

# Carbon Capture Using Solid Sorbents. Amine-tethered Polystyrene and Polyacrylic Polymers for CO<sub>2</sub> Adsorption

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Efficient carbon dioxide (CO<sub>2</sub>) separation from mixed gas streams is necessary in industrial flue gas remediation, fuel gas refining, and chemical production such as sulfur, ammonia, and hydrogen. Established liquid amine technology for CO<sub>2</sub> capture has the primary disadvantage of requiring high energy for regeneration due to water's heat capacity and covalent bonding of CO<sub>2</sub> to monoethanolamines. Solid sorbents represent a practical alternative due to their lower heat capacity and alternate sorption mechanisms. Using column breakthrough techniques, this study compared CO<sub>2</sub> adsorption performance across fifteen polystyrene and polyacrylic copolymers at typical flue gas CO<sub>2</sub> concentrations (11.4 – 11.8%). A110, a polystyrene polymer functionalized with primary amines, had high CO<sub>2</sub> adsorption capacity ( $Q_e$ ) and removed 1.138 mmol CO<sub>2</sub> g<sup>-1</sup> ( $p < 0.001$ ), which was consistent with chemisorption to form carbamate. Eight polystyrene copolymers functionalized with tertiary or quaternary amines performed poorly, with  $Q_e$  values ranging between 0.009340 and 0.4038 mmol CO<sub>2</sub> g<sup>-1</sup>, due to steric hindrance or decreased amine density if hypercrosslinked. Polyacrylic copolymers A870, A830, and A847, functionalized with tertiary and/or quaternary amines, had high  $Q_e$  values ranging between 0.9327 and 1.140 mmol CO<sub>2</sub> g<sup>-1</sup> owing to favorable amine spatial arrangements for CO<sub>2</sub> adsorption, which is consistent with electrostatic attraction of bicarbonate to cationic amine moieties. Physisorption of CO<sub>2</sub> was trivial across differing polymer types. A847, A110, A830, and A870 show promise for CO<sub>2</sub> capture technologies. Further study should define CO<sub>2</sub> adsorption selectivity with appropriate contaminants, adsorption/desorption kinetics, regenerability, and operating limits (temperature, pressure, and humidity).

## Awards Won:

Second Award of \$2,000