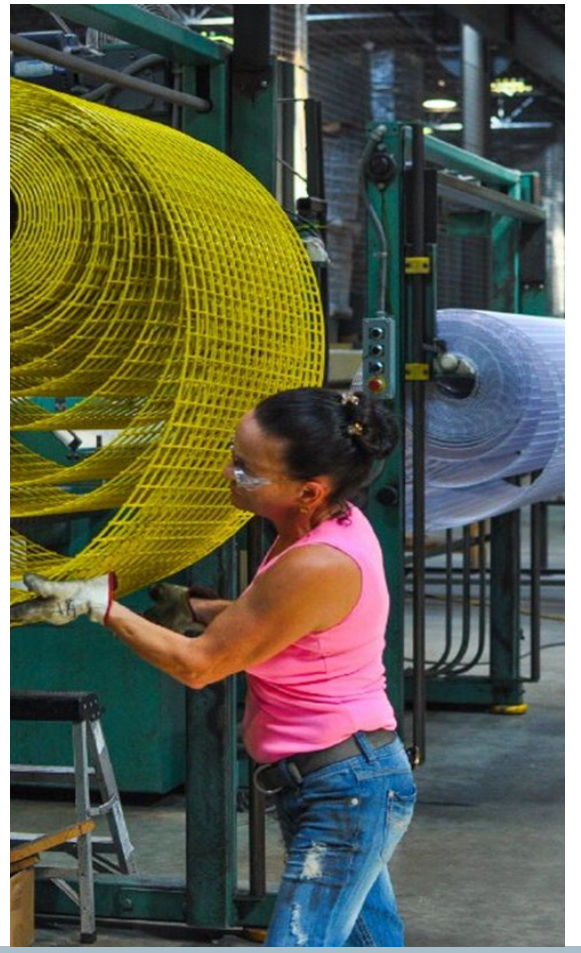
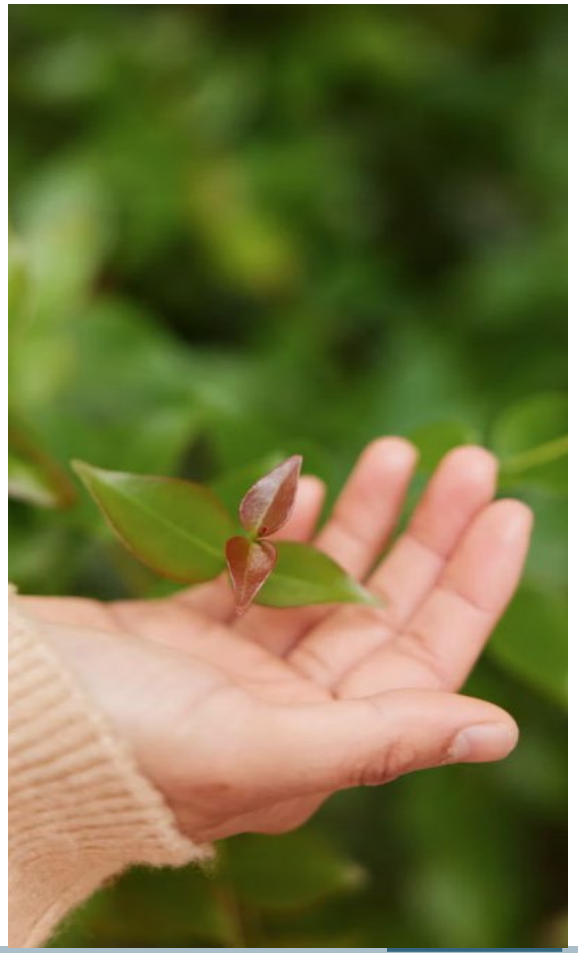
Safer Products and Processes: Research Update

August 20, 2025

Toxics Use Reduction Institute webinar



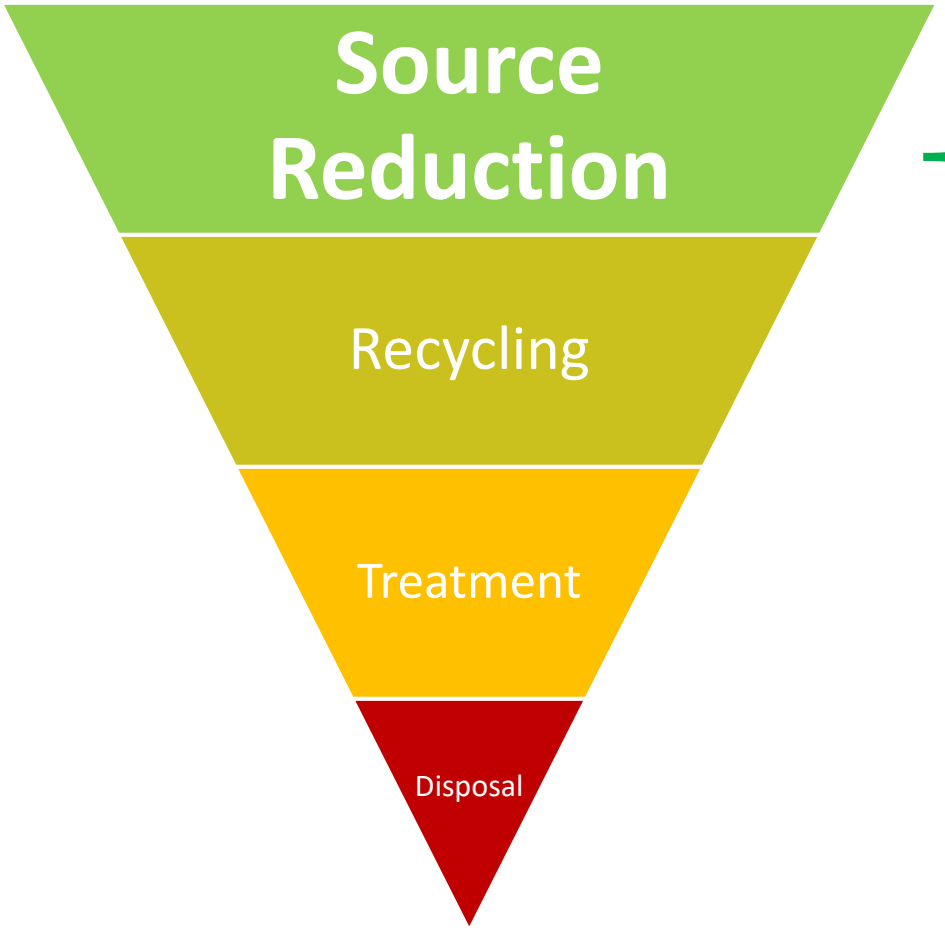


Welcome!

Agenda

- Safer alternatives to solvents used in plumbing and painting
- Hexavalent chromium-free coatings in aerospace/defense
- Safer alternatives to PFAS in products
- Safer industrial surface cleaning technology

Core Principles of Toxics Use Reduction



Reduce toxics at the source (use-based analysis)

Focus on inherent hazard of chemicals used

Identify suite of opportunities to eliminate or reduce hazard

Implement affordable and effective opportunities

PFAS remediation costs are in the trillion USD range* vs. market value for PFAS = ~20 billion USD

*U.S. Chamber of Commerce: PFOS and PFOA Private Cleanup Costs at Non-Federal Superfund Sites. Ling (2024) https://doi.org/10.1016/j.scitotenv.2024.170647

TURI
TOXICS USE REDUCTION INSTITUTE

Toxics Use Reduction and Alternatives Assessment

A process for identifying and comparing potential chemical, material, product or other alternatives that can be used as substitutes to replace chemicals of high concern

Is it safer?

- Workers
- Community
- Customers
- Environment

Is it effective?

- Performance standards
- Sufficiency
- Impact on quality

Is it affordable?

- Capital availability
- Ancillary costs
- External costs

TURI
TOXICS USE REDUCTION INSTITUTE

TURI Lab and Research Efforts

Assisting facilities reduce their use of toxic chemicals through hands on assistance

- Safety
- Technical feasibility
- Cost savings of safer alternative

Supporting business success

- Implement projects that protect their workers, communities and the environment by reducing use of toxic chemicals
- TURI offers grants to help businesses succeed in their TUR efforts
  - Research feasible options
  - Evaluate relative hazard and performance
  - Support adoption of safer alternatives

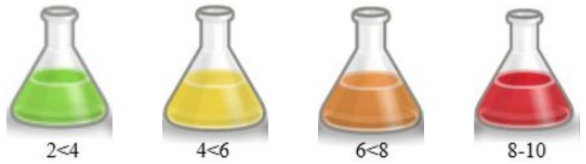
Are the Alternatives Safer?

Pollution Prevention Options Analysis System (P2OASys):
https://p2oasys.turi.org

Compares potential Environmental Health and Safety (EHS) hazard categories:

Categories	Trichloroethylene	Neutral Aqueous	Acidic Aqueous	Biobased	Hyrdocarbon	Modified Alcohol
Acute Human Effects	8	4	8	6	8	8
Chronic Human Effects	9	4	2	5	6	2
Ecological Hazards	8	4	2	4	8	4
Environmental Fate & Transport	9	4	4	4	6	5
Atmospheric Hazard	6	2	2	2	2	2
Physical Properties	10	4	6	5	9	8
Process Factors	7	4	5	4	4	4
Life Cycle Factors	10	3	4	4	6	4
Product Score	8.4	3.6	4.1	4.3	6.1	4.6

- Both quantitative data and qualitative input.
- Each category is rated using values, key phrases, GHS classifications, or other hazard designations.
- Depend upon available data (SDS, PubChem, computational toxicology).



TURI
TOXICS USE REDUCTION INSTITUTE

Our presenters

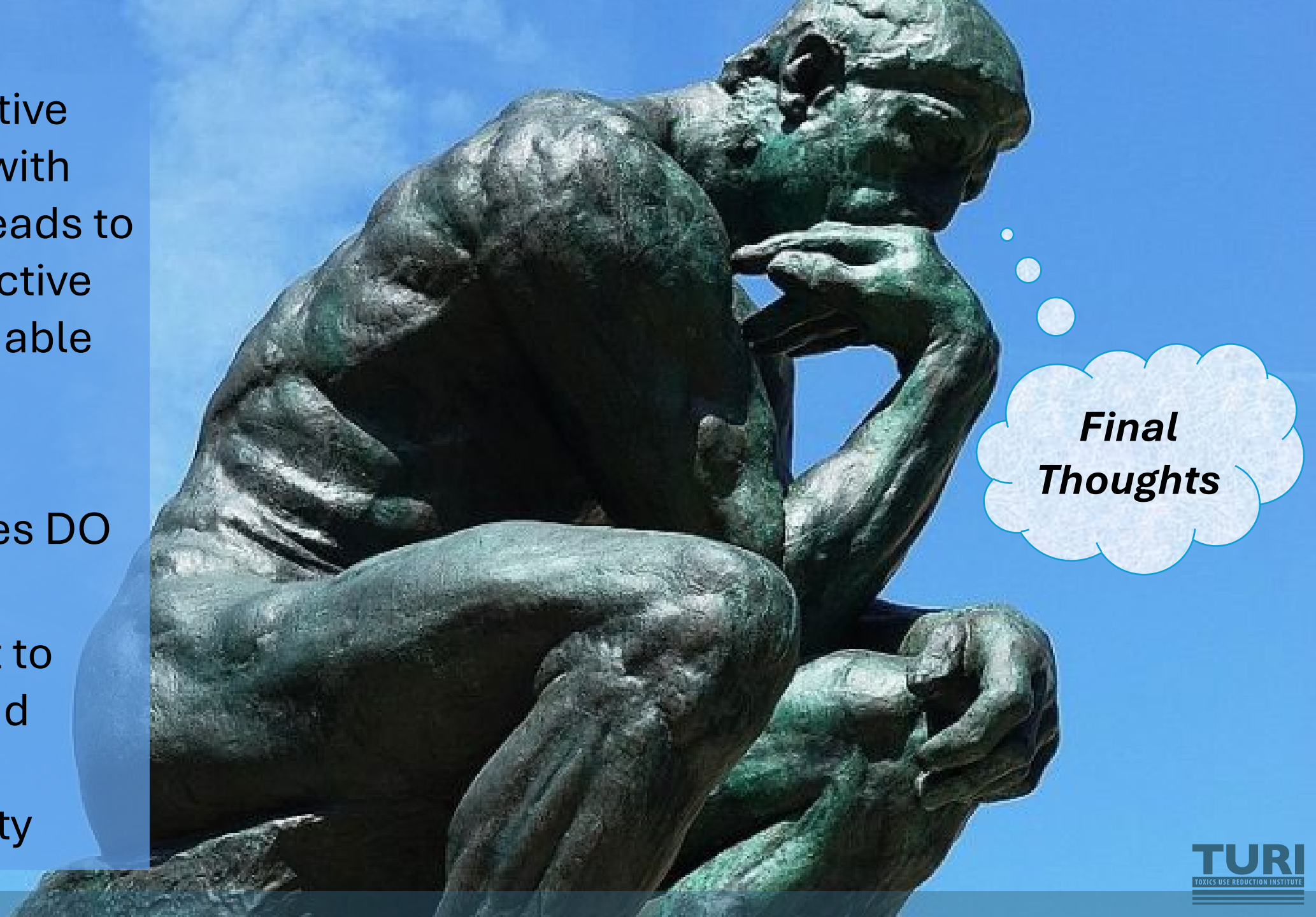
Dr. Greg Morose, TURI Research Director

Dr. Gabriel Salierno, TURI Green Chemist

Dr. Jason Marshall, TURI Lab Director

TURI
TOXICS USE REDUCTION INSTITUTE

- Collaborative research with industry leads to safer, effective and affordable solutions
- Safer alternatives DO exist
- Reach out to TURI to find YOUR opportunity



TURI
TOXICS USE REDUCTION INSTITUTE

Toxics Use Reduction Institute

www.turi.org

978-934-3275

The Offices at Boott Mills West
126 John Street, Suite 14
Lowell, MA 01852

Greg Morose, TURI Research Director
Gregory_Morose@uml.edu
978-934-2954

Gabriel Salierno, TURI Green Chemist
Gabriel_Salierno@uml.edu
978-934-4521

Jason Marshall, TURI Lab Director
Jason_Marshall@uml.edu
978-934-3133

TURI
TOXICS USE REDUCTION INSTITUTE

Upcoming Webinars

12 Sept., 12:00 PM – 1:30 PM

Determining the cost of toxics: TUR fundamentals

19 Nov., 12:00 PM – 1:30 PM

Implementing TUR: Company examples

Evaluating chemicals of concern

8 Oct., 9:00 AM – 10:30 AM

Using machine learning to support TUR

9 Dec., 10:00 AM – 11:30 AM

TURI
TOXICS USE REDUCTION INSTITUTE

Reminder

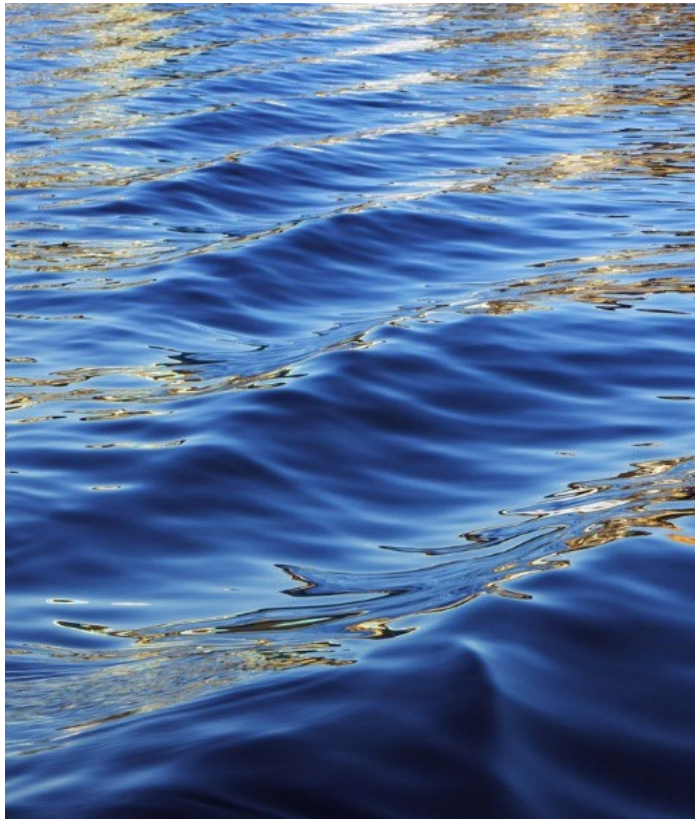
- To receive CEUs for attending today's webinar you must:
  - Attend the full webinar
  - Complete the survey which will be distributed in the next few days

- Please never hesitate to reach out to TURI's training team if you have questions:
  - training@turi.org
  - Pam Eliason, Training Director: Pamela_Eliason@uml.edu
  - Agnes Cheng, Training Associate: Agnes_Cheng@uml.edu

Safer Products: Paint strippers and PVC Cement

Gregory Morose
TURI Research Manager
Gregory_Morose@uml.edu

August 20, 2025



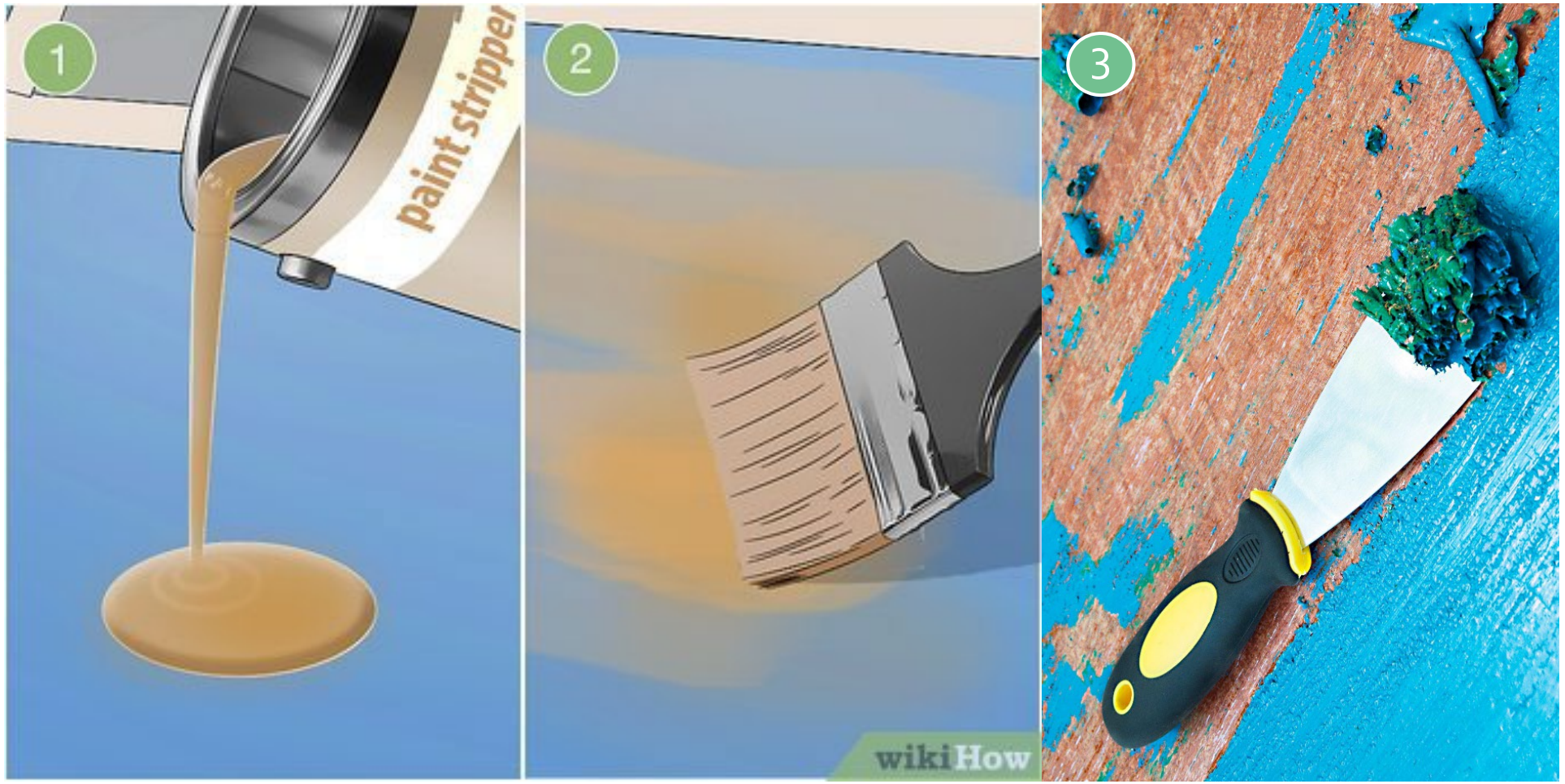
TURI
TOXICS USE REDUCTION INSTITUTE
UMASS LOWELL

PVC Primer & Cement

These products are used by plumbers, mechanical contractors, and DIYers to join PVC pipe and couplings.

Paint Strippers

These products are used by professional painters and DIYers to strip paint and other coatings from a surface.



Products Contain Highly Hazardous and Volatile Solvents

Paint Strippers

Ethyl benzene
Methanol
Xylene

NMP

Methylene chloride
Methanol

PVC Cement

THF

THF

Professional painters/plumbers, trade school students, and do-it-yourselfers use these products with exposure risk.

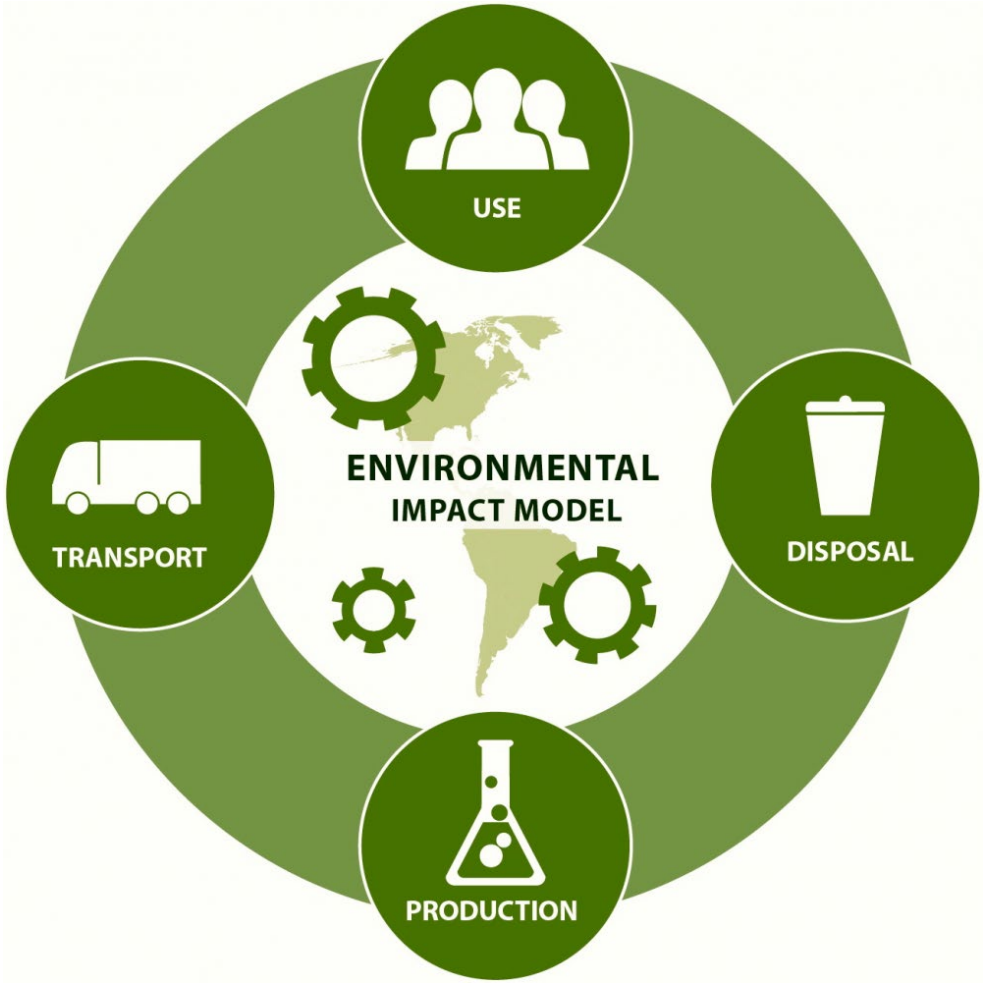
3.6 million total product users annually in the U.S.

Potential Exposure During Product Life Cycle

Product user exposure (professionals and DIYers).

Many of these hazardous solvents evaporate rapidly.

Potential for spills, leaks, and accidents.



Improper disposal can contaminate soil and water.

Product manufacturing worker exposure during mixing and filling operations .

https://news.ucsb.edu/2014/014070/faster-environmental-testing-new-synthetic-chemicals-and-materials

Safer Pipe and Paint Products Program (SP4)

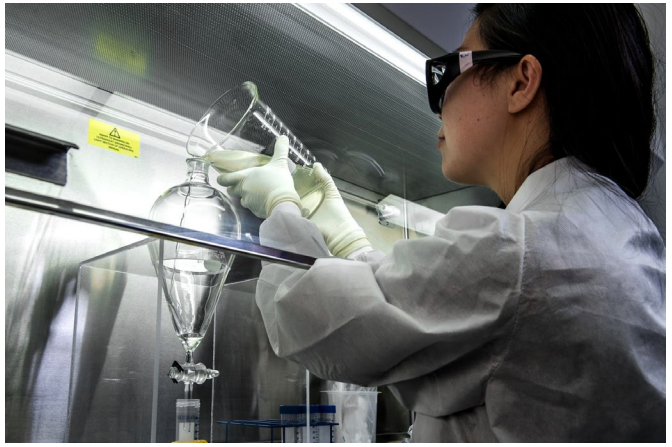
Solution:

A pilot program for a new voluntary model to provide safer products.

SP4 is funded ($1.18 million) by the U.S. EPA and led by the UMass Lowell/TURI to work with unions, retailers, and manufacturers to transition to safer PVC cement and paint stripper products without chemicals of high concern.

Start: February 2024
Complete: January 2027

SP4 Process



Reformulation: Provide free technical and financial assistance to manufacturers to reformulate their products with safer ingredients.

Performance: Conduct independent performance testing (ASTM, etc.) of all products to validate product performance.

Safety: Review product ingredients for safety to ensure that chemicals of high concern are not used, to prevent regrettable substitutions.

Education: Share results with retailers, unions, and other product users to make informed decisions.

TURI
TOXICS USE REDUCTION INSTITUTE
UMASS LOWELL

Product Manufacturers

PVC Cement Manufacturer	Location
Atlantic Chemical & Equipment	Atlanta, GA
Arrow Adhesives	Norcross, GA
Black Swan Mfg.	Chicago, IL
EZ Weld	Riviera Beach, FL
Gorilla	Cincinnati, OH
IPS Corp.	Gardena, CA
LH Dottie	Commerce, CA
Oatey	Cleveland, OH
Rectorseal	Houston, TX
Spears Manuf. Co.	Sylmar, CA
Weld-on	Compton, CA

Paint Stripper Manufacturer	Location
Benco	Crossville, TN
Flo Strip	Kirkwood, MO
Packaging Services	Pearland, TX
PPG	Pittsburgh, PA
Rustoleum	Vernon Hills, IL
Savogran	Norwood, MA
Sunnyside Corp.	Wheeling, IL
WM Barr	Memphis, TN

Labor Unions

Unified customer voice to emphasize the importance of SP4.

International Union of Painters and Allied Trades (IUPAT)

Represents approximately 140,000 members.

United Association of Journeymen and Apprentices of the Plumbing and Pipefitting Industry (UA)

Represents approximately 365,000 members.

The Center for Construction Research and Training (CPWR), the research arm of the North America's Building Trades Unions (NABTU)

Represents over 3 million members.

Affected Retailers/Distributors

Online sales only

Amazon

Grainger

Physical stores & online sales

Ace Hardware

Autozone

Home Depot

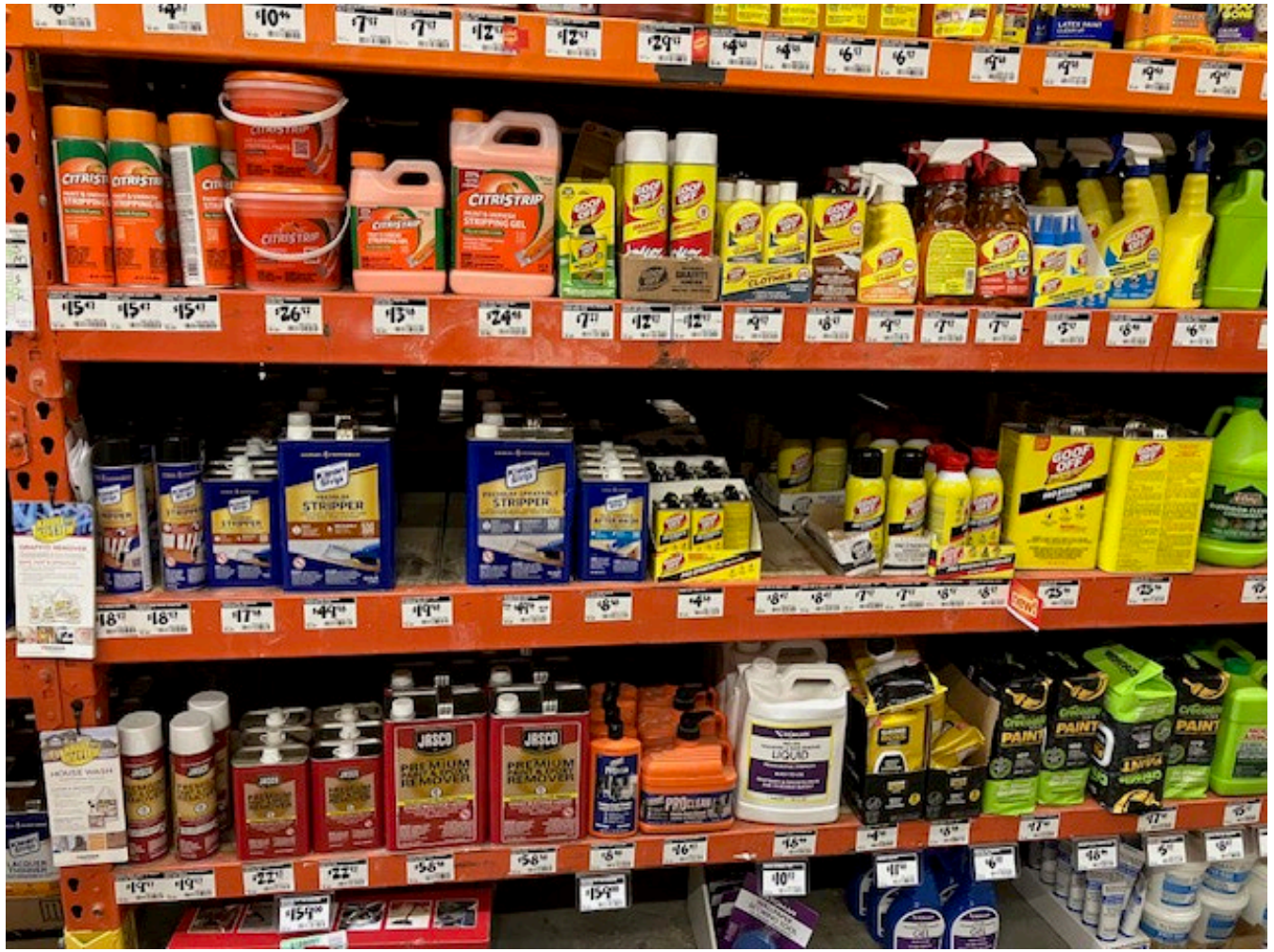
Ferguson

Lowe's

True Value

Walmart

etc.



SP4 supports retailer safer chemical policies/strategies/commitments

TURI
TOXICS USE REDUCTION INSTITUTE
UMASS LOWELL

Retailer	Total Linear Feet Shelf Space	Number of Products	Products with COC	Linear Feet with COC	Products with no COC	Linear Feet with no COC
Ace Hardware	37,346	6	6	37,346.17	0	0
Aubuchon Hardware	225	2	1	112.50	1	113
Do it Best	2,475	3	3	2,475.00	0	0
Ferguson	20,292	19	15	16,019.92	4	4,272
F.W. Webb	4,000	4	4	4,000.00	0	0
Graybar	0	0	0	0	0	0
Hajoca	3,915	7	4	2,237.14	3	1,678
Home Depot	42,773	5	5	42,773.33	0	0
Johnstone	1,725	2	1	862.50	1	863
Lowe's	40,233	5	5	40,233.33	0	0
Menards	5,400	3	3	5,400.00	0	0
Reese	2,240	4	4	2,240.10	0	0
Sonepar	0	0	0	0	0	0
True Value	6,580	5	5	6,580.00	0	0
Walmart	3,841	2	2	3,840.83	0	0
Wesco	0	0	0	0	0	0
Winsupply	0	0	0	0	0	0
Total feet	171,046			164,121		6,925
Total miles	32.4			31.1		1.3
				96%		4%

PVC Cement Products in U.S. in 2024

Zero linear feet:

- On-line sales only, or
- No access behind the sales counter

Retailer	Total Linear Feet Shelf Space	Number of Products	Products with COC	Linear Feet with COC	Products with no COC	Linear Feet with no COC	Products with ? COC	Linear Feet with ? COC
Ace Hardware	40,395	8	4	20,197	3	15,148	1	5,049
Advance Auto Parts	2,229	1	1	2,229	0	-	0	-
Aubuchon Hardware	292	4	2	146	1	73	1	73
Autozone	7,980	1	1	7,980	0	-	0	-
Benjamin Moore	13,750	2	0	-	1	6,875	1	6,875
Do it Best	1,125	1	1	1,125	0	-	0	-
Dunn Edwards	149	1	1	149	0	-	0	-
Home Depot	14,035	6	3	7,018	3	7,018	0	-
Lowe's	14,733	6	3	7,367	3	7,367	0	-
Menards	8,525	10	3	2,558	5	4,263	2	1,705
NAPA Auto Parts	8,000	2	2	8,000	0	-	0	-
O'Reilly Auto Parts	8,175	3	3	8,175	0	-	0	-
PPG Paint Stores	318	1	0	-	0	-	1	318
Sherwin Williams	16,667	4	0	-	2	8,333	2	8,333
True Value	3,455	6	5	2,879	1	576	0	-
Walmart	12,291	4	2	6,145	2	6,145	0	-
West Marine	1,802	3	3	1,802	0	-	0	-
Total feet	153,918			75,768		55,797		22,353
Total miles	29.2			14.3		10.6		4.2
				49%		**36%**		**15%**

Paint Stripper Products in U.S. in 2024

? COC

- Trade secret
- Proprietary ingredient
- No SDS

Chemical Substitution Approaches

1) Green Chemistry (Principle #4)

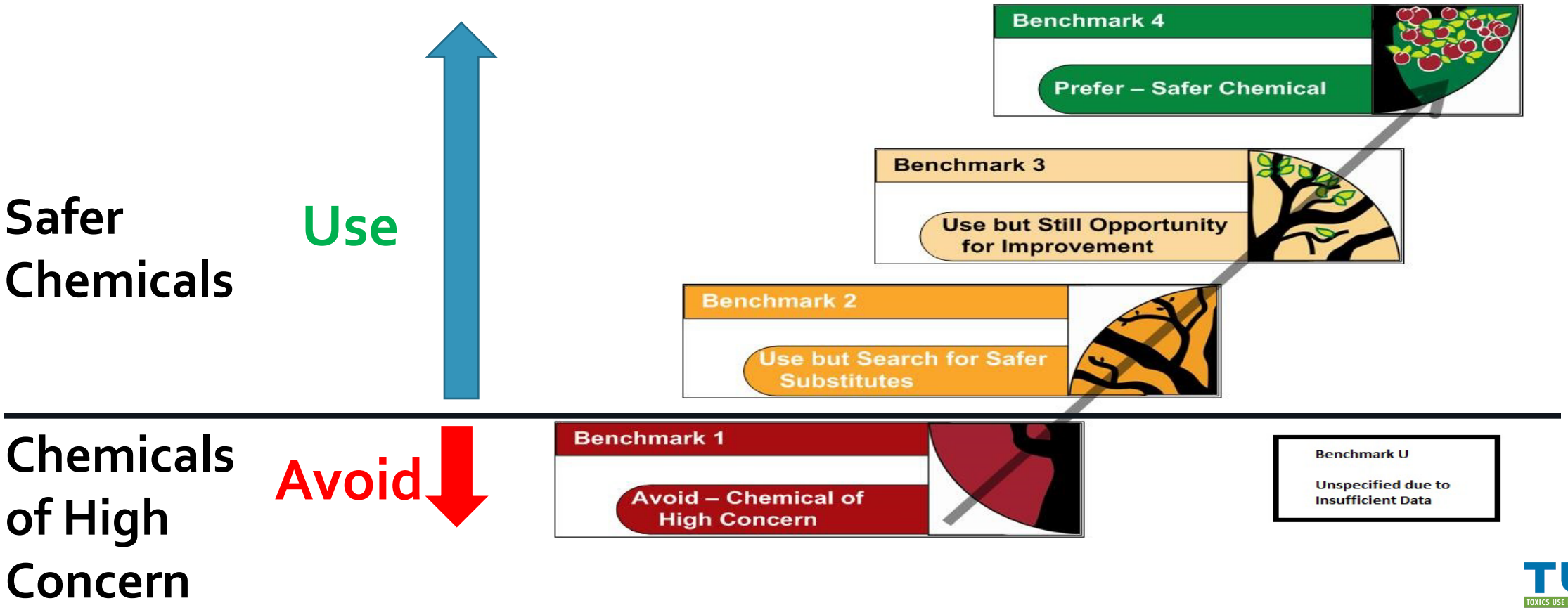
*Design chemical products that are fully effective while **reducing** toxicity.*

2) Regrettable Substitution

Replacing a chemical of high concern with another chemical of high concern.

How can we distinguish between toxic and safer solvents in products and avoid future regrettable substitutions?

- We use tools like the Green Screen for Safer Chemicals to compare chemicals in formulations



Advancing Safer Product Adoption

Education and awareness training and providing THF free products:

Plumber's Union Training Centers

- Massachusetts
- Connecticut
- New York
- Arizona
- California

Regional Vocational Technical High Schools

- Assabett Valley: Marlborough, MA
- Whittier: Haverhill, MA

Collaborating with Product Manufacturers

WELD-ON®

THE WORLD'S MOST TRUSTED BOND

WELD-ON PARTNERS WITH TURI TO ADVANCE ECO-FRIENDLY PRODUCTS

ULTRA LOW VOC

With a legacy spanning over 70 years, Weld-On has consistently set the standard for innovation, performance, and safety in the solvent cement industry. Our commitment to developing products that are not only reliable but also environmentally responsible has led us to collaborate with like-minded organizations that share our vision. One such partner is the Toxics Use Reduction Institute (TURI) at the University of Massachusetts Lowell.

viable solvent alternatives that are not considered "regrettable substitutions"—chemicals that solve one problem but create another. Weld-On then rigorously tests these formulations in-house to ensure they meet and exceed internal and industry standards.

Sustainable Innovation Without Compromise

Products developed through this initiative are undergoing a comprehensive testing process, including dissolution efficiency, cold stability, and bond strength. Weld-On's internal standards often surpass ASTM and NSF benchmarks, ensuring our customers receive products that are not only safe but exceptionally reliable.

TURI TOXICS USE REDUCTION INSTITUTE UMASS LOWELL

ASTM Product Performance Testing

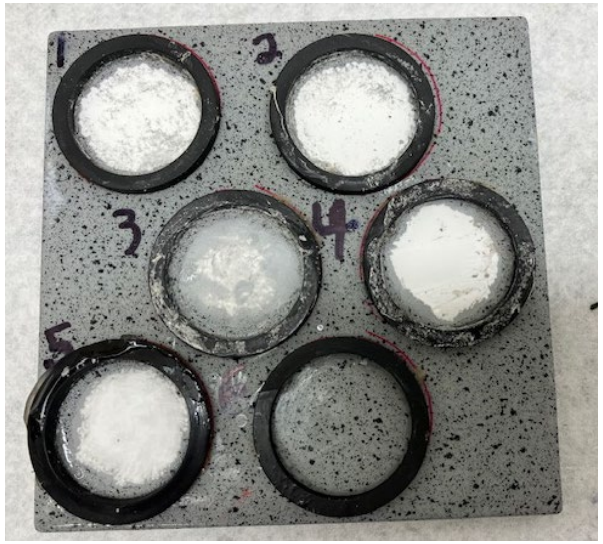
Finishing Trades Institute (IFTI) New England

Test panels prepared and ASTM performance testing conducted at:

- International Union of Painters and Allied Trades (IUPAT) Finishing Trades Institute (IFTI) New England
- Located in Brentwood, New Hampshire

Finishing Trades Institute (IFTI) New England

Field Trials for Performance Validation



Outstanding Bath (Mendon, MA)
Bathtub tiles

Raytheon (Andover, MA)
Chemical agent resistant coatings and conformal coatings

Belcastro Furniture Refinishing (Tyngsboro, MA)
Antique furniture

Share Information

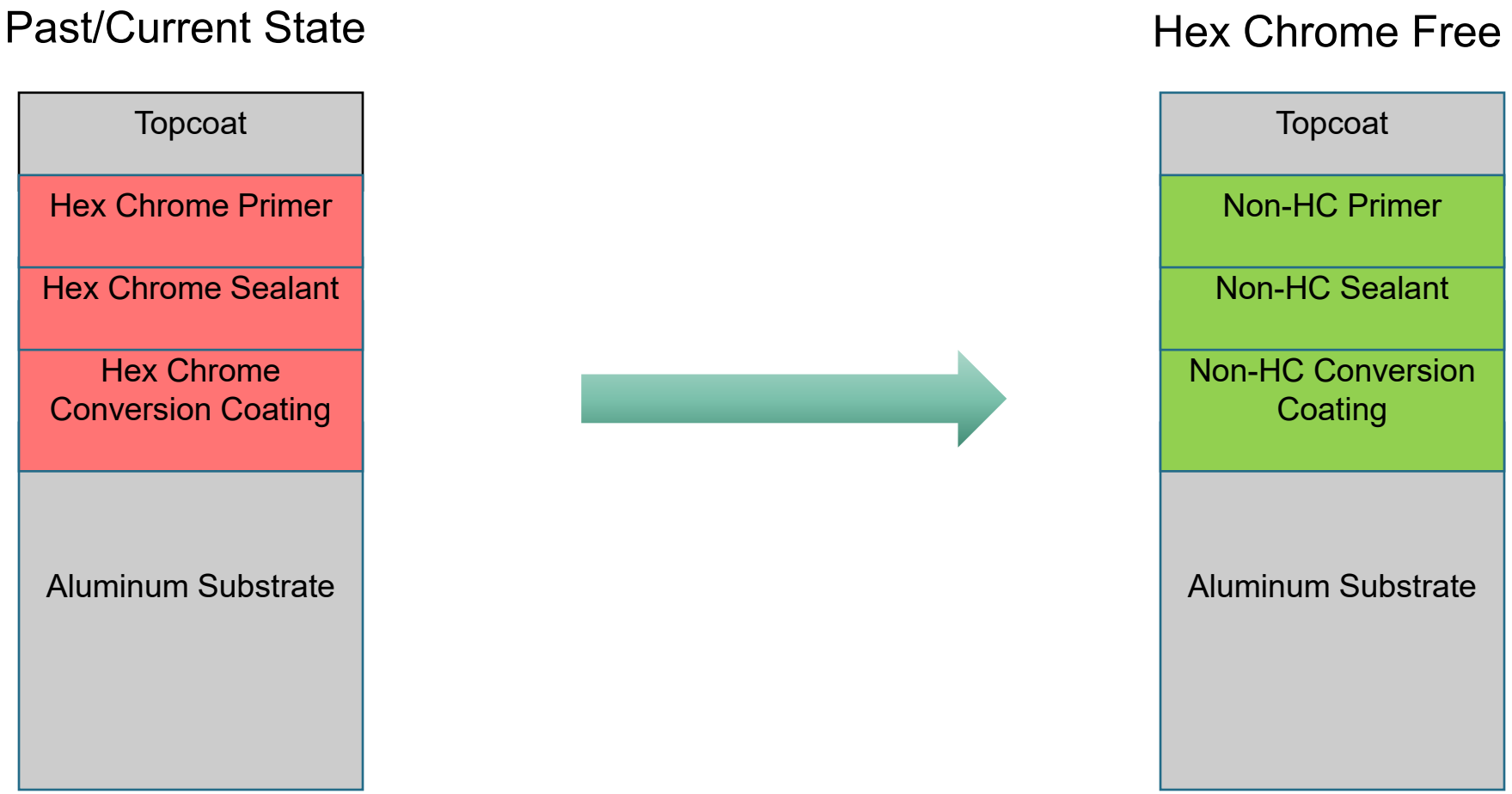
	ASTM Oil based	ASTM latex	VOC	Ingredient Safety	Comments
Product 1	✓	✓	✓	✓	
Product 2	x	✓	x	x	
Product 3	✓	x	✓	✓	
Product 4	✓	✓	x	✓	

Share product performance and safety information in a summary format with retailers, unions, and other users to enable them to make informed product purchasing decisions.

EPA SP4 Project Next Steps

Continue to assist product manufacturers with product reformulation to safer ingredients.
Develop a fact sheet with ASTM performance testing results and product ingredients for safer paint stripper products.
Continue to provide education and awareness and safer products to union training centers and vocational technical high schools across the U.S.
Work with EPA to develop a retailer recognition program for selling safer products.
Conduct outreach to retailers about including safer products in upcoming 2026 product line reviews.

Hexavalent Chromium In Coating Layers for Aerospace Products



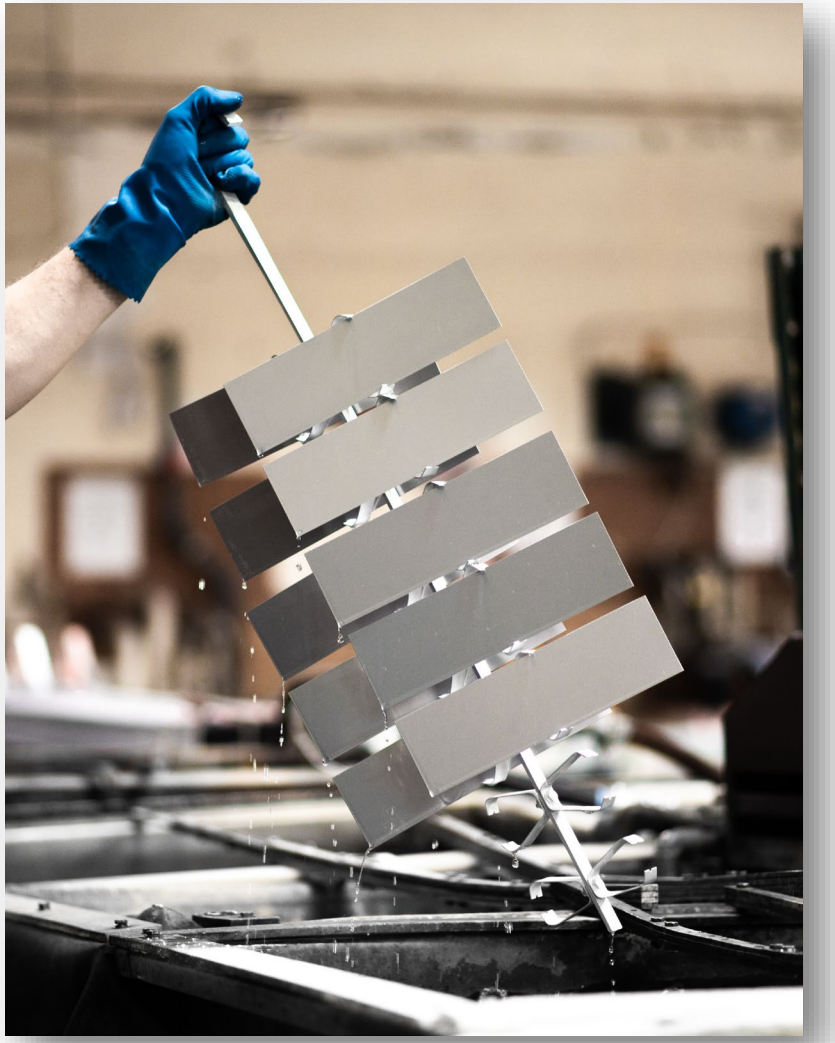
Hexavalent chromium used for corrosion protections in primers, sealants, and conversion coatings

Aerospace Industry Hex Chrome Free Coatings Consortium

Founded and led by TURI since 2012

Coating Application	Phase	Timeframe
Sealants	1	2012 - 2014
Bond primers	2	2015 - 2017
Conversion coatings	3	2018 - 2025

TURI
TOXICS USE REDUCTION INSTITUTE
UMASS LOWELL



Phase 3: Conversion Coatings

Test panels

- Blue Origin (Florida)
- Textron Aviation (Kansas)

Conversion Coatings

- Polymetal (Springfield, MA)
- International Hardcoat (Michigan)
- PPG (Pennsylvania)

Primer/Topcoat

- CIL (Lawrence, MA)

Paint adhesion, salt fog corrosion testing (short term)

- Lockheed Martin (Texas)

Funding contributions

- Raytheon
- Boeing

Overall, Socosurf TCS/PACS was the best performing hexavalent chromium free conversion coating across all alloys.

Long Term Corrosion Testing for Conversion Coatings

NASA Beachside Atmospheric Corrosion Test Site
Kennedy Space Center, Florida

Started: September 2020

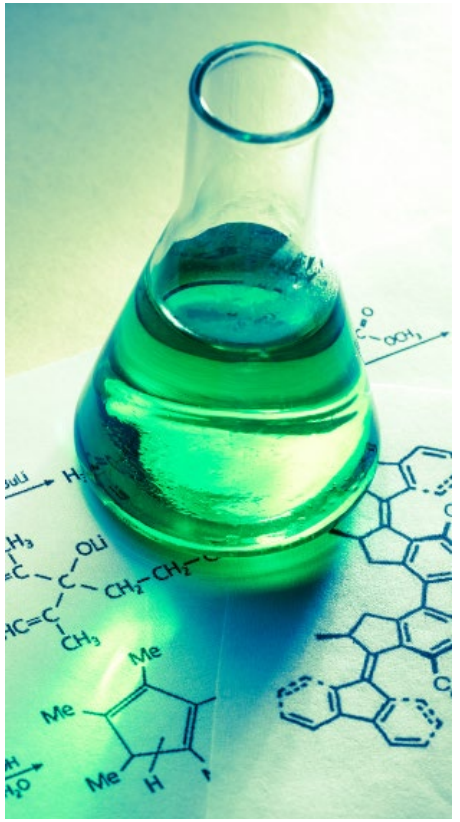
Five-year test results available: October 2025

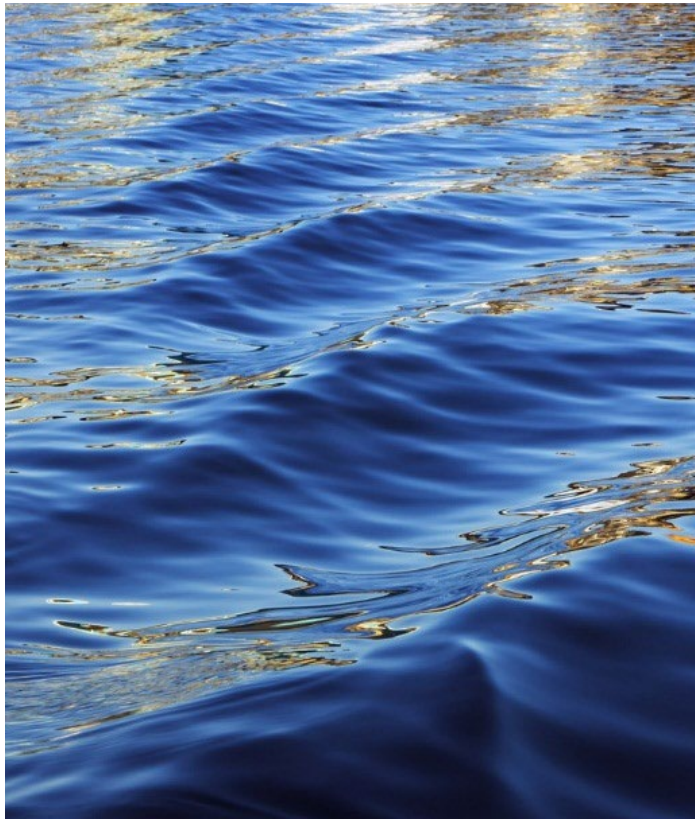
TURI
TOXICS USE REDUCTION INSTITUTE
UMASS LOWELL

Identifying and Evaluating Safer PFAS Replacements

Dr. Gabriel Salierno – TURI
Bahareh Rahimi – Plastics Eng. Dept., UMass Lowell
Dr. Greg Morose – TURI

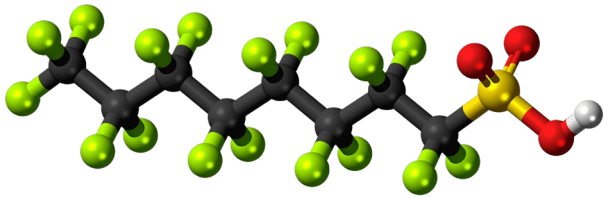
August 20, 2025

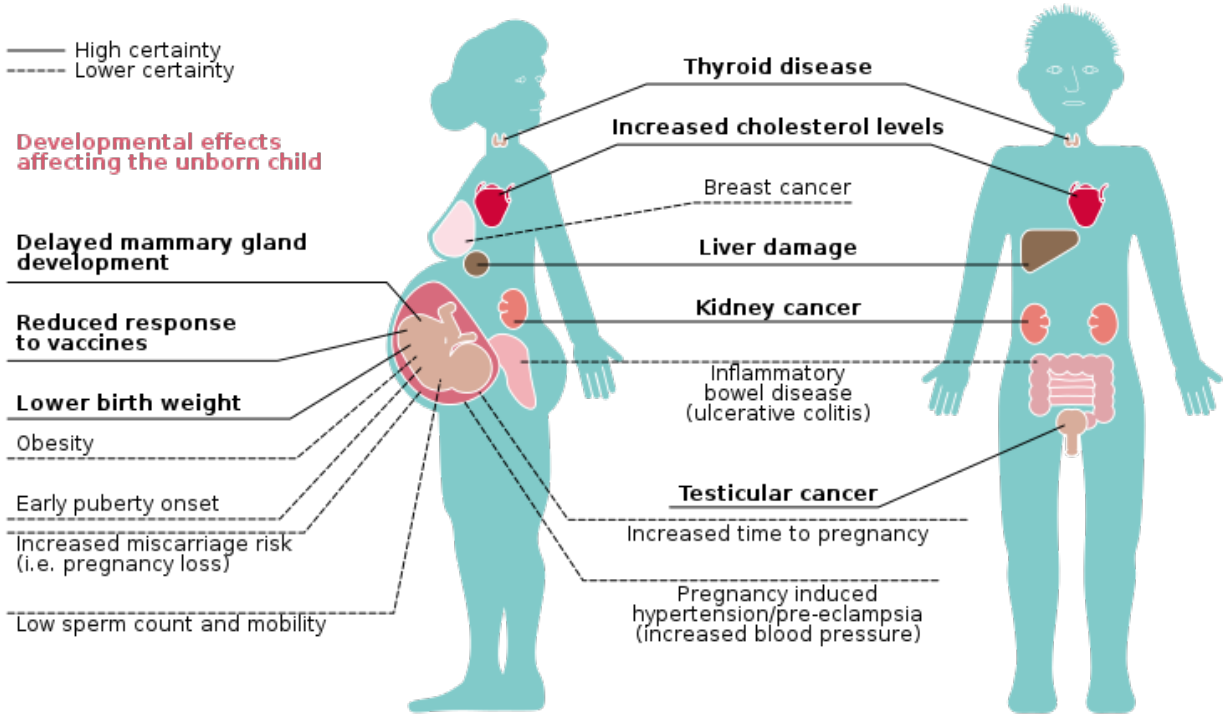




Why are we concerned about PFAS

- Resist breakdown, persist in environment/bodies for years.
- Health Concerns: Linked to cancer, immune disorders, developmental issues …





Costs of PFAS Pollution

- Public Health Impacts (U.S.): $5.5–$62 billion/year in healthcare, lost productivity. Cordner et al., (2021)
- Remediation: Billions annually; global estimates up to trillions. Ling (2024)
- Cleanup costs (only for PFOA/PFOS non-Federal private Superfund sites): >$17.4 billion. U.S. CoC (2022)
- MPCA PFAS cleanup costs report (2023): 14 – 26 billion (MN only)

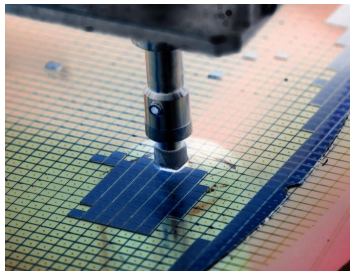
TURI
TOXICS USE REDUCTION INSTITUTE

PFAS alternatives from TURI research grants

TRANSENE COMPANY, INC.

Transene

Safer alternative to PFAS surfactants in semiconductor manufacturing



HAARTZ

Haartz Corporation

Safer alternatives to PFAS coated fabrics

UMASS LOWELL

Food Wrap

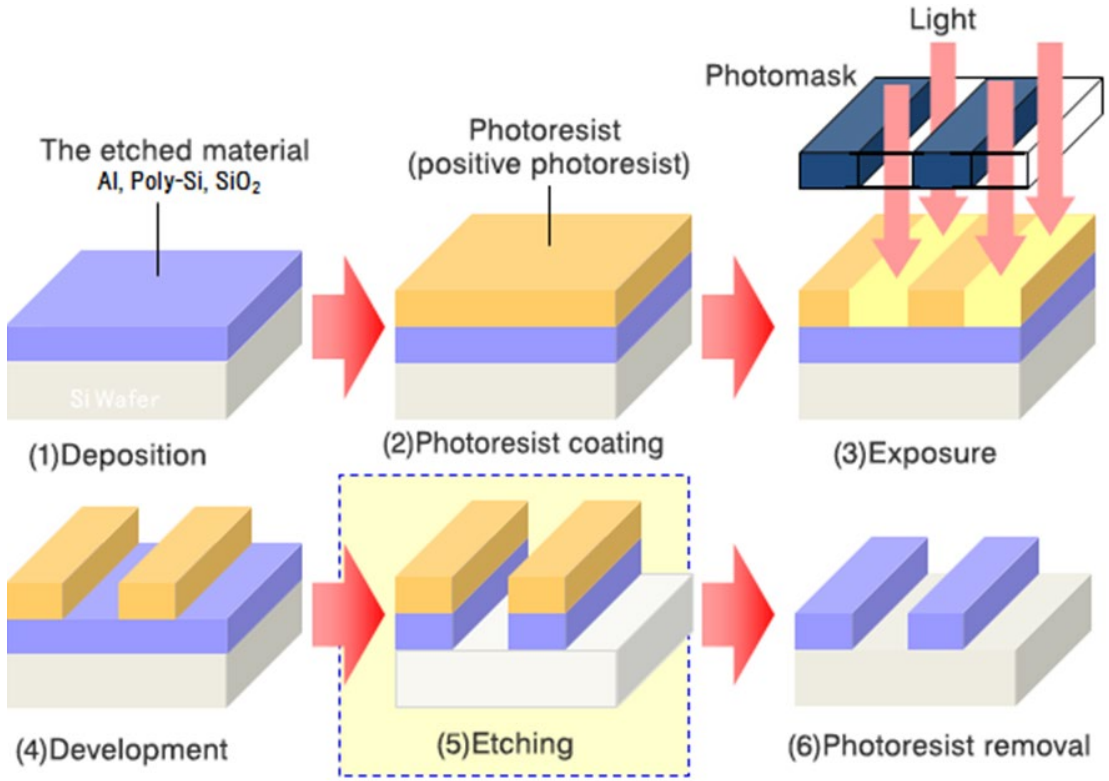
Safer alternatives to PFAS coated paper

TURI TOXICS USE REDUCTION INSTITUTE

PFAS surfactants in the semiconductor industry

TRANSENE COMPANY, INC.

Massachusetts-based supplier of chemical etchants, photoresists, dielectrics for electronics and aerospace.



PFAS surfactant improves the wettability of etchants.

A major PFAS manufacturer has exited the market.

Alternative surfactants must:

- Be compatible with strong acidic/oxidizing solutions (nitric, phosphoric acid, etc.).
- Reduce etchant surface tension (comparable to PFAS, <0.1 wt.% consumption).
- Be less hazardous and toxic (no sodium ions).
- Stability: >1-year shelf life.

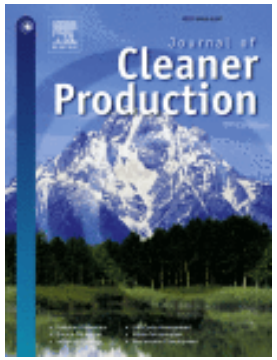
TURI
TOXICS USE REDUCTION INSTITUTE

Semiconductor Manufacturing Applications

Parameter	Buffered Oxide Etchants (BOE)	Chrome Etchant	PAN	TMAH
Composition	NH_4HF_2: HF mixture 6:1	Ceric ammonium nitrate + acid (perchloric/nitric/ acetic)	Phosphoric, Acetic & Nitric Acids	Tetramethyl ammonium hydroxide (2.38%)
pH	pH = 3-5	pH <1	pH < 2	pH =13-14
Color	Colorless	Orange	Colorless	Colorless
PFAS-based surfactant	Novec 4200	FC95	Novec 4300	Novec 4200
Substrate	Glass	Chromium	Aluminum	Photoresist
Alternative Surfactant	CG-50	Brij 35 Brij S100	BG-10	BG-10

TRANSENE COMPANY, INC.

UMASS LOWELL



Safer and effective alternatives to perfluoroalkyl-based surfactants in etching solutions for the semiconductor industry

Journal of Cleaner Production 415, 20 (2023) 137879
https://doi.org/10.1016/j.jclepro.2023.137879

TURI
TOXICS USE REDUCTION INSTITUTE

Project Results

- Replaced Novec-4200 and other PFAS-based surfactants with PFAS-free surfactants:
  - Engaged with TURI's academic research team to develop and test options
  - Overcame challenging performance requirements
  - New products are less expensive
- Successfully converted over 90% of its customers to the new products.
- PFAS-based surfactants cost $2,400 per gallon, but the new safer surfactants cost only $80 per gallon.

TRANSENE COMPANY, INC.

UMASS LOWELL

Case study: https://www.turi.org/content/download/14435/223838/file/Transene%20Case%20Study%202023.pdf

TURI TOXICS USE REDUCTION INSTITUTE

PFAS free stain-resistant cotton textiles

UMass Lowell - Plastics Engineering Department researchers, funded by TURI research grants, are developing PFAS-free coatings for textiles used in apparel, upholstery, and protective gear.

A Comparative Study of PFAS-free Liquid-Repellent Coatings on Cotton Fabric.
Progress in Organic Coatings, 195 (2024) 108670
https://doi.org/10.1016/j.porgcoat.2024.108670

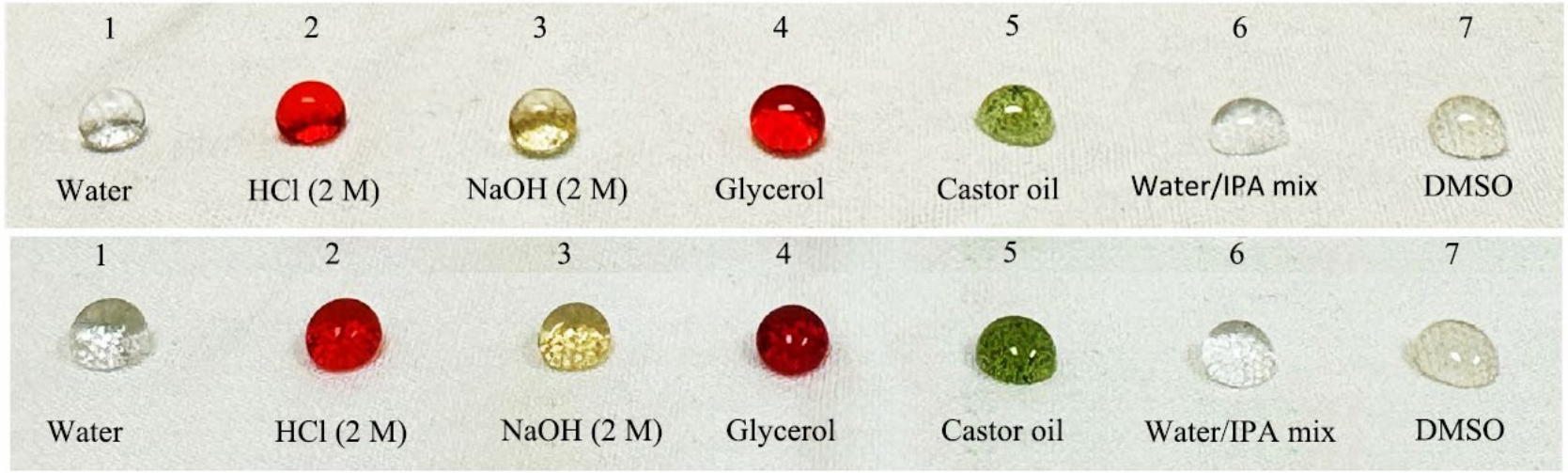


Fig. 9. Liquid-repellent cotton fabrics, a) F—C12 b) F-3600 (The droplets are dyed to enhance visibility).

PFAS Free Omniphobic coatings for acrylic fabrics

Alcohol repellency comparison (PFAS coating vs PFAS-free Coatings)

Repellency grade	1	2	3	4	5	6	7
H2O:iPrOH (by Vol.)	98:2	95:5	90:10	80:20	70:30	60:40	50:50

PFAS Coated

Alternative 1

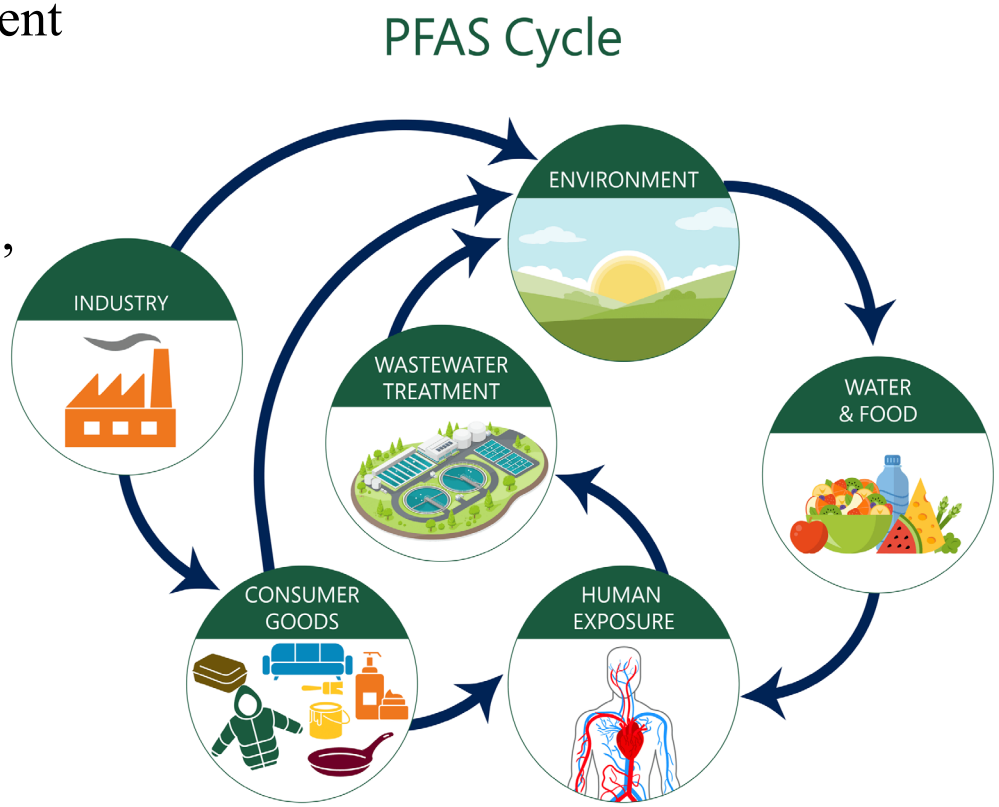
Alternative 2

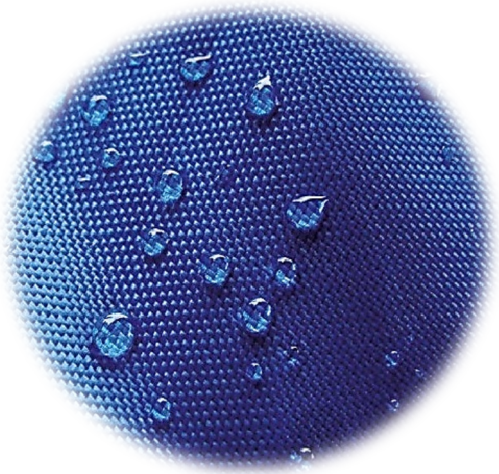
Alternative 3

Safer and as effective as PFAS

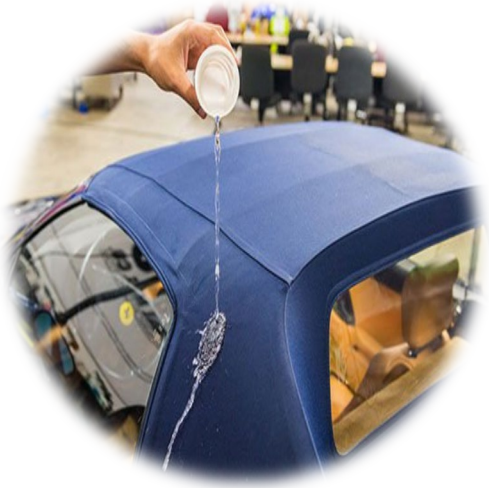
THE CHALLENGE WE FACED

- PFAS offer strong liquid repellency but persist in the environment
- Regulations are tightening (TURA and beyond)
- Haartz, a supplier of textiles for military to automotive markets, seeks PFAS-free solutions that are scalable and cost-effective



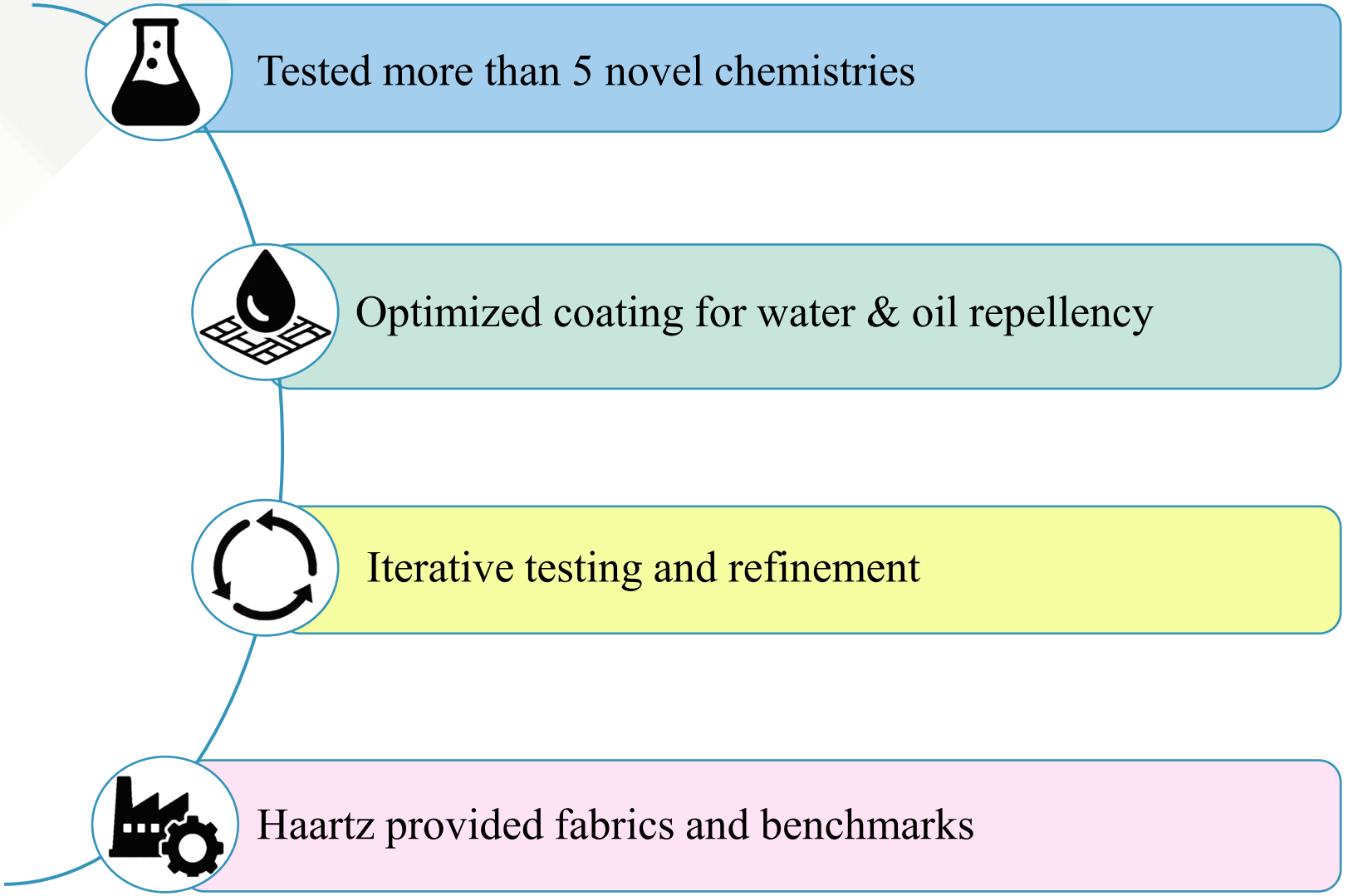


Stain repellent fabrics



Automotive application: Convertible car tops

THE RESEARCH JOURNEY



TURI'S ROLE IN SHAPING THE RESEARCH

- Early guidance aligned the work with safer chemistry
- Funding support for two academic year
- P2OASys screening helped avoid harmful, regretful results
- Helped connect with Haartz for industry-relevant testing

P2OASYS hazard color code: Low Medium High Very high

MY PERSONAL EXPERIENCE WITH TURI

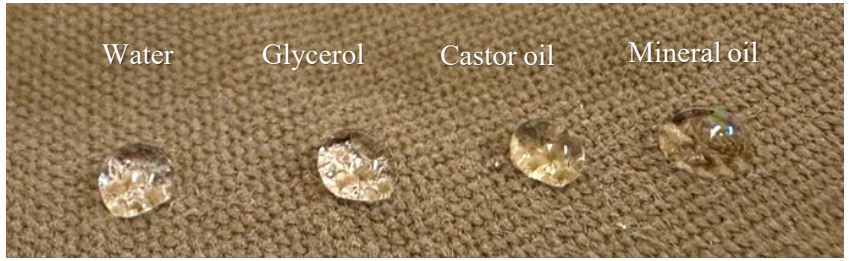
- Monthly check-ins with TURI guided our work
- Applied safer chemical assessment in formulations
- Industry links enabled real-world testing
- Opportunity to visit industry partner
- Workshop for students on PFAS and our research
- Support turned research into practical impact

TURI
TOXICS USE REDUCTION INSTITUTE

KEY ACHIEVEMENTS MADE POSSIBLE BY TURI'S SUPPORT

- **Water Contact Angle:** >150° (comparable to PFAS coatings)
- **Oil Repellency:** Up to Grade 1 on AATCC 118 test without fluorine
- **Durability:** Maintained >90% of repellency after 10 accelerated wash cycles & 1000 abrasion cycles
- **Industrial tests:** Achieved better performance than PFAS-based coatings

PFAS Treated Fabric



PFAS-free Treated Fabric

TURI
TOXICS USE REDUCTION INSTITUTE

PROJECT OUTCOMES

Industrial Impact

- PFAS-free solution that is scalable and low-cost, unlike EMPEL technology
- Bio-derived and water-based, safer and more sustainable
- Supports military and automotive adoption without sacrificing performance

As a Researcher

- 3 Conference presentations (SPE 2024, 24th Sukant Symposium, ASC GC&E 2025)
- 1 Publication (Progress in Organic Coatings)
- 1 Patent under review (UML)
- 1 Manuscript draft

PFAS-free options for food packaging

Alternatives are readily available, EU and FDA full ban feasible.

Restriction of PFAS under REACH:
Sufficiently strong evidence that technically and economically feasible alternatives to PFAS use are available for packaging.

https://echa.europa.eu/de/-/restriction-of-per-and-polyfluoroalkyl-substances-pfass-under-reach

FDA NEWS RELEASE

FDA, Industry Actions End Sales of PFAS Used in US Food Packaging

The following is attributed to Jim Jones, Deputy Commissioner for Human Foods

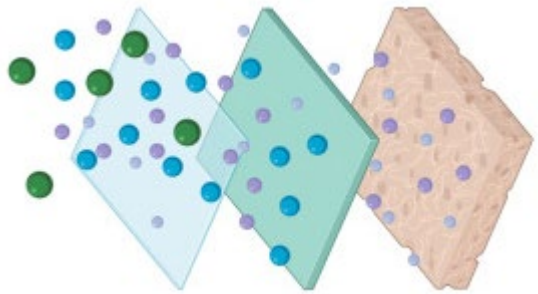
For Immediate Release:
February 28, 2024

https://www.fda.gov/news-events/press-announcements/fda-industry-actions-end-sales-pfas-used-us-food-packaging

Two approaches to achieve combined water and oil/fat repellency of paper

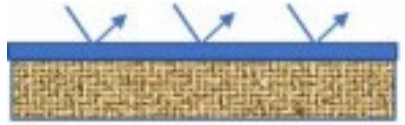
Dual layer: Hydrophobic material / oleophobic material

The paper is coated twice:
- First, with an oleophobic polymer such as alginate and chitosan.
- Then, with a hydrophobic layer (waxes, some proteins, silanes, lignin)



Modified polymer single layer coatings

The surface is coated once with a modified polymer.
- Hydrophilic biopolymers, such as cellulose, enhance hydrophobicity.
- Hydrophobic polymers, such as silanes, enhance hydrophilicity.

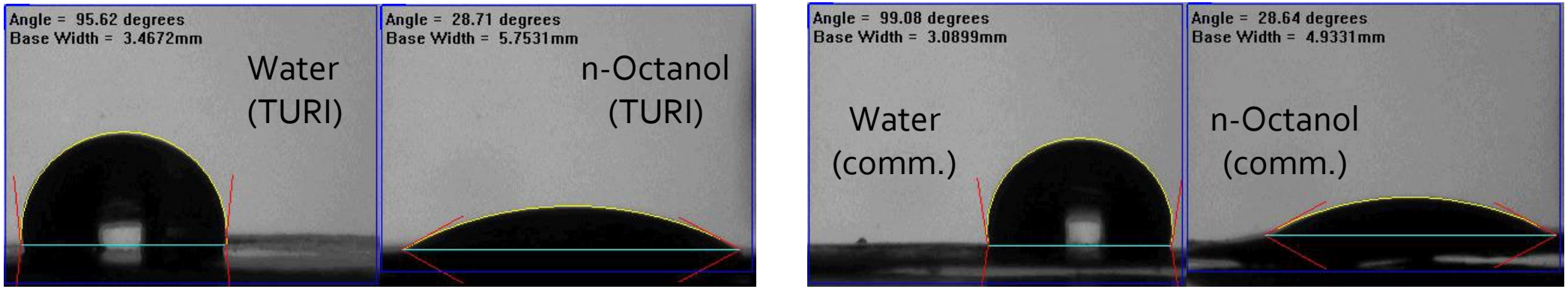


TURI
TOXICS USE REDUCTION INSTITUTE

Dual layer coating on Kraft paper – results at TURI

- Bilayer optimization of a biowax and hydrophilic biopolymer was performed.
- Weight gain, visual appearance, and drop test contact angle were utilized to characterize the films.
- Higher contact angle values correlate with improved liquid repellency.

TURI bilayer kraft paper vs. Commercial burger wrap



- The optimal combination for hydrophobicity showed fair oleophobicity but was comparable or superior to most commercially available food wrap paper.
- Conducted formulation optimizations with UML researchers under a TURI Research Grant FY2025.

	Contact angle (°)								
Sample	Water			n-Octanol			Sunflower oil		
Optimized bilayer 1	80	±	9	25	±	3	39	±	6
Optimized bilayer 2	87	±	11	23	±	4	43	±	3
Commercial wraps	83	±	7	29	±	6	36	±	11

TURI
TOXICS USE REDUCTION INSTITUTE

TURI Safer Refrigerants Webinar

April 13, 2025

https://www.youtube.com/watch?v=S8unGzkamUM

- Dr. Gabriel Salierno (TURI): AA report highlights
- Prof. Dr. Ian Cousins (Stockholm University).
- Morgan Vanzo (NASRC).

https://www.turi.org/publications/assessment-of-alternatives-to-f-gas-refrigerants/

TURI
TOXICS USE REDUCTION INSTITUTE

Hydrofluoroolefins (HFOs) life cycle

HFO manufacturing

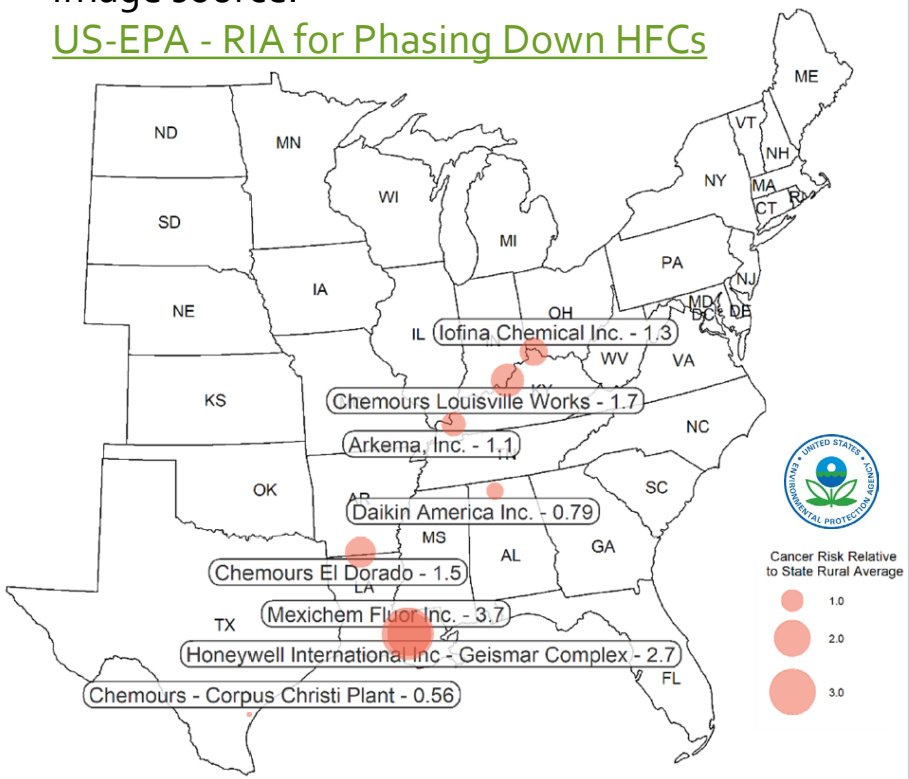
CMR precursors are required.

Proximity to manufacturing sites increases exposure risk to hazardous chemicals (CTC, PCE, HF, toxic HFCs).

Cancer Risk within 1 mile of HFC Facilities

Image source:

US-EPA - RIA for Phasing Down HFCs



Utilization

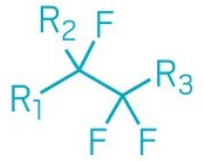
HFOs are the new generation of low-GWP F-gases to replace HFCs.

Some high-GWP (>150) HFCs are still used in new blends:

- HFOs require HFCs to reduce their flammability.
- HFCs require HFOs to reduce GWP.

Are HFCs and HFOs gases considered PFAS?

✓**Yes** & ✗**No**



OECD, 2021 **US EPA, 2021**

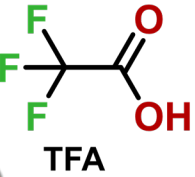
R_1, R_2, R_3 = nonhydrogen atoms

Image source:

Hogue (ACS C&EN, 2022): How to define PFAS.

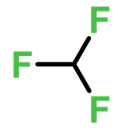
Environmental fate

HFOs mostly form Trifluoroacetic acid (TFA).



TFA

- G. Salierno (2024): HFOs byproducts might potentially produce HFC-23. Only takes 1.1% HFO conversion into HFC-23 for a GWP 150+ contribution.



HFC-23 ***GWP 14800***

- Potential creation of unknown PFAS by *operando* Polymerization.

Reproduced from Mahle technical messenger report

Figure 3: Polymerization: refrigerant bottle

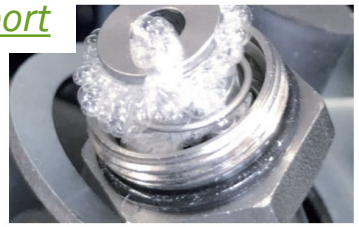
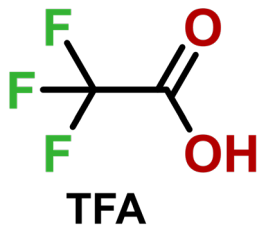


Figure 1: Polymerized refrigerant in connecting piece

Adapted from Prof. Dr. Ian Cousins (Stockholm University)

TURI Safer Refrigerants Webinar

TFA is increasing in what we drink and eat



TFA

Trifluoroacetic acid

Chemically resistant and long lasting

Due to HFO emissions, TFA exposure dramatically increased.

Now, we are exposed over threshold globally.

RIVM (2022)

Chronic rat toxicity (feeding)

Dose response: Male liver weight vs dose

Relevant potency factor: TFA is 0.002 x toxic as PFOA

*Corresponds to a **water threshold value of 2.2 µg/L***

Exceeded in an increasing number of areas

ECHA REACH Dossier (2024)

Han Wistar Rabbits

embryo-fetal developmental toxicity <180 mg/kg/day

Category 1B: Presumed human reproductive toxicant

Drinking water (*median*)[1,2]

- Germany: 1.5 µg/L
- 19 countries: 0.23 µg/L

Barely under threshold

Tea (median): 2.4 µg/L[2]

Beer (median) 6.1 µg/L[2]

Way over Threshold!!

Orange juice (mean 34 µg/L)[3]

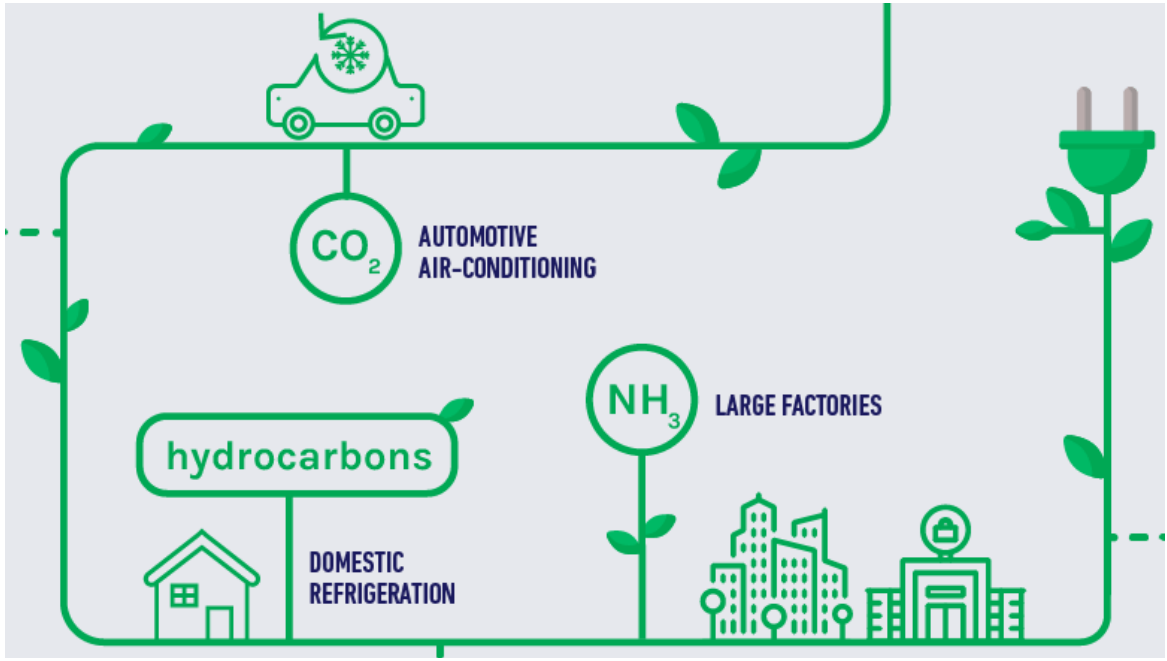
Apple juice (mean 6.2 µg/L)[3]

Bread (13 – 420 µg/Kg; median: 165 µg/Kg)[4]

1. Neuwald et al. *Environmental Science & Technology* **2022** *56* (10), 6380-6390
2. Scheurer & Nödler. *Food Chemistry*, *351*, 129304.
3. Van Hees et al. https://cdnmedia.eurofins.com/european-east/media/uxcnaa2c/eurofins_tfa_tfms_juice_24_final.pdf
4. The forever chemical in your daily bread report

TURI TOXICS USE REDUCTION INSTITUTE

Alternatives to HFC Refrigerants



HFOs are potentially regrettable substitutions.

Non F-gases have appropriate market readiness:

- *Feasibility is translating into wider adoption; Payback period <1 to 3 years.*
- *New CO2 designs offer operational cost savings* Wide adoption in supermarkets, cold warehouses.
- *Equipment design & safety standards mitigate HC flammability*:
  - 150 g HC charge allowed indoors (US)
  - 500 g HC charge allowed indoors (Europe; heat pumps)

EPA ENERGY STAR Certified HC-based equipment:
- 600+ household fridges
- 700+ Lab Grade Refrigerators

- Ammonia (NH_3) is the preferred industrial refrigerant but not for domestic applications. *Ultra Low Charge (ULC) systems* reduce but not completely eliminate liabilities.

Solid-state technologies **(Peltier; magnetocaloric) offer a refrigerant-free cooling solution.**

https://www.turi.org/publications/assessment-of-alternatives-to-f-gas-refrigerants/

TURI
TOXICS USE REDUCTION INSTITUTE

PFAS alternatives for Businesses and Communities

Parts manufacturers in MA use surfactants or solvents that might involve PFAS for critical cleaning and surface preparation. On-site chemists are not common in these companies.

The Professional Firefighters of Massachusetts (PFFM), in collaboration with the Nantucket PFAS Action Group and Michigan State University, work with fire marshals, unions, and cancer prevention groups in MA by creating PFAS alternatives fact sheets and providing targeted training.

The Field Fund, Inc. preserved Martha's Vineyard's natural grass fields using organic methods, avoiding PFAS-containing synthetic turf or tire crumbs to protect athletes, landscapes, and the aquifer.

https://www.turi.org/artificial-turf/

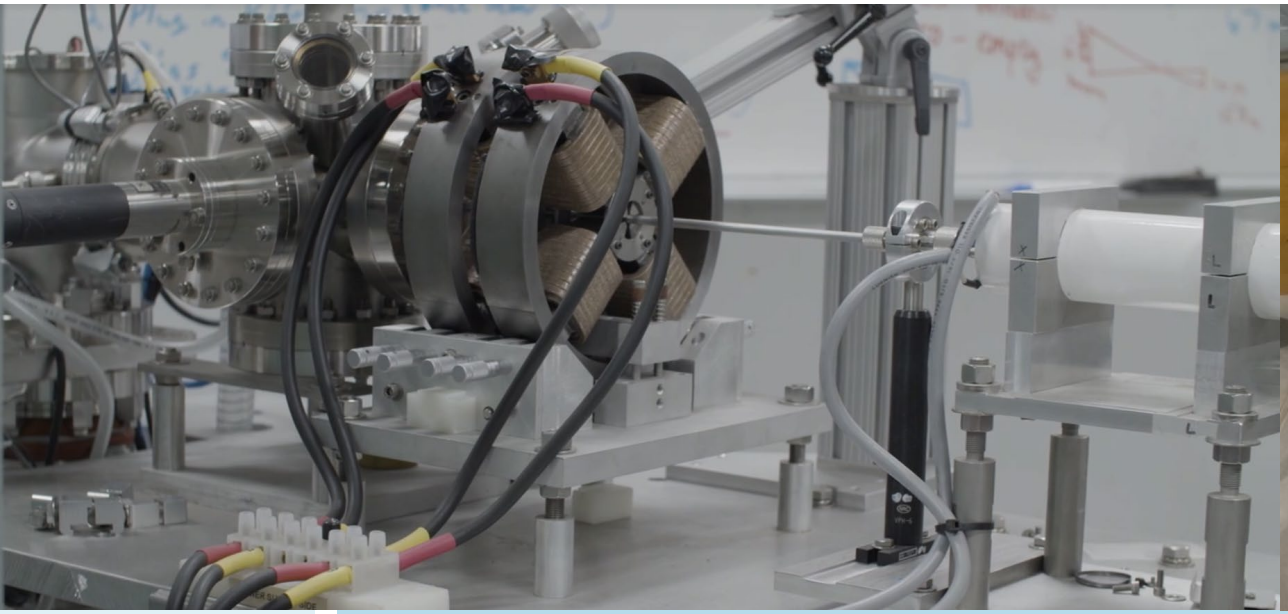
TURI
TOXICS USE REDUCTION INSTITUTE

PFAS alternatives for Businesses and Communities

Too many unknown PFAS sources and exposure due to supply chain information loss and trade secrets

TURI community grant FY25:

- Collaboration between Silent Spring and Clean Water Action with the UML Department of Physics and Applied Physics.
- Total fluorine detection using Particle-Induced Gamma Emission (PIGE): Limit of detection ≈ 10 ppm
  Sorting cosmetics and children's products to discriminate samples worth further PFAS analysis.



TURI
TOXICS USE REDUCTION INSTITUTE

EU Substitution Centers

chemical watch news & insight

EU agrees on funds for hazardous chemicals substitution centre

CHEMICAL WATCH NEWS | 29 November 2023

Pilot project will draw inspiration from Massachusetts Toxics Use Reduction Institute

https://product.enhesa.com/904816/eu-agrees-on-funds-for-hazardous-chemicals-substitution-centre

AGENCY IQ By POLITICO

Are 'EU substitution centers' in the cards for quicker substitution of toxic chemicals?

The European Commission has issued a call inviting companies to submit tenders for a 1.5-million-euro contract to deliver a pilot project setting up "substitution centers" envisioned to help companies negotiate the convoluted process of substituting hazardous substances with safer alternatives.

BY Scott Stephens, MPA | Aug 13, 2024 2:45 PM CDT

https://www.agencyiq.com/thank-you-article-periodic-are-eu-substitution-centers-in-the-cards-for-quicker-substitution-of-toxic-chemicals-006881/

The implementation of the substitution principle in European chemical legislation: a comparative analysis
Environ Sci Eur 35, 107 (2023).
https://doi.org/10.1186/s12302-023-00817-1

TURI-inspired 1.55-MM€ Pilot Project Details:

- Provide scientific, technical, and practical advice to SMEs and authorities.
- Innovation Support: Facilitate innovation and investment in safer alternatives.
- Batteries: Focus on finding safer alternatives for PFAS in battery manufacturing.
- Hard Chrome Plating: Explore substitutes for chromium VI in hard chrome plating processes.
- Paint Manufacturing: Identify and promote safer alternatives for a specific group used in paint production.

EU Budget: Definitive 2024/207 - 1408/2087 PP 03 24 01-03
EU Commission Tender released in July 2023:
https://ted.europa.eu/en/notice/-/detail/440404-2024

TURI
TOXICS USE REDUCTION INSTITUTE

Key takeaway: PFAS pollution source reduction through alternatives is the optimal path forward

- Successes in semiconductor manufacturing, textiles, packaging, and refrigerants prove that safer, effective, and more affordable options are already available and scalable.
- TURI's research grants and collaborations have accelerated innovations, planting seeds to convert industries and reduce PFAS hazards without compromising performance.
- Community and business initiatives in MA are setting a PFAS-free future now.
- Emerging options can advance faster than expected—often in years, not decades—through policies like TURI and EU Substitution Centers.
- Such investments are minimal compared to rising remediation costs and annual PFAS-related public health expenses.

PFAS-free innovation is safer, smarter, and economically superior

TURI
TOXICS USE REDUCTION INSTITUTE

Thank you!

Visit our website www.turi.org for **free publicly available d**atabases, tools, and case studies:

- www.Cleanersolutions.org
- https://P2OASys.turi.org
- www.TURAdata.org
- https://www.turi.org/Our_Work/Resources

Contact us!

gregory_morose@uml.edu
gabriel_salierno@uml.edu
alicia_mccarthy@uml.edu
info@turi.org

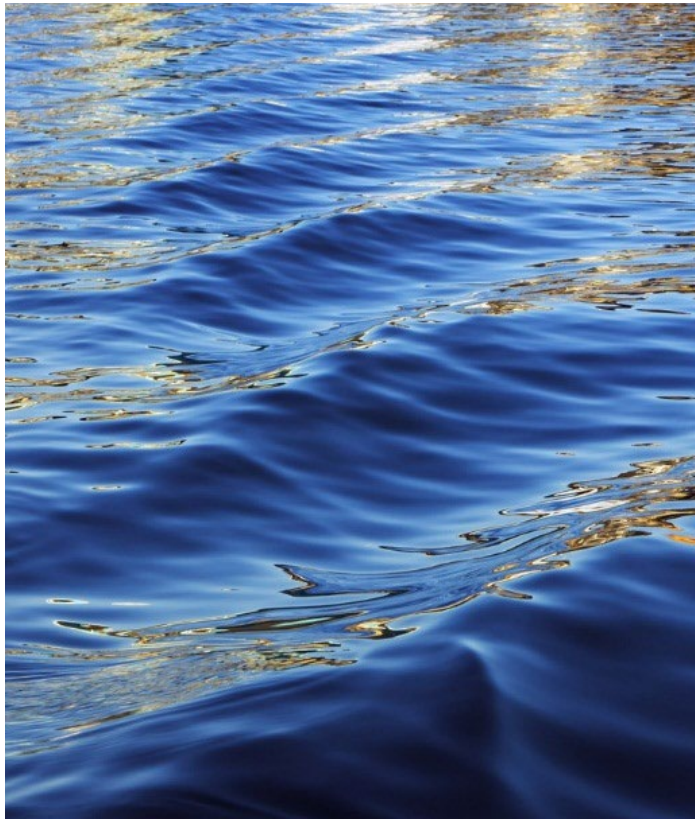
Follow us:

@reducingtoxics

Vacuum Vapor Degreasing Research for TCE Alts

TURI Lab

TURI
TOXICS USE REDUCTION INSTITUTE
UMASS LOWELL



TURI Lab & Research Team

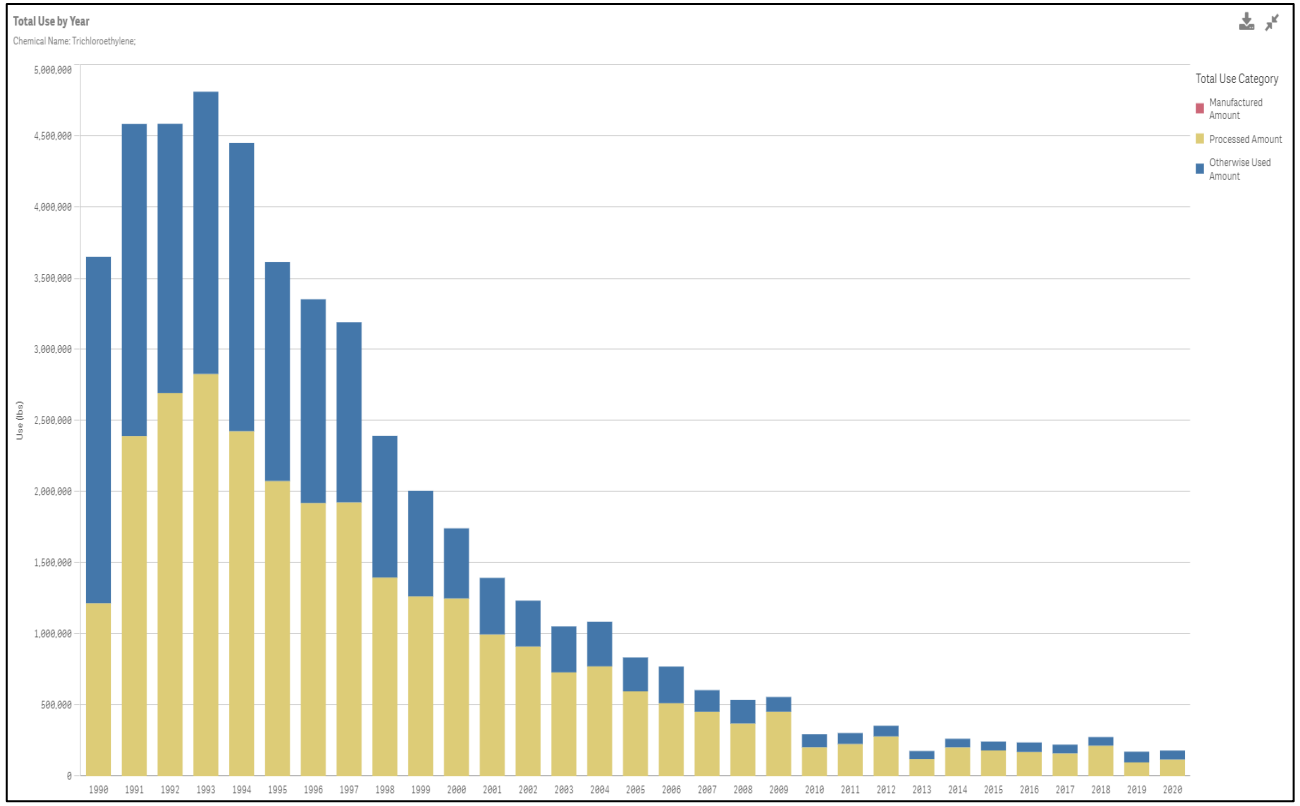
- Jason Marshall – lab director
- Alicia McCarthy – sanitizing performance testing and training
- Amelia Wagner – cleaning performance testing, on-site visit assistance
- Alex Symko – cleaning performance testing, on-site visit assistance
- Gabriel Salierno – green chemistry research
- Greg Morose – research program manager






TURI
TOXICS USE REDUCTION INSTITUTE
UMASS LOWELL

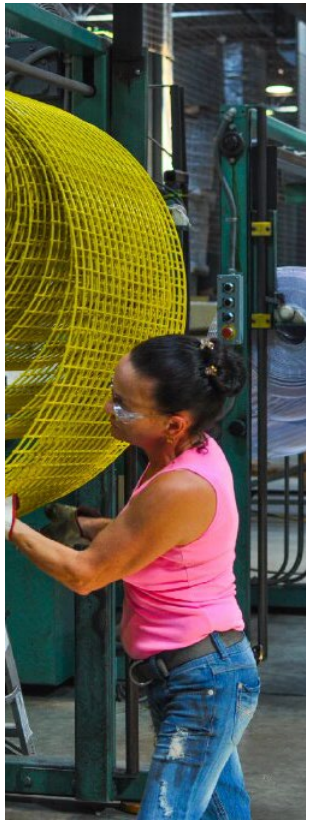
How TURI Can Help if EPA Bans TCE



Work closely with TCE end users to identify operating conditions that will best fit the desired cleaning needs

Carry out process specific P2 projects with a goal of eliminating TCE

TURI
TOXICS USE REDUCTION INSTITUTE
UMASS LOWELL



Vacuum Vapor Cleaning Hub

EPA Grant to Provide
Technical Assistance to
Businesses in New England

What We Will Be Doing

Identify and support the implementation of opportunities to protect worker health and the environment using safer cleaning chemicals and technologies for New England

We will work with our P2 partners to:

- Train staff on the use of traditional cleaners and processes
  - Site visits, sample collection and transportation methods to enable our testing efforts
- Provide technical, financial, EHS, and basic regulatory information on alternatives to the traditional cleaners
- Assist in the process of identifying which alternative(s) offer the best fit for their facility
- Coordinate implementation efforts to increase successful adoption

Why a Vacuum Degreasing Hub?

Hockh

Baron Blakeslee VAC Series

L.un.a

iSLA

Facilities use solvents for a wide variety of applications, on a variety of surfaces and geometries of metal

Identifying a substitute for solvents in cleaning applications is not an easy task

- There are thousands of formulations from which to choose

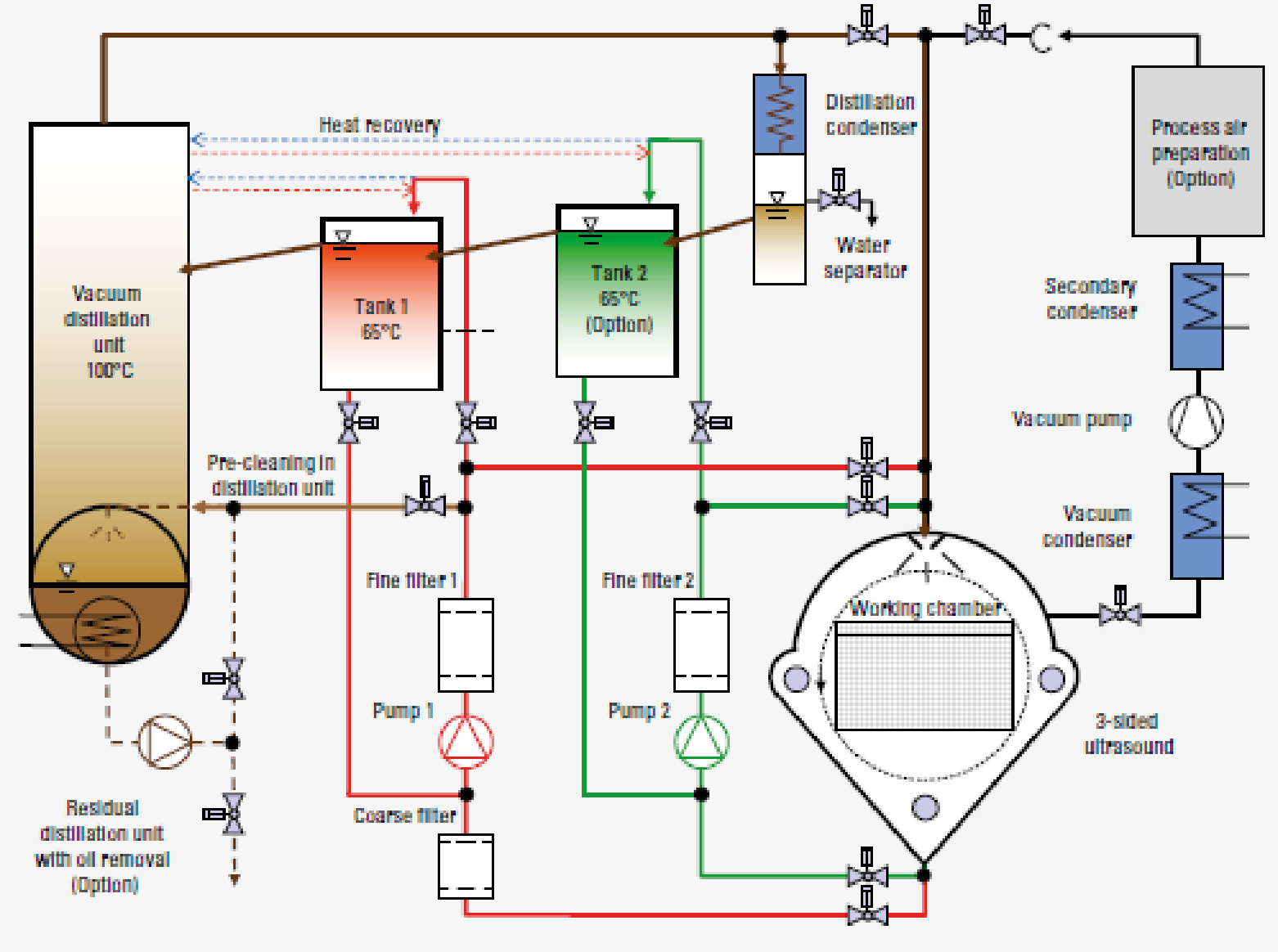
Obstacles to change have been the lack of testing data specific to these end users

With recent equipment innovations, vacuum degreasing may be one solution to help

iFP - Gosiger

TURI
TOXICS USE REDUCTION INSTITUTE
UMASS LOWELL

Basic Process



VVD HUB

Demonstrate

effectiveness of a TCE-free cleaning process

- Conduct preliminary testing
- Perform process-specific testing
- Document results for participating companies

Assess

feasibility of alternative cleaning practices

- Relative hazard
- Performance

TURI
TOXICS USE REDUCTION INSTITUTE
UMASS LOWELL

P2OASys Profiles of Modified Alcohols vs TCE, nPB

Categories	Dowclene 1601	Metalnox M6386	Dowanol PnBGE	Dipropylene glycol dimethyl ether isomer mixture	Trichloroethylene	n Propyl Bromide
Acute Human Effects	8	8	8	4	8	10
Chronic Human Effects	4	2	3	2	9	9
Ecological Hazards	2	4	2	2	8	6
Environmental Fate & Transport	4	5	4	7	9	10
Atmospheric Hazard	2	2	2	2	6	6
Physical Properties	5	8	6	4	10	10
Process Factors	6	4	8	4	7	9
Life Cycle Factors	4	4	4	4	10	9
Product Score	4.4	4.6	4.6	3.6	8.4	8.6

Product	CAS#s
Dowclene 1601	5131-66-8 (70-90%); 15821-83-7 (<5%)
Metalnox M6386	5131-66-8 (90%), 111109-77-4 (10%)
Dowanol PnBGE	5131-66-8
Dipropylene glycol dimethyl ether isomer mixture	11109-77-4
Trichloroethylene	79-01-6
n Propyl Bromide	106-94-5

TURI
TOXICS USE REDUCTION INSTITUTE
UMASS LOWELL

Vacuum Vapor Degreaser Pilot Testing

The TURI Lab is actively engaged with various vendors of potential systems

Purchase costs as well as operating requirements need to be compiled so that the TURI Lab can best inform their partners on what their options will be

The TURI Lab will be working on developing performance profiles for possible options without disrupting end user's operating conditions

TURI
TOXICS USE REDUCTION INSTITUTE
UMASS LOWELL

VVD HUB Project Timeline

Fall 25

- Project set up
- Identify and contact halogenated solvent users in MA
- Recruit initial companies from Region 1

Winter 25/26

- Hold in-person (or webinar) on the project scope and how companies can utilize the testing center
- Site visits and material collection for process-specific testing

Spring 26

- Conduct preliminary (solvent) testing for participating companies
- Preform batch production testing (bench scale testing)

Summer 26

- Equipment installation and training for TURI and P2 regional staff
- Using identified optimum conditions, conduct pilot testing on company parts

Year 2

- Document success of testing, highlighting industry specific results
- Conduct outreach to companies in EPA Region 1 with similar sectors
- Recruit companies from additional EPA regions

TURI
TOXICS USE REDUCTION INSTITUTE
UMASS LOWELL

Vacuum Degreasing Hub Will…

Expand	• Expand success beyond Massachusetts
Partner	• Partner with three pollution prevention agencies
Support	• Support nine manufacturing facilities, three in each of those states
Design and carry out	• P2 projects to replace halogenated solvent vapor degreasing applications

TURI
TOXICS USE REDUCTION INSTITUTE
UMASS LOWELL

Will this work for you

Not sure this will work?

Want to hear from a peer before deciding

Good, we've got one for you

New Method Plating, Worcester MA

TURI
TOXICS USE REDUCTION INSTITUTE
UMASS LOWELL

New Method Plating

TURI Industry Grant Recipient FY 25

Assist in purchase of equipment

Partner with TURI to showcase success of new system

Share their story to help others have more confidence in alternatives to TCE (Coming Nov 2025)

TURI
TOXICS USE REDUCTION INSTITUTE
UMASS LOWELL

New Method Plating TCE Replacement Project

What was learned

- CHEMICAL SUPPLIERS
  - Chemical suppliers will help find the proper solvent based on needs
  - Supplier offered field testing using various chemistries on actual production parts

- EQUIPMENT MANUFACTURERS
  - Request information from various equipment manufacturers to see what works best for your plant
  - Many manufacturers will offer site visits to view operating equipment

TURI
TOXICS USE REDUCTION INSTITUTE
UMASS LOWELL

COST ANALYSIS

Old TCE Machine

- Hazardous Waste Removal:
  - 55 Gallon Drum of Oil & TCE $647.75
    - Avg 3 Times Year= $1943.25
  - 55 Gallon Drum of TCE Carbon $722.0
    - Avg 2 Times Year= $1444.00
- Electricity Costs per month*
  - 2 Machines & Steam Boiler: $4452.06

*Avg 5 days week, 10 Hour Days

New Machine - Alcohol Solvent Machine

- Hazardous Waste Removal:
  - Drums of **Oil ONLY** (TBD)
  - Drums of Carbon-No Longer Required ($0)
- Electricity Costs per month*
  - Only 1 Machine & NO Boiler: $1272.02

~$38,000 savings in electricity per year

Machine Footprint

Benchtop Testing for Vapor Degreasing

Operating in parallel to the existing vacuum vapor degreasing equipment and solvents

The TURI Lab will conduct research into alternative vapor degreasing utilizing safer solvents compared to TCE

Azeotropes

Co-Solvents

Bi-Solvents

Grant Summary

Form partnerships with pollution prevention groups in EPA Region 1 to provide technical assistance, training, outreach and laboratory performance testing

Conduct research on alternative vapor degreasing processes utilizing safer solvents

Set up a lab-scale vacuum degreasing system with focus on optimizing the cleaning processes for industrially relevant soils

Address environmental concerns for communities

TURI
TOXICS USE REDUCTION INSTITUTE
UMASS LOWELL