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Evaluation of natural and synthetic sorbents for carbon dioxide capture using pulse thermal analysis

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The worrisome rise of carbon dioxide (CO_2(g)) levels in the atmosphere has heightened interest in adsorption technology. Twelve natural and synthetic sorbents, including metal organic frameworks (MOFs), activated granular carbon (AGC), synthetic and natural zeolites and biochars (BC), were evaluated for CO_2(g) uptake. Simultaneous thermal analysis coupled with pulse thermal analysis (STA-PTA) was used to determine mass and enthalpy changes due to CO_2(g) sorption and desorption by the sorbents during and after gas injection. Attenuated total reflectance Fourier transform infrared spectroscopy (ATR-FTIR) was used to characterize the sorbents both before and after STA-PTA. The synthetic sorbent Zeolite 5A had the highest CO_2(g) sorption capacity (90.48 mg g-1), followed by MOF-HKUST (52.59 mg g-1), with ATR-FTIR confirming sorption of CO_2(g). For the desorption step, Zeolite 5A retained the highest percentage of CO_2(g) (12.1%) relative to the other sorbents. This sorbent also had the highest enthalpies for both the sorption (-59.35 J g-1) and desorption (40.26 J g-1) steps, indicating that a significant amount of energy was released and absorbed, respectively, in these processes. Zeolite 13X had the 3rd highest sorption capacity (35.14 mg g-1) for all samples but had the second highest CO_2(g) retention (9.2%) of all sorbents after desorption. Natural zeolite had the lowest sorption capacity in the zeolite group at 10.68 mg g-1. Natural and synthetic carbon-based BC and AGC substrates had sorption capacities ranging between 19 mg g-1 to 31 mg g-1 while MOFs had sorption capacities of 5 mg g-1 to 53 mg g-1. Sorption was reversible for all of these sorbents. In all, the synthetic sorbents, Zeolite 5A and Zeolite 13X had the highest percentages of CO_2(g) retained and Zeolite 5A also had the highest sorption capacity, followed by MOF-HKUST. Altogether, Zeolite 5A is the best performing sorbent in the study and may be a viable sorbent for CO_2(g) capture from air.