

Carbon Capture Using Solid Sorbents. CO₂ Adsorption Using Amine-Tethered Polystyrene and Polyacrylic Polymers in Humid Conditions

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Removing carbon dioxide (CO₂) from mixed gas streams is vital for industrial flue gas remediation, fuel gas refining, and chemical production. Existing liquid amine technology is hampered by high regeneration costs due to water's heat capacity and covalent bonding of CO₂. Solid sorbents are appealing because of lower heat capacities and alternate sorption mechanisms. Using column breakthrough techniques, this study evaluated CO₂ adsorption capacity in mmol CO₂/g (Q_e), equilibrium, and breakthrough times across four amine-tethered polystyrene and polyacrylic copolymers at typical flue gas CO₂ concentrations (14.5%) with nitrogen carrier gas, comparing 0, 14, 27, and 40% relative humidity (RH) conditions. A110, a polystyrene copolymer with primary amines, had stable Q_e (~ 1.4) across escalating RH up to 40% while three polyacrylic copolymers, A847 with tertiary amines (~ 1.6), A830 with primary/secondary polyamines (~ 1.5), and A870 with tertiary/quaternary amines (~ 0.97), maintained Q_e stability up to 27% RH. Compared to anhydrous influent gas, at 40% RH the Q_e declined by 10, 5, and 2.5% for A830, A870, and A847 respectively, suggesting interaction of water with amine moieties and/or physisorption to the polymer which interferes with CO₂ adsorption. The hydration of influent CO₂ to carbonic acid, bicarbonate, and/or carbonate is negligible since the CO₂ concentration did not statistically decline across 0 to 40% RH. A847, A830, A110, and A870 show promise for remediation of industrial flue gas which contains 10% water vapor. Further study should explore CO₂ adsorption under varying temperature and pressure; adsorption/desorption kinetics; polymer regenerability; and contaminant selectivity.