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Carbon Dioxide Capture from Flue Gas using 13X binder free Zeolite: effect of the presence of Sulfur Dioxide

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Carbon dioxide (CO2) capture is a subject of extensive research, particularly with Carbon Capture and Storage (CCS) methods gaining attention, notably those based on gas-solid adsorption. However, there is a notable gap in the literature concerning the impact of contaminants present in gaseous streams, particularly sulfur and nitrogen oxides, on CO2 adsorption. This study evaluated the effect of sulfur dioxide (SO2) presence in gas streams on the performance of CO2 adsorbents using a commercial Köstrolith 13X binder free (13XBF) zeolite (Chemiewerk Bad Köstritz GmbH ,Germany), with a magnetic suspension balance (Rubotherm, Germany) [1].

Before and after exposure to SO2, the 13XBF zeolite underwent physical and chemical characterizations. N2 adsorption/desorption isotherms at 77K revealed a decrease in the amount of adsorbed N2 post-SO2 exposure, while the isotherm shape remained consistent, indicating a type I isotherm according to the IUPAC classification [2]. The decrease in textural properties post-SO2 exposure was attributed to the irreversible adsorption of sulfur species, confirmed through elemental analysis and X-ray photoelectron spectroscopy. The S2p spectrum for 13XBF zeolite after SO2 exposure displayed peaks corresponding to elemental sulfur and sulfate ions, whereas no sulfur species were evident on the zeolite surface before SO2 exposure. Even at low partial pressures (0.045 bar) and constant flow, exposure to SO2 led to irreversible adsorption, with residual SO2 adsorbed even after thermal regeneration under typical zeolite degassing conditions (300 ℃ in vacuum for 10 hours). This residual SO2 caused a reduction in CO2 adsorption at 0.15 bar across the studied temperature range.

In any cyclic adsorption process, whether thermal swing adsorption (TSA) or pressure swing adsorption (PSA), it is crucial to assess the adsorbent behavior through several adsorption/desorption cycles. After the initial SO2 exposure, a ~35% decrease in CO2 adsorption capacity was observed. However, in subsequent adsorption/desorption cycles, the CO2 adsorption capacity remained essentially constant over 10 cycles.

References:

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