NO IGNITION, NO FIRE!

The Science Behind Fire Safety

presented by

American Chemistry Council | North American Flame Retardant Alliance

Tuesday, July 12, 2022

Introductions & Background

Panelists & Moderator

- **Panelists**
  - Matt Blais, PhD – Southwest Research Institute
  - Tom Osimitz, PhD – Science Strategies
  - Alex Morgan, PhD – Univ. of Dayton Research Institute
- **Moderator**
  - Ben Gann – American Chemistry Council

Agenda

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FIRE RETARDANTS & HOW THEY WORK

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FRs: SAFETY ASSESSMENT & REGULATORY CLIMATE

03

TRADE-OFFS FOR E&E PLASTICS

04

QUESTIONS & DISCUSSION

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About NAFRA

- **ACC’s North American Flame Retardant Alliance (NAFRA)**
    - Represents leading producers of flame retardants used in industrial and consumer applications
- **Dedicated to improving fire safety in a variety of product applications**
- **Members include Albemarle, LANXESS, and ICL Industrial Products**

Fire Safety, Electronics & Electrical Equipment

- **Increased use of electronics & electrical equipment in homes**
  - Total of 25 connected devices across 14 product categories in homes
- **In 2021, US CPSC recalled over 6.2 million units due to fire/shock risk**
- **Changing energy sources & output of electronics – and increased use of plastics – increases fire risk**

Key Factors in FR Selection for Use in Products

- Physical Properties
- Ease of Compounding
- Adequate Thermal Stability
- Corrosivity Issues
- Compatibility
- Health & Environmental Toxicity
- Appearance
- UV Stability
- Electrical Properties
- Combustion Products
- Efficiency/Cost

Regulatory Landscape for Flame Retardants

- **Increased regulatory activity**
- **Creates challenges for companies involved throughout the supply chain**
- **Regulators do not always take a risk-based approach**
  - Hazard + Exposure = Risk
  - Fire safety needs to be a consideration for regulators

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Need for Value-Chain Perspectives in the Regulatory Process

- **Flame retardants need to remain an option for product manufacturers**
- **Upcoming opportunities for engagement**
- **Industry Workshop on WA State**
  - Hosted by ACC
  - Tuesday, July 19 at 12 p.m. EDT
  - Registration is open
- **Canada regulatory proposal for DBDPE**
  - Public consultation open through July 28
  - Send comments to ec.interdiction-prohibition.ec@ec.gc.ca

Flame Retardants and How They Work

Matt Blais, PhD
Director of Fire Technology
Southwest Research Institute

July 12, 2022

How do Flame Retardants Work?

Displace oxygen by releasing other gases like CO_2 (Blowing Agents)

Creating noncombustible barriers: Chars and glassine coatings: phosphorus, silica

Remove Heat: releasing water vapor or other molecules (Gypsum board)

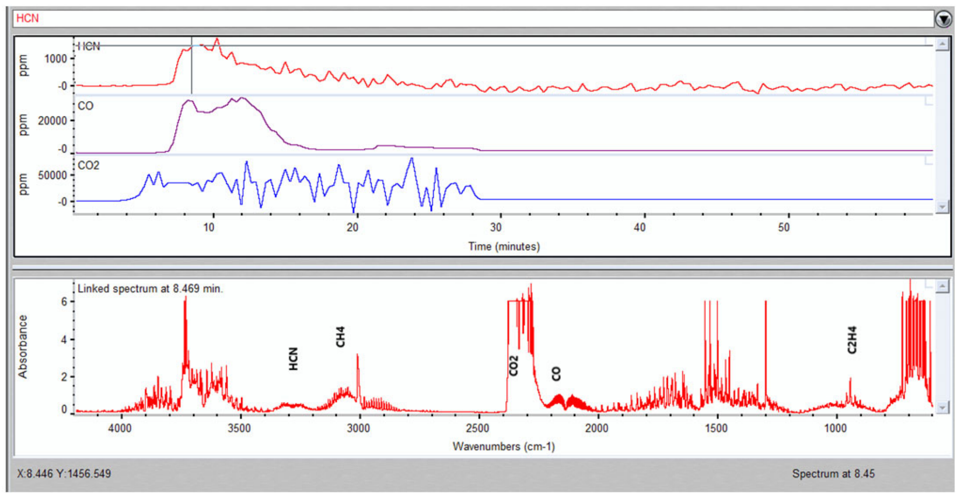
Chemically disrupt the fire through the release of radical scavengers

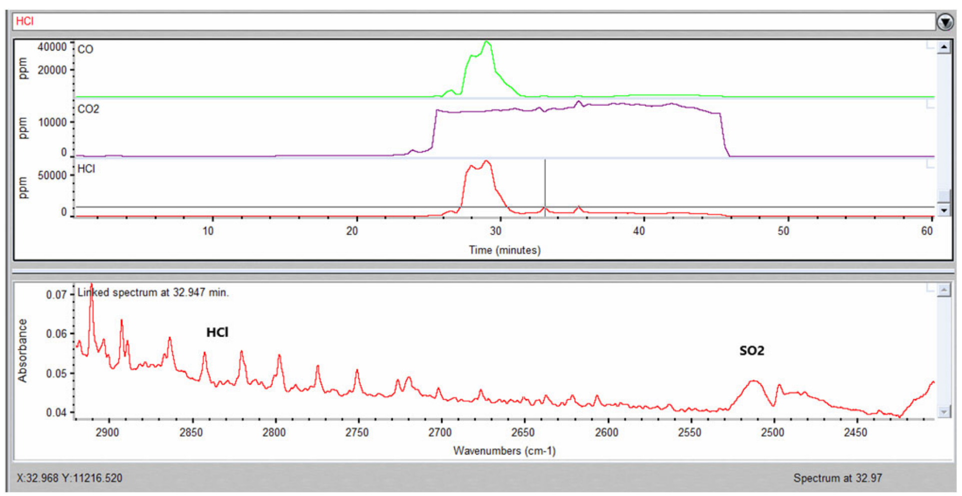
- Halogens
- Synergists Like Antimony

Why are Flame Retardants Needed?

- **Polymers in general have very high energy content**
- **When involved in fire can result in very large, fast-growing fires**
- **FR can prevent ignition and fire or slow the growth of fire to allow escape**
  - Slower fire growth increases available oxygen resulting in cleaner burn (less products of incomplete combustion
  - Less acute toxicity – reduced CO and HCN

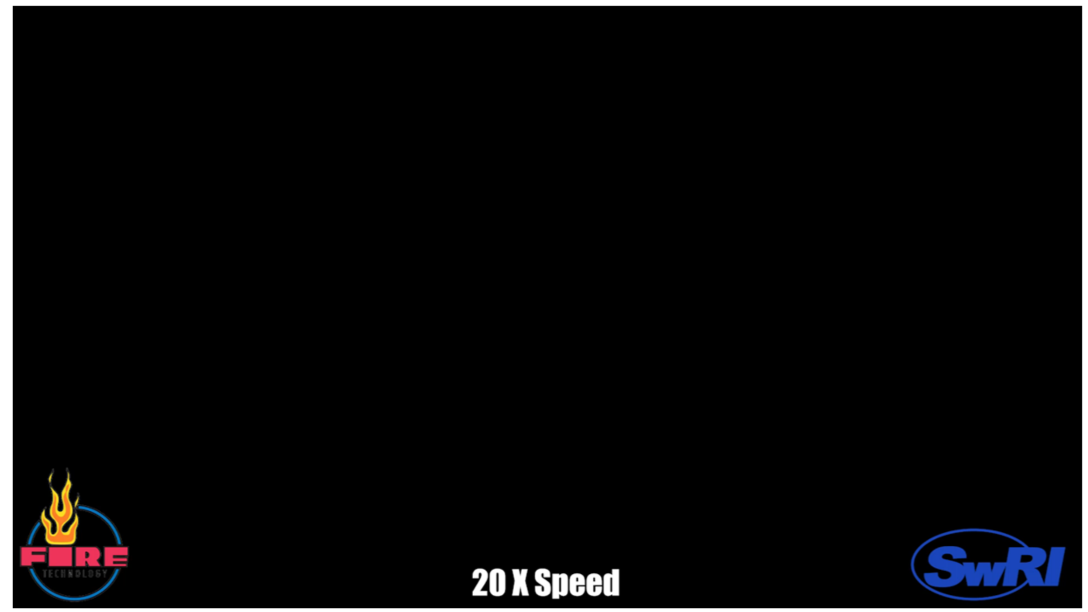
Example of Acute Toxicity Comparison





- Top example is a Fast-burning couch fire, no FR (US)
  - High Cyanide, 1500 PPM
  - High Caron Monoxide 20,000 PPM
  - Very early in the fire 8 minutes after ignition
- Bottom example is a slow burning couch fire, FR
  - NO cyanide detected
  - CO not detected till very late in the fire, 28 minutes

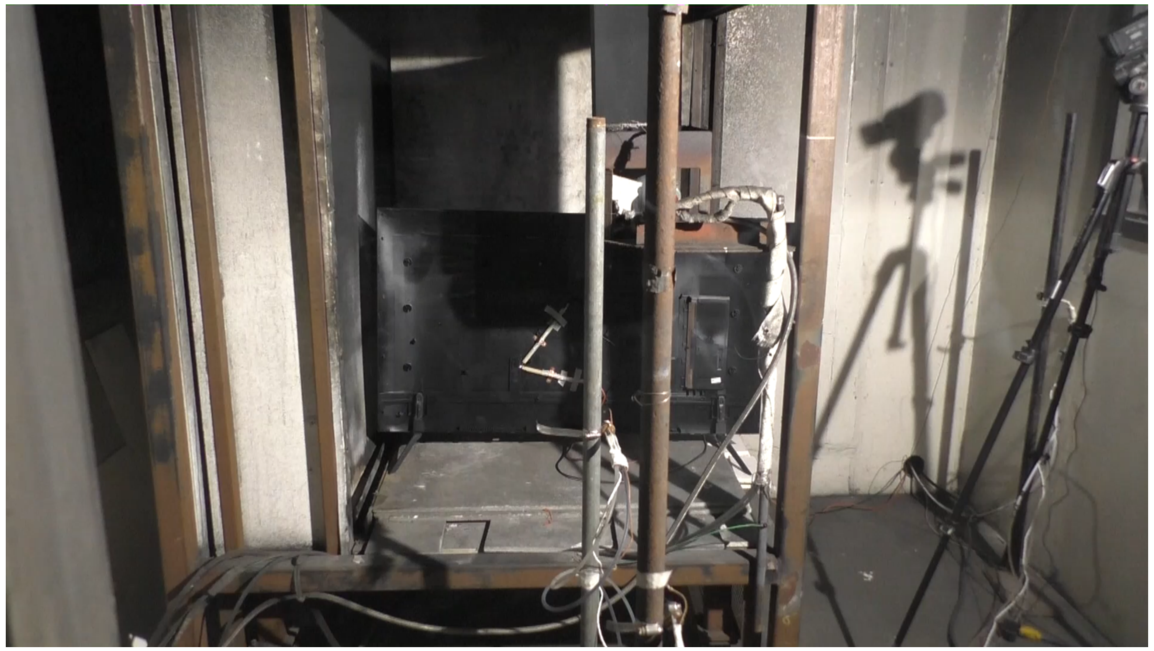
Fire Room Burns



Spark Ignition of Large Screen TVs (55-inch)

- **Two models from Brazil, different manufacturers**
- **1 U.S. model from Brazil with flame retardants**
- **Spark ignition built and applied to inside surface of casing proximal to the power supply of the TV**
    - 1 cm spark gap
    - 2 mm from surface back casing
    - Applied for up to 30 seconds

Brazilian TV #1 Spark Ignition



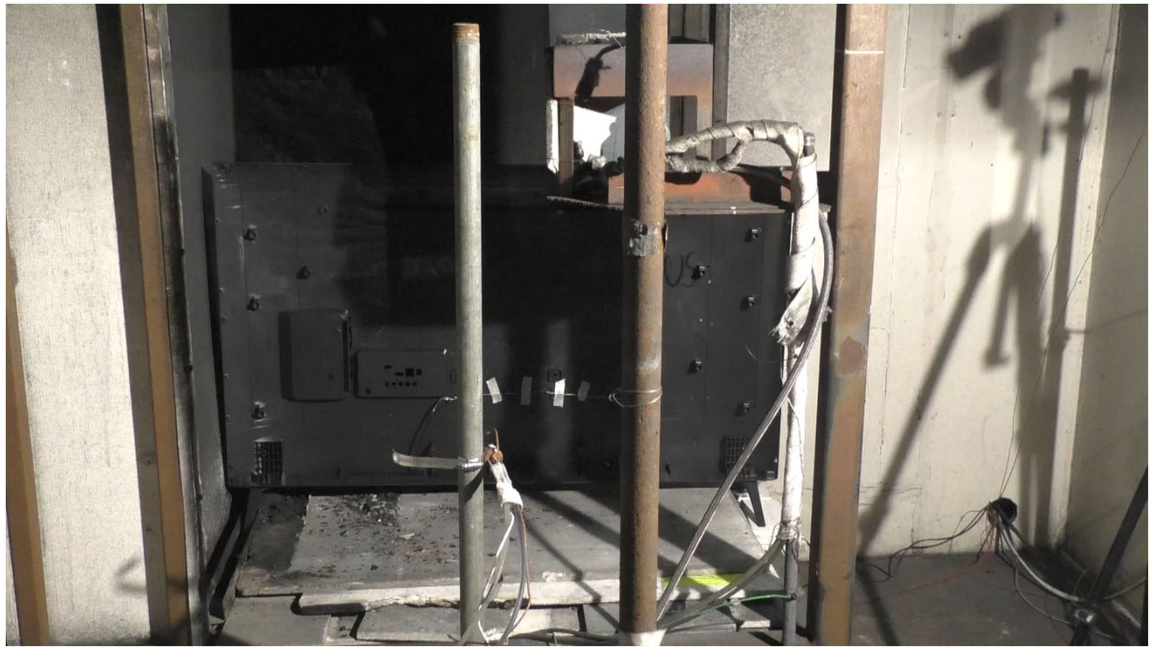
- Brazilian TV
- Spark ignition for 30 second
- No FR
- Completely consumes casing in 18 minutes

Brazilian TV #2 Spark Ignition

- Brazilian TV – different brand
- NO FR
- 4 second spark exposure
- Completely consumes television casing in 15 minutes

US FR Television Casing, Spark Ignition

- Three 30-second attempts
- Each time spark extinguishes
- Final attempt resulted in small fire that extinguishes when spark is turned off



Conclusions

- **Flame retardants prevent ignition in some instances**
- **Flame retardants reduce rate of combustion**
- **Flame retardants greatly delays the formation and reduces the level of acutely toxic gases**
- **Flame retardants are an essential part of fire protection**

Flame Retardants: Safety Assessment and Regulatory Climate

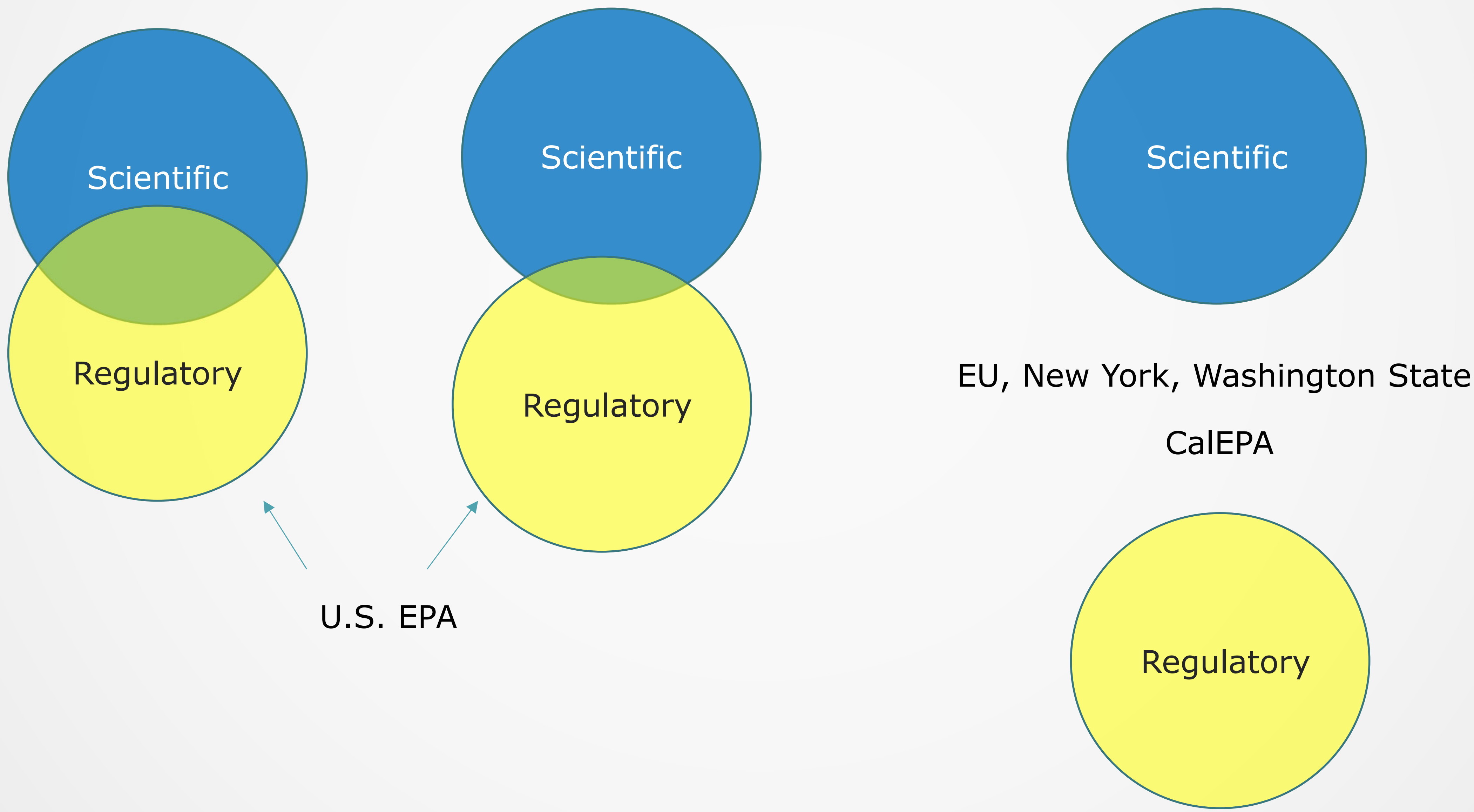
Tom Osimitz, PhD
Principal Toxicologist
Science Strategies

July 12, 2022

Introduction

- ❑ **Complexity of FRs and their applications can be overwhelming**
  - Uses and exposure
  - Science of exposure and toxicity
- ❑ **Driver for regulatory concerns**
  - Extensive data on presence of certain flame retardants in the environment and biological media
    - ◇ Water, soil sediment
    - ◇ Human tissues, blood, urine, breast milk
  - Easy to confuse issues with legacy FRs (no longer being used) in PBDEs with issues with current FRs
- ❑ **We will consider both scientific and regulatory aspects**
  - These sometimes overlap, but not always

Current Situation



Bases for Restrictions – (additive, non-reactive FRs)

- ❑ **Hazard Properties - traditional**
  - Persistent, Bioaccumulative, Toxic (PBT)
  - Carcinogenic, Mutagenic, Reprotoxic (CMR)
    - ◇ Authoritative lists
- ❑ **Use-based – volumes of use**
  - Furniture
  - Electronics – Washington State
- ❑ **Chemical Class – becoming more common**
  - Brominated flame retardants
  - Halogenated flame retardants
  - Note: non-halogenated or non-brominated ≠ non-toxic

Chart – Bases for Regulation (additive FRs)

Flame Retardant (additive)
Bases for Regulation

Hazard-Based
(C,M,R) (P,B,T)

Use-Based

Chemical Class-Based

FR manufacturers closely involved

Risk – Based
Informed by Hazard and Exposure

Both FR manufacturers and application producers involved

Bases for Regulation – The "New and Emerging Rules" for EPA Risk Evaluations

- ❑ **Hazard is important, but so is exposure**
- ❑ **U.S. EPA Risk Evaluation under TSCA**

"The purpose of risk evaluation is to determine whether a chemical substance presents an unreasonable risk to health or the environment, under the conditions of use, including an unreasonable risk to a relevant potentially exposed or susceptible subpopulation. As part of this process, EPA must evaluate both hazard and exposure, exclude consideration of costs or other non-risk factors, use scientific information and approaches in a manner that is consistent with the requirements in TSCA for the best available science, and ensure decisions are based on the weight-of-scientific-evidence."

Risk Evaluation

Hazard Identification

Cancer, mutations, developmental/ reproductive toxicity, immunotoxicity, neurotoxicity,

Exposure Assessment

Likely duration, intensity, frequency, and number of exposures to a chemical under use conditions, Includes the nature/types of individuals exposed

Dose-response Assessment

How potent is the chemical?

Risk Characterization

Expression of Risk

Risk Determination

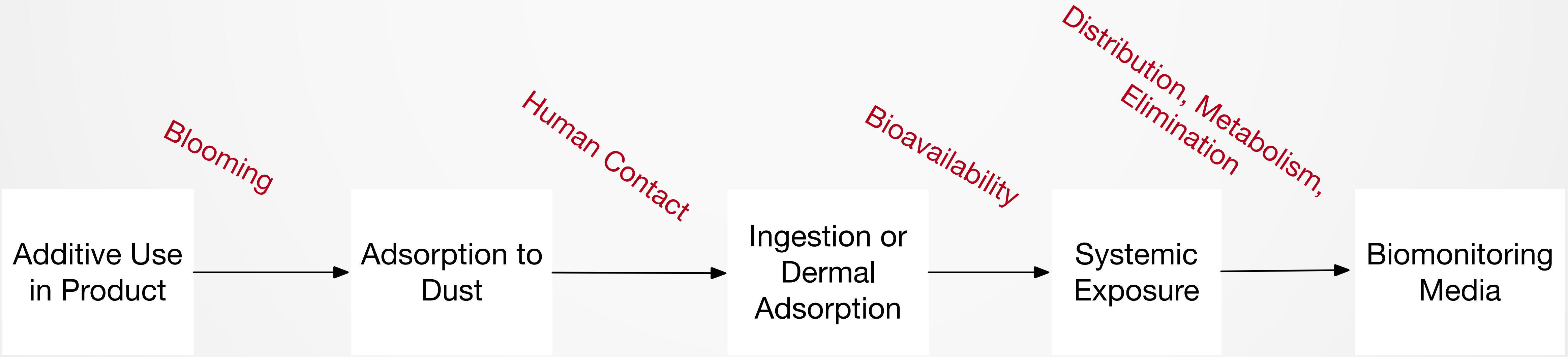
Under the conditions of use, does the FR present an unreasonable risk to health or the environment.

Risk Management

Reformulation, regulation, legislation, etc.

Risk Evaluation - Exposure

- Essential to understand FR-containing product & use conditions
- Consider exposure pathway for TBBPA (e.g. in electronic casings)



U.S. EPA - Risk Considerations Emerging

- **EPA Test Order (March 2022) – requires study of consumer exposure to TBBPA from additive use in plastic battery enclosures**
  - Transfer of chemical from source to settled dust from electrical and electronic products
  - Chemical loading on the skin surface from contact with settled dust on electrical and electronic products
- **Moving toward Risk Cup approach – sum of all potential exposures cannot exceed a threshold exposure level**

Other Dynamics at Play – Firefighter Health

- ❑ **WHO-IARC: Firefighting is "carcinogenic to humans" (July 2022)**
- ❑ **Does the use of flame retarded materials (when burned) pose a greater health threat to firefighters?**
- ❑ **Acute toxicity**
  - Lethal levels of acutely toxic gasses are reached regardless of flame retardant content, such production is much delayed, providing occupants of the room more time to escape prior to being subjected to the toxicity of the smoke (Blais et al. 2020)
- ❑ **Chronic toxicity**
  - Smoke from the combustion of flame-retarded furnishings did not enhance chronic potential chronic toxicity (Osimitz et al. 2022)
- ❑ **No specific flame retardants are cited**

Advice from a Toxicologist to Today's Product Designers

- **Selection of an FR (additive – non-reactive)**
  - Products with a significant flame retardant content (e.g., 20% w/w)
  - Old rules do not apply
- **Beyond simple hazard criteria → consider exposure and risk (EPA) – *You are the experts***
  - Location of FR being used – external casings vs. interior components
  - Life-cycle
  - Exposure pathway – extent of exposure and to whom
  - Risk evaluation

Thank You…

Flame Retardant Deselection and Bans: Trade-offs for Electrical & Electronics Plastics

Alex Morgan, Ph.D
Center for Flame Retardant Material Science
University of Dayton Research Institute

The Science Behind Fire Safety

July 12, 2022

Outline

- Flame Retardant Material Selection for E&E Plastics
  - Current and Future Fire Risk Scenarios
  - Selection Criteria
- Flame Retardant Deselection and Bans
  - Current Regulatory Environment
  - Trade-offs and what remains available
- Conclusions

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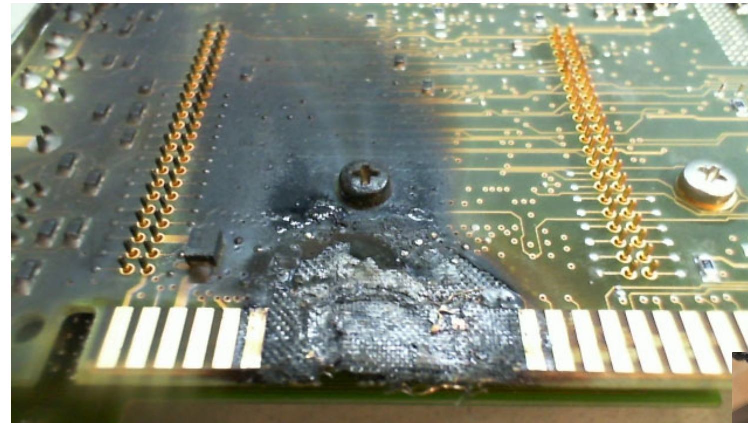
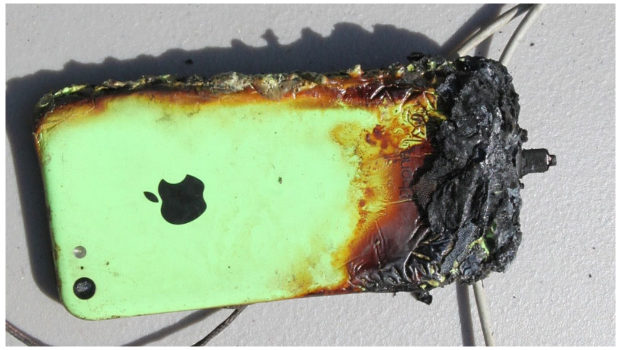
Current Fire Risk Scenarios

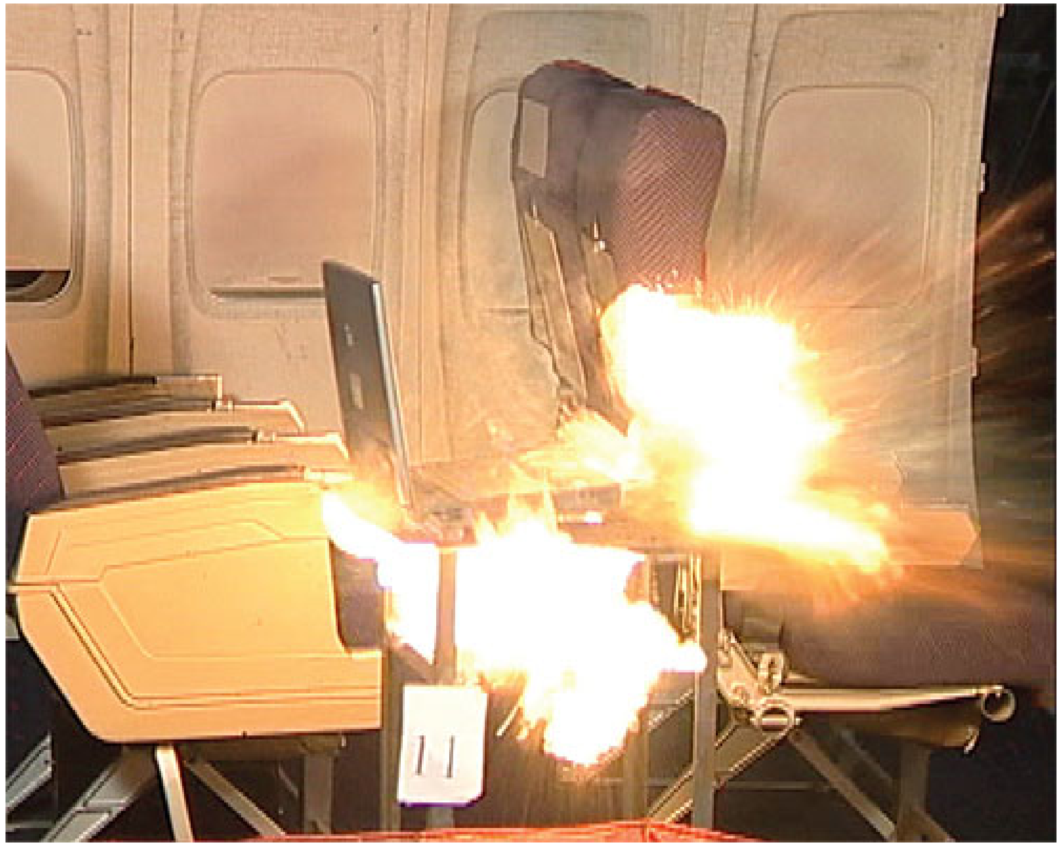
- For most E&E plastics, the fire risk scenarios are usually electrical short circuits leading to a fire, or external heat sources igniting the plastic.
  - Electrical short on circuit board
  - Frayed wire carrying current
  - Power supply failure
  - Something else on fire radiating heat onto E&E plastic
- Flame retardants designed for the plastic they are put into to meet a specific fire risk scenario.
  - Flame retardants are not interchangeable with other polymers in other fire risk scenarios.



Future Fire Risk Scenarios

- Current E&E plastics are getting exposed to new fire risk scenarios as new technologies enter the market
  - DC vs AC power
  - “Always On” power generation (i.e., solar, wind, geothermal)
  - Li-Ion Batteries & Capacitors
  - Higher voltage and amperage
  - Tightly packed electronic devices with battery packs





Flame Retardant Selection Criteria

- Flame retardants are designed to work in a specific polymer to provide fire protection against a specific test which meets a specific fire risk scenario.
  - No universal flame retardant exists (other than inherently non-flammable material)
- One chooses a flame retardant based upon a wide range of technical and non-technical criteria.
  - Technical criteria
    - Balance of Mechanical, Thermal, Electrical, Water-absorption, Flammability, Processing Compatibility properties
      - ***All at desired thickness in end-use application.***
  - Non-technical criteria
    - Cost, Intellectual Property, Color, Capital Equipment Limitations, Regulatory, Recycling/Reuse needs, Customer Desires

Current Regulatory Environment

- Flame retardants (FRs) have been under environmental scrutiny since the 1990s.
  - Poor environmental persistence, bioaccumulation, and toxicity (PBT) properties have led to some brominated and phosphorus FRs being removed from United States (US), European Union (EU), Australian, and some Asian markets
    - Many banned FRs still available for sale in China, and are still produced there.
- EU has led the way with many regulatory bans.
  - Prevention of dioxin in waste-to-energy systems
  - Reduction of Hazardous Substances (RoHS), and Waste Electrical and Electronic Enclosures (WEEE)
- Select US states have implemented newer bans which are broad-brush bans of FRs, regardless of chemical structure.
  - <u>*In some cases, fire safety requirements have been reduced to prevent FR use.*</u>
- Not all of the data on FRs having negative PBT properties is wrong.
  - <u>*FRs migrating out of polymers and getting into the environment is problematic, both from a fire safety perspective, and from an environmental / human health and safety perspective.*</u>

Trade-offs and What Remains Available

- Reactive flame retardants for epoxies (circuit boards) do exist, are commercially available, and address PBT issues because they cannot migrate out of the circuit board.
  - Do have to learn how to process these materials differently, and may have to invest in different capital equipment / processes to use these materials.
- Reactive FRs for thermoplastic materials are not as common, and require the polymer manufacturer to use them during polymer synthesis/manufacture.
  - Potentially, these systems not only address PBT issues, but enable FR plastic recycling – chemistry dependent.
- Polymeric FRs for thermoplastic materials are commercially available, and do address most PBT issues as they cannot easily migrate out of the final part / connector / housing.
  - Polymer/polymer blends easier to make, but getting balance of properties can be tricky.

Trade-offs and What Remains Available

- Moving to inherently low-flammability plastics.
  - Polyetherimides, polyimides, polybenzoxazines, polyaryletherketones, polysulfones, silicones, etc.
    - Much higher melt temperature, so higher cost for processing. Polymers much higher cost as well vs. commodity thermoplastics. Specialized tooling may be needed as well.
    - Silicones show promise, but not appropriate for all applications.
    - Note – chlorinated (PVC) and fluorinated (PTFE, PVF, PVDF) polymers are inherently non-flammable plastics, but are under some regulatory scrutiny as well.
      - Specialized tooling to handle small releases of corrosives is needed for working with these polymers.
- Removing the power supply / ignition source away from the plastic
  - Probably impractical to carry your impact hardened battery pack outside the device.
- Moving to metals, ceramics, and non-flammable materials.
  - Not practical for all applications.

Conclusions

- While there are less FR chemicals available, there are still some choices remaining.
  - How long they will remain viable in light of regulatory US perception that all FR chemicals are bad, regardless of chemistry, is unknown.
  - Low flammability engineering plastics are an option for now, but recycling of these is unknown.
- Currently there is no appetite to reduce fire safety of E&E plastics.
  - UL, NFPA, FAA, other organizations will push back against weakening of fire safety requirements as was done in California and later 16 CFR 1640 for furniture.
- It is possible to have fire safety AND low to no environmental impact.
  - It is likely possible to achieve this with halogen as well as non-halogenated materials, but this will likely be achieved with reactive and polymeric FRs, not small-molecule FRs.
- Understanding the fire threat, fire physics, and chemistry, regardless of the test method, is still critical to the advancement of the FR chemical field.
  - But no funding for this type of work. Will need to collaborate, scrape together resources, and continue to work on this problem.

Thank You

Key Takeaways & Industry Coordination

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Key Takeaways

- **Flame retardants do work and help provide an important layer of fire protection**
- **Regulatory landscape continues to evolve and companies should be aware of the challenges**
- **Need for more/continued active input from downstream users**
  - Perspectives of those with product design experience and expertise are particularly valuable

Industry Coordination

- **Opportunities to work together to ensure the E&E sector's interests are protected**
- **Industry Workshop on WA State**
  - Hosted by ACC
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- **Reach out to us with questions**
  - NAFRA – Ben Gann

Questions & Discussion

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Thank You for Attending