Bulletin de veille n° 12

Retardateurs de flamme

Juillet 2024

Objectifs : Recherche de rapports, articles scientifiques, réglementation sur les retardateurs de flamme. Plus spécifiquement sur : la caractérisation, les techniques d'analyse, le vieillissement, les émissions dans l'atmosphère, les risques chimiques.

La validation des informations fournies (exactitude, fiabilité, pertinence par rapport aux principes de prévention, etc.) est du ressort des auteurs des articles signalés dans la veille. Les informations ne sont pas le reflet de la position de l'INRS.
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Sources surveillées

INRS-Biblio
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Editions législatives
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Rapports et articles (sources : INRS-Biblio, google scholar, Web of Science, Lens, Les Techniques de l'ingénieur, internet)

L. Yan, W. Wang and Z. Xu
Impact of thermal aging temperatures on the combustion behavior and mechanical properties of flame-retardant electrical cables
Journal of Thermal Analysis and Calorimetry, 2024/07/19 2024.
To assess the fire safety of cables in the service process, the influence of thermal-aging temperature on the combustion properties, pyrolysis properties, and mechanical properties of civilian-type flame-retardant electrical cables was investigated. Flammability test shows that the LOI value of the sheath increases with the rise of thermal-aging temperature, primarily ascribed to the formation of a dense carbon layer. Cone calorimeter test shows that the total heat release (THR) value and residual mass of the cables firstly decrease and then increase as the thermal-aging temperature rises. After 21 days of aging treatment at 120 °C, the THR and peak heat release rate values of the cable are reduced to the lowest values of 88.9 kW m−2 and 109.2 MJ m−2, respectively. TG analysis shows that the onset decomposition temperature of the sheath first increases and then decreases with the rise of the thermal-aging temperature, where the onset decomposition temperature declines sharply after 150 °C thermal aging for 21 days. Mechanical test shows that as thermal-aging temperature increases, the elongation at break of the sheath decreases sharply, while the tensile strength increases significantly. This is mainly because the molecular structure of the aged sheathing material is changed, as supported by SEM and FTIR analyses.
10.1007/s10973-024-13437-5
https://doi.org/10.1007/s10973-024-13437-5

M. Combeau, M. Batistella, A. Breuillac, A. Impola, P. Didier and J. Lopez-Cuesta
How POSS in intumescent flame-retardant systems can contribute to the improvement of the fire behavior of virgin and recycled HDPE ?
Présentation extraite de MoDeSt 2024 - 11th conference of the Modification, Degradation, Stabilization of Polymers Society, Palerme, Italy, 2024-09-01 2024.
The circular economy's requirements are now driving up the use of recycled polymers. Nevertheless, these recycled polymers are often used through downgraded applications (1). This work aims to design high-performance recycled HDPE to replace virgin polymers in technical applications (e.g. housing, cables, urban furniture) which need highly fire-resistant materials. Various flame-retardant systems have been studied in literature. In particular, intumescent flame-retardant (IFR) system combining ammonium polyphosphate (APP) and polyamide 6 (PA 6) is known to be very effective for polyolefins (2). Furthermore, a variety of nanoparticles were assessed as synergistic agents in IFR systems (3). The current study examined the effects of an IFR system combining APP and PA6 on the fire behavior and mechanical properties of virgin and recycled PE. In addition, the effect of POSS nanoparticles as a synergistic agent (4) was also evaluated.
https://imt-mines-ales.hal.science/hal-04650937

S. Paszkiewicz, E. Piesowicz, I. Irska, K. Walkowiak, Z. C. O. Medina, K. Sałasińska, A. Boczkowska, D. Rutkowska, J. Andrzejewski, M. Barczewski, M. Borowicz, J. Paciorek-Sadowska and K. Pokwicka-Croucher
Preparation and characterization of polypropylene/rubber powder blends containing two flame retardant systems intended for the automotive industry
Issue, 2024, pp., p.
Two series of polymer blends based on post-consumer materials, i.e. postconsumer polypropylene (rPP) and rubber dust (Rd) under the trademark ECOPLASTOMER® PP70 with a mutual ratio of components 70/30 wt.% containing 10, 20, and 30 wt.% of flame retardants, have been prepared using a twin-screw eco-friendly system based on melamine phosphate (MP), aluminum hydroxide oxide (AC), and peanut shells (PS), used as flame retardant agents on the mechanical, thermal, and flammability properties of polymer blends was assessed. The incorporation of ATH-sil results in the appearance of peaks related to OH groups, with higher intensity for increased ratio of filler; similar observations are made for the MP-AC-PS system, although mainly

finding the P-OH from MP, Al-O from AC. DSC analysis revealed that the inclusion of the selected flame retardants did not impact the melting and crystallization temperatures of the polymer matrix. Conversely, an attenuation in the melt flow rate ofthe composites was observed with increasing proportions ofboth additives, leading to enhanced rigidity, elevated elastic modulus, and diminished elongation at break following a similar pattern. Tensile strength experienced a minor decrease, particularly in composites containing more than 20% of the flame retardants, while hardness remained unaffected by their integration. Both flame retardants diminished the combustibility of the modified polypropylene/rubber powder blends; nevertheless, the most favorable outcomes were achieved with ATH-sil, especially when employed ata minimum of 30wt%. The formulated MP/AC/PS system proved more adept at diminishing combustibility and smoke emissions at lower levels of flame retardants.
http://hdl.handle.net/10553/132190

B. Qian, H. Zhu, P. Wang, P. Peng, J. Zhang, M. Wu, J. Liu, Q. Wu and J. Yang
Synthesis, characterization and performance evaluation of different alkyl chain lengths flame-retardant plasticizers for poly(vinyl chloride) derived from sustainable vanillic acid
European Polymer Journal, Vol. 214, 2024/06/24/ 2024, p. 113154.
The current market for poly(vinyl chloride) (PVC) plasticizers is dominated by flammable petroleum-based compounds, accounting for over 80 % of the total share. Due to their high flammability, the search for novel approaches to enhance the fire resistance of flexible PVC has gained urgency. However, traditional flame-retardant schemes suffer from shortcomings such as poor compatibility, inferior long-term performance, and weak mechanical properties. Herein, we synthesized a novel biobased flame-retardant plasticizer (VAn-P) using vanillic acid as a skeleton. This plasticizer exhibits remarkable properties, including a substantially lower glass transition temperature compared to unplasticized PVC. The binding energy between VAn-P and PVC is calculated to be –33.30 kcal/mole, indicating a strong interaction. Furthermore, the maximum elongation at break of VAn-P plasticized PVC is 16 times higher than that of unmodified PVC. All PVC samples plasticized with VAn-P achieved a UL-94 VTM-0 rating. TGA-FTIR analysis revealed that the flame-retarding mechanism of VAn-P involves solid-phase action, significantly delaying the dehydrochlorination process of PVC. Moreover, VAn-P exhibits superior migration resistance compared to dioctyl phthalate (DOP). We also investigated the effects of alkyl chain lengths in VAn-P on various properties of PVC blends, including thermal stability, flame retardancy, mechanical properties, and optical performance. The toxicity of vanillic acid-based flame-retardant plasticizer has undergone an initial assessment. Overall, this green plasticizer is expected to endow polymers with high plasticizing performance and flame retardancy, providing a novel and sustainable approach for the synthesis of functional plasticizers.
https://doi.org/10.1016/j.eurpolymj.2024.113154
https://www.sciencedirect.com/science/article/pii/S0014305724004154

S. G. Orkun Elcin, Gulsah Turker, Aysegul Erdem, Firat Hacioglu
Production and characterization of flame-retardant poly (butylene terephthalate) composites containing boron compounds
Polymer-Plastics Technology and Materials.
Within the scope of this work, flame retardant polybutylene terephthalate (PBT) was produced using boron compounds, namely, anhydrous borax (BX), colemanite (C), and zinc borate (ZnB) in three different concentrations of 40, 50, and 60 wt%. The thermal, flame retardant, and tensile properties of PBT composites were systematically investigated using thermogravimetric analysis (TGA), limiting oxygen index (LOI), vertical UL 94 test (UL-94V), mass loss calorimeter (MLC), and tensile tests. The thermal stability of PBT slightly enhanced with the use of BX, whereas the use of C and ZnB reduced the thermal stability. Improvement in LOI value, a reduction in peak heat release rate (pHRR), and total heat release (THR) values were observed with the use of all boron compounds. The improvement in UL-94V rating was observed only with the use C. The addition of all boron compounds deteriorates the tensile strength of the composites. In brief, the highest flame retardant performance with V0 rating (UL-94 V), 33.5% (LOI), and 48 Kwm(-2) (pHRR) was achieved with the use of C.

B. Schwaebe, H. Y. He, C. Glaubensklee, O. A. Ogunseitan and J. M. Schoenung
Chemical hazard assessment toward safer electrolytes for lithium-ion batteries
Integrated Environmental Assessment and Management, 2024 Jun 2024.
Commercialization of rechargeable lithium-ion (Li-ion) batteries has revolutionized the design of portable electronic devices and is facilitating the current transition to electric vehicles. The technological specifications of Li-ion batteries continue to evolve through the introduction of various high-risk liquid electrolyte chemicals, yet critical evaluation of the physical, environmental, and human health hazards of these substances is lacking. Using the GreenScreen for Safer Chemicals approach, we conducted a chemical hazard assessment (CHA) of 103 electrolyte chemicals categorized into seven chemical groups: salts, carbonates, esters, ethers, sulfoxides-sulfites-sulfones, overcharge protection additives, and flame-retardant additives. To minimize data gaps, we focused on six toxicity and hazard data sources, including three empirical and three nonempirical predictive data sources. Furthermore, we investigated the structural similarities among selected electrolyte chemicals using the ChemMine tool and the simplified molecular input line entry system inputs from PubChem to evaluate whether chemicals with similar structures exhibit similar toxicity. The results demonstrate that salts, overcharge protection additives, and flame-retardant additives contain the most toxic components in the electrolyte solutions. Furthermore, carbonates, esters, and ethers account for most flammability hazards in Li-ion batteries. This study supports the complementary use of quantitative structure-activity relationship models to minimize data gaps and inconsistencies in CHA. Integr Environ Assess Manag 2024;00:1-14. (c) 2024 The Author(s). Integrated Environmental Assessment and Management published by Wiley Periodicals LLC on behalf of Society of Environmental Toxicology & Chemistry (SETAC). Chemical hazard assessment was conducted for 103 electrolyte chemicals, categorized into seven groups, used in lithium-ion batteries. Most of the 103 electrolyte chemicals exhibited high levels of concern relative to human health and environmental hazard endpoints. Nonempirical predictive data sources are essential for filling data gaps commonly encountered in empirical data sources. Structure similarity analysis highlights that chemicals with structure similarity correlate with similar hazard endpoints, increasing the value of predictive data sources.
https://doi.org/10.1002/ieam.4963

S. Gülel and Y. Güvenilir
Preparation and characterization of novel bio-based polyamide 5.6 composites as sustainable alternatives to petroleum-derived polyamide 6.6
Polymer Composites, 2024 May 2024.
In the pursuit of sustainable solutions, this study investigates the potential of bio-based polyamide 5.6 (PA56) as a promising alternative to petroleum-derived polyamide 6.6 (PA66). Novel composites of PA56 and PA66 were prepared with the incorporation of glass fibers and flame retardant additives by twin screw extruder. Subsequently, these composites were subjected to comprehensive characterization to determine their performance. The physical, mechanical, rheological, thermal, and flammability properties of PA56 composites were investigated and compared with those of PA66 composites with the same formulations. This article aims to unveil the remarkable potential of bio-based PA56 composites in industrial applications. The results showed that bio-based PA56 exhibits comparable, and in some cases superior, performance to PA66 while offering the added advantage of environmental sustainability. The findings suggest that bio-based polyamide 5.6 can serve as a sustainable alternative to petroleum-derived polyamide 6.6, contributing to a greener future in industrial applications.Highlights Bio-based PA56 exhibits comparable properties to petroleum-derived PA66. Incorporation of glass fibers and flame retardants enhances the properties of PA56. Findings propose PA56 as a sustainable alternative to PA66 in various applications. Prepared novel PA56 and PA66 composites and their investigated properties. image
https://doi.org/10.1002/pc.28529

X. Zeng, Z. Xu, H. Li, Y. Xiong, Y. Ding, L. Xu and S. Liu
Characterization and Flame-Retardant Properties of Cobalt-Coordinated Cyclic Phosphonitrile in Thermoplastic Polyurethane Composites
Molecules, Vol. 29, n° 8, 2024, p. 1869.
Halogen-free organophosphorus flame retardants have promising application prospects due to their excellent safety and environmental protection properties. A cobalt-coordinated cyclic phosphonitrile flame retardant (Co@CPA) was synthesized via a hydrothermal method using hexachlorocyclotriphosphonitrile (HCCP), 5-amino-tetrazolium (5-AT), and cobalt nitrate hexahydrate (Co(NO3)2 center dot 6H2O) as starting materials.

The structure was characterized using Fourier transform infrared (FTIR), nuclear magnetic resonance spectroscopy (1H-NMR), scanning electron microscopy (SEM), and thermogravimetric analysis (TGA). Thermoplastic polyurethane (TPU) composites were prepared by incorporating 10-(2,5-dihydroxyphenyl)-9,10-dihydro-9-oxa-10-phosphame-10-oxide (ODOPB), Co@CPA, and silicon dioxide (SiO2) via melt blending. The flame-retardant performance and thermal stability of the TPU composites were evaluated through limiting oxygen index (LOI), vertical combustion (UL-94), TG, and cone calorimetric (CCT) tests. SEM and Raman spectroscopy were used to analyze the surface morphology and structure of the residual carbon. A synergistic flame-retardant effect of ODOPB and Co@CPA was observed, with the most effective flame retardancy achieved at a TPU:ODOPB:Co@CPA:SiO2 ratio of 75:16:8:1. This composition exhibited an LOI value of 26.5% and achieved a V-0 rating in the UL-94 test. Furthermore, compared to pure TPU, the composite showed reductions in total heat release, CO production, and CO2 production by 6.6%, 39.4%, and 48.9%, respectively. Our research findings suggest that Co@CPA demonstrates outstanding performance, with potential for further expansion in application areas. Different metal-based cyclic phosphonitrile compounds are significant in enriching phosphorus-based fine chemicals.
https://www.mdpi.com/1420-3049/29/8/1869

V. S. Hiremath, D. M. Reddy, R. Reddy Mutra, A. Sanjeev, T. Dhilipkumar and N. J
Thermal degradation and fire retardant behaviour of natural fibre reinforced polymeric composites- A comprehensive review
Journal of Materials Research and Technology, Vol. 30, 2024/05/01/ 2024, pp. 4053-4063.
In this comprehensive review, we dive into the potential of natural fibre composites, tracing their historical use spanning three millennia and their recent incorporation into polymer matrices. Various natural fibres, including flax, hemp, jute, and more, have been explored as potential reinforcements due to their renewable nature and environmental appeal. Moreover, these fibers are gaining traction in industries such as automotive and packaging. Leveraging abundant agricultural waste such as, wheat husk, rice husk, straw, and hemp fibre into commercially viable fibre-reinforced polymer composites. A thorough summary is given in this article of the diverse array of natural fibers, their current research status, encompassing properties, processing techniques, filler materials on structural factors, thermogravimetric analysis, dynamic mechanical performance under thermal loading, fire retardant behaviour, cone calorimetric analysis and various other applications, all while referencing the latest developments in the field, exploring a sustainable future with natural fibre composites. Furthermore, the difficulties associated with natural fibre-reinforced composites, including their vulnerability to humidity, fire retardancy and compliance with fibre matrices, are examined. This paper summarizes the complex field of natural fibre composites and covers several thermal stability-related appearance.
https://doi.org/10.1016/j.jmrt.2024.04.085
https://www.sciencedirect.com/science/article/pii/S2238785424008597

O. Akpojevwe Abafe, S. Harrad and M. Abou-Elwafa Abdallah
Assessment of human dermal absorption of flame retardant additives in polyethylene and polypropylene microplastics using 3D human skin equivalent models
Environment International, 2024/04/05/ 2024, p. 108635.
To overcome ethical and technical challenges impeding the study of human dermal uptake of chemical additives present in microplastics (MPs), we employed 3D human skin equivalent (3D-HSE) models to provide first insights into the dermal bioavailability of polybrominated diphenyl ether (PBDEs) present in MPs; and evaluated different factors influencing human percutaneous absorption of PBDEs under real-life exposure scenario. PBDEs were bioavailable to varying degrees (up to 8 % of the exposure dose) and percutaneous permeation was evident, albeit at low levels (≤0.1 % of the exposure dose). While the polymer type influenced the release of PBDEs from the studied MPs to the skin, the polymer type was less important in driving the percutaneous absorption of PBDEs. The absorbed fraction of PBDEs was strongly correlated ($r2 = 0.88$) with their water solubility, while the dermal permeation coefficient Papp of PBDEs showed strong association with their molecular weight and logKOW. More sweaty skin resulted in higher bioavailability of PBDEs from dermal contact with MPs than dry skin. Overall, percutaneous absorption of PBDEs upon skin contact with MPs was evident, highlighting, for the first time, the potential significance of the dermal pathway as an important route of human exposure to toxic additive chemicals in MPs.
https://doi.org/10.1016/j.envint.2024.108635

https://www.sciencedirect.com/science/article/pii/S0160412024002216

P. Whaley, S. Wattam, C. Bedford, N. Bell, S. Harrad, N. Jones, T. Kirkbride, D. Naldzhiev, E. Payne, E. J. Wooding and T. R. Hull

Reconciling chemical flame retardant exposure and fire risk in domestic furniture

Plos One, Vol. 18, n° 11, Nov 2023.

Introduction : Evidence suggests that standards for resistance of furniture to ignition may lead to an increase in use of chemical flame retardants (CFRs). This is motivating the development of new approaches that maintain high levels of fire safety while facilitating a reduction in use of CFRs. However, reconciling potential fire risk with use of CFRs in relation to specific policy objectives is challenging.ObjectivesTo inform the development of a new policy in the UK for the fire safety of furniture, we developed for domestic furniture quantitative models of fire risk and potential for CFR exposure. We then combined the models to determine if any lower fire risk, higher CFR exposure categories of furniture were identifiable.Methods : We applied a novel mixed-methods approach to modelling furniture fire risk and CFR exposure in a data-poor environment, using literature-based concept mapping, qualitative research, and data visualisation methods to generate fire risk and CFR exposure models and derive furniture product rankings.Results : Our analysis suggests there exists a cluster of furniture types including baby and infant products and pillows that have comparable overall properties in terms of lower fire risk and higher potential for CFR exposure.Discussion : There are multiple obstacles to reconciling fire risk and CFR use in furniture. In particular, these include a lack of empirical data that would allow absolute fire risk and exposure levels to be quantified. Nonetheless, it seems that our modelling method can potentially yield meaningful product clusters, providing a basis for further research.

https://doi.org/10.1371/journal.pone.0293651

S. J. Tan, J. P. Yue, Z. Chen, X. X. Feng, J. Zhang, Y. X. Yin, L. Zhang, J. C. Zheng, Y. Luo, S. Xin and Y. G. Guo

Asymmetric Fire-Retardant Quasi-Solid Electrolytes for Safe and Stable High-Voltage Lithium Metal Battery

Energy Material Advances, Vol. 5, Feb 2024.

Lithium metal batteries (LMBs) with high energy density show substantial promise as advanced electrochemical energy storage solutions, although they encounter persistent challenges pertaining to cycling stability and safety performance. Conventional homogeneous electrolytes widely employed in LMBs are inherently flammable, possessing a limited electrochemical window, thereby presenting obstacles to meeting the stringent safety and cycling criteria. In this investigation, we devised an asymmetric fire-retardant quasi-solid polymer electrolyte to mitigate thermal runaway risks and chemical/electrochemical instability at the electrolyte-electrode interface in LMBs. Specifically, on the cathode side, a poly(vinylidene fluoride-co-hexafluoropropylene gel electrolyte incorporating flame-retarded organophosphates exhibited remarkable compatibility and heightened thermal stability when paired with high-voltage Ni-rich layered materials. Simultaneously, a thin yet resilient polyether gel electrolyte was in-situ synthesized on lithium metal anodes, expanding the applicability of fire-retardant electrolytes to lithium metal anodes while suppressing the formation of lithium dendrites. Consequently, high-voltage LMBs utilizing asymmetric fire-retardant electrolytes demonstrated a substantial enhancement in safety performance and cycling stability. This research delineates a viable pathway toward realizing secure and consistent cycling in high- energy-density energy storage systems.

https://doi.org/10.34133/energymatadv.0076

B. S. Regmi and A. Apblett

Spectroscopic characterization, thermal, and flame retarding properties of melaminium cyanoacetate monohydrate

Polymer Bulletin, Vol. 80, n° 10, Oct 2023, pp. 11155-11166.

FTIR and Raman spectra of melaminium cyanoacetate have been recorded and analyzed. Band assignments are given based on the melamine and cyanoacetic acid molecules. The ring breathing vibrations of the triazine

ring show frequency shift toward the high wavenumber side. This change is attributed to an increase in rigidity of the ring as a consequence of protonation and the formation of donor-acceptor types of hydrogen bonding interactions. Notably, this melaminium cyanoacetate salt also contributes to the efficient flame-retardant properties of polyurethane foam substrate as revealed by the flammability test and thermogravimetric analysis.
https://doi.org/10.1007/s00289-022-04594-4

J. Deng, Q. Huang, X. Li, G. Zhang, C. Li and S. Li
Influence mechanism of battery thermal management with flexible flame retardant composite phase change materials by temperature aging
Renewable Energy, Vol. 222, 2024/02/01/ 2024, p. 119922.
The phase change immigration of flame retardant Composite Phase Change Material (CPCM), especially the temperature aging effect during multicycle process, greatly restricted its application in power battery pack of electric vehicle and energy storage system. In this study, the properties of flexible flame-retardant CPCMs before and after temperature aging were investigated, and the battery thermal management effects of battery modules were compared. The results revealed that flexible CPCMs with styrene block copolymers exhibited little volume change owing to their elastic and anti-leakage properties, effectively alleviating flow and agglomeration. In addition, battery modules with flexible flame-retardant CPCMs exhibited prominent battery thermal management. These mechanisms in flame-retardant CPCMs can profoundly affect the design and preparation of multifunction CPCMs, providing novel insights into passive thermal management of battery systems.
https://doi.org/10.1016/j.renene.2023.119922
https://www.sciencedirect.com/science/article/pii/S0960148123018372

P. Singh, S. Pandit, M. Sinha, D. Yadav and R. Parthasarathi
Computational Risk Assessment of Persistence, Bioaccumulation, and Toxicity of Novel Flame-Retardant Chemicals
Journal of Physical Chemistry A, Vol. 127, n° 51, Dec 2023, pp. 10747-10757.
Novel brominated flame retardants (NBFRs) have emerged as chemicals of environmental concern, as they have been widely used as an alternative to polybrominated diphenyl ethers (PBDEs). Considering the similar structural features of NBFRs and PBDEs necessitates a comprehensive investigation to understand the physicochemical relationships of these compounds and their ability to alter biological functions. In this study, we investigated the persistent nature of NBFRs in terms of thyroid-disrupting potential by understanding the structure-stability aspects using density functional theory (DFT)-based reactivity parameters and interactions via molecular docking and molecular dynamics (MD) simulations. The results indicate that the DFT-based stability descriptor (chemical hardness) is associated with the persistent nature of NBFRs. The computed molecular interaction profile revealed prominent interactions between thyroid receptor-beta (TR-beta) and NBFRs. Stable trajectory and interactions with TR-beta were obtained with ATE, p-TBX, PBT, PBEB, and TBBPA-DBPE during 100 ns of MD simulation. The results of these studies have suggested that the presence of a higher number of halogenated atoms increases the stability vis-a-vis the persistence and endocrine disruption potential of NBFRs.
https://doi.org/10.1021/acs.jpca.3c04160

T. Wang, Y. Li, Y. Zeng, G. Zhang, G. Zhao, X. Li and Z. Rao
Investigation on the battery thermal management and thermal safety of battery-powered ship with flame-retardant composite phase change materials
Journal of Energy Storage, Vol. 81, 2024/03/15/ 2024, p. 110228.
Pure battery-powered ships have attracted much attention because of its unique advantages of zero-emission. However, the problems of adaptability to extreme working conditions and thermal safety risks restrict the development of battery-powered ships. In this study, a novel flexible flame-retardant composite phase change materials (CPCM) with paraffin (PA)/EVA grafted on maleic anhydride (EVA-g-MAH)/expanded graphite (EG)/ammonium polyphosphate (APP)/triphenyl phosphate (TPP)/Na2SiO3 has been proposed and utilized in battery module. Among them, the sample ATPCM2 with APP/TPP/Na2SiO3 ratio of 5/10/10 achieved the

optimal thermal properties and flame-retardant effect. The designed multifunctional CPCM harmonizes the competition between flame retardancy, mechanical properties and phase change latent heat by the synergistic effect. Besides, the ATPCM2-Module shows a good temperature control performance during charge-discharge cycles, such as the maximum temperature of battery module can be still controlled below 50 °C at 2C discharge rate and the corresponding temperature difference was effectively maintained within 4.1 °C. This is owing to the constructed stable three-dimensional heat conductive skeleton formed by synergistic flame retardancy effect, which could improve the dissipation heat capacity and thermal safety. With these prominent performances, the designed flexible CPCM with desired flame-retardant and thermal management performance can provide insights into the passive thermal management and thermal safety improvement of both battery-powered ships and high-power battery module under extreme conditions.
https://doi.org/10.1016/j.est.2023.110228
https://www.sciencedirect.com/science/article/pii/S2352152X23036277

J. N. Li, H. Y. Jiang, J. J. Qin, Y. Y. Qin, X. M. Zhou, S. X. Shi, Z. Shu, Y. W. Gao and J. H. Tan
Unexpectedly high levels and health risks of atmospheric polychlorinated biphenyls in modern mechanical dismantling of obsolete electrical equipment: Investigations in a large integrated e-waste dismantling industrial estate
Environment International, Vol. 182, Dec 2023.
Large industrial estates for electrical and electronic waste (e-waste) mechanical dismantling and recycling are gradually replacing outmoded small factories and intensive domestic workshops for e-waste manual and chemical dismantling. However, the air pollution and health risks of persistent organic pollutants during the modern mechanical processing of e-waste, especially obsolete electrical equipment, still remain unclear. Here, unexpectedly high levels (409.3 ng/m3) and health risks of airborne polychlorinated biphenyls (PCBs) were found during the mechanical processing of obsolete electric equipment or parts in a large integrated dismantling industrial estate, which is comparable to or a dozen times higher than those reported during chemical processing. In contrast, the levels (936.0 pg/m3) and health risks of particulate polybrominated diphenyl ethers (PBDEs) were all lower than those of previous studies. PCB emissions (44.9-3300.5 ng/m3) varied significantly across six mechanical dismantling places specifically treating waste motors, electrical appliances, hardware, transformers, and metals, respectively. The high PCB content and mass processing number of obsolete electrical equipment probably result in the highest PCB emissions from the mechanical dismantling of obsolete motors, followed by waste electrical appliances and metals. The PCB non-cancer and cancer risks associated with inhalation and dermal exposure in different mechanical dismantling places were all above the given potential risk limits. In particular, the health risks of dismantling obsolete motor exceeded the definite risk levels. Little difference in PCB emissions and health risks between working and non-working time suggested the importance of PCB volatilization from most e-waste. Such high PCB emissions and health risks of PCBs undoubtedly posed a severe threat to frontline workers, but fortunately, they decreased significantly with the increasing distance from the industrial estate. We highlight that PCB emissions and associated health risks from obsolete electrical equipment with high PCB content during mechanical dismantling activities should be of great concern.
https://doi.org/10.1016/j.envint.2023.108333