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Testing of Fire Retardants

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Abstract. The authors deal with the importance and significance of fire retardants for fire protection in practice. The main aim of this paper is to inform the readers about the possibilities of wood modifications by fire retardants. The authors present the experiment of testing wood specimens applying the experimental scientific method of test for limited flame spread on the test bench under laboratory conditions. The results of the experiment represent fire-technical characteristics that describe the wood behavior during the process of combustion. Different types of fire retardants are evaluated according to the selected evaluation criterion - the weight loss of test specimens. The conclusion summarizes the results of the experiment and recommendations for fire retardant modification in practice.

Introduction

In order to achieve the maximum level of protection of people against fire, it is necessary to create certain environmental conditions, acquire theoretical knowledge, and to be able to apply efficient methods and technical measures in practice. The public interest demands for increased safety and protection of society against fire in all sectors and areas. As a result, this particular attention also leads to greater interest in modifications of flammable materials.

Each fire contributes to the improvement and development of test methods for examination and evaluation of materials. It also helps to appeal to scientists, academic experts and people from practice to try to find different ways of fire protection and complex fire prevention. In the field of fire science, the method of conversion of combustible to noncombustible materials is one of the most ambitious challenges. Out of many fire prevention measures, a possible solution is the proper application of fire retardants.

Fire Retardants

Fire retardants have a long history of research, they have evolved considerably and their importance has grown rapidly. After their introduction into production, manufacturing technologies and general use in the previous century, they have significantly reduced losses of life and fire-related property damage. Nowadays, these substances have their specific place in nearly all industries. The quality and effectiveness of fire retardants are increasing in terms of safety, ease of application, economic efficiency and environmental protection.

In the effective interaction with other fire-fighting equipment and measures, such as fire extinguishers, smoke detectors, fire alarms and fire closures, fire retardants represent one of the most affordable and effective solutions how to protect people, property and environment against fire. A fireproof combustible material has always been a challenging target, not only in the field of fire science.

Fire retardants are chemical impregnating substances that in chemical, physical or combined way protect and prevent ignition, slow down the process of burning of combustible materials and eliminate undesirable causes of fire and conflagration. The principle of retardation process is based either on physical blocking of fire or initiating the chemical reaction that stops the process of combustion.

Most retardants work by preventing the access of oxidizing agent (for example air), but they are also able to affect the ratio of flammability or to upgrade flammability parameters and characteristics of impregnated material which is protected.

Fire retardants have the ability to protect impregnated material from direct contact with flame, flameless combustion (smoldering) and higher temperatures of fire. The retardation of process of combustion is a complex process that depends on several synergistically contingent factors. The process of retardation of new materials (e.g. plastics) is relatively simple compared to the process of retardation of natural materials (e.g. wood), which is considerably more complicated [1, 2].

In current engineering practice, a variety of different types of fire retardants and retardant modifications are being used, primarily to achieve flammability reduction of the most commonly used substances. They can be applied to finished products or added during the material processing. The application methods and mechanism of action of fire retardants depend on the characteristics of the fire retardant and the properties of the treated material that we want to protect against the negative effects of fire.

Fire retardants can be applied to various types of surfaces and materials: construction and design elements, claddings on ceilings and walls, flooring, insulation materials, electrical appliances, electronic equipment, cable bundles, wood, furniture, plastics, metals, indoor and outdoor paints, textiles, toys and others [3].

Types of Fire Retardants

Classification of fire retardants according to the principle of retardation [4]:

- Fire retardants that release and emit inflammable gases in the heat interval, when the combustible gases are generated by thermal decomposition of the flammable material. This leads to dilution of flammable gases and their difficult ignition.
- Fire retardants that accumulate heat from the heat source and cool it.
- Intumescing (foaming) fire retardants that have two levels of effectiveness (physical and chemical). On the first level they create a few centimeters layer of foam that separates flammable material surface from the heat source. Then the material is slowly heated and the second level follows – the consequent chemical reaction slows the process of burning.
- Fire retardants of mechanical type for example films and various claddings of non-flammable materials.

Classification of fire retardants depending on the way of application:

- Application by coating – e.g. coatings on metals.
- Application by soaking – e.g. additives in plastics (PVC).
- Application by impregnation – e.g. impregnation of wood and wood products.

The proper choice of fire retardant, its application and the professional assessment of conditions the retarded component or material is exposed to and will be affected by, represent functional unit retardation [5]. In other words, the quality and functional system of retardation consists of appropriate selection of fire retardant, its suitable application and professional evaluation of environmental conditions of the protected material, as well as external factors affecting this material. Currently the wood is becoming popular material for houses, buildings and similar constructions [6].

In Slovakia, there is no compulsory standard testing of wood constructions. The risk of fires in residential timber constructions cannot be completely eliminated, therefore there is a need for proper and correct implementation of preventive measures and application of fire retardants. They may significantly reduce the risk of fire, in case of fire they slow down the combustion process, protect the life of people, animals and also the building itself until the fire and rescue service intervention.

Experiment

The experiment presented experimental scientific method of testing fire retardants using the test for limited flame spread on the test specimens on the test bench under laboratory conditions. This laboratory method was developed in the Fire-chemical laboratory of the Department of Fire Engineering, Faculty of Security Engineering, University of Žilina as an internal document [7] with the aim of becoming an STN standard. The methodology was created with the purpose of evaluating the specimen combustion behavior when exposed to a direct mid-height flame for a longer time period. It describes and specifies a fire test for testing retardant treatments of combustible materials exposed to a mid-height flame, with the surface exposure angle of 45° to the vertical axis [8].

The construction of the test bench for the test of limited flame spread determination is made of materials resistant to heat and combustion products released during the test. The test bench for the experiment consists of these parts: propane gas cylinder with technical propane, flow meter, gas burner, test specimen and the holder for the test specimen. The scheme of the test bench is shown in Figure 1. The fuel source in the experiment is a pressure cylinder with a technical propane-butane mixture with purity of at least 95%. Other devices required for the realization of the experiment are calibrated scales (with a precision of at least two hundredths of a gram) used for mass measurement of the specimens and time measurement devices for the measurement of flame exposure duration.

The test specimen was placed in the device holder at angle 45° and exposed to the effects of flame for 5 minutes. For each individual measurement, the distance from the center of the test specimen to the mouth of the gas burner and also the defined height of flame were accurately defined. In every single testing the unified testing procedure was strictly observed [7].

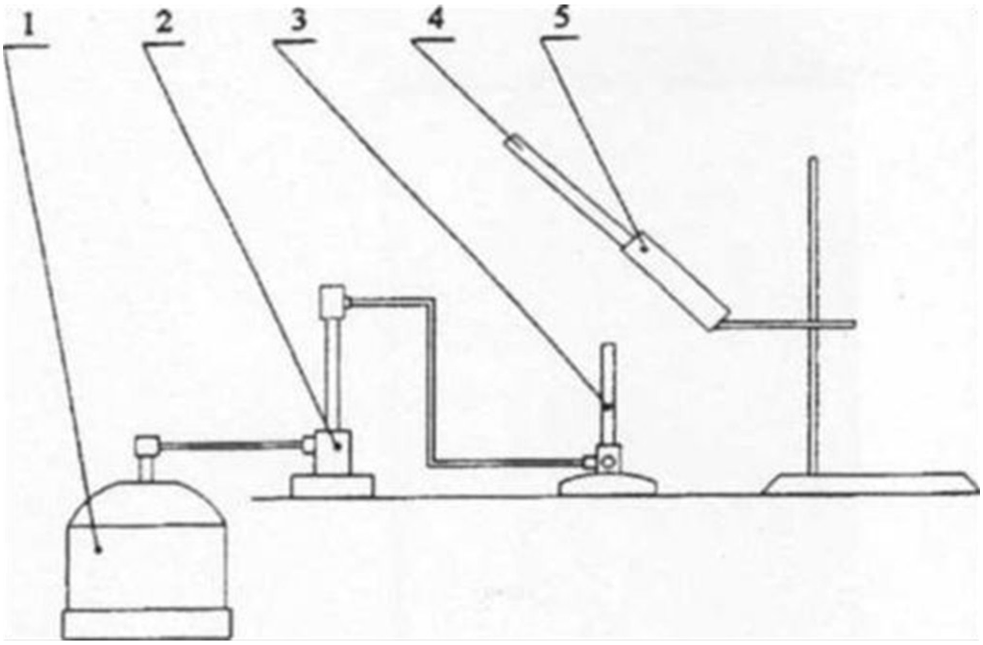

***Figure 1.** Scheme of test bench: 1 – propane gas cylinder, 2 – flow meter, 3 – gas burner, 4 – test specimen, 5 – test specimen holder. [9]*

The test specimens were spruce wood boards with dimensions 200 x 95 x 10 mm (± 1 mm). On each set of test specimens of 5 pieces (Figure 2) different types of fire retardants were applied. The specimens were subsequently tested and evaluated by the combustion process characteristics. We used the following fire retardants: FaluRed commercial (FR), Plamostop Standard (PS STD), PLS 75 - PKH 4 - Nanopol 1264 (R 01), OLS 75 - alkyd - PKH 4 - Nanopol 1264 – AcA (R 02), OLS 75 - PKH 12 - Nanopol 1264 (R 03), Hydrospol D-01 alkyd dispersion (HD 01), OLS 75 - PKH 16 - Nanopol 1264 - alkyd 5 (R 04), Hydrospol 01 - PKH 5 - FaluRed 5 (R 05), OLS 75 - PKH 26 - FaluRed 5 - 9 Nanopol 1264 (R 06) and OLS 70 - Cloisite 30B/2 - PKH 13 (R 07).

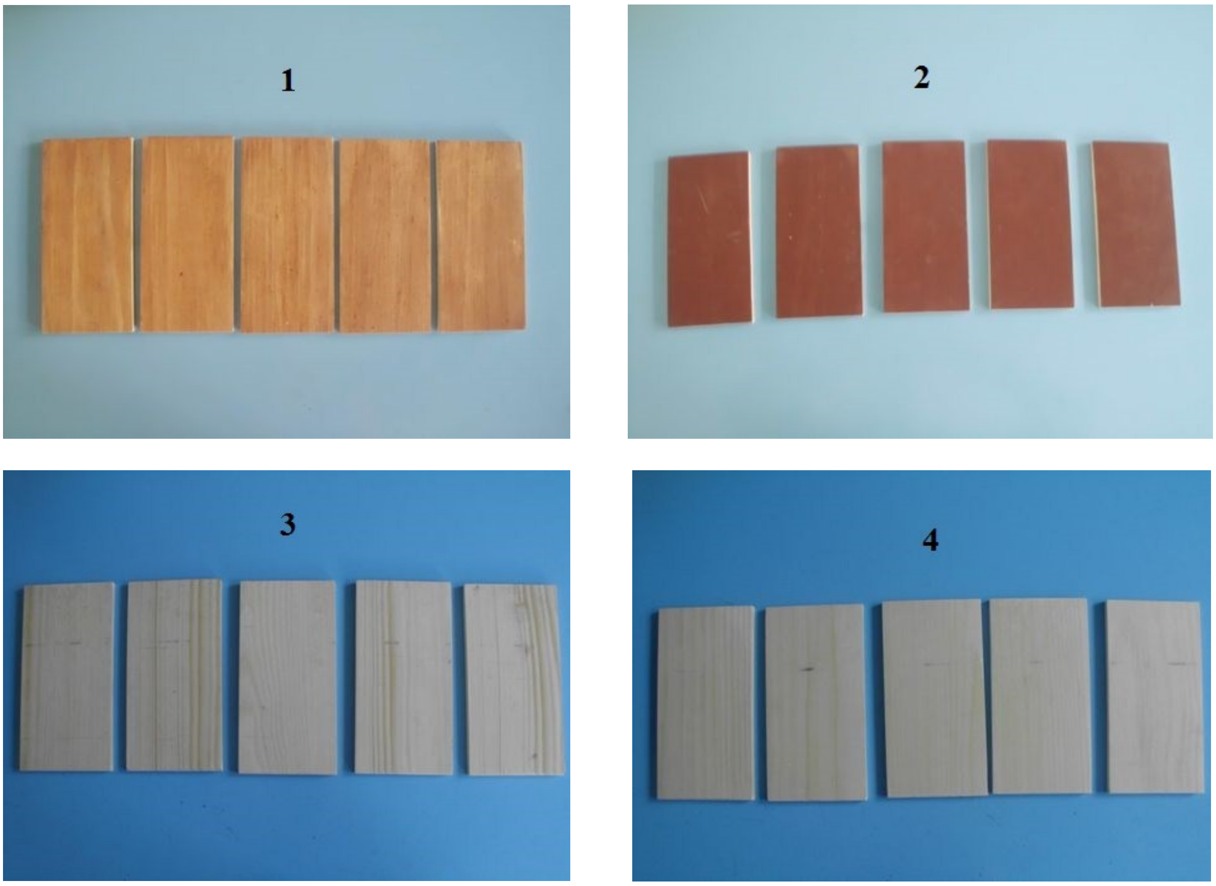

Figure 2. *Sets of test specimens before the experiment: 1 – Plamostop Standard (PS STD), 2 – OLS 75 - PKH 26 - FaluRed 5 - 9 Nanopol 1264 (R 06), 3 – OLS 70 - Cloisite 30B/2 - PKH 13 (R 07) and 4 – PLS 75 - PKH 4 - Nanopol 1264 (R 01).*

Results of Experiment

The experiment was performed in accordance with the methodology for the test of limited flame spread: each test specimen was placed in the test device (in the holder under the angle of 45°) and was exposed to the effects of an open mid-height flame for 5 minutes (Fig. 3). For each individual test the height of the flame was exactly defined. Similarly, for each test the unified test verification methodology was adhered to. Fire retardants have been rated by evaluation criterion: weight loss of test specimens.

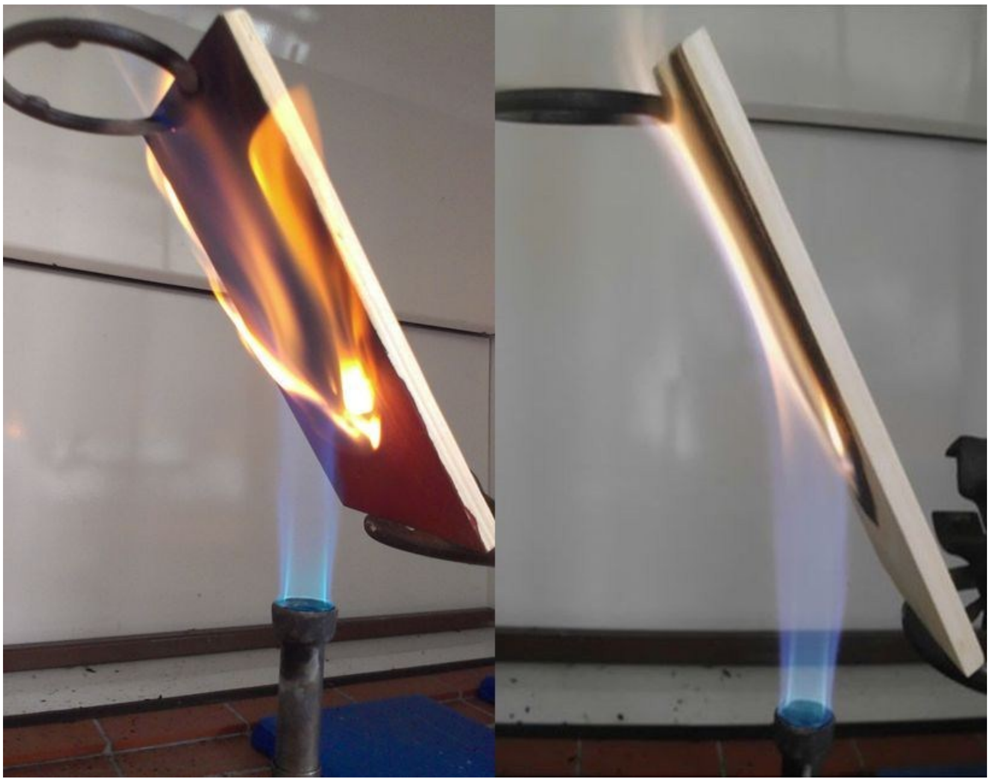

Figure 3. *The realization of experiment - test specimens during the test of limited flame spread.*

The following Table 1 shows the results of the experiment - the average values of evaluation criteria for each set of test specimens of tested fire retardants. The Figure 4 and Figure 5 present the comparison of results of evaluation criterion weight loss (in grams) from the experiment.

Table 1. *The data of weight loss of test specimens.*

Fire Retardants	Weight before Experiment [g]	Weight after Experiment [g]	Weight Loss [g]	Weight Loss [%]
FR	93.48	80.22	13.26	14.14
PS STD	84.10	78.74	5.35	6.49
R 01	91.27	76.13	15.14	16.63
R 02	83.53	71.27	12.25	14.91
R 03	92.98	77.32	15.66	16.81
HD 01	93.81	76.91	16.90	17.76
R 04	90.84	74.23	16.61	18.26
R 05	84.62	72.61	12.01	14.23
R 06	79.10	69.43	9.67	12.21
R 07	92.86	79.71	13.16	14.28

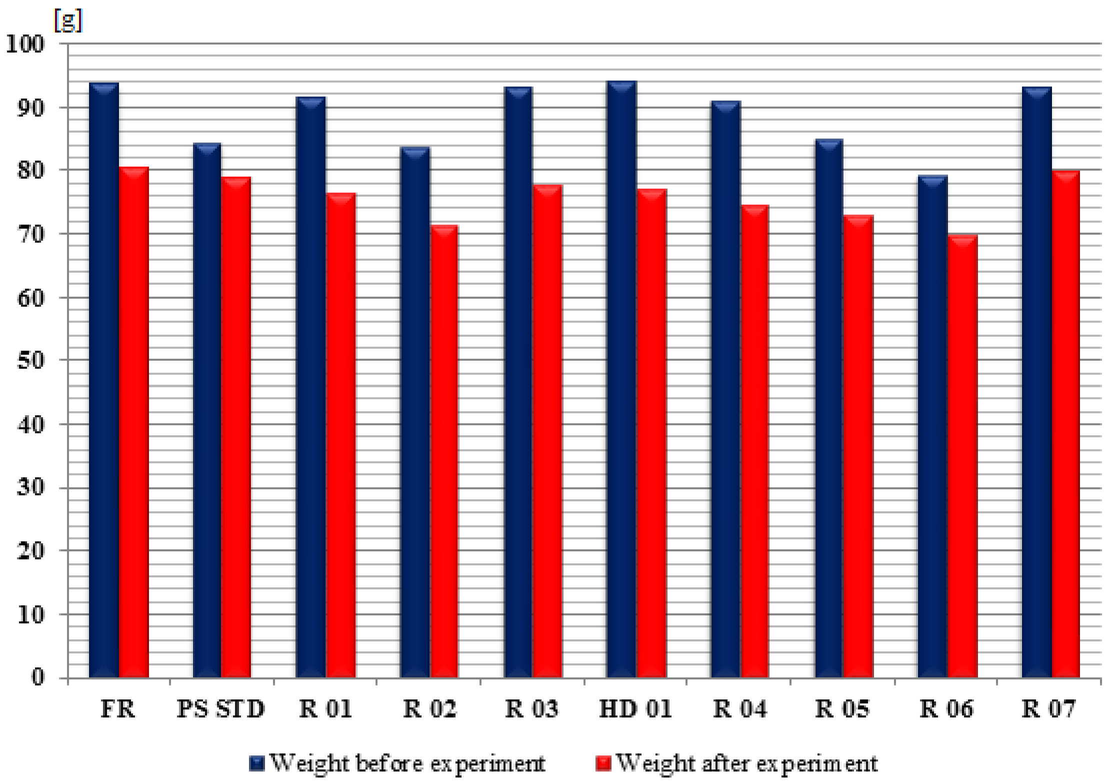

Figure 4. *The comparison of weight of test specimens before and after the experiment.*

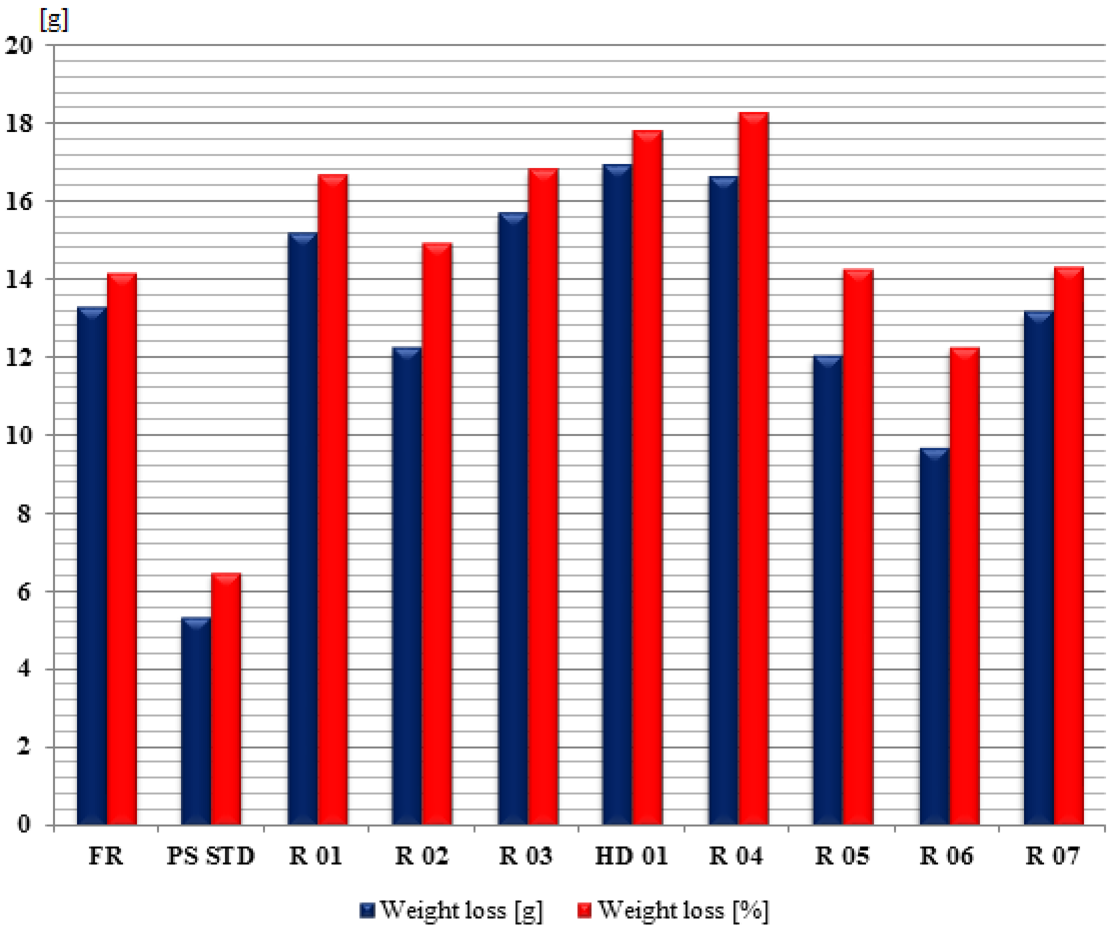

Figure 5. *The comparison of weight loss of test specimens.*

Conclusion

The experiment tested different types of fire retardants by the test method for limited flame spread test in laboratory conditions. If we consider chemical-physical reaction in the flame attack, each of the tested retardants worked on a different principle. Due to this fact, we were able to achieve interesting results.

From the obtained values of the individual evaluation criteria we can select the most effective fire retardants of all the tested types: Plamostop Standard (PS STD), OLS 75 - PKH 26 - FaluRed 5 - 9 Nanopol 1264 (R 06), OLS 70 - Cloisite 30B/2 - PKH 13 (R 07) and FaluRed commercial (FR). The best results were achieved by Plamostop Standard. It had the lowest value of weight loss and was able to withstand initiation of the combustion process longer than the other tested retarders.

This retardant is opaque, white color and is applied by coating. It is one of intumescent fire retardants that work on the principle of creating an insulating layer in the form of foam during testing to prevent the transfer of heat to the wood as the material of test specimens (Figure 6).

Figure 6. *Sets of test specimens after the experiment.*

Besides fire-fighting equipment, signaling and alarm equipment, material means and fire prevention inspections, fire retardants are one of the most affordable and effective systems used to protect life and health of people, animals, property and environment from potential fire hazard.

Currently, fire hazards are associated with the use of flammable components and materials that cause loss of life, damage to property and contamination of environment. Their risk reduction is particularly desirable with government regulators, manufacturers etc. To reduce the unwanted effects of fire, it is advisable to use fire retardants that limit the combustion process and are able to slow the spread of fire time. The proper application and use of fire retardants to reduce the risk of fire and increase fire protection is becoming a key part of the development and use of new technologies. Various statistical studies and scientific research have repeatedly demonstrated the importance of fire retardants for the whole society.

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