

Preface

This volume follows in a tradition of ten previous biennial meetings and publications by those working to reduce the hazards associated with burning polymers. The 11th Meeting on Fire Retardant Polymers (FRPM'07), which took place in the Albert Halls in Bolton in July 2007, brought together over 200 scientists from across the globe with representatives from over 20 countries, to discuss the latest developments in fire retardant technology. There were around 100 presentations at the meeting, and as editors we have extracted the highlights, summarised in 25 chapters, in order to present the state of the art in fire retardant strategies and mechanisms.

All of the papers in this volume were subject to peer review, by two independent experts in fire retardancy. We are extremely grateful for the efforts put in, both by our authors and by the reviewers in helping us to maintain the highest standards in this volume.

The volume opens with a brief overview on *Polymers and Fire* setting the context by outlining the stages of a fire and the broad groups of fire retardants and their modes of action.

The first section discusses the new **Fire Retardant Strategies** which are currently emerging. The *Synergy between nanometric alumina and organoclay in conventional fire retardant systems for ethylene-vinyl acetate* leads in with the novel approach of investigating the effect of conventional fire retardants in nanoscopic form. *Strained organophosphorus compounds as reactive flame retardants for polymeric materials* continues the quest for halogen free fire retardants by designing phosphorus compounds which will decompose in sequence with the polymer to optimise the flame retardant effect. *Amorphous silicon dioxide as additive to improve the fire retardancy of polyamides* describes the novel application of smooth silica microspheres for flammability reduction. *Use of organosilicone composites as flame retardant additives and coatings for polypropylene* demonstrates the dual effects on flame retardancy and reducing surface adhesion of treatments based on polyborosiloxane. *Organo-modified*

Fire Retardancy of Polymers: New Strategies and Mechanisms

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Published by the Royal Society of Chemistry, www.rsc.org

ultrafine kaolin for mechanical reinforcement and improved flame retardancy of recycled PET shows how the interaction of ultrafine kaolins with triphenylphosphite leads to the formation of a barrier which enhances charring. *Complex micro-analysis assisted design of fire retardant nanocomposites-contribution to the nano-mechanism* uses a novel laser-Raman system to simultaneously decompose and probe the decomposition products of fire retardant polymer systems.

The second section is focussed on **Nanoparticulate Fillers** which have combined the potential to improve the physical properties of polymeric materials while also reducing their flammability. The section opens with a discussion on the *Impact of nano-particle shape on the flammability of nanocomposites*. The majority of fire retardant nanotechnology is currently focussed on the incorporation of nanoscale carbon and clay to form polymer nanocomposites. The *Thermal and combustion behaviour of polymer-carbon nanofibre composites* describes an approach with one form of these new materials. This is followed by an extensive investigation of the *Combination of carbon nanotubes with fire retardants: the thermal and fire properties of polystyrene nanocomposites*. *Significant assessment of nanocomposites combustion behaviour by the proper use of the cone calorimeter* describes the interpretation of the novel burning behaviour of polymer nanocomposites, and its investigation using cone calorimetry. The combination of traditional and nanocomposite approaches to fire retardancy using *Phosphorus based epoxy resins nano-clay composites* is reported. A novel approach to the somewhat elusive, and variable, mechanisms of nanocomposite fire retardancy is approached using viscosity measurements in the *Study of the relationship between flammability and melt rheological properties of flame retarded poly(butylene terephthalate) containing nanoclays*. The section concludes with another investigation combining novel and nanocomposite fire retardants outlining the *Thermal and fire performance of flame-retarded epoxy resin: Investigating interaction between resorcinol bis(diphenyl phosphate) and epoxy nanocomposites*.

The third section investigates another important class of fire retardants, **Intumescent**s, whose effect is created by the formation of a barrier layer which is then driven from the surface of the substrate by the release of a volatile or gaseous component. These may take the form of coatings or may be incorporated into the bulk of the material. A major application is in the creation of a polymer-based coating which is applied to structural members such as steelwork for fire protection. The section opens with an analysis of the bubble formation responsible for blocking the transfer of heat using *Image analysis of 2D intumescent char sections to estimate porosity*. This is followed by a description of *Efficient modelling of temperatures in steel plates protected by intumescent coating in fire*. The section finishes with a discussion focussed around *Fire retardancy and fire protection of materials using intumescent coatings - a versatile solution?*

The fourth section describes one of the major and most challenging application areas for fire retardant systems, namely **Fibres and Textiles**. The section opens with a discussion of *Trends in textile flame retardants – a market review*.

This is followed by an overview of *New and potential textile flammability regulations and test methods within the USA*. From this contextual setting of the market and regulatory framework, an investigation of the *Flame retardancy of cellulosic fabrics: interactions between nitrogen additives and phosphorus-containing flame retardants* is described. The section then covers two detailed investigations into the fire retardancy of polyacrylonitrile fibres. The *Synergistic flame retardant copolymeric polyacrylonitrile fibres containing dispersed phyllosilicate clays and ammonium polyphosphate* is reported, followed by reactive fire retardant approach to *Flame retardance of polyacrylonitriles covalently modified with phosphorus- and nitrogen-containing groups*. This is followed by *Novel fire retardant back-coatings for textiles*. The section concludes with a description of *The effect of yarn and fabric construction and colour in respect of red reflectance and pigmentation on the thermal properties and LOI of flame retardant polypropylene fabrics*.

The final section of the book describes investigations into the effects of fire retardant on the major hazard to life in fire, that resulting from **Fire Toxicity**. The *Influence of fire retardants on toxic and environmental hazards from fires* describes a large body of work assessing the hazards associated with burning polymers and their flame retardant counterparts. The volume concludes with a discussion on the specific influence of nanocomposite formation and fire retardants on the toxic product yields of nylon 6 and polypropylene in *Assessment of fire toxicity from polymer nanocomposites*.

We trust that the book will provide fire retardant materials' developers with latest developments in research or design of new fire retardant materials and understanding their mechanisms of action.

Finally, we would like to thank our colleagues, Prof Dennis Price, Prof Richard Horrocks, Dr Shonali Nazare, Dr Everson Kandare and Dr Anna Stec for their support during completion of this book.

