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To: Department of Ecology – State of Washington
From: Dr. Marcelo M. Hirschler (GBH International)

Comments on "Draft Regulatory Determinations Report to the Legislature: Safer Products for Washington Implementation Phase 3"

I am a fire safety expert, with over 40 years of experience and I am extremely disturbed by the fire safety implications if the above report is implemented.

I attach a recent Curriculum Vitae that indicates that I have an extensive background in fire safety research and in the development of codes and standards, both in the United States and internationally. I have worked at university (in the United Kingdom and in Argentina), at a manufacturer and as a consultant, and have extensive knowledge and understanding of the societal needs for fire safety. I have published more than 500 scientific articles and books, mostly in the area of fire safety. I have been primarily responsible for the development and issuance of a variety of codes and standards.

The report is based on three basic assumptions, all of which are flawed: (a) safe alternatives exist to using flame retardants (or at least organohalogen flame retardants), (b) it is safe to eliminate many (if not all) fire safety requirements) and (c) ***all*** organohalogen flame retardants as a class are toxic and linked to various undesirable effects to health or the environment.

It is not true that there are safe alternatives to flame retardants in every application

There are multiple examples of areas where there are no alternatives to the use of the existing flame retardants or the use of other organohalogen materials. I will give some examples.

The technology of using flame retardants to improve the fire performance of materials that burn too easily requires a very sophisticated study involving the development of combinations of substrates (meaning the material to be flame retarded) and flame retardants to obtain a new material with adequate fire safety properties. However, it is critical that such a material also be suitable for the application in terms of all the other material requirements, namely properties such as mechanical, electrical, optical, visual, and/or any other specific need. Therefore, it is typically not possible to simply replace one flame retardant by another one, because the entire new material must be re-engineered. In some cases, replacement of one flame retardant by any other one is simply not possible.

For example, it is essential that materials used for cushioning (or paddings) must exhibit resilience (meaning that they are not too hard when pressed and will return to their original shape when the pressure is released) so that seating, sleeping, or leaning on the paddings is a comfortable experience. The same applies to paddings on the walls of public areas. However, experience has indicated that the vast majority of common padding materials are highly flammable. Therefore, in order to keep using materials that maintain the needed level of comfort, and still provide adequate fire safety, common padding materials need to be treated. This can be done by incorporating flame retardants into the material after manufacture (using additive flame retardants) or by re-engineering the material with a new chemical composition before manufacture (using reactive flame retardants or other additives to improve fire performance). Again, the simple replacement of one flame retardant by another one is almost never a suitable option.

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Therefore, the alternatives shown in pages 52-58 of the report are simply sales or marketing recommendations provided by certain manufacturers that indicate the flame retardants exist that are not organohalogens. It is undoubtedly true that a variety of flame retardants exist that are halogen-free but it is typically not possible to just simply replace an existing flame retardant by an alternate one and provide both the same level of safety and the same level of alternate material properties. For example, even my own work (see references 1, 28, 284, 485, 486, 488 in my Curriculum Vitae attached) has shown how the effectiveness of flame retardant additive systems is highly dependent on the complete formulation and that flame retardants that can be used for a specific application will not be suitable for other applications, even if they appear to be similar.

One example where every one of the suitable materials contains organohalogens is the case of electrical or optical fiber cables used in plenums. Plenums are not directly regulated by the building codes (whether the International Building Code (IBC, issued by the International Code Council) or NFPA 5000 (issued by the National Fire Protection Association) but the building codes refer to the National Electrical Code (NEC, NFPA 70) or to mechanical codes for such regulation. The very high fire performance required for materials contained in plenums is critical because plenums are part of the air distribution system and a fire starting in a plenum can spread throughout a building without the occupants being aware and then burst through an opening far away from the fire origin and penetrate into the living area. Research has been underway for decades for alternative plenum cable materials and no materials have been found that do not contain halogens and that can meet the (appropriately) severe requirements that have been in the National Electrical Code (as well as in mechanical codes) for decades for use in fire safe wires and cables. In this application, the options for fire safe cables consist of the use of materials flame retarded with complex combinations of additives, including organohalogen flame retardants, or the use of fluoropolymer materials (which are also organohalogens and may fall under the category of PFAs). In other words, there is no alternative to the use of organohalogens for plenum wire and cable materials.

It is not true that it is safe to eliminate fire safety requirements for many applications

In the US, in 1950 there were 71.4 fire fatalities per million population; that was before many (if not most) of the fire safety measures in codes and regulations in effect today had been adopted (and before flame retardants were in use to any significant extent, if at all). By 2010 that same number was reduced to 10.1 fire fatalities per million population, and it has been holding statistically steady since that time (10.6 fire fatalities per million in 2020).

In the US, regulation of products on the basis of flammability can occur in two ways: at point of sale (typically by the federal government, although some state or local authorities have occasionally issued such regulation) or at point of use (typically by codes and standards). Regulation at point of sale means that it is illegal to sell products that do not comply. The major federal government organization regulating products at point of sale is the Consumer Products Safety Commission (CPSC). However, CPSC regulates very few products at point of sale. It only regulates the following ones: wearing apparel (16 CFR1610), children's sleepwear (16 CFR 1615 and 16 CFR 1616), carpets and rugs (16 CFR 1630 and 16 CFR 1631), smoldering flammability of mattress components (16 CFR 1632), open flame flammability of mattresses (16 CFR 1633), extremely flammable solids (16 CFR 1500.44) and, most recently, smoldering flammability of upholstered furniture components (16 CFR 1634). Components of one other product are being regulated, at the federal level, by the National Highway Traffic Safety Administration (NHTSA), namely materials contained in the interior of the occupant compartment of motor vehicles, within 1 inch of the air space (FMVSS 302).

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On the other hand, codes and standards regulate at point of use, meaning that they regulate where it is inappropriate to use products that are legal to sell but are not safe to use in various applications. Building codes (as well as residential codes) regulate materials and products that go into various buildings before the building is deemed safe for use, by having a "certificate of occupancy" issued by the local authority having jurisdiction.

One example of the need for improved flammability requirements is the area of interior finish (meaning the surfaces of walls and ceilings). Before any code requirements existed for interior finish materials (and specifically for foam plastics), fast flame spread along the insulated walls in a home in Missouri led to the deaths of two children and to a landmark decision by the Federal Trade Commission in 1973. The FTC decided that foam plastic insulation needed to undergo fire testing that was reliable and accurate for evaluating and predicting the burning characteristics or the materials under actual fire conditions. This resulted in changes in all the applicable codes that severely restricted the unsafe use of such materials; since then foam plastic insulation materials (whether exposed or covered by a flexible wallcovering) had to undergo (and pass) a severe fire test (namely what has been called a room-fire test) or be protected from the interior (meaning the occupiable space) of the building by a thermal barrier. That has resulted in a massive decrease in fires (and fire fatalities) resulting from interior finish materials. There have been three massive fires internationally (one in the US) where the lack of compliance with those requirements resulted in a very high number of fire fatalities in nightclubs: The Station (West Warwick, RI, 2003, 100 fatalities), Cromagnon (Buenos Aires, Argentina, 2004, 194 fatalities), and Kiss (Santa Maria, Brazil, 242 fatalities). In all of those cases, the flames spread along the interior finish, which was a plastic foam material. The case of The Station nightclub is particularly poignant because the owners (or the operators) of the venue knew (or should have known) that the material used for walls and ceilings did not comply with code requirements.

Another example of an application where improved flammability requirements have shown to be extremely helpful to fire safety is the case of TV cabinets and computer monitors. In the US, the flammability of appliances is not regulated by the CPSC (as pointed out earlier, only a few consumer products are regulated by CPSC on flammability) nor by codes, such as the building codes or the fire codes, since such products can be purchased freely and introduced into various occupancies. Voluntary standards (such as UL 746, in its various parts) govern the requirements for appliances, but they are only mandatory if the appliance is "listed" to a specific industry standard. The housings for TV cabinets and computer monitors in the US have traditionally been required to comply with a certain fire test (typically UL 94 V-0 flammability ratings), while European TV cabinets were not. A famous study by Jürgen Troitzsch, in Germany, way back in the 1990s (Fire Safety of TV-Sets and PC-Monitors), showed how the European TVs were able to be ignited (and cause a room to go to flashover) with the simple application of a very small candle (typically used as a food warmer), while the US TV sets were not ignited until a much more severe ignition source was used, and the compartment did not reach flashover. Similar work was performed by Matthew Blais and collaborators, at Southwest Research Institute (San Antonio, TX) in 2014 ("Combustion Characteristics of Flat Panel Televisions With and Without Fire Retardants in the Casing", Fire Technology 51(1), pp. 19-40, Jan. 2014), and it showed that "US market televisions required more than 500 W with greater than 180 s exposure to ignite and in four out of the 6 trials these televisions did not achieve sustained ignition". This contrasted with TV cabinets imported from Brazil and Mexico, where "televisions ignited easily with 60 s exposure to a 50 W flame". In view of the ubiquitous presence of TV cabinets and/or computer monitors in many office and home environments, such a significant difference in fire safety is critical.

In the context of TV cabinets, it is worth referencing a life cycle assessment study, involving large-scale fire tests, small-scale fire tests and modeling, conducted in Sweden comparing the environmental emission effects of TV cabinets containing flame retardants to meet the UL 94 V-0 requirement and others that did not ("Fire-LCA Model: TV Case Study" by M. Simonson-McNamee et al. SP Technical Research Inst. Sweden, 2000, Report 2000-13). The report shows that the use of the flame retarded TV cabinets decreases the number of accidental TV fires from some 165 per million sets (statistics from Europe at the time) to a very small number. Even more interestingly, the environmental emissions associated with the TV fires also decreased significantly (including the emissions of key toxic species such as dibenzodioxins and polynuclear aromatic hydrocarbons). TV fires in Europe at the time resulted in some 160 fire fatalities per year; with fewer fires, the number of fire fatalities also decreases.

Fire propagation in any fire scenario is affected to a very large degree (probably more than anything else) by the heat release rate of the combustible materials and it has been shown that flame retardants decrease heat release rate. Babrauskas and Peacock demonstrated, in 1992 (Babrauskas, V. and Peacock, R.D., "Heat Release Rate: The Single Most Important Variable in Fire Hazard", Fire Safety Journal, vol. 18, pp. 255-272, 1992.), that it is heat release rate that controls most other fire properties. One of the key effects of flame retardants is to decrease the heat release rate (note, again my own publications numbers 485 and 486). However, even more important is the fact that decreasing heat release will increase the time available for escape and rescue in a fire. This was demonstrated in great detail by work conducted at the National Bureau of Standards (NBS) in 1988 (Babrauskas, V., Harris, R.H., Gann, R.G., Levin, B.C., Lee, B.T., Peacock, R.D., Paabo, M., Twilley, W., Yoklavich, M.F. and Clark, H.M., "Fire Hazard Comparison of Fire-Retarded and Non-Fire-Retarded Products," NBS Special Publ. 749, National Bureau of Standards, Gaithersburg, MD, 1988.). The NBS work showed how adding flame retardants lowers heat release and significantly increases time available for escape and rescue, while not increasing smoke obscuration and significantly decreasing the degree of toxicity without changing its characteristics (in the words of the report: "The results showed that none of the test specimens produced smoke of extreme toxicity. The smoke from both the FR [meaning flame retarded] and NFR [meaning non flame retarded] products was similar in potency and comparable to the potency of the smoke produced by materials commonly found in buildings."). The NBS work addressed five commercial products not containing flame retardants and the equivalent five products containing some flame retardants. The report states that the flame retarded formulations were chosen to represent ones which are (or were, at the time) commercially available and in common use, but which were anticipated to represent high quality performance. None of the systems was designed to provide exceptional fire performance. The five products assessed were: (a) television housings, (b) business machine housings, (c) upholstered chairs, (d) electric cable arrays, and (e) laminated electronic circuit boards. The significant improvement in time available for escape and rescue from using flame retarded products is an indication of the importance of retaining fire safety requirements.

The assumption that all organohalogen flame retardants are toxic is incorrect.

In fact, the report states (page 23) "***<u>Some</u>*** organohalogen flame retardants are linked to human and environmental health problems", which is correct. However, the flame retardants industry has ceased manufacturing those flame retardants that have been shown to have adverse health or environmental effects. The health effects of flame retardants have now been studied extensively and it is inappropriate to ban an entire family of materials just due to the similarity to some materials that are inappropriate for use. It is well-known that the toxicology of chemicals is highly dependent on the exact chemical formulation and that materials with very similar formulations can have very different toxicologies.

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The production of most organohalogenated flame retardants that have been demonstrated to have deleterious effects has already been discontinued For example, the production of all polybrominated diphenyl oxides has long been discontinued by all US manufacturers (Albemarle, Chemtura (now Lanxess) and ICL): production of pentabromodiphenyl oxide and octabromodiphenyl oxide ceased as of 2005 and production of decabromodiphenyl oxide ceased as of 2013, on a voluntary agreement between the manufacturers and the Environmental Protection Agency.

One example of the fact that chemicals should not be regulated as chemical groups are the so-called dioxins, which are not flame retardants. In fact, dioxins are a group of chlorinated organic chemicals, and the term usually includes all polychlorinated dibenzodioxins (PCDDs) and polychlorinated dibenzo-furans (PCDFs). A few of them have harmful characteristics depending on the number and structural position of the chlorine atoms but many others are not toxic. PCDDs and PCDFs are formed of two benzene rings bonded via oxygen atoms. In PCDDs, two rings are joined by two oxygen bridges and in PCDFs by a carbon bond and one oxygen bridge. Chlorine atoms can be attached to eight different places on the molecule, numbered from 1 to 8. That means that there are a possible 210 dioxin and dibenzofuran congeners (meaning 210 different materials identified generically as "dioxins). Of those 210 materials, only 17 are toxic (7 of 75 PCDDs and 10 out 135 PCDFs). In particular, 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD, TCDD), a molecule with four chlorine atoms, is the best known and the most toxic dioxin (GreenFacts, Facts on health and the environment. Scientific facts on dioxins 2004 [displayed 12 November 2010]. Available from http://www.greenfacts.org/en/dioxins/index.htm; "Dioxins and Human Toxicity", N. Marinkovic, D. Pasalic, G. Ferenkac, B. Grskovic, and Stavljenic Rukavina, Arh. Hig. Rada. Toksikol. 2010;61:445-453; "Effects of Dioxins on Human Health: A Review", S. Watanabe, K. Kitamura and M,. Nagahashi, J. Epidemiology, 1998, 9, 1-13).

I have done an analysis of the toxic effects of flame retardants as studied by the US National Research Council. (Committee on Toxicology, Subcommittee on Flame-Retardant Chemicals: D.E. Gardiner (chair), J.F. Borzelleca, D.W. Gaylor, S. Green, R. Horrocks, M.A. Jayjock, S. Kacew, J.N. McDougal, R.K. Miller, R. Snyder, G.C. Stevens, R.G. Tardiff and M.E. Vore, "Toxicological Risks of Selected Flame-Retardant Chemicals", National Academy Press, Washington, DC (2000) in a chapter of a book on flame retarded textiles (see reference 476 in my Curriculum Vitae attached). The analysis indicated that, by and large, the use of flame retardants in textiles (and the conclusion would be equally valid for other applications) provides significant societal benefits. The chapter analyzed the potential hazards of flame retardants from the point of view of smoke toxicity, inherent toxicity, carcinogenicity and environmental damage. It is apparent that the use of flame retardants presents a benefit to society and the environment. Undoubtedly not all flame retardants ever developed or about to be developed are safe from all points of view, but the use of appropriate scientific knowledge and the regulatory environment can effectively ensure that unsafe materials are kept away from consumers.

Conclusions

As a scientist who has spent over 40 years studying fire safety and advocating for improvements in fire safety for the general public, I am fully convinced that a ban on organohalogen flame retardants will not result in an improvement in safety but will, in fact, cause serious negative effects. I hereby urge the State of Washington Department of Ecology not to implement the recommendations of the "Draft Regulatory Determinations Report to the Legislature: Safer Products for Washington Implementation Phase 3".

Dated: January 14, 2022
Attachment: Curriculum Vitae of Marcelo M. Hirschler

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MARCELO M. HIRSCHLER, Lic., Ph.D.

CURRICULUM VITAE

EDUCATION

University:	University of Buenos Aires 1966-70 Licentiate in Chemistry - Major: Physical Chemistry
Post-graduate:	University of Buenos Aires 1971-75 Doctor in Chemistry - Major: Polymer Physical Chemistry

EMPLOYMENT HISTORY

- September 1995 -
  Fire Science Consultant/President
  GBH International, Mill Valley, California
- March 1995 - September 1995
  Fire Science Consultant
  GBH International, Rocky River, Ohio
- March 1991 - February 1995
  Fire Science Consultant
  Safety Engineering Laboratories, Inc., Rocky River, Ohio
- December 1986 - February 1991
  R & D Manager - Fire Sciences
  BFGoodrich Co. - Geon Vinyl Division, Avon Lake, Ohio
- June 1986 - December 1986
  Sr. R & D Associate - Flammability
  BFGoodrich Co. - Geon Vinyl Division, Avon Lake, Ohio
- August 1984 - June 1986
  R & D Associate - Flammability
  BFGoodrich Co. - Chemical Group, Avon Lake, Ohio
- October 1977 - July 1984
  Temporary Lecturer (Physical Chemistry)
  Department of Chemistry - The City University, London, England
- October 1975 - October 1977
  Post Doctoral Research Fellow
  School of Molecular Sciences - University of Sussex, Brighton, England

- June 1975 - October 1975
  Researcher - Physical Chemistry of Carbons
  R & D Department - ALUAR Aluminio Argentino, Buenos Aires, Argentina
- March 1971 - June 1975
  Post-graduate Research Assistant, Department of Physical Chemistry
  School of Pharmacy and Biochemistry - University of Buenos Aires
  Buenos Aires, Argentina
- March 1970 - December 1971
  Undergraduate Teaching Assistant, Department of Physical Chemistry
  School of Exact and Natural Sciences - University of Buenos Aires
  Buenos Aires, Argentina

SOME AWARDS

- Interflam Trophy (UK): 1988
- ASTM E-5 Certificate of Appreciation: 1989
- Wire Association International: Best Electrical Paper 1989
- ASTM Society Frank W. Reinhardt Award for Fire Terminology: 1990
- ASTM E-5 Award of Recognition: 1995
- ASTM E-5 Award of Recognition: 1998
- Canadian Standards Association: Award of Merit: 1999
- ASTM D-9 Award of Appreciation: 2001
- ASTM E-5 Wayne Ellis Award from Society Chairman: June 2002
- ASTM E-5 Award of Appreciation: 2005
- ASTM E-5 Award of Special Recognition: 2006
- ASTM D-20 Award of Appreciation: 2006
- ASTM E-5 Award of Appreciation: 2007
- ASTM E-5 Certificate of Appreciation: 2008
- ASTM E-5 Award of Recognition: 2009
- NFPA Committee Service Award: 2011
- ASTM D-20 Award of Recognition: 2012
- ASTM E-5 Award of Recognition: 2012
- NFPA Certificate of Appreciation: 2013
- ASTM E-5 Award of Recognition: 2013
- ASTM E-5 Special Recognition Award: 2015
- ASTM E-5 Award of Recognition: 2015
- ASTM Society: Award of Merit: 2017
- ASTM D-20: Outstanding Achievement Award: 2017
- ASTM E-5 Award of Recognition: 2019

LANGUAGES

English, German, Spanish, French

MEMBERSHIP PROFESSIONAL SOCIETIES

- American Society for Testing and Materials (ASTM): (See below for committee details)
- Canadian Standards Association (CSA)
- Combustion Institute (Western States Section)
- Institute of Electrical and Electronics Engineers (IEEE)
- International Association for Fire Safety Science
- International Association of Plumbing and Mechanical Officials (IAPMO)
- International Code Council (ICC)
- International Heat Release Association (IHRA)
- National Fire Protection Association (NFPA) (Various Sections and committees)

ACTIVITIES

Marcelo Hirschler Provides Technical Expertise in Fire Safety Including:

- **Product Liability Expert Witness**
- **Codes and Standards**
- **Fire Safety Research and Testing Projects**

WORK ACCOMPLISHED

- **Consultancy**

Product Liability: Expert Witness on Fire Safety Subjects

- Fire safety of mattresses
- Fire safety of upholstered furniture
- Flammability of textiles, including apparel and protective clothing
- Fire safety in transportation, including especially automobiles and trains
- Fire properties and fire testing of plastics
- Fire properties and fire testing of cables
- Smoke toxicity
- Smoke corrosivity
- Fire hazard
- Codes and standards

Fire Research (Public Activities)

- Manager Program for Interlaboratory Precision of Intermediate Scale Calorimeter Test Method (ASTM E1623) (1997-1998)
- Technical Coordinator, Fire Protection Research Foundation (NFPA, FPRF) Research Advisory Council on Transportation Vehicles (2002-06)
- Member of NIBS Smotox Steering Committee (1987-91)
- Member of NFPRF Risk Assessment Advisory Committee (1987-91)

- Session chairman at many fire conferences, including: Fire and Materials, Materials for Increased Fire Safety at Int. Conf. Fire Safety (Dr. C.J. Hilado), BCC Flame Retardancy, Int. Association Fire Safety Science, Combustion Institute, American Chemical Society Fire & Polymers, Fire Retardant Chemicals Association.

Editorial

- Associate Editor, Fire and Materials Journal (1991-)
- Editor: Flame Retardancy News (2005)
- Editor: Fire Safety & Technology Bulletin (2006 -)
- Member Editorial Board Journal Fire Sciences, Fire Safety Journal, Fire & Flammability Bulletin (1995 to 2003), Journal of Testing and Evaluation

California State Fire Marshal Advisory Committees:

* Member California State Fire Marshal Flame Retardant Advisory Committee (2013-5)
* Member California State Fire Marshal Working Group on Implementation of Assembly Bill 127 regarding flammability testing for insulation (2014-2015)
* Member California State Fire Marshal Working Group on Wildland Urban Interface Code (2016 through 2020, ongoing)

Codes and standards:

- **International Code Council**

* Member International Building Code Fire Safety Code Committee (2006-7, 2008-9 and 2010-11)
* Proponent of code changes for IBC, IEBC, IFC, IMC, IPC, IRC, IWUIC, IgCC, at various code development cycles

- **ASTM Committee Memberships**

C16: Thermal Insulation
D07: Wood
D09: Electrical and Electronic Insulating Materials
D11: Rubber and Rubber-like Materials
D13: Textiles
D20: Plastics
E05: Fire
E34: Occupational Health and Safety
F07: Aerospace and Aircraft
F08: Sports Equipment, Playing Surfaces, and Facilities
F15: Consumer Products
F23: Personal Protective Clothing and Equipment
F24: Amusement Rides and Devices
F25: Ships and Marine Technology
F33: Detention and Correctional Facilities
F44: General Aviation Aircraft

- **ASTM E05 (Fire Standards):**

* Chairman ASTM E-5.91 and First Vice-Chairman Committee E05: Subcommittee on Fire and Planning and Review (2014 -19)
* Chairman ASTM E-5.15: Subcommittee on Fire and Interior Furnishings and Contents (1990-95)
* Chairman ASTM E-5.17: Subcommittee on Fire and Transportation (2010-15): developed ASTM E2574, new standard fire test for school bus seating
* Chairman ASTM E-5.21: Subcommittee on Smoke and Combustion Products (2004-9)
* Chairman ASTM E-5.31: Subcommittee on Fire Terminology and Editorial (2000-5)
* Recording Secretary ASTM E05: Committee on Fire Standards (2000-5)
* Member-at-large of executive subcommittee of ASTM E05 (2006 - 07)
* Membership Secretary ASTM E05 (2008-13)
* Recording Secretary ASTM E-5.15: Subcommittee on Fire and Interior Furnishings and Contents (1988-90 and 1996-2015)
* Recording Secretary ASTM E-5.91: Subcommittee on Planning and Review of Fire Standards (1990-1999 and 2000-14)
* Recording Secretary ASTM E-5.17: Subcommittee on Fire and Transportation (2003-2009)
* Recording Secretary ASTM E-5.21: Subcommittee on Smoke and Combustion Products (2010-17)
* Chairman ASTM E-5.22.02: Task Group on ASTM E84 Steiner Tunnel Mounting Methods (2002-). Developed several tunnel testing mounting practices - including ASTM E2231, ASTM E2404, ASTM E2573, ASTM E2579 and ASTM E2599
* Chairman ASTM E-5.13.1: Task Group on ASTM E603, Standard Guide for Room Fire Experiments (1992-2009).
* Chairman ASTM E-5.13.8: Task Group on New Practice for Large Scale Heat Release Tests (1997-2009). Developed practice ASTM E2067 and test method ASTM E2257
* Chairman ASTM E-5.15.3: Task Group on Fire Hazard Assessment of Floor Coverings (1987-92)
* Chairman ASTM E-5.15.8: Task Group on Full Scale Fire Testing of Upholstered Furniture (1989-). Developed full scale fire test methods: ASTM E1537, ASTM E1590 and ASTM E1822
* Chairman ASTM E-5.15.12: Task Group on Vandalized Mattresses for Correctional Institutions (1991-93).
* Chairman ASTM E-5.15.13: Task Group on Fire Hazard Assessment of Upholstered Furniture (1994-2009). Developed ASTM E2280, Standard guide on fire hazard assessment for health care occupancies
* Chairman ASTM E-5.17.94: Task Group on Fire Hazard Assessment of Rail Transportation Vehicles (1991-). Developed ASTM E2061, new guide on fire hazard assessment of passenger rail vehicles
* Chairman ASTM E-5.21.13: Task Group on Smoke Toxicity for Flashover Fires (1993-)
* Chairman ASTM E-5.21.33: Task Group on ASTM E906 (Ohio State University Rate of Heat Release Apparatus) (1994-2004).
* Chairman ASTM E-5.21.34: Task Group on Intermediate Scale Calorimeter (1997-2004). Managed interlaboratory round robin for ASTM E1623 and updated standard

* Chairman ASTM E-5.21.35: Task Group on Rate of Heat Release Apparatus by Thermopile Method (1995-). Developed new test method ASTM E2102
* Chairman ASTM E-5.21.3: Task Group on ISO (5659-2) Smoke Chamber (1995-2004) and NBS Smoke Chamber. Developed new test method ASTM E1995
* Chairman ASTM E-5.21.60: Task Group on cone calorimeter (ASTM E 1354) (2009-)
* Chairman ASTM E-5.21.80: Large scale heat release (2009-)
* Chairman ASTM E-5.23.1: Task Group on Non-Combustibility (2008 -12) (merged into ASTM E-5.23.2)
* Chairman ASTM E-5.23.2: Task Group on Alternate Method of Non-Combustibility (2007 -): Developed Test Method ASTM E2652
* Chairman ASTM E-5.31/91 Task Group on Uncertainty (2002-)
* Chairman ASTM E-5.31 Task Group on Terminology (2014-)
* Chairman ASTM E-5.31 Task Group on Services/Functions Standards (2014-)
* Chairman ASTM E-5.32.2: Task Group on 1990 Symposium on Fire Hazard and Fire Risk Assessment (1988-1992). Editor of ASTM STP 1150 (Fire Hazard & Fire Risk Assessment)
* Chairman ASTM E-5.35.2: Task Group on Examples of Fire Hazard Assessment Standards (1989-91)

● **NFPA**

* Chairman NFPA Technical Committee on Hazard and Risk of Contents and Furnishings (2001-2013). Developed new NFPA 556, Guide on Vehicle Fire Safety, & NFPA 557, Standard on Fire Loads
* Chairman NFPA Technical Advisory Committee on Glossary of Terminology (2007-15)
* Member NFPA Life Safety Technical Committee on Furnishings and Contents (1991-)
* Member NFPA Building Code Technical Committee on Structures, Construction, and Materials (2014 -)
* Member NFPA Technical Committee on Hazard and Risk of Contents and Furnishings (1991-)
* Member NFPA National Electrical Code CMP 15: National Electrical Code Panel on Places of Assembly (1993-2001)
* Member NFPA Technical Committee on Fire Tests: (1996-)
* Member NFPA Technical Committee on Merchant Vessels: (1998-)
* Member (Alternate, for Society of the Plastics Industry) of NFPA Technical Committee on Fixed Guideway Transit Systems [Trains]: (2001)
* Member (for North American Flame Retardant Alliance/Plenum Cable Association) of NFPA Technical Committee on Air Conditioning [NFPA 90A-B]: (2002-)
* Member (for North American Flame Retardant Alliance) of NFPA Technical Committee on Fixed Guideway Transit Systems [Trains] [NFPA 130]: (2019-)

- **ASTM D09 (Electrical Insulation Materials)**

* Chairman ASTM D09: (2017-)
* Chairman ASTM D-9.94: Subcommittee on Editorial (2008-)
* Chairman ASTM D-9.21: Subcommittee on Fire Performance Standards (2010-6)
* Chairman ASTM D-9.17: Subcommittee on Fire and Thermal Properties (2016 -)
* Secretary ASTM D09: (2016-2017)
* Secretary ASTM D-9.94: Subcommittee on Terminology and Editorial for Electrical Insulation Materials (1994-2008)
* Chairman ASTM D-9.21.3: Task Group on Smoke Obscuration on Burning of Electrical Cables (1987-2016). Developed ASTM D5424
* Chairman ASTM D-9.21.7: Task Group on Rate of Heat Release from Electrical Cables (1992-2016). Developed ASTM D5537 and ASTM D6113
* Chairman ASTM D-9.21.1: Task Group on Fire Hazard Assessment of Electrotechnical Products (1995-2016). Developed Guide ASTM D5425
* Chairman ASTM D-9.97-1: Task Group on March1999 "90th Anniversary Symposium on Electrical Insulating Materials: International Issues" (1997-1999). Editor of ASTM STP 1376 (1999)
* Chairman ASTM D-9.97 Task Group on ASTM D9 Symposium on Electrical Materials and Fire October 2004.

- **ASTM D20 (Plastics)**

* Chairman ASTM D20-20: Subcommittee on Plastic Lumber (2009-) [Originally subcommittee on Plastic Products]
* Vice-chairman ASTM D20.20.03: Section on Plastics and Combustibility (2013-2017)
* Chairman Task Group on ASTM D4968 (Practice for Review of Test Methods and Specifications for Plastics (2015-)

- **ASTM F33 (Detention and Correctional Occupancies)**

* Chairman ASTM F33.05 Task Group on Furnishings within Detention Occupancies (1997-). Developed test methods ASTM F1534 and F1550 and guide ASTM F1870.

- **ASTM F15, ASTM F08 and other ASTM committees:**

* Chairman ASTM F15.15: Subcommittee on Wall Coverings (Responsible for a standard specification and a standard classification for wall coverings)
* Task group chair and member various task groups.

- **CSA (Canadian Standards Association)**

* Chairman Task Group on Circuit Integrity for CSA C22.2 No. 0.3 (1997-2000)
* Member Committee CSA C22.2 No. 0.3 Wiring Test Methods (1992 -2010)
* Member Committee CSA C22.2 No. 239 Control & Instrumentation Cables (1995 -2010)

- **IEEE (Institution of Electrical and Electronic Engineers)**

* Member IEEE Technical Committee on Electrical Installations in Ships (IEEE 45) (1999-2007)
* Member IEEE Technical Committee on Shipboard Wire and Cable (IEEE 1580) (2000-07)
* Member IEEE Technical Committee on Environmental Assessment of Computer Products, Imaging Equipment and Television (IEEE 1680) (2010-2018)

- **ISO (International Organization for Standardization)**

* Convenor ISO TC 61 SC4 WG8 (Plastics – Burning Behavior - Ignitability and fire growth tests) (2013 -)
* Convenor ISO TC 92 WG8 (Fire Safety – Fire terms and definitions) (2013 -8)
* Member ISO TC61 SC4 (Plastics Burning Behavior)
* Member ISO TC61 SC4 WG2 (Smoke and corrosivity) (2017 -)
* Member ISO TC61 SC4 WG9 (Other Products) (2017 -)
* Member ISO TC61 SC4 WG11 (PVC Products) (2015 -2019)
* Member ISO TC92 SC1 (Building Products - Reaction to fire)
* Member ISO TC92 SC3 (Building Products – Toxicity)

- **IEC (International Electrotechnical Commission)**

* Member US TAG IEC TC89 (Cables and Fire)

Fire Safety Industrial Consultant (Public Information)

- Consultant to the Vinyl Institute on fire and PVC (1991-)
- Consultant to the Fire Retardant Chemicals Association/American Fire Safety Council/North American Flame Retardants Alliance on codes and standards (1997 -)
- Consultant to the National Cotton Council on code issues (2003 -05)
- Expert on various fire issues, for a variety of industrial clients

EMPLOYMENT RESPONSIBILITIES IN PREVIOUS WORK

■ BFGoodrich - Geon Vinyl Division (Fire Sciences Manager)

- Head of BFGoodrich fire testing laboratory: routine small-scale tests.
- Head of BFGoodrich fire research: smoke toxicity and fire hazard assessment; combustion and thermal analysis of poly(vinyl chloride) and other polymers; generation, transport and decay of hydrogen chloride; smoke corrosivity; analytical techniques for measuring combustion products. Provided a presence at national and international fire conferences, for participation and presentation of scientific work. Carried out full scale fire demonstrations, for research and public relations purposes. Supported line groups in the development of new commercial compounds.
- Technical consultant for BFGoodrich on litigation and other external affairs regarding fire and combustion toxicity
- Standards activities representing BFGoodrich: e.g. ASTM, NFPA, Canadian Standards Association.
- Vinyl industry spokesperson
- Chairman Technical Fire Sciences Subcommittee, Coordinating Committee for Fire Safety, Society of the Plastics Industry. Main spokesperson on fire activities for the plastics industry. Liaison with Center for Fire Research (National Bureau of Standards), NFPA, NIBS, etc.
- Technical Monitor SPI Carbon Monoxide and Fire Fatalities Project, etc. (1987-91)
- Chairman Combustibility Subcommittee, Vinyl Institute Technical Committee. Technical monitor of projects at Center for Fire Research (NBS), Southwest Research Institute
- Chairman ASTM E-5.15: Subcommittee on Fire and Interior Furnishings and Contents
- Secretary ASTM E-5.91: Subcommittee on Planning and Review of Fire Standards
- Chairman ASTM E-5.15.3: Task Group on Fire Hazard Assessment of Floor Coverings
- Chairman ASTM E-5.15.8: Task Group on Full Scale Fire Testing of Upholstered Furniture
- Chairman ASTM E-5.31.3: Task Group on Smoke Toxicity Definitions
- Chairman ASTM E-5.32.2: Task Group on 1990 Symposium on Fire Hazard and Fire Risk Assessment
- Chairman ASTM E-5.35.2: Task Group on Examples of Fire Hazard Assessment Standards
- Chairman ASTM D-9.21.3: Task Group on Smoke Obscuration on Burning of Electrical Cables
- Member of NIBS Smotox Steering Committee (1987-91)
- Member of NFPRF Risk Assessment Advisory Committee (1987-91)
- Session chairman on Materials for Increased Fire Safety at Int. Conf. Fire Safety (Dr. C.J. Hilado) (1987-91)
- Session chairman at Combustion Institute Eastern Section meetings
- Session Chairman at Fire Retardant Chem. Association meetings
- Member of ASTM Task Groups E-5.21.70 and D-9.21-4 (smoke corrosivity test development), ASTM E-5.21.02 and E-5.21.03 (smoke obscuration test development), and E5-21.11 (quick toxic fire hazard assessment)

■ **BFGoodrich - Chemical Group & Geon Vinyl Division**

● As subsequent job, at a lower level of responsibility.

■ **Department of Chemistry - The City University**

● Supervision of post-graduate and undergraduate research students
● Research in combustion and air pollution: medium and high molecular weight hydrocarbons, liquid fuels (gasoline, diesel efficiency and effects of additives), polymers (thermal decomposition, flammability and flame retardance: efficiency and mechanism), cellulosic materials (cellulose, cotton, cigarette paper: mechanisms and means of decreasing emissions), emission processes of gaseous pollutants, etc.
● Consultant to the "Unit for Oxidation and Combustion Technology": Ministry of Defense and industrial contract research organization.
● Consultant to the OECD (Organization for Economic Cooperation and Development; Paris, France): industrial and automotive pollution issues.

■ **School of Molecular Sciences - University of Sussex**

● Research in physical organic chemistry: syntheses and kinetics of radioactive decay by protiodetritiation of polycyclic aromatic hydrocarbons.

■ **R & D Department - ALUAR Aluminio Argentino**

● Planning for setting up a laboratory and literature search

■ **Department of Physical Chemistry - School of Pharmacy and Biochemistry - University of Buenos Aires**

● Research into polymerization mechanisms, leading to Ph.D.

PUBLICATIONS

Books:

1) "The Combustion of Organic Polymers", C.F. Cullis and M.M. Hirschler, Oxford University Press, Oxford, UK, 1981.

2) "Oxidation of Organic Compounds. Solvent Effects in Radical Reactions", N.M. Emanuel', G.E. Zaikov and Z.K. Maizus, translators: A.K. Henn and I.G. Evans, translation editor: M.M. Hirschler, Pergamon Press, Oxford, UK, 1984.

3) "Fire hazard and fire risk assessment", ASTM STP 1150, Amer. Soc. Testing and Materials, Philadelphia, PA, US, Editor: M.M. Hirschler, (1992).

228) "Carbon monoxide and human lethality: Fire and non fire studies", Editor in Chief: M.M. Hirschler, Associate Editors: S.M. Debanne, J.B. Larsen and G.L. Nelson, Elsevier, New York, US, 1993.

274) "Fire Calorimetry", Editors: M.M. Hirschler and R.E. Lyon, DOT/FAA/CT-95-46, NTIS, Alexandria, VA, US, 1995.

345) "Electrical Insulating Materials - International Issues", ASTM STP 1376, Amer. Soc. Testing and Materials, West Conshohocken, PA, US, Editor: M.M. Hirschler (2000).

453) "Practical Guide to Smoke and Combustion Products from Burning Polymers – Generation, Assessment and Control", M.M. Hirschler, S. Levchik and E.D. Weil, Smithers Rapra Technical Publications, Shawbury, UK, 2011.

Other Scientific Publications and Presentations:

1974

4) "Free radical polymerization of methyl methacrylate in the presence of benzoquinone and triethyl aluminium", J. Grotewold and M.M. Hirschler, Int. Symp. On Macromolecules, Rio de Janeiro, Brazil, July 26-31, 1974.

5) "Formation of a methyl methacrylate oligomer by combining triethyl aluminium and azobisisobutyronitrile", J. Grotewold and M.M. Hirschler, Kinetics and Photochemistry Symposium, Rio Cuarto (Argentina), August 6-10, 1974.

1975

6) "Mechanism of polymerization of methyl methacrylate in the presence of triethyl aluminium together with a typical free radical inhibitor or an initiator", Doctoral Dissertation, University of Buenos Aires.

7) "Report on carbons, carbonization, additives (oxidative and reductive) and polycyclic aromatic hydrocarbons", M.M. Hirschler, Internal Publication, ALUAR Aluminio Argentino, 1975.

1977

8) "Stoichiometric formation of methyl methacrylate oligomer by triethyl aluminium in the presence of azobisisobutyronitrile", J. Grotewold and M.M. Hirschler, J. Polymer Sci., A-1 (Polymer Chemistry), 15, 383-91 (1977).

9) "Triethyl aluminium as a concentration-dependent coinitiator and chain-transfer agent of free radical polymerization of methyl methacrylate in the presence of benzoquinone", J. Grotewold and M.M. Hirschler, J. Polymer Sci., A-1 (Polymer Chemistry), 15, 393-404 (1977).

10) "Electrophilic aromatic substitution. Part 18. Protiodetritiation of anthracene, coronene and triphenylene in anhydrous trifluoroacetic acid", H.V. Ansell, M.M. Hirschler and R. Taylor, J. Chem. Soc., Perkin II, 353-5 (1977).

1978

11) "The formation and destruction of pentenes during the combustion of pentane", C.F. Cullis and M.M. Hirschler, Proc. Royal Soc. (London) A 364, 75-88 (1978).

12) "Isotopic tracer studies of the further reactions of pentenes in the combustion of pentane", C.F. Cullis and M.M. Hirschler, Proc. Royal Soc. (London) A 364, 309-29 (1978).

1979

13) "Sulphur emissions into the atmosphere", C.F. Cullis and M.M. Hirschler, Int. Symp. On Sulphur Emissions and the Environment, London (U.K.), May 8-10, Soc. Chem. Industry, pp. 1-23 (1979).

1980

14) "Atmospheric cycles of some common elements: II. Man's activities", C.F. Cullis and M.M. Hirschler, Educ. Chem. 17, 40-3 (1980).

15) "Sulphur emissions, the environment and chemical industry", M.M. Hirschler, Introductory Lecture, Int. Symp. On Sulphur Emissions and the Environment, London (U.K.), May 8-10, 1979, Soc. Chem. Industry, pp. 445-55 (Discussion Volume) (1980).

16) "Atmospheric sulphur: natural and man-made sources", C.F. Cullis and M.M. Hirschler, Atmos. Environ., 14, 1263-78 (1980).

17) "Ignition of Kynar oxygen valve material", M.M. Hirschler, Report for Health and Safety Executive, U.K., Contract No. 1186-46.04, November 1980.

18) "The effect of atropisomerism upon electrophilic aromatic reactivity: detritiation of hexa- and tetra-o-phenylene", M.M. Hirschler and R. Taylor, J. Chem. Soc., Chem. Comm., 967-9 (1980).

1981

19) "Man's emission of carbon dioxide into the atmosphere", M.M. Hirschler, Atmos. Environ., 15, 719-27 (1981).

20) "Smoking and air pollution", C.F. Cullis and M.M. Hirschler, Seventh Int. Clean Air Conf., Clean Air Soc. Australia and New Zealand, Adelaide (Australia), August 21-27, pp. 115-29 (1981).

21) "Biogenic sulphur emissions", M.M. Hirschler, Atmos. Environ. 15, 1336 (1981).

22) "The oxidative thermal stability of plastic propellants", A.W. Benbow and M.M. Hirschler, Report for Procurement Executive, Propellants, Explosives and Rockets Motor Establishment, Ministry of Defence, U.K., Contract No. D/RM 1/11/240, February 1981.

23) "The combined action of aluminium oxides and halogen compounds as flame retardants", F.K. Antia, C.F. Cullis and M.M. Hirschler, Europ. Polymer J., 17, 451-5, (1981).

24) "The inhibition of polymer combustion by metal oxides", F.K. Antia, C.F. Cullis and M.M. Hirschler, First Specialists' Mtg Combustion Institute, Bordeaux (France), July 20-25, pp. 602-7 (1981).

25) "Experimental techniques for the combustion of fuels of low volatility and high reactivity", C.F. Cullis, M.M. Hirschler and R.L. Rogers, 18th. Symp. (Int.) on Combustion, pp. 1575-82, The Combustion Institute, Pittsburgh, 1981.

26) "The oxidation of decane in the gaseous and liquid phases", C.F. Cullis, M.M. Hirschler and R.L. Rogers, Proc. Royal Soc. (London), A 375, 543-63 (1981).

1) "The Combustion of Organic Polymers", C.F. Cullis and M.M. Hirschler, Oxford University Press, Oxford, 1981.

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27) "The cool-flame combustion of decane", C.F. Cullis, M.M. Hirschler and R.L. Rogers, Proc. Royal Soc. (London), A 382, 429-40 (1982).

28) "Recent developments in flame-retardant mechanisms", M.M. Hirschler, in "Developments in Polymer Stabilisation, Vol. 5", Ed. G. Scott, pp. 107-52, Applied Science Publ., London, 1982.

29) "Binary mixtures of metal compounds as flame retardants for organic polymers", F.K. Antia, C.F. Cullis and M.M. Hirschler, Europ. Polymer J., 18, 95-107 (1982).

30) "Comprehensive study of the effect of composition on the flame-retardant activity of antimony oxide and halogenated hydrocarbons in thermoplastic polymers", F.K. Antia, P.J. Baldry and M.M. Hirschler, Europ. Polymer J., 18, 167-74 (1982).

31) "Effect of oxygen on the thermal decomposition of poly(vinylidene fluoride)", M.M. Hirschler, Europ. Polymer J. 18, 463-7, (1982).

32) "Relation between the thermal behaviour and flame-retardant effectiveness of metal oxides in halogen-containing thermoplastics", M.M. Hirschler, Sixth European Conf. on Flammability and Fire Retardants, Alena Enterprises of Canada, June 24-25, Nice (France), 1982.

33) "Thermal stability and flammability of organic polymers", C.F. Cullis and M.M. Hirschler, I.U.P.A.C. Macro '82, Polymer Degradation and Stabilisation, July 12-16, Amherst (U.S.), p. 286, 1982.

1983

34) "The role of specific elements in flame-retardant mechanisms", M.M. Hirschler, Polymer Flammability: Mechanistic and Practical Aspects, P.D.D.G. Conf., Macro Group U.K. (Royal Soc. Chemistry), September 2-3, Cambridge (U.K.), 1983 (Industrial Chemistry Bulletin, 2, 52 (1983)).

35) "The pyrolysis of cellulose under conditions of rapid heating", C.F. Cullis, M.M. Hirschler, R.P. Townsend and V. Visanuvimol, Combust. Flame 49, 235-48 (1983).

36) "The combustion of cellulose under conditions of rapid heating", C.F. Cullis, M.M. Hirschler, R.P. Townsend and V. Visanuvimol, Combust. Flame 49, 249-54 (1983).

37) "Flame retardance and smoke suppression by tin (IV) oxide phases and decabromobiphenyl", J.D. Donaldson, J. Donbavand and M.M. Hirschler, Europ. Polymer J. 19, 33-41 (1983).

38) "Thermal analysis and flammability of polymers: Effect of halogen-metal additive systems", M.M. Hirschler, Europ. Polymer J. 19, 121-9 (1983).

39) "The effect of combinations of aluminium (III) oxides and decabromobiphenyl on the flammability of and smoke production from acrylonitrile-butadiene-styrene terpolymer", M.M. Hirschler and O. Tsika, Europ. Polymer J., 19, 375-80 (1983).

40) "Mechanism of action of pyrogenic silica as a smoke suppressant for polystyrene", R. Chalabi, C.F. Cullis and M.M. Hirschler, Europ. Polymer J., 19, 461-8 (1983).

41) "The significance of thermoanalytical measurements in the assessment of polymer flammability", C.F. Cullis and M.M. Hirschler, Polymer, 24, 834-40 (1983).

42) "The influence of metal chelates on the oxidative degradation of polypropylene", C.F. Cullis and M.M. Hirschler, in Proc. Fifth Ann. Int. Conf. Advances in the Stabilisation and Controlled Degradation of Polymers, Zurich (Switzerland), June 1-3, pp. 195-207 (1983).

43) "Metal oxides as flame retardants-smoke suppressants: recent developments", M.M. Hirschler, Seventh Europ. Conf. on Flammability and Fire Retardants, Alena Enterprises of Canada, London (U.K.), June 9-10, 1983.

44) "A novel dilution tunnel-flame burner system for studying the effects of automotive diesel fuels on air quality", C.F. Cullis, M.M. Hirschler and M.A.M. Stroud, Sixth World Congress on Air Quality, Paris (France), May 16-20, Int. Union Air Pollution Prevention Assocns, Vol. 4, pp. 265-72 (1983).

45) "Effects of organic sulphur compounds on the ignition of unleaded and leaded hydrocarbon fuels", C.F. Cullis, M.M. Hirschler and G.O.G. Okorodudu, 19th. Symp. (Int.) on Combustion, pp. 1475-86, The Combustion Institute, Pittsburgh, 1983.

46) "The effects on alkane combustion of added sulphur compounds", C.F. Cullis, M.M. Hirschler, G.O.G. Okorodudu and H.A.G. Okuns, Combust. Flame 54, 209-24 (1983).

1984

47) "Char formation from polyolefins: correlations with low-temperature oxygen uptake and with flammability in the presence of metal-halogen systems", C.F. Cullis and M.M. Hirschler, Europ. Polymer J. 20, 53-60 (1984).

48) "Reduction of smoke formation from and of flammability of thermoplastic polymers by metal oxides", M.M. Hirschler, Polymer 25, 405-11 (1984).

49) "Degradation of polystyrene in the presence of magnesium compounds", M.M. Hirschler and T.R. Thevaranjan, Pre-prints, Polymer Div., Amer. Chem. Soc., 189th. Ann. Mtg, pp 91-2 (1984).

50) "Effect of dispersing and binding agents on the flammability of, and smoke production from, thermoplastic polymers", J.D. Donaldson, J. Donbavand and M.M. Hirschler, Europ. Polymer J., 20, 323-7 (1984).

51) "The flame retardance of a natural polymer by a sulphur-aluminium-bromine system", C.F. Cullis, M.M. Hirschler and M.A.A.M. Khattab, Europ. Polymer J. 20, 559-62 (1984).

52) "The flame-retardant and smoke-suppressant activity of molybdenum (VI) oxide and other metal oxides", C.F. Cullis, M.M. Hirschler and T.R. Thevaranjan, Eighth Europ. Conf. on Flammability and Fire Retardants, Alena Enterprises of Canada, Amsterdam (Holland), June 8-9, 1984.

53) "Combustion of cigarette paper under conditions similar to those during smoking", C.F. Cullis, D. Goring and M.M. Hirschler, Cellucon '84 (Macro Group U.K.), Wrexham (Wales), Chapter 35, pp. 401-10, July 16-20, Ellis Horwood, Chichester, 1984.

54) "Heat transfer from fires", M.M. Hirschler, Report for BFGoodrich Chemical Co., July 1984.

55) "Metal chelates as flame retardants and smoke suppressants for thermoplastic polymers", C.F. Cullis, A.M.M. Gad and M.M. Hirschler, Europ. Polymer J., 20, 707-11 (1984).

56) "Combinations of titanium (IV) oxide, iron (III) oxide and molybdenum (VI) oxide as flame retardants and smoke suppressants for thermoplastic polymers", C.F. Cullis, M.M. Hirschler and T.R. Thevaranjan, Europ. Polymer J. 20, 841-7 (1984).

57) "Red phosphorus as a flame retardant for a thermoplastic nitrogen-containing polymer", J.R.A. Broadbent and M.M. Hirschler, Europ. Polymer J. 20, 1087-93 (1984).

58) "The role of diffusion in the rapid combustion of cellulose", M.M. Hirschler and R.P. Townsend, Proc. Royal Soc. (London), A 396, 119-30 (1984).

59) "Carbon monoxide from cigarette paper combustion", M.M. Hirschler and Y.R. Shashoua, Chemical and Physical Processes in Combustion, Eastern Section Combustion Inst., 1984 Fall Tech. Mtg, Clearwater Beach (FL, U.S.), p. 104/1-4, Dec. 3-5 1984.

60) "A novel engine-free dilution tunnel for the collection of particulate matter formed during combustion", C.F. Cullis, M.M. Hirschler and M.A.M. Stroud, J. Phys. E: Sci. Instrum., 17, 317-22, (1984).

61) "The combustion of deuterium-labelled decane", D. Herron and M.M. Hirschler, Oxidation Communications, 7, 321-32 (1984).

62) "Environmental implications of energy strategies (Transportation) Chapter 5: Diesel engines and Fuels", C.F. Cullis and M.M. Hirschler, O.E.C.D., Paris, 1984.

63) "Environmental implications of energy strategies (Transportation) Chapter 6: Two-stroke engines", M.M. Hirschler, O.E.C.D., Paris, 1984.

64) "Environmental implications of energy strategies (Transportation) Chapters 1-8", M.M. Hirschler (Editor), O.E.C.D., Paris, 1984.

65) "Diesels: Increased air pollution vs. energetic and economic advantages", C.F. Cullis and M.M. Hirschler, Eighth Int. Clean Air Conf., Clean Air Society of Australia and New Zealand, Melbourne (Australia), May 1984.

2) "Oxidation of Organic Compounds. Solvent Effects in Radical Reactions", N.M. Emanuel', G.E. Zaikov and Z.K. Maizus, translators: A.K. Henn and I.G. Evans, translation editor: M.M. Hirschler, Pergamon Press, Oxford, 1984.

1985

66) "Effects of magnesium oxide/hydroxide on flammability and smoke production tendency of polystyrene", M.M. Hirschler and T.R. Thevaranjan, Europ. Polymer J., 21, 371-5 (1985).

67) "Simultaneous thermal analysis of PVC compounds", M.M. Hirschler, Ninth Europ. Conf. Flammability and Fire Retardants, Alena Enterprises of Canada, Bad Hofgastein (Austria), May 9-10, 1985.

68) "The effects of red phosphorus on the flammability and smoke-forming tendency of organic polymers", C.F. Cullis, M.M. Hirschler and Q.M. Tao, Ninth Europ. Conf. Flammability and Fire Retardants, Alena Enterprises of Canada, Bad Hofgastein (Austria), May 9-10, 1985.

69) "Efficiency of Metal-Containing Compounds in the Flame Retardance and Smoke Suppression of Polymers", M.M. Hirschler, Am. Chem. Soc., Central Regional Meeting, paper 133, p. 54, June 5-7, Akron, (OH, U.S.A.) 1985.

70) "Update on vinyl flammability, smoke and toxicity issues", M.M. Hirschler, Eighth Vinyl Formulators Tech. Seminar, Sept. 24-27, Bolton Landing (NY, U.S.A.), 1985.

71) "Hazards in a house fire: example of a chair", M.M. Hirschler and G.F. Smith, Chemical and Physical Processes in Combustion, Eastern Section Combustion Institute, 1985 Fall Tech. Mtg, Philadelphia (PA, U.S.A.), p. 59/1-4, Nov. 4-6, 1985.

72) "Soot from fires. I. Properties and methods of investigation", M.M. Hirschler, J. Fire Sciences, 3, 343-74 (1985).

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74) "Organosilicon compounds as antiknock additives", C.F. Cullis, D. Herron and M.M. Hirschler, Combust. Flame, 59, 151-65 (1985).

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75) "Halogen-free flame-retardant thermoplastic polyurethanes", D.R. Hall, M.M. Hirschler and C.M. Yavornitzky, in Fire Safety Science, Proc. First Int. Symp. on Fire Safety Science, Oct. 7-11, Gaithersburg (MD, U.S.A.), Eds. C.E. Grant and P.J. Pagni, pp. 421-30, Hemisphere, Washington, 1986.

76) "Thermal decomposition of poly(vinyl chloride). Kinetics of generation and decay of hydrogen chloride in large and small systems and the effect of humidity", C.A. Bertelo, W.F. Carroll, M.M. Hirschler and G.F. Smith, in Fire Safety Science, Proc. First Int. Symp. on Fire Safety Science, Oct. 7-11, Gaithersburg (MD, U.S.A.), Eds. C.E. Grant and P.J. Pagni, pp. 1079-88, Hemisphere, Washington, 1986.

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