

Review

Mechanisms of the Action of Fire-Retardants on Reducing the Flammability of Certain Classes of Polymers and Glass-Reinforced Plastics Based on the Study of Their Combustion

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Abstract: In the present review, using an integrated approach based on the experimental and theoretical study of the processes of thermal decomposition and combustion of practically important polymers, such as polymethyl methacrylate, polyethylene, and glass-fiber-reinforced epoxy resin, the features of the mechanism for reducing the combustibility of these materials with phosphorus-containing flame-retardants (FR), as well as graphene, are identified. A set of original experimental methods was developed and applied that make it possible to study the kinetics of thermal decomposition and the thermal and chemical structure of the flames of the studied materials, including those with FR additives, as well as to measure the flame propagation velocity, the mass burning rate, and the heat fluxes from the flame on the surface of a material. Numerical models were developed and tested to describe the key parameters of the flames of the studied polymeric materials. An analysis of the experimental and numerical simulation data presented showed that the main effect of phosphorus-containing fire-retardants on reducing the combustibility of these materials is associated with the inhibition of combustion processes in the gas phase, and the effect of adding graphene manifests itself in both gas and condensed phases.

Keywords: polymer composites; flame-retardants; flame spread; numerical modeling; flame structure; inhibition mechanism; pyrolysis; flammability; opposed flow; counterflow

1. Introduction

At present, the use of polymeric materials is constantly growing: they are widely used in the building industry, automobiles, railways, air transportation, shipbuilding, the electric power industry, etc. The use of polymers as constructional materials provides good strength and weight characteristics, and as ornamental materials, they ensure necessary comfort and opportunities for design. In recent years, the greatest growth in the use of polymeric materials has been noted for constructional materials, where many elements are made from polymer composites. However, polymeric materials, unlike most metals, are capable of exothermic oxidation reactions and have a fire hazard (they ignite, spread flame, emit heat, smoke, and give off the toxic products of thermal-oxidative degradation). Therefore, one of the urgent tasks researchers and engineers around the world are trying to solve is a way to reduce the fire hazard of polymeric materials and the structural elements based on them.

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