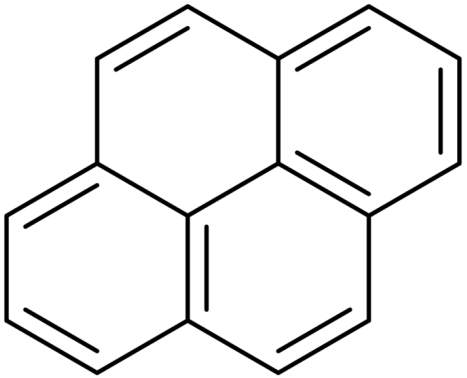
# Microbially-Driven Fenton Reaction for Degradation of Oil Spill Contaminants

Yael Toporek[1], Nan Xie[2], Ramanan Sekar[1], Hyun-Dong Shin[1], Martial Taillefert[2], Thomas DiChristina[1]

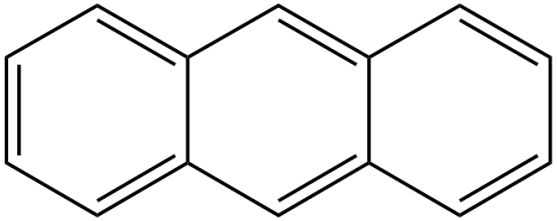
[1]School of Biological Sciences, Georgia Tech, [2]School of Earth and Atmospheric Sciences, Georgia Tech


# Objective:

To determine the ability of a novel microbially-driven Fenton reaction to degrade the oil spill components anthracene and pyrene at source zone concentrations.



**Pyrene: 10 uM**



**Anthracene: 1uM**

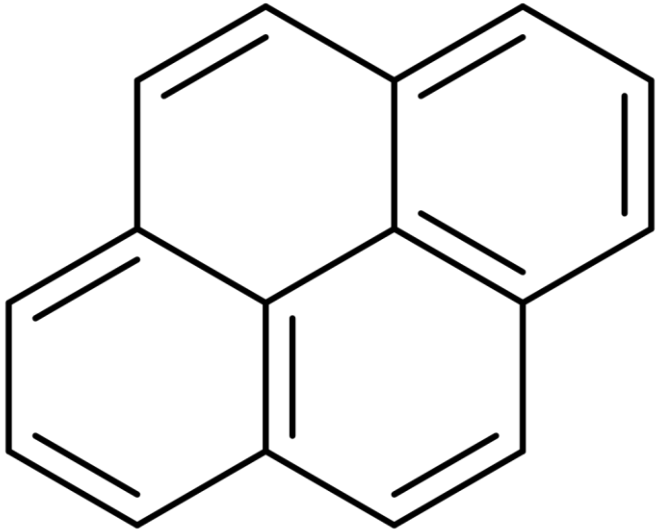
# Deepwater Horizon Oil Spill

- Physical oil collection (containment booms, skimmers)
- *Ex situ* bioreactor treatment processes
- Chemical sorbents and dispersants: Corexit

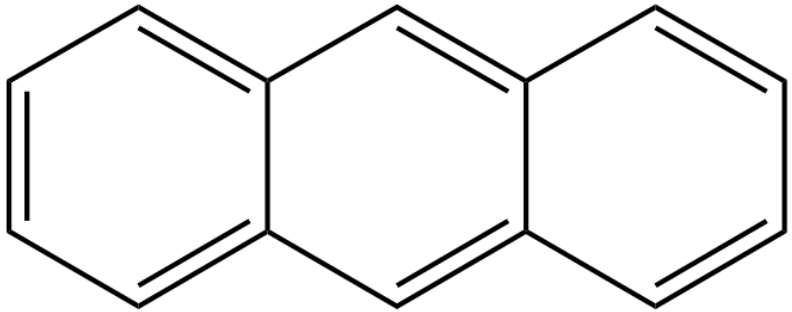

By Technical Sergeant Adrian Cadiz - US Air Force public affairs story direct link, Public Domain, https://commons.wikimedia.org/w/index.php?curid=10277175

- What's in oil?
  - Hydrocarbons: saturated, aromatic, polar, nonpolar…
    - Alkanes (paraffins)
    - Monocyclic saturated hydrocarbons (cycloalkanes)
    - Aromatic hydrocarbons
- What's degraded?
  - Lighter compounds degraded first
  - Low solubility, higher molecular weight compounds persist in plumes and sediments
    - Polycyclic aromatic hydrocarbons (PAHs): pyrene, anthracene

# Polycyclic aromatic hydrocarbons (PAHs): recalcitrant compounds



**Pyrene**



**Anthracene**

Degradation: Fenton reaction?

**The Fenton reaction is a hydroxyl radical-producing reaction used for degradation of recalcitrant compounds**

$$Fe(II) + H_2O_2 \rightarrow Fe(III) + OH^- + HO^\bullet$$

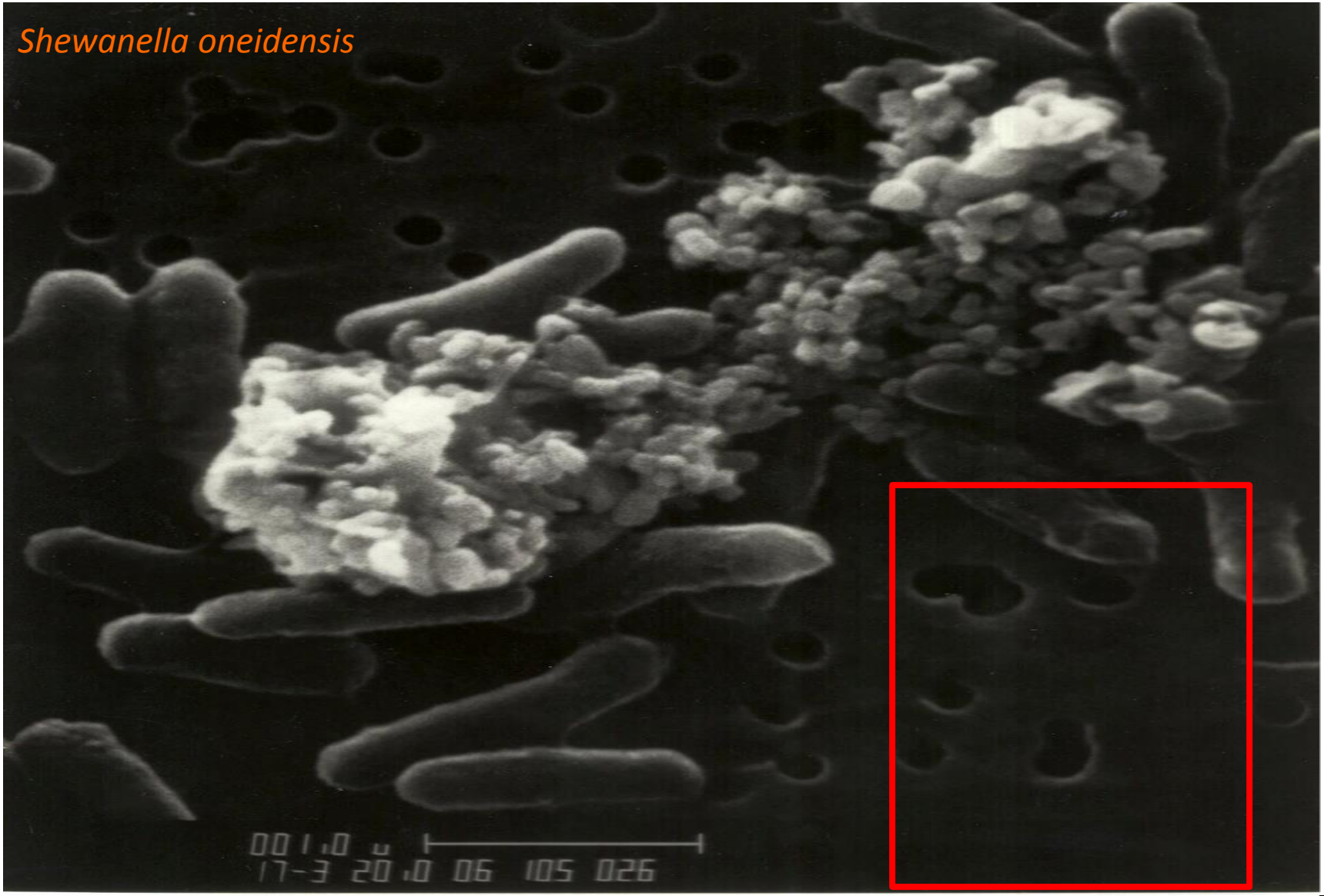
Chemical Fenton

- pH requirement: 2.5-3.5
- High reagent concentrations
  - Must be continuously supplied
- UV-induced Fe(III) re-reduction to Fe(II) is difficult

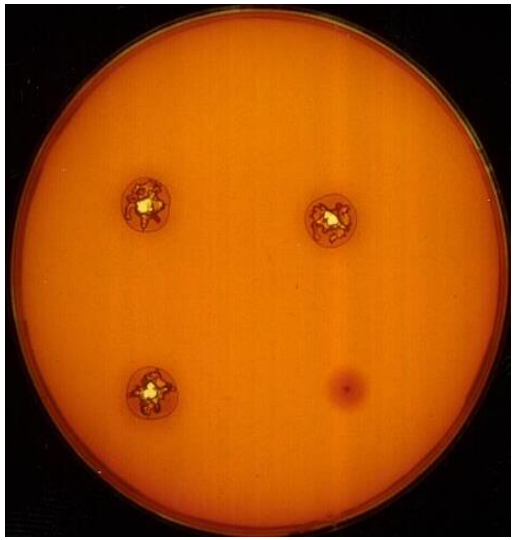
Microbial Fenton

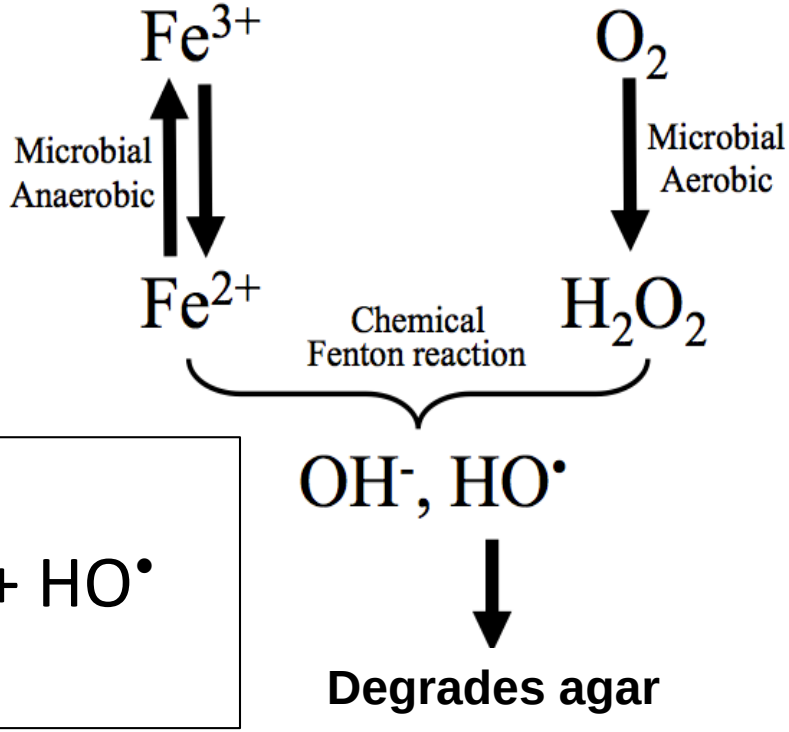
- Circumneutral pH
- No need to continuously supply Fenton reagents
- Autocatalytic

# Original observation of microbially-driven Fenton reaction



# Microbially-driven Fenton reaction



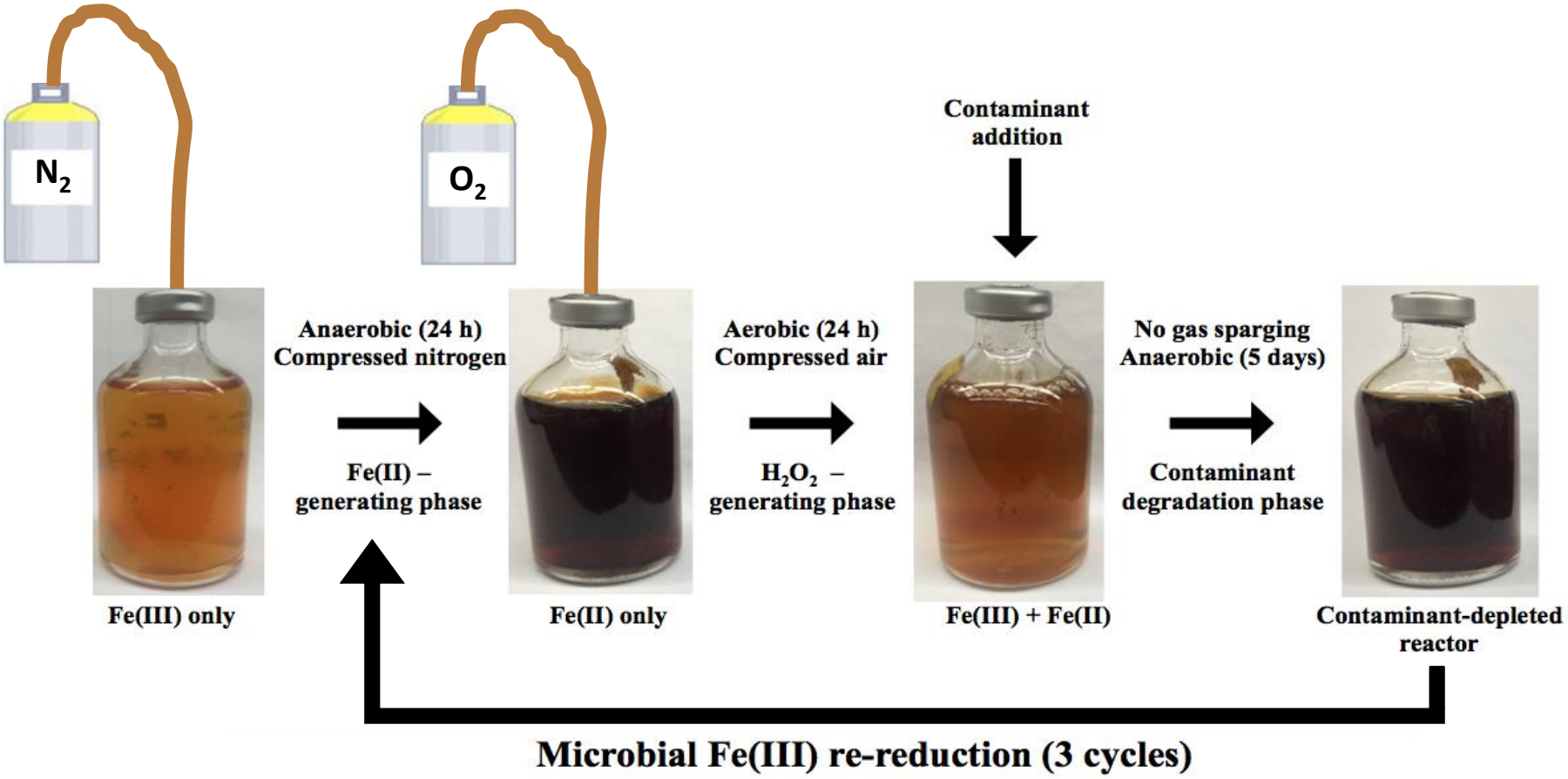



$$Fe(II) + H_2O_2 \rightarrow Fe(III) + OH^- + HO^\bullet$$

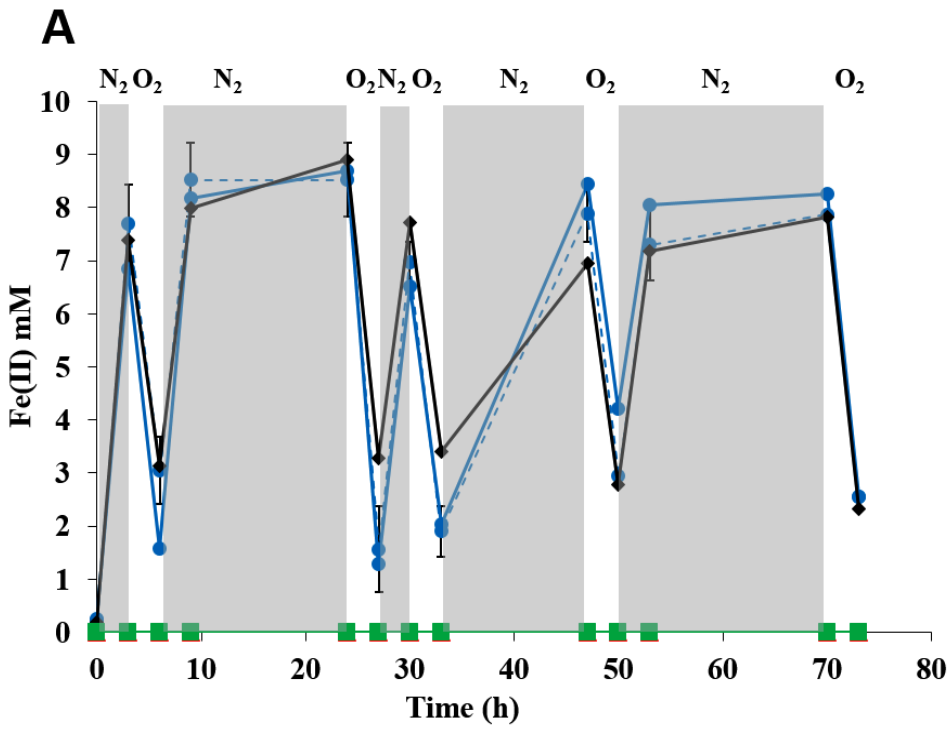
**Can we harness the power of microbially-driven Fenton reaction to degrade recalcitrant organic compounds?**

| Compound | Year |
| --- | --- |
| Pyrene, anthracene | Sekar et al., submitted |
| Cellulose | Sekar et al. 2016 |
| TCE, PCE | Sekar et al. 2016 |
| Dioxane | Sekar et al. 2014 |
| Pentachlorophenol | McKinzi, 1999 |

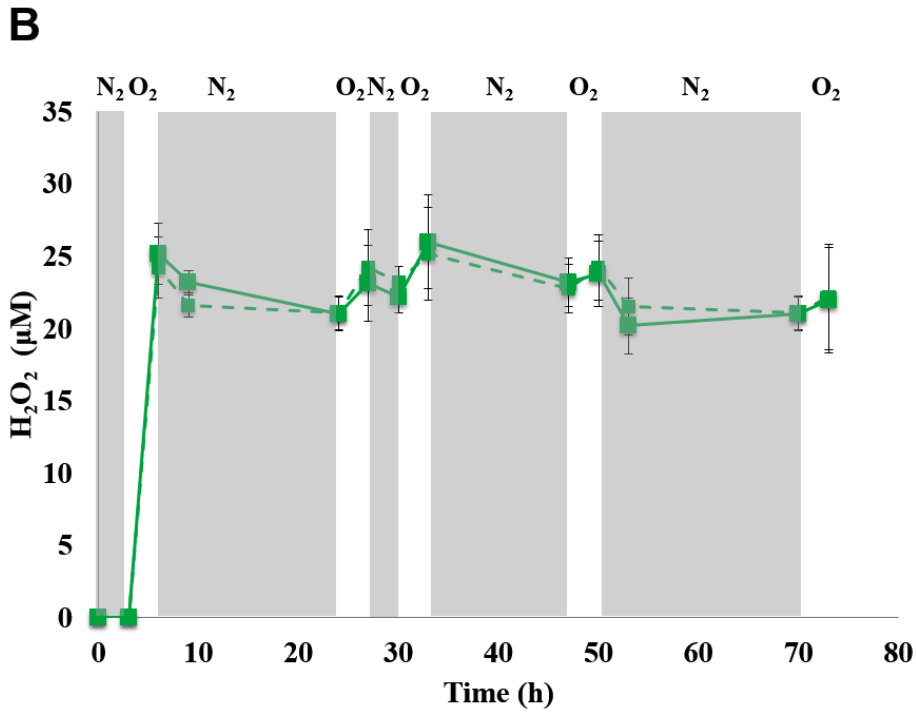
# Separated Fe(II) – generating, $H_2O_2$ – generating, and contaminant degradation phases



# Oscillating Fe(II) levels and $H_2O_2$ production

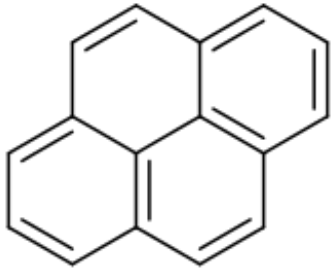



Iron

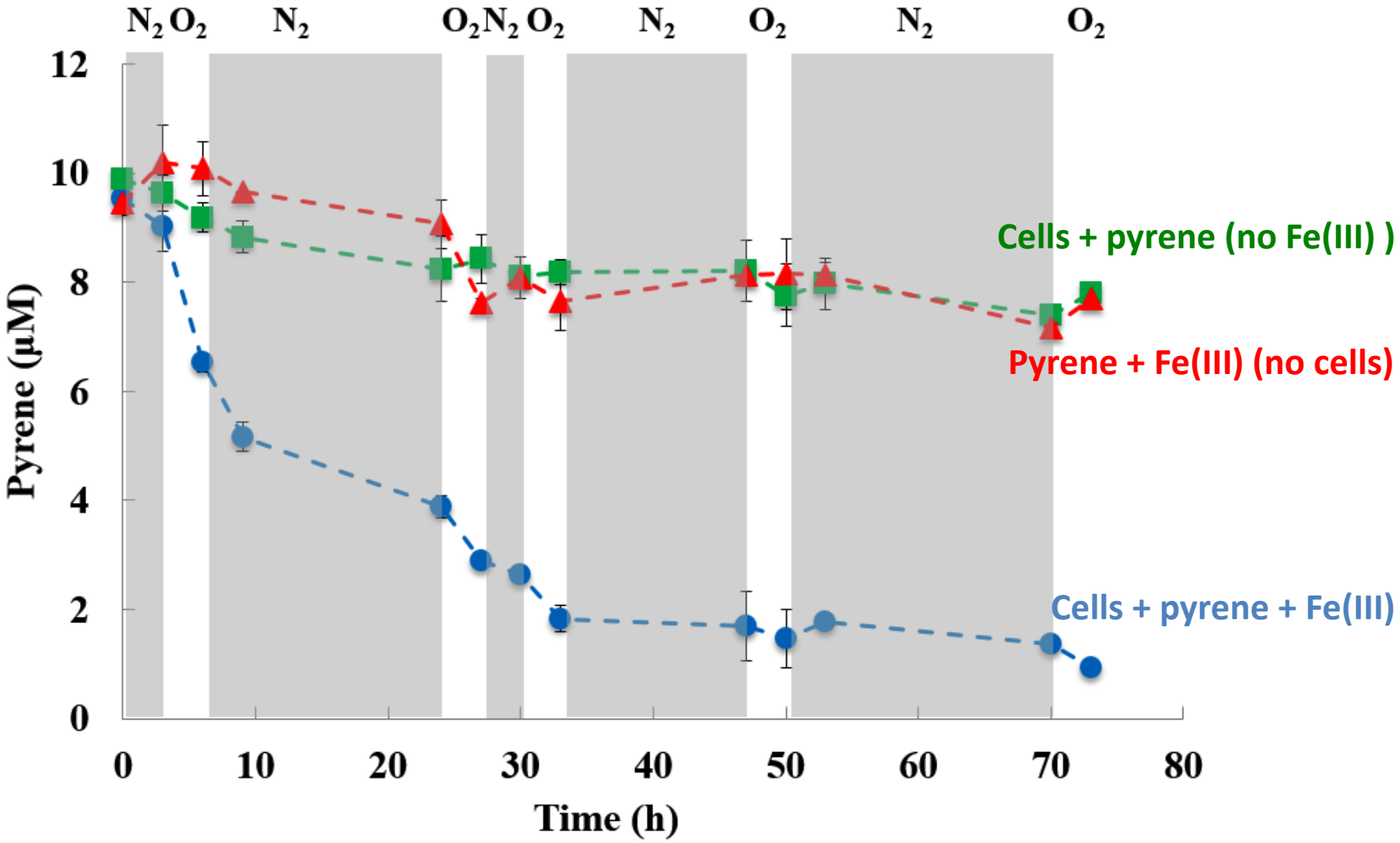



Hydrogen peroxide

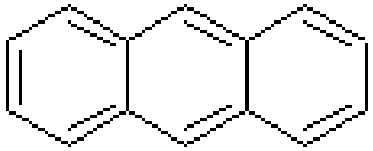
# Degradation of pyrene

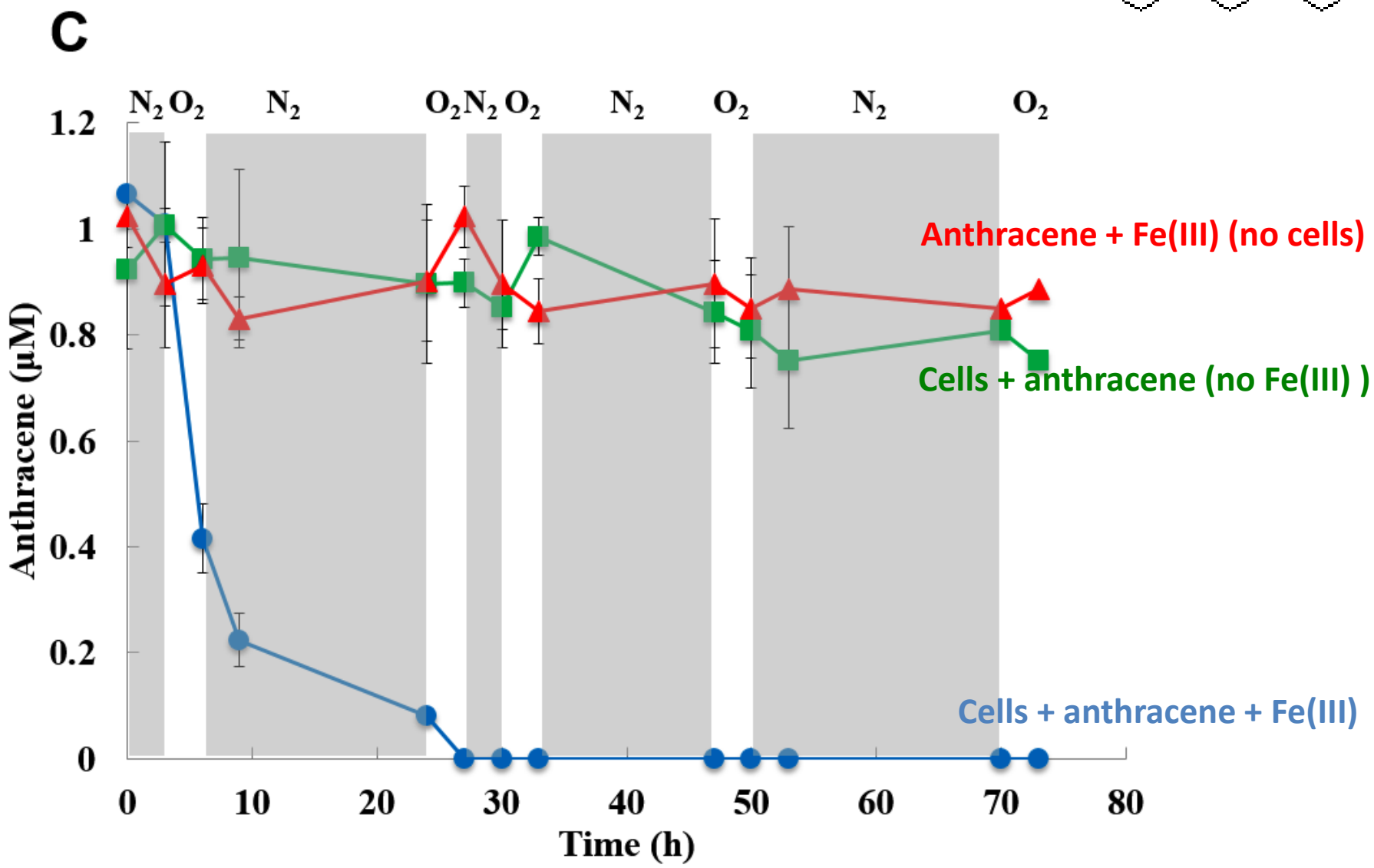


D



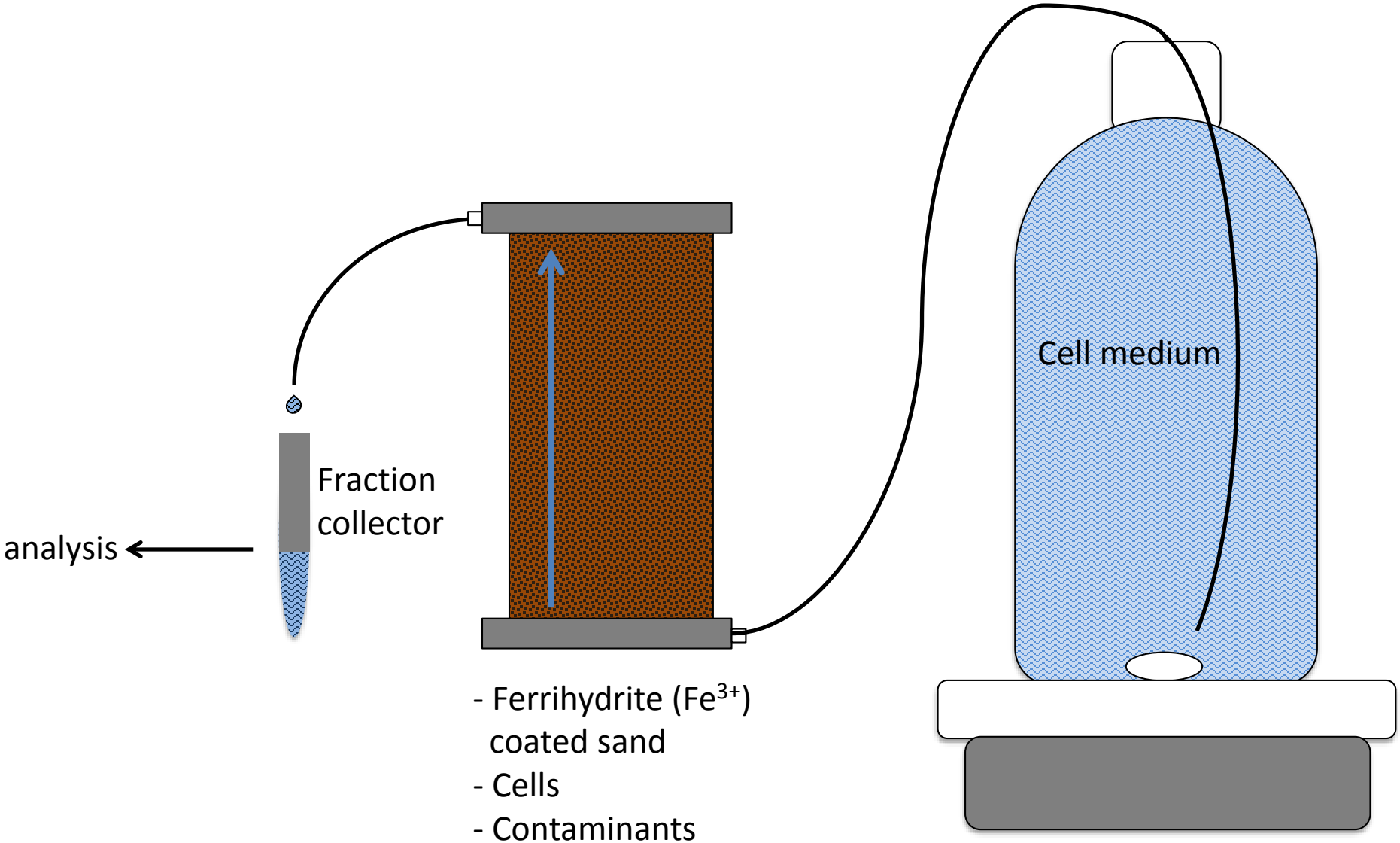
# Complete degradation of anthracene



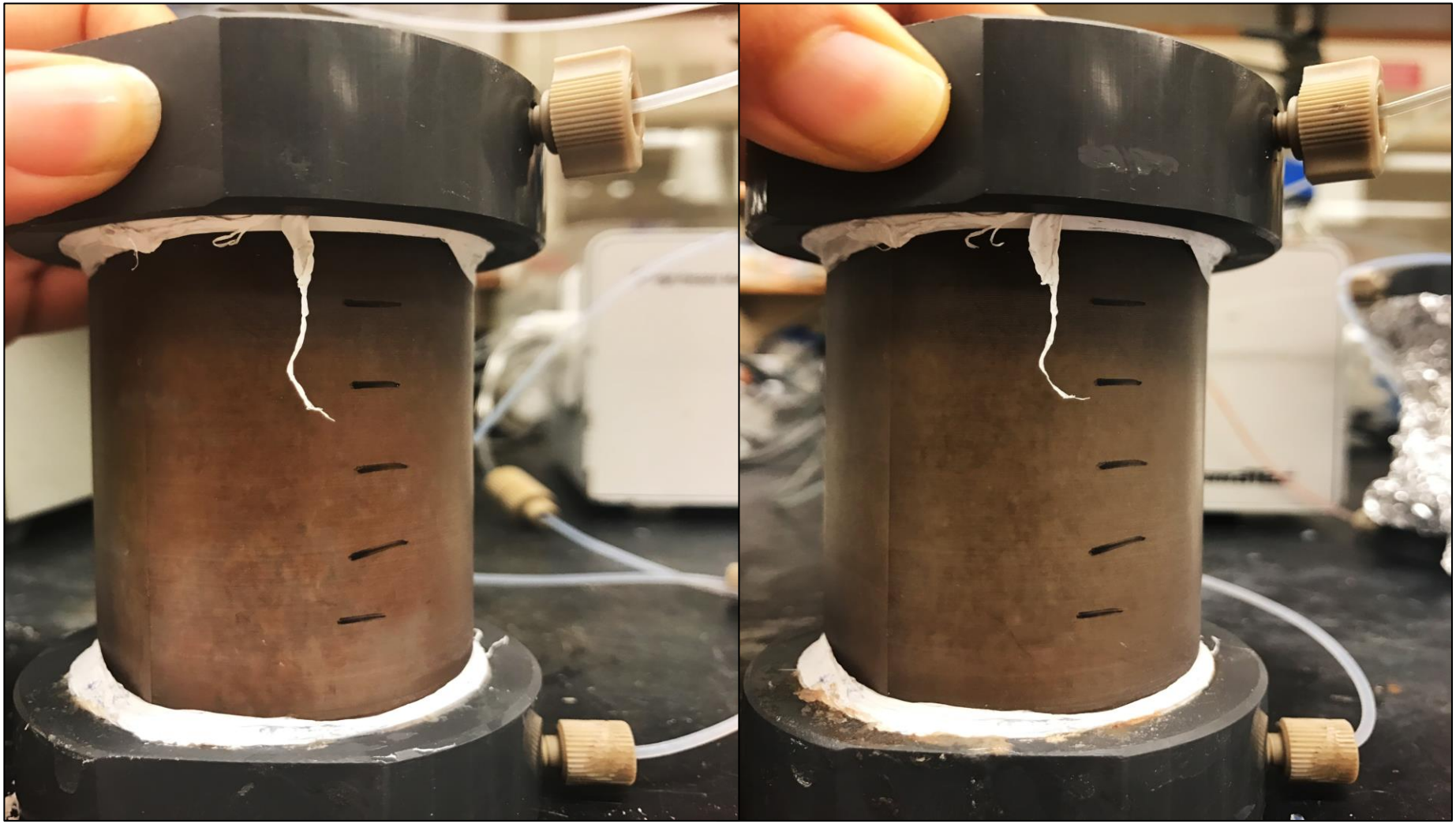


# Current work

# Degradation of pyrene and anthracene in a flow-through reactor system



| Before: Fe(III) | After: Fe(II) |
| --- | --- |



# Future directions: *in situ* degradation

1. Identify degradation products of pyrene and anthracene
2. Exploit naturally-occurring iron-reducing facultative anaerobes at the sediment/water interface of contaminated regions (intermittently overlapping anaerobic iron and aerobic redox zones)

   → *In situ* contaminant degradation by the microbial Fenton reaction

1. Alternating aerobic/anaerobic conditions in the environment: injecting $N_2/O_2$ gas

   → *In situ* contaminant degradation by the microbial Fenton reaction

# Thank you!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