PFAS – Emission along lifecycle of DWR treated work wear

Christina Jönsson, Stefan Posner, Sandra Roos,
Anne-Charlotte Hanning, Philip Gillgard (Swerea IVF)
Greg Peters, Hanna Holmquist (Chalmers)
Steffen Schellenberger, Ian Cousins (SU – Stockholm University)
Ike van der Veen, Jana Weiss, Pim Leonards (VU – University Amsterdam)

Contact person Christina Jönsson

Christina.jonsson@swerea.se

SUPFES - Substitution of prioritized poly- and perfluorinated substances to eliminate diffuse sources

SUPFES

SUBSTITUTION IN PRACTICE ©

HAGLÖFS

IVM

VU

Institute for Environmental Studies

CHALMERS

AVANCEZ 1829

KÄPPALA

swerea IVF

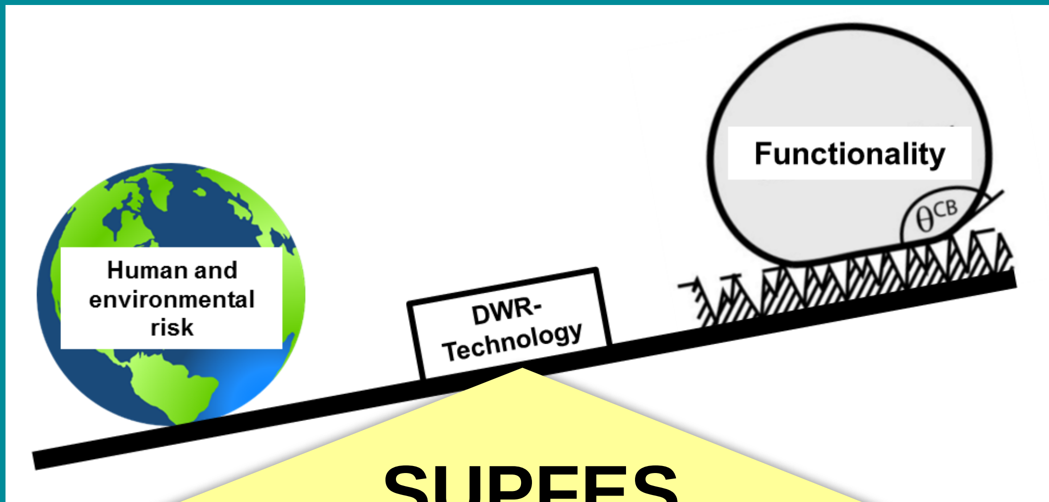
UNIVERSITET STOCKHOLMS

Stockholm University

Swerea IVF is coordinator

Project duration until 2017

Project budget: 1,85 M€



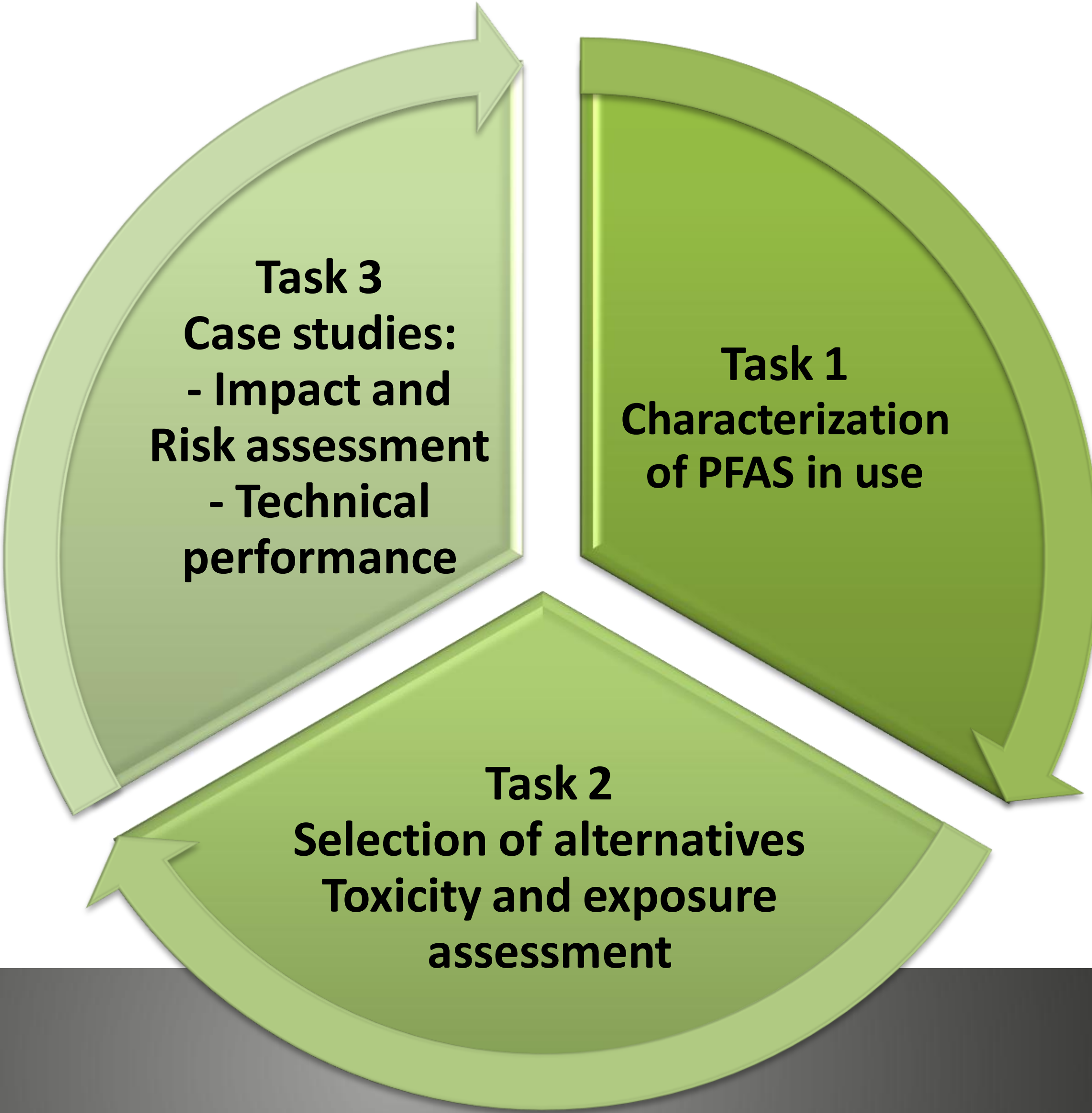
SUPFES

Swerea IVF Textile Research	VU University Amsterdam	Stockholm University	Chalmers University
Performance Testing LCA, LCC	Chemical Screening & Leaching Studies	Hazard Assessment: Measure & Model	Risk & Life Cycle Assessment (LCA)

SUPFES' objective:
Characterize the physical performance and assess the risks of alternative Durable Water Repellent (DWR) chemistries for textiles

A unique consortium of scientific and industrial partners with strong stakeholder involvement

SUPFES approach – substitution in practice



Life cycle perspective

Production | Use | End of life

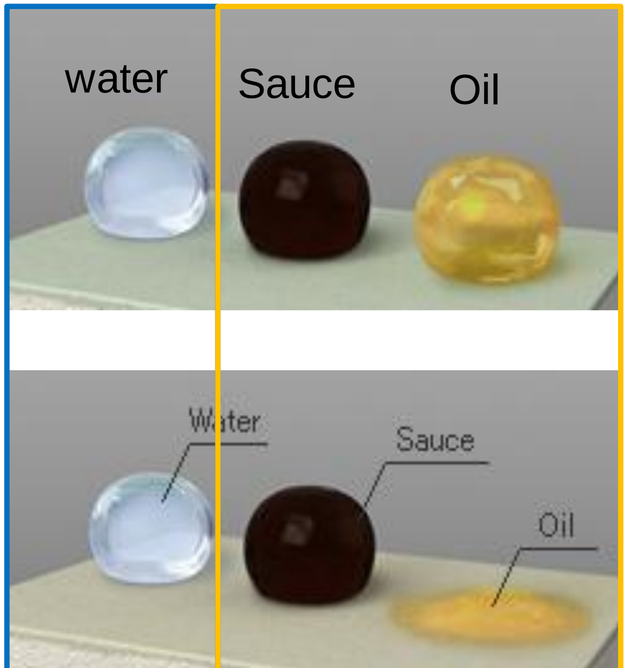
Site emissions | **Diffuse emissions**

Chemical alternatives assessment in SUPFES

- **Chemical hazard assessment** - inherent hazard properties
- **Technical/functional assessment** – technical performance test scheme
- **Risk assessment**, hazard assessment in combination with exposure assessment – diffuse emissions via e.g. household waste water
- **Life cycle assessment (LCA)** on four garment types
- **Economic assessment** – Life cycle costing (LCC)

Why do we need water and stain repellency?

Liquids with decreasing polarity



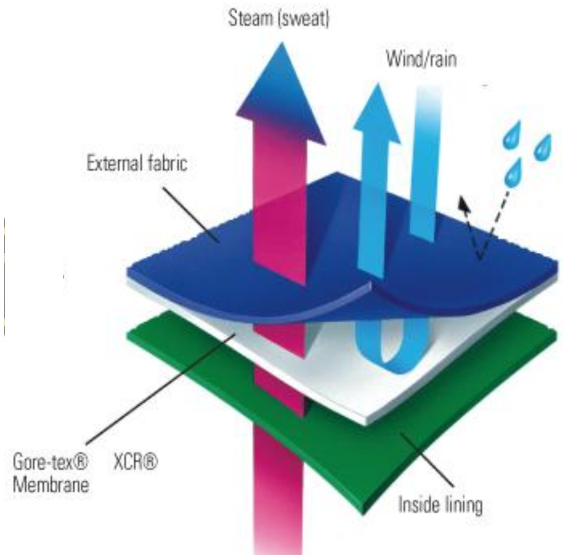
Surveys show that consumers are not well aware of oil repellency

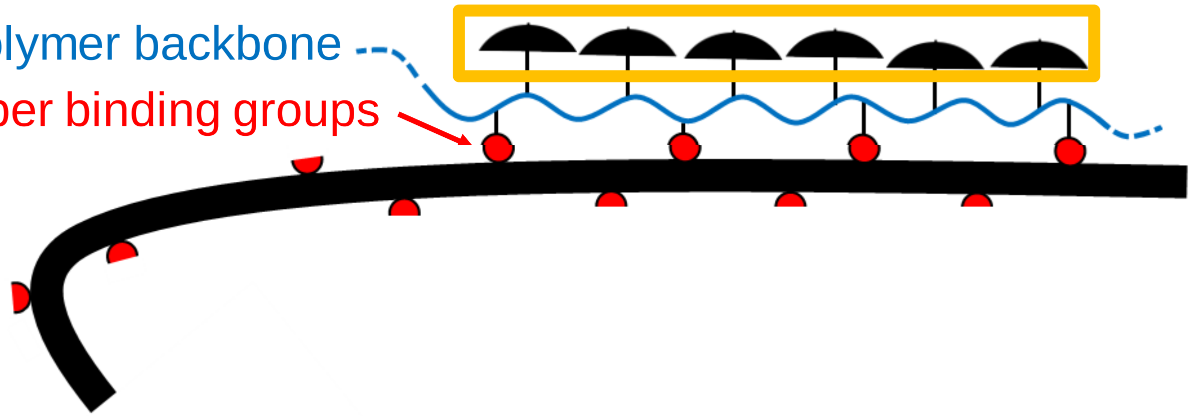
Water repellency is a key requirement in waterproof apparel

Soil/oil/stain repellency also desired property in waterproof apparel and indispensable for protective clothing (e.g. ambulance jacket, military)

What are durable water repellents (DWR)?

Multi-layered outdoor fabric with different functions





- Durable Water Repellency (DWR) is the hydrophobic coating added to the fabric fibers to make them water and oil resistant
- Fabric's ability to withstand the penetration of water and oil cannot ***yet*** be achieved by the fiber materials alone

Case studies

Vitally important
Work wear
Medical application
Chemical production

Performace level

Comfort
Bad weather and leisure clothing

Repellency against blood, acids

Ambulance jacket (work wear)

Outdoor Jacket ("extreme")

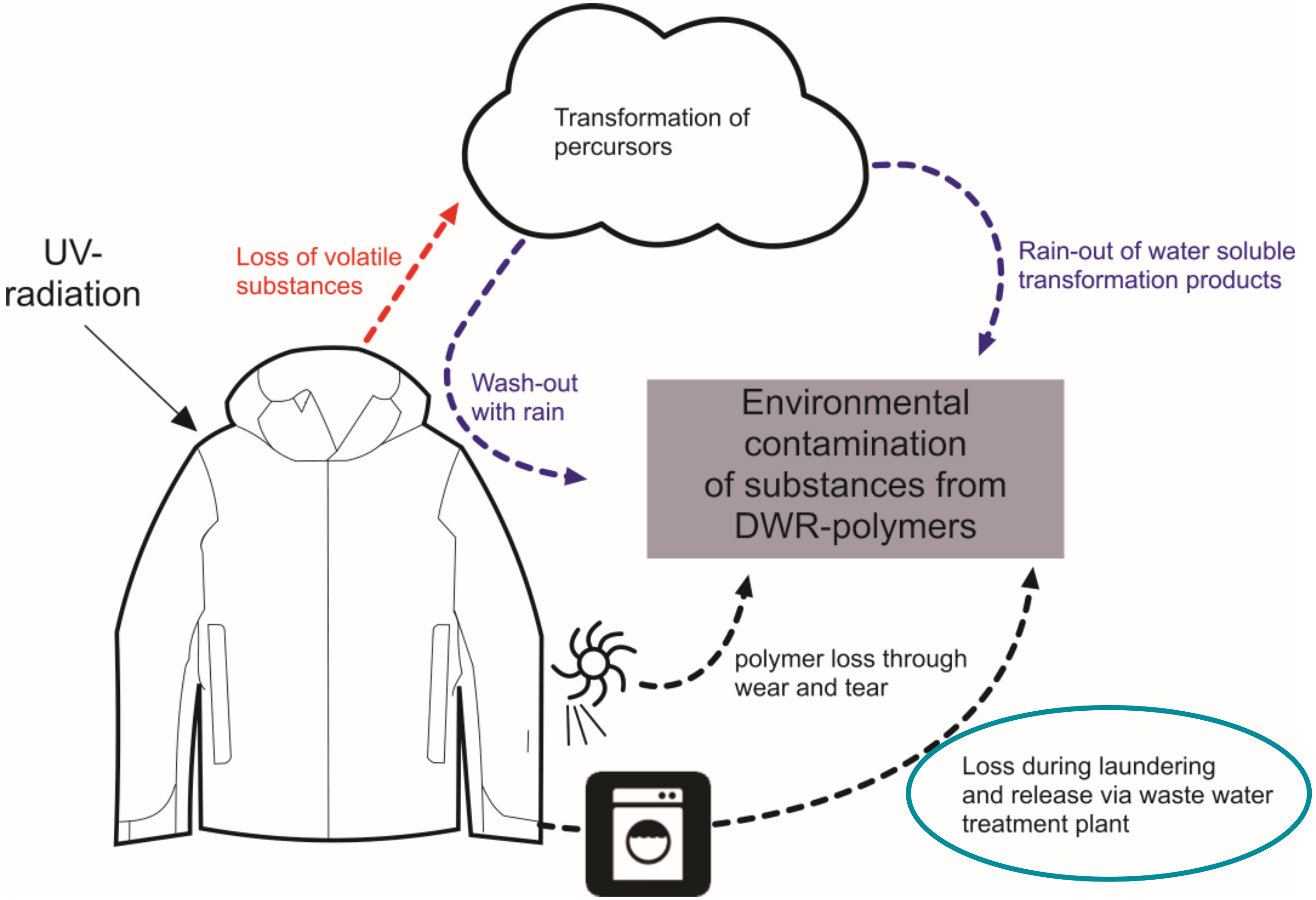
Children's overall

Outdoor Jacket ("leisure")

Water repellency

Specifications
Test methods

Possible mechanisms for loss of chemicals from DWR-treated fabrics



Materials collected and studied

- Commercial jackets, gloves, trousers (n=50) from outdoor and textile industry with DWR
- Alternative compounds applied as DWR to PA and PES (PET) materials
- Textiles analysed for the presence of ionic and neutral PFASs using validated method
    - Extraction of textile (9.8 cm^2)

Talanta 147 (2016) 8–15

Contents lists available at ScienceDirect

Talanta

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

ELSEVIER

Development and validation of a method for the quantification of extractable perfluoroalkyl acids (PFAAs) and perfluorooctane sulfonamide (FOSA) in textiles

Ike van der Veen [a,*], Jana M. Weiss [a], Anne-Charlotte Hanning [b], Jacob de Boer [a], Pim E.G. Leonards [a]

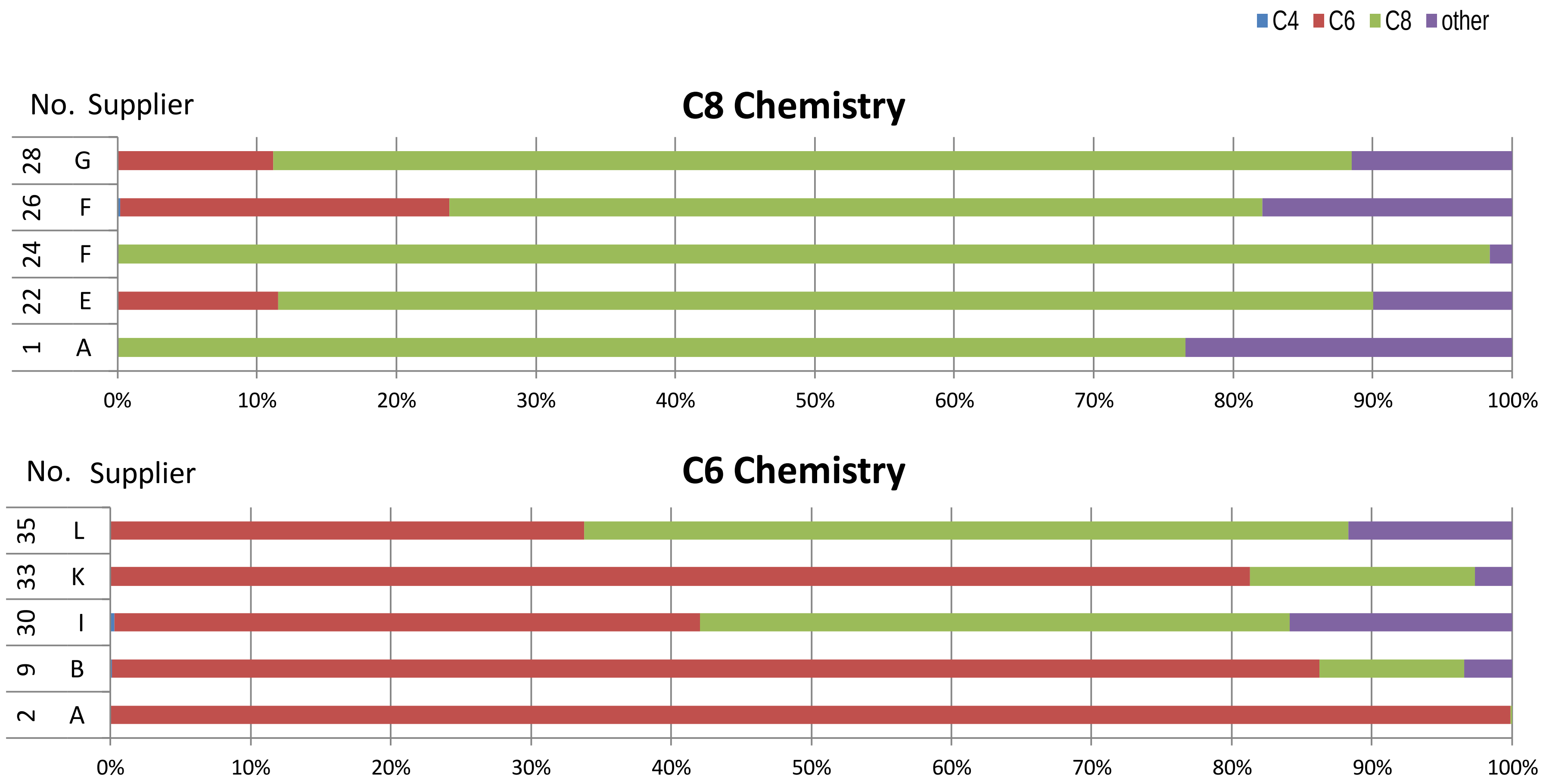
IVM Institute for Environmental Studies

Main PFASs detected in textile samples

- PFBA
  - 47% of samples
  - 0.02-28 µg/m^2 (median 0.17 µg/m^2)
- PFHxA
  - 76% of samples
  - 0.03-6.4 µg/m^2 (median 0.21 µg/m^2)
- PFOA
  - 96% of samples
  - 0.01-5.1 µg/m^2 (median 0.25 µg/m^2)
- PFBS
  - 18% of samples
  - 0.02-42 µg/m^2 (median 0.69 µg/m^2)
- L-PFOS
  - 18% of samples
  - 0.02-3.2 µg/m^2 (median 0.09 µg/m^2)
- 6:2 FTOH*
  - 88% of samples
  - 0.43-360 µg/m^2 (median 24 µg/m^2)
- 8:2 FTOH*
  - 92% of samples
  - 1.5-380 µg/m^2 (median 17 µg/m^2)
- 10:2 FTOH*
  - 90% of samples
  - 0.06-130 µg/m^2 (median 4.1 µg/m^2)
- 8:2 FTAC*
  - 46% of samples
  - 0.29-280 µg/m^2 (median 2.6 µg/m^2)

Ionic PFASs and neutral PFASs are detected in textiles of outdoor clothing at quantifiable concentrations. Neutral PFASs are present at higher concentrations then ionic PFASs.

Patterns of PFASs in textile samples



Weathering test

- Humidity + UV
- 300 hours → lifetime of a jacket
- 9 jacket samples before and after weathering
- 2 “SUPFES” textiles (PA and PES (PET))

Weathering

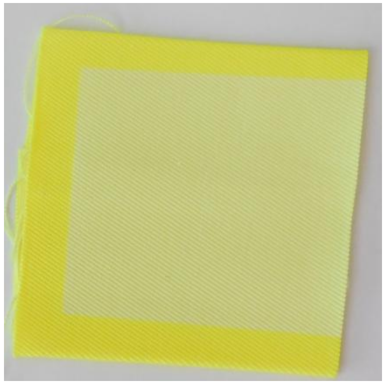
- 2 “SUPFES” textiles (PA and PES (PET)) with each batch were free of ionic PFASs

  → No carry-over of ionic PFASs

Sample 1: Before

Sample 1: After

Sample 25: Before



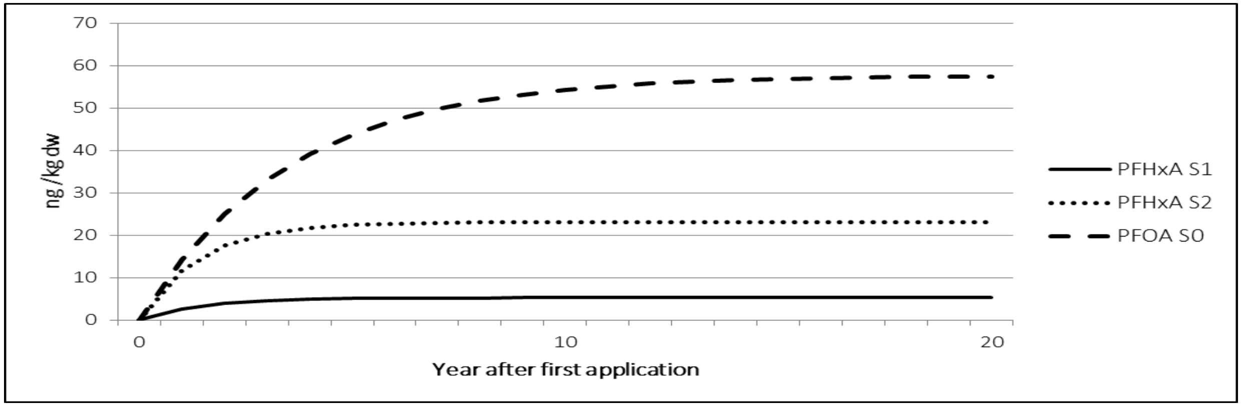
Sample 25: After

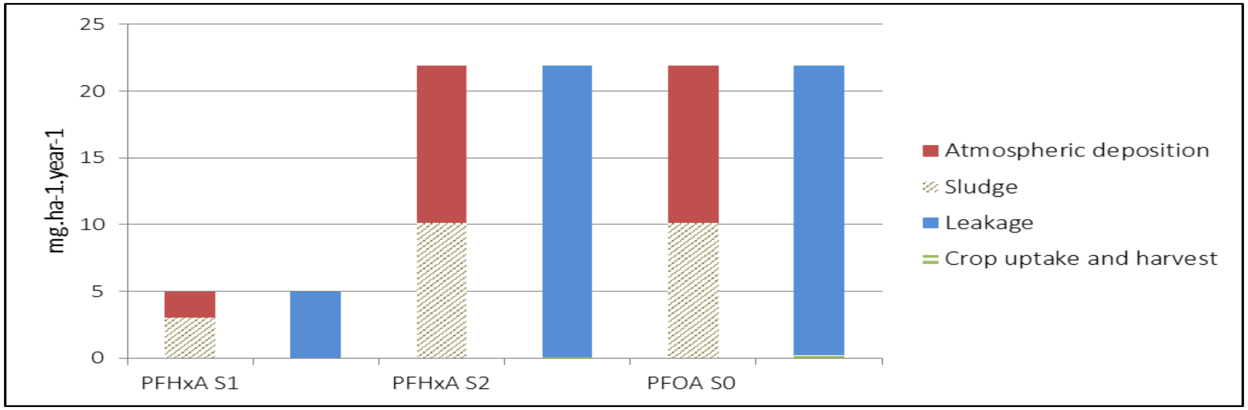
- Preliminary data showed degradation of PFCs

PFAS risks connected to sludge land application

- How will the risks change if diffuse emissions go from C8 (here PFOA) to C6 (here PFHxA)?
- If levels of PFHxA in sludge increase to current levels of PFOA, local risks to human health and the environment will lowered.
- A larger portion of the amount applied to the field will be further dispersed and thus contribute to global contamination.
- Because PFASs are not degraded in the environment by any mechanism, this global dispersion is a long-term environmental concern that requires further scrutiny.
- Continued work within SUPFES will include local risk assessment with data on total organofluorine content, further assessment of textile fibre contribution as well as connection to a life cycle assessment.

PFAS risks connected to sludge land application



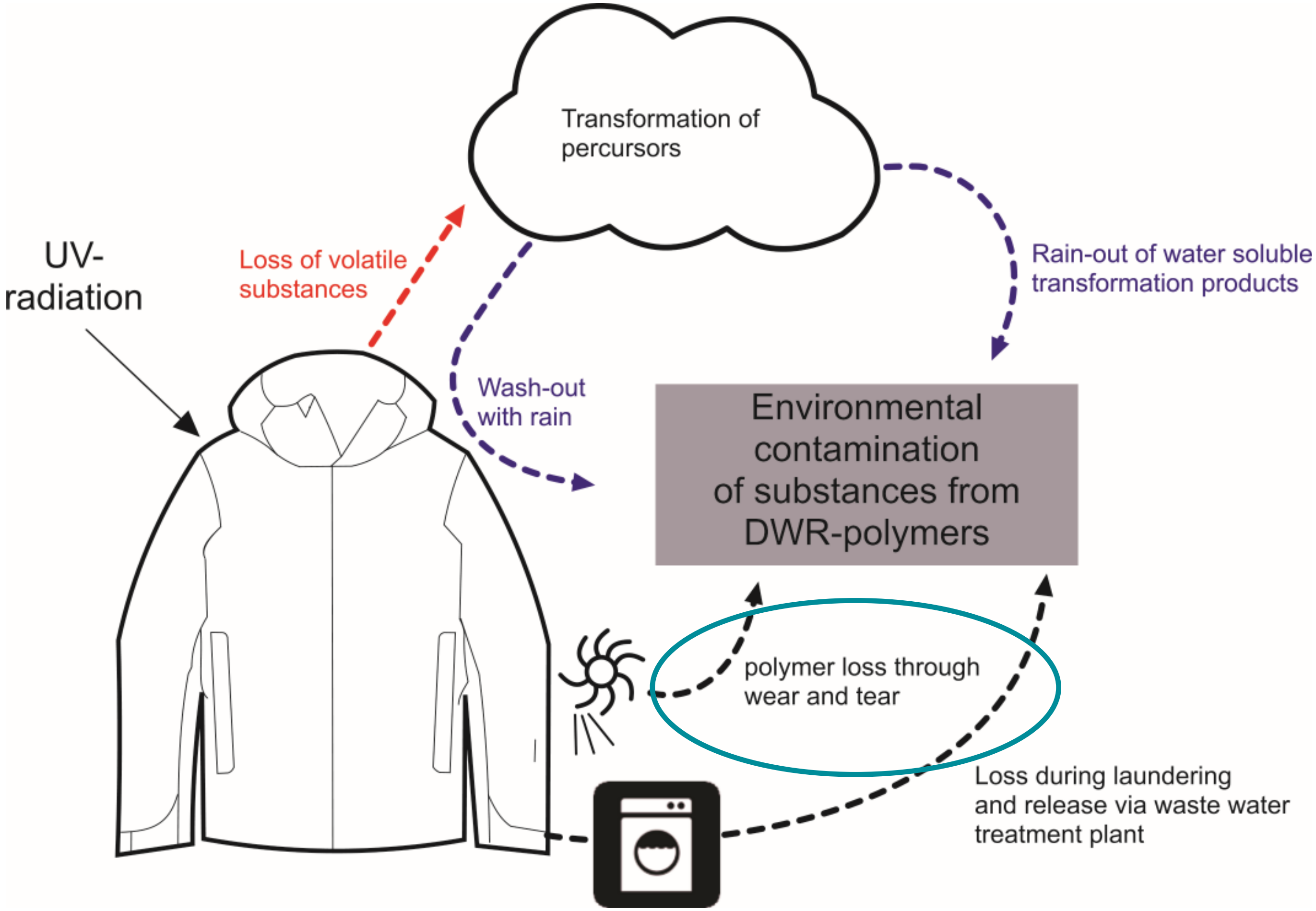


PFHxA scenarios :

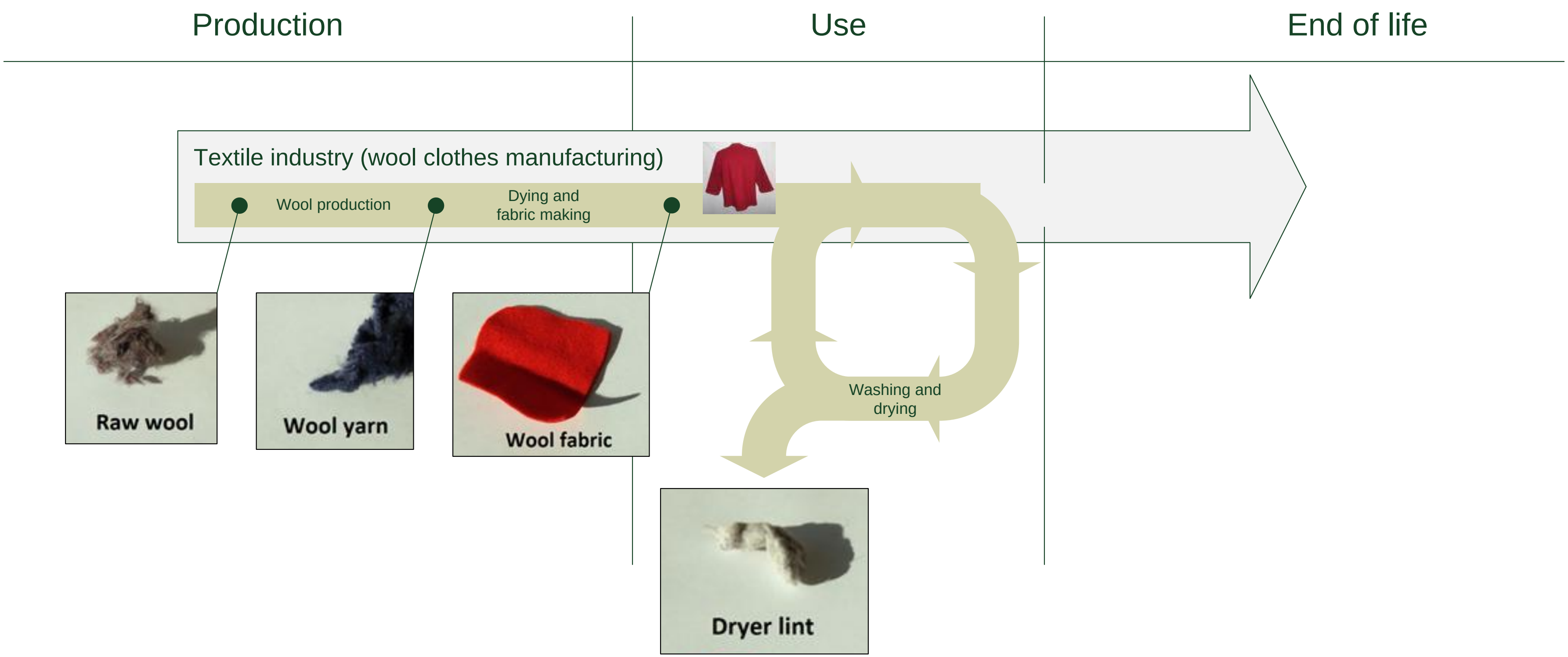
- **Current state levels of PFHxA in sludge and deposition (S1)**
- **Sludge and deposition levels of PFHxA increased to the same as for PFOA (S2). Compared to the current state for PFOA (S0).**

Monitoring data from the Swedish EPA (2013), Screening database

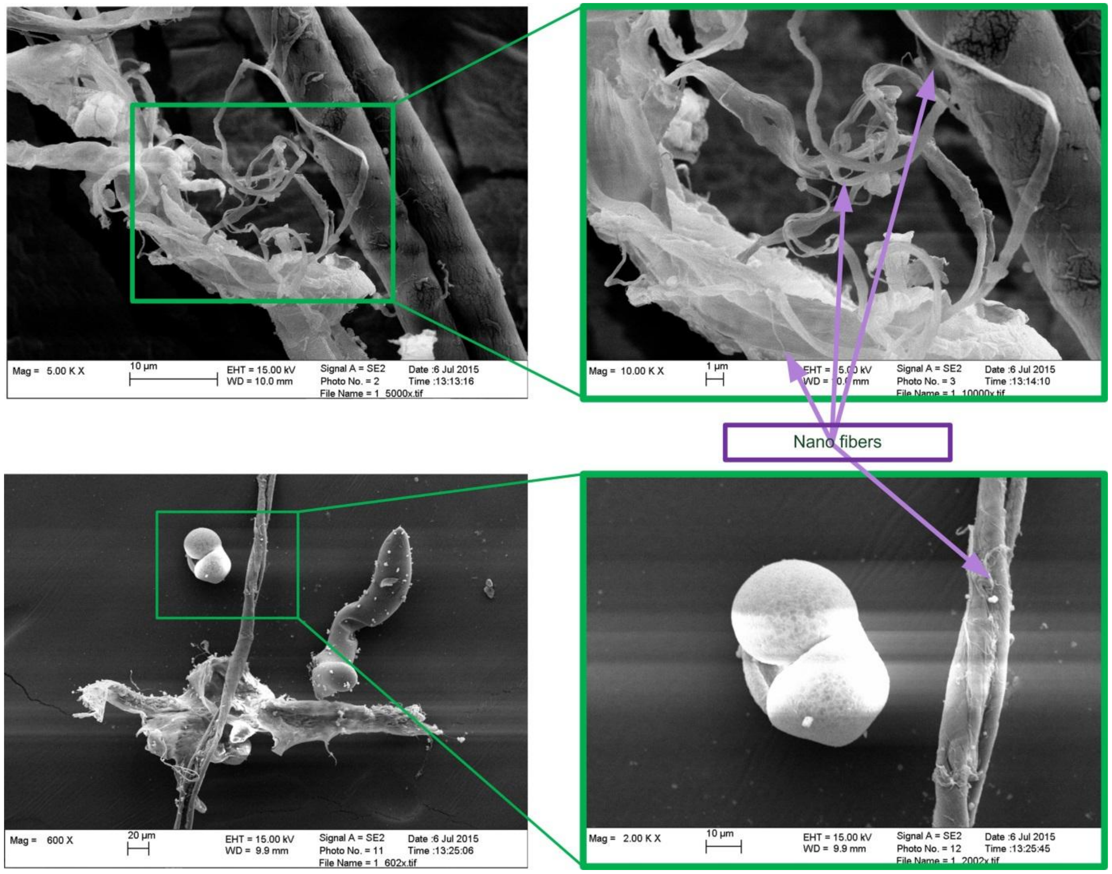
Possible mechanisms for loss of chemicals from DWR-treated fabrics



Nanomaterial in the life cycle



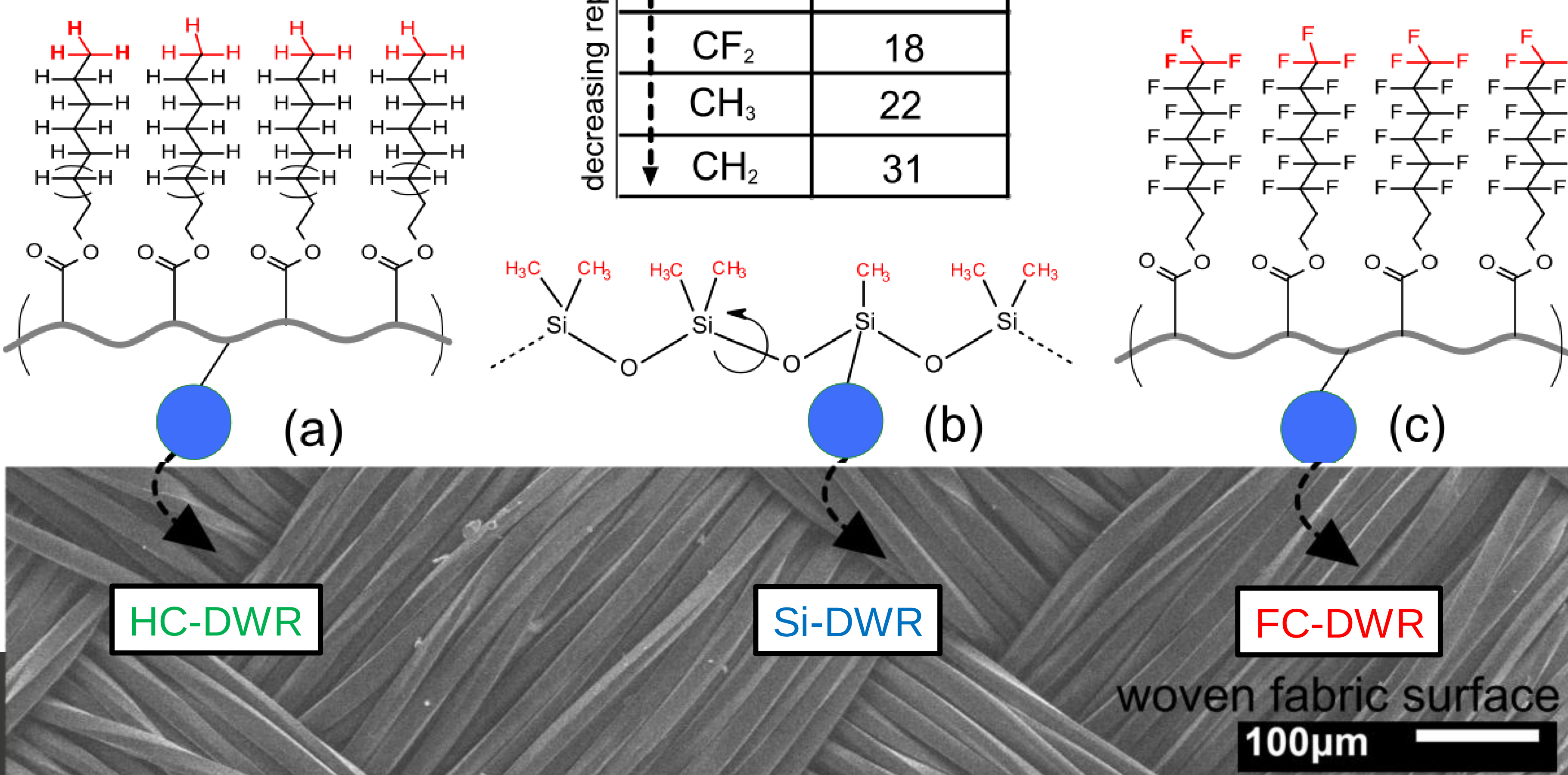
Scanning electron microscope (SEM)



Lint from tumble dry

Alternatives chemicals for DWR

- Fluorocarbon-based
- Silicon-based
- Hydrocarbon-based polymers



Group	γ_c [mN/m]
CF_3	6
CF_2	18
CH_3	22
CH_2	31

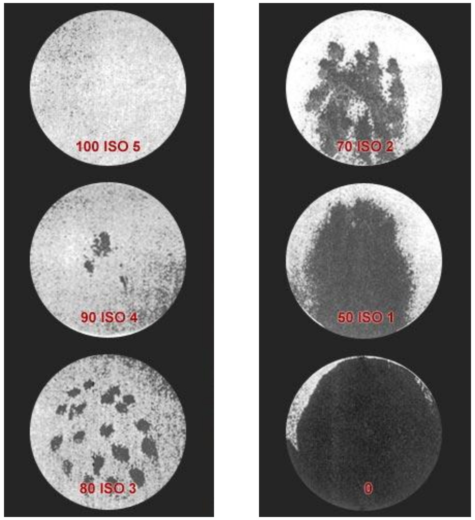
swerea swedish research

Water and oil repellency performance testing

Spray test (ISO 4920)

Determination of water resistance to surface wetting

- 250 ml water
- Spray rating
- Determination of the remaining water after the spray test



Spray rating [0-5]

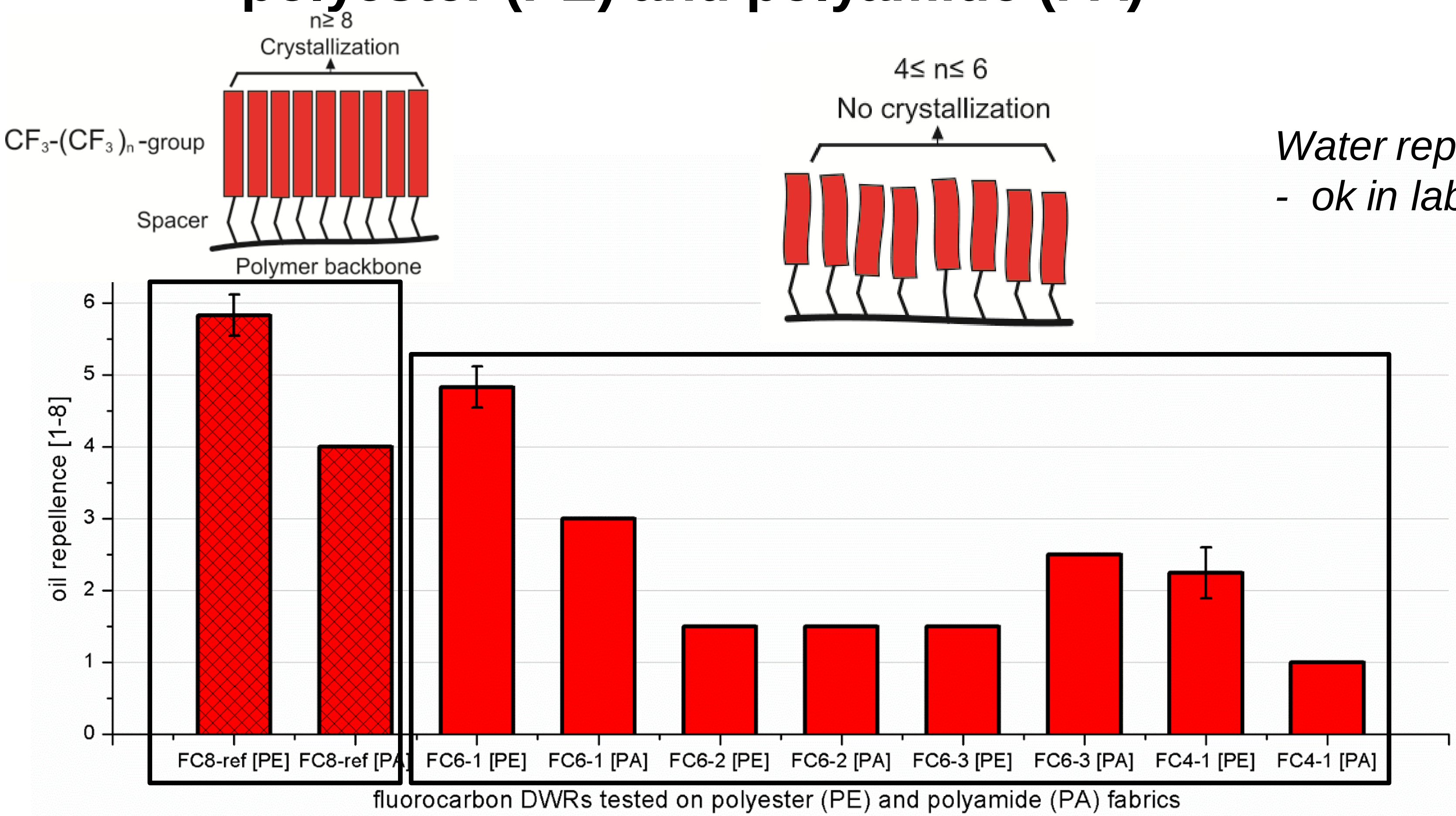
Oil repellency (ISO 14419)

Fluid	rating	γ [mN/m]
mineral oil	1	35
65/45 hexadecane/hexadecane	2	31,5
hexadecane	3	27,5
tetradecane	4	26,5
dodecane	5	25,5
decane	6	23,3
octane	7	21,6
heptane	8	20,2

Oils with decreasing surface tension (γ)

- Determination of fabrics`s repellency with different oils

Oil repellency (ISO 14419) on:
polyester (PE) and polyamide (PA)



Water repellency
- ok in lab tests

- Fluorocarbons: Decreasing oil repellency with decreasing CF_3-$(CF_3)_n$- chain length
- Siloxanes and Hydrocarbons: No oil or dirt repellency

swerea
swedish research

Chemical hazard assessment of alternatives

- Our preliminary hazard ranking suggests that hydrocarbon-based polymers are the most environmentally benign, followed by silicone- and PFAS-based polymers.

Substance	Hazard classification per endpoint											
	Human health								Ecotox		Fate	
	C	M	R	D	E	AT	ST	N	AA	CA	P	B
Benchmark												
PFOA	H	L	*H*	H	PEA	M	[illegible]	DG	L	*L*	vH	H
PFAS												
PFHxA	*L*	[illegible]	M	*M*	PEA	L	*M*	DG	*L*	*H*	vH	*L*
PFBS	DG	*L*	*L*	L	PEA	L	*L*	DG	*L*	*L*	vH	*L*
Silicones												
Short-chain silanols	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG
DMSD	DG	DG	DG	DG	DG	DG	*M*	DG	DG	DG	*vH*	*L*
TMS	DG	*L*	DG	DG	DG	*M*	*M*	DG	L	DG	DG	*L*
D4	*L*	*L*	*L*	*L*	DG	L	vH	DG	*L*	vH	vH	*vH*
D5	*L*	L	*L*	*L*	DG	*H*	*H*	DG	*L*	*L*	vH	*vH*
Hydrocarbons												
Paraffin Wax	L	L	*L*	*L*	DG	L	DG	DG	L	L	vL	L
Nanotechnologies												
Dendrimers	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG
Inorg. nanoparticles	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG

The silicone industry is committed to reduce the levels of residual cyclic volatile methyl siloxanes present in the silicone-based DWR products and this will lower the actual risks.
There is a lack of information on the hazards associated with DWR nanotechnologies and these data gaps must be filled.

- To assess the human and environmental risks of critical chemicals from DWRs the exposure have to be considered

For chemical usage not only hazard counts

- Intended use of fabric
  - Performance requirements
  - Customer demands
- Life length
  - Fastness on fabric during use (weathering, abrasion and wash)
  - Stability (degradation)
- Exposure mode
  - Particle/fiber to air and water
  - Leakage to air and water
- Quantity
  - Lower amounts of more efficient chemicals vs higher amounts of low efficient chemicals
- Quality
  - Byproducts
  - Address legal verification possibility

Holistic view on chemicals

Production | Use | End of life





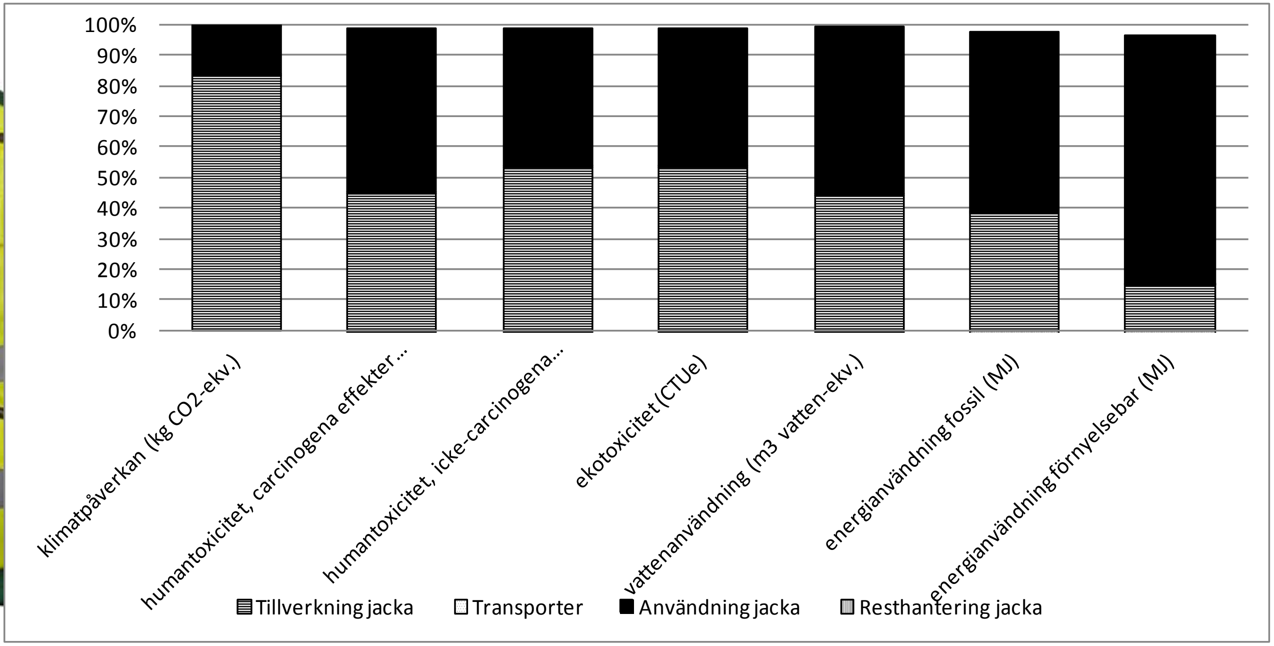


Site emissions – chemicals management

Diffuse emissions – ecodesign

Screening LCA

Emission data will be included



Fabrication of the jacket, and the use, in which the jacket is assumed to be washed and dried a total of 100 times, dominates the environmental impact, while transport and waste management are negligible.

Take home message

- Substitution in practice
  - Technical performance
  - Health and environmental performance
  - Precautionary principle
- Holistic approach
  - Life cycle perspective
- Cost efficiency
  - Direct cost - Company
  - Indirect cost – Socio-economic effects

Note that the risk is associated to both hazard and exposure

Thank you for your attention!
http://www.supfes.eu

Scientific Work for Industrial Use
www.swerea.se