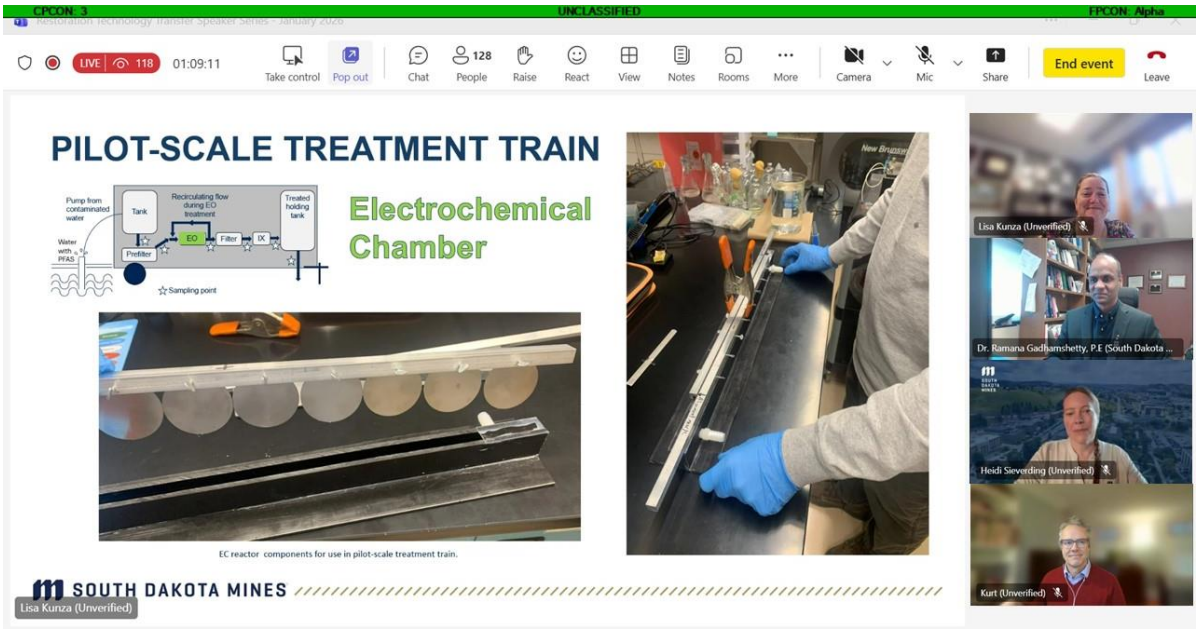
A Pilot-Scale, Portable Water Treatment Train for Remediation of Per- and Polyfluoroalkyl Substances

Presenters: Dr. Lisa Kunza, Dr. Venkataramana Gadhamshetty, PE, Dr. Heidi Sieverding & Dr. Kurt Chowanski (South Dakota School of Mines)

Per- and polyfluoroalkyl substances (PFAS) are highly persistent contaminants in groundwater due to their strong C–F bonds, and current treatment technologies often struggle to destroy them at field scale. Many existing approaches rely on expensive materials or fixed infrastructure that is difficult to scale, deploy, or adapt to real-world site conditions. In practice, PFAS-impacted sites vary widely in water chemistry, flow rates, and operational constraints, highlighting the need for treatment systems that can be tailored to specific field conditions rather than relying on one-size-fits-all solutions. To address these challenges, this study targets a key gap in electrochemical oxidation (EO), where existing systems depend on costly bulk Magnéli-phase materials or Boron-doped diamond and lack practical demonstrations of nanotechnology-enabled thin films for field-deployment. Here we demonstrate a mobile treatment train that places EO upstream of ion exchange (IX) resin and uses ~50 nm Magnéli-phase titanium suboxides (Ti_4O_7) thin films deposited on stainless steel (SS). EO reduced the sum of PFOA + PFOS by 66% in untreated groundwater without detectable increases in any evaluated PFAS. Downstream, IX achieved >99% removal across assessed PFAS, producing effluent consistent with 4-ng L-1 EPA MCL. Together, these results establish a practical field-deployable EO–IX treatment system using nanometer-scale Ti_4O_7 coatings on stainless-steel hardware. The modular, trailer-mounted design enables scalable deployment and customization of treatment trains to accommodate site-specific groundwater conditions, while delivering degradation performance comparable to boron-doped diamond at lower material cost and with flexible integration into groundwater treatment infrastructure.



South Dakota School of Mines Team detailing the pilot-scale treatment train for PFAS remediation.

This event and future events are updated and posted on the AFIT website at: https://www.afit.edu/CE/index.cfm.

POCs:
Joseph Dimisa, AFIT (joseph.dimisa@us.af.mil)
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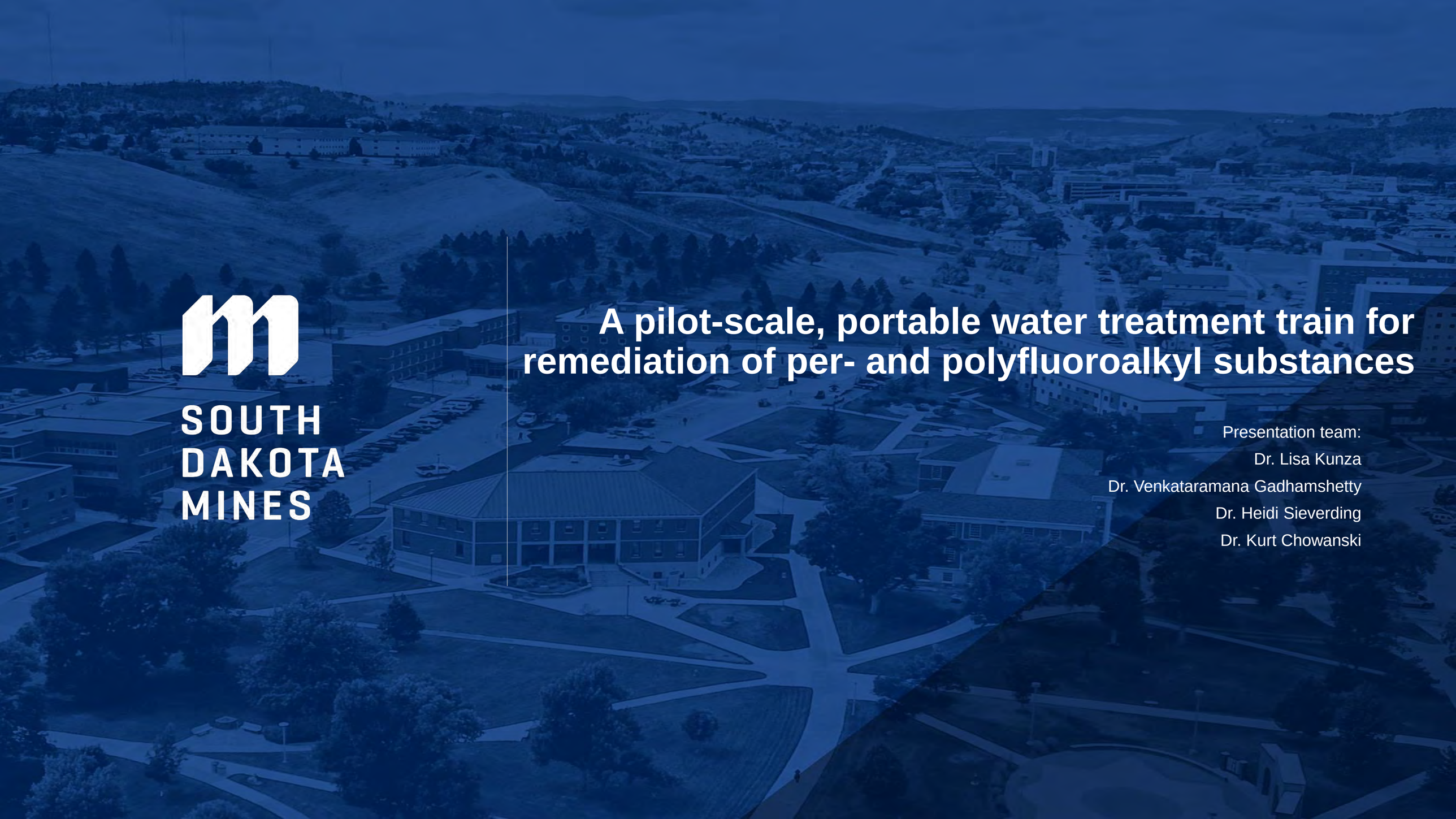
Webinar Structure

	Restoration Technology Transfer Webinar Series – eDASH Archive
5 min	Welcome and Administrative Business
30 min	*A Pilot-Scale, Portable Water Treatment Train for Remediation of PFAS (South Dakota School of Mines)*
10-15 min	Questions and Answers
5 min	Final Thoughts

A Pilot-Scale, Portable Water Treatment Train for Remediation of PFAS

Dr. Lisa Kunza
Dr. Venkataramana Gadhamshetty
Dr. Heidi Sieverding
Dr. Kurt Chowanski
South Dakota School of Mines

January 2026



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A pilot-scale, portable water treatment train for remediation of per- and polyfluoroalkyl substances

Presentation team:

Dr. Lisa Kunza

Dr. Venkataramana Gadhamshetty

Dr. Heidi Sieverding

Dr. Kurt Chowanski

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Presentation Team

Introduction
- -Background information
- -Site Selection
- -Demonstration Site
- -Project Overview

Electrochemistry

Bench-scale Testing

Pilot Scale Treatment Train

Initial and Final Demonstrations

Summary

Dr. Lisa Kunza, Professor
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Civil and Environmental Engineering

Dr. Heidi Sieverding, Assistant Professor
Civil and Environmental Engineering

Dr. Kurt Chowanski, Research Scientist
Chemistry, Biology, and Health Sciences

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PFAS Challenges

Chain of carbon-fluorine bonds (531.5 kJ/mol), lends PFAS incredibly high thermal, chemical, and biological stability [1]

Persistent within the environment and the human body. Nicknamed: “forever chemicals”

Reported health effects of PFAS include immunotoxicity, increased cholesterol levels, kidney and testicular cancer, effects on reproduction and fertility, among others [2, 3]

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Site Selection

- Ellsworth AFB
- Goodfellow AFB
- Offutt AFB

**Offutt AFB had groundwater available within the parameters desired

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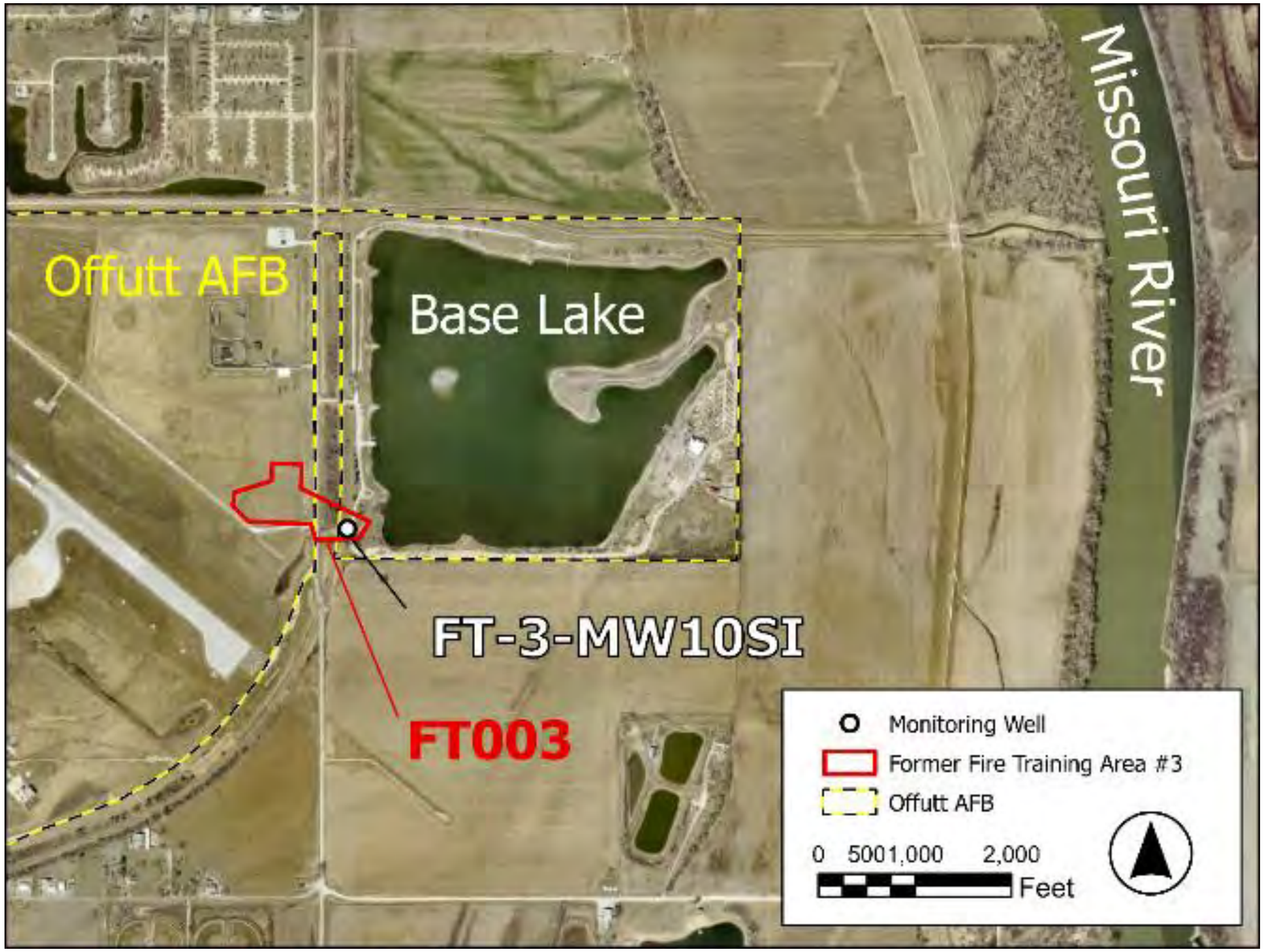
Demonstration Site-Offutt AFB



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Recent Studies on Electrochemical Degradation of PFAS

Electrode	Type of PFAS	Electrolyte	Reaction Time (min.)	% Removal	Rate Constant	Reference	Knowledge/Technical Gap(s)
BDD	PFOA (0.5 mM)	$NaClO_4$ (20 mM)	180	98.8 ± 1.9	$2.7 \times 10^{-2} \pm 6.6 \times 10^{-4}$ min^{-1}	H. Lin et al., Chem. Eng. J. (2018)	Expensive, lack of results with real water matrices/short-chain PFAS, potential toxic byproduct(s) formation
BDD (micro crystalline coating on Si)	PFOA (0.24 mM)	Na_2SO_4 (5 g/L)	240	100	8.33×10^{-5} m s^{-1}	B. Gomez-Ruiz et al., Sep. Purif. Technol. (2019)	Expensive, lack of results with real water matrices/short-chain PFAS, slow reaction kinetics
BDD	PFOS (2 µM)	Na_2SO_4 (100 mM)	20	85.7	4.19×10^{-5} m s–1	Lu Wang et al., Water Res. (2020)	Expensive, lack of results with real water matrices/short-chain PFAS, slow reaction kinetics
Ti_4O_7	PFOS (0.1 mM)	$NaClO_4$ (20 mM)	180	93.1 ± 3.4	$1.3 \times 10^{-2} \pm 5.5 \times 10^{-4}$ min^{-1}	H. Lin et al., Chem. Eng. J. (2018)	Lack of results with real water matrices/short-chain PFAS, potential toxic byproduct(s) formation, potential long-term stability/fouling issues
Ti_4O_7	PFOS (2 µM)	Na_2SO_4 (100 mM)	20	98.6	1.43×10^{-4} m s^{-1}	Lu Wang et al., Water Res. (2020)	Lack of results with real water matrices/short-chain PFAS, potential long-term stability/fouling issues
Ti_4O_7/amorphous Pd	PFOA (0.12 mM)	Na_2SO_4 (50 mM)	60	86.7 ± 6.3	3.37×10^{-2} $\pm 7 \times 10^{-4}$ min^{-1}	D. Huang et al., Environ. Sci. Technol. (2020)	Lack of results with real water matrices/short-chain PFAS, potential long-term stability/fouling issues
$[(Ti_{1-x}Ce_x)_4O_7]$ (x = 3%)	PFOS (10 µM)	$NaClO_4$ (0.1 M)	120	98.9 ± 0.3	$3.6 \pm 0.2 \times 10^{-2}$ min^{-1}	H. Lin et al., Environ. Sci. Technol. (2021)	Lack of results with real water matrices/short-chain PFAS, potential toxic byproduct(s) formation, potential long-term stability/fouling issues
Ti/SnO_2-Sb, Ti/SnO_2-Sb/PbO_2	PFOA (0.24 mM)	$NaClO_4$ (10 mM)	90	98.8	0.064 min^{-1}	Lin H. et al., Water Res. (2012)	Lack of results with real water matrices/short-chain PFAS, limited oxidation potential, high potential for toxic byproduct(s) formation, long-term stability/fouling concerns
PbO_2-Ce-Ti	PFOA (0.25 mM)	Na_2SO_4 (10 mM)	120	100	1.3×10^{-2} min^{-1}	Niu J, Environ Sci Technol. (2013)	Lack of results with real water matrices/short-chain PFAS, limited oxidation potential, high potential for toxic byproduct(s) formation, long-term stability/fouling concerns

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Per- and Poly-fluoroalkyl Substances (PFAS)

- **Limitations of Current Electrochemical PFAS Treatment Solutions**
  - Expensive, lack of results with real water matrices/short-chain PFAS, potential toxic byproduct(s) formation, and potential long-term stability/fouling issues
  - Limited oxidation potential and slow reaction kinetics
- **Key Benefits of Proposed Technology**
  - Degradation of PFAS via electrochemical oxidation
  - Nanoscale thin-film Ti_4O_7 anode used herein offer potential cost advantage over the BDD electrodes
  - No toxic by-products formation

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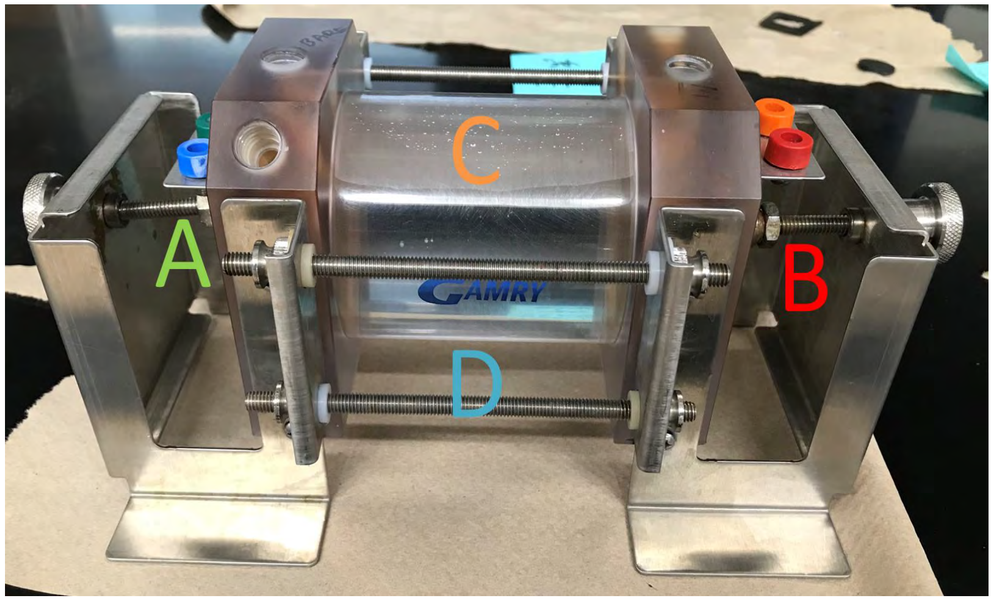
Bench-scale Materials & Methods

- Goal Statement: To develop a cost-efficient novel electrode using Ti_4O_7 thin films for efficient electrochemical degradation of PFAS with a removal efficiency comparable to BDD.
- All electrochemical assessments were completed in 3-electrode Gamry ParaCell™ comprising a Ag/AgCl reference electrode, graphite counter electrode, and n-Ti_4O_7 working electrode.
- Electrolytes used in
  - Phase-I BST: 0.05 M $K_3[Fe(CN)_6]$ + 0.1 M PBS
  - Phase-II BST: Various PFOA + PFOS + 0.1 M Na_2SO_4 concentrations
  - Phase-III BST: Source water containing PFAS
- For the fabrication of n-Ti_4O_7 electrodes, a PVD Products PLD/MBE-2300 pulsed-laser deposition unit was used.
- Electrochemical tests including OCV, CV, and EIS values under alternating current (AC) and open circuit potential conditions were conducted to assess electrochemical performance.



Single chambered electrochemical cell

A - Ti_4O_7/SS working electrode
B - Graphite counter electrode
C - ParaCell reaction chamber
D - Aqueous solution containing PFAS + Na_2SO_4

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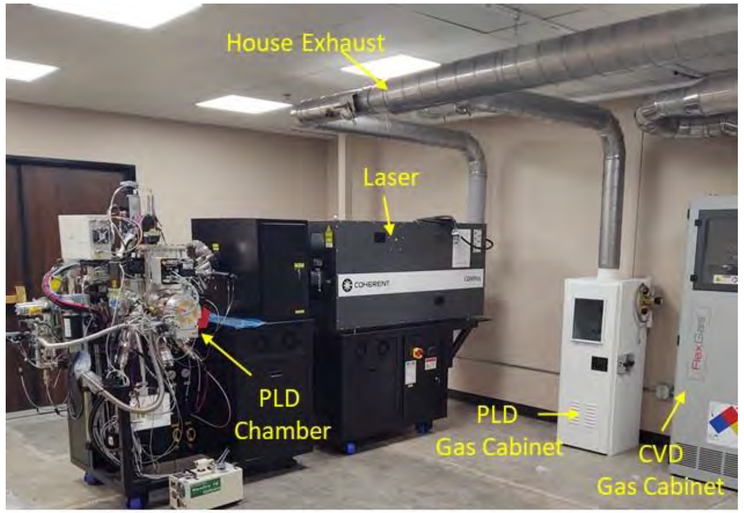
CHEMICAL VAPOR & PULSE LASER DEPOSITION

EasyTube® 3000 – H-BN Chemical Vapor Deposition System



PVD 2300- Pulsed Laser Deposition System

PE- CVD for Graphene
(from CVD Equipment Corp)

Features:

- Pulsed Laser Deposition/Molecular Beam Epitaxy
  - High pressure RHEED, In-situ Ellipsometry
- Magnetron Sputtering, Reactive Sputtering
- Ti_4O_7 deposition on stainless steel substrate
- Chemical Vapor Deposition (CVD)
- Graphene- Plasma Enhanced CVD

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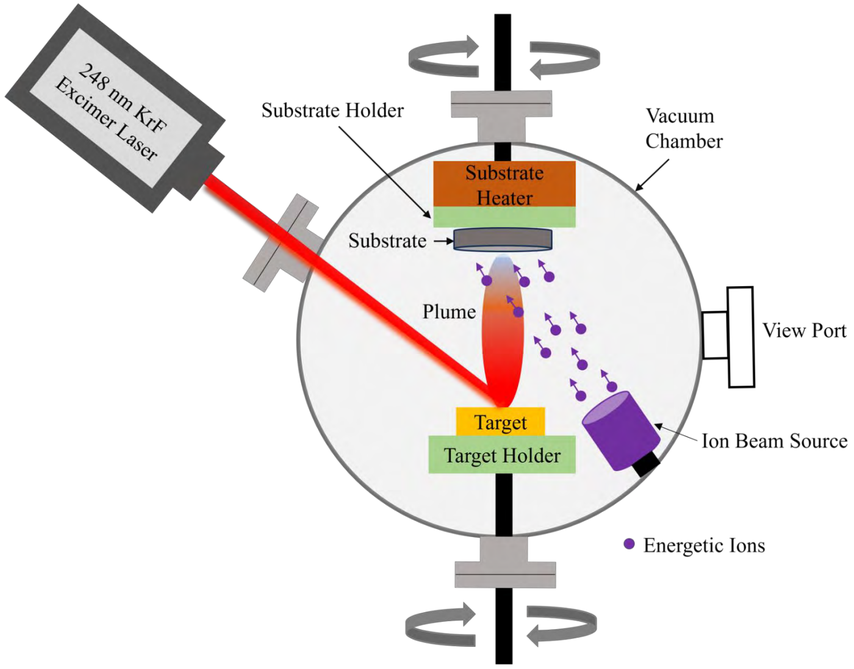
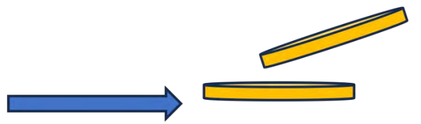
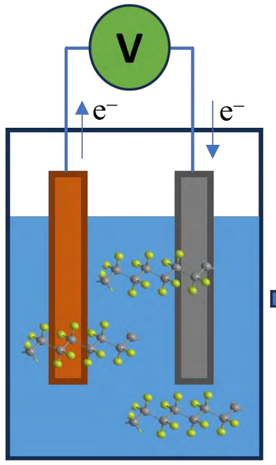
PFAS TREATMENT USING PULSED-LASER DEPOSITED THIN-FILM ELECTRODES



Pulsed-Laser Deposition



n-Ti_4O_7/SS, n-TiO_2/SS, h-BN, Graphene Electrodes



Electrochemical PFAS Treatment

Characterization

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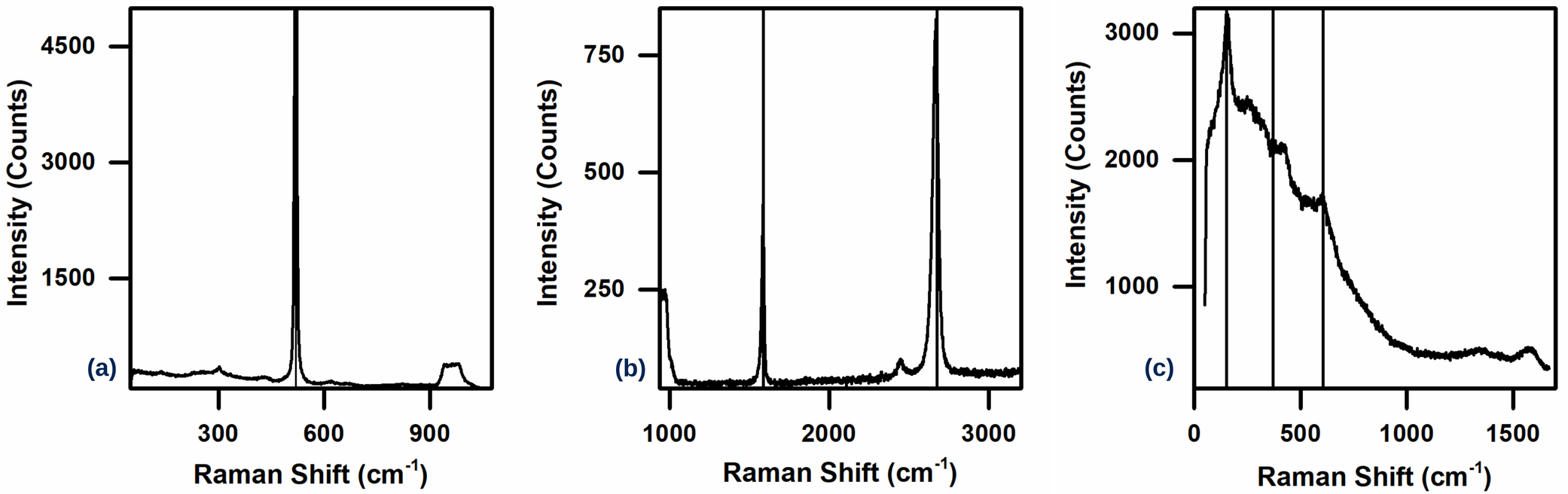
Characterization of TiO_2, Gr/TiO_2 and Ti_4O_7 Electrodes

- Raman spectra were obtained for TiO_2, Gr/TiO_2 and Ti_4O_7 electrodes to confirm the presence of titania oxides and single-layer graphene after the transfer method.



Raman Spectra for (a) bare TiO_2, (b) Gr/TiO_2 and (c) Ti_4O_7 electrodes

- From Fig. a, peaks observed for Raman shift at ~517 cm^{-1} confirm the presence of TiO_2 and peaks for the Raman shift at around 1600 cm^{-1} and 2700 cm^{-1} are consistent with literature for the formation of single-layered graphene on TiO_2 substrate. from Fig. b.

- Peaks observed at ~140, 400 and 603 cm^{-1} for Ti_4O_7 WE are consistent with literature for Ti_4O_7 formation.

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Phase-I BST Electrochemistry Data for BDD and Ti_4O_7 Electrodes

- Electrochemical impedance spectroscopy (EIS), cyclic voltammetry (CV), and open circuit voltage (OCV) measurements were obtained using a 50 mM potassium ferricyanide ($K_3[Fe(CN)_6]$) and 100 mM phosphate buffer solution (PBS) electrolyte.
- From Fig. a, redox potentials were determined to be -0.3345 V and 0.6987 V with current densities of -1.77 mA and 1.28 mA for BDD electrode respectively.
- In comparison, redox potentials for Ti_4O_7 electrode determined to be -0.708 V and 1.1 V with current densities of -4.52 mA and 1.11 Ma respectively from Fig. b.
- The total impedance was calculated to be 735 Ω/cm^2 and 153,702 Ω/cm^2 for BDD and Ti_4O_7 electrodes from Fig. c and Fig. d respectively.
- Using Ti_4O_7 electrode, pH was observed to drop from 5.80 to 4.57 after chronoamperometry treatment at 2.117 V (vs Ag/AgCl) for 30 mins with simulated PFAS water samples.

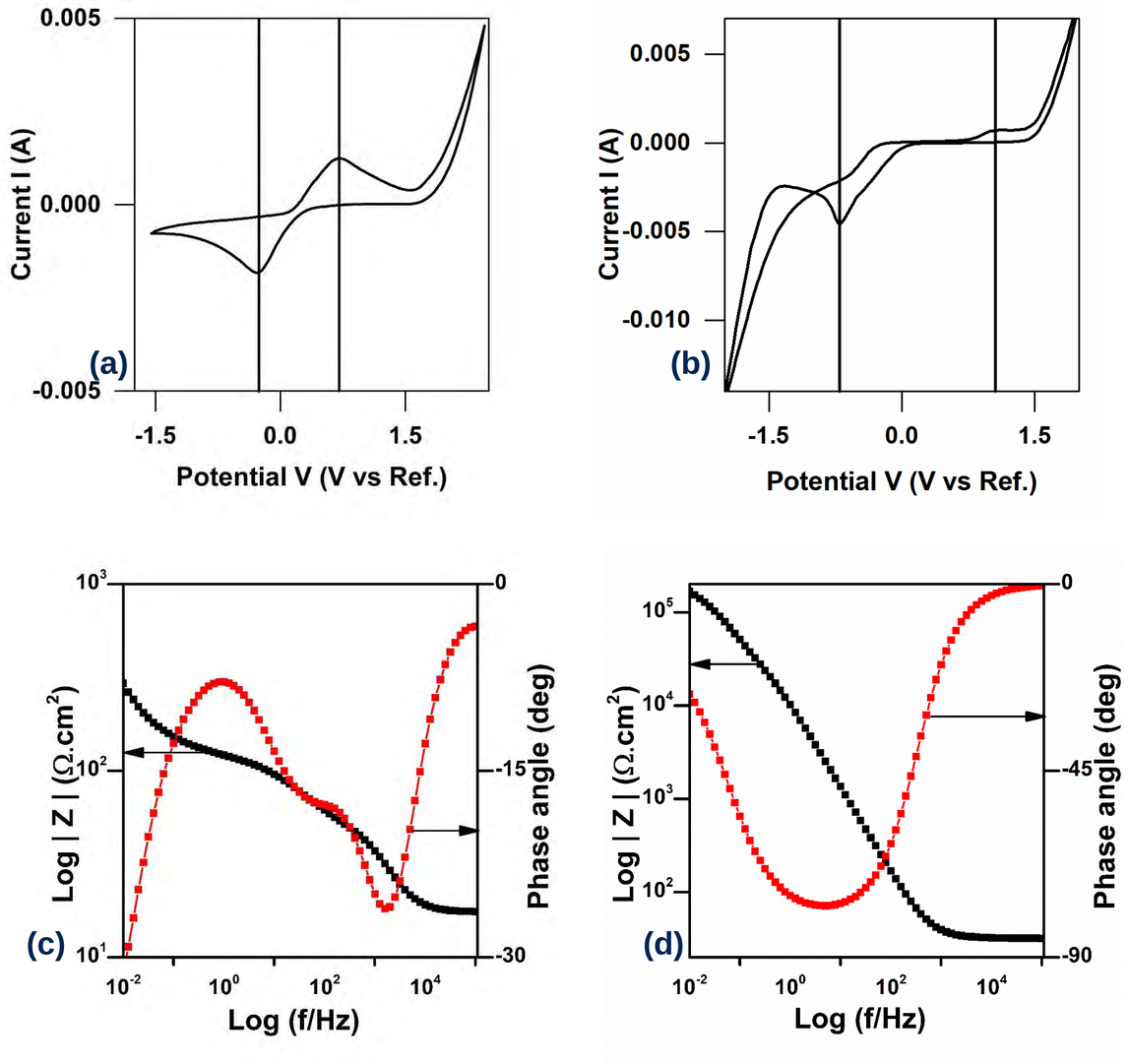

Figure: Representative CV plots for (a) BDD and (b) Ti_4O_7 and EIS Bode plots for (c) BDD and (d) Ti_4O_7 using an electrolyte containing 0.05 M [$K_3(FeC_6N_6)$] and 0.1 M PBS.

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Phase-II BST Electrochemistry Data using Ti_4O_7 Electrodes

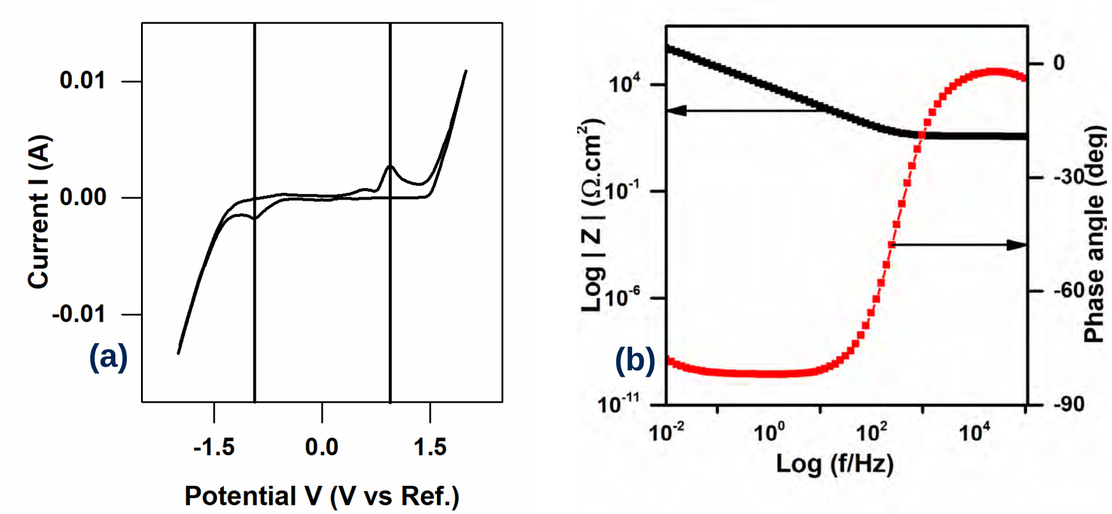

Figure: Representative (a) CV plot and (b) EIS Bode plot for an electrolyte containing 2,500 ppb PFOA, 2,500 ppb PFOS and 0.1 M Na_2SO_4 using Ti_4O_7/SS electrodes.

- Electrochemical impedance spectroscopy (EIS), cyclic voltammetry (CV), and open circuit voltage (OCV) measurements were obtained using various concentrations of PFAS and 100 mM sodium sulfate (Na_2SO_4) electrolyte.
- From Fig. a, redox potentials were determined to be -0.9503 V and 0.9494 V with current densities of -1.74 mA and 2.76 mA for Ti_4O_7/SS electrode respectively.
- The total impedance was determined to be 9,694.2 KΩ/cm^2 for Ti_4O_7/SS electrodes from Fig. b.

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PFAS Results for Source Water using n-Ti_4O_7/SS Electrodes

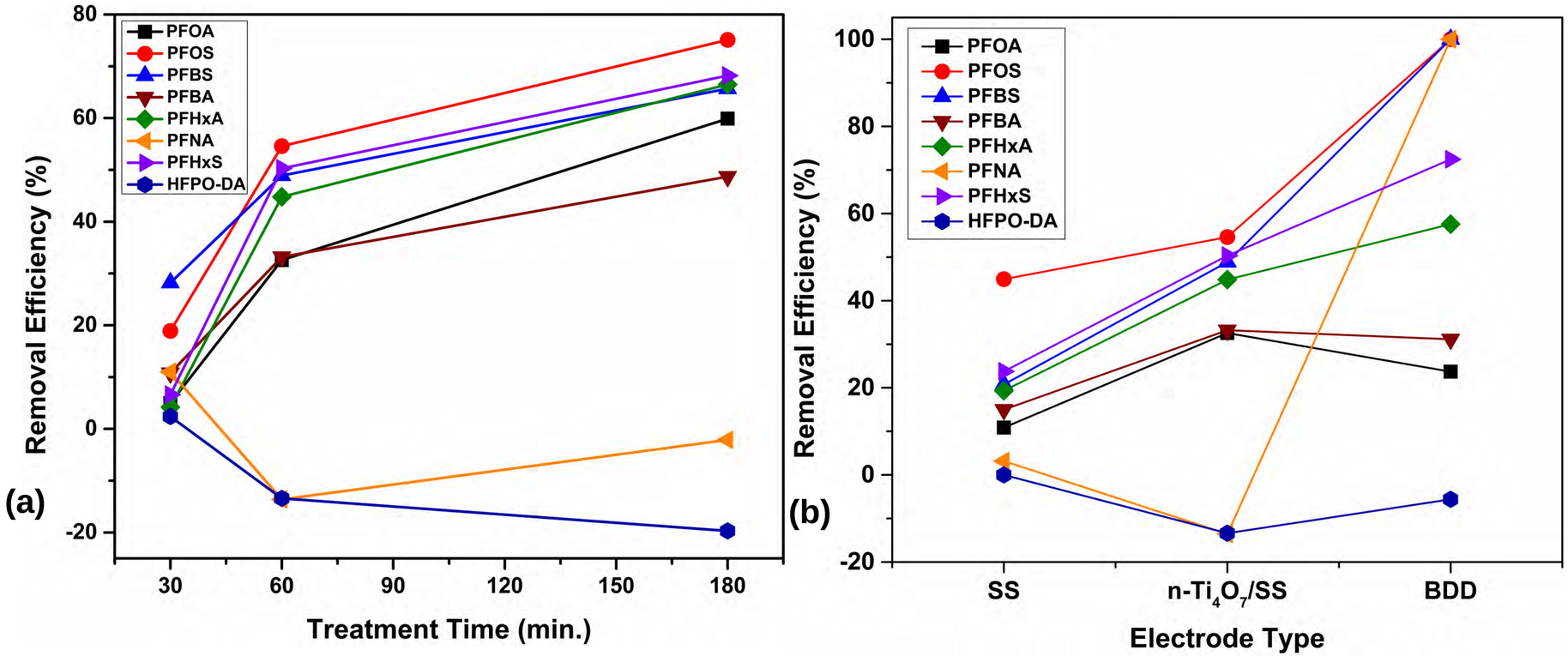

Figure: (a) Representative PFAS removal efficiencies for phase-III source water samples from a military installation using n-Ti_4O_7/SS electrodes, and (b) Representative PFAS results for source water samples from the military installation comparing treated water using SS, n-Ti4O7/SS electrodes, and BDD electrodes at 2.117 V for 60 min, vs Ag/AgCl.

- A supporting electrolyte, 0.033 M Na_2SO_4, was added to all source water samples to catalyze PFAS degradation reactions
- Treatment times were varied as 30 min, 60 min, and 180 min at a constant potential (2.117 V vs Ag/AgCl) using our novel n-Ti_4O_7/SS electrodes
- Electrochemical treatment (2.117 V for 180 min, vs Ag/AgCl) with n-Ti_4O_7/SS thin films decreased concentrations of perfluorooctanoic acid (PFOA), perfluorooctanesulfonic acid (PFOS), and perfluorobutane sulfonate (PFBS) by 59.9%, 75.1% and 65.7% in source water samples from the military installation, respectively

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Rate Constants for Source Water using n-Ti_4O_7/SS Electrodes

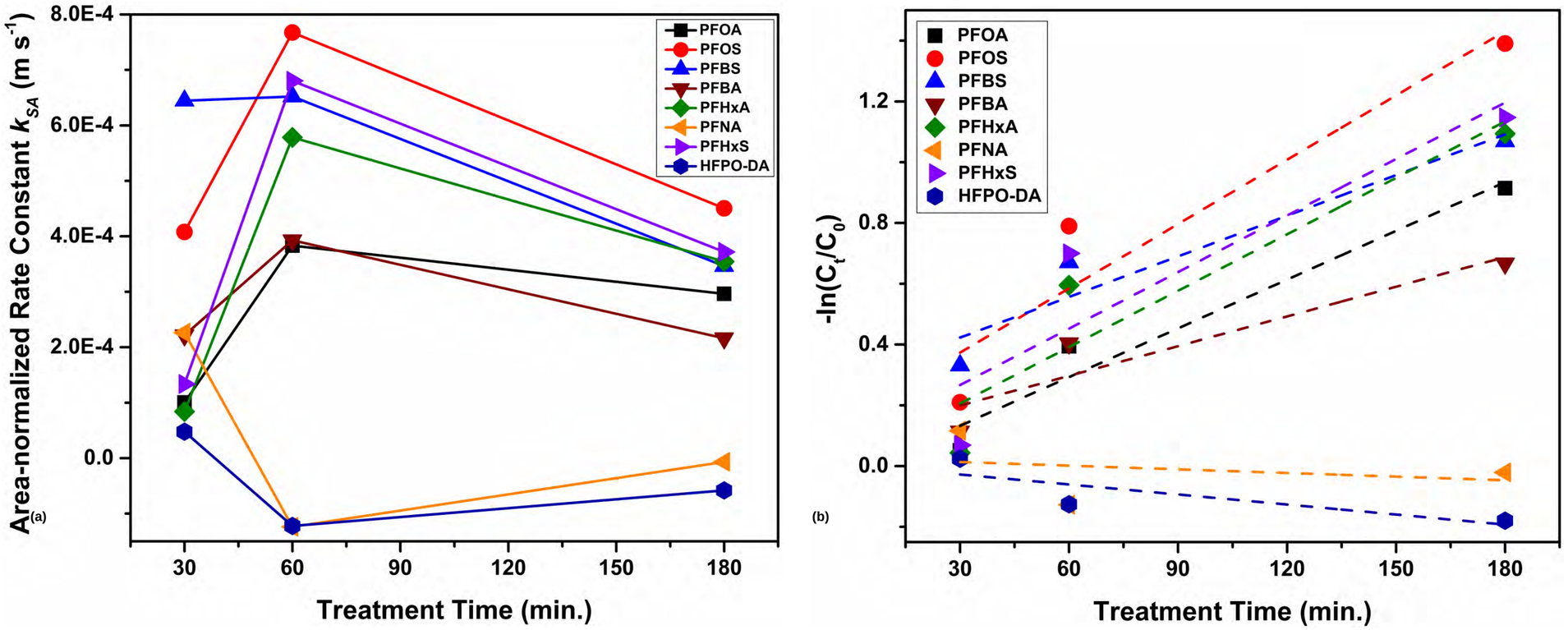

Figure: (a) Representative surface area-normalized rate constants for selected 8 PFAS compounds using n-Ti_4O_7/SS electrodes determined for various treatment durations (2.117 V vs Ag/AgCl), and (b) Representative kinetic fit curves for the degradation of 8 select PFAS compounds using n-Ti_4O_7/SS electrodes determined for treatment durations of 30, 60, and 180 mins (2.117 V vs Ag/AgCl) for source water samples from the field site.

- Initial molar concentrations of PFOA, PFOS, PFBS, PFBA, PFHxA, PFNA, PFHxS, HFPO-DA in source water collected from the military installation were 0.064, 0.396, 0.038, 0.031, 0.124, 8.1 x 10–4, 0.222, and 7.2 x 10–6 µM, respectively

- The observed k_{SA} values for the n-Ti_4O_7/SS electrode were 1–2 orders of magnitude higher than previously reported values for bulk Ti_4O_7 anodes

- For example, at 180 minutes, k_{SA} values for PFOA and PFOS were 3.0 x 10^{-4} and 4.5 x 10^{-4} m s^{-1}, respectively, compared to previously reported values such as 1.13 × 10^{-5} m s^{-1} (PFOA) and 4.3 × 10^{-6} m s^{-1} (PFOS) [4], 9.6 × 10^{-5} m s^{-1} (PFOS) [5], 1.3 × 10^{-4} m s^{-1} (PFOA) and 4.4 × 10^{-5} m s^{-1} (PFOS) [6]

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General Chemistry Data for Source Water using Ti_4O_7/SS Electrodes

Table: Representative anionic analyte results for source water samples obtained using IC for phase-III source water samples using Ti_4O_7/SS electrodes.

Dilution Corrected	Bucket 2 – bulk water	Ti_4O_7/SS: bucket 2 - bulk water: 2.417 V: 30 mins	Ti_4O_7/SS: bucket 2 – bulk water: 2.117 V: 30 mins	Ti_4O_7/SS: bucket 2 – bulk water: 2.117 V: 60 mins	Ti_4O_7/SS: bucket 2 – bulk water: 2.117 V: 90 mins	Method Detection Limit (MDL)	Minimum Reporting Limit (MRL)
	Conc. (mg/L)	Conc. (mg/L)	Conc. (mg/L)	Conc. (mg/L)	Conc. (mg/L)	Conc. (mg/L)	Conc. (mg/L)
Fluoride	<MRL	<MRL	<MRL	<MRL	<MRL	0.02	0.20
Chloride	78.491	99.113	77.057	89.889	213.752	0.03	0.30
Nitrite	<MRL	<MRL	<MRL	<MRL	<MRL	0.07	0.50
Sulfate	36.785	37.574	38.311	39.652	36.751	0.10	0.30
Bromide	<MRL	<MRL	<MRL	<MRL	<MRL	0.06	0.50
Nitrate	<MRL	<MRL	<MRL	<MRL	<MRL	0.07	0.50
Phosphate	<MRL	<MRL	<MRL	<MRL	<MRL	0.11	0.30

Table: Representative cationic analyte results for source water samples obtained using IC for phase-III source water samples using Ti_4O_7/SS electrodes.

Dilution Corrected	Bucket 2 – bulk water	Ti_4O_7/SS: bucket 2 - bulk water: 2.417 V: 30 mins	Ti_4O_7/SS: bucket 2 – bulk water: 2.117 V: 30 mins	Ti_4O_7/SS: bucket 2 – bulk water: 2.117 V: 60 mins	Ti_4O_7/SS: bucket 2 – bulk water: 2.117 V: 90 mins	Method Detection Limit (MDL)	Minimum Reporting Limit (MRL)
	Conc. (mg/L)	Conc. (mg/L)	Conc. (mg/L)	Conc. (mg/L)	Conc. (mg/L)	Conc. (mg/L)	Conc. (mg/L)
Lithium	<MRL	<MRL	<MRL	<MRL	<MRL	0.02	0.05
Sodium	21.33	21.43	22.22	21.31	21.29	0.08	0.20
Ammonia	<MRL	<MRL	<MRL	<MRL	<MRL	0.34	0.40
Potassium	19.05	40.12	14.83	31.26	161.63	0.10	1.00
Magnesium	45.43	45.52	47.68	46.04	45.65	0.08	0.20
Calcium	28.07	30.70	28.42	43.05	35.65	0.38	1.00

Table: Representative TOC results for phase-III source water samples using Ti_4O_7/SS electrodes.

Sample Name	Conc. (mg/L)
81.4 ppm QC	87.41
Bucket 2 – bulk water	5.688
Ti_4O_7/SS: bucket 2 - bulk water: 2.417 V: 30 mins	6.163
Ti_4O_7/SS: bucket 2 - bulk water: 2.117 V: 30 mins	7.144
Ti_4O_7/SS: bucket 2 - bulk water: 2.117 V: 60 mins	6.53
Ti_4O_7/SS: bucket 2 - bulk water: 2.117 V: 90 mins	6.485

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Mechanism of PFAS Degradation

- EO involves an oxidation reaction at the anode and reduction reaction at the cathode.
  - Direct anodic oxidation – on the anode
  - Indirect oxidation – mediated electrolysis
- Electrochemical Advanced Oxidation Processes (EAOP) utilize OH• radicals to attack PFAS and degrade them to fragments or inorganic ions/molecules
- Degradation reaction is a sequence of chain reactions
- These reactions can be initiated owing to the detachment of functional groups and formation of perfluoroalkyl radicals (C_nF_{2n+1}•) as shown in cycle I
- In a series of subsequent steps, the OH• radicals attack the alkyl radicals and reduce the size of the chains as C_nF_{2n+1} until it forms CF_2O and eventually non-toxic by-products such as HF and CO_2 in the presence of water
- Taking PFOA as an example, the total reaction :
  $C_7F_{15}COOH + 14H_2O \rightarrow 8CO_2 + 15HF + 14H^+ + 14e^-$
- The degradation mechanism observed in this study is proposed to follow this dual-pathway model, with evidence of the involvement of electrochemical advanced oxidation processes (EAOP) through •OH radicals supported by the high surface area-normalized rate constants and formation of shorter-chain PFAS transformation products [9-11]

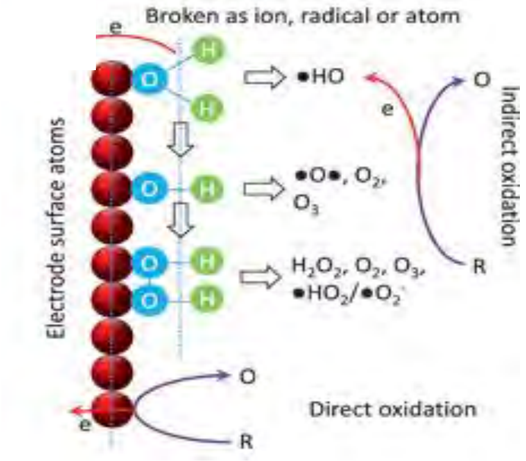

Figure: Schematic illustration of the oxidation reaction at anode; Reproduced from Ref. [1].

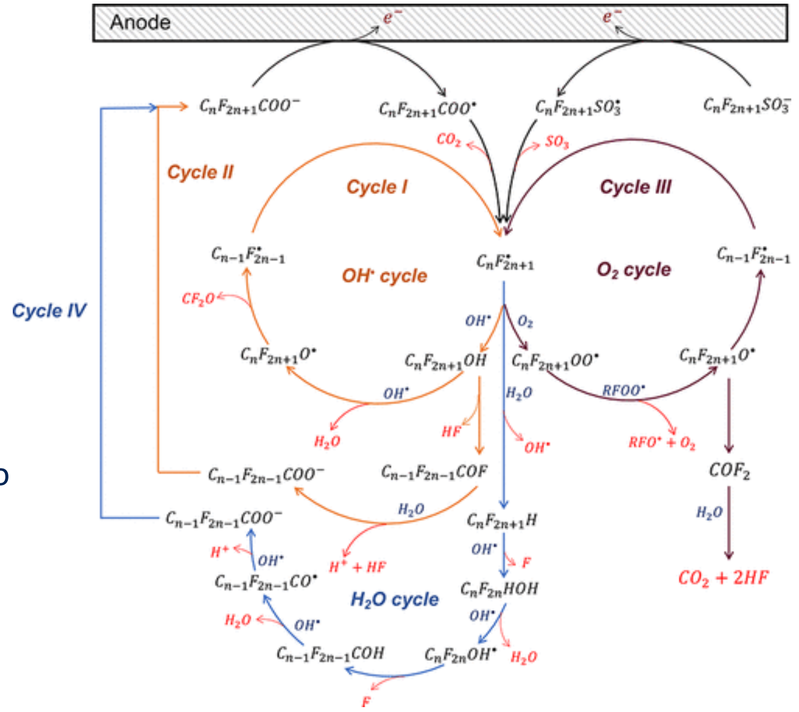

Figure: Mechanisms of PFAS degradation; Reproduced from Ref. [8].

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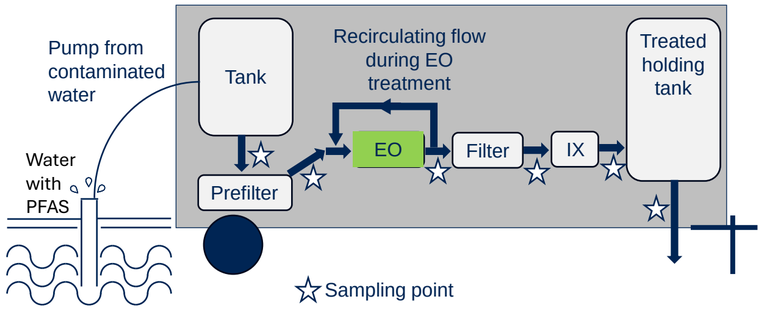
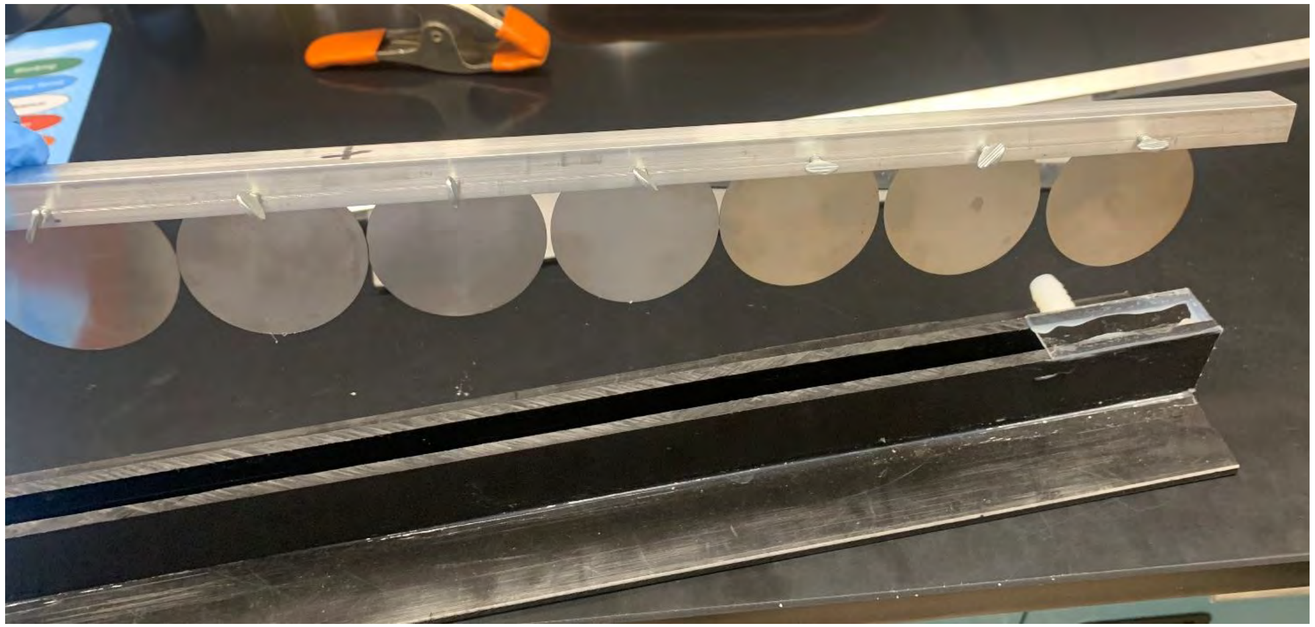
Bench-scale summary

- Testing with real source water including short-chain PFAS compounds
- High reaction kinetics: Surface area-normalized rate constants (k_{SA}) for n-Ti_4O_7/SS were one to two orders of magnitude higher (3.0 x 10^{-4} m s^{-1} (PFOA); 4.5 x 10^{-4} m s^{-1} (PFOS)) than reported values for bulk Ti_4O_7 (1.13 × 10^{-5} m s^{-1} (PFOA) and 4.3 × 10^{-6} m s^{-1} (PFOS) [4]; 9.6 × 10^{-5} m s^{-1} (PFOS) [5]) and in several cases comparable to BDD (8.33 × 10^{-5} m s^{-1} (PFOA) [6]; 4.19 × 10^{-5} m s^{-1} (PFOS) [7])

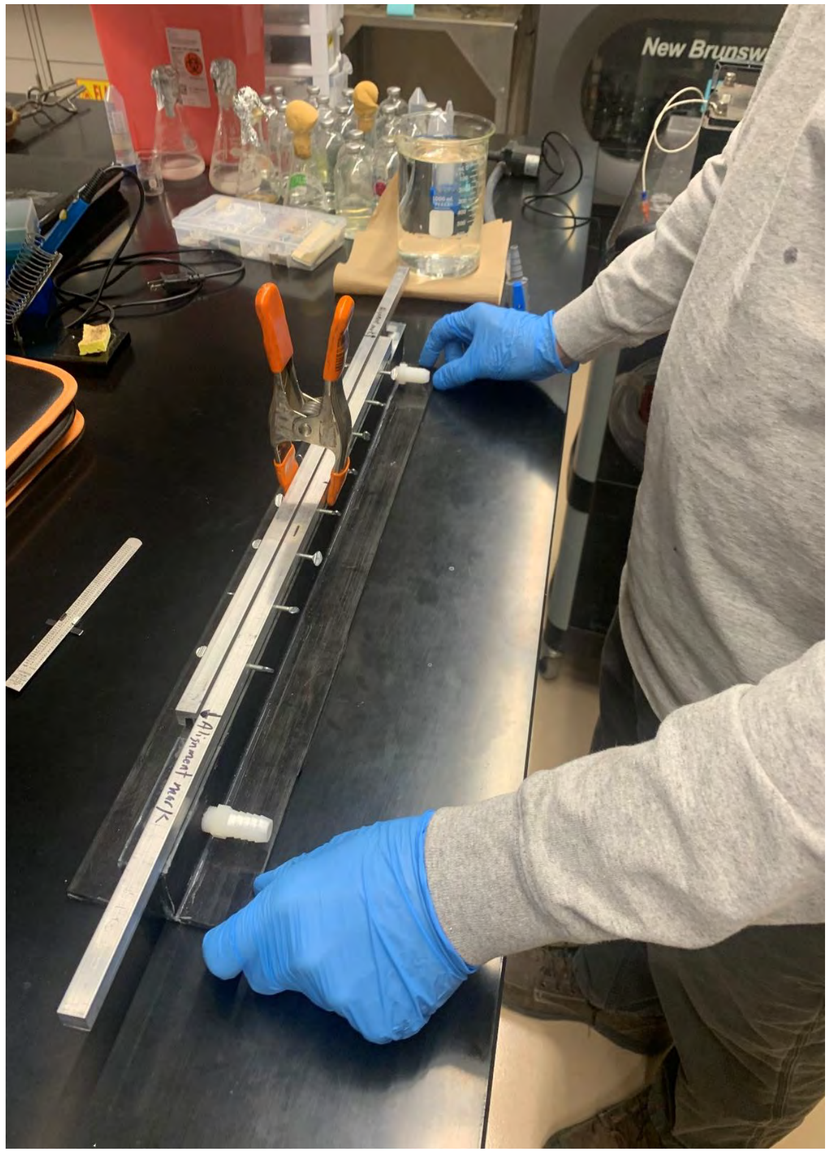
PILOT-SCALE TREATMENT TRAIN



Electrochemical Chamber



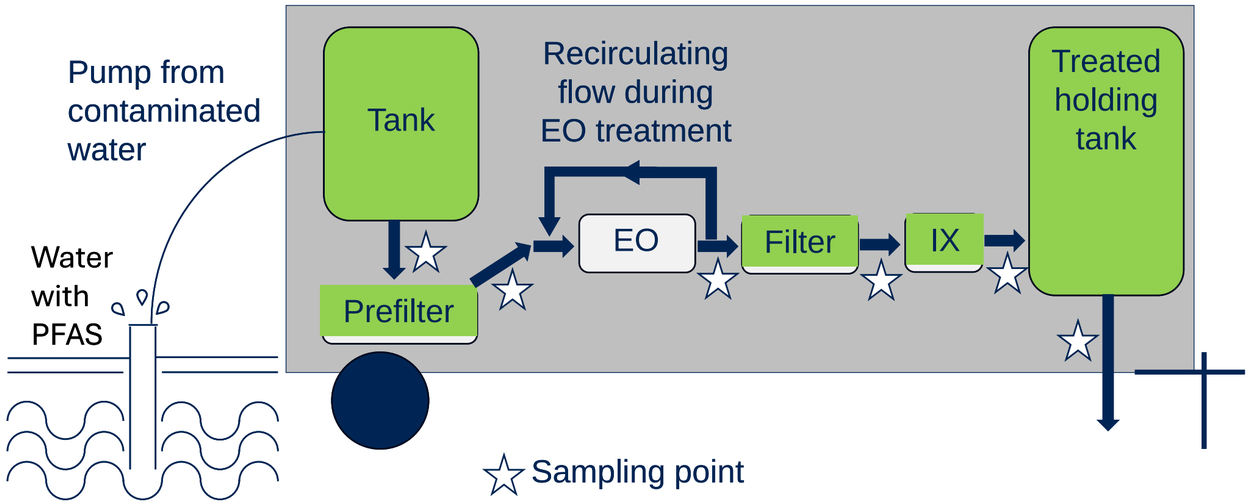
EC reactor components for use in pilot-scale treatment train.



Treatment System – Fabrication

- Reproducible
- Low-Cost

Off-the-Shelf Parts

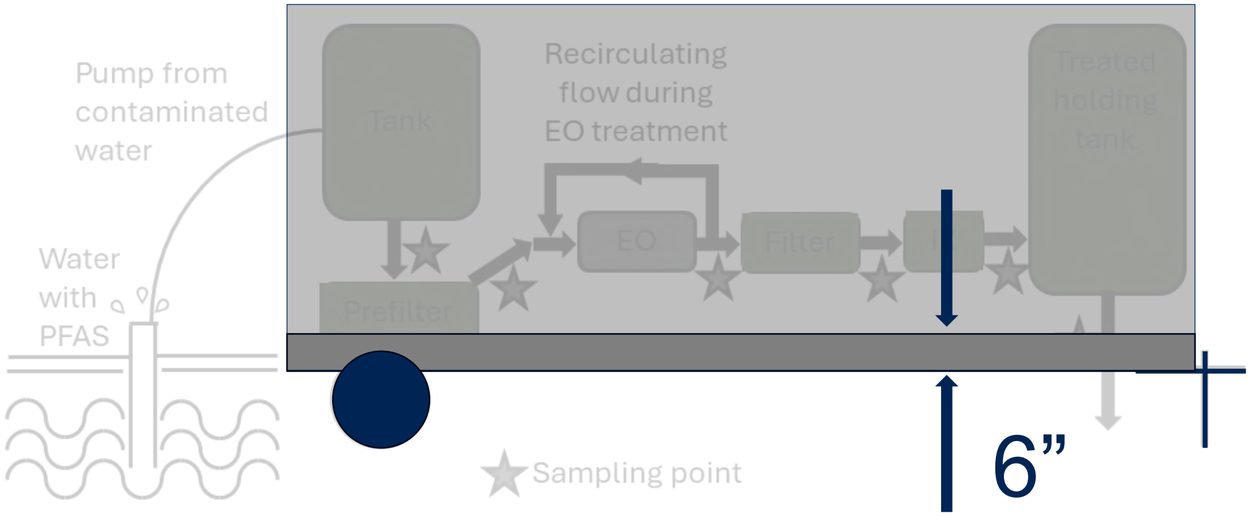


Treatment System – Trailer

- 5’ by 10’ Enclosed Trailer with 3500lb Axel and Ramp Door
- 5000lb – 24” Lift Scissor Jacks on Each Corner

Treatment System – Containment

- Silicone Mat Lined Floor
- Silicone Mat Lined Wall to 6”
- 100% Silicone Sealed



Treatment System – Water Pumping

- Peristaltic Pumps
- Silicone or HDPE Tubing
- Brass or Stainless-Steel Valves

Treatment System – Water Storage

- US Plastics
- HDPE or XLPE Tanks
- 100% Silicone Caulk

United States Plastic Corp.®

Treatment System – Sediment Filtration

- Pentair OMNIfilter 10”
- String Filter (5 µm)
- Spun Polypropylene (10 µm)

PENTAIR
WATER SOLUTIONS

Treatment System – Purolite™ Purofine™ PFA694E Ion Exchange Resin

- Polystyrenic Gel, Potable Water Grade
- Certified by WQA to NSF/ANSI-61 Standard
- Followed Design & Operational Guidelines
- 1.5 to 2.5 min. Empty Bed Contact Time

Treatment System – Power Supply

- Propane-Fueled AC/DC Generator
- Breaker Panel, GFI, Emergency Shut-off
- Sorensen XPF 60-20DP

AMETEK®
PROGRAMMABLE POWER

Treatment System – Assembly

- Stainless-Steel Bench
- Adjustable Configuration

Pilot Scale Demonstration had 3 phases

Initial Demonstration – July 2024

- Treatment Train located onsite at Offutt AFB

Design Optimization – August to October 2024

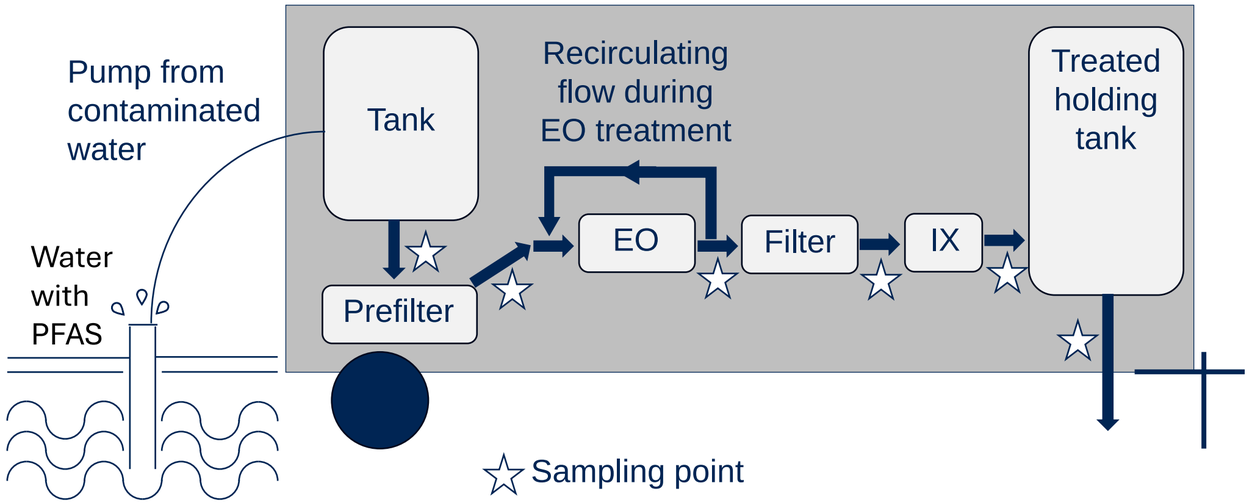
- Treatment Train located at SD Mines

Final Demonstration – December 2024

- Treatment Train located onsite at Offutt AFB

Initial Pilot Scale Demonstration – July 2024

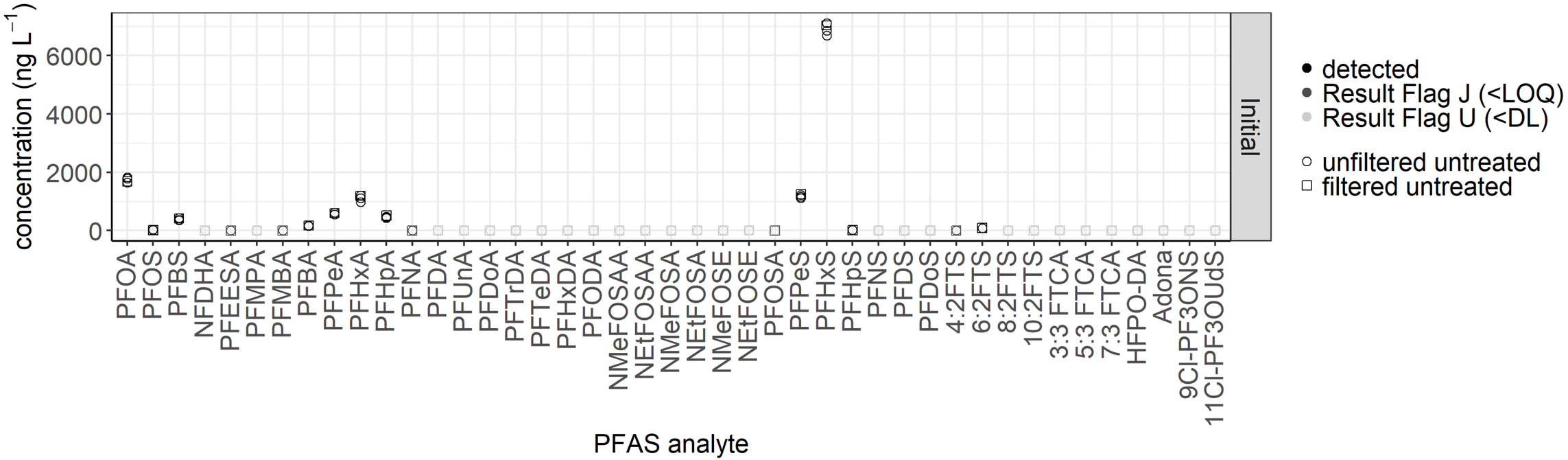
- 3 treatment voltages (5, 10, and 12 volts)
- 2 treatment durations (15, 20, 40 minutes)
- Treatment Train located onsite at Offutt AFB



Initial Pilot Scale Demonstration – July 2024

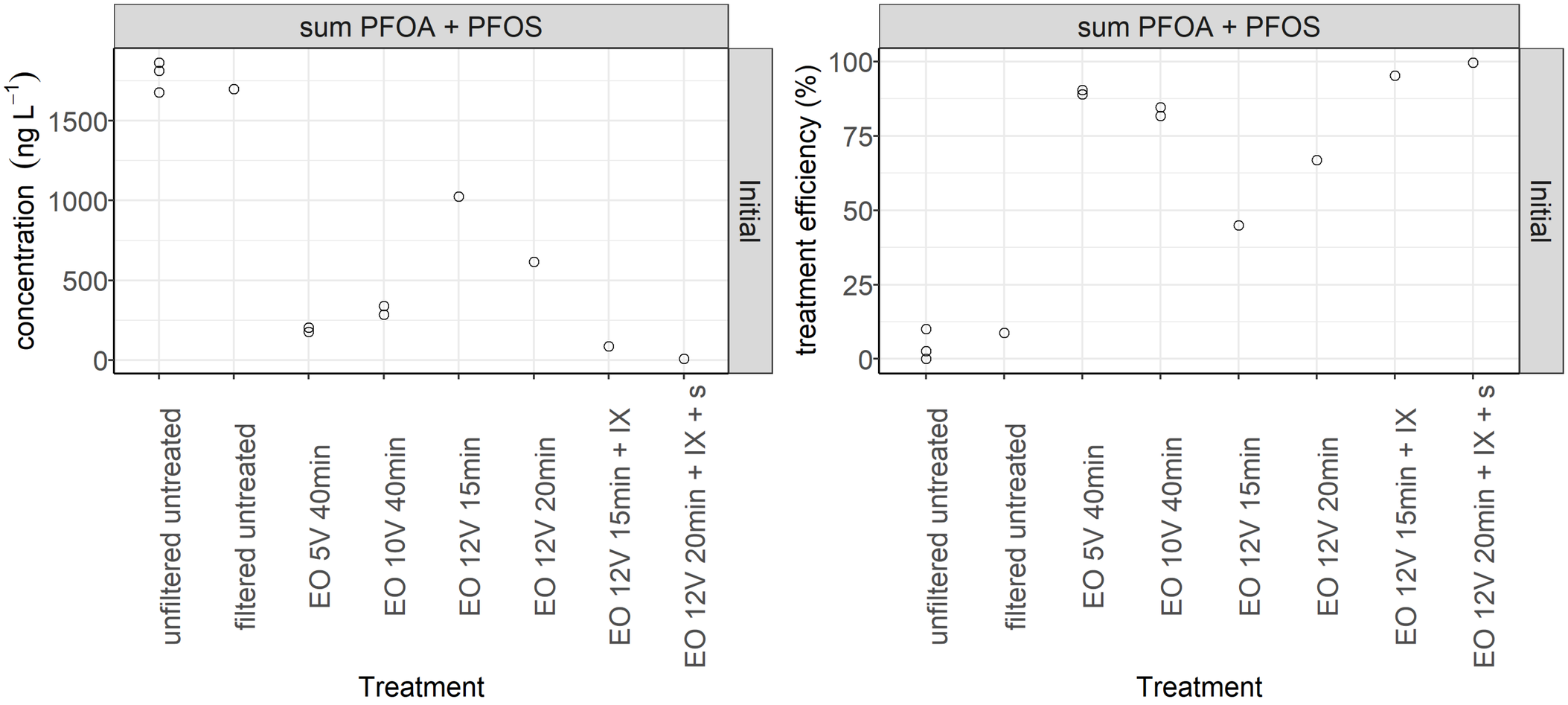
Untreated water

- 11 PFAS have concentrations > LOQ,
- 5 PFAS have concentrations < LOQ,
- 27 have concentrations < DL



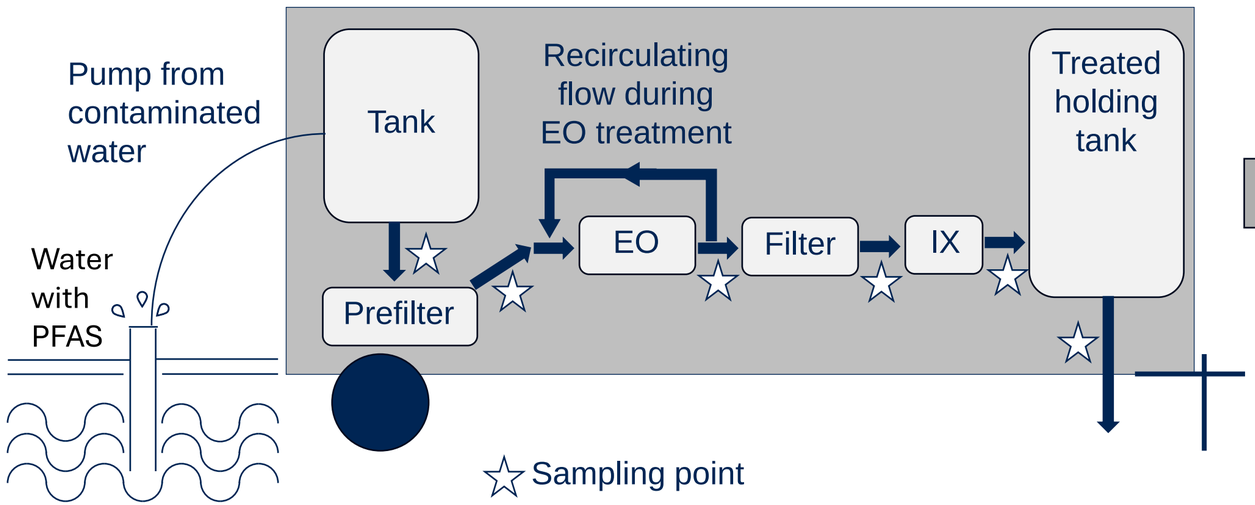
Initial Pilot Scale Demonstration – July 2024

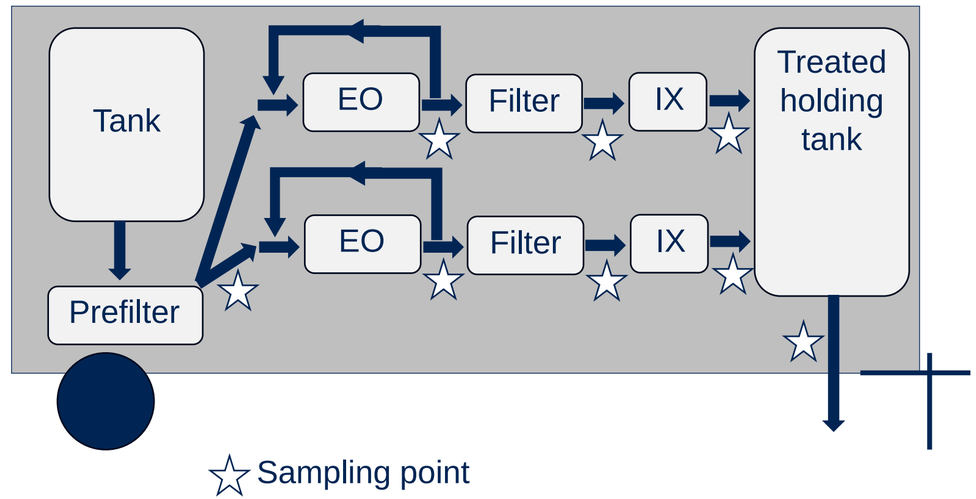
Treatment efficiency 66.9% for EO 12V 20 min



Design Optimization – August to October 2024

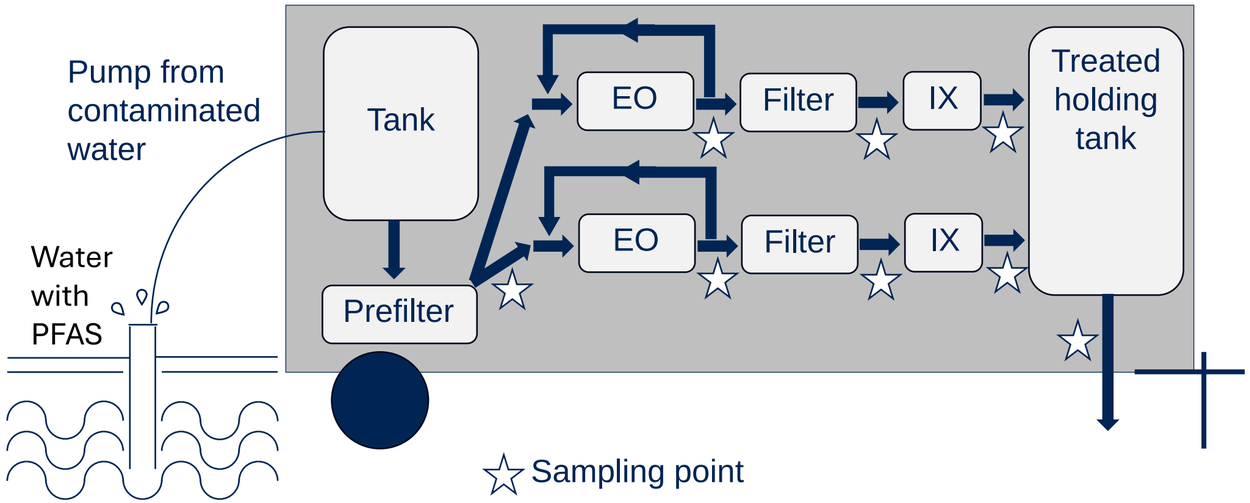
- Treatment Train located onsite at SD Mines
- Optimized electrochemical parameters
- Added a second parallel treatment system





Final Pilot Scale Demonstration – December 2024

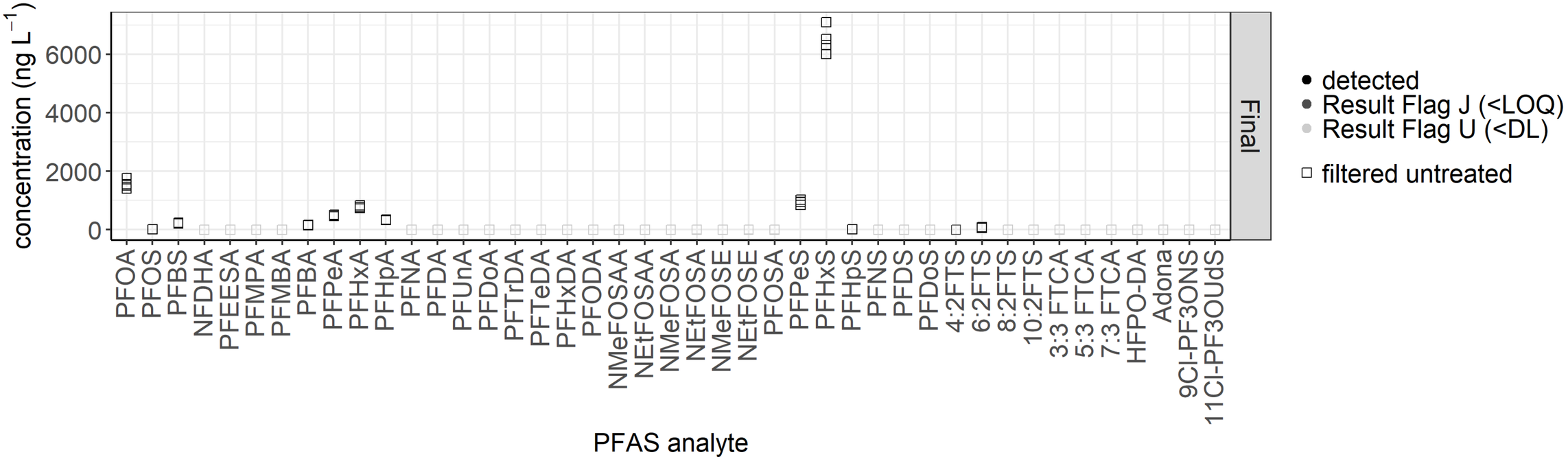
- 2 parallel treatment systems
- EO treatment - 12 volt for 20 minutes
- Treatment Train located onsite at Offutt AFB



Final Pilot Scale Demonstration – December 2024

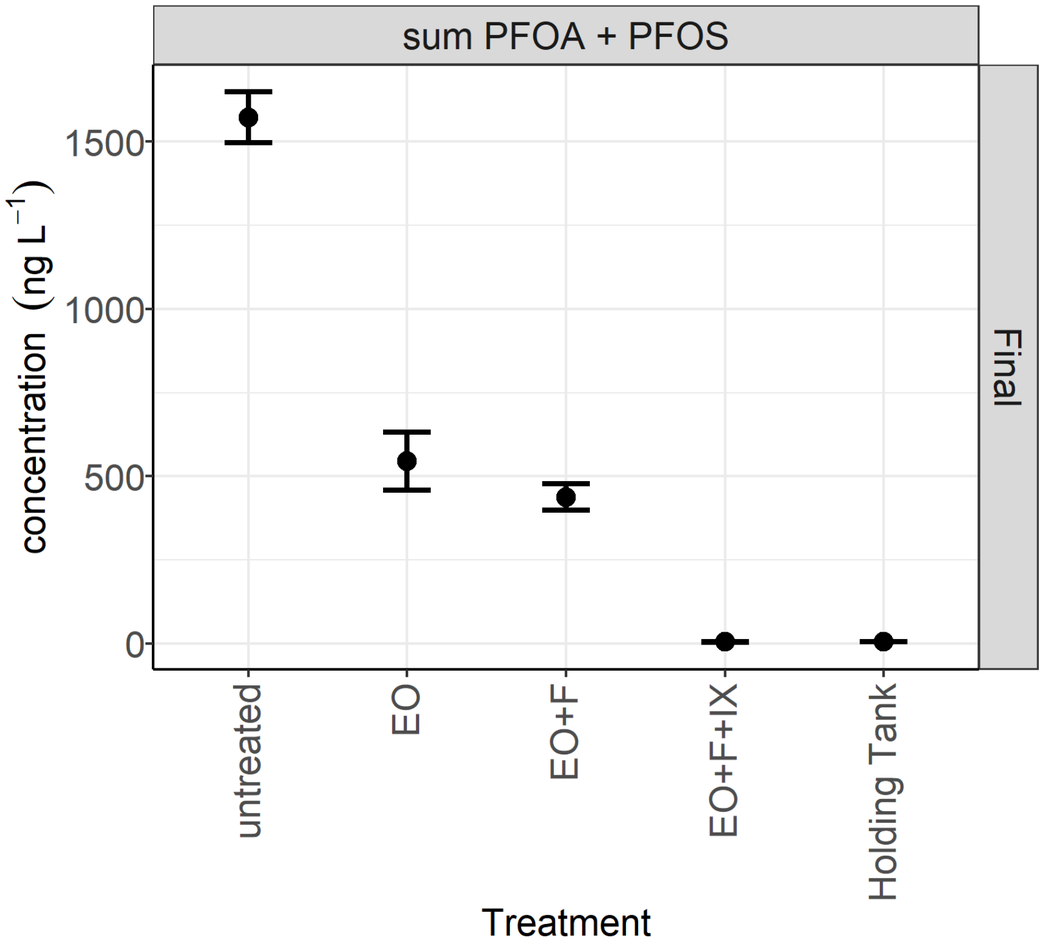
Untreated water

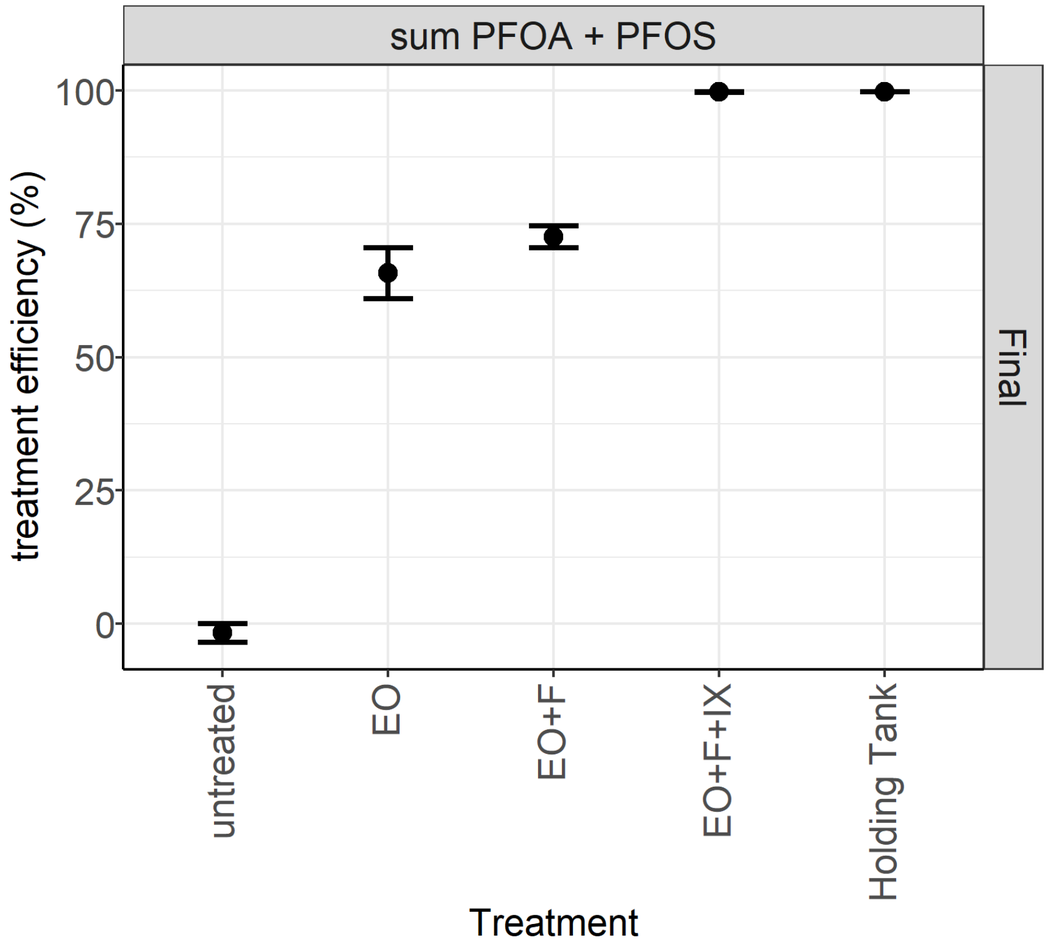
- 11 PFAS have concentrations > LOQ,
- 1 PFAS have concentrations < LOQ,
- 31 PFAS have concentrations < DL



Final Pilot Scale Demonstration – December 2024

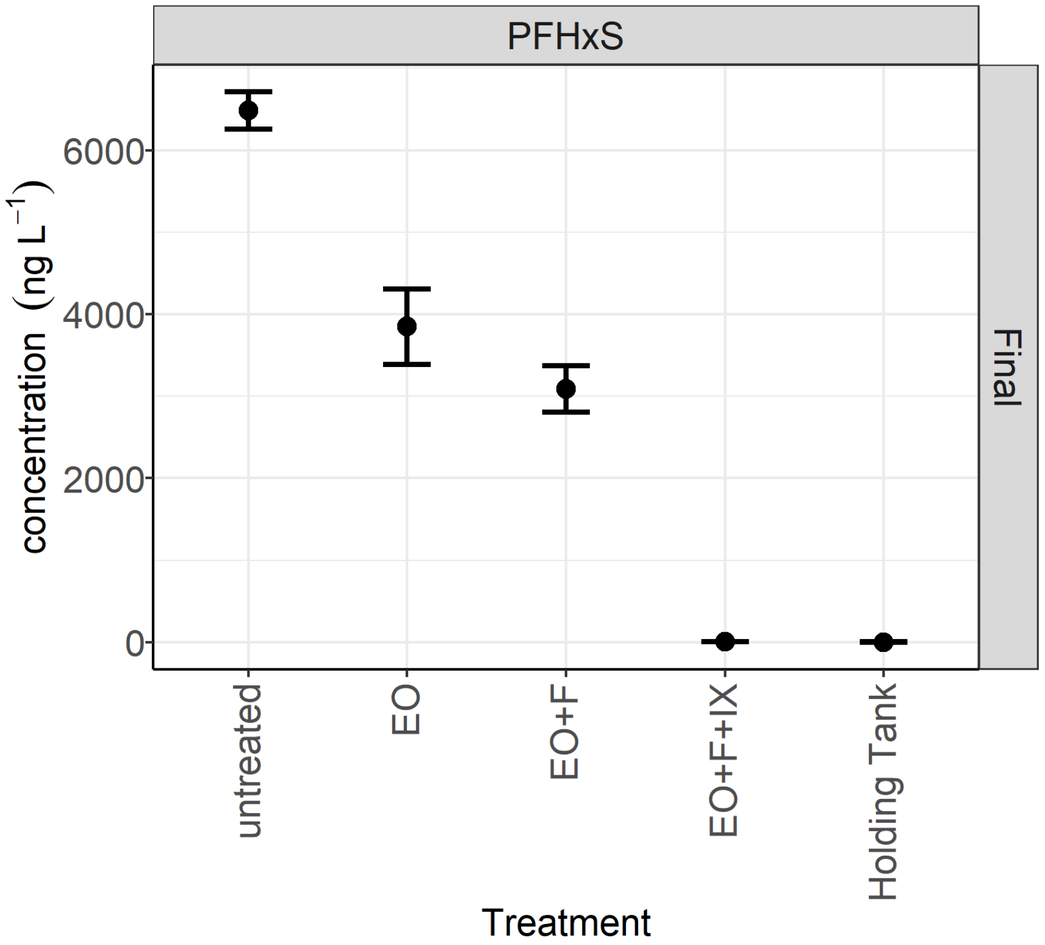
Treatment efficiency 65.7% for EO and 99.7% for EO+F+IX

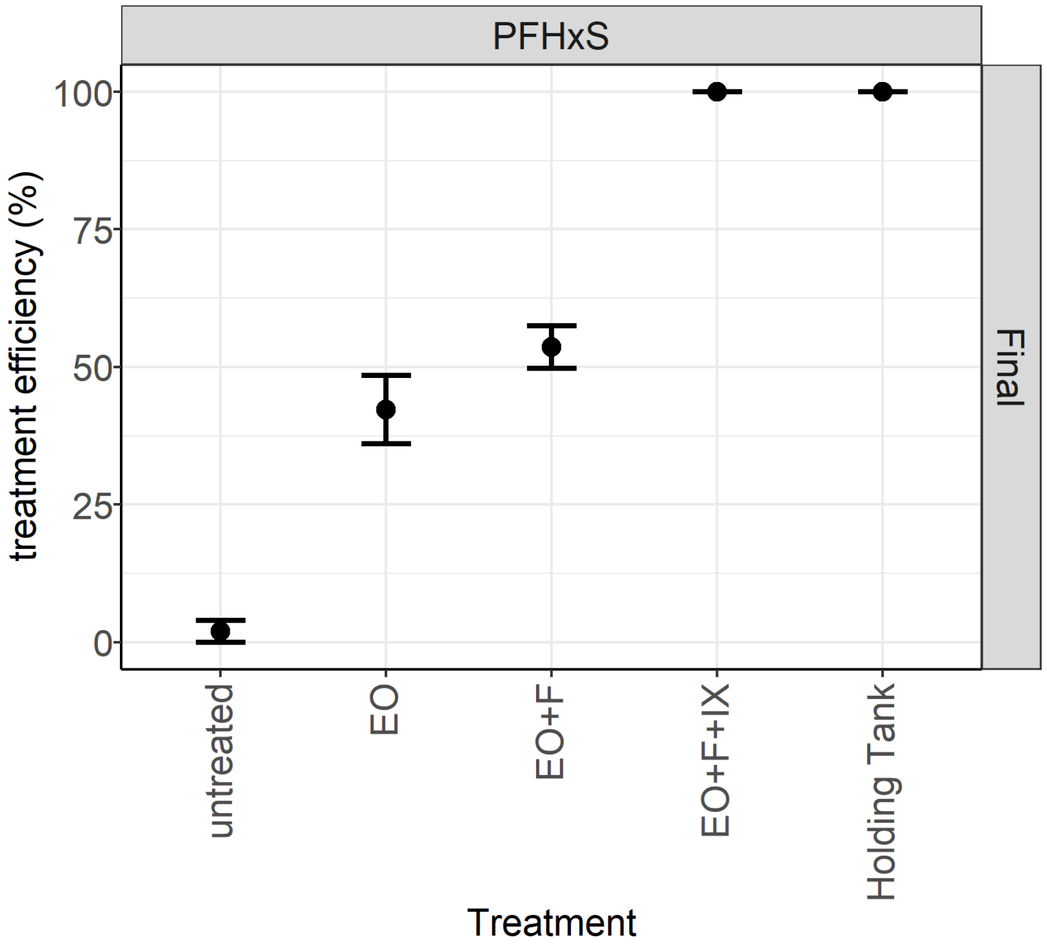




Final Pilot Scale Demonstration – December 2024

Treatment efficiency 42.3% for EO and 99.9% for EO+F+IX





SOUTH DAKOTA MINES

CURIOUS
SMART
TENACIOUS

Pilot-scale summary

- EO at 12 V for 20 minutes reduced the sum of PFOA + PFOS by 66% in untreated groundwater without detectable increases in any evaluated PFAS
- EO at 12 V for 20 minutes reduced PFHxS by 42%
- Downstream, IX achieved >99% removal across assessed PFAS, producing effluent consistent with 4-ng L^{-1} EPA MCL

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Project Summary- Key Performance Metrics

Project Summary:

- Created cost-effective electrodes using nanotechnology
- Developed portable water treatment train for PFAS remediation
- Training the next generation of scientists and engineers

Key Performance Metrics:

- Electrochemical Oxidation (EO) treatment reduced PFOS+PFOA concentration to 545 ng/L, achieving 66.2% destruction with no detectable PFAS byproducts.
- Ion Exchange (IX) treatment removed the remaining PFAS lowering individual PFOS and PFOA concentrations to near or below the detection limit (DL=2.3 ng/L). The combined PFOS+PFOA was reduced to 4.6 ng/L, resulting in 99.7% overall treatment efficiency.
- Samples from the treated holding tank which combined all treated water confirmed successful destruction and removal of 99.7% PFOS+PFOA, validating the mobile pilot-scale treatment

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SOUTH DAKOTA MINES

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Questions?

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