Removing CO_2 from Industrial Gas Streams by Adsorption into Jordanian Zeolite

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Abstract: ***Removing of CO2 from industrial gas streams is essential to prevent pollution and corrosion of Equipment. Several methods are used to remove CO2 from gas streams. Adsorption of CO2 into zeolite is a common method in the last years. The objective of this research was to use Jordan naturally occurring zeolite for adsorption of CO2. The adsorption effect in a fixed bed of naturally occurring Jordanian zeolite on air stream contains different concentrations of CO2 gas was used for this Study. The pressure and zeolite particles sizes effects were measured, and the breakthrough curves were obtained. It was found that for fine sizes at a pressure around 4 atm the adsorption capacity of naturally occurring Jordan zeolite is comparable to commercially processed zeolite. For fine sizes at around4atm, the saturation capacity of naturally occurring zeolite is about0.21 g CO2/ g zeolite.***

Keywords: Jordanian Zeolite, Adsorption of Carbon Dioxide, Acid Gases

1. Introduction

Carbon dioxide (CO2) is one of the main greenhouse gases which constantly increasing in the atmosphere due to the huge increase of CO2 emissions results from rapid expansion of the industrial sector and the number of vehicles. Moreover, Removing CO2 from gas streams is very important in process industrial streams. Carbon dioxide is an acidic gas, and therefore, when contact with water forms acidic solution and this acidic solution in turn cause high rate of equipment corrosion [AL Jarrah, 1997]. Recently, Capturing CO2 by means of adsorption into solids becomes a growing field of interest [Wong 2009] and zeolite is very attractive material for this purpose. Natural Zeolite in Jordan is widely distributed, and a low - cost raw material found in different. Three areas associated with Volcanic tuff belonging to Cenozoic volcanism (Al Dwairi 2007). Zeolites from Ataita Volcano is highly weathered and high zeolitic minerals content reaches 65 % (AlDwairi2007) Fig.1 shows the location of natural zeolite in Jordan. The objective of this research was to investigate and evaluate naturally occurring Jordan zeolite for adsorption of CO2.

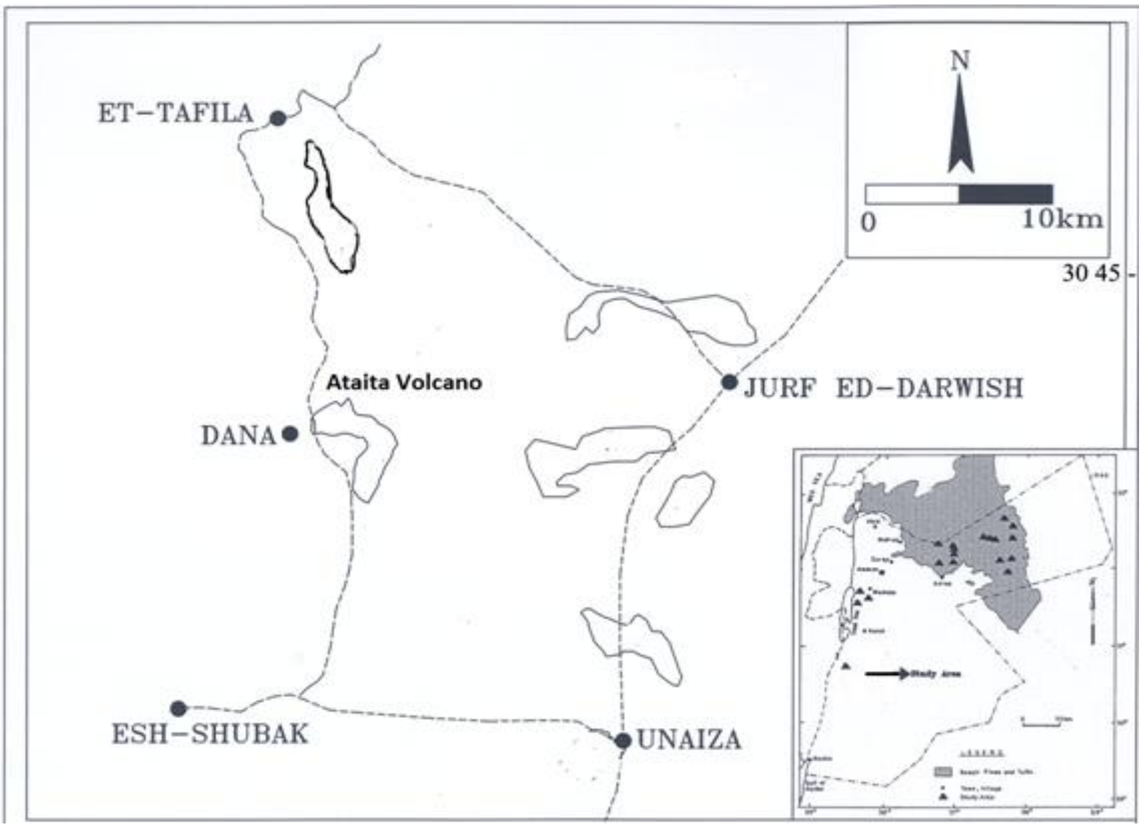

Figure 1: Map of Jordan Zeolite [AL Dwairi 2007].

2. Experiment

Several samples were collected from naturally occurring zeolite from Jabal Ataita south Jordan (30° 39' 32" Longitude (N), 35° 39' 54" Latitude (E)) (Elevation 1636). The samples were well mixed and crushed followed by sieving for the size fraction between 1.0 mm - 0.3 mm which has the highest zeolite content (Al Dwairi 2007). The samples then cleaned by water to remove dust and fine sizes.

The experimental setup used in this research is shown in Figure 1. Air is compressed in a tank and filtered to remove impurities then mixed with CO2 gas coming from 99.9% purity food grade carbon dioxide gas cylinder. The concentration of CO2 was controlled by adjusting valves V1 and V2. The gas after mixing was compressed by compressor 2 to the pressure as required then enters the adsorption column. The flow rate of the gas in the bed is controlled by vale V3. The concentration of CO2 is measured by carbon dioxide analyzer (GPro 500). The pressure inside the column was controlled by V4. The length of the column is 40cm and the diameter is 8cm. The Experiments were cover Pressures from 1 - 6 atm and concentrations from 1 - 3 mol % inlet CO2 concentration. The sizes of zeolite used were 14/20, 35/48 and 200/pan.

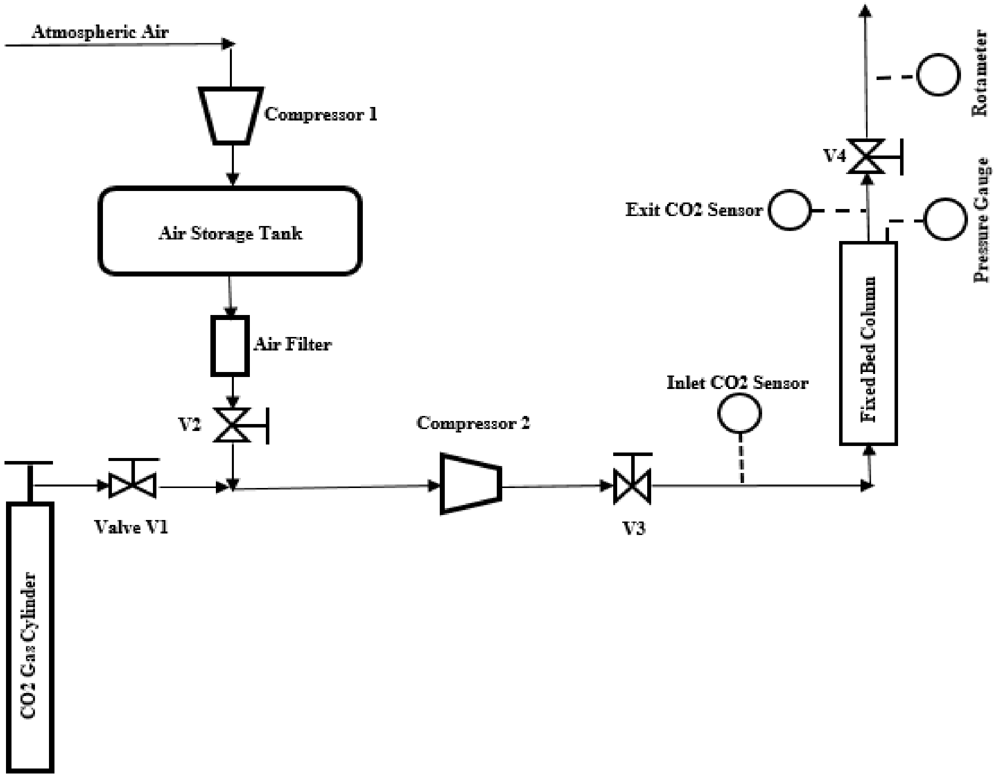

Figure 2: Equipment Setup

3. Obtained Results

The outlet concentration of CO2 over the inlet concentration as a function of time for different pressures at mesh size of 35/48 was plotted in Fig 3. This figure shows that for pressures 1, 2 and 3 atm no adsorption occurs. The adsorption starts at approximately 3.7atmosphere and continue to increase to approximately 4 atmosphere and then becomes very weekly increased.

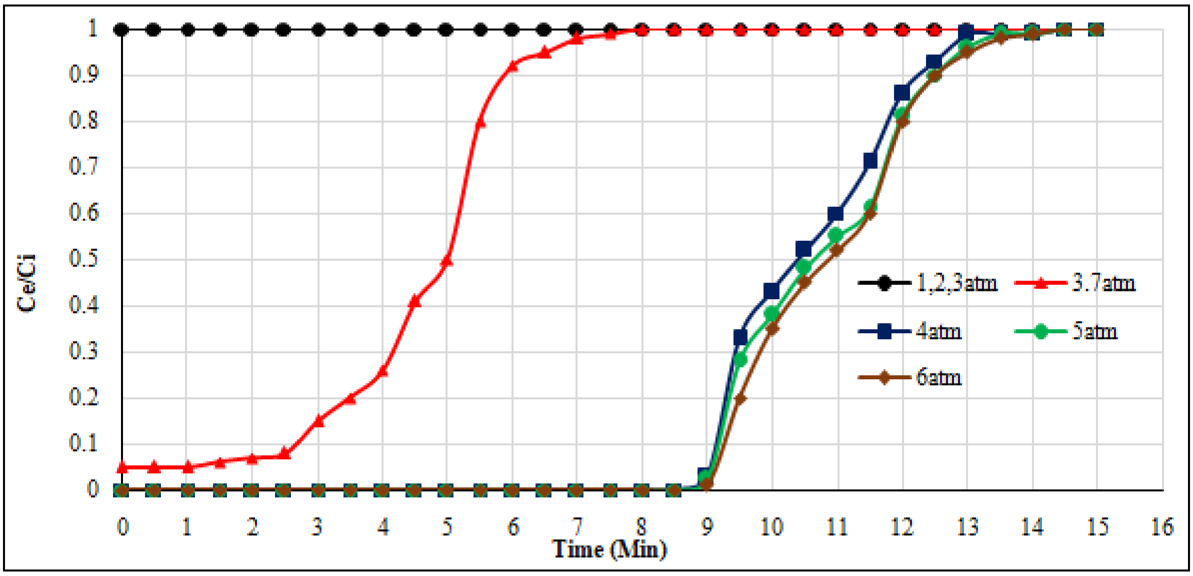

Figure 3: Exit CO2 Concentration at deferent pressures for mesh size of 35/48and CO2inlet concentration of2mol %.

The effect of particle size on the rate of adsorption is shown in fig.4. The size is significantly affecting the rate of adsorption. As the size decreases the surface area increases and hence more sites for adsorption are created, and therefore the rate of adsorption increased. The effect of inlet concentration on the adsorption is shown in fig.5. The time for breakthrough becomes shorter as the inlet concentration increased.

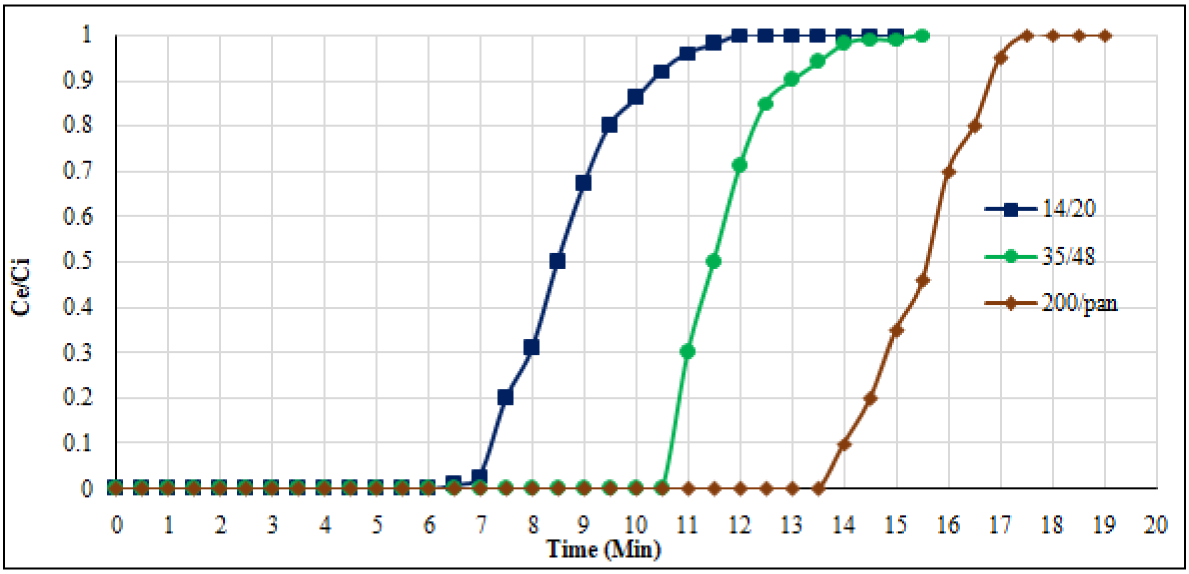

Figure 4: Exit CO2 concentration as a function of time for different zeolite sizes at pressure 5atmosphere and inlet CO2 concentration of 2mole %.

The adsorption capacity versus pressure is shown in fig.6. The amount of CO2 adsorbed by the zeolite is [Warren et. al.1993]

$$W_{sat} = \frac{Q\,\dot{C}_i\,M}{w}\int_0^{t_e}(1-\frac{C_e}{C_I})dt \qquad (1)$$

Where, W_{sat} is the saturation adsorption capacity, Q is the flow rate, C_i is the concentration of CO2 at the inlet, M is the molecular weight of carbon dioxide, and w is the weight of zeolite.

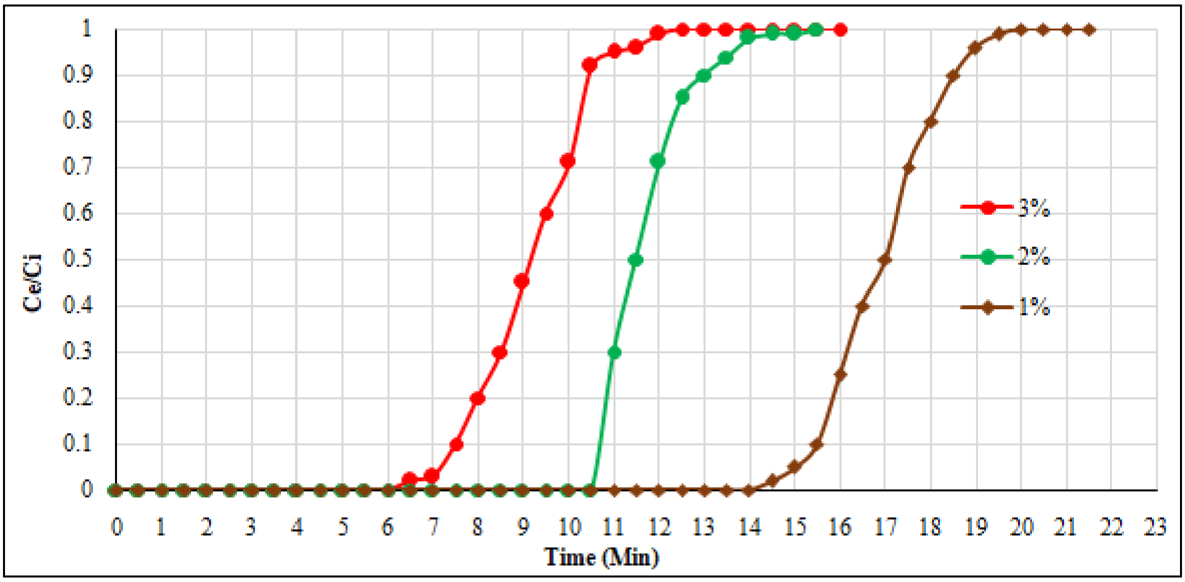

Figure 5: Concentration as a function of time for different inlet concentration of CO2 for size of 35/48 and pressure of 5 atm.

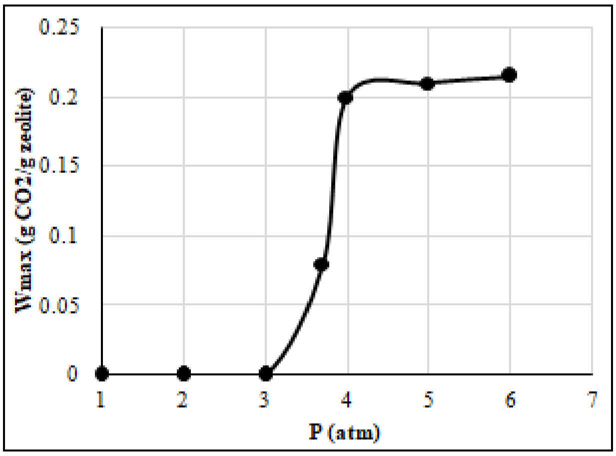

Figure 6: Adsorption capacity versus Pressure of Jordanian natural zeolite

4. Conclusion

Jordanian naturally occurring zeolites at 4 atm shows an excellent absorption capacity for removing of CO2. At 4 atmthe saturation capacity of zeolite is around 0.21 g CO2/ g zeolite, which considered high compared to other adsorption materials. Thus. the capability of Jordanian natural zeolite for capturing CO2 add another great property for it. Moreover, Jordanian zeolite can be used in variety of applications (fertilizer, water and wastewater treatment…etc.). With its huge quantities, Jordanian natural zeolite is a promising material for investment in Jordan.

5. Recommendation

In this work, evaluation of Jordanian natural zeolites for capturing CO2 was evaluated. Further studies on the capability of Jordanian natural zeolites for capturing another acid gasses (H2S, NOx, COx…etc.) are recommended for future work.

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