The development of thermo- and fire-resistant composite nanomaterials based on unsaturated polyester resin with metal oxides nanoparticles.

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Abstract. Composite materials based on unsaturated polyester resins (UPR) are used in many areas: aviation, railway, construction. But on the other hand, there is a major drawback - the low fire resistance of such materials, which combustion of composite materials based on UPR is accompanied by the formation of toxic substances. For example, the release of carbon monoxide (CO) with the formation of toxic gaseous hydrocarbon compounds, which are a threat to human life. Also, during combustion, the polymer melting and the formation of molten polymer droplets occur, as a result, the combustion area is significantly increased. Therefore, the development of composite materials based on UPR has become an urgent task to resist combustion, as well as reduce the release of toxic gases. In the present work, the nanoparticles (NPs) of the following metal oxides were used: ZnO, Al_2O_3, Cu_2O, $ZnO@SiO_2$, and $Al_2O_3@SiO_2$ as fire retardants with polyphosphate melamine, they are effective materials to enhance the fire resistance properties of composite materials based on UPR during combustion.

The main goal of the present work was to develop thermo- and fire-resistant nanocomposite materials based on UPR using the various metal oxides of NPs as flame retardants.

To achieve this goal, it was necessary to solve the following tasks:

1- Modification methods and synthesis of spherical and rod-shaped zinc oxide NPs and study the effect of surfactants: sodium oleate and sodium lauryl sulfate on the morphology and size of zinc oxide NPs;

2- Synthesis of aluminum oxide NPs and determine the influence of the main synthesis parameters (synthesis time and pH) on particle formation, and study the effect of sodium oleate and glycerol on the morphology and size of aluminum oxide NPs;

3- Synthesis of Cu_2O NPs;

4- Preparation of NPs with core-shell structure: $ZnO@SiO_2$ and $Al_2O_3@SiO_2$;

5- Obtaining composite materials based on UPR by the chemical curing method;

6- Studying the combined effect of polyphosphate melamine with ZnO NPs various shapes, $ZnO@SiO_2$ and $Al_2O_3@SiO_2$ particles on the thermo- and fire-resistant properties of nanocomposite materials based on UPR.

Scientific novelty.

1. For the first time, flame- and heat-resistant polymer composite materials based on UPR containing $ZnO@SiO_2$, $Al_2O_3@SiO_2$, and Cu_2O particles with polyphosphate melamine have been obtained, it was found that the polymer nanocomposite materials containing 6 wt.% MPP, 1.9 wt.% $ZnO@SiO_2$ particles and 0.1 wt.% Cu_2O NPs or 6 wt.% MPP, 1.8 wt.% $Al_2O_3@SiO_2$ particles and 0.2 wt% Cu_2O NPs are self-extinguish at the beginning of combustion;
2. 2. The role of Cu_2O NPs in the combustion of polymer nanocomposites based on UPR has been established. It is shown that with an increase in the concentration of Cu_2O NPs from 0.1 to 0.5 wt%, the formation of char residue increases, which creates a thermo- and fire-resistant barrier that leads to self-extinguishing of the polymer nanocomposite.

The theoretical and practical significance of the work. In this work, nanoparticles (NPs) of the following metal oxides: ZnO, Al_2O_3, Cu_2O, $ZnO@SiO_2$, and $Al_2O_3@SiO_2$ were synthesized and used as fire retardants to develop nanocomposite materials based on unsaturated polyester resin. The importance of developing composite materials based on UPR is to create thermo- and fire-resistant composite materials for use in many fields. According to the set of the experimental investigations conducted in this work, the developed composite materials with the combination of nanoparticles ZnO, Al_2O_3, Cu_2O, $Al_2O_3@SiO_2$, and $ZnO@SiO_2$ were successfully presented to improve the fire - and thermal resistance.

Defense provisions.

1. Increasing the fire and heat resistance of polymer composite materials based on UPR due to insert a combination of ZnO, Al_2O_3 and Cu_2O NPs and $Al_2O_3@SiO_2$, $ZnO@SiO_2$ particles with melamine polyphosphate.
2. The synergistic effect of metal oxides NPs, and $Al_2O_3@SiO_2$, $ZnO@SiO_2$ particles with melamine polyphosphate on the fire- and heat-resistant properties of nanocomposites based on UPR.