UPISC UNIVERSITY OF PITTSBURGH INFRASTRUCTURE SENSING COLLABORATION WORKSHOP

NATIONAL ENERGY TECHNOLOGY LABORATORY

H_2 Sensing with an Optical Fiber Sensor in the Subsurface H_2 Storage Conditions

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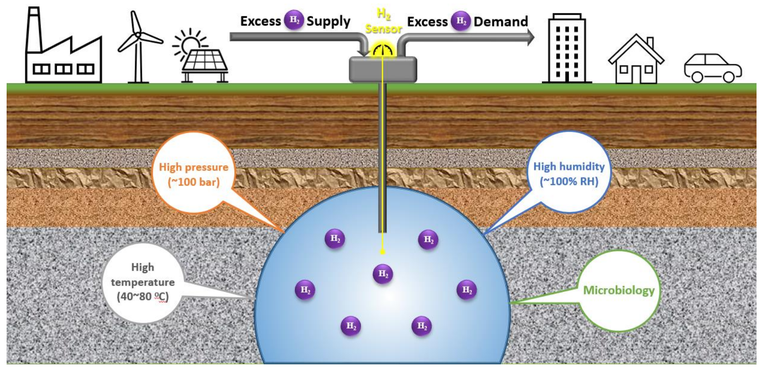
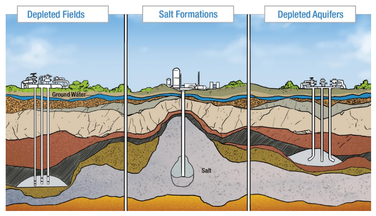
Subsurface Hydrogen Storage

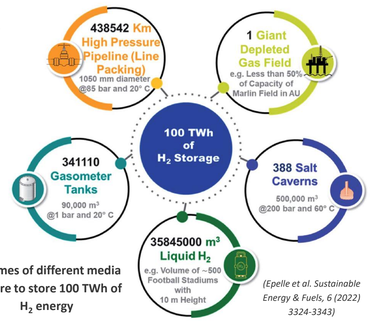
Monitoring H_2 concentration to ensure the integrity and safety of subsurface H_2 storages reservoirs



Three different types of underground gas storage



(energyinfrastructure.org)

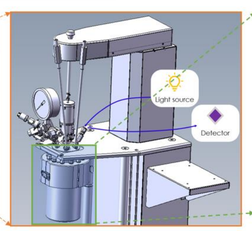


Volumes of different media require to store 100 TWh of H_2 energy

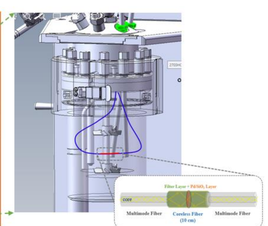
(Epelle et al. Sustainable Energy & Fuels, 6 (2022) 3324-3343)

Subsurface Sensor Development Reactor (SSDR)

- **Automation** with LabView
- **High-Temperature High-Pressure**: 450 ºC, 4500 psi
- **Multi-phase**: aqueous, gas
- **Gas**: **H_2**, CO_2, **CH_4**, N_2, Air



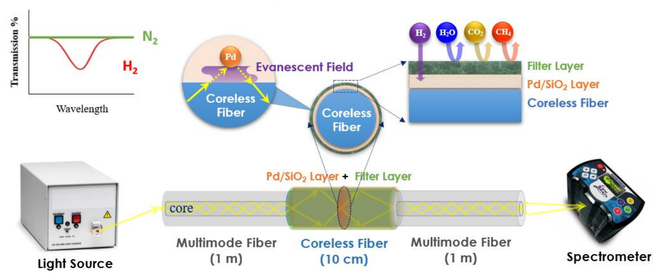
Experimental conditions:
~ 80 ºC, 1000 psi, 99% RH



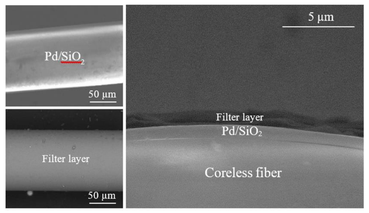
H_2 sensor
installed inside the vessel

Optical Fiber H_2 Sensor

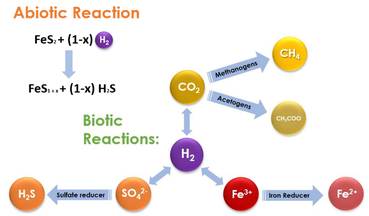
Evanescent Field-Based Optical Fiber H_2 Sensor



SEM Images of the Pd/SiO_2 & Filter Layers



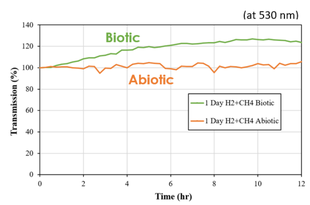
Abiotic/Biotic Activities in Subsurface Storage

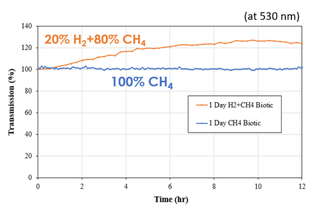


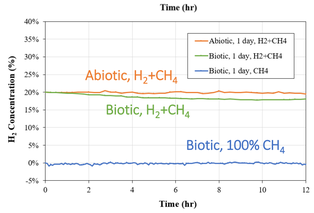
SSDR Tests with Biological Samples

- **Biotic Samples**: procured from Playa del Rey (PDR) in CA
- **Abiotic samples**: filtered from the biotic samples

H_2 Sensing with the Optical Fiber Sensor in the presence of Biological Samples for 1 Day



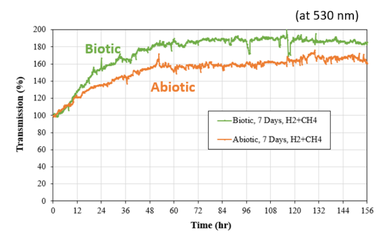


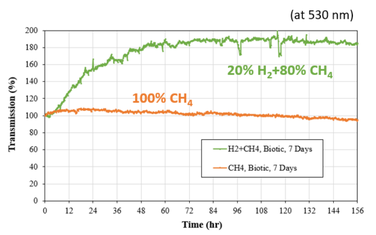


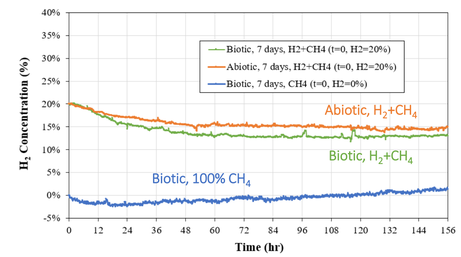
- The **biotic** sample has a **higher effect** on hydrogen sensing than the **abiotic** sample.
- **H_2 concentration** has **decreased** by **~2%** with the **biotic** sample for 1 day.

Real Time Hydrogen Sensing

H_2 Sensing with the Optical Fiber Sensor in the Presence of Biological Samples for 7 Days

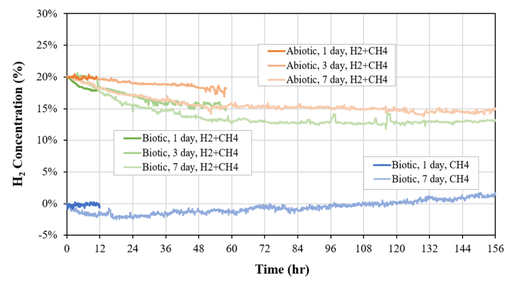






- The **biotic** sample has shown much **higher impact** on H_2 sensing for 7 days than the **abiotic** sample.
- **H_2 concentration** has **decreased** for **7 days** by about **5%** and **7%** with the **abiotic** and **biotic** sample, respectively.

Real Time H_2 Sensing in Subsurface Storage Conditions



- Demonstrates **real-time monitoring of H_2 concentration** using the optical fiber H_2 sensor in the subsurface H_2 storage conditions (**80 ºC, 1000 psi**, and **99% RH** with **biological samples**).

Summary

- The **optical fiber hydrogen sensor** was capable of detecting H_2 concentration **at high temperatures** and **pressures** in the presence of **biological samples**.
- The **H_2 concentration** has **decreased** more with the **biotic sample** than the abiotic sample.
- The H_2 sensing responses indicate that **H_2 is consumed with both abiotic and biotic samples** under the subsurface storage environment.
- **Repeatability** of hydrogen sensing at different temperature and pressure will be carried out in near future.