

An Introduction to the Essential Use Concept and its Application to PFAS

Ian T. Cousins

**CHE EDC Strategies Partnership
Webinar,
January 13th, 2021**

What are PFAS?

- Perfluoroalkyl and polyfluoroalkyl substances
- Buck et al. (2011) first definition
- OECD: broader definition will be published in 2021
 - “...any chemical with at least a perfluorinated methyl group ($-CF_3$) or a perfluorinated methylene group ($-CF_2-$)...”
- Many thousands (9252?) of **structurally diverse PFAS** in use in society
 - polymers & non-polymers; neutral, anionic, cationic & zwitterionic; solids, liquids & gases; reactive & inert; soluble & insoluble; volatile & involatile; mobile & immobile; and bioaccumulative & non-bioaccumulative; toxic and relatively non-toxic

Common features of PFAS that make them so useful

- Major characteristics of perfluoroalkyl moieties:
 - **high chemical and thermal stability** due to the strength of C-F bond
 - **hydrophobic** and **oleophobic** nature
- Especially useful as:
 - **Fluorosurfactants**
 - can lower the surface tension of water to 16 mN/m (half that compared to hydrocarbon surfactants)
 - **Surface protectors**
 - very low surface energies compared to hydrocarbon-based or silicone polymers, simultaneous water and oil/stain repellence

Uses of PFAS?

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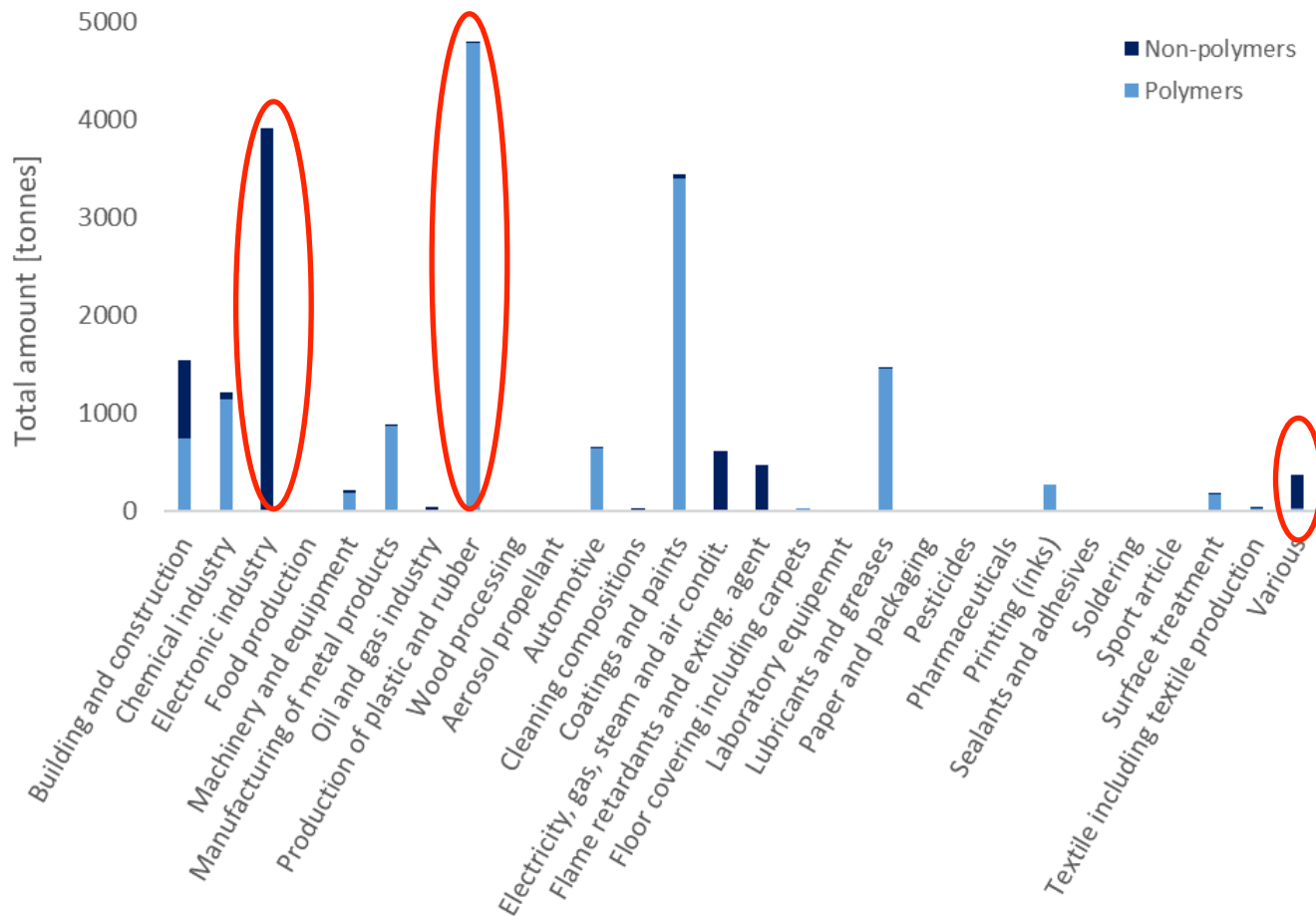
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An overview of the uses of per- and polyfluoroalkyl substances (PFAS)[†]

Cite this: *Environ. Sci.: Processes Impacts*, 2020, 22, 2345

Juliane Glüge,^a Martin Scheringer,^a Ian T. Cousins,^b Jamie C. DeWitt,^c Gretta Goldenman,^d Dorte Herzke,^e Rainer Lohmann,^g Carla A. Ng,^h Xenia Trier^a and Zhanyun Wang^a



- More than 200 uses identified for more than 1400 PFAS
- Less well known uses:
 - ammunition,
 - climbing ropes,
 - guitar strings,
 - artificial turf,
 - soil remediation

Madrid Statement

Perspectives | Brief Communication

The Madrid Statement on Poly- and Perfluoroalkyl Substances (PFASs)

May 2015

<http://dx.doi.org/10.1289/ehp.1509934>

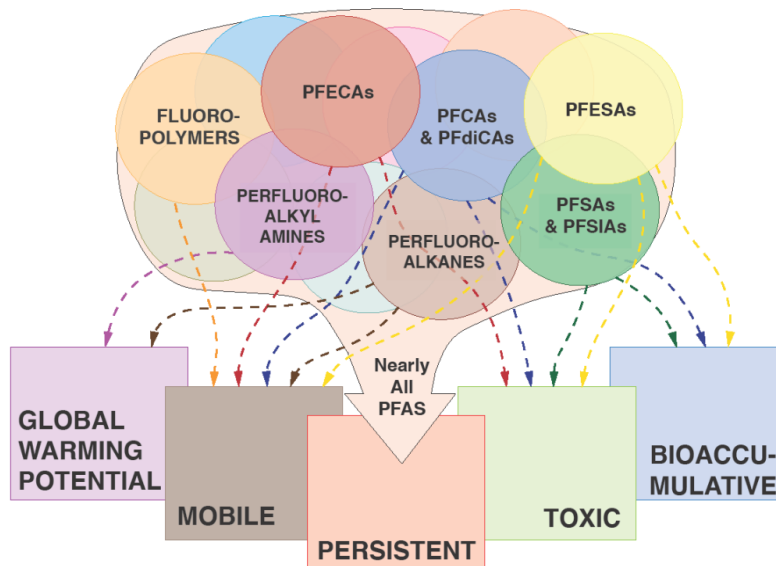
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- Production and use of PFAS should be limited
- Based on concerns regarding high persistence and lack of knowledge on chemical structures, properties, uses, and toxicological profiles

Are all PFAS of concern?

- **All PFAS are highly persistent** (EU REACH)
 - they are either non-degradable or transform ultimately into stable terminal transformation products
- Continual release of high P chemicals results in increasing levels and increasing probabilities of known and unknown effects. Exposure poorly reversible

PFAS Structural Sub-classes:



Potential Classification Options:

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Cite this: Environ. Sci.: Processes Impacts, 2019, 21, 781

Why is high persistence alone a major cause of concern?

Ian T. Cousins, ^a Carla A. Ng, ^b Zhanyun Wang ^c and Martin Scheringer ^{c,d}

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Cite this: Environ. Sci.: Processes Impacts, 2020, 22, 2307

The high persistence of PFAS is sufficient for their management as a chemical class

Ian T. Cousins, ^a Jamie C. DeWitt, ^b Juliane Glüge, ^c Greta Goldenman, ^d Dorte Herzke, ^{ef} Rainer Lohmann, ^g Carla A. Ng, ^h Martin Scheringer ^c and Zhanyun Wang

Phasing out uses of PFAS

- Impractical to ban all uses of PFAS in one step
 - Some applications may serve a critical role for which alternatives currently do not exist
 - However, if some uses of PFAS are found **not** to be **essential**, they could be eliminated without having to first find functional alternatives
- Montreal Protocol on Substances that Deplete the Ozone Layer
 - Introduced concept of essential uses or essentiality

Essentiality of PFAS?

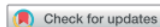
- To critically evaluate the idea that uses of PFAS are essential in modern society, the essentiality of PFAS should be carefully tested against the available evidence for each of their uses
- Given the thousands of PFAS on the market and their many uses, this is a formidable task
- Adapt the definition of essentiality from the Montreal Protocol

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CRITICAL REVIEW

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Cite this: *Environ. Sci.: Processes Impacts*, 2019, 21, 1803

The concept of essential use for determining when uses of PFASs can be phased out

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Defining essentiality

Category	Definition	PFAS examples
1 “Non-essential”	Uses that are not essential for health and safety, and the functioning of society. The use of substances is driven primarily by market opportunity.	Dental floss, water repellent surfer shorts, ski waxes
2 “Substitutable”	Uses that have come to be regarded as essential by society because they perform important functions, but where alternatives to the substances have now been developed that have equivalent functionality and adequate performance, which makes those uses of the substances no longer essential.	Most uses of AFFFs, certain water-resistant textiles.
3 “Essential”	Uses considered essential by society because they are necessary for health or safety or other highly important purposes <i>and</i> for which alternatives are not yet established.*	Certain medical devices, occupational protective clothing.

* This essentiality should not be considered permanent; rather, a constant pressure is needed to search for alternatives in order to move these uses into Category 2 above.

Application of Essentiality: 4 case studies

Cosmetics

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Cite this: Environ. Sci.: Processes
Impacts, 2018, 20, 1680

Per- and polyfluoroalkyl substances and fluorine mass balance in cosmetic products from the Swedish market: implications for environmental emissions and human exposure†

Lara Schultes,^{a*} Robin Vestergren,^{ab} Kristina Volkova,^c Emelie Westberg,^{cd} Therese Jacobson^e and Jonathan P. Benskin^{ef*}



- PFAS found in hair products, mascara, foundations, face creams, sun blocks, skin creams, lip pencils
 - Technical function?
 - Potential human exposure (dermal/oral)
- Several major retailers/brands (L'Oréal, H&M, Lumene, The Body Shop, Isadora and Kicks) rapidly announced phase outs of PFAS
- Difficult to substitute 1:1, new formula needed
- Technical function of PFAS not essential:

Category 1

Ski waxes

- Fluorinated waxes are favored by competitive skiers
- Waxes contain fluorinated alkanes, but also perfluoroalkyl carboxylates, including PFOA
- Functional alternatives have always been available. Non-essential, **Category 1**

Fluorvallor används i dag brett inom skidsporten men även av motionärer som söker snabbaste skidan från Sälen till Mora i fädrens spår. Baksidan är att farliga kemikalier sprids i miljön. Det är hög tid att förbjuda fluorvallorna och att tänka nytt och göra rätt vid substitution och riskbedömning av kemikalier, skriver fyra forskare.



FIS BANS SOME SKI WAXES

6TH DECEMBER 2019

LAST MODIFIED ON FEBRUARY 19TH, 2020

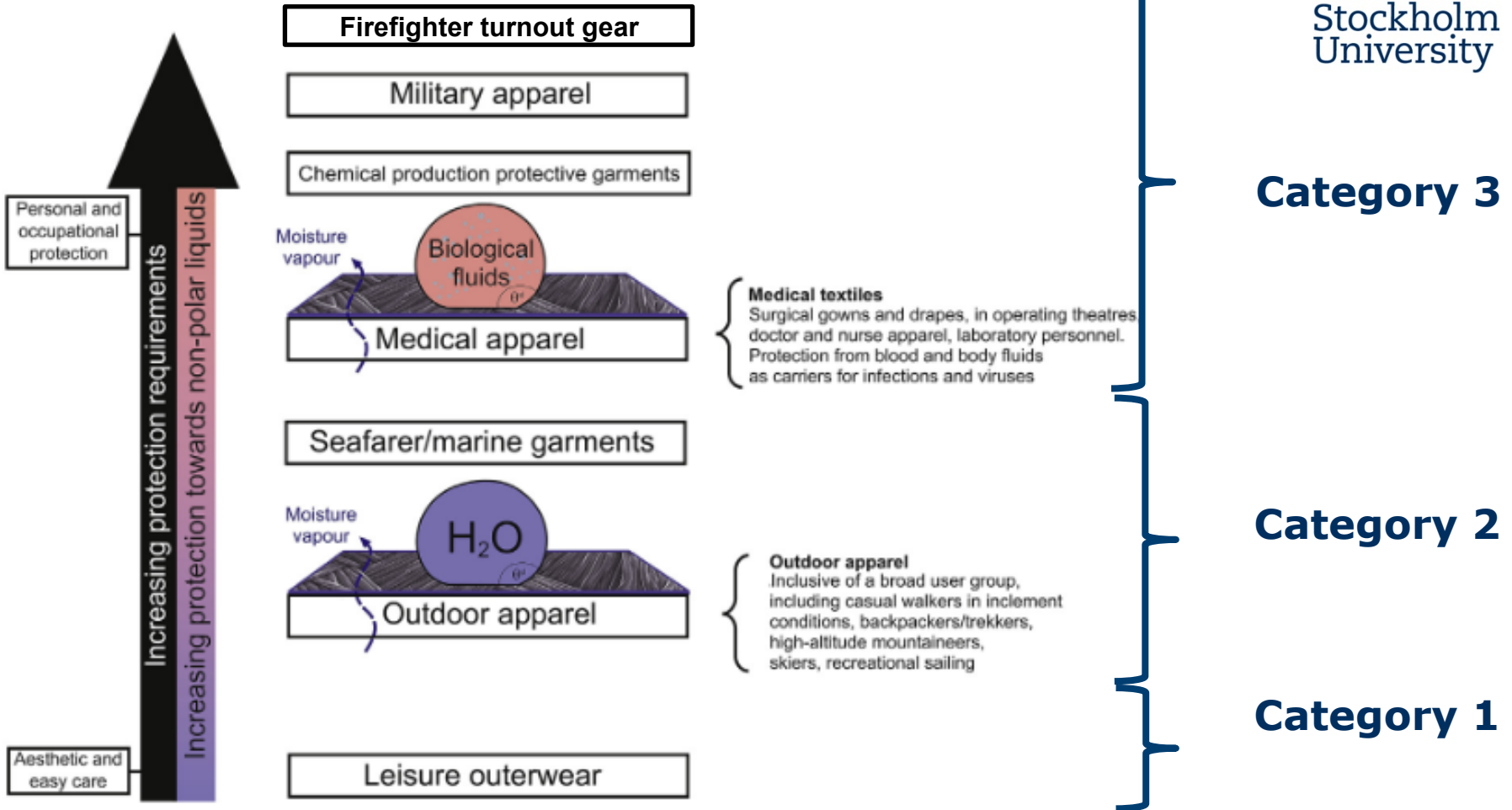
Fluorinated ski wax will not be able to be used by racers next season due to its impact on the environment and health.

AFFFs

- Extinguishing class B fuel fires
- Irreversible contamination of groundwater
- Fluorine-free class B foams (3F) available since early 2000s
 - meet the standard firefighting performance certifications
 - many commercial airports have phased out AFFFs
- Still some debate if AFFFs needed for certain scenarios
 - Grey zone between **Categories 2 and 3**



Textiles



Journal of Cleaner Production 217 (2019) 134–143

Contents lists available at ScienceDirect

Journal of Cleaner Production

ELSEVIER

journal homepage: www.elsevier.com/locate/jclepro



Highly fluorinated chemicals in functional textiles can be replaced by re-evaluating liquid repellency and end-user requirements

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More examples

Use	Table 1 Category*
Personal care products including cosmetics	1
Ski waxes	1
Fire-fighting foams (commercial airports)	2
Fire-fighting foams (military)	2 or 3
Apparel (medical: long operations)	3
Apparel (protective clothing oil and gas industry)	3
Apparel (medical: short operations, everyday)	2
Apparel (military: occupational protection)	2 or 3
Waterproof jacket (general use)	2
Easy care clothing	1
Food contact materials (paper and board)	1
Food production equipment (fluoropolymers)	1, 2 or 3
Medical devices (fluoropolymers)	1, 2 or 3
Pharmaceuticals	2 or 3
Laboratory supplies, equipment and instrumentation	1, 2 or 3
Perfluorosulfonic membranes in fuel cells	2
Perfluorosulfonic membranes in chlor-alkali process	3

*Note that the categories in the above table represent the current evaluation and may change in the future.

Conclusions/way forward

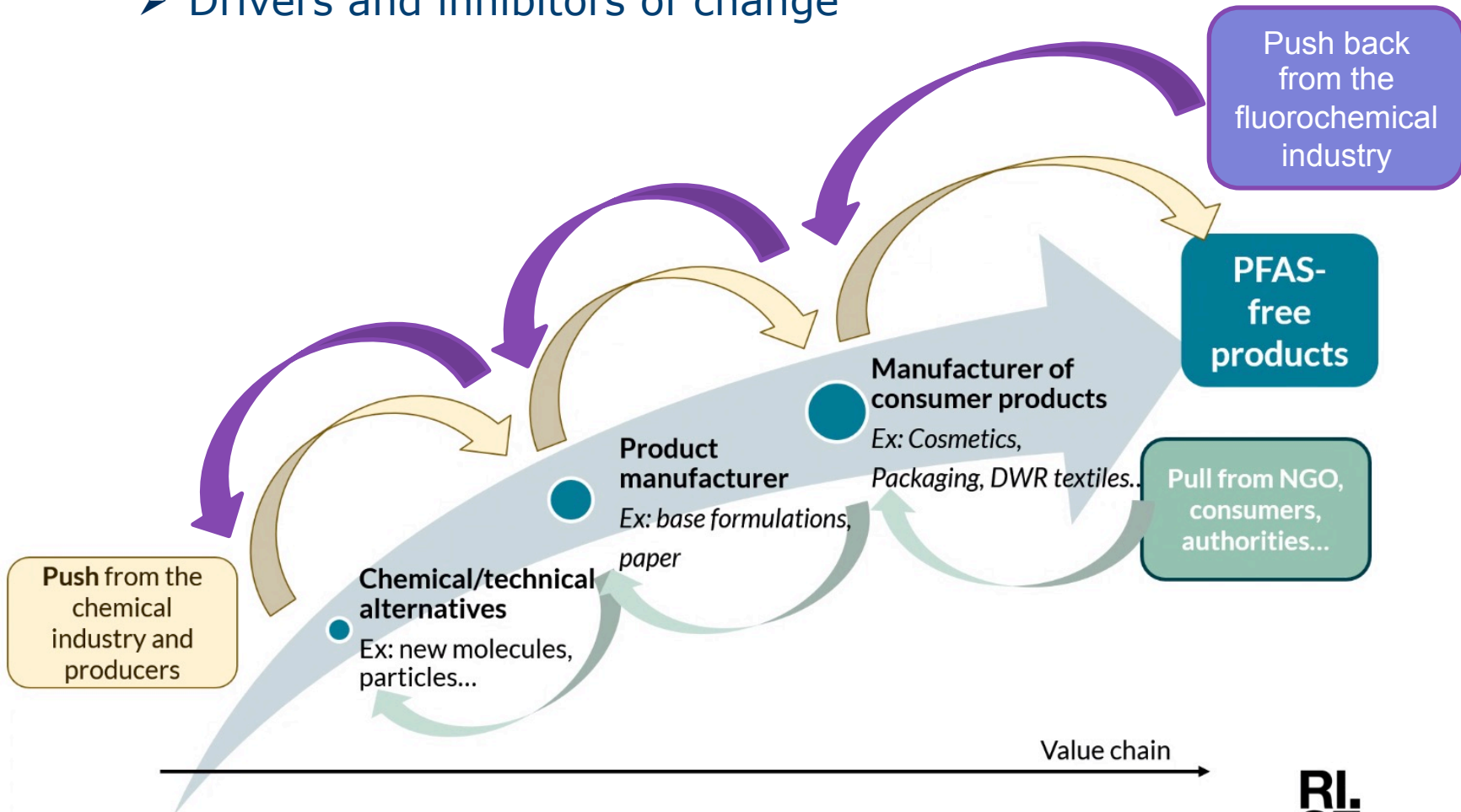
- Essential use concept can guide the phase-out of PFAS
 - Focus on category 1 (non-essential uses)
- Category 2 (substitutable uses) of PFAS
 - avoid regrettable solutions: chemical alternatives assessment (CAA)
 - US EPA's **Design for the Environment (DfE)**, Clean Production Action's **GreenScreen** and McDonough Braungart Design Chemistry **Cradle to Cradle™**
- Even when PFAS are considered category 3 (essential uses):
 - innovation should be encouraged to find safer alternatives

International Success Stories

- Banning of PFAS in paper and board used in food contact materials in Denmark
- Banning of fluorinated ski waxes in international competition
- Transition to Class B fluorine-free foams around the world
- Phasing out of PFAS in cosmetics by multiple retailers
- Fluorine-free durable water repellent outdoor equipment
- > 200 uses: The work is far from done!

Systemic Change Underway

- PFAS under global pressure
- Drivers and inhibitors of change



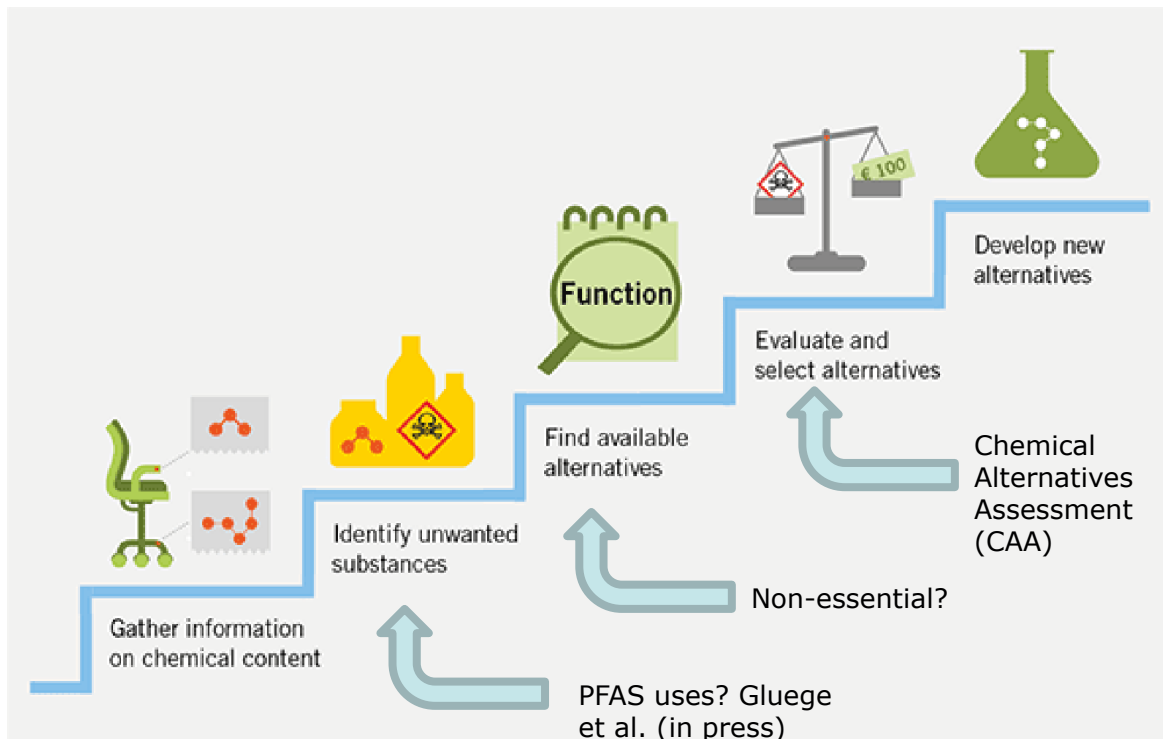
Thank you for your attention!

Acknowledgements

- This work has been undertaken by the scientists collaborating as the Global PFAS Science Panel.
- We would like to thank the Tides Foundation for supporting our cooperation.
- This does not necessarily reflect the opinion or the policies of the German Environment Agency or the European Environment Agency.

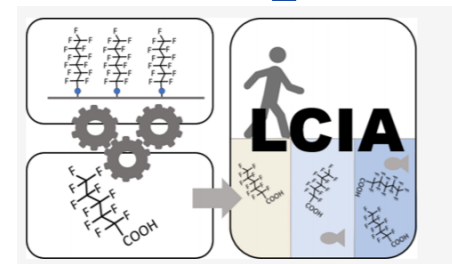


Chemical Substitution Model



An (Eco)Toxicity Life Cycle Impact Assessment Framework for Per-And Polyfluoroalkyl Substances

Hanna Holmquist,* Peter Fantke, Ian T. Cousins, Mikolaj Owsianiak, Ioannis Liagkouridis, and Gregory M. Peters



Welcome to the Swedish Centre for Chemical Substitution



Ongoing in the European Union

- Authorities of Denmark, Germany, Netherlands, Norway and Sweden are preparing a REACH restriction proposal for a wide range of PFAS
 - Unclear which PFAS included
 - Derogations granted according to essentiality
- Interested parties were invited to send in evidence and information on the use of PFAS by 31 July 2020
 - Glüge et al. was a key piece of evidence



PERSISTENT POLLUTANTS

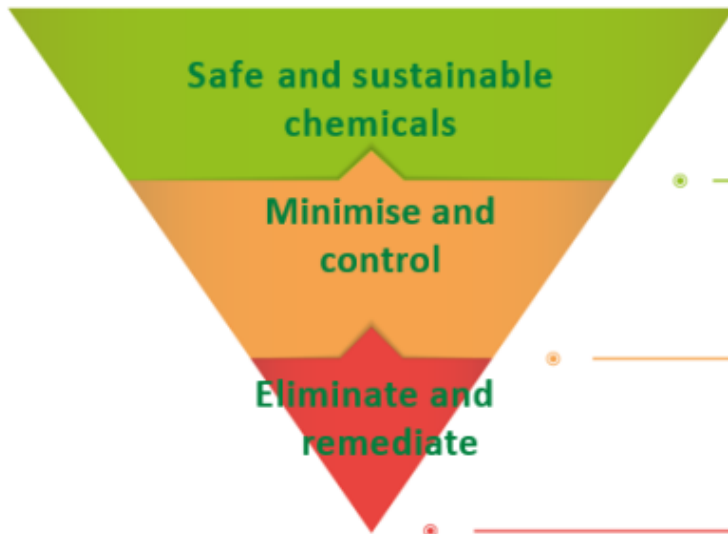
PFAS restriction plan developing in EU

by *Cheryl Hogue*

MAY 16, 2020 | APPEARED IN **VOLUME 98, ISSUE 19**

EU Chemicals Strategy, Oct. 2020

- “Essential use” concept incorporated
 - concept can speed up phase outs of non-essential uses of multiple classes of hazardous substances



Discussion points

- Scope of essentiality concept?
- Practical application
 - Criteria too vague? Essential for society?
 - Who decides?
 - Essential uses not essential chemicals or products!
- Lack of knowledge of uses of PFAS
- Chemical Alternative Assessment
 - Paralysis by analysis?
 - Who does it and how?