Addressing PFAS Upstream: TURA Program Activities

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Toxics Use Reduction Institute

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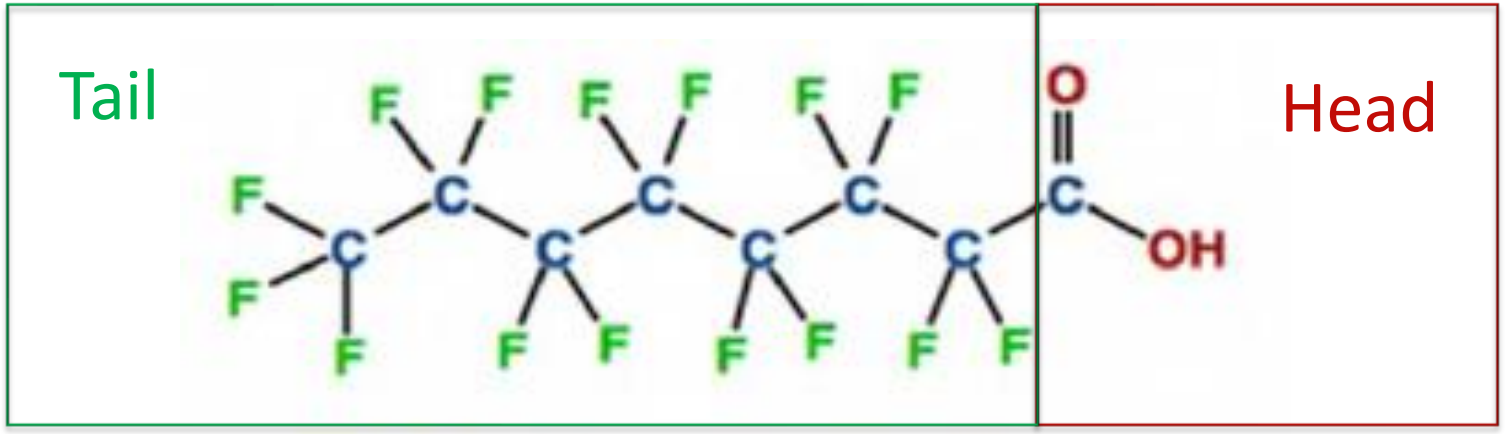
TURI
TOXICS USE REDUCTION INSTITUTE
UMASS LOWELL

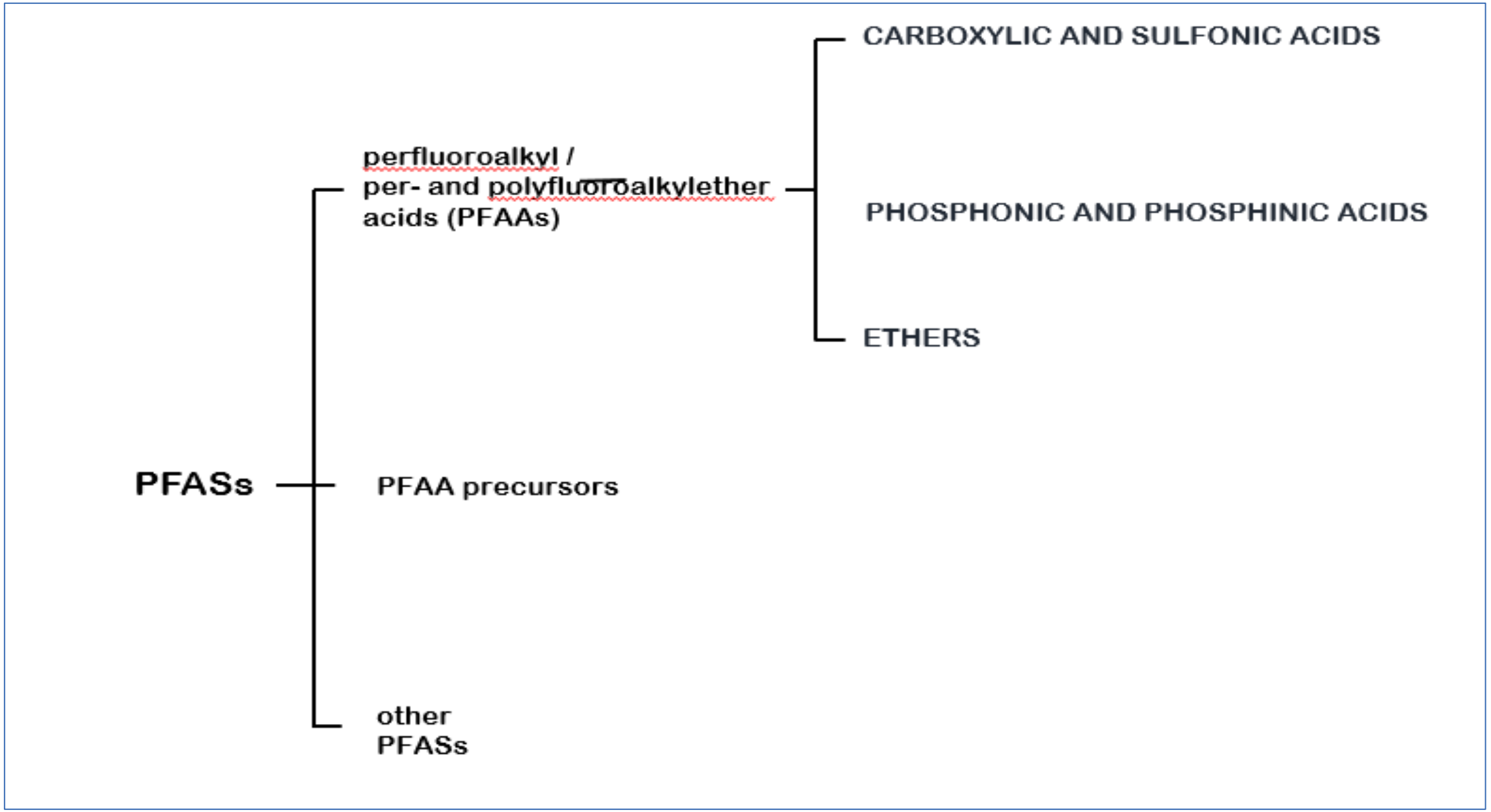
Overview

- Background on PFAS
- Listing PFAS under TURA
- Uses of PFAS
- Safer Alternatives
- Regulatory context: International and other states

Background on PFAS



PFOA - perfluorooctanoic acid

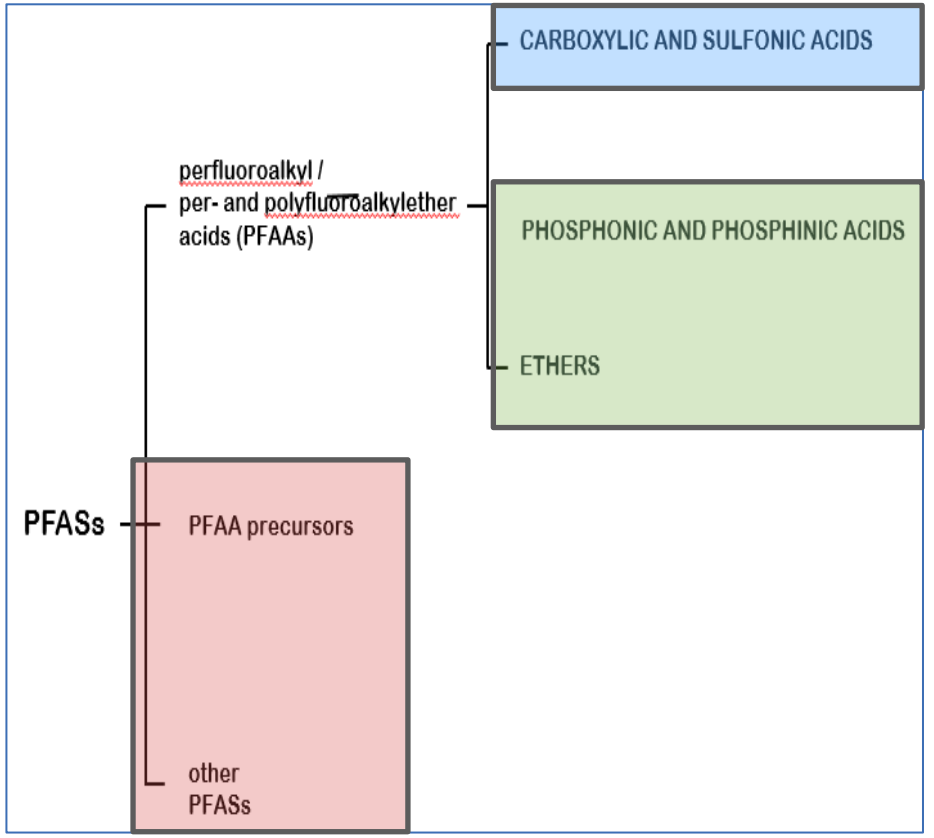

PFASs
perfluoroalkyl /
per- and polyfluoroalkylether
acids (PFAAs)
CARBOXYLIC AND SULFONIC ACIDS
PHOSPHONIC AND PHOSPHINIC ACIDS
ETHERS
PFAA precursors
other
PFASs

TURA SAB PFAS Evaluation

To understand the characteristics of a range of PFAAs, the SAB examined eight substances of varying chain lengths: PFNA (C9); PFOS and PFOA (C8); PFHpA (C7); PFHxA and PFHxS (C6); and PFBA and PFBS (C4).

The SAB then reviewed two ethers (GenX and ADONA), and phosphonic and phosphinic acids (PFPA and PFPiAs) of varying chain lengths.

The SAB reviewed various health impacts as well as a number of degradation/transformation pathways, through which a PFAS precursor breaks down into one of the end degradation products.



Health and Environmental Effects

- **Highly persistent and mobile in the environment**
  - Do not break down under normal environmental conditions
- **Bioaccumulative**
  - In animals or plants
- **Health effects include:**
  - Effects on endocrine system, including liver and thyroid
  - Immunotoxicity (with implications for vaccines)
  - Metabolic effects
  - Developmental effects
  - Neurotoxicity

Chronic Health Effects

	PFNA	PFHpA	PFHxA	PFHxS	PFBA	PFBS	GenX	ADONA	PFPA/ PFPiA
Cancer							X		
Immunotoxicity	X					X	X		
Thyroid			X	X	X	X		X	X
Endocrine (other than thyroid)			X	X	X	X			
Hematological				X	X	X			
Liver/metabolic	X	X	X	X	X	X	X	X	X
Reproductive	X						X	X	X
Developmental	X	X	X		X	X	X		
Neurodevelopmental				X					
Neurotoxicity	X		X	X		X			
Asthma				X		X			
Other	Mutagenicity		Kidney			Kidney	Kidney		Acute toxicity

Note: The SAB did not conduct a literature review for PFOS and PFOA due to the volume of information available through authoritative bodies and large scale epidemiological studies.

Persistence, Presence in the Environment, and Bioaccumulation

	PFNA	PFOA	PFOS	PFHpA	PFHxA	PFHxS	PFBA	PFBS	GenX	ADONA	PFPA/ PFPiA
Persistence	X	X	X	X	X	X	X	X	X	X	X
Bioaccumulation	X	X	X	X	X	X	X	X	X		X
Presence in the environment	X	X	X	X	X	X	X	X	X		
Presence in biota, including humans	X	X	X	X	X	X	X	X	X		X

PFAS-TOX DATABASE

How to Use

Database Chemicals Health

PFAS-TOX DATABASE

The numbers in the heat map indicate the number of studies, not the number of significant effects. Click to select studies, click again to deselect.

Colors correspond to the study type: human in green, animal in blue, in vitro in orange.

PFAS	Total	Metabolic & Digestive System			Body Weight, Size & Growth			Endocrine System			Systemic/ Nonspecific/Other			Reproductive System			Cell Toxicity / Mortality			Circulatory System			Nervous System & Behavior			Immune System			Urinary System			Respiratory System			Genotoxicity			Sensory System			Skeletal System			Cancers		
PFNA	434	75	51	26	107	46	1	83	38	30	14	23	32	93	13	6	1	23	40	37	6	9	29	10	4	34	11	4	25	6	2	12		1	2	3	6	7	4		3	6		9	1	
PFDA	364	39	90	30	55	61		41	28	27	3	51	41	59	10	3		15	44	16	11	8	16	10	3	21	18	5	10	12	1	8	3	1		4	6	4	1			3		5	2	3
PFHxS	360	72	13	15	109	19	1	77	13	28	12	6	21	92	5	1	1	5	23	33	4	5	26	9	8	36	4		23	3		11	3		2		2	7	1		3	2		10		
PFUnA	197	33	15	14	44	19		37	9	21	5	3	14	36	5	1		6	19	19	2	5	7	4	2	10	6	2	6	2	1	6	1				1	6				1		5		1
PFDoA	143	12	20	12	18	22		13	14	20	3	9	22	19	11	3		7	20	5	2	5	5	6	2	9	2		3	3	1	3	1				2	4	1			2		3		1
PFAS mix	121	18	24	7	20	19		27	19	10	1	17	6	18	12	1	2	12	10	7	11		4	11		6	8	1	2	6		4	3			2		2	2		1	4		7	2	
PFHpA	95	16	10	13	13	7		12	6	16	2	2	12	18		1		2	15	8	1	2	5		2	4	3	1	1		1	2				1	4						3		
PFBS	94	5	6	13	7	12		5	6	20	2	3	13	9	9			11	16	2	4	4	4	9	4	3	2	1	1	3	1	3	1			1	2	2	3			2		1	1	
PFHxA	84	10	12	17	6	12		7	5	20		7	18	3	6	2		10	21	2	5	4		6	2	1	3		2	4	1	3	4				5		4			3			1	
PFBA	68	4	11	16	4	15		3	4	21		11	12	4	4	1		11	19	1	5	2		4	2		3		1	3	1		2			1	2		2			3				
PFTrDA	51	5	7	2	11	9		7	7	4	1	2	3	8	3			1	2	2		1		2		2	1		2	1	1											1	1		
PFTeA	47	7	3	7	5	9		4	4	8	1	1	8	2	1	1		1	9	1		1			1	2	1		2	1	1	3												1
PFPeA	40	4	4	11	4	5		4	1	9			14	4	1			2	8	1		1							1		1	1											1	1
PFHpS	38	5		1	13	2		10	2	2			1	13					2	2			3		1	3	1		1			2					2					1			
PFAS + other	37	1	16	1	1	10		3	12	4		11	2	3	8		1	6	4	1	3			6			3	1	1	2			1			2					2		1		
NMeFOSAA	36	5		1	8			7	1				1	12						2			7						3								2					1			
NEtFOSAA	30	4		1	5	1		4					2	9						2			6						2								2					1			
PFDS	17	3	3	1	4	4		1	2	2			2	1				1	1	1							1		1																
6:2 Cl-PFESA	16		4	2	1	8			5	2		7			3			6	2	1	2		1	1		1			1																
GenX	10		4	3		6			3	2		2			4			3	2		1			1			1			2													1		
6:2 FTSA	5		1	1		2		1				1	1					1	1			1					1																		
8:2 Cl-PFESA	3			1	1					1									1	1			1						1																
HFPO-TA	3		1	2		1				1									1																										
ADONA	2		1			1			1	1		1			1			1	2		1			1			1			1					1	1		1			1				
PFO4DA	1		1			1																		1																					
PFPeS	1	1						1						1																																

Study Type

Click for study type specific histograms, hover for study counts

human | animal | in vitro

Early Life Effects

Show All Effects

Financial Conflict of Interest

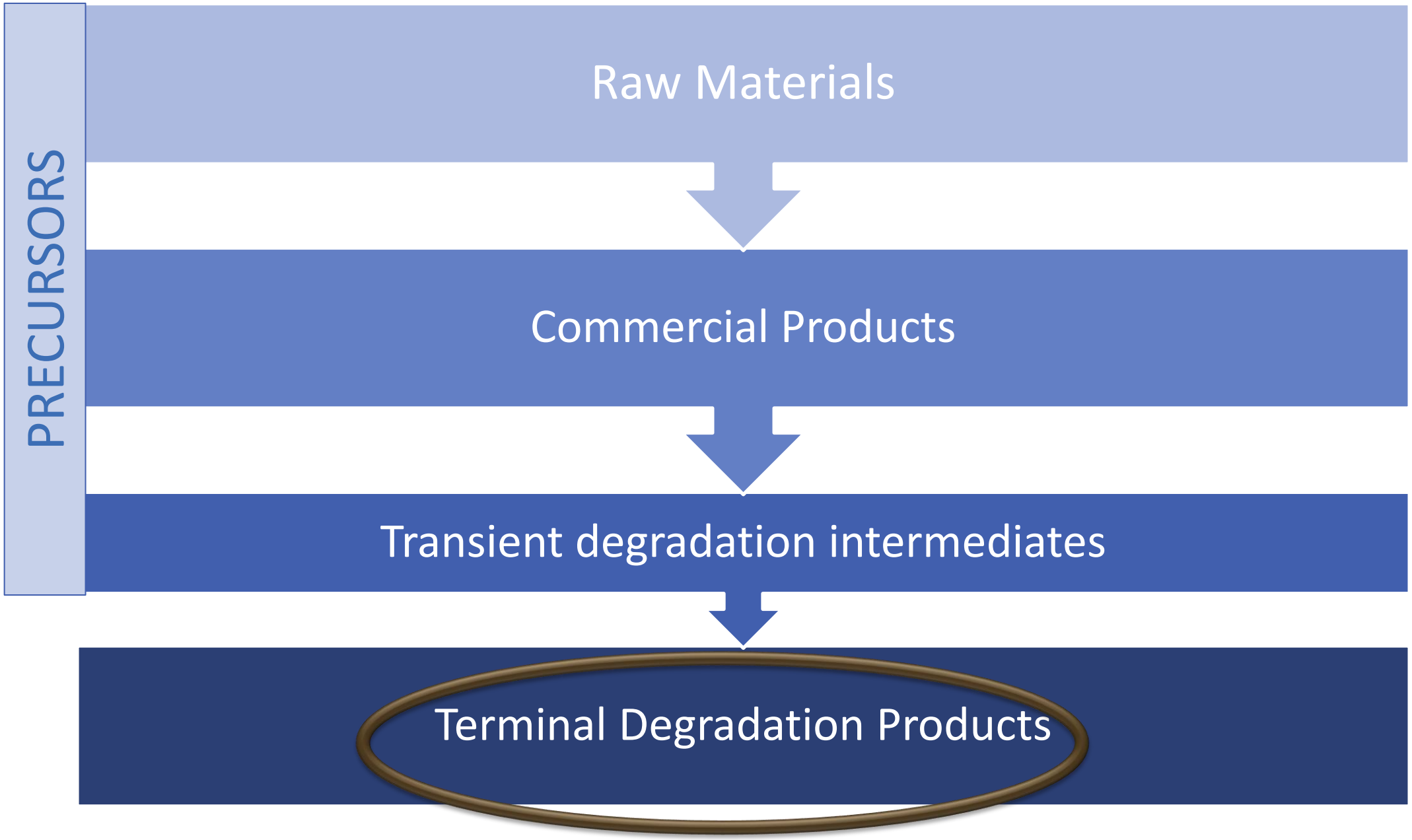
(All)

Selected Studies

Hover to see details, click for PubMed.

- Abe et al. 2017
- Abe et al. 2017
- Adinehzadeh and Reo 1998
- Adinehzadeh et al. 1999
- Ahmed et al. 2019
- Akerblom et al. 2017
- Alderete et al. 2019
- Alkhalawi et al. 2016
- Alves et al. 2016
- Ammitzboll et al. 2019
- Annunziato et al. 2019
- Antignac et al. 2013
- Arand et al. 1991
- Arbuckle et al. 2013
- Arrebola et al. 2019
- Ashley-Martin et al. 2015
- Ashley-Martin et al. 2016
- Ashley-Martin et al. 2017

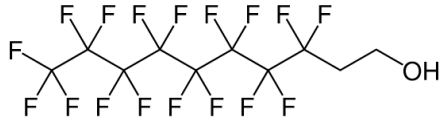
Download Study List


PRECURSORS
Raw Materials
Commercial Products
Transient degradation intermediates
Terminal Degradation Products

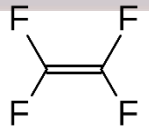
PRECURSORS

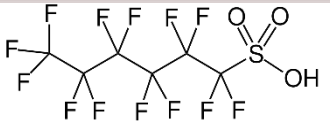
Raw Materials

8:2 FTOH



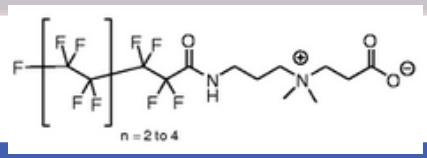
TFE and PFAAs



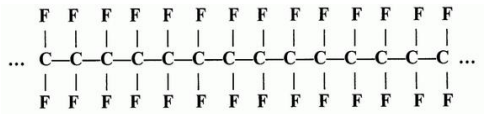


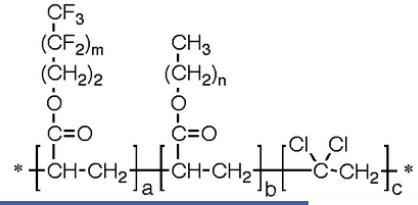
Commercial Products

Surfactants, e.g., AFFF



PTFE (Teflon); side chain polymers

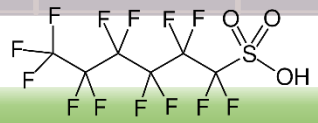




Transient degradation intermediates

Terminal Degradation Products - PFAAs

PFBA	PFBS	PFHxA	PFHxS	PFHpA	PFOA	PFOS	PFNA	GenX	PFPAs



Listing PFAS under TURA

- Massachusetts List of Toxic or Hazardous Substances
  - Facilities meeting TURA program requirements would be required to report, plan, and pay annual fee

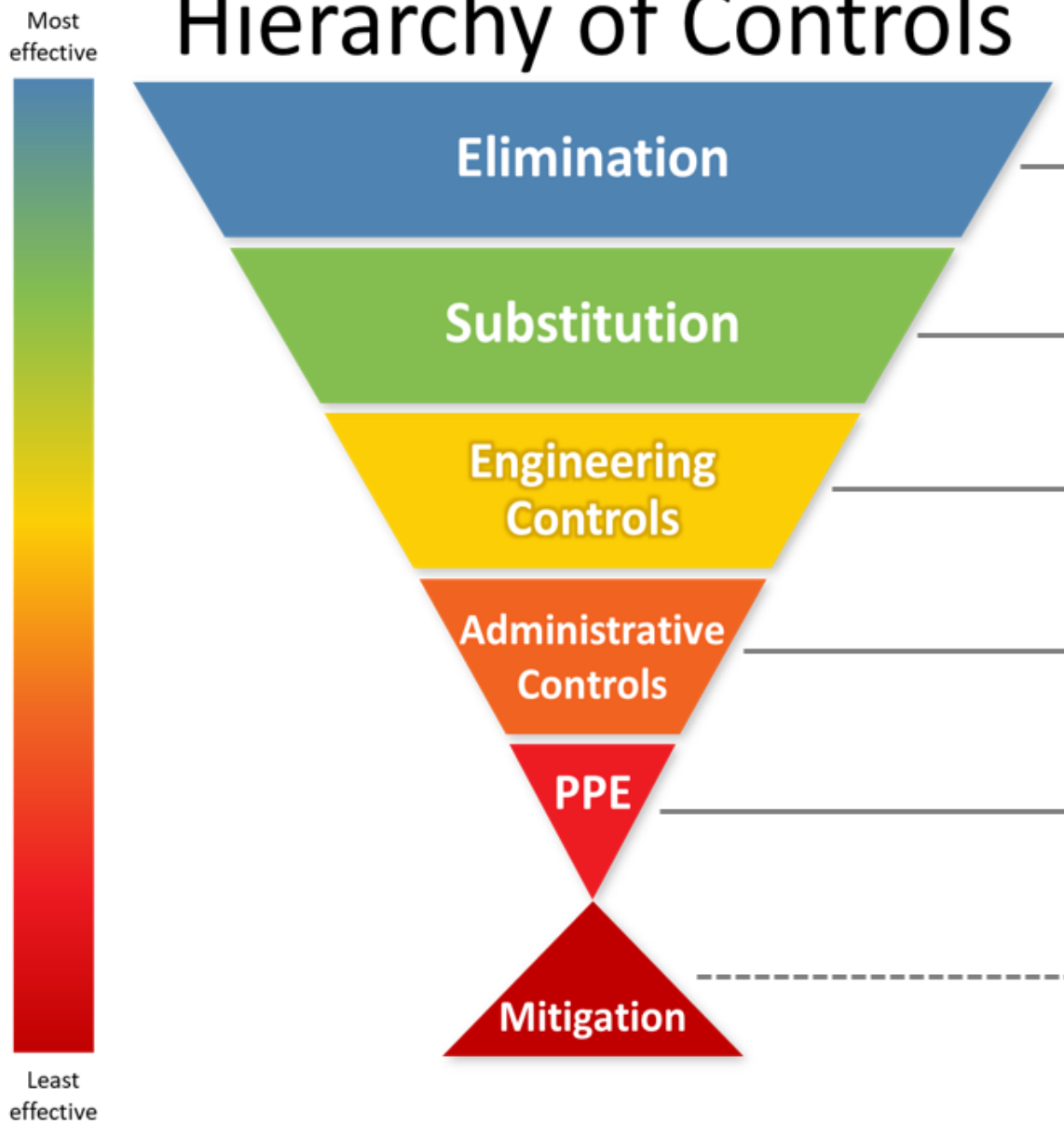
TURA Science Advisory Board Listing Recommendation

- Those PFAS that contain:
  - a perfluoroalkyl moiety with three or more carbons
    - (e.g., $–C_nF_{2n}–$, $n \geq 3$; or $CF_3–C_nF_{2n}–$, $n \geq 2$) or
  - a perfluoroalkylether moiety with two or more carbons
    - (e.g., $–C_nF_{2n}OC_mF_{2m}–$ or $–C_nF_{2n}OC_mF_m–$, n and $m \geq 1$), and
  - that are not otherwise listed

Implications of Category Designation

- **Similar hazards across a group**
- Avoid **adverse substitutions**
- If there is an **incomplete set of CAS numbers**, a category defined through chemical structure is more informative
- If manufacturers have claimed chemical identity as **Confidential Business Information**, facilities reporting under TURA would not have to obtain and report specific chemical identity

Hierarchy of Controls



Physically remove the hazard	Eliminate need for PFAS functionality (e.g., switch to trivalent Cr to eliminate need for fume suppressants, carpet fibers that are inherently stain resistant)
Replace the hazard	Material or chemical substitution (e.g., fluorine-free fire fighting foams, safer non-fluorinated polymers and surfactants)
Isolate people from the hazard	Closed loop processing equipment and circular economy to prevent exposure, emissions and waste
Change the way people work	Treatment, emissions control and best practices in manufacturing facilities; end of life management for products
Protect the worker	Prevent worker exposure using personal protective equipment; prevent exposure to public/biota once PFAS contamination exists
Repair the damage	Mitigation: remediation of environment, biomonitoring, treatment of disease

TUR

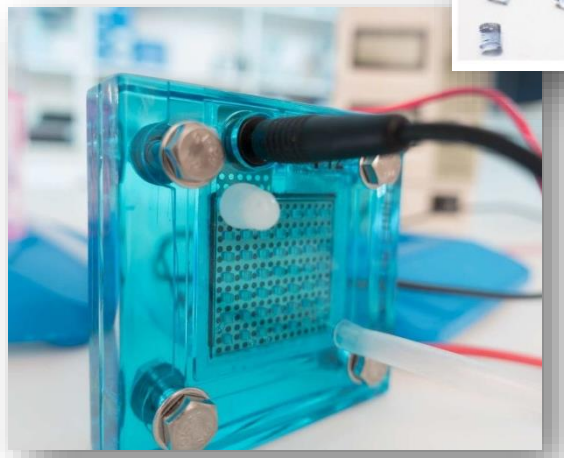
Some Uses and Sources of PFAS

- Oil and water repellency
- Lubricant, emulsifier
- Surfactant, film former
- Non-reactive/low surface tension

Source: Green Science Policy Institute, used with permission. www.greensciencepolicy.org

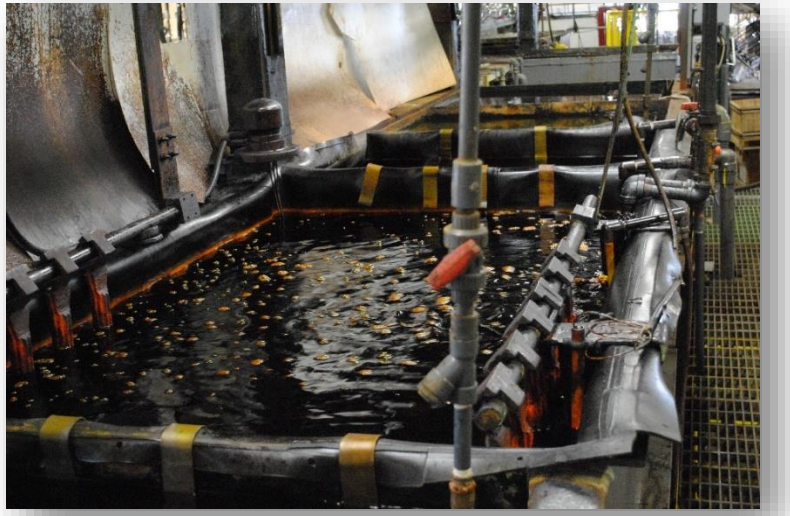
Industrial Uses

- Polymers and Resins
  - Fluoropolymers, and as feedstock and processing aids in their manufacture (e.g., PTFE, PVDF, FEP)
  - Side-chain fluoropolymers
  - Non-fluorinated resin processing aids
  - Fluorination of HDPE containers
  - Additives in coatings
  - Membranes (e.g., Nafion)



Industrial Uses

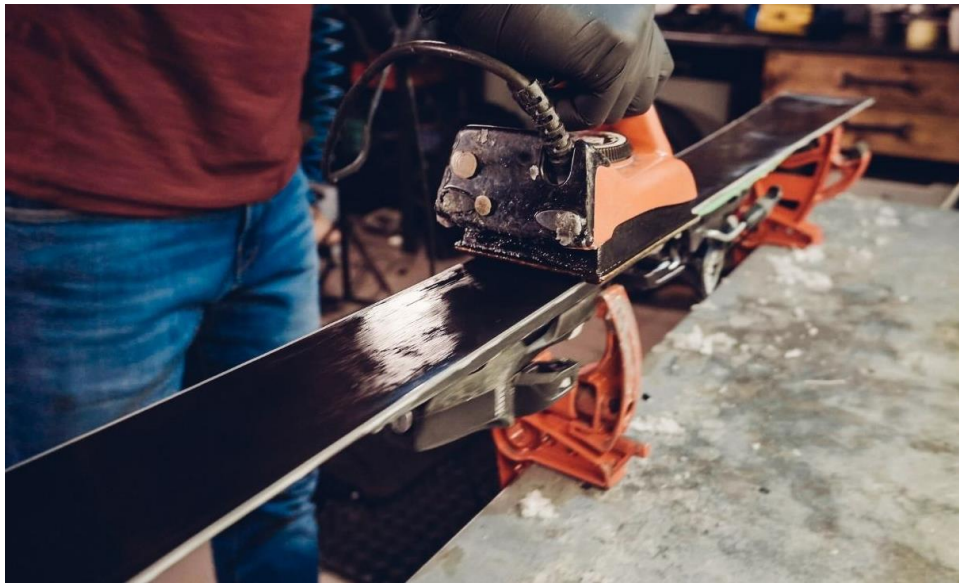
- Metal finishing
  - Surfactants - Fume/mist suppressants
  - Bath additive in nickel, copper and tin plating
- Solvents - HFE's (hydrofluoroethers),
- Solvents, blowing agents, refrigerants - HFO's, HFC's
- Surfactants, lubricants, coatings in many industries



Focus on Safer Alternatives

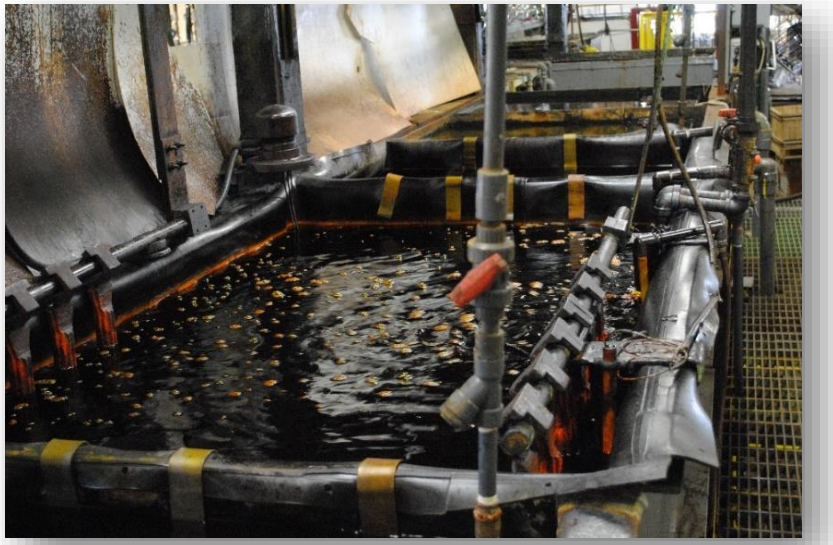
Example: Ski Wax

- Function
  - Low friction, water resistant coating
- Essential? For all or some applications?
  - Performance criteria varies with application
- Alternatives
  - Drop in/alternative coatings
    - Hydrocarbon wax
    - C6 fluorowax (same chemical class)
    - Novel non-fluorowaxes (e.g., SWIX Pro)
  - Alternative ski material or surface topography
- Assess alternatives for hazard, specific performance requirements, cost, life cycle impacts



Example: Hex Chrome Fume/Mist Suppressants

- Function – low surface tension
  - Limits release of Cr^{+6} from metal finishing baths
- Essential? For all or some applications?
  - Performance criteria vary somewhat with application
- Alternatives
  - Non-hex chrome metal finishing
  - Closed systems
  - Drop in alternatives
    - C6 fluorinated surfactants (same chemical class)
    - Non-fluorinated surfactants
- Need for continued R&D for Cr^{+6} metal finishing alternatives and non-fluorinated fume suppressants

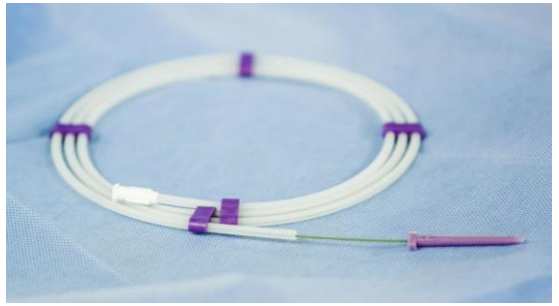


Additional Examples of TUR Opportunities

Coatings

- Food packaging and food contact paper
  - Information on alternatives has been collected by Toxic-Free Future and Clean Production Action; Oregon; Washington
    - Uncoated paper; Paper with alternative coatings (petroleum or bio-based wax, kaolin clay, silicone and plastic (e.g., PET, PE, PVA, PLA); and Non-paper materials, such as aluminum foil

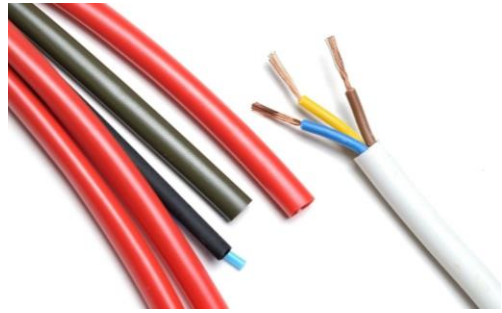
Low-Friction Fluoropolymer Coatings



- Medical devices
  - Siloxane-based coatings
- Cookware
  - E.g., cast iron, enamel-coated cast iron, ceramic and stoneware, stainless steel, carbon steel

Fluoropolymer Resins

- Used in manufacturing, e.g., insulation and jacketing of wire & cable
  - Variety of high-performance, non-fluorinated alternative resins



Textile and Fabric Treatment

- For visual/cosmetic applications, elimination may be most practical
- For protective applications (e.g. firefighters' protective clothing), need for research on safer alternatives
- Alternatives can include paraffins, silicones, urethanes

Aqueous Film-Forming Foam (AFFF)

- Primarily used by airports, military and fire depts
- Internationally, many airports have shifted to fluorine free foams (F3)
- Many foam manufacturers now offer both options
  - Alternatives are cost competitive
- MassDEP working with CT DEEP to test several F3 foams

Regulatory Context

- On-going revelations about health and environmental impacts
- Water supply contamination
- State, federal and international bodies working to respond

International

- Certain PFAS addressed under Stockholm Convention
- EU: certain PFAS designated as Substances of Very High Concern (SVHCs); others on Registry of Intentions for SVHC designation; restriction proposal for PFAS being prepared under REACH
  - Proposal being prepared by 5 member countries (Germany, Netherlands, Norway, Sweden & Denmark) and expected to enter into force in 2025

European Commission's Chemical Strategy for Sustainability (Oct 2020)

Goal:

"the use of PFAS is phased out in the EU, unless it is proven essential for society."

EU Chemical Strategy for Sustainability commitments include:

“ban all PFAS as a group in fire-fighting foams as well as in other uses, allowing their use only where they are essential for society;
address PFAS with a group approach, under relevant legislation on water, sustainable products, food, industrial emissions, and waste;”
address PFAS concerns globally;
establish EU-wide approach to develop remediation methods;
Provide research funding for safe innovations to substitute PFAS

Regulatory Context: States

- Policies and approaches include:
  - **Monitor and study** PFAS;
  - **Label or disclose** PFAS in products
  - **Limit or ban** the use of PFAS;
  - **Specify** that certain product types must be free of PFAS;
  - **Regulate PFAS levels** in groundwater or drinking water.

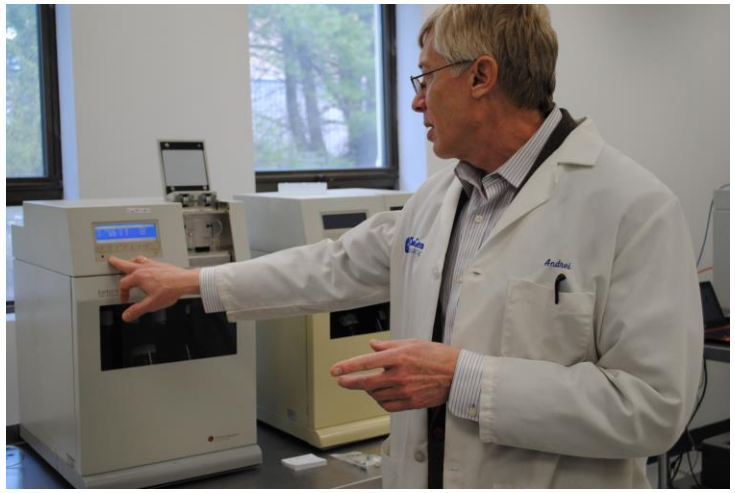
State Approaches: California

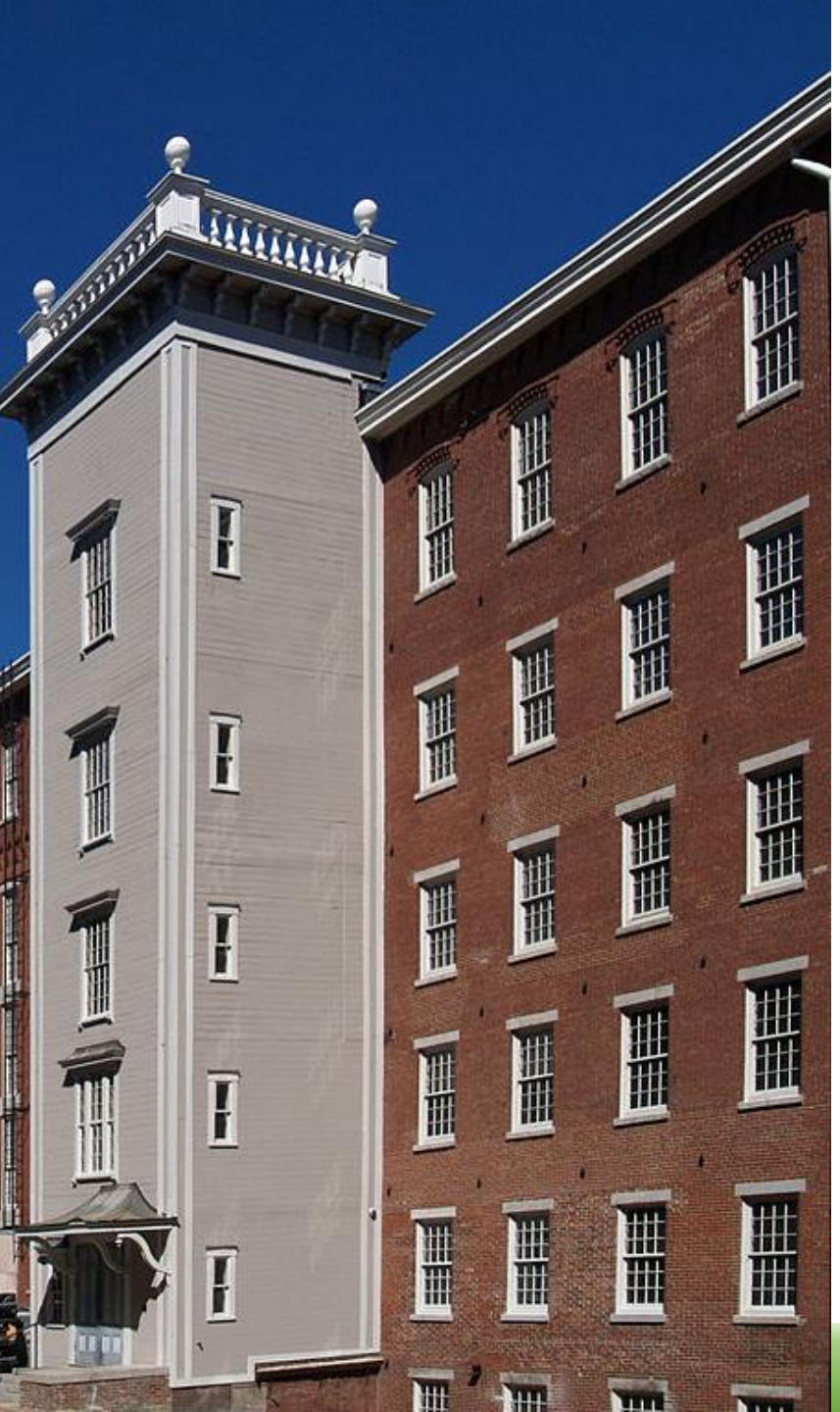
- Biomonitoring:
  - PFAS included as a class in the Biomonitoring California Priority Chemicals list.
- Labelling and disclosure:
  - PFOS and PFOA listed Proposition 65
  - Review of reproductive toxicity of PFDA, PFHxS, PFNA and PFUnDA.
- Safer Consumer Products Program:
  - In 2020, DTSC proposed to list carpets and rugs containing PFAS as a Priority Product under the Safer Consumer Products Regulation.

Activity	States (examples)
Labeling and disclosure	CA (Prop 65); WA (children's products; firefighting PPE)
Environmentally Preferable Purchasing	MN (compostable foodware); WA (firefighting foams and PPE)
Restrictions and Bans	WA (AFFF; food packaging); NY (food packaging)
Statewide plans and task forces	WA, ME, MI, CT, MA

TURI Resources *(ww.turi.org)*

- Education and training
- Grants – businesses, municipalities, community organizations, researchers
- Demonstration events
- Laboratory
- Industry sector work groups
- Policy analysis





Thank you

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www.turi.org

Toxics Use Reduction Institute
University of Massachusetts Lowell

State Approaches: Minnesota

- **Environmentally Preferable Purchasing:**
  - State contracts: no PFAS in compostable food ware products.
- **Bans and restrictions:**
  - Use of Class B firefighting foam with intentionally added PFAS is prohibited for use in testing and training (with some exceptions).
  - Use of PFAS-containing class B foam on a fire must be reported to the State Fire Reporting System.
- **Toxics Reduction and Pollution Prevention:**
  - MPCA working to reduce PFAS "in firefighting foam, chrome plating, and food packaging, with related efforts in state and local government purchasing."