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Investigation of Smoke-Forming Properties of Fire-Resistant Convex Polymer Composite Coatings

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ABSTRACT: In this paper, the dependence of the smoke formation coefficient of epoxy resin-based fire-resistant convex polymer composite coatings E-44-1, E-44-2 on the ratio of polymer binders, corrosive chemical additives and the proposed new type of flame retardants.

KEYWORDS: Epoxy resin, composite, intumescent, polymer binder, adhesion, antipyretic.

I. INTRODUCTION

The construction industry is a large-scale consumer of diane epoxy oligomers, which is due to a wide range of technological, physico-mechanical, thermophysical and physico-chemical properties of materials based on them and a relatively accessible raw material base for their synthesis [1-3]. Epoxy oligomers are used as binders in the production of carbon-, basalt-, and glass-reinforced plastics, composite reinforcement, various chemically resistant coatings, polymer solutions, and polymer concrete for the repair and reinforcement of building structures, foam plastics, adhesives, and monolithic floor coverings [4–14]. Epoxy oligomers are used, as a rule, in the form of multicomponent compositions containing, in addition to epoxy resins and hardeners, various plasticizers, fillers, pigments, fire retardants, synergists, and other functional additives.

The wider use of polymer composite materials (PCM) based on epoxy oligomers in the construction industry is hindered by their increased fire hazard [15–18]. Therefore, establishing the influence of the content and chemical nature of the initial components on the main indicators of the fire hazard of epoxy PCMs will make it possible to purposefully control the flammability, combustibility, and smoke-generating ability of such materials.

The effect of mineral additives, foaming chemical additives, flame retardants and other chemicals on the temperature stability, flammability, oxygen index and smoke-forming properties of polymer composite materials based on epoxy resin was studied in experimental processes.

Based on the samples taken in the experimental work, studies were conducted to determine the coefficient of smoke formation experimentally: temperature, 14.2^{o}C; atmospheric pressure, 97.7 kPa. Features of measuring instruments: "Determination of smoke formation coefficient" GOST 12.1.044-2018 [19, 20].

The positive effect of phosphorus-containing chemicals on the smoke-forming properties of the proposed epoxy resin-based fire-retardant convex polymer composite coatings was identified during the experiments. According to that, different ratios of phosphorus-containing substances were studied, and an increase in the amount of phosphorus substance reduced the ability to form smoke.

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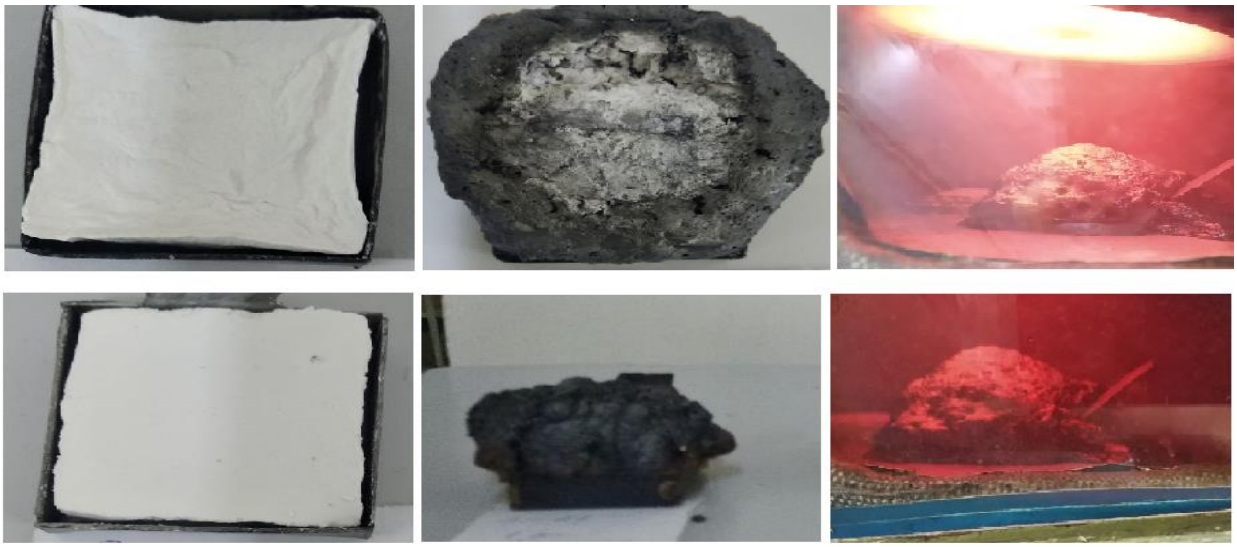

Figure 1. Experimental testing processes of smoke formation coefficients of epoxy-based fire protection, convex polymer composites.

The dependence of the smoke formation coefficient of epoxy resin-based fire-resistant corrugated polymer composite coatings E-44-1, E-44-2 on the ratio of polymer binders, corrosive chemical additives and the proposed new type of flame retardants was studied.

Pentaerythritol: urotropin (1:0.5), melamine: urea (1:1.5), ammonium sulfate: ammophos (1:1.5) from the chemicals that form the convex polymer composite coating of fire protection brand E-44-1 based on epoxy resin. (1:1) and convex graphite: urea (1:1.5) was obtained in the above proportions and added to the polymer composite in different percentages to form smoke. When the results were analyzed using the data presented in Figure 2, it was found that the proposed ratios of pentaerythritis: urotropin (1: 0.5) were more effective than the other ingredients.

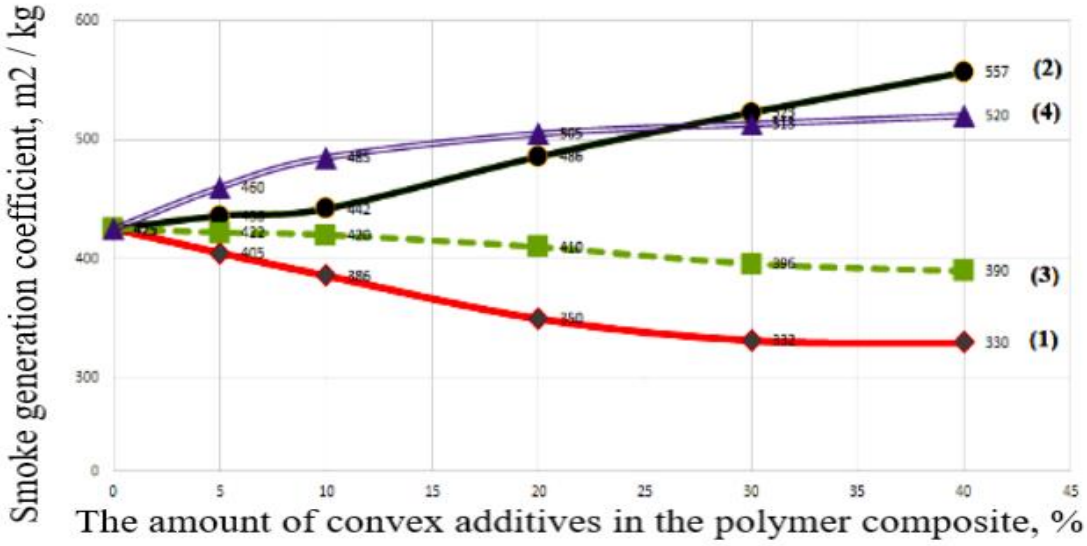

Figure 2. The polymer composite contains (1) pentaerythritol: urotropin (1:0.5), (2) melamine: urea (1:1.5), (3) ammonium sulfate: ammophos (1:1) and (4) convex graphite: the effect of urea (1:1.5) on the formation of smoke.

In these results, various ratios of pentaerythritis: urotropin mixture, which gave a good effect on the formation of polymer composite smoke, were also analyzed and scientific conclusions were drawn. Thus, the ratios of pentaerythritis: urotropin (1:0.5; 1:1 and 0.5:1) were studied (Fig. 3).

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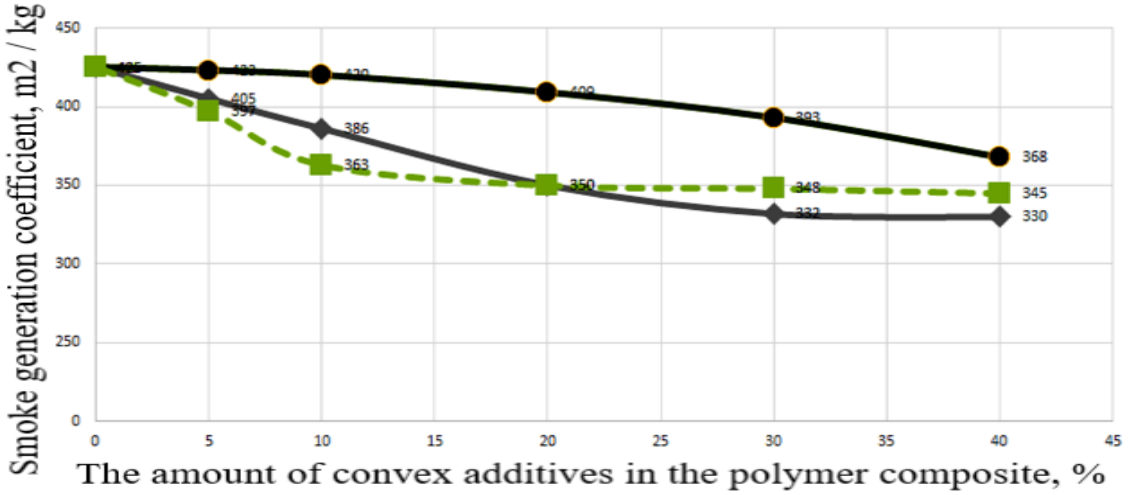

Figure 3. Pentaerythritis, a bulging chemical in the polymer composite: effects of urotropin in different ratios on the formation of smoke 1- (1: 0.5), 2- (1: 1), 3- (0.5: 1).

Thus, the 1:0.5 ratio of pentaerythritol and urotropin added to the E-44-1 refractory polymer composite coating based on the proposed epoxy resin gives better results than the analogues in the E-44-1 polymer polymer about 28% were found during the study.

In the following experimental studies, the amount of flame retardant compounds in the polymer composite of the brand E-44-1 was studied. According to it, the effect of ARM-1, ARM-2, ARM-3, ARM-4, ARM-5 and pyrilox brand flame retardants on the property of polymer composite smoke formation of different proportions of mass fractions was determined (Fig. 4).

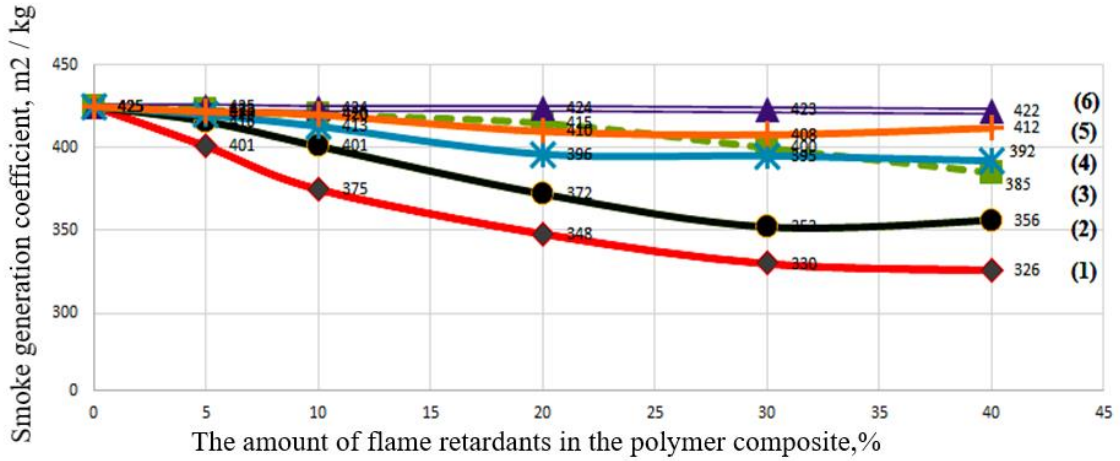

Figure 4. Flame retardants of polymer composite (1) -ARM-5, (2) -ARM-1, (3) -pyrylox, (4) -ARM-2, (5) -ARM-3 and (6) -ARM-4 The effect of the amount on the property of smoke generation.

The different ratios of the new proposed flame retardants of different brands and analogous flame retardants imported from different figures shown in Figure 4 were studied and it was determined that the ARM-5 brand flame retardant is relatively good. That is, it can be seen that the smoke formation coefficient of E-44-1 brand polymer composite based on epoxy resin decreased from 425 m^2/kg to 326 m^2/kg with the addition of 40% flame retardant. However, the adhesion of the polymer coating was found to drop from 1 to 2 points. Therefore, it was required that the proportion of ARM-5 flame retardant in the proposed polymer composite E-44-1 should not exceed 30%. When 30% flame retardant is added, the smoke formation coefficient equals to 330 m^2/kg and the adhesion makes up 1 point.

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The composition of the polymer composite brand E-44-1 based on epoxy resin was found to be effective in obtaining the following ratios.

Polymer binder:

epoxy resin	28
polysulfide rubber	10
zinc oxide	1
hardener	3
Convex extra:	
pentaerythritis	20
urotropin	8
Flame retardant: ARM-5	
metal-bearing adduct	30

The chemical composition of the convex polymer composite coating of fire protection brand E-44-2 based on epoxy resin and the amount of flame retardant were studied. The effect of the amounts of different chemical compounds forming the convexity in Table 1 on the convection temperature of the polymer composite, the oxygen index and the formation of smoke was studied and the experimental test results were compared with analogues.

Table 1

Effect of chemical compounds forming bubbles on the properties of epoxy resin-based E-44-2 fire-retardant convex polymer composite coating

Convex-forming chemical compounds, %		Convection temperature, °C	Oxygen index,%	Smoke generation coefficient (pyrolysis), Dm = m^2/kg
-		-	17-18	425-430
pentaerythritis urotropin (1:1)	45%	200-350	30	410-415
pentaerythritis	20%	200-400	34	350-362
pentaerythritis chlorparaffin graphite (1:0,5:0,5)	48%	200-300	26	440-450
pentaerythritis vermiculite ammonium polyphosphate (1:0,5:1)	44%	200-400	24	410-400

Experiments have shown that the addition of pentaerythrite at a rate of 20% of the chemical composition of the convex polymer composite coating for fire protection E-44-2 has a better effect than other similar compounds.

Subsequent experiments studied the effect of different proportions of flame retardants on the swelling temperature, oxygen index and smoke formation coefficient for the E-44-2 brand fire-resistant convex polymer composite coating.

Table 2

Effect of flame retardants on the properties of epoxy resin-based fire-resistant corrugated polymer composite coating brand E-44-2

Convex-forming chemical compounds, 15%	Convection temperature, °C	Oxygen index,%	Smoke generation coefficient (pyrolysis), Dm = m^2 /kg
-	-	17-18	425-430
APM-1	200-420	30	410-415
APM-2	200-400	34	350-360
APM-3	200-400	26	440-450
APM-4	200-420	24	410-400
APM-5	200-380		388-395
APM-6	180-300		360-372
Pyrilox	200-400		380-410

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The ratios of up to 15% of newly offered flame retardants of different brands and analogous flame retardants imported from abroad are shown in Table 2 and it was determined that ARM-2 brand flame retardants are relatively good. That is, it can be seen that the smoke formation coefficient of the polymer composite brand E-44-2 based on epoxy resin decreased from 425 m^2/kg to 350-360 m^2/kg with the addition of 15% antipyrene. Therefore, it was required that the proportion of ARM-2 brand flame retardant in the E-44-2 polymer composite we offer should not exceed 15%. Adhesion accounts for 1 point when 15% flame retardant is added.

The composition of the polymer composite E-44-2 based on epoxy resin was found to be effective in obtaining the following ratios.

Polymer binder.	
epoxy resin	31
polysulfide rubber	5
zinc oxide	0,5
hardener	3,5
Convex extra	
pentaerythritis	20
Flame retardant ARM-6	
ammonium polyphosphate	35
urea formaldehyde resin	5

II. CONCLUSION

Thus, the proposed epoxy resin-based E-44-1, convex polymer composite coating added to the fire-resistant convex polymer coating gives better results than its analogues. E-44-1 polymer contains about 28% of the total mass detected.

It can also be seen that the smoke formation coefficient of the epoxy resin-based polymer composite E-44-2 decreased from 425 m^2/kg to 350-360 m^2/kg with the addition of 15% antipyrene. Therefore, it was required that the proportion of ARM-2 brand flame retardant in the E-44-2 polymer composite we offer should not exceed 15%.

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