Alternative Fluorochemistries to PFOS, PFOA & other PFAS with Known Human Health Risks

May 10, 2018

FluoroCouncil
Global Industry Council
for FluoroTechnology

Overview

- About FluoroCouncil
- History of PFAS Manufacturing and Transition to Modern PFAS Products
- PFAS Uses
- Best Practices and Product Stewardship
- Questions/Discussion

About FluoroCouncil

About FluoroCouncil

Represents the world's leading manufacturers of FluoroTechnology products

- Archroma Management LLC
- Arkema France
- Asahi Glass Co., Ltd.
- Daikin Industries, Ltd.
- Solvay Specialty Polymers
- The Chemours Company LLC
- Dynax (associate)
- Tyco Fire Products LP (associate)

Our Focus:

- Support end use market access to the unique and critical benefits of FluoroTechnology
- Work with regulators to facilitate global transition from long-chain substances (e.g., PFOA) to more sustainable alternatives
- Support science- and risk-based regulatory outcomes that facilitate this transition

History of PFAS Manufacturing and Transition to Modern PFAS Products

Overall Transition to Today's PFAS Products

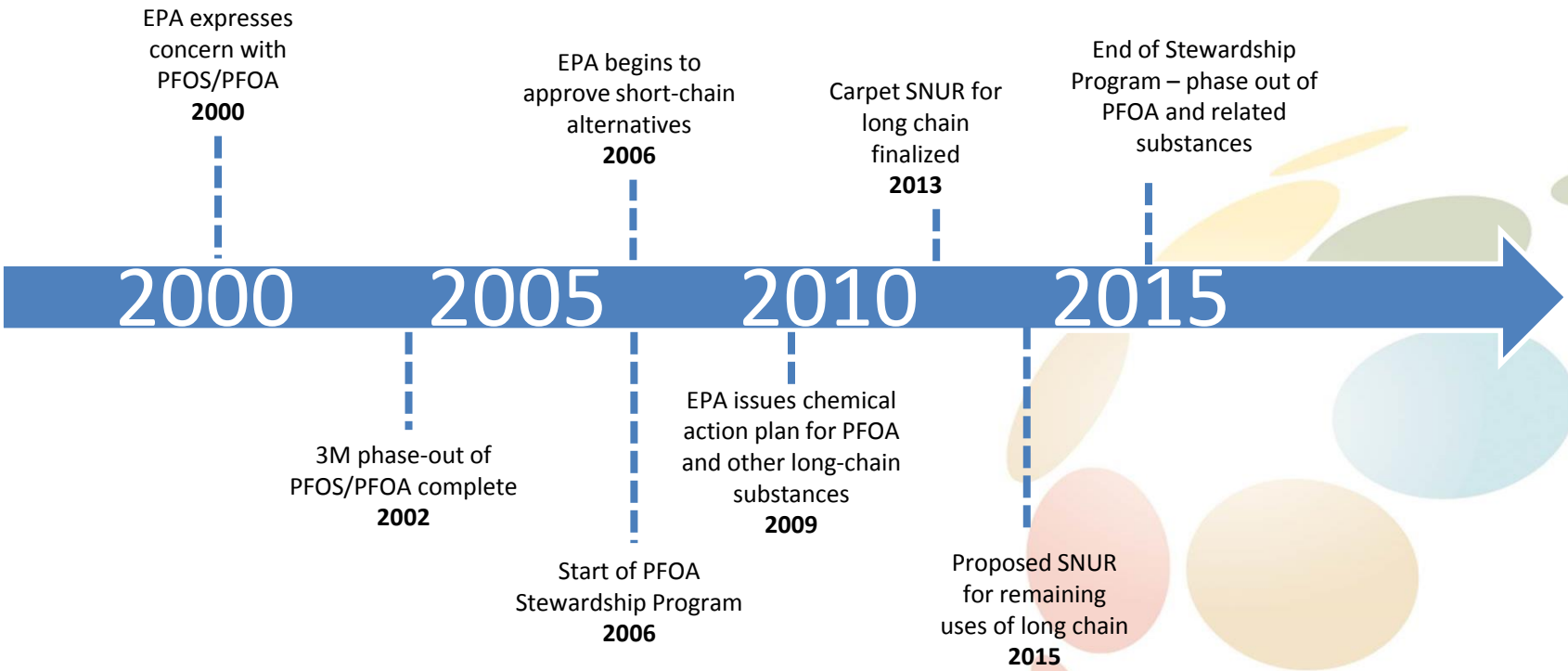
Shift in Fluoropolymer Polymerization Aids

PFOA/Long-Chain Polymerization Aids → Today's Polymerization Aids (a variety of solutions)

Shift in Fluorotelomer-based Products Manufactured

Long-chain Fluorotelomer-based Products → **Short-chain** FluoroTelomer-based Products

U.S. Long-chain PFAS History Highlights



Phase-out of PFOS

- 3M/EPA announced phase-out plan in May 2000
  - 3M U.S. production of PFOS stopped at end of 2002
- EPA issued TSCA Significant New Use Rules (SNUR) to lock in 3M commitment to phase-out
  - Rules issued in 2002 and 2007 (271 chemicals)
  - Rules did not cover PFOS in imported articles
- Proposed rule (2015) issued to cover PFOS in carpets
  - Gap in coverage for other articles will remain

PFOS: Shifts in Global Market Profile

- Est. global historic emissions (1970 – 2002)*:
  - Raw Material: PFOSF ($F\text{-}C_8F_{16}\text{-}SO_2F$): 6,800t – 42,250t
  - PFOS ($F\text{-}C_8F_{16}\text{-}SO_3^-$) : 450t – 2,700t
- 2003: PFOSF and PFOS production ceased in the U.S.
- 2006: PFOSF production in China** increased to 250t/a
- Today:
  - PFOSF and PFOS production continues outside the U.S.
  - PFOS contains >10% PFOA, ~10% PFHxS, and other short-chain PFSAs and PFCAs as impurities***
  - Potential use of stockpiled PFOS-based firefighting foams

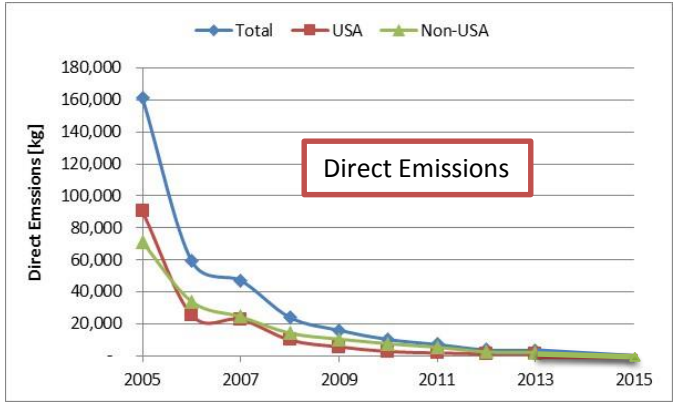
*Paul et al., Environ. Sci. Technol. 2009, **43**, 386-292

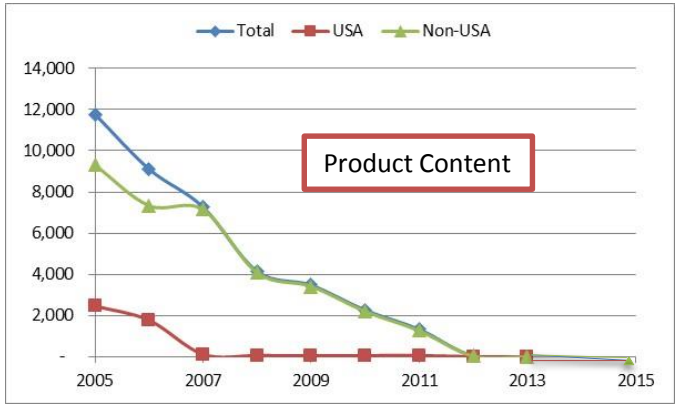
** W. Han, 2009. PFOS Related Actions in China. International Workshop on Managing Perfluorinated Chemicals and Transitioning to Safer Alternatives, p. 12-13 and Xie et al., Environ. Int. 2013, 52, 1-8

*** Jiang et al., Chemosphere 2015, **127**, 180-187

While FluoroCouncil members have never manufactured, sold or used PFOS, this public information is provided for historical context.

EPA 2010/2015 PFOA Stewardship Program





- Global and voluntary partnership between U.S. EPA and industry aimed to reduce human and environmental exposure to PFOA, its precursors and higher homologues
  - ✓ **All companies met the goal in 2015 or earlier:** https://www.epa.gov/sites/production/files/2017-02/documents/2016_pfoa_stewardship_summary_table_0.pdf
  - ✓ **Led to virtual elimination of those chemicals from facility emissions to all media and product content**
- Similar program in place with Canada
- Participating companies:
  - Archroma
  - Asahi Glass Company
  - DuPont/Chemours
  - BASF Corporation
  - Arkema Inc.
  - Daikin America, Inc.
  - Solvay Solexis, Inc.
  - 3M/Dyneon
- https://www.epa.gov/assessing-and-managing-chemicals-under-tsca/risk-management-and-polyfluoroalkyl-substances-pfass#tab-3
- Baseline = Year 2000 or other

U.S. EPA New Chemicals Program – Alternative Products

- Industry submitted PMNs for alternatives
- EPA issued TSCA Section 5(e) Orders
  - For fluorotelomers, focus on common degradant (PFHxA)
    - Testing allocated among PMN submitters to assure comprehensive picture
    - For example: testing for cancer, reproductive/developmental, systemic toxicity, bioretention, ecological endpoints, environmental fate and transport
- Alternative products approved for manufacture, sale and use
- Data generated during this process established the value of transitioning from long-chain to short-chain chemistry

Status of PFAS of Concern

- **Through the EPA PFOA Stewardship Program, PFOA and related "long chain" PFASs have been voluntarily phased out by major manufacturers in the U.S., Europe, and Japan**
  - PFOA no longer used as processing aid in manufacture of fluoroplastics
  - Long-chain fluorotelomer-based products replaced with short-chains

- EPA plan to back up this stewardship with regulation did not occur
  - Proposed EPA SNUR is limited and would not stop import of components made with PFOA

- Manufacture and use of PFOA and long-chain fluorotelomer-based products continues in China/India/Russia under **no existing regulation**

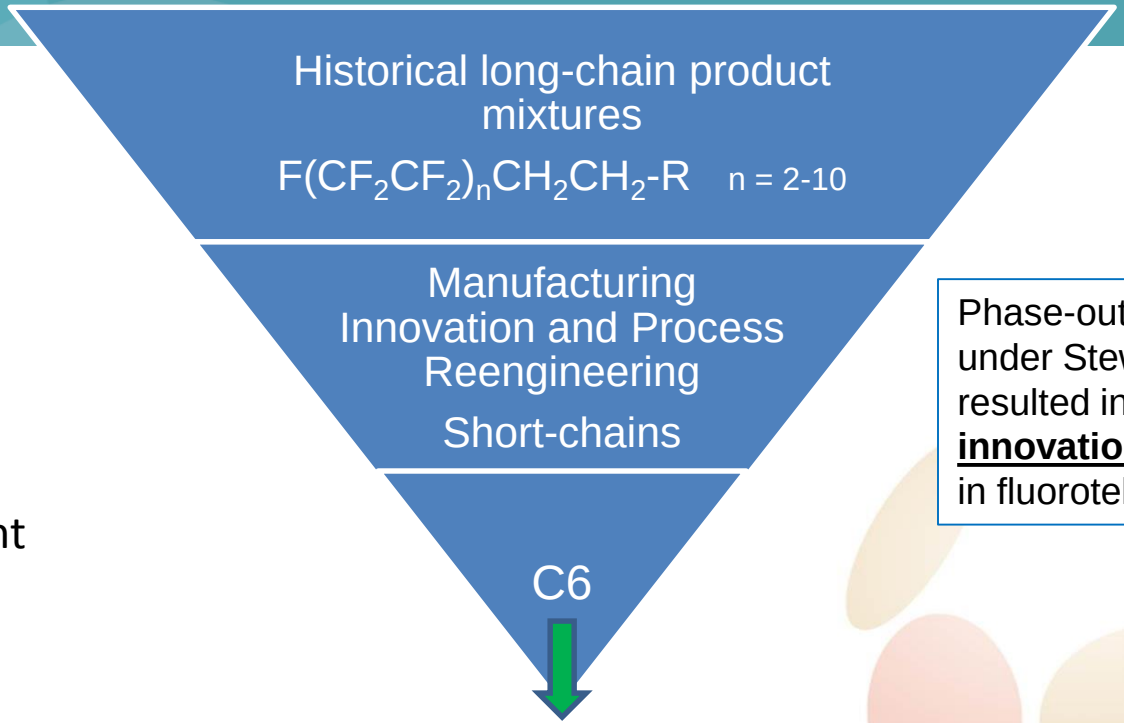
- Import of PFOA in consumer articles is currently permitted in the U.S.

Fluorotelomer Manufacturing: Shift to Short-Chains

1970s - 2015

2002 - 2015

2005 - Present



Phase-out of long-chain PFAS under Stewardship Program resulted in significant **innovation** and **simplification** in fluorotelomer manufacturing

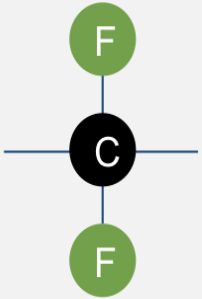
Transition to Alternatives

- Replacing long-chain substances has been a major challenge:
  - → Over $700M invested and ten+ years of research into the development of alternatives
  - → Investigated a large universe of options: “short-chain” alternatives represent the most feasible and sustainable of those options.
- Replacement products reflect a careful balance.
  - → Meet or approximate performance and current products and manufacturing standards of long-chain technology
  - → Extensive toxicological and environmental testing data have been generated
  - → Are approved/registered for use in key countries/regions around the world
- Lack of other options that meet all these criteria.
  - → Non-fluorinated alternatives have not always met criteria for performance set by downstream industries
  - → Lack of human health and environmental data about many non-fluorinated materials

PFAS Uses

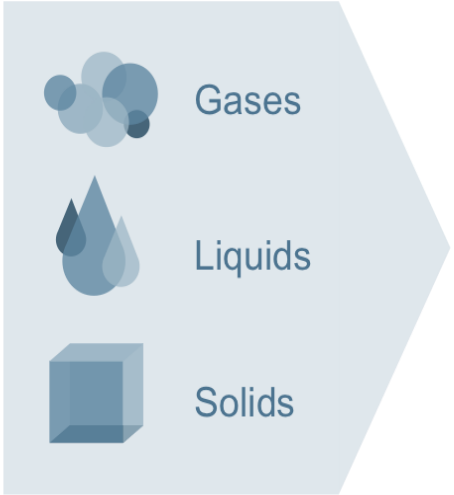
Overview: PFAS includes thousands of substances with *very different* properties

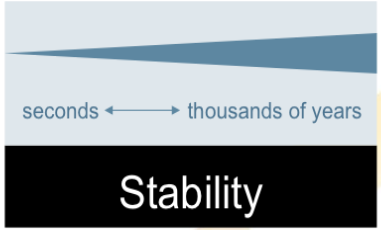
Similarities

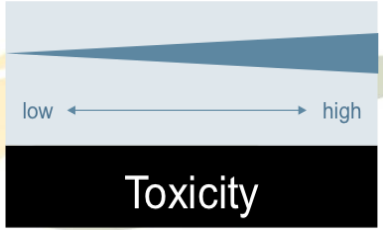


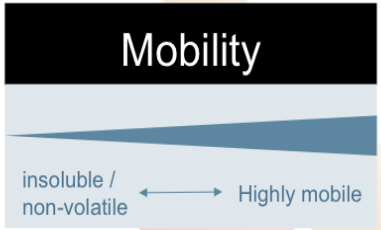
1 fully fluorinated carbon

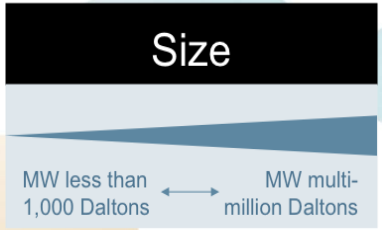
Differences





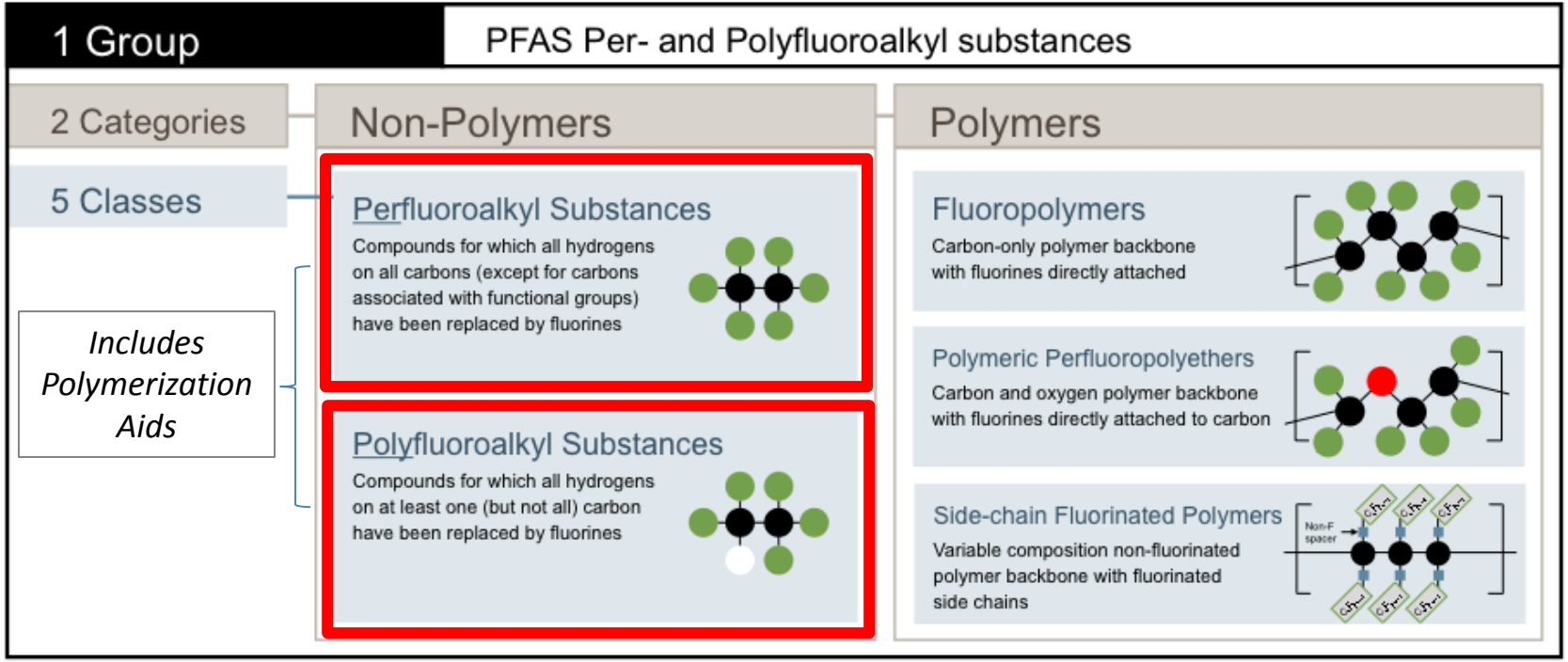






PFAS - Categories and Classes: Polymerization Aids

Fluorine
Carbon
Oxygen
Hydrogen



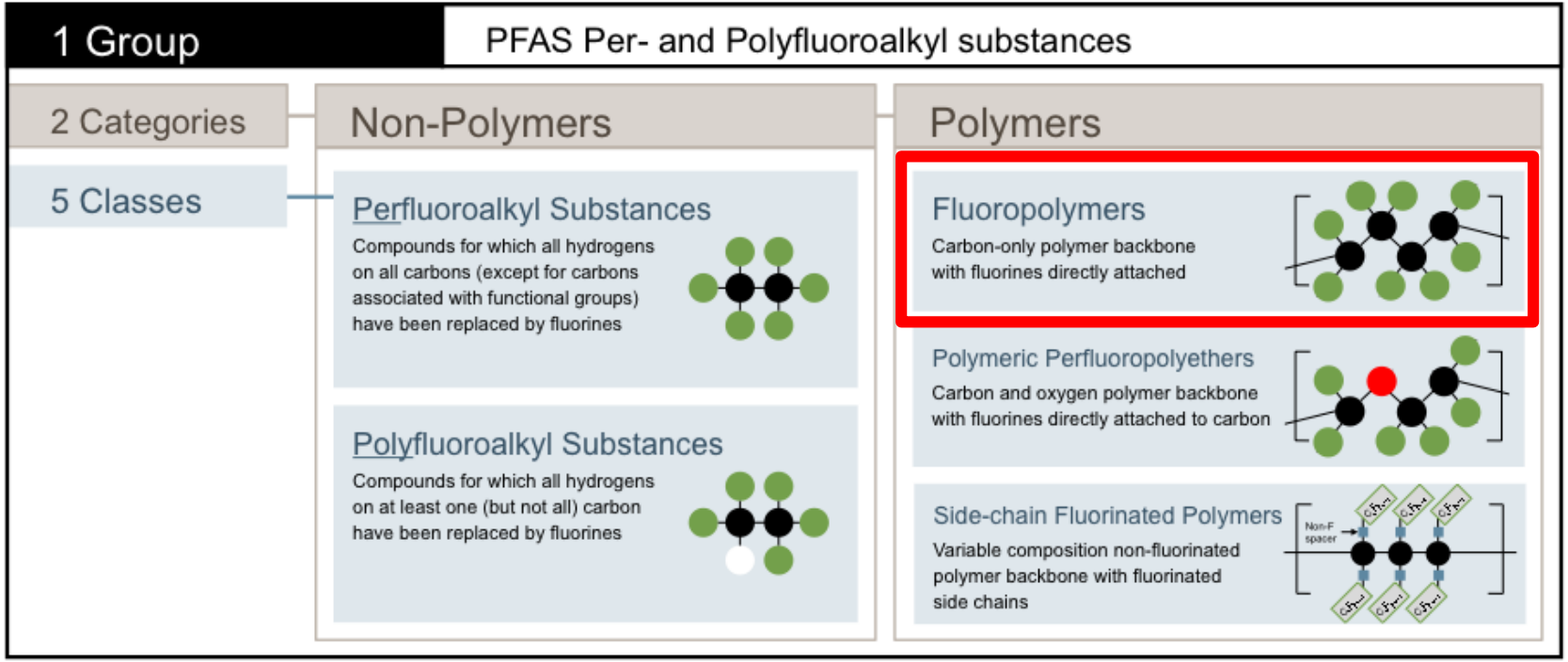
Perfluoroalkyl and polyfluoroalkyl substances in the environment: Terminology, classification, and origins.
Integrated Environmental Assessment and Management **2011,** *7*, (4), 513-541.
http://dx.doi.org/10.1002/ieam.258

Polymerization Aids Used in the U.S. Today

- Have been reviewed by EPA's new chemicals program,
  - Subject to administrative orders under TSCA Section 5(e)
  - Supported by health and safety data
- Working to develop and implement a polymerization aid stewardship program
  - Minimizing emissions
  - Reducing product content (in fluoropolymer products)

PFAS - Categories and Classes: Fluoropolymers

Fluorine
Carbon
Oxygen
Hydrogen



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About Fluoropolymers

- High molecular weight polymers
  - e.g., PTFE, ETFE, PVDF, FEP, fluoroelastomers (FKM)
- Too large to be bioavailable: 0.5-1MM MW
  - Not toxic, Not bioaccumulative
- Highly stable under all types of environmental conditions
  - Therefore cannot break down to PFAS of concern
- Do not present a significant risk to human health or the environment

Fluoropolymers - Key Properties

Durability

Inertness

Mechanical strength

Thermal stability

Resistance to degradation

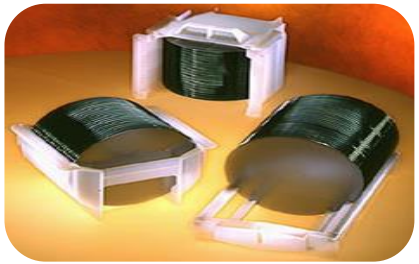
Example Fluoropolymer Applications

Electronics: High frequency signal transmission; smudge-resistant touch screens

Membranes in outdoor apparel, providing a breathable barrier against wind and rain

Medical Devices: High dielectric insulators in medical equipment that relies on high frequency signals

Aerospace/Auto: Weight reducing fuel lines; heat/chemical resistant wire coatings

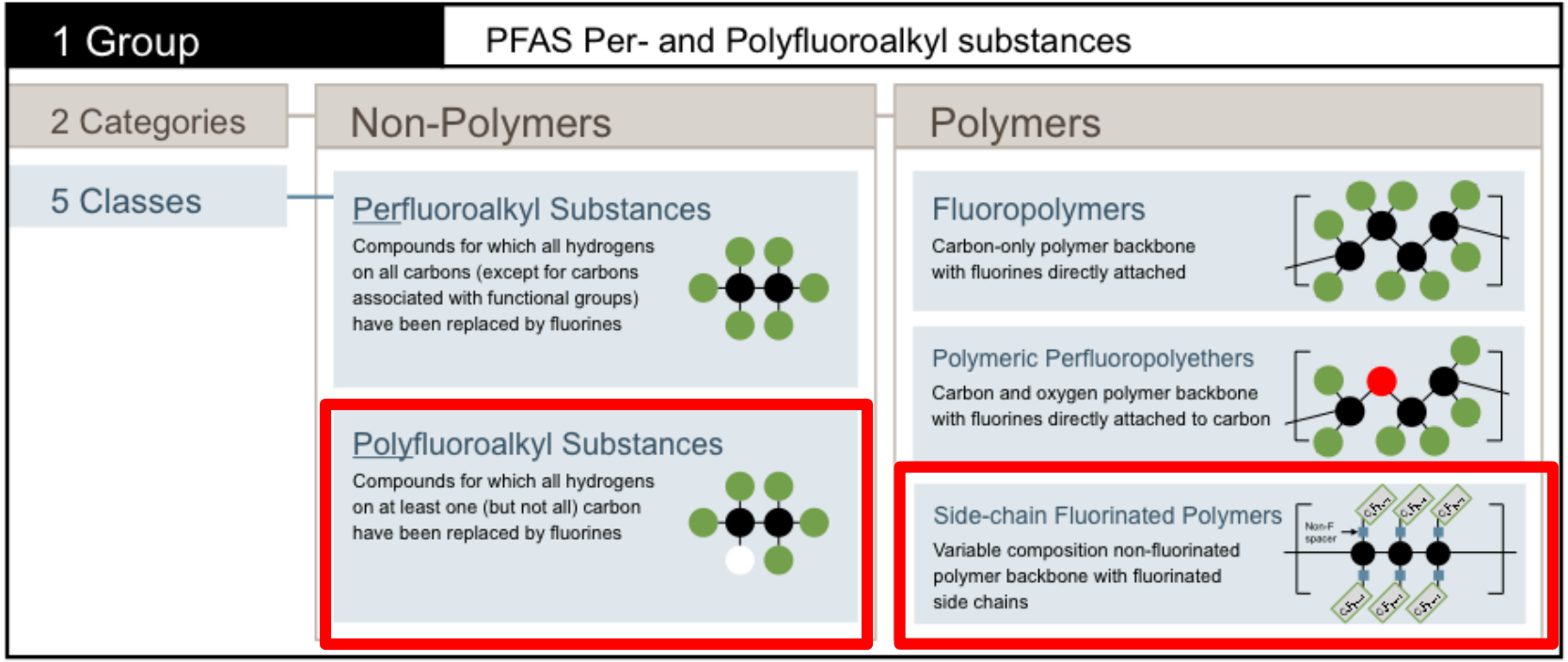


Semiconductor manufacturing: Providing pure environments to transport/store harsh chemicals

Nonstick surfaces in cookware and small appliances

PFAS - Categories and Classes: Fluorotelomer-based Substances

Fluorine
Carbon
Oxygen
Hydrogen



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Fluorotelomer-based Products: Short-chain PFAS

- Chemistry:
  - C6 fluorinated chains attached to organic polymer backbones (e.g., side-chain fluorinated polymers).
  - For polymers with C6 fluorinated side-chains, any degradation is likely to take a very long time (i.e., 1,000+ years). Recently completed 15-month OECD 307 aerobic soil study* on this type of polymer reported:
    - "The study revealed a very low potential for aerobic biological transformation processes of the test item."
    - The calculated half-lives ($t_{1/2}$) of the polymer were between 3,000 to 5,500 years depending on soil type
- Hazard Profile of Polymeric Products:
  - Widely understood not to present toxicity concerns
  - Not bioavailable
  - Hazard is characterized by their degradation products (example: PFHxA)
- Properties:
  - Polymers: Surface modification & protection, water & oil repellency, grease resistance as well as soil resistance and release
  - Surfactants: Wetting and leveling

* Nuva RP2116 GA 39/13-1 - Aerobic Transformation in Soil study conducted under OECD 307 by Noack Laboratory GmbH (November 1, 2017). Submitted to U.S. EPA by Archroma U.S. Inc. on November 11, 2017.

Example Fluorotelomer-based Product Applications

Healthcare: Garments/Drapes that Protect Against Disease Transmission

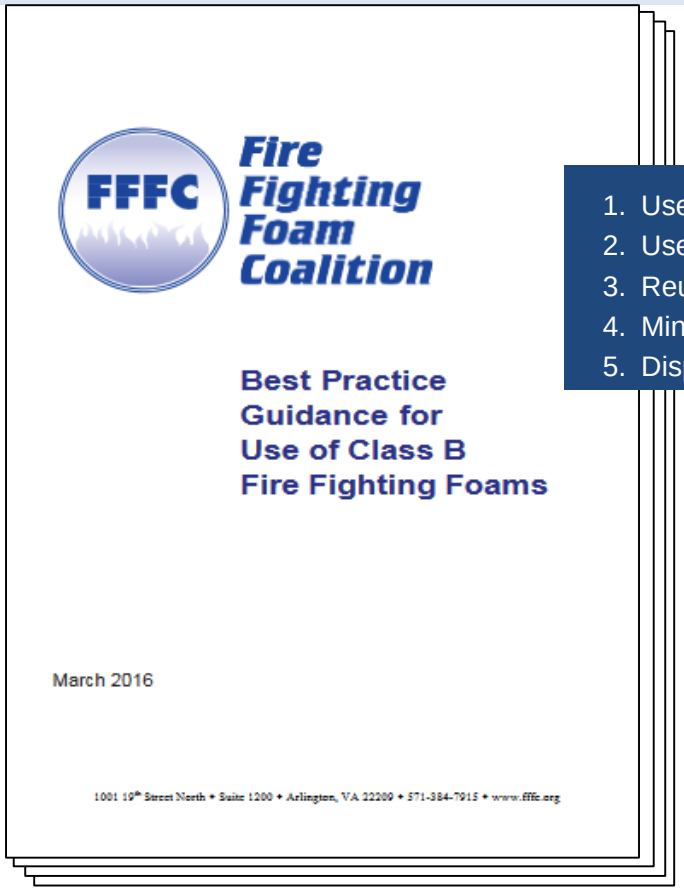
First Responder Gear Treatments and Bulletproof Vests that Maintain Performance in Extreme Conditions

Oil/Grease Resistant Food Packaging that is Recyclable, Increases Shelf-Life, Reduces Packaging

Textiles/Carpet with Water/Oil Repellency, Stain Resistance and Soil Release and Longer Useful Life

Class B (Flammable Liquid) Fire Fighting Foam with Shorter Extinguishing Time and Burnback Resistance

Industry Best Practices - Reduces Environmental Release and Potential For Exposure



1. Use the product only when necessary
2. Use only what you need
3. Reuse/recycle residual liquids if possible
4. Minimize waste and emissions
5. Dispose of all chemicals properly

Links: https://fluorocouncil.com/PDFs/Guidance-for-Best-Environmental-Practices-BEP-for-the-Global-Apparel-Industry.pdf
https://fluorocouncil.com/PDFs/Best-Practice-Guide-for-Use-of-Class-B-Fire-Fighting-Foams-PDF.pdf

Thank You

Please contact Jessica Bowman of FluoroCouncil for further information at jessica_bowman@fluorocouncil.org or 202-249-6737 or visit https://fluorocouncil.org/

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