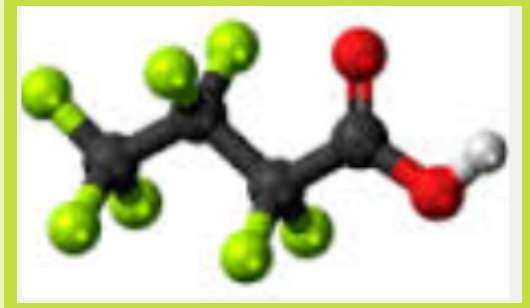
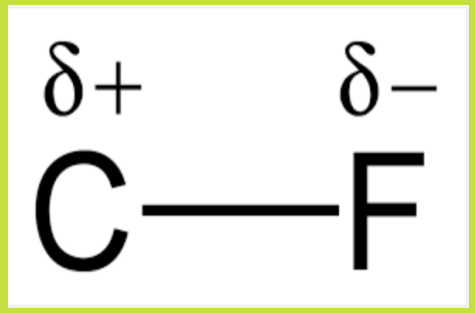
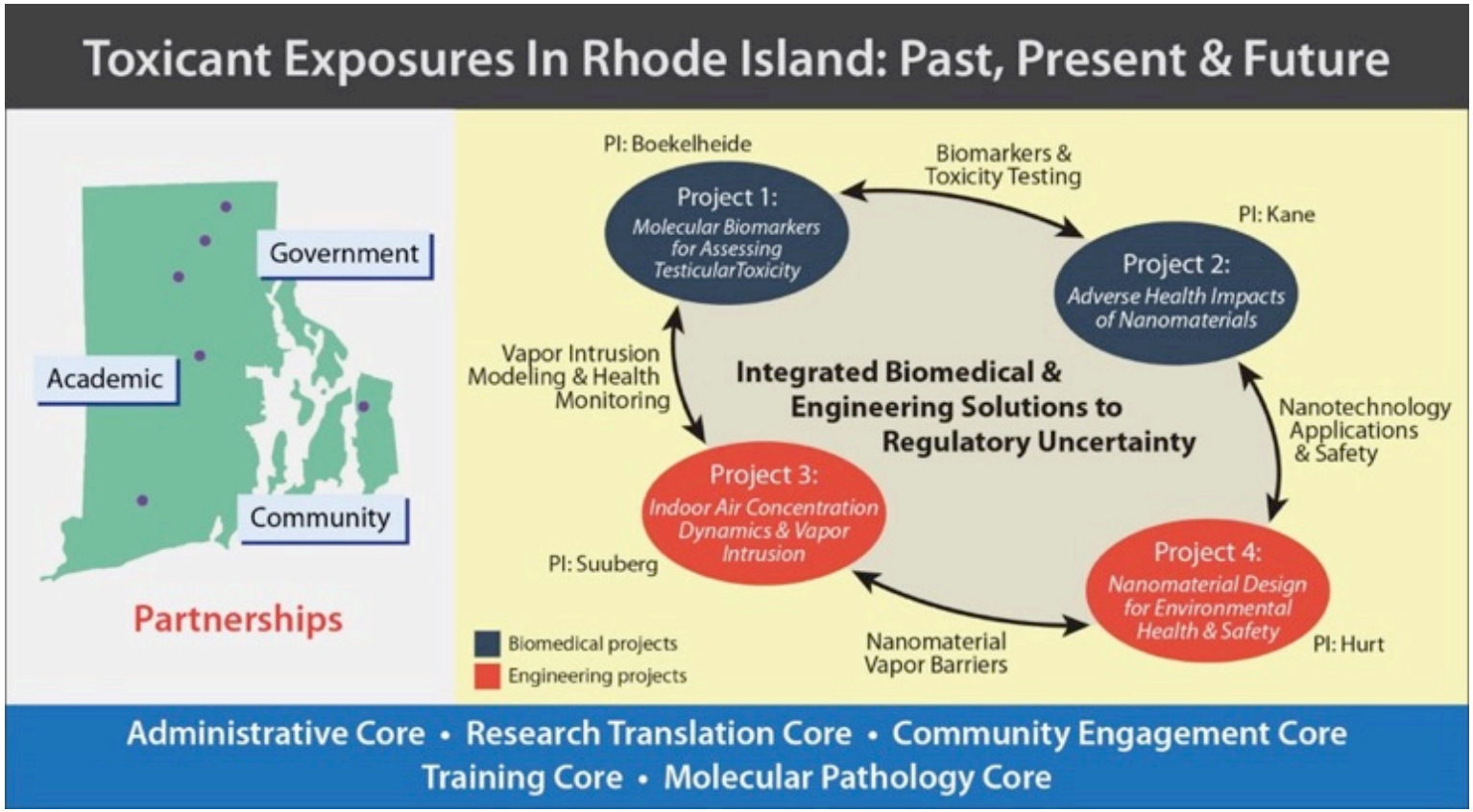
INTRODUCTION TO PER- AND POLYFLUOROALKYL SUBSTANCES (PFASs)

Jennifer Guelfo, PhD
State Agencies Liaison, Brown SRP
May 8th-10th, 2017





Brown University Superfund Research Program



NIH National Institute of Environmental Health Sciences
Superfund Research Program

NEWMOA

INTRODUCTION: ROLE OF RESEARCH TRANSLATION

Clarkson UNIVERSITY

BROWN

The goal of the survey is to identify key site characteristics associated with PFAS sites, and to recognize real and perceived challenges to managing sites. We also seek to identify stakeholders' knowledge and experiences with treatment approaches.

Survey link: goo.gl/zakRX3

Thank you!

PRESENTATION OUTLINE

PFAS Overview

Regulation, Sampling & analysis

Uses & Sources

PRESENTATION OUTLINE

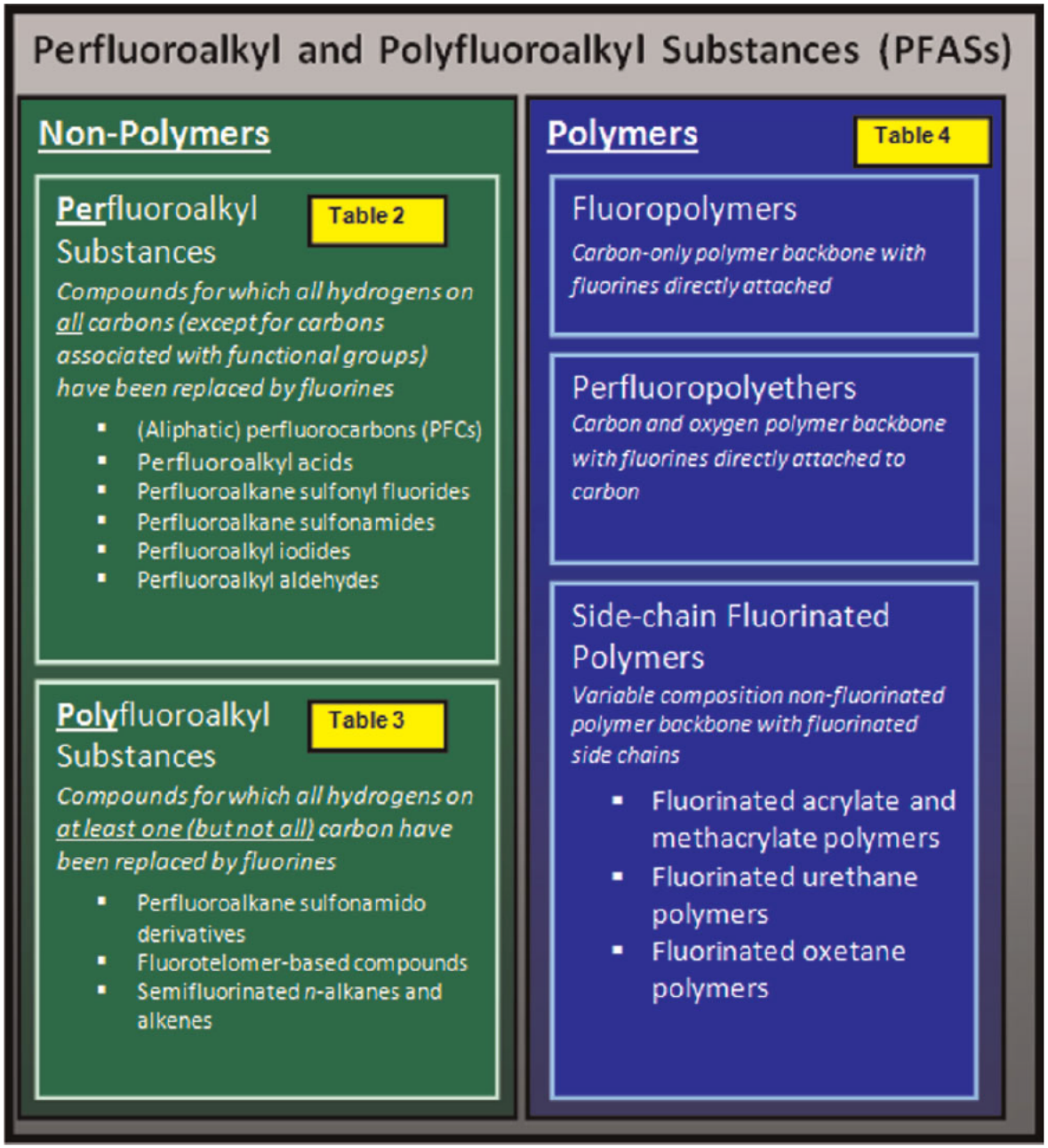
PFAS Overview

Regulation, Sampling & analysis

Uses & Sources

- Terminology
- Manufacturing Processes
- Chemistry

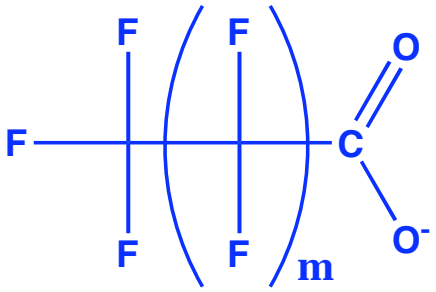
PFAS OVERVIEW: TERMINOLOGY & STRUCTURE[1]



[1]Buck, Robert C., et al. *Integrated environmental assessment and management* 7.4 (2011): 513-541.

PFAS OVERVIEW: TERMINOLOGY & STRUCTURE

Perfluoroalkyl carboxylates (PFCAs):



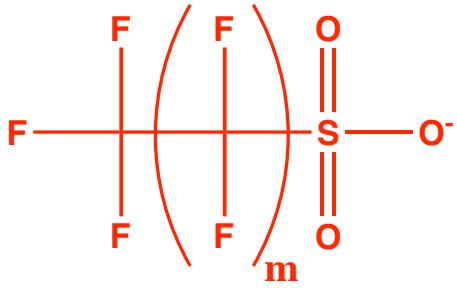
Examples:

m=2 PFBA

m=4 PFHxA

m=6 PFOA

Perfluoroalkane sulfonates (PFSAs):



Examples:

m=3 PFBS

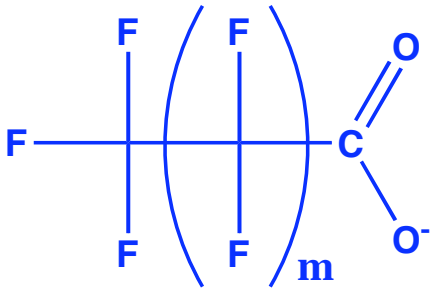
m=5 PFHxS

m=7 PFOS

Per = fully fluorinated alkyl tail.

PFAS OVERVIEW: TERMINOLOGY & STRUCTURE

Perfluoroalkyl carboxylates (PFCAs):



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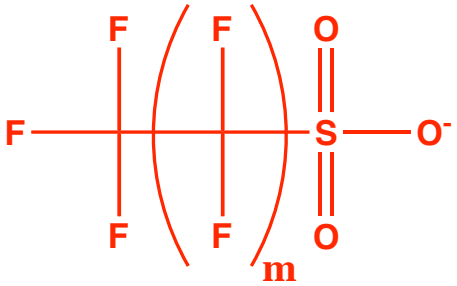


Examples:

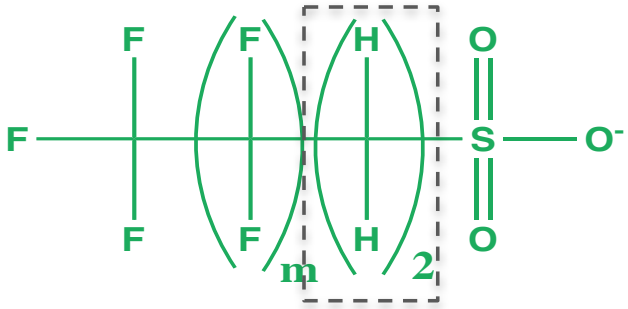
m=3 PFBS

m=5 PFHxS

m=7 PFOS

Poly = partially fluorinated alkyl tail.

Polyfluoroalkyl substances:

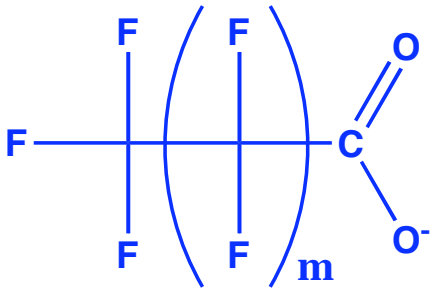


m=5 6:2 FtS

m=7 8:2 FtS

PFAS OVERVIEW: TERMINOLOGY & STRUCTURE

Perfluoroalkyl carboxylates (PFCAs):



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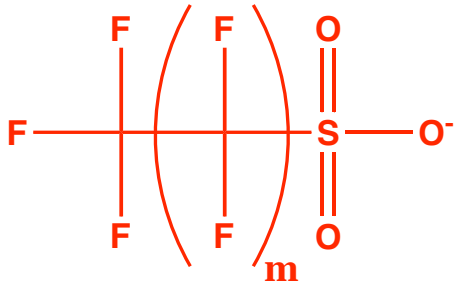


Examples:

m=3 PFBS

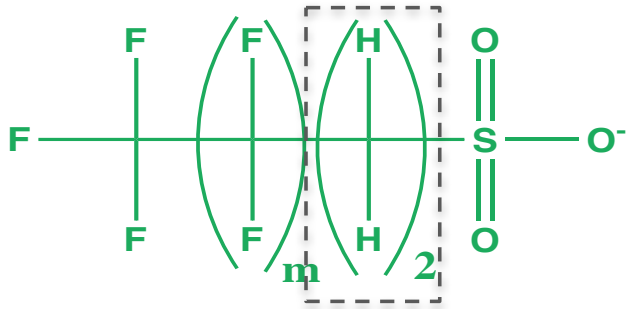
m=5 PFHxS

m=7 PFOS

Per + Poly =

Per & polyfluoro alkyl substances (PFAS)

Polyfluoroalkyl substances:



m=5 6:2 FtS

m=7 8:2 FtS

PFAS OVERVIEW: TERMINOLOGY & STRUCTURE

What is a precursor?

Polyfluroalkyl substances that can undergo transformation to form ***per***fluoroalkyl acids

8:2 FtTAoS (precursor)

8:2 FtS (intermediate)

PFOA (terminal endpoint)

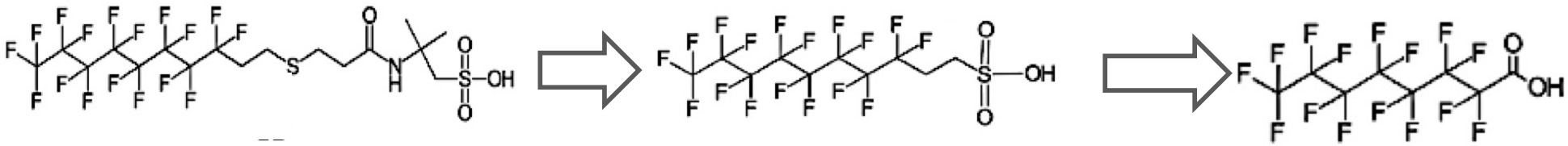


Figure adapted from Ref. 2

2. Harding-Marjanovic, Katie C., et al. "Aerobic biotransformation of fluorotelomer thioether amido sulfonate (Lodyne) in AFFF-amended microcosms." *Environmental science & technology* 49.13 (2015): 7666-7674.

PFAS OVERVIEW: TERMINOLOGY & STRUCTURE

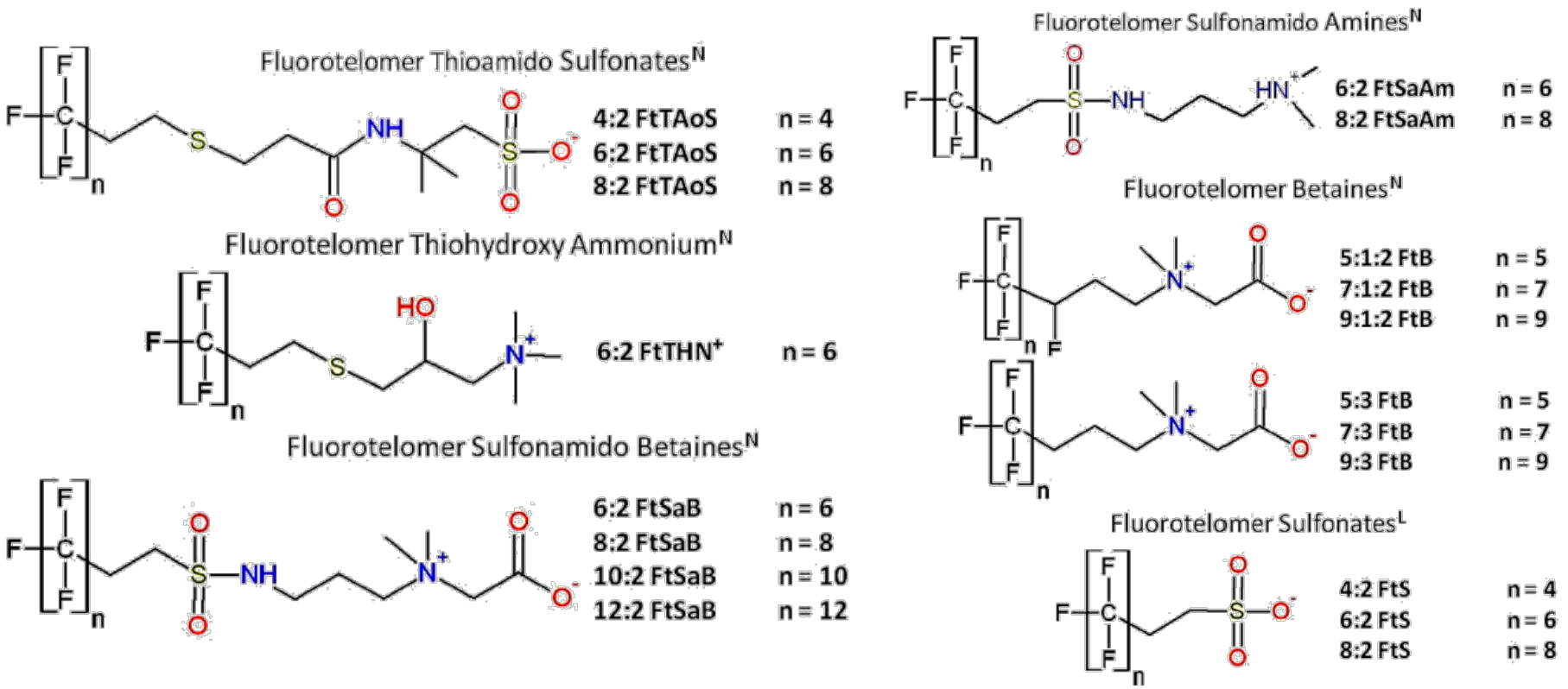
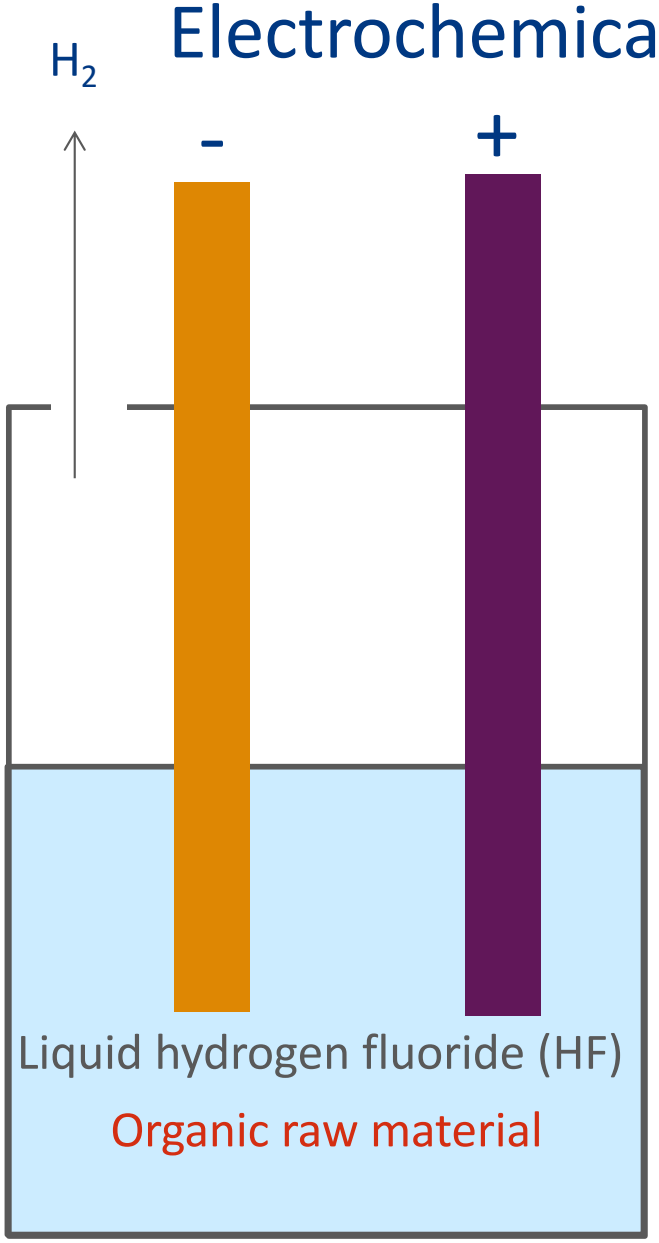


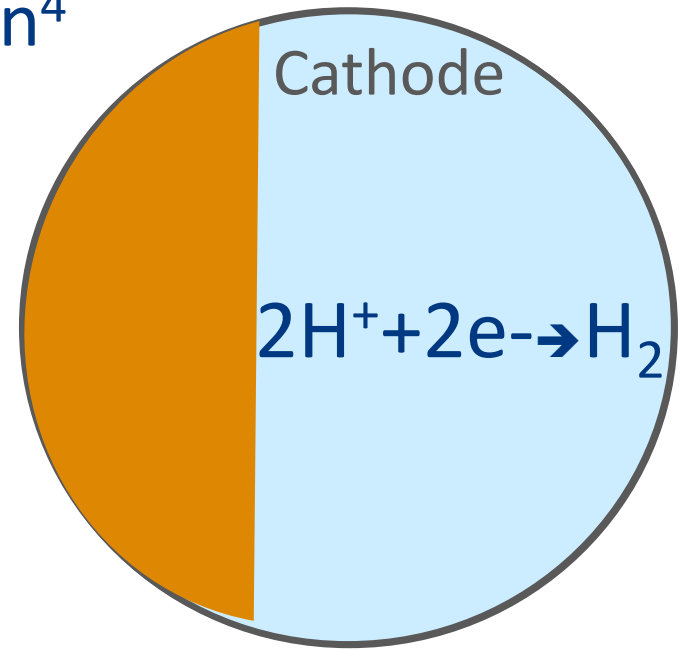
Figure adapted from Ref. 3

3. Backe, Will J., Thomas C. Day, and Jennifer A. Field. "Zwitterionic, cationic, and anionic fluorinated chemicals in aqueous film forming foam formulations and groundwater from US military bases by nonaqueous large-volume injection HPLC-MS/MS." *Environmental science & technology* 47.10 (2013): 5226-5234.

PFAS OVERVIEW: MANUFACTURING

Electrochemical fluorination[4]

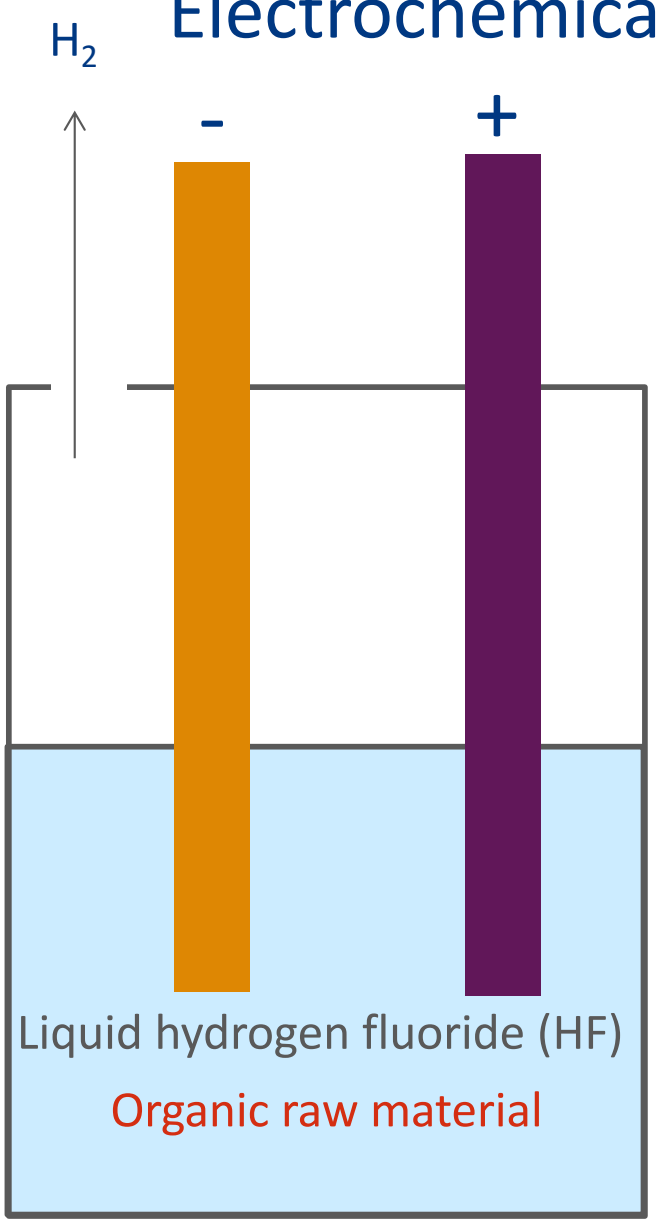


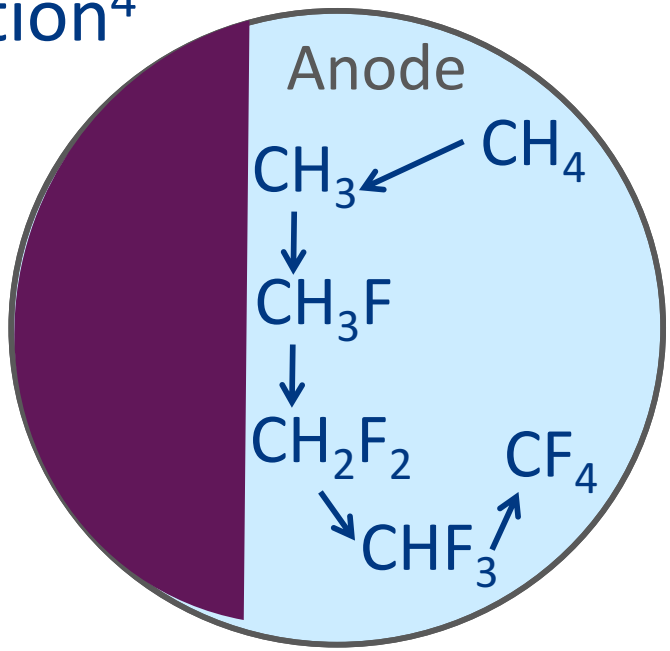


4. Kissa, Erik, ed. *Fluorinated surfactants and repellents*. Vol. 97. CRC Press, 2001.

PFAS OVERVIEW: MANUFACTURING

Electrochemical fluorination[4]





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PFAS OVERVIEW: MANUFACTURING

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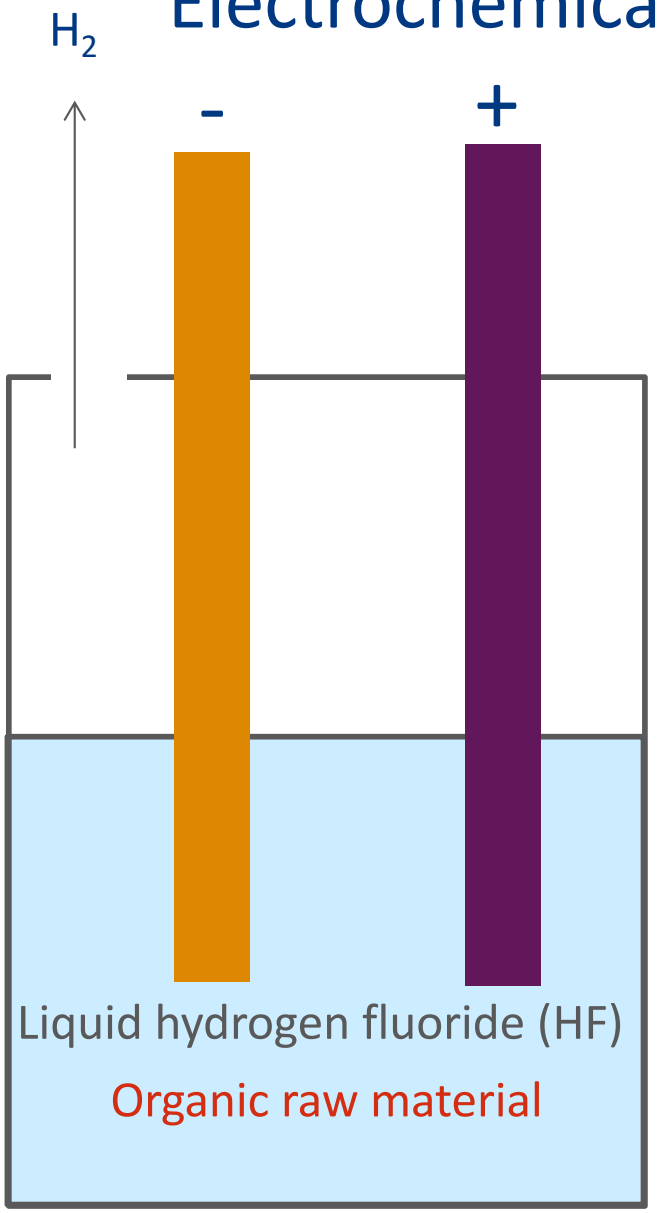
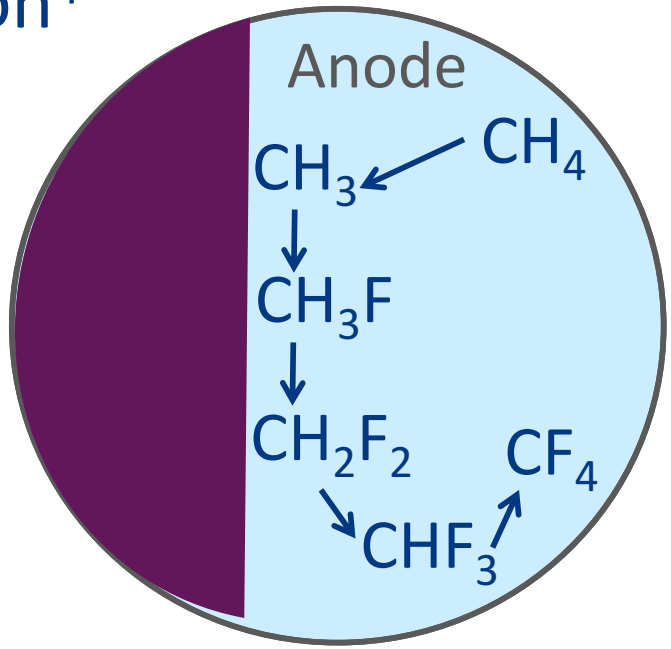




$C_8H_{17}SO_2F$ → $C_8F_{17}SO_2F$

Octane sulfonyl fluoride → Perfluorooctane sulfonyl fluoride

$C_8F_{17}SO_2F$ → $C_8F_{17}SO_2H$

Perfluorooctane sulfonyl fluoride → Perfluorooctane sulfonic acid (PFOS)

4. Kissa, Erik, ed. *Fluorinated surfactants and repellents*. Vol. 97. CRC Press, 2001.

PFAS OVERVIEW: MANUFACTURING

Telemorization[1,4]

$$YZ + nA \longrightarrow Y\text{-}(A)_n\text{-}Z$$

Telogen Taxogen Telomer

PFAS OVERVIEW: MANUFACTURING

Telemorization[1,4]

$$YZ + nA \longrightarrow Y\text{-}(A)_n\text{-}Z$$

Telogen — Taxogen — Telomer

$$F(CF_2)_2I + \frac{n-2}{2}CF_2{=}CF_2 \longrightarrow F(CF_2)_nI$$

Perfluoroalkyl iodide, e.g. pentafluoroethyl iodide

Tetrafluoroethylene
n=desired chain length

Perfluoroalkyl iodide

PFAS OVERVIEW: MANUFACTURING

Telemorization[1,4]

$$YZ + nA \longrightarrow Y - (A)_n - Z$$

Telogen — Taxogen — Telomer

$$F(CF_2)_2I + \frac{n-2}{2} CF_2{=}CF_2 \longrightarrow F(CF_2)_nI$$

Perfluoroalkyl iodide, e.g. pentafluoroethyl iodide

Tetrafluoroethylene
n=desired chain length

Perfluoroalkyl iodide

Ex. 1 $F(CF_2)_nI + CH_2{=}CH_2 \longrightarrow F(CF_2)_nCH_2CH_2I$

Perfluoroalkyl iodide — Ethylene — n:2 Fluorotelomer iodide

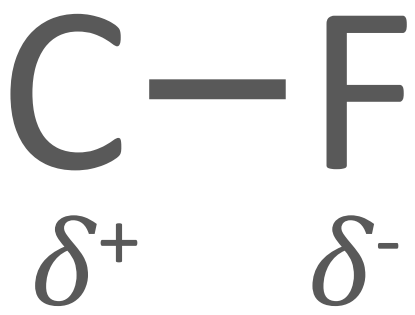
Ex. 2 $F(CF_2)_nI \xrightarrow{\text{Oleum, heat, pressure}} CF_3(CF_2)_{n-1}CF_2OOH + \frac{1}{2}I_2$

Perfluoroalkyl iodide — Perfluoroalkyl carboxylic acid

PFAS OVERVIEW: CHEMISTRY

Fluorine Property: high electronegativity[4,5]

Description:



Effects:

- Strongest covalent bond in organic chemistry
- Polar bond

5. Banks, Ronald Eric, Bruce E. Smart, and J. C. Tatlow, eds. *Organofluorine chemistry: principles and commercial applications*. Springer Science & Business Media, 2013.

PFAS OVERVIEW: CHEMISTRY[4,5]

Fluorine Property: high electronegativity[4,5]

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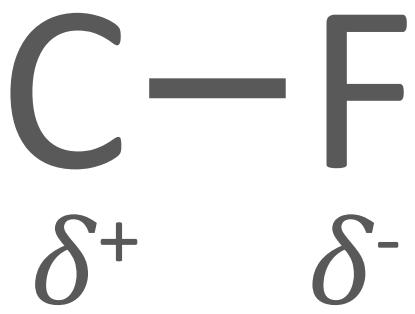

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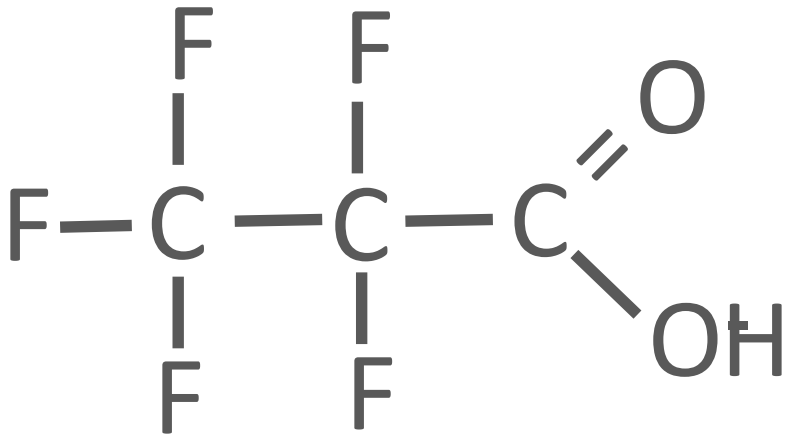
Resulting PFAS properties:



\+

- Strong acidity (low pK_a)*
- Thermal stability
- Chemical stability

*When paired with an acidic functional group

5. Banks, Ronald Eric, Bruce E. Smart, and J. C. Tatlow, eds. *Organofluorine chemistry: principles and commercial applications*. Springer Science & Business Media, 2013.

PFAS OVERVIEW: CHEMISTRY

Fluorine Property: low polarizability[4,5]

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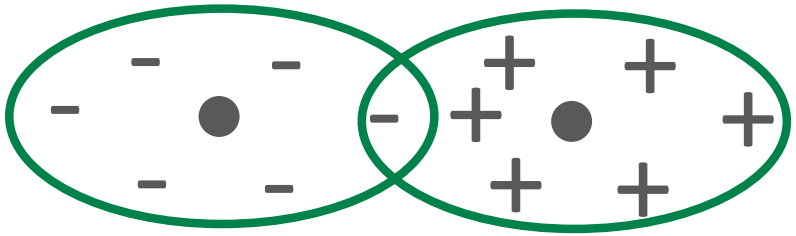
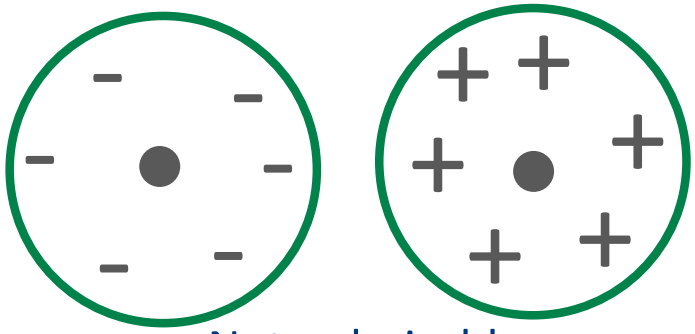


Polarizable

PFAS OVERVIEW: CHEMISTRY

Fluorine Property: low polarizability[4,5]

Description:



Not polarizable

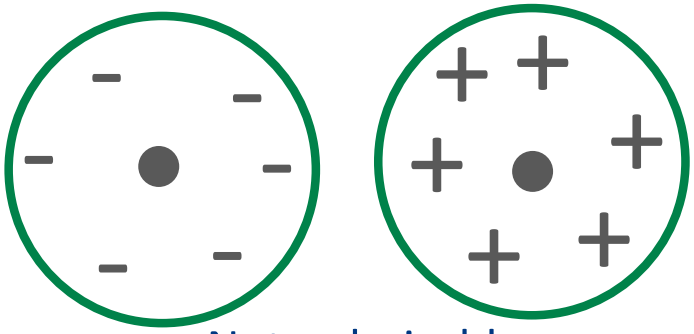
Effects:

- Weak intermolecular interactions
- Ex: van der Waals

PFAS OVERVIEW: CHEMISTRY

Fluorine Property: low polarizability[4,5]

Description:



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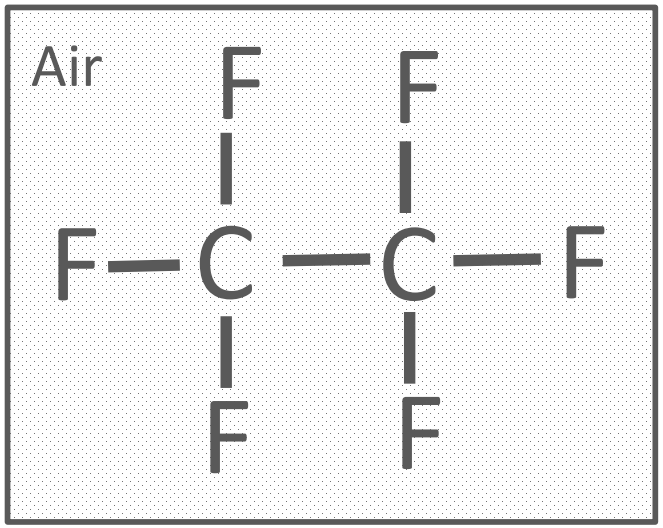
Resulting PFAS properties:



- Hydrophobic & lipophobic

PFAS OVERVIEW: CHEMISTRY

Fluorine Property: low polarizability[4,5]

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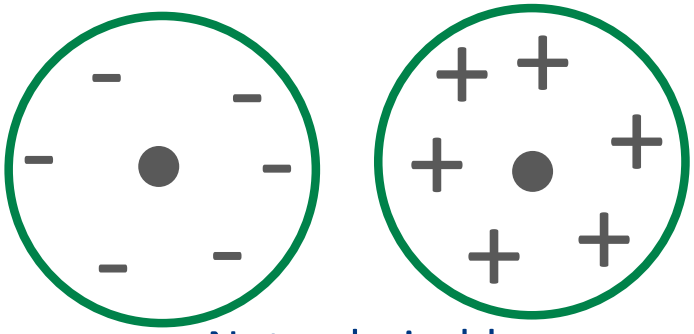

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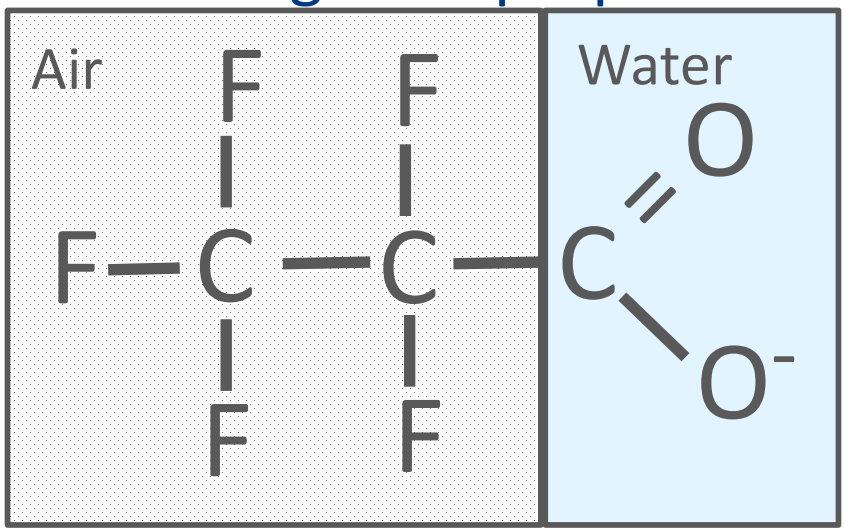


- Hydrophobic & lipophobic
- Surfactant*

*When paired with a hydrophilic functional group

CHEMISTRY[3]

Fluorine Property: small size[4,5]

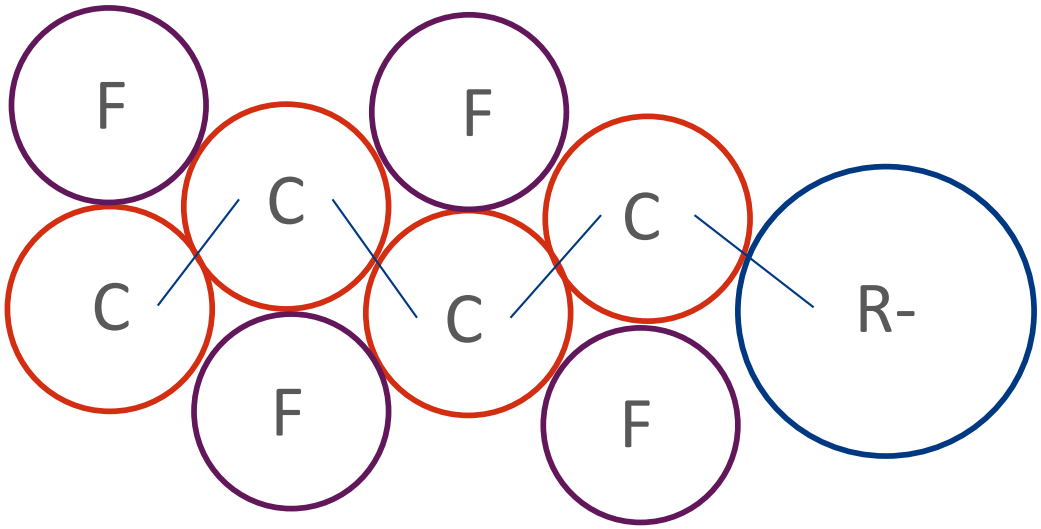
Description:

- ^{9}F
- ^{17}Cl
- ^{35}Br
- ^{53}I
- ^{85}At

Effects:

- Atomic radius = 0.72Å
- Shields carbon

Resulting PFAS properties:



- Chemical stability

PRESENTATION OUTLINE

PFAS Overview

Regulation, Sampling & analysis

Uses & Sources

- Summary of state regulations
- Typical sample precautions
- Target methods and PFASs, state by state
- Overview of standard methods & labs
- Other analytical tools

PFAS REGULATION, SAMPLING & ANALYSIS

Drinking Water Health Advisories for PFOA, PFOS

70 ng/L: individually or in combination

State	Drinking Water Standard	Other Matrices?	Which?
Connecticut	70 ng/L ∑ PFOA, PFOS, PFNA, PFHxS, PFHpA	Yes	Soil, groundwater
Maine	70 ng/L ∑ PFOA, PFOS[1]	Yes[1]	Soil, sediment, groundwater, surface water, fish
Massachusetts	70 ng/L ∑ PFOA, PFOS	No	NA
New Hampshire	70 ng/L ∑ PFOA, PFOS	Yes	Soil
New Jersey	40 ng/L PFOA[2] 10 ng/L PFNA[2]	No	NA
New York	70 ng/L ∑ PFOA, PFOS[3]	No	NA
Rhode Island	70 ng/L ∑ PFOA, PFOS	No	NA
Vermont	20 ng/L ∑ PFOA, PFOS	Yes	Soil

[1] Guidelines (not standards)

[2] Standard under review

[3] Other PFASs may be considered if ∑PFOA,PFOS is slightly less than 70 ng/L

PFAS REGULATION, SAMPLING & ANALYSIS

Prohibited Items	Acceptable Items
Field Equipment	
Teflon® containing materials	High-density polyethylene (HDPE) materials
Low density polyethylene (LDPE) materials	Acetate liners
Paper towels containing recycled materials	Silicon tubing
Waterproof field books	Loose paper
Plastic clipboards, binders, or spiral hard cover notebooks	Masonite or aluminum clipboards
Sharpies or markers	Pens
Post-It Notes	Loose paper
Chemical (blue) ice packs	Regular ice
Field Clothing and PPE	
New cotton clothing or synthetic water resistant, waterproof, or stain-treated clothing, clothing containing Gore-Tex	Well laundered clothing made of natural fibers (preferable cotton)
Clothing laundered using fabric softener	No fabric softener
Boots containing Gore-Tex	Boots made with polyurethane and PVC
Tyvek	Cotton clothing
No cosmetics, moisturizers, hand cream, or other related products as part of personal cleaning/showering routine on the morning of sampling	100% Natural sunblock and insect repellent
Sample Containers	
LDPE or glass containers	HDPE or polypropylene
Teflon-lined caps	Unlined polypropylene caps
Rain Events	
Waterproof or resistant rain gear	Gazebo tent that is only touched or moved prior to and following sampling activities
Equipment Decontamination	
Decon 90	Alconox or Liquinox
Water from an on-site well	Potable water from municipal drinking water supply
Food Considerations	
All food and drink, with exceptions noted on the right	Bottled water and hydration drinks (i.e. Gatorade and Powerade) to be brought and consumed only in the staging area

Is it necessary?

- Some literature show PFAS occurrence in cosmetics, sunscreens[6,7]
- Textbooks/literature support historical use in other relevant products (but w/no supporting analysis)[4]

But…

- No literature data about transfer from prohibited items during sampling
- Unpublished data suggests no transfer from many field materials (e.g. personal products, field notebooks, etc.)

Bottom line: Many precautions may prove unnecessary but currently there is little data to support which can be eliminated

6. Keawmanee, Sasipin, Suwanna Kitpati Boontanon, and Narin Boontanon. "Method development and initial results of testing for perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA) in waterproof sunscreens." *Environmental Engineering Research* 20.2 (2015): 127-132.
7. Fujii, Yukiko, Kouji H. Harada, and Akio Koizumi. "Occurrence of perfluorinated carboxylic acids (PFCAs) in personal care products and compounding agents." *Chemosphere* 93.3 (2013): 538-544.

PFAS REGULATION, SAMPLING & ANALYSIS

State	Drinking Water	Soil	Ground- and Surface water	Target PFAS
CT	EPA 537	ASTM D-7968-14	ASTM D7979-15	No set list (more is better)
ME	EPA 537	EPA 537	EPA 537	26 PFAS (list not provided)
MA	EPA 537 or other approved method	NA	NA	UCMR 3
NH	DoD/NELAP certified lab or EPA 537	DoD/NELAP certified lab	DoD/NELAP certified lab	PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFBS, PFHxS, PFOS
NJ	EPA 537[1]	NA	NA	PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUnA, PFDoA, PFTrDA, PFTA, PFBS, PFHxS, PFOS
NY	EPA 537 (past) ISO 25101 (now)	NA	NA	UCMR 3 + others depending on lab
RI	EPA 537	NA	NA	See New Hampshire
VT	EPA 537	EPA 537		UCMR 3 required, 12 usually reported

DoD = Department of Defense NELAP = National Environmental Laboratory Accreditation Program

[1] At NJDEP-certified lab with RL ≤ 6ng/L for PFOA and ≤ 10 ng/L for all other PFASs

PFAS REGULATION, SAMPLING & ANALYSIS

Standard methods for PFASs:

Method Name	Method 537	ASTM D7979-16	ASTM D7968-14
Matrix	Drinking water	Water, influent/effluent wastewater, sludge	Soil
Compound Classes	PFAA, FASAA	PFAA, n:3 acid, FTUCA, FTCA	PFAA, n:3 acid, FTUCA, FTCA
Sample container	Polypropylene	Polypropylene	Polypropylene
Sample volume	250 mL	5 mL	2g, adjust if needed
Extraction	SPE	None	50:50 H_2O: MeOH
Filtering	None	Polypropylene	Polypropylene
Reporting Limits	2.9-14 ng/L	10-300 ng/L	25-750 ng/kg
Holding Times	14 days	28 days	28 days
Preservation	5 g/L buffer, cooled <10°C	Cooled, <6°C	Cooled, <6°C
Quantification	Internal std.	External cal.+ recovery of isotope labeled PFAS	

- PFAA = perfluoroalkyl acids
- FASAA = perfluoroalkyl sulfonamidoacetic acid
- n:3 acid = n:3 saturated acid
- FTUCA = fluorotelomer unsaturated carboxylic acid
- FTCA = flurotelomer carboxylic acid

PFAS REGULATION, SAMPLING & ANALYSIS

Commercial lab availability:

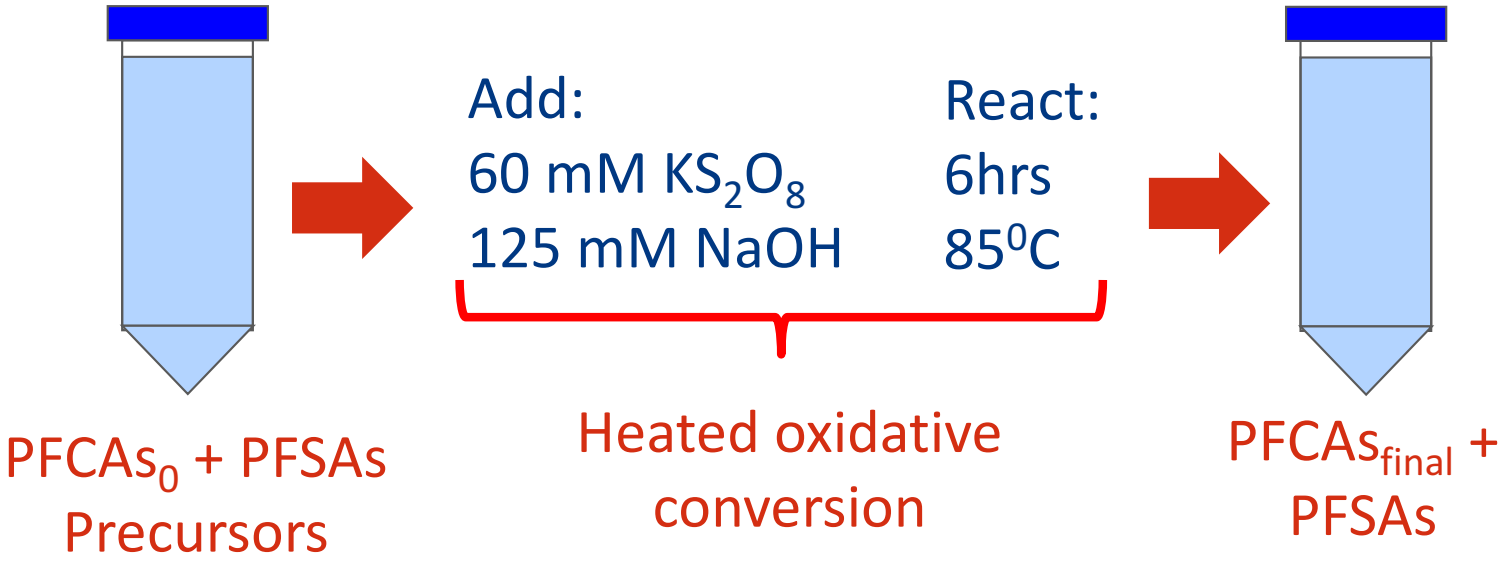
Laboratory	Method	Matrices	Compound Classes	Aqueous RL*
Axys	Internal, TOP	Water, Solid, Air, Tissue, Serum, Urine	PFAA, FTS, FASA, FASAA, PAP, FTCA	1-80 ng/L
Eurofins	EPA 537 or direct injection	Water, Solid, Tissue, Products	PFAA, FTS, FASAA	2-10 ng/L
Test America	Mod EPA 537, TOP	Water, Solid	PFAA, FTS, FASA, FASAA, FASE, precursors	2-100 ng/L
Vista	Mod EPA 537	Water, Solid, Tissue	PFAA, FTS, FASA, FASE, FASAA	1-40 ng/L

* Reporting limit (RL) range encompass all compound classes; RLs for all labs were below EPA HA levels for PFOS/PFOA

- PFAA = perfluoroalkyl acids
- FTS = fluorotelomer sulfonates
- PAP = polyfluoroalkyl phosphate esters
- FASA = perfluroalkyl sulfonamides
- FTCA = fluorotelomer carboxylic acid
- FASE = perfluoroalkyl sulfonamidoethanol
- FASAA = perfluoroalkyl sulfonamidoacetic acid
- FTUCA = fluorotelomer unsaturated carboxylic acid
- TOP = total oxidizable precursors

PFAS REGULATION, SAMPLING & ANALYSIS

Other analytical tools: total oxidizable precursor (TOP) assay:



$$\text{Total Precursors} = PFAA_{final} - PFAA_0$$

- *Bulk* precursor quantification = total amt. precursors present
- Does *not* identify individual precursor compounds present

PFAS REGULATION, SAMPLING & ANALYSIS

Other analytical tools: mobile laboratory technology

PFAS Mobile Lab:

- Cascade Environmental
- Mobile LC-MS/MS
- SPE & direct inject
- DoD QSM PFAS (24)

PFTreA	PFOA	PFNS	PFOSA
PFTriA	PFHpA	PFOS	FtS 8:2
PFDoA	PFHxA	PFHpS	FtS 6:2
PFUnA	PFPeA	PFHxS	FtS 4:2
PFDA	PFBA	PFPeS	NEtFOSAA
PFNA	PFDS	PFBS	NMeFOSAA

PRESENTATION OUTLINE

PFAS Overview

Regulation, Sampling & analysis

Uses & Sources

- PFAS manufacturing
- AFFF
- Other manufacturing
- Waste streams

PFAS USES & SOURCES

PFAS Manufacturing (NAICS 325)[8,9]

PFAS manufacturers

- Arkema
- Asahi
- BASF/Ciba
- Clariant
- Daikin
- 3M/Dyneon
- DuPont/Chemours
- Solvay Solexis
- Dynax

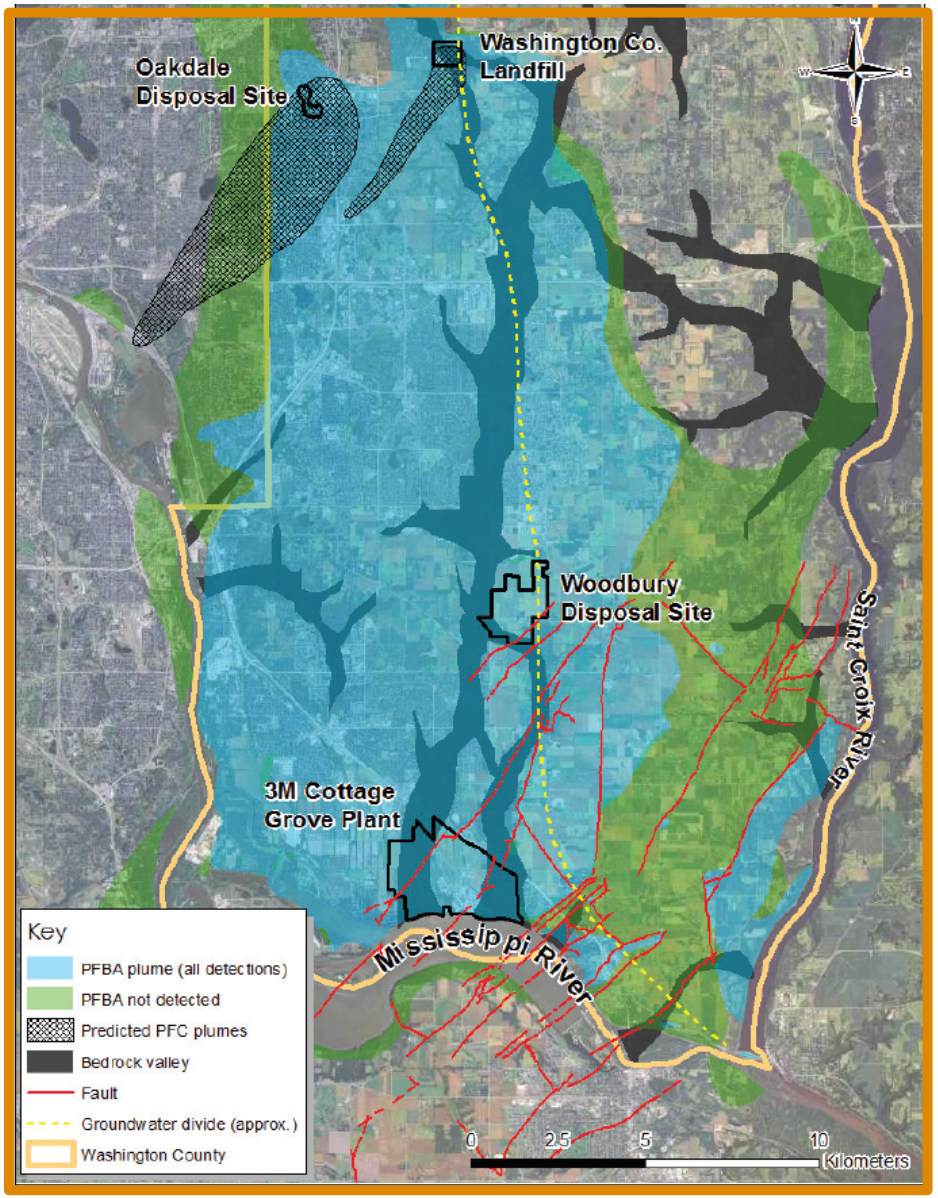
Current manufacturing focus:

- 3M: no AFFF or food wrappers, current focus on 'short chain' (PFCA <8, PFSA <6) , Ex: PFBS-based products, ADONA
- DuPont: GenX (a perfluropolyether)
- Daikin: 6:2 fluorotelomer products
- Solvay: perfluoropolyethers
- Asahi: perfluoropolyethers

8. Wang, Zhanyun, et al. "Fluorinated alternatives to long-chain perfluoroalkyl carboxylic acids (PFCAs), perfluoroalkane sulfonic acids (PFSAs) and their potential precursors." *Environment international* 60 (2013): 242-248.
9. http://www.3m.com/3M/en_US/sustainability-us/policies-reports/3m-and-fluorochemicals/

PFAS USES & SOURCES

PFAS Manufacturing (NAICS 325)



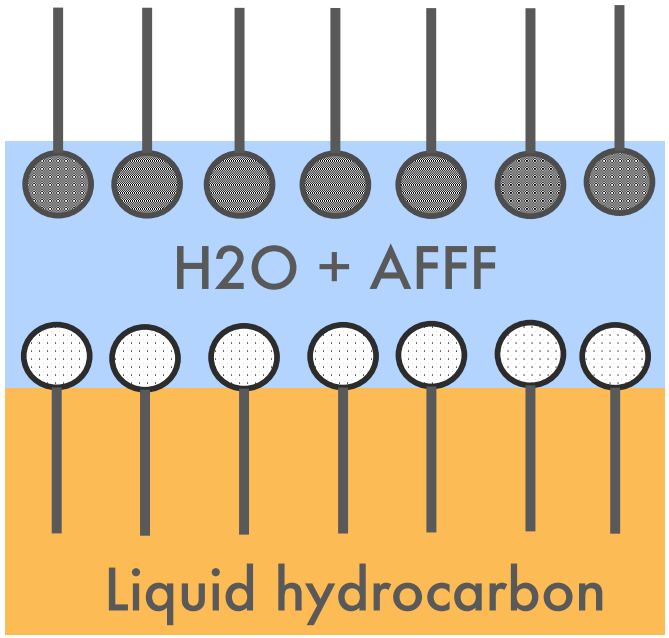
Source zone examples:[10,11]

- 3M, MN
- 3M, AL
- Daikin, AL

10. Yingling, Virginia. "Perfluorochemicals: How Groundwater-Surface Water Interactions Helped Create a Megaplume." *2014 NGWA Groundwater Summit*. Ngwa, 2014.
11. Oliaei, Fardin, et al. "PFOS and PFC releases and associated pollution from a PFC production plant in Minnesota (USA)." *Environmental Science and Pollution Research* 20.4 (2013): 1977-1992.

PFAS USES & SOURCES

Aqueous Film Forming Foams (AFFF, NAICS 325)



Adapted from ref. 12

AFFF and PFAS:[13]

- 3M, 1980's-2000:
  - ~7-13 g/L PFCAs + PFSAs
  - 4.9-11.4 g/L PFOS
  - 0.5-1.4 g/L PFHxS
  - Negligible precursors
- 3M, National Foam, Buckeye, Chemguard, Ansul, 2000's-present:
  - Negligible PFCAs + PFSAs
  - Primarily precursors

12. Moody, Cheryl A., and Jennifer A. Field. "Perfluorinated surfactants and the environmental implications of their use in fire-fighting foams." *Environmental science & technology* 34.18 (2000): 3864-3870.
13. Houtz, Erika F., et al. "Persistence of perfluoroalkyl acid precursors in AFFF-impacted groundwater and soil." *Environmental science & technology* 47.15 (2013): 8187-8195.

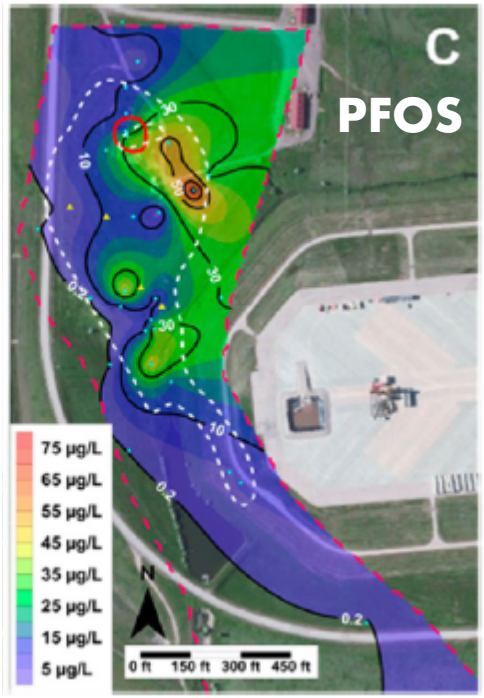
PFAS USES & SOURCES

AFFF manufacturers:

- 3M before 2002
- Chemguard
- Ansul
- National Foam
- Angus
- Solberg
- Buckeye

AFFF end users:

- Department of Defense
- Airports
- Fire stations
- Fire training areas
- Petroleum (NAICS 324)



Source zone examples:[14-16]

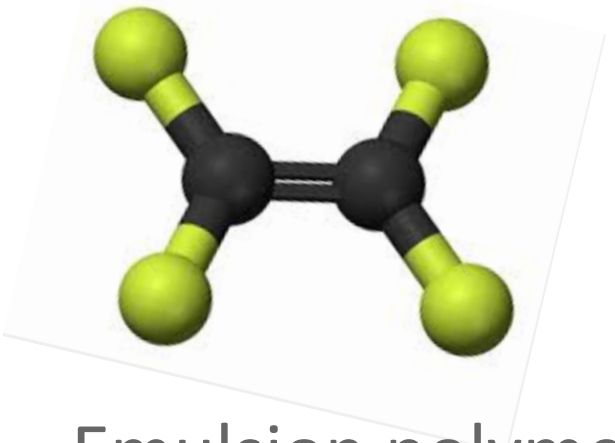
- Ellsworth AFB, SD
- Wurtsmith AFB, SD
- Tyndall AFB, FL

14. McGuire, Meghan E., et al. "Evidence of remediation-induced alteration of subsurface poly- and perfluoroalkyl substance (PFAS) distribution at a former firefighter training area." (2014).
15. Moody, Cheryl A., et al. "Occurrence and persistence of perfluorooctanesulfonate and other perfluorinated surfactants in groundwater at a fire-training area at Wurtsmith Air Force Base, Michigan, USA." *Journal of Environmental Monitoring* 5.2 (2003): 341-345.
16. Schultz, Melissa M., et al. "Quantitative determination of fluorotelomer sulfonates in groundwater by LC MS/MS." *Environmental science & technology* 38.6 (2004): 1828-1835.

PFAS USES & SOURCES

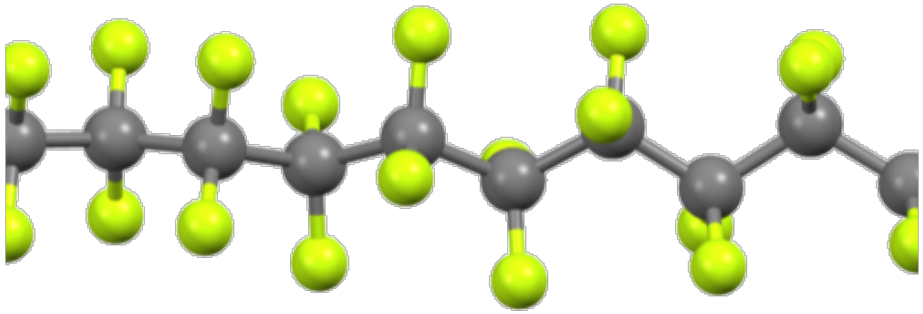
Other manufacturing: fluoropolymer (NAICS 325, 326)

Tetrafluoroethylene (TFE)



Emulsion polymerization →

Polytetrafluoroethylene (PTFE)



Emulsion polymerization and PFASs

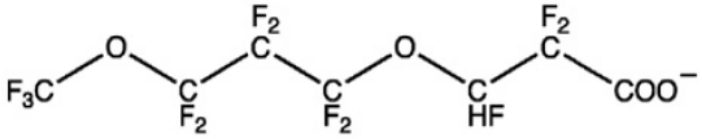
- PFOA historically for PTFE and others
- PFNA historically for polyvinylidene fluoride (PVDF)
- Used as ‘polymerization aids’ in emulsion polymerization
- Solubilize monomers
- Generates fine powder and dispersed fluoropolymers
- Used primarily in coatings (e.g. metals, plastics, fabrics)

PFAS USES & SOURCES

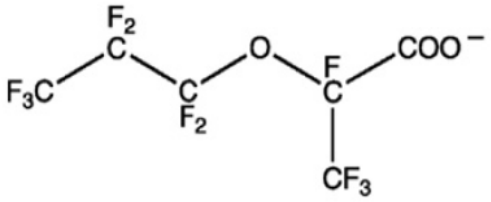
Other manufacturing: fluoropolymer (NAICS 325, 326)

Example replacement polymerization aids:[8]

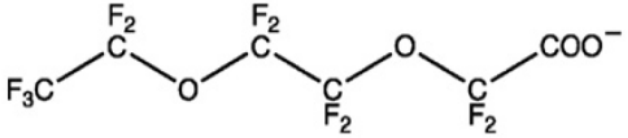
ADONA (CAS No. 958445-44-8)



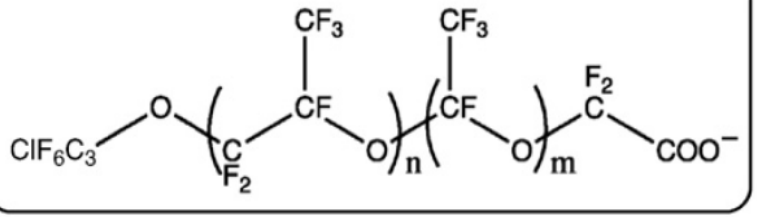
GenX (CAS No. 62037-80-3)



Asahi's product (CAS No. 908020-52-0)

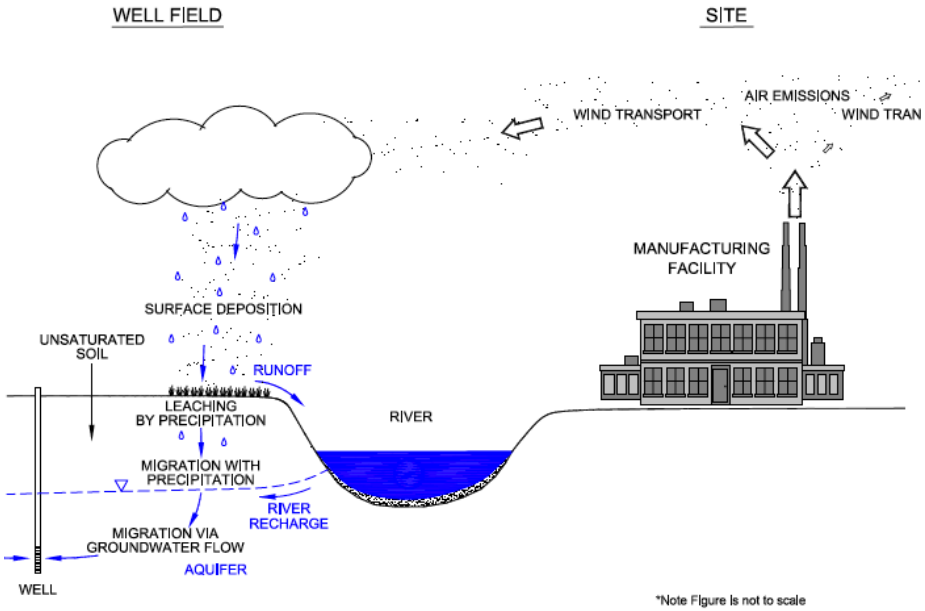


Solvay's product (CAS No. 329238-24-6)



Source zone examples:[17,18]

- DuPont, Parkersburg, WV
- St. Gobain, NY, VT



17. Davis, Katherine L., et al. "Transport of ammonium perfluorooctanoate in environmental media near a fluoropolymer manufacturing facility." *Chemosphere* 67.10 (2007): 2011-2019.
18. Shin, Hyeong-Moo, et al. "Environmental fate and transport modeling for perfluorooctanoic acid emitted from the Washington Works Facility in West Virginia." *Environmental science & technology* 45.4 (2011): 1435-1442.

PFAS USES & SOURCES

Other manufacturing: Miscellaneous

Electroplating (NAICS 332)

- PFOS used as mist suppressant

Paper

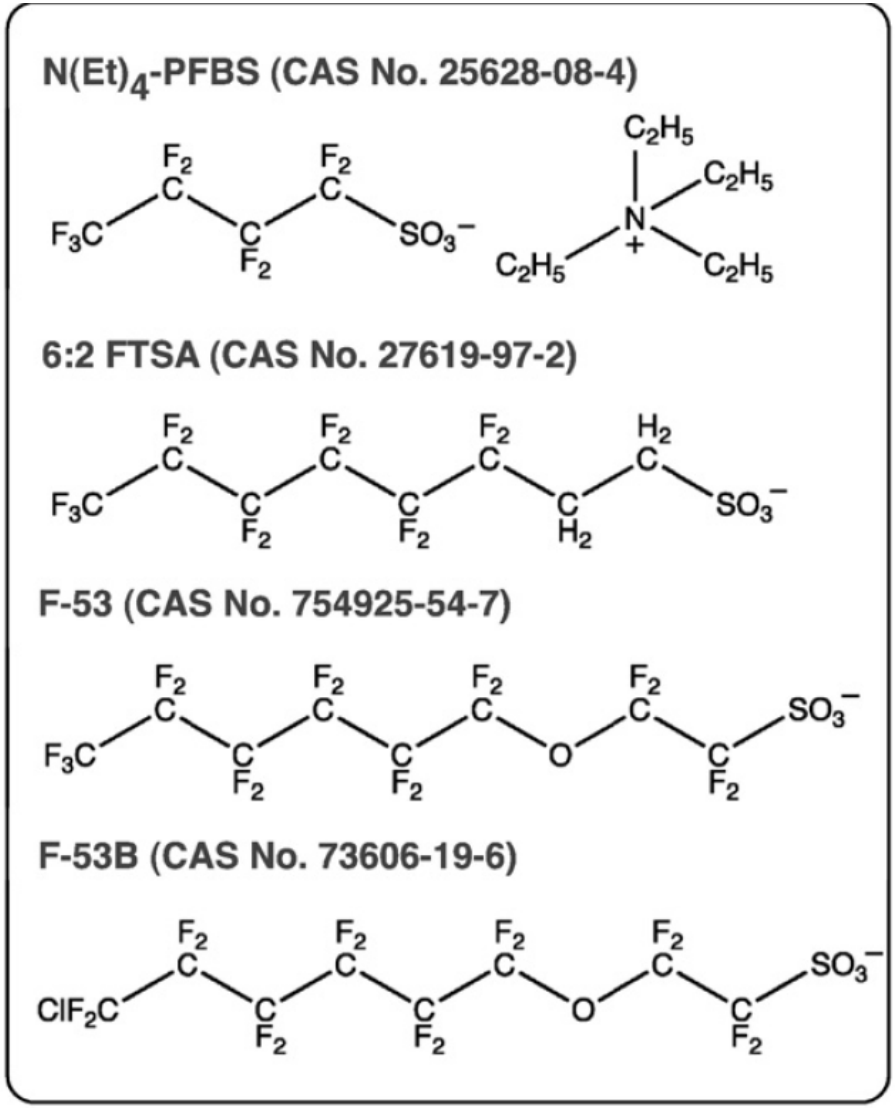
- PFAS used as grease/water repellant

Textiles (NAICS 313), carpets (NAICS 314, 561), furnishings (NAICS 423)

- Stain-resistant coatings
- Textiles source zone: Amherst, NH (NHDES)

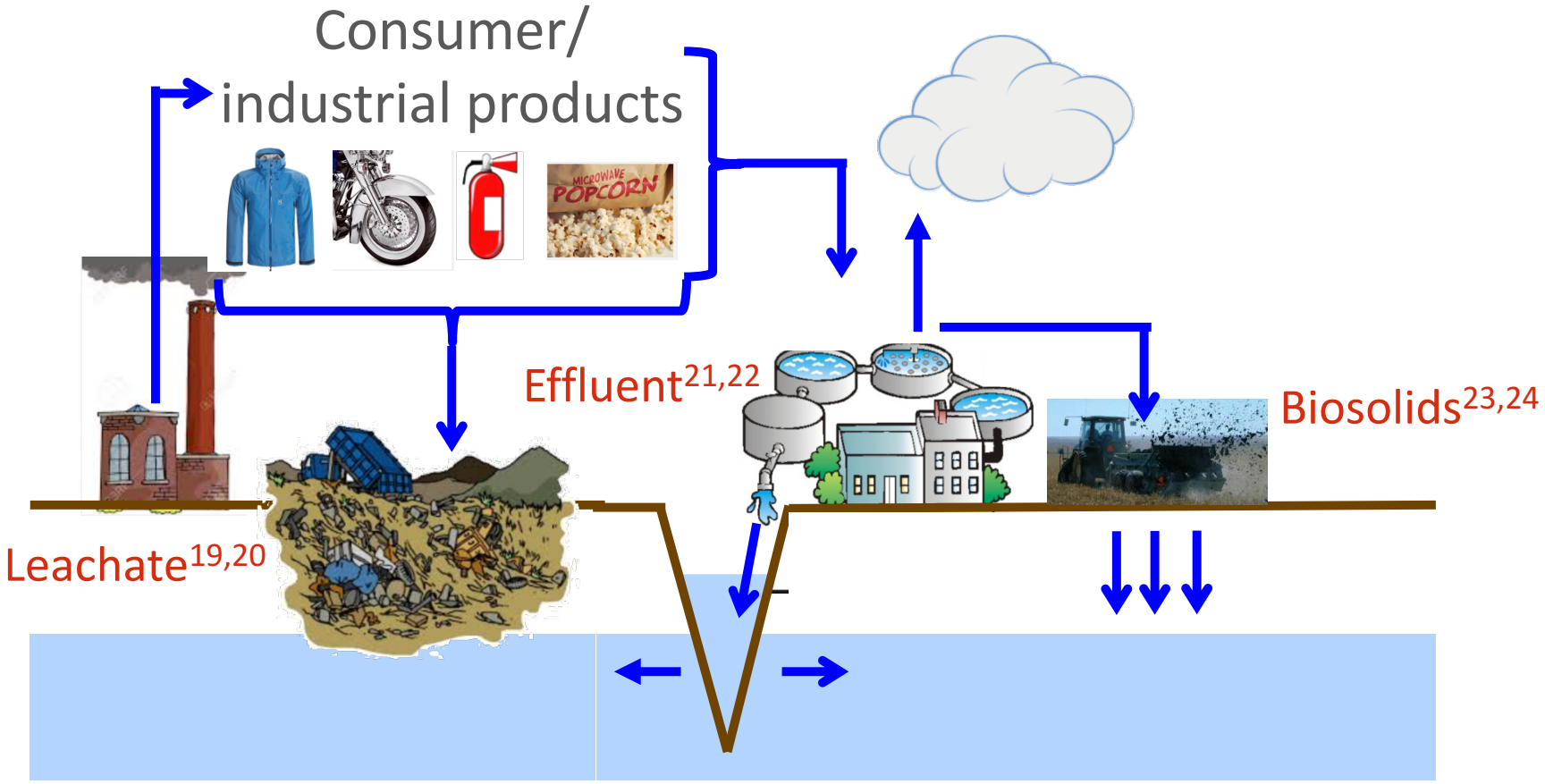
Plus other uses too numerous to list

Electroplating replacement PFAS[8]



PFAS USES & SOURCES

Other sources: WWTPs, biosolids, landfills



Considerations

- PFAS occur in industrially- and municpally- sourced waste streams
- Target PFAS will vary based on waste received

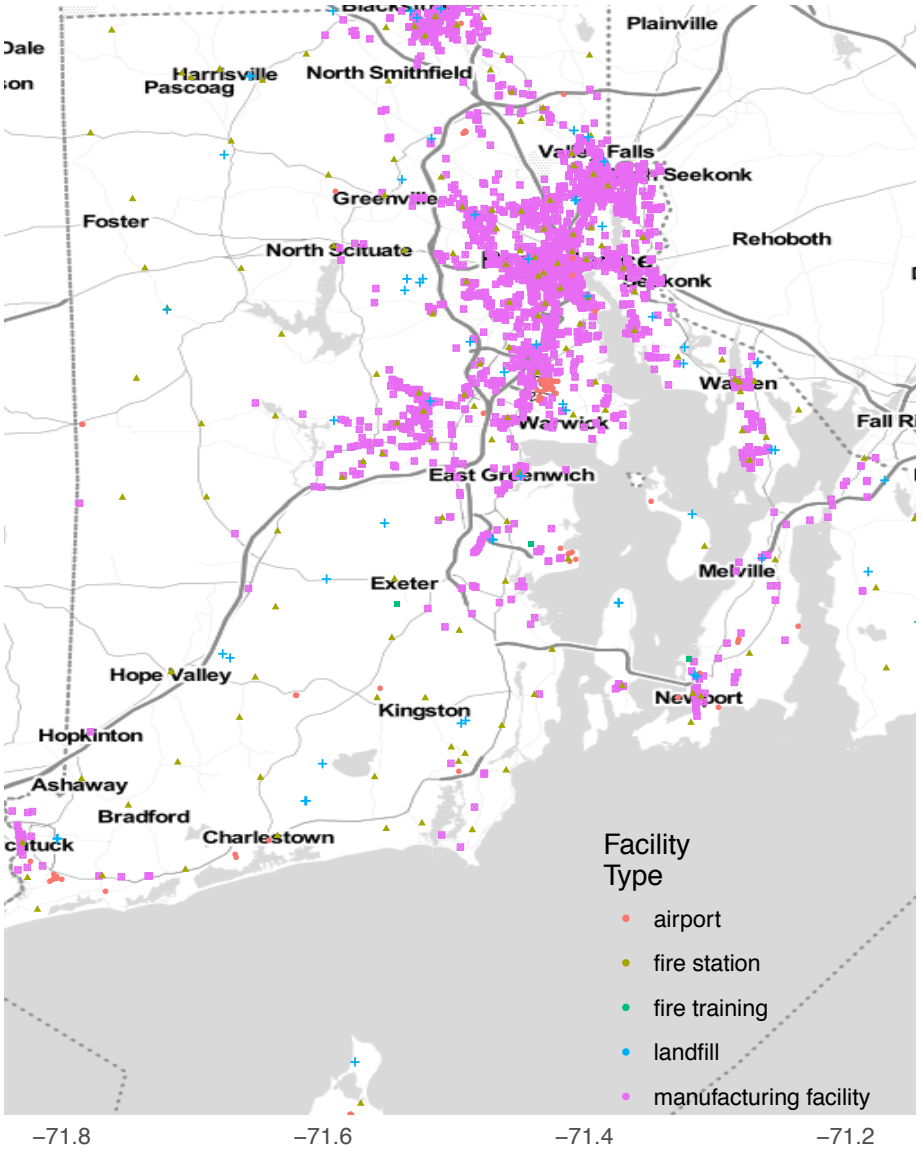
PFAS USES & SOURCES

Other sources: WWTPs, biosolids, landfills

19. Benskin, Jonathan P., et al. "Per-and polyfluoroalkyl substances in landfill leachate: patterns, time trends, and sources." *Environmental science & technology* 46.21 (2012): 11532-11540.
20. Huset, Carin A., et al. "Quantitative determination of fluorochemicals in municipal landfill leachates." *Chemosphere* 82.10 (2011): 1380-1386.
21. Loganathan, Bommanna G., et al. "Perfluoroalkyl sulfonates and perfluorocarboxylates in two wastewater treatment facilities in Kentucky and Georgia." *Water Research* 41.20 (2007): 4611-4620.
22. Schultz, Melissa M., et al. "Fluorochemical mass flows in a municipal wastewater treatment facility." *Environmental science & technology* 40.23 (2006): 7350.
23. Yoo, Hoon, et al. "Analysis of perfluorinated chemicals in sludge: Method development and initial results." *Journal of Chromatography A* 1216.45 (2009): 7831-7839.
24. Sepulvado, Jennifer G., et al. "Occurrence and fate of perfluorochemicals in soil following the land application of municipal biosolids." *Environmental science & technology* 45.19 (2011): 8106-8112.

PFAS USES & SOURCES

Potential PFAS sources, RI



Future work and resources:

- Framework for geospatial ID of potential PFAS source zones (Brown)
  - NIEHS webinar (6/17): https://www.niehs.nih.gov/research/supported/centers/srp/events/riskelearning/analytical/index.cfm
- PFAS Fact Sheets (ITRC)
  - History & Use (8/17)
  - Nomenclature (8/17)
  - Regulatory Summary (8/17)
  - Fate & Transport (12/17)
  - Site Characterization (12/17)
  - Remediation (12/17)
  - *Reviewed by*: EPA, DOD, DOE, industry, stakeholder, academic


9
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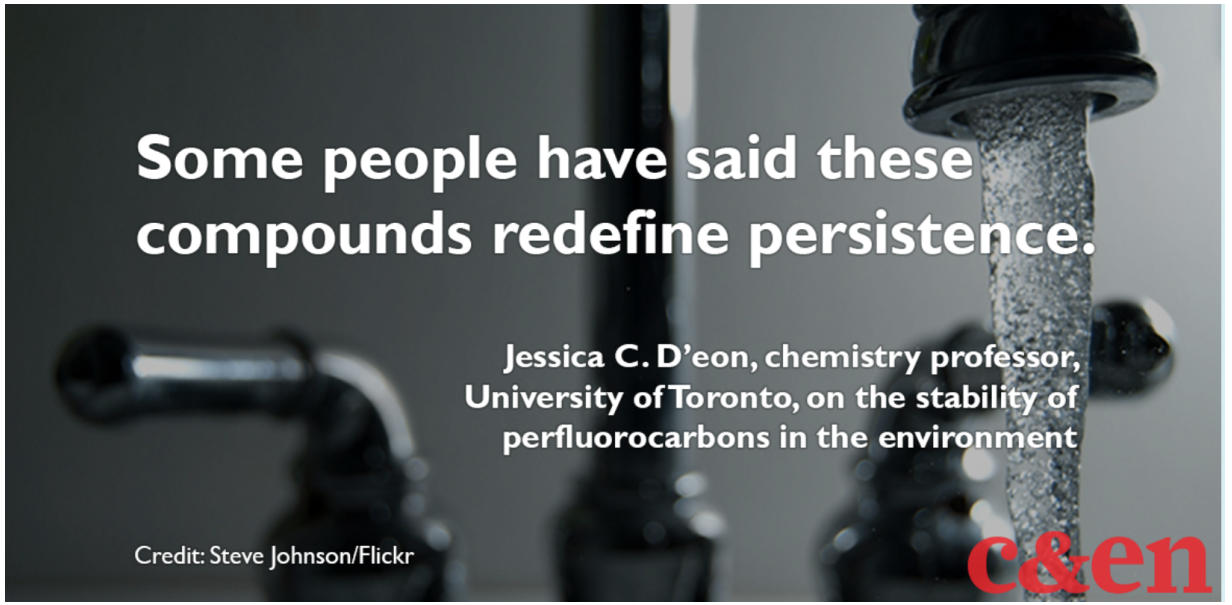
18.9984032
Fluorine


Some people have said these compounds redefine persistence.
Jessica C. D'eon, chemistry professor, University of Toronto, on the stability of perfluorocarbons in the environment
Credit: Steve Johnson/Flickr
c&en

Questions?

ADDITIONAL STATE BY STATE INFORMATION

Connecticut

For now, PFASs should be treated as an Additional Polluting Substance (APS) under CT's Remediation Standard Regulations (RSRs), using EPA's RfD of 0.00002 mg/kg/day for calculations.
Recommended criteria to be applied at remediation sites:
Applies to **∑ PFOA, PFOS, PFNA, PFHxS, and PFHpA**

Residential Direct Exposure Criteria (DEC, soil)	**1.35 mg/kg**
Industrial/Commercial DEC	**41 mg/kg**
GA Pollutant Mobility Criteria (PMC, soil leaching to GW)	**1.4 µg/kg**
GB Pollutant Mobility Criteria	**14 µg/kg**
Groundwater Protection Criteria	**0.07 µg/L**
Surface Water Protection Criteria (GW discharge to SW)	**Pending**

Note that site specific criteria can also be requested under the RSRs.

New Hampshire

- Does your state have standards or guidelines for soil or other media? If so, please answer the same set of Qs, as applicable

Direct contact soil screening levels – 500 ppb for PFOA, 500 ppb for PFOS. Similar recommended analyte list and lab method.

ADDITIONAL STATE BY STATE INFORMATION

New York

Part 597 - Hazardous Substances Identification, Release Prohibition, and Release Reporting - effective March 3, 2017. The amendments under this rule making finalized the (1) addition of perfluorooctanoic acid (PFOA-acid), ammonium perfluorooctanoate (PFOA-salt), perfluorooctane sulfonic acid (PFOS-acid), and perfluorooctane sulfonate (PFOS-salt) to the list of hazardous substances at 6 NYCRR Section 597.3; (2) allowance for continued use of firefighting foam that may contain PFOA-acid, PFOA-salt, PFOS-acid or PFOS-salt to fight fires (but not for training or any other purposes) on or before April 25, 2017 even if such use may result in the release of a reportable quantity (RQ), which is otherwise prohibited; and (3) correction to the list of hazardous substances by providing units for RQs.

More info: **http://www.dec.ny.gov/regulations/104968.html**

Vermont

For soil, the Vermont direct contact standard is 300 ug/kg combined PFOA/PFOS. Since EPA has no standard protocol for this analysis, labs have been using an Modified form of 537 (EPA doesn't like this nomenclature). Number of compounds analyzed for varies from 12 to 22 compounds, but Vermont only has a standard for combined PFOA/PFOS.

ADDITIONAL STATE BY STATE INFORMATION

Maine:

Information on screening levels in various media:
https://www1.maine.gov/dep/ftp/RAGS-Background-Documents/PFC_ScreeninigLevels_060514.pdf