

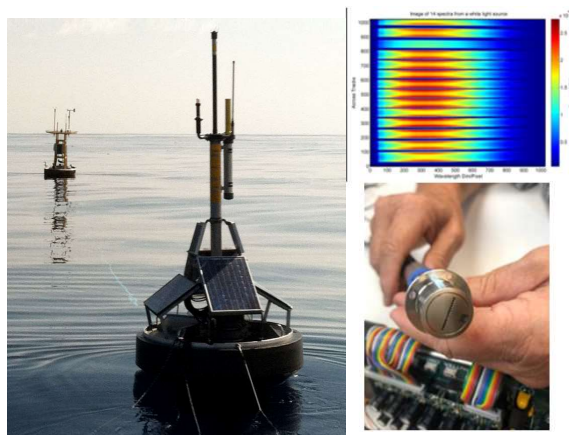
Metrology for CDR and CCUS

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Mission

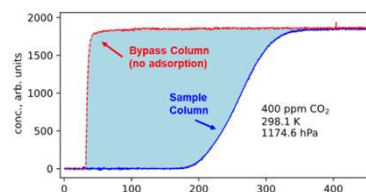
Promote U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology in ways that enhance economic security and improve our quality of life.

Technology



Develop critical measurement science to accelerate innovation, scalability, & reduce uncertainties

Benchmark Measurements Data & Materials

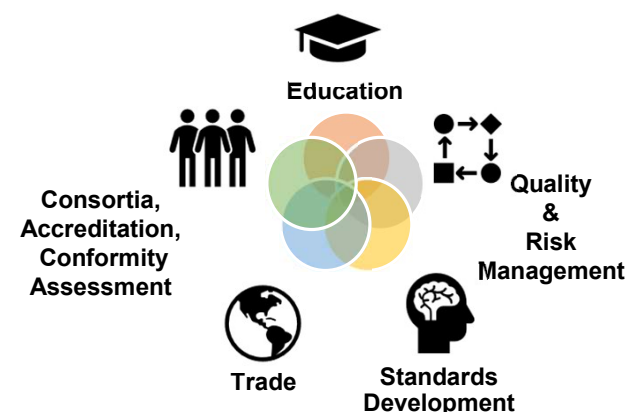


<https://doi.org/10.1021/acs.iecr.2c04050>



Facilitate rigor and reproducibility across measurement ecosystems

Documentary Standards



Support industry and Federal use of voluntary consensus standards

Climate Measurements and Monitoring

- Traceability of GHG measurements
- GHG measurement technology
- Ensuring climate data quality and standardization

Decarbonization of the Economy

- Built environment
- Energy infrastructure
- Carbon Dioxide Removal (CDR), Carbon Capture Use and Storage (CCUS)
- Manufacturing

Adaptation and Resilience

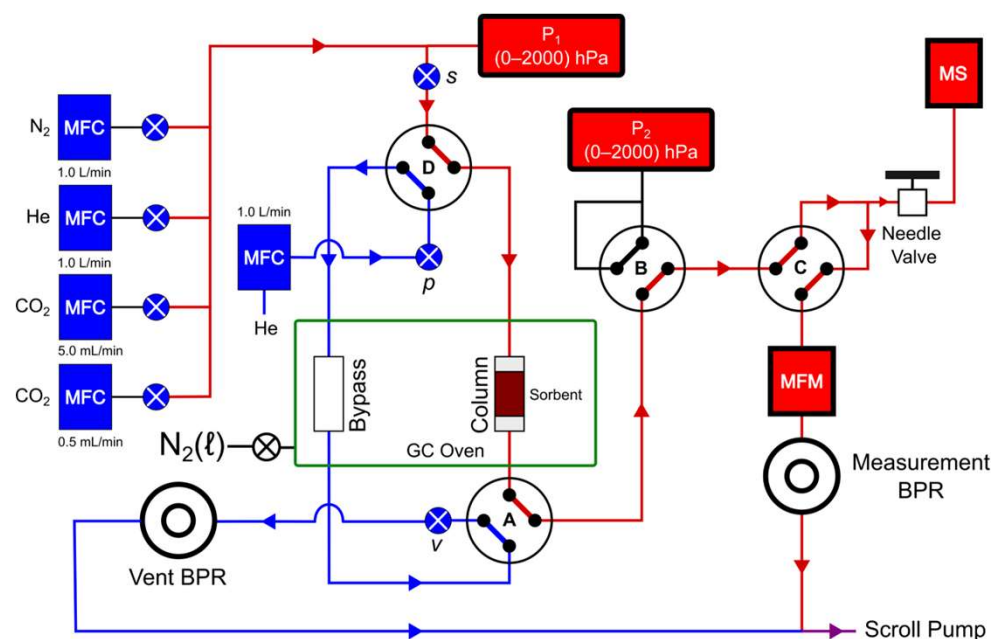
- Disaster and failure studies
- Wildland-Urban Interface fires
- Community resilience
- Connected systems resilience

Life Cycle Analysis, Carbon Accounting

Dynamic Column Breakthrough Measurements

Designed and built new instrument specifically for DAC Conditions

- Minimize dispersion and uncertainties
- Fully evaluated uncertainties, $u_r=0.05$
- CO₂ uptake of 13X zeolite
- Compared to adsorption isotherms
- Identifying candidate benchmark materials



MFC: mass flow controller; BPR: backpressure regulator; MFM: mass flow meter; P_i: manometer

Benchmark Material Characterization

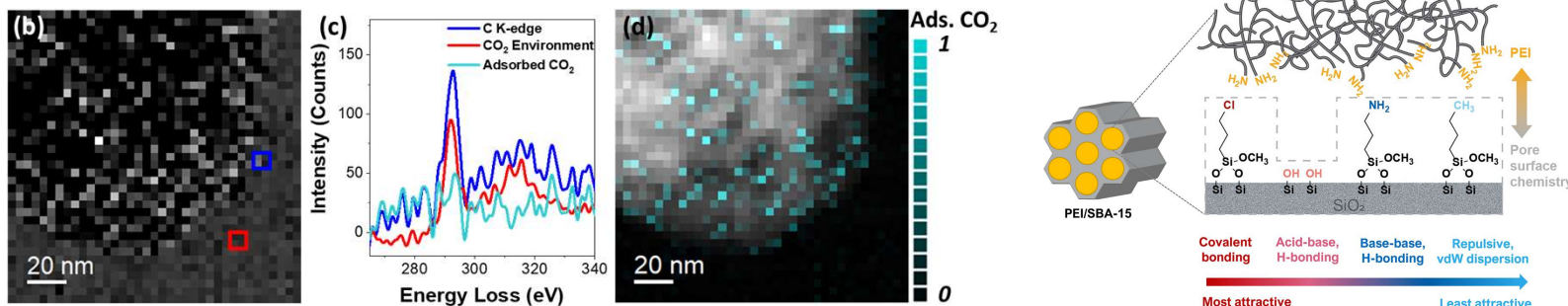
NIST

Examine:

- CO₂ locations & binding
- Diffusion, kinetics
- Structures & microstructures
- Local adsorption potential and vibrations
- Effects of water and competitive binding
- Effects of trace gases and particulates

- Environmental Transmission Electron Microscopy (ETEM)
- Scanning Electron Microscopy
- Neutron and X-ray Scattering
- Tandem Polarization Modulated IR Reflection Absorption Spectroscopy (PMIRRAS with QCM)
- Diffuse Reflectance Spectroscopy (DRIFTS)
- Molecular Simulations

In situ observation of CO₂ adsorption on MCM-41 in ETEM using EELS



Locally confined PEI exhibit slower motions

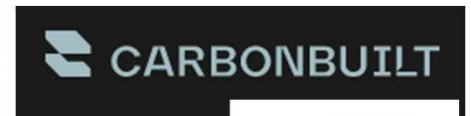
Moon et al., JACS 144, 26, 116644 (2022)

Carbon Sequestration in Building Materials

Accelerate adoption of innovative low-carbon building materials Cements & Concretes

Convening Low Carbon Cement and Concrete Consortium

- 38 member organizations – industry, academics, other agencies
- Coordinate with voluntary consensus standards organizations, e.g. ASTM
- Facilitate standards development, interlaboratory comparisons and standard test materials
- Coordinate with other agencies EOP/CEQ, DOE-LPO, EPA



Foundational Metrology

- **Trusted measurements, standards, and methods provide**
 - Validation
 - Metrological Traceability
 - Quantification of Measurement Uncertainty
- **Enables measurement comparability across space and time**

