Microplastics, PFAS, & Other Contaminants of Emerging Concern

Wednesday, May 21, 2025

10:00 am – 11:30 am

Marriott Library, Room 1130

PEAK WATER
SUSTAINABILITY ENGINE

Agenda

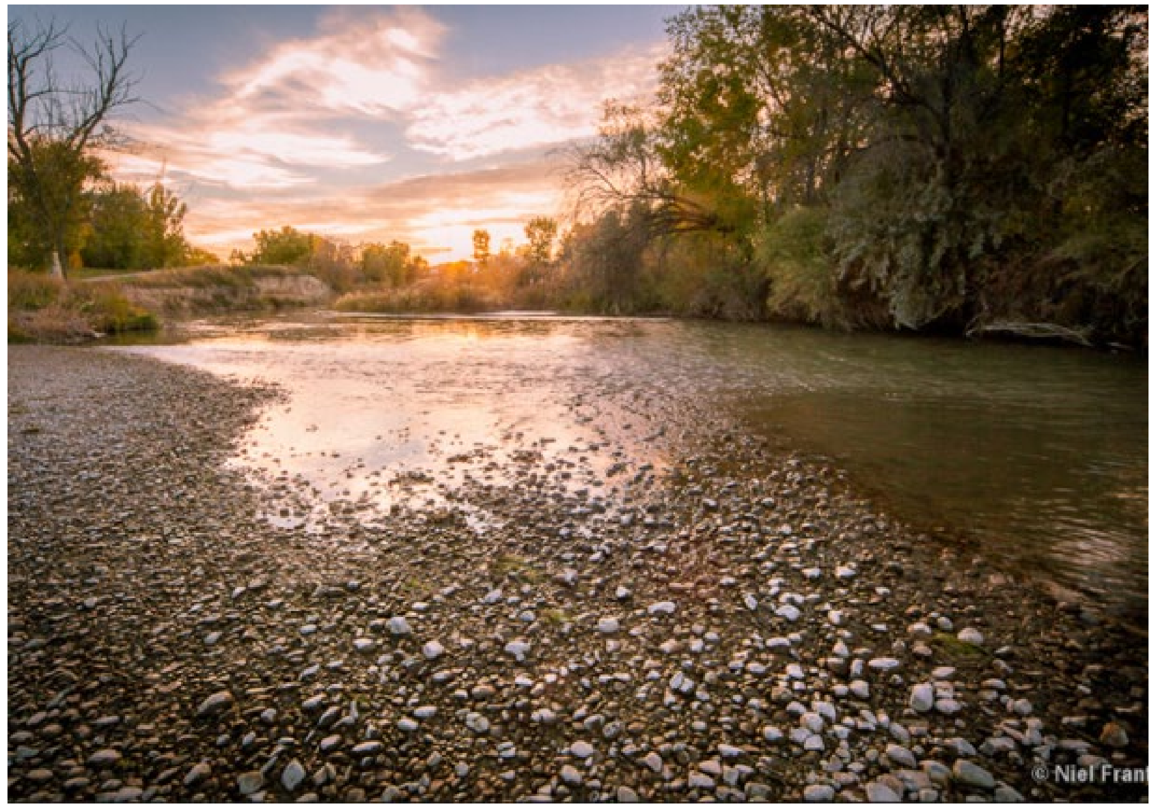
Timing	Title	Lead
10:00-10:10 am	Welcome PEAK Water Overview	Dr. Marian Rice Associate Director, PEAK Water Sustainability Engine
10:10-11:15 am	Lightning Talks	
11:15-11:25 pm	Open Discussion	
11:25-11:30 am	Close	Dr. Marian Rice Associate Director, PEAK Water Sustainability Engine

PEAK WATER
SUSTAINABILITY ENGINE

Peak Water Sustainability Engine

Holistically and collaboratively examining water to enable local and global solutions

Forum connecting interdisciplinary research community



Fostering collaboration with partners

Serve as scaffolding to support research efforts

PEAK WATER
SUSTAINABILITY ENGINE

Join Peak Water Research Roster

Contaminates of Emerging Concern

Per- and Polyfluoroalkyl Substances (PFAS)

Pesticides

Microplastics and Nanomaterials

Pharmaceuticals & Personal Care Products

Polybrominated Diphenyl Ethers (PBDEs)

NOAA, 2025

PEAK WATER
SUSTAINABILITY ENGINE

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10:10-10:15 am	Jeffrey Bates	Biological Interactions with Microplastics	College of Engineering
10:15-10:20 am	Bill Johnson	Micro- & Nano-Particle Surface Interaction & Transport in Groundwater	College of Science
10:20-10:25 am	Judy Ou	Microplastics and Cancer Survival	School of Medicine
10:25-10:30 am	Yunshan Wang	In-Situ Microplastic Manipulation & Sensing	College of Engineering
10:30-10:35 am	Jennifer Weidhaas	Quantification & Characterization of Microplastics in Biosolids & Soils Along the Wasatch Front	College of Engineering
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NOVEL CHARACTERIZATION OF ZETA POTENTIAL AND ELECTROCHEMICAL INTERACTIONS BETWEEN CELLS AND MICROPLASTICS

Jeffrey Bates, PhD
Assistant Professor
Materials Science and Engineering
Jeff.bates@utah.edu

Observations and Problems

Microplastics have been found in all human tissues and body fluids tested

The are comprised of tire rubber, silanes, commodity plastics, polyurethanes, etc.

Published papers were in the tens until 2020, and there have been over 1,000 this year

People are becoming more aware of them

BUT we still don’t know the biological or human health impacts

Sources of Microplastics

Single-Use Plastics
Synthetic Textiles
Vehicle Tires
City Dust
Road Markings
Personal Care Products
Plastic Pellets
Marine Coatings
Dish Detergents
Wastewater Treatment Plants
Bottled Water

Hospital and Medical Waste
Plastic Containers and Packaging
Baby Bottles
Single-Use Plastic Products
Construction Materials
Clothing and Textile Industry
Industrial Activities
Sewage Sludge
Food Packaging
Agricultural Soils and Fertilizers
Oil and Gas Sector

Guiding Research Questions

- How do microplastics interact with cell surfaces?
- What is the effect of microplastic size on cells?
- How do PFAS affect microplastic zeta potential changes?
- What is the role of surface charge in microplastic agglomeration?
- How do microplastics adhere to and retain on cells?
- What are the implications of microplastic retention on cells?

Hypotheses:

1

Size-Dependent Effects: We hypothesize that smaller microplastic particles are more likely to interact with cells and elicit biological responses compared to larger particles

2

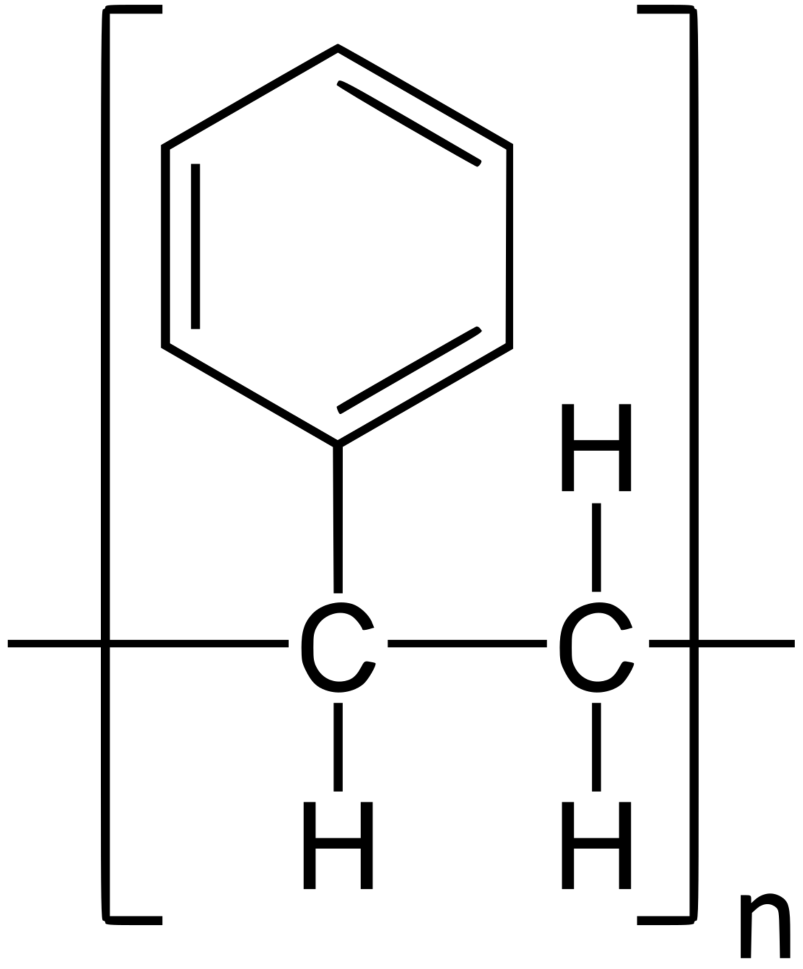
Agglomeration and Surface Charge: We hypothesize that biochemical interactions occur through and can be measured by analyzing the zeta potential

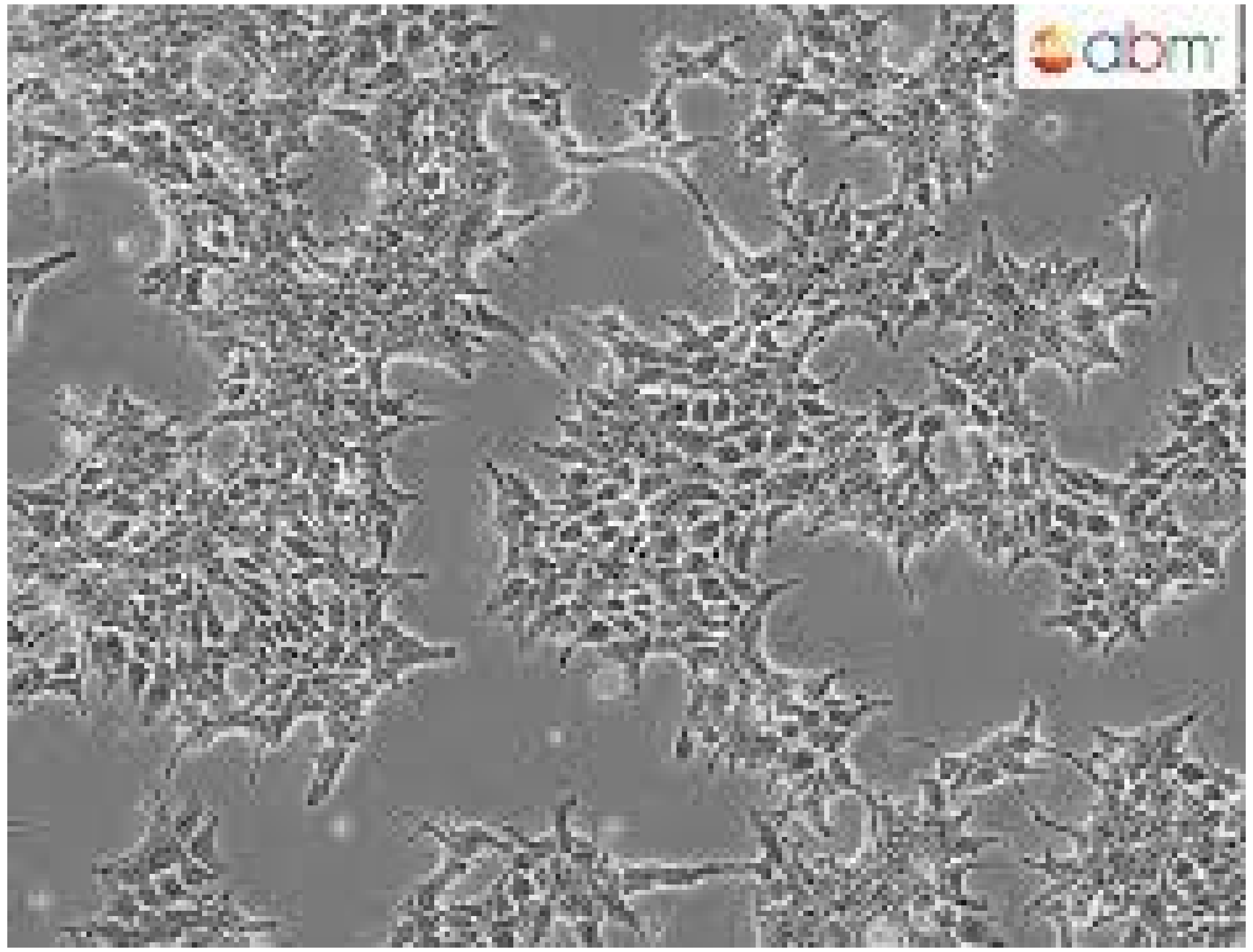
3

Cell Adhesion and Retention: We hypothesize that microplastics adhered to cell surfaces have reacted biochemically with membrane bound proteins on the cell surface

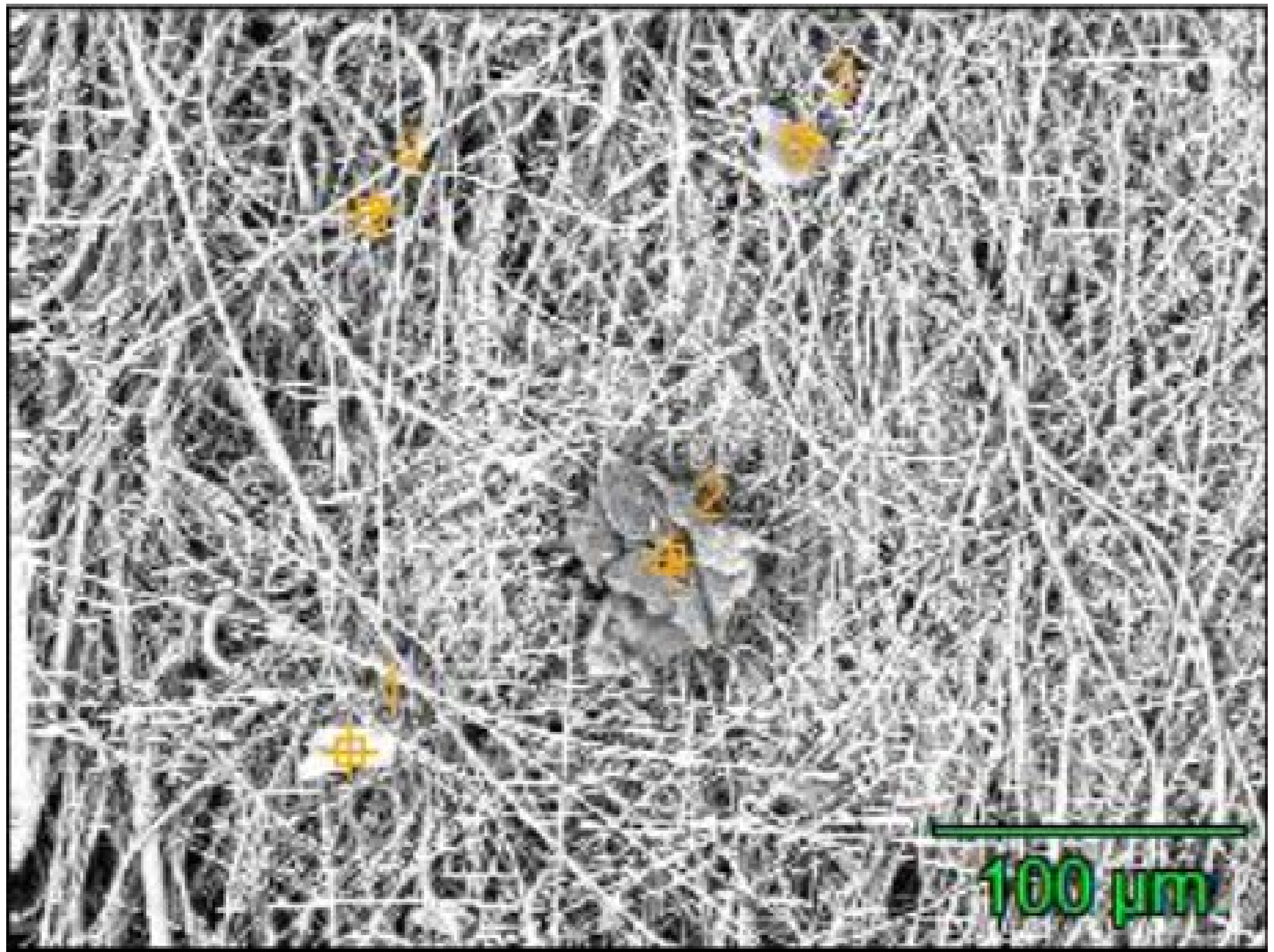
Methods

PS → Microplastics → 293T Cells

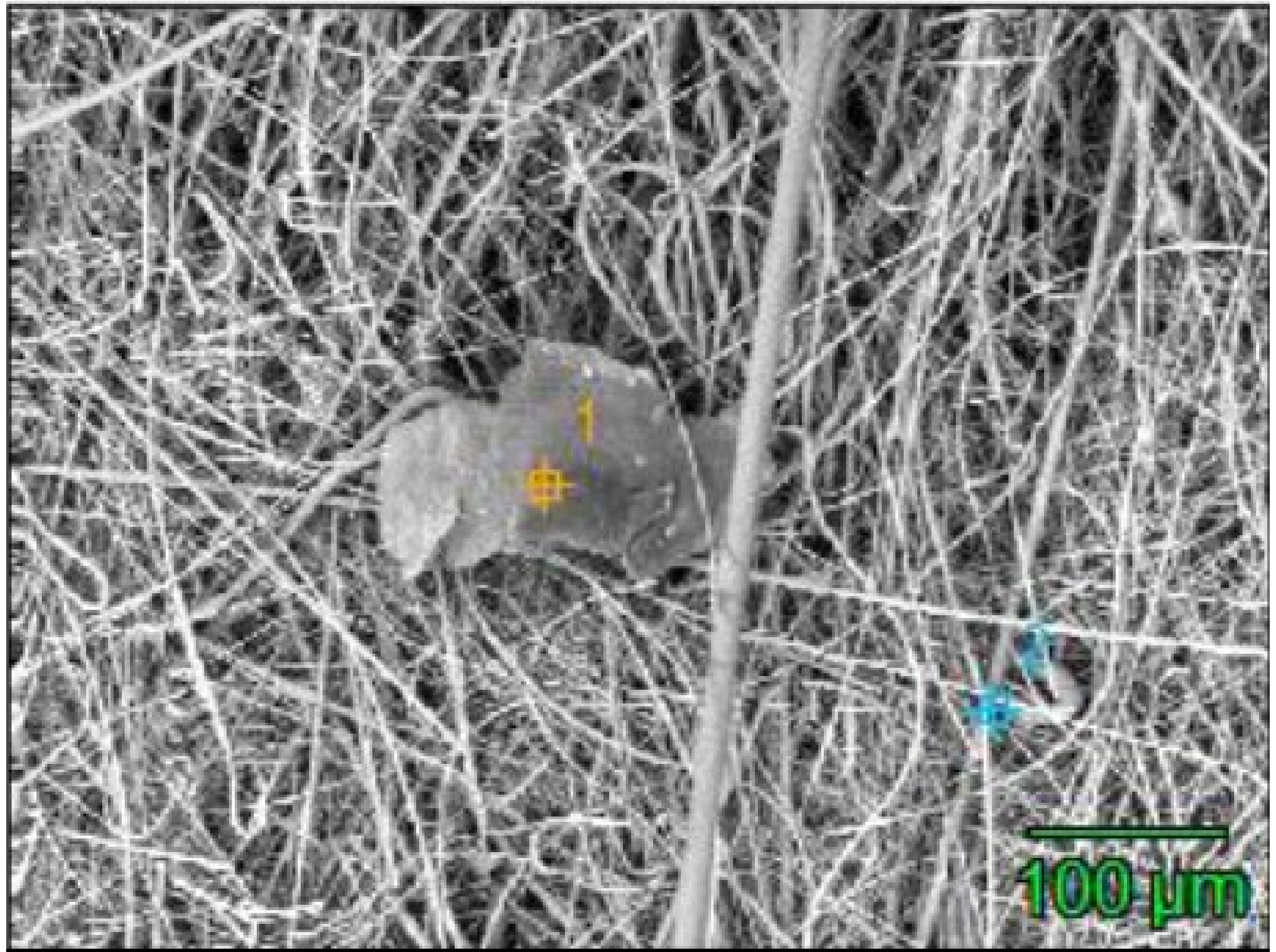




SEM



Base(1)_512x384_px. 0.80 µm_15.0 kV_400x



Base(5)_512x384_px. 1.28 µm_15.0 kV_250x

Elemental Analysis

Sample		Atom %												
		C	N	O	Na	Al	Si	Cl	K	Ca	Zn	Ba	Au	Mg
Left	Pt 1	18.29	7.55	45.73	6.6	1.91	15.19	-	1.21	1.09	-	0.54	1.89	-
	Pt 2	35.64	15.18	33.75	3.74	0.48	3.67	2.71	2.78	0.53	-	-	1.21	0.33
	Pt 3	5.89	-	45.62	6.22	3.29	29.29	-	2	1.7	2.81	1.28	1.89	-
	Pt 4	2.75	-	40.63	8.96	4.05	35.73	-	2.5	1.61	-	1.79	1.98	-
Right	Pt 1	30.77	5.94	40.41	5.09	1.34	11.22	1.78	1.23	0.73	-	0.47	1.01	-
	Pt 2	1.49	-	53.58	7.81	3.34	28.4	-	1.63	0.85	1.42	0.97	0.5	-

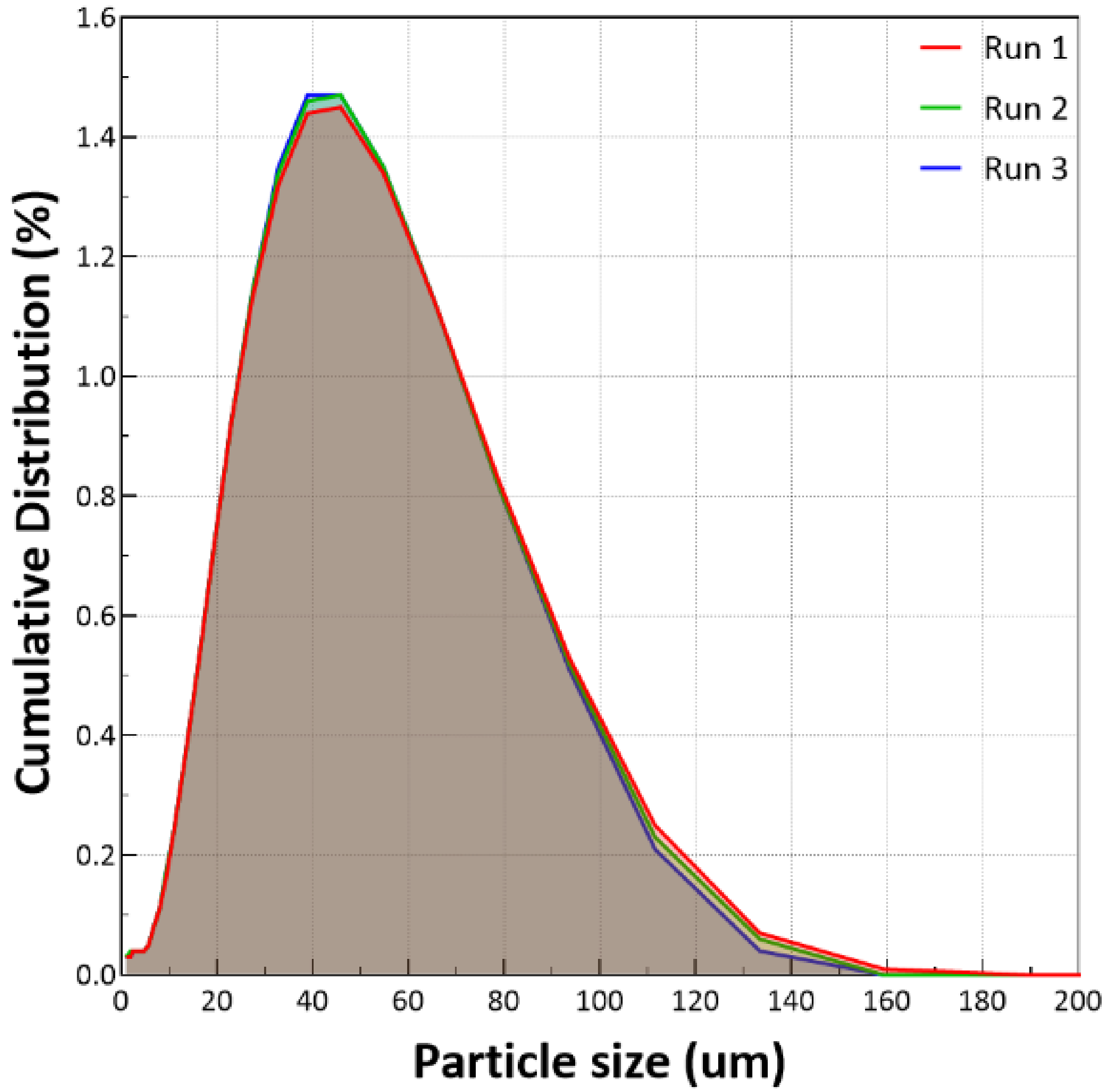
Part 1: Conclusions

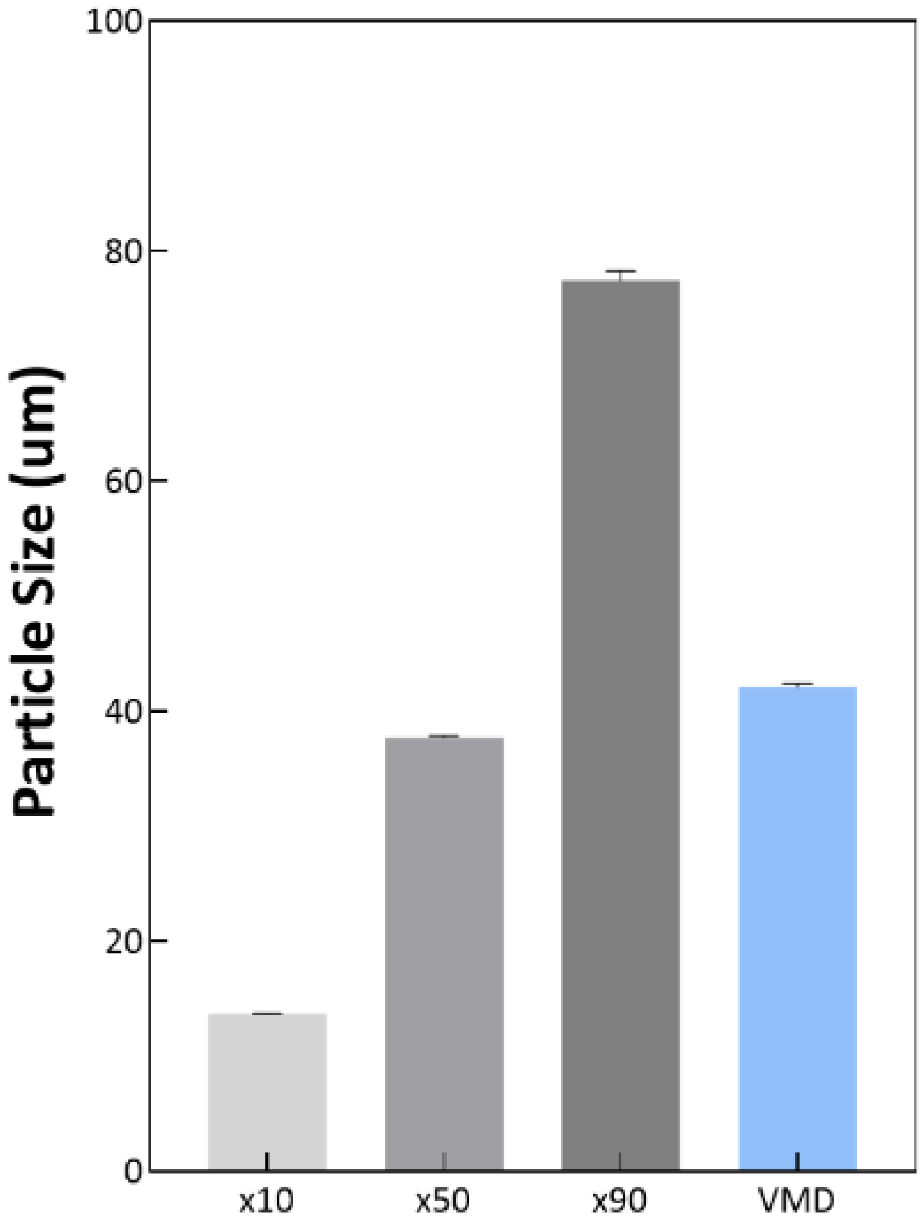
SEM images of MPs showed distinct particles without agglomeration

SEM images were useful in determining the size and morphology of MPs

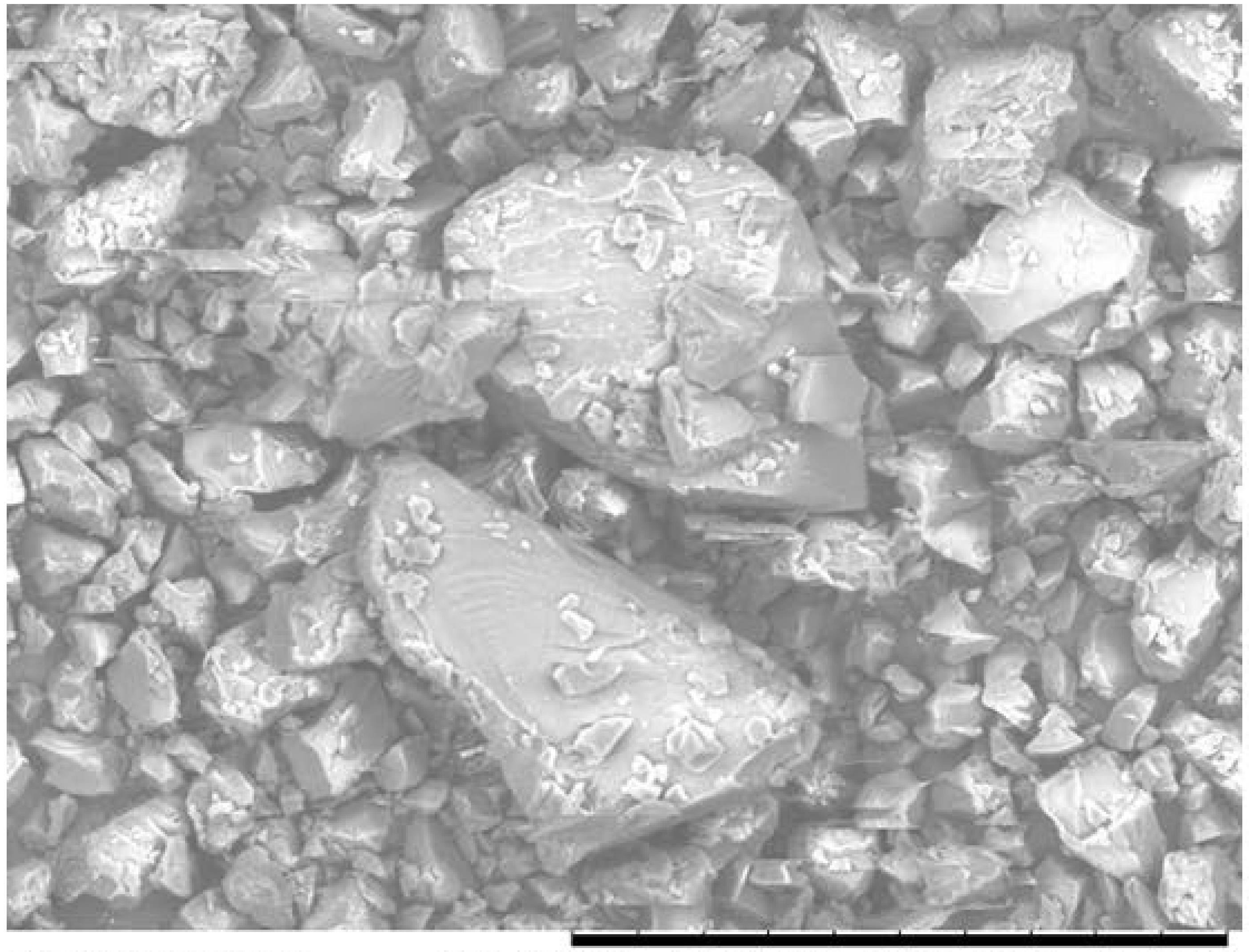
EDS mapping showed the presence of additional elements

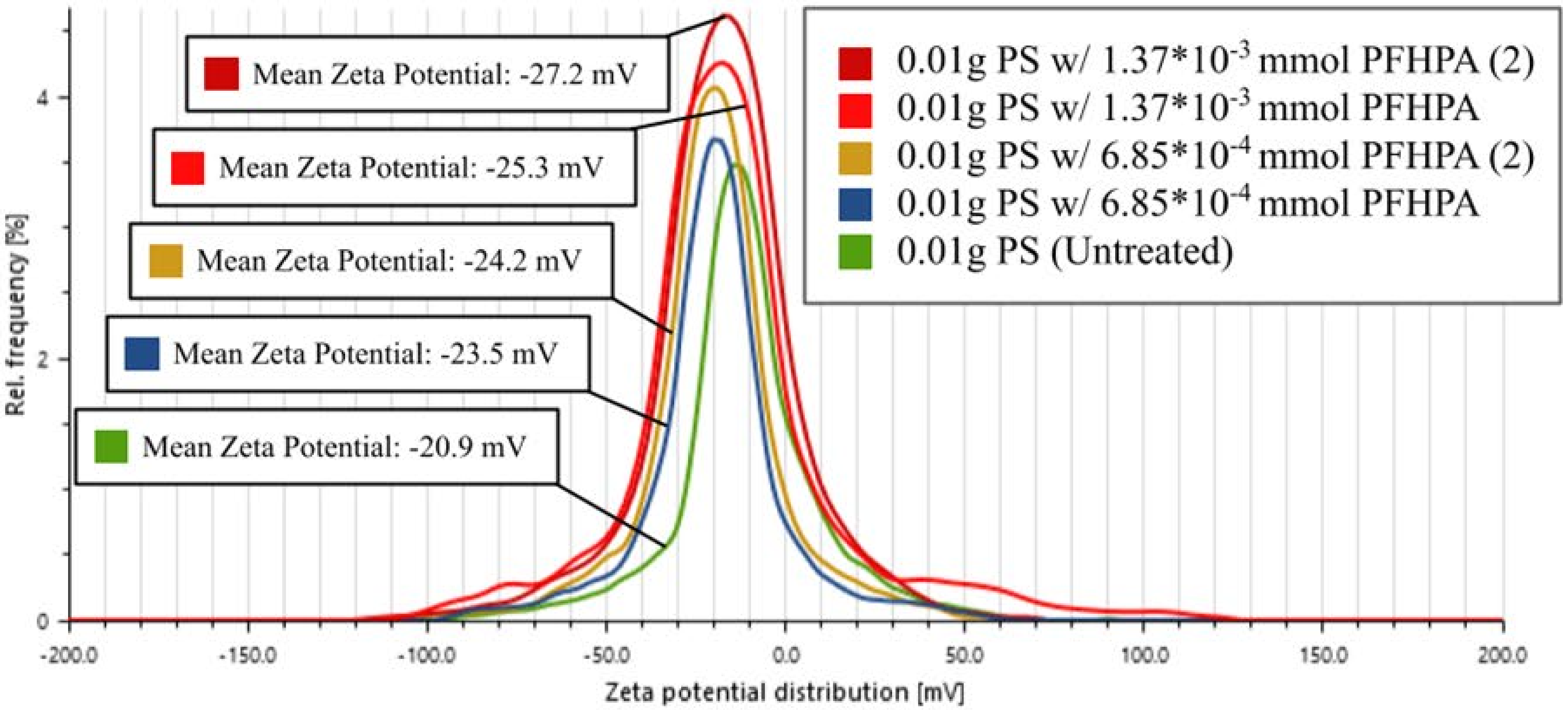
Particle Size Analysis





Change in Zeta Potential with MPs





Part 2: Conclusions

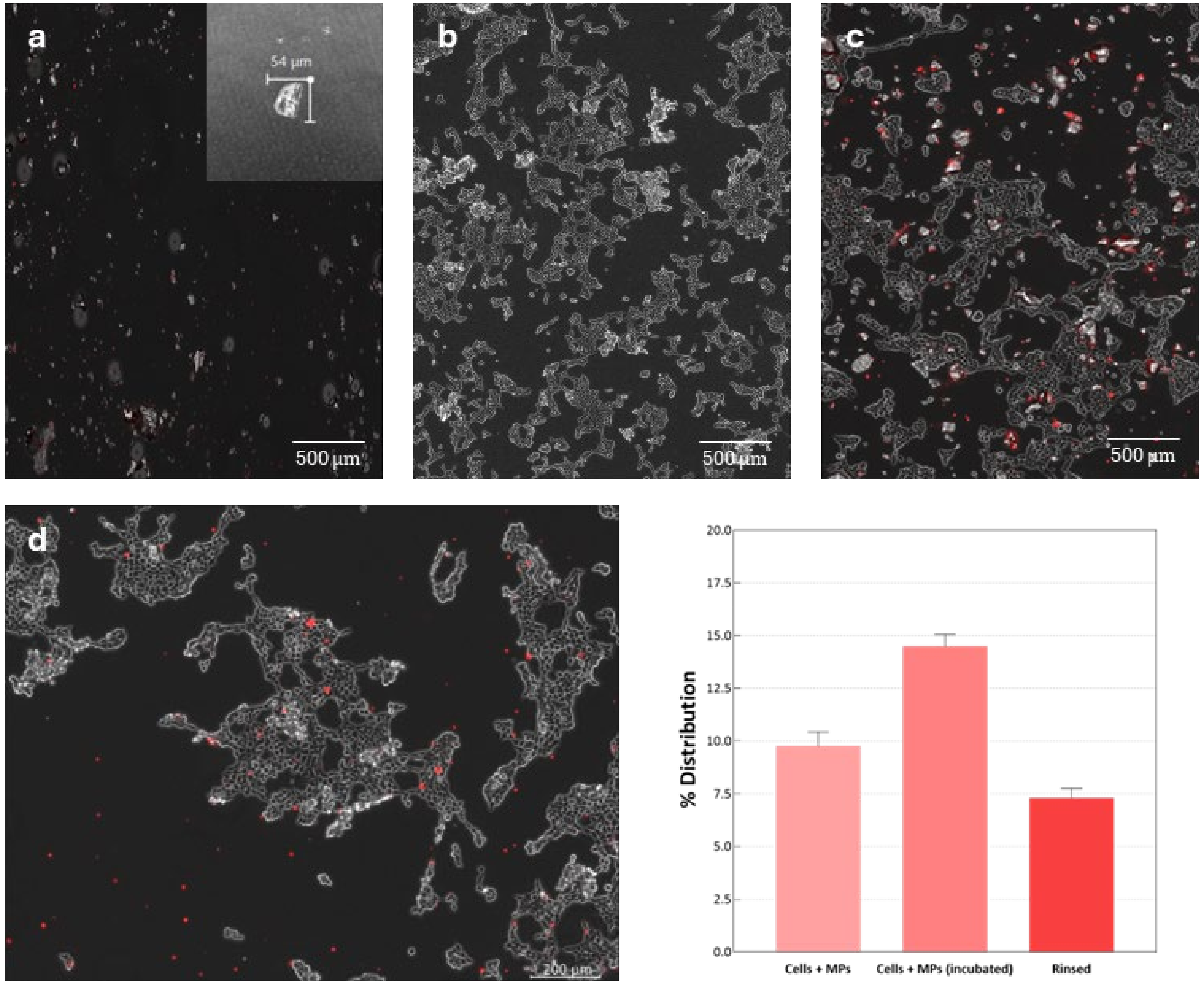
Particle size analysis of MPs (left) showing cumulative distribution across particle sizes ranging from 0 – 200 µm

The mean distribution of 10%, 50% and 90% of total particle volume and their mean diameters

The mean and standard deviation values of particle size in microns with distribution span indicating polydispersity

There was a change in zeta potential—no agglomeration among MPs alone, but agglomeration in contact with cells

Part 3: Fluorescence Imaging



Part 3: Conclusions

Fluorescence imaging was useful in imaging MPs and cells

Imaging revealed interactions of smaller MPs with cells

Washing indicated a sustained interaction between MPs and cells

Cells retain MPs after incubation and multiple rinses

MP retention was calculated against initial seeded concentration using image analysis

Second Research Project

Filter water sources to find microplastics

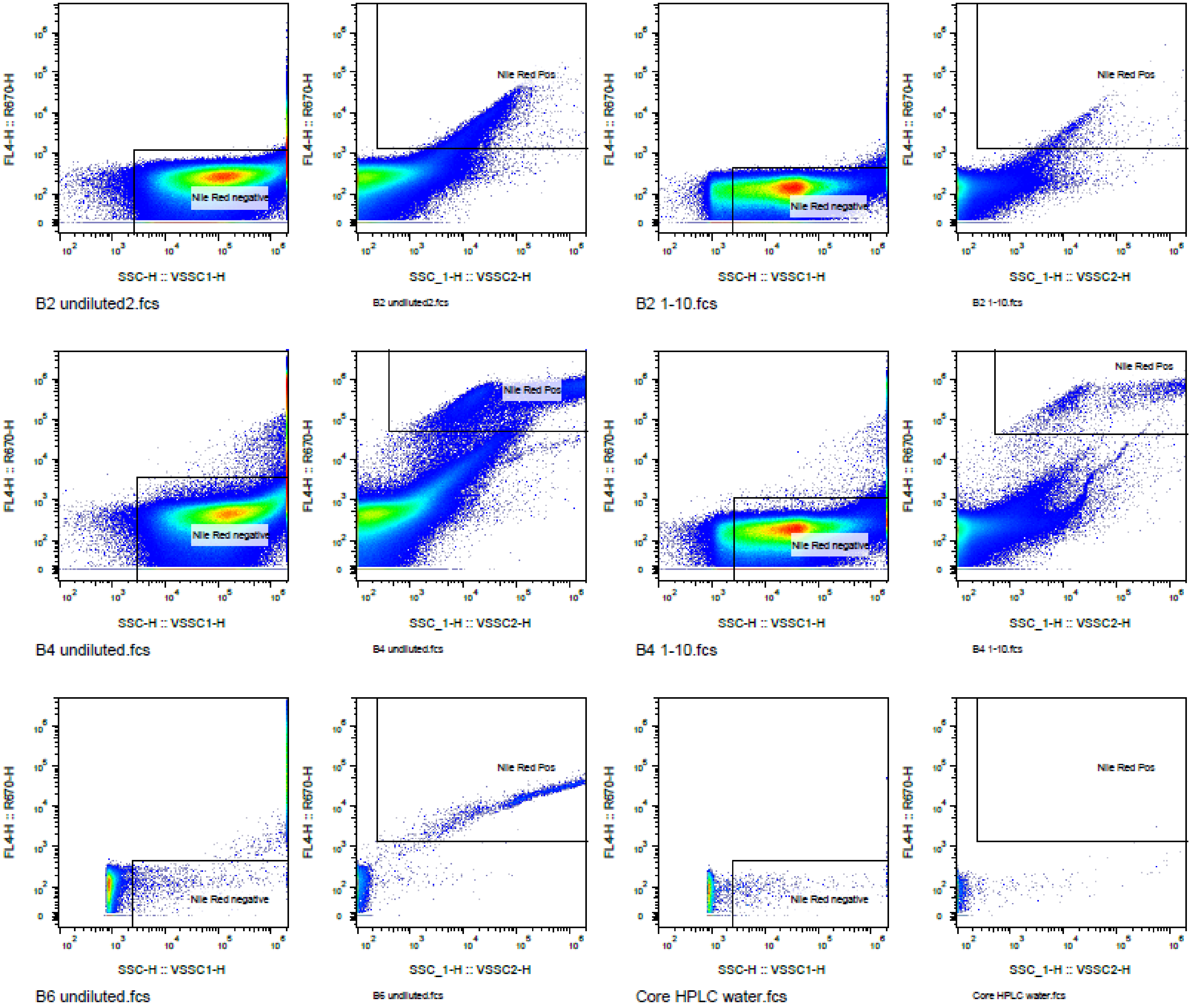
Characterize:

Quantity

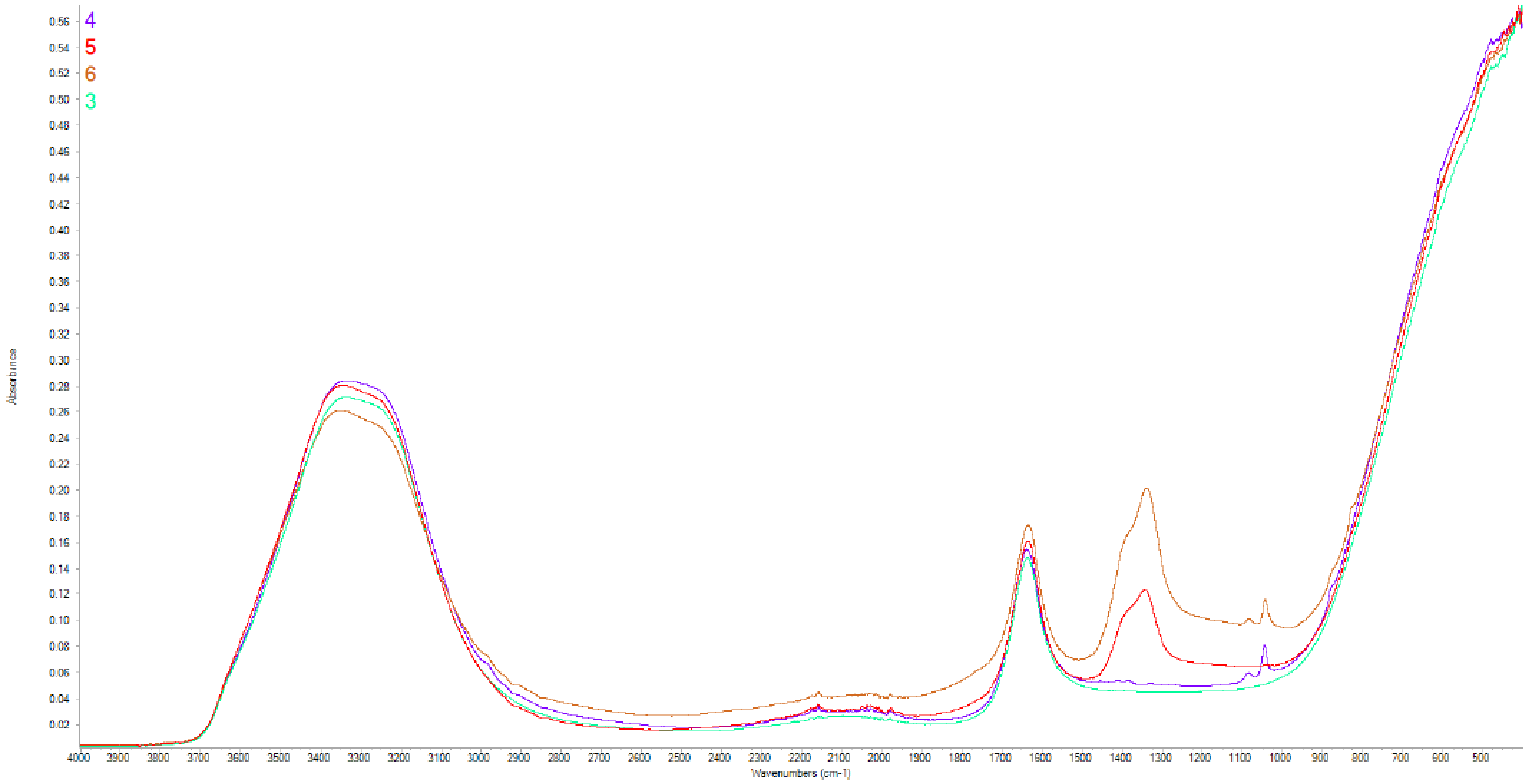
Type

Morphology

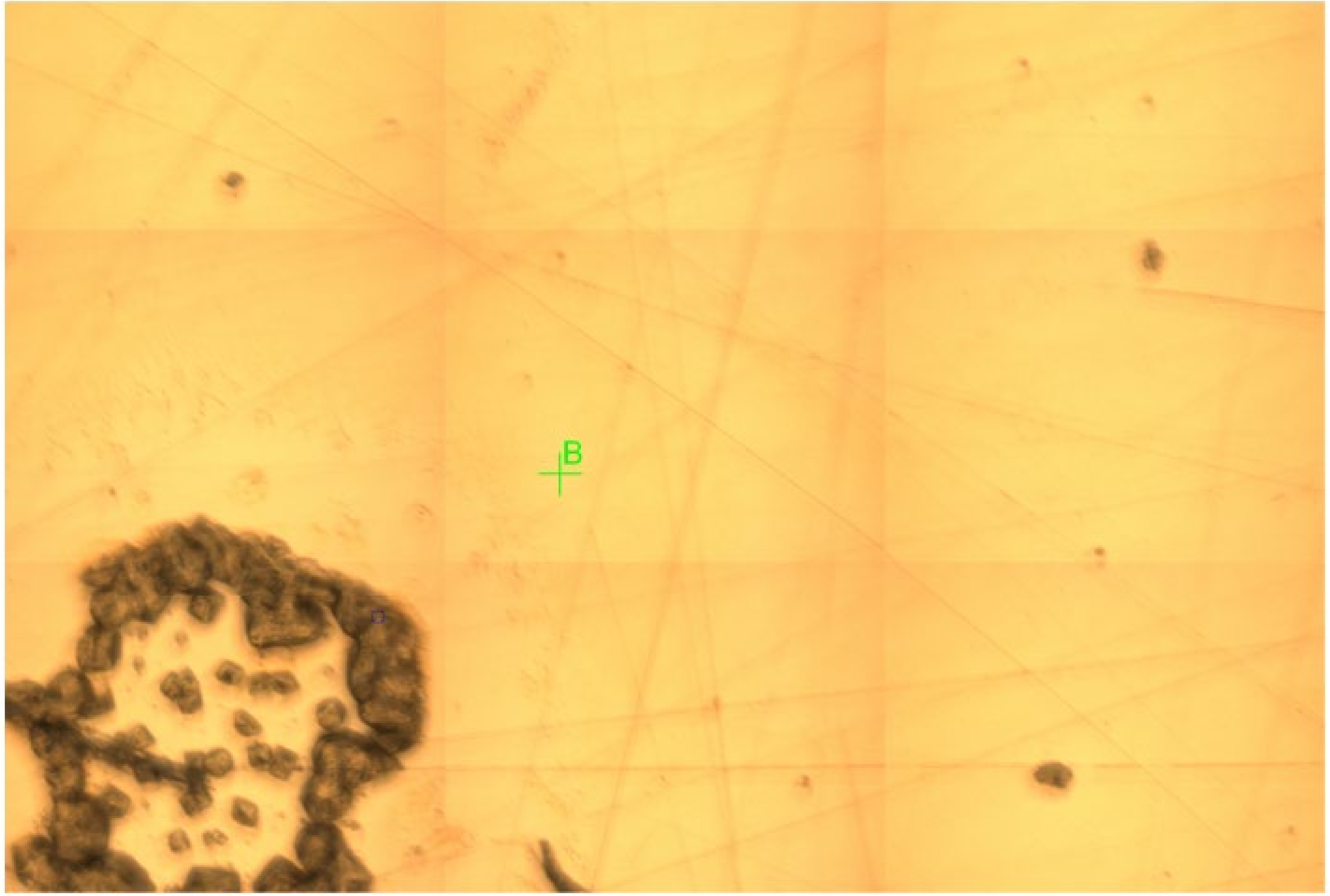
Quantity: Flow Cytometry



Type of Microplastics



Morphology



Significant Conclusions

- Many MPs
- Mostly PET and HDPE, but include many types
- Rough shapes ranging in size from nm to µm to mm

Questions

Jeff.bates@utah.edu

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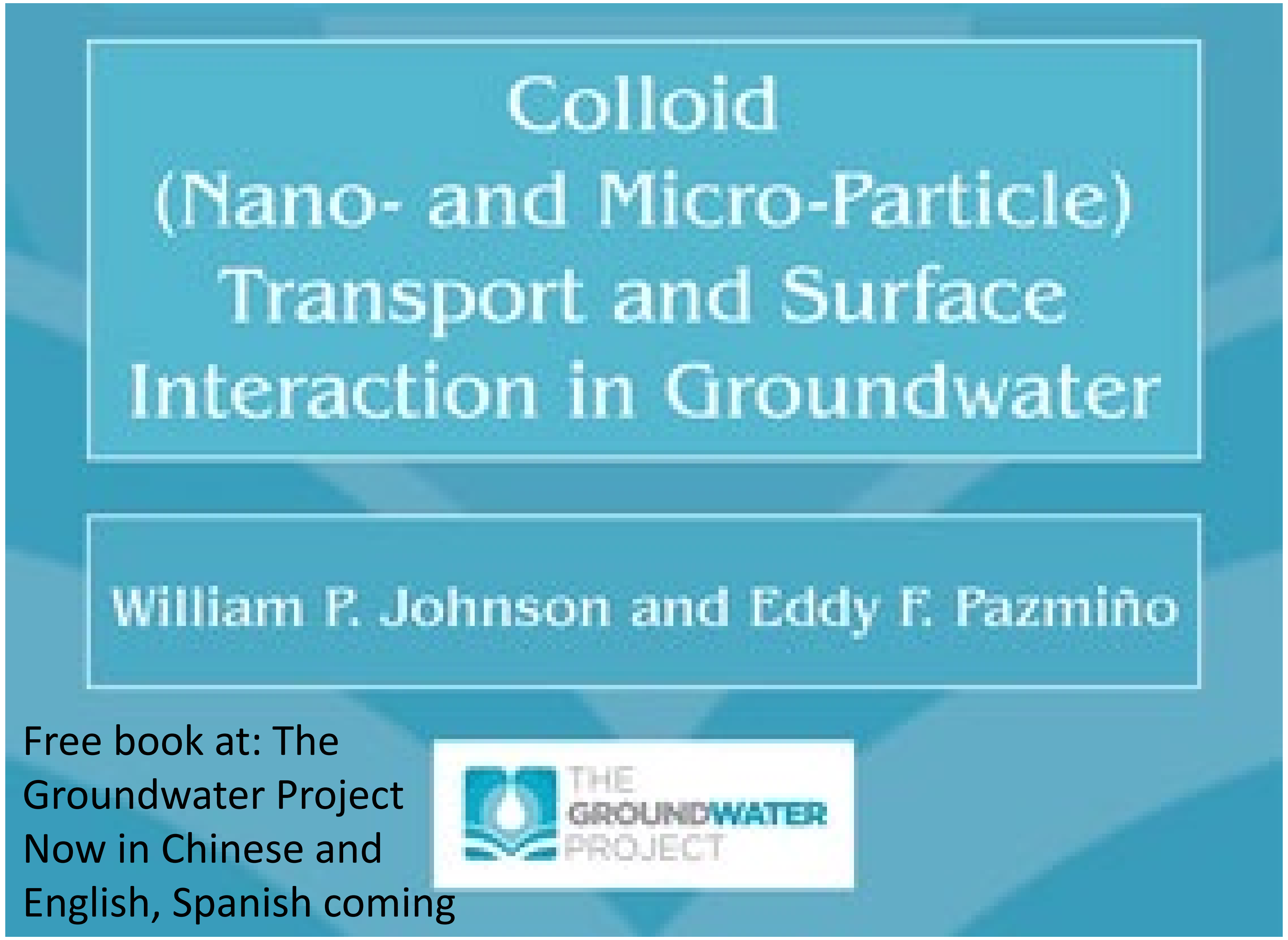
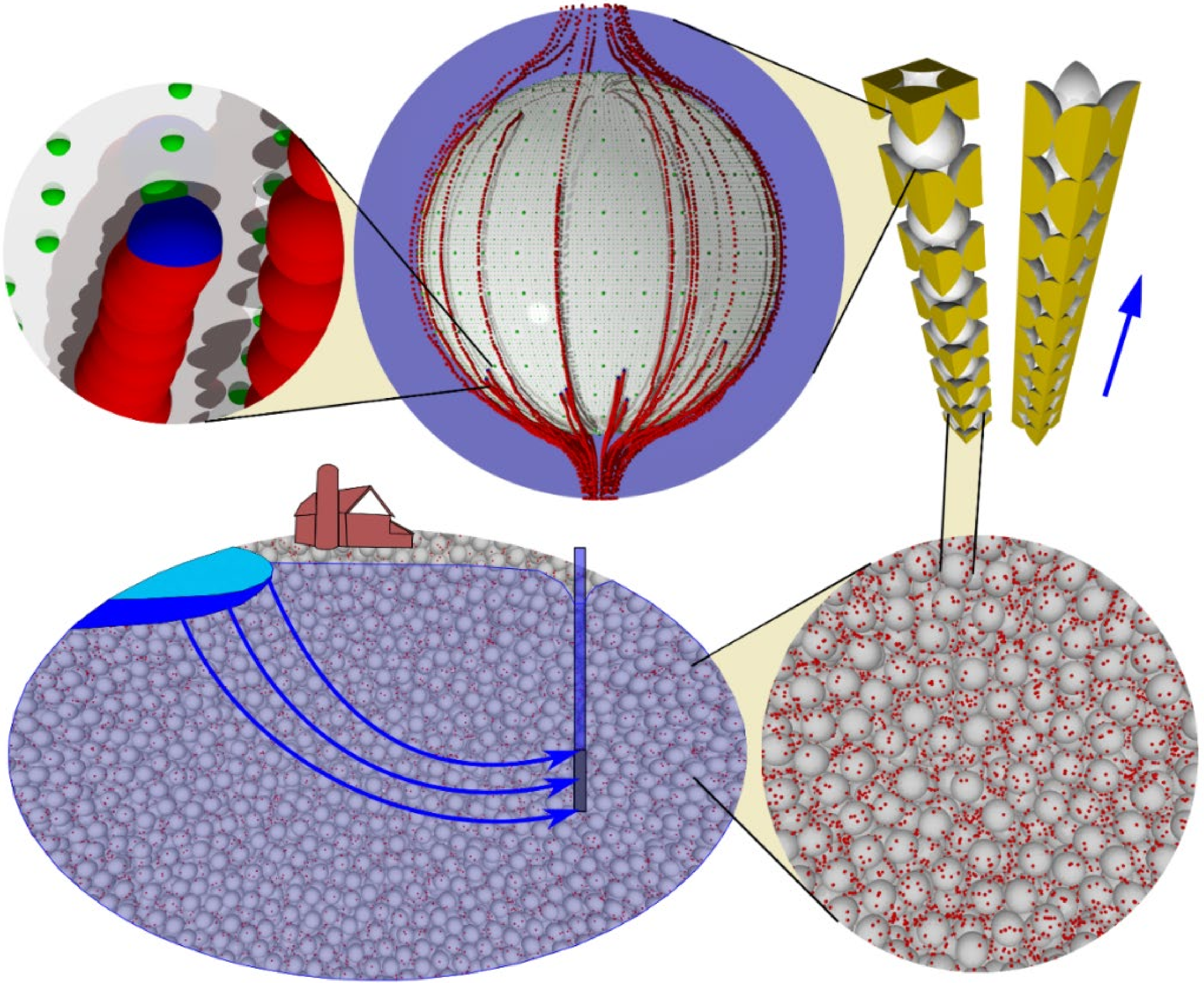
William (Bill) Johnson

Dept. Geology & Geophysics

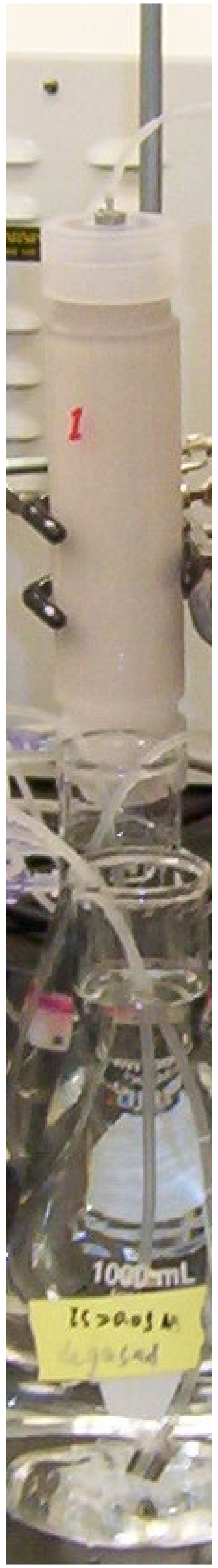
Nano to continuum scale
Porous media: environmental biomedical
Surface interaction impacts on transport



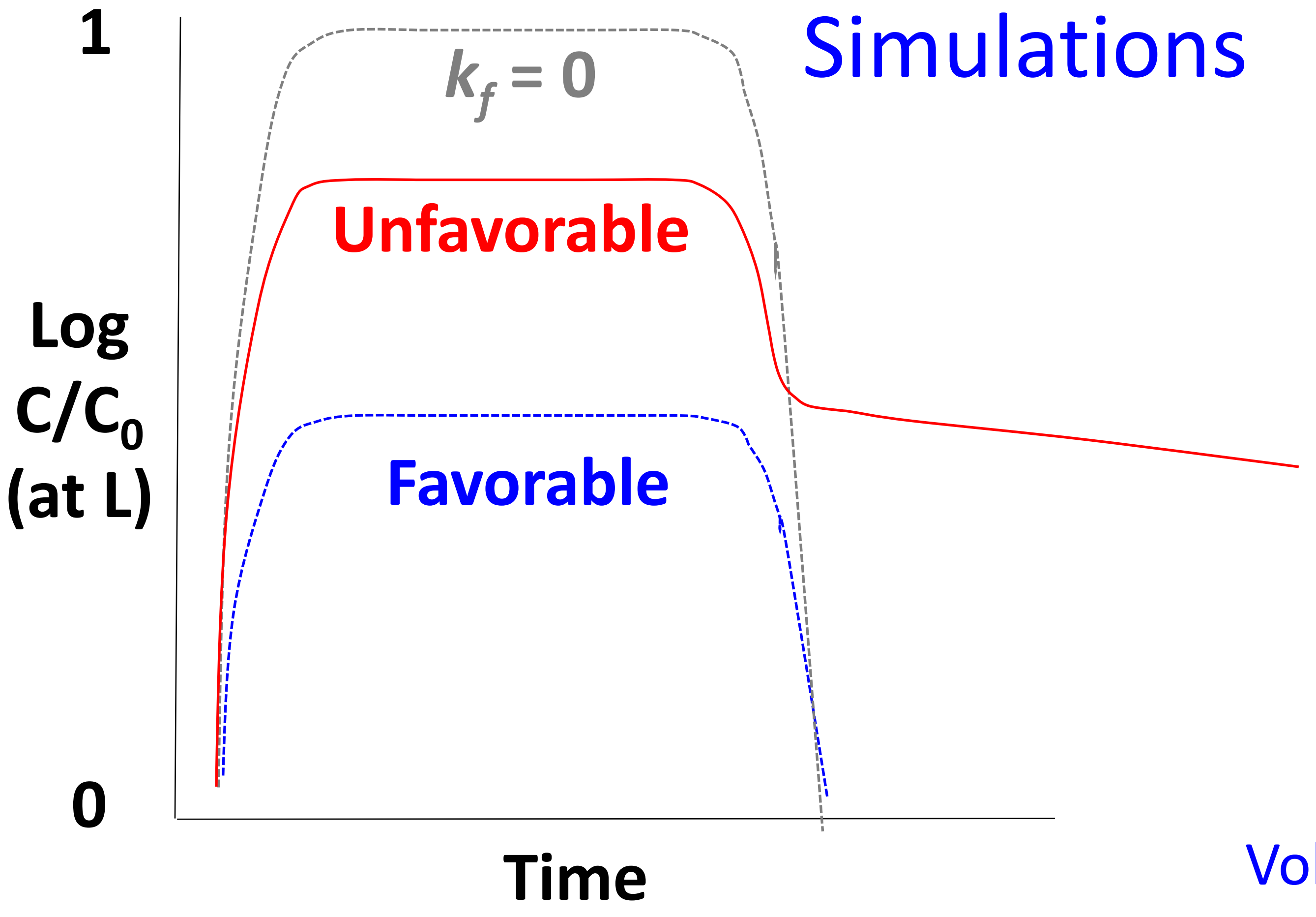
Free book at: The Groundwater Project
Now in Chinese and English, Spanish coming

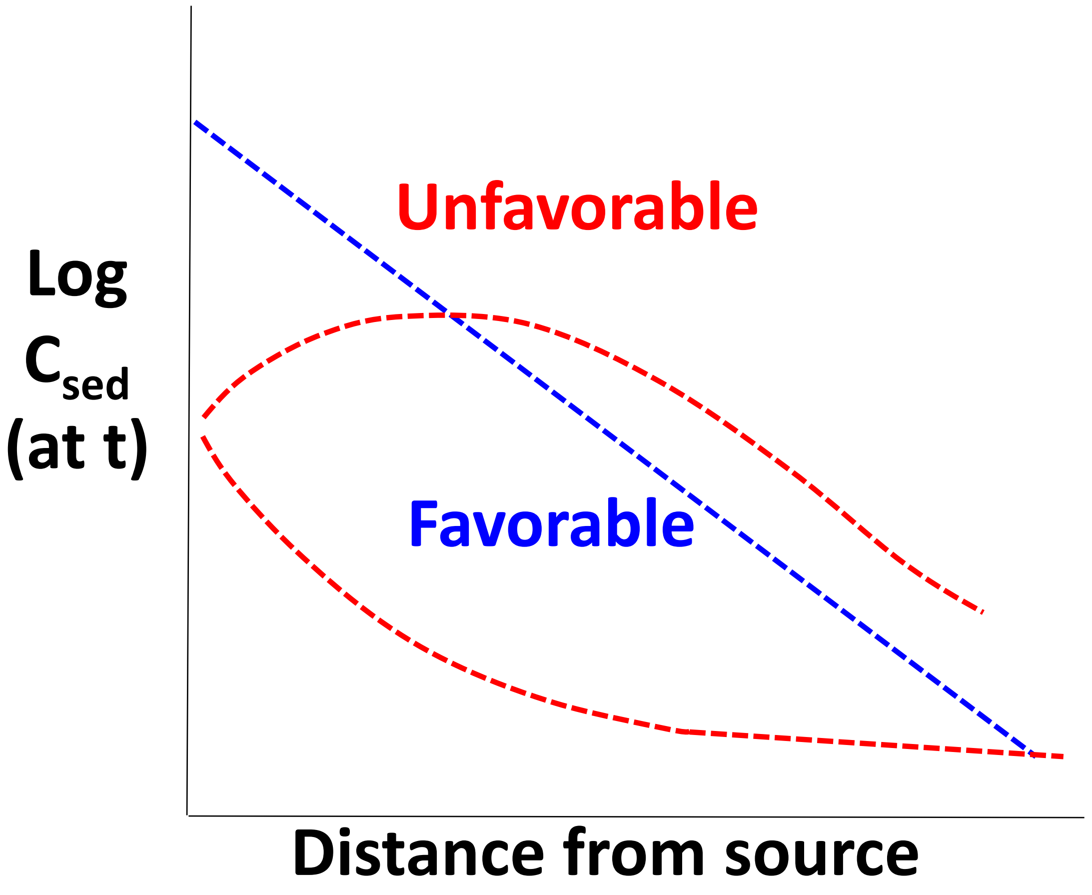


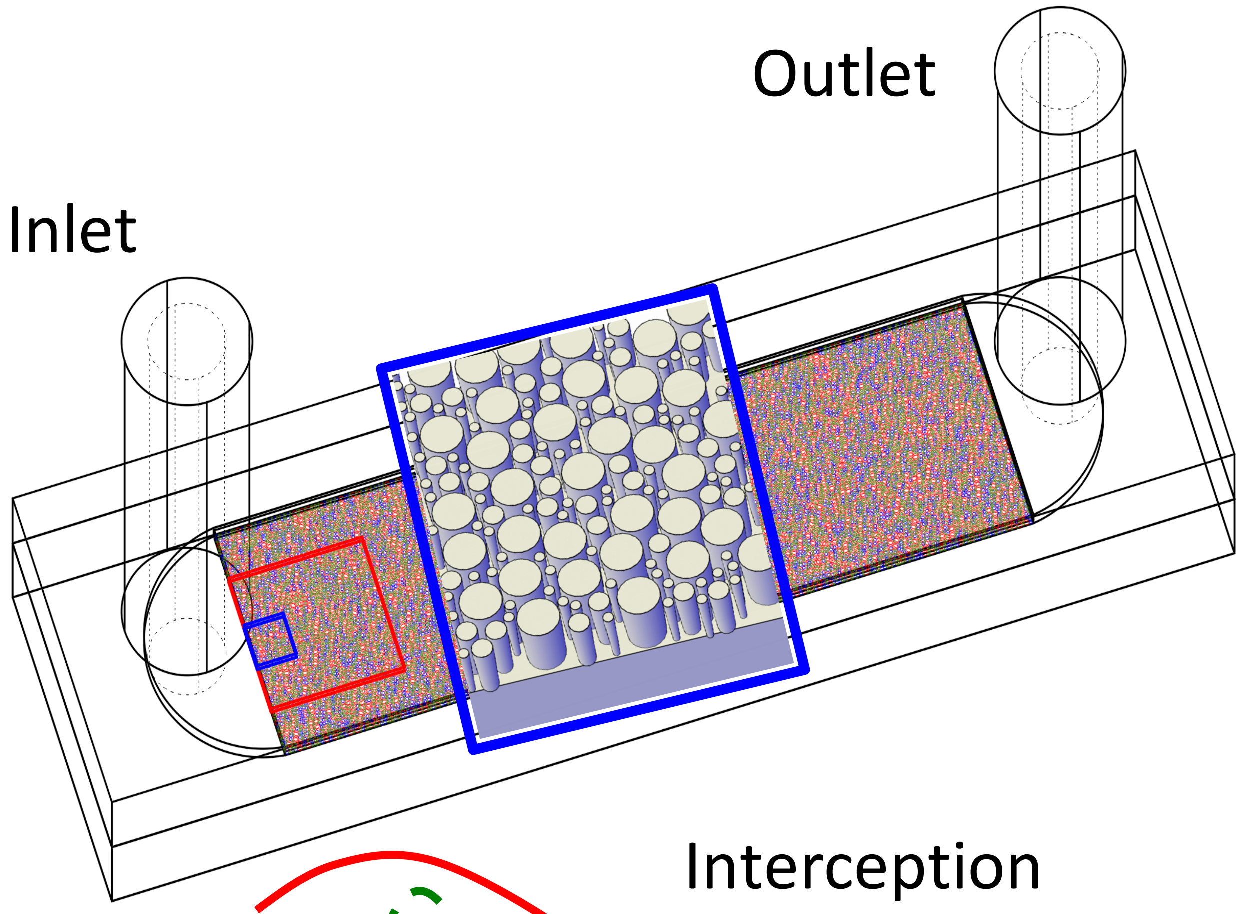
https://gw-project.org/books/colloid-nano-and-micro-particle-transport-and-surface-interaction-in-groundwater/



Experiments and Simulations

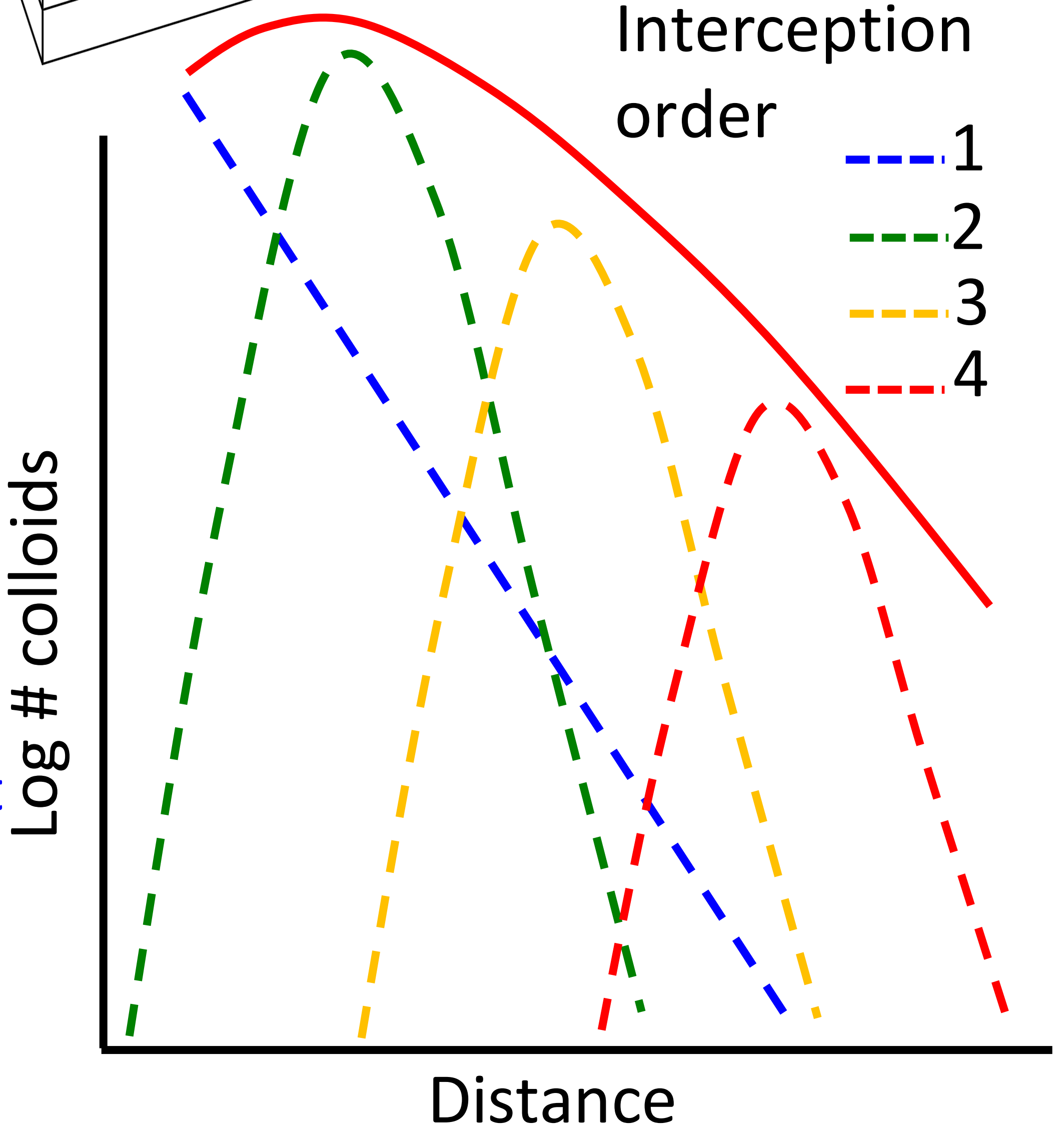




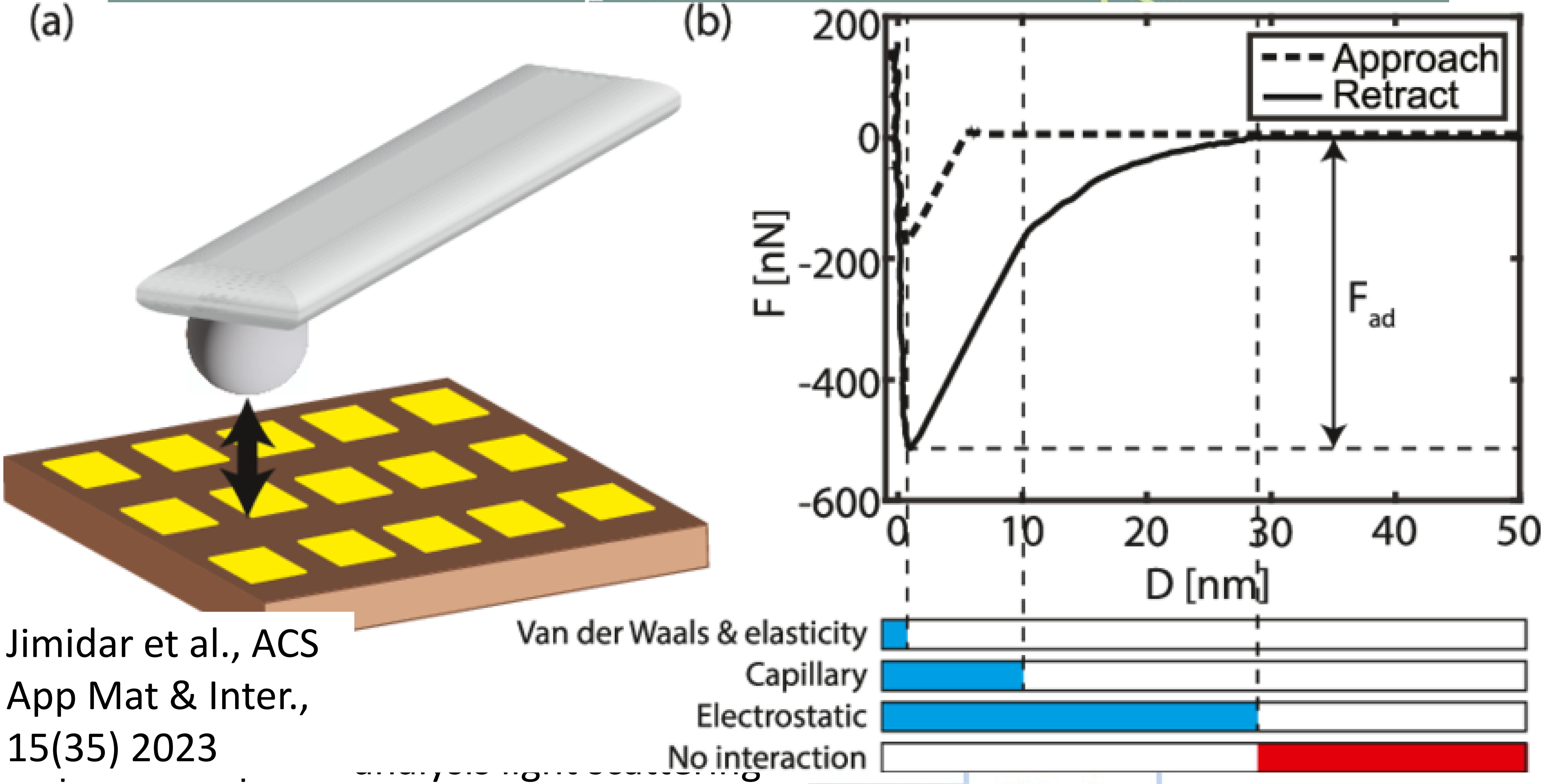


Volponi et al., ES&T, 59(6) 2025

Johnson et al.,2025 ES&T, just accepted



③Sample Addition



Jimidar et al., ACS App Mat & Inter., 15(35) 2023

Waste


Installed more piezometers at 30 and 60 ft
M.S. student Ebenezer Adomako sampling
Mike Thorne's ERT line
Microplastics role in playa soil cohesion and moisture retention

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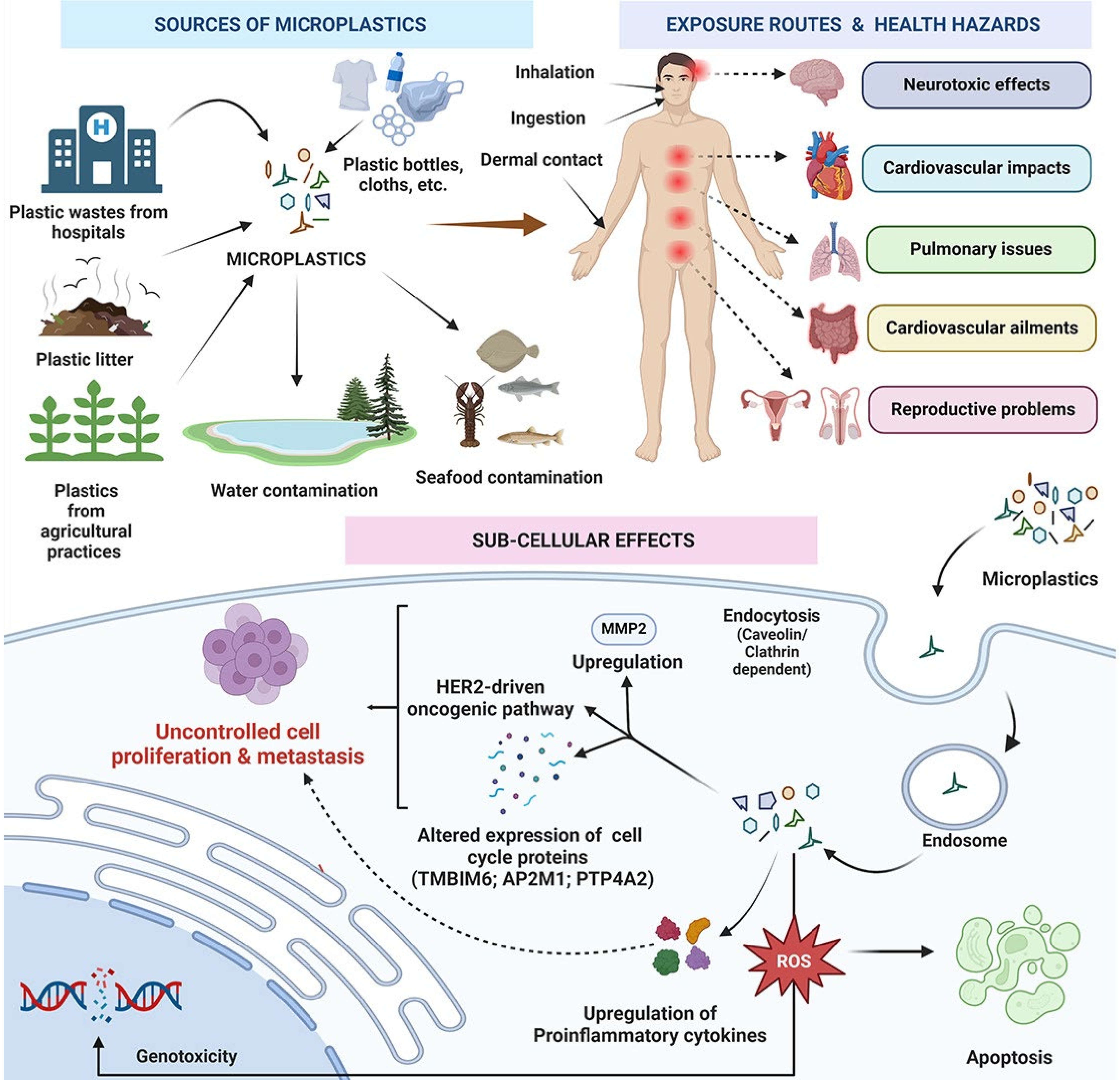
Microplastics and cancer survival

Judy Ou, PhD MPH

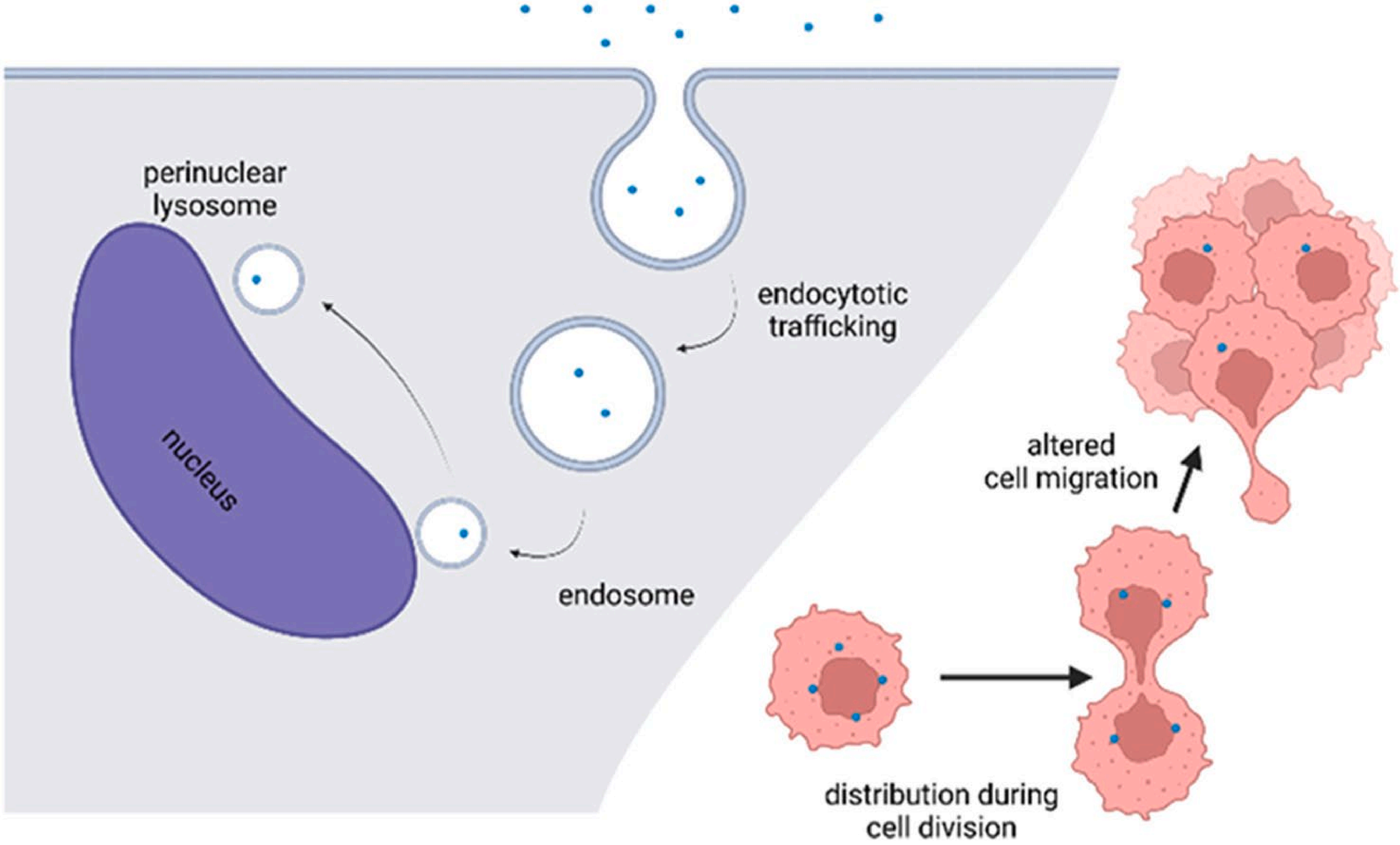
Assistant Professor, Division of Pediatric Hematology/Oncology, Department of Pediatrics

Principal Investigator, Huntsman Cancer Institute



Goswai et al. The alarming link between environmental microplastics and health hazards with special emphasis on cancer - ScienceDirect

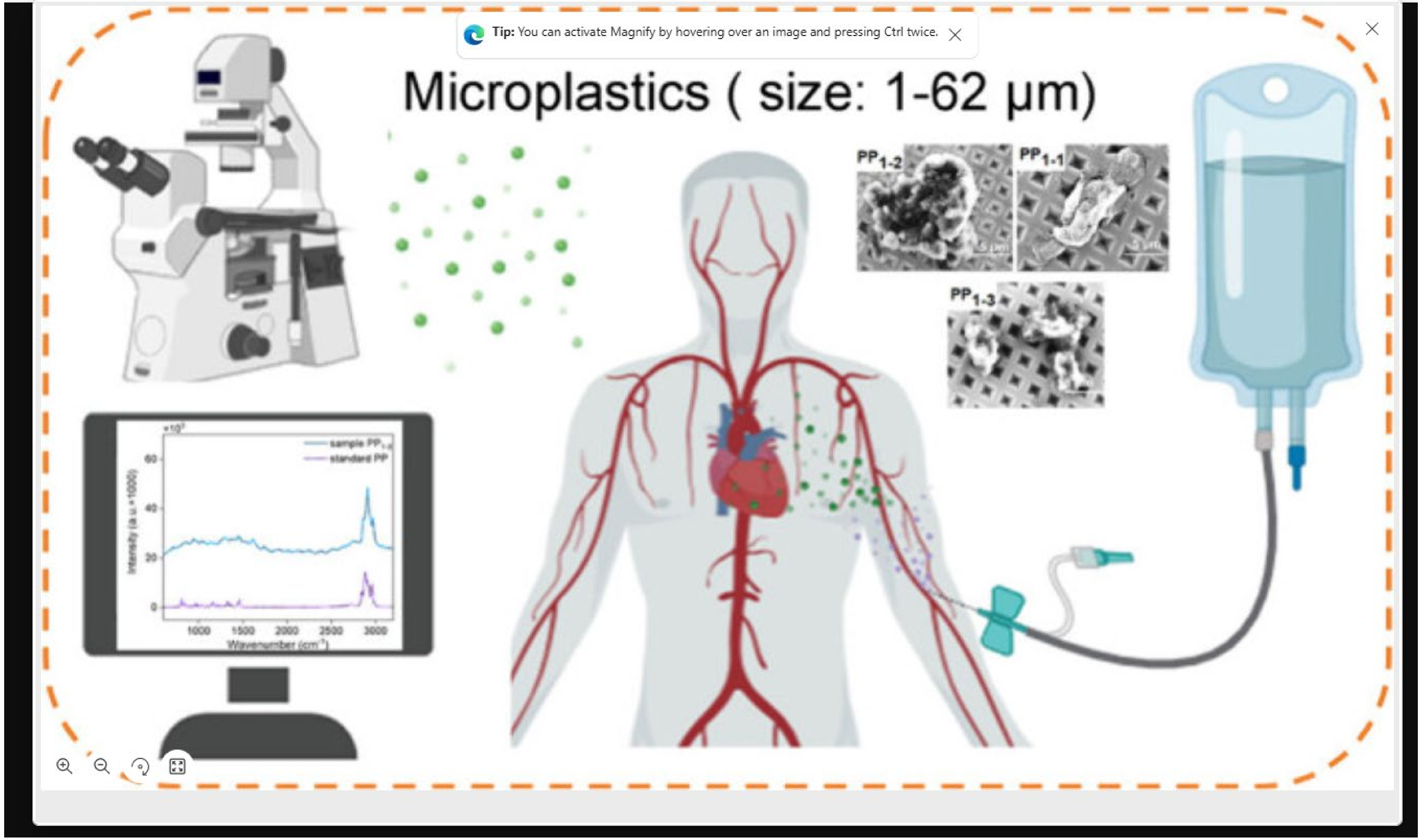
Microplastics encourage metastatic behavior from colorectal cancer cells



Brynzak-Schreiber et al.

[Microplastics role in cell migration and distribution during cancer cell division - ScienceDirect]

Medical IV bags are a source of microplastic exposure



Huang et al. MPs Entering Human Circulation through Infusions: A Significant Pathway and Health Concern | Environment & Health

Seeking collaborators

MY SKILLS AND RESOURCES

10 years in cancer epidemiology

- Observational study design
- Biostatistics

Access to randomized control trial resources

Active partnership with clinicians at Primary Children's Hospital and HCI

Experience with patient recruitment

POTENTIAL COLLABORATORS

Materials science

Detection of microplastics in human tissue, environment, food

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Micro/Nanoplastics and PFAS

Yunshan Wang
Chemical Engineering
University of Utah

Current detection methods for micro/nanoplastic

After collection, filtration, organic matter removal, density separation from environmental samples (water, soil, fish)

a. Microscopy (optional pre-screening)

- **Stereomicroscopy**: For morphology and preliminary counting (≥300 µm).
- **Fluorescence microscopy**: If particles are stained with Nile Red (selective binding to hydrophobic plastic).

b. Spectroscopy

- **Micro-FTIR (µ-FTIR)**:
- Most common for particles >10 µm.
- Can be combined with focal plane array (FPA) imaging for automation.
- **Micro-Raman Spectroscopy**:
- High spatial resolution (~1 µm), better for smaller particles.
- Fluorescence background can be a limitation, especially in environmental samples.
- **Nile Red staining + Fluorescence Microscopy + FTIR/Raman confirmation**:
- Rapid screening + polymer ID combo.

Current detection methods for micro/nanoplastic

c. Thermal Analysis

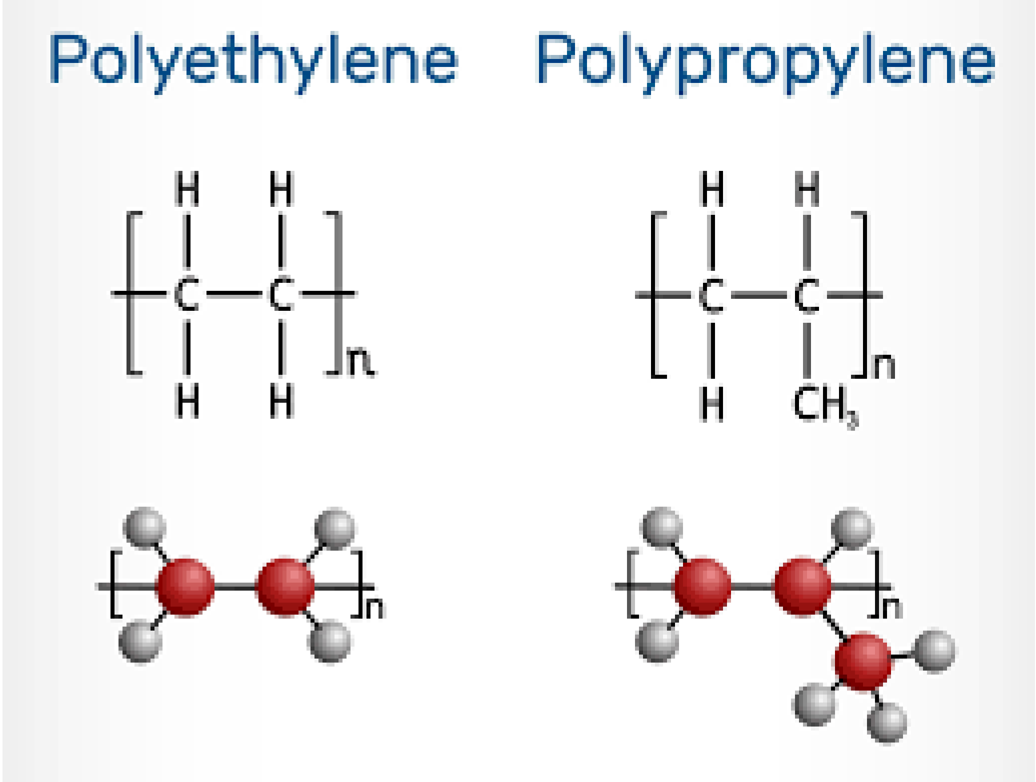
Pyrolysis-GC/MS:

- Destructive but accurate quantification and polymer identification.
- Useful when particle morphology is not needed.

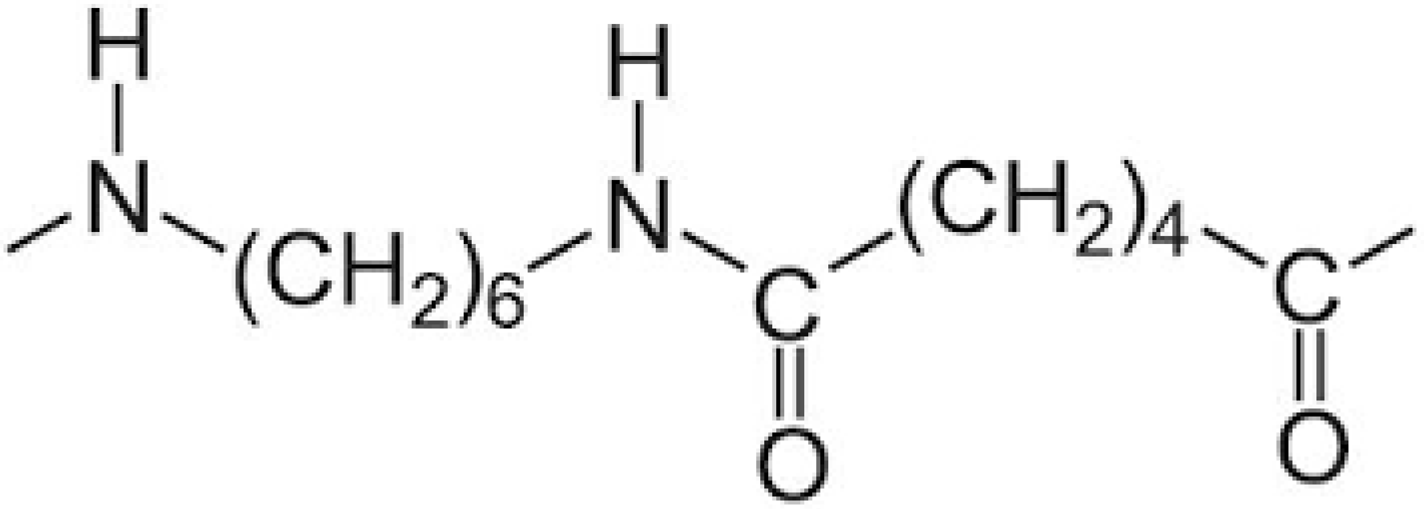
TED-GC/MS (Thermal Extraction Desorption)

- Less sample prep, allows semi-quantitative detection of polymer types

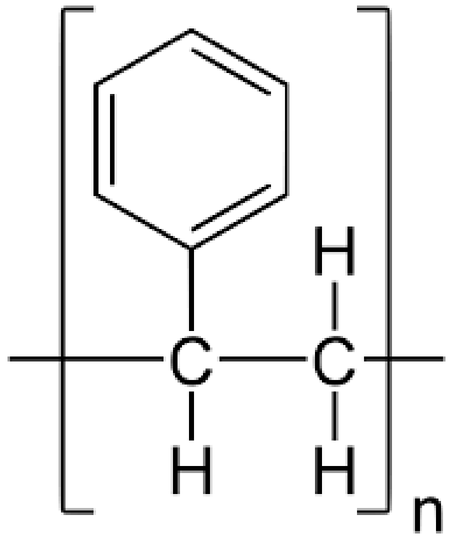
Type of micro/nanoplastics



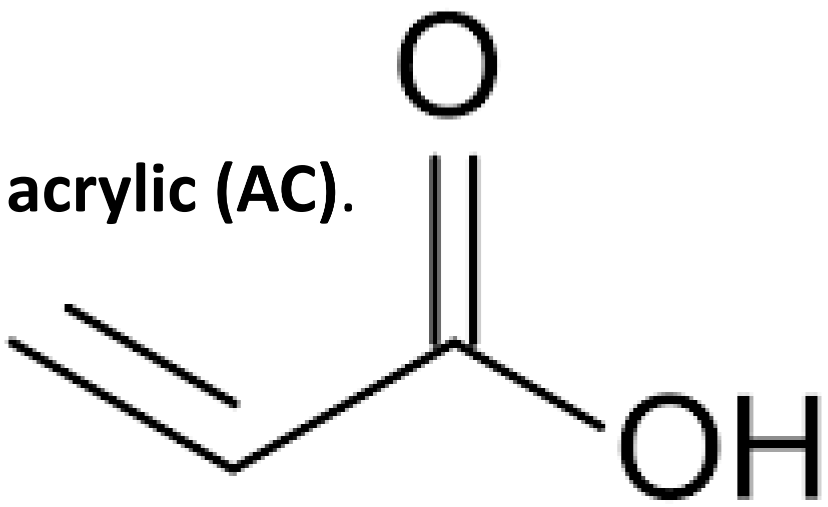
polyamide (PA, e.g., nylon)



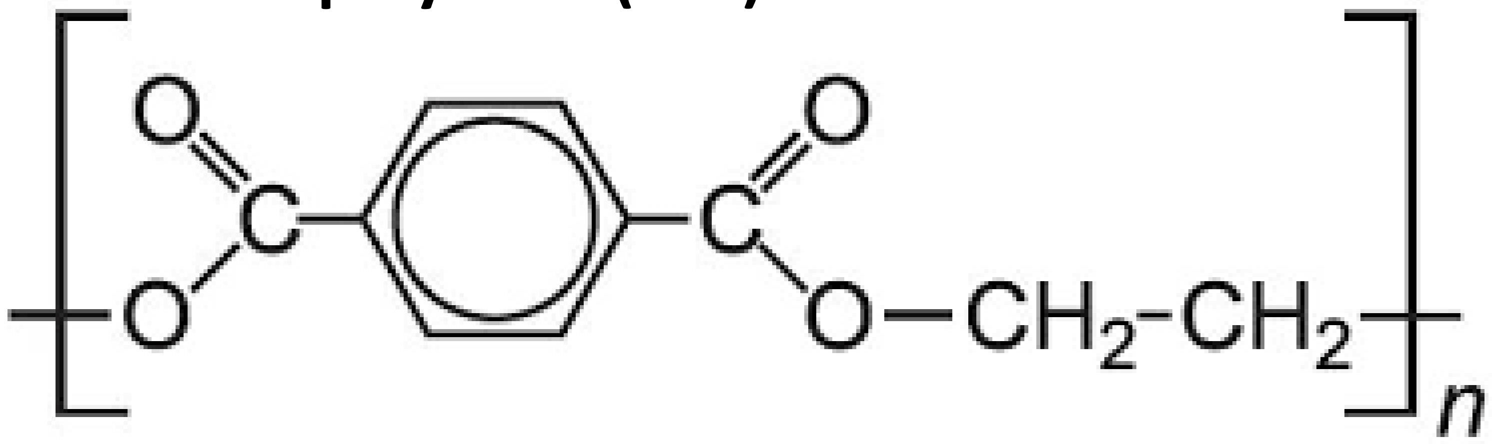
polystyrene (PS)



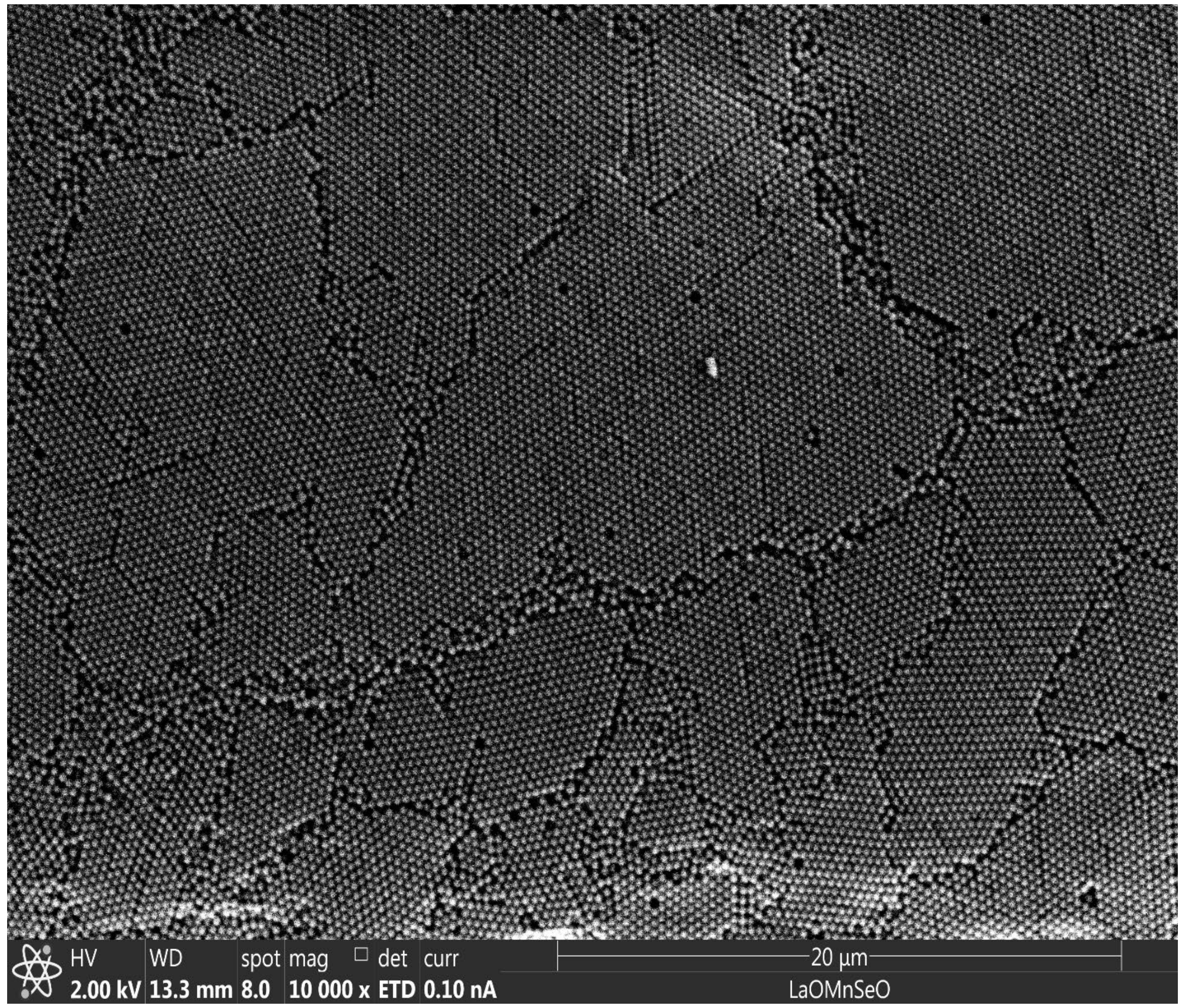
acrylic (AC).



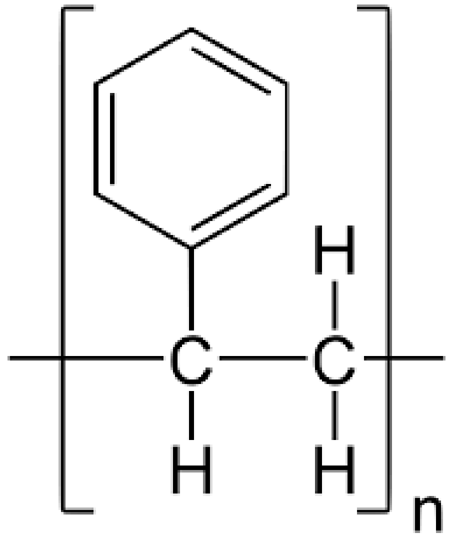
polyester (PES)

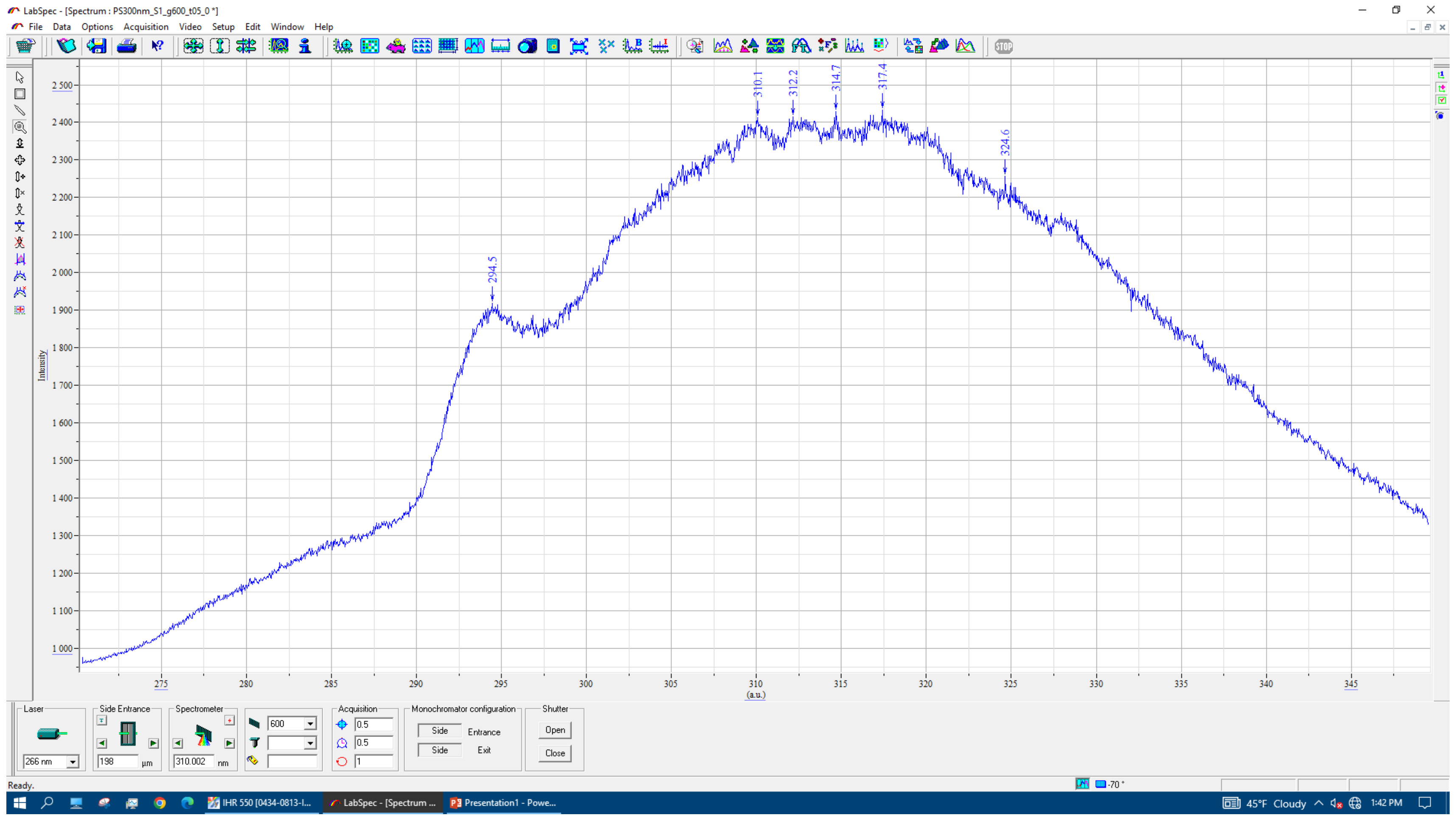


Nondestructive spectroscopy for size and chemical information



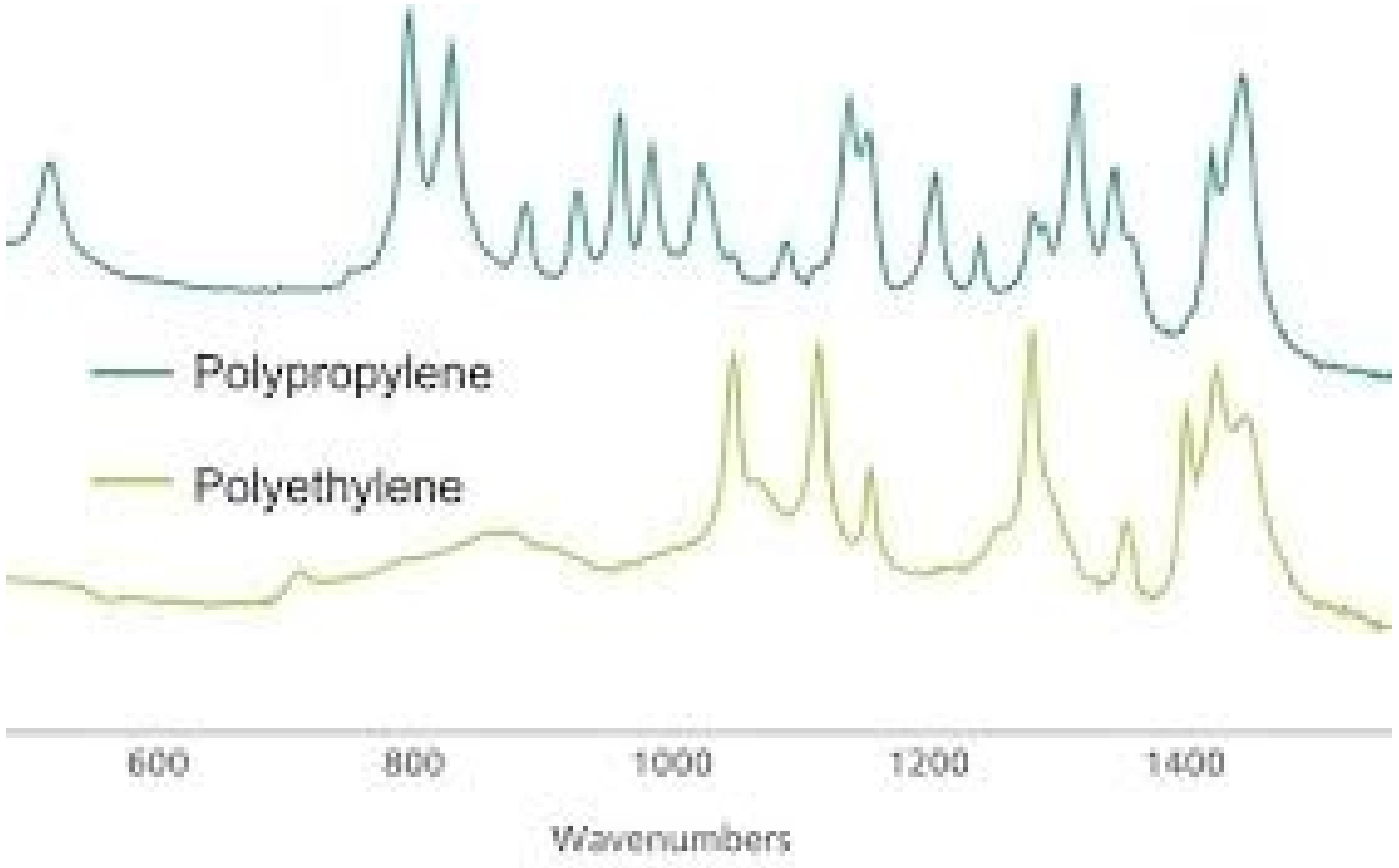
polystyrene (PS)



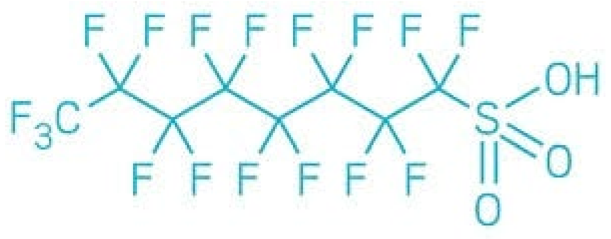


UVRRS-UV resonance Raman for low FL background identification of plastics

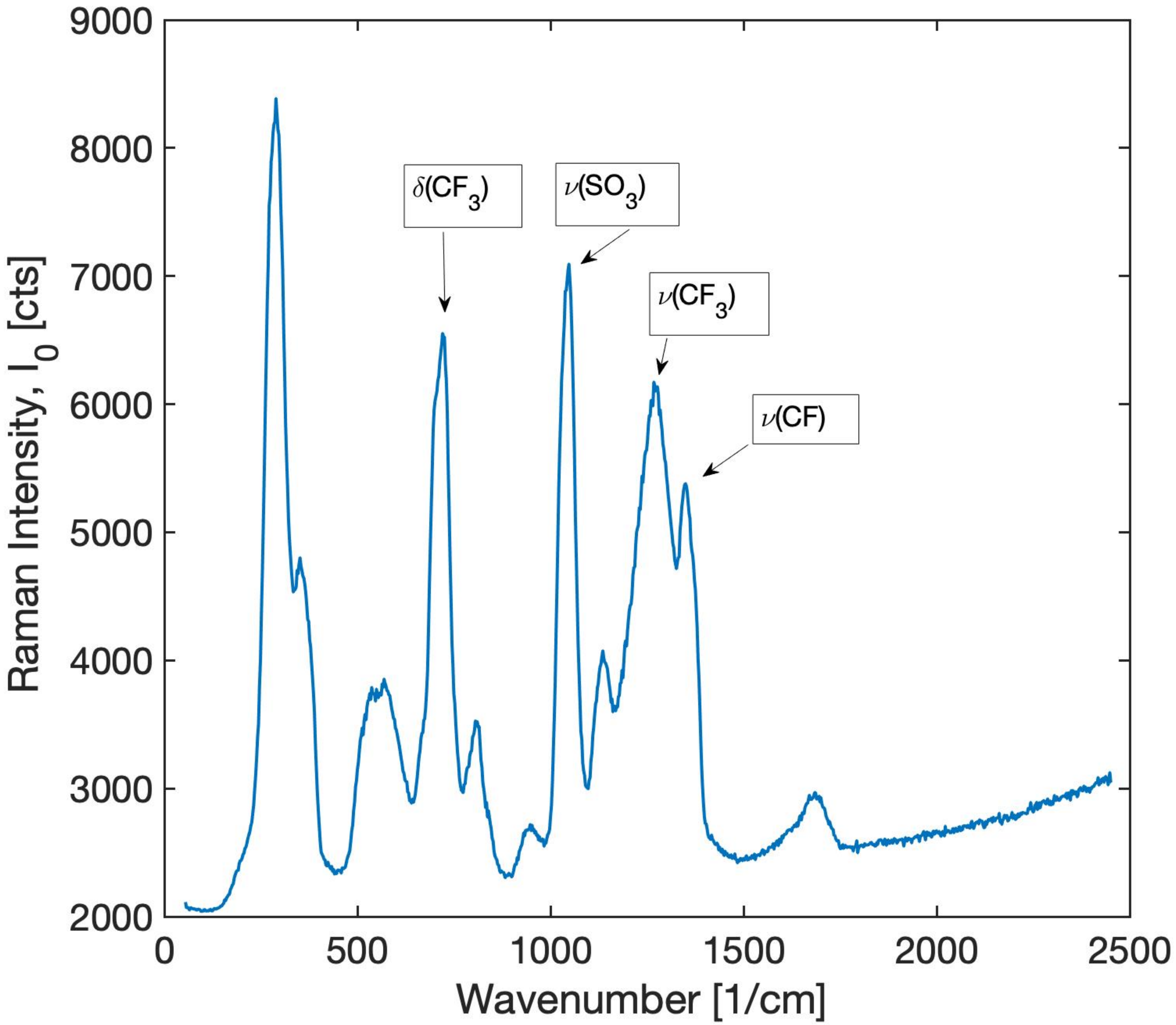
- https://www.azom.com/article.aspx?ArticleID=23846



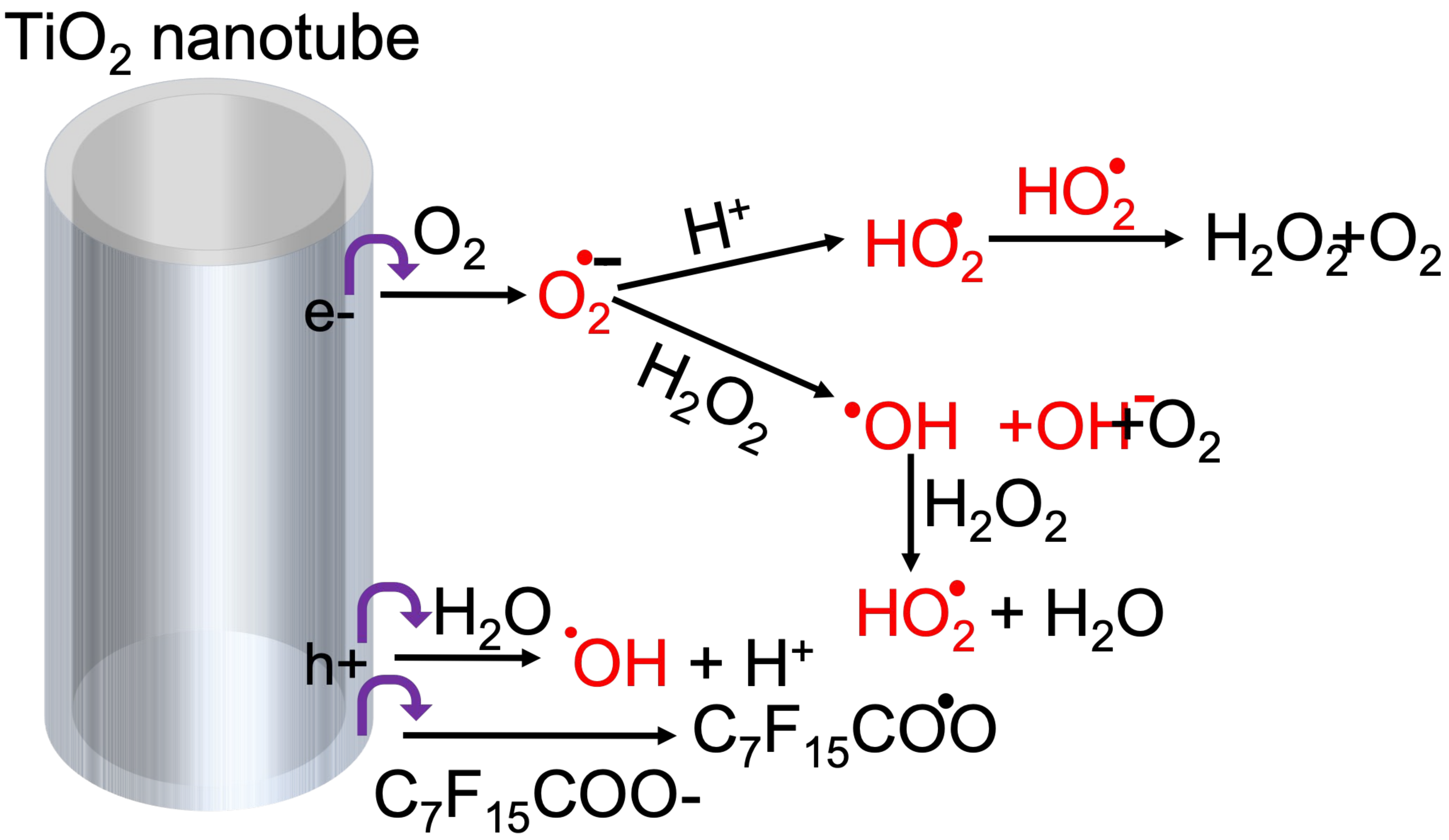
PFAS detection



PFOS



PFAS degradation using photocatalyst



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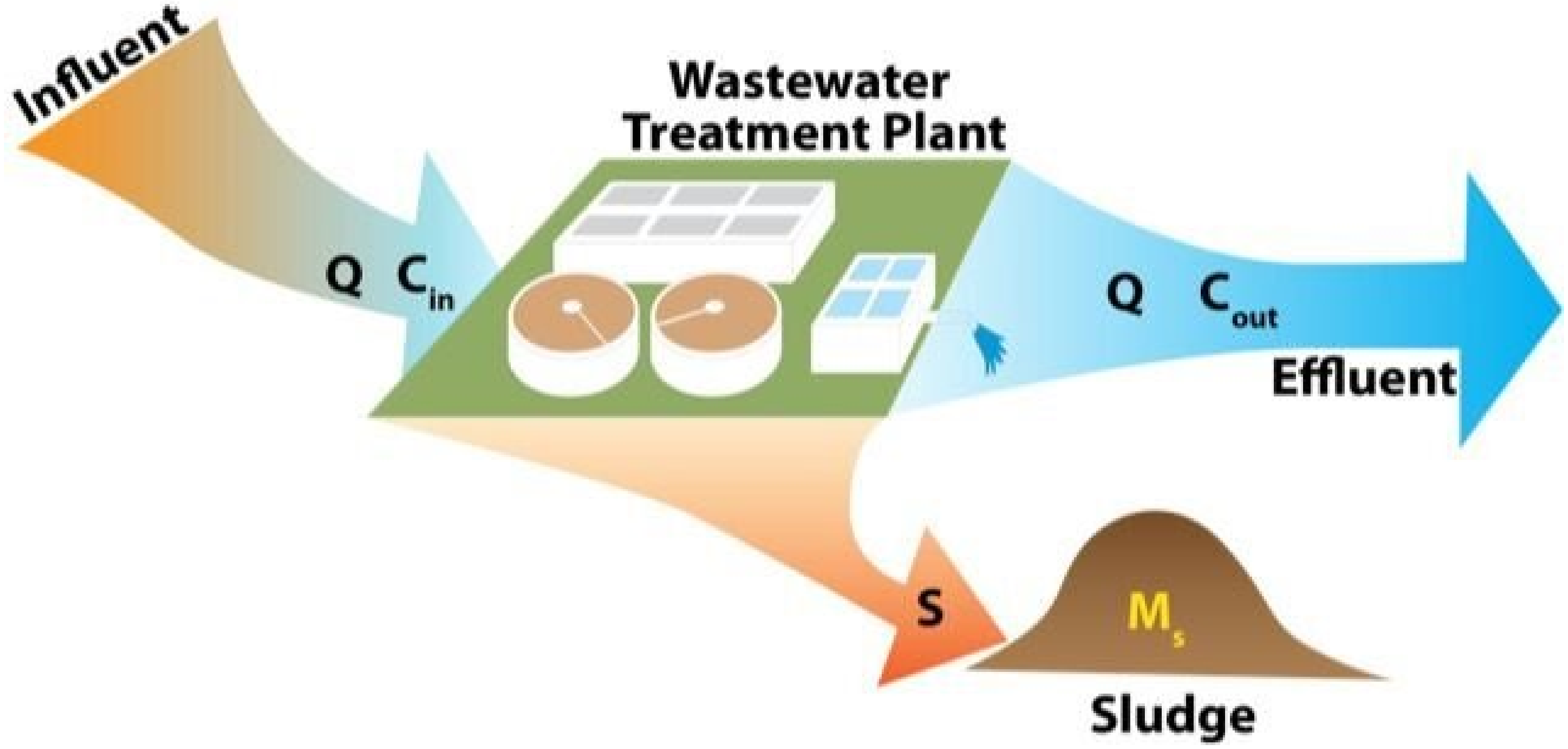
Quantification & Characterization of Microplastics in Biosolids & Soils Along the Wasatch Front

Jennifer Weidhaas, PhD, PE

Aspen Dalby, UROP scholar

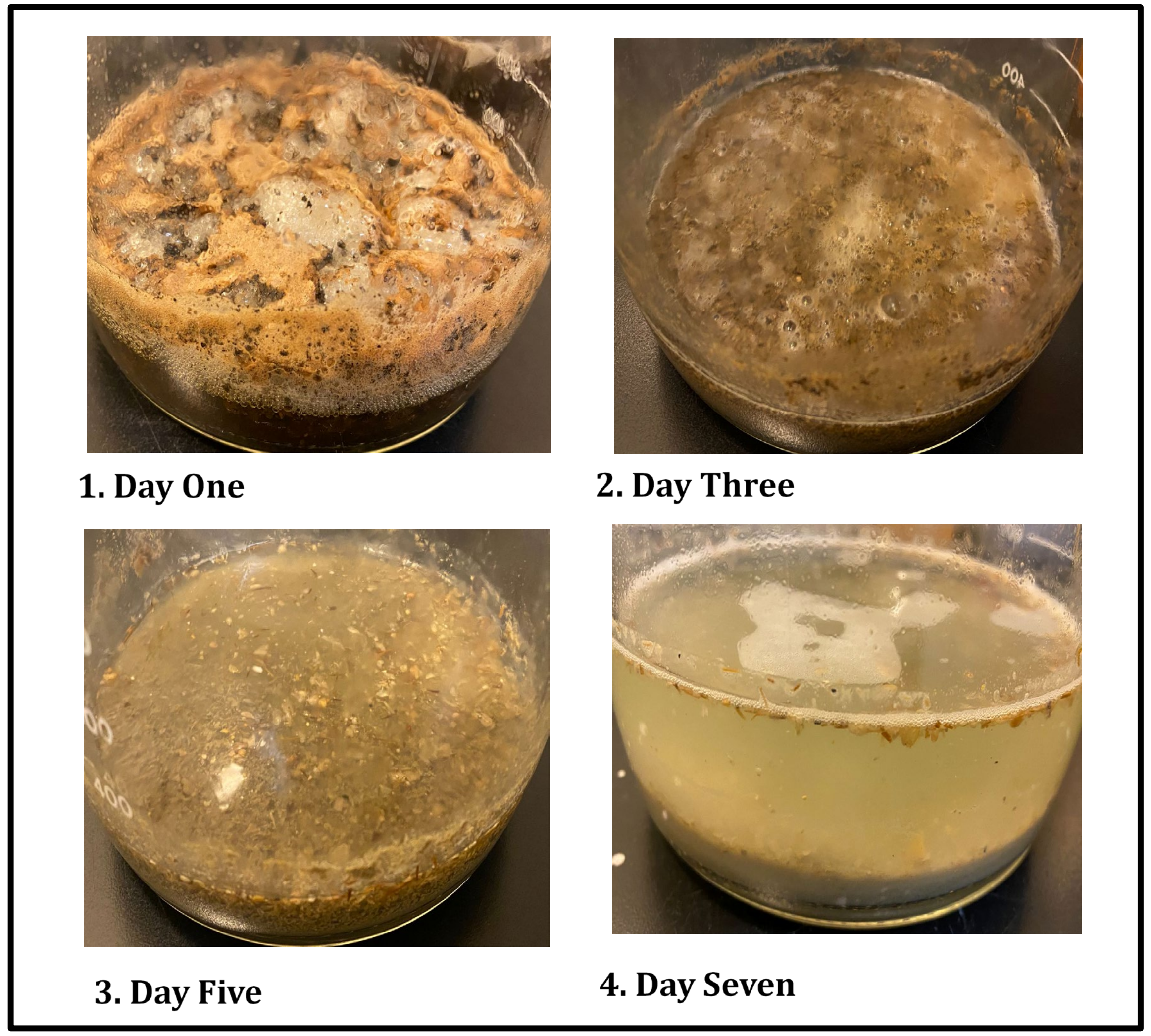
May 21, 2025

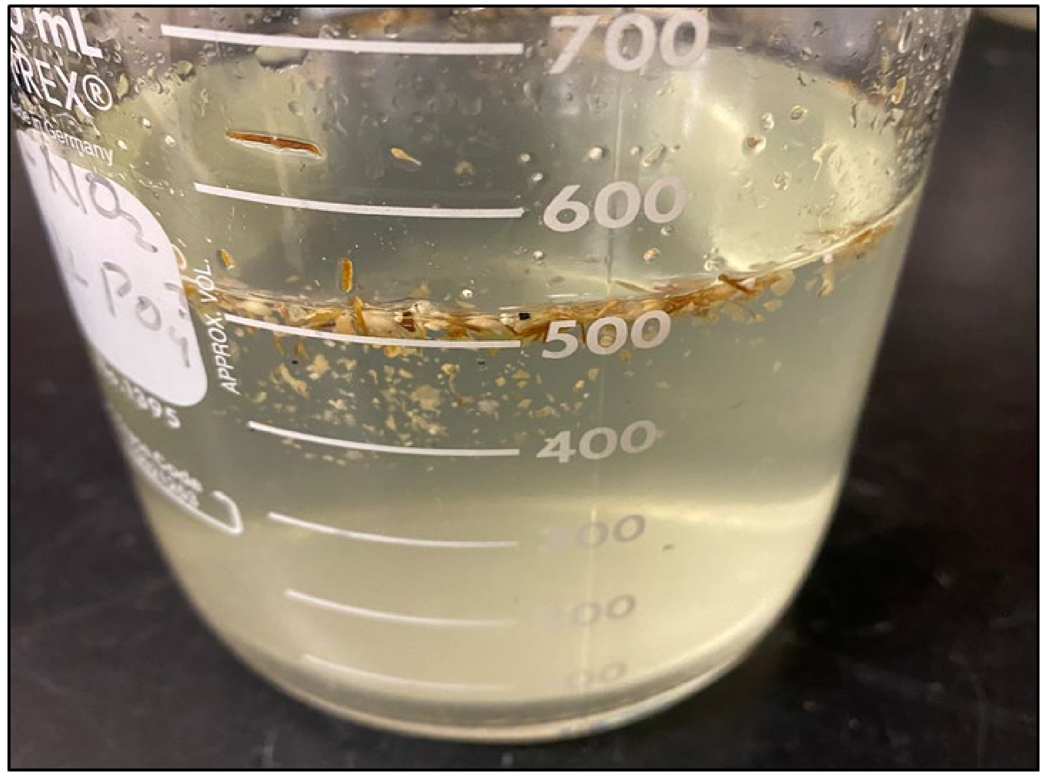


X to y tons per acre per year

Characterization methods

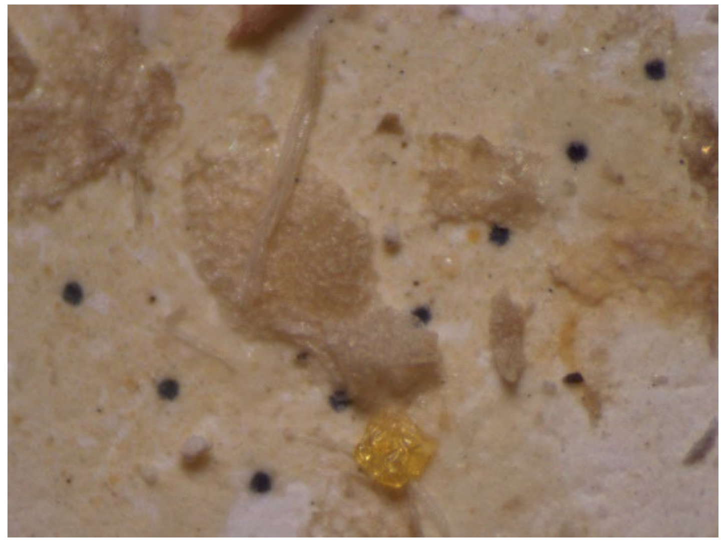
- 30 g of biosolids or soil
- Fenton's reagent (iron II sulfate + hydrogen peroxide)
- Supernatant split
  - Filtered through 0.45 um filter
  - Density separation in salt solution then filtration
- Settled solids
  - density separated in salt solution then filtered
- Microscope observations, FTIR

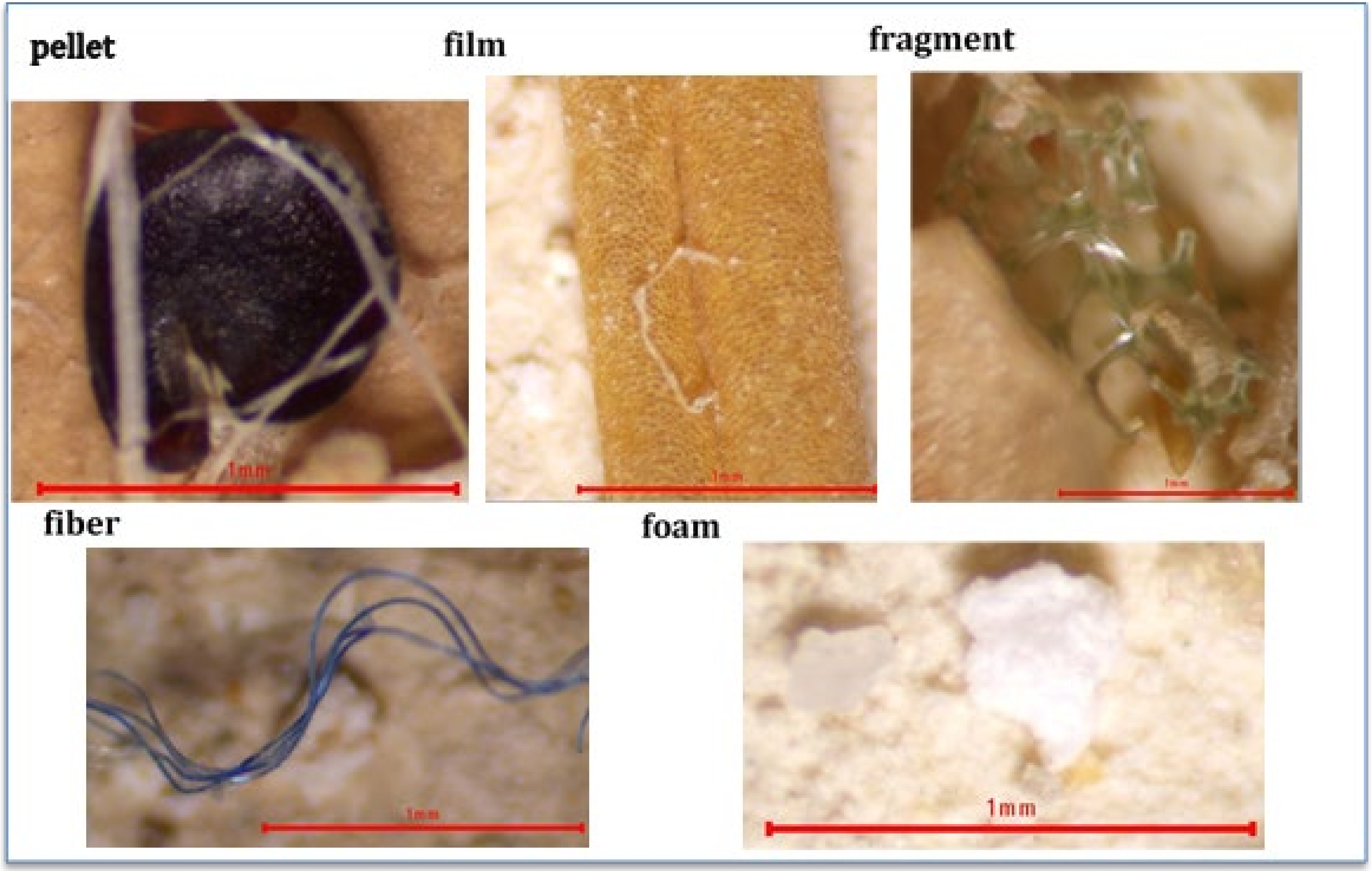


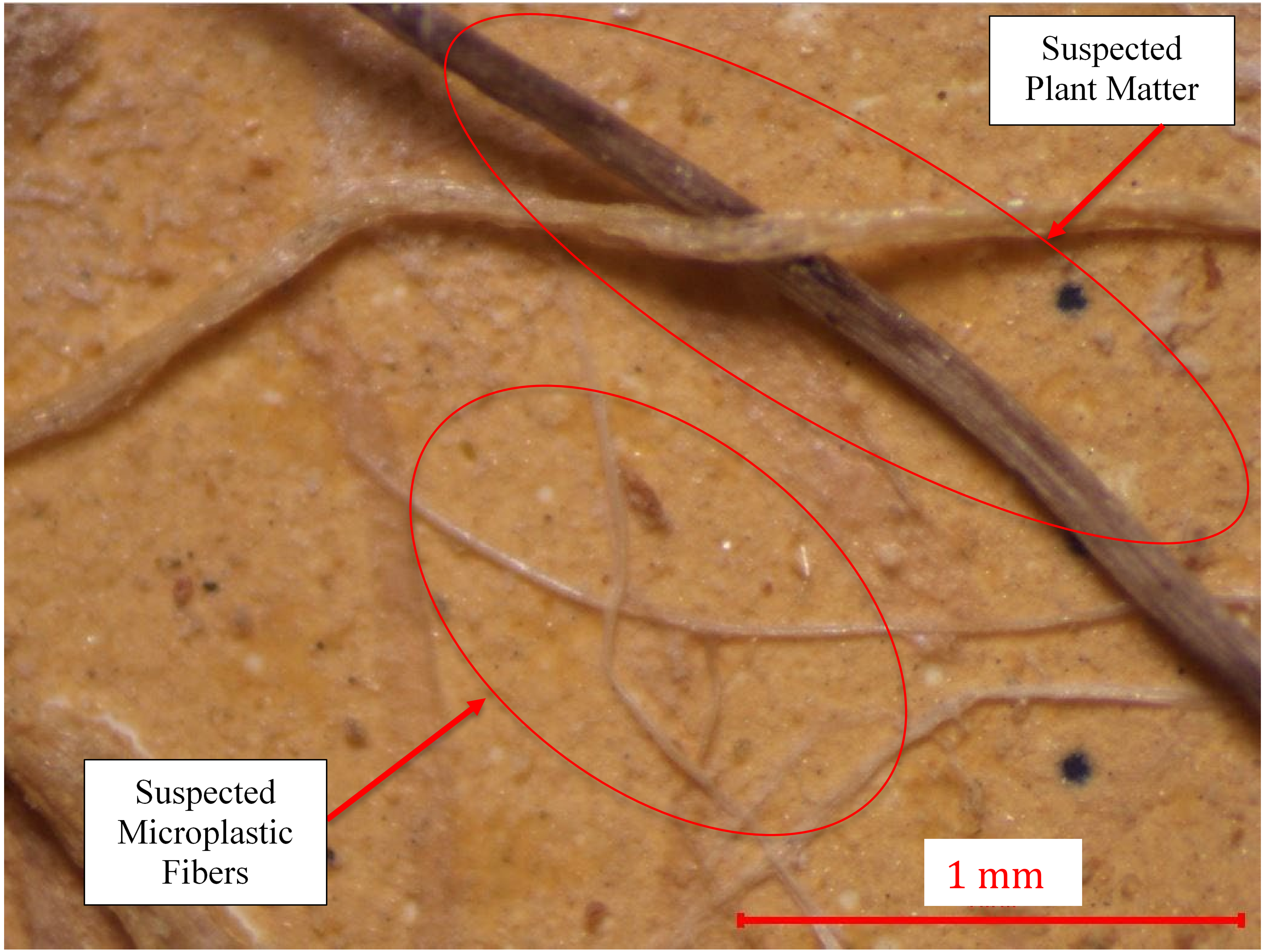


THE UNIVERSITY OF UTAH

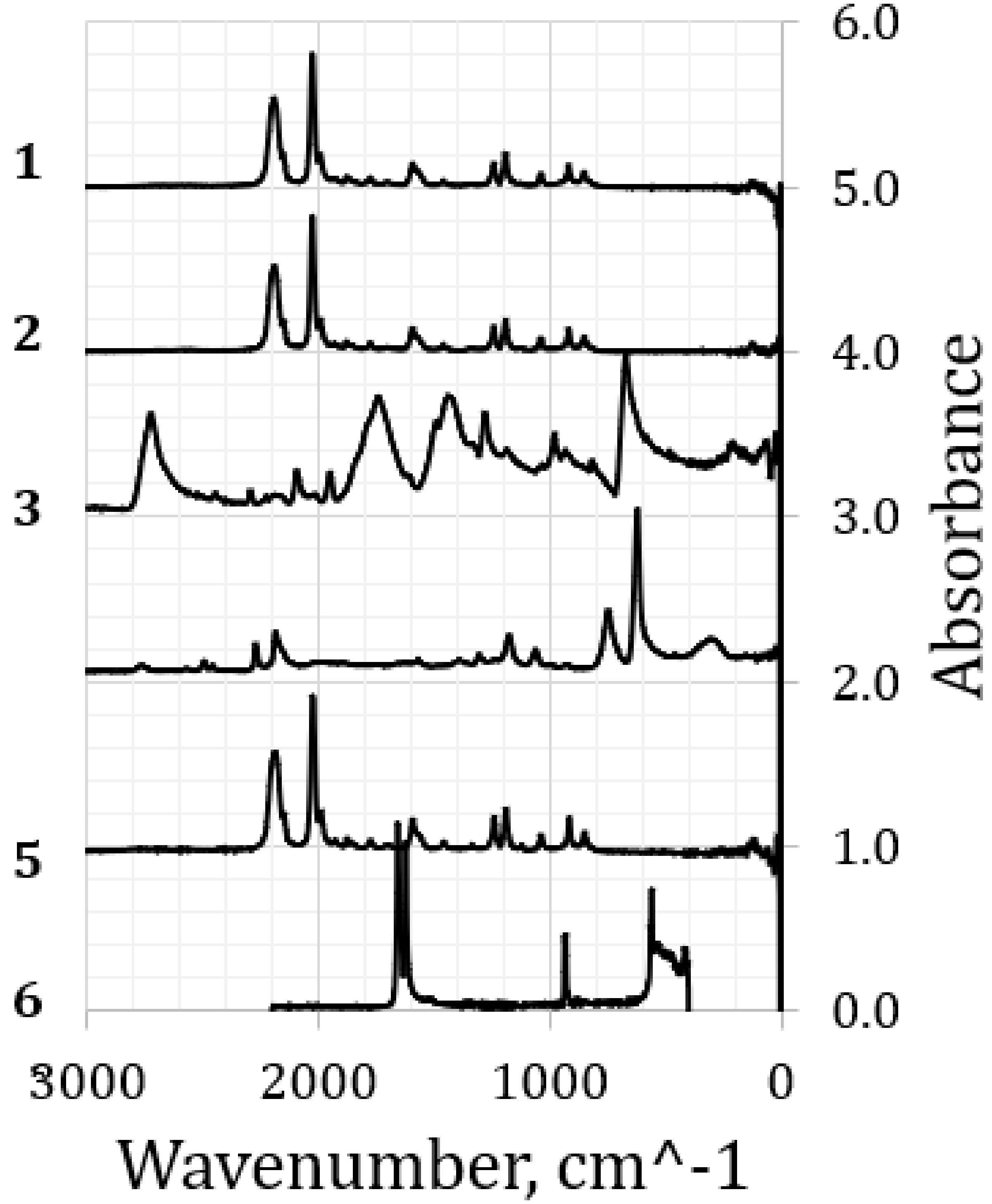
Sample type	Microplastic counts
Biosolids 1	43 per g biosolids
Biosolids 2	32 per g of biosolids
Composite soil where biosolids applied	20 per gram of soil
Composite soil where biosolids applied	28 per gram of soil
Control soil	8 per gram of soil




pellet
film
fragment
fiber
foam
1mm
1mm
1mm
1mm
1mm


Suspected
Plant Matter
Suspected
Microplastic
Fibers
1 mm

Reference Plastic FTIR Scans



1 32 Mesh Polypropylene

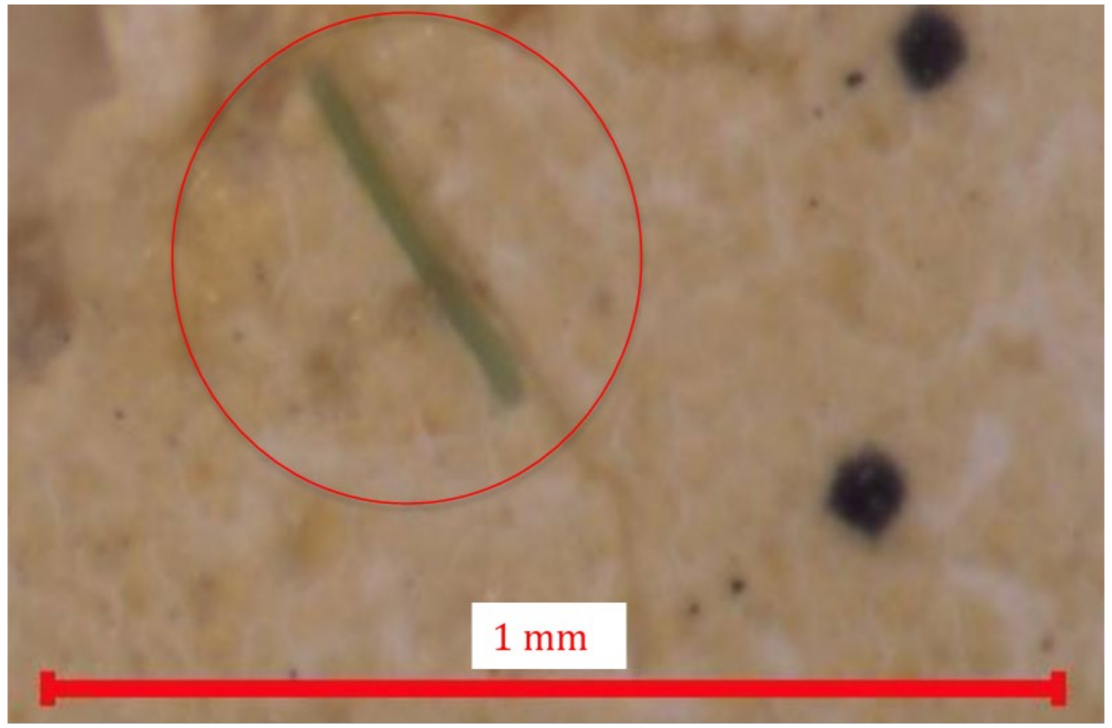
2 32 Mesh Polyethylene

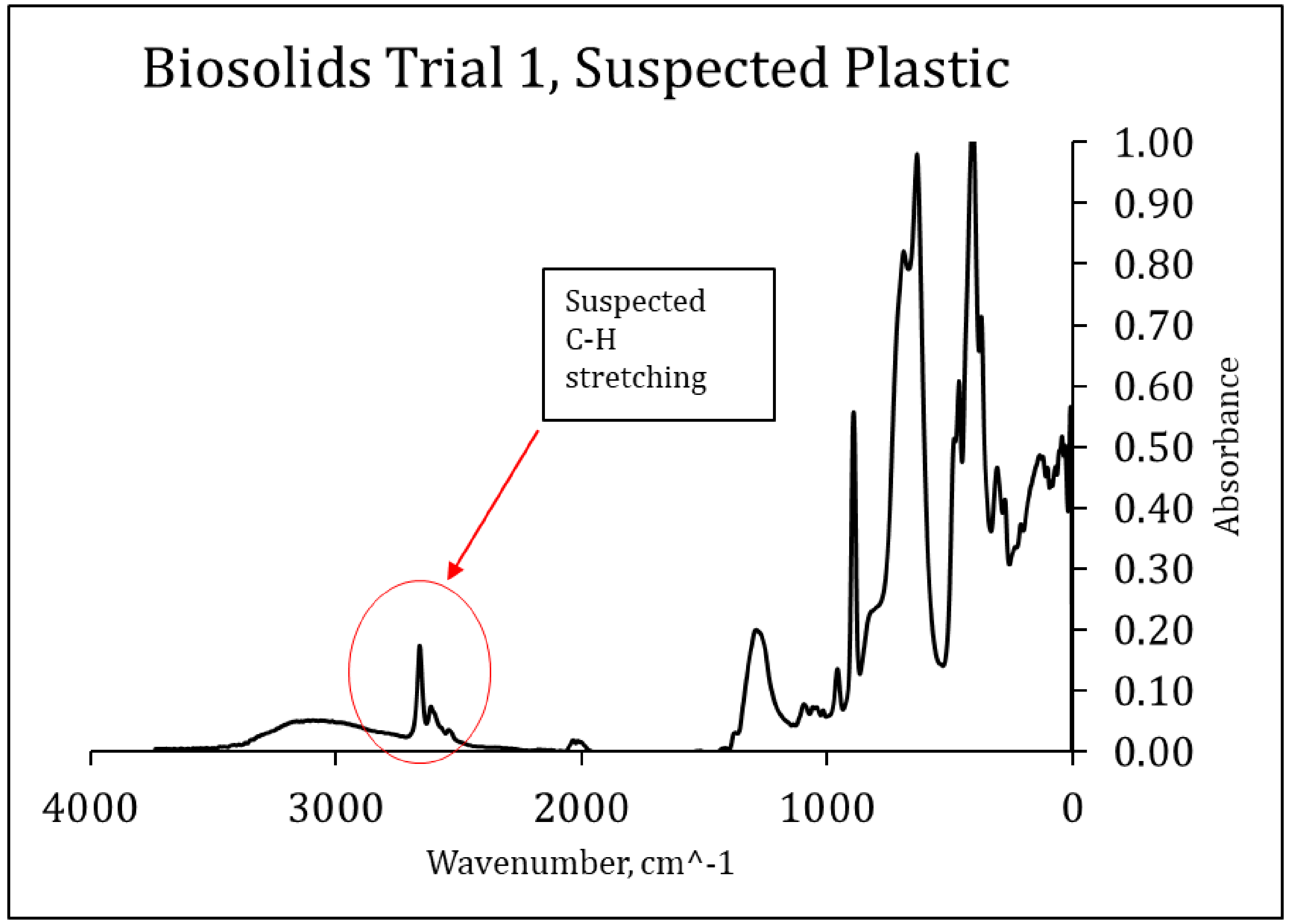
3 Polyethylene terephthalate (PET) from a recycling center

4 Polypropylene from a recycling center

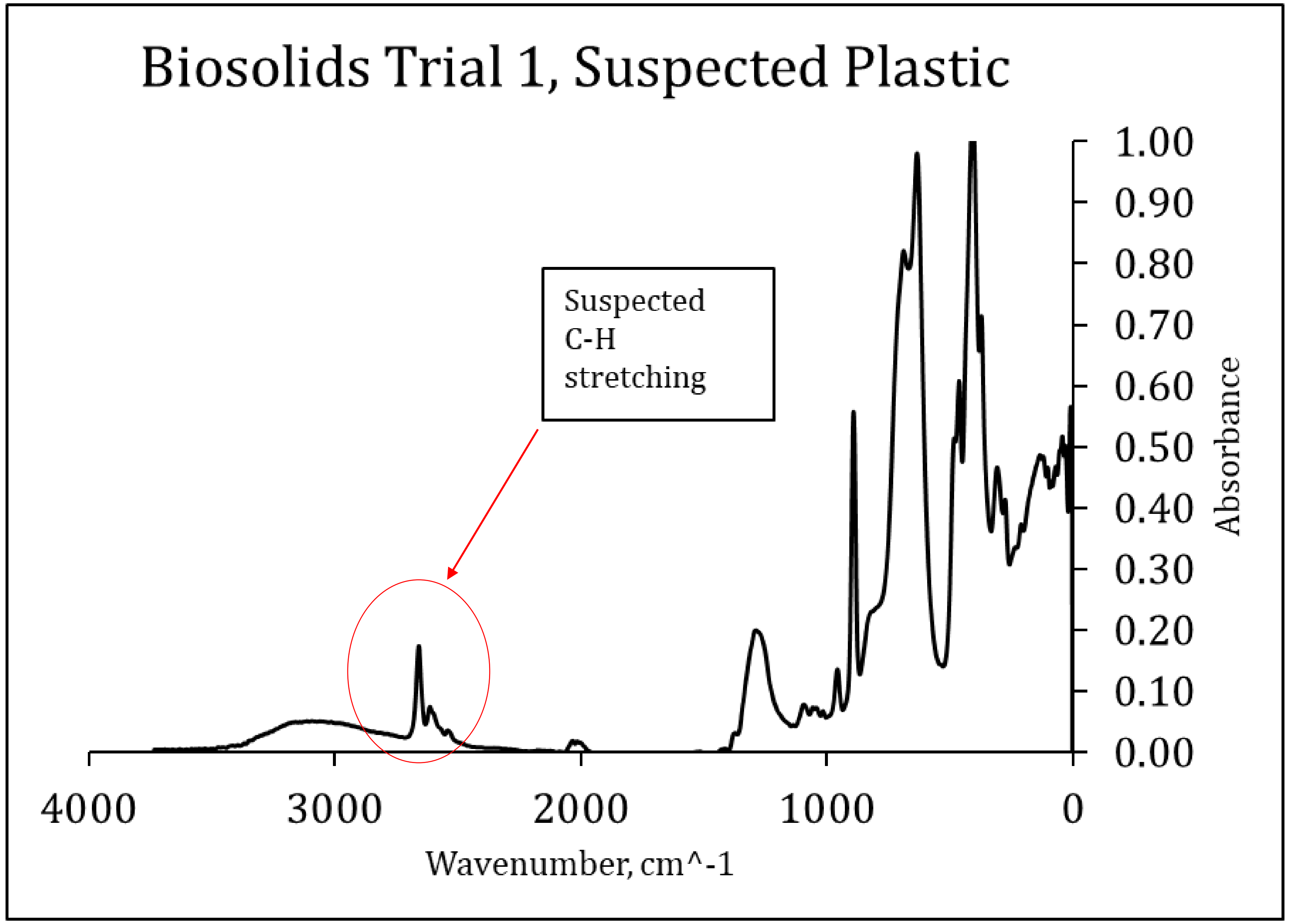
5 Acrylonitrile Butadiene Styrene (ABS) from a recycling center

6 High Density Polyethylene (HDPE) from a recycling center






1 mm


Biosolids Trial 1, Suspected Plastic
Suspected
C-H
stretching
4000
3000
2000
1000
0
Wavenumber, cm^-1
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
Absorbance

Questions?

jennifer.weidhaas@utah.edu

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PFAS and State of UT Rules

Rebecca Yoo, P.E.

UTAH DEPARTMENT of ENVIRONMENTAL QUALITY
DRINKING WATER

What does it mean for you?

- Provide input to rule change
- Utilities: meet rule requirements
- Engineers: support utilities to meet rule affordably
- Manufacturers: provide treatment systems
- Public health researchers

EPA Drinking Water PFAS Rule

- PFAS initial monitoring: due April 26, 2027
- Latest announcements by EPA
  - PFOA & PFOS – 4.0 ppt MCL
  - Rescind MCLs on PFHxS, PFNA, HFPO-DA, PFBS, and Hazard Index
  - MCL compliance deadline is 2031

Treatment Rule

- Governs design of BATs (GAC, IX, and RO systems)
- Considerations
  - Influent water quality
  - Pilot study
  - Manufacturer recommendations
  - Loading rate, EBCT, and redundancy

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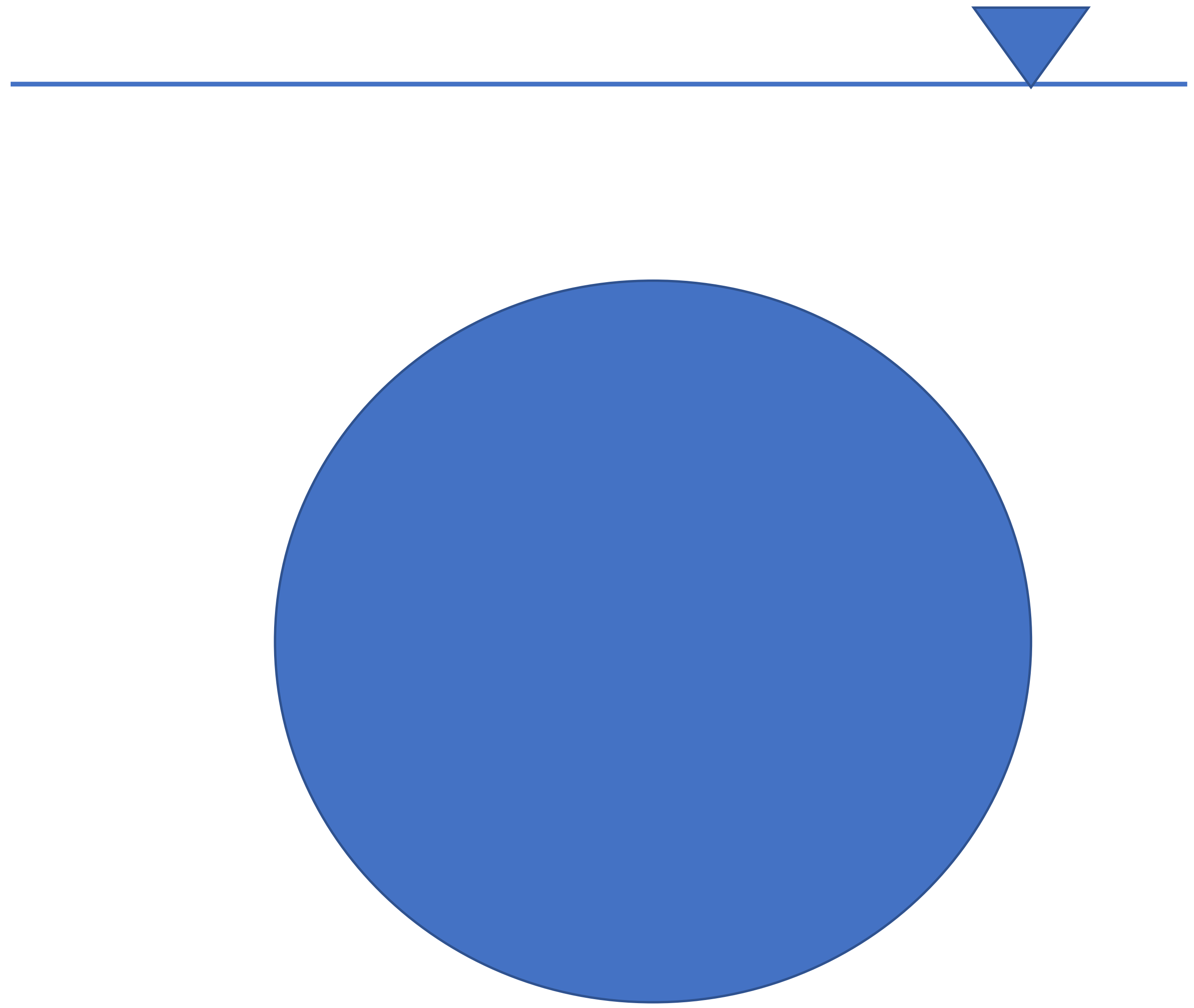
Ozone Nanobubbles Technology

Andy Hong, Professor
Civil & Environmental Engineering
hong@civil.Utah.edu
May 21, 2025

Nanobubbles



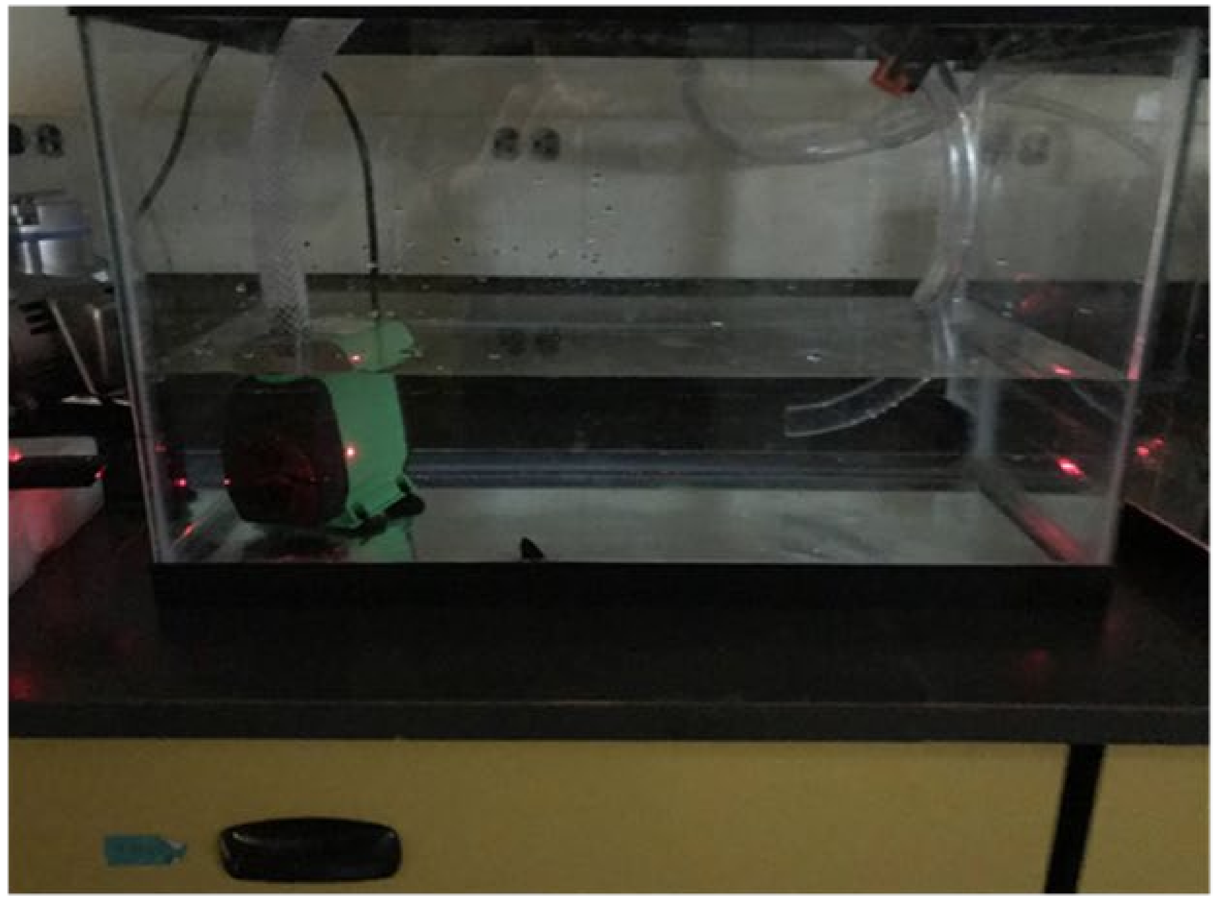
- < 65 µm, rise very slowly, allowing it to shrink to nano sizes
- Very high pressure
  - P = 4 σ/d

    P = 2.9 atm at 1 µm

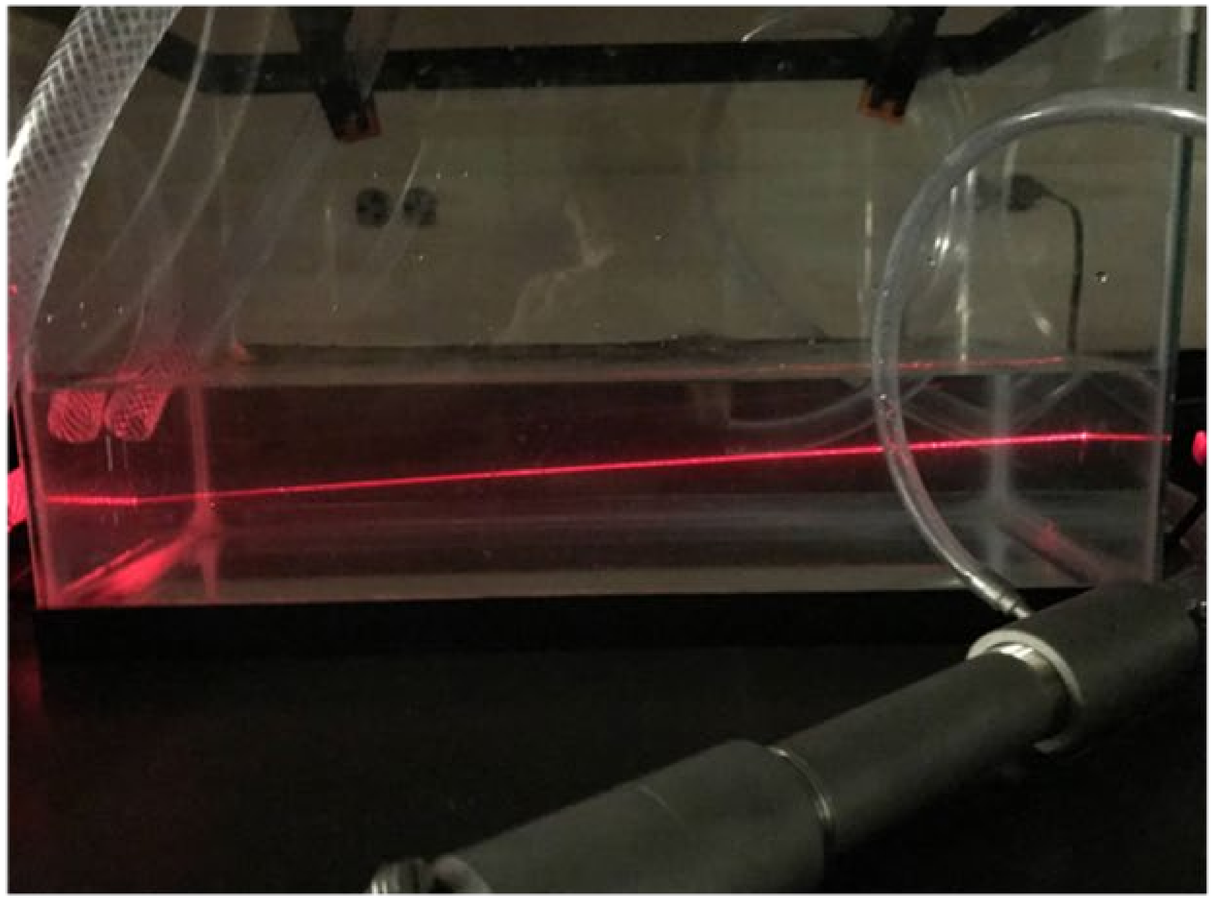
    P = 2,900 atm at 1 nm

    P ~ 60 atm at 50 nm

Light scattering before and after aeration

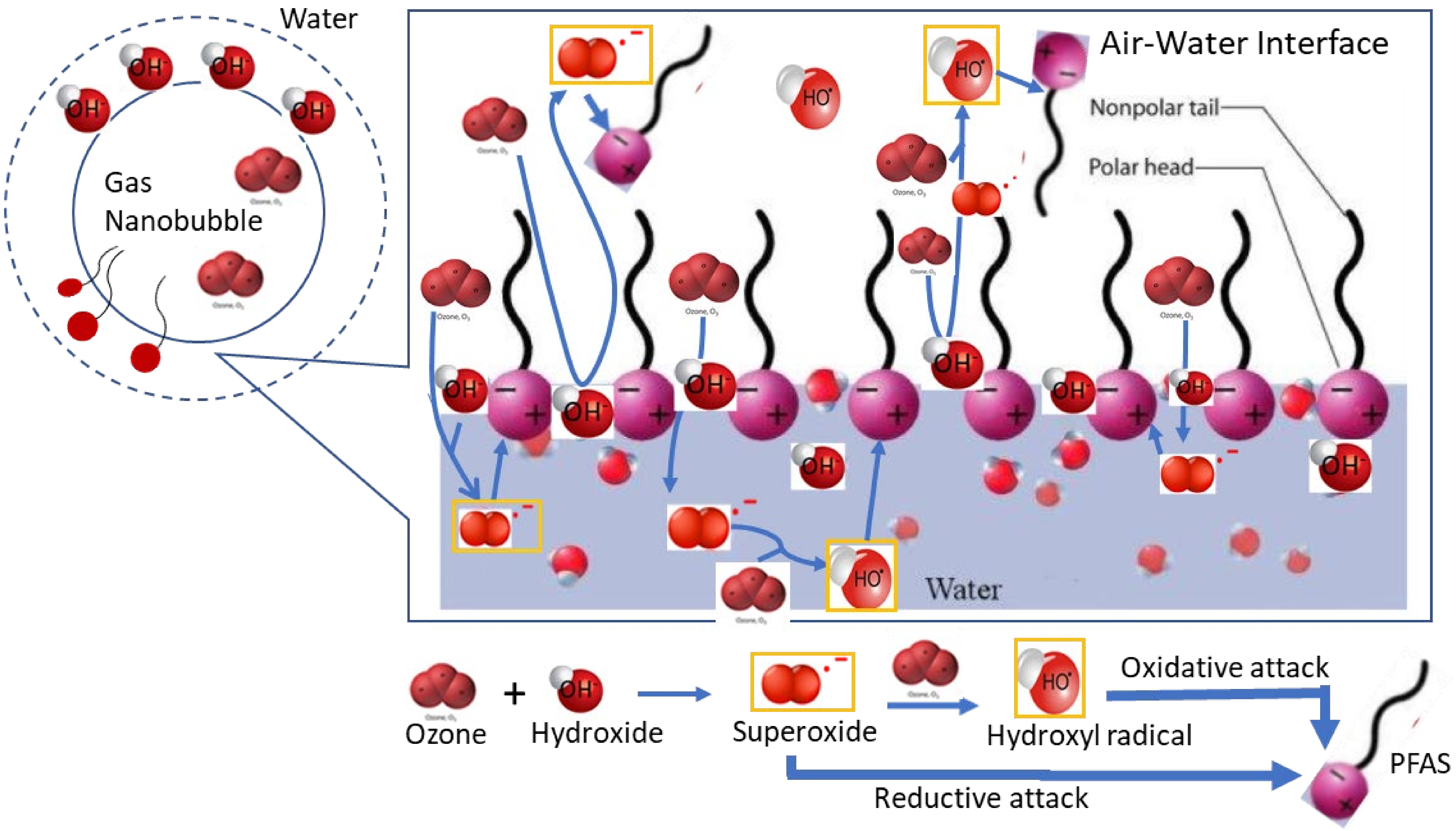


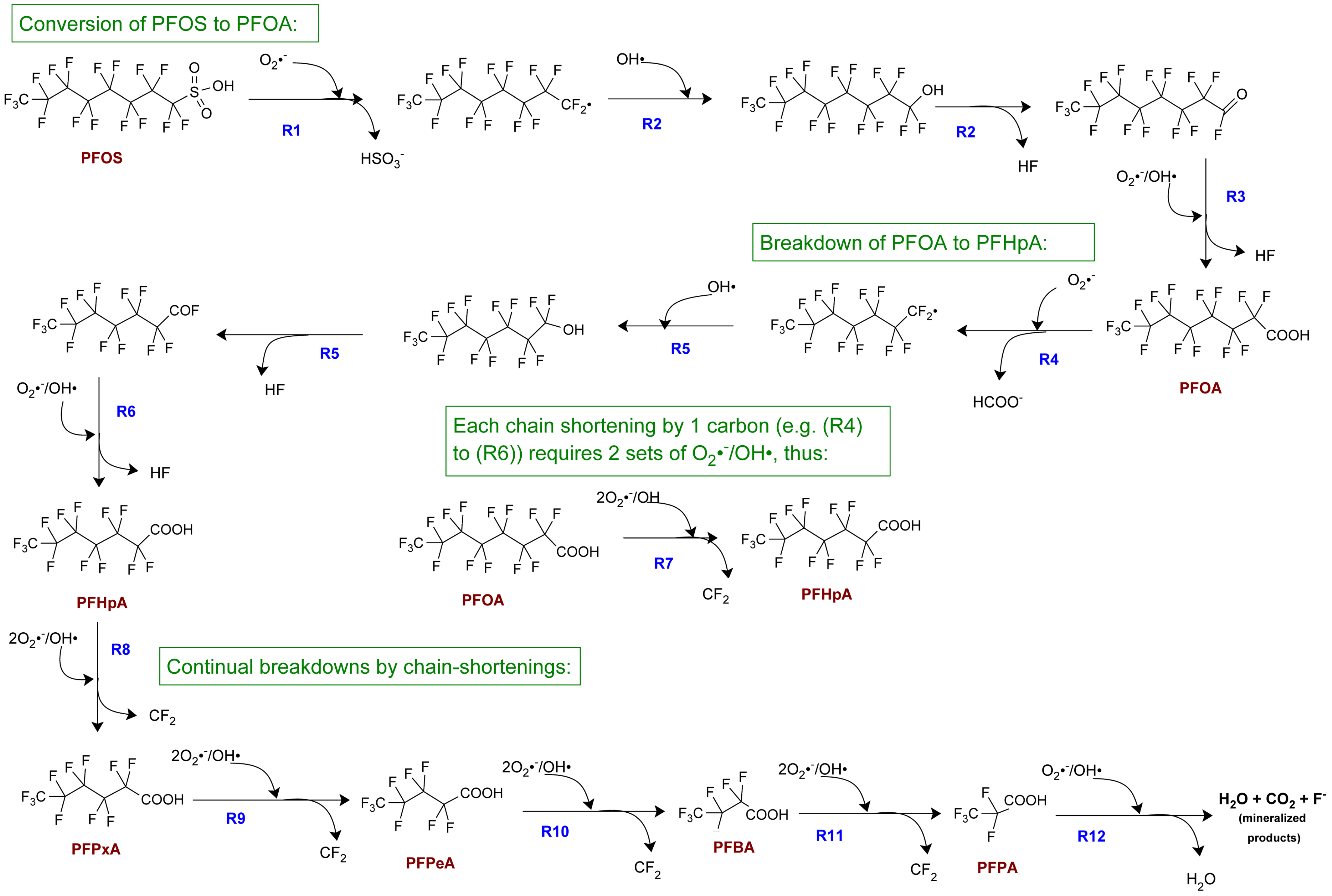
Before



After

Reductive-Oxidative Degradation of PFAS





Conversion of PFOS to PFOA:
PFOS
R1
HSO3-
OH•
R2
HF
R3
Breakdown of PFOA to PFHpA:
PFOA
R4
HCOO-
R5
R6
Each chain shortening by 1 carbon (e.g. (R4) to (R6)) requires 2 sets of O2•-/OH•, thus:
PFHpA
R7
CF2
R8
Continual breakdowns by chain-shortenings:
PFPxA
R9
PFPeA
R10
PFBA
R11
PFPA
R12
H2O + CO2 + F-
(mineralized products)

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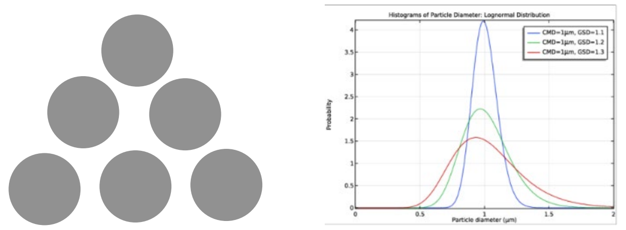
Novel High Temperature Catalyst System for Microplastics Breakdown

Swomitra Mohanty
Department of Chemical Engineering
Department of Materials Science Engineering

System Construction

Feed Stock

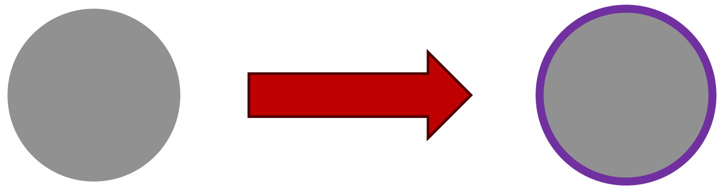
Advanced Alloy Powder with Tight Particle Distribution



https://doc.comsol.com/5.5/doc/com.comsol.help.particle/particle_ug_fluid_flow.08.50.htm

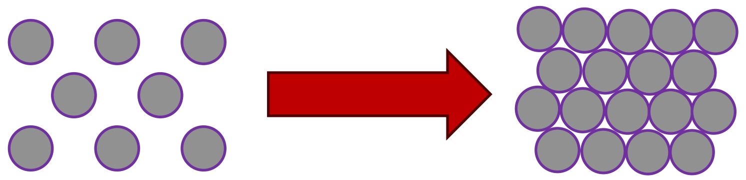
Catalytic Activation

Electroless Plating Via Ascorbic Acid Reduction



Assembly

Pleasureless Sintering to Create High Porosity

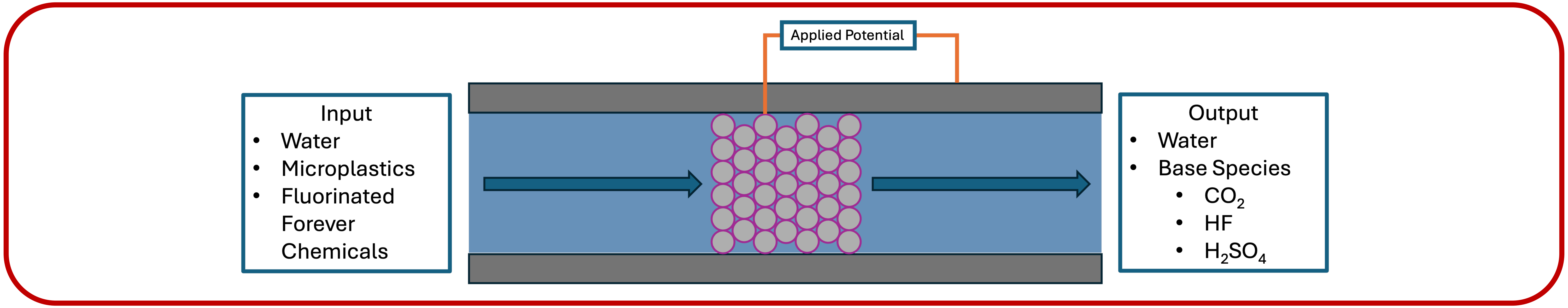


Novelty

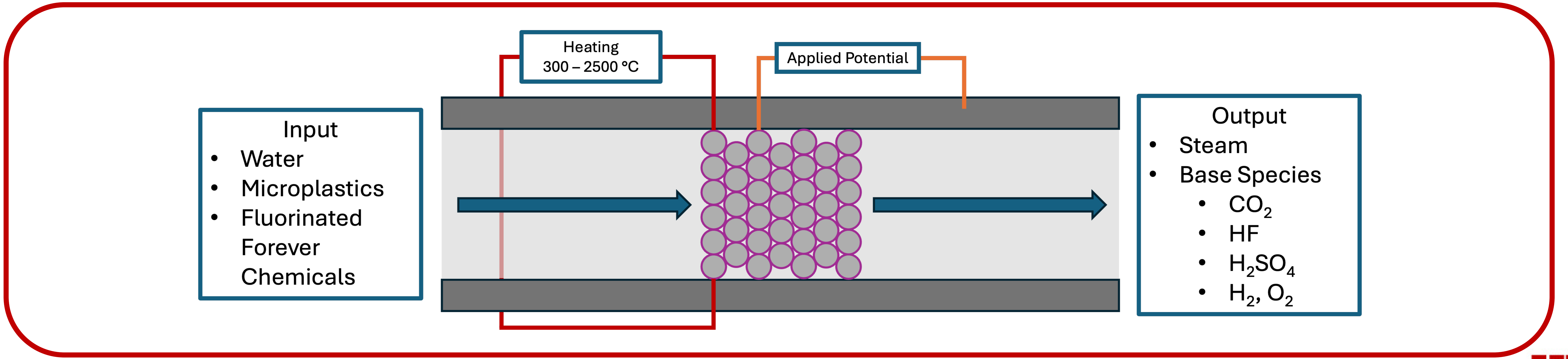
- Additively manufactured
- Superalloy or Refractory Alloy Substrate
- Highly Porus Atomizing System
- Electrically Conductive

System Use

Low Temperature

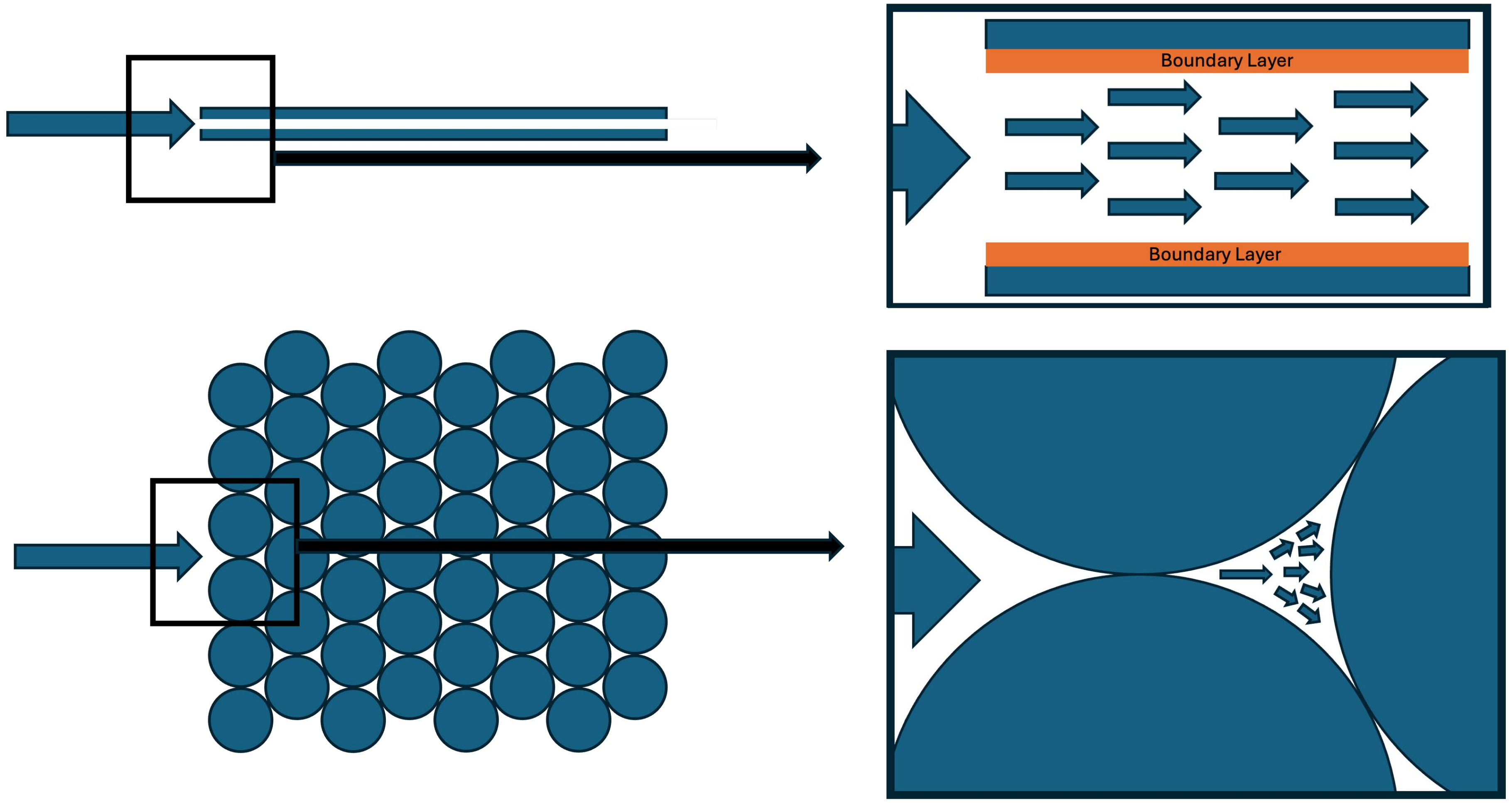


High Temperature

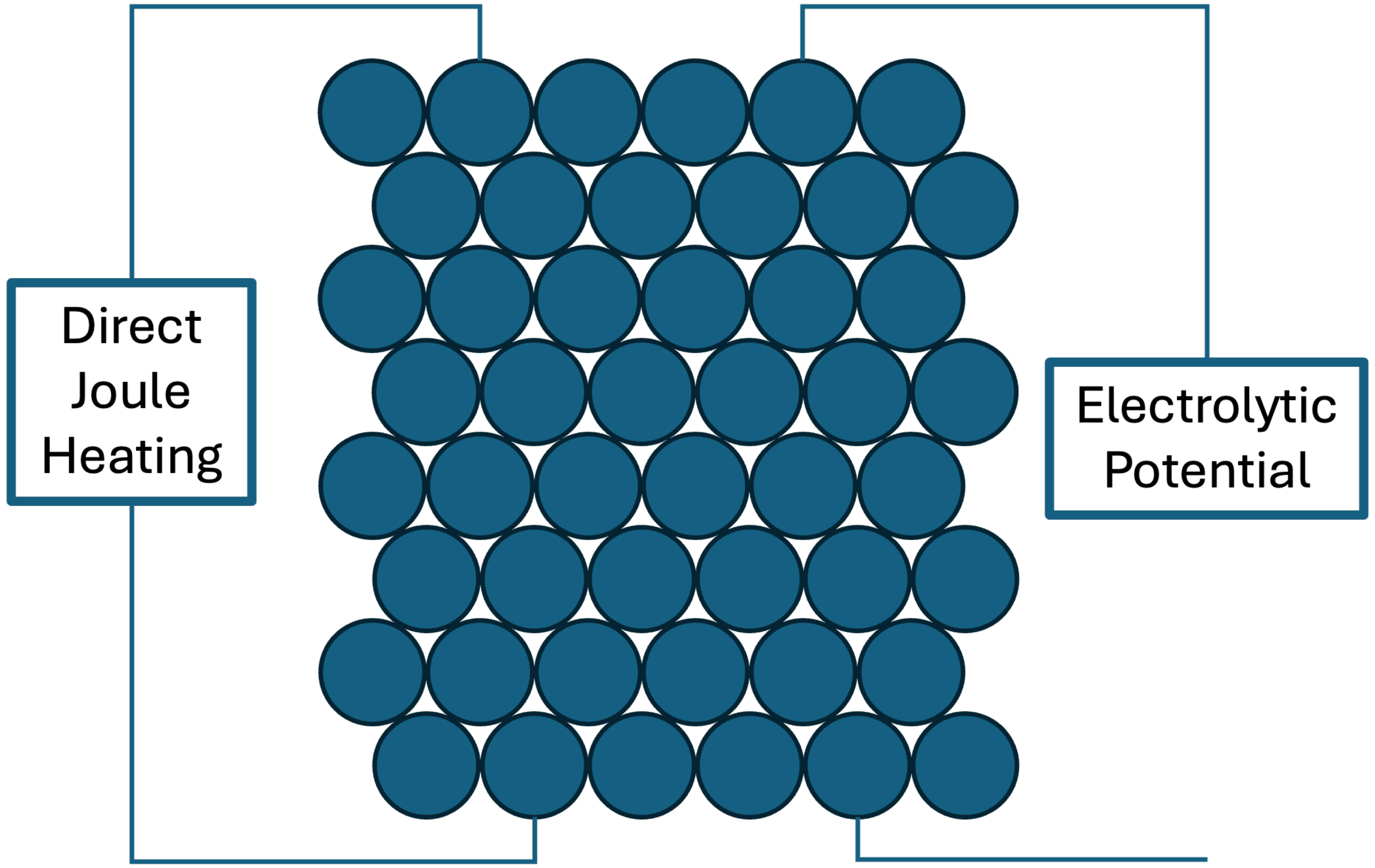


System Advantages

Kinetic enhancement via boundary layer thinning and reduced diffusion resistance



Efficient Direct Heating and Ability to Apply High Potentials



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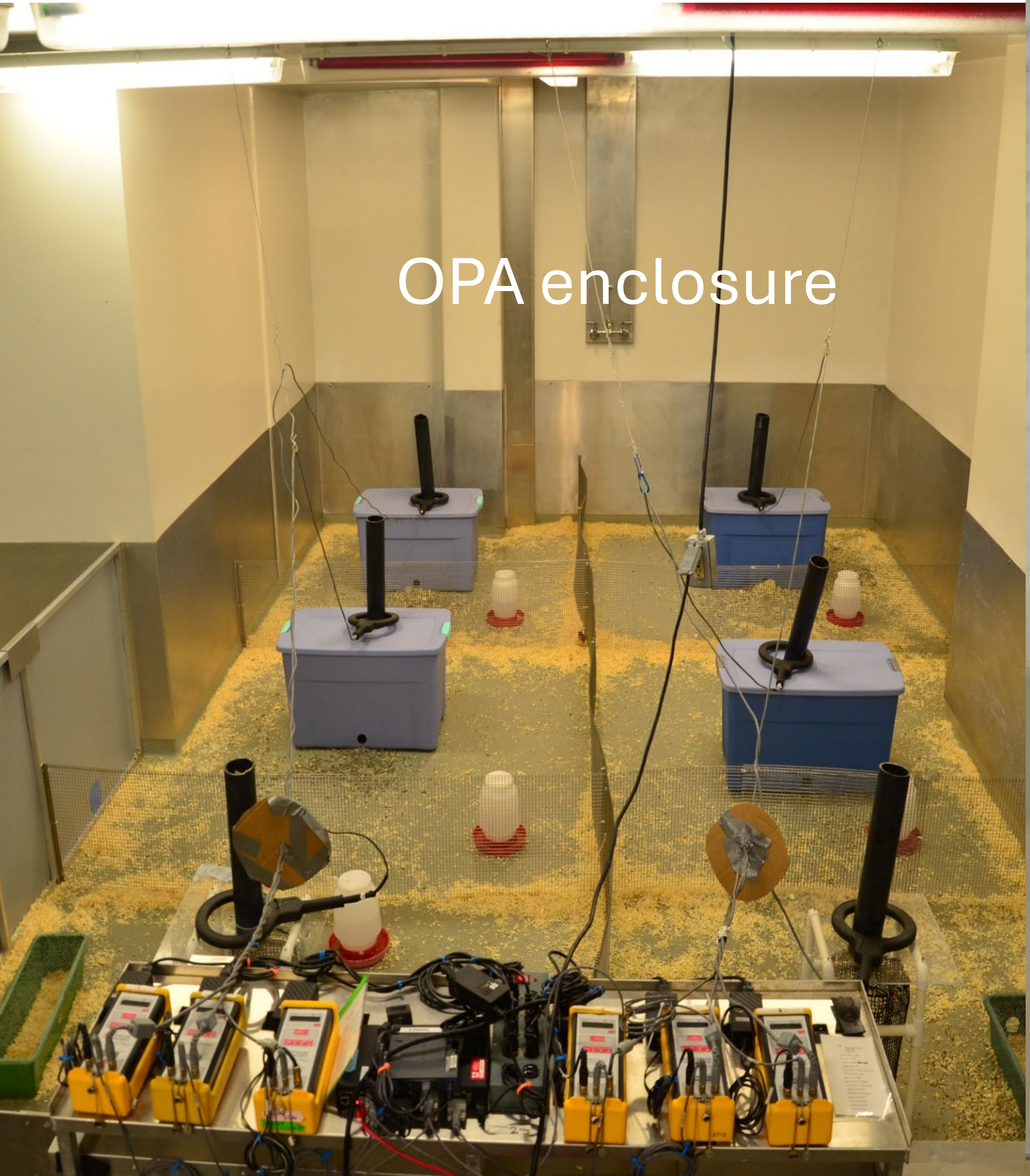
Identifying hard-to-detect environmental toxicants: an innovative method for toxicity testing

Wayne Potts, School of Biological Sciences, 21 May 2025

This method is called the **O**rganismal **P**erformance **A**ssay (OPA), which:

- Was the first to reveal mammalian health declines due to dietary **refined sugar** at human relevant doses (a major ingredient of **ultra-processed foods**)
- Revealed that mammalian health consequences from **inbreeding** was far worse than expected
- Revealed health consequences from two **pharmaceuticals** that had passed a billion $ of safety testing, but were withdrawn after public release due to unacceptable side effects
- Revealed negative health consequences of **Capecchi's Hox swaps,** contrary to the claim that the animals were normal

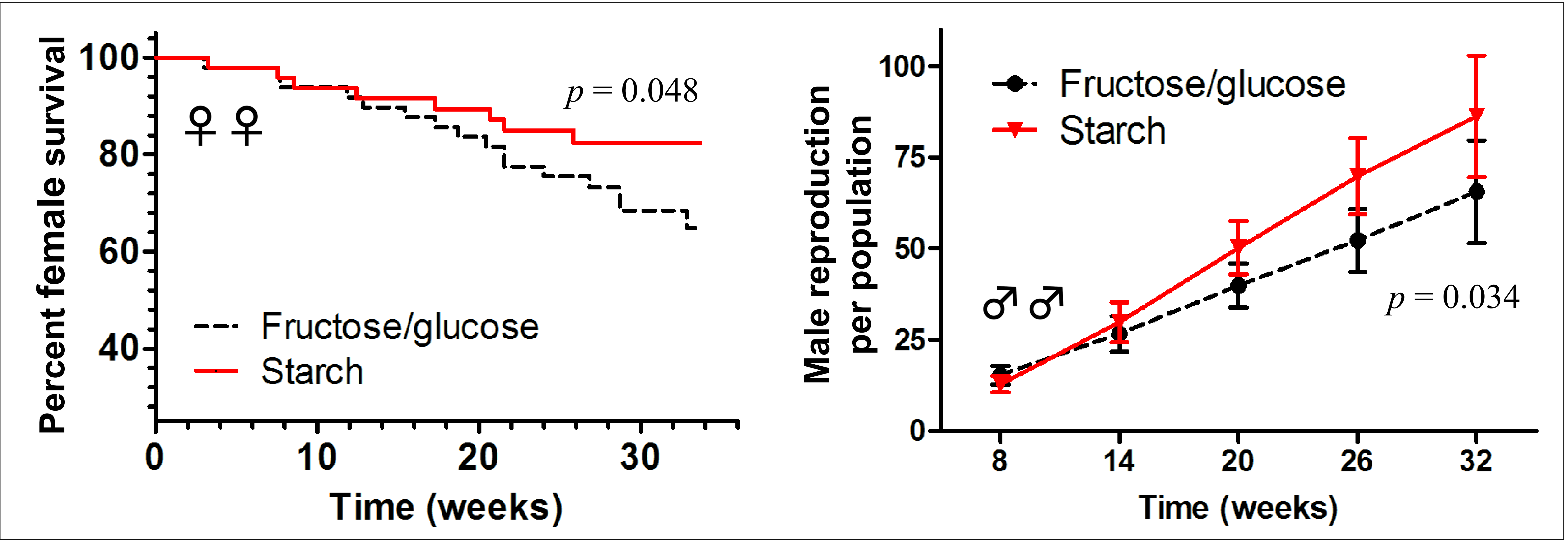

OPA enclosure


Video of territorial dispute

Received 23 Dec 2012 | Accepted 5 Jul 2013 | Published 13 Aug 2013 DOI: 10.1038/ncomms3245

Human-relevant levels of added sugar consumption increase female mortality and lower male fitness in mice

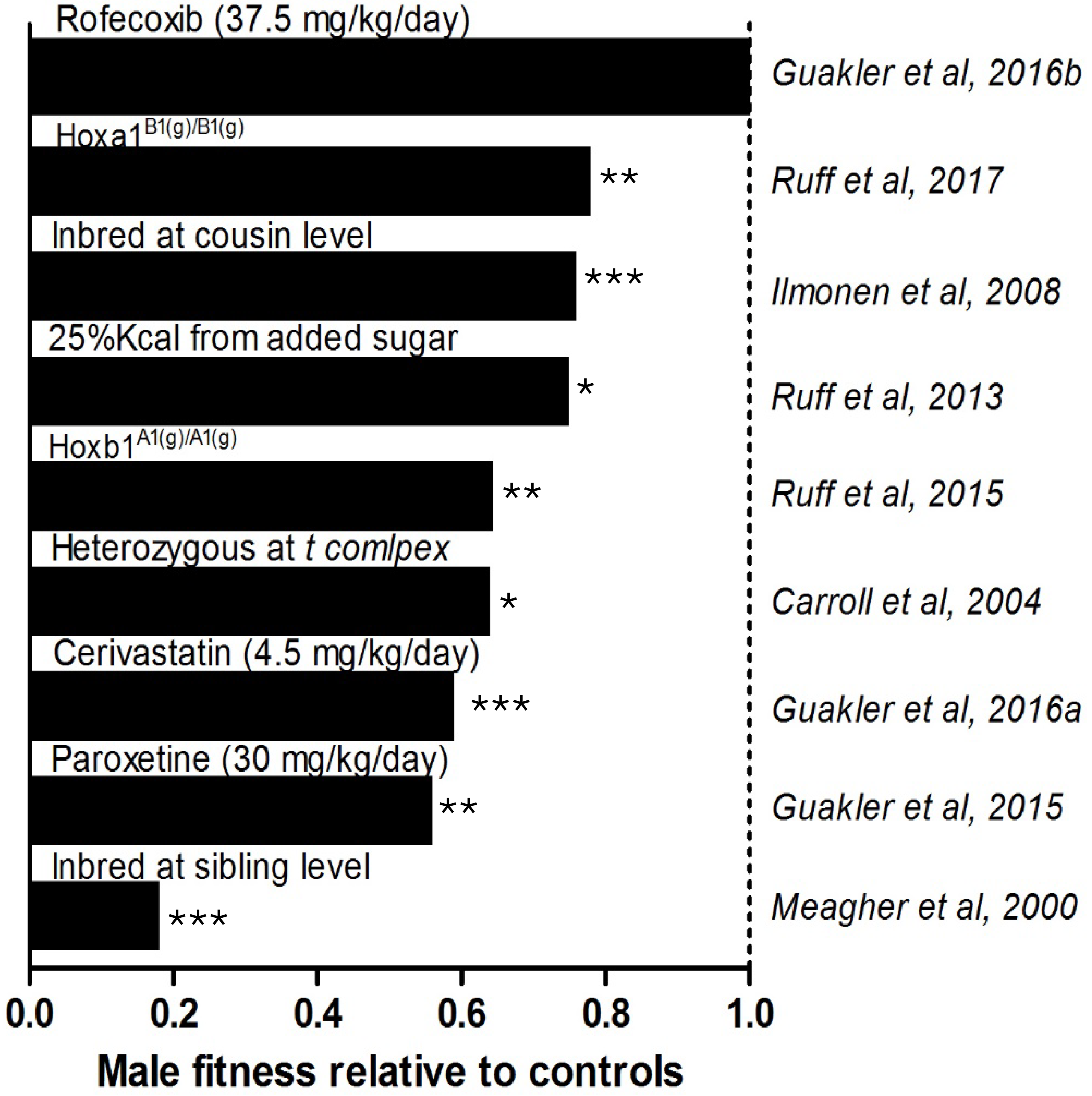
nature COMMUNICATIONS



1. Mortality rate of ♀♀ mice doubled ($p = 0.048$).
2. Reproduction of ♂♂ mice decreased by 25% ($p = 0.034$).
3. First demonstration of adverse health effects at human-relevant fructose levels.
4. **These data are conservative** as mice are on identical diets while in OPAs.

Ruff, Potts et. al

Male fitness comparisons among OPA studies



*p<0.05; **p<0.01; ***p<0.001

How OPAs detect toxicants often missed by conventional toxicity assessment methods

1. **OPAs are sensitive** because they use direct competition between treatment and control mice during the stress and rigors of natural population conditions.

2. **OPAs have broad detection capabilities** because **high performance** from **most physiological systems** is required for individual reproductive success. No *a priori* assumptions about the mechanism of toxicity are needed. Thus, **OPAs are high throughput and unbiased**.

3. **OPAs provide unambiguous adversity/health information**, unlike most genomic approaches. OPAs tell you if your mouse is sick (unable to compete effectively).

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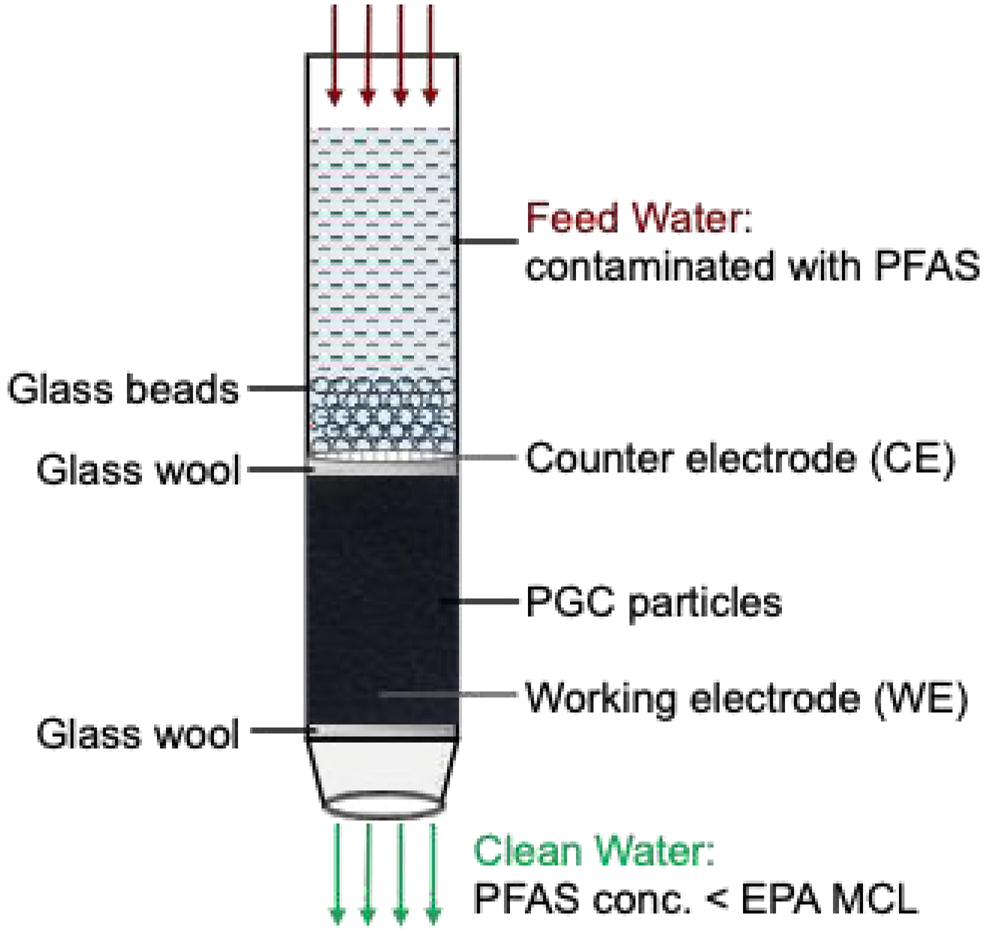
Full range treatment of PFAS: detection, filtration, concentratio

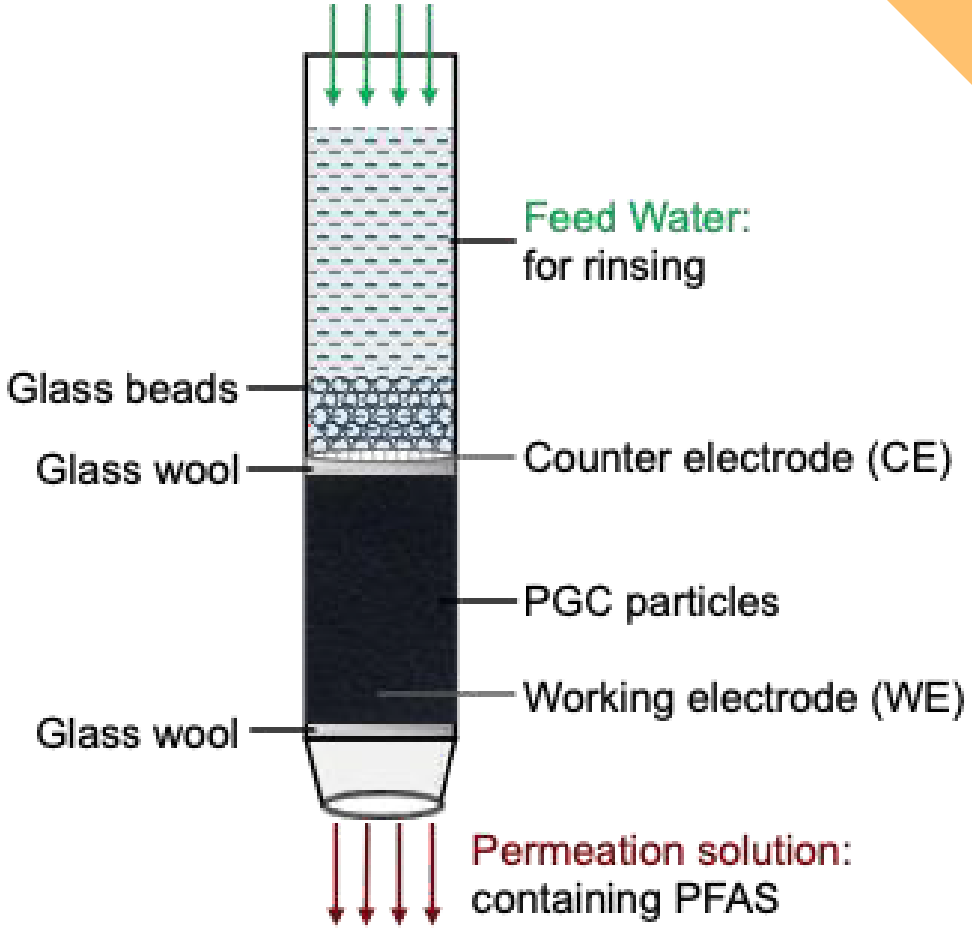
Ling Zang Lab, MSE Department, University of Utah, LZANG@eng.

Adsorption



Enhanced adsorption by applying positive surface potential to PGC

Desorption



Enhanced desorption by applying negative surface potential to PGC

PGC: *porous graphitic carbon*

Chemical sensors for realtime, onsite monitoring of PFAS like PFOS, PFOA

Destruction

Complete defluorination (mineralization) of PFAS, degradaded to non-toxic species like F^- ion, small acids.

Patents: U-7522, U-8030, U-8554, U-8556, U-8676, U-8712

PEAK WATER

SUSTAINABILITY ENGINE