2024 National Pollution Prevention Training and Conference

Reducing PFAS in Consumer and Other Products

December 11, 2024
2:50– 4:15PM ET

Moderated by John Schierlmann, IndSpyre Solutions, Inc.

Speakers:

- **Kim Hazard, California Department of Toxic Substances Control**
- **Megan Arnett, University of California at Berkley, Center for Green Chemistry**
- **Donna Walden, greenUP!**
- **Katy Wolf, Consultant and Former Director of the Institute for Research and Technical Assistance**
- **John Schierlmann, IndSpyre Solutions, Inc**

Overview of "PFAS"

- What are "PFAS" Products?
  - Perfluorooctoanoic acid PFOA
  - Perfluorooctyl sulfonates PFOS
  - And others…
- Regulations
  - How do we find out these are toxic chemicals?
  - How do we regulate and slow down their use?
  - How do we find safter alternatives and eliminate toxic ones?
- Chemistry that has been severely regulated
  - Nonylphenolethoxylates (laundry)
  - Alkylphenolethoxylates (detergents, intermediates in chemicals)
  - Bisphenol A (plastics, water bottles)
  - Microplastics in products (cosmetics)

Overview

- What is being done? – a lot now
  - Minnesota
    - Ban of products entering the state Jan 1, 2025, containing “PFAS”
  - Maine
    - Required corporations to submit formulations containing “PFAS” Jan 1, 2023
  - EPA
  - Other States are inquiring with industry and universities
  - Product Validators – EPA Safer Choice / Green Seal
  - NGOs
  - Canada

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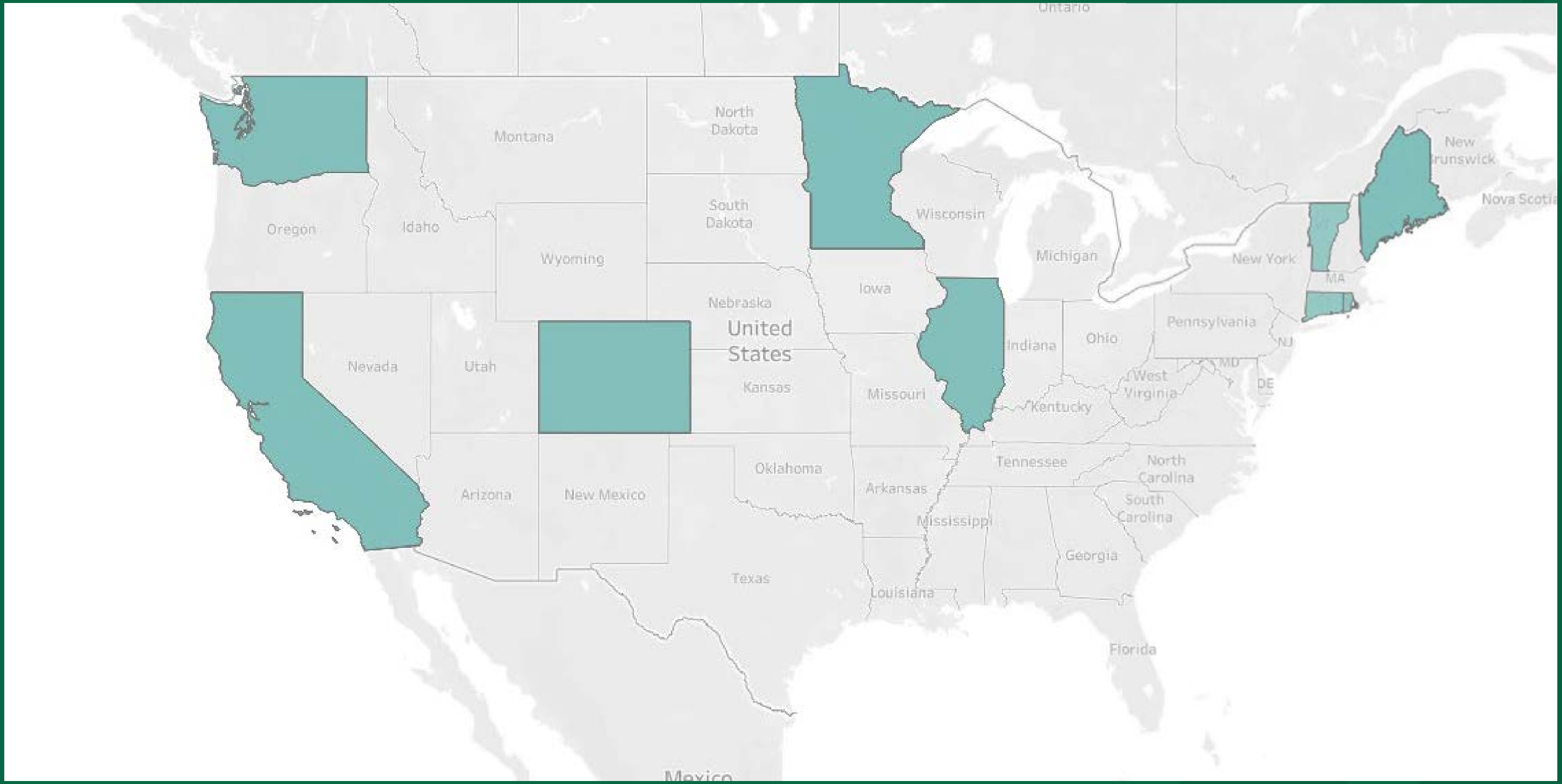
States with Legislation in Motion



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PFAS Pollution Prevention in California

Kimberly Hazard, PhD
Kim.Hazard@dtsc.ca.gov

National Pollution Prevention Training and Conference
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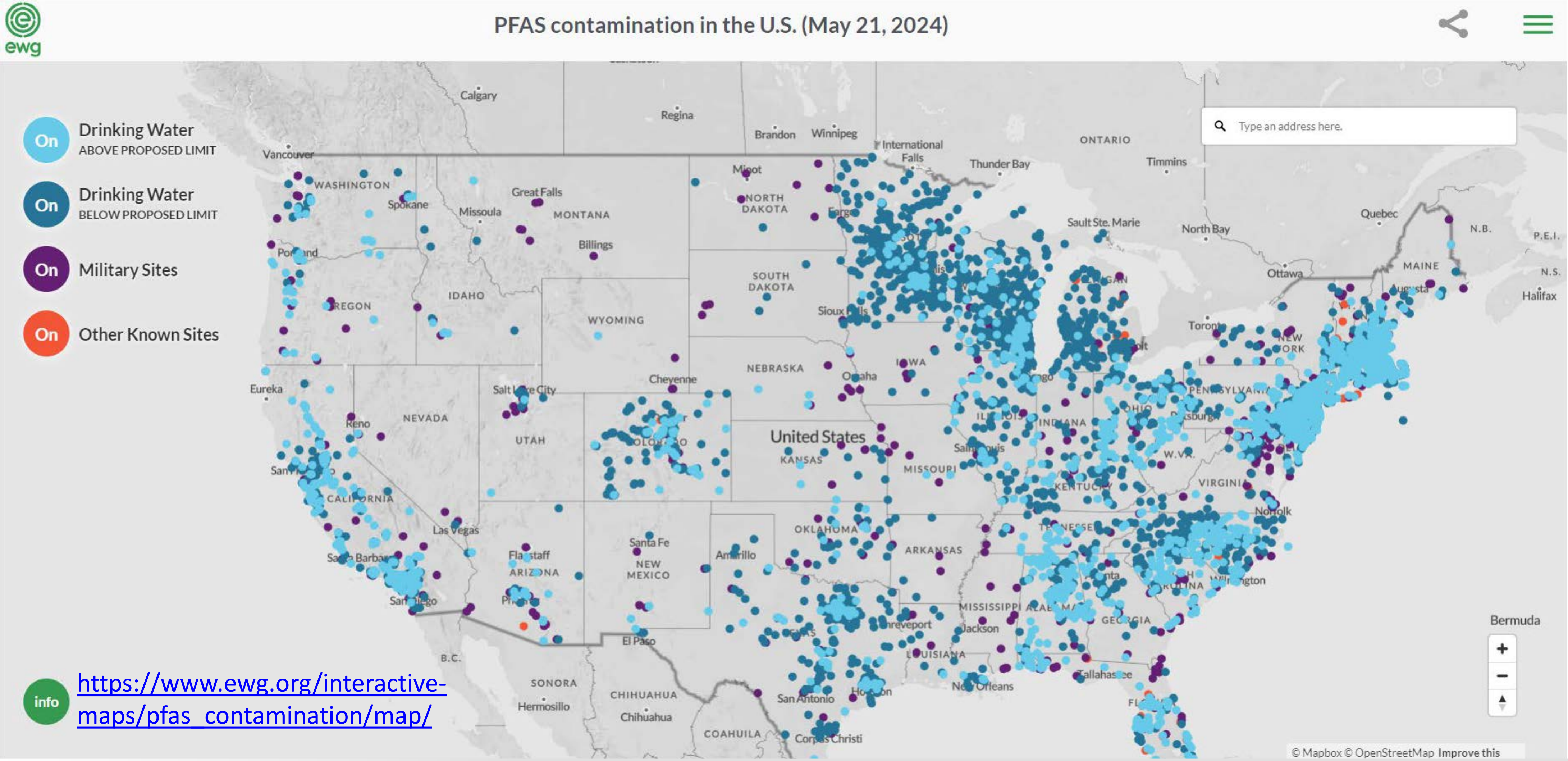
Per- and polyfluoroalkyl substances (PFASs) are a class of many thousands of chemicals containing one of the strongest bonds in chemistry.

$$^{\delta+}\mathrm{C} - \mathrm{F}^{\delta-}$$

PFASs are found pretty much everywhere we look…



… and have been associated with multiple hazards

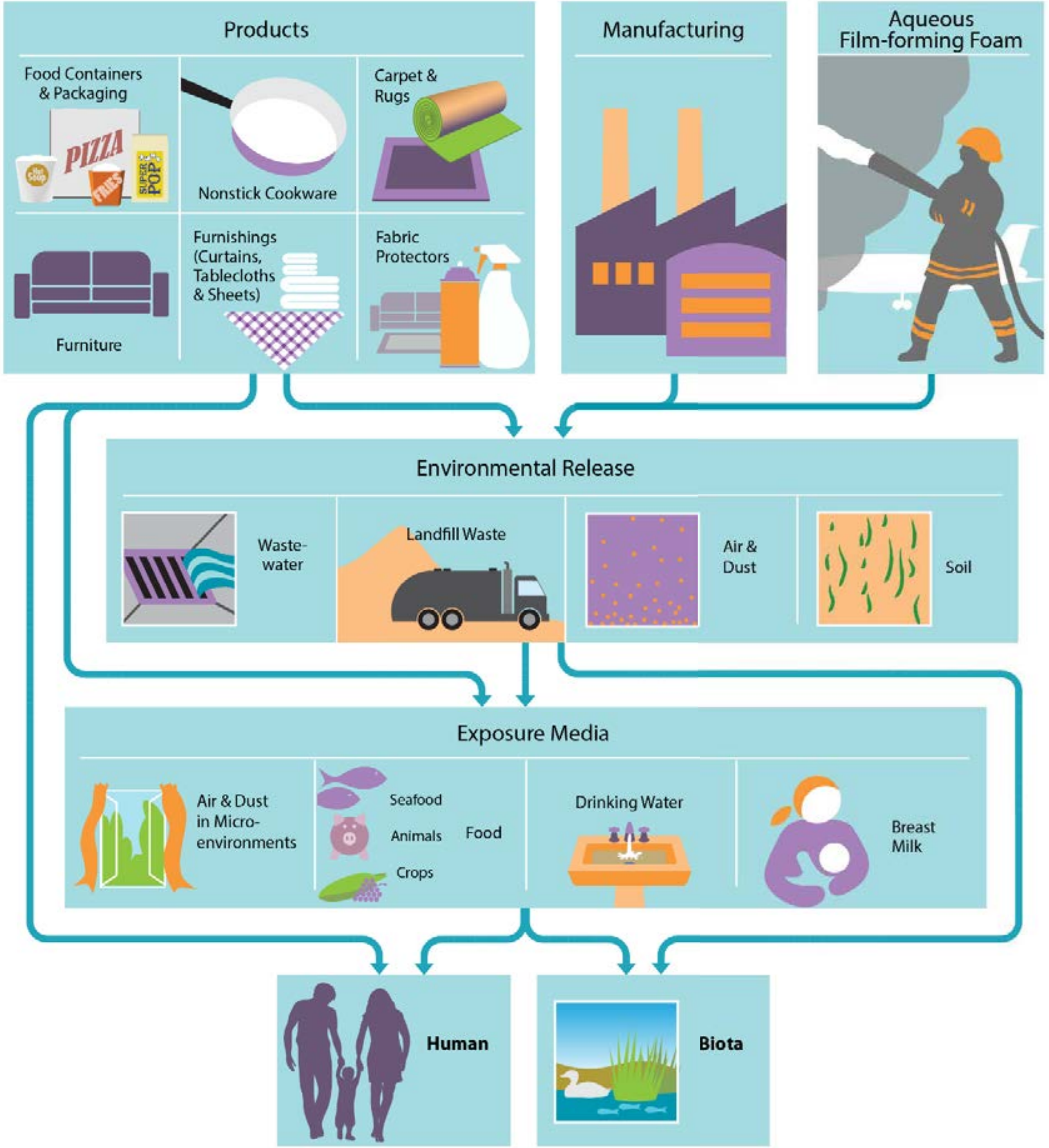
- Carcinogenicity
- Cardiovascular toxicity
- Developmental toxicity
- Endocrine toxicity
- Hepatotoxicity
- Immunotoxicity
- Nephrotoxicity
- Ocular toxicity

- Reproductive toxicity
- Environmental persistence
- Mobility in the environment
- Bioaccumulation
- Lactational and transplacental transfer

- Phytotoxicity and wildlife developmental, reproductive, and survival impairment
- Can cross the blood-brain barrier

The root of the problem?

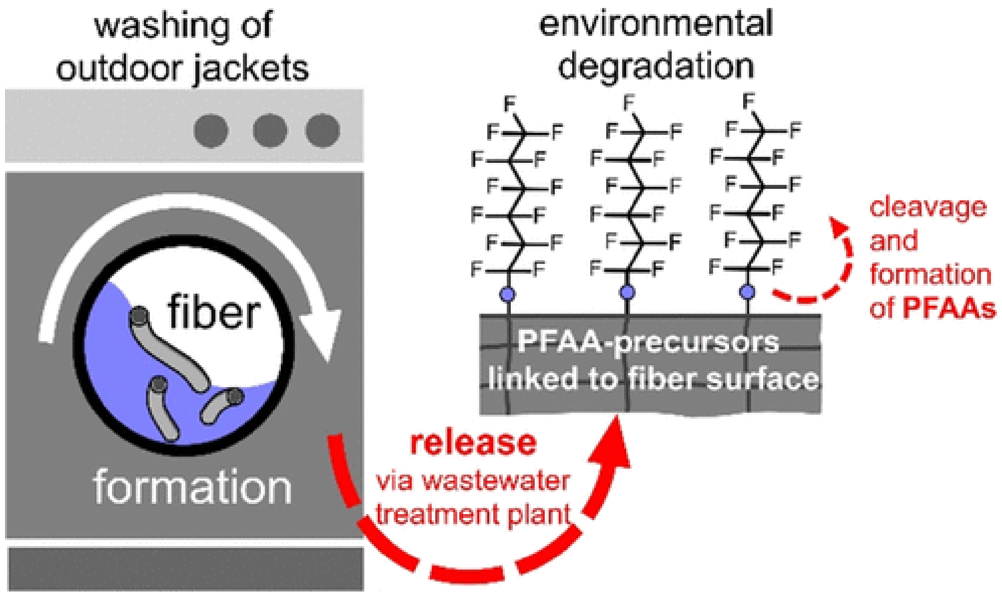
PFASs are **used in products** and released to the environment during manufacturing, use, and at their end of life



PFAS releases from consumer products

Schellenberger et al. 2019, Environ. Sci. Technol.

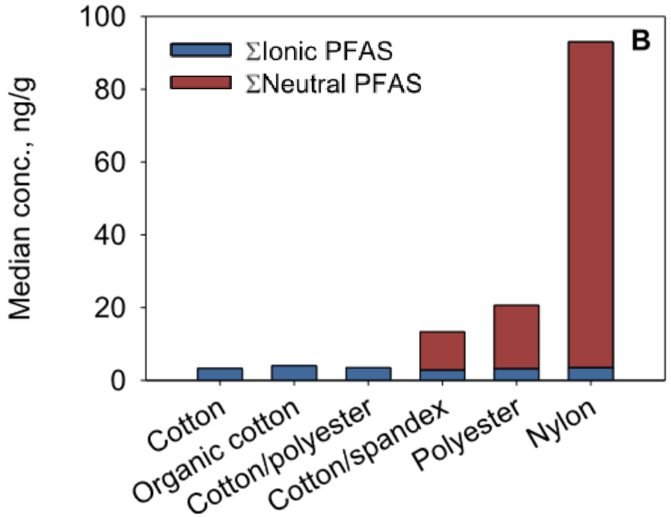
- Washing of jackets releases microfibers coated with polymeric PFASs
- Estimated 0.7 ton 6:2 FTOH/yr for Europe

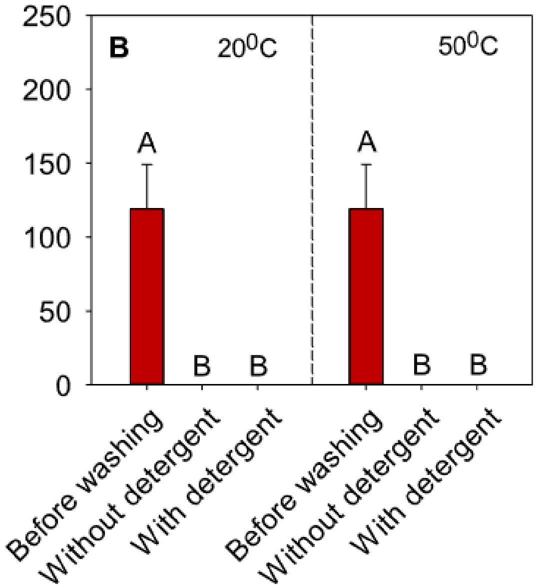


https://pubs.acs.org/doi/abs/10.1021/acs.est.9b04165

Zheng and Salamova 2020, Environ. Sci. Technol.

- Laundering resulted in 100% removal of measured PFASs





https://pubs.acs.org/doi/abs/10.1021/acs.est.0c03035

DTSC Safer Consumer Products Program

- Science-based, 4-part process that identifies specific products containing hazardous chemicals and evaluates safer alternatives
- Reducing hazardous chemicals in products that consumers buy and use
- Prevent regrettable substitutes

1 Candidate Chemicals List	Chemicals listed as a concern by Authoritative Bodies
2 Priority Products	Product-Chemical combinations that may cause harm
3 Alternatives Analysis	Manufacturer evaluation of safer alternatives
4 Regulatory Response	Wide range of possible actions to protect human health and the environment

Cal. Code Regs., Title 22, Division 4.5, Chapter 55 – Safer Consumer Products
SCP website: https://dtsc.ca.gov/scp/

Our approach: Regulating PFASs as a Class

- All PFASs* are Candidate Chemicals under the SCP regulations
- Class-based regulation prevents regrettable substitution

ehp Environmental Health Perspectives

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Vol. 129, No. 2 | Commentary

Regulating PFAS as a Chemical Class under the California Safer Consumer Products Program

Simona Andreea Bălan, Vivek Chander Mathrani, Dennis Fengmao Guo, and André Maurice Algazi

Published: 17 February 2021 | CID: 025001 | https://doi.org/10.1289/EHP7431

Sections PDF Tools Share

The P-sufficient approach

"if a chemical is **highly persistent**, its continuous release will lead to **continuously increasing contamination** (…) [and] **increasing probabilities of the occurrence of known and unknown effects**." (Cousins et al. 2019)

*As defined by Buck et al. (2011) Integr. Environ. Assess. Manag. 7(4):513-541

The SCP regulatory framework allowed us to take a "P-sufficient approach"

1. Candidate Chemical List
2. Priority Products
3. Alternatives Analysis
4. Regulatory Response

California Code of Regulations, Title 22, Division 4.5, Chapters 54 and 55

There are potential **exposures** to a Candidate Chemical in the product

AND

One or more exposures have the potential to contribute to or cause **significant or widespread adverse impacts**

Priority Product: Carpets and rugs containing PFASs

- Carpets in California contained up to 60 tons of PFASs as of 2017
- Likely source of human exposure and PFASs in landfill leachate
  - PFAS emissions detected in indoor air and dust
  - Children may be exposed at levels 5x greater than adults

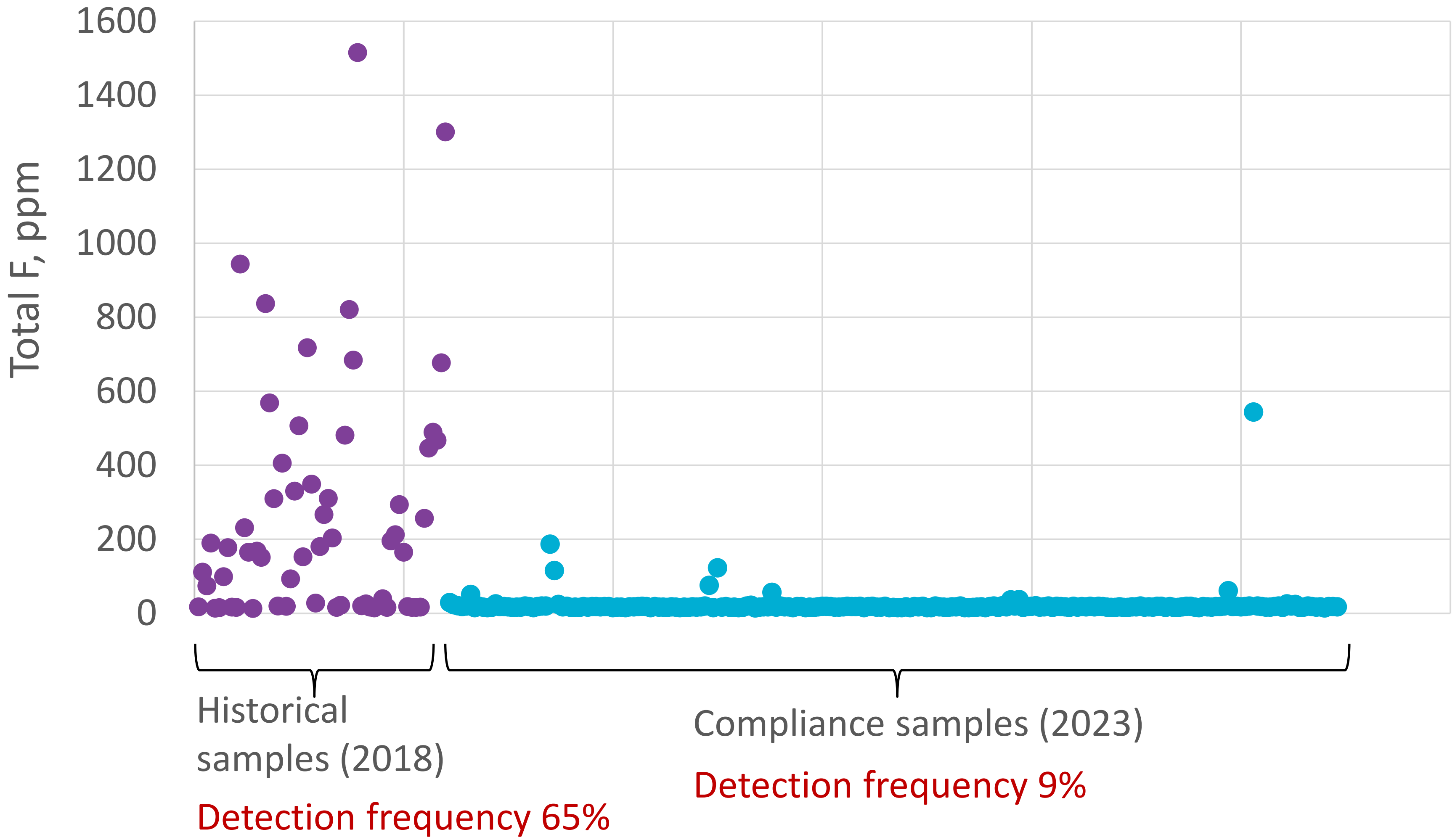
https://pubs.acs.org/doi/abs/10.1021/acs.est.9b06956
https://pubs.rsc.org/en/content/articlelanding/2005/em/b507731c
https://pubs.acs.org/doi/abs/10.1021/acs.est.5b06237
https://pubs.acs.org/doi/abs/10.1021/acs.est.9b06956

Priority Product: Carpets and rugs containing PFASs

- Regulation effective 7/1/21
- Manufacturers of carpets and rugs containing PFASs were required to notify DTSC by 8/30/21
- No notifications were received
- DTSC conducted compliance testing
    - Testing for total fluorine by combustion-ion chromatography (CIC)

https://dtsc.ca.gov/scp/carpets-and-rugs-with-perfluoroalkyl-and-polyfluoroalkyl-substances-pfass/

Compliance Testing: Total F in Carpet & Rug Fibers



Priority Product: Treatments containing PFASs for Use on Converted Textiles or Leathers

- Products sold for use on carpets, furnishings, clothing, shoes, etc.

  Including: aerosols, wipes, liquids, gels




Priority Product: Treatments containing PFASs for Use on Converted Textiles or Leathers

- Regulation effective 4/1/22
- Aftermarket treatments only; not products sold for use during manufacturing
- 30 manufacturers have confirmed replacement of PFASs or removal of products from California market
- DTSC conducting compliance testing

https://dtsc.ca.gov/scp/treatments-with-pfass/

SCP’s regulations are not the same as a product ban

The focus is on alternatives analysis and having manufacturers answer key questions:

- Is it necessary?
- Is there a safer alternative?
- What are the tradeoffs?

Goal:

Encourage innovation and green chemistry

https://dtsc.ca.gov/scp/alternatives-analysis-guide-version-1-0-downloads/

California PFAS Legislative Bans

- Plant fiber-based food packaging – AB 1200* (ban effective 2023)
- Juvenile products – AB 652* (ban effective 2023)
  - Highchairs, playpens, strollers, crib mattresses, etc.
- Cosmetics and personal care products – AB 2771 (beginning in 2025)
  - DTSC is not responsible for implementation or enforcement.
- Textiles – AB 1817* (beginning in 2025)
  - Apparel, handbags, backpacks, shower curtains, furnishings, upholstery, towels, etc.
- Take All Menstrual Product-PFAS Out Now (T.A.M.P.O.N.) Act – AB 2515*
- AB 347: Grants DTSC authority for enforcement of juvenile products, textile articles, and food packaging

*DTSC granted compliance & enforcement authority

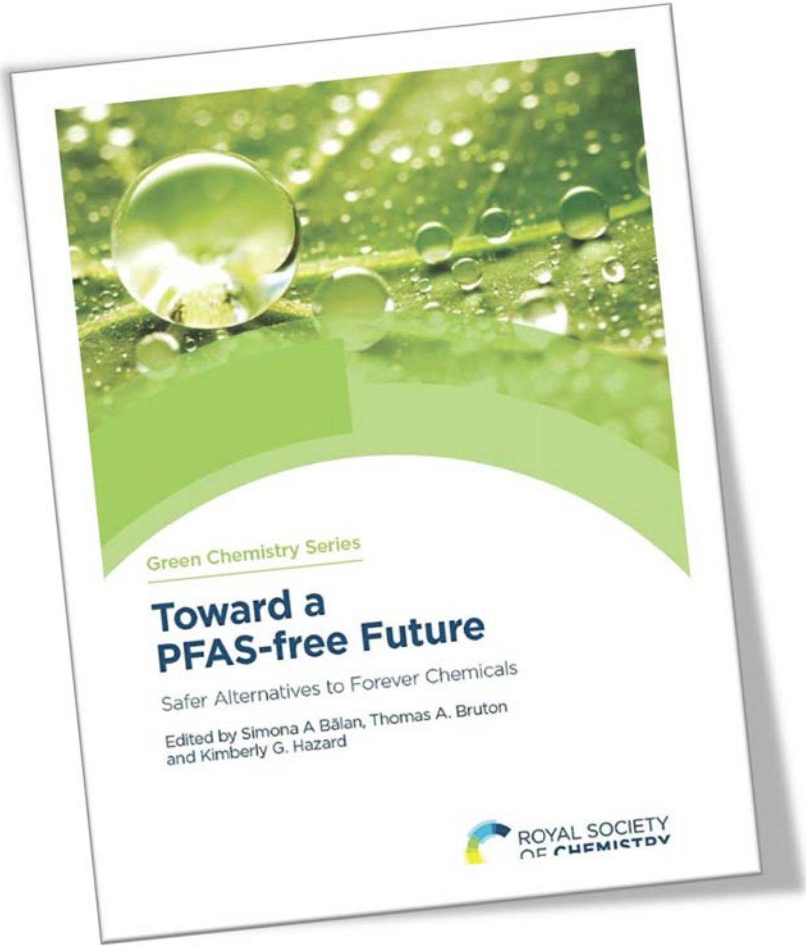
More work to do!

What’s next?
Priority Product Work Plan

- Identifies product categories DTSC will evaluate during a given three-year period
- For quarterly updates, see the SCP timeline
- Early-stage projects:
  - Candidate Chemicals in Artificial Turf
  - Floor Polishes and Waxes Containing PFASs

Priority Product Work Plan | Department of Toxic Substances Control

Collaborating on the quest for safer consumer products



Let's stay in touch!

My contact: kim.hazard@dtsc.ca.gov

SCP home page: dtsc.ca.gov/scp

Sign up for the SCP E-List to get the latest program updates!

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Safer by Design:

An Industry + Academic Collaboration to find PFAS Alternatives

Megan Arnett, PhD

marnett@Berkeley.edu

National Pollution Prevention Training and Conference

December 11, 2024

BERKELEY CENTER FOR GREEN CHEMISTRY

Innovation for Safer Materials

The nation's first center for interdisciplinary studies in green chemistry

Interdisciplinary education in green chemistry

Research
to identify safer alternatives to hazardous chemicals and materials

Engagement
providing technical support to decision-makers, community groups and advocates to promote the design and use of safer products

Greener Solutions

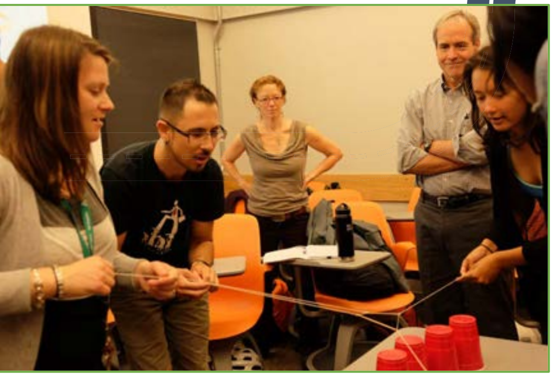
Not Just an Academic Exercise

PBHLTH 271H

Berkeley Center for Green Chemistry - University of California, Berkeley

Greener Solutions Course

1. Partner's challenge
2. Chemical function
3. Understand design constraints
4. Identify alternatives
5. Evaluate alternatives:
   - Function
   - Hazard
6. **Opportunity Map**
7. **Greener Partnerships**
   Industry Internships:
   - R&D



BCGC has identified safer alternatives to PFASs in a range of products

PFAS in Firefighter Turnouts
Partner: International Association of Firefighters

PFASs in compostable food packaging
Partner: Method

PFAS removal for carpet recycling
Partner: DTSC, GSPI, XT Green

PFASs in home product packaging
Partner: Method

PFAS in Floor Polishes
Partner: Defend Our Health

PFAS in Aftermarket Carpet Treatments
Partner: DTSC

Safer Consumer Products Program Alternatives Assessment

- Is it necessary?
- Is there a safer alternative?
- What are the tradeoffs?

BERKELEY CENTER FOR GREEN CHEMISTRY

BCGC's search for a safer alternative:

- What are the **mechanisms of performance?**
- What are the **mechanisms of toxicity?**
- How does **biology (organisms) accomplish similar functions?**

Case Study #1: Alternatives to PFAS in Floor Polish

Alternatives to PFAS in Floor Polish

Yuning Xu

MPH in Environmental Health Sciences
Class of 2022

Jenna Tan

PhD in Chemistry
Class of 2022

Tessa Wardle

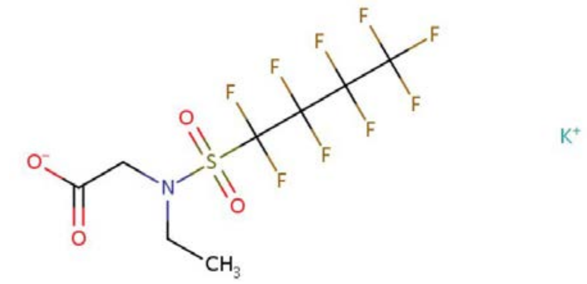
MS in Environmental Health Sciences
Class of 2022

(slide credit 10-15: modified from floor polish student team final presentations)

State of the Floor Polish Industry

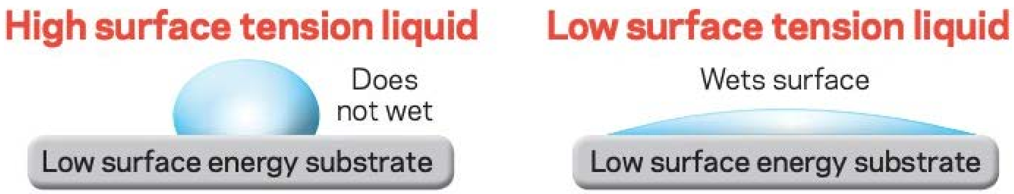
Chemours™

- Fluorochemicals commonly used in floor polish: Capstone FS-60 and FS-65
- 2008 survey revealed that nearly every floor polish on the market contained a fluorochemical
  - Existing drive from within industry to remove PFAS
- Primary commercial users: schools, hospitals, retail and grocery stores



Potassium N-ethyl perfluoro alkane sulfonamidoacetate (N-EtFOSAA)

PFAS in floor polish highly effective - posing challenge for comparable replacement

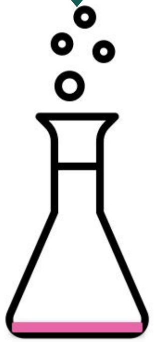


Wetting
Spreads more evenly over floor surface

Leveling
Creates a smooth and even surface

Recoating
Formulations without fluorosurfactant do not perform as well

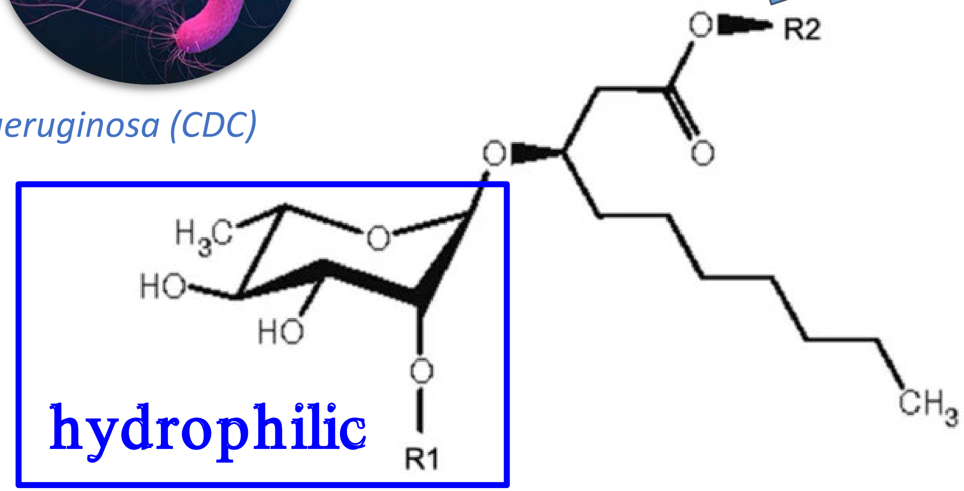
Low concentration
Doesn't affect the viscosity of the formulation



Chemours Fluorochemicals, "Capstone™ Fluorosurfactants: For High Value-in-Use Applications That Require Maximum Performance."

Strategy 1: Rhamnolipids - bacterially produced surfactants

P. aeruginosa (CDC)



- Use renewable feedstocks by fermentation
- Stable in wide range of conditions (pH, temp)
- Biodegradable and low toxicity

Current commercial applications

Pharmaceuticals

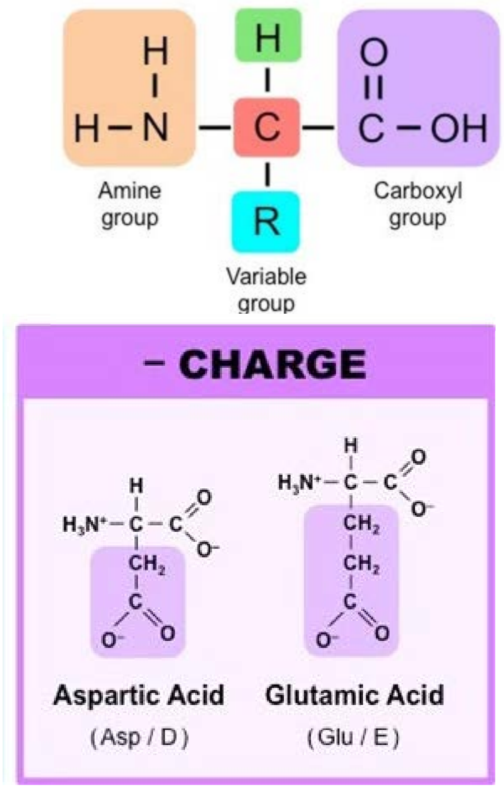
Cosmetics

Agriculture

Bioremediation

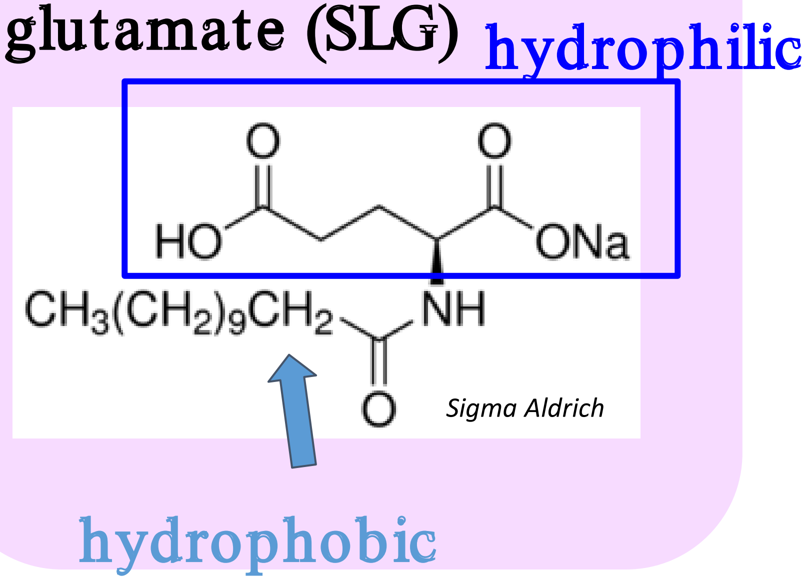
Liepins, J. *et al.*. Glycolipid Biosurfactant Production from Waste Cooking Oils by Yeast: Review of Substrates, Producers and Products. *Fermentation* **2021**, *7*, 136.
Image credits: PxHere, Pixabay, Flickr, The Science Explorer

Strategy 2: Amino acids - versatile building blocks to make a variety of surfactants



- Anionic - cleaning
- Cationic - anti-microbial agent

Sodium lauroyl glutamate (SLG)



- Produce from renewable and raw feedstock (e.g. vegetable oils)
- High surface activity
- Low toxicity and quick biodegradation

Current commercial applications

Cosmetics

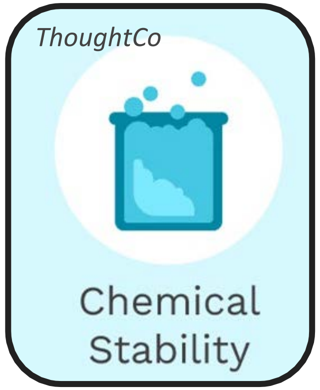
Cleaning

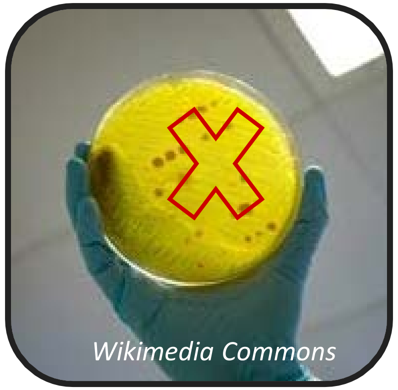
Image credits: BioNinja, Pixabay, Flickr

Rhamnolipids and amino acids form environmentally friendly surfactants.

Advantages

Biodegradation





Anti-microbial

Bioremediation

Disadvantages

Production costs

Solvent use in production

Feedstock could be food

Potentially pathogenic

Both, Rhamnolipids only

Safer Consumer Products Program Alternatives Assessment

- Is it necessary?

  PFASs offer critical advantages in floor polish formulation, but its worth evaluating the necessity and timing of floor polishing

- Is there a safer alternative?

  Based on our research, safer alternatives for PFASs used in floor polishes exist

- What are the tradeoffs?

  Cost, feedstocks

Case Study #2: Alternatives to PFAS in Firefighter Turnout Gear

The Team

Grace Campbell
Environmental Health Sciences MS Candidate

Sophia Glazer
Environmental Health Sciences MPH Candidate

Brittany Stinger
Chemistry PhD Candidate

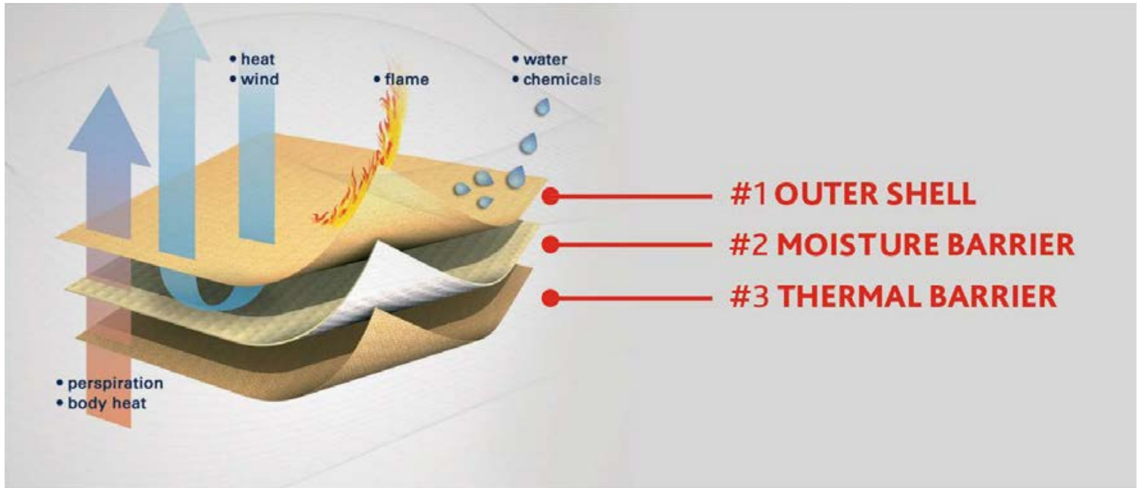
McKenna Thompson
Environmental Health Sciences MPH Candidate

Sophie Thompson
Environmental Health Sciences MPH Candidate

(slide credit 18-20: firefighter student team final presentation)

Current Turnout Gear

Typically 3 layers in firefighter turnout gear: Thermal Layer, Moisture Barrier, Outer Shell



(*Peeling Back the Fire Suit "Onion", Layer #2*, n.d.)

The Moisture Barrier contains a Polytetrafluoroethylene (PTFE) layer.

PTFE is …

- a synthetic fluoropolymer (a polymer with multiple fluorine carbon bonds)
- one of the most well-known and applied per- and polyfluoroalkyl substances (PFAS) - also used in the coating of non-stick cookware.

PFAS were detected in all three layers of the firefighter turnout gear. PFAS chemicals present on firefighter turnout gear pose a risk to human and environment health.
(Graham et al., 2020)

Conclusions and Recommendations

Science Recommendations

Fibers

Cellulose Fibers

Short Chain PHAs

Graphene

\+

Coatings

Silicon Based Flame Retardants

\+

Laminates

Polyethylene

Policy Recommendations

- We advise the NFPA to *drop the light degradation and viral penetration tests* and keep those that remain.
  - Light degradation & viral penetration tests result in over-engineered moisture barrier
  - Standards are limiting viable PFAS-free options

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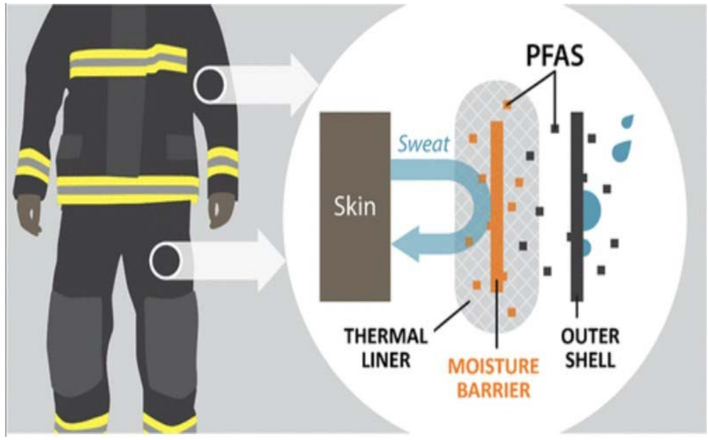
NFPA Standards Critique
Light Degradation Resistance: The UV Test

- **Unnecessary** for moisture barrier: the middle layer of turnout gear does not come into contact with UV light.
- PTFE is the **only material** that meets this requirement → Removing the UV test allows for PFAS-free moisture barriers.
- May 2021, a Tentative Interim Amendment was filed by IAFF to remove UV test from the standards but NFPA denied it and subsequent appeals



(Graham et. al., 2020)

"The UV light degradation test for moisture barriers is ***illogical, not supported by science****, stands as a hurdle to advancing the state of the art in firefighter PPE"*

- IAFF TIA Appeal

"The UV light test is stopping fire departments from moving towards procurement of PPE that doesn't contain forever chemicals. ***Firefighters should be fighting fires, not NFPA and the gear companies.****"*

- Retired battalion chief of New Haven CT Fire Department

(*Latest,* n.d.)

Safer Consumer Products Program Alternatives Assessment

- Is it necessary?

Based on our research, PFASs in firefighter turnout gear are not necessary for optimal performance and firefighter protection

- Is there a safer alternative?

By removing the NFPA requirements for UV protection in the middle layer of turnout gear, the industry would open the door to safer materials innovation

- What are the tradeoffs?

“[Chemicals] are the connection between cancer and climate change, so if you really want to make an impact, focus on chemistry.” (Marty Mulvihill, 2019)

Extra Slides

Conclusions and Recommendations

Technical Assessment

Fibers

Cellulose Fibers

Meets Tears Resistance
Low Water Contact angle

Short Chain PHAs

High Water Contact Angle
Data Gaps

Graphene

Low Water Contact Angle
Low Thermal Resistance

Coatings

Silicon Based Flame Retardants

Increase Water Contact Angle
Data Gaps

Phosphorus Based Flame Retardants

Increase Thermal Decomposition Temperature
Data Gaps

Laminates

Polyethylene

High Water Contact Angle
Data Gaps on Thermal Resistance

Polyurethane

Low Water Contact Angle
Meets other standards

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Conclusions and Recommendations
Hazard Assessment

Fibers

Cellulose Fibers

Manufacturing Risk
Data Gaps

Short Chain PHAs

Biodegradable
Data Gaps

Graphene

Concerns of Persistence
Data Gaps

Coatings

Silicon Based Flame Retardants

Few Group 1 Endpoints
Potential Manufacturer Risk

Phosphorus Based Flame Retardants

Many Group 1 Endpoints
Data Gaps for Novel PFRs

Laminates

Polyethylene

Monomer Potential Carcinogen
Polymer Persistence

Polyurethane

Monomer Potential Carcinogen
Potential Manufacturer Risk

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Technical performance is highly dependent on concentration and surface choice

	Baseline Surfactants			Alternative Surfactants	
Technical properties	**FS-60**	**FS-65**	**Sodium dodecyl sulfate (SDS)**	**Rhamnolipid**	**Sodium lauroyl glutamate (SLG)**
Water contact angle (°)	**M** ~51-56°*		**H** ~20° at 3.48 mM on PVC	**M** ~20° at 1.5 mM on PVC	**L** 138.69° on sericite (mineral)
Surface tension (mN/m)	**H** 19 at 0.05%	**H** 18 at 0.05%	**H** 23.8 - 34.6	**H** 26-29	**H** <30
Critical micelle concentration (mM)	**H** 0.23*		**M** 8-8.5	**H** 0.41	**H** 0.48
LogKow (octanol water partition coefficient)	**M** 2.51 (0.276 - 5.99)*		**H** 1.69	**L** 5.77 (4.22 - 7.38)	**H** 0.597*

High efficacy **(H)** | Moderate efficacy **(M)** | Low efficacy **(L)** | * = data for similar compound

The surfactant has assistance in floor polish formulas!

Hazard Table

		N-EtFOSAA	PFBS	PFOS	Rhamnolipid	Sodium lauroyl glutamate	
		67584-51-4	375-73-5	1763-23-1	4348-76-9	29923-31-7	Key
Group I endpoints	Carcinogen	*3*	*3*	**2**	5	DG	LC = Low concern
	Mutagen	LC	LC	*3*	*4*	LC	PC= Potential concern
	Repro/Dev	DG	*2*	**1**	DG	PC	*prediction based on similar compounds
	Endocrine disruptor	DG	1	*1*	DG	DG	Color scale:
Group II endpoints	Mammalian Toxicity	*4**	2	*4*	4	5	1= Very High Hazard
	Systemic Toxicity	DG	2	**1**	LC	LC	2= High Hazard
	Neurotoxicity	DG	*3*	*1*	DG	DG	3 = Moderate Hazard
	Respiratory Toxicant	DG	PC	PC	*4*	LC	4 = Low Hazard
	Skin irritation	PC	*1*	LC	*4*	2	5 = Very Low Hazard
	Eye irritation	DG	2	2	*1*	2	LC = Low Concern
Eco toxicity	Aquatic Toxicity	*2**	*3*	2	*2*	LC	PC = Potential Concern
Fate	Persistence	*1**	1	**1**	5	5	**Bold** = confidence in score
	Bioaccumulation	PC*	PC	**1**	PC	PC	*Italicized* = potential score

Technical performance is highly dependent on concentration and surface choice

Technical properties	Baseline Surfactants: FS-60	Baseline Surfactants: FS-65	Baseline Surfactants: Sodium dodecyl sulfate (SDS)	Alternative Surfactants: Rhamnolipid	Alternative Surfactants: Sodium lauroyl glutamate (SLG)
Water contact angle (°)	**M** ~51-56°*		**H** ~20° at 3.48 mM on PVC	**M** ~20° at 1.5 mM on PVC	**L** 138.69° on sericite (mineral)
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	Mutagen	LC	LC	*3*	*4*	LC	PC= Potential concern
	Repro/Dev	DG	*2*	**1**	DG	PC	*prediction based on similar compounds
	Endocrine disruptor	DG	1	*1*	DG	DG	Color scale:
Group II endpoints	Mammalian Toxicity	*4**	2	*4*	4	5	1= Very High Hazard
	Systemic Toxicity	DG	2	**1**	LC	LC	2= High Hazard
	Neurotoxicity	DG	*3*	*1*	DG	DG	3 = Moderate Hazard
	Respiratory Toxicant	DG	PC	PC	*4*	LC	4 = Low Hazard
	Skin irritation	PC	*1*	LC	*4*	2	5 = Very Low Hazard
	Eye irritation	DG	2	2	*1*	2	LC = Low Concern
Eco toxicity	Aquatic Toxicity	*2**	*3*	2	*2*	LC	PC = Potential Concern
Fate	Persistence	*1**	1	**1**	5	5	**Bold** = confidence in score
	Bioaccumulation	PC*	PC	**1**	PC	PC	*Italicized* = potential score

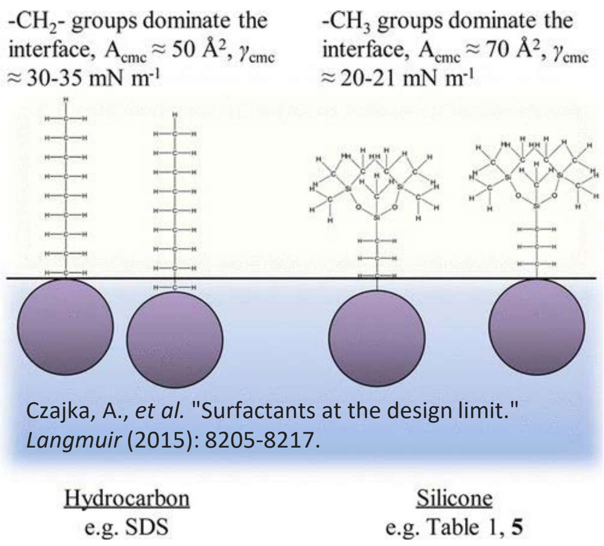
Case Study #3: Removing PFAS from recycled carpets

Recycled carpets are contaminated with PFAS

- Nearly 4 billions pounds of post consumer carpets are disposed of annually
- CA recycles >20% of carpets *but these are contaminated with PFAS*
- U.S states without carpet stewardship programs send 96% of carpets to landfills/burning
  - PFAS released through air emissions and landfill leachate

Image credit ACS GC consortium 2021

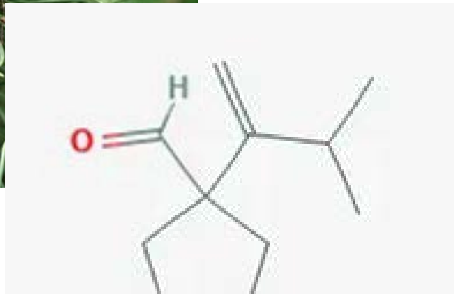
Additional alternatives considered



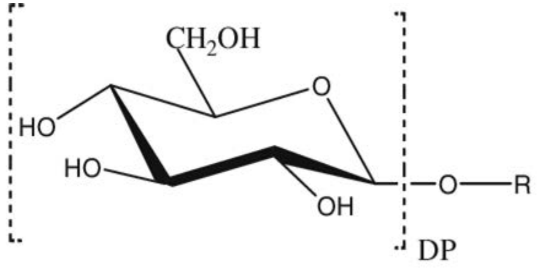
Czajka, A., *et al.* "Surfactants at the design limit." *Langmuir* (2015): 8205-8217.

Siloxanes/silicones

- Higher surface activity than hydrocarbons (lowers surface tension to values similar to fluorosurfactants)
- But persistent, bioaccumulative, and toxic



Turpentine oil



Sułek, M.W., et al. "Alkyl polyglucosides as components of water based lubricants." *Journal of surfactants and detergents* (2013): 369-375.

Alkyl Polyglucosides

- Can be low-cost and low-ecological impact
- Current commercial applications
- Has been tested by floor polish industry and is not successful when mixed into formulation

Pine oil

Active component: turpentine oil

- Low mammalian toxicity
- Current application in detergents/cleaning products
- Concern with skin and eye irritation/corrosivity
- Mixture of chemical constituents

XT Green's Search for PFAS Solutions

How much PFAS did we remove from the carpet fiber?

- Round #4 of testing: Determine the residual PFAS in fiber & % removal
  - Strong base in aqueous solution plus organic solvent #4 removes 99 to > 99% of PFAS from carpet fiber

PFAS	# of Carbons	PFAS in fiber (ppt)	2 M NaOH + 50% Solvent #4 (ppt)	Residual PFAS in Treated Fiber (ppt)	% Removal
PFBA	4	ND	591,524	1020	>99
PFBS	4	ND	ND	ND	--
PFPeA	5	143000	ND	ND	--
PFHxA	6	257,100	160,088	1698	99
PFHxSaAm	6	Surprise!	3,498,975	ND	>99
PFHpA	7	49,000	131,438	2	>99
6:2 FtS	8	8,804,400	ND	ND	--
PFOA	8	125,000	91,050	1035	99
PFOS	8	83,800	209,738	630	>99

- Determine the concentration of PFAS in the PC4

  Concentration of PFAS in PC4 similar to fiber, short-chain PFAS in PC4

PFAS	# of Carbons	PFAS in PC4 (ppt)	2 M NaOH + 50% Solvent #4 (ppt)	Residual PFAS in Treated PC4 (ppt)	% Removal
PFBA	4	265,920	TBD	TBD	TBD
PFBS	4	40,588	TBD	TBD	TBD
PFPeA	5	158,330	TBD	TBD	TBD
PFHxA	6	47,833	TBD	TBD	TBD
PFHxSaAm	6	2,695,133	TBD	TBD	TBD
PFHpA	7	38,830	TBD	TBD	TBD
6:2 FtS	8	ND	TBD	TBD	TBD
PFOA	8	46,535	TBD	TBD	TBD
PFOS	8	19,243	TBD	TBD	TBD
PFNA	9	46,368	TBD	TBD	TBD

Slide credit Ned Antell, ACS GC consortium 2021

Safer Alternatives to Industrial PFAS Use

National Pollution Prevention Training and Conference

December 11, 2024

Katy Wolf, Ph.D

Donna Walden, President, greenUP!

Background

- Worked on EPA project on ozone depleting substance alternatives for U.S. ban at the Rand Corporation as part of the Montreal Protocol
  - Focused on air conditioning and refrigeration, foam blowing, solvent and fire extinguishant applications
- Established nonprofit organization in Los Angeles with heavy focus on solvents and solvent alternatives
- Worked with flexible foam manufacturers on alternatives in California
- Continued following developments in other applications

Historical Perspective

- CFCs,1,1,1-trichloroethane (TCA) banned worldwide under Montreal Protocol in 1996 because they contributed to ozone depletion
  - Used in refrigeration and air conditioning, foam blowing, solvent, aerosol and fire extinguishant applications
- HCFCs marketed as replacements
  - Phased out later since they also contributed to ozone depletion
  - Note that nPB came on the market at the same time and chlorinated solvents took an increasing market share

Historical Perspective (Continued)

- HFCs and HFEs marketed as replacements
  - Don’t cause ozone depletion
  - Do cause global warming
- HFCs are being phased out but will take many years
- 3M is voluntarily phasing out HFEs
- HFOs are now being marketed as replacements
  - Don’t cause ozone depletion or global warming
  - Replacement is well underway

Chain of Substitution

CFCs

↓

HCFCs

↓

HFCs and HFEs

↓

HFOs

What is the Problem?

- European countries define nearly all HFCs, HFEs, HFOs as PFAS chemicals
  - Definition covers chemicals containing certain structural components
- U.S. has a less comprehensive definition that includes some HFCs and some HFOs based on structural components
- Current U.S. position is that it designates PFAS chemicals on a case-by-case basis which has not included HFCs, HFEs or HFOs
- Issue has become controversial

Hydrofluorocarbons – H-**F**-C
Hydrofluoroethers – H-**F**-E
Hydrofluoroolefins – H-**F**-O

"F" - Fluorinated gases (F-gases) contain fluorine.

Emerging PFAS Issue

- Replacement of HFCs and HFEs with HFOs is underway and could end up being regrettable substitution
- Have focused attention on PFAS water problem and detection methods for air are still being worked out
- Regulating PFAS are used in consumer and institutional products but generally not in industrial products
- To avoid a regrettable substitution, need to find not in kind (NIK) alternatives as replacements in industrial products

New PFAS Project

- Focus is primarily on industrial product PFAS
- Evaluate safer NIK alternatives to HFCs, HFEs and HFOs in several applications
    - Refrigerants
    - Foam blowing agents
    - Solvents
    - Propellants

Initial List of Specific Uses

- Refrigerants used in chillers for large commercial buildings
- Refrigerants used in motor vehicle air conditioners
- Foam blowing agents used in spray polyurethane foam for walls and roofs in homes and buildings
- Foam blowing agents for flexible foam used in furniture
- Solvents used in precision, electronics, metal cleaning
- Propellants and solvents used in aerosol products
- May add a few fluoropolymer applications

Project Tasks

- Work with manufacturers/users of NIK alternatives
  - Evaluate costs
  - Evaluate feasibility
  - Evaluate health & environmental effects
- Develop at least four case studies
- Arrange and hold webinars
- Prepare final project report

Summary and Conclusions

- HFCs, HFEs and HFOs may eventually be designated as PFAS chemicals in the U.S.
- Under an abundance of caution, we need to find safe, viable and cost-effective NIK alternatives for companies to adopt in industrial applications
- The project described here is designed to do this

THANK YOU!

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IndSpyre Solutions, Inc.

John Schierlmann

Reducing PFAS in Consumer and Other Products

December 2024

Overview

- ❑ Where are "PFAS"?
- ❑ Health Effects
- ❑ Challenges of Removal
- ❑ Products Seeing Successful Removal
- ❑ How does industry know what to do?
- ❑ Next Steps

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Products Containing Fluorinated Materials

- Shoes (water repellency)
- Clothing (oil resistance)
- Food wrappers (oil resistance)
- Fire Fighting foam (fire suppression)
- Carpets (non-staining)
- Paints and coatings (flow/leveling/UV resistance/chemical resistance)
- Industrial intermediates (emulsifying, others)

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Human Health Effects

- High cholesterol
- Ulcerative colitis
- Pregnancy induced hypertension
- Thyroid disease
- Testicular, rectal and kidney cancer
- Decreased response to vaccines

IndSpyre
SOLUTIONS

Benefits of Fluorine Chemistry in Paints, Coatings and Cleaners

- Extreme chemical resistance in coatings
- Extreme UV resistance in buildings and exterior surfaces
- Outstanding surface wetting and emulsification

Fluorinated acrylic sealers

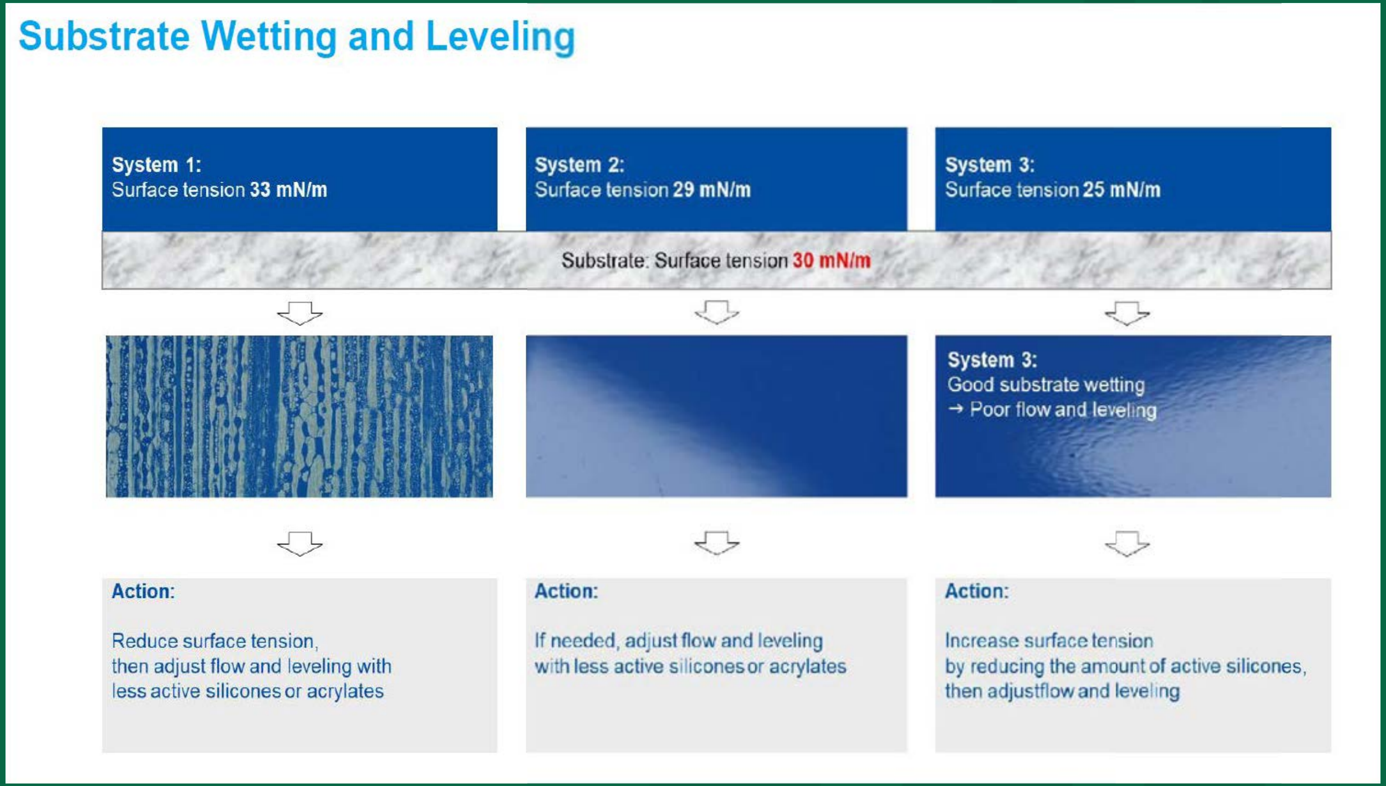
Fluorinated vinyl coatings for buildings

Coating with poor surface wetting

IndSpyre SOLUTIONS

Why PFAS are Hard to Replace

- Surface tension is affected by many factors
- Unbalanced surface tension causes wetting problems and adhesion failure
- Typically, fluorinated surfactants must be replaced by two or three different surfactants



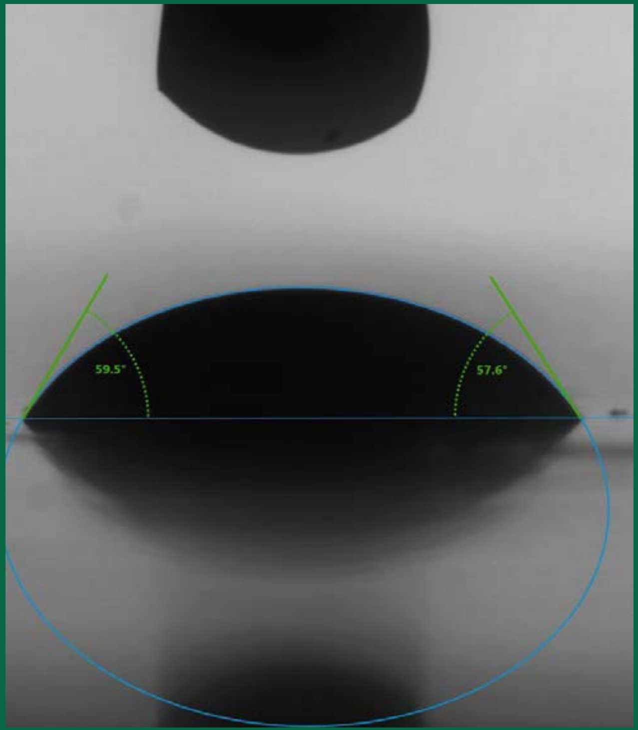
Testing Gloss and Haze Polishes
Silicone/alcohol ethoxylate hybrid

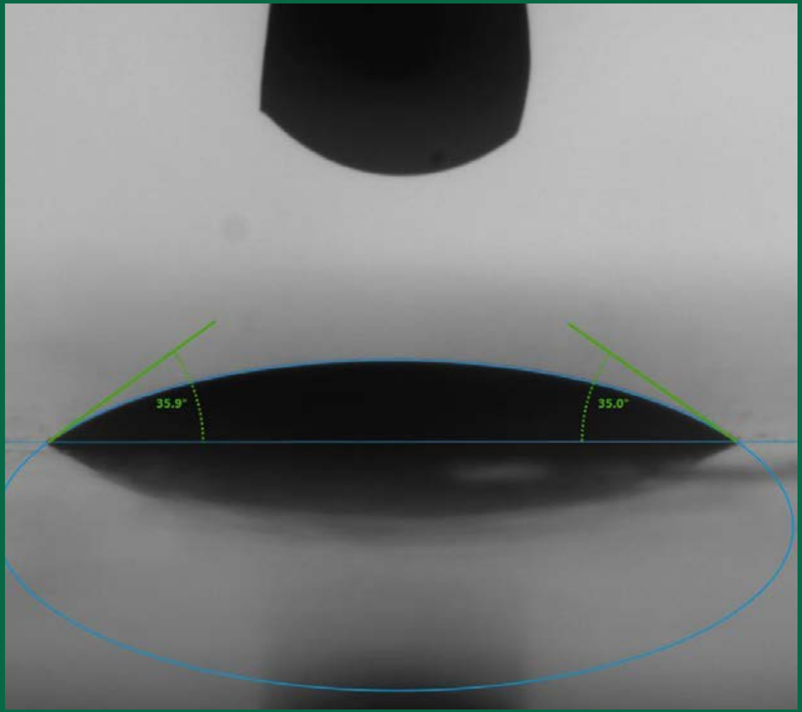
Product without PFAS

Product with
silicone replacement

Product with silicone chemistry

Contact Angle measured by Goniometer:
Acrylic Polymer Floor Finish (PFAS)





Formula B: Acrylic Polymer Floor Finish (PFAS)	
Starting Contact Angle (mN/m) [°]	56
Ending Contact Angle (mN/m) [°]	35

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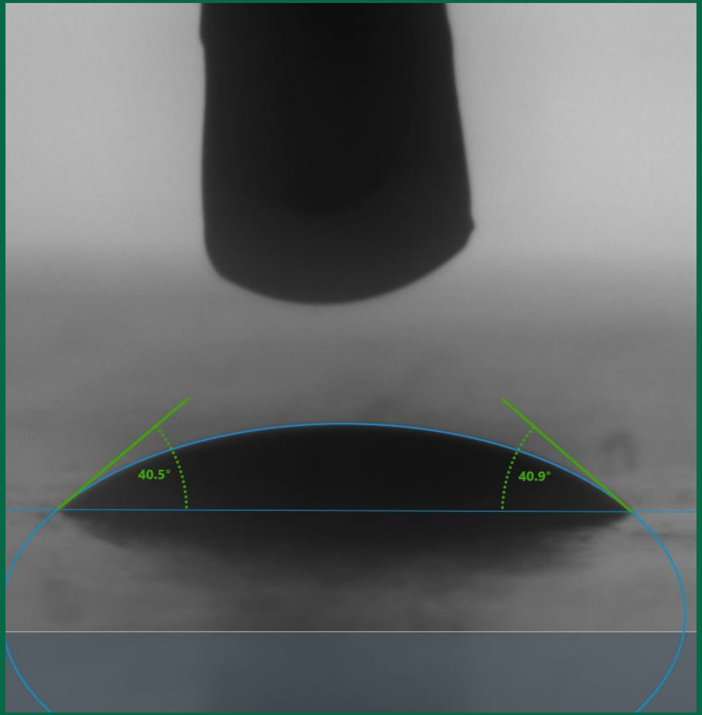
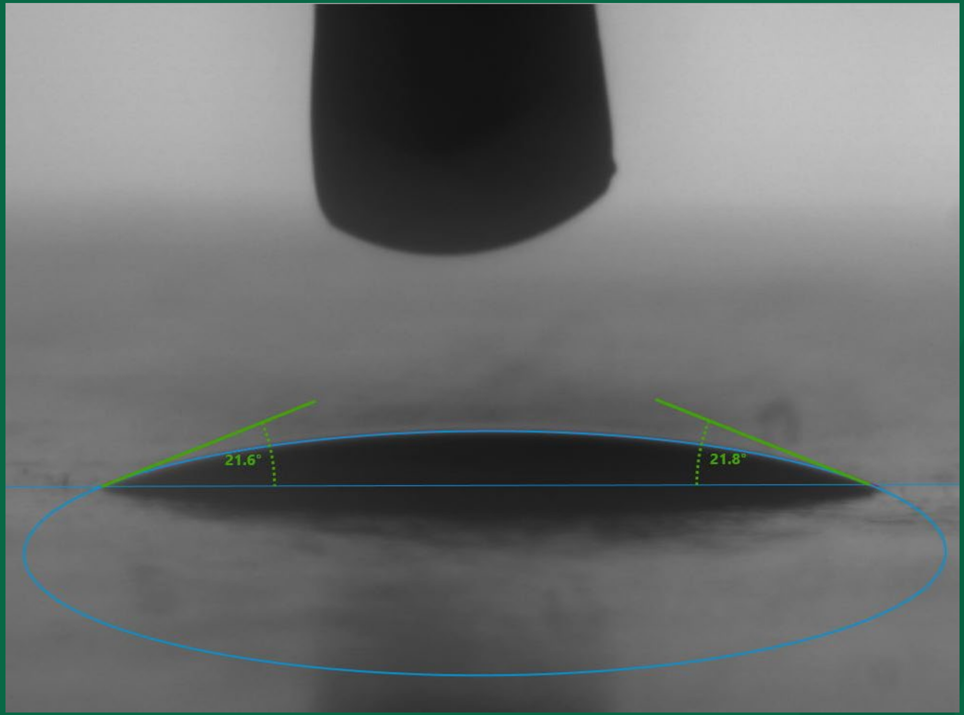
Contact Angle measured by Goniometer:
Acrylic Polish with Silicone/Alcohol ethoxylate hybrid





Formula A: Acyrlic polish with hybrid surfactants	[°]
Starting Contact Angle (mN/m) [°]	40
Ending Contact Angle (mN/m) [°]	21

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How Does Industry Keep Up?

- EPA and State regulations
- Trade Organizations
  - HCPA – Household Commercial and Products Association
  - ACI – American Cleaning Institute
  - ISSA – Industrial Sanitation
  - ACA – American Coatings Association
- Product Validation Organizations
  - EPA Safer Choice
  - Green Seal

Changes to Products

- Paints and Coatings
  - Silicone replacements
- Cleaners
  - Silicone or biobased surfactant replacements
- Carpets
- Fire Fighting Foam
  - Bio alternatives

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Conclusions

- “PFAS” chemistry has been around for over 60 years
  - Very hard to displace
- States are moving to ban intentionally added PFAS from products
- Industry is acting, replacements are difficult

2024 National Pollution Prevention Training and Conference

Reducing PFAS in Consumer and Other Products

December 11, 2024
2:50– 4:15PM ET

Moderated by John Schierlmann, IndSpyre Solutions, Inc.

Speakers:

- **Kim Hazard, California Department of Toxic Substances Control**
- **Megan Arnett, University of California at Berkley, Center for Green Chemistry**
- **Donna Walden, greenUP!**
- **Katy Wolf, Consultant and Former Director of the Institute for Research and Technical Assistance**
- **John Schierlmann, IndSpyre Solutions, Inc**