformation-strength properties, pyrolysis mechanisms and evaluation of flammability indicators.
4. Effectiveness of using modified fibres in the production of carbon fibre.

**Conclusion**

1. The technology of modification of finished and newly spun PAN fibres has been developed, which ensures the creation of fire-resistant fibres for textile and technical purposes, CI. up to 34% by volume for modified finished fibre. and the modified new spun fibre retains the flame retardant effect after wet processing at -40.5% volume.
2. The effect of CG on physicochemical processes during pyrolysis and combustion of modified PAN fibres was determined. CGs have been proven to initiate the process of polymer cyclization, which is a decrease in the magnitude of exothermic peaks corresponding to this process, a decrease in the activation energy of the cyclization process (from 130 to 61 kJ / mol), an increase in CO yield (from 4% to 13%) and its thermal stability;
3. It was found that there is a chemical interaction between the carbonyl groups of the fibre and the hydroxyl groups of CG.
4. It has been proven that the use of modified PAN fibre in the production of hydrocarbons leads to a decrease in the cost of heat energy used for its production, a decrease in the defect and hairiness of the hydrocarbon, and a decrease in the amount. waste.

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