WELCOME! The webinar will begin shortly.

A recording of the webinar and the slides will be available afterwards.

FIND OUT HOW TO REPLACE “DIFFICULT” PFAS USES WITH SAFER ALTERNATIVES
FIND OUT HOW TO REPLACE “DIFFICULT” PFAS USES WITH SAFER ALTERNATIVES
TODAY

• Introduction to ChemSec
• Smorgasbord of PFAS alternatives
  • Technical textiles
  • Alternatives to F-gases
  • Semiconductor manufacturing
  • Green energy solutions
• Questions - use the Q&A function!

☐ Slides and recording will be available afterwards
WHAT WE DO AT CHEMSEC

• Drive the political discussion on hazardous chemicals
• Challenge companies to improve their chemicals management
• Develop online tools to help companies switch to safer chemicals
• Inform investors about risks and opportunities in the chemical industry
Breakthrough Hydrocarbon Materials for the Energy Transformation
Company Overview

Ionomr – the leader in next-gen ion-exchange materials

Founded 2018
50 Employees
$30M+ USD Funding
Two Breakthrough Materials Families

Diverse Marketplace
Hydrogen Production, Fuel Cells & CCUS

Innovative
50-year breakthroughs in both AEM and PEM solutions

Industry Experts
Supported by more than 10 years / 100K hours of R&D

Protected IP
Broad patent portfolio: material, process, composite, device
Selected Recognition

- **NOURYON’S IMAGINE CHEMISTRY**
  - "Collaborative innovation challenge" winner and recipient of JDA for eco-friendly membrane technology

- **F-CELL "PRODUCTS & MARKETS"**
  - Pemion® as a breakthrough product for FCEV’s @ largest European FC Expo (Stuttgart)

- **SHELL GAMECHANGER ACCELERATOR**
  - Powered by Shell & NREL, validating Aemion+® for electrolysis & CCU

- **WEF TOP 100 TECHNOLOGY PIONEERS**
  - World-leading innovative companies solving critical global challenges

- **GLOBAL CLEANTECH 100**
  - Top companies globally driving the future sustainable economy

- **DELOITTE TECHNOLOGY FAST 50**
  - “Ones to watch” technology companies in Canada

- **GLOBAL CLEANTECH 100**
  - The leading companies and innovators in cleantech today

Year:
- 2020
- 2021
- 2022
- 2023
The ion-exchange membrane defines and determines a system’s **durability, performance** and **efficiency**.
Material Design Considerations

Ion-exchange materials have numerous interconnected properties

Ionomr’s design experience enables creation of next-generation membranes and ionomers

• Strong emphasis on fundamental R&D and materials knowledge
• Rigorous design, development, & new product integration / characterization processes
• Each material is specifically application-designed with properties comprehensively screened prior to scale-up and pre-production release
Developing Next-Generation Materials

Rapid iteration and the flexibility of hydrocarbon chemistry and composites allows markedly faster progress than previous development.
Ionomr’s Focus Verticals

**Heavy Duty Fuel Cells**
Materials exceeding world-leading performance, full-scale cells being tested & full-scale system pilots in bring-up

**Green Hydrogen**
9000+ hour durability demo, >700x durability in industry-relevant conditions, whole system exceeding EU 2024 goals

**CO₂ Capture (CCUS)**
Unlocking Carbon-to-Value
Numerous systems including a 3x for CO₂-to-CO + the first/only long-lived direct conversion to high-value ‘C2+’
The Urgency

- We must decarbonize before 2050 and limit warming to <1.5 °C
- What stands in the way? Rate-limiting factors must be removed, primarily supply & grid-related issues
  - Speed, certainty, low environmental impact, & circularity are all highly valuable

“Limiting warming to 1.5 °C would reduce economic damages relative to 2 °C... the accumulated global benefits will exceed US $20 trillion” – Burke et al (Nature, 2019)
Hydrogen on the same exponential growth as wind & solar

Current Ion-Exchange Materials: PFSAs

**Perfluorosulfonic acid-based materials**
- Archetypal Nafion® membranes and ionomers & short side chain (SSC) variants
- Fundamental chemistry unchanged for over 50 years

**Perfluorination gives rise to advantageous properties**
- Hydrophobic backbone
- Chemical stability
- Water management
- Ionic conductivity

**However..**
- High material costs & scalability challenges
- High gas crossover – undesirable permeability of the hydrophobic region
- **Growing environmental concerns** & impending regulation
Use & End-of-Life

- *In situ* degradation mechanisms established theoretically & experimentally (e.g. F-release rate)
- Mitigations can be established immediately but not to ultimately acceptable levels (<1 part per trillion)
- End-of-Life – thermolysis of PFSAs generate PFAS of the highest concern in meaningful abundance
  - Higher temperatures no panacea, also an issue in battery recycling, (e.g. LiPF6-carbonate forms at 230 °C but not at 195 °C)
  - Environmental mobility of sulfonic acids >100,000 km & persistence >1 m.a. >100x of other still-to-be-regulated PFAS (ECHA Annex B p108ff)
  - Iridium recycling necessary for PEMWE scaling or will only achieve 10-15% of market share by 2050 (e.g. JM Whitepaper)

Pemion® for Fuel Cells
# Pemion®: The Future of Hydrogen Fuel Cells

Unlike Nafion, Hydrocarbons Achieve:

<table>
<thead>
<tr>
<th>Feature</th>
<th>Pemion®</th>
</tr>
</thead>
<tbody>
<tr>
<td>High efficiency &amp; high performance</td>
<td>✓</td>
</tr>
<tr>
<td>Increased conductivity, water transport</td>
<td></td>
</tr>
<tr>
<td>Selectivity for improved H₂ efficiency</td>
<td>✓</td>
</tr>
<tr>
<td>Impermeable to reactant gases (H₂, O₂)</td>
<td></td>
</tr>
<tr>
<td>Extreme Durability</td>
<td>✓</td>
</tr>
<tr>
<td>Long lifetimes to meet HD requirements</td>
<td></td>
</tr>
<tr>
<td>Cost-effective and scalable chemistry</td>
<td>✓</td>
</tr>
<tr>
<td>Capable of meeting growing PEM demands</td>
<td></td>
</tr>
<tr>
<td>Environmentally friendly materials</td>
<td>✓</td>
</tr>
<tr>
<td>Green chemistry for the green revolution</td>
<td></td>
</tr>
<tr>
<td>High temperature stability</td>
<td>✓</td>
</tr>
<tr>
<td>Operation up to 120 °C for major system cost reduction, meeting long-term goals</td>
<td></td>
</tr>
</tbody>
</table>
Pemion® – Corrects Past Shortfalls of Hydrocarbons

Historical Challenges

- Functionalization control
- Water uptake and swelling
- Solubility in hot water at high IECs
- Ketones, sulfones, & protected ethers unstable
- Sensitivity to oxidative degradation
- Incompatibility with antioxidants – irreversible rxn

Responses

- Controlled functionalization
- Chemical strategy & down-selection/optimization limits
- Insoluble to IECs of ~4 / EWs ~250 (!)
- Zero ketones, sulfones, or ethers – all sp² C & -SO₃H
- Above strategy orders-of-magnitude improvement
- Enables antioxidant compatibility – reversible 1ˢᵗ rxn
Pemion® Reinforced Membranes Today

- Current generation composite membrane design yields greatly improved through-plane conductivity, eliminating anisotropy.
- Higher conductivity corroborated by large in-situ resistance decreases.
  → Greater fuel cell efficiency & performance in all conditions.

![Graph showing in-plane and through-plane conductivity](image)

- Current generation composite membrane design yields greatly improved through-plane conductivity, eliminating anisotropy.
- Higher conductivity corroborated by large in-situ resistance decreases.
  → Greater fuel cell efficiency & performance in all conditions.

![Graph showing in-plane and through-plane conductivity](image)
**Pemion® – Low-Humidity Performance**

Dramatic improvements to water management and 400% higher performance over previous-generation R2R membranes under hot/dry

- Decreases in area resistance >75%, in-line with performance improvements
- Unprecedented (!) performance for a hydrocarbon-based polymer electrolyte membrane

Graph 4: Polarization (left) and resistance (right) curves of membranes measured under 30/30 %RH, H₂/Air 150 kPaₐ symmetrical, 80 °C (3 min/pt)
The Pemion® polymer is inherently chemically resilient against radical-induced degradation:

- 1000 h without failure (2x DOE membrane target) without radical scavengers
- DOE-specified chemical stability accelerated stress test – extended hold at open circuit voltage under 30% RH, 90 °C

• Successful PEMFC operation after accelerated stress test @ ~70% of initial performance
State-of-the-Art Membrane Durability

First and only hydrocarbon-based material to ever achieve industry durability targets

- Multiple tests showcase limited degradation across entire target timeline
- **20k cycle target achieved, and doubled**, under combined chemical/mechanical (COCV cycling) via DOE protocol
- Membrane gas crossover < ½ PFSA membranes for life of test

OCV (left) and gas crossover current @ 100 kPa<sub>g</sub> cathode, 50 kPa<sub>g</sub> anode (50 kPa differential) – (right) curves of membranes measured under COCV (OCV and cycling RH ambient to 100%) at 90 °C as well as RH cycling (OCV step added for comparison). Both methods per DOE ASTM protocols, method validated by area resistance differentials.
Highly preliminary data in non-optimized conditions, but performances near-parity

- 5 cm² active area, high stoichiometry, 80 °C, 150 kPa gH₂/air backpressure, consistent performance ~1 W/cm²
- 0.3 mg Pt/cm² cathode / 0.1 mg Pt/cm² anode (25% lower cathode loading vs. slides 4-6), ultrasonic spray-coated
- Comparable area resistance in all conditions (~3-5 mΩ·cm² increase fully humidified, <10 mΩ·cm² dry, consistent w/ high stoichiometry & slightly thinner electrodes), comparable kinetics both high and low RH
- Fast transient quite comparable with PFSA-based results, suggests unit cell design & optimization fully effective to approximate performance parity
Pemion® Materials

Composite Membranes
PF1-HLF8-15-X
Our standard reinforced membrane ("Gen 2")

Ionomer Powders
PP1-HNN8-00
Readily soluble in common low boiling point solvents

PEMFC Reference Platforms
Catalyst coated membranes
&
Membrane electrode assemblies
Aemion® Electrolyzers for Capital-Efficient Green Hydrogen
Aemion+® Unlocks Disruptive Hydrogen Economics

AEMWE for the Most Cost-Effective Green H₂

Enables Cost-Effective Hydrogen
- High-performance, high-efficiency, compact systems
- Step-change in CAPEX & OPEX to meet ‘hydrogen shot’ $1/kg

High electron efficiency / low hydrogen crossover
- Efficient renewable pairing
- Highest safety factor

Solved key durability challenges
- Long-lived, efficient catalysts enabled by hot caustic
- Only indefinitely stable material to meet industrial req’s
- Exceeds 2024 EU targets, meeting 2030 targets

Compact, Scalable Systems
- Abundant, low-cost catalysts eliminating iridium use
- Enables scalable, low-cost alloys for system reductions
- Enables full circularity
The Evolution of Water Electrolysis

<table>
<thead>
<tr>
<th>An ideal system exhibits:</th>
<th>AWE</th>
<th>PEM</th>
<th>Aemion®</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>High performance = &lt;150 mΩ·cm² area resistance</strong> Enables compact, cost-effective systems</td>
<td>![X]</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><strong>Low gas permeability with variable load</strong> Safety + turn-down required for renewable pairing</td>
<td>![X]</td>
<td>✓</td>
<td>✓✓</td>
</tr>
<tr>
<td><strong>Durability</strong> Long lifetimes to meet system requirements</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><strong>Cost-effective, scalable membrane, electrode, and stack components</strong> To enable and meet rapid market growth</td>
<td>✓</td>
<td>![X]</td>
<td>✓✓</td>
</tr>
<tr>
<td><strong>Be made from environmentally friendly materials</strong> Meets the requirements of the circular economy</td>
<td>✓</td>
<td>![X]</td>
<td>✓</td>
</tr>
<tr>
<td><strong>High temperature &amp; pressure stability</strong> Operation to 90 °C, ≥5 bar for large system design</td>
<td>![X]</td>
<td>![X]</td>
<td>✓</td>
</tr>
</tbody>
</table>
Aemion+® Unlocks Disruptive Hydrogen Economics

**BENEFITS**
- Scalable
- High Stability

**ISSUES**
- Very Large Systems
- Poor Renewables Pairing
- Low Safety at Pressure

**PEM electrolysis**
- Highly Compact
- Pairs with Renewables
- Scale Issues: Ir & PFAS
- Very High Cost
- Toxic Material Use

**AEM electrolysis**
- Compact + Scalable
- Pairs with Renewables
- Moderate Performance
- Poor Durability
- Poor Consistency

**Alkaline electrolysis**

AEMWE is a hybrid of the two systems – AEL components and PEMWE design, de-risking scalability.
AEMWE Flexibility Only Way to Meets H₂ Shot $1/kg by 2030

- Traditional alkaline is slated for 60-92% market share, nominally 80%, but entirely fails to serve grid needs (!)
- PEM off the bottom of the graph in reality – CAPEX cost >$1/kg and PGM use is intractable
- Hard to properly cost higher power densities when low-cost electricity on the grid, 3x rated possible
Critical Catalysis Advantages in Alkaline

- Acidic electrolyzers have irreconcilable supply challenges due to iridium (& other PGM) + PFSA requirements
- PFSA scaling arguably more problematic than iridium independent of PFAS issues – difficult & dangerous chemistry
- Alkaline chemistries have preferential kinetics & stability, offering a wealth of potential improvements

Alkaline Electrolyte, the Superpower of AEMWE

- DI water limits ‘reaction band’ to ~2 µm
- ≥0.1 M KOH electronic connectivity enables a reaction band potentially mm-scale (e.g. VRFBs) + non-conducting oxides
- Markedly higher performances achievable
- Lower turnover frequency assists long-lived non-PGM
- ‘Iridium equal’ performances achieved in AEMWE

Weber & coworkers, 2021 - https://doi.org/10.1149/1945-7111/ac0019/meta
Also see Danilovic & coworkers 2022 – https://doi.org/10.1149/1945-7111/ac4fed
Exceeding Stability Targets

AEM Water Electrolysis with 2nd Gen Aemion+®

1) 9000+ hour AEM electrolyzer demonstration in large 50 cm² lab-scale cell
   • First long-lived stability demonstration in industry-relevant conditions
   • Degradation rate within 2024 EU target
     • Membrane: 0.034%/1000 hr
     • System: 0.52%/1000 hr
     • System lifetime: >25000 hr, 3 years constant operation to 2.2 V cutoff

2) 5000 hours at 3x current density with no measurable degradation (whole system)
   • Exceeding all 2024 EU Clean Hydrogen Joint Undertaking targets together at once
   • Degradation rate
     • Membrane: 0.04%/1000 hr
     • System: 0.62%/1000 hr
     • System lifetime: 55000 hr – 4.4 years to 2.2 V cutoff


• Measured cell voltage
• ‘Low frequency’ resistances (metal component oxidation)
• No membrane-associated losses
AEM Water Electrolysis with 3rd Gen Aemion+®
Exceeding every 2024 EU target, now achieving all 2030 targets

Numerous demonstrations of breakthrough durability, >1000x achieved in AEMWE:
- No measurable membrane degradation in tests up to 9000 h (2nd gen)
- No whole-system degradation >3500 h (3rd gen) (<1 µV/h, >3x 2030 target)

← S. Alia & coworkers @ NREL, through Shell Gamechanger program
Ionomr Providing AEMWE Reference Designs

Cost-effective, short lead-time design for efficient & scalable testing

- Specify all cell components for mesh electrode or CCM
- Ensures first-pass success for rapid adoption
- Small performance cell 5-10 cm²
- Large durability cell 50 cm²
- Cost-effective, especially for pressure
- <16 week lead time vs. 52+ weeks
Scaling Our Advanced Solutions

ISO 9001/14001 & IATF 16949

Quality & environment systems being implemented
Thank You

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111-2386 East Mall
Vancouver, BC V6T 1Z3
Canada

Ionomr Innovations, Inc.
285 Metro Park
Rochester, New York 14623
USA

Dr. Benjamin Britton
Chief Technology Officer
britton@ionomr.com
+1 778-887-8558
Accelerating Clean Cooling & Heating

www.atmosphere.cool
Alternatives to PFAS working fluids – natural refrigerants

ATMOsphere
Thomas Trevisan

Deputy Manager for Public Affairs – Ozone, Climate, Energy and Chemicals
ATMOsphere is a global, independent market accelerator with a mission to clean up heating and cooling.

Whether you are an investor, an end-user, or a manufacturer, we have developed a comprehensive offering to assist you in transitioning to more sustainable technologies – globally and at scale.
Ever asked yourself how does your fridge work?
Why are refrigerants important? The vapour compression cycle

The blood of the system: refrigerant, heat carrier, heat medium, working fluid -> f-gases and often PFAS, or alternatives
Where do we control mechanically temperatures? In more familiar places than we can think of...

Refrigerants can factually be everywhere!
Where can f-gases that are PFAS leak from?
Mechanical control of temperatures – refrigeration, cooling and heating

**Halogenated substances**
CFCs, HCFCs, HFCs, HFOs..

**Ozone hole**
Global warming
Persistent chemicals

- Substances not produced by nature -> hence, synthetic
- Useful in the past when environmental problems were less of a concern

**Natural heat carriers**
Carbon dioxide, hydrocarbons, ammonia, air, water

- NO Ozone hole
- NEGLIGIBLE global warming
- NO persistent chemicals

- Substances that nature produce -> hence, natural
- Inherent concerns such as flammability and toxicity are well managed by industry

- RACHP: Refrigeration, air-conditioning and heat pumps
- HVAC&R: Heating, ventilation, air-conditioning and refrigeration
Availability across applications, regions, and temperatures

- F-gases that are PFAS used as working fluids are not essential
- Natural refrigerants are not a regrettable substitution
- Also development of systems without refrigerants – not-in-kind technologies

Sources: European Commission, German Environmental Agency - UBA, Norwegian Environmental Agency, UNEP, ATMOsphere
But concretely, which natural refrigerants can be used in which application TODAY?

Some examples for stationary and mobile refrigeration equipment – e.g., supermarkets, butchers, delivery trucks, industrial facilities...

<table>
<thead>
<tr>
<th>Refrigerants</th>
<th>Composition</th>
<th>Global warming potential (IPCC Sixth AR – 20 and 100 years)</th>
<th>PFAS (OECD)</th>
<th>TFA creation (UBA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HFC-134a</td>
<td>Single component</td>
<td>4140 - 1530</td>
<td>Yes, CF3-CH2F</td>
<td>Yes 7 – 20%</td>
</tr>
<tr>
<td>HFC-404a</td>
<td>Blend</td>
<td>7208 - 4728</td>
<td>Yes, HFC-125: CF3-CHF2 HFC-134a: CF3-CH2F HFC-143a: CF3-CH3</td>
<td>Yes No HFC-125 HFC-134a: 7 – 20% HFC-143a: &lt; 10%</td>
</tr>
<tr>
<td>HFO-513a</td>
<td>Blend</td>
<td>1823 - 673</td>
<td>Yes, HFC-134a: CF3-CH2F HFO-1234yf: CH2=CF-CF3</td>
<td>Yes HFC-134a: 7 – 20% HFO-1234yf: 100%</td>
</tr>
<tr>
<td>R-744</td>
<td>Single component – carbon dioxide</td>
<td>1</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Hydrocarbons</td>
<td>Single components – isobutane, propane, propene…</td>
<td>Less than 1</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>R-717</td>
<td>Single component - ammonia</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

Sources: European Commission, German Environmental Agency - UBA, Norwegian Environmental Agency, UNEP, ATMOsphere
But concretely, which natural refrigerants can be used in which application TODAY?

Some examples for stationary cooling and heating equipment – e.g., heat pumps, ACs, chillers...

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<thead>
<tr>
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<th>Composition</th>
<th>Global warming potential (IPCC Sixth AR – 20 and 100 years)</th>
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<th>TFA creation (UBA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HFC-410A</td>
<td>Blend</td>
<td>4715 - 2255</td>
<td>Yes</td>
<td>HFC-125: CF3-CHF2</td>
</tr>
<tr>
<td>HFC-32</td>
<td>Single component</td>
<td>2690 - 771</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>HFC-407C</td>
<td>Blend</td>
<td>4456 - 1907</td>
<td>Yes, HFC-125: CF3-CHF2, HFC-134a: CF3-CH2F</td>
<td>Yes, HFC-134a: 7 – 20%</td>
</tr>
<tr>
<td>R-744</td>
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<td>1</td>
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<td>Less than 1</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>R-717</td>
<td>Single component - ammonia</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>R-718</td>
<td>Single component - water</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

Sources: European Commission, German Environmental Agency - UBA, Norwegian Environmental Agency, UNEP, ATMOsphere
But concretely, which natural refrigerants can be used in which application TODAY?

<table>
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<th>Composition</th>
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<th>PFAS (OECD)</th>
<th>TFA creation (UBA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HFO-1234yf</td>
<td>Single component</td>
<td>1.81 - 0.501</td>
<td>Yes, HFO-1234yf: CH₂=CF-CF₃</td>
<td>Yes, HFO-1234yf: 100%</td>
</tr>
<tr>
<td>HFC-32</td>
<td>Single component</td>
<td>2690 - 771</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>HFC-134a</td>
<td>Single component</td>
<td>4140 - 1530</td>
<td>Yes, CF₃-CH₂F</td>
<td>Yes 7 – 20%</td>
</tr>
<tr>
<td>R-744</td>
<td>Single component – carbon dioxide</td>
<td>1</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Hydrocarbons</td>
<td>Single components – isobutane, propane, propene…</td>
<td>Less than 1</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>R-729</td>
<td>Single component - air</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

Sources: European Commission, German Environmental Agency - UBA, Norwegian Environmental Agency, UNEP, ATMOsphere
Enough!
Thank you for listening.

Find out more on

www.atmosphere.cool
JOURNEY AWAY
FROM PFAS

10 Electronics Ave. Danvers Mass. - www.transene.com
• Students: Rashmi Sharma, Chemistry; Shreyas Shelke, Plastics Engineering; Mohammad BagheriKashani, Plastics Engineering at UML
• Investigator: Prof. Ramaswamy Nagarajan, Plastics Engineering
• Research Manager: Dr. Gregory Morose, Toxics Use Reduction Institute
• TURI for funding academic research grant
COMPANY HISTORY

• Founded in 1965

• Manufacturer of electronic chemicals, diagnostic stains and reagents, analytical chemicals

• Factories in Danvers MA and Oakland CA, USA

• 33 Employees
WHO ARE ELECTRONICS CUSTOMERS?

- Semiconductor fabs
- Chip manufacturers
- MEMS
- Photronics
- Optics
ROLE OF SURFACTANTS IN SEMICONDUCTOR INDUSTRY (ETCHING PROCESS)

Desired Surfactant Properties:

- Increase the wettability of the etching solution
- Allow for release of gases
- No residue/contamination
- Effective at low concentration
- Low or no foaming

PFAS surfactants may be found in steps 4 - 6.
### PFAS REPLACEMENT REQUIREMENTS

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Compatibility</strong></td>
<td>Strongly acidic/oxidizing solutions - nitric acid, phosphoric acid etc.</td>
</tr>
<tr>
<td><strong>Sufficient surface tension reduction</strong></td>
<td>75 to 25-30 mN/m with &lt; 0.1wt% surfactant concentration</td>
</tr>
<tr>
<td><strong>Contaminants</strong></td>
<td>low sodium ions</td>
</tr>
<tr>
<td><strong>Stability</strong></td>
<td>&gt; 1 year shelf life in solution</td>
</tr>
<tr>
<td><strong>Low foaming</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Cost</strong></td>
<td></td>
</tr>
</tbody>
</table>
PFAS HISTORY AT TRANSENE

PFOS

TYPE 1

TYPE 2

TYPE 3

CUST SPEC

PFAS---PFAS---PFAS---PFAS---PFAS---PFAS---PFAS

WHAT NEXT?
Learning with Purpose

**IDENTIFYING OPTIONS**

- Transene focused on sources we knew

**UML group had other options**

- Group technology
- Related materials
CUSTOMER ACCEPTANCE

Customers use the chemicals in different ways (spray, circulate, etc.)

Easy targets—one-off purchases

No complaints? Let some customers know the change has been made

Still no complaints? Start qualifications with the big customers

Not a 100% success rate

Initial phase engendered some comments about foaming—slight level reduction
CONCLUSIONS

- Strength of industry-academic collaboration
- PFAS replacement is viable
- Cost impact; sales impact
- Reduced liability
Performance and development of PFAS-free textile alternatives
SYMPATEX JOURNEY

OVERVIEW

01
FUNCTIONAL FABRICS

02
PERFORMANCE OF PFAS-FREE FABRICS

03
DEVELOPMENT OF PFAS-FREE FABRICS
Functional fabrics for garment & shoes

- Outer lining
  → treatment
  → water repellence

- Barrier layer
  → membrane or coating
  → waterproofness
PROTECTION AGAINST RAIN

PERFORMANCE – PFAS VS. PFAS-FREE

WATER REPELLENCE

• Spray Test (ISO 4920)
• Bundesmann Test (ISO 9865)
• Rain Tower Test (EN 14360)

→ Slightly more frequent reimpregnation of fluorine-free DWR after washing could be necessary

WATERPROOFNESS

• Determination of resistance to water penetration (EN 1734)

→ No difference, compact systems even better
Correct adjustment of all parameters:

1. textile surface
2. DWR
3. Finishing parameter
4. Intended use

⇒ same performance of PFAS-free and PFAS DWR:
   10 min Bundesmann grade 5, even after 5x 40°C washing
PROTECTION AGAINST RAIN

DEVELOPMENT OF PFAS-FREE ALTERNATIVES

PFAS-FREE WATER REPELLENCE

- 2008 – 1st fluorine free DWR
- 2012 – increased demand from customers
- 2013 – today: testing of market available DWRs

Currently **2 working groups** at Sympatex

- Performance comparison C0 – C6
- Customer oriented issues:
  - Customer communication
  - Benchmark
  - different DWR on Sympatex laminate
LET’S DIVE INTO THE QUESTIONS!
CHEMSEC CHANNELS

- Website: chemsec.org
- PFAS Guide: pfas.chemsec.org
- SIN List: sinlist.chemsec.org
- Marketplace: marketplace.chemsec.org
- LinkedIn: @chemsec
- Twitter: @chemsec
- Instagram: @no_to_pfas
- Facebook: @chemsecsweden