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$C0_2$ ADSORPTION IN ZEOLITE 13X

INTRODUCTION

Breakthrough analysis is a powerful technique for determining the adsorption capacity of a material under flow conditions. Breakthrough analysis allows users to precisely control temperature, pressure, and gas flowrates. This allows users to mimic process conditions and analyze adsorbates under conditions similar to those found in a production plant.

Zeolite 13X is a commercially available alumino-silicate material that has been thoroughly studied in the fields of adsorption and catalysis. Zeolite 13X has shown adsorption potential for a variety of substances including carbon dioxide and water vapor. Carbon dioxide adsorption is gaining increasing interest due to concerns regarding its impact on global warming. This application note will examine the carbon dioxide adsorption performance of Zeolite 13X in dry and humid (60%) conditions.

EXPERIMENTAL

Zeolite 13X is a standard reference material that was obtained in pelletized form. The pellets were of sufficient size such that they could be analyzed as-is in the breakthrough system. A stainless-steel sample column was first packed with a pinch of quartz wool to ensure that the zeolite 13X remained in the furnace's ideal heating zone. Roughly 400 mg of zeolite 13X was then added to the sample column. The sample column was then loaded into the BreakThrough Analyzer (BTA) and activated under nitrogen flow at 100 °C for 2 hours followed by 200 °C for an additional 10 hours. After activation the sample was cooled to the analysis temperature of 30 °C.

Dry CO_2 breakthrough analysis was conducted on zeolite 13X using a flowrate of 10 ml/min nitrogen, 10 ml/min CO_2, and 1 ml/min He. Following breakthrough, the sample was reactivated under nitrogen flow for 2 hours. This procedure was repeated until 5 breakthrough curves were collected.

Humid CO_2 breakthrough analysis was conducted using a similar procedure as was stated above. Breakthrough analysis was conducted using a flowrate of 7.4 ml/min dry nitrogen, 2.6 ml/min humid nitrogen, 10 ml/min humid CO_2, and 1 ml/min dry He. Reactivation conditions were the same and a total of 5 breakthrough curves were collected.

RESULTS - DRY

The resulting breakthrough curves for 5 successive dry CO_2 adsorption experiments are shown in **Figure 1**. The deadtime of the breakthrough experiments have been subtracted out for clarity. The breakthrough curves display no loss in capacity after 5 runs, obtaining an average CO_2 adsorption capacity of 2.87 mmol/g. Additionally, the slope of the breakthrough curves are very steep which signifies that there are little to no mass transfer limitations in the system.

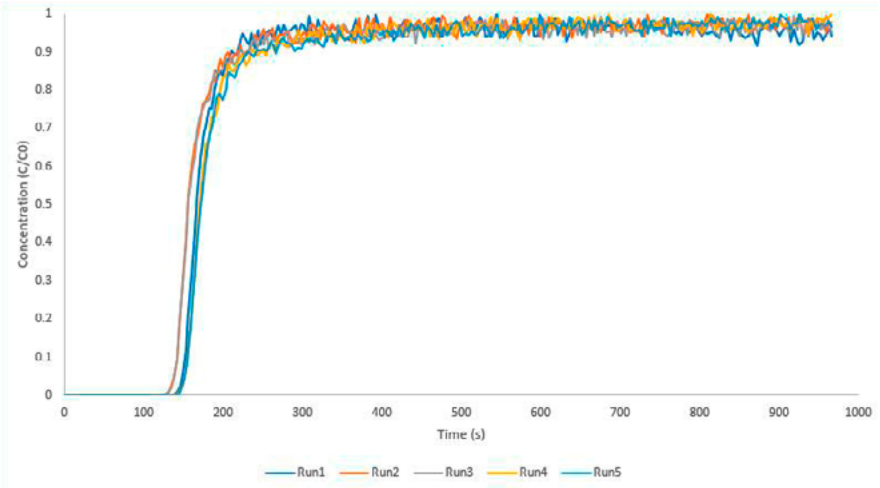

Figure 1. CO_2 breakthrough adsorption experiments conducted in dry conditions.

RESULTS - HUMID

The resulting breakthrough curves for 5 successive humid CO_2 adsorption experiments are shown in **Figure 2**. Once again, the deadtime of the breakthrough experiment has been subtracted out. The breakthrough curves display a very steep slope which implies that there are little to no mass transfer limitations in this system. With each successive trial, the CO_2 adsorption performance decreased across the five run. This decrease in performance is the result of strong interactions between water and zeolite 13X such that it cannot be removed without significant heating. This results in a decrease in CO_2 adsorption capacity over time. The vapor saturation pressure of water at 30 °C is only 0.043 bar such that the concentration of water in our gas stream is only about 2.5 % compared to the CO_2 concentration of 48 %. However, even at low concentrations zeolite 13X will adsorb significantly more water (mmol/g) compared to CO_2 such that water adsorption breakthrough studies would take many hours and are beyond the scope of this work.

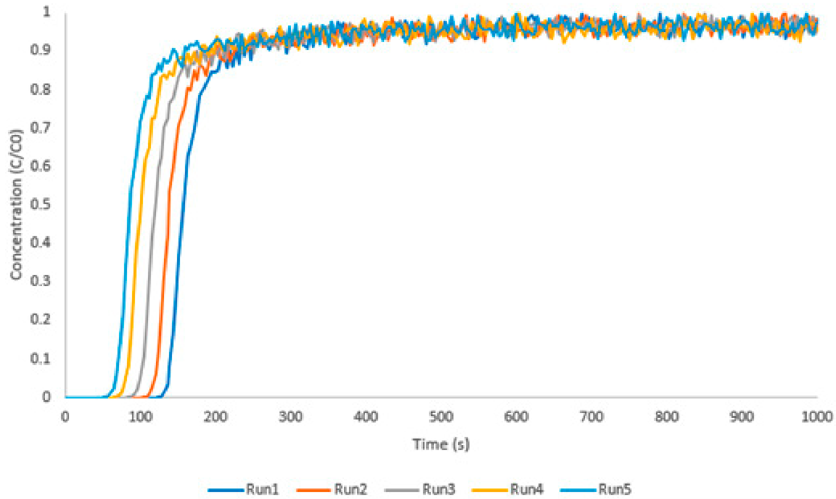

Figure 2. CO_2 breakthrough adsorption experiments conducted at 60 % relative humidity.

SUMMARY

Breakthrough curves for CO_2 adsorption on zeolite 13X were measured under dry and humid (60% RH) conditions. Under dry conditions, zeolite 13X displayed excellent cyclic adsorption of CO_2 with an average quantity adsorbed of 2.87 mmol/g. Under humid conditions, zeolite 13X slowly became saturated with water decreasing its capacity to adsorb CO_2. Higher activation temperatures would be required to completely reactivate the material. This study provides a baseline for the BreakThrough Analyzer (BTA) and its ability to measure CO_2 adsorption capacity

	Run	CO_2 Adsorption (mmol/g)
Dry	1	2.88
	2	2.72
	3	2.78
	4	2.94
	5	3.00

	Run	CO_2 Adsorption (mmol/g)
Humid	1	2.89
	2	2.65
	3	2.40
	4	2.18
	5	1.97

Table 1. Summary of CO_2 Adsorption in Zeolite 13X under dry and humid (60%) conditions

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