Key technological considerations for the advancement of adsorption-based direct air capture

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Direct air capture (DAC) using solid adsorbents has gained significant attention as a carbon dioxide removal (CDR) technology to help limit global temperature rise to below 2 °C. To advance the discovery and deployment of adsorbents and adsorption-based technologies for DAC, two main research challenges must be addressed.

One challenge is collecting the necessary data needed to assess existing and emerging adsorbents in process models for adsorbents screening. These data include material properties (e.g. porosity, density, heat capacity, thermal conductivity) as well as equilibrium and kinetic sorption performance. In fact, the rate of CO_2 sorption can strongly influence the performance of the overall DAC process. Another challenge is the creation of process-scale models that allow the evaluation and optimisation of adsorbents and adsorption technologies. Here the implementation of a range of contactor designs and desorption approaches provide room for innovation and improved performance.

In this talk, we will discuss our recent work done to tackle the above two challenges. We will report the chemical, textural and thermal properties of two DAC chemisorbents as well as their equilibrium sorption properties for CO_2, N_2, H_2O, Ar and O_2, all relevant species for DAC application. We will also present an experimental framework developed to characterise the internal sorption dynamics within a single adsorbent pellet. We will demonstrate its applicability to CO_2 sorption on a range of physisorbents and describe our plans to extend to chemisorbents. Finally, we will cover a mathematical model of a rotary adsorber for use in CO_2 capture and DAC, and describe how materials and sorption properties impact the process key performance indicators (KPIs), i.e. recover, purity and productivity.

References

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