“A Novel Sensor For Detecting Landfill Odors”

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HINKLEY CENTER FOR SOLID AND HAZARDOUS WASTE MANAGEMENT

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Challenges for Quantification

- **Subjectivity and different individual perception of odors**
- **Human odor sensing panels are the standard**
- **Low-cost, objective methods are not readily available**

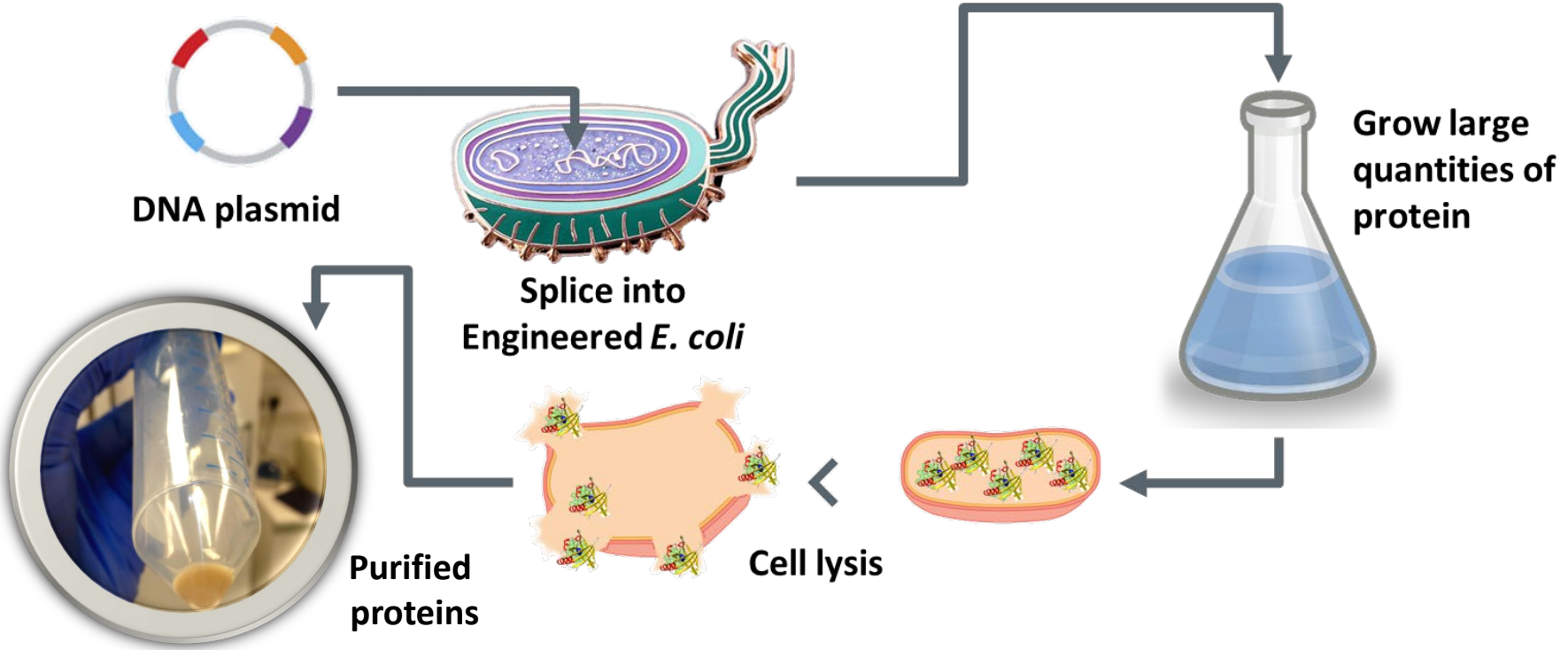
State-of-the-art Odor Measurement Devices

- Typically work only for specific odorants
- Unable to deal with adverse environmental or meteorological conditions (temperature, humidity, etc.)

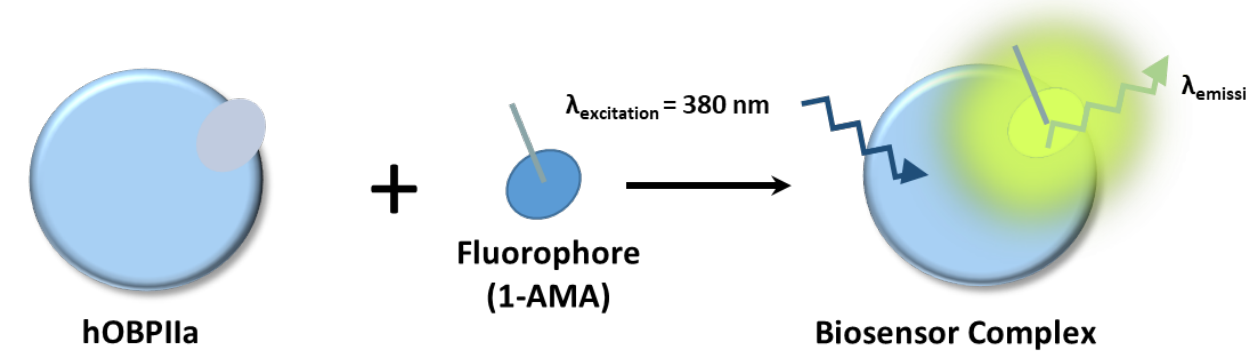
Research Inspiration

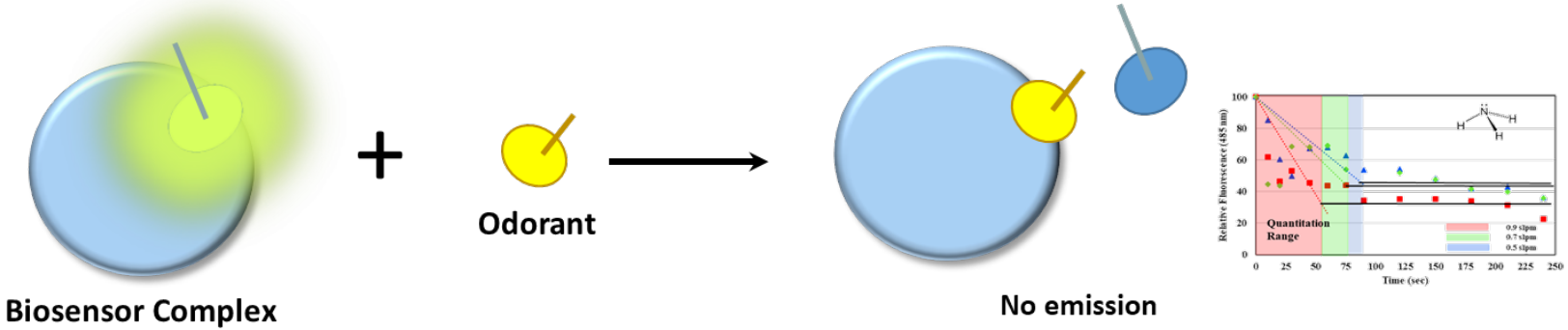
- Turn to biology for inspiration
- Silva et al. (2013) used porcine Odorant Binding Proteins (pOBP) to mask the smell of cigarettes
- OBPs can bind with odorants in the μM-range and the odor intensity is based on the number of bound receptors
- OBP biosensors can be a potential game-changer for dealing with odors

Protein Manufacture

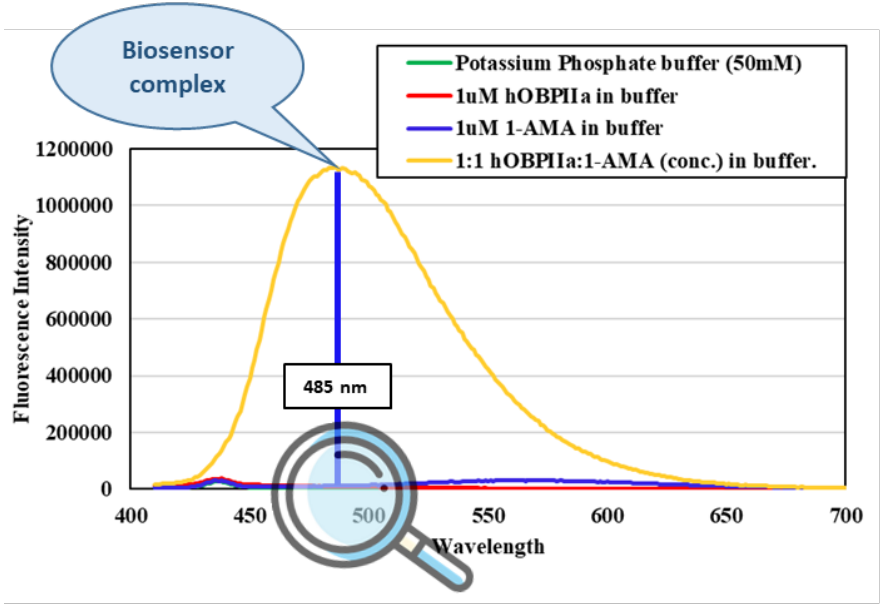


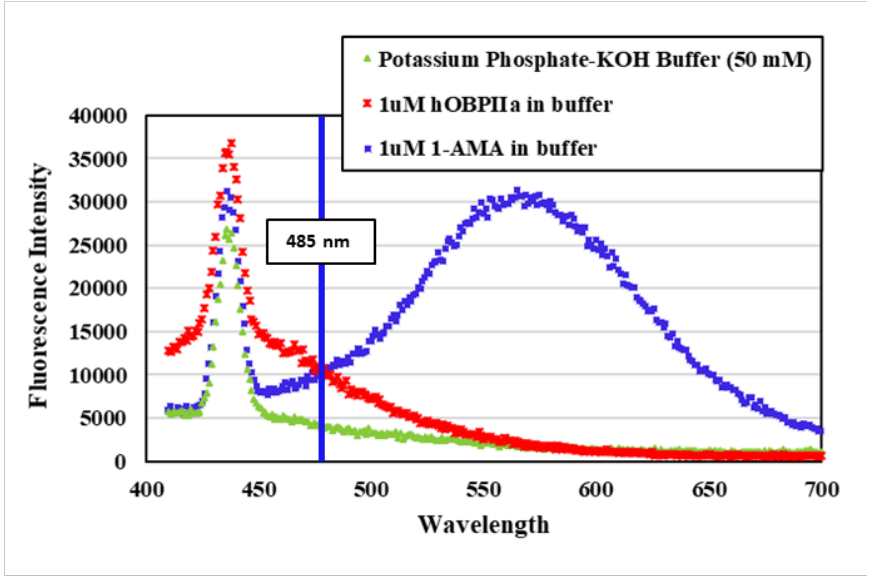
Biosensor Design





Fluorescence Binding Assay

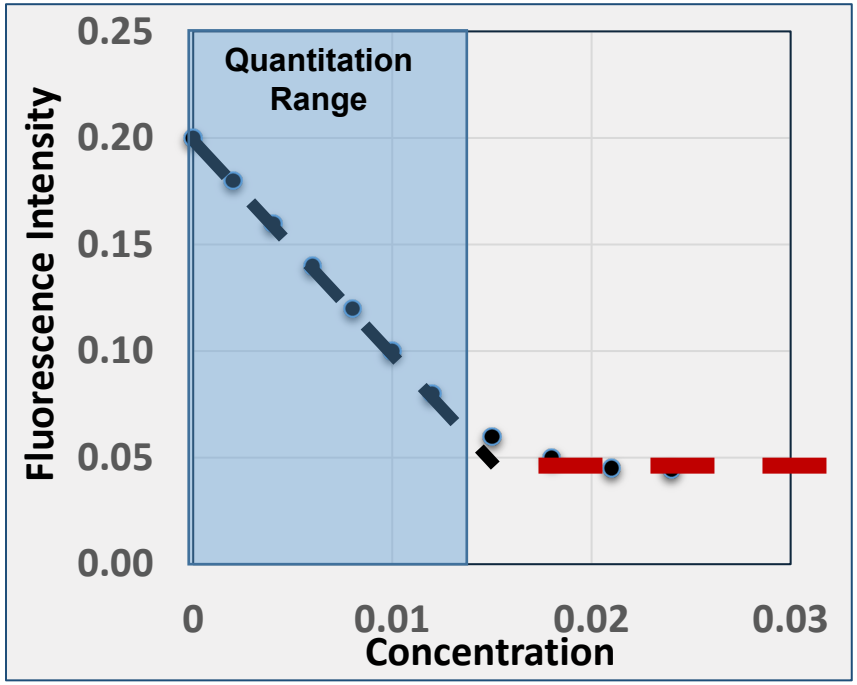


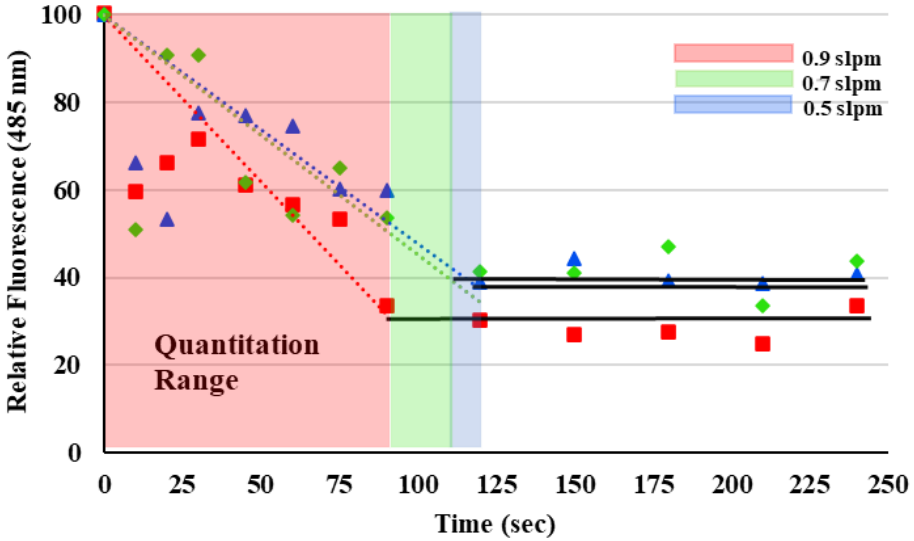


Year 1 Findings

- **Created prototype biosensor**
  - hOBPIIa + 1-AMA complex
  - Verified no signal interference from biosensor components and non-odorant gas
  - Verified optimum fluorophore to protein ratio (1:1)
- **Exposed biosensor to single odorants, LFG components & mixtures**
  - H_2S, NH_3, CH_4, CH_4S, CO, ambient air, N_2
- **Measured spectroscopic signal to determine concentration dependence and quantitation range at various flowrates**
  - Fluorescence response curves decreased in peak fluorescence intensity with time, until saturated, and then become flat

Proof of Concept

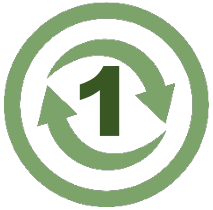




Year 1 Findings

- **The biosensor saturates faster with a higher gas flow rate, as expected**
- **No pH change was observed during the experiments**
- **Depending on the gas flow rates, the sensor quantified:**
  - 35-45 µg of hydrogen sulfide (H_2S)
  - 12-18 µg of ammonia (NH_3)
  - 83-95 µg of methyl mercaptan (CH_3SH)
  - 15 µg of methane (CH_4)
- **We saw promising initial results with respect to potential reversibility of the reaction**

Year 2 Objectives



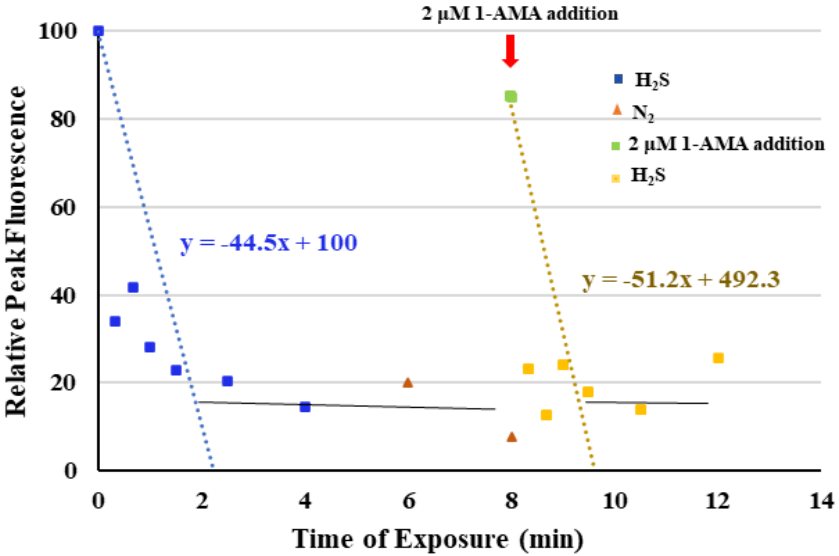
Explore biosensor complex reversibility

Upgrade reactor to flow through for real time sensitivity

Build a bigger odorant library of signal responses

1. Reversibility

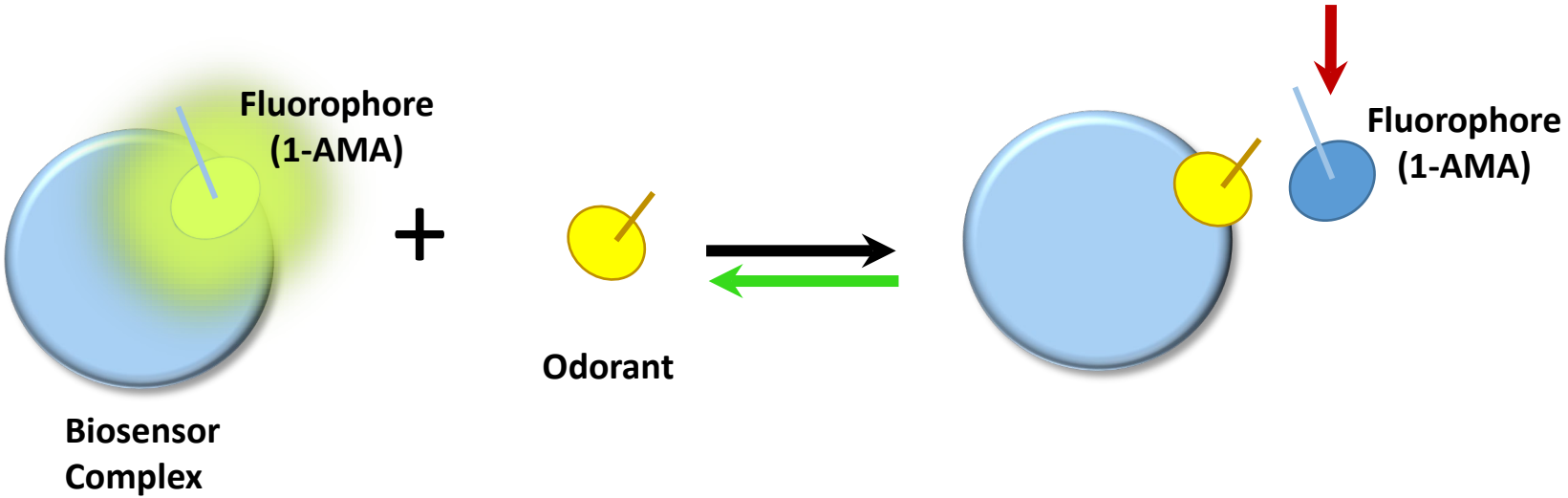
- **Methods Attempted**
  - ☒ Purging with inert N_2 gas for an extended period of time
  - ☒ Adjusting to human body temp (37°C) while purging with N_2
  - ☑ Adding more fluorophore at saturation shifts the equilibrium to the left following La Chatelier's principle
    - Intensity decreases for a second round of detection
    - Slopes for the two cycles were similar
    - Similar detection amount (70 µg of hydrogen sulfide reacts with 270 µg of hOBPIIa up to the saturation points in both cycles)



Adding 1-AMA at reaction equilibrium

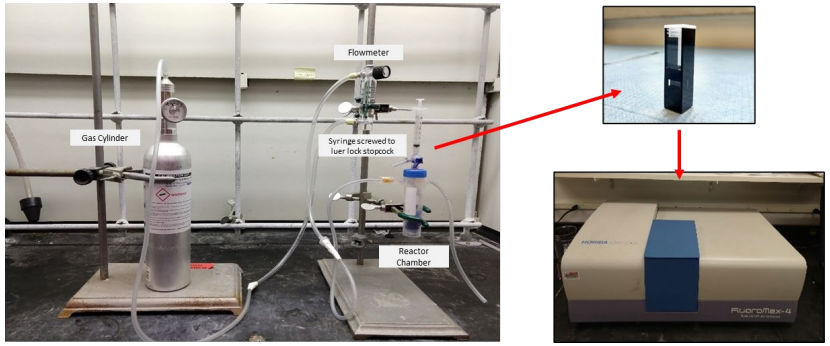
1. Reversibility

If the reaction is reversible, adding more fluorophore at equilibrium favors more reactant formation

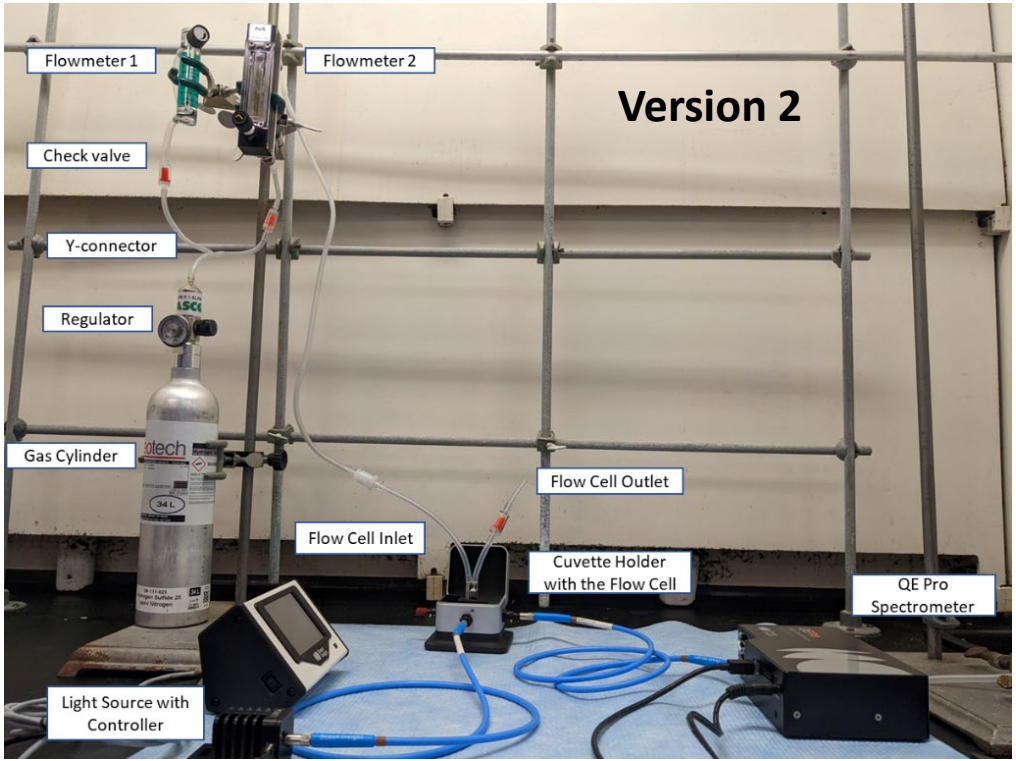


Potentially, this will reduce the cost of reagents and make it easy to take multiple readings in the field

2. Reactor Upgrade

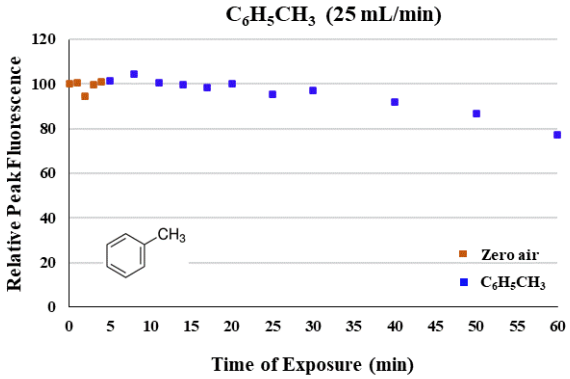


Version 1

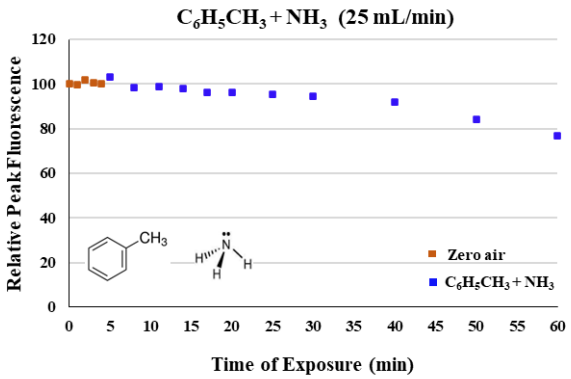


3. Build a Bigger Odorant Library

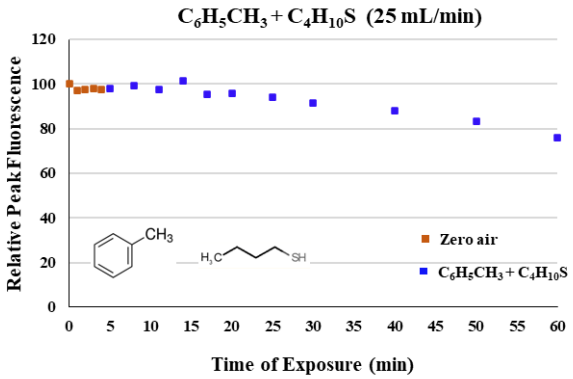
Toluene



Toluene + Ammonia



Toluene + Butyl Mercaptan



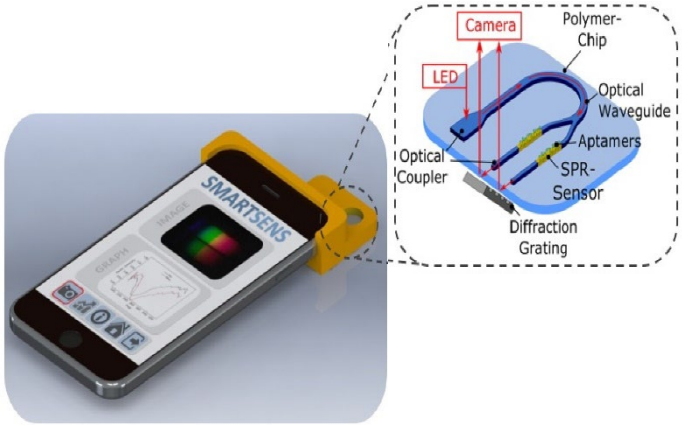
Toluene	Formaldehyde	Butyl mercaptan
Hydrogen sulfide	Methyl mercaptan	Ammonia

Year 2 Findings

- **Biosensor regeneration was possible with addition of fluorophore, causing the equilibrium to shift and regenerate nearly all the original protein**
- **Miniaturization of the reactor setup was accomplished using a flow-through portable spectrofluorometer to collect real-time fluorescence readings**
- **The biosensor showed the strongest response signal with hydrophobic gaseous odorants (toluene and other similar odorants)**
- **Gas mixtures demonstrate the ability of hOBPIIa to indicate the presence of hydrophobic gases within a mixture of varied odorants**

Future Work

- **Need to determine the number of cycles for analysis before the protein is spent**
  - **To date we only performed 2 cycles for proof of concept**
- **Need to determine limit of hydrophobicity and binding energies for detection and explore modification of odorants for non-hydrophobic gas detection**
- **Need to explore potential interferents in the field**
- **Design and test a prototype field analyzer**



The Goal

To deploy this technology in a portable handheld platform to detect and quantify odors to help improve operations and reduce complaints

Funding Partners

Current Funded Research

- Air quality biosensor development
- Leachate collection systems
- Food waste diversion
- Watershed management, flood risk mitigation
- Algae control
- SARS-CoV-2 surveillance
- Education/Student Success Grants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