

# Fundamental Investigations of Nanostructured Chemical Sensing Layers

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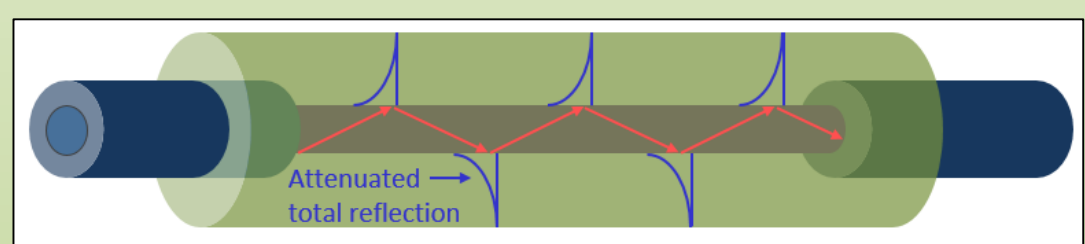
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## Abstract

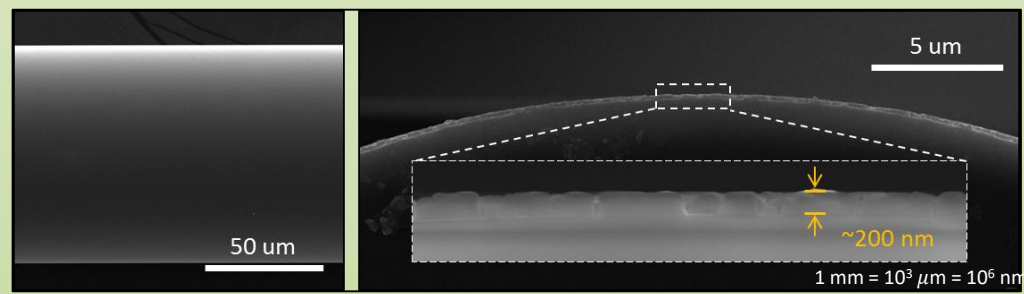
Fiber optic sensors can be coated with metal-organic frameworks (MOFs) to deliver a viable CO<sub>2</sub> sensing technology. This sensing technology is relevant for Carbon Capture and Storage (CCS) where it can be used to monitor CO<sub>2</sub> in geological formations. Fundamental investigations of these nanostructured chemical sensing layers, using Fourier Transform Infrared (FTIR) Spectroscopy, provided validating results of the MOF coated sensor to have a high selectivity to CO<sub>2</sub> relative to other small gases. Research was also conducted to investigate how the presence of a redox-active, conjugated guest molecule affects the MOF's selectivity of CO<sub>2</sub>. The MOF under investigation was Cu<sub>3</sub>(BTC)<sub>2</sub> (benzene-1,2,5-tricarboxylic acid) and the redox-active molecule was TCNQ (7,7,8,8-tetracyanoquinodimethane). This MOF was selected for its high absorption of small gases due to tunable conductivity. The promising results of the project indicate that Cu<sub>3</sub>(BTC)<sub>2</sub> coated fiber optic sensors can be used not only in optical sensing applications such as monitoring CO<sub>2</sub> in geological formations for CCS, but also in industrial process applications such as monitoring flue gas of power plants.

## Project Overview

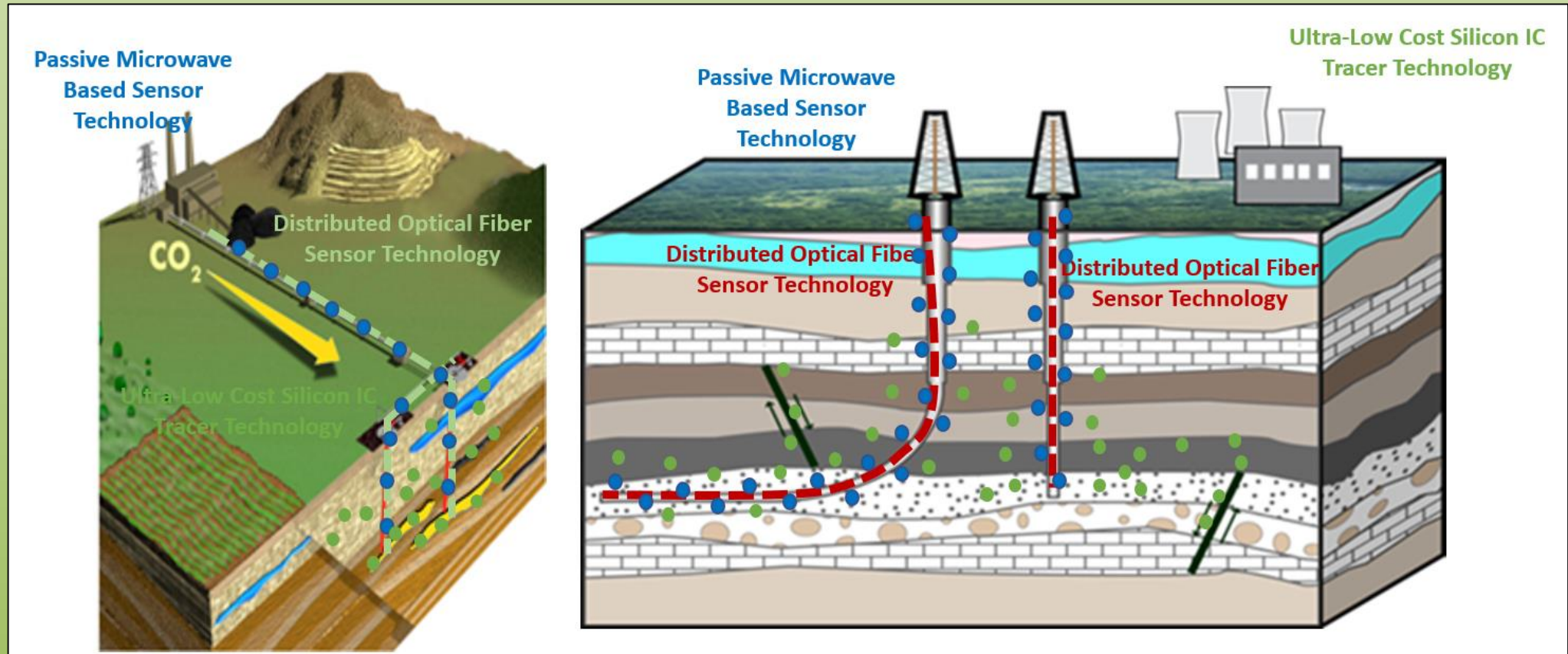
Fiber optic sensors can be coated with metal-organic frameworks (MOFs) to deliver a viable CO<sub>2</sub> sensing technology in geological formations relevant for Carbon Capture and Storage (CCS) applications.



MOF-coated optical fiber



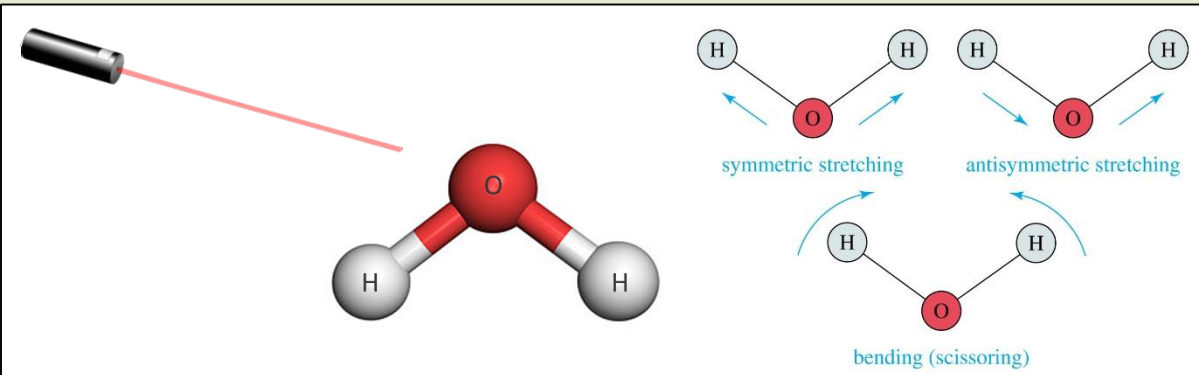
SEM image of MOF-coated optical fiber



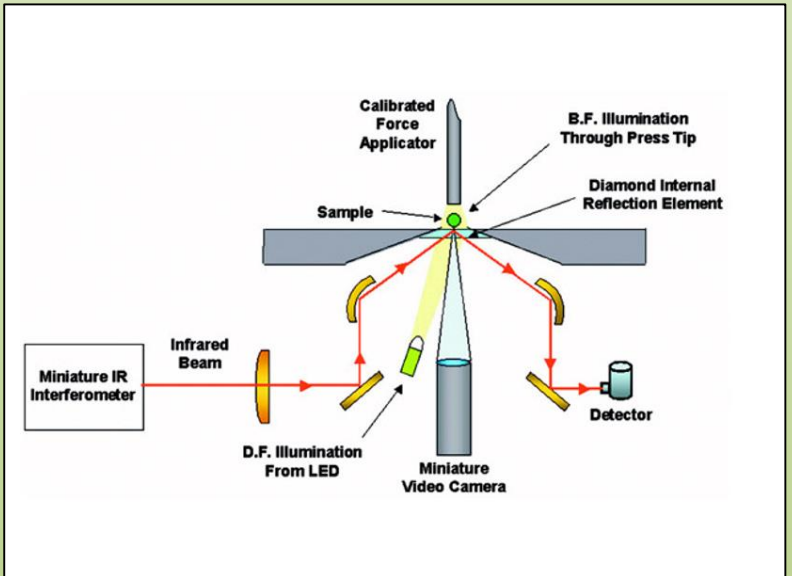
CO<sub>2</sub> sensing technology in geological formations

## Infrared Spectroscopy

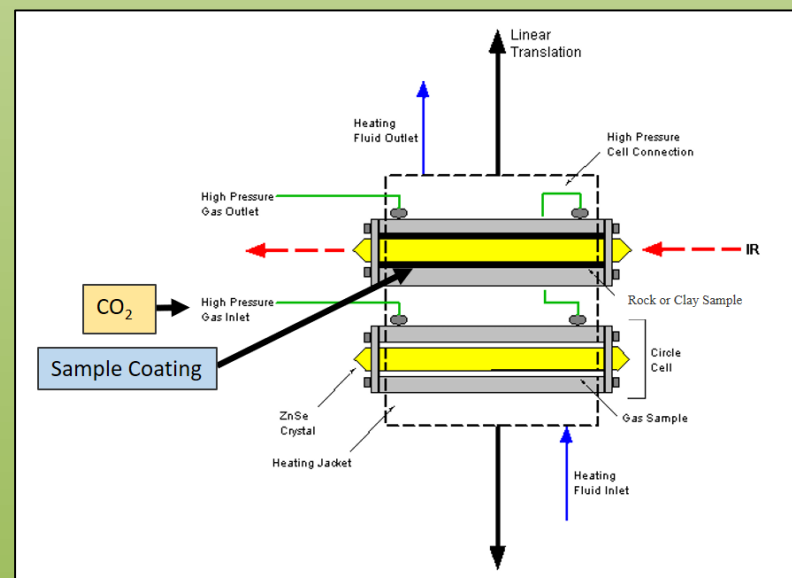
- Infrared spectroscopy analyzes the interaction of infrared light with a molecule.
- The analysis is based on measuring the vibrations of atoms that are specific for each functional group.



Molecular vibrations detected with IR spectroscopy



Single bounce ATR



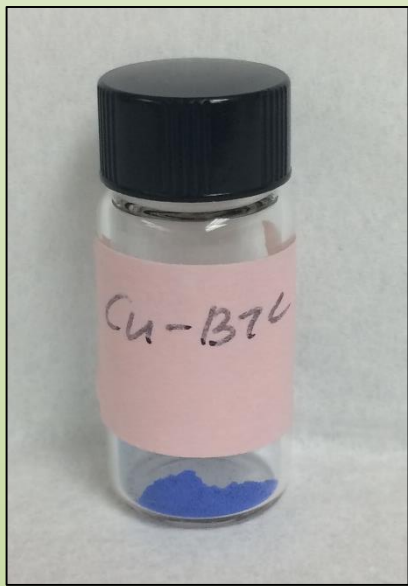
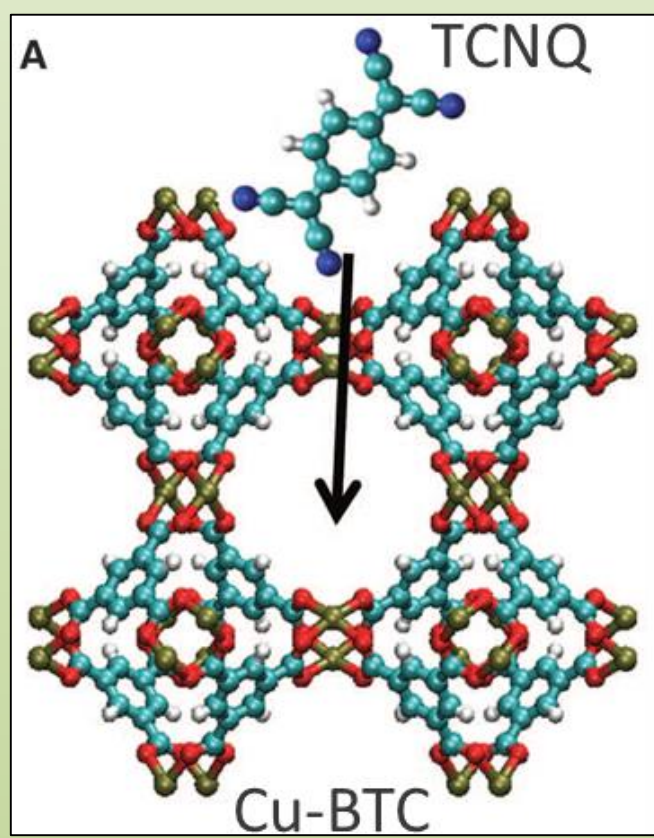
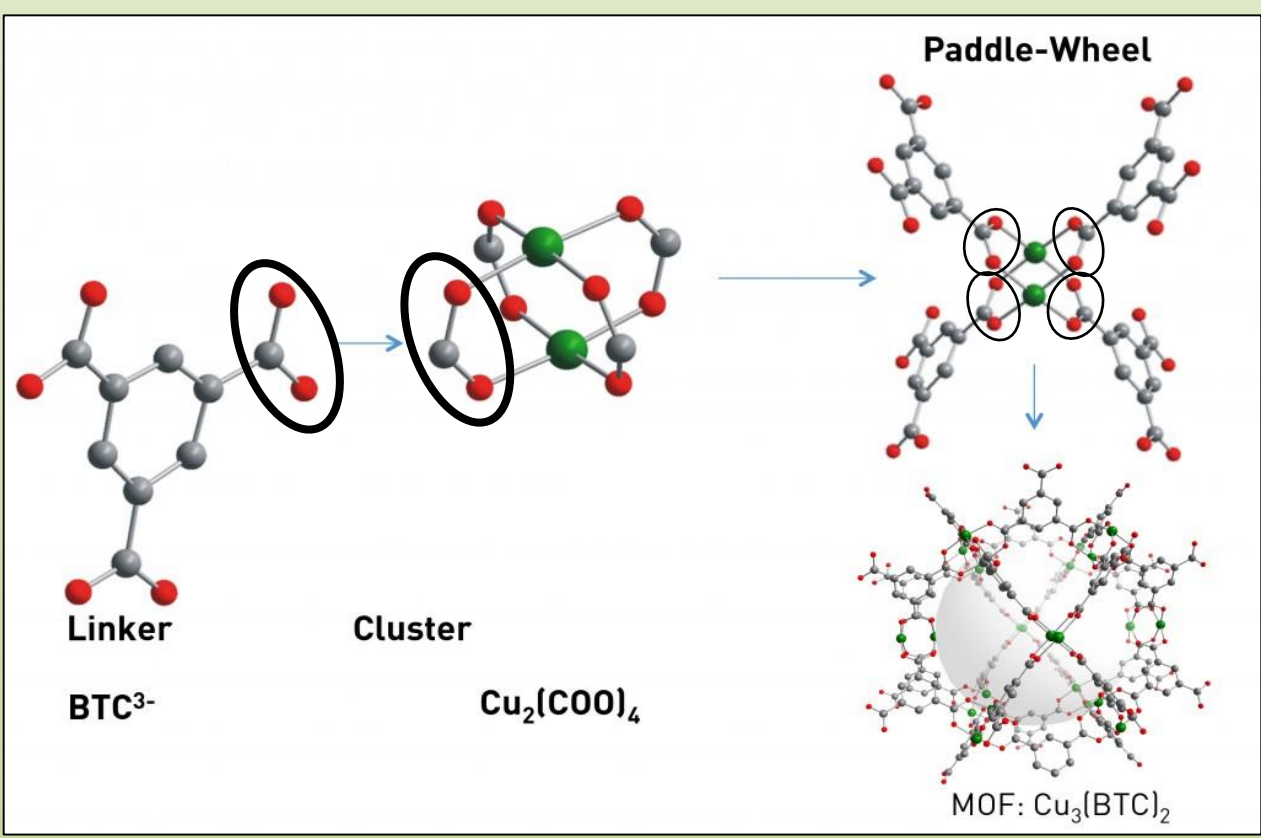
Multi-bounce with sample holder for FT-IR



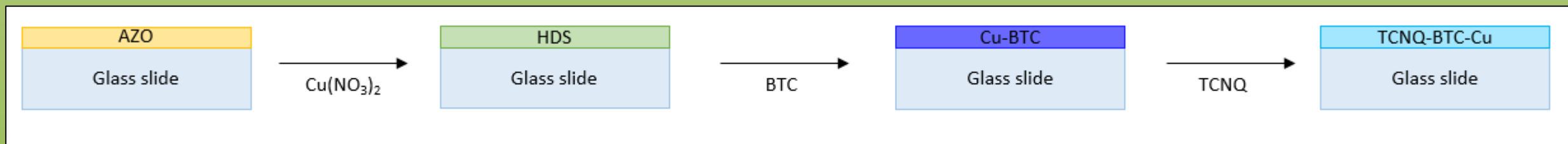
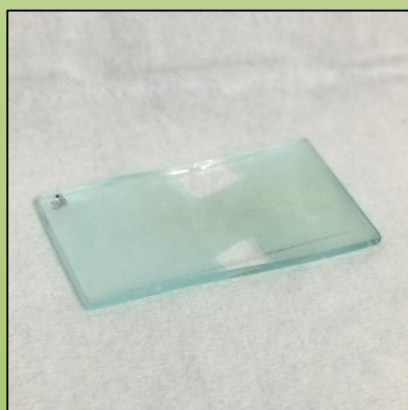
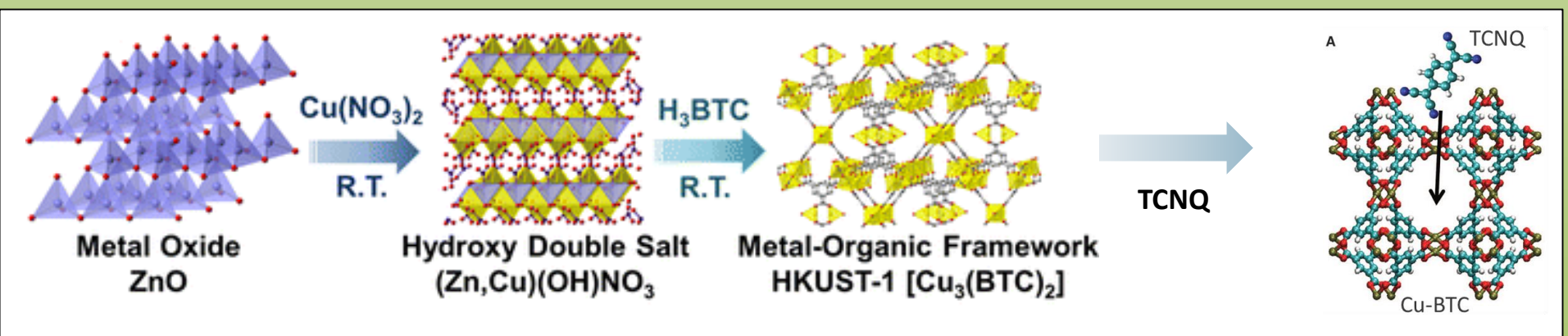
FT-IR Spectrometer used to conduct in-situ high temperature and pressure experiments.

## Metal Organic Framework Synthesis

### Solvothermal Synthesis Method

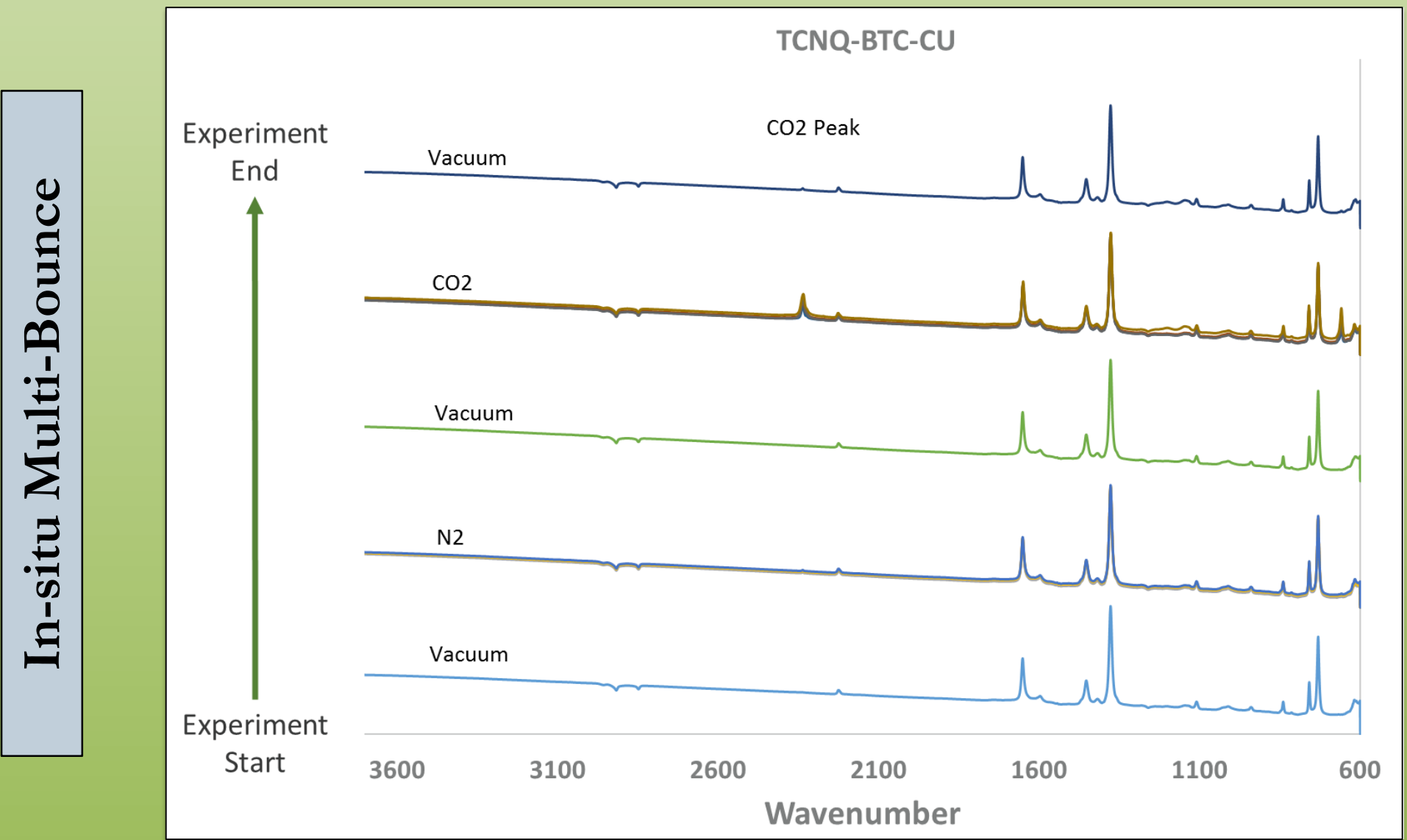
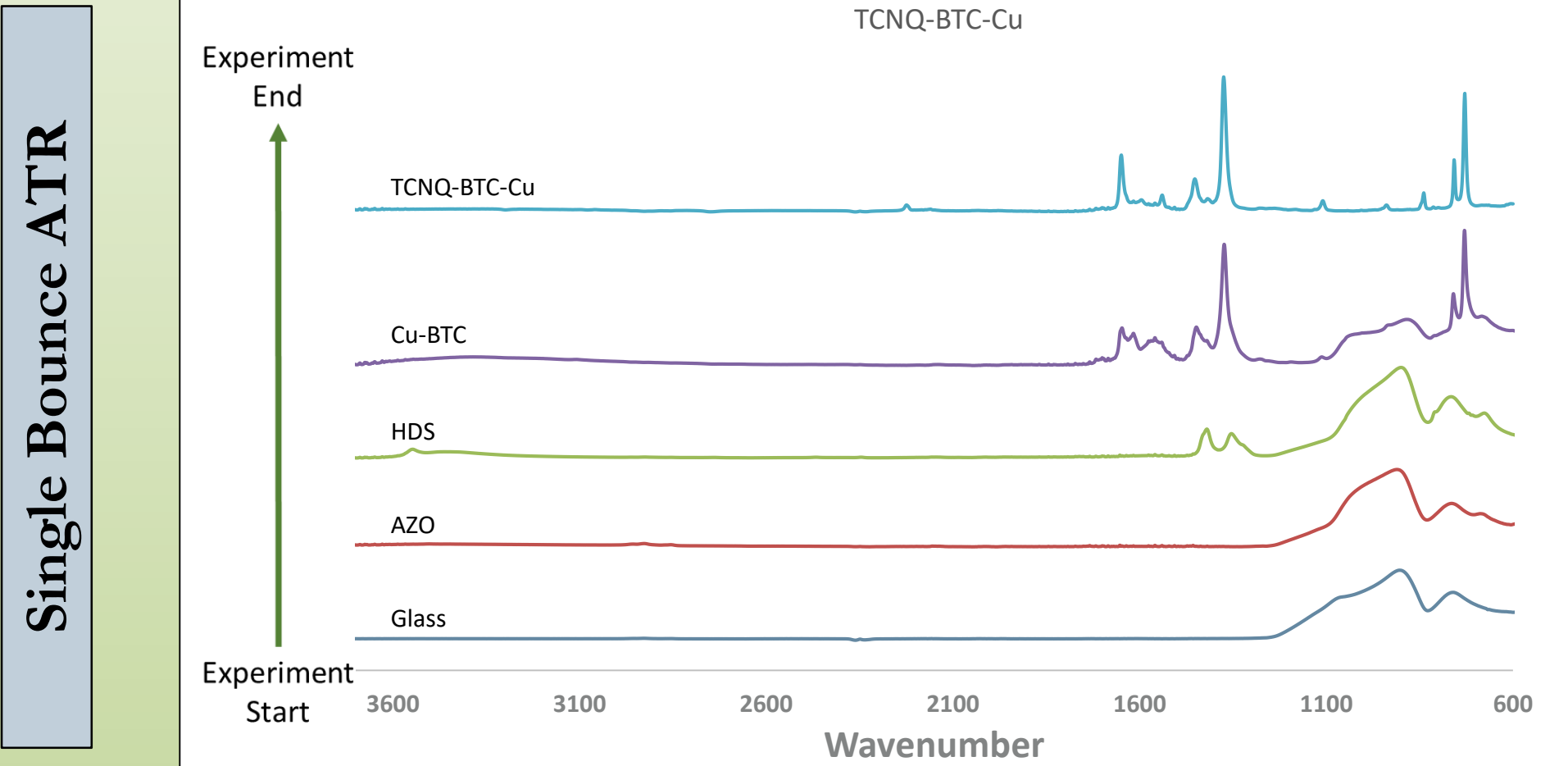


### Thin Film Synthesis on Silica Glass Substrate



Layer	Thickness (nm)
AZO	120-140
HDS	150-200
Cu-BTC	500-800

## Infrared Spectroscopy: Results



## Conclusions

- IR spectroscopy is part of the tool set
- Provided insight into the selectivity to CO<sub>2</sub> relative to other small gases
- Determined successful synthesis of thin film Cu<sub>3</sub>(BTC)<sub>2</sub>
- MOF coated fiber optic sensors can be used in:
  - Geological formations for CCS
  - Flue gas of power plants
  - Natural gas pipelines

## References

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