OCTAVIA CARBON

LAB NOTE

Testing How Geothermal Hydrogen Sulphide Affects Our Direct Air Capture Sorbent

Project: Exploring Geothermal-DAC Integration in Kenya — Evaluating the Impact of Hydrogen Sulphide on DAC Adsorbents

Why we asked this question

Octavia Carbon is developing direct air capture (DAC) technology in Kenya, where geothermal energy from the Rift Valley could provide a reliable and renewable energy source for carbon removal. Geothermal power is available continuously and is well suited to the steady energy demand of DAC systems.

However, geothermal environments can contain trace acid gases, including hydrogen sulphide, H_2S. Since our DAC sorbent captures CO_2 using amine chemistry, we wanted to understand whether H_2S could interact with the same amine sites responsible for CO_2 capture and reduce sorbent performance.

If H_2S significantly reduces CO_2 capacity or shortens sorbent lifetime, it could affect the technical and economic feasibility of coupling DAC with geothermal energy. This study was designed as an initial experimental assessment of that risk.

What we did

Working with Dr. Ryan P. Lively's research group at Georgia Tech, we exposed a silica-supported PEI adsorbent (SiO_2 with 30 wt% polyethylenimine) to 5 ppm H_2S in a stream containing 400 ppm CO_2 at 60% relative humidity and a total flow rate of 1,000 sccm.

Samples were removed after 1, 2, 3, 4, and 5 days of exposure. Each sample was regenerated at 90 °C under nitrogen and then tested for CO_2 adsorption capacity using thermogravimetric analysis (TGA).

The 5 ppm H_2S concentration was selected as a conservative stress condition. It is higher than the low ambient H_2S levels typically measured around Kenya's Olkaria geothermal field, allowing us to test a more challenging exposure case rather than only mild ambient conditions.

The capacity results

The measured CO_2 adsorption capacities are summarized below.

Table 1: Summary adsorption data

Sample	Capacity (mmol/g)	Change vs. fresh
Fresh (baseline)	**0.402**	—
1 day	0.367	**–8.7%**
2 days	0.443	+10.2% *
3 days	0.499	+24.1% *
4 days	0.543	+35.1% *
5 days	0.391	**–2.7%**

**The apparent increases observed on days 2–4 are not interpreted as real capacity gains. They are likely influenced by differences in adsorption kinetics, as discussed below.*

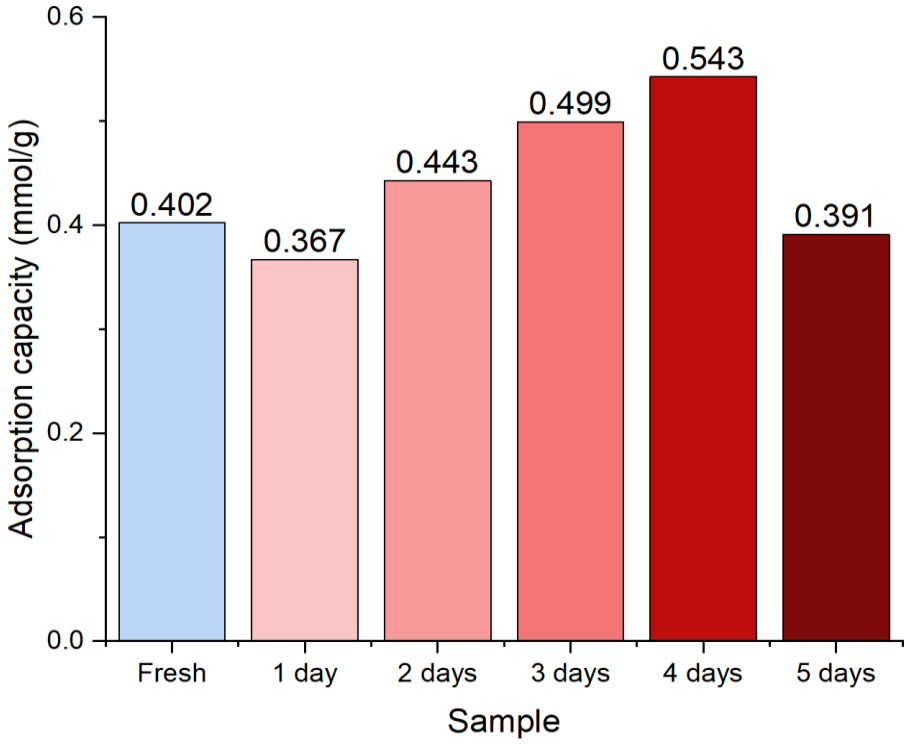

Figure 1. Calculated CO_2 adsorption capacity (mmol/g) for the fresh and H_2S-exposed samples after 1–5 days at 5 ppm H_2S. Day 1 was 8.7% below the fresh baseline, while the apparent increases on days 2–4 are discussed as kinetic effects.

The lowest apparent capacity was observed after one day of exposure, at 8.7% below the fresh baseline. This reduction did not continue with exposure time. By day 5, the measured capacity was within 2.7% of the fresh baseline. Taken together, the screening results show no progressive loss in CO_2 uptake over five days. Without replicate samples, however, the magnitude of the individual changes should be interpreted cautiously.

The surprise in the adsorption curves

The adsorption profiles showed an unexpected trend: several H_2S-exposed samples approached CO_2 equilibrium faster than the fresh material.

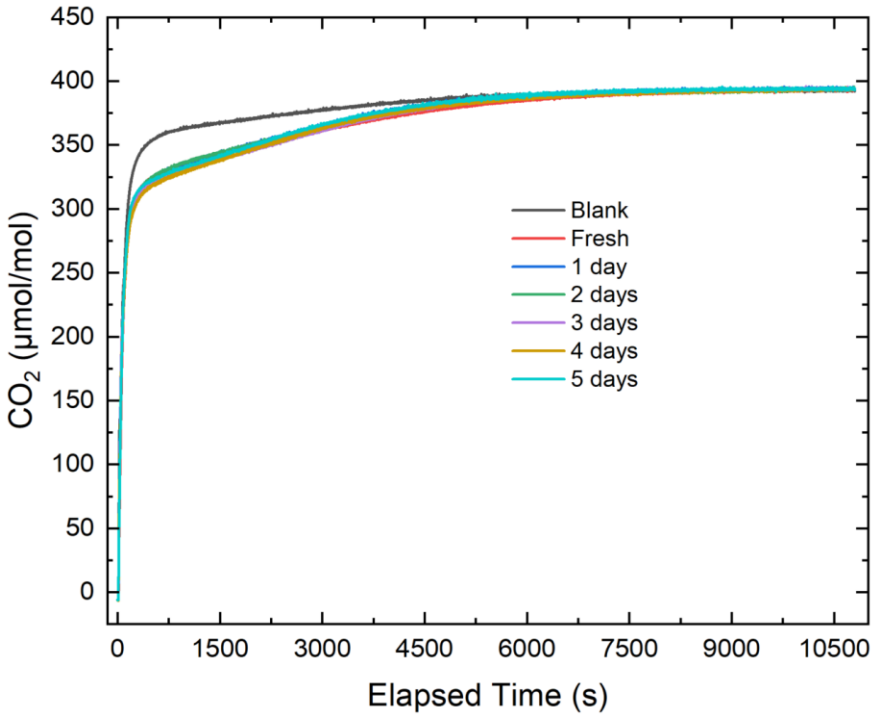

Figure 2. CO_2 breakthrough and equilibration profiles for the blank, fresh sorbent, and H_2S-exposed samples. The samples approached similar final outlet concentrations, while the longer-exposed samples—especially days 4 and 5—appeared to equilibrate faster.

The exposed samples approached similar final equilibrium levels, but some—particularly the longer-exposed samples—did so more quickly. Because capacity was calculated over a fixed adsorption window, faster equilibration can increase the apparent calculated capacity.

This explains why the samples from days 2–4 show apparent capacity increases in Table 1. These increases should not be interpreted as true improvements in equilibrium CO_2 capacity. Instead, they suggest a kinetic effect, possibly linked to changes in amine accessibility, pore diffusion, or the interaction between CO_2 and the exposed sorbent surface. The mechanism behind this faster equilibration remains under investigation.

A note on sample consistency

The TGA sample masses were comparable across the test set, ranging from 2.17 to 2.48 mg, against a fresh-sample mass of 2.34 mg. Because adsorption capacity was normalized by sample mass, these modest loading differences are unlikely to explain the capacity pattern. These values describe the material

loaded into the TGA and should not, by themselves, be interpreted as evidence of long-term sorbent durability.

Most importantly, the day 5 sample returned close to the fresh baseline. Within the limits of this screening test, exposure to 5 ppm H_2S did not produce a measurable progressive loss in CO_2 uptake over five days. Further chemical characterization is still needed to determine whether reversible or weakly bound H_2S interactions occurred.

What this means for geothermal DAC

These results provide encouraging early evidence that low-level H_2S exposure is unlikely to be a dominant short-term degradation mechanism for the PEI–silica sorbent under the conditions tested.

However, the findings should be interpreted carefully. This was an initial screening study at one H_2S concentration over a five-day exposure period. The dataset is not sufficient to quantify long-term sorbent lifetime, define a degradation rate, or directly update techno-economic assumptions.

A fuller assessment of lifetime and scale-up implications will require longer-duration exposure studies across multiple H_2S concentrations, ideally with replicate samples. Additional characterization, including FTIR and physisorption analysis, would also help determine whether the sorbent chemistry or pore structure changed and explain the faster equilibration observed in the adsorption curves.

Huge thanks to Mario Zorrilla Valtierra and the Lively group at Georgia Tech for the experimental work, and to the Bezos Earth Fund for supporting both this study and the lab infrastructure that made it possible.