Carbon Capture Using Solid Sorbents. CO2/N2 Selectivity with Amine-Tethered Polystyrene and Polyacrylic Polymers

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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 due to lower heat capacities and alternate sorption mechanisms. Using column breakthrough techniques, this study evaluated CO2 adsorption across thirteen polystyrene and polyacrylic copolymers at typical flue gas CO2 concentrations (11.4%), comparing between argon and nitrogen carrier gases. A110, a primary amine functionalized polystyrene polymer, and A847, a tertiary amine functionalized polyacrylic polymer, had high CO2 adsorption capacity (Qe) in nitrogen, removing 2.048 and 1.622 mmol CO2/g respectively, rivaling best in literature performance for amine-tethered organic polymers. All three polyacrylic polymers with tertiary and/or quaternary amines had high Qe values ranging between 1.245 and 1.622 mmol CO2/g due to favorable amine-CO2 spatial arrangements, which facilitated the hydration of CO2 by tertiary or quaternary amines. Four polystyrene copolymers functionalized with tertiary or quaternary amines performed poorly, with Qe values ranging between 0.08037 and 0.5113 mmol CO2/g, due to steric hindrance or decreased amine density if hypercrosslinked. Qe decreased by 18% if CO2 was admixed with argon instead of nitrogen, potentially owing to the higher polarizability of argon. Physisorption of CO2 was trivial. A847, A110, A830, and A870 show promise for carbon capture technologies. Further study should explore CO2 adsorption under varying temperature, pressure and humidity; adsorption/desorption kinetics; polymer regenerability; and contaminant selectivity.