Welcome to PFAS-FREE FUTURE

Safe & Sustainable Alternatives for Packaging & Textiles

20 November 2025, 9-16h

ZeroF's Final Event

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Agenda

Time	Session	Speaker
09:00–09:30	Welcome by ZeroF Coordinator & Leitat	Ruth Garcia (Leitat) Miika Nikinmaa (VTT)
09:30–10:00	Policy and Regulation Evolution in Europe	Blanca Suarez-Merino (TEMAS Solutions)
10:00–10:45	ZeroF Solutions for Upholstery Textiles & Food Packaging	**Textile:** Diana Lau (Fraunhofer ISC) & Ruth Garcia (Leitat) **Packaging:** Miika Nikinmaa (VTT) & Mika Vähä-Nissi (VTT)
Coffee Break (30 min)		
11:15–11:45	PFAS-Free Solutions: Understanding and Engaging Consumers	Tom Tamlander (VTT) Eddo Da Silva Rosa (LGI)
11:45–12:30	**PANEL DISCUSSION** Advancing PFAS Solutions in Europe: Challenges, Collaboration with PROPLANET PROJECT & TORNADO PROJECT	Miika Nikinmaa (VTT) Òscar Calvo (AITEX & PROPLANET) Raquel Rodríguez (Tecnalia & TORNADO) Moderator: Alina Giesler (LGI)
Lunch Break		
13:30 – 14:45	From Assessment to Action: Safe & Sustainable Design	Panagiotis Isigonis (LIST) Elise Morel (TEMAS Solutions) Federico Busio (LIST) Imad Audi (LGI)
Coffee Break (15 min)		
15:00–15:45	**PANEL DISCUSSION** Scaling PFAS-Free Innovations: Challenges & Needs	**Textile:** Estel Sarrau (E.Cima) & Marta Casadesús (Tèxtils.CAT) **Packaging** Mårten Alkhagen (Yangi) & Tarja Turkki (Kemira) **Moderator**: Hille Helkiö (VTT)
15:45–16:00	Closing Remarks	Miika Nikinmaa (VTT)

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Welcome to the ZeroF Stakeholder event!

Ruth Garcia
(Leitat – Event Host)

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About Leitat

FIRST RTO IN EUROPE

FOUNDED IN 1906

Leitat is an international benchmark reference in applied R&D, project management and leadership of large initiatives

400
experts

10
sites

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EARTO IMPACT DELIVERED

WAITRO

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TECHNOLOGICAL INNOVATION TO RESPOND TO

THE MAIN SOCIETAL AND INDUSTRIAL CHALLENGES

HEALTH

Health and biomedicine, diagnosis and advanced therapies for different pathologies

DIGITALIZATION

Transition to a digital, sustainable and competitive industry

SUSTAINABILITY

Transition to the circular economy, bioeconomy and decarbonisation

CHEMISTRY AND MATERIALS

Holistic view from raw materials to validation and certification

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Leitat's facilities

Terrassa

Headquarters

Vilanova del Camí

Anoia Innovation Center

Lleida

Agrobiotech Park

Valencia

Biopolo La Fe

Barcelona

Barcelona Chamber of Commerce

22@

Barcelona Science Park

DFactory Barcelona

Vall d'Hebron Research Institute

- Circular Economy & Decarbonization
- Digital Industry
- Health & Biomedicine
- Advanced Technological Services
- Applied Chemistry & Materials

Great things happen together

Welcome to the ZeroF Stakeholder event!

Miika Nikinmaa
(VTT & ZeroF Coordinator)

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ZeroF Who Are We and What We Do

Chemistry

Fraunhofer ISC

VTT

Kemira

TEMAS Solutions
Safe & Sustainable Innovations

LIST

SSbD

Coating

Fraunhofer ISC

LEITAT managing technologies

VTT

Kemira

YANGI
RENEWABLE PACKAGING TECHNOLOGIES

ALMA MATER STUDIORUM UNIVERSITÀ DI BOLOGNA

IDEA consult

Concept

LEITAT managing technologies

AEI Textils.cat

e.cima, s.a.u.

YANGI
RENEWABLE PACKAGING TECHNOLOGIES

VTT

Computational safety and design

Communication, Dissemination & Exploitation

LGi
sustainable innovation

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ZeroF Progress

Year 1: 2023

- Delivery of the first generation of modified molecules for the formulation and development of new PFAS-free coatings.
- Development of a Safe and Sustainable By Design (SSbD) methodological framework and guidelines as support for the coating development.

Year 2: 2024

- Development of PFAS-free coating formulations.
- Pilot tests with various packaging and textile applications.
- Validation of chemicals and concepts for both value chains.
- Development of a computational model for continuous evaluation and improvement.

Year 3: 2025

- Completion of laboratory and pilot production trials.
- Assessment of environmental sustainability and chemical safety.
- Assessment of technical performance and life cycle cost evaluation.
- Development of a certification and standardisation roadmap.
- Awareness campaign for ZeroF's PFAS-free coatings.

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ZeroF Scope And Solution

Food packaging has used PFAS in internal sizing agent in moulded packaging, pizza boxes, straws, etc. In ZeroF we develop a new wood-based barrier material and coating technology for **moulded packaging**.

In textile applications, PFAS are used as coatings, sprays and films. In ZeroF textile applications we focus on Fraunhofer's **ORMOCER® technology** development where building an oil and water barrier for upholstery textile is a key challenge.

In both solutions the target is to achieve significant improvements in environmental impacts without increasing the cost for consumers

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What Are PFAS

ECHA definition

Any substance that contains at least one fully fluorinated methyl (CF3-) or methylene (-CF2-) carbon atom (without any H/Cl/Br/I attached to it). Substance that only contains the following structural elements is excluded from the scope of the restriction: CF3-X or X-CF2-X',

- Over 10 000 known compounds
- Fully degradable PFAS subgroups are excluded from the scope of this restriction proposal

Including mixtures, constituents and articles of these compounds

where X = -OR or -NRR' and X' = methyl (-CH3), methylene (-CH2-), an aromatic group, a carbonyl group (-C(O)-), -OR'', -SR'' or –NR''R''';
and where R/R'/R''/R''' is a hydrogen (-H), methyl (-CH3), methylene (-CH2-), an aromatic group or a carbonyl group (-C(O)-).

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PFAS: Applications & Impact

Per-and Polyfluoroalkyl Substances (PFAS)

- Used for non-stick cookware, food packaging, textiles, and firefighting foam
- Benefits: Non-stick properties, improved durability, chemical stability & efficient fire fighting

Environmental Impact

- Persistence: PFAS are not degradable, nicknamed “Forever chemicals”
- Bioaccumulation: can accumulate in organisms and affect the food chain.
- Contamination risk: PFAS can contaminate water, soil and air
- Mobility: High potential for human exposure

Health Concerns

- PFAS exposure has been linked to adverse health effects, including cancer and reproductive issues
- Potential exposure through food packaging, indoor environments with PFAS-containing products and contaminated water sources

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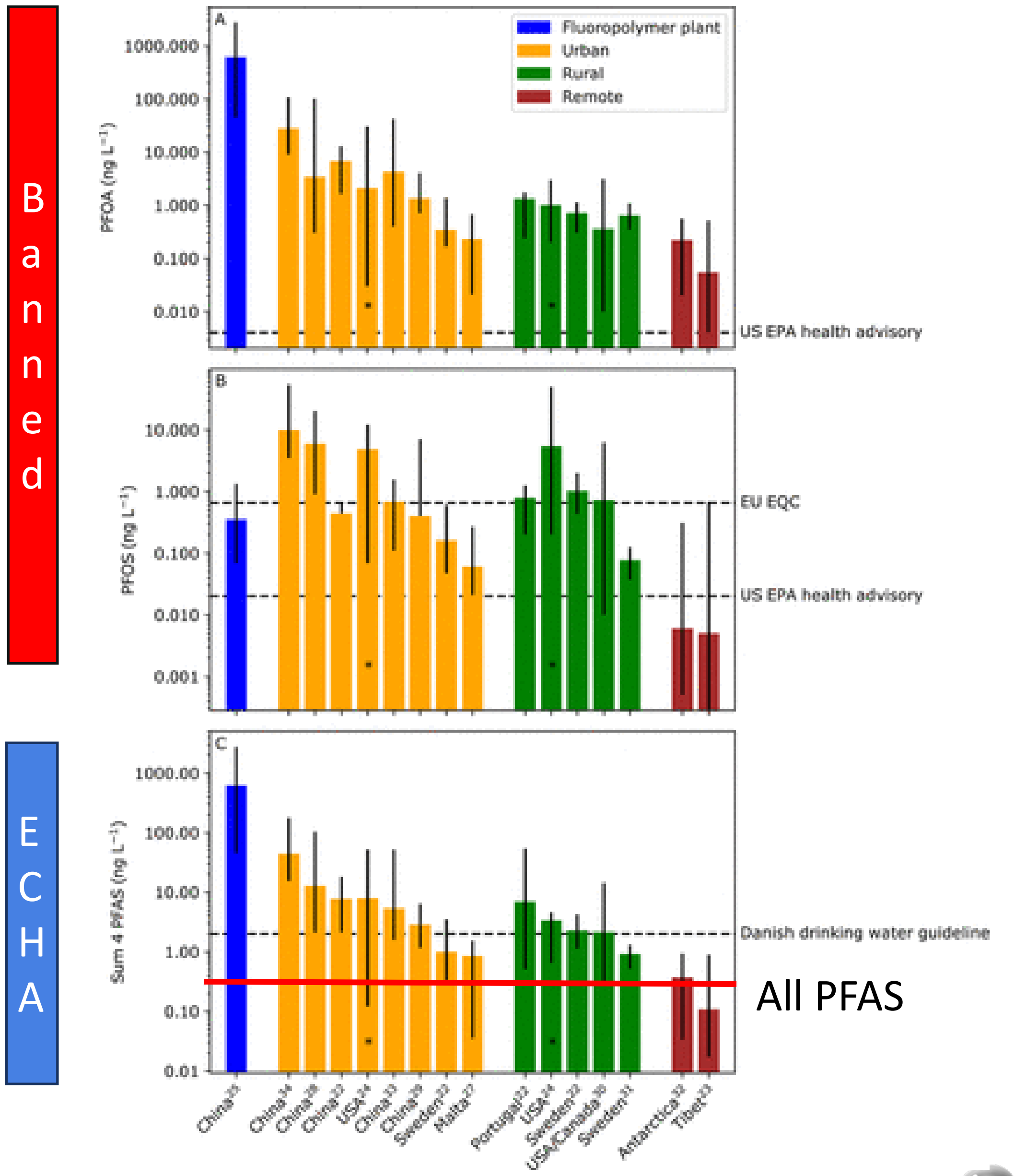
The Problem With PFAS

Exposure limits observed are already higher than recommended by many safety authorities

Everyone in the society is impacted, urban areas generally more than remote

PFAS were invented around 1930 and became used in consumer products in 1950

- Accumulation is just beginning



Outside the Safe Operating Space of a New Planetary Boundary for Per- and Polyfluoroalkyl Substances (PFAS) Ian T. Cousins, Jana H. Johansson, Matthew E. Salter, Bo Sha, and Martin Scheringer *Environmental Science & Technology* **2022** *56* (16), 11172-11179, DOI: 10.1021/acs.est.2c02765

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Timeline to Policy Implementation

2023
Consultation open by ECHA to restrict up to 10,000 PFAS containing substances

2024
ECHA, RAC and SEAC to complete their evaluation including socioeconomic analysis

2025
The EU Commission to provide feedback including a ban or phase out, and derogations in case of no alternatives for particular applications

2026-2027
Restrictions coming into force with industries having an 18 month implementation plan (exception for FCM or MD expected up to 5 years)

Further restrictions expected in waste management, to make sure PFAS does not enter the environment

2030
ZERO POLLUTION ACTION PLAN
Phase out all non-essential PFAS

*Option for highly controlled use of PFAS in selected applications is being considered

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Policy and Regulation Evolution in Europe

Blanca Suarez-Merino
(TEMAS Solutions)

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Policy and Regulatory Evolution in Europe

Blanca Suarez Merino

Elise Morel

Joanke van Dijk

TEMAS Solutions GmbH

Barcelona, Spain

20.11.2025

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Policy and Regulation Evolution in Europe

Why we need to understand EU policy evolution

Europe is undergoing major regulatory shifts affecting:

- Food-contact coatings and fibre-based packaging
- Textile finishing and surface treatments
- All PFAS-based chemistries

Aims

To show how EU regulations are evolving

To demonstrate how ZeroF is positioned within this landscape

To highlight opportunities and gaps for regulatory compliance

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Regulatory and Policy Timeline

Green Deal Policies

Circular Economy Action Plan
Chemical Strategy for Sustainability
Zero Pollution Action Plan
EU Strategy for Sustainable and Circular Plastics
Farm to Folk Strategy
Biodiversity and Microplastics Initiatives

2020-2022

Major Implementation Phase

Packaging & Packaging Waste Regulation (PPWR)
Textile Specific Ecodesign rules
Microplastics release requirements
PFAS restrictions under REACH
Digital Product Passport for Textiles

2023-2024

2025-2030

+2030

-High recyclability standards for all materials
-Textile-to-textile recycling targets
-Substitution of hazardous chemicals
-**Safe & Sustainable by Design (SSbD) chemicals & materials**

New Regulatory Drivers

CLP Regulation
Ecodesign (ESPR)
Digital Product Passport
Packaging & Packaging Waste Regulation

Full Circularity and Zero Pollution Objectives

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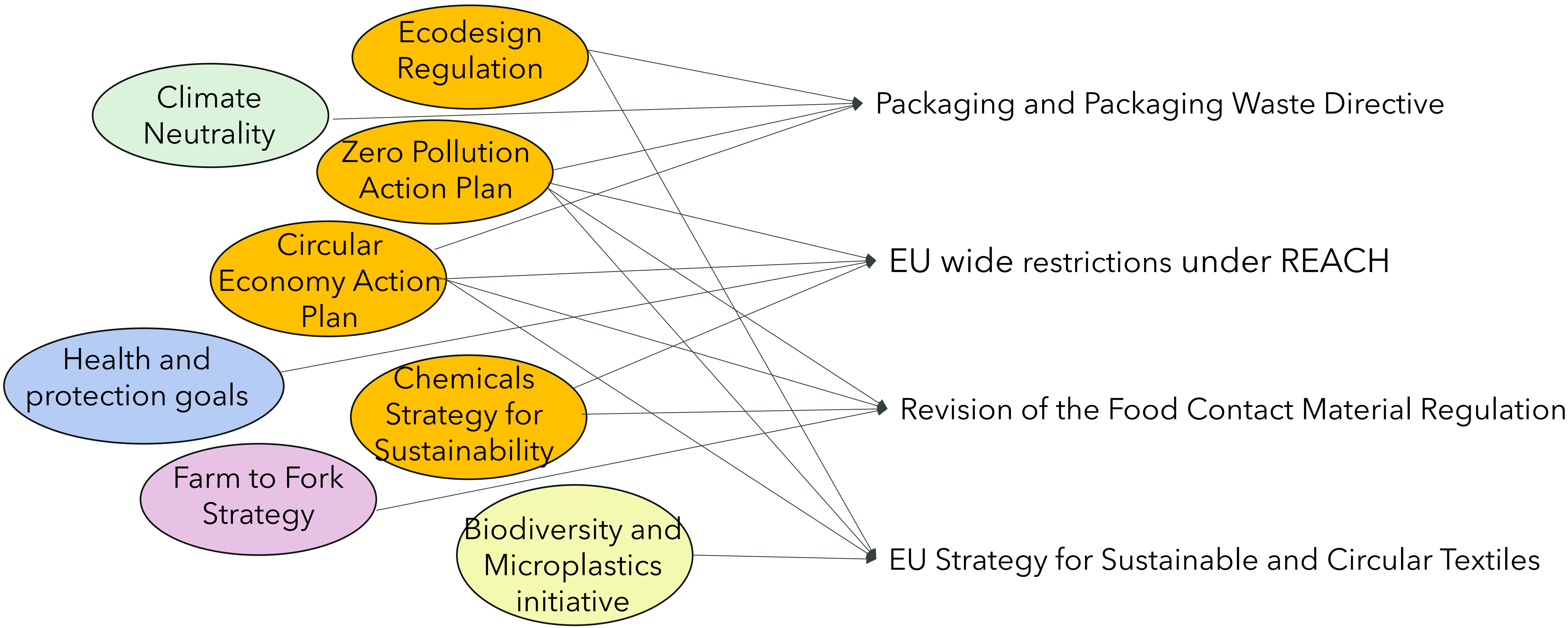
EU Green Deal: Implications for ZeroF materials



EU is undergoing a large regulatory shift

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Food Contact Materials

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Future work to achieve regulatory compliance FCM (EC)1935/2004

Framework Regulation (EC) 1935/2004 – Food Contact Materials (FCM)

coatings must ensure:

•No transfer of substances that endanger human health

•No unacceptable change in food composition

➢ No deterioration of organoleptic characteristics
Requires overall migration testing + specific migration for identified substances.

Good Manufacturing Practice Regulation (EC) 2023/2006

Any coating process (powder coating, hot-pressing) must follow GMP:

•Documented processes

•Quality assurance

•Control of residuals (monomers, solvents, catalysts)

•NIAS risk assessment

19th Amendment" to Regulation (EU) 10/2011 (enforced March 2025)

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Requirements for non-intentionally added Substances (NIAs)

Regulation (EC) 1935/2004 + Food Contact Materials (FCM) guidance:

- All NIAS must be identified or screened
- Their migration must be assessed
- A toxicological risk assessment is required
- Manufacturer must demonstrate no risk to human health

- Perform non-targeted GC–MS / LC–MS screening
- Quantify potential migrants under EN 1186 conditions
- Apply EFSA TTC (Threshold of Toxicological Concern) principles for NIAS
- Ensure migration < 10 μg/kg for unknowns (common safety threshold)
- Update the documentation of compliance (DoC) with NIAS assessment

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EU Policy Expectations: Future Food-Contact Packaging Recycling

Packaging and Packaging Waste Regulation (PPWR) 2025/40 – Direct restrictions

•Packaging must not contain chemicals above limits posing a risk to health or recycling.

•REACH and CLP hazard classes → carcinogenic, mutagenic, reprotoxic, PBT/vPvB, endocrine-disrupting to be avoided.

Restrictions specifically for packaging recyclability

Packaging containing chemicals that interfere with recycling processes may become non-compliant, even if the chemical is legally allowed.

Examples include:

- ✓ **PFAS**
- ✓ Certain silicones, resins, varnishes that prevent fibre separation
- ✓ Heavy metals
- ✓ Problematic adhesives & barrier coatings

From 2030

•All packaging must meet recyclability performance grades (A/B/C).

•Hazardous or persistent chemicals automatically lower recyclability and may prevent market placement.

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MOSH/MOAH Requirements for Fibre-Based Food-Contact Materials

MOSH = Mineral Oil Saturated Hydrocarbons (paraffins, cycloparaffins)
MOAH = Mineral Oil Aromatic Hydrocarbons (aromatic rings; some are genotoxic)
Can migrate from:

- Recycled fibres
- Printing inks
- Lubricants and adhesives
- Processing aids / coatings

Regulatory & market requirements
No harmonised EU limits yet, but strong national pressure:

- **Germany (BfR)** draft ordinance:
  - **MOAH = "not detectable"** (LOQ-based, typically < 0.5 mg/kg)
  - **MOSH migration ≤ 2 mg/kg food**
- **France & Italy** apply similarly strict expectations

CEN/TS 17073 requires MOSH/MOAH evaluation for all paper FCM

And need to pay special attention to National regulations…

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Specific Requirements for Fibre-Based Packaging

EN Standards for Fibre-Based Food-Contact Packaging

- **EN 643** – Paper recycling quality
- **EN 13430** – Packaging recyclability
- **CEN/TS 17073** – Paper & board for food contact (NIAS, mineral oil, impurities)
- **EN 13676** – Screening for substances migrating from paper into food
- **EN 1186 series** – Food simulants & migration testing
- **EN 13130** – Materials & articles in contact with food

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Textiles

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ZeroF Textile Coatings

Target Application	Upholstery Fabrics
Selected Substrates	Polyester (PES 2D or 3D fabric), Cotton and Blend
Reference product	PFAS-based finishing product (Unidyne TG-5601)

Functional and Safety Targets		
Water Repellence	Grade ≥ 4	ISO 4920, AATCC 22
Oil Repellence	≥ 4–6	ISO 14419, AATCC 118
Safety	Irritation, sensitisation, Cytotoxicity	OECD 431, OECD TG 439, OECD TG 487 ISO10993-5 (MTT), Inflammation through IL8 expression, cytotoxicity (Alamar blue), respiratory sensitisation in vitro.

Skin sensitisation OECD TG 442 C/D/E also required

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ZeroF Textile Coatings

Safety Targets		
Safety	Aquatic Toxicity	OECD TG 201, 202, 203
	Biodegradability	Organic additives OECD 301B/F Copolymers / polymeric binders OECD 302B Microfibre release: ISO 4484-1/2 Biodegradability of released fibres: ISO 14851 or 14852
	Microfibre release (Environmental fate)	ISO 4484
	Plasma pre-treatment chemicals/process must be included in safety documentation	

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Pathway to regulatory compliance for Textiles Safety

Regulatory Area	Requirements	Tests / Evidence Required
REACH & CLP	• No SVHCs > 0.1% (Art. 33) • No Annex XVII restricted substances • CLP compliance incl. new hazard classes (ED, PBT/vPvB, PMT/vPvM) • No PFAS once restriction is in force	• Ingredient inventory & safety data • CLP classification verification • In silico hazard screening • Analytical screening for restricted substances
General Product Safety Regulation (GPSR)	• Textile coating must be safe under normal use • No skin irritation • No sensitisation • No cytotoxicity	In vitro toxicology: • ISO 10993-5 (cytotoxicity) • OECD TG 439 (skin irritation) • OECD 442C/442D/442E (skin sensitisation)
REACH Microplastics Restriction (2023)	• Limit release of microplastics / polymer particles • Evaluate shedding from coated textiles	• Microfibre / particle release test (ISO 4484-1 or CEN draft) • Polymer characterisation • Particle size / morphology analysis

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Pathway to regulatory compliance for Textiles Functionality

Market Area	Requirements	Tests / Evidence Required
EU Textile Strategy 2030	• Durable & recyclable textiles • Low microfibre shedding • No harmful chemicals • Sustainable materials	• Abrasion: ISO 12947 (Martindale) • Washing fastness: ISO 105-C06 • Microfibre release testing • Recycling compatibility assessment
ESPR (Ecodesign for Sustainable Products Regulation)	• Demonstrate durability • Show recyclability of coated textile • Digital Product Passport compliance (future)	• Durability tests • Adhesion testing • Recyclability assessment • Documentation for DPP fields
Textile Performance Standards	• Water repellence ≥ 4 • Oil repellence ≥ 4–6 • Retain performance after use	• ISO 4920 / AATCC 22 (water) • ISO 14419 / AATCC 118 (oil/hydrocarbon resistance) • Contact angles (screening) • Post-washing / post-abrasion performance
Market Standards (OEKO-TEX, ZDHC, Bluesign) *ONLY relevant if demanded by consumers*	*• No restricted chemicals (solvents, surfactants…) • Low VOCs • Skin safety + ecological safety*	*• Restricted Substance List (RSL) and Manufactured RSL compliance screening* *• VOC emission tests* *• Chemical inventory + traceability*

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Pathway to regulatory compliance for Textiles

WHAT ZEROF HAS ACHIEVED

- ✓ Develop PFAS-free textiles coatings (ORMOCER hybrids)
- ✓ Achieve high WCA/OCA on PES fabrics
- ✓ SSbD hazard screening of coating components
- ✓ Identify hazardous chemicals requiring substitutions
- ✓ Partial ISO14419 oil repellency testing
- ✓ Domestic washing/drying ISO6330
- ✓ Rigidity ASTM D1388
- ✓ Durability ISO 13938-2
- ✓ Abrasion ISO 12947-2
- ✓ Mapped private ecolabel requirements

STILL TO BE PERFORMED…

- x Skin sensitisation
- x Microfibre release testing
- x Recyclability of coated textiles
- x Analytical verification of banned/restricted chemicals
- x Market standard compliance checks

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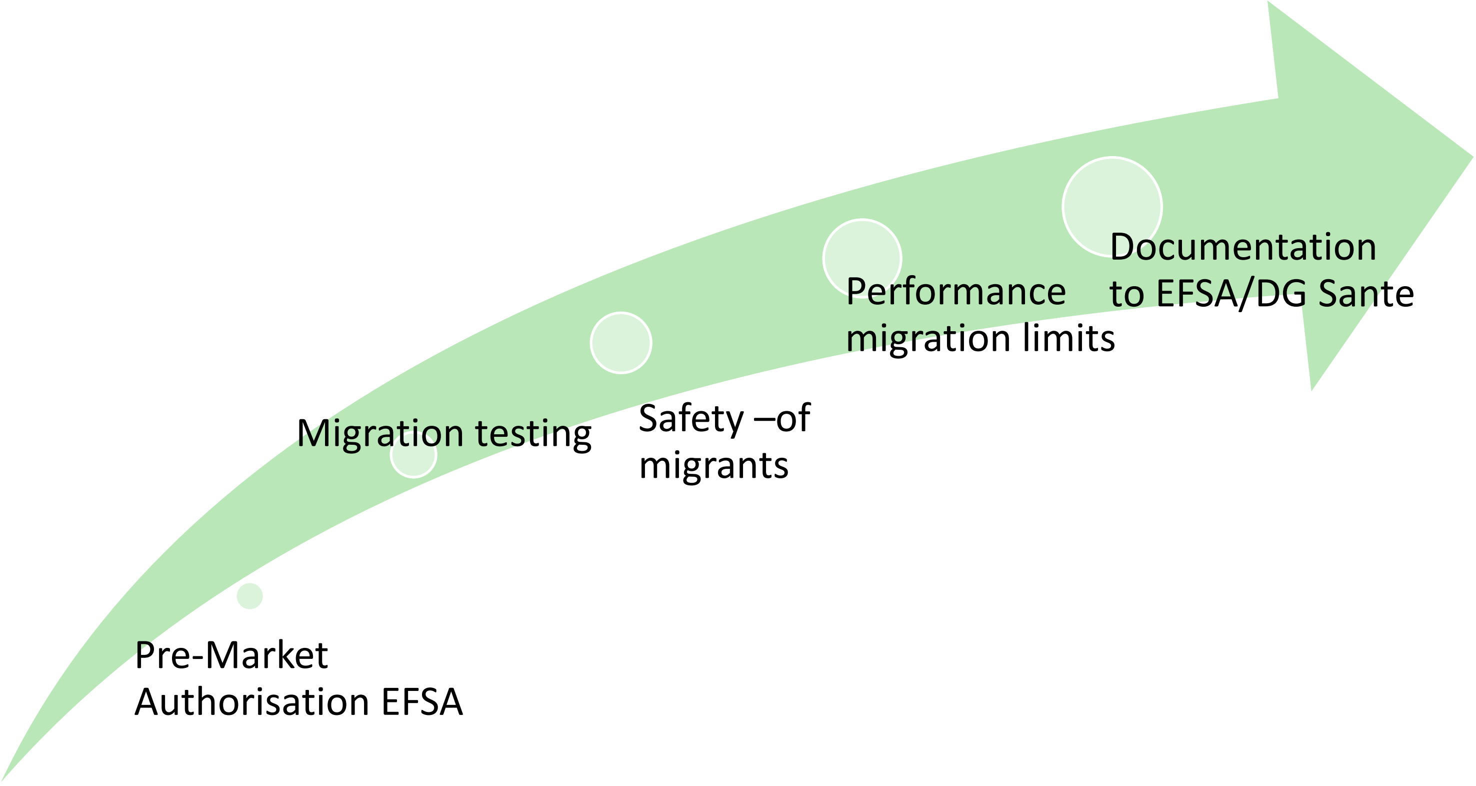
Pathway to regulatory compliance for FCM



EFSA (EU-Level Scientific Submission)

- For *new* coating substances
- For non-listed IAS or NIAS requiring toxicological assessment
- Receives: migration, NIAS, toxicology, manufacturing dossier

National Competent Authorities (Enforcement)

- Germany BfR, France DGCCRF, NL NVWA, Spain AESAN, Italy MoH, etc.
- Receive: DoC + Technical File upon request (REACH + FCM rules)

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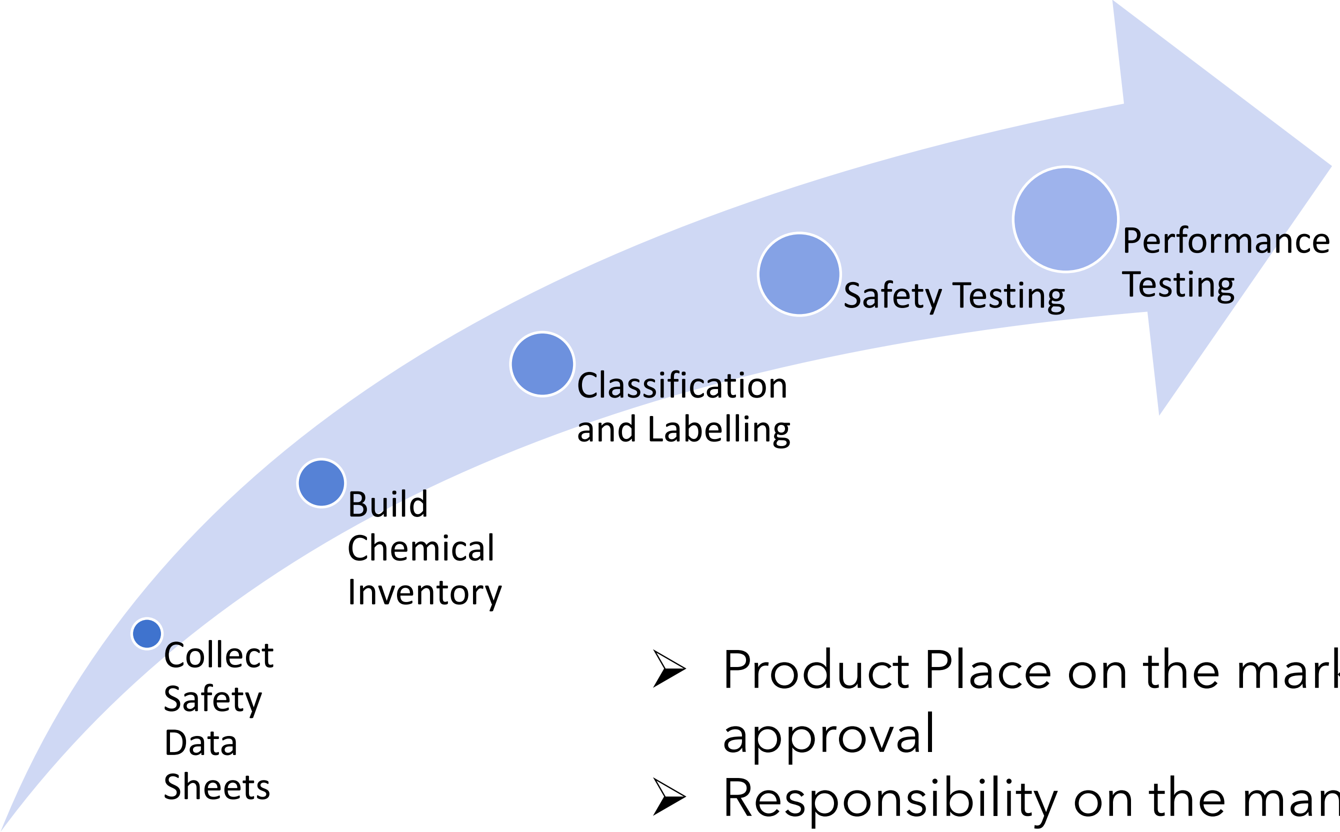
Pathway to regulatory compliance for Textiles



Dossiers provided to EU national market surveillance authorities under REACH + GPSR

- Product Place on the market without prior approval
- Responsibility on the manufacturer
- National authorities perform compliance checks

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PFAS restrictions drive substitution across Textiles and Packaging

- REACH PFAS restriction eliminates most PFAS uses
- PFAS downgrade recyclability under PPWR
- PFAS finishes disappearing from textiles
- PFAS not authorised for most FCM applications
- PFAS migration concerns - NIAS & toxicological risk
- PPWR: PFAS hinder fibre-based packaging recyclability
- National bans (BE, NL) accelerate phase-out

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THANK YOU

Connect with us to learn more.

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ZeroF Solutions for Upholstery Textiles

Diana Lau
(Fraunhofer ISC)

Ruth Garcia
(Leitat)

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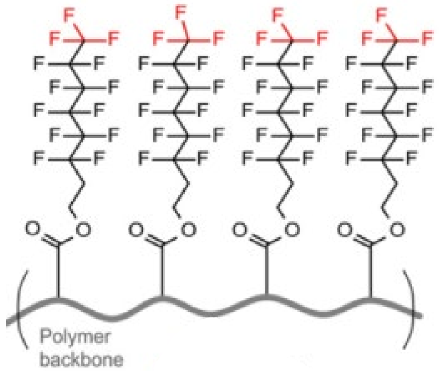
Water and Oil Repellent Coatings for Textiles

- In the textile industry, **water- and oil-proofing** are properties in demand for many applications, including upholstery, sporting apparel, personal protective equipment, workwear, fashion, walls and floor coverings.
- Conventional water and oil repellency coatings are based on **PFAS-containing** substances:
  - PFAS can be **released to water** during textile production and use, and disposal and degradation of PFAS containing textiles can also lead to PFAS migration through **soil and groundwater contamination**. PFAS can also penetrate through the **skin** when in direct contact.
- **PFAS-free** alternatives are based on paraffines, silicones, dendrimers, polyurethanes and silica nanoparticles:
  - They lack oil and stain repellent properties and there is a lack of data about their current health and environmental impacts.
- The industry and consumers are hesitant to switch to **non-fluorinated products** due to the lack of alternatives at comparable performance and cost.



ZEROF is exploring **novel alternatives** beyond the existing PFAS-free solutions, by developing **silane-based organic-inorganic hybrid coatings** applicable to **upholstery textiles**.

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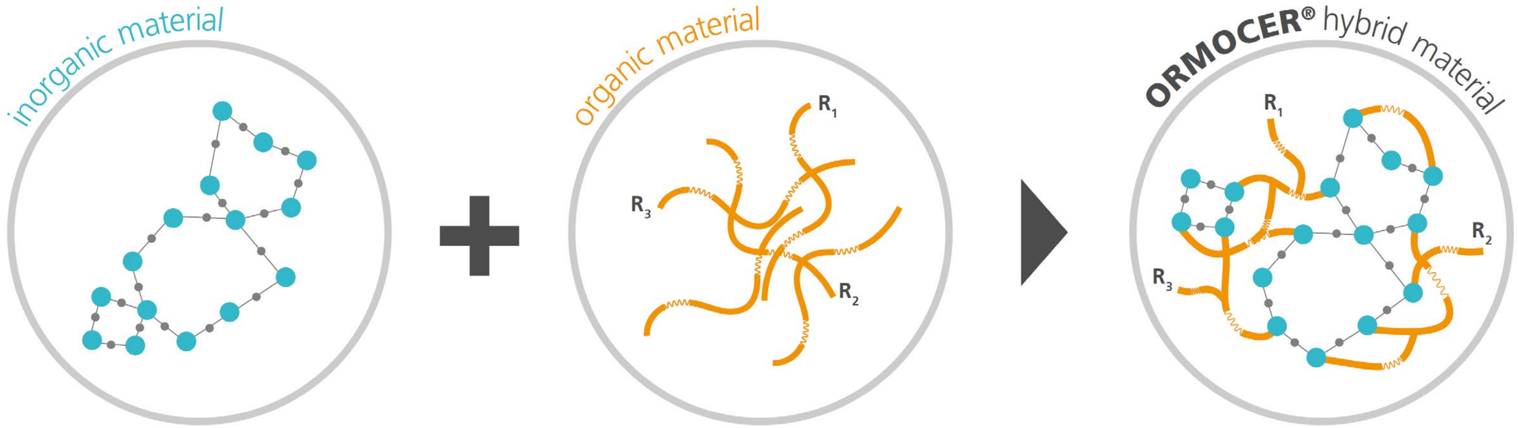
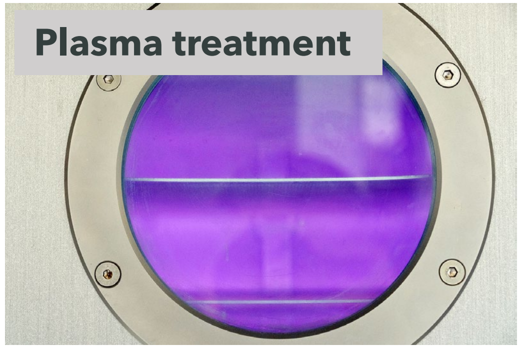
ZEROF Approach





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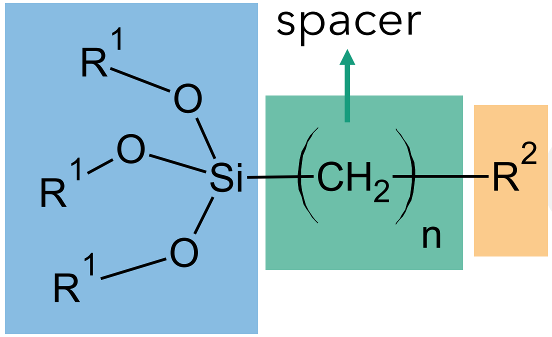
Synthesis of Hybrid Inorganic-Organic Coatings

inorganic network

hydrolysis and condensation reactions ← network former ←



→ network modifier or network former →

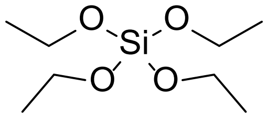
organic network

photochemically or thermally induced curing

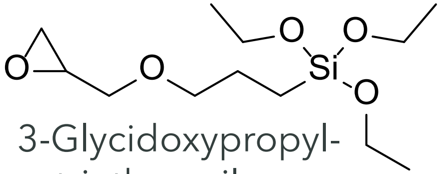
Performance additives (nanoparticles, PDMS, polymers)

Auxiliary products (cross-linkers, dispersants, wetting agents)

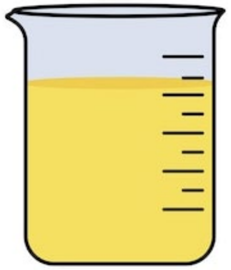
Hybrid-coating formulation

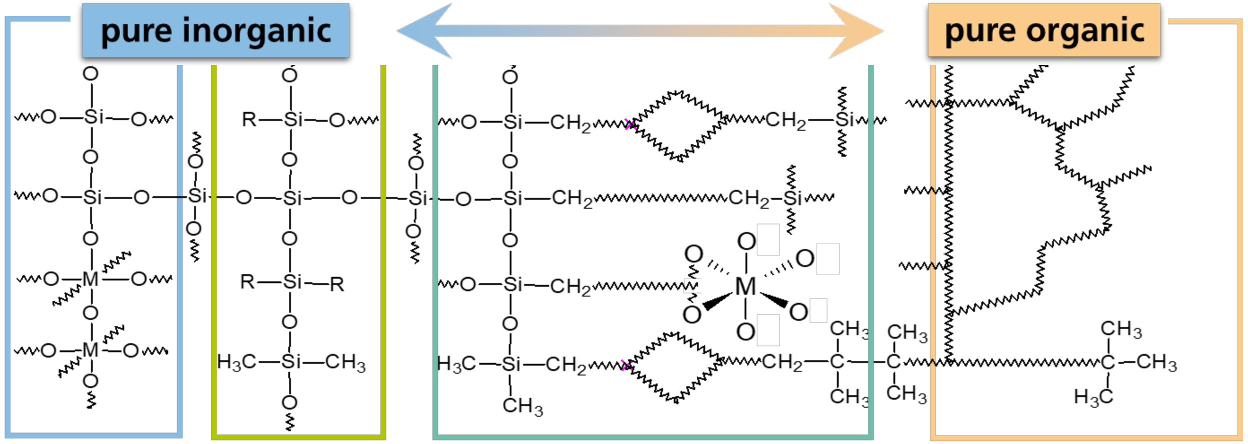


Tetraethyl orthosilicate



3-Glycidoxypropyl-triethoxysilane





inorg. network (glass, ceramic)

modified inorg. network (silicone)

organic crosslinking, inorganic-organic network (hybrid polymer)

organic network (organic polymer)

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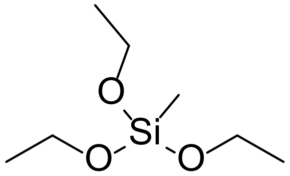
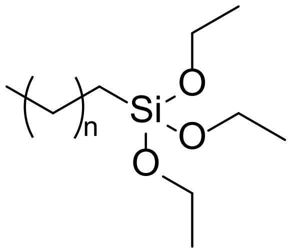
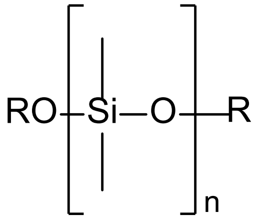
Different Modifications and Performance Additives



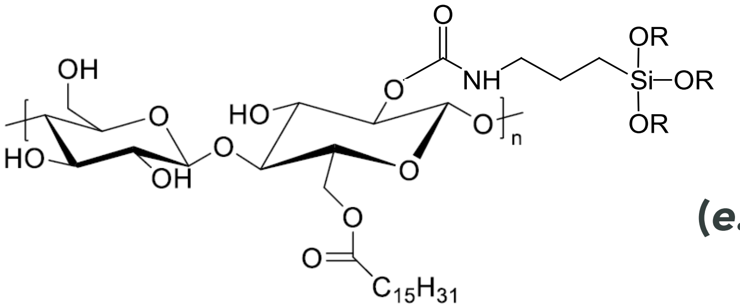
silanes with methyl groups (*e.g.*, methyl-triethoxysilane)



silanes with a long alkyl chain (*e.g.*, octyl-triethoxysilane)

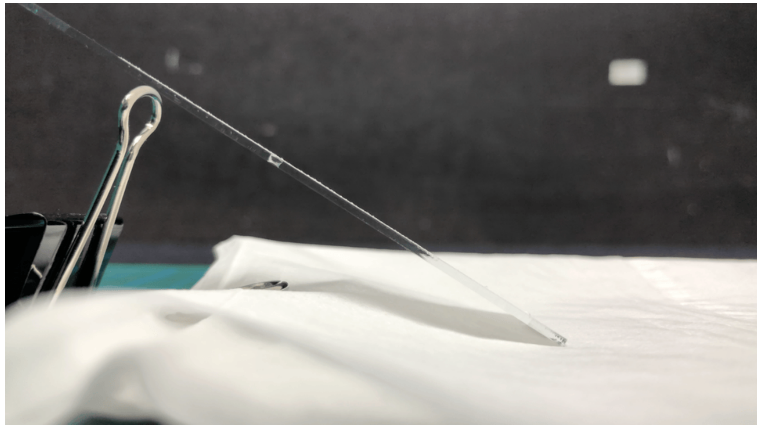


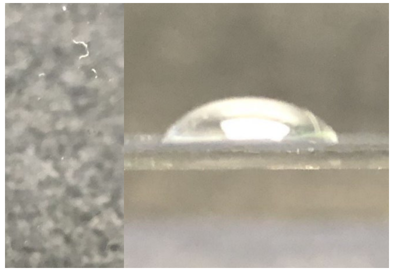
(self-made) polymers (*e.g.*, PDMS)



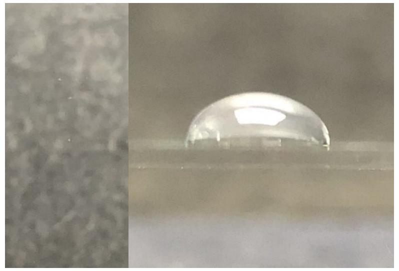
silanized CFAE-derivatives

silica particles (*e.g.*, Ultrasil®, Sipernat® self-made)

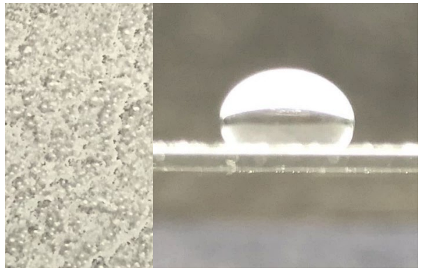




ORMOCER®-coating on glass



+ PDMS (10 wt%) & tenside (0.2 wt%)



+ particles (37 wt%) on glass

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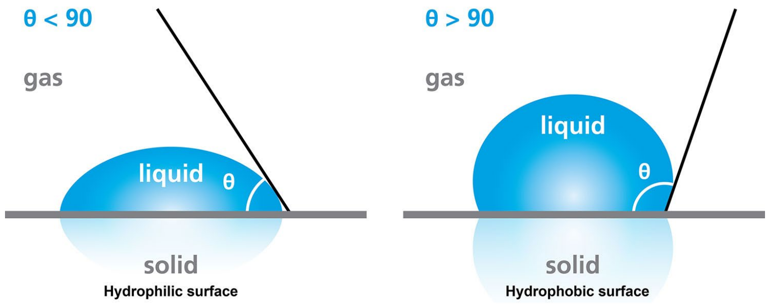
Characterization methods

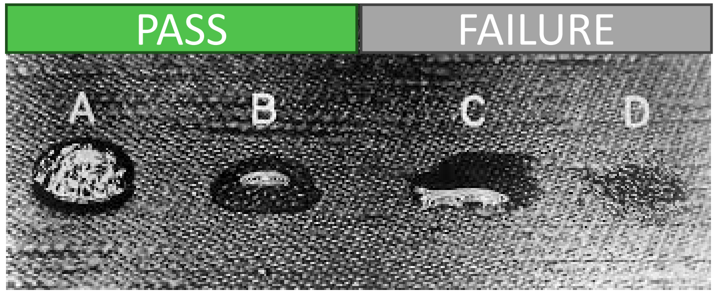
Water and oil repellency

Scientific approach (goniometer)

Liquid	Surface tension (25ºC)
Water	72.0 mN/m
Diiodomethane	50.8 mN/m
Paraffin oil	31.7 mN/m



Standard test for oil repellency (ISO 14419)



- Deposition of small drops (0.05 ml) at 0.6 cm of textile surface.
- Drop observation for **30 s** from a 45° angle.

Oil number	Composition	Surface tension (25ºC)
1	**White mineral oil**	**31.5 mN/m**
2	65:35 white mineral oil: *n*-hexadecane	29.6 mN/m
3	*n*-hexadecane	27.3 mN/m
4	*n*-tetradecane	26.4 mN/m
5	*n*-dodedecane	24.7 mN/m
6	*n*-decane	23.5 mN/m
7	*n*-octane	21.4 mN/m
8	*n*-heptane	14.9 mN/m

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Characterization methods

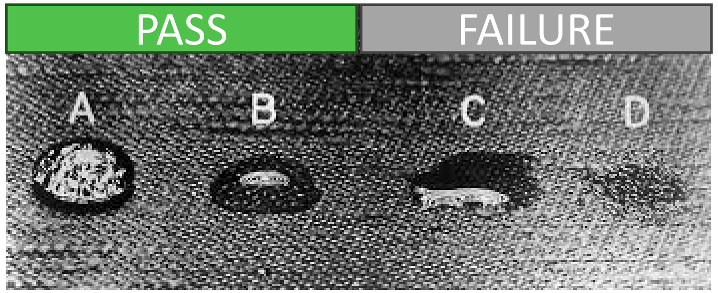
Water and oil repellency

Scientific approach (goniometer)

Liquid	Surface tension (25ºC)
Water	72.0 mN/m
Diiodomethane	50.8 mN/m
Paraffin oil	31.7 mN/m

Composition	Surface tension (20ºC)
Castor Oil	39.0 mN/m
Peanut Oil	35.5 mN/m
Cottonseed oil	35.2 mN/m
Sunflower Oil	33.7 mN/m
Coconut Seed Oil	33.4 mN/m
Palm Oil	33.2 mN/m
Olive Oil	33.0 mN/m

Standard test for oil repellency (ISO 14419)



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6	*n*-decane	23.5 mN/m
7	*n*-octane	21.4 mN/m
8	*n*-heptane	14.9 mN/m

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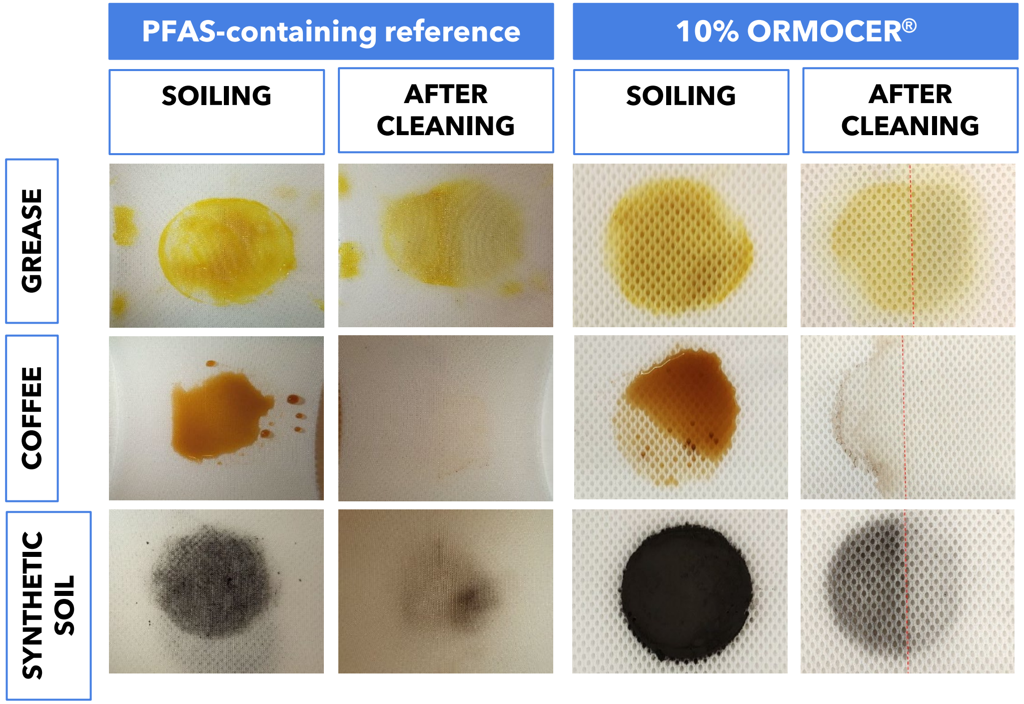
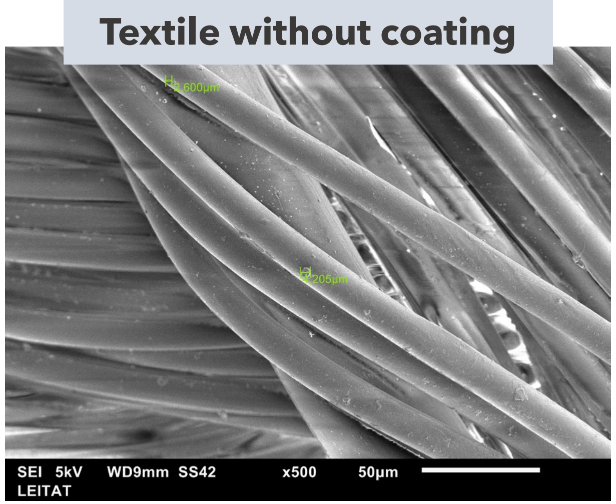
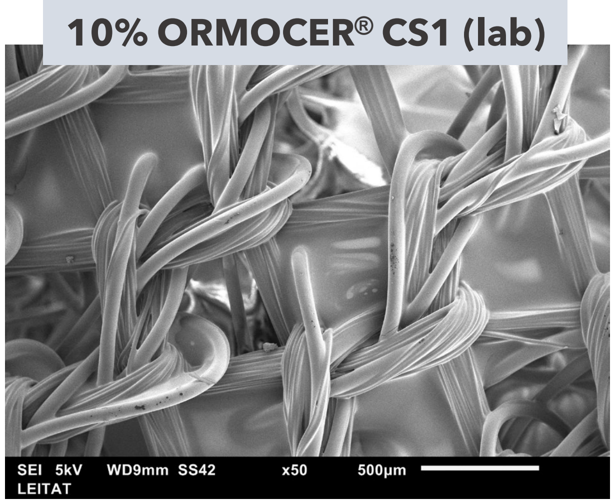
Application Results – Pure ORMOCER®



- WCA up to 135°
- Spray test grade 4

- OCA up to 85° (<10 s)
- Oil test grade 0





WCA = water contact angle, OCA = paraffin oil contact angle, Spray test = ISO 4920, Oil test = ISO 14419

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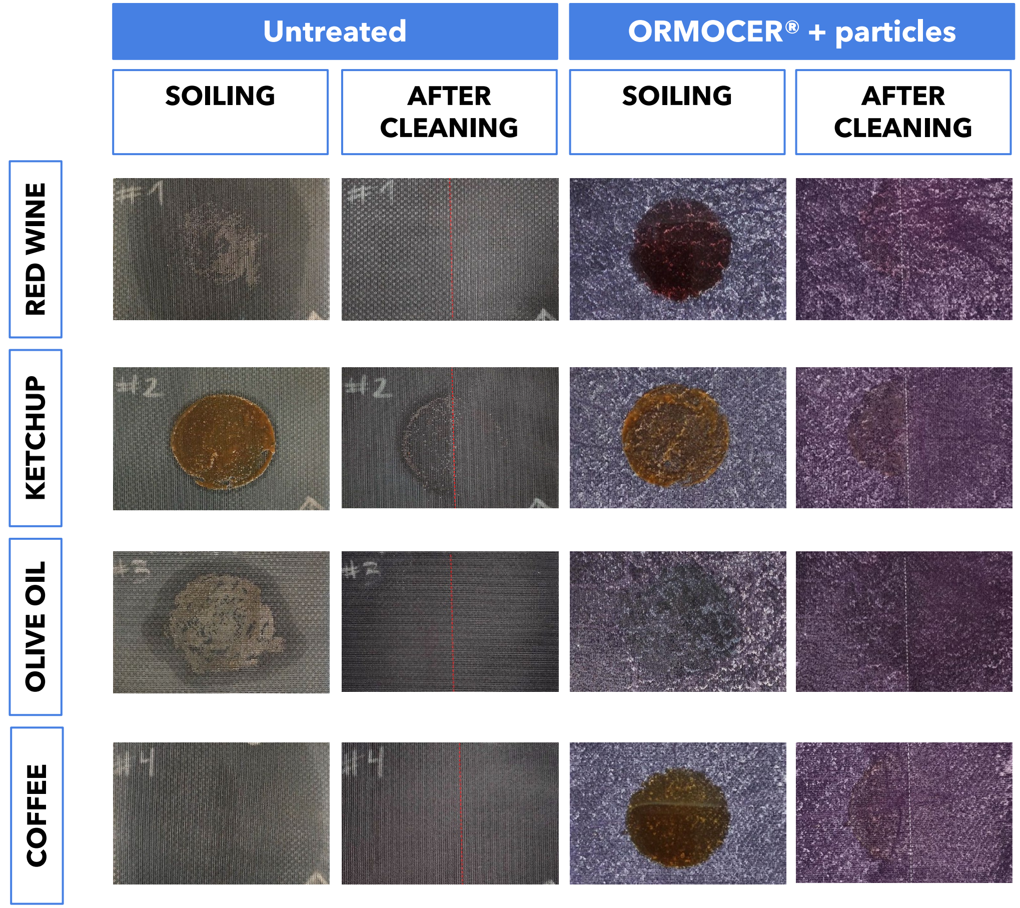
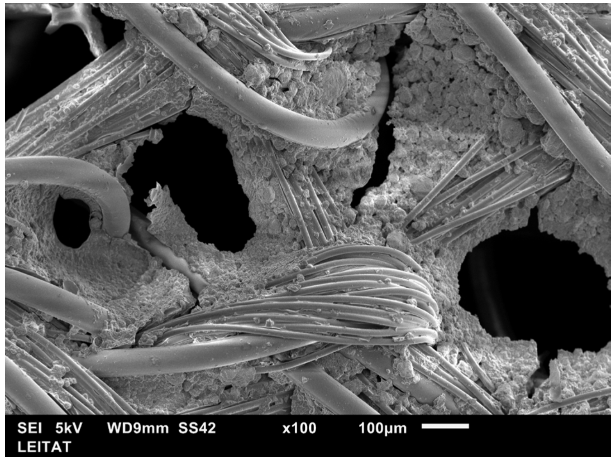
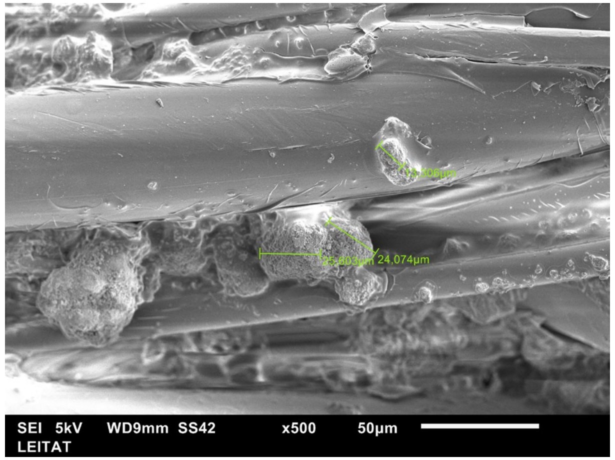
Application Results – Particles



- WCA up to 132°
- Spray test grade 3

- OCA up to 125° (>90 s)
- Oil test grade 1





WCA = water contact angle, OCA = paraffin oil contact angle, Spray test = ISO 4920, Oil test = ISO 14419

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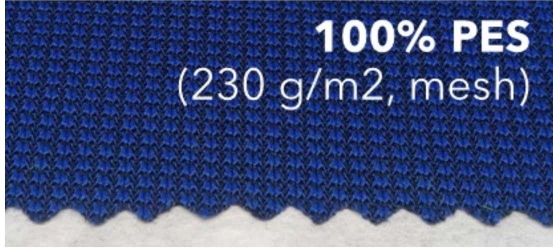
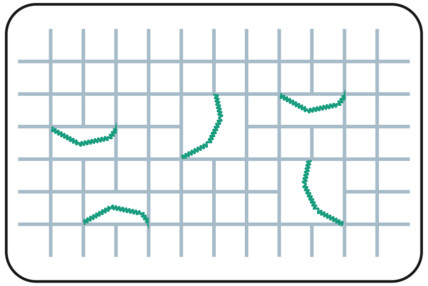
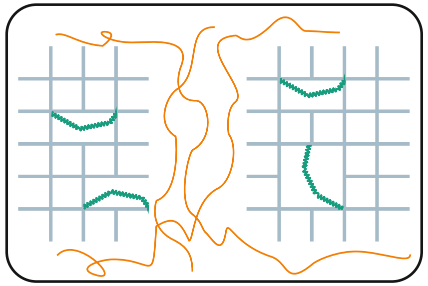
Application Results – Self-made polymers



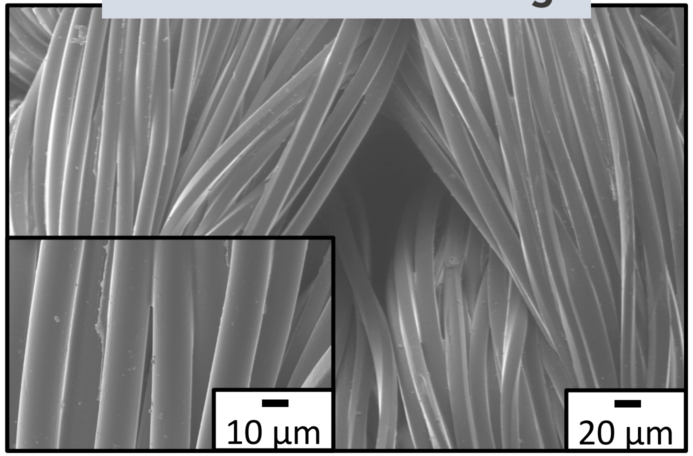
Pure ORMOCER®



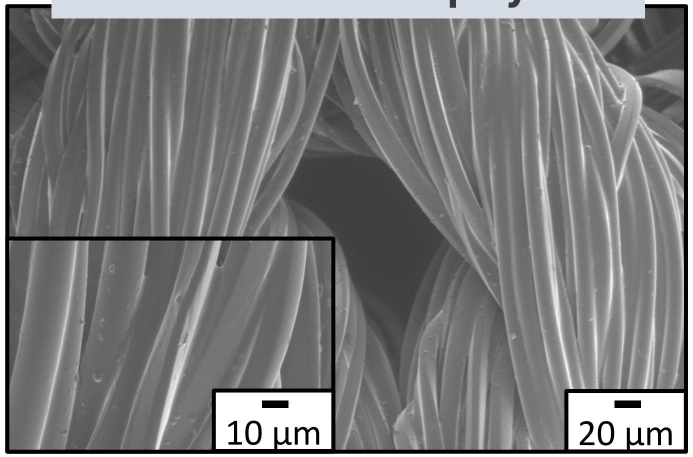
ORMOCER® + polymer



Textile without coating



10% ORMOCER® + polymer



- WCA up to 140°
- Spray test grade 3

- OCA up to 114° (>90 s)
- Oil test grade 2

Olive oil CA	112°
White mineral oil CA	114°
Mineral oil / *n*-hexadecane CA	104°

WCA = water contact angle, OCA = paraffin oil contact angle, Spray test = ISO 4920, Oil test = ISO 14419

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Application results - Exhaustion

- ORMOCER® **applied by exhaustion** achieves the same performance as by padding, without the need for 1 hour curing.
- When **combined with dyes**:
  - ORMOCER® does not affect dyeing performance.
  - 1% of disperse dyes do not affect ORMOCER® performance.

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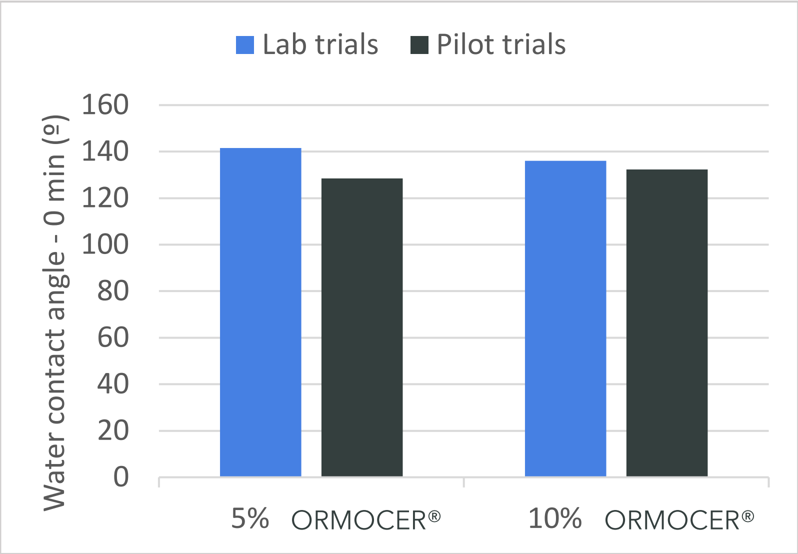
Semi-industrial trials at E.Cima

Main outcomes

- The application of pure ORMOCER® resulted in spray test grade 4 (ISO 4920), oil test grade 0 (ISO 14419).
- The formulations with particles and self-made polymers did not achieve the same performance as in lab application due to formulation instability during application.
- The coatings applied reduced the abrasion resistance of the original fabric, possibly due to an increased stiffness.
- Formulations need optimization to be more stable for industrial application.



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Conclusions

Main results

- **Plasma pre-treatments** enhance the fabric wettability and improve coating fixation.
- PFAS-free coatings have achieved **excellent water barrier properties** (WCA up to 144°).
- PFAS-free coatings can be applied by **exhaustion together with dyes**, with good performance.
- The addition of **particles** has achieved oil repellency grade 1, and other performance additives (such as **self-made polymers**) have been tested to achieve oil repellency grade 2.
- PFAS free coatings cannot achieve the same performance as PFAS in terms of oil repellency. We should be more realistic in the levels of oil repellency required for some applications, such as upholstery.

Future perspectives

- Optimize **coating formulations** for:
  - Better coating **fixation**, to increase washing fastness.
  - Reduced **stiffness**.
  - Enhanced stability for industrial formulations.

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ZeroF
Solutions for Food Packaging

Mika Vähä-Nissi
(VTT)

Miika Nikinmaa
(VTT)

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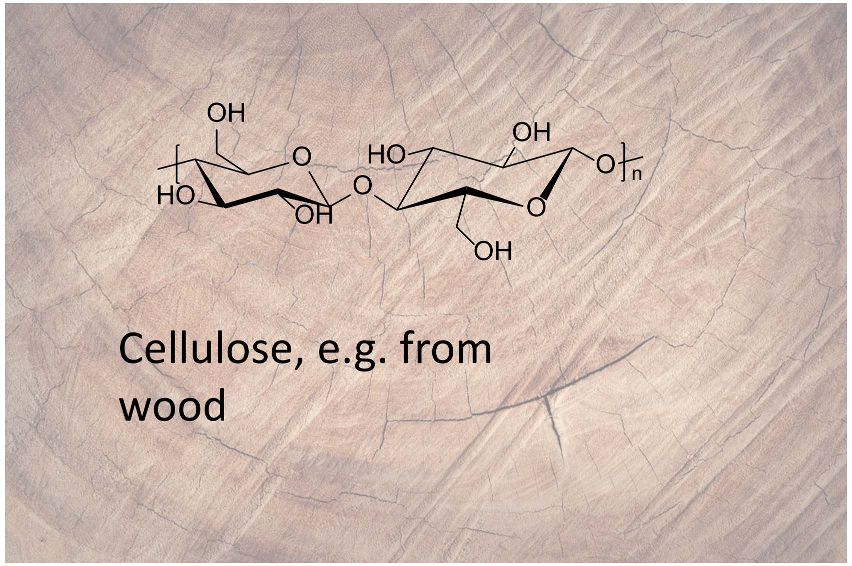
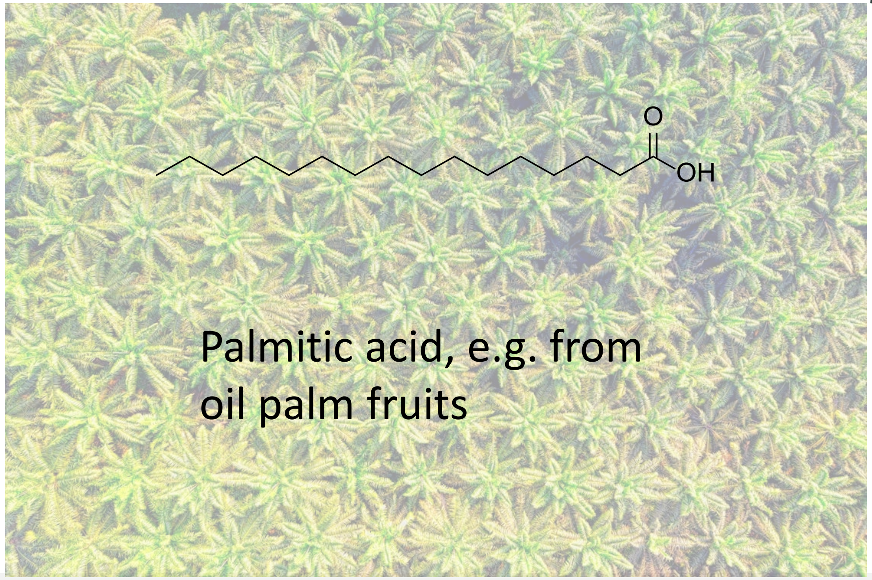
Introduction

- In the project, the fluorinated compounds are being replaced by more sustainable options.
- The presented work divides into two parts:
    1. Syntheses of sustainable materials
    2. Application of the new materials
- The main compounds are polysaccharides combined with fatty acids.





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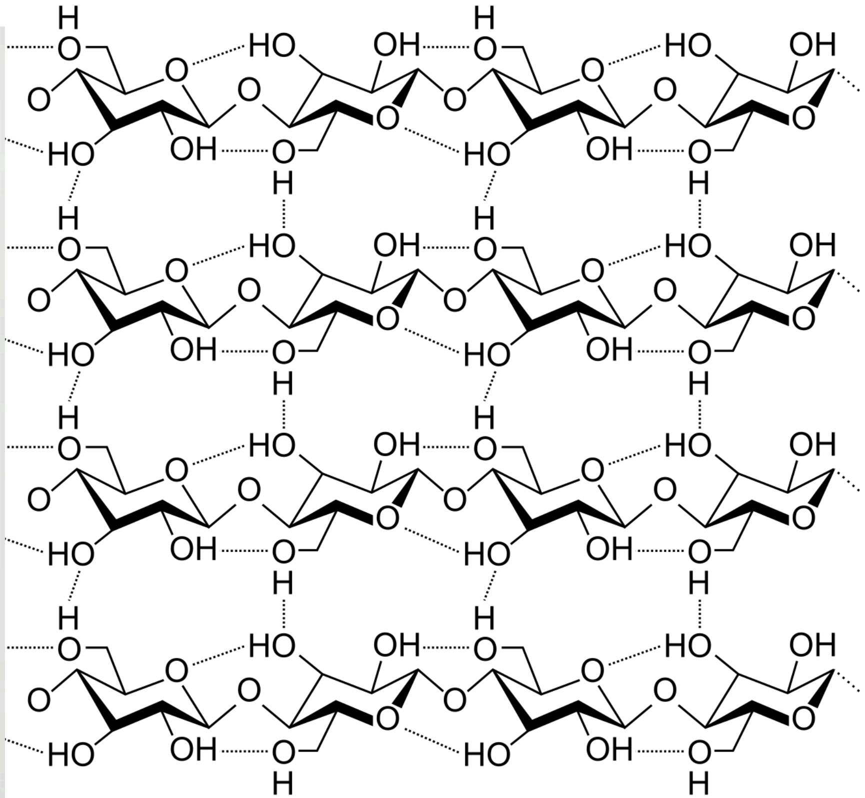
Cellulose

- Cellulose is the most abundant organic polymer on Earth.
  - Found in plants and some bacteria produce it too
  - Responsible for the stiffness in wood
- Trees, cotton etc.
- Rich in hydroxyl (OH) groups that are hydrophilic (“water-loving”) and tightly hydrogen-bound to each other.
- Paper is mainly made of cellulose.



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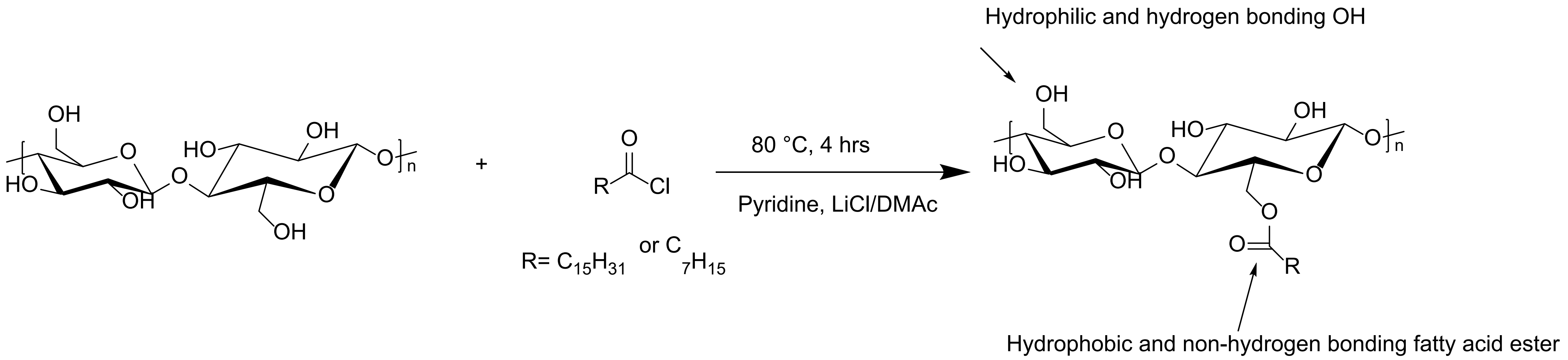
Derivatization

- Cellulose and starch were derivatized by fatty acid to yield materials that are more processable and better coatings.
- Varying the derivatization degree allows varying the properties between hydrophilicity and hydrophobicity.



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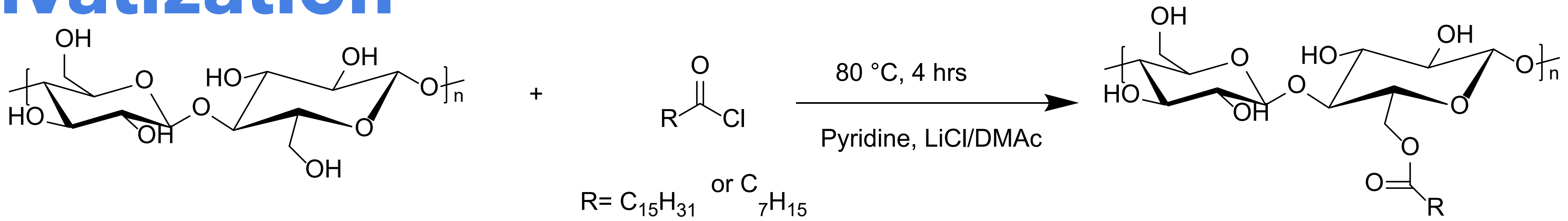
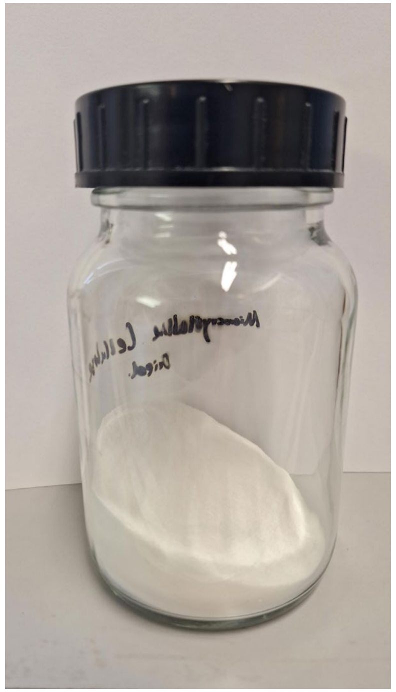
Derivatization





- By varying the ratio of the reagents in the feed it is possible to vary the degree of substitution (DS) i.e., the amount of OH groups per repeating unit that have reacted.
- DS affects the properties of the materials.

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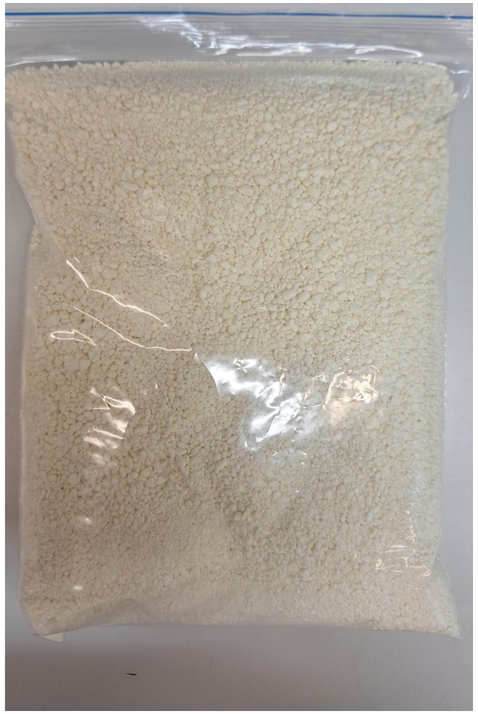
Larger-scale production

- The production was upscaled to pilot scale.
- 10 kg of starting cellulose pulp -> Up to 36 kg of cellulose ester

A 500 L Büchi reactor was employed in the synthesis

A Seitz filter unit was utilized in separation of the materials



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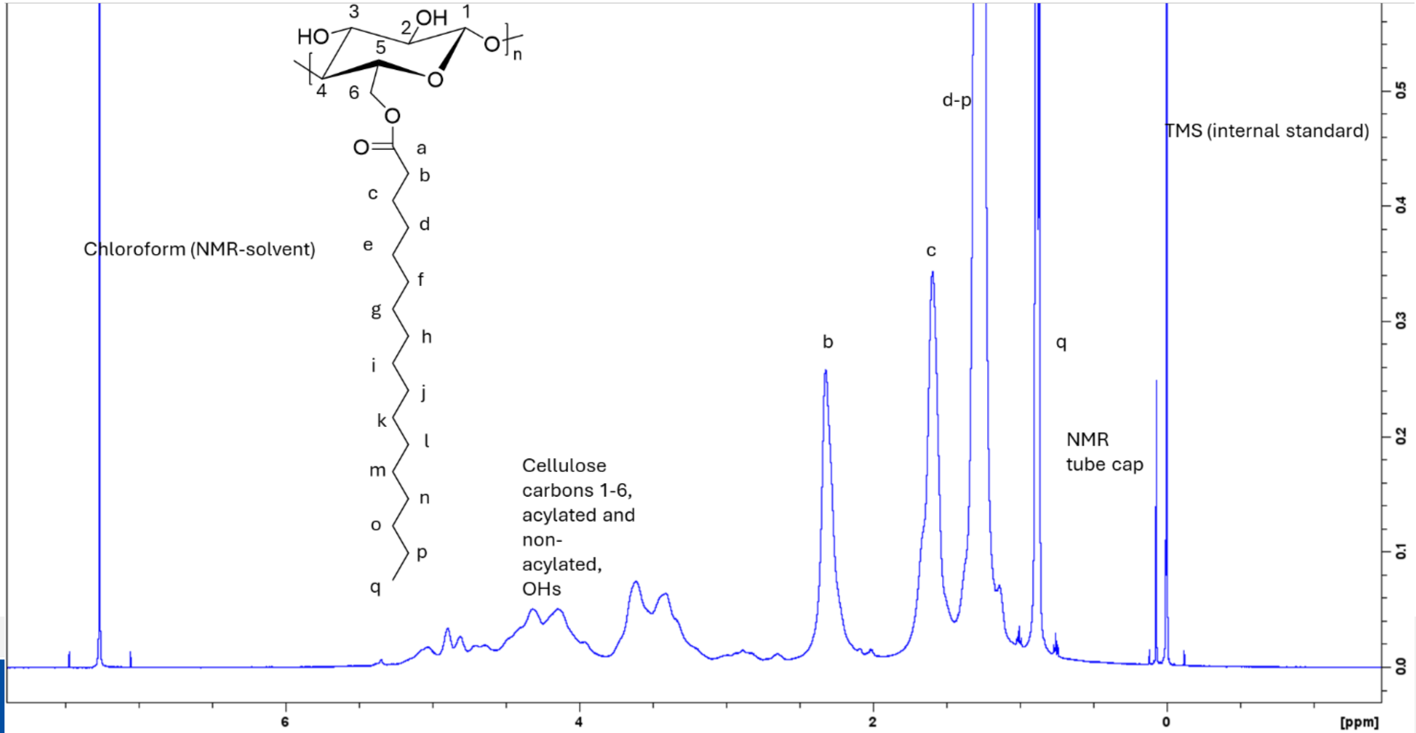
Characterization

- The main method for characterization of the materials has been nuclear magnetic resonance spectroscopy (NMR).
- The sample is placed on a magnetic field and subjected to a radiofrequency pulse.
  - The signal in the receiver coil allows determination of chemical structure



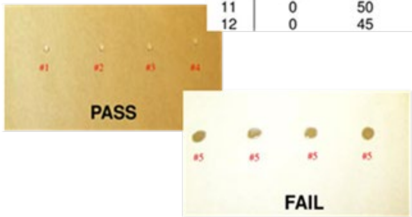
Barrier targets

METHOD	MINIMUM TARGET	ULTIMATE TARGET
KIT test	≥ 7	12
VTT method	6 h	5 d
Cobb (30 min)	< 30 g/m²	≤ 10 g/m²

OIL/GREASE BARRIER

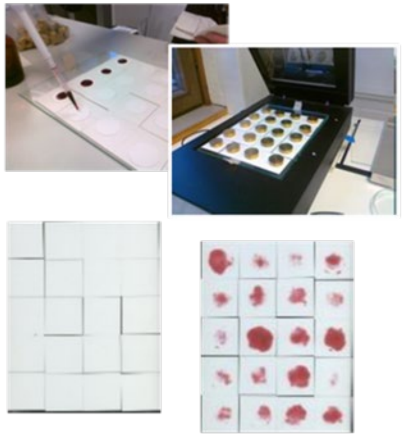
KIT test (TAPPI T559)

Value	Castor Oil (% vol.)	Toluene (% vol.)	n-Heptane (% vol.)
1	100	0	0
2	90	5	5
3	80	10	10
4	70	15	15
5	60	20	20
6	50	25	25
7	40	30	30
8	30	35	35
9	20	40	40
10	10	45	45
11	0	50	50
12	0	45	55



Result: Highest liquid number not causing visible change in coating.

VTT method



Result: Area (%) of substrate with staining on reverse as function of time

Also other test methods possible

WATER BARRIER

Cobb water absorptiveness (ISO 535:2014, TAPPI T-441)

Result: Water absorbed into a sample with specific area during speciic time

COATED 3D SHAPES

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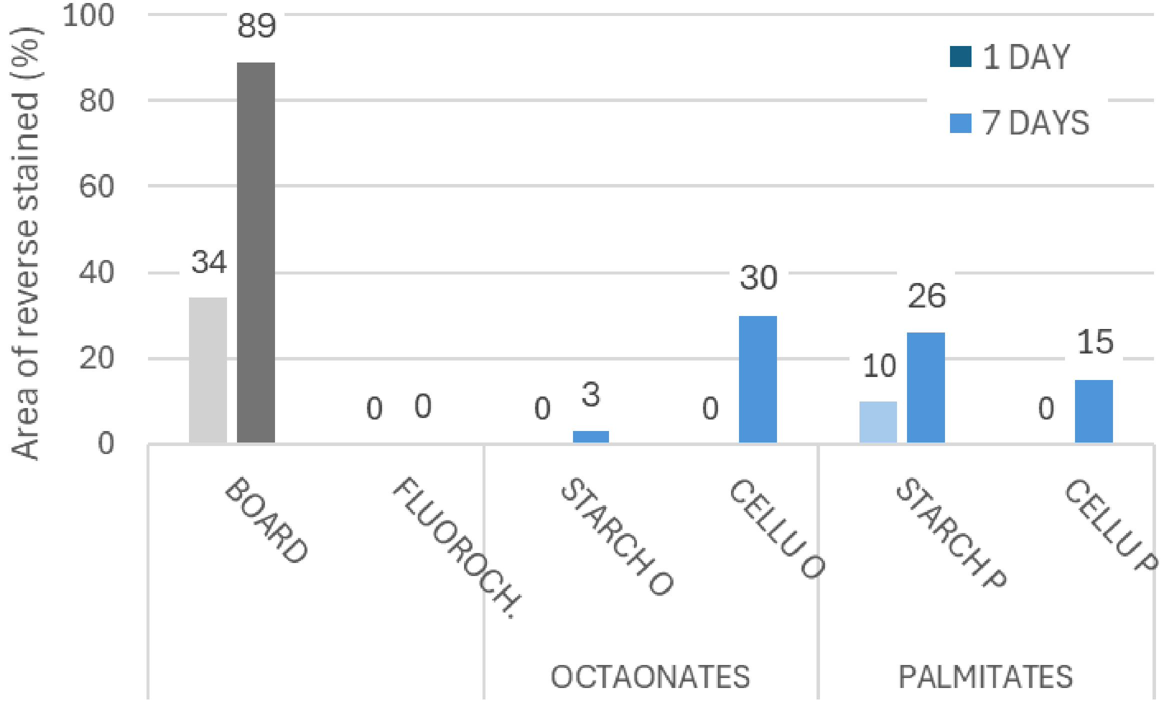
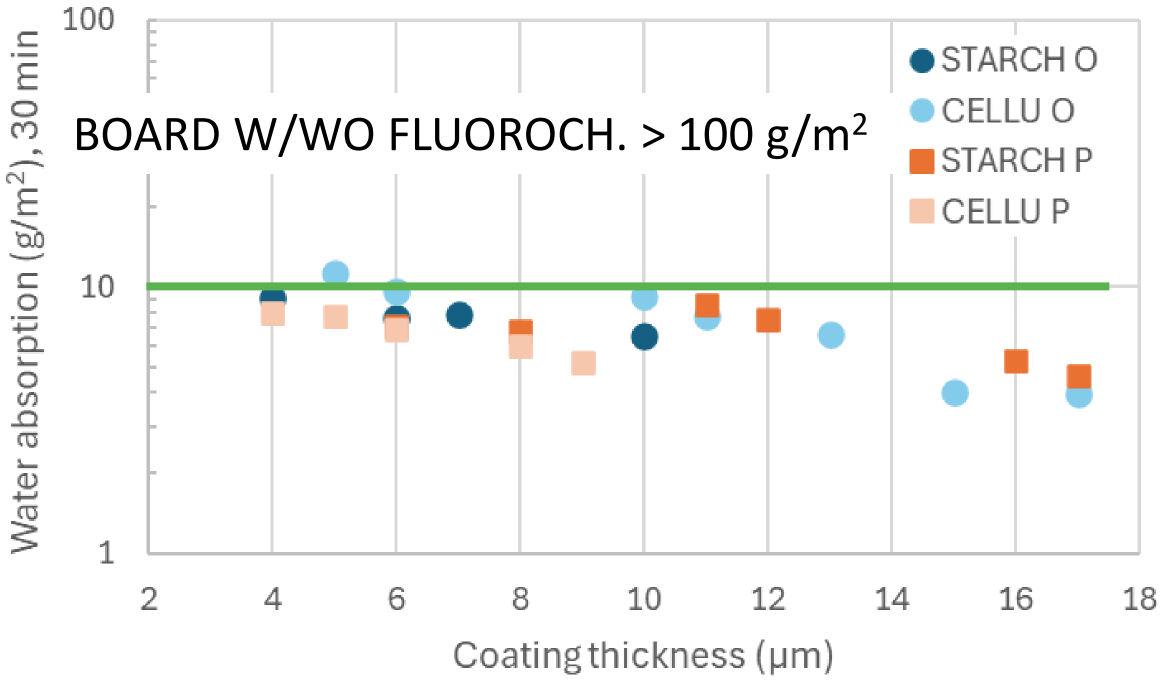
Polysaccharide esters – initial screening

OLIVE OIL BARRIER AT 40 °C



WATER BARRIER (COBB 30 MIN)



SEVERAL DERIVATIVES MET MINIMUM TARGET

SEVERAL DERIVATIVES MET ULTIMATE TARGET

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RESULTS TO BE PUBLISHED

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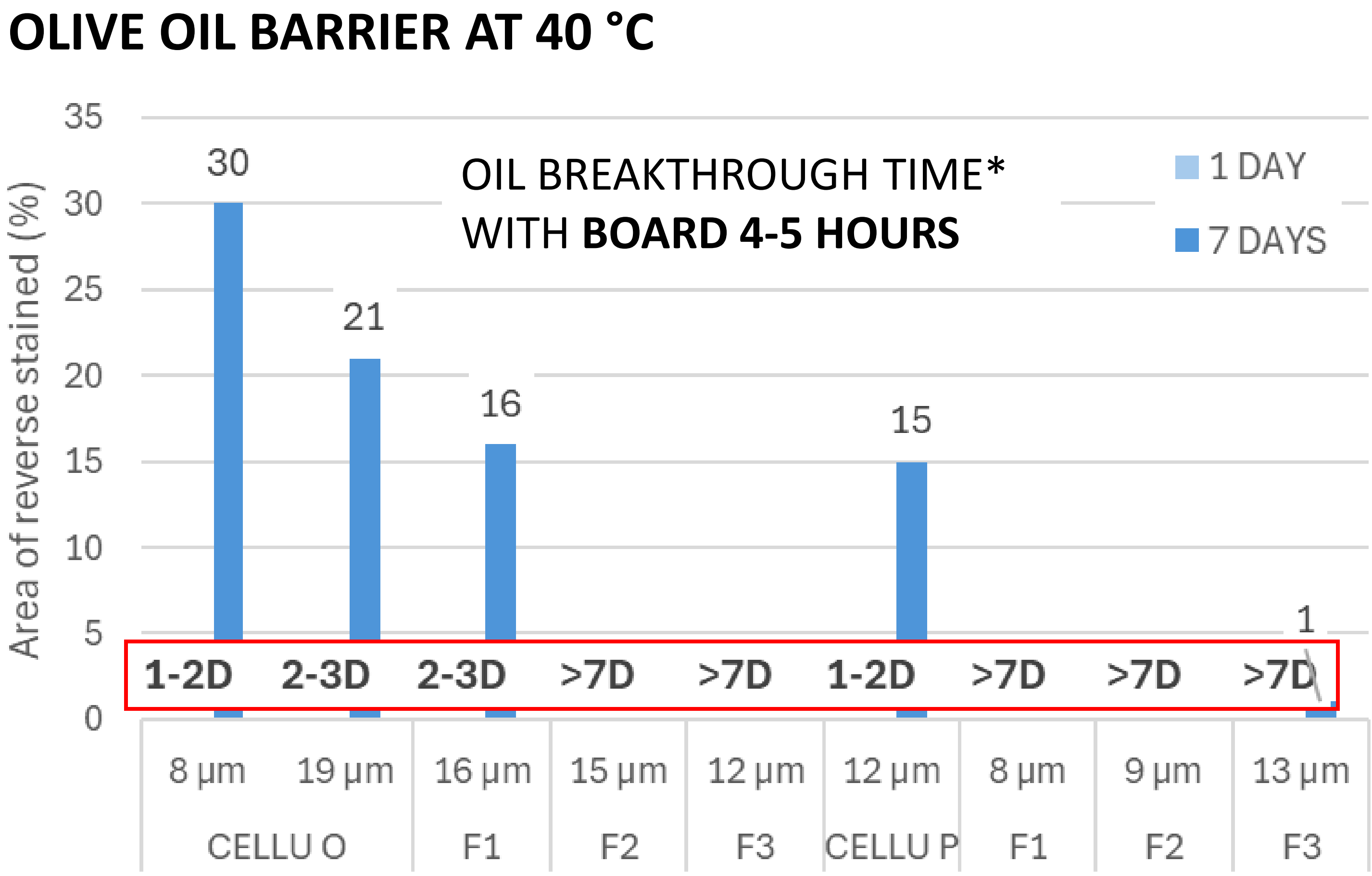
Formulations for enhanced barrier

- Ultimate barrier target was reached without impairing water barrier,
- Best KIT value 8 meeting the minimum target,
- Novel derivatives were also synthesized providing both oil barrier and oleophobicity similar to those of the fluorochemical reference.



* TIME WHEN AT LEAST 2 OUT OF 5 PARALLEL SAMPLES HAD STAINING OF 2%

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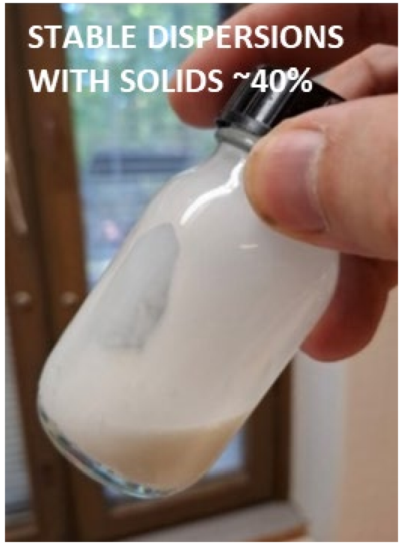
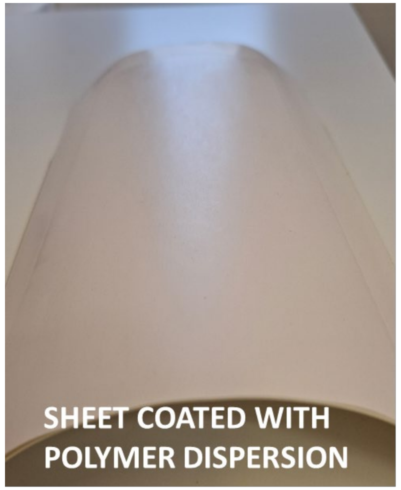
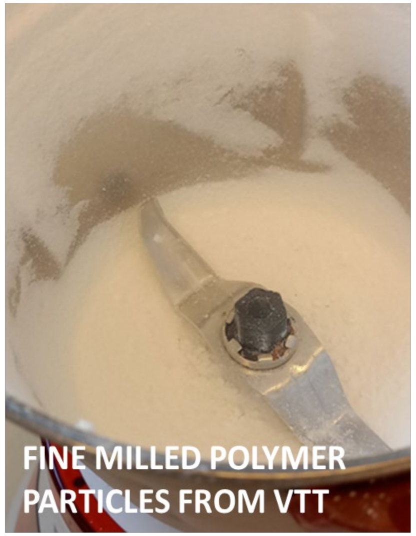
Coatings and their performance







		OLIVE OIL BARRIER (40 °C)	
	COBB 30 MIN	AFTER 1 D	AFTER 7 D
BOARD 1	> 100 g/m²	34%	89%
DISPERSION 1	63 g/m²	0%	10%
DISPERSION 2	16 g/m²	0%	21%

		OLIVE OIL BARRIER (40 °C)	
	COBB 30 MIN	AFTER 1 D	AFTER 7 D
BOARD 2	75 g/m²	64%	N.A. (100%)
POWDER 1	2 g/m²	0%	11%
POWDER 2	3 g/m²	0%	0%

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RESULTS TO BE PUBLISHED

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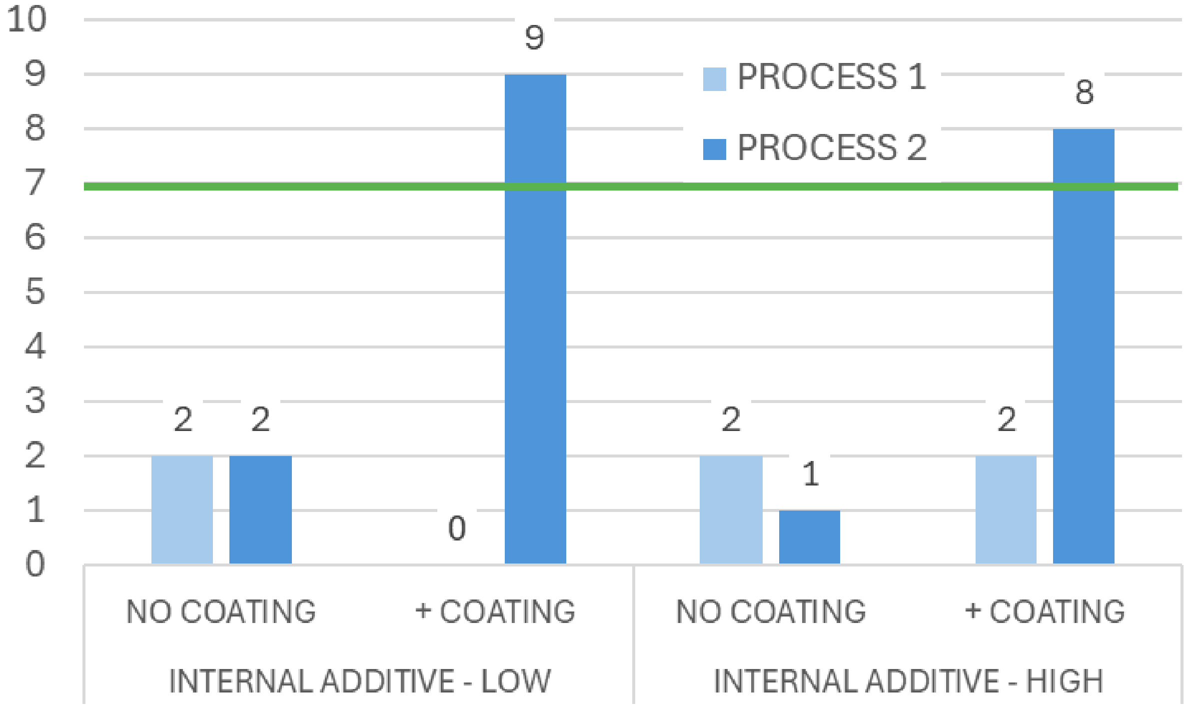
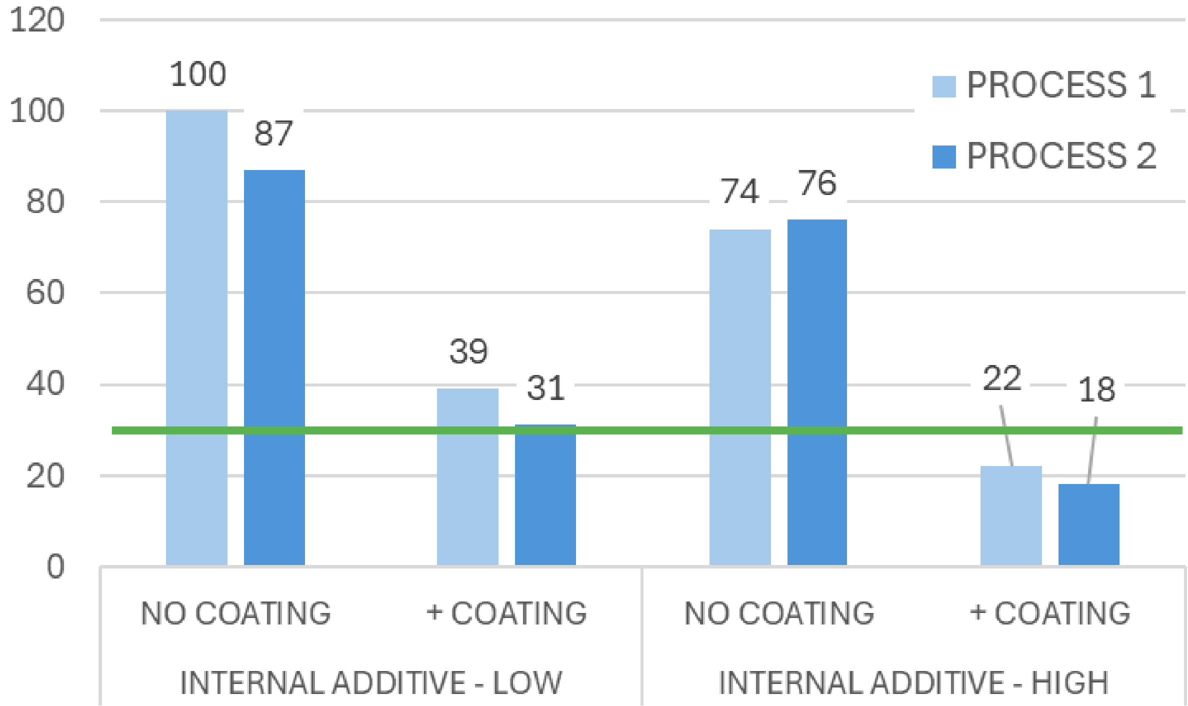
Examples of coated 3D shapes

GREASE RESISTANCE (KIT)



WATER BARRIER (COBB 30 MIN)



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Takeaways

- Novel polysaccharide-based coating materials were developed offering viable alternatives for the current fossil-based materials in packaging applications.
- These were made by reacting cellulose and starch with long chain fatty acids, and the properties were adjusted by the reagent ratios.
- These polymers demonstrated potential for water and oil/grease barrier, and barrier performance was successfully improved further by formulation.
- They were processed into water-based dispersions and dry powders and coated onto fiber-based sheets and 3D shapes with promising performance.
- The overall performance of the final packaging material can be further enhanced by optimizing the process conditions and using specific additives in the fiber furnish.

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Coffee Break

30 min

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Understanding and Engaging Consumers

Tom Tamlander
(VTT)

Eddo Da Silva Rosa
(LGI)

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PFAS-Free Acceptance: What Matters Now

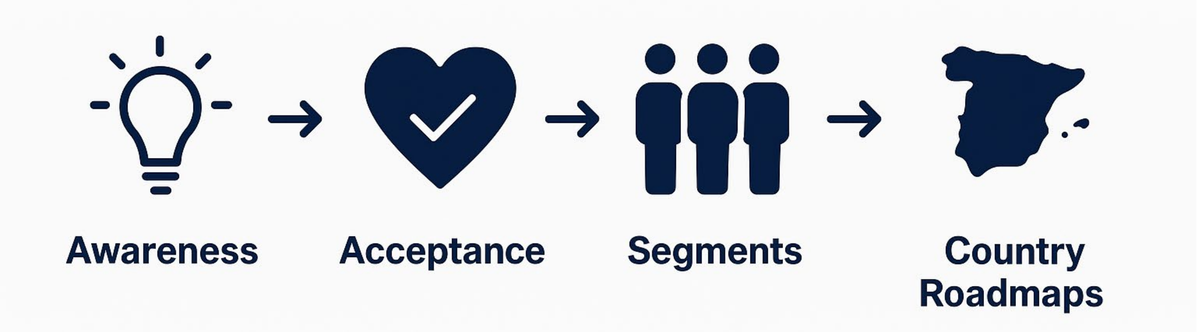
Focus on **consumer acceptance** of PFAS-free (Per- and Polyfluoroalkyl Substances) across four countries.

Cover: topline trends, awareness, benefits & worries, behaviours, categories, main drivers, willingness to pay (WTP), diffusion segments, and **country roadmaps** with a light business lens.

Outcome: a **clear roadmap** for credible PFAS-free adoption per country.

Total Sample Size (N): 1,500 respondents

Country	Respondents (N)	Percentage of Total
Luxembourg (LUX)	100	6.7%
Finland (FIN)	500	33.3%
Spain (ESP)	500	33.3%
France (FRA)	400	26.7%



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Topliners: The Signal in the Noise

Low PFAS awareness, but **high openness** to PFAS-free if everyday use is unchanged.

PFAS-free preference strongest in food packaging, followed by textiles.

Consumers reward: **no performance loss**, **simple proof**, **no drama**.

Industry & policy context: regulation is tightening → transition is no longer optional.

PFAS-free packaging: strong preference

PFAS-free textiles: strong but proof-sensitive

PFAS knowledge: patchy

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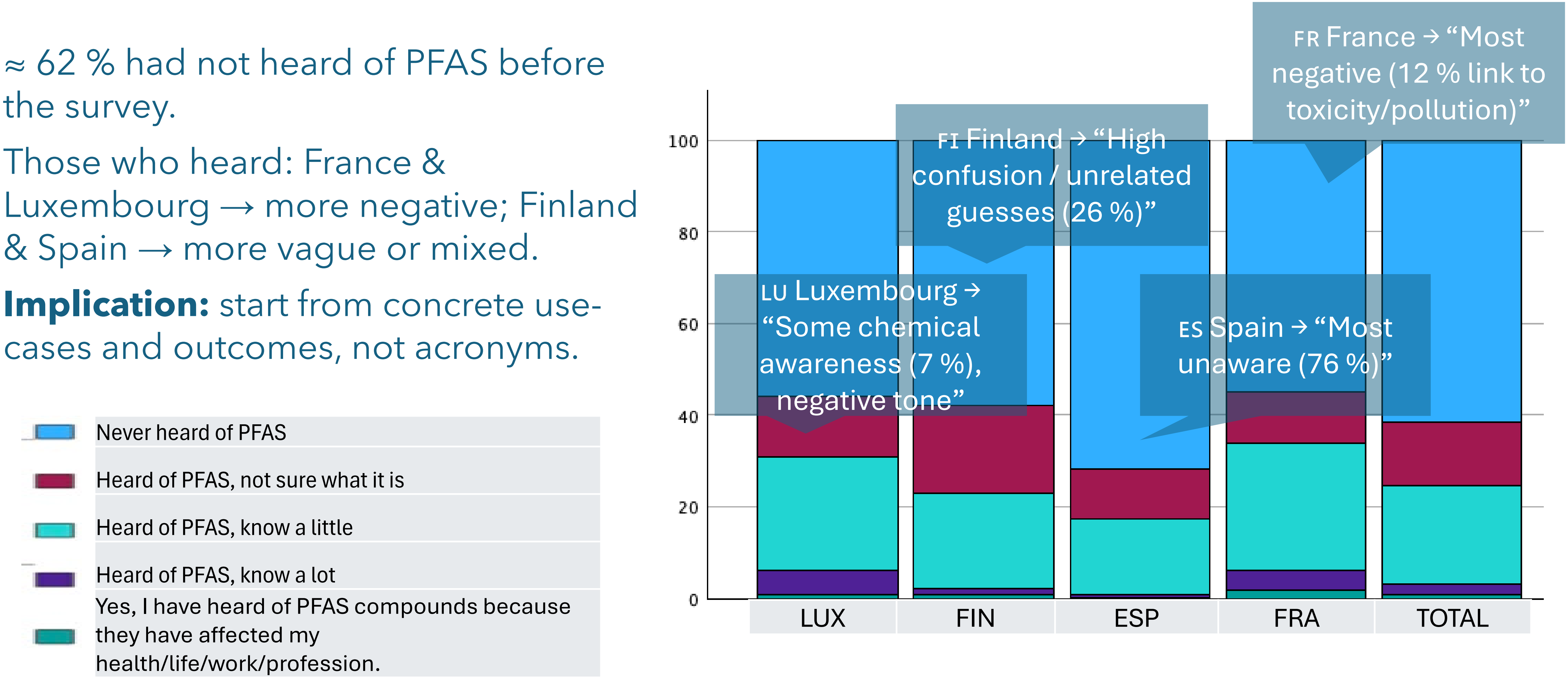
Have you ever heard about PFAS?

≈ 62 % had not heard of PFAS before the survey.

Those who heard: France & Luxembourg → more negative; Finland & Spain → more vague or mixed.

Implication: start from concrete use-cases and outcomes, not acronyms.



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Perceived PFAS Landscape

High suspicion: non-stick pans, outdoor gear; plastic toys (esp. FIN)

Moderate suspicion: cosmetics (esp. LUX), carpets, food packaging (esp. ESP)

Implication: focus attention on real high-exposure categories

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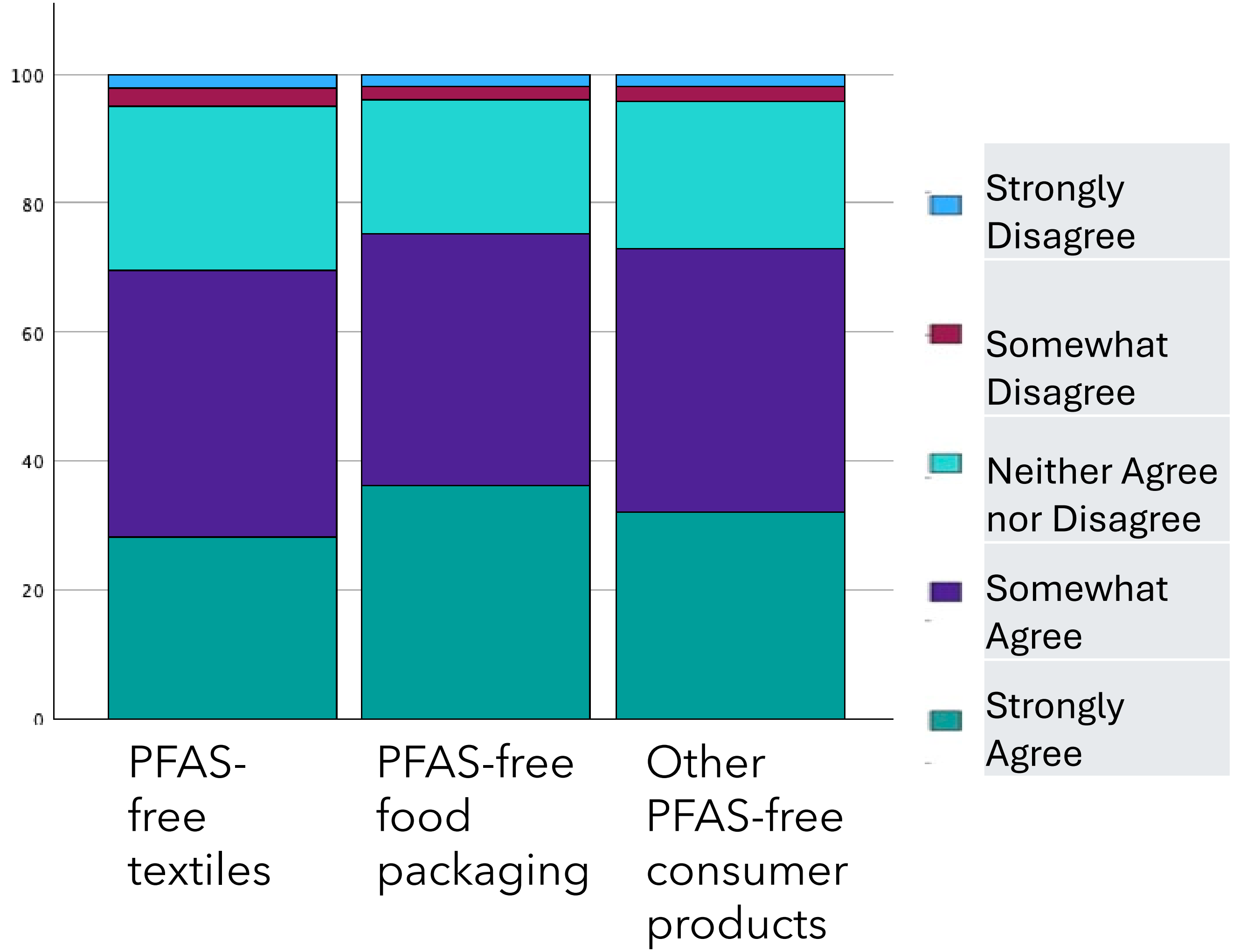
Categories: Where Expectations Are Strongest

- Overall food packaging is preferred most (≈75% agree); textiles and other products also have broad support (≈70%).
- **Country Comparison:**
  - Preference for PFAS-free is **strongest in France and Spain** (≈80% agree).
  - **Finland** shows the **highest "neutral" share**, especially for other consumer products.



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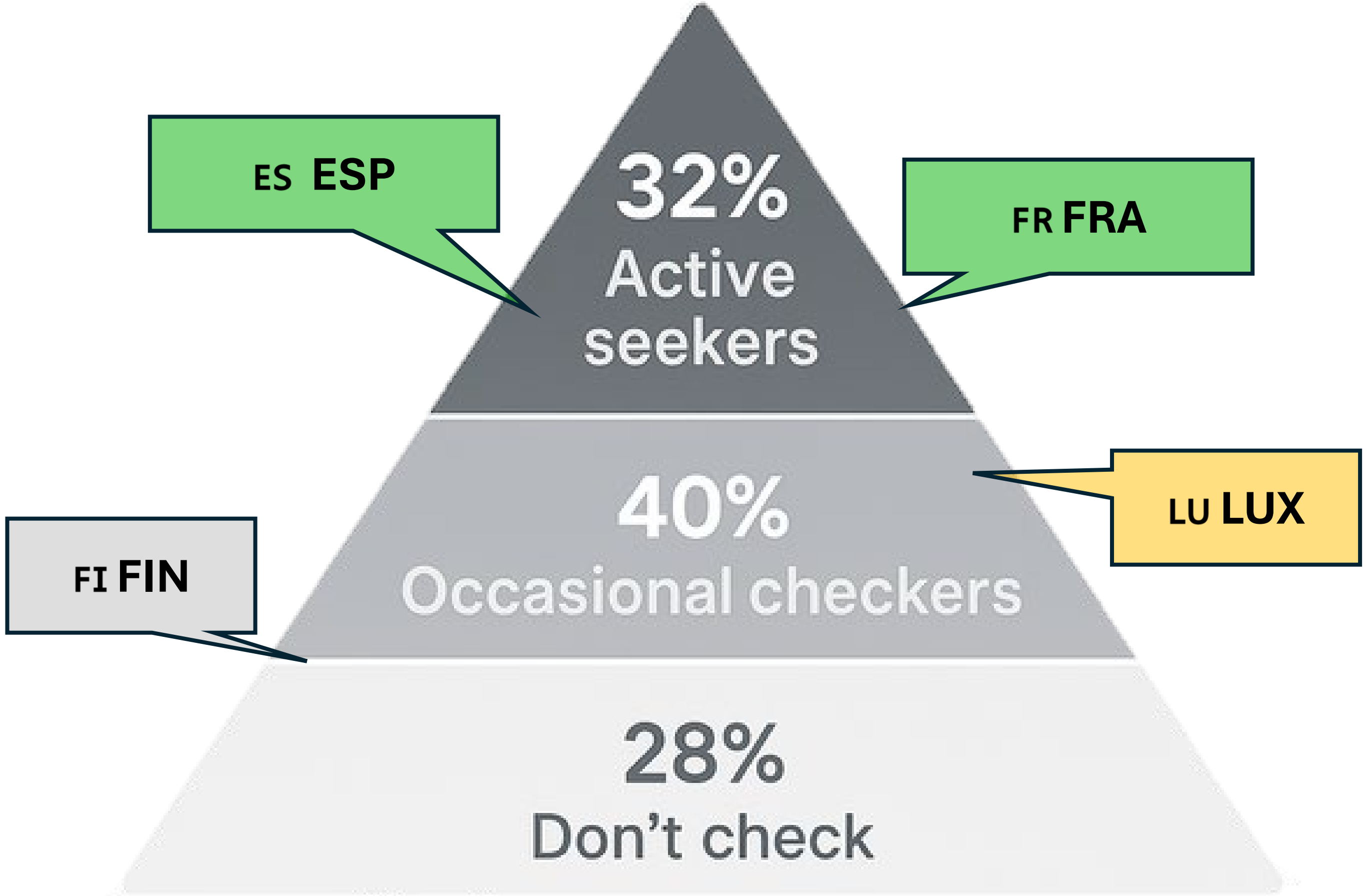
Actively seeking PFAS-free alternatives in consumer products (country comparison)

≈ 32% actively seek PFAS-free options; higher in Spain and France; lower in Finland and Luxembourg.

Label reading highest in France/Spain; lowest in Finland/Luxembourg.

→ There is a solid base of seekers, but many people still rely on defaults rather than label reading



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PFAS-free Acceptance Is Conditional

Country	Tone	Top perceived benefits	Main concerns / barriers
France FR	High concern; high readiness	Health & safety; Environmental protection; Transparency rewards (QR/data)	Price/premiums; Greenwashing risk; Performance (esp. textiles)
Spain ES	Emotionally engaged; proof-sensitive	Health & family safety; Environmental responsibility; “Future” framing	Needs visible proof; Performance (leaks/stains); Price
Finland FI	Pragmatic; trusts institutions	Reliability/safety by default; Institutional testing assumed	Performance penalty (waterproof/seal); Price/effort; Low label attention
Luxembourg LU	Rational; data-first	Clean/safe materials; Standards/compliance; Some technical awareness	Price sensitivity; Over-claim fatigue; Trust needs data

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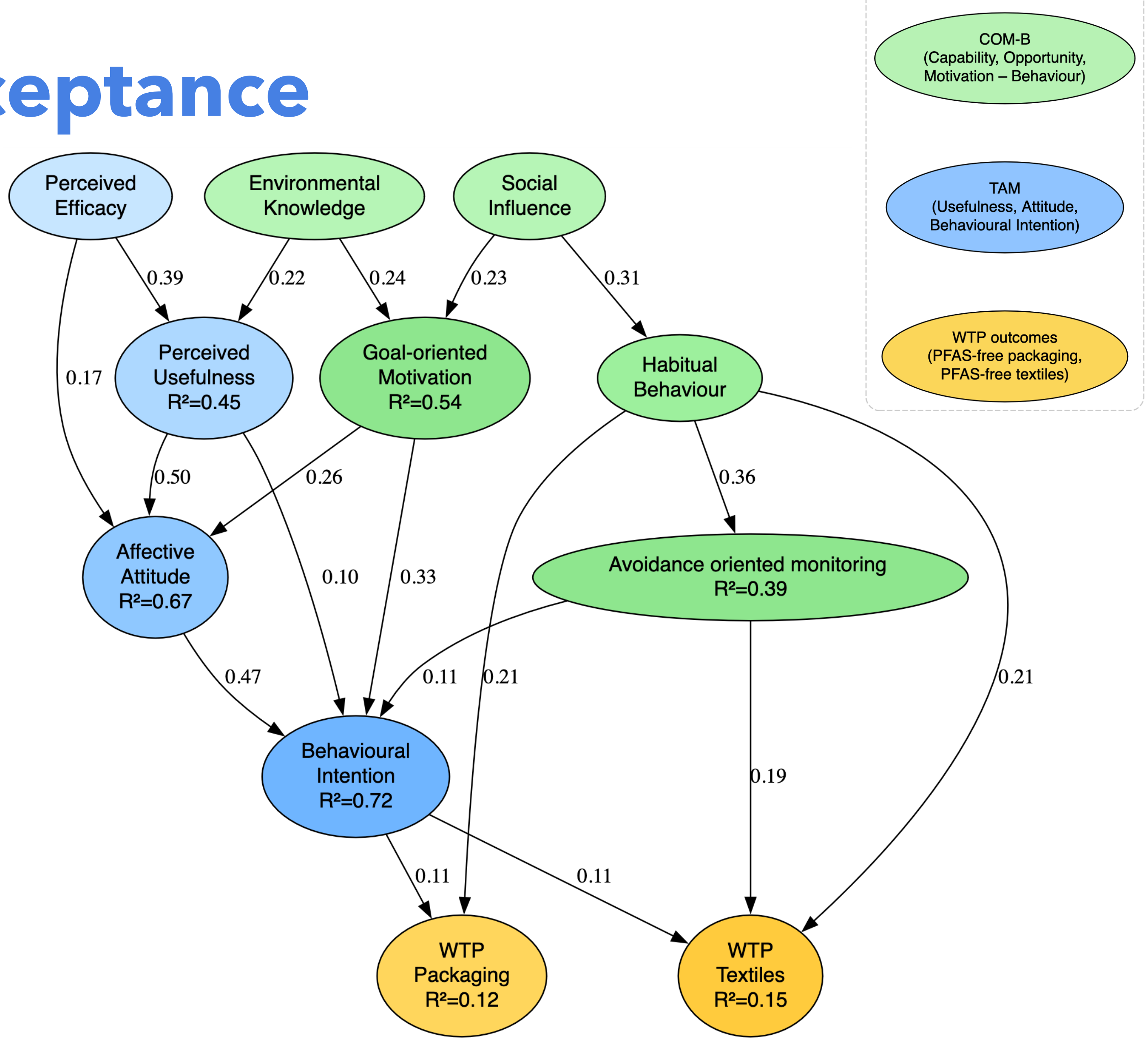
What Really Drives Acceptance

Positive feelings about PFAS-free → strongest driver of **intention to choose**

Everyday "green" routines & PFAS avoidance → **main driver of paying more**

Proven usefulness & efficacy → strengthens both



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Integrated PLS-SEM model explains ≈ 72% of Behavioural Intention

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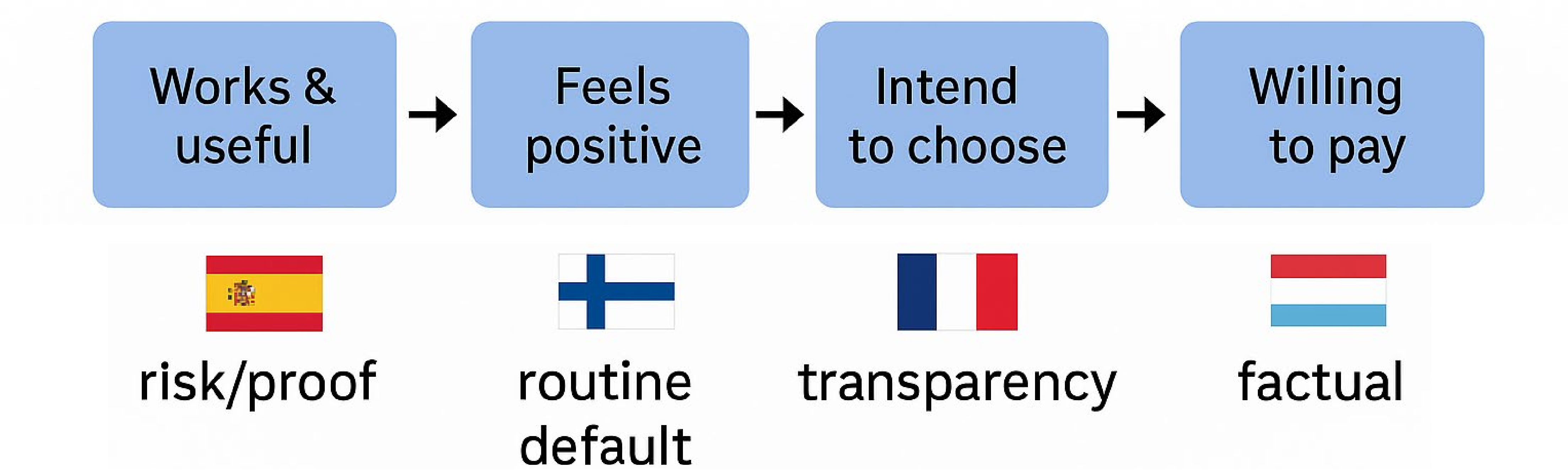
Willingness to Pay: Who Pays, For What, When



Lead with risk + visible proof: emotive benefits plus strong PFAS-free / hazard cues and simple test info (e.g. QR).

Make a silent default: same price & performance, backed by peer norms and practical care guidance.

Use credible labels + transparency: clearly state who tested what and when, with easy access to lab results.

Go factual with eco-defaults: pilots with trusted retailers, standard-based labels and small nudges to switch.

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Consumer segmentation and core traits




Segment	Enthusiastic Adopters	Cautious Optimists	Informed Skeptics	Resistant Traditionalists
Share of Sample	**37%**	**17%**	**17%**	**29%**
Demographics	Mixed gender; slight skew to women; strong presence of Generation Y and Generation X; engaged Baby Boomer women; **“values + verification” crowd.**	Often women; mix of Generation Y, Generation X, and Boomers (varies by country); **pragmatic, risk-aware, not activist, focused on personal health**	More Generation Y/Z; often men in Spain and France; also Generation X women and Boomer men in Luxembourg; **intellectually engaged, hard to persuade.**	Predominantly men; strong presence of Generation Y and Generation X; includes older males; “**do not bother me unless it breaks my routine.”**
Country over-representation	Strong in France, Spain, and Finland; present in Luxembourg.	Over-represented in Spain and France; present in Finland and Luxembourg.	Concentrated in Spain; pockets in Luxembourg.	Over-represented in Finland and Luxembourg; also parts of Spain and France.
Core traits & behavioural profile	**Very positive attitudes; strong intention to choose PFAS-free;** high perceived usefulness and perceived efficacy; **actively avoid PFAS (read labels, seek information); often advocate or recommend PFAS-free.**	**Recognise benefits and ease of PFAS-free; generally positive but less intense; want reassurance and low effort**; move when defaults, guarantees, and clear proof are in place; **PFAS knowledge typically low to moderate.**	**High prior knowledge with moderate concern; sceptical about performance, price, and authenticity**; inspect evidence; some avoidance but conditional; challenge weak or inflated claims.	**Low knowledge, low concern, and low intention; lowest perceived benefits**; rely on habit, price, and convenience; sceptical of “green” messaging; behaviour shifts only when forced or entirely frictionless (defaults, regulation, price parity).

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Willingness to Pay (WTP) by Segment: Quick Guide

Enthusiastic Adopters (37%) – High WTP in packaging and textiles; least price-sensitive when performance is proven and labels are transparent → use for early PFAS-free launches and moderate premiums.

Cautious Optimists (17%) – Above-average WTP once reassured; move when PFAS-free is the low-friction default, especially in packaging → convert with defaults and simple reassurance.

Informed Skeptics (17%) – Pay more only with strong, independent proof, especially in textiles → target with data and conservative, well-evidenced claims.

Resistant Traditionalists (29%) – Very low WTP; change comes via regulation, procurement and PFAS-free defaults at the same usability and cost → don't chase premiums; rely on defaults and compliance.

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Country Roadmaps: What to Do Where (Consumer Lens)

Proof-first (ESP/FRA) · Default-first (FIN) · Factual-first (LUX)

Spain ES

- Lean on Enthusiastic Adopters + Informed Skeptics.
- Use **risk (emotive) + visible proof** at point of use; strong front-of-pack cues.

France FR

- Strong Enthusiastic Adopters; some Skeptics.
- Lead with **radical transparency, QR-linked test data**, name **independent labs** and thresholds.

Finland FI

- Strong gender split between Enthusiastic Adopters and Resistant Traditionalists (Cautious Optimists also present).
- Make PFAS-free **silent default**; emphasise reliability; no extra effort or price change

Luxembourg LU

- All four clusters; more Skeptics/Traditionalists.
- **Neutral, data-first** claims; rely on **standards & documentation** (no emotive framing)

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What This Means in Practice – Packaging vs Clothing

integrating company expectations

Topic	Packaging	Clothing & Textiles
Consumers	PFAS-free fine if nothing else changes: **no leaks, no sogginess, no taste/odour.** Prefer PFAS-free as the normal option, not a special eco choice.	Accept PFAS-free if **clothes perform the same after washing.** Will pay more only when **durability and comfort** are clearly shown.
Companies	PFAS-free coatings work when **tuned for grease, moisture and sealing on existing lines**. Scaling easier with **shared tests and standardised compliance documentation.**	Alternatives exist but **are more sensitive** and **costly; must balance repellency, breathability and comfort**. Need clear **use-classes** (basics vs outdoor) and **after-wash rules.**
Roadmap	**Companies are ready to move toward PFAS-free as the default where performance is proven.** Lock in leak-free performance before big claims. **Use a simple common test set + periodic independent checks,** so suppliers know the target.	Start with **basics and mid-demand items,** then move to **tough outdoor gear**. Show **after-X-washes results** and **clear care tips**. Use a **textile test set** (water repellency, water resistance, wear, UV) and **retest after changes,** so brands and suppliers can rely on it.

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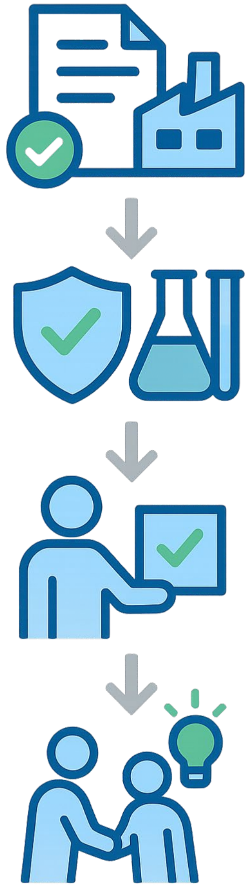
What This Means for Companies and Other Stakeholders in the Next 5 Years



Align regulation, markets and expectations

- Make PFAS-free the **default where performance is proven** and give **clear, predictable rules** so early movers aren't penalised.

Back credible proof, not louder claims

- Use a **simple claims ladder, shared test set and independent checks** so PFAS claims mean the same everywhere.

Design change around real people, not chemistry alone

- Keep **formats working as before** and ask premiums only for **visible, verified benefits**, with clear, conservative wording tailored by country and segment.

Use collaboration to tackle the hard cases

- Run **joint pilots and pre-competitive work** on tests and specs for the toughest packaging and textile applications.

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Conclusions

01

KEEP USE IDENTICAL

02

PROVE PERFORMANC E SIMPLY

03

MAKE PFAS-FREE THE DEFAULT WHERE FEASIBLE

04

TUNE PROOF AND TONE TO SEGMENT + COUNTRY

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How to inform and raise awareness about PFAS risks and ZeroF's works

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PFAS Awareness Gap

Problem:

- Low consumer awareness of PFAS (~62% unaware).
- PFAS are harmful, posing serious health and environmental risks, and they bioaccumulate in the body and environment.

Audience Insight: Consumers vary in knowledge and comfort with new technologies - most have limited understanding of PFAS.

Need for Action: Educate consumers using relatable, everyday examples to make risks tangible.

Objective: Promote behaviour change and make PFAS-free alternatives visible, trusted, and desirable.

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Awareness Raising Campaign

Why a Campaign?

- Raise awareness to build understanding of PFAS risks
- Relatable examples make the issue tangible to the consumer
- Build trust and confidence to reduce hesitation
- Encourage adoption of PFAS-free alternatives

Concept: PFAS Awareness Video Campaign

- **Objective:** Educate on PFAS risks and safer solutions like ZeroF
- **Approach:** Address concerns (performance, comfort, safety, price, etc.)
- **Format:** Engaging series of videos that informs, reassures, and builds trust

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Storytelling Approach

Interviewing our ZeroF Expert Voices:
Provide in-depth insights into their work and give the videos and work credibility

One moderator:
accompanying viewers
throughout the complex journey

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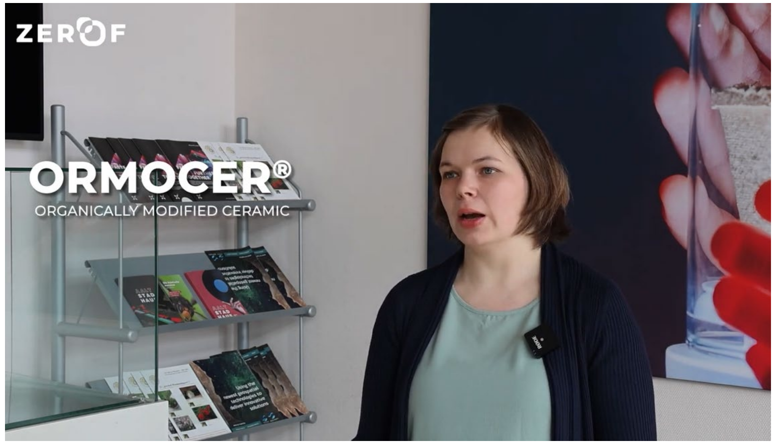
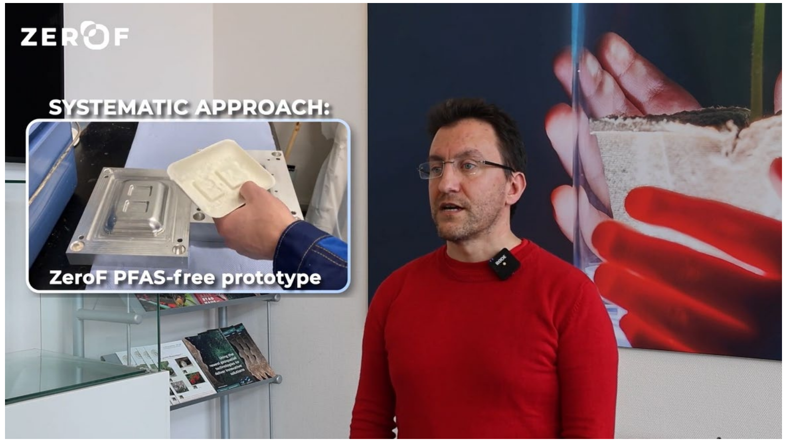
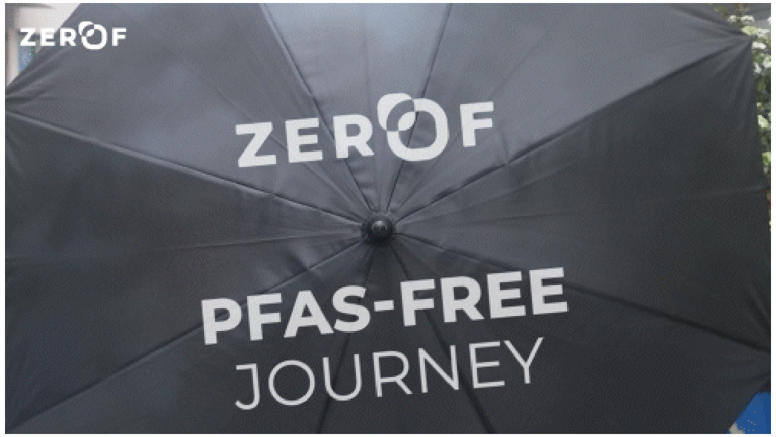
Designing an Accessible Campaign

➢ Simple visuals for complex concepts, engaging and animated sections







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Consumer Insights: 4 Personas




Segment	Enthusiastic Adopters (37.1%)	Cautious Optimists (17.3%)	Informed Skeptics (16.6%)	Resistant Traditionalists (29.0%)
Characteristics	Predominantly Baby Boomers and Generation X, **mixed gender. FRA includes different generations**	Entirely women from Generations Y, X and B **(FIN)**, Y **(LUX)**	Predominantly Generation Y and Z, mostly men **(ESP and FRA)**, X females and B males **(LUX)**	Predominantly Generation Y and X, mostly men **(FIN and LUX)**
Country Presence (total by country)	France (71.8%), Spain (50.6%), Luxembourg (16%)	Finland (48.8%), Luxembourg (16%)	Luxembourg (32%), Spain (20.8%), France (28.2%)	Finland (51.2%), Luxembourg (36%), Spain (28.6%)
TAM Insights	Highly positive attitudes toward PFAS-free products, **high proactive behavior,** and strong future behavioral intention	Perceive high value and ease of use of PFAS-free products, but **negative proactive attitudes and future intention**	**Negative attitudes toward PFAS-free products**, slight proactive tendencies	Strongly negative across all TAM factors, least perceived value and future intention to adopt PFAS-free products
Pre-knowledge of PFAS	Moderate pre-knowledge	**Low**	**High, but does not translate into positive adoption behavior**	**Low**
Perceived Benefits of PFAS-free Products	High confidence in safety, environmental benefits, sustainability, and green toxicology alignment.	Strong belief in benefits, slightly less than Enthusiastic Adopters; **trust in environmental and health advantages.**	Moderate support for benefits; **skeptical about performance** but acknowledge some environmental advantages.	Lowest perceived benefits; minimal belief in environmental or health benefits.
Perceived Concerns of PFAS-free Products	Moderate concerns about technical challenges and pricing; low concern about product effectiveness and safety.	**Higher concern about pricing** and potential price hikes; moderate concerns about authenticity.	Consistent concerns about **technical feasibility**, pricing, and performance; higher skepticism about effectiveness.	Least concerned overall, but **still wary of costs and counterfeit products; most skeptical of PFAS-free product performance.**
Level of Concern about PFAS	Highest concern about bioaccumulation, environmental persistence, and difficulty of PFAS removal.	Fairly high concern about **PFAS persistence and health risks**, though slightly less intense than Enthusiastic Adopters.	Moderate concern about bioaccumulation and environmental persistence; **less alarmed than more optimistic clusters.**	Lowest concern about PFAS; **minimal worry about accumulation or persistence**, aligning with overall resistance to environmental risk awareness.

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Targeted Messaging for each Persona

1. **Enthusiastic Adopters**
   → Love performance & sustainability
   → Message: “PFAS-free, high-quality, eco-friendly”
2. **Cautious Optimists**
   → Care about price & ease
   → Message: “Affordable, easy to switch, no compromises”
3. **Informed Sceptics**
   → Need proof & data
   → Message: “Scientifically validated, safe, reliable”
4. **Resistant Traditionalists**
   → Focus on simplicity & price
   → Message: “Practical, cost-effective, ready to adopt”

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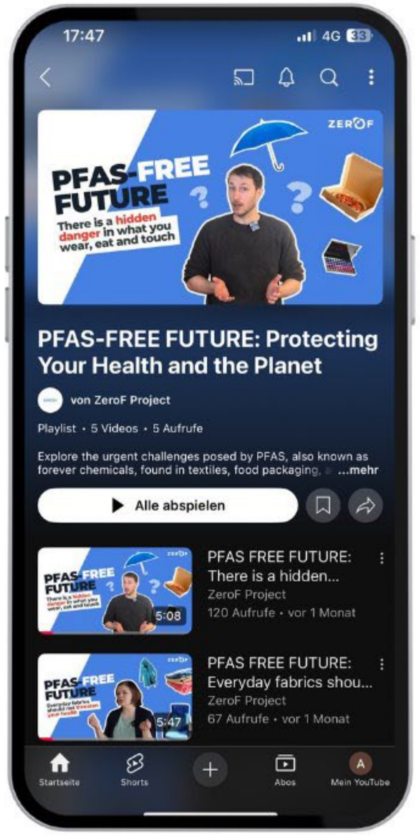
PFAS-Free Future - Educational & Engaging Video Series

Video	Target Persona
The Hidden PFAS Problem	Introduction to the Problem & ZeroF Project
PFAS in Textiles: The **Performance** Puzzle	Cautious Optimists
PFAS in Packaging: **Safety and Beyond**	Informed Sceptics
Ensuring **Sustainable PFAS Alternatives**	Enthusiastic Adopters
Cost-Effective PFAS Alternatives	Resistant Traditionalists



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Video Playlist

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Campaign Impact: Reach

Subscribers:
15

Impressions:
+24 000

Views:
390

Like ratio:
100%

Impressions:
+5 000

Views:
+3 600

Reposts:
41

Engagement rate:
9%

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Impact: Multipliers

Innovation News Network

A digital publisher focused on science, research, policy, and innovation.

Article about campaign in quaterly publication (PFAS Special Edition) & channels:

- **Website:** ~125K sessions in March 2025
- **Database for publication:** 250K+
- **LinkedIn:** ~10K followers

ECOSYSTEX Community

Promotion of the campaign on ECOSYSTEX LinkedIn (+3K Followers), Website and during an Insight Series Webinar with 60 participants.

PFAS | PROFILE

From PFAS-free alternatives to public engagement: ZeroF's video campaign on risks and solutions of forever chemicals

The Horizon Europe project ZeroF has launched a video campaign to raise public awareness about the risks of PFAS and to highlight its efforts in developing safe, sustainable alternatives. The campaign is designed to support policy goals, inform citizens, and encourage the uptake of innovative PFAS-free alternatives across Europe

FEW PEOPLE pause to consider what makes their raincoat water-resistant, their frying pan non-stick, or their takeaway coffee cup leak-proof. The answer often lies with PFAS, per- and polyfluoroalkyl substances, a family of synthetic chemicals invented for convenience and durability. But the same qualities that make PFAS useful have also caused growing environmental and health problems in recent years.

Because of their extreme persistence, PFAS do not break down once released into the environment. Instead, they accumulate in soil, water, wildlife, and even in human bodies. Scientific studies, including the large-scale C8 Science Panel investigation in the US and reviews by the European Food Safety Authority (EFSA), have linked PFAS exposure to certain cancers (such as kidney and testicular cancer), immune system disorders, and hormone-related illnesses.

How the EU is taking action

In response, the European Union is strengthening PFAS oversight through the REACH Regulation, with the European Chemicals Agency and EFSA conducting broad risk assessments. A major group-wide restriction proposal covering over 10,000 PFAS substances, led by Denmark, Germany, the Netherlands, Norway, and Sweden, is underway, with final decisions expected after ECHA's evaluations. Meanwhile, some Member States have introduced national bans or tighter rules: Denmark restricts PFAS in clothing and food packaging, Sweden leads the EU-wide proposal, and Germany enforces stricter drinking water standards and penalties. Despite progress, many hazardous PFAS remain in products and supply chains, highlighting the complexity of phasing out these persistent chemicals. This coordinated effort supports the EU Green Deal and Chemicals Strategy goals to protect health and the environment while enabling industry transition to safer alternatives.

PFAS-FREE FUTURE
ZeroF's video campaign on risks and solutions of forever chemicals
ZEROF
PFAS

As a consequence, strong and sustained policy action is essential, alongside political commitment, investment in safer alternatives, and active public involvement. Providing transparent information is key to building public understanding of health and environmental decisions. To support this effort, the Horizon Europe project ZeroF recently launched a video campaign to highlight the risks of PFAS and demonstrate how its new alternatives deliver safe and sustainable performance.

ZeroF's work on safer alternatives

The ZeroF project, launched in 2023 and coordinated by VTT in Finland, brings together twelve European partners to develop safe and sustainable alternatives to PFAS chemicals. Its main objective is to create new coatings for upholstery textiles and food packaging that offer the same resistance to water, oil, and grease as PFAS, but without the associated risks to human health or the environment. The project takes a comprehensive approach, using the Safe and Sustainable by Design (SSbD) framework to guide the development, optimisation, and safety assessment of these coatings. In addition, ZeroF includes cost-benefit analysis, social acceptance studies, and life cycle assessments to ensure the new materials are economically viable, socially accepted, and environmentally responsible throughout their lifespan. Communication is a key part of the project, helping to ensure that ZeroF's results reach industry, policymakers, and the public. This outreach is led by LGI Sustainable Innovation.

Raising awareness through video

In June 2025, the ZeroF project launched a public engagement campaign aimed at raising awareness and encouraging acceptance of sustainable PFAS-free alternatives across Europe. Building on an internal social acceptance analysis led by VTT, which surveyed people in France, Finland, Spain, and Luxembourg, the campaign delivers tailored messages that address varying levels of awareness and concerns among different European audiences, including early adopters and cautious stakeholders who are worried about product performance, cost, and technical feasibility.

This evidence-based approach ensures that communication is transparent and includes all stakeholders, in line with the EU's aim for careful chemical regulation and the promotion of safer alternatives. The campaign serves as a bridge between the scientific research taking place in the lab and the consumers who will benefit from these innovations. At the heart of the campaign is a series of videos on the ZeroF YouTube channel. These videos address the concerns of consumers by clearly presenting a systematic approach that explains the risks of PFAS, the development and safety of new alternatives, the need to avoid unintended harmful replacements, and the ways to ensure these solutions are practical and cost-effective.

The PFAS-free future: A five-part educational series

The ZeroF campaign named 'PFAS-FREE FUTURE' is structured as a five-part video series, each guided by a moderator from ZeroF's communication team who introduces viewers to the scientists and experts driving the project. This educational journey begins with an accessible overview of PFAS and their widespread health and environmental risks, establishing the urgency behind seeking safer alternatives (video 1). The series then demonstrates through real examples how ZeroF's PFAS-free coatings match or surpass the performance of conventional PFAS products, particularly in textiles, addressing a key concern for both policymakers and industry (video 2). To establish trust in these innovations, the third video focuses on the rigorous safety evaluations carried out under the Safe and Sustainable by Design framework, with a special emphasis on the development of PFAS-free food packaging. The fourth video focuses on environmental evaluation, showing how ZeroF researchers use life cycle assessment and related methods to ensure that PFAS-free alternatives deliver real ecological benefits without introducing new harms. The final video concludes with a focus on affordability, illustrating that scalable, cost-effective PFAS-free solutions are achievable and within reach for European industry. This series has been made possible through the valuable contributions and collaboration of our key partners: Fraunhofer ISC, Leitat, Luxembourg Institute of Science and Technology, LGI Sustainable Innovation, TEMAS Solutions, and VTT.

A shared responsibility to tackle PFAS

ZeroF invites EU stakeholders to watch and share the campaign videos, integrate the content into PFAS policy discussions and training sessions, and join ZeroF for its final event on 20 November in Barcelona, where the project will present its results.

"Ending PFAS pollution is a shared responsibility," the ZeroF communication team affirms. "We believe policy can move faster when the public understands what's at stake." As Europe prepares to phase out harmful PFAS chemicals, ZeroF shows that change begins not only in the lab but also in the minds of consumers. By combining scientific research, social insights, and targeted outreach, the ZeroF campaign actively supports the EU Green Deal and Chemicals Strategy for Sustainability. It helps drive policy that protects human health and the environment while encouraging innovation and the adoption of safer chemical alternatives.

ZEROF

Alina Giesler
Communication Officer
ZeroF/LGI Sustainable Innovation

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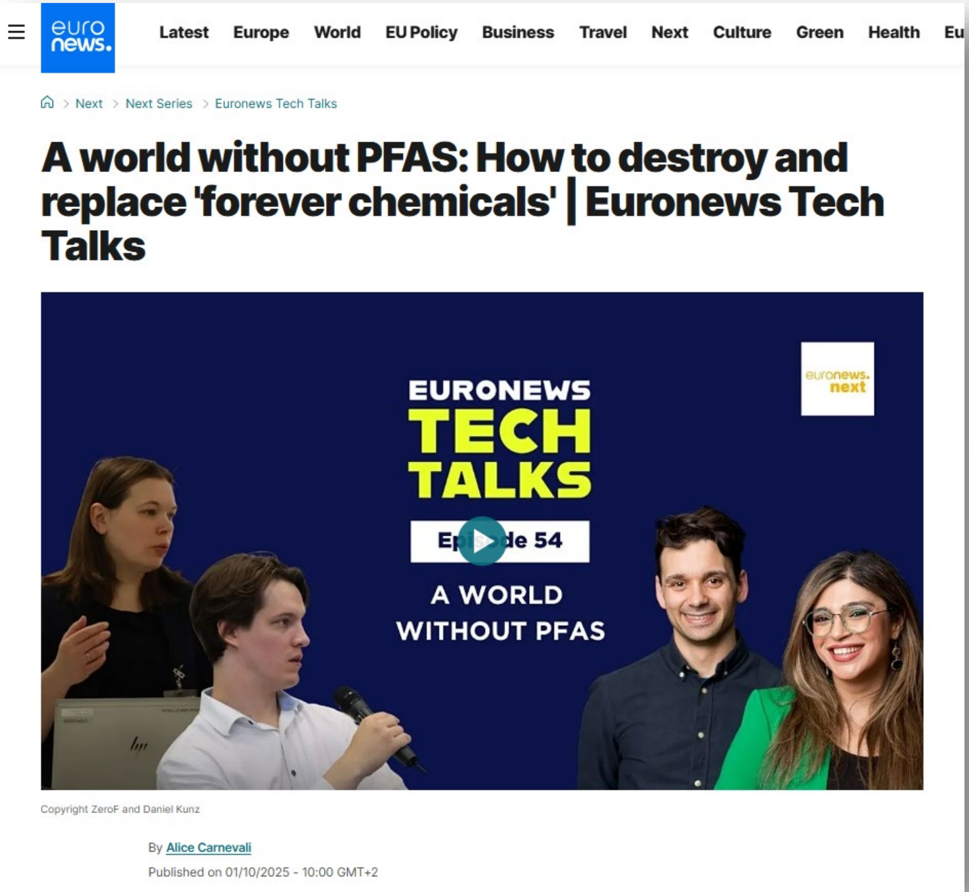
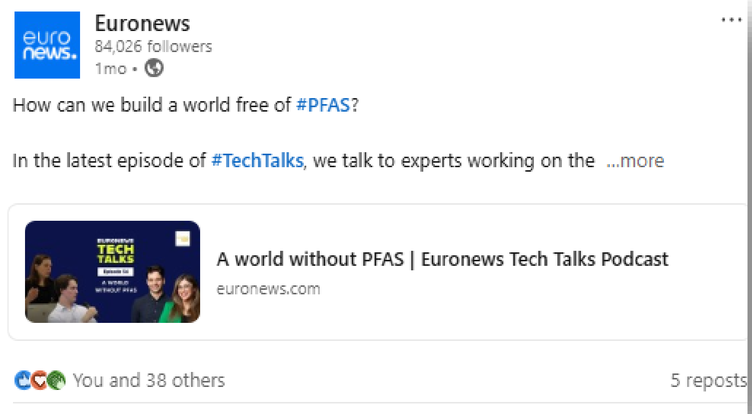
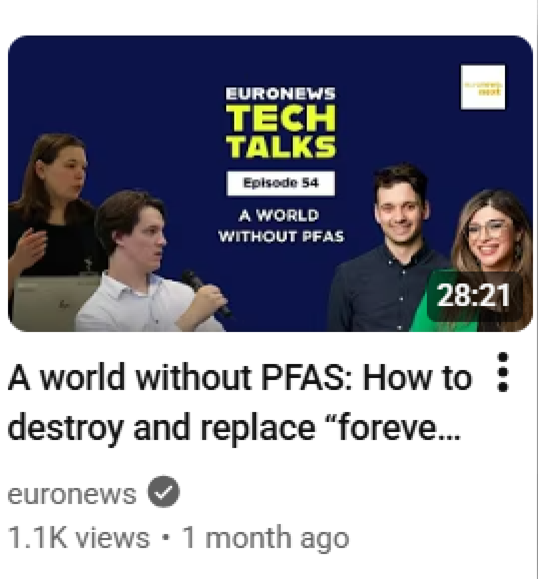
Impact: Multipliers

Awareness campaign achievement: Featured in Euronews most famous podcast format "Tech Talks"







Euronews Reach Highlights

- **LinkedIn:** +84K followers
- **YouTube:** ~2.5M subscribers, ~1.5B total views
- **Podcasts:** 1.7M downloads in 2024 (entire portfolio)
- **Digital platforms:** 31.5M monthly active users in 2024

Our Podcast edition

- Featured on euronews website, YouTube channel and LinkedIn
- **YouTube: 1,1K views** over the last month

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MAKING THE CAMPAIGN LONG-LASTING

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We welcome your questions and feedback !

Scan the QR code if you want to follow our final steps in our journey to PFAS-free coatings.

Or check out our website or newsletter!

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Panel discussion

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Panel Discussion: Sister Projects

Advancing PFAS Solutions in Europe: Challenges & Collaboration with PROPLANET PROJECT & TORNADO PROJECT

Miika Nikinmaa
Lead Biomaterial Solutions at **VTT**

ZEROF COORDINATOR

Òscar Calvo
R&D Project manager & Materials & Chem. Tech. Engineer at **AITEX.**

PROPLANET PROJECT

Raquel Rodríguez
Researcher at **TECNALIA**

TORNADO COORDINATOR

Alina Giesler
Communication Officer at **LGI**

ZEROF COMMUNICATION

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Lunch Break

60 min

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From Assessment to Action: Safe & Sustainable Design

Panagiotis Isigonis (LIST)

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ZeroF scope and solution

- Development of a new bio-based barrier material and **coating technology** for **moulded packaging** (polysaccharides combined with fatty acids).
- Development of silane-based organic-inorganic hybrid coatings (based on **ORMOCER® technology**) applicable to **upholstery textiles**.

Design safer and more sustainable PFAS-free alternatives with sufficient water and oil repellent properties

- In both solutions the target is **to achieve significant improvements in environmental impacts (>25%) without increasing the cost for consumers (<20%)**

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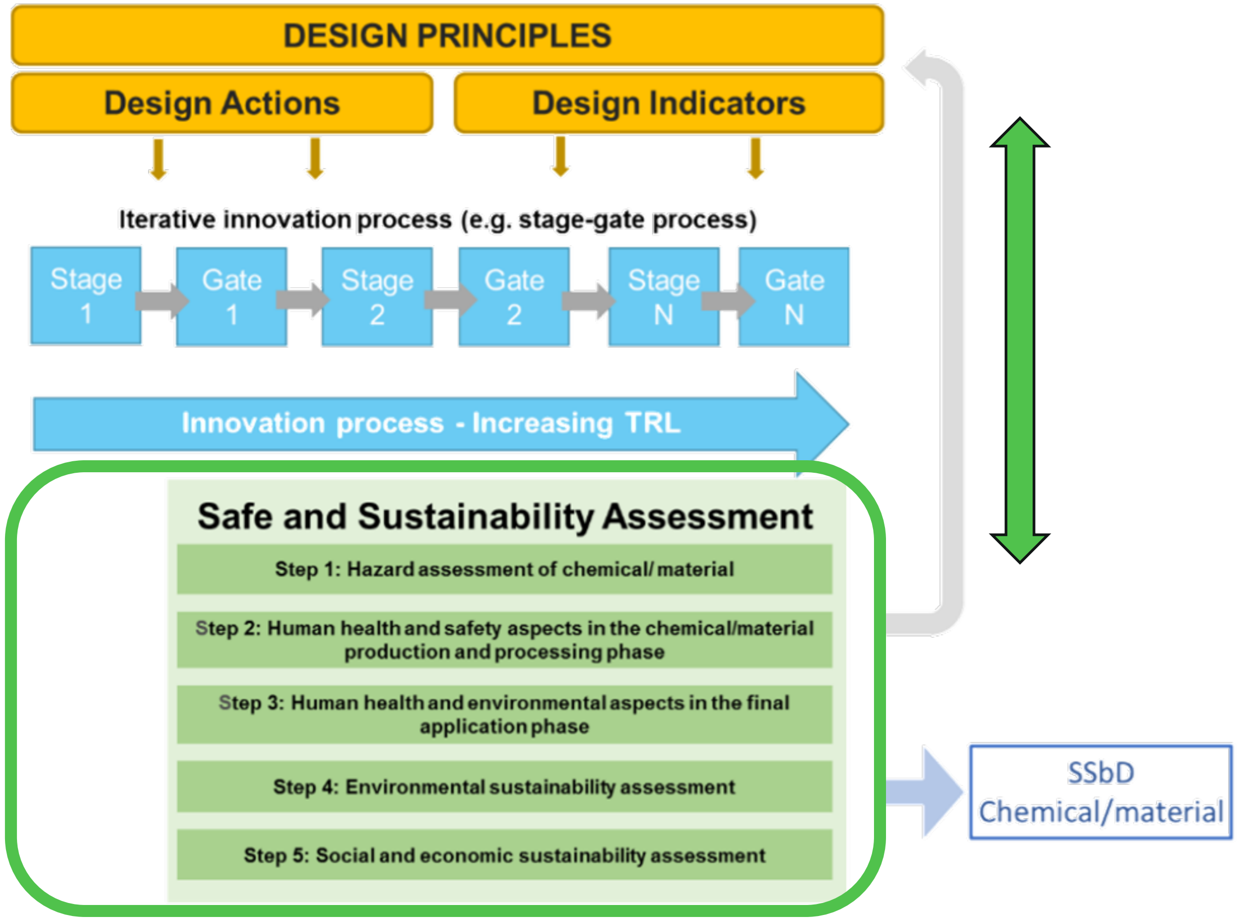
ZeroF approach to SSbD



- Multiple iterations of assessments
  - Dependency on availability of data
- Safety assessment
  - Phase out harmful chemicals
  - Steps 1-2-3
- Sustainability assessment
  - Life Cycle Assessment
- Economic assessment
  - Life Cycle Costing (LCC)
- Social assessment
  - Technology acceptance evaluation
- Integration of results / SSbD criteria
- Computational modelling - FAIRness

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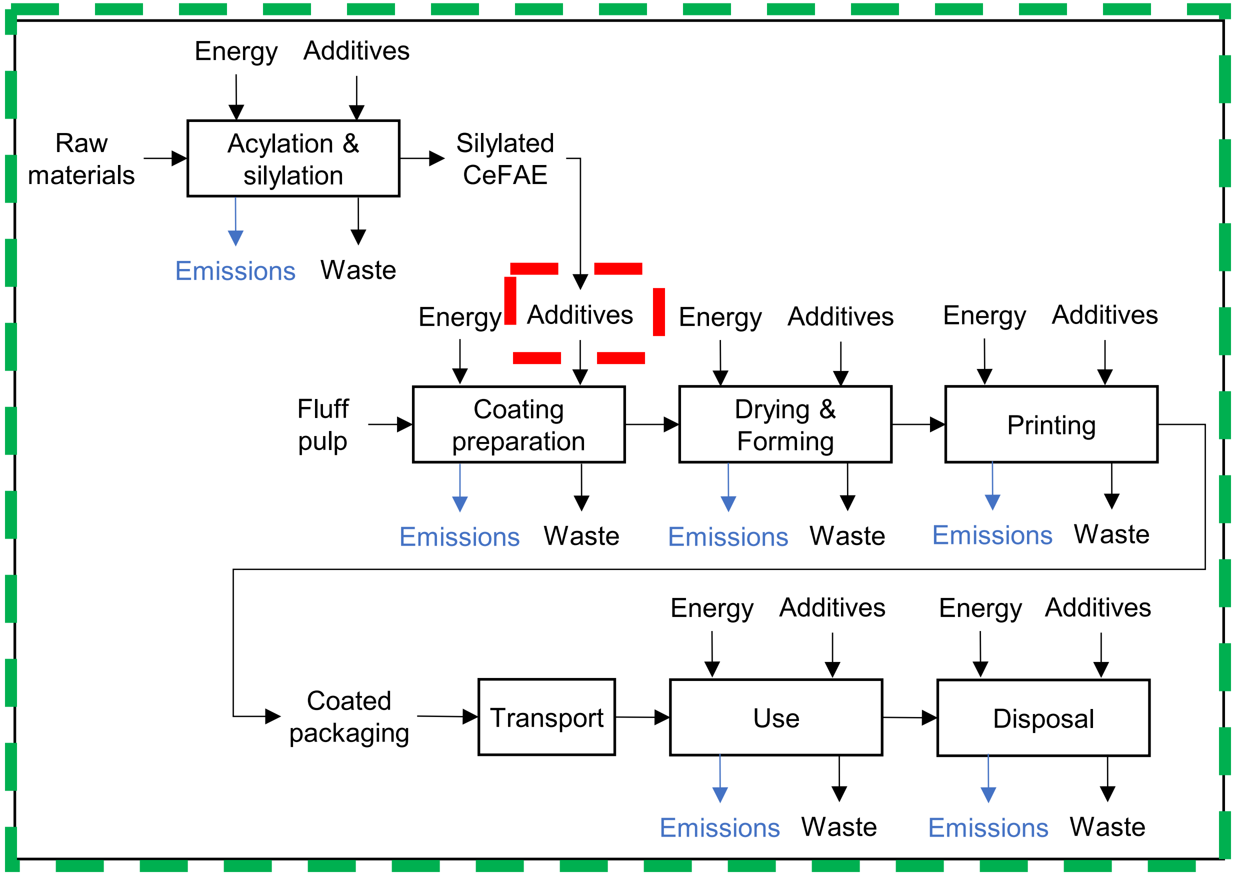
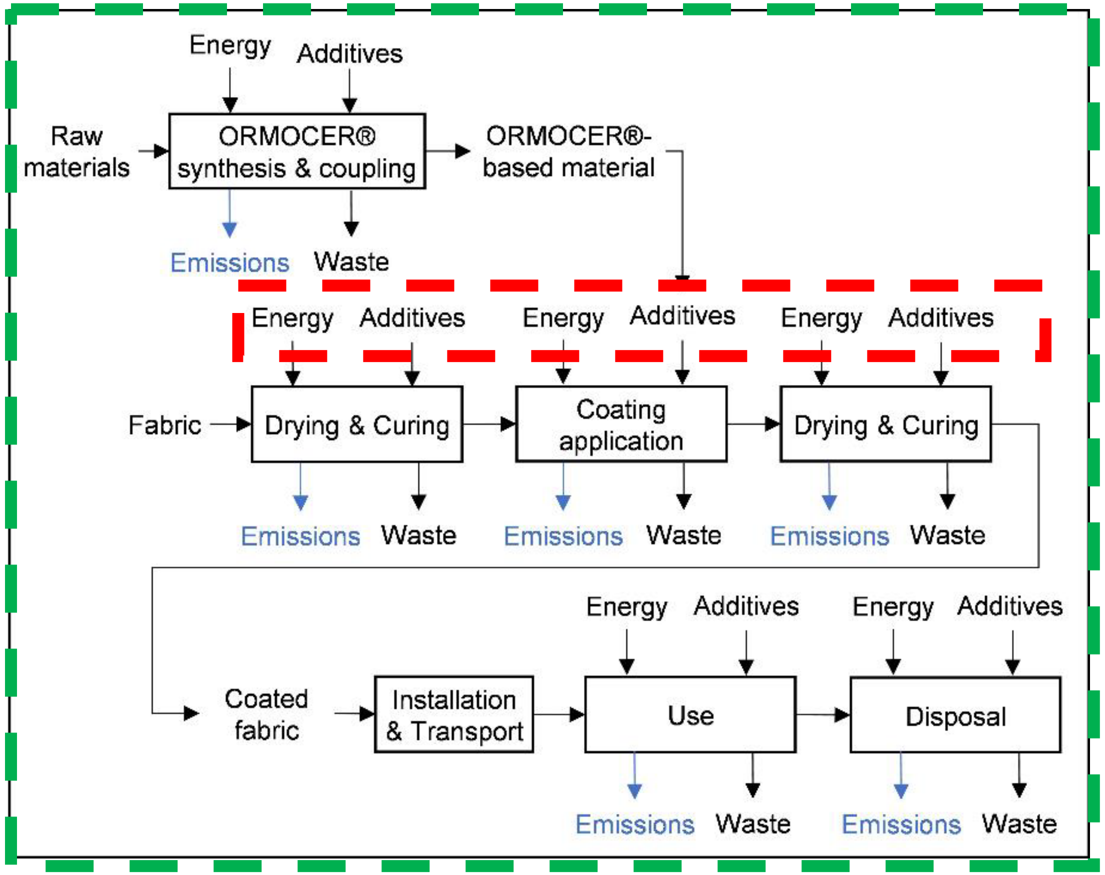
System boundaries

Packaging application



Textile application



Green dash line: SSbD boundaries / Red dash lines: Examples of screening assessments

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Building blocks and process optimisation

- Building blocks
  - Carbohydrate fatty acid ester-based coatings for packaging
  - Silane-based organic-inorganic hybrid polymers (ORMOCER®) for textiles
- Optimisations via SSbD – in parallel with process optimisations
  - (Re)design principles
  - Screening assessment of safety and sustainability (env + econ)
- Safety, sustainability and economic assessment through life-cycle
  - Eliminate the use of harmful solvents and materials
  - Replace hazardous catalysts from the beginning and along the innovation process
  - Minimise energy use, improve safety, sustainability and economic profiles
  - Assessment of additives (e.g., curing agents, solvents, dispersing agents and surfactants, crosslinking agents) case by case → improve the adhesion, flexibility, and longevity of the coating but also reduce impacts

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SSbD process and successes

- Scoping analysis → Extremely important and highly appreciated
  - Setting a common basis for the various research teams
- Screening of hazardous chemicals – Elimination of SVHC and other SoC
  - Manual and Automated
  - Cross-check of resources
- Incorporation of design principles
  - Early incorporation, supporting SSbD in multiple ways
- Identification of hotspots → Steps 1-2-3-4-5
  - Iterations with technical partners, changes applied to experimental processes
  - Potential tradeoffs
- Multiple iterations, targeted support of technical partners

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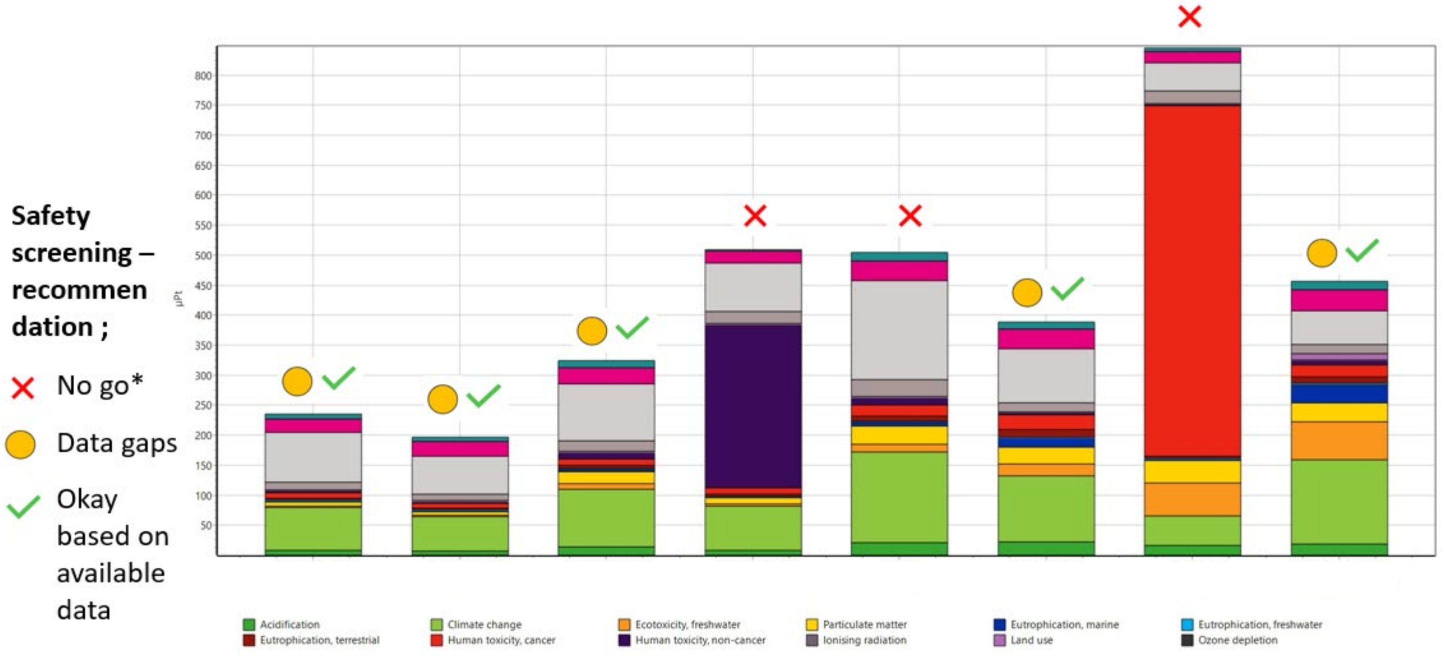
Intermediate results

- 20+ substances and materials (e.g., raw materials, solvents, additives) have been <u>substituted</u>, <u>prioritised</u> for substitution or used in <u>reduced amounts</u> in case of necessary use due to technical requirements
  - Screening of use/no use in final coating formulation
- Employment of innovative laboratory techniques to minimise use of resources (e.g., materials, energy) and reduce process emissions in the air (→ reduction of environmental impacts)

*Example of safety/sustainability screening of dispersants and more



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Safety assessment and computational modelling

Elise Morel (TEMAS Solutions)

Joanke van Dijk (TEMAS Solutions)
Nina Jeliazkova (IDEAconsult)
Panagiotis Isigonis (LIST)

ZeroF Consortium

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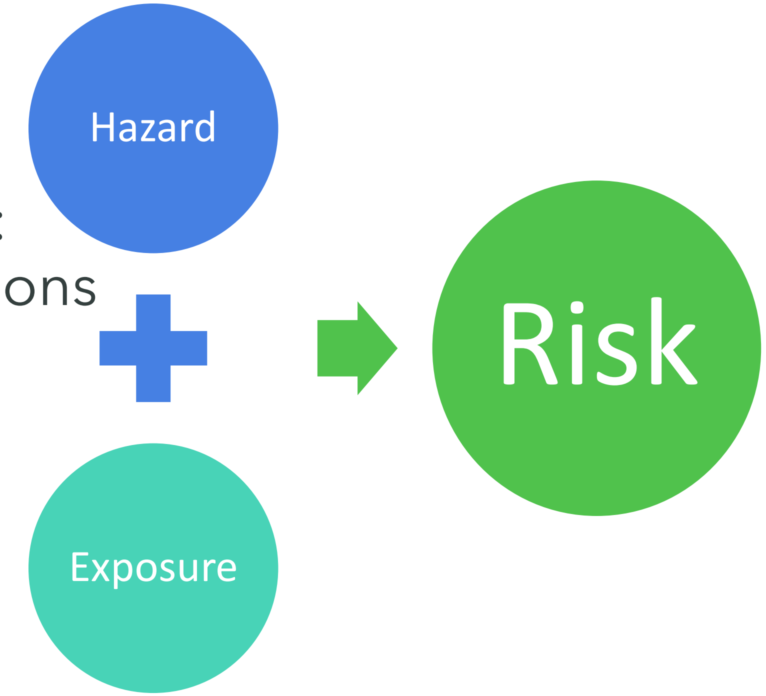
Safety assessment - methodologie

Hazard assessment to filter out the most hazardous substances:

- Data collection from regulatory databases and open literature
- *In silico* modelling
- *In vitro* assays

Risk assessment to identify additional management requirements:
Comparing safety thresholds with predicted exposure concentrations

- Worker risk
- Consumer risk
- Environmental risk



Product specific use and end of life considerations:

- Compostability and migration testing (Packaging)
- Leachate from washability performance tests (Textile)
- **Degradability** – recyclability

Safety driven innovation

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Data collection and *in silico* modelling

1. Harmonised hazard classifications and notifications for substances and mixtures based on the Classification, Labelling and Packaging regulation, REACH dossier and literature data.

2. Quantitative Structure Activity Relationship (QSARs)
   - Fill in data gaps after collection of experimental/regulatory data
   - Prediction of properties for substances that are not registered

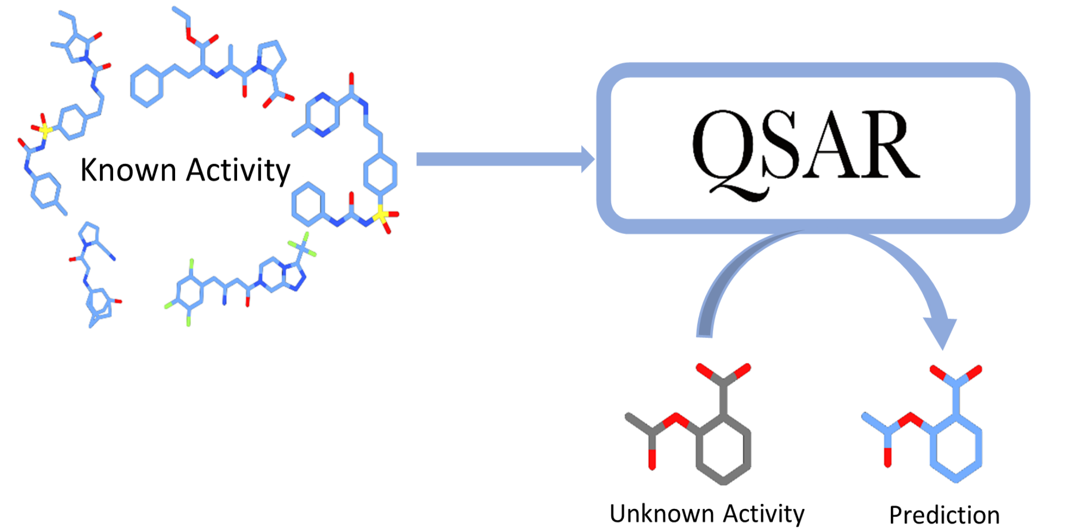

Image ref: ProtoQSAR

QSAR tools used within ZeroF for both process related substances and conformal structures modelled for C(e)FAE polymers (Packaging) or ORMOCER® polymeric networks (Textile);

- VEGA version 1.2.4
- Danish QSAR database

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Challenges in applying *in silico* modelling to support the design of new polymers or materials using SSbD

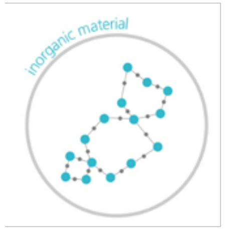
CHALLENGE:
How to use QSPR/QSAR models to estimate polymer properties?

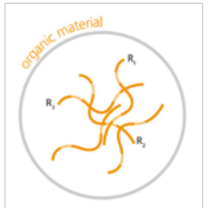
→ **Molecular-level description of materials**

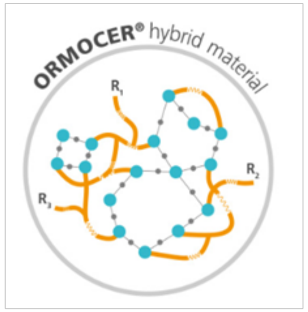
→ **Generation of structural variations of materials**

→ **Development and application of QSPR/QSAR models to the generated structures**

→ **SSbD assessments**







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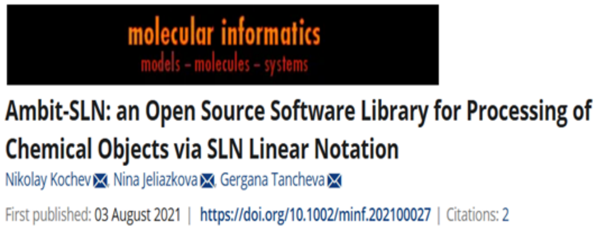
Generating combinatorial sets with Sybyl Linear Notation (SLN)


molecular informatics
models - molecules - systems
Ambit-SLN: an Open Source Software Library for Processing of Chemical Objects via SLN Linear Notation
Nikolay Kochev, Nina Jeliazkova, Gergana Tancheva
First published: 03 August 2021 | https://doi.org/10.1002/minf.202100027 | Citations: 2

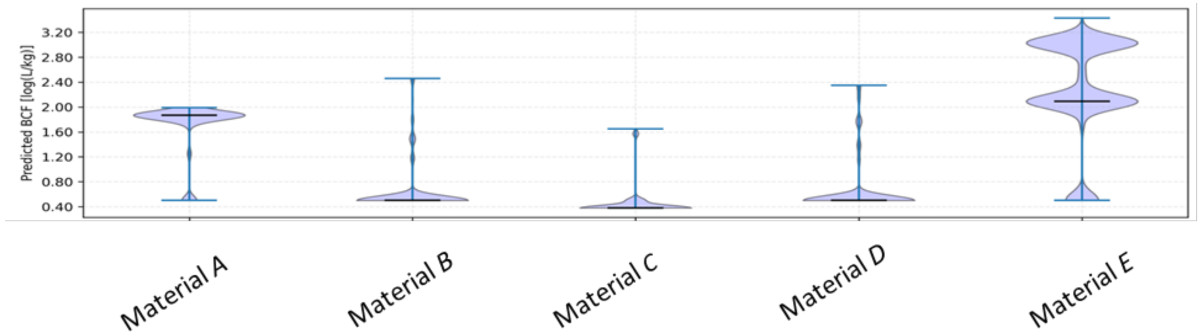
Approach: create a variety of polymer structures, <u>based on synthesis and curing reactions</u>.

Modification of the monomer unit by different substituents

➔ Generation of CeFAE polymers and ORMOCER® materials

ORMOCER®	Number of topologies	Generated structures per topology	Total number of structures
Material A	37	59 049	2 185 813
Material B	11	27 648	304 128
Material C	11	27 648	304 128
Material D	37	59 049	2 185 813
Material E	37	59 049	2 185 813

Apply QSAR for SSbD relevant properties for the set of structures – obtain distribution of predictions per material per model !



Predict High concerns (H1) related endpoints ; Carcinogenicity, Mutagenicity, Reproductive toxicity (CMR), Endocrine Disruption (ED), Respiratory Sensitization (RS), Specific target organ toxicity - repeated exposure (STOT-RE), Persistency (P), Bioaccumulation (B), Mobility (M) and aquatic toxicity (T)

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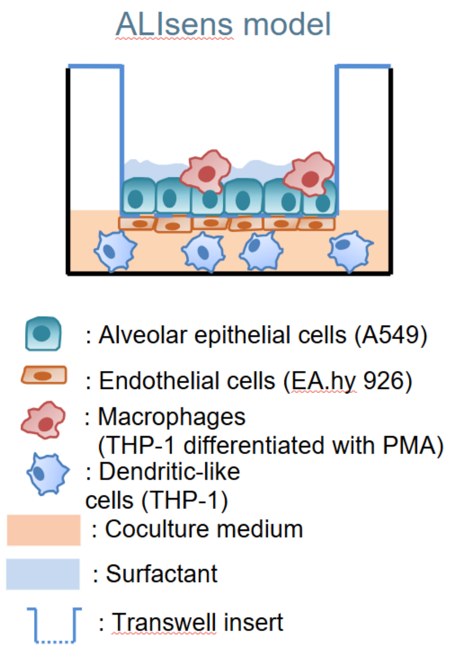
In vitro studies

- Applicability of QSAR models remains to be validated
  - No training with polymers !
  - Limited biological or physical reliability of the predictions or contradictory results.
  - Not for all properties required to be tested under SSbD a QSAR is available (Respiratory Sensitization (RS))

➔ *In vitro* studies to obtain information on additional endpoints that could not be modelled or to confirm predictions.

Inhalation exposure pathway



(Chary *et al.* 2017, 2019, Klein *et al.* 2013, 2017, Patent WO2018/122219 A1)

Viability

Sensitization

Inflammation

Endpoints (at 24h)

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In vitro studies

Inhalation exposure pathway

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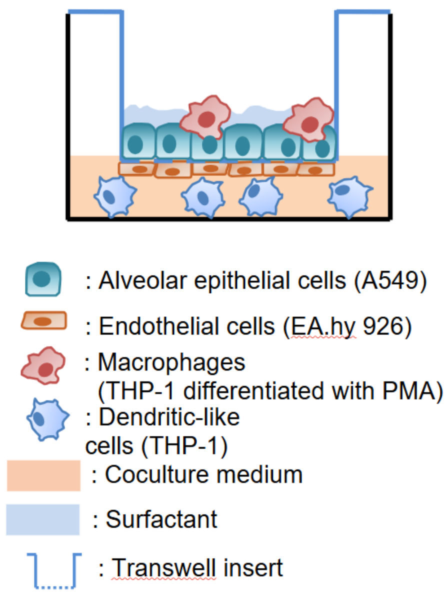
➔ *In vitro* studies to obtain information on additional endpoints that could not be modelled or to confirm predictions.

ALIsens model



(Chary *et al.* 2017, 2019, Klein *et al.* 2013, 2017, Patent WO2018/122219 A1)

Packaging Innovation	Physical form	SSbD hazard class	Unresolved data gaps for 'high concerns' classification
C(e)FAE C8	Powder	4	CMR, RS, ED, STOT RE, PBT
C(e)FAE C16	Powder	4 Not RS	CMR, ED, STOT RE, PBT

<u>Viability</u>
<u>Sensitization</u>
<u>Inflammation</u>

Endpoints (at 24h)

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Risk characterisation workflow (Step 2)

Substances inventory

\+

Details on process conditions

Relative flows of inputs and outputs

Physico-chemical properties

— Identification of Process category (PROC) & Environmental release category (ERC)

\+

Hazard screening

Mixture considerations

In silico tools + literature

In vitro assays

Modelled exposure concentrations for workers and environment

ECETOC TRA, ProScale, complex modeling

Modelled toxicological thresholds

⇨ Risk characterization ratio (RCR) for each PROC and ERC of a process

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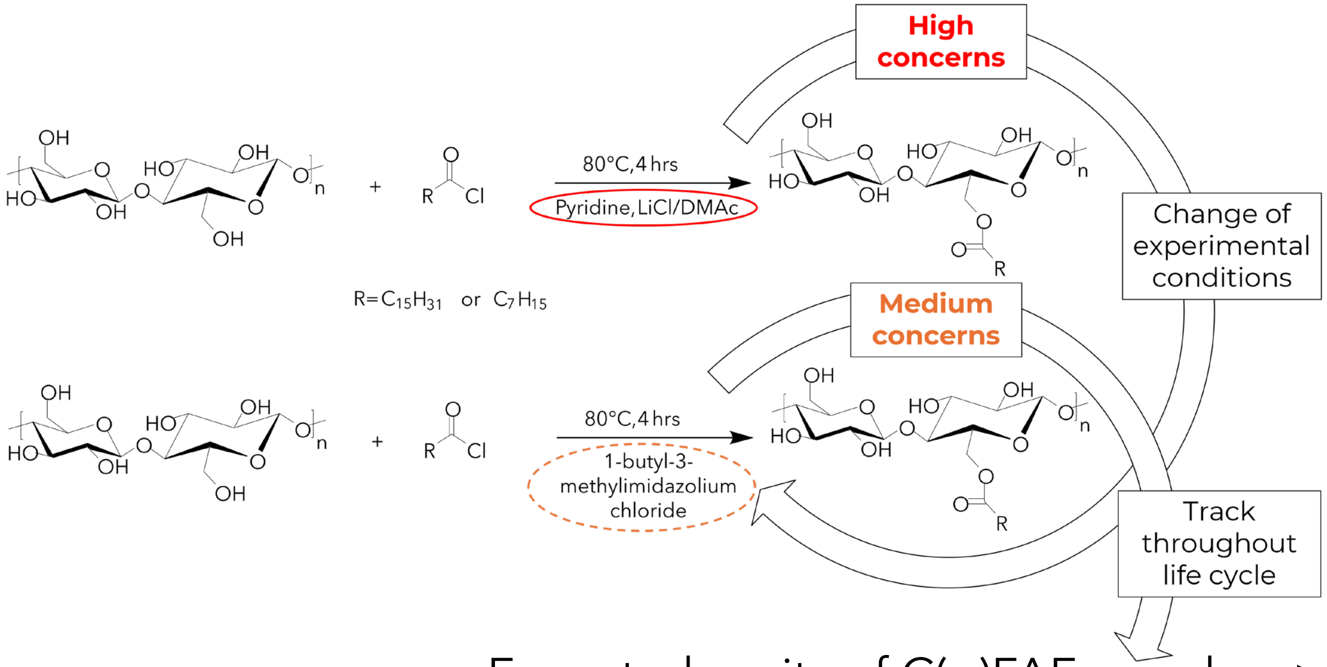
Process safety results for packaging

- Process safety

Most hazardous substances replaced but data needed to **avoid "regrettable substitution".**

Powder handling (inhalable fraction and ATEX/Fire risks), toxic waste and volatile organic compounds (VOCs) at risk for workers and ENT ➔ Protective equipment, emission controls adapted waste water treatment needed.



- Product safety

Overall migration testing + specific migration for identified substances

➔ migrated components > 10 mg/dm^2 migration limit (EN 1186-3) but not associated to CeFAEs.

Partial compostability of the coated trays

Expected purity of C(e)FAE powders >95 %

Characterise non-intentionally added substances (NIAs)

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Safety assessment - Conclusions and limitations

- Data gaps are tried to be filled as much as possible but also inherent to SSbD assessments
- Challenges at early-stage application of the SSbD framework

Design principles related to safety	Challenges at early innovation phase
Reduce or eliminate hazardous substances	Keep up-to-date with technical developments
Minimize the generation of hazardous waste and emissions	Lab scale-based estimations (e.g. limited considerations for close loops potential)
Ensure compliance of PFAS-alternatives with regulations and targeted certification scheme for final products (i.e. design for end-of life)	Limited characterisation data for residual chemicals e.g. general threshold of 0.1% w/w in final product for most SVHC

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Safety assessment – results for Textile

- Chemical safety

ORMOCER® materials was predicted with NAMs to be of high concern (e.g., CMR, persistency) but limited bioavailability so low exposure then low risks expected ➔ **Future tests are needed to confirm these toxic properties** as the *in silico* predictions are not reliable (other *in vitro* assays on-going to complete risk assessment).

- Process safety

Potential risk for workers of dermal and inhalation exposure during coating formulation preparation ==> adequate protective equipment

Risk for environmental releases of additives after textile washing to remove particle excess ==> adequate waste management

- Product safety

For consumers and the environment risk assessment, further data are needed to characterize the leachate, by-products and emissions associated to end of life scenarios (e.g. incineration for textile).

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Sustainability Assessment

Federico Busio (LIST)

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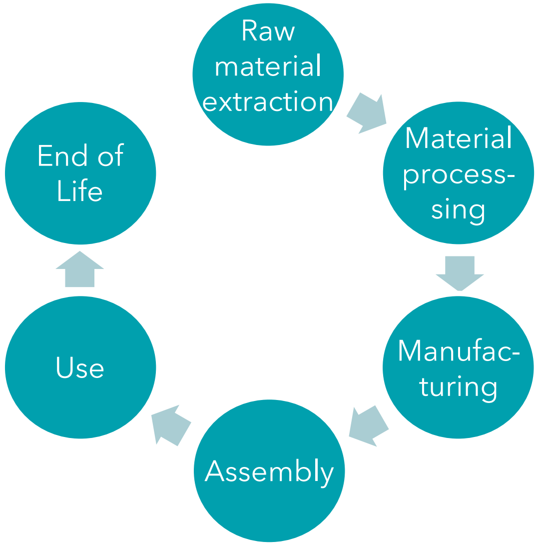
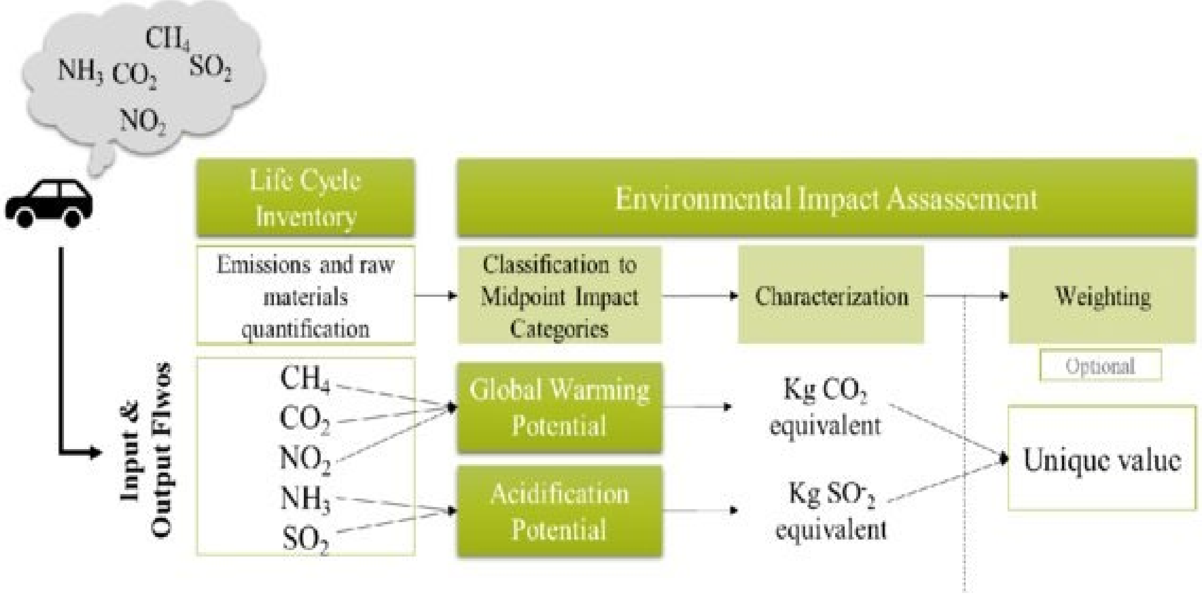
Environmental sustainability assessment method

- ➢ Standardised methodology (ISO 14040/44) to evaluate the environmental impacts of products/services along its life cycle
- ➢ Life cycle perspective and multi-criteria to identify potential transfer of impacts



∑ Emissions
∑ Resources

Climate change
Eutrophication
Acidification
Toxicity
Fossil resources depletion
Mineral resources depletion
…



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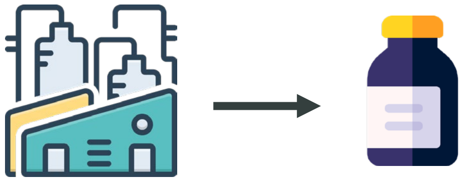
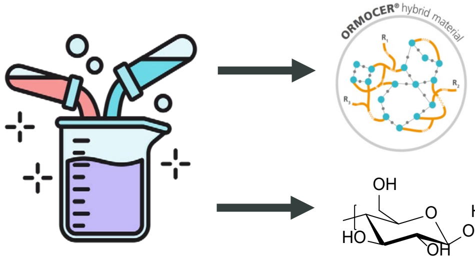
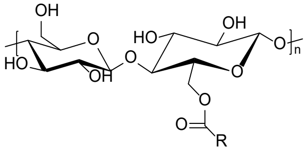
Environmental sustainability assessment method



1. Preliminary LCA of ORMOCER® and CeFAE chemical inputs

Comparison of the manufacturing impacts of functionally equivalent chemicals (i.e. solvents, catalysts, bases etc..)





2. Preliminary LCA of multiple ORMOCER® and CeFAE variations

Comparison of the environmental impacts of 1 kg of each formulation alternative based on laboratory data

3. Full LCA for ZeroF innovation product manufacturing

ORMOCER® and CeFAE synthesis process upscaled to commercial level production for materials and energy consumption estimation

Comparison of the impacts of the production of final product with ZeroF coating material and with reference PFAS coating

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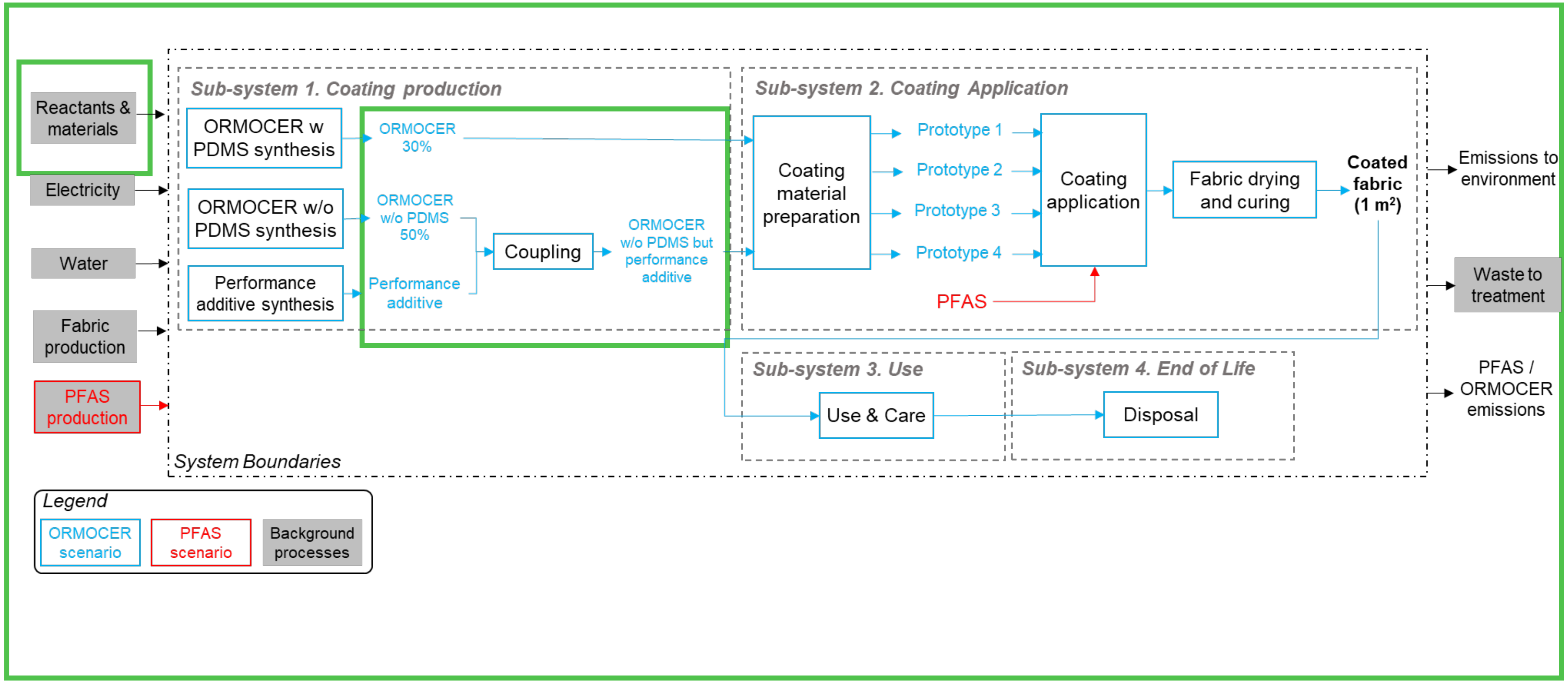
Textile case study

- **System boundary**: Cradle to grave assessment
- **FU**: "keep 1 m^2 of upholstery textile resistant to water, oil and abrasion for one year in Europe"
- **Reference product**: 1 m^2 of upholstery textile coated with C6 PFAS



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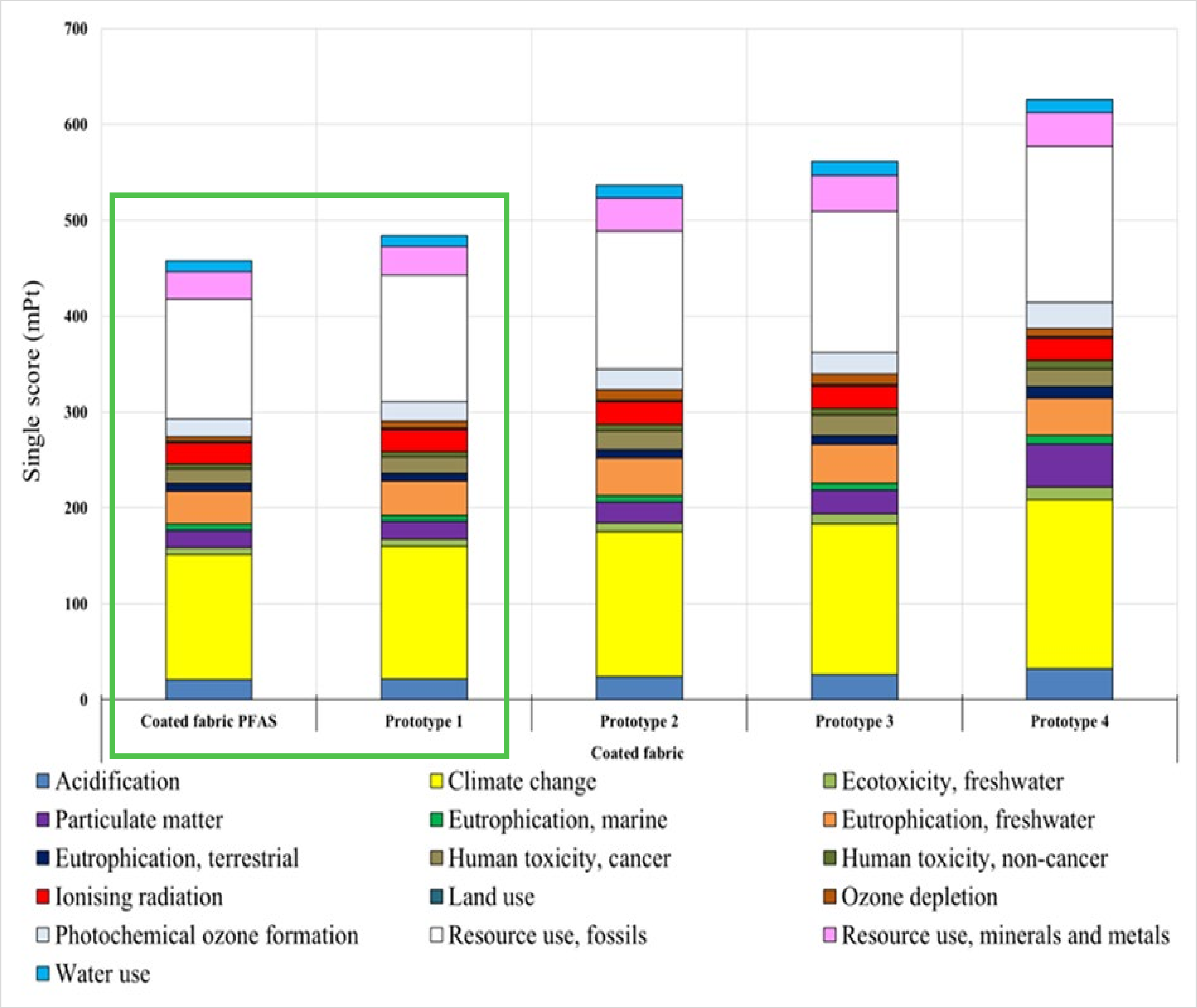
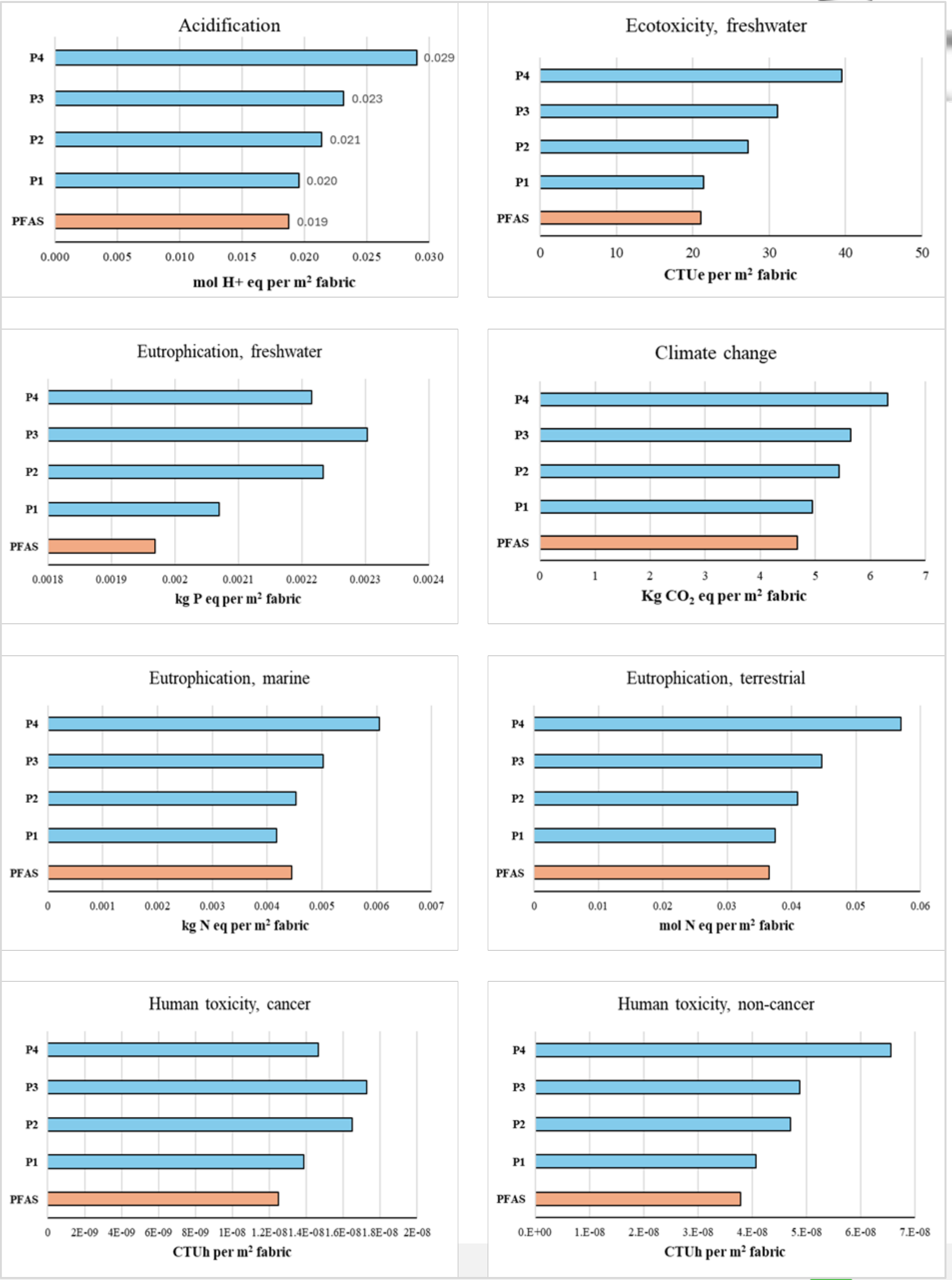
Textile case study – Full LCA





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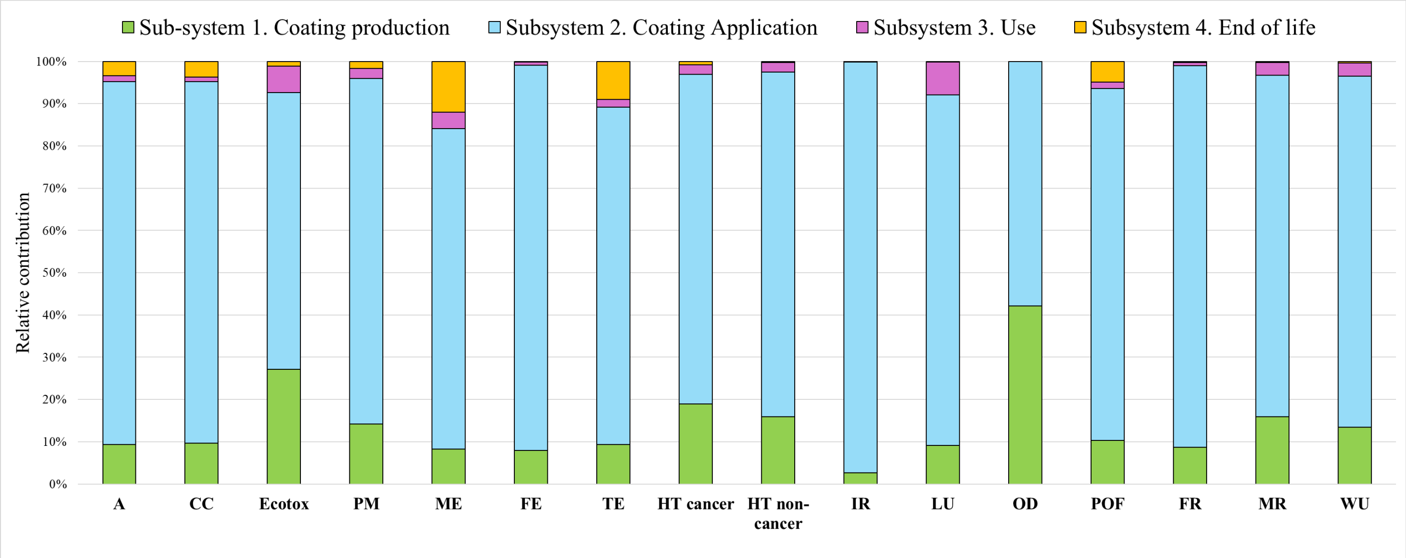
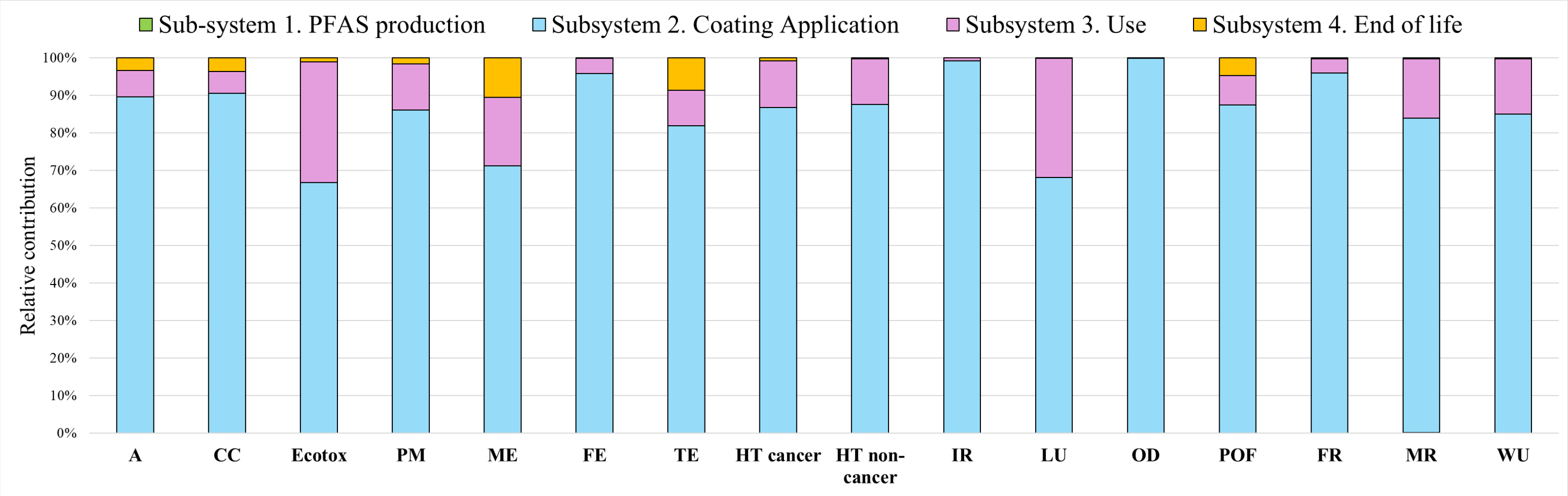
Textile case study – Life cycle stages contribution



- Higher contribution of the ORMOCER® coating production compared to reference PFAS



- Higher contribution of PFAS release during use phase

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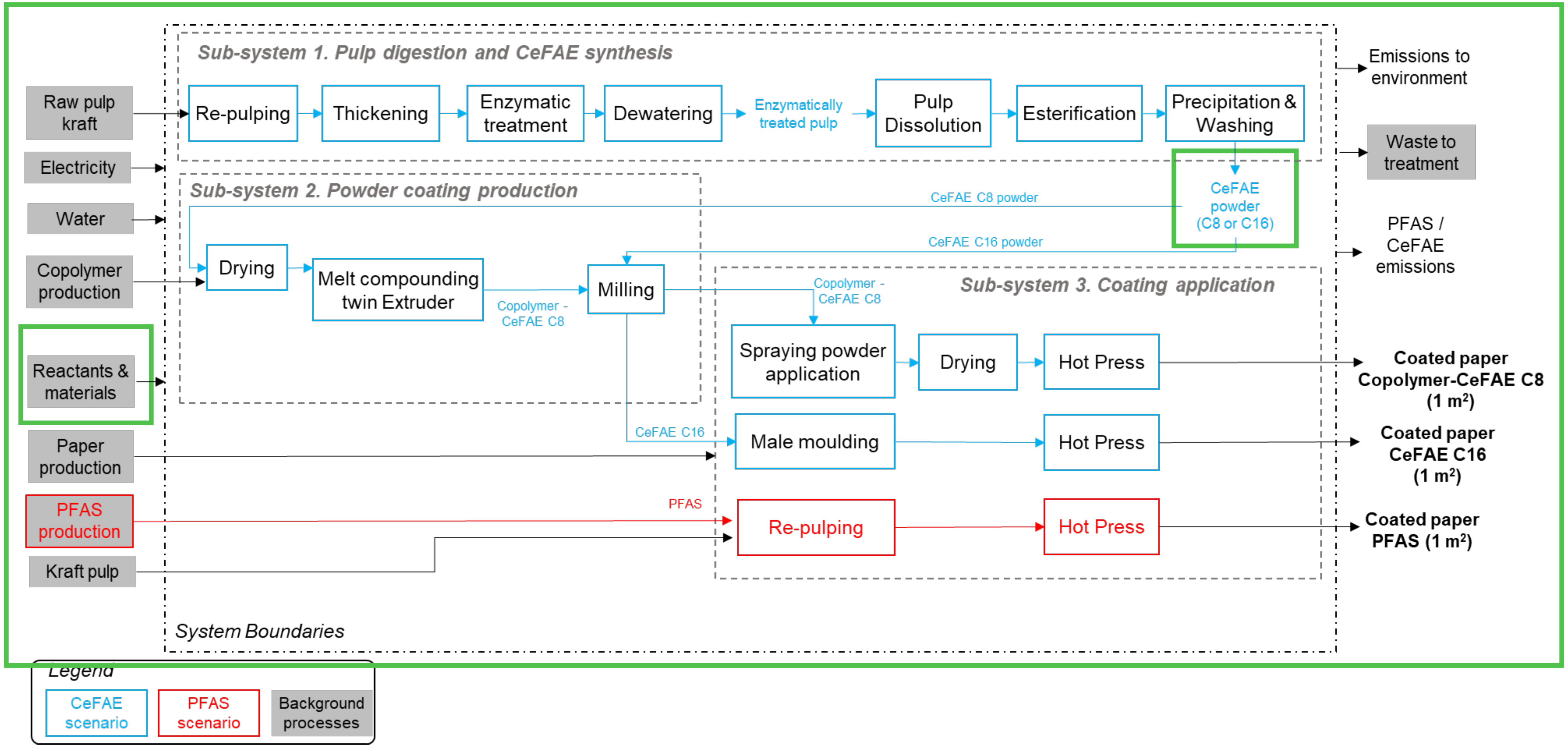
Packaging case study

- **System boundaries**: Cradle to gate assessment
- **FU**: "keep 1 m² of paper-based single-use packaging resistant to water and oil in Europe"
- **Reference product**: 1 m² of paper based packaging containing C6 PFAS



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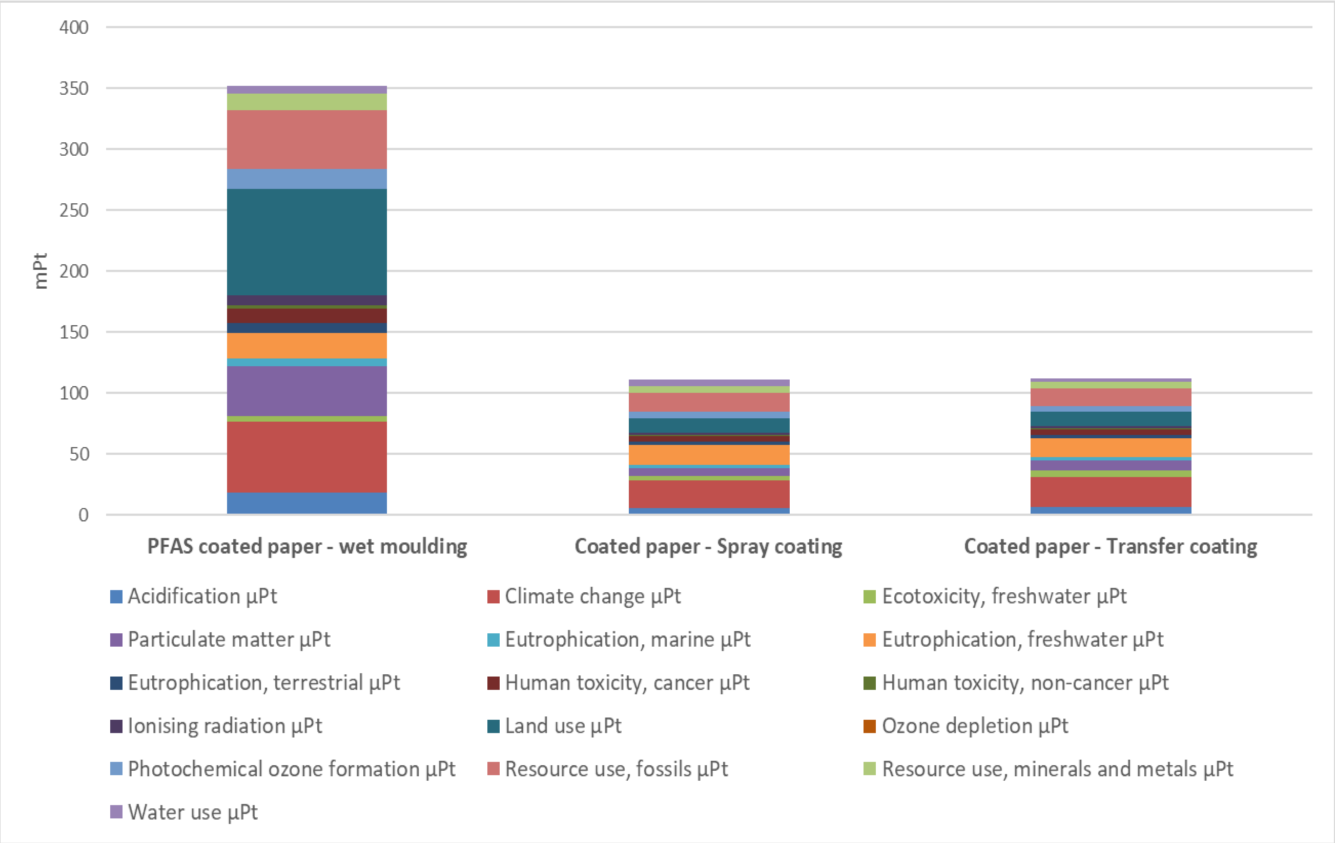
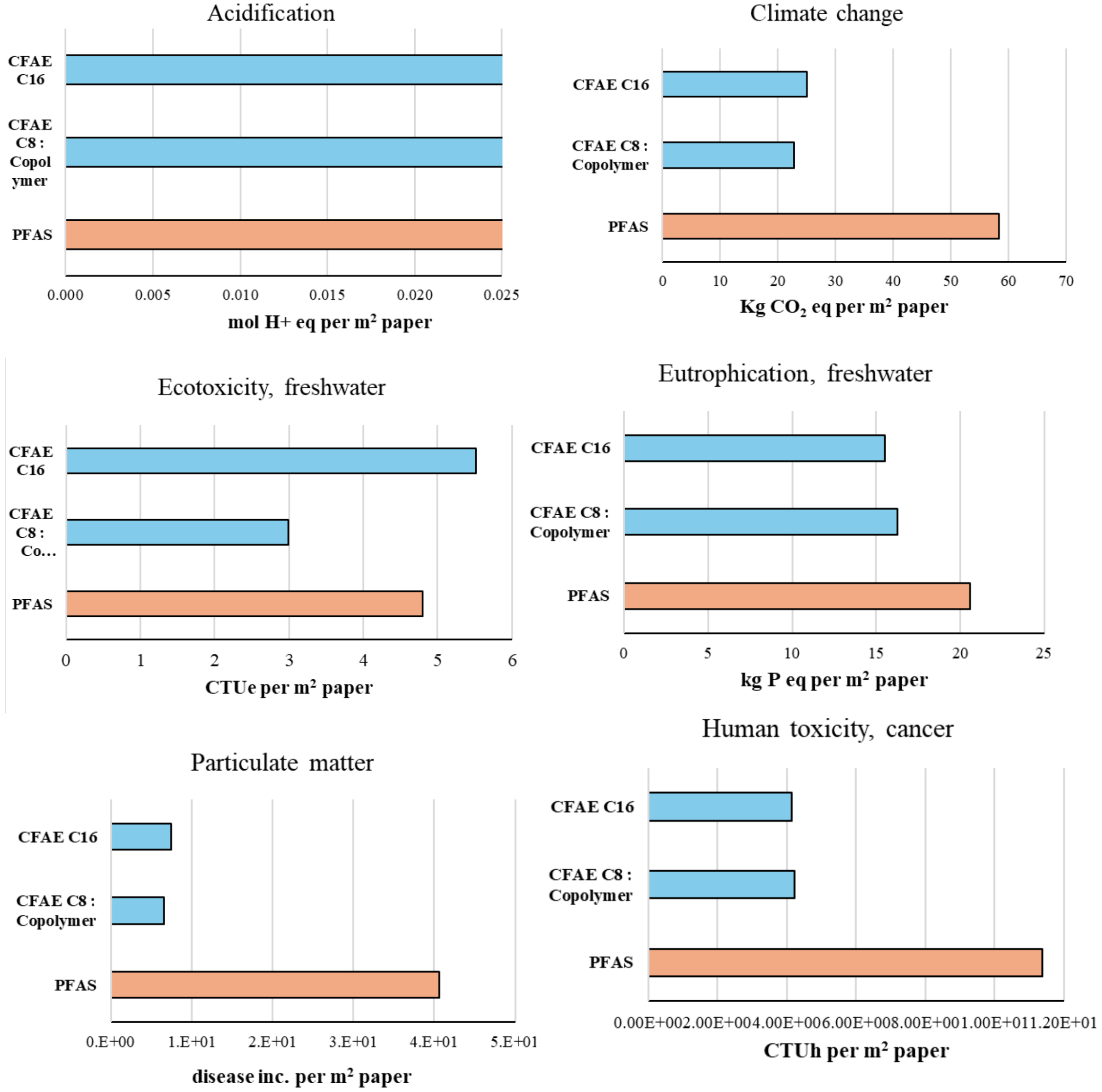
Packaging case study – Full LCA





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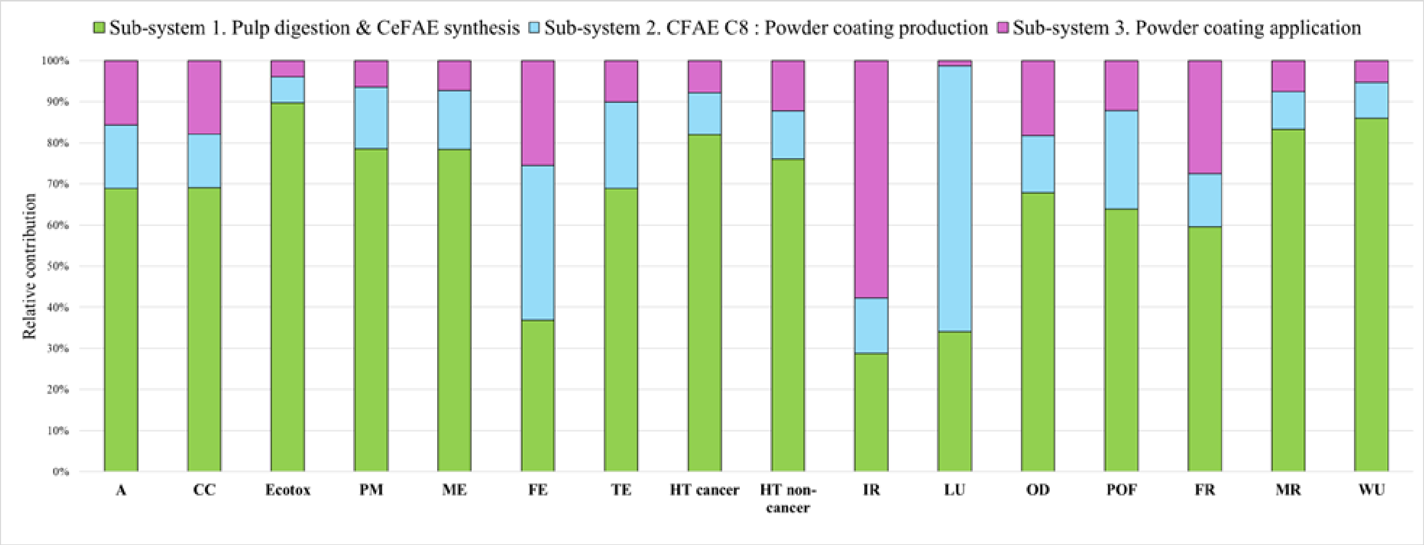
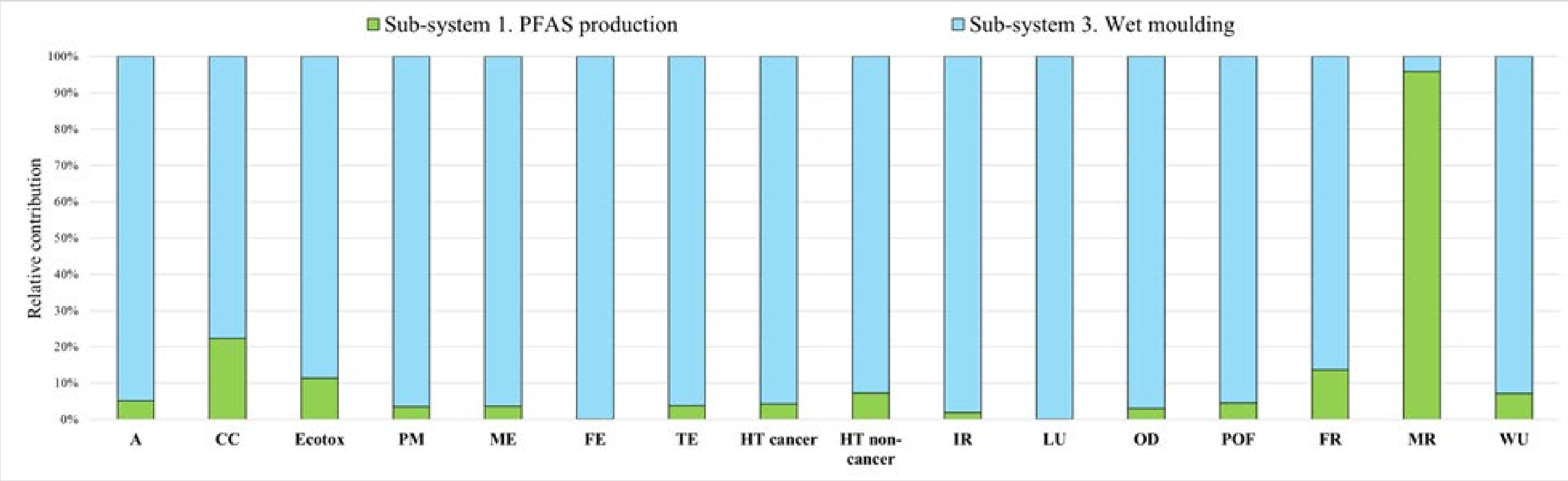
Packaging case study – Life cycle stages contribution



ZeroF product:

- Higher contribution of the CFAE coating production (C8 : copolymer) relative to the reference PFAS



Reference product:

- Higher contribution of coating process in reference product

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Textile case study SSbD scoring

LCA Assessment level	Impact category	Unit	Impact Proto1	Impact PFAS	% change	Score	Level
Toxicity	Human toxicity, cancer effects	CTUh	1.38E-08	1.25E-08	-0.11	1	Fail
	Human toxicity, non-cancer effects	CTUh	4.06E-08	3.79E-08	-0.07	1	
	Ecotoxicity freshwater	CTUe	21.43	21.04	-0.01	1	
Climate change	Climate change	Kg CO2eq	4.95	4.67	-0.05	1	Fail
Pollution	Ozone depletion	Kg CFC11eq	6.34E-06	3.68E-06	-0.72	1	Fail
	Particulate matter	Disease inc.	1.25E-07	1.19E-07	-0.05	1	
	Ionising radiation	kBq U-235 eq	1.88	1.85	-0.02	1	
	Photochemical ozone formation	kg NMVOC eq	0.017	0.016	-0.04	1	
	Acidification	mol H+ eq	0.019	0.018	-0.04	1	
	Eutrophication, terrestrial	mol N eq	0.037	0.036	-0.02	1	
	Eutrophication, freshwater	kg P eq	0.002	0.002	-0.05	1	
	Eutrophication, marine	kg N eq	0.004	0.004	0.06	1	
Resources	Land use	Pt	15.85	19.29	0.17	1	Fail
	Water use	m3 depriv.	1.57	1.55	-0.01	1	
	Resource use, minerals and metals	kg Sb eq	2.51E-05	2.43E-05	-0.03	1	
	Resource use, energy carriers	MJ	103.49	97.5	-0.06	1	

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Packaging case study SSbD scoring

LCA Assessment level	Impact category	Unit	Impact PFAS	Impact CFAE C8 : PLA	% change	Score	Level
Toxicity	Human toxicity, cancer effects	CTUh	1.14E+01	4.22	68%	3	**Pass**
	Human toxicity, non-cancer effects	CTUh	3.08	1.34	61%	3	
	Ecotoxicity freshwater	CTUe	4.79	2.99	38%	3	
Climate change	Climate change	Kg CO2eq	58.42	22.84	84%	3	**Pass**
Pollution	Ozone depletion	Kg CFC11eq	5.46E-02	0.017	55%	3	**Pass**
	Particulate matter	Disease inc.	4.06E+01	6.51E+00	21%	3	
	Ionising radiation	kBq U-235 eq	8.38	1.99	67%	3	
	Photochemical ozone formation	kg NMVOC eq	15.87	4.90	63%	3	
	Acidification	mol H+ eq	18.084	5.799	56%	3	
	Eutrophication, terrestrial	mol N eq	8.86	2.96	76%	3	
	Eutrophication, freshwater	kg P eq	20.60	16.24	86%	3	
	Eutrophication, marine	kg N eq	6.21	2.79	69%	3	
Resources	Land use	Pt	87.085948	11.846616	86%	3	**Pass**
	Water use	m3 depriv.	6.9122348	4.6094349	33%	3	
	Resource use, minerals and metals	kg Sb eq	13.053498	5.4528998	58%	3	
	Resource use, energy carriers	MJ	48.74031	16.028008	67%	3	

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Sustainability assessment - Conclusions and limitations

Textile case study

- Textile coated with ORMOCER® Prototype 1 best performing ZeroF innovation product.
- Refinement of the modelling of the ORMOCER® synthesis process could improve the final impact assessment results

Packaging case study

- CFAE coated paper shows lower environmental manufacturing impacts than PFAS coated paper

Assessment limitations

- Consideration of the recyclability/compostability of ORMOCER® and CFAE coated products should be included in the assessment to evaluate material recovery potential
- Biodegradation of ORMOCER® and CFAE formulations not considered in the assessment
- Modelling of the packaging reference product based on experimental work

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Economic Assessment

Imad Audi (LGI)

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Economic sustainability assessment method

1. Preliminary cost analysis of key chemical inputs (ORMOCER®, CeFAE, additives)
    - Comparison of the unit costs and procurement conditions of functionally equivalent inputs (solvents, catalysts, auxiliaries, etc.).
2. Prototype-level LCC of coating formulations
    - Estimation of the material, energy, labour, and ownership costs for each ZeroF formulation based on laboratory or pilot-scale data.
3. Full LCC for ZeroF coating production at industrial scale
    - Upscaling of the production process to commercial conditions to estimate industrial-scale material flows, energy use, and fixed costs.
    - Comparison of the total cost of ZeroF-coated products with reference PFAS-based coatings.

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Material and energy costs were assessed for the developed formulations of packaging and textile

Packaging

- Powder 1 is the lower-cost option.
- Powder 2 shows a ~15% higher cost, driven almost entirely by material & energy inputs.
- Ownership and labour costs are negligible (<1%).
- Material price fluctuations strongly influence €/m² cost.

	Powder 1	Powder 2
Material and energy cost	€ 0.374	€ 0.430
Ownership cost (capital + maintenance)	€ 0.0026	€ 0.0026
Labour cost	€ 0.0017	€ 0.0017
Total cost (per m^2)	€ 0.379	€ 0.434

Textile

- Prototype 1 is the lowest-cost formulation due to low ORMOCER® content.
- Prototypes 2 & 3 are the most expensive, linked to higher ORMOCER® levels and additives.
- Prototype 4 shows intermediate cost, with the polymer offsetting PDMS removal.
- ORMOCER® remains the dominant cost driver across formulations.

Coating material	Material and energy cost (€/kg)
Prototype 1	€30.05/kg
Prototype 2	€50.24/kg
Prototype 3	€50.29/kg
Prototype 4	€44.60/kg

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Ownership and labour cost are also crucial aspects to consider

Packaging

Ownership Cost (CAPEX + Maintenance)

- Ownership cost is very small when expressed per m^2, thanks to large industrial-scale output.
- Under these conditions, ownership cost is essentially negligible within the total LCC.

Labour Cost

- Labour needs are modest: operation led by one main operator + one assistant at standard industrial wages.
- When allocated over the same industrial-scale output, labour cost is around €0.0017/m^2.
- Labour therefore represents only a minimal share of total unit cost in packaging.

Textile

Ownership Cost (CAPEX + Maintenance)

- Annualised cost of the coating line results in ~€5.5–6.0/kg of coated fabric.
- Differences between prototypes come mainly from grammage variations (mass processed per year).

Labour Cost

- Labour cost ranges from ~€7.6–8.2/kg, driven by fabric grammage and total annual output.
- Labour remains a significant contributor in the overall LCC.

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LCC cost comparison with reference PFAS scenario

Packaging

- **Reference scenario:** Kraft paper coated with a PFAS-based grease-resistant formulation.
- Powder 1: €0.379/m² → ~**24% more expensive** than PFAS reference.
- Powder 2: €0.434/m² → ~**42% more expensive** than PFAS reference.

Textile

- **Reference scenario:** PFAS-based UNIDYNE TG-8111 coating for PES upholstery fabric.
- Prototype 1: €43.5/kg → ~**16% cheaper** than PFAS reference.
- Prototypes 2 & 3: €63.5/kg → ~**22% more expensive** than PFAS reference.
- Prototype 4: €58.9/kg → ~**13% higher** than PFAS reference.

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Sensitivity analysis

Packaging

- Material prices and coat weight are the main cost drivers.
- Energy & water tariffs have a smaller impact (only a few cents per m²).
- Ownership & labour costs remain marginal at industrial scale.

Textile

- Energy & water prices: Large variation across EU (Spain baseline; Germany higher; Poland lower).
- Labour cost differences: Germany = high-cost, Poland = low-cost, Spain = mid-range.
- Combined effect: Leads to up to **~±20% total cost difference** depending on location.

Table 23. Total cost of prototype 1 coating fabric for a number of selected EU countries

Country	Prototype 1 total cost (€/kg)
Spain	43.50
Germany	48.46
Poland	39.93

Conclusion

- Energy and labour are major geographical cost drivers for PFAS-free coating production.
- Location matters: selecting low-cost regions can substantially improve competitiveness.
- Crucial for planning industrial scale-up and choosing optimal EU manufacturing sites.

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Economic assessment - Conclusions and limitations

Textile case study

- PFAS-free textile coatings show competitive costs for some prototypes (e.g., Prototype 1 cheaper than PFAS reference).
- Cost differences across EU regions can reach ±20%, mainly driven by energy and labour variability.

Packaging case study

- PFAS-free packaging prototypes remain more expensive than PFAS-based reference, mainly due to material costs.
- Sensitivity analysis shows material prices and coat weight are the main drivers, with utilities and scale playing secondary roles.

Assessment limitations

- Assumes PFAS-free coatings match PFAS performance; real-world deviations may affect costs.
- Cost data based on lab-scale inputs and simplified scaling, which may overestimate industrial costs.
- System boundaries limited to core coating process (excluding finishing, logistics, end-of-life). Results reflect 2025 conditions in selected EU countries; no modelling of future economic or policy changes.

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Integration and final considerations

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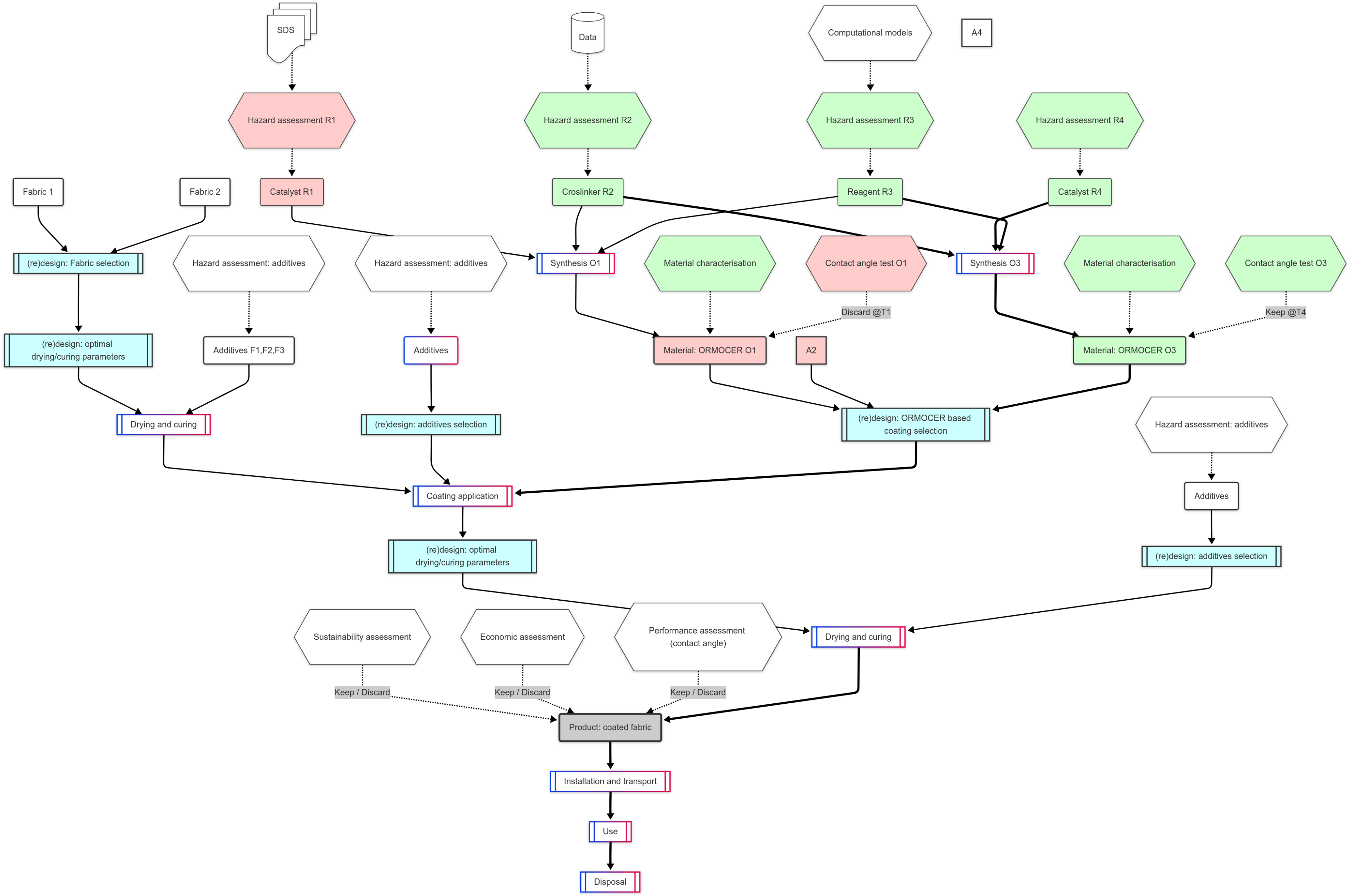
Parallel activities

- *In silico* modelling to support data gap filling (VEGA, QSARs)
  - Carcinogenicity, mutagenicity, reproductive toxicity (CMR), skin sensitization (SS), endocrine disruption (ED), toxicity, biodegradability, bioaccumulation and mobility.
- *In vitro* testing (cytotoxicity, viability, respiratory sensitisation)
- Employment of a hybrid model for reducing the data gaps on the surface tension properties of SSbD textile coatings
- Use of a FAIR-compliant Electronic Laboratory Notebook (ELN) workflow integrated with structured, machine-readable processes
- Consumer awareness and acceptance of PFAS-free solutions

Example of SSbD ELN diagram



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SSbD results for packaging

- Step 1: Important data gaps
  - Due to limited applicability of computational safety expected for polymers and cost and requirements associated to newly developed alternative methods.
- Step 2 & 3: Performed based on guidance (PROCs / ERCs)
  - Potential risks for workers and the environment due to the use of toxic solvent mixtures and the generation of toxic waste + risk of impurities or NIAS for consumers (e.g. Data gaps filling needed to avoid "regrettable substitution” with ionic liquid as still missing reliable data).
- Step 4: Scoring (0-3) based on LCA results
  - Improvement on predicted impacts vs PFAS coating – Major assumptions
- Step 5: Estimation of costs and social acceptance
  - Comparison of prototypes (0.379- 0.434 €/ m²) vs PFAS (~ €0.305/m²)

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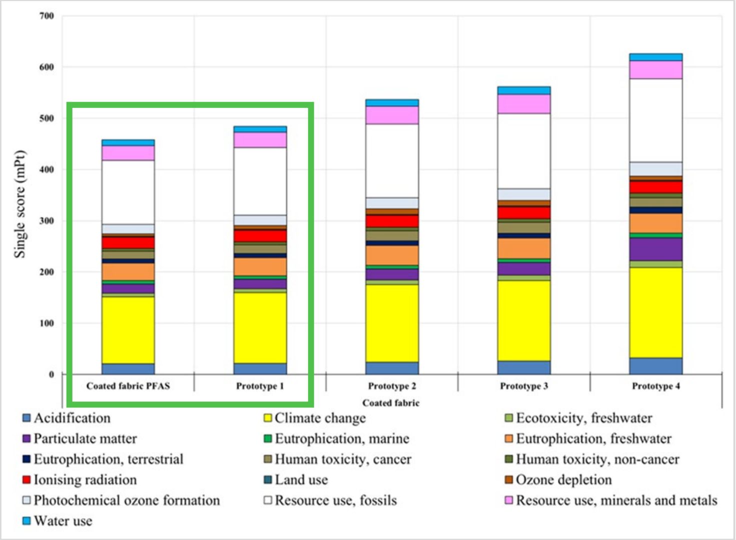
SSbD results for textile

- Step 1: Important data gaps but significant concerns observed
  - Due to limited applicability of computational safety expected for polymers and cost and requirements associated to newly developed alternative methods.
- Step 2 & 3: Performed based on guidance (PROCs / ERCs)
- Step 4: Scoring (0-3) based on LCA results
  - Limited improvement on predicted impacts vs PFAS coating –
- Step 5: Estimation of costs and social acceptance
  - Comparison of prototypes (40-60€/kg) vs PFAS (~50€/kg)



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SSbD application – takeaway messages

- **Technical performance and requirements** will always influence the innovation routes
  - Trade-offs may be required
- Low-tier innovation processes → important data gaps, various unknown parameters (e.g. toxicity, bioavailability and degradability potential)
  - limited applicability of available *in silico* tools for innovative polymeric substances
- Methodologies to reduce data gaps (e.g., complex modelling, New Approach methodologies, *in vitro* testing) → time and resource consuming
  - may be employed at a late stage of the innovation, but data may be relevant early in the innovation process
- Applicability of the SSbD framework → benefit from certain **timelines for decision-making** (vs open-end, continuous decision spaces),
  - increase the convergence of the complex relationships among technical requirements, safety, and sustainability

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Coffee Break

15 min

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Panel discussion

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Panel Discussion: Scaling PFAS-Free Innovations Challenges & Needs

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Closing Remarks

Miika Nikinmaa (VTT)

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Thanks for joining us today!

We welcome your questions and feedback !

Scan the QR code if you want to follow our final steps in our journey to PFAS-free coatings.

Or check out our website or newsletter!

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THANK YOU

Connect with us to learn more.

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