120b Dynamic Adsorption and Desorption of Carbon Dioxide in Potassium-Promoted Hydrotalcite

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An International Energy Agency study evaluated CO2 separation and capture using an adsorption system employing 13X zeolite as the adsorbent and both PSA and temperature swing adsorption (TSA) operational modes and concluded that these technologies are not attractive to the gas- and coal-fired power systems. This conclusion has lead many to extrapolate the findings and conclude that adsorption systems, in general, are not applicable for CO2 separation and capture. This is not necessarily true. It is true that the commonly studied adsorbents (e.g., zeolites and activated carbons) suffer from low capacity at elevated temperatures. However, there are new adsorbents, such as potassium-promoted hydrotalcite (K-promoted HTlc), that selectively adsorb CO2 at elevated temperatures and release it simply by changing the pressure. K-promoted HTlc, as first shown by researchers at Air Products and Chemicals, has considerable potential for use in sorption enhanced reaction processes. It also has potential for use in high temperature PSA cycles based on the heavy reflux concept, as shown recently by the authors. Notwithstanding the research that has been done with K-promoted HTlc, detailed fundamental information on this novel adsorbent material is still lacking. Therefore, the objective of this presentation is to shed some light on this important material for high temperature CO2 adsorption.

A very broad study has been carried out, wherein K-promoted HTlc was synthesized and subjected to testing under dynamic adsorption and desorption cycling conditions to reveal adsorption and desorption kinetics, as well as the working capacity of the material for CO2 at elevated temperatures. The effects of activation time (8 to 20 hr), activation temperature (250 to 500 oC), cycle time (30 to 150 min), cycling temperature (250 to 500 oC), adsorption (800 torr) to desorption (50 to 400 torr) cycling pressure ratio, promotion solution concentration (0.25 to 4.00 M) at constant K to Al ratio, and K to Al ration in the K-promoted HTlc were all studied. From these results, adsorption and desorption mass transfer coefficients and working capacities were evaluated and correlated with the synthesis, activation and cycling conditions. The effects of the variations in these kinetic and capacity parameters on the performance of a high temperature CO2 capture and concentration process based on a PSA cycle was determined. This presentation will discuss all of these findings, with an emphasis placed on elucidating a fundamental understanding of the parameters that affect the performance of K-promoted HTlc for high temperature CO2 capture.