Summary

The doctoral thesis concerned the development of innovative systems that reduce the flammability of polymeric materials.

The study was divided into five parts:

- ✓ The use of natural fibers to obtain environmentally friendly elastomer composites.
- ✓ Application of POSS in a synergistic system with organic phosphorus compounds.
- ✓ Development of ceramizing composites based on a low weight, metal-modified cenospheric filler.
- ✓ The use of basalt filler to obtain composites with a reduced fire risk, including ceramizing composites.
- ✓ Preparation of elastomer composites with reduced fire risk with the use of carbon filler.

The first part of the work describes the results of research on the influence of cellulose filler, in the form of wheat straw, on thermal and mechanical properties as well as fire hazard of natural rubber composites. It has been shown that cellulose, also in its chemically unmodified form, can effectively reduce the flammability of elastomer composites containing it. On the basis of the obtained test results, it was proved that in the synergistic system with natural fiber, the ammonium polyphosphate and aluminum hydroxide system is characterized by the highest effectiveness.

The second part presents the effect of POSS also in a synergistic system with melamine polyphosphate on the thermal properties and flammability of silicone rubber composites.
On the basis of analyzes performed with the SEM-EDX technique and cone calorimetry, it was shown that POSS, by catalysing the formation of a ceramic barrier between the sample and the flame, significantly reduces the flammability of SR rubber. Using the FB-FTIR technique (fluidized bed coupled with infrared spectrometry) it has been proven that POSS effectively reduces the amount of toxic, potentially lethal gaseous products in the high temperature range.

In the third part of the work, a cenospheric filler, also covered with iron, was used to produce ceramizing composites based on nitrile rubber. Ceramization is an innovative method of physically reducing the fire risk of polymeric materials, based on the formation of a solid, thermally resistant ceramic layer on the surface of the composite as a result of the action of fire and / or high temperature. The created ceramic barrier protects against the diffusion of heat and oxygen into the composite, while inhibiting the processes of transporting liquid polymer waste (fuel) to the flame zone.
Thermal analysis as well as the flammability tests performed proved that the cenospheric filler not only disperses very well in the elastomer matrix, but also has excellent barrier properties.

It has been proven that iron on the surface of the cenosphere, acting as a radical scavenger, can inhibit thermo-oxidative degradation processes of the composite, while increasing the efficiency of the thermal crosslinking reaction. In addition, the cenospheric-metallic filler, in the presence of wollastonite, mica and inorganic flux, replacing silica, allows for the production of an effective, from the point of view of mechanical parameters, ceramic coating.

In the fourth part of the work, the effectiveness of basalt filler in the processes of reducing the fire risk of elastomer composites containing it was demonstrated.
It has been proven that by absorbing the energy of thermal radiation, basalt acts as a thermal shield protecting the polymer against subsequent degradation and thermal destruction reactions.
Based on the EDS analyzes (map of Si, Ca, Na, O decomposition), it was found that in the presence of basalt flakes there was a much lower aggregation degree of silica, calcium oxide, zinc borate or alumina. Probably, the basalt filler, characterized by both high heat capacity and particle size, limited the processes of formation of the so-called filler islands, contributing to the formation of a homogeneous, continuous ceramic layer.

In the last part of the work it was shown that the synergism of the action of carbon fillers in the form of graphene flakes or carbon nanotubes and basalt reduces the fire hazard of EPDM rubber composites, while positively influencing its mechanical parameters.

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