

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.

# Flammability Of Cellular Plastics Volume 8 Fire And Flammability Series

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*Designing with Plastics and Composites: A Handbook* Donald Rosato, 2013-04-18 For some time there has been a strong need in the plastic and related industries for a detailed practical book on designing with plastics and composites reinforced plastics This one source book meets this criterion by clearly explaining all aspects of designing with plastics as can be seen from the Table of Contents and Index It provides information on what is ahead as well as today's technology It explains how to interrelate the process of meeting design performance requirements with that of selecting the proper plastic and manufacturing process to make a product at the lowest cost This book has been prepared with an awareness that its usefulness will depend greatly upon its simplicity The overall guiding premise has therefore been to provide all essential information Each chapter is organized to best present a methodology for designing with plastics and composites of industrial designers whether in engineering This book will prove useful to all types or involved in products molds dies or equipment and to people in new product ventures research and development marketing purchasing and management who are involved with such different products as appliances the building industry autos boats electronics furniture medical recreation space vehicles and others In this handbook the basic essentials of the properties and processing behaviors of plastics are presented in a single source intended to be one the user will want to keep within easy reach

**Fire and Flammability of Furnishings and Contents of Buildings** Andrew J. Fowell, 1994 **Applied Mechanics Reviews**, 1986 **References to Scientific Literature on Fire**, 1975 **Flammability of Cellular Plastics**, 1985-07-04 *Fire Journal*, 1978

**National Library of Medicine Current Catalog** National Library of Medicine (U.S.), 1971 Fire Technology Abstracts, 1981 *Plastics* H. Macskásy, Gyula Palyi, 2012-12-02 Presented here in detail is a number of generally accepted standardised inflammability tests A comprehensive survey of ISO IEC ASTN VL BS and DIN is given and other standards are also mentioned The testing of materials products and full scale model testing are described Furthermore the book describes methods for reducing the inflammability of plastics various techniques for fires involving plastics and fire regulations

**Fire Resistance of Industrial Fluids** ASTM Committee D-2 on Petroleum Products and Lubricants, 1996 Papers presented at the symposium of the same name held in Indianapolis IN on 20 June 1995 sponsored by ASTM Committee D02 on Petroleum Products and Lubricants Foreword Includes bibliographical references and index Scientific and Technical Books and Serials in Print, 1989 **Flame Retardants 101** Frca, 1998-01-14 **NBS Technical Note**, 1977 Current

Catalog National Library of Medicine (U.S.), First multi year cumulation covers six years 1965 70 **Journal of Research of the National Bureau of Standards** United States. National Bureau of Standards, 1973 **Toxicity of Plastics and Rubber in Fire** P. J. Fardell, 1993 This report does not seek to single out synthetic polymers as a special case It aims to provide an overview of the whole subject of combustion toxicity and threat to life whilst supplying specific information on the most frequently encountered polymeric materials and combustion products such as dioxins which have received high levels

of media attention An additional indexed section containing several hundred abstracts from the Rapra Polymer Library database provides useful references for further reading *Federal Register* ,1997-12 HSL Abstracts Great Britain. Health and Safety Executive. Library and Information Service,1979 **Handbook of Polyolefins** Cornelia Vasile,2000-06-21 A handbook on polyolefins This second edition includes new material on the structure morphology and properties of polyolefin PO synthesis It focuses on synthetic advances the use of additives special coverage of PO blends composites and fibres and surface treatments It also addresses the problem of interfacial and superficial phenomena **Frca** Frca,2000-03-24

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