PolyFlame

PolyFlame est une newsletter à destination des chercheurs et des industriels du domaine du «comportement au feu des matériaux organiques». Cette newsletter périodique est publiée via la Société Chimique de France (SCF).

A travers cette newsletter, vous découvrirez les nouveautés et les dernières avancées dans le domaine du comportement au feu en matière de recherche et développement, la synthèse et la production de nouveaux systèmes de retardateurs de flamme, les besoins industriels. Pour faire avancer la connaissance et l'expertise, une partie de cette newsletter est consacrée à l'écoute des chercheurs et des industriels reconnus dans ce domaine.

Bonne Lecture,

Interview of Dr Alexander Morgan

Center for Flame Retardant Materials Science, University of Dayton, USA

Would you please introduce yourself, your carrier and your research activities, especially in regard with "flame retardancy of polymers"?

My name is Dr. Alexander B. Morgan, and I work as a distinguished research scientist at the University of Dayton Research Institute, and am the leader of the Center for Flame Retardant Materials Science at the University of Dayton. I have been working on material flammability and fire safety since 1994 since my graduate work was on fire safety of aircraft materials. You can read more about my background and labs with the following links:

https://udayton.edu/directory/udri/powerenergy/morgan-alexander.php

https://udayton.edu/engineering/research/centers/flame-retardant-materials-science/index.php

https://udayton.edu/udri/capabilities/energy_and_power/fire_safety_science_and_material_flammability.php

My research activities are very broad, and focus on fire protection and new flame retardant chemistry/materials for all applications, including aerospace, ground transportation, electrical & electronics, wire & cable, building and construction, furniture, and even unusual niche applications. I also have general work in combustion science, including novel clean fuels and waste-to-energy research. Outside of fire research, I conduct materials science research, including development of new additive manufacturing materials and durability of polymer composites.

In your opinion, what have been the major advances in the field of flame retardancy of polymers over the last decade? And what do you expect to see the future horizon?

In my opinion, we have not had what I would call major advances in flame retardancy for polymers over the last 10 years. We have had some new products come out, and some new approaches for combining things, but no major new concepts. Funding for fire safety research in the US is at levels below the 1970s, and appears to have some support in the EU. Our Chinese colleagues have the wealth of funding in this area, but what I have seen is mostly new combinations of older technologies. Indeed, that is probably the one research advance I would point out, which is the realization that multiple chemistries need to be combined together to yield superior fire safety that balances cost, non-fire properties (electrical, thermal, mechanical, environmental), and fire safety.

You have done a lot of work on flame retardancy of nanocomposites. Which specific issues have you ever found concerning the flame retardancy of these materials?

While I do have work in this area, I have not been active in nanocomposite research for several years now as funding in this area is all gone. However, I can comment that there are some issues, which still need to be addressed:

1- Environmental Health and Safety aspects of nanoparticles.

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The fate of nanoparticles released from polymers during cutting /grinding/milling/processing nanocomposites still need to be addressed. Likewise, the fate of these nanoparticles in fire events also needs to be addressed, or at least researched. Very likely, given all the toxins that come off from fires in general, nanoparticles are not expected to make the emissions any worse (they should lessen them), but, dealing with the ash/soot from a nanocomposite material may require some additional care.

2- Remaining hurdles for nanocomposites to be commercialized as flame retardant materials. Despite over a decade of sustained research in this area, very few nanocomposite materials were commercialized for fire safety applications. The reasons why continue to be unclear. I do not know if this is due to the above EH&S issue, a lack of commercial vendors, or some of the temperature limits of nanoparticles. It could be cost, but given how little material needs to be used, I am not convinced it is just cost preventing nanocomposites from being used.

Which aspects of sustainability issues must be considered in flame retardancy research area?

In my opinion, the days of small molecule flame retardants and additives for polymers have ended. Unless the flame retardant can be considered to be sustainable unless it is polymeric in structure, or, is reactive (can covalently bond with a polymer during manufacture). Small molecules can be studied as basic research targets, but commercially they are not viable or sustainable. Along with polymeric / reactive flame retardants, the life cycle of a flame retardant material must be considered. Bio-derived flame retardants may be useful, but, if they cannot meet the long-lifetime for some polymer applications, then they're not sustainable either. Therefore, life cycle assessments should be something that is considered in flame retardant materials research, including for development of new flame retardant chemistry. Sustainability is more than just environmental friendliness – it is economic sustainment and end-use sustainment as well.

Dr Alexander Morgan

Recommandations sur l'approche scientifique dans l'ignifugation : terminologie, méthodes et concepts

Comme tous les champs scientifiques, le domaine de l'ignifugation nécessite l'utilisation de termes et de concepts bien définis. Cela permet d'éviter de fausses interprétations induites par un mauvais usage (le plus souvent non intentionnel) de termes et/ou concepts vagues ou imprécis. Malheureusement, non seulement des articles de vulgarisation, mais même des articles évalués par les pairs (peer-review) et publiés par des éditeurs scientifiques peuvent présenter ce genre de défauts.

En 2016, afin de limiter ces « abus de langage », B. Schartel, G. Camino et C. Wilkie ont publié un article en deux parties appelant à être vigilant vis-à-vis de l'utilisation impropre de la terminologie scientifique. Ils précisent ainsi, par exemple, les définitions et l'utilisation correcte de termes courants tels que « résistance au feu » ou « pyrolyse ». Ils mettent également en garde contre la présentation dithyrambique (cette fois, plus souvent intentionnelle) de résultats souvent banals, dans le but de publier plus facilement un article.

Ces auteurs détaillent enfin les principaux tests au feu, leur utilité mais aussi leurs limites, car trop souvent les résultats de ces tests sont mal ou sur-interprétés. Enfin, ils reviennent sur un concept, important mais problématique : la synergie. Si la combinaison de plusieurs retardateurs de flamme est une stratégie pertinente pour améliorer les performances ignifuges, il convient de bien la caractériser. Plusieurs méthodes sont ainsi recensées dans la seconde partie de cet article.

Nous ne pouvons que conseiller la lecture attentive de ce double article à tous ceux qui s'intéressent aux travaux de recherche sur l'ignifugation des matériaux.

JOURNAL OF FIRE SCIENCES

Original Article

Recommendations on the scientific approach to polymer flame retardancy: Part 1—Scientific terms and methods

Journal of Fire Sciences
2016, Vol. 34(6) 447–467

DOI: 10.1177/0734904116675881
jfs.sagepub.com
SAGE

Bernhard Schartel[1], Charles A Wilkie[2] and Giovanni Camino[3]

Date received: 2 September 2016; accepted: 4 October 2016

Abstract

The correct use of scientific terms, performing experiments accurately, and discussing data using unequivocal scientific concepts constitute the basis for good scientific practice. The significance and thus the quality of scientific communication rely on the proper use of terms and methods. It is the aim of this two-part article to support the community with recommendations for discussing the flame retardancy of polymers by addressing some of the most relevant points. The first article (part one of two) clarifies some scientific terms and, in some cases, such as for "pyrolysis," "thermal decomposition," and "fire resistance," critically discusses their definitions in the field of fire science. Several comments are made on proper fire testing and thermal analysis, including some thoughts on uncertainty in fire testing. The proper use of distinct concepts in flame retardancy is discussed briefly in the subsequent second article (part two). This article tries to balance imparting background on the subject with recommendations. It encourages to check scientific practice with respect to communication and applying methods.

https://doi.org/10.1177/0734904116675881

JOURNAL OF FIRE SCIENCES

Original Article

Recommendations on the scientific approach to polymer flame retardancy: Part 2—Concepts

Journal of Fire Sciences
1–18

DOI: 10.1177/0734904116675370
jfs.sagepub.com
SAGE

Bernhard Schartel[1], Charles A Wilkie[2] and Giovanni Camino[3]

Date received: 2 September 2016; accepted: 19 September 2016

Abstract

The usage of concepts in scientific communication is critical to our ability to inform the reader about work that has been performed. The significance and thus the quality of scientific discussion rely on the precise use of concepts. In this second part of a two-part paper, concerning the scientific basis of polymer fire retardancy, the proper use of concepts is addressed. Distinct concepts in flame retardancy are discussed, such as fire residue, the correlation of fire performance with char yield according to van Krevelen, catalysis, and wicking. Synergy is discussed in detail, as well as approaches to quantify it, due to its importance for flame retardant polymers. The preceding first paper (part 1) discussed the proper use of scientific terms, thermal analysis, and fire testing. Thus, together these two papers support the community by offering recommendations and addressing some of the most relevant points. They encourage to review scientific practice in the field of flame retardancy of polymers.

https://doi.org/10.1177/0734904116675370

Tour d'horizon sur les 20 dernières années concernant l'igifugation :

Focus sur les résines époxy

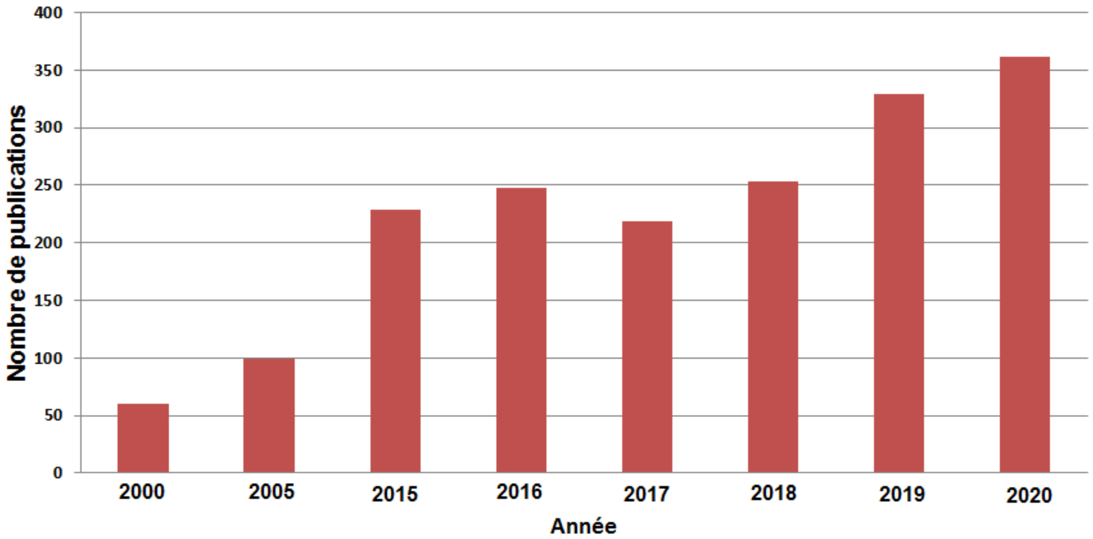
Cette section a pour but de présenter succinctement quelques travaux importants, principalement des revues faisant le point sur un sujet touchant à l'ignifugation.

Pour ce numéro, les résines époxy :

Les résines époxy sont sans doute parmi les polymères dont le comportement au feu est le plus étudié, en raison de leurs nombreuses applications dans des domaines exigeant le respect de normes de sécurité incendie.

Les stratégies d'ignifugation des résines époxy sont particulièrement variées[1]. Si les retardateurs de flamme phosphorés, avec une grande variété de groupements (phosphate, phosphonate, phosphinate, phosphazène…) sont aujourd'hui beaucoup utilisés, d'autres systèmes sont - envisageables, via des approches soit additives, soit réactives (c'est-à-dire que l'un des monomères entrant dans la composition du réseau - prépolymère époxy ou durcisseur - contient un groupement ignifuge, le plus souvent phosphoré mais d'autres solutions existent, telles que des groupements borés). Les résines époxy peuvent aussi être partiellement biosourcées[2]. Dans cette optique, la recherche de solutions ignifuges issues de ressources renouvelables fait l'objet de bon nombre de travaux[3,4,5]. La phosphorylation de bioressources a également été reviewée[6], et intéressera tous ceux qui s'intéressent à ce type d'approches pour ignifuger des résines époxy.

Ici, nous vous présentons quelques revues sur l'ignifugation des résines epoxy :



Nombre de publications sur l'ignifugation des résines époxy entre 2000 et 2020 (Ces données sont issues de notre recherche bibliographique sur la base de données Sci Finder avec ces mots clefs : epoxy, flame retardant, flame retardancy).

Références :

1 https://www.mdpi.com/1996-1944/13/9/2145/htm

2 https://pubs.acs.org/doi/abs/10.1021/cr3001274

3 https://www.sciencedirect.com/science/article/abs/pii/S1359836819327805

4 https://www.sciencedirect.com/science/article/abs/pii/S1359836819327805

5 https://www.mdpi.com/1420-3049/24/20/3746/htm

6 https://doi.org/10.1039/C5PY00812C

Polymer International

Polym Int 53:1901–1929 (2004)
DOI: 10.1002/pi.1473

Review

Thermal decomposition, combustion and flame-retardancy of epoxy resins — a review of the recent literature

Sergei V Levchik[1]* and Edward D Weil[2]

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[2]Polytechnic University, Six Metrotech Center, Brooklyn, NY 11201, USA

Abstract: An overview of the recent literature on combustion and flame-retardancy of epoxy resins is presented. A brief overview of the structures of cured epoxy resins is also presented as a background for better understanding of the thermal decomposition and combustion phenomena. The literature sources were mostly taken from the publications of 1995 and later; however, for basic descriptions of the structural and thermal decomposition principles, older publications are also cited. New developments in flame-retardant additives, epoxy monomers and curing agents are described. It is shown that the main attention in recent years has been focused on phosphorus-containing epoxy monomers and epoxy resins. Silicon-containing or nitrogen-containing products and inorganic additives remain of great interest as supplementary materials to phosphorus flame-retardants.

https://doi.org/10.1002/pi.1473

materials

MDPI

Review

Recent Developments in the Flame-Retardant System of Epoxy Resin

Quanyi Liu [1], Donghui Wang [1], Zekun Li [1], Zhifa Li [1], Xiaoliang Peng [1], Chuanbang Liu [1], Yu Zhang [2,*] and Penglun Zheng [1,*]

Abstract: With the increasing emphasis on environmental protection, the development of flame retardants for epoxy resin (EP) has tended to be non-toxic, efficient, multifunctional and systematic. Currently reported flame retardants have been capable of providing flame retardancy, heat resistance and thermal stability to EP. However, many aspects still need to be further improved. This paper reviews the development of EPs in halogen-free flame retardants, focusing on phosphorus flame retardants, carbon-based materials, silicon flame retardants, inorganic nanofillers, and metal-containing compounds. These flame retardants can be used on their own or in combination to achieve the desired results. The effects of these flame retardants on the thermal stability and flame retardancy of EPs were discussed. Despite the great progress on flame retardants for EP in recent years, further improvement of EP is needed to obtain numerous eco-friendly high-performance materials.

https://doi.org/10.3390/ma13092145

Contents lists available at ScienceDirect

Progress in Organic Coatings

journal homepage: www.elsevier.com/locate/porgcoat

ELSEVIER

Review

Bio-epoxy resins with inherent flame retardancy

Elaheh Rohani Rad[a], Henri Vahabi[b,c,*], Agustin Rios de Anda[d], Mohammad Reza Saeb[b,c,*], Sabu Thomas[e,**]

A B S T R A C T

Nowadays, roughly 90% of worldwide epoxy resin materials are made from diglycidyl ether of bisphenol A (DGEBA). This resin offers unique features such as outstanding mechanical properties, chemical resistance, and shape stability. By contrast, the growing awareness of environmental issues, global warming, and depletion of petroleum reservoir suggest search for using bio-epoxy resin from sustainable resources. Indeed, DGEBA is a petroleum-based monomer obtained from bisphenol A and epichlorohydrin, two potential precursors harmful for the environment and human health as well. The problem deepens when it comes to the high flammability of such materials, which restricts their use in strategic applications. Although the introduction of flame retardant (FR) additives to epoxy matrices has been a major strategy to induce flame retardancy, negative impact on mechanical properties and migration of FRs to the materials' surface remained unresolved issues. Tailoring epoxy chains with chemically bonded reactive flame retardants to epoxy resins would be the solution to avoid migration of FRs to surface, along with protecting mechanical properties of resin. With the rapid development of reactive bio-based FRs and epoxy resins, production of flame retardant bio-epoxy with high biomass content has become a promising strategy to address these issues. This conside review encompasses latest progress in flame retardant bio-epoxy resins made of different resources, with inherent chemical structures of either epoxy monomers or embedded reactive flame retardant elements.

https://doi.org/10.1016/j.porgcoat.2019.05.046

A Review of Current Flame Retardant Systems for Epoxy Resins

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SERGEI LEVCHIK
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(Received May 19, 2003)

ABSTRACT: The review covers materials currently available or which appear to be in serious development, with emphasis on electrical laminates and encapsulation, and brief coverage of other applications. The dominant technology for FR-4 printed wiring boards uses tetrabromobisphenol-A reacted into the epoxy resin. Nonhalogen systems include additives such as alumina trihydrate, alumina trihydrate plus red phosphorus, and aromatic phosphates. Reactives include a dihydrooxaphosphaphenanthrene oxide and various adducts thereof, and hydroxyl-terminated oligomeric phosphorus-containing esters. A further approach is the modification of the epoxy resin by placement of aromatic groups between the glycidyloxyphenyl groups, and/or by use of a triazine-modified novolac as crosslinker. Flame retardant epoxy coatings continue to make use of ammonium polyphosphate plus char-forming additives.

https://doi.org/10.1177/0734904104038107

molecules

MDPI

Review

Flame Retardant Epoxy Composites on the Road of Innovation: An Analysis with Flame Retardancy Index for Future Development

Elnaz Movahedifar [1], Henri Vahabi [2,3,*], Mohammad Reza Saeb [4,*] and Sabu Thomas [5]

Abstract: Nowadays, epoxy composites are elements of engineering materials and systems. Although they are known as versatile materials, epoxy resins suffer from high flammability. In this sense, flame retardancy analysis has been recognized as an undeniable requirement for developing future generations of epoxy-based systems. A considerable proportion of the literature on epoxy composites has been devoted to the use of phosphorus-based additives. Nevertheless, innovative flame retardants have coincidentally been under investigation to meet market requirements. This review paper attempts to give an overview of the research on flame retardant epoxy composites by classification of literature in terms of phosphorus (P), non-phosphorus (NP), and combinations of P/NP additives. A comprehensive set of data on cone calorimetry measurements applied on P-, NP-, and P/NP-incorporated epoxy systems was collected and treated. The performance of epoxy composites was qualitatively discussed as *Poor*, *Good*, and *Excellent* cases identified and distinguished by the use of the universal Flame Retardancy Index (FRI). Moreover, evaluations were rechecked by considering the UL-94 test data in four groups as V0, V1, V2, and nonrated (NR). The dimensionless FRI allowed for comparison between flame retardancy performances of epoxy composites. The results of this survey can pave the way for future innovations in developing flame-retardant additives for epoxy.

https://doi.org/10.3390/molecules24213964

Periodic Graphics

A collaboration between C&EN and Andy Brunning, author of the popular graphics blog ***Compound Interest***

More online

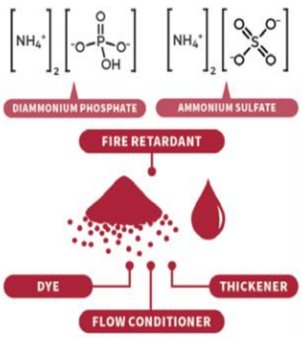
To see more of Brunning's work, go to **compoundchem.com.** To see all of C&EN's Periodic Graphics, visit **cenm.ag/periodicgraphics.**

SUPPRESSING WILDFIRES WITH CHEMISTRY

Planes dumping large amounts of red powder are a common sight during wildfires. Here we examine what's in the powder, its safety, and how it helps halt forest fires.

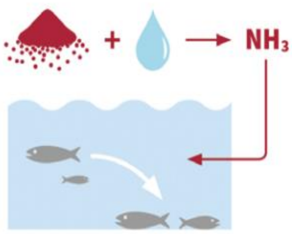
WHAT'S USED?

The commonly used fire retardant to combat the spread of wildfires is Phos-Chek. The powdered form contains ammonium phosphates (one shown) or sulfates as the active ingredient, and the liquid form contains ammonium polyphosphates.



Other ingredients include gum-based thickeners, which hold the cloud of retardant together as it's applied from the air. Flow conditioners allow the powder to be easily transferred and mixed. The red color of Phos-Chek, which aids air crews in applying it, derives from iron(III) oxide or a nonpermanent, light-sensitive dye.

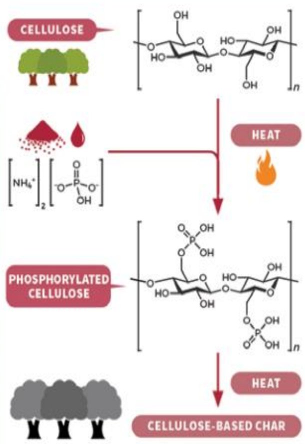
IS IT SAFE?



Reports have indicated only minor incidents of skin and eye irritation for humans. Phos-Chek, however, can be hazardous to aquatic organisms, as ammonium phosphates dissociate in water to form ammonia. As a result, delivery is avoided near streams.

HOW DOES IT WORK?

Applied to vegetation before a fire, phosphate salts react with cellulose in the organic matter, forming phosphate esters. Heat decomposes these esters, forming a protective char that slows the spread of wildfires.



After a fire has passed, ammonium compounds in the retardant can act as fertilizers, aiding forest regrowth. But scientists are concerned that they may also enhance invasive species.

PERIODIC GRAPHICS

6th International conference on Fires in vehicles

25-26 March 2021,
Amsterdam, The Netherlands

https://www.ri.se/en/five?refdom=firesinvehicles.com

13th International Symposium on Fire Safety Science (IAFSS Symposium)

26-30 April, 2021,
Waterloo, Ontario, Canada

https://uwaterloo.ca/international-symposium-on-fire-safety-science/

European Meeting on Fire Retardant Polymeric Materials

27-30 June 2021,
Budapest, Hungary

https://www.frpm21.com/frpm21

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Liens utiles :

http://gcf-scf.lmops.univ-lorraine.fr/

www.polymer-fire.com