

CHARACTERIZING THE CO₂ ADSORPTION PROPERTIES OF METAL-ORGANIC FRAMEWORKS FOR CARBON CAPTURE APPLICATIONS

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INTRODUCTION

Adsorption by porous materials such as metal-organic frameworks (MOFs) is one of the methods currently being considered for the capture of CO₂ from air and waste gas streams. Carbon capture involves the removal of CO₂ to reduce either its emission from industrial processes or the reduction of its concentration in the atmosphere. Different methods require CO₂ capture under different conditions. Direct air capture (DAC), for example, is the removal of CO₂ from atmospheric air and therefore requires CO₂ adsorption at low concentrations, around 400 ppm, from a complex gas mixture (air) at ambient pressure. Post-combustion carbon capture, meanwhile, is the removal of CO₂ from the flue gas of point sources such as fossil fuel power plants. In this case, CO₂ must be adsorbed from a mixture containing mostly N₂, but with varying levels of minor contaminants, with a CO₂ level dependent on the source; although typically at a concentration of 15%. CO₂ adsorption from an 85%/15% mixture of N₂/CO₂ at ambient pressure has become the standard under which sorbents for post-combustion carbon capture are studied.

In each case, adsorbents must be characterized under the appropriate set of conditions. Adsorption isotherms are required for each gas in the mixture¹, as well as CO₂, while adsorption kinetics are also important², together with thermodynamic parameters such as the enthalpy of adsorption. Although a comprehensive set of data is not needed for an initial assessment of an adsorbent, such data is required for process modelling and design. Recent work has identified significant gaps in the data on adsorbent properties required for this purpose for DAC³, but there are also more general challenges associated with the characterization of adsorbents for gas separations⁴. In this poster, we present isotherms for different adsorbents including ZIF-8; isotherms for a benchmark adsorbent, zeolite 13X, at different temperatures; and example cycling data that can be used to demonstrate adsorbent stability.

RESULTS AND DISCUSSION

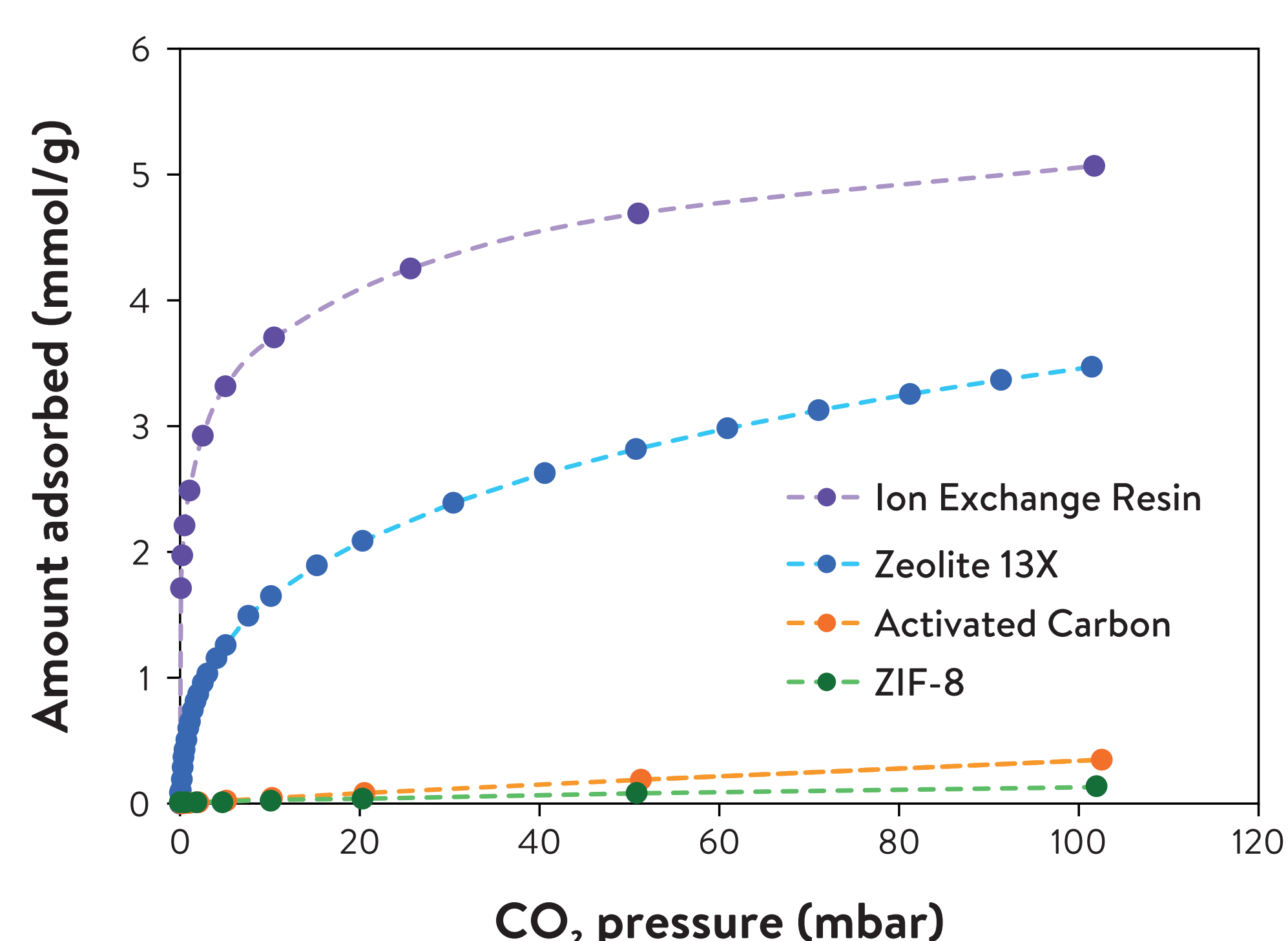


Figure 1: Pure CO₂ adsorption isotherms measured at 25 °C for an ion exchange resin (Lewatit® VP OC 1065), a zeolite (13X powder), an activated carbon (NORIT ROW 0.8mm pellets), and ZIF-8.

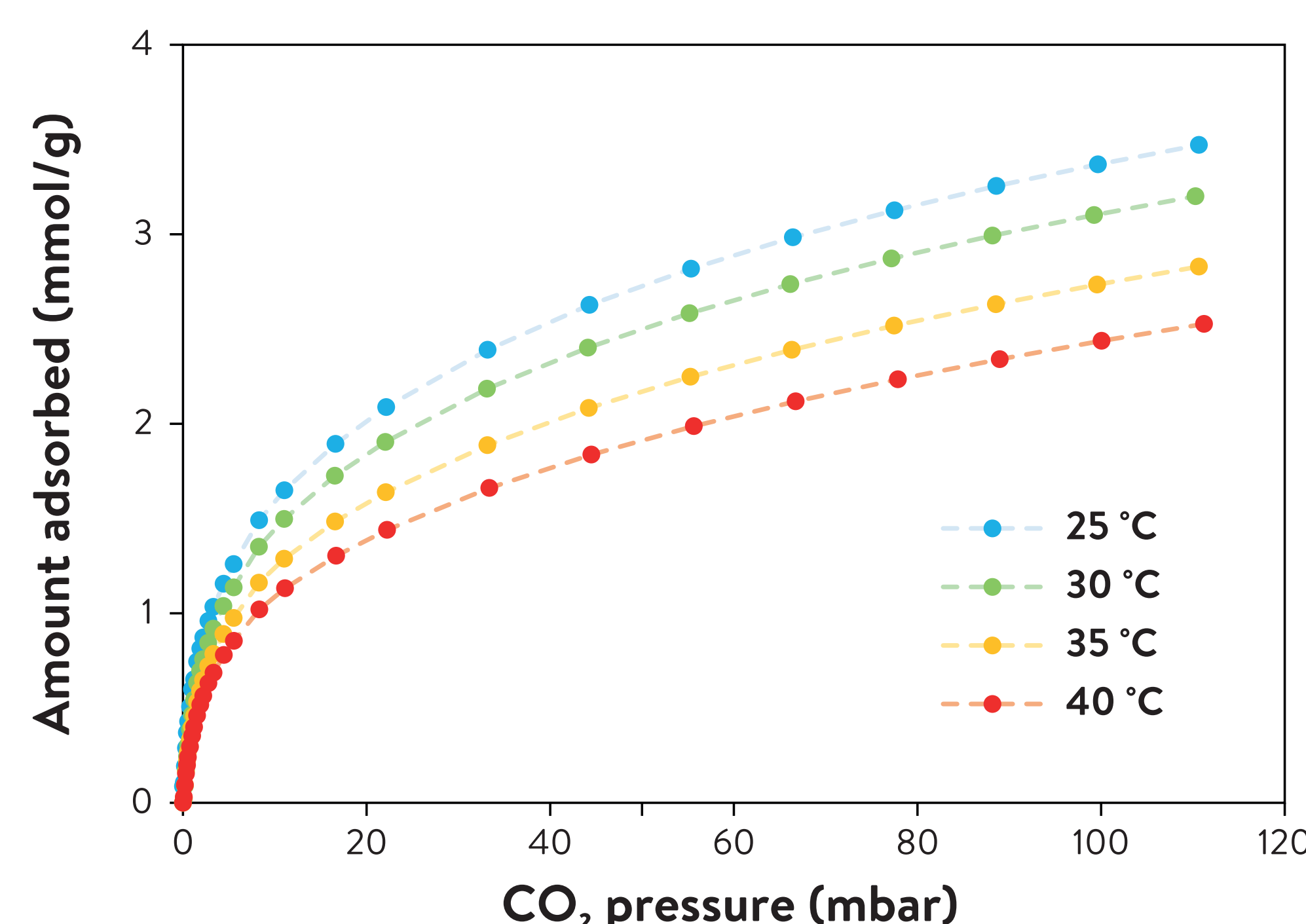


Figure 2: Pure CO₂ adsorption isotherms measured at four temperatures for a 26 mg zeolite 13X sample

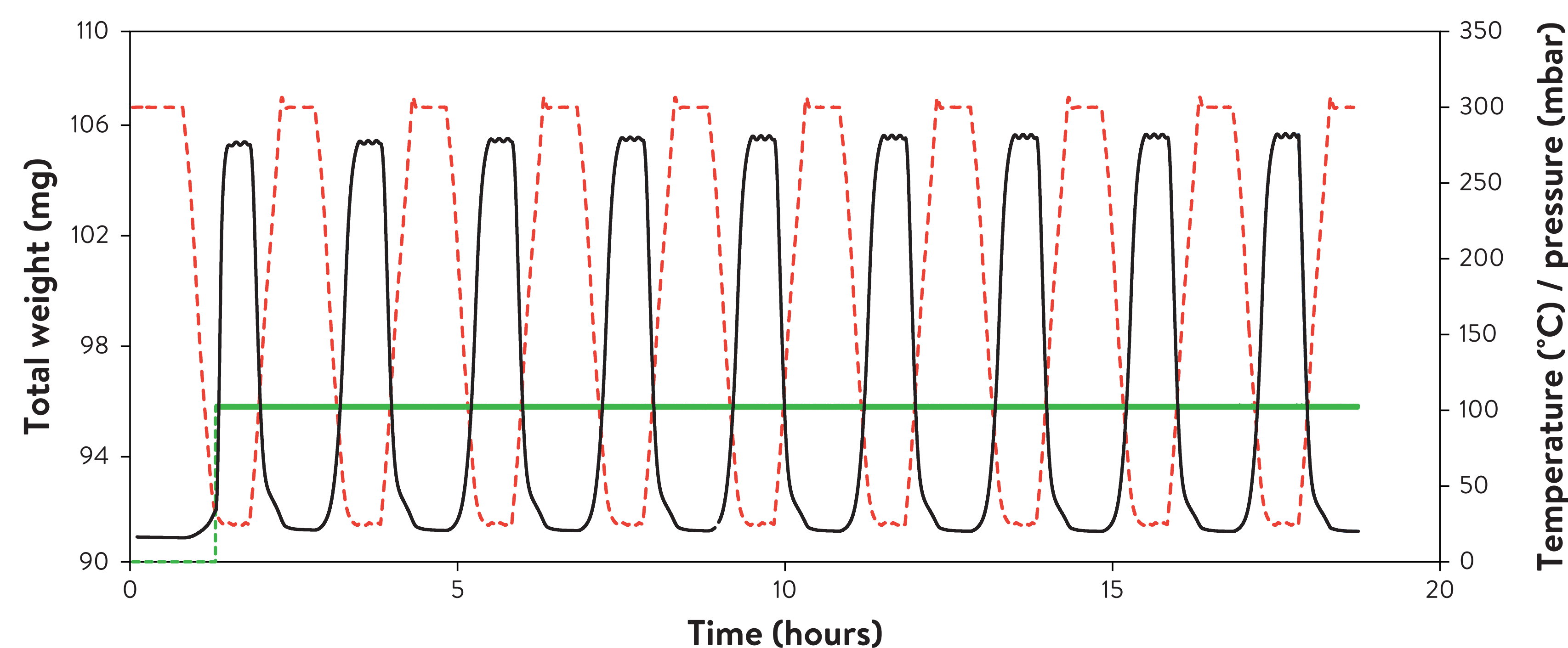


Figure 3: Cyclic stability test for a 91 mg zeolite 13X sample.

EXPERIMENTAL DETAILS

Pure CO₂ isotherms were measured at 25 °C for an ion exchange resin (Lewatit® VP OC 1065), a zeolite (13X powder), an activated carbon (NORIT ROW 0.8mm pellets), and ZIF-8 (ChemScene LLC) using a **Hidden Isochema IGA ECOsorp**. This instrument is equipped with four mass flow controllers (MFCs), two for CO₂ in different flow ranges and a wet and dry N₂ stream. Additional pure CO₂ isotherms were measured at 30, 35 and 40 °C for zeolite 13X using the same instrument. A cyclic stability test was also performed with zeolite 13X. Prior to each measurement, samples were dried in situ under dry gas flow at appropriate temperatures. Barometric pressure was measured throughout to provide accurate partial pressure values for CO₂.



SUMMARY

- ▶ Low-concentration CO₂ isotherms are essential for evaluating sorbents for Direct Air Capture.
- ▶ Isotherms at multiple temperatures allow determination of isosteric enthalpy of adsorption.
- ▶ Cyclic testing assesses sorbent stability and performance after repeated regeneration.
- ▶ These methods were demonstrated on several porous materials, including ZIF-8.

REFERENCES

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