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 (Qe), 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 Qe (~ 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 Qe stability up to 27% RH. Compared to anhydrous influent gas, at 40% RH the Qe 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.

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