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Realistic evaluation of prototypical porous materials for carbon capture

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Carbon capture, utilization, and storage (CCUS) is an attractive approach to help decarbonization from point sources, like energy supply and other industries, as well as for pulling CO2 out of the atmosphere (i.e., direct air capture, DAC). Among several approaches at differing technology readiness levels, solid sorbents are promising as they generally combine high uptakes and selectivity with milder regeneration energies.

Adsorption screening and testing of promising materials are often performed using pure component or point uptake experiments, which only give information about adsorption capacity and ideal selectivity. At realistic process conditions, competitors such as moisture and temperature have a large effect on the uptake of CO2, wherein the presence of water could either increase CO2 capacity, compete for the same adsorption sites, or even induce material collapse. The kinetics on the other hand is another important factor for an effective separation.

Figure 1 shows that apparent CO2 uptake decreases by 5% RH in Zeolite 13X. Figure 2 presents the details of the sorption kinetics of both components highlighting replacement effects.

In this work, several porous materials including zeolites, MOFs, and functionalized resins are screened in realistic conditions for CO2 capture using advanced dynamic gravimetric sorption and breakthrough methods. The tests were conducted under varied conditions, e.g., different CO2 concentrations and relative humidity. The results showed that humidity is the key factor affecting the CO2 capture efficiency. This study provides a reference for screening the effective sorbents for carbon capture.

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References

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