Scientific Achievement
Amine/oxide adsorbent materials with different amine loadings were prepared, and the CO\textsubscript{2} adsorption behavior of similar amines on the two alumina supports are demonstrated to behave differently, emphasizing the importance of support choice in CO\textsubscript{2} sorbent design.

Significance and Impact
These results aid in the optimal design of CO\textsubscript{2} sorbents as the support can potentially be an active entity in the sorbent especially at low amine loadings. Although tuning the support properties on alumina-based supports contrasts results achieved previously on silica-based supports, it emphasizes the importance of support choice on effective sorbent design, specifically regarding amine loading, and amine-amine interactions.

Research Details
- Two class 2 aminosilyl-modified CO\textsubscript{2} sorbents were created by grafting primary amines associated with 3-aminopropyltriethoxysilane onto two different alumina materials having different levels of basicity
- Surface-amine interactions were shown to play a pivotal role in the development of CO\textsubscript{2} sorbents.
- This combined microcalorimetry and spectroscopy study reveals the influence of the specific attributes of the support on the CO\textsubscript{2}-amine species formed, and their potential applications to DAC and flue-gas capture technologies.

XRD and N$_2$ Physisorption show structural differences between ordered and disordered alumina supports (bare and with APS).

**Powder XRD shows difference in crystallinity in bare alumina supports**

Nitrogen physisorption confirms APS is being deposited inside mesopores instead of purely on exterior surface.
Unique trends in CO$_2$ uptake capacity as function of amine loading in Class 2 supports (differ from previous reports for silica or alumina)

Simulated flue gas = 10% CO$_2$ in He.
Simulated direct air capture = 400 ppm CO$_2$ in N$_2$

CO$_2$ uptake improved with more APS. Flue gas conditions have higher CO$_2$ absorbed than direct air capture, as expected.
In-situ FTIR spectroscopy shows nature of adsorbed species differs in both systems, D-Al₂O₃ support contained more basic sites. D-Al₂O₃ support shown to be more basic than O-Al₂O₃ material through formation of carbonate species and higher CO₂ uptake. Porous alumina supports form different adsorbed intermediates due to different combinations of amine species upon interacting with CO₂.
Different heats of adsorption for D-Al₂O₃ and O-Al₂O₃ with varying levels of APS loading due to different species formed

D-Al₂O₃ had higher heats of adsorption than O-Al₂O₃ due to more strongly basic sites

Introducing APS decreased heat of adsorption for D-Al₂O₃ but not O-Al₂O₃ suggesting APS lowered CO₂ capacity of more basic sites

At high amine loadings, both materials gave similar types of adsorbed CO₂ where support surface influence was minimized

As APS loading increased, amines became less isolated, more ion pairs formed, and higher heats of adsorption were observed