Carbon Capture Using Solid Sorbents. Amine-tethered Polystyrene and Ppolyacrylic Polymers for CO2 Adsorption

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Efficient carbon dioxide (CO2) 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 CO2 capture has the primary disadvantage of requiring high energy for regeneration due to water's heat capacity and covalent bonding of CO2 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 CO2 adsorption performance across fifteen polystyrene and polyacrylic copolymers at typical flue gas CO2 concentrations (11.4 – 11.8%). A110, a polystyrene polymer functionalized with primary amines, had high CO2 adsorption capacity (Qe) and removed 1.138 mmol CO2 g-1 ($p < 0.001$), which was consistent with chemisorption to form carbamate. Eight polystyrene copolymers functionalized with tertiary or quaternary amines performed poorly, with Qe values ranging between 0.009340 and 0.4038 mmol CO2 g-1, 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 Qe values ranging between 0.9327 and 1.140 mmol CO2 g-1 owing to favorable amine spatial arrangements for CO2 adsorption, which is consistent with electrostatic attraction of bicarbonate to cationic amine moieties. Physisorption of CO2 was trivial across differing polymer types. A847, A110, A830, and A870 show promise for CO2 capture technologies. Further study should define CO2 adsorption selectivity with appropriate contaminants, adsorption/desorption kinetics, regenerability, and operating limits (temperature, pressure, and humidity).

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