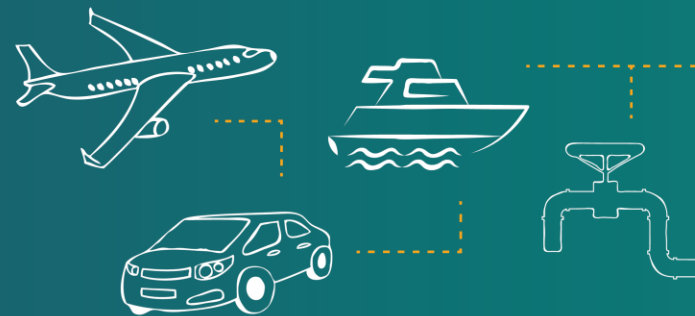




A NEW CAMX FOR A NEW TIME



COMBINED STRENGTH. UNSURPASSED INNOVATION

CAMX
THE COMPOSITES AND ADVANCED MATERIALS EXPO

SEPTEMBER 21-24

A VIRTUAL EXPERIENCE

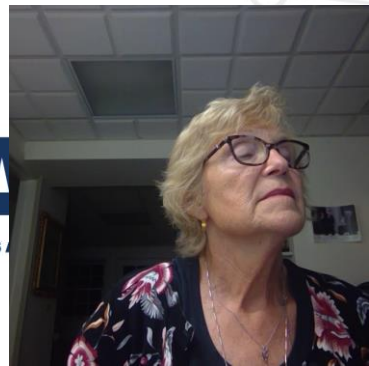
2020



Working Toward More Sustainable Fire Safety Solutions



Maggie Baumann, Vice Chair
pinfa North America
CAMX 2020- Virtual Program



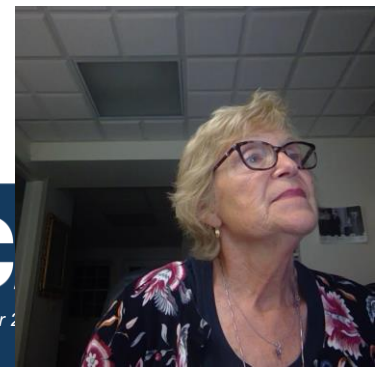
Presentation Content

- I. Who is Pinfa
- II. The Role of Fire Retardants
- III. Flame Retardant Additives
- IV. Flame Retardant Additive Innovation (2000-2020)
- V. FRs: Federal/state law & regulation (USA/Canada)
- VI. Achieving Fire Safety while protecting humans/environment
- VII. Future opportunities for sustainable solutions
- VIII. Summary and Conclusions

A NEW CAMX
FOR A NEW TIME



C
September 2

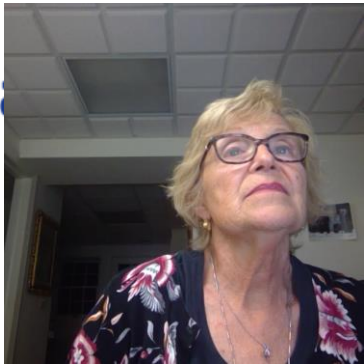


Phosphorus, Inorganic and Nitrogen Flame Retardant Association (pinfa)

(EU, Asia, NA)

Who is Pinfa?

Pinfa is an organization of member companies - producers, formulators and users of PIN FRs.



Your Resource for Flame Retardant Technical and Market Information



PIN FR Product Selector: www.pinfa.eu/product-selector/ - information for over 65 commercial NHFR products

FR Application Brochures (markets: E&E, B&C, Transportation):
www.pinfa.eu/media-events/brochures-publications/

Free Monthly Newsletter (FR materials/Market developments/Regulatory updates):
Sign up @ www.pinfa.eu/media-events/newsletter/

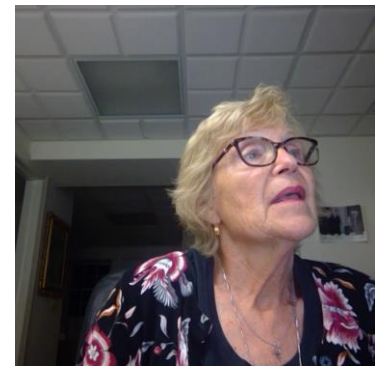
Sponsorship and Educational Outreach to Related Associations, Markets and Industry Events - Networking Opportunities

- SPE, SAMPE, ACMA, PIA, USGBC, GEC, ACS, AMI, Other

Industry Workshops with Market Focus

Technical Training via NHFR Formulators Workshop

For more info please visit www.pinfa-na.org



Protection of Human Life and Property

Meeting fire safety regulations/codes/standards - Options:

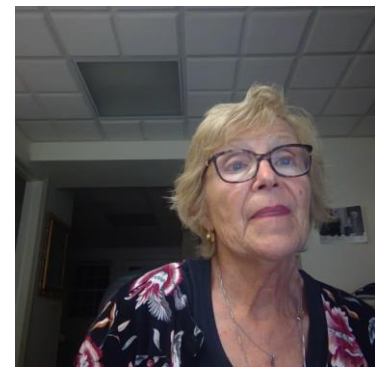
1. Engineering solutions



2. Inherently flame retardant materials i.e. materials not easily ignited or readily combustible - - certain phenolics, PEEK, PTFE (Teflon), LCP, PPS, aromatic polyamide (Kevlar, Nomex)

or....

3. Using flame retardant additives



Specialty Chemicals Industry & FRs

Specialty Chemicals (global): \$556B* (2017)

Flame Retardants (global): \$7.3B** (2017)

Specialty Chemicals - a mature market

- ***CAGR in Net Income (last 5 yrs)
 - Specialty Chemicals: **2.6%**
 - Beverage (alcoholic): **2.9%**
 - Brokerage/Investment Banking: **19.3%**
 - Semiconductor: **24.1%**
 - Telecom (wireless): **52.4%**

Specialty Chemical Market Challenges

- Declining margins, commoditization
- Contraction (mergers & acquisition)

Flame retardant Additives are growing 6-7% annually

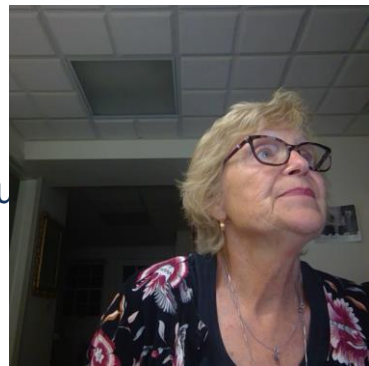


Source(s):

* MarketWatch, 1/3/20 press release

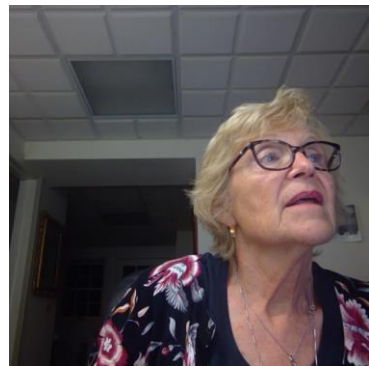
** VisionGain 8/15/17 press release

*** New York University, Stern School of Business, U

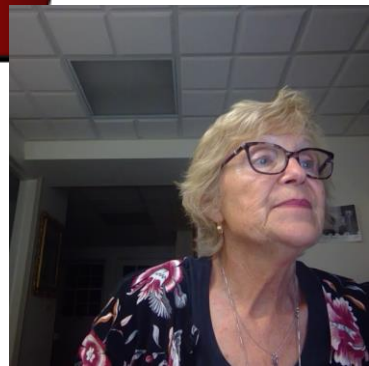
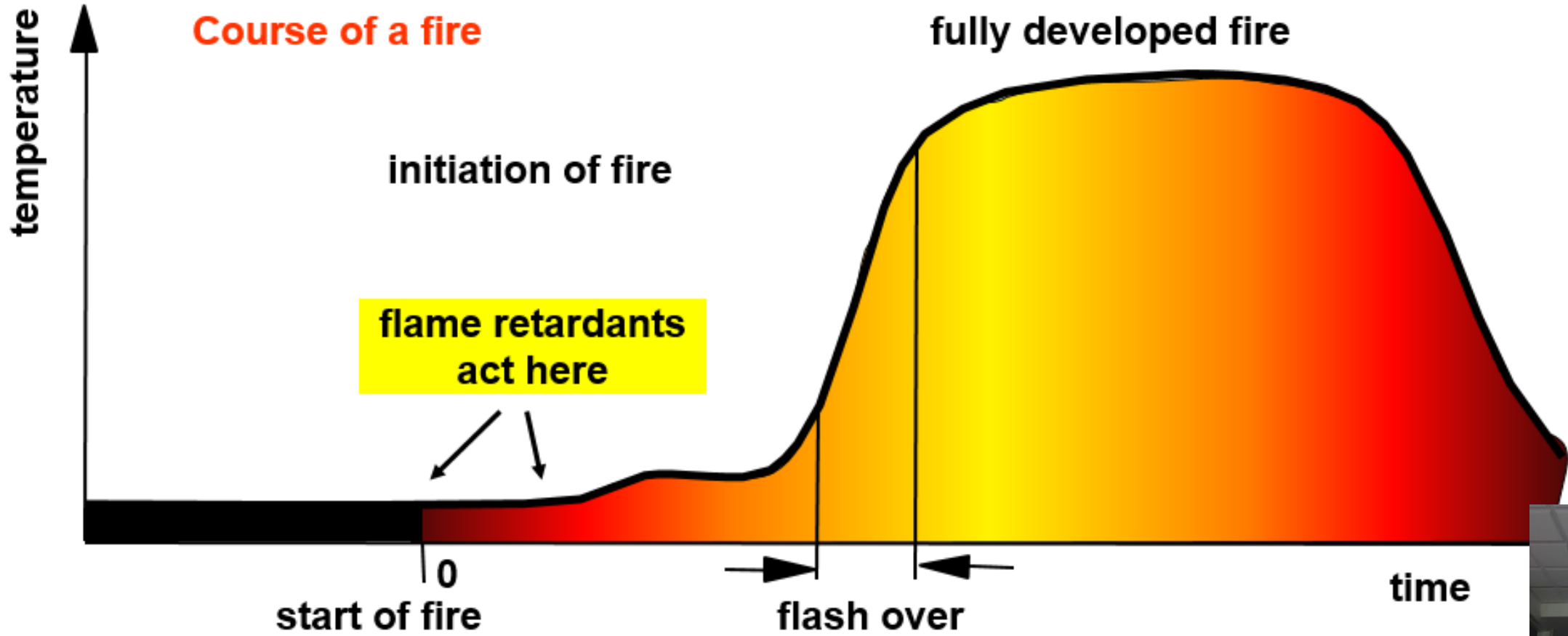


Flame Retardant Additives: New product commercialization- Challenges and Timeline

- 1) **Focused R&D** w/market “need” in mind. **Homework done up front!!** (re. cost, non-exotic rms, .etc.) \$\$\$
- 2) **Screen new molecules/cmpds** for FR efficacy/synergies (resin dependent). **Mfg feasibility?**
Additional question: is this a new chemistry/polymer- recognition that education will also be a component
- 3) **Explore possible application(s)** w/customer collaboration: E&E, B&C, transportation
 - Make sure you understand needs as well as value of the improvement.
- 4) **Patent protection** for chemistry/application IP \$\$
- 5) **Pilot plant production** - (AR approval) or 3rd party toll mfg \$\$\$
- 6) **Global registration** of new chemical \$\$\$
- 7) **Commercial plant production** (AR approval/license) \$\$\$\$\$\$\$+
- 8) **On-spec quality shipments** to customer, **ongoing tech support & product improvement**
- 9) **Tech/Sales/Marketing:** ongoing search for **new applications & increased sales** \$\$\$\$



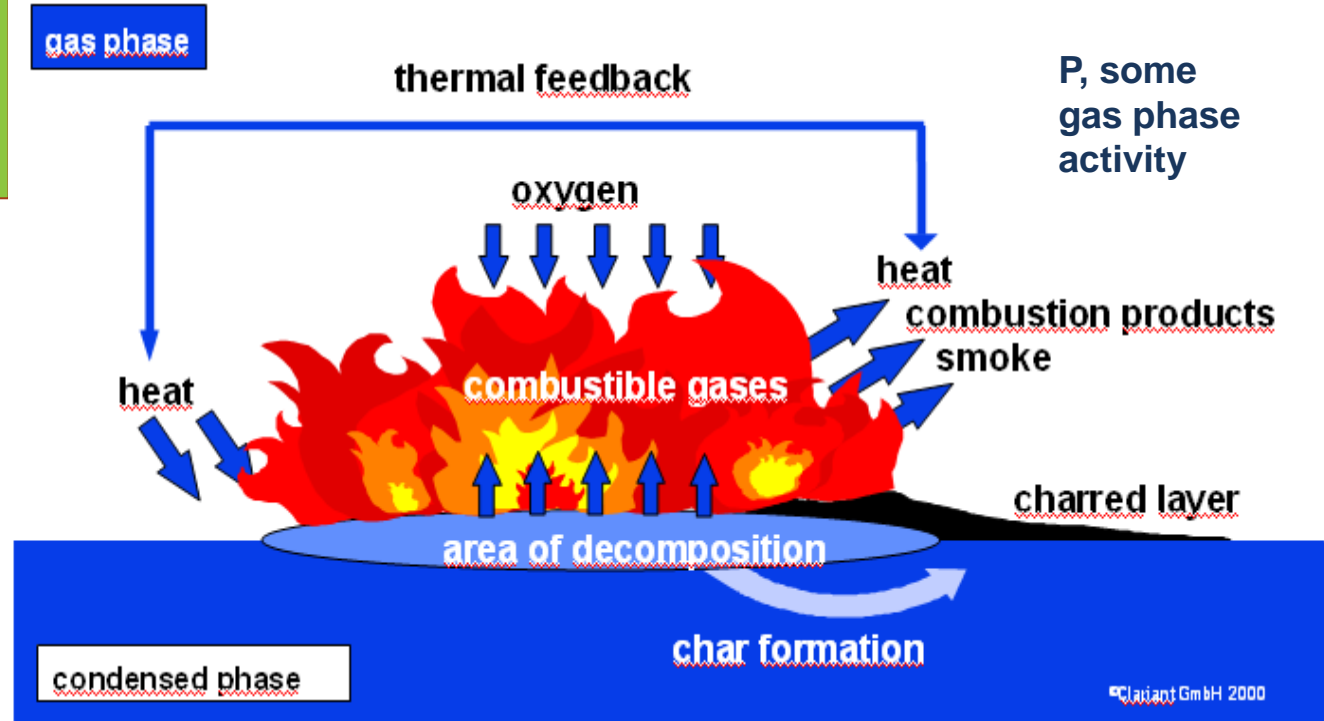
FR benefits: help prevent ignition, slow flame spread & prolong escape time



Combustion of Plastics

Halogenated systems primarily work in the gas phase

NonHal primarily work in the condensed phase



P, some gas phase activity

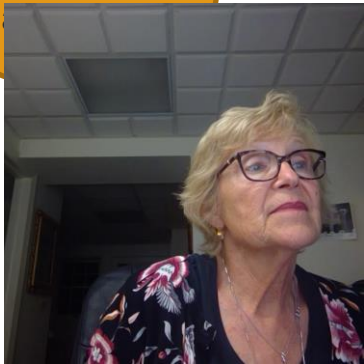
Mineral intumescent

Phosphorus, Nitrogen

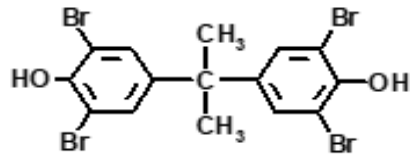
Binary

Multi-

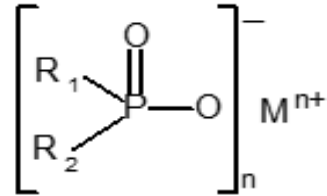
Flame Retardants can inhibit or suppress combustion mechanism by:
Physical Action: cooling, formation of protective layer (coating), dilution
Chemical Action: reaction in gas phase, reaction in solid phase



Many Different Chemistries Can Achieve Flame Retarding Effects



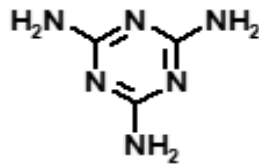
^{35}Cl



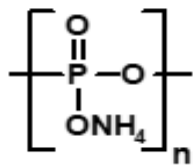
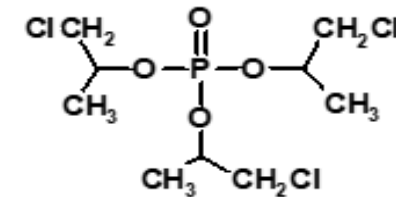
^{31}P

^{27}Al

$\text{Al}(\text{OH})_3$

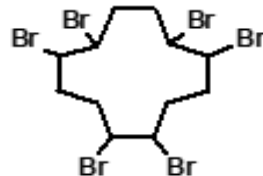


^{80}Br



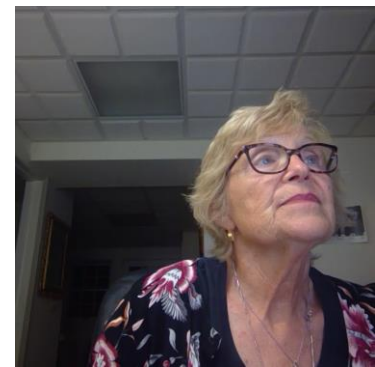
^{11}B

^{14}N



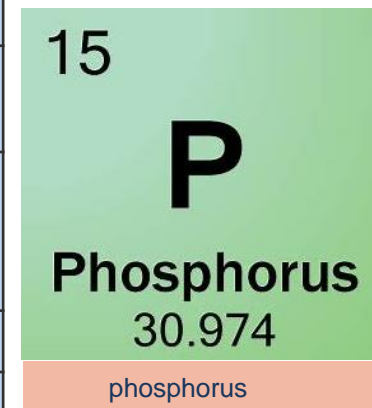
^{24}Mg

- different physical/chemical properties, environmental fate, toxicology, and regulatory status
- additive & reactive FRs, solid & liquid forms
- dosage of flame retardants typically is much higher v. other additives: antioxidants, light stabilizers, antistatic agents, lubricants or pigments

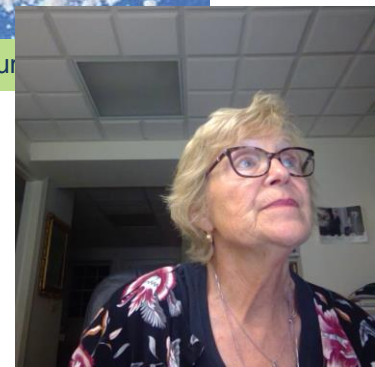


Most Common/Commercial Types of FR Additive Chemistries

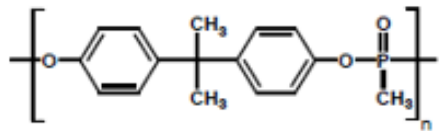
	Type of Flame Retardant Additive		
	Halogen	Non-Hal	Minerals
Amount needed	~13%	~25%	55+ weight %
Primary	Brominated	Phosphates	ATH
	Chlorinated	Phosphinates	MgOH
	Fluorinated	Polyphosphonate	Nanosilicas
Synergist		Polyphosphazene	
	ATO	Melamine	Silicone surface treatment
		Melamine cpds	



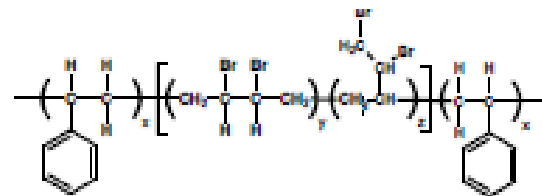
Non Hal systems are more complex and require a balance of FR and properties



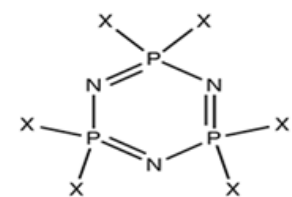
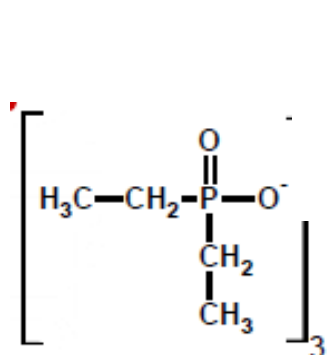
Notable FR innovation: commercial products 2000-2020



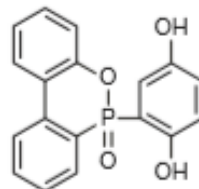
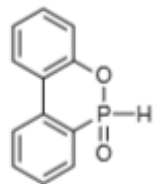
*Polyphosphonate (FRX Polymers)



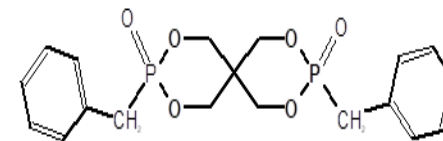
*Butadiene styrene BR Co-P (Dow)



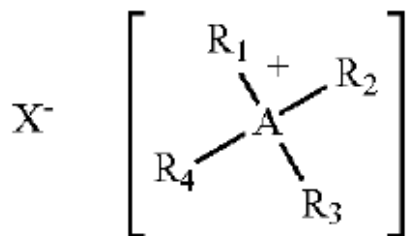
Phosphazene



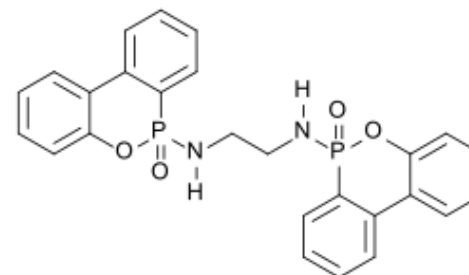
**DOPO & DOP-HQ (Schill & Seilacher)



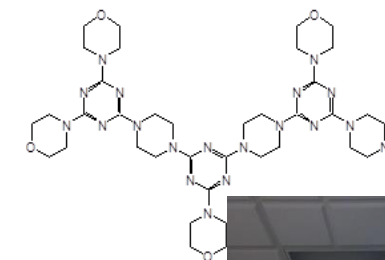
***NH P-FR (Teijin)



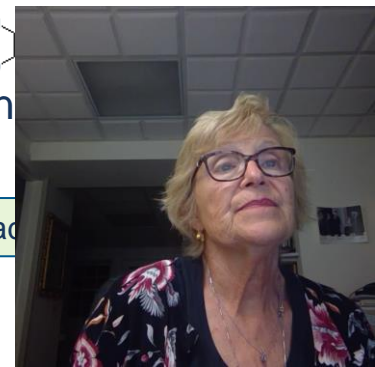
***Ionic Liquids (Inovia)



***EDA-DOPO (Metadynea)



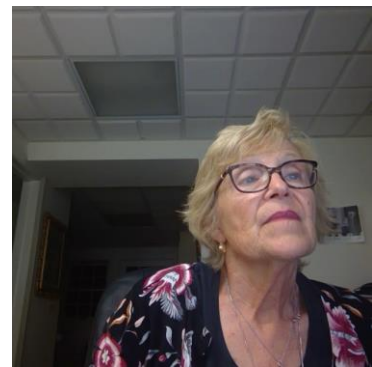
***PPM Triazine



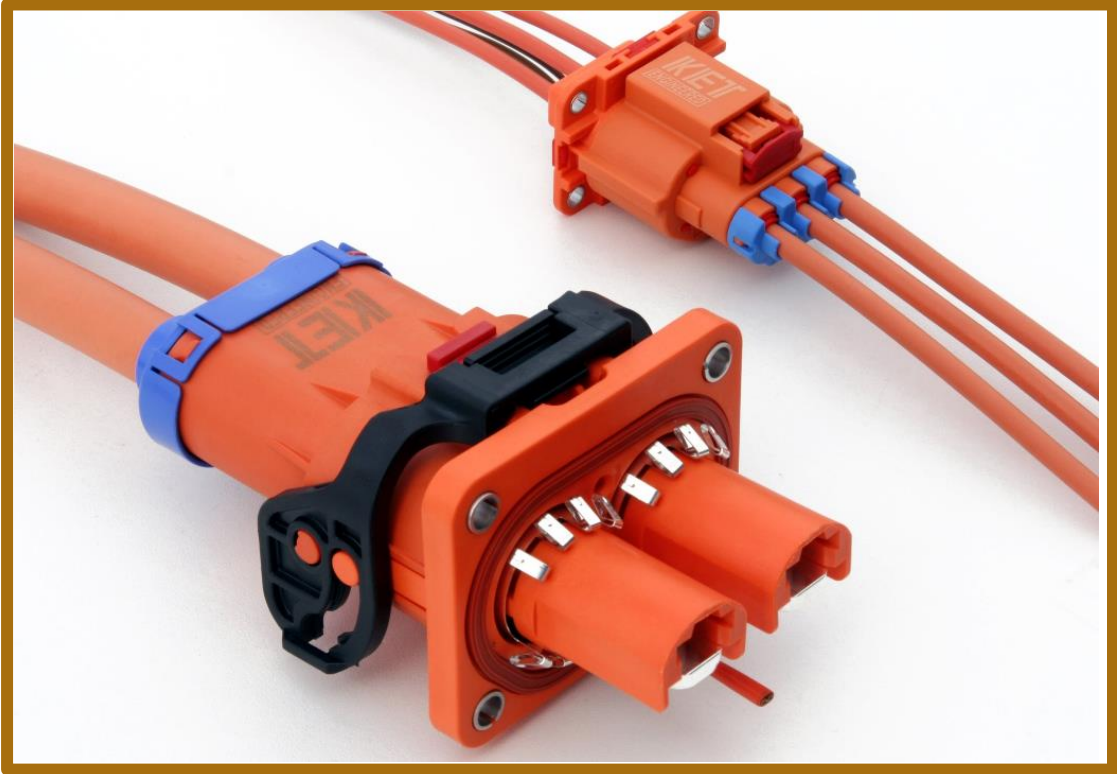
Flame Retardant Additive Types-Evolution



	Phosphor Based FRs	Halogenated FRs
Polymeric	<p>Polyphosphonates</p> <ul style="list-style-type: none"> + Halogen free + Do not migrate + Favorable toxicity profile. + Do not bioaccumulate + Melt processable and transparent + Deliver more properties than only FR 	<p>Brominated polymers</p> <ul style="list-style-type: none"> + Do not migrate from host plastic - Use antimony trioxide as synergist - Formation of dioxins and furans possible at incomplete incineration
Small Molecules	<p>Phosphates, phosphinate salts, DOPO, Nitrogen FRs</p> <ul style="list-style-type: none"> + Halogen free - Can migrate from host plastic - Can negatively affect thermal and mechanical properties of host plastic (act as plasticizer) - Some Environmental concerns <p>Minerals- ATH, Mg OH2</p> <ul style="list-style-type: none"> - Often at levels needed impact polymer properties 	<p>PBEs, PBDEs, TBBPA, decaBDE, HBCD</p> <ul style="list-style-type: none"> - Persistent, Bioaccumulate, Toxic - Use antimony trioxide as synergist - Migrate from host plastic - Formations of dioxins and furans at incomplete incineration



**Requirements: FR resin for high voltage EV connector



E-modulus
 weld line strength
 shrinkage
 volume resistivity
 color stability @ elevated temps
 durability (high temp, high humidity, heat shock)



cost
 HDT
 hydrolysis resistant
 elongation at break
 humidity absorption
 creep resistance

Engine oil, fluid fastness

RTI electrical strength

water absorption

recyclability

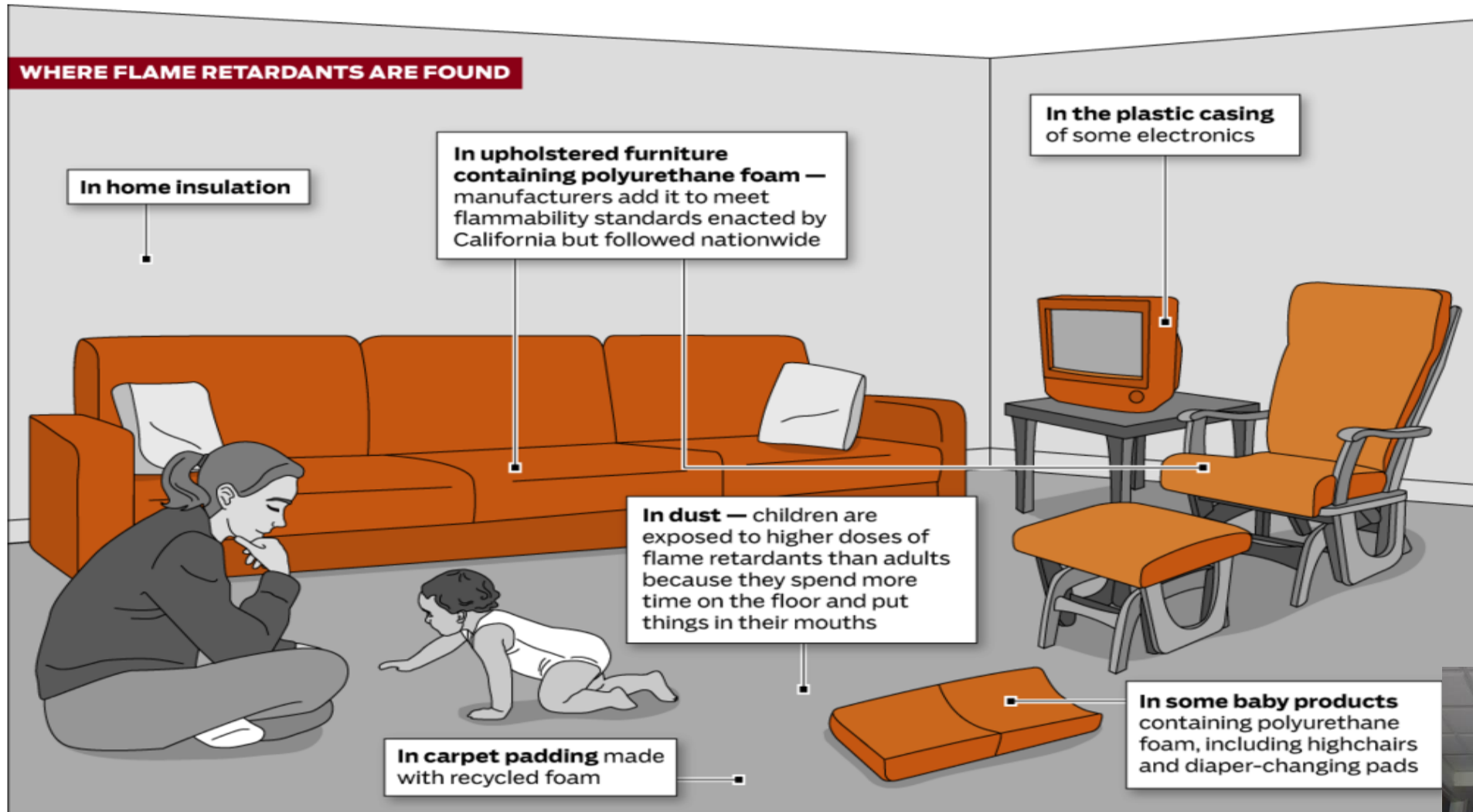
Corrosivity (conductor)

GWFI

dielectric strength

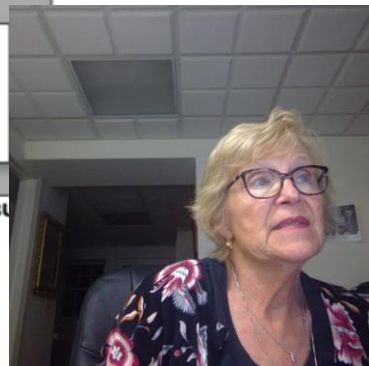


Societal concerns: ..mainly EH&S



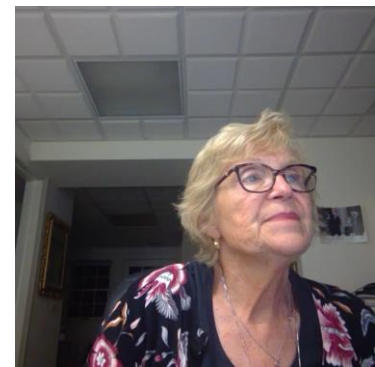
SOURCES: EPA, Tribune reporting

KATIE NIELAND/TRIBUNE



United states - Government Action

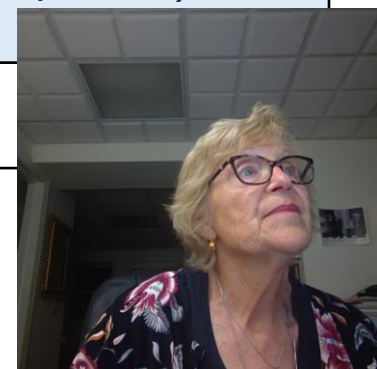
- Toxic Substances Control Act (1976)
- Frank R. Lautenberg Chemical Safety Act – 21st Century (2016)
- U.S. EPA/Industry agreement voluntary phase-out of FR mfg w/in U.S.:
PentaBDE (2004), OctaBDE (2004) & DecaBDE (2013)
- U.S. EPA Design for Environment Alternative FR Assessment Studies:
F-PUR foam(2005), DecaBDE(2014), HBCD(2014), PCBs(2015), F-PUR foam*(2015)
- U.S. EPA workplan - 7 FRs (2012). Planning process risk assess. – 3 clusters – 10 FRs (2015).
MARCH 2019 (US EPA): TCEP, TBBPA & TPP -- “high priority substance” candidate for RA.
- U.S. CPSC grants organohalogen petition (2017). NAS study complete (2019)
- U.S. CPSC decision (2019): TB 117-2013 as national STD for upholstered furniture



State of California takes lead...



Year	Law/Regs /Reqs	Scope
1986-2019	PROP 65	LABELING (products, workplaces, businesses, rental housing): "chemicals known to CA to cause cancer or reproductive toxicity" (TDCPP, TCEP, TDBPP)
2013	TB117-2013	REPEAL FIRE TEST (residential furniture): Replacement of TB117 -1975 "open flame" with less rigorous "smolder" test requirement (TB117-2013).
2013	AB 127	FIRE TEST (building insulation): requires CA Fire Marshall to "review" flammability standards of building insulation materials (re. necessity of "FRs").
2014	SB 1019	LABELING (upholstered furniture) : requirement to inform public whether FR chemicals were added to a covered product or component.
2017	City SF Ord. No. 211-17	BAN/RESTRICTION FR CHEMICALS (upholstered furniture, juvenile products): prohibits the sale of products that contains or is made with a flame retardant chemical at a level above 1,000 parts per million.
2018	CalSafe Work Plan	SAFER ALTERNATIVES ASSESSMENT (household/school/workplace furnishings & décor, building products & materials). Three year priority workplan in place (w/numerous FRs included on CA DTSC "chemical candidate" list).
2018	AB 2998	Ban/Restriction FR CHEMICALS (juvenile products, upholstered furniture, mattresses). As of 1/1/20; FRs halogenated, organophosphorus, organonitrogen, nanoscale @ >1,000 ppm.
2019	BEARHFTI OMN 2018-1210-03S	REPEAL FIRE TEST (FURNITURE – PUBLIC OCCUPANCY – prisons, nursing home, daycare, hospitals, auditoriums, hotels...). Replacement "open flame" TB 133 to less rigorous TB116/ TB117-2013.
2019	CBSC SFM 02/18	AMENDED BLDG STDs CODE : Allows non-FR treated foam insulation below grade.

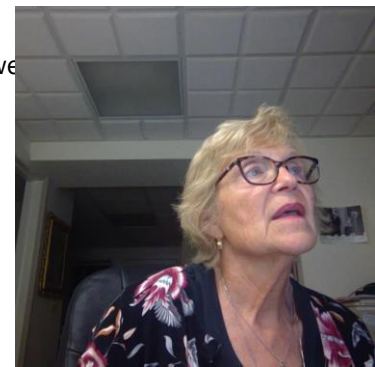


Canada - Government Actions



- Canadian Environmental Protection Act – CEPA (1999)
- Chemical Management Plan – CMP (2006) melamine, tricresyl phosphate (TCP), **Dechlorane Plus** (DP), **TCPP**, TDCPP, EBTBP, ATE (BFR), **DBDPE**, TBB, TBPH, ATO - Sb_2O_3
- PBDE Regulations: pentaBDE/OctaBDE (2008)
- Canada Consumer Product Safety Act – CCPSA (2010) TCEP (foam products – children), TDBPP (textile wearing apparel)
- Prop. Amendments “Prohibition of Certain Toxic Substances” (2018) HBCD, PBDEs(7), Dechlorane Plus & **Decabromodiphenyl ethane***

*2019 update: Per Canadian authorities - DBDPE may contribute to the formation of persistent, bioaccumulative, and inherently toxic transformation products, such as lower brominated BDPEs, in the environment. A **ban** on the manufacture, sale or import of the brominated FR DBDPE has been proposed.



OEM Requirements, Ecolabels & FRs

Consumer Electronic OEM example*:

Apple Regulated Substances Specification
069-0135-K



We've eliminated harmful chemicals like mercury, brominated flame retardants, PVC, phthalates, and beryllium from our products.¹

Ecolabels:



How the EPEAT Ecolabel Helps You Address Chemicals of Concern

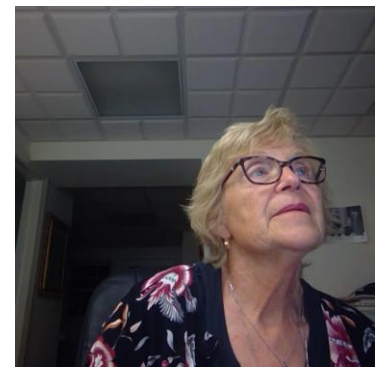
The EPEAT ecolabel empowers purchasers to meet their organizational sustainability goals through their purchasing decisions. Products available through EPEAT include computers, monitors, copiers, mobile phones, televisions, and servers. EPEAT is just one of several sustainable purchasing resources freely available from the Green Electronics Council (GEC).

TCO Development



- Some ecolabels have restrictions on halogenated flame retardants.
- TCO introduced list of approved halogen free flame retardants = white list

source: *<https://www.apple.com/environment/our-approach/>



Real Life Evolution Of A Fire Test Standard



I. Engineered wood I-beams developed during 1960s (used now in ~50% of new residential construction)



II. Several firefighter deaths due to unexpected collapse of floors during fire incidents



ASTM E119

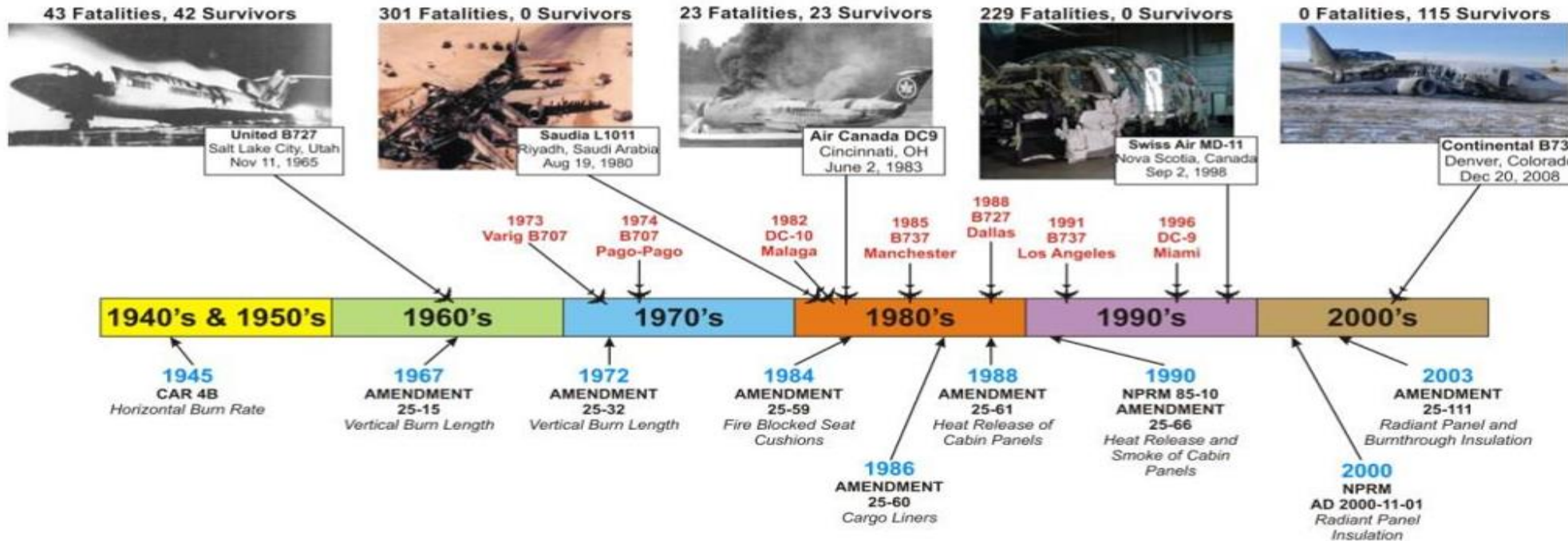


i-Joist w/FR protective coating

III. 2012: International Residential Code change!!

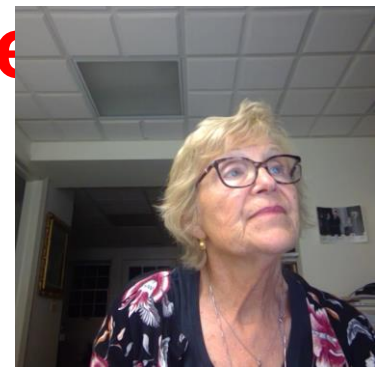


Enhanced Interior Material Fire Safety



718 survivors,
0 Fire Fatalities

Source: U.S. Federal Aviation Administration



3rd Party Alternatives Assessment Example

Risk = **hazard** x exposure (dose)

II. GreenScreen[®] Hazard Summary Table[™] (chemical example)

Group I Human					Group II and II* Human								Ecotox		Fate		Physical		
C	M	R	D	E	AT	ST		N		SnS*	SnR*	IrS	IrE	AA	CA	P	B	Rx	F
						SINGLE	REPEATED*	SINGLE	REPEATED*										
H	H	H	H	M	L	Vh	H	M	H	L	L	H	H	H	H	vL	vL	L	H

C	Carcinogenicity	SnR	Respiratory Sensitization	SnS	Skin Sensitization	vH	Very High
M	Mutagenicity/Genotoxicity	IrS	Human Skin Irritation/Corrosivity	CA	Chronic Aquatic Toxicity	H	High
R	Reproductive Toxicity	IrE	Human Eye Irritation/Corrosivity	P	Persistence in the Environment	M	Medium
D	Developmental Toxicity	AA	Acute Aquatic Toxicity	B	Bioaccumulation in the Environment	L	Low
E	Endocrine Activity	ST	Human Systemic Toxicity	Rx	Physical Reactivity	vL	Very Low
AT	Human Acute Toxicity	N	Neurotoxicity	F	Flammability	DG	Data Gap

GreenScreen[®] for Safer Chemicals Benchmarks

Benchmark 4 = Preferred

Benchmark 3 = Use but Still Opportunity for Improvement

Benchmark 2 = Use but Search for Safer Substitute

Benchmark 1 = Avoid – Chemical of High Concern

Source: www.greenscreenchemicals.com.



OPPORTUNITIES FOR SUPPLIERS & OEMs TO PROVIDE MORE SUSTAINABLE FR MATERIALS (EXAMPLES)

- Polyisocyanurate building insulation
 - Better insulation properties



- Interior Automotive
 - E-Mobility



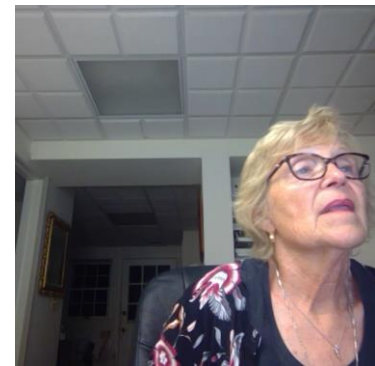
- Children's Car Seats
 - Increased safety



- Electronic Enclosures
 - Greener electronics

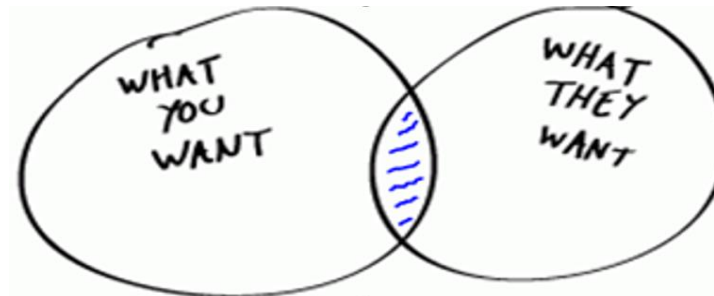


- firefighting foam (containing PFAS)



Summary and Conclusions

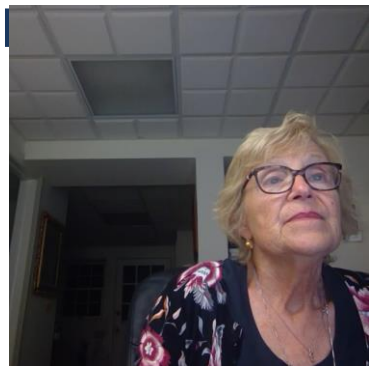
- FR R&D should be focused on market needs and solutions.
- Stakeholders have a strong voice in influencing change.
- North American law and regulations (re: FRs) will continue to undergo incremental change over next decade.
- There exists a fire safety paradox... Industry must improve its communications concerning the benefits of FR materials to our modern society.
- Industry must strive to offer more sustainable solutions supported by 3rd party EHS data.

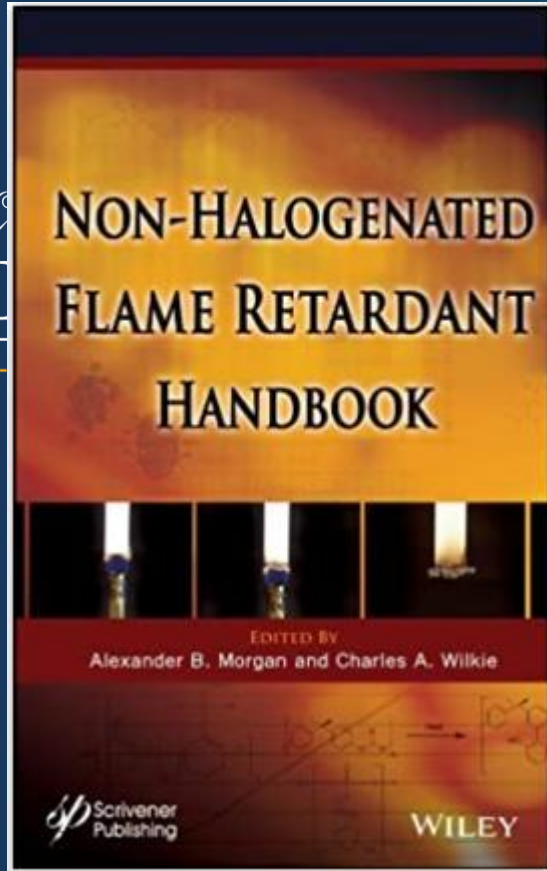


Thank you for your attention!

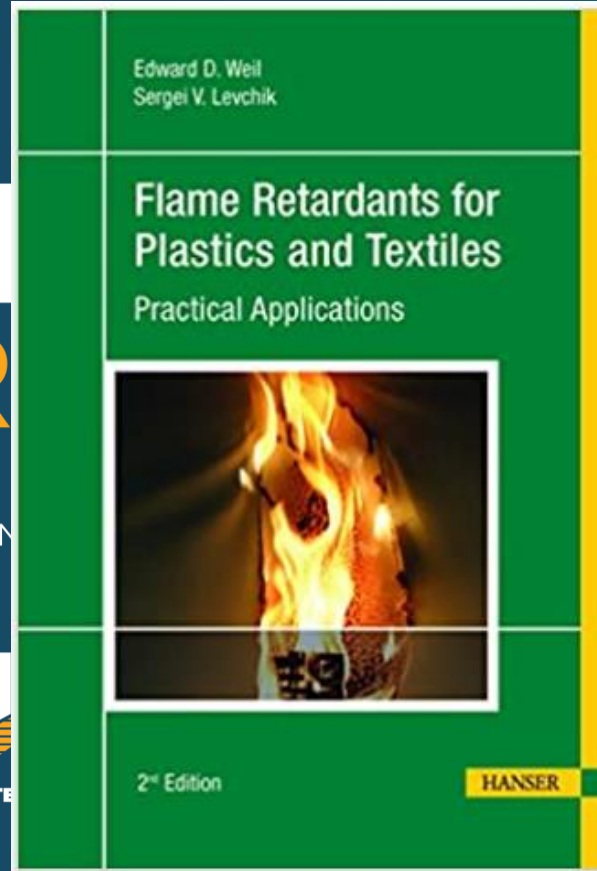


- Acknowledgement: Clariant Corporation USA, pinfa-NA, pinfa EU, pinfa China, A. Worku PhD (FR Advisers LLC) & K. Shen PhD (FR International LLC), Avakian Polychem Consulting, Maggie Baumann (FRX Polymers, Performance Polymers and Additives)
- contact info: timothy.reilly@clariant.com; mbaumann@frxpolymers.com

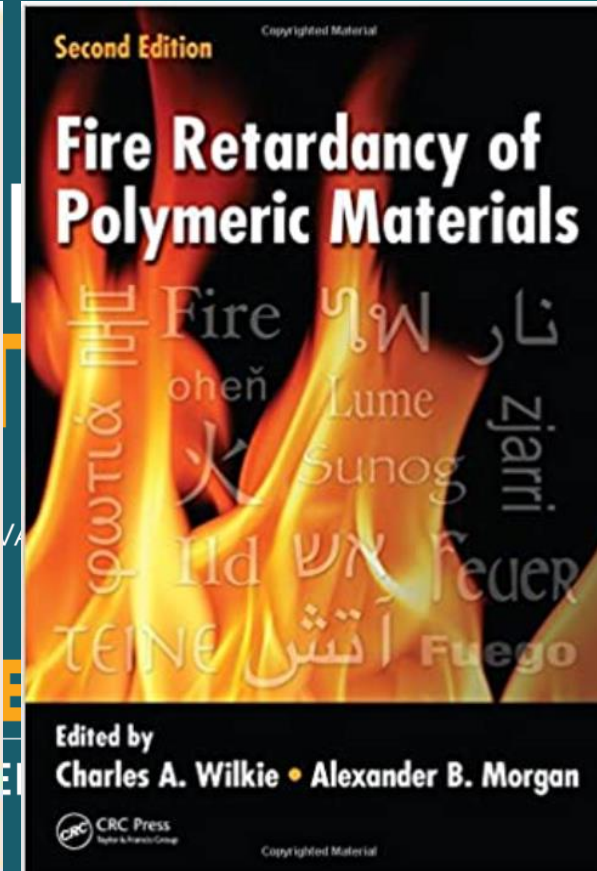




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