

DESIGNING MATERIALS AND PROCESSES FOR CO₂ CAPTURE WITH SOLID SORBENTS

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Cyclic adsorption and regeneration of solid sorbents to remove CO₂ from gas streams can be accomplished with a variety of different adsorbents and processes. Determining which adsorbents and which processes will be best suited for a given application requires simulations or experimental measurements of many different materials in many different processes. However, general principles can guide the development of carbon capture systems, based primarily on the performance and limitations of different adsorbents, types of gas-solid contactors used, heat exchange method, and managing pressure changes.

The main types of adsorption processes are temperature swing, pressure swing, or a combined temperature and pressure swing. Temperature swing adsorption processes involve regenerating a sorbent saturated with CO₂ through heating. In these processes heat transfer is generally the rate-limiting step and heating and cooling the sorbent is also the most energy intensive component of the process. To minimize the energy consumption of the process, the sorbent should have a moderate heat of adsorption to allow a large change in CO₂ capacity through changing the temperature, the heat capacity of the heated and cooled material should be minimized, and heat transfer should be maximized. For pressure swing adsorption processes, on the other hand, the driving force for regenerating CO₂ is provided by changing the partial pressure of CO₂ between the adsorption and regeneration steps. Changing the pressure is the main component of the energy consumption and cycle time, and these are minimized by allowing complex process configurations with multiple pressure differentials and using an adsorbent with high capacity but low heat of adsorption. Combined temperature and pressure swing adsorption can be optimized through a combination of the factors above. Each of these cases yields a different optimal material, contacting strategy, and process configuration, but all can be approached using a common design methodology.

This paper will present a design methodology for solid sorbent CCS systems. This will include design considerations for how to maximize the performance of a range of traditionally deployed and newly-discovered solid sorbents. Similarly, standard and novel process configurations will be discussed with descriptions of the possible benefits or drawbacks and the types of sorbent material that are best suited for each configuration. By comparing the performance of mature adsorbents and processes and the expected performance of adsorbents and processes currently under development, the state of the art and potential advances for CCS with solid adsorbents will be presented.