NET-ZER0 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.

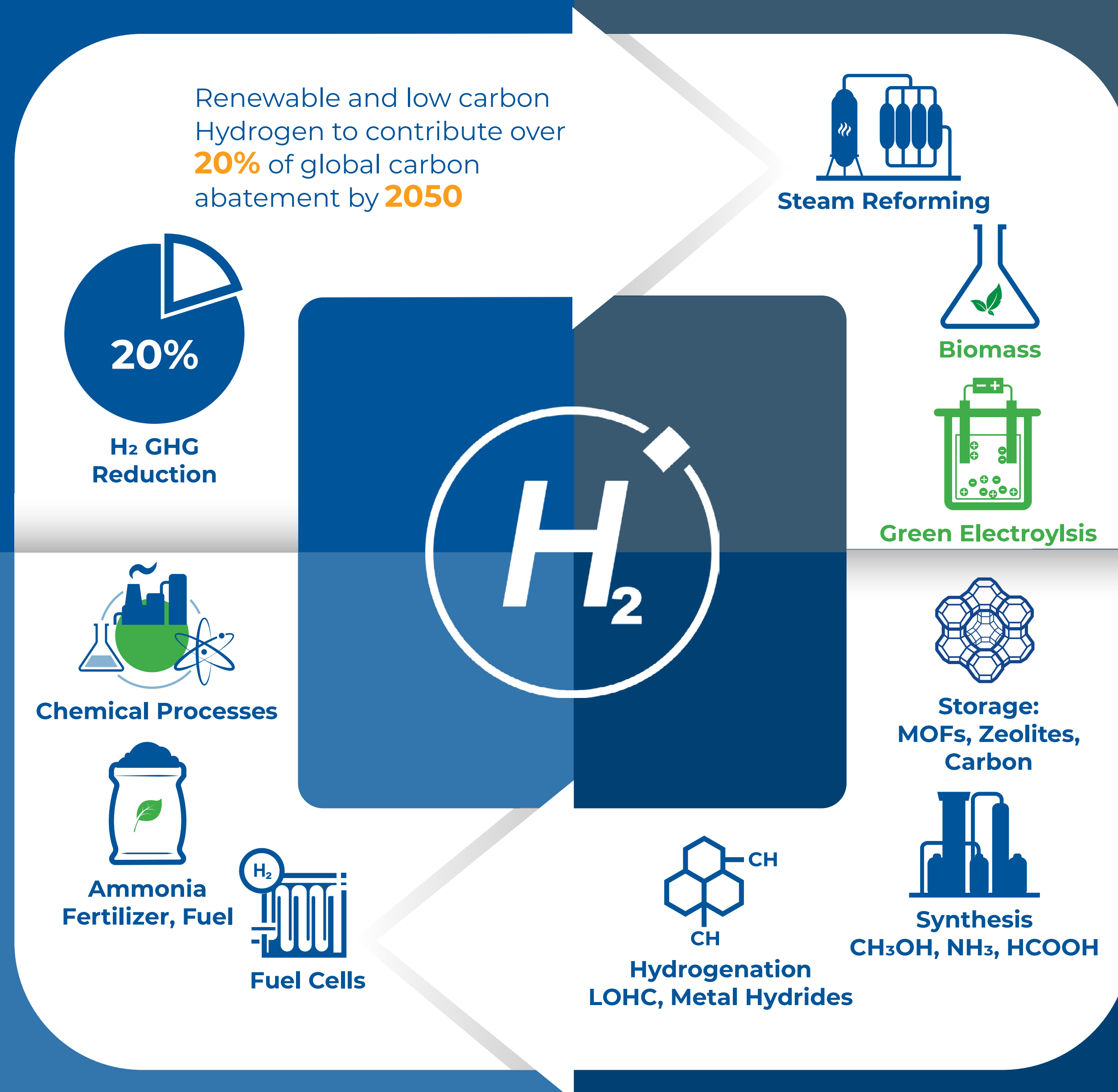
Micromeritics products play a key role in the development of Adsorbents, Membranes, and Catalysts critical for technology development.

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

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 APPLICATION

HYDROGEN STORAGE

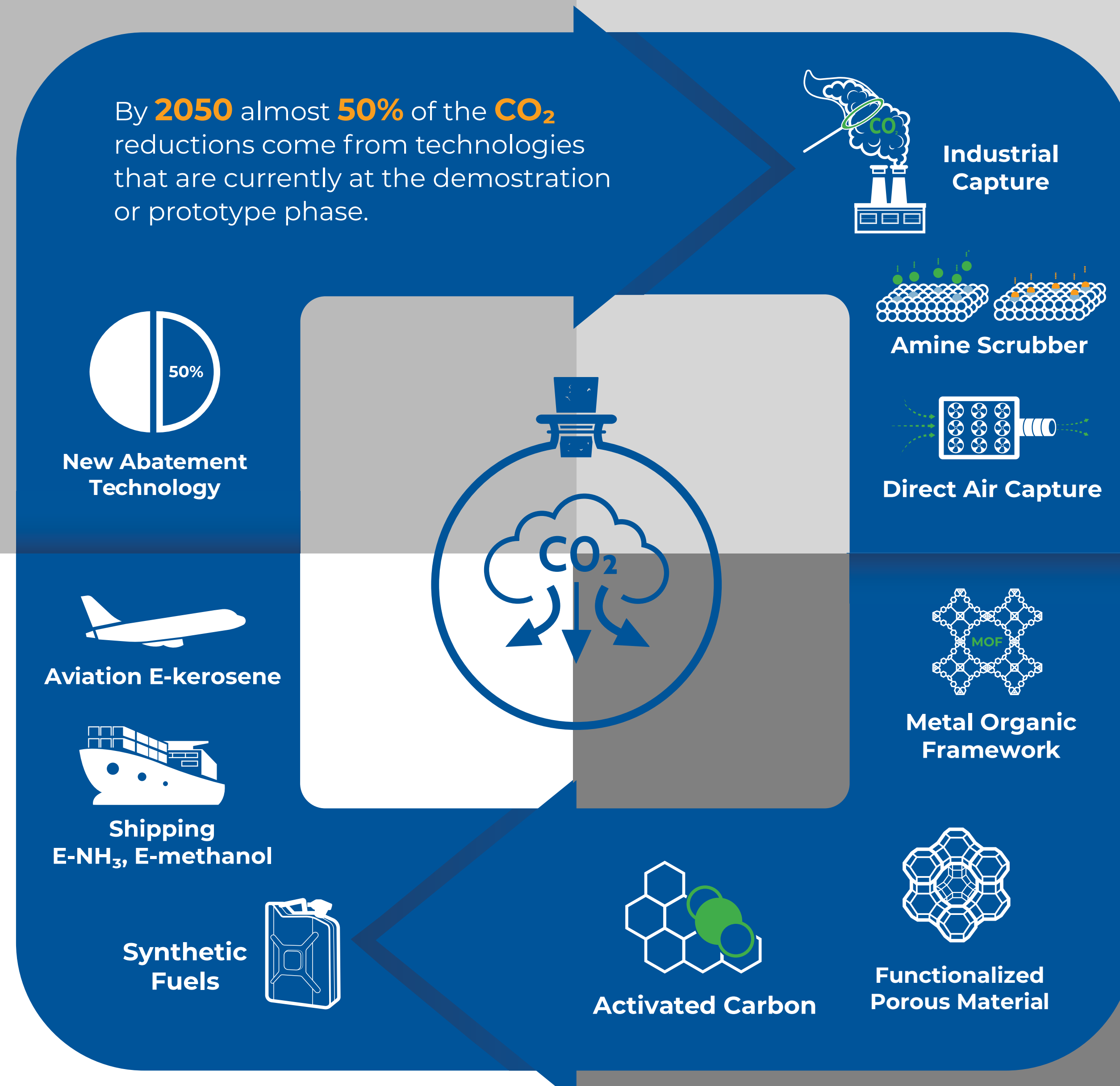
CARBON DIOXIDE MITIGATION

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.

CO_2 CAPTURE

Adsorbents. Membranes

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

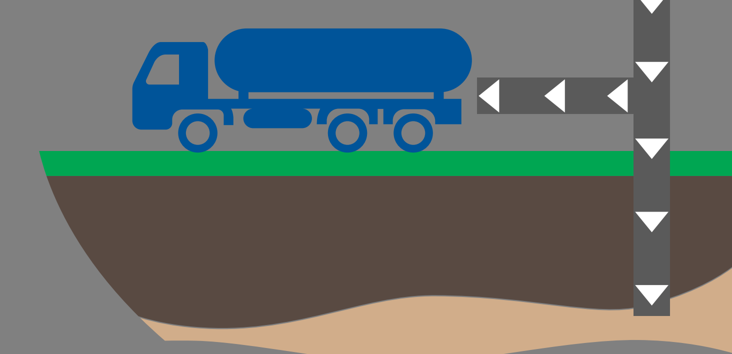


Catalysts

- Evaluate effects of temperature, pressure, and time on stream 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

Adsorbents. Membranes

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



CO_2 UTILIZATION

CO_2 STORAGE

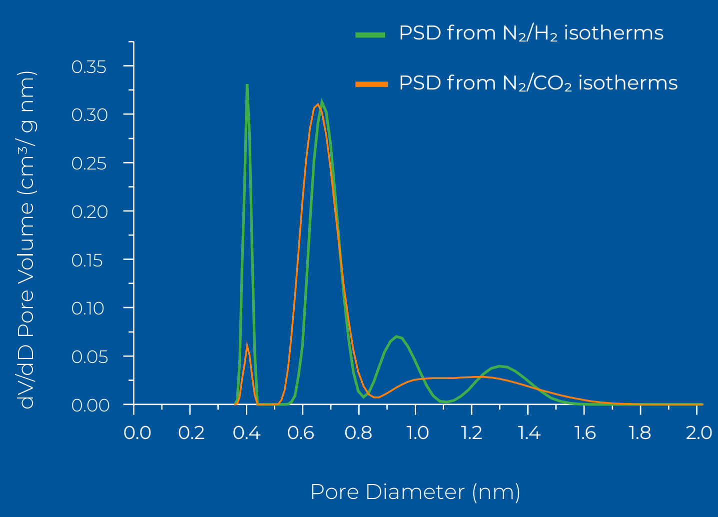
ADSORBENT AND MEMBRANE SOLUTIONS

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)

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

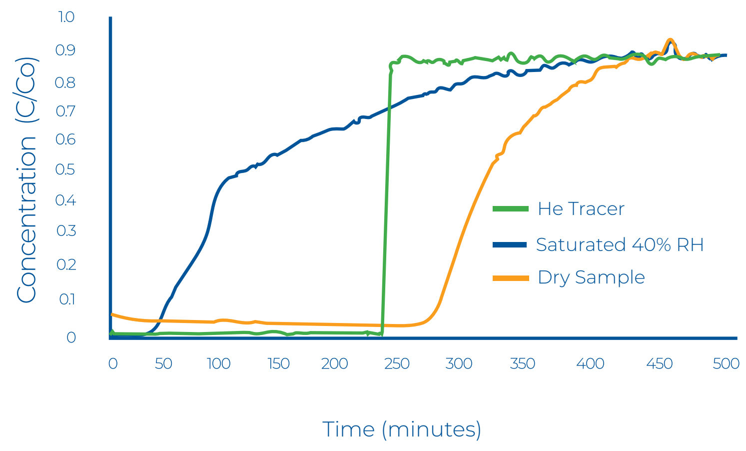


BreakThrough Analyzer (BTA)

Precise characterization of adsorbents or membranes under process relevant conditions

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

CO_2 BREAKTHROUGH CURVES SiAl LOADED WITH PEI

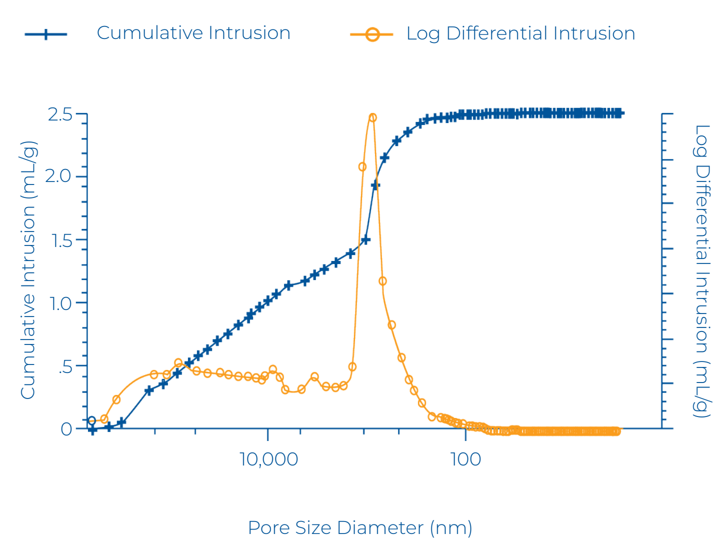


AutoPore

Mercury porosimetry analysis permits 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

NaY ZEOLITE CUMULATIVE INTRUSION VS PORE SIZE

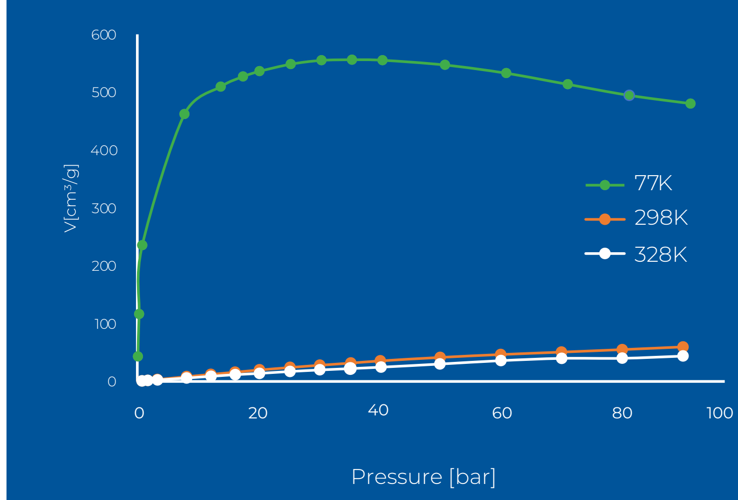


HPVA *

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

H_2 ADSORPTION ON MICROPOROUS CARBON



* Not all products and configurations are available in all regions

CATALYST SOLUTIONS

FR/MR REACTOR SYSTEMS

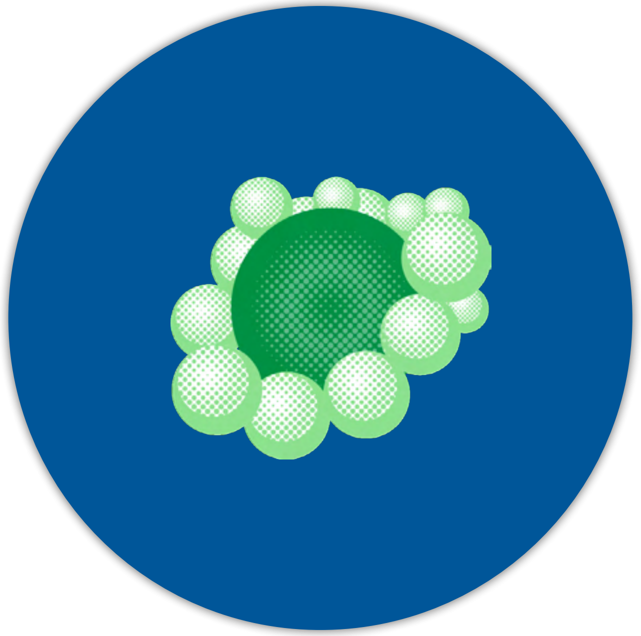
Benchtop reactor studies to understand and optimize catalyst performance

- 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

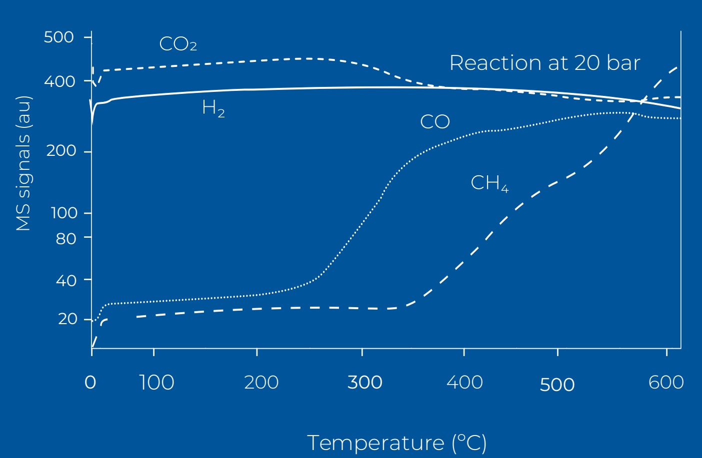
- Optimize adsorption and dissociation of H_2/O_2 on electrolysis electrodes
- Understand if desorption occurs near reaction conditions
- Measure and quantify acid or base sites to optimize reactivity and selectivity

3Flex CHEMISORPTION

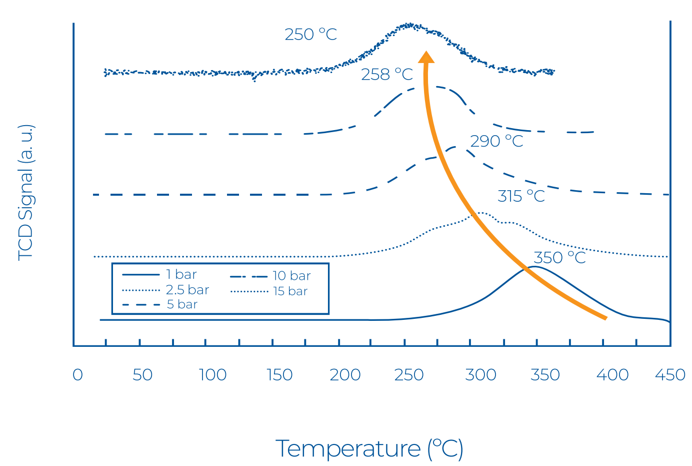
Offers physisorption and static/dynamic chemisorption for characterizing catalysts

- 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

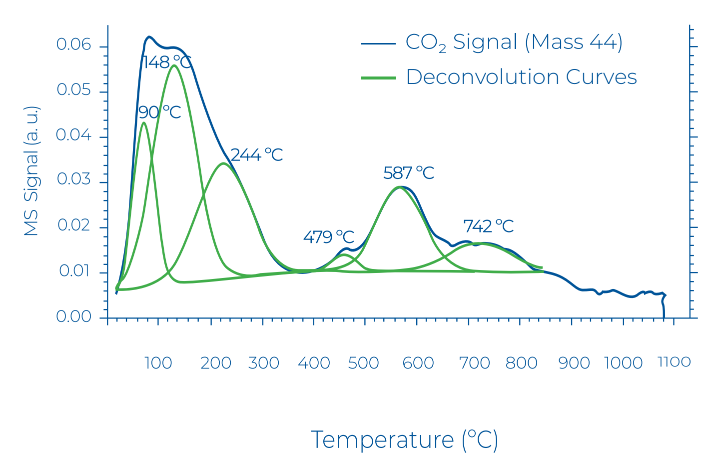
REDUCTION OF CO_2 IN THE SABATIER REACTION



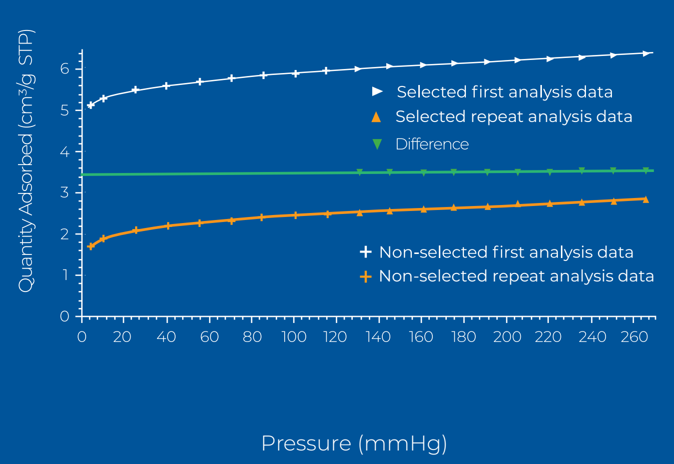
PRESSURE IMPACT ON REDUCTION TEMPERATURE Cu-OXIDE CATALYST

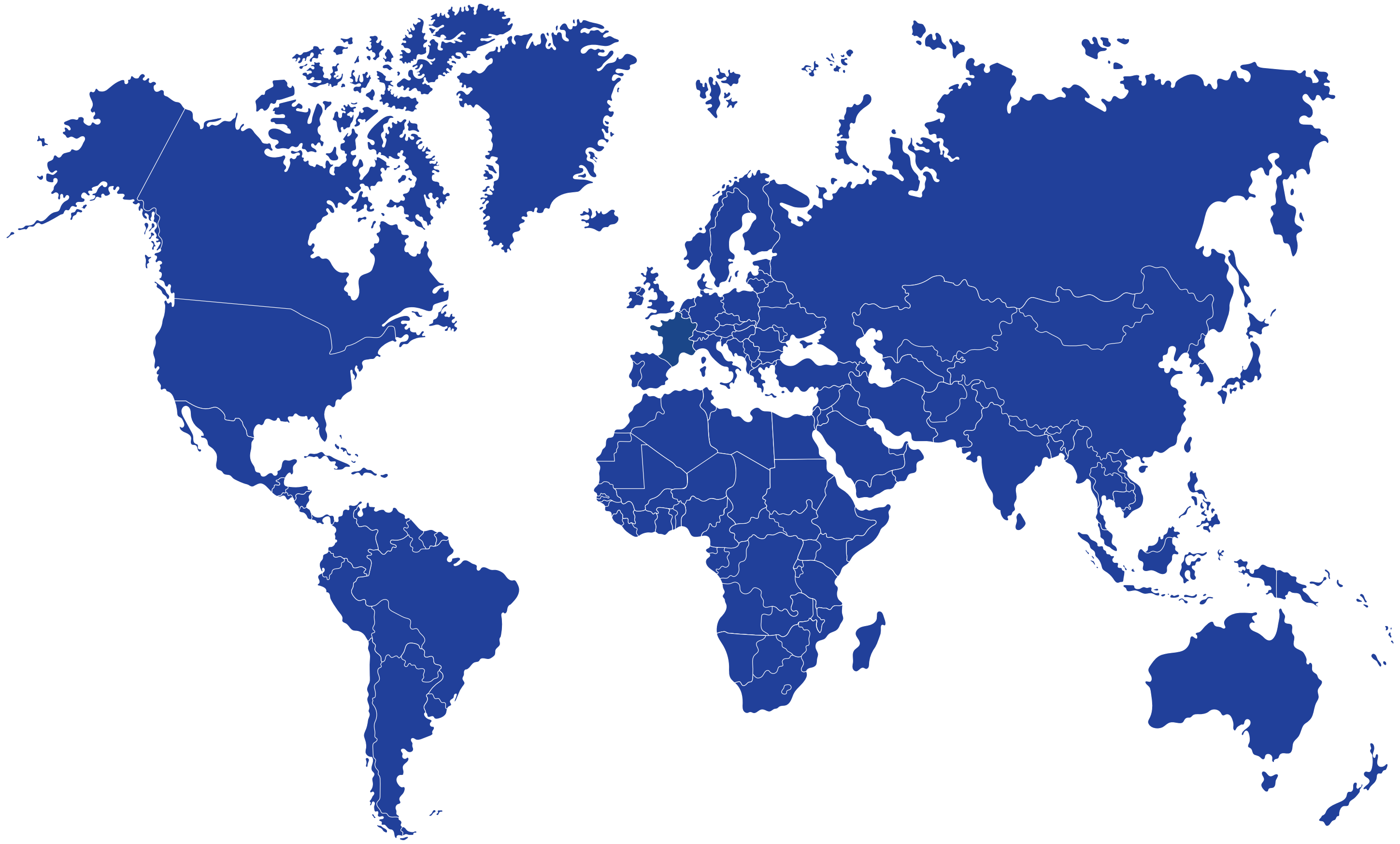


DECONVOLUTION OF CO_2 DESORBED BY CaO/MgO



ANALYSIS OF A SUPPORTED Ni CATALYST USING H_2





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PARTICLE TESTING AUTHORITY

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The Micromeritics PTA lab is the leading contract laboratory for the characterization of adsorbents, catalysts, and membranes. The same engineers and scientists that develop and support our market-leading technologies are available to help you develop methods, test samples, and analyze the results.

- 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.

Micromeritics products are 3rd party tested to conform to the highest level of compliance and safety. Visit micromeritics.com/compliance/ for full details by product.

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