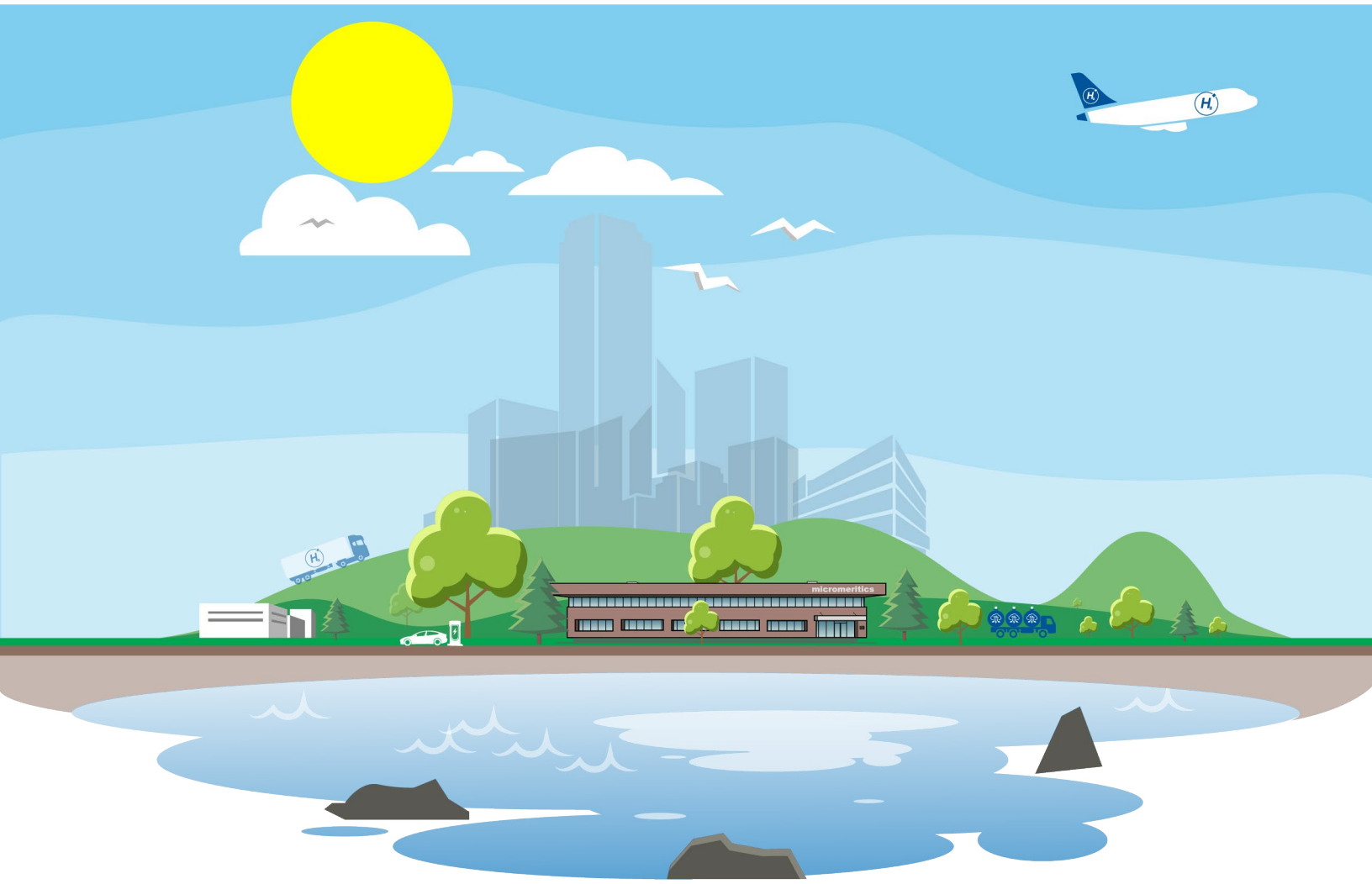
NET-ZERO TECHNOLOGIES

Micromeritics offers the most comprehensive portfolio of high-performance instruments to characterize the materials required to achieve a more sustainable future



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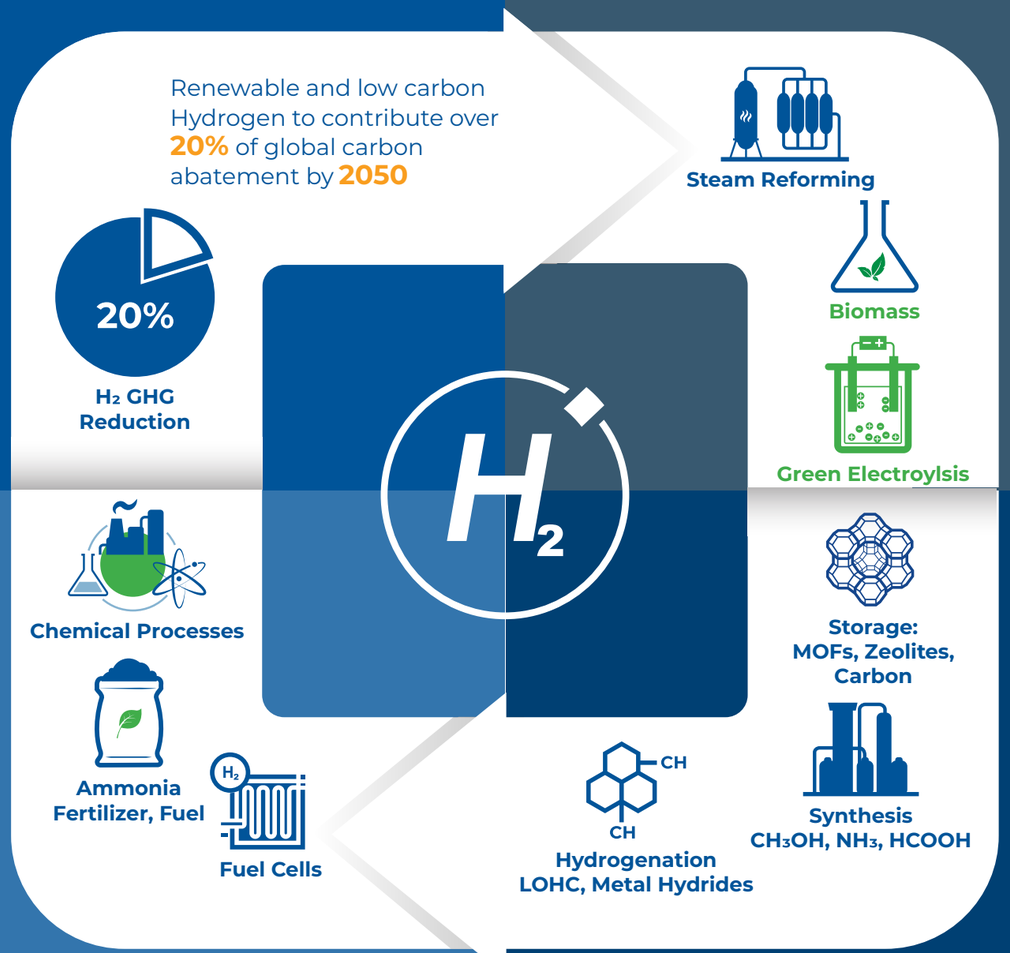
HYDROGEN LIFE CYCLE

Hydrogen will play a key role in decarbonization as it supports **60%** of the applications with greenhouse gas (GHG) emissions.

Micromeritics products play a key role in the development of Adsorbents, Membranes, and Catalysts critical for technology development.



HYDROGEN PRODUCTION

Blue Hydrogen is derived from natural gas with CO_2 capture and Green Hydrogen is produced by water electrolysis using renewable electricity.

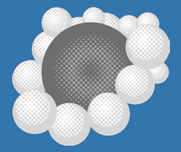
Adsorbents, Membranes, and Catalysts

- Optimize adsorption / desorption cycle to increase productivity and reduce cost
- Determine CO_2 that can be adsorbed
- Maximize activity and lifetime of the catalyst
- Measure membrane pore size to optimize transport and reactivity

Adsorbents, Membranes, and Catalysts

- Optimize pore size of fuel cell membranes
- Use chemisorption to determine catalyst active area
- Adsorb/Desorb cycle optimization to minimize costs
- Study fuel cell efficiencies

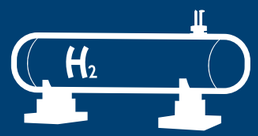
HYDROGEN APPLICATION



Adsorbents, Catalysts

- Develop materials with high H_2 adsorption
- Determine critical parameters to scale adsorbents
- Understand efficiency and lifetime of catalysts
- Maximize catalytic activity

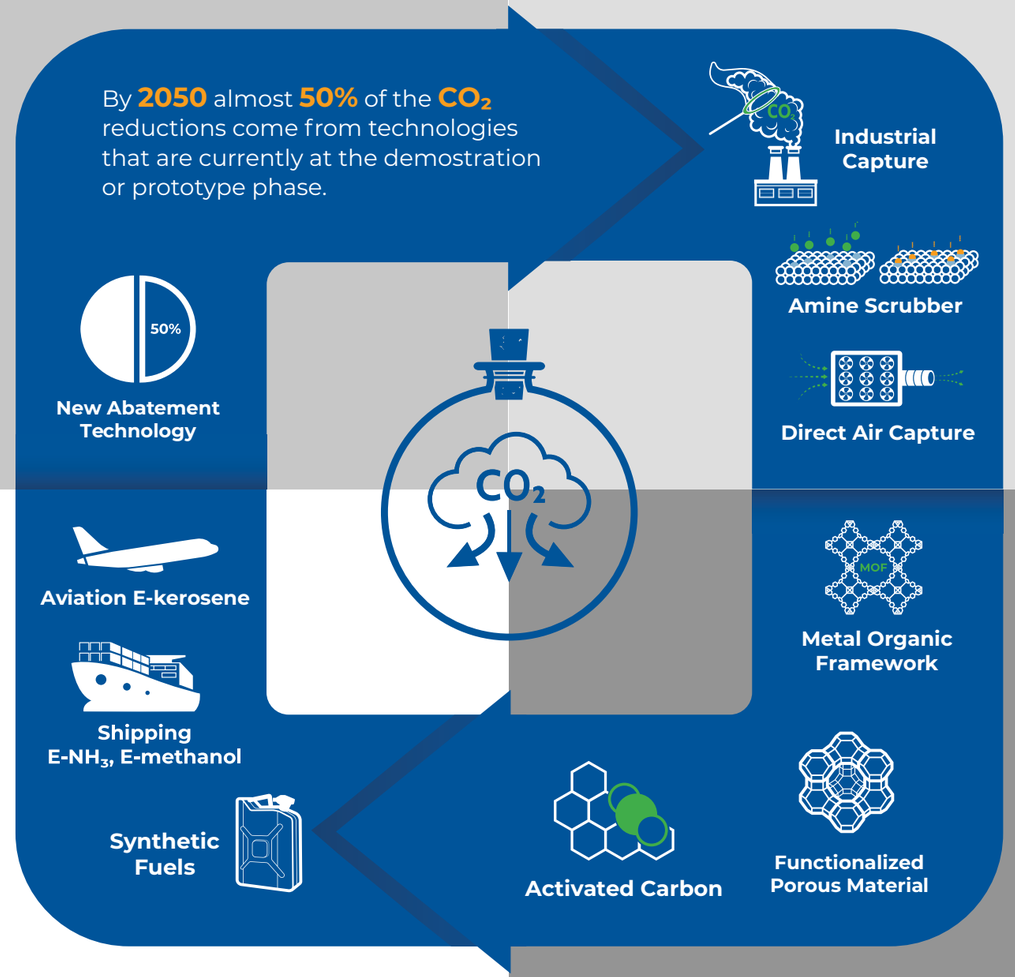
HYDROGEN STORAGE



CARBON DIOXIDE MITIGATION

Carbon capture, **utilization**, and **storage**, CCUS, is an important portfolio of emissions reduction technologies. A clean energy future includes electric vehicles, **valorizing CO_2** for synthethic fuels, and industrial plants using carbon capture.

By **2050** almost **50%** of the **CO_2** reductions come from technologies that are currently at the demostration or prototype phase.



CO_2 CAPTURE

Adsorbents. Membranes

- Effect of water on performance
- Tailor pore size of membrane for application
- Optimize adsorption / desorption cycle to minimize cost

Catalysts

- Evaluate effects of time-on-stream, temperature, and pressure on process economics
- Textural characterization of catalyst support
- Ascertain deactivation mechanisms
- Optimize metal dispersion and activity
- Determine reaction kinetics, activity, and selectivity of the catalyst

CO_2 UTILIZATION

CO_2 STORAGE

Adsorbents. Membranes

- Determine lifetime, cycling performance and adsorbent CO_2 capacity
- Understand local pollutants effect on adsorbent cycle life

ADSORBENT AND MEMBRANE SOLUTIONS

3FLEX

High-performance adsorption analyzer for measuring surface area, pore size and volume

- Understand adsorbent process cost using isoteric heat of adsorption
- Optimize pore size to maximize uptake capacity of the adsorbent
- Predict the selectivity of a gas mixture using Ideal Adsorption Solution Theory (IAST)

BreakThrough Analyzer (BTA)

Precise characterization of adsorbents or membranes under process relevant conditions

- Lifetime and cycling studies to choose best adsorbent technology
- Measure kinetic performance of adsorbents
- Understand humidity effects for CO_2/N_2 competitive adsorption

AutoPore

Mercury porosimetry analysis provides detailed porous material characterization

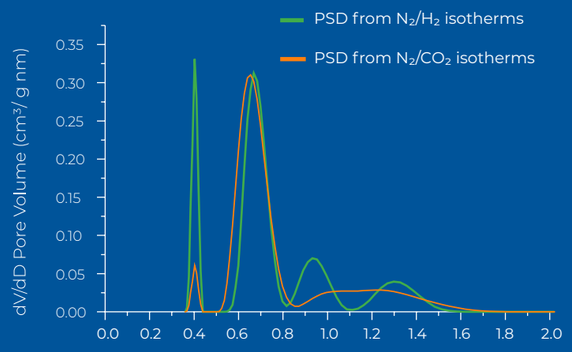
- Characterize pore size to understand diffusion into adsorption sights
- Study and optimize pore size distribution, total pore volume, percent porosity, particle size, and total surface area
- Assure reproducible adsorbent manufacturing process

HPVA *

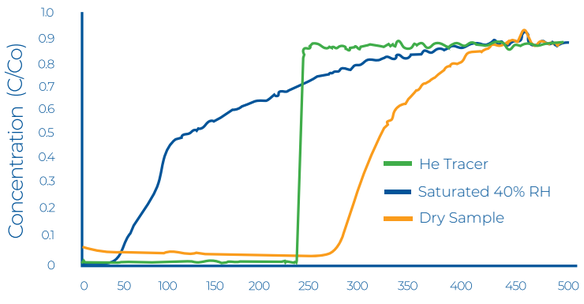
Static volumetric method to obtain high pressure adsorption and desorption isotherms

- Investigate the quantity of H_2 or CO_2 adsorbed
- Increase productivity and reduce cost by optimizing the adsorption / desorption cycle
- Study candidate materials and CO_2 storage sites

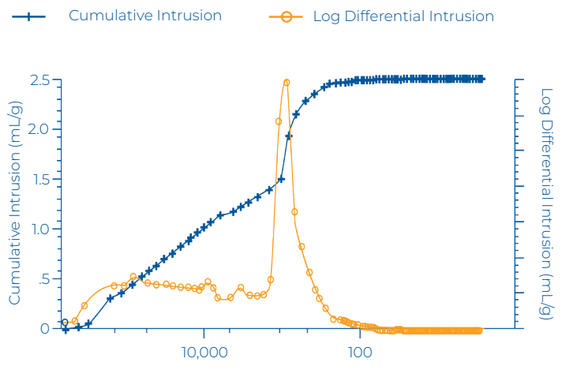
COMPLETE PORE SIZE DISTRIBUTION (PSD) USING DUAL NLDFT FOR ACTIVATED CARBON



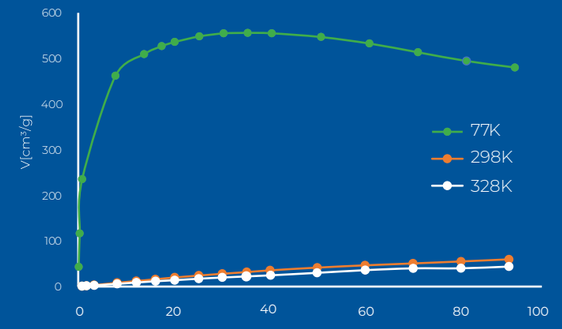
CO_2 BREAKTHROUGH CURVES SiAl LOADED WITH PEI



NaY ZEOLITE CUMULATIVE INTRUSION VS PORE SIZE



H_2 ADSORPTION ON MICROPOROUS CARBON



* Not all products and configurations are available in all regions

CATALYST SOLUTIONS

FR/MR REACTOR SYSTEMS

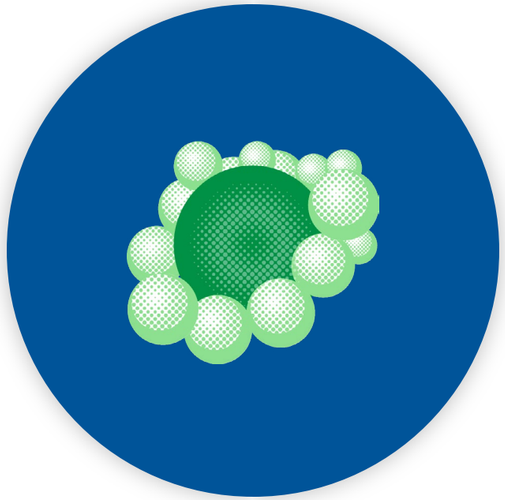
Benchtop reactor studies to understand and optimize catalyst performance

- Understand reaction kinetics to optimize operating parameters and conversion
- Measure selectivity, efficiency, and lifetime of catalysts
- Study reactions requiring gas / liquid separation at temperature and pressure

ICCS

Provides in-situ characterization to understand the effect of reaction conditions on the catalyst

- Understand changes in performance over extended periods
- Determine deactivation mechanism to maximize the catalysts' lifetime
- Monitor changes in active sites, oxidative state, metal dispersion, and desorption behavior



AutoChem

Utilizes dynamic techniques to characterize materials' active sites

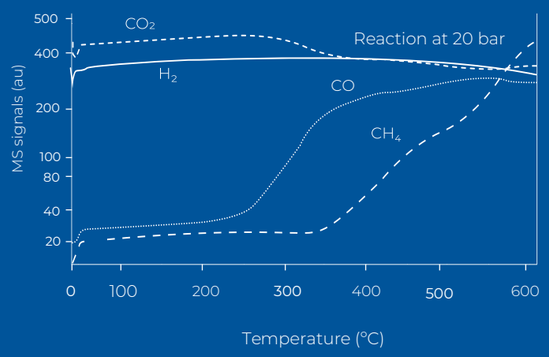
- Optimize adsorption and dissociation of H_2/O_2 on electrolysis electrodes
- Understand if desorption occurs near reaction conditions
- Measure and quantify acid or base sites to optimize reactivity and selectivity

3Flex CHEMISORPTION

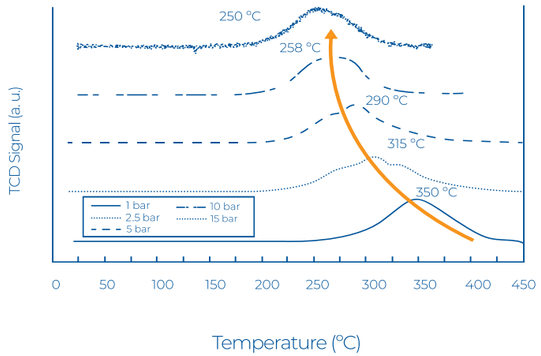
Offers physisorption and static/dynamic chemisorption for characterizing catalysts

- Understand multi-metal catalysts' effects on activation and adsorption of active species
- Select catalysts providing a higher turnover frequency
- Investigate influence of heat of adsorption

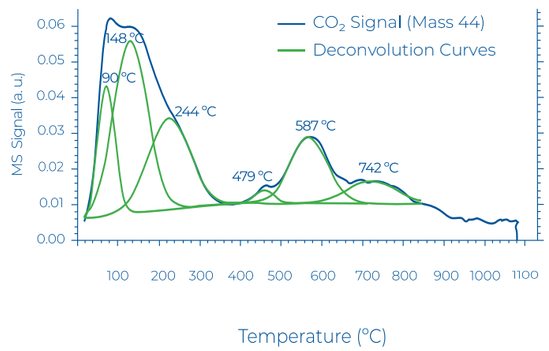
REDUCTION OF CO_2 IN THE SABATIER REACTION



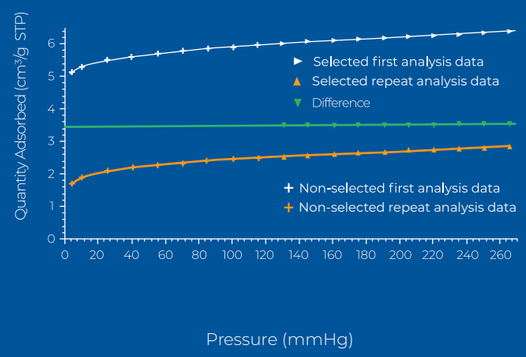
PRESSURE IMPACT ON REDUCTION TEMPERATURE Cu-OXIDE CATALYST



DECONVOLUTION OF CO_2 DESORBED BY CaO/MgO



ANALYSIS OF A SUPPORTED Ni CATALYST USING H_2



WORLDWIDE PRESENCE

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- ISO 17025 accredited and FDA registered.
- Globally recognized scientists.
- Typical turnaround time: 7 business days
- Over 25 analytical techniques.

Contact PTA today to learn how our world-class laboratory can advance the development of your materials for the Net Zero economy.

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