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FIRE SAFETY OF FILLED POLYOLEFINS BY STUDYING FLAMMABILITY AND SMOKE-PRODUCING ABILITY

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Abstract:
This article discusses the fire safety of polyolefins in the example of polyethylene filled with silicon-containing flame retardants used in everyday life and the construction industry. The flammability and smoke formation of the proposed polyolefin materials has been studied, and based on the results they can be classified as fireproof materials

Keywords: fire safety, polymer material, fire retardant, polyethylene, flammability, smoke generation.

INTRODUCTION

Today, studies of large fires in the world show that the rapid spread of flames through polymer materials and the release of thick smoke by them lead to great problems in evacuating people and saving material assets. That is why large-scale scientific research into the problems of finding scientific and technical solutions in the direction of ensuring fire safety is being carried out all over the world. In particular, much attention is paid to the use of a number of effective means in the field of fire protection of various building structures, finishing and textile materials, including through treatment with heat-insulating compounds, as well as the creation and study of fire-retardant properties of elements of heat-resistant polyolefins, paints and other materials [1-2].

When studying the flammability of the proposed fire retardants, local raw materials of LDPE grades P–Y 342 and F–Y–720 with a density ρ=0.9220 g/cm^3 were used for stabilization. The preparation of the studied compositions from the indicated components is carried out using a method using electronic scales. All created PE components were weighed in 1.0 g (PE) from 1 to 3% and then we added flame retardants AP-1, AP-2, AP-3, AP-4, AP-5, AP-6 to them. For dry PE powders, fire retardants were added and thoroughly mixed, then the resulting mass was heated at a temperature of 373–393 K. Having prepared a thoroughly mixed mass, a film 2.5–3.5 mm thick was formed using the pressing method. The synthesized fire retardants were modified by adding water-based acrylic paints in a ratio of 1:0.01 moles per 10 ml of 1–7%

fire retardant coating to determine the increase in their heat resistance and flammability. The prepared mass was thoroughly stirred and applied as a coating 2–3 mm thick on wood [3], after which it was dried in the open air for one day. In order to carry out the above modifications of fire retardants, the test sample in the form of a plate measuring 100x10x1 was fastened across its width in a horizontal position so that the length of the unfastened part of the sample was at least 80 mm. Then the samples were ignited using a burner. The flame was fixed at an angle of 45 ± 1°. After 60 sec the sample was ignited, the fire was extinguished. At the same time, a stopwatch was started and the burning time of the sample was determined. The method is intended for comparative assessment of the relative ability of plastics to ignite when exposed to an ignition source. Figures 1–2 show the combustion process and combustion performance of the original low-density PE and the silicon-based AP-6 flame retardant improved [4].

As a result of the research, it was found that silicon flame retardant AP-6 helps to increase thermal conductivity, unlike other flame retardants AP-1, AP-3, AP-4, since it is associated with fluorine and silicon atoms, which inhibit the combustion process of polyethylene.

а б

Fig. 1. Combustion (a) and coke residue (b) of LDPE film without fire retardant

а б

Fig. 2. Combustion (a) and results after combustion (b) of a film modified with silicon containing fire retardant LDPE AP–6

The catalytic effect of fluorosilicates on the destruction process of polymer materials also makes it possible to move the process in the direction of lowering the thermal result, and, consequently, lowering the maximum heat release rate [5-6].

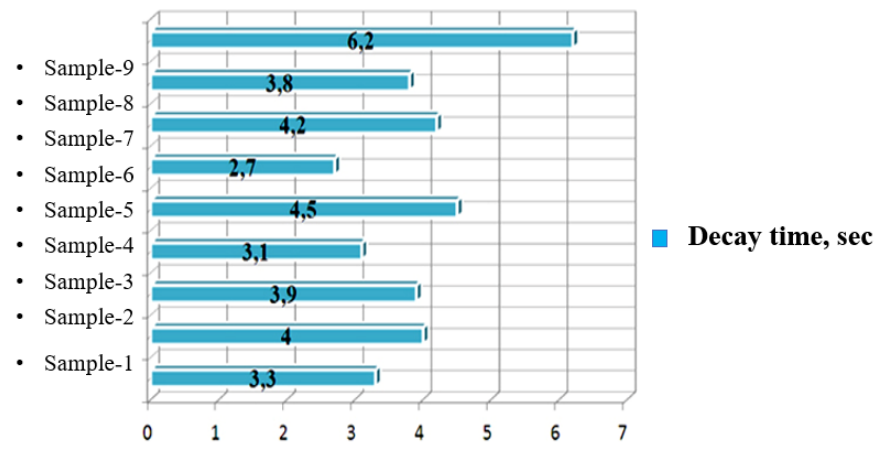

Fig.3. Dependence of the decay period on the composition of the modified polyolefin: 1–PE+ AP–1 (1%); 2–PE+AP–2; 3– PE+ AP–3; 4– PE+ AP–4; 5– PE+ AP–5; 6– PE+ AP–6; 7–PE+AP–1(0.5%); 8–PE+AP–1(2%); 9– PE without fire retardant.

The study of the flammability of the modified polyolefin in accordance with GOST 21317–81 suggests that the use of certain general flame retardant systems leads to a reduction in the remaining burning time, and in terms of this parameter, LDPE+AP–5 turned out to be the most effective fire extinguishing composition (Fig. 3).

For this reason, the remaining heating of the polyolefin improved with the AP-5 flame retardant, which contains silicon, did not exceed 10 s, and this made it possible to transfer the polyethylene material to the TG category. According to research conducted on the heat resistance of the resulting compounds, the oligomeric mixture of PE and fire retardant leads to synergistic effects and, therefore, indicates the moisture resistance of the resulting compound (tabl.1).

During combustion, coke is formed on the surface of the modified polymer material, since the adduct of urea and orthophosphoric acid forms a foaming layer, thereby helping to create a polyphosphoric acid barrier that slows down the interpenetration of oxygen from the air into the combustion zone, and also stops the release of floating destructive products from the outside .

Table 1.Results of a study of the flammability of composites based on PE with silicon-containing oligomeric flame retardants

№	Samples	Time of independent combustion with sequential attenuation, s.	Ignition temperature, K	Oxygen index, %
1.	PE without stabilizer	180	616	18
2.	PE with addition + 1% AP–1	95	674	27
3.	PE with addition + 1% AP–2	98	671	26
4.	PE with addition + 1% AP–3	91	705	25,7
5.	PE with addition + 1% AP–4	87	714	30
6.	PE with addition + 1% AP–5	115	638	23
7.	PE with addition + 1% AP–6	76	710	29

8.	PE with addition + 1% CESA™–flam PE 41329/A	95,5	706	26,4

An important role in the search for new fire-resistant and heat-resistant materials is determined by the need to solve constantly emerging technical and environmental problems [7-8]. To solve these problems, there are at least two approaches. The first approach is to create completely new fire-resistant materials. The second approach is the modification of a known material, for example, the introduction of additives into large polymer production that change their properties. The economic efficiency of the second method is obvious, since its implementation does not require large expenses.

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