MAX-IR LABS

Making infrared sense

PFAS sensor for remediation and industrial wastewater treatment optimization applications

Max-IR Labs
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NIEHS Grant # 2R44ES033581-02

Technology overview: Field analysis

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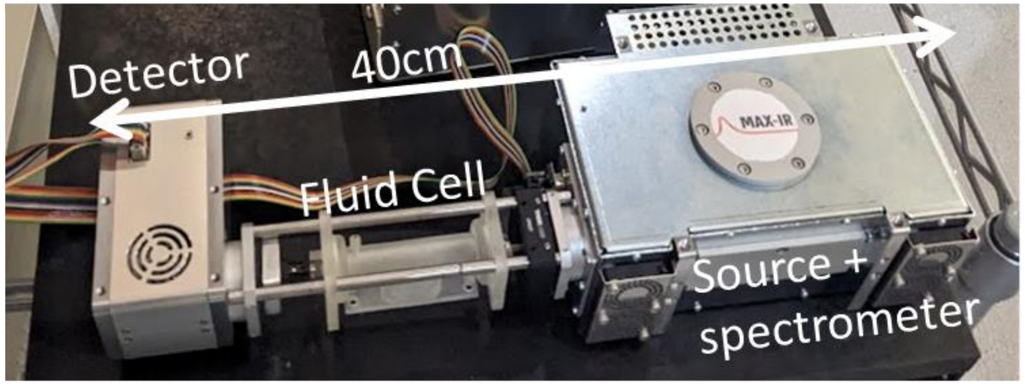
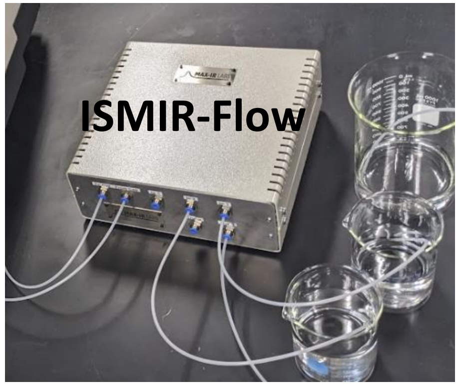
- **Field-ready PFAS sensor**
- **Based on infrared sensing**
- **Direct analysis of fluids**
- **Limit of detection (ΣPFAS):**
  - **10ppb field**
  - **0.1-1ppb lab**
- **Sensor cost $50K-$70K (Lab version:$10K)**
- **Inline analysis**
- **Continuous flow**
- **Data available every 20-30min**
- **Applications:**
  - **Remediation**
  - **Industrial wastewater effluent**
  - **Reclamation**

Fluid sampling





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ISMIR: Ion-selective Measurement using Infrared

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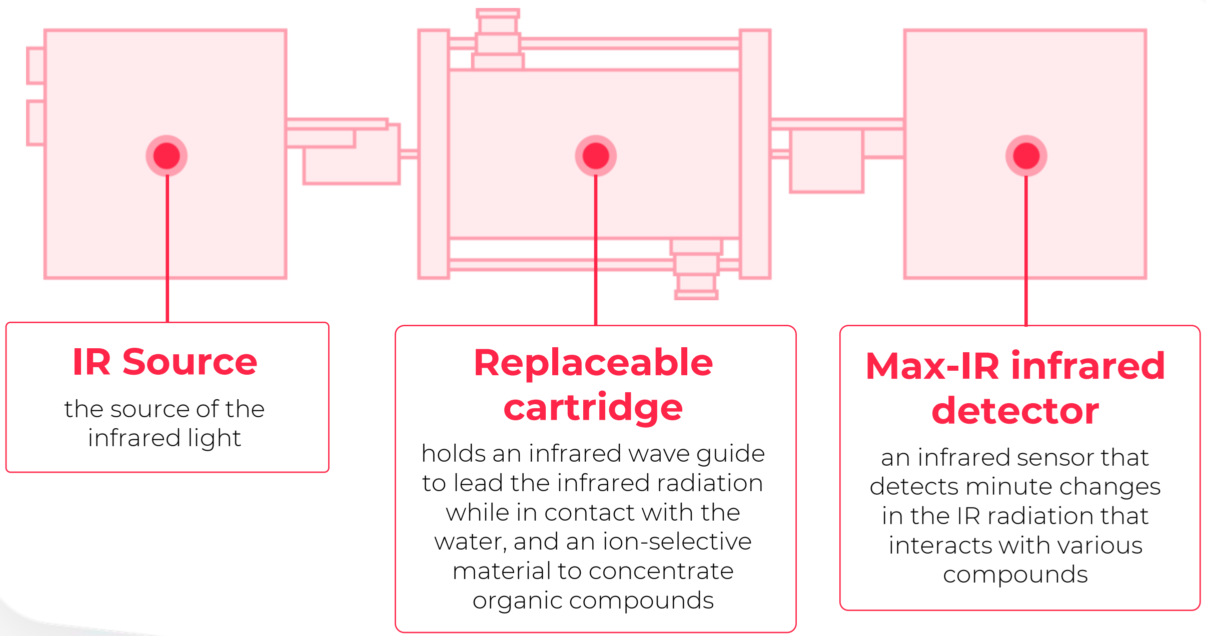
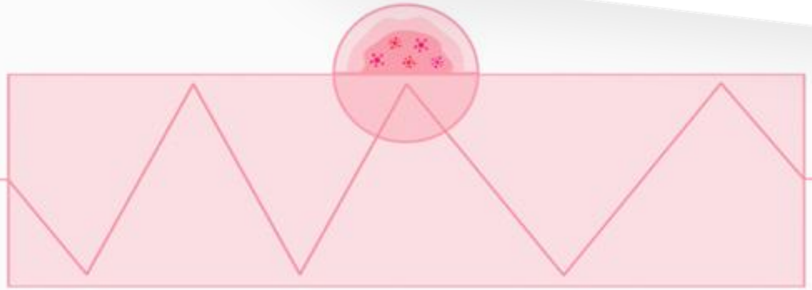
1. An infrared signal is passed down a special optical fiber in contact with the liquid.
2. The electromagnetic field associated with the infrared signal penetrates a short distance into the water where it is absorbed by target compounds.
3. This effect generates small changes in the IR signal, which are detected by the sensor.

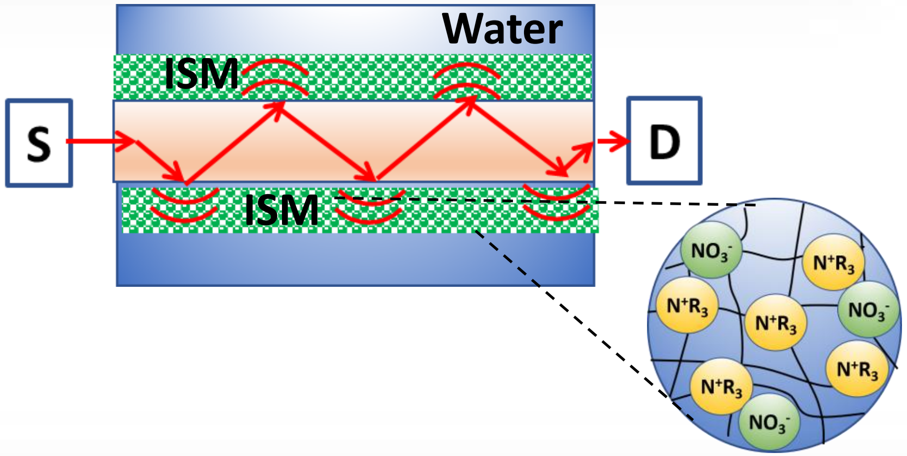


US. Patents #10,890,525, #10,883,930, #10,613,025, and #10,458,907

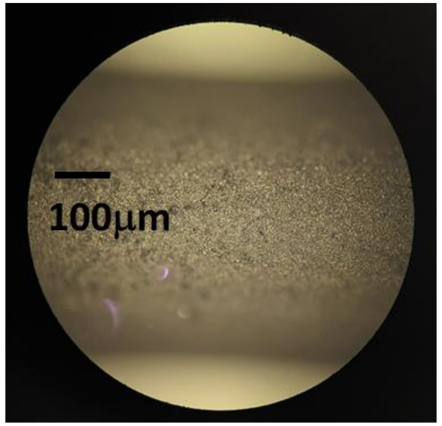


Waveguide coating

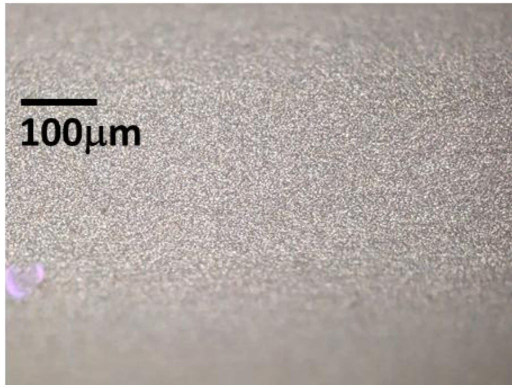
Operation principles: infrared absorption



Activated Carbon

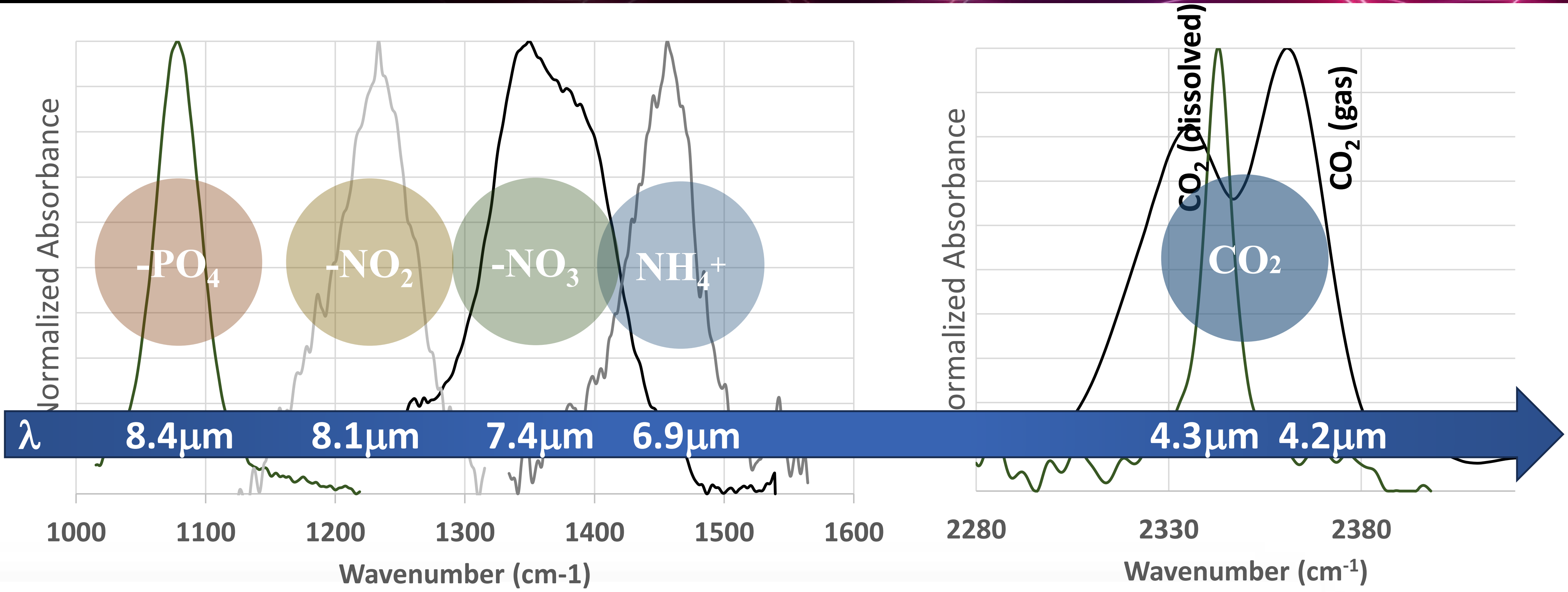


ISM (ion-selective material)



- **Chemical coating of waveguides:**
  - Efficient
  - Good contact with the waveguide surface
  - Good IR signal transfer

Operation in IR spectral range: non-PFAS



- IR spectroscopy is a very powerful tool for water analysis
- Detection of molecular species
- Blind to free atoms (free fluorine, free chlorine)

PFAS capture: PFSA, PFCA, short and long chain

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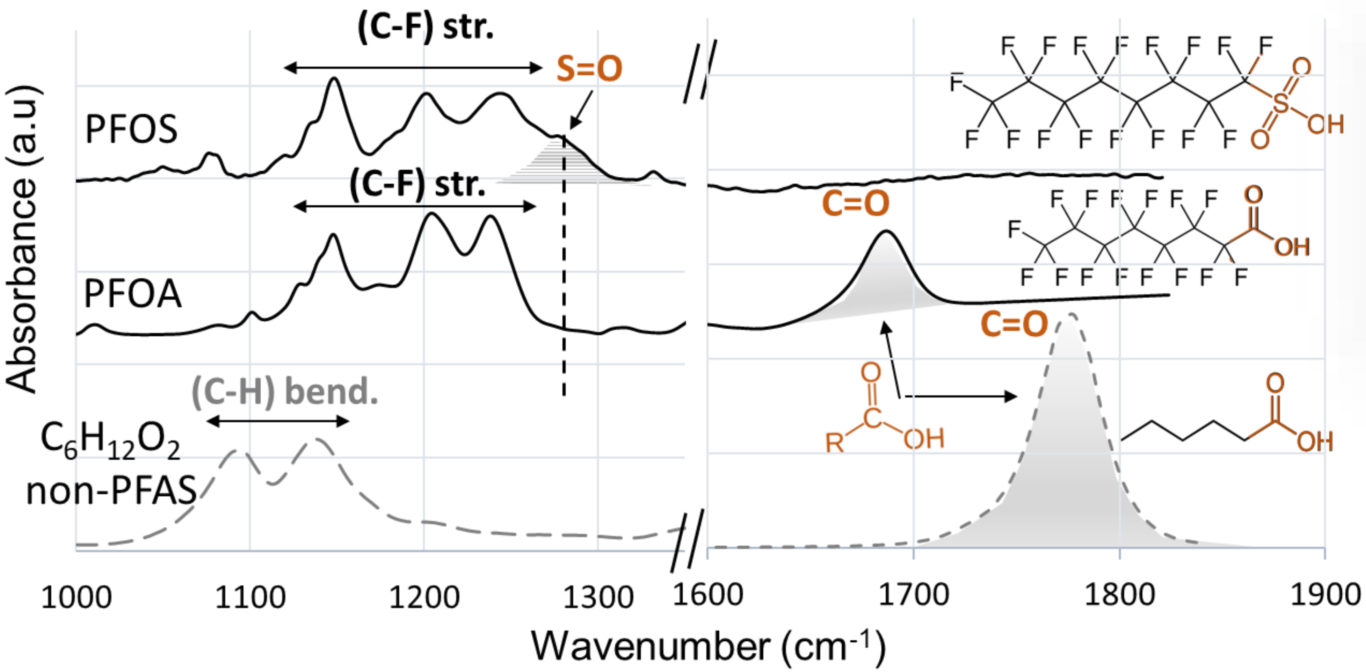
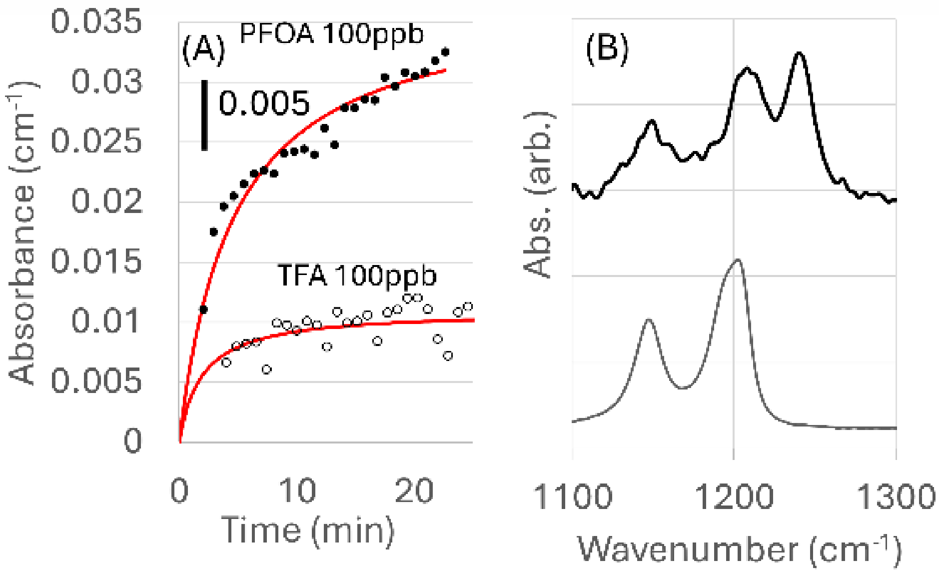
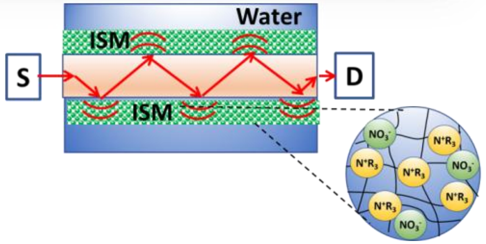


- **Field tests:**
  - **Short and long chain PFAS**
  - **Speciation capability (by chain length, head group)**



Operation principles: infrared absorption



RO Brine analysis

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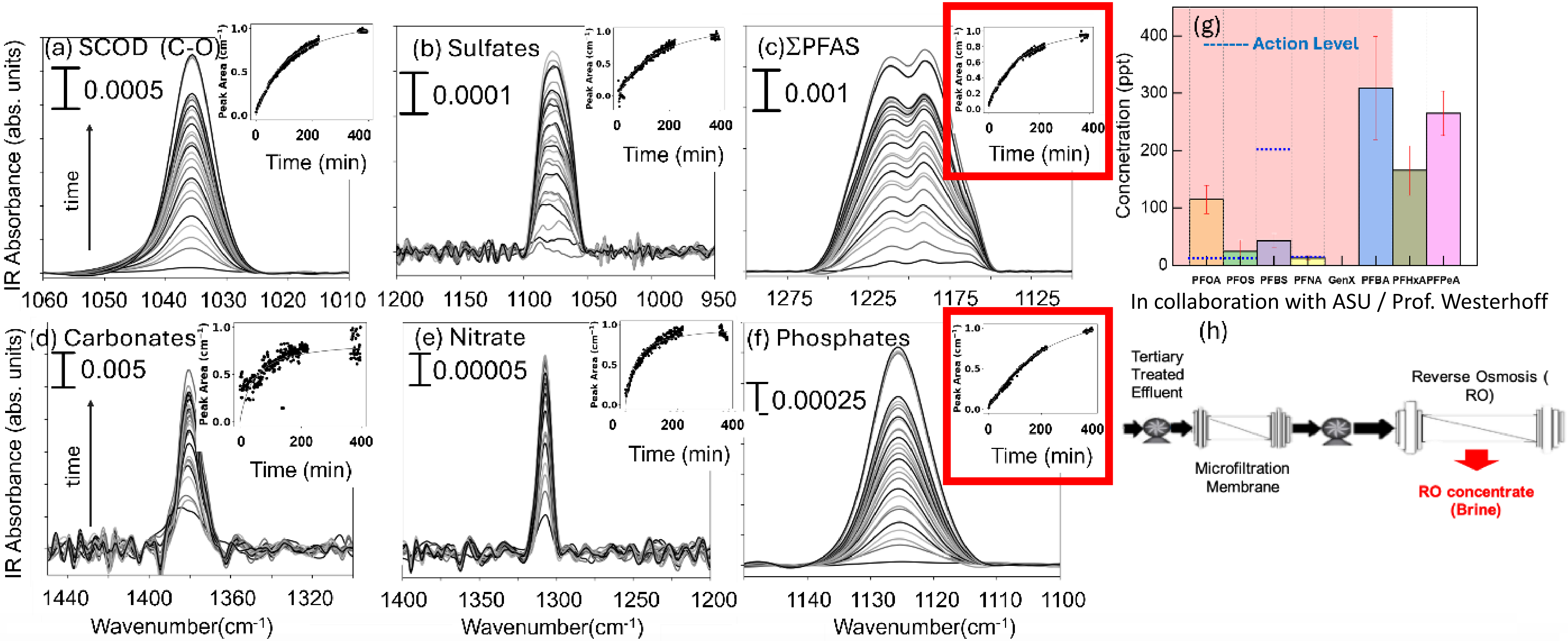

- **In addition to PFAS, the senor provides information on nitrate, sulfates, phosphates and other compounds present in water**

PFOA measurement – Data fitting

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Data is fit to a pseudo-second-order kinetic model

Pseudo-second-order kinetics

$$\frac{dC_t}{dt} = \pm k_2 (C_t - C_e)^2$$

Solve for concentration in fiber coating (q_t)

$$q_t = \frac{k_2 q_e^2 t}{k_2 q_e t + 1}$$

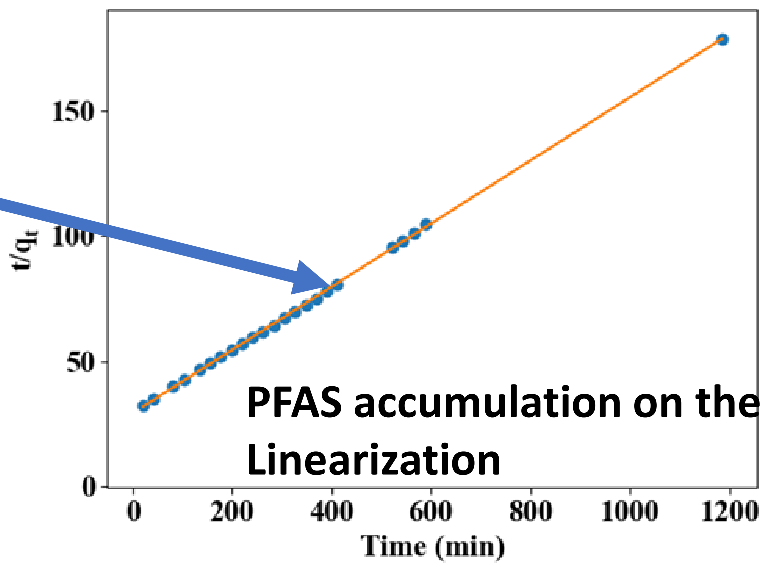
Linearized equation

$$\frac{t}{q_t} = \frac{1}{q_e^2 k_2} + \frac{1}{q_e} t$$

Linear equation – constant change in output with time

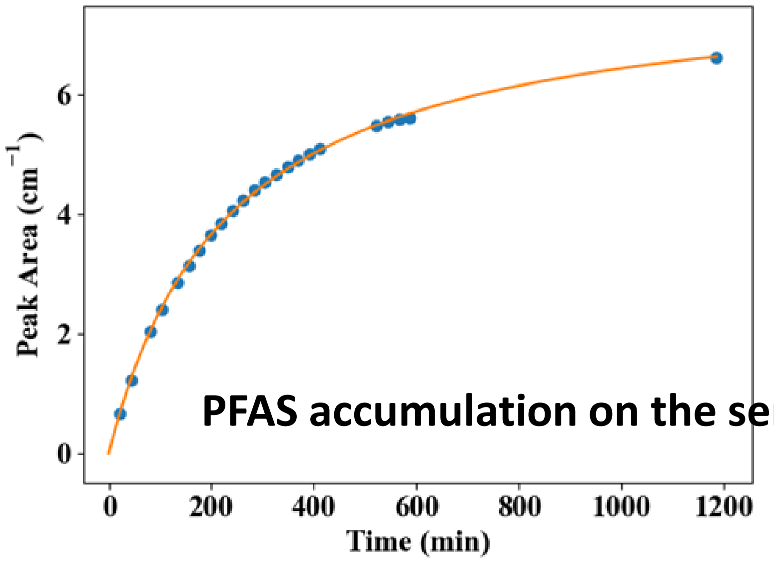
We can use this to predict the final value at any time

Psuedo-second order linearization



PFAS accumulation on the sensor: Linearization

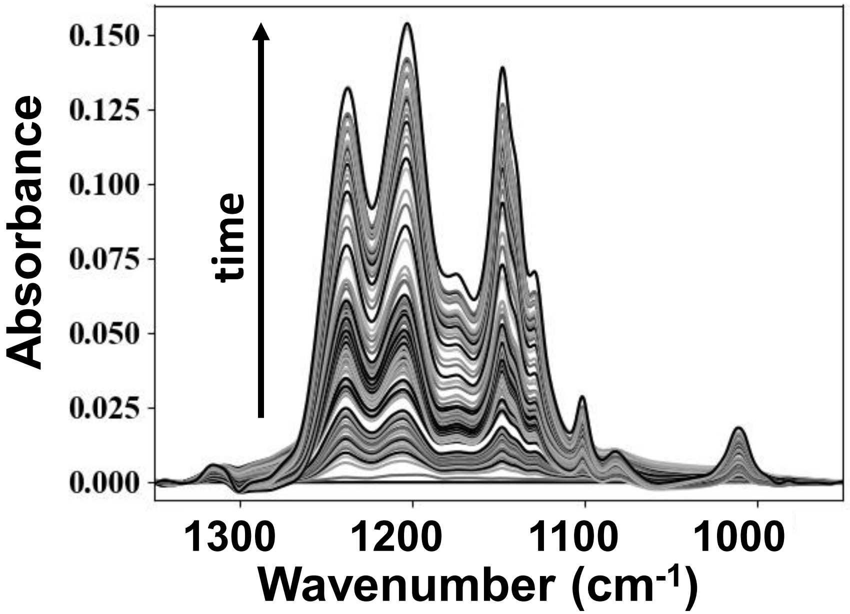
Psuedo-second order data fit



PFAS accumulation on the sensor

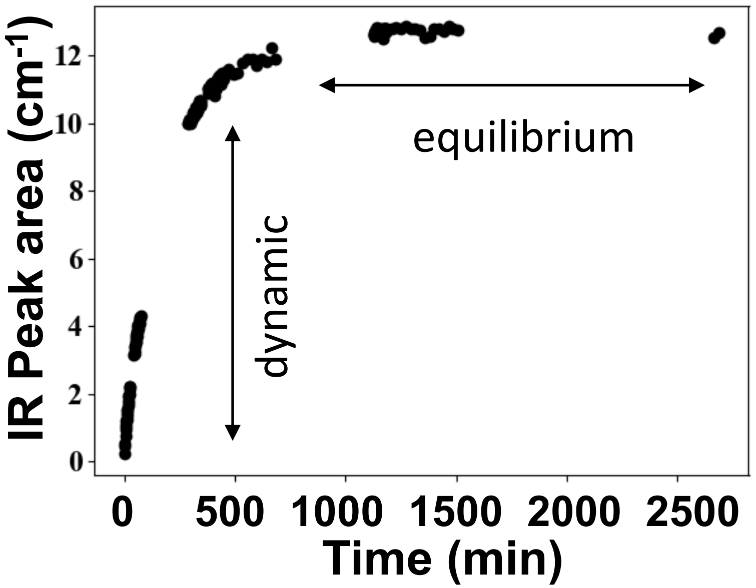
Measurement and regeneration

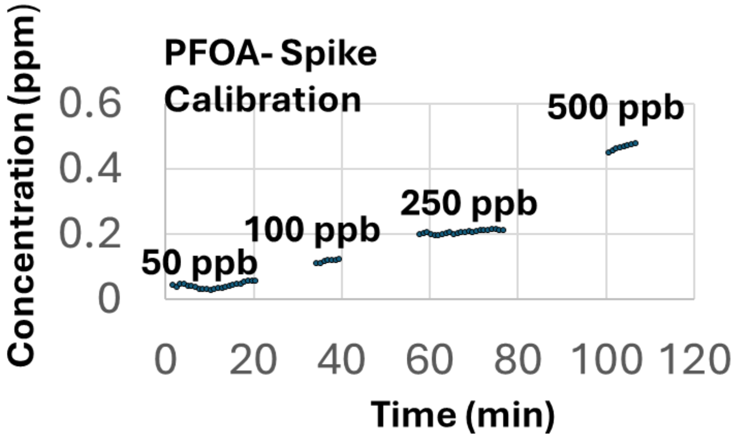
(a) Trap-and-measure analyte



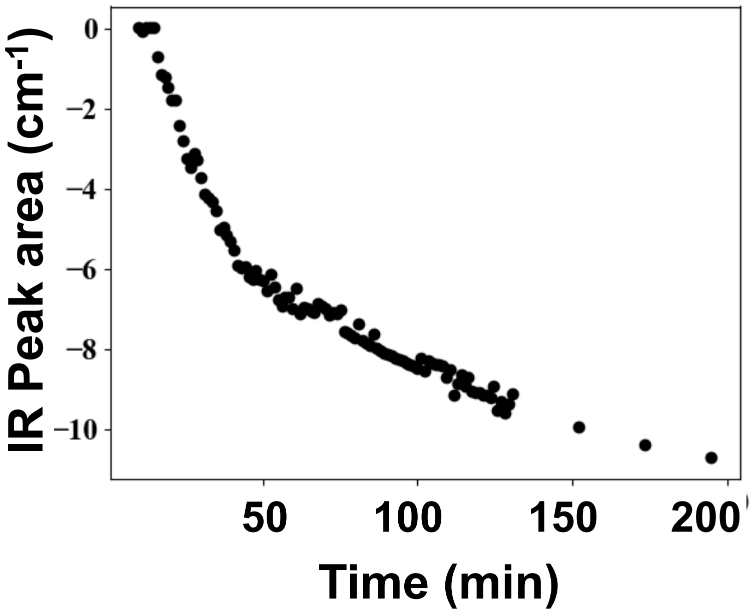
Real-time analysis of kinetic behavior
➔ PFAS concentration in fluids

(b) Analyze IR absorption vs. time





(c) 1%-10% NaCl regeneration

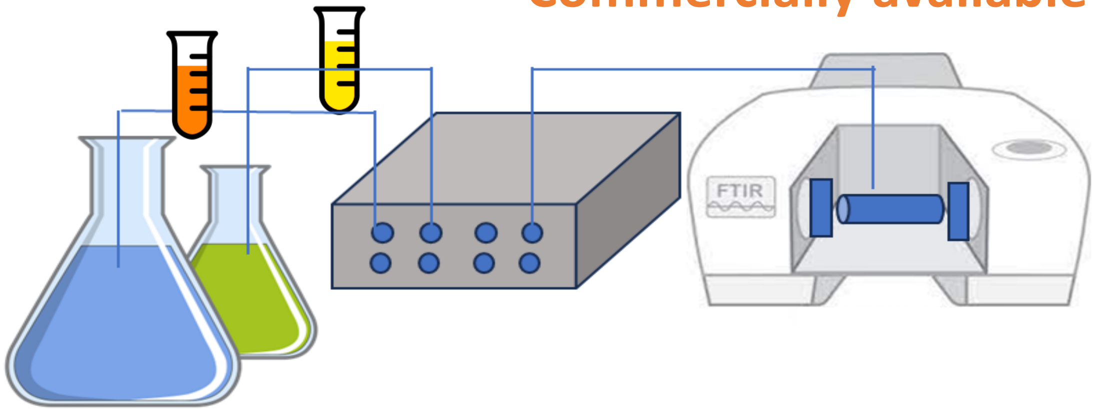


T.B. Daunis et al., Proc. SPIE 12835 (2024)
https://doi.org/10.1117/12.3008672

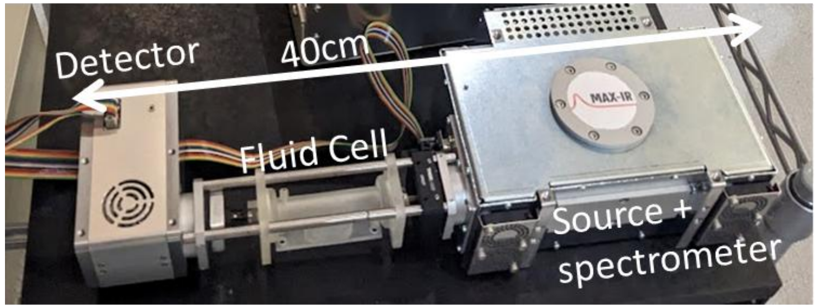
PFAS sensor: lab product for sorbent material screening

- **Streamline characterization of novel sorbent materials (GAC, ion-exchange resins, etc.)**
- **Quality control**
- **Fast characterization of new materials, screening of multiple conditions**
- **Rapid small-scale column tests (RSSCT)**

Commercially available

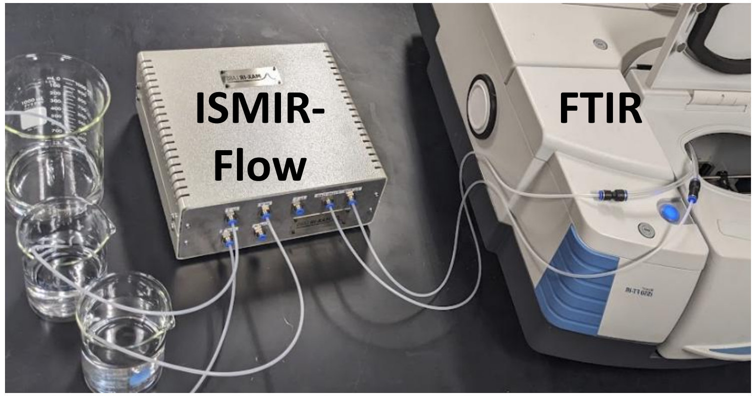


Full Field system (in development) $50K-$70K



Or

Lab Accessory (commercial) ($10K)

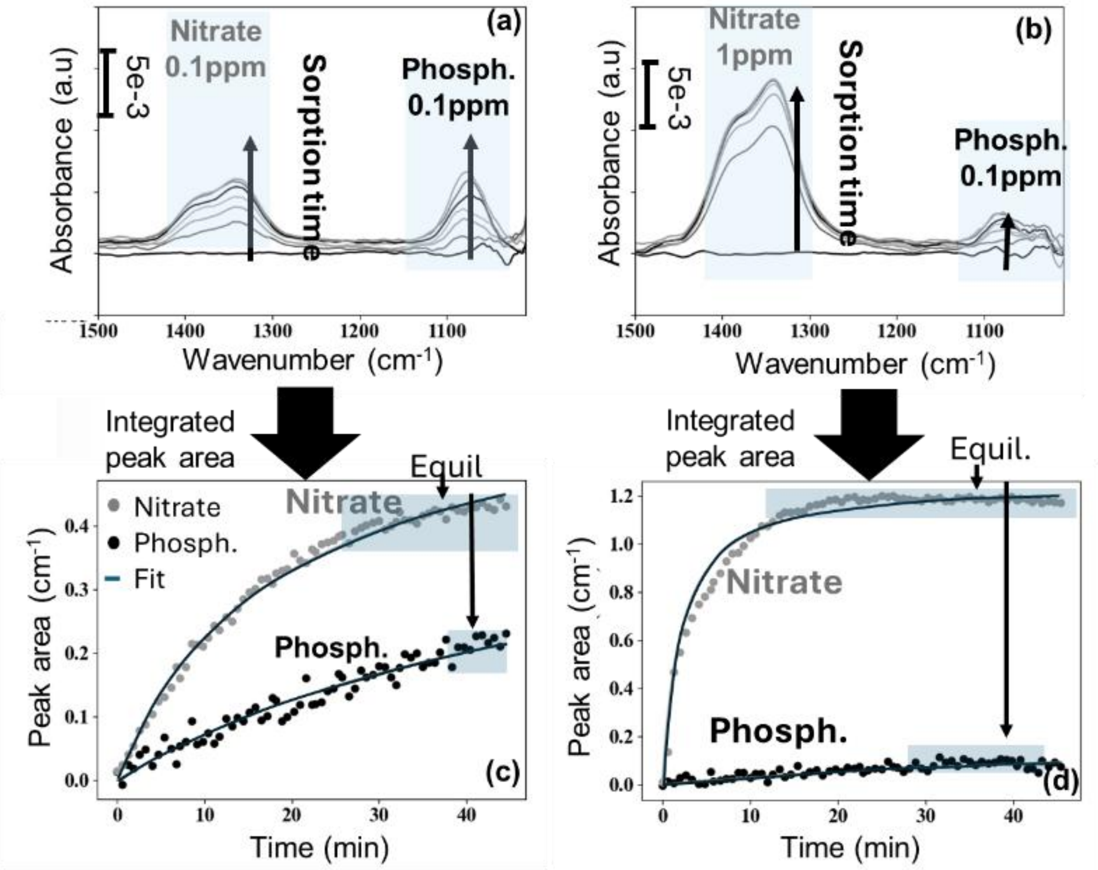


- **Accessory** price for customers who have their own FTIR
- **Max-IR Labs' field sensor (including FTIR)** is available upon request as beta-prototype

Other applications: screening of sorbents

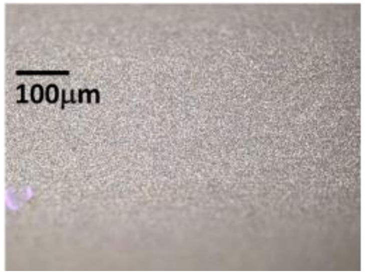
- **Helping customers in development of their sorbent materials**
- **Characterize competing ions in real time**
- **Characterize rates, capacity in real time**
- **Multiple conditions, in a controlled manner**

Nitrate / orthophosphate competition and sorption rates



Tests for ion-exchange resins

Coated waveguides (available at Max-IR Labs)



Max-IR Labs Team

Grant Information	Dr. Katy Roodenko, CEO, Max-IR Labs, "PFAS sensor for remediation and industrial wastewater treatment optimization applications", Grant # 2R44ES033581-02, https://reporter.nih.gov/project-details/11005267
Presenter	Katy Roodenko, PI
Technology Name and Description	**IR-SMART™ (Infra-red Sorbent Material-Amplified Rapid Trace)** is a PFAS monitoring sensor that integrates **infrared spectroscopy with sorption-enhanced optical waveguides**. The technology is based on Max-IR Labs' ion-selective material with IR detection (**ISMIR™**).The device employs a "trap-and-measure" approach, using ion-exchange polymer coatings and attenuated total reflection (ATR) for **real-time, field-deployable detection of PFAS at 0.1ppb or better** in complex water and wastewater conditions.
Innovation	**IR-SMART™ is** the first field-deployable PFAS detection system that combines sorption-based preconcentration with infrared spectroscopy, enabling direct, inline measurements at sub-ppb levels. Unlike existing LC-MS or ion chromatography methods, IR-SMART™ provides on-site monitoring without costly consumables or specialized operators. The platform is adaptable across water, wastewater, and industrial effluents, with estimated cost savings of 60–80% compared to LC-MS workflows due to lower instrument cost, simplified operation, and reduced sample handling. Its modular fiber cartridge design further supports application extension to other contaminants (e.g., nitrates, ammonia, inorganic carbon). **IP Status:** Patent application filed (U.S. Non-Provisional, Patent # **19/277,335** "METHOD FOR INTEGRATION OF SORPTION MATERIALS AND DATA ANALYSIS FOR DETECTION OF CONTAMINANTS IN FLUIDS" filed Aug 2025.
Contaminant and Media	**IR-SMART™** sensor targets per- and polyfluoroalkyl substances (PFAS), including a range of carboxylic (PFCA) and sulfonic (PFSA) acids, in groundwater, surface water, and industrial wastewater. The sensor achieves a limit of detection of 0.1 ppb, with measurement times of 3-6 hours, compared to weeks for laboratory analysis. Estimated costs are <$50 per measurement versus ~$550 for lab-based methods. Current efforts include optimized coatings for different PFAS classes and ongoing ruggedization for long-term field deployment.
Technology Readiness Level	**IR-SMART™** sensor is currently at TRL 5-6 (pilot scale system), having been validated in laboratory and controlled water settings. Field testing at remediation sites is planned in 2026, advancing the system to TRL 7 (full scale demonstration). Market availability is anticipated within 2-3 years, with beta prototypes already commercially available.
Site Work	Site work will be conducted at a water reclamation facility under NDA; while the location cannot be disclosed, it provides representative conditions for remediation testing.
Main Point of Contact and Social Media	[Main Point of Contact: Dr. Katy Roodenko, email,: kroodenko@max-ir-labs.com phone: 214-228-7213] [Links to Social Media: LinkedIn: https://www.linkedin.com/company/max-ir-labs]
Graphics (s)	Provided in this talk