



VAMAS

Project 3

Low-Pressure CO₂ Sorption Isotherms on Zeolite 13X

BACKGROUND

Adsorption of ultralow CO₂ concentration is relevant to applications, such as direct air capture (DAC) of the approximately 400 ppm CO₂ in air to mitigate climate change, CO₂ scrubbing for inhabitable air in enclosed space (e.g. spaceships, submarines), and specialized industrial processes that require high-purity gases or precisely controlled air composition. As such, the ability to fine tune the capture and release of CO₂ has garnered much interest. Solid adsorbent to adsorb CO₂ is one means for carbon capture, storage, and utilization by adjusting temperature and pressure.

However, no low-pressure CO₂ adsorption reference standards (materials or data) exist from NIST or other organizations. To address this metrology gap, the Facility for Adsorbent Characterization and Testing (FACT Lab) at the National Institute of Standard and Technology (NIST) coordinated an international interlaboratory study (ILS) to evaluate Research-Grade Test Material (RGTM) 10257 (zeolite 13X) for ultralow CO₂ adsorption measurements to provide

reference adsorption data, enable instrument validation and ultimately to accelerate the commercialization of materials.

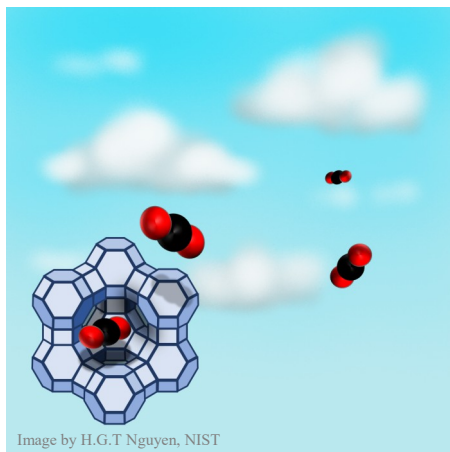


Image by H.G.T Nguyen, NIST

400 ppm CO₂ and Zeolite 13X

Zeolite 13X, a Faujasite (FAU) molecular sieve, was chosen for the study because it is expected to be stable and exhibits a measurable quantity of CO₂ uptake at DAC-relevant, ultra-dilute CO₂ concentrations in the parts per million (mmol/mol) range allowing for reference adsorption data at as low as 1 Pa. The beaded form of zeolite 13X offers benefits such as easier sample handling, recovery, and clean up after testing, while also reducing sample loss and dust generation compared with powder form.

Solid Sorbents

Technical Working Area 39

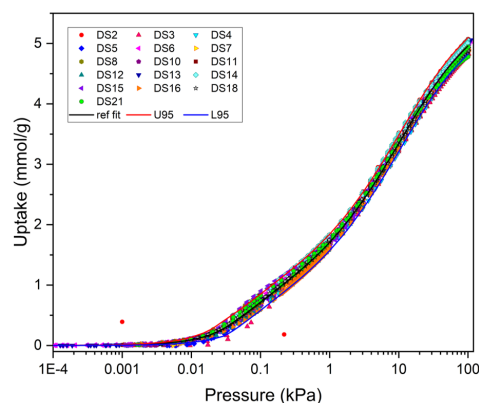
Summary of Results

WORK PROGRAMME

Participants were asked to measure low-pressure CO₂ sorption isotherms on NIST RGTM 10257 (zeolite 13X) at 25 °C up to 100 kPa.

NIST provided the protocol for the ILS. Eighteen laboratories participated in the study and contributed 21 datasets (4 sorption isotherms each). From these datasets, the reference adsorption isotherm and the 95% uncertainty interval were determined. Recommendations to achieve the reference adsorption isotherm were also provided.

REFERENCE SORPTION ISOTHERM



Datasets and reference isotherm

Expert review of the submitted isotherms identified 5 datasets for

omission due to pitfalls, such as inaccurate or improper mass measurements, issue with instrument calibration, and failure to re-outgas the sample or apply blank subtraction. A reference isotherm was extracted from the remaining 16 datasets. The remaining datasets and reference adsorption isotherm, along with the associated confidence interval, are shown in the graph.

DISSEMINATION

The datasets and reference isotherms are available in a peer-reviewed journal article¹ and through the NIST/ARPA•E Database of Novel and Emerging Adsorbent Materials.²

REFERENCES

- [1] H.G.T. Nguyen *et al.* *Adsorption*, **2026**, 32, 42.
- [2] <https://adsorption.nist.gov>

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