DOE-FIU Cooperative Agreement Annual Research Review – FIU Year 2

Tuesday, September 27, 2022		
9:30 - 9:35 am EDT	Kick-Off /Welcoming Remarks (DOE-EM)	Kurt Gerdes (Director, Technology Development) – DOE EM-3.2
9:35 - 9:40 am EDT	Welcoming Remarks (DOE-LM)	Leonel Lagos on behalf of DOE Office of Legacy Management
9:40 - 10:00 am EDT	Projects 4 & 5: STEM Workforce Development and Training	FIU, DOE HQ (EM & LM), SRNL, PNNL, WIPP, SRS, ORP, LBNL, WRPS, INL, Grand Junction
BREAK		
11:00 - 12:00 pm EDT	Projects 4 & 5 (cont'd): STEM Workforce Development and Training	FIU, DOE HQ (EM & LM), SRNL, PNNL, WIPP, SRS, ORP, LBNL, WRPS, INL, Grand Junction
BREAK		
1:00 - 2:30 pm EDT	Project 1: Chemical Process Alternatives for Radioactive Waste	FIU, DOE HQ, PNNL, WRPS, SRNL, SRS
2:30 - 4:00 pm EDT	Project 3: Waste and D&D Engineering & Technology Development	FIU, DOE HQ, SRNL, PNNL, LBNL, INL, ANL
Wednesday, September 28, 2022		
10:00 - 11:30 am EDT	Project 2: Environmental Remediation Science & Technology	FIU, DOE HQ, SRNL, PNNL, ORNL, LANL, CBFO
11:30 - 1:00 pm EDT	Wrap Up (FIU Projects 1, 2, 3, 4 & 5)	FIU, DOE HQ (EM & LM)

PROJECT 3

Waste and D&D Engineering & Technology Development

FIU Personnel and Collaborators

Project Manager: Leonel Lagos

Faculty/Researcher: Himanshu Upadhyay, Joseph Sinicrope, Walter Quintero, Clint Miller, Santosh Joshi, Tushar Bhardwaj, Suresh Peddoju, John Dickson, Mellissa Komninakis, Kexin Jiao, *Yolanda Rodriguez

DOE Fellows/Students: Roger Boza, David Mareno, Aurelien Meray, Adrian Muino Ayala, Christian Lopez, Christian Dau, Philip Moore, *Oscar Roa

DOE-EM: Jennifer McCloskey, Dinesh Gupta, Genia McKinley, Jean Pabon, Jonathan Kang, Douglas Tonkay,

SRNL: Jennifer Wohlwend, Justin Kidd, Emily Fabricatore, *Connor Nicholson, *Tristan Simoes-Ponce, Carol Eddy-Dilek

ORNL: Alexander Johs

PNNL: Vicky Freedman, Rob Mackley

LBNL: Haruko Wainwright

*Former staff/student contributors

Project Tasks and Scope

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TASK 1: WASTE INFORMATION MANAGEMENT SYSTEM (WIMS) (HQ)	
Subtask 1.1	WIMS System Administration - Database Management, Application Maintenance & Performance Tuning
Subtask 1.2	Waste Stream Annual Data Integration
Subtask 1.5	Cyber Security of WIMS Infrastructure
TASK 2: D&D SUPPORT TO DOE EM FOR TECHNOLOGY INNOVATION, DEVELOPMENT, EVALUATION AND DEPLOYMENT	
Subtask 2.1	Development of Uniform Testing Protocols and Standard Specifications for Dust Suppressant Technologies in Support of Open-Air Demolition during D&D
Subtask 2.2	Applications of Intumescent Foams and Other Fire-Retardant Materials to Mitigate Contaminate Release during Nuclear Pipe Dismantling and other D&D Activities
Subtask 2.3	Certifying Fixative Technology Performance when Exposed to Impact Stressors as Postulated in Contingency Scenarios Highlighted in Safety Basis Documents
Subtask 2.4	Multi-functional 3D Polymer Framework for Mercury Abatement
TASK 3: D&D KNOWLEDGE MANAGEMENT INFORMATION TOOL (KM-IT) (HQ, SRNL, INL, ANL)	
Subtask 3.4	Content Management
Subtask 3.5	Marketing and Outreach
Subtask 3.6	D&D KM-IT System Administration
Subtask 3.7	Cyber Security of D&D KM-IT Infrastructure

Project Tasks and Scope

TASK 6: AI FOR EM PROBLEM SET (D&D): STRUCTURAL HEALTH MONITORING OF D&D FACILITY TO IDENTIFY CRACKS AND STRUCTURAL DEFECTS FOR SURVEILLANCE AND MAINTENANCE (SRNL)	
Subtask 6.5	Design & Development of Machine Learning and Deep Learning Models to Identify and Locate Cracks in D&D Mockup Facility (NEW)
Subtask 6.6	Design & Development of a Mobile Application to Deploy Machine Learning and Deep Learning Models on the iOS Devices at SRS (NEW)
Subtask 6.7	Research and Prototype Deployment of a Web Service API framework for AI Deep Learning Model (NEW)
TASK 7: AI FOR EM PROBLEM SET (SOIL & GROUNDWATER) - EXPLORATORY DATA ANALYSIS & MACHINE LEARNING MODEL FOR HEXAVALENT CHROMIUM [CR (VI)] CONC. IN 100-H AREA (PNNL)	
Subtask 7.2	Data Pre-Processing & Exploratory Data Analysis to Evaluate the Chromium Conc. in the Samples (NEW)
Subtask 7.3	Groundwater and Surface Water Spatiotemporal Relationship Identification (NEW)
TASK 8: AI FOR EM PROBLEM SET (SOIL AND GROUNDWATER) - DATA ANALYSIS AND VISUALIZATION OF SENSOR DATA FROM WELLS AT THE SRS F-AREA USING MACHINE LEARNING (LBNL, SRNL)	
Subtask 8.4	Data Ingestion/Communication Module Development for the AI/ML System (NEW)
Subtask 8.5	Development of the AI/ML-Based System to Perform Predictive Analytics using Datasets containing Time-Series and Imagery Data from Sensors (NEW)

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Task 2

D&D Support to DOE EM for Technology Innovation, Development, Evaluation and Deployment

Research Activity 1: Foam Fixative Plugs to Mitigate Contaminate Release during Nuclear Pipe Dismantling and other D&D Activities

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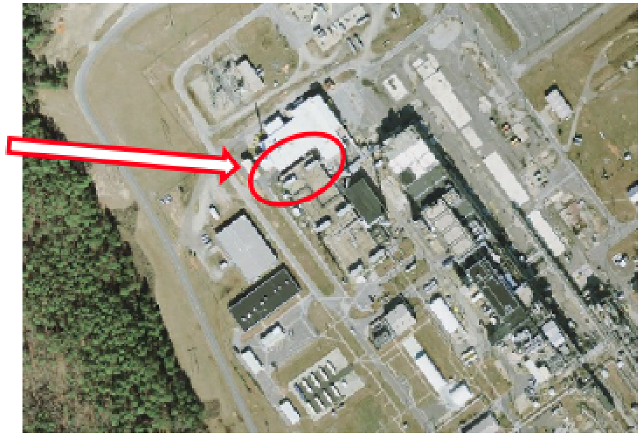
What is the current need?

- By FY '27, the F/H Laboratory Deactivation Project Team plans to remove all the buried LAD and HAD piping in the Courtyard between 772-F and 772-1F.
- The driver for removal is to prevent future release(s) to the environment from the buried, highly-contaminated piping.
- Our intent is to remove the piping to within 1' of the respective buildings and then to cap both the 2 & 3-inch "core" pipe and the 3 & 4-inch "jacket" pipe.
- The piping is generally buried to a depth of 3-5 feet.
- Total length of piping to be removed is approximately 250 feet. Piping will be cut to 5' lengths so that it may be disposed to a B-25.

Buried LAD and HAD Piping between 772-F and 772-1F

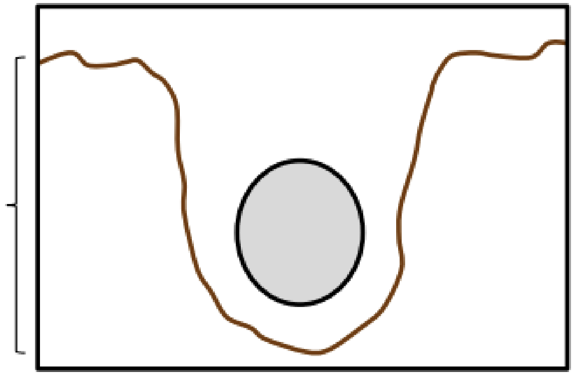


Aerial view of Potential Hot Site at F-Area

2"-3" Core Piping Hastelloy C-22

3"-4" Jacket Piping 304 SS

3-5 ft trench to expose pipes



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Research Activity 1: Foam Fixative Plugs to Mitigate Contaminate Release during Nuclear Pipe Dismantling and other D&D Activities

Research Highlights & Accomplishments:

Evaluation of the adhesion and bonding properties of the Hilti CP-620 foam plug to Hastelloy C-22 piping

Evaluation of the adhesion and bonding properties of the Hilti CP-620 foam plug to Hastelloy C-22 piping under various moisture conditions

Determination of the heat profile of Hilti CP-620 foam during curing in Hastelloy C-22 piping

Establish the relationship between piping diameter and necessary quantity of Hilti CP-620 foam

Determine the internal pipe pressure after Hilti CP-620 foam deployment and curing time

Develop a leak test standard operating procedure to test for the effectiveness of the of Hilti CP-620 foam plug

Conduct a literature review to determine if using a hot tap is a viable method to deliver of Hilti CP-620 foam into piping

Gather information and reference material to initiate the construction of the mock-up test of the F/H labs courtyard.

- Phase I Test Plan developed and approved in January 2022 and near completion.
- Provided 5 updates to stakeholders throughout Year 2 (January – July).
- Alternative technology identified that may be more compatible with hot tap procedures.

FIU Year 3 Way Ahead:

Alternative Fixative Foams (In the Event Hilti CP-620 is NOT Viable) - FOAMBAG™

- **FOAMBAG is very similar to the DRAINBLOCK technology.**
  - PU resin foam that expands to form a permanent seal.
- **The FOAMBAG technique has been in use in the UK in gloveboxes at Sellafield and meets the UK gas industry technical standard T/SP/E/59.**

The FOAMBAG™ holds the resin foam in place as it expands. At full expansion some of the foam seeps through the semi-porous panels of the bag to form an adhesive seal with the pipe

- Complete execution of Phase I Test Plan (Assessment of Hilti CP-620 Foam)
- Develop Phase II Test Plan (same series of tests on FOAMBAG technology)
- Initiate planning for construction of F/H Lab Courtyard mock-up in preparation for site demo in FY’24 / FY ‘25

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Research Activity 2: Certifying Fixative Technology Performance when Exposed to Impact Stressors Postulated in Contingency Scenarios Highlighted in Safety Basis Document

Site Needs:

- Outdated regulations, such as the DOE-HDBK-3010, outline factors for dealing with residual contamination, but fail to account for the positive impacts provided by fixative technologies in reducing ARF coefficients.
  - Results in inconsistent certification methodology for fixative technologies.
  - Produces varying Source Term calculations.
  - Fails to provide sufficient credit for improvements in state-of-the-art fixative technologies.
  - Key finding in the SRS 235F-PuFF research activity – after fixative deployment, site personnel could not take credit for fixatives in the safety basis calculations.
  - Potential to reduce cost due to a more accurate/lower Source Term.

FIXATIVE STATE

- Reduces ARFs
- Reduces RFs

Contaminant Form	Impact ARF
Gas / Vapor	1.0
Powder	**3e-4**
Liquid	4e-5
Metal / Solid	No significant airborne release is postulated for this accident configuration.

High Risk

Low Risk

Objectives:

- Develop an experimental design for the quantification of contamination release during impact stress.
- Reevaluate ARF coefficients for powder contaminants under impact.
- Determine ARF coefficients for fixative materials under impact.
  - Fixative/Polymer State
- Integrate results to update DOE-HDBK-3010.

Objective 1 - Experimental Methodology

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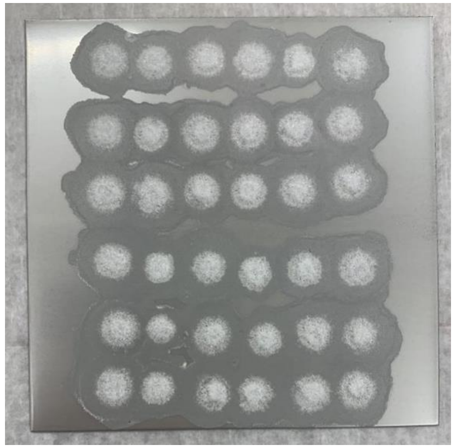
ASTM E3283 – Standard Practice for Preparation of Loose Radiological/Surrogate Contamination on Nonporous Test Coupon Surfaces

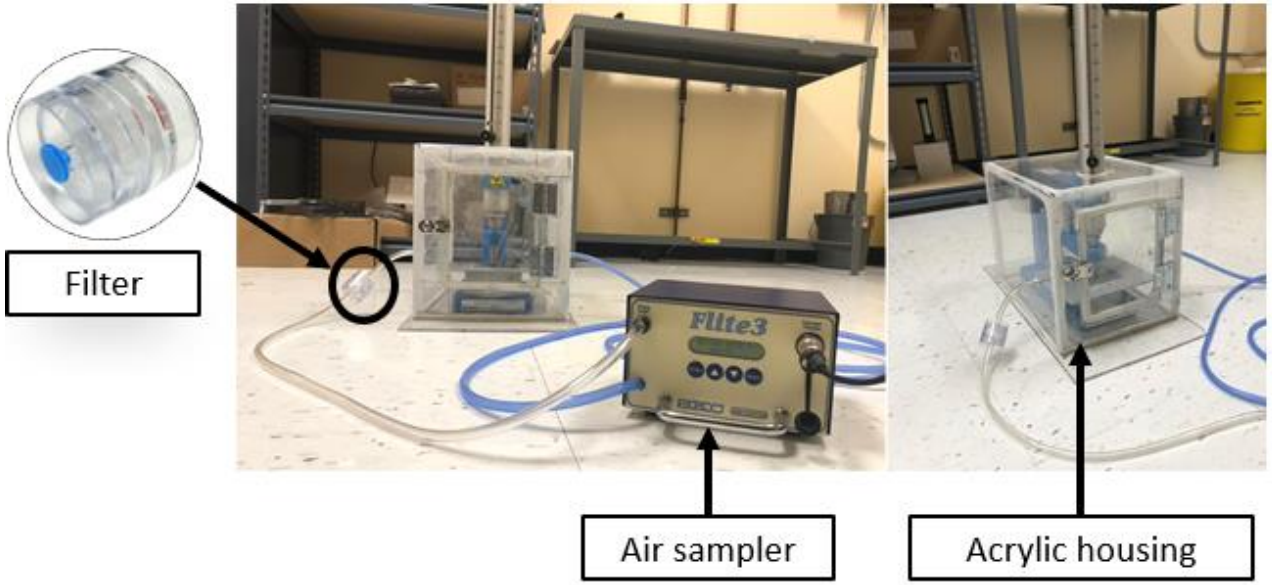
- Surrogate contaminant – Cesium Chloride (CsCl)
  - Unique signature that is detectable in the analysis process.

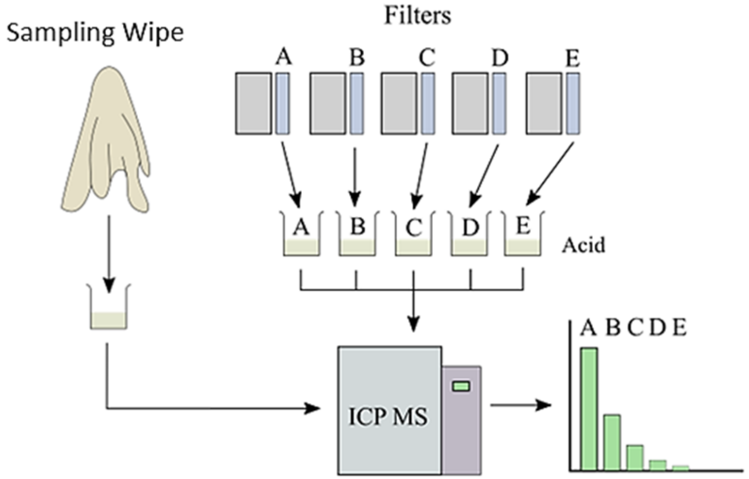


ASTM D2794 – Standard Test Method for Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact)

- BYK Gardner Impact Tester
  - Evaluates impact resistance and determines the exact point of failure and/or establish pass/fail specifications.
  - Maximum force of 320 in-lb (368 kg-cm).

Objective 1 - Experimental Methodology





- Airtight acrylic housing to contain released particulates.
- Air Sampler & Mixed cellulose ester (MCE) filters to capture airborne release.
  - Flow rate of 17L/min – about 82 cycles for collecting airborne particulates.
- Sampling wipes to collect resettled release.
- ICP-MS is used to detect only the specific element in the surrogate and quantifies the amount detected.

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Objective 1 - Experimental Methodology

- Determine Total Cs from ICP-MS:

$$Mass\ of\ Cs = \left(C_{ppb} \times 10^{-6}\right) \times \frac{m}{\rho} \times DF$$

  - Cppb is the concentration in parts per billion as determined by ICP-MS analysis (1 ppb = 10^{-6} mg/mL)
  - m is the mass of the prepared solution matrix (CsCl + 2% HNO_3 solution)
  - ρ is the density of that solution (for very dilute such as 2% HNO_3, this can be approximated to equal 1 kg/L)
  - DF is the dilution factor if original solution was diluted for analysis

- Determine Airborne Release Fraction:

$$ARF = \frac{m_{ICP\ Filter}}{m_{released}}$$

  - mICP-Filter is the mass of Cs from the air filter determined from the ICP-MS
  - mreleased is the total mass of contamination released

Objective 1 - Experimental Methodology - VALIDATED

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Objective 2 – Reevaluate Powder ARFs

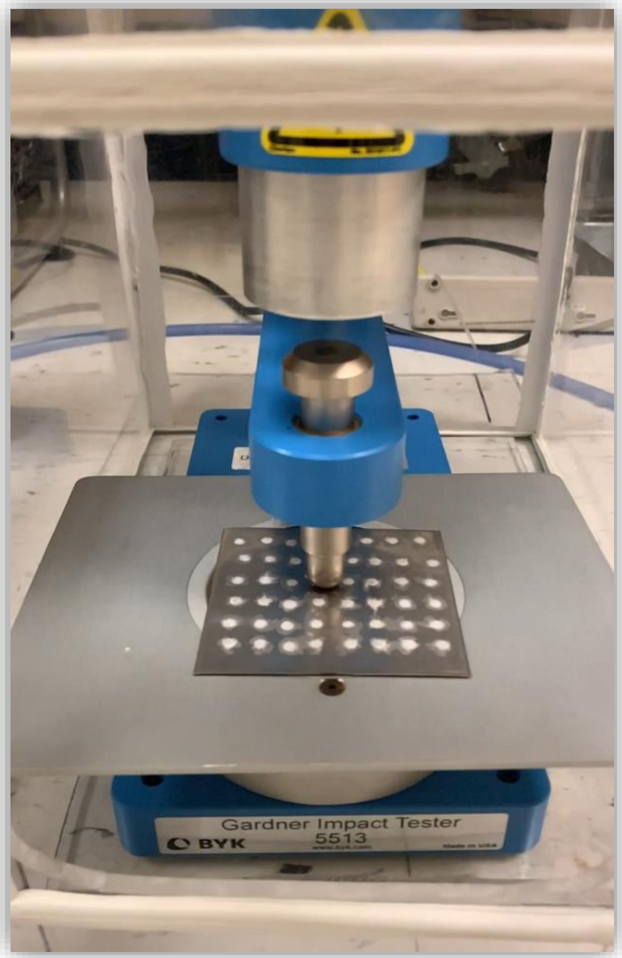
- Current ARFs for powder form under impact, as defined by the DOE-HDBK-3010, is 3e-4.
- Powder contaminant only coupons were tested at various impact forces.
- Impact with no fixative shows a potential for a large release.
  - Higher ARFs
  - Coupon deformation
- Average ARF is 3.47E-04.

Contaminant Form	Impact ARF
Gas / Vapor	1.0
Powder	**3e-4**
Liquid	4e-5
Metal / Solid	No significant airborne release is postulated for this accident configuration.

High Risk

Low Risk

	Impact (in-lb) / (kg-cm)	Average Airborne Release Fraction
Powder	320 / 368	2.27E-04
	240 / 276	1.08E-04
	200 / 230	1.05E-05
	160 / 184	6.32E-07
Total Average		**3.47E-04**



Powder state

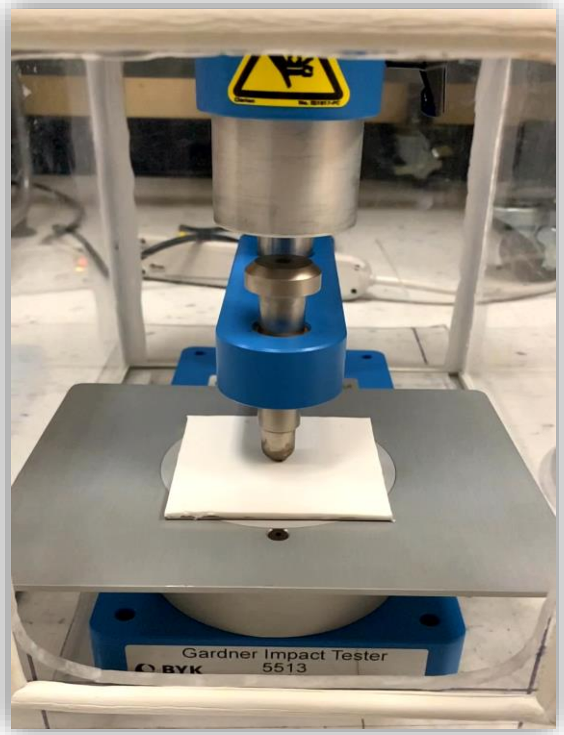
Objective 2 - Revaluation of historical data for powder ARFs under impact - CONFIRMED

Objective 3 – Confirm Fixative/Polymer State

Key Findings:

- Applying fixative technologies significantly reduced ARFs under impact stressors.
  - Should be it's own designation
- Facilitates the comparison of various fixative technologies based on their ability to contain contamination release when exposed to impact stressors (e.g. FD vs. PBS).

Fixative / Polymer state



Contaminant Form	Impact ARF
Gas / Vapor	1.0
Powder	**3e-4**
Liquid	4e-5
Metal / Solid	No significant airborne release is postulated for this accident configuration.

High Risk

Low Risk

	Impact (in-lb) / (kg-cm)	Average Airborne Release Fraction
FD	320 / 368	5.55E-07
	240 / 276	6.78E-07
	200 / 230	8.34E-07
	160 / 184	3.33E-08
Total Average		**5.25E-07**

	Impact (in-lb) / (kg-cm)	Average Airborne Release Fraction
BPBS	320 / 368	6.00E-07
	160 / 184	3.18E-07
Total Average		**4.59E-07**

Objective 3 – Validation of Fixative/Polymer State – INITIALLY CONFIRMED

Research Activity 2: Certifying Fixative Technology Performance when Exposed to Impact Stressors Postulated in Contingency Scenarios Highlighted in Safety Basis Document

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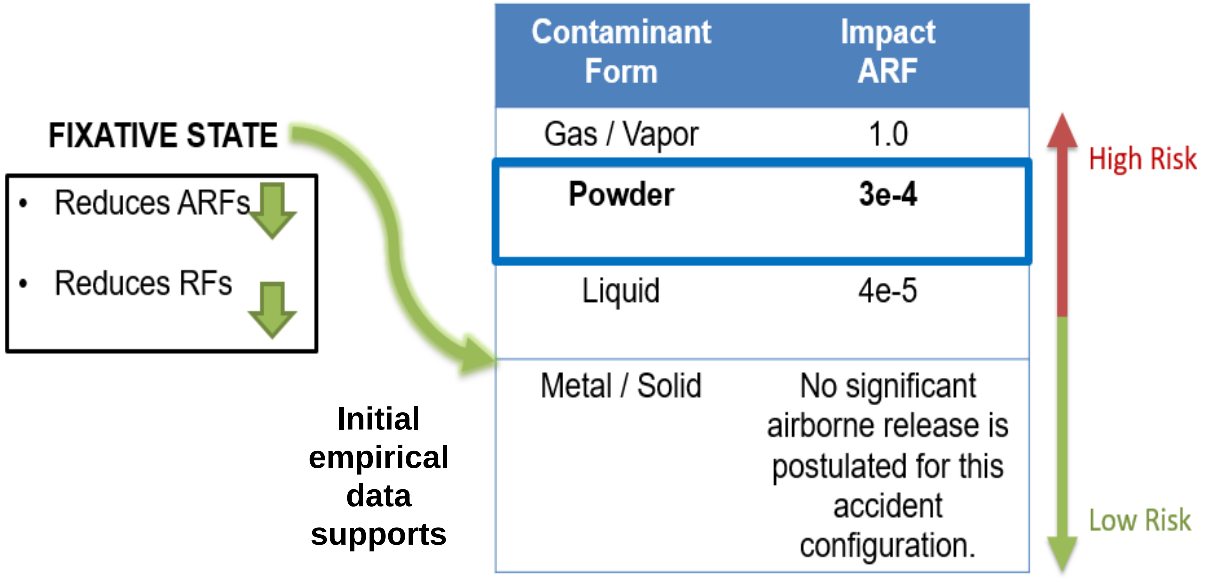
FIU Year 2 Research Highlights & Accomplishments:

- Baseline results (powder contamination only) support ARF coefficients outlined in DOE-3010-HDBK.

- Initial results when applying fixative technologies support the addition of a “fixative / polymer state” in DOE-3010-HDBK due to **<u>significant reductions</u>** in the ARFs.
  - Initial data shows that fixatives have a lower ARF than liquid form.



Research Activity 2: Certifying Fixative Technology Performance when Exposed to Impact Stressors Postulated in Contingency Scenarios Highlighted in Safety Basis Document

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FIU Year 3 Way Ahead:

Experimental Design

- Standardize process and equipment

Further Confirm ARFs under Impact

- Powder contamination
- Fixative / Polymer state

ASTM Testing Practice

Methods for Direct Comparison of Fixative Technologies

Important for consideration as an ASTM standard

Research Activity 3: Polydimethylsiloxane Micro-ribbons for Mercury Remediation

Site Needs:

- Developing novel technologies that support Hg remediation in water
- Address the adsorbing of various forms of Hg contaminants
- Enable an easy, cost-effective method to recycle the used sorbent

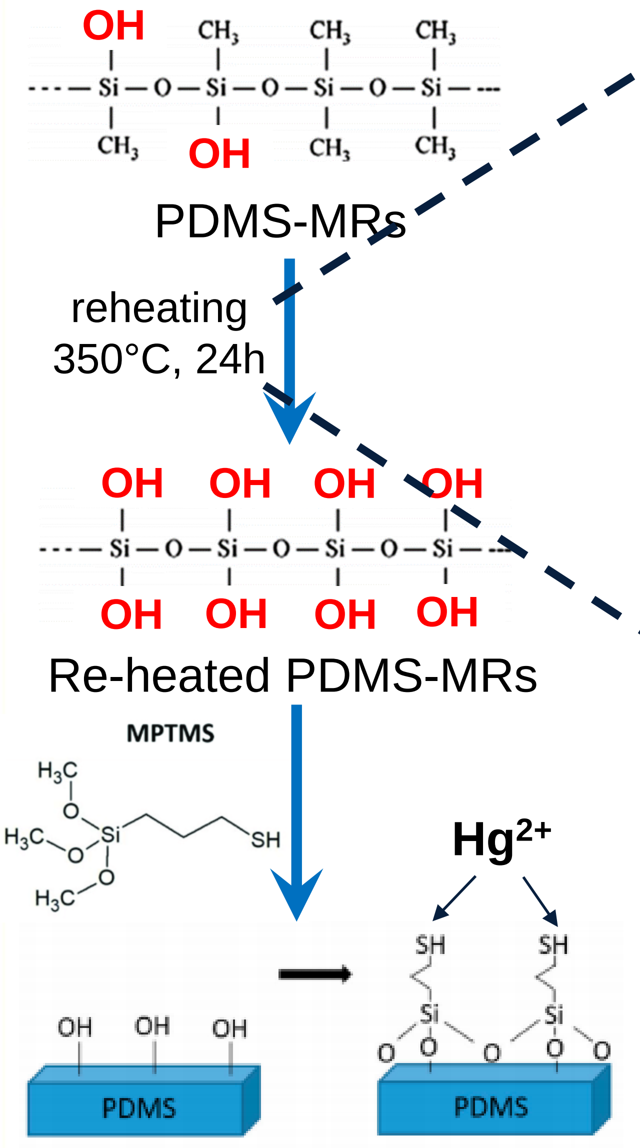
Objectives:

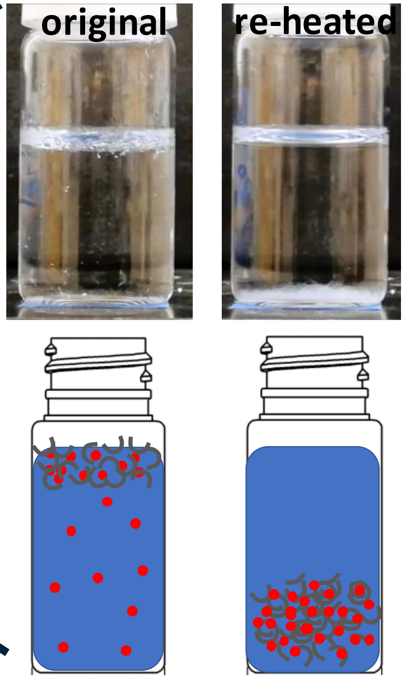
- Design recyclable polydimethylsiloxane micro-ribbons (PDMS-MRs) to achieve Hg^{2+} and CH_3Hg^+ abatement.

  - Confirm application of PDMS-MRs for Hg^{2+} remediation in water
  - Confirm application of of PDMS-MRs for CH_3Hg^+ remediation in water
  - Synthesis of magnetic PDMS-MRs (mPDMS-MRs)
  - Confirm the recycling of mPDMS-MRs in water

Research Activity 3: Polydimethylsiloxane Micro-ribbons for Mercury Remediation

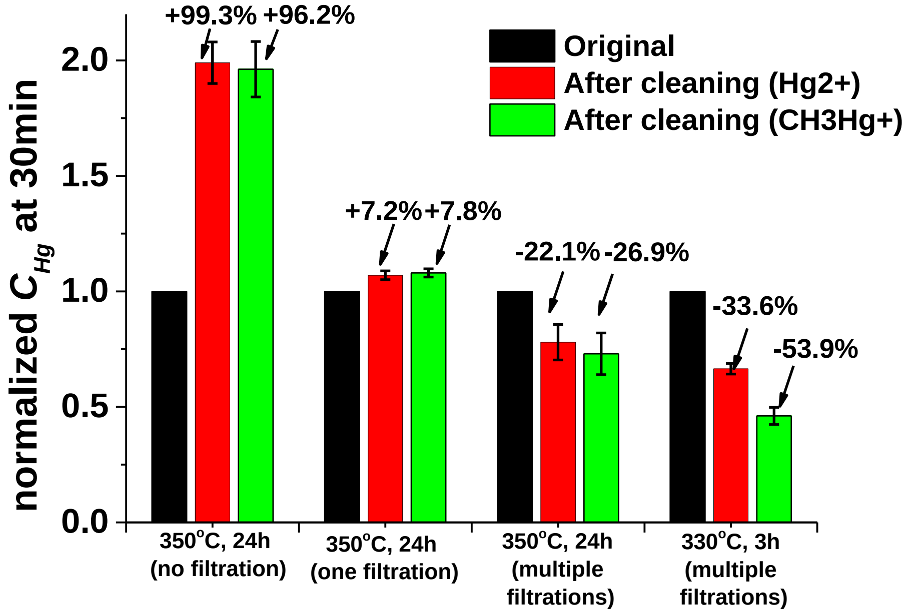
- **Hg^{2+} and CH_3Hg^{+} remediation using PDMS-MRs**





10 mg of PDMS-MRs was added into:

a. 10 mL of 0.5 ppm Hg^{2+} solution
b. 10 mL of 0.5 ppm CH_3Hg^{+} solution



Conclusion:
Re-heated PDMS-MRs did better job because:
1. Better contact with the solution
2. More efficient surface functionalization

Conclusion:
After 30 min, ~ **33.6%** of Hg^{2+} and ~**53.9%** of CH_3Hg^{+} was removed using 10 mg/mL PDMS-MRs sorbent

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Research Activity 3: Polydimethylsiloxane Micro-ribbons for Mercury Remediation

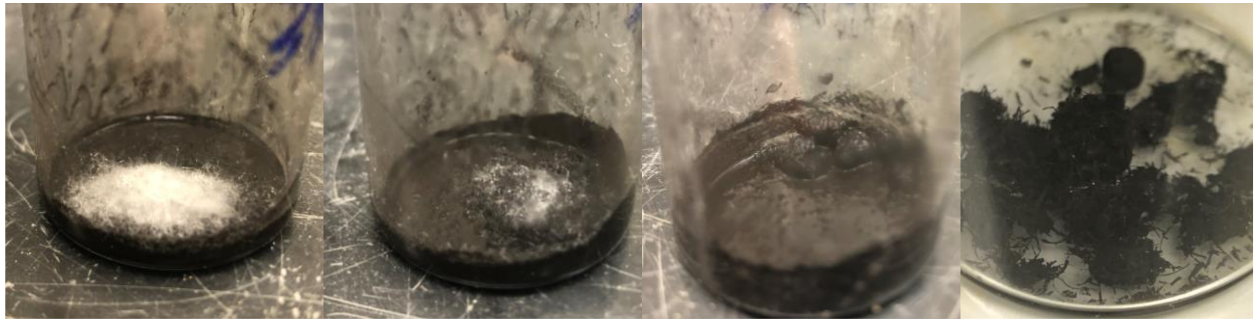
- **Synthesis of recyclable mPDMS-MRs to facilitate removal**

Magnetic driver: Iron Oxide (Fe_3O_4) powder (~ 5 μm)

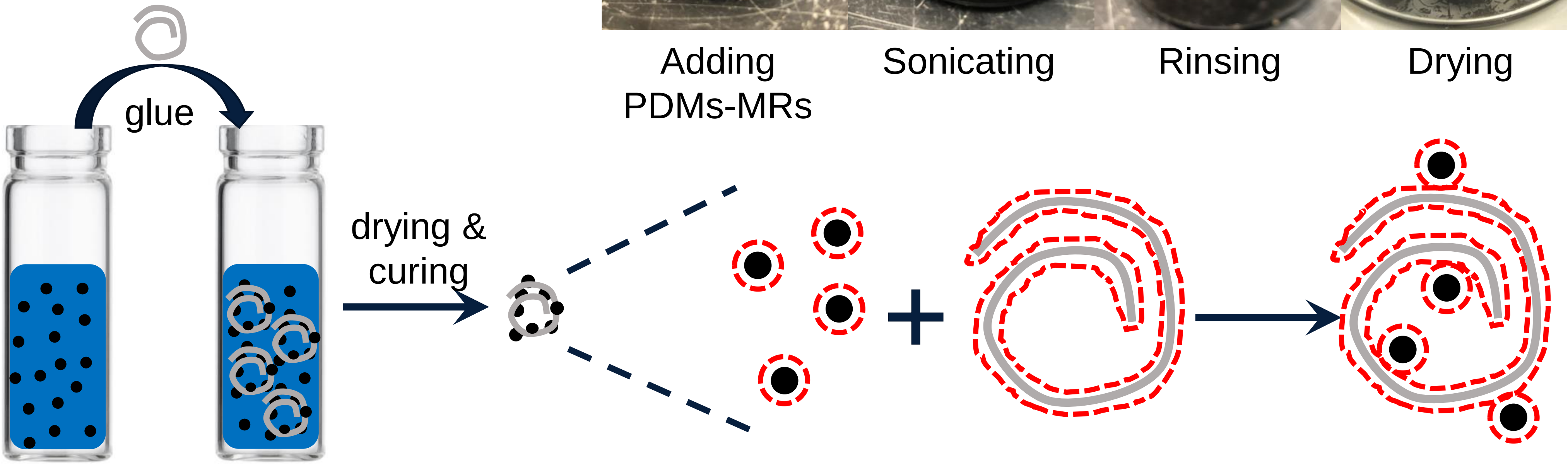
Sorbent base: PDMS-MRs

Glue: PDMS Part A (monomer)

Synthesis medium: Acetone



Adding PDMs-MRs | Sonicating | Rinsing | Drying



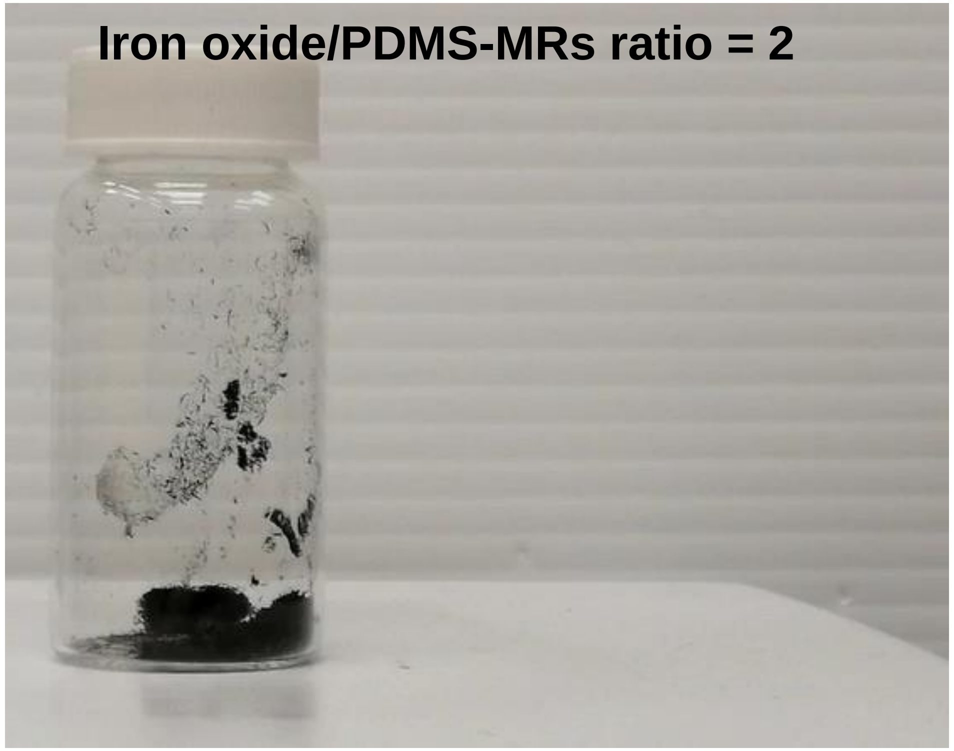
Research Activity 3: Polydimethylsiloxane Micro-ribbons for Mercury Remediation

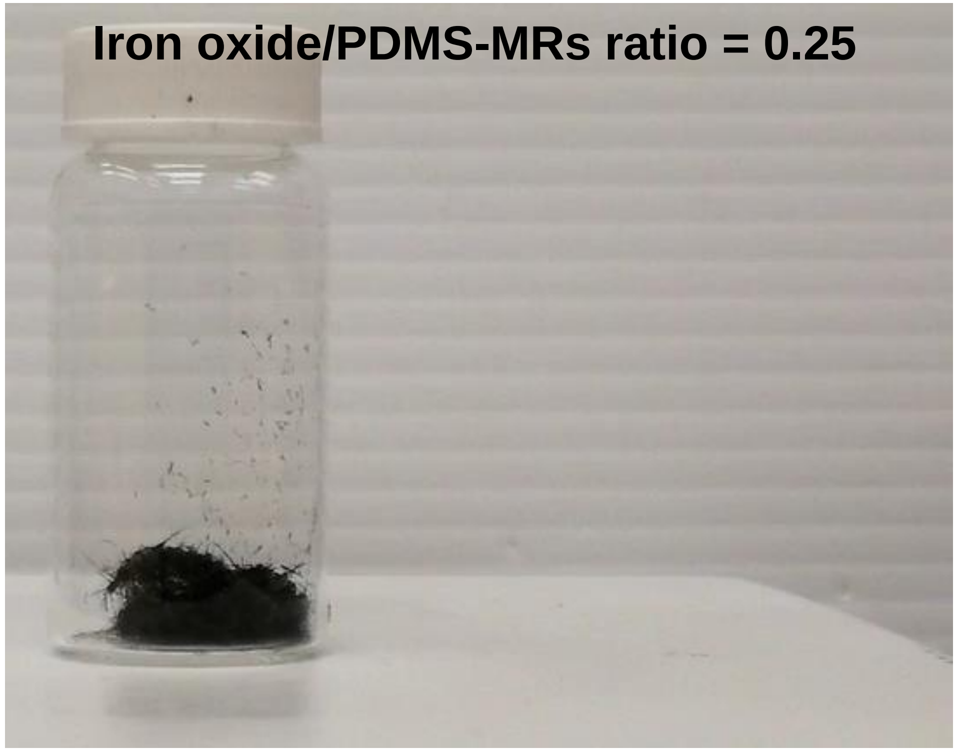
- **Optimization of mPDMS-MRs**

	Sample A	Sample B	Sample C	Sample D
Iron oxide powder	0.1 g	0.1 g	0.1 g	0.1 g
PDMS monomer (glue)	0.025 g	0.05 g	0.075 g	0.1 g
Acetone for dispersing	3 mL	3 mL	3 mL	3 mL
PDMS-MRs	0.05 g	0.1 g	0.05 g	0.1 g
Acetone for rinsing	5 mL	5 mL	5 mL	5 mL
Glue concentration	8.3 g/L	**16.6 g/L**	24.9 g/L	33.2 g/L

	Sample A	Sample B	Sample C	Sample D
PDMS-MRs	100 mg	100 mg	100 mg	100 mg
Iron oxide powder	200 mg	100 mg	50 mg	25 mg
Weight ratio (Iron oxide/PDMS-MRs)	2	1	0.5	0.25

Research Activity 3: Polydimethylsiloxane Micro-ribbons for Mercury Remediation

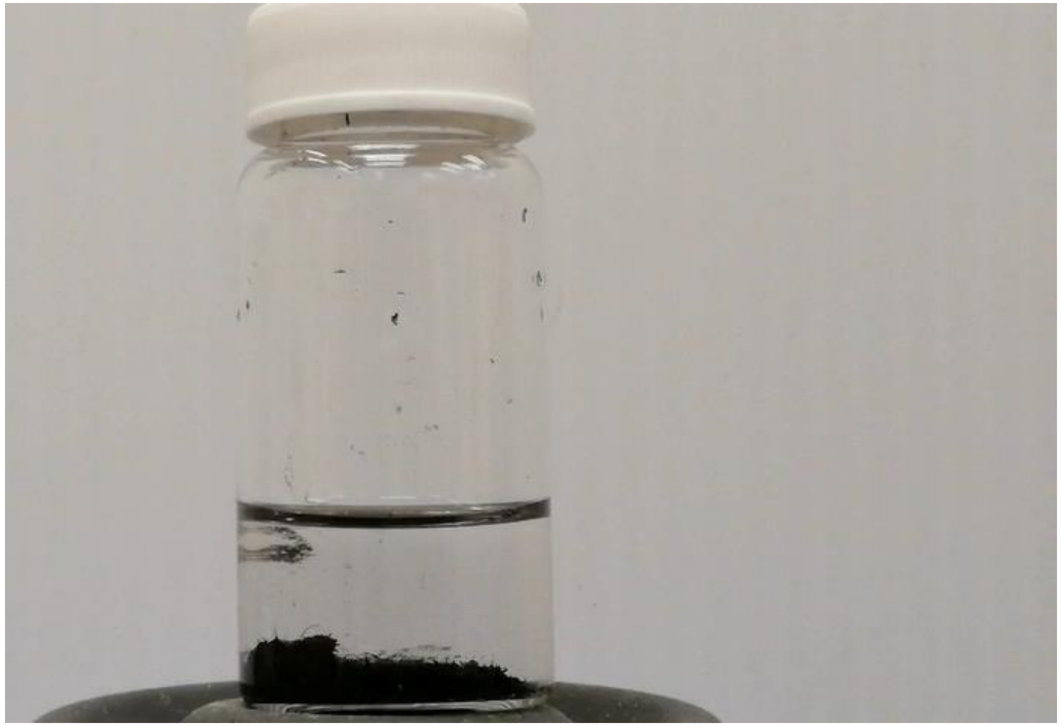




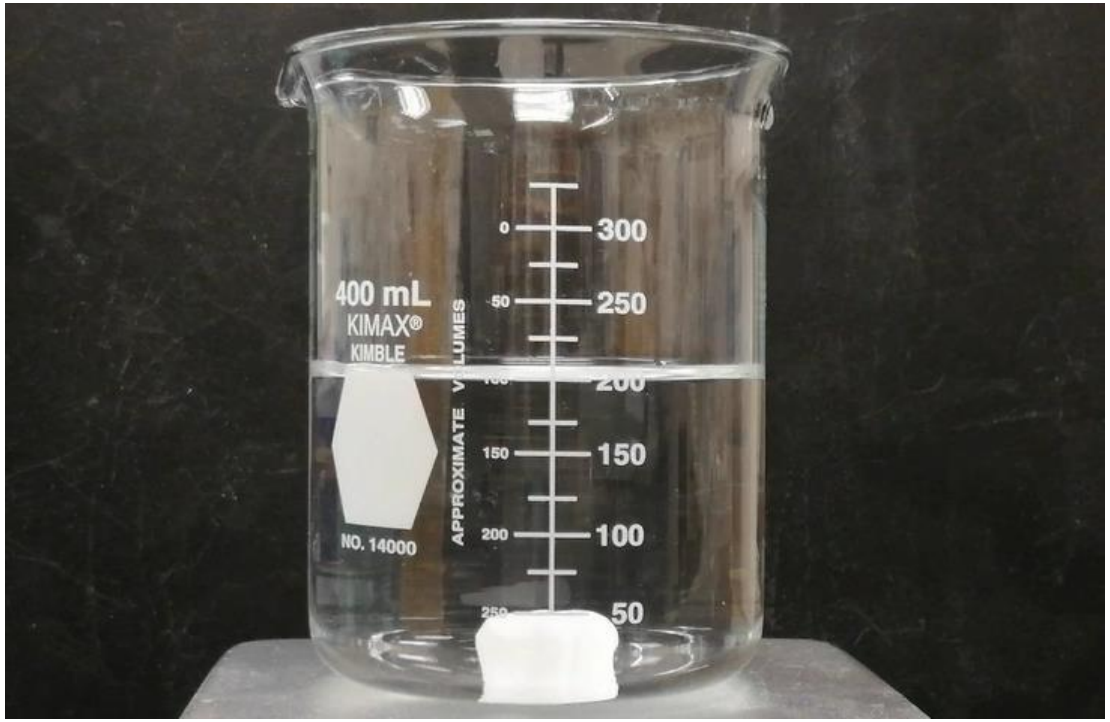
Conclusion:

All the samples with Iron oxide powder/PDMS-MRs ratio between 2 and 0.25 showed strong magnetic field responsibilities. The order of the strength from high to low is: sample A (ratio = 2) > sample B (ratio = 1) > sample C (ratio = 0.5) > sample D (ratio = 0.25).

Research Activity 3: Polydimethylsiloxane Micro-ribbons for Mercury Remediation



Recycling m-PDMS-MRs from water



m-PDMS-MRs in Oil/Water separation

Conclusion:

1. The mPDMS-MRs are stable in water. The magnetic powders did not come off from the PDMS-MRs even after vigorous stirring.
2. The mPDMS-MRs maintain their ability of entanglement (physical property)
3. The mPDMS-MRs maintain their surface chemistry (chemical property)

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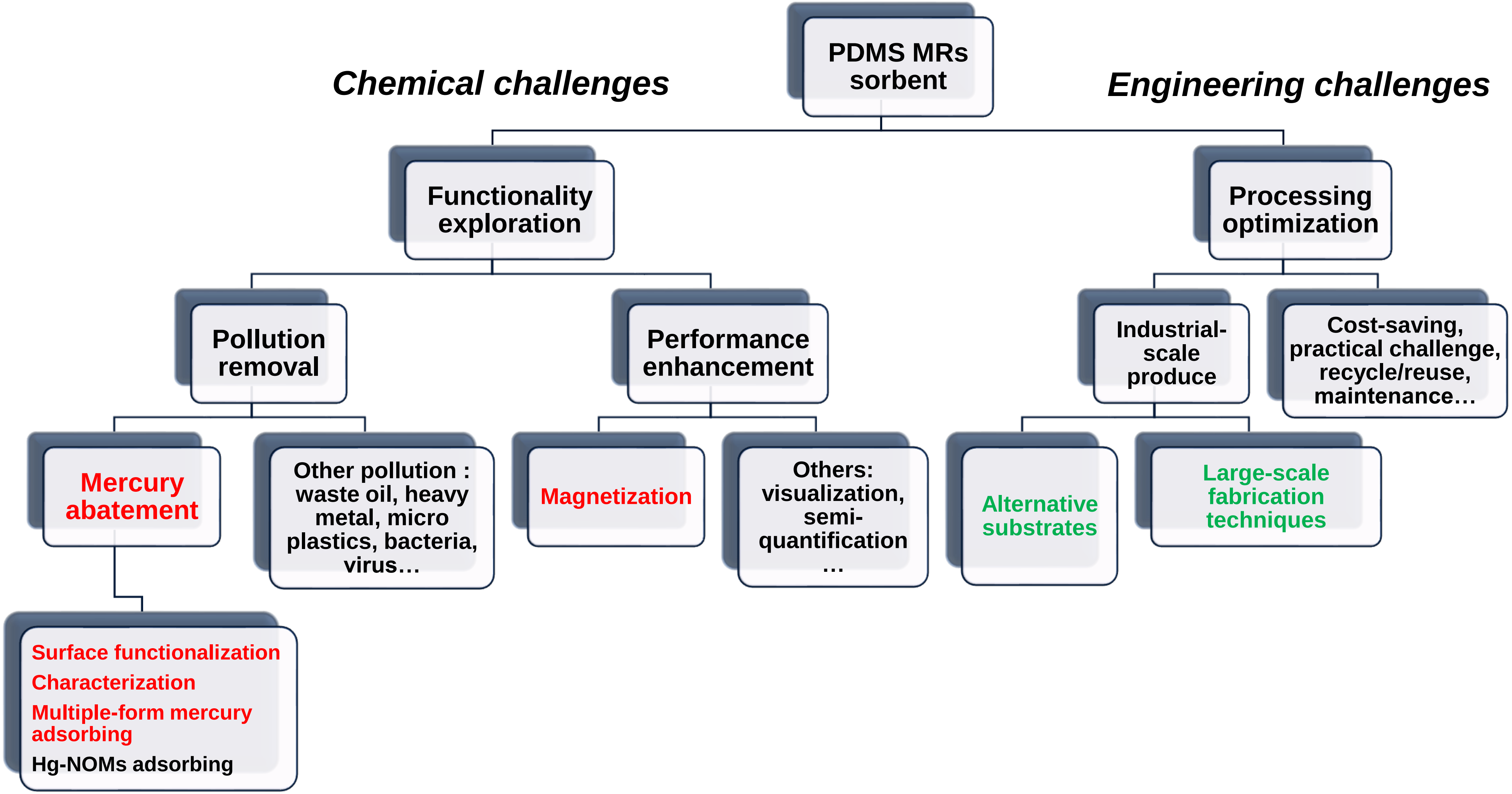
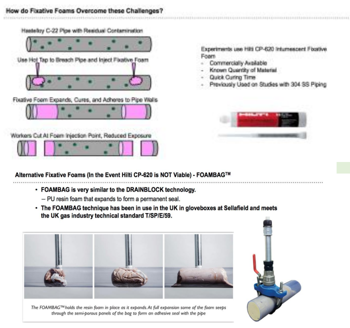
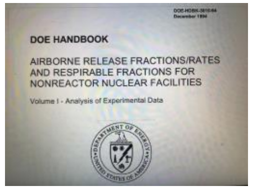
Research Activity 3: Polydimethylsiloxane Micro-ribbons for Mercury Remediation



Technology Development and Deployment Road Map

D&D Roadmap

Activity		2022	2023	2024	2025
Foam Fixatives ISO F/H Labs Pipe Dismantling		Complete Phase I Test Plan	Complete Phase II Test Plan	Complete Construction of Mock-up and Cold Demo	F/H Lab Site Deployment
DOE EM Complex-wide		ASTM E3104 Updated ASTM E3105 Updated	ASTM E3104 Balloted and Approved ASTM E3105 Balloted and Approved	WK77334 Development and Balloting	WK77334 Approval & Promulgation as Formal Standard
			First Technical Progress Report	Final Technical Progress Report Initiate DOE-HDBK-3010 Update	PhD Dissertation Published
		Proof-of-Concept for Hg Remediation	Optimization and Bench-scale T&E	In-house Demonstration	Site Demonstration

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DOE-FIU Cooperative Agreement

Upcoming Events Announcement

FIU
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DOE Fellows Poster Exhibition

FIU Applied Research Center

DOE Fellows Induction Ceremony


Thank You. Questions?